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Wave measurements at Galgeschoor

Sub report 1
Analysis of velocities and waves
during an intensive measuring campaign

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Wave measurements at Galgeschoor

Sub report 1 –
Analysis of velocities and waves during an intensive measuring campaign (November 2015)

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Abstract

In the framework of the planned construction of the Saeftinghedok, it is important to get more information on the possible effects of the expected increased wave climate on the protected area of Galgeschoor, with its mud flats and tidal marshes. Furthermore, the construction of the Kieldrechtsluis is finished, which can lead to increased shipping traffic to the Deurganckdok. To estimate the possible environmental effects due to this economic developments, this study was started.

This study, carried out by INBO (Research Institute for Nature and Forest), UA (University of Antwerp), NIOZ (Royal Netherlands Institute for Sea Research) and FHR (Flanders Hydraulics Research) includes two short, intensive measurement campaigns of 4 to 6 weeks. One intensive measurement campaign is performed in 2015, before the opening of the Kieldrechtsluis, and these results are discussed in this report. Over the whole period, a long term monitoring campaign is set up, to evaluate the morphology changes of the intertidal areas. This report focuses on the wave measurements performed on the lower, middle and high part of the tidal flat. Wave measurements are analysed and compared with information of the ship traffic, obtained by AIS (Automatic Identification System) and IVS (Informatie Verwerkend Systeem).

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1 Nederlandse samenvatting

In de komende jaren zal het Deurganckdok intensiever gebruikt worden, enerzijds door de opening van de Kieldrechtsluis en anderzijds door de verhuis van rederij MSC naar het Deurganckdok zelf. Eveneens zijn er op langere termijn plannen voor de bouw van het iets noordelijker gelegen Saeftinghedok. Het natuurreservaat Galgeschoor, bestaande uit slikken en schorren, is hier tegenover gelegen, aan de rechter Schelde-oever. Het is belangrijk om meer inzicht te krijgen over de mogelijke gevolgen van de verwachte toename van scheepsbewegingen op het golfklimaat te Galgeschoor. Om de mogelijke milieu-effecten als gevolg van deze economische ontwikkelingen, in te schatten, werd dit onderzoek opgestart door het Havenbedrijf Antwerpen.

Deze studie, uitgevoerd door INBO (Instituut voor Natuur- en Bosonderzoek), UA (Universiteit Antwerpen), NIOZ (Koninklijk Nederland Instituut voor Onderzoek der Zee) en WL (Waterbouwkundig Laboratorium) bestaat uit twee intensieve meetcampagnes van 1 maand, respectievelijk voor en na de opening van de Kieldrechtsluis (zowel najaar 2015 als 2016). Aanvullend is een langdurige monitoring voorzien van de sedimentatie – erosie op het slik. In dit rapport worden de metingen, verzameld tijdens de eerste intensieve meetcampagne van ongeveer 4 weken, opgemeten in november 2015, gerapporteerd en geanalyseerd. Dit rapport richt zich voornamelijk op de golfmetingen uitgevoerd op het laag, middelhoog en hoog slik. Een overzicht van de uitgevoerde metingen wordt gegeven in Tabel 1.

De waterpeil metingen worden uitgevoerd bij Zandvlietsluis en Liefkenshoek. De afstand tussen beide meetlocaties is 5,9 km (Vanlierde et al., 2016). Over de volledige periode van de meetcampagne wordt een laagste laagwater van -0.6m TAW en een hoogste hoogwater van 6,70 m TAW waargenomen. Metingen van de windsnelheid en -richting worden uitgevoerd door het Havenbedrijf Antwerpen ter hoogte van Zandvlietsluis, op een hoogte van 10 meter boven het maaiveld. De gemiddelde windsnelheid en –richting over de meetcampagne is respectievelijk 6,35 m/s en 205° (zuid-zuidwestelijke richting). De maximale windsnelheid bedraagt ongeveer 24 m/s, en komt overeen met een zuidwestelijke (~ 225°) windrichting. Een overzicht van de windsterkte en –richting is weergegeven in Figuur 4-6.

1.1 Snelheidsmetingen

Diepte-gemiddelde snelheden op het laag slik (zowel zuidelijk als noordelijk transect) worden gemeten met een ADP (Acoustic Doppler Profiler). In het algemeen zijn de pieksnelheden tijdens vloed aan Meetpaal Lillo hoger dan de snelheden gemeten op het slik. Voor de eb snelheden, worden vergelijkbare snelheden gevonden.

Eveneens wordt de relatie tussen het getijverschil en de maximale vloed- en ebsnelheid berekend. Voor de vloedsnelheden kan een duidelijk verband worden waargenomen tussen het getijverschil en de maximale snelheden. Dit verband is gelijkaardig voor het zuidelijk en noordelijk transect. Voor de ebsnelheden is de correlatie minder tot niet duidelijk (R^2 waarde kleiner dan 0,3).

Tijdens de intensieve meetcampagne worden aanvullende snelheidsmetingen uitgevoerd door het INBO met een ADV (Acoustic Doppler Velocimeter). Deze puntmetingen, gemeten op een hoogte van 5 cm boven de bodem, worden vergeleken met de diepte-gemiddelde snelheden op het zuidelijke transect. Een sterk gelijkaardig verloop werd geobserveerd tussen deze punt en diepte-gemiddelde snelheden, met uiteraard lagere snelheden nabij de bodem.

Eveneens werd een vergelijking tussen de pieksnelheden tijdens vloed aan Meetpaal Lillo en de pieksnelheden op laag slik opgesteld. Voor de ADCP (Acoustic Doppler Current Profiler) metingen op laag slik worden pieksnelheden opgemeten die 60 – 70 % bedragen van de snelheden te Meetpaal Lillo. Voor de

ADV punt metingen, bedragen de pieksnelheden ongeveer 45% van de pieksnelheden te Meetpaal Lillo. Voor de maximale ebsnelheden kon geen duidelijke relatie tussen de gemeten snelheden op laag slik en Meetpaal Lillo worden gevonden.

1.2 Golfmetingen

De waterfluctuaties worden continu gemonitord met behulp van vijf druksensoren tijdens de intensieve meetcampagne. Op het noordelijke transect werd één van de sensoren geïnstalleerd op laag slik (Gsb4) en één op het hoog slik (Gsb2). De andere sensoren in het zuidelijke transect werden, respectievelijk op het laag slik (Gsc4), middelhoog slik (Gsc3) en hoog slik (Gsc2) geïnstalleerd. Om informatie over de golfvoortplanting in het interessegebied te verkrijgen, werden de ruwe gegevens verwerkt. De gevolgde procedure hiervoor omvat de volgende stappen:

1. Compensatie van de ruwe data met behulp van atmosferische druk en conversie naar waterhoogte met 0 m TAW als referentie niveau
2. Correctie van het opgemeten signaal (bestaande uit een getijsignaal en waterfluctuaties) met waterdieptes als gevolg van druk attenuatie met de diepte (gebaseerd op de lineaire golftheorie).
3. Indeling van de tijdreeksen volgens de getijdencycli
4. Toepassen van een low-pass filter (in frequentiedomein) op de tijdreeks voor de scheiding van het getij signaal van de waterfluctuaties
5. Berekening van de golfkarakteristieken per getij (maximale golfhoogte H_{max}, significante golfhoogte $H_{1/3}$ en de respectievelijke golfperiodes) uit de resulterende tijdreeksen van de waterfluctuaties

Voor alle meetplaatsen (Gsb4, Gsb2, Gsc2, Gsc3, Gsc4) is de maximale en significante golfhoogte berekend. De significante golfhoogte, $H_{1/3}$, wordt gedefinieerd als het gemiddelde van de hoogste 1/3 van alle golven. De variatie van de significante golfhoogte tijdens de campagne vertoont een vergelijkbaar gedrag voor de drie laagst gelegen meetlocaties. Piekwaarden tot 0,15 à 0,20 m worden waargenomen, terwijl de meeste $H_{1/3}$ waarden gedurende de campagne varieren van 0,05 tot 0,08 m. De maximale golfhoogte (H_{max}) in locatie Gsb4 vertoont twee pieken (ca. 0,75 m), terwijl in het grootste deel van de onderzochte periode H_{max} varieert van 20 tot ca. 50 cm. Voor de meetposities op hoog slik zijn enkele gaten in de data te verklaren door doodtij periodes, waarin de hoogwaters zo laag zijn, dat de instrumenten niet onder water staan. Op beide meetlocaties hier zijn de significante golfhoogtes hoofdzakelijk gelegen tussen 5 en 10 cm. De golfpatronen zijn gelijkaardig aan deze voor de lager gelegen meetpunten, maar minder duidelijk.

Met behulp van AIS (Automatic Identification System) data kunnen alle scheepspassages in beeld worden gebracht. Tijdens deze meetcampagne van 4 weken werden ca. 7000 scheepspassages waargenomen ter hoogte van het Galgeschoor. Er wordt een onderscheid gemaakt tussen binnenschepen en zeeschepen, gebruik makende van de IVS (Informatie Verwerkend Systeem) data en enkel andere criteria (vlag (land) en diepgang van het schip). Zeeschepen blijken verantwoordelijk te zijn voor ongeveer 25% van de scheepspassages.

Windgolven zijn in deze studie gedefinieerd door de significante en maximale golfhoogte (over een tijdvenster van 10 min). Scheepsgolven worden opgesplitst in een primair en secundair golfpatroon. Het primair golfpatroon is gekenmerkt door een waterspiegeldaling, het secundaire golfpatroon wordt gevormd door de transversale en diagonale golven achter het schip, i.e. het Kelvin golfpatroon. Deze golftrein wordt gekarakteriseerd door de maximale golfhoogte van de golftrein, nadat een bandpass filter werd toegepast op de gemeten reeks van waterfluctuaties (tussen 0,1 en 0,5 Hz). Voor de primaire golf wordt eveens de maximale golfhoogte gebruikt, na toepassing van een low-pass filter (0,05 Hz) op de meetresultaten. Deze scheepsgolven worden berekend op een periode van 9 minuten rond de passage van het schip.

De analyse van scheepsgolven (secundaire golfpatroon) omvat de detectie van gebeurtenissen waarbij één enkel schip wordt beschouwd (‘single ship events’), aangevuld met gebeurtenissen waarbij sleepboten bevestigd zijn aan grote vrachtschepen. Deze events met één schip werden geselecteerd om interferentie van scheepsgolven, afkomstig van meerdere schepen, maximaal uit te sluiten. Uit de analyse bleek dat:

- ca. 400 scheepspassages op de meetlocaties ter hoogte van laag slik (Gsb4, Gsc4), 190 op middelhoog slik (Gsc3) en enkele tientallen passages op hoog slik (Gsb2, Gsc2) voldeden aan de criteria van een ‘single ship event’ (met inbegrip van de passages ‘sleepboot+grote vrachtschip’)
- er geen duidelijke correlatie is tussen de significante golfhoogte ($H_{1/3}$), of maximale golfhoogte (H_{max}) enerzijds, en één van de beschouwde parameters anderzijds (vaarsnelheid, scheepslengte, afstand van het schip tot de meetplaats en het waterpeil) voor zeeschepen
- een beperkte, positieve relatie werd gevonden tussen de secundaire golfhoogte en de vaarsnelheid van binnenschepen (vnl. sleepboten) voor de metingen op laag slik, voor condities waarbij weinig wind aanwezig was (< 6 Beaufort)
- voor dezelfde scheepspassage zijn de golfhoogtes hoger op laag slik dan op hoog slik. Bemerk dat deze bevinding gebaseerd is op een zeer beperkt aantal metingen.

Voor de analyse van ‘single ship events’, zijn, na het toepassen van de selectiecriteria, veel grote schepen uitgesloten. Daarom is een extra analyse uitgevoerd waarbij gefocust werd op de detectie van passages van grote schepen, meer bepaald om de geïnduceerde primaire golfpatronen te bekijken. Hieruit bleek dat:

- de primaire golfhoogte van het grootste deel van de schepen is lager dan 0,35, 0,2 en 0,15 voor respectieveijk de Gsb4, Gsc4 en Gsc3 locatie
- de primaire golfhoogte (H_{max}) neemt toe bij toenemende vaarsnelheid ter hoogte van locatie Gsb4, deze correlatie lijkt zelfs sterker bij Gsc4 locatie
- de primaire golfhoogte is omgekeerd evenredig met het waterpeil, voor alle meetlocaties
- voor het noordelijke transect is er een positieve correlatie tussen H_{max} en de diepgang van het schip, maar meer specifiek met de ratio van diepgang vs. waterhoogte

De analyse van windgolven is gebaseerd op de detectie van gebeurtenissen, waarbij wind als enige mechanisme voor het genereren van golven kon worden aangeduid. Dit komt overeen met periodes van 30 minuten waarin geen scheepspassages werden waargenomen. De analyse van ongeveer 120 van dergelijke tijdvensters voor de posities op laag slik (Gsb4, Gsc4), 60 op middelhoog slik (Gsc3) en een 10-tal op hoog slik gaf aan dat:

- Er een duidelijke positieve correlatie is van $H_{1/3}$ en H_{max} met de windsnelheid, dit wil zeggen dat voor alle meetlocaties $H_{1/3}$ en H_{max} toenemen met toenemende windsnelheid
- Voor alle meetlocaties worden de hoogste $H_{1/3}$ en H_{max} waarden geïnduceerd door een zuidwestelijke wind (WDir = 225° ± 10 °) met windsnelheden boven 10 à 15 m/s
- Er is geen duidelijke correlatie van $H_{1/3}$ en H_{max} waarden met het water niveau, voor elk van de meetlocaties
- de hoogste $H_{1/3}$ waarden liggen tussen 0,20-0,30 m voor de diepere locaties (Gsb4 en Gsc4 en Gsc3). Op de hoogste posities liggen de hoogste $H_{1/3}$ waarden tussen 0,10 en 0,20 m.
- metingen van dezelfde events geven over het algemeen lagere golfhoogtes op laag slik versus hoog slik. Hierbij dient opgemerkt te worden dat deze bevinding gebaseerd is op slechts een beperkt aantal metingen.

2 Introduction

In the coming year, an extended use of the existing Deurganckdok is foreseen, with an opening of the Kieldrechtsluis in 2016, which connects the dock to the Waaslandhaven, and the move of MSC from Delwaidedok to Deurganckdok itself. In the longer term, also the building of the Saeftinghedok is planned. These facts will lead to a modification of the shipping traffic in the harbour of Antwerp. Especially, the protected nature area of Galgeschoor, which lies opposite of these docks on the right hand shore of the lower Seascheldt, might potentially experience a change in hydrodynamic exposure with an expected increased wave climate. To estimate the possible environmental effects due to these economical developments, a study was commissioned by the Antwerp Port Authority.

This study, carried out by INBO (Research Institute for Nature and Forest), UA (University of Antwerp), NIOZ (Royal Netherlands Institute for Sea Research) and FHR (Flanders Hydraulics Research) is set up by two intensive measurement campaigns of 1 month before and after the opening of the Kieldrechtsluis. To have the same seasonal conditions, the measurements are performed in autumn, both in 2015 and 2016. In between the intensive measurement campaigns, long term monitoring is foreseen to measure the tidal flats morphological evolution for the full year.

In this report, the measurements gathered during an intensive measurement campaign of about 4 weeks in November 2016 are reported and analysed. This report focuses on the wave measurements on several levels of the tidal flat. The measurements on the lower and middle height of the tidal flats are performed using instruments provided by FHR. The measurements performed on the higher tidal flats are performed using instruments by UA. The analysis methods are identical for all measurement devices and locations.

Waves can be caused by meteorological conditions (wind waves) as by sailing ships (ship waves). In this report the importance of both wind and ship waves is investigated. The characteristics of wind waves reaching the river banks mainly depend on wind speed and wind direction (affecting the fetch length to the measurement locations, i.e. length of open water over which the wind can blow and generate waves). For ship waves, the characteristics will be influenced by ship properties such as sailing speed, sailing direction and draught. The link between the ship characteristics (length, beam, speed, distance from the mud flat) and its resulting wave heights is investigated.

Wind and ship waves produce contrasting wave fields: in fair weather conditions wind-generated waves in estuaries usually have short wave periods in the order of 1-2 s. As they depend on wind conditions, their characteristics typically vary over longer time scales in the order of hours to days. Ship-generated waves, in contrast, appear as events of only several minutes at a certain location and occur in two phases: first, a long period primary wave (with a wave period in the order of 20-120 s) reaches the shore. It is the result of a bow wave, a drawdown and a stern wave. The wave length is usually in the order of the length of the ship. A train of short secondary waves then follows this long primary wave. These have wave periods that are related to the speed of the ship and which are typically in the order of 2-7 s.

In Chapter 3, the location of the field measurements, the devices used in the intensive measuring campaign and the main measurement settings, are presented. Tidal information (water level), meteorological data (wind speed and direction), current velocity (both depth-averaged values over the vertical profiles and point measurements), pressure and suspended sediment concentration data that were recorded during the intensive measuring campaign are included in Chapter 4. Particular attention is paid in the transfomation of the pressure data measured by high-frequency pressure sensors, to water fluctuation series (wave data) which are used in the ship and wind wave analysis. In Chapter 5, information about the shipping traffic during the measuring campaign in the investigated area, is analyzed. The processed information, which includes static (type, length, width, etc.) and dynamic (speed, course, draught, etc.) information of all ships, was retrieved by the database of the AIS (Automatic Identification System) tracking system. In Chapter 6, the coupling of the wave measurements with the ship passages, is presented. The coupling procedure was accomplished by means of MATLAB scripts developed for this purpose. Chapter 7 includes the implementation of a similar methodology for the coupling of the measured wind data with the wave measurements. At the end of each result section the findings from the high tidal flat are compared to the results for the low tidal flat. Finally, in Chapter 8, the main conclusions resulting from the ship- and wind- wave analysis are presented.

3 Field description & measurement settings

3.1 Study area of Galgeschoor

The nature reserve Galgeschoor is located on the right bank of the Lower Seascheldt, between the village of Lillo and the Europaterminal (see Figure 3-1). On the left bank, in front of the Galgeschoor area, the Deurganckdok is situated, as well as the scheduled Saeftinghedok. Galgeschoor is a marsh that is under environmental protection by European legislation (Natura 2000, Habitat and Birds directives). Mean tidal range in this part of the estuary is approximately 5 m, reaching from 0.10 m TAW at mean low tides to 5.23 m TAW at mean high tides for the tidal gauge at Liefkenshoek. At spring and neap tides, the high water reaches up to 5.69 m TAW and 4.63 m TAW, respectively, and the respective low waters retreat on average to -0.16 m TAW and 0.45 m TAW (Vanlierde et al., 2016).

The marsh edge is at most places formed by a cliff with a height in the order of up to 50 cm. *Phragmites australis* is the dominant marsh species present on top of the cliffed marsh edge. On the seaward side of the marsh edge, a riprap ridge stabilizes a steep slope that covers an elevation gradient of locally more than 2 m onto the gentle-sloping tidal flat. This profile is shown in Figure 3-2.

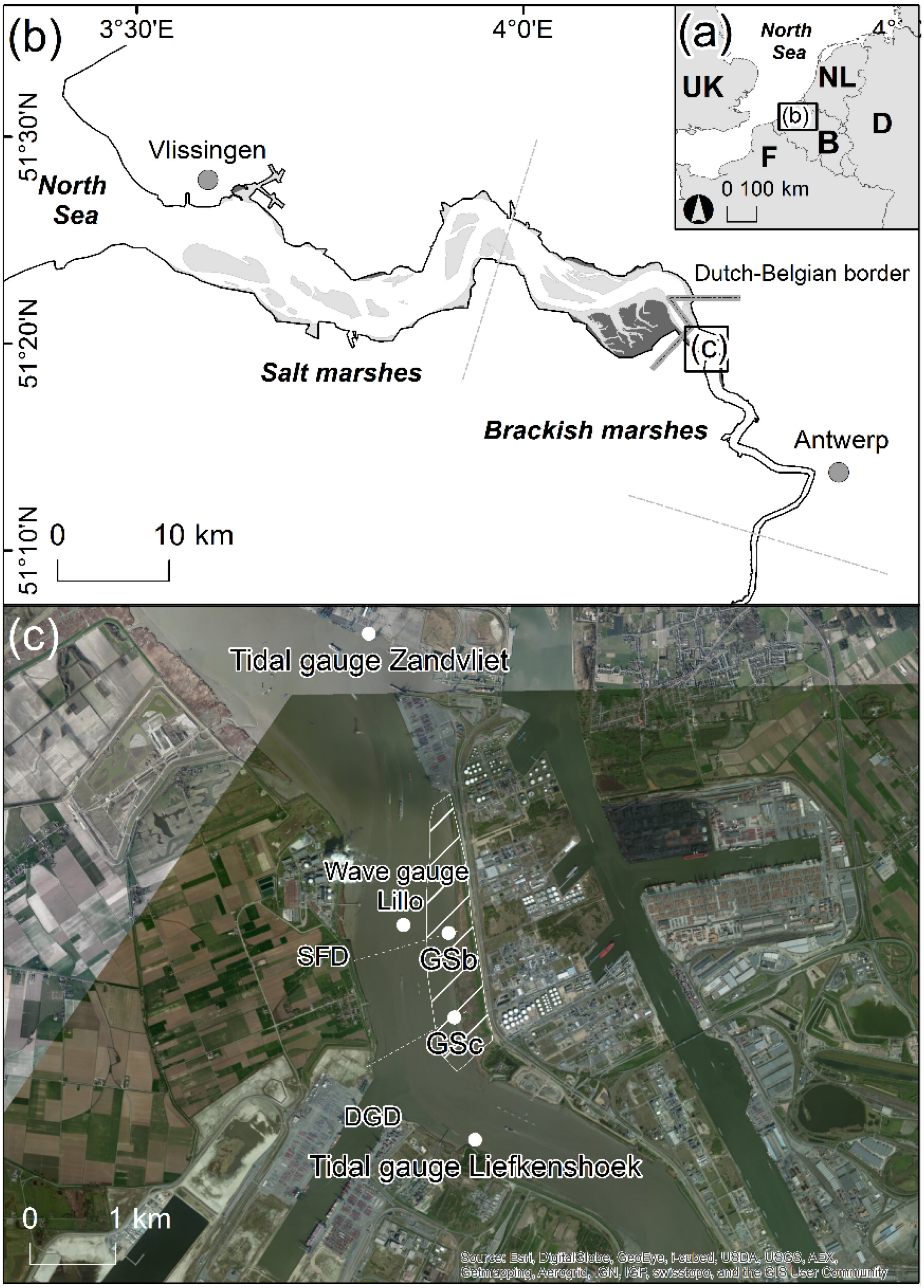
3.2 Measurement locations

Within the MONEOS program, several parameters are measured to evaluate the physical and biological system of the Scheldt estuary. Within this program, water level, flow velocities and turbidity are measured in the interest zone of this study. In Figure 3-1 the tidal gauges in the neighbourhood of the study (in casu Zandvlietsluis en Liefkenshoek) are indicated. Additional the measurement pole “wave gauge Lillo” where since 2015 continuous measurements are performed is indicated.

The measurement transects on the tidal flat, where measurements are located, as well as in the navigation channel, where shipping traffic data (AIS = Automatic Identification System) are filtered, are shown in Figure 3-1 (b). In the south, the transect is located in the stretch of Deurganckdok (DGD), in the north the transect is located in the stretch of the planned Saeftinghedok (SFD). These locations coincide with the measurement locations presented in Verelst et al. (2011). The location of the transects is chosen this way to (1) analyse the effect of the evolution of ship traffic near Deurganckdok after the opening of the Kieldrechtsluis (southern transect DGD) and (2) to collect information as a reference situation near the location of the planned Saeftinghedok. These two locations allow to gain insight in the spatial variation of wave characteristics with regard to wind and shipping traffic (e.g. different fetch length, ship’s sailing speed, distance to gauge/tidal flat,…).

The detailed measurement locations in the intensive measurement campaign are shown in Figure 3-2. On the 2 transects (SFD in the north and DGD in the south), sedimentation-erosion measurements are performed on the full range of the mud to monitor the evolution of the mud flat (measurements performed by the Research Institute for Nature and Forest (INBO) and Royal Netherlands Institute for Sea Research (NIOZ)). On each transect, FHR placed an ADCP and a pressure sensor on the lower mud flat (Figure 3-3). Additionally, on the transect in the stretch of Deurganckdok (DGD) a pressure sensor is placed in the middle of the mud flat. University of Antwerp (UA) placed a pressure sensor on the high mudflat of both the northern and southern transect during the intensive measurement campaign of November 2015.

Figure 3-1 – Overview of the location of the Scheldt Estuary and the study area.



Overview of the location of the Scheldt Estuary within Europe (a), of the Scheldt Estuary over the stretch from Antwerp to the North Sea (b) and of the study area (c), with indication of Galgeschoor, including the tidal flats (hatched area), the location of the two monitoring transects (GSb and GSc, indicated by points). The two tidal gauges (Zandvliet and Liefkenshoek) used for water level measurements, the measuring gauge Lillo (waves, currents and turbidity) and the entrance lines (white dashed lines) used for ship wave analysis. Saeftinghedok (SFD) and Deurganckdok (DGD) are also indicated.

Figure 3-2 – Overview of the measurement locations along a measurement transect during the intensive measurement campaigns.

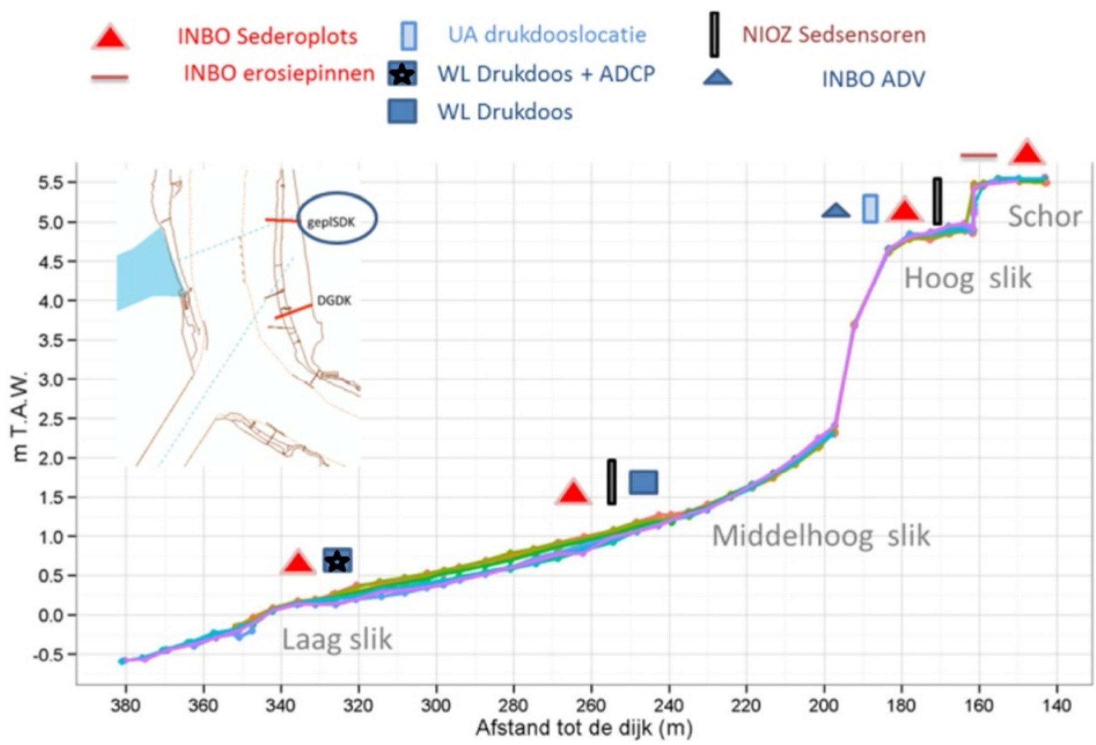


Figure 3-3 – Pressure sensor (left), ADCP (middle) and sedsensor (right) on the low mudflat

3.3 Measurement settings

For the measurement of wind and ship waves and the according variables which influence these waves, a list of parameters which are measured or requested by the responsible authorities, are indicated in Table 1. The campaign started on 29th of October and lasted till 1st of December 2015.

The high-frequency pressure measurements deployed by FHR (see Figure 3-3) are from the type OSSI-010-003B/C and measure at a frequency of 20 Hz. Wave data collected by UA, was done using PDCR 1830 pressure transducers (GE Sensing) built into stand-alone data loggers by the Civil Engineering Department of UGent (Figure 3-4). Measurement frequency of this device is 16 Hz.

Figure 3-4 – Photograph of one UA wave sensor, next to a NIOZ SEDsensor, installed on the high tidal flat at Galgeschoor.

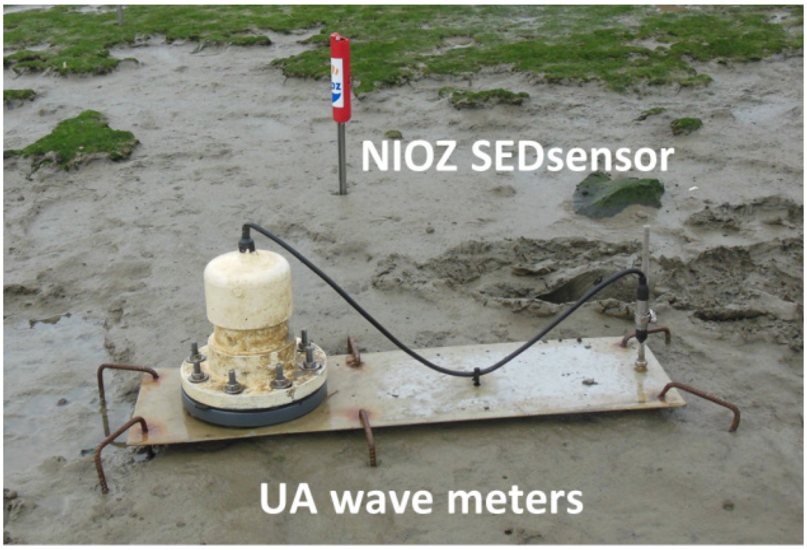


Table 1 – Overview of the measured variables, the responsible, the location, duration and frequency of the measurements.
(FHR = Flanders Hydraulics Research, UA = University of Antwerp, HA = Port Authority Antwerp, INBO = Research Institute for Nature and Forest)

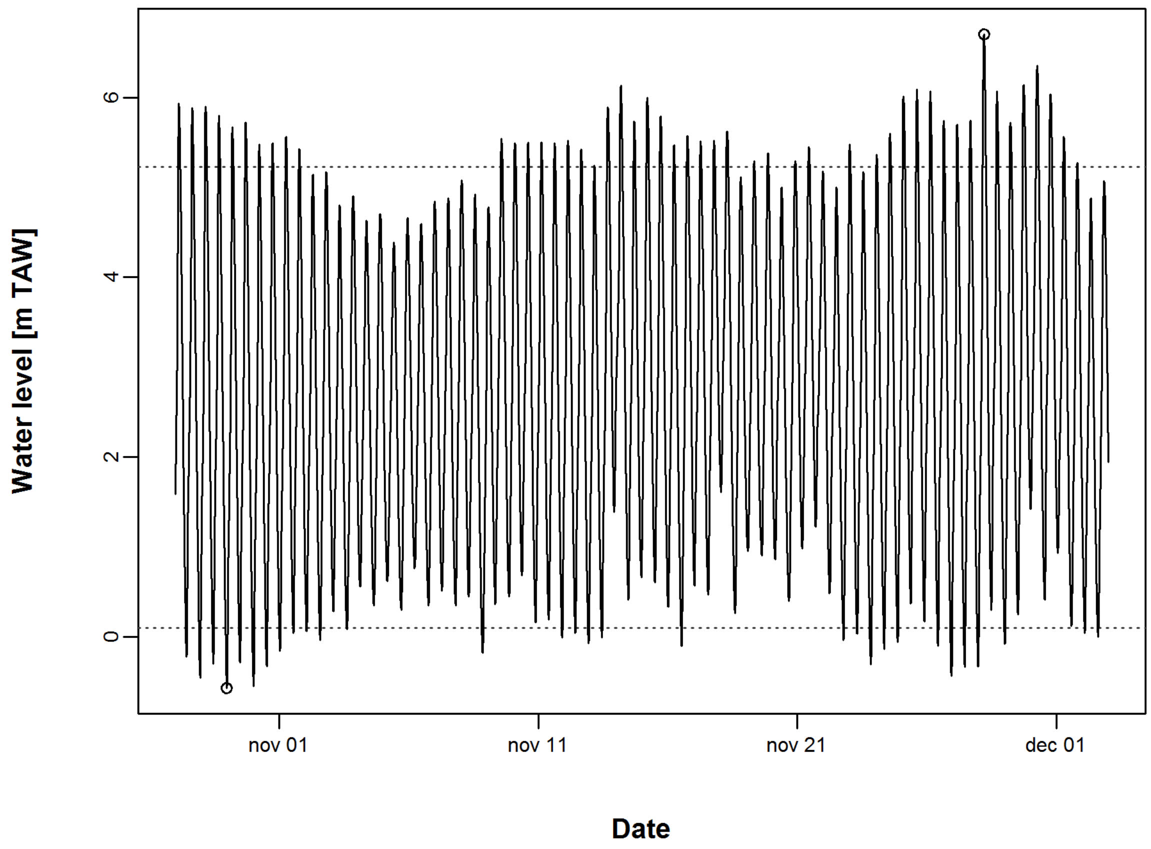
Measurement	Performed by	Location	Duration	Frequency	Measurement principle	Comments
Water level	FHR	Liefkenshoek Zandvliet	Continuous	1 min	Radar (OTT-RLS)	Moneos
Wave measurement	FHR	DGD transect SFD transect	Project (4 weeks)	20 Hz	Pressure (OSSI-010-003B/C)	1 location at LW-line At DGD: 1 location at middle height of tidal flat
Wave measurement	UA	DGD transect SFD transect	Project (4 weeks)	16 Hz	Pressure	1 location at high position on tidal flat
Wave measurement	FHR	Meetpaal Lillo	Continuous	5 Hz	Radar (LOG_aLevel®-General Accoustics)	subtidal
Ship passage	Schelde Radar Keten (SRK)	Region of Galgeschoor	Continuous	Ship dependent		2 transects at measurement locations are defined to define ship passages based on AIS-data
Wind	HA	Zandvlietsluis	Continuous	1 min		10m above ground level
Flow velocity	FHR	DGD transect SFD transect	Project (4 weeks)	5 min	ADCP (Nortek AquaDopp)	Vertical profile with cells of 10 cm
Flow velocity	INBO	DGD transect	Project (several days)	4 Hz	ADV	Point measurement close to bottom (ca. 5 cm above)
Flow Velocity	FHR	Lillo	Continuous	10 min	Aanderaa Seaguard	Moneos
Turbidity	FHR	Lillo	Continuous	10 min	Aanderaa Seaguard	Moneos Suspended sediment concentration based on turbidity measurements

4 Measurements

4.1 Water level measurements

Water level measurements are performed at Zandvlietsluis and Liefkenshoek, where measurements are recorded every minute. The distance between both measurement locations is 5.9 km (Vanlierde et al., 2016). In Figure 4-1, an overview of the tidal variation at Liefkenshoek over the period of the measurement campaign is shown. The 10-year average, from 2001 till 2010 (Vanlierde et al. 2016), of low and high water are indicated by horizontal lines. The lowest low water, -0.6 m TAW, and the highest high water, 6.70 m TAW, during the measurement campaign are indicated with dots.

Figure 4-1 – An overview of the tidal variation at Liefkenshoek during the measurement campaign. The 10-year averages of low and high water are indicated by horizontal, dashed lines. The lowest low water and highest high water are indicated with dots.



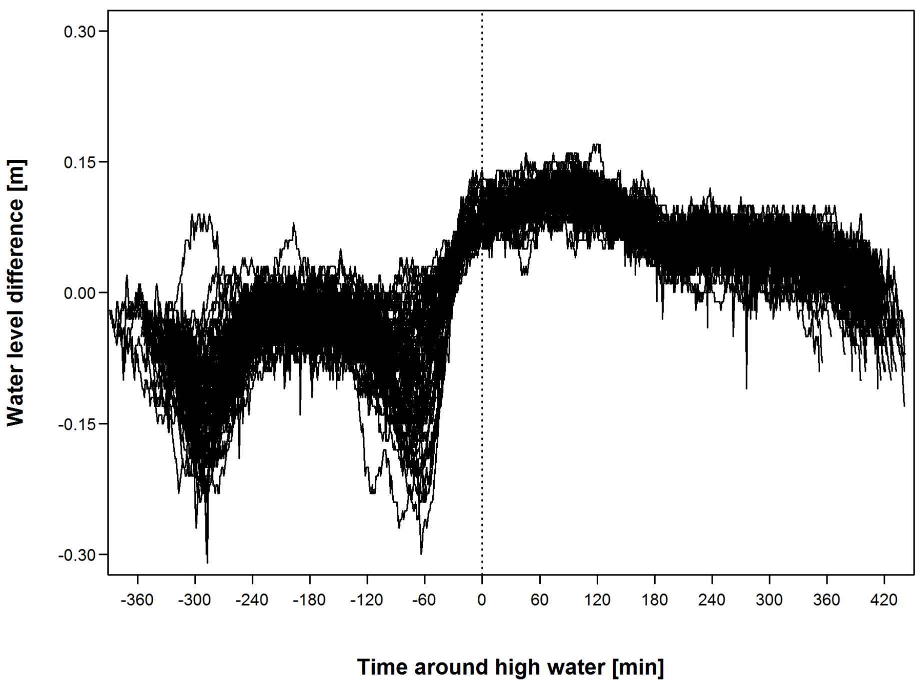
The average tidal range for a 10 years period (2001-2010) is 5.01 m for Zandvlietsluis and 5.13 m for Liefkenshoek (Vanlierde et al., 2016). Considering the range of tidal ranges, compared with a 10 year- averaged values, means that in Zandvlietsluis a tidal index from 0.76 till 1.36 is found during the measurent campaign. For Liefkenshoek, this ranges from 0.73 till 1.37.

Table 2 – Overview of the tidal conditions during the measurement campaign. The water levels are indicated in m TAW.

		Zandvliet		Liefkenshoek	
		Value	*Time*	*Value*	*Time*
High water	*Mean*	5.37	-	5.46	-
	Min	4.31	05/11/2015 10 :19	4.39	05/11/2015 10 :21
	Max	6.62	28/11/2015 04 :36	6.70	28/11/2015 04 :36
Low water	*Mean*	0.32	-	0.28	-
	Min	-0.54	29/10/2015 23 :42	-0.60	29/10/2015 23 :44
	Max	1.66	18/11/2015 01 :07	1.60	18/11/2015 01 :09
Tidal range	*Mean*	5.04	-	5.18	-
	Min	3.78	-	3.91	-
	Max	6.28	-	6.40	-

The average time lag of high waters between Zandvlietsluis and Liefkenshoek is 3 minutes. For low waters, the difference is 8 minutes (Vanlierde et al, 2016). The difference of water levels between Liefkenshoek and Zandvlietsluis is shown in Figure 4-2, for all tides. A different pattern for the flood and ebb period can be distinghuished. In the flood phase, two peaks can be observed. One peak occurs one hour before high water, the other approximately five hours before high water (or one hour after low water). During ebb, the curve is smoother, with highest values in the beginning of the ebb phase and reducing towards the end of the ebb phase.

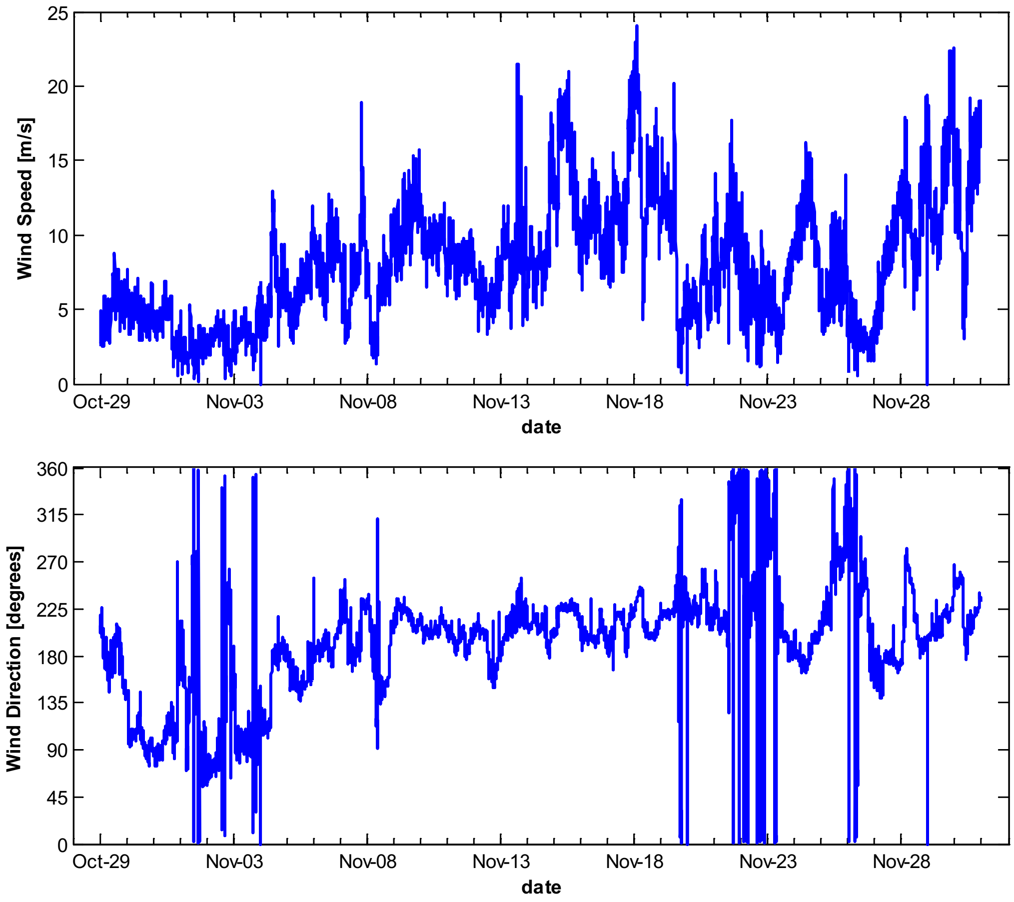
Figure 4-2 – Water level difference between Liefkenshoek and Zandvlietsluis (Liefkenshoek – Zandvlietsluis) tidal gauges during the measurement campaign.



4.2 Wind measurements

Wind measurements are performed by the Antwerp Port Authority at Zandvlietsluis, at a height 10 m above the ground level. The period of the measurements considered ranges from 29/10/2015 to 30/11/2015. The time interval of the recorded data equals 1 min. The variation of instantaneous wind speed and direction during the measurement period are shown in Figure 4-3. It is noted that wind direction follows the nautical convention (North = 0°, East = 90°).

Figure 4-3 – Variation of instantaneous wind speed (above) and direction (below) during the measuring campaign (29/10-30/11/2015).



In Figure 4-4, the average and the maximum daily wind speed are presented. In Figure 4-5, the average daily wind direction and the direction of the maximum daily wind speed are shown. In both figures the campaign averages are depicted as well. The campaign average of wind speed and direction equals 6.35 m/s and 205° (south-southwest direction), respectively. The maximum wind speed, approximately 24 m/s, is observed during the 21st day of the campaign (18/11/2015) and corresponds to a southwest (~225°) wind direction. The maximum daily-averaged wind speed, approximately 14 m/s, appears on the 18th day (15/11/2015) and corresponds again to a southwest wind direction. The minimum daily averages are observed on the 4th (01/11/2015) and the 29th day (26/11/2015), i.e. 1.3 m/s and 2 m/s, respectively. In general the most windy days of the campaign (with speeds around or larger than 20 m/s) are those from 13/11/2015 to 19/11/2015 (day 16 to day 22) and also the last 3 days.

Figure 4-4 – Day-averaged wind speed (blue line), maximum wind speed (red line) and campaign average (green line).

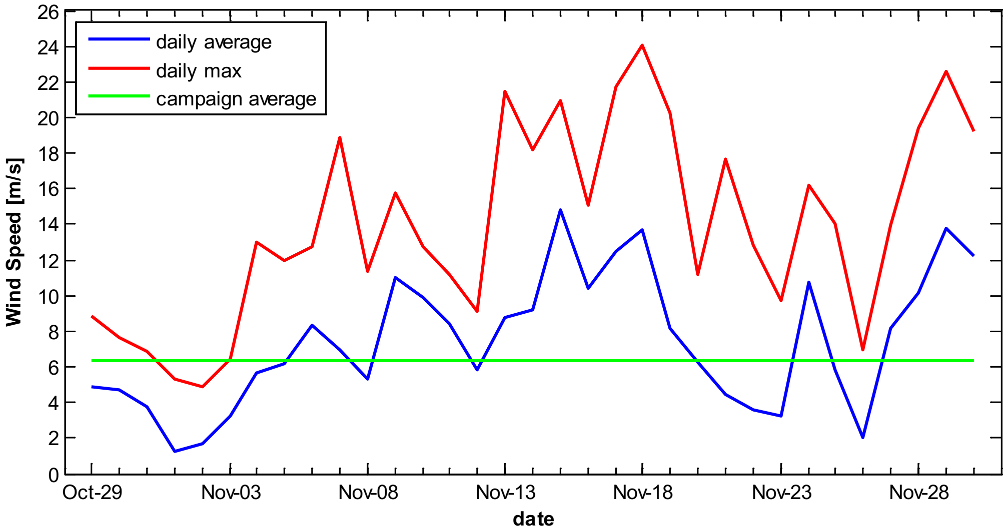
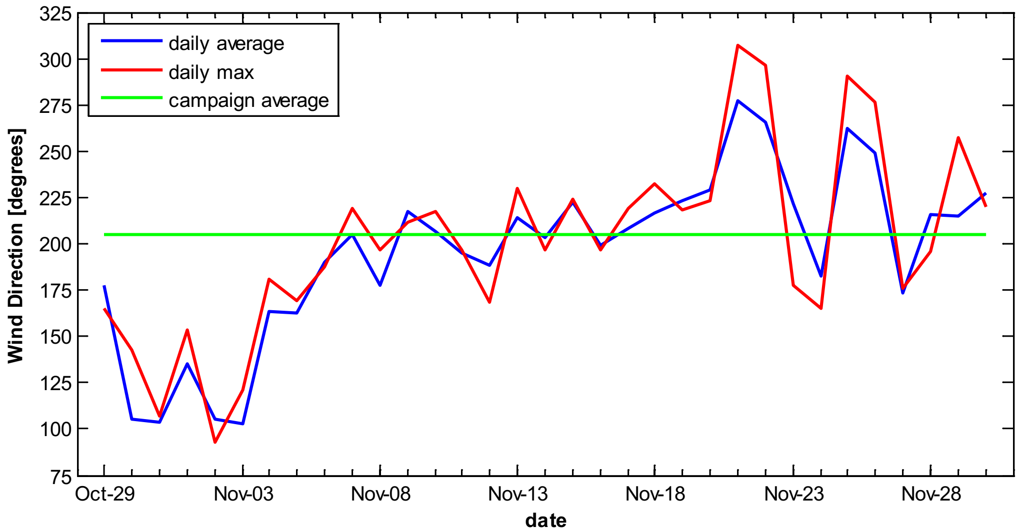
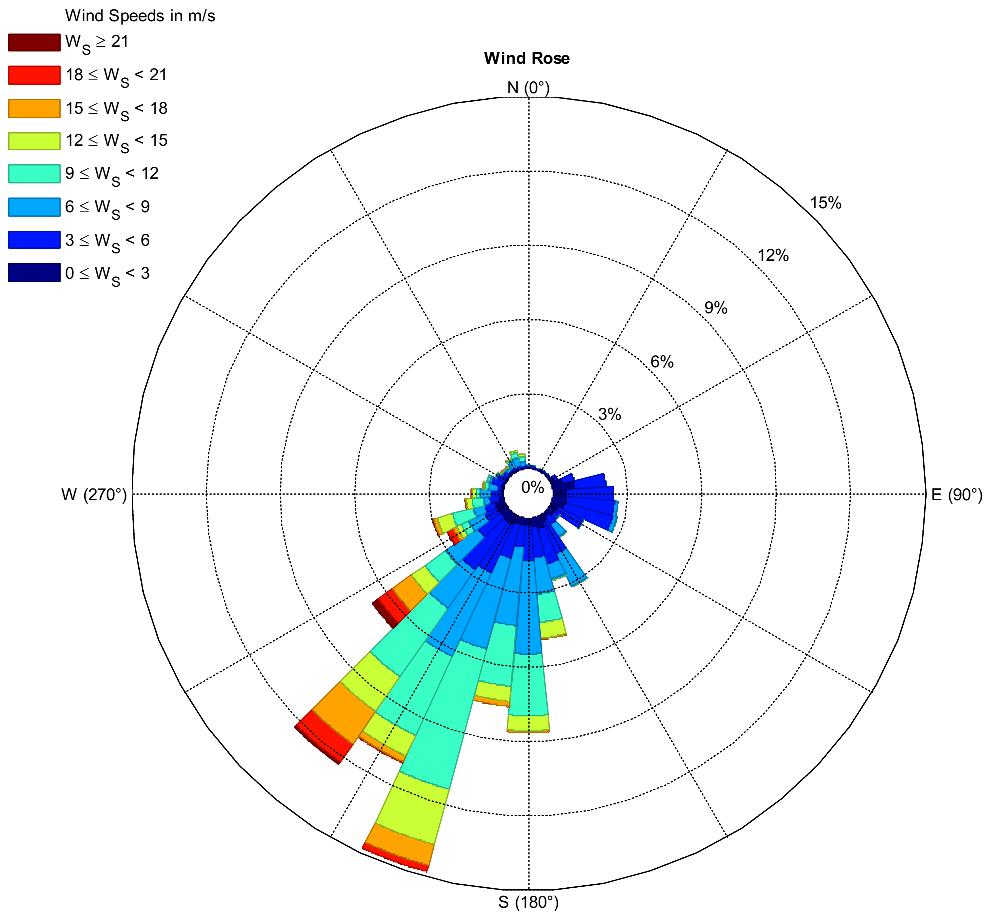


Figure 4-5 – Daily-averaged wind direction (blue line), direction that corresponds to maximum wind speed (red line) and campaign average (green line).



For a deeper insight into the wind measurements during the campaign, a wind rose is presented in Figure 4-6. In this graph the frequency of winds blowing from particular directions (directional bin amplitude = 5°), along with several wind speed ranges, are shown. It is indicated that the dominant wind directions range from southwest to south-southwest and around 70% of the wind directions belong to the South-West quadrant. Furthermore, as indicated by the colored bars, the strongest winds are also from the southwest direction.

Figure 4-6 – Wind rose with directional bins of 5°, for the whole measurement period.



4.3 Flow velocity measurements (ADCP)

As mentioned in Chapter 3 (Table 1), velocity profile measurements are performed using Accoustic Doppler Current Profiler (ADCP) technology. Both in the northern and southern transect, measurements are performed on the low tidal flat position. Measurement records are available every 5 minutes. In this section, depth-averaged values of the velocity are discussed.

4.3.1 Overview per tide

In Figure 4-7, an overview of the ADCP measurements is shown. In the upper subplot, the water depth above the instrument is shown. In the lower plot the depth-averaged velocities are shown. Additionally, the velocities measured at Meetpaal Lillo (former Boei 84) are shown too. The maximum flood and maximum ebb velocities are indicated with a ‘dot’ for the northern transect and a ‘square’ for the southern transect. The dotted line indicates the moment of high water. The vertical, discontinuous line indicates the moment of high water slack (for the northern transect). In Table 3 an overview of the mean, minimum and maximum ebb and flood peak velocities is given.

Figure 4-7 – Water depth above the ADCP measurements (top). Depth-averaged flow velocities on the tidal flat for both the northern and southern transect, together with flow measurement at Meetpaal Lillo (bottom).

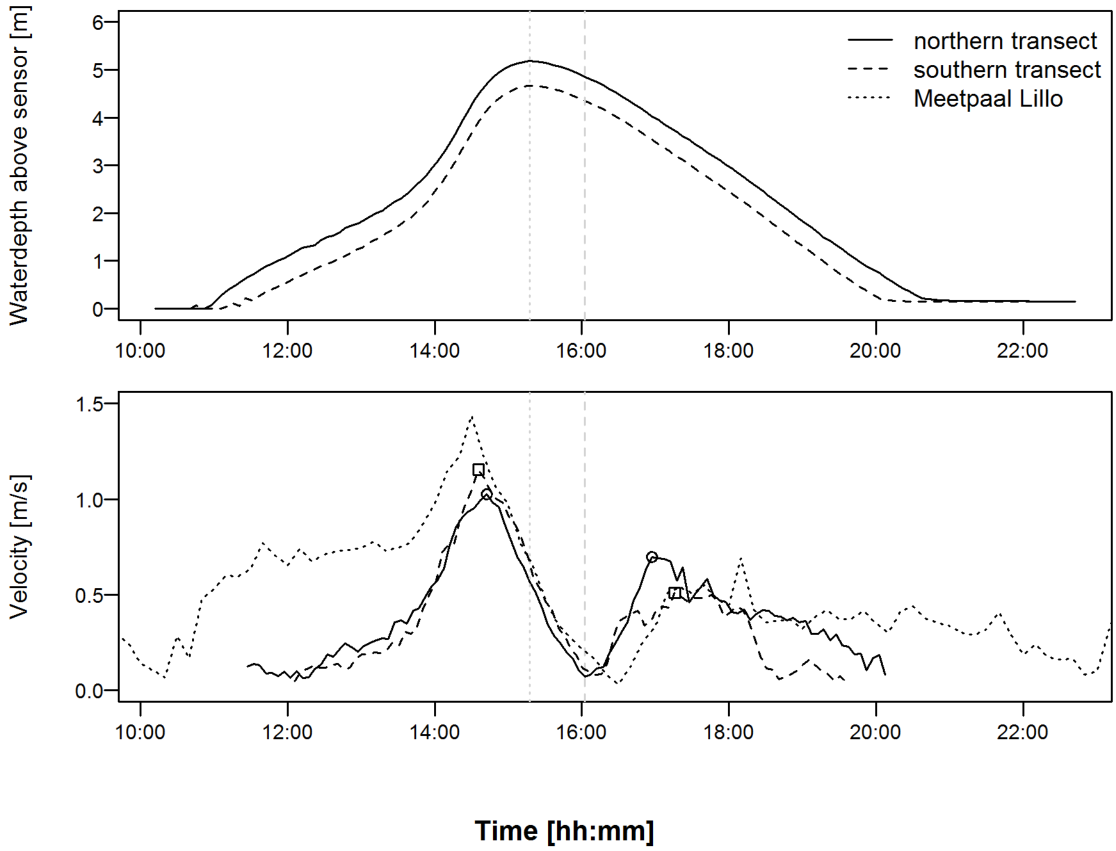


Table 3 – Overview of the minimum, mean and maximum ebb and flood peak velocity [m/s] over the measuring campaign

		Northern transect	Southern transect
Ebb	*Mean*	0.65	0.56
	Min	0.53	0.45
	Max	0.76	0.74
Flood	*Mean*	0.71	0.75
	Min	0.37	0.32
	Max	1.15	1.34

In general, the flood peak velocities at Meetpaal Lillo are higher compared to the velocities measured on the tidal flats. For the ebb velocities, similar values can be found between the measurement close to the navigation channel (Lillo wave gauge) and the tidal flats. Comparing both measurements on the transects, the ebb peak velocities are on average slightly higher on the northern transect compared to the southern transect. The ebb velocities in the southern transect drop much faster (approximately two hours after high water slack) to low values compared to the northern transect.

4.3.2 Maximum flow velocities in relation to tidal range

For both sensors, the maximum flood and ebb velocities are determined for each tidal cycle. The tidal cycle is divided into two periods, before and after high water slack. For each period a maximum function is applied, to calculate the maximum flood peak and maximum ebb peak respectively. In Figure 4-8 and Figure 4-9 the relation between the tidal range, calculated both for the flood and ebb phase, and the maximum flood and ebb velocities are shown for the ADCP measurements at respectively the southern and northern transect. For the flood velocities a clear relation can be observed between the tidal range and the maximum velocities, with slopes of respectively 0.28 and 0.33. For the ebb velocities the correlation is less clear (R^2 are smaller than 0.2). In Vanlierde et al. (2014) a relation between the water level rising and falling in Antwerpen and the flood and ebb velocity at Boei 84 (now Meetpaal Lillo) is shown. Similar slopes of 0.28 and 0.06 for respectively flood and ebb velocities are found.

Figure 4-8 – Relation between the tidal range [m] and the maximal ebb or flood velocity (southern transect).

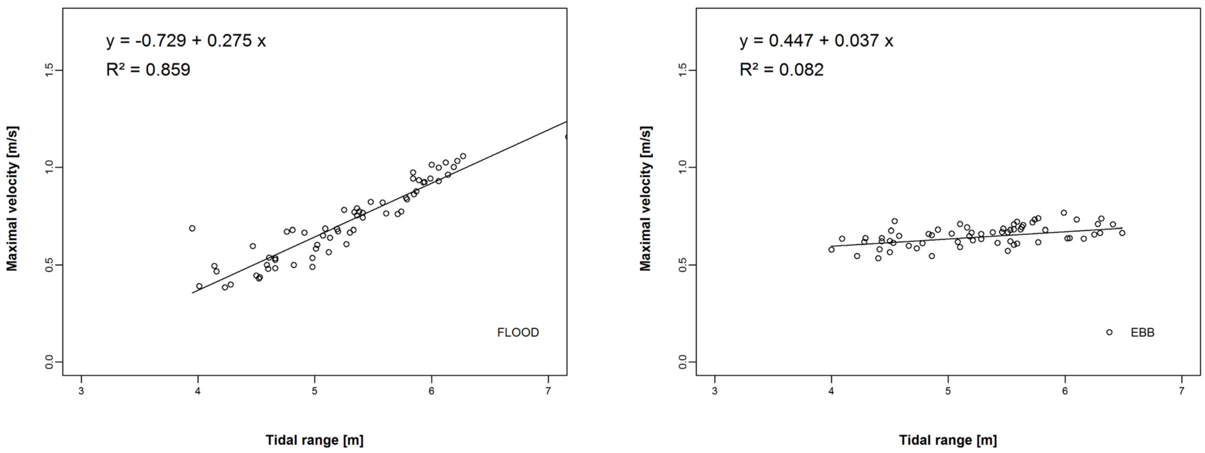
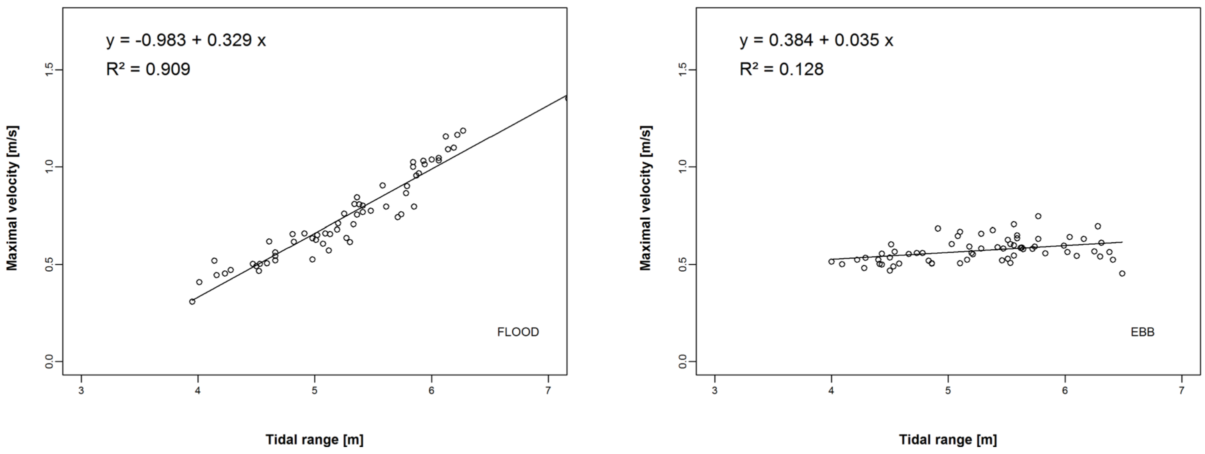


Figure 4-9 – Relation between the tidal range [m] and the maximal ebb or flood velocity (northern transect).



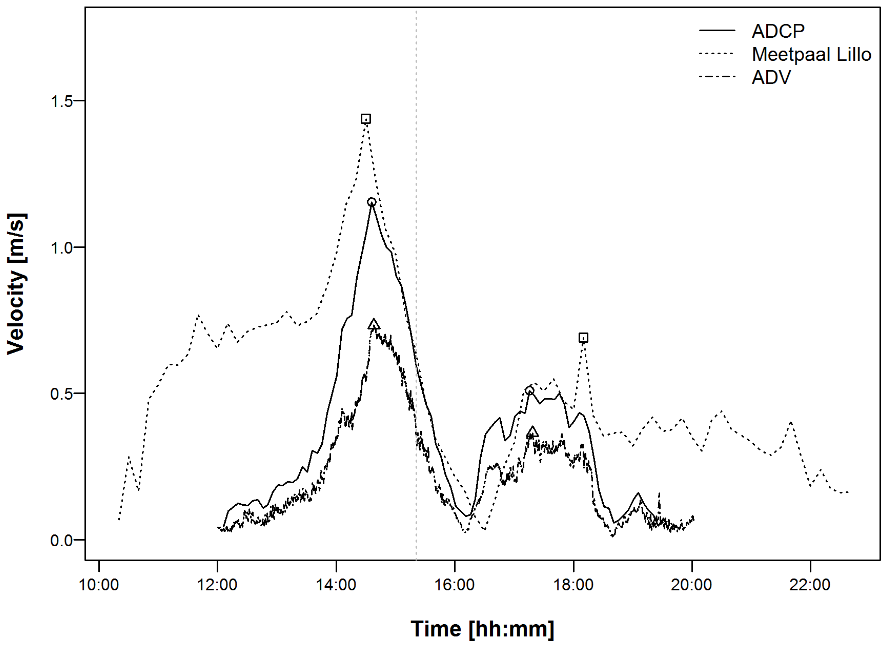
4.4 Flow velocity measurements (ADV)

During the intensive measurement campaign, additional velocity measurements are performed by INBO using an ADV (Acoustic Doppler Velocimeter). These point measurements, measured at a height of 5 cm above the bottom of the tidal flat, are compared with the depth-averaged velocities on the southern transect. The ADV measurements are performed in three periods. The first period runs from 29/10/2015 till 02/11/2015, the second from 12/11/2015 till 16/11/2015 and the third from 26/11/2015 till 30/11/2015. In total 24 tidal cycles are measured simultaneously with ADV and ADCP.

4.4.1 Overview per tide

In Figure 4-10, the velocity measurements at Meetpaal Lillo are shown together with ADCP and ADV measurements at the southern transect for 1 tidal cycle. The curves have a similar shape. Obviously the velocities at Meetpaal Lillo are higher, as this measurement is performed closer to the channel (subtidal). The differences are higher during flood compared to ebb. The depth-averaged velocities measured with ADCP are also higher compared to the ADV measurements, which are measured close to the bottom. At the end of the ebb phase the velocities on the tidal flat show an unexpected pattern. Probably low water levels combined with local eddies influence the measurements here.

Figure 4-10 – Velocity measurements with ADCP (solid line) and ADV (dashed line) on the lower tidal flat and measurements at Meetpaal Lillo (dotted line). The vertical line indicates the moment of high water at Liefkenshoek. The ADV measurements are averaged values over 1 minute.



4.4.2 Maximum velocities

For all tidal cycles, the maximum flood and ebb velocities are derived. In Figure 4-11, a comparison between these flood peak velocities at Meetpaal Lillo and on the lower tidal flat, is shown. For the ADCP measurements, a linear relation y = -0.23 + 0.93 x could be found, with an R^2 value of 0.9. For the ADV point measurements, a linear relation y = 0.03 + 0.45 x could be found, with an R^2 value of 0.58. On average, over the measuring period of all instruments together, the maximum flood velocity measured with ADCP on the lower tidal flat is around 60 - 70% of the value at Meetpaal Lillo. For the ADV, a value of around 45% is found.

Figure 4-11 – Comparison of the flood peak velocities at Meetpaal Lillo [m/s] to the velocities on the lower tidal flat measured with ADCP (depth-averaged velocity, dots) and ADV (point velocity, triangle).

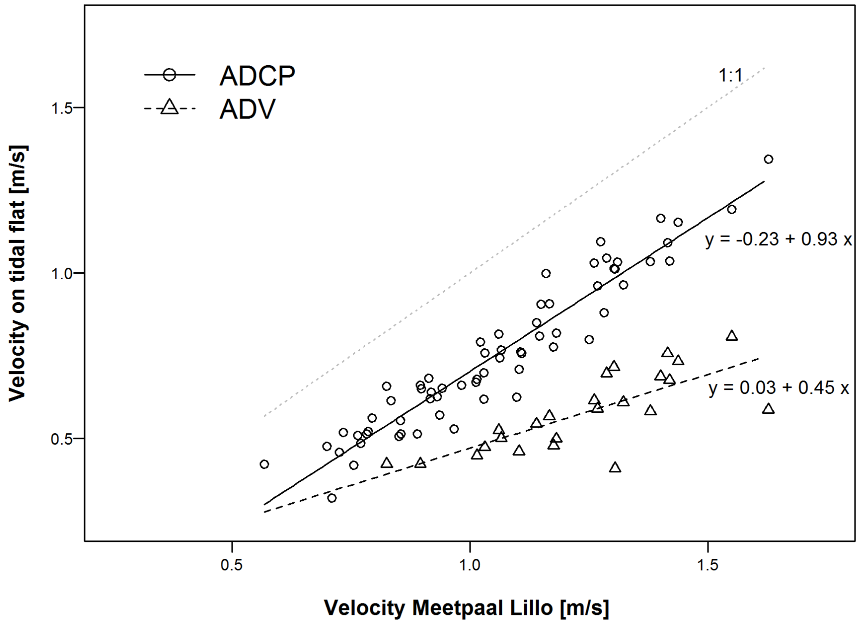
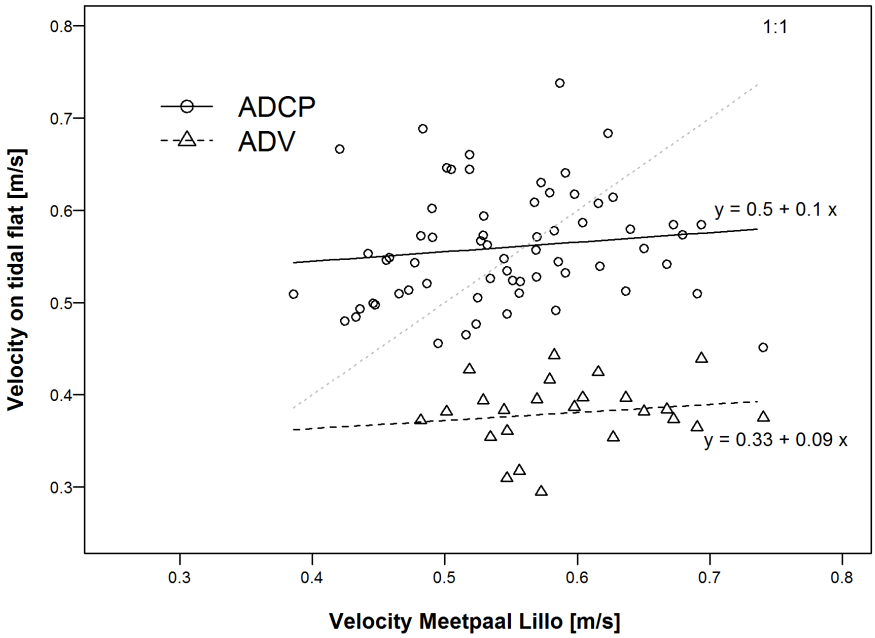


Figure 4-12 – Comparison of the ebb peak velocities at Meetpaal Lillo [m/s] to the velocities on the lower tidal flat measured with ADCP (depth-averaged velocity, dots) and ADV (point velocity, triangle).



In Figure 4-12, a similar analysis is performed for the maximal ebb velocities. Here, no clear relation between the measured velocities at the different locations could be found.

4.5 Wave measurements (pressure sensors)

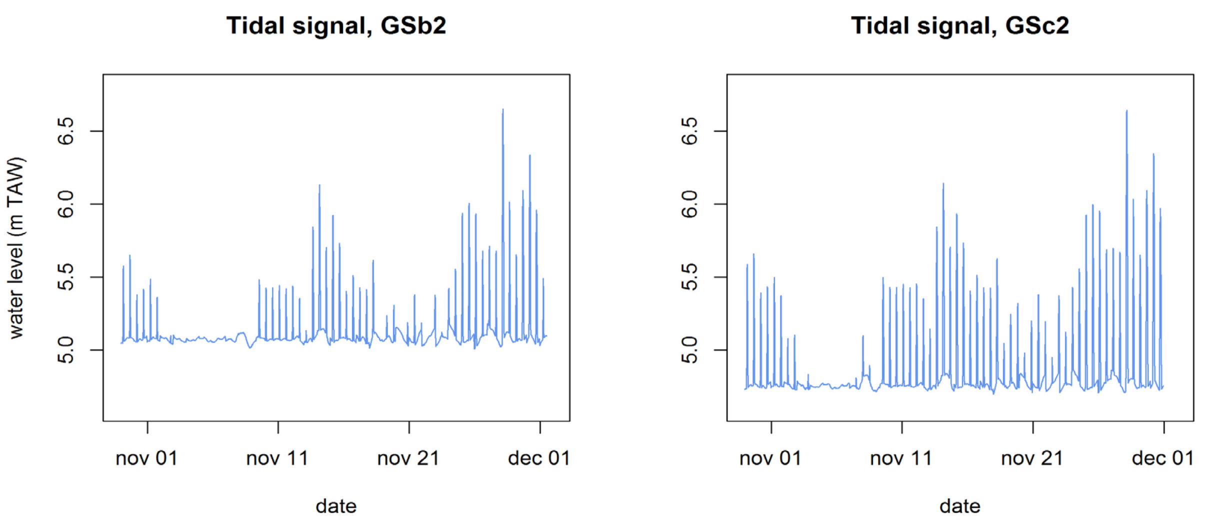
The wave measurements are based on data recorded continuously by five pressure sensors (wave gauges) during the intensive measuring campaign of November 2015. As mentioned in Chapter 3, in the northern transect one of the sensors was installed at a low mudflat position (position identifier: Gsb4), the other on the high mudflat (Gsb2). In the southern transec3t, gauges were installed at a low mudflat (Gsc4) and at a middle-high mudflat position (Gsc3). An additional instrument was placed at the high mudflat (Gsc2) by UA. In Table 4, the vertical coordinates of the pressure sensors in respect with the TAW reference level, are given. For all gauges deployed by FHR, the sampling frequency was set equal to 20 Hz. The sensor orifice was located 12 cm above the ground level. For UA sensors, the sampling frequency is 16 Hz.

Table 4 – Identifiers and position of the pressure sensors.

Transect	Location ID	Position	Deployed by	height (m TAW)
North (SFD)	Gsb4	low mudflat	FHR	+ 0.57
North (SFD)	Gsb2	high mudflat	UA	+ 5.00
South (DGD)	Gsc4	low mudflat	FHR	+ 1.17
South (DGD)	Gsc3	middle-high mudflat	FHR	+ 2.73
South (DGD)	Gsc2	high mudflat	UA	+ 4.69

The recorded data, using the sensors deployed by FHR, are stored separately by the gauges in time series of about 24 hours (from 00:00:00 to 23:59:40 of day n), presenting a time-gap of 20 sec between two successive days, which is used for saving the data. The UA sensors are positioned on the high mudflat. Due to the high position within the tidal frame, the devices were not inundated during the days around neap tides, especially in the period of November 2 -9, 2015 (Figure 4-13). During the campaign, the inundation frequency (i.e. percentage of high tides that flood the measuring plots) at GSb2 was 75%, while it was 80% at GSc2. Furthermore, average inundation times (i.e. duration of inundation for an average semi-diurnal tide with a total duration of 12 h 25 min) were 110 minutes and 140 minutes for GSb2 and GSc2, respectively. This limited inundation time will of course limit the number of detected ship events and periods with no-ship events, given the restrictive constraints for each event type (Chapter 6).

Figure 4-13 – Tidal signals at GSb2 (located at 5.00 m TAW) and GSc2 (located at 4.69 m TAW) during the monitoring period, showing the impact of bottom elevation on inundation frequency and inundation depth (and time).



4.5.1 Methodology for data processing

In order to acquire information about wave characteristics in the area of interest, the raw data were processed by means of MATLAB (version 2014a) scripts that were developed exclusively for this purpose. An overview of the followed procedure includes the following steps:

1. Compensation of raw data using atmospheric pressure and conversion to water levels using 0 m TAW as reference level
2. Correction of resulting water level time series to account for the depth-dependent pressure attenuation
3. Division of water level time series to time windows identical to the tidal cycles
4. Low-pass filtering (in frequency domain) of the data to remove the tidal influence from the water level fluctuations
5. Calculation of wind and ship wave characteristics per tidal cycle from the time series of water level fluctuations

These 5 steps are explained in more detail below.

1) A typical time series of the raw pressure data recorded by the gauge at Gsb4 (northern transect) is presented in Figure 4-14. For the compensation of atmospheric pressure, corresponding barometric measurements by a barodiver installed at Liefkenshoek, were used (Figure 4-15).

As the pressure sensors are calibrated to read zero at standard atmospheric pressure, 1.01325 bar, the compensation was accomplished by subtracting the fluctuations around the standard atmospheric pressure from the raw pressure data, i.e. $P_{comp} = P_{raw} - (P_{atm} - 1.01325)$. Then, the conversion of compensated pressure to water level in m TAW takes place, in which pressure is multiplied by a factor equal to 10.1972 (conversion from bars to m watercolumn) and the vertical position of each gauge, included in Table 4, is added. A typical water level variation at Gsb4 location is presented in Figure 4-16.

Figure 4-14 – Typical daily pressure time series as stored by the gauge at Gsb4 location (northern transect).

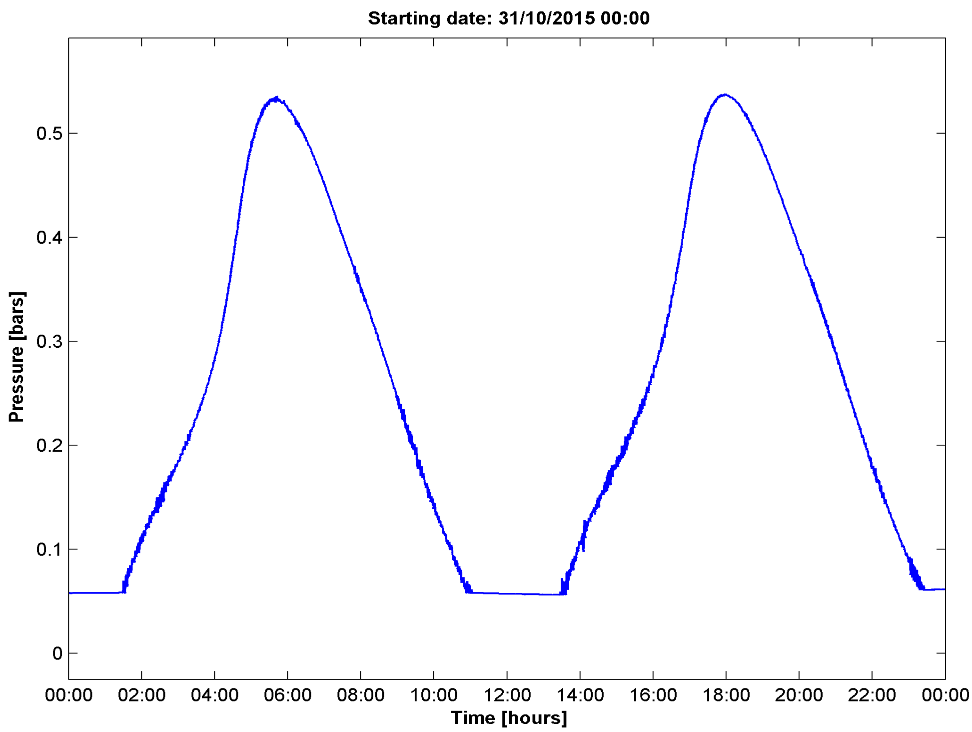


Figure 4-15 – Atmospheric pressure variation (at Liefkenshoek) during the measuring campaign.

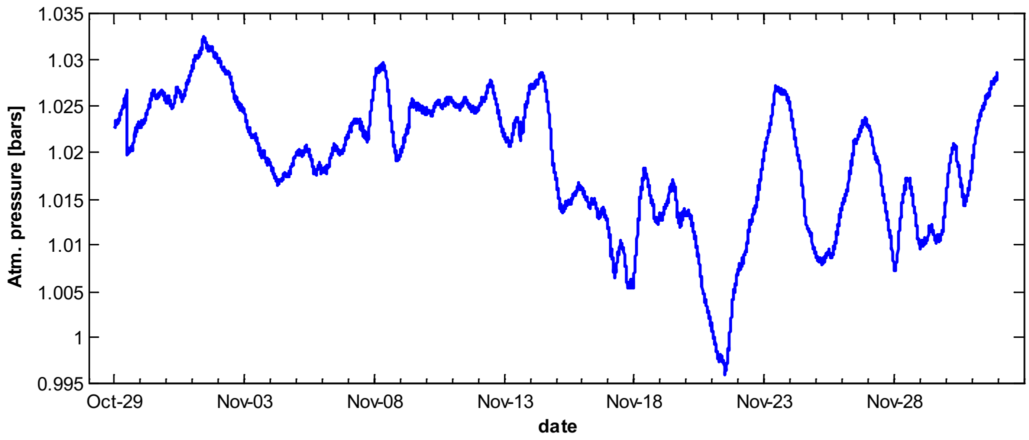
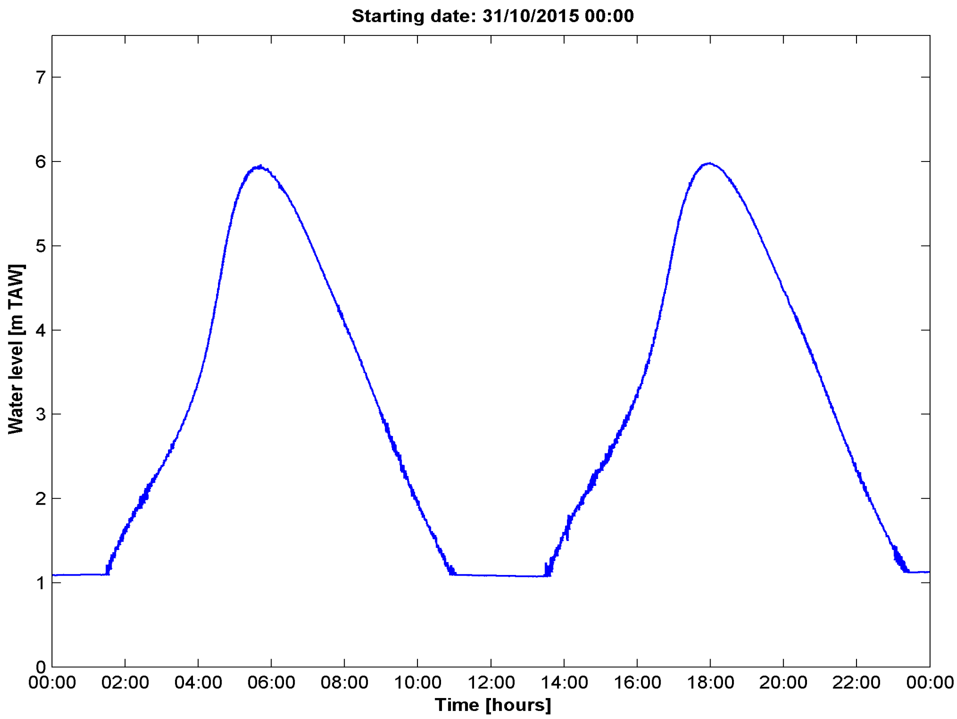


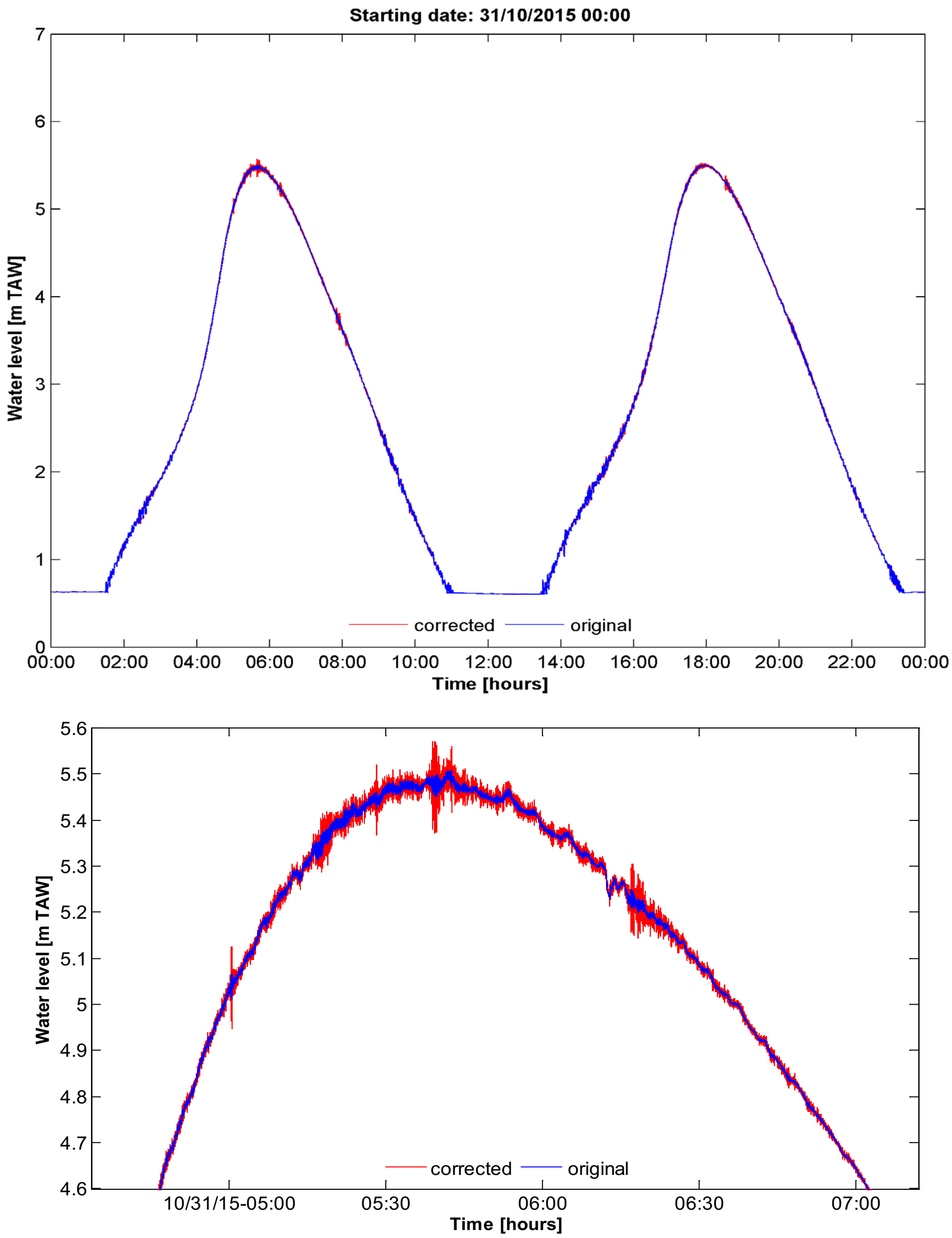
Figure 4-16 – Typical daily water level time series [m TAW] after atmospheric pressure compensation.



2) A correction of the water level fluctuations is required because of the depth-dependent pressure attenuation of the dynamic pressure component (induced by wave motion). The reader is referred to additional sources for deeper insight in theory of pressure sensor time-series (e.g. Kamsteeg, 1997; Ellis et al., 2006). This correction was accomplished using a modified version of the routine for pressure correction written by Neumeier (http://neumeier.perso.ch/matlab/waves.html), which follows the linear wave theory. Due to the non-linearity of waves in shallow water, this method may introduce some inaccuracies. However, currently it is the most widely used and reliable method for pressure correction. The water level variations before and after correction for pressure attenuation are compared in Figure 4-17. As expected, correction of water level fluctuations increases for higher water levels compared to lower water levels (the correction factor increases with increasing water depth). In the lower figure of Figure 4-17, the effect of the pressure correction on the water fluctuations, is more clearly demonstrated.

The main parameters to define as input in the 'pressure correction' routine are the uncorrected water levels above the bottom level (in meters), the height of the pressure sensor above the bottom and the sampling frequency. As reported by Neumeier, the attenuation correction is only applied over a given frequency range, to avoid the over-amplification of high frequency variations, which do not correspond to surface waves but are regarded as noise. By default, the correction is applied over the range 0.05-0.33 Hz. In this study, a maximum cutoff frequency equal to 0.45 (instead of 0.33) is opted for, following the findings of Verelst et al. (2011b), who compared similar data of high-frequency pressure sensors to data measured by a remote ultrasound sensor (Log_aLevel) in the same area. In addition, the maximal correction factor is considered equal to 6.7, again in accordance to Verelst et al. (2011). These considerations imply that pressure variation measured by the pressure gauge cannot be less than the 15% of the real pressure variation at the water surface.

Figure 4-17 – Comparison of water level variation measured at location Gsb4, before (blue line) and after pressure attenuation compensation (red line).



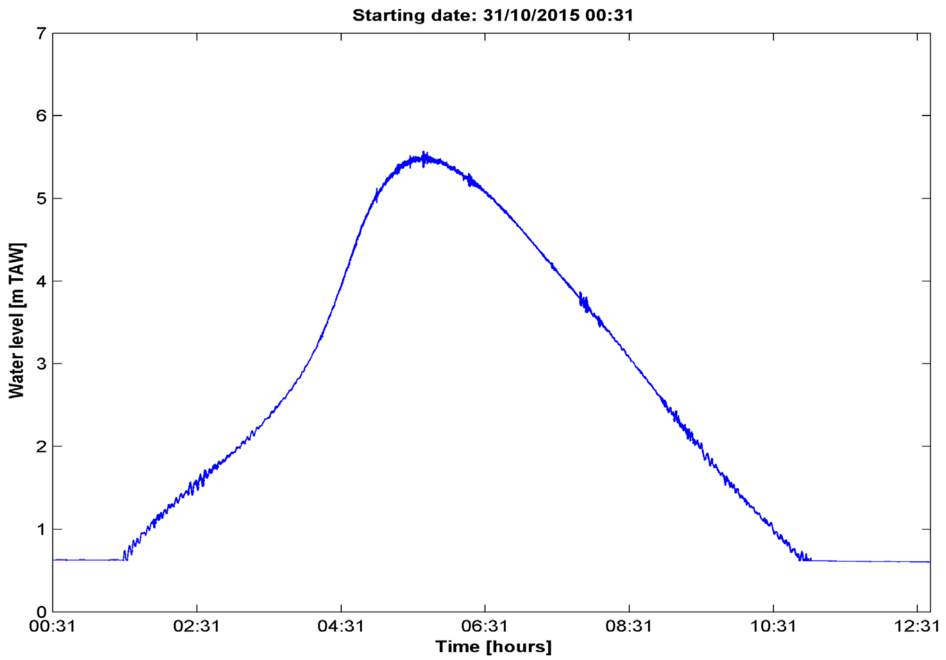
In the figure below, which is a detail of the upper one, the effect of the pressure correction is more clearly demonstrated.

3) The division of the original, daily water level time series to time windows equal to one tidal cycle, is based on the tidal measurements at Liefkenshoek. The duration of the tidal cycle is defined by the time interval between two successive low tide levels. In Table 5, the time of low water, resulting from the measurements at Liefkenshoek, and the corresponding numbering of tidal cycles, are shown. Figure 4-18 illustrates a typical time series of water level variation equaling one tidal cycle.

Table 5 – Time of low tide levels measured at Liefkenshoek and numbering of tidal cycles of the measuring campaign.

time (mm/dd/yyyy HH:MM)	no. tidal cycle	time (mm/dd/yyyy HH:MM)	no. tidal cycle
29/10/2015 11:11	1	14/11/2015 23:30	33
29/10/2015 23:44	2	15/11/2015 12:04	34
30/10/2015 11:48	3	16/11/2015 00:15	35
31/10/2015 00:31	4	16/11/2015 12:47	36
31/10/2015 12:42	5	17/11/2015 00:37	37
01/11/2015 00:56	6	17/11/2015 13:23	38
01/11/2015 13:26	7	18/11/2015 01:09	39
02/11/2015 01:28	8	18/11/2015 14:06	40
02/11/2015 13:58	9	19/11/2015 02:05	41
03/11/2015 02:13	10	19/11/2015 15:01	42
03/11/2015 14:49	11	20/11/2015 03:29	43
04/11/2015 03:04	12	20/11/2015 16:17	44
04/11/2015 15:41	13	21/11/2015 04:21	45
05/11/2015 03:58	14	21/11/2015 16:34	46
05/11/2015 17:10	15	22/11/2015 05:41	47
06/11/2015 05:32	16	22/11/2015 18:44	48
06/11/2015 17:58	17	23/11/2015 07:12	49
07/11/2015 06:47	18	23/11/2015 20:02	50
07/11/2015 19:36	19	24/11/2015 08:18	51
08/11/2015 07:34	20	24/11/2015 20:58	52
08/11/2015 20:33	21	25/11/2015 08:52	53
09/11/2015 08:11	22	25/11/2015 21:24	54
09/11/2015 20:59	23	26/11/2015 10:06	55
10/11/2015 08:52	24	26/11/2015 22:33	56
10/11/2015 21:39	25	27/11/2015 10:49	57
11/11/2015 09:43	26	27/11/2015 23:14	58
11/11/2015 21:56	27	28/11/2015 11:31	59
12/11/2015 10:22	28	29/11/2015 00:07	60
12/11/2015 22:34	29	29/11/2015 12:07	61
13/11/2015 10:54	30	30/11/2015 00:04	62
13/11/2015 22:16	31	30/11/2015 12:54	63
14/11/2015 11:24	32	01/12/2015 01:10	-

Figure 4-18 – Typical water level time-series corrected for pressure attenuation.
The time-window length equals the duration of a tidal cycle (defined by two successive low tide levels).



4) The tidal signal was removed from the water level fluctuations using a low pass filter in the spectral domain. The cutoff frequency is equal to 0.002 Hz, corresponding to a wave period of 8.33 min, ensuring that only water level variations related to tide will pass. Figure 4-19 shows the tide variation after the implementation of the filtering operation compared to the unfiltered water level variation. Obviously, the filtering operation eliminates successfully the high-frequency water fluctuations. In Figure 4-20, these high-frequency water level fluctuation time series is shown.

Figure 4-19 – Tide variation (blue line) in time after implementation of a low-pass filter (f_{cut} < 0.002) versus the unfiltered water level variation.

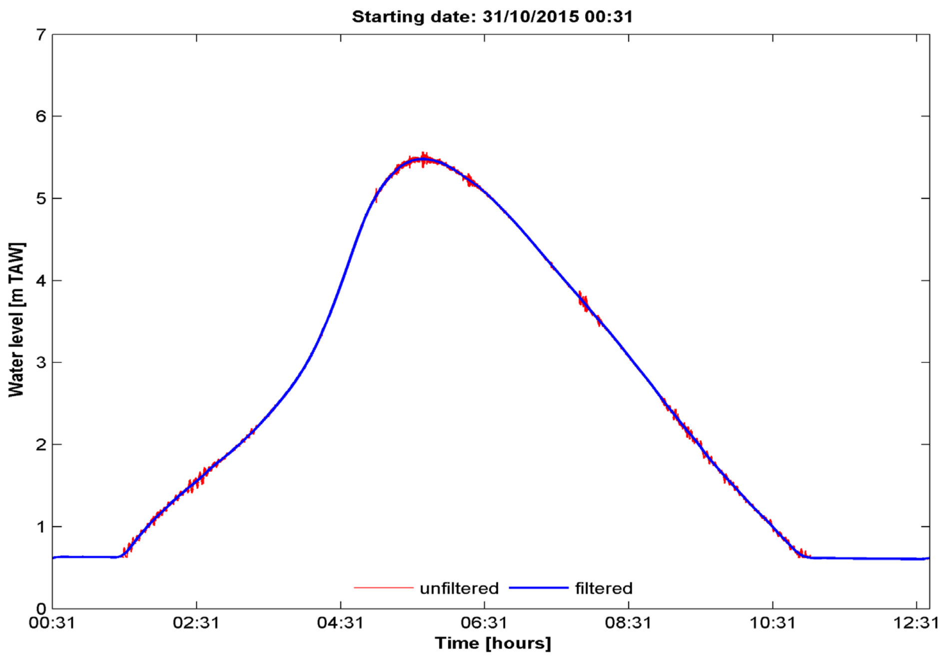
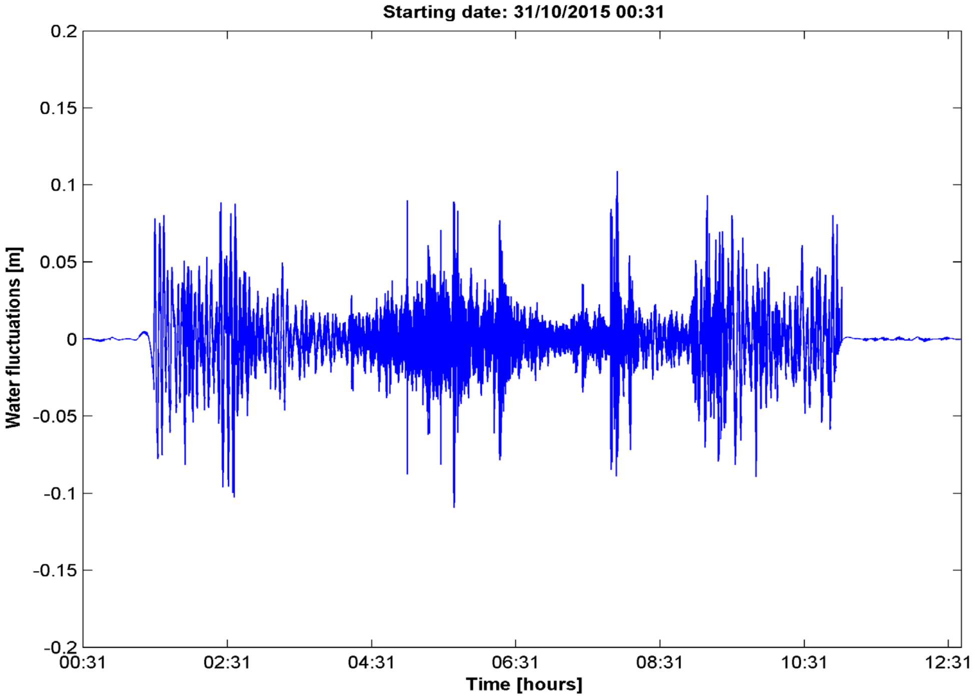
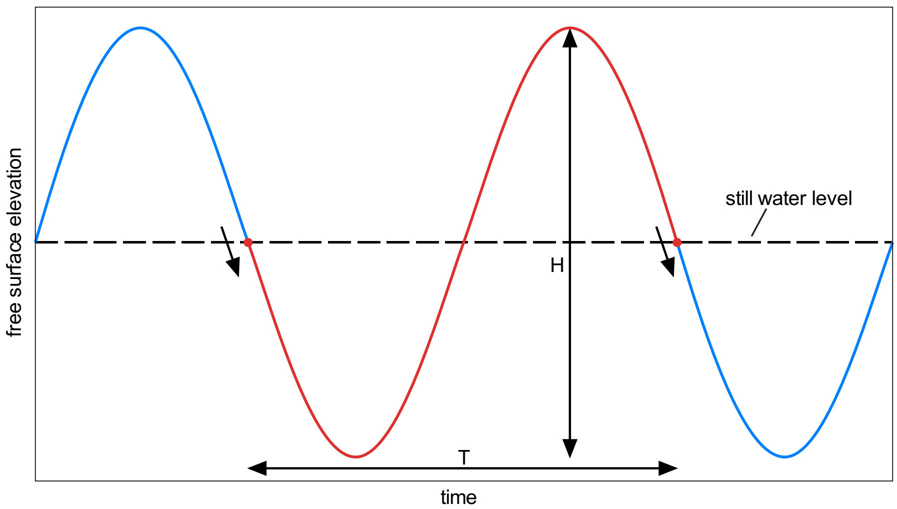


Figure 4-20 – Water fluctuations resulting from the subtraction of the tide from the unfiltered water level.



5) The resulting water fluctuations time series were used for the calculation of wave characteristics per tidal cycle. The zero-downcrossing method was applied in order to determine and characterize individual waves by their wave height and period. Using this method, a wave is determined as the variation of free-surface confined between two consecutive zero level crossings appearing prior to a wave trough (see Figure 4-21). According to Mizuguchi (1982), the down-crossing method is to be preferred to the up-crossing method because of clearly reproducing one of the characteristic features of shallow water wave deformation, that is, the development of secondary water surface fluctuations. For this reason, as this study deals with shallow water deformation of waves, and for the reason of consistency with previous studies (e.g. Verelst et al., 2011a), it was also employed in the present study. In addition the script for wave calculation foresees the detection and removal of possible outliers in the signal. A sample which differs from the median of a window (consisting of 25 samples) by more than four standard deviations was characterized as outlier, and consequently, it was removed.

Figure 4-21 – Determination of a wave using zero-down crossing method (wave is denoted by the red solid line).



4.5.2 Wave statistics

The significant and the maximum wave height per tidal cycle were calculated from the individual wave characteristics for each of the measurement locations (Gsb2, Gsb4, Gsc2, Gsc3, Gsc4). The significant wave height, $H_{1/3}$, is defined as the mean of the highest 1/3 of all waves in the record's ranking. Figure 4-22, Figure 4-24, Figure 4-26, Figure 4-28 and Figure 4-30 show the significant and the maximum wave heights per tidal cycle at locations Gsb4, Gsb2, Gsc4, Gsc3 and Gsc2 respectively. The mean wave period of the highest 1/3 of all waves in the ranking, $T_{1/3}$, and the wave period of the highest wave, T_{max}, per tidal cycle for locations Gsb4, Gsb2, Gsc4, Gsc3 and Gsc2 are shown in Figure 4-23, Figure 4-25, Figure 4-27, Figure 4-29 and Figure 4-31 respectively. Note that in some figures, outlying T_{max} values are included in separate windows (above), for clarity of the results.

The variation in significant wave height shows a similar behavior for the 3 measurement locations on the low and middle-high mudflat, presenting peaks ($H_{1/3}$ = 15 to 20 cm) between November 17 and 18 and on November 29, while during most of the campaign, $H_{1/3}$ ranges from 5 to 8 cm. For the high mudflat positions, the gaps in the data for November 3-10 (GSb2) and November 3-6 (GSc2) are due to the low high water levels in that period (neap tide), i.e. the instruments were not inundated. As such, no wave data could be recorded for those days (see also Figure 4-13). At both plots, the greatest proportion of significant wave heights lies between 5 and 10 cm. However, the pattern is less similar compared to the other locations.

The variation in maximum wave height (H_{max}) in location Gsb4 (Figure 4-22) presents two peaks (~75 cm) on November 1 and 27, while in the greatest part of the considered period, H_{max} ranges from 20 to ~50 cm. The greatest proportion of maximum wave heights is comprised between 15 and 30 cm at GSc2. The highest peak here is around 60 cm on November 27.

At the measurement locations in the southern transect (Gsc3, Gsc4), variations in H_{max} are similar to one another, presenting peak values on November 17, with a deviation of about 10 cm (Figure 4-26 and Figure 4-28). However, higher values around 6 and 8 November at Gsc4 are not represented in Gsc3. Similar to Gsb4, the range of H_{max} variation is limited between 20 and 50 cm in the largest period, however it is obvious that the shallower gauge (Gsc3) recorded in general attenuated H_{max} values compared to the deeper ones (Gsc4, Gsb4). This behavior can be attributed to the processes of breaking and dissipation of waves propagating towards shallower regions. At GSc2 on the high mudflat, the greatest proportion of maximum wave heights is comprised between 10 and 30 cm, with maximum values of 0.45 m and 0.65 m.

Regarding the variation of $T_{1/3}$, it is found that it exhibits a similar behavior for the measurement locations of the southern DGD transect (Figure 4-27 and Figure 4-29), presenting values that range from 2 s to around 5.5 s, while in the northern SFD transect (Figure 4-23) the highest $T_{1/3}$ can reach values up to 8 s. For all the measurement locations, the lowest $T_{1/3}$ values appear at the interval between November 9 and November 19.

The wave period of the highest waves (T_{max}) varies between 2 s and 4 s for the greatest part of the measurement campaign at all locations (Gsb4, Gsc4, Gsc3). However, at location Gsb4 (Figure 4-23) outlying T_{max} values ranging from 80 s to 350 s, appear (almost exclusively) in the interval between October 31 to November 9. For Gsc4 location one clear T_{max} maximum (about 35 s) is observed in the last day of measurements.

Regarding wave period at the high positions, the largest proportion of both, $T_{1/3}$ and T_{max}, lies at both high tidal flat plots between 2 and 4 s, with occasional outliers of up to 40 s. For several tides, $T_{1/3}$ is higher than T_{max}, meaning that the waves with maximum wave height do not necessarily have the longest wave period. Nonetheless, $T_{1/3}$ and T_{max} are overall fairly similar.

Figure 4-22 – Significant ($H_{1/3}$) and maximum wave height (H_{max}) per tidal cycle at Gsb4 location (northern transect).

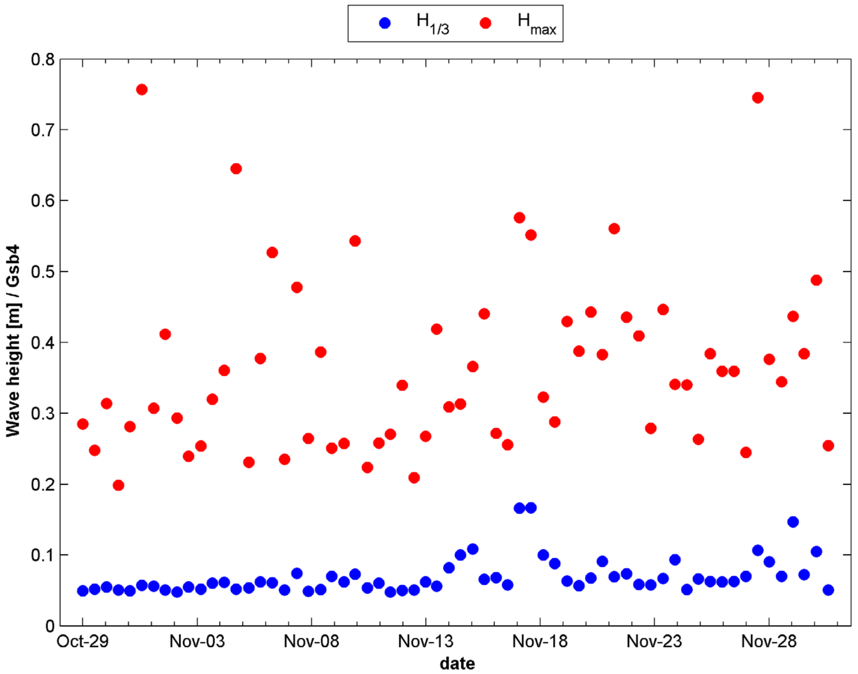


Figure 4-23 – Mean wave period of the highest 1/3 wave ($T_{1/3}$) and wave period of the highest wave (T_{max}) per tidal cycle at Gsb4 location (northern transect). T_{max} outliers are denoted in separate window above.

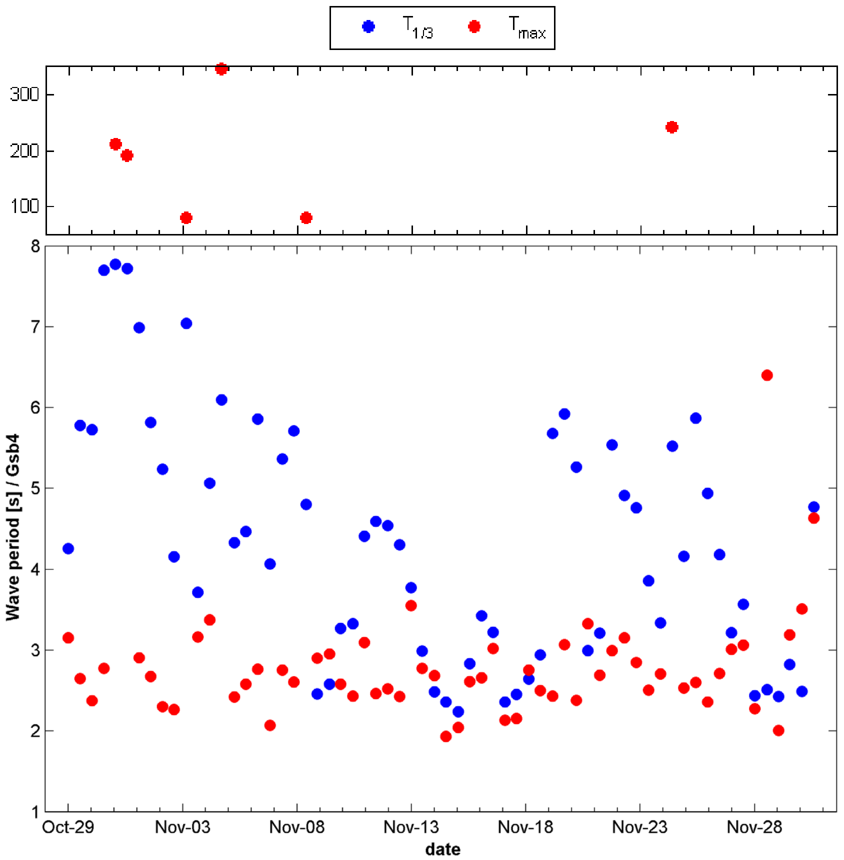


Figure 4-24 – Significant ($H_{1/3}$) and maximum wave height (H_{max}) per tidal cycle at Gsb2 location (northern transect).

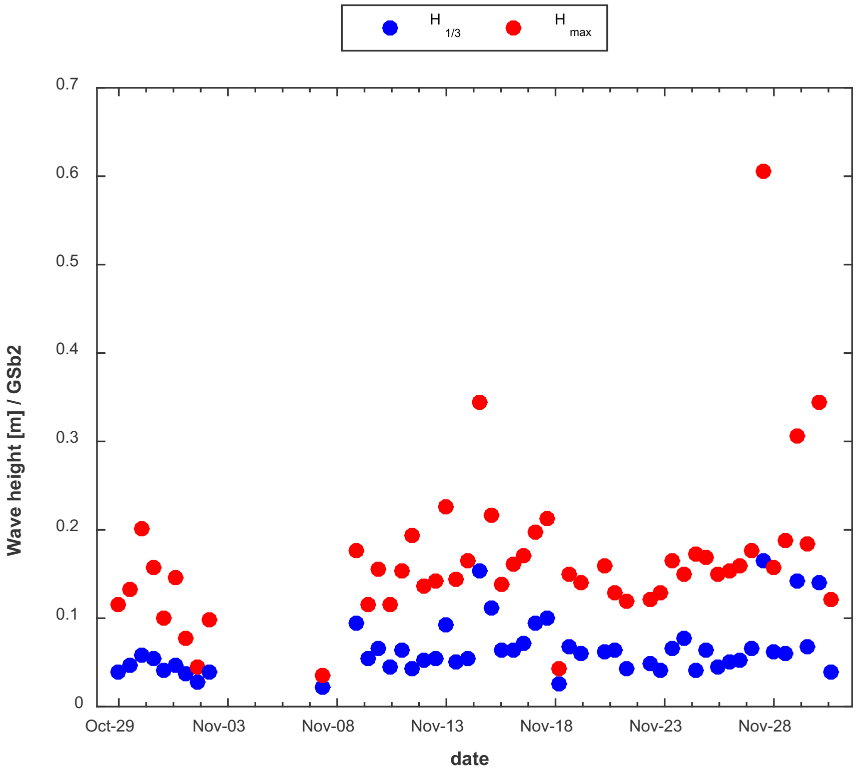


Figure 4-25 – Mean wave period of the highest 1/3 wave ($T_{1/3}$) and wave period of the highest wave (T_{max}) per tidal cycle at Gsb2 location (northern transect). T_{max} outliers are denoted in separate window above.

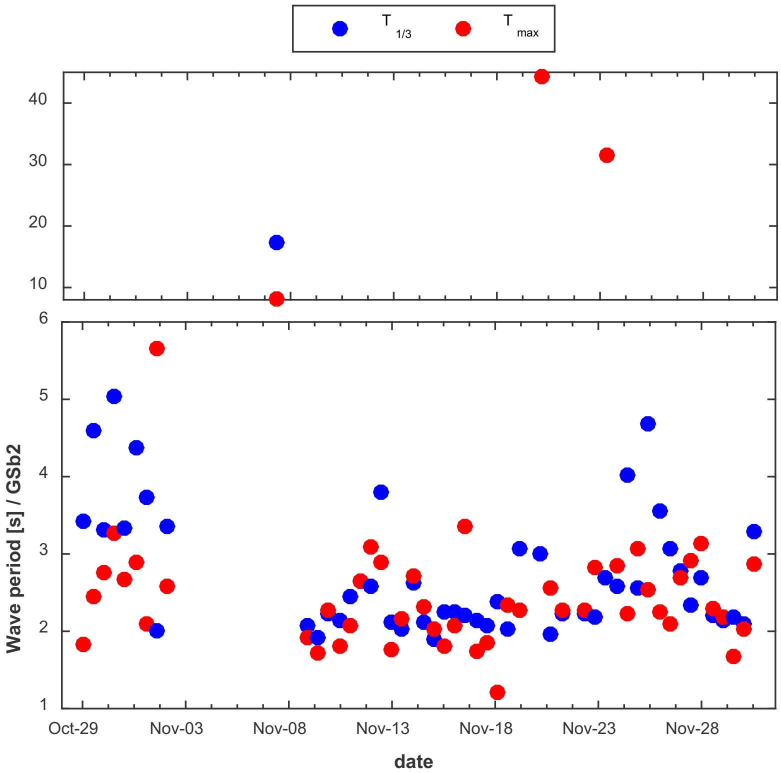


Figure 4-26 – Significant ($H_{1/3}$) and maximum wave height per tidal cycle at Gsc4 location (southern transect – low mudflat).

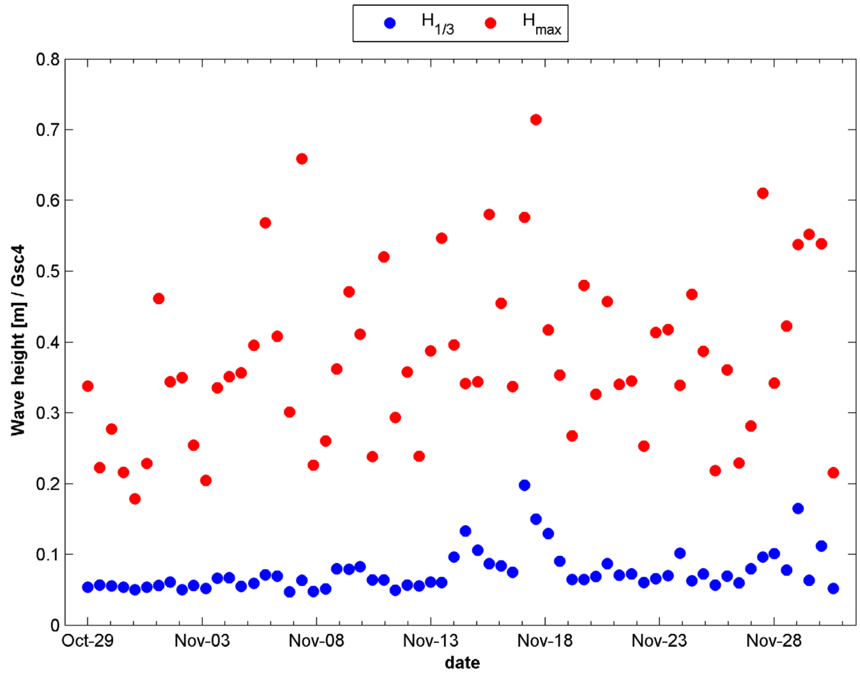


Figure 4-27 – Mean wave period of the highest 1/3 wave ($T_{1/3}$) and wave period of the highest wave (T_{max}) per tidal cycle at Gsc4 location (southern transect). T_{max} outliers are denoted in separate window above.

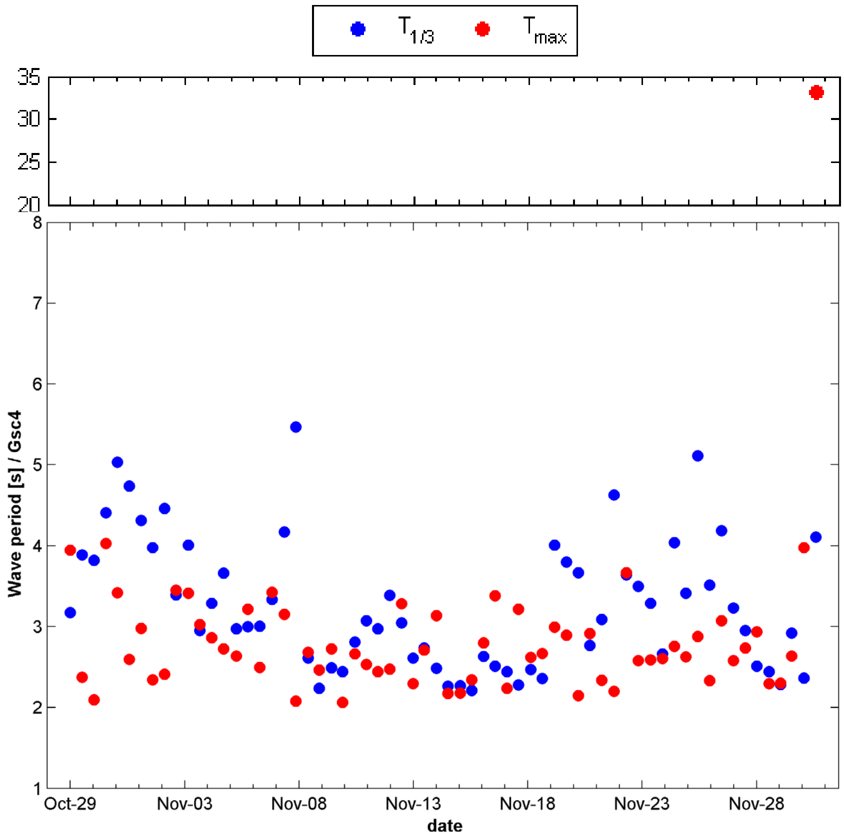


Figure 4-28 – Significant ($H_{1/3}$) and maximum wave height per tidal cycle at Gsc3 location (southern transect – middle high mudflat).

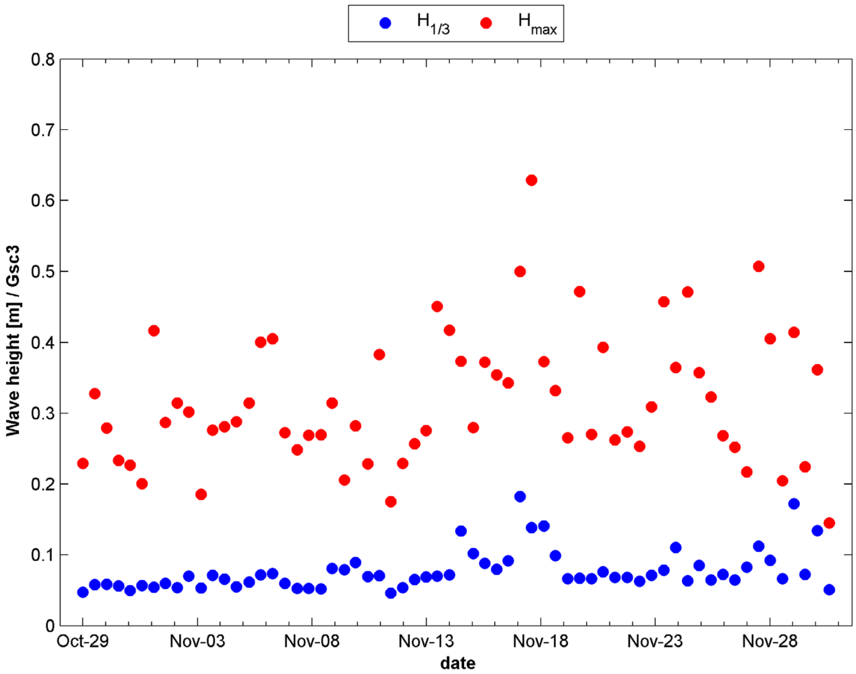


Figure 4-29 – Mean wave period of the highest 1/3 wave ($T_{1/3}$) and wave period of the highest wave (T_{max}) per tidal cycle at Gsc3 location (southern transect).

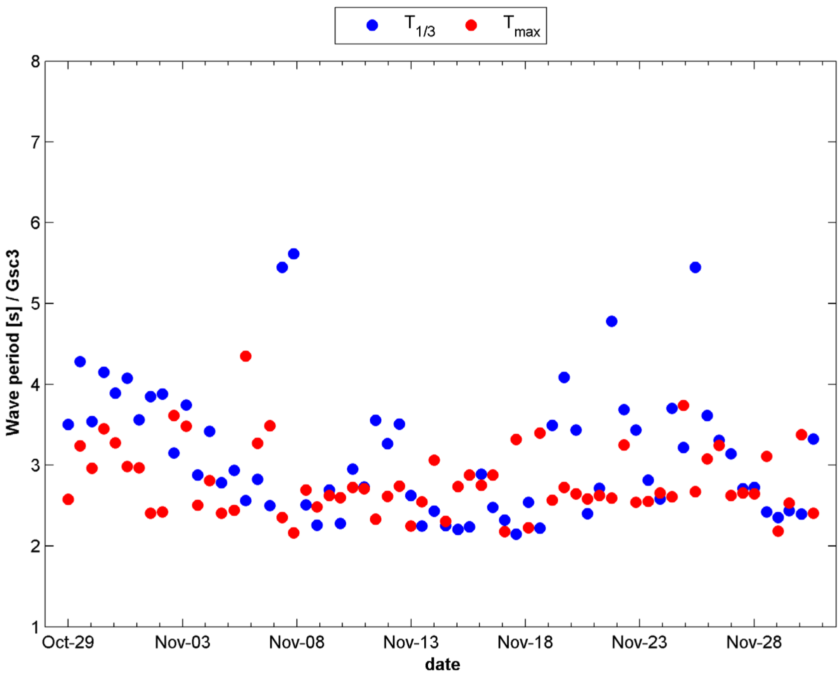


Figure 4-30 – Significant ($H_{1/3}$) and maximum wave height per tidal cycle at Gsc2 location (southern transect –high mudflat).

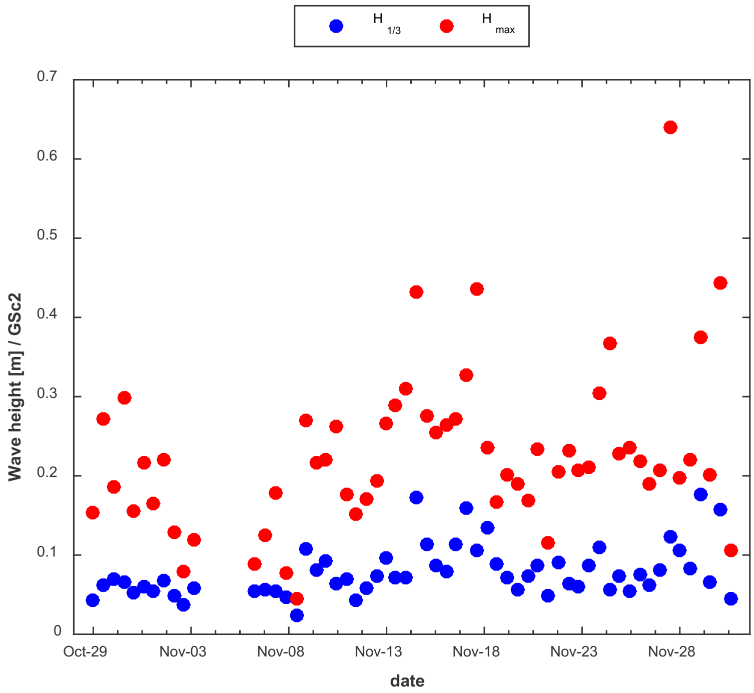
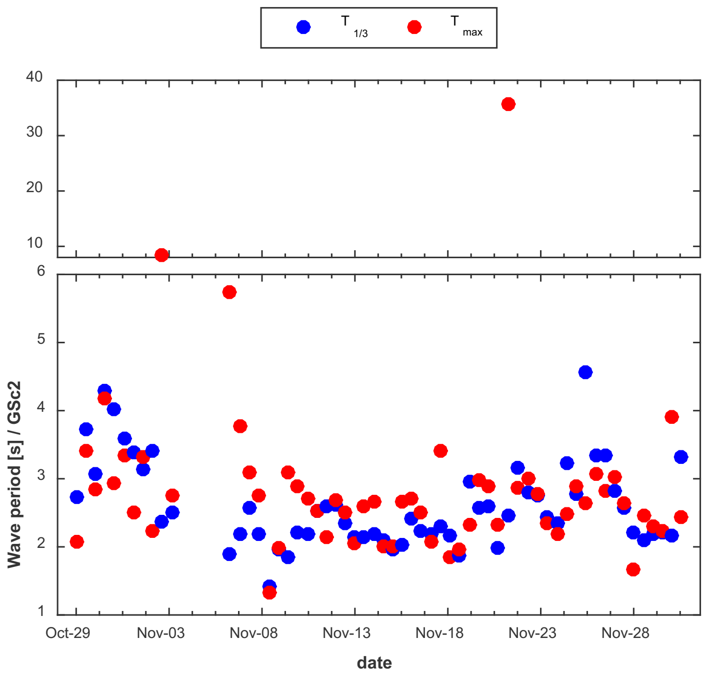


Figure 4-31 – Mean wave period of the highest 1/3 wave ($T_{1/3}$) and wave period of the highest wave (T_{max}) per tidal cycle at Gsc2 location (southern transect). T_{max} outliers are denoted in separate window above.



4.6 Suspended sediment concentration (SSC)

In Figure 4-32 an overview is given of the suspended solid concentration [mg/l] at meetpaal Lillo. Suspended sediment concentrations are calculated from turbidity values, measured with Aanderaa devices. Only the upper sensor at Meetpaal Lillo is considered here.

Figure 4-32 – Overview of the SSC concentration at Meetpaal Lillo over the measurement period

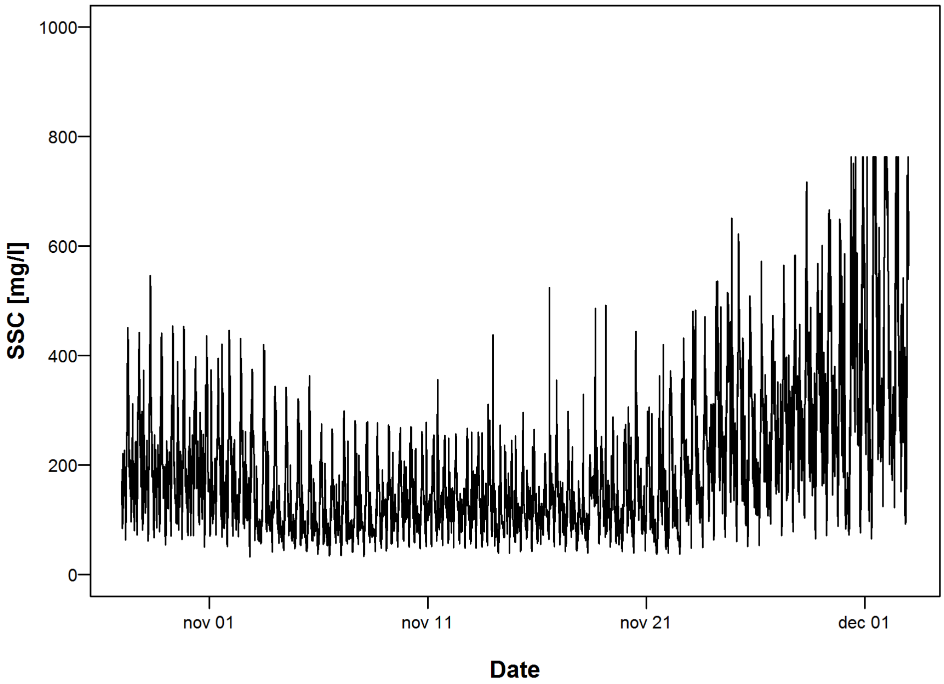
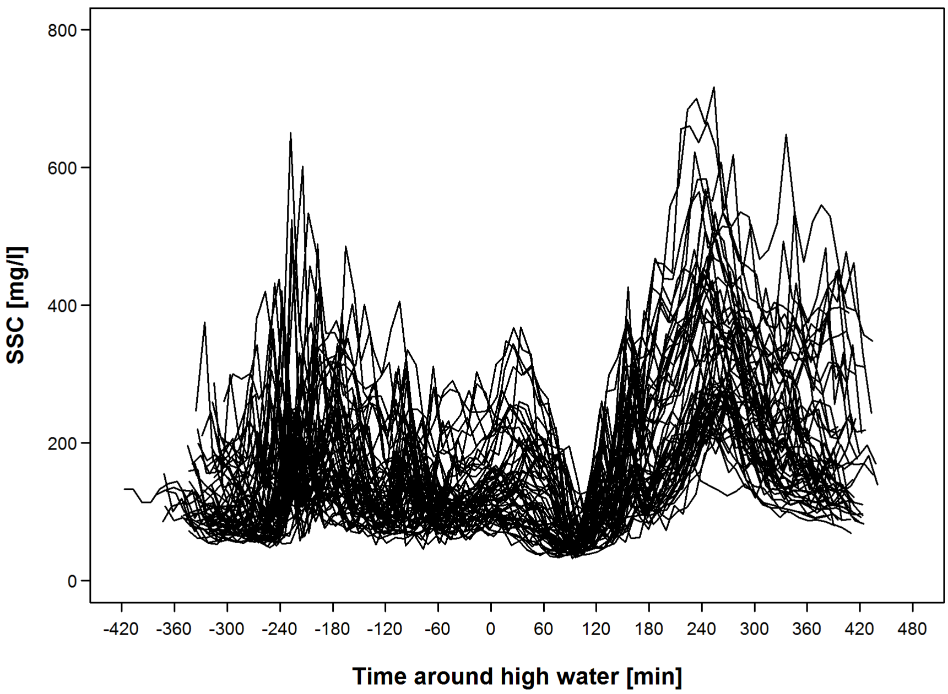


Figure 4-33 – Overview of the SSC concentration at Meetpaal Lillo over the tidal cycle. Saturated values are not included in the plot



It is clear that at the end of the measurement period, the sensor saturated corresponding with a suspended sediment concentration of around 760 mg/l. Over the measurement period, a minimum value of 32 mg/l and an average concentration of 193 mg/l is measured. In Figure 4-33 the evolution of the suspended sediment concentration over the tidal cycles is shown. It is clear that during the flood phase, maximal concentrations are found about 4 hours before high water. Between one to two hours after high water, around high water slack, the concentrations tend to become small. During the ebb phase, maximal concentrations seem to occur about 4 hours after high water.

5 Ship data (AIS)

5.1 General information about AIS data

The Automatic Identification System (AIS) is a tracking system used by Vessel Traffic Services (VTS) for identifying and locating ships. Each ship exchanges data with other ships or base stations containing information on its position, course and sailing speed. On the Western Scheldt and the North Sea AIS data are received by more than 10 base stations, which are logged in a central server operated by the Scheldt Radar Chain (Knowledge Centre Maneuvering in Shallow and Confined Water, 2015).

According to the Economic Commission for Europe (ECE) (2007), vessel tracking and tracing systems in inland navigation should be compatible with maritime AIS, and therefore, AIS messages should contain:

- Static information, such as official ship number (mmsi), call sign of vessel, name of vessel, type of vessel
- Dynamic information, such as vessels position with accuracy indication and integrity status
- Voyage related information, such as length and beam of vessel combination, hazardous cargo on board
- Inland navigation specific information, e.g. number of blue cones/lights or estimated time of arrival at lock/bridge/terminal/border

For moving ships an update rate for the dynamic information on tactical level is foreseen (order of magnitude equals a few seconds). In inland waterway mode it can be assigned between 2 seconds and 10 minutes depending on the navigational status of the vessel (mainly it depends on the speed and the course of the ship). For vessels at anchor it is recommended to have an update rate of several minutes, or if information is amended.

As mentioned before, AIS data contain useful information that can for example be used to analyze shipping traffic for operational purposes or to analyze specific maneuvers at particular locations. However, the mere size of the data files are a real challenge to work with. To this end, Flanders Hydraulics Research (FHR) has developed a tool to analyze AIS information in a flexible and effective way. Voyage information is structured based on the passing times of predefined entry lines. The data can then be filtered based on different parameters, such as ship characteristics (dimensions, type) or voyage characteristics (destination, in- or outbound sailing, draft, time). For visualisation purposes the tool also provides export options in different formats, which can be opened with Google Earth TM or other GIS-viewers (Knowledge Centre Maneuvering in Shallow and Confined Water, 2015).

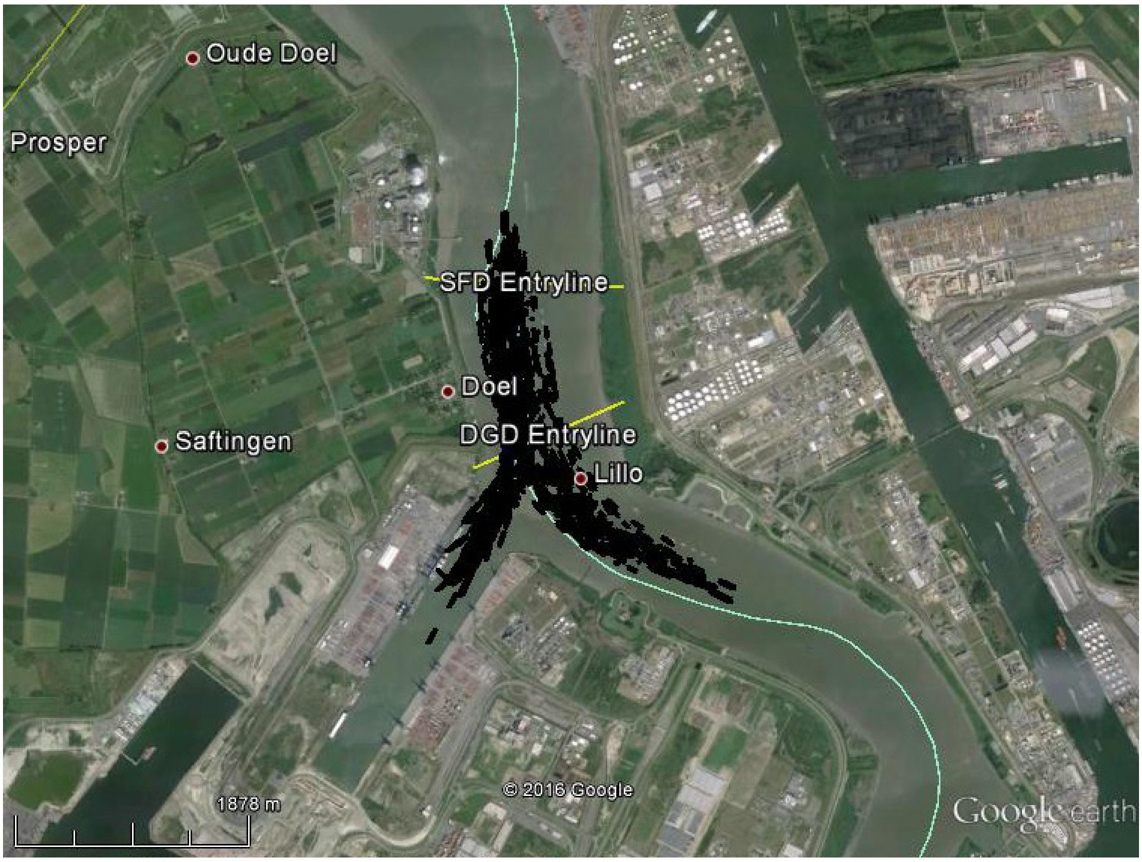
5.2 AIS data analysis

This inhouse developed tool was used considering the two measurement transects (northern SFD and southern DGD) as entry lines. This lines contain the measurement locations and are extended in order to connect the right and the left bank of Scheldt estuary (Figure 5-1). The resulting data files (one for each entry line) contain the following static and dynamic information about the passing ships:

- time of passage
- mmsi number
- name of ship and type
- ship characteristics : length, beam, draught
- sailing speed (over ground)
- course and sailing direction

The distance to the measurement devices is added to the AIS information. In Figure 5-1, the traces of ships crossing the two considered entry lines during one tidal cycle, are depicted.

Figure 5-1 – Traces of ships that cross the two considered entry lines, north (SFD) and south (DGD), during tidal cycle 5 (31/10/2015 12:42 – 01/11/2015 00:56), as produced by the FHR tool.



The total number of ship passages from the northern (SFD) entry line during the measuring campaign was equal to 7159, while a slightly lower number of 7097 passages was recorded at the southern (DGD) entry line.

It was also found that 2551 out of the 7097 trajectories (~36% of the total amount) that crossed the DGD entry line were directed towards the Deurganckdok itself. The passages from SFD entry line were done by 1611 different ships, while 1609 ships crossed the DGD entry line. These small difference between the two entry lines in the total amount of both ship passages and different ships are attributed to the traffic from/to the marina located in between them (at Doel) and the irregular passages of the tug boats. The analysis that follows is based on the AIS data at SFD entry line, where the largest number of ship passages was recorded.

The information about ship type contained in an AIS-message is a two-digit number, in which the first digit represents the general category of the vessel (Table 6).

Table 6 – Classification of vessel type in regard to the first digit of the AIS code.

ship type	first digit	ship type	first digit	ship type	first digit
Reserved	1	High-Speed Craft	4	Cargo	7
Wing in Ground	2	Special Category	5	Tanker	8
Special Category	3	Passenger	6	Other	9

In certain cases (e.g. Cargo Vessels, Tankers) the second digit provides additional information regarding the subject vessel's type of cargo:

1 = Major Hazard, 2 = Hazard, 3 = Minor Hazard, 4 = Recognizable Hazard

The two-digit identifiers that belong in the Special Category (first digit = 3 and 5, Table 6) correspond to the following main types of vessels:

30 = Fishing, 31,32 = Tug, 33 = Dredger, 34 = Dive vessel, 35 = Military, 36 = Sailing, 37 =Pleasure craft

51 = Search & Rescue, 52 = Tug, 53 = Port Tender, 54 = Anti-Pollution, 55 = Law Enforce

The aforementioned information about AIS coding of vessel type was retrieved by the following URL: https://help.marinetraffic.com/hc/en-us/articles/205579997-What-is-the-significance-of-the-AIS-SHIPTYPE-number-information.

5.3 Combination of AIS and IVS data

Due to the fact that AIS data used for the classification of vessels does not discriminate between seagoing and inland vessels and also does not include further information about the exact type (bulk, container, etc.) of the cargo vessels, additional data was retrieved by the Information Processing System (IVS – Informatie Verwerkend Systeem) used by VTS (Vessel Traffic Services). IVS system supports navigation in the Scheldt area by recording information mainly of the seagoing vessels. The classification of the seagoing vessels and their identifying acronyms according to the IVS database are shown in Table 7.

Table 7 – Acronyms of the seagoing vessel types according to the IVS classification.

ship type	Acronym	ship type	Acronym	ship type	Acronym
Bulker	BLK	Gas carrier	GAS	Ro-Ro carrier	RRC
Vehicle carrier	CAR	General Cargo	GEN	Special/Other	SPC/OTS
Container vessel	CON	Reefer	REF	Tanker	TNK

The coupling procedure of AIS and IVS data was semi-automated. Firstly, passages recorded by the IVS system were identified in the AIS database, mainly based on the mmsi number of the vessel and the time of the passage. Additional criteria (matching ship name and dimensions) were applied in cases where a passage included in IVS was not found in AIS data, until all the IVS recorded passages to be identified in the AIS database. Secondly, in order to track possible passages of seagoing vessels recorded by the AIS system but not included in the IVS database, filtering of the AIS data was applied. The passages selected by this filtering operation should satisfy simultaneously the following criteria:

- ships draught greater than 4.5m
- ships with foreign flag (excluding ships coming from The Netherlands, France, Germany, Luxembourg, Switzerland and Czech Republic)

Finally, manual inspection of the vessels that remained from the above filtering operation (183 ships), was performed consulting the "marinetraffic.com" website, in order to verify remaining seagoing vessels and categorize them according to Table 7.

It was found that the total number of seagoing vessel passages from the north (SFD) entry line during the measuring campaign was equal to 1631, consequently 5528 passages correspond to inland vessels. In other words, about 25% of the passages correspond to seagoing vessels. The passages from SFD entry line were done by 677 and 934 different seagoing and inland ships, respectively.

5.4 Graphical representation of AIS-IVS data analysis

The graphical representation of the analysis of the coupled AIS-IVS data refers separately to the inland and the seagoing vessels, i.e. identical bar plots are presented for both cases.

5.4.1 Inland vessels

The number of inland vessel passages with respect to ship type during the measuring campaign is shown in Figure 5-2. It is found that the cargo ships correspond to almost 50% of the total number of passages, while the second and the third place is occupied by tug boats (~20%) and tankers (~15%), respectively. Ship passage frequency with respect to ship length and type is presented in Figure 5-3. It is indicated that ships of length ranging from 101 to 150m prevail in the number of passages presenting a proportion equal to about 38% of the total number of passages. Next in the ranking and very close to each other, are the ships of length between 51-100m and the ships smaller or equal to 50m, with number of passages equal to about 27% of the total amount. Therefore, the percentage of inland vessels of length smaller or equal to 150 m crossing the SFD entry line is more than 90% of the total amount of passages.

Figure 5-2 – Inland vessel passage frequency with respect to ship type at SFD entry line (north transect) during the measuring campaign. Type 'other' includes a small number of WIG, Passenger, Law enforce and Port tender boats.

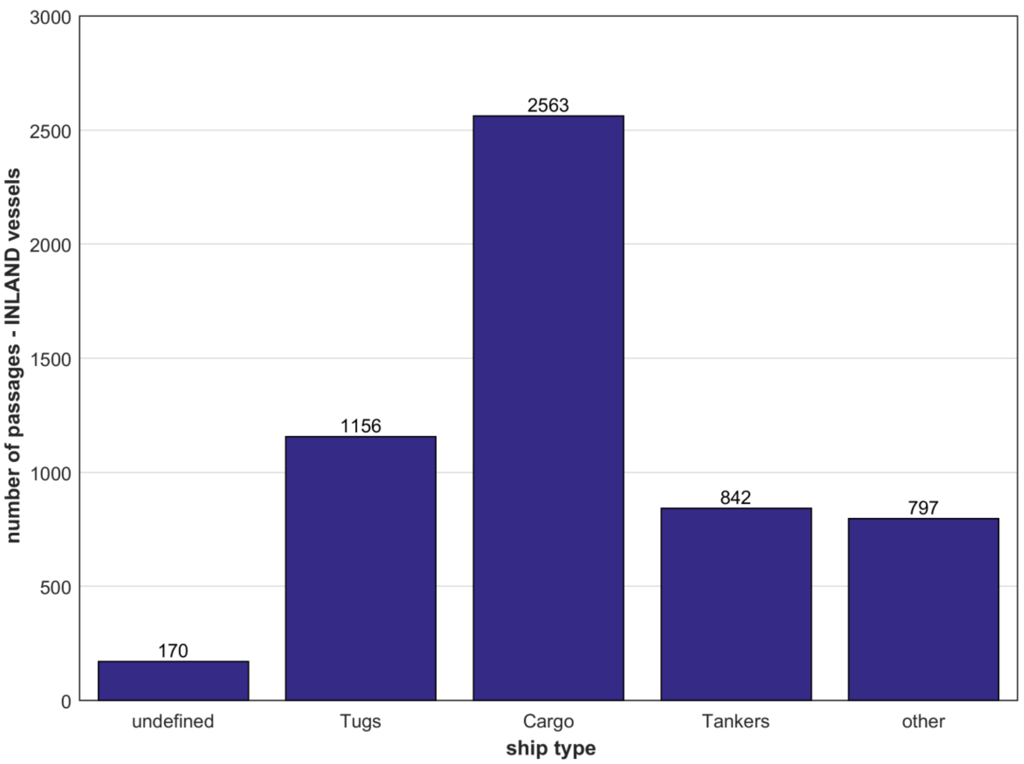


Figure 5-3 – Inland vessel passage frequency with respect to ship length and type at SFD entry line (north transect) during the measuring campaign.

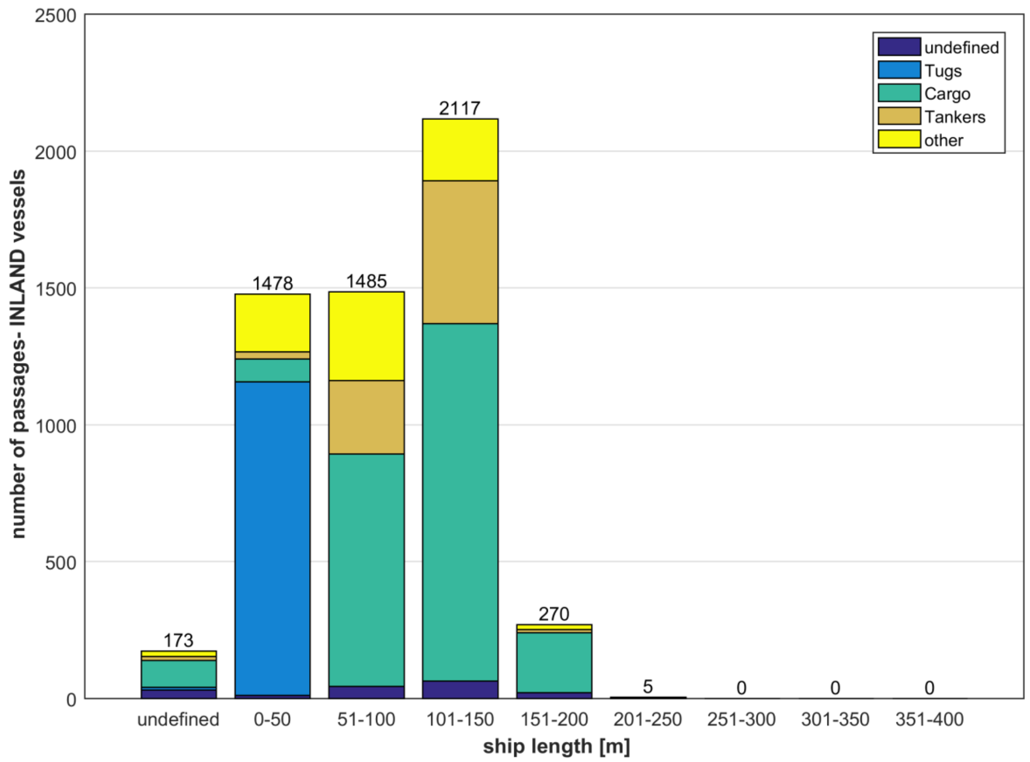
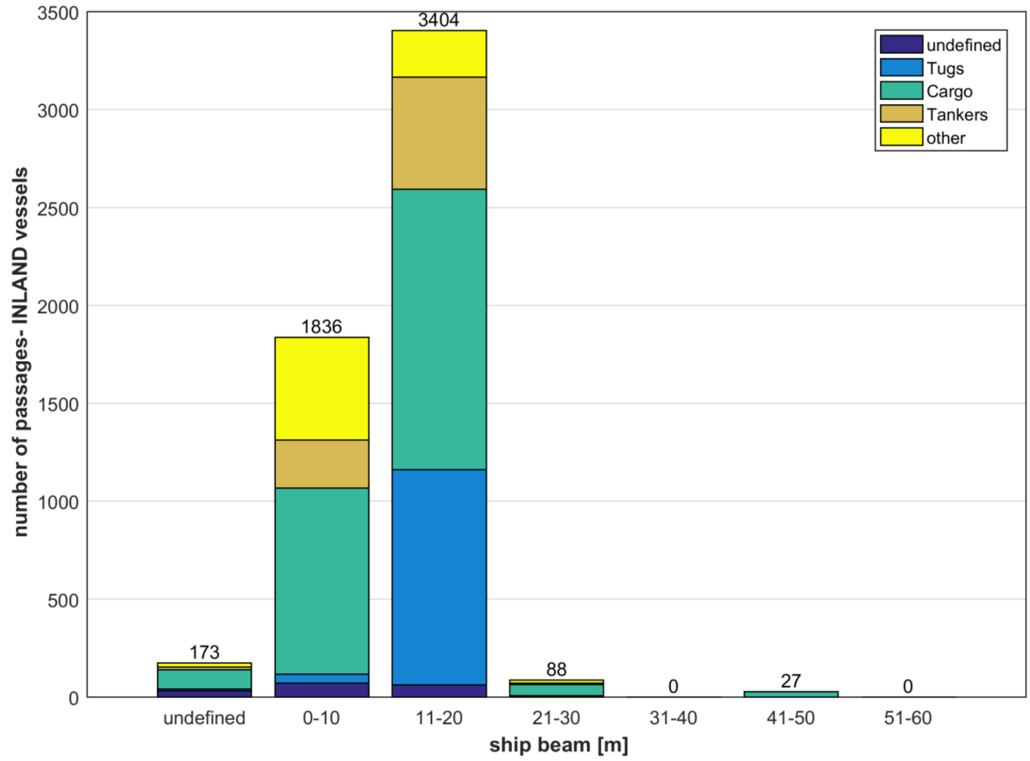
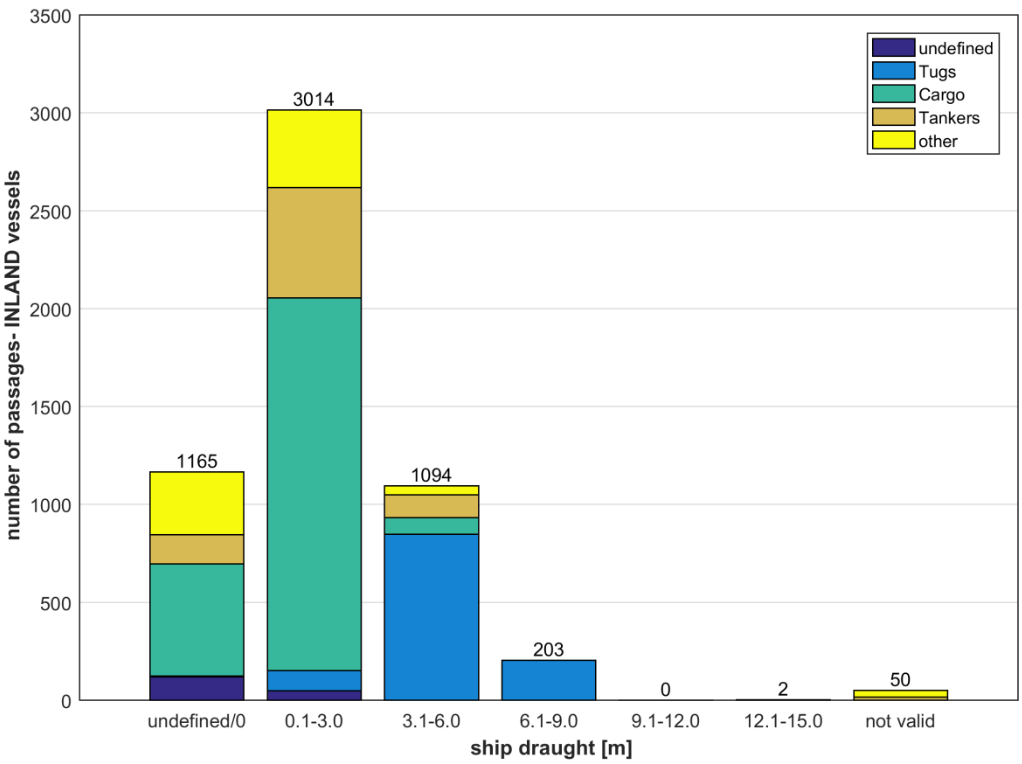


Figure 5-4 – Inland vessel passage frequency with respect to ship beam and type at SFD entry line (north transect) during the measuring campaign.



In Figure 5-4, the number of passages with respect to ship beam (width) and type is presented and it is indicated that inland ships of beam in the range 11 to 20m exhibit by far the highest frequency of appearance (~62% of the total inland vessel passages). The second place is occupied by relatively small ships of beam less or equal to 10, corresponding to about 33% of the total passages. Finally, ship passage frequency with respect to ship draught is presented in Figure 5-5. Ships of draught between 0.1 and 3m are the most frequently observed (~55%), while ships of draught in the range 3.1-6m cover the 20% of the total number of inland vessel passages. Note that the passages of ships with undefined or 0m draught occupy a significant part (~20%) of the total number of passages. Sometimes the information about draught may hide inaccuracies, as it is entered by each ship's crew and there is no other confirmation about it.

Figure 5-5 – Inland vessel passage frequency with respect to ship draught and type at SFD entry line (north transect) during the measuring campaign. The 'not valid' column corresponds to large values usually greater than 20 m.



5.4.2 Seagoing vessels

The number of seagoing vessel passages with respect to ship type during the measuring campaign is shown in Figure 5-6. It has to be noted that the categorisation shown in this figure results from Table 7 after the following merging of types:

CAR+RRC = Ro-Ro, CON+REF = Container, TNK+GAS = Tanker

It is found that each of the tanker and container vessel passages correspond to about 25% of the total number of (seagoing) passages, while dredger, general cargo and Ro-Ro vessel passages range (each) between 17% and 14% of the total amount. Merged container and general cargo categories lead to about 40% of the total number of passages. Ship passage frequency with respect to ship length and type is presented in Figure 5-7.

Figure 5-6 – Seagoing vessel passage frequency with respect to ship type at SFD entry line (north transect) during the measuring campaign.

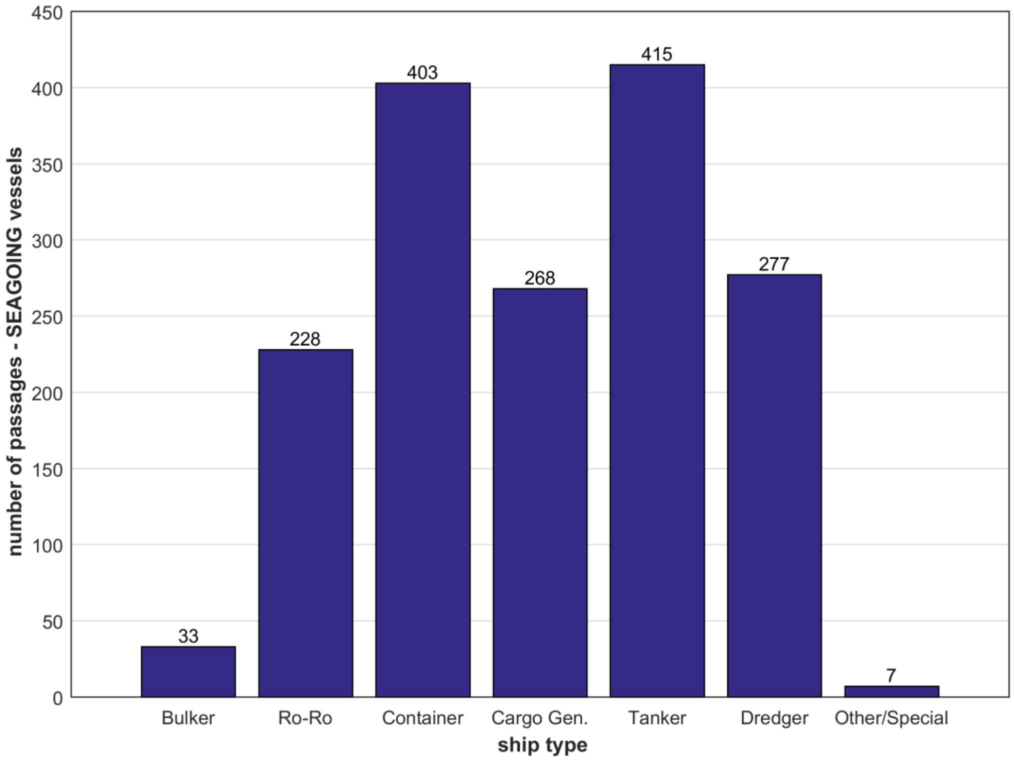
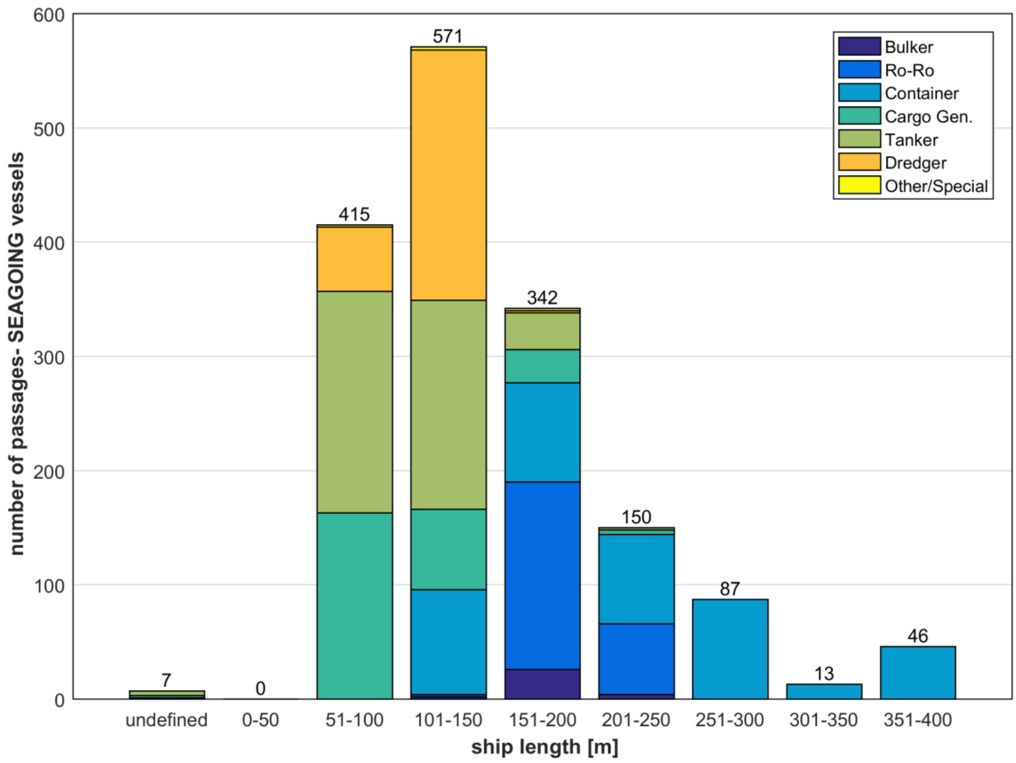


Figure 5-7 – Seagoing vessel passage frequency with respect to ship length and type at SFD entry line (north transect) during the measuring campaign.



It is indicated that ships of length ranging from 101 to 150m prevail in the number of passages presenting a proportion equal to 35% of the total number of passages. Next in the ranking are the ships of length between 151 and 200 m and those of length in the range 201-250m, with number of passages equal to about 25% and 20% of the total amount, respectively. Finally, the percentage of seagoing vessels of length greater than 200m crossing the SFD entry line is slightly less than 20% of the total amount of passages. Of the largest ships (all container ships), on average ca. 1 ship per tidal is observed.

In Figure 5-8, the number of passages with respect to ship beam and type is presented and it is indicated that seagoing ships of beam in the range 21 to 30m exhibit the highest frequency of appearance (~40% of the total seagoing vessel passages). The second place is occupied by relatively smaller ships of beam between 11 and 20m (~37%), while the third place is occupied by ships of beam in the range 21-30m corresponding to about 17% of the total passages. Finally, ship passage frequency with respect to ship draught is presented in Figure 5-9. Ships of draught between 6.1 and 9m are the most frequently observed (~52%), while ships of draught in the range 3.1-6m cover 27% of the total number of seagoing vessel passages. Ship passages with increased draught values (>9m) correspond to about 17% of the total passages. Finally, it was also found that only 23 seagoing vessel passages had tide dependent draught, i.e. a draught larger than 13.1m.

Figure 5-8 – Seagoing vessel passage frequency with respect to ship beam and type at SFD entry line (north transect) during the measuring campaign.

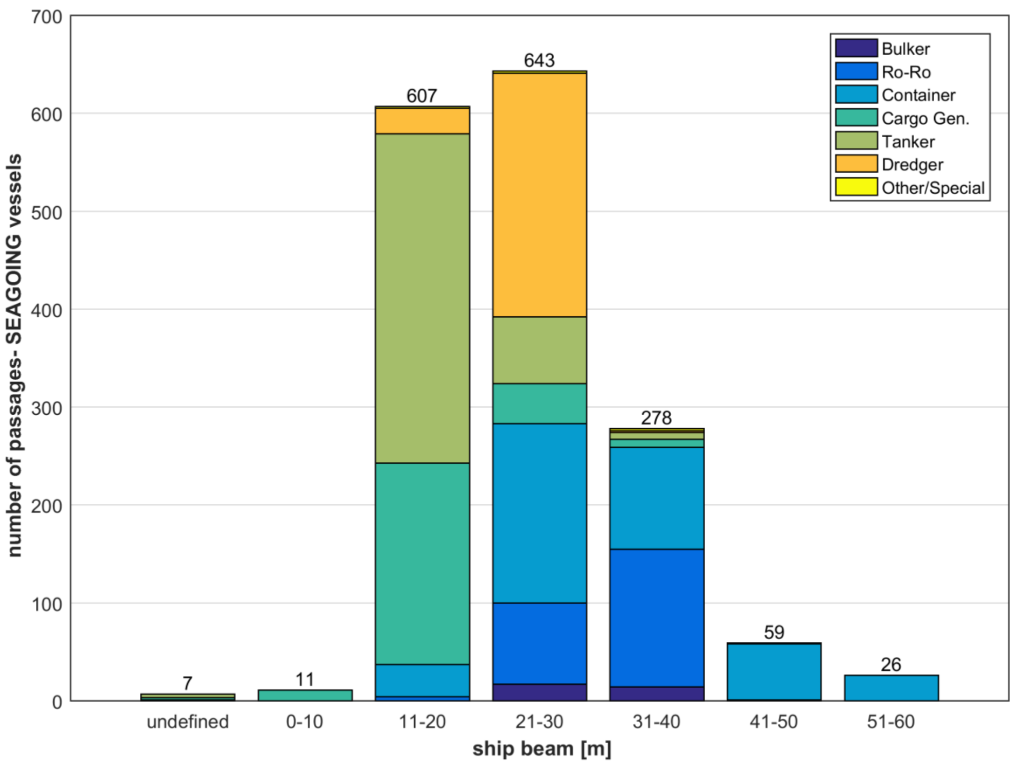
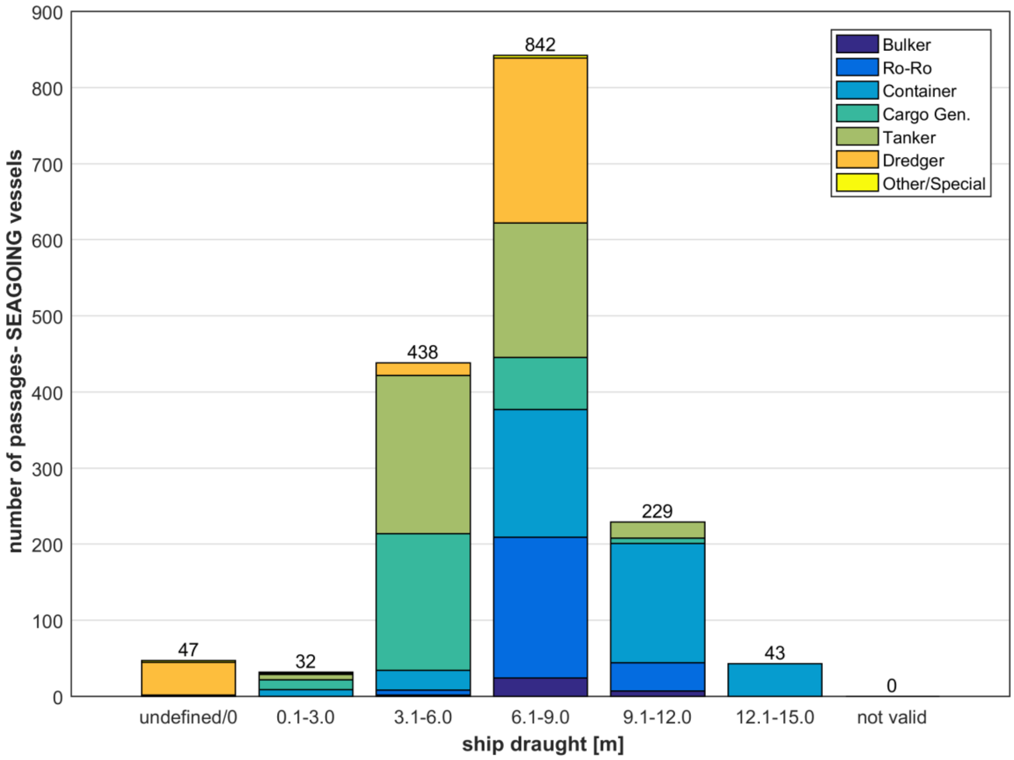


Figure 5-9 – Seagoing vessel passage frequency with respect to ship draught and type at SFD entry line (north transect) during the measuring campaign. The 'not valid' column corresponds to large values usually greater than 20 m.



6 Ship wave analysis

In this chapter, the methodology for the coupling of the wave measurements (presented in Chapter 4 ,§ 4.5) with the passages of the vessels from the two investigated entry lines (SFD-north, DGD-south), is presented. The coupling procedure was accomplished by means of MATLAB (version 2014a) scripts. Then, the results of this coupling are graphically visualized, illustrating the distribution of wave statistical parameters ($H_{1/3}$, H_{max}) with respect to selected static and dynamic information of the ships (AIS-IVS data), in order to acquire deeper knowledge about ship-induced waves in the Scheldt waterway.

6.1 Theory of ship waves

The wave patterns of a single ship consist of the superposition of the so-called primary wave and the secondary waves. The primary wave pattern, which is a water level depression (drawdown) observed along the hull of the ship, propagates in the sailing direction and has a wave length about equal to the ship's length (Schiereck, 2001). The secondary wave pattern includes transverse and diverging waves induced by discontinuities in the ship's hull profile, which are found at the bow and the stern. These wave patterns form interference cusps, of which the envelope propagates obliquely towards the river bank with an angle of attack equal to 55° considering that the bank is parallel to the sailing line (De Roo, 2013). A typical ship wave pattern for a heavy trimmed displacement ship is shown in Figure 6-1. For more information about the theoretical background of the ship wave patterns the reader is referred to Schiereck (2001) and to De Roo (2013).

Figure 6-1 – Typical ship wave pattern for a heavy trimmed displacement ship consisting of a primary wave and a secondary wave pattern (p. 51, De Roo, 2013).

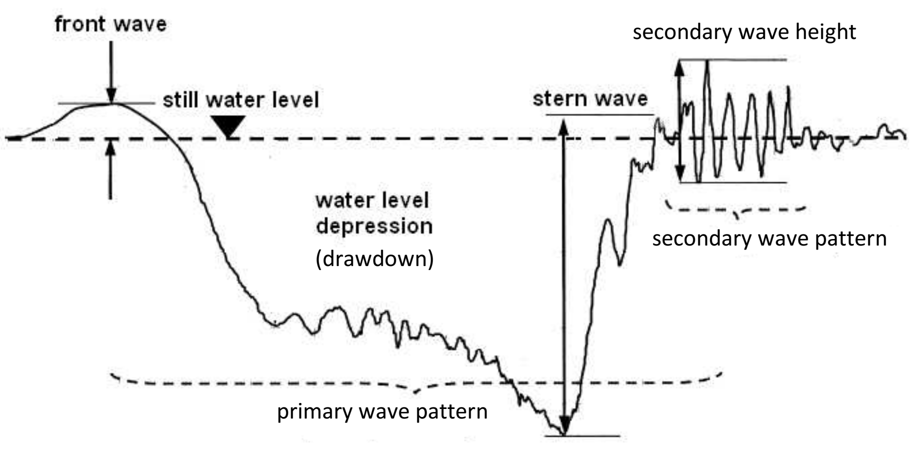
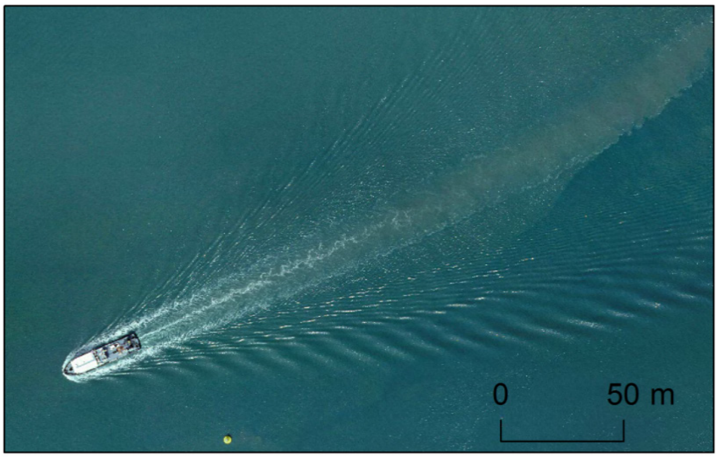


Figure 6-2 – Top view of a ship with its ship-generated wave field (detail of a false-colour aerial ortophoto (Rijkswaterstaat, 2011)).



The analysis of secondary waves is discussed in section 6.2, the analysis of primary waves is discussed in section 6.3.

6.2 Secondary waves: single ship events

The Scheldt is a busy waterway since around 7000 ship passages were recorded at the entry lines during the intensive measuring campaign of approximately 1 month. Therefore, it is very common that ships follow or cross each other closely in time and/or space resulting in the development of wave signals that consist of various patterns, which are recorded by the wave gauges. As a result, a recorded event that includes multiple ship passages very close to each other may lead to mistaken representation of a single ship's hydrodynamics. For this reason specific criteria for the detection of isolated or single ship events were determined.

6.2.1 Detection of single ship events

First, the traces of all ship crossings of the entry lines, were detected on the water fluctuation time series for every tidal cycle of the measuring campaign (Figure 6-3). Then, one criterion was determined for the detection of single ship events:

- The minimum length of the time windows before and after a ship passage that have to be clear (meaning that no other ship is present), is considered equal to 9 min. That is, t_i-t_{i-1} > 9 min and t_i-t_{i+1} >9 min (t_i is the time of ship passage i)

The considered single ship event duration was also set equal to 9 min and its starting point is identical to the time that the ship crosses the entry line. The chosen event duration resulted from visual inspection of an important number of event signals in order to ensure that the whole ship wave pattern is included in the time window (time windows of 7,8 and 10 minutes were also tested). The selected duration is somewhat shorter than the corresponding duration of 10 minutes considered in De Roo (2013) and larger than the mean duration of a ship wave pattern (7.1 min) reported in Verelst et al. (2012).

A second criterion regarding the considered time window of water fluctuations was applied in order to remove ship passages that occurred during that period in the tidal cycle where the wave gauges were not inundated or the water level was very low. Specifically, the threshold for the considered water level is given by the following expression:

- Critical water level = minimum (recorded) water level + 20 cm

A typical illustration of the single ship events detected in the 6th tidal cycle after applying the two aforementioned criteria is shown in Figure 6-4. As shown in Table 8, the number of single ship events detected for each of the wave gauges is much less compared to the total number of passages. The reduced number of single ship events detected at the signals of the shallower gauges, is attributed to the implementation of the second criterion about the critical water level (the period of the tidal cycle that this higher gauges are inundated is much less compared to the gauges on the low tidal flat).

Figure 6-3 – Ship passages (red dots) plotted on water fluctuation time-series of one tidal cycle measured by Gsb4 gauge (mmsi numbers of the ships are also shown).

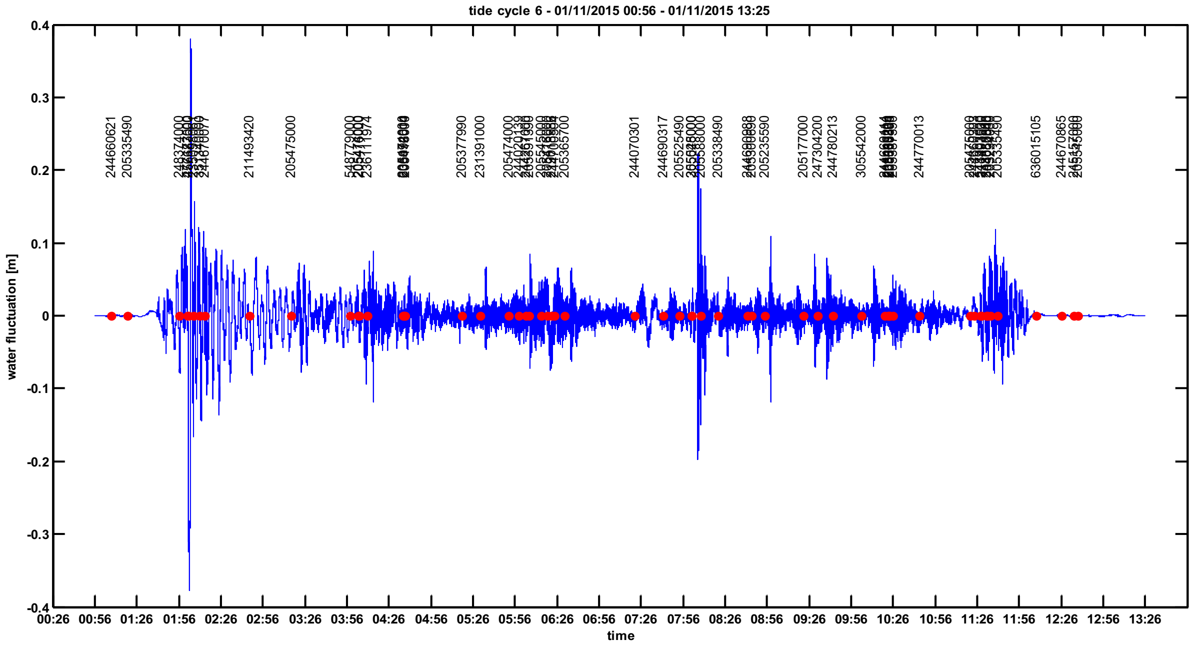


Figure 6-4 – Ship passages (red dots) plotted on water fluctuation time-series (Gsb4 gauge) after satisfying the criteria for a single ship event and for the critical water level.

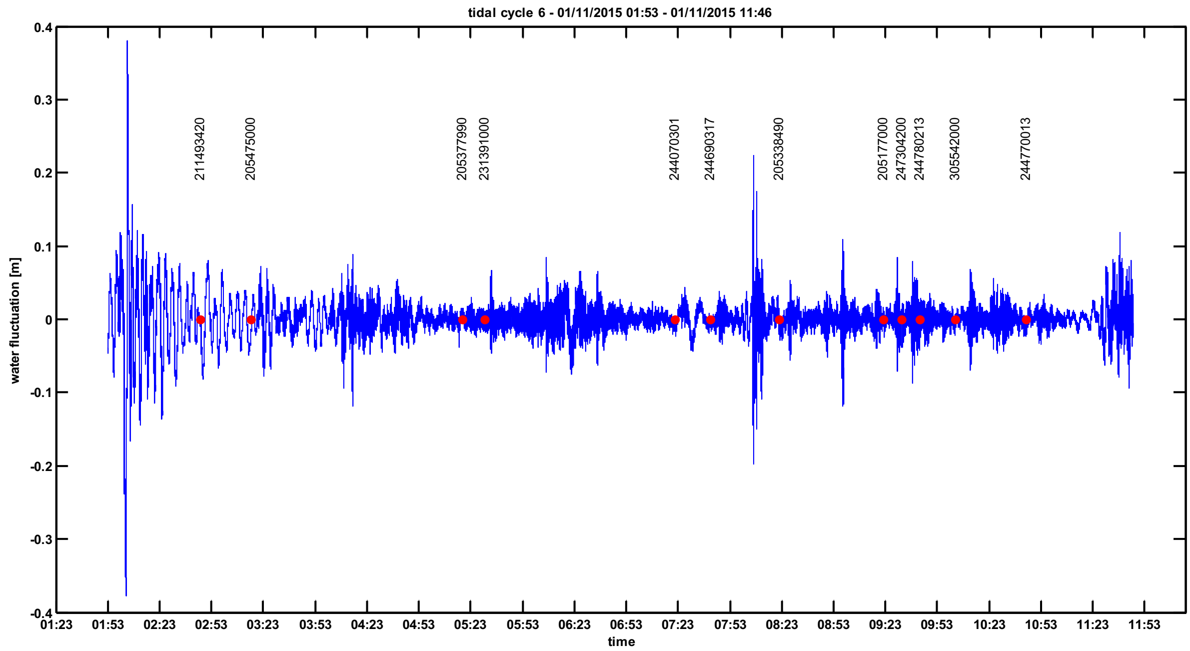


Table 8 – Number of single ships events and total number of passages detected at the locations of the wave gauges.

wave gauge location	single ship events	total no. passages
Gsb2 (north)	23	7159
Gsb4 (north)	383	
Gsc2 (south)	44	7097
Gsc3 (south)	190	
Gsc4 (south)	331	

6.2.2 Detection of additional large vessel-tug (LV-T) events

There are cases of multi-ship events where tug boats are attached to large vessels (cargo, tankers and other), assisting their navigation on the Scheldt and maneuvering in the docks. Apparently, the implemented criteria for single ship events cause the removal of such kind of events from the list of the detected ship events. However for those events, it can be considered that the influence of the waves induced by the attached tug boats (sailing with low speeds) on the wave pattern induced by a large vessel is not substantial. Therefore, some extra criteria were added prior to the implementation of single ship criteria, in order to consider large vessel-tug events as single ship events.

These additional criteria, which have to be met cumulatively, are:

- The length of the large vessel has to be at least 150 m
- The maximum time interval between a large vessel and a tug boat passage from the entry line has to be less than 2 min
- The distance between a large vessel and a tug at the moment they cross the entry line, i.e. the distance of the ship marks on the entry line, has to be less than 50 m
- The large vessel and the tug have to move in the same direction

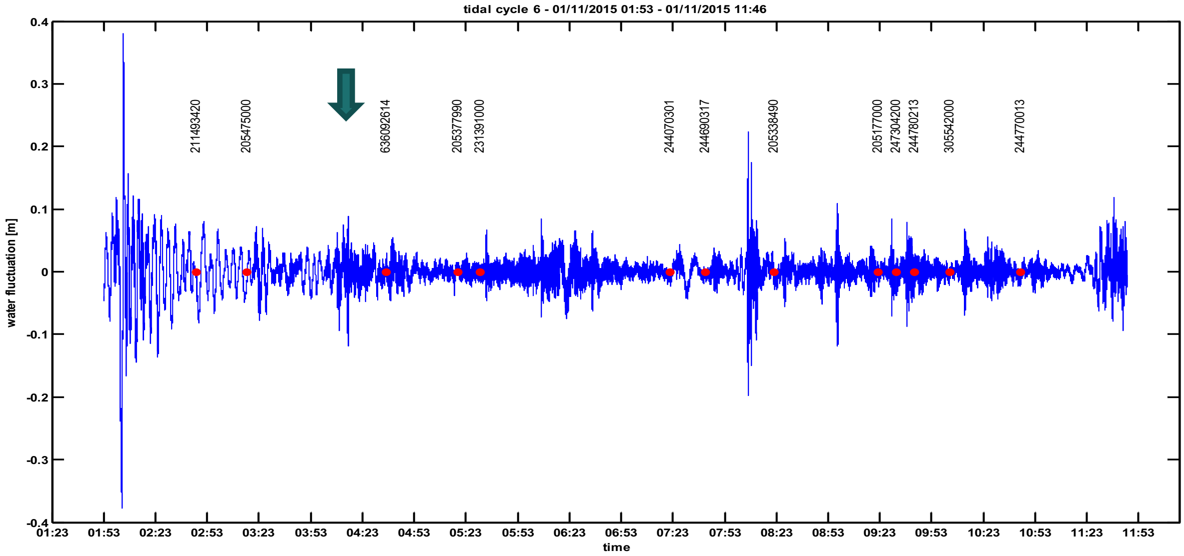
After the implementation of the aforementioned criteria, the tug boats participating in the detected LV-T events were removed from the list of the total passages, allowing for a large vessel passage that fulfilled the criteria to be considered as a single ship event. However, a LV-T event may not be considered as a single ship event if other vessels are moving closely. The removal of these kind of LV-T events is achieved after the implementation of single ship event criteria that follow the LV-T event detection.

In Figure 6-5, a typical example of the addition of an LV-T event in the list of single ship events (shown in Figure 6-4) is presented. The number of LV-T events (less than 20) that were added to the single ship events and the updated number of single ship events for the three wave gauges are shown in Table 9.

Table 9 – Number of large vessel-tug events and updated number of single ship events at the locations of the wave gauges.

location	LV-T events	Total single ship events
Gsb2 (north)	26	49
Gsb4 (north)	18	401
Gsb2 (south)	46	90
Gsc3 (south)	12	202
Gsc4 (south)	18	349

Figure 6-5 – Single ship passages (red dots) plotted on water level fluctuation time series (Gsb4 gauge) with a large vessel-tug event added as a single ship event (noted by the blue arrow).



Analysis of single ship events

Typical examples of ship events

The analysis of the single ship events (including the LV-T events) starts with the investigation of water level fluctuations during some selected events (selection was based on the maximum H_{max} values).

Two typical examples of single ship events recorded by four wave gauges are presented in Figure 6-6 and Figure 6-7. In Figure 6-6, the wave signals of a tanker with a relatively high sailing speed (~14 knots), heading upstream, recorded by the considered gauges (Gsb4, Gsc4, Gsc3 and Gsc2, except for Gsb2), are shown. This ship passage was not recorded at the GSb2 plot because the tidal water level was 4.99 m TAW at the moment of the passage (Table 3), i.e. GSb2 was not inundated at that time. At this sailing speed, it takes the tanker about 3 min to sail the distance between both entry lines. The distance from the ship to the lowest wave gauges is in the order of 600 m.

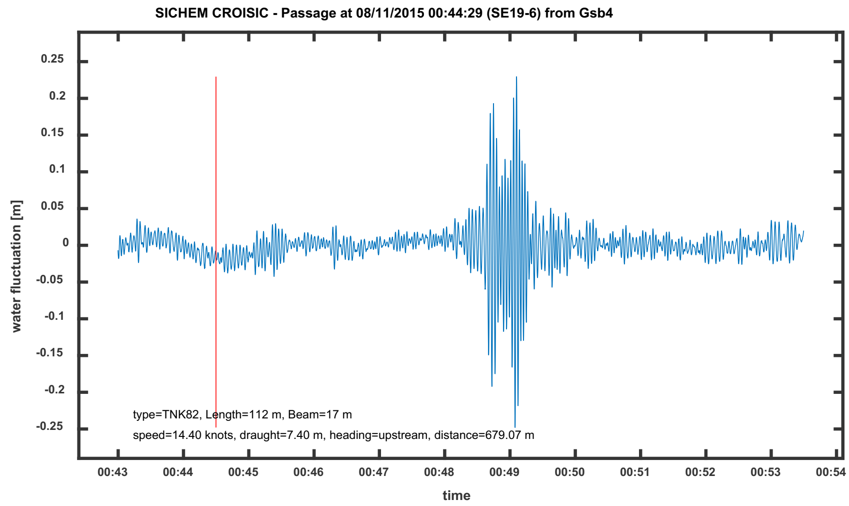
The secondary wave pattern, appearing about 4 min after the ship passage at the entry line (noted by the red line), is the prevailing component of the ship wave signal. It 's presenting an H_{max} value greater than 0.45 m at Gsb4 location. Moreover two distinct peaks are observable, due to wave interference. A primary wave, however, can not be distinguished. Comparing the signals of the gauges to each other, it is clearly indicated that the amplitude of the wave system decreases substantially (about 50%), as the ship moves from the north (Gsb4) to the south (Gsc2, Gsc3, Gsc4) transect, while the sailing speed is only slightly decreased. Note that the speed corresponds to the instantaneous speed through water at the moment the ship crosses the entry line. This wave height difference can probably be attributed to the difference in the local bathymetry. Comparing the ship wave patterns on the southern transect, it can be noticed that the wave at Gsc4, with a wave height of approximately 25 cm, dampens to approximately 15 – 20 cm (at Gsc3) and 10 cm at Gsc2.

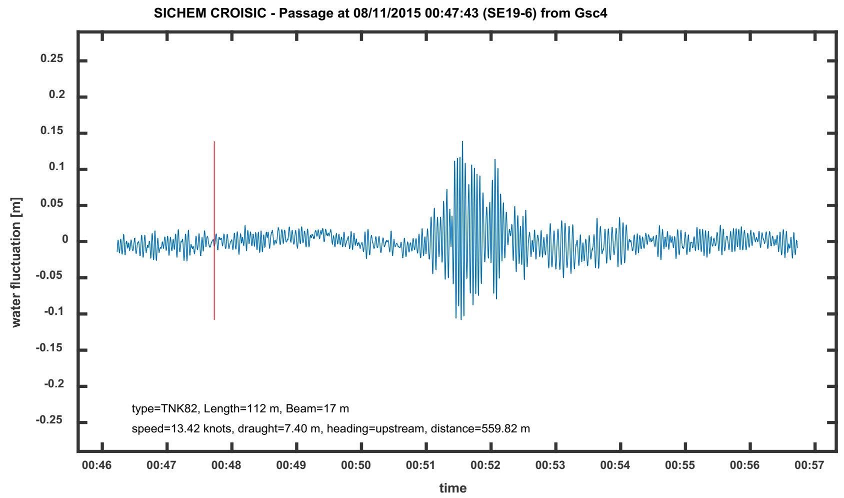
In Figure 6-7 the wave signals of a fast sailing tug boat (>10 knots), also heading upstream, recorded at both transects, are shown. At this sailing speed, it takes the tug boat about 4 min to sail the distance between both entry lines. The distance from the ship to the lowest gauge is around 800 to 900 m.

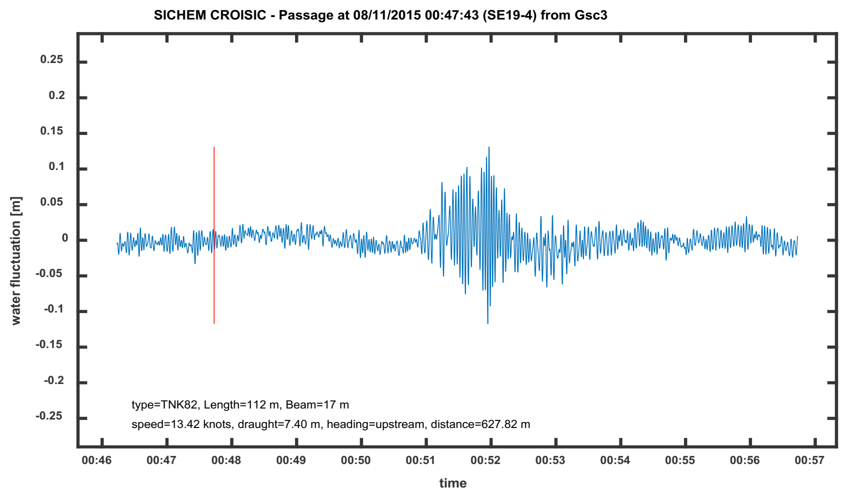
Again, as for the case of the tanker, the secondary wave pattern prevails, presenting $H_{max} \approx 0.30$ m at Gsb4 location. Wave interference can be observed also in this case, especially in the southern transect. At the higher tidal flat, the secondary wave pattern is not distinguishable anymore. Wave heights in this period are approximately 15 cm. There is also a decrease of the ship wave amplitude, around 30%, as the boat moves from north to south (comparison between Gsb4 and Gsc4), while the speed decreases around 15%. At the shallower position (Gsc3) a second separate wave group of similar amplitude and length is observed.

Besides this ship passage, also water fluctuations of height around 10 cm can be observed, and characterized as wind waves. This is in accordance with the wind measurements (see Figure 4-4, §4.2), which showed increased wind speeds during 29/11/2015.

Figure 6-6 – A single ship (tanker) event recorded at four measuring positions (Gsb4-north, Gsc4-south, Gsc3-south and Gsc2-south). The red line corresponds to the ship passage at the entry line







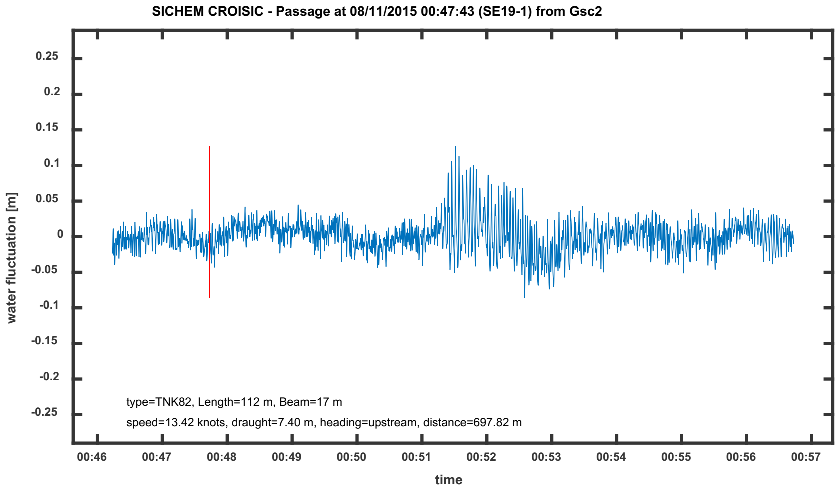
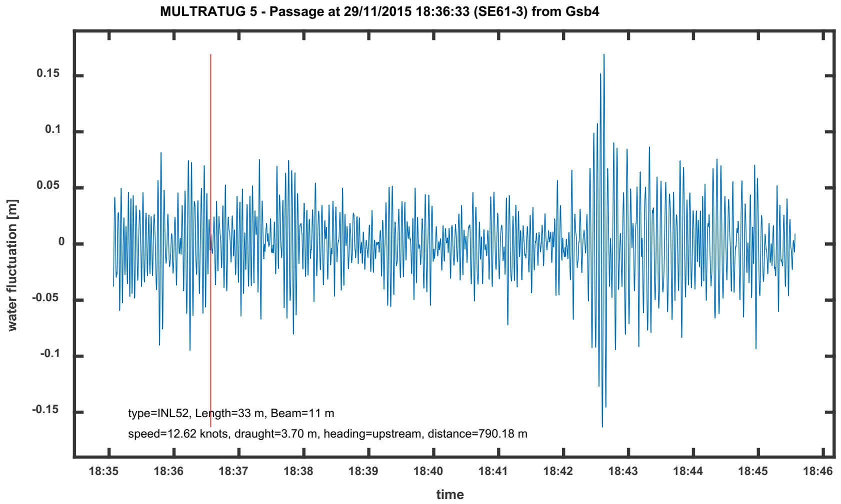
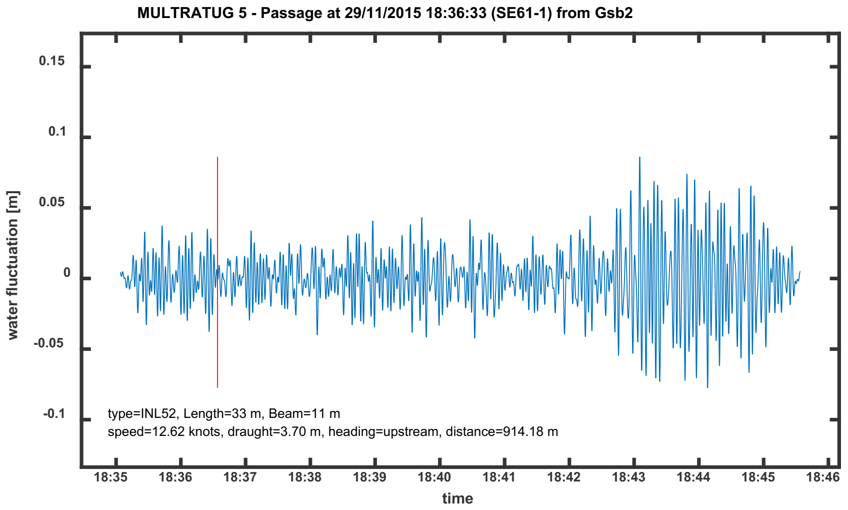
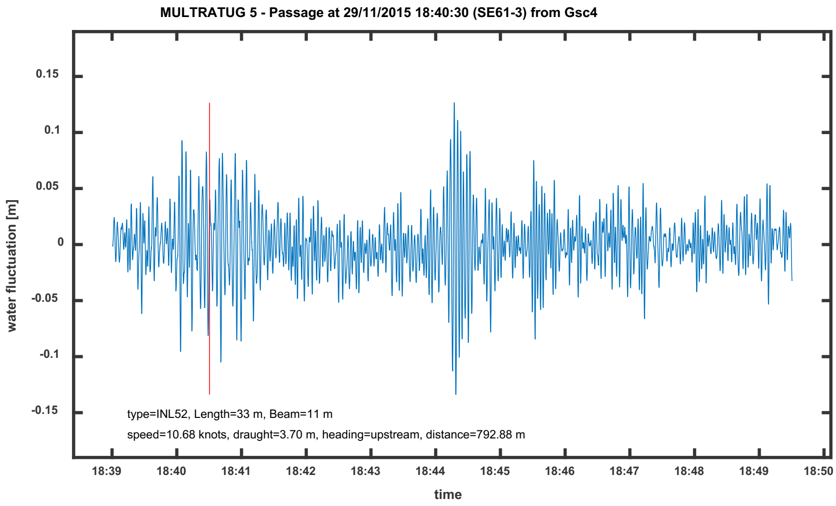
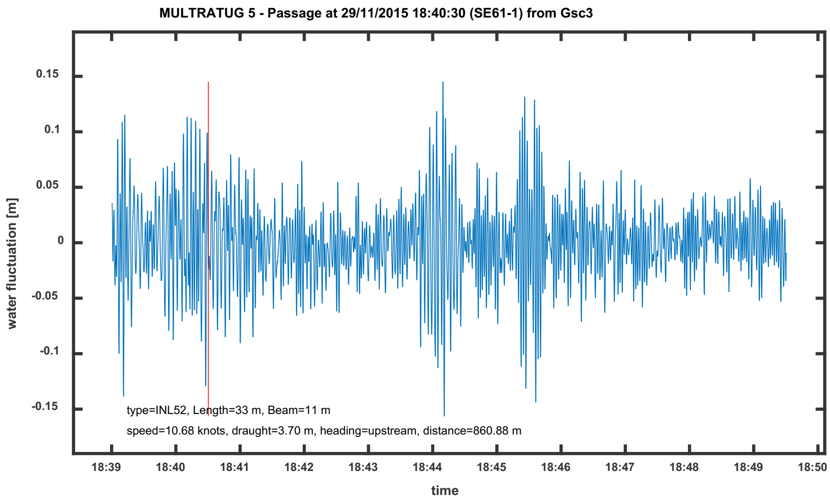


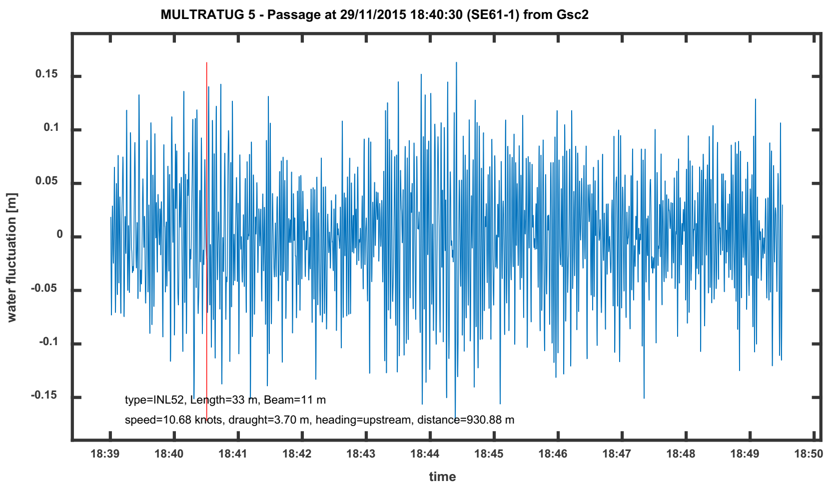
Figure 6-7 – A single ship (tug boat) event recorded at the three measuring positions (Gsb4-north, Gsb2-north, Gsc4-south, Gsc3-south, Gsc2-south).
The red line corresponds to the time of the ship passage at the entry line





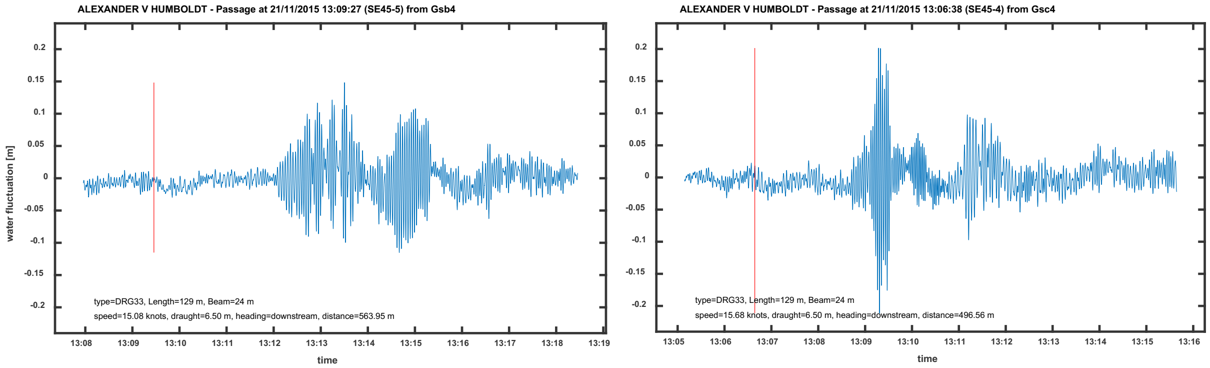






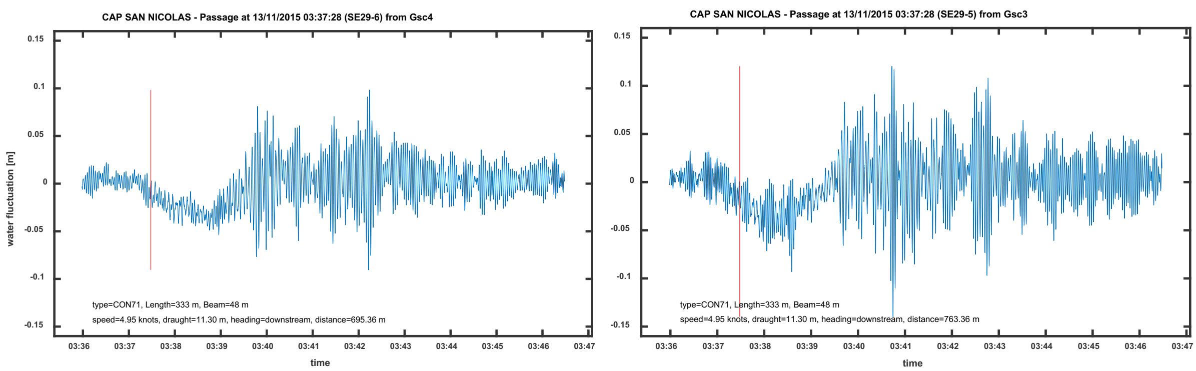
The wave signals measured at Gsb4 and Gsc4 locations, induced by the passage of a dredger heading downstream with a sailing speed of ~15 knots, are shown in Figure 6-8. The secondary wave pattern appears about 2.5 min after the ship passage from the northern SFD entry line presenting an $H_{max} \approx 0.25$ m at Gsb4 location. Comparing this signal to the signal at the southern DGD entry line, it is found that the amplitude of the wave pattern increases substantially (~40%), as the ship moves from the south (Gsc4) to the north (Gsb4) transect, although the speed is slightly decreased. This result is in contrast to what is found for ships sailing upstream, which induced higher waves at the north transect than at the south transect. However, this behavior should be further investigated, as there are no direct, obvious reasons for the dependence of the ship-wave amplitude variation on the heading.

Figure 6-8 – Single ship (dredger) event signals measured at Gsb4 (north) location (left figure) and at Gsc4 (south) location (right figure).



In Figure 6-9, the wave signals measured at Gsc4 and Gsc3 locations, that correspond to an LV-T event are presented. Note that only the AIS data and the passage time of the cargo vessel are shown. The investigated cargo vessel has a length of 333 m and is sailing downstream at 6.32 knots (speed over ground), or relative through water at around 5 knots. Its induced wave pattern includes a primary wave component with a relatively small drawdown (< 5 cm) and secondary waves pattern. Comparing the two signals, it is found that the amplitude of the secondary wave pattern increases about 20%, as the waves propagate from the deeper (Gsc4) to the shallower (Gsc3) gauge.

Figure 6-9 – Large vessel-tug event signals measured at Gsc4 (south - low mudflat) location (left figure) and at Gsc3 (south - middle high mudflat) location (right figure).



Distinction between ship and wind waves

In order to investigate possible differences in the peak wave periods between the fluctuations induced by ships and those attributed to wind, the power spectral density (PSD) distribution of the ship event signals were calculated.

The case of the tug boat event presented in Figure 6-7 can be considered as a characteristic example of simultaneous presence of ship and (secondary) wind waves because of the concurrent occurrence of high wind speeds (~17 m/s). Therefore the corresponding PSD distribution for the signal measured at Gsb4 location is presented in Figure 6-10. The peak of wave energy distribution is observed for frequency f_p = 0.32 corresponding to peak wave period $T_p \approx 3$ sec, which can be considered as the peak period of the secondary wave pattern. However, it is quite difficult to distinguish ship from wind waves without the clear existence of a second peak in the PSD distribution. In general, typical wind wave periods are expected to be smaller than those of ship waves in a fetch limited inland waterway.

A different case of a tug boat event signal during high-speed winds (~15 m/s) and its corresponding PSD distribution are shown in Figure 6-11. Now two peaks of wave energy distribution are observed for frequencies $f_p \approx 0.45$ and 0.55 Hz corresponding to peak wave periods $T_p \approx 2.2$ s and 1.8 s, respectively. The higher peak probably could be attributed to the secondary wave pattern, while the lower one probably corresponds to wind waves.

Taking into account the aforementioned observations, the practice of setting a critical value of wave period equal to 2 s ($f_{cr} = 0.5$) as a limit between ship and wind waves, which is also followed in other similar studies (e.g. Baur, 2008; De Roo, 2013), is adopted in the present study. This 'conservative' critical value, even if it does not stand for all the selected ship events as the ideal threshold, prevents from removing of ship wave energy which would lead in underestimation of wave height statistics. Note also that the critical value of 2 s (0.5 Hz) is only applied in the calculation of the ship wave characteristics and not for the case of pure wind wave statistics (no-ship events, Chapter 7), where only the low-frequency oscillations are filtered.

Figure 6-10 – Power spectral density distribution for a tug boat event signal measured at Gsb4 (north) location.

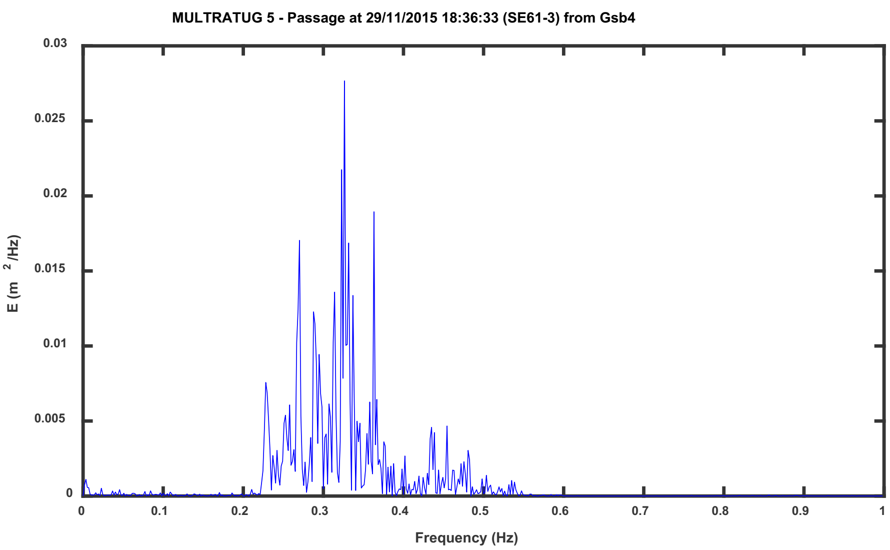
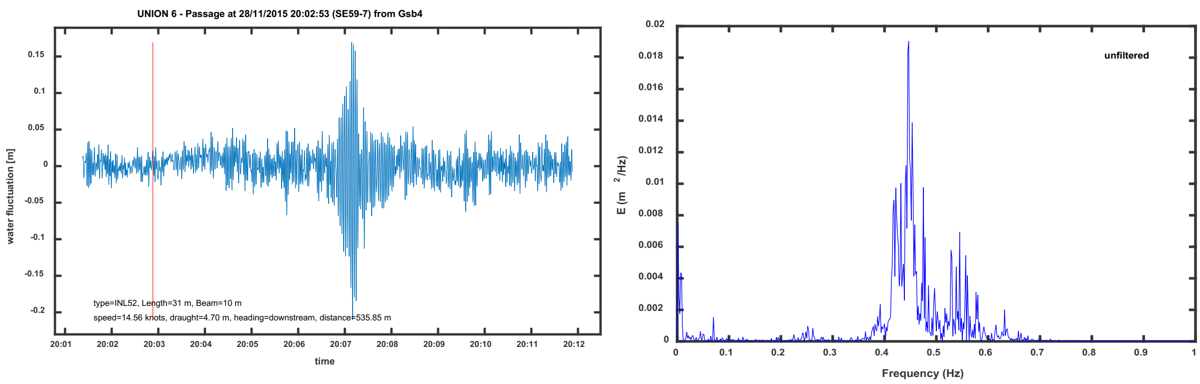


Figure 6-11 – Tug boat event signal measured at Gsb4 (north) location (left figure) and the corresponding power spectral density distribution (right figure).

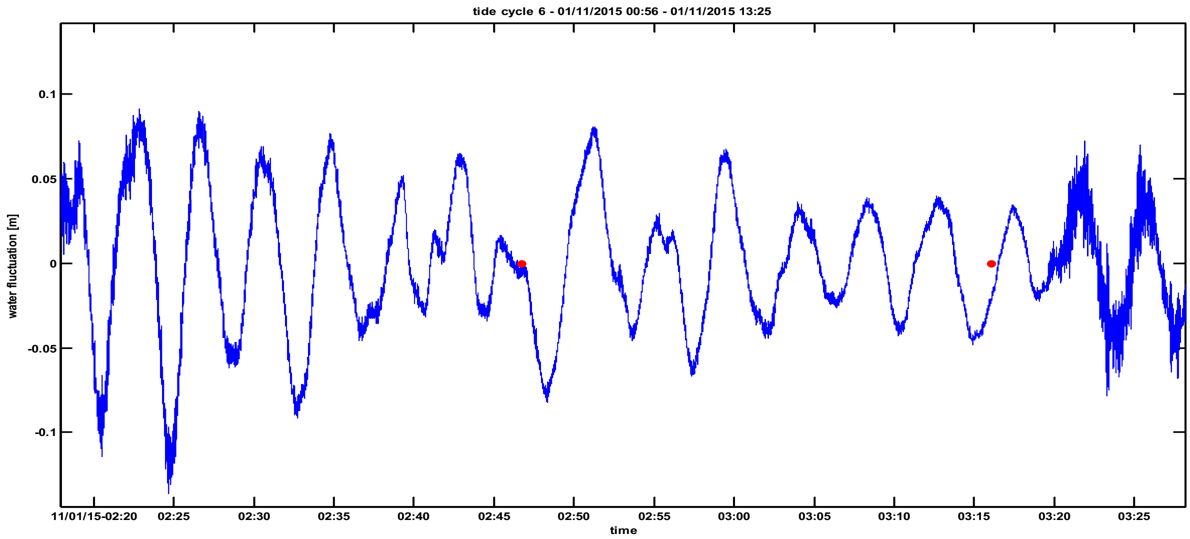


Removal of low frequency disturbances

An interesting finding during the analysis of the ship events, was the detection of low frequency wave patterns of maximum height around 20 cm and period of about 2.5 min that are not related with the ship-induced waves. Figure 6-12, which is a detail of Figure 6-3, illustrates these low frequency waves for a time window in the tidal cycle where the ship traffic is low (2 passages in 1.5 hours). Note that these waves are usually detected during the lower tide levels. These patterns are also reported by Verelst et al. (2011) who conducted wave measurements in the same area.

In order to avoid the interference of the aforementioned wave patterns in the ship wave analysis, a high pass filter with a cutoff frequency f_{cut} = 0.0067 (T_{cut} = 150 sec), was applied at the wave signals of each tidal cycle (e.g. Figure 6-3). For a small number of events, where this filtering operation affected the primary wave patterns (of similar period), special treatment was applied, i.e. either the filter was deactivated or the event was removed from the list.

Figure 6-12 – Example of low frequency wave patterns of period about 2.5 min usually detected in the lower tide levels.



This figure is a detail of Figure 6-3.

6.2.3 Results of the analysis

The information related to each single ship event, which combines AIS ship data with hydrodynamic (wave characteristics, water level) and wind data, was stored in separate tables, one for each of the measurement locations (see Appendix A, Table 16 - Table 18). Part of a typical table with the aforementioned information is shown in Table 10. Note that

- in the index SExx-x, the number of the tidal cycle is given by the first two numerical digits, while the last digit shows the number of the event in this tidal cycle
- the type identifier results from the merging of the IVS acronyms (see Table 7) and the two-digit identifiers of AIS coding system (see Table 6). The abbreviation INL stands for inland vessels.
- Ship speed refers to the speed through water and not to the speed over ground. The AIS speed over ground (an instantaneous value at the entry line) is translated to a speed through water using the velocities measured at “Meetpaal Lilo”
- the parameter ‘distance’ refers to the distance between the ship and the gauge, measured along the entry line
- the $H_{1/3}$ and H_{max} values resulted from the implementation of the zero-down crossing method, as described in §4.5.1, on the filtered signal of each single ship event, after imposing a band pass filter

with lower and upper cutoff frequencies equal to 0.1 Hz and 0.5 Hz, respectively, corresponding with a period between 2 and 10 s

- Wind speed (WSpeed) and direction (WDir) correspond to the closest two-hour averaged value prior to the respective event (see Chapter 7)

The filtered signal consists of short period waves in the range 2 s <T< 10 s, and includes only the secondary pattern of the ship waves. This pattern will be characterized by the maximum wave height H_{max} of the filtered signal (as depicted in Figure 6-1). As such, hereafter in this section parameter H_{max} will stand for the secondary wave height.

Using the tabulated information, figures for the distribution of the secondary wave height, H_{max}, with regard to the sailing speed through water, the ship length, the distance of the ship from the gauges and the water level, were generated for the inland navigation ships (Figure 6-13 to Figure 6-18) and seagoing vessels (Figure 6-19 to Figure 6-23) for all measurement locations. In both kind of figures (inland and seagoing), different colored symbols are used to denote the different types of ships.

For inland navigation, no clear correlation of H_{max} values with any of the considered parameters (speed, length, distance and water level), was found (Figure 6-13 to Figure 6-18). However, it seems that there is a weak positive correlation of H_{max} with sailing speed (especially for tug boats) at the lower tidal flat locations Gsb4 (Figure 6-13) and Gsc4 (Figure 6-15). In order to minimize possible influence of wind on the H_{max}-speed correlation, the events occuring during high wind speeds (> 6 Beaufort = 12.3 m/s) were excluded from the analysis (Figure 6-18). The positive correlation between the two variables is now more obvious. An investigation of possible correlation of secondary wave height with more than one independent variables simultaneously did not lead to interesting findings and therefore these results are not presented here.

It was also found that 8 inland ship events for the Gsb4 location and 13 ship events for Gsc4 location, presented H_{max} > 0.30 m (Figure 6-13 and Figure 6-15), while for the Gsc3 location H_{max} was higher than 0.30 m only in 6 cases and always less than 0.40 m (Figure 6-16). Note that the highest H_{max} values correspond to cargo vessels at the Gsb4 (north) location, while higher H_{max} values were generated by tug boats at the (Gsc4) location. On the higher tidal flats (Figure 6-14 and Figure 6-17, for respectively Gsb2 and Gsc2) the highest H_{max} is around 0.25 m, for one ship. Most measurements show an H_{max} below 0.15 m.

For the case of the seagoing vessel passages, no clear correlation of H_{max} values with any of the considered parameters (speed, length, distance and water level), was found (Figure 6-19 to Figure 6-23). It was found that only 2 ship events for each of the cases of Gsb4 and Gsc4 locations presented H_{max} > 0.30 m (Figure 6-19 and Figure 6-21), while for the case of Gsc3 location H_{max} was always less than 0.30 m (Figure 6-22). On the higher part of the tidal flat, one wave with a wave height around 0.25 m is found at the south location (Figure 6-23). Other wave heights are 0.15 m or lower (see Figure 6-20 and Figure 6-23).

Table 10 – Typical table with information of the selected single ship events including large vessel-tug events (index with asterisk) detected at Gsc4 location.

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE01-1	29/10/2015 19:37	INL80	110	12	0.1	7.48	upstream	749.1	2.74	0.036	0.021	5.60	177.8
SE02-1	30/10/2015 02:57	INL90	86	10	4	12.08	upstream	658.7	2.60	0.030	0.020	4.14	97.7
SE02-2	30/10/2015 05:43	INL79	80	9	0	4.15	upstream	694.3	5.22	0.034	0.025	4.86	102.1
SE02-3	30/10/2015 07:53	GEN70	89	12	5.5	6.05	upstream	544.8	2.94	0.028	0.022	5.23	106.3
SE03-1	30/10/2015 15:55	INL52	33	11	3.7	9.21	downstream	399.8	4.22	0.123	0.065	4.99	103.2
SE03-2	30/10/2015 20:05	INL52	28	12	6.2	11.98	downstream	406.7	3.02	0.069	0.032	4.55	89.3
SE04-1	31/10/2015 03:37	INL80	77	8	1	6.38	downstream	389.5	2.55	0.022	0.017	3.77	81.9
SE04-2	31/10/2015 03:54	INL79	113	44	1	2.89	downstream	540.9	2.88	0.029	0.022	3.77	81.9
SE04-3	31/10/2015 04:04	INL79	110	12	2.5	8.02	downstream	630.0	3.15	0.118	0.050	3.99	86.3
SE04-4	31/10/2015 07:00	INL79	127	11	0	4.58	upstream	750.8	4.56	0.033	0.024	4.61	90.0
SE05-1	31/10/2015 16:05	INL52	32	12	5.4	12.26	downstream	372.1	2.96	0.181	0.078	3.05	117.8
SE05-2	31/10/2015 18:09	INL52	32	12	5.4	9.31	upstream	546.6	5.45	0.021	0.018	2.15	101.8
SE05-3	31/10/2015 19:24	INL79	135	14	0.4	11.37	downstream	684.6	4.50	0.028	0.019	2.15	101.8
SE05-4	31/10/2015 20:45	CON73	222	30	10.4	11.92	downstream	618.9	3.13	0.054	0.032	2.14	107.6
SE05-5	31/10/2015 21:17	INL80	135	12	3.4	12.47	downstream	457.7	2.52	0.035	0.025	2.14	107.6
SE05-6	31/10/2015 21:53	RRC70	199	35	8.9	12.42	downstream	608.1	1.85	0.024	0.016	2.14	107.6
SE06-1	01/11/2015 02:52	INL80	85	12	2.2	8.92	upstream	576.6	1.74	0.010	0.010	1.82	172.3
SE06-2	01/11/2015 03:10	INL52	26	12	5.8	8.39	downstream	383.9	1.97	0.134	0.051	1.82	172.3
SE06-3	01/11/2015 04:13	TNK80	151	22	6.7	16.40	upstream	577.4	2.85	0.229	0.083	1.73	138.1
SE06-4*	01/11/2015 04:45	CON73	260	32	10.1	6.45	upstream	693.4	3.46	0.060	0.030	1.73	138.1
SE06-5	01/11/2015 05:12	INL90	110	17	3	5.45	downstream	656.5	4.25	0.046	0.027	1.73	138.1
SE06-6	01/11/2015 05:34	GEN70	105	16	6.4	14.09	upstream	568.7	4.98	0.075	0.048	1.73	138.1
SE06-7	01/11/2015 05:45	INL52	26	12	5.8	5.23	downstream	504.5	5.23	0.148	0.061	1.73	138.1
SE06-8	01/11/2015 06:34	INL90	83	12	2.4	12.34	upstream	586.4	5.54	0.084	0.045	1.40	102.2
SE06-9	01/11/2015 07:17	INL69	100	12	0.2	9.20	downstream	396.4	5.15	0.099	0.058	1.40	102.2
SE06-10	01/11/2015 08:26	INL89	135	11	2	7.34	upstream	584.4	4.05	0.103	0.051	3.74	151.3

Figure 6-13 – Secondary wave height versus ship speed& length, distance from the measuring gauge, and water level for the selected **inland** ship events at **Gsb4 lower tidal flat** (north) location.

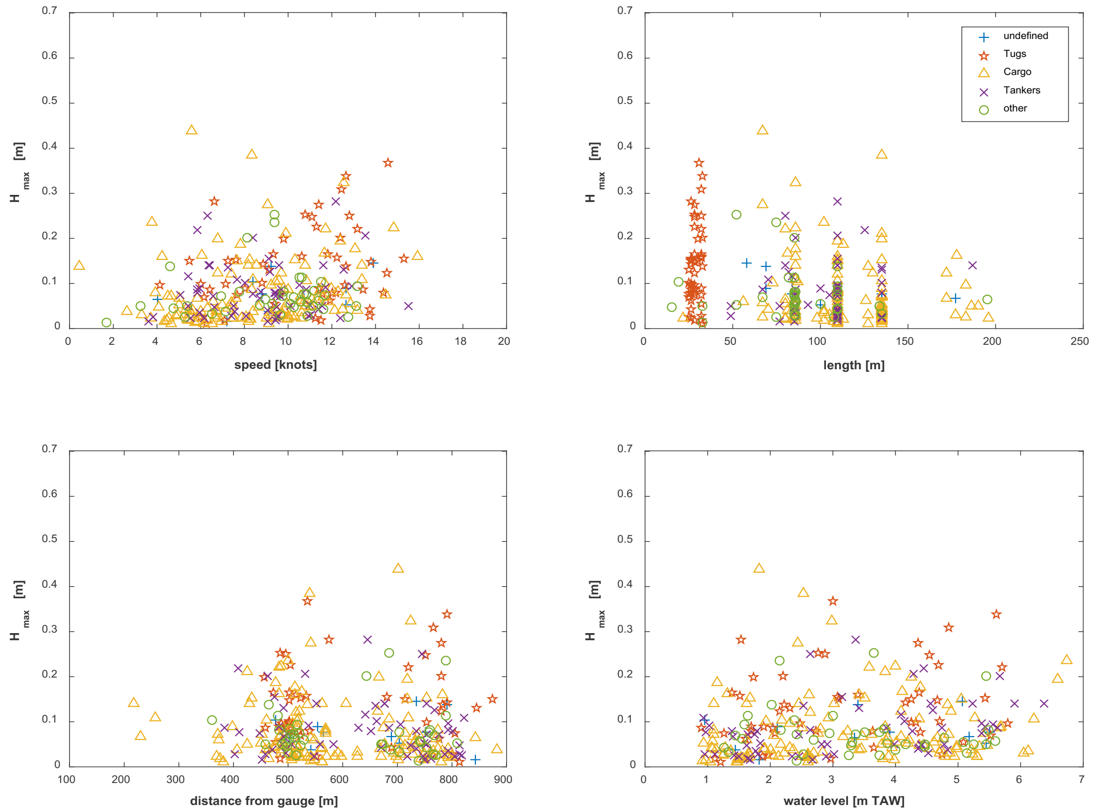


Figure 6-14 – Secondary wave height versus ship speed& length, distance from the measuring gauge, and water level for the selected **inland** ship events at **Gsb2 high tidal flat SFD** (north) location.

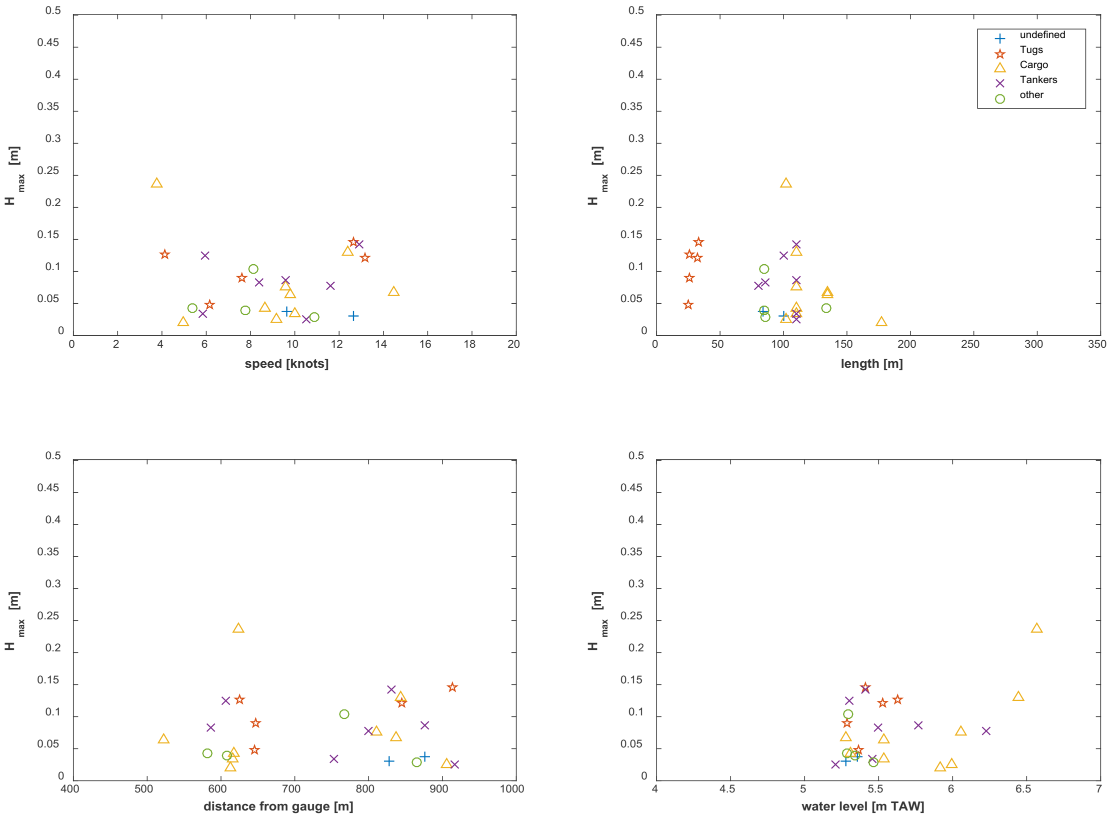


Figure 6-15 – Secondary wave height versus ship speed& length, distance from the measuring gauge, and water level for the selected **inland** ship events at **Gsc4 lower tidal flat** (south) location.

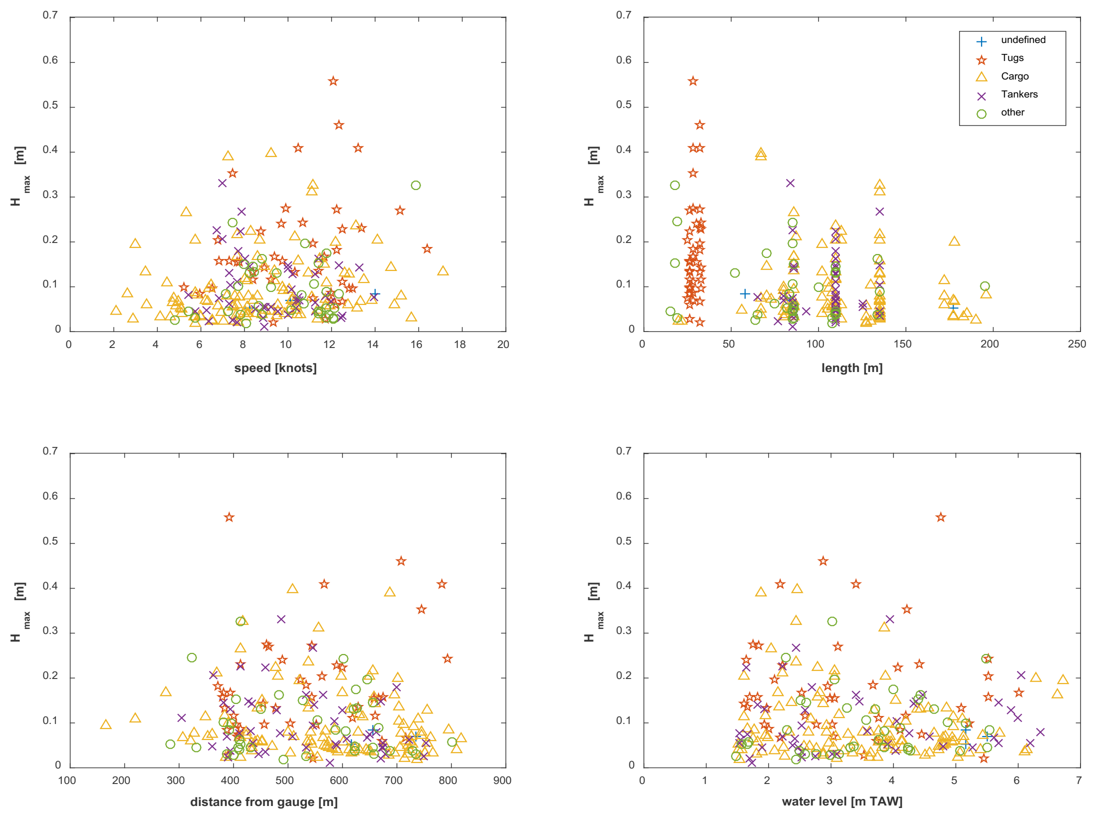


Figure 6-16 – Secondary wave height versus ship speed& length, distance from the measuring gauge, and water level for the selected **inland** ship events at **Gsc3 middle high tidal flat** (south) location.

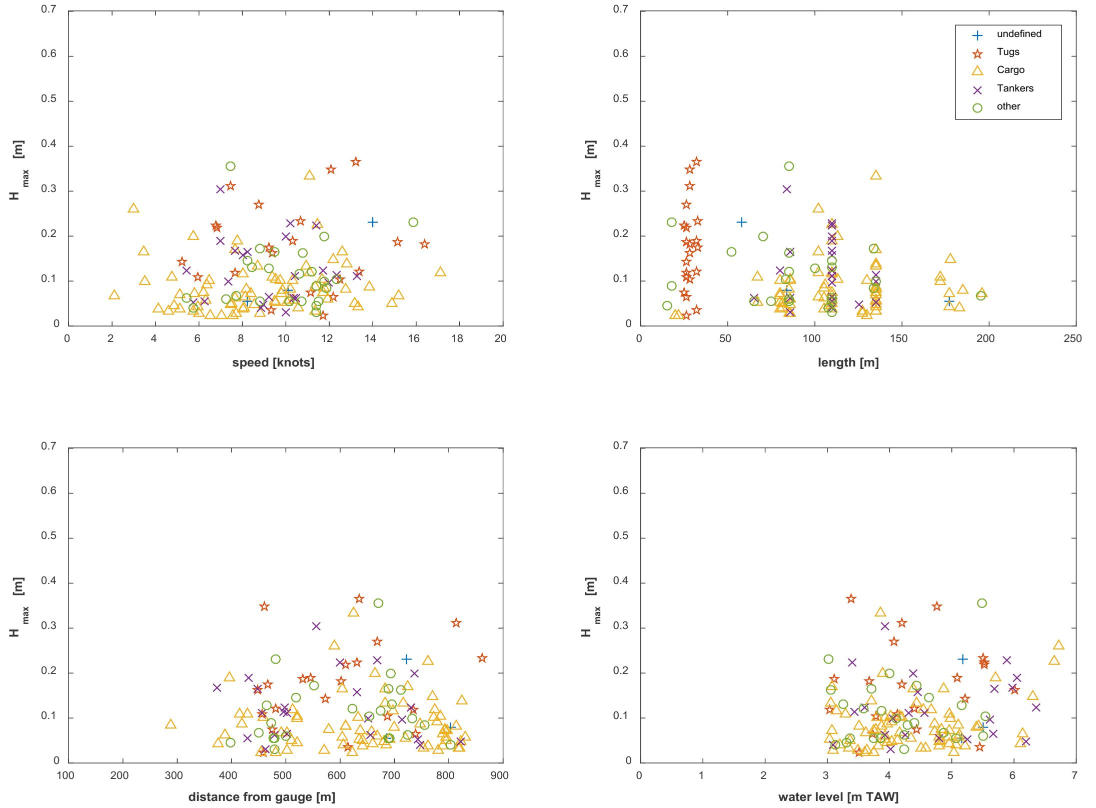


Figure 6-17 – Secondary wave height versus ship speed &length, distance from the measuring gauge, and water level for the selected **inland** ship events at **GSc2** high flat (South) location.

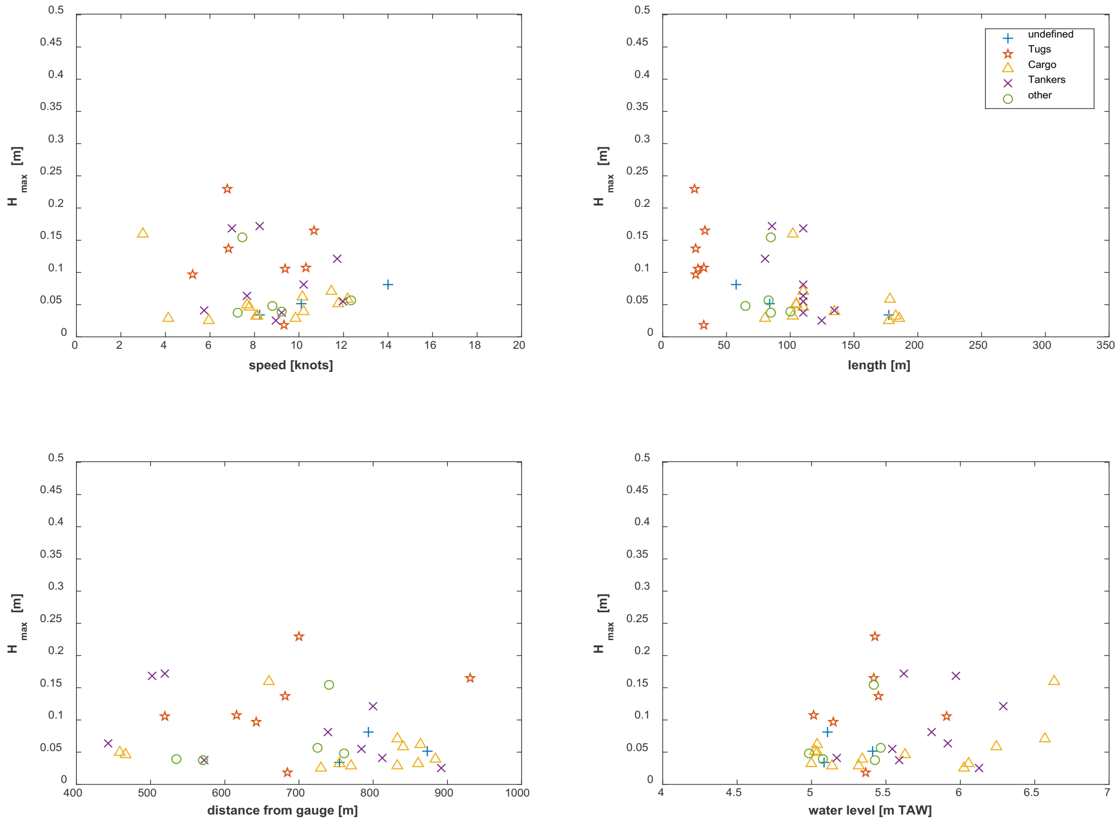


Figure 6-18 – Secondary wave height versus ship speed for the **inland** ship events during wind speeds less than 12.3 m/s (6 Beaufort), at Gsb4 (north), Gsc4 and Gsc3 (south) locations.

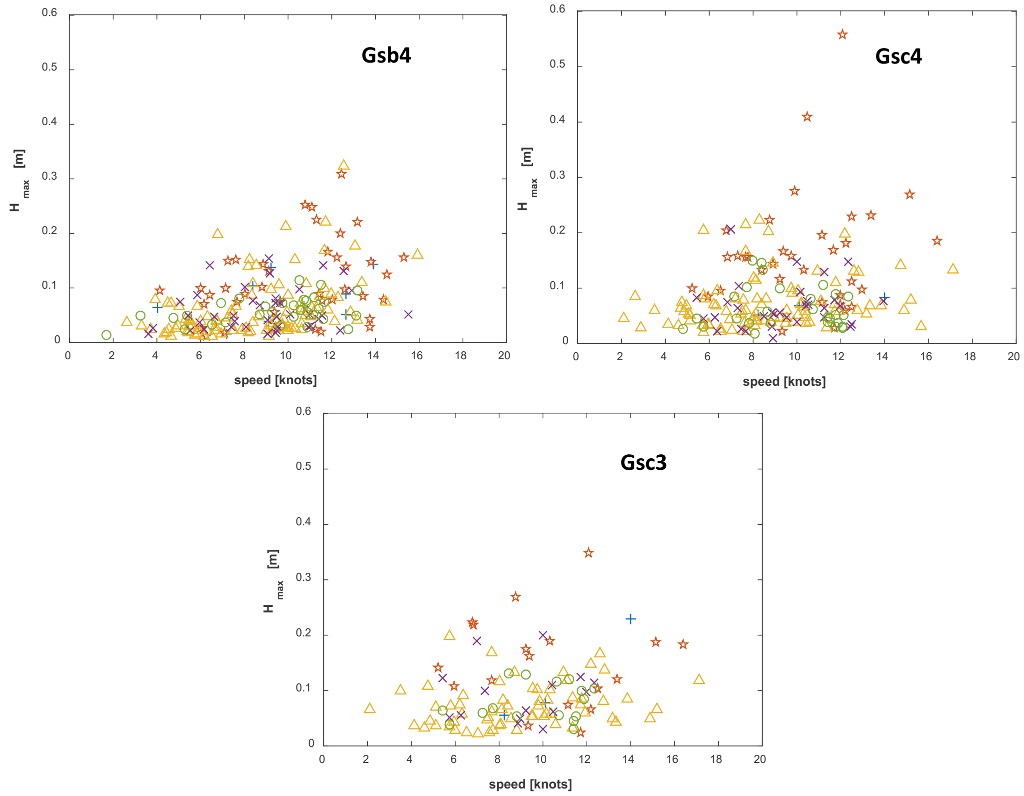


Figure 6-19 – Secondary wave height versus ship speed & length, distance from the measuring gauge, and water level for the selected **seagoing** ship events at **Gsb4** (north) location.

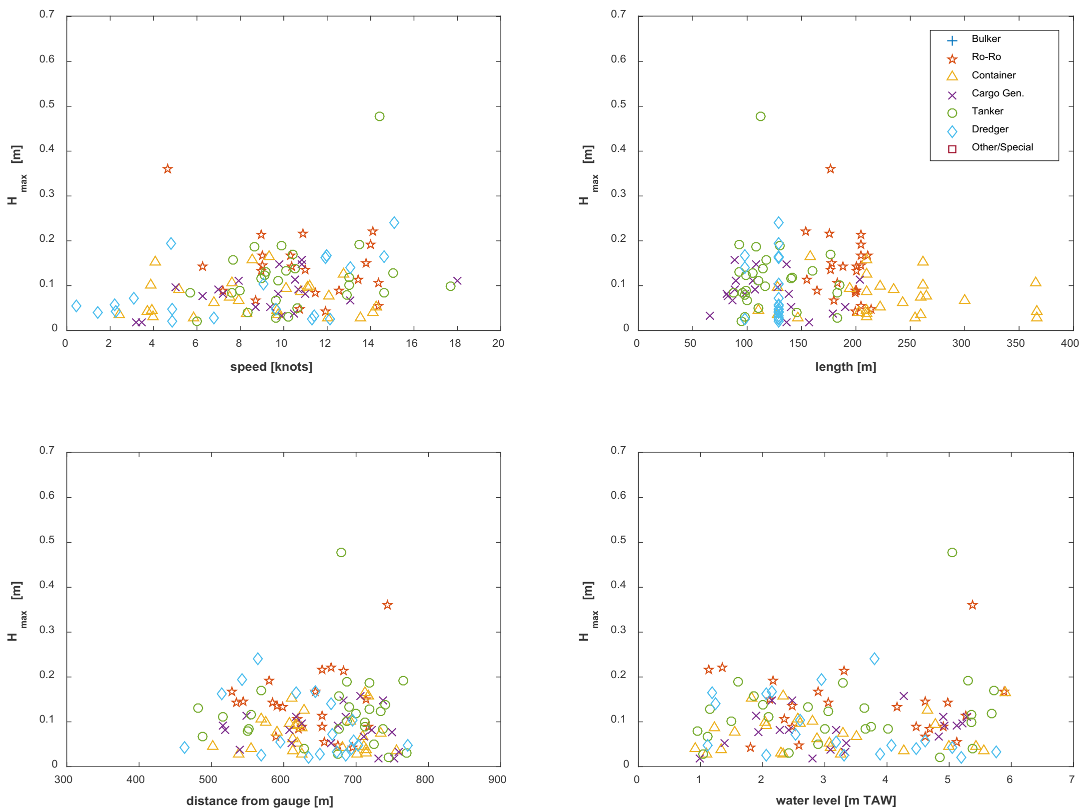


Figure 6-20 – Secondary wave height versus ship speed & length, distance from the measuring gauge, and water level for the selected **seagoing** ship events at **Gsb2** (north) location.

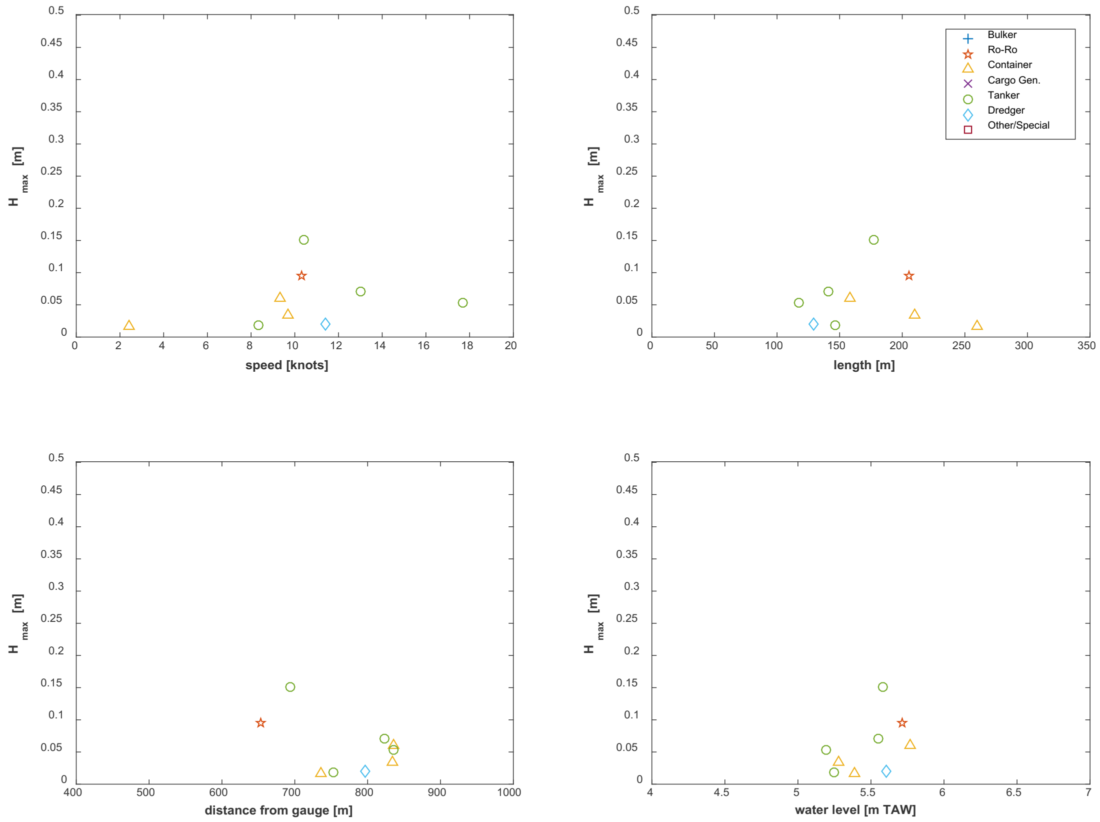


Figure 6-21 – Secondary wave height versus ship speed & length, distance from the measuring gauge, and water level for the selected **seagoing** ship events at **Gsc4** (south) location.

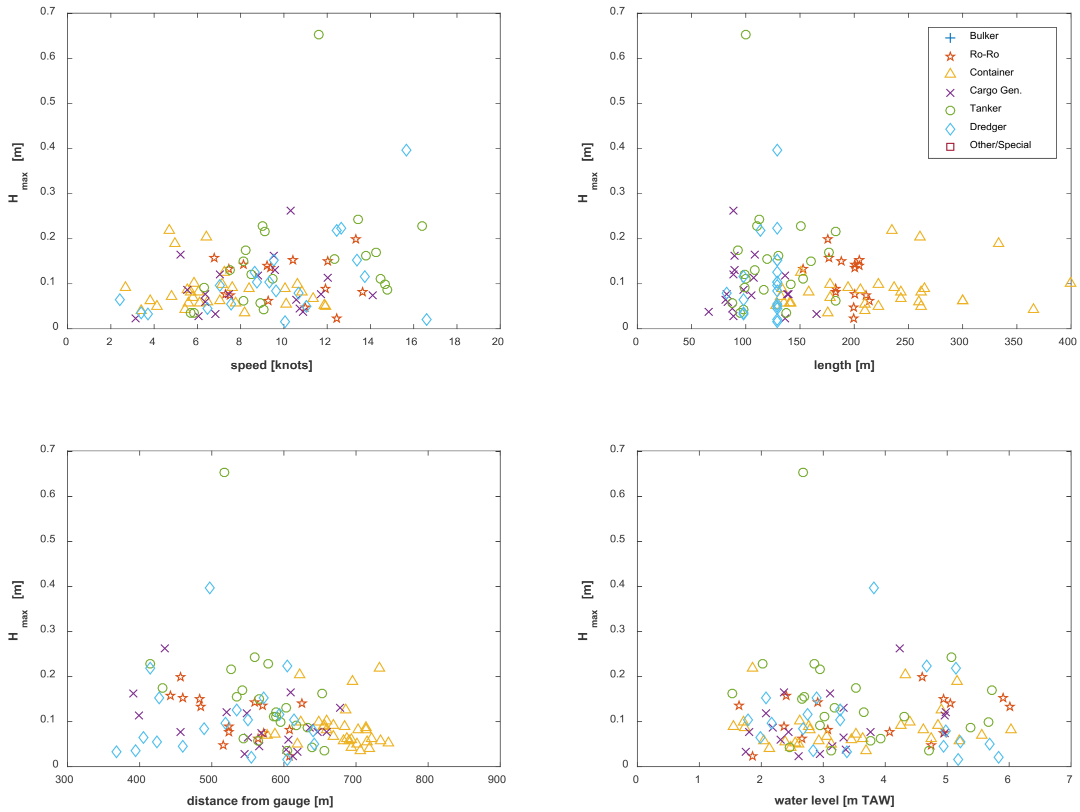


Figure 6-22 – Secondary wave height versus ship speed & length, distance from the measuring gauge, and water level for the selected **seagoing** ship events at **Gsc3**(south) location.

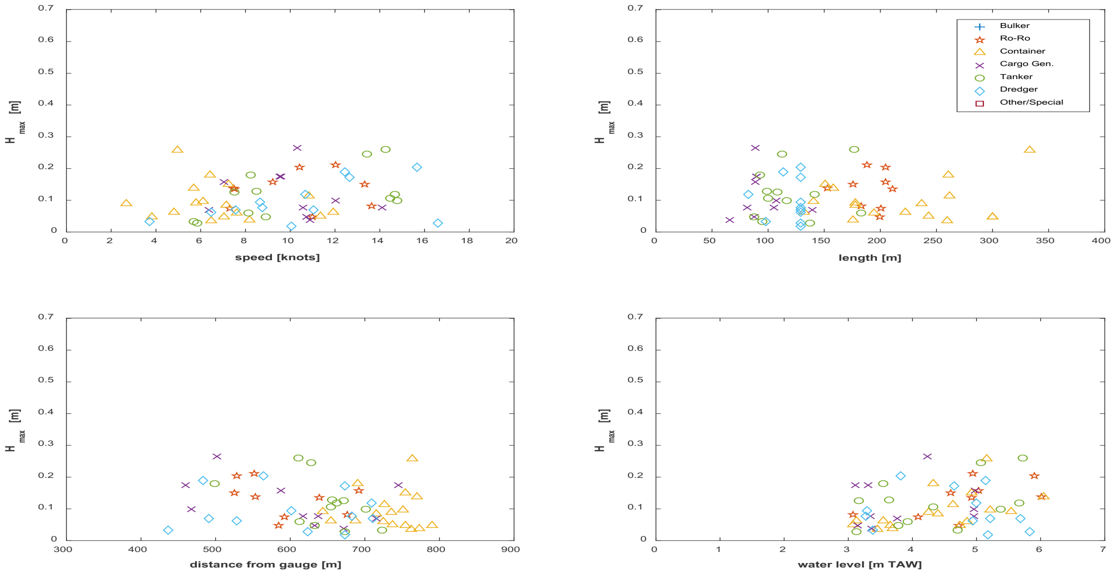
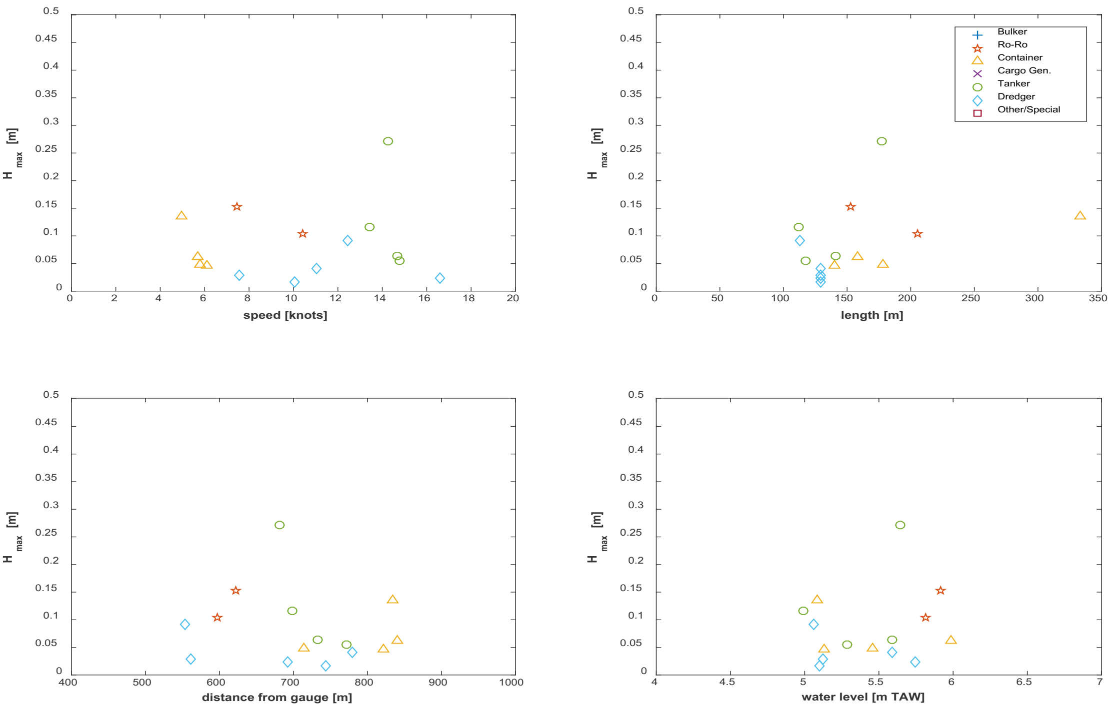


Figure 6-23 – Secondary wave height versus ship speed & length, distance from the measuring gauge, and water level for the selected **seagoing** ship events at **Gsc2** (south) location.

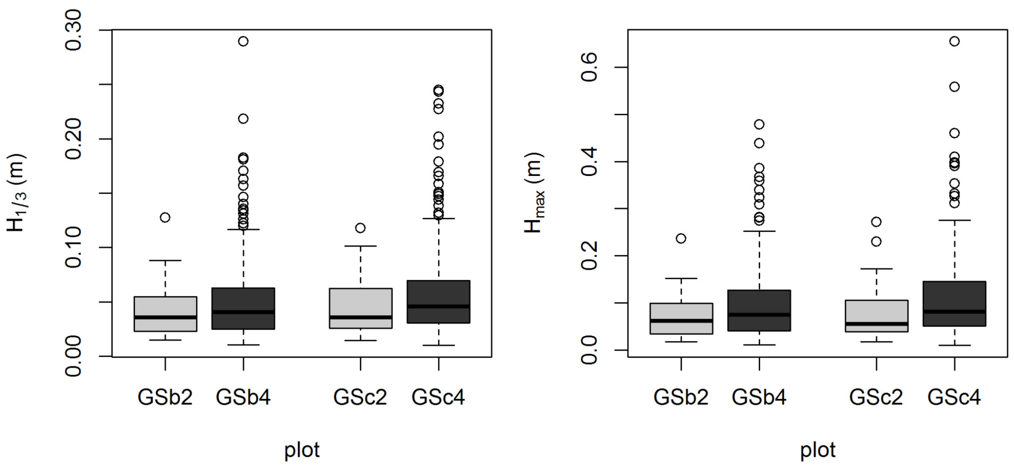


6.2.4 Ship wave comparison between low and high tidal flat

It is interesting to compare the wave heights of ship-induced waves recorded at the low tidal flat plots (GSb4 and GSc4) to the ones recorded at the high tidal flat plots (GSb2 and GSc2). Figure 6-24 shows the distribution of wave heights of all recorded waves at the four plots (n(GSb2)=26, n(GSb4)=327, n(GSc2)=46, n(GSc4)=287).

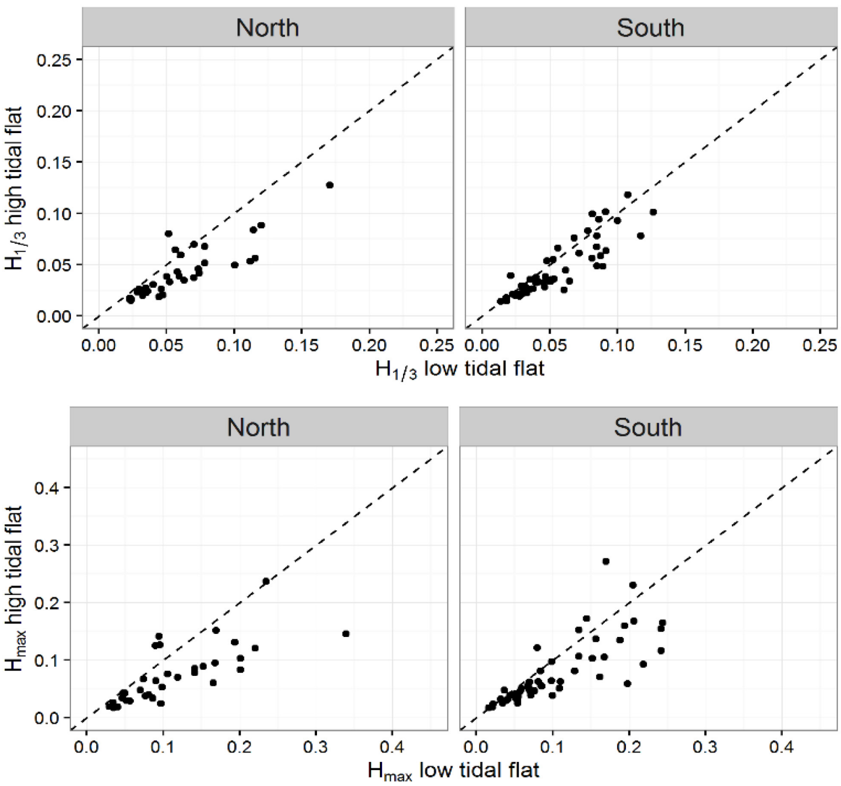
In Figure 6-25, only concurrent ship wave recordings for the low and high tidal flat are shown (n(GSb)=24, n(GSc)=46), and the wave heights are plotted against one another. For points that lie below the x=y line, ship wave heights decrease while travelling over the tidal flat. 84 % of all significant wave heights and 91 % of all maximum wave heights decreased when reaching the sensors at the high tidal flat (Table 11). For ship wave events registered at both low and high tidal flat plots, the tidal water level has to exceed 5 m TAW in order to inundate all sensors. This implies that, at concurrent ship events, the water depth at the low tidal plots has to exceed 4 m, while the water depth at the high tidal flat plots is maximum around 1.5 m.

Figure 6-24 – Comparison of ship waves (significant, $H_{1/3}$, and maximum, H_{max}, wave heights), recorded at the lower and higher tidal flat (plots 2 and 4, at around 5 m TAW and 1 m TAW, respectively) of both transects (GSb and GSc).



The boxes represent the interquartile range of the data and the whiskers delimit 1.5 times the interquartile range. The horizontal line indicates the median.

Figure 6-25 – Wave heights (significant, $H_{1/3}$, and maximum, H_{max}) for ship passages recorded simultaneously at low and high tidal flat plots at GSb (northern transect) and GSc (southern transect).



Wave heights recorded at the high tidal flat (approximately 5 m TAW) are plotted against wave heights recorded at the low tidal flat (approximately 1 m TAW). The dashed lines indicate where x=y.

Table 11 – List of simultaneous records of ship passages at high (5 m TAW) and low (1 m TAW) tidal flat at both transects. Relative values of maximum wave heights (H_{max} (high/low)) and significant wave heights ($H_{1/3}$ (high/low)) are given. The wave heights recorded at the high tidal flat are expressed relatively to the corresponding low plot.

Plot ID	index	time (dd/mm/yyyy HH:MM)	type	H_{max} high/low (m)	$H_{1/3}$ high/low (m)
GSb	SE02-1	30/10/2015 5:19	INL79	0.911	0.794
	SE04-1	31/10/2015 5:22	INL52	0.584	0.742
	SE07-1	1/11/2015 18:46	INL79	0.902	0.762
	SE07-2	1/11/2015 19:02	INL80	0.252	0.417
	SE23-1	10/11/2015 2:49	TNK81	0.451	0.669
	SE24-1	10/11/2015 14:35	INL99	0.493	0.667
	SE25-1	11/11/2015 2:51	INL52	0.692	0.760
	SE25-2	11/11/2015 3:13	INL90	0.860	0.877
	SE27-1*	12/11/2015 3:04	CON71	0.741	0.818
	SE27-2	12/11/2015 3:29	INL00	0.492	0.791
	SE30-1	13/11/2015 15:35	INL80	1.494	1.553
	SE31-1	14/11/2015 3:36	INL90	0.517	0.650
	SE31-2	14/11/2015 4:21	INL79	0.759	0.764
	SE31-3	14/11/2015 4:45	INL79	0.652	0.711
	SE31-4	14/11/2015 5:20	INL79	0.390	0.428
	SE32-1	14/11/2015 16:46	TNK81	0.897	0.864
	SE32-2	14/11/2015 16:59	TNK82	0.587	0.658
	SE33-1	15/11/2015 5:21	INL80	0.607	0.661
	SE34-1	15/11/2015 16:30	INL84	1.396	1.136
	SE34-2	15/11/2015 16:46	INL79	0.708	0.636
	SE38-1	17/11/2015 18:19	INL90	0.513	0.487
	SE50-1	24/11/2015 1:02	TNK80	0.536	0.553
	SE52-1	25/11/2015 1:30	DRG33	0.605	0.714
	SE52-2	25/11/2015 2:54	INL52	0.547	0.993
	SE55-1	26/11/2015 14:52	INL00	0.573	0.614
	SE56-1*	27/11/2015 4:11	CON71	0.488	0.638
	SE58-1	28/11/2015 4:10	INL79	0.676	0.736
	SE58-2	28/11/2015 4:33	INL79	1.009	0.747
	SE59-1	28/11/2015 16:10	INL52	1.320	0.981
	SE59-2	28/11/2015 17:09	RRC71	0.565	0.492
	SE59-3	28/11/2015 17:30	INL80	0.393	0.570
	SE61-1	29/11/2015 18:36	INL52	0.429	0.736
	SE62-1*	30/11/2015 5:04	CON71	0.367	0.533
	SE62-2	30/11/2015 5:24	INL79	0.714	0.625
	SE62-3	30/11/2015 5:58	INL89	0.552	0.561
	SE63-1	30/11/2015 19:12	INL80	0.414	0.475

Plot ID	index	time (dd/mm/yyyy HH:MM)	type	H_{max} high/low (m)	$H_{1/3}$ high/low (m)
GSc	SE01-1	29/10/2015 17:26	INL79	0.465	0.608
	SE02-1	30/10/2015 5:43	INL79	0.834	0.824
	SE05-1	31/10/2015 18:09	INL52	0.865	0.824
	SE06-1	1/11/2015 5:45	INL52	0.981	1.049
	SE06-2	1/11/2015 6:34	INL90	0.665	0.826
	SE06-3	1/11/2015 7:17	INL69	0.387	0.421
	SE07-1	1/11/2015 18:50	INL79	0.545	0.701
	SE09-1	2/11/2015 19:47	INL00	0.644	0.727
	SE09-2	2/11/2015 20:04	INL99	1.294	1.854
	SE19-1	8/11/2015 0:47	TNK82	0.480	0.697
	SE19-2	8/11/2015 0:59	INL52	0.796	0.853
	SE22-1	9/11/2015 13:45	INL52	0.875	0.922
	SE23-1	10/11/2015 3:21	INL79	1.015	0.934
	SE24-1	10/11/2015 14:30	INL99	0.868	0.817
	SE25-1	11/11/2015 2:28	INL79	0.747	0.845
	SE25-2	11/11/2015 2:46	INL52	1.122	1.094
	SE25-3	11/11/2015 3:45	DRG90	0.423	0.672
	SE27-1	12/11/2015 3:34	INL00	0.734	0.791
	SE29-1*	13/11/2015 3:37	CON71	0.714	1.094
	SE30-1	13/11/2015 15:21	INL00	0.965	1.122
	SE30-2	13/11/2015 15:39	INL80	0.811	0.815
	SE31-1	14/11/2015 4:27	INL79	0.795	0.809
	SE31-2	14/11/2015 4:38	INL79	0.730	0.808
	SE32-1	14/11/2015 16:43	TNK81	1.599	1.111
	SE32-2	14/11/2015 17:03	TNK82	0.655	0.702
	SE32-3	14/11/2015 17:50	INL70	0.888	0.953
	SE33-1	15/11/2015 5:25	INL80	0.628	0.576
	SE34-1	15/11/2015 17:37	INL79	0.614	0.714
	SE35-1	16/11/2015 5:00	CON71	0.801	0.922
	SE38-1	17/11/2015 18:26	INL90	0.638	0.799
	SE42-1	19/11/2015 21:21	INL79	0.857	1.009
	SE46-1	21/11/2015 23:35	DRG33	1.048	1.048
	SE48-1	23/11/2015 1:04	DRG33	0.546	0.683
	SE50-1	24/11/2015 1:06	TNK80	0.639	0.669
	SE52-1	25/11/2015 1:34	DRG33	1.103	1.009
	SE52-2	25/11/2015 2:08	RRC70	1.135	1.117
	SE54-1	26/11/2015 3:13	INL52	0.630	0.695
	SE56-1	27/11/2015 3:51	DRG33	0.820	1.004
	SE58-1	28/11/2015 3:54	INL79	0.299	0.527
	SE58-2	28/11/2015 4:15	INL79	0.439	0.543
	SE58-3	28/11/2015 4:25	INL79	0.822	0.667
	SE59-1	28/11/2015 16:31	INL89	0.815	1.062
	SE59-2	28/11/2015 17:05	RRC71	0.682	0.795
	SE59-3	28/11/2015 17:25	INL80	0.671	0.746
	SE59-4	28/11/2015 17:35	CON71	0.688	0.911
	SE59-5	28/11/2015 17:55	INL80	0.872	0.981
	SE61-1	29/11/2015 18:40	INL52	0.677	0.931
	SE62-1*	30/11/2015 5:11	CON71	0.773	0.678
	SE62-2	30/11/2015 6:02	INL89	1.527	1.184
	SE62-3	30/11/2015 6:26	INL80	0.469	0.691
	SE63-1	30/11/2015 18:31	INL80	0.572	0.727
	SE63-2	30/11/2015 19:07	INL80	1.194	1.220

6.3 Primary waves: large vessel events

During the analysis of single ship events many large vessels events were excluded, because of the implemented criteria. Consequently, only a small number of events with primary wave patterns were investigated. In this section another technique for the detection of large vessel events and the analysis that follows, are presented.

6.3.1 Detection of large vessel events

The detection of large vessel events on the water fluctuation time series for every tidal cycle was achieved by the application of the following criteria:

- The minimum length of a large vessel is set equal to 200 m, i.e. exclusively seagoing cargo vessel events
- The minimum speed of a large vessel is set equal to 2.5 knots

Then, the same criterion for the detection of single ship events was applied for the large vessel events:

- The minimum length of the time windows before and after a large vessel passage that have to be clear, is considered equal to 9 min. That is, t_i-t_{i-1}> 9 min and t_i-t_{i+1}>9 min (t_i is the time of a large vessel passage *i*)

The large vessel event duration was also set equal to 9 min and its starting point is identical to the time that the ship crosses the entry line. However, the calculation of primary wave patterns takes also into account a time interval equal to 90 s prior to the time of passage.

Also, the same criterion, as in the case of single ship events, for omitting the periods of the tidal cycle during which the wave gauges were not inundated is used:

- Critical water level = minimum (recorded) water level +20 cm

It has to be noted that:

- The minimum sailing speed criterion was applied in order to avoid the removal of events, where a large vessel was moving close to a very slow one, which is not expected to influence substantially the generated wave signal.
- The criterion about the 9 minute clearance before and after the passage, does not exclude ships that are not considered as large vessels (and also the large ones of speed < 2.5 knots) from the event window. E.g. if a large vessel sails next to a fast sailing inland vessel (< 200 m), the event is still taken into consideration.
- Detected ship events having a very small amplitude of primary wave (drawdown < 4 cm) were eliminated. The drawdown amplitude was calculated after the implementation of a low-pass filter, with a cutoff frequency f_{cut} = 0.05 (T_{cut} = 20 sec), at the event signal.

In Table 12, the number of the large vessel events detected for each of the wave gauges, is shown. The small number of events detected at wave measurements of the shallower gauge (Gsc3) located at the middle-high mudflat, compared to the deeper one (Gsc4), is attributed to the implementation of the critical water level criterion (the period of the tidal cycle that this gauge is inundated is much less compared to the deeper ones). For the same reason the number of detected events at GSb2 and GSc2 is limited to 4 and 7. Given this limited number of events, only two simulatenously monitored large ship events for both high tidal flat plots can be compared.

The main reasons for the difference in event numbers between low tidal flat gauges Gsb4 and Gsc4, are:

(a) the implementation of the critical water level criterion (z_{Gsb4} = 0.57 m TAW, while z_{Gsc4} = 1.17 m TAW)

(b) the elimination of ship passages introducing a small amplitude primary wave. Small amplitude primary waves were observed more often at the southern DGD entry line, probably due to the lower sailing speed of large vessels compared to the northern SFD entry line.

Table 12 – Number of large vessel events at all measurement locations.

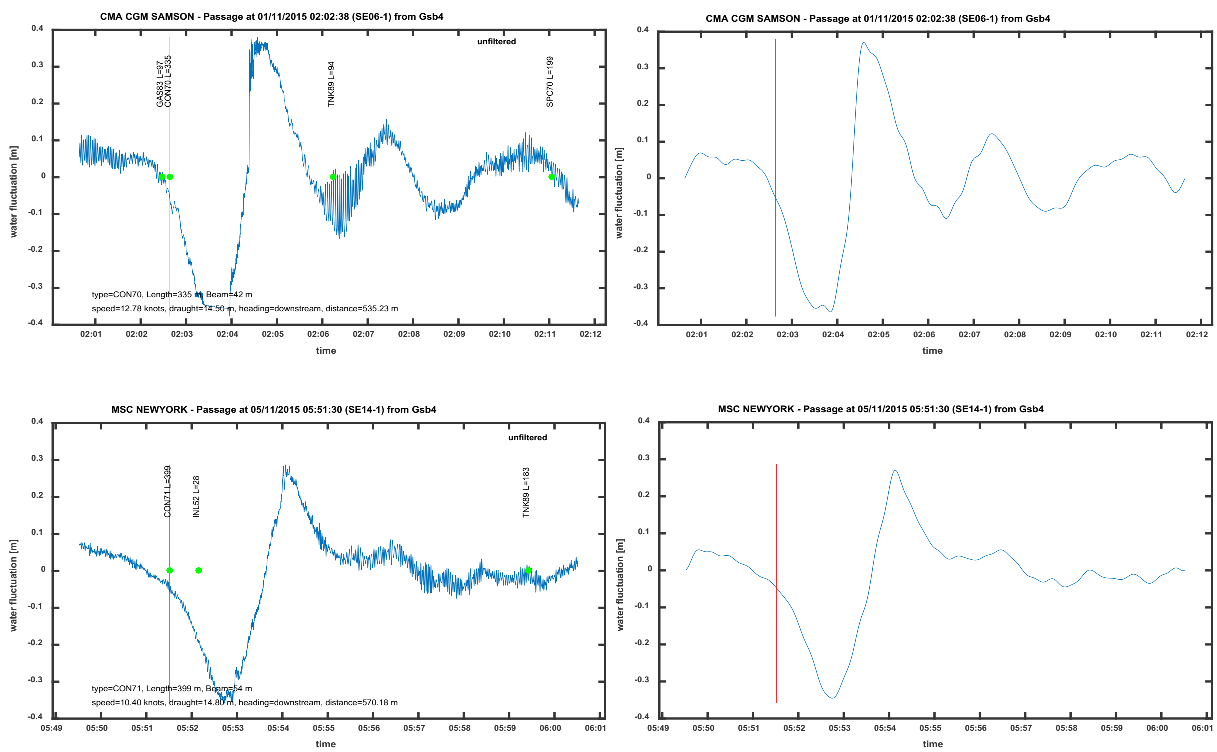
wave gauge location	Position on tidal flat	large vessel events
Gsb4 (north)	Low	91
Gsb2 (north)	high	4
Gsc4 (south)	Low	50
Gsc3 (south)	middle – high	18
Gsc2 (south)	high	7

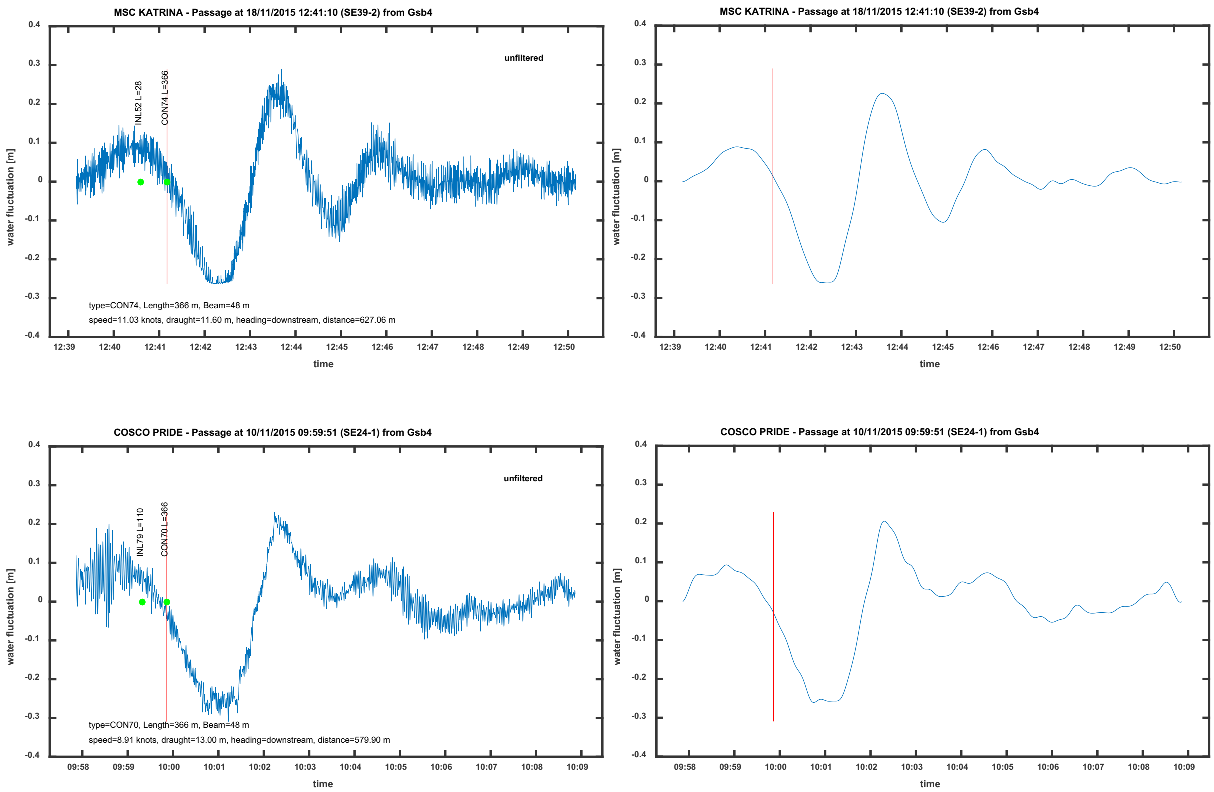
6.3.2 Analysis of large vessel events

First, an analysis of large vessel wave patterns having the largest primary wave heights is carried out. These were mainly observed at the northern entry line for the lower water levels (< 1.6 m TAW). This is probably due to the fact that the action of a primary wave pattern is enhanced in an area of reduced water depth. Smaller depths result in an increase of the blockage coefficient. The blockage coefficient is defined as the ratio of the mid-ship cross sectional area to the area of the waterway's cross section.

Four characteristic examples of large cargo vessels of length greater than 300 m, recorded by the Gsb4 wave gauge are included in the left column of Figure 6-26. In the right column, the corresponding low-pass filtered signals (f_{cut} = 0.05) are shown. In all cases, the sailing speeds are in the order of 10 knots or higher, the vessels headed downstream and H_{max} values are found to be greater than 0.45 m. Note that the first ship (CMA CGM SAMSON) induced a H_{max} of roughly 0.70 m. However, it has to be noted that in the first and the last presented events, ships of length around 100 m were moving close to the large vessels. Furthermore, the fact that the time of passage (denoted by the red line), is transmitted later than the initiation of the drawdown (starting when the bow crosses the entry line), is probably due to the position of the AIS data transmitter, usually installed close to the stern of the ship.

Figure 6-26 – Four wave signals of large vessel events recorded by Gsb4 (northern SFD) wave gauge (left column). In the right column the low-pass filtered signals are shown. The red line corresponds to the time of passage of the large vessel, other ships are indicated with green dots.





Two sets of wave signals measured at Gsb4 and Gsc4 locations, characterized by the passage of the largest cargo vessels (MSC NEWYORK and MATHILDE MAERSK) of length L = 399 m, heading downstream, are shown in Figure 6-27 and Figure 6-28.

Figure 6-27 clearly indicates that the primary wave pattern recorded at Gsb4 location (left figures) presents a substantially enhanced amplitude compared to the one recorded at Gsc4 location (right figures), including a pronounced stern wave. At this event, the vessel was moving from the southern DGD to northern SFD transect with increasing sailing speed, i.e. from about 7 knots at Gsc4 to 10.5 knots at Gsb4, what partially can explain the growth of the primary wave. Also the distance to the gauge decreases, the ship sails about 150 m closer to the sensor at the northern transect. Another potential influence in this behavior, is a possible difference between the blockage coefficient of the two transects, i.e. the blockage coefficient at the southern transect could be affected (decrease) by the existence of Deurganckdok at its west side. In the contrary, the northern cross section is confined by the river banks. Note that this event did not meet the criterion of critical water level at Gsc4 location (it was modified to WL_{cr} = WL_{min} + 10 cm), however it was included for qualitative comparison of the generated wave signals at the two investigated locations. Note also that the trough of the primary wave at the right figures seems to be truncated (at this interval the gauge was inundated). In Figure 6-28, an illustration of another ship passage, it is indicated that the primary wave height increases about 20%, as the ship moves from the south (Gsc4) to the north (Gsb4) transect, while the sailing speed and distance to the gauge slightly decreased.

In Figure 6-29 the power spectral density distributions for the unfiltered signals of the same large vessel presented in Figure 6-28, are shown as an example of the difference in wave energy distribution between the north and the south transect. In both cases wave energy is almost exclusively accumulated at frequency bins less than 0.01 Hz (100 s), while the energy of secondary and wind waves is negligible (after inspection of the frequency band 0.05 - 1 Hz, which is not shown in Figure 6-29). The reduction of the peak energy between Gsb4 and Gsc4 signals is about 50%.

Figure 6-27 – Wave signals of a very large vessel (MSC NEWYORK) recorded by Gsb4 wave gauge (left) and Gsc4 wave gauge (right). In the figures below the corresponding low-pass filtered signals are shown.

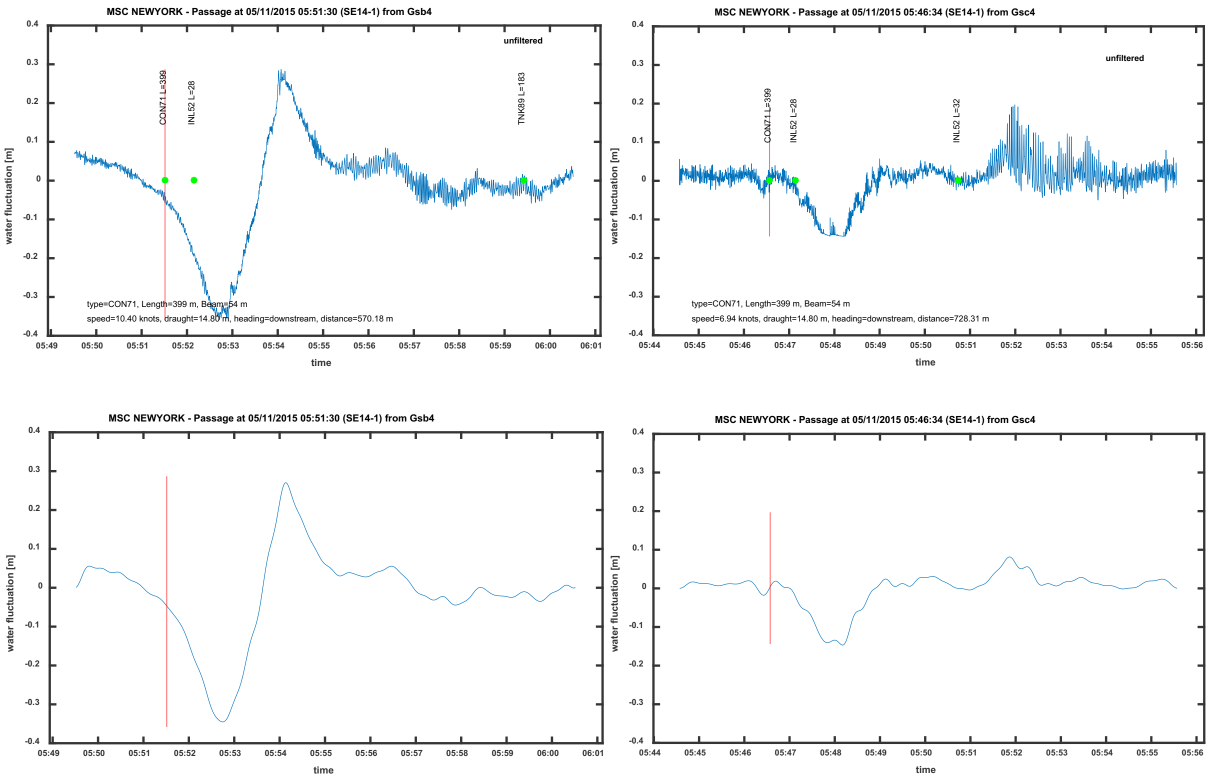


Figure 6-28 – Wave signals of a very large vessel (MATHILDE MAERSK) recorded by Gsb4 wave gauge (left) and Gsc4 wave gauge (right). In the figures below the corresponding low-pass filtered signals are shown.

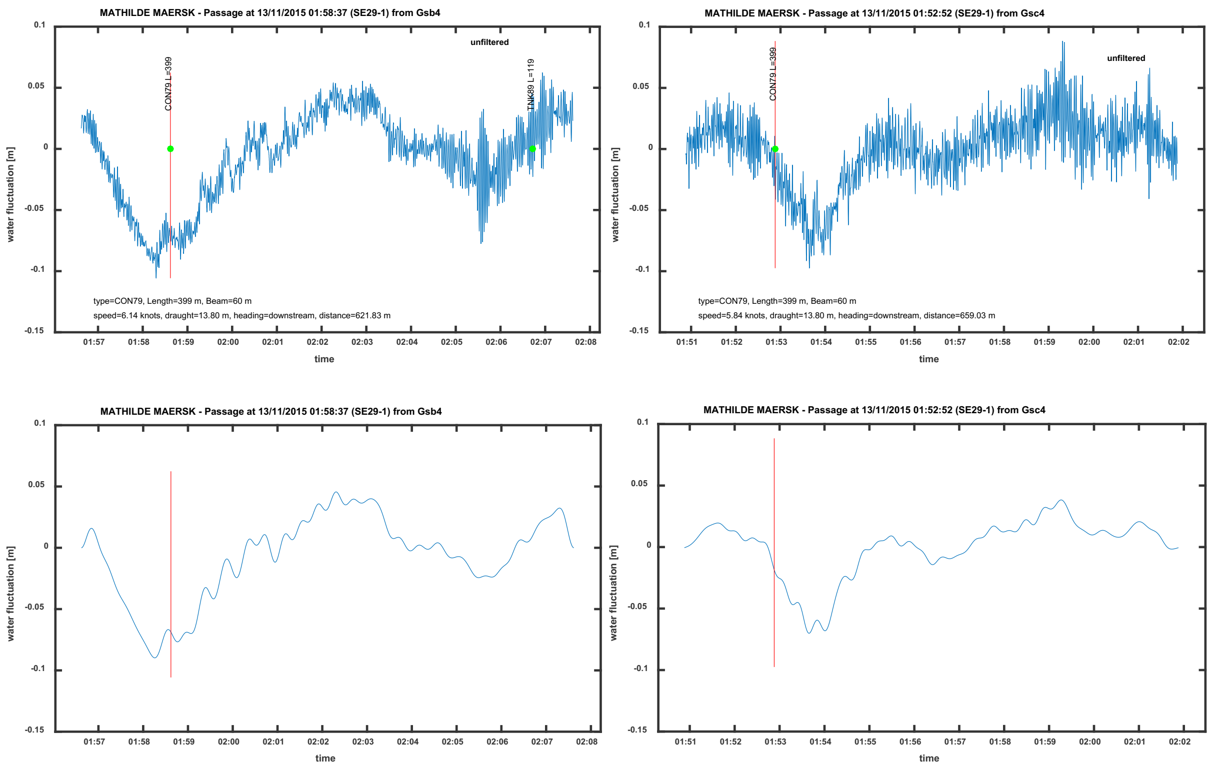
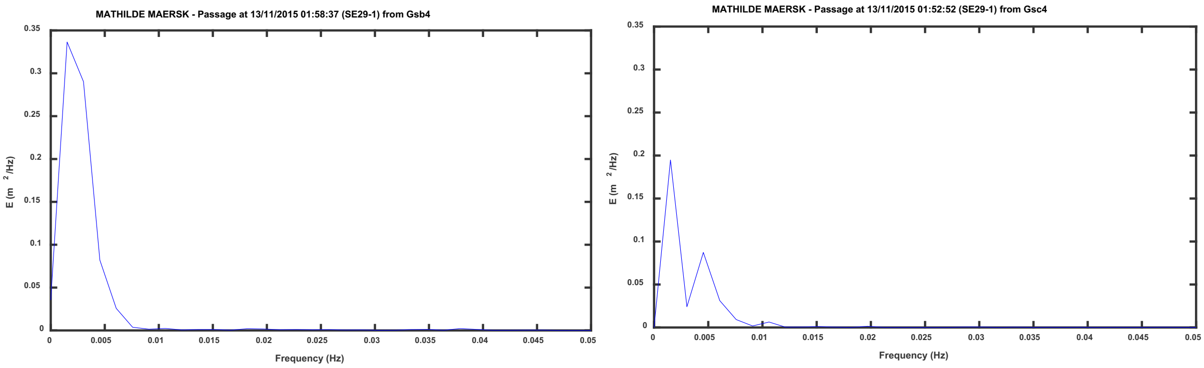
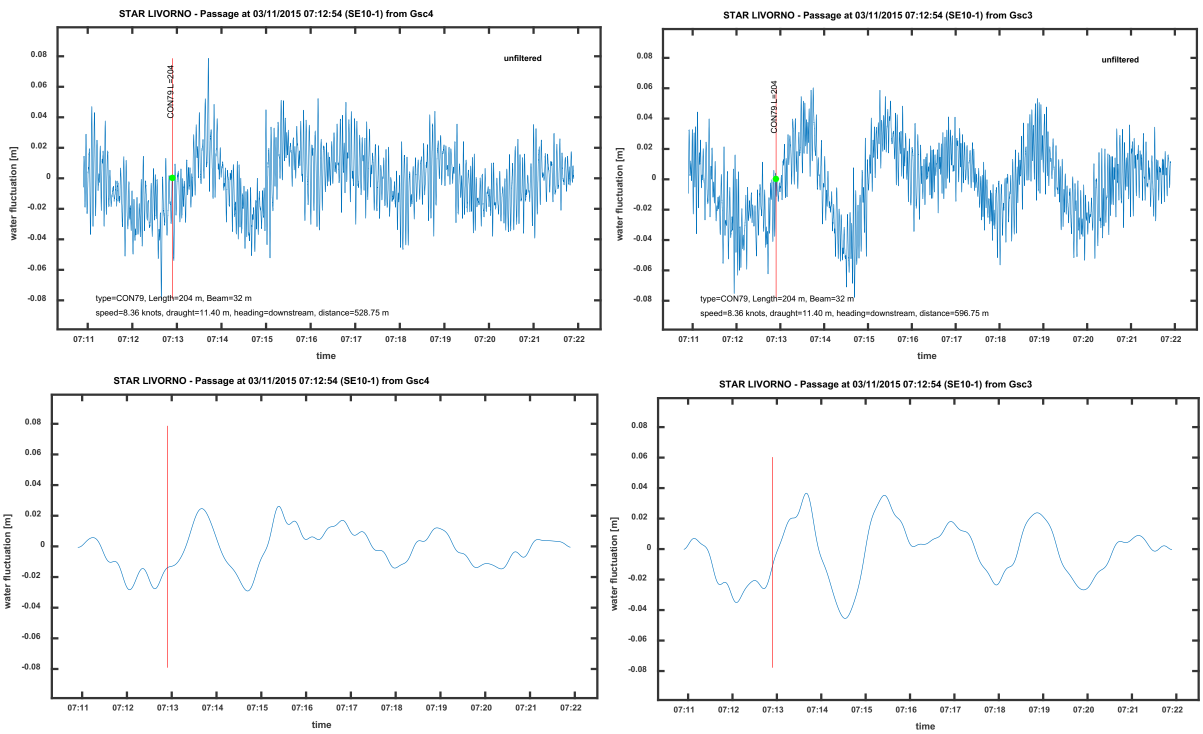


Figure 6-29 – Power spectral density distributions for the large vessel event of Figure 6-28,
at Gsb4 (left figure) and Gsc4 (right figure) location.



In Figure 6-30, the wave signals of a large ship measured at Gsc4 and Gsc3 locations (south transect), are compared to each other. The length of the cargo ship is 204 m; it is sailing downstream with a speed of 8.4 knots. The amplitude of its primary wave pattern, which is less than 10 cm, appears to be enhanced about 30%, at the shallower (Gsc3) gauge compared to the deeper (Gsc4) one. Furthermore, it is conjectured that the wave patterns that follow the primary wave (and makes its distinction difficult) may be related to the low frequency disturbances described in §0.

Figure 6-30 – Large vessel signals measured at Gsc4 (south-low mudflat) location (left) and
at Gsc3 (south-middle high mudflat) location (right). In the figures below the corresponding low-pass filtered signals are shown.



6.3.3 Results of the analysis

The information related to each large vessel event, which includes AIS-IVS ship data, wave characteristics, water level and wind data, was stored in tables for each of the measurement locations (Appendix A, Table 20 - Table 22), similar to the ones created for the case of single ship events. Note that the primary wave height, denoted as H_{prim}, results from the implementation of the zero down-crossing method, as described in §4.5.1, on the low-pass filtered (T_{cut} = 20 sec) signal of each large vessel event.

Using the ship-related information (Appendix A, Table 20 - Table 22), figures for the distribution of primary wave height (H_{prim}) with regard to sailing speed, ship length, distance of the ship from the measurement gauge and water level, were generated for each of the measurement locations (Figure 6-31 to Figure 6-33).

A negative correlation between H_{prim} and the water level is observed for all measurement locations, i.e. H_{prim} increases for decreasing water level. It has to be noted that most of the highest primary waves (H_{prim} > 0.4) are observed for water levels lower than about 1.5 m, which were recorded almost exclusively by the Gsb4 wave gauge. As mentioned before, this behavior is due to the enhanced action of primary waves in areas of reduced water depth, and also to a possible difference between the blockage coefficients of the two transects.

A positive correlation is found between H_{prim} and sailing speed as well, i.e. H_{prim} increases for increasing speed, for the Gsb4 case (Figure 6-31), while this correlation appears to be stronger for the Gsc4 location (Figure 6-32). In the contrary this correlation is not obvious for the shallower location, Gsc3 (Figure 6-33), probably due to the reduced number of included events.

Furthermore, most of the events correspond to H_{prim} values less than 0.35 m, 0.2 m and 0.15 m for the Gsb4, Gsc4 and Gsc3 locations, respectively.

In Figure 6-31 and Figure 6-32, a decreasing trend of H_{prim} with increasing distance of the ship from the wave gauge is shown. This trend is not illustrated in Figure 6-33 due to the reduced number of the included events. In addition, the ship length does not seem to present a correlation with primary wave height.

Figure 6-31 – Maximum wave height (primary) versus ship speed & length, distance from the measuring gauge, and water level for the selected ship events at Gsb4 (north) location.

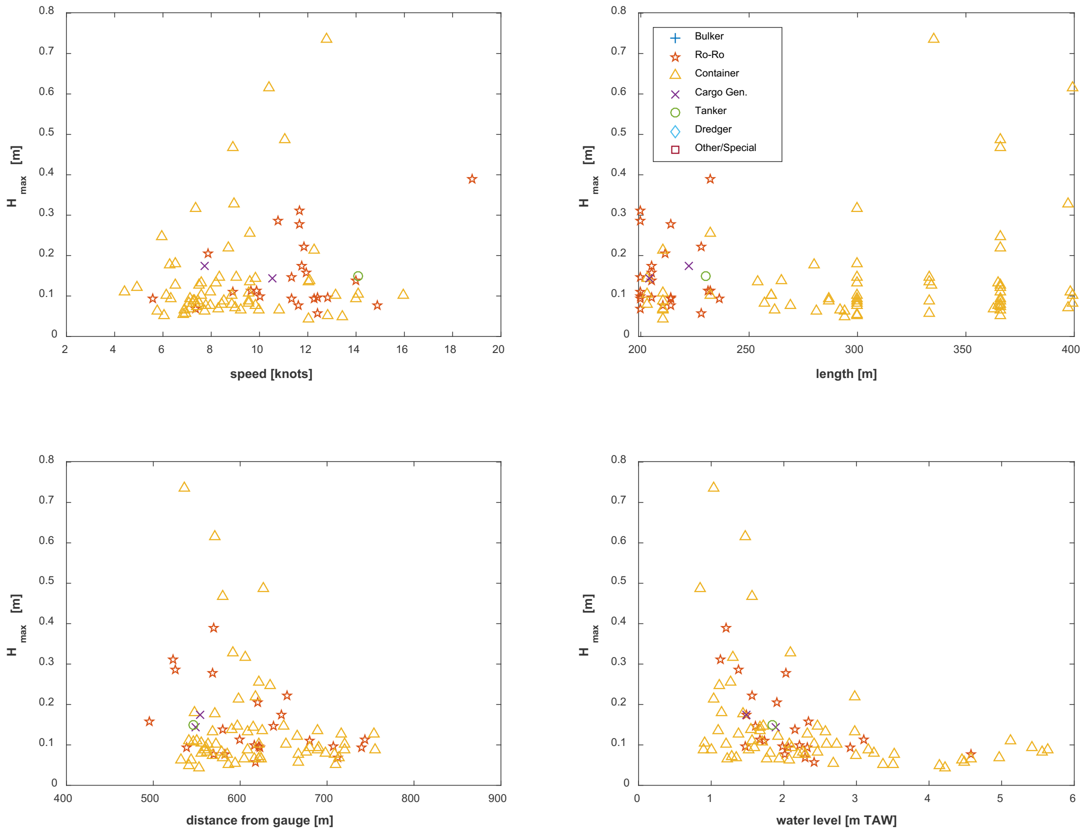


Figure 6-32 – Maximum wave height (primary) versus ship speed & length, distance from the measuring gauge, and water level for the selected ship events at Gsc4 (south) location.

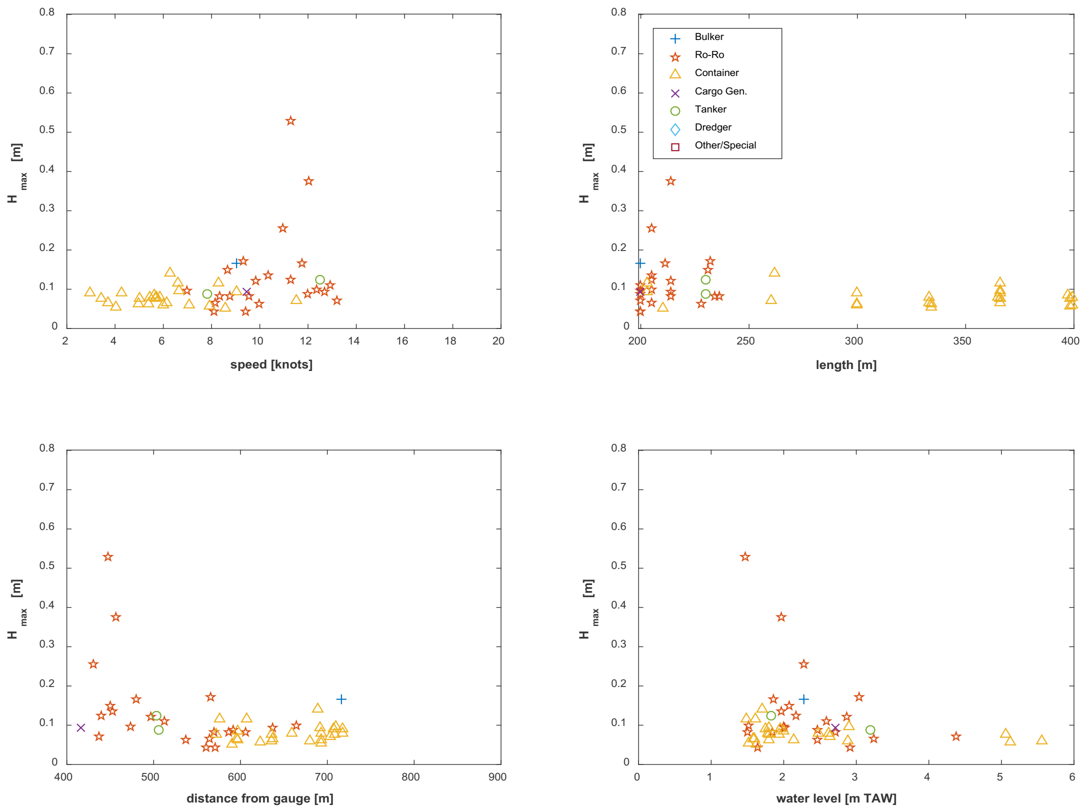
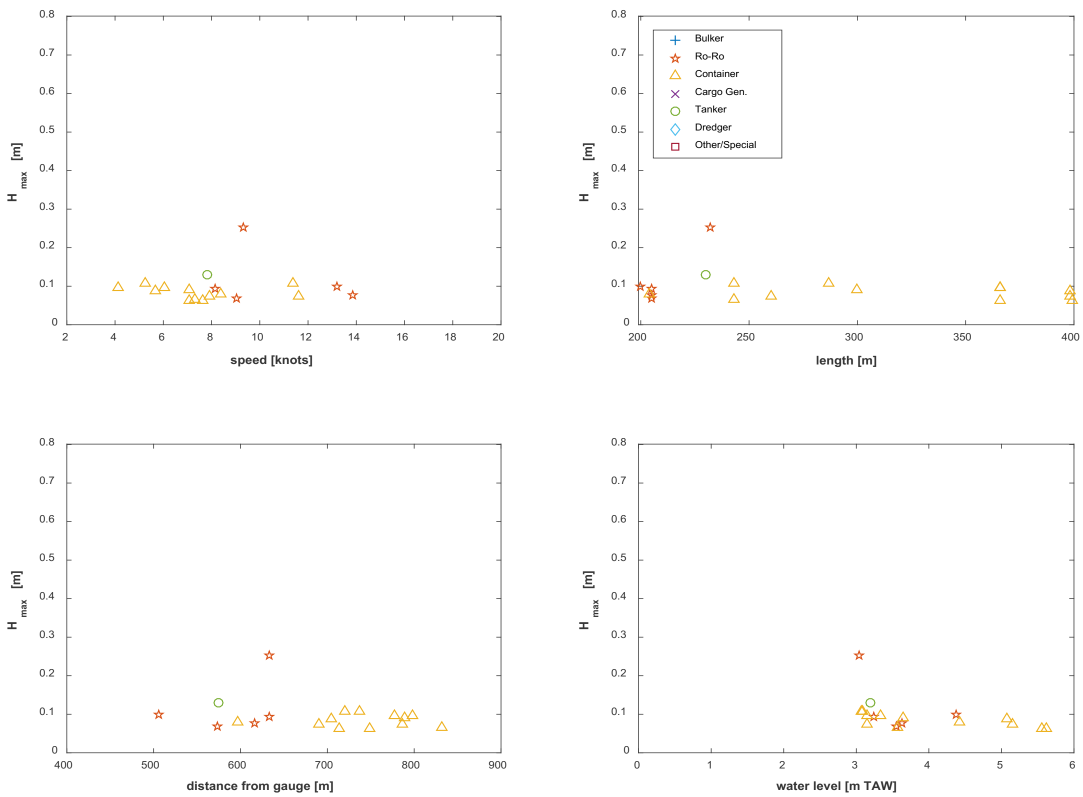


Figure 6-33 – Maximum wave height (primary) versus ship speed & length, distance from the measuring gauge, and water level for the selected ship events at Gsc3 (south) location.



Investigating a possible correlation of primary wave height with more than one independent variables simultaneously, it was found that H_{prim} presents a better positive correlation with the product of speed and length, based on personal communication with the Antwerp Maritime Academy) than the one of the H_{prim} versus speed plot for the Gsb4 (north) location, as shown in Figure 6-34. For the Gsc4 (south) location the trend of the H_{prim} variation with the product of speed and length shows more or less the same behavior as the one of H_{prim} versus speed plot.

Furthermore, it was found that H_{prim} presents a positive correlation to the ratio of sailing speed to water level for both Gsb4 and Gsc4 locations (Figure 6-35). The most clear positive correlation of H_{prim} with multiple parameters is found versus the product of speed and length divided by water level for the Gsb4 location (Figure 6-36).

Figure 6-34 – Maximum wave height (primary) versus the product of ship speed & length for the selected ship events at Gsb4 location (left figure) and at Gsc4 location (right figure).

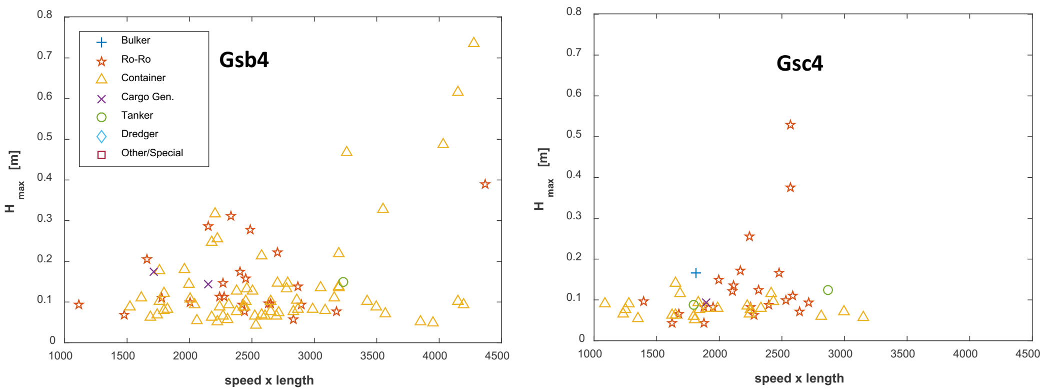


Figure 6-35 – Maximum wave height (primary) versus the ratio of ship speed & water level for the selected ship events at Gsb4 location (left figure) and at Gsc4 location (right figure).

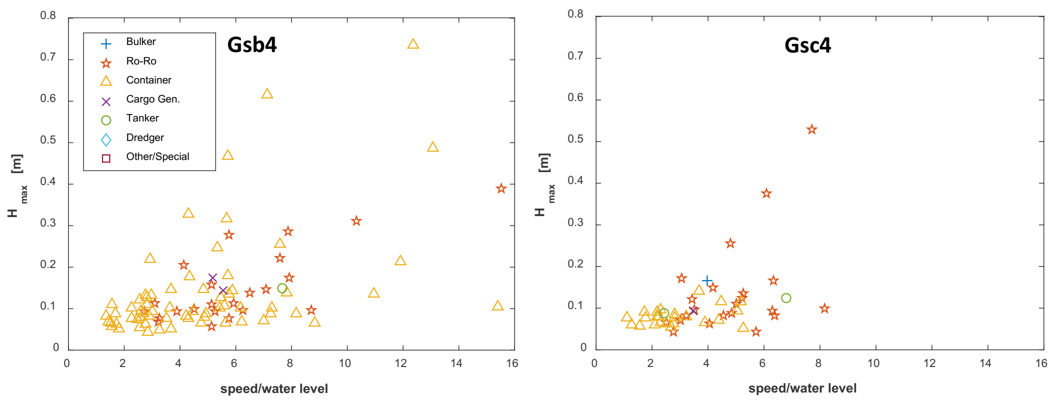
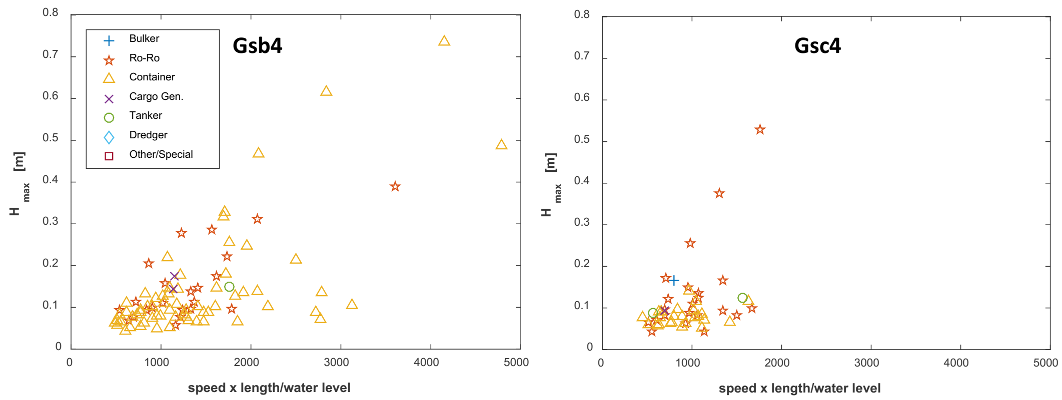


Figure 6-36 – Maximum wave height (primary) versus the product of speed and length divided by water level for the selected ship events at Gsb4 location (left figure) and at Gsc4 location (right figure).



The distribution of primary wave height with respect to ship draught, as well as the combined influence of the latter with other parameters on H_{prim}, were investigated for all the measurement locations. However results from the shallower location are not presented here, since they did not lead to interesting findings.

The distribution of H_{prim} with regard to the draught, the product of draught and speed, the ratio of the draught to water level and the product of draught and speed divided by water level for locations Gsb4 and Gsc4 are shown in Figure 6-37 and Figure 6-38, respectively. For Gsb4 location (Figure 6-37), it is found that H_{prim} presents a positive correlation with draught and also with the other combined variables, but especially with the ratio of the draught to water level. For Gsc4 location (Figure 6-38), the behavior of H_{prim} with respect to the draught and the other combined parameters differs substantially compared to Gsb4 results. In this case, obvious positive correlation exists only between H_{prim} and the product of draught and speed divided by water level. The difference in the results can be attributed to the different conditions at the two measuring cross-sections, i.e. the south entry line is in the stretch of Deurganckdok, while the northern one is confined by the river banks. Furthermore, there is a big difference in the amount of the recorded large vessel events between the two locations.

Finally, the distribution of primary wave height with respect to the ship beam, the product of beam and draught, the ratio of the beam to water level and the product of beam and draught divided by water level, were investigated for all the measuring locations. However results only from the north (Gsb4) location are presented here, as they led to some interesting findings (Figure 6-39). Specifically, it was found that H_{prim} presents a positive correlation with the ratio of beam to water level, which is improved by multiplying this ratio by the draught (i.e. draught x beam/water level). No obvious correlation is observed between H_{prim} and ship beam or the product of beam and draught.

Figure 6-37 – H_{max} versus the ship draught, the ratio of the draught to water level, the product of draught and speed, and the product of draught and speed divided by water level for the large vessel events at Gsb4 (north) location.

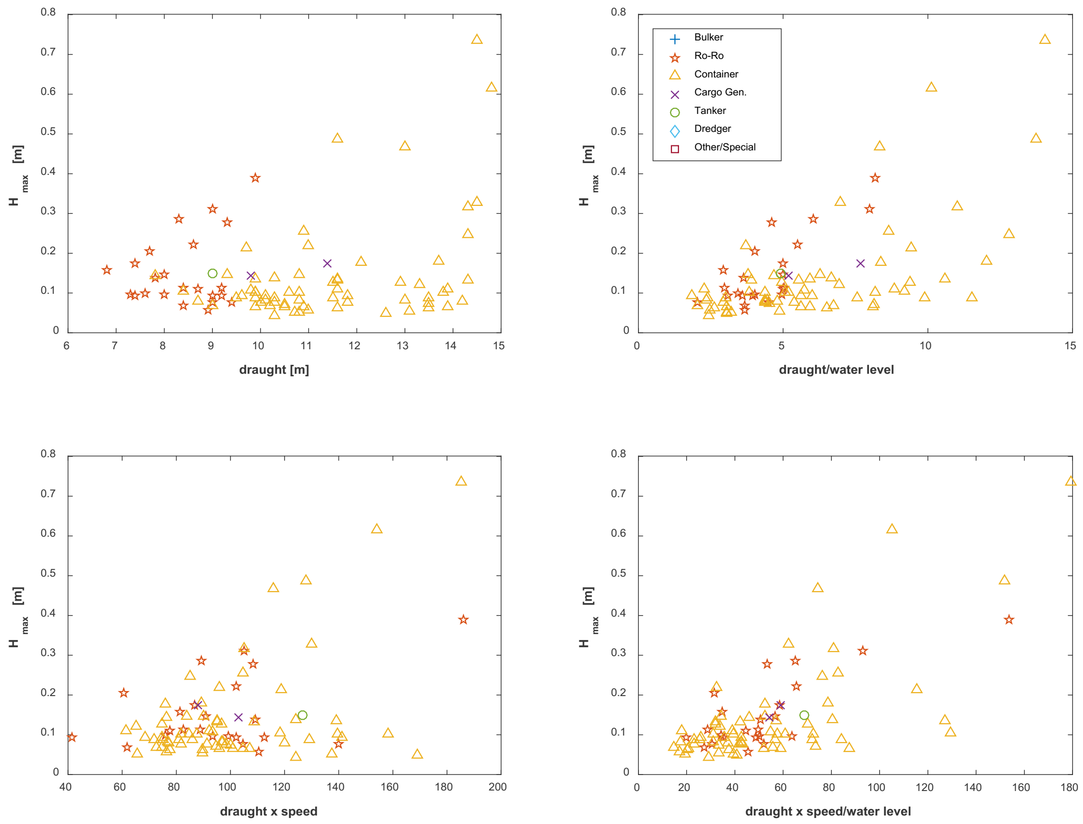


Figure 6-38 – H_{max} versus the ship draught, the ratio of the draught to water level, the product of draught and speed, and the product of draught and speed divided by water level for the large vessel events at Gsc4 (south) location.

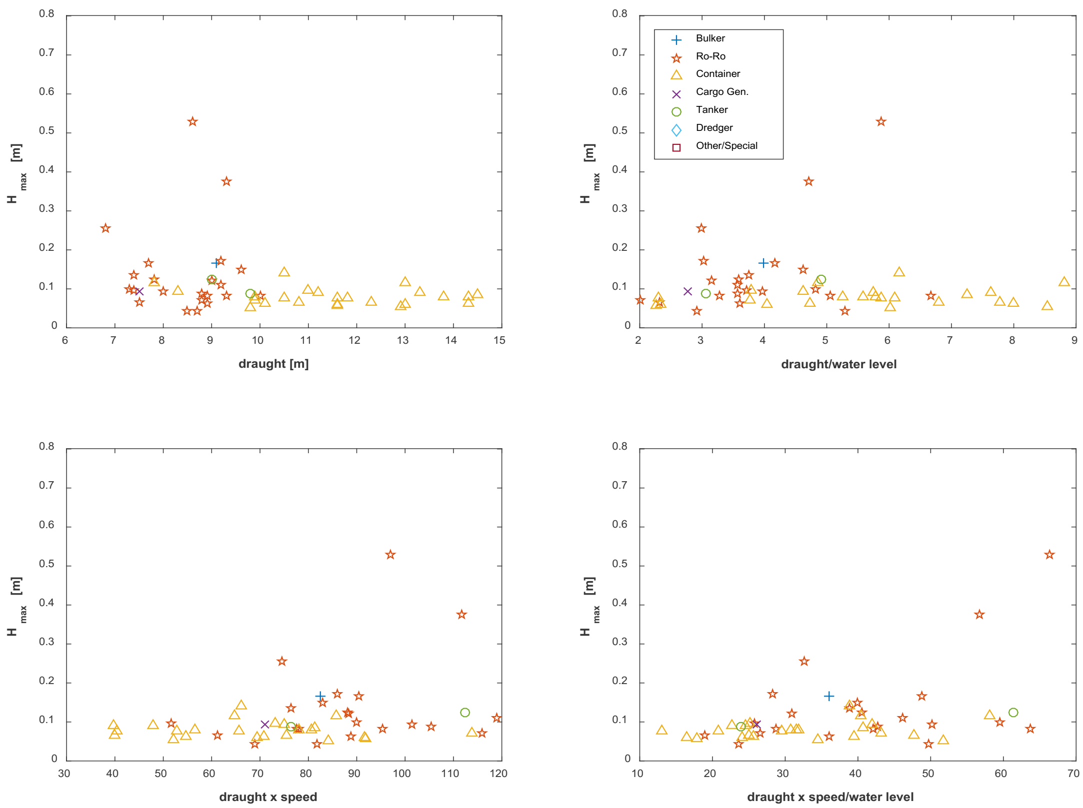
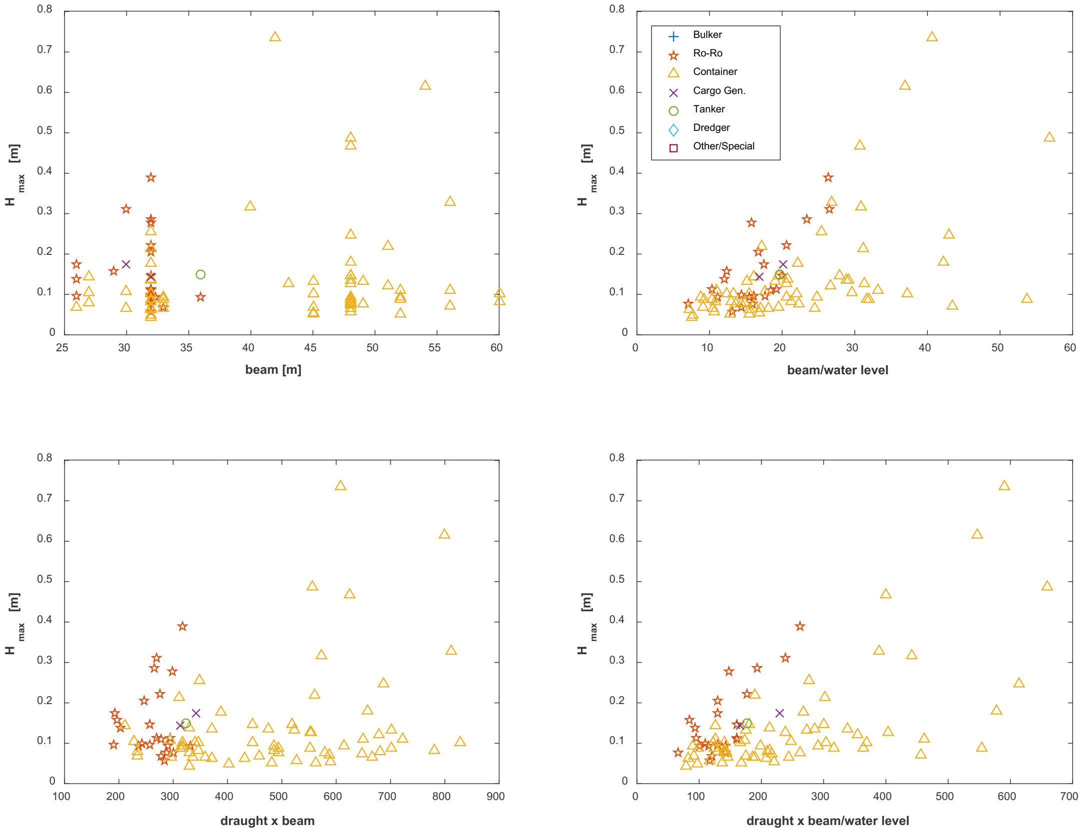


Figure 6-39 – H_{max} versus the ship beam, the ratio of the beam to water level, the product of beam and draught, and the product of beam and draught divided by water level for the large vessel events at Gsb4 (north) location.



7 Wind wave analysis

In this chapter the methodology implemented for the coupling of the measured wind data during the measuring campaign (presented in §4.2) with the wave measurements (presented in §4.5), is presented. As for the case of ship wave analysis, the coupling procedure was accomplished by means of MATLAB (version 2014a) scripts developed for this purpose. The results of this coupling are visualized, illustrating the distribution of wave statistical parameters ($H_{1/3}$, H_{max}) with respect to wind speed and direction, in order to find a possible correlation.

7.1 Detection of no-ship events

The wind wave analysis is based on the detection of events, where wind is considered to be the only generating mechanism of waves, i.e. shipping traffic does not affect the recorded wave signal. The process of detection of these no-ship events is similar to the ship event detection. Because of heavy shipping traffic (cf. Chapter 5), the number of no-ship events is limited.

The criterion for the detection of no-ship events is:

- The minimum length of the time window between two ship passages that has to be clear, is considered equal to 30 min.

The no-ship event duration is set equal to 10 min and its starting point is set at the middle of the selected time window, i.e. at t = 15 min. This ensures that preceding ship waves do not affect the considered signal. The duration of 10 min is chosen as a minimum acceptable length of the time windows, in order to ensure the occurrence of a significant large number of waves in the signal (>100) for the calculation of the wave statistics. This 10 min duration is fixed for all the selected no-ship events, even when the time gap between two ship passages is longer than 30 min. This is chosen for consistency when plotting the $H_{1/3}$ values from different no-ship events in the same graph. In addition, the criterion of 30 min 'clear' windows provided a buffer zone of, at least, 5 min duration between the end of a no-ship event and the passage of a following ship.

Also, the same criterion, as in the case of ship event detection, for omitting the periods of the tidal cycle during which the wave gauges were not inundated:

- Critical water level = minimum water level +20 cm

Finally, in order to eliminate any possible interference of the low frequency wave patterns that were described in §0, a high-pass filter with a cutoff frequency f_{cut} = 0.0067 (T_{cut} = 150 sec), was applied to the wave signals of the selected no-ship events.

In Table 13, the number of the no-ship events detected for each of the wave gauges, is shown. Again, the small number of events detected at the shallower gauges (Gsb2, Gsc2 and Gsc3), located at the low and middle-high mudflat, compared to the lower positioned Gsb4 and Gsc4 is due to the fact that the wave recording time (per tidal cycle) of the first is much less compared to the latter.

Typical wave signals corresponding to no-ship events are shown in Figure 7-1 and Figure 7-2. During these no-ship events high wind speeds (around 20 m/s) were blowing from the southwestern direction, generating relatively high waves of H_{max} ≈ 0.40 m.

In Figure 7-1, the compatibility of the two simultaneously recorded signals in the same (southern DGD) transect is obviously indicated, and confirmed by the spectral energy distribution. For both signals, the energy peak appears to be around 0.42 Hz peak, while in the shallower one (Gsc3) the energy is spread in more frequency bins than in the deeper (Gsc4) signal.

Figure 7-2 depicts two no-ship events recorded with a time shift of a few minutes by the gauges on the lower tidal flat at the northern (Gsb4) and southern transect. The southwestern winds may result into the development of higher waves in the southern DGD transect than in the northern SFD because of an extended fetch length into the Deurganckdok (approximately 2500 m length). However for the considered event, the differences are small. The significant wave height $H_{1/3}$ at Gsb4 equals 0.17 m and at Gsc3 0.21m. The waves at the south transect are slightly higher, approximately 20%, compared to the north transect. The power spectral density graphs show that energy is contained in the frequency range from 0.3 to 0.6 Hz; however, slightly more energy is accumulated in that range for the southern DGD transect.

Table 13 – Number of large vessel events detected at the locations of the wave gauges.

location	Position on tidal flat	no-ship events
Gsb2 (north)	high	9
Gsb4 (north)	low	127
Gsc2 (south)	high	16
Gsc3 (south)	middle	63
Gsc4 (south)	low	114

Figure 7-1 – Typical no-ship events during the windy tidal cycle 61 (29/11/2015),
measured at Gsc4 (upper left) and Gsc3 (upper right) locations.
The figures below illustrate the corresponding Power Spectral Density (PSD) distributions.

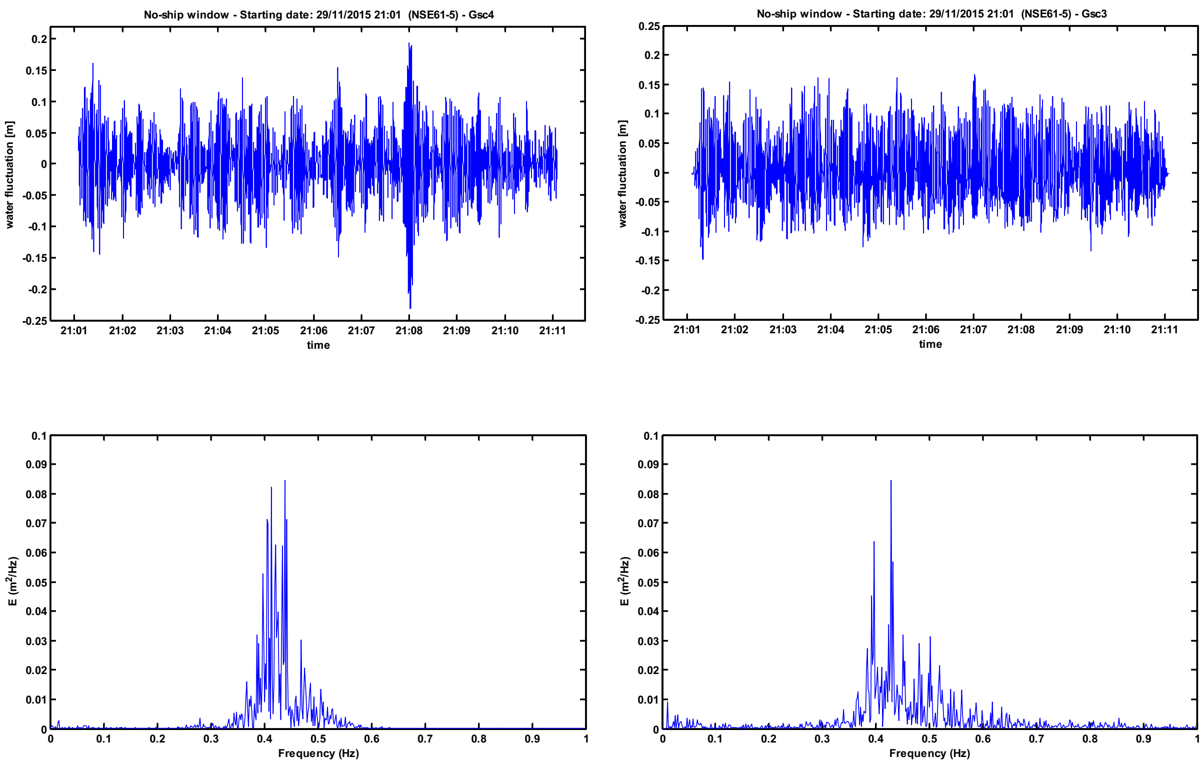
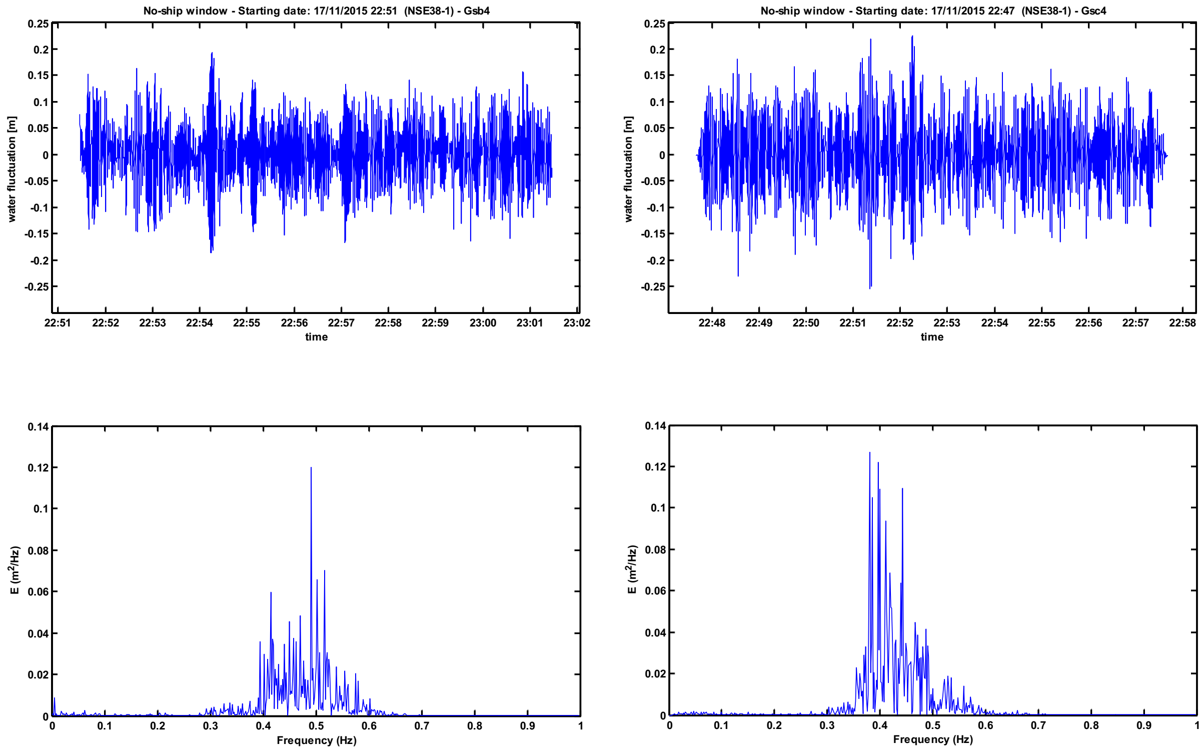


Figure 7-2 – Typical no-ship events during the windy tidal cycle 38 (17/11/2016), measured at Gsb4 (upper left) and Gsc4 (upper right) locations.
The figures below illustrate the corresponding Power Spectral Density (PSD) distributions.



7.2 Results of the analysis

The information related to each no-ship event, which combines hydrodynamic data (wave characteristics, water level) with wind data, was stored in separate tables, one for each of the measurement locations (Appendix B). The most relevant information, i.e. about the most energetic events, is shown in Table 15.

Note that

- in the index NSExx-x, the number of the tidal cycle is given by the first two numerical digits, while the last digit shows the number of the event in the respective tidal cycle
- the $H_{1/3}$ and H_{max} values resulted from the implementation of the zero down crossing method, as described in §4.5.1, on the signal of each no-ship event.
- Wind speed (WSpeed) and direction (WDir) correspond to the closest two-hour averaged values that are prior to the respective event

Table 15 indicates that the most energetic wind wave events are developed when 1.) wind blows from the southwestern direction (around 225° ± 10°) having a wind speed of about 18-20 m/s (see Figure 4-6), and 2.) for the lower tidal flat locations only, the water levels range between 2 and 3 m TAW.

Using all selected wind wave events (cf. Appendix B), figures for the distribution of significant wave height, $H_{1/3}$, and maximum wave height, H_{max} (Figure 7-3 to Figure 7-7), with regard to wind speed, wind direction, and water level were generated for each of the measurement locations.

It was found that

- $H_{1/3}$ and H_{max} correlate positively with wind speed: $H_{1/3}$ and H_{max} increase with increasing wind speed for all measuring locations

- the $H_{1/3}$ increase with increasing wind speed. An exponential relation can be observed, where the wave height becomes important for speeds greater than 10 m/s for all the measuring locations (see Table 14)
- the peak $H_{1/3}$ and H_{max} values are induced by southwestern winds (WDir = 225° ± 10°) of speed greater than 10-15 m/s for all the measuring locations

For the different locations, an exponential fit between the wind speed and the maximum and significant wave height for wind events was established (see Table 14).

Table 14 – Exponential fit between wind speed and maximum and significant wave height for wind events (y = exp(a + b*x)) for the diferent gauge locations

	Maximum wave height		**Significant wave height**	
	a	**b**	**a**	**B**
Gsb2 (north)	-3.81 ± 0.16	0.14 ± 0.01	-4.28 ± 0.21	0.14 ± 0.01
Gsb4 (north)	-4.22± 0.16	0.15 ± 0.01	-4.72 ± 0.16	0.15 ± 0.01
Gsc2 (south)	-3.16 ± 0.22	0.11 ± 0.01	-3.85 ± 0.26	0.12 ± 0.02
Gsc3 (south)	-3.59 ± 0.16	0.12±0.01	-4.18 ± 0.15	0.12 ± 0.01
Gsc4 (south)	-3.98 ± 0.15	0.15 ± 0.01	-4.53 ± 0.15	0.14 ± 0.01

For the Gsb4 location, 6 out of 127 events lead to $H_{1/3}$ > 0.15 m (Figure 7-3). For Gsc4 and Gsc3 locations the number of events was found to be 8 (out of 114) and 4 (out of 63) respectively (Figure 7-5 and Figure 7-6). The highest $H_{1/3}$ values were in the range from 0.20 to 0.30 m on the lower tidal flat (Gsb4 and Gsc4) and slightly decreased (from 0.20 to 0.25 m) on the shallower middle-high tidal flat (Gsc3). On the higher tidal flat positions (both Gsb2 and Gsc2), maximum $H_{1/3}$ values to 0.15 to 0.20 m are observed.

For the H_{max} distribution, 5 out of 127 and 7 out of 114 wind wave events lead to H_{max} > 0.30 m on the lower tidal flat at Gsb4 and Gsc4 respectively. 3 out of 63 events on the middle-high tidal flat (Gsc3) and 1 out of 9 and 2 out of 16 on the high tidal flat at Gsb2 and Gsc2 respectively show an H_{max} > 0.30 m. These lower numbers of higher wind waves at the (middle-)higher tidal flat locations occurred of course because inundation depths are smaller at these higher elevations.

Table 15 – Information of the most energetic no-ship events detected at the three measuring locations.

	index	Time (dd/mm/yyyy HH:MM)	Water level (m TAW)	H_{max} (m)	$H_{1/3}$ (m)	Wind Speed (m/s)	Wind Direction (degrees)
Gsb4	NSE38-2	17/11/2015 23:47	2.107	0.499	0.304	18.99	219.3
	NSE39-2	18/11/2015 03:04	3.029	0.420	0.261	21.23	235.3
	NSE38-1	17/11/2015 22:51	2.685	0.381	0.220	18.99	219.3
	NSE39-1	18/11/2015 01:56	2.006	0.346	0.243	20.59	228.1
	NSE61-4	29/11/2015 21:04	3.151	0.293	0.166	20.12	223.9
Gsb2	NSE33-1	15/11/2015 05:36	5.650	0.26	0.170	18.24	225.1
	NSE34-1	15/11/2015 17:40	5.540	0.18	0.125	14.33	227.4
	NSE59-1	28/11/2015 16:25	5.85	0.09	0.063	11.52	186.5
	NSE60-1	29/11/2015 5:12	5.56	0.08	0.043	10.22	204.2
	NSE62-1	30/11/2015 6:13	6.17	0.08	0.045	7.48	247.1
Gsc4	NSE38-1	17/11/2015 22:47	2.681	0.474	0.267	18.99	219.3
	NSE38-2	17/11/2015 23:54	2.010	0.460	0.291	18.99	219.3
	NSE39-1	18/11/2015 02:03	2.086	0.427	0.265	21.23	235.3
	NSE61-5	29/11/2015 21:01	3.140	0.422	0.205	20.12	223.9
	NSE39-2	18/11/2015 03:08	3.064	0.403	0.212	21.23	235.3
Gsc3	NSE61-4	29/11/2015 20:30	3.655	0.414	0.237	20.12	223.9
	NSE61-3	29/11/2015 19:28	4.716	0.353	0.156	17.10	217.6
	NSE61-2	29/11/2015 18:55	5.266	0.303	0.150	17.10	217.6
	NSE61-5	29/11/2015 21:01	3.133	0.292	0.201	20.12	223.9
	NSE39-1	18/11/2015 04:31	3.906	0.247	0.156	17.39	243.0
Gsc2	NSE33-1	15/11/2015 16:40	5.67	0.24	0.15	18.24	227.4
	NSE34-1	21/11/2015 10:59	5.54	0.21	0.10	14.33	204.0
	NSE61-1	29/11/2015 17:36	6.03	0.32	0.19	15.70	219.7
	NSE61-2	29/11/2015 18:55	5.17	0.29	0.20	17.10	217.6
	NSE62-1	30/11/2015 4:54	5.69	0.11	0.15	11.84	255.1

Figure 7-3 – Significant (left figures) & maximum wave height (right figures) versus wind speed, direction and water level for the no-ship events detected at Gsb4 location.

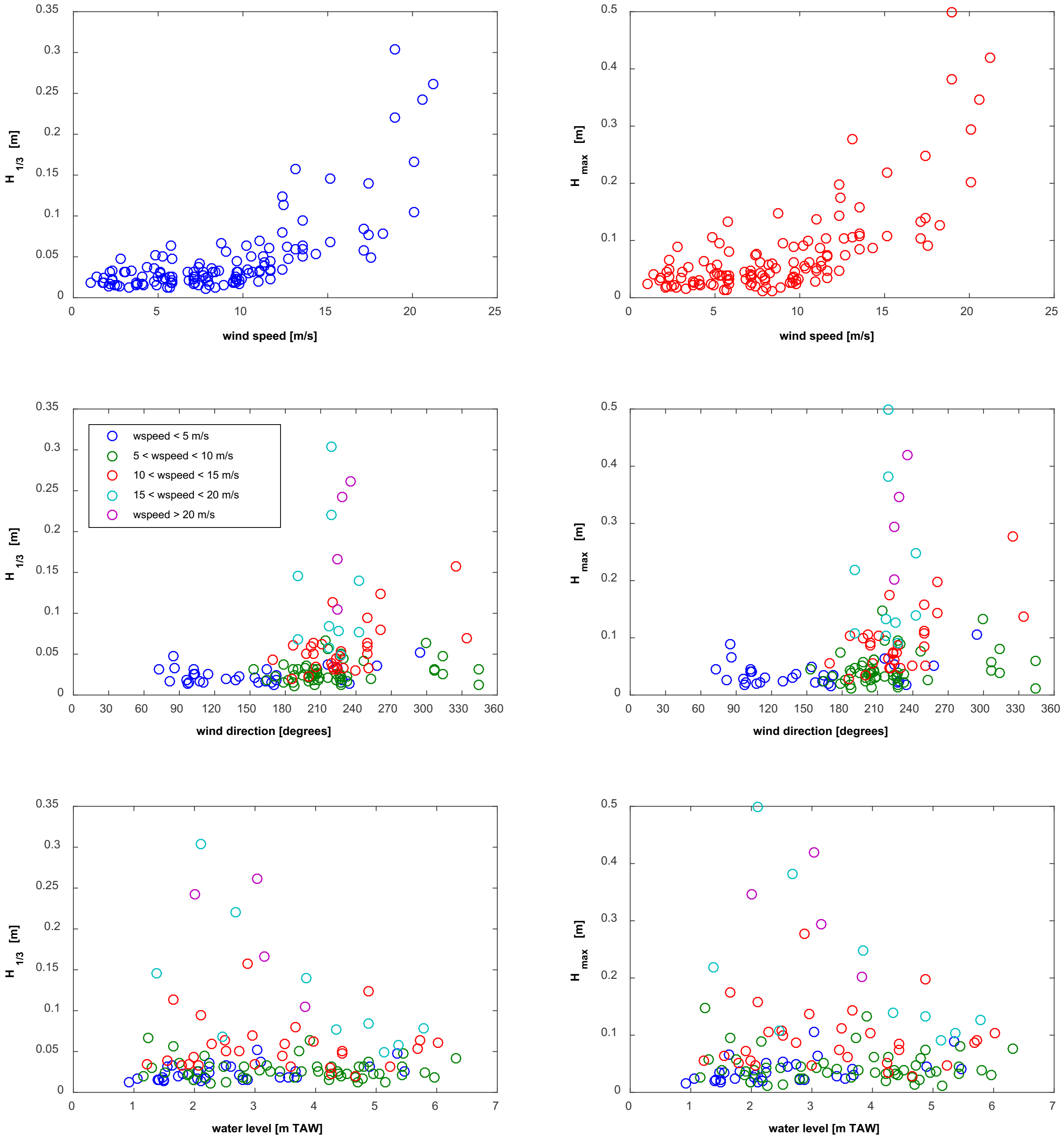
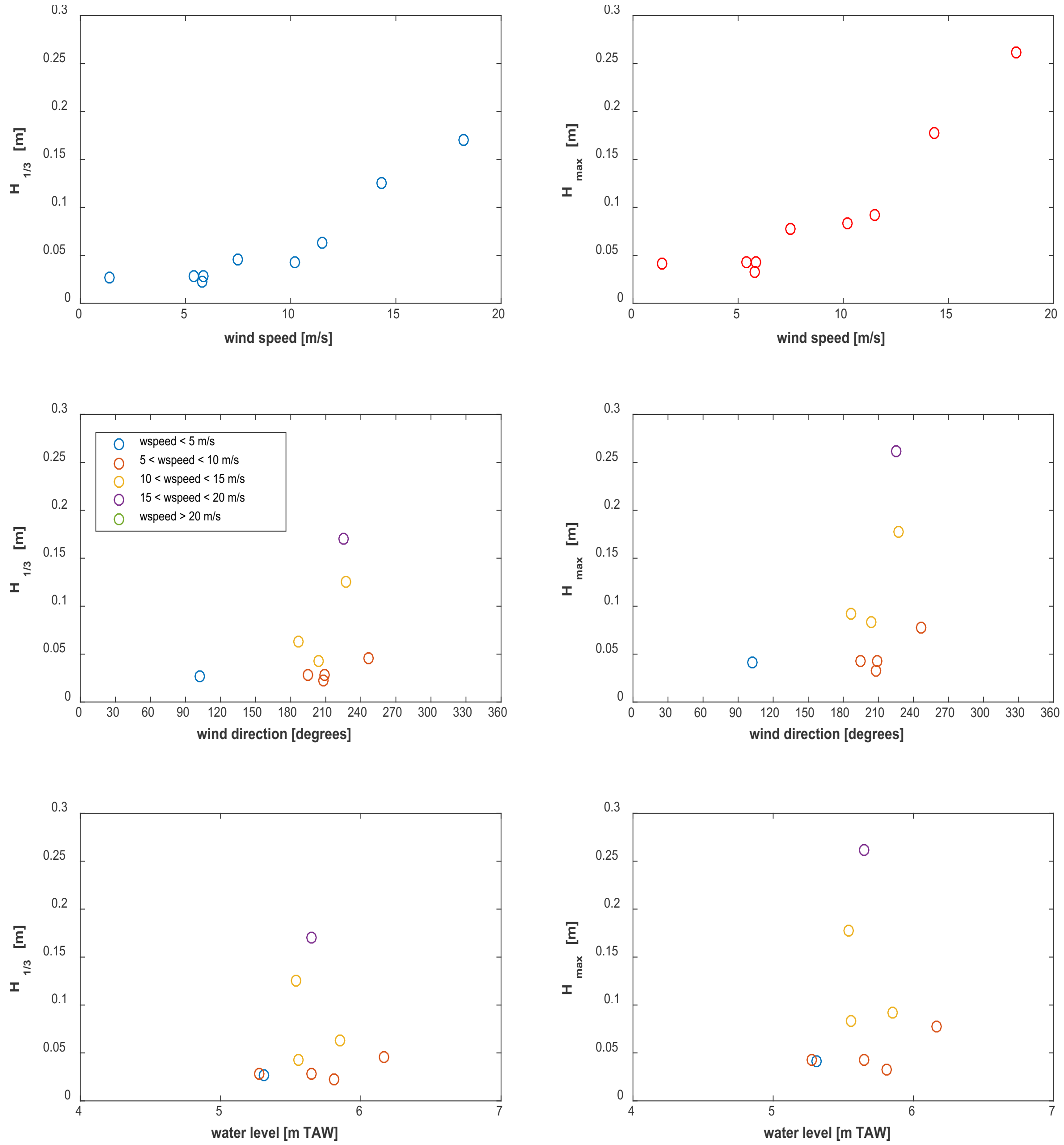


Figure 7-4 – Significant (left figures) & maximum wave heights (right figures) versus wind speed, wind direction and water level for the no-ship events detected at GSb2.



The legend only applies to the second row of figures (wind direction).

Figure 7-5 – Significant (left figures) & maximum wave height (right figures) versus wind speed, direction and water level for the no-ship events detected at Gsc4 location.

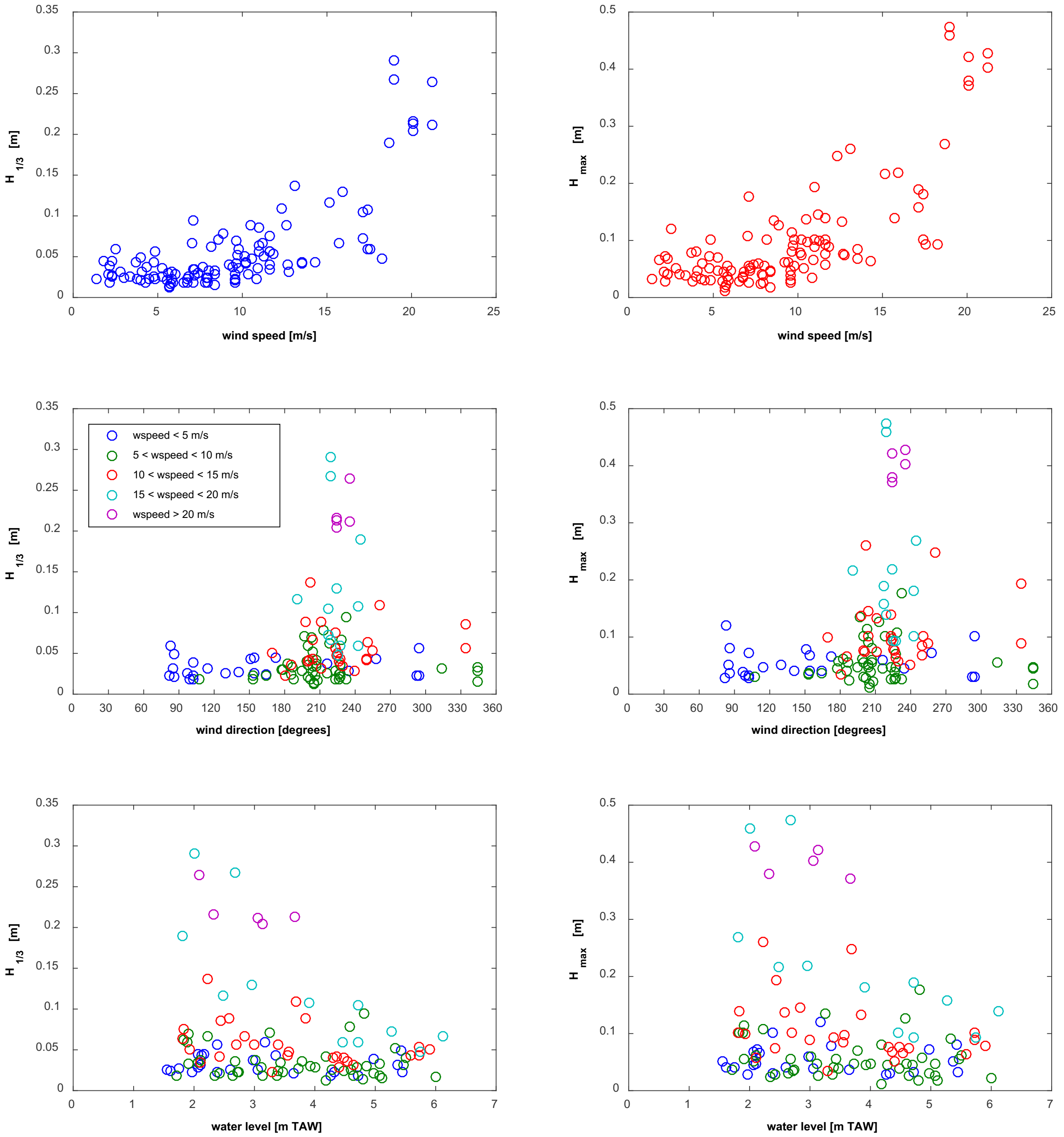


Figure 7-6 – Significant (left figures) & maximum wave height (right figures) versus wind speed, direction and water level for the no-ship events detected at Gsc3 location.

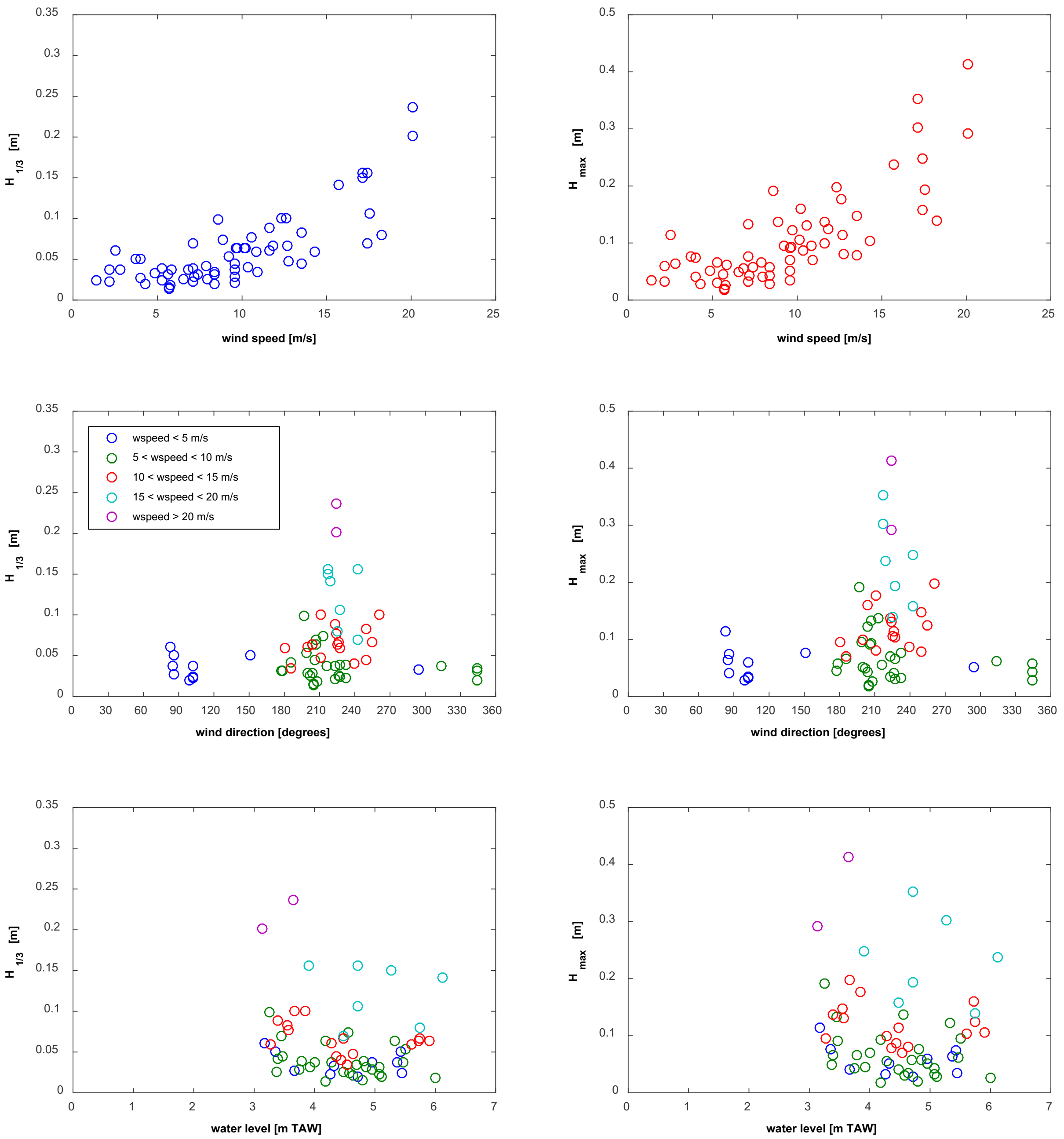
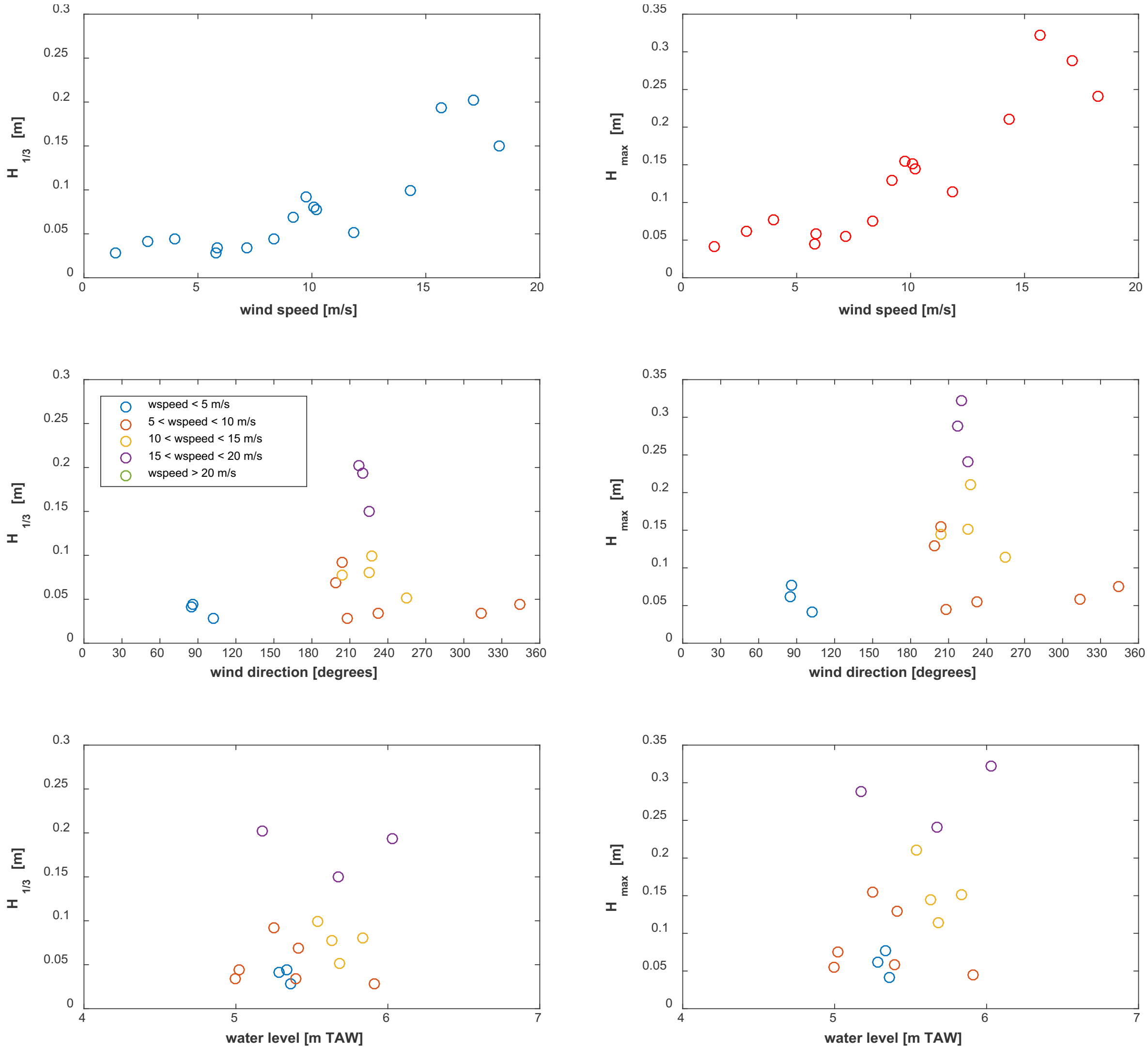


Figure 7-7 – Significant (left figures) & maximum wave heights (right figures) versus wind speed, wind direction and water level for the no-ship events detected at GSc2.



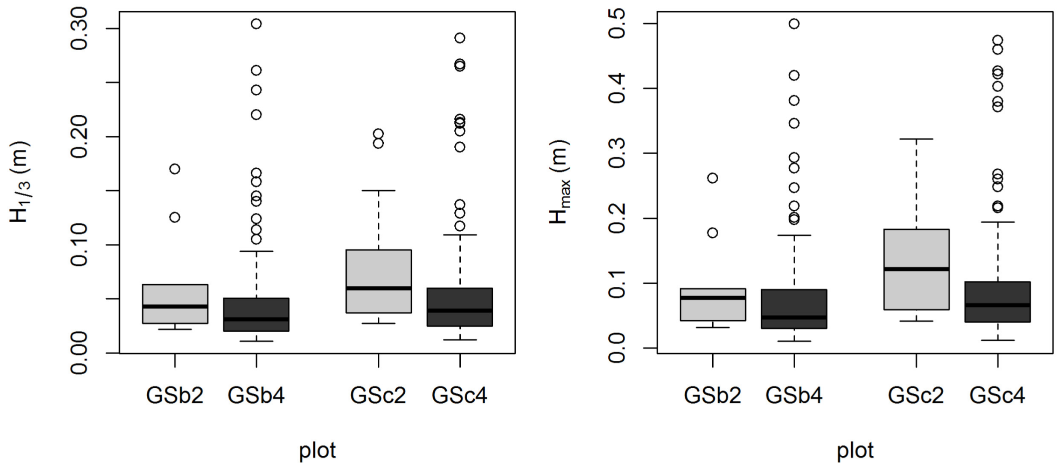
The legend only applies to the second row of figures (wind direction).

7.3 Wind wave comparison between low and high tidal flat

As for the ship wave analysis, it is interesting to directly compare the relative importance of wind-generated waves recorded at the low tidal flat (GSb4 and GSc4) to the waves measured at the high tidal flat (GSb2 and GSc2). Figure 7-8 gives an overview of the wave heights recorded for all no-ship events at all plots (n(GSb2)=9, n(GSb4)=127, n(GSc2)=16, n(GSc4)=113).

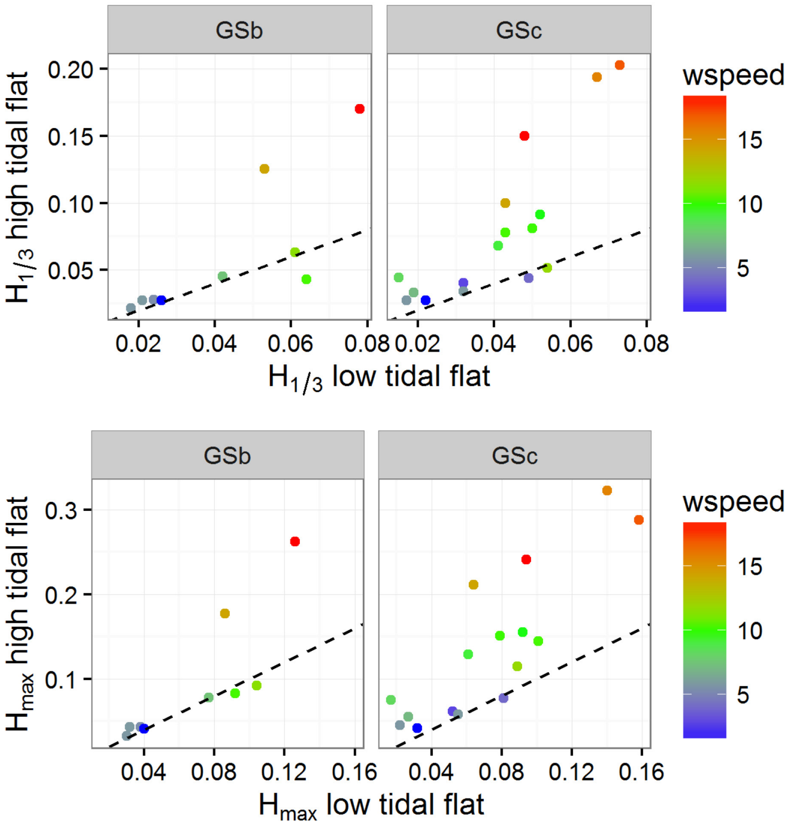
In Figure 7-9, wave heights recorded at the high tidal flat are plotted against wave heights recorded at the low tidal flat for concurrent no-ship windows. Additionally, respective wind speed is indicated by colour-coding of the plotted data points. If a point lies above the x=y line, wave heights recorded at the high tidal flat plot are higher than the incoming wave height recorded at the respective low tidal flat plot. It seems that wave heights of wind-induced waves do generally not increase at the northern SFD transect GSb, except for strong-wind events (orange and red points, > 14 m/s). Of course, it should be mentioned that only 9 data points are available, which makes it not possible to check if this statement is robust. As the southern DGD transect GSc, however, the waves recorded at the high tidal flat were generally higher than at the low tidal flat, but also here the increase in wave height was more pronounced under stronger winds (orange and red points, > 14 m/s). Again, this is based only on 16 observations. Overall, 88 % of all events led to higher wave heights (both, significant and maximum) at the high tidal flat compared to the low tidal flat.

Figure 7-8 – Comparison of wind waves (significant, $H_{1/3}$, and maximum, H_{max}, wave heights), recorded at the low and high tidal flat (plots 2 and 4, at around 5 m TAW and 1 m TAW, respectively) of both transects (GSb and GSc).



The boxes represent the interquartile range of the data and the whiskers delimit 1.5 times the interquartile range. The horizontal line indicates the median.

Figure 7-9 – Wave heights (significant, $H_{1/3}$, and maximum, H_{max}) for simultaneous no-ship events recorded simultaneously at low and high tidal flat plots at GSb (northern SFD transect) and GSc (southern DGD transect).



Wave heights recorded at the high tidal flat (approximately 5 m TAW) are plotted against wave heights recorded at the low tidal flat (approximately 1 m TAW). The dashed lines indicate where x=y. The colour gradient indicates wind speed (wspeed, m/s).

8 Conclusions

In this study, measurements gathered during an intensive measuring campaign of about 4 weeks at the intertidal area of Galgeschoor (November 2015), are reported and analysed. The generating mechanisms of waves that may have a substantial impact on the tidal marshes and mudflats at the area of interest, are related to dense shipping traffic, as well as to the action of wind. Therefore, the importance of ship and wind waves is further investigated.

The wave measurements are based on data recorded continuously by five pressure sensors (wave gauges) during the intensive measuring campaign. The sensors were installed at respectively a low and high mudflat position in the Saeftingedok (SFD, northern) transect (identifier: Gsb4 and Gsb2), while the other gauges were installed in the Deurganckdok (DGD, southern) transect at a low mudflat (Gsc4), a middle-high mudflat position (Gsc3) and a high mudflat position (Gsc2).

Static (type, length, beam, etc.) and dynamic (sailing speed, course, draught, etc.) data of the shipping traffic was retrieved by the AIS (Automatic Identification System) tracking system data base. Then, the coupling of wave measurements with ship data took place in order to investigate any correlations between ship and wave characteristics.

Wind data of Zandvlietsluis was used to carry out a similar wind wave analysis in order to correlate wind and wave characteristics.

Ship waves are characterized by a primary wave followed by secondary waves. The primary wave impact the river bank once (per ship). The secondary waves, a wave train, attack the banks of the river for a longer time period. The ship wave analysis in this report included the detection of single ship events (isolated and large vessel+tug boat events). It was found that

- Out of 7000 ship passages, about 350 to 400 events at the lower tdial positions (Gsb4, Gsc4), about 200 events at the middle-high mudflat position (Gsc3) and 26 and 46 events at the higher tidal flat locations Gsb2 and Gsc2 respectively fulfilled the criteria of a single ship event. This significantly lower number at the higher locations is due to their low inundation time, i.e. average the inundation time per tidal cycle is only 2 h.
- for inland navigation, a weak positive correlation of secondary wave height (H_{max}) with sailing speed (especially for tug boats) is found for the lower mudflat positions, which becomes stronger when the influence of wind is minimized by excluding the events during high wind speeds (> 6 Beaufort)
- for seagoing vessels, no obvious correlation is found between the secondary wave height and any of the considered parameters (ship speed, length, distance from the measuring location and water level)
- for the higher tidal positions, no obvious correlation of wave heights with any considerd parameters (ship speed, length, distance from the measuring location and water level) could be found for the limited number of considered events (less than 45)
- it was found that only a very few number of ship events (2-4%) for all the measuring locations presented a secondary wave height H_{max} > 0.30 m , while for the case of Gsc3 location H_{max} was always less than 0.40 m
- Simultaneously recorded ship passages at the low and high tidal flat indicate that in most cases (approximately 80%) the waves recorded at the high tidal flat are lower compared to the lower tidal flat. It should be noted however that this findings are based on a limited number of recordings of common events (respectively 24 and 46 for the northern and southern transect).

During the analysis of single ship events, many large vessels events were excluded because of the implemented criteria. Therefore, an extra analysis focusing on the detection of large vessel was performed, in order to investigate their induced primary wave patterns. It was found that

- the primary wave pattern recorded at the northern SFD transect (Gsb4 location) has a substantially enhanced wave height (maximum H_{prim} close to 0.80 m) compared to the southern DGD transect (Gsc4 location) when the ships were sailing downstream. This is mainly attributed to the increase of their sailing speed. The greater part of the ship wave events at the Gsb4, Gsc4 and Gsc3 locations had H_{prim} values less than 0.35 m, 0.2 m and 0.15 m respectively.
- in general, H_{prim} increases for increasing speed for the Gsb4 case, while this correlation appears to be even stronger for the case of Gsc4 location
- primary wave height increases for decreasing water level in all measurement locations and decreasing distance from the gauges at the lower mudflat locations (Gsb4, Gsc4)
- primary wave height can be correlated to different combinations of parameters (speed, length, water level), such as the product of speed and length, the ratio of speed to water level, and the product of speed and length divided by water level. These correlations are more pronounced for the two lower mudflat locations.
- for the northern location (Gsb4), there is a positive correlation between H_{prim} and draught and also with other combinations of parameters (draught x speed, draught x speed/water level), but especially with the ratio of the draught to water level. Results for the southern location (Gsc4) differ substantially, probably due to the fact that Gsc4 is at the stretch of Deurganckdok, while Gsb4 refers to a confined cross-section
- for the northern location only, H_{prim} presents a positive correlation with the ratio of beam to water level, which is improved by multiplying this ratio by the draught (i.e. draught x beam/water level)

The wind wave analysis was based on the detection of events, where no ships were passing and hence, wind was the only wave generating mechanism (no-ship events). The analysis of around 120 no-ship events at the lower mudflat positions (Gsb4, Gsc4), 60 events at the middle-high mudflat position (Gsc3) and approximately 10 at the high tidal flats (Gsb2, Gsc2) indicated that

- there is a positive correlation of $H_{1/3}$ and H_{max} and wind speed, i.e. $H_{1/3}$ and H_{max} increase with increasing wind speed for all the measuring locations
- the peak $H_{1/3}$ and H_{max} values are induced by southwestern winds (WDir = 225^o ± 10^o) having a wind speed higher than 10-15 m/s for all the measuring locations
- the highest $H_{1/3}$ values were in the range from 0.20 to 0.30 m on the lower tidal flat (Gsb4 and Gsc4) and slightly decreased (from 0.20 to 0.25 m) on the middlhe-high tidal flat Gsc3. On the highest positions the highest significant wave heights are in the order of 0.10 to 0.20 m. It was found that only a very few number of ship events for all the measuring locations presented H_{max} values greater than 0.30 m.
- Simultaneously recorded no-ship events at the low and high tidal flat indicate that in most cases (approximately 90%) the waves recorded at the high tidal flat are higher compared to the lower tidal flat. This effect is most pronounced at higher wind speeds. It should be noted however that this findings are based on a limited number of recordings of common events.

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Appendix A

Table 16 – Single ship events including large vessel-tug events (index with asterisk) detected at Gsb4 location (low mudflat – north transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE01-1	29/10/2015 19:30	INL80	110	12	0.1	5.55	upstream	746.61	2.889	0.023	0.016	5.60	177.81
SE01-2	29/10/2015 20:40	INL69	110	11	1.6	13.15	downstream	515.90	1.587	0.095	0.046	5.90	157.45
SE02-1	30/10/2015 01:15	INL79	110	12	1.5	12.27	upstream	773.69	1.103	0.082	0.047	6.23	139.02
SE02-2	30/10/2015 01:27	INL90	110	11	0	11.60	upstream	752.50	1.262	0.042	0.031	6.23	139.02
SE02-3	30/10/2015 02:52	INL90	86	10	4	10.91	upstream	765.56	2.523	0.028	0.018	4.14	97.74
SE02-4	30/10/2015 03:52	CAR70	180	32	7.1	8.69	downstream	589.47	4.624	0.066	0.033	4.14	97.74
SE02-5	30/10/2015 05:19	INL79	110	11	0	8.64	downstream	493.27	5.469	0.047	0.031	4.86	102.10
SE02-6	30/10/2015 06:56	INL79	80	9	0	9.94	downstream	488.44	4.009	0.055	0.034	5.23	106.30
SE02-7	30/10/2015 08:12	INL79	135	12	0.2	4.64	downstream	382.50	2.594	0.012	0.012	5.87	107.60
SE02-8	30/10/2015 09:11	INL79	110	11	0	8.16	downstream	547.35	1.493	0.017	0.015	5.87	107.60
SE03-1	30/10/2015 16:25	INL70	135	12	3.7	6.34	downstream	508.88	5.337	0.046	0.028	4.27	90.87
SE03-2	30/10/2015 20:09	INL52	28	12	6.2	11.50	downstream	485.70	2.969	0.019	0.015	4.55	89.32
SE04-1	31/10/2015 03:44	INL80	77	8	1	3.60	downstream	451.74	2.681	0.015	0.014	3.77	81.87
SE04-2	31/10/2015 04:34	CON74	128	21	6.1	9.76	upstream	756.42	4.274	0.035	0.025	3.99	86.28
SE04-3	31/10/2015 05:13	TNK89	140	22	7.2	8.95	downstream	555.33	5.353	0.116	0.074	3.99	86.28
SE04-4	31/10/2015 05:22	INL52	26	12	5.8	7.62	downstream	523.28	5.440	0.152	0.058	3.99	86.28
SE04-5	31/10/2015 06:51	INL79	127	11	0	5.46	upstream	693.53	4.706	0.030	0.021	4.61	89.99
SE04-6	31/10/2015 09:28	INL79	102	12	2	5.48	upstream	793.63	1.922	0.041	0.026	4.89	95.73
SE04-7	31/10/2015 10:12	INL52	33	12	5.4	6.24	upstream	812.74	1.198	0.012	0.012	5.51	105.90
SE05-1	31/10/2015 14:55	INL70	84	10	0	9.46	upstream	754.21	1.896	0.041	0.026	5.28	115.29

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE05-2	31/10/2015 16:52	INL80	110	12	0.2	5.42	downstream	488.99	4.419	0.049	0.026	3.05	117.80
SE05-3	31/10/2015 17:08	INL79	81	10	2	13.16	upstream	667.85	4.972	0.041	0.029	3.05	117.80
SE05-4	31/10/2015 19:28	INL79	135	14	0.4	11.05	downstream	514.52	4.444	0.048	0.026	2.15	101.81
SE05-5	31/10/2015 19:55	INL79	110	11	0.3	4.32	upstream	700.69	3.985	0.016	0.014	2.15	101.81
SE05-6	31/10/2015 20:48	CON73	222	30	10.4	14.25	downstream	618.88	3.077	0.051	0.033	2.14	107.61
SE05-7	31/10/2015 21:01	INL79	135	11	0.1	9.74	downstream	626.24	2.835	0.032	0.022	2.14	107.61
SE05-8	31/10/2015 21:21	INL80	135	12	3.4	12.38	downstream	547.66	2.466	0.022	0.018	2.14	107.61
SE05-9	31/10/2015 21:57	RRC70	199	35	8.9	11.90	downstream	695.05	1.807	0.042	0.032	2.14	107.61
SE06-1	01/11/2015 02:46	INL80	85	12	2.2	9.05	upstream	749.43	1.686	0.016	0.015	1.82	172.26
SE06-2	01/11/2015 03:16	INL52	26	12	5.8	6.40	downstream	458.68	2.044	0.087	0.047	1.82	172.26
SE06-3*	01/11/2015 04:37	CON73	260	32	10.1	7.51	upstream	733.48	3.298	0.076	0.046	1.73	138.05
SE06-4	01/11/2015 05:18	INL90	110	17	3	4.74	downstream	498.43	4.477	0.044	0.024	1.73	138.05
SE06-5	01/11/2015 05:31	GEN70	105	16	6.4	17.98	upstream	685.87	4.901	0.111	0.045	1.73	138.05
SE06-6	01/11/2015 07:21	INL69	100	12	0.2	9.28	downstream	495.13	5.095	0.055	0.030	1.40	102.21
SE06-7	01/11/2015 07:41	INL99	195	23	0.1	8.97	downstream	512.21	4.782	0.065	0.046	1.40	102.21
SE06-8	01/11/2015 08:21	INL89	135	11	2	8.04	upstream	662.93	4.140	0.102	0.050	3.74	151.29
SE06-9	01/11/2015 08:54	INL79	80	9	1	11.69	downstream	484.25	3.584	0.221	0.088	3.74	151.29
SE06-10	01/11/2015 09:21	INL52	30	11	5.2	7.23	upstream	873.32	3.099	0.150	0.048	3.74	151.29
SE06-11	01/11/2015 09:32	RRC71	211	32	8.1	9.00	upstream	643.41	2.896	0.168	0.080	3.74	151.29
SE06-12	01/11/2015 09:42	INL99	86	11	0.2	10.57	downstream	529.55	2.702	0.059	0.037	3.74	151.29
SE06-13	01/11/2015 10:03	INL52	25	11	5	9.11	upstream	845.50	2.319	0.131	0.050	2.42	168.34
SE06-14	01/11/2015 10:44	INL80	86	10	0.2	9.48	upstream	814.28	1.623	0.047	0.031	2.42	168.34
SE07-1	01/11/2015 14:16	TNK81	183	32	8.3	9.62	upstream	674.87	1.037	0.027	0.020	1.22	223.80
SE07-2	01/11/2015 15:06	INL00	0	0	0	7.18	upstream	843.36	1.825	0.016	0.014	1.22	223.80
SE07-3	01/11/2015 16:32	INL80	77	8	1	15.48	upstream	583.31	2.919	0.051	0.032	1.46	23.97
SE07-4	01/11/2015 17:09	INL52	26	12	5.8	13.75	upstream	690.06	3.653	0.043	0.025	1.46	23.97
SE07-5	01/11/2015 18:46	INL79	135	17	1.5	14.46	upstream	713.17	5.437	0.074	0.050	2.78	85.31
SE07-6	01/11/2015 19:02	INL80	110	11	0.4	10.50	upstream	792.66	5.369	0.097	0.045	2.78	85.31

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE07-7	01/11/2015 19:25	INL90	85	9	0	9.63	downstream	499.61	5.145	0.030	0.020	2.78	85.31
SE07-8	01/11/2015 19:48	INL52	32	12	5.4	12.42	upstream	765.18	4.844	0.309	0.077	2.78	85.31
SE07-9	01/11/2015 20:48	INL79	196	11	2.8	4.56	upstream	698.25	3.890	0.024	0.018	2.50	82.63
SE08-1	02/11/2015 04:00	RRC70	178	24	7	13.79	upstream	714.55	2.116	0.151	0.066	3.07	72.39
SE08-2	02/11/2015 05:02	CON70	243	33	10	6.75	downstream	612.51	2.871	0.062	0.036	3.07	72.39
SE08-3	02/11/2015 05:11	INL80	110	11	3.2	9.52	upstream	813.79	3.016	0.028	0.022	3.07	72.39
SE08-4*	02/11/2015 05:24	CON79	366	48	12.6	5.85	upstream	701.76	3.247	0.029	0.022	3.07	72.39
SE08-5	02/11/2015 11:13	INL79	135	12	1.7	8.25	upstream	432.48	1.680	0.152	0.051	3.39	86.90
SE08-6	02/11/2015 11:43	INL79	183	12	1	8.07	downstream	507.50	1.237	0.025	0.016	3.39	86.90
SE09-1	02/11/2015 19:42	INL00	177	5	0.3	10.71	upstream	689.14	5.175	0.066	0.036	2.40	238.21
SE09-2	02/11/2015 21:23	INL99	85	9	2	7.16	upstream	687.81	3.996	0.037	0.024	1.05	228.72
SE09-3	02/11/2015 23:13	INL79	190	22	1.4	7.45	upstream	425.52	2.171	0.051	0.028	2.26	153.78
SE10-1*	03/11/2015 05:03	CON70	210	30	9.5	8.56	upstream	716.53	2.327	0.159	0.062	3.32	96.69
SE10-2	03/11/2015 06:03	INL80	110	16	0.5	9.09	upstream	474.21	3.142	0.155	0.061	3.69	96.57
SE10-3	03/11/2015 12:25	INL52	28	12	6.2	7.64	upstream	804.43	1.258	0.075	0.053	3.24	95.84
SE11-1	03/11/2015 18:16	INL79	86	9	0.4	8.38	downstream	255.95	2.925	0.109	0.060	2.22	81.59
SE11-2	03/11/2015 18:28	INL79	86	10	1	5.84	downstream	230.49	3.166	0.066	0.030	2.22	81.59
SE11-3	03/11/2015 23:28	INL79	110	11	0.3	11.45	downstream	569.56	2.796	0.084	0.038	3.96	116.77
SE11-4	03/11/2015 23:47	INL52	28	12	6.2	12.57	downstream	487.09	2.481	0.097	0.052	3.96	116.77
SE11-5	03/11/2015 23:59	GEN70	98	17	4.9	7.20	upstream	721.53	2.284	0.082	0.040	3.96	116.77
SE11-6	04/11/2015 01:07	RRC79	154	22	6.3	14.10	upstream	664.76	1.347	0.221	0.107	4.76	129.24
SE12-1	04/11/2015 03:46	INL79	110	11	0.3	5.72	downstream	542.58	0.923	0.013	0.013	3.84	114.58
SE12-2	04/11/2015 04:26	INL99	67	8	2.8	10.24	upstream	767.22	1.438	0.069	0.041	4.09	114.19
SE13-1	04/11/2015 17:30	TNK89	185	28	8.2	13.04	upstream	687.55	1.498	0.101	0.049	5.30	181.58
SE13-2	04/11/2015 19:14	INL79	86	10	1	8.56	downstream	217.39	3.013	0.141	0.059	7.55	187.44
SE13-3	04/11/2015 21:27	INL52	25	12	6	8.80	downstream	502.56	4.711	0.101	0.064	7.08	190.40
SE13-4	04/11/2015 23:08	INL79	110	12	2	9.78	downstream	518.64	3.936	0.043	0.026	6.25	181.08
SE13-5	04/11/2015 23:54	DRG33	98	22	0	12.15	downstream	568.90	3.301	0.025	0.019	6.25	181.08

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE13-6*	05/11/2015 02:31	CON71	210	30	9.9	10.80	downstream	624.53	1.222	0.086	0.047	4.03	163.49
SE15-1	05/11/2015 18:47	INL80	0	0	0	8.70	downstream	492.49	1.410	0.068	0.039	7.46	171.79
SE15-2	05/11/2015 23:07	INL52	28	12	6.2	13.78	downstream	502.28	4.663	0.147	0.080	9.90	171.41
SE15-3	05/11/2015 23:17	INL80	82	11	0	9.19	upstream	768.67	4.591	0.127	0.065	9.90	171.41
SE15-4	05/11/2015 23:48	INL80	110	14	3.2	9.06	upstream	735.49	4.355	0.040	0.026	9.90	171.41
SE15-5	06/11/2015 00:23	INL80	86	11	2.3	10.11	downstream	506.78	3.976	0.051	0.032	8.95	183.71
SE15-6	06/11/2015 01:40	TNK82	96	15	4.6	14.64	downstream	552.37	2.999	0.083	0.046	8.95	183.71
SE15-7	06/11/2015 02:15	CAR70	199	32	9.1	24.98	upstream	653.31	2.484	0.089	0.052	8.19	184.74
SE15-8	06/11/2015 02:27	CON72	147	23	6.9	13.52	downstream	537.96	2.322	0.029	0.019	8.19	184.74
SE15-9	06/11/2015 02:40	DRG33	98	22	0	11.96	upstream	643.41	2.142	0.168	0.073	8.19	184.74
SE15-10	06/11/2015 02:51	TNK89	114	17	7.4	10.51	upstream	739.50	2.001	0.137	0.083	8.19	184.74
SE15-11	06/11/2015 03:18	INL79	135	7	0.1	9.40	downstream	570.66	1.684	0.024	0.018	8.19	184.74
SE15-12	06/11/2015 03:39	INL79	127	11	0	6.16	downstream	563.02	1.456	0.011	0.011	8.19	184.74
SE16-1	06/11/2015 06:37	DRG33	98	22	0	13.06	upstream	665.24	1.234	0.142	0.061	7.00	183.42
SE16-2	06/11/2015 06:56	INL79	135	11	1.7	4.46	downstream	464.62	1.486	0.018	0.015	7.00	183.42
SE16-3	06/11/2015 08:13	INL53	19	5	1.6	11.49	upstream	361.20	2.379	0.105	0.046	6.68	191.63
SE17-1	06/11/2015 21:15	INL79	110	11	1	10.14	upstream	728.52	2.593	0.027	0.018	10.17	200.74
SE17-2	06/11/2015 21:26	INL52	28	12	6.2	10.80	downstream	485.81	2.774	0.252	0.095	10.17	200.74
SE17-3	06/11/2015 22:00	INL99	110	11	4	6.95	downstream	511.35	3.367	0.072	0.040	8.73	206.54
SE17-4	06/11/2015 23:18	RRC74	205	26	7.5	9.04	downstream	543.42	4.619	0.145	0.058	8.73	206.54
SE17-5	06/11/2015 23:51	INL89	110	10	0.1	7.54	downstream	470.02	4.824	0.038	0.027	8.73	206.54
SE17-6	07/11/2015 00:01	GEN70	87	11	3.3	13.05	upstream	711.32	4.842	0.067	0.032	7.35	216.95
SE17-7	07/11/2015 01:53	INL79	86	11	0	11.08	downstream	541.79	3.877	0.064	0.031	7.35	216.95
SE17-8	07/11/2015 02:34	RRC71	205	29	7.5	8.98	upstream	682.64	3.310	0.213	0.102	6.08	235.38
SE17-9	07/11/2015 04:42	INL89	110	10	0.1	6.17	upstream	805.96	1.498	0.023	0.019	3.97	226.04
SE17-10	07/11/2015 05:28	INL80	86	10	0.3	8.37	upstream	410.13	0.974	0.076	0.036	3.97	226.04
SE18-1	07/11/2015 07:47	INL79	110	11	2.5	5.30	downstream	472.23	1.066	0.043	0.024	3.93	193.27
SE18-2	07/11/2015 08:26	INL80	110	11	3.2	9.44	upstream	761.07	1.646	0.018	0.015	5.64	184.95

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE18-3	07/11/2015 09:18	INL52	33	12	5.4	12.63	upstream	783.52	2.228	0.139	0.066	5.64	184.95
SE18-4	07/11/2015 09:50	INL79	113	44	1	5.36	upstream	793.57	2.607	0.020	0.014	5.64	184.95
SE18-5	07/11/2015 13:09	INL52	32	12	5.4	13.73	upstream	800.80	4.737	0.029	0.020	7.40	178.95
SE18-6	07/11/2015 15:01	INL90	108	11	0	5.25	upstream	770.07	3.247	0.025	0.019	7.90	185.66
SE18-7	07/11/2015 15:22	INL99	85	8	0.3	11.65	downstream	521.44	2.941	0.075	0.042	7.90	185.66
SE18-8	07/11/2015 15:39	INL79	135	11	1.8	6.91	downstream	505.21	2.670	0.015	0.014	7.90	185.66
SE18-9	07/11/2015 16:52	TNK81	130	20	6	9.89	upstream	686.61	1.607	0.189	0.106	8.04	186.47
SE19-1	07/11/2015 20:27	TNK89	100	15	6	9.65	downstream	487.53	1.118	0.067	0.043	11.59	229.09
SE19-2	07/11/2015 21:08	INL80	93	12	1.7	11.00	upstream	748.94	1.845	0.052	0.032	11.59	229.09
SE19-3	07/11/2015 22:02	CON71	365	49	14.3	7.61	downstream	568.80	2.575	0.107	0.051	7.93	226.52
SE19-4*	08/11/2015 00:09	CON71	194	28	8.9	10.10	upstream	618.14	4.784	0.094	0.049	7.13	232.15
SE19-5	08/11/2015 00:29	RRC70	188	27	6.8	10.35	downstream	533.77	4.974	0.144	0.069	7.13	232.15
SE19-6	08/11/2015 00:44	TNK82	112	17	7.4	14.40	upstream	679.07	5.057	0.479	0.122	7.13	232.15
SE19-7	08/11/2015 01:03	INL52	32	12	5.3	9.37	downstream	476.87	5.094	0.056	0.040	7.13	232.15
SE19-8	08/11/2015 01:38	GEN70	107	14	3.8	10.68	downstream	516.42	4.926	0.091	0.056	7.13	232.15
SE19-9	08/11/2015 04:49	GEN70	136	21	7.4	9.82	upstream	682.53	2.156	0.147	0.075	3.01	190.64
SE19-10	08/11/2015 05:00	INL79	135	11	2.6	6.73	upstream	714.83	1.996	0.038	0.028	3.01	190.64
SE19-11	08/11/2015 06:04	INL89	110	11	2	8.07	downstream	402.05	1.111	0.029	0.021	3.27	170.29
SE20-1	08/11/2015 10:03	INL52	33	12	5.4	12.39	upstream	780.44	2.202	0.200	0.097	5.80	163.87
SE20-2	08/11/2015 10:17	INL89	110	13	2.4	9.46	upstream	718.87	2.343	0.023	0.017	5.80	163.87
SE20-3	08/11/2015 10:41	CON70	128	21	8	11.10	downstream	607.93	2.601	0.096	0.064	5.80	163.87
SE20-4*	08/11/2015 11:47	CON70	300	48	10.3	7.94	upstream	708.88	3.515	0.067	0.039	5.80	163.87
SE20-5	08/11/2015 12:04	INL70	67	7	0	10.74	upstream	738.03	3.847	0.058	0.036	6.37	149.05
SE20-6	08/11/2015 13:37	INL79	105	10	1.5	9.72	upstream	758.95	4.862	0.029	0.022	6.37	149.05
SE20-7	08/11/2015 14:12	INL33	33	18	3	3.26	downstream	489.43	4.467	0.050	0.030	7.58	146.41
SE20-8	08/11/2015 15:24	INL79	135	17	2	6.72	upstream	774.07	3.455	0.041	0.025	7.58	146.41
SE20-9	08/11/2015 15:51	TNK83	99	16	6.7	9.10	upstream	733.76	3.049	0.123	0.054	7.58	146.41
SE20-10	08/11/2015 16:32	INL33	33	18	3	1.70	upstream	738.91	2.420	0.013	0.013	6.76	152.84

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE20-11	08/11/2015 16:44	INL70	135	11	3	5.58	upstream	590.88	2.221	0.031	0.027	6.76	152.84
SE21-1	08/11/2015 23:41	RRC79	214	32	8.7	10.74	upstream	674.43	2.579	0.047	0.028	10.28	205.82
SE21-2	09/11/2015 00:02	CAR70	200	32	8.5	6.28	downstream	585.13	3.050	0.142	0.068	9.52	216.98
SE21-3	09/11/2015 01:47	INL80	49	8	2.6	7.53	upstream	752.64	4.774	0.049	0.026	9.52	216.98
SE21-4	09/11/2015 01:57	INL70	126	12	0.1	10.61	upstream	769.89	4.756	0.062	0.032	9.52	216.98
SE21-5	09/11/2015 02:52	GEN70	89	14	5.4	10.85	upstream	706.22	4.275	0.157	0.084	9.55	223.72
SE21-6	09/11/2015 04:39	GAS80	160	26	8.2	10.13	upstream	689.93	2.735	0.132	0.067	8.84	227.16
SE22-1	09/11/2015 11:23	INL52	26	12	5.8	15.30	upstream	680.23	3.077	0.155	0.066	11.74	224.61
SE22-2	09/11/2015 11:40	GEN70	140	21	7.4	8.72	upstream	665.43	3.340	0.052	0.035	11.74	224.61
SE22-3	09/11/2015 12:22	INL79	172	11	0.4	5.01	downstream	485.77	4.094	0.066	0.039	12.06	221.50
SE23-1	09/11/2015 22:22	INL79	56	8	0.1	6.56	upstream	373.81	1.631	0.059	0.037	12.58	212.85
SE23-2	10/11/2015 02:49	TNK81	146	24	9.1	8.33	upstream	628.56	5.384	0.040	0.024	10.36	197.94
SE23-3	10/11/2015 03:06	INL79	110	11	0.3	6.66	downstream	517.46	5.234	0.027	0.019	10.36	197.94
SE23-4	10/11/2015 04:52	INL52	28	12	6.2	14.39	downstream	507.60	3.630	0.079	0.041	9.45	205.19
SE23-5	10/11/2015 05:04	INL79	135	14	2.6	8.39	downstream	487.53	3.426	0.037	0.020	9.45	205.19
SE23-6*	10/11/2015 06:11	CON71	210	30	10	3.98	upstream	713.13	2.297	0.030	0.023	9.65	202.39
SE23-7	10/11/2015 06:21	INL79	110	12	0	9.98	downstream	541.95	2.138	0.023	0.017	9.65	202.39
SE23-8	10/11/2015 07:44	INL79	110	12	2.5	6.49	upstream	779.57	1.052	0.012	0.012	9.65	202.39
SE24-1	10/11/2015 13:54	INL99	85	5	0.2	11.12	upstream	673.16	5.247	0.051	0.036	10.51	204.67
SE24-2	10/11/2015 14:35	INL99	85	9	2	7.75	downstream	484.05	5.488	0.081	0.036	8.94	205.28
SE25-1	11/11/2015 00:17	INL79	110	10	1.4	8.99	upstream	800.24	2.615	0.023	0.016	8.86	200.71
SE25-2	11/11/2015 02:51	INL52	25	12	6	6.14	downstream	521.86	5.518	0.070	0.040	9.20	198.76
SE25-3	11/11/2015 03:13	INL90	134	14	2.5	5.40	downstream	457.60	5.444	0.050	0.030	9.20	198.76
SE26-1	11/11/2015 16:21	INL70	110	12	2.6	5.98	upstream	881.79	4.720	0.038	0.026	7.91	182.06
SE26-2	11/11/2015 19:25	INL79	135	14	0	4.87	upstream	749.71	1.654	0.027	0.020	8.54	186.46
SE26-3	11/11/2015 20:03	CON70	254	32	11.6	12.01	downstream	625.40	1.097	0.029	0.020	9.10	196.25
SE26-4	11/11/2015 20:19	INL52	28	12	6.2	13.41	downstream	498.48	0.891	0.086	0.048	9.10	196.25
SE27-1	12/11/2015 00:53	CAR70	177	32	7.6	10.96	downstream	591.40	2.475	0.136	0.069	7.20	203.45

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE27-2	12/11/2015 02:33	INL79	135	12	1.7	10.57	upstream	451.48	4.853	0.073	0.039	5.85	208.82
SE27-3*	12/11/2015 03:04	CON71	210	32	10.3	9.71	upstream	710.63	5.430	0.046	0.029	5.85	208.82
SE27-4	12/11/2015 03:29	INL00	84	9	0	9.63	upstream	751.37	5.510	0.077	0.035	5.85	208.82
SE27-5	12/11/2015 04:00	INL79	98	11	2	6.68	downstream	505.79	5.306	0.023	0.017	5.65	204.80
SE27-6	12/11/2015 04:29	INL79	22	11	2	7.45	downstream	597.63	4.940	0.022	0.016	5.65	204.80
SE27-7	12/11/2015 05:05	INL79	135	18	2.1	10.82	downstream	518.65	4.374	0.107	0.045	5.65	204.80
SE27-8	12/11/2015 05:27	TNK80	183	32	8.8	7.60	upstream	676.99	4.021	0.085	0.047	5.65	204.80
SE27-9	12/11/2015 06:45	INL79	86	9	0	9.24	downstream	530.60	2.698	0.031	0.020	6.56	202.30
SE27-10	12/11/2015 06:55	INL70	110	11	3.2	8.31	upstream	673.72	2.516	0.087	0.049	6.56	202.30
SE27-11	12/11/2015 07:30	INL52	26	12	5.8	11.27	downstream	551.57	1.881	0.023	0.019	6.56	202.30
SE27-12	12/11/2015 07:42	INL52	32	12	5.4	11.41	downstream	482.86	1.689	0.090	0.055	6.56	202.30
SE27-13	12/11/2015 07:52	INL79	80	9	0	8.27	downstream	513.08	1.538	0.021	0.016	6.56	202.30
SE27-14	12/11/2015 08:35	CON71	203	27	8.4	14.08	downstream	555.13	0.914	0.041	0.029	5.82	200.96
SE28-1	12/11/2015 11:16	INL00	84	9	0	8.40	downstream	476.99	0.946	0.103	0.053	6.12	201.59
SE28-2	12/11/2015 15:01	CON70	110	17	2.5	3.91	downstream	501.93	4.998	0.045	0.024	5.92	170.24
SE29-1	12/11/2015 23:57	TNK80	105	17	6.1	15.01	upstream	718.76	1.159	0.127	0.051	7.00	184.77
SE29-2	13/11/2015 00:37	INL79	110	11	1	3.31	downstream	519.29	1.668	0.030	0.021	8.20	186.54
SE29-3	13/11/2015 02:42	INL79	135	14	1	9.92	upstream	425.23	3.832	0.212	0.071	9.86	195.60
SE29-4	13/11/2015 02:52	INL90	134	14	2.7	13.11	upstream	671.29	4.164	0.050	0.034	9.86	195.60
SE29-5	13/11/2015 03:06	INL79	135	15	0	12.83	upstream	703.26	4.609	0.056	0.034	9.86	195.60
SE29-6	13/11/2015 08:20	INL89	135	23	1.6	3.82	upstream	818.62	1.430	0.026	0.019	5.69	212.99
SE30-1	13/11/2015 13:49	INL79	86	10	3.2	9.42	upstream	793.48	2.594	0.027	0.019	8.75	214.28
SE30-2	13/11/2015 15:17	INL00	58	7	0	13.92	upstream	735.48	5.069	0.144	0.069	11.77	224.32
SE30-3	13/11/2015 15:35	INL80	110	11	0.3	12.91	upstream	706.45	5.558	0.095	0.052	11.77	224.32
SE31-1	14/11/2015 00:15	TNK80	110	17	6.4	10.61	upstream	725.07	2.900	0.049	0.032	7.10	206.73
SE31-2	14/11/2015 00:27	INL79	86	11	3.4	12.55	upstream	724.10	2.981	0.323	0.075	7.10	206.73
SE31-3	14/11/2015 03:36	INL90	86	11	2	10.88	upstream	740.95	5.595	0.056	0.035	9.64	206.70
SE31-4	14/11/2015 04:21	INL79	102	12	2	9.17	upstream	782.22	6.128	0.034	0.023	7.92	213.60

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE31-5	14/11/2015 04:45	INL79	177	12	1.7	4.97	downstream	488.31	6.055	0.030	0.023	7.92	213.60
SE31-6	14/11/2015 05:20	INL79	110	10	1	10.00	downstream	491.25	5.671	0.086	0.047	7.92	213.60
SE31-7	14/11/2015 07:15	INL79	86	10	1	6.33	upstream	743.40	3.802	0.019	0.015	6.78	215.78
SE31-8	14/11/2015 09:28	INL79	0	0	3.4	9.12	downstream	562.02	1.485	0.011	0.011	7.18	208.08
SE32-1	14/11/2015 12:28	INL00	0	0	0	9.12	upstream	540.64	1.438	0.038	0.024	7.77	213.16
SE32-2	14/11/2015 12:57	INL52	25	12	6	6.03	upstream	765.05	1.965	0.026	0.018	7.77	213.16
SE32-3	14/11/2015 13:34	TNK80	98	14	4.5	10.23	upstream	769.93	2.418	0.031	0.021	7.77	213.16
SE32-4	14/11/2015 14:51	INL79	186	11	2	11.02	upstream	676.50	3.311	0.050	0.029	7.69	207.24
SE32-5	14/11/2015 16:46	TNK81	177	31	9.4	10.40	downstream	569.08	5.723	0.169	0.078	8.21	199.31
SE32-6	14/11/2015 16:59	TNK82	141	24	8.7	13.00	upstream	699.17	5.694	0.119	0.059	8.21	199.31
SE32-7	14/11/2015 19:15	TNK83	99	16	6.9	7.99	upstream	712.87	3.748	0.088	0.049	10.88	185.53
SE32-8	14/11/2015 21:12	INL80	110	12	2.8	5.85	upstream	800.90	1.779	0.079	0.048	14.67	194.44
SE32-9	14/11/2015 21:21	INL80	110	12	3.4	6.59	upstream	776.82	1.645	0.073	0.041	14.67	194.44
SE32-10	14/11/2015 22:23	INL79	110	12	2	7.00	upstream	450.77	0.938	0.054	0.031	14.74	201.27
SE33-1	15/11/2015 01:05	TNK80	110	17	5.9	9.72	downstream	515.52	2.088	0.110	0.055	13.13	201.49
SE33-2	15/11/2015 01:47	INL80	110	11	3.2	8.74	upstream	792.73	2.631	0.082	0.044	13.13	201.49
SE33-3	15/11/2015 02:15	INL90	85	9	0	10.60	upstream	788.98	2.996	0.113	0.070	12.63	210.91
SE33-4	15/11/2015 02:56	TNK80	93	14	5.8	9.19	downstream	482.04	3.628	0.131	0.085	12.63	210.91
SE33-5	15/11/2015 05:21	INL80	110	13	0.5	9.60	upstream	752.82	5.907	0.141	0.078	18.24	225.13
SE33-6	15/11/2015 06:40	INL79	172	12	1.6	9.70	downstream	520.52	4.894	0.123	0.069	17.58	227.27
SE33-7	15/11/2015 06:51	INL89	67	8	2.6	9.69	downstream	384.36	4.734	0.087	0.056	17.58	227.27
SE33-8	15/11/2015 07:01	INL89	110	11	3	6.38	upstream	676.41	4.559	0.141	0.068	17.58	227.27
SE33-9	15/11/2015 09:00	INL89	135	12	0	7.22	upstream	659.29	2.533	0.135	0.081	18.11	225.26
SE33-10	15/11/2015 09:22	INL79	87	12	2.7	9.42	downstream	460.65	2.192	0.103	0.060	18.11	225.26
SE33-11	15/11/2015 09:32	CON70	222	30	11.2	11.19	downstream	574.55	2.045	0.098	0.061	18.11	225.26
SE33-12	15/11/2015 10:41	INL79	113	44	1	7.84	downstream	477.08	1.149	0.187	0.074	17.98	225.00
SE33-13	15/11/2015 11:02	INL80	70	12	0	7.65	upstream	822.69	0.925	0.110	0.067	17.98	225.00
SE34-1	15/11/2015 13:02	INL52	26	12	5.8	6.63	downstream	574.53	1.525	0.281	0.146	18.55	225.14

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE34-2	15/11/2015 13:42	INL90	75	7	20	9.37	upstream	789.63	2.155	0.237	0.136	18.55	225.14
SE34-3	15/11/2015 16:30	INL84	100	11	2.4	5.96	downstream	483.25	5.440	0.090	0.057	14.33	227.42
SE34-4	15/11/2015 16:46	INL79	135	11	2.5	9.81	upstream	398.90	5.678	0.090	0.052	14.33	227.42
SE34-5*	15/11/2015 18:11	RRC70	177	31	7.2	4.67	upstream	743.86	5.373	0.359	0.113	12.68	226.11
SE34-6	15/11/2015 18:23	GEN70	128	16	7.1	5.00	downstream	625.65	5.215	0.096	0.052	12.68	226.11
SE34-7	15/11/2015 18:57	CAR70	199	32	8.4	11.46	downstream	620.74	4.684	0.085	0.051	12.68	226.11
SE34-8	15/11/2015 21:13	INL79	135	17	0	5.55	upstream	703.92	2.362	0.038	0.024	11.65	222.92
SE34-9	15/11/2015 22:40	INL79	135	11	0.2	12.12	downstream	559.69	1.076	0.039	0.025	9.27	211.68
SE35-1	16/11/2015 01:35	INL52	32	12	5.3	12.22	downstream	532.70	1.513	0.157	0.076	8.16	197.62
SE35-2	16/11/2015 02:39	INL79	70	7	0.1	9.41	upstream	733.20	2.317	0.042	0.027	10.52	197.78
SE35-3	16/11/2015 04:03	INL99	0	0	0	10.73	upstream	758.05	3.750	0.078	0.050	10.24	198.38
SE35-4*	16/11/2015 04:35	CON74	210	30	8.5	12.76	upstream	628.69	4.648	0.126	0.085	10.24	198.38
SE35-5	16/11/2015 06:30	INL79	135	11	0.2	7.22	downstream	477.76	4.972	0.044	0.029	11.13	195.76
SE35-6	16/11/2015 06:47	INL52	28	12	6.4	11.30	downstream	503.75	4.694	0.225	0.102	11.13	195.76
SE35-7	16/11/2015 07:14	INL79	110	11	2	11.80	downstream	547.50	4.223	0.060	0.039	11.13	195.76
SE35-8	16/11/2015 08:02	INL80	135	13	0	12.57	downstream	492.11	3.421	0.130	0.056	11.84	199.88
SE35-9	16/11/2015 09:21	INL00	69	9	0	12.64	downstream	554.61	2.110	0.089	0.038	11.84	199.88
SE35-10	16/11/2015 10:17	INL79	135	12	0	12.51	downstream	561.35	1.285	0.044	0.023	12.56	195.92
SE36-1	16/11/2015 23:33	GEN70	157	18	7.8	3.43	upstream	731.19	0.983	0.018	0.015	9.98	196.77
SE37-1	17/11/2015 04:25	TNK89	88	13	4.7	5.68	upstream	737.42	3.661	0.085	0.045	10.82	192.22
SE37-2	17/11/2015 04:36	INL99	52	7	0	8.69	upstream	810.17	3.869	0.052	0.033	10.82	192.22
SE37-3	17/11/2015 05:10	INL79	80	9	0.2	11.30	upstream	841.99	4.674	0.065	0.040	10.82	192.22
SE37-4	17/11/2015 07:48	INL70	110	12	2.4	5.61	upstream	465.69	4.550	0.040	0.024	12.77	210.74
SE37-5	17/11/2015 08:19	INL79	135	11	2.6	5.03	upstream	730.99	4.201	0.053	0.036	12.31	219.70
SE37-6	17/11/2015 09:54	INL52	26	12	5.8	12.16	downstream	521.44	2.727	0.079	0.040	12.31	219.70
SE37-7	17/11/2015 10:43	INL79	73	8	1	11.67	downstream	516.47	1.929	0.100	0.040	11.26	218.91
SE37-8	17/11/2015 10:53	INL80	85	12	2.4	5.95	upstream	793.60	1.776	0.036	0.022	11.26	218.91
SE38-1	17/11/2015 18:19	INL90	85	8	25.5	8.11	upstream	642.72	5.444	0.201	0.116	16.42	204.74

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE38-2	17/11/2015 22:36	INL52	32	12	3	12.80	downstream	495.58	2.868	0.250	0.157	18.99	219.27
SE38-3	17/11/2015 23:14	INL79	67	8	0.2	9.05	downstream	540.89	2.441	0.274	0.181	18.99	219.27
SE39-1	18/11/2015 01:41	INL79	67	8	0.2	5.59	upstream	701.88	1.814	0.439	0.289	20.59	228.05
SE39-2	18/11/2015 02:27	INL79	135	11	0	8.35	downstream	538.55	2.530	0.386	0.218	21.23	235.29
SE39-3	18/11/2015 03:42	INL89	110	12	25.5	12.17	upstream	645.34	3.367	0.282	0.182	21.23	235.29
SE39-4	18/11/2015 04:10	INL99	52	7	0	9.37	upstream	685.56	3.659	0.252	0.163	17.39	242.97
SE39-5	18/11/2015 04:44	INL79	130	11	3	6.79	upstream	664.05	4.094	0.124	0.081	17.39	242.97
SE39-6	18/11/2015 08:46	INL52	25	12	6	11.54	downstream	509.26	4.398	0.077	0.041	6.70	210.58
SE40-1	18/11/2015 16:07	INL90	110	11	0	4.59	downstream	464.42	2.015	0.137	0.087	13.58	198.82
SE40-2	18/11/2015 18:21	INL80	125	11	4	5.86	downstream	408.75	4.449	0.220	0.117	15.92	199.09
SE40-3	18/11/2015 19:05	INL79	110	11	2	7.68	upstream	717.26	5.058	0.150	0.098	15.92	199.09
SE40-4	18/11/2015 22:59	INL79	109	23	0.1	3.70	upstream	670.21	2.502	0.024	0.019	10.34	215.54
SE40-5	18/11/2015 23:58	INL80	86	11	0.2	9.62	downstream	499.53	1.746	0.072	0.033	10.34	215.54
SE40-6	19/11/2015 00:07	INL79	135	12	0.2	8.22	downstream	510.81	1.641	0.022	0.017	12.51	218.64
SE40-7	19/11/2015 00:54	DRG33	129	24	6.5	14.63	downstream	616.74	1.192	0.165	0.081	12.51	218.64
SE40-8	19/11/2015 01:03	INL79	110	11	2	6.70	downstream	407.20	1.135	0.037	0.024	12.51	218.64
SE41-1	19/11/2015 03:00	INL80	135	15	1.8	9.36	upstream	650.67	1.393	0.079	0.037	12.42	220.34
SE41-2	19/11/2015 05:35	INL79	110	11	0	10.31	upstream	753.75	3.506	0.153	0.088	12.16	220.55
SE41-3	19/11/2015 06:23	INL89	110	12	20	9.44	upstream	735.09	4.277	0.080	0.050	11.80	219.58
SE41-4	19/11/2015 08:00	GEN70	90	13	3.7	7.94	upstream	616.89	5.289	0.111	0.050	10.95	221.06
SE41-5	19/11/2015 10:40	INL99	15	5	0.2	10.25	downstream	522.86	3.298	0.048	0.032	10.56	223.99
SE41-6	19/11/2015 12:55	CON71	265	32	10.3	12.06	downstream	590.29	1.542	0.078	0.039	12.32	232.79
SE42-1	20/11/2015 00:24	INL70	0	0	0	8.18	upstream	429.77	2.459	0.140	0.053	5.87	228.88
SE42-2	20/11/2015 00:52	DRG33	129	24	6.5	11.90	downstream	513.96	2.054	0.162	0.060	5.87	228.88
SE42-3	20/11/2015 02:16	RRC70	176	31	7.9	10.89	upstream	652.83	1.131	0.216	0.088	5.29	219.72
SE43-1	20/11/2015 05:10	INL79	183	11	1	9.24	downstream	507.54	2.313	0.097	0.041	6.24	222.57
SE43-2	20/11/2015 06:58	INL00	69	9	0	9.24	upstream	790.12	3.399	0.138	0.079	5.68	225.68
SE43-3	20/11/2015 08:09	INL80	85	11	2.3	6.63	upstream	724.62	4.407	0.048	0.029	4.17	218.94

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE43-4	20/11/2015 12:07	GEN70	136	20	5.6	3.19	upstream	753.24	2.799	0.018	0.015	8.87	249.68
SE43-5	20/11/2015 12:21	INL79	108	11	0.1	5.89	downstream	369.82	2.583	0.023	0.017	8.87	249.68
SE44-1*	20/11/2015 17:25	CON79	210	26	9	8.29	upstream	713.90	1.338	0.038	0.026	6.96	241.25
SE44-2	20/11/2015 19:40	INL00	135	14	0.1	4.00	downstream	501.39	3.353	0.065	0.030	5.61	219.31
SE44-3	20/11/2015 20:41	DRG33	129	24	6.5	2.19	downstream	696.18	4.623	0.057	0.033	6.30	213.82
SE44-4	21/11/2015 00:42	INL79	110	11	2	7.59	upstream	729.11	3.475	0.067	0.040	10.68	244.26
SE44-5*	21/11/2015 01:06	CON71	366	48	13	3.73	upstream	680.65	3.084	0.043	0.028	10.68	244.26
SE44-6	21/11/2015 02:29	TNK89	118	18	5.5	7.67	upstream	676.49	1.860	0.158	0.078	7.04	228.81
SE44-7	21/11/2015 02:43	INL52	26	11	5.5	12.01	downstream	540.50	1.696	0.079	0.054	7.04	228.81
SE45-1	21/11/2015 05:07	INL79	135	18	2.1	10.61	upstream	765.78	1.378	0.035	0.024	6.69	207.14
SE45-2	21/11/2015 05:21	INL79	102	12	2	5.42	downstream	375.75	1.569	0.018	0.015	6.69	207.14
SE45-3	21/11/2015 07:26	GEN70	179	28	9.6	10.45	downstream	538.79	3.087	0.039	0.026	8.75	209.71
SE45-4	21/11/2015 12:50	INL79	81	10	2	11.67	downstream	524.80	4.106	0.168	0.094	3.52	226.38
SE45-5	21/11/2015 13:09	DRG33	129	24	6.5	15.08	downstream	563.95	3.805	0.241	0.140	3.52	226.38
SE45-6	21/11/2015 14:25	INL80	80	10	0.2	6.30	upstream	745.80	2.632	0.250	0.131	13.08	325.25
SE45-7	21/11/2015 15:03	RRC70	205	26	7.8	14.01	downstream	580.02	2.158	0.192	0.112	13.08	325.25
SE46-1	21/11/2015 17:52	INL52	28	12	6.4	8.04	downstream	496.63	1.891	0.090	0.051	11.67	344.95
SE46-2	21/11/2015 18:51	INL90	85	9	2	9.73	downstream	503.60	2.417	0.073	0.044	10.95	333.98
SE46-3	21/11/2015 19:19	DRG33	129	24	6.5	9.07	upstream	695.03	2.610	0.103	0.060	10.95	333.98
SE46-4	21/11/2015 20:30	GEN70	66	11	3.9	9.89	upstream	759.47	3.334	0.033	0.024	8.88	345.83
SE46-5	21/11/2015 21:27	DRG33	129	24	6.5	6.76	upstream	650.39	3.898	0.029	0.021	8.88	345.83
SE46-6	21/11/2015 23:02	DRG33	129	24	6.5	2.25	downstream	462.65	5.052	0.042	0.025	8.34	344.64
SE46-7	21/11/2015 23:28	DRG33	129	24	6.5	4.83	upstream	634.24	5.203	0.022	0.016	8.34	344.64
SE46-8	22/11/2015 00:47	INL52	32	12	5.3	11.84	downstream	502.13	4.377	0.165	0.066	5.79	299.76
SE46-9	22/11/2015 01:03	INL52	26	12	5.8	8.84	upstream	791.32	4.168	0.144	0.055	5.79	299.76
SE46-10	22/11/2015 02:22	INL80	85	11	2.3	11.55	downstream	557.51	2.829	0.050	0.032	4.78	257.82
SE46-11	22/11/2015 02:42	GEN79	108	18	6.3	10.83	upstream	736.43	2.484	0.148	0.072	4.78	257.82
SE46-12	22/11/2015 03:16	GEN70	82	11	3.4	6.26	upstream	749.79	1.929	0.078	0.028	4.78	257.82

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE46-13	22/11/2015 03:53	GEN70	190	32	7.5	9.40	downstream	611.49	1.394	0.053	0.030	4.78	257.82
SE46-14	22/11/2015 04:14	DRG33	129	24	6.5	4.86	downstream	771.68	1.119	0.048	0.034	4.00	316.04
SE46-15	22/11/2015 04:28	TNK80	98	14	4.5	12.91	downstream	549.55	0.958	0.079	0.049	4.00	316.04
SE47-1	22/11/2015 06:33	INL80	110	12	20	7.43	upstream	787.70	0.954	0.029	0.022	2.11	233.98
SE47-2	22/11/2015 11:08	DRG33	129	24	6.5	1.43	downstream	693.00	4.464	0.040	0.025	6.29	242.54
SE47-3*	22/11/2015 14:42	CON71	262	32	10	3.88	upstream	691.55	2.796	0.102	0.063	3.42	224.20
SE48-1	22/11/2015 20:34	INL80	49	8	2.6	10.92	upstream	459.33	1.813	0.029	0.019	4.47	292.35
SE48-2	22/11/2015 22:30	INL79	86	11	0.5	15.95	upstream	782.62	3.413	0.159	0.069	5.75	312.75
SE48-3	23/11/2015 02:30	INL90	110	10	2	11.17	downstream	501.70	3.816	0.083	0.051	4.85	293.98
SE48-4	23/11/2015 03:01	GAS80	108	17	6.8	8.66	upstream	717.82	3.298	0.187	0.106	4.85	293.98
SE48-5	23/11/2015 03:46	DRG33	129	24	6.5	3.08	downstream	667.66	2.532	0.073	0.046	4.85	293.98
SE48-6	23/11/2015 04:43	INL90	86	10	4	11.42	downstream	502.55	1.546	0.062	0.030	5.10	306.83
SE48-7	23/11/2015 05:14	INL79	0	0	1.7	7.42	upstream	733.25	1.074	0.057	0.032	5.10	306.83
SE49-1	23/11/2015 08:34	INL70	110	12	2.9	9.98	upstream	705.16	1.254	0.028	0.021	2.58	227.11
SE49-2	23/11/2015 11:52	INL80	110	13	0.2	11.39	upstream	670.57	4.379	0.043	0.028	3.00	221.94
SE50-1	24/11/2015 00:50	INL79	86	11	3.4	13.35	upstream	721.18	5.264	0.110	0.060	9.22	183.98
SE50-2	24/11/2015 01:02	TNK80	117	18	5.7	17.70	upstream	711.89	5.354	0.099	0.063	9.22	183.98
SE50-3	24/11/2015 01:42	INL89	187	23	0	6.42	downstream	552.58	5.238	0.141	0.063	9.22	183.98
SE51-1	24/11/2015 11:18	INL79	110	11	0.3	4.24	downstream	511.84	2.614	0.159	0.081	13.15	169.28
SE51-2	24/11/2015 12:40	INL79	127	11	0	0.47	downstream	536.12	4.832	0.138	0.083	13.20	177.03
SE51-3	24/11/2015 15:29	INL79	110	11	0.3	4.10	upstream	714.31	4.378	0.047	0.026	13.34	184.50
SE52-1	24/11/2015 22:45	INL79	67	8	0	10.33	upstream	763.23	2.049	0.026	0.021	6.56	205.13
SE52-2	25/11/2015 00:48	INL52	26	11	5.5	6.02	downstream	501.38	4.326	0.099	0.039	5.77	208.28
SE52-3	25/11/2015 01:30	DRG33	129	24	6.5	11.38	upstream	673.23	5.756	0.033	0.024	5.77	208.28
SE52-4	25/11/2015 02:54	INL52	32	12	5.3	13.15	upstream	721.21	5.695	0.221	0.070	4.46	215.60
SE52-5	25/11/2015 03:26	RRC79	155	22	5.7	13.45	upstream	652.70	5.259	0.115	0.067	4.46	215.60
SE52-6	25/11/2015 04:27	INL52	26	12	5.8	7.16	upstream	754.27	4.256	0.100	0.045	5.69	231.35
SE52-7	25/11/2015 04:50	INL79	110	12	2	11.97	downstream	516.66	3.842	0.089	0.041	5.69	231.35

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE52-8	25/11/2015 05:37	DRG33	129	24	6.5	4.80	downstream	542.20	2.949	0.195	0.064	5.69	231.35
SE52-9	25/11/2015 05:54	INL70	84	10	0	9.97	downstream	536.34	2.605	0.021	0.016	5.69	231.35
SE53-1	25/11/2015 10:43	CAR70	183	32	7.8	14.37	upstream	619.26	2.343	0.106	0.055	7.04	282.37
SE53-2	25/11/2015 16:39	INL79	86	11	3.4	13.04	downstream	513.05	4.404	0.177	0.113	6.84	269.86
SE53-3	25/11/2015 16:49	INL79	135	14	2	6.79	upstream	666.56	4.250	0.199	0.107	6.84	269.86
SE53-4	25/11/2015 17:26	INL79	110	10	1.4	4.51	upstream	371.67	3.614	0.072	0.047	6.84	269.86
SE54-1	26/11/2015 00:52	DRG33	129	24	6.5	0.43	downstream	595.48	3.186	0.054	0.034	3.02	290.45
SE54-2	26/11/2015 01:39	DRG33	129	24	6.5	9.64	upstream	703.20	4.066	0.049	0.026	3.02	290.45
SE54-3	26/11/2015 04:39	TNK89	95	15	6.8	6.02	upstream	744.47	4.844	0.020	0.016	3.91	285.28
SE54-4	26/11/2015 07:33	INL79	80	10	0.2	10.62	downstream	585.36	1.627	0.024	0.018	1.34	2.22
SE55-1	26/11/2015 14:42	INL79	86	9	0	2.63	downstream	458.53	5.211	0.037	0.024	3.37	253.54
SE55-2	26/11/2015 14:52	INL00	100	10	0	12.64	upstream	703.67	5.458	0.052	0.032	3.37	253.54
SE55-3	26/11/2015 17:45	INL90	75	7	20	12.78	downstream	514.87	3.741	0.025	0.018	2.72	246.01
SE55-4	26/11/2015 20:20	INL79	108	11	0.1	5.82	upstream	749.22	0.967	0.016	0.014	2.63	174.68
SE56-1	27/11/2015 01:07	DRG33	129	24	6.5	11.31	upstream	685.39	2.067	0.026	0.018	3.95	171.66
SE56-2*	27/11/2015 04:11	CON71	260	32	10.4	2.42	upstream	611.78	5.564	0.035	0.024	5.99	162.92
SE56-3	27/11/2015 04:33	INL79	135	16	0	7.89	downstream	521.14	5.306	0.023	0.016	5.99	162.92
SE56-4	27/11/2015 05:07	INL79	110	11	0.3	7.49	upstream	627.13	4.795	0.022	0.017	5.99	162.92
SE57-1	27/11/2015 17:41	INL52	28	12	6.2	11.12	upstream	750.74	4.550	0.248	0.091	9.96	178.91
SE58-1	28/11/2015 00:29	INL79	110	11	0	10.79	upstream	606.39	1.101	0.140	0.086	12.76	182.38
SE58-2*	28/11/2015 00:43	INL79	178	11	1.8	6.07	downstream	483.20	1.324	0.162	0.077	12.76	182.38
SE58-3	28/11/2015 03:15	RRC71	205	29	7.3	14.38	upstream	655.93	5.118	0.056	0.037	10.38	239.83
SE58-4	28/11/2015 04:10	INL79	110	12	2	12.41	upstream	719.12	6.600	0.193	0.114	13.61	271.19
SE58-5	28/11/2015 04:33	INL79	102	12	2	3.76	downstream	499.94	6.730	0.235	0.171	13.61	271.19
SE58-6	28/11/2015 07:16	INL80	110	11	0	13.54	downstream	530.30	4.285	0.207	0.126	12.31	260.97
SE58-7	28/11/2015 07:29	INL70	86	10	2.6	14.81	downstream	487.55	4.000	0.224	0.134	12.31	260.97
SE58-8	28/11/2015 08:04	INL79	110	11	0.3	3.93	upstream	568.78	3.232	0.078	0.054	10.99	251.16
SE58-9	28/11/2015 08:42	GEN70	138	21	6.8	10.99	downstream	519.37	2.416	0.082	0.047	10.99	251.16

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE58-10	28/11/2015 09:00	INL52	32	12	5.3	9.63	downstream	493.68	2.076	0.073	0.047	10.99	251.16
SE58-11	28/11/2015 09:59	INL79	135	18	2.1	4.63	upstream	738.84	1.105	0.072	0.042	10.99	251.16
SE59-1	28/11/2015 14:59	INL99	85	8	0.2	10.81	upstream	702.81	3.513	0.077	0.042	8.57	197.12
SE59-2	28/11/2015 16:10	INL52	26	11	5.5	4.13	downstream	500.92	5.800	0.096	0.061	11.52	186.54
SE59-3	28/11/2015 17:09	RRC71	205	29	7.5	10.30	downstream	528.56	5.892	0.168	0.101	11.52	186.54
SE59-4	28/11/2015 17:30	INL80	110	12	0	5.83	downstream	628.32	5.637	0.086	0.046	11.52	186.54
SE59-5	28/11/2015 18:44	RRC71	164	24	6.3	7.19	upstream	717.49	4.463	0.089	0.035	12.04	191.02
SE59-6	28/11/2015 19:22	INL79	86	11	0	10.80	downstream	491.79	3.786	0.049	0.028	12.04	191.02
SE59-7	28/11/2015 20:02	INL52	31	10	4.7	14.56	downstream	535.85	2.996	0.367	0.091	15.16	190.86
SE59-8	28/11/2015 20:14	INL79	135	18	2.1	12.63	downstream	568.53	2.766	0.076	0.040	15.16	190.86
SE59-9*	28/11/2015 20:51	CON70	235	32	8.7	5.18	upstream	616.12	2.054	0.092	0.050	15.16	190.86
SE59-10	28/11/2015 21:18	INL79	110	12	1.5	13.35	downstream	563.19	1.616	0.140	0.059	15.16	190.86
SE59-11	28/11/2015 21:57	INL80	110	12	0	11.73	downstream	538.24	1.027	0.092	0.059	15.16	190.86
SE60-1	29/11/2015 01:25	INL52	28	12	6.4	9.32	downstream	473.65	1.393	0.165	0.068	16.04	197.51
SE60-2	29/11/2015 01:38	INL52	26	12	5.8	11.94	upstream	776.25	1.600	0.062	0.041	16.04	197.51
SE60-3	29/11/2015 02:19	INL52	28	12	6.4	14.51	upstream	779.55	2.142	0.124	0.062	11.20	203.68
SE60-4	29/11/2015 02:43	INL80	110	14	2.2	9.44	upstream	752.85	2.454	0.073	0.042	11.20	203.68
SE60-5	29/11/2015 03:17	GEN70	81	11	3.3	9.74	upstream	608.53	3.189	0.081	0.048	11.20	203.68
SE60-6	29/11/2015 04:08	CAR70	200	32	7.8	12.54	upstream	624.83	4.901	0.088	0.055	10.22	204.18
SE60-7	29/11/2015 04:25	INL89	105	9	2.2	5.04	downstream	448.29	5.380	0.073	0.045	10.22	204.18
SE60-8	29/11/2015 06:56	INL80	110	11	2.6	11.03	downstream	496.03	4.531	0.030	0.022	11.65	199.82
SE60-9	29/11/2015 09:43	INL20	82	9	0	10.52	downstream	482.02	1.645	0.114	0.054	9.76	199.88
SE60-10	29/11/2015 10:07	INL90	135	14	0	6.50	upstream	704.15	1.329	0.033	0.024	9.93	204.90
SE60-11	29/11/2015 10:25	INL52	32	12	5.4	7.07	upstream	752.41	1.108	0.019	0.015	9.93	204.90
SE61-1	29/11/2015 13:35	INL52	30	9	4.8	9.82	downstream	455.71	1.732	0.199	0.075	13.37	209.19
SE61-2	29/11/2015 16:17	TNK80	93	14	4.8	13.46	upstream	765.79	5.300	0.192	0.111	15.70	219.66
SE61-3	29/11/2015 18:36	INL52	33	11	3.7	12.62	upstream	790.18	5.607	0.339	0.120	17.10	217.57
SE61-4	29/11/2015 19:07	GEN70	89	12	4.8	7.00	upstream	674.60	5.122	0.092	0.064	17.10	217.57

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE61-5	29/11/2015 19:53	INL52	28	12	6.2	11.42	upstream	780.20	4.357	0.274	0.112	17.10	217.57
SE61-6	29/11/2015 20:09	INL80	84	10	2.1	5.41	upstream	641.38	4.096	0.116	0.071	20.12	223.93
SE61-7	29/11/2015 20:49	INL52	32	12	5.3	10.64	downstream	514.38	3.402	0.159	0.099	20.12	223.93
SE61-8*	29/11/2015 22:54	CON71	262	32	9.4	4.06	upstream	611.31	1.817	0.153	0.072	18.65	244.39
SE62-1	30/11/2015 00:34	GEN70	204	32	9.8	10.52	downstream	549.11	1.894	0.114	0.078	13.54	250.02
SE62-2	30/11/2015 02:34	INL90	85	9	0	10.11	upstream	742.46	3.315	0.055	0.037	13.51	250.10
SE62-3	30/11/2015 03:16	INL80	86	9	3	10.82	upstream	684.74	3.855	0.087	0.055	13.51	250.10
SE62-4	30/11/2015 03:35	CAR70	200	32	8.9	8.95	downstream	598.38	4.167	0.134	0.074	13.51	250.10
SE62-5*	30/11/2015 05:04	CON71	158	23	7	9.32	upstream	712.17	5.909	0.165	0.070	11.84	255.11
SE62-6	30/11/2015 05:24	INL79	110	11	2	9.60	upstream	685.95	6.204	0.106	0.073	11.84	255.11
SE62-7	30/11/2015 05:58	INL89	80	8	1.2	11.59	upstream	675.78	6.370	0.141	0.074	11.84	255.11
SE63-1	30/11/2015 14:15	INL99	86	8	0	9.80	upstream	759.42	2.173	0.083	0.051	14.38	215.57
SE63-2	30/11/2015 19:12	INL80	86	10	0.3	8.37	downstream	462.90	5.664	0.201	0.112	17.33	220.27
SE63-3	30/11/2015 20:47	INL52	26	12	5.8	5.49	upstream	713.56	4.259	0.149	0.071	15.89	224.45
SE63-4	30/11/2015 21:07	INL00	135	14	0	8.82	downstream	564.09	3.906	0.077	0.055	15.89	224.45
SE63-5	30/11/2015 22:20	INL79	110	10	1.4	7.43	upstream	515.55	2.645	0.122	0.060	17.74	233.61
SE63-6	30/11/2015 22:59	INL70	135	14	0	11.63	downstream	485.64	2.053	0.071	0.048	17.74	233.61

Table 17 – Single ship events including large vessel-tug events (index with asterisk) detected at Gsc4 location (low mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE01-1	29/10/2015 17:26	INL79	105	10	0.2	11.76	downstream	219.63	5.100	0.109	0.046	5.41	194.48
SE01-2	29/10/2015 19:37	INL80	110	12	0.1	7.48	upstream	749.07	2.752	0.025	0.020	5.60	177.81
SE02-1	30/10/2015 02:57	INL90	86	10	4	12.08	upstream	658.72	2.589	0.031	0.020	4.14	97.74
SE02-2	30/10/2015 05:43	INL79	80	9	0	4.15	upstream	694.32	5.223	0.034	0.025	4.86	102.10
SE02-3	30/10/2015 07:53	GEN70	89	12	5.5	6.05	upstream	544.82	2.949	0.027	0.021	5.23	106.30
SE03-1	30/10/2015 13:23	INL99	64	7	0	4.82	downstream	532.48	1.471	0.026	0.019	3.85	121.26
SE03-2	30/10/2015 15:55	INL52	33	11	3.7	9.21	downstream	399.80	4.197	0.116	0.057	4.99	103.16
SE03-3	30/10/2015 20:05	INL52	28	12	6.2	11.98	downstream	406.73	3.031	0.069	0.032	4.55	89.32
SE04-1	31/10/2015 03:37	INL80	77	8	1	6.38	downstream	389.53	2.539	0.022	0.017	3.77	81.87
SE04-2	31/10/2015 03:54	INL79	113	44	1	2.89	downstream	540.92	2.870	0.029	0.022	3.77	81.87
SE04-3	31/10/2015 04:04	INL79	110	12	2.5	8.02	downstream	629.96	3.137	0.118	0.054	3.99	86.28
SE04-4	31/10/2015 07:00	INL79	127	11	0	4.58	upstream	750.80	4.573	0.033	0.025	4.61	89.99
SE05-1	31/10/2015 16:05	INL52	32	12	5.4	12.26	downstream	372.13	2.945	0.181	0.080	3.05	117.80
SE05-2	31/10/2015 18:09	INL52	32	12	5.4	9.31	upstream	546.65	5.449	0.021	0.018	2.15	101.81
SE05-3	31/10/2015 19:24	INL79	135	14	0.4	11.37	downstream	684.59	4.513	0.028	0.019	2.15	101.81
SE05-4	31/10/2015 20:45	CON73	222	30	10.4	11.92	downstream	618.89	3.137	0.050	0.032	2.14	107.61
SE05-5	31/10/2015 21:17	INL80	135	12	3.4	12.47	downstream	457.68	2.527	0.035	0.025	2.14	107.61
SE05-6	31/10/2015 21:53	RRC70	199	35	8.9	12.42	downstream	608.12	1.862	0.024	0.016	2.14	107.61
SE06-1	01/11/2015 02:52	INL80	85	12	2.2	8.92	upstream	576.61	1.738	0.010	0.010	1.82	172.26
SE06-2	01/11/2015 03:10	INL52	26	12	5.8	8.39	downstream	383.88	1.967	0.134	0.053	1.82	172.26
SE06-3	01/11/2015 04:13	TNK80	151	22	6.7	16.40	upstream	577.42	2.847	0.229	0.088	1.73	138.05
SE06-4*	01/11/2015 04:45	CON73	260	32	10.1	6.45	upstream	693.45	3.449	0.060	0.030	1.73	138.05
SE06-5	01/11/2015 05:12	INL90	110	17	3	5.45	downstream	656.47	4.231	0.046	0.028	1.73	138.05
SE06-6	01/11/2015 05:34	GEN70	105	16	6.4	14.09	upstream	568.71	4.966	0.075	0.050	1.73	138.05

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE06-7	01/11/2015 05:45	INL52	26	12	5.8	5.23	downstream	504.47	5.218	0.099	0.053	1.73	138.05
SE06-8	01/11/2015 06:34	INL90	83	12	2.4	12.34	upstream	586.39	5.544	0.084	0.047	1.40	102.21
SE06-9	01/11/2015 07:17	INL69	100	12	0.2	9.20	downstream	396.39	5.159	0.099	0.060	1.40	102.21
SE06-10	01/11/2015 07:36	INL99	195	23	0.1	7.69	downstream	381.28	4.872	0.101	0.056	1.40	102.21
SE06-11	01/11/2015 07:46	INL79	135	12	2.3	5.11	downstream	589.92	4.724	0.041	0.029	1.40	102.21
SE06-12	01/11/2015 08:26	INL89	135	11	2	7.34	upstream	584.36	4.061	0.103	0.053	3.74	151.29
SE06-13	01/11/2015 08:51	INL79	80	9	1	15.17	downstream	422.86	3.624	0.079	0.042	3.74	151.29
SE06-14	01/11/2015 09:26	INL52	30	11	5.2	7.76	upstream	658.60	2.991	0.155	0.071	3.74	151.29
SE06-15	01/11/2015 10:49	INL80	86	10	0.2	8.86	upstream	674.68	1.538	0.055	0.033	2.42	168.34
SE07-1	01/11/2015 17:13	INL52	26	12	5.8	12.18	upstream	671.44	3.730	0.060	0.043	1.46	23.97
SE07-2	01/11/2015 18:50	INL79	135	17	1.5	10.22	upstream	745.94	5.426	0.071	0.038	2.78	85.31
SE07-3	01/11/2015 20:55	INL79	196	11	2.8	5.77	upstream	568.97	3.755	0.081	0.043	2.50	82.63
SE08-1	02/11/2015 04:56	CON70	243	33	10	6.07	downstream	713.40	2.785	0.083	0.047	3.07	72.39
SE08-2	02/11/2015 05:16	INL80	110	11	3.2	8.84	upstream	678.41	3.086	0.031	0.020	3.07	72.39
SE09-1	02/11/2015 19:47	INL00	177	5	0.3	8.23	upstream	616.70	5.161	0.052	0.030	2.40	238.21
SE09-2	02/11/2015 20:04	INL99	65	7	0	8.78	upstream	622.50	5.063	0.037	0.021	1.05	228.72
SE09-3	02/11/2015 20:17	INL79	135	14	2.6	10.38	downstream	535.62	4.949	0.057	0.033	1.05	228.72
SE09-4*	02/11/2015 20:34	CON70	300	42	12.8	3.80	upstream	687.04	4.740	0.061	0.036	1.05	228.72
SE09-5	02/11/2015 22:31	INL79	177	12	1.7	5.69	upstream	766.37	2.867	0.032	0.021	2.26	153.78
SE09-6	02/11/2015 23:03	INL79	172	11	0	8.58	upstream	744.37	2.328	0.080	0.040	2.26	153.78
SE10-1*	03/11/2015 05:08	CON70	210	30	9.5	10.11	upstream	715.37	2.376	0.055	0.029	3.32	96.69
SE11-1	03/11/2015 18:12	INL79	86	9	0.4	7.65	downstream	276.07	2.821	0.167	0.082	2.22	81.59
SE11-2	03/11/2015 20:57	INL79	135	12	0.2	6.23	downstream	510.04	4.841	0.070	0.043	4.48	85.11
SE11-3	03/11/2015 21:43	INL70	0	0	0	12.58	upstream	614.72	4.377	0.130	0.052	4.48	85.11
SE11-4	03/11/2015 22:14	INL79	80	9	0	9.72	downstream	390.71	3.935	0.100	0.051	3.96	116.77
SE11-5	03/11/2015 23:43	INL52	28	12	6.2	11.65	downstream	394.64	2.526	0.168	0.059	3.96	116.77
SE11-6	04/11/2015 00:05	GEN70	98	17	4.9	5.52	upstream	635.68	2.184	0.086	0.041	4.76	129.24
SE11-7	04/11/2015 00:33	INL79	0	0	3.4	2.64	upstream	794.96	1.762	0.084	0.041	4.76	129.24

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE12-1	04/11/2015 06:26	DRG33	98	22	0	3.40	upstream	394.99	2.840	0.034	0.023	4.94	110.70
SE12-2	04/11/2015 12:36	DRG33	98	22	0	2.41	upstream	405.88	1.979	0.064	0.042	9.95	183.50
SE13-1	04/11/2015 18:59	DRG33	98	22	0	13.73	upstream	593.61	2.739	0.117	0.059	7.55	187.44
SE13-2	04/11/2015 19:10	INL79	86	10	1	10.06	downstream	165.22	2.922	0.095	0.044	7.55	187.44
SE13-3	04/11/2015 22:45	INL80	65	10	0.4	10.46	downstream	410.58	4.247	0.077	0.048	6.25	181.08
SE13-4	04/11/2015 23:16	INL79	110	12	2.7	8.02	downstream	573.85	3.820	0.046	0.025	6.25	181.08
SE13-5	04/11/2015 23:48	DRG33	98	22	0	3.71	downstream	367.88	3.380	0.033	0.022	6.25	181.08
SE14-1	05/11/2015 08:06	INL79	127	11	0	7.69	upstream	713.51	3.090	0.022	0.018	5.40	160.87
SE15-1	06/11/2015 00:18	INL80	86	11	2.3	10.01	downstream	394.69	4.029	0.039	0.022	8.95	183.71
SE15-2	06/11/2015 03:31	INL79	127	11	0	5.76	downstream	737.09	1.530	0.019	0.015	8.19	184.74
SE17-1	06/11/2015 21:42	INL52	33	12	5.4	6.54	downstream	404.06	3.025	0.095	0.048	10.17	200.74
SE17-2	06/11/2015 21:55	INL99	110	11	4	8.45	downstream	626.89	3.255	0.132	0.060	10.17	200.74
SE17-3	06/11/2015 23:46	INL89	110	10	0.1	6.25	downstream	361.56	4.803	0.047	0.033	8.73	206.54
SE17-4	07/11/2015 01:49	INL79	86	11	0	11.93	downstream	601.19	3.932	0.058	0.033	7.35	216.95
SE17-5	07/11/2015 02:03	INL79	130	11	3	6.50	downstream	554.50	3.747	0.022	0.017	6.08	235.38
SE17-6	07/11/2015 03:00	INL79	135	11	0.3	7.55	downstream	629.87	2.933	0.079	0.041	6.08	235.38
SE17-7	07/11/2015 03:44	INL79	190	12	3	6.54	upstream	743.26	2.253	0.026	0.018	6.08	235.38
SE17-8	07/11/2015 04:25	INL52	26	12	5.8	7.28	upstream	673.70	1.699	0.157	0.071	3.97	226.04
SE17-9	07/11/2015 04:40	INL79	110	11	0.3	5.08	upstream	543.77	1.517	0.053	0.034	3.97	226.04
SE18-1	07/11/2015 08:31	INL80	110	11	3.2	7.67	upstream	669.45	1.700	0.021	0.016	5.64	184.95
SE18-2	07/11/2015 08:41	INL52	26	12	5.8	9.75	downstream	380.28	1.818	0.158	0.045	5.64	184.95
SE18-3	07/11/2015 09:01	CON71	141	22	6.3	5.61	upstream	733.76	2.032	0.056	0.035	5.64	184.95
SE18-4	07/11/2015 09:41	INL90	110	17	2.5	7.84	upstream	729.21	2.490	0.037	0.023	5.64	184.95
SE18-5	07/11/2015 15:08	INL90	108	11	0	5.76	upstream	734.91	3.128	0.030	0.021	7.90	185.66
SE18-6	07/11/2015 15:18	INL99	85	8	0.3	12.08	downstream	400.68	2.979	0.029	0.019	7.90	185.66
SE18-7	07/11/2015 15:32	INL79	135	11	1.8	6.91	downstream	581.73	2.765	0.044	0.028	7.90	185.66
SE18-8	07/11/2015 15:53	INL90	108	11	0	8.05	downstream	490.67	2.442	0.018	0.015	7.90	185.66
SE18-9	07/11/2015 16:56	TNK81	130	20	6	13.79	upstream	653.54	1.534	0.162	0.084	8.04	186.47

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE19-1	07/11/2015 21:13	INL80	93	12	1.7	11.26	upstream	672.82	1.894	0.046	0.030	11.59	229.09
SE19-2	07/11/2015 21:57	CON71	365	49	14.3	5.45	downstream	693.00	2.477	0.043	0.024	11.59	229.09
SE19-3	07/11/2015 23:21	INL79	108	11	0.1	4.85	downstream	452.96	3.954	0.058	0.030	7.93	226.52
SE19-4*	08/11/2015 00:16	CON71	194	28	8.9	7.62	upstream	656.03	4.854	0.091	0.043	7.13	232.15
SE19-5	08/11/2015 00:25	RRC70	188	27	6.8	12.04	downstream	483.88	4.945	0.151	0.094	7.13	232.15
SE19-6	08/11/2015 00:47	TNK82	112	17	7.4	13.42	upstream	559.82	5.067	0.242	0.091	7.13	232.15
SE19-7	08/11/2015 00:59	INL52	32	12	5.3	10.32	downstream	478.02	5.093	0.134	0.072	7.13	232.15
SE19-8	08/11/2015 01:35	GEN70	107	14	3.8	12.00	downstream	399.29	4.965	0.115	0.060	7.13	232.15
SE19-9	08/11/2015 03:16	INL79	20	8	3	7.02	downstream	413.49	3.610	0.023	0.017	4.36	216.51
SE19-10	08/11/2015 04:15	TNK82	100	17	4.6	11.59	upstream	518.02	2.668	0.654	0.166	3.01	190.64
SE19-11	08/11/2015 04:54	GEN70	136	21	7.4	8.81	upstream	548.68	2.074	0.118	0.051	3.01	190.64
SE19-12	08/11/2015 05:06	INL79	135	11	2.6	7.62	upstream	620.55	1.892	0.036	0.025	3.01	190.64
SE19-13*	08/11/2015 05:18	CON74	222	30	10.3	10.60	downstream	623.37	1.716	0.098	0.055	3.01	190.64
SE20-1	08/11/2015 10:07	INL52	33	12	5.4	12.48	upstream	588.65	2.228	0.229	0.103	5.80	163.87
SE20-2	08/11/2015 10:23	INL89	110	13	2.4	8.50	upstream	589.53	2.393	0.049	0.033	5.80	163.87
SE20-3	08/11/2015 10:37	CON70	128	21	8	11.86	downstream	744.21	2.548	0.053	0.034	5.80	163.87
SE20-4	08/11/2015 11:09	TNK89	183	28	8.7	9.14	downstream	526.99	2.944	0.216	0.087	5.80	163.87
SE20-5*	08/11/2015 11:54	CON70	300	48	10.3	7.06	upstream	721.41	3.642	0.062	0.032	5.80	163.87
SE20-6	08/11/2015 12:09	INL70	67	7	0	10.05	upstream	567.44	3.928	0.050	0.034	6.37	149.05
SE20-7	08/11/2015 15:30	INL79	135	17	2	5.76	upstream	751.16	3.349	0.032	0.021	7.58	146.41
SE20-8	08/11/2015 15:45	TNK89	137	22	7.1	5.83	upstream	604.93	3.125	0.036	0.022	7.58	146.41
SE20-9	08/11/2015 15:56	TNK83	99	16	6.7	6.33	upstream	616.70	2.954	0.092	0.046	7.58	146.41
SE21-1	08/11/2015 22:46	INL52	33	12	5.4	8.92	downstream	453.88	1.612	0.143	0.070	10.28	205.82
SE21-2	08/11/2015 23:46	RRC79	214	32	8.7	9.27	upstream	564.43	2.657	0.063	0.036	10.28	205.82
SE21-3	08/11/2015 23:57	CAR70	200	32	8.5	8.11	downstream	560.12	2.918	0.144	0.055	10.28	205.82
SE21-4	09/11/2015 00:24	INL80	110	14	4.1	5.42	downstream	430.41	3.585	0.083	0.054	9.52	216.98
SE21-5	09/11/2015 02:56	GEN70	89	14	5.4	10.29	upstream	434.35	4.229	0.262	0.099	9.55	223.72
SE21-6	09/11/2015 04:44	GAS80	160	26	8.2	8.13	upstream	566.26	2.651	0.149	0.061	8.84	227.16

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE21-7	09/11/2015 05:37	INL79	135	12	0.1	15.65	upstream	720.46	1.808	0.031	0.021	8.84	227.16
SE22-1	09/11/2015 09:40	INL79	135	17	2	8.14	downstream	637.71	1.606	0.114	0.053	11.48	225.18
SE22-2	09/11/2015 11:26	INL52	26	12	5.8	15.16	upstream	463.84	3.112	0.269	0.066	11.74	224.61
SE22-3	09/11/2015 13:45	INL52	26	12	5.8	6.81	downstream	542.94	5.526	0.157	0.085	12.06	221.50
SE22-4	09/11/2015 18:17	INL79	110	11	0	13.50	downstream	384.61	1.951	0.115	0.070	12.99	206.84
SE23-1	10/11/2015 03:21	INL79	183	12	1	8.08	downstream	615.92	5.071	0.032	0.023	10.36	197.94
SE23-2	10/11/2015 04:06	INL79	135	11	2	9.46	downstream	652.70	4.352	0.036	0.023	9.45	205.19
SE23-3	10/11/2015 04:49	INL52	28	12	6.2	16.37	downstream	533.38	3.676	0.185	0.065	9.45	205.19
SE23-4	10/11/2015 04:59	INL79	135	14	2.6	8.18	downstream	542.02	3.510	0.080	0.041	9.45	205.19
SE23-5*	10/11/2015 06:20	CON71	210	30	10	3.41	upstream	718.84	2.138	0.041	0.028	9.65	202.39
SE24-1	10/11/2015 13:40	DRG33	82	12	5.1	10.66	upstream	640.64	4.986	0.079	0.046	10.51	204.67
SE24-2	10/11/2015 14:30	INL99	85	9	2	7.26	downstream	432.35	5.502	0.044	0.030	8.94	205.28
SE24-3	10/11/2015 18:42	INL79	127	11	0	6.78	downstream	439.93	1.815	0.058	0.034	10.81	218.62
SE25-1	11/11/2015 00:02	INL80	85	9	1.5	11.25	upstream	607.06	2.419	0.064	0.034	8.86	200.71
SE25-2	11/11/2015 02:28	INL79	185	11	2	9.83	upstream	631.39	5.396	0.039	0.024	9.20	198.76
SE25-3	11/11/2015 02:46	INL52	25	12	6	6.76	downstream	562.16	5.514	0.205	0.108	9.20	198.76
SE25-4	11/11/2015 03:45	DRG90	113	20	5	12.42	downstream	415.02	5.147	0.219	0.087	9.20	198.76
SE25-5	11/11/2015 04:40	INL90	110	11	0	11.41	downstream	411.55	4.242	0.040	0.024	9.30	197.50
SE25-6	11/11/2015 04:52	INL79	135	12	0.1	8.52	downstream	611.84	4.040	0.041	0.025	9.30	197.50
SE25-7	11/11/2015 05:53	GAS80	153	20	7.3	9.50	upstream	588.34	3.023	0.110	0.067	9.30	197.50
SE25-8	11/11/2015 07:13	CAR70	200	32	8.7	9.39	upstream	571.14	1.646	0.137	0.053	7.82	188.10
SE25-9	11/11/2015 07:23	INL79	110	12	0.2	8.19	upstream	809.64	1.508	0.041	0.026	7.82	188.10
SE26-1	11/11/2015 18:19	INL79	113	44	1	8.26	downstream	476.42	2.776	0.223	0.098	8.54	186.46
SE27-1	12/11/2015 00:49	CAR70	177	32	7.6	6.76	downstream	443.20	2.411	0.157	0.068	7.20	203.45
SE27-2	12/11/2015 01:22	CON71	135	22	5.3	7.77	downstream	690.80	2.935	0.057	0.034	7.20	203.45
SE27-3	12/11/2015 02:37	INL79	135	12	1.7	13.31	upstream	307.58	4.948	0.068	0.031	5.85	208.82
SE27-4	12/11/2015 03:34	INL00	84	9	0	10.11	upstream	734.89	5.498	0.069	0.042	5.85	208.82
SE27-5	12/11/2015 04:24	INL79	22	11	2	7.58	downstream	385.78	5.029	0.022	0.016	5.65	204.80

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE27-6	12/11/2015 05:02	INL79	135	18	2.1	10.91	downstream	614.14	4.440	0.131	0.054	5.65	204.80
SE27-7	12/11/2015 05:32	TNK80	183	32	8.8	8.11	upstream	544.38	3.932	0.061	0.035	5.65	204.80
SE27-8	12/11/2015 05:49	INL79	86	9	0	6.01	upstream	503.33	3.640	0.033	0.021	5.65	204.80
SE27-9	12/11/2015 07:26	INL52	26	12	5.8	12.96	downstream	455.50	1.937	0.097	0.050	6.56	202.30
SE28-1	12/11/2015 14:24	INL79	85	10	0.2	12.75	upstream	541.75	3.860	0.060	0.037	5.92	170.24
SE29-1	13/11/2015 01:52	CON79	399	60	13.8	5.84	downstream	659.03	2.622	0.101	0.048	8.20	186.54
SE29-2	13/11/2015 02:33	CON79	132	16	6.4	4.81	upstream	586.78	3.529	0.072	0.038	9.86	195.60
SE29-3	13/11/2015 02:46	INL79	135	14	1	13.85	upstream	351.46	3.948	0.069	0.041	9.86	195.60
SE29-4	13/11/2015 02:56	INL90	134	14	2.7	11.89	upstream	687.38	4.276	0.037	0.027	9.86	195.60
SE29-5	13/11/2015 03:11	INL79	135	15	0	11.36	upstream	679.50	4.716	0.047	0.028	9.86	195.60
SE29-6*	13/11/2015 03:37	CON71	333	48	11.3	4.95	downstream	695.36	5.157	0.188	0.086	9.86	195.60
SE29-7	13/11/2015 05:01	RRC70	176	31	8.7	13.30	downstream	456.85	4.596	0.198	0.088	9.60	200.12
SE29-8*	13/11/2015 05:13	CON71	178	28	10.1	7.15	upstream	647.93	4.406	0.099	0.047	9.60	200.12
SE30-1	13/11/2015 14:55	INL79	113	44	1	9.53	upstream	716.62	4.142	0.061	0.033	11.77	224.32
SE30-2	13/11/2015 15:21	INL00	58	7	0	14.00	upstream	654.96	5.163	0.084	0.048	11.77	224.32
SE30-3	13/11/2015 15:39	INL80	110	11	0.3	11.99	upstream	646.40	5.608	0.067	0.040	11.77	224.32
SE30-4	13/11/2015 19:05	GEN70	139	21	6	6.37	upstream	646.86	3.768	0.077	0.050	9.13	232.26
SE31-1	14/11/2015 00:43	INL79	177	12	1.7	8.38	upstream	725.67	3.066	0.070	0.048	7.10	206.73
SE31-2	14/11/2015 00:53	GEN79	90	13	3.6	9.53	downstream	391.19	3.113	0.162	0.063	7.10	206.73
SE31-3	14/11/2015 04:27	INL79	102	12	2	8.12	upstream	721.81	6.130	0.041	0.027	7.92	213.60
SE31-4	14/11/2015 04:38	INL79	177	12	1.7	5.96	downstream	591.69	6.098	0.035	0.025	7.92	213.60
SE31-5	14/11/2015 06:31	INL79	110	12	2.5	17.11	downstream	443.61	4.554	0.133	0.052	6.78	215.78
SE31-6	14/11/2015 09:21	INL79	0	0	3.4	7.99	downstream	642.71	1.561	0.041	0.028	7.18	208.08
SE32-1	14/11/2015 13:39	TNK80	98	14	4.5	9.07	upstream	638.57	2.461	0.042	0.025	7.77	213.16
SE32-2	14/11/2015 15:32	INL70	110	11	1.9	2.09	downstream	433.84	4.145	0.045	0.028	7.69	207.24
SE32-3	14/11/2015 16:43	TNK81	177	31	9.4	14.28	downstream	542.84	5.715	0.170	0.091	8.21	SE32-3
SE32-4	14/11/2015 17:03	TNK82	141	24	8.7	14.65	upstream	595.07	5.670	0.098	0.051	8.21	SE32-4
SE32-5	14/11/2015 17:50	INL70	0	0	1.5	10.13	downstream	726.39	5.119	0.070	0.040	8.21	SE32-5

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE32-6	14/11/2015 18:10	INL79	105	12	1.7	5.10	upstream	720.34	4.796	0.050	0.031	10.88	SE32-6
SE32-7	14/11/2015 19:20	TNK83	99	16	6.9	8.50	upstream	588.87	3.645	0.121	0.054	10.88	SE32-7
SE32-8	14/11/2015 20:21	INL52	26	12	5.8	8.37	upstream	660.39	2.591	0.117	0.063	14.67	SE32-8
SE33-1	15/11/2015 01:01	TNK80	110	17	5.9	9.04	downstream	414.42	2.024	0.228	0.149	13.13	SE33-1
SE33-2	15/11/2015 01:53	INL80	110	11	3.2	7.73	upstream	699.29	2.701	0.180	0.112	13.13	SE33-2
SE33-3	15/11/2015 02:20	INL90	85	9	0	10.80	upstream	644.77	3.056	0.196	0.121	12.63	SE33-3
SE33-4	15/11/2015 02:52	TNK80	93	14	5.8	8.25	downstream	431.06	3.534	0.175	0.116	12.63	SE33-4
SE33-5	15/11/2015 05:25	INL80	110	13	0.5	10.23	upstream	600.39	5.881	0.129	0.085	18.24	SE33-5
SE33-6	15/11/2015 06:36	INL79	172	12	1.6	9.39	downstream	347.50	4.965	0.114	0.065	17.58	SE33-6
SE33-7	15/11/2015 07:07	INL89	110	11	3	8.03	upstream	563.75	4.463	0.163	0.073	17.58	SE33-7
SE33-8	15/11/2015 09:05	INL89	135	12	0	7.86	upstream	546.68	2.431	0.267	0.147	18.11	SE33-8
SE33-9	15/11/2015 09:18	INL79	87	12	2.7	10.31	downstream	368.74	2.228	0.212	0.123	18.11	SE33-9
SE33-10	15/11/2015 10:00	INL89	110	13	1.6	7.82	upstream	459.15	1.638	0.223	0.108	17.98	SE33-10
SE34-1	15/11/2015 13:35	INL79	86	11	0	5.31	downstream	413.46	2.039	0.264	0.151	18.55	SE34-1
SE34-2	15/11/2015 14:05	INL79	110	12	2	13.10	upstream	537.97	2.432	0.235	0.129	15.75	SE34-2
SE34-3	15/11/2015 17:37	INL79	110	12	0.2	7.76	downstream	328.27	5.698	0.076	0.046	14.33	SE34-3
SE34-4	15/11/2015 18:53	CAR70	199	32	8.4	10.96	downstream	515.94	4.735	0.047	0.031	12.68	SE34-4
SE35-1	16/11/2015 02:44	INL79	70	7	0.1	8.92	upstream	540.11	2.375	0.145	0.094	10.52	SE35-1
SE35-2	16/11/2015 04:08	INL99	0	0	0	10.64	upstream	605.54	3.857	0.081	0.054	10.24	SE35-2
SE35-3	16/11/2015 05:00	CON71	140	23	6.8	6.11	upstream	683.07	5.203	0.058	0.032	10.24	SE35-3
SE35-4	16/11/2015 06:43	INL52	28	12	6.4	12.06	downstream	391.53	4.760	0.559	0.132	11.13	SE35-4
SE35-5	16/11/2015 07:58	INL80	135	13	0	12.34	downstream	427.26	3.450	0.147	0.067	11.13	SE35-5
SE36-1	16/11/2015 16:39	GAS83	100	18	6.2	14.45	upstream	586.44	4.315	0.111	0.065	10.84	SE36-1
SE36-2	16/11/2015 17:02	INL79	172	11	0.4	3.50	downstream	453.21	4.980	0.060	0.040	10.84	208.73
SE36-3	16/11/2015 22:36	INL99	86	10	0.1	8.67	upstream	800.51	1.669	0.057	0.035	9.98	196.77
SE36-4	16/11/2015 22:46	INL89	110	12	25.5	13.93	downstream	485.39	1.533	0.077	0.048	9.98	196.77
SE37-1	17/11/2015 02:07	INL79	178	11	1.8	4.99	downstream	412.67	1.988	0.068	0.037	9.41	197.39
SE37-2	17/11/2015 03:43	CAR70	183	32	8.3	13.63	upstream	608.50	3.077	0.082	0.038	9.41	197.39

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE37-3	17/11/2015 04:31	TNK89	88	13	4.7	8.92	upstream	564.61	3.768	0.058	0.034	10.82	192.22
SE37-4	17/11/2015 07:59	INL90	18	6	1	11.39	downstream	404.38	4.403	0.152	0.074	12.77	210.74
SE37-5*	17/11/2015 08:13	CON73	237	32	9.3	2.68	upstream	668.09	4.257	0.093	0.050	12.31	219.70
SE37-6	17/11/2015 09:51	INL52	26	12	5.8	12.82	downstream	551.83	2.764	0.096	0.055	12.31	219.70
SE37-7	17/11/2015 10:01	INL80	110	13	0.5	11.23	downstream	478.66	2.593	0.128	0.066	11.26	218.91
SE37-8	17/11/2015 10:40	INL79	73	8	1	11.73	downstream	423.38	1.958	0.071	0.035	11.26	218.91
SE37-9	17/11/2015 11:00	INL80	85	12	2.4	6.81	upstream	649.86	1.658	0.075	0.041	11.26	218.91
SE38-1	17/11/2015 18:26	INL90	85	8	25.5	7.47	upstream	602.78	5.483	0.242	0.127	16.42	204.74
SE38-2	17/11/2015 21:27	INL79	135	12	2.8	11.11	downstream	556.58	3.853	0.311	0.179	18.03	220.47
SE38-3	17/11/2015 22:22	INL53	18	6	1.2	15.89	upstream	413.39	3.022	0.326	0.227	18.99	219.27
SE38-4	17/11/2015 22:32	INL52	32	12	3	12.36	downstream	708.15	2.876	0.460	0.245	18.99	219.27
SE38-5	17/11/2015 23:09	INL79	67	8	0.2	9.23	downstream	508.67	2.450	0.396	0.243	18.99	219.27
SE39-1	18/11/2015 01:48	INL79	67	8	0.2	7.25	upstream	686.19	1.871	0.391	0.233	20.59	228.05
SE39-2	18/11/2015 02:23	INL79	135	11	0	11.16	downstream	417.85	2.433	0.327	0.202	21.23	235.29
SE39-3	18/11/2015 03:46	INL89	110	12	25.5	11.41	upstream	532.69	3.398	0.163	0.110	21.23	235.29
SE39-4	18/11/2015 04:16	INL99	52	7	0	9.48	upstream	620.62	3.710	0.132	0.082	17.39	242.97
SE39-5	18/11/2015 04:52	INL79	130	11	3	6.47	upstream	703.75	4.196	0.104	0.060	17.39	242.97
SE39-6	18/11/2015 08:42	INL52	25	12	6	11.16	downstream	407.60	4.448	0.074	0.045	6.70	210.58
SE40-1	18/11/2015 22:45	INL70	70	10	2	7.18	upstream	499.44	2.641	0.080	0.043	10.34	215.54
SE40-2	18/11/2015 23:21	DRG33	129	24	6.5	7.02	upstream	518.43	2.173	0.097	0.052	10.34	215.54
SE41-1	19/11/2015 03:34	INL80	110	11	0	7.28	downstream	393.99	1.923	0.130	0.076	12.42	220.34
SE41-2	19/11/2015 03:50	INL79	86	11	3.4	8.57	upstream	600.48	2.152	0.168	0.091	12.42	220.34
SE41-3	19/11/2015 04:36	TNK80	120	17	5.5	12.34	downstream	534.25	2.690	0.155	0.091	12.16	220.55
SE41-4	19/11/2015 06:00	INL79	113	44	0.1	5.76	upstream	596.94	3.876	0.204	0.089	11.80	219.58
SE41-5	19/11/2015 06:28	INL89	110	12	20	9.98	upstream	669.73	4.367	0.148	0.075	11.80	219.58
SE41-6	19/11/2015 10:36	INL99	15	5	0.2	11.41	downstream	330.96	3.317	0.046	0.031	10.56	223.99
SE41-7	19/11/2015 11:45	GEN70	83	11	4.3	6.38	upstream	606.19	2.314	0.059	0.034	10.56	223.99
SE41-8	19/11/2015 12:51	CON71	265	32	10.3	10.03	downstream	684.07	1.543	0.089	0.044	12.32	232.79

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE42-1	19/11/2015 17:05	INL90	86	10	20	7.97	downstream	527.98	2.506	0.150	0.054	1.23	96.18
SE42-2	19/11/2015 21:21	INL79	105	23	0.2	7.69	upstream	320.62	5.122	0.059	0.035	5.19	230.86
SE42-3	19/11/2015 22:38	INL79	106	10	0.3	6.39	upstream	711.42	4.034	0.095	0.053	5.96	230.50
SE42-4	20/11/2015 00:48	DRG33	129	24	6.5	13.38	downstream	427.63	2.075	0.154	0.063	5.87	228.88
SE43-1	20/11/2015 08:39	INL79	110	11	2	6.33	upstream	762.55	4.797	0.068	0.037	4.17	218.94
SE43-2	20/11/2015 09:25	INL79	80	9	0.2	9.81	upstream	730.06	4.965	0.091	0.043	4.17	218.94
SE43-3	20/11/2015 12:17	GEN70	136	20	5.6	3.13	upstream	612.36	2.605	0.024	0.018	8.87	249.68
SE44-1	20/11/2015 23:01	INL70	86	10	2.8	7.45	upstream	755.07	4.798	0.054	0.036	8.85	213.30
SE44-2	21/11/2015 00:47	INL79	110	11	2	7.49	upstream	574.31	3.367	0.058	0.036	10.68	244.26
SE45-1	21/11/2015 06:37	INL90	110	12	25.5	8.38	downstream	656.33	2.607	0.146	0.074	8.75	209.71
SE45-2*	21/11/2015 12:34	CON71	261	32	10.9	6.41	downstream	622.30	4.331	0.203	0.089	3.52	226.38
SE45-3	21/11/2015 12:47	INL79	81	10	2	14.89	downstream	443.12	4.134	0.060	0.035	3.52	226.38
SE45-4	21/11/2015 13:06	DRG33	129	24	6.5	15.68	downstream	496.56	3.817	0.398	0.117	3.52	226.38
SE45-5	21/11/2015 13:51	INL79	135	18	2.1	8.72	upstream	649.09	3.064	0.203	0.081	3.52	226.38
SE45-6	21/11/2015 14:02	DRG33	129	24	6.5	9.53	upstream	571.25	2.900	0.154	0.101	13.08	325.25
SE45-7	21/11/2015 15:28	INL80	86	11	0.2	9.99	downstream	548.53	1.826	0.141	0.092	13.08	325.25
SE46-1	21/11/2015 17:47	INL52	28	12	6.4	9.87	downstream	459.94	1.752	0.275	0.082	11.67	344.95
SE46-2	21/11/2015 19:36	CON71	133	18	5.2	8.39	upstream	654.68	2.764	0.089	0.044	10.95	333.98
SE46-3	21/11/2015 20:09	GEN70	88	12	5.6	10.73	upstream	565.39	3.140	0.046	0.028	8.88	345.83
SE46-4	21/11/2015 20:19	INL79	81	10	2	10.58	upstream	538.19	3.203	0.039	0.023	8.88	345.83
SE46-5	21/11/2015 20:35	GEN70	66	11	3.9	10.87	upstream	603.36	3.366	0.038	0.022	8.88	345.83
SE46-6*	21/11/2015 21:11	CON71	176	24	7.4	8.18	upstream	705.35	3.688	0.036	0.023	8.88	345.83
SE46-7	21/11/2015 22:51	DRG33	129	24	6.5	6.45	downstream	460.26	4.937	0.046	0.030	8.34	344.64
SE46-8	21/11/2015 23:35	DRG33	129	24	6.5	10.05	upstream	605.02	5.175	0.016	0.014	8.34	344.64
SE46-9	22/11/2015 00:43	INL52	32	12	5.3	13.36	downstream	413.32	4.412	0.231	0.109	5.79	299.76
SE46-10	22/11/2015 01:08	INL52	26	12	5.8	8.74	upstream	599.53	4.078	0.223	0.062	5.79	299.76
SE46-11	22/11/2015 02:47	GEN79	108	18	6.3	5.24	upstream	609.34	2.373	0.166	0.082	4.78	257.82
SE46-12	22/11/2015 03:22	GEN70	82	11	3.4	7.47	upstream	658.52	1.807	0.076	0.043	4.78	257.82

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE47-1*	22/11/2015 07:17	CON79	206	16	7.5	5.51	upstream	713.60	1.735	0.086	0.040	2.11	233.98
SE47-2	22/11/2015 08:06	INL90	83	12	4.3	7.15	downstream	392.87	2.303	0.085	0.044	5.55	227.13
SE47-3	22/11/2015 13:51	INL52	26	12	5.8	11.70	downstream	389.59	3.523	0.028	0.019	5.26	227.65
SE47-4	22/11/2015 14:09	DRG33	129	24	6.5	8.77	upstream	614.09	3.276	0.104	0.047	3.42	224.20
SE47-5	22/11/2015 14:25	INL52	26	11	5.5	7.66	upstream	666.75	3.051	0.156	0.067	3.42	224.20
SE47-6*	22/11/2015 14:51	CON71	262	32	10	4.14	upstream	700.89	2.607	0.049	0.034	3.42	224.20
SE48-1	22/11/2015 20:30	GEN70	165	27	7.9	6.86	upstream	618.35	1.749	0.032	0.023	4.47	292.35
SE48-2	22/11/2015 21:09	INL52	32	12	5.4	12.51	upstream	715.13	2.194	0.066	0.036	4.47	292.35
SE48-3*	22/11/2015 22:14	CON70	243	33	8.7	11.37	upstream	669.31	3.053	0.067	0.034	5.75	312.75
SE48-4	22/11/2015 22:44	INL79	135	17	2.5	12.83	upstream	755.55	3.698	0.129	0.058	5.75	312.75
SE48-5	23/11/2015 01:04	DRG33	129	24	6.5	7.54	downstream	423.43	5.207	0.054	0.033	5.86	313.74
SE48-6	23/11/2015 02:27	INL90	110	10	2	11.50	downstream	408.32	3.857	0.046	0.030	4.85	293.98
SE48-7	23/11/2015 03:07	GAS80	108	17	6.8	7.53	upstream	603.07	3.179	0.130	0.080	4.85	293.98
SE48-8	23/11/2015 03:36	DRG33	129	24	6.5	9.65	downstream	490.08	2.671	0.085	0.058	4.85	293.98
SE48-9	23/11/2015 04:13	INL52	28	12	6.2	12.00	downstream	411.89	2.008	0.086	0.044	5.10	306.83
SE48-10	23/11/2015 04:26	DRG33	129	24	6.5	9.34	upstream	549.92	1.791	0.104	0.054	5.10	306.83
SE48-11	23/11/2015 04:39	INL90	86	10	4	12.16	downstream	283.60	1.576	0.052	0.032	5.10	306.83
SE49-1	23/11/2015 13:44	DRG33	129	24	6.5	12.67	downstream	605.37	4.665	0.223	0.068	3.83	218.07
SE49-2	23/11/2015 16:12	INL89	80	9	2.4	10.51	downstream	508.87	2.230	0.070	0.041	6.79	199.17
SE50-1	23/11/2015 23:06	INL79	56	8	0.1	10.37	upstream	571.18	2.575	0.047	0.028	9.20	180.19
SE50-2	23/11/2015 23:30	INL79	135	17	2.5	7.65	downstream	656.05	3.064	0.216	0.083	9.20	180.19
SE50-3	24/11/2015 00:21	INL79	102	12	2	11.08	upstream	706.79	4.656	0.077	0.044	9.22	183.98
SE50-4	24/11/2015 01:06	TNK80	117	18	5.7	14.79	upstream	633.13	5.368	0.086	0.050	9.22	183.98
SE50-5	24/11/2015 04:08	INL80	86	10	1.2	12.42	downstream	446.93	3.018	0.030	0.022	10.76	175.83
SE51-1	24/11/2015 10:21	INL52	32	12	5.4	12.21	upstream	542.61	1.845	0.273	0.158	13.15	169.28
SE51-2	24/11/2015 12:41	INL79	102	12	2	3.46	downstream	536.37	4.856	0.133	0.088	13.20	177.03
SE52-1	24/11/2015 22:50	INL79	67	8	0	10.43	upstream	647.40	2.101	0.037	0.027	6.56	205.13
SE52-2	25/11/2015 00:10	INL79	67	7	0.2	4.74	downstream	361.53	3.280	0.075	0.045	5.77	208.28

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE52-3	25/11/2015 00:43	INL52	26	11	5.5	5.96	downstream	388.07	4.107	0.085	0.051	5.77	208.28
SE52-4	25/11/2015 01:34	DRG33	129	24	6.5	16.61	upstream	554.72	5.826	0.022	0.018	5.77	208.28
SE52-5	25/11/2015 02:08	RRC70	153	20	6.2	7.43	downstream	484.58	6.011	0.134	0.068	4.46	215.60
SE52-6	25/11/2015 05:07	INL79	85	9	0.3	8.83	downstream	433.64	3.488	0.039	0.024	5.69	231.35
SE52-7	25/11/2015 05:49	INL70	84	10	0	8.94	downstream	470.79	2.655	0.047	0.032	5.69	231.35
SE52-8	25/11/2015 05:59	INL89	110	13	3.6	9.55	downstream	533.29	2.469	0.046	0.026	5.69	231.35
SE52-9	25/11/2015 06:39	INL70	0	0	1.5	4.70	upstream	817.34	1.753	0.065	0.037	5.36	220.47
SE53-1	25/11/2015 10:36	INL79	110	11	2	9.20	upstream	706.47	2.243	0.045	0.029	7.04	282.37
SE53-2	25/11/2015 10:48	CAR70	183	32	7.8	11.93	upstream	522.99	2.369	0.089	0.042	7.04	282.37
SE54-1	26/11/2015 01:27	INL52	28	12	6.4	12.48	upstream	619.12	3.769	0.112	0.053	3.02	290.45
SE54-2	26/11/2015 03:13	INL52	28	12	6.2	9.36	downstream	380.60	6.015	0.167	0.081	4.55	272.62
SE54-3	26/11/2015 04:45	TNK89	95	15	6.8	5.68	upstream	655.87	4.714	0.036	0.021	3.91	285.28
SE55-1	26/11/2015 13:44	DRG33	129	24	6.5	8.67	downstream	534.21	3.274	0.126	0.059	3.03	254.91
SE55-2	26/11/2015 17:41	INL90	75	7	20	10.74	downstream	411.47	3.762	0.061	0.035	2.72	246.01
SE55-3	26/11/2015 18:36	INL53	19	5	1.2	11.74	downstream	386.82	2.758	0.030	0.020	2.09	201.77
SE56-1	27/11/2015 00:35	INL79	108	11	0.1	5.73	downstream	584.18	1.665	0.087	0.049	3.95	171.66
SE56-2	27/11/2015 03:51	DRG33	129	24	6.5	11.02	upstream	642.16	5.692	0.050	0.029	4.70	162.29
SE56-3	27/11/2015 04:50	RRC74	205	26	6.8	9.24	upstream	624.65	5.043	0.140	0.059	5.99	162.92
SE57-1	27/11/2015 13:32	INL53	19	5	1.2	28.07	upstream	324.17	2.272	0.245	0.107	9.14	178.95
SE57-2	27/11/2015 18:50	GEN79	90	13	3.6	9.57	upstream	677.27	3.321	0.132	0.063	10.25	173.75
SE57-3	27/11/2015 20:23	INL89	125	11	0	7.32	upstream	721.43	1.556	0.063	0.036	11.28	169.60
SE58-1	28/11/2015 01:42	INL79	86	10	1	9.38	upstream	704.62	2.172	0.135	0.082	12.76	182.38
SE58-2	28/11/2015 02:21	INL70	0	0	0	14.73	upstream	659.99	2.868	0.142	0.064	10.38	239.83
SE58-3	28/11/2015 02:46	INL79	110	12	2.5	11.73	upstream	725.23	3.764	0.058	0.040	10.38	239.83
SE58-4	28/11/2015 03:54	INL79	178	11	1.8	12.19	upstream	702.04	6.292	0.198	0.065	10.38	239.83
SE58-5	28/11/2015 04:15	INL79	110	12	2	11.47	upstream	694.35	6.637	0.161	0.089	13.61	271.19
SE58-6	28/11/2015 04:25	INL79	102	12	2	2.99	downstream	520.95	6.711	0.194	0.117	13.61	271.19
SE58-7	28/11/2015 06:56	INL90	110	17	3	8.25	downstream	450.70	4.651	0.130	0.092	12.31	260.97

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE58-8	28/11/2015 07:12	INL80	110	11	0	13.28	downstream	433.37	4.325	0.143	0.081	12.31	260.97
SE58-9	28/11/2015 07:25	INL70	86	10	2.6	11.66	downstream	453.13	4.029	0.150	0.091	12.31	260.97
SE58-10	28/11/2015 08:38	GEN70	138	21	6.8	11.71	downstream	457.16	2.443	0.078	0.049	10.99	251.16
SE58-11	28/11/2015 08:56	INL52	32	12	5.3	11.15	downstream	523.07	2.100	0.196	0.102	10.99	251.16
SE59-1	28/11/2015 14:29	INL79	80	8	0	9.53	upstream	622.28	3.041	0.045	0.028	8.57	197.12
SE59-2	28/11/2015 15:03	INL99	85	8	0.2	11.18	upstream	554.93	3.566	0.105	0.055	8.57	197.12
SE59-3	28/11/2015 16:31	INL89	110	13	0	7.00	downstream	363.88	6.049	0.206	0.078	11.52	186.54
SE59-4	28/11/2015 17:05	RRC71	205	29	7.5	10.41	downstream	459.89	5.909	0.152	0.084	11.52	186.54
SE59-5	28/11/2015 17:25	INL80	110	12	0	9.23	downstream	434.86	5.684	0.055	0.035	11.52	186.54
SE59-6	28/11/2015 17:35	CON71	178	28	10.1	5.78	downstream	576.37	5.553	0.070	0.030	11.52	186.54
SE59-7	28/11/2015 17:55	INL80	135	11	1.5	5.73	upstream	674.24	5.265	0.046	0.030	11.52	186.54
SE59-8	28/11/2015 19:18	INL79	86	11	0	10.30	downstream	564.86	3.812	0.066	0.042	12.04	191.02
SE59-9	28/11/2015 20:10	INL79	135	18	2.1	10.49	downstream	657.78	2.783	0.158	0.103	15.16	190.86
SE59-10*	28/11/2015 20:59	CON70	235	32	8.7	4.70	upstream	731.98	1.860	0.219	0.138	15.16	190.86
SE59-11	28/11/2015 21:15	INL79	110	12	1.5	14.09	downstream	481.76	1.608	0.203	0.112	15.16	190.86
SE60-1	29/11/2015 01:42	INL52	26	12	5.8	11.42	upstream	629.41	1.664	0.136	0.082	16.04	197.51
SE60-2	29/11/2015 02:23	INL52	28	12	6.4	10.48	upstream	782.06	2.178	0.410	0.144	11.20	203.68
SE60-3	29/11/2015 02:48	INL80	110	14	2.2	10.15	upstream	546.15	2.529	0.094	0.061	11.20	203.68
SE60-4	29/11/2015 03:22	GEN70	81	11	3.3	10.60	upstream	549.63	3.331	0.065	0.042	11.20	203.68
SE60-5*	29/11/2015 04:00	CON71	262	32	9.5	10.83	upstream	658.99	4.612	0.082	0.052	10.22	204.18
SE60-6	29/11/2015 06:53	INL80	110	11	2.6	10.43	downstream	387.61	4.570	0.069	0.039	11.65	199.82
SE60-7	29/11/2015 08:21	INL79	108	11	0.1	8.11	downstream	433.08	2.958	0.054	0.035	9.76	199.88
SE60-8	29/11/2015 09:39	INL20	82	9	0	11.75	downstream	411.90	1.659	0.051	0.032	9.76	199.88
SE61-1	29/11/2015 13:31	INL52	30	9	4.8	9.70	downstream	489.96	1.646	0.241	0.119	13.37	209.19
SE61-2	29/11/2015 14:09	INL89	85	11	2.3	6.71	downstream	412.47	2.226	0.226	0.107	16.56	221.57
SE61-3	29/11/2015 18:40	INL52	33	11	3.7	10.68	upstream	792.88	5.516	0.244	0.100	17.10	217.57
SE61-4	29/11/2015 19:13	GEN70	89	12	4.8	7.02	upstream	519.78	4.987	0.120	0.063	17.10	217.57
SE61-5	29/11/2015 19:58	INL52	28	12	6.2	7.43	upstream	744.93	4.213	0.354	0.169	17.10	217.57

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE61-6	29/11/2015 20:15	INL80	84	10	2.1	6.98	upstream	488.20	3.936	0.332	0.194	20.12	223.93
SE61-7	29/11/2015 20:46	INL52	32	12	5.3	13.24	downstream	566.96	3.396	0.410	0.232	20.12	223.93
SE62-1	30/11/2015 02:39	INL90	85	9	0	10.16	upstream	621.98	3.364	0.047	0.031	13.51	250.10
SE62-2	30/11/2015 03:21	INL80	86	9	3	10.37	upstream	587.33	3.914	0.053	0.029	13.51	250.10
SE62-3	30/11/2015 03:31	CAR70	200	32	8.9	7.32	downstream	523.76	4.079	0.077	0.047	13.51	250.10
SE62-4	30/11/2015 04:19	CON79	151	23	6.9	7.22	downstream	686.14	4.913	0.126	0.052	11.84	255.11
SE62-5*	30/11/2015 05:11	CON71	158	23	7	5.70	upstream	702.40	6.030	0.081	0.053	11.84	255.11
SE62-6	30/11/2015 06:02	INL89	80	8	1.2	11.72	upstream	662.19	6.354	0.080	0.056	7.48	247.08
SE62-7	30/11/2015 06:26	INL80	125	11	4.2	8.98	downstream	754.04	6.201	0.054	0.028	7.48	247.08
SE62-8	30/11/2015 07:46	INL70	0	0	1.5	13.17	downstream	727.75	4.829	0.054	0.027	7.48	247.08
SE62-9	30/11/2015 08:23	INL90	135	14	0	11.77	downstream	665.50	4.111	0.089	0.056	5.21	193.61
SE63-1	30/11/2015 16:19	INL90	70	9	0	11.78	upstream	625.65	3.995	0.174	0.103	15.45	214.80
SE63-2	30/11/2015 18:31	INL80	110	13	0.2	7.66	downstream	305.00	5.986	0.110	0.062	17.33	220.27
SE63-3	30/11/2015 19:07	INL80	86	10	0.3	8.25	downstream	380.75	5.689	0.144	0.082	17.33	220.27
SE63-4	30/11/2015 20:01	RRC70	211	32	9.3	7.50	upstream	571.43	4.938	0.076	0.048	15.89	224.45
SE63-5	30/11/2015 20:33	INL90	134	14	1.8	8.79	upstream	483.72	4.436	0.163	0.079	15.89	224.45
SE63-6	30/11/2015 22:13	INL70	0	0	1.5	4.45	upstream	738.32	2.678	0.108	0.066	17.74	233.61

Table 18 – Single ship events including large vessel-tug events (index with asterisk) detected at Gsc3 location (middle high mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE01-1	29/10/2015 17:26	INL79	105	10	0.2	11.76	downstream	287.63	5.104	0.084	0.042	5.41	194.48
SE02-1	30/10/2015 05:43	INL79	80	9	0	4.15	upstream	762.32	5.223	0.038	0.026	4.86	102.10
SE03-1	30/10/2015 15:55	INL52	33	11	3.7	9.21	downstream	467.80	4.198	0.176	0.087	4.99	103.16
SE04-1	31/10/2015 04:04	INL79	110	12	2.5	8.02	downstream	697.96	3.143	0.117	0.060	3.99	86.28
SE04-2	31/10/2015 07:00	INL79	127	11	0	4.58	upstream	818.80	4.572	0.033	0.022	4.61	89.99
SE05-1	31/10/2015 18:09	INL52	32	12	5.4	9.31	upstream	614.65	5.449	0.037	0.022	2.15	101.81
SE05-2	31/10/2015 19:24	INL79	135	14	0.4	11.37	downstream	752.59	4.513	0.032	0.019	2.15	101.81
SE05-3	31/10/2015 20:45	CON73	222	30	10.4	11.92	downstream	686.89	3.136	0.063	0.034	2.14	107.61
SE06-1*	01/11/2015 04:45	CON73	260	32	10.1	6.45	upstream	761.45	3.453	0.036	0.027	1.73	138.05
SE06-2	01/11/2015 05:12	INL90	110	17	3	5.45	downstream	724.47	4.236	0.063	0.033	1.73	138.05
SE06-3	01/11/2015 05:34	GEN70	105	16	6.4	14.09	upstream	636.71	4.969	0.077	0.049	1.73	138.05
SE06-4	01/11/2015 05:45	INL52	26	12	5.8	5.23	downstream	572.47	5.221	0.142	0.075	1.73	138.05
SE06-5	01/11/2015 06:34	INL90	83	12	2.4	12.34	upstream	654.39	5.545	0.103	0.042	1.40	102.21
SE06-6	01/11/2015 07:17	INL69	100	12	0.2	9.20	downstream	464.39	5.159	0.128	0.057	1.40	102.21
SE06-7	01/11/2015 07:36	INL99	195	23	0.1	7.69	downstream	449.28	4.873	0.067	0.038	1.40	102.21
SE06-8	01/11/2015 07:46	INL79	135	12	2.3	5.11	downstream	657.92	4.724	0.070	0.036	1.40	102.21
SE06-9	01/11/2015 08:26	INL89	135	11	2	7.34	upstream	652.36	4.059	0.099	0.059	3.74	151.29
SE06-10	01/11/2015 08:51	INL79	80	9	1	15.17	downstream	490.86	3.623	0.066	0.046	3.74	151.29
SE07-1	01/11/2015 17:13	INL52	26	12	5.8	12.18	upstream	739.44	3.731	0.065	0.047	1.46	23.97
SE07-2	01/11/2015 18:50	INL79	135	17	1.5	10.22	upstream	813.94	5.426	0.082	0.049	2.78	85.31
SE07-3	01/11/2015 20:55	INL79	196	11	2.8	5.77	upstream	636.97	3.754	0.073	0.039	2.50	82.63
SE08-1	02/11/2015 05:16	INL80	110	11	3.2	8.84	upstream	746.41	3.091	0.040	0.023	3.07	72.39
SE09-1	02/11/2015 19:47	INL00	177	5	0.3	8.23	upstream	684.70	5.161	0.056	0.030	2.40	238.21
SE09-2	02/11/2015 20:04	INL99	65	7	0	8.78	upstream	690.50	5.062	0.054	0.031	1.05	228.72

index	time (dd/mm/yyyy HH:MM)	type	length (m	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE09-3	02/11/2015 20:17	INL79	135	14	2.6	10.38	downstream	603.62	4.947	0.057	0.036	1.05	228.72
SE09-4*	02/11/2015 20:34	CON70	300	42	12.8	3.80	upstream	755.04	4.741	0.048	0.033	1.05	228.72
SE11-1	03/11/2015 20:57	INL79	135	12	0.2	6.23	downstream	578.04	4.839	0.074	0.042	4.48	85.11
SE11-2	03/11/2015 21:43	INL70	0	0	0	12.58	upstream	682.72	4.374	0.166	0.062	4.48	85.11
SE11-3	03/11/2015 22:14	INL79	80	9	0	9.72	downstream	458.71	3.933	0.101	0.043	3.96	116.77
SE13-1	04/11/2015 22:45	INL80	65	10	0.4	10.46	downstream	478.58	4.244	0.062	0.032	6.25	181.08
SE13-2	04/11/2015 23:16	INL79	110	12	2.7	8.02	downstream	641.85	3.816	0.037	0.026	6.25	181.08
SE13-3	04/11/2015 23:48	DRG33	98	22	0	3.71	downstream	435.88	3.377	0.032	0.020	6.25	181.08
SE14-1	05/11/2015 08:06	INL79	127	11	0	7.69	upstream	781.51	3.093	0.029	0.019	5.40	160.87
SE15-1	06/11/2015 00:18	INL80	86	11	2.3	10.01	downstream	462.69	4.026	0.029	0.023	8.95	183.71
SE17-1	06/11/2015 21:55	INL99	110	11	4	8.45	downstream	694.89	3.258	0.131	0.065	10.17	200.74
SE17-2	06/11/2015 23:46	INL89	110	10	0.1	6.25	downstream	429.56	4.803	0.056	0.036	8.73	206.54
SE17-3	07/11/2015 01:49	INL79	86	11	0	11.93	downstream	669.19	3.928	0.060	0.036	7.35	216.95
SE17-4	07/11/2015 02:03	INL79	130	11	3	6.50	downstream	622.50	3.744	0.023	0.017	6.08	235.38
SE18-1	07/11/2015 15:08	INL90	108	11	0	5.76	upstream	802.91	3.124	0.040	0.027	7.90	185.66
SE19-1	07/11/2015 23:21	INL79	108	11	0.1	4.85	downstream	520.96	3.957	0.044	0.029	7.93	226.52
SE19-2*	08/11/2015 00:16	CON71	194	28	8.9	7.62	upstream	724.03	4.857	0.061	0.035	7.13	232.15
SE19-3	08/11/2015 00:25	RRC70	188	27	6.8	12.04	downstream	551.88	4.948	0.211	0.103	7.13	232.15
SE19-4	08/11/2015 00:47	TNK82	112	17	7.4	13.42	upstream	627.82	5.068	0.244	0.084	7.13	232.15
SE19-5	08/11/2015 00:59	INL52	32	12	5.3	10.32	downstream	546.02	5.093	0.189	0.074	7.13	232.15
SE19-6	08/11/2015 01:35	GEN70	107	14	3.8	12.00	downstream	467.29	4.963	0.098	0.050	7.13	232.15
SE19-7	08/11/2015 03:16	INL79	20	8	3	7.02	downstream	481.49	3.606	0.023	0.017	4.36	216.51
SE20-1*	08/11/2015 11:54	CON70	300	48	10.3	7.06	upstream	789.41	3.646	0.049	0.031	5.80	163.87
SE20-2	08/11/2015 12:09	INL70	67	7	0	10.05	upstream	635.44	3.932	0.053	0.036	6.37	149.05
SE20-3	08/11/2015 15:30	INL79	135	17	2	5.76	upstream	819.16	3.346	0.034	0.020	7.58	146.41
SE20-4	08/11/2015 15:45	TNK89	137	22	7.1	5.83	upstream	672.93	3.121	0.029	0.022	7.58	146.41
SE21-1	09/11/2015 00:24	INL80	110	14	4.1	5.42	downstream	498.41	3.592	0.123	0.054	9.52	216.98
SE21-2	09/11/2015 02:56	GEN70	89	14	5.4	10.29	upstream	502.35	4.228	0.265	0.081	9.55	223.72

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SE22-1	09/11/2015 11:26	INL52	26	12	5.8	15.16	upstream	531.84	3.116	0.187	0.061	11.74	224.61
SE22-2	09/11/2015 13:45	INL52	26	12	5.8	6.81	downstream	610.94	5.527	0.220	0.099	12.06	221.50
SE23-1	10/11/2015 03:21	INL79	183	12	1	8.08	downstream	683.92	5.071	0.039	0.022	10.36	197.94
SE23-2	10/11/2015 04:06	INL79	135	11	2	9.46	downstream	720.70	4.346	0.054	0.032	9.45	205.19
SE23-3	10/11/2015 04:49	INL52	28	12	6.2	16.37	downstream	601.38	3.672	0.183	0.067	9.45	205.19
SE23-4	10/11/2015 04:59	INL79	135	14	2.6	8.18	downstream	610.02	3.506	0.082	0.049	9.45	205.19
SE24-1	10/11/2015 13:40	DRG33	82	12	5.1	10.66	upstream	708.64	4.991	0.118	0.071	10.51	204.67
SE24-2	10/11/2015 14:30	INL99	85	9	2	7.26	downstream	500.35	5.501	0.059	0.036	8.94	205.28
SE25-1	11/11/2015 02:28	INL79	185	11	2	9.83	upstream	699.39	5.399	0.080	0.040	9.20	198.76
SE25-2	11/11/2015 02:46	INL52	25	12	6	6.76	downstream	630.16	5.515	0.223	0.112	9.20	198.76
SE25-3	11/11/2015 03:45	DRG90	113	20	5	12.42	downstream	483.02	5.146	0.189	0.073	9.20	198.76
SE25-4	11/11/2015 04:40	INL90	110	11	0	11.41	downstream	479.55	4.238	0.031	0.021	9.30	197.50
SE25-5	11/11/2015 04:52	INL79	135	12	0.1	8.52	downstream	679.84	4.037	0.048	0.028	9.30	197.50
SE27-1	12/11/2015 02:37	INL79	135	12	1.7	13.31	upstream	375.58	4.954	0.043	0.028	5.85	208.82
SE27-2	12/11/2015 03:34	INL00	84	9	0	10.11	upstream	802.89	5.497	0.078	0.045	5.85	208.82
SE27-3	12/11/2015 04:24	INL79	22	11	2	7.58	downstream	453.78	5.025	0.023	0.016	5.65	204.80
SE27-4	12/11/2015 05:02	INL79	135	18	2.1	10.91	downstream	682.14	4.435	0.133	0.061	5.65	204.80
SE27-5	12/11/2015 05:32	TNK80	183	32	8.8	8.11	upstream	612.38	3.926	0.060	0.040	5.65	204.80
SE27-6	12/11/2015 05:49	INL79	86	9	0	6.01	upstream	571.33	3.636	0.029	0.021	5.65	204.80
SE28-1	12/11/2015 14:24	INL79	85	10	0.2	12.75	upstream	609.75	3.868	0.081	0.042	5.92	170.24
SE29-1	13/11/2015 02:33	CON79	132	16	6.4	4.81	upstream	654.78	3.544	0.062	0.037	9.86	195.60
SE29-2	13/11/2015 02:46	INL79	135	14	1	13.85	upstream	419.46	3.963	0.086	0.044	9.86	195.60
SE29-3	13/11/2015 02:56	INL90	134	14	2.7	11.89	upstream	755.38	4.289	0.084	0.051	9.86	195.60
SE29-4	13/11/2015 03:11	INL79	135	15	0	11.36	upstream	747.50	4.726	0.087	0.048	9.86	195.60
SE29-5*	13/11/2015 03:37	CON71	333	48	11.3	4.95	downstream	763.36	5.159	0.257	0.117	9.86	195.60
SE29-6	13/11/2015 05:01	RRC70	176	31	8.7	13.30	downstream	524.85	4.593	0.149	0.080	9.60	200.12
SE29-7*	13/11/2015 05:13	CON71	178	28	10.1	7.15	upstream	715.93	4.404	0.085	0.041	9.60	200.12
SE30-1	13/11/2015 14:55	INL79	113	44	1	9.53	upstream	784.62	4.157	0.104	0.057	11.77	224.32

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SE30-2	13/11/2015 15:21	INL00	58	7	0	14.00	upstream	722.96	5.169	0.230	0.108	11.77	224.32
SE30-3	13/11/2015 15:39	INL80	110	11	0.3	11.99	upstream	714.40	5.611	0.097	0.057	11.77	224.32
SE30-4	13/11/2015 19:05	GEN70	139	21	6	6.37	upstream	714.86	3.767	0.070	0.045	9.13	232.26
SE31-1	14/11/2015 00:43	INL79	177	12	1.7	8.38	upstream	793.67	3.066	0.071	0.050	7.10	206.73
SE31-2	14/11/2015 00:53	GEN79	90	13	3.6	9.53	downstream	459.19	3.112	0.175	0.081	7.10	206.73
SE31-3	14/11/2015 04:27	INL79	102	12	2	8.12	upstream	789.81	6.130	0.066	0.037	7.92	213.60
SE31-4	14/11/2015 04:38	INL79	177	12	1.7	5.96	downstream	659.69	6.097	0.043	0.032	7.92	213.60
SE31-5	14/11/2015 06:31	INL79	110	12	2.5	17.11	downstream	511.61	4.547	0.119	0.047	6.78	215.78
SE32-1	14/11/2015 15:32	INL70	110	11	1.9	2.09	downstream	501.84	4.153	0.066	0.041	7.69	207.24
SE32-2	14/11/2015 16:43	TNK81	177	31	9.4	14.28	downstream	610.84	5.714	0.260	0.114	8.21	199.31
SE32-3	14/11/2015 17:03	TNK82	141	24	8.7	14.65	upstream	663.07	5.665	0.119	0.057	8.21	199.31
SE32-4	14/11/2015 17:50	INL70	0	0	1.5	10.13	downstream	794.39	5.109	0.058	0.038	8.21	199.31
SE32-5	14/11/2015 18:10	INL79	105	12	1.7	5.10	upstream	788.34	4.790	0.037	0.024	10.88	185.53
SE32-6	14/11/2015 19:20	TNK83	99	16	6.9	8.50	upstream	656.87	3.637	0.128	0.067	10.88	185.53
SE33-1	15/11/2015 02:20	INL90	85	9	0	10.80	upstream	712.77	3.059	0.162	0.095	12.63	210.91
SE33-2	15/11/2015 02:52	TNK80	93	14	5.8	8.25	downstream	499.06	3.539	0.180	0.112	12.63	210.91
SE33-3	15/11/2015 05:25	INL80	110	13	0.5	10.23	upstream	668.39	5.879	0.228	0.155	18.24	225.13
SE33-4	15/11/2015 06:36	INL79	172	12	1.6	9.39	downstream	415.50	4.960	0.107	0.067	17.58	227.27
SE33-5	15/11/2015 07:07	INL89	110	11	3	8.03	upstream	631.75	4.458	0.158	0.090	17.58	227.27
SE34-1	15/11/2015 17:37	INL79	110	12	0.2	7.76	downstream	396.27	5.695	0.188	0.071	14.33	227.42
SE34-2	15/11/2015 18:53	CAR70	199	32	8.4	10.96	downstream	583.94	4.728	0.049	0.034	12.68	226.11
SE35-1	16/11/2015 04:08	INL99	0	0	0	10.64	upstream	673.54	3.866	0.116	0.076	10.24	198.38
SE35-2	16/11/2015 05:00	CON71	140	23	6.8	6.11	upstream	751.07	5.209	0.097	0.054	10.24	198.38
SE35-3	16/11/2015 06:43	INL52	28	12	6.4	12.06	downstream	459.53	4.754	0.349	0.113	11.13	195.76
SE35-4	16/11/2015 07:58	INL80	135	13	0	12.34	downstream	495.26	3.445	0.114	0.079	11.13	195.76
SE36-1	16/11/2015 16:39	GAS83	100	18	6.2	14.45	upstream	654.44	4.327	0.107	0.071	10.84	208.73
SE36-2	16/11/2015 17:02	INL79	172	11	0.4	3.50	downstream	521.21	4.983	0.099	0.057	10.84	208.73
SE37-1	17/11/2015 03:43	CAR70	183	32	8.3	13.63	upstream	676.50	3.083	0.082	0.040	9.41	197.39

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SE37-2	17/11/2015 04:31	TNK89	88	13	4.7	8.92	upstream	632.61	3.776	0.049	0.033	10.82	192.22
SE37-3	17/11/2015 07:59	INL90	18	6	1	11.39	downstream	472.38	4.399	0.090	0.051	12.77	210.74
SE37-4*	17/11/2015 08:13	CON73	237	32	9.3	2.68	upstream	736.09	4.253	0.088	0.050	12.31	219.70
SE38-1	17/11/2015 18:26	INL90	85	8	25.5	7.47	upstream	670.78	5.487	0.355	0.173	16.42	204.74
SE38-2	17/11/2015 21:27	INL79	135	12	2.8	11.11	downstream	624.58	3.850	0.332	0.203	18.03	220.47
SE38-3	17/11/2015 22:22	INL53	18	6	1.2	15.89	upstream	481.39	3.022	0.231	0.142	18.99	219.27
SE39-1	18/11/2015 03:46	INL89	110	12	25.5	11.41	upstream	600.69	3.400	0.224	0.139	21.23	235.29
SE39-2	18/11/2015 04:16	INL99	52	7	0	9.48	upstream	688.62	3.713	0.164	0.111	17.39	242.97
SE39-3	18/11/2015 04:52	INL79	130	11	3	6.47	upstream	771.75	4.201	0.101	0.069	17.39	242.97
SE39-4	18/11/2015 08:42	INL52	25	12	6	11.16	downstream	475.60	4.441	0.074	0.039	6.70	210.58
SE41-1	19/11/2015 06:00	INL79	113	44	0.1	5.76	upstream	664.94	3.882	0.198	0.099	11.80	219.58
SE41-2	19/11/2015 06:28	INL89	110	12	20	9.98	upstream	737.73	4.375	0.200	0.094	11.80	219.58
SE41-3	19/11/2015 10:36	INL99	15	5	0.2	11.41	downstream	398.96	3.310	0.045	0.029	10.56	223.99
SE42-1	19/11/2015 21:21	INL79	105	23	0.2	7.69	upstream	388.62	5.119	0.063	0.039	5.19	230.86
SE42-2	19/11/2015 22:38	INL79	106	10	0.3	6.39	upstream	779.42	4.031	0.091	0.042	5.96	230.50
SE43-1	20/11/2015 08:39	INL79	110	11	2	6.33	upstream	830.55	4.801	0.058	0.036	4.17	218.94
SE43-2	20/11/2015 09:25	INL79	80	9	0.2	9.81	upstream	798.06	4.963	0.071	0.042	4.17	218.94
SE44-1	20/11/2015 23:01	INL70	86	10	2.8	7.45	upstream	823.07	4.796	0.048	0.033	8.85	213.30
SE44-2	21/11/2015 00:47	INL79	110	11	2	7.49	upstream	642.31	3.358	0.051	0.032	10.68	244.26
SE45-1*	21/11/2015 12:34	CON71	261	32	10.9	6.41	downstream	690.30	4.324	0.180	0.073	3.52	226.38
SE45-2	21/11/2015 12:47	INL79	81	10	2	14.89	downstream	511.12	4.127	0.050	0.028	3.52	226.38
SE45-3	21/11/2015 13:06	DRG33	129	24	6.5	15.68	downstream	564.56	3.810	0.204	0.092	3.52	226.38
SE45-4	21/11/2015 13:51	INL79	135	18	2.1	8.72	upstream	717.09	3.053	0.133	0.062	3.52	226.38
SE46-1	21/11/2015 20:09	GEN70	88	12	5.6	10.73	upstream	633.39	3.142	0.048	0.029	8.88	345.83
SE46-2	21/11/2015 20:19	INL79	81	10	2	10.58	upstream	606.19	3.206	0.040	0.026	8.88	345.83
SE46-3	21/11/2015 20:35	GEN70	66	11	3.9	10.87	upstream	671.36	3.371	0.038	0.022	8.88	345.83
SE46-4*	21/11/2015 21:11	CON71	176	24	7.4	8.18	upstream	773.35	3.692	0.037	0.025	8.88	345.83
SE46-5	21/11/2015 22:51	DRG33	129	24	6.5	6.45	downstream	528.26	4.941	0.062	0.034	8.34	344.64

index	time (dd/mm/yyyy HH:MM)	type	length (m	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE46-6	21/11/2015 23:35	DRG33	129	24	6.5	10.05	upstream	673.02	5.174	0.018	0.015	8.34	344.64
SE46-7	22/11/2015 00:43	INL52	32	12	5.3	13.36	downstream	481.32	4.404	0.121	0.053	5.79	299.76
SE46-8	22/11/2015 01:08	INL52	26	12	5.8	8.74	upstream	667.53	4.069	0.270	0.075	5.79	299.76
SE47-1	22/11/2015 13:51	INL52	26	12	5.8	11.70	downstream	457.59	3.516	0.024	0.018	5.26	227.65
SE47-2	22/11/2015 14:09	DRG33	129	24	6.5	8.77	upstream	682.09	3.270	0.076	0.044	3.42	224.20
SE47-3	22/11/2015 14:25	INL52	26	11	5.5	7.66	upstream	734.75	3.042	0.118	0.066	3.42	224.20
SE48-1*	22/11/2015 22:14	CON70	243	33	8.7	11.37	upstream	737.31	3.067	0.051	0.034	5.75	312.75
SE48-2	22/11/2015 22:44	INL79	135	17	2.5	12.83	upstream	823.55	3.712	0.138	0.059	5.75	312.75
SE48-3	23/11/2015 01:04	DRG33	129	24	6.5	7.54	downstream	491.43	5.205	0.070	0.033	5.86	313.74
SE48-4	23/11/2015 02:27	INL90	110	10	2	11.50	downstream	476.32	3.848	0.054	0.033	4.85	293.98
SE48-5	23/11/2015 03:07	GAS80	108	17	6.8	7.53	upstream	671.07	3.170	0.125	0.064	4.85	293.98
SE49-1	23/11/2015 13:44	DRG33	129	24	6.5	12.67	downstream	673.37	4.660	0.173	0.058	3.83	218.07
SE50-1	23/11/2015 23:30	INL79	135	17	2.5	7.65	downstream	724.05	3.079	0.169	0.078	9.20	180.19
SE50-2	24/11/2015 00:21	INL79	102	12	2	11.08	upstream	774.79	4.673	0.119	0.062	9.22	183.98
SE50-3	24/11/2015 01:06	TNK80	117	18	5.7	14.79	upstream	701.13	5.370	0.099	0.062	9.22	183.98
SE51-1	24/11/2015 12:41	INL79	102	12	2	3.46	downstream	604.37	4.873	0.164	0.104	13.20	177.03
SE52-1	25/11/2015 00:10	INL79	67	7	0.2	4.74	downstream	429.53	3.298	0.108	0.042	5.77	208.28
SE52-2	25/11/2015 00:43	INL52	26	11	5.5	5.96	downstream	456.07	4.132	0.109	0.061	5.77	208.28
SE52-3	25/11/2015 01:34	DRG33	129	24	6.5	16.61	upstream	622.72	5.830	0.029	0.021	5.77	208.28
SE52-4	25/11/2015 02:08	RRC70	153	20	6.2	7.43	downstream	552.58	6.010	0.139	0.078	4.46	215.60
SE52-5	25/11/2015 05:07	INL79	85	9	0.3	8.83	downstream	501.64	3.483	0.028	0.020	5.69	231.35
SE54-1	26/11/2015 01:27	INL52	28	12	6.4	12.48	upstream	687.12	3.782	0.103	0.064	3.02	290.45
SE54-2	26/11/2015 03:13	INL52	28	12	6.2	9.36	downstream	448.60	6.012	0.162	0.084	4.55	272.62
SE54-3	26/11/2015 04:45	TNK89	95	15	6.8	5.68	upstream	723.87	4.706	0.034	0.022	3.91	285.28
SE55-1	26/11/2015 13:44	DRG33	129	24	6.5	8.67	downstream	602.21	3.284	0.095	0.063	3.03	254.91
SE55-2	26/11/2015 17:41	INL90	75	7	20	10.74	downstream	479.47	3.753	0.056	0.034	2.72	246.01
SE56-1	27/11/2015 03:51	DRG33	129	24	6.5	11.02	upstream	710.16	5.691	0.069	0.043	4.70	162.29
SE56-2	27/11/2015 04:50	RRC74	205	26	6.8	9.24	upstream	692.65	5.039	0.158	0.066	5.99	162.92

index	time (dd/mm/yyyy HH:MM)	type	length (m	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE57-1	27/11/2015 18:50	GEN79	90	13	3.6	9.57	upstream	745.27	3.312	0.174	0.066	10.25	173.75
SE58-1	28/11/2015 02:46	INL79	110	12	2.5	11.73	upstream	793.23	3.789	0.074	0.044	10.38	239.83
SE58-2	28/11/2015 03:54	INL79	178	11	1.8	12.19	upstream	770.04	6.311	0.148	0.093	10.38	239.83
SE58-3	28/11/2015 04:15	INL79	110	12	2	11.47	upstream	762.35	6.645	0.227	0.137	13.61	271.19
SE58-4	28/11/2015 04:25	INL79	102	12	2	2.99	downstream	588.95	6.714	0.261	0.157	13.61	271.19
SE58-5	28/11/2015 06:56	INL90	110	17	3	8.25	downstream	518.70	4.641	0.145	0.088	12.31	260.97
SE58-6	28/11/2015 07:12	INL80	110	11	0	13.28	downstream	501.37	4.315	0.112	0.070	12.31	260.97
SE58-7	28/11/2015 07:25	INL70	86	10	2.6	11.66	downstream	521.13	4.018	0.104	0.070	12.31	260.97
SE59-1	28/11/2015 14:29	INL79	80	8	0	9.53	upstream	690.28	3.047	0.053	0.031	8.57	197.12
SE59-2	28/11/2015 15:03	INL99	85	8	0.2	11.18	upstream	622.93	3.576	0.120	0.058	8.57	197.12
SE59-3	28/11/2015 16:31	INL89	110	13	0	7.00	downstream	431.88	6.049	0.189	0.105	11.52	186.54
SE59-4	28/11/2015 17:05	RRC71	205	29	7.5	10.41	downstream	527.89	5.900	0.204	0.106	11.52	186.54
SE59-5	28/11/2015 17:25	INL80	110	12	0	9.23	downstream	502.86	5.673	0.064	0.039	11.52	186.54
SE59-6	28/11/2015 17:35	CON71	178	28	10.1	5.78	downstream	644.37	5.542	0.092	0.043	11.52	186.54
SE59-7	28/11/2015 17:55	INL80	135	11	1.5	5.73	upstream	742.24	5.256	0.052	0.032	11.52	186.54
SE59-8	28/11/2015 19:18	INL79	86	11	0	10.30	downstream	632.86	3.800	0.102	0.060	12.04	191.02
SE60-1	29/11/2015 03:22	GEN70	81	11	3.3	10.60	upstream	617.63	3.353	0.077	0.054	11.20	203.68
SE60-2*	29/11/2015 04:00	CON71	262	32	9.5	10.83	upstream	726.99	4.635	0.113	0.068	10.22	204.18
SE60-3	29/11/2015 06:53	INL80	110	11	2.6	10.43	downstream	455.61	4.561	0.110	0.039	11.65	199.82
SE61-1	29/11/2015 18:40	INL52	33	11	3.7	10.68	upstream	860.88	5.512	0.234	0.114	17.10	217.57
SE61-2	29/11/2015 19:13	GEN70	89	12	4.8	7.02	upstream	587.78	4.978	0.159	0.103	17.10	217.57
SE61-3	29/11/2015 19:58	INL52	28	12	6.2	7.43	upstream	812.93	4.206	0.312	0.191	17.10	217.57
SE61-4	29/11/2015 20:15	INL80	84	10	2.1	6.98	upstream	556.20	3.929	0.303	0.193	20.12	223.93
SE61-5	29/11/2015 20:46	INL52	32	12	5.3	13.24	downstream	634.96	3.388	0.366	0.235	20.12	223.93
SE62-1	30/11/2015 02:39	INL90	85	9	0	10.16	upstream	689.98	3.369	0.055	0.029	13.51	250.10
SE62-2	30/11/2015 03:21	INL80	86	9	3	10.37	upstream	655.33	3.922	0.063	0.033	13.51	250.10
SE62-3	30/11/2015 03:31	CAR70	200	32	8.9	7.32	downstream	591.76	4.088	0.074	0.045	13.51	250.10
SE62-4	30/11/2015 04:19	CON79	151	23	6.9	7.22	downstream	754.14	4.924	0.150	0.071	11.84	255.11

index	time (dd/mm/yyyy HH:MM)	type	length (m	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
SE62-5*	30/11/2015 05:11	CON71	158	23	7	5.70	upstream	770.40	6.039	0.137	0.087	11.84	255.11
SE62-6	30/11/2015 06:02	INL89	80	8	1.2	11.72	upstream	730.19	6.354	0.124	0.070	7.48	247.08
SE62-7	30/11/2015 06:26	INL80	125	11	4.2	8.98	downstream	822.04	6.196	0.048	0.030	7.48	247.08
SE62-8	30/11/2015 07:46	INL70	0	0	1.5	13.17	downstream	795.75	4.818	0.049	0.030	7.48	247.08
SE62-9	30/11/2015 08:23	INL90	135	14	0	11.77	downstream	733.50	4.100	0.099	0.056	5.21	193.61
SE63-1	30/11/2015 16:19	INL90	70	9	0	11.78	upstream	693.65	4.007	0.199	0.123	15.45	214.80
SE63-2	30/11/2015 18:31	INL80	110	13	0.2	7.66	downstream	373.00	5.984	0.168	0.099	17.33	220.27
SE63-3	30/11/2015 19:07	INL80	86	10	0.3	8.25	downstream	448.75	5.684	0.164	0.111	17.33	220.27
SE63-4	30/11/2015 20:01	RRC70	211	32	9.3	7.50	upstream	639.43	4.930	0.136	0.069	15.89	224.45
SE63-5	30/11/2015 20:33	INL90	134	14	1.8	8.79	upstream	551.72	4.426	0.173	0.106	15.89	224.45

Table 19 – Single ship events including large vessel-tug events (index with asterisk) detected at Gsc2 and Gsb2 location (locations on high tidal flat).

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
GSb2	SE02-1	30/10/2015 05:19	INL79	110	11	0	8.64	downstream	617.3	5.31	0.043	0.025	4.86	102.1
	SE04-1	31/10/2015 05:22	INL52	26	12	5.8	7.62	downstream	647.3	5.28	0.089	0.043	3.99	86.3
	SE07-1	01/11/2015 18:46	INL79	135	17	1.5	14.46	upstream	837.2	5.28	0.067	0.038	2.78	85.3
	SE07-2	01/11/2015 19:02	INL80	110	11	0.4	10.50	upstream	916.7	5.21	0.024	0.019	2.78	85.3
	SE23-1	10/11/2015 02:49	TNK81	146	24	9.1	8.33	upstream	752.6	5.24	0.018	0.016	10.36	197.9
	SE24-1	10/11/2015 14:35	INL99	85	9	2	7.75	downstream	608.1	5.34	0.040	0.024	8.94	205.3
	SE25-1	11/11/2015 02:51	INL52	25	12	6	6.14	downstream	645.9	5.37	0.048	0.031	9.20	198.8
	SE25-2	11/11/2015 03:13	INL90	134	14	2.5	5.40	downstream	581.6	5.29	0.043	0.026	9.20	198.8
	SE27-1*	12/11/2015 03:04	CON71	210	32	10.3	9.71	upstream	834.6	5.28	0.034	0.023	5.85	208.8
	SE27-2	12/11/2015 03:29	INL00	84	9	0	9.63	upstream	875.4	5.35	0.038	0.027	5.85	208.8
	SE30-1	13/11/2015 15:35	INL80	110	11	0.3	12.91	upstream	830.5	5.41	0.141	0.080	11.77	224.3
	SE31-1	14/11/2015 03:36	INL90	86	11	2	10.88	upstream	864.9	5.47	0.029	0.023	9.64	206.7
	SE31-2	14/11/2015 04:21	INL79	102	12	2	9.17	upstream	906.2	5.99	0.026	0.018	7.92	213.6
	SE31-3	14/11/2015 04:45	INL79	177	12	1.7	4.97	downstream	612.3	5.92	0.019	0.016	7.92	213.6
	SE31-4	14/11/2015 05:20	INL79	110	10	1	10.00	downstream	615.3	5.53	0.034	0.020	7.92	213.6
	SE32-1	14/11/2015 16:46	TNK81	177	31	9.4	10.40	downstream	693.1	5.58	0.152	0.068	8.21	199.3
	SE32-2	14/11/2015 16:59	TNK82	141	24	8.7	13.00	upstream	823.2	5.55	0.070	0.039	8.21	199.3
	SE33-1	15/11/2015 05:21	INL80	110	13	0.5	9.60	upstream	876.8	5.77	0.086	0.052	18.24	225.1
	SE34-1	15/11/2015 16:30	INL84	100	11	2.4	5.96	downstream	607.2	5.30	0.125	0.064	14.33	227.4

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsb2	SE34-2	15/11/2015 16:46	INL79	135	11	2.5	9.81	upstream	522.9	5.54	0.064	0.033	14.33	227.4
	SE38-1	17/11/2015 18:19	INL90	85	8	25.5	8.11	upstream	766.7	5.29	0.103	0.056	16.42	204.7
	SE50-1	24/11/2015 01:02	TNK80	117	18	5.7	17.70	upstream	835.9	5.20	0.053	0.035	9.22	184.0
	SE52-1	25/11/2015 01:30	DRG33	129	24	6.5	11.38	upstream	797.2	5.60	0.020	0.017	5.77	208.3
	SE52-2	25/11/2015 02:54	INL52	32	12	5.3	13.15	upstream	845.2	5.53	0.121	0.070	4.46	215.6
	SE55-1	26/11/2015 14:52	INL00	100	10	0	12.64	upstream	827.7	5.28	0.030	0.020	3.37	253.5
	SE56-1*	27/11/2015 04:11	CON71	260	32	10.4	2.42	upstream	735.8	5.39	0.017	0.015	5.99	162.9
	SE58-1	28/11/2015 04:10	INL79	110	12	2	12.41	upstream	843.1	6.45	0.131	0.084	13.61	271.2
	SE58-2	28/11/2015 04:33	INL79	102	12	2	3.76	downstream	623.9	6.57	0.237	0.128	13.61	271.2
	SE59-1	28/11/2015 16:10	INL52	26	11	5.5	4.13	downstream	624.9	5.63	0.127	0.060	11.52	186.5
	SE59-2	28/11/2015 17:09	RRC71	205	29	7.5	10.30	downstream	652.6	5.71	0.095	0.049	11.52	186.5
	SE59-3	28/11/2015 17:30	INL80	110	12	0	5.83	downstream	752.3	5.45	0.034	0.026	11.52	186.5
	SE61-1	29/11/2015 18:36	INL52	33	11	3.7	12.62	upstream	914.2	5.41	0.145	0.088	17.10	217.6
	SE62-1*	30/11/2015 05:04	CON71	158	23	7	9.32	upstream	836.2	5.76	0.061	0.037	11.84	255.1
	SE62-2	30/11/2015 05:24	INL79	110	11	2	9.60	upstream	810.0	6.06	0.076	0.046	11.84	255.1
	SE62-3	30/11/2015 05:58	INL89	80	8	1.2	11.59	upstream	799.8	6.22	0.078	0.042	11.84	255.1
	SE63-1	30/11/2015 19:12	INL80	86	10	0.3	8.37	downstream	586.9	5.49	0.083	0.053	17.33	220.3
Gsc2	SE01-1	29/10/2015 17:26	INL79	105	10	0.2	11.76	downstream	357.6	5.02	0.051	0.028	5.41	194.5
	SE02-1	30/10/2015 05:43	INL79	80	9	0	4.15	upstream	832.3	5.13	0.028	0.021	4.86	102.1
	SE05-1	31/10/2015 18:09	INL52	32	12	5.4	9.31	upstream	684.6	5.37	0.018	0.015	2.15	101.8
	SE06-1	01/11/2015 05:45	INL52	26	12	5.8	5.23	downstream	642.5	5.14	0.097	0.055	1.73	138.1

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsc2	SE06-2	01/11/2015 06:34	INL90	83	12	2.4	12.34	upstream	724.4	5.46	0.056	0.039	1.40	102.2
	SE06-3	01/11/2015 07:17	INL69	100	12	0.2	9.20	downstream	534.4	5.08	0.039	0.025	1.40	102.2
	SE07-1	01/11/2015 18:50	INL79	135	17	1.5	10.22	upstream	883.9	5.34	0.039	0.026	2.78	85.3
	SE09-1	02/11/2015 19:47	INL00	177	5	0.3	8.23	upstream	754.7	5.08	0.033	0.022	2.40	238.2
	SE09-2	02/11/2015 20:04	INL99	65	7	0	8.78	upstream	760.5	4.98	0.048	0.039	1.05	228.7
	SE19-1	08/11/2015 00:47	TNK82	112	17	7.4	13.42	upstream	697.8	4.99	0.116	0.064	7.13	232.2
	SE19-2	08/11/2015 00:59	INL52	32	12	5.3	10.32	downstream	616.0	5.01	0.107	0.061	7.13	232.2
	SE22-1	09/11/2015 13:45	INL52	26	12	5.8	6.81	downstream	680.9	5.45	0.137	0.078	12.06	221.5
	SE23-1	10/11/2015 03:21	INL79	183	12	1	8.08	downstream	753.9	5.00	0.033	0.021	10.36	197.9
	SE24-1	10/11/2015 14:30	INL99	85	9	2	7.26	downstream	570.3	5.43	0.038	0.025	8.94	205.3
	SE25-1	11/11/2015 02:28	INL79	185	11	2	9.83	upstream	769.4	5.31	0.029	0.020	9.20	198.8
	SE25-2	11/11/2015 02:46	INL52	25	12	6	6.76	downstream	700.2	5.43	0.230	0.118	9.20	198.8
	SE25-3	11/11/2015 03:45	DRG90	113	20	5	12.42	downstream	553.0	5.06	0.093	0.059	9.20	198.8
	SE27-1	12/11/2015 03:34	INL00	84	9	0	10.11	upstream	872.9	5.41	0.051	0.033	5.85	208.8
	SE29-1*	13/11/2015 03:37	CON71	333	48	11.3	4.95	downstream	833.4	5.08	0.134	0.094	9.86	195.6
	SE30-1	13/11/2015 15:21	INL00	58	7	0	14.00	upstream	793.0	5.11	0.081	0.054	11.77	224.3
	SE30-2	13/11/2015 15:39	INL80	110	11	0.3	11.99	upstream	784.4	5.55	0.055	0.032	11.77	224.3
	SE31-1	14/11/2015 04:27	INL79	102	12	2	8.12	upstream	859.8	6.06	0.033	0.022	7.92	213.6
	SE31-2	14/11/2015 04:38	INL79	177	12	1.7	5.96	downstream	729.7	6.02	0.025	0.020	7.92	213.6
	SE32-1	14/11/2015 16:43	TNK81	177	31	9.4	14.28	downstream	680.8	5.64	0.271	0.101	8.21	199.3
	SE32-2	14/11/2015 17:03	TNK82	141	24	8.7	14.65	upstream	733.1	5.59	0.064	0.036	8.21	199.3

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsc2	SE32-3	14/11/2015 17:50	INL70	0	0	1.5	10.13	downstream	864.4	5.04	0.062	0.038	8.21	199.3
	SE33-1	15/11/2015 05:25	INL80	110	13	0.5	10.23	upstream	738.4	5.81	0.081	0.049	18.24	225.1
	SE34-1	15/11/2015 17:37	INL79	110	12	0.2	7.76	downstream	466.3	5.62	0.047	0.033	14.33	227.4
	SE35-1	16/11/2015 05:00	CON71	140	23	6.8	6.11	upstream	821.1	5.13	0.046	0.029	10.24	198.4
	SE38-1	17/11/2015 18:26	INL90	85	8	25.5	7.47	upstream	740.8	5.42	0.154	0.101	16.42	204.7
	SE42-1	19/11/2015 21:21	INL79	105	23	0.2	7.69	upstream	458.6	5.04	0.050	0.036	5.19	230.9
	SE46-1	21/11/2015 23:35	DRG33	129	24	6.5	10.05	upstream	743.0	5.10	0.017	0.014	8.34	344.6
	SE48-1	23/11/2015 01:04	DRG33	129	24	6.5	7.54	downstream	561.4	5.12	0.029	0.022	5.86	313.7
	SE50-1	24/11/2015 01:06	TNK80	117	18	5.7	14.79	upstream	771.1	5.29	0.055	0.034	9.22	184.0
	SE52-1	25/11/2015 01:34	DRG33	129	24	6.5	16.61	upstream	692.7	5.75	0.024	0.018	5.77	208.3
	SE52-2	25/11/2015 02:08	RRC70	153	20	6.2	7.43	downstream	622.6	5.92	0.152	0.076	4.46	215.6
	SE54-1	26/11/2015 03:13	INL52	28	12	6.2	9.36	downstream	518.6	5.91	0.105	0.056	4.55	272.6
	SE56-1	27/11/2015 03:51	DRG33	129	24	6.5	11.02	upstream	780.2	5.59	0.041	0.029	4.70	162.3
	SE58-1	28/11/2015 03:54	INL79	178	11	1.8	12.19	upstream	840.0	6.24	0.059	0.034	10.38	239.8
	SE58-2	28/11/2015 04:15	INL79	110	12	2	11.47	upstream	832.3	6.57	0.071	0.048	13.61	271.2
	SE58-3	28/11/2015 04:25	INL79	102	12	2	2.99	downstream	659.0	6.63	0.160	0.078	13.61	271.2
	SE59-1	28/11/2015 16:31	INL89	110	13	0	7.00	downstream	501.9	5.97	0.168	0.083	11.52	186.5
	SE59-2	28/11/2015 17:05	RRC71	205	29	7.5	10.41	downstream	597.9	5.81	0.103	0.067	11.52	186.5
	SE59-3	28/11/2015 17:25	INL80	110	12	0	9.23	downstream	572.9	5.59	0.037	0.026	11.52	186.5
	SE59-4	28/11/2015 17:35	CON71	178	28	10.1	5.78	downstream	714.4	5.46	0.048	0.027	11.52	186.5
	SE59-5	28/11/2015 17:55	INL80	135	11	1.5	5.73	upstream	812.2	5.17	0.040	0.029	11.52	186.5

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsc2	SE61-1	29/11/2015 18:40	INL52	33	11	3.7	10.68	upstream	930.9	5.42	0.165	0.093	17.10	217.6
	SE62-1*	30/11/2015 05:11	CON71	158	23	7	5.70	upstream	840.4	5.99	0.062	0.036	11.84	255.1
	SE62-2	30/11/2015 06:02	INL89	80	8	1.2	11.72	upstream	800.2	6.29	0.121	0.066	7.48	247.1
	SE62-3	30/11/2015 06:26	INL80	125	11	4.2	8.98	downstream	892.0	6.13	0.025	0.019	7.48	247.1
	SE63-1	30/11/2015 18:31	INL80	110	13	0.2	7.66	downstream	443.0	5.92	0.063	0.045	17.33	220.3
	SE63-2	30/11/2015 19:07	INL80	86	10	0.3	8.25	downstream	518.8	5.62	0.172	0.099	17.33	220.3

Table 20 – Large vessel events detected at Gsb4 location (low mudflat – north transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE01-1	29/10/2015 13:18	CON71	292	33	10.9	9.24	upstream	621.39	1.941	0.066	0.066	6.45
SE02-1	30/10/2015 08:27	CON71	269	33	10	9.85	upstream	585.27	2.290	0.077	0.077	5.87
SE03-1	30/10/2015 20:56	CON71	232	32	10.8	7.58	upstream	719.73	2.076	0.102	0.102	4.55
SE04-1	31/10/2015 02:19	RRC70	205	26	7.3	12.82	upstream	706.52	1.471	0.097	0.097	3.77
SE05-1	31/10/2015 14:05	CON71	232	32	10.9	9.58	downstream	621.62	1.261	0.255	0.255	5.28
SE06-1	01/11/2015 02:02	CON70	335	42	14.5	12.78	downstream	535.23	1.033	0.735	0.735	1.82
SE06-2	01/11/2015 06:21	CON79	399	60	13	7.48	downstream	579.04	5.560	0.082	0.082	1.40
SE06-3	01/11/2015 11:23	INL79	206	12	2.3	4.15	upstream	407.77	1.047	0.094	0.094	2.42
SE07-1	01/11/2015 22:02	CON73	260	32	9.9	15.97	downstream	652.17	2.591	0.102	0.102	2.30
SE08-1	02/11/2015 04:19	CON72	366	48	11.5	6.50	upstream	753.51	2.323	0.127	0.127	3.07
SE09-1	02/11/2015 16:17	RRC71	211	32	7.7	7.87	downstream	620.15	1.912	0.205	0.205	1.65
SE11-1	03/11/2015 16:19	CON79	366	48	14.3	5.95	downstream	634.83	1.117	0.247	0.247	2.35
SE11-2	03/11/2015 16:41	CON71	280	32	12.1	6.28	downstream	571.18	1.443	0.176	0.176	2.35
SE12-1	04/11/2015 05:40	RRC70	200	33	8.4	7.37	upstream	711.89	2.288	0.068	0.068	4.09
SE13-1	04/11/2015 16:49	CON71	333	48	10.3	7.31	upstream	755.72	0.893	0.088	0.088	5.30
SE13-2	04/11/2015 20:44	CON79	281	32	11.6	7.74	downstream	543.50	4.451	0.063	0.063	7.08
SE13-3	05/11/2015 00:08	RRC70	232	32	9.2	9.65	upstream	599.57	3.106	0.114	0.114	6.07
SE13-4	05/11/2015 02:31	CON71	210	30	9.9	10.80	downstream	624.53	1.222	0.065	0.065	4.03
SE14-1	05/11/2015 05:51	CON71	399	54	14.8	10.40	downstream	570.18	1.462	0.616	0.616	4.06
SE14-2	05/11/2015 06:06	CON71	203	27	7.8	9.81	downstream	614.70	1.672	0.143	0.143	5.15
SE14-3	05/11/2015 13:42	CAR71	210	32	9	11.61	downstream	569.33	2.010	0.076	0.076	7.11
SE14-4	05/11/2015 14:46	CON91	300	45	9.9	8.84	downstream	572.11	1.209	0.103	0.103	6.82
SE15-1	05/11/2015 18:20	CON71	210	32	9.9	7.27	upstream	720.63	1.000	0.089	0.089	7.46
SE16-1	06/11/2015 06:19	CON71	210	32	9.7	12.26	downstream	597.43	1.029	0.215	0.215	7.00
SE16-2	06/11/2015 16:12	RRC70	232	32	9.9	18.82	downstream	569.61	1.211	0.390	0.390	8.51
SE17-1	07/11/2015 03:48	CON71	365	49	11.8	7.75	upstream	666.44	2.200	0.077	0.077	6.08

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE17-2	07/11/2015 04:59	CON79	397	56	10.5	9.00	downstream	622.14	1.287	0.071	0.071	3.97
SE19-1	07/11/2015 20:37	CON79	300	40	14.3	7.34	downstream	606.37	1.297	0.318	0.318	11.59
SE19-2	07/11/2015 22:02	CON71	365	49	14.3	7.61	downstream	568.80	2.575	0.134	0.134	7.93
SE19-3	07/11/2015 22:28	CON71	300	45	11.6	8.19	downstream	608.16	2.978	0.133	0.133	7.93
SE20-1	08/11/2015 11:47	CON70	300	48	10.3	7.94	upstream	708.88	3.515	0.078	0.078	5.80
SE22-1	09/11/2015 14:25	CON70	300	48	10.1	13.99	downstream	560.29	5.419	0.094	0.094	11.17
SE24-1	10/11/2015 09:59	CON70	366	48	13	8.91	downstream	579.90	1.560	0.467	0.467	10.02
SE25-1	11/11/2015 07:09	CAR70	200	32	8.7	8.91	upstream	679.44	1.737	0.109	0.109	7.82
SE26-1	11/11/2015 16:30	RRC79	214	32	9.4	14.87	downstream	581.99	4.571	0.076	0.076	7.91
SE26-2	11/11/2015 20:03	CON70	254	32	11.6	12.01	downstream	625.40	1.097	0.137	0.137	9.10
SE27-1	12/11/2015 08:35	CON71	203	27	8.4	14.08	downstream	555.13	0.914	0.106	0.106	5.82
SE28-1	12/11/2015 11:26	CAR70	200	30	9	11.68	downstream	522.17	1.129	0.310	0.310	6.12
SE28-2	12/11/2015 12:03	RRC00	231	32	8.4	9.86	upstream	743.87	1.669	0.113	0.113	4.47
SE28-3	12/11/2015 17:25	CON71	210	32	10.3	12.03	downstream	552.84	4.221	0.044	0.044	5.22
SE29-1	13/11/2015 01:58	CON79	399	60	13.8	6.14	downstream	621.83	2.728	0.101	0.101	8.20
SE30-1	13/11/2015 12:29	CON70	300	48	11.5	7.47	upstream	689.59	1.521	0.088	0.088	8.75
SE30-2	13/11/2015 18:45	CON71	294	32	12.6	13.42	downstream	540.44	4.136	0.049	0.049	9.13
SE33-1	15/11/2015 00:09	CON70	300	48	13.7	6.52	downstream	547.61	1.138	0.181	0.181	13.13
SE34-1	15/11/2015 14:24	CON70	300	45	13.1	6.85	downstream	593.64	2.678	0.054	0.054	15.75
SE36-1	16/11/2015 14:27	CAR70	200	32	8	11.34	upstream	638.44	1.604	0.147	0.147	12.17
SE37-1	17/11/2015 03:56	CON74	366	48	14.2	8.44	upstream	697.47	3.246	0.080	0.080	9.41
SE38-1	17/11/2015 15:25	RRC71	205	29	6.8	11.94	downstream	495.05	2.333	0.157	0.157	11.67
SE39-1	18/11/2015 06:40	CON71	366	52	13.5	9.56	downstream	559.59	5.630	0.087	0.087	12.03
SE39-2	18/11/2015 12:41	CON74	366	48	11.6	11.03	downstream	627.06	0.844	0.486	0.486	13.87
SE40-1	18/11/2015 20:43	CON71	333	48	11	6.93	upstream	666.94	4.481	0.056	0.056	14.22
SE41-1	19/11/2015 07:03	CON70	363	45	10.2	7.11	downstream	579.52	4.967	0.067	0.067	11.80
SE41-2	19/11/2015 12:24	GAS83	230	36	9	14.06	downstream	546.56	1.834	0.148	0.148	12.32
SE41-3	19/11/2015 12:55	CON71	265	32	10.3	12.06	downstream	590.29	1.542	0.138	0.138	12.32

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE43-1	20/11/2015 04:36	CON71	203	27	8.7	8.85	downstream	555.39	1.814	0.080	0.080	6.24
SE43-2	20/11/2015 04:54	CON79	397	56	14.5	8.95	downstream	591.09	2.083	0.327	0.181	6.24
SE44-1	20/11/2015 17:25	CON79	210	26	9	8.29	upstream	713.90	1.338	0.067	0.067	6.96
SE44-2	20/11/2015 21:16	CON71	398	56	11.6	7.94	downstream	541.15	5.128	0.111	0.111	6.30
SE44-3	21/11/2015 02:58	RRC70	205	26	7.4	11.74	upstream	647.30	1.486	0.173	0.173	7.04
SE45-1	21/11/2015 15:03	RRC70	205	26	7.8	14.01	downstream	580.02	2.158	0.137	0.137	13.08
SE46-1	21/11/2015 22:22	CON71	366	48	13.9	6.90	downstream	604.84	4.582	0.064	0.064	8.34
SE48-1	22/11/2015 20:08	CON71	334	43	12.9	7.49	upstream	716.52	1.375	0.126	0.126	4.47
SE48-2	22/11/2015 20:57	CAR70	200	32	7.4	5.58	downstream	538.76	2.062	0.093	0.093	4.47
SE49-1	23/11/2015 09:12	CON71	262	32	10.5	9.95	downstream	616.59	1.767	0.065	0.065	2.58
SE49-2	23/11/2015 09:30	RRC74	214	32	8	12.39	upstream	621.88	1.982	0.096	0.096	2.58
SE50-1	23/11/2015 22:04	CON79	210	30	9.8	9.54	downstream	546.71	1.706	0.107	0.107	9.20
SE50-2	24/11/2015 03:42	CON70	300	45	10.7	12.84	downstream	586.70	3.499	0.051	0.051	10.83
SE50-3	24/11/2015 05:10	CON71	366	51	13.3	4.90	upstream	666.11	1.916	0.122	0.122	10.76
SE51-1	24/11/2015 09:54	GEN70	222	30	11.4	7.71	downstream	554.18	1.485	0.175	0.175	11.96
SE51-2	24/11/2015 17:41	CON71	366	52	11.8	6.32	upstream	679.67	2.102	0.093	0.093	11.43
SE51-3	24/11/2015 18:13	CON70	287	33	9.6	7.11	upstream	689.92	1.599	0.095	0.095	10.08
SE52-1	24/11/2015 22:19	CON70	333	48	9.9	9.61	upstream	688.64	1.668	0.135	0.135	6.56
SE52-2	24/11/2015 23:06	RRC74	236	36	9.2	12.25	upstream	738.98	2.323	0.094	0.067	6.56
SE52-3	25/11/2015 00:03	CON70	287	33	9.5	8.50	downstream	608.75	3.169	0.089	0.089	5.77
SE52-4	25/11/2015 06:53	CAR70	228	32	8.6	11.86	upstream	653.53	1.559	0.222	0.222	5.36
SE53-1	25/11/2015 11:47	CON71	366	51	11	8.73	downstream	617.03	2.973	0.219	0.219	7.04
SE54-1	25/11/2015 22:47	CON70	333	48	10.8	8.36	downstream	650.03	1.725	0.147	0.147	6.77
SE54-2	25/11/2015 23:11	CON70	294	32	13.5	5.75	downstream	532.27	2.071	0.062	0.062	6.77
SE54-3	26/11/2015 00:30	RRC71	214	32.3	9	11.33	downstream	622.39	2.911	0.094	0.094	3.02
SE54-4	26/11/2015 06:02	CON71	366	52	10.8	6.07	upstream	709.11	3.359	0.053	0.053	1.34
SE54-5	26/11/2015 06:50	CAR70	228	32	8.9	12.41	downstream	617.77	2.424	0.057	0.057	1.34
SE55-1	26/11/2015 11:26	CON71	366	52	13.9	4.41	downstream	549.90	1.569	0.110	0.110	2.72

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE55-2	26/11/2015 19:07	RRC70	200	32	7.6	10.00	upstream	615.65	2.217	0.100	0.100	2.09
SE57-1	27/11/2015 19:39	CON71	260	32	10.6	13.15	downstream	562.57	2.419	0.102	0.102	10.25
SE58-1	28/11/2015 01:32	RRC74	214	32	9.3	11.63	downstream	568.72	2.024	0.277	0.277	12.76
SE59-1	28/11/2015 13:28	CON70	257	32	10.8	7.09	downstream	562.26	2.467	0.082	0.082	8.98
SE59-2	28/11/2015 14:23	CON74	366	48	13.5	7.41	downstream	568.78	2.992	0.074	0.074	8.57
SE61-1	29/11/2015 13:14	CAR70	200	32	8.3	10.76	downstream	525.16	1.370	0.287	0.287	13.37
SE61-2	29/11/2015 22:06	CON70	300	48	10.1	9.57	upstream	676.41	2.267	0.082	0.082	18.65
SE62-1	30/11/2015 00:34	GEN70	204	32	9.8	10.52	downstream	549.11	1.894	0.144	0.144	13.54
SE63-1	30/11/2015 14:32	CON70	300	48	9.3	9.02	downstream	596.47	2.463	0.148	0.148	14.38

Table 21 – Large vessel events detected at Gsc4 location (low mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE04-1	31/10/2015 02:23	RRC70	205	26	7.3	12.34	upstream	664.89	1.513	0.099	0.089	3.77
SE04-2	31/10/2015 09:07	BLK70	200	33	9.1	9.05	upstream	716.50	2.283	0.167	0.167	4.89
SE05-1	31/10/2015 15:03	RRC70	205	26	7.4	10.33	downstream	452.20	1.970	0.136	0.136	5.28
SE06-1	01/11/2015 06:16	CON79	399	60	13	7.05	downstream	680.06	5.553	0.060	0.060	1.40
SE07-1	01/11/2015 21:59	CON73	260	32	9.9	11.50	downstream	702.88	2.633	0.071	0.071	2.50
SE09-1	02/11/2015 16:13	RRC71	211	32	7.7	11.74	downstream	479.35	1.850	0.167	0.167	1.65
SE12-1	04/11/2015 04:39	CON72	366	48	12.3	6.13	downstream	636.66	1.583	0.066	0.066	4.09
SE13-1	05/11/2015 00:12	RRC70	232	32	9.2	9.34	upstream	565.31	3.040	0.171	0.171	6.07
SE14-1	05/11/2015 06:02	CON71	203	27	7.8	8.31	downstream	607.29	1.607	0.115	0.115	5.15
SE17-1	07/11/2015 02:38	RRC71	205	29	7.5	8.16	upstream	564.86	3.242	0.065	0.065	6.08
SE19-1	07/11/2015 21:57	CON71	365	49	14.3	5.45	downstream	693.00	2.477	0.080	0.080	11.59
SE19-2	07/11/2015 22:23	CON71	300	45	11.6	5.98	downstream	636.32	2.877	0.059	0.059	7.93
SE21-1	08/11/2015 23:57	CAR70	200	32	8.5	8.11	downstream	560.12	2.918	0.044	0.044	10.28
SE24-1	10/11/2015 09:55	CON70	366	48	13	6.59	downstream	575.40	1.477	0.117	0.117	10.02
SE25-1	11/11/2015 07:13	CAR70	200	32	8.7	9.39	upstream	571.14	1.646	0.044	0.044	7.82
SE27-1	12/11/2015 00:00	CON71	203	27	8.3	9.05	upstream	691.44	1.793	0.095	0.095	7.20
SE28-1	12/11/2015 19:01	CAR70	200	32	9.2	12.92	downstream	512.94	2.581	0.110	0.110	6.09
SE29-1	13/11/2015 01:52	CON79	399	60	13.8	5.84	downstream	659.03	2.622	0.079	0.079	8.20
SE32-1	14/11/2015 13:08	RRC00	231	32	9.6	8.65	downstream	449.65	2.081	0.149	0.149	7.77
SE33-1	15/11/2015 08:47	RRC74	214	32	8.9	8.76	upstream	568.89	2.708	0.084	0.084	18.11
SE36-1	16/11/2015 21:03	GAS83	230	36	9.8	7.80	upstream	506.11	3.201	0.088	0.056	9.02
SE38-1	17/11/2015 15:22	RRC71	205	29	6.8	10.94	downstream	430.62	2.277	0.255	0.255	11.67
SE40-1	18/11/2015 16:57	GEN79	200	28	7.5	9.46	downstream	415.64	2.712	0.095	0.095	13.58
SE41-1	19/11/2015 12:21	GAS83	230	36	9	12.49	downstream	503.69	1.834	0.123	0.101	12.32
SE43-1	20/11/2015 04:49	CON79	397	56	14.5	5.61	downstream	597.38	2.000	0.085	0.085	6.24
SE44-1	20/11/2015 21:11	CON71	398	56	11.6	5.66	downstream	636.13	5.064	0.076	0.076	6.30

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE45-1	21/11/2015 14:59	RRC70	205	26	7.8	11.28	downstream	439.28	2.170	0.125	0.125	13.08
SE48-1	22/11/2015 20:17	CON71	334	43	12.9	4.04	upstream	692.49	1.512	0.055	0.046	4.47
SE48-2	22/11/2015 20:52	CAR70	200	32	7.4	6.96	downstream	473.43	1.993	0.095	0.095	4.47
SE49-1	23/11/2015 09:07	CON71	262	32	10.5	6.30	downstream	688.79	1.703	0.140	0.128	2.58
SE49-2	23/11/2015 09:34	RRC74	214	32	8	12.66	upstream	637.67	2.016	0.095	0.095	2.58
SE50-1	23/11/2015 21:59	CON79	210	30	9.8	8.59	downstream	590.39	1.628	0.053	0.048	8.02
SE50-2	23/11/2015 22:11	CON71	334	43	14.3	4.95	downstream	596.65	1.790	0.063	0.063	9.20
SE50-3	24/11/2015 05:18	CON71	366	51	13.3	2.98	upstream	717.57	1.743	0.090	0.090	10.76
SE51-1	24/11/2015 17:49	CON71	366	52	11.8	3.42	upstream	708.22	1.938	0.076	0.076	11.43
SE52-1	24/11/2015 22:26	CON70	333	48	9.9	5.72	upstream	717.15	1.773	0.079	0.071	6.56
SE52-2	25/11/2015 06:56	CAR70	228	32	8.6	11.28	upstream	447.19	1.463	0.530	0.352	5.36
SE53-1	25/11/2015 11:42	CON71	366	51	11	6.64	downstream	710.38	2.904	0.098	0.098	7.04
SE54-1	25/11/2015 22:40	CON70	333	48	10.8	3.69	downstream	595.00	1.591	0.065	0.064	6.77
SE54-2	26/11/2015 00:26	RRC71	214	32.3	9	9.82	downstream	496.32	2.861	0.122	0.122	3.02
SE54-3	26/11/2015 06:46	CAR70	228	32	8.9	9.98	downstream	537.08	2.463	0.063	0.063	1.34
SE55-1	26/11/2015 19:43	RRC74	236	36	10	9.54	downstream	586.93	1.499	0.082	0.080	2.09
SE56-1	27/11/2015 03:05	CON74	398	56	11.6	7.92	downstream	622.59	5.129	0.056	0.056	4.70
SE57-1	27/11/2015 12:54	CON71	366	52	10.5	5.03	downstream	572.19	1.789	0.076	0.076	9.14
SE57-2	27/11/2015 13:06	CON70	300	48	11.2	4.27	upstream	707.05	1.952	0.092	0.083	9.14
SE57-3	27/11/2015 17:49	CAR00	200	32	8.8	13.18	downstream	437.52	4.378	0.070	0.070	9.96
SE58-1	28/11/2015 01:28	RRC74	214	32	9.3	12.02	downstream	456.54	1.973	0.374	0.374	12.76
SE58-2	28/11/2015 02:00	CAR70	200	32	8.8	11.97	upstream	591.13	2.466	0.088	0.088	10.38
SE60-1	29/11/2015 01:55	CAR70	234	32	9.3	8.35	upstream	605.40	1.841	0.082	0.082	16.04
SE61-1	29/11/2015 22:11	CON70	300	48	10.1	5.41	upstream	692.25	2.139	0.064	0.058	18.65

Table 22 – Large vessel events detected at Gsc3 location (middle high mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	Wspeed (m/s)	Wdir (degrees)
SE06-1	01/11/2015 06:16	CON79	399	60	13	7.05	downstream	748.06	5.555	0.064	0.064	1.40
SE10-1	03/11/2015 07:12	CON79	204	32	11.4	8.36	downstream	596.75	4.418	0.081	0.081	3.69
SE13-1	05/11/2015 00:12	RRC70	232	32	9.2	9.34	upstream	633.31	3.035	0.254	0.254	6.07
SE17-1	07/11/2015 02:38	RRC71	205	29	7.5	8.16	upstream	632.86	3.238	0.092	0.092	6.08
SE18-1	07/11/2015 14:32	RRC71	205	29	7.4	13.85	downstream	615.66	3.632	0.078	0.078	7.90
SE20-1	08/11/2015 11:54	CON70	300	48	10.3	7.06	upstream	789.41	3.646	0.091	0.091	5.80
SE24-1	10/11/2015 12:09	CON70	260	32	10.5	11.63	upstream	786.84	3.152	0.074	0.074	10.51
SE32-1	14/11/2015 15:06	RRC74	205	26	7.3	9.05	downstream	573.58	3.546	0.069	0.069	7.69
SE36-1	16/11/2015 21:03	GAS83	230	36	9.8	7.80	upstream	574.11	3.193	0.129	0.129	9.02
SE37-1	17/11/2015 04:04	CON74	366	48	14.2	6.05	upstream	777.77	3.342	0.096	0.096	10.82
SE39-1	18/11/2015 06:35	CON71	366	52	13.5	7.64	downstream	713.91	5.624	0.062	0.062	12.03
SE44-1	20/11/2015 21:11	CON71	398	56	11.6	5.66	downstream	704.13	5.069	0.089	0.089	6.30
SE48-1	22/11/2015 22:14	CON70	243	33	8.7	11.37	upstream	737.31	3.067	0.106	0.078	5.75
SE52-1	24/11/2015 23:59	CON70	287	33	9.5	5.26	downstream	720.66	3.092	0.106	0.106	6.56
SE54-1	26/11/2015 01:17	CON71	243	33	11	7.33	upstream	831.32	3.570	0.066	0.066	3.02
SE54-2	26/11/2015 06:11	CON71	366	52	10.8	4.14	upstream	797.83	3.141	0.096	0.096	1.34
SE56-1	27/11/2015 03:05	CON74	398	56	11.6	7.92	downstream	690.59	5.147	0.074	0.074	4.70
SE57-1	27/11/2015 17:49	CAR00	200	32	8.8	13.18	downstream	505.52	4.369	0.099	0.099	9.96

Table 23 – Large vessel events detected at high locations: Gsc2 and Gsb2

plot ID	index	time (dd/mm/yyyy HH:MM)	type	length (m)	beam (m)	draught (m)	speed (knots)	heading	distance (m)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsb2	SE06-1	01/11/2015 06:21	CON79	399	60	13	7.48	downstream	703.0	5.41	0.089	0.089	1.40	102.2
	SE22-1	09/11/2015 14:25	CON70	300	48	10.1	13.99	downstream	684.3	5.27	0.111	0.111	11.17	218.0
	SE38-1	17/11/2015 18:56	RRC72	236	36	10.2	10.25	downstream	741.7	5.31	0.042	0.041	16.42	204.7
	SE39-1	18/11/2015 06:40	CON71	366	52	13.5	9.56	downstream	683.6	5.49	0.117	0.117	12.03	241.7
Gsc2	SE06-1	01/11/2015 06:16	CON79	399	60	13	7.05	downstream	818.1	5.47	0.000	0.000	1.40	102.2
	SE29-1	13/11/2015 03:37	CON71	333	48	11.3	4.95	downstream	833.4	5.08	0.068	0.068	9.86	195.6
	SE39-1	18/11/2015 05:50	CAR70	200	32	8.5	10.03	downstream	640.8	5.16	0.077	0.077	17.39	243.0
	SE39-2	18/11/2015 06:35	CON71	366	52	13.5	7.64	downstream	783.9	5.55	0.088	0.088	12.03	241.7
	SE44-1	20/11/2015 21:11	CON71	398	56	11.6	5.66	downstream	774.1	5.00	0.079	0.061	6.30	213.8
	SE51-1	24/11/2015 14:42	CON00	300	43	10.7	5.02	downstream	591.9	4.99	0.045	0.037	13.34	184.5

Appendix B

Table 24 – No-ship (wind-wave) events detected at Gsb4 location (low mudflat – north transect).

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE01-1	29/10/2015 16:13	5.797	0.038	0.024	5.41	194.48
NSE02-1	30/10/2015 03:07	2.872	0.023	0.016	4.14	97.74
NSE03-1	30/10/2015 15:39	3.667	0.04	0.025	4.99	103.16
NSE04-1	31/10/2015 03:04	2.043	0.026	0.017	3.77	81.87
NSE05-1	31/10/2015 18:59	4.895	0.046	0.031	2.15	101.81
NSE05-2	31/10/2015 21:36	2.181	0.02	0.017	2.14	107.61
NSE05-3	31/10/2015 22:12	1.552	0.034	0.031	3.02	164.56
NSE06-1	01/11/2015 02:29	1.47	0.035	0.018	1.82	172.26
NSE06-2	01/11/2015 03:31	2.249	0.035	0.024	1.82	172.26
NSE06-3	01/11/2015 04:52	3.69	0.03	0.019	1.73	138.05
NSE06-4	01/11/2015 06:46	5.464	0.04	0.026	1.4	102.21
NSE06-5	01/11/2015 10:59	1.385	0.02	0.016	2.42	168.34
NSE07-1	01/11/2015 18:18	5.343	0.089	0.048	2.78	85.31
NSE07-2	01/11/2015 22:58	1.625	0.065	0.033	2.3	85.82
NSE08-1	02/11/2015 04:41	2.609	0.045	0.032	3.07	72.39
NSE09-1	02/11/2015 21:51	3.547	0.024	0.018	1.05	228.72
NSE09-2	02/11/2015 22:39	2.733	0.05	0.021	2.26	153.78
NSE09-3	03/11/2015 00:02	1.411	0.021	0.016	3.71	157.43
NSE10-1	03/11/2015 03:49	1.5	0.017	0.014	2.7	96.95
NSE10-2	03/11/2015 06:18	3.413	0.028	0.019	3.69	96.57
NSE11-1	04/11/2015 00:36	1.73	0.025	0.02	4.76	129.24
NSE12-1	04/11/2015 05:18	2.059	0.03	0.026	4.09	114.19
NSE12-2	04/11/2015 06:22	2.807	0.022	0.015	4.94	110.7
NSE13-1	04/11/2015 21:42	4.714	0.047	0.031	7.08	190.4
NSE13-2	05/11/2015 02:46	1.067	0.024	0.017	4.03	163.49
NSE15-1	05/11/2015 22:05	4.372	0.032	0.023	9.9	171.41
NSE16-1	06/11/2015 14:56	2.175	0.027	0.019	9.41	182.66
NSE18-1	07/11/2015 12:30	4.87	0.074	0.037	7.4	178.95
NSE18-2	07/11/2015 13:52	4.212	0.019	0.016	7.4	178.95
NSE18-3	07/11/2015 16:24	1.997	0.018	0.015	8.04	186.47
NSE19-1	07/11/2015 21:23	2.064	0.048	0.033	11.59	229.09
NSE19-2	07/11/2015 22:43	3.258	0.034	0.025	7.93	226.52
NSE19-3	07/11/2015 23:43	4.422	0.031	0.02	7.93	226.52
NSE19-4	08/11/2015 01:18	5.053	0.037	0.023	7.13	232.15
NSE19-5	08/11/2015 01:53	4.768	0.022	0.017	7.13	232.15
NSE19-6	08/11/2015 03:50	3.086	0.064	0.038	4.36	216.51
NSE19-7	08/11/2015 06:19	0.918	0.015	0.013	3.27	170.29
NSE20-1	08/11/2015 09:24	1.811	0.036	0.023	2.29	140.66
NSE20-2	08/11/2015 10:56	2.797	0.025	0.018	5.8	163.87

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE20-3	08/11/2015 16:06	2.811	0.046	0.031	6.76	152.84
NSE21-1	08/11/2015 22:17	1.213	0.056	0.034	10.28	205.82
NSE21-2	09/11/2015 02:12	4.665	0.026	0.019	9.55	223.72
NSE21-3	09/11/2015 03:07	4.053	0.035	0.025	9.55	223.72
NSE21-4	09/11/2015 05:25	1.988	0.018	0.015	8.84	227.16
NSE23-1	10/11/2015 06:36	1.913	0.036	0.022	9.65	202.39
NSE25-1	11/11/2015 06:37	2.272	0.011	0.011	7.82	188.1
NSE25-2	11/11/2015 07:24	1.504	0.039	0.024	7.82	188.1
NSE27-1	12/11/2015 00:19	2.038	0.039	0.025	7.2	203.45
NSE27-2	12/11/2015 01:54	3.638	0.027	0.018	7.2	203.45
NSE27-3	12/11/2015 03:44	5.434	0.032	0.021	5.85	208.82
NSE27-4	12/11/2015 04:44	4.703	0.014	0.013	5.65	204.8
NSE27-5	12/11/2015 05:42	3.769	0.038	0.025	5.65	204.8
NSE29-1	13/11/2015 01:42	2.491	0.042	0.031	8.2	186.54
NSE29-2	13/11/2015 04:33	4.962	0.035	0.023	9.6	200.12
NSE30-1	13/11/2015 12:10	1.242	0.148	0.067	8.75	214.28
NSE31-1	13/11/2015 23:15	2.156	0.089	0.045	9.67	229.5
NSE31-2	14/11/2015 01:30	3.417	0.04	0.026	7.1	206.73
NSE31-3	14/11/2015 02:40	4.258	0.062	0.031	9.64	206.7
NSE31-4	14/11/2015 06:50	4.231	0.032	0.021	6.78	215.78
NSE32-1	14/11/2015 14:34	3.083	0.043	0.027	7.69	207.24
NSE32-2	14/11/2015 15:27	4.03	0.062	0.032	7.69	207.24
NSE32-3	14/11/2015 18:18	4.664	0.029	0.02	10.88	185.53
NSE33-1	15/11/2015 01:20	2.289	0.105	0.06	13.13	201.49
NSE33-2	15/11/2015 03:11	3.971	0.103	0.062	12.63	210.91
NSE33-3	15/11/2015 05:36	5.788	0.126	0.078	18.24	225.13
NSE33-4	15/11/2015 06:24	5.138	0.092	0.049	17.58	227.27
NSE34-1	15/11/2015 17:40	5.687	0.086	0.053	14.33	227.42
NSE34-2	15/11/2015 19:12	4.44	0.075	0.047	12.68	226.11
NSE34-3	15/11/2015 20:09	3.459	0.075	0.044	11.65	222.92
NSE34-4	15/11/2015 21:40	1.911	0.072	0.035	11.65	222.92
NSE35-1	16/11/2015 01:50	1.741	0.058	0.036	8.16	197.62
NSE35-2	16/11/2015 02:54	2.518	0.099	0.05	10.52	197.78
NSE37-1	17/11/2015 09:38	3.001	0.048	0.034	12.31	219.7
NSE37-2	17/11/2015 11:08	1.562	0.063	0.039	11.26	218.91
NSE38-1	17/11/2015 22:51	2.685	0.381	0.22	18.99	219.27
NSE38-2	17/11/2015 23:47	2.107	0.499	0.304	18.99	219.27
NSE39-1	18/11/2015 01:56	2.006	0.346	0.243	20.59	228.05
NSE39-2	18/11/2015 03:04	3.029	0.42	0.261	21.23	235.29
NSE39-3	18/11/2015 04:25	3.841	0.247	0.14	17.39	242.97
NSE39-4	18/11/2015 04:59	4.345	0.139	0.077	17.39	242.97
NSE41-1	19/11/2015 03:15	1.648	0.174	0.114	12.42	220.34
NSE41-2	19/11/2015 08:15	5.222	0.048	0.031	10.95	221.06
NSE41-3	19/11/2015 10:18	3.593	0.061	0.032	10.56	223.99

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE43-1	20/11/2015 14:05	1.157	0.026	0.02	9.42	252.35
NSE45-1	21/11/2015 10:16	5.435	0.046	0.031	9.72	203.97
NSE45-2	21/11/2015 14:06	2.871	0.277	0.158	13.08	325.25
NSE46-1	21/11/2015 19:46	2.951	0.138	0.07	10.95	333.98
NSE46-2	21/11/2015 22:37	4.793	0.059	0.032	8.34	344.64
NSE46-3	21/11/2015 23:43	5.159	0.012	0.012	8.34	344.64
NSE46-4	22/11/2015 01:18	3.909	0.133	0.064	5.79	299.76
NSE46-5	22/11/2015 02:57	2.237	0.052	0.036	4.78	257.82
NSE47-1	22/11/2015 07:47	2.11	0.018	0.014	2.11	233.98
NSE47-2	22/11/2015 08:34	2.528	0.013	0.012	5.55	227.13
NSE47-3	22/11/2015 12:49	4.526	0.038	0.022	5.26	227.65
NSE47-4	22/11/2015 13:38	3.725	0.095	0.051	5.26	227.65
NSE47-5	22/11/2015 14:58	2.516	0.054	0.033	3.42	224.2
NSE48-1	23/11/2015 00:04	5.453	0.081	0.048	5.86	313.74
NSE48-2	23/11/2015 01:59	4.369	0.038	0.025	5.86	313.74
NSE48-3	23/11/2015 03:16	3.04	0.105	0.052	4.85	293.98
NSE48-4	23/11/2015 04:01	2.254	0.042	0.031	5.1	306.83
NSE48-5	23/11/2015 04:58	1.302	0.058	0.03	5.1	306.83
NSE49-1	23/11/2015 08:49	1.489	0.022	0.015	2.58	227.11
NSE52-1	25/11/2015 01:45	5.972	0.03	0.018	5.77	208.28
NSE57-1	27/11/2015 20:01	1.989	0.055	0.043	11.28	169.6
NSE58-1	28/11/2015 02:57	4.244	0.052	0.03	10.38	239.83
NSE58-2	28/11/2015 06:45	4.869	0.198	0.124	12.31	260.97
NSE58-3	28/11/2015 07:44	3.658	0.144	0.08	12.31	260.97
NSE58-4	28/11/2015 09:15	1.793	0.051	0.033	10.99	251.16
NSE59-1	28/11/2015 12:36	1.66	0.095	0.056	8.98	216.24
NSE59-2	28/11/2015 14:38	3.19	0.052	0.033	8.57	197.12
NSE59-3	28/11/2015 16:25	6.025	0.104	0.061	11.52	186.54
NSE59-4	28/11/2015 20:29	2.465	0.107	0.068	15.16	190.86
NSE59-5	28/11/2015 21:33	1.371	0.219	0.145	15.16	190.86
NSE60-1	29/11/2015 02:58	2.731	0.087	0.051	11.2	203.68
NSE60-2	29/11/2015 05:12	5.731	0.092	0.064	10.22	204.18
NSE60-3	29/11/2015 07:11	4.266	0.035	0.022	11.65	199.82
NSE60-4	29/11/2015 08:28	2.862	0.025	0.017	9.76	199.88
NSE60-5	29/11/2015 09:27	1.88	0.031	0.021	9.76	199.88
NSE61-1	29/11/2015 18:51	5.37	0.103	0.058	17.1	217.57
NSE61-2	29/11/2015 19:22	4.865	0.132	0.084	17.1	217.57
NSE61-3	29/11/2015 20:24	3.832	0.201	0.105	20.12	223.93
NSE61-4	29/11/2015 21:04	3.151	0.293	0.166	20.12	223.93
NSE62-1	30/11/2015 00:49	2.108	0.158	0.094	13.54	250.02
NSE62-2	30/11/2015 01:30	2.497	0.107	0.064	13.54	250.02
NSE62-3	30/11/2015 02:49	3.497	0.112	0.059	13.51	250.1
NSE62-4	30/11/2015 03:50	4.436	0.084	0.05	13.51	250.1
NSE62-5	30/11/2015 06:13	6.316	0.077	0.042	7.48	247.08

Table 25 – No-ship (wind-wave) events detected at Gsc4 location (low mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE01-1	29/10/2015 14:39	3.112	0.048	0.028	6.04	194.86
NSE01-2	29/10/2015 18:33	3.933	0.044	0.03	5.6	177.81
NSE02-1	30/10/2015 08:08	2.639	0.031	0.018	5.87	107.6
NSE04-1	31/10/2015 03:00	1.969	0.028	0.023	3.77	81.87
NSE04-2	31/10/2015 04:19	3.653	0.036	0.021	3.99	86.28
NSE04-3	31/10/2015 05:52	5.419	0.081	0.049	3.99	86.28
NSE05-1	31/10/2015 18:55	4.964	0.072	0.039	2.15	101.81
NSE05-2	31/10/2015 19:39	4.258	0.029	0.019	2.15	101.81
NSE05-3	31/10/2015 22:08	1.605	0.041	0.024	3.02	164.56
NSE06-1	01/11/2015 03:25	2.156	0.066	0.044	1.82	172.26
NSE06-2	01/11/2015 06:49	5.44	0.032	0.022	1.4	102.21
NSE06-3	01/11/2015 09:06	3.355	0.079	0.043	3.74	151.29
NSE07-1	01/11/2015 18:22	5.368	0.052	0.032	2.78	85.31
NSE07-2	01/11/2015 21:29	3.169	0.12	0.06	2.5	82.63
NSE09-1	02/11/2015 22:46	2.597	0.04	0.026	2.26	153.78
NSE09-2	02/11/2015 23:18	2.068	0.067	0.044	2.26	153.78
NSE10-1	03/11/2015 05:59	3.058	0.039	0.025	3.32	96.69
NSE10-2	03/11/2015 08:23	4.707	0.032	0.019	4.25	99.03
NSE11-1	04/11/2015 00:48	1.561	0.051	0.025	4.76	129.24
NSE12-1	04/11/2015 05:24	2.111	0.047	0.032	4.09	114.19
NSE16-1	06/11/2015 15:00	2.097	0.061	0.037	9.41	182.66
NSE17-1	06/11/2015 21:04	2.417	0.075	0.042	10.17	200.74
NSE18-1	07/11/2015 12:27	4.862	0.057	0.03	7.4	178.95
NSE18-2	07/11/2015 14:49	3.388	0.04	0.024	7.9	185.66
NSE18-3	07/11/2015 16:29	1.91	0.055	0.033	8.04	186.47
NSE19-1	07/11/2015 21:28	2.11	0.058	0.035	11.59	229.09
NSE19-2	07/11/2015 22:38	3.138	0.026	0.019	7.93	226.52
NSE19-3	07/11/2015 23:47	4.482	0.038	0.024	7.93	226.52
NSE19-4	08/11/2015 01:14	5.079	0.027	0.019	7.13	232.15
NSE19-5	08/11/2015 01:50	4.82	0.176	0.094	7.13	232.15
NSE19-6	08/11/2015 03:56	2.985	0.059	0.037	4.36	216.51
NSE20-1	08/11/2015 09:19	1.743	0.04	0.027	2.29	140.66
NSE20-2	08/11/2015 10:52	2.733	0.036	0.023	5.8	163.87
NSE20-3	08/11/2015 16:11	2.714	0.035	0.023	6.76	152.84
NSE20-4	08/11/2015 17:15	1.715	0.037	0.019	6.76	152.84
NSE21-1	09/11/2015 02:17	4.64	0.027	0.019	9.55	223.72
NSE21-2	09/11/2015 03:11	4	0.048	0.029	9.55	223.72
NSE23-1	10/11/2015 06:36	1.902	0.115	0.069	9.65	202.39
NSE25-1	11/11/2015 03:01	5.503	0.061	0.041	9.2	198.76
NSE25-2	11/11/2015 06:32	2.336	0.025	0.019	7.82	188.1

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE27-1	12/11/2015 00:23	2.076	0.052	0.034	7.2	203.45
NSE27-2	12/11/2015 01:58	3.732	0.047	0.027	7.2	203.45
NSE27-3	12/11/2015 04:39	4.802	0.017	0.014	5.65	204.8
NSE27-4	12/11/2015 05:17	4.18	0.012	0.012	5.65	204.8
NSE27-5	12/11/2015 06:04	3.379	0.029	0.019	6.56	202.3
NSE29-1	13/11/2015 04:34	4.968	0.031	0.021	9.6	200.12
NSE29-2	13/11/2015 06:12	3.471	0.038	0.023	9.6	205.59
NSE30-1	13/11/2015 16:20	5.907	0.079	0.05	10.1	225.76
NSE30-2	13/11/2015 21:09	1.835	0.102	0.062	8.13	218.16
NSE31-1	14/11/2015 01:34	3.44	0.055	0.035	7.1	206.73
NSE31-2	14/11/2015 02:36	4.186	0.08	0.042	9.64	206.7
NSE31-3	14/11/2015 06:46	4.28	0.044	0.026	6.78	215.78
NSE32-1	14/11/2015 14:30	3.017	0.06	0.037	7.69	207.24
NSE32-2	14/11/2015 18:25	4.536	0.065	0.036	10.88	185.53
NSE33-1	15/11/2015 01:16	2.233	0.26	0.137	13.13	201.49
NSE33-2	15/11/2015 03:07	3.845	0.132	0.089	12.63	210.91
NSE33-3	15/11/2015 05:40	5.749	0.094	0.048	18.24	225.13
NSE33-4	15/11/2015 06:51	4.717	0.093	0.059	17.58	227.27
NSE34-1	15/11/2015 16:40	5.595	0.064	0.043	14.33	227.42
NSE34-2	15/11/2015 19:08	4.486	0.076	0.04	12.68	226.11
NSE34-3	15/11/2015 20:11	3.392	0.093	0.057	11.65	222.92
NSE34-4	15/11/2015 20:51	2.695	0.102	0.056	11.65	222.92
NSE34-5	15/11/2015 21:43	1.836	0.139	0.076	11.65	222.92
NSE35-1	16/11/2015 02:59	2.578	0.138	0.088	10.52	197.78
NSE37-1	17/11/2015 07:41	4.637	0.075	0.032	12.77	210.74
NSE38-1	17/11/2015 22:47	2.681	0.474	0.267	18.99	219.27
NSE38-2	17/11/2015 23:54	2.01	0.46	0.291	18.99	219.27
NSE39-1	18/11/2015 02:03	2.086	0.427	0.265	21.23	235.29
NSE39-2	18/11/2015 03:08	3.064	0.403	0.212	21.23	235.29
NSE39-3	18/11/2015 04:31	3.902	0.182	0.107	17.39	242.97
NSE39-4	18/11/2015 05:07	4.464	0.101	0.059	17.39	242.97
NSE41-1	19/11/2015 10:17	3.573	0.097	0.047	10.56	223.99
NSE44-1	20/11/2015 23:16	4.568	0.126	0.079	8.85	213.3
NSE44-2	21/11/2015 02:00	2.233	0.108	0.066	7.04	228.81
NSE45-1	21/11/2015 10:59	5.333	0.092	0.052	9.72	203.97
NSE46-1	21/11/2015 19:02	2.45	0.194	0.085	10.95	333.98
NSE46-2	21/11/2015 19:51	2.996	0.089	0.056	10.95	333.98
NSE46-3	21/11/2015 22:31	4.689	0.046	0.029	8.34	344.64
NSE46-4	21/11/2015 23:06	5.07	0.048	0.033	8.34	344.64
NSE46-5	21/11/2015 23:50	5.104	0.017	0.015	8.34	344.64
NSE46-6	22/11/2015 03:02	2.128	0.072	0.043	4.78	257.82
NSE47-1	22/11/2015 07:43	2.06	0.045	0.028	2.11	233.98
NSE47-2	22/11/2015 08:21	2.416	0.029	0.021	5.55	227.13
NSE47-3	22/11/2015 12:44	4.591	0.047	0.025	5.26	227.65

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE47-4	22/11/2015 13:31	3.794	0.07	0.036	5.26	227.65
NSE48-1	22/11/2015 21:24	2.387	0.03	0.022	4.47	292.35
NSE48-2	23/11/2015 00:07	5.471	0.055	0.032	5.86	313.74
NSE48-3	23/11/2015 02:02	4.323	0.031	0.023	4.85	293.98
NSE48-4	23/11/2015 03:51	2.392	0.101	0.056	4.85	293.98
NSE50-1	24/11/2015 03:52	3.284	0.035	0.022	10.83	180.59
NSE52-1	25/11/2015 01:49	5.996	0.022	0.017	5.77	208.28
NSE57-1	27/11/2015 20:01	1.926	0.1	0.05	11.28	169.6
NSE58-1	28/11/2015 03:01	4.405	0.052	0.029	10.38	239.83
NSE58-2	28/11/2015 07:40	3.686	0.248	0.109	12.31	260.97
NSE58-3	28/11/2015 09:11	1.818	0.102	0.063	10.99	251.16
NSE59-1	28/11/2015 14:44	3.246	0.134	0.071	8.57	197.12
NSE59-2	28/11/2015 20:25	2.481	0.216	0.117	15.16	190.86
NSE60-1	29/11/2015 03:03	2.836	0.145	0.067	11.2	203.68
NSE60-2	29/11/2015 05:08	5.726	0.101	0.043	10.22	204.18
NSE60-3	29/11/2015 07:08	4.3	0.076	0.04	11.65	199.82
NSE60-4	29/11/2015 08:36	2.673	0.056	0.036	9.76	199.88
NSE60-5	29/11/2015 09:23	1.884	0.101	0.06	9.76	199.88
NSE61-1	29/11/2015 17:36	6.128	0.14	0.067	15.7	219.66
NSE61-2	29/11/2015 18:55	5.272	0.158	0.073	17.1	217.57
NSE61-3	29/11/2015 19:28	4.725	0.189	0.105	17.1	217.57
NSE61-4	29/11/2015 20:30	3.663	0.371	0.213	20.12	223.93
NSE61-5	29/11/2015 21:01	3.14	0.422	0.205	20.12	223.93
NSE61-6	29/11/2015 21:56	2.331	0.38	0.216	20.12	223.93
NSE61-7	29/11/2015 22:45	1.817	0.268	0.19	18.65	244.39
NSE62-1	30/11/2015 02:54	3.547	0.084	0.043	13.51	250.1
NSE62-2	30/11/2015 03:46	4.352	0.068	0.042	13.51	250.1
NSE62-3	30/11/2015 04:54	5.724	0.089	0.054	11.84	255.11
NSE63-1	30/11/2015 21:56	2.956	0.219	0.129	15.89	224.45

Table 26 – No-ship (wind-wave) events detected at Gsc3 location (middle high mudflat – south transect).

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE01-1	29/10/2015 18:33	3.931	0.046	0.031	5.6	177.81
NSE04-1	31/10/2015 04:19	3.66	0.04	0.027	3.99	86.28
NSE04-2	31/10/2015 05:52	5.42	0.075	0.05	3.99	86.28
NSE05-1	31/10/2015 18:55	4.963	0.06	0.037	2.15	101.81
NSE05-2	31/10/2015 19:39	4.256	0.032	0.022	2.15	101.81
NSE06-1	01/11/2015 06:49	5.44	0.034	0.024	1.4	102.21
NSE06-2	01/11/2015 09:06	3.353	0.076	0.051	3.74	151.29
NSE07-1	01/11/2015 18:22	5.367	0.063	0.038	2.78	85.31
NSE07-2	01/11/2015 21:29	3.166	0.115	0.061	2.5	82.63
NSE10-1	03/11/2015 08:23	4.707	0.028	0.02	4.25	99.03
NSE18-1	07/11/2015 12:27	4.863	0.058	0.031	7.4	178.95
NSE18-2	07/11/2015 14:49	3.385	0.065	0.042	7.9	185.66
NSE19-1	07/11/2015 23:47	4.486	0.04	0.025	7.93	226.52
NSE19-2	08/11/2015 01:14	5.079	0.032	0.023	7.13	232.15
NSE19-3	08/11/2015 01:50	4.82	0.076	0.039	7.13	232.15
NSE21-1	09/11/2015 02:17	4.637	0.034	0.021	9.55	223.72
NSE21-2	09/11/2015 03:11	3.996	0.07	0.037	9.55	223.72
NSE25-1	11/11/2015 03:01	5.503	0.095	0.053	9.2	198.76
NSE27-1	12/11/2015 01:58	3.741	0.042	0.029	7.2	203.45
NSE27-2	12/11/2015 04:39	4.798	0.019	0.015	5.65	204.8
NSE27-3	12/11/2015 05:17	4.175	0.017	0.014	5.65	204.8
NSE27-4	12/11/2015 06:04	3.374	0.049	0.026	6.56	202.3
NSE29-1	13/11/2015 04:34	4.962	0.052	0.028	9.6	200.12
NSE29-2	13/11/2015 06:12	3.47	0.092	0.045	9.6	205.59
NSE30-1	13/11/2015 16:20	5.91	0.105	0.063	10.1	225.76
NSE31-1	14/11/2015 01:34	3.441	0.133	0.069	7.1	206.73
NSE31-2	14/11/2015 02:36	4.192	0.093	0.063	9.64	206.7
NSE31-3	14/11/2015 06:46	4.276	0.056	0.038	6.78	215.78
NSE32-1	14/11/2015 18:25	4.529	0.071	0.034	10.88	185.53
NSE33-1	15/11/2015 03:07	3.853	0.177	0.101	12.63	210.91
NSE33-2	15/11/2015 05:40	5.746	0.139	0.08	18.24	225.13
NSE33-3	15/11/2015 06:51	4.712	0.193	0.106	17.58	227.27
NSE34-1	15/11/2015 16:40	5.598	0.104	0.06	14.33	227.42
NSE34-2	15/11/2015 19:08	4.479	0.115	0.066	12.68	226.11
NSE34-3	15/11/2015 20:11	3.385	0.136	0.088	11.65	222.92
NSE37-1	17/11/2015 07:41	4.633	0.081	0.047	12.77	210.74
NSE39-1	18/11/2015 04:31	3.906	0.247	0.156	17.39	242.97
NSE39-2	18/11/2015 05:07	4.471	0.157	0.07	17.39	242.97
NSE41-1	19/11/2015 10:17	3.566	0.13	0.077	10.56	223.99
NSE44-1	20/11/2015 23:16	4.562	0.138	0.074	8.85	213.3

index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
NSE45-1	21/11/2015 10:59	5.33	0.123	0.063	9.72	203.97
NSE46-1	21/11/2015 22:31	4.695	0.057	0.034	8.34	344.64
NSE46-2	21/11/2015 23:06	5.074	0.043	0.031	8.34	344.64
NSE46-3	21/11/2015 23:50	5.102	0.028	0.02	8.34	344.64
NSE47-1	22/11/2015 12:44	4.587	0.031	0.024	5.26	227.65
NSE47-2	22/11/2015 13:31	3.787	0.065	0.039	5.26	227.65
NSE48-1	23/11/2015 00:07	5.473	0.061	0.037	5.86	313.74
NSE48-2	23/11/2015 02:02	4.314	0.051	0.033	4.85	293.98
NSE50-1	24/11/2015 03:52	3.273	0.096	0.06	10.83	180.59
NSE52-1	25/11/2015 01:49	5.996	0.027	0.019	5.77	208.28
NSE58-1	28/11/2015 03:01	4.434	0.087	0.04	10.38	239.83
NSE58-2	28/11/2015 07:40	3.673	0.198	0.1	12.31	260.97
NSE59-1	28/11/2015 14:44	3.254	0.192	0.099	8.57	197.12
NSE60-1	29/11/2015 05:08	5.728	0.16	0.063	10.22	204.18
NSE60-2	29/11/2015 07:08	4.29	0.1	0.061	11.65	199.82
NSE61-1	29/11/2015 17:36	6.127	0.237	0.141	15.7	219.66
NSE61-2	29/11/2015 18:55	5.266	0.303	0.15	17.1	217.57
NSE61-3	29/11/2015 19:28	4.716	0.353	0.156	17.1	217.57
NSE61-4	29/11/2015 20:30	3.655	0.414	0.237	20.12	223.93
NSE61-5	29/11/2015 21:01	3.133	0.292	0.201	20.12	223.93
NSE62-1	30/11/2015 02:54	3.553	0.147	0.083	13.51	250.1
NSE62-2	30/11/2015 03:46	4.361	0.079	0.045	13.51	250.1
NSE62-3	30/11/2015 04:54	5.737	0.125	0.066	11.84	255.11

Table 27 – No-ship (wind-wave) events detected at Gsc2 and Gsb2 location (high tidal flats).

plot ID	index	time (dd/mm/yyyy HH:MM)	wlevel (m)	H_{max} (m)	$H_{1/3}$ (m)	Wspeed (m/s)	Wdir (degrees)
Gsb	NSE01-	29/10/2015	5.64	0.04	0.028	5.41	194.5
	NSE06-	1/11/2015 6:46	5.31	0.04	0.027	1.40	102.2
	NSE27-	12/11/2015 3:44	5.28	0.04	0.027	5.85	208.8
	NSE33-	15/11/2015 5:36	5.65	0.26	0.170	18.24	225.1
	NSE34-	15/11/2015	5.54	0.18	0.125	14.33	227.4
	NSE52-	25/11/2015 1:45	5.81	0.03	0.022	5.77	208.3
	NSE59-	28/11/2015	5.85	0.09	0.063	11.52	186.5
	NSE60-	29/11/2015 5:12	5.56	0.08	0.043	10.22	204.2
	NSE62-	30/11/2015 6:13	6.17	0.08	0.045	7.48	247.1
Gsc	NSE04-	31/10/2015 5:52	5.33	0.08	0.040	3.99	86.3
	NSE06-	1/11/2015 6:49	5.36	0.04	0.030	1.40	102.2
	NSE07-	1/11/2015 18:22	5.29	0.06	0.040	2.78	85.3
	NSE19-	8/11/2015 1:14	5.00	0.06	0.030	7.13	232.2
	NSE25-	11/11/2015 3:01	5.41	0.13	0.070	9.20	198.8
	NSE30-	13/11/2015	5.83	0.15	0.080	10.10	225.8
	NSE33-	15/11/2015 5:40	5.67	0.24	0.150	18.24	225.1
	NSE34-	15/11/2015	5.54	0.21	0.100	14.33	227.4
	NSE45-	21/11/2015	5.25	0.16	0.090	9.72	204.0
	NSE46-	21/11/2015	5.02	0.07	0.040	8.34	344.6
	NSE48-	23/11/2015 0:07	5.39	0.06	0.030	5.86	313.7
	NSE52-	25/11/2015 1:49	5.91	0.04	0.030	5.77	208.3
	NSE60-	29/11/2015 5:08	5.64	0.14	0.080	10.22	204.2
	NSE61-	29/11/2015	6.03	0.32	0.190	15.70	219.7
	NSE61-	29/11/2015	5.17	0.29	0.200	17.10	217.6
	NSE62-	30/11/2015 4:54	5.69	0.11	0.150	11.84	255.1

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