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Coastal Inlets Research Program

Field Measurements, Sediment Tracer Study, and Numerical Modeling at Coos Bay Inlet, Oregon

Honghai Li, Tahirih C. Lackey, Tanya M. Beck, Hans R. Moritz,
Katharine C. Groth, Trapier Puckette, and Jon Marsh

June 2018



Coastal and Hydraulics Laboratory

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Abstract

This report documents a field data collection program, including the sediment tracer study, and numerical modeling investigation for dredged material placed in the nearshore area of an ocean dredged material disposal site (ODMDS) adjacent to Coos Bay Inlet, OR. The collected data around the inlet system were assembled, analyzed, and used to calibrate and validate the Coastal Modeling System (CMS) and the Particle Tracking Model (PTM). Sediment transport pathways and fate of placed material were evaluated. The model and sediment tracer study results indicate that the tracer placed within the nearshore ODMDS primarily moves alongshore towards the inlet at the initial stage of the release. Material arriving at the inlet channel and ebb shoal is jettisoned offshore by strong ebb currents. The results also show that the sediment tracer spreads northward alongshore due to strong dominant southerly wind across the inner continental shelf. At and outside the inlet, finer particles are transported the farthest offshore and away from the navigation channel and nearshore ODMDS area. A new sediment mapping technique applied in model simulations demonstrates migration and burial for sediments placed in the nearshore ODMDS. Both CMS and PTM results compare well with those of the sediment tracer study.

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Preface

This study was performed by the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center (ERDC) at the request of the U.S. Army Corps of Engineers (USACE), Portland District (NWP). The Coastal Inlets Research Program (CIRP) conducted this study with additional funding from the NWP. The CIRP is administered for Headquarters, USACE (HQUSACE), by the ERDC-CHL, Vicksburg, MS, under the Navigation Program of HQUSACE. Mr. Jeff Mckee is HQUSACE Navigation Business Line Manager overseeing the CIRP. Mr. W. Jeff Lillycrop, CHL, is the ERDC Technical Director for Navigation. Dr. Julie Rosati, CHL, is the CIRP Program Manager.

The field data collection program was contracted to and completed by RPS Evans-Hamilton Inc.

This work was conducted under the general administrative supervision of Ms. Tanya M. Beck and Ms. Ashley Frey, Chiefs of Coastal Engineering Branch and Coastal Processes Branch, respectively, and Dr. Jackie S. Pettway, Chief of the Navigation Division. Mr. Jeffrey R. Eckstein and Mr. José E. Sánchez were the Deputy Director and Director of CHL during this study period, respectively.

At the time of publication of this report, COL Bryan S. Green was Commander of ERDC. Dr. David W. Pittman was ERDC Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
yards	0.9144	meters

Abbreviations

ADCP	acoustic Doppler current profiler
AST	acoustic surface tracking
AWAC	acoustic wave and current profiler
CHL	Coastal and Hydraulics Laboratory
CIRP	Coastal Inlets Research Program
CMS	Coastal Modeling System
DEM	Digital Elevation Model
ERDC	U.S. Army Engineer Research and Development Center
ETS	Environmental Tracing Systems
GMT	Greenwich Mean Time
HW	high water
JALBTCX	Joint Airborne Lidar Bathymetry Technical Center of Expertise
LW	low water
LST	local standard time
MLLW	mean lower low water
MSDS	material safety data sheet
NDBC	National Data Buoy Center
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
NRMSE	normalized root-mean-square error
NS	nearshore
NWP	USACE Portland District
ODMDS	ocean dredged material disposal site

PTM	Particle Tracking Model
R	correlation coefficient
RM	river mile
RMSE	root-mean-square error
RPS EHI	RPS Evans-Hamilton Inc.
SMS	Surface-water Modeling System
USACE	U.S. Army Corps of Engineers
WSE	water surface elevation

1 Introduction

1.1 Background

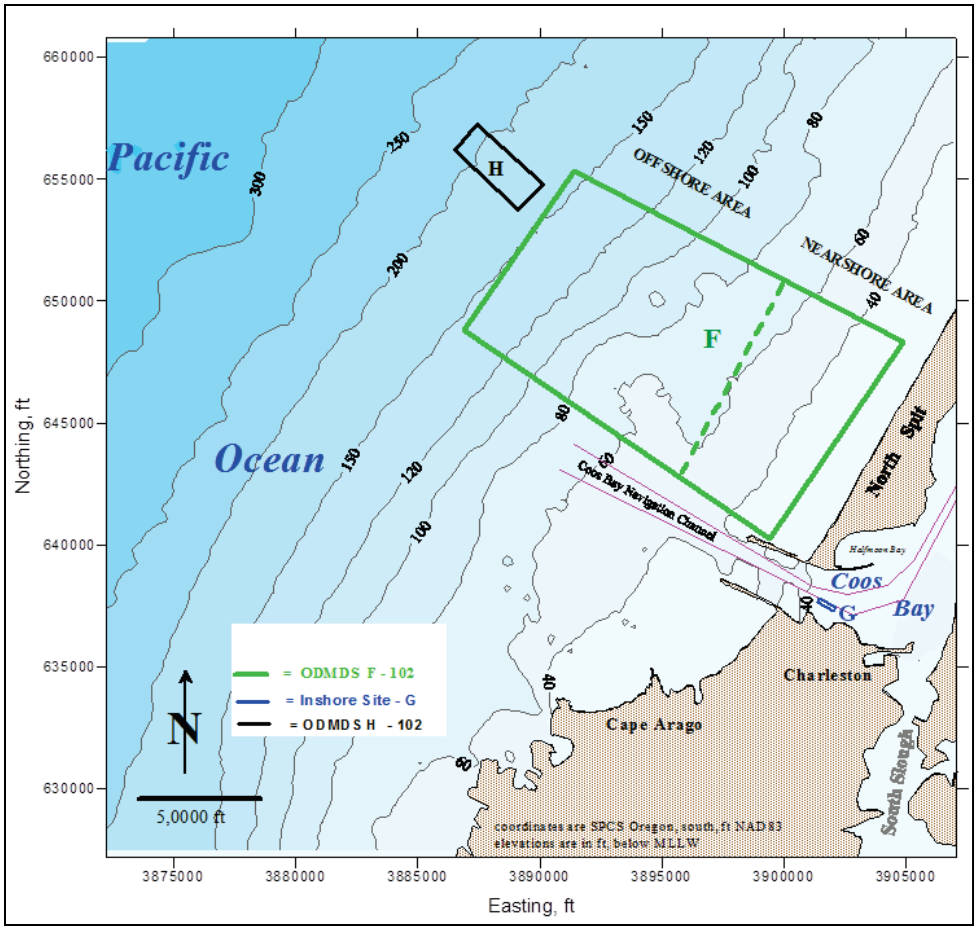
Coos Bay is located on the Oregon coast approximately 200 miles south of the Columbia River in Coos County, OR. The U.S. Army Corps of Engineers (USACE) (hereafter, the Corps) maintains a navigation channel from the estuary's mouth at river mile (RM) 0 to RM 15, including the South Slough (Charleston) side channel at RM 2. The Corps dredges over 764,000 cubic meters (m^3) of material from the Coos Bay project each year between April and October. This material is placed at a number of in-water disposal sites, including two Environmental Protection Agency-designated Ocean Dredged Material Disposal Sites (ODMDS) called Site H and Site F (Figure 1-1). Site H receives fine-grained material from the upstream portion of the federal project. Site F, a larger placement area located north of the north jetty, receives more sandy material from the project with up to 500,000 cy of material per year being placed in the nearshore portion of the site (F-nearshore [NS]). The Corps preferentially utilizes the F-NS 6.1 to 18.3 meters (m) of water depth) for the purpose of augmenting the littoral sediment budget on the north side of the north jetty (called the North Spit) and for stabilizing the base (shore-connected portion) of the north jetty.

The Oregon International Port of Coos Bay, a deep-draft port, is expanding its service to accommodate additional commercial activity including planning for deeper draft vessels. It is expected that ODMDS F-NS will be used more in the future for dredged material placement upon the need to increase the amount of material placed within the nearshore area. Dredged material (mostly medium sand) placement is mainly conducted by hopper dredges, which have 764 to 3,440 m^3/load capacity. Coastal engineering analyses are needed to supplement the Portland District (NWP) knowledge base to meet a future dredging and placement schedule and to understand nearshore sediment transport in the area.

Over the years, local commercial fishermen have voiced concerns over wave conditions, which could be related to dredged material placement near the entrance to the Coos Bay inlet. The original Site F was significantly smaller, and use of the site between 1977 and 1995 created significant mounding. That mounding resulted in several iterations of the configuration of Site F to what is now the current location and size, which

was officially designated in 2006. Since the expansion of Site F, the previous mound has decreased significantly 3.0–6.1 m and continues to disperse. Other than the previous mound, the remaining Site F bathymetry has not changed significantly since the baseline of 1994. In addition to increasing the overall footprint of Site F, the disposal site is intensely managed to prevent and reduce significant vertical accumulation of dredged material on the seabed. The ODMD F-NS area is currently being managed to ensure that placed material is dispersed by waves and currents and to promote material being returned to the littoral system. The ODMD F-NS portion closest to the north jetty and navigation channel is not used to keep placed material away from the channel. The offshore portion provides disposal for a finite time; however, management ensures uniform placement within the site to prevent the formation of large mounds that can adversely impact navigation.

Figure 1-1. Coos Bay inlet study area, the federal navigation channel (pink outline), and dredged material placement sites ODMDS F and H.



1.2 Objective

The primary objective of this study is to determine if any dredged material placed in the nearshore (Coos Bay ODMDS F), adjacent to the dredged navigation channel, will be transported and deposited in the channel. To accomplish this, the study has four objectives:

1. Collect a wave and hydrodynamic field dataset while conducting a sediment tracer study.
2. Set up, calibrate and validate, and run the Coastal Modeling System (CMS) with multiple grain size sediment mapping for the project area.
3. Run the Particle Tracking Model (PTM).
4. Compare the results of the sediment pathway mapping within the CMS and the sediment tracer study.

The tracer study component will determine the aerial dispersal pattern (location) of sediment tracer after a given time frame from initial release within or near the ODMD F-NS, based on each of the sampling campaigns. The deployed sediment tracer should *behave* the same (in terms of expressing sediment transport) as the dredged material that would potentially be placed within ODMD F-NS. The sediment tracer was deployed in a water depth of 6.1–18.3 m , approximately 530 m offshore of the North Spit. The tracer is expected to continue to move on the seabed or become suspended by waves and currents, in a similar manner as dredged material placed within or near ODMD F-NS.

The Coastal Inlets Research Program has been developing routines for the calculations of multiple grain size sediment transport and the sediment mapping capability in the CMS, sediment tracking in an Eulerian sediment transport model. Eulerian models have the advantage in simulating local and global sediment mass conservation, bed change, sorting, layering, and complex interaction between bed change and hydrodynamics. The Coos Bay tracer study provides a good opportunity to test and validate the implementation of sediment mapping calculations in the CMS.

Therefore, the CMS will be used to calculate waves, current, tide, and sediment transport within and around the immediate vicinity of the Coos Bay ODMDS F. The sediment mapping feature in the CMS will be applied to determine the sediment pathways in the vicinity of the project area and the

differences in pathways due to various forcing factors. Besides, the PTM will be used in combination with the CMS sediment mapping to evaluate and compare the resultant transport pathways of sediment particles and gain insight on the sediment transport rate, burial, resuspension, and medium-term fate (1-3 months) of material in the nearshore area of the Coos Bay ODMDS F and the Coos Bay navigation channel.

The CMS and the PTM modeling effort corresponds to 3–6 months of the sediment tracer experiment. The resultant pathways and sediment transport details could be compared and analyzed to support model validation of sediment transport. The validated CMS and PTM will present wave and hydrodynamic conditions and provide evidence for the understanding of sediment dynamics and sediment characteristics within or outside the ODMDS domains.

1.3 Methodology

The methodology of the study is addressed in Chapter 3 Methods.

1.4 Report outline

This report is organized as follows. Chapter 1 introduces the field data collection effort. Chapter 2 describes the environmental forcing conditions for the study area and lists already existing data that were applied to drive the numerical simulations. Chapter 3 describes the methods for both the field study and numerical study. Chapter 4 details the data collected in the field and provides an analysis of sediment transport for the study area based on the sediment tracer study. Chapter 5 presents the results of numerical modeling including the validation of sediment transport to the field sediment tracer study results. Transport pathways are also analyzed and discussed in Chapter 5. Chapter 6 summarizes the results of the study and provides conclusions regarding nearshore sediment transport at Coos Bay Inlet, OR.

2 Data

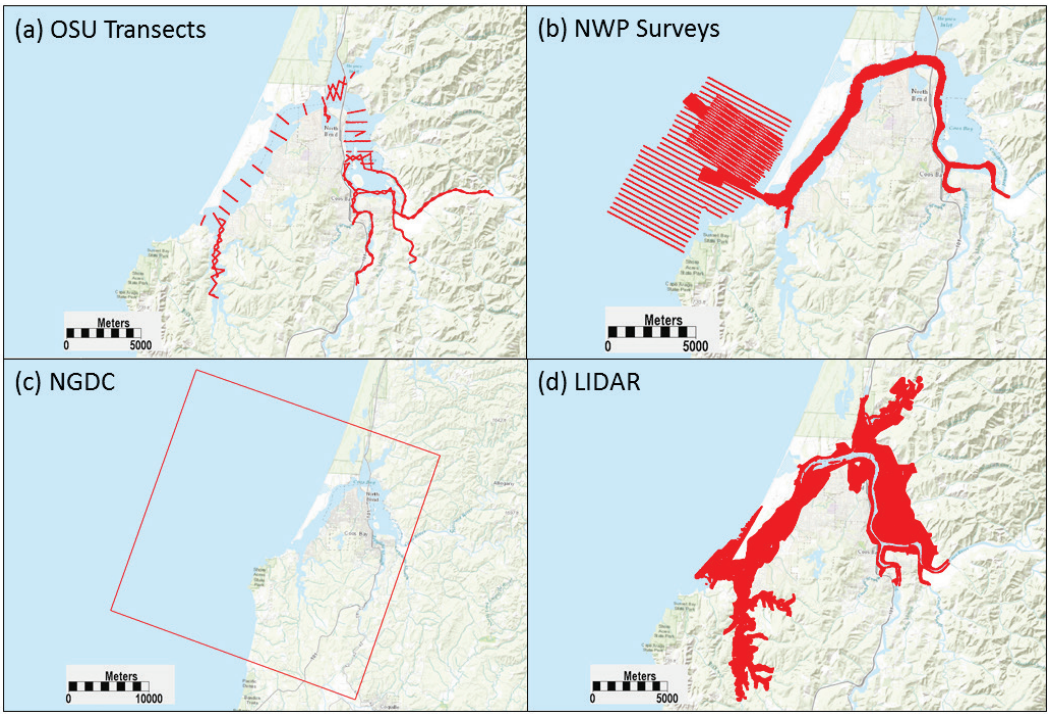
A variety of environmental forcing data for the Coos Bay study area were assembled and analyzed in the present study. Data previously available include nearshore, inlet channel and estuarine bathymetry, tidal variations, coastal wind and waves, riverine inflows, and sediment composition.

2.1 Bathymetry

Regional bathymetric data used for the numerical modeling study come mainly from four sources. Oregon State University conducted a bathymetric survey in the Coos Bay Estuary in 2014 (Wood and Ruggiero 2014). The NWP provided the most recent Coos Bay dredging placement site and inlet entrance channel surveys in digital format from 2014 to 2015. To support the Coos Bay project of the NWP, the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) performed a lidar survey of the project in 2014. An additional bathymetry dataset was obtained from the National Geophysical Data Center (NGDC) Coastal Digital Elevation Models (DEM), mostly covering the deeper offshore area (NOAA 2016a).

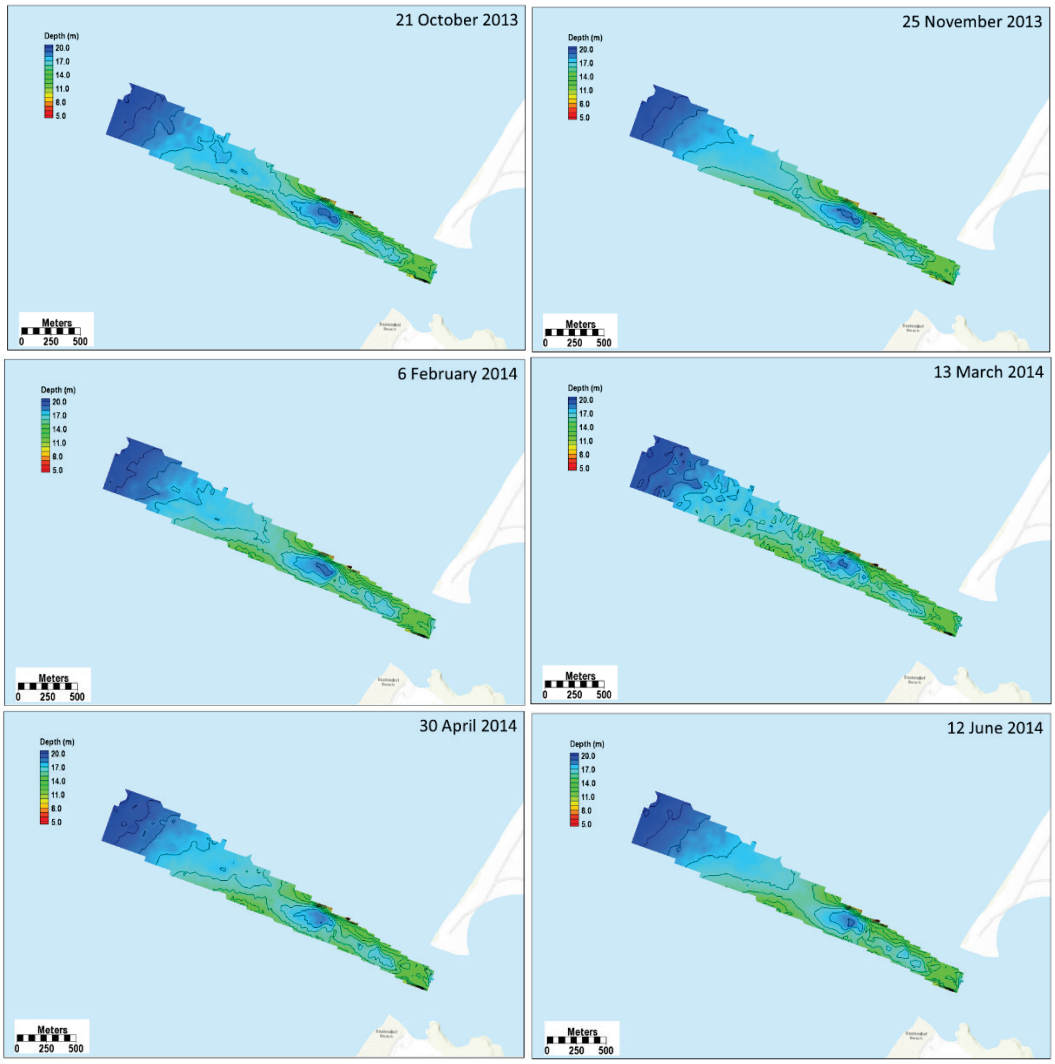
Figure 2-1 shows the spatial coverages of the four surveys of the study area. The JALBTCX data have complete coverage of the bay area with less than 1 m resolution. The DEM dataset has more thorough coverage of coastal and offshore areas. Because of its uniform and dense data distribution, only the extent of the spatial coverage is shown in Figure 2-1(c). In the inlet entrance channel and the dredging placement site, the latest surveyed data collected by the NWP were used to update areas of overlap with DEM data. Using the datum information of National Oceanic and Atmospheric Administration (NOAA) tide gage #9432780 at Charleston, OR (NOAA 2016b), all datasets were converted to local mean sea level and incorporated in numerical wave and flow models.

Figure 2-1. Bathymetry survey coverage. (a) Transects by Oregon State University, (b) surveys by USACE, (c) area covered by NGDC DEM, (d) 2014 lidar survey by the NWP and JALBTCX.



Besides the latest channel and dredging placement area surveys, the NWP provided historical bathymetry survey data covering both the bay area and the shelf areas from 2011 to 2012 as well as conditional survey data at the inlet entrance channel from October 2013 to June 2014. Of those historical surveys, the six most recent surveys occurred on 21 October 2013; 25 November 2013; 6 February 2014; 13 March 2014; 30 April 2014; and 12 June 2014. Figure 2-2 shows the depth contours of those surveys.

Figure 2-2. Conditional channel surveys by the NWP on 21 October 2013; 25 November 2013; 6 February 2014; 13 March 2014; 30 April 2014; and 12 June 2014, respectively.



2.2 Tide

Water surface elevation (WSE) data were downloaded from NOAA Charleston tide gage #9432780 (NOAA 2016b) (Figure 2-3). A mixed, predominately semi-diurnal tidal regime is characteristic of the study area. Figure 2-4 shows the WSEs from 11 September to 31 to October 2015, which indicates distinguished spring and neap tidal ranges. The mean tidal range (mean high water – mean low water) is 1.73 m and the maximum tidal range (mean higher high water - mean lower low water) is 2.32 m.

Figure 2-3. Locations of NOAA tide gauge at Charleston, OR (#9432780) and acoustic Doppler current profiler (ADCP) gauge deployed by University of Oregon.

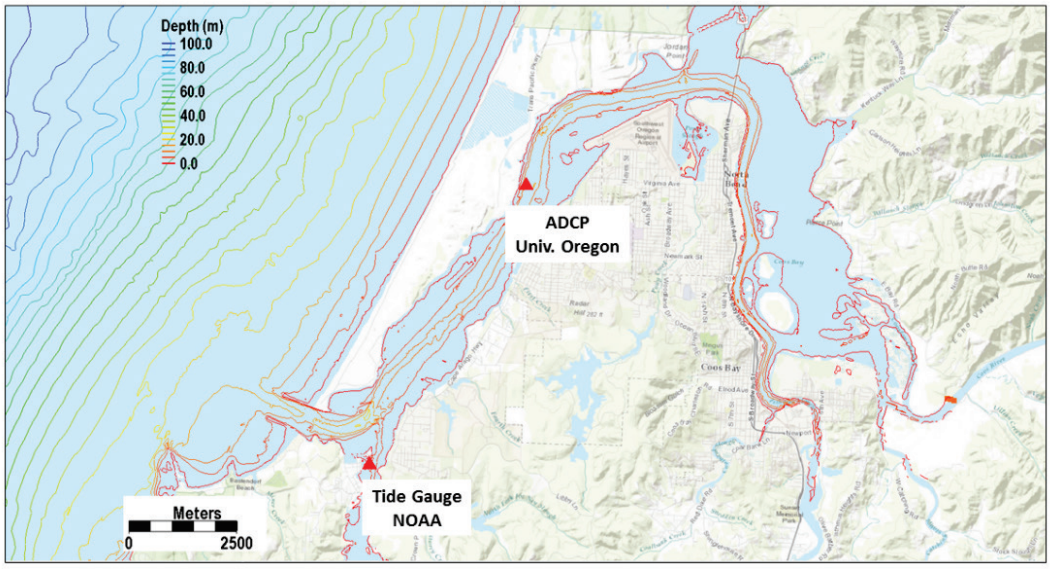
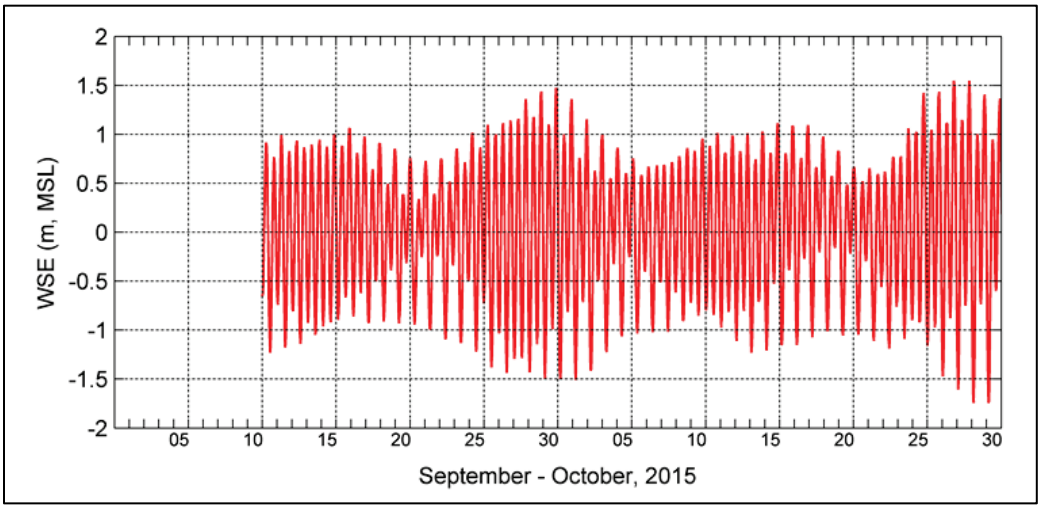


Figure 2-4. WSEs measured at Charleston, OR, from 11 September to 31 October 2015.



2.3 Wind and waves

Wind and wave data were obtained from the National Data Buoy Center (NDBC) (NDBC 2016) Buoy 46015, located approximately 75 km southwest of Coos Bay. Figure 2-5 shows monthly wind roses from September 2015 to March 2016. Because only a few days of data were collected in November 2015, the wind rose for this month was not included. During the September time period, wind blows prodominantly from the north. The October rose indicates a wind transition period. Northerly wind occurs over 40% of the time with southerly wind for close to 60% of the time. Entering the winter period, the dominant wind

direction is from the south, and storm wind speed reaches 15 m/second (sec) and above more frequently. The frequency of occurrence is between 5% to 10% for each month from December to March. During this fall-winter period, most of the storms occur in December and January. The wind roses also indicate that the wind along the coast is predominantly shore parallel. The monthly mean wind speeds in these 2 months are 9.40 and 9.04 m/sec, respectively. The mean wind speeds in September and October are around 6.5 m/sec.

Figure 2-6 shows the monthly wave roses at Buoy 46015 for September 2015 to March 2016. In September 2015, waves propagate primarily from the northwest sector. From October 2015 to March 2016, 10%–20% of waves propagate from the west sector, and dominant incident wave directions are west-northwest. Significant wave heights at the offshore buoy vary from month to month. December and January have larger monthly mean wave heights of 4.56 m and 3.83 m, respectively. The peak wave height of 6.44 m occurred on 29 January 2016.

Figure 2-5 and Figure 2-6 show that the study area is characterized by a high-energy wave climate and experiences energetic wave conditions during the passages of extra-tropical storms in the winter. Because of the pattern changes in monthly mean waves and wind, the sediment transport pattern in this region is also expected to change during the study period from September 2015 to March 2016.

Figure 2-5. Monthly wind roses at the NDBC buoy 46015 from September 2015 to March 2016. The November 2015 rose is not included because of missing data. The 4-digit year and 2-digit month are indicated in the title of each panel.

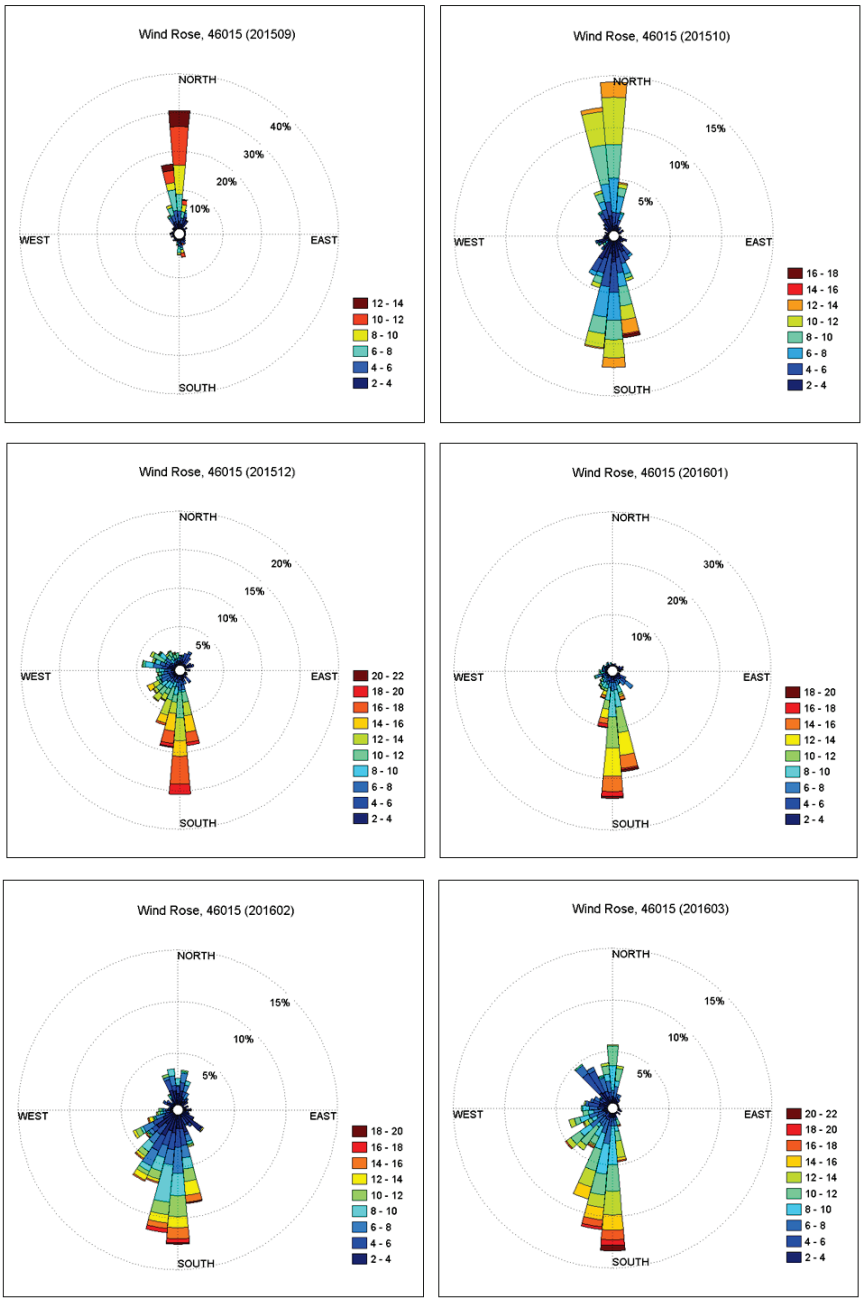
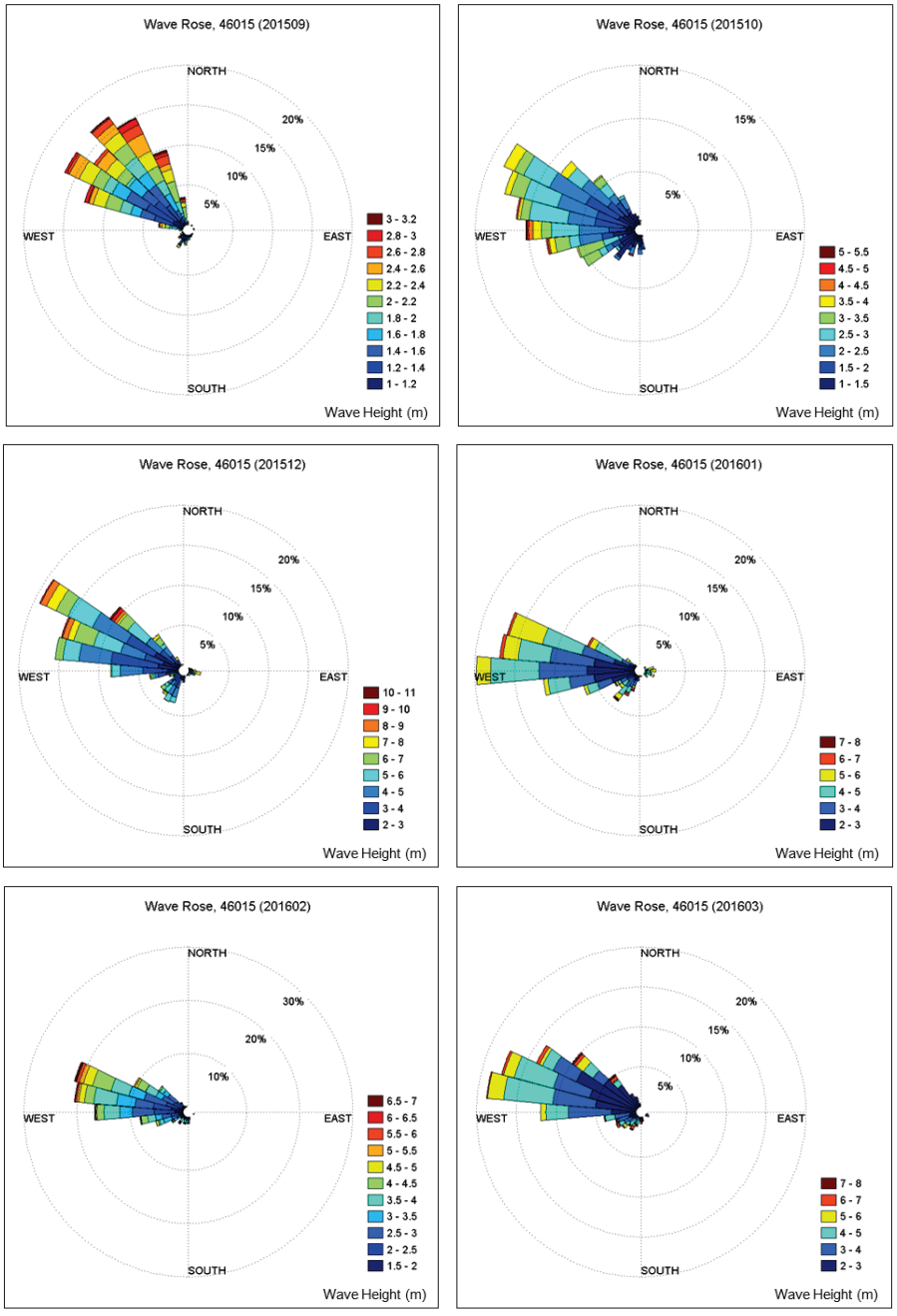


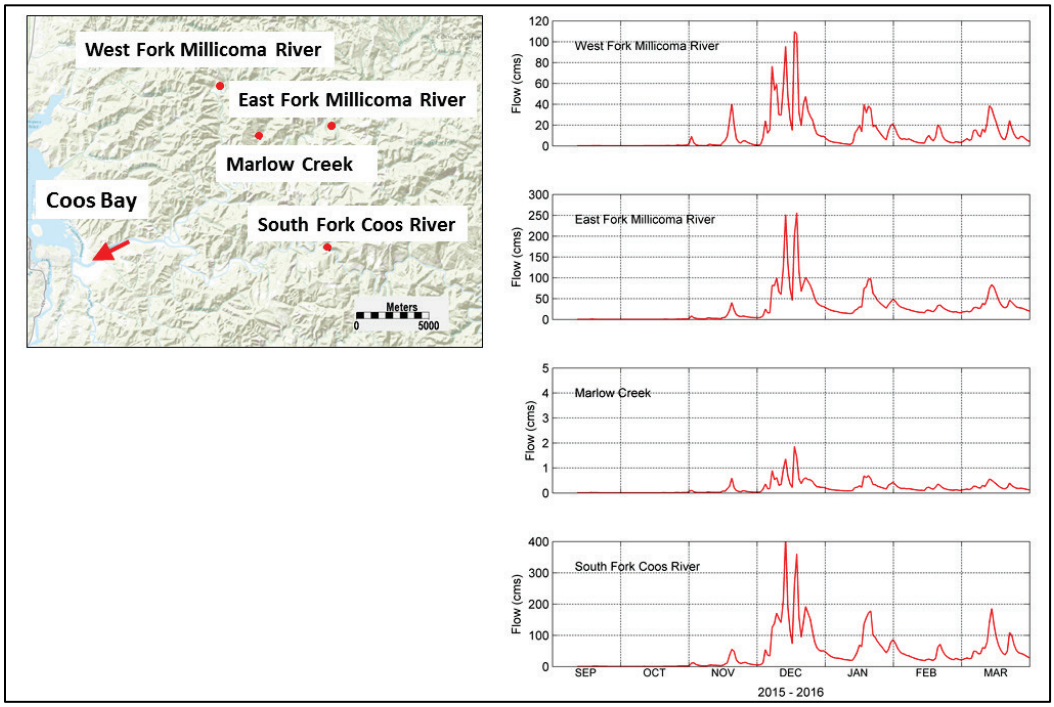
Figure 2-6. Monthly wave roses at the NDBC buoy 46015 from September 2015 to March 2016. The November 2015 rose is not included because of missing data.



2.4 River flow

River discharge data were obtained from the Coos Watershed Association at four gauging stations, West Fork Millicoma River, East Fork MiIlicoma River, Marlow Creek, and South Fork Coos River. Figure 2-7 shows the locations of the four river gauges and daily river flows from September 2015 to March 2016. River discharges in September and October are close to zero and increase in November. Peak flows occurred in December 2015. The South Fork Coos and East Fork Millicoma Rivers contributed the highest volume of water. The 7-month mean flow rates from these two rivers are 40.93 m^3/sec and 25.55 m^3/sec, and the corresponding peak flow rates are 400 m^3/sec and 250 m^3/sec, respectively.

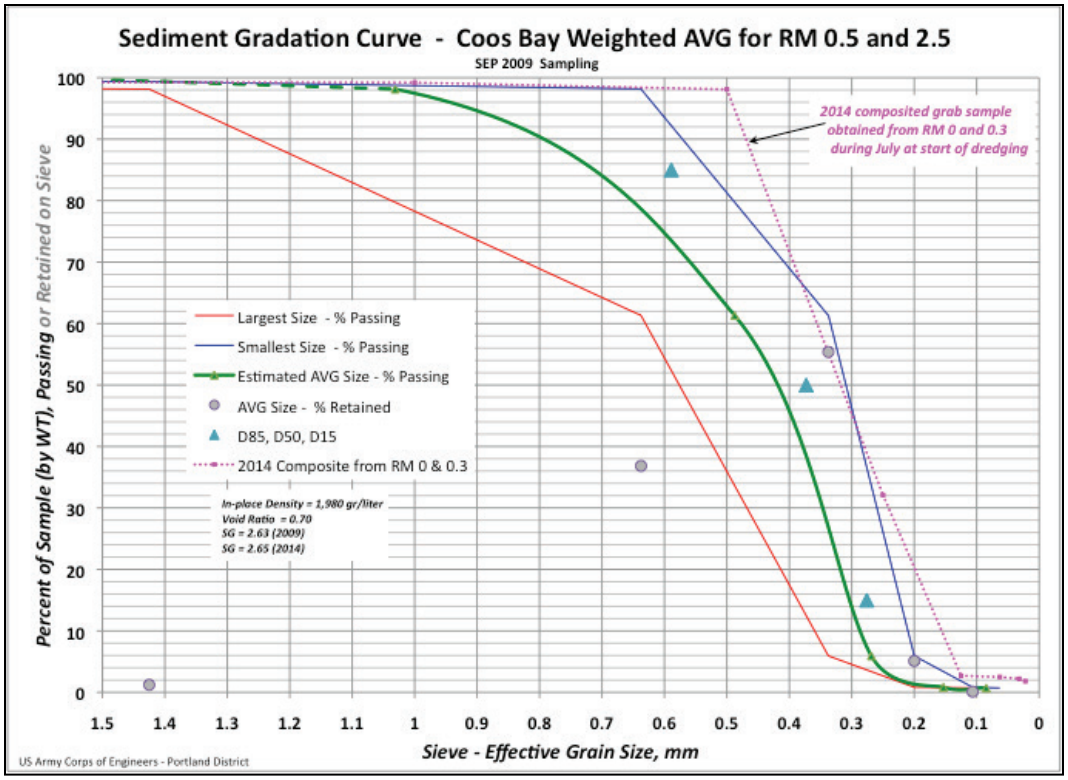
Figure 2-7. Four gauge locations of West Fork Millicoma River, East Fork Millicoma River, Marlow Creek, and South Fork Coos River and corresponding river flows from September 2015 to March 2016. The red arrow indicates the freshwater inflow location into the Coos Bay.



2.5 Sediments

The NWP provided sediment gradation curves at the Coos Bay Inlet entrance, RM 0.5 and in the bay, RM 2.5. The analysis of sediment grain sizes was based on sediment sampling data collected in 2009. The final grain size distribution was determined from a correction by more recent sediment sampling data in 2014. Figure 2-8 shows the modified sediment gradation curve. D10, D50, and D90 obtained from the curve are 0.15, 0.32, and 0.47 mm, respectively.

Figure 2-8. Particle size data and target size distribution based on a weighted average of 2009 and 2014 NWP sediment gradation data from surface sediment samples collected in the entrance channel, Coos Bay.

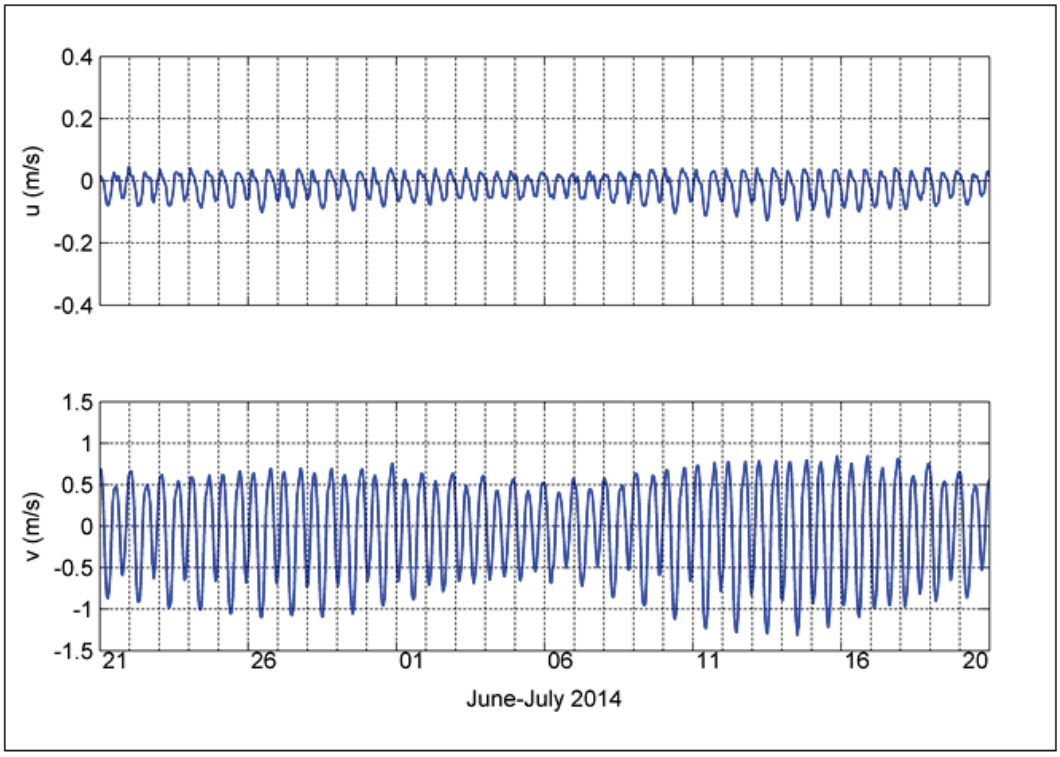


2.6 Estuarine current

For an environmental study in the Coos Bay estuary, an ADCP was deployed in the bay (Sutherland and O'Neill 2016). Figure 2-3 shows the location of the upward-looking ADCP moored at a water depth of 10.3 m, which is off the deepest part of the channel near mid-estuary (RM 8.0). The deployment lasted over a year starting in late November 2013 and ending in July 2014. Both current and WSE were measured at the location.

The ADCP-measured velocities were vertically averaged, and 30 days' worth of data were extracted for 21 June – 20 July 2014. Figure 2-9 shows the east-west (u) and the north-south (v) velocity components. Because the Coos Bay channel orients approximately in the north-south direction, the u-component roughly corresponds to cross-channel and the v-component to along-channel velocities. The current variations in the plot illustrate that the bay current at this location is tidally dominated and down-estuary (seaward flowing), and vertically averaged current can be as large as 1.3 m/sec.

Figure 2-9. Current measurements at the ADCP gauge from 21 June to 20 July 2014.

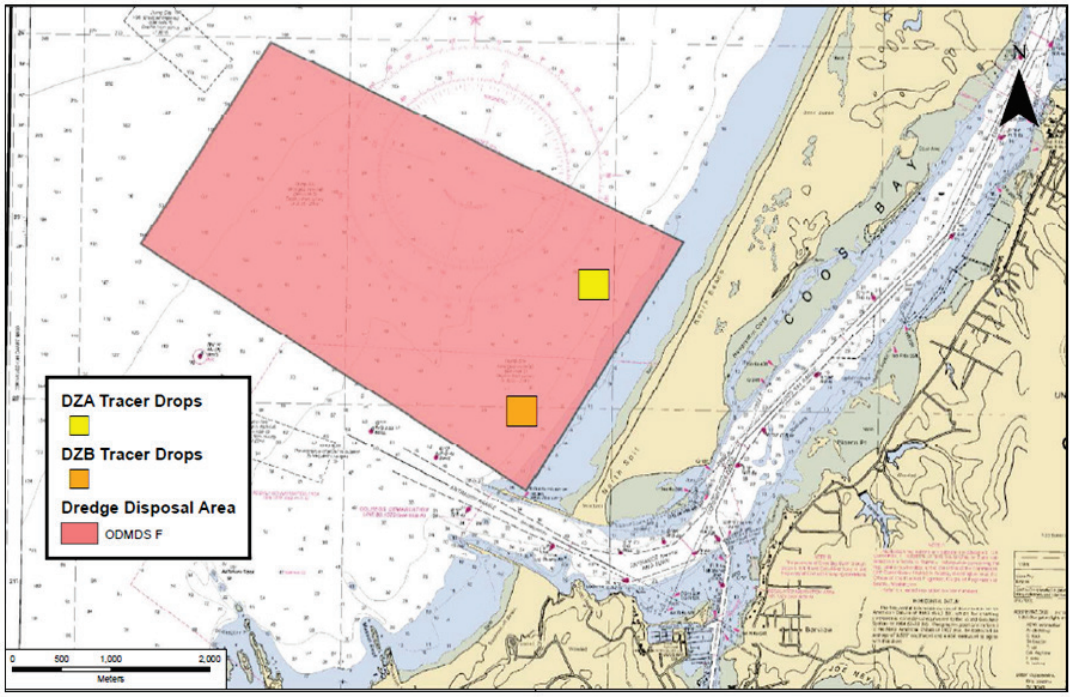


3 Methods

This study employs preexisting and newly collected hydrodynamic and sediment transport data in a comprehensive numerical analysis of sediment transport pathways at Coos Bay Inlet, OR. Existing datasets applied in this study were discussed in Chapter 2. Chapter 3 describes the field data collection plan as well as the methods applied in numerical modeling of the site.

RPS Evans-Hamilton Inc. (RPS EHI) was contracted by the U.S. Army Engineer Research and Development Center (ERDC) to conduct a field hydrodynamic data collection effort and sediment tracer study at a nearshore disposal site north of the Coos Bay Entrance Channel. The work was conducted under Task Order 034 of Contract W912HZ-11-D-0002 (USACE 2015). The project site was located within the nearshore portion of ODMDS F, immediately north of the Coos Bay Entrance Channel and surrounding areas, and sediment tracer was released in two drop zones (DZ), DZ-A (yellow) and DZ-B (orange) (Figure 3-1).

Figure 3-1. Study area at Coos Bay, OR. Illustrating ODMDS F is outlined in pink; the tracer DZ are shown in yellow (DZA) and orange (DZB).



There were two primary components to the field study: (1) the collection of current, wave and water level data at the project site and (2) the deployment and monitoring of sediment tracers at the project site and broadly across the study area. In an attempt to gain insights into the movement and dispersion of sediments placed in the dredged material disposal site and support modeling efforts of sediment transport, the study team deployed different-colored sediment tracers at two locations as shown in Figure 3-1 and monitored their movement over time. To support the calibration and validation of numerical models for the site, the following oceanographic field measurements were also collected:

1. Stationary temporal measurements
    a. 2 months of currents, waves and water level at the dredge material disposal site
    b. 1 month of currents, waves and water level in the Coos Bay entrance channel
    c. 1 month of water levels in the upper reaches of the Coos Bay Channel
2. Spatial coverage of currents throughout the project area over a 4-day period.

The USACE ERDC CMS and PTM were selected in support of the NWP requirement for evaluating the transport and fate of dredged material placed in the nearshore and offshore areas of ODMDS F. The CMS performed wave, hydrodynamic, and sediment transport simulations, and the model results were calibrated and validated using the survey data. The PTM was driven by wave and hydrodynamic forcing generated by the CMS. Both models are used to investigate sediment transport pathways under combined wave, hydrodynamic, and atmospheric forcing conditions.

3.1 2015–16 Field data collection program

3.1.1 Hydrodynamic measurements

3.1.1.1 Acoustic wave and current profiler (AWAC) nearshore measurements

As shown in Figure 3-2, RPS EHI deployed a bottom-mounted tripod between the two tracer release locations. The tripod was equipped with the following instrumentation:

- An upward-looking AWAC configured for waves and currents. The AWAC collected a 20-minute wave burst every hour and a 2-minute current burst every 10 minutes.
- A downward looking Nortek Aquadopp current profiler configured to measure a profile of near-bottom current velocities over a 2-minute burst every 10 minutes.
- A non-directional wave sensor consisting of an internal recording pressure sensor set to collect a 20-minute burst every hour.
- A diverless recovery system consisting of a buoy held in place by an acoustic release. Upon activation, the release will disconnect from the buoy and the buoy will then float to the surface bringing with it a recovery line connected to the tripod.

Figure 3-3 shows the nearshore tripod just prior to deployment. It was deployed on 18 September 2015 in approximately 12.8 m of water at the following coordinates:

- 43° 22.3280' N
- 124° 20.5481' W

It was recovered on 21 November 2015 without incident.

Figure 3-2. Hydrodynamic measurement mount and pressure sensor positions in Coos Bay, deployed in fall 2015.



Figure 3-3. Wave and current Instruments on the nearshore tripod prior to deployment.



3.1.1.2 Coos Bay channel current

A low-profile bottom mount (Figure 3-4) was deployed just outside the southern edge of the channel approximately 502.9 m east of the tip of the southern jetty. The deployment location is shown in Figure 3-2. The bottom mount was equipped with the following:

- An upward-looking ADCP configured for current measurements only. The ADCP was configured to collect a 2-minute burst every 10 minutes.
- A diverless recovery system consisting of a buoy held in place by an acoustic release. Upon activation, the release will disconnect from the buoy, and the buoy will then float to the surface bringing with it a recovery line connected to the bottom mount.

The bottom mount was deployed on September 18 2015 in approximately 12.5 m of water at the following coordinates:

- 43° 21.3119994 N
- 124° 20.693994 W

It was recovered on 2 October 2015 approximately 2 weeks after deployment. Originally, the plan had been to deploy the instrument for a total for 60 days, but due to concerns about burial, it was decided, in consultation with the USACE project team, to limit the deployment to 2 weeks.

Figure 3-4. Low-profile bottom mount for current measurements in the Coos Bay entrance channel.



Upon recovery of the bottom mount, it was determined that the battery in the ADCP had failed approximately 20 hours in to the deployment. To collect the requested data, RPS EHI replaced the battery and redeployed that bottom mount in the same area on 28 October 2015. The deployment coordinates were the following:

- 43° 21.320271 N
- 124° 20.700982 W

On 20 November 2015, an attempt was made to recover the bottom mount, but the recovery team was unable to establish communication with the acoustic release. The recovery buoy attached to the mount had been found washed up on the rocks in the southern jetty, and an inspection of it indicated it had been ripped off the mount. Numerous attempts were

made to establish communications with the release throughout the channel without success, and the mount was considered lost. Since the ADCP was never recovered, no current data were collected for this site.

3.1.1.3 Upper Coos Bay Channel (USACE dock)

In the upper reaches of the bay, an internal recording pressure sensor was installed on 22 September 2015 at the USACE dock located in the town of Coos Bay (Figure 3-2). The coordinates of the installation are the following:

- 43° 22.7638N
- 124° 12.9785 W

For the installation, a HOBO water level sensor was installed on a pipe secured to the piling. The elevation of the sensor was surveyed in to a benchmark located in close proximity to the deployment station. A second pressure sensor was installed above the water on the pier, and data from it were used to correct the water level measurements for variation in atmospheric pressure.

The water level sensor was recovered on 20 November 2015. Upon recovery of the HOBO sensor, it was determined that the stainless steel housing of the instrument had experienced extensive corrosion during the deployment, which allowed water ingress into the electronics. The data card on the sensor was still readable and contained approximately 1 month of recoverable/useable data. It is speculated that the severe corrosion of the stainless steel instrument housing was caused by stray electrical current in the water at the pier where the instrument was deployed.

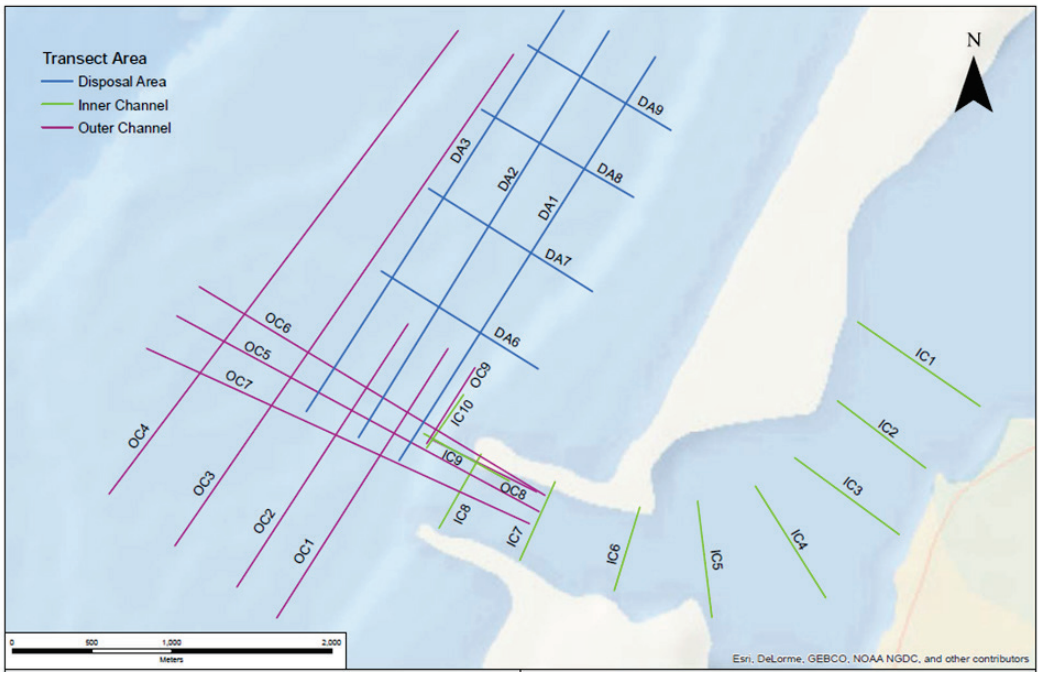
3.1.1.4 Current surveys using vessel-mounted ADCP

A current survey was conducted in the lower portion of the Coos Bay Channel and in the nearshore area extending from just south of the entrance channel to approximately 3.2 kilometers (km) north, 0.8 km south, and approximately 2.4 km offshore as shown in Figure 3-5. To conduct the survey, a downward-looking ADCP configured for bottom tracking was installed over the side of a 8.5 m survey vessel. Four sets of survey lines were established for the site with the intention being that approximately 10–12 hours of measurements would be conducted on each set of lines. The four sets of lines included the following:

- the inlet throat (denoted IC)
- ODMDS F (denoted DA)
- the ebb delta parallel to the centerline of the entrance channel (denoted OC5-7)
- the ebb delta parallel to the shoreline (denoted OC1-4).

The current surveys were conducted over a 4-day period starting on 28 September 2015 and going through 1 October 2015. Due to high waves at the entrance channel and offshore during some periods of the survey period, it was not possible to work continuously offshore for periods of 10–12 hours. Consequently, the field team adjusted which lines were surveyed based on the sea conditions, attempting to collect a uniform amount of data from all sets of lines.

Figure 3-5. Coos Bay tracer study, transect lines, 28 September – 1 October 2015.



3.1.2 Sediment tracer release and sampling

A sediment tracer field study was designed to address questions about the movement of dredged sediment particles along the nearshore portion of the ODMDS F-NS. To assess the relative influence that the distance to the inlet has on the placed sediments, two tracer DZ were chosen at different distances from the Coos Bay Inlet north jetty along the nearshore edge of ODMDS F-NS. DZ-A was placed approximately 3 km north of the inlet, and DZ-B was placed approximately 1 km north of the inlet (Figure 3-1).

The sediment tracer field team, comprised of RPS EHI and ETS personnel, carried out the following fieldwork:

1. Collected 30 background surface sediment grab samples prior to releasing any sand tracers.
2. Released orange sand tracer particles in DZ-B.
3. Released yellow sand tracer particles in DZ-A.
4. Containment samples: collected 24 surface grab samples from DZ-B followed by 24 surface grab samples from DZ-A, approximately 24 hours after each tracer release to assess initial dispersal and containment.
5. Round 1 samples: collected 97 surface grab samples from the study area approximately 3 months after the sand tracer releases in November 2015.
6. Round 2 samples: collected 225 surface grab samples and beach samples from the study area approximately 6 months after the sand tracer releases in March 2016.

3.1.2.1 Tracer characteristics

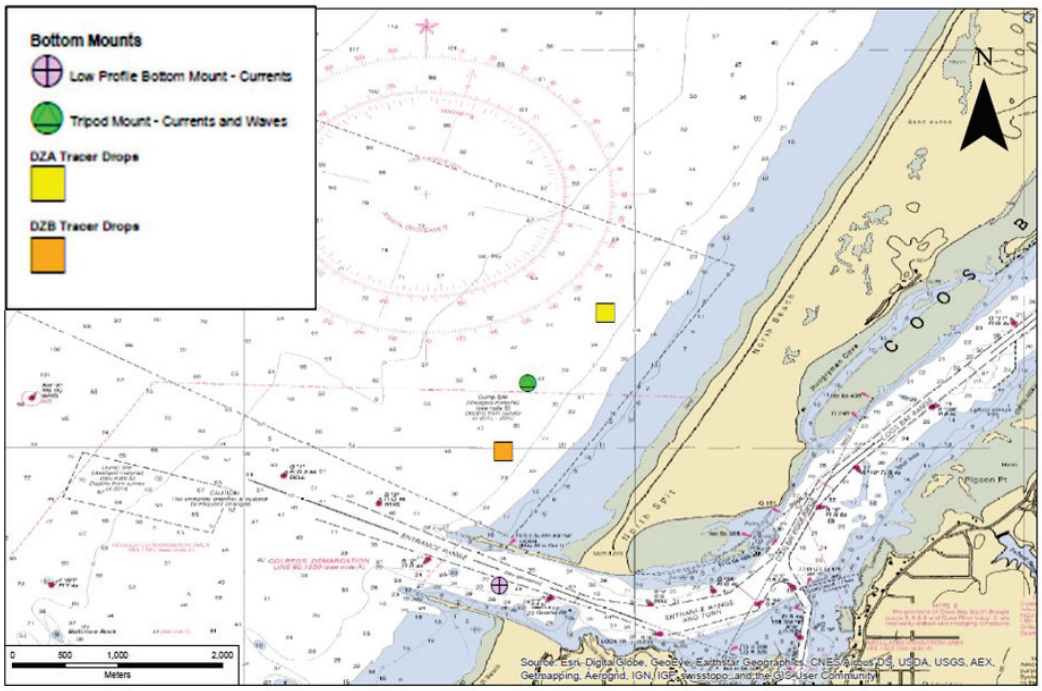
EcoTrace™ fluorescent sediment particle tracers, developed by Environmental Tracing Systems (ETS), assimilate the properties of native sediment particles and are similarly acted upon by the processes of tidal currents, wind-driven circulation, and waves to give an integrated assessment of native sediment transport processes, pathways, and patterns of deposition.

The tracer particles include fluorescent dyes in a thermoplastic polymer base (see Material Safety Data Sheet (MSDS) in Appendix J), and therefore the whole of each tracer particle contains fluorescence throughout rather than a coating on natural sediment grains from the environment. Coated sediment grains can be abraded, thereby reducing recoverability and detection whereas ETS EcoTrace particles remain highly fluorescent and can be detected over long time periods at high dilutions even after some abrasion. Prior to release, tracer particles are always pre-wet and mixed with sediment from the site to ensure they absorb the same electro-chemical charge as natural sediment particles. Silt-sized tracers become incorporated into natural flocs, thus behaving in the same way as the natural silt particles.

EcoTrace particles do not contain any substances that are considered a health hazard. An MSDS is provided in Appendix J, providing further details of hazard testing that has been carried out on the EcoTrace particles.

To understand the sediment transport from two different sections of the Coos Bay ODMDS F-NS, NWP identified two sites of interest, both in approximately 12.2 m of water designated DZ-A and DZ-B. Different colors of sand tracer were released to distinguish sand transport patterns from the two areas: Yellow at DZ-A and Orange at DZ-B (Figure 3-6).

Figure 3-6. Tracer release locations and bottom mounted sensors, Coos Bay, OR.



It is essential that the tracer particles have the same physical properties and characteristics as the target natural sediment. To compare the observed transport pathways, rates, and fate of material from DZ-A and DZ-B, the size distributions for these two sand tracers should be kept similar.

NWP initially supplied particle size data, carried out by sieve analysis, for nine surface sediment samples collected during dredging operations from the entrance channel and interior channel for Coos Bay, in the area where the majority of the maintenance dredging takes place. The samples were referenced AECOM-SEA Retec with sample notation ranging from 091609CB-BC-01 to 091609CB-BC-09 (per NWP records). It was

hypothesized that the average grain size of the sediment within the samples was increased by the dredging action due to *lag* effects.

To accommodate this trend, it was requested that the two sand tracers should be *weighted* in terms of particle size distribution on the basis of 1/10th interior channel and 9/10ths entrance channel equating to samples 091609CB-BC-05 and 091609CB-BC-03 collected from RM 2.5 and 0.5, respectively.

However, after further analysis of more recent sediment particle size data including analysis of a composite sample collected in 2014 (per NWP records) from the area offshore of the entrance to Coos Bay, it was determined that the sediment in this area had a smaller grain size gradation than indicated from the comparable 2009 data. It was concluded that this was as a result of (1) the 2014 data including sediment from areas offshore of RM 0.5, where sediment grain size is typically smaller than within the inlet interior (between the jetties), and (2) that the 2014 samples were collected at the start of dredging, before sediment gradation becomes biased by larger material lagging behind the dredging operations, as noted above.

NWP provided a summary graph (Figure 3-7) of the particle size data and target size distribution for the two sand tracers based on the initial 2009 sediment gradation data delineated between the blue and green lines with the blue triangles denoting the target D15, D50, and D85. However, in light of the 2014 sediment gradation data, the graph was modified to reflect the 2014 data, shown as red points in Figure 3-7.

The target size distribution for the sand tracers was the following:

- D10: 150 microns (μm)
- D50: 320 μm
- D90: 470 μm.

Background samples were collected by RPS EHI prior to the tracer release and are plotted along with AECOM SEA-Retec data for 2009 and the target particle size specified by NWP for the sand tracers in Figure 3-7.

Figure 3-7. Particle size data for the two sand tracers and background sediment samples collected in September 2015. The target size distribution indicated and agreed with NWP is shown as red circles for D10, D50, and D90. The tracer particle sizing bands are shown as fine (125 to 280 µm), medium (>280 to <400 µm) and coarse (>400 to 700 µm) and are denoted by the green and red lines.

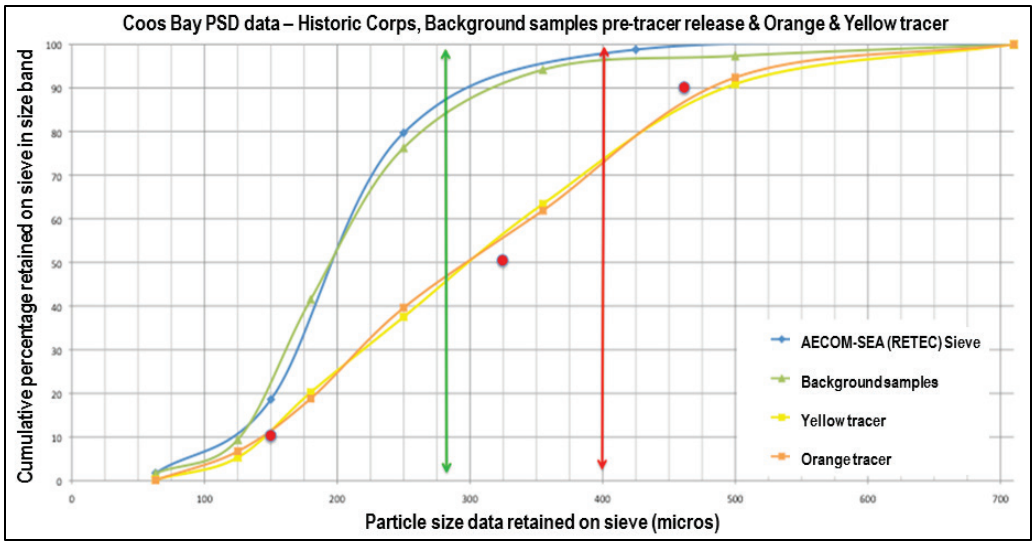


Figure 3-7 shows the orange and yellow sand tracers have similar size distributions close to the target size gradation. The sand tracers were slightly finer around the D50 and slightly coarser around the D90. Approximately 5%–6% of the sand tracers were below 125 µm, equivalent to very fine sand; these were not counted in the analysis process with only particles greater than 125 µm being counted for all samples and analysis.

In terms of the size distributions used to separate fine, medium, and coarse particles, approximately 45% of the tracer was in the fine fraction (125 to 280 µm), 27% in the medium fraction (>280 to <400 µm), and 28% in the coarse fraction (>400 to 700 µm); this compares with the target requested by NWP of approximately 33% in each size band.

Clearly the average of the AECOM SEA-Retec 2009 data and the average of the background samples collected by RPS EHI in September 2015 indicate much finer sediment with corresponding D10, D50, and D90 of 120, 195, and 305 µm respectively.

ETS manufactured both sand tracers with the same sediment particle density of 2.63 grams/cubic centimeter (g/cm^3), to reflect the overall density of sediment in the area based on data provided by NWP. The tracer particle density was measured as 2.63 g/cm^3 by an external accredited laboratory following procedures set out in British Standard BS812.

Given that the tracer particles were intended to represent natural non-cohesive sand, ETS carried out fall velocity tests on the yellow and orange tracer particles and sand collected by RPS EHI during the background sediment sampling. A composite sand sample was made from 10 of the 30 background surface sediment samples collected in the immediate vicinity of the DZ-A and DZ-B release sites; 5 samples were collected in each area on 18 September 2015.

The tests were carried out to compare the two different types of particles (sand tracer and natural sand) to ensure they behaved in a similar manner in terms of key sediment transport processes in the water column including erosion, resuspension, transport, and settling.

The fall velocity tests involved timing the fall of an individual particle of known size over a 1 m (1000 mm) vertical distance in seawater at constant temperature. A total of five grains were tested per size band per color/background material. For these tests, the temperature was maintained at 20°C ±1°C (equivalent to ambient room temperature at time of test) and 35.0 parts per thousand (ppt) salinity (as per ocean water). ETS used ambient room temperature since it is difficult to warm the entire 1 m water column consistently and continuously and avoid pockets of warmer and cooler water. In addition, ETS always conducts fall velocity tests at or approximately 20 °C to allow comparison from one tracer/sediment to another for all project sites tested; it is also a standard temperature for fall velocity tests carried out in other laboratories.

For the test, the two colors of tracer particles (yellow and orange) and background sediment were soaked and wetted in the same way for the same duration from a dry state. Individual particles were selected by microscope and sized using a microscope eyepiece graticule to ensure comparison among grain sizes. Sizing in this way only allows measurements in two dimensions (X and Y) and not Z, which leads to variability in the actual grain size; however, the same approach is used for natural sand and tracer particles. Three size bands were compared, corresponding to the fine, medium, and coarse sizes adopted for the study, equating to 125–280, 280–400 and 400–700 μm, respectively. However, due to the very broad range of particles in the coarse size band (300 μm), particles were selected for both the sand tracers and the natural sand at between 400 to 525 μm only to ensure they were comparable with the other size bands and ranges.

Table 3-1 presents the results of the fall velocity tests. Note that the sizes cover a wide range (125 to 525 µm). The large size range corresponds to the large variation in fall velocities, particularly compared with velocities reported in the literature, which tend to isolate one size of particle or use a sphere to compare measured with mathematical calculations. By comparison, the purpose of these measurements was to ensure that the sand tracers and the natural sand were similar in laboratory conditions for equivalent grain sizes.

Table 3-1. Fall velocity results for yellow and orange tracer particles and background sediment samples. Note that individual measurements are in parentheses.

Grain size (µm)	Average fall velocity Yellow tracer (mm/sec)	Average fall velocity Orange tracer (mm/sec)	Average fall velocity background sand samples (mm/sec)
Fine 125–280	20.1 (18.5, 20.7, 22.3, 21.9, 17.6)	19.9 (22.3, 17.1, 20.4, 21.0, 18.8)	19.4 (16.3, 20.6, 18.4, 22.1, 19.7)
Medium 280–400	32.9 (34.9, 38.7, 27.7, 30.4, 32.6)	33.7 (27.3, 37.9, 32.5, 37.0, 33.6)	32.4 (36.6, 29.1, 26.0, 33.8, 36.7)
Large 400–525	56.3 (53.1, 60.2, 54.3, 55.8, 58.0)	54.2 (57.1, 50.4, 51.9, 52.1, 59.6)	54.7 (49.9, 62.4, 50.5, 52.1, 58.7)

For the given size ranges, allowing for the variability in finding identical size grains, the fall velocities for the three size bands were very similar for the two sand tracers and the natural sand; the minor differences are not considered to be significant.

3.1.2.2 Background sediment samples

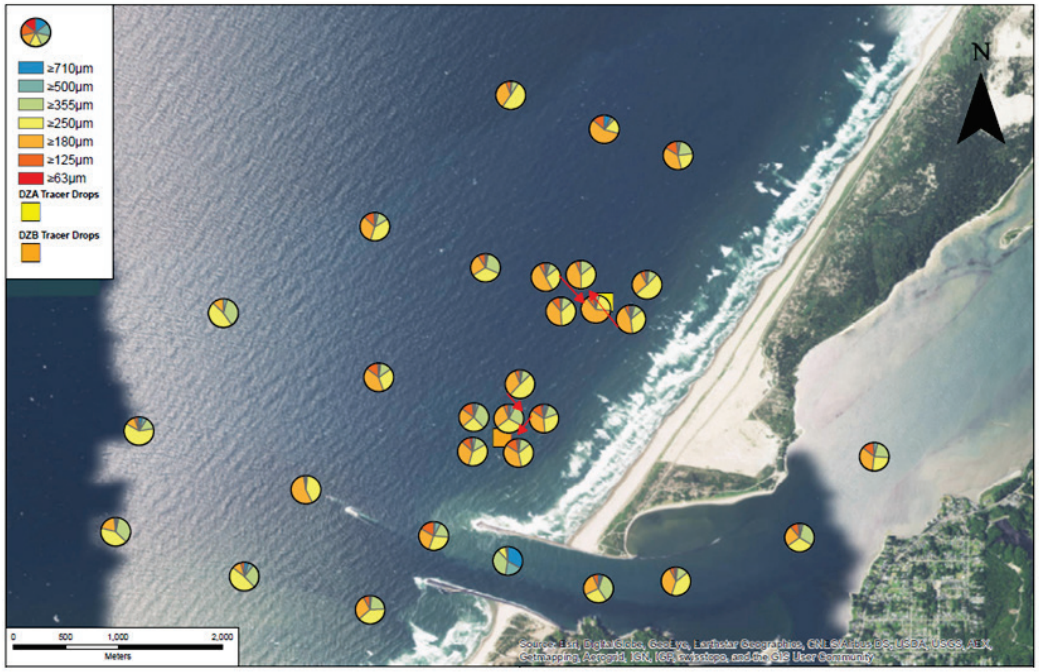
Following deployment of the metocean instrumentation, the study team collected 30 background surface sediment grab samples on 18 September 2015, 20 samples from the wider sampling area, and 5 samples around both DZ-A and DZ-B (Figure 3-8).

ETS analyzed these samples and found no fluorescent material or particles that interfered with either of the sand tracers. ETS conducted particle size analysis of the samples using the following sieve sizes ranging from coarse to very fine sand:

- 710, 500, 355, 250, 180, 125, and 63 µm.

Figure 3-8 shows the locations of 30 surface grab samples and summarizes the particle size information given for each sample.

Figure 3-8. Background particle size data for grab samples collected from the study area, 18 September 2015.



Surface sediment grab samples were collected using a Shipek grab sampler. The method has proved very successful and reliable in collecting a sediment sample in harsh conditions and variable sediment types common off the Oregon coastline including previous studies at the mouth of the Columbia River. Figure 3-9 shows the Shipek grab in operation at Coos Bay, OR. A Shipek grab was used to collect all subsequent sediment samples for the study including the Containment, Round 1, and Round 2 sediment samples.

Figure 3-9. Shipek grab sampler being deployed off the vessel for sediment collection offshore of Coos Bay Inlet, OR.



Due to the compact nature of the sediment offshore of Coos Bay Inlet, the study team struggled (on occasion) to get a full grab sample, particularly in the entrance channel with strong currents, resulting in more grab samples needing to be collected. If the study team did not get a grab that was at least 50% full after several attempts, samples from the same location were composited into one sample with the positions noted.

The particle size data shown in Figure 3-8 confirm that the majority of the surface sediment samples collected, including inside of the entrance channel were comprised of sand (180–355 µm) with an average composition of 32% and 35% in the size fraction 180–250 and 250–355 µm respectively. The data show that some samples have much higher percentages in these size fractions. There is some variability in localized areas, but for the most part the sediment is relatively well sorted. The only exception to this is within the entrance channel itself, and adjacent areas to a lesser degree, where coarser material in the range of >355, >500, and even >710 µm were present. The particle size data also indicate that surface sediment in the region of DZ-A and DZ-B were not markedly different from the surrounding areas.

3.1.2.3 Tracer mixing and dosing

The study team collected buckets of sand from Sunset Bay State Beach approximately 2.4 km south of Charleston, OR.

A total of 600 kilograms (kg) of orange sand tracer was mixed initially with approximately 300kg of dry sand collected from the beach into a slightly wet sand tracer/sand mixture. It was important not to make the material too wet given that the study team intended to release the sand tracer onto the seabed using dissolving starch-based bags. The dissolving bags can hold approximately 15 kg of material per bag and allow the sand tracer to be released onto the seabed without any spillage or dispersion into the water column. This essentially allows the transport of the sand tracer to be monitored as a seabed mobility study.

The dissolving bags remained intact for approximately 2 minutes in the ambient conditions at the time of the study, allowing approximately 1 minute to place sand tracer/sand mixture into the bag and 1 minute to seal the bag, lower it over the side of the vessel and for it to reach the seabed; it is estimated in 12.2 m of water the dissolving bag would be on the bottom within a few seconds once it was released at the sea surface. The position and time was logged for each dissolving bag released.

For the orange sand tracer release in DZ-B, the study team defined a release area of approximately 75 m radius around the DZ-B position supplied by NWP, and the skipper of the vessel maneuvered within this circle while all the dissolving bags were released. A total of 59 bags of orange sand tracer/sand mixture were released, equivalent to approximately 15.2 kg per bag (approximately 10 kg of sand tracer) over a period from 08:40 to 12:54 local standard time (LST) on 19 September 2015, to coincide approximately with slack tide. Low water (LW) for the day was at 09:54 LST with an elevation of 0.9 m relative to the mean lower low water (MLLW) and high water (HW) was at 16:18 LST with an elevation of 2.2 m MLLW (NOAA gauge 9432780). Figure 3-10 shows the distribution of the dissolving bags released in DZ-B. Unfortunately, one dissolving bag split slightly on contact with the sea, possibly because the sand tracer-sand mixture was a little wetter, and it dissolved faster than expected. From a visual inspection, a small proportion of the sand tracer was visible in the water column, but it is estimated that 90%–95% of the material remained in the bag and went directly to the seabed. Figure 3-11 shows the tracer release area within DZ-B in context with the sediment sampling areas for the Containment, Round 1, and Round 2 sampling events.

Figure 3-10. Tracer release positions within DZ-A and DZ-B.

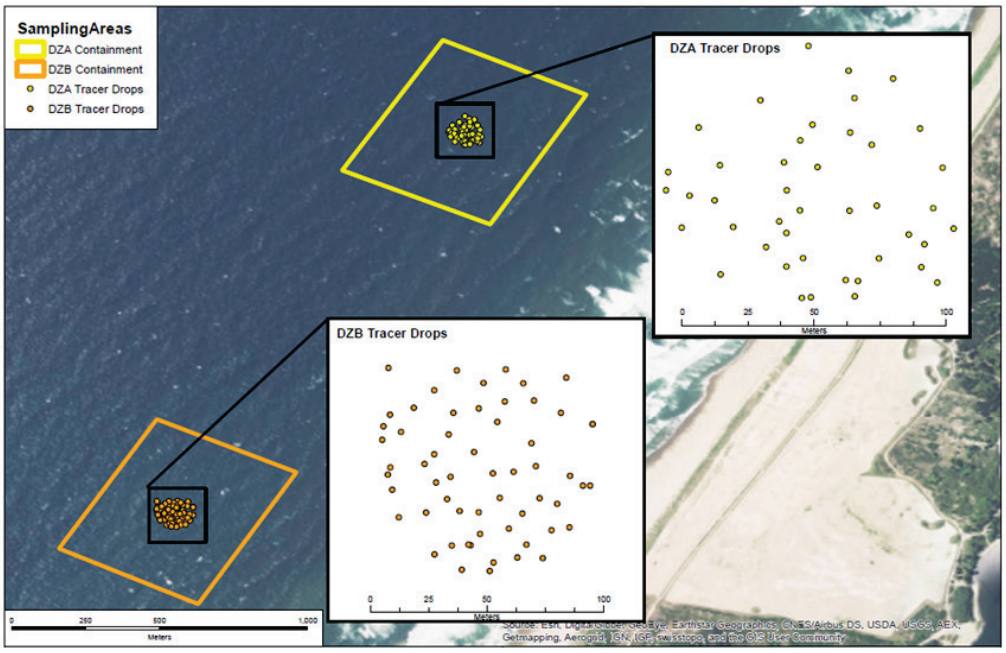


Figure 3-11. Sediment sampling areas for the Containment, Round 1, and Round 2 sampling events.

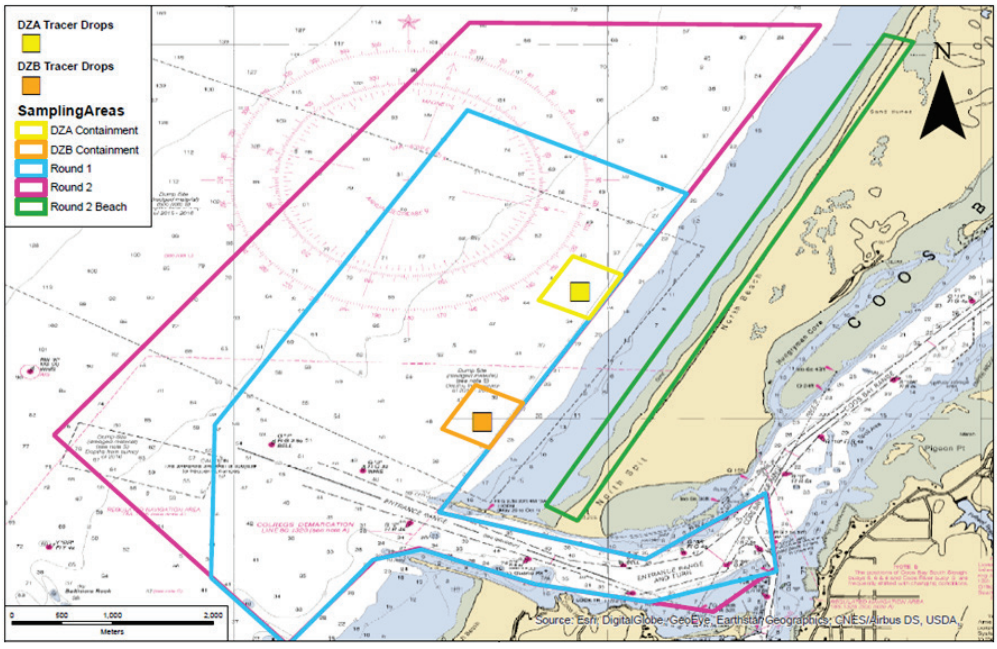


Figure 3-12 and Figure 3-13 show the orange sand tracer-sand mixture being added to a dissolving bag and then the dissolving bag being lifted out of the bucket and released over the side of the vessel.

Figure 3-12. Orange sand tracer sand mixture being added to a dissolving bag (center bucket).



Figure 3-13. Dissolving bag with orange sand tracer being released over the side of the vessel.



Following the orange sand tracer release, the study team changed clothes and showered to remove any risk of cross-contamination and used clean/new equipment to mix a total of 600 kg of yellow sand tracer with approximately 300 kg of natural sand from Sunset Bay State Beach.

On 20 September 2015, the study team released a total of 43 bags of yellow sand tracer/sand between 14:39 and 16:17 LST, equivalent to approximately 20.9 kg per bag (approximately 14 kg of sand tracer), again to coincide with slack tide; LW for the day was at 11:06 LST with an elevation of 1.0 m; MLLW and HW was at 17:18 LST with an elevation of 2.1 m MLLW. Figure 3-10 shows the distribution of each dissolving bag released in DZ-A.

3.1.2.4 Containment samples

The study team established a sample grid approximately 500 m by 500 m centered around each tracer release site, DZ-B and DZ-A, comprising samples from a 5 × 5 grid; however, the sample in the very center of the grid was not collected as this was the area for each tracer release. Therefore, a total of 24 surface sediment grab samples were collected per tracer release area (Figure 3-10).

Samples from DZ-B were collected between 07:04 and 09:17 LST on 20 September 2015, approximately 22 (18–25) hours after the orange tracer release and prior to the yellow sand tracer release.

Samples from DZ-A were collected between 07:58 and 10:44 LST on 21 September 2015, approximately 18.5 (16–21) hours after the yellow tracer release.

For each sample, the position, time, and date were noted and placed into a clean ziplock bag and shipped to the ETS ISO9001 certified laboratory for analysis.

ETS counted the number of yellow and/or orange sand tracer grains present in a known dry weight for each sample, typically approximately 300 g equivalent to 400–500 g wet sediment which represents approximately 40% of a full Shipek grab bucket. In addition, ETS measured every tracer grain detected and placed them into the three size bands: fine, medium, and coarse equivalent to >125–280, 280–400 and 400–700 μm, respectively.

3.1.2.5 Round 1 sampling

RPS EHI collected a total of 97 surface grab samples from the study area during 20–22 November 2015, equivalent to approximately 62–64 elapsed days after the orange and yellow sand tracers were released. Figure 3-11 shows the sampling area for Round 1. All samples were shipped to the ETS laboratory and were analyzed for tracer counts per fine, medium, and coarse size fractions for both orange and yellow sand tracers.

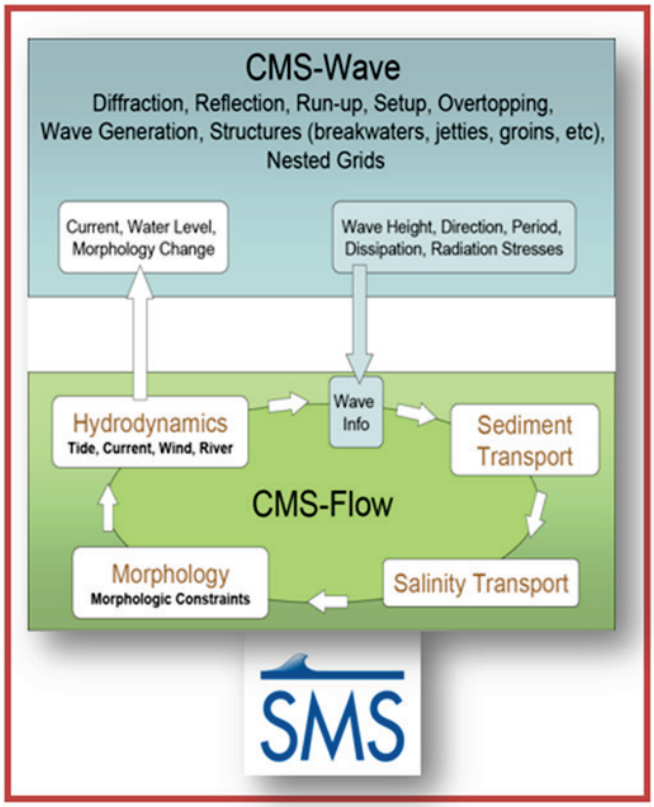
3.1.2.6 Round 2 sampling

Based on the sand tracer results from Round 1, numerical modeling output and the anticipated movement of the sand tracers over the remainder of the 2015/2016 winter, the sampling area for Round 2 was increased including sampling along the beach on the north side of the inlet (Figure 3-11). In addition, extra samples were collected within the area originally sampled for Round 1 to increase the definition and detail in areas of interest. RPS EHI collected a total of 36 beach samples at approximately the low-tide and high-tide mark between 12 and 14 March 2016 and 189 surface grab samples offshore between 15 and 18 March 2016, equivalent to approximately 175–181 elapsed days after the orange and yellow tracers were released. All samples were shipped to the ETS laboratory and were analyzed for tracer counts per fine, medium, and coarse size fractions for both orange and yellow sand tracers.

3.2 The Coastal Modeling System (CMS)

The CMS is an integrated suite of numerical models for waves, flows, sediment transport, and morphology change in coastal and inlet applications. This modeling system includes representation of relevant nearshore processes for practical applications of navigation channel performance and sediment management at coastal inlets and adjacent beaches. The CMS consists of a hydrodynamic and sediment transport model (CMS-Flow) and a spectral wave transformation model (CMS-Wave) and can be coupled with the PTM (Buttolph 2006; Sanchez et al. 2011a, 2011b; Lin et al. 2008; MacDonald et al. 2006). All pre- and post-processing for these models is performed within the ERDC Surface-water Modeling System interface (Aquaveo 2013). The framework of CMS is shown in Figure 3-14.

Figure 3-14. The CMS framework.



CMS-Flow is a two-dimensional, depth-integrated, finite-volume model that solves the mass conservation and shallow-water momentum equations of water motion on a non-uniform Cartesian grid (Buttolph 2006; Sanchez et al. 2011a, 2011b; Wu et al. 2011). CMS-Flow calculates hydrodynamics, sediment transport and morphology change, and salinity due to tide, wind, and waves. Wave radiation stresses and other wave parameters are calculated by CMS-Wave and supplied to CMS-Flow for hydrodynamic and sediment transport calculations. For the Coos Bay application, CMS-Wave was run at a 2-hour interval.

CMS-Wave is a spectral wave transformation model. It solves the steady-state wave-action balance equation on a non-uniform Cartesian grid and is designed to simulate wave processes with ambient currents at coastal inlets and in navigation channels (Lin et al. 2008, 2011). The model can be used either in half-plane or full-plane mode and includes coastal wave processes, such as wind wave generation and growth, diffraction, reflection, dissipation due to bottom friction, white-capping and breaking, wave-current interaction, wave runup, wave setup, and wave transmission through structures.

The CMS includes the calculation of multiple-sized, non-equilibrium sediment transport, which combines the bed and suspended load transport equations into a single total-load transport equation (Sanchez et al. 2014). In the CMS, the sediment transport is separated into current- and wave-related components. The transport due to currents includes the stirring effect of waves, and the wave-related transport includes the contributions due to asymmetric oscillatory wave motion, Stokes drift, surface roller, and undertow. CMS-Flow can simulate any number of sediment size fractions and considers the interactions between size fractions, bed sorting and layering, and morphology change. The model divides the sediment bed into multiple layers to consider the heterogeneity of bed material size composition. The fraction of each size class is then calculated and stored in each layer using the mixing or active layer concept (Hirano 1971; Wu 1991). The sediment in the mixing layer (i.e., the top layer of the bed) directly exchanges with the sediment moving in the water column whereas the sediment in non-moving subsurface layers below the mixing layer does not. By tagging the sediments and bookkeeping the history of bed composition within each layer, a multiple-sized sediment transport simulation can present the tracking information of sediment movement.

3.3 The Particle Tracking Model (PTM)

The PTM is a Lagrangian particle tracker designed to simulate particle transport processes. The PTM has been developed for application to dredging and coastal projects including dredged material dispersion and fate, sediment pathways and fate, and constituent transport. The model contains algorithms that appropriately represent transport, settling, deposition, mixing, and resuspension processes in nearshore wave/current conditions.

PTM requires the input of hydrodynamics (i.e., WSE and velocities, wave data), mesh and bathymetry information, and sediment characterization of both the native or bed sediment and the sediment sources. These sources may initiate from sediment re-suspended during dredging and/or placement. Instead of modeling every grain of sand, silt, and clay, sediment is discretized into *parcels*. Each parcel is representative of a specific mass of sediment. These parcels preserve the overall size distribution and total mass of the sediment source. The model then steps through time, tracking the position of each parcel. The PTM output includes time-accurate horizontal and vertical positions of sediment

parcels. Other attributes such as mass, density, and suspension status are also assigned to each of the output parcels.

For this study, the PTM will be tested for the evaluation of sediment particle transport and sediment dynamics within the nearshore area of the Coos Bay inlet for each of the simulation periods. The PTM-predicted sand transport pathways will be compared to the sediment tracer results. Due to the faster settling rates, coarser material such as sand may travel predominantly along the bed. The PTM includes simplifications in the bottom boundary physics that are required for model efficiency. Often the result is that particles move faster than expected. This limits the quantitative analysis of sand transport due to the frequency of particle bed interactions. The model is best applied to simulate qualitative analysis for sand transport such as sediment pathways. PTM results have less uncertainty in the quantitative evaluation of fine-grained sediment transport. Basic PTM algorithms (MacDonald et al. 2006; Lackey et al. 2016) have recently been enhanced with the capability of sand transport in complex environments of strong wave and current interaction.

PTM transport is in the reference frame of the particle, ultimately solving a classic system of equations:

$$\frac{d\vec{\mathbf{x}}}{dt} = \vec{\mathbf{u}} \tag{1-1}$$

In this system, **x** is the particle position vector x=(x,y,z), and **u** is the flow field velocity vector u=(u,v,w). Numerically this system of equations can be discretely solved as

$$\mathbf{x}^{n+1} = \mathbf{x}^{n} + \Delta t \vec{\mathbf{u}}^{n} \tag{1-2}$$

For sediment transport performed utilizing PTM, the equation becomes more complex:

$$\mathbf{x}^{n+1} = \mathbf{x}^{n} + \Delta t \mathbf{F}^{n} \tag{1-3}$$

where F is a function of the flow field velocity, diffusion, settling, and multiple other sediment transport processes (MacDonald et al. 2006).

Sediments released into the water column during the dredging process are in one of three states: (1) primary particles, (2) bed aggregates, and (3) flocs. Primary particles are individual grains (usually sand or coarse silt) that are not bound with other particles. In this study it was assumed that placed material will be transported as primary particles

As particles move within the water column based on the hydrodynamic forcing around them, they also fall towards the bed at the settling rate of the particles. Heavier particles tend to settle faster.

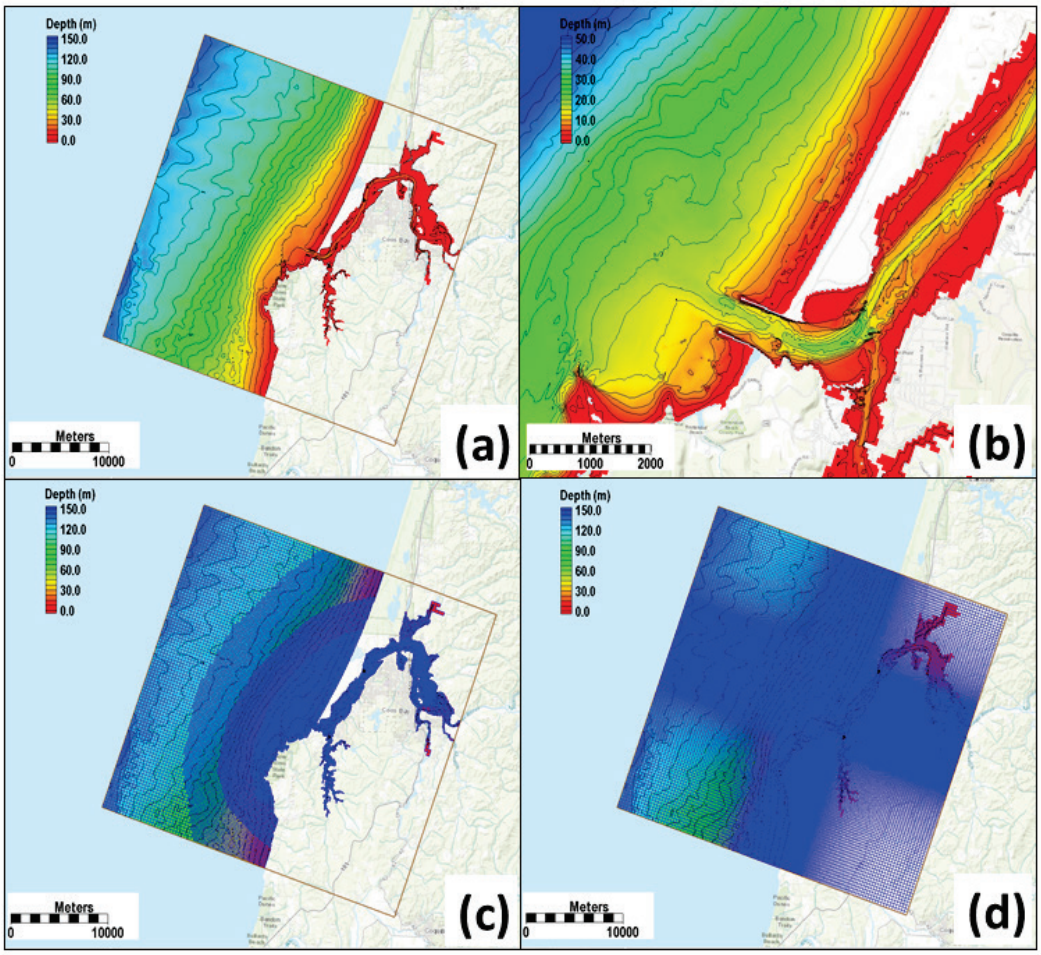
When the particle deposits at the bed, algorithms are applied that determine whether the particle should be resuspended, how high the particle should be entrained within the flow, and at what velocity the particle should move. The PTM uses a predictive algorithm to determine the probability of re-entrainment. However, as mentioned, new methods to determine resuspension height and particle velocity were recently added for strong wave-current interaction environments.

3.4 CMS and PTM Simulations

3.4.1 CMS model setup

A telescoping variable-resolution CMS-Flow grid was developed for the Coos Bay estuarine system (Wu et al. 2011). The areal extent for the modeling domain is approximately 31 km alongshore and 32 km across shore. The CMS domain consists of 132,000 ocean cells, which covers the entire Coos Bay and the open ocean region. The water depth ranges from 1 to 2 m below mean sea level at tidal marsh areas in the bay area to 16 m at the inlet navigation channel and further increases to 130 m at the offshore boundary of the CMS domain. The telescoping grid system permits much finer local grid resolution to resolve hydrodynamic and sediment features in areas of high interest. For this study, the cell sizes vary from 20 m around the Coos Bay Inlet and navigation channel to 320 m in the open ocean. The CMS-Wave grid with varying cell sizes was generated for wave modeling, covering the same domain and with similar spatial resolution as the CMS-Flow grid (Figure 3-15).

Figure 3-15. The CMS domain. (a) Bathymetry for entire CMS grid domain, (b) bathymetry at the inlet entrance channel and the bay, (c) CMS-Flow telescoping grid, and (d) CMS-Wave variable rectangular grid.



CMS-Flow was driven by WSE time-series along the CMS open boundaries. NOAA tide gauge (#9432780) at Charleston, OR, is located on the bayside and provides the tidal forcing for the model (Figure 2-4). The close proximity of the bayside tidal gauge to the open ocean results in minimally filtered water levels that compared well with observations (see the model-data comparison later in Chapter 5). Also, the focus of this modeling effort was on the nearshore adjacent to the tidal inlet, of which the tide is typically very similar in amplitude and phase. As such, the NOAA tide gauge was chosen over other methods (such as regional simulated tides).

Wind speed and direction are available at the Charleston gauge and at the NOAA offshore buoy #46015. Because of the coastal sheltering effect, the coastal gauge shows much weaker wind speeds than the open-ocean measurements. To better reproduce wind-driven current on the ocean

side, the buoy wind data were selected and specified at the air-sea interface (Figure 2-5).

Three NDBC buoys, #46015, #46226, and #46050, measure directional wave spectra. Buoys #46015 and #46226 are located approximately 75 and 50 km from the Coos Bay Inlet, respectively. Buoy #46050 located farther north is 150 km from the study area, but the buoy provides a more complete data record. Through model tests, buoy #46015 was selected to drive CMS-Wave. The wave spectra at the buoy were retrieved at a 2-hour interval and transformed to the model seaward boundary. Data were analyzed for gaps, and large missing sections were filled with spectral wave data downloaded from buoy #46050 (Figure 2-6).

As shown in Figure 2-7 and Figure 3-15, the inland boundary of the CMS domain was not extended upstream to the four river gauging stations. All the river flows measured at those gauges enter the Coos Bay from the downstream location of the South Coos River (the arrow in Figure 2-7). The combined river flow is multiplied by a factor of two because there was indication[1] that the measured flows at four gauges count for 53.84% of the area that drains into Coos Bay.

3.4.2 Simulation periods

Simulations were conducted for a summer month (21 June – 20 July 2014, 30 days), a 7-month (21 October 2013 – 17 June 2014, 240 days), and a 6-month (19 October 2015 – 31 March 2016, 165 days) period. The 6-month simulation period corresponds to the tracer study period.

The monthly simulation corresponds to the latest ADCP survey period by Sutherland and O'Neill (2016). The CMS calibration was performed using the measured WSE and current at the bay location (RM 8.0). From 21 October 2013 to 12 June 2014, the NWP conducted six conditional channel surveys (Figure 2-2). The 7-month simulation covers the duration of all six surveys and was set up to validate the CMS capability in simulating channel depth evolution. Accompanying the sediment tracer release at the nearshore location in ODMDS F was the survey program of hydrodynamic and wave data collection and tracer samplings. The results of the 6-month simulation validate the CMS hydrodynamic and wave calculations against WSE, current, and wave measurements,

[1] Freelin Reasor; Coos Watershed Association; Personal communication; 6 August 2015.

and demonstrate the CMS sediment mapping feature and PTM capability in tracking sand-sized sediment tracer.

3.4.3 PTM model setup

A 2-month PTM simulation was run to track the sediment tracer from the site. The simulation start date and stop date were 19 September 2015 and 23 November 2015, respectively. Hydrodynamic forcing was obtained from the CMS currents and waves described in Chapter 3.

A total of 600 kg of sediment tracer was placed at two locations (Figure 3-16): yellow tracer (DZA) at P1(x,y) = (3901797, 647367) and orange tracer (DZB) at P2(x,y) = (3899351, 643102). The orange tracer was placed on 19 September 2015, and the yellow tracer was placed a day later (on 20 September 2015).

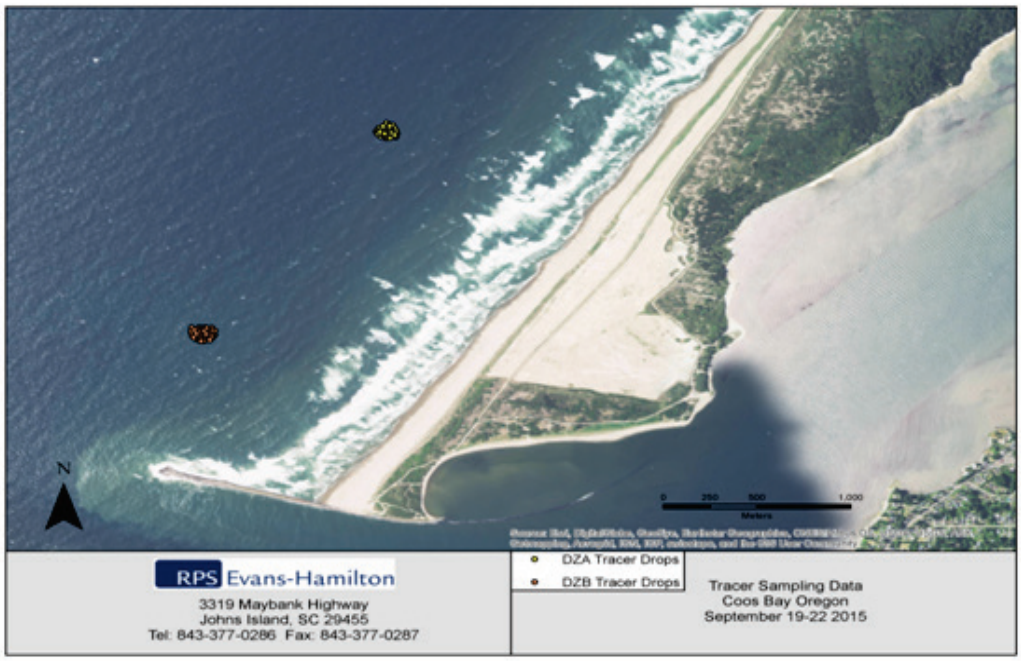
When dredged material is placed, mound dynamics suggest that the material may be impacted by the surrounding material. Because of the complex mound dynamics, sediment may be buried and then eroded from the bed sporadically. A dynamic erosional source term that takes into account mound dynamics is needed to accurately determine the amount of tracer eroding from the bed. Development of such a source term was not within the scope of this work. However, through extensive testing during the calibration process, it was determined that a constant time release source from the bed produced more realistic results than an instantaneous release. Therefore, a mass rate PTM source term was developed that released the total mass of 600 kg over the entire 2-month simulation at a constant rate (Rate = 600 kg/2 months).

Additional parameters were required for computing diffusion and other processes that are required for transport (MacDonald et al. 2006). Table 3-2 lists the values used for the simulation. For this study, the diffusion was turned off (KEW=0), and all the other parameters are the default values specified in MacDonald et al. (2006).

Table 3-2. PTM Computational runtime parameters.

PTM Parameter/Keyword	Value	Description
BED_POROSITY	0.4	Bed porosity
RHOS	2650 kg/m^3	Sediment density
MIN_DEPTH	0.01 m	Minimum cut-off depth refers to the minimum water depth for which a particle will be tracked
TEMPERATURE	15.0 °C	Water temperature
KET	0.25	Horizontal turbulent diffusion scalar
SALINITY	34.0 ppt	Water salinity
KEW	0	Coefficient that relates the diffusion
KEV	0.00859	Vertical turbulent diffusion scalar

Figure 3-16. Initial source locations for PTM simulations.



3.4.4 Sediment characterization

The sediment grainsize description of the PTM source was developed based on the tracer distribution shown in Figure 3-7. Based on this distribution, the D50 of the sediment was 320 μm, and the standard deviation in phi units was 0.55.

4 Field Study Results and Discussion

4.1 Hydrodynamics

4.1.1 Processing and results of stationary, temporal data

Data from the long-term measurement program were reviewed and analyzed using a combination of instrument manufacturer software and in-house analytical programs. Details of the processing approach for each of the sensors are provided below. Note that all times provided are in Greenwich Mean Time (GMT), and directions are referenced to true North.

The current data were extracted from the raw binary files collected by the upward-looking AWAC on the Tripod using Nortek software and then further analyzed and processed using in-house analysis tools. To ensure that the AWAC collected data from the entire water column, the instrument was programmed to collect some bins that would be positioned above the water surface. The instrument would record data for these bins even though they were out of the water, and often these data appear reasonable. To remove the data above the water surface, the spike in the backscatter amplitude was used to determine which bin should be considered the last valid water bin. In addition, the water depth measurements based on the acoustic surface tracking (AST) were used to confirm that the correct cutoff point had been selected.

After the out-of-the water data were removed from the files, the data quality codes reported by the AWAC were used to assess and flag invalid data from the data set. The data quality codes, generated by the Nortek data processing software, indicate potential quality issues with the data, such as a high number of bad surface detections or any wave parameter estimated out of range. As a final step, the data were visually inspected, and any questionable data were flagged and marked as bad in the final data set. Plots of the final current data set for the AWAC are provided in Appendix A, and plots of the ancillary data and data quality parameters from the AWAC are provided in Appendix B.

In addition to the plots, the ancillary data and data quality parameters measured by the AWAC are presented in Appendix B. These datasets include currents, water levels above the instrument location, water temperature, instrument pitch, roll and heading, vertical velocity, and

signal amplitude. The pitch, roll, and heading data indicate that the instrument was stable for the duration of the deployment and experienced very limited settling. The signal amplitude exceeded minimal thresholds for adequate signal strength throughout the deployment with a limited number of spikes in the amplitude. The abnormal signal could be related to fish/seaweed in the water column, interference with line to the surface buoy, or significant bubbles in the water column due to breaking waves.

The wave data were processed using the Nortek Storm software. No issues were encountered processing the nearshore data using standard parameters and settings. There were a few instances of the instrument-reported errors with the wave height calculations using the AST method, such as during the storm event on 14 November 2015.

Appendix C presents plots of the wave time series. The raw data from the RBR pressure-based wave sensor were processed using the RBR Ruskin Software. Plots of the data are shown in Appendix F. The software generates significant wave height as well as maximum wave height. As discussed previously, approximately 30 days of water level data were recovered from the water level sensor. This data were corrected for variations in barometric pressure, and then an offset based on the survey information was applied to the data to adjust it to MLLW. Results of the water level measurements are presented in Appendix I.

4.1.2 Processing and results of spatially variable current data

The current data collected by the downward looking profiling Aquadopp were extracted using the Nortek Storm software. The data underwent further quality analysis and review using in-house software. Spikes in the backscatter signal were used to reduce the downward-looking profile to only water bins. The resulting current magnitude and direction profiles reported by the Aquadopp are shown in Appendix D. As can be seen in Appendix D, the data indicate the bottom elevation under the tripod varied over time. Generally, the depth-averaged magnitude for each profile was less than 0.13 m/sec. However, there were periods when the depth averaged values exceed 0.5 m/sec. The depth-averaged direction varied significantly over the measurement period, though during the times with the higher magnitudes the direction tended to be to the south towards the inlet.

The pitch and roll data from the Aquadopp indicate that the instrument was relatively stable during deployment though the roll was approximately

10 degrees. While it is preferred to have the pitch and roll less than 5 degrees, the instrument can account for higher values in the processing of the data, so the quality of the current measurements was not impacted. The signal amplitude throughout the data set does not indicate any issues with the signal strength or quality.

The data collected during the current survey using the vessel-mounted ADCP were processed using the Teledyne RDI WinRiver software. As part of the processing, the horizontal averaging of the ensembles was set to 2. Some of the transects had extensive data dropouts due to the excessive movement of the vessel and bubbles around the transducer head due to breaking waves. This occurred most frequently on the survey lines near the tips of the jetties during the first day of data collection.

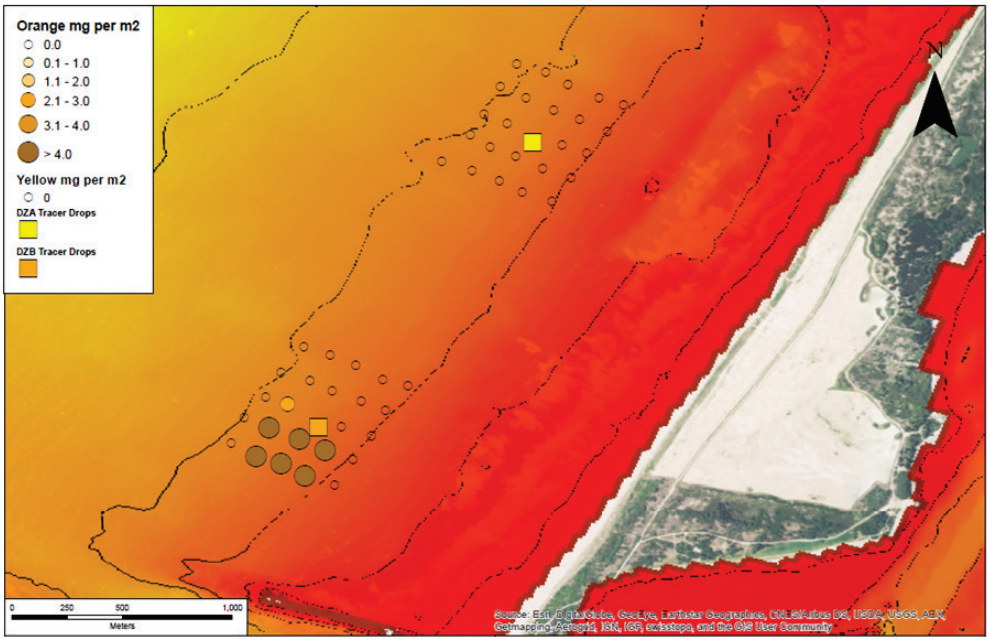
Vector plots of depth-averaged velocity collected during the survey are shown in Appendix H. Transect lines collected within approximately 2 to 3 hours of each other have been plotted together to provide a *snapshot* of hydrodynamic conditions during different phases of the tidal cycle. Vertical contour plots of the data collected on each transect have also been created and are shown in Appendix I. The contour plots have been oriented such that the left-hand side of the plot is the left-hand side of the channel headed out to sea.

4.2 Sediment tracer deployment

4.2.1 Containment grab samples

Figure 4-1 summarizes the tracer results for the Containment grab samples collected at DZ-B and DZ-A, 18–25 hours and 16–21 hours after the orange and yellow tracer releases, respectively. Sea conditions between the orange tracer release and the subsequent sampling were relatively calm compared with sea conditions after the yellow tracer release when swell and wind was building and a little more ground swell was evident. Despite the observed increase in swell conditions, the yellow sand tracer results indicate no transport and deposition outside the tracer deployment zone in any of the 24 grab samples collected.

Figure 4-1. Orange and yellow tracer counts for containment grab samples collected from DZ-B and DZ-A, respectively, on 20 and 21 September 2015. Note that samples indicated that no tracer had migrated outside of the immediate placement zone at DZ-A.

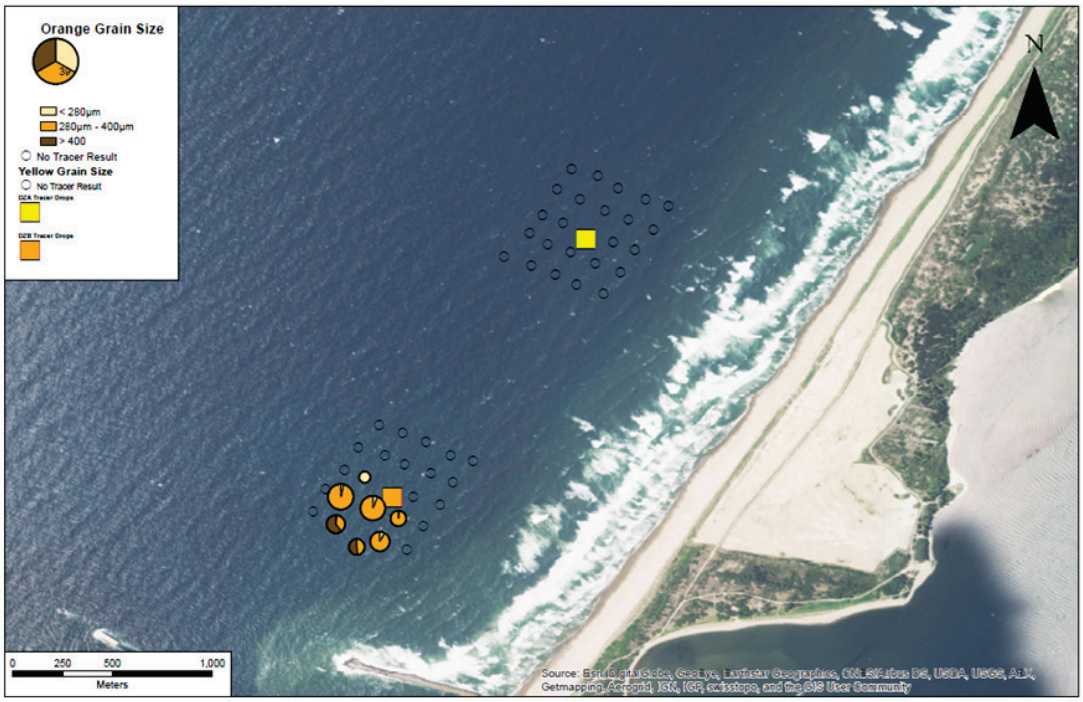


By comparison, despite the calmer conditions the orange sand tracer results indicate initial transport approximately due south, southwest, and west with the highest counts recorded in samples up to 250 m out from the tracer deployment zone, approximately in line with the seaward end of the north jetty. Given the apparent lower wave activity between the orange sand tracer release and the sampling in DZ-B, it is assumed that the bulk of the transport and deposition of orange sand tracer measured in these results was due to near-bed tidal currents in line with observed tidal streams around the seaward end of the north jetty and comments from NWP.

In terms of the tracer particle sizes, coarse tracer particles (>400 µm) were measured in two out of the seven positive (for tracer) samples located in the farthest southwest samples. Medium tracer particles (280–400 µm) were recorded in all of the positive samples in an approximate southwesterly direction from the release site; the only exception was a positive sample approximately west-northwest of the tracer release site, which also had the lowest tracer counts (Figure 4-2). These data suggest that medium and coarse tracer particle sizes were transported and deposited within 24 hours of the tracer release along with fine tracer size fractions. The movement of medium- and coarse-sized fractions was most likely due to erosion and resuspension of the tracer from the seabed as a result of tidal currents rather than as a result of the tracer release itself,

particularly when compared with the yellow sand tracer results, which indicated no dispersal from the tracer release area for any tracer particle size fraction, despite more energetic metocean conditions being observed during that time interval.

Figure 4-2. Orange and yellow tracer particle size results for Containment grab samples collected from DZ-B and DZ-A on 20 and 21 September 2015.



4.2.2 Round 1 grab samples: 20–22 November 2015, 62–64 elapsed days

4.2.2.1 Orange sand tracer

Figure 4-3 and Figure 4-4 summarize the orange sand (DZ-B) tracer counts, expressed as milligram per square meter (mg/m²), and the orange tracer grain size distribution results for the Round 1 grab samples respectively (Table 4-1).

Figure 4-3. Orange tracer (DZ-B) counts for Round 1 grab samples collected on 20-22 November 2015.

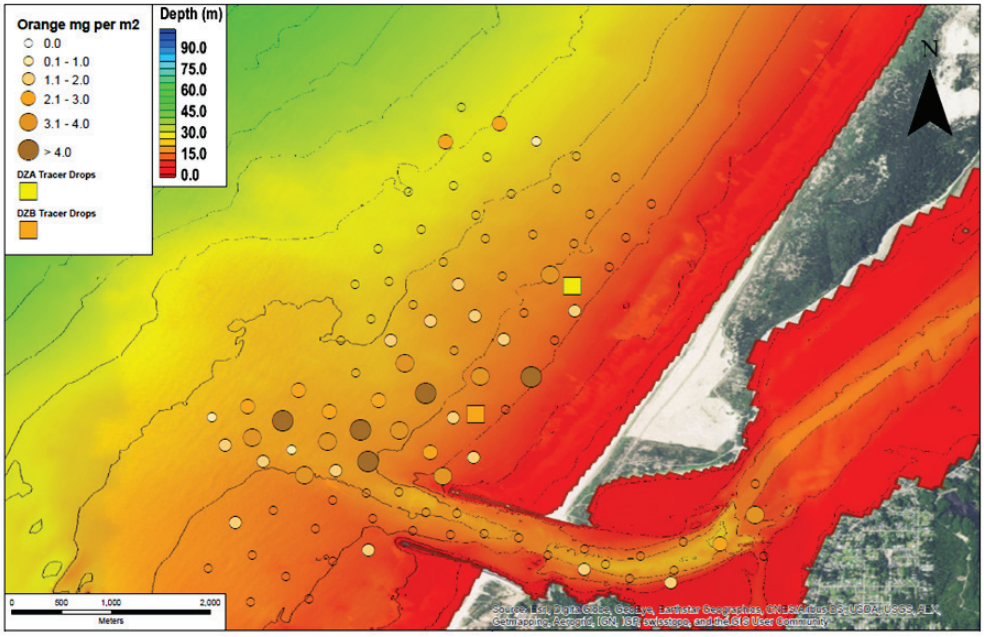


Figure 4-4. Orange tracer (DZ-B) particle size distribution results for Round 1 grab samples collected on 20–22 November 2015.

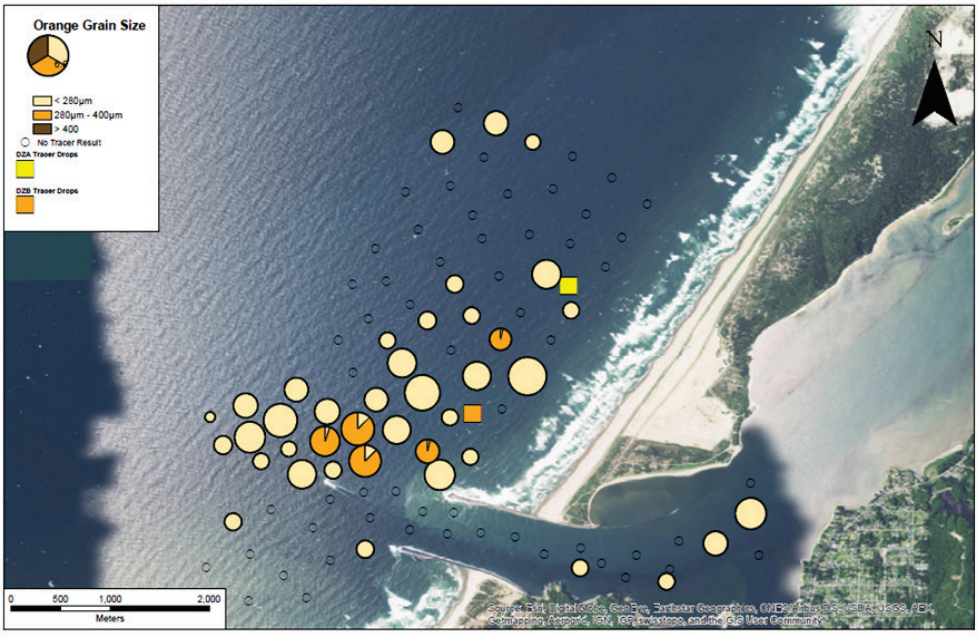


Table 4-1. Coos Bay sediment tracer study Round 1 results of the grain size distribution per sample location.

Client Reference	Total		Small (< 280 µm)		Medium (280 – 400 µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB1R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB2R1A	0.00	2.40	0.00	2.52	0.00	0.00	0.00	0.00
CB3R1	0.00	0.94	0.00	0.98	0.00	0.00	0.00	0.00
CB4R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR5R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB6R1	1.40	0.00	1.46	0.00	0.00	0.00	0.00	0.00
CB11R1A	0.64	0.00	0.67	0.00	0.00	0.00	0.00	0.00
CB10R1	0.79	0.00	0.83	0.00	0.00	0.00	0.00	0.00
CB9R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB8R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB7R1A	0.00	2.25	0.00	2.36	0.00	0.00	0.00	0.00
CB12R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB13R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB14R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB15R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB16R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB17R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB18R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB21R1	4.56	3.38	4.76	3.54	0.00	0.00	0.00	0.00
CB24R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB20R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB19R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB22R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB23R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB28R1	0.00	1.23	0.00	1.29	0.00	0.00	0.00	0.00
CB29R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB25R1A	0.00	1.08	0.00	1.14	0.00	0.00	0.00	0.00
CB79R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB78R1A	0.00	2.39	0.00	2.50	0.00	0.00	0.00	0.00
CB83R1	0.00	3.96	0.00	4.15	0.00	0.00	0.00	0.00
CB84R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB82R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280 – 400 µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB77R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB76R1	0.00	1.11	0.00	1.16	0.00	0.00	0.00	0.00
CB99R1A	1.44	0.00	1.50	0.00	0.00	0.00	0.00	0.00
CB75R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB74R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB98R1	0.00	1.14	0.00	1.19	0.00	0.00	0.00	0.00
CB73R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB72R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB71R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB70R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB69R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB65R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB67R1	1.27	3.78	1.33	3.96	0.00	0.00	0.00	0.00
CB41R1	1.08	1.07	1.13	1.12	0.00	0.00	0.00	0.00
CB35R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB97R1	4.00	5.93	4.18	6.21	0.00	0.00	0.00	0.00
CB30R1	2.03	0.00	1.06	0.00	31.45	0.00	0.00	0.00
CB88R1	0.99	1.95	1.03	1.02	0.00	28.59	0.00	0.00
CB100R1	0.00	1.13	0.00	1.19	0.00	0.00	0.00	0.00
CB36R1	3.26	3.22	3.40	3.37	0.00	0.00	0.00	0.00
CB34R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB33R1	0.00	1.31	0.00	1.37	0.00	0.00	0.00	0.00
CB32R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB27R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB26R1	1.04	0.00	1.09	0.00	0.00	0.00	0.00	0.00
CB31R1	1.18	0.00	1.23	0.00	0.00	0.00	0.00	0.00
CB37R1	0.00	1.08	0.00	1.13	0.00	0.00	0.00	0.00
CB38R1	0.00	3.39	0.00	3.55	0.00	0.00	0.00	0.00
CB39R1	0.87	5.13	0.90	5.37	0.00	0.00	0.00	0.00
CB40R1	2.19	1.08	2.29	1.13	0.00	0.00	0.00	0.00
CB45R1A	2.29	2.27	2.39	1.19	0.00	33.22	0.00	0.00
CB44R1A	2.39	3.15	2.49	3.29	0.00	0.00	0.00	0.00
CB43R1A	0.00	2.27	0.00	2.37	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280 – 400 µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB42R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB49R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB46R1	1.18	2.34	1.24	2.45	0.00	0.00	0.00	0.00
CB47R1	0.87	2.58	0.91	2.70	0.00	0.00	0.00	0.00
CB48R1A	1.82	4.50	1.90	3.77	0.00	26.37	0.00	0.00
CB52R1	1.23	2.43	1.29	2.55	0.00	0.00	0.00	0.00
CB50R1A	0.43	0.42	0.45	0.44	0.00	0.00	0.00	0.00
CB51R1	0.00	1.39	0.00	1.45	0.00	0.00	0.00	0.00
CB53R1	0.00	3.88	0.00	4.06	0.00	0.00	0.00	0.00
CB55R1A	0.92	4.56	0.96	4.78	0.00	0.00	0.00	0.00
CB58R1	1.45	3.58	1.51	2.25	0.00	41.97	0.00	0.00
CB56R1	0.97	0.96	1.02	1.01	0.00	0.00	0.00	0.00
CB54R1	2.12	1.05	2.21	1.10	0.00	0.00	0.00	0.00
CB57R1	0.00	3.27	0.00	3.43	0.00	0.00	0.00	0.00
CB59R1	0.00	1.19	0.00	1.25	0.00	0.00	0.00	0.00
CB61R1	1.68	4.15	1.75	3.47	0.00	24.33	0.00	0.00
CB64R1	4.48	0.00	4.67	0.00	0.00	0.00	0.00	0.00
CB62R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB60R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB63R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB96R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB68R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB95R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB94R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB93R1A	1.21	1.19	1.26	1.25	0.00	0.00	0.00	0.00
CB92R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB91R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB89R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB87R1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB90R1	1.21	0.00	1.27	0.00	0.00	0.00	0.00	0.00
CB86R1A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB85R1A	0.00	1.22	0.00	1.27	0.00	0.00	0.00	0.00

The majority of the positive samples indicated fine tracer particle size (<280 μm) present in all samples confirming that the dominant transport and deposition over the 2-month period was of the smaller-sized fractions of tracer released. The only exceptions with predominantly medium tracer particle sizes present (280 – 400 μm) included one sample to the northeast parallel with the shoreline and four samples clustered around the seaward end of the north jetty, also in similar water depths. The latter four samples appear to define an ebb-tide derived flow out of the entrance channel in line with the remainder of the fine tracer particle size results and bathymetry. The fact that medium-size fractions are present in this transport pattern confirms there is sufficient energy in this area to erode and transport coarser material from the tracer release site over the 2-month period; this is consistent with the Containment sample results with medium and coarse tracer particles transported away from the tracer release area within 24 hours after the tracer releases (Figure 4-1 and Figure 4-2).

The results shown in Figure 4-3 and Figure 4-4 indicate that fine tracer particles were transported into the inner harbor and channel with several relatively high concentrations occurring where the channel starts to widen and become shallower. However, the majority of the samples collected in this area, in particular the entrance channel, which experiences high tidal velocities, indicate no tracer particles were measured. Similarly, the bay south of the channel and the south jetty had only two positive samples with relatively low counts indicating limited transport and deposition occurred within this area.

The vast majority of the positive counts, comprising mainly fine tracer particles, and a few medium particles, were collected in an area seaward and north of the entrance channel approximately southwest, west and northwest of the tracer release area. The distribution of these particles suggests and also defines an ebb-tide transport process deflected offshore to the northwest due to ambient coastal currents and Coriolis force (in the northern hemisphere) as it emerges from the channel into the Pacific Ocean once it is beyond the constraints of the north and south jetty. This pattern of sand tracer deposition effectively demonstrates the formation and dynamics of an ebb shoal evident from the bathymetry contours (Figure 4-3 and Figure 4-4). The combination of the results for the Containment samples with strong movement towards the north jetty primarily driven by tidal currents, followed by strong ebb tide flow offshore that is deflected to the right heading north indicates and describes a circular transport pathway

and process. The pattern of deposition of orange sand tracer particles confirms this transport process and pathway in addition to the tracer particle sizes measured and the distribution of tracer counts. It is proposed that the orange sand tracer particles that are transported offshore during ebb-flow are then transported back onshore as the effects of northerly longshore transport interacts with the ebb-tide flow. This process could possibly explain the presence of fine orange tracer particles to the north of the tracer release site including at the northerly extent of the Round 1 sampling area. It is also possible that during periods of flood tide conditions and/or high wave energy when the ebb-tide flow exiting the channel is less dominant, that orange sand tracer is also transported directly up the coast alongshore, explaining the presence and relatively high orange tracer concentrations towards DZ-A, the yellow sand tracer release site.

The data clearly show and confirm that the area of ODMDS F-NS around tracer release site DZ-B is a very dynamic site with sand tracer and natural sand/dredged material likely to return to the channel and enter the inner bay during flood tide conditions. In addition, material is also transported seaward into deeper water as a function of the ebb-tide conditions followed by a combination of cross-shore and longshore transport towards the north-east and east through net wave-driven transport.

4.2.2.2 Yellow sand tracer

Figure 4-5 and Figure 4-6 summarize the yellow sand tracer (DZ-A) counts, expressed as milligram per square meter (mg/m^2), and the tracer grain size distribution results for the Round 1 grab samples, respectively.

Figure 4-5. Yellow tracer (DZ-A) counts for Round 1 grab samples collected on 20-22 November 2015.

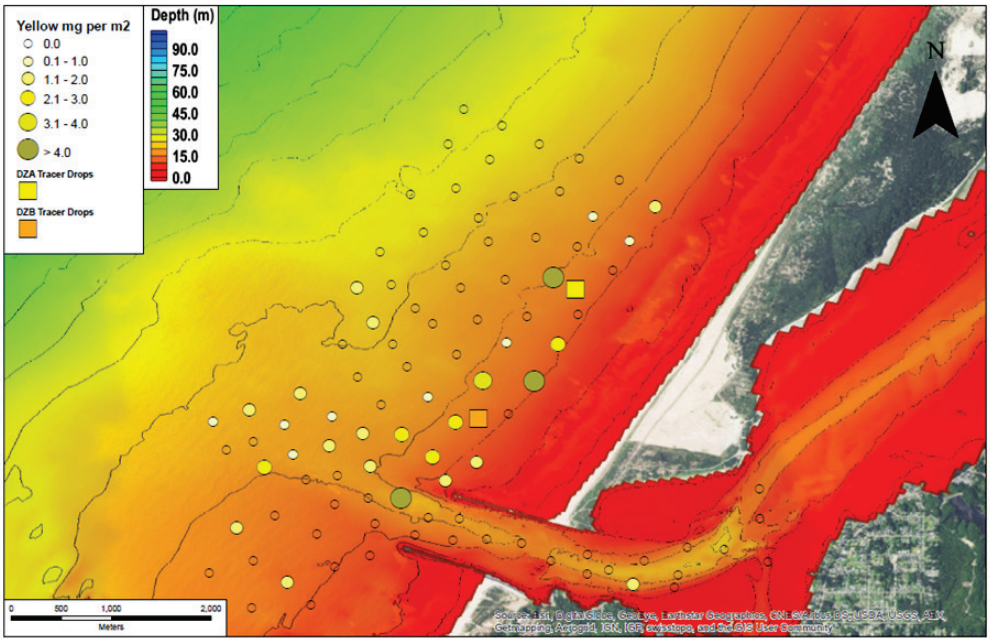
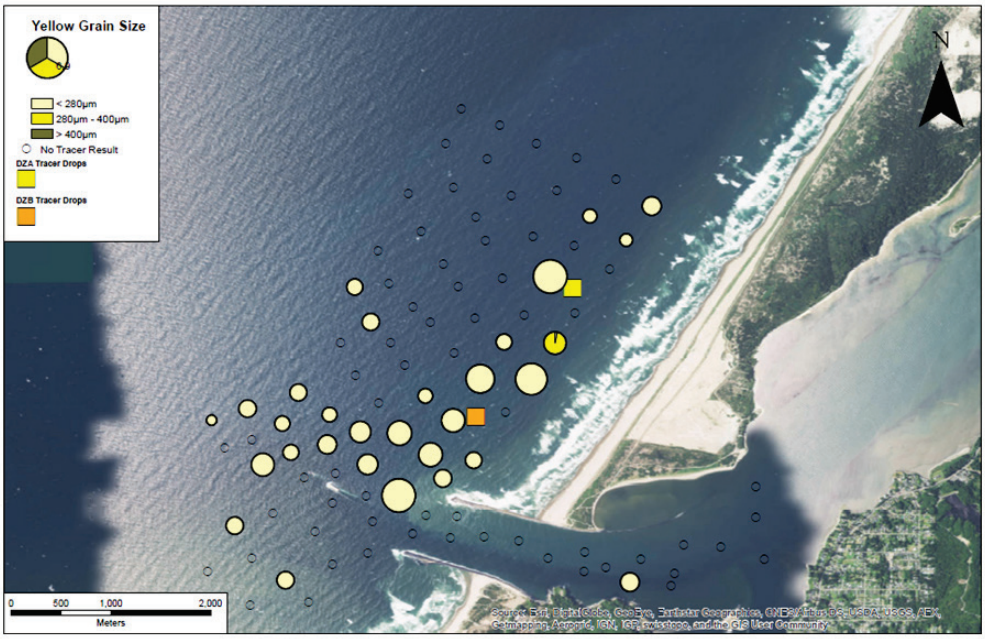


Figure 4-6. Yellow tracer (DZ-A) particle size distribution results for Round 1 grab samples collected on 20–22 November 2015.



The notable difference between the yellow sand tracer results, compared with the orange sand tracer results, is that only one positive sample contained medium-sized tracer particles located approximately 500 m south of the tracer release site, DZ-A. The remainder of the positive samples throughout the sampling area were comprised of fine-sized tracer

particles equivalent to >125–280 μm in size. This suggests that the metocean conditions (i.e., the combined tidal and wave energy) over the 2-month period between the yellow sand tracer release and the Round 1 sampling were weaker or less energetic, erosive, and dispersive than the area around the orange sand tracer release site (DZ-B). The fact that DZ-A appears to be a less dynamic site, compared with DZ-B, was also borne out by the Containment sample results, which showed no yellow sand tracer transported away from the tracer release site DZ-A within 24 hours of the release versus DZ-B, which showed rapid erosion and transport of fine, medium, and coarse tracer particles over the same period.

Overall, the results for Round 1 define a relatively similar pattern to the orange sand tracer results with a few small variations. Only one positive sample was measured inside of the entrance channel in the inner bay compared with four positive samples for the orange tracer with higher concentrations, also suggesting limited transport and deposition of the yellow sand tracer. Yellow sand tracer particles were also found in the area south of the channel similar to the orange sand tracer results.

As with the orange sand tracer results, the yellow sand tracer results describe and define a similar pattern in terms of transport pathways and deposition. The yellow sand tracer results indicate material deposited from the vicinity of the north jetty, effectively passing through the DZ-B placement zone, and farther offshore into deeper water in line with an ebb-tidal flow leading to deposition of yellow sand tracer throughout this ebb shoal feature and area, albeit at lower concentrations compared with the orange tracer results. These data further suggest that less of the yellow sand tracer was eroded and dispersed compared with the orange sand tracer results.

In addition to the above, there are isolated positive counts parallel to the coast from DZ-A towards the northeast and due west in deeper water that may be associated with return transport of material moved offshore as per the orange sand tracer results. Notably, no yellow sand tracer particles were recorded to the north and northwest of DZ-A in contrast to the orange sand tracer results. This further suggests that the yellow sand tracer was released in a location that was less energetic for this 2-month study period, compared with DZ-B, and therefore the yellow sand tracer was not eroded or dispersed as far as the orange sand tracer.

4.2.3 Round 2 grab samples: 12–18 March 2016, 175–181 elapsed days

4.2.3.1 Orange sand tracer

Figure 4-7 and Figure 4-8 summarize the orange sand tracer (DZ-B) counts, expressed as milligram per square meter (mg/m²), and the orange tracer grain size distribution results for the Round 2 grab samples respectively. The data are also provided in Table 4-2.

Figure 4-7. Orange tracer (DZ-B) counts for Round 2 grab samples collected on 12-18 March 2016.

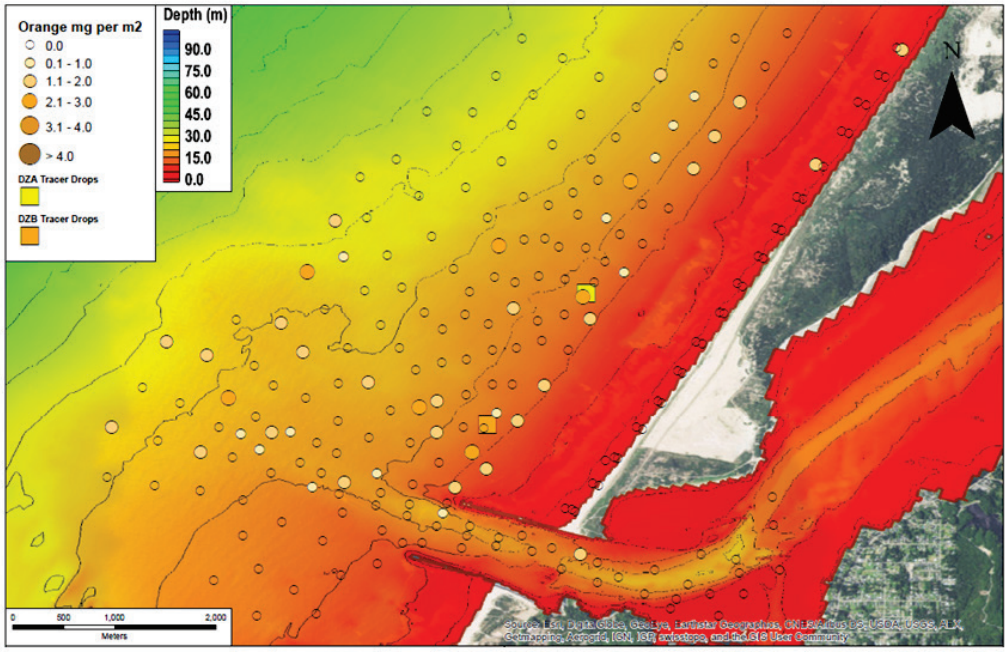


Figure 4-8. Orange tracer (DZ-B) particle size distribution results for Round 2 grab samples collected on 12–18 March 2016.

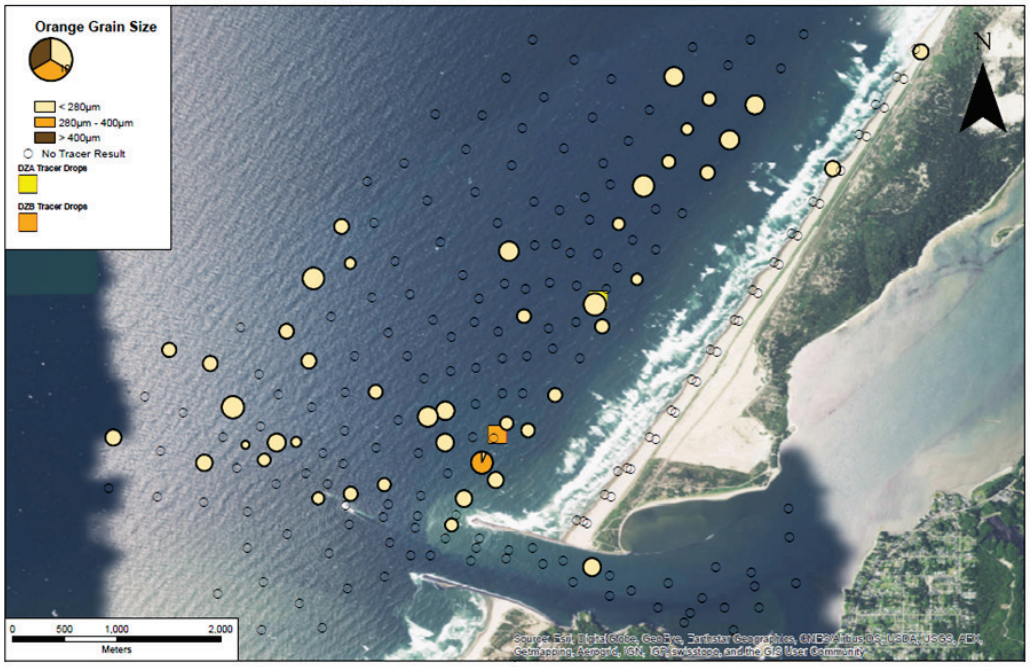


Table 4-2. Coos Bay sediment tracer study Round 2 results of the grain size distribution per sample location.

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 001	1.15	0.00	0.00	0.00	35.51	0.00	0.00	0.00
CB 002	0.00	2.48	0.00	2.59	0.00	0.00	0.00	0.00
CB 003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 004	2.58	0.00	1.80	0.00	26.61	0.00	0.00	0.00
CB 005	1.49	1.48	1.56	1.54	0.00	0.00	0.00	0.00
CB 006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 007	0.45	0.00	0.47	0.00	0.00	0.00	0.00	0.00
CB 008	0.69	0.00	0.72	0.00	0.00	0.00	0.00	0.00
CB 009	2.88	0.00	3.01	0.00	0.00	0.00	0.00	0.00
CB 010	1.64	0.00	1.71	0.00	0.00	0.00	0.00	0.00
CB 011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 012	5.38	0.00	3.74	0.00	55.41	0.00	0.00	0.00
CB 013	2.18	0.00	2.28	0.00	0.00	0.00	0.00	0.00
CB 014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 016	1.81	0.00	1.89	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 019	3.30	0.00	3.44	0.00	0.00	0.00	0.00	0.00
CB 020	2.80	0.00	2.93	0.00	0.00	0.00	0.00	0.00
CB 021	2.83	0.00	2.95	0.00	0.00	0.00	0.00	0.00
CB 022	2.10	0.00	2.20	0.00	0.00	0.00	0.00	0.00
CB 023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 024	3.27	1.08	2.84	1.13	16.83	0.00	0.00	0.00
CB 025	1.06	0.00	1.10	0.00	0.00	0.00	0.00	0.00
CB 026	0.00	0.78	0.00	0.81	0.00	0.00	0.00	0.00
CB 027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 028	0.00	1.38	0.00	1.44	0.00	0.00	0.00	0.00
CB 029	1.04	1.02	0.00	1.07	32.01	0.00	0.00	0.00
CB 030	0.00	1.06	0.00	1.11	0.00	0.00	0.00	0.00
CB 031	2.18	1.08	2.28	1.13	0.00	0.00	0.00	0.00
CB 032	0.69	0.68	0.72	0.72	0.00	0.00	0.00	0.00
CB 033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 034	0.00	0.79	0.00	0.83	0.00	0.00	0.00	0.00
CB 035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 038	0.47	0.00	0.49	0.00	0.00	0.00	0.00	0.00
CB 039	0.96	0.00	1.00	0.00	0.00	0.00	0.00	0.00
CB 040	0.92	1.83	0.97	1.91	0.00	0.00	0.00	0.00
CB 041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 044	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 045	1.10	0.00	1.14	0.00	0.00	0.00	0.00	0.00
CB 046	1.04	2.06	1.09	2.16	0.00	0.00	0.00	0.00
CB 047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 049	0.41	0.00	0.43	0.00	0.00	0.00	0.00	0.00
CB 050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 052	1.11	0.00	1.16	0.00	0.00	0.00	0.00	0.00
CB 053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 054	1.65	0.00	1.72	0.00	0.00	0.00	0.00	0.00
CB 055	1.24	0.00	1.30	0.00	0.00	0.00	0.00	0.00
CB 056	1.08	1.07	1.13	1.12	0.00	0.00	0.00	0.00
CB 057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 058	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 059	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 061	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 062	1.74	0.00	1.81	0.00	0.00	0.00	0.00	0.00
CB 063	0.96	0.00	1.00	0.00	0.00	0.00	0.00	0.00
CB 064	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 065	0.58	0.00	0.61	0.00	0.00	0.00	0.00	0.00
CB 066	0.00	0.89	0.00	0.93	0.00	0.00	0.00	0.00
CB 067	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 069	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 071	0.69	0.00	0.72	0.00	0.00	0.00	0.00	0.00
CB 072	1.28	0.00	1.34	0.00	0.00	0.00	0.00	0.00
CB 073	3.66	0.00	3.82	0.00	0.00	0.00	0.00	0.00
CB 074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 075	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 077	0.00	0.53	0.00	0.56	0.00	0.00	0.00	0.00
CB 078	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 079	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 082	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 083	1.03	0.00	1.07	0.00	0.00	0.00	0.00	0.00
CB 084	0.92	0.00	0.96	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 085	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 086	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 087	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 088	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 089	0.85	0.00	0.89	0.00	0.00	0.00	0.00	0.00
CB 090	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 091	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 092	0.55	0.00	0.57	0.00	0.00	0.00	0.00	0.00
CB 093	1.34	0.00	1.40	0.00	0.00	0.00	0.00	0.00
CB 094	1.12	0.00	1.17	0.00	0.00	0.00	0.00	0.00
CB 095	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 096	0.68	0.00	0.71	0.00	0.00	0.00	0.00	0.00
CB 097	0.00	0.93	0.00	0.97	0.00	0.00	0.00	0.00
CB 098	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 099	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 103	0.00	1.24	0.00	1.30	0.00	0.00	0.00	0.00
CB 104	0.00	1.42	0.00	1.48	0.00	0.00	0.00	0.00
CB 105	1.27	0.00	1.33	0.00	0.00	0.00	0.00	0.00
CB 106	3.72	1.23	3.89	1.28	0.00	0.00	0.00	0.00
CB 107	0.00	1.17	0.00	1.22	0.00	0.00	0.00	0.00
CB 108	1.38	0.00	1.45	0.00	0.00	0.00	0.00	0.00
CB 109	1.30	2.56	1.35	2.68	0.00	0.00	0.00	0.00
CB 110	0.00	0.67	0.00	0.71	0.00	0.00	0.00	0.00
CB 111	0.00	1.19	0.00	1.25	0.00	0.00	0.00	0.00
CB 112	1.30	0.00	1.35	0.00	0.00	0.00	0.00	0.00
CB 113	2.08	0.00	2.18	0.00	0.00	0.00	0.00	0.00
CB 114	1.24	0.00	1.30	0.00	0.00	0.00	0.00	0.00
CB 115	2.02	0.00	2.11	0.00	0.00	0.00	0.00	0.00
CB 116	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 117	1.49	1.47	1.56	1.54	0.00	0.00	0.00	0.00
CB 118	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 119	2.04	0.00	2.13	0.00	0.00	0.00	0.00	0.00
CB 120	1.27	0.00	1.33	0.00	0.00	0.00	0.00	0.00
CB 121	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 122	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 124	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 126	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 127	0.00	2.56	0.00	1.78	0.00	24.99	0.00	0.00
CB 128	1.73	1.71	0.90	1.79	26.76	0.00	0.00	0.00
CB 129	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 131	0.00	1.01	0.00	1.06	0.00	0.00	0.00	0.00
CB 132	2.01	0.00	2.10	0.00	0.00	0.00	0.00	0.00
CB 133	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 135	0.76	0.00	0.79	0.00	0.00	0.00	0.00	0.00
CB 136	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 137	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 138	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 139	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 140	1.12	0.00	1.17	0.00	0.00	0.00	0.00	0.00
CB 141	1.10	2.18	1.15	2.28	0.00	0.00	0.00	0.00
CB 142	4.54	1.12	4.75	1.18	0.00	0.00	0.00	0.00
CB 143	2.01	1.98	2.10	2.08	0.00	0.00	0.00	0.00
CB 144	0.97	0.96	1.01	1.01	0.00	0.00	0.00	0.00
CB 145	0.72	0.72	0.76	0.75	0.00	0.00	0.00	0.00
CB 146	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 147	0.67	0.00	0.70	0.00	0.00	0.00	0.00	0.00
CB 148	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 149	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 151	0.92	0.91	0.96	0.95	0.00	0.00	0.00	0.00
CB 152	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
CB 153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 154	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 155	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 156	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 157	0.00	1.76	0.00	1.84	0.00	0.00	0.00	0.00
CB 158	1.74	1.72	1.82	1.80	0.00	0.00	0.00	0.00
CB 159	0.36	0.35	0.37	0.37	0.00	0.00	0.00	0.00
CB 160	3.03	2.00	3.17	2.09	0.00	0.00	0.00	0.00
CB 161	0.94	0.00	0.99	0.00	0.00	0.00	0.00	0.00
CB 162	0.00	0.98	0.00	1.02	0.00	0.00	0.00	0.00
CB 163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 164	0.00	2.00	0.00	2.09	0.00	0.00	0.00	0.00
CB 165	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 166	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 168	0.58	0.00	0.60	0.00	0.00	0.00	0.00	0.00
CB 169	0.00	1.09	0.00	1.14	0.00	0.00	0.00	0.00
CB 170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 171	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 172	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 173	1.46	0.00	1.52	0.00	0.00	0.00	0.00	0.00
CB 174	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 176	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 177	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 178	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 179	1.80	2.68	1.88	2.80	0.00	0.00	0.00	0.00
CB 180	0.98	0.97	1.03	1.02	0.00	0.00	0.00	0.00
CB 181	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 182	1.35	2.67	1.41	2.80	0.00	0.00	0.00	0.00
CB 183	1.07	0.00	1.12	0.00	0.00	0.00	0.00	0.00
CB 184	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 185	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 186	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
NS 001 L	11.87	0.00	10.63	0.00	52.45	0.00	0.00	0.00
NS 001 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 002 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 002 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 003 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 003 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 004 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 004 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 005 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 005 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 006 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 006 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 007 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 007 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 008 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 008 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 009 L	1.73	0.00	0.00	0.00	0.00	0.00	168.60	0.00
NS 009 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 010 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 010 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 011 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 011 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 012 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 012 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 013 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 013 U	0.00	1.26	0.00	1.32	0.00	0.00	0.00	0.00
NS 014 L	1.26	0.00	1.31	0.00	0.00	0.00	0.00	0.00
NS 014 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 015 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 015 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 016 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 016 U	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS 017 L	10.89	0.00	11.37	0.00	0.00	0.00	0.00	0.00
NS 017 U	10.12	1.25	10.57	1.31	0.00	0.00	0.00	0.00

Client Reference	Total		Small (< 280 µm)		Medium (280-400µm)		Large (> 400 µm)	
	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²	Calculated Yellow mg/m²	Calculated Orange mg/m²
AX 001 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AX 002 L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 003 A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 006 A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB 009 A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 3-10 indicates the additional areas sampled for Round 2 over and above the areal extent of Round 1 including the beach north of the north jetty, farther offshore adjacent to the entrance channel and to the north into deeper water. In addition, extra samples were collected inside the entrance channel, in the channel itself, and within ODMDS F-NS to provide greater detail and definition.

In total, 43 of the 189 grab samples and 2 of the 36 beach samples contained orange sand tracer particles; only 1 grab sample contained medium-sized tracer particles, with the remainder containing fine-sized tracer particles equivalent to 125–280 µm in size.

The orange sand tracer results for Round 2 indicate fewer positive tracer samples with lower concentrations recorded inside the entrance channel as well as farther inshore into the inner channel compared with the Round 1 data. Similarly, south of the south jetty and the channel, no positive counts were recorded in any of the samples.

As per the Round 1 results, fine-sized tracer particles were deposited between DZ-B and the north jetty and out into much deeper water, with deposition extending beyond the westerly limits of Round 1. These results, once again, demonstrate and define an ebb-tidal transport process with positive samples collected in an approximately 30 m water depth and possibly farther offshore, with some relatively high counts measured in the inlet ebb shoal area. Similar to the Round 1 results, there also appears to be transport and deposition towards the north possibly due to the Coriolis force as well as regional shelf currents deflecting any tracer particles towards the north, and potentially back inshore (or cross-shore). The only medium-sized tracer particles detected in Round 2 were collected in a sample immediately south of the orange tracer release site at DZ-B.

Notably, a significant number of samples collected north of DZ-B, including within deeper water, indicated no orange tracer deposited in the area including in deeper water. However, along the shoreline towards the northeastern extremity of the sampling area, including in a few isolated locations on the beach itself, fine-sized orange tracer particles were sampled indicating that longshore transport, rather than cross-shore transport, was dominant during the period between Round 1 and Round 2. The remainder of the beach samples collected north of the north jetty indicated that no orange sand tracer was measured, even adjacent to DZ-B, suggesting little cross-shore transport during the winter 2015–2016 period; this is consistent with the fact that beaches tend to erode rather than build during the winter months.

4.2.3.2 Yellow sand tracer

Figure 4-9 and Figure 4-10 summarize the yellow sand tracer (DZ-A) counts, expressed as milligram per square meter (mg/m^2), and the yellow tracer grain size distribution results for the Round 2 grab samples, respectively (see also Table 4-2).

Figure 4-9. Yellow tracer (DZ-A) counts for Round 2 grab samples collected on 12-18 March 2016.

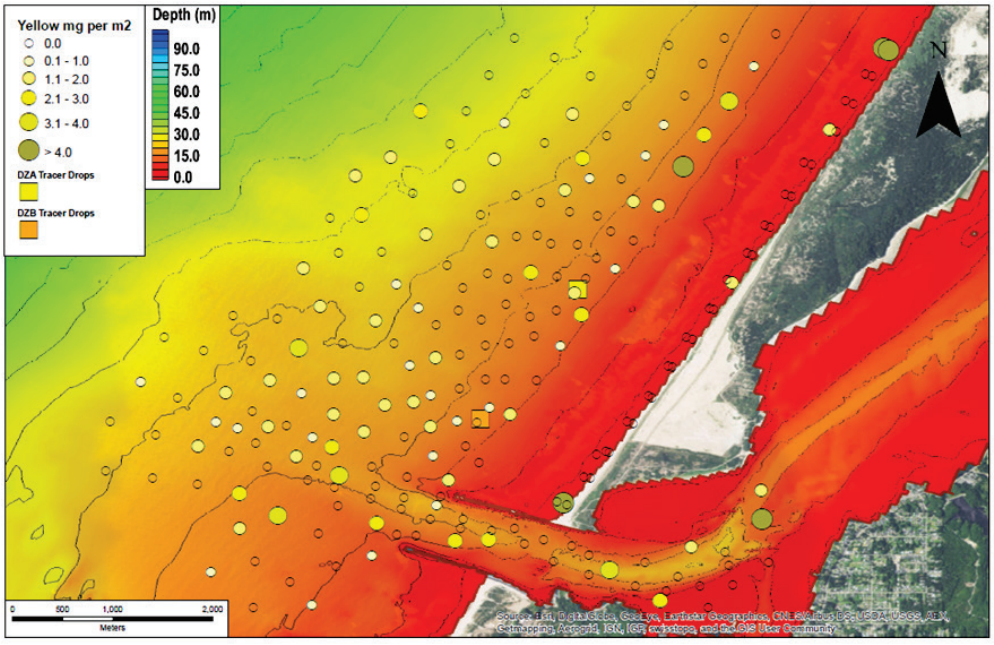
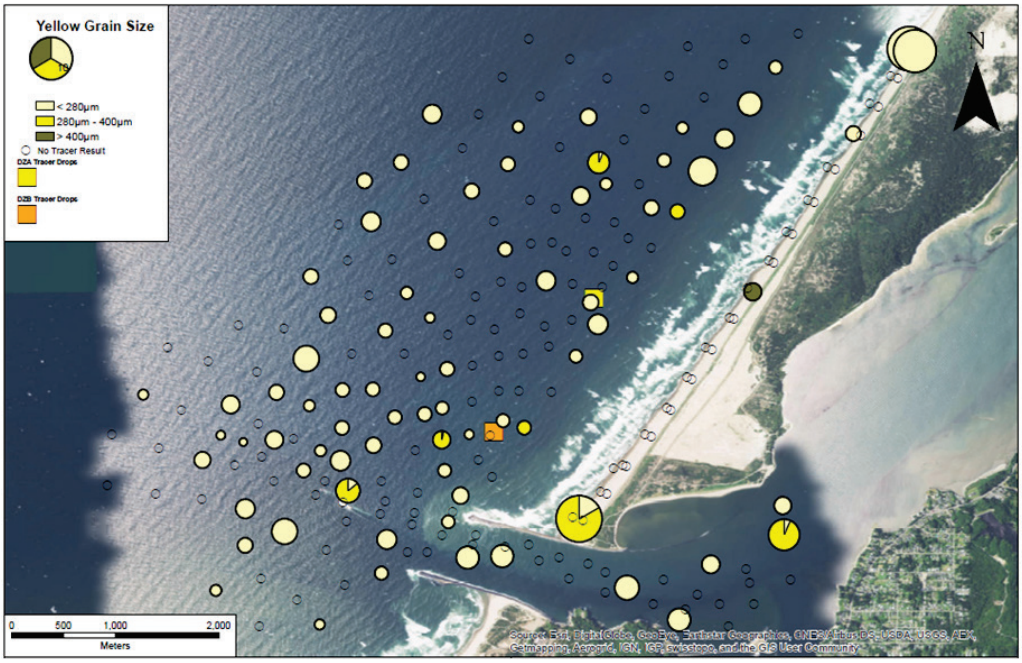


Figure 4-10. Yellow tracer (DZ-A) particle size distribution results for Round 2 grab samples collected on 12–18 March 2016.



As described in the orange sand tracer section above, the sampling area and spatial distribution increased for Round 2 sampling, including the beach north of the north jetty, compared with Round 1.

By comparison with the orange tracer results for Round 2, significantly more positive samples were measured in Round 2 for the yellow sand tracer with 74 positive grab samples (out of 225 grab samples) and 5 positive beach samples being collected, equivalent to almost double the amount of positive orange sand tracer samples. Positive samples were collected throughout the sampling area including areas where no orange sand tracer particles were measured. In addition, in contrast with the orange sand tracer results, medium-sized tracer particles were measured in several locations, with regards to DZ-A, including the following:

- alongshore to the north and due north in deeper water
- the dry beach immediately north of the north jetty in high concentrations
- around DZ-B and offshore in deeper water as part of the ebb-tidal transport pathway
- inside the bay at one of the most upstream sampling points in the inner channel, in relatively high concentrations.

Coarse-sized sand tracer particles were also measured immediately inshore of DZ-A deposited on the beach. The presence of medium and coarse-sized yellow sand tracer particles deposited on the beach is in contrast with the orange sand tracer results, which showed no cross-shore transport onto the beach from DZ-B for the same period.

The high number of positive samples, distributed throughout the sampling area including areas where no orange sand tracer was measured in Round 2 and the fact that medium- and coarse-sized tracer particles were recorded some distance from DZ-A, indicate that the yellow tracer release site was exposed to high-energy events between mid-November 2015 (Round 1) and mid-March 2016 (Round 2). This increased energy, most likely due to increased wave activity, led to increased transport and wider deposition of the yellow sand tracer. The results suggest that DZ-B experiences different energy and transport processes than DZ-A, and as a result, had varying transport pathways for sand movement.

It is hypothesized that sediment transport processes and transport pathways are controlled by a combination of strong tidal currents near the north jetty and wave energy at DZ-B, with perhaps some wave energy reduced at DZ-B due to the slightly shallower depth adjacent and offshore of DZ-B associated with an ebb shoal. Conversely, at DZ-A, the tidal currents and tidally driven transport appears to be slightly weaker than at DZ-B. However, the area appears to be subjected to greater wave energy (owing to its distance from the shallow ebb shoal) leading to greater energy, erosion, and transport of fine, medium, and coarse sand tracer fractions than at DZ-B.

Several positive samples, including relatively high concentrations of the yellow sand tracer, were measured inside the entrance channel. Yellow sand tracer particles were also measured in several samples on the south side of the south jetty in the bay, though the tracer counts were relatively low.

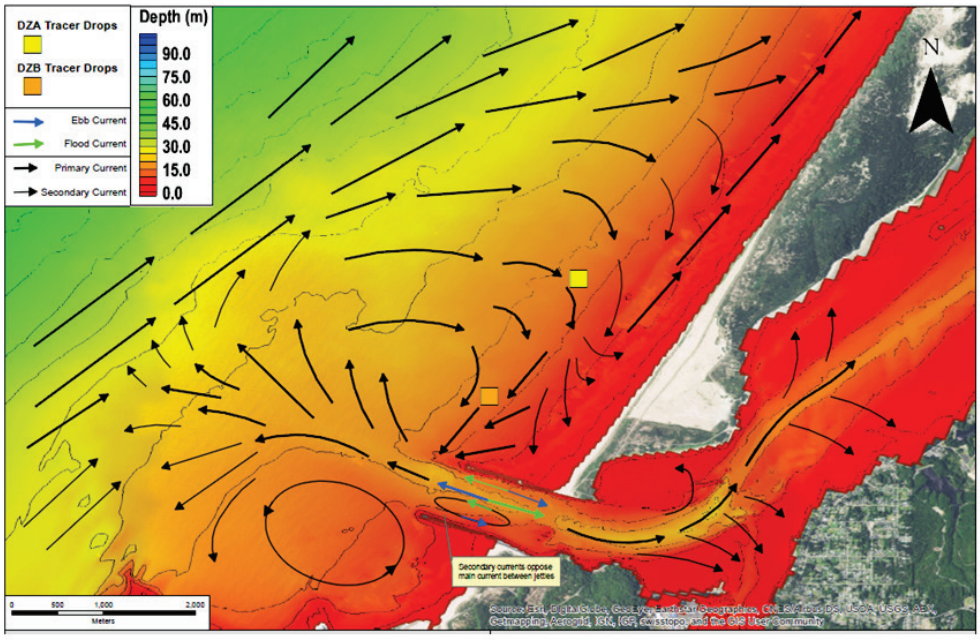
The bulk of the positive yellow tracer samples was identified around DZ-B (orange tracer release site), seaward of the south and north jetty in deeper water and in the vicinity of the ebb shoal with tracer particles detected out to approximately the 30 m contour. Yellow tracer particles were also measured in deeper water towards the northeast of the ebb shoal parallel to the shore. It is unclear whether transport across the ebb shoal and offshore areas was the result of longshore or cross-shore transport from

the tracer release site. The pattern of deposition of orange and yellow sand tracer moving northeast and back into shallower water in the Round 1 and Round 2 data may indicate that the fine-sized yellow sand tracer was transported northeast from the ebb shoal area. However, high-energy winter conditions and the distribution of yellow sand tracer deposited cross-shore from DZ-A in an offshore direction would also tend to suggest the yellow tracer measured in deeper water was a result of these transport processes and pathways. Cross-shore transport was also evident from yellow tracer being detected on the beach north of the north jetty and in deeper water north and northeast of DZ-A. It is therefore likely that the presence of yellow tracer particles in deeper water along the western edge of the sampling area from the ebb shoal towards the northeast may be due to a combination of both transport processes.

4.2.4 Sediment transport vectors

Figure 4-11 summarizes the inferred sediment transport vectors based on the combined sediment tracer results for the Containment, Round 1, and Round 2 sampling rounds for both orange and yellow tracer particles. The figure shows primary or dominant transport vectors denoted by bolder arrows and secondary or less dominant transport vectors shown as less bold arrows.

Figure 4-11. Proposed sediment transport pathways based on tracer observations from September 2015–March 2016. The inferred pathways are based on tracer results and known coastal inlet and nearshore processes. Tidal currents within the entrance channel are outlined in blue and green, representing ebb and flood currents, respectively; general sediment pathways are given in black with dominant pathways emboldened.



The dominant transport feature in the study area is the tidal exchange and associated strong flood and ebb tidal currents that flow in and out of the entrance channel. The influence of the flood tidal currents and associated sand transport extends well into the inner bay area confirmed by the deposition of yellow and orange sand tracer in the inner channel and surrounding areas. The influence of the ebb tide extends far beyond the entrance channel into deeper water (at least as far as the 30 m water depth) with a very clear ebb shoal defined by the pattern of deposition of both orange and yellow sand tracers throughout this area. It is proposed that given the volume and speed of the ebb tide flow in particular, once it is no longer constrained by the north and south jetty, the water mass will be deflected to the right (north) by Coriolis forces in the northern hemisphere. During the peak ebb and flood tide, there are likely reverse flows creating null zones and resulting in sediment settlement in the main channel, as indicated by yellow and orange tracer.

In terms of the overall extent of the study area, the ebb tidal flow loses momentum as it emerges into the deeper coastal water where it is influenced by the main ocean mass and net longshore transport towards the north. The headland to the south of Coos Bay (Cape Arago) and the ebb shoal tends to deflect or divert the net northward flow creating a less dynamic area immediately south of south jetty in the lee of the northward longshore transport; this is highlighted by limited deposition of orange and yellow tracer particles in this area. As the influence of the headland and ebb shoal on the net longshore transport vectors reduces transport towards the north, it is inferred that the sediment transport vectors veer towards the coast. As a result, any orange or yellow sand tracer particles that were advected into deeper water are transported northeast and slightly shoreward as a result of wave-driven and longshore transport processes with particles returning into shallower water. This combination of processes and transport vectors tends to suggest and describe an almost cyclical movement of sediment from the entrance channel. Moving out into deeper water and veering to the north due to Coriolis forces, the sediment moves back into the shallow water towards the northeast due to the ebb shoal formation and longshore transport, which explains the transport and deposition of orange and yellow tracer in the northern sections of the Round 1 and Round 2 sample areas.

In terms of the ODMDS F-NS, and specifically sand placed at DZ-B and DZ-A, the sediment tracer results tend to indicate strong movement of

material from DZ-B towards the end of the north jetty but less dominant from DZ-A due to its position relative to the entrance and the forcing conditions in the region. The sand tracer results indicate rapid transport, certainly from DZ-B Containment samples, with material almost *drawn in* and transported in this direction as a result of the strong ebb tide flow. To counter this, it is inferred that a return flow heading north along the shoreline from the north jetty exists leading to transport alongshore to the north as observed from the tracer results with orange and yellow sand tracer transported up the coast and with some deposition on the beach itself.

Finally, based on the combined sand tracer results, material placed at DZ-B (orange tracer) is more influenced by the ebb and flood tidal currents associated with the entrance channel, compared with DZ-A, with the Round 2 orange tracer results suggesting a degree of sheltering and less dispersion and transport compared with the yellow sand tracer data. It is possible that DZ-B is partially sheltered by the ebb shoal and Cape Arago from large, long-period swell waves. Conversely, the results from Round 2 for DZ-A (yellow tracer) suggest greater dispersion and transport over a wider area, possibly because it is a more dynamic site and exposed to large, long-period swell waves.

5 Numerical Modeling Results and Discussion

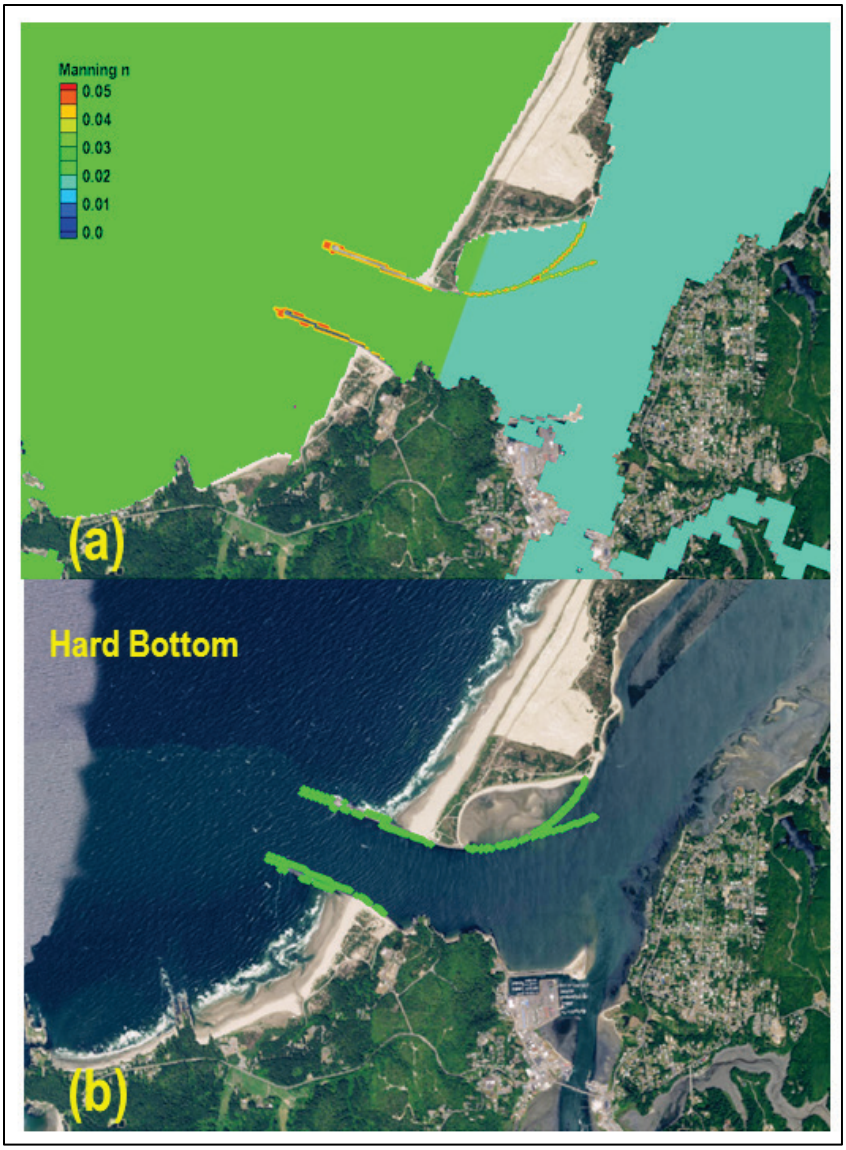
5.1 CMS calibration and validation

5.1.1 Model calibration

WSE and current measurements near the navigation channel in Coos Bay were used as the comparative data for the initial CMS-Flow calibration (Figure 2-9). The calibration period is 21 June to 20 July 2014. WSE, wind, wave, and river flow data were used as input, and model results were compared with the ADCP data. The input data were obtained from NOAA ocean buoys, NOAA coastal tidal gage, and Coos Watershed Association (see Chapter 2). Calibration procedures included the examination and tuning of adjustable model parameters, such as bottom friction, wall friction, tidal prism, freshwater inflow.

For this coastal and estuarine application, a Manning's *n* value of 0.021 is used in the open coast and 0.015 inside the bay (Figure 5-1(a)) because these values are standard, representative open water *n* values for these environments as given in Sanchez et al. (2011a). Considering the jetty structure and navigation channel in the inlet system, Manning's *n* was increased to 0.045, and hard (non-erodible) bottom was specified for the jetty area (Figure 5-1(b)). In addition, single-grain size sediment transport modeling was conducted in the study. Referring to the sediment grab sample analysis (Figure 2-8), the sediment transport grain size, D50, was set to 0.32 mm. With spatially varying Manning coefficients and the settings of the other above-described parameters, final hydrodynamic calibration results were obtained.

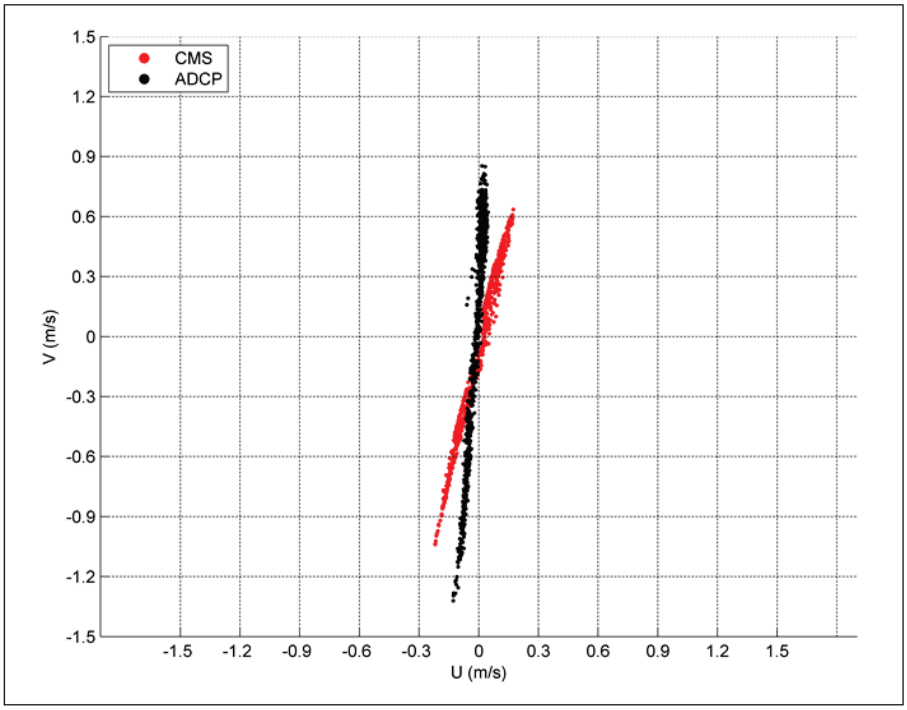
Figure 5-1. Specifications of (a) Manning's *n* and (b) non-erodible bed.



To quantitatively demonstrate model skill in the calibration process, goodness-of-fit statistics were calculated for water levels and current velocities, which included the calculation of the correlation coefficient (R), root-mean-square error (RMSE), and normalized root-mean-square error (NRMSE). The correlation coefficient R measures the linear co-variation between two datasets and can range from -1 to 1, with negative R values indicating inverse correlation and a value of 1 indicating perfect agreement. The RMSE measures the actual differences between the measured and calculated datasets, and the NRMSE is defined as RMSE/(data range) and measures the relative differences between the measured and calculated datasets.

Figure 5-2 shows the scatter plot of calculated and measured currents at the ADCP station. U is the east-west velocity component and V the north-south velocity component. The principal current direction represents along-channel flow. The positive values indicate the flood tidal current, and the negative values indicate the ebb tidal current. Relative to north, the calculated and measured principal current axes have an angle of 12.8° and 3.7°, respectively.

Figure 5-2. Scatter plot of the calculated and measured currents at the ADCP station deployed by University of Oregon from 21 June to 20 July 2014.



The current comparison in the principal direction between the CMS results and the measurements is shown in Figure 5-3(a). The current measurements show a strong tidal signal, with the measured currents ranging from -1.3 (southward, ebb current) to 0.9 m/sec (northward, flood current) in the along-channel direction. The asymmetry in tidal current indicates that the Coos Bay estuary is ebb dominated. Besides the tidal contribution, the monthly-averaged river flow is 60 m^3/sec during this 30-day period, which could be another factor contributing to the tidal asymmetry. Overall, the calculated principal currents are in good agreement with the measured currents. The RMSE is 0.16 m/sec, the NRMSE is 7.43%, and the correlation coefficient R between the model and data is 0.98.

Figure 5-3. Comparisons between the measurements and the CMS calculations at the ADCP station and the tide gauge deployed by University of Oregon from 21 June to 20 July 2014. (a) Principal current and (b) WSE.

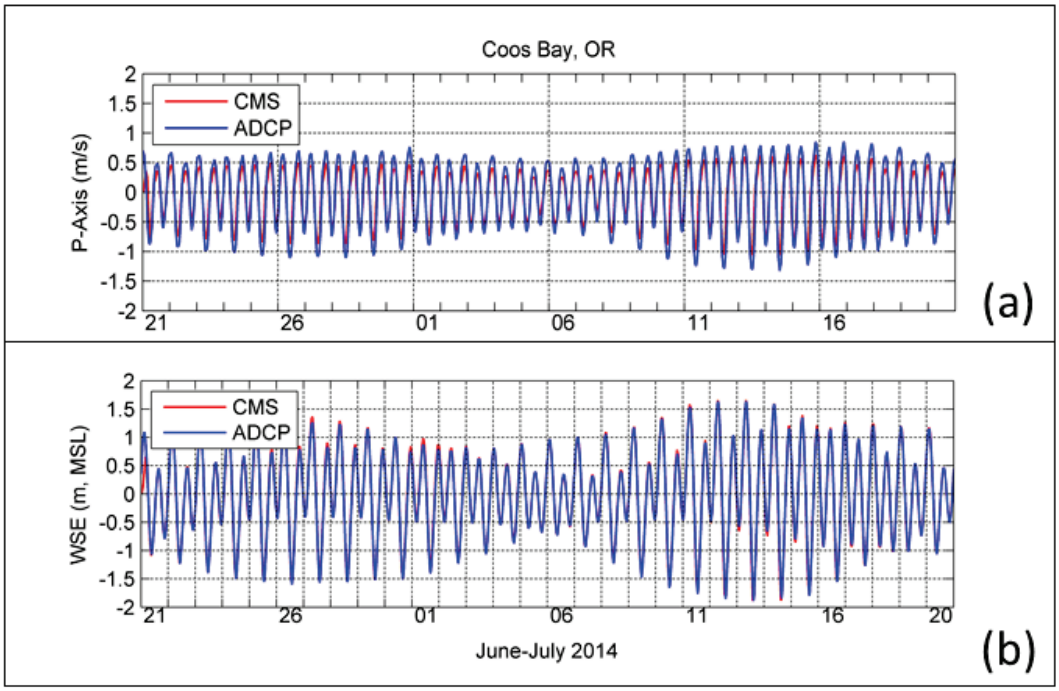


Figure 5-3(b) shows the calculated and measured WSEs at the ADCP gauge. Both the measurements and calculations show that the spring tidal range is close to 3.5 m. Visual inspection indicates that the CMS results well reproduce the tidal signals displayed in the WSE survey. The RMSE is 0.06 m and a relative RMSE of 1.56%. The correlation coefficient R between the model and data is 0.99.

5.1.2 Model validation

WSE, current, and wave data collected by RPS EHI are used for CMS validation. The measurements cover the open ocean, the inlet and entrance channel, and the bay area. As described in Chapter 3, the bottom-mounted ADCP was lost, and no time-series current data were recovered in the channel. The current validation was performed using the vessel-mounted ADCP from the bay and channel to the nearshore areas over a 4-day period and the AWAC within ODMDS F-NS. In addition, the conditional survey data provided by the NWP are used to validate the channel depth evolution at the inlet entrance from October 2013 to June 2014.

Figure 5-4 shows the AWAC ocean current measurements and the calculated CMS results from September to November 2015. The velocity scatter figure clearly displays that the principal current direction is approximately parallel to the coastline. Both the calculated and the measured currents are rotated to this direction for model current validation at this open ocean location. Figure 5-5(a) shows the time series of the measured and calculated current speeds in the longshore direction. The calculations fairly well reproduce the tidal currents combined with the low-frequency, storm-driven flows. Major discrepancies between the calculated results and measured data occurred during a few low-frequency events. The RMSE for the current comparison at the AWAC gauge is 0.08 m/sec and the NRMSE is 14.98%. The correlation coefficient is 0.54. Due to the limited spatial coverage of buoy data, offshore wind and wave data as model input might result in the model-data discrepancies in nearshore zones.

Figure 5-4. Scatter plot of the calculated and measured currents at the AWAC gauge from September to November 2015.

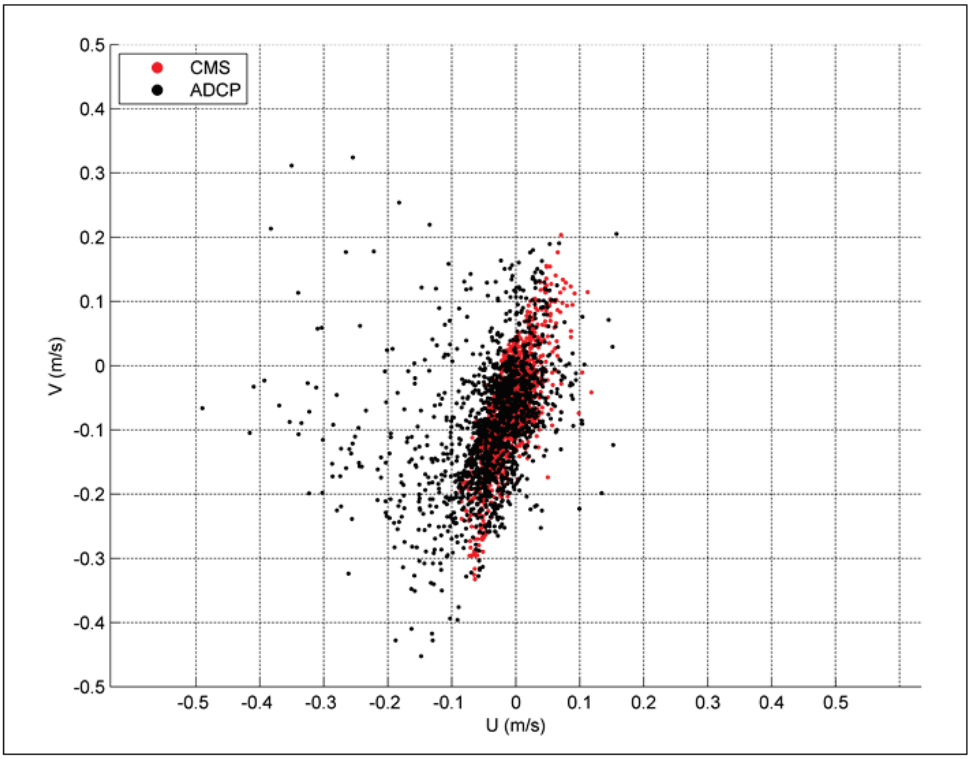


Figure 5-5. Comparisons between the measurements and the CMS calculations at the AWAC gauge and the tide gauge in the upper Coos Bay from September to October 2015. (a) Current and (b) WSE.

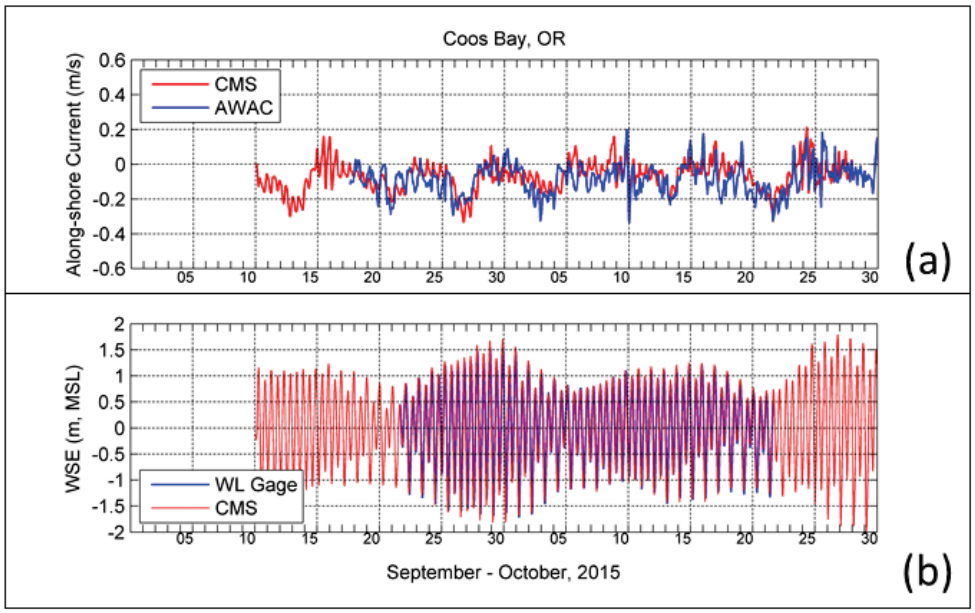
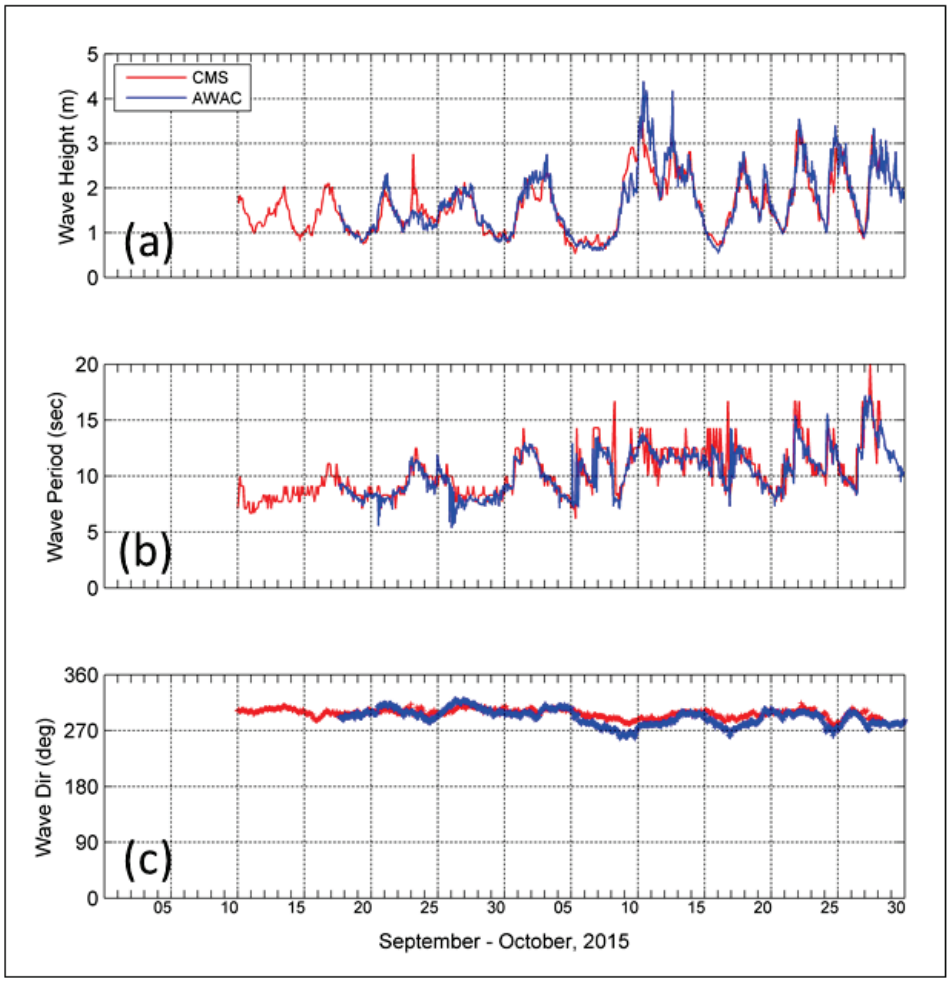


Figure 5-5(b) shows the calculated and measured WSEs at the tidal gauge inside Coos Bay (Figure 3-2). Similar to the calibration case, the measurements and calculations show good agreement. The goodness-of-fit statistics for WSEs result in a correlation coefficient of 0.97. The RMSE and the NRMSE are 0.21 m and 6.19%, respectively.

The calculated wave parameters are compared with the measurements at the AWAC gauge (Figure 5-6). The mean significant wave height is 1.7 m. Wave heights exceed 3 m for five time periods during the 50-day simulation. The mean wave period is 10.3 sec, and the predominant wave direction is west-northwest. The calculated wave parameters are well correlated with the measurements. The correlation coefficients are 0.90, 0.81, and 0.84 for wave height, wave period, and wave direction, respectively. The RMSE and the NRMSE are 0.32 m and 7.35% for wave height, 1.39 sec and 8.05% for wave period, and 10.0° and 5.56% for wave direction, respectively. The sensitivity tests on wave transformation show that the calculated wave parameters are closely associated with the specifications of boundary conditions from the measurements at different buoys. Buoy #46015 measurements applied as boundary forcing were selected because of the better goodness-of-fit statistics between model and data.

Figure 5-6. Comparisons of wave parameters between the calculations and the measurements at the AWAC gauge from September to October 2015. (a) Significant wave height, (b) peak wave period, and (c) mean wave direction.



Vessel-mounted ADCP transects provided depth-averaged currents over multiple tidal cycles in and around Coos Bay inlet from 28 September through 1 October 2015. Considering the average time for the vessel to traverse the transects, current output was retrieved at 10-minute intervals from the CMS simulation to compare with the measurements on selected transects over the 4-day period.

Figure 5-7 through Figure 5-9 show comparisons of measured current transects and calculated currents in the bay collected on 28 September 2015. The calculated current vectors well match the measured flood and ebb current magnitudes and directions at each transect. Current variations along transects (i.e., strong currents in the center of the navigation channel and weaker currents on the channel margins) are also well

reproduced by the CMS. Ebb currents around the inlet entrance were measured between 30 September and 1 October 2015. Two outstanding current features adjacent to an inlet were clearly shown in Figure 5-10 through Figure 5-12: (1) the strong ebb jet was captured well beyond the jettied inlet channel. Figure 5-12 shows that the ebb jet has a speed of 1.0–1.5 m/sec more than 3 km away from tip of jetties and (2) an eddy formed due to the interactions between the ebb jet and longshore current north of the entrance channel (Figure 5-10 and Figure 5-11). Figure 5-13 through Figure 5-16 show a transition period from an ebbing tide to a flooding tide on 1 October 2015. Because the measurements along transects were not conducted simultaneously (typically several minutes per transect), surveyed currents over the longer open ocean transects (10–30 minutes per transect) tend to have more fluctuations and more discrepancies between the calculated and measured currents.

Figure 5-7. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 28 September 2015 between 17:59 and 19:21 GMT.

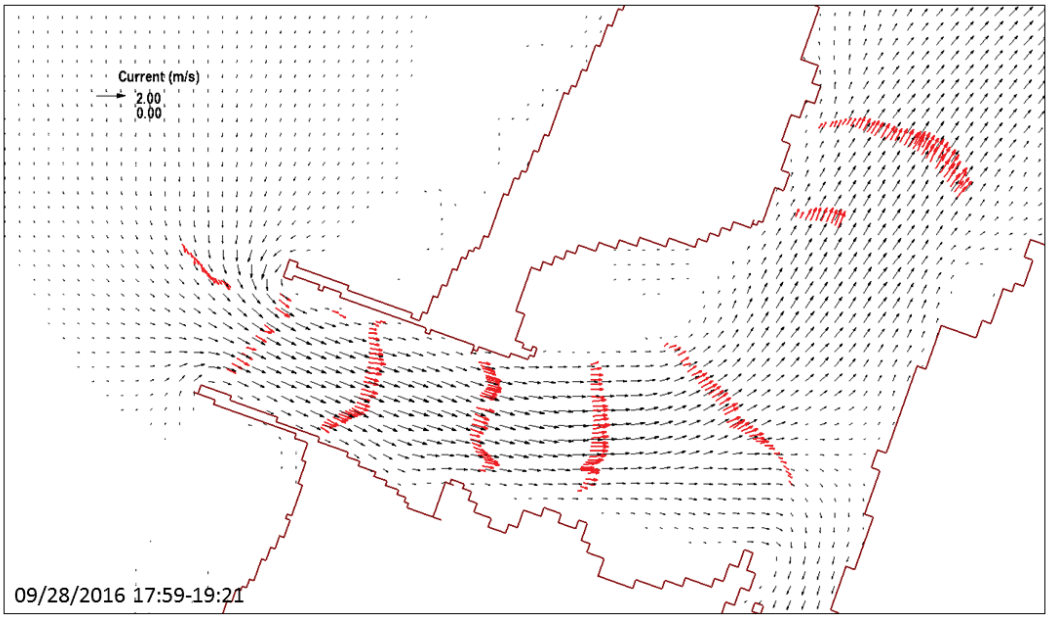


Figure 5-8. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 28 September 2015 between 20:49 and 21:52 GMT.

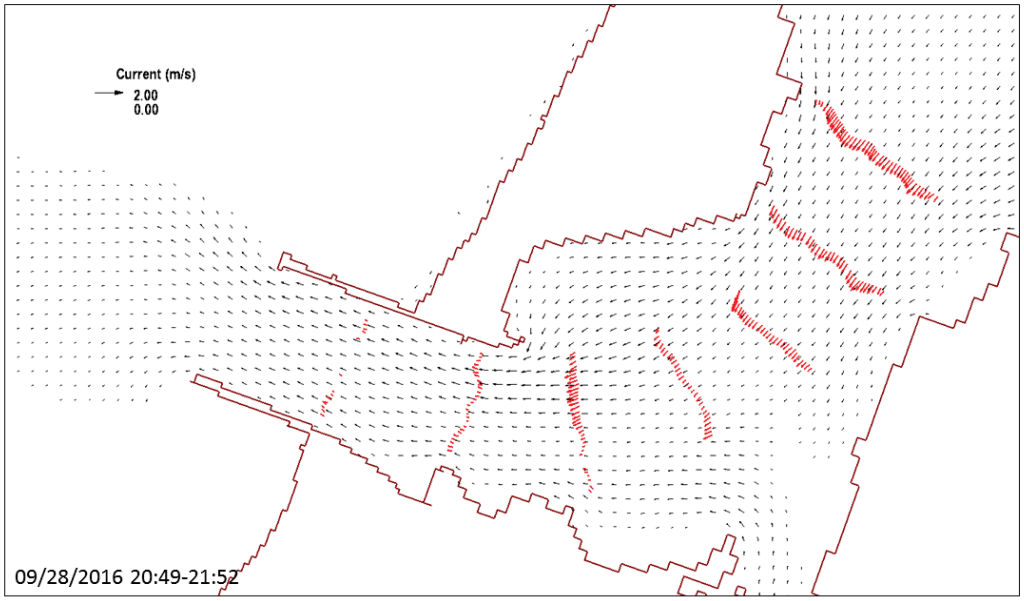


Figure 5-9. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 28 September 2015 between 22:56 and 23:33 GMT.

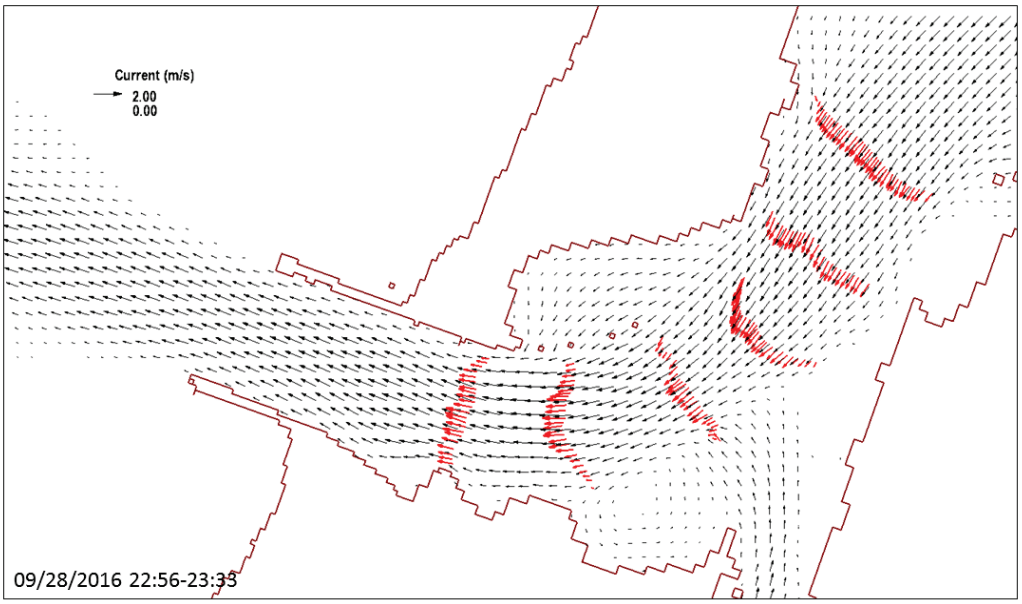


Figure 5-10. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 30 September 2015 between 23:17 and 23:50 GMT.

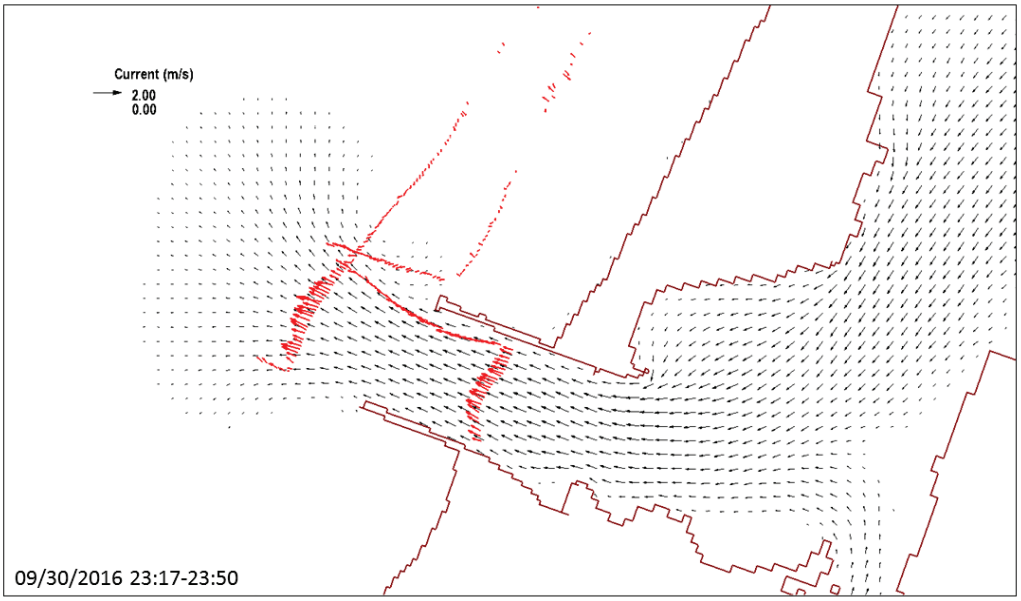


Figure 5-11. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 00:15 and 00:38 GMT.

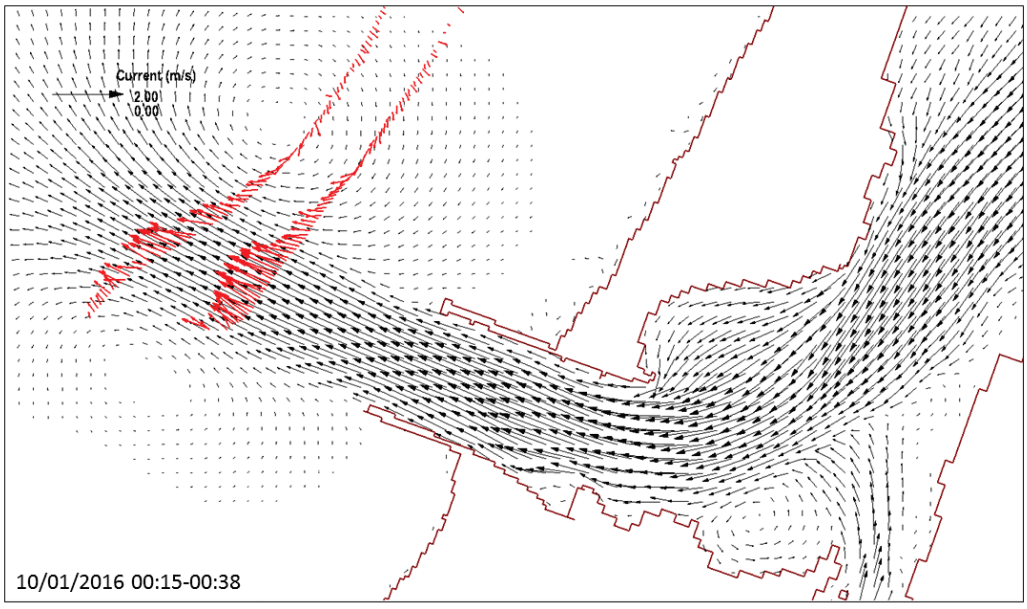


Figure 5-12. Current comparisons between the vessel mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 01:02 and 01:31 GMT.

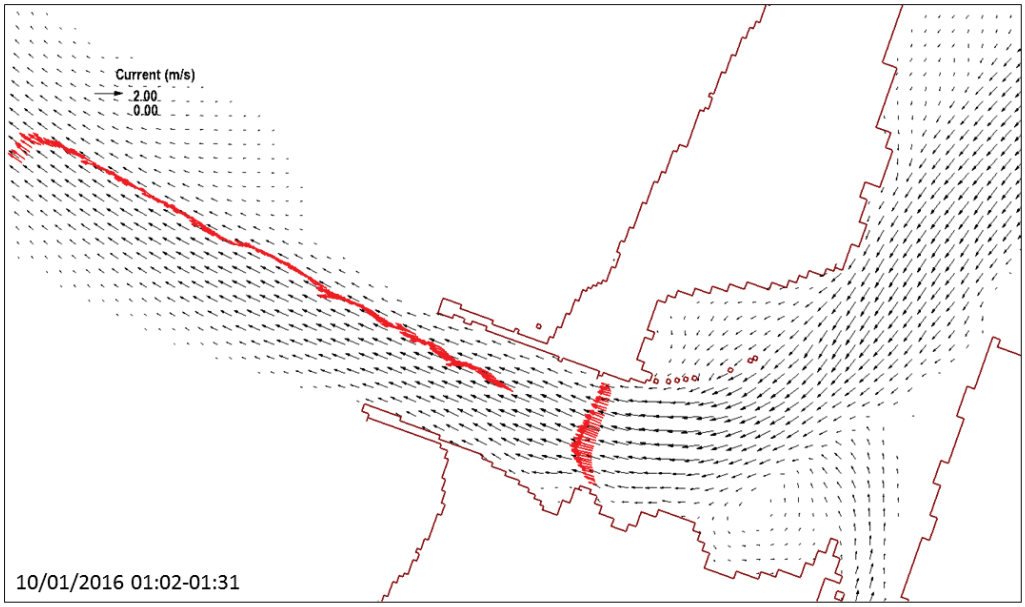


Figure 5-13. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 15:55 and 16:28 GMT.

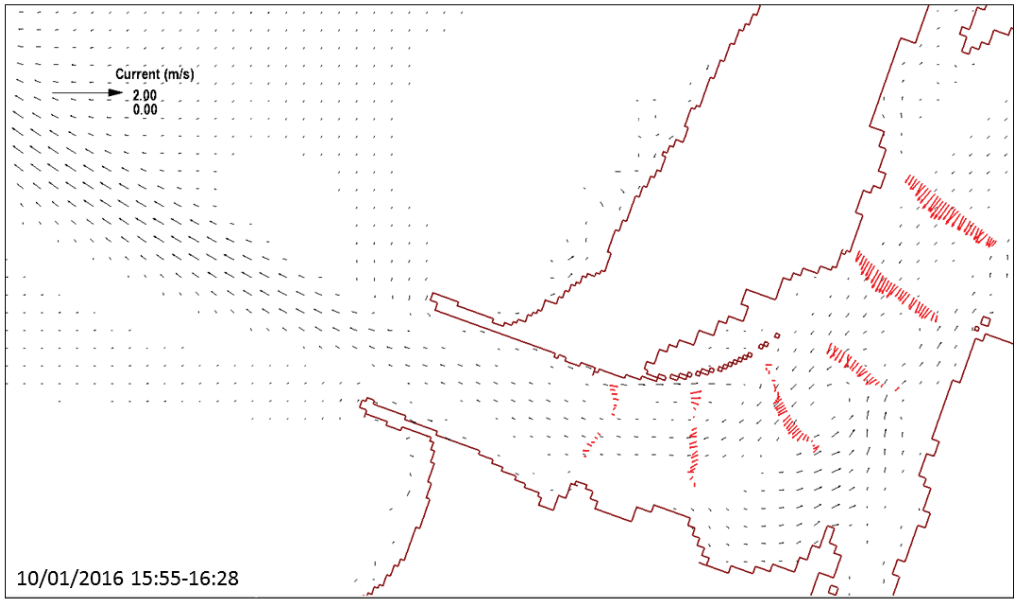


Figure 5-14. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 16:34 and 17:20 GMT.

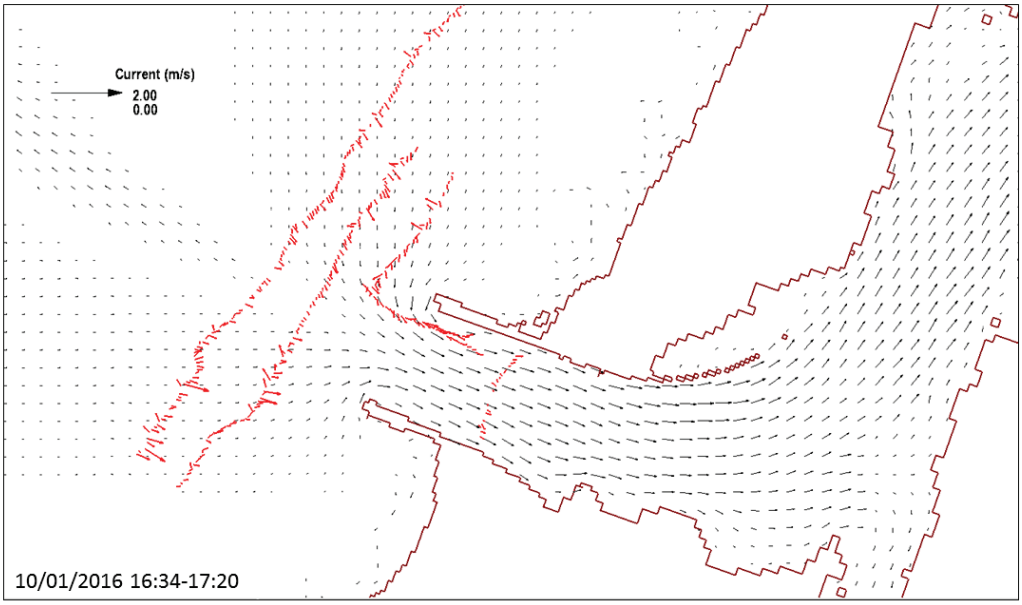


Figure 5-15. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 17:52 and 18:01 GMT.

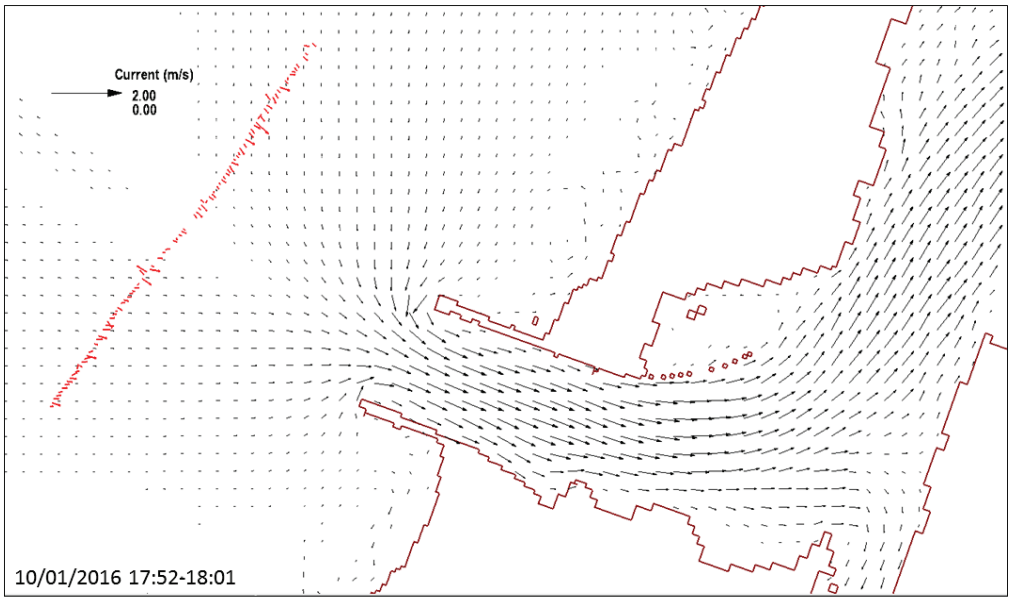
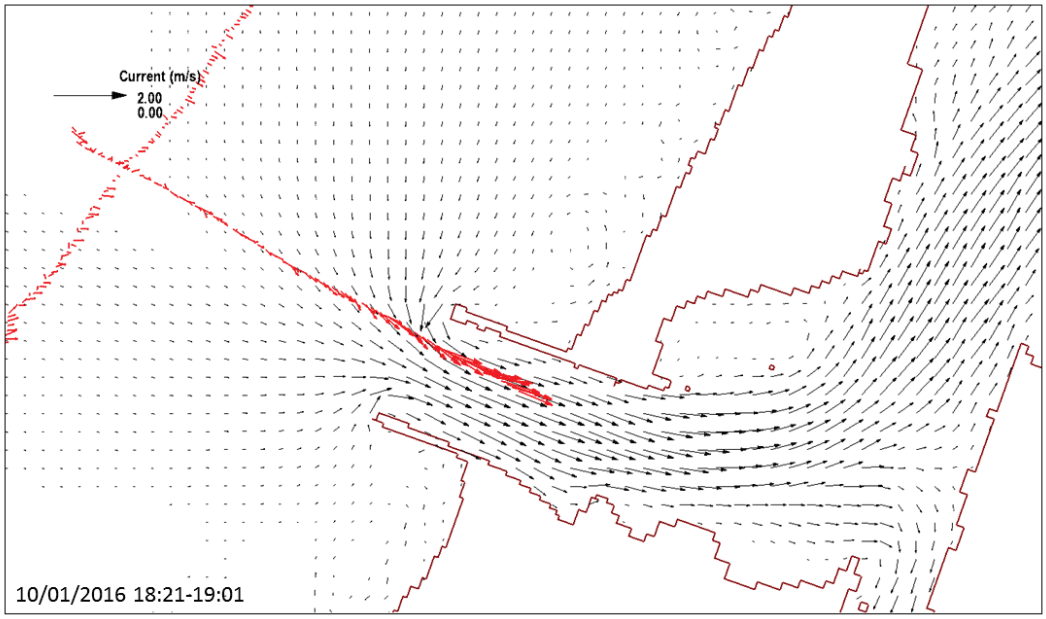


Figure 5-16. Current comparisons between the vessel-mounted ADCP measurements and the CMS calculations in transects on 1 October 2015 between 18:21 and 19:01 GMT.



Goodness-of-fit statistics were calculated for U (east-west) and V (north-south) current components, respectively. The results are provided in Table 5-1. Model and data compare well for bay transects (28 September 2015; 17:59–23:33 GMT) and close to a peak flood (28 September 2015; 17:59–19:21 GMT) or ebb (1 October 2015; 00:15–00:38 GMT) current period. The overall comparison indicates a close correlation between the model results and the measured, depth-averaged ADCP current data.

Table 5-1. Goodness-of-fit statistics between the vessel-mounted ADCP current measurements and the CMS calculations in transects from 28 September to 1 October 2015.

	U Component			V Component		
Period (2015)	R	RMSE (m/sec)	NRMSE (%)	R	RMSE (m/sec)	NRMSE (%)
28-Sep (17:59 and 19:21 GMT)	0.891	0.143	12.5	0.977	0.126	7.0
28-Sep (20:49 and 21:52 GMT)	0.715	0.162	18.6	0.960	0.106	9.9
28-Sep (22:56 and 23:33 GMT)	0.822	0.187	10.7	0.962	0.212	9.4
30-Sep (23:17 and 23:50 GMT)	0.856	0.178	10.7	0.834	0.106	11.0

Period (2015)	U Component			V Component		
	R	RMSE (m/sec)	NRMSE (%)	R	RMSE (m/sec)	NRMSE (%)
1-Oct (00:15 and 00:38 GMT)	0.950	0.130	8.0	0.886	0.109	10.3
1-Oct (01:02 and 01:31 GMT)	0.640	0.263	21.4	0.665	0.103	13.6
1-Oct (15:55 and 16:28 GMT)	0.832	0.177	26.1	0.427	0.217	38.8
1-Oct (16:34 and 17:20 GMT)	0.396	0.116	11.1	0.538	0.085	12.2
1-Oct (17:52 and 18:01 GMT)	0.316	0.101	15.7	0.381	0.067	13.2
1-Oct (18:21 and 19:01 GMT)	0.923	0.136	9.9	0.893	0.079	9.7
Total (28/09 - 01/10)	0.959	0.159	5.2	0.947	0.122	4.2

To evaluate the accuracy of channel depth evolution in the model, measured morphology change datasets (difference plots) were developed from surveyed bathymetry collected on 21 October 2013 and the depths of five subsequent channel surveys from 2013 and 2014. The CMS was set up on 21 October 2013, and the calculated morphology change results are compared with surveyed channel depth differences between the 21 October 2013 survey and the 25 November 2013; 6 February 2014; 13 March 2014; 30 April 2014; and 12 June 2014 surveys in Figure 5-17 through Figure 5-21, respectively.

Figure 5-17. Comparisons of channel morphology changes between the conditional surveys and the CMS calculations from 21 October to 25 November 2013.

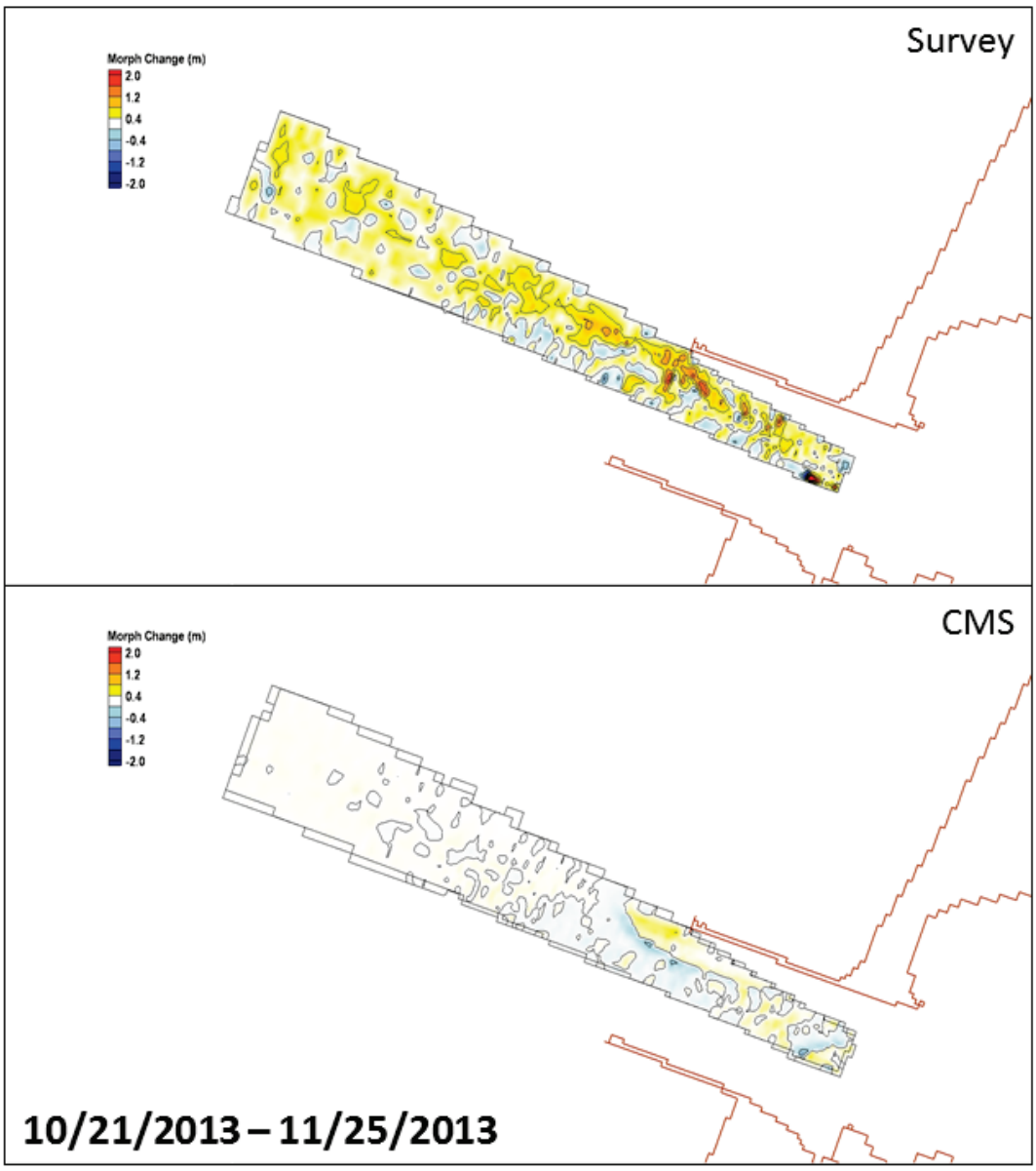


Figure 5-18. Comparisons of channel morphology changes between the conditional surveys and the CMS calculations from 21 October 2013 to 6 February 2014.

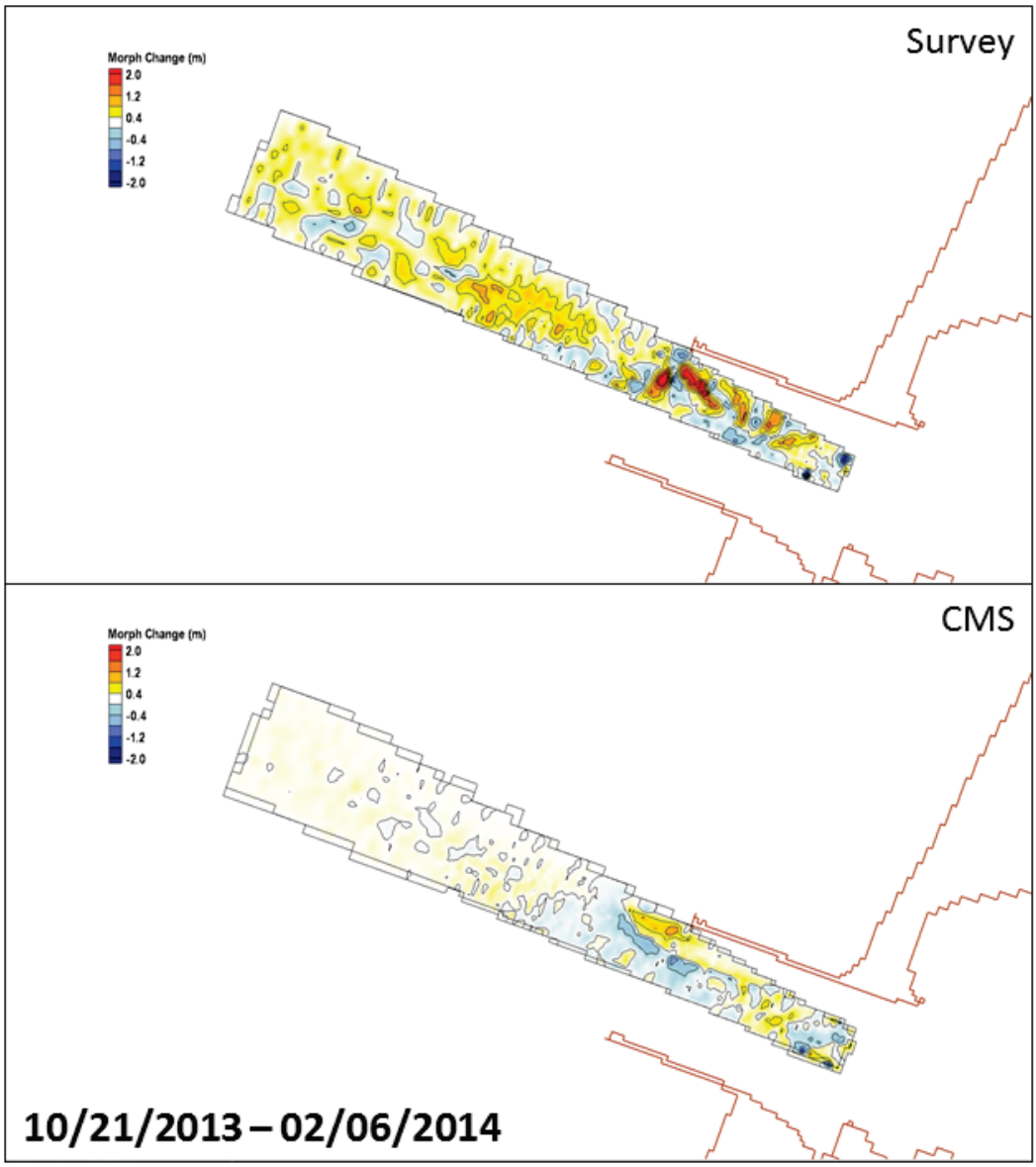


Figure 5-19. Comparisons of channel morphology changes between the conditional surveys and the CMS calculations from 21 October 2013 to 13 March 2014.

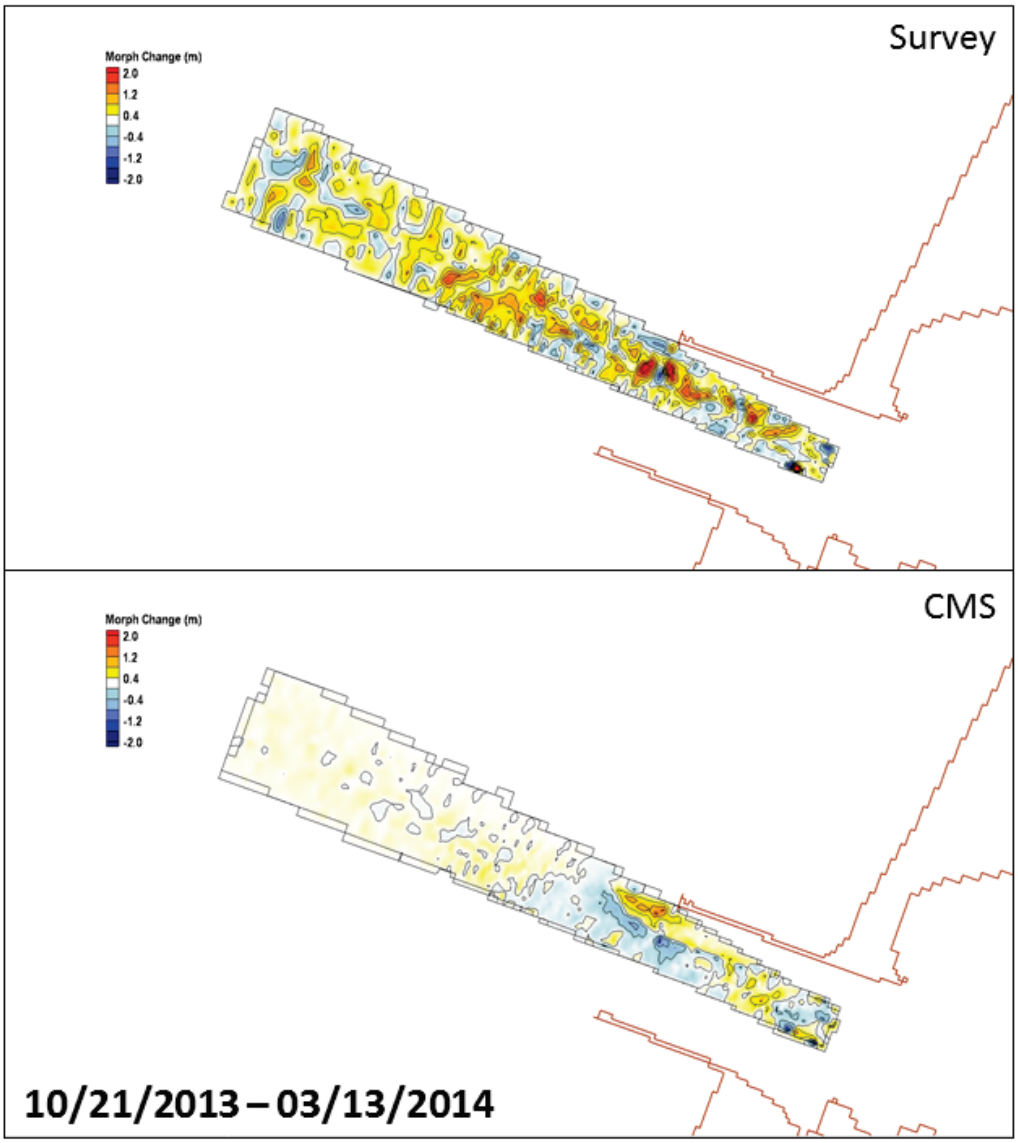


Figure 5-20. Comparisons of channel morphology changes between the conditional surveys and the CMS calculations from 21 October 2013 to 30 April 2014.

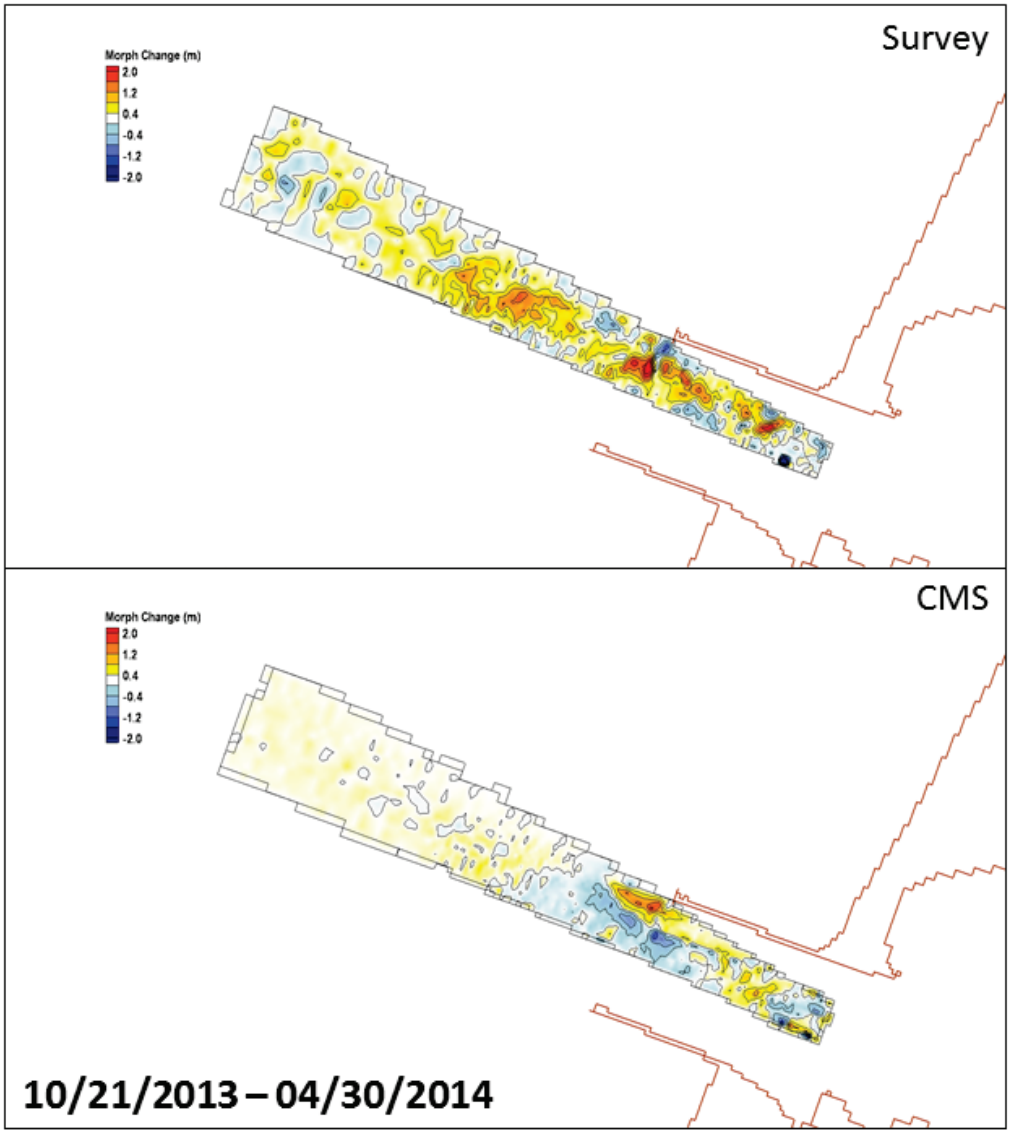
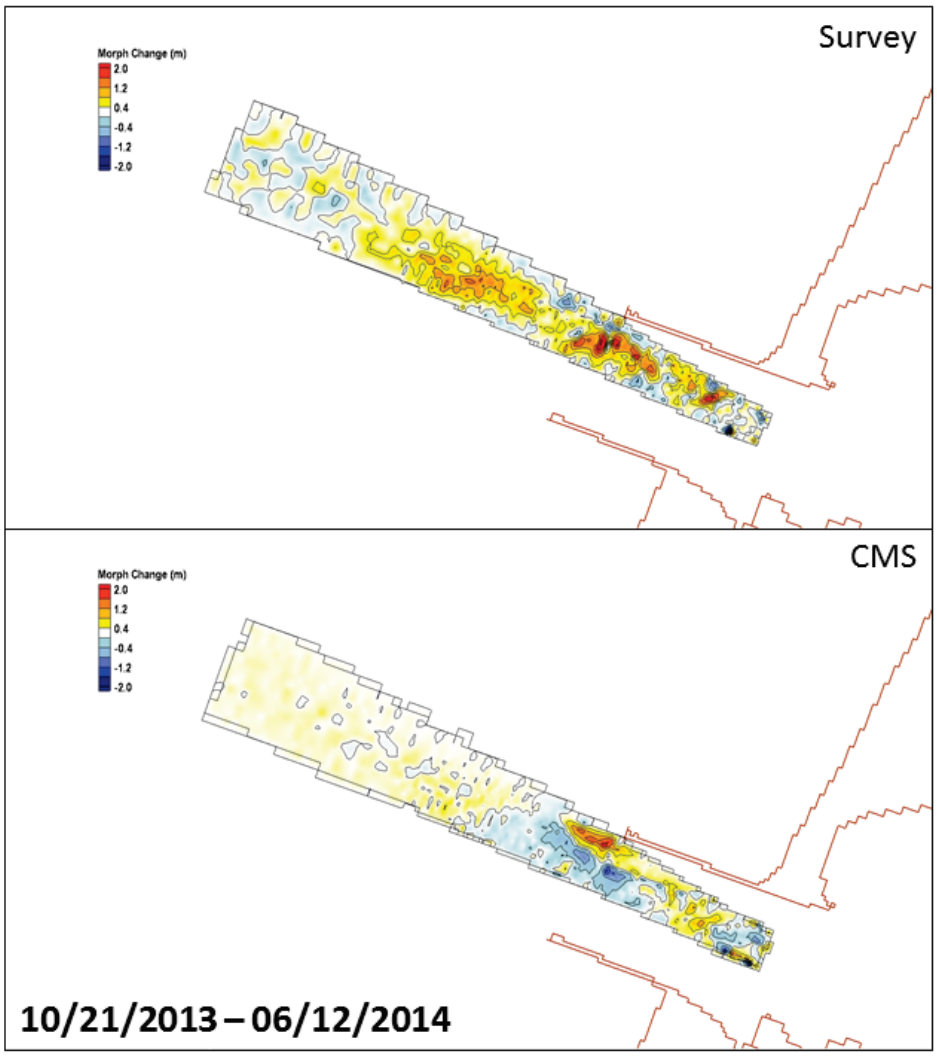


Figure 5-21. Comparisons of channel morphology changes between the conditional surveys and the CMS calculations from 21 October 2013 to 12 June 2014.



In Figure 5-17 through Figure 5-21, warmer colors indicate sediment deposition while cooler colors represent erosion. The major morphologic features are represented although the magnitude and location of the bed change may vary and the distribution pattern may not have an exact match. For example, the model properly simulated sediment movement towards the open ocean, sediment accumulation on the northern side of the navigation channel, sediment erosion on the southern side of the navigation channel, and more significant accretion around the tip of the north jetty near the inlet entrance. Sporadic and inconsistent erosion and accretion patterns can be seen outside the inlet, but the overall calculated net bed change displays an increasing trend in sediment accretion within an order of magnitude of measured values.

5.2 CMS sediment mapping

Based on the field sediment tracer study, 6-month hydrodynamic, wave, and PTM simulations were conducted with the calibrated and validated CMS. The simulation period spans the energetic winter months and the entire duration of the sediment tracer release and measurement period, including two rounds of tracer sampling.

5.2.1 Current and sediment transport

Figure 5-22 through Figure 5-25 show depth-averaged ebb and flood current vector plots for 5 December at 19:00 GMT; 6 December at 01:00 GMT; 12 December 2015 at 00:00 GMT; and at 05:00 GMT, respectively. Model results show that December 5–6 corresponds to a winter storm period and December 12 to a high river flow period. During the December 5–6 ebb-flood cycle, waves propagated from the southwest direction accompanied by strong southerly wind. Longshore currents driven by the winter storm were as much as 1 m/sec in the shallower nearshore area. Compared with the storm-driven flow, tidal currents in the channel and bay were relatively weak during this period. Conversely, very strong ebb currents occurred on December 12, corresponding to peak riverine discharge into the bay, and the calculated maximum current speed was approximately 2 m/sec around the inlet entrance channel. The ebb jet seaward of the inlet turned to the north due to the interactions between tidal and longshore currents.

Figure 5-22. Calculated depth-averaged ebb currents on 5 December 2015 at 19:00 GMT.

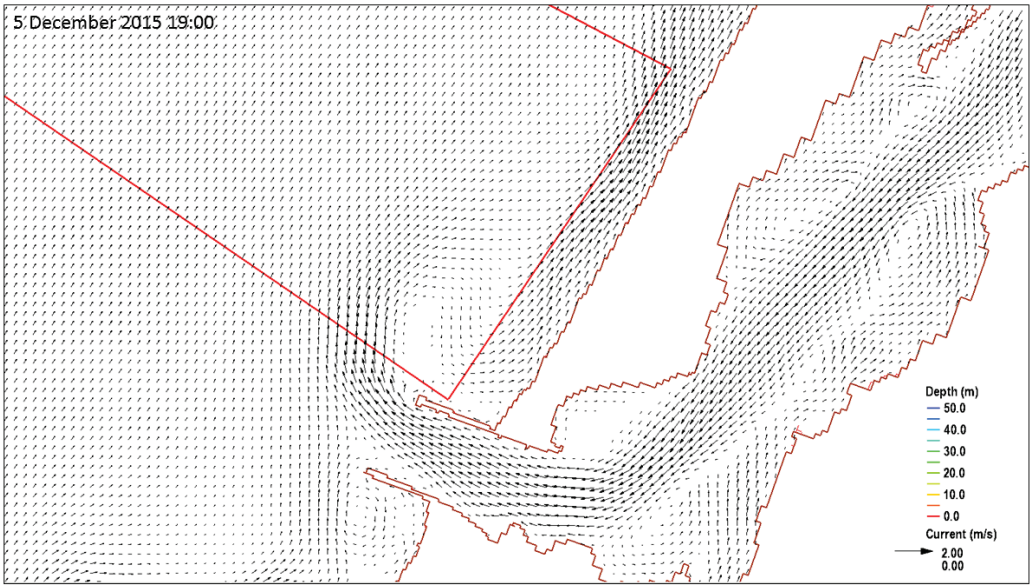


Figure 5-23. Calculated depth-averaged flood currents on 6 December 2015 at 01:00 GMT.



Figure 5-24. Calculated depth-averaged ebb currents on 12 December 2015 at 00:00 GMT.

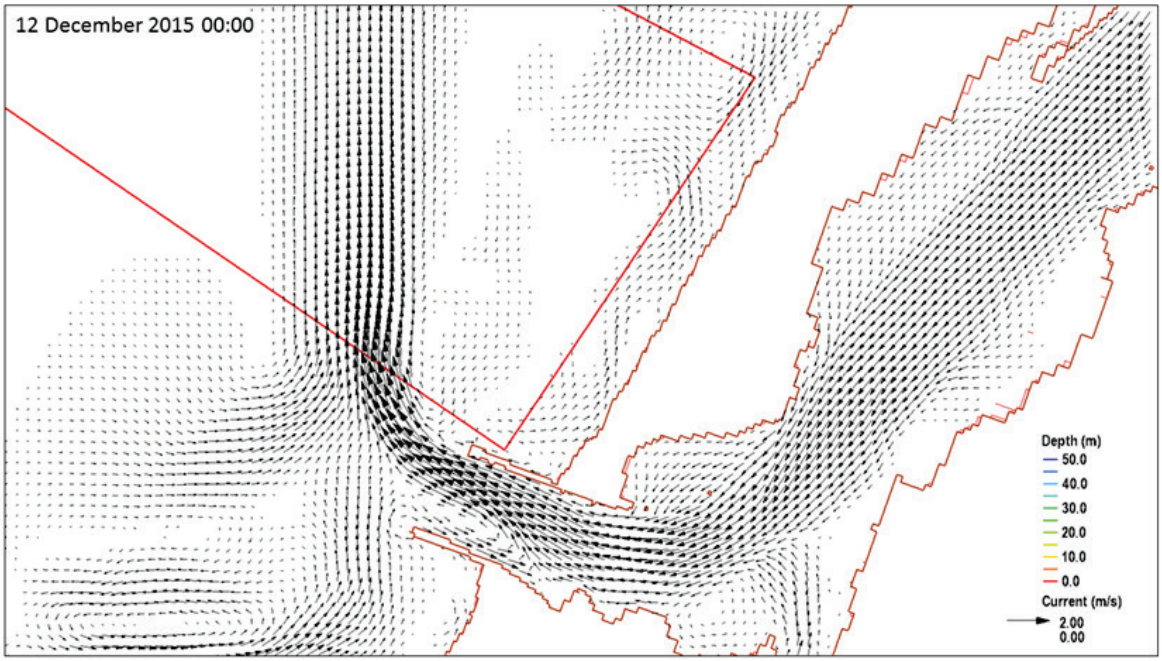
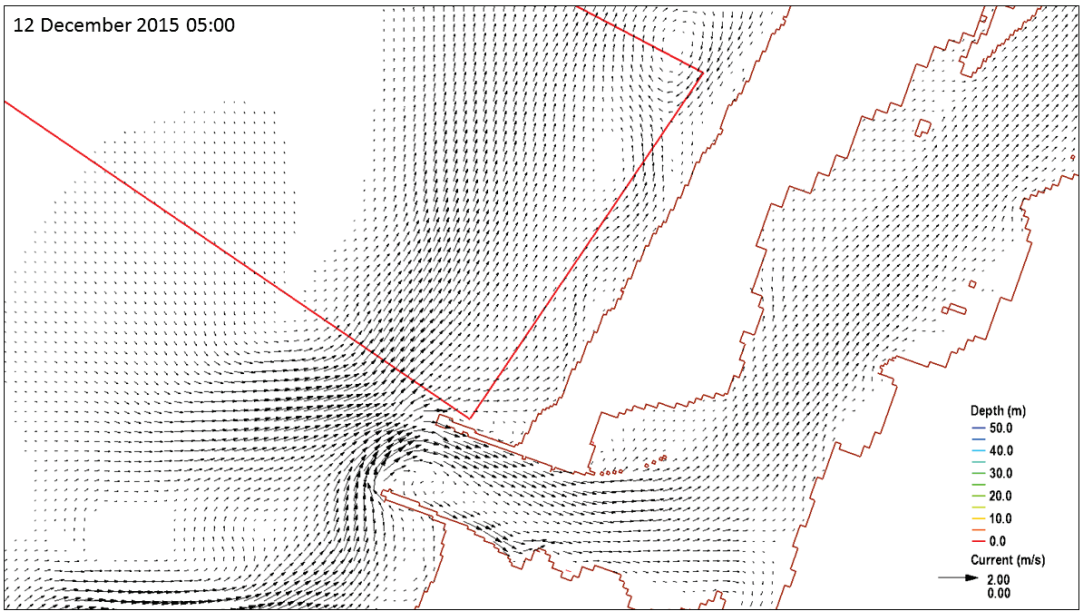
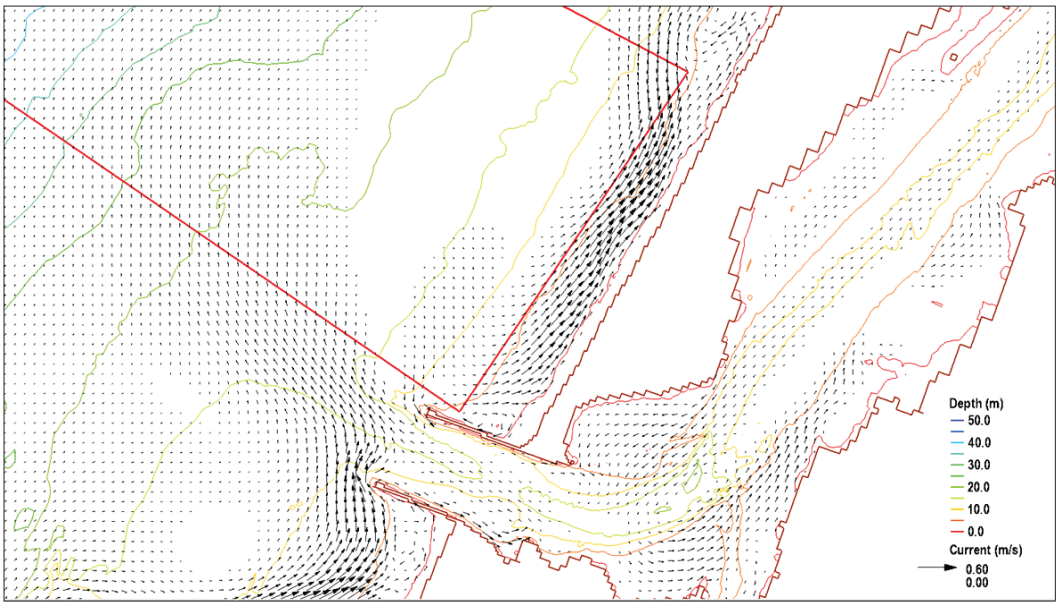


Figure 5-25. Calculated depth-averaged flood currents on 12 December 2015 at 05:00 GMT.



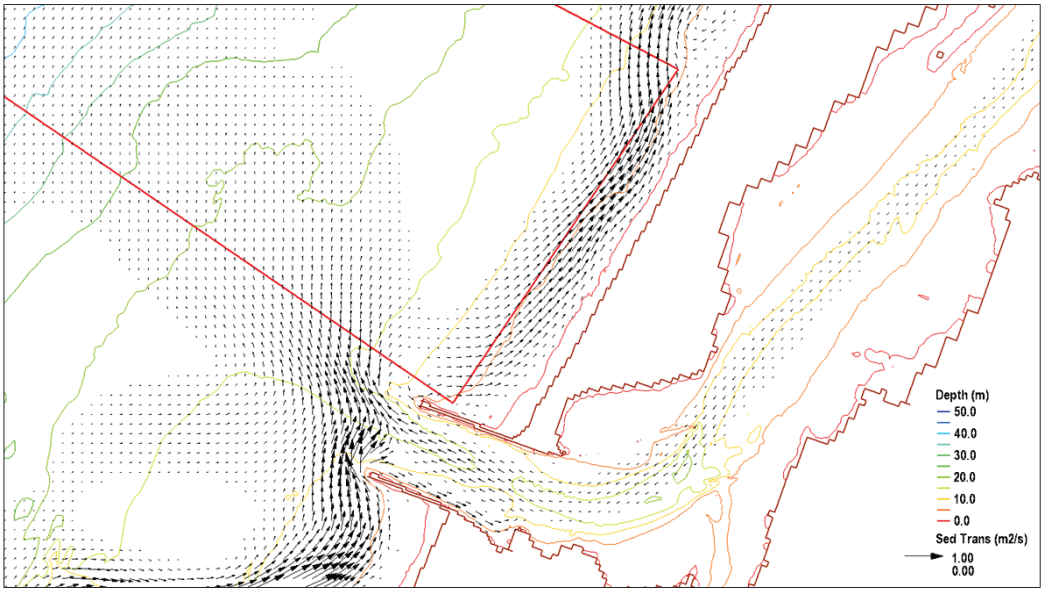
To examine circulation and sediment transport patterns, the 6-month model simulation results were averaged, and mean current and corresponding sediment transport were calculated. As shown in Figure 5-26, the mean current at the entrance channel was ebb-dominated (flowing out the inlet), and longshore currents were strongly oriented to the north in shallow coastal areas with local reversals adjacent to the jetties. The maximum, average current speed was approximately 0.1 m/sec in the bay and 0.4 m/sec in the open ocean. From the current analysis it is noted that there exists a net return flow from the nearshore area of ODMDS F-NS, just offshore of the active longshore current zone, which flows towards the inlet entrance channel around the tip of the north jetty.

Figure 5-26. Calculated mean current for the period of September 2015 to March 2016.



The mean sediment transport pattern (Figure 5-27) corresponds closely with the mean current pattern (Figure 5-26). As the inlet-bay system is ebb dominated, the sediment in the bay is transported oceanward along the channel. This flushing of bay sediments is nominal in comparison to the amount of sediment transported along the coast. The mean longshore current is driven by dominant, northerly directed storm waves during the 6-month period. The return flow near the jetties moved sediment into the inlet. The ebb jet tends to transport sediment in a north-northwesterly direction towards the offshore portion of ODMDS F. In general, the calculations indicate that coastal sediments were dominantly transported alongshore towards the north, and those entrained by flood tidal currents at the inlet entrance channel were mainly redistributed in a net oceanward direction.

Figure 5-27. Calculated mean sediment transport for the period of September 2015 to March 2016.



Net sediment transport directions were also obtained by examining morphological changes and performing a sediment budget analysis, for which the area surrounding the inlet and ODMDS F was divided into nine subareas (Figure 5-28). Based on net bed volume changes in each subarea, the sediment transport directions can be estimated. As a demonstration, the calculated sediment volume changes in the nine subareas were used to estimate transport directions between 11 September and 23 November 2015 are shown in Figure 5-29. For this specific period, it can be seen that the nearshore area of ODMDS F and the bay area are losing sediment and the inlet entrance channel and the ebb shoal are gaining sediment.

Figure 5-28. Nine divided subareas around the inlet entrance and ODMDS F.

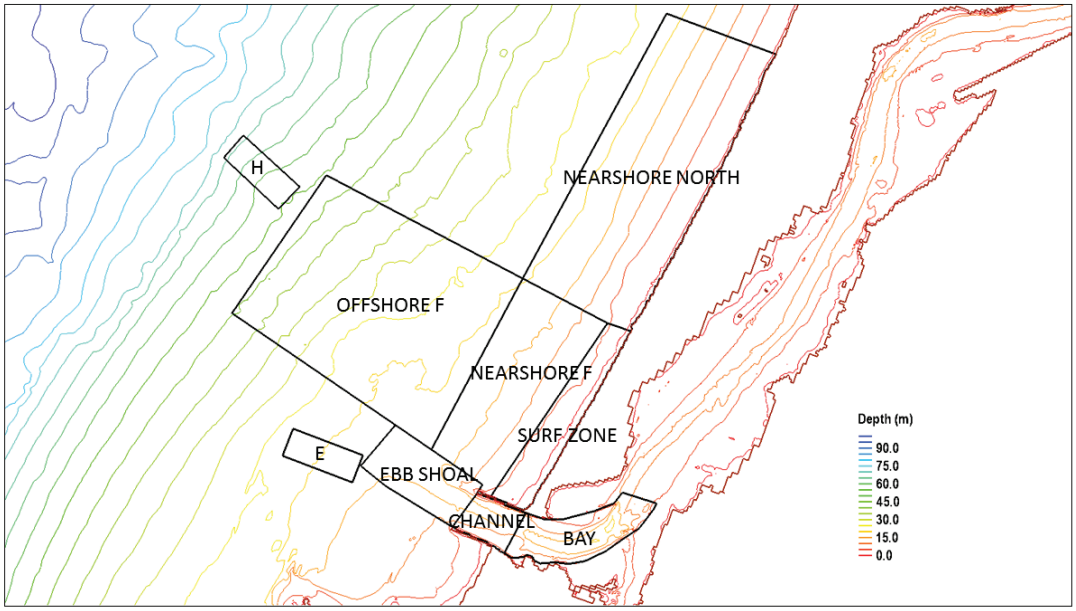
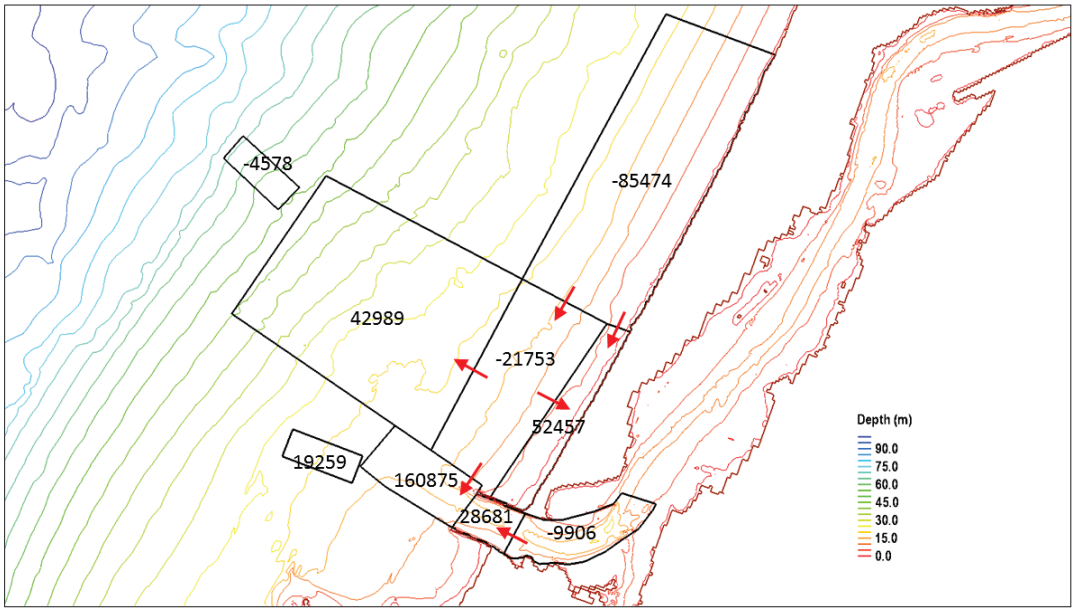


Figure 5-29. Bed volume changes in nine divided polygons around the inlet entrance and ODMDS F from 11 September to 23 November 2015.



5.2.2 Sediment tracer

Sediment mapping simulations were set up for the period of September 2015 to March 2016. Referring to the sand tracer release and sampling program by RPS EHI, 600 kg of tracer were specified at DZ-A and DZ-B sites. The grain size of the sediment tracer was 0.32 mm, the same as the mean grain size of the native material, five bed layers were

specified in the CMS, and the tracer was tracked from the beginning of the simulations, which was 20 and 19 September 2015 for the DZ-A and DZ-B releases, respectively.

Sediment tracer distributions in the top (active) bed layer of the CMS simulations are plotted for every 10 days of the simulation (starting at Day 5) in Figure 5-30 and Figure 5-31 for the 6-month simulation period after sediment was released at DZ-A and DZ-B, respectively. Temporal variations in tracer distributions indicate different transport and dissipation patterns for sediment tracer released at different locations. At the initial stage of the simulation, the sediment tracer released at DZ-A shows more onshore movement while the sediment tracer released at DZ-B displays further offshore spreading. After 3 months of simulations, all the tracer distributions show northward, longshore transport.

Figure 5-30. Temporal evolution of sediment tracer concentration for the DZ-A release in every 10 days from 20 September 2015 through 31 March 2016 (continued on following page).

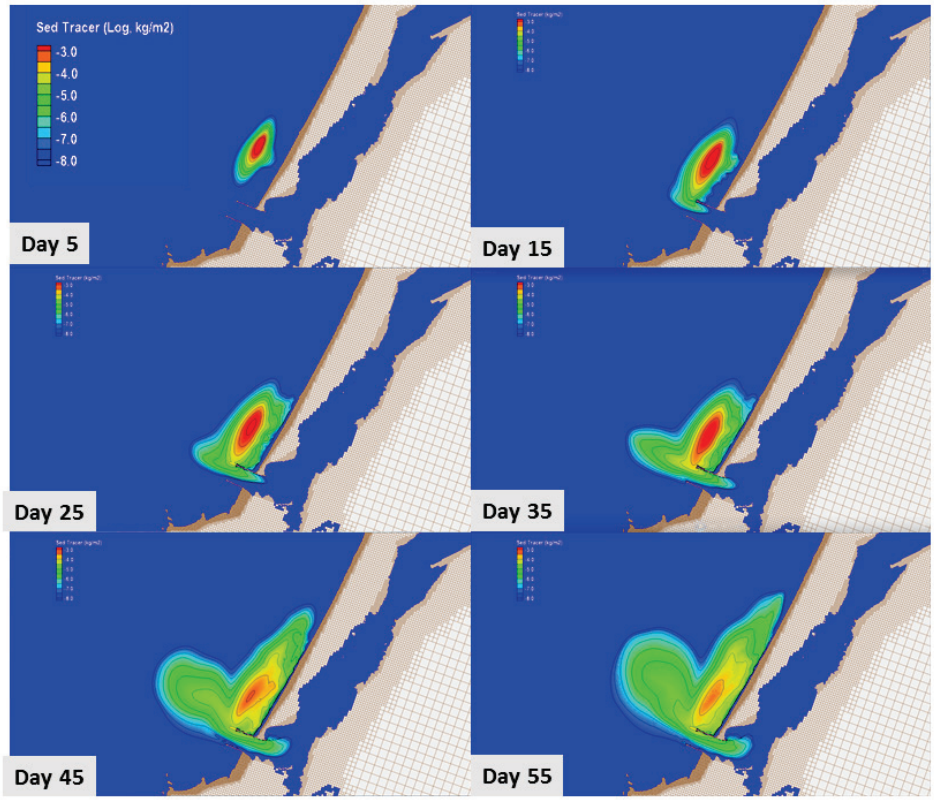


Figure 5-30. Concluded.

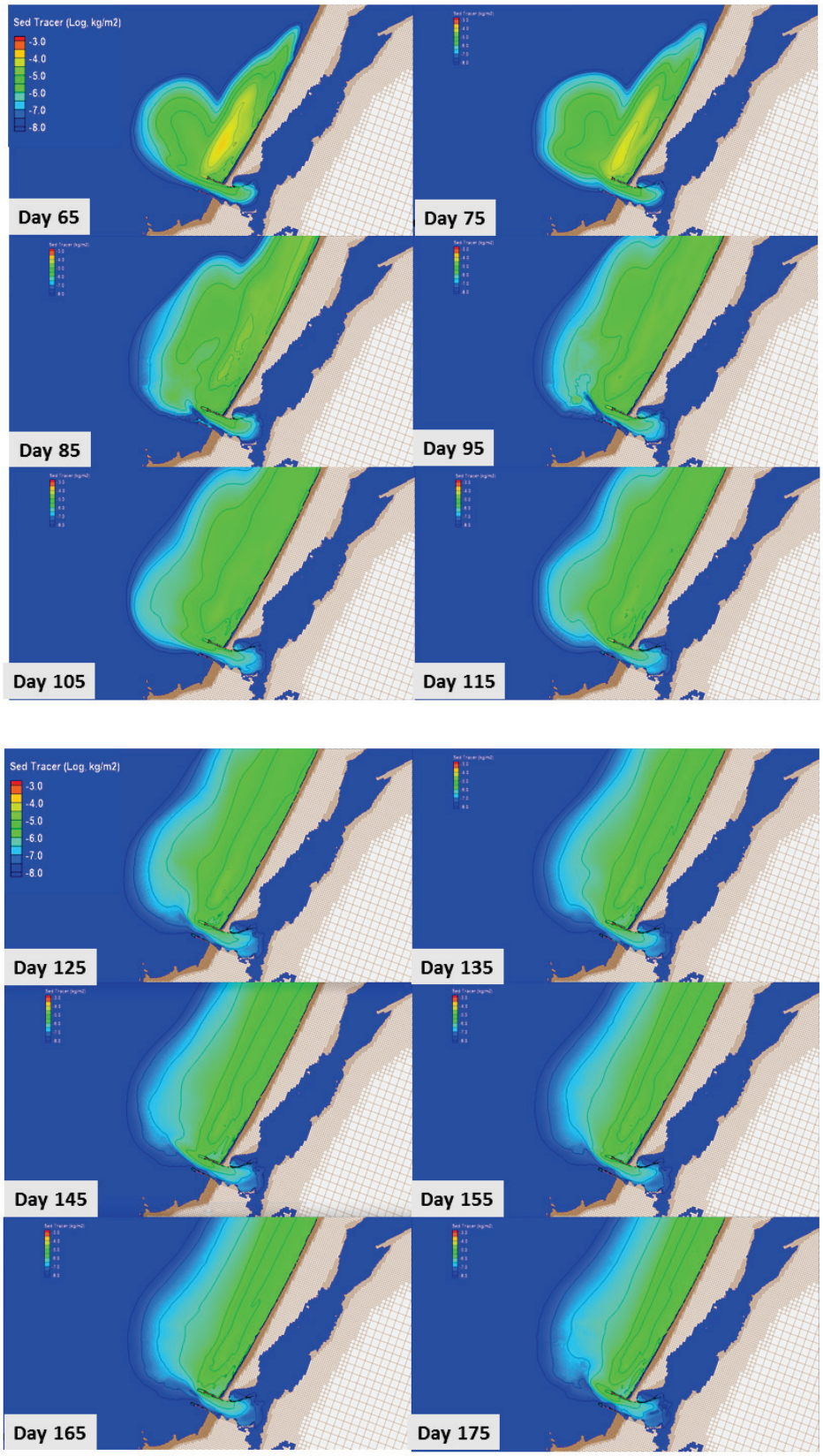


Figure 5-31. Temporal evolution of sediment tracer concentration for the DZ-B release in every 10 days from 19 September 2015 through 31 March 2016 (continued on following page).

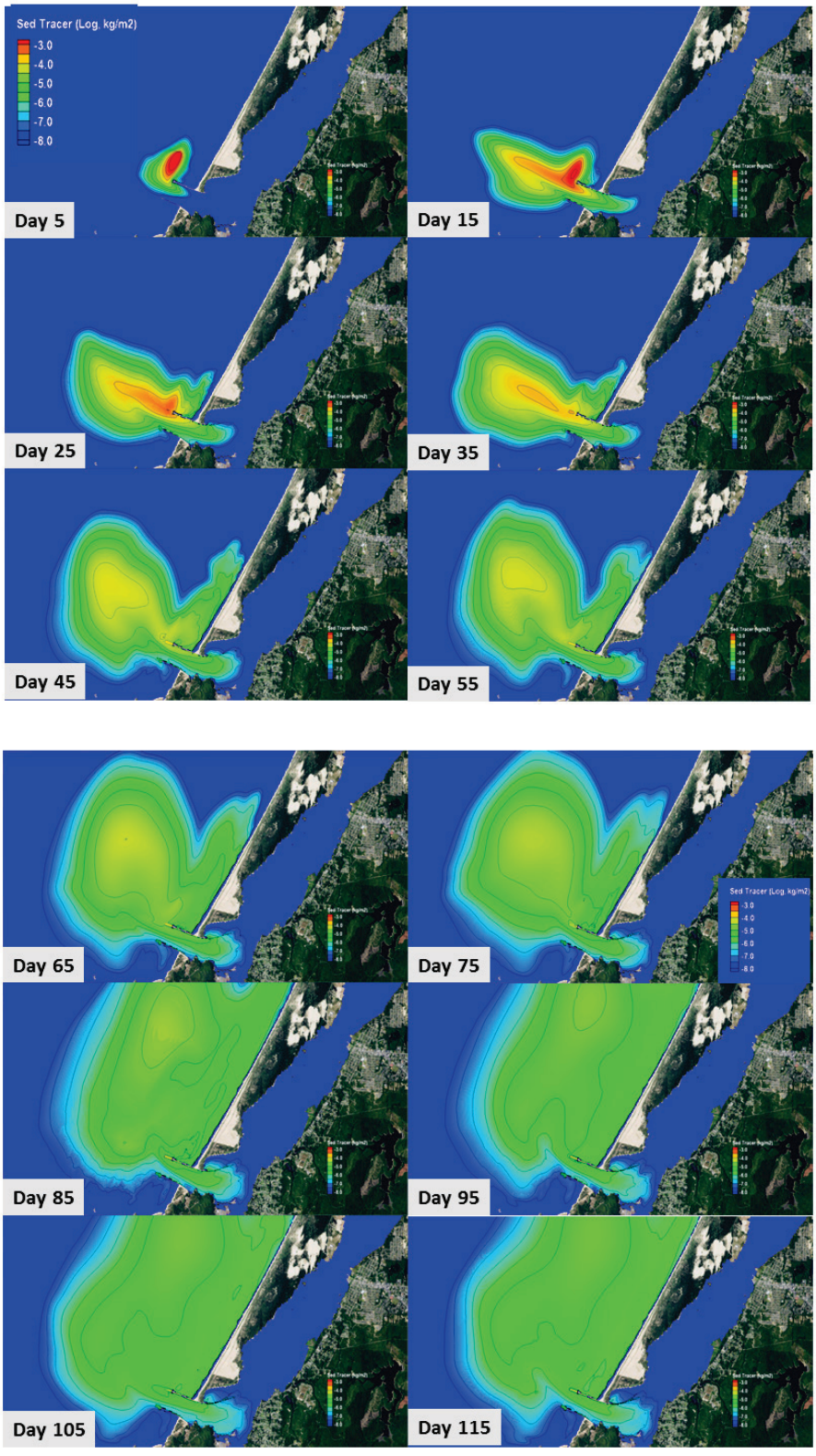
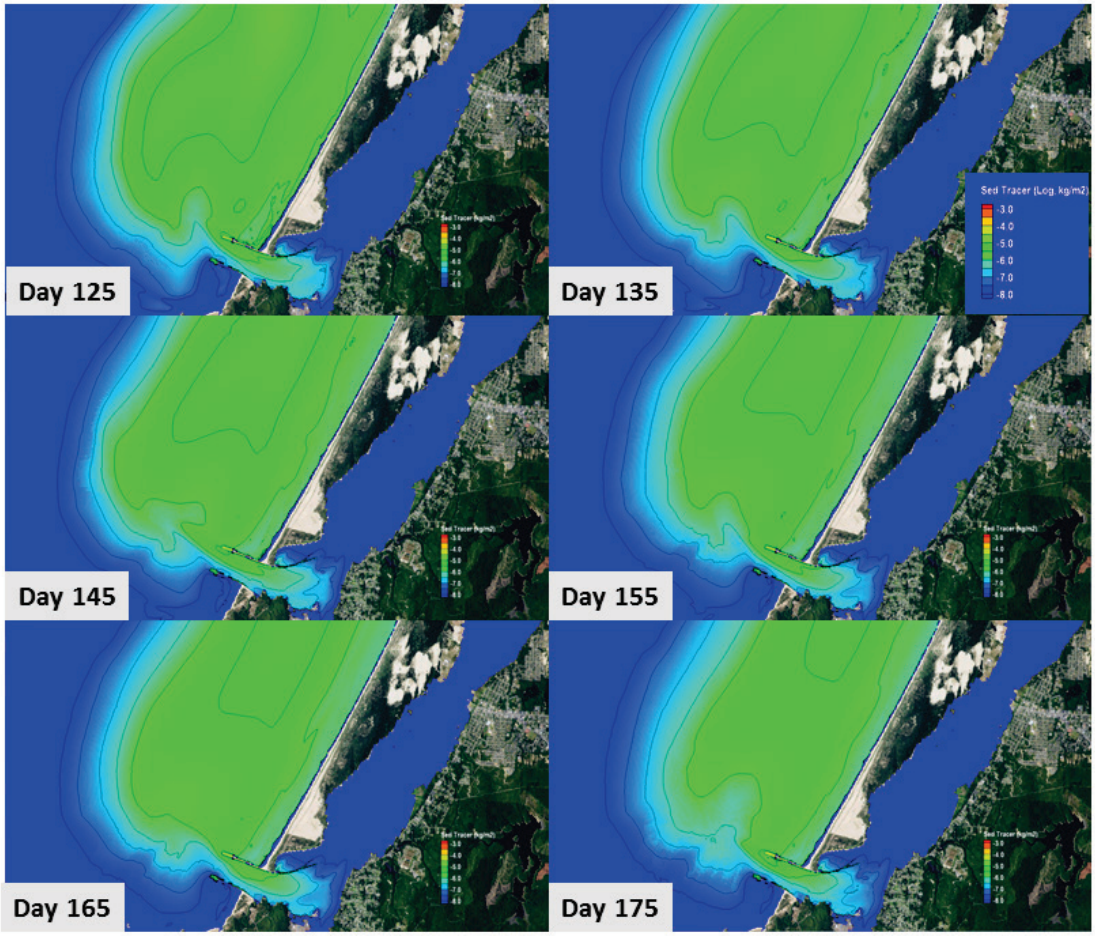


Figure 5-31. Concluded.



Corresponding to two rounds of samplings between 20 and 22 November 2015 and between 12 and 18 March 2016, the calculated results were analyzed on 23 November 2015 at 00:00 GMT and 16 March 2016 at 00:00 GMT. Figure 5-32 and Figure 5-33 show the sediment tracer distributions released at DZ-A on 23 November 2015 and 16 March 2016, respectively, and Figure 5-34 and Figure 5-35 at DZ-B, respectively.

Figure 5-32. Sediment tracer concentration for the DZ-A release on 23 November 2015.

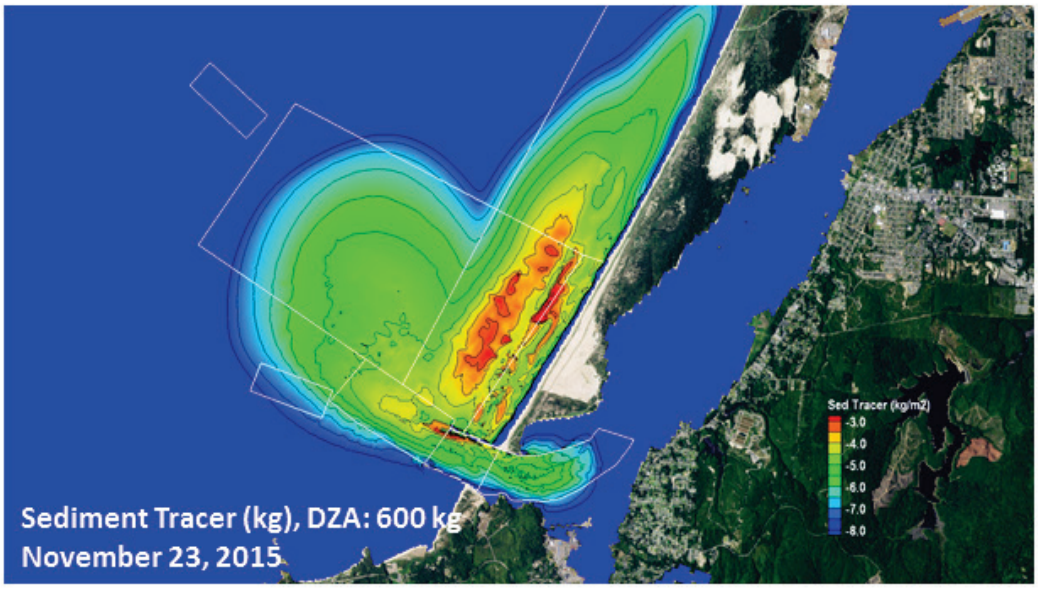


Figure 5-33. Sediment tracer concentration for the DZ-A release on 16 March 2016.

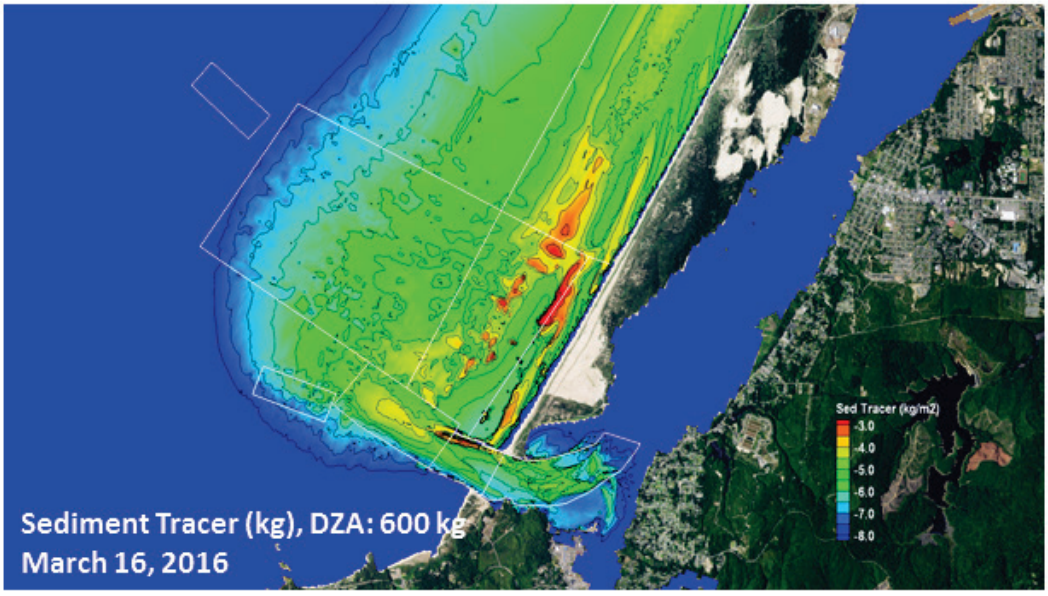


Figure 5-34. Sediment tracer concentration for the DZ-B release on 23 November 2015.

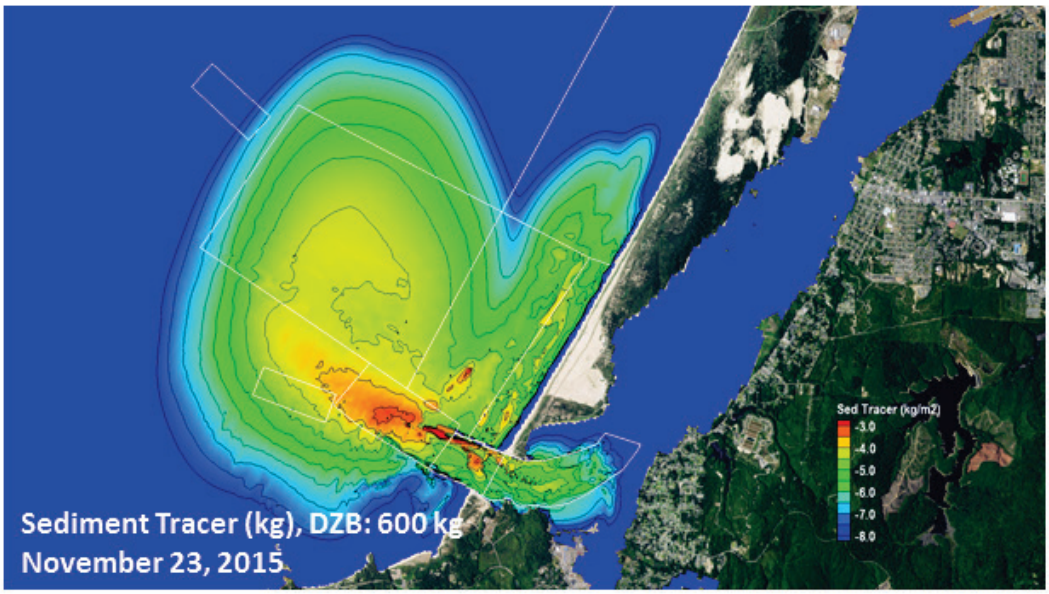
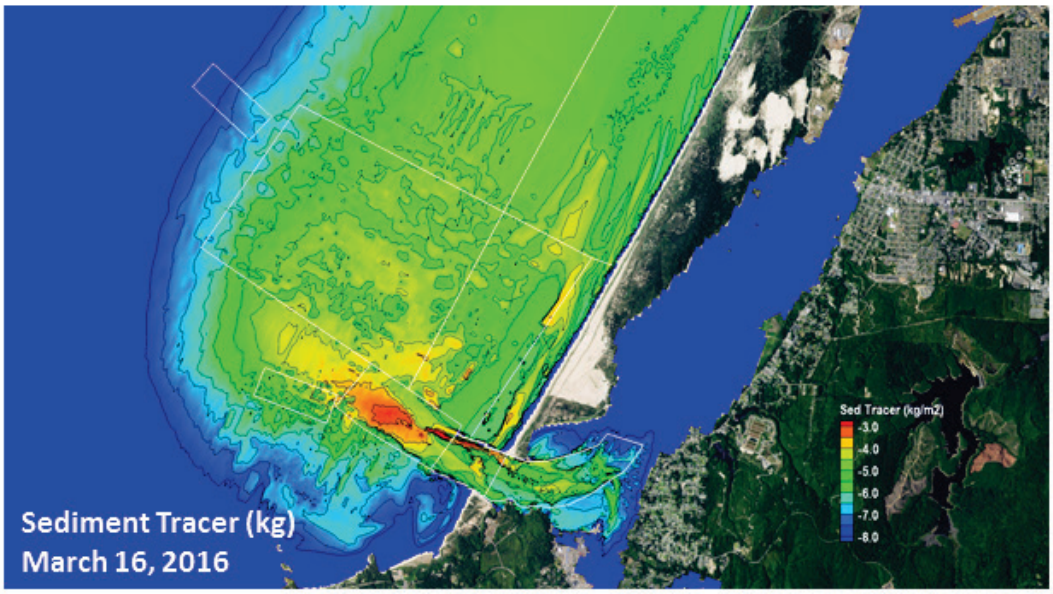


Figure 5-35. Sediment tracer concentration for the DZ-B release on 16 March 2016.



Quantitative sediment tracer tracking was also completed by estimating tracer mass within nine polygons encompassing the inlet and ODMDS F (Figure 5-28). Figure 5-36 and Figure 5-37 show the tracer mass distributions and the percentages relative to initial released 600 kg of tracer from DZ-A on 23 November 2015 and 16 March 2016, respectively, and Figure 5-38 and Figure 5-39 from DZ-B, respectively.

Figure 5-36. Sediment tracer mass distribution (kilogram/kg) and percentages relative to initial released 600 kg of tracer from DZ-A within nine polygons on 23 November 2015.

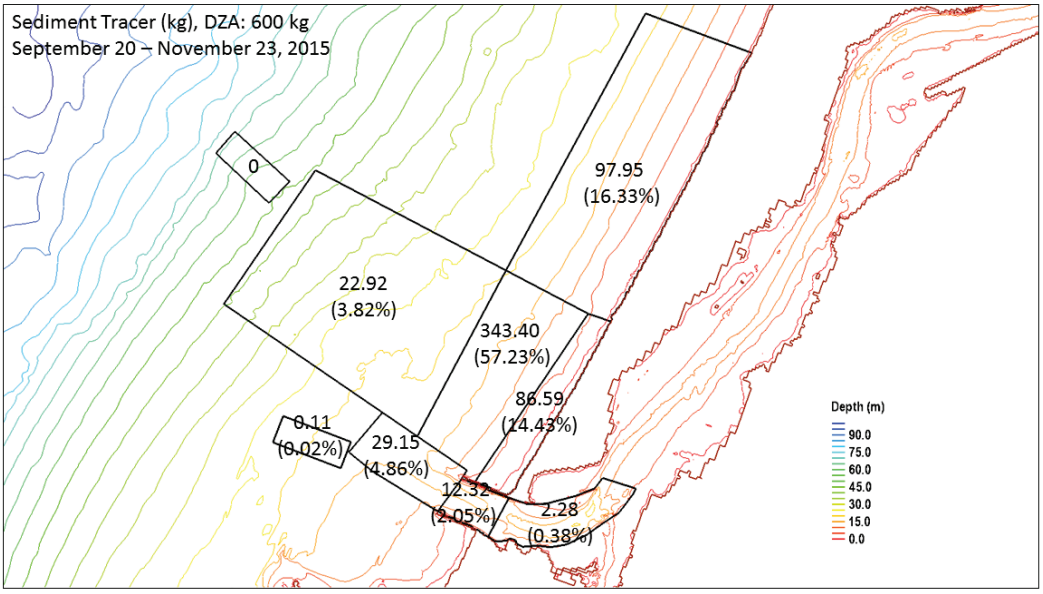


Figure 5-37. Sediment tracer mass distribution (kilogram/kg) and percentages relative to initial released 600 kg of tracer from DZ-A within nine polygons on 16 March 2016.

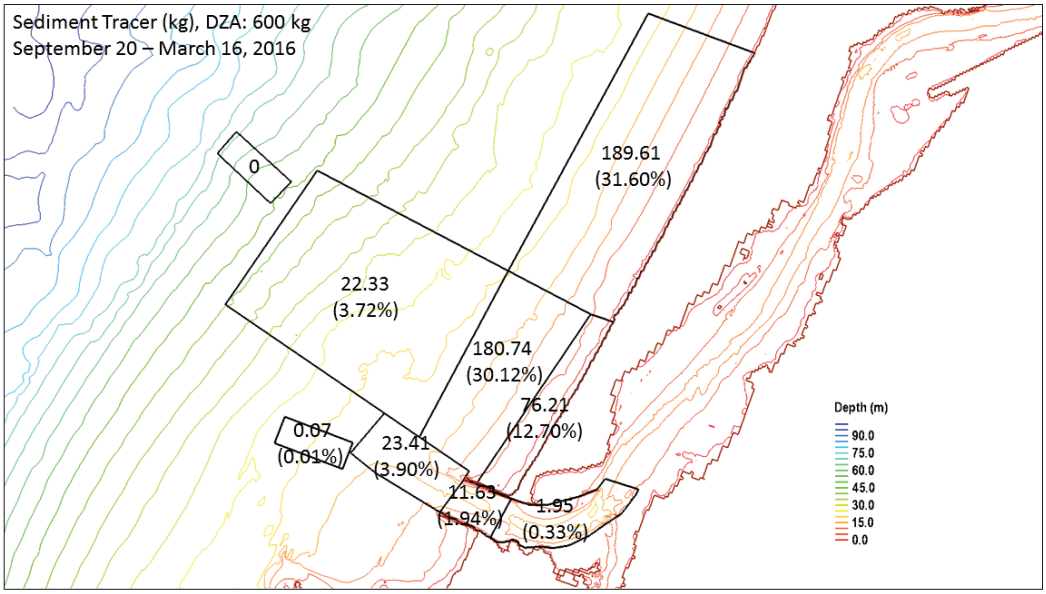


Figure 5-38. Sediment tracer mass distribution (kilogram/kg) and percentages relative to initial released 600 kg of tracer from DZ-B within nine polygons on 23 November 2015.

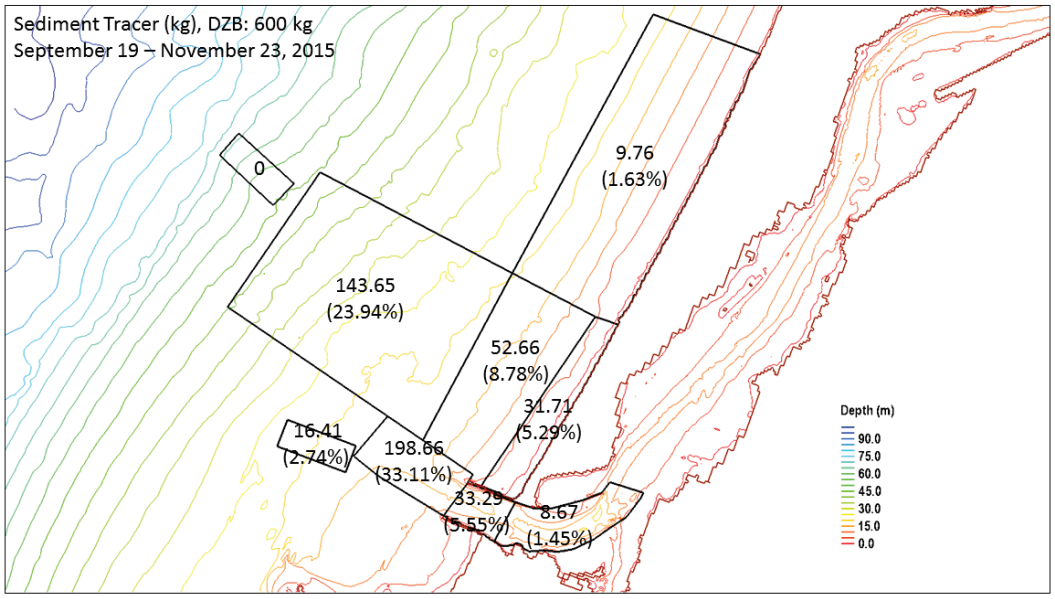
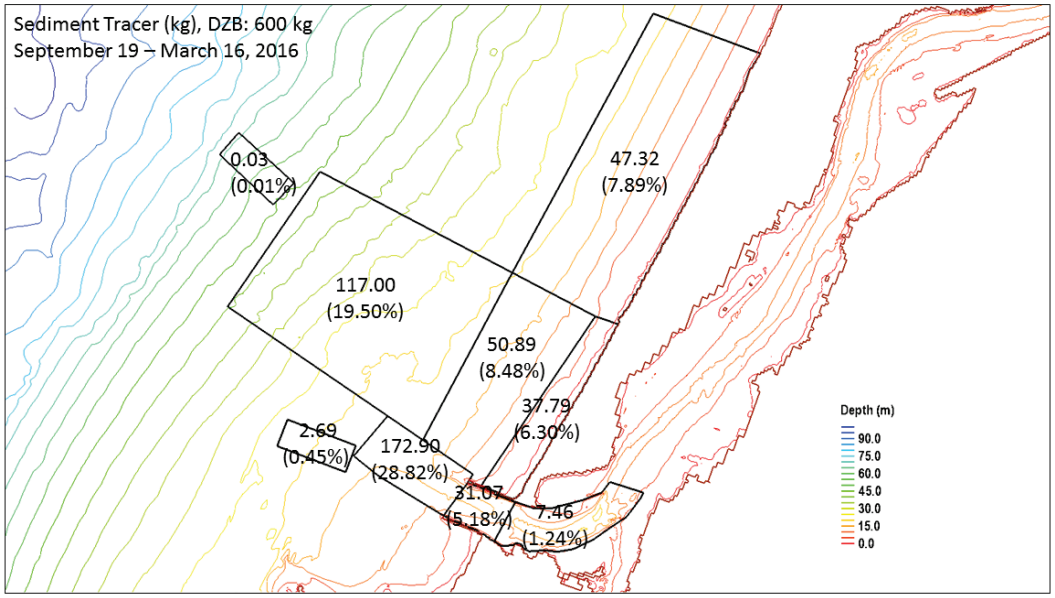


Figure 5-39. Sediment tracer mass distribution (kilogram/kg) and percentages relative to initial released 600 kg of tracer from DZ-B within nine polygons on 16 March 2016.



The sediment tracer distributions in Figure 5-32 and Figure 5-36 indicate that most of the sediment tracer stays adjacent to the DZ-A release site (more than 60%) and a small portion, approximately 9%, of tracer is moved to the inlet entrance around the north jetty and the inlet ebb shoal 2 months after the tracer release. Figure 5-33 and Figure 5-38 show a significant reduction of tracer counts in the nearshore area of ODMDS F

almost 6 months into tracking the tracer movement. In the nearshore polygon of ODMDS F, the total measured tracer mass was reduced to less than 30% of the initial released tracer. The inlet entrance and ebb shoal areas also show reduced tracer counts, and the tracer mass was reduced to 5%. Because southerly wind had been dominant from December 2015 to March 2016 (Figure 2-5), the sediment tracer moved alongshore to the north. The sediment tracer mass in the northern-most polygon increased from 9% on 23 November 2015 and to 23% on 16 March 2016. Only 3% of the sediment tracer released at DZ-A moved to the offshore area of ODMDS F, and less than 1% was measured in the bay polygon.

Compared with the DZ-A site, the DZ-B site is located closer to the inlet entrance (Figure 3-6), and the sediment tracer was released from DZ-B was 1 day earlier. The difference in tracer release time and location resulted in the difference in sediment tracer distributions as shown in Figure 5-34, Figure 5-35, Figure 5-37, and Figure 5-38. On 23 November 2015, approximately 40% of the sediment tracer was measured in the inlet entrance and the inlet ebb shoal areas, and less than 10% stayed near the release location. Additional tracer was transported to the offshore area and the bay area. Similar tracer dissipation occurred in areas of high tracer concentration in 23 November 2015 sampling were found to have greatly decreased on 16 March 2016. The tracer mass was reduced to less than 30% in the inlet entrance and approximately 16% in the offshore polygon. Sediment tracer spread parallel to shoreline towards the north; however, a limited amount of sediment tracer transported to the northeastern corner of the nearshore polygon area.

An attempt was made to compare the calculated sediment tracer distribution with that obtained from the tracer release and sampling program. Although the comparison has limitations related to tracer recovery rate, spatial sampling coverage, and superficial sampling, the comparisons still give a general idea of the transport trends and quantities. Figure 5-40 and Figure 5-41 show the measured tracer mass distributions of each area and the percentages relative to total recovered (measured) tracer mass within sampling-covered polygon areas for the DZ-A release on 23 November 2015 and 16 March 2016, respectively, and Figure 5-42 and Figure 5-43 for the DZ-B release, respectively.

Figure 5-40. Surveyed tracer mass distribution (kilogram/kg) and percentages relative to total mass in the Round 1 sampling area for the DZ-A release within nine polygons on 23 November 2015.

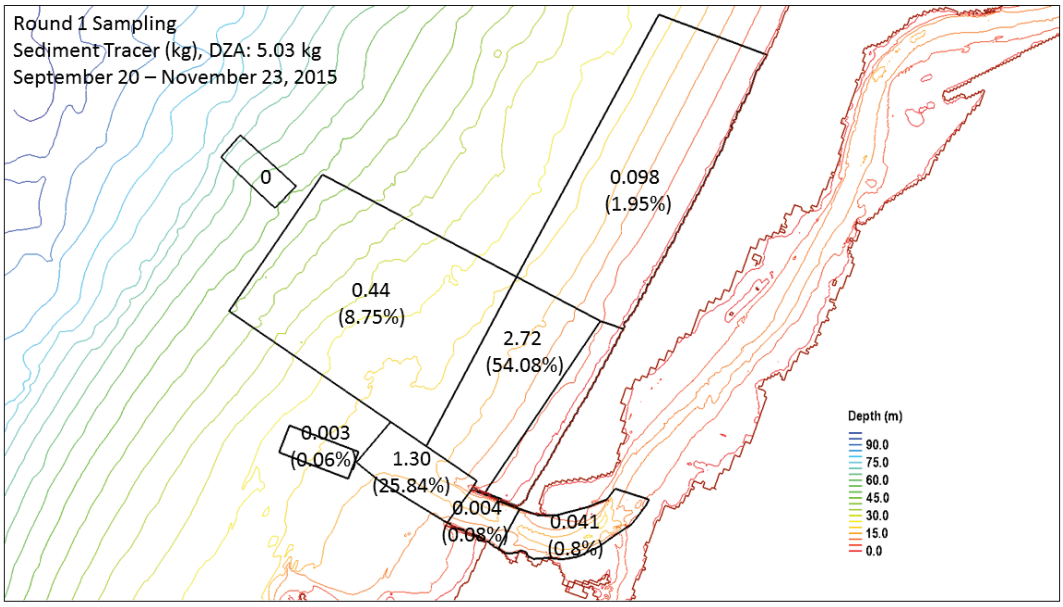


Figure 5-41. Surveyed tracer mass distribution (kilogram/kg) and percentages relative to total mass in the Round 2 sampling area for the DZ-A release within nine polygons on 16 March 2016.

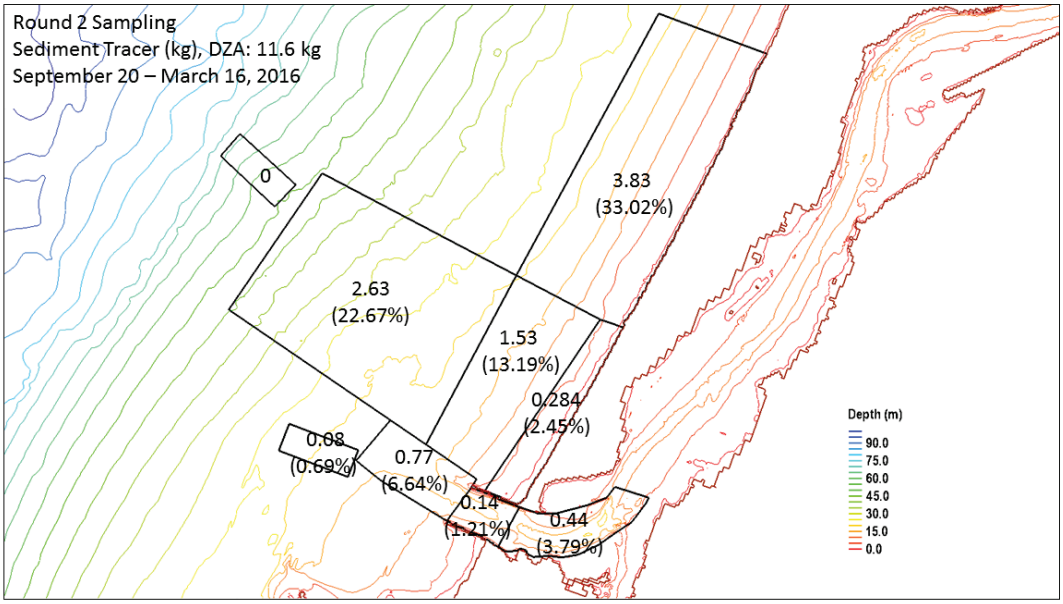


Figure 5-42. Surveyed tracer mass distribution (kilogram/kg) and percentages relative to total mass in the Round 1 sampling area for the DZ-B release within nine polygons on 23 November 2015.

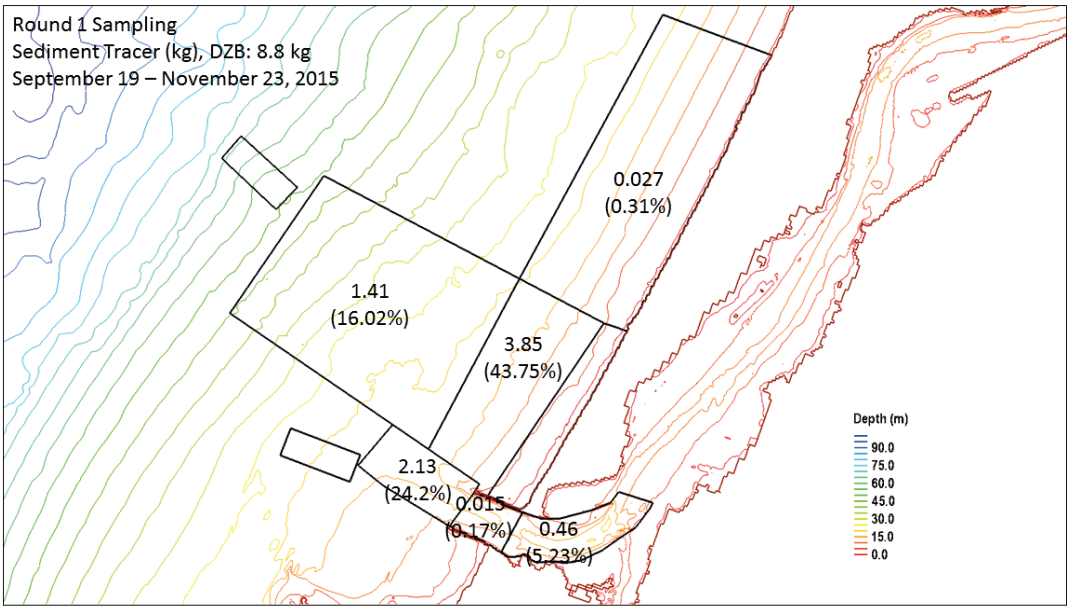
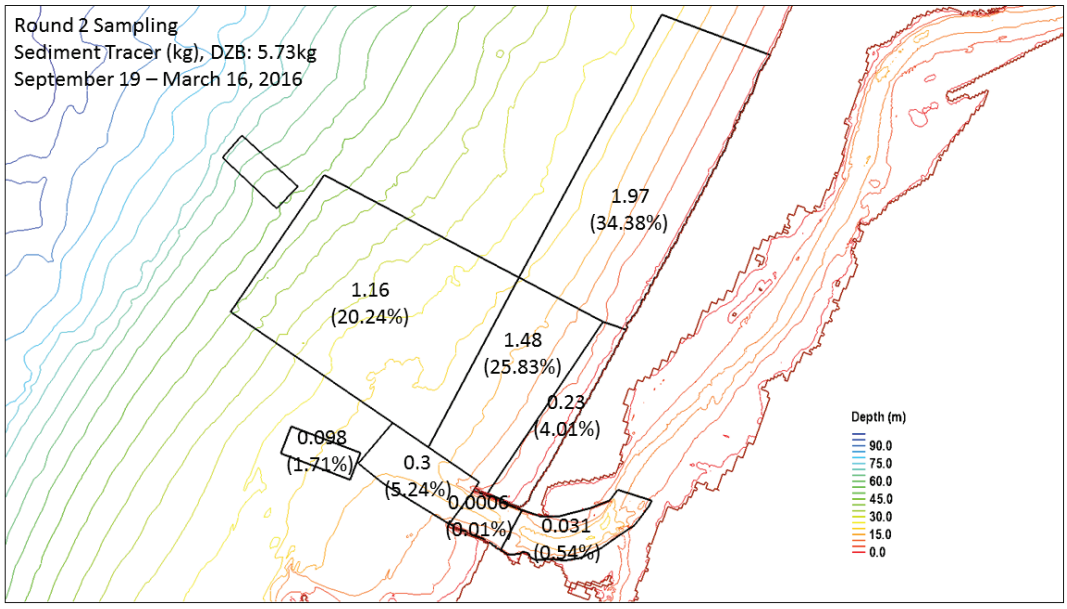


Figure 5-43. Surveyed tracer mass distribution (kilogram/kg) and percentages relative to total mass in the Round 2 sampling area for the DZ-B release within nine polygons on 16 March 2016.

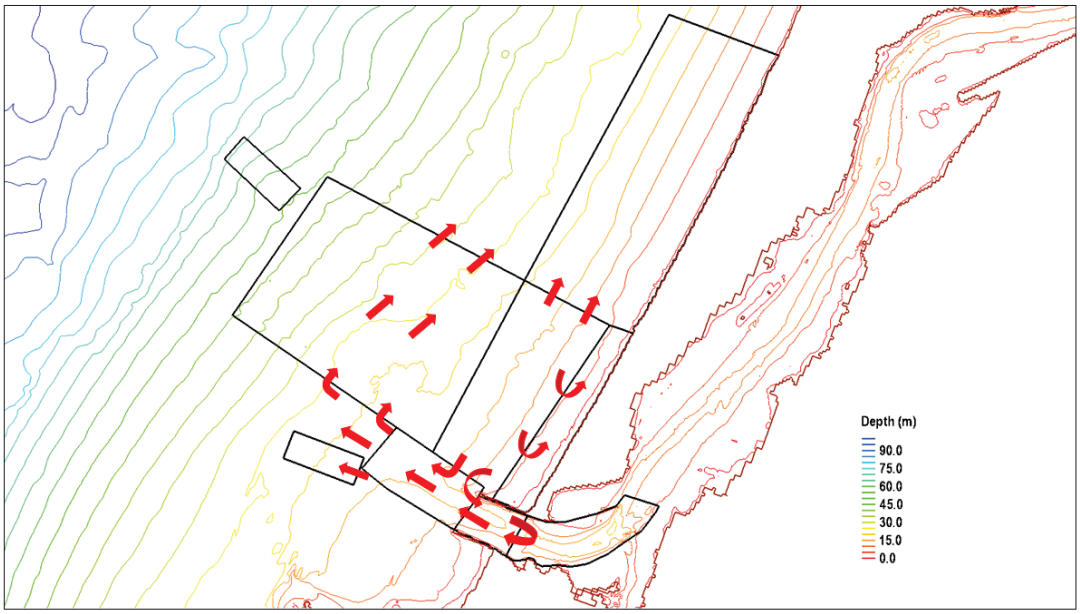


Within the polygons well covered by both Rounds 1 and 2 samplings, the measured tracer relative distributions are consistent with the calculated tracer distributions. The sediment tracer released from DZ-A was found in high concentrations in the nearshore release zone during the Round 1

sampling period, and the concentrations in the nearshore and in the inlet ebb shoal polygons show substantial reduction from the Round 1 to Round 2 sampling period. The measured high tracer concentration in the nearshore northern most polygon indicated longshore sediment movement towards the north. Model results also indicated that some tracer was buried within the sedimentation in the channel on 23 November 2015 but was flushed out on 16 March 2016 (Figure 5-32, Figure 5-33, Figure 5-34, and Figure 5-35). Sampling results show that the channel area has a much lower accumulation of tracer and that there was slightly more tracer was settled in the bay. Both tracer release locations resulted in increasing tracer concentrations in the offshore over time.

Based on the CMS and the tracer sampling results, Figure 5-44 shows a schematic map of potential sediment tracer pathways. After tracer was released within the nearshore of ODMDS F, the dominant direction of sediment tracer transport was towards the inlet entrance with moderate circulation across-shore and alongshore towards the north. On approach to the inlet, most of the tracer, and particularly the finer-sized sediments, was carried seaward and dispersed offshore by strong ebb currents. At the latter stages of the simulation period, in 3 to 6 months during the active winter season, the dominant southerly wind-directed tracer transport farther to the north across the offshore area of ODMDS-F.

Figure 5-44. Analyzed sediment tracer pathways around ODMDS F and the inlet entrance based on the CMS/PTM results and the sediment tracer field program.



5.3 PTM results

The PTM was used to simulate the first 2 months of tracer transport from the placement site. The following results show the pathway of the tracer, comparison of the overall foot print with field data at the end of the 2-month simulation, and finally a percentage of sediment transported for specific assessment areas, similar to that seen in the previous section detailing the CMS sediment mapping results. Final results are presented in Table 5-2 and Table 5-3, which shows the PTM, CMS, and surveyed tracer results.

5.3.1 Particle pathways

Figure 5-45 and Figure 5-46 show results from tracer DZB and DZA, respectively. Tracer DZB (orange) was placed on September 19. After 2 days, most of the particles remained very close to the initial location. There is slight transport towards the southern side of the placement area. Movement over the first week is towards the channel. Within the first month, a pattern of transport from north to south along the shoreline with some additional transport within the channel towards offshore occurs. This pattern appears to repeat itself until some material has moved out of the placement site at the end of the simulation.

Figure 5-45. Particle positions DZB.

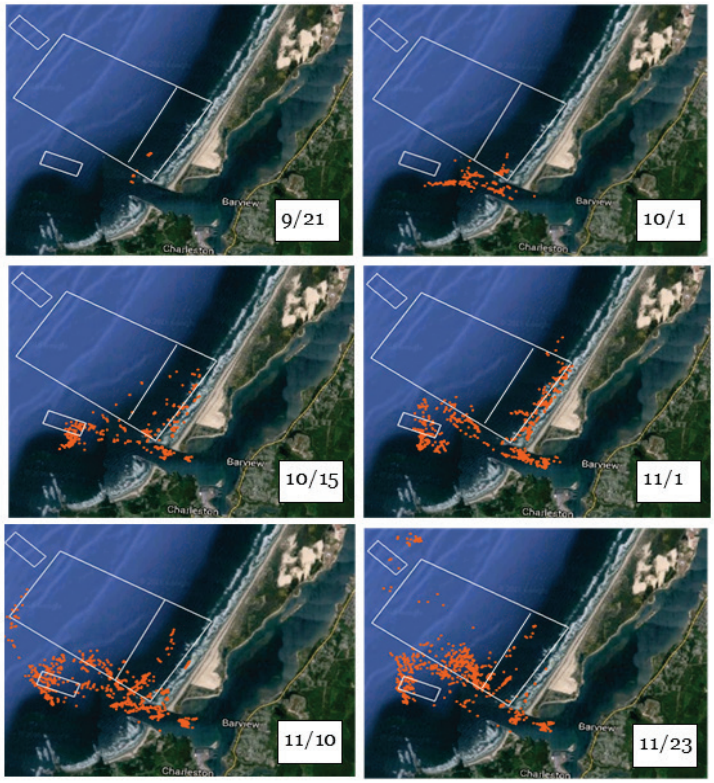
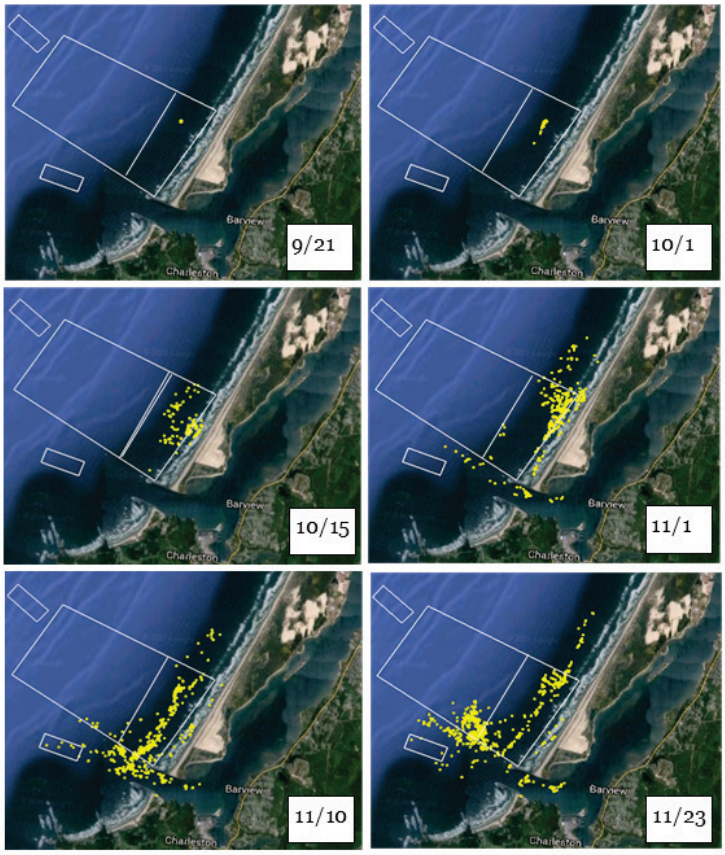


Figure 5-46. Particle positions DZA.

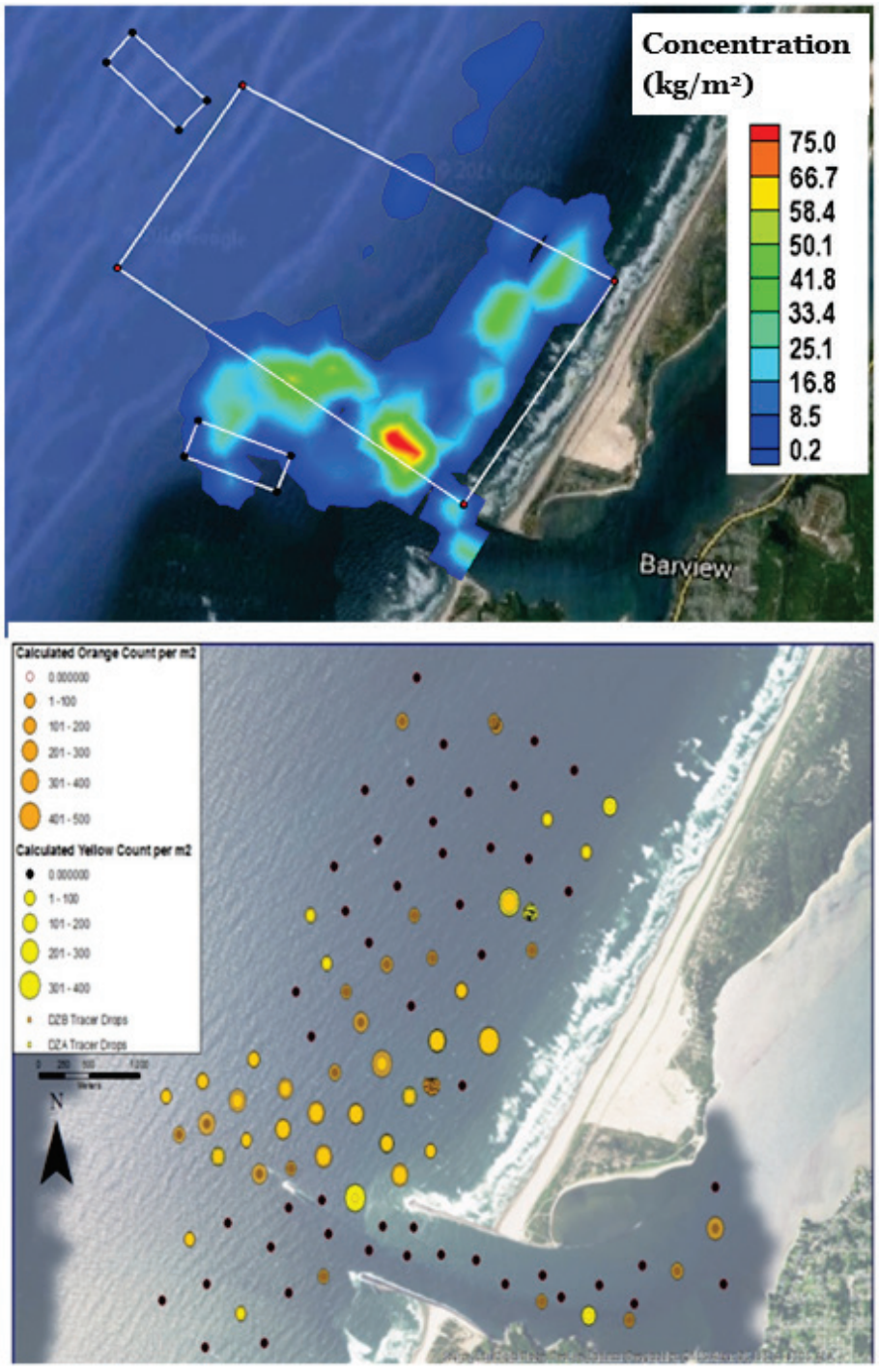


The DZA tracer (yellow) had a release time 1 day after the DZB tracer was released. Sediment transport was mostly confined to the area closest to shore of the placement site. Transport occurs primarily along the shoreline for the first month until some material is transported into the channel and then is subsequently flushed seaward.

Ultimately, these results show that through a qualitative examination of transport of placed material within the first month of placement, sediment particles remain primarily within the nearshore, and there are definitive pathways into the channel.

Figure 5-47 shows the footprint of the PTM sediment tracer spreading pattern in comparison to the field data sampling. The PTM contours of concentration show a similar overall footprint to the tracer sampling data and to the CMS results after 2 months. In the comparison, the largest amount of tracer appears to be parallel to the channel, a small portion of tracer is trapped in the channel, and there is also a significant amount that has spread within the nearshore region of the placement site.

Figure 5-47. PTM contours of concentration (kilograms per square meter) comparison to field data collection.



5.3.2 Particle percentages

The same regions of analysis used in the CMS modeling were used to analyze the PTM results (Figure 5-48). For the 2-month PTM simulation, the amount of simulated tracer that reached each analysis area was determined. Figure 5-49, Figure 5-50, and Figure 5-51 show the results for the DZA, DZB, and total sediment released, respectively. These results show that the majority of the DZA tracer (65%) remains in the lower portion of the placement site (region 7), potentially only spreading within that nearshore region. A significant percentage (18.2 %) moves into the offshore portion of the placement site (region 6), and a small amount makes it into the channel.

Figure 5-48. Sediment transport assessment areas 1 through 9.

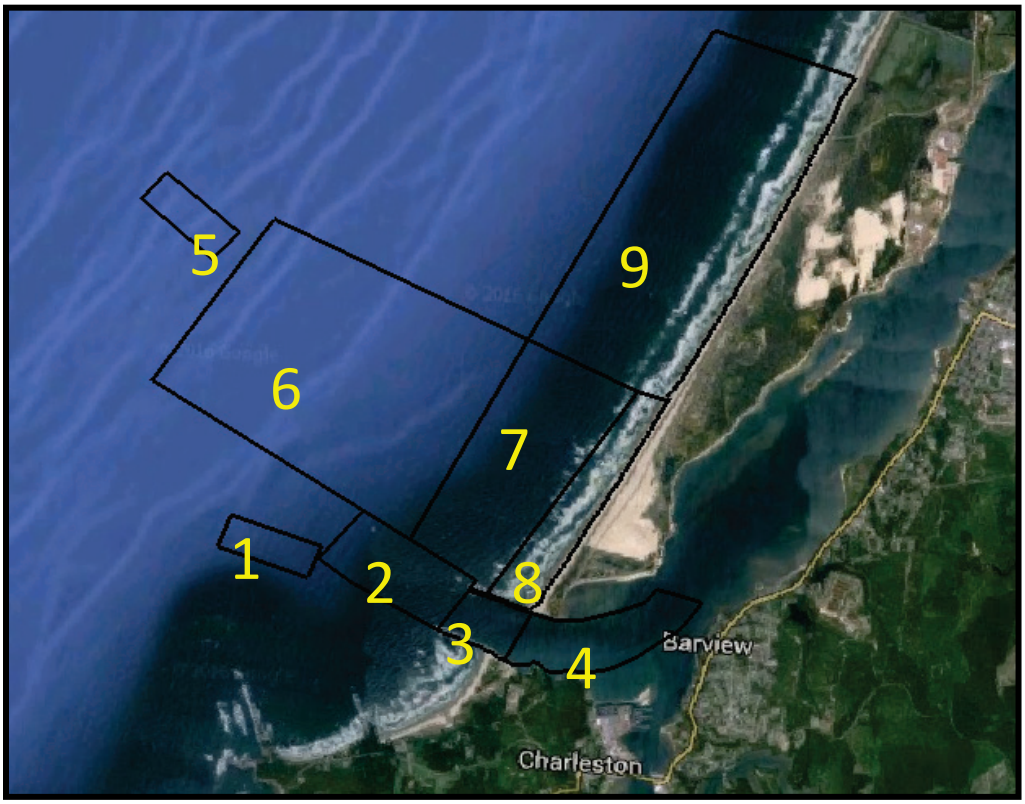


Figure 5-49. Sediment transport percentages (DZA) from PTM for 23 November 2016.

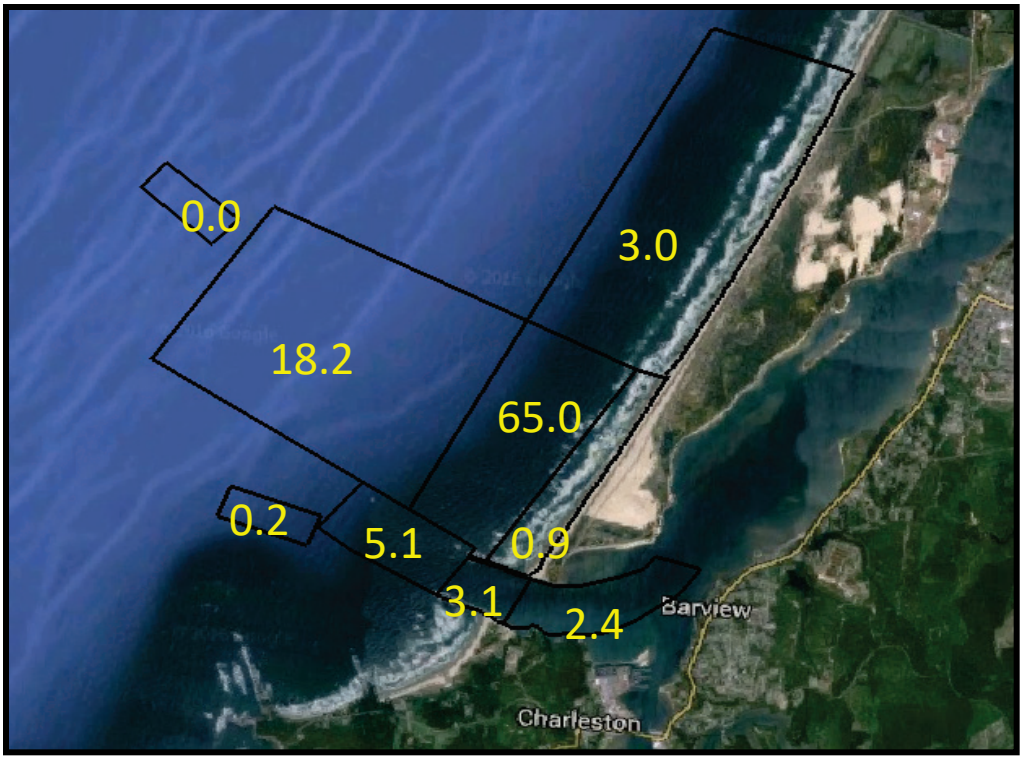
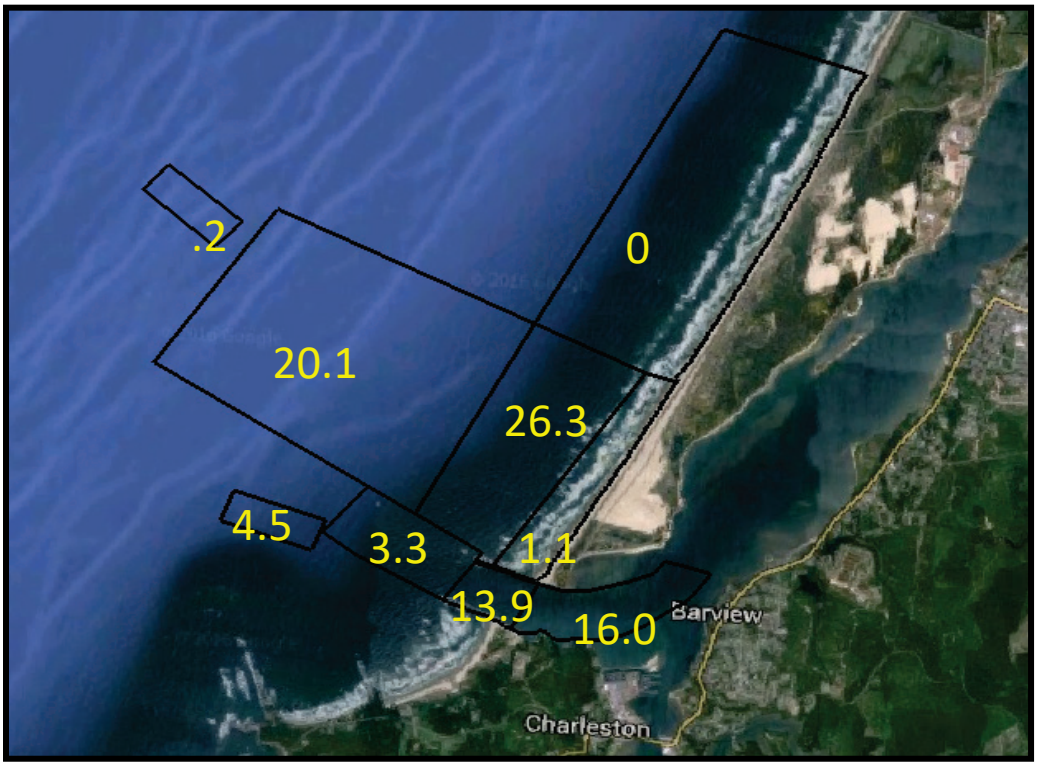


Figure 5-50. Sediment transport percentages (DZB) from PTM for 23 November 2016.



The DZB results show more transport as expected from the particle pathways results. Approximately half of the placed tracer stays at the placement site, but a significant amount is transported into the channel. Note that approximately 15% of the total placed mass did not reside in any of the defined regions after the 2-month period. Most of that material remained in areas between regions 1 and 6 and were therefore out of the boundaries of the analysis.

Figure 5-51. Sediment transport percentages (total) from PTM for 23 November 2015.

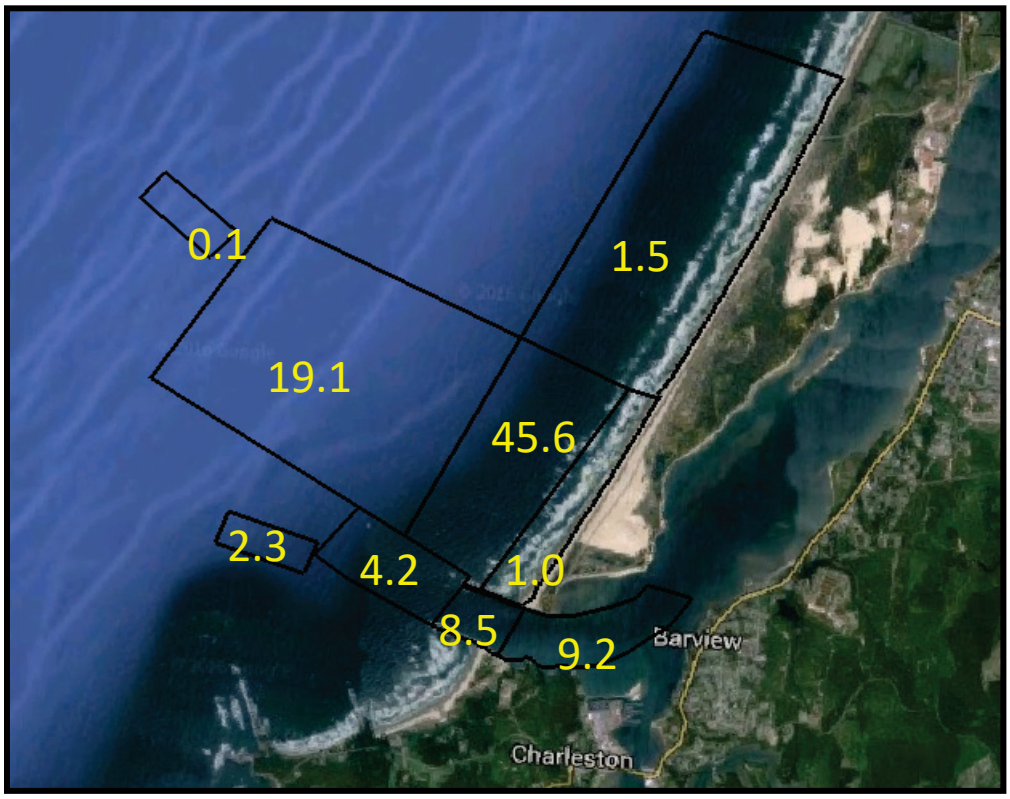


Figure 5-51 shows the total percentages of all the tracer (DZA+DZB) in each of the nine regions. Overall within the 2-month period, most of the tracer is predicted to remain at the placement site (67%). Approximately 23% of the material falls in to regions 2-4, which cover the channel from the immediate exterior through the interior of the inlet. A small percentage (2.5%) was predicted to spread farther along the coast towards the north or along the beach. The values of mass corresponding to those percentages are shown in Table 5-2. Note that because the model potentially overpredicts the total amount of sediment entering the water column, these values are significantly larger than the field data results. Therefore, percentages are a more useful method of comparison.

Table 5-2. Distribution of sediment mass results from PTM for 2 months. Region numbers are in parentheses.

Area	Mass DZA (kg)	Mass DZB (kg)	Mass Total (kg)
E (1)	1.2	26.7	28.0
EBB SHOAL (2)	30.8	19.9	50.6
CHANNEL (3)	18.6	83.5	102.1
BAY (4)	14.6	96.0	110.6
H (5)	0.0	1.2	1.2
OFFSHORE F (6)	109.0	120.3	229.3
NEARSHORE F (7)	390.1	157.6	547.7
SURF ZONE (8)	5.3	6.5	11.7
NEARSHORE NORTH (9)	17.8	0.0	17.8
Total Area	587.4	511.7	1099.1

Table 5-3 shows the percentages of sediment found in each area based on the PTM results, CMS results, and Survey for DZA, and DZB. Overall comparison shows that for both models and the survey results, the majority of the tracer remains in the placement areas (Regions 6 and 7) and that a significant portion also goes into the channel (Regions 2-4). The models appear to differ regarding the amount of material that deposits along the beach in Region 8. The CMS model shows a percentage more in alignment with the survey results. However, PTM shows more agreement with the amount of material that is transported alongshore to Region 9.

Table 5-3. Percentage of placed sediment in 2 months. Region numbers are in parentheses, and the dash sign indicates that the area is not covered by the sampling program.

Area	%DZA			%DZB		
	PTM	CMS	Survey	PTM	CMS	Survey
E (1)	0.2	0.02	0.06	4.5	2.43	0
EBB SHOAL (2)	5.1	4.75	25.84	3.3	35.22	24.2
CHANNEL (3)	3.1	0.29	0.08	13.9	4.53	0.17
BAY (4)	2.4	0.35	0.8	16.0	1.16	5.23
H (5)	0.0	0	-	0.2	0.01	-
OFFSHORE F (6)	18.2	3.69	8.75	20.1	28.56	16.02
NEARSHORE F (7)	65.0	65.75	54.08	26.3	7.89	43.75
SURF ZONE (8)	0.9	14.11	-	1.1	2.70	2.7
NEARSHORE NORTH (9)	3.0	8.9	1.95	0.0	0.38	0.31
Total % in all areas	97.9	97.86	91.56	85.3	82.88	92.38

6 Conclusions

With the implementation of a field sediment tracer study, a coupled wave, hydrodynamic, sediment transport modeling system (Coastal Modeling System [CMS]) and a Lagrangian particle tracking model (PTM) were applied to investigate sediment tracer movement after the placement of material in the nearshore zone of an ocean dredged material disposal site (ODMDS F) adjacent to Coos Bay Inlet, OR. Field data collection included the deployment of water level and current sensors within the channel and estuary, waves and current within the nearshore, and sediment samples analyzed for tracer quantities across the study area. Driven by tide, waves, wind, and river discharge, the CMS simulations include a 30-day calibration, an 80-day validation for hydrodynamics and waves, a 7-month validation for morphology change, and a 6-month production run corresponding to the sediment tracer study time period. The PTM simulations were also conducted to evaluate sediment transport pathways for a 2-month production run corresponding to the sediment tracer study. From the CMS/PTM application in this high-energy coastal location, the major findings are as follows:

1. Field data collection is an integral component to the successful implementation of the two numerical models, CMS and PTM, and to properly validate the physical forces driving sediment transport along the coastal zone at Coos Bay. Tidal flushing of Coos Bay Inlet was captured through spatial and temporal field data collection of water levels and current fields across the nearshore and inlet/bay area elucidating the magnitude and spatial patterns of ebb and flood currents. Nearshore waves and vertically averaged currents collected near the ODMDS F-NS placement site provided a strong validation for numerical simulation of sediment entrainment and transport potential. Sediment grain size distribution and tracer counts provided specific sedimentologic events to track within a numerical simulation to validate pathways and rates of movement.
2. The CMS calibration and validation results demonstrate the model's capability to simulate waves, current, WSE, sediment transport, and morphology changes in the coastal estuarine environment. Primary driving forcing in the Coos Bay Inlet system is tide, wind, and waves. Tidal currents are the dominant flow component in the bay, and storm-/wave-driven currents are dominant in the open ocean area. River discharges have a significant contribution to residual current during

the seasonal high flow period but generally play a relatively weak role in hydrodynamics and nearshore sediment transport.

3. The calibration of the CMS provided a close representation of the primary physical forcing factors that drive sediment transport in the nearshore zone at Coos Bay Inlet. The validation to morphology demonstrated the model's capability to calculate similar volumetric changes and sedimentation patterns within the navigation channel, particularly the shoaling pattern at the north jetty tip.
4. The sediment mapping feature in the CMS shows its promising performance in simulating sediment tracer tracking and helping identify sediment transport pathways. The sediment tracer pathways analyzed in the study correspond to the specific wave and wind forcing conditions during the selected simulation period, and the results might vary for different wave, hydrodynamic, atmospheric, and environmental forcing.

Comparisons of the CMS/PTM results and the sediment tracer sampling data indicate that the sediment tracer placed within the nearshore zone of ODMDS F moved towards the inlet entrance area at the initial stage of the release. A small portion of the tracer was captured within the area of regular sedimentation within the navigation channel. However, most tracer became entrained in the tidal flow within the inlet and tracer results identified offshore transport by strong ebb currents and deposition seaward of the navigation channel. Three months into the simulation, during the high-energy winter months, the sediment tracer distributions indicated northward transport along the deeper areas of the ODMDS F site due to strong dominant southerly wind conditions. This deeper water transport was validated by distal samples collected along the mid-reach of ODFMDS-F.

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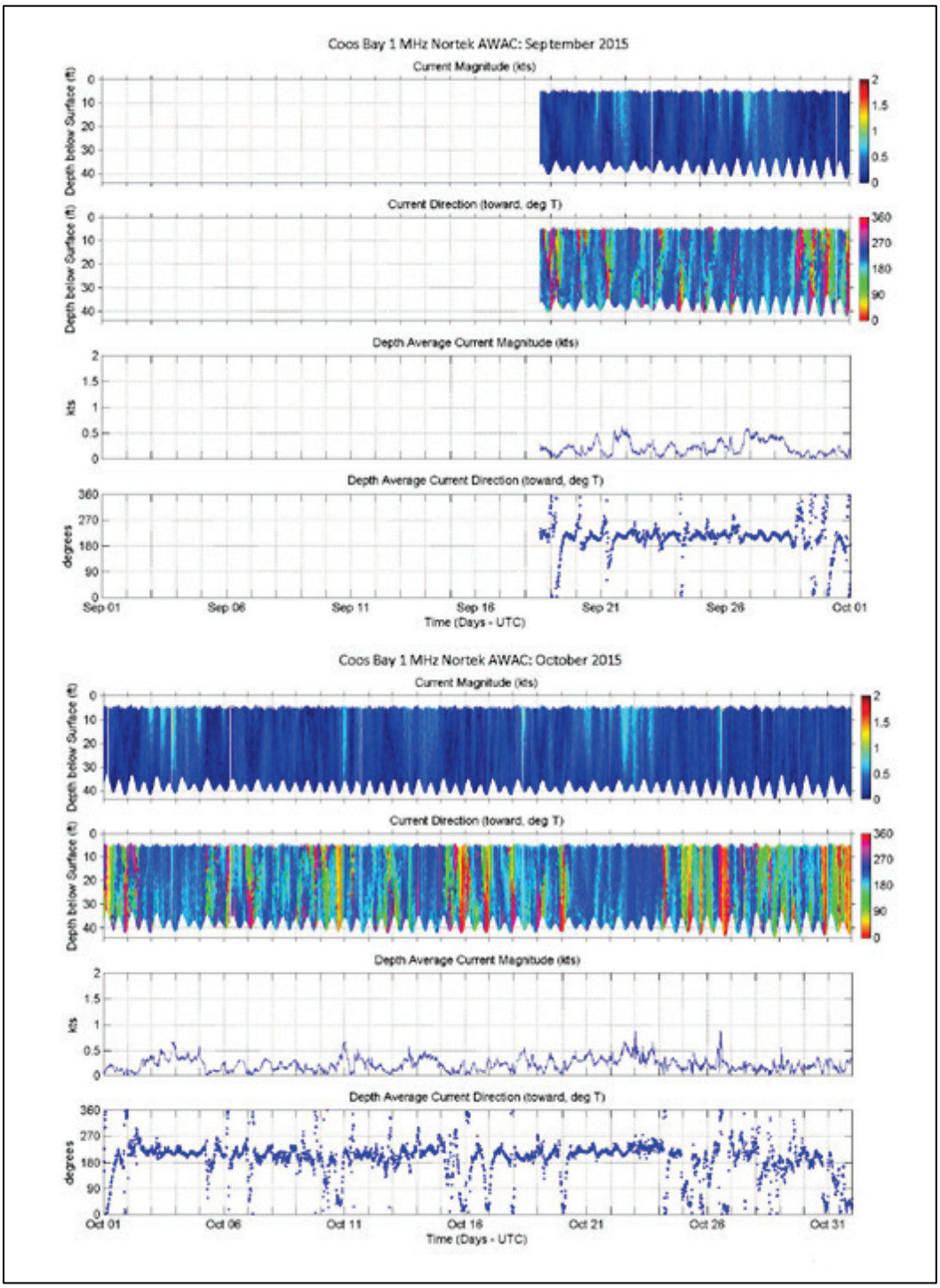
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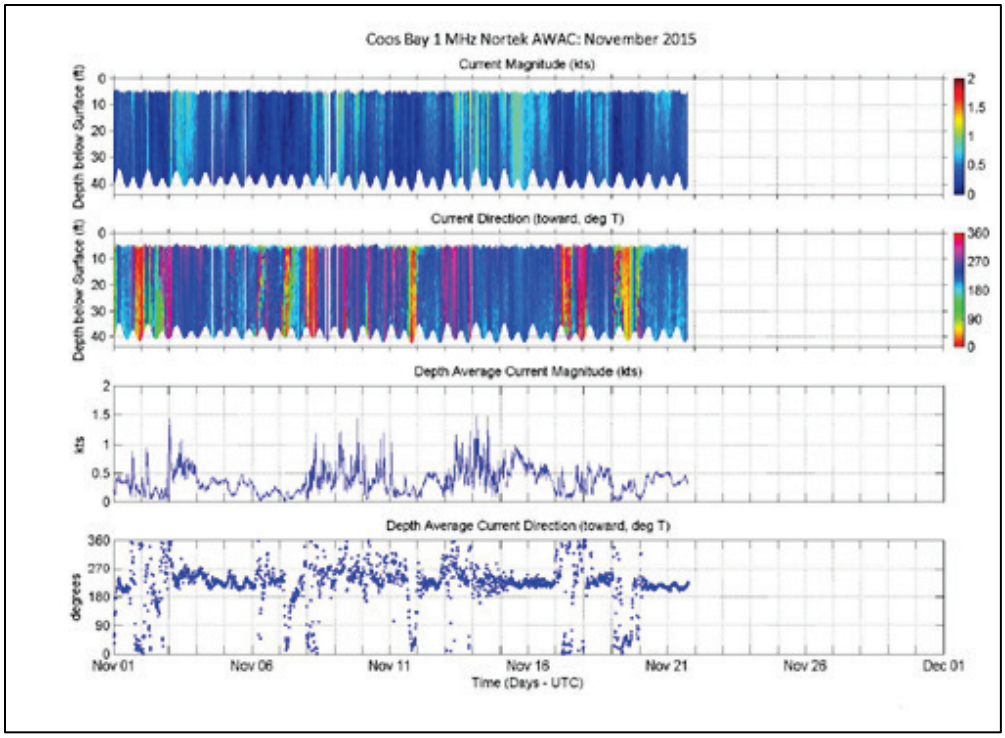
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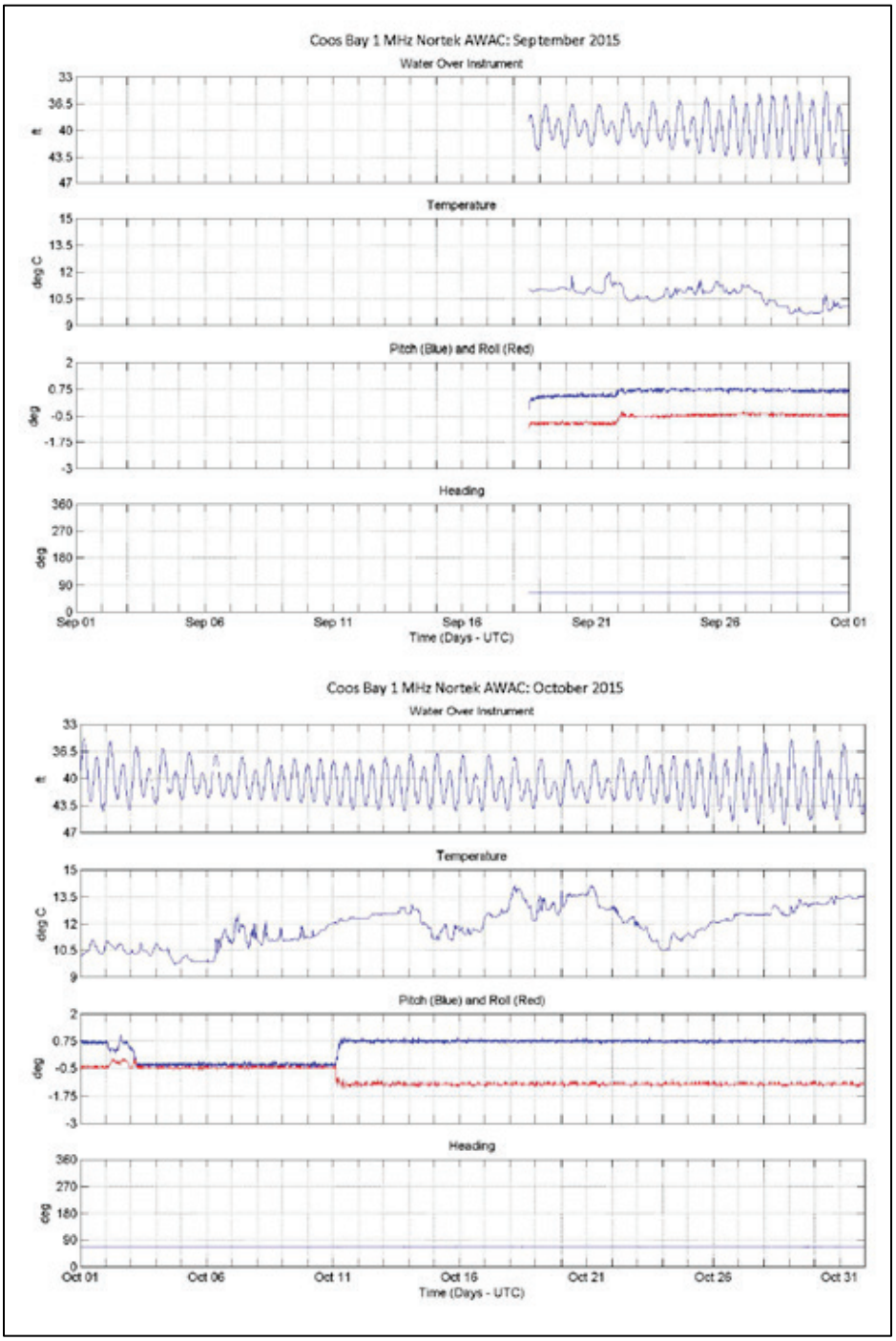
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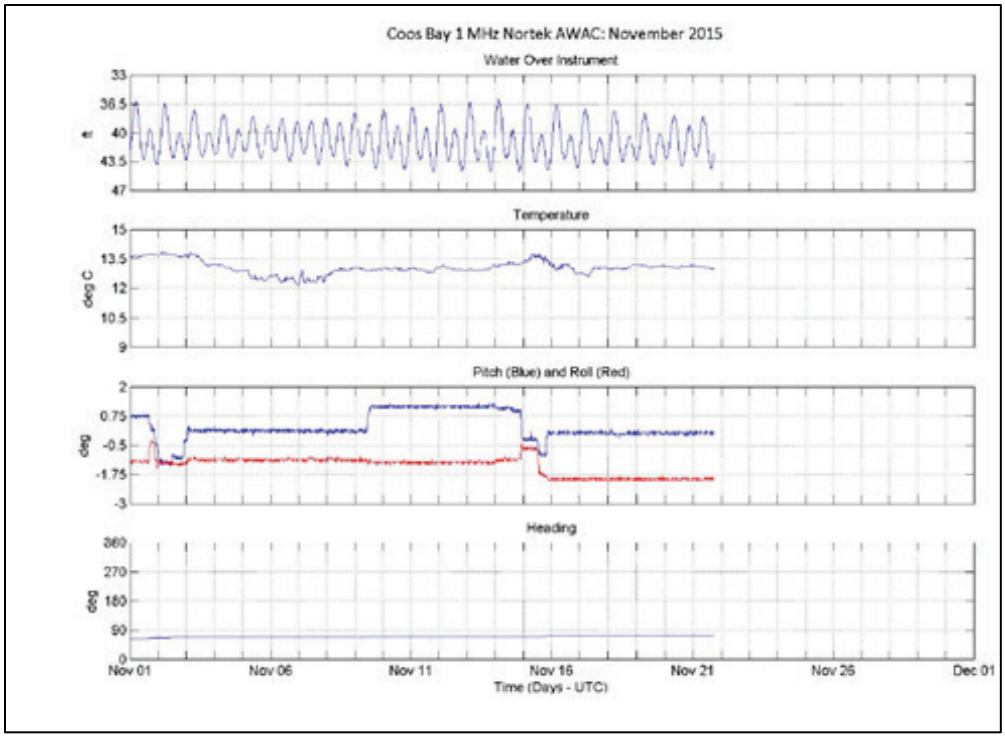
Appendix A: Plots of Current Data from Acoustic Wave and Current Profiler (AWAC)

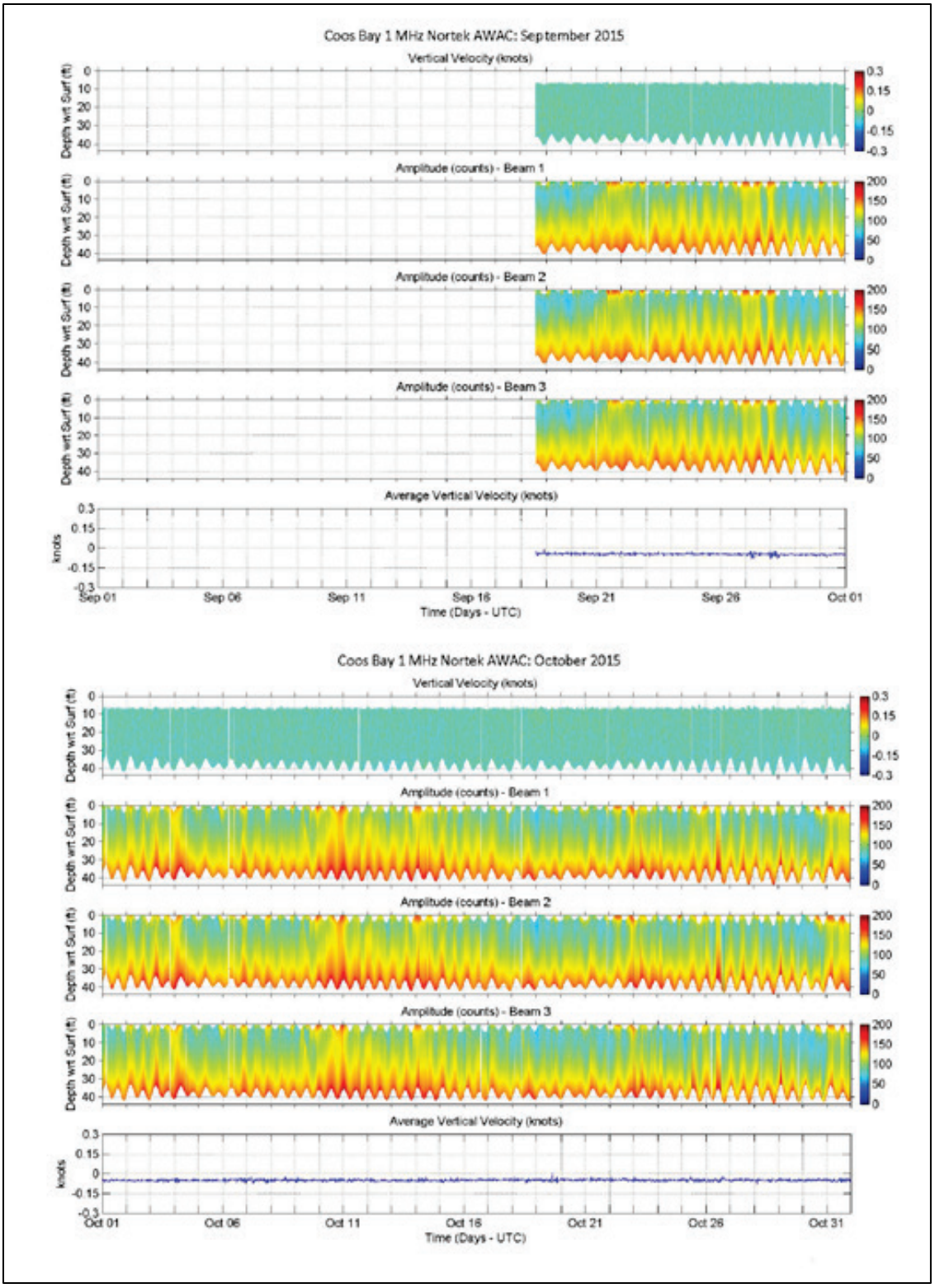


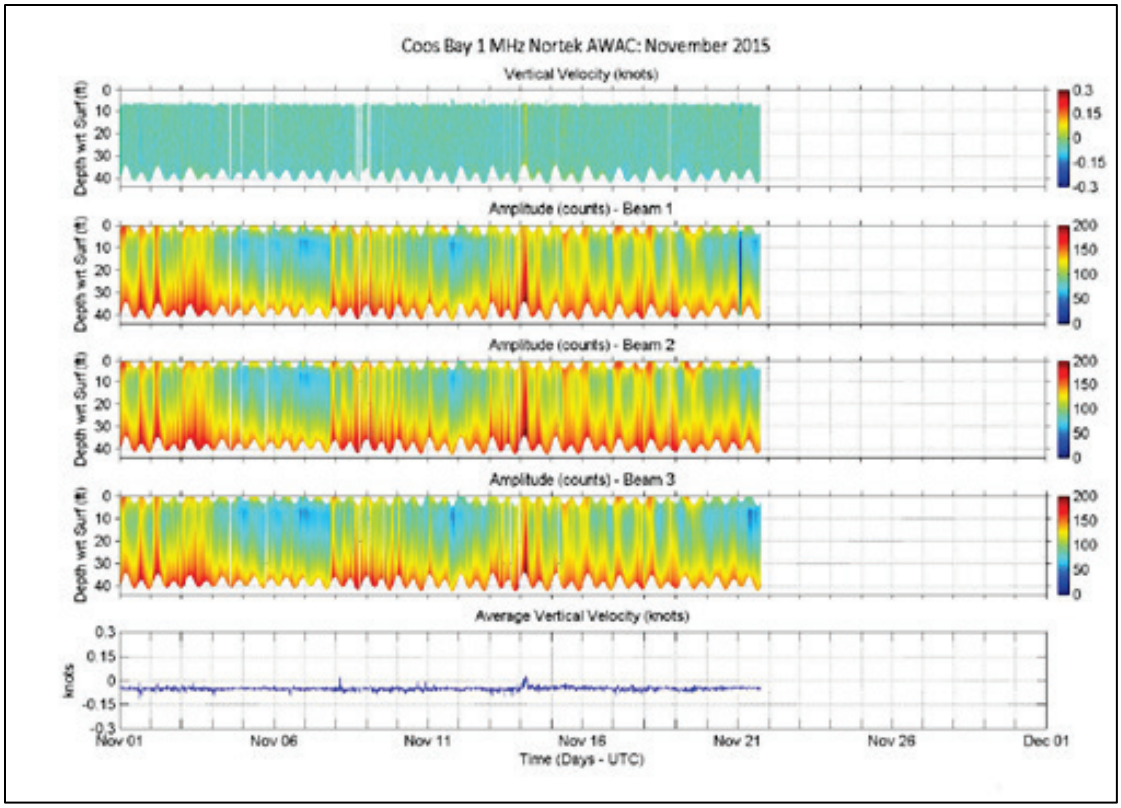

Coos Bay 1 MHz Nortek AWAC: November 2015
Current Magnitude (kts)
Depth below Surface (ft)
Current Direction (toward, deg T)
Depth below Surface (ft)
Depth Average Current Magnitude (kts)
kts
Depth Average Current Direction (toward, deg T)
degrees
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

Appendix B: Plots of Data Quality Parameters and Ancillary Data from AWAC

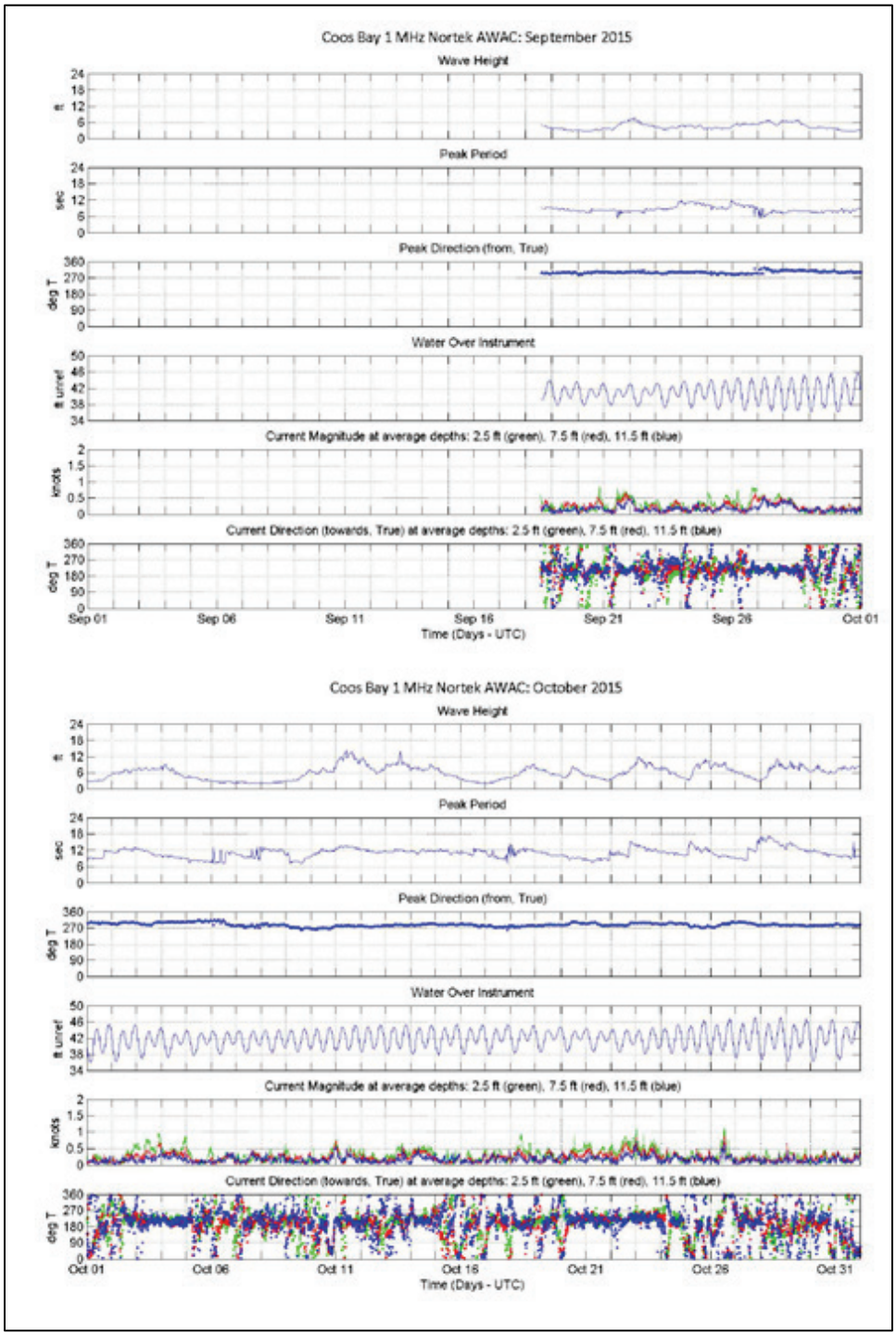


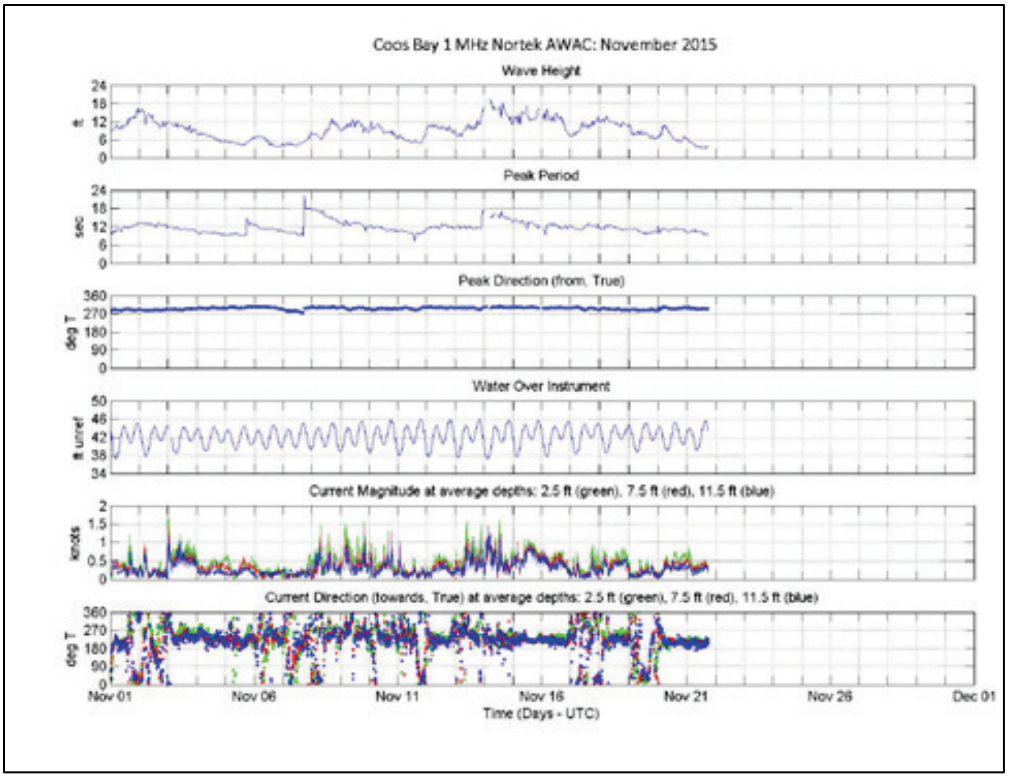

Coos Bay 1 MHz Nortek AWAC: November 2015
Water Over Instrument
33
36.5
40
43.5
47
Temperature
deg C
15
13.5
12
10.5
9
Pitch (Blue) and Roll (Red)
deg
2
0.75
-0.5
-1.75
-3
Heading
deg
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)


Coos Bay 1 MHz Nortek AWAC: September 2015
Vertical Velocity (knots)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
Depth wrt Surf (ft)
knots
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Time (Days - UTC)
Coos Bay 1 MHz Nortek AWAC: October 2015
Vertical Velocity (knots)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
Depth wrt Surf (ft)
knots
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)

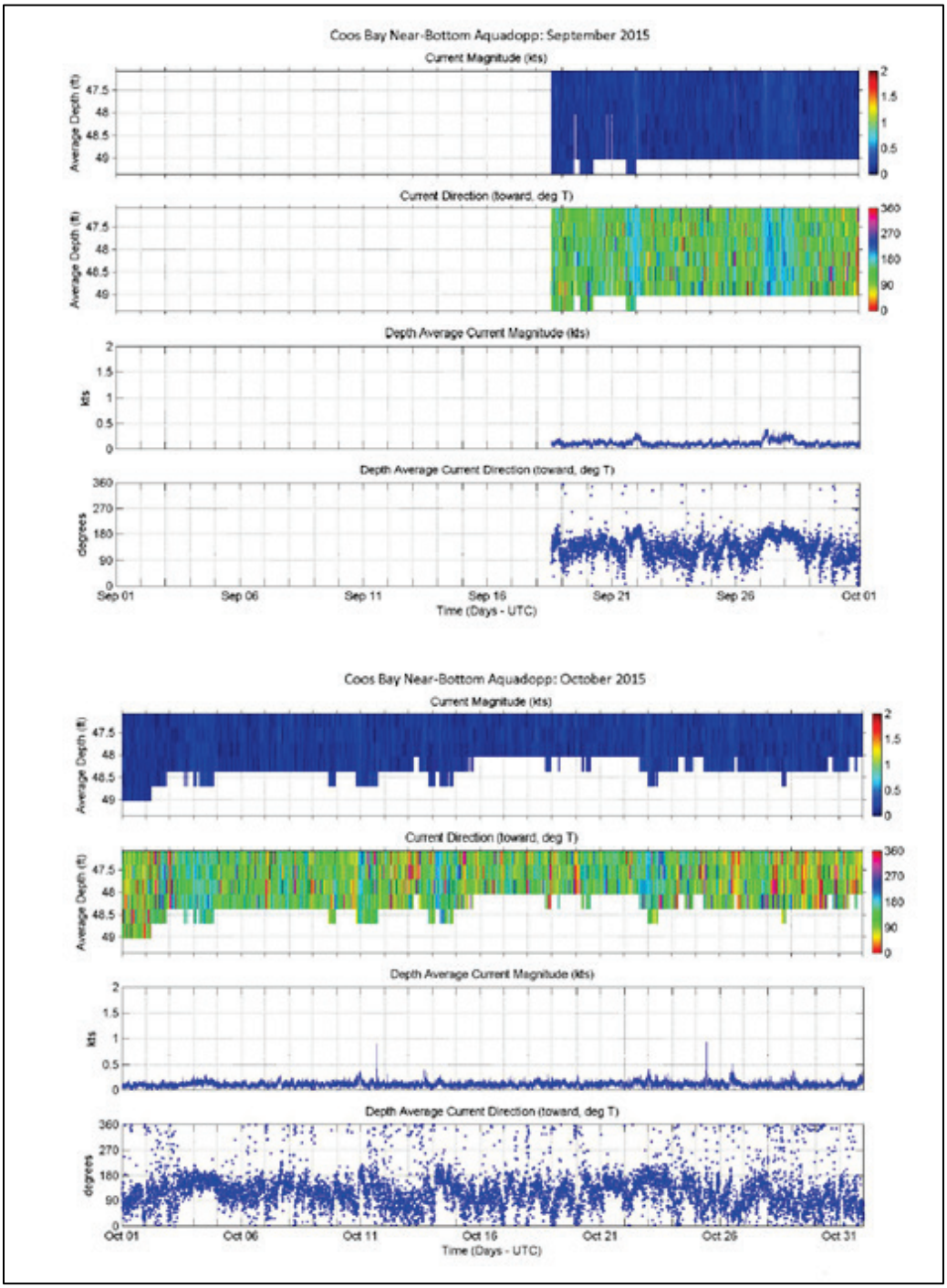

Coos Bay 1 MHz Nortek AWAC: November 2015
Vertical Velocity (knots)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
Depth wrt Surf (ft)
knots
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

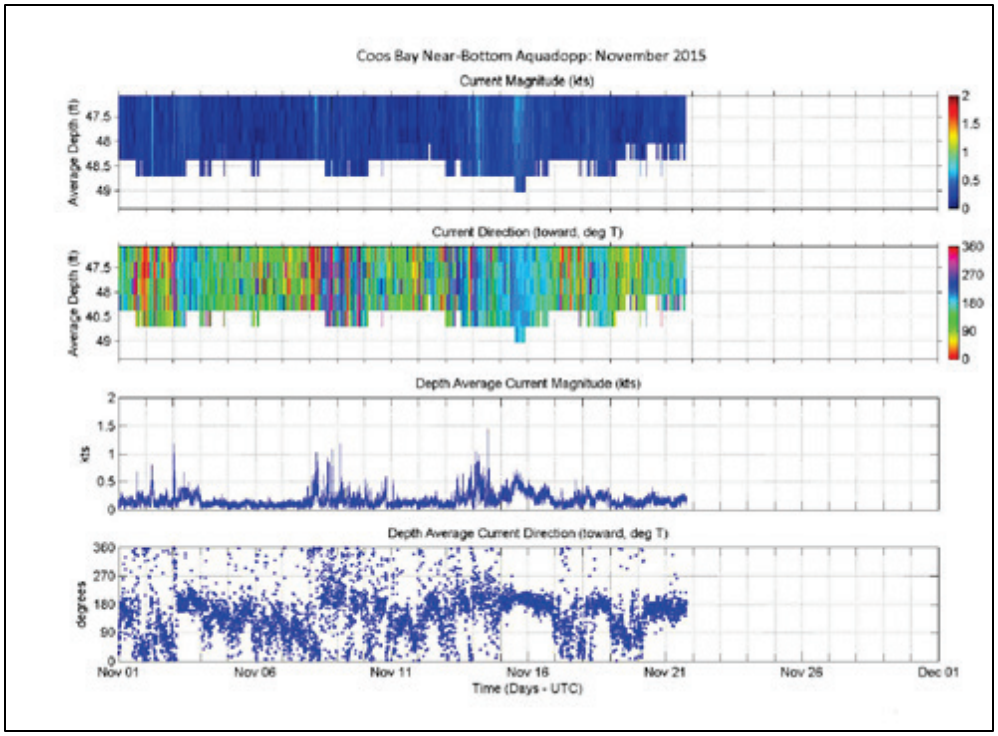
Appendix C: Plots of Time Series Wave Data from AWAC



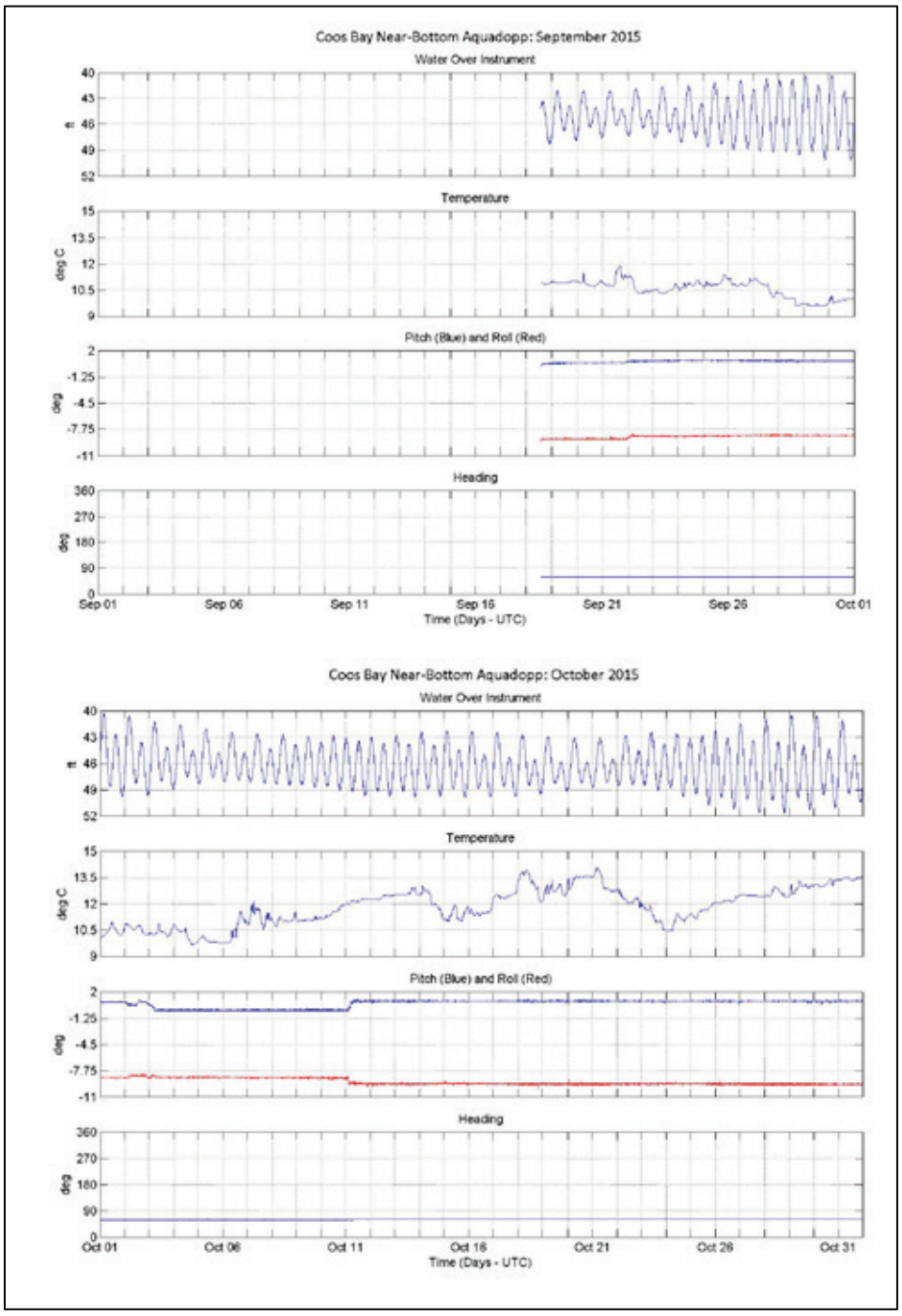

Coos Bay 1 MHz Nortek AWAC: November 2015
Wave Height
ft
Peak Period
sec
Peak Direction (from, True)
deg T
Water Over Instrument
ft ussref
Current Magnitude at average depths: 2.5 ft (green), 7.5 ft (red), 11.5 ft (blue)
knots
Current Direction (towards, True) at average depths: 2.5 ft (green), 7.5 ft (red), 11.5 ft (blue)
deg T
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

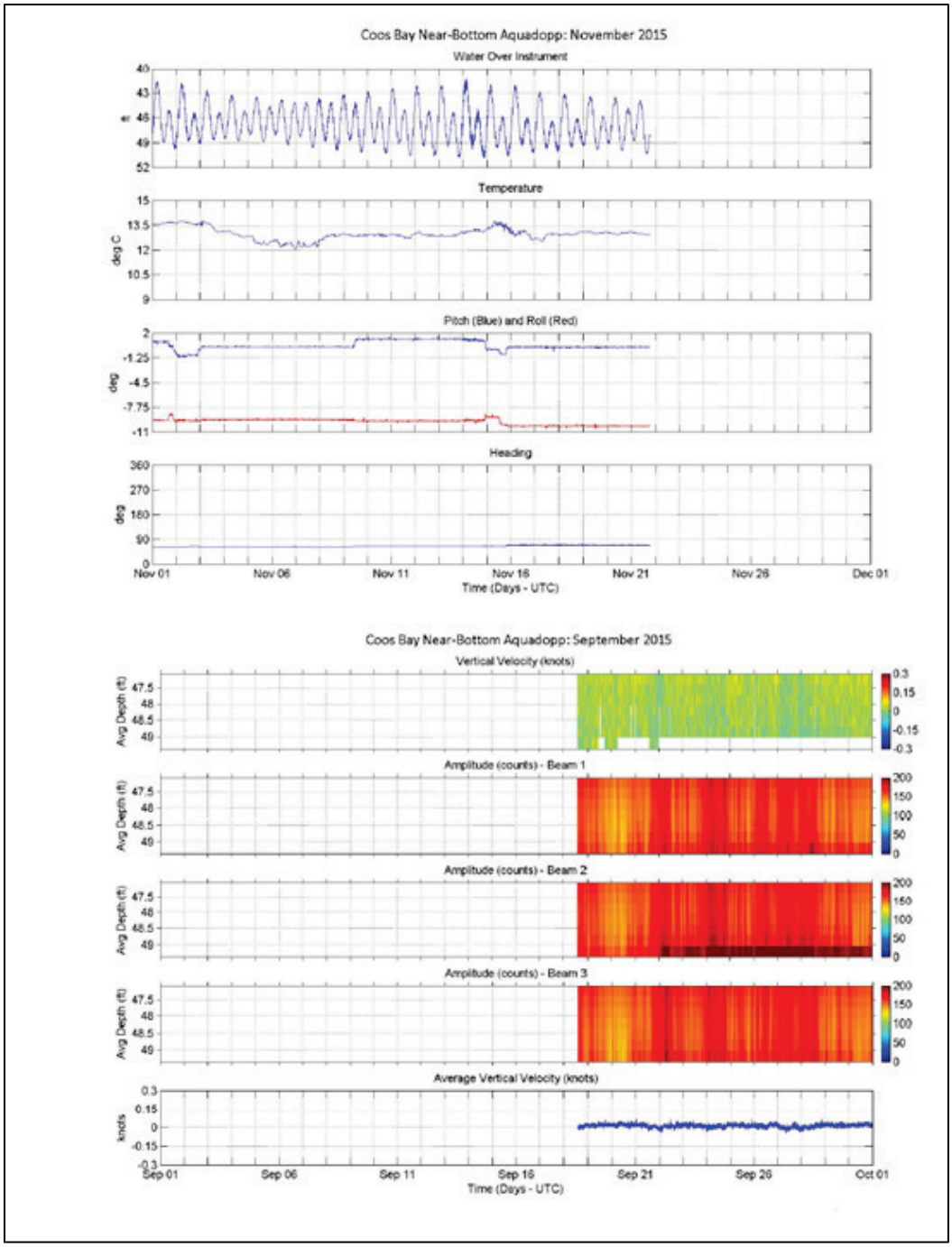
Appendix D: Plots of Current Data from Aquadopp

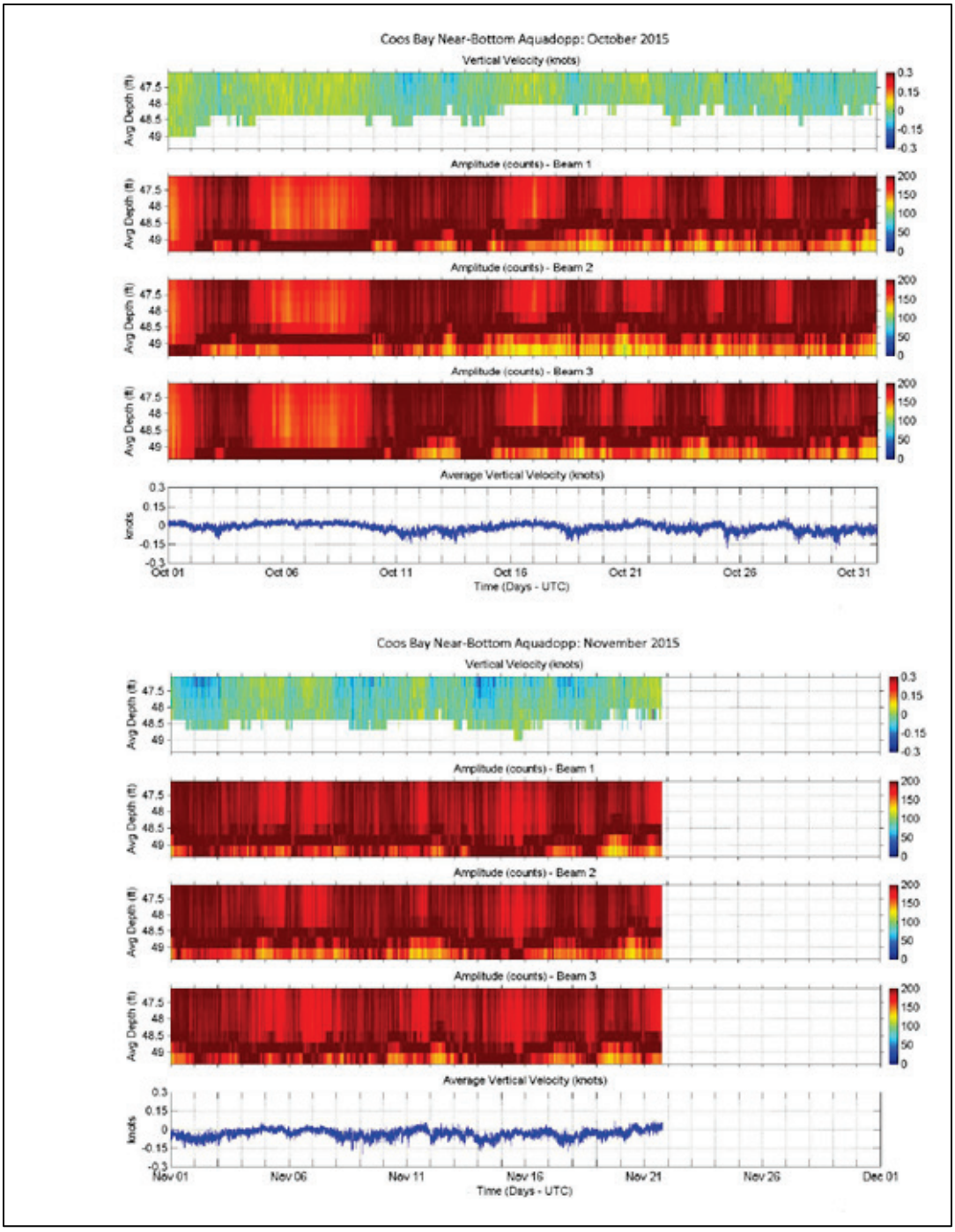



Coos Bay Near-Bottom Aquadopp: November 2015
Current Magnitude (kts)
Average Depth (ft)
47.5
48
48.5
49
2
1.5
1
0.5
0
Current Direction (toward, deg T)
Average Depth (ft)
47.5
48
48.5
49
360
270
180
90
0
Depth Average Current Magnitude (kts)
kts
2
1.5
1
0.5
0
Depth Average Current Direction (toward, deg T)
degrees
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

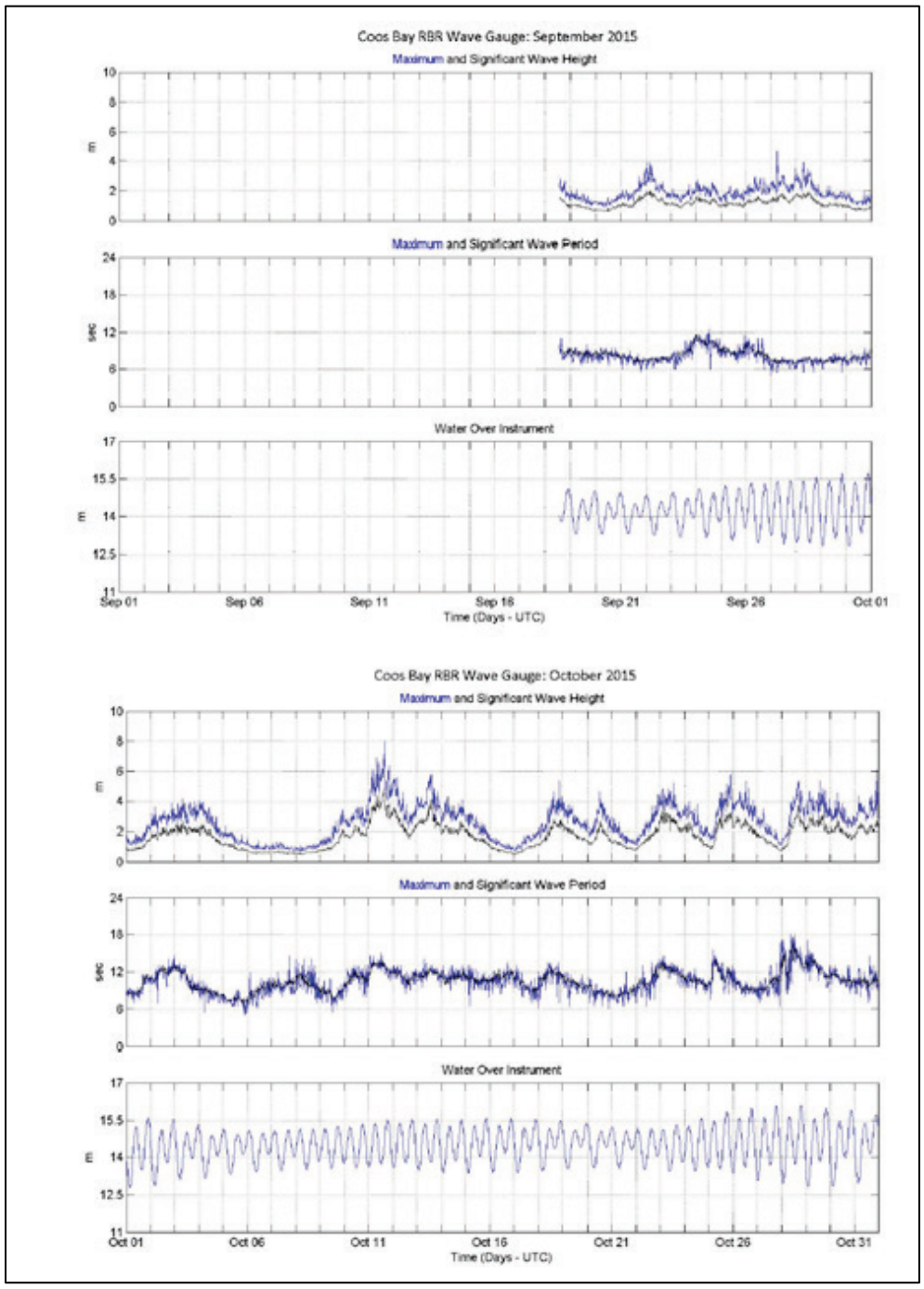
Appendix E: Plots of Data Quality Parameters and Ancillary Data from Aquadopp

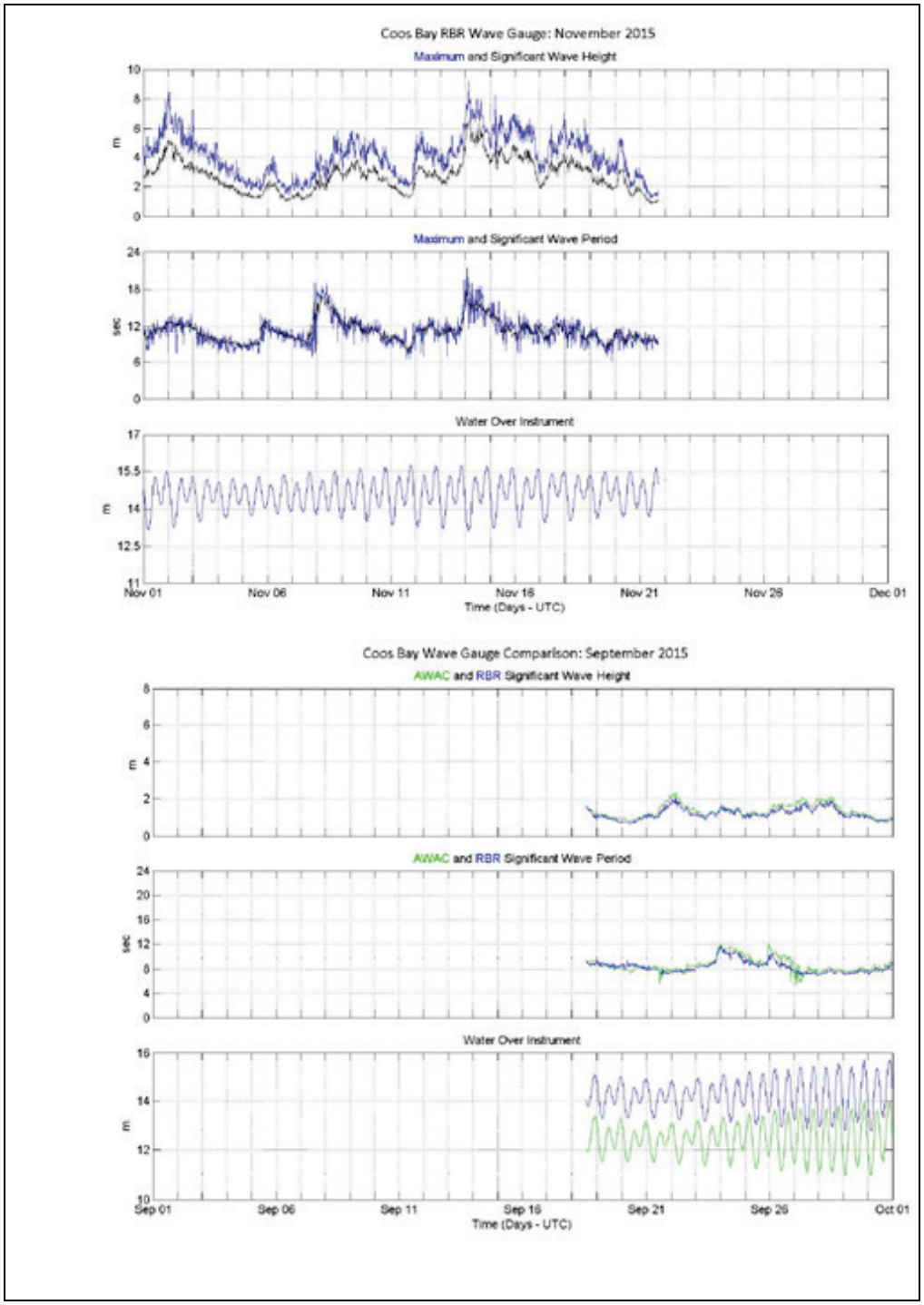


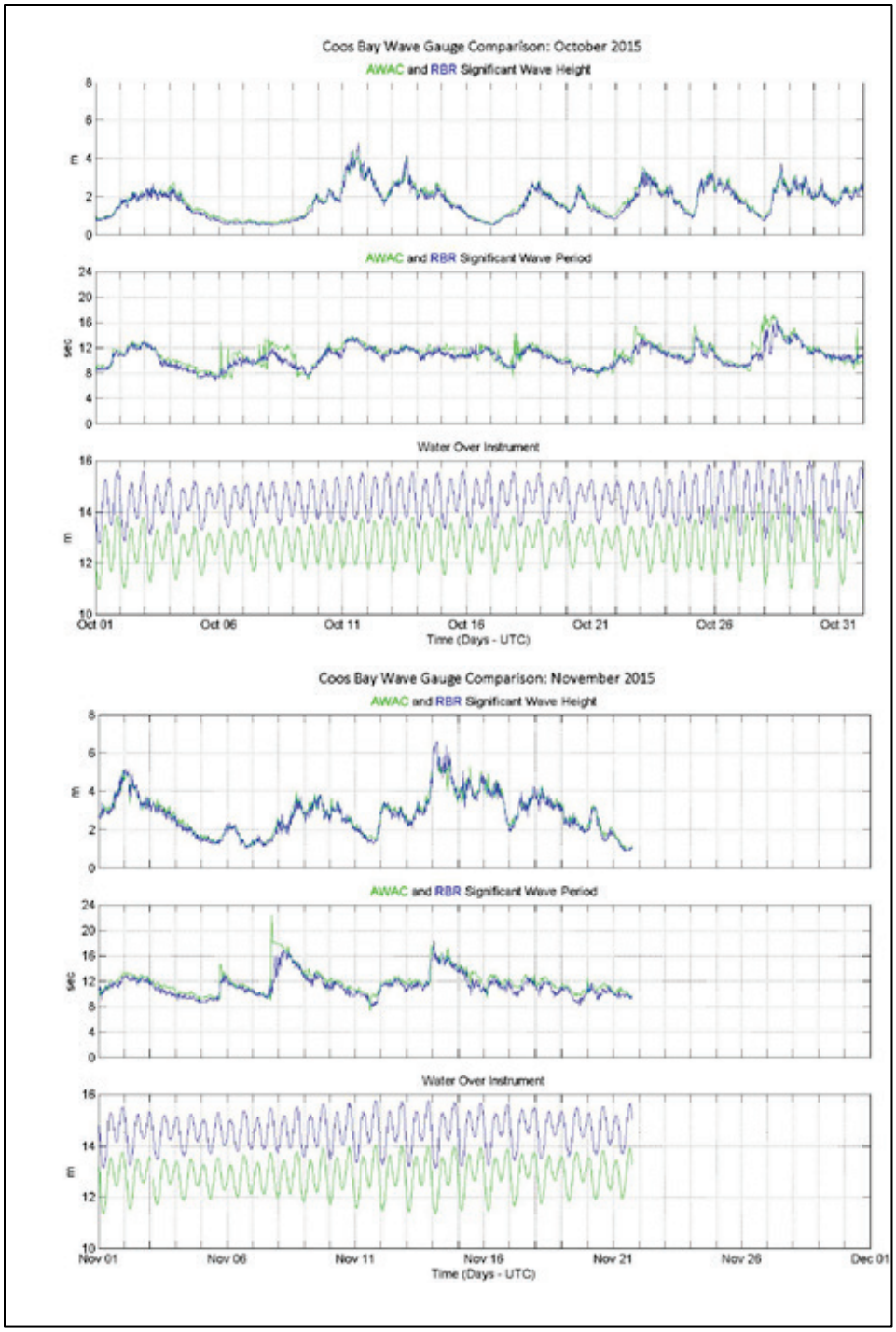

Coos Bay Near-Bottom Aquadopp: November 2015
Water Over Instrument
ft
Temperature
deg C
Pitch (Blue) and Roll (Red)
deg
Heading
deg
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)
Coos Bay Near-Bottom Aquadopp: September 2015
Vertical Velocity (knots)
Avg Depth (ft)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
knots
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Time (Days - UTC)


Coos Bay Near-Bottom Aquadopp: October 2015
Vertical Velocity (knots)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
Avg Depth (ft)
knots
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)
Coos Bay Near-Bottom Aquadopp: November 2015
Vertical Velocity (knots)
Amplitude (counts) - Beam 1
Amplitude (counts) - Beam 2
Amplitude (counts) - Beam 3
Average Vertical Velocity (knots)
Avg Depth (ft)
knots
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

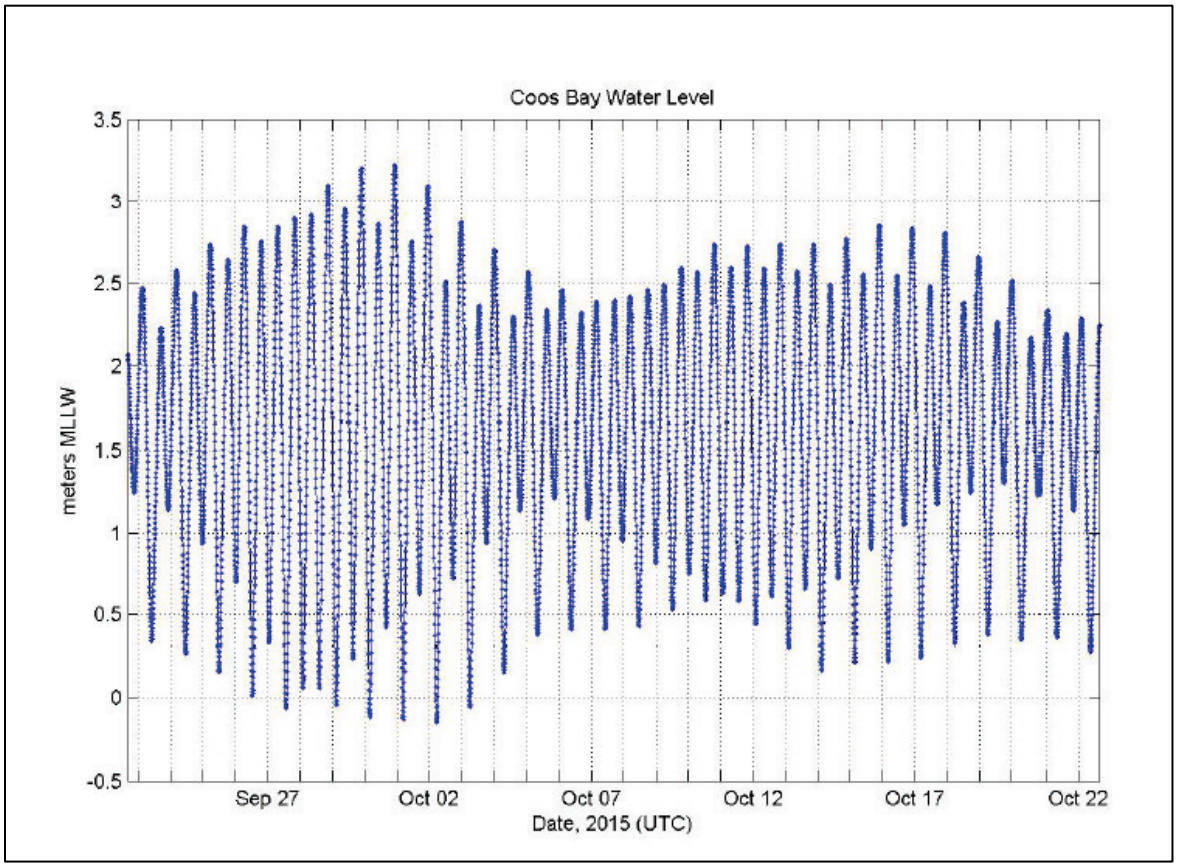
Appendix F: Plots of Non-Directional Wave Data



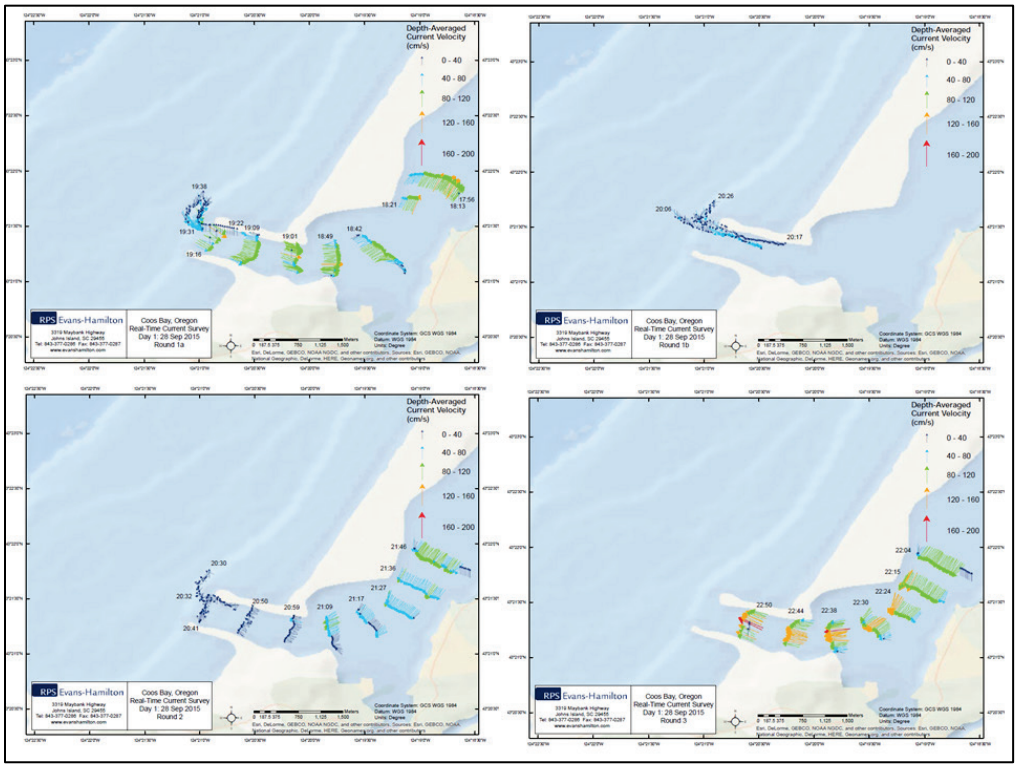

Coos Bay RBR Wave Gauge: November 2015
Maximum and Significant Wave Height
m
Maximum and Significant Wave Period
sec
Water Over Instrument
m
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)
Coos Bay Wave Gauge Comparison: September 2015
AWAC and RBR Significant Wave Height
m
AWAC and RBR Significant Wave Period
sec
Water Over Instrument
m
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Time (Days - UTC)

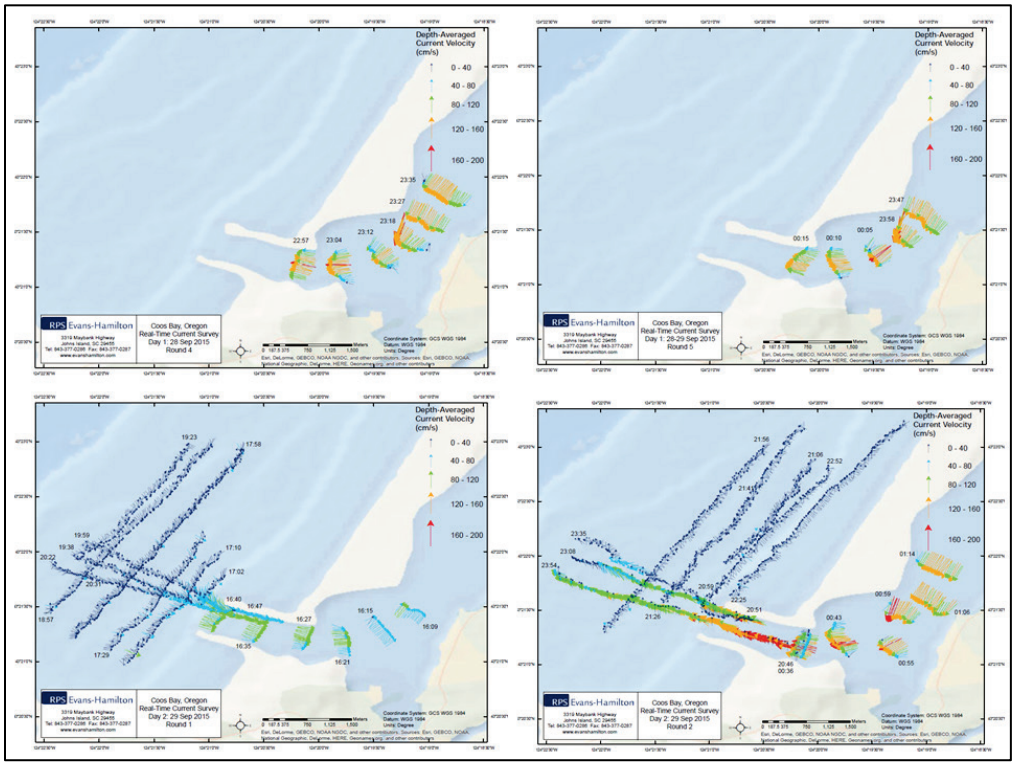

Coos Bay Wave Gauge Comparison: October 2015
AWAC and RBR Significant Wave Height
m
AWAC and RBR Significant Wave Period
sec
Water Over Instrument
m
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)
Coos Bay Wave Gauge Comparison: November 2015
AWAC and RBR Significant Wave Height
m
AWAC and RBR Significant Wave Period
sec
Water Over Instrument
m
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

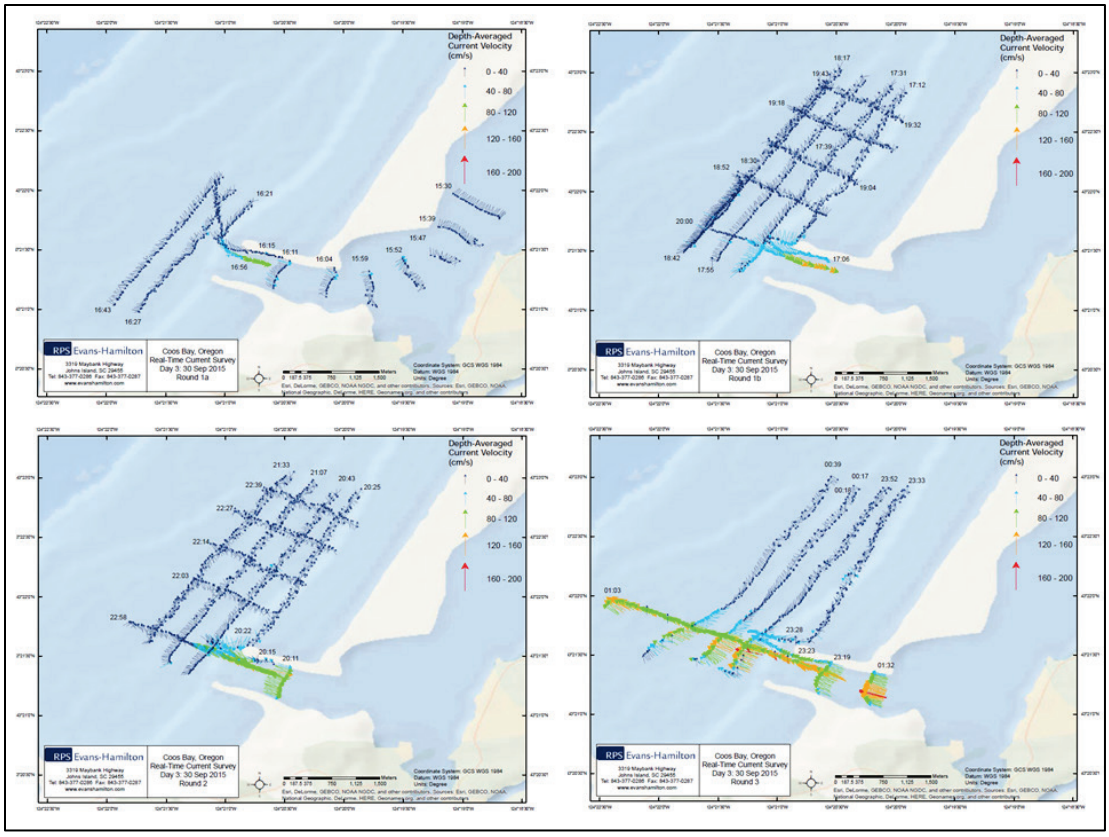
Appendix G: Plots of Water Level Data

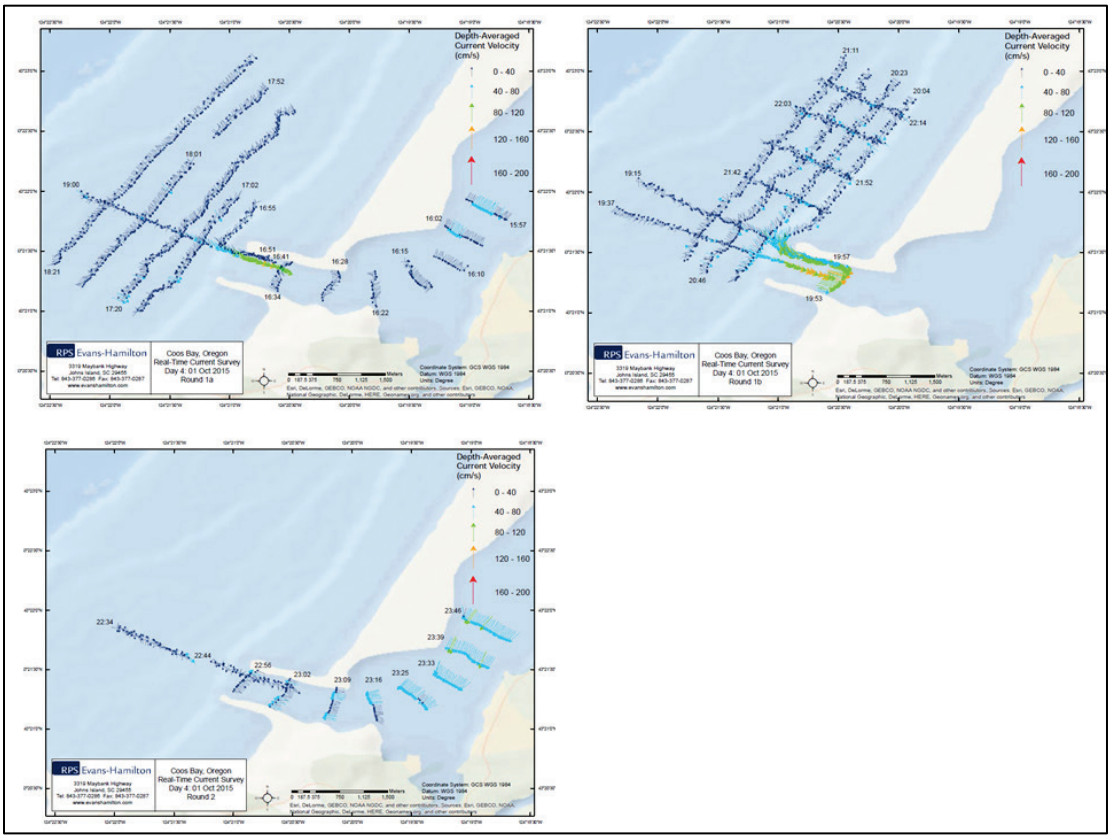


Appendix H: Velocity Vector Plots of Current Data from Current Survey

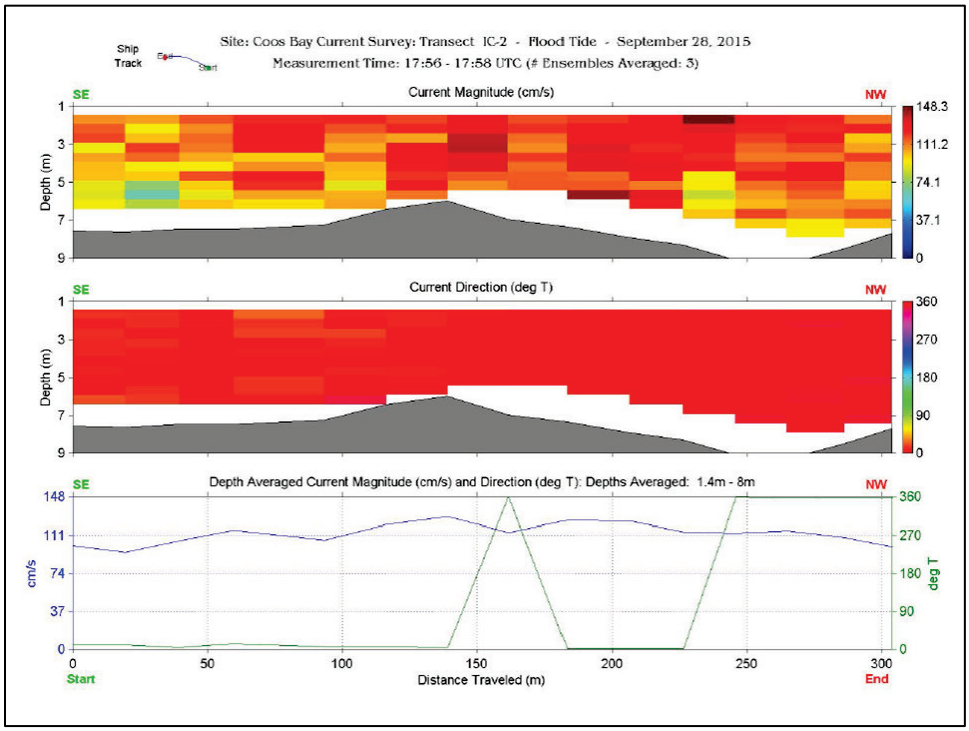


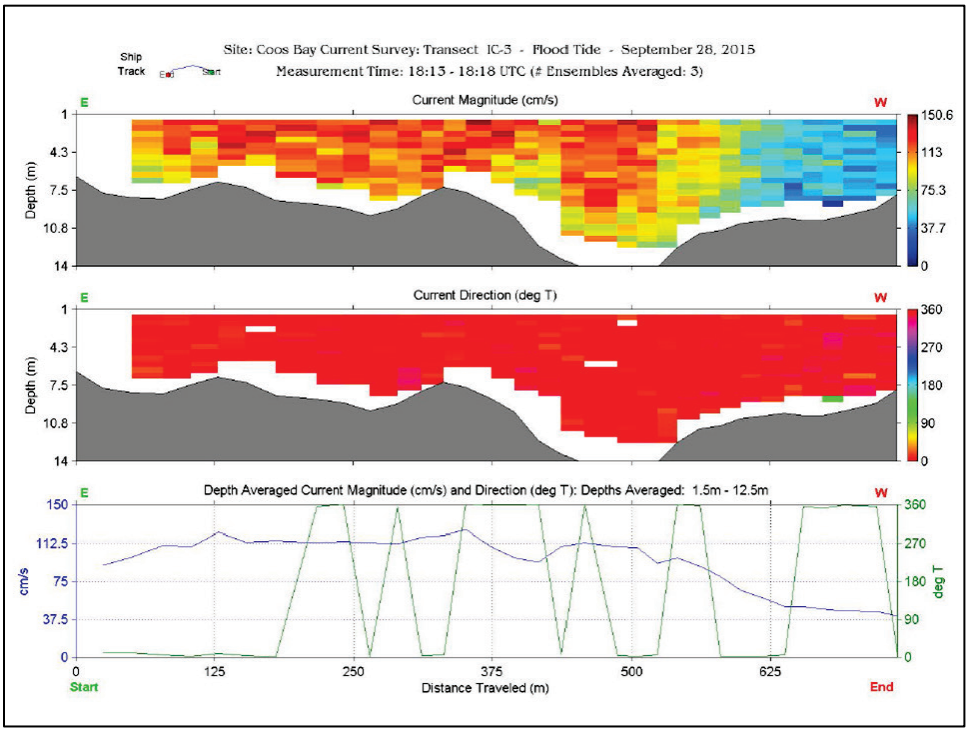


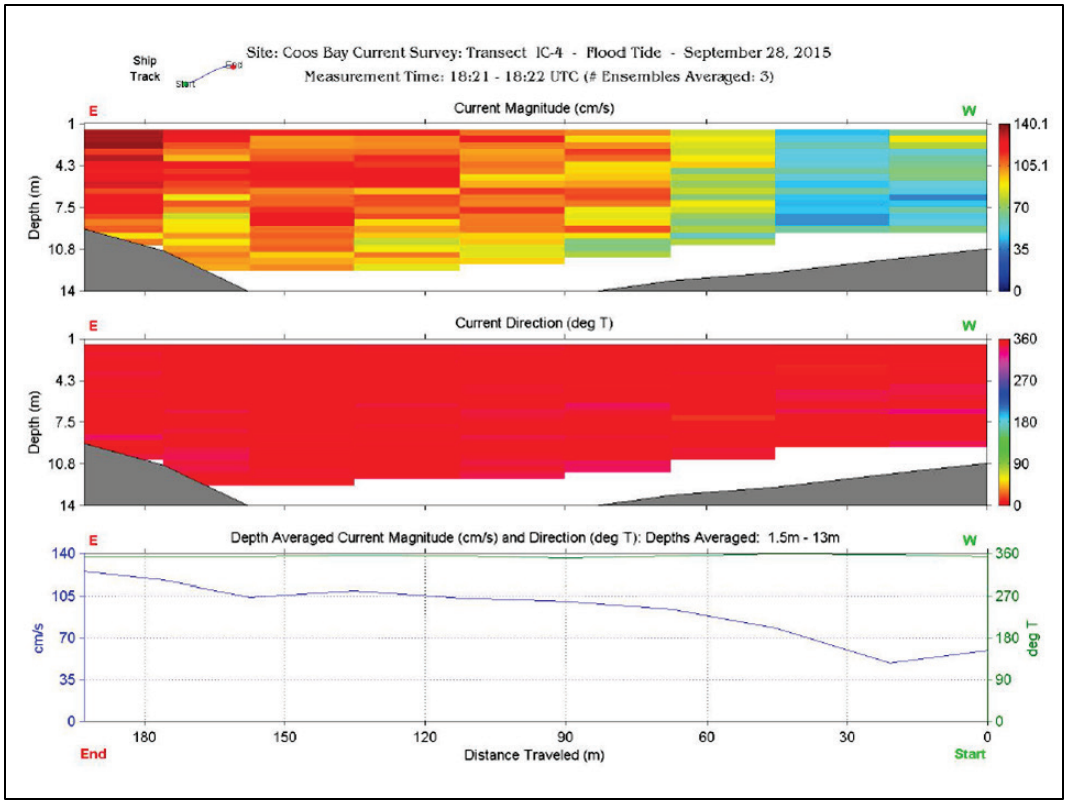

Depth-Averaged Current Velocity (cm/s)
0 - 40
40 - 80
80 - 120
120 - 160
160 - 200
RPS Evans-Hamilton
Coos Bay, Oregon Real-Time Current Survey Day 3: 30 Sep 2015 Round 1a
Coos Bay, Oregon Real-Time Current Survey Day 3: 30 Sep 2015 Round 1b
Coos Bay, Oregon Real-Time Current Survey Day 3: 30 Sep 2015 Round 2
Coos Bay, Oregon Real-Time Current Survey Day 3: 30 Sep 2015 Round 3

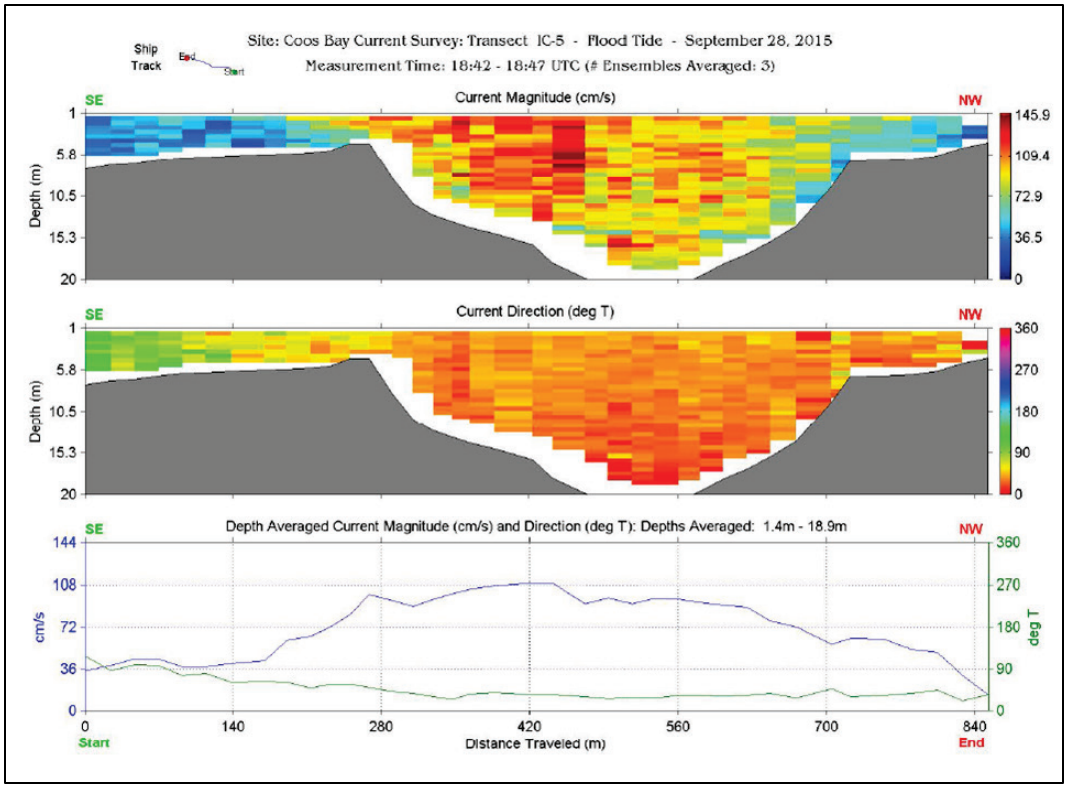

Depth-Averaged Current Velocity (cm/s)
0 - 40
40 - 80
80 - 120
120 - 160
160 - 200
RPS Evans-Hamilton
Coos Bay, Oregon Real-Time Current Survey Day 4: 01 Oct 2015 Round 1a
Coos Bay, Oregon Real-Time Current Survey Day 4: 01 Oct 2015 Round 1b
Coos Bay, Oregon Real-Time Current Survey Day 4: 01 Oct 2015 Round 2

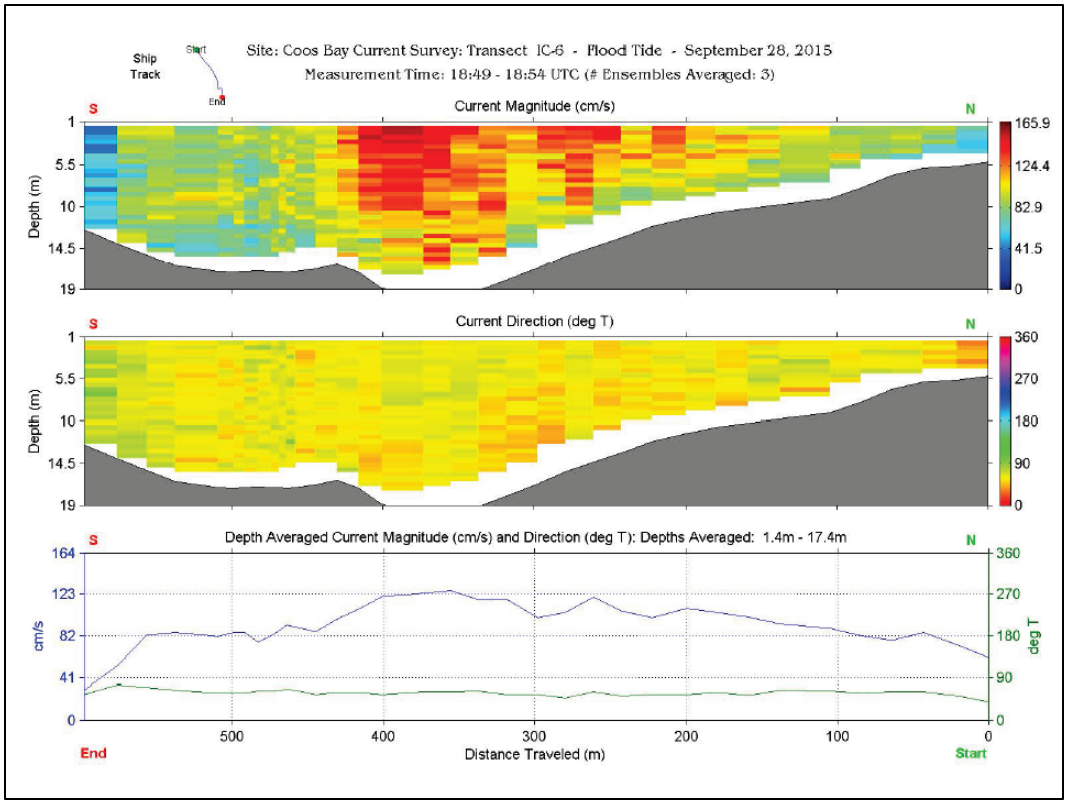
Appendix I: Profile Plots of Current Data from Current Survey

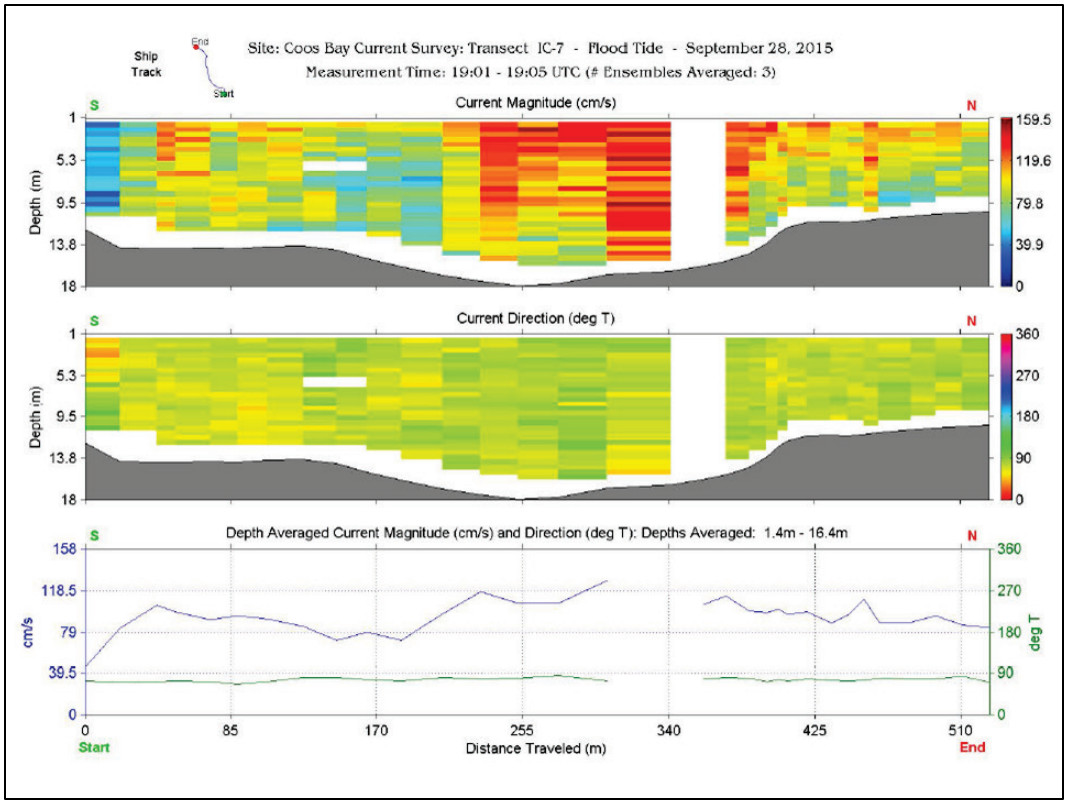


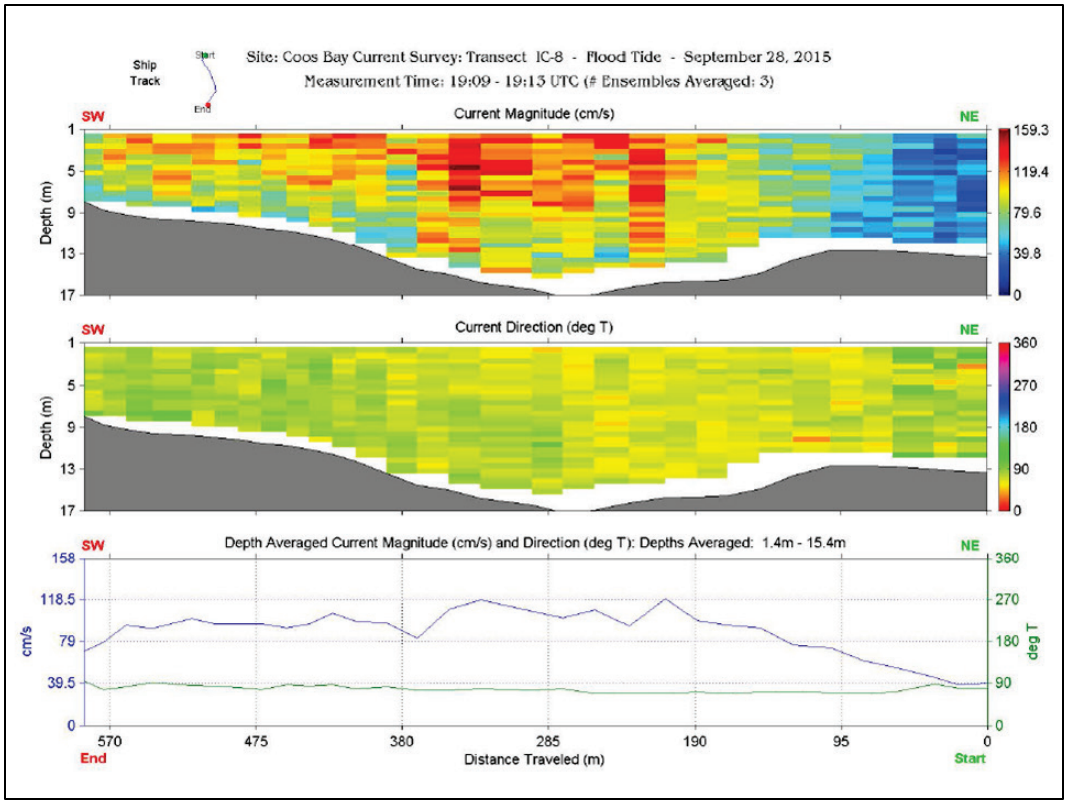


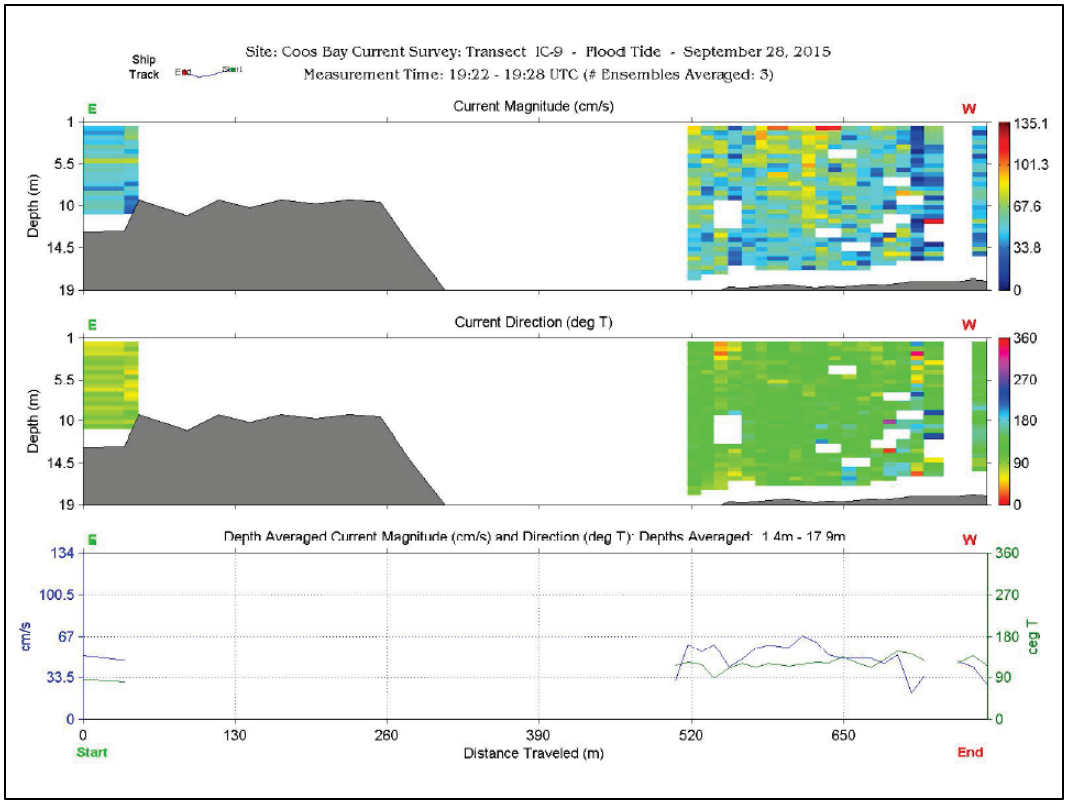

Ship Track
Site: Coos Bay Current Survey: Transect IC-4 - Flood Tide - September 28, 2015
Measurement Time: 18:21 - 18:22 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.3
7.5
10.8
14
140.1
105.1
70
35
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 13m
cm/s
deg T
140
105
70
35
180
150
120
90
60
30
End
Start
Distance Traveled (m)

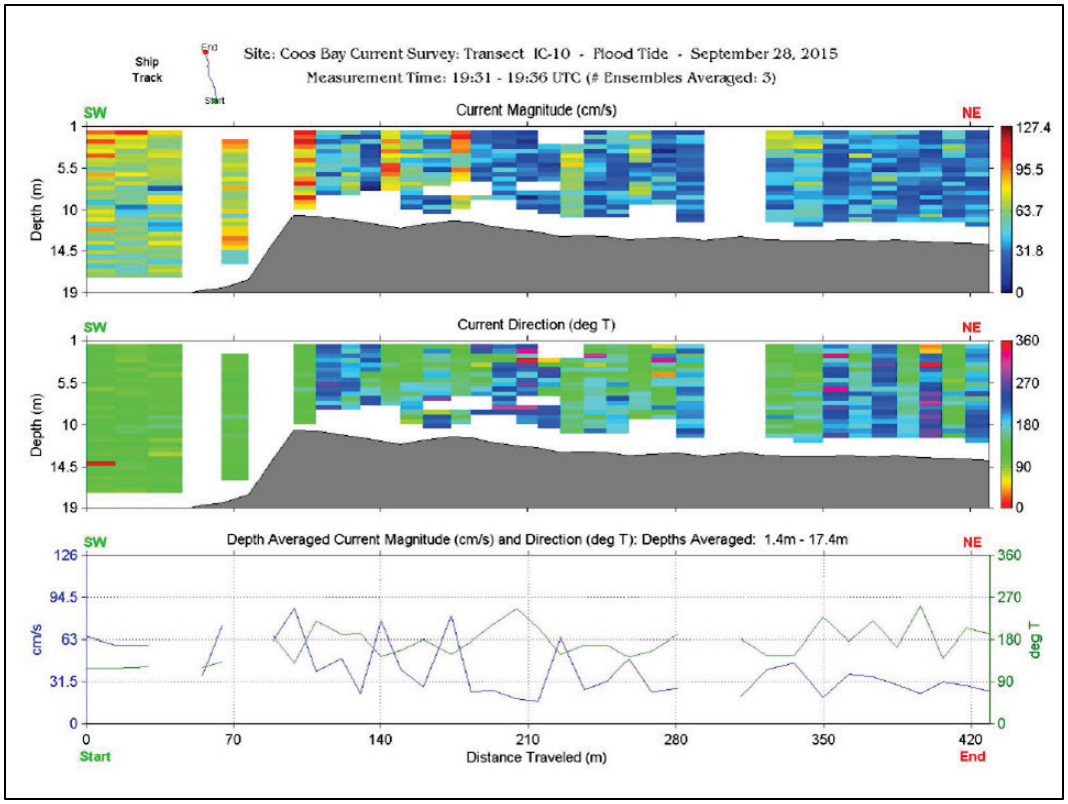

Ship Track
Site: Coos Bay Current Survey: Transect IC-5 - Flood Tide - September 28, 2015
Measurement Time: 18:42 - 18:47 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
145.9
109.4
72.9
36.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 18.9m
cm/s
deg T
144
108
72
36
0
140
280
420
560
700
840
Start
End
Distance Traveled (m)

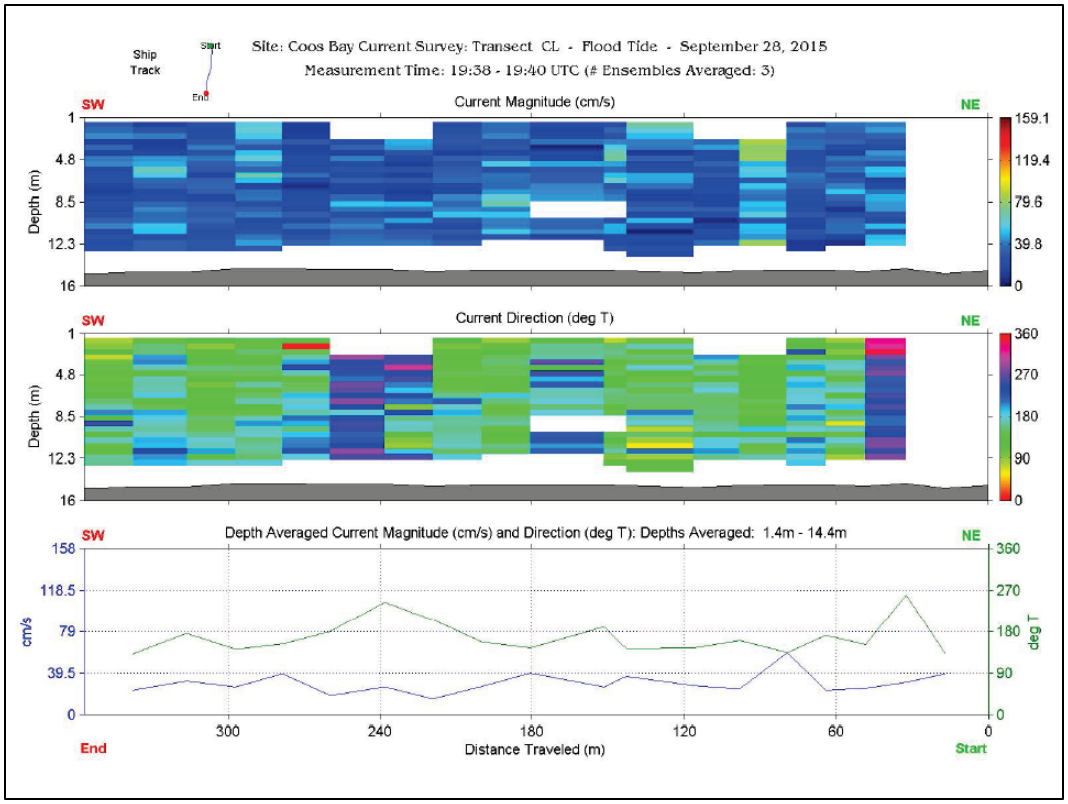

Site: Coos Bay Current Survey: Transect IC-6 - Flood Tide - September 28, 2015
Measurement Time: 18:49 - 18:54 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.5
10
14.5
19
165.9
124.4
82.9
41.5
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.4m
cm/s
164
123
82
41
0
deg T
500
400
300
200
100
Distance Traveled (m)
End
Start

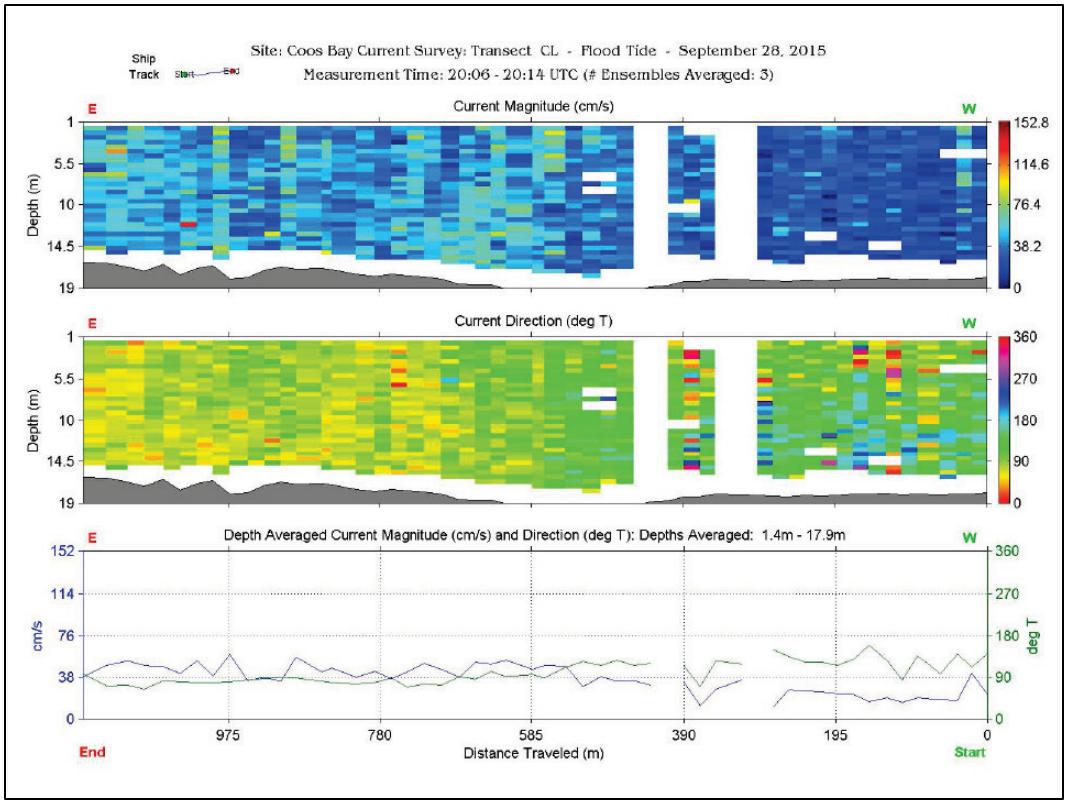

Site: Coos Bay Current Survey: Transect IC-7 - Flood Tide - September 28, 2015
Measurement Time: 19:01 - 19:05 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
159.5
119.6
79.8
39.9
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 16.4m
cm/s
158
118.5
79
39.5
0
deg T
0
85
170
255
340
425
510
Distance Traveled (m)
Start
End

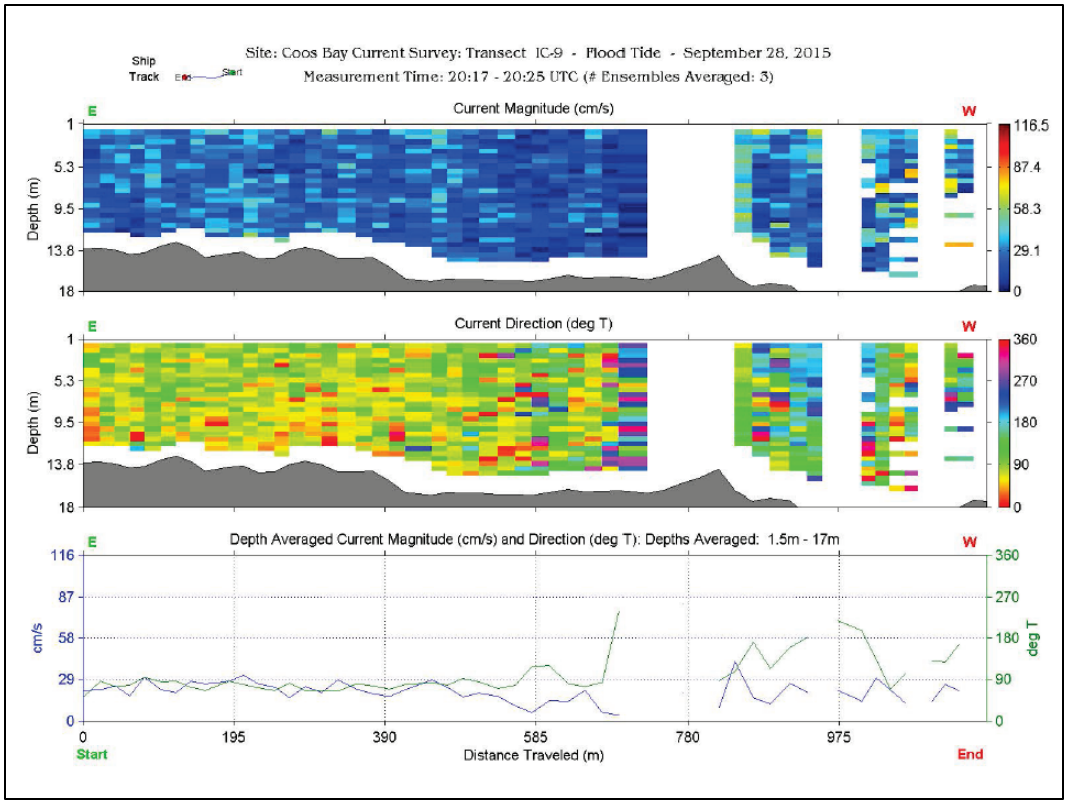

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-8 - Flood Tide - September 28, 2015
Measurement Time: 19:09 - 19:13 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
159.3
119.4
79.6
39.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 15.4m
158
118.5
79
39.5
cm/s
deg T
570
475
380
285
190
95
0
End
Start
Distance Traveled (m)

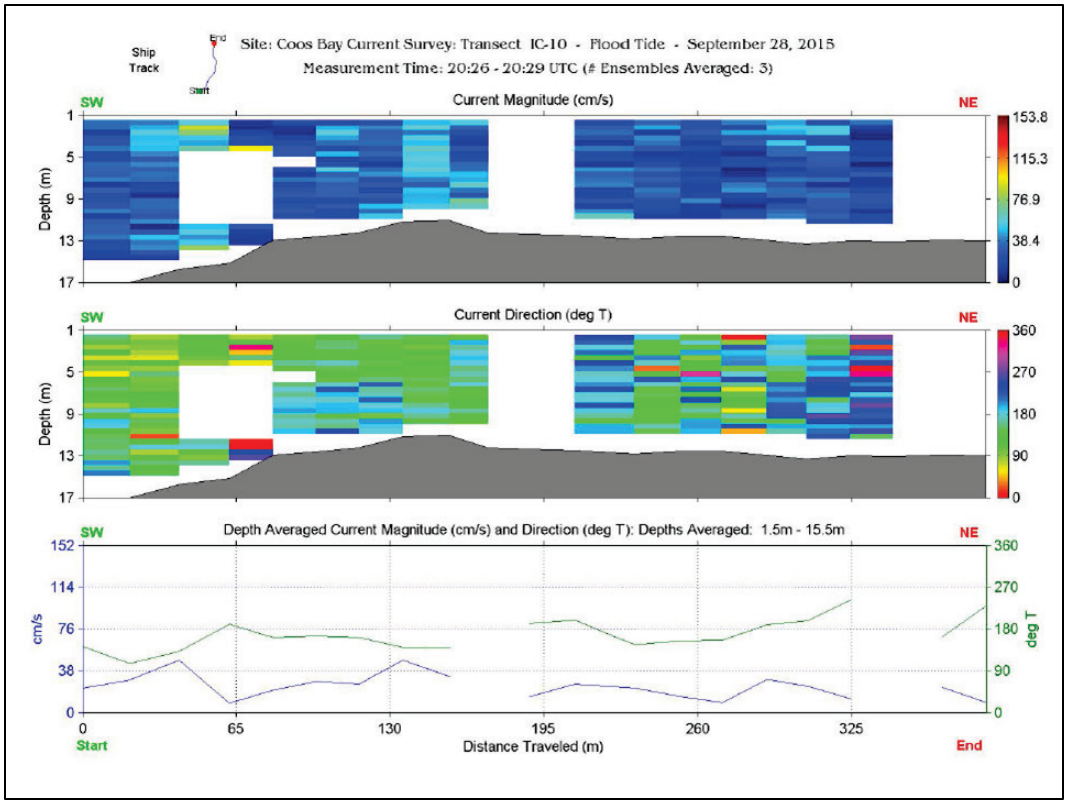

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-9 - Flood Tide - September 28, 2015
Measurement Time: 19:22 - 19:28 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
135.1
101.3
67.6
33.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.9m
134
100.5
67
33.5
cm/s
deg T
0
130
260
390
520
650
Start
End
Distance Traveled (m)

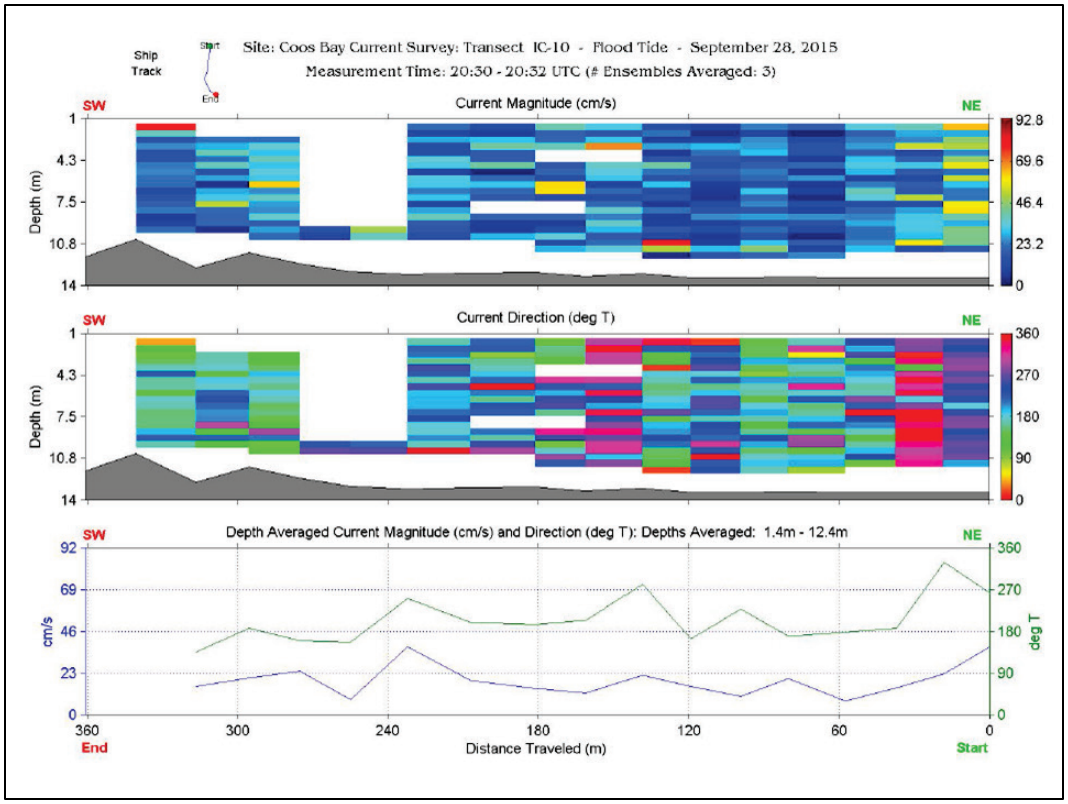

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-10 - Flood Tide - September 28, 2015
Measurement Time: 19:31 - 19:36 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.5
10
14.5
19
127.4
95.5
63.7
31.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.4m
cm/s
126
94.5
63
31.5
deg T
0
70
140
210
280
350
420
Distance Traveled (m)
Start
End

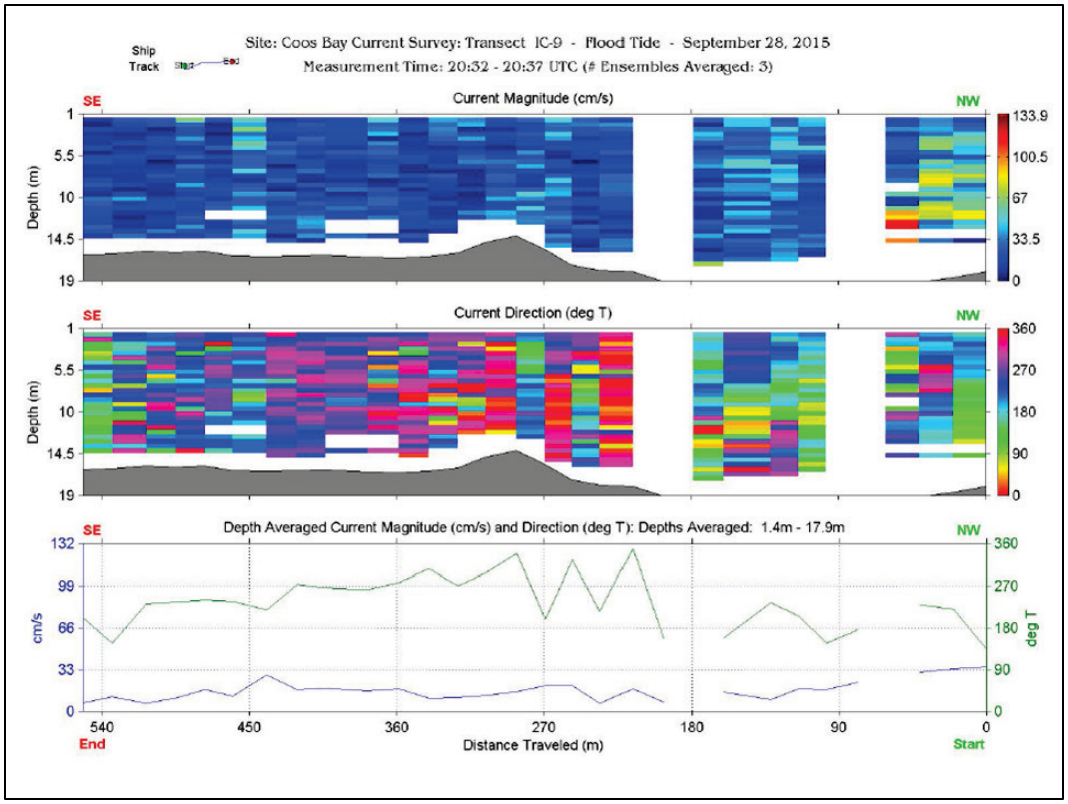

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect CL - Flood Tide - September 28, 2015
Measurement Time: 19:38 - 19:40 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
159.1
119.4
79.6
39.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 14.4m
cm/s
158
118.5
79
39.5
deg T
300
240
180
120
60
Distance Traveled (m)
End
Start

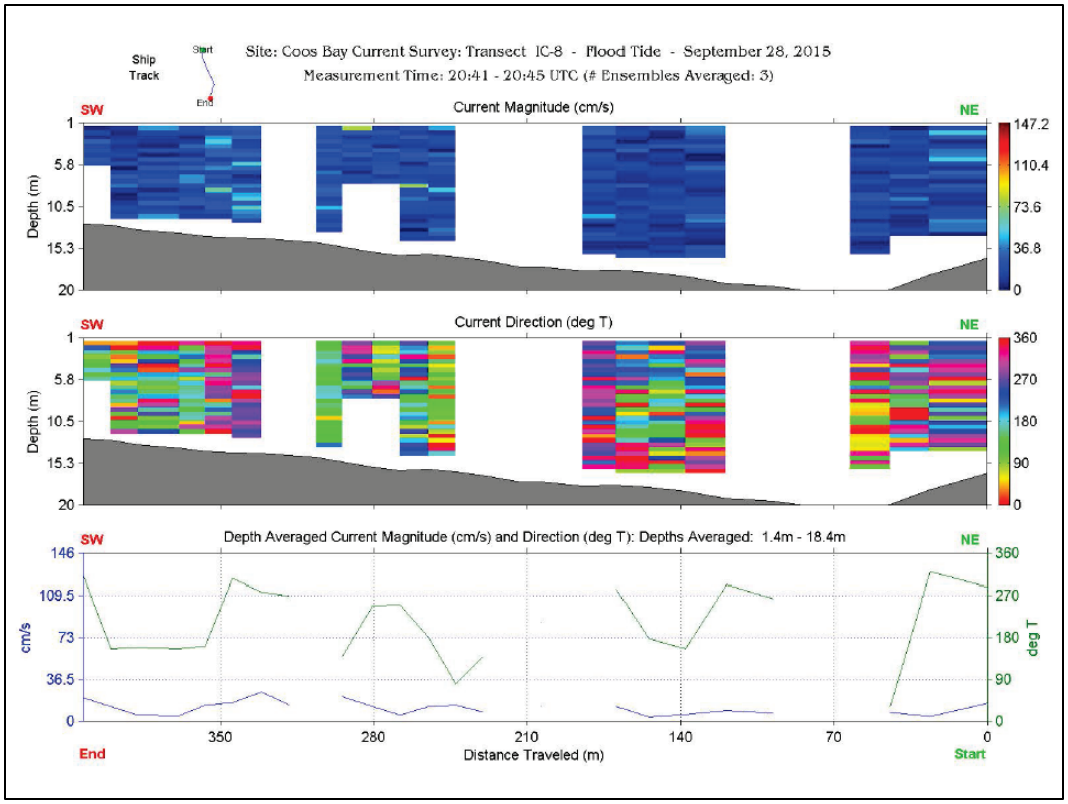

Site: Coos Bay Current Survey: Transect CL - Flood Tide - September 28, 2015
Measurement Time: 20:06 - 20:14 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.9m
Depth (m)
cm/s
deg T
Distance Traveled (m)
E
W
Start
End

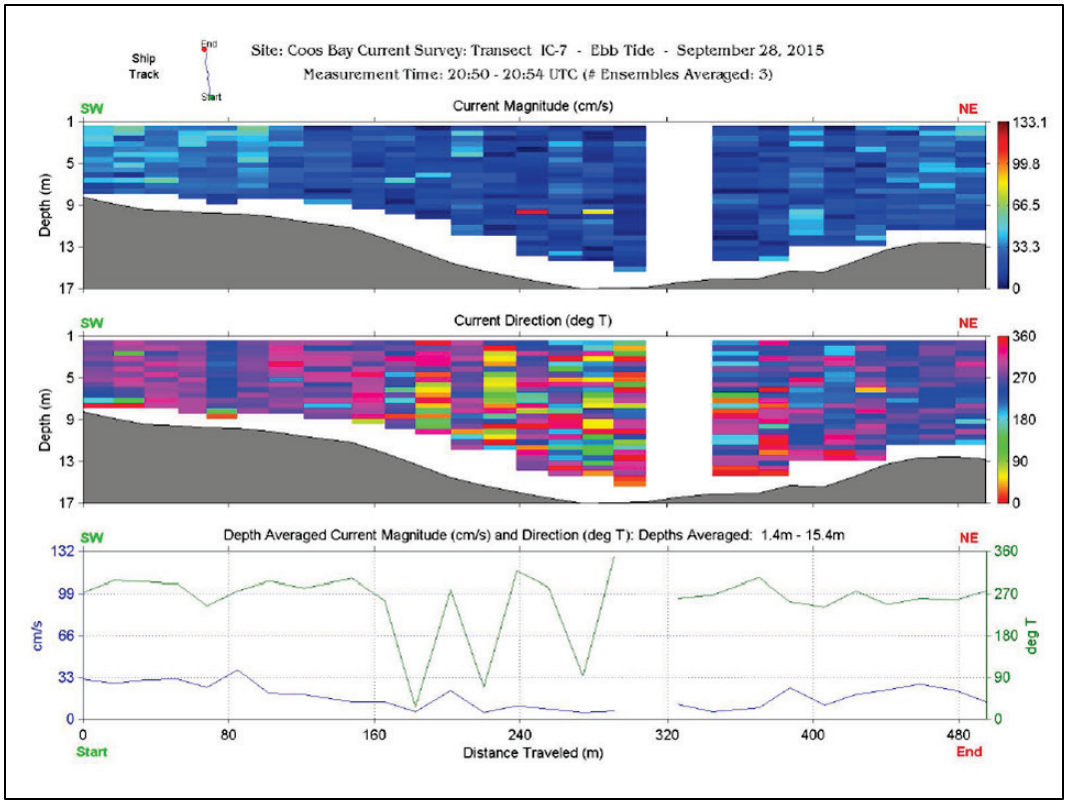

Site: Coos Bay Current Survey: Transect IC-9 - Flood Tide - September 28, 2015
Measurement Time: 20:17 - 20:25 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 17m
Depth (m)
cm/s
deg T
Distance Traveled (m)
E
W
Start
End

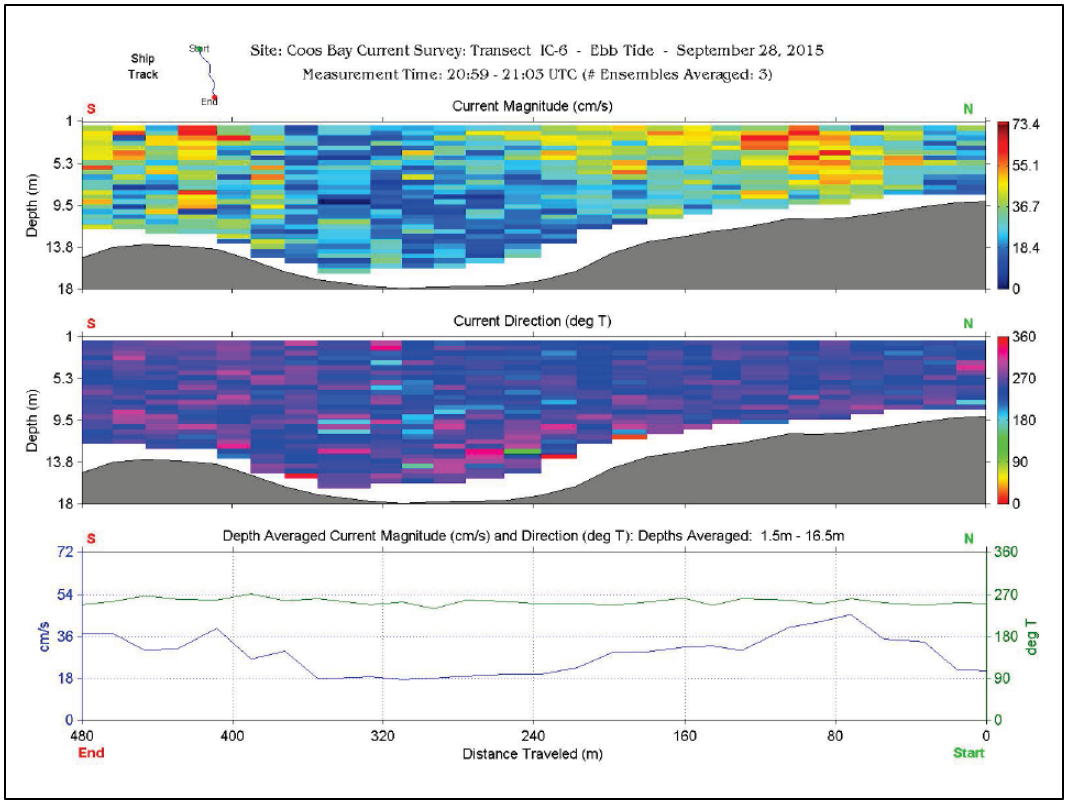

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-10 - Flood Tide - September 28, 2015
Measurement Time: 20:26 - 20:29 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
153.8
115.3
76.9
38.4
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 15.5m
cm/s
deg T
152
114
76
38
0
0
65
130
195
260
325
Start
End
Distance Traveled (m)

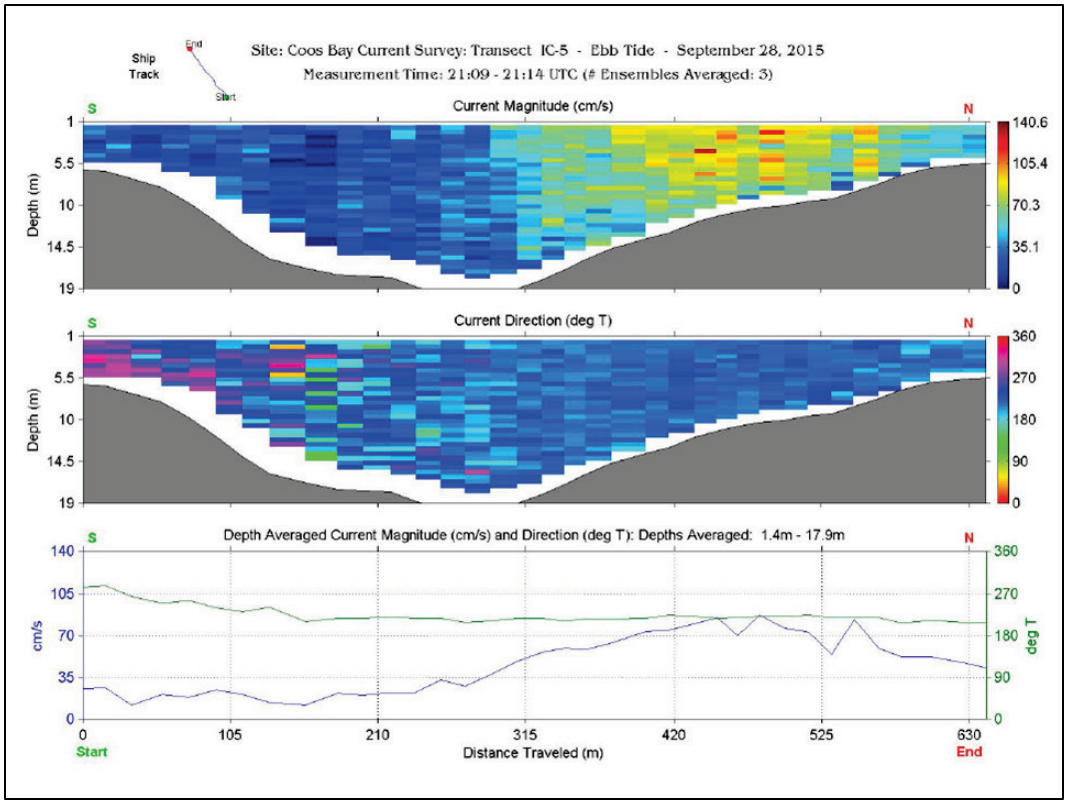

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-10 - Flood Tide - September 28, 2015
Measurement Time: 20:30 - 20:32 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.3
7.5
10.8
14
92.8
69.6
46.4
23.2
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 12.4m
cm/s
deg T
92
69
46
23
0
360
300
240
180
120
60
0
End
Start
Distance Traveled (m)

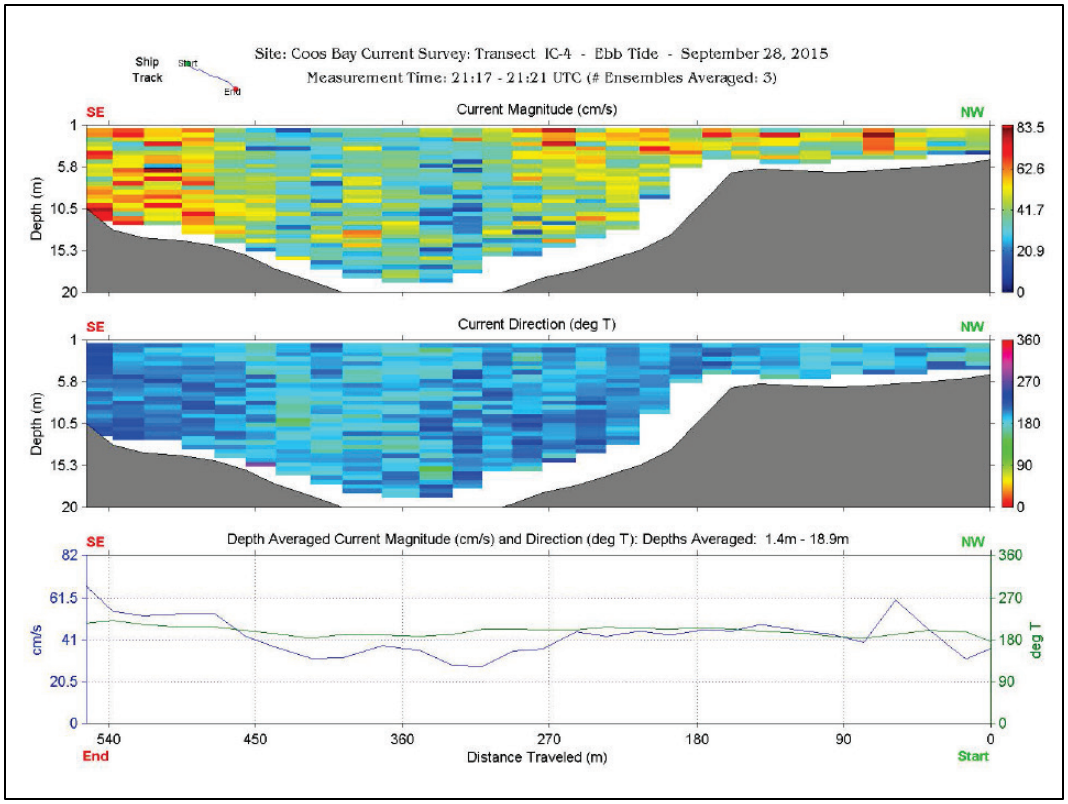

Site: Coos Bay Current Survey: Transect IC-9 - Flood Tide - September 28, 2015
Measurement Time: 20:32 - 20:37 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.9m
SE
NW
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

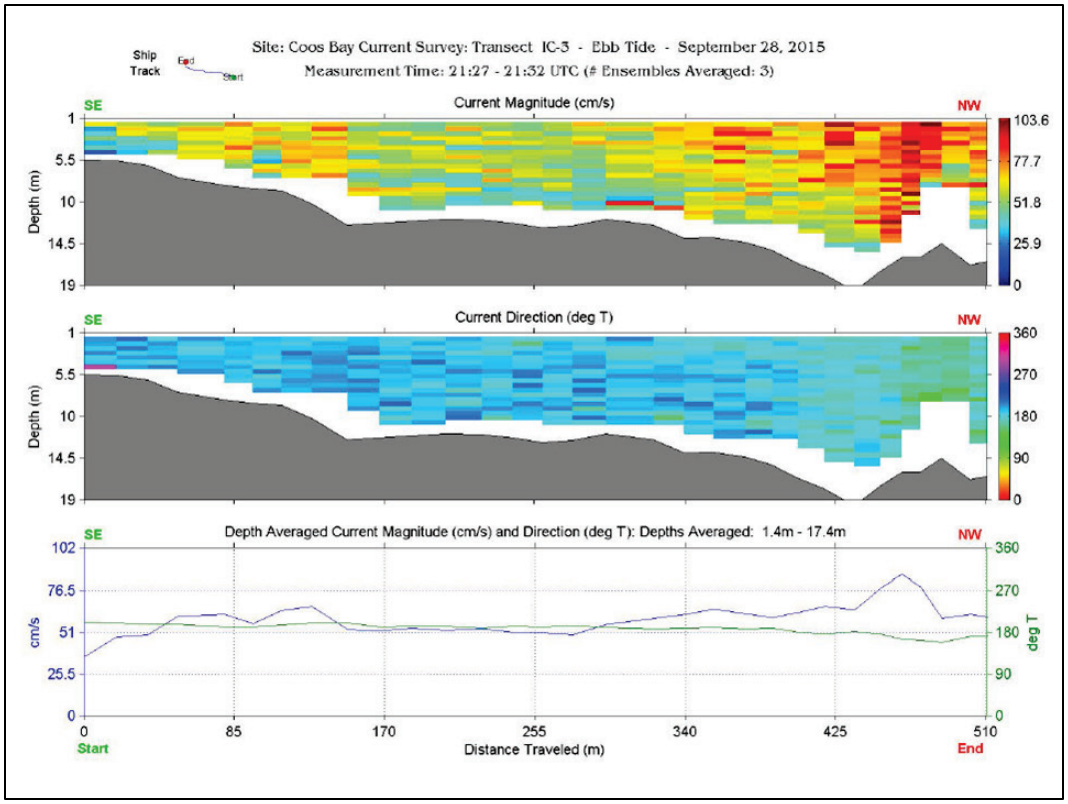

Site: Coos Bay Current Survey: Transect IC-8 - Flood Tide - September 28, 2015
Measurement Time: 20:41 - 20:45 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 18.4m
SW
NE
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

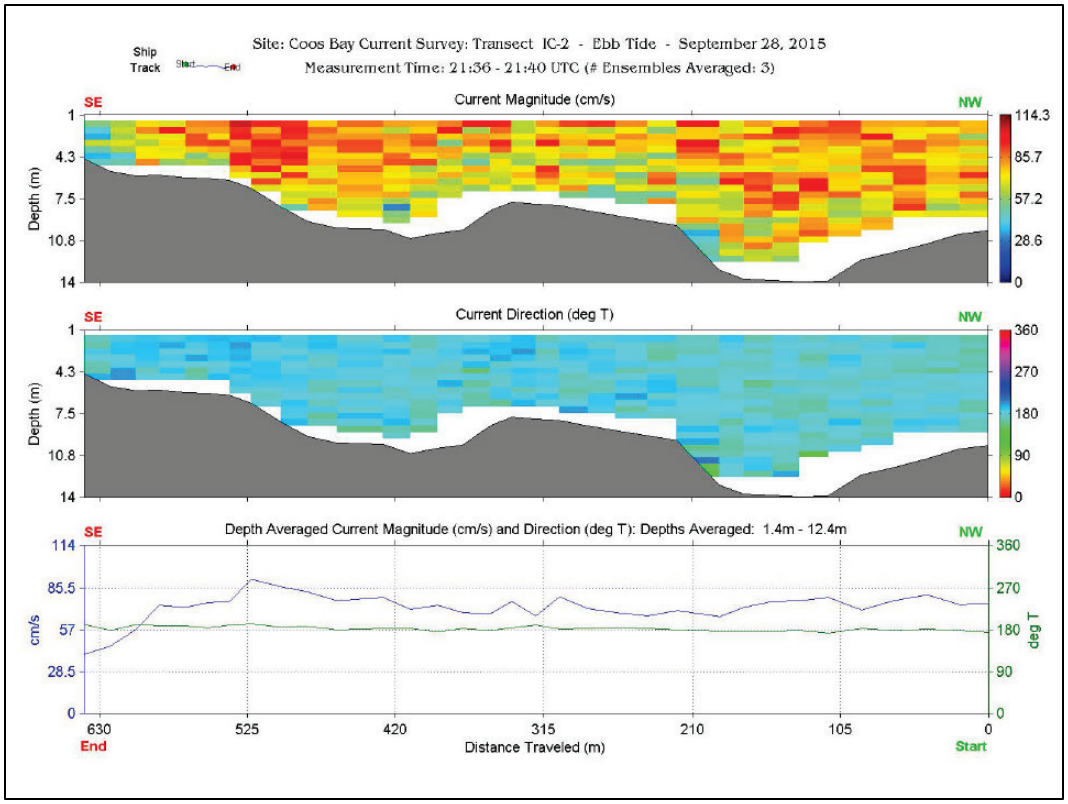

Site: Coos Bay Current Survey: Transect IC-7 - Ebb Tide - September 28, 2015
Measurement Time: 20:50 - 20:54 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SW
NE
Depth (m)
133.1
99.8
66.5
33.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 15.4m
cm/s
deg T
Distance Traveled (m)
Start
End

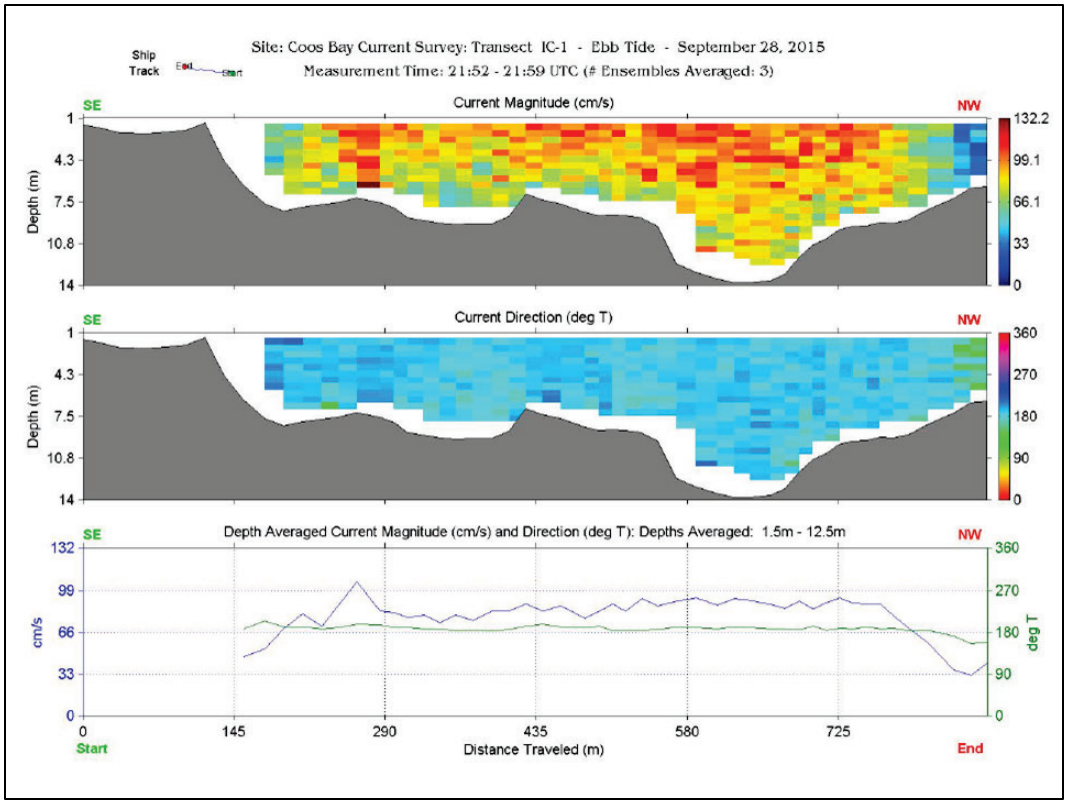

Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - September 28, 2015
Measurement Time: 20:59 - 21:03 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
73.4
55.1
36.7
18.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 16.5m
cm/s
deg T
Distance Traveled (m)
End
Start

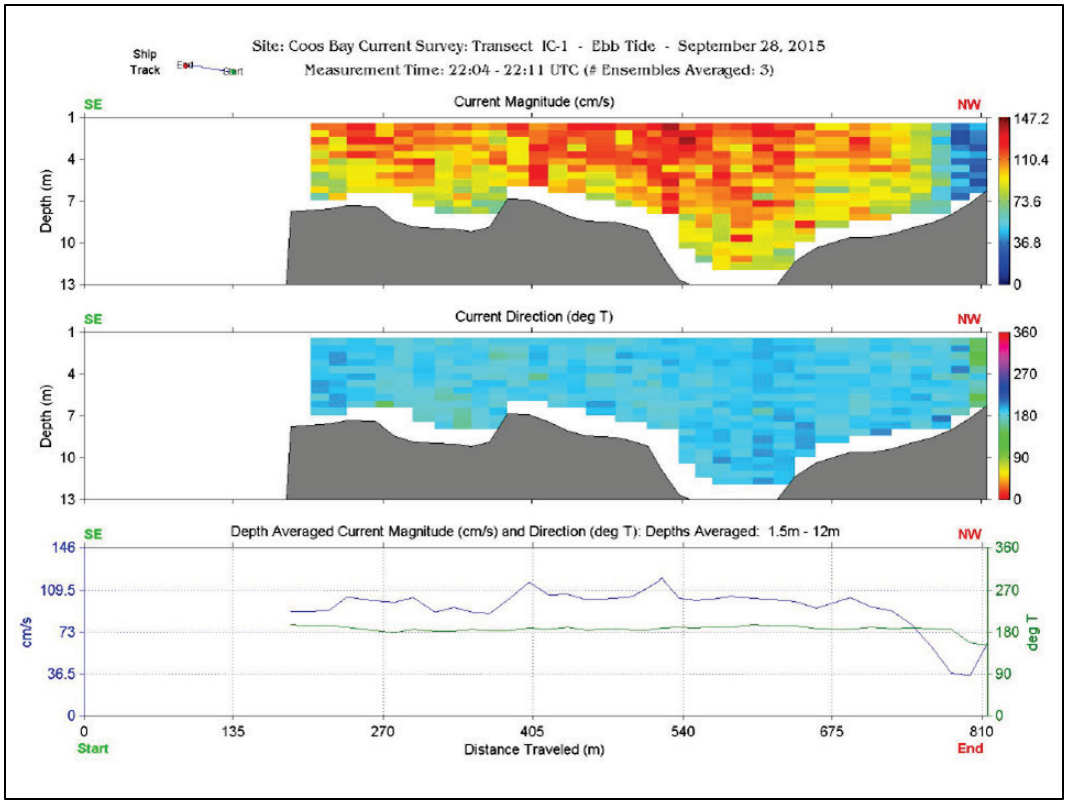

Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 28, 2015
Measurement Time: 21:09 - 21:14 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.5
10
14.5
19
140.6
105.4
70.3
35.1
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.9m
cm/s
deg T
140
105
70
35
0
0
105
210
315
420
525
630
Start
End
Distance Traveled (m)

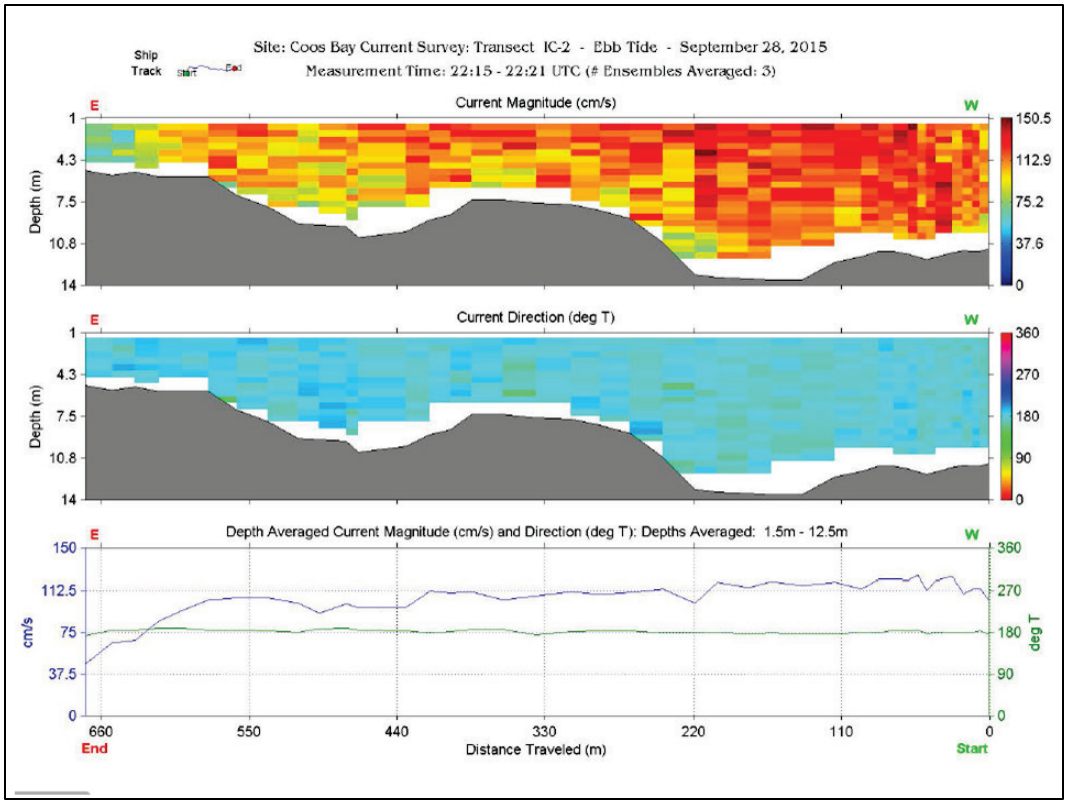

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 28, 2015
Measurement Time: 21:17 - 21:21 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
83.5
62.6
41.7
20.9
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 18.9m
cm/s
deg T
82
61.5
41
20.5
0
540
450
360
270
180
90
0
End
Start
Distance Traveled (m)

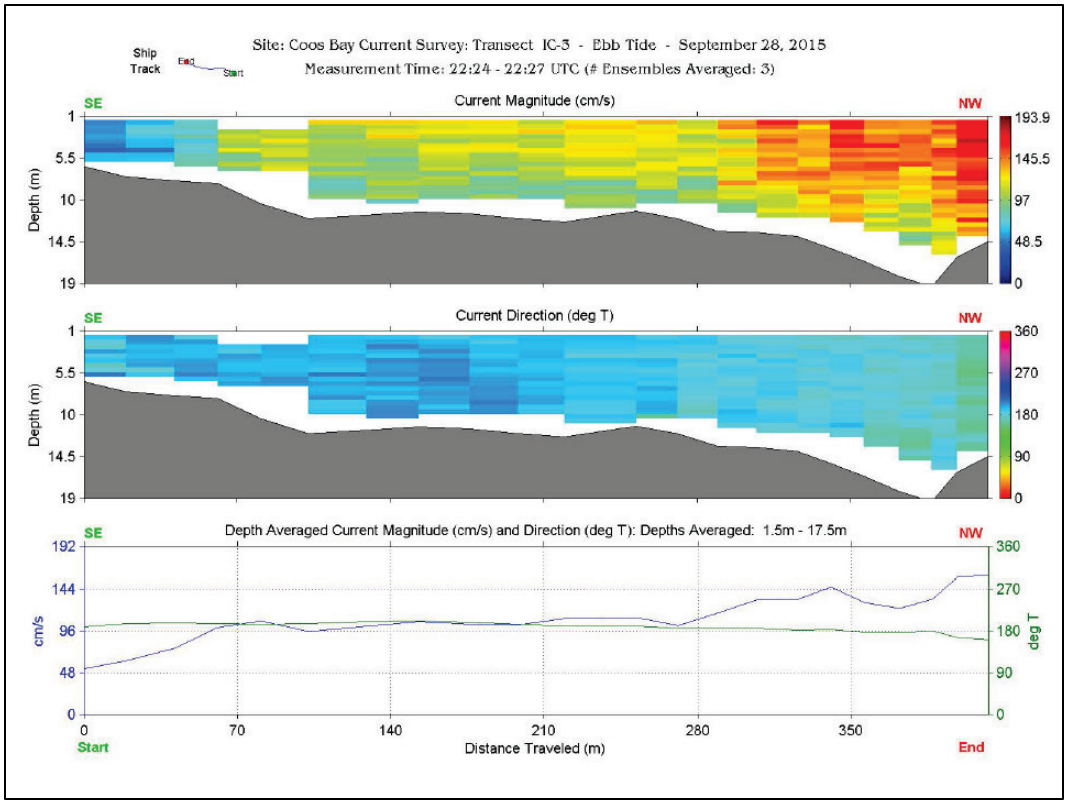

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 28, 2015
Measurement Time: 21:27 - 21:32 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 17.4m
SE
NW
Depth (m)
cm/s
deg T
Distance Traveled (m)
Start
End

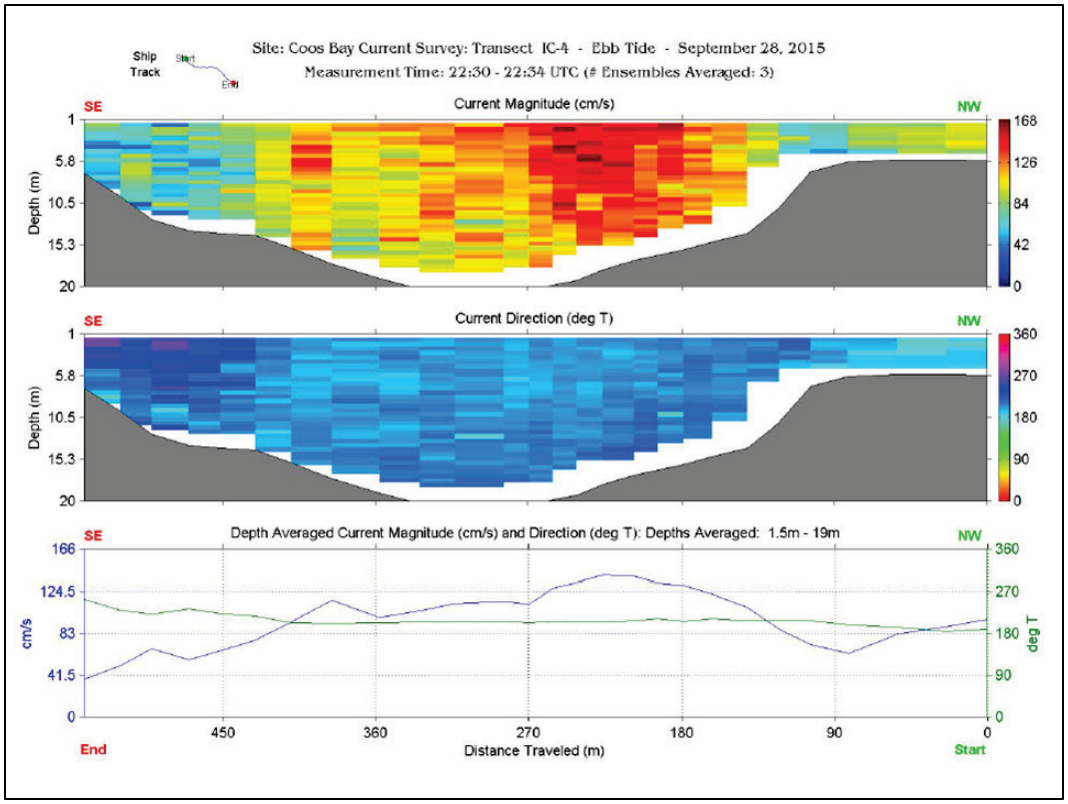

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 28, 2015
Measurement Time: 21:36 - 21:40 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 12.4m
SE
NW
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

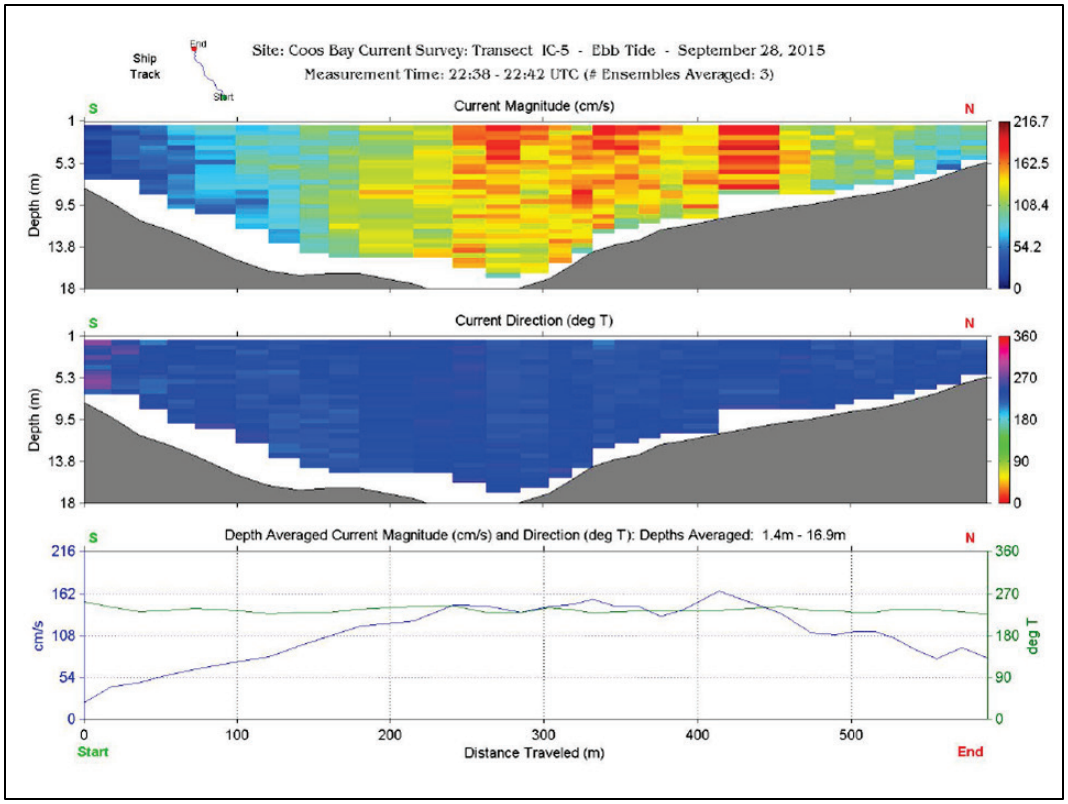

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - September 28, 2015
Measurement Time: 21:52 - 21:59 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4.3
7.5
10.8
14
132.2
99.1
66.1
33
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 12.5m
cm/s
deg T
132
99
66
33
0
0
145
290
435
580
725
Start
Distance Traveled (m)
End

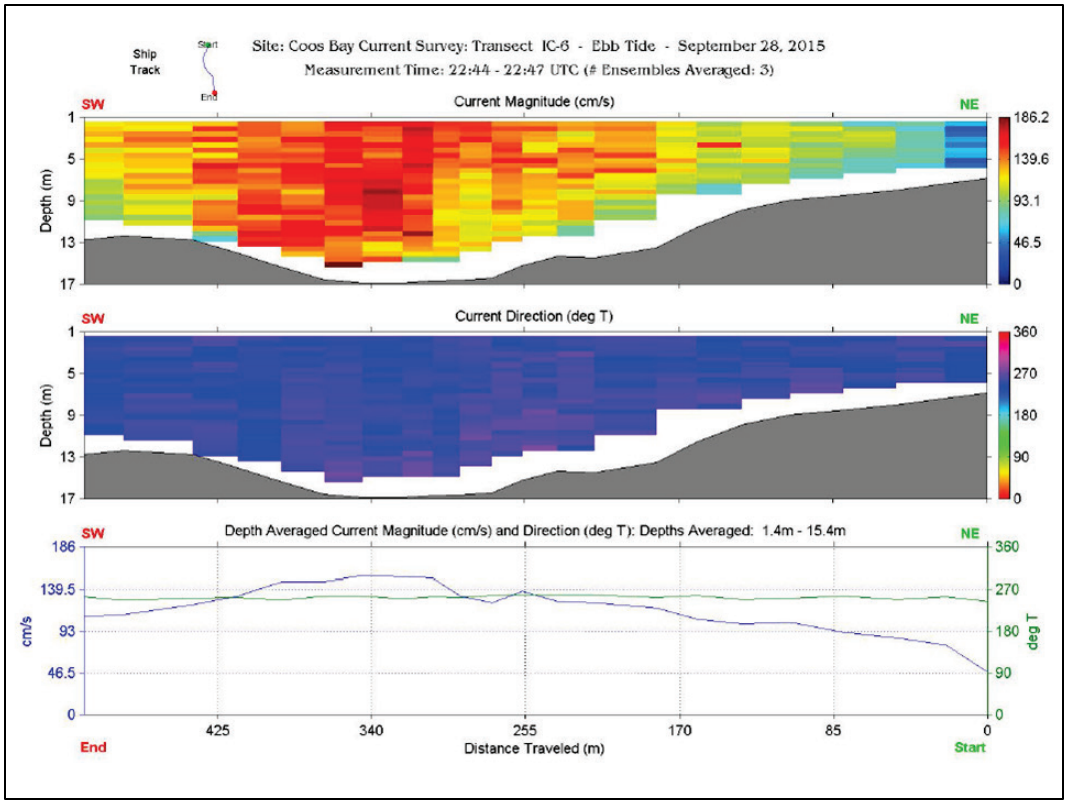

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - September 28, 2015
Measurement Time: 22:04 - 22:11 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4
7
10
13
147.2
110.4
73.6
36.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 12m
cm/s
deg T
146
109.5
73
36.5
0
0
135
270
405
540
675
810
Start
Distance Traveled (m)
End

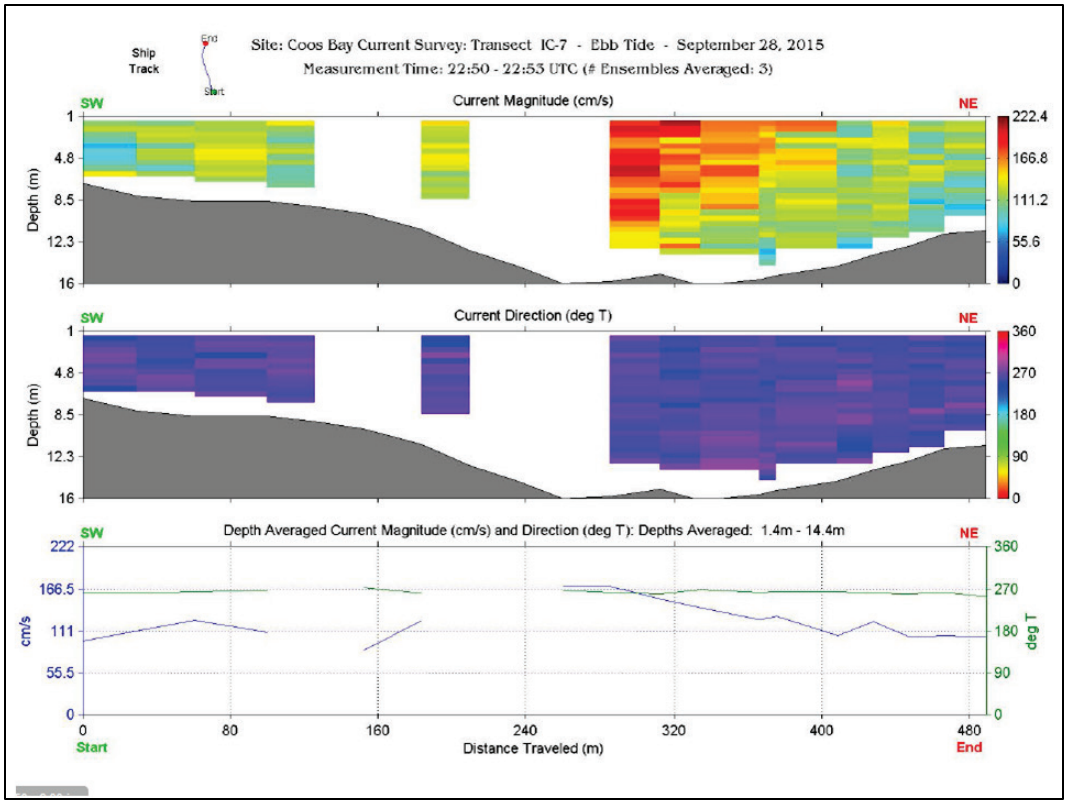

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 28, 2015
Measurement Time: 22:15 - 22:21 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.3
7.5
10.8
14
150.5
112.9
75.2
37.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 12.5m
cm/s
150
112.5
75
37.5
deg T
660
550
440
330
220
110
Distance Traveled (m)
End
Start

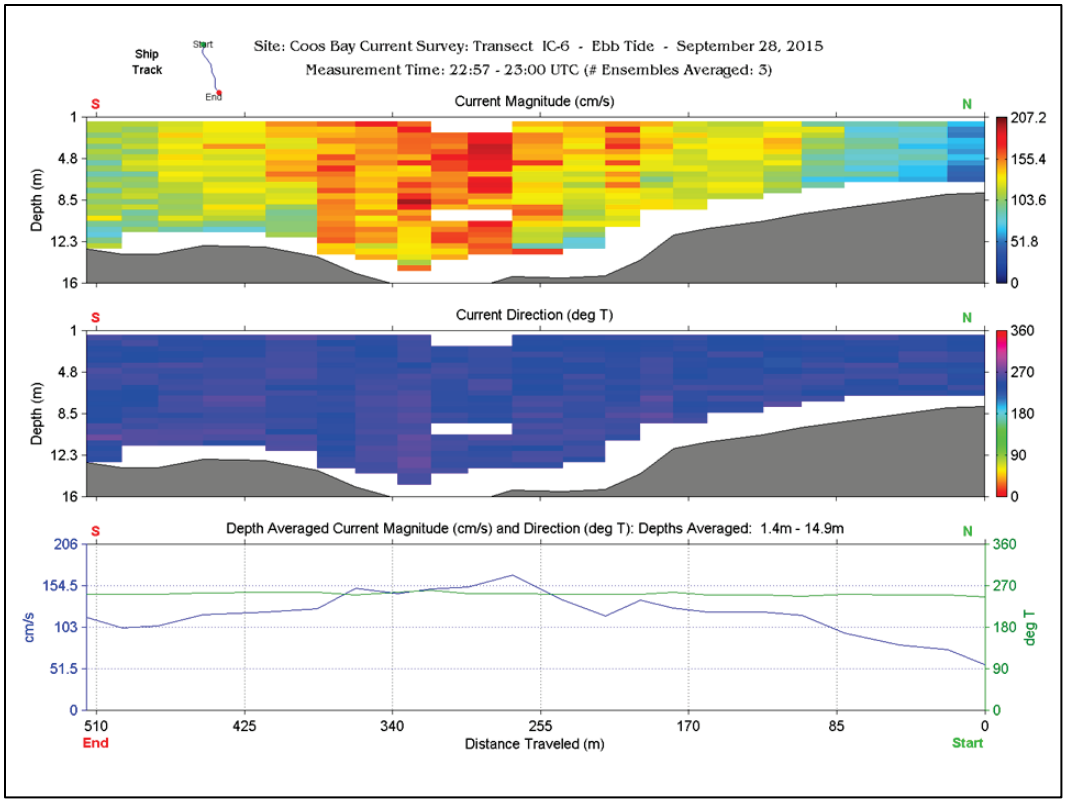

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 28, 2015
Measurement Time: 22:24 - 22:27 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
193.9
145.5
97
48.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 17.5m
cm/s
192
144
96
48
deg T
0
70
140
210
280
350
Distance Traveled (m)
Start
End

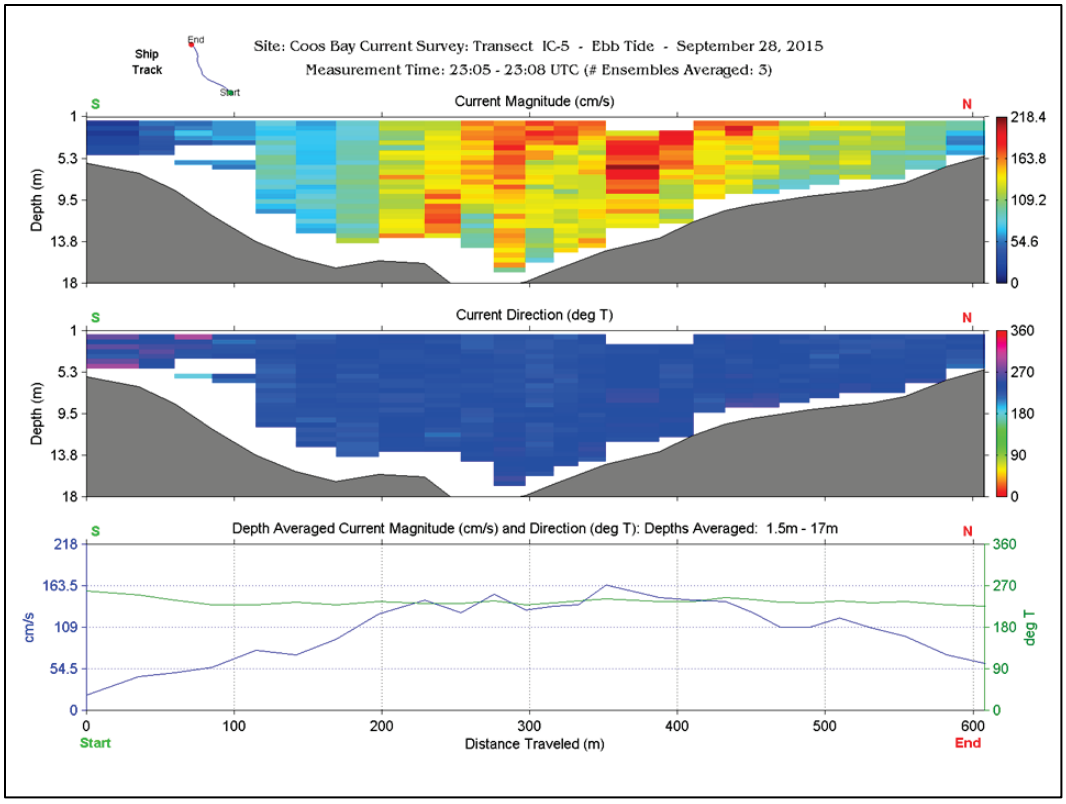

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 28, 2015
Measurement Time: 22:30 - 22:34 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
168
126
84
42
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 19m
cm/s
deg T
166
124.5
83
41.5
450
360
270
180
90
Distance Traveled (m)
End
Start

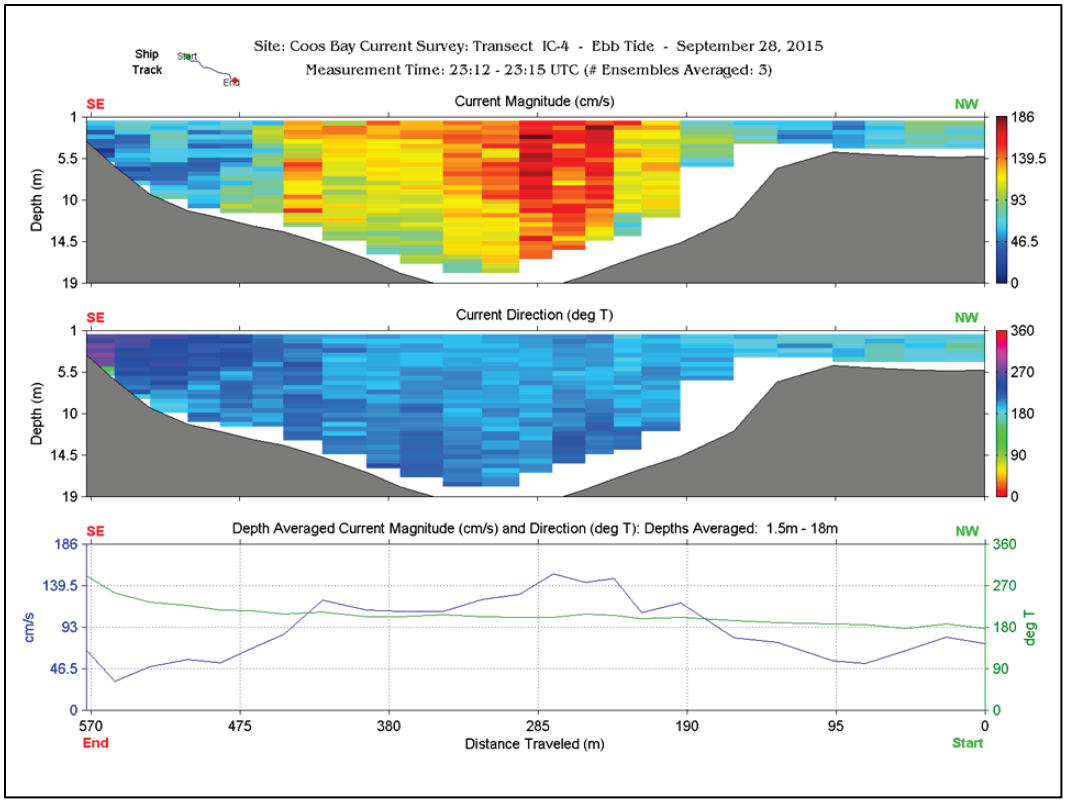

Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 28, 2015
Measurement Time: 22:38 - 22:42 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
216.7
162.5
108.4
54.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 16.9m
cm/s
deg T
216
162
108
54
0
100
200
300
400
500
Distance Traveled (m)
Start
End

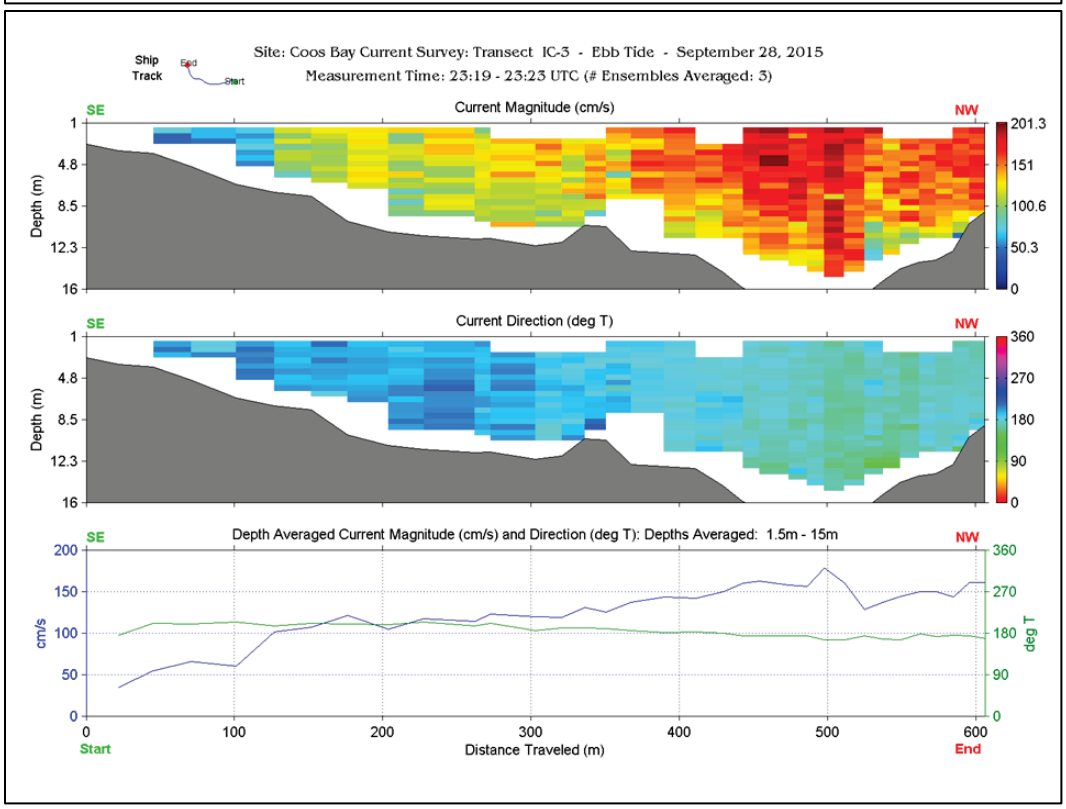

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - September 28, 2015
Measurement Time: 22:44 - 22:47 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
186.2
139.6
93.1
46.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 15.4m
cm/s
deg T
186
139.5
93
46.5
425
340
255
170
85
Distance Traveled (m)
End
Start

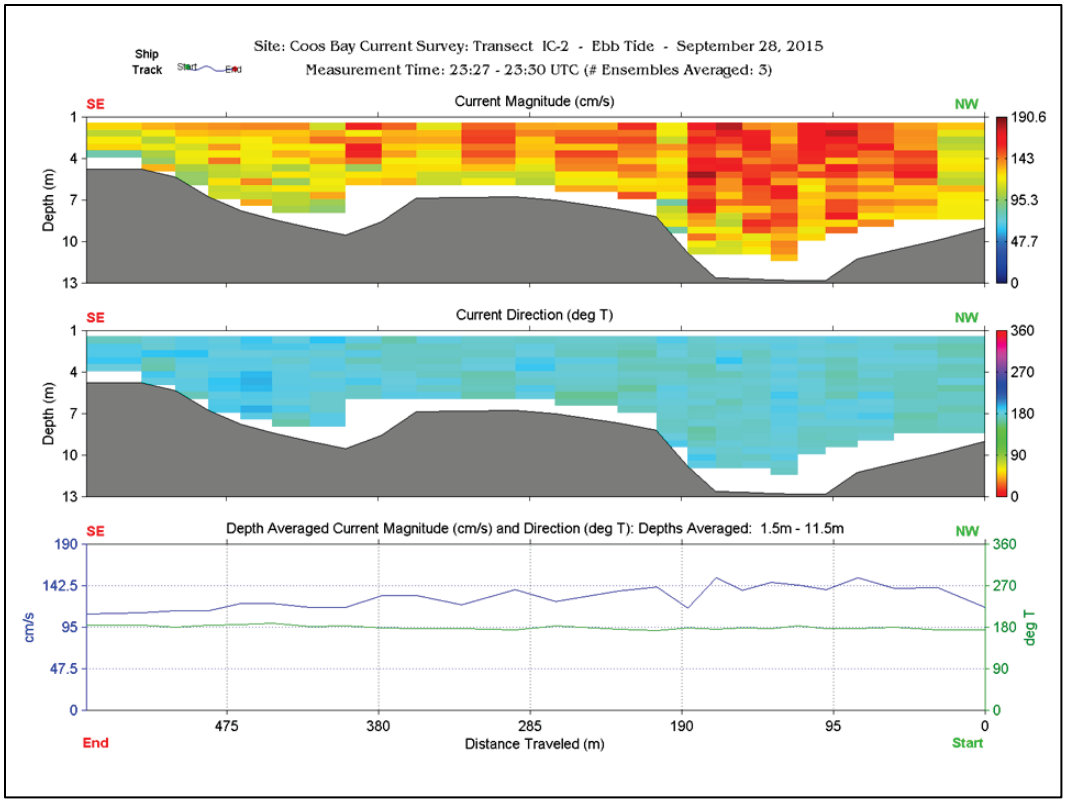

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Ebb Tide - September 28, 2015
Measurement Time: 22:50 - 22:53 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
222.4
166.8
111.2
55.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 14.4m
cm/s
deg T
222
166.5
111
55.5
0
80
160
240
320
400
480
Distance Traveled (m)
Start
End

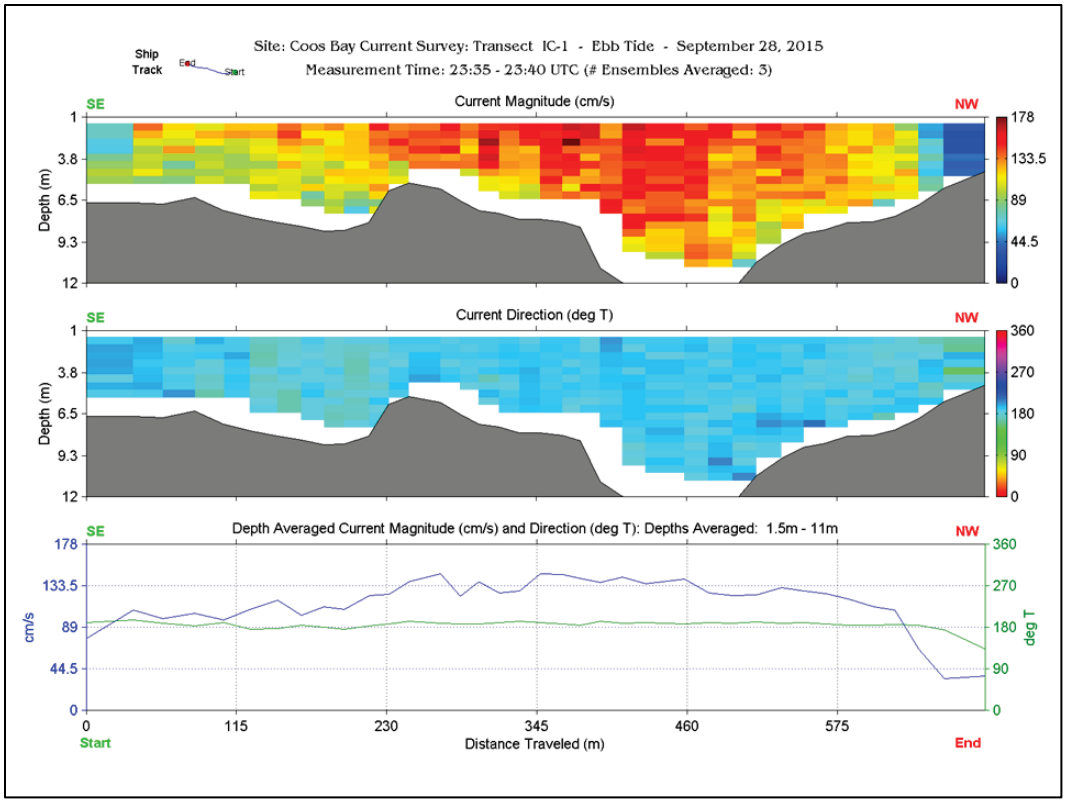

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - September 28, 2015
Measurement Time: 22:57 - 23:00 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.8
8.5
12.3
16
207.2
155.4
103.6
51.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.4m - 14.9m
cm/s
206
154.5
103
51.5
deg T
510
425
340
255
170
85
End
Start
Distance Traveled (m)

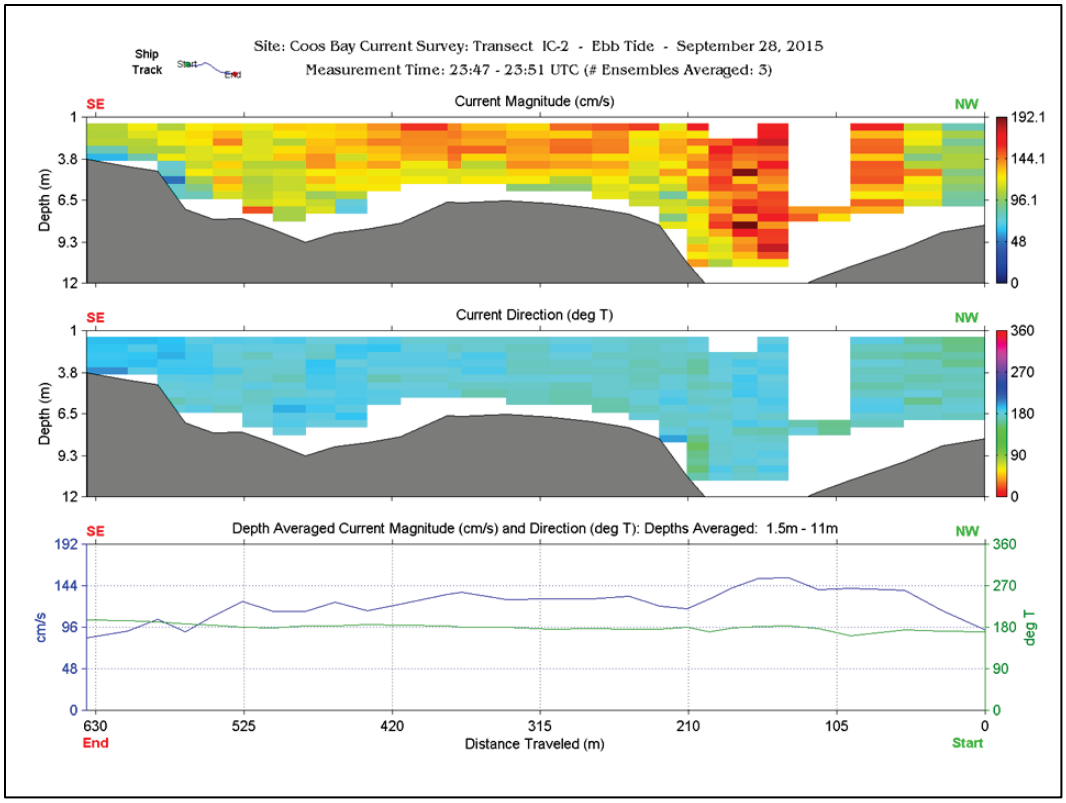

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 28, 2015
Measurement Time: 23:05 - 23:08 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
218.4
163.8
109.2
54.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 17m
cm/s
218
163.5
109
54.5
deg T
0
100
200
300
400
500
600
Start
End
Distance Traveled (m)

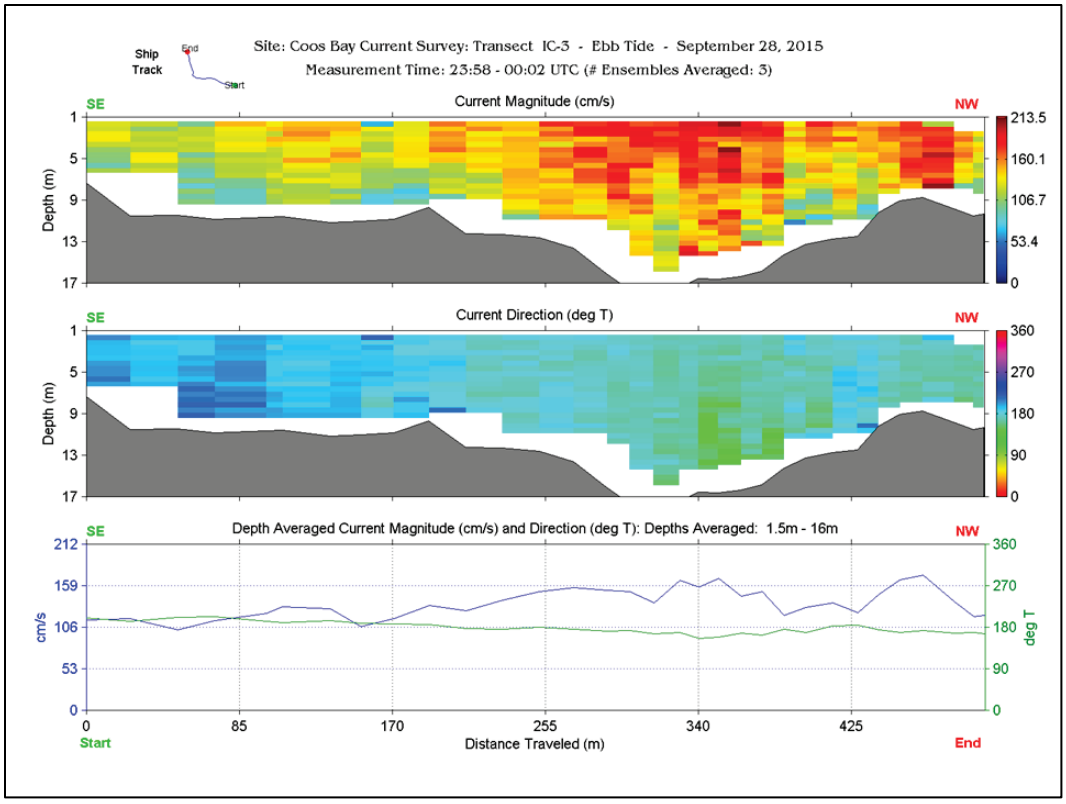

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 28, 2015
Measurement Time: 23:12 - 23:15 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
186
139.5
93
46.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 18m
cm/s
deg T
570
475
380
285
190
95
0
End
Start
Distance Traveled (m)

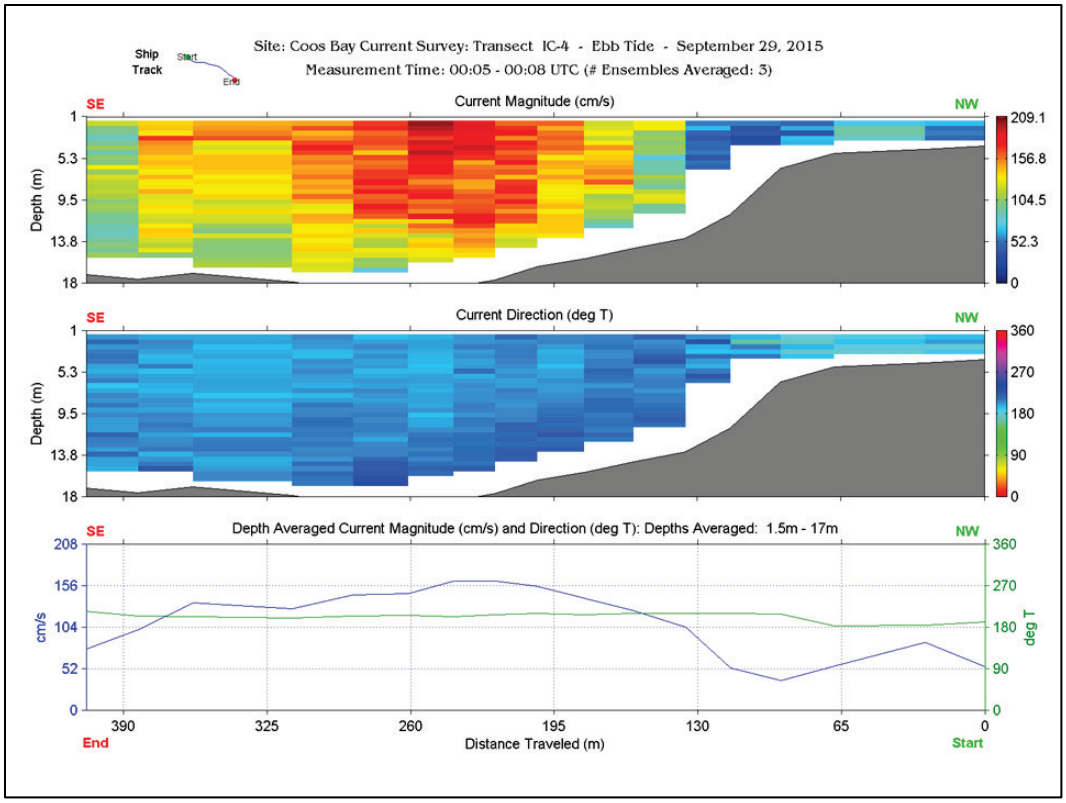

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 28, 2015
Measurement Time: 23:19 - 23:23 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4.8
8.5
12.3
16
201.3
151
100.6
50.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 15m
200
150
100
50
cm/s
deg T
0
100
200
300
400
500
600
Start
End
Distance Traveled (m)

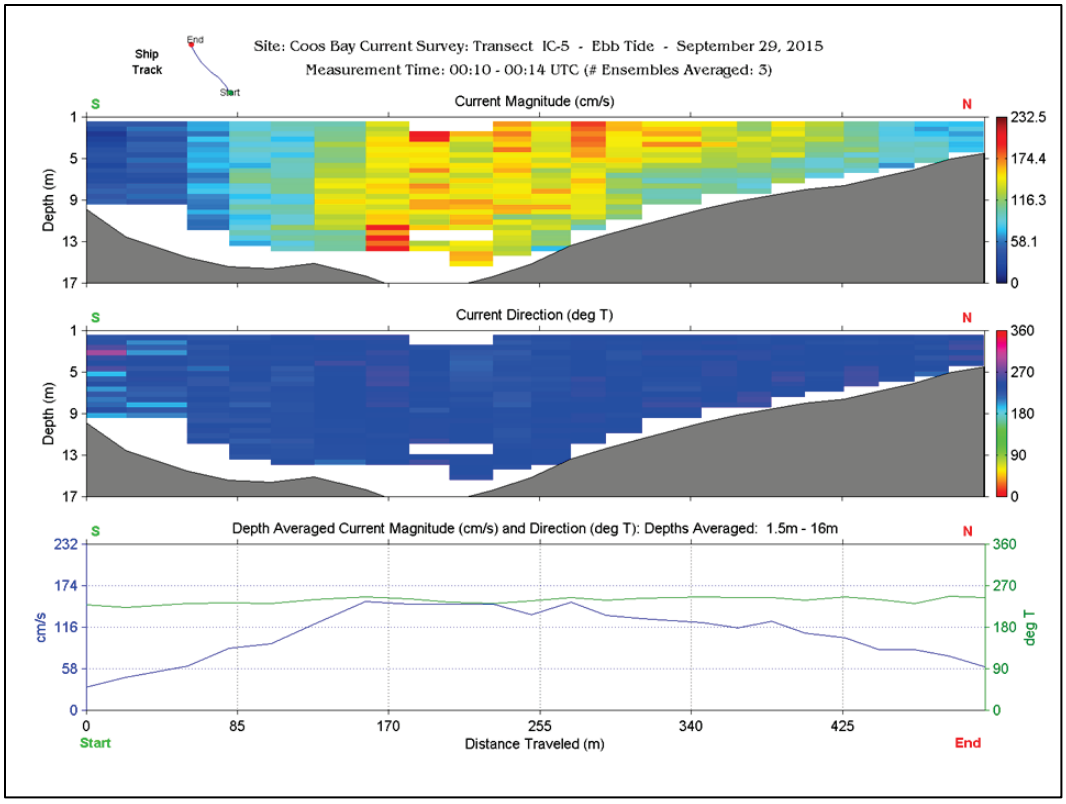

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 28, 2015
Measurement Time: 23:27 - 23:30 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4
7
10
13
190.6
143
95.3
47.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 11.5m
cm/s
deg T
190
142.5
95
47.5
475
380
285
190
95
End
Start
Distance Traveled (m)

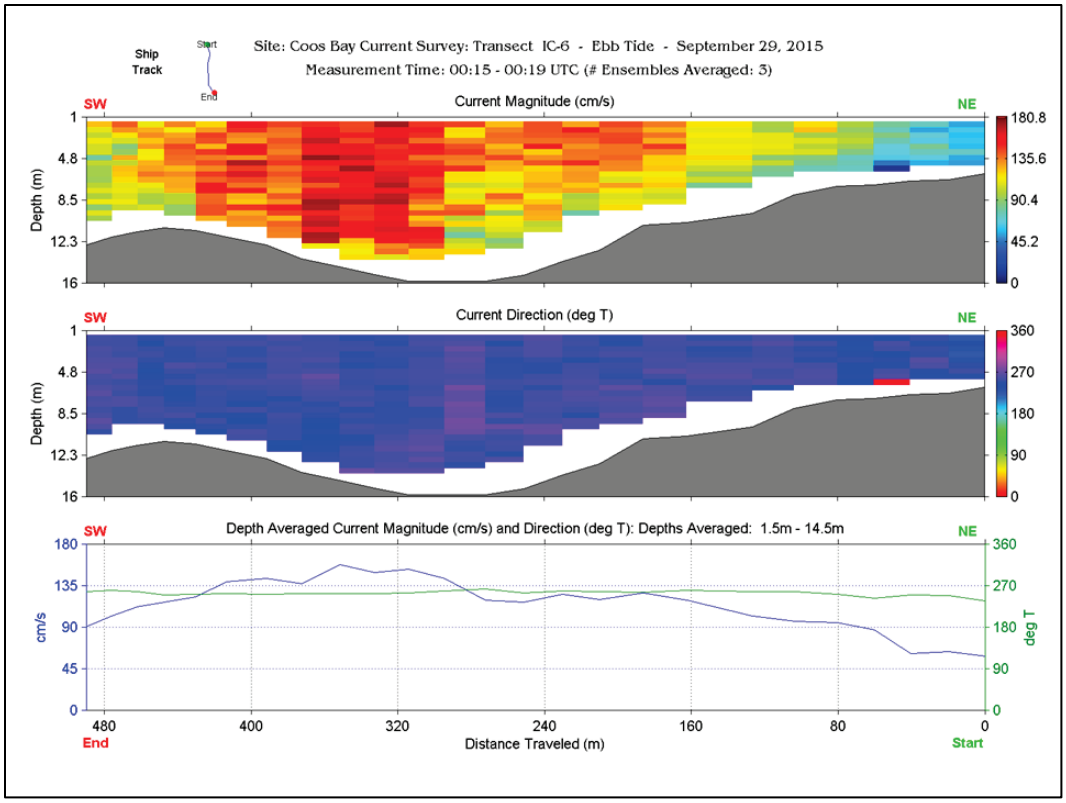

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - September 28, 2015
Measurement Time: 23:35 - 23:40 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
178
133.5
89
44.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 11m
cm/s
deg T
178
133.5
89
44.5
0
115
230
345
460
575
Start
End
Distance Traveled (m)

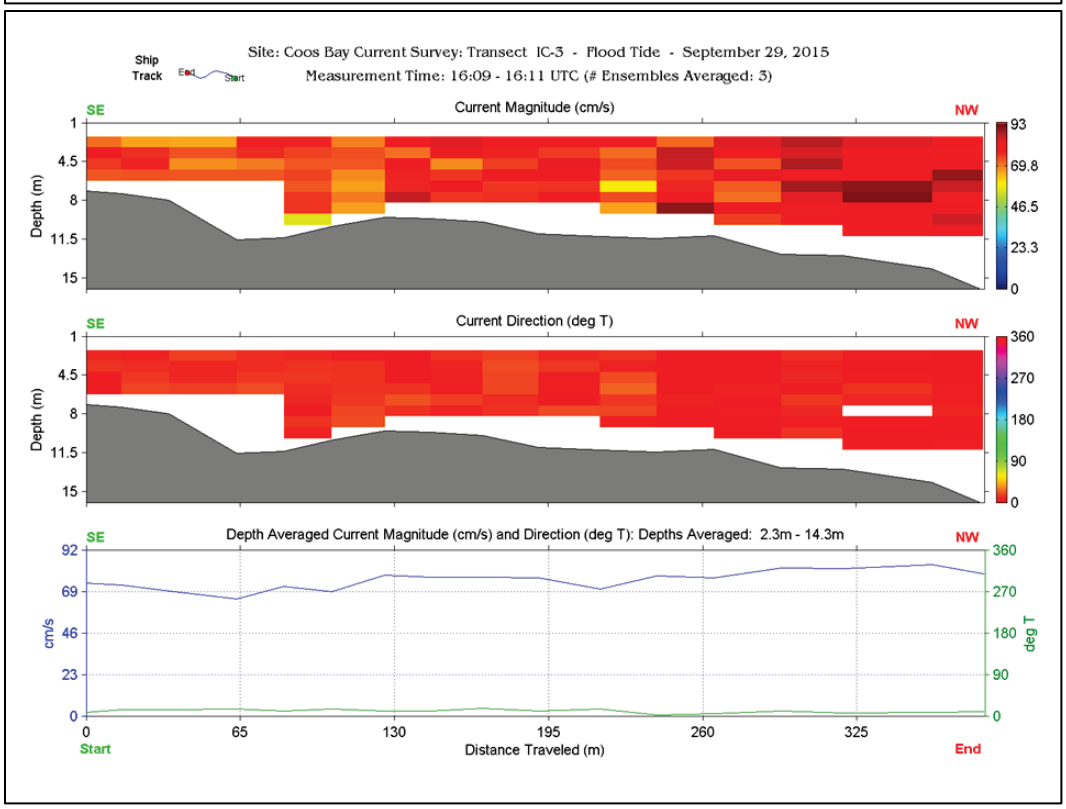

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 28, 2015
Measurement Time: 23:47 - 23:51 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
192.1
144.1
96.1
48
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 11m
cm/s
deg T
192
144
96
48
630
525
420
315
210
105
Distance Traveled (m)
End
Start

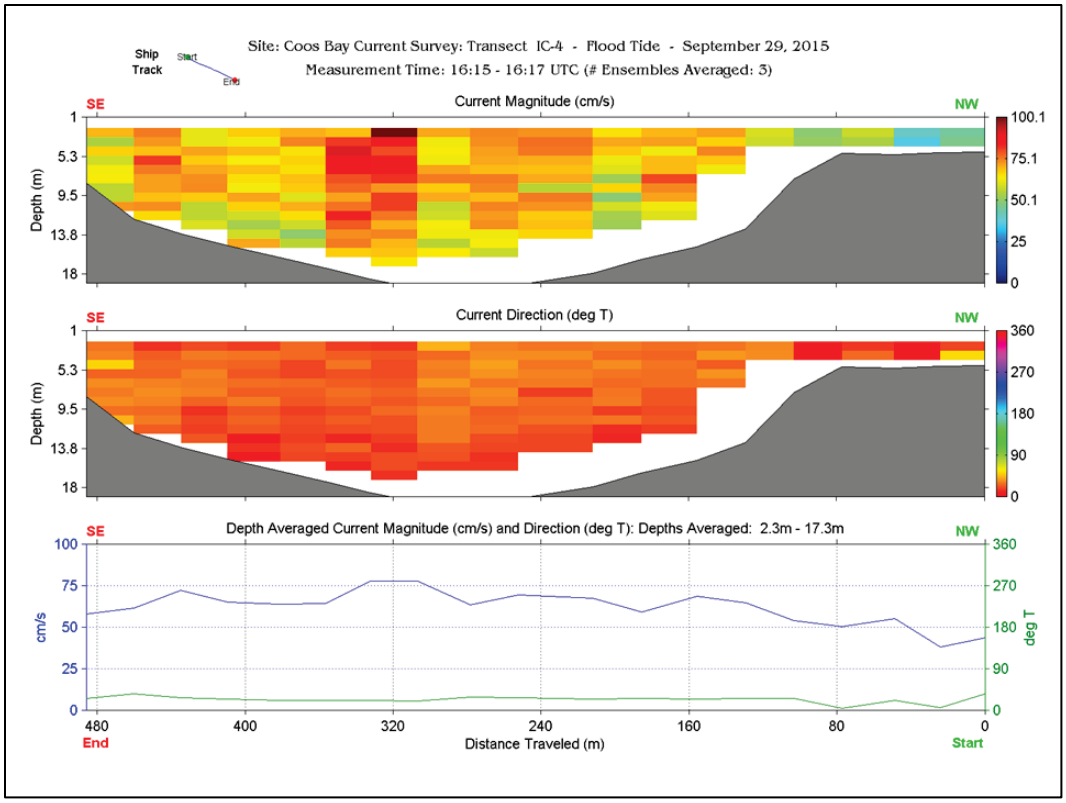

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 28, 2015
Measurement Time: 23:58 - 00:02 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5
9
13
17
213.5
160.1
106.7
53.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 16m
cm/s
deg T
212
159
106
53
0
85
170
255
340
425
Distance Traveled (m)
Start
End

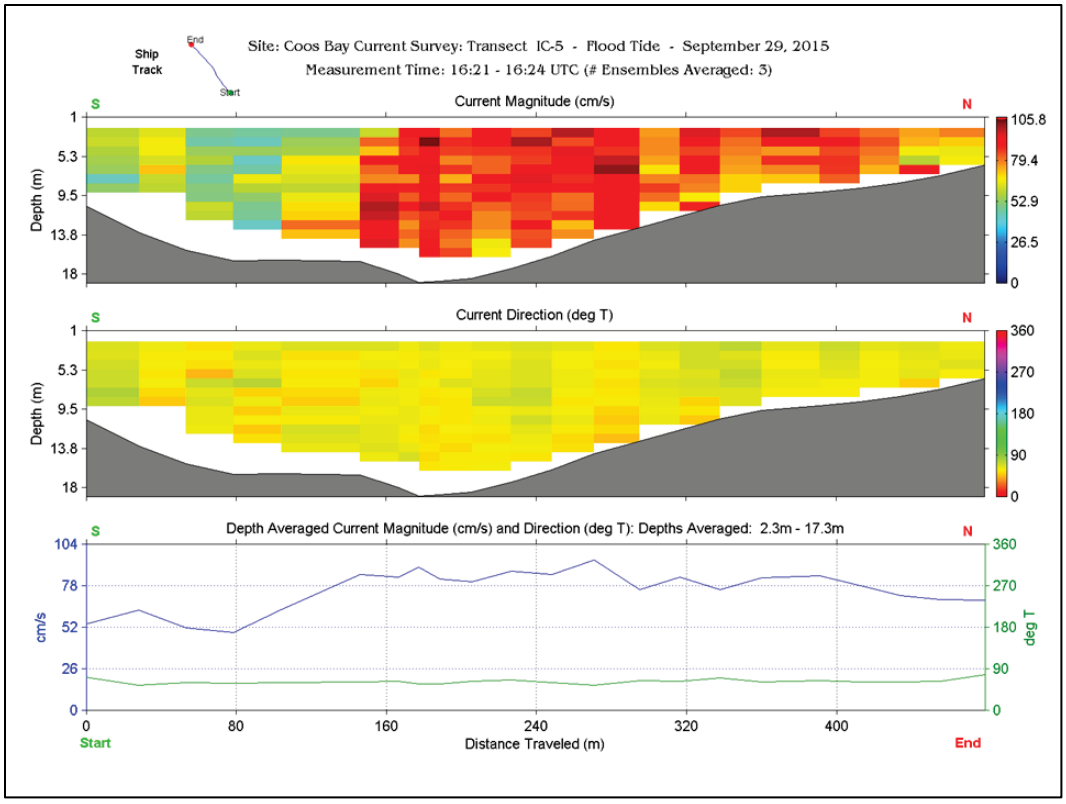

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 29, 2015
Measurement Time: 00:05 - 00:08 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.3
9.5
13.8
18
209.1
156.8
104.5
52.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 17m
cm/s
deg T
208
156
104
52
390
325
260
195
130
65
Distance Traveled (m)

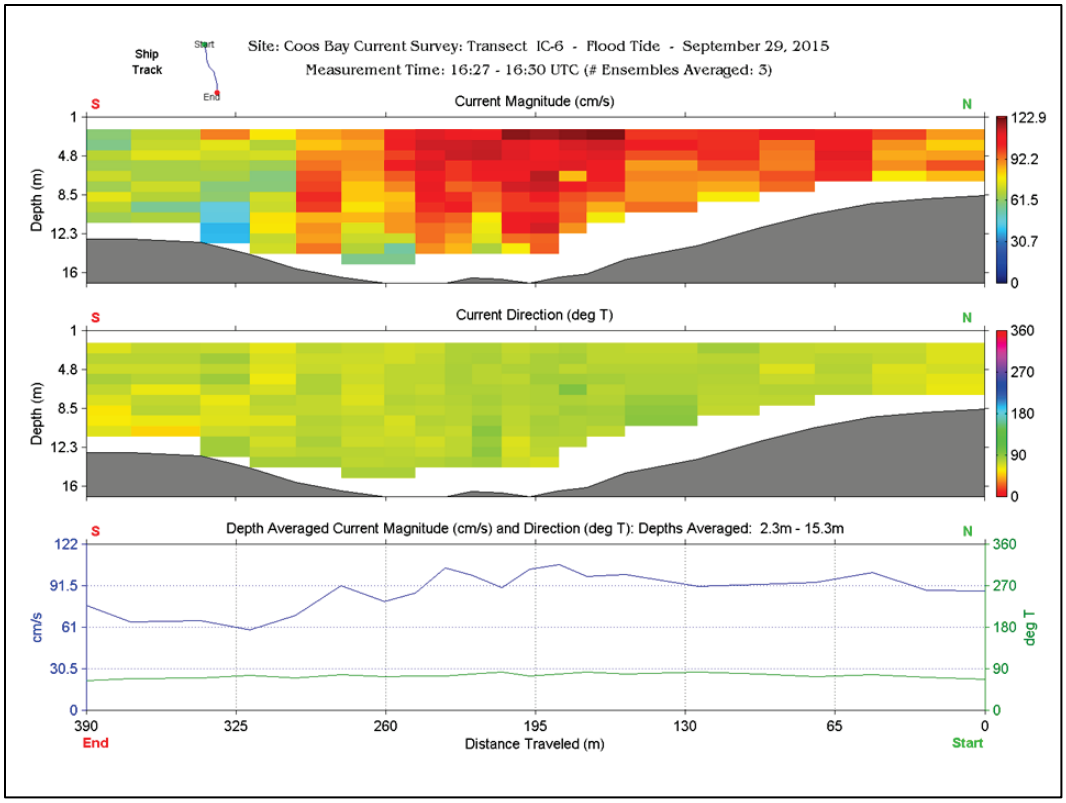

Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 29, 2015
Measurement Time: 00:10 - 00:14 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
232.5
174.4
116.3
58.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 16m
cm/s
deg T
232
174
116
58
0
85
170
255
340
425
Distance Traveled (m)

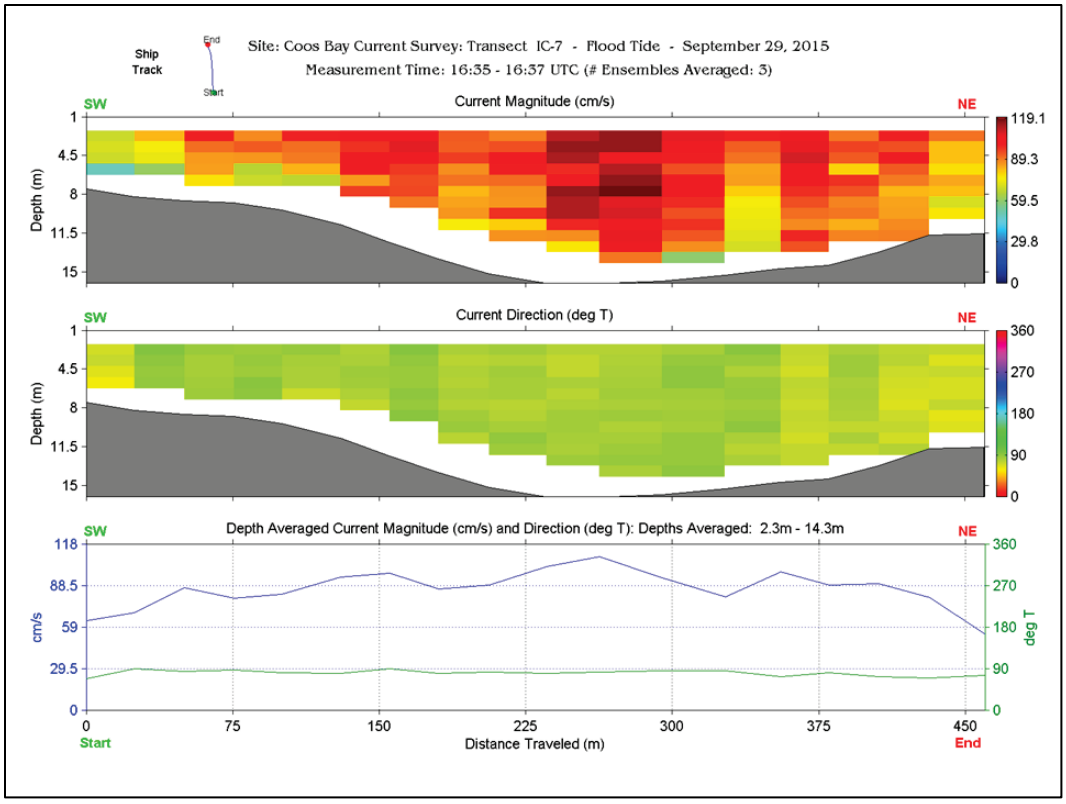

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - September 29, 2015
Measurement Time: 00:15 - 00:19 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
180.8
135.6
90.4
45.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 1.5m - 14.5m
cm/s
deg T
480
400
320
240
160
80
0
End
Start
Distance Traveled (m)

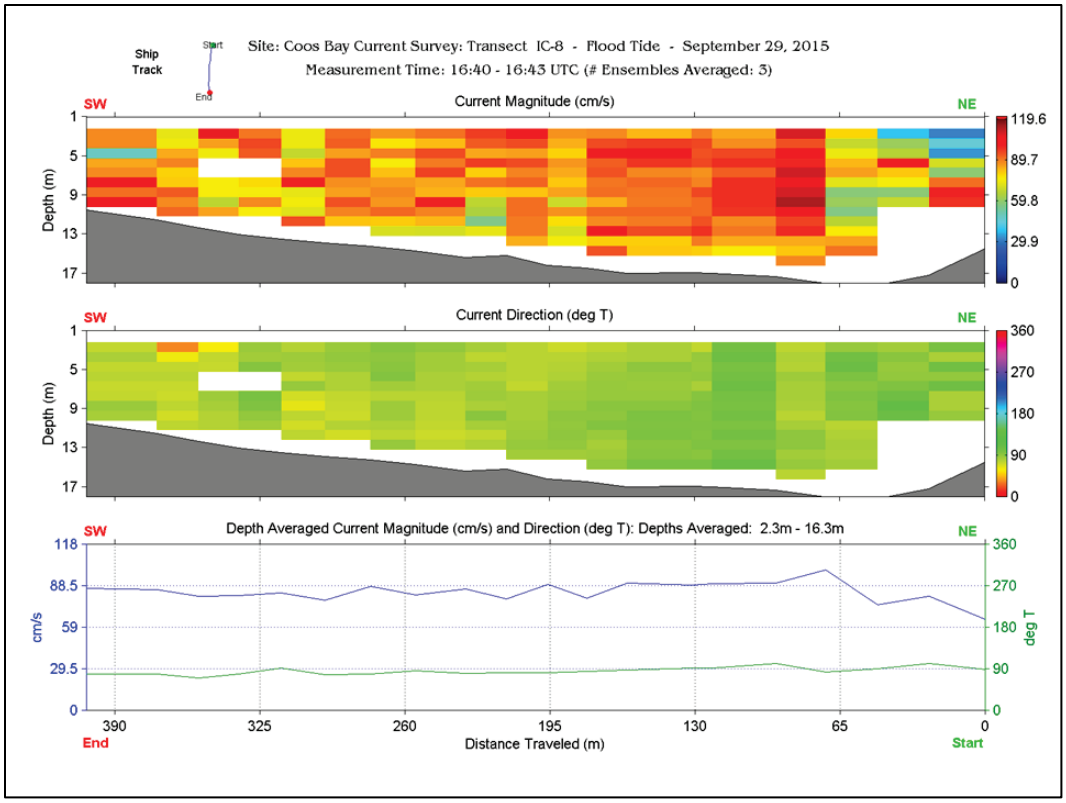

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-3 - Flood Tide - September 29, 2015
Measurement Time: 16:09 - 16:11 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4.5
8
11.5
15
93
69.8
46.5
23.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
deg T
92
69
46
23
0
65
130
195
260
325
Start
End
Distance Traveled (m)

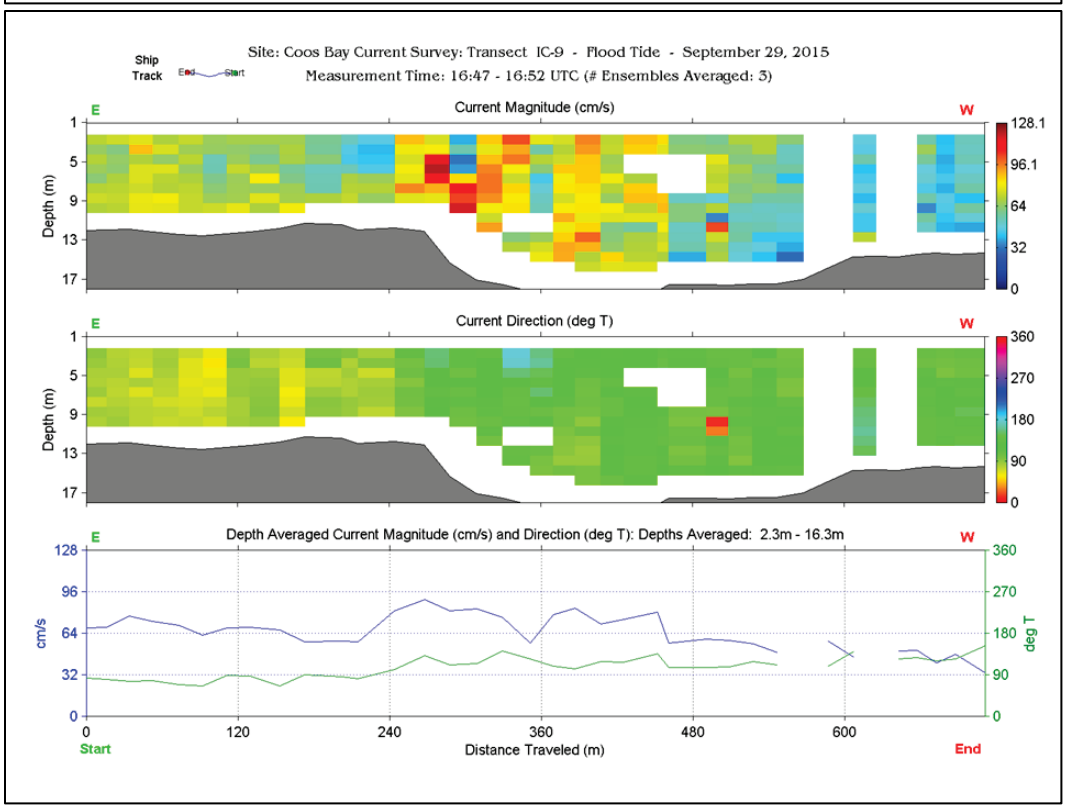

Site: Coos Bay Current Survey: Transect IC-4 - Flood Tide - September 29, 2015
Measurement Time: 16:15 - 16:17 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.3
9.5
13.8
18
100.1
75.1
50.1
25
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
100
75
50
25
480
400
320
240
160
80
Distance Traveled (m)

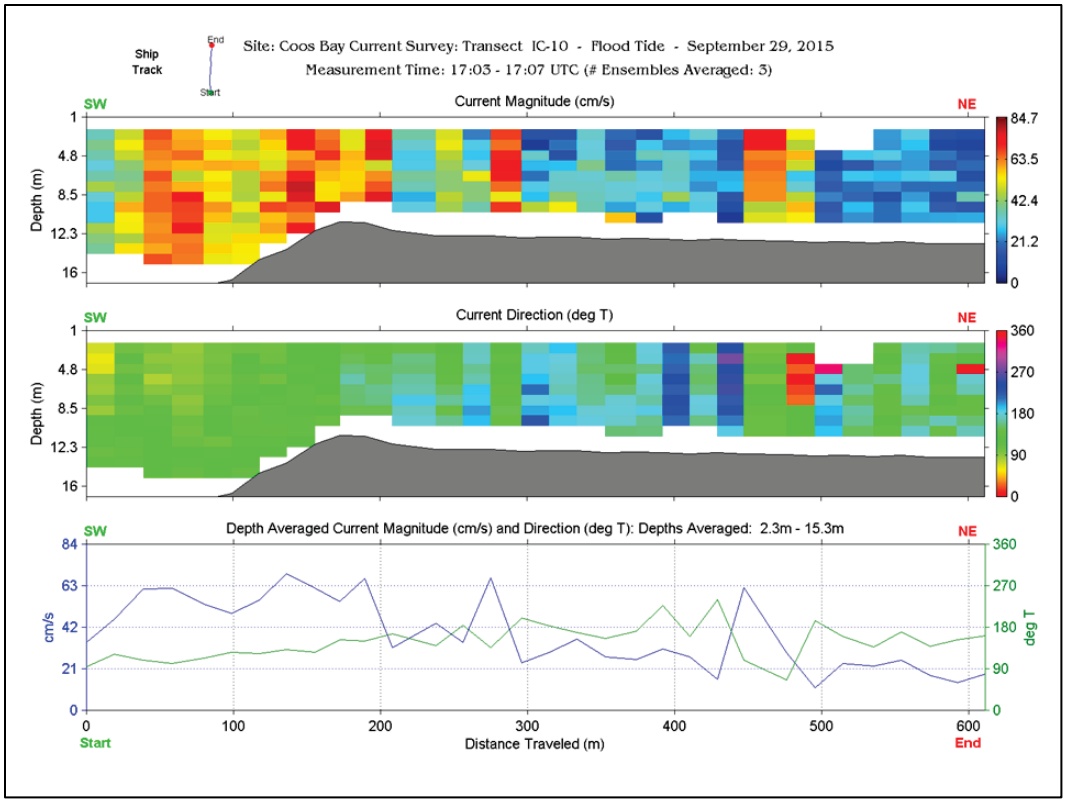

Site: Coos Bay Current Survey: Transect IC-5 - Flood Tide - September 29, 2015
Measurement Time: 16:21 - 16:24 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
105.8
79.4
52.9
26.5
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
104
78
52
26
0
80
160
240
320
400
Distance Traveled (m)

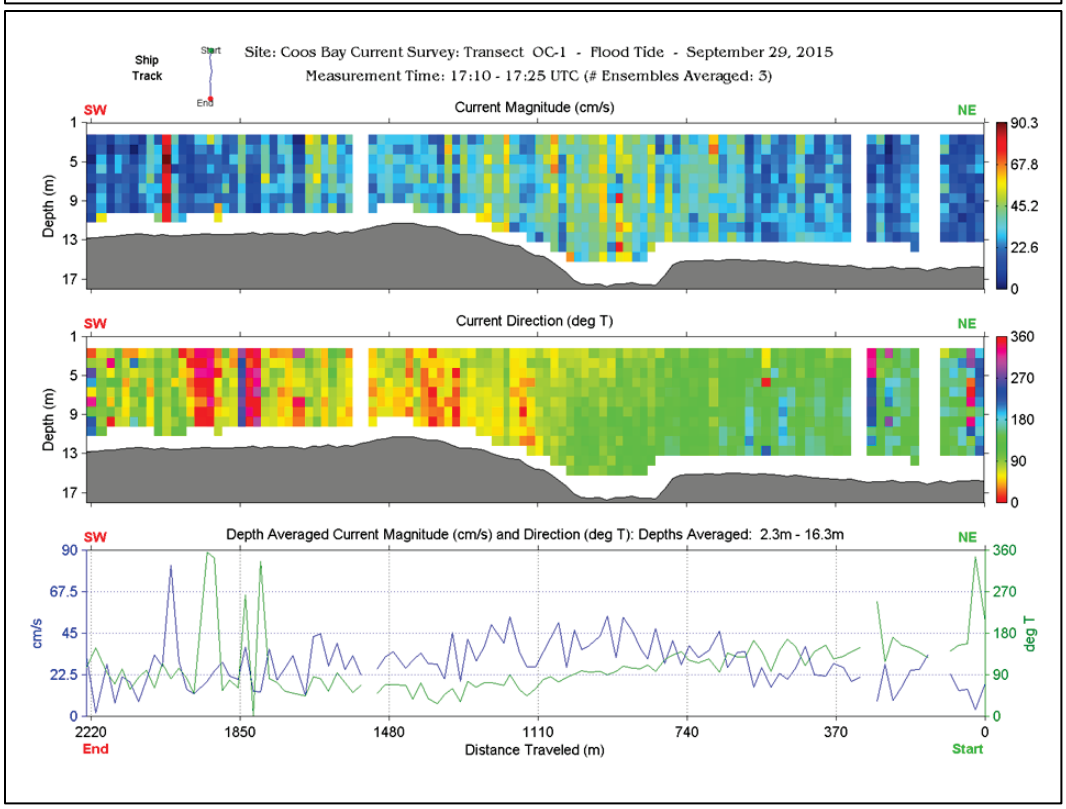

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Flood Tide - September 29, 2015
Measurement Time: 16:27 - 16:30 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.8
8.5
12.3
16
122.9
92.2
61.5
30.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
122
91.5
61
30.5
0
390
325
260
195
130
65
End
Start
Distance Traveled (m)

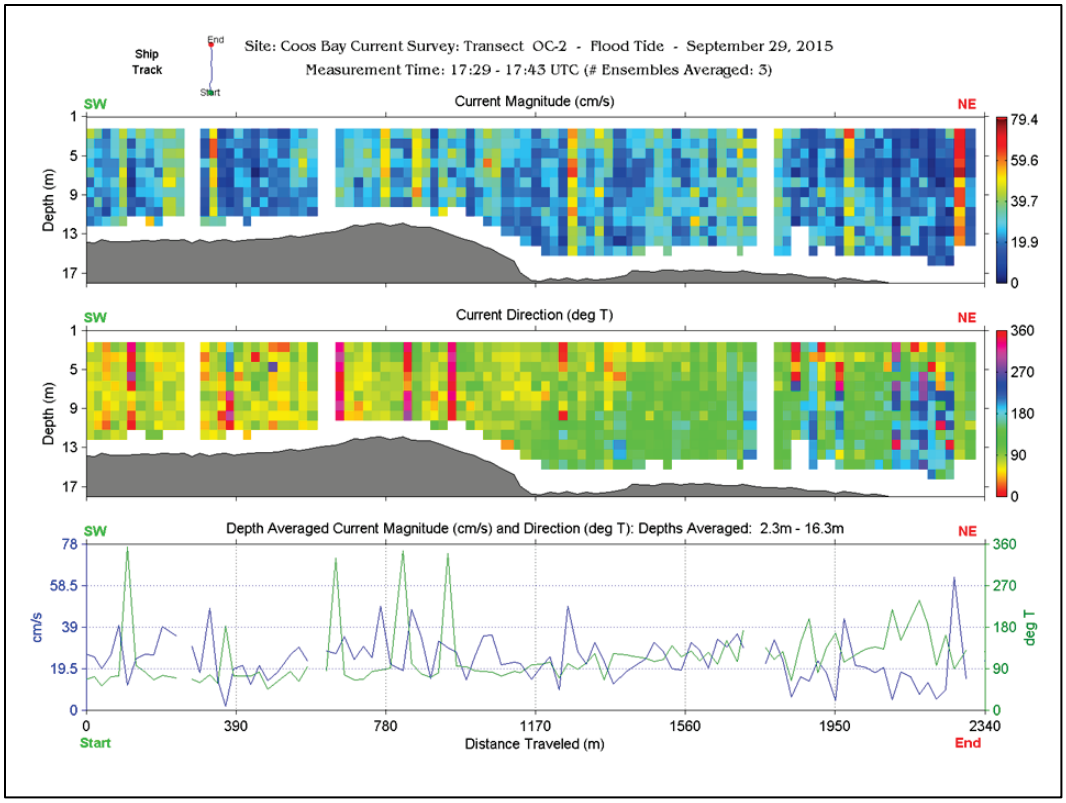

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Flood Tide - September 29, 2015
Measurement Time: 16:35 - 16:37 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.5
8
11.5
15
119.1
89.3
59.5
29.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
deg T
118
88.5
59
29.5
0
75
150
225
300
375
450
Start
End
Distance Traveled (m)

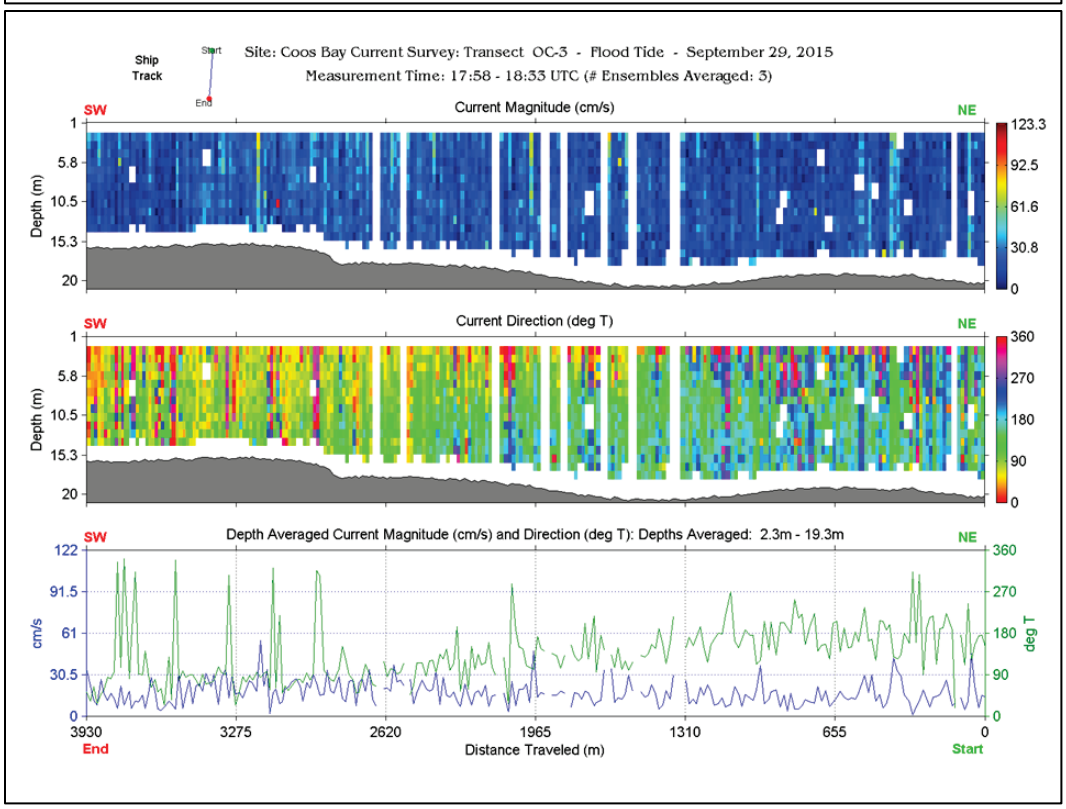

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-8 - Flood Tide - September 29, 2015
Measurement Time: 16:40 - 16:43 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
119.6
89.7
59.8
29.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
118
88.5
59
29.5
390
325
260
195
130
65
End
Start
Distance Traveled (m)

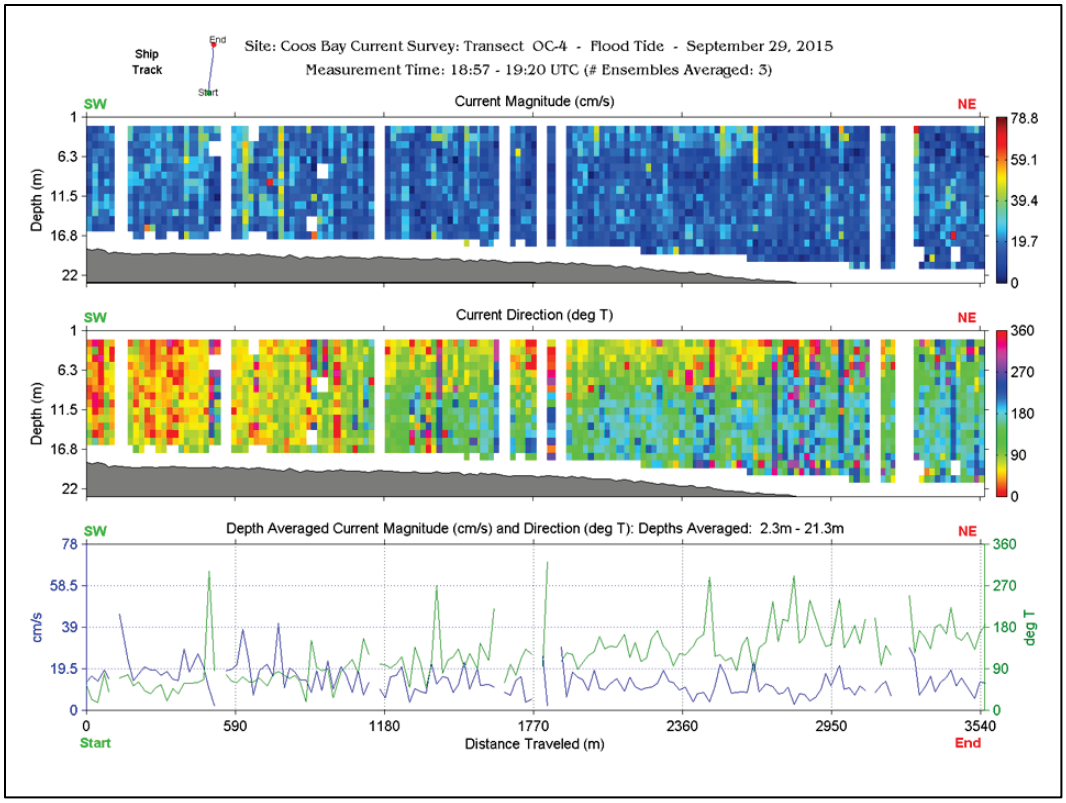

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-9 - Flood Tide - September 29, 2015
Measurement Time: 16:47 - 16:52 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5
9
13
17
128.1
96.1
64
32
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
128
96
64
32
0
120
240
360
480
600
Start
End
Distance Traveled (m)

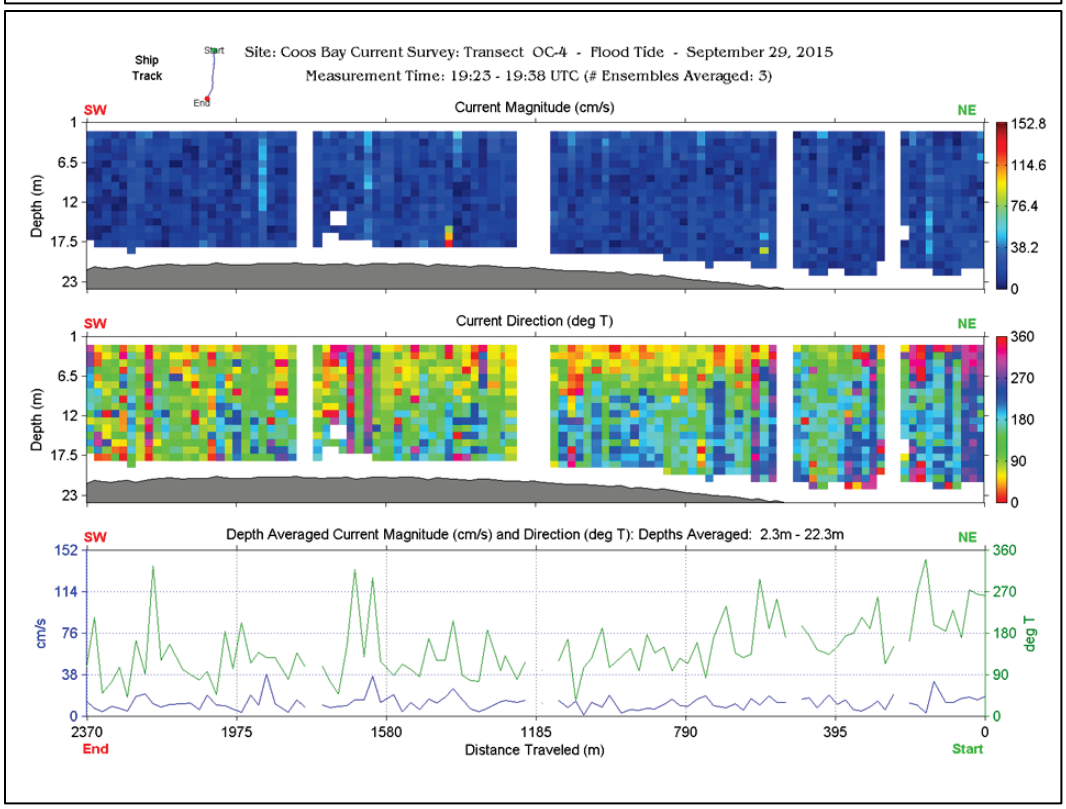

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-10 - Flood Tide - September 29, 2015
Measurement Time: 17:03 - 17:07 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
84.7
63.5
42.4
21.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
84
63
42
21
deg T
0
100
200
300
400
500
600
Start
End
Distance Traveled (m)

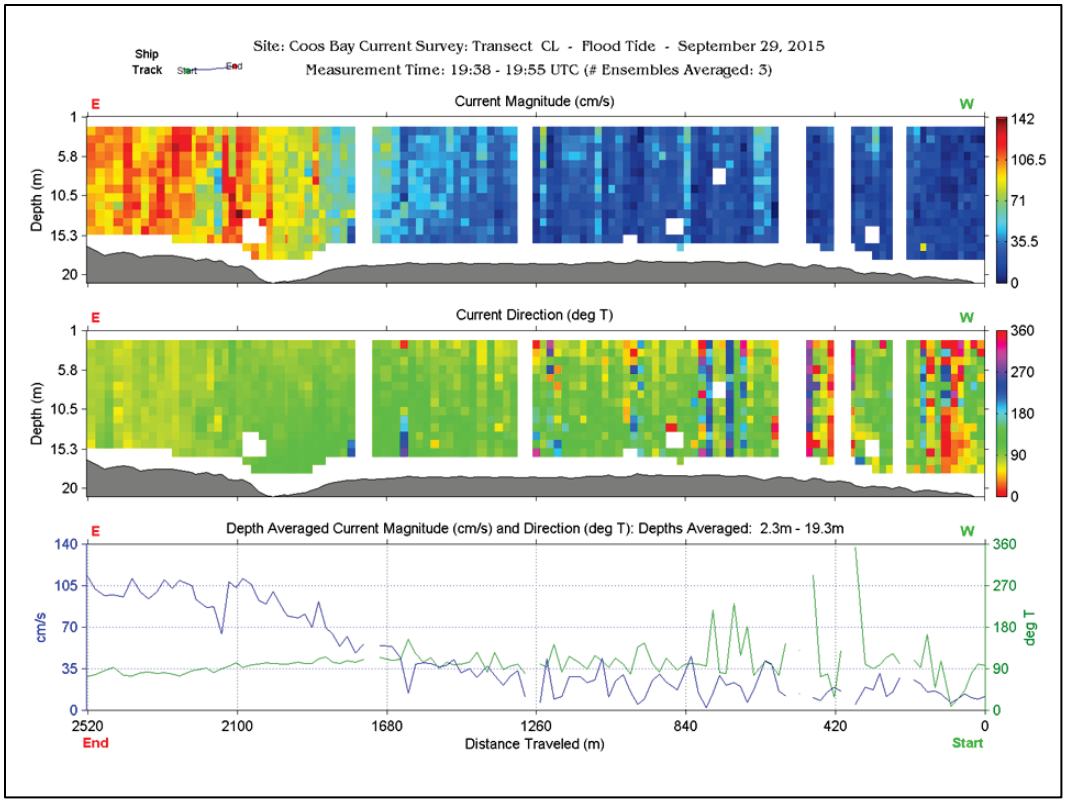

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-1 - Flood Tide - September 29, 2015
Measurement Time: 17:10 - 17:25 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
90.3
67.8
45.2
22.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
90
67.5
45
22.5
deg T
2220
1850
1480
1110
740
370
End
Start
Distance Traveled (m)

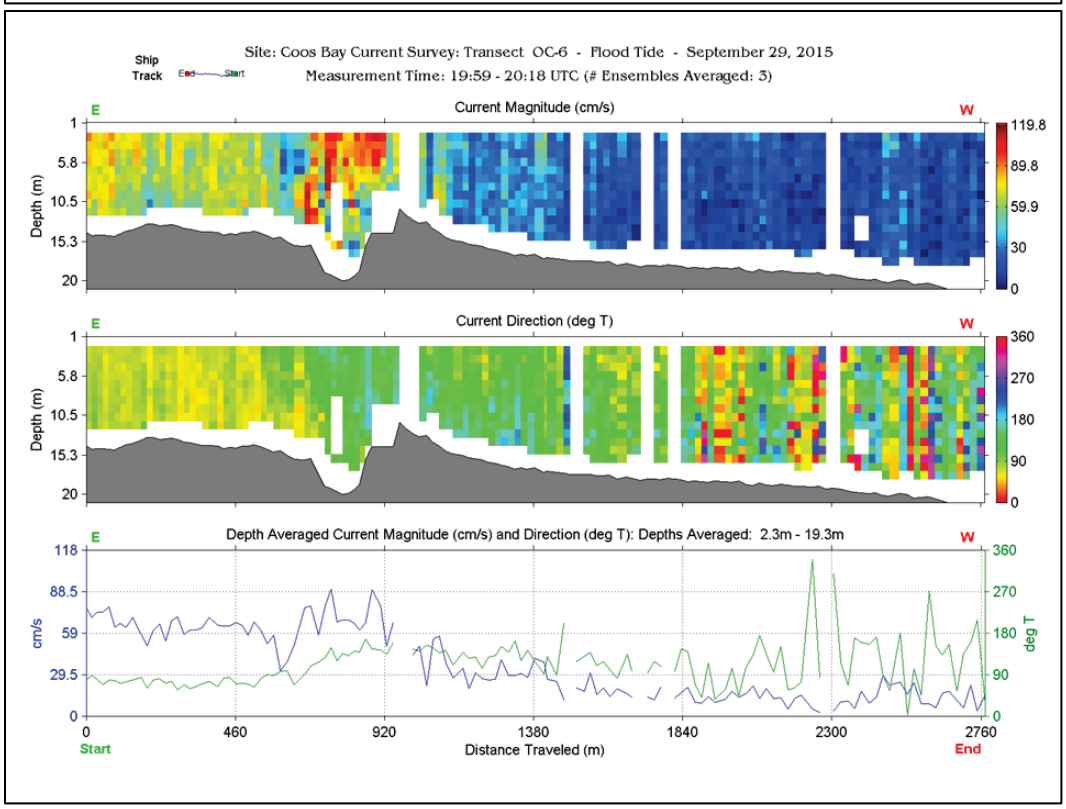

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-2 - Flood Tide - September 29, 2015
Measurement Time: 17:29 - 17:43 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
79.4
59.6
39.7
19.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
78
58.5
39
19.5
0
0
390
780
1170
1560
1950
2340
Start
End
Distance Traveled (m)

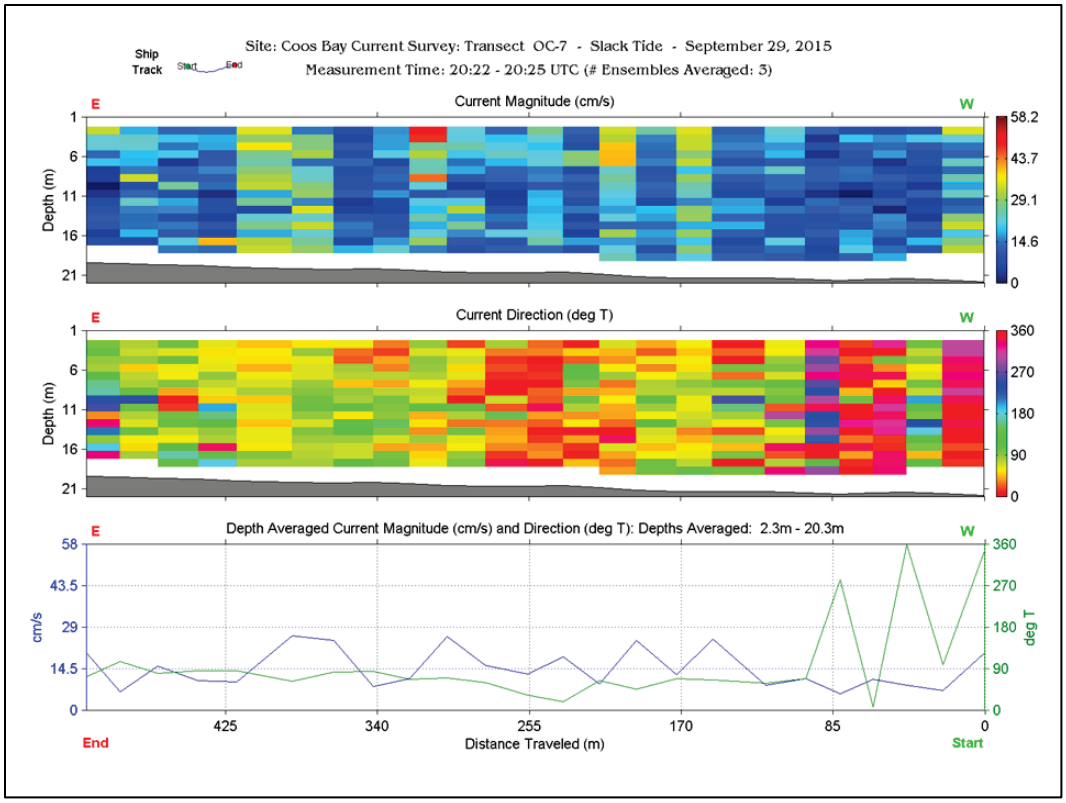

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-3 - Flood Tide - September 29, 2015
Measurement Time: 17:58 - 18:33 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.8
10.5
15.3
20
123.3
92.5
61.6
30.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
122
91.5
61
30.5
0
3930
3275
2620
1965
1310
655
0
End
Start
Distance Traveled (m)

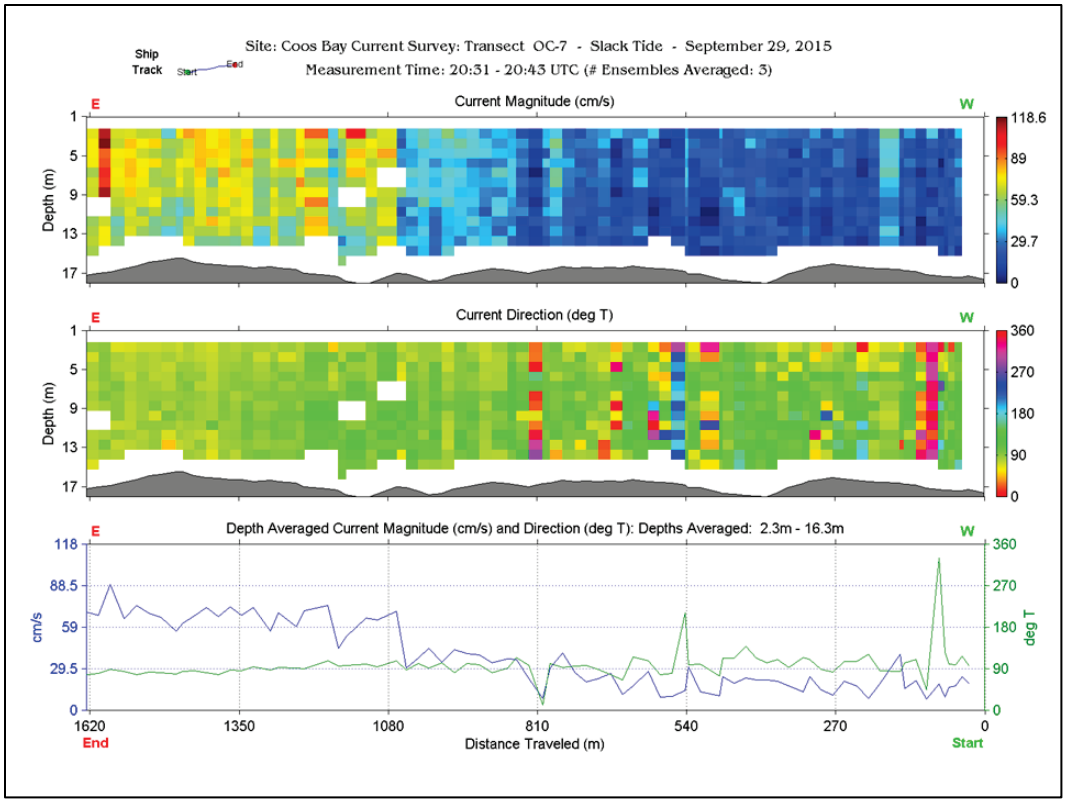

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-4 - Flood Tide - September 29, 2015
Measurement Time: 18:57 - 19:20 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
6.3
11.5
16.8
22
78.8
59.1
39.4
19.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 21.3m
cm/s
deg T
78
58.5
39
19.5
0
0
590
1180
1770
2360
2950
3540
Start
End
Distance Traveled (m)

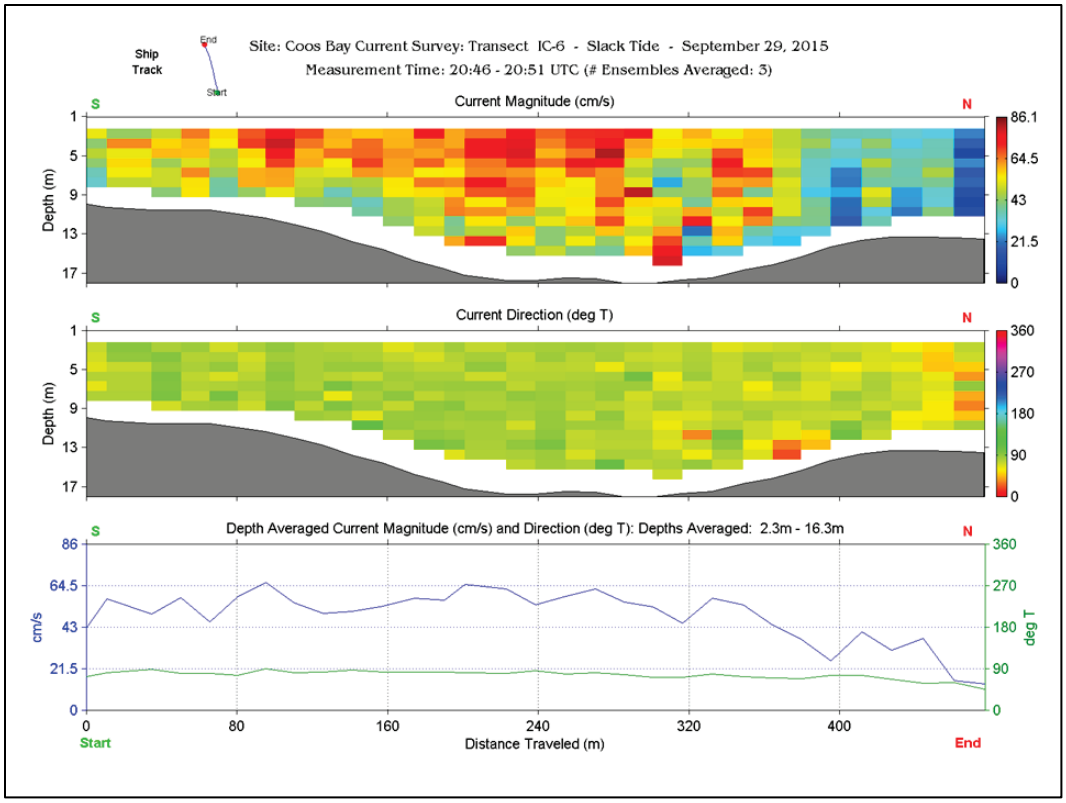

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-4 - Flood Tide - September 29, 2015
Measurement Time: 19:23 - 19:38 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
6.5
12
17.5
23
152.8
114.6
76.4
38.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 22.3m
cm/s
deg T
152
114
76
38
0
2370
1975
1580
1185
790
395
0
End
Start
Distance Traveled (m)

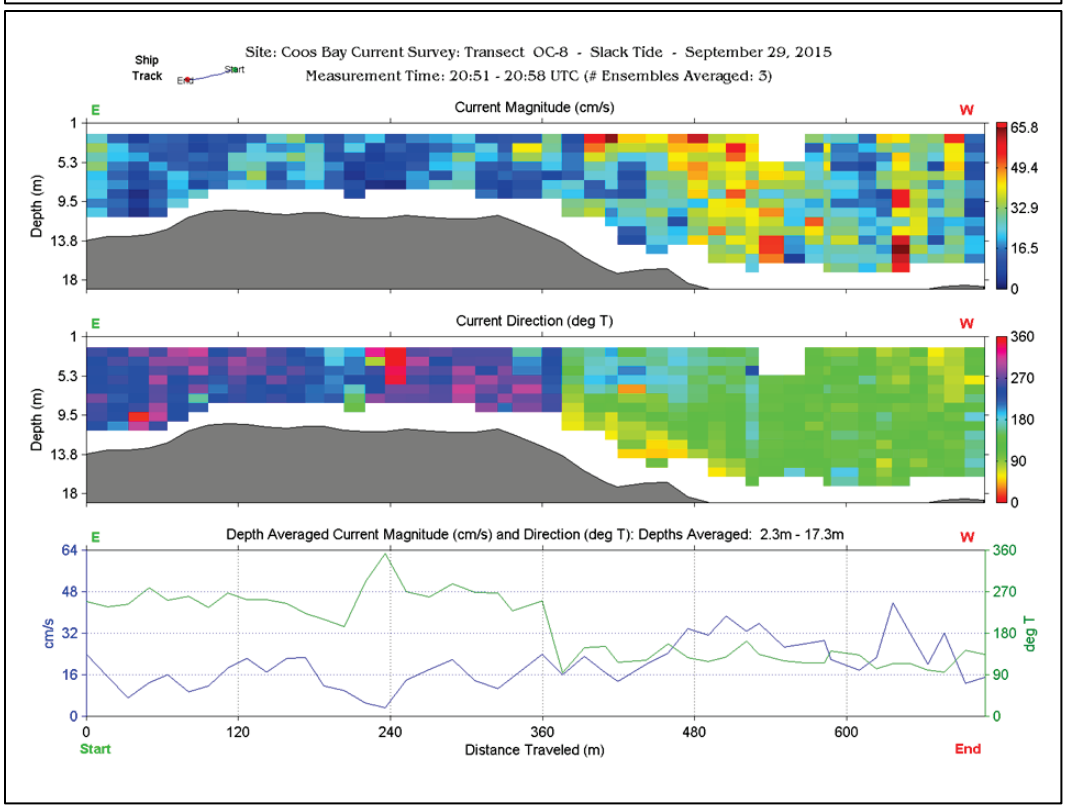

Site: Coos Bay Current Survey: Transect CL - Flood Tide - September 29, 2015
Measurement Time: 19:38 - 19:55 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
E
W
End
Start

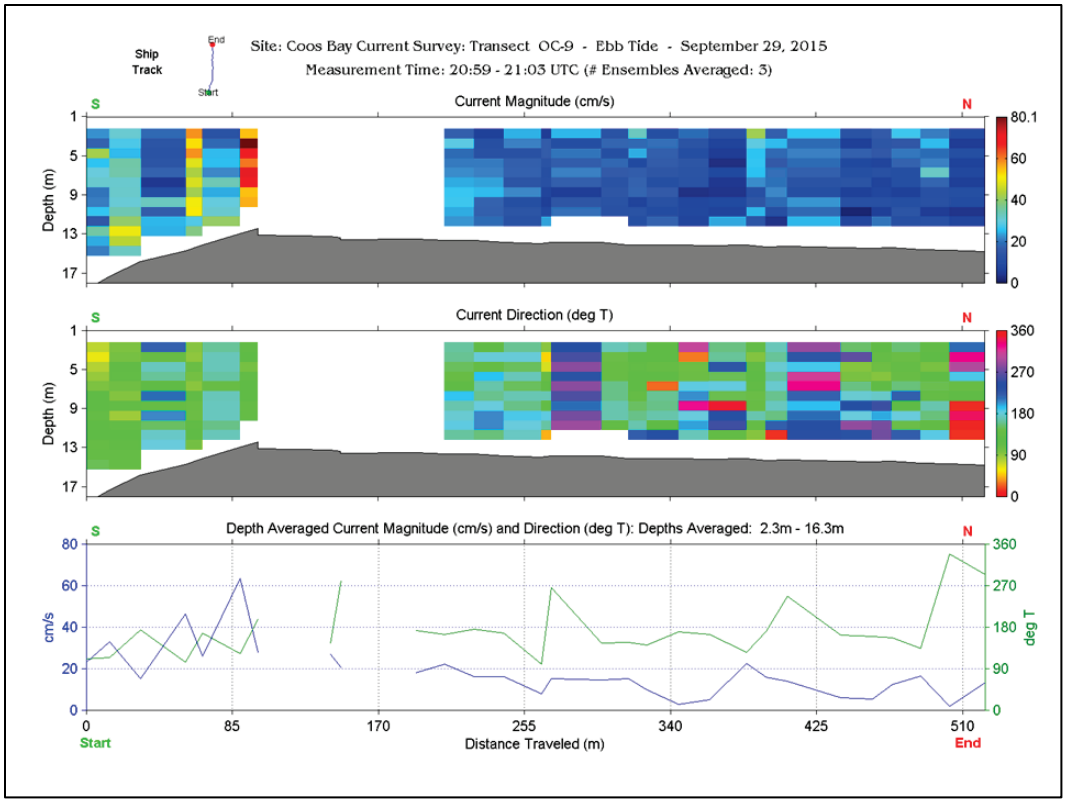

Site: Coos Bay Current Survey: Transect OC-6 - Flood Tide - September 29, 2015
Measurement Time: 19:59 - 20:18 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
E
W
Start
End

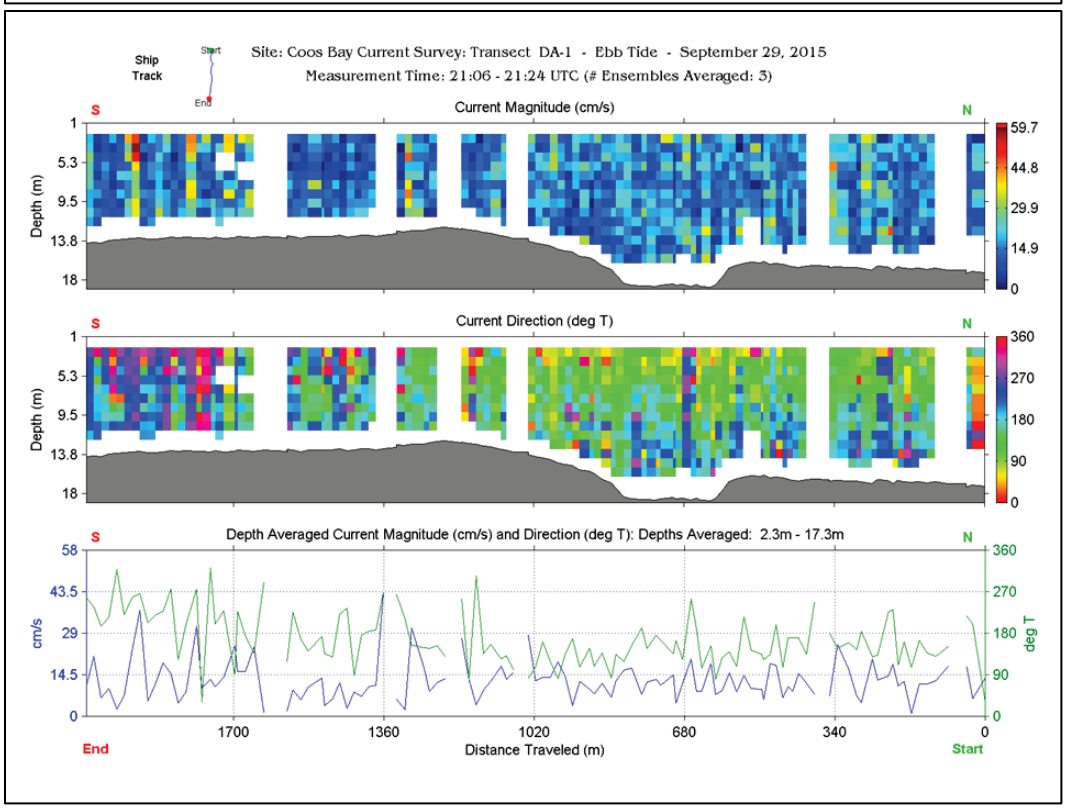

Site: Coos Bay Current Survey: Transect OC-7 - Slack Tide - September 29, 2015
Measurement Time: 20:22 - 20:25 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
6
11
16
21
58.2
43.7
29.1
14.6
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 20.3m
cm/s
58
43.5
29
14.5
0
deg T
425
340
255
170
85
Distance Traveled (m)

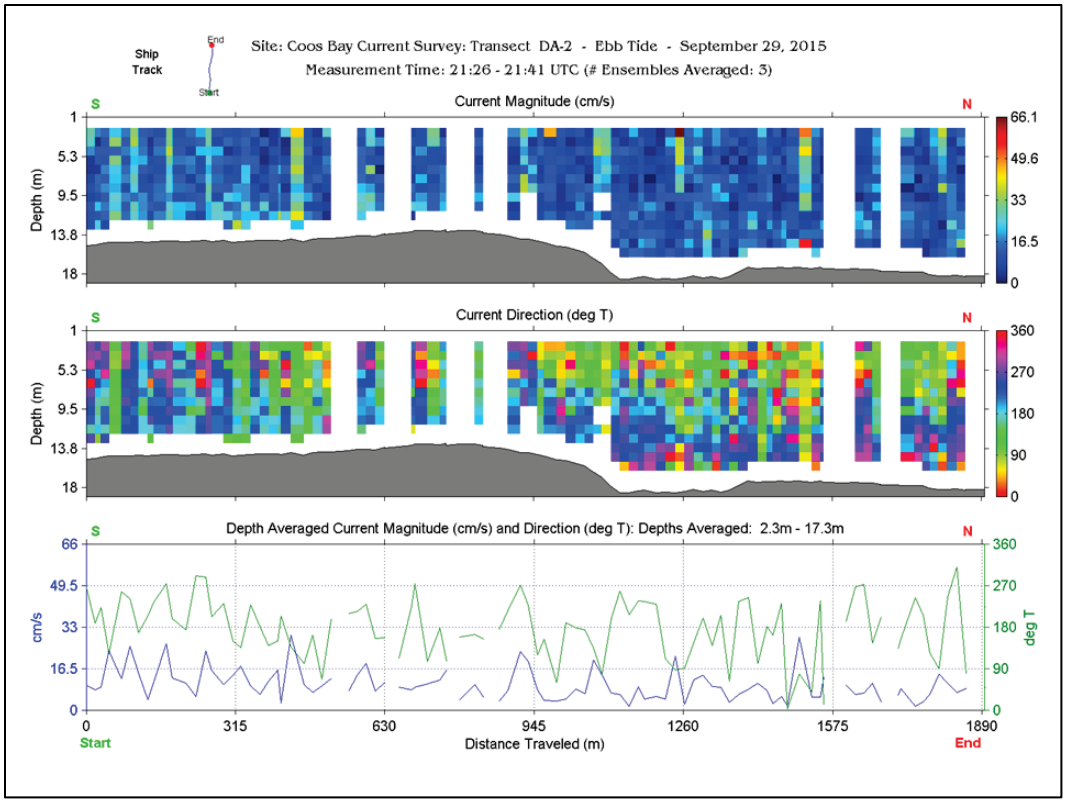

Site: Coos Bay Current Survey: Transect OC-7 - Slack Tide - September 29, 2015
Measurement Time: 20:31 - 20:43 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
5
9
13
17
118.6
89
59.3
29.7
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
118
88.5
59
29.5
0
deg T
1620
1350
1080
810
540
270
Distance Traveled (m)

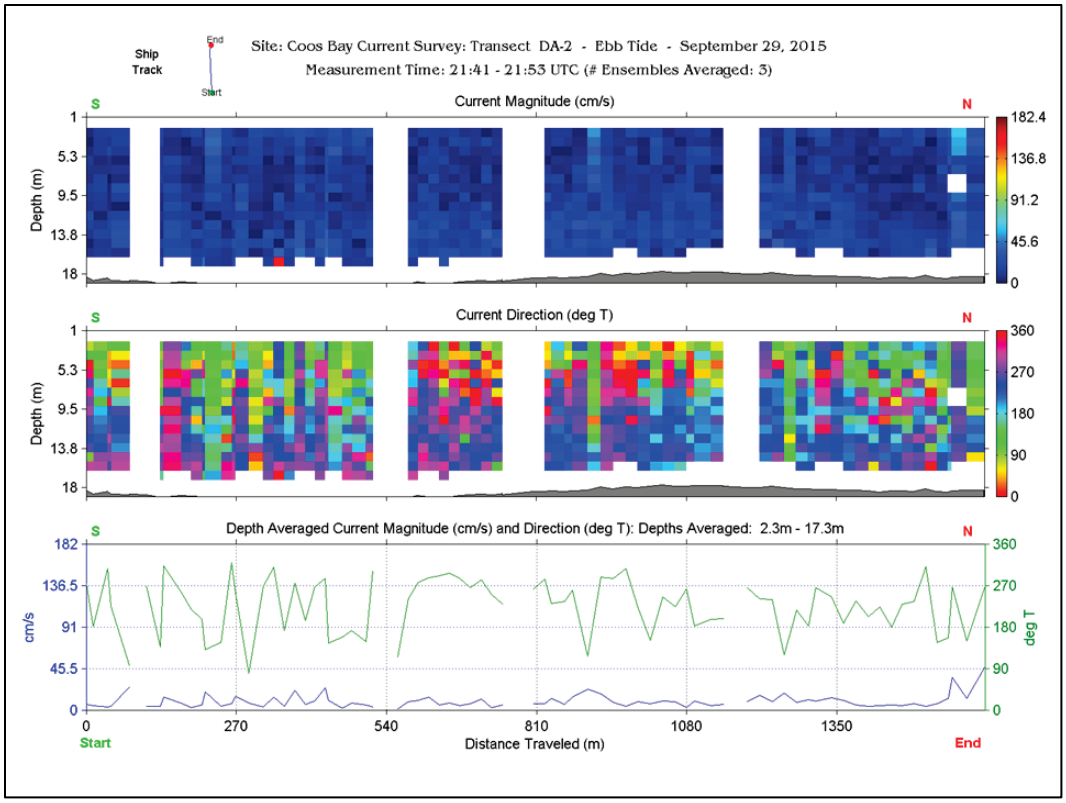

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-6 - Slack Tide - September 29, 2015
Measurement Time: 20:46 - 20:51 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
86.1
64.5
43
21.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
0
80
160
240
320
400
Distance Traveled (m)
Start
End

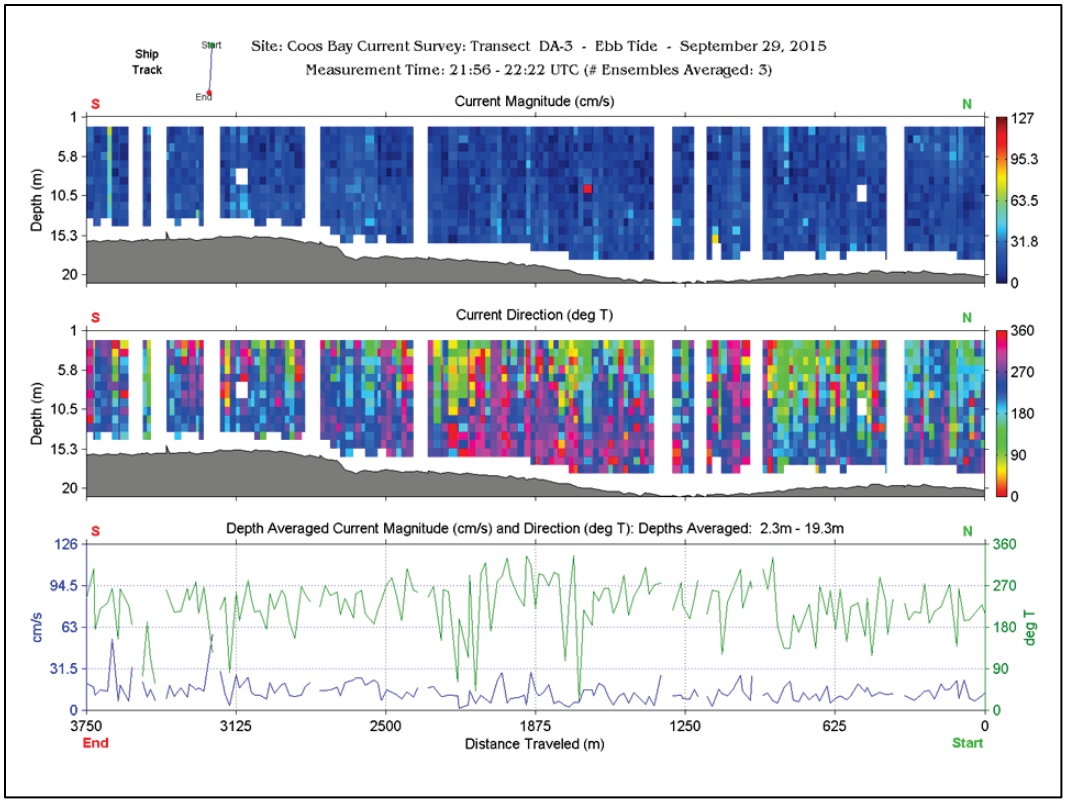

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-8 - Slack Tide - September 29, 2015
Measurement Time: 20:51 - 20:58 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.3
9.5
13.8
18
65.8
49.4
32.9
16.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
64
48
32
16
0
120
240
360
480
600
Distance Traveled (m)
Start
End

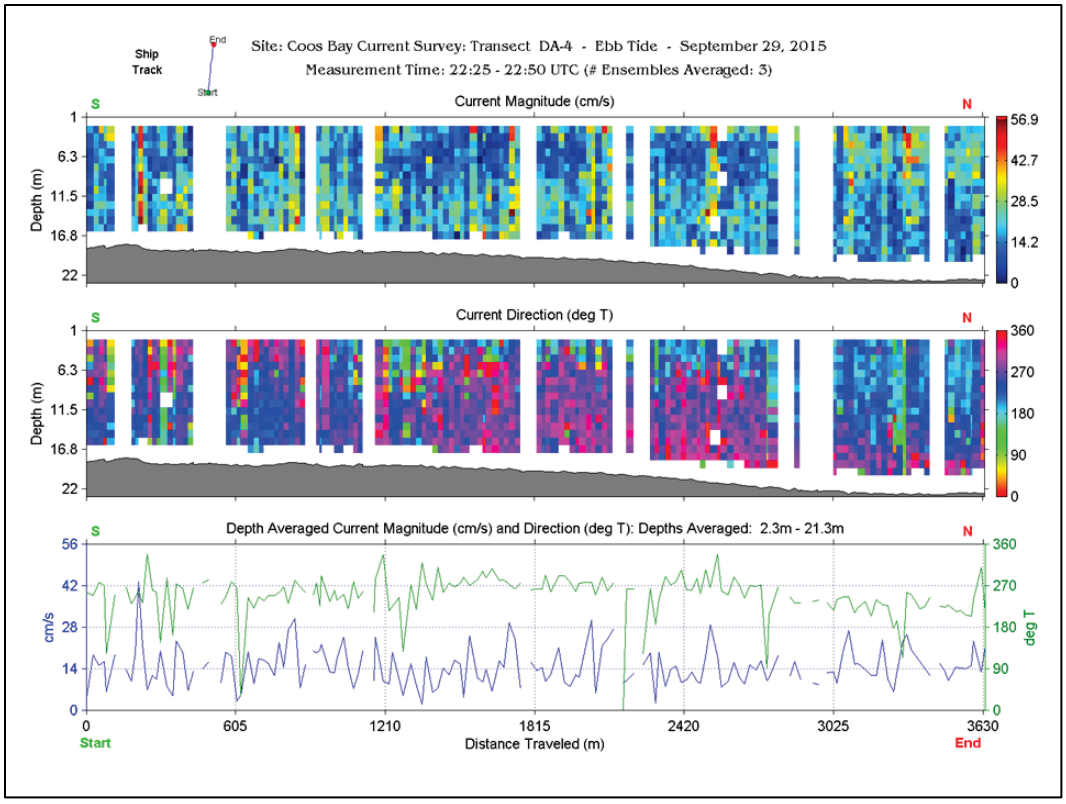

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-9 - Ebb Tide - September 29, 2015
Measurement Time: 20:59 - 21:03 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
80.1
60
40
20
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
80
60
40
20
0
0
85
170
255
340
425
510
Start
End
Distance Traveled (m)

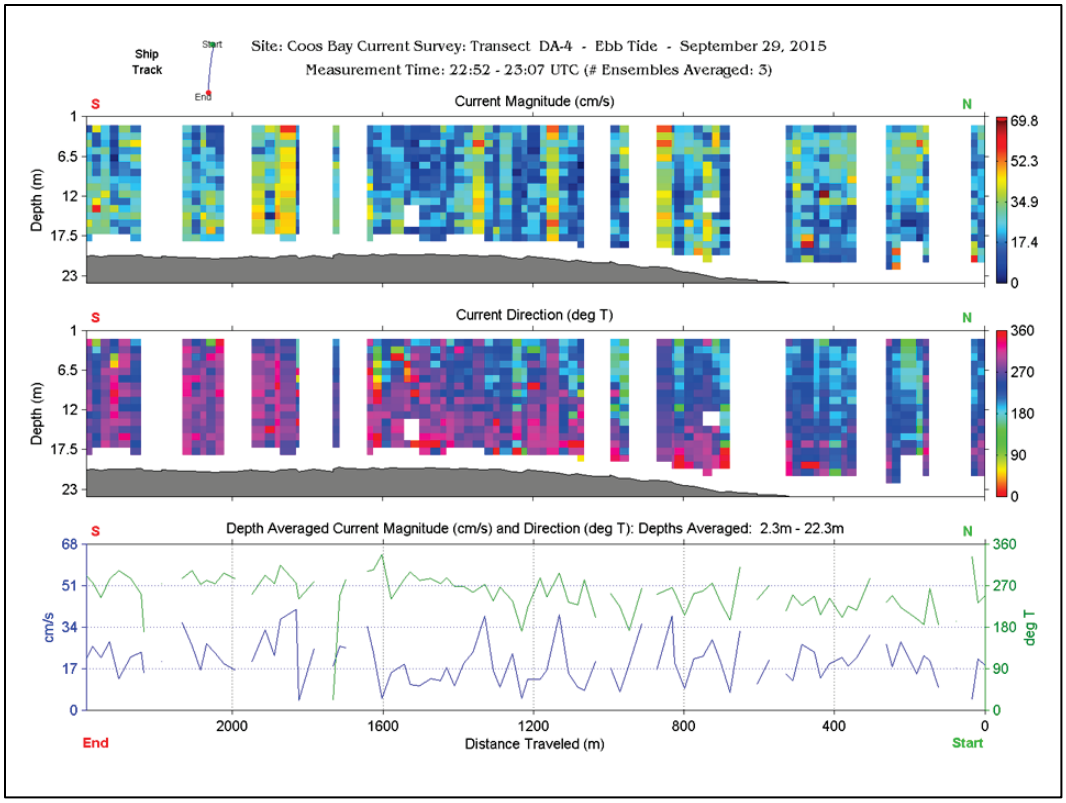

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Ebb Tide - September 29, 2015
Measurement Time: 21:06 - 21:24 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
59.7
44.8
29.9
14.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
58
43.5
29
14.5
0
1700
1360
1020
680
340
0
End
Start
Distance Traveled (m)

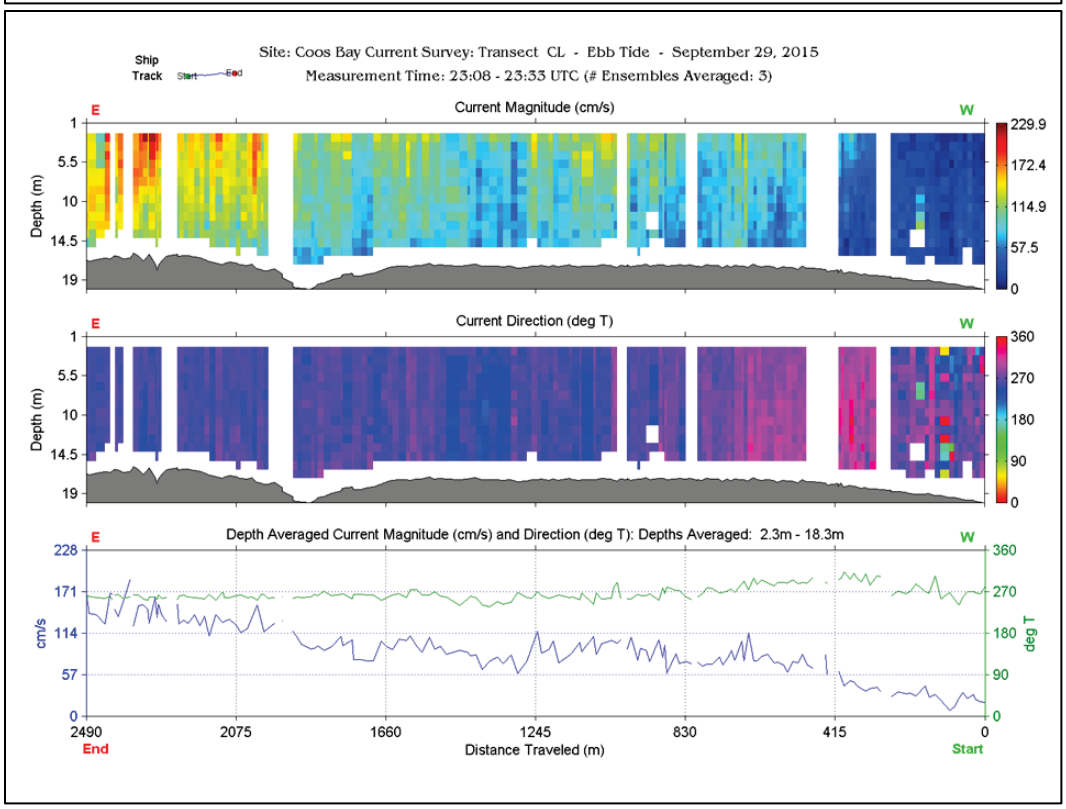

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Ebb Tide - September 29, 2015
Measurement Time: 21:26 - 21:41 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
66.1
49.6
33
16.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
66
49.5
33
16.5
0
0
315
630
945
1260
1575
1890
Start
End
Distance Traveled (m)

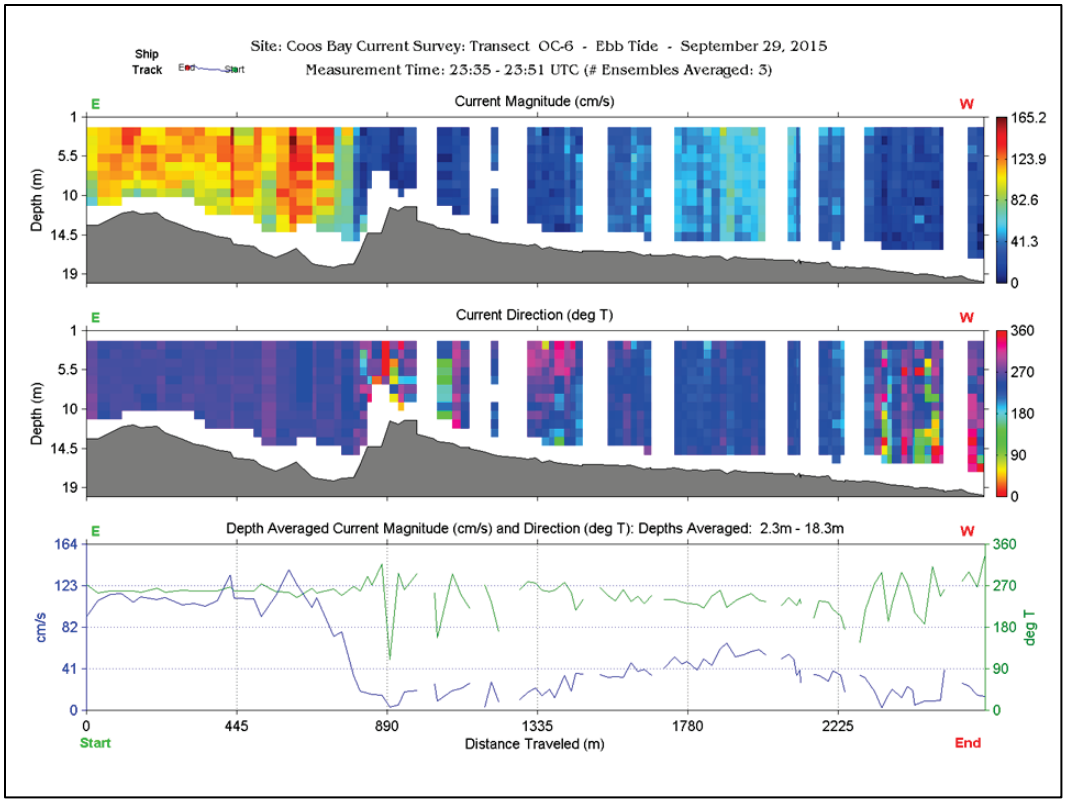

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Ebb Tide - September 29, 2015
Measurement Time: 21:41 - 21:53 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
182.4
136.8
91.2
45.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
182
136.5
91
45.5
0
0
270
540
810
1080
1350
Start
End
Distance Traveled (m)

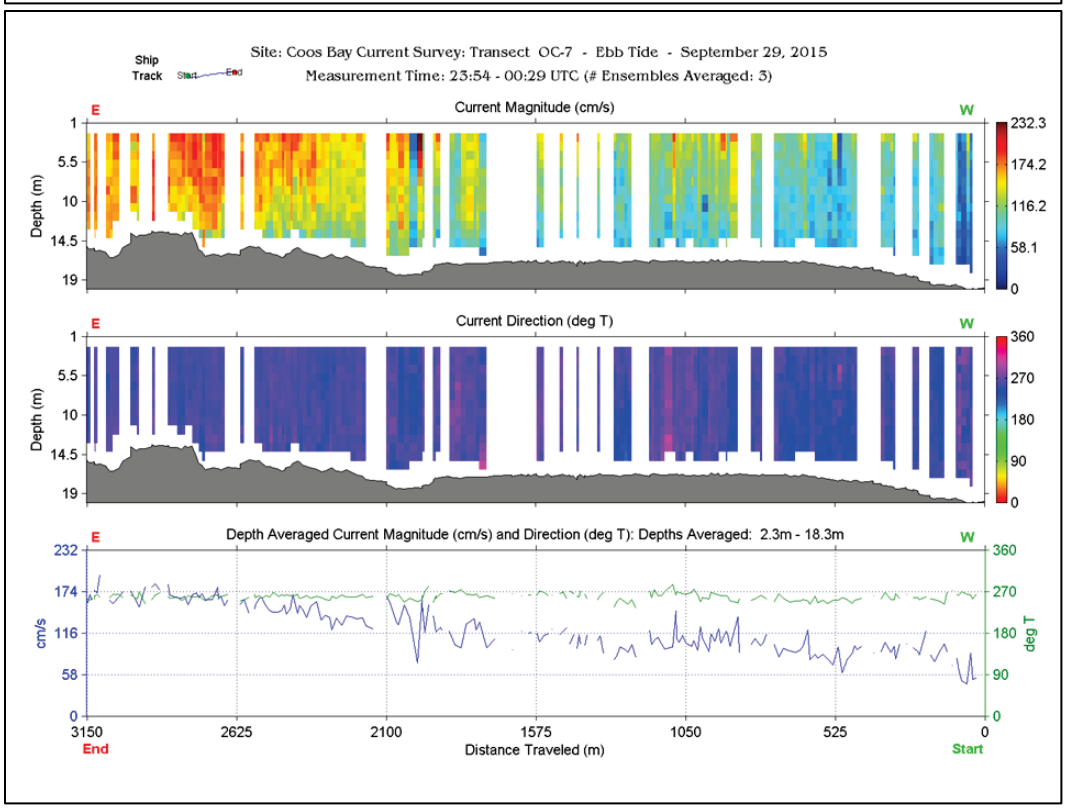

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Ebb Tide - September 29, 2015
Measurement Time: 21:56 - 22:22 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.8
10.5
15.3
20
127
95.3
63.5
31.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
126
94.5
63
31.5
3750
3125
2500
1875
1250
625
End
Start
Distance Traveled (m)

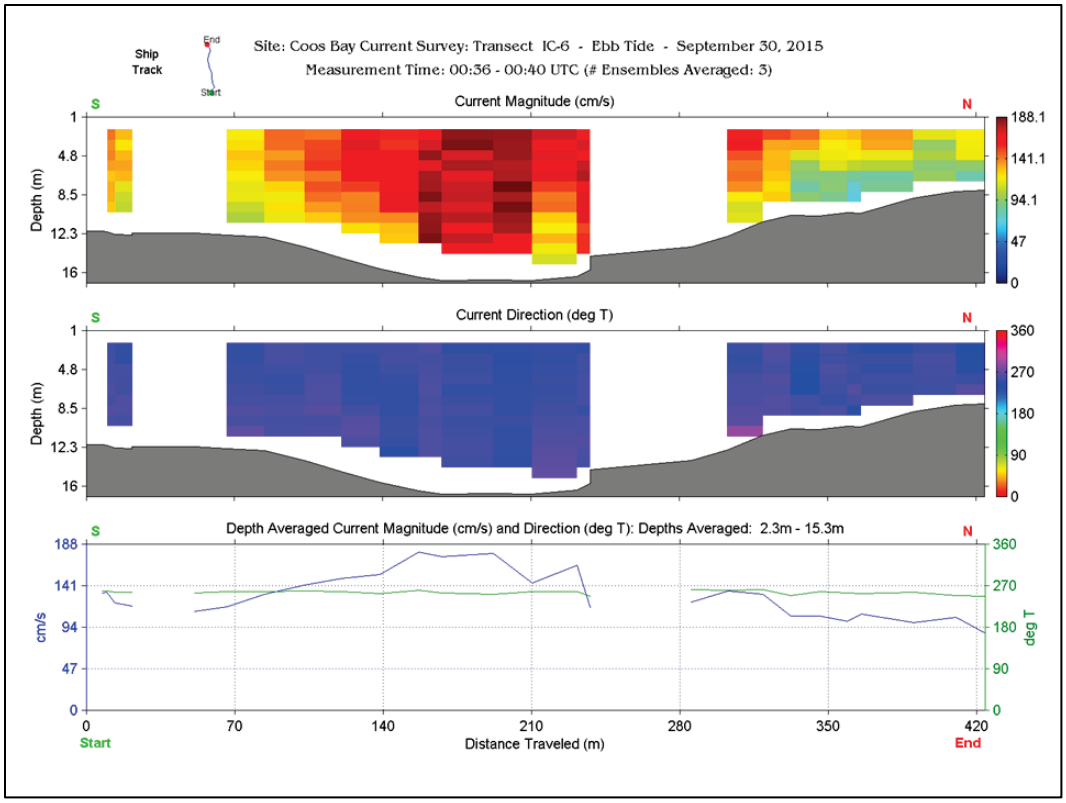

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Ebb Tide - September 29, 2015
Measurement Time: 22:25 - 22:50 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
6.3
11.5
16.8
22
56.9
42.7
28.5
14.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 21.3m
cm/s
deg T
56
42
28
14
0
605
1210
1815
2420
3025
3630
Start
End
Distance Traveled (m)

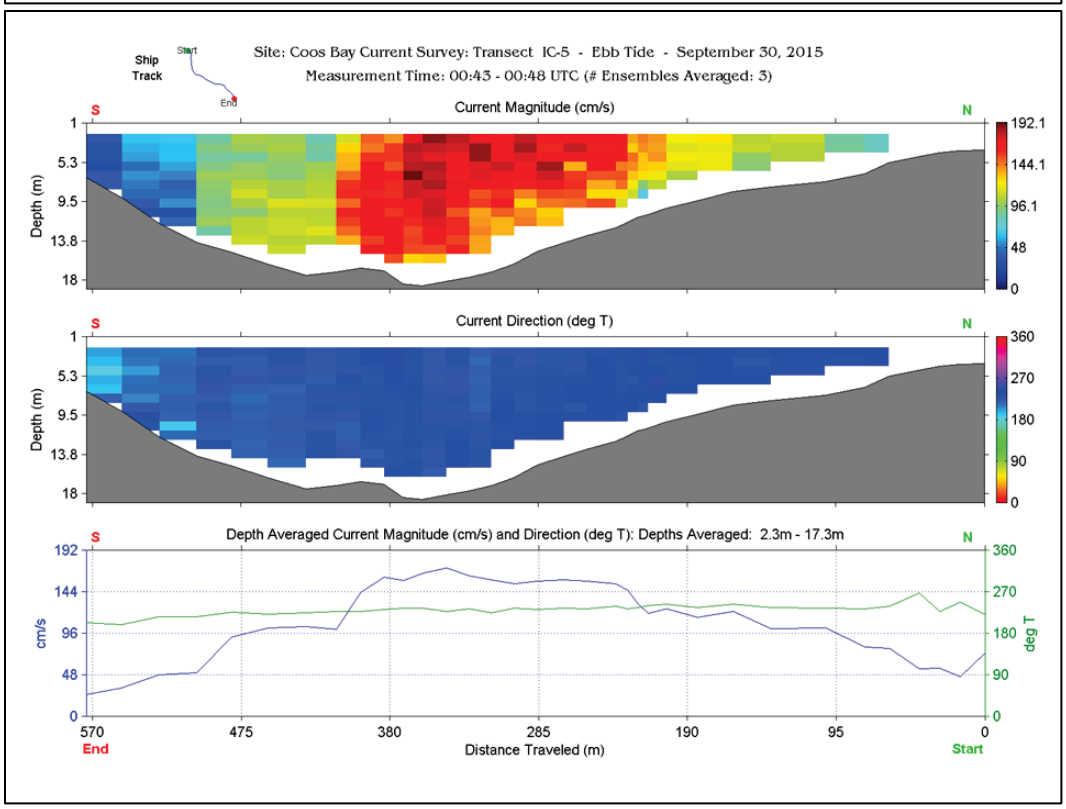

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-4 - Ebb Tide - September 29, 2015
Measurement Time: 22:52 - 23:07 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
6.5
12
17.5
23
69.8
52.3
34.9
17.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 22.3m
cm/s
deg T
68
51
34
17
2000
1600
1200
800
400
End
Start
Distance Traveled (m)

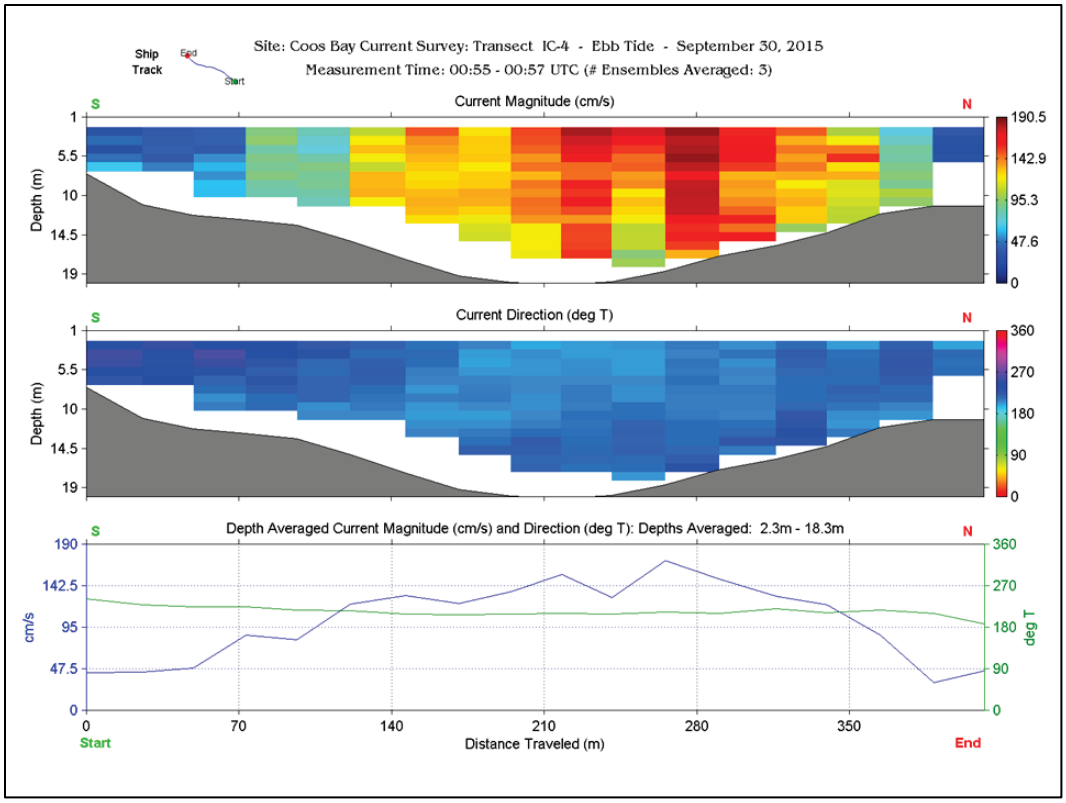

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect CL - Ebb Tide - September 29, 2015
Measurement Time: 23:08 - 23:33 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
229.9
172.4
114.9
57.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
228
171
114
57
2490
2075
1660
1245
830
415
End
Start
Distance Traveled (m)

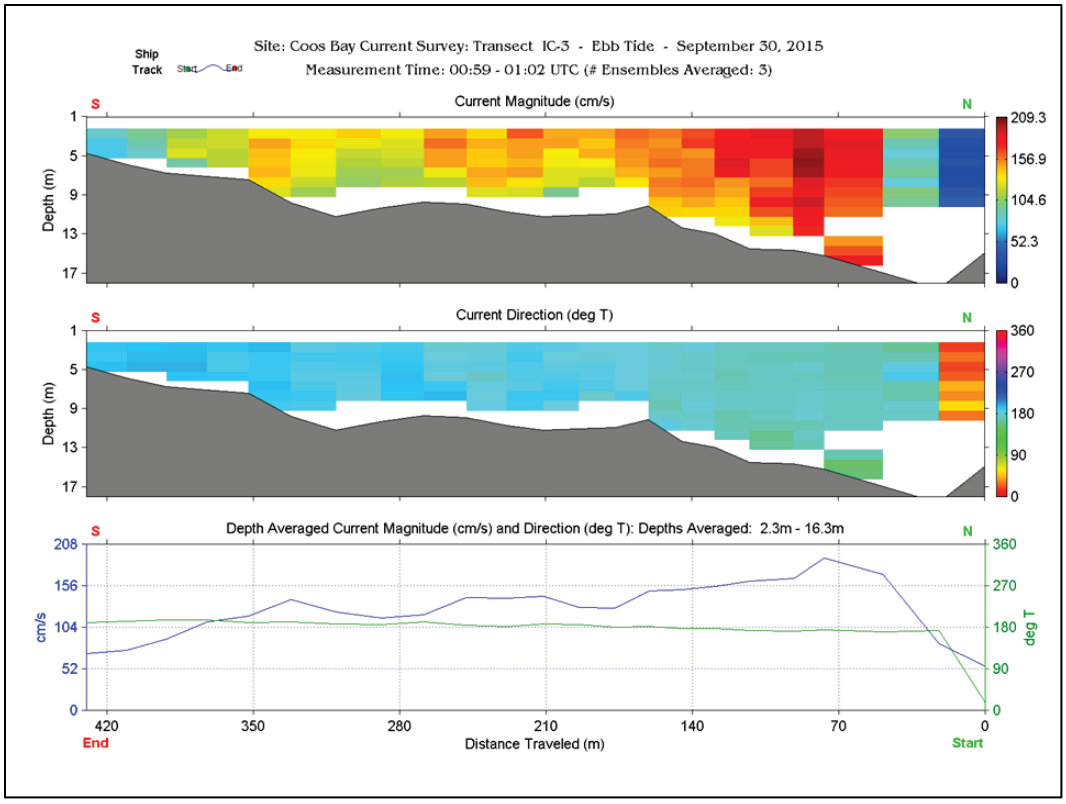

Site: Coos Bay Current Survey: Transect OC-6 - Ebb Tide - September 29, 2015
Measurement Time: 23:35 - 23:51 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
Start
End

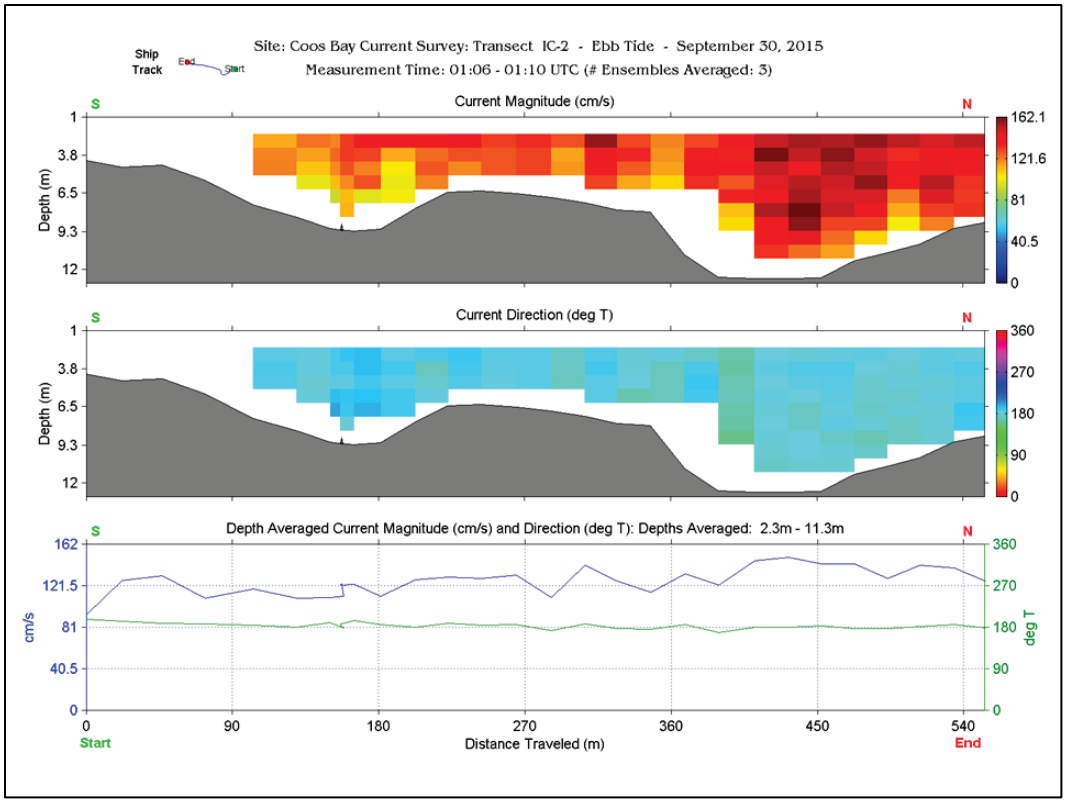

Site: Coos Bay Current Survey: Transect OC-7 - Ebb Tide - September 29, 2015
Measurement Time: 23:54 - 00:29 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

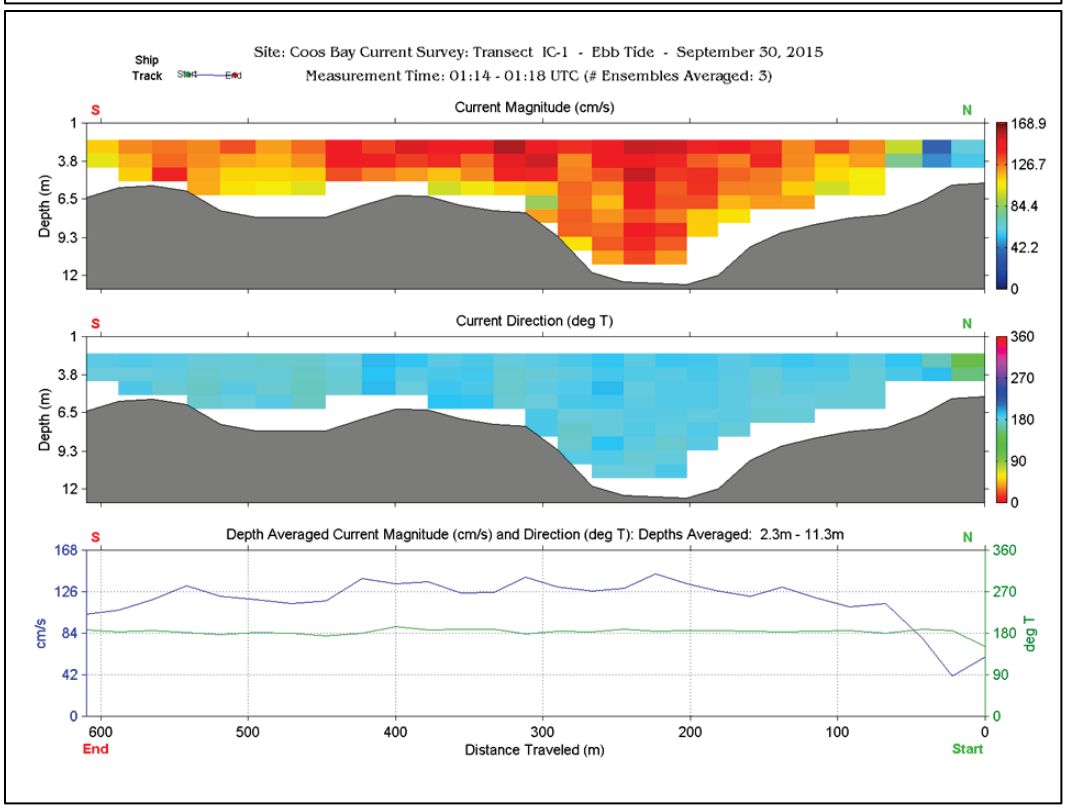

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - September 30, 2015
Measurement Time: 00:36 - 00:40 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.8
8.5
12.3
16
188.1
141.1
94.1
47
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
188
141
94
47
0
0
70
140
210
280
350
420
Start
End
Distance Traveled (m)

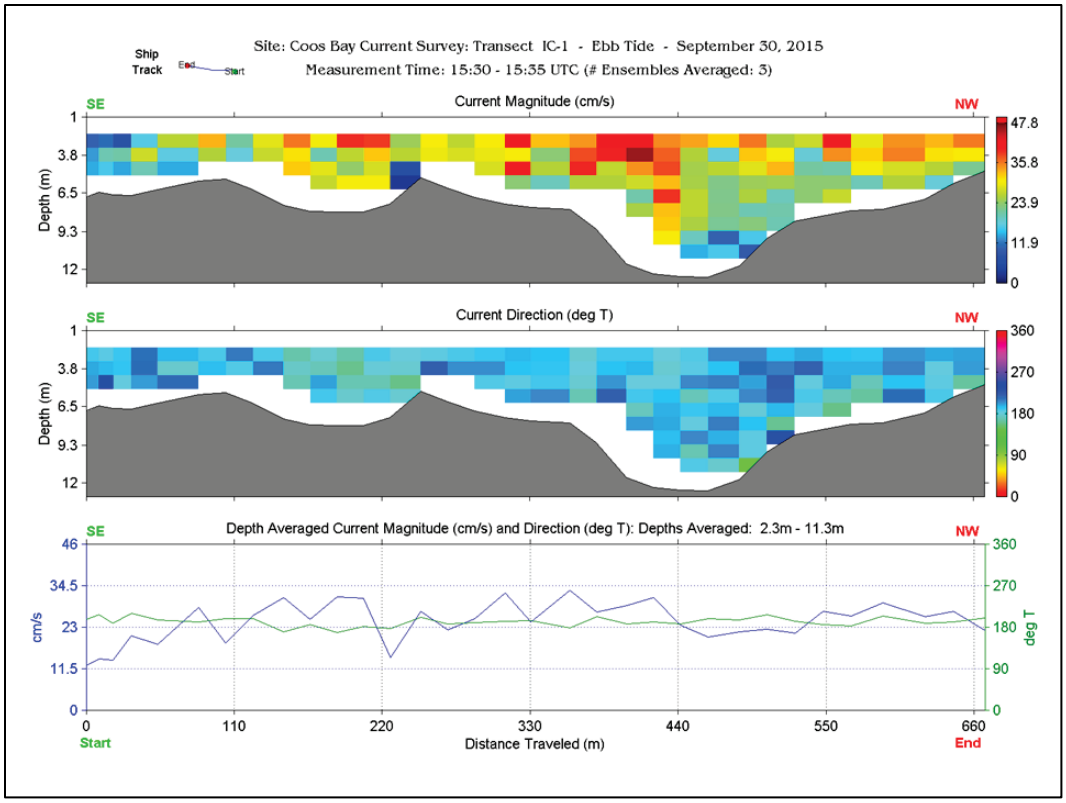

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 30, 2015
Measurement Time: 00:43 - 00:48 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.3
9.5
13.8
18
192.1
144.1
96.1
48
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
192
144
96
48
0
570
475
380
285
190
95
End
Start
Distance Traveled (m)

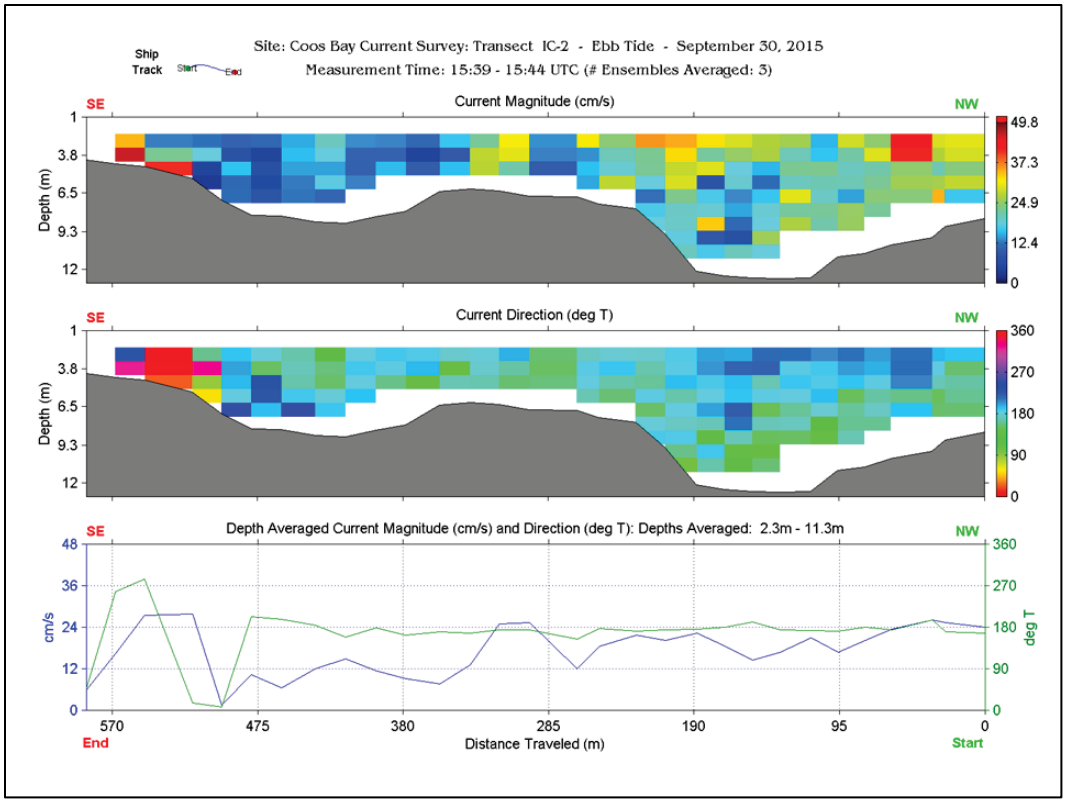

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 30, 2015
Measurement Time: 00:55 - 00:57 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.5
10
14.5
19
190.5
142.9
95.3
47.6
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
190
142.5
95
47.5
0
deg T
0
70
140
210
280
350
Start
End
Distance Traveled (m)

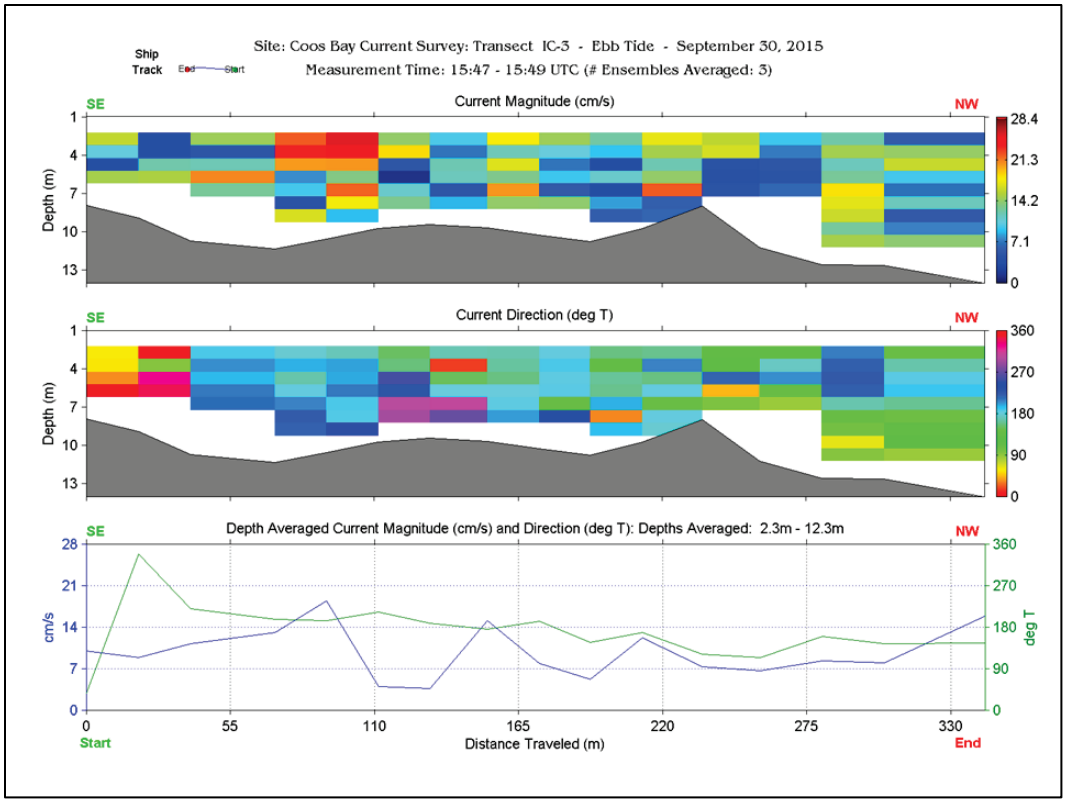

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 30, 2015
Measurement Time: 00:59 - 01:02 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
209.3
156.9
104.6
52.3
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
208
156
104
52
0
deg T
420
350
280
210
140
70
0
End
Start
Distance Traveled (m)

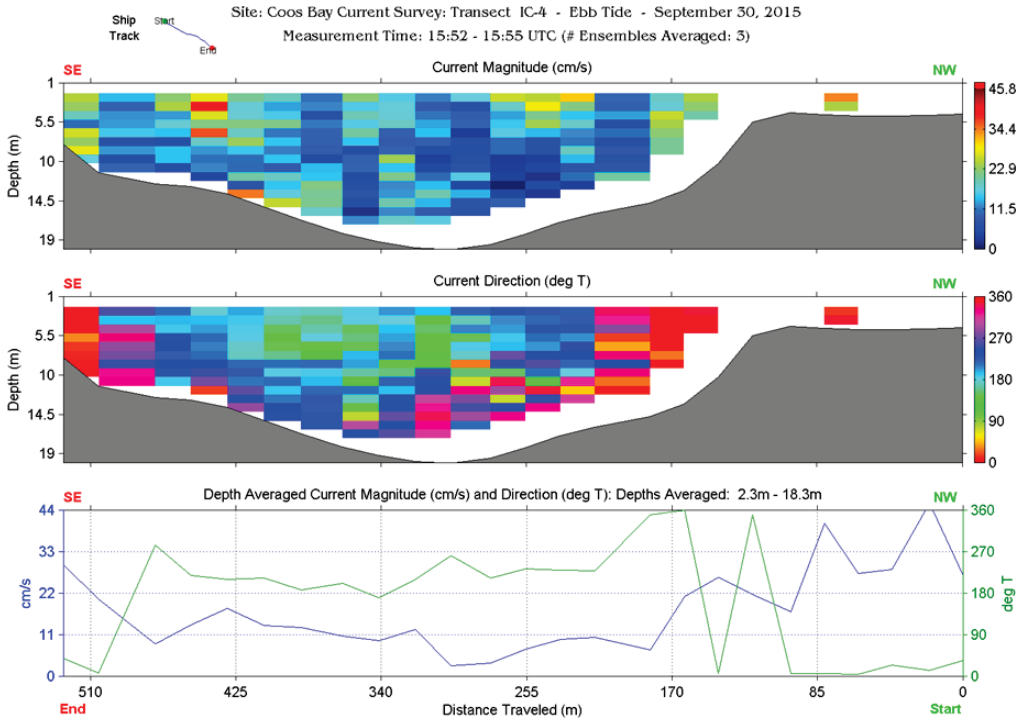

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 30, 2015
Measurement Time: 01:06 - 01:10 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
S
N
Depth (m)
1
3.8
6.5
9.3
12
162.1
121.6
81
40.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
162
121.5
81
40.5
0
0
90
180
270
360
450
540
Start
End
Distance Traveled (m)

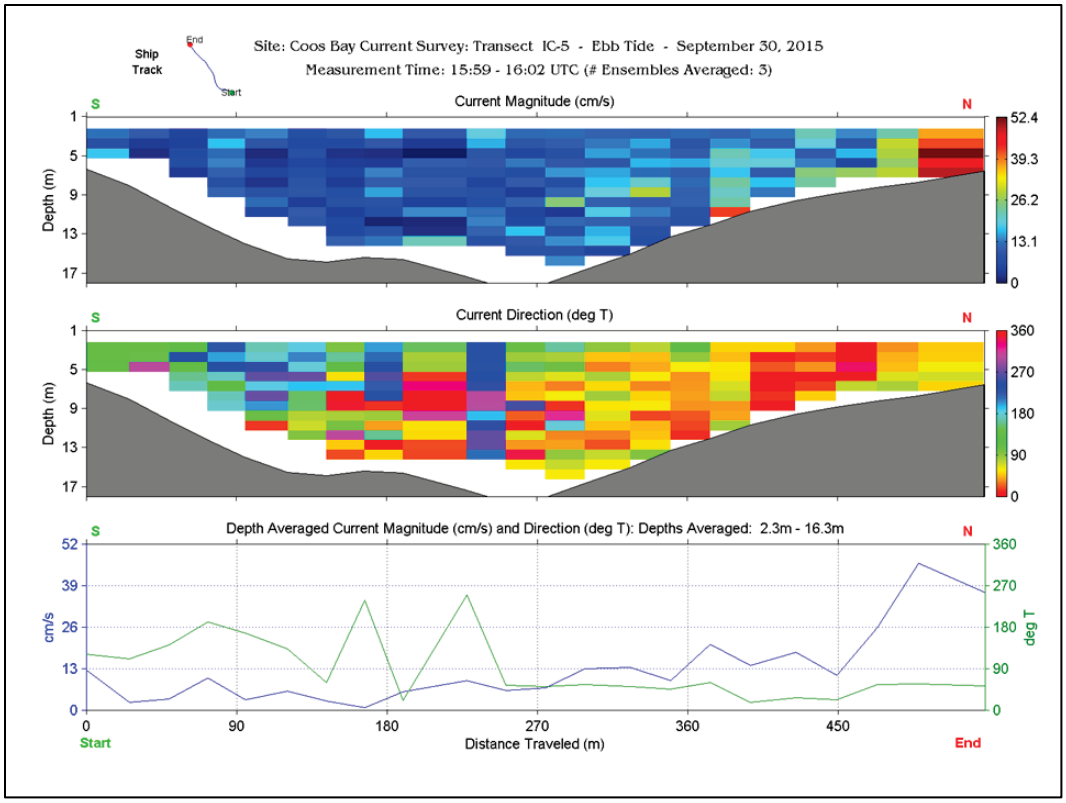

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - September 30, 2015
Measurement Time: 01:14 - 01:18 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
1
3.8
6.5
9.3
12
168.9
126.7
84.4
42.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
168
126
84
42
0
600
500
400
300
200
100
0
End
Start
Distance Traveled (m)

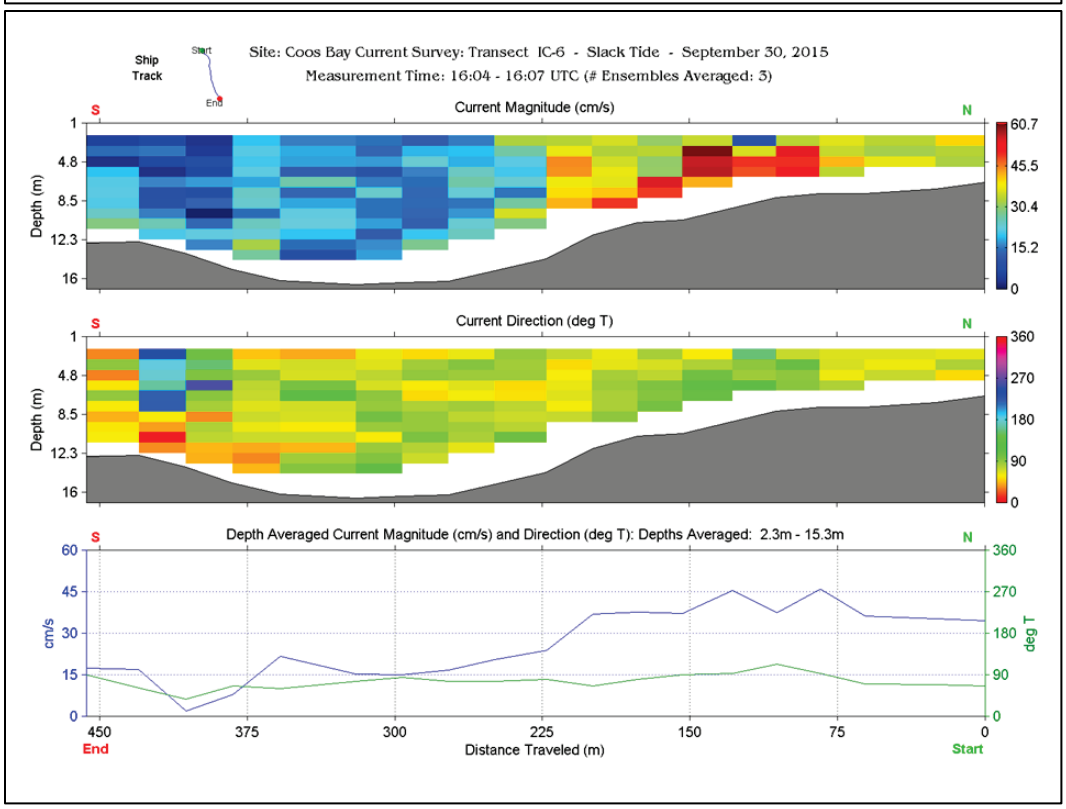

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - September 30, 2015
Measurement Time: 15:30 - 15:35 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
47.8
35.8
23.9
11.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
46
34.5
23
11.5
0
0
110
220
330
440
550
660
Start
End
Distance Traveled (m)

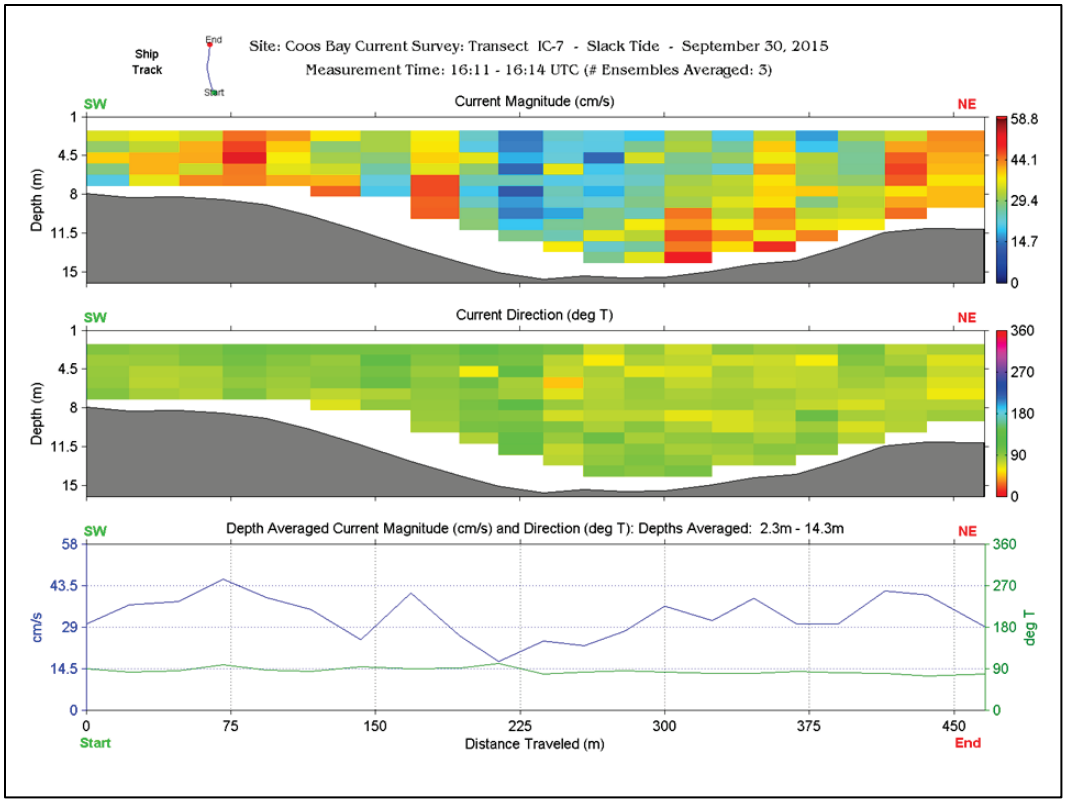

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - September 30, 2015
Measurement Time: 15:39 - 15:44 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
49.8
37.3
24.9
12.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
48
36
24
12
0
570
475
380
285
190
95
0
End
Start
Distance Traveled (m)

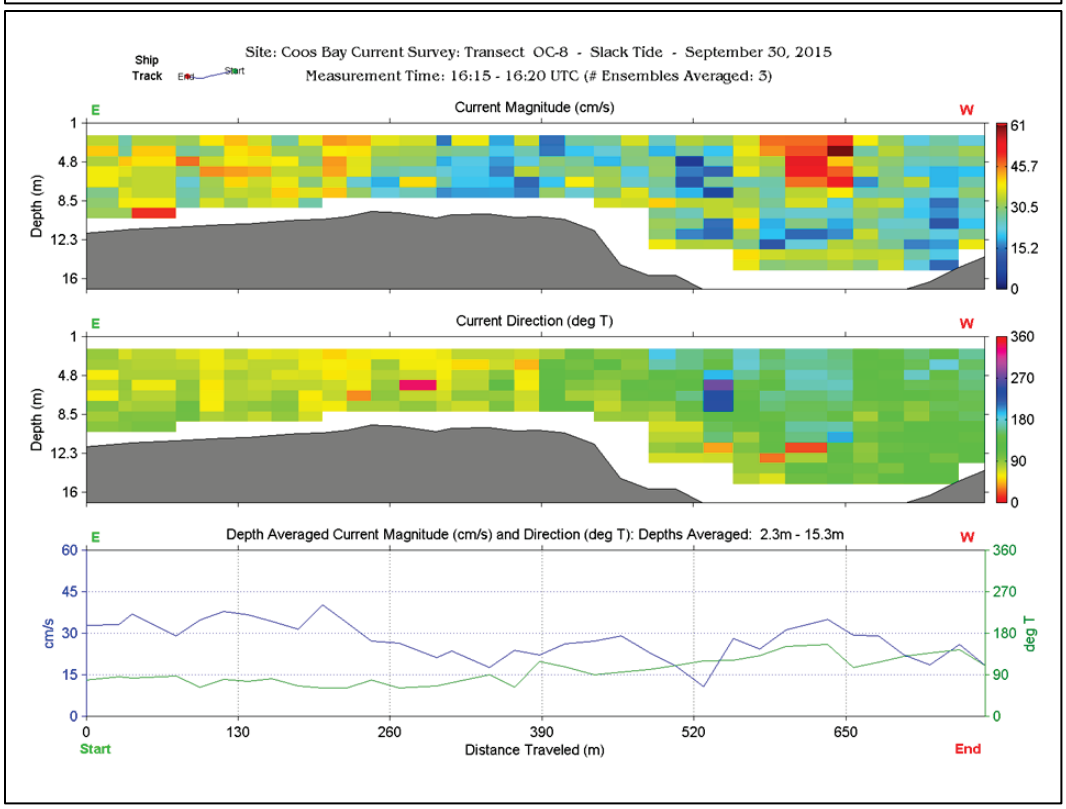

Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - September 30, 2015
Measurement Time: 15:47 - 15:49 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
4
7
10
13
28.4
21.3
14.2
7.1
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
deg T
28
21
14
7
0
0
55
110
165
220
275
330
Start
End
Distance Traveled (m)

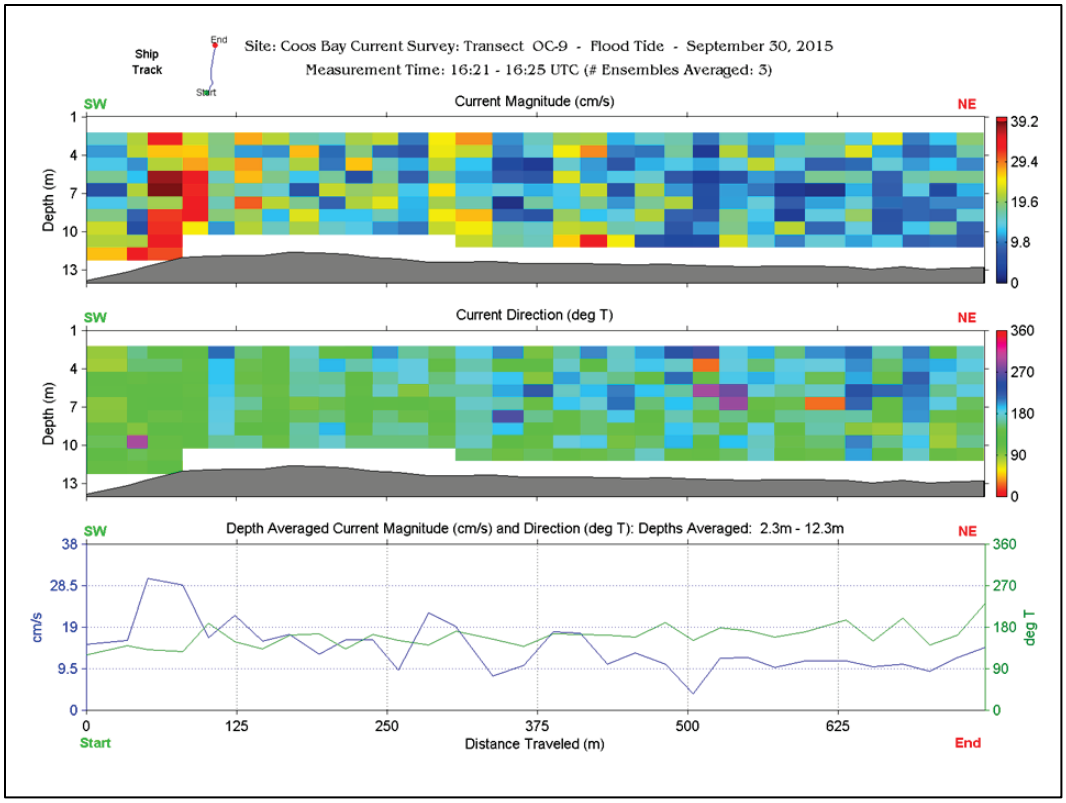

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - September 30, 2015
Measurement Time: 15:52 - 15:55 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
45.8
34.4
22.9
11.5
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
44
33
22
11
0
510
425
340
255
170
85
0
End
Start
Distance Traveled (m)

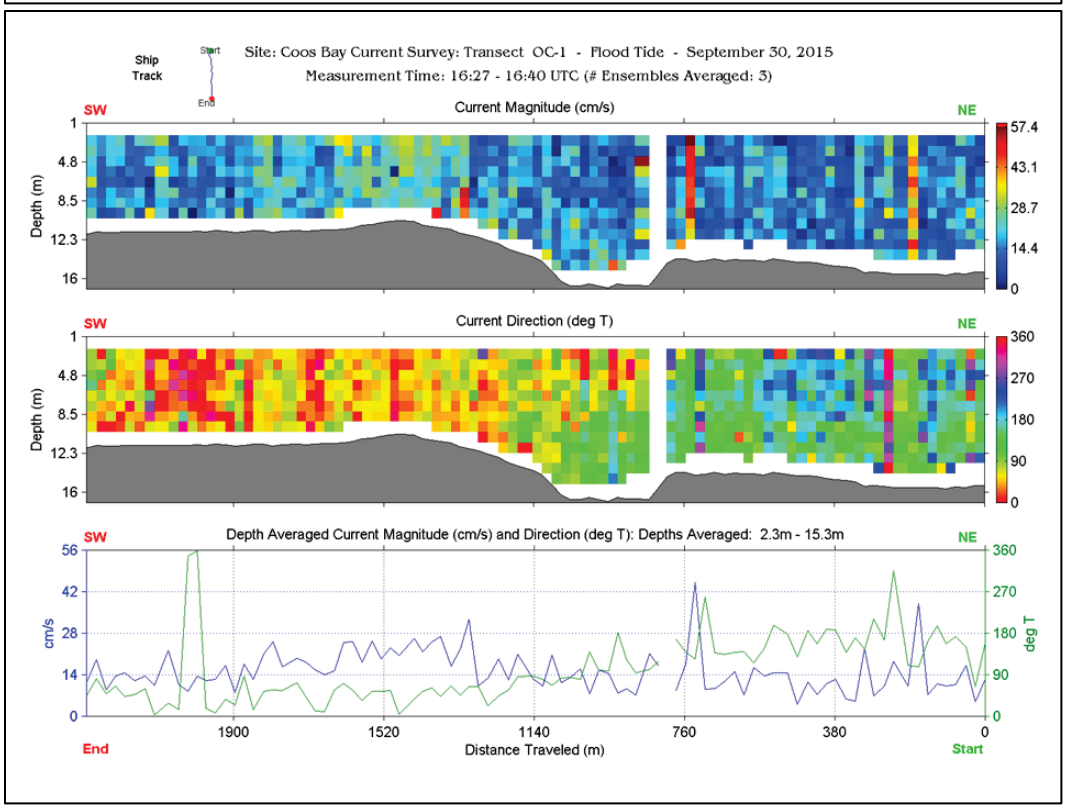

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - September 30, 2015
Measurement Time: 15:59 - 16:02 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
52.4
39.3
26.2
13.1
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
52
39
26
13
0
0
90
180
270
360
450
Start
End
Distance Traveled (m)

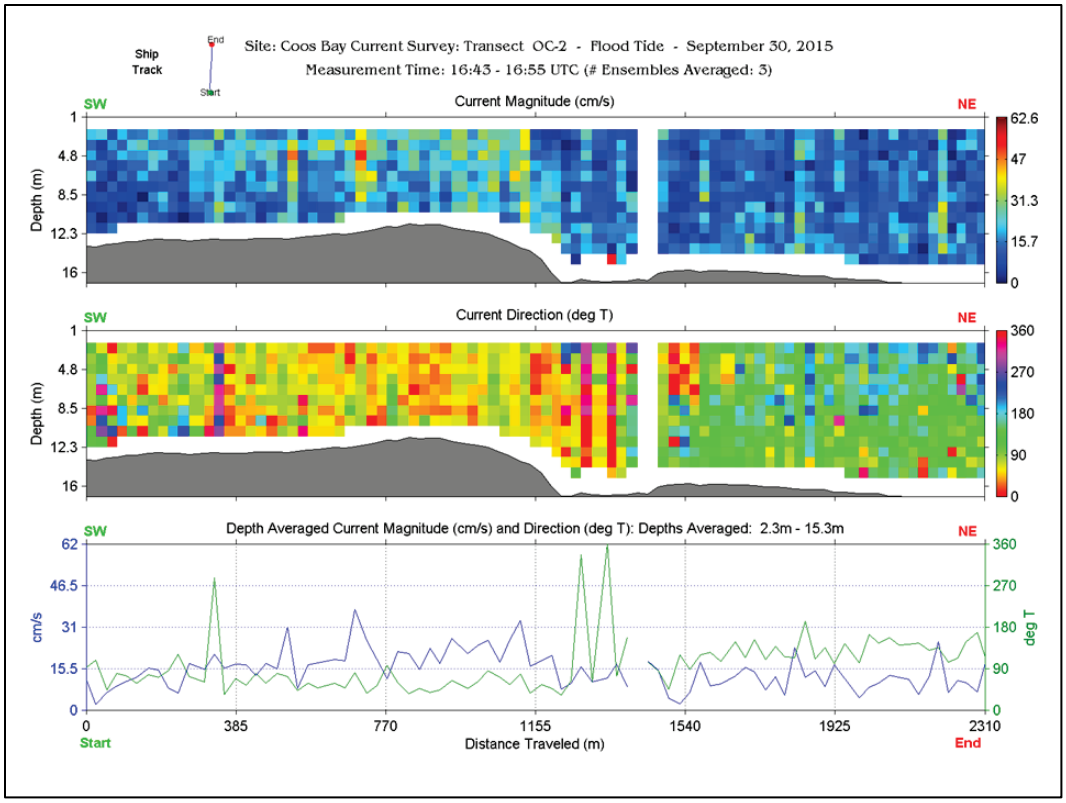

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Slack Tide - September 30, 2015
Measurement Time: 16:04 - 16:07 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.8
8.5
12.3
16
60.7
45.5
30.4
15.2
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
60
45
30
15
0
450
375
300
225
150
75
0
End
Start
Distance Traveled (m)

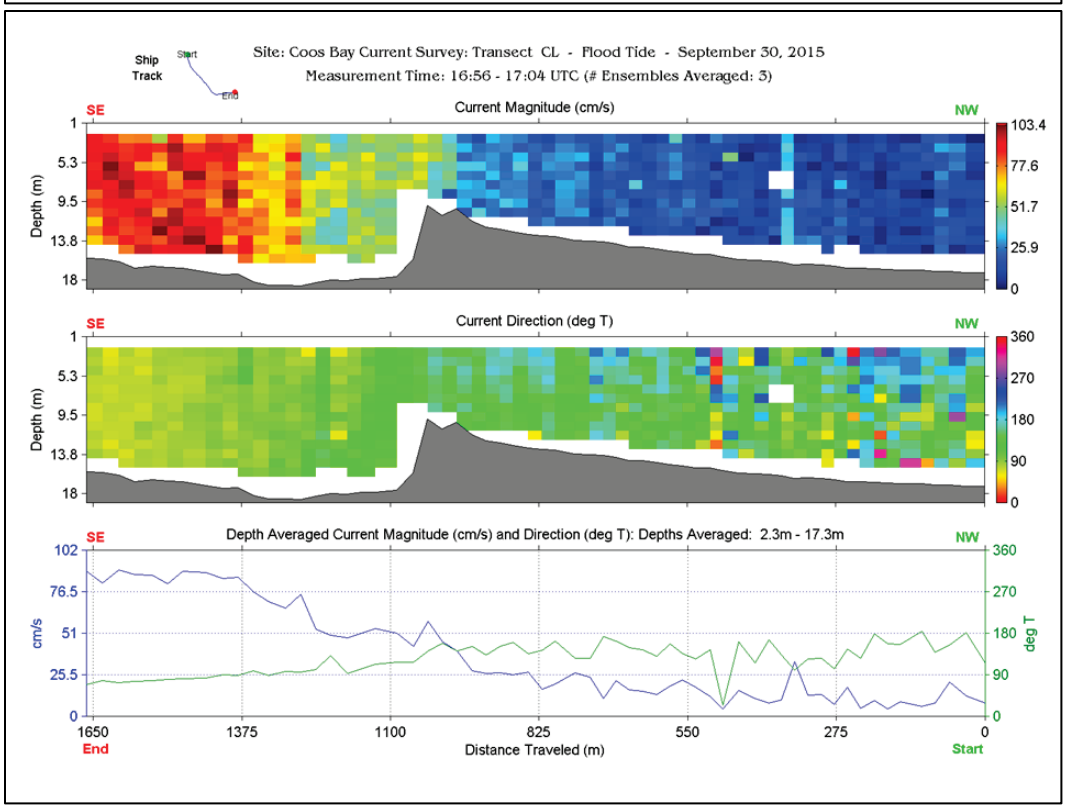

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Slack Tide - September 30, 2015
Measurement Time: 16:11 - 16:14 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.5
8
11.5
15
58.8
44.1
29.4
14.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
58
43.5
29
14.5
0
deg T
0
75
150
225
300
375
450
Start
End
Distance Traveled (m)

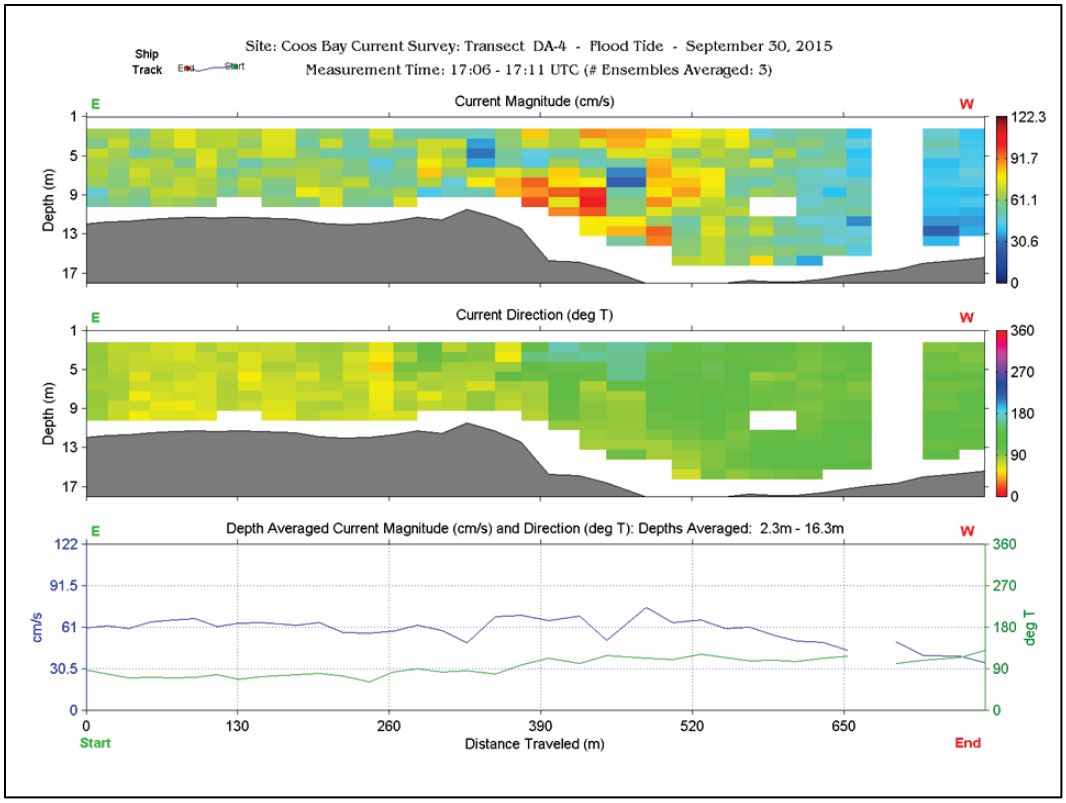

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-8 - Slack Tide - September 30, 2015
Measurement Time: 16:15 - 16:20 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.8
8.5
12.3
16
61
45.7
30.5
15.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
60
45
30
15
0
deg T
0
130
260
390
520
650
Start
End
Distance Traveled (m)

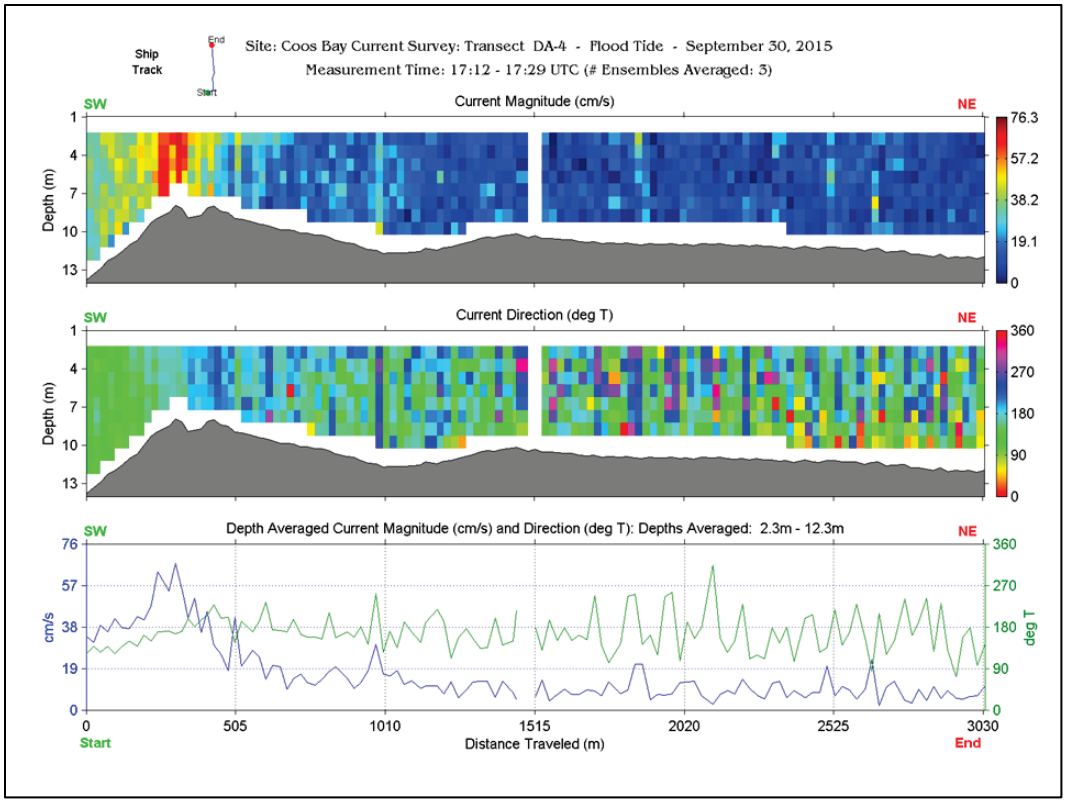

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-9 - Flood Tide - September 30, 2015
Measurement Time: 16:21 - 16:25 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4
7
10
13
39.2
29.4
19.6
9.8
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
deg T
38
28.5
19
9.5
0
0
125
250
375
500
625
Start
End
Distance Traveled (m)

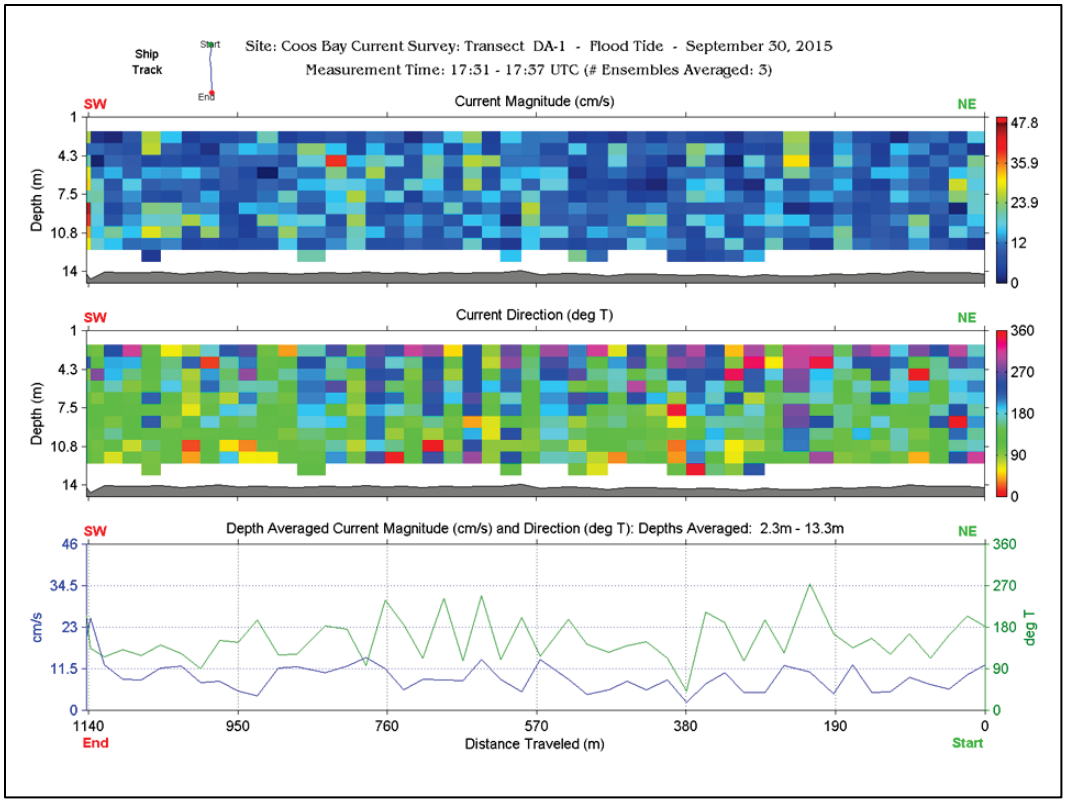

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-1 - Flood Tide - September 30, 2015
Measurement Time: 16:27 - 16:40 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
57.4
43.1
28.7
14.4
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
56
42
28
14
0
1900
1520
1140
760
380
0
End
Start
Distance Traveled (m)

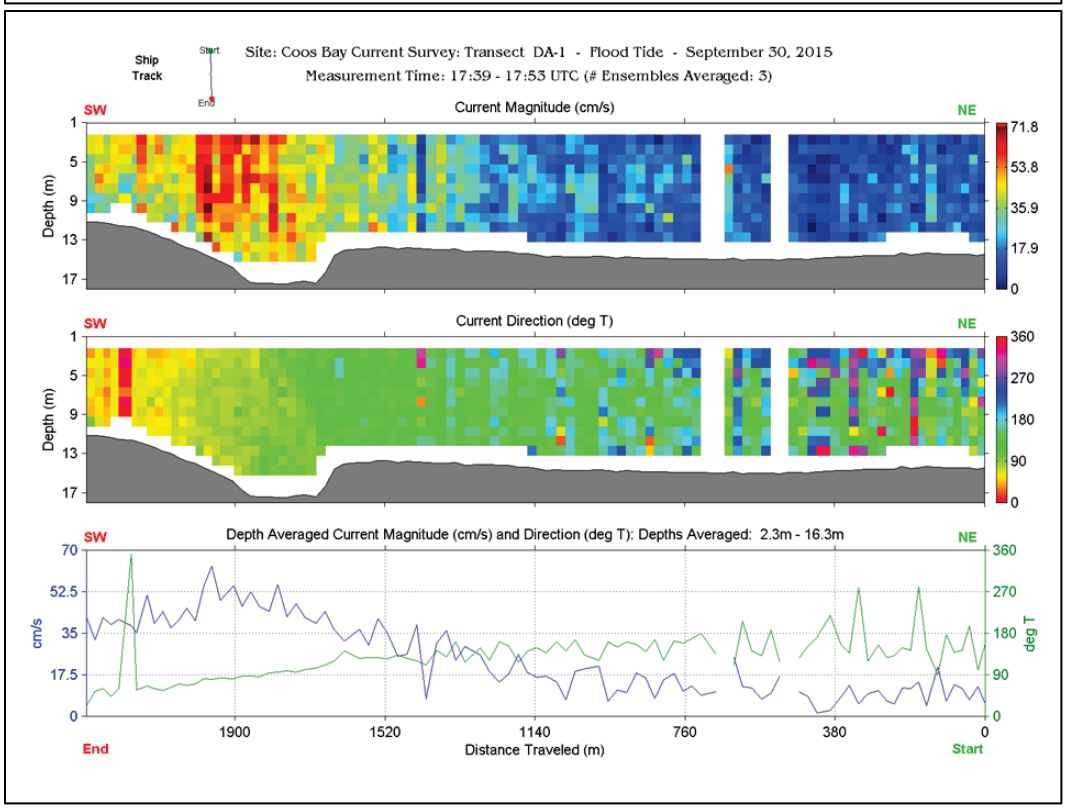

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-2 - Flood Tide - September 30, 2015
Measurement Time: 16:43 - 16:55 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
62.6
47
31.3
15.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
62
46.5
31
15.5
0
0
385
770
1155
1540
1925
2310
Start
End
Distance Traveled (m)

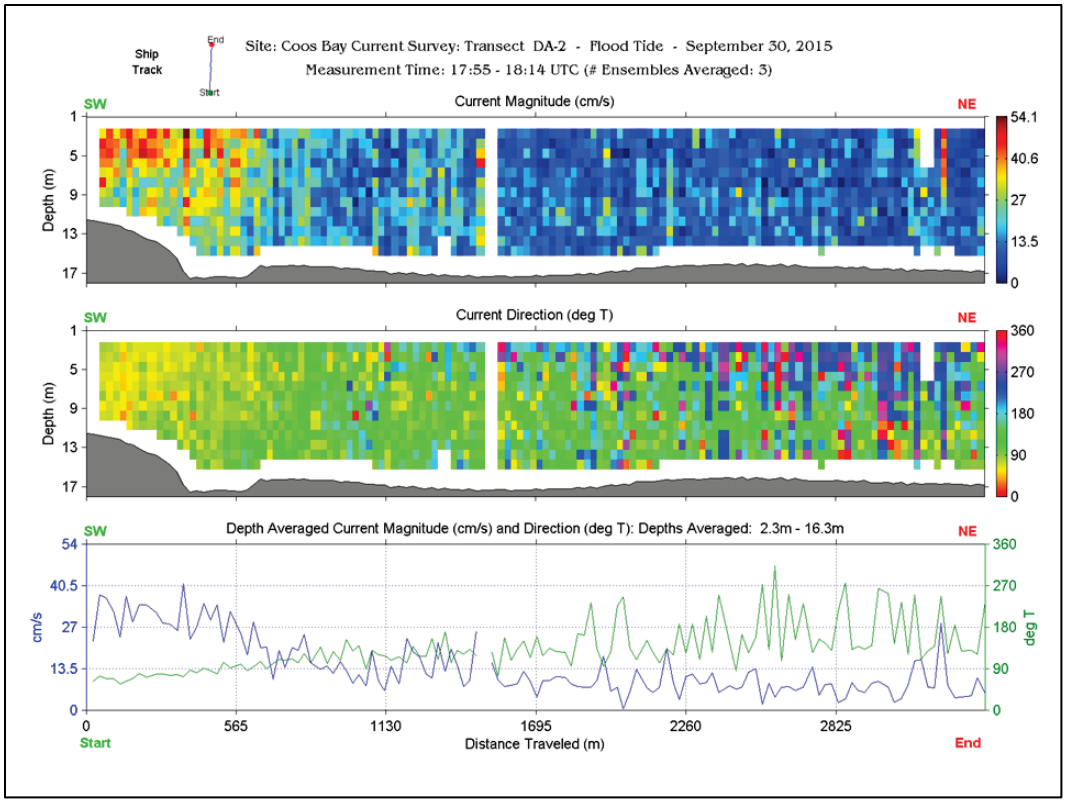

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect CL - Flood Tide - September 30, 2015
Measurement Time: 16:56 - 17:04 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.3
9.5
13.8
18
103.4
77.6
51.7
25.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
102
76.5
51
25.5
0
1650
1375
1100
825
550
275
0
End
Start
Distance Traveled (m)

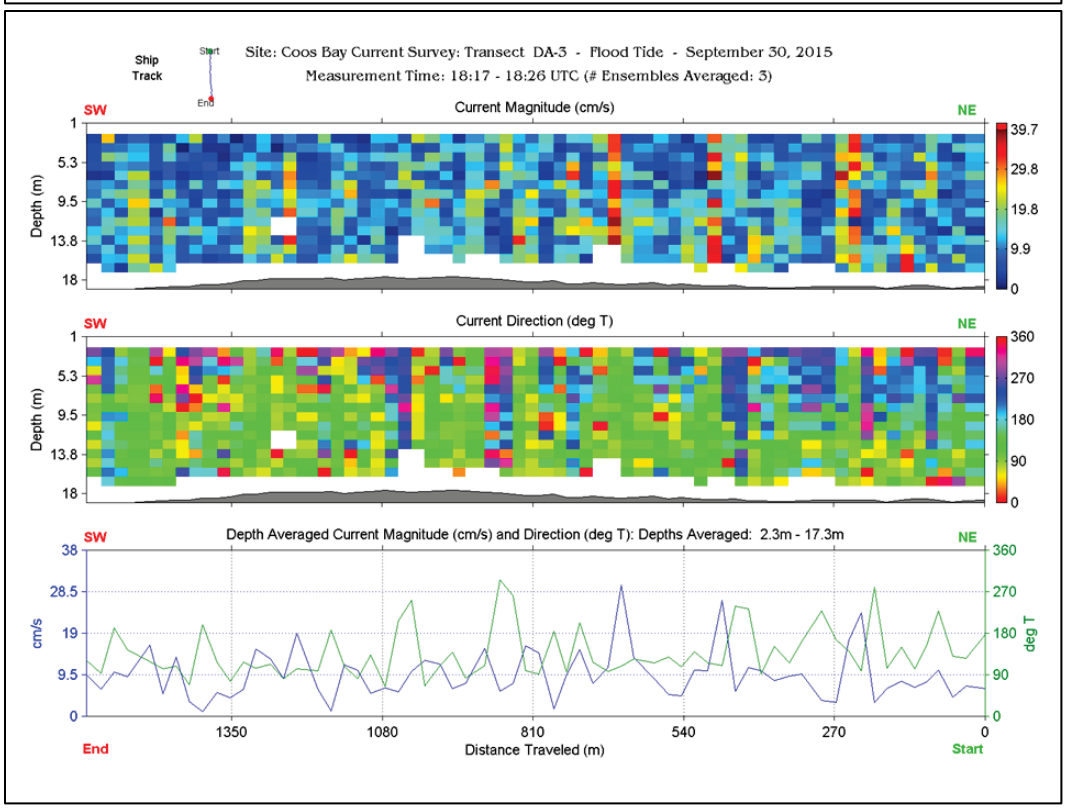

Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - September 30, 2015
Measurement Time: 17:06 - 17:11 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
E
W
Depth (m)
1
5
9
13
17
122.3
91.7
61.1
30.6
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
122
91.5
61
30.5
0
deg T
0
130
260
390
520
650
Distance Traveled (m)
Start
End

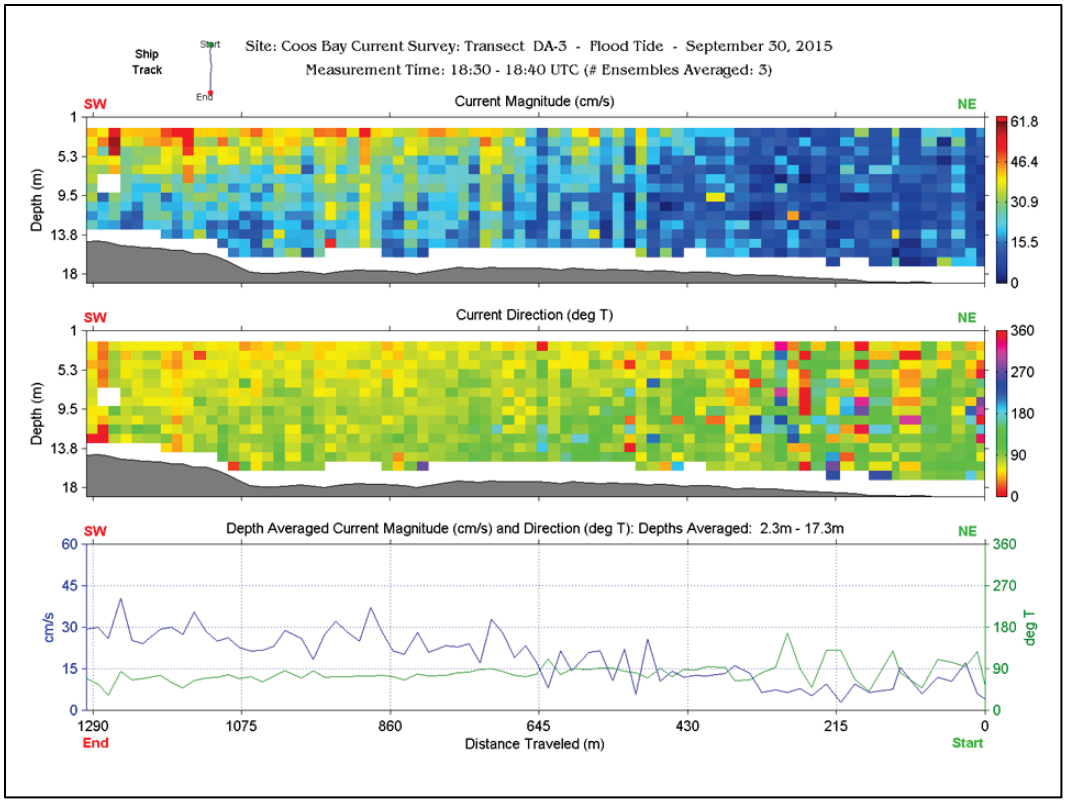

Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - September 30, 2015
Measurement Time: 17:12 - 17:29 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4
7
10
13
76.3
57.2
38.2
19.1
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
76
57
38
19
0
deg T
0
505
1010
1515
2020
2525
3030
Distance Traveled (m)
Start
End

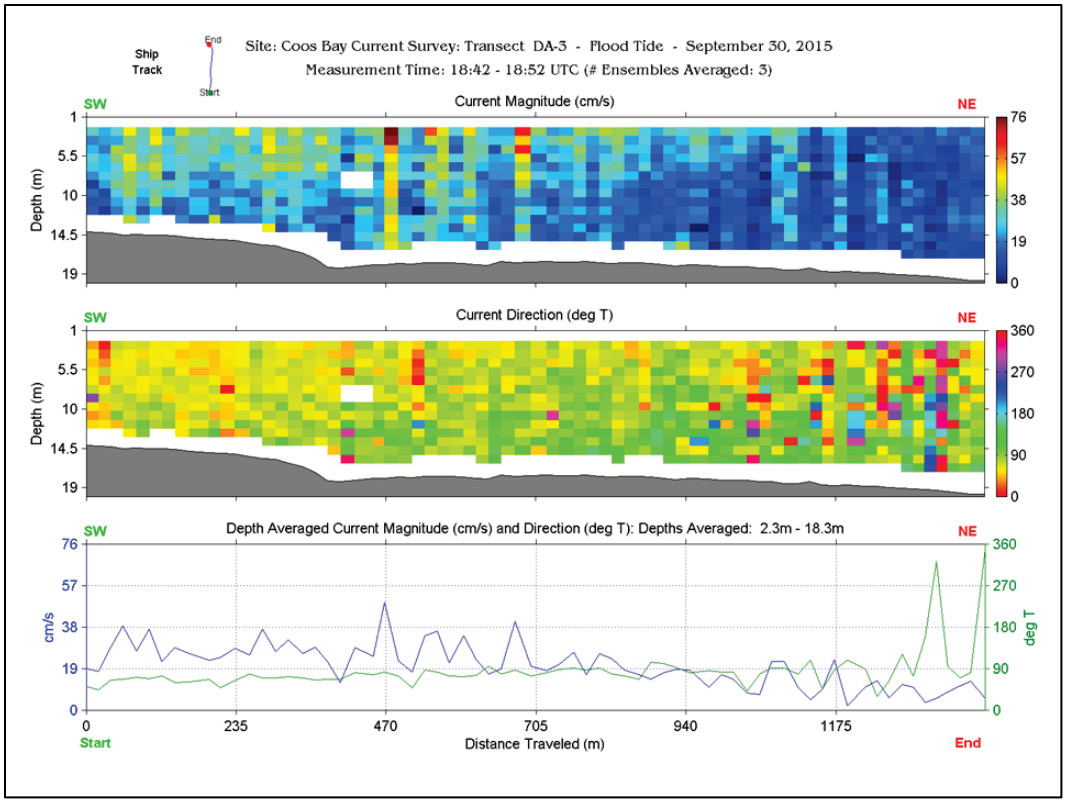

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Flood Tide - September 30, 2015
Measurement Time: 17:31 - 17:37 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.3
7.5
10.8
14
47.8
35.9
23.9
12
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 13.3m
cm/s
deg T
46
34.5
23
11.5
0
1140
950
760
570
380
190
End
Start
Distance Traveled (m)

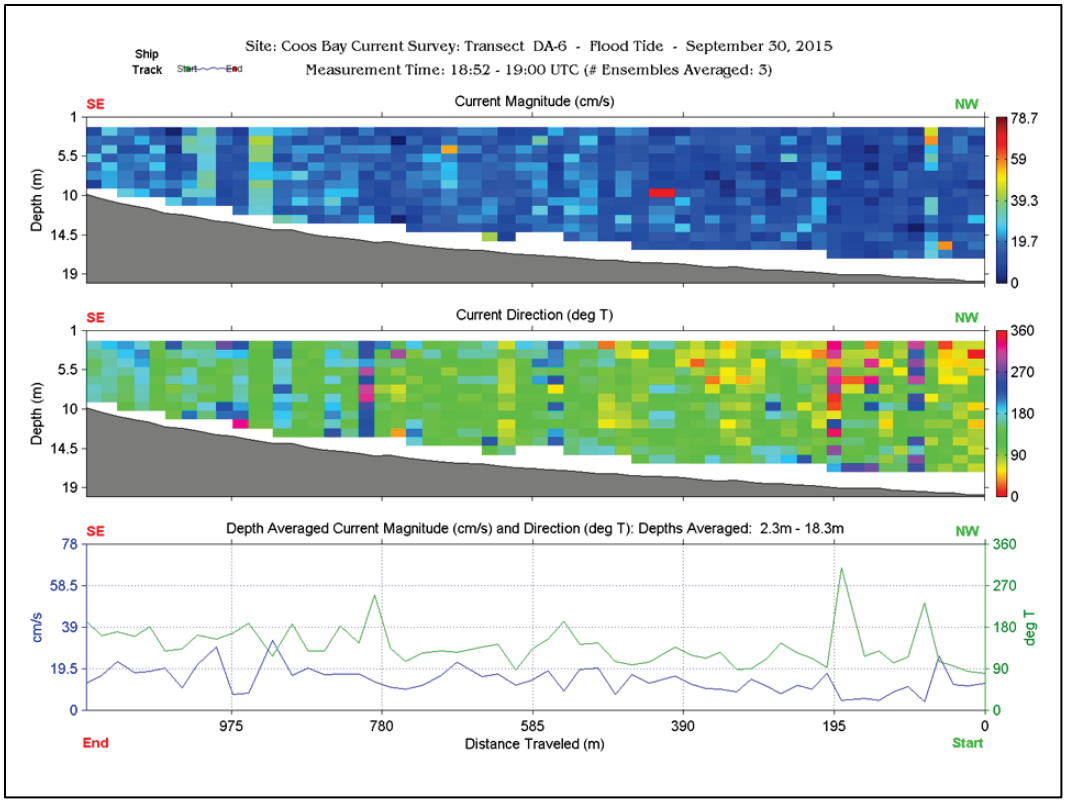

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Flood Tide - September 30, 2015
Measurement Time: 17:39 - 17:53 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
71.8
53.8
35.9
17.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
70
52.5
35
17.5
0
1900
1520
1140
760
380
End
Start
Distance Traveled (m)

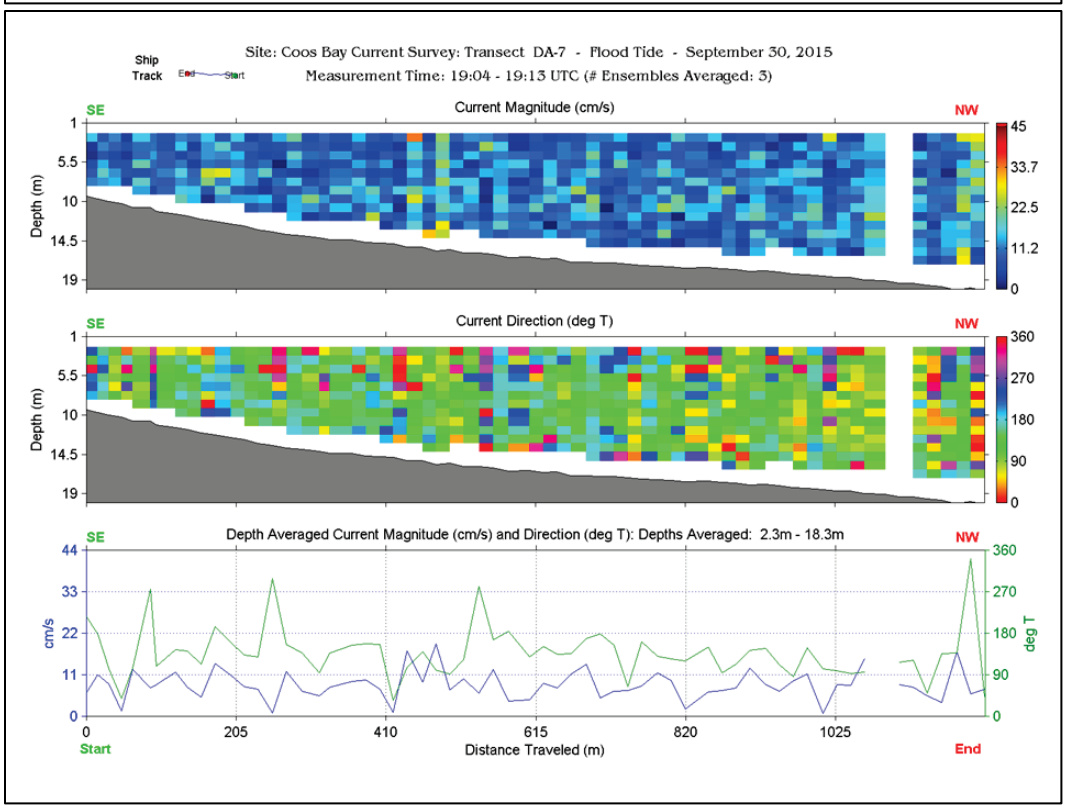

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Flood Tide - September 30, 2015
Measurement Time: 17:55 - 18:14 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
54.1
40.6
27
13.5
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
54
40.5
27
13.5
0
0
565
1130
1695
2260
2825
Start
End
Distance Traveled (m)

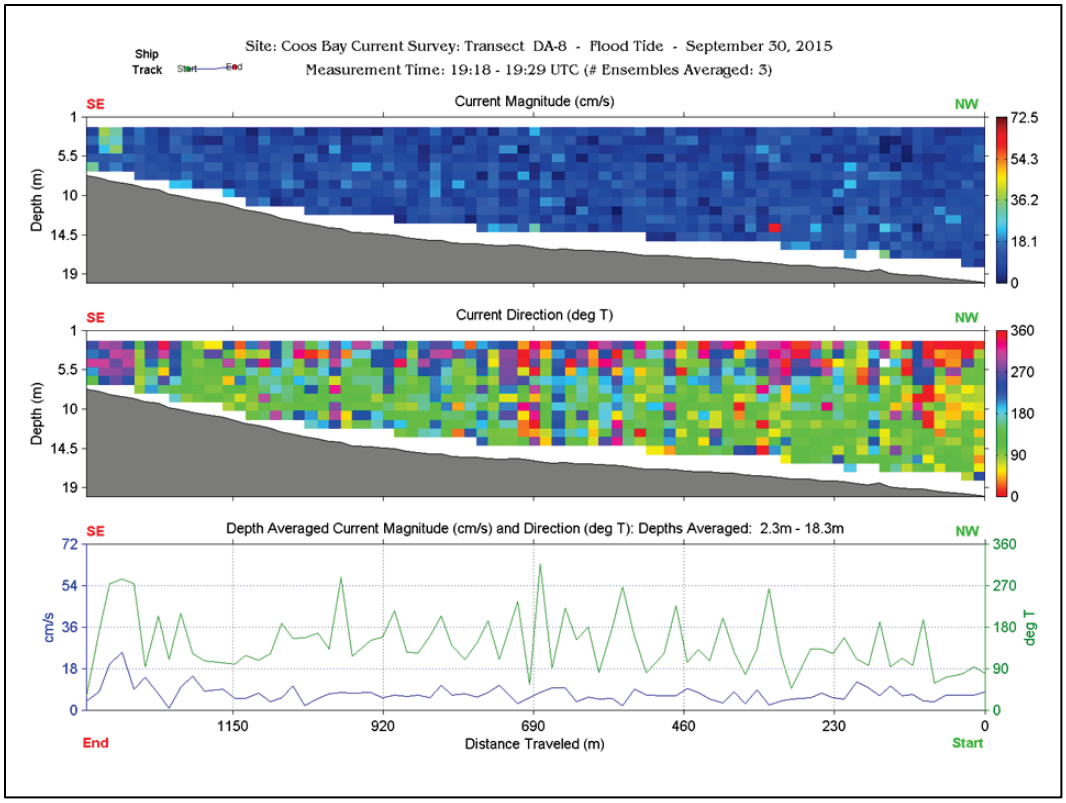

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - September 30, 2015
Measurement Time: 18:17 - 18:26 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
39.7
29.8
19.8
9.9
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
38
28.5
19
9.5
0
1350
1080
810
540
270
0
End
Start
Distance Traveled (m)

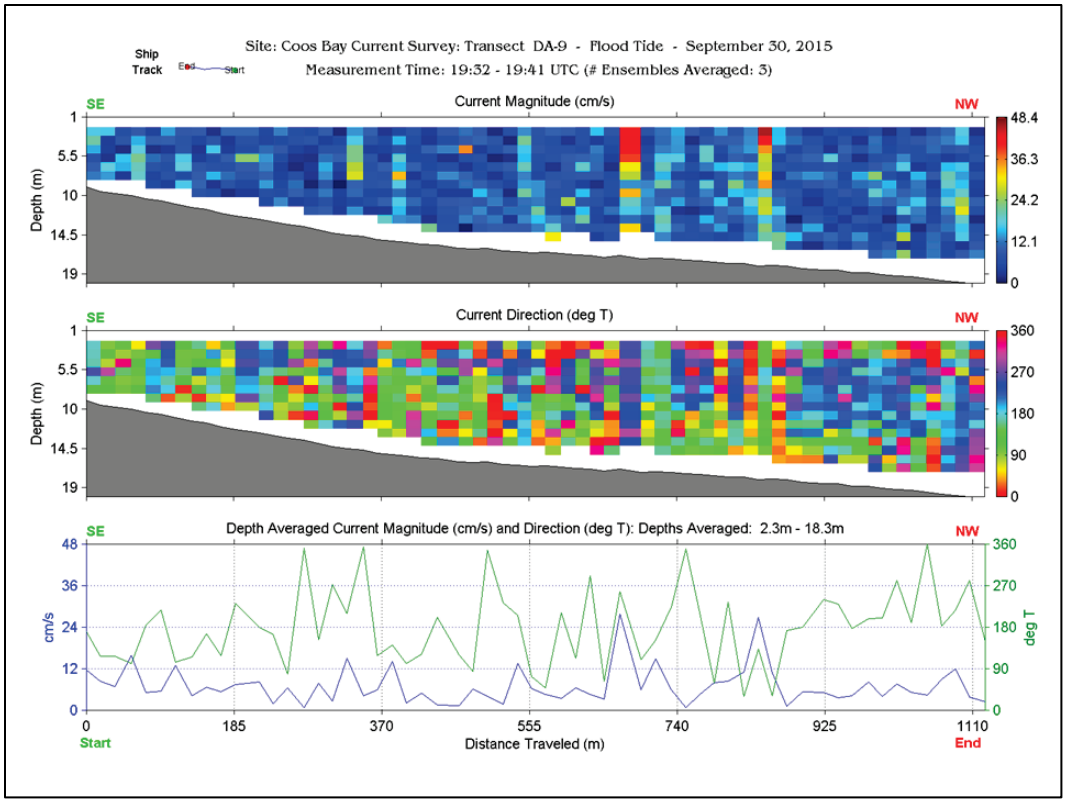

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - September 30, 2015
Measurement Time: 18:30 - 18:40 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
61.8
46.4
30.9
15.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
60
45
30
15
1290
1075
860
645
430
215
End
Start
Distance Traveled (m)

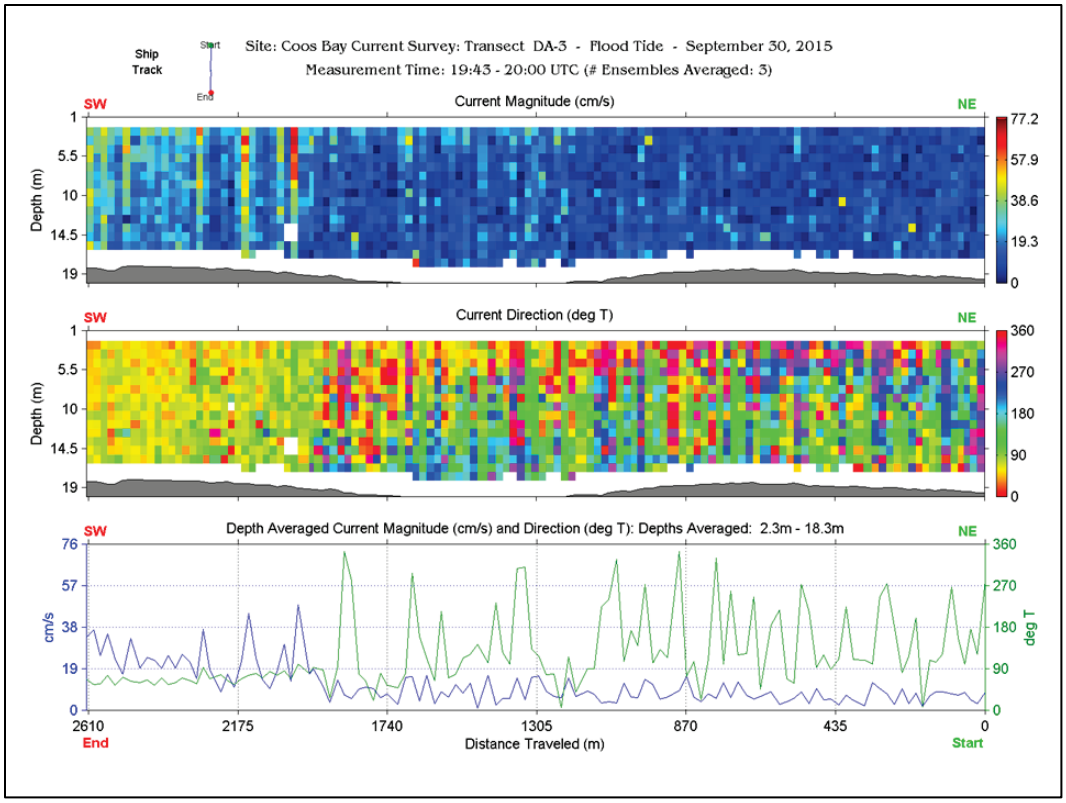

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - September 30, 2015
Measurement Time: 18:42 - 18:52 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.5
10
14.5
19
76
57
38
19
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
76
57
38
19
0
235
470
705
940
1175
Start
End
Distance Traveled (m)

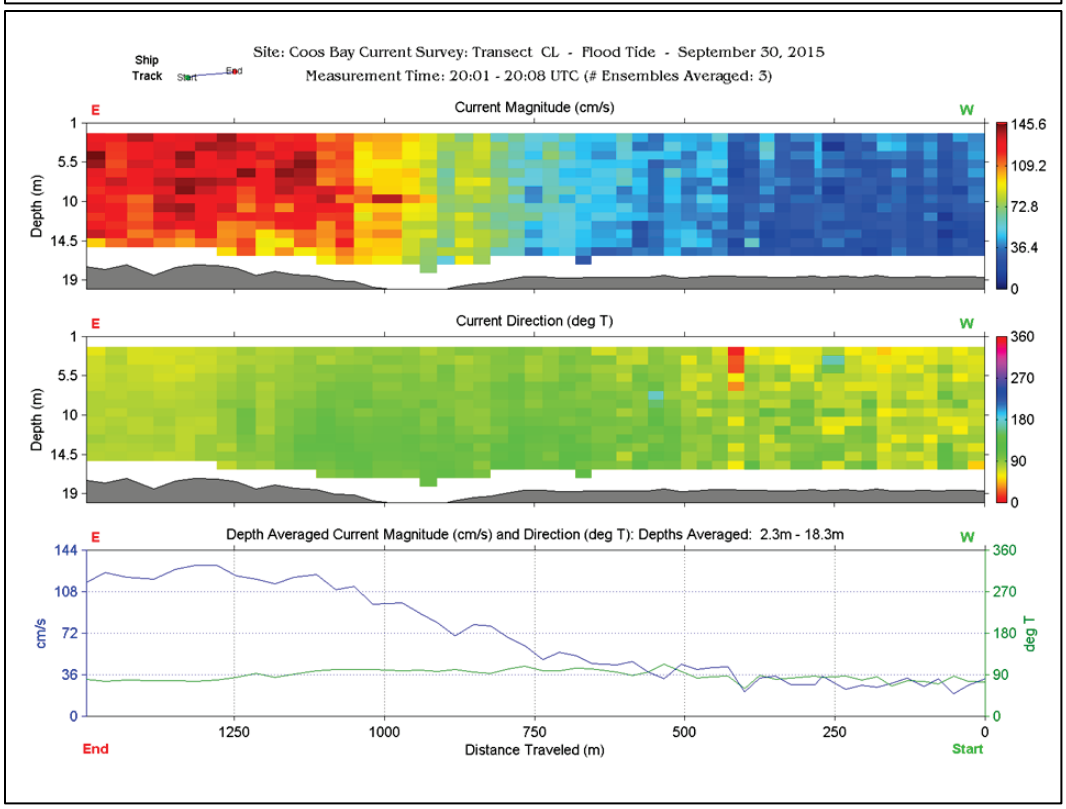

Site: Coos Bay Current Survey: Transect DA-6 - Flood Tide - September 30, 2015
Measurement Time: 18:52 - 19:00 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
SE
NW
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

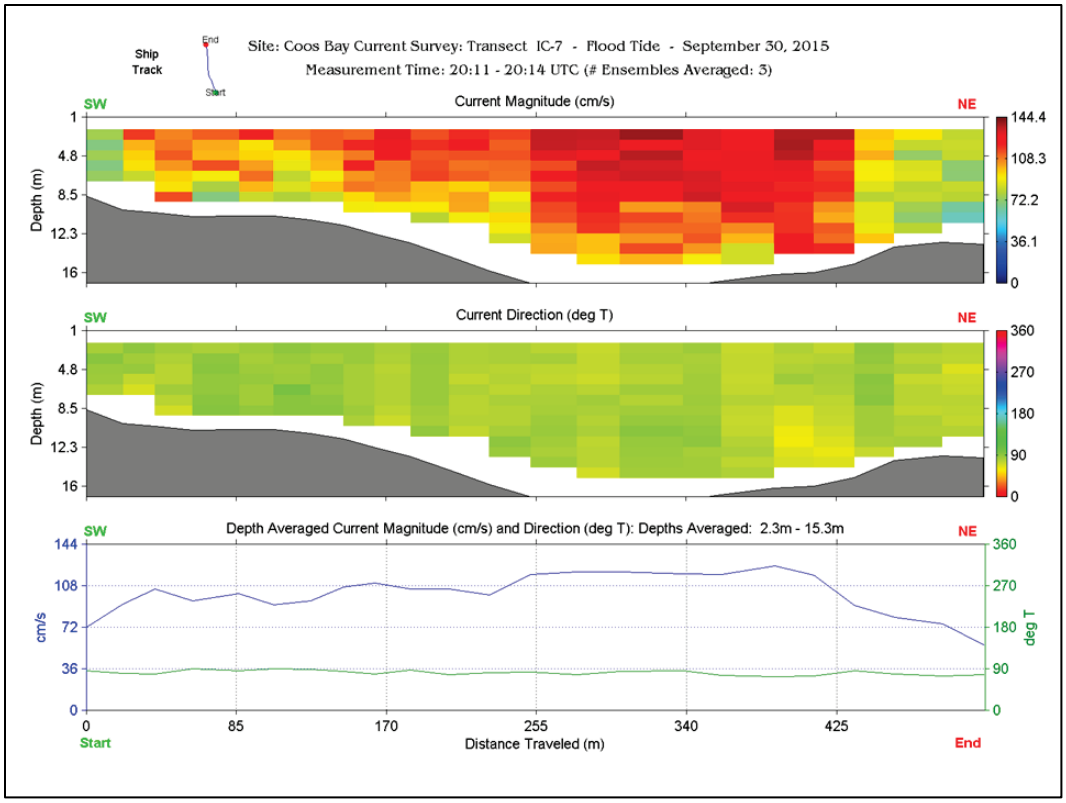

Site: Coos Bay Current Survey: Transect DA-7 - Flood Tide - September 30, 2015
Measurement Time: 19:04 - 19:13 UTC (# Ensembles Averaged: 3)
Ship Track
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
SE
NW
Depth (m)
cm/s
deg T
Distance Traveled (m)
Start
End

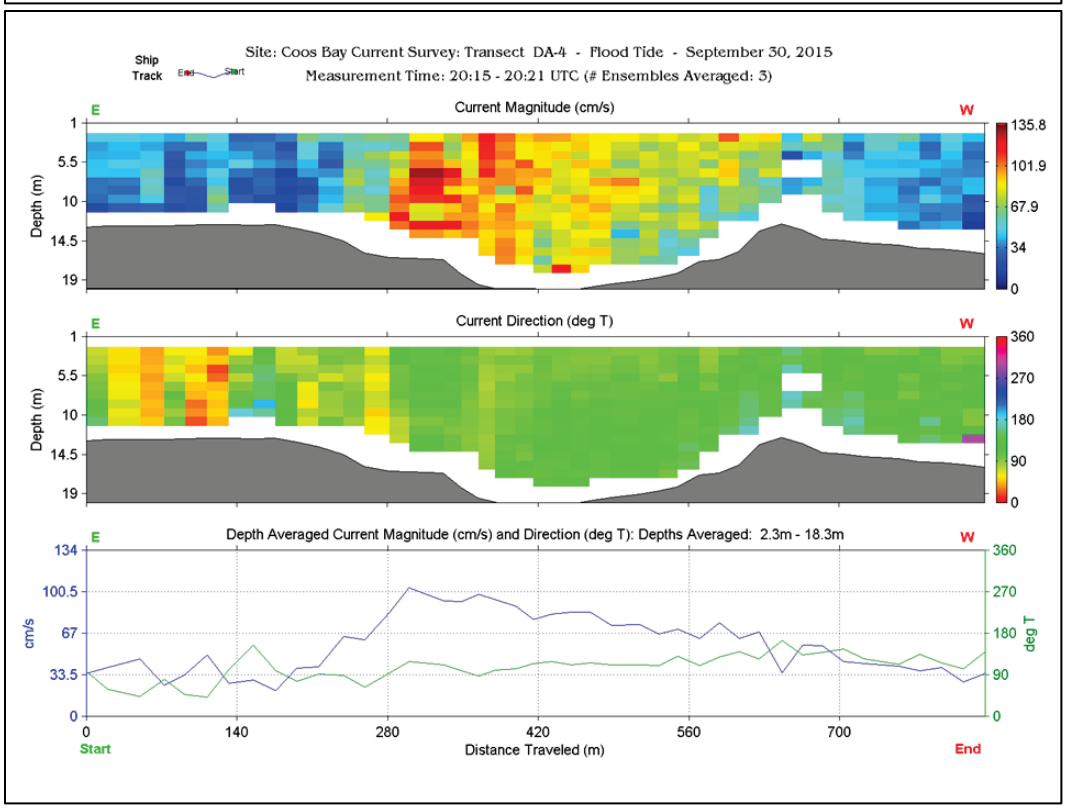

Site: Coos Bay Current Survey: Transect DA-8 - Flood Tide - September 30, 2015
Measurement Time: 19:18 - 19:29 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
72.5
54.3
36.2
18.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
72
54
36
18
1150
920
690
460
230
End
Start
Distance Traveled (m)


Site: Coos Bay Current Survey: Transect DA-9 - Flood Tide - September 30, 2015
Measurement Time: 19:32 - 19:41 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
48.4
36.3
24.2
12.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
48
36
24
12
0
185
370
555
740
925
1110
Start
End
Distance Traveled (m)

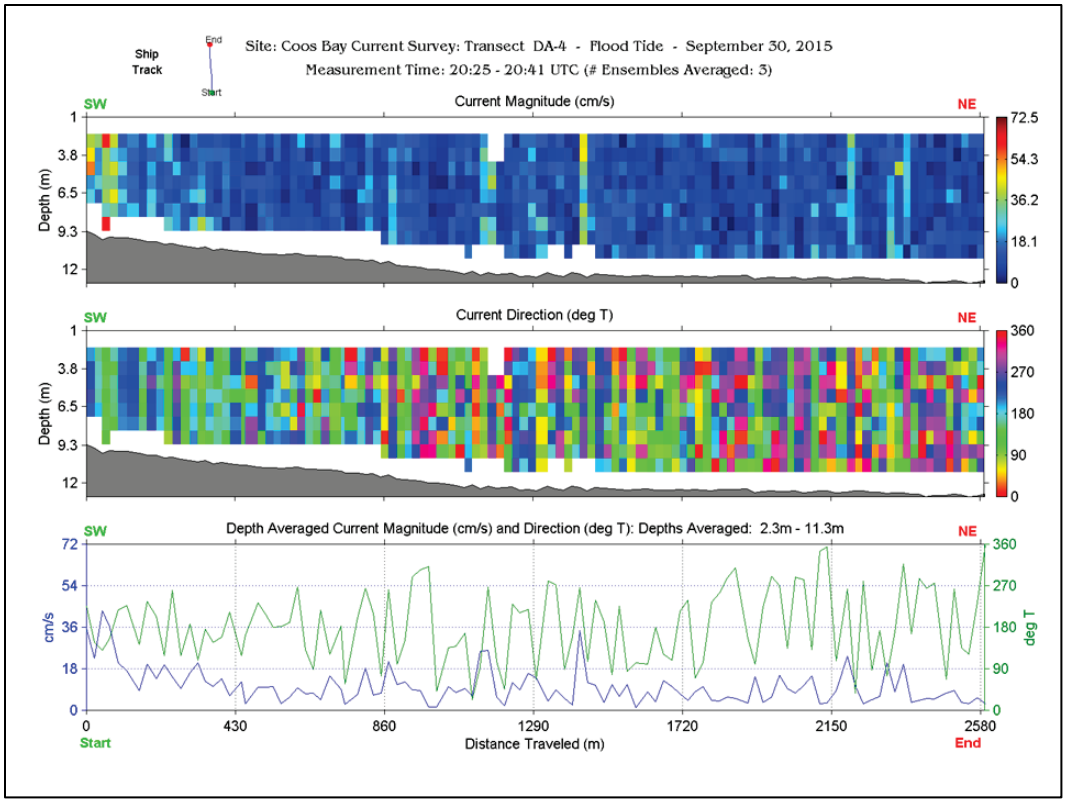

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - September 30, 2015
Measurement Time: 19:43 - 20:00 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.5
10
14.5
19
77.2
57.9
38.6
19.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
76
57
38
19
2610
2175
1740
1305
870
435
Distance Traveled (m)
End
Start

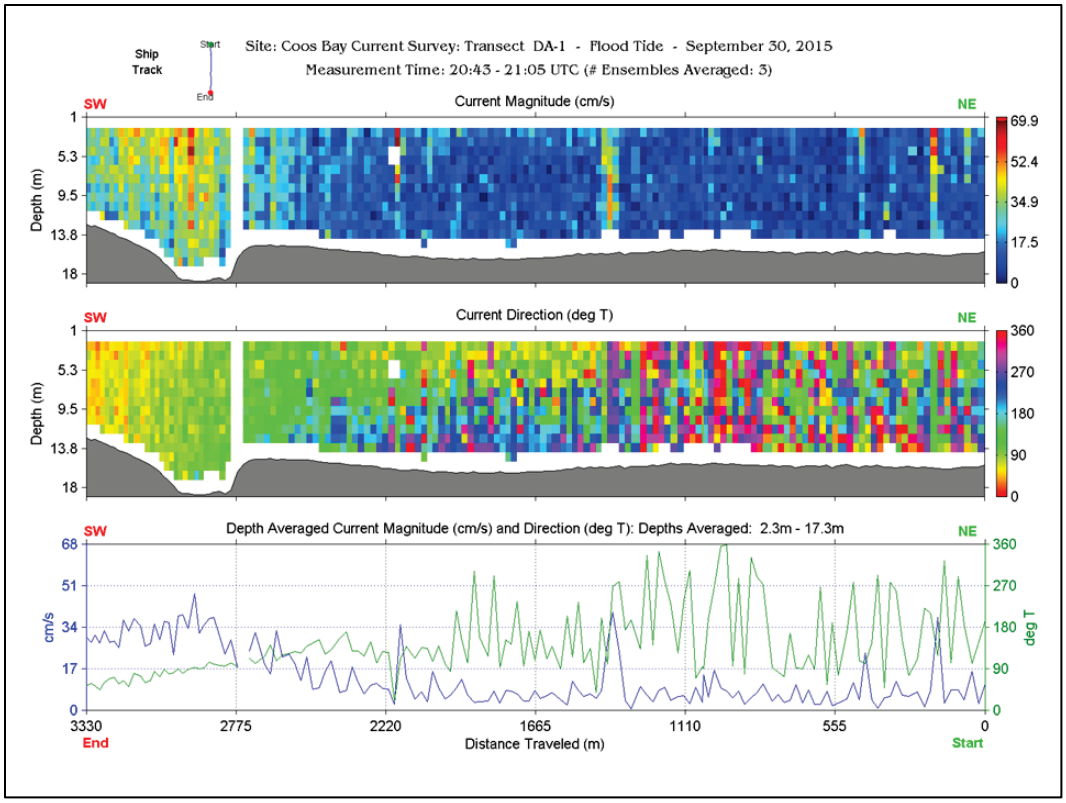

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect CL - Flood Tide - September 30, 2015
Measurement Time: 20:01 - 20:08 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
145.6
109.2
72.8
36.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
144
108
72
36
1250
1000
750
500
250
Distance Traveled (m)
End
Start

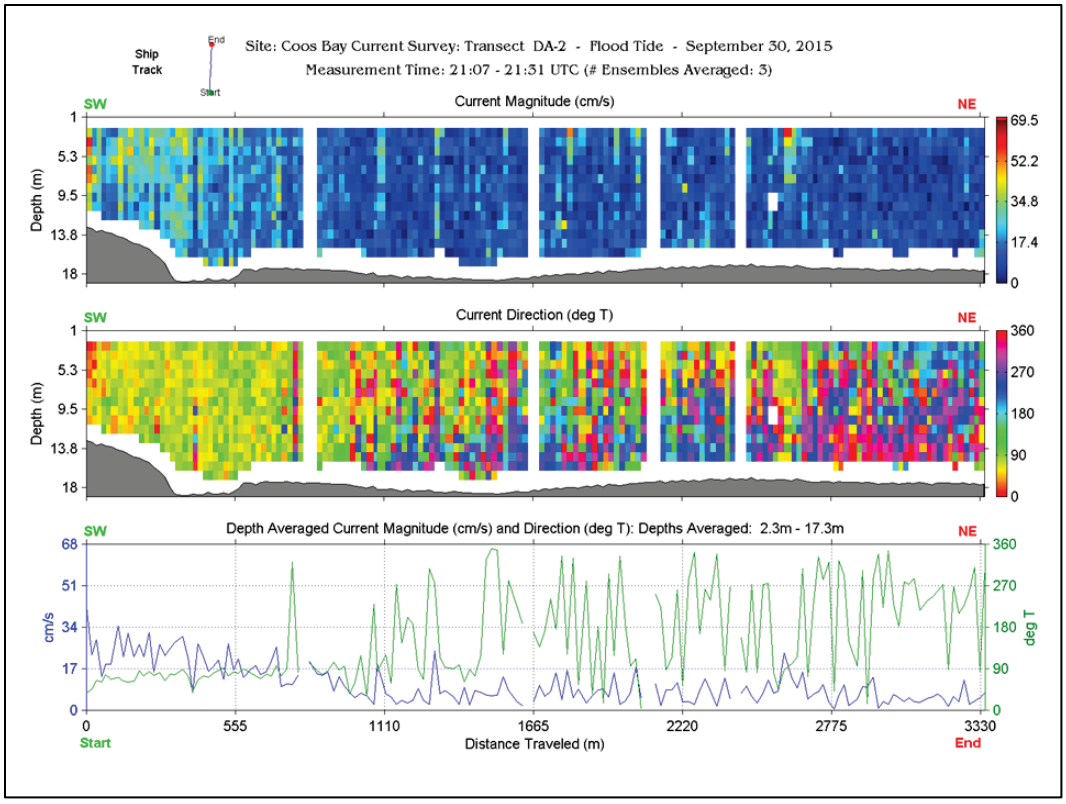

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Flood Tide - September 30, 2015
Measurement Time: 20:11 - 20:14 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
144.4
108.3
72.2
36.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
144
108
72
36
0
0
85
170
255
340
425
Distance Traveled (m)
Start
End

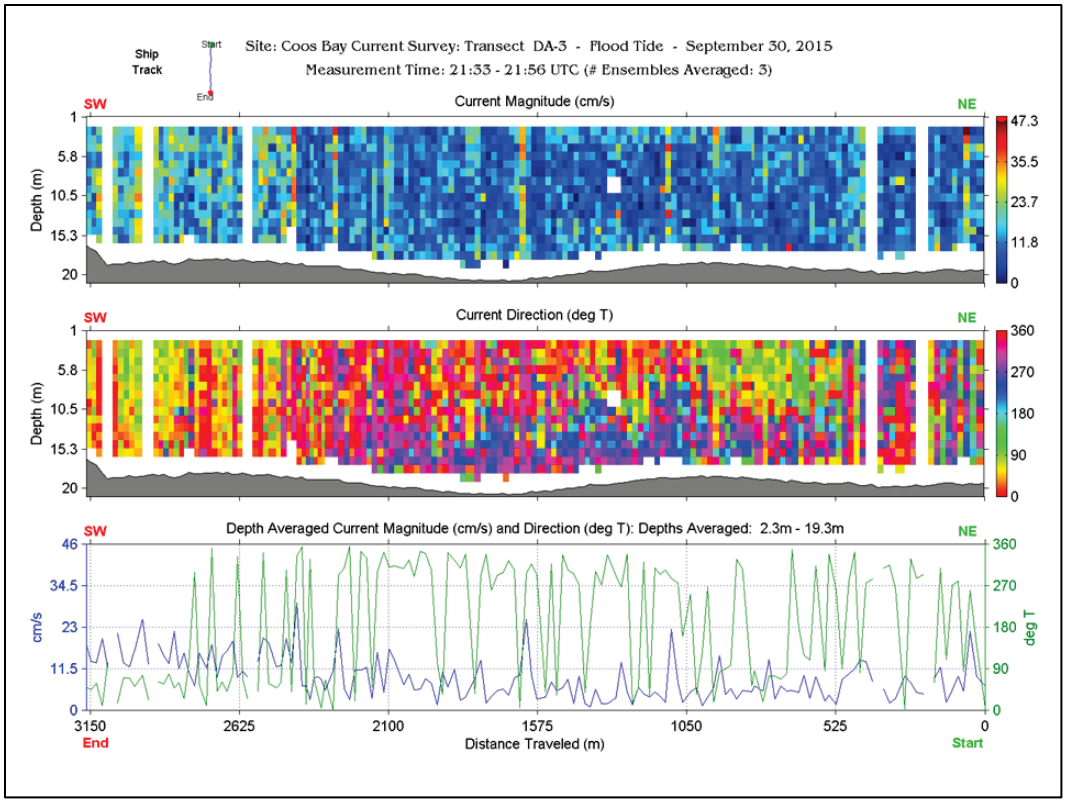

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - September 30, 2015
Measurement Time: 20:15 - 20:21 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
135.8
101.9
67.9
34
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
134
100.5
67
33.5
0
0
140
280
420
560
700
Distance Traveled (m)
Start
End

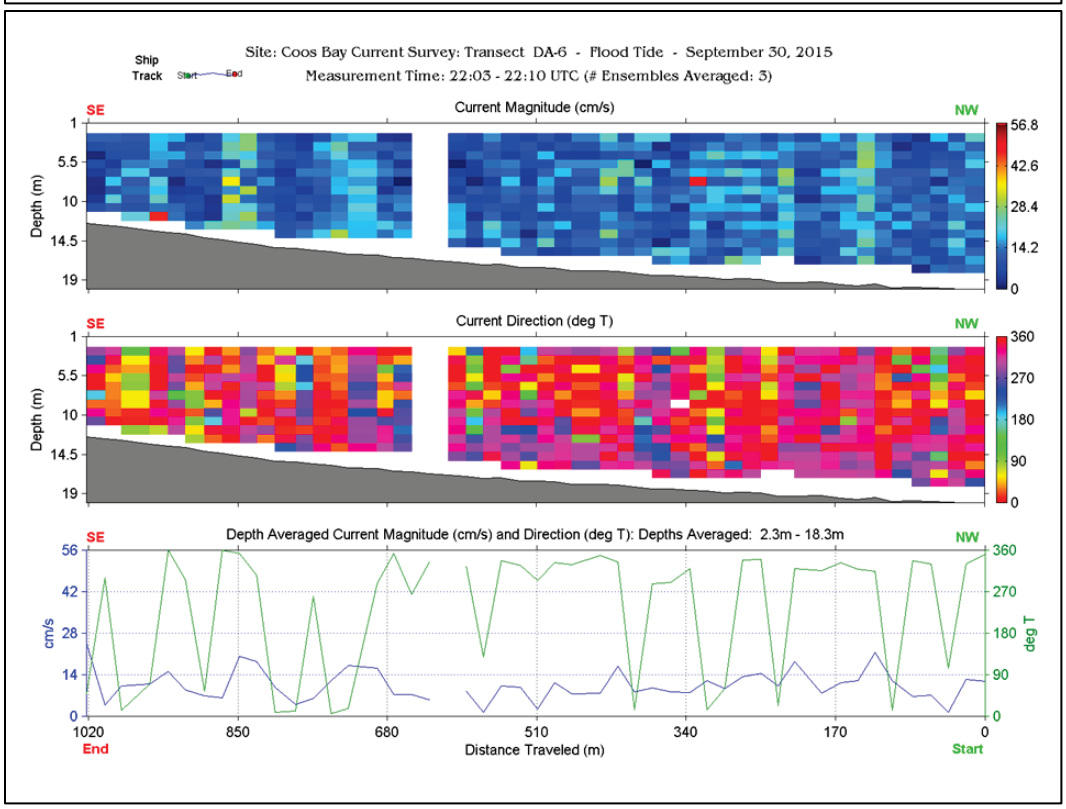

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - September 30, 2015
Measurement Time: 20:22 - 20:25 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.8
8.5
12.3
16
92
69
46
23
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
90
67.5
45
22.5
570
475
380
285
190
95
Distance Traveled (m)

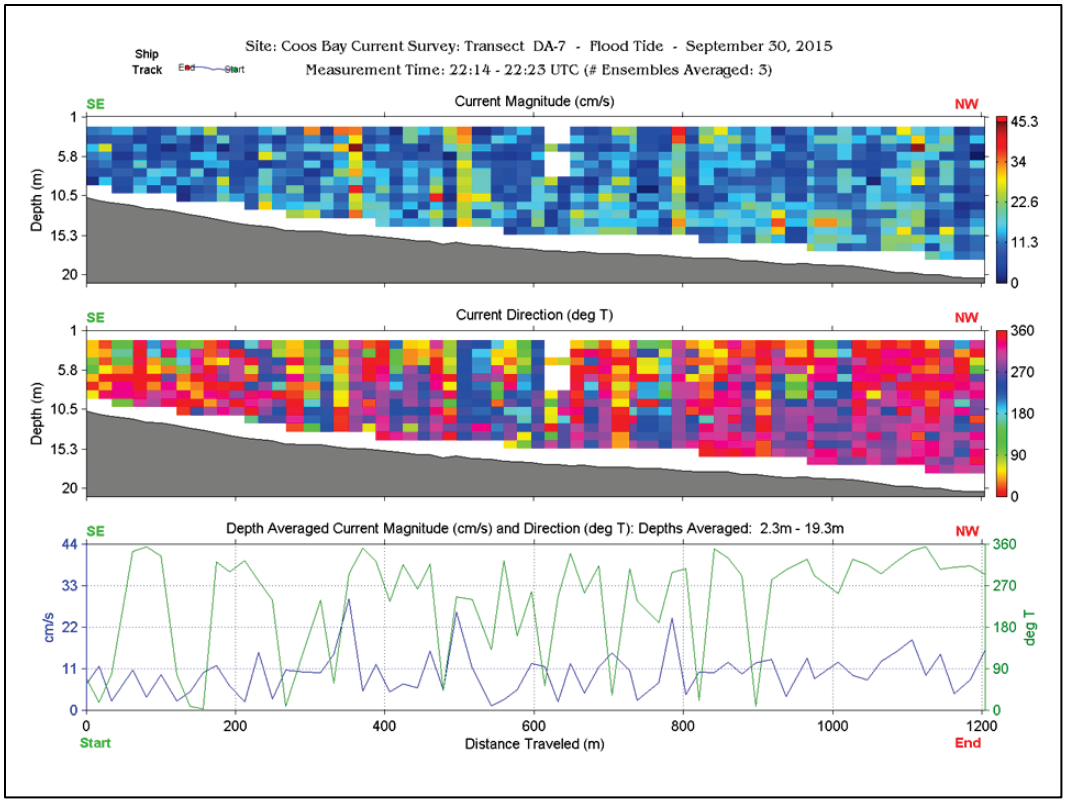

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - September 30, 2015
Measurement Time: 20:25 - 20:41 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
3.8
6.5
9.3
12
72.5
54.3
36.2
18.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
72
54
36
18
0
430
860
1290
1720
2150
2580
Distance Traveled (m)

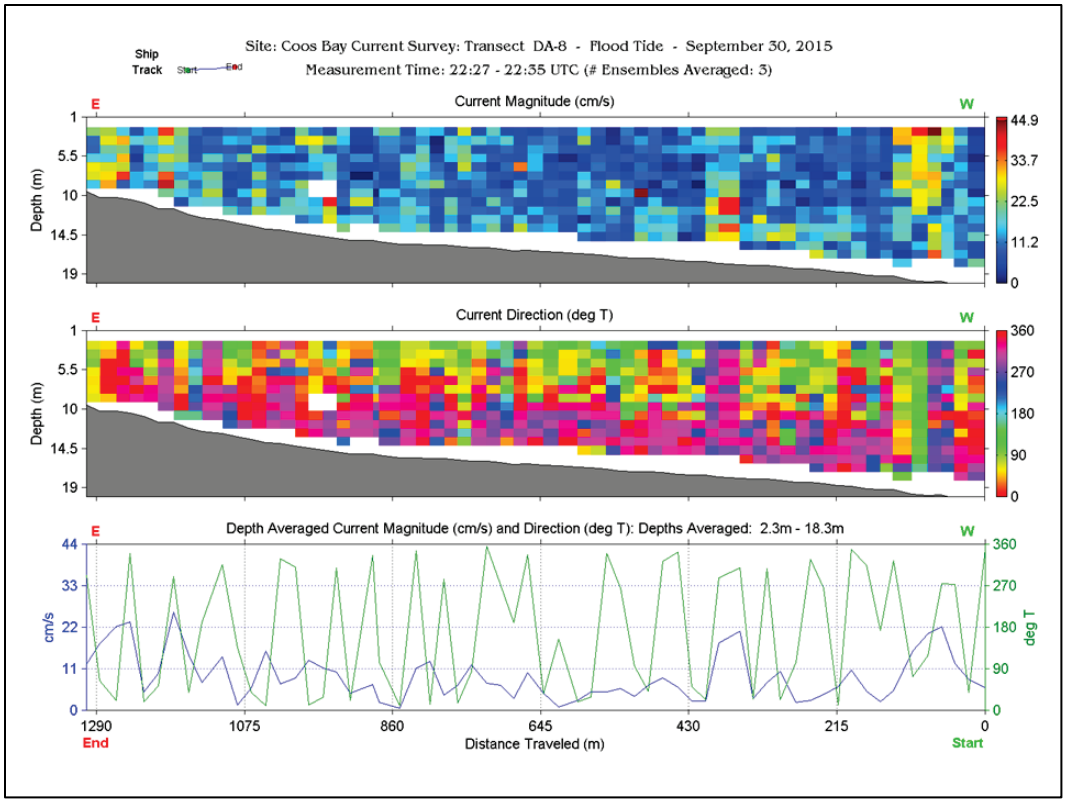

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Flood Tide - September 30, 2015
Measurement Time: 20:43 - 21:05 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
69.9
52.4
34.9
17.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
68
51
34
17
deg T
3330
2775
2220
1665
1110
555
End
Start
Distance Traveled (m)

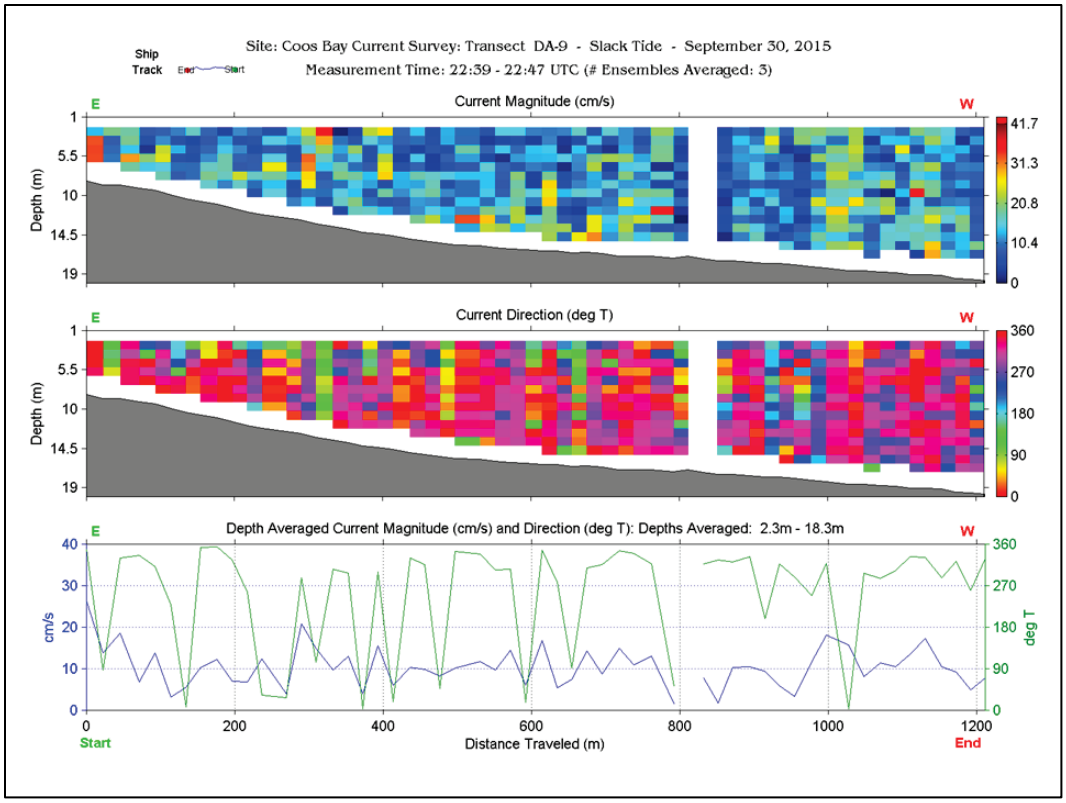

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Flood Tide - September 30, 2015
Measurement Time: 21:07 - 21:31 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
69.5
52.2
34.8
17.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
68
51
34
17
deg T
0
555
1110
1665
2220
2775
3330
Start
End
Distance Traveled (m)

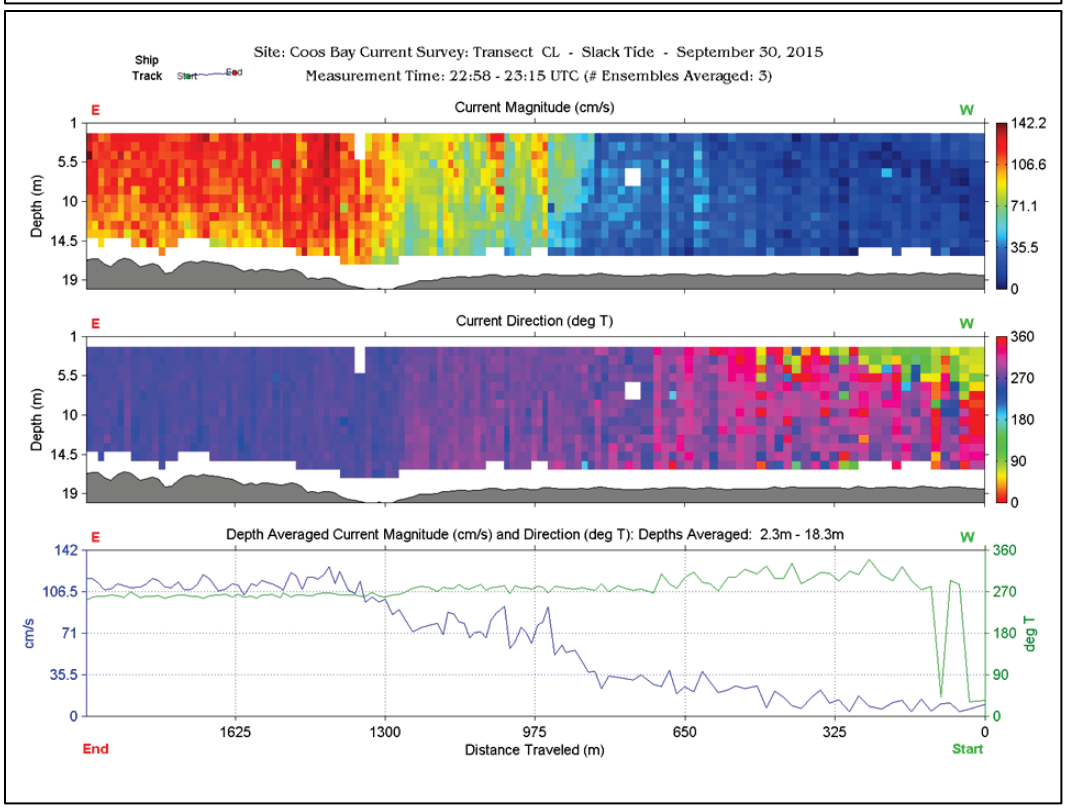

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - September 30, 2015
Measurement Time: 21:33 - 21:56 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.8
10.5
15.3
20
47.3
35.5
23.7
11.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
46
34.5
23
11.5
deg T
3150
2625
2100
1575
1050
525
End
Start
Distance Traveled (m)

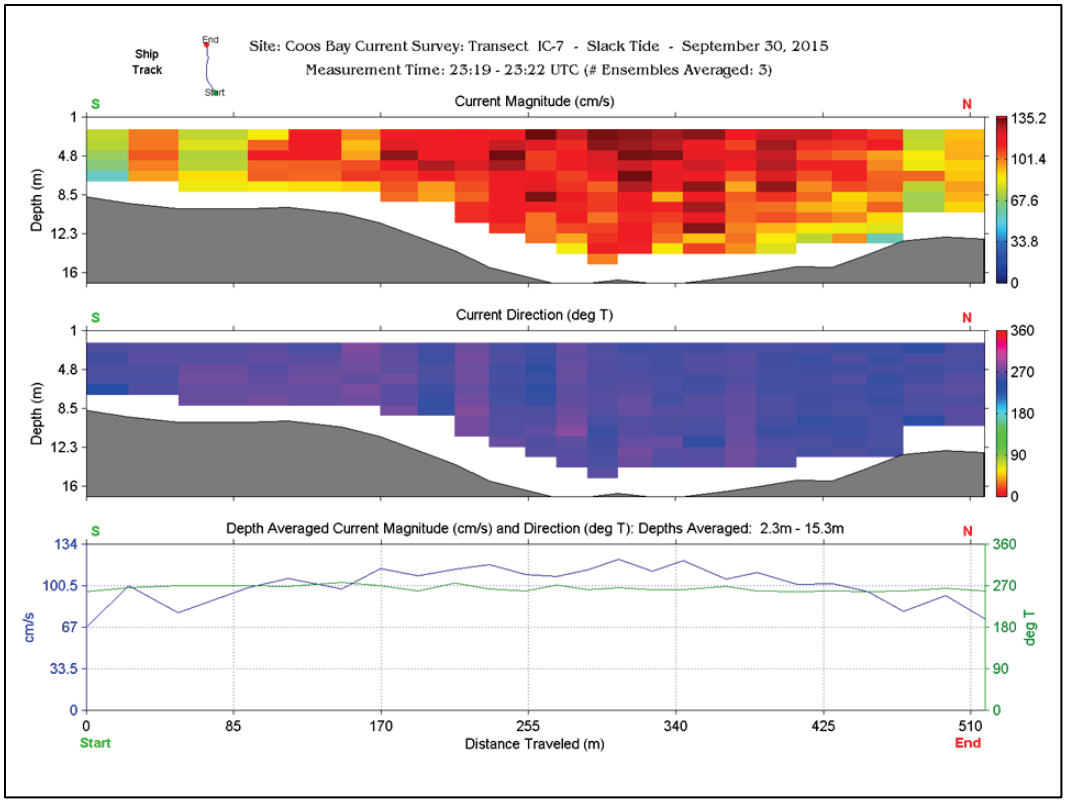

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-6 - Flood Tide - September 30, 2015
Measurement Time: 22:03 - 22:10 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
56.8
42.6
28.4
14.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
56
42
28
14
deg T
1020
850
680
510
340
170
End
Start
Distance Traveled (m)

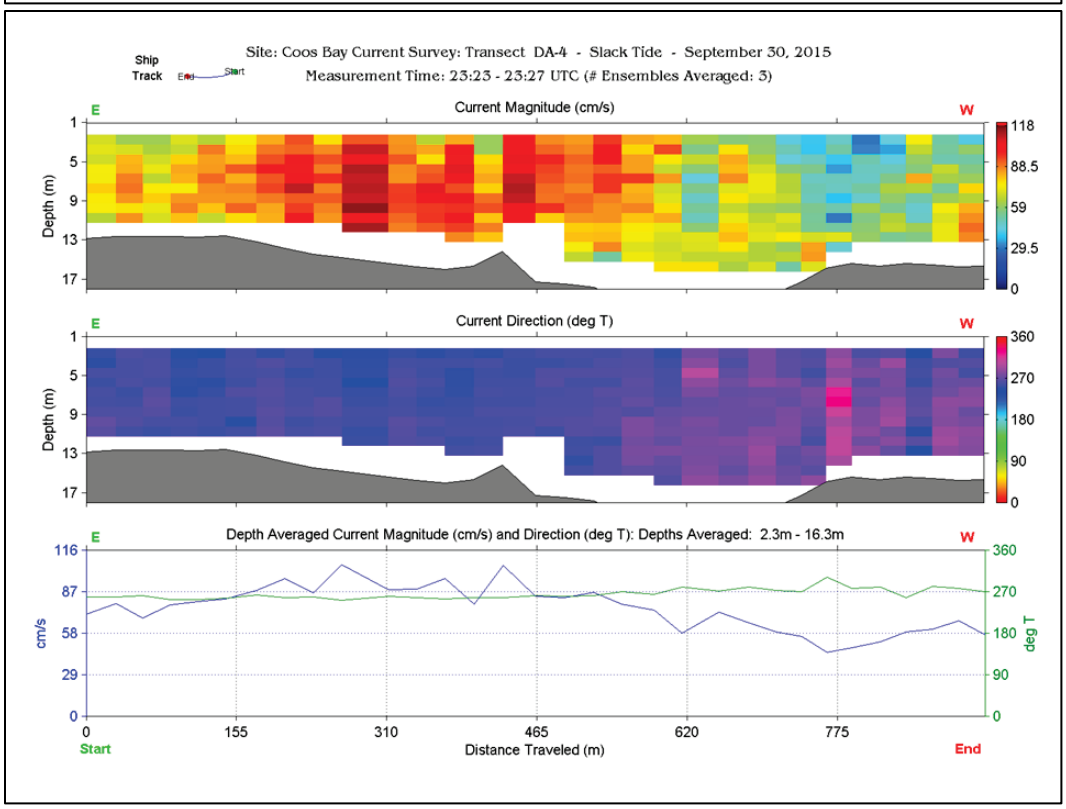

Site: Coos Bay Current Survey: Transect DA-7 - Flood Tide - September 30, 2015
Measurement Time: 22:14 - 22:23 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
45.3
34
22.6
11.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
44
33
22
11
0
0
200
400
600
800
1000
1200
Start
End
Distance Traveled (m)

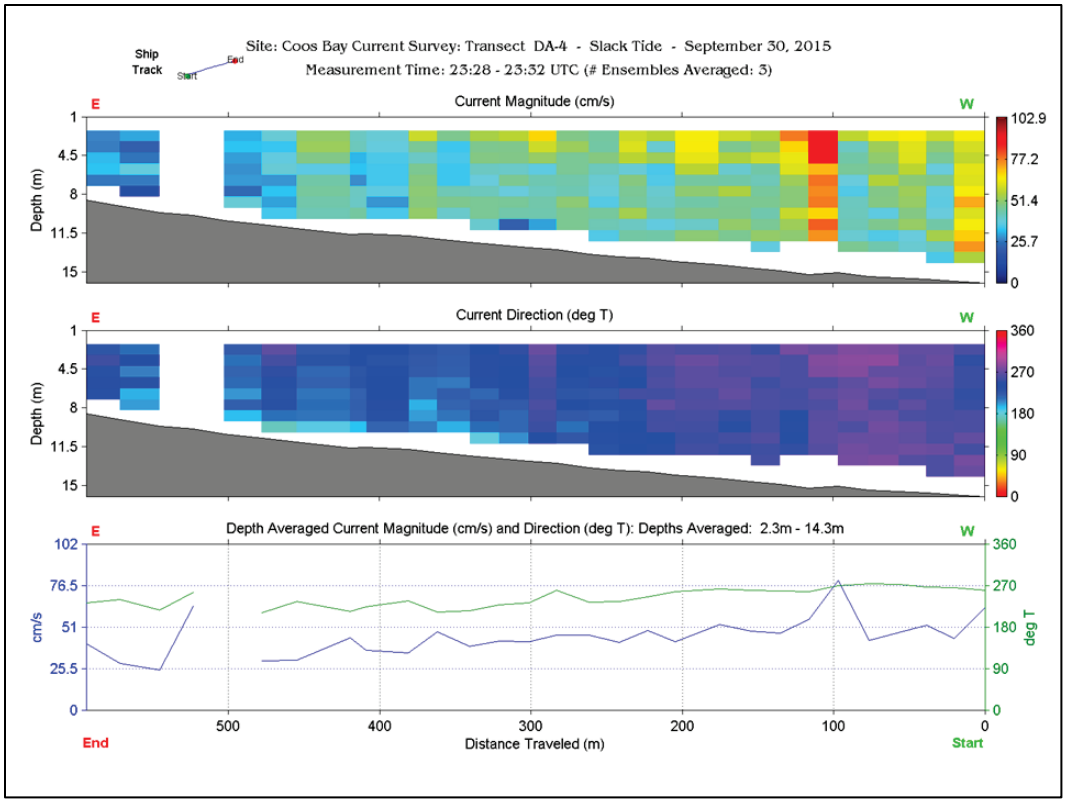

Site: Coos Bay Current Survey: Transect DA-8 - Flood Tide - September 30, 2015
Measurement Time: 22:27 - 22:35 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
44.9
33.7
22.5
11.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
44
33
22
11
0
1290
1075
860
645
430
215
0
End
Start
Distance Traveled (m)

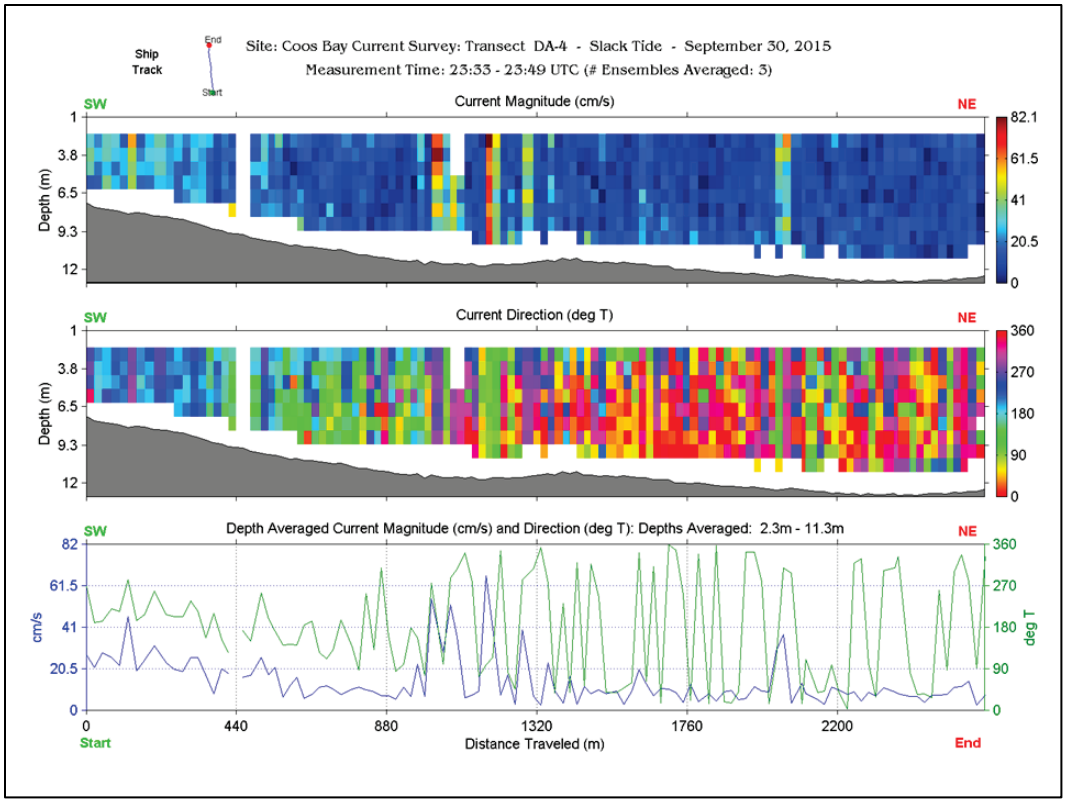

Site: Coos Bay Current Survey: Transect DA-9 - Slack Tide - September 30, 2015
Measurement Time: 22:39 - 22:47 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
Start
End

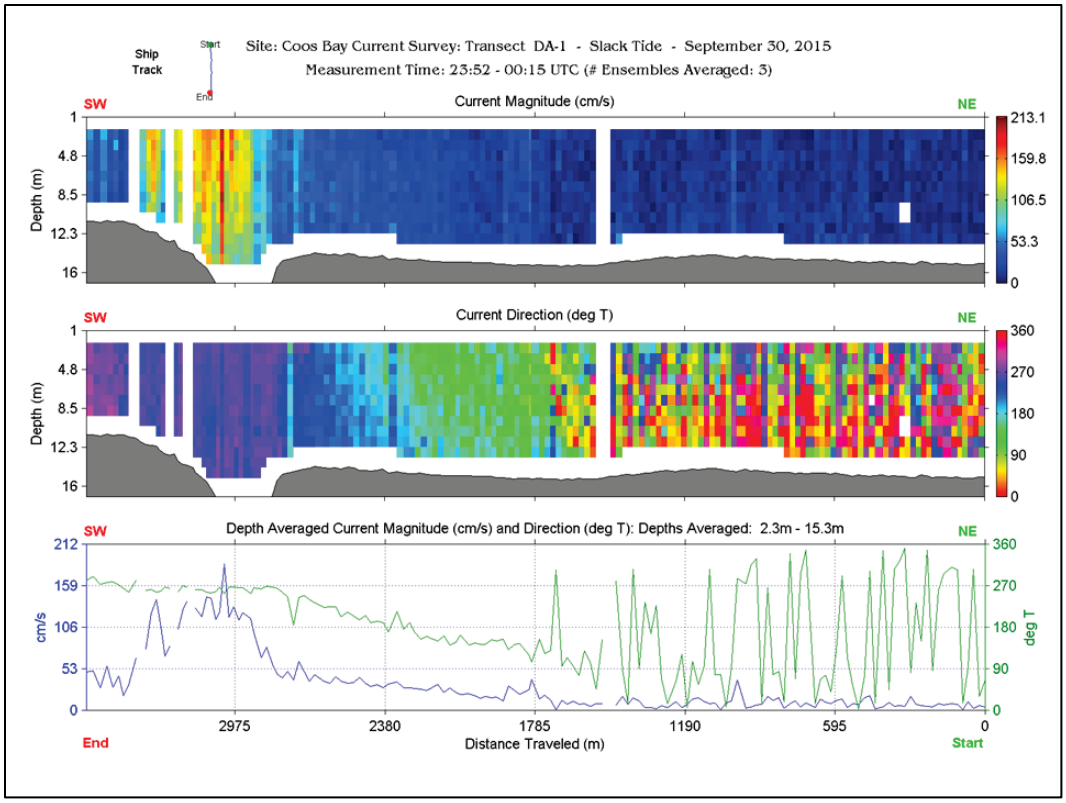

Site: Coos Bay Current Survey: Transect CL - Slack Tide - September 30, 2015
Measurement Time: 22:58 - 23:15 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
Depth (m)
cm/s
deg T
Distance Traveled (m)
End
Start

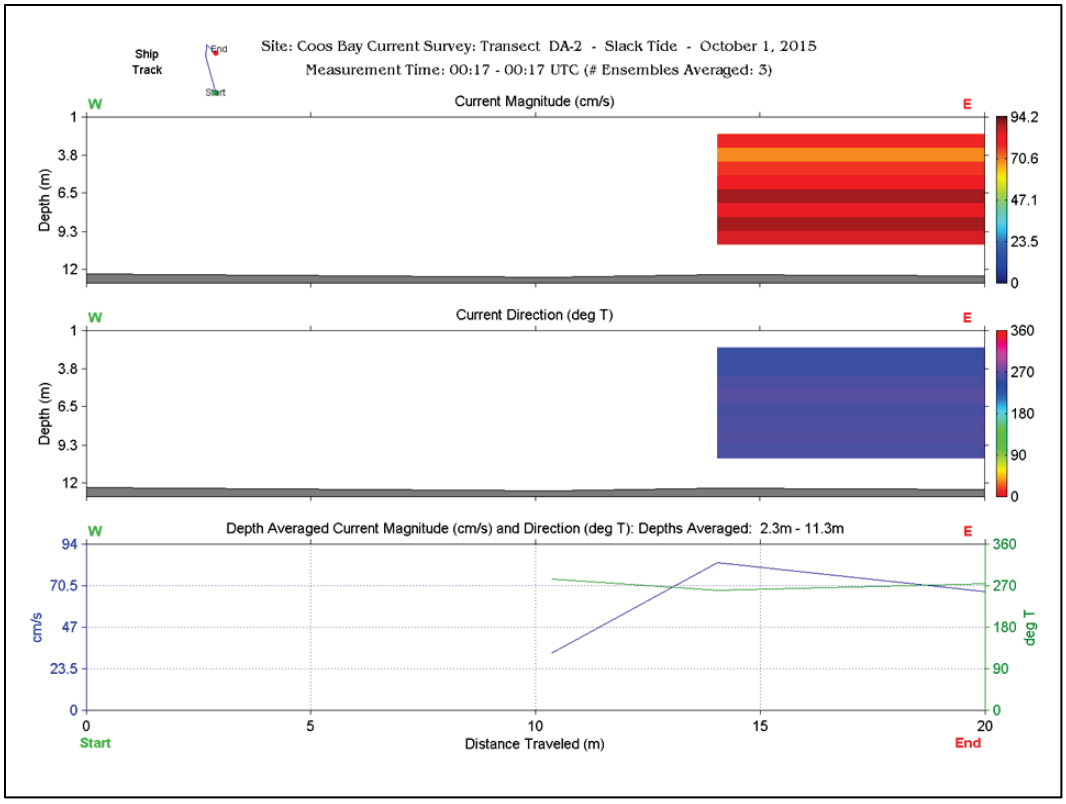

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Slack Tide - September 30, 2015
Measurement Time: 23:19 - 23:22 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.8
8.5
12.3
16
135.2
101.4
67.6
33.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
134
100.5
67
33.5
0
0
85
170
255
340
425
510
Start
Distance Traveled (m)
End

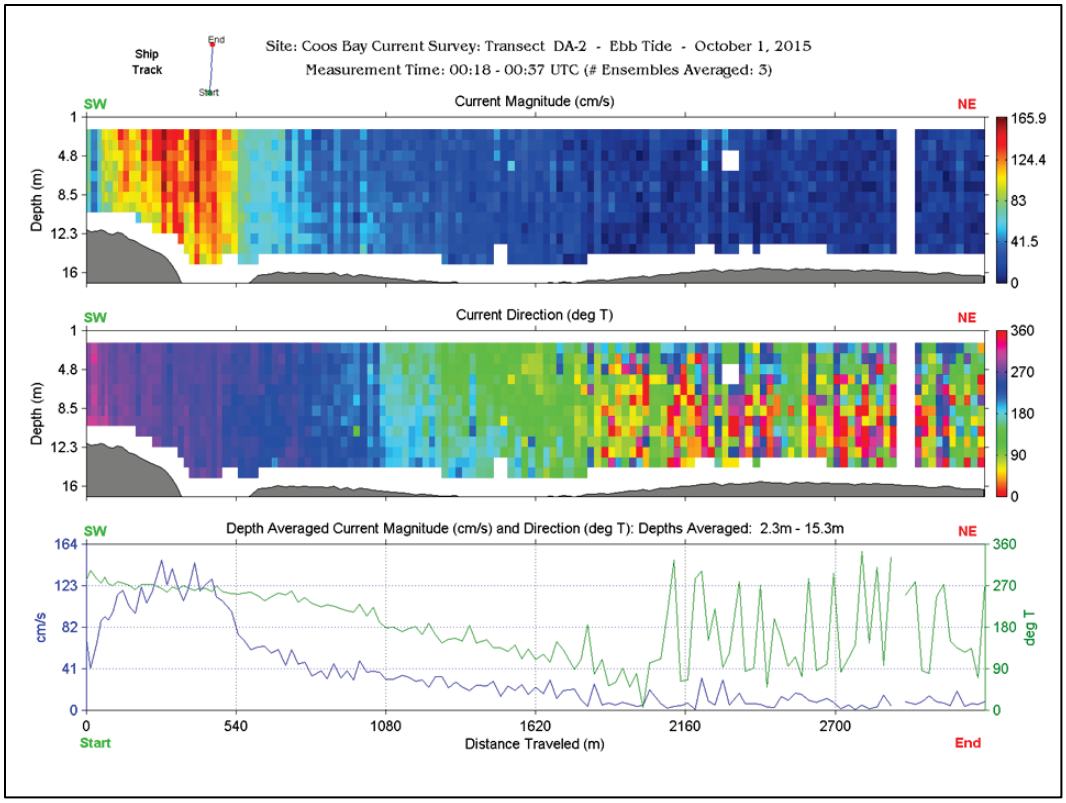

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Slack Tide - September 30, 2015
Measurement Time: 23:23 - 23:27 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5
9
13
17
118
88.5
59
29.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
116
87
58
29
0
0
155
310
465
620
775
Start
Distance Traveled (m)
End

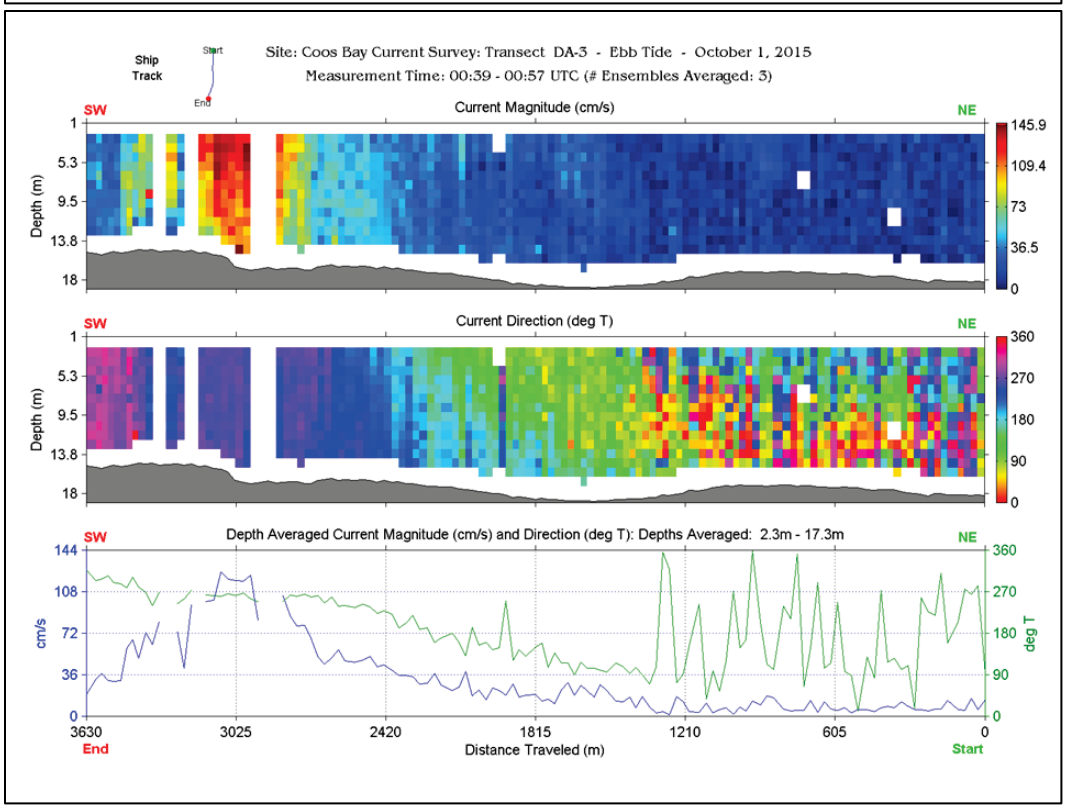

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-4 - Slack Tide - September 30, 2015
Measurement Time: 23:28 - 23:32 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.5
8
11.5
15
102.9
77.2
51.4
25.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
deg T
102
76.5
51
25.5
500
400
300
200
100
Distance Traveled (m)
End
Start

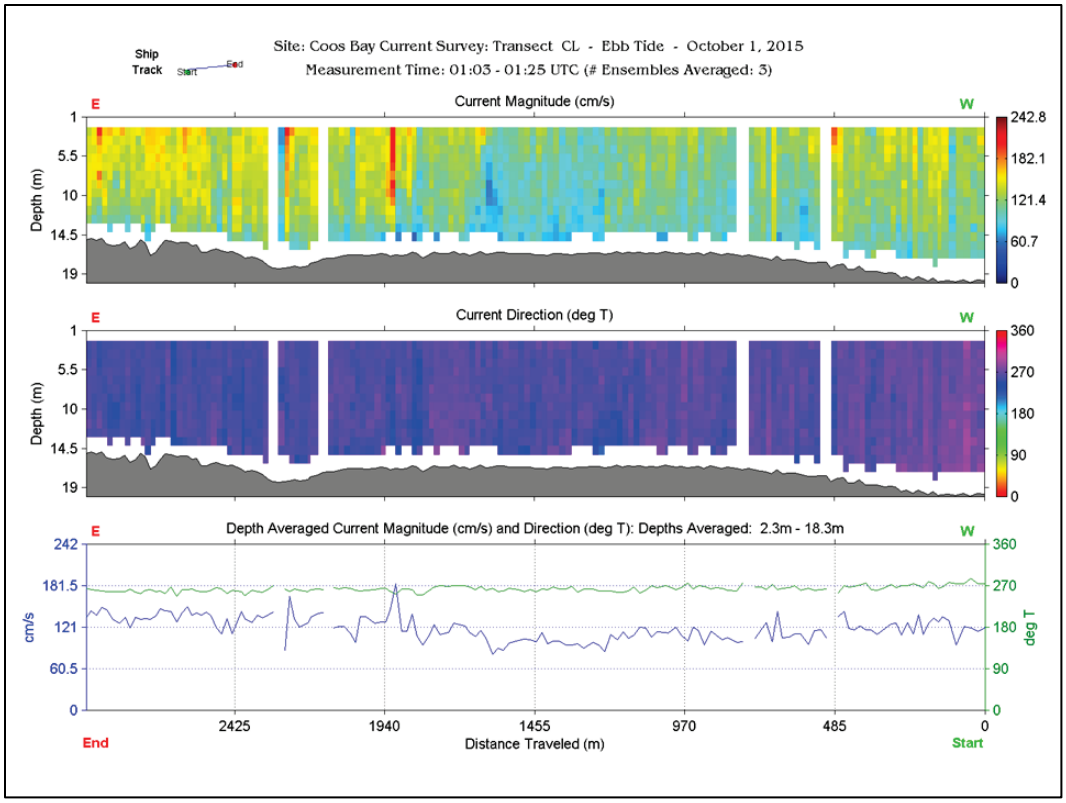

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-4 - Slack Tide - September 30, 2015
Measurement Time: 23:33 - 23:49 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
3.8
6.5
9.3
12
82.1
61.5
41
20.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
82
61.5
41
20.5
0
440
880
1320
1760
2200
Distance Traveled (m)
Start
End

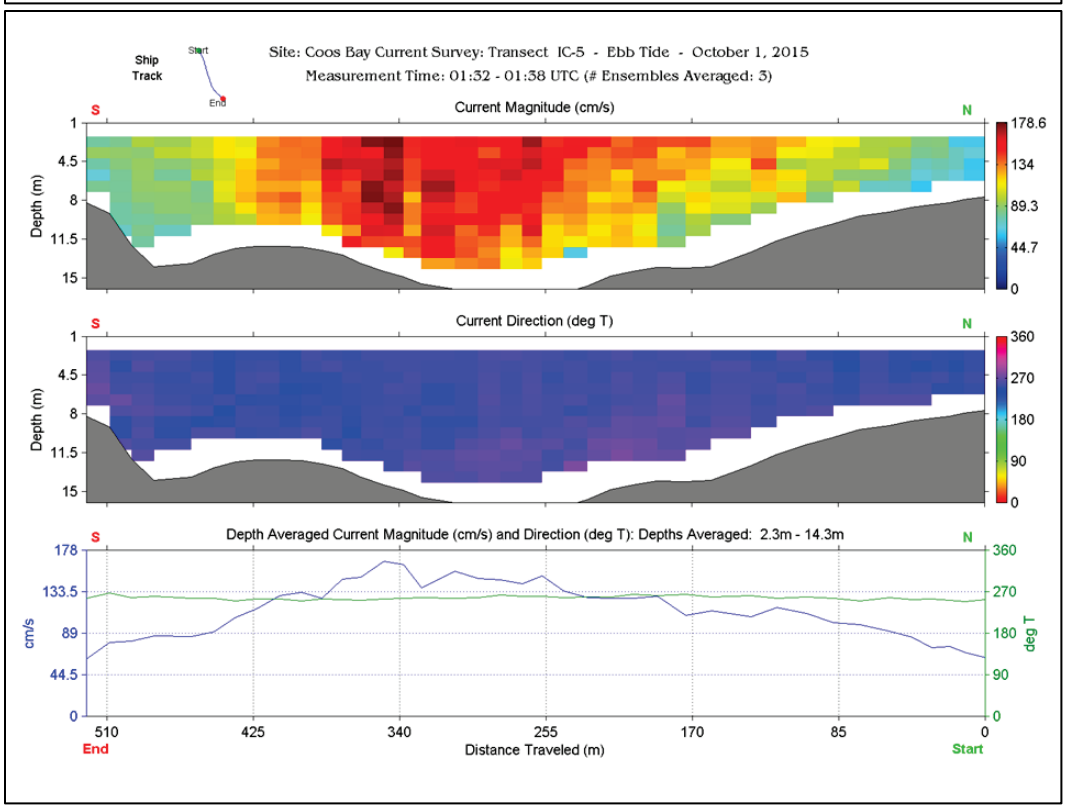

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Slack Tide - September 30, 2015
Measurement Time: 23:52 - 00:15 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
213.1
159.8
106.5
53.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
212
159
106
53
2975
2380
1785
1190
595
Distance Traveled (m)
End
Start

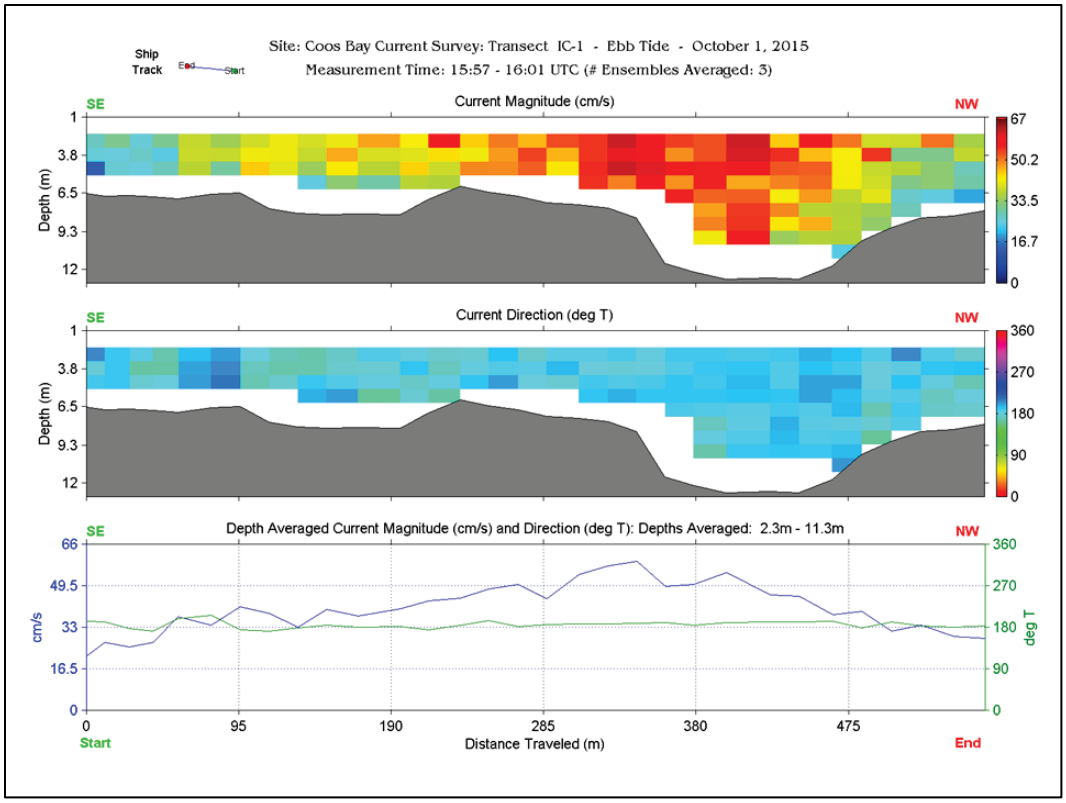

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Slack Tide - October 1, 2015
Measurement Time: 00:17 - 00:17 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
W
E
Depth (m)
1
3.8
6.5
9.3
12
94.2
70.6
47.1
23.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
deg T
94
70.5
47
23.5
0
5
10
15
20
Distance Traveled (m)
Start
End

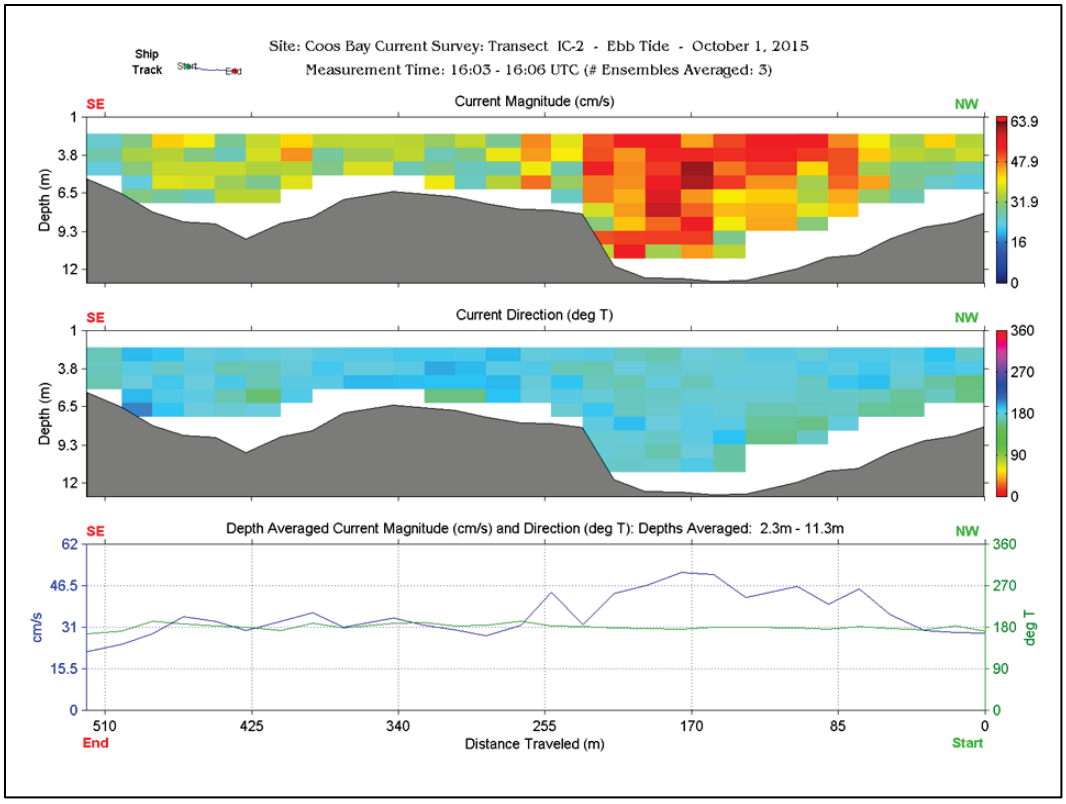

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Ebb Tide - October 1, 2015
Measurement Time: 00:18 - 00:37 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
165.9
124.4
83
41.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
164
123
82
41
deg T
0
540
1080
1620
2160
2700
Start
End
Distance Traveled (m)

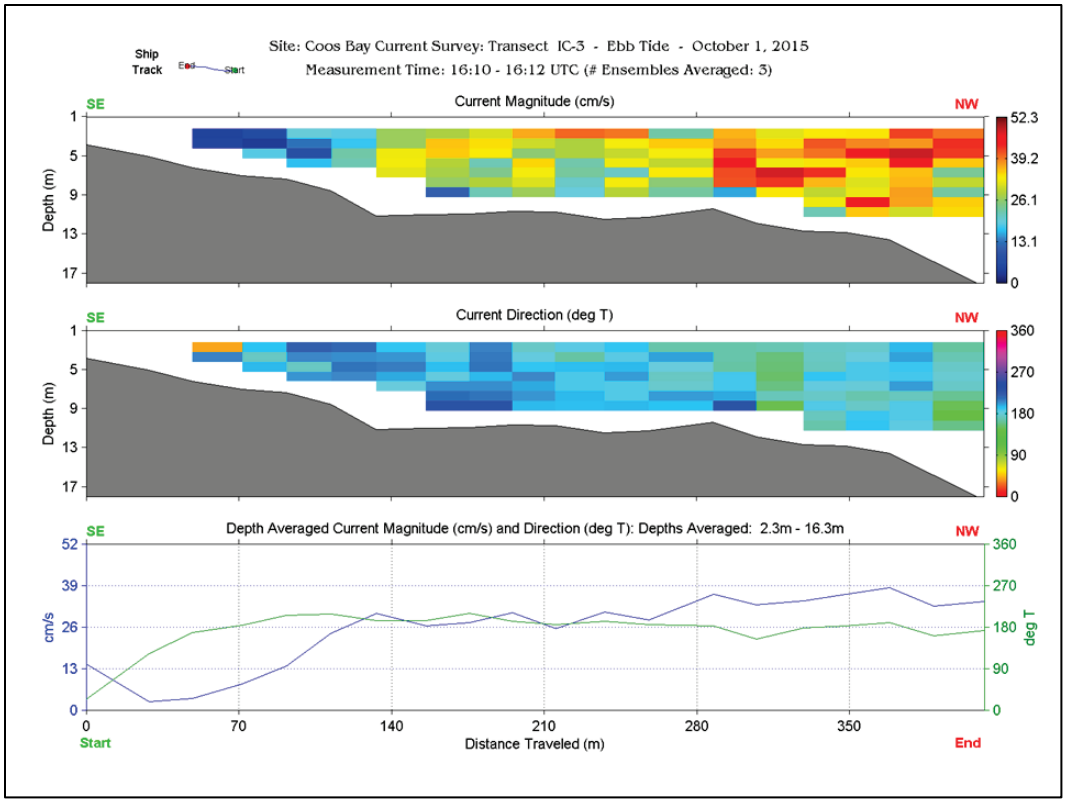

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Ebb Tide - October 1, 2015
Measurement Time: 00:39 - 00:57 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
145.9
109.4
73
36.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
144
108
72
36
deg T
3630
3025
2420
1815
1210
605
End
Start
Distance Traveled (m)

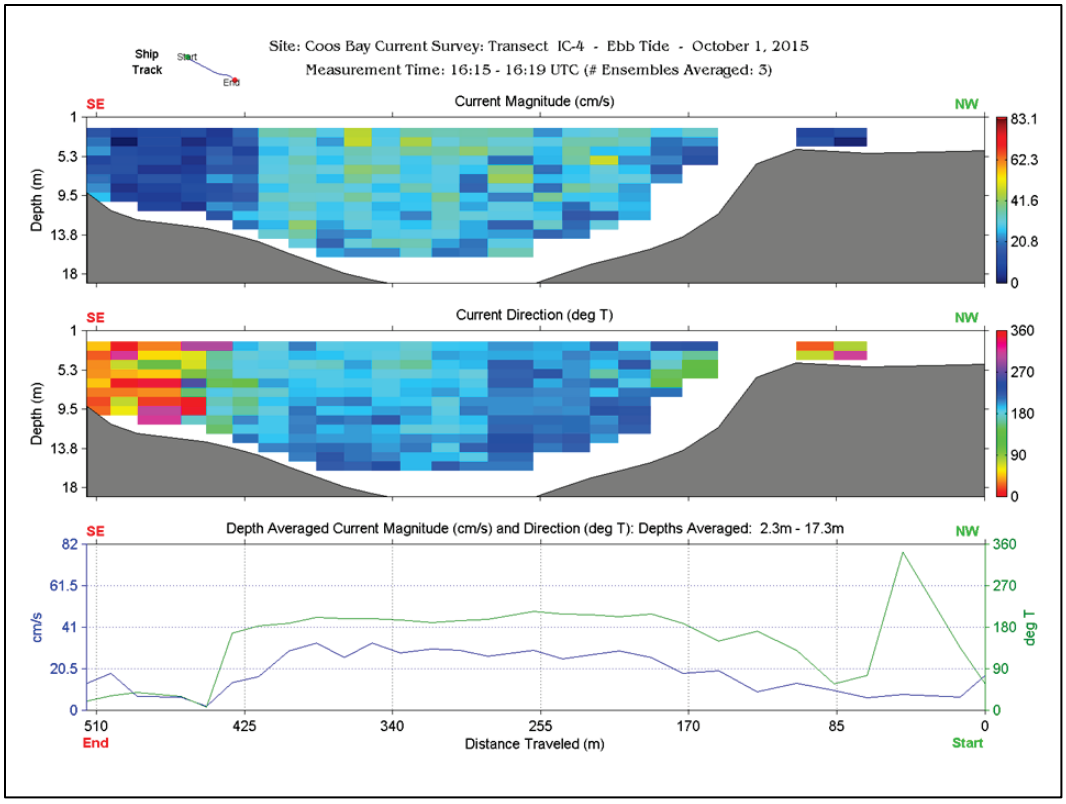

Site: Coos Bay Current Survey: Transect CL - Ebb Tide - October 1, 2015
Measurement Time: 01:03 - 01:25 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
242.8
182.1
121.4
60.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
242
181.5
121
60.5
deg T
2425
1940
1455
970
485
Distance Traveled (m)

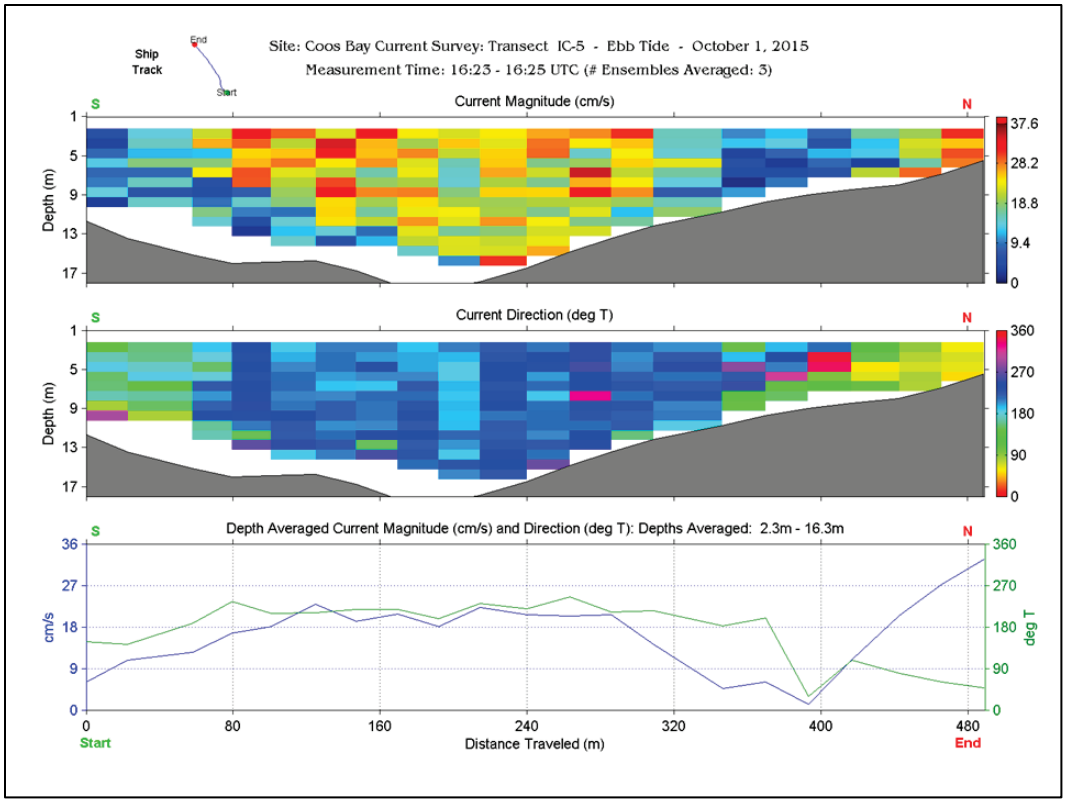

Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - October 1, 2015
Measurement Time: 01:32 - 01:38 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
S
N
Depth (m)
1
4.5
8
11.5
15
178.6
134
89.3
44.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
178
133.5
89
44.5
deg T
510
425
340
255
170
85
Distance Traveled (m)

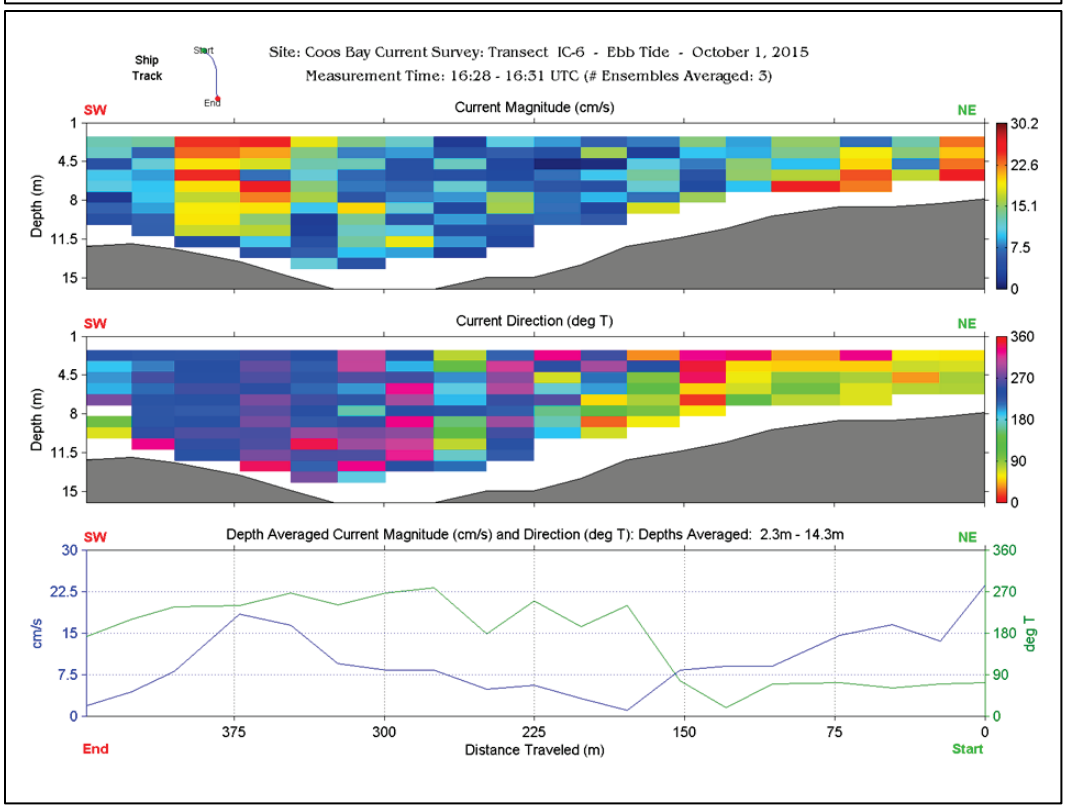

Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - October 1, 2015
Measurement Time: 15:57 - 16:01 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
67
50.2
33.5
16.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
66
49.5
33
16.5
deg T
0
95
190
285
380
475
Start
End
Distance Traveled (m)

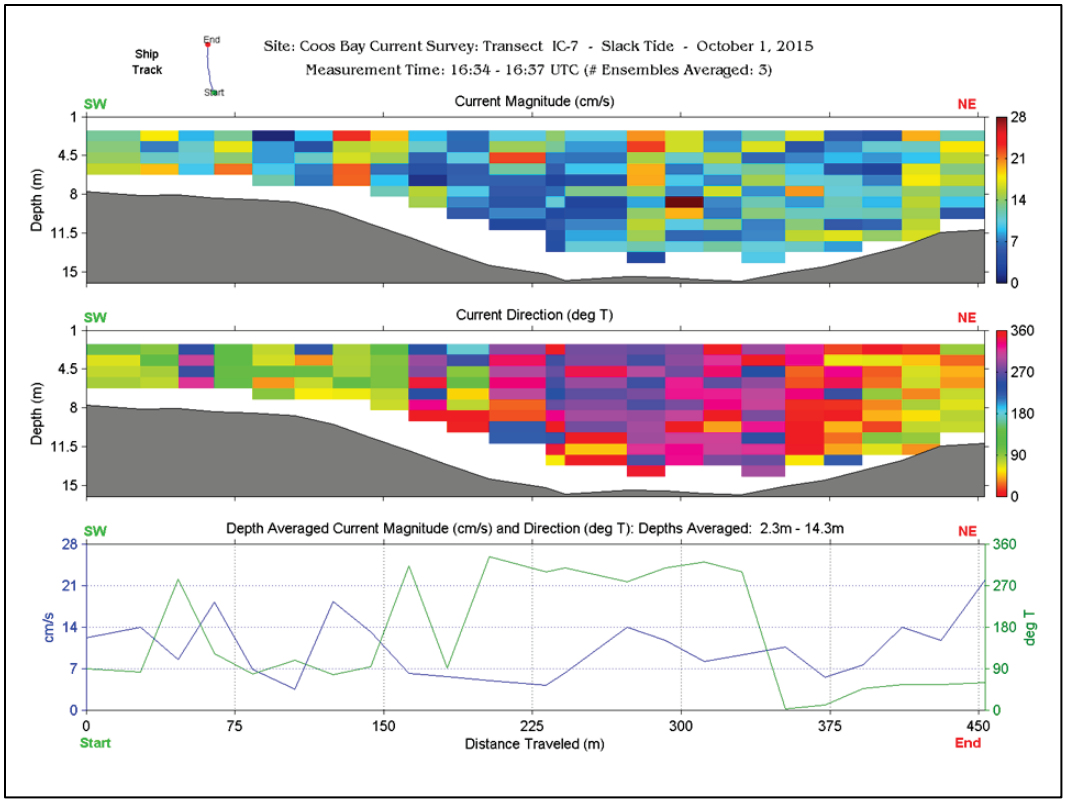

Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - October 1, 2015
Measurement Time: 16:03 - 16:06 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
3.8
6.5
9.3
12
63.9
47.9
31.9
16
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 11.3m
cm/s
62
46.5
31
15.5
deg T
510
425
340
255
170
85
0
End
Start
Distance Traveled (m)


Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - October 1, 2015
Measurement Time: 16:10 - 16:12 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5
9
13
17
52.3
39.2
26.1
13.1
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
52
39
26
13
0
0
70
140
210
280
350
Start
End
Distance Traveled (m)

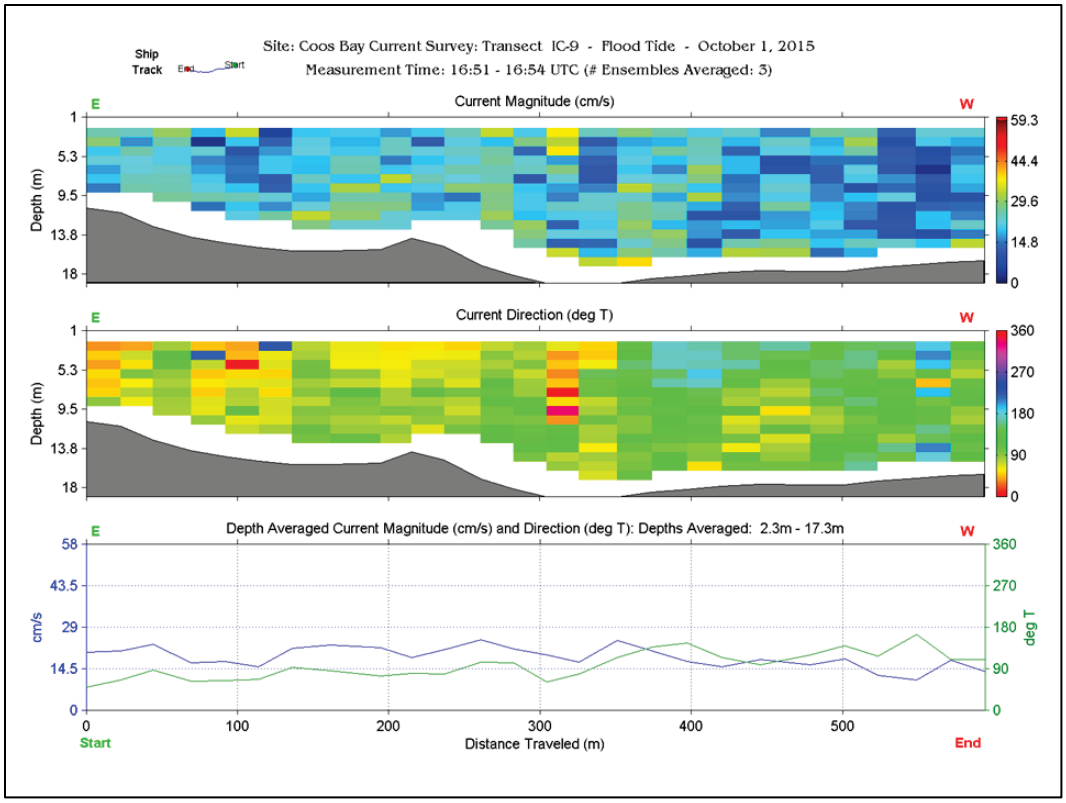

Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - October 1, 2015
Measurement Time: 16:15 - 16:19 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.3
9.5
13.8
18
83.1
62.3
41.6
20.8
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
82
61.5
41
20.5
0
510
425
340
255
170
85
0
End
Start
Distance Traveled (m)

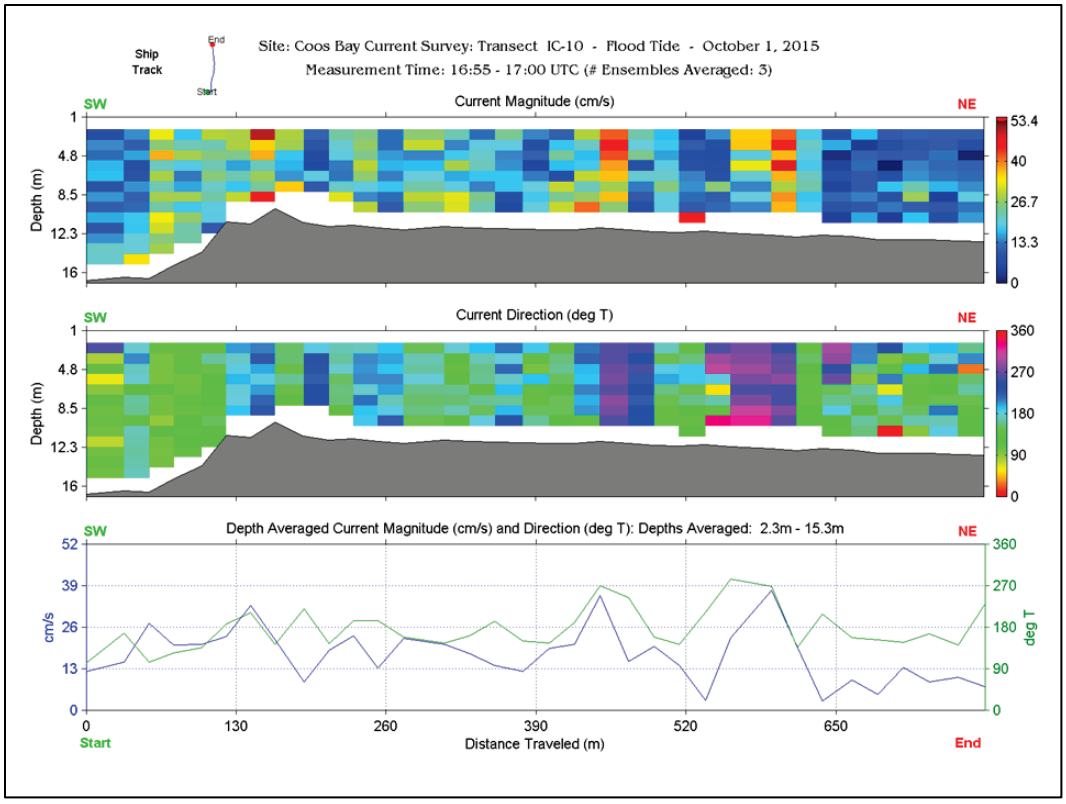

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - October 1, 2015
Measurement Time: 16:23 - 16:25 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
37.6
28.2
18.8
9.4
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
36
27
18
9
0
0
80
160
240
320
400
480
Start
End
Distance Traveled (m)

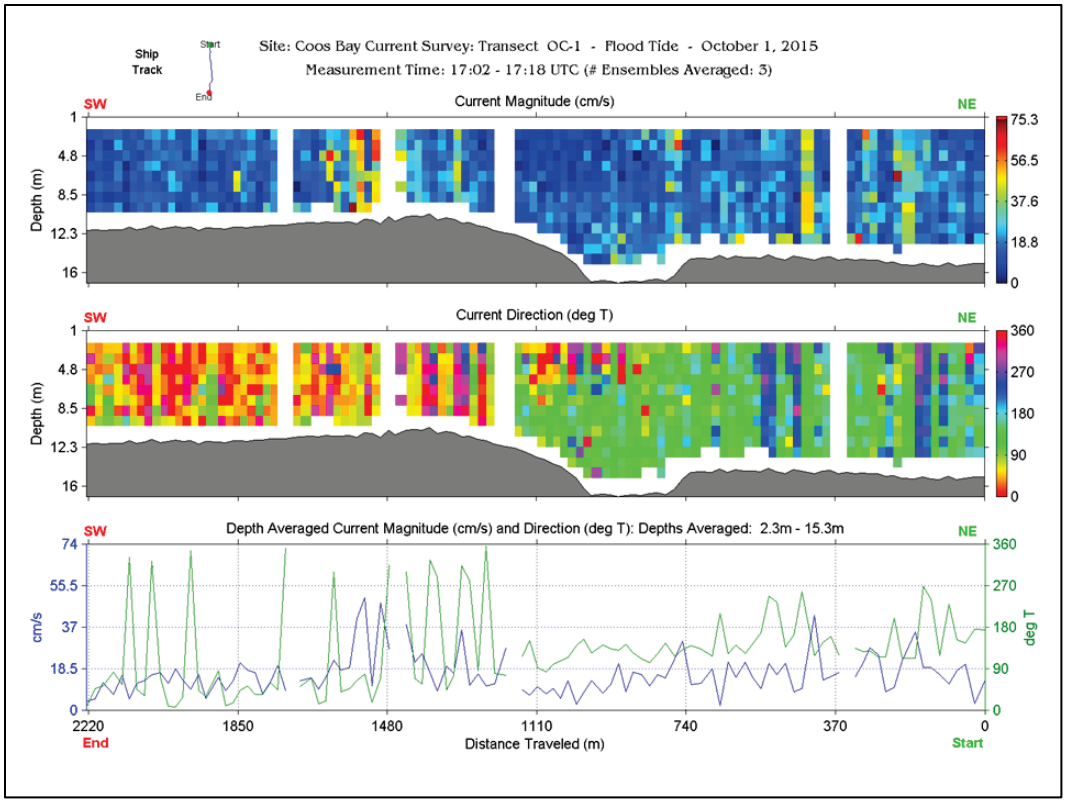

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - October 1, 2015
Measurement Time: 16:28 - 16:31 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.5
8
11.5
15
30.2
22.6
15.1
7.5
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
deg T
30
22.5
15
7.5
0
375
300
225
150
75
0
End
Start
Distance Traveled (m)

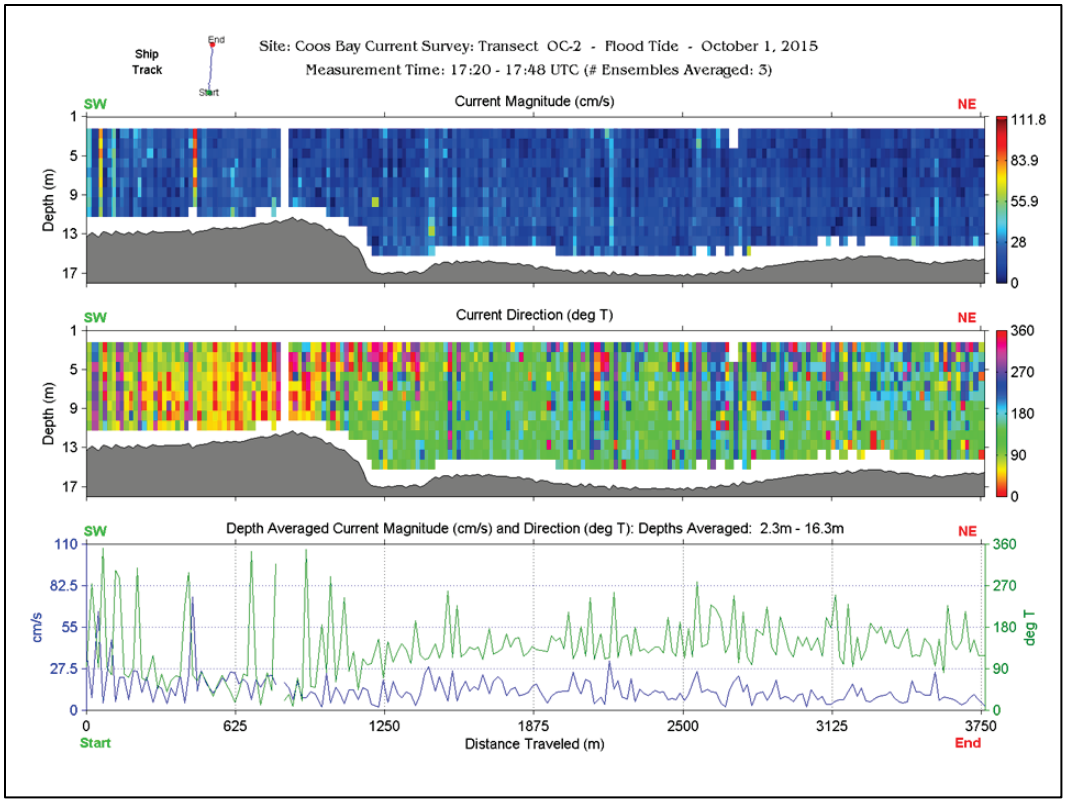

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Slack Tide - October 1, 2015
Measurement Time: 16:34 - 16:37 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.5
8
11.5
15
28
21
14
7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
cm/s
deg T
0
75
150
225
300
375
450
Start
End
Distance Traveled (m)

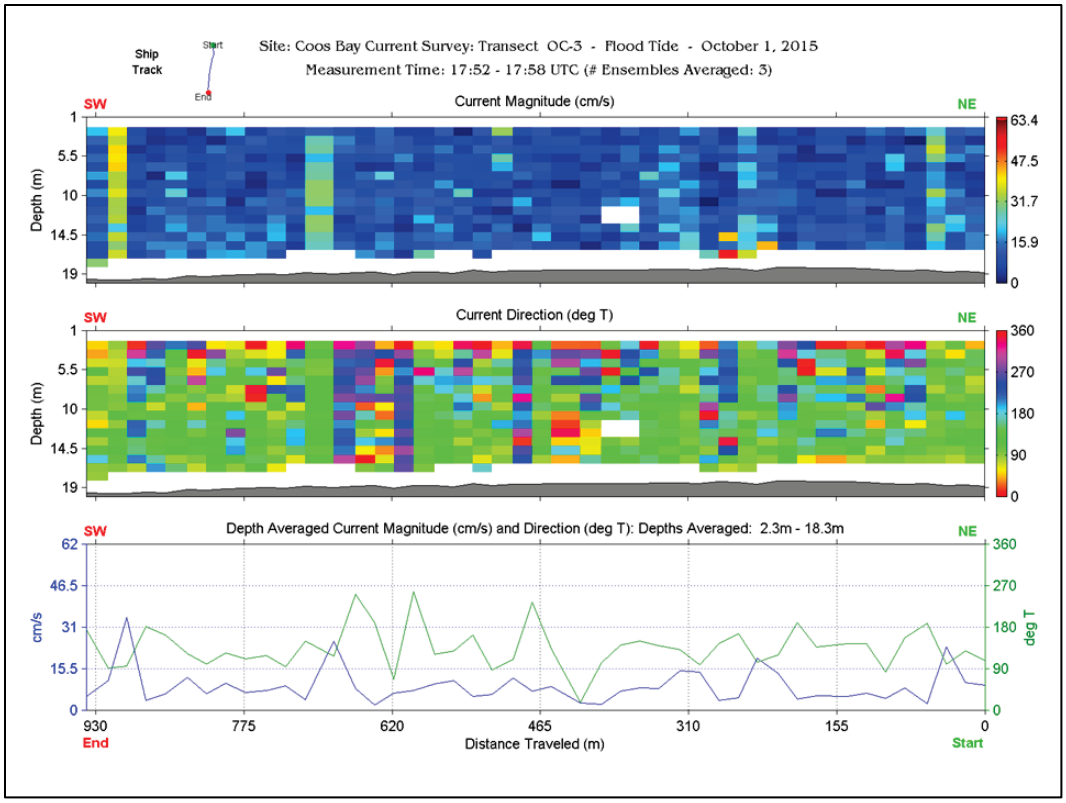

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-9 - Slack Tide - October 1, 2015
Measurement Time: 16:42 - 16:44 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
4.5
8
11.5
15
40.4
30.3
20.2
10.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 14.3m
40
30
20
10
cm/s
deg T
0
55
110
165
220
275
Start
End
Distance Traveled (m)

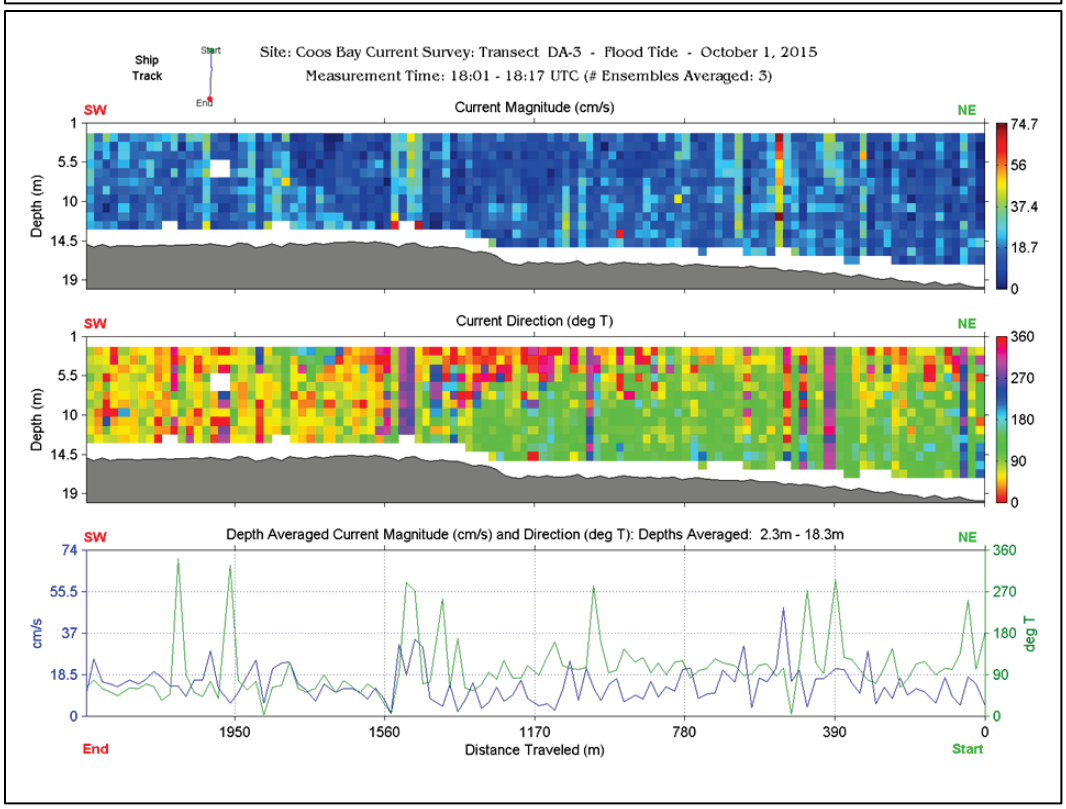

Site: Coos Bay Current Survey: Transect IC-9 - Flood Tide - October 1, 2015
Measurement Time: 16:51 - 16:54 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.3
9.5
13.8
18
59.3
44.4
29.6
14.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
58
43.5
29
14.5
0
0
100
200
300
400
500
Distance Traveled (m)
Start
End

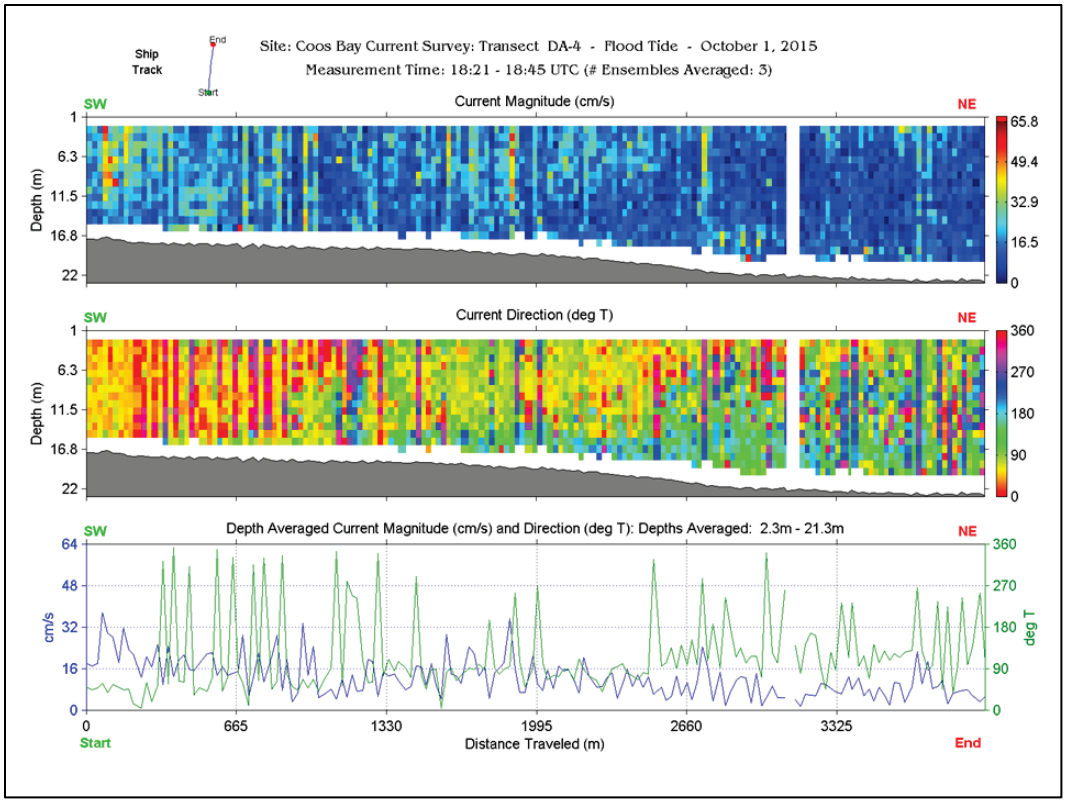

Site: Coos Bay Current Survey: Transect IC-10 - Flood Tide - October 1, 2015
Measurement Time: 16:55 - 17:00 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
53.4
40
26.7
13.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
52
39
26
13
0
0
130
260
390
520
650
Distance Traveled (m)
Start
End

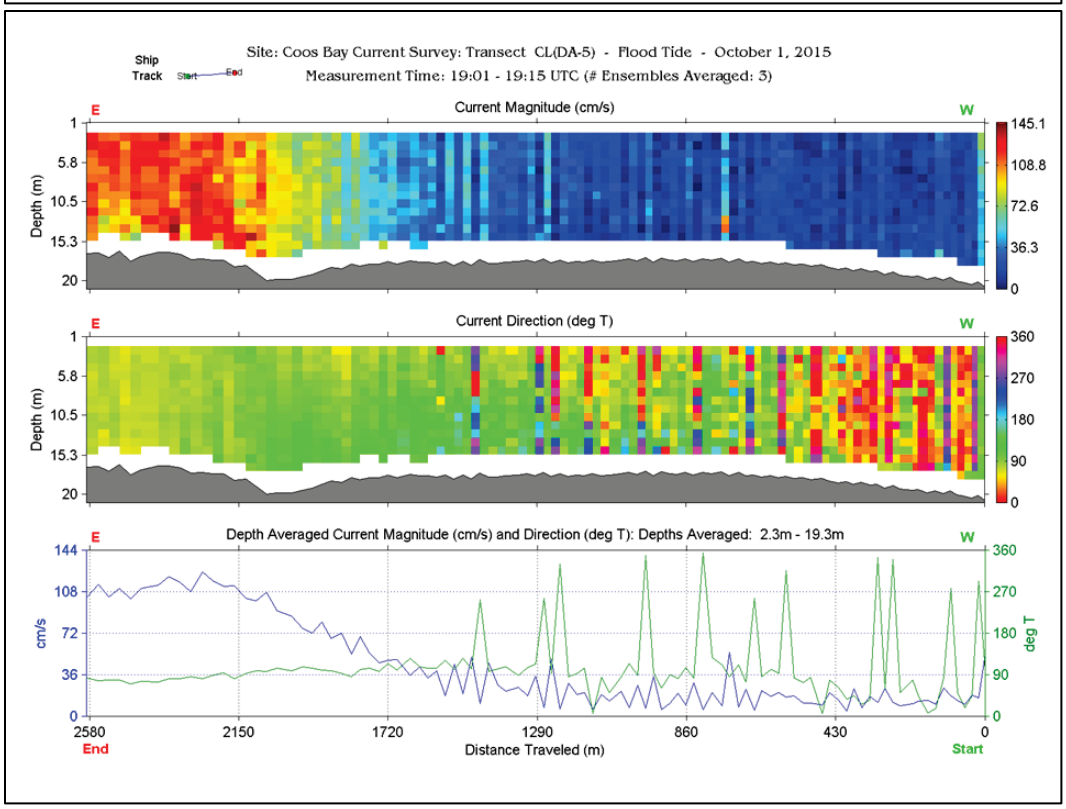

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-1 - Flood Tide - October 1, 2015
Measurement Time: 17:02 - 17:18 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4.8
8.5
12.3
16
75.3
56.5
37.6
18.8
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
74
55.5
37
18.5
deg T
2220
1850
1480
1110
740
370
0
End
Start
Distance Traveled (m)

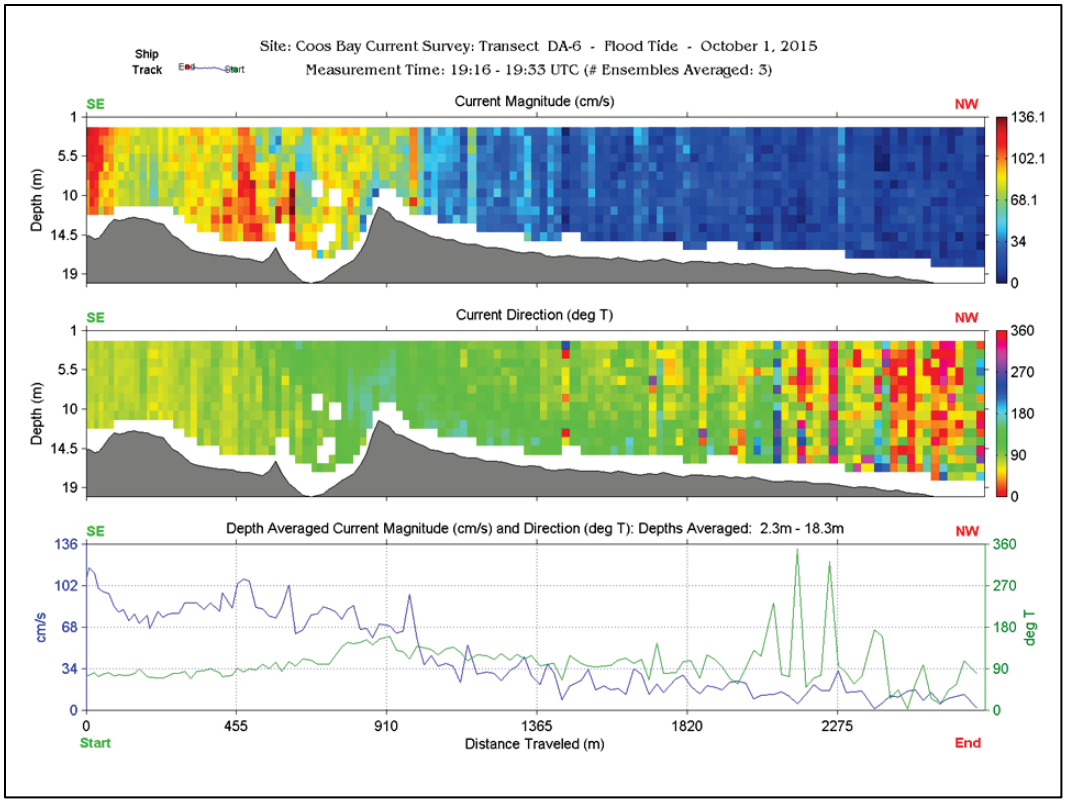

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect OC-2 - Flood Tide - October 1, 2015
Measurement Time: 17:20 - 17:48 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
111.8
83.9
55.9
28
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
110
82.5
55
27.5
deg T
0
625
1250
1875
2500
3125
3750
Start
End
Distance Traveled (m)

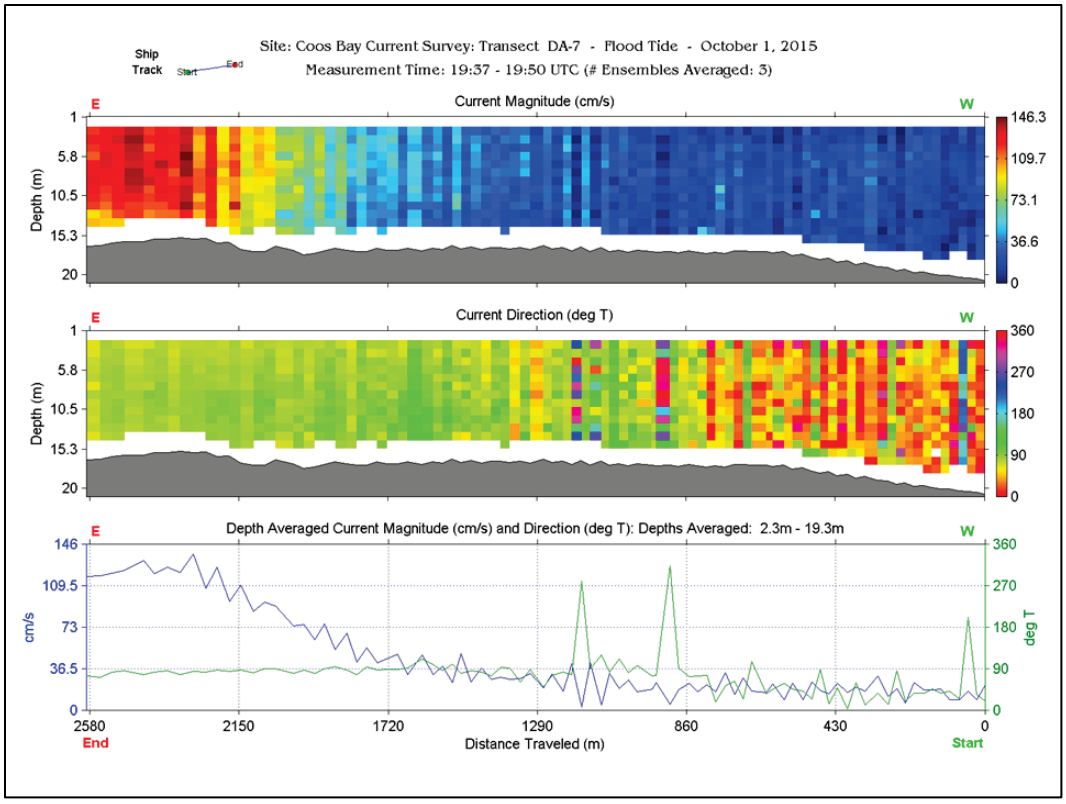

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect OC-3 - Flood Tide - October 1, 2015
Measurement Time: 17:52 - 17:58 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.5
10
14.5
19
63.4
47.5
31.7
15.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
62
46.5
31
15.5
deg T
930
775
620
465
310
155
End
Start
Distance Traveled (m)

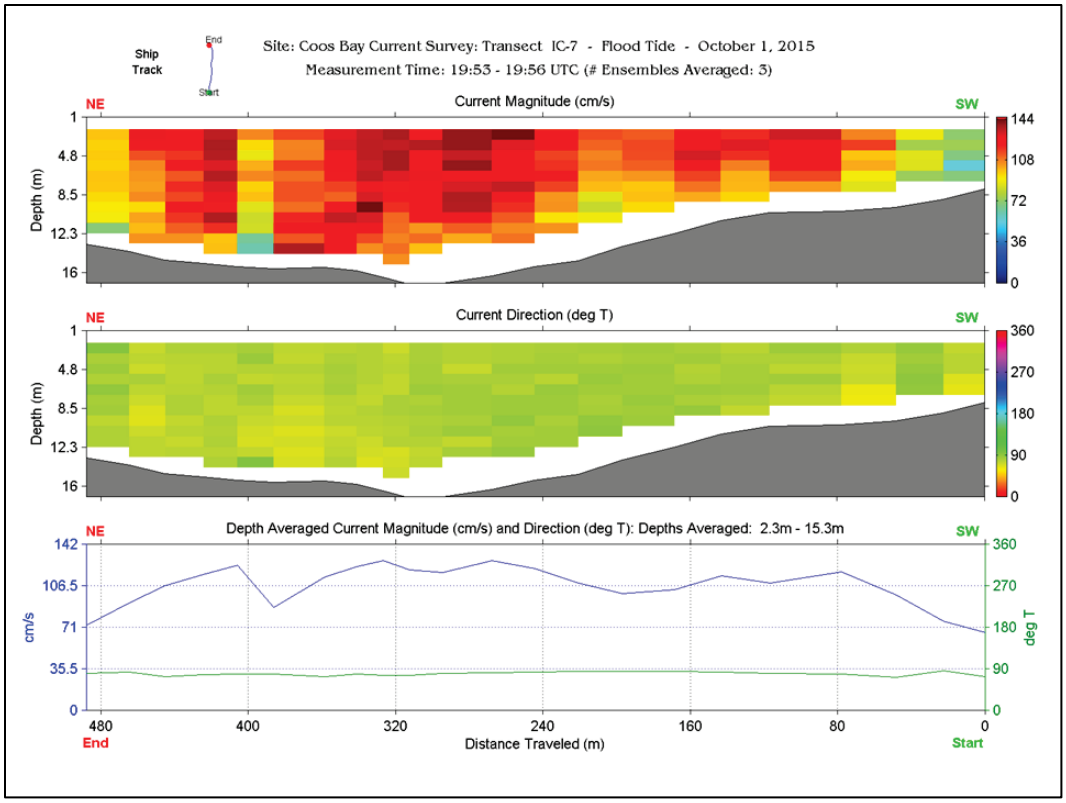

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - October 1, 2015
Measurement Time: 18:01 - 18:17 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.5
10
14.5
19
74.7
56
37.4
18.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
74
55.5
37
18.5
deg T
1950
1560
1170
780
390
End
Start
Distance Traveled (m)

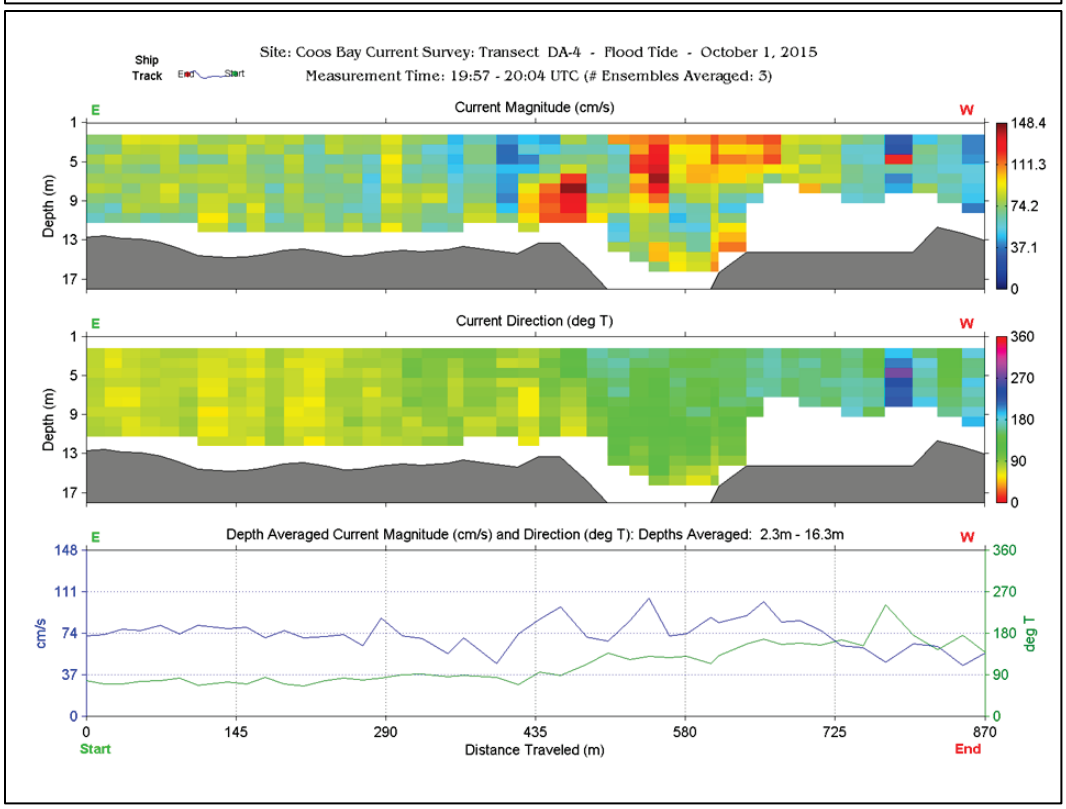

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - October 1, 2015
Measurement Time: 18:21 - 18:45 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
6.3
11.5
16.8
22
65.8
49.4
32.9
16.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 21.3m
cm/s
deg T
64
48
32
16
0
0
665
1330
1995
2660
3325
Start
End
Distance Traveled (m)

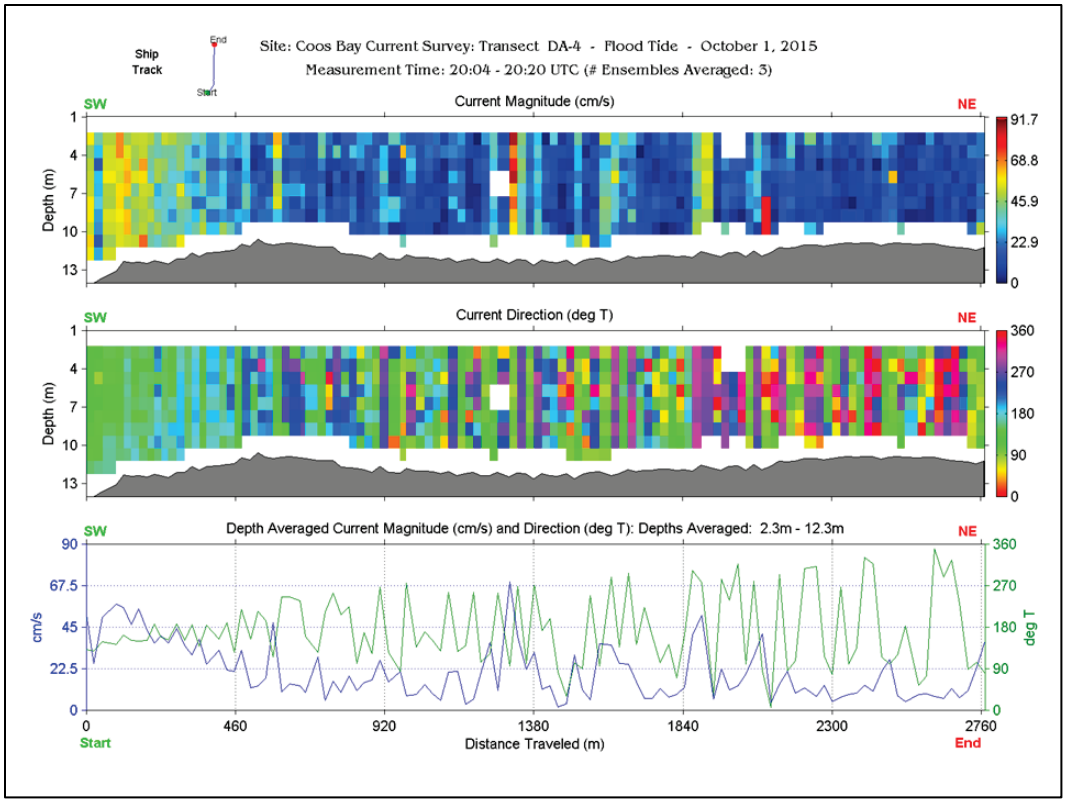

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect CL(DA-5) - Flood Tide - October 1, 2015
Measurement Time: 19:01 - 19:15 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.8
10.5
15.3
20
145.1
108.8
72.6
36.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
144
108
72
36
0
2580
2150
1720
1290
860
430
End
Start
Distance Traveled (m)

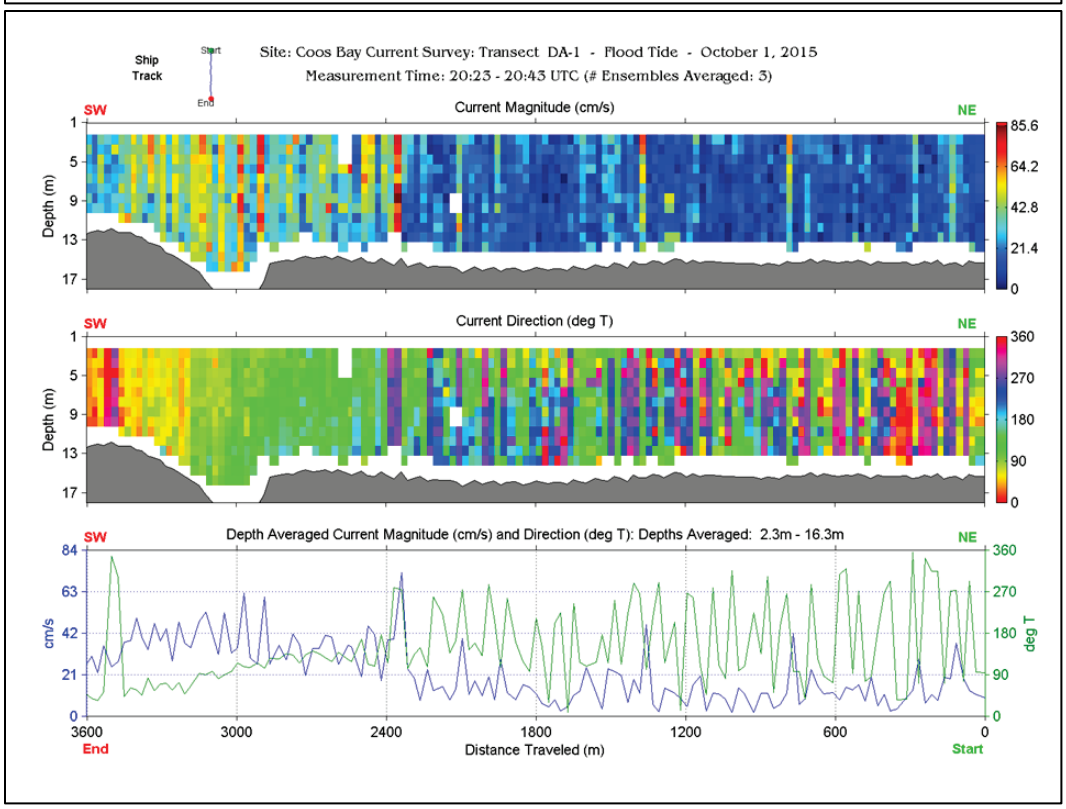

Site: Coos Bay Current Survey: Transect DA-6 - Flood Tide - October 1, 2015
Measurement Time: 19:16 - 19:33 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
136.1
102.1
68.1
34
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
136
102
68
34
0
0
455
910
1365
1820
2275
Start
End
Distance Traveled (m)

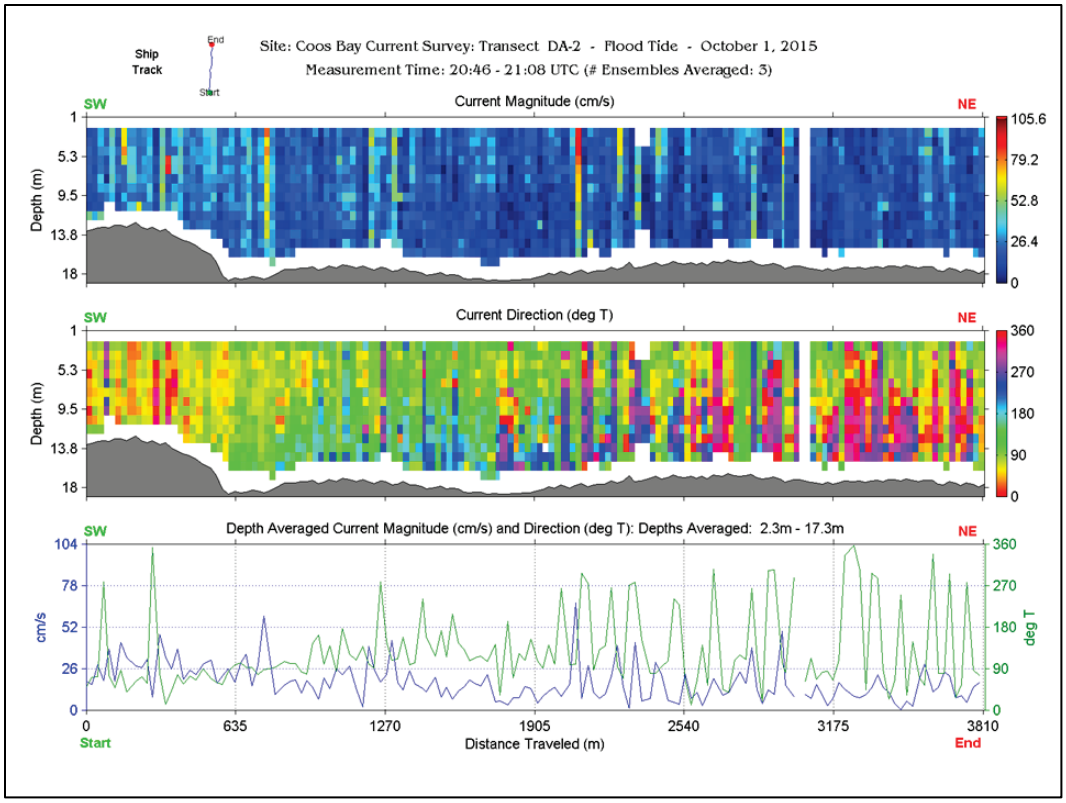

Site: Coos Bay Current Survey: Transect DA-7 - Flood Tide - October 1, 2015
Measurement Time: 19:37 - 19:50 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.8
10.5
15.3
20
146.3
109.7
73.1
36.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
146
109.5
73
36.5
0
2580
2150
1720
1290
860
430
0
End
Start
Distance Traveled (m)

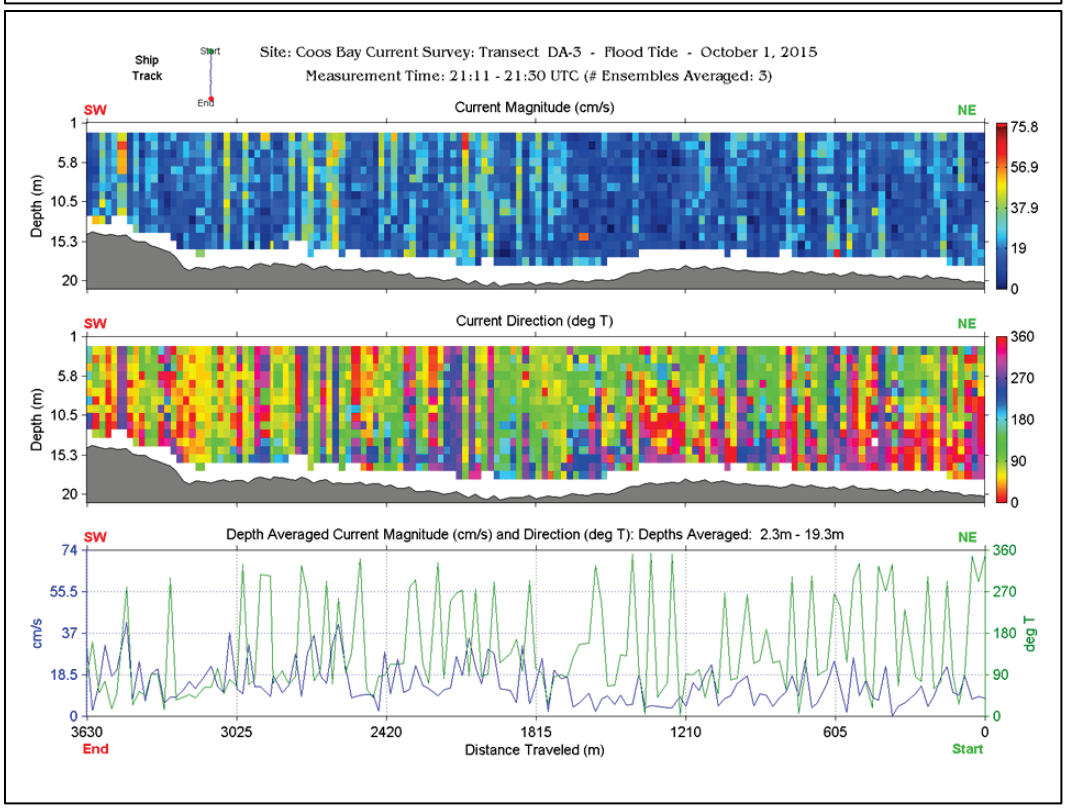

Site: Coos Bay Current Survey: Transect IC-7 - Flood Tide - October 1, 2015
Measurement Time: 19:53 - 19:56 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
NE
SW
Depth (m)
1
4.8
8.5
12.3
16
144
108
72
36
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 15.3m
cm/s
deg T
142
106.5
71
35.5
480
400
320
240
160
80
Distance Traveled (m)

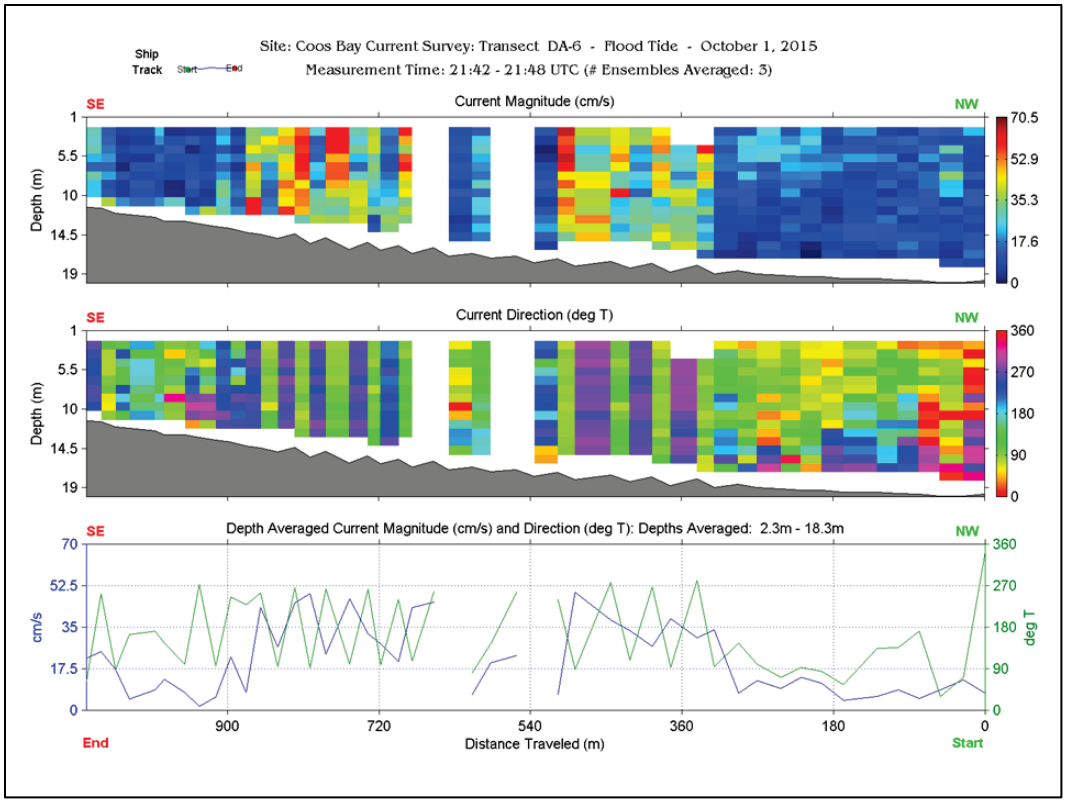

Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - October 1, 2015
Measurement Time: 19:57 - 20:04 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
E
W
Depth (m)
1
5
9
13
17
148.4
111.3
74.2
37.1
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
148
111
74
37
0
145
290
435
580
725
870
Distance Traveled (m)

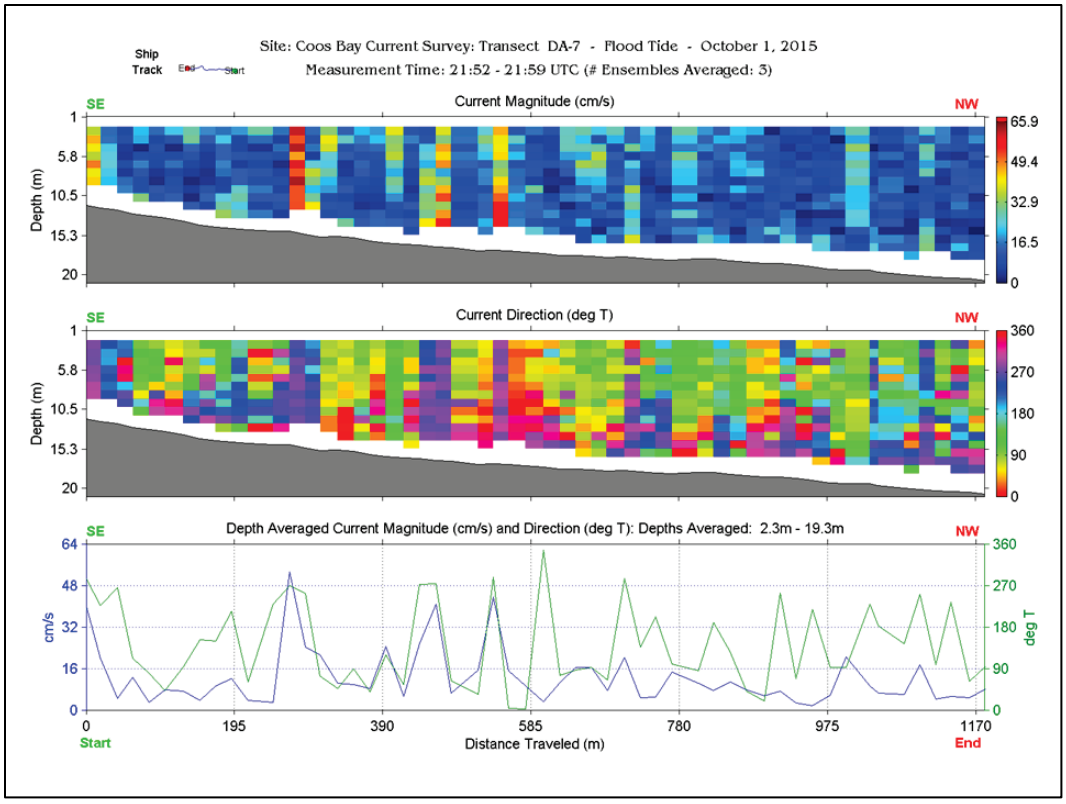

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-4 - Flood Tide - October 1, 2015
Measurement Time: 20:04 - 20:20 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
4
7
10
13
91.7
68.8
45.9
22.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
90
67.5
45
22.5
deg T
0
460
920
1380
1840
2300
2760
Start
End
Distance Traveled (m)

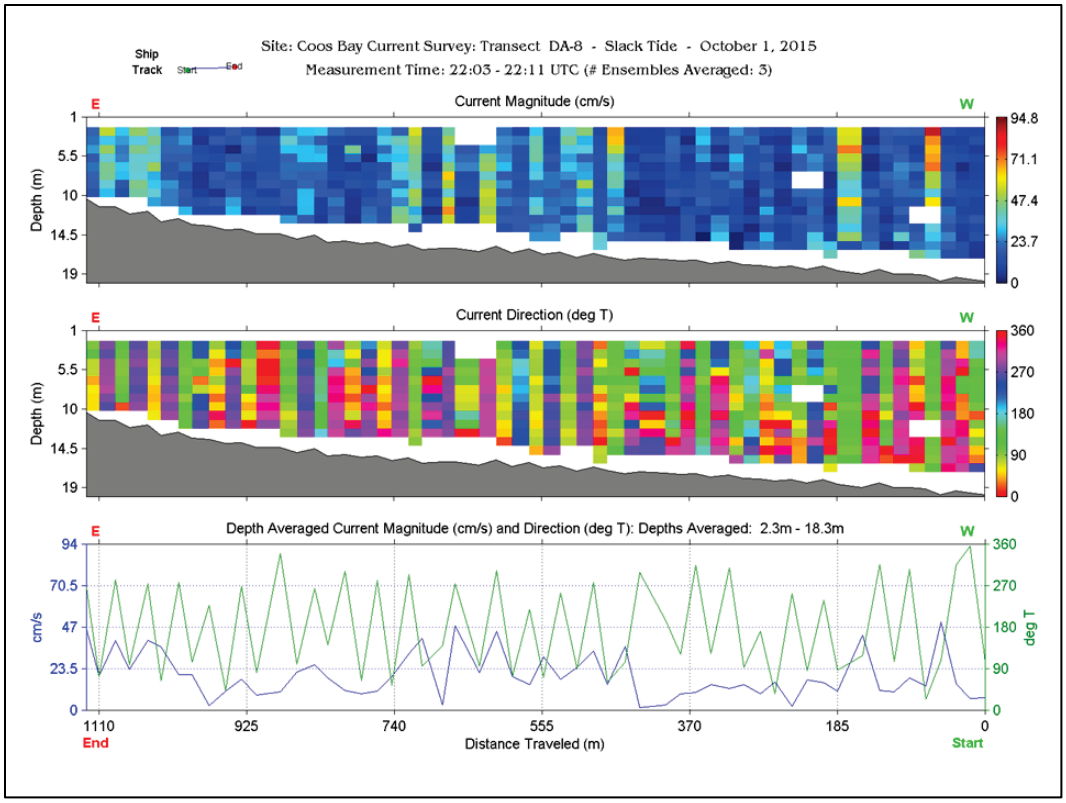

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-1 - Flood Tide - October 1, 2015
Measurement Time: 20:23 - 20:43 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
85.6
64.2
42.8
21.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
84
63
42
21
deg T
3600
3000
2400
1800
1200
600
End
Start
Distance Traveled (m)

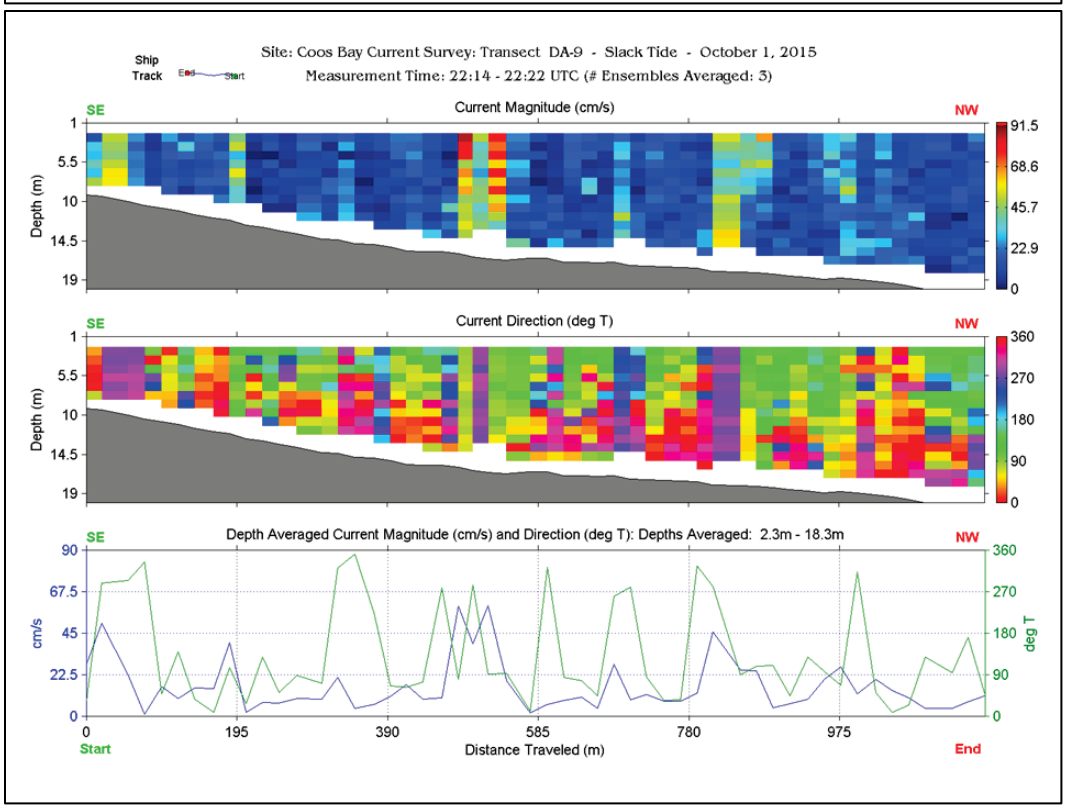

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect DA-2 - Flood Tide - October 1, 2015
Measurement Time: 20:46 - 21:08 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
105.6
79.2
52.8
26.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
104
78
52
26
0
0
635
1270
1905
2540
3175
3810
Start
End
Distance Traveled (m)

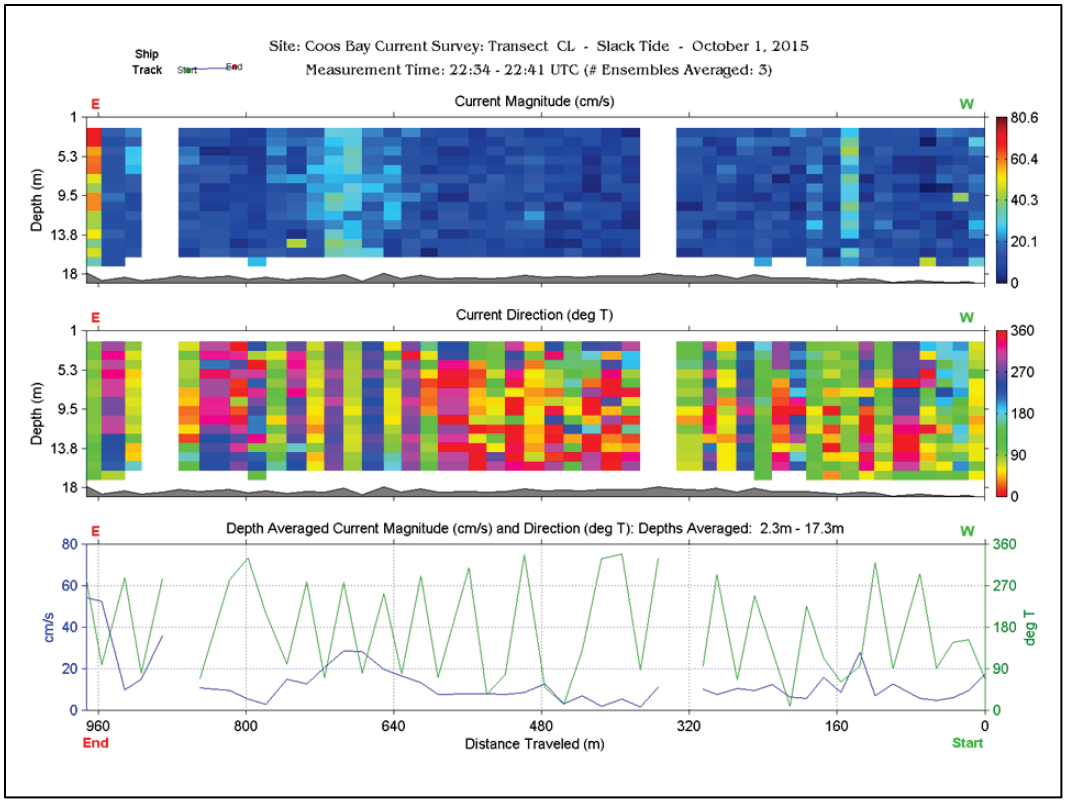

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect DA-3 - Flood Tide - October 1, 2015
Measurement Time: 21:11 - 21:30 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.8
10.5
15.3
20
75.8
56.9
37.9
19
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
74
55.5
37
18.5
0
3630
3025
2420
1815
1210
605
0
End
Start
Distance Traveled (m)


Site: Coos Bay Current Survey: Transect DA-6 - Flood Tide - October 1, 2015
Measurement Time: 21:42 - 21:48 UTC (# Ensembles Averaged: 3)
Ship Track Start End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
70.5
52.9
35.3
17.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
70
52.5
35
17.5
900
720
540
360
180
End
Start
Distance Traveled (m)

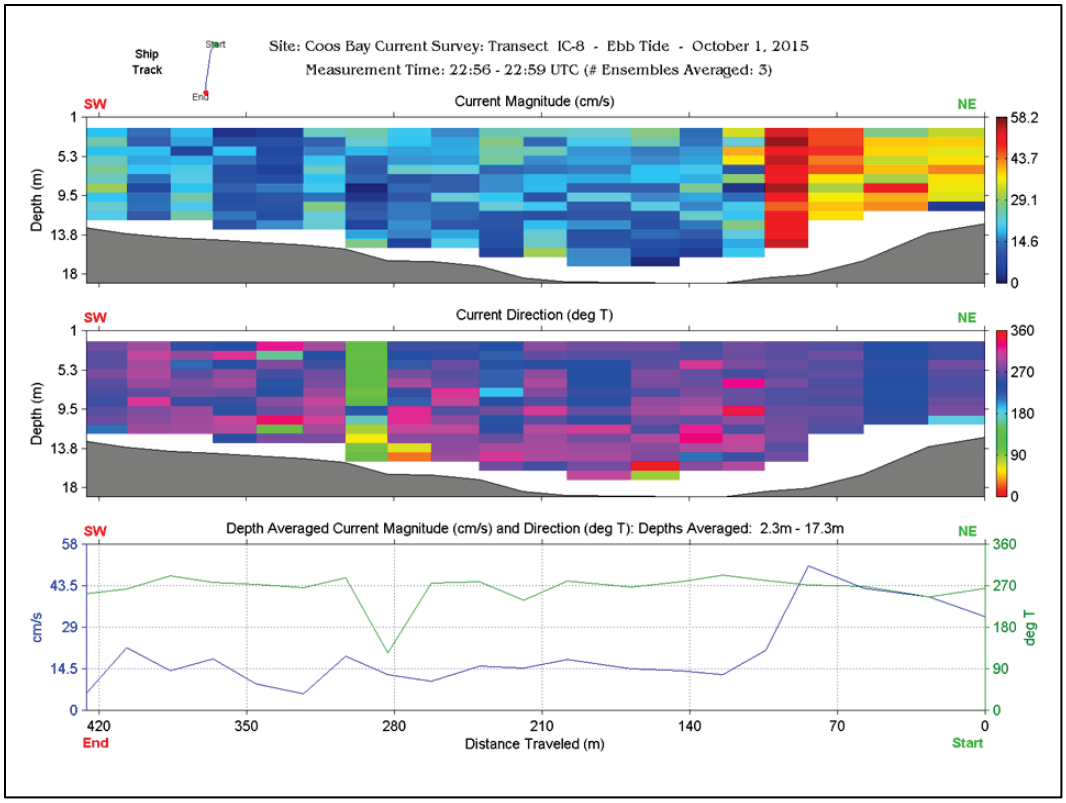

Site: Coos Bay Current Survey: Transect DA-7 - Flood Tide - October 1, 2015
Measurement Time: 21:52 - 21:59 UTC (# Ensembles Averaged: 3)
Ship Track End Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
65.9
49.4
32.9
16.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
64
48
32
16
0
195
390
585
780
975
1170
Start
End
Distance Traveled (m)

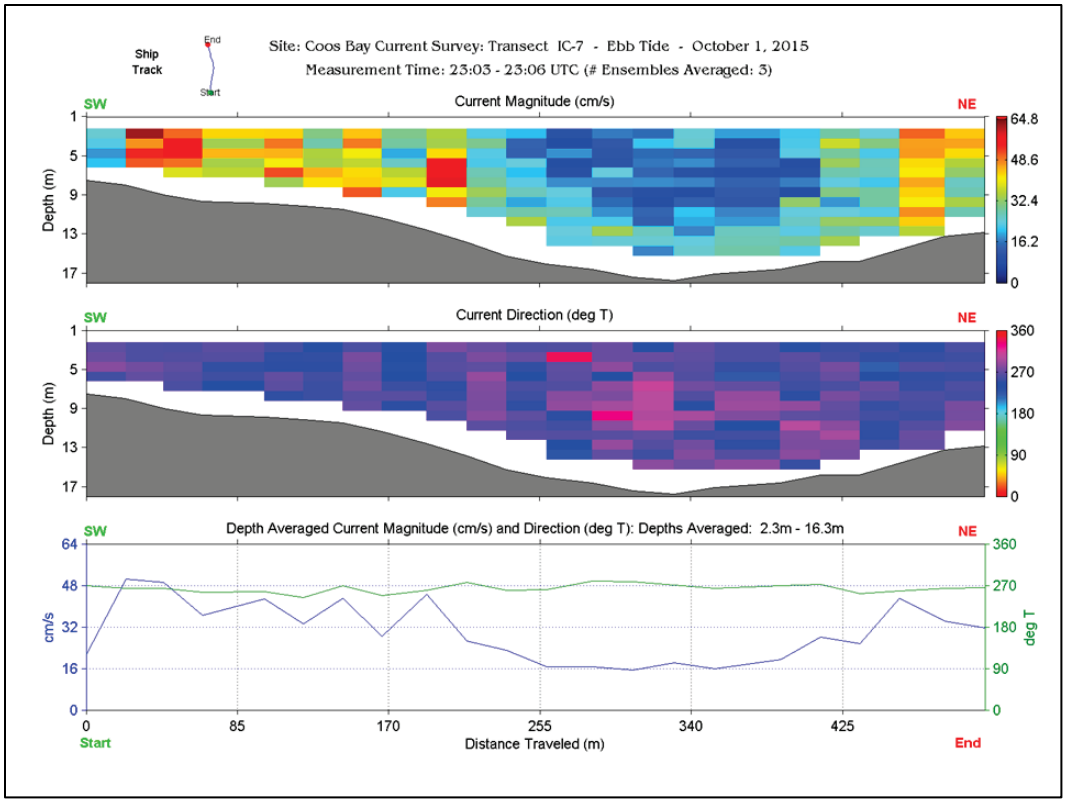

Site: Coos Bay Current Survey: Transect DA-8 - Slack Tide - October 1, 2015
Measurement Time: 22:03 - 22:11 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
E
W
Depth (m)
1
5.5
10
14.5
19
94.8
71.1
47.4
23.7
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
94
70.5
47
23.5
1110
925
740
555
370
185
0
End
Start
Distance Traveled (m)

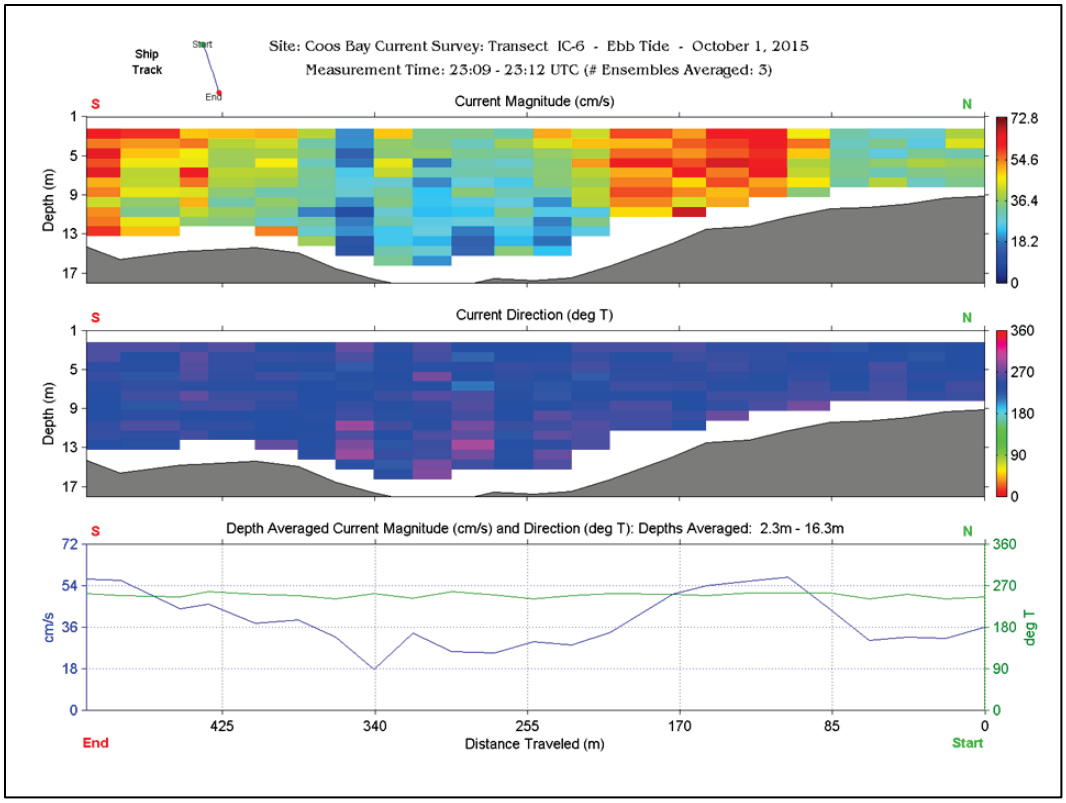

Site: Coos Bay Current Survey: Transect DA-9 - Slack Tide - October 1, 2015
Measurement Time: 22:14 - 22:22 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
91.5
68.6
45.7
22.9
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
90
67.5
45
22.5
0
195
390
585
780
975
Start
End
Distance Traveled (m)

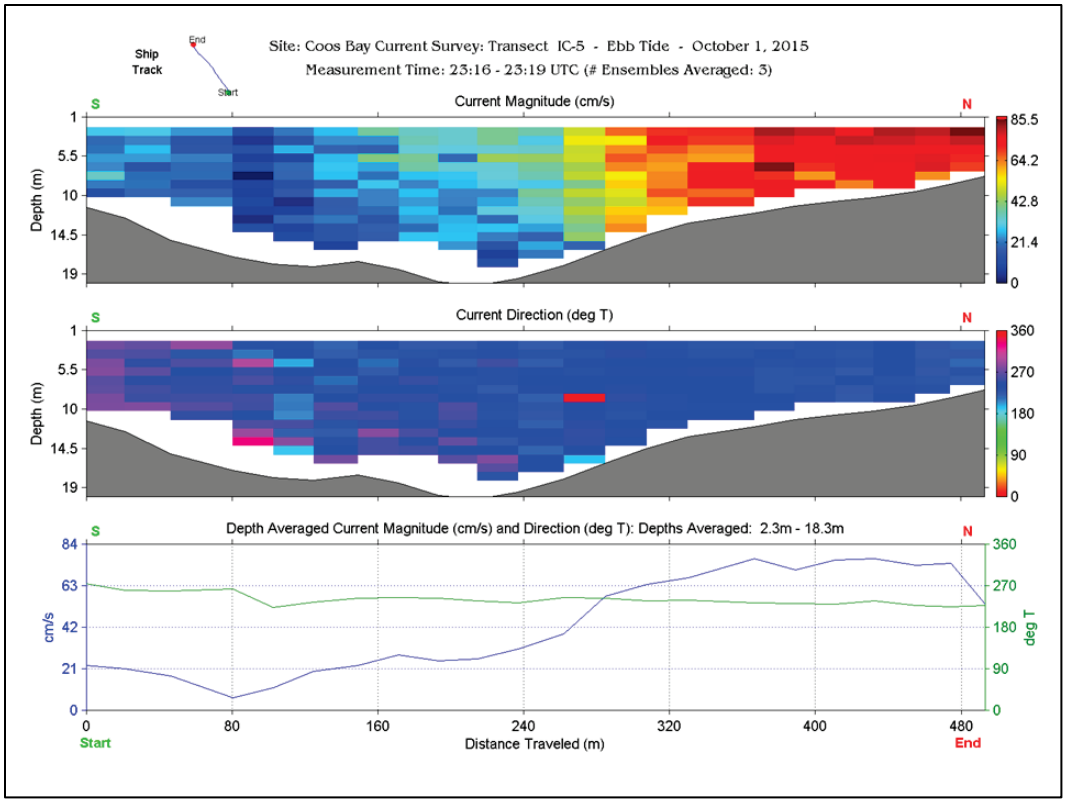

Site: Coos Bay Current Survey: Transect CL - Slack Tide - October 1, 2015
Measurement Time: 22:34 - 22:41 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
Depth (m)
cm/s
deg T
E
W
Distance Traveled (m)

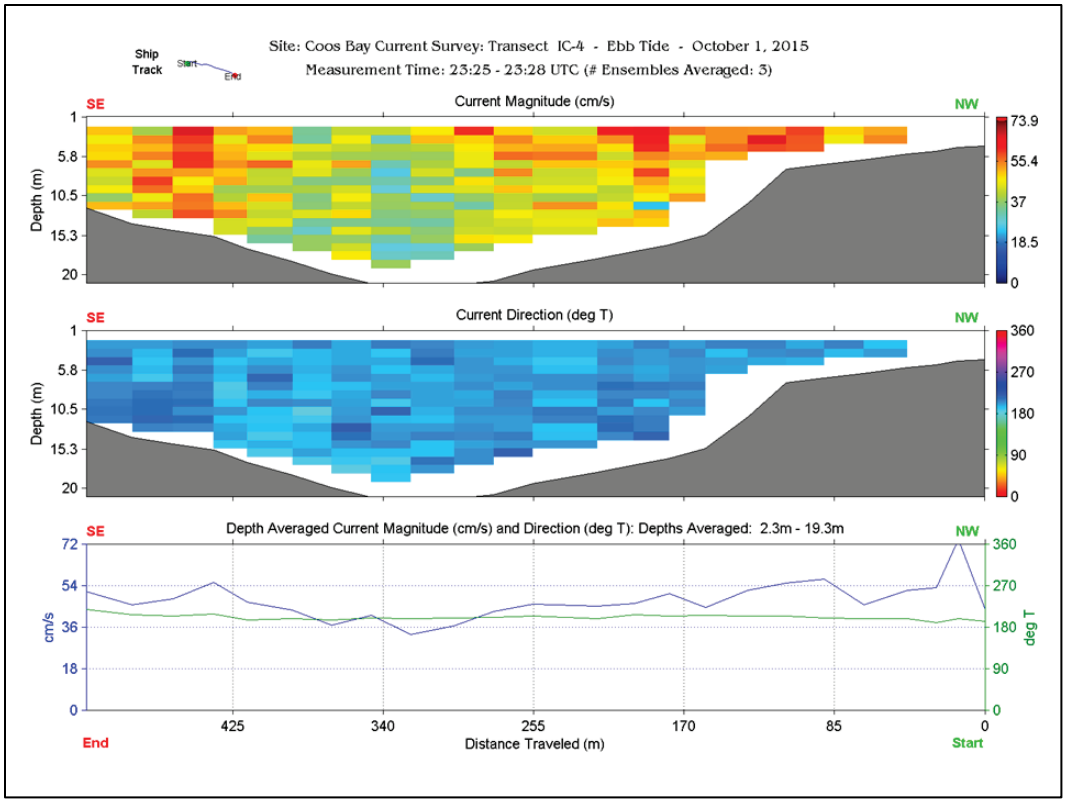

Site: Coos Bay Current Survey: Transect CL - Ebb Tide - October 1, 2015
Measurement Time: 22:44 - 22:51 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
Current Direction (deg T)
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
Depth (m)
cm/s
deg T
E
W
Distance Traveled (m)

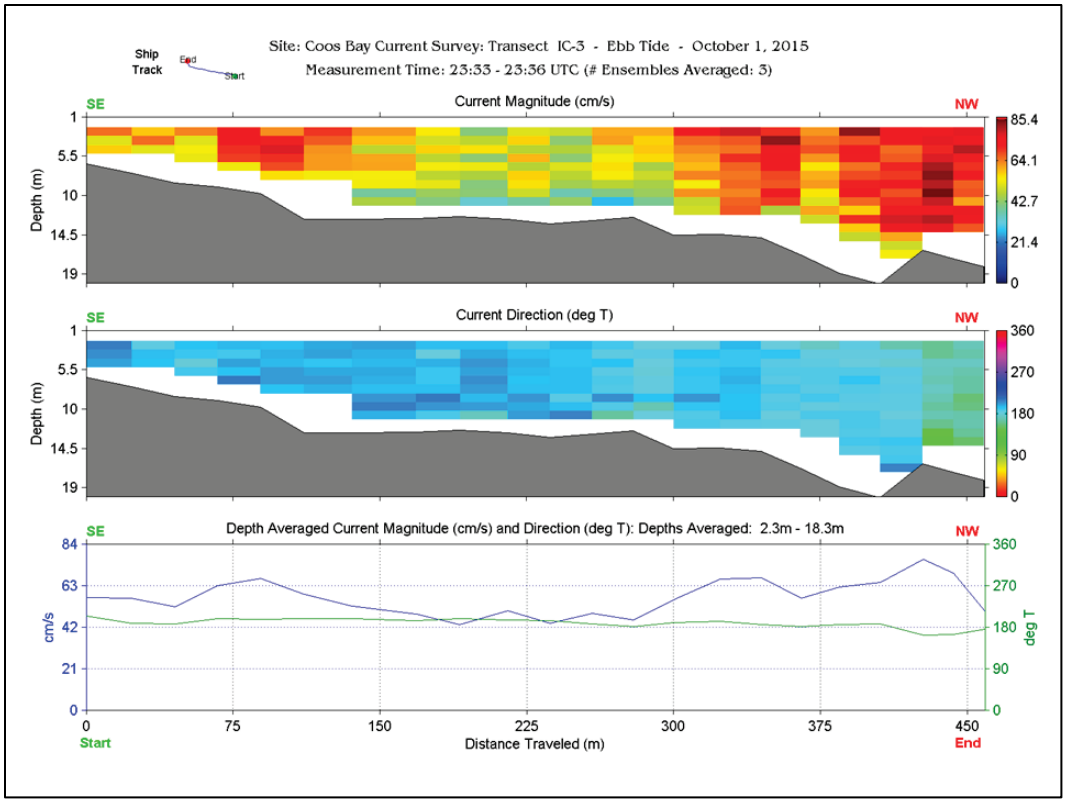

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-8 - Ebb Tide - October 1, 2015
Measurement Time: 22:56 - 22:59 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5.3
9.5
13.8
18
58.2
43.7
29.1
14.6
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 17.3m
cm/s
deg T
58
43.5
29
14.5
420
350
280
210
140
70
End
Start
Distance Traveled (m)

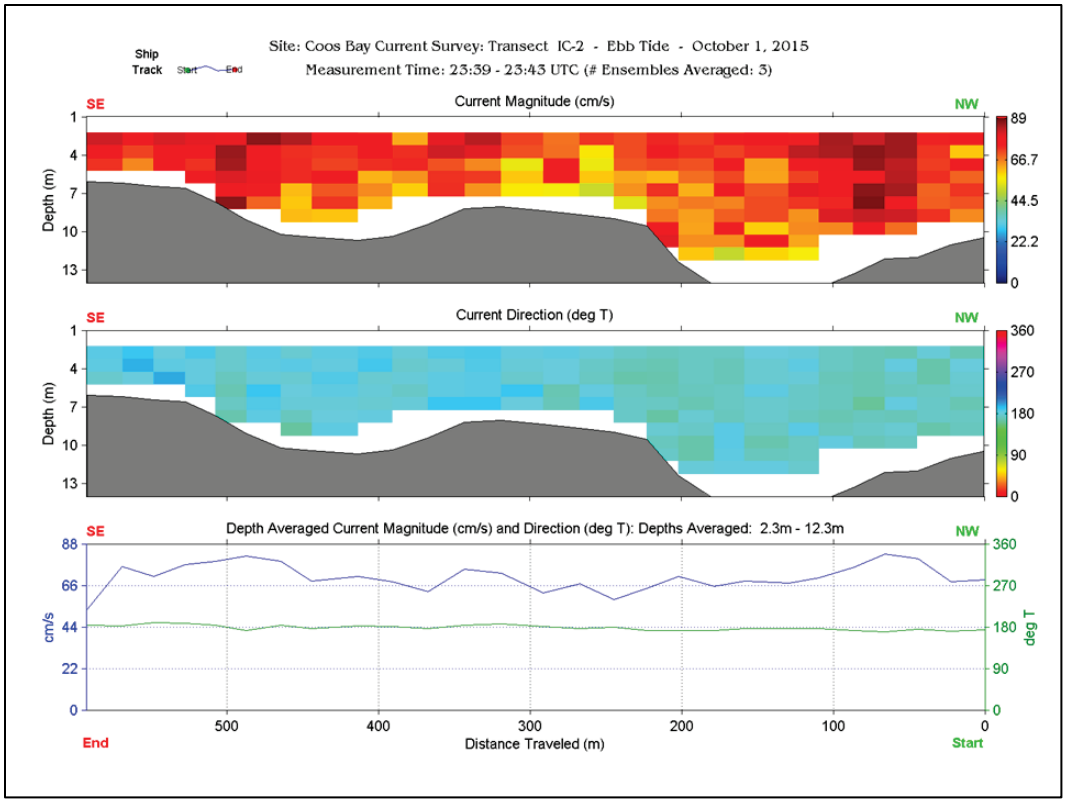

Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-7 - Ebb Tide - October 1, 2015
Measurement Time: 23:03 - 23:06 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
SW
NE
Depth (m)
1
5
9
13
17
64.8
48.6
32.4
16.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
64
48
32
16
0
85
170
255
340
425
Start
End
Distance Traveled (m)

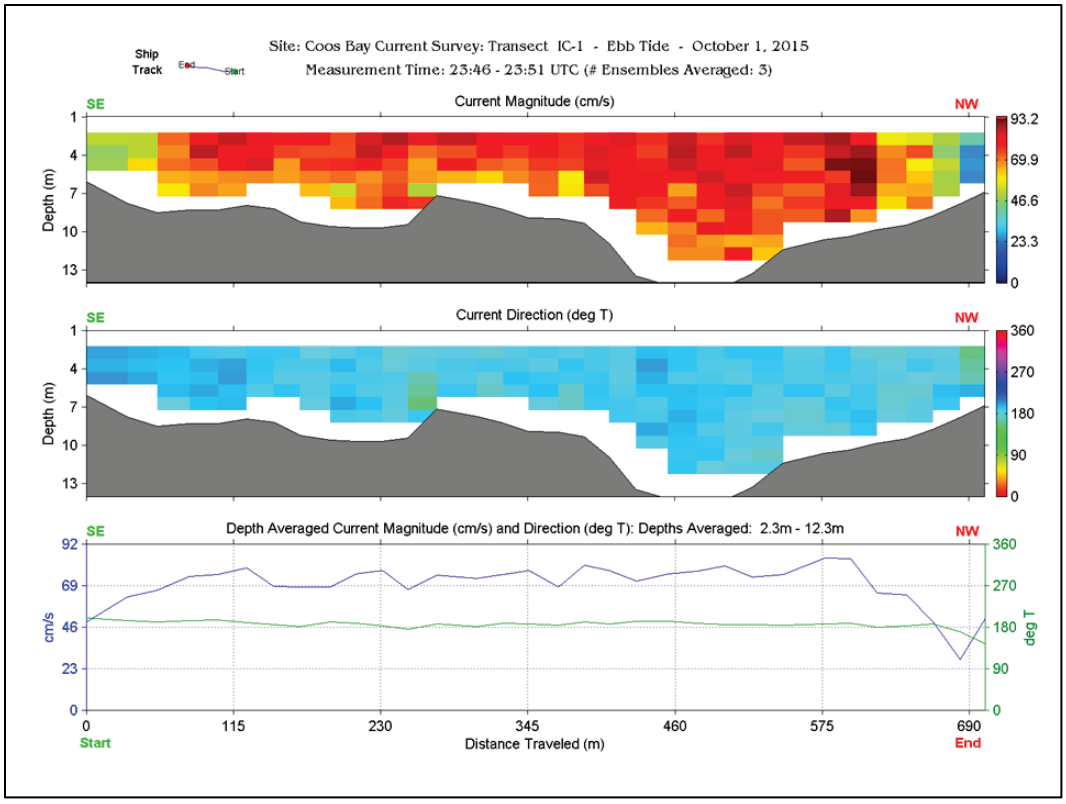

Ship Track
Start
End
Site: Coos Bay Current Survey: Transect IC-6 - Ebb Tide - October 1, 2015
Measurement Time: 23:09 - 23:12 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5
9
13
17
72.8
54.6
36.4
18.2
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 16.3m
cm/s
deg T
72
54
36
18
0
425
340
255
170
85
End
Start
Distance Traveled (m)


Ship Track
End
Start
Site: Coos Bay Current Survey: Transect IC-5 - Ebb Tide - October 1, 2015
Measurement Time: 23:16 - 23:19 UTC (# Ensembles Averaged: 3)
Current Magnitude (cm/s)
S
N
Depth (m)
1
5.5
10
14.5
19
85.5
64.2
42.8
21.4
0
Current Direction (deg T)
360
270
180
90
0
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
84
63
42
21
0
0
80
160
240
320
400
480
Start
End
Distance Traveled (m)


Site: Coos Bay Current Survey: Transect IC-4 - Ebb Tide - October 1, 2015
Measurement Time: 23:25 - 23:28 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.8
10.5
15.3
20
73.9
55.4
37
18.5
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 19.3m
cm/s
deg T
72
54
36
18
425
340
255
170
85
Distance Traveled (m)
End
Start


Site: Coos Bay Current Survey: Transect IC-3 - Ebb Tide - October 1, 2015
Measurement Time: 23:33 - 23:36 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
1
5.5
10
14.5
19
85.4
64.1
42.7
21.4
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 18.3m
cm/s
deg T
84
63
42
21
0
75
150
225
300
375
450
Distance Traveled (m)
Start
End


Site: Coos Bay Current Survey: Transect IC-2 - Ebb Tide - October 1, 2015
Measurement Time: 23:39 - 23:43 UTC (# Ensembles Averaged: 3)
Ship Track
Start
End
Current Magnitude (cm/s)
SE
NW
Depth (m)
89
66.7
44.5
22.2
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
deg T
Distance Traveled (m)
End
Start


Site: Coos Bay Current Survey: Transect IC-1 - Ebb Tide - October 1, 2015
Measurement Time: 23:46 - 23:51 UTC (# Ensembles Averaged: 3)
Ship Track
End
Start
Current Magnitude (cm/s)
SE
NW
Depth (m)
93.2
69.9
46.6
23.3
0
Current Direction (deg T)
360
270
180
90
Depth Averaged Current Magnitude (cm/s) and Direction (deg T): Depths Averaged: 2.3m - 12.3m
cm/s
deg T
Distance Traveled (m)
Start
End

Appendix J: Material Safety Data Sheet (MSDS)

Product name: EcoTrace Fluorescent Tracer **Page 1 of 5**
Printing date: 12/03/2015

1. Product/Manufacturer's Details:

SERIES NAME: EcoTrace Fluorescent Tracer
APPLICATION: Silt and Sand Particle tracing
MANUFACTURER'S NAME: c/o ETS Ltd., The Coach House, Bannachra, Helensburgh, Argyll, UK, G84 9EF
TELEPHONE: 01389 711001
CONTACT: Dr. Jonathan Marsh

2. Composition/Information on Ingredients

COMPOSITION: Solid solution of fluorescent dye in a natural mineral and thermoplastic polymer base.
HAZARDOUS INGREDIENTS: Does not contain any substances presenting a health hazard within the meaning of the Dangerous Substance Directive 67/548/EEC as amended by the Seventh Amendment 92/32/EEC.

3. First Aid Measures

GENERAL: In all cases of doubt or when symptoms persist, seek medical attention. Never give anything by mouth to an unconscious person.
INHALATION: Remove to fresh air, keep patient warm and at rest; if breathing is irregular or stopped, administer artificial respiration. Give nothing by mouth. If unconscious, place in recovery position and seek medical advice.
EYE CONTACT: Irrigate copiously with clean fresh water for at least 10 minutes holding the eyelids apart and seek medical advice.
SKIN CONTACT: Wash skin thoroughly with soap and water or use recognised skin cleaner. Do NOT use solvents or thinners.
INGESTION: If accidentally swallowed give two glasses of water to drink. Do NOT induce vomiting. If symptoms persist seek medical advice.

4. Fire Fighting Measures

EXTINGUISHING MEDIA:	Foam, CO_2 powders, water fog.
PRECAUTIONS:	Exposure to decomposition products may cause a health hazard (Section 9).

5. Accidental Release Measures

PERSONAL PRECAUTIONS:	Refer to protective measures listed in Section 7. Avoid dust formation. Take precautionary measures against static discharges.
METHODS FOR CLEANING UP:	Contain spillage with suitable dust binding materials such as sand/sawdust and dispose in accordance with Section 12. Clean affected areas with water/biodegradable surfactant solution; avoid use of solvents. Refer to protective measures listed in Section 7. Avoid dust formation. Take precautionary measures against static discharges.
METHODS FOR CLEANING UP:	Contain spillage with suitable dust binding materials such as sand/sawdust and dispose in accordance with Section 12. Clean affected areas with water.

6. Handling and Storage

HANDLING:	Avoid dust formation. Take precautionary measures against static discharges.
STORAGE:	Store in a dry well ventilated place away from sources of heat and direct sunlight. Keep away from sources of ignition. Keep away from strong oxidising agents and alkaline and acidic materials. Containers, which are open, should be closed and kept upright to prevent leakage and control contamination. Keep in original packaging.

Product name: EcoTrace Fluorescent Tracer **Page 3 of 5**
Printing date: 12/03/2015

7. Exposure Controls/Personal Protection

ENGINEERING MEASURES:	Provide local exhaust ventilation if required. See exposure limits:	
EXPOSURE LIMITS:	SHORT TERM EXPOSURE LIMITS	LONG TERM EXPOSURE LIMITS
Total inhalable dust:	10 mg/m^3	10 mg/m^3
Respirable dust:	5 mg/m^3	5 mg/m^3
RESPIRATORY PROTECTION:	Provide local extraction if required. See exposure limits. If exposure limits are likely to be exceeded then ensure that masks are used – EN 143 type P2 is recommended.	
HAND PROTECTION:	Wear gloves.	
EYE PROTECTION:	Wear goggles.	
GENERAL SAFETY & HYGIENE MEASURES:	The usual precautions for the handling of chemicals must be observed.	

8. Physical and Chemical Properties

FORM:	Coloured fine powder
SOFTENING POINT:	Not applicable – Thermoset product
DECOMPOSITION POINT:	Above 190°C
SOLUBILITY IN WATER:	None
pH VALUE:	6–7.5 (5% in water @ 25°C)
SPECIFIC GRAVITY	up to 2.65 @ 20°C
FLASH POINT:	Not applicable
ODOUR:	Slight smell
VISCOSITY:	Not applicable
BOILING POINT:	Not applicable
VAPOUR DENSITY:	Not applicable
VAPOUR PRESSURE:	Not applicable
EXPLOSION HAZARD:	Dust explosion hazard
MIN EXPLOSIBLE CONC:	67–75 g/M^3
MIN IGNITION ENERGY:	7–10 mJ

Product name: EcoTrace Fluorescent Tracer **Page 4 of 5**
Printing date: 12/03/2015

9. Stability and Reactivity

CONDITIONS CONTRIBUTING TO INSTABILITY:	Product is stable under recommended storage and handling conditions. If exposed to elevated temperatures gas can be liberated; in these cases suitable control procedures should be implemented.
MATERIALS TO AVOID:	Keep product away from strong oxidising agents, strongly alkaline and strongly acidic materials.
HAZARDOUS DECOMPOSITION PRODUCTS:	Fumes may contain oxides of sulphur, carbon and nitrogen.

10. Toxicological Information (of fluorescent pigment)

ACUTE ORAL TOXICITY LD50:	More than 16 g/kg
ACUTE DERMAL TOXICITY LD50:	More than 23 g/kg
ACUTE DUST INHALATION LC50:	More than 4.4 mg/L (4 hours)*
EYE IRRITATION:	No significant irritation
HEAVY METAL CONTENT:	Typical Analysis Expressed in mg/kg Antimony <1, Arsenic <1, Barium <1, Cadmium <1, Chromium <1, Lead <1, Mercury <1, Selenium <2
FREE PRIMARY AROMATIC AMINE:	Less than 0.1% w/w typical analysis
NOTES:	The values for acute oral toxicity, acute dermal toxicity and acute dust inhalation refer to tests conducted on representative samples. These tests resulted in NO DEATHS OF THE TEST ANIMALS, therefore tests were stopped.

Product name: EcoTrace Fluorescent Tracer **Page 5 of 5**
Printing date: 12/03/2015

11. Ecological Information

See additional information in Sections: A1 & A2 below for tests conducted on lower specific gravity (SG 1.0-1.03) ETS EcoTrace particles with a particle size <5 microns (equivalent to bacteria or smaller) carried out by a UK Government Research Laboratory (CEFAS) to assess any impact on Pacific Oysters and by NSF-WRc, the UK Public Health and Safety Organisation in terms of Potable (Drinking) Water Quality and Regulations.

12. Disposal considerations

Waste and emptied containers should be disposed of in accordance with current regulations.

13. Transport information

Considered as Non-Hazardous under Transport Regulations.

14. Regulatory Information

LABELLING ACCORDING TO EU DIRECTIVES:	Not subject to labelling
NATIONAL LEGISLATION/ REGULATIONS:	This product is classified as NON-HAZARDOUS under the UK 'Chemicals (Hazard Information and Packaging/Regulations' CHIP Regulations.

15. Other Information

The information in this MSDS is based on the present state of our knowledge and on current EU and National Laws. It is the responsibility of the user to ensure that their employees are aware of the content of this MSDS and also to ensure that any additional local rules and regulations are satisfied. The information contained herein is provided in accordance with the current legal requirement and should not be considered as a guarantee of the product's properties or performance. The information in this Safety Data Sheet is pursuant to:

a) The Chemicals (Hazard Information and Packaging) Regulation 1994
b) Article 27 of the Dangerous Substances Directive – 67/548/EEC as amended by the Seventh Amendment – 92/32/EEC (Official Journal No. L154. 5 June 1992 P1)
c) Article 10 of the Dangerous Preparation Directive – 88/379/EEC (Official Journal No. L187. 16 July 1988 P14)
d) The Safety Data Sheets Directive – 91/155/EEC as amended by Directive 93/112/EEC (Official Journal No. L314. 16 December 1993, P38)

J.1 Uptake and Elimination Tests of EcoTrace Fluorescent Tracer Particles by Pacific Oysters

ETS carried out tests in conjunction with the Centre for Environment, Fisheries & Aquaculture Science (CEFAS), a UK Government laboratory, to establish baseline information on the effect of releasing EcoTrace fluorescent tracer particles (bacteria size and neutral buoyant SG) in close proximity to shellfish areas including oyster beds. The tests involved exposing Pacific Oysters to an extremely concentrated level of EcoTrace particles and measuring the rate of uptake and concentration held within the oyster over time. Further tests were then carried out to assess whether the oysters retained or eliminated the tracer when added to clean water (depuration). CEFAS undertook the uptake and elimination trials at the Weymouth laboratories using bacteria-sized neutral buoyancy tracer supplied by ETS.

The tests clearly indicated that tracer was taken up (ingested) by the oysters. Maximum concentrations of tracer in the oysters occurred at Time 2 hours after exposure. The concentration of tracer measured in the oysters at Time 2 hours, expressed as a percentage of the total tracer in the circulation tank at Time 0 hours, ranged between 14%–58%. Furthermore, the tests indicated that after the peak uptake at Time 2 hours, the oysters begin to export the tracer particles in faecal waste/strands, with concentrations decreasing to between 1%–3% in the oysters after 24 and 48 hours. During this time the oysters remained in the circulation tank and were continually exposed to tracer particles. Further testing indicated that the tracer particles were depurated when the oysters were placed in clean water, with concentrations after 5 days of 0.1%–0.2% of the total tracer present in the exposure circulation tank. It is believed that the tracer particles remaining in the oyster after 5 days was present on the outer shell and/or inside the shell, rather than in the gut. These results are entirely consistent with bacteria uptake and depuration by oysters, demonstrating the tracer particles were not preferentially selected or rejected by the oysters when feeding naturally. The full report is available on request.

ETS EcoTrace particles have also been fed to *Daphnia* over a prolonged period by ALcontrol Laboratories UK who were using it to label the Daphnia to identify and select them as part of water quality testing procedures. ALcontrol found no mortalities during any of the tests as a result of the uptake of the tracer particles.

J.2 Effect of Non-Metallic Products on the Quality of Potable Water

In 2000, micron-sized neutral buoyancy samples of the ETS EcoTrace particles were tested by NSF-WRc, the Public Health and Safety Organisation in the UK, in accordance with the methods specified in the following:

1. BS6920: 1996 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water.
2. Methods of Test and the Water Regulations Advisory Scheme Information Note and Guidance Note No- 9-01-02 Issue 1, June 1995, Requirements for the testing of non-metallic products for use in contact with potable water.
3. Water Regulation Advisory Scheme Instruction No Admin 7, January 1998 update amendments.

NSF-WRc concluded that the ETS EcoTrace tracer particles satisfied the criteria set out in BS6920: Part 1: 1996 'Specification' and therefore comply with the requirements of the Water Regulations Advisory Scheme Tests of Effect on Water Quality for use in cold potable (drinking) water. The report is available upon request.

J.3 Other Uses of EcoTrace Particles

Numerous international research laboratories and universities around the world have used ETS EcoTrace tracer particles (mostly silt and sand tracers) to test a number of geochemical and fauna feeding processes, looking at bioturbation, uptake in digestive systems and pseudofaeces including feeding them to mussels, sea slugs, sea cucumbers, etc. None of these tests have resulted in any deaths or premature illnesses or have raised concerns. Many of the studies and results have been published.

Over the past 21 years, ETS has not received a single expression of concern over the use of the tracers, impact or toxicity.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

This report documents a field data collection program, including the sediment tracer study, and numerical modeling investigation for dredged material placed in the nearshore area of an ocean dredged material disposal site (ODMDS) adjacent to Coos Bay Inlet, OR. The collected data around the inlet system were assembled, analyzed, and used to calibrate and validate the Coastal Modeling System (CMS) and the Particle Tracking Model (PTM). Sediment transport pathways and fate of placed material were evaluated. The model and sediment tracer study results indicate that the tracer placed within the nearshore ODMDS primarily moves alongshore towards the inlet at the initial stage of the release. Material arriving at the inlet channel and ebb shoal is jettisoned offshore by strong ebb currents. The results also show that the sediment tracer spreads northward alongshore due to strong dominant southerly wind across the inner continental shelf. At and outside the inlet, finer particles are transported the farthest offshore and away from the navigation channel and nearshore ODMDS area. A new sediment mapping technique applied in model simulations demonstrates migration and burial for sediments placed in the nearshore ODMDS. Both CMS and PTM results compare well with those of the sediment tracer study.

15. SUBJECT TERMS
Coos Bay (Or.:Bay), Dredging, Dredging spoil, Hydrodynamics, Sedimentation and deposition, Sediment transport

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