Padilla Bay (PDB) NERR Meteorological Metadata
January through December 2020
Latest Update: May 25, 2022

I. Data Set and Research Descriptors

1) Principal investigator(s) and contact persons –

Heath Bohlmann, Environmental Specialist
Phone: (360) 428-1046
Email: hbohlmann@padillabay.gov

Sylvia Yang, Research Coordinator
Phone: (360) 428-1089
Email: syang@padillabay.gov

Address:
Padilla Bay NERR
10441 Bayview-Edison Road
Mount Vernon, WA 98273-9668
Phone: (360) 428-1558

2) Entry verification –

Data are uploaded from the CR1000 data logger to a personal computer with a Windows 7 or newer operating system. Files are exported from LoggerNet in a comma-delimited format and uploaded to the CDMO where they undergo automated primary QAQC and become part of the CDMO's online provisional database. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the Reserve where it is opened in Microsoft Excel and processed using the CDMO's NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged data and summary statistics, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, append files, and export the resulting data file to the CDMO for tertiary QAQC and assimilation into the CDMO's authoritative online database. For more information on QAQC flags and QAQC codes, see Sections 11 and 12. Heath Bohlmann completed this process for entry verification and data verification and compiled this metadata for the 2020 data.

3) Research objectives –

The principal objective is to measure and record meteorological data at Padilla Bay for use in studies investigating correlations between meteorological data and water quality data, biological data, or other phenomenon in Padilla Bay and its watershed.

4) Research methods –

The weather parameters, air temperature, relative humidity, barometric pressure, wind speed and direction, photosynthetically active radiation, and precipitation were measured with a Campbell Scientific weather station at the Padilla Demonstration Farm near the southeast shore of Padilla Bay. Fifteen minute data were stored in a data logger and downloaded monthly. The sensors were visually inspected for debris or damage when the data were downloaded. Due to the location of the weather station in the middle of flat farm fields, the sensors require very little cleaning. The most common problem occurs seasonally from air

borne seeds partially blocking the rain gauge funnel. To mitigate this problem weeds near the site were cut before they set seed. While at the station downloading data, a Kestrel 4000 Pocket Weather Tracker is used to make a general, comparative check of the Campbell station sensors. Suspicious data are also checked against other local weather data posted on Washington State University's website (http://weather.wsu.edu)*. All sensors were calibrated on a regular basis unless otherwise noted in section 9. All data are collected in Pacific Standard Time (PST).

Campbell Scientific data telemetry equipment was installed at the Padilla Bay Farm station on 11/11/05 and transmits data to the NOAA GOES satellite, NESDIS ID #3B005706. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The "real-time" telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO's authoritative online database. Provisional and authoritative data are available at http://cdmo.baruch.sc.edu.

The 15 minute Data are collected in the following formats for the **CR1000**:

Averages from 5-second data:

Air Temperature (°C), Relative Humidity (%), Barometric Pressure (mb), Wind Speed (m/s), Wind Direction (degrees), Battery Voltage (volts)

Maximum and Minimum Air Temperature (°C) and their times from 5-second data (these data are available from the Reserve)

Maximum Wind Speed (m/s) and time from 5-second data

Wind Direction Standard Deviation (degrees)

Totals:

Precipitation (mm), PAR (millimoles/m^2), and Cumulative Precipitation (mm) (Cumulative precipitation is no longer available via export from the CDMO. Please contact the Reserve or the CDMO for more information or to obtain these data.)

Recommended calibration frequency for the MET station sensors:

- Temperature/Humidity- yearly recalibration
- Rain Gauge- yearly recalibration
- Wind Speed/Direction- yearly or every 2 years (depending on the sensor)
- Barometric Pressure- every 2 years recalibration
- PAR- every 2 years recalibration
- CR1000-every 5 years (required beginning 2014)

5) Site location and character –

Padilla Bay (48° 30' N; 122° 30' W) is a shallow embayment in northern Puget Sound located in the greater Puget Sound-Georgia Basin estuary. It is an "orphaned" estuary in that the Skagit River, which formed the delta mud flats of Padilla Bay, no longer enters the bay directly. Most of the land in the 9300 ha Padilla Bay watershed is agricultural, and is drained by four sloughs which empty into the bay. Other major freshwater influences to Padilla Bay include the Skagit River from the south, flowing through the Swinomish Channel which connects Padilla Bay to Skagit Bay and the Nooksack and Fraser Rivers to the north. The tide flats are dominated by the eelgrass *Zostera marina*, which when last mapped in 2004 covered approximately 3,000 ha. *Zostera japonica*, a recent invader to the region, covered about 700 ha of the bay in 2004 and has since expanded in coverage. Currently, Padilla Bay has large areas of mixed eelgrass beds throughout the mid-intertidal range. Tides are mixed semi-diurnal with a mean range of 2.4 m.

Salinity varies from about 15 to 31 PSU. Padilla Bay is bordered on the east and south by flat, diked farmland; farther to the east are foothills of the Cascade Range. March Point, on the western edge of the reserve, is the site of two large oil refineries. To the north and west are the San Juan Islands of northern Puget Sound.

The weather station is located near the southeast corner (48° 27' 49.85" N; 122° 28' 09.49" W) of Padilla Bay on a 40 hectare demonstration farm that is owned by the Reserve. Flat fields that are farmed for seasonal crops surround the site. Access is off of Bayview-Edison Road about 150 m down a gravel driveway. Base elevation of the weather station in orthometric height is 2.2 m elevation (NAVD88, 2010).

The sensors are mounted on a 3 m tower that is secured to a concrete pad as specified by the manufacturer, Campbell Scientific. The relative humidity/temperature sensor is mounted 2 m high and the wind and PAR sensors are at the top of the tower 3 m above ground level. The barometric pressure sensor is mounted 1 m above the ground (inside the CR1000 enclosure). The rain gauge is mounted on a cement cylinder approximately 1 meter high and 2m SE of the sensor tower. Surrounding the site is a six foot high chain link fence for security. The weather station is about 300 m from the diked edge of the bay and approximately 4 km SE of the Bayview Channel YSI deployment site and about 4 km south of the Padilla Bay NERR Laboratory.

SWMP Station Timeline:

Station Code	Station Name	SWMP Status	Location	Active Dates	Reason Decommissioned	Notes
PDBPFMET	Padilla Farm	P	48° 27' 49.85 N, 122° 28' 9.49 W	01/01/2001-Current	NA	NA

6) Data collection period –

Data collection at the Padilla Bay Farm site began in January 2001. The following dates and times represent the raw data file collection periods for 2020 data.

12/3/2019 12:00 - 1/2/2020 10:45
1/2/2020 11:00 - 1/9/2020 12:30
1/9/2020 13:15 - 2/12/2020 12:45
2/12/2020 13:00 - 3/4/2020 14:45
3/4/2020 15:00 - 4/8/2020 13:30
4/8/2020 13:45 - 5/20/2020 11:00
5/20/2020 11:15 - 6/4/2020 14:00
6/4/2020 14:15 - 7/7/2020 10:15
7/7/2020 10:30 - 8/5/2020 13:45
8/5/2020 14:00 - 9/9/2020 12:30
9/9/2020 12:45 - 10/9/2020 7:45
10/9/2020 8:00 - 11/5/2020 12:00
11/19/2020 14:30 - 12/4/2020 14:00
12/4/2020 14:15 - 1/5/2021 11:00

7) Distribution –

NOAA retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The NERRS retains the right to be fully credited for having collected and process the data. Following academic courtesy standards, the NERR site where the data were collected should be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

Requested citation format:
NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed* 12 October 2020.

NERR meteorological data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Principal Investigators and Contact Persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page www.nerrsdata.org. Data are available in comma delimited format.

8) Associated researchers and projects –

In coordination with the SWMP weather data collected at Padilla Bay, water quality and nutrient data are also collected. The water quality part of SWMP consists of placing YSI 6600 and EXO datasondes at four sites in Padilla Bay. The sondes collect such parameters as water temperature, salinity, dissolved oxygen, depth, pH, and turbidity. The nutrient component of SWMP consists of monthly grab samples taken at each of the same four sites and monthly diel sampling taken at one of the sites (Bayview Channel Site). The nutrients analyzed include, but are not limited to, nitrate, nitrite, ammonium, silicate, orthophosphate, and chlorophyll a. These data are available at www.nerrsdata.org.

Other projects currently conducted at Padilla Bay include a zooplankton monitoring project with monthly sampling occurring at the three water quality/ nutrient sampling sites within the bay. In August 2009 Padilla Bay started long term monitoring of the rocky intertidal habitat in partnership with the Multi-Agency Rocky Intertidal Network (MARINe). See the MARINe website for further information on this monitoring project: pacificrockyintertidal.org. In 2011, Padilla Bay started a long term monitoring project of vegetative characteristics of two species of eelgrass: *Zostera marina* and *Z. japonica* on transects extending from the shoreline to the lower limit of distribution of eelgrasses. Dr. John Rybczyk, Western Washington University, established and maintains eighteen Surface Elevation Tables (SETs) throughout Padilla Bay and the Padilla Bay Reserve maintains 6 SETs along the eelgrass monitoring transects. Padilla Bay NERR sponsors graduate research in the bay through the Padilla Bay Research Assistantships and Margaret Davidson Fellowship in research related to Estuarine Science and Coastal Zone Management. Contact the Research Coordinator (see I. above) for further information about these projects and other monitoring or research in Padilla Bay.

II. Physical Structure Descriptors

9) Sensor specifications –

Parameter: Temperature
Units: Celsius
Sensor type: Pt1000 Class A
Model #: EE181 Temperature and Relative Humidity Probe
Operating Temperature: -40°C to +60°C
Range: -40°C to +60°C
Accuracy: ±0.2 °C @ 23°C
Calibration Frequency: 1 year

Sensor Serial #	calibration date	deployment dates
201516001378C0	11/18/2020 new	11/19/2020 – Current as of 01/17/2021
192016000545E8 (blue)	1/6/2019 new	11/6/2019 – 11/05/2020

Parameter: Relative Humidity
Units: Percent
Sensor type: HC101
Model #: EE181 Temperature and Relative Humidity Probe
Range: 0-100% non-condensing
Accuracy: –15 to 40 °C: ≤90% RH ± (1.3 + 0.003 • RH reading) % RH
–15 to 40 °C: >90% RH ± 2.3% RH
–25 to 60 °C: ± (1.4 + 0.01 • RH reading) % RH
–40 to 60 °C: ± (1.5 + 0.015 • RH reading) % RH
Temperature dependence of RH measurement: typically 0.03% RH/°C
Note: This sensor caps relative humidity values at 100%, measured values >100% are altered to 100%
Calibration Frequency: 1 year

Sensor Serial #	calibration date	deployment dates
201516001378C0	11/18/2020 new	11/19/2020 – Current as of 01/17/2021
192016000545E8 (blue)	1/6/2019 new	11/6/2019 – 11/05/2020

Parameter: Barometric Pressure
Units: millibars (mb)
Sensor type: Vaisala Barocap © silicon capacitive pressure sensor
Model #: CS-106 (PTB110)
Operating Range: Pressure: Pressure: 500 to 1100 mb; Temperature: -40°C to +60°C; Humidity: non-condensing
Accuracy: ± 0.3 mb at +20°C, ± 0.6 mb at 0°C to 40°C, ± 1 mb at -20°C to +45°C, ± 1.5 mb at -40°C to +60°C
Stability: ± 0.1 mb per year
Calibration Frequency: 2 years

Sensor Serial #	calibration date	deployment dates
K1420007 CS106	11/09/2020	11/19/2020 – Current as of 01/27/2021
K1420007 CS106	7/3/2018	8/7/2018 – 11/05/2020

Parameter: Wind speed
Units: meter per second (m/s)
Sensor type: 12 cm diameter cup wheel assembly, 40 mm diameter hemispherical cups
Model #: R.M. Young 03001-5 Wind Sentry
Range: 0-50 m/s (112 mph); gust survival 60 m/s (134 mph)
Accuracy: +/- 2%
Calibration Frequency: 1 year

Sensor Serial #	calibration date	deployment dates
A1	8/26/2020	11/19/2020 – Current as of 1/27/2021
B2	6/29/2018	11/6/2019 – 11/05/2020

Parameter: Wind direction
Units: degrees
Sensor type: balanced vane, 16 cm turning radius
Model #: R.M. Young 03001-5 Wind Sentry
Range: 360° mechanical, 355° electrical (5° open)
Accuracy: +/- 5%
Calibration Frequency: 1 year

Sensor Serial #	calibration date	deployment dates
B1	8/26/2020	11/19/2020 – Current as of 1/27/2021
A2	6/29/2018	11/6/2019 – 11/05/2020

Parameter: Photosynthetically Active Radiation (PAR)
Units: mmoles m-2 (total flux)
Sensor type: anodized aluminum with cast acrylic diffuser
Model #SQ110 Apogee Quantum Sensor
Light spectrum waveband: 410 to 655 nm
Temperature dependence: 0.06+/-0.06% per °C
Stability: <±2% change over 1 yr
Operating Temperature: -40°C to 70°C; Humidity 0 to 100%
Cosine Response: 45° zenith angle: +/- 2%; 75° zenith angle: +/- 5%
Sensitivity: 0.2mV per µmol s-1 m-2

Sensor Serial #	calibration date	deployment dates	PAR Multiplier
23772 #2	New: 06 - 2019	11/07/2019- current as of 01/27/2021	0.025
23772 (blue)	New: 09 - 2017	11/7/2017-11/5/2019	0.025

Parameter: Precipitation
Units: millimeters (mm)
Sensor type: Tipping Bucket Rain Gauge
Model #: RG-2000-C
Rainfall per tip: 0.01 inch
Operating range: Not specified
Accuracy: +/- 1.0% at 14 inches per hour
Calibration Frequency: 1 year

Sensor Serial #	calibration date	deployment dates
PDBRG3	11/08/2020	11/19/2020 – current as 01/27/2021
PDBRG3	05/14/2019	05/14/2019 – 11/05/2021

CR1000 Measurement and Control System

The CR1000 has 2 MB of Flash EEPROM that is used to store the Operating System. Another 128 K Flash is used to store configuration settings. A minimum of 2 MB SRAM is (4 MB optional upgrade) available for program storage (16K), operating system use, and data storage. Additional storage is available by using a compact flash card in the optional CFM100 Compact Flash Module.

Serial #	calibration date	deployment dates
69902	11/10/2020	11/19/2020-current as of 01/27/2021
69902	12/24/2014 (New)	01/21/2015- 11/05/2020

CR1000 Firmware Version (s):

OS Version: CR1000.Std.32.05
OS Date: 11/10/2020

CR1000 Program Version(s):

Current program - PDBPFMET_CR1000_6.6_111920.CR1
Previous program – PDBPFMET_CR1000_6.6_010920.CR1

10) Coded variable definitions –

Sampling station:	Sampling site code:	Station code:
Padilla Farm	PF	pdbpfmet

11) QAQC flag definitions –

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is above or below sensor range, or missing. All remaining data are then flagged 0, as passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

-5 Outside High Sensor Range
-4 Outside Low Sensor Range
-3 Data Rejected due to QAQC
-2 Missing Data
-1 Optional SWMP supported parameter
0 Passed Initial QAQC Checks
1 Suspect Data
2 *Open - reserved for later flag*
3 *Open - reserved for later flag*
4 Historical Data: Pre-Auto QAQC
5 Corrected Data

12) QAQC code definitions –

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories, general, sensor, and comment. General errors document general problems with the CR1000, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column.

General Errors

GIM	Instrument Malfunction
GIT	Instrument Recording Error, Recovered Telemetry Data
GMC	No Instrument Deployed due to Maintenance/Calibration
GMT	Instrument Maintenance
GPD	Power Down
GPF	Power Failure / Low Battery
GPR	Program Reload
GQR	Data Rejected Due to QA/QC Checks
GSM	See Metadata

Sensor Errors

SDG	Suspect due to sensor diagnostics
SIC	Incorrect Calibration Constant, Multiplier or Offset
SIW	Incorrect Wiring
SMT	Sensor Maintenance
SNV	Negative Value
SOC	Out of Calibration
SQR	Data rejected due to QAQC checks
SSD	Sensor Drift
SSN	Not a Number / Unknown Value
SSM	Sensor Malfunction
SSR	Sensor Removed

Comments

CAF	Acceptable Calibration/Accuracy Error of Sensor
CCU	Cause Unknown
CDF	Data Appear to Fit Conditions
CML	Snow melt from previous snowfall event
CRE*	Significant Rain Event
CSM*	See Metadata
CVT*	Possible Vandalism/Tampering
CWE*	Significant weather event

13) Other remarks/notes –

Data are missing due to equipment or associated specific sensors not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for "not a number" and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Relative Humidity data greater than 100 are within range of the sensor accuracy of +/-3% and are flagged and coded as suspect, <1> (CAF). Values greater than 103 are rejected <-3>.

Please note that the 3001 Wind Monitor has an offset of 0.2 and does not record values of 0.

Data recorded for all parameters (with the exception of cumulative precipitation) at the midnight timestamp (00:00) are the 15 minute averages and totals for the 23:45-23:59 time period of the previous day. Cumulative precipitation data at the midnight timestamp (00:00) are the sum of raw (unrounded) precipitation data from 00:00 to 23:59 of the previous day. Summing each individual 15-minute total precipitation value from the same period will result in small differences from cumulative precipitation due to rounding. It is especially important to note how data at the midnight timestamp are recorded when using January 1st and December 31st data. **Note: Cumulative precipitation is no longer available via export from the CDMO. Please contact the Reserve or the CDMO for more information or to obtain these data.**

All Parameter Records
1/9/2020 12:45 through 1/9/2020 13:15
System power down and data rejection due to GPS transmitter hardware replacement. Campbell scientific GPS transmitter (TX312) was replaced with new model (TX321B). This should permanently fix telemetry communication issues related to the GOES satellite date rollover starting in April 2019.

All data from 01/21/2020 00:15 – 11/05/2020 12:00 are considered suspect. Although the sensors were all within calibration, the CR1000 logger was considered out of calibration as of 01/21/2020. The CR1000 instrument calibration condition was confirmed to be within tolerance when received for calibration in Nov 2020. Though data is flagged as suspect due to the datalogger calibration schedule, data from this time period should be treated as accurate. Contact Heath Bohlmann for a copy of CR1000 calibration certificate.

11/5/2020 12:15 through 11/19/2020 14:15
Sensors were not collecting data due to CR1000 datalogger being sent in for calibration.

11/19/2020 14:30
Data rejected due to new program upload.

11/19/2020 14:45
Data rejected due to sensor maintenance and installation of newly calibrated instruments. Newly calibrated CR1000 datalogger, Temp/Rh, BP, Precip and Wind sensors installed.

Barometric Pressure Records
10/30/2020 11:00 through 11:45
BP flagged as rejected due to QAQC checks, BP no local data was available to corroborate a similar drop in barometric pressure.

Precipitation Records
CumPrcp
Cumulative precipitation data were corrected on 01/09/2020 13:15 – 01/10/2020 00:00 to reflect rainfall from earlier in the day. A program upload reset the logger at 13:15 and reset rainfall totals to from 1.3 to 0.0. Values were corrected back to 1.3.

Tot Prcp
11/19/2020 14:45
Precip data corrected due to rain gauge bucket tips during instrument installation.
Newly calibrated RG installed.

CumPrcp
11/19/2020 14:45 through 11/20/2020 00:00
CumPrcp data corrected due to rain gauge bucket tips during instrument installation.

PAR Records
Data from the following dates/times were marked as suspect due to positive values (>0) recorded at night.

12/05/2020 05:00
12/22/2020 18:30
12/22/2020 20:15
12/22/2020 22:45
12/23/2020 23:30
12/24/2020 00:30
12/24/2020 04:30
12/24/2020 04:45
12/24/2020 05:00
12/24/2020 06:30
12/25/2020 01:30
12/25/2020 05:00
12/25/2020 05:15
12/29/2020 02:45
12/29/2020 03:30
12/29/2020 04:15
12/29/2020 06:30

* Meteorological Data References:

Meteorological data used for comparison can be found at the AgWeatherNet network. To access raw data for the AgWeaterNet network, go to the AgWeatherNet web site URL as follows: www.weather.wsu.edu.

Station: **WSU Mt Vernon** Lat: 48.43849, Lng: -122.38566, Elevation: 7.01m, Distance from Padilla Bay Farm MET station: 6.5 km.

Station: **Sakuma** Lat: 48.49735, Lng: -122.37847, Elevation: 8.53m, Distance from Padilla Bay Farm MET station: 8 km.

Station: **Fir Island** Lat: 48.35654, Lng: -122.42188, Elevation: 0m, Distance from Padilla Bay Farm MET station: 16 km.