

Padilla Bay (PDB) NERR Meteorological Metadata
January through December 2009
Latest Update: September 12, 2013

I. Data Set and Research Descriptors

1) Principal investigator(s) and contact persons –

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2) Entry verification –

Data are uploaded from the CR1000 data logger to an Itronix Go Book III laptop (IBM compatible). Files are exported from LoggerNet in a comma-delimited format, transferred to ECY network file storage via thumbdrive 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 Padilla Bay NERR 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. In the secondary QAQC process, data are reviewed with graphs created to determine if there are any outliers, suspect, or erroneous data that were not part of the flagging process. The macro also 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. Files are compiled quarterly and submitted after the secondary QAQC is completed. A final yearly file is compiled from the quarterly files, run once again through the QAQC process and submitted with metadata to CDMO. For more information on QAQC flags and QAQC codes, see Sections 11 and 12. Heath Bohlmann completed this process for entry verification for the 2009 data. Heath Bohlmann completed final verification and this metadata. Doug Bulthuis reviewed final datasheets and metadata.

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. From January 1 through December 31, 2009 data were downloaded about once a month from the weather station. 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 precipitation data were checked against weather data from this area posted on Washington State University's website. All sensors were calibrated on a regular basis unless otherwise noted in section 14)

Other/Remarks and Notes. Specifically, the PAR and barometer sensors are sent to Campbell Scientific or the manufacturer every two years for calibration. The temperature (and relative humidity) and wind sensors are sent to Campbell Scientific or the manufacturer every year for calibration. The rain gauge is calibrated in house every year. The QAQC process described in Section 2 above is also used to check for sensor drift and malfunctions.

Campbell Scientific data telemetry equipment was installed at the Padilla Farm station on 11/11/05 and transmits data to the NOAA GOES satellite, NESDIS ID #3B005706. (Where 3B335706 is the GOES ID for that particular station.) 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, Minimum, and their times from 5-second data:

Air Temperature (°C) (these data are not included in the dataset, but are available from PDB
NERR)

Maximum and their times from 5-second data:

Wind Speed, (m/s)

Wind Direction Standard Deviation (degrees) from 5-second data

▲ Totals:

Precipitation 15 min. (mm), PAR 15 min. (millimoles/m²), and Cumulative Daily Precipitation
(mm)

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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. The tide flats are dominated by the eelgrass *Zostera marina*, which covers approximately 3,000 ha. *Zostera japonica*, a recent invader to the region, now covers about 800 ha of the bay. Tides are mixed semi-diurnal with a mean range of 1.5 m. Salinity varies from about 15 to 31 PSU. Most of the land in the 9300 ha Padilla Bay watershed is agricultural, and is drained by four sloughs which empty into the bay. Some freshwater from the Skagit now enters Padilla Bay from the south through the Swinomish Channel which connects Padilla Bay to Skagit Bay. Other major freshwater flows into this area of the Puget Sound-

Georgia Basin estuary are from the Fraser and Nooksack Rivers to the north. 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 (122° 28' 09.49" W; 48° 27' 49.85" N) 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. Elevation of the weather station is near mean sea level though the station has yet to be surveyed.

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 3 feet high. 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.

6) Data collection period –

January 1, 2009 at 00:00 to December 31, 2009 at 23:45 2009. Data have been collected at the Padilla Farm weather station since January 1, 2001.

7) Distribution –

NOAA/ERD retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the PI and NERR site where the data were collected will be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. Manuscripts resulting from this NOAA/OCRM supported research that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under an award from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration. 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.

NERR weather 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 <http://cdmo.baruch.sc.edu/>. Data are available in comma separated 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 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.

Other projects at Padilla Bay include a zooplankton monitoring project (monthly sampling) and a barnacle settlement project (semi-monthly). The sampling for each of these projects occurs at the three water quality/ nutrient sampling sites within the bay. In August 2009 Padilla Bay also 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 <http://www.marine.gov/index.htm>.

II. Physical Structure Descriptors

9) Sensor specifications –

Parameter: Temperature
Units: Celsius
Sensor type: Platinum resistance temperature detector (PRT)
Model #: HMP45C Temperature and Relative Humidity Probe
Operating Temperature: -40°C to +60°C
Range: -40°C to +60°C
Accuracy: $\pm 0.2^\circ\text{C}$ @ 20°C
Calibration Frequency: 1 year

Sensor Serial #	Calibration date	Deployment dates
X1130020	2/13/2008	2/13/2008-5/15/2009
X1130021	12/18/2008	5/15/2009-5/7/2010

Parameter: Relative Humidity
Units: Percent
Sensor type: Vaisala HUMICAP® 180 capacitive relative humidity sensor
Model #: HMP45C Temperature and Relative Humidity Probe
Range: 0-100% non-condensing
Accuracy at 20°C: $\pm 2\%$ RH (0-90%) and $\pm 3\%$ (90-100%)
Temperature dependence of RH measurement: $\pm 0.05\%$ RH/°C
Calibration Frequency: 1 year

Sensor Serial #	Calibration date	Deployment dates
X1130020	2/13/2008	2/13/2008-5/15/2009
X1130021	12/18/2008	5/15/2009-5/7/2010

Parameter: Barometric Pressure
Units: millibars (mb)

▲ Sensor type: Vaisala Barocap © silicon capacitive pressure sensor

Model #: CS-105

Operating Range: Pressure: 600 to 1060 mb; Temperature: -40°C to +60°C;

Humidity: non-condensing

Accuracy: ± 0.5 mb @ 20°C; ± 2 mb @ 0°C to 40°C; ± 4 mb @ -20°C to 45°C; ± 6 mb @ -40°C to 60°C

Stability: ± 0.1 mb per year

Calibration Frequency: 2 years

Sensor Serial #	Calibration date	Deployment dates
R1630013	8/15/2006	8/15/2006-7/17/2008
X0350002	7/17/2008	7/17/2008-6/18-2010

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: $\pm 2\%$

Calibration Frequency: 1 year

Sensor Serial #	Calibration date	Deployment dates
A	2/13/2008	2/13/2008-5/15/2009
B	2/13/2009	5/15/2009-5/7/2010

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: $\pm 5\%$

Calibration Frequency: 1 year

Sensor Serial #	Calibration date	Deployment dates
A	2/13/2008	2/13/2008-5/15/2009
B	2/13/2009	5/15/2009-5/7/2010

Parameter: Photosynthetically Active Radiation (PAR)

▲ Units: $\mu\text{moles m}^{-2}$ (total flux)

Sensor type: LI-COR Quantum Sensor. High stability silicon photovoltaic detector (blue enhanced)

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Model #: LI190SB

Light spectrum waveband: 400 to 700 nm

Temperature dependence: 0.15% per °C maximum

Stability: $\leq \pm 2\%$ change over 1 yr

Operating Temperature: -40°C to 65°C; Humidity: 0 to 100%

Sensitivity: typically 5 μA per 1000 $\mu\text{moles s}^{-1} \text{m}^{-2}$

Calibration Frequency: 2 years

Sensor Serial #	PAR Multiplier	Calibration date	Deployment dates
Q22187	1.595	5/9/2008	7/17/2008-6/18/2010

Parameter: Precipitation

Units: millimeters (mm)

Sensor type: Tipping Bucket Rain Gauge

Model #: RG-2000-C

Instrument #: PDBRG1

Rainfall per tip: 0.01 inch

Operating range: Not specified

Accuracy: $\pm 1.0\%$ at 14 inches per hour

Calibration Frequency: 1 year

Sensor Serial #	Calibration date	Deployment dates
PDBGR2	12/4/2008	12/4/2008-1/21/2010

CR1000 Measurement and Control System

Date Installed: Aug/01/2006

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.

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.

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

SIC	Incorrect Calibration Constant, Multiplier or Offset
SNV	Negative Value
SOC	Out of Calibration
SSN	Not a Number / Unknown Value
SSM	Sensor Malfunction
SSR	Sensor Removed

Comments

CAF	Acceptable Calibration/Accuracy Error of Sensor
CDF	Data Appear to Fit Conditions
CRE	Significant Rain Event
CSM	See Metadata
CVT	Possible Vandalism/Tampering

13) Other remarks/notes –

General Data

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.

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.

The following records were missing or rejected due to instrument maintenance or the data downloading process.

08/05/2009 09:15 TotPAR
10/08/2009 08:00 TotPAR

05/15/2009 13:15 All Parameters
05/15/2009 13:30 All Parameters
05/15/2009 13:45 All Parameters
09/15/2009 08:30 All Parameters

Rh Data

Relative Humidity data greater than 100 are within range of the sensor accuracy of $\pm 3\%$.

The following relative humidity data were rejected due to high Rh reading ($>103\%$). Data appears to fit conditions but is outside of sensor accuracy.

01/20/2009 01:30 through 01/20/2009 03:45
01/21/2009 01:45 through 01/21/2009 04:00
01/22/2009 17:15 through 01/22/2009 20:00
01/22/2009 23:45 through 01/23/2009 04:15

PAR Data

Small negative PAR values are within range of the sensor and are due to normal errors in the sensor and the CR1000 Datalogger. The Maximum signal noise error for the Licor sensor is ± 2.214 mmol/m² over a 15 minute interval.

All PAR data from Jan 01 @ 00:00 to Sept 15 @ 08:15 were adjusted post data download, due to an incorrect PAR multiplier in the sensor programming. Original data were divided by the incorrect PAR multiplier, then multiplied by the correct multiplier to get the corrected value. (original data/1.419)*1.595 = corrected data. Negative PAR data during this time were not flagged as $<1>$

CAF, but instead <5> CSM. Slightly elevated PAR data during this time were also not flagged as <1> CSM, but instead <5> CSM. Both the negative and slightly elevated PAR data are still considered suspect.

Elevated nighttime PAR values were recorded during some nights of the year. Nighttime PAR values <2.214 but >0 are marked as suspect, and nighttime values >2.214 were rejected. Data rejection times at dusk and dawn were based on having a < 2.0 change in the PAR value in conjunction with a preceding fall or subsequent rise in values. Daytime PAR values following rejected elevated nighttime datasets were also marked as suspect. The cause for the elevated values is suspected to be moisture intrusion into the sensor body.

PAR data from the following dates were rejected due to sensor obstruction from bird droppings. Data were rejected starting from the first recorded change in the PAR levels on Sept 19th due to the uncertainty of the time of obstruction until the sensor was cleaned on 08 Oct, 2009.

09/19/2009 06:30 TotPAR through 10/08/2009 07:45 TotPAR

All PAR data for 2009 are coded with CSM to bring attention to all of the issues that occurred during the year.

Precipitation Data

The precipitation funnel was found fully clogged with debris on May 6, 2009, probably due to recent plowing of the field. The initial clogging date is unknown. The funnel was clean during routine download and check on April 02, 2009. From April 2 through April 21, the rainfall data at the Padilla Bay Farm Station were similar to the data recorded at WSU Mt Vernon Station and Sakuma Station located 6.75 km and 8 km from the Padilla Bay Station. These data were considered accurate and not affected by the clog discovered on May 6. From April 22, 2009 00:15 to May 2, 2009 18:45, no precipitation was recorded at the Padilla Bay Farm Station, Sakuma Station or WSU Mt Vernon Station. Therefore the data were flagged as suspect because debris may have accumulated in the funnel during this time. On May 2, 2009 18:45, mean precipitation was recorded at Sakuma Station and WSU Mt Vernon Station but not at Padilla farm Station, presumably because the funnel was clogged with debris. Padilla Bay precipitation data from May 2, 2009 18:45 until May 6, 2009 13:00 (when the funnel was unclogged) were rejected. When the clog was removed, the water ran through the funnel giving an inaccurate and very high reading. Cumulative precipitation data for the rest of that day were also rejected.

Suspect data:

04/22/2009 00:15 through 05/02/2009 18:45 Totprcp
04/22/2009 00:15 through 05/02/2009 18:45 Cumprcp

Rejected data:

05/02/2009 19:00 through 05/06/2009 13:00 TotPrcp
05/02/2009 19:00 through 05/07/2009 00:00 CumPrcp

Station: **WSU Mt Vernon** Lat: 48.44, Lng: 22.39, Elevation: 23, Distance from Padilla Bay Farm MET station: 6.5 km.

Station: **Sakuma** Lat: 48.50, Lng: 122.38, Elevation: 28, Distance from Padilla Bay Farm MET station: 8 km.

Data used for comparison can be found at the following website: <http://weather.wsu.edu/awn.php>.

Exceedingly high precipitation measurements on the following date were rejected after QAQC. No precipitation was recorded throughout western WA on this day (<http://weather.wsu.edu/awn.php>) and no other recorded measurements suggest an isolated precipitation anomaly.

Rejected data:

07/30/2009 20:00 through 07/30/2009 20:45 TotPrcp

07/30/2009 20:00 through 07/31/2009 00:00 Cum Precip