

# PICO biogeochemical data collected from Duke Marine Lab dock from 2011-2022

**Website:** <https://www.bco-dmo.org/dataset/956182>

**Data Type:** Other Field Results

**Version:** 1

**Version Date:** 2025-03-17

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## Abstract

Core biogeochemical data from the Pivers Island Coastal Observatory (PICO), first described in Johnson et al. 2013. This dataset includes time-series data from ~weekly sampling near Pivers Island at the Duke University Marine Laboratory dock in Beaufort North Carolina USA. 34.7181 °N 76.6707 °W. Current dataset is from 2011-2021 and includes a variety of primary physical, chemical and biological variables.

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## Coverage

**Location:** Duke University Marine Laboratory Pivers Island Beaufort, North Carolina, USA 34.7181 °N 76.6707 °W Coastal Marine / Estuary Environment

**Spatial Extent:** Lat: 34.7181 Lon: -76.6707

**Temporal Extent:** 2011 - 2022

## Methods & Sampling

Water was sampled at ~10:30am local from a dock using a 5 L niskin bottle centered at 1 m with a bottle length of 0.7 m. Subsamples were processed immediately following water collection.

**DIC:** DIC was measured on mercuric chloride poisoned samples by acidification and subsequent quantification of released CO<sub>2</sub> using a CO<sub>2</sub> detector (Li-Cor 7000). DIC samples were collected following recommended procedures {Dickson et al., 2007} and measurements were calibrated against Certified Reference Materials provided by Dr. A. G. Dickson at Scripps Institution of Oceanography (SIO), University of California, San Diego (UCSD).

**Chlorophyll:** Methods described in Johnson et al. 2010: Chlorophyll concentrations were measured by filtering 25 mL of seawater sample onto a 0.22 µm pore size polycarbonate filter using gentle vacuum (<100 mm Hg) and extracting in 100% MeOH at -20°C in the dark for >24 h following (Holm-Hansen and Riemann, 1978). Fluorescence was measured using a Turner Designs 10-AU fluorometer following (Welschmeyer, 1994) that was calibrated against a standard chlorophyll solution (Ritchie, 2006).

**Secchi Depth:** Secchi depth was measured in duplicate using a 20 cm disk with four alternating white and

black quadrants by lowering the disk until no longer visible and recording the depth.

**Salinity:** Salinity was measured using a calibrated handheld digital refractometer (Atago PAL-06S), using a refractometer (Vista A366ATC), YSI Pro30, YSI ProODO, YSI ProSolo or using a Guideline Portasal 8410A all according to manufacturer's instructions and calibrated against known reference materials.

**Turbidity:** Turbidity reported in Nephelometric Turbidity Units [NTU] was measured in duplicate on discrete samples using a calibrated handheld turbidimeter (Orion AQ4500) according to manufacturer's instructions.

**Temperature:** Temperature was measured in duplicate using NIST traceable thermocouples (VWR#23609-232) from bottle water or from in situ probes YSI Pro30, YSI ProODO or YSI ProSolo according to manufacturer's instructions.

**pH:** pH was measured spectrophotometrically (Clayton and Byrne, 1993) in triplicate at standard temperature (25 degrees C) immediately following collection. pH samples were collected following recommended procedures (Dickson et al., 2007).

**Bacteria, *Synechococcus*, picocyanobacteria, pico-photosynthetic eukaryotes:** Bacterioplankton ("bacteria", DNA containing, non-red fluorescing populations), *Synechococcus* (small, red and orange fluorescing populations), "picocyanobacteria" (small, red fluorescing populations; includes *Prochlorococcus* and 'green' *Synechococcus*), and "picoeukaryotes" (DNA containing, red and orange fluorescing populations) were measured flow cytometrically as previously described (Johnson et al., 2010) using a BD FACSCalibur, or using Hoechst 34580 or Sybr Green I DNA stains using an Attune NxT with 405 nm excitation and 440±25, 512±13, 603±24, 710±25 nm emission and 488 nm excitation and 530±15, 574±13, 695±20, 780±30 nm emission as previously described (Selph 2021).

**Inorganic Nutrients (NH<sub>4</sub>, NO<sub>3</sub>, SiOH<sub>4</sub>):** Water was filtered through a 0.22 um Sterivex cartridge filter, Millipore #SVGPL10RC using a peristaltic pump input line at 1 m for later nutrient analysis (NO<sub>3</sub>, NH<sub>4</sub>, SiOH<sub>4</sub>). Water was sampled in duplicate into HCl-cleaned HDPE bottles (VWR#414004-110) and stored at -80 degrees C until later analysis using an Astoria-Pacific A2 autoanalyzer (NO<sub>3</sub> and SiOH<sub>4</sub>), following the manufacturer's recommended protocols by running each replicate sample in duplicate. NH<sub>4</sub> was measured in triplicate following Holmes et al. 1999 using a Turner 10-AU fluorometer. For some time points inorganic nutrients were processed by the Scripps Institute of Oceanography STS/ODF chemistry laboratory

Certified reference materials were used to verify protocols (Inorganic Ventures: QCP-NT, QCP-NUT-1, CGSI1-1). The detection limits were: NO<sub>2</sub> = 0.05 uM, NO<sub>3</sub> = 0.1 uM, PO<sub>4</sub> = 0.05 uM, SiOH<sub>4</sub> = 0.2 uM. Values measured below these limits are reported as zero.

**Production and Respiration:** Production and respiration quantified using Winkler oxygen (Labasque et al., 2004) were measured using the light/dark bottle technique with 24 h incubations at ambient temperature in a sinusoidal incubator (Sanyo MLR-351H) with ~1000 μmol quanta m<sup>-2</sup> sec<sup>-1</sup> peak PAR.

## Data Processing Description

Means, where replicates were available, were calculated and reported with standard deviations. All variable means represent n=2, except pH and DIC where n=3.

blank = missing data

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## Related Publications

Clayton, T. D., & Byrne, R. H. (1993). Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results. *Deep Sea Research Part I: Oceanographic Research Papers*, 40(10), 2115–2129. doi:[10.1016/0967-0637\(93\)90048-8](https://doi.org/10.1016/0967-0637(93)90048-8)  
*Methods*

Dickson, A.G.; Sabine, C.L. and Christian, J.R. (eds) (2007) Guide to best practices for ocean CO<sub>2</sub> measurement. Sidney, British Columbia, North Pacific Marine Science Organization, 191pp. (PICES Special Publication 3; IOCCP Report 8). DOI: <https://doi.org/10.25607/OBP-1342>

## Methods

Holm-Hansen, O., & Riemann, B. (1978). Chlorophyll a Determination: Improvements in Methodology. *Oikos*, 30(3), 438. doi:[10.2307/3543338](https://doi.org/10.2307/3543338)

### Methods

Johnson, Z. I., Shyam, R., Ritchie, A. E., Mioni, C., Lance, V. P., Murray, J. W., & Zinser, E. R. (2010). The effect of iron- and light-limitation on phytoplankton communities of deep chlorophyll maxima of the western Pacific Ocean. *Journal of Marine Research*, 68(2), 283–308. doi:[10.1357/002224010793721433](https://doi.org/10.1357/002224010793721433)

### Methods

Ritchie, R. J. (2008). Universal chlorophyll equations for estimating chlorophylls a, b, c, and d and total chlorophylls in natural assemblages of photosynthetic organisms using acetone, methanol, or ethanol solvents. *Photosynthetica*, 46(1), 115–126. doi:[10.1007/s11099-008-0019-7](https://doi.org/10.1007/s11099-008-0019-7)

### Methods

Selph, K. E. (2021). Enumeration of marine microbial organisms by flow cytometry using near-UV excitation of Hoechst 34580-stained DNA. *Limnology and Oceanography: Methods*, 19(10), 692–701. Portico.

<https://doi.org/10.1002/lom3.10454>

### Methods

Welschmeyer, N. A. (1994). Fluorometric analysis of chlorophyll a in the presence of chlorophyll b and pheopigments. *Limnology and Oceanography*, 39(8), 1985–1992. doi:[10.4319/lo.1994.39.8.1985](https://doi.org/10.4319/lo.1994.39.8.1985)

### Methods

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## Parameters

| Parameter   | Description                                   | Units    |
|-------------|---|----------|
| PICONumber  | sequential sample ID                          | unitless |
| Depth       | depth   | m        |
| Latitude    | latitude                                      | degreesN |
| Longitude   | longitude                                     | degreesE |
| DecimalYear | Decimal Year (local time)                     | year     |
| Chl         | mean Chlorophyll a                            | µg/L     |
| ChlStd      | standard deviation Chlorophyll a              | µg/L     |
| DIC         | mean Dissolved Inorganic Carbon               | µM       |
| DICStd      | standard deviation Dissolved Inorganic Carbon | µM       |
| NH4         | mean NH4                                      | nM       |

|                  |                                     |          |
|------------------|-------------------------------------|----------|
| NH4Std           | standard deviation NH4              | nM       |
| NO3              | mean NO3                            | μM       |
| NO3Std           | standard deviation NO3              | μM       |
| pH               | mean pH                             | unitless |
| pHStd            | standard deviation pH               | unitless |
| Salinity         | mean salinity                       | unitless |
| SalinityStd      | standard deviation salinity         | unitless |
| SecchiDepth      | mean Secchi depth                   | m        |
| SecchiDepthStd   | standard deviation                  | m        |
| SiOH4            | mean SiOH4                          | μM       |
| SiOHStd          | standard deviation SiOH4            | μM       |
| Temperature      | mean temperature                    | °C       |
| TemperatureStd   | standard deviation temperature      | °C       |
| Turbidity        | mean turbidity                      | NTU      |
| TurbidityStd     | standard deviation turbidity        | NTU      |
| Bacteria         | mean bacterioplankton               | cells/mL |
| BacteriaStd      | standard deviation bacterioplankton | cells/mL |
| Synechococcus    | mean Synechococcus                  | cells/mL |
| SynechococcusStd | standard deviation Synechococcus    | cells/mL |

|                      |  |            |
|----------------------|--|------------|
| picocyanobacteria    | mean picocyanobacteria                           | cells/mL   |
| picocyanobacteriaStd | standard deviation picocyanobacteria             | cells/mL   |
| picoeuks             | mean picophotosynthetic eukaryotes               | cells/mL   |
| picoeuksStd          | standard deviation picophotosynthetic eukaryotes | cells/mL   |
| O2Respiration        | mean 24h oxygen dark respiration                 | mgO2/L/day |
| O2RespirationStd     | standard deviation 24h oxygen dark respiration   | mgO2/L/day |
| O2Production         | mean 24h gross oxygen production                 | mgO2/L/day |
| O2ProductionStd      | standard deviation 24h gross oxygen production   | mgO2/L/day |

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## Instruments

|   |  |
|---|--|
| <b>Dataset-specific Instrument Name</b> |  |
| <b>Generic Instrument Name</b>          | Apollo SciTech AS-C3 Dissolved Inorganic Carbon (DIC) analyzer   |
| <b>Generic Instrument Description</b>   | A Dissolved Inorganic Carbon (DIC) analyzer, for use in aquatic carbon dioxide parameter analysis of coastal waters, sediment pore-waters, and time-series incubation samples. The analyzer consists of a solid state infrared CO <sub>2</sub> detector, a mass-flow controller, and a digital pump for transferring accurate amounts of reagent and sample. The analyzer uses an electronic cooling system to keep the reactor temperature below 3 degrees Celsius, and a Nafion dry tube to reduce the water vapour and keep the analyzer drift-free and maintenance-free for longer. The analyzer can handle sample volumes from 0.1 - 1.5 milliliters, however the best results are obtained from sample volumes between 0.5 - 1 milliliters. It takes approximately 3 minutes per analysis, and measurement precision is plus or minus 2 micromoles per kilogram or higher for surface seawater. It is designed for both land based and shipboard laboratory use. |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> |   |
| <b>Generic Instrument Name</b>          | BD FACSCalibur Flow Cytometer   |
| <b>Dataset-specific Description</b>     | Flow Cytometer: BD FACSCalibur or Invitrogen Attune NxT   |
| <b>Generic Instrument Description</b>   | The FACSCalibur flow cytometer is an autonomous benchtop flow cytometer designed for routine cell analysis, assay development, verification and identification of cellular populations. It is equipped with a blue (488 nm) air-cooled argon laser and a red (635 nm) diode laser. For each particle (cell), five optical parameters can be recorded from the 488 nm laser beam excitation: two light scatter signals, namely forward and right angle, and three fluorescences corresponding to emissions in green (530/30 nm BP), orange (585/42 nm BP) and red (670 nm LP) wavelength ranges. A far red fluorescence (661/16 nm BP) induced by the red diode can also be recorded. Data are analysed using BD Biosciences CellQuest software. Optional features include a cell sorting option, allowing users to identify and isolate a population of interest and a HTS option (High-throughput (HT) or Standard (STD) mode), where sample volumes range from 2-10 microlitres in HT mode and 2-200 microlitres in STD mode. An optional BD FACS Loader tube-lifter can be used to verify tube position and rack identification. The instrument has a capture rate of 300 cells per second, supports 40 (12 x 75 mm) tubes per rack, and has an operating temperature ranging from 16-29 degC. |

|   |  |
|---|--|
| <b>Dataset-specific Instrument Name</b> | Invitrogen Attune NxT  |
| <b>Generic Instrument Name</b>          | Flow Cytometer   |
| <b>Generic Instrument Description</b>   | Flow cytometers (FC or FCM) are automated instruments that quantitate properties of single cells, one cell at a time. They can measure cell size, cell granularity, the amounts of cell components such as total DNA, newly synthesized DNA, gene expression as the amount messenger RNA for a particular gene, amounts of specific surface receptors, amounts of intracellular proteins, or transient signalling events in living cells. (from: <a href="http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm">http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm</a> ) |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> | Astoria-Pacific A2 autoanalyzer   |
| <b>Generic Instrument Name</b>          | Nutrient Autoanalyzer   |
| <b>Dataset-specific Description</b>     | Inorganic Nutrients: Astoria-Pacific A2 autoanalyzer (NO3 and SiOH4); Turner 10-AU (NH4)  |
| <b>Generic Instrument Description</b>   | Nutrient Autoanalyzer is a generic term used when specific type, make and model were not specified. In general, a Nutrient Autoanalyzer is an automated flow-thru system for doing nutrient analysis (nitrate, ammonium, orthophosphate, and silicate) on seawater samples. |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> | YSI ProODO  |
| <b>Generic Instrument Name</b>          | Oxygen Sensor   |
| <b>Generic Instrument Description</b>   | An electronic device that measures the proportion of oxygen (O <sub>2</sub> ) in the gas or liquid being analyzed |

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|---|---|
| <b>Dataset-specific Instrument Name</b> | Atago PAL-06S   |
| <b>Generic Instrument Name</b>          | Refractometer   |
| <b>Generic Instrument Description</b>   | A refractometer is a laboratory or field device for the measurement of an index of refraction (refractometry). The index of refraction is calculated from Snell's law and can be calculated from the composition of the material using the Gladstone-Dale relation. In optics the refractive index (or index of refraction) $n$ of a substance (optical medium) is a dimensionless number that describes how light, or any other radiation, propagates through that medium. |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> | Vista A366ATC   |
| <b>Generic Instrument Name</b>          | Refractometer   |
| <b>Generic Instrument Description</b>   | A refractometer is a laboratory or field device for the measurement of an index of refraction (refractometry). The index of refraction is calculated from Snell's law and can be calculated from the composition of the material using the Gladstone-Dale relation. In optics the refractive index (or index of refraction) $n$ of a substance (optical medium) is a dimensionless number that describes how light, or any other radiation, propagates through that medium. |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> | YSI Pro30   |
| <b>Generic Instrument Name</b>          | Refractometer   |
| <b>Generic Instrument Description</b>   | A refractometer is a laboratory or field device for the measurement of an index of refraction (refractometry). The index of refraction is calculated from Snell's law and can be calculated from the composition of the material using the Gladstone-Dale relation. In optics the refractive index (or index of refraction) $n$ of a substance (optical medium) is a dimensionless number that describes how light, or any other radiation, propagates through that medium. |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> | YSI ProSolo or Guideline Portasal 8410A   |
| <b>Generic Instrument Name</b>          | Salinometer   |
| <b>Generic Instrument Description</b>   | A salinometer is a device designed to measure the salinity, or dissolved salt content, of a solution. |

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| <b>Dataset-specific Instrument Name</b> | Cary 4000  |
| <b>Generic Instrument Name</b>          | Spectrometer   |
| <b>Dataset-specific Description</b>     | pH: Spectrophotometer Cary 4000 with 10 cm cylindrical cell or Genesys 10A VIS with a 10 cm cylindrical cell                         |
| <b>Generic Instrument Description</b>   | A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum. |

|   |  |
|---|--|
| <b>Dataset-specific Instrument Name</b> | Genesys 10A VIS  |
| <b>Generic Instrument Name</b>          | Spectrometer   |
| <b>Dataset-specific Description</b>     | Production and respiration: Incubator: Sanyo MLR-351H; Spectrophotometer: Genesys 10A VIS  |
| <b>Generic Instrument Description</b>   | A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum. |

|   |  |
|---|--|
| <b>Dataset-specific Instrument Name</b> | Orion AQ4500   |
| <b>Generic Instrument Name</b>          | Turbidity Meter  |
| <b>Generic Instrument Description</b>   | A turbidity meter measures the clarity of a water sample. A beam of light is shown through a water sample. The turbidity, or its converse clarity, is read on a numerical scale. Turbidity determined by this technique is referred to as the nephelometric method from the root meaning "cloudiness". This word is used to form the name of the unit of turbidity, the NTU (Nephelometric Turbidity Unit). The meter reading cannot be used to compare the turbidity of different water samples unless the instrument is calibrated. Description from: <a href="http://www.gvsu.edu/wri/education/instructor-s-manual-turbidity-10.htm">http://www.gvsu.edu/wri/education/instructor-s-manual-turbidity-10.htm</a> (One example is the Orion AQ4500 Turbidimeter) |

|   |  |
|---|--|
| <b>Dataset-specific Instrument Name</b> |  |
| <b>Generic Instrument Name</b>          | Turner Designs Fluorometer 10-AU   |
| <b>Generic Instrument Description</b>   | The Turner Designs 10-AU Field Fluorometer is used to measure Chlorophyll fluorescence. The 10AU Fluorometer can be set up for continuous-flow monitoring or discrete sample analyses. A variety of compounds can be measured using application-specific optical filters available from the manufacturer. (read more from Turner Designs, turnerdesigns.com, Sunnyvale, CA, USA) |

|   |   |
|---|---|
| <b>Dataset-specific Instrument Name</b> |   |
| <b>Generic Instrument Name</b>          | Water Temperature Sensor  |
| <b>Dataset-specific Description</b>     | Temperature: Thermocouples (VWR#23609-232) in niskin bottle or from in situ probes YSI Pro30, YSI ProODO or YSI ProSo |
| <b>Generic Instrument Description</b>   | General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).  |



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