NOAA Atlas NESDIS 98

WORLD OCEAN DATABASE 2023
USER'S MANUAL

Hernan E. Garcia, Tim P. Boyer, Ricardo A. Locarnini, James R. Reagan, Alexey V. Mishonov, Olga K. Baranova, Christopher R. Paver, Zhankun Wang, Courtney Bouchard, Scott Cross, Dan Seidov, and Dmitry Dukhovskoy

Technical Editor: Alexey V. Mishonov

National Centers for Environmental Information
Ocean Climate Laboratory

Silver Spring, MD U.S.A.
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NOAA/NESDIS
National Centers for Environmental Information
SSMC3, 4th floor
1315 East-West Highway
Silver Spring, MD 20910
U.S.A.

Phone: +1 (828)-271-4800
Email: ncei.info@noaa.gov
WEB: https://www.ncei.noaa.gov/

For updates on the data, documentation, and additional information about the WOA23 please refer to:
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U.S. DEPARTMENT OF COMMERCE
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To Sydney (Syd) Levitus

Syd exemplifies the craft of careful, systematic inquiry of the large-scale distributions and low-frequency variability from seasonal-to-decadal time scales of ocean properties. He was one of the first to recognize the importance and benefits of creating objectively analyzed mean climatological fields of measured ocean variables including temperature, salinity, oxygen, nutrients, and derived fields such as mixed layer depth. Upon publishing the Climatological *Atlas of the World Ocean* in 1982, he distributed this work without restriction, an act not common at the time. This seminal atlas moved the oceanographic diagnostic research from using hand-drawn maps to using objectively analyzed fields of ocean variables.

With his NODC Ocean Climate Laboratory (OCL) colleagues, and unprecedented cooperation from the U.S. and international ocean scientific and data management communities, he created the *World Ocean Database (WOD)*; the world's largest collection of ocean profile data that are available internationally without restriction. The *World Ocean Atlas (WOA)* series represents the gridded objective analyses of the WOD and these fields have also been made available without restriction.

The WOD and WOA series are used so frequently that they have become known generically as the "Levitus Climatology". These databases and products enable systematic studies of ocean variability in its climatological context that were not previously possible. His foresight in creating WOD and WOA has been demonstrated by their widespread use over the years. Syd has made major contributions to the scientific and ocean data management communities. He has also increased public understanding of the role of the oceans in climate. He retired in 2013 after 39 years of distinguished civil service. He distilled the notion of the synergy between rigorous data management and science; there are no shortcuts.

All of us at the Ocean Climate Laboratory would like to dedicate this manual to Syd, his legacy, vision, and mentorship.

The Ocean Climate Laboratory Team
NOAA National Centers for Environmental Information
Silver Spring, MD;
April 2024

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Acknowledgments

This work was made possible by a grant from the National Oceanic and Atmospheric Administration (NOAA) Climate and Global Change Program, which enabled the establishment of a research group at the National Centers for Environmental Information (NCEI). The purpose of this group is to prepare research quality oceanographic databases, as well as to compute objective analyses of, and diagnostic studies based on, these databases. This work is funded in partnership with the NOAA's Global Ocean Monitoring and Observing Program (GOMO).

The World Ocean Database 2023 (WOD23, Mishonov *et al.* 2024) is the latest major update release to NOAA's World Ocean Database (WOD); the world's largest collection of uniformly formatted, quality controlled, publicly available ocean profile of Essential Ocean Variables (EOV) collected since 1772 to present. Many data were acquired as a result of the IOC/IODE Global Oceanographic Data Archaeology and Rescue (GODAR) project, the IOC/IODE World Ocean Database project, the World Data Service for Oceanography (WDS Oceanography) of the World Data System (WDS) hosted at NCEI, Global Data Acquisition Centers, IODE network of National Oceanographic Data Centers, and other global data sources.

The WOD is a composite of publicly available shared ocean profile data from all around the world, both historical and recent. We acknowledge the scientists, technicians, and programmers who have collected and processed data, those individuals who have submitted and shared data to national, regional, and global data centers as well as the data managers and staff at the various data centers. All of the originator's data in the WOD are archived at NCEI exactly as received including metadata provided by the data provider including provenance and attribution. When requested, NCEI can add a Digital Object Identifier (DOI) to new data being archived if one does not already exist. Until we have a more comprehensive system in place within the WOD metadata that includes DOIs, we direct the reader's attention to lists of primary investigators, institutions, and projects which contributed data (See WOD Code Table Library). We thank our colleagues at the NCEI. Their efforts have made this and similar works possible.

We dedicate this work to Carla Coleman who always contributed with a smile and was taken from us too soon.

I. INTRODUCTION

A. OVERVIEW

NOAA's World Ocean Database (WOD) is a scientifically quality-controlled database of historical and recent oceanographic profiles of *in situ* measured Essential Ocean Variables (EOV), Essential Climate Variables (ECV), and plankton abundance data. The WOD is a sustained effort for over 30 years to facilitate open and equitable access to the world's largest collection of uniformly formatted, quality controlled, publicly available ocean profile data collected in the oceanographic instrumental record irrespective of year of collection. WOD was conceived as a way to provide reproducibility for the World Ocean Atlas (WOA) series (Table 1a) consisting of global gridded climatological mean fields of oceanographic variables as a function of depth in the ocean.

Table 1a. *World Ocean Atlas* 2023 Volumes

Volumes	Digital Object Identifier (DOI)
Volume 1: Temperature (Locarnini *et al.* 2024a)	https://doi.org/10.25923/54bh-1613
Volume 2: Salinity (Reagan *et al.* 2024)	https://doi.org/10.25923/70qt-9574
Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, Dissolved Oxygen Saturation, and 30-year Climate Normal (Garcia *et al.* 2024a)	https://doi.org/10.25923/rb67-ns53
Volume 4: Dissolved Inorganic Nutrients: phosphate, nitrate and silicate (Garcia *et al.* 2024b)	https://doi.org/10.25923/39qw-7j08

The WOD 2023 version includes data collected by institutes and projects worldwide shared and archived at NCEI (Mishonov et al., 2024). The data spans from December 1772 to November 2023 consisting of approximately 18.6 Million casts of measured physical and chemical variables, 245,059 plankton biomass casts, 9.3 Million surface underway measurements, and 22.7 million meteorological/sea state observations (Table 1b). Figure 4 illustrated the geographic density of number of profiles. We note that WOD is updated quarterly with new and updated data that can all be freely and openly accessed online using the NCEI WOD data select and search tool (WODSelect), THREDDS, HTML, WOD Landing Page, WOD web page, and at the U.S. Government's Open Data (data.gov) catalog.

The earliest *in situ* measurements currently in the WOD are of temperature at the sea surface and at 100 fathoms (~183 m) depth. These were collected on December 15 (~55ºS, 22ºE) and 23 (~55.3ºS, 31ºE) of 1772 as well as later in January 13 (~64.5ºS, 39ºE), 1773 onboard the "His Britannic Majesty's Sloop" *HMS Resolution*, commanded by Captain James Cook. In an account of the voyage, the entry for December 23, 1772 indicates in part "On the 23d. We seized this opportunity to hoist out a boat, and continue the experiments on the current, and on the temperature of the sea" (page 102, Forster, 1777). It is likely that the temperature measurements at depth were collected using a Stephen Hales water sampling bottle or "Hales Apparatus" with an enclosed thermometer (page 591, Prestwich, 1875). All of the historical and recent data in the WOD are derived from the primary source data archived at NOAA's National Centers for Environmental Information (NCEI) as a result of global open science data sharing and international efforts including the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the World Data Service for Oceanography of the World Data System, World Meteorological Organization. Additional details such as data sources, format, and quality control are described in more detail following this overview.

The WOD is managed and developed by the NCEI Ocean Climate Laboratory (OCL) Team. The OCL Team aims to make the data in the WOD FAIR-compliant (Findable, Accessible, Interoperable, and Reusable; Wilkinson *et al.* 2016), quality controlled, and analysis-ready. All of the data and metadata are made available online free of charge and without restrictions. This is conceptually consistent with the IOC Oceanographic Data Exchange Policy and Terms of Use (2023). The WOD's metadata enables data users to search, access, and retrieve analysis-ready data. All of the data and metadata provided including data provenance and attribution in the WOD were extracted from the original data (*i.e.*, primary source) archived at NCEI. The WOD data holdings are quarterly updated with new or revised data and metadata from to the archive and placed online.

The World Ocean Database 2023 (WOD23, Mishonov *et al.* 2024) is the latest major release of the WOD. The WOD23 updates and expands on the previous World Ocean Database 2018 (WOD18; Boyer *et al. 2*018) by adding a substantial volume of measurements and data quality control flags. WOD23 includes about 18.6 million oceanographic casts (Table 1b). The WOD23 follows the same data format used in the World Ocean Database 2018 (WOD18; Garcia *et al.* 2019). A few changes have been incorporated into the WOD23. There are still additional data archived at NCEI as well as in other worldwide places that may not yet have been incorporated in the WOD. The WOD is continuously being updated as new or updated data are archived at NCEI.

The WOD includes *in situ* measurements collected as of December 31, 2022 of temperature, salinity (conductivity), dissolved oxygen, dissolved inorganic nutrients (phosphate, nitrate, nitrate + nitrite, nitrite, silicate), chlorophyll, alkalinity, pH, partial pressure of carbon dioxide (pCO_2), dissolved inorganic carbon, Tritium (^3H), Carbon-13 (^{13}C), Carbon-14 (^{14}C), Oxygen-18 (^{18}O), chlorofluorocarbons (CFC-11, CFC-12, CFC-113), Helium, Helium-3 (^3He), Neon, and plankton (Table 3a). As described in the cast description section, WOD contains metadata-rich granularity (*e.g.*, location, time, dates, methods, country, units, platform, institutions, investigators, specific descriptors of the variables such as measurement scale, instruments, methods, quality control flags, as well as plankton specific information). WOD includes Global Ocean Observing System (GOOS) variables for physics, biogeochemistry, and biology and ecology used in ocean research, diagnostic, and climate studies. The WOD participates in global ocean project activities including the International Oceanographic Data and Information Exchange (IODE) and the World Data Service for Oceanography (WDS-Oceanography) of the World Data System hosted at NCEI.

The quality-controlled data in the WOD are the primary data source for the development of the *World Ocean Atlas* (WOA) climatologies. The *World Ocean Atlas* 2023 (WOA23; Reagan *et al.* 2024) is the latest major release of the WOA series and it is based on the quality controlled data in the WOD23. The WOA23 includes objectively analyzed climatological fields of temperature, salinity, dissolved oxygen (including the parameters Apparent Oxygen Utilization and oxygen saturation), dissolved inorganic nutrients (phosphate, silicate, nitrate and nitrate + nitrite), density, conductivity, mixed layer depth, and bottom temperature (Table 1a). The data and figures in the WOA23 and previous WOA versions are available online. The WOA23 data collection can be obtained as part of the Ocean Data View (ODV, version 4.6.0 or later required) software developed by Dr. Reiner Schlitzer (Alfred Wegener Institute, AWI). The ODV ocean data collection also includes the WOA 2001, 2005, 2009, 2013, and 2018 versions.

The WOD measured data variables (temperature, salinity, conductivity, dissolved oxygen, dissolved nutrients: phosphate, nitrate and silicate) used in the development of the WOA23 climatologies received primary and secondary QC (Table 3a). The primary QC includes a comprehensive and rigorous automated data quality control (QC) in addition to Subject Matter Expert assessments. The secondary QC consists of ocean community data recalibrations and adjustments. Other variables have a more limited set of quality control tests performed (See Section III, Quality Control Procedures). The QC performed is an end-to-end process starting when the observations are added to their use in the calculation of the WOA data product series. In all cases, we have aimed to ensure clear and prominent data provenance and attribution in the data itself. Every cast in the WOD contains (when supplied) metadata information on the instrumentation, platform, project, institution, principal investigators, countries, provenance, Digital Object Identifiers (DOI). If the originator provided a DOI, this is used as the dataset DOI. If not available, NCEI can issue DOIs to datasets being archived if requested. The OCL Team aims to add these DOIs to the metadata of each dataset integrated into the WOD. The WOD metadata contains links to the original data archived at NCEI.

To understand the data structure of the WOD requires definitions of the terms "observed depth level data" and "standard depth level data". In this document, we refer to the *in situ* measurement of an oceanographic variable as an "observation" and to the depth at which such a measurement was made as the "observed depth level". We refer to such data collectively simply as "observed level data". In addition, the WOD contains observed level data interpolated to 102 standard depth levels (0-5500 m depth) if the observations did not occur at the desired standard depths (Appendix 10). The interpolation techniques follow the Joint Panel on Oceanographic Tables and Standards (JPOTS) Editorial Panel (1991) recommendations. We refer to the depth interpolated data as "standard depth level". The glossary (Appendix 15) and acronym tables provide additional information.

The WOD observed level data are depth interpolated on 102 vertical standard depth levels (0-5500m depth; Appendix 9). Since the originators' data are generally sampled on various observed depth (pressure) levels, the measurements in the profiles are interpolated to standard depth levels to facilitate their integrated analysis. Both the original measurements (observed level data) and the interpolated measurements (standard level data) are available in the WOD and each has its own set of quality control flags. No data are removed from the WOD if they fail one or more quality control checks; however, if the data fails the automatic objective tests and Subject Matter Expert (SME) assessment the data are marked with a quality control flag.

The WODselect online retrieval system allows users to search the WOD as well as any new data that are quarterly updated and added. The query results will provide a data distribution map and cast count and give the user the option to have the data extracted in the WOD native (American Standard Code for Information Interchange, ASCII), comma-separated values (.csv), and NetCDF (.nc) data formats (Appendix 12). The WOD native format and NetCDF can be directly imported into the Ocean Data View (ODV) software and other data programs.

The data in WOD are organized in datasets (Table 2). Each dataset represents a subset of data grouped by similar type of oceanographic measurements: Ocean Station Data (OSD); High-resolution Conductivity-Temperature-Depth (CTD); Mechanical/Digital/Micro Bathythermograph (MBT); eXpendable BathyThermograph (XBT); Surface (SUR); Autonomous Pinniped Bathythermograph (APB); Moored Buoy (MRB); Profiling Float (PFL); Drifting Buoy (DRB); Undulating Oceanographic Recorder (UOR); and Glider (GLD). In the remainder of this document, the following terms OSD, CTD, MBT, XBT, SUR, APB, MRB, PFL, DRB, UOR, and GLD are used (see Datasets Section)

Over the past years, a substantial number of datasets archived at the NCEI as part of the World Data Service for Oceanography (WDS) have been received as a result of projects such as the Intergovernmental Oceanographic Commission (IOC) International Oceanographic Data and Information Exchange (IODE) Global Oceanographic Data Archaeology and Rescue project (GODAR) (Levitus *et al.* 1994, 1998, 2005), NODC Global Ocean Database project, IOC IODE World Ocean Database project (Levitus, 2012), Global Temperature-Salinity Profile Program (GTSPP), World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Studies (JGOFS), Climate and Ocean: Variability, Predictability and Change (CLIVAR), Global Ocean Observing System (GOOS), Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP), Argo and Biogeochemical Argo (BGC-ARGO), Deep Argo, Global Data Acquisition Centers, CLIVAR and Carbon Hydrographic Data Office (CCHDO), IODE network of National Oceanographic Data Centers, International Council for the Exploration of the Sea (ICES), World Ocean Circulation Experiment (WOCE), Ocean Data and Information System (ODIS), and many others. The number of profiles in the WOD has increased substantially from 1982 to 2023. A description of data included in the WOD23 can be found in Mishonov *et al.* (2024).

Table 1b shows the data holdings in the database since 1974. The NCEI OCL Team has attempted to ensure that the conversion of data from the originator (*i.e.*, primary data) to the WOD native format was accurate, that duplicates were identified and removed, and that "unrepresentative" or questionable data values were flagged during the initial quality control process using quantifiable metrics and quality control flags (Table 12). When made available, the WOD preserves the QC flags by the data provider, if made available (See secondary header 96: Originator's Flags; Table 4b). In this way the data user has a choice of quality control flags or conduct their own quality control as needed. This last task is an ongoing effort. Every effort is made to identify, flag, and when possible, correct errors in the database. As scientists and data managers utilize the data in the WOD, and additional errors are identified, they will be corrected and documented. Some data that we have flagged as "unrepresentative" may not deserve this designation and therefore could be reassessed. The WOD is quarterly updated with data and metadata and posted online on the WOD web page.

Table 1b. Number of casts in the WOD product series

Dataset	NCEI (1974)[1]	NCEI (1991)[2]	WOA 1994	WOD 1998	WOD 2001	WOD 2005	WOD 2009	WOD 2013	WOD 2018	WOD 2023
OSD[3]	425,000	783,912	1,194,407	1,373,440	2,121,042	2,258,437	2,541,298	3,115,552	3,233,155	3,256,037
CTD[4]	n/a	66,450	89,000	189,555	311,943	443,953	641,845	848,911	1,089,421	1,132,680
MBT[5]	775,000	980,377	1,922,170	2,077,200	2,376,206	2,421,940	2,426,749	2,425,607	2,426,301	2,426,245
XBT	290,000	704,424	1,281,942	1,537,203	1,743,590	1,930,413	2,104,490	2,211,689	2,334,267	2,360,444
MRB[6]	n/a	n/a	n/a	107,715	297,936	445,371	566,544	1,411,762	1,656,204	1,277,591
DRB	n/a	n/a	n/a	n/a	50,549	108,564	121,828	251,712	245,592	272,872
PFL	n/a	n/a	n/a	n/a	22,637	168,988	547,985	1,020,216	2,215,341	2,748,011
UOR	n/a	n/a	n/a	n/a	37,645	46,699	88,190	88,190	127,544	127,574
APB	n/a	n/a	n/a	n/a	75,665	75,665	88,583	1,713,132	1,871,303	2,056,367
GLD	n/a	n/a	n/a	n/a	n/a	338	5,857	103,798	1,665,453	2,968,167
Total casts	**1,490,000**	**2,535,163**	**4,487,519**	**5,285,113**	**7,037,213**	**7,900,368**	**9,155,099**	**13,190,569**	**16,864,581**	**18,625,988**
Plankton	n/a	n/a	n/a	83,650	142,900	150,250	218,695	242,727	245,059	245,059
SUR[7]	n/a	n/a	n/a	n/a	4,743	9,178	9,178	9,289	9,289	9,289

[1] Based on statistics from *Climatological Atlas of the World Ocean* (Levitus, 1982).
[2] Based on NODC Standard Product: Global ocean temperature and salinity profiles (2 disc set) (NCEI Accession 0098058).
[3] WOD23 OSD dataset includes data from 179,616 low-resolution CTD and 1,708 low-resolution XCTD casts.
[4] WOD23 CTD dataset includes data from 12,741 high-resolution XCTD casts.
[5] WOD23 MBT dataset includes data from: 2,340,323 MBT, 80,200 DBT and 5,659 Micro-BT casts.
[6] MRB data submitted under NCEI Accession 0063240 in WOD18 were recorded at the 15-min interval; in 2021 those data were re-converted as daily averages, the daily average profiles matched with the first unique station number each day, and the extra stations were removed, hence total of MRB record counts in WOD23 decreased.
[7] Surface data are represented differently from cast (profile) data in the database – all observations in a single cruise have been combined into one "cast" with zero depth, value(s) of variable(s) measured, latitude, longitude, and Julian year-day to identify data and position of individual observations.

The OCL Team seeks feedback from scientists, data producers, data users, and data managers, to improve various aspects of quality control, and in particular to identify potentially questionable data and properly flag them, as well as to reassess and remove flags from data that may have been erroneously flagged as questionable. We encourage data users to provide their comments and feedback through our NCEI e-mail address at ncei.info@noaa.gov. As we receive input from users, corrections to the WOD will be implemented and amended data will be placed online on a quarterly basis. The OCL Team is committed to providing the ocean scientific community with comprehensive analysis-ready data of the highest research quality and will continue to pursue this goal.

B. DATA SOURCES AND UNITS

Open data shared with NCEI for long-term archival as of December 31, 2022 which contained subsurface *in situ* measurements of one or more of the variables listed in Table 3a or plankton measurements were potential data sources for integration into WOD23. The WOD23 includes approximately 18.7 million ocean casts with profiles of *in situ* variables (Table 1b). The WOD is not a static database. The OCL Team continues to add new and updated data and the data posted online for public access on a quarterly basis. Approximately, every 4-5 years the OCL Team generates a new version of the WOA based on the data available in the WOD at that time (*e.g.*, WOA23 based on WOD23). We note that most variables in the WOD are also EOVs for ocean physics, biogeochemistry, and biology and ecosystems as identified by the GOOS Expert Panels. A significant number of the global historical and even recent oceanographic data received for archival at NCEI are not in common digital data formats (*i.e.*, non-interoperable formats). As a result, not all submitted data received were converted in time for inclusion in the WOD23. All of the original datasets found in the WOD can be found and accessed in their original submitted form to NCEI.

All of data integrated into the WOD use a uniform format and standardized units. When necessary, the measured data were converted from their original reported unit to the WOD standard units if necessary (Table 3a; Table 3b). For example, some chemical variables were originally reported on a per volume molar concentration basis such as for example, Micromole Liter^{-1} (µmol l^{-1}). Since the seawater volume depends on temperature, salinity, and pressure through the equation of state for seawater, the chemical variables reported on a per volume basis were converted to per mass such as Micromole kilogram^{-1} (µmol kg^{-1}) of seawater (Table 3a). However, in some cases, the sample sea water density or the temperature and salinity of the sample at the time of measurement were not reported or were deemed of questionable quality and flagged. We have opted to use a constant seawater density of 1025 kg·m^{-3} in the unit conversion from a per volume to a per mass basis. In the WOD, variables such as dissolved inorganic carbon, alkalinity, and chlorophyll have not yet been converted to Micromole kilogram^{-1} (µmol·kg^{-1}). This conversion was not done in time for the release of the WOD23. Where appropriate, we plan to convert these data to µmol·kg^{-1} in future WOD quarterly data updates.

The utility of the WOD to the global ocean community as an analysis-ready data research tool would not be possible without global open data sharing. Many of the datasets included in the WOD were gathered as a result of dedicated efforts performed by various international institutions, projects, and countries. A list of the project names and codes are available online in table s_2_project in the WOD Code Table library. The OCL Team strives to provide attribution of all individual sources as proper credit of data sources is essential for traceability and highlighting the individual contributions. In the Acknowledgments, we have attempted to give credit and gratitude to all data centers, investigators, organizations, data managers worldwide for sharing their data. We note the importance of preserving the original source data in readily accessible archives for global equitable open data access and use. We also note that our observation-based approach to documenting ocean climate variability requires integration of all possible available historical oceanographic measurements.

C. DEFINITIONS

A few terms important for understanding the data structure of the WOD require definitions. These terms are accession number, cast, cruise, profile, and station. These are described in more detail in Section D and Section E as well as the glossary (Appendix 15). These terms include:

Accession number: A group of stations received and archived at the NCEI. Each dataset submitted to NCEI is given a unique accession number. Using this number, a user can get access to the original data from NCEI as well as information about the data itself. Cruises are not always subsets of accession numbers, as data from the same cruise may come from multiple accession numbers. Each station has an accession number (with a few exceptions). If a station is replaced by higher quality data, the accession number will reflect the new source of the data while the unique station number will remain unchanged. If a profile for a variable not previously stored with a station becomes available, the profile will be added to the existing station, and a profile specific accession number will be added to the station to record the source of the new profile.

Cast: A set of one or more oceanographic subsurface profiles taken concurrently. Meteorological and ocean condition information are also included for a cast if measurements were taken concurrently with the profile(s). Observations and measurements of plankton from net-tows are included if taken concurrently or in close time proximity to profiles. If there are no profiles in close proximity, a net-tow by itself will constitute a cast. Each cast in the WOD is assigned a unique cast number. If the cast is subsequently replaced by higher quality data, the unique cast number remains the same. If any alteration is made to a cast, this information is noted online, referenced by the unique cast number. For surface-only data in dataset SUR, a cast is defined as a collection of concurrent profiles of surface measurements at discrete latitudes and longitudes over an entire cruise (see definition of cruise). Profiles of latitude, longitude and Julian year-day are included with profiles of measured oceanographic variables.

Cruise: A set of casts is grouped together if they fit the cruise definition. A cruise is defined as a specific deployment of a unique platform for the purposes of a coherent oceanographic investigation. For an oceanographic research vessel, this deployment is usually well defined with a unique set of scientific investigators collecting data for a specific project or set of projects. In some cases, different legs of a deployment with the same equipment and investigators are assigned different cruise numbers, as per the investigator's designation (*e.g.*, principal investigators, chief scientists, researchers). In the case of merchant ships of opportunity, a cruise is usually defined as the time between major port calls. Profiling floats, moored buoys, and drifting buoys are assigned the same cruise number for the life of the platform. A glider deployment is defined as a cruise. For surface-only data in dataset SUR, a cast and cruise are the same, except for 27 cruises which were split into 2 casts each due to the large number of sets of measurement (> 24,000). In the WOD, a cruise identifier consists of two parts, the ISO 3166-1 country code and the unique cruise number. The unique cruise number is only unique with respect to the country code. The country code is usually assigned based on the flag under which the ship from which the data were measured operates. If the platform from which data were measured was not a ship, (*e.g.* profiling float, moored buoy, glider), the country of the primary investigator or institute which operates or releases the platform is used. For data for which no information on country is present, a country code of 99 is used. For data for which there is no way to identify a specific cruise, a cruise number of zero (0) is used. Now, all data for a cruise should be listed under one unique country code/unique cruise number combination. It should be possible to g*et al*l of the bottle (OSD), high-resolution CTD, BT, and towed-CTD data for a cruise using one unique cruise identifier. However, this is not yet the case for all BT data. It is an ongoing project to match the BT data with the correct bottle and high-resolution CTD data.

Profile: A set of measurements for a single variable (temperature, salinity, etc.) at discrete depths taken as an instrument drops or rises vertically in the water column. For surface-only data, the profile consists of measurements taken along a horizontal path. For moored buoys and drifting buoys, the instrument does not move vertically in the water column, so a profile is a discrete set of concurrent measurements from the instruments at different depths attached to the buoy.

Station: Profile measurements of one or more variables from one or more casts at one geographic location.

D. DATASETS

The data in the WOD are organized into eleven datasets that are briefly described in this section (Table 2). Mishonov *et al.* (*2*024) provides in-depth description of each dataset.

Table 2. Dataset names

Name	Description
OSD	Ocean Station Data, Low-resolution CTD/XCTD, Plankton data
CTD	High-resolution Conductivity-Temperature-Depth / XCTD data
MBT	Mechanical / Digital / Micro Bathythermograph data
XBT	Expendable Bathythermograph data
SUR	Surface-only data
APB	Autonomous Pinniped data
MRB	Moored buoy data
PFL	Profiling float data
DRB	Drifting buoy data
UOR	Undulating Oceanographic Recorder data
GLD	Glider data

Table 3a. Depth-dependent measured variables, codes, and datasets

Code	Variable Name	Standard unit (abbreviation)	Dataset(s) where variable(s) is/are stored
1	Temperature	Degrees Celsius (°C)	OSD, CTD, MBT, XBT, SUR, APB, MRB, PFL, UOR, DRB, GLD
2	Salinity	Dimensionless (unitless)	OSD, CTD, SUR, APB, MRB, PFL, UOR, DRB, GLD
3	Oxygen	Micromole kilogram^{-1} (µmol·kg^{-1})	OSD, CTD, SUR, MRB, PFL, UOR, DRB, GLD
4	Phosphate	Micromole kilogram^{-1} (µmol·kg^{-1})	OSD, SUR
6	Silicate	Micromole kilogram^{-1} (µmol·kg^{-1})	OSD, SUR
8	Nitrate and Nitrate + Nitrite	Micromole kilogram^{-1} (µmol·kg^{-1})	OSD, CTD, SUR, MRB, PFL
9	pH	Dimensionless	OSD, CTD, SUR, MRB, PFL
11	Chlorophyll	Microgram liter^{-1} (µg·l^{-1})	OSD, CTD, SUR, MRB, PFL, UOR, DRB, GLD
17	Alkalinity	Millimole liter^{-1} (mmol l^{-1})	OSD, SUR
20	Partial pressure of carbon dioxide	Micro atmosphere (µatm)	OSD, CTD, SUR, MRB, PFL
21	Dissolved inorganic carbon	Millimole liter^{-1} (mmol·l^{-1})	OSD, SUR
24	Transmissivity (Beam Attenuation Coefficient)	Per meter (m^{-1})	OSD, CTD, SUR, MRB, PFL, DRB, UOR, GLD
25	Pressure	Decibar	OSD, CTD, SUR, MRB, UOR, GLD, PFL, DRB
26	Air temperature	Degrees Celsius (°C)	SUR
29	Air pressure	Millibar (mbar)	SUR
30	Latitude	Degrees	SUR, APB, UOR
31	Longitude	Degrees	SUR, APB, UOR
32	Julian year-day^{-1}	Day	SUR, APB, UOR
33	Tritium	Tritium Unit (TU)	OSD
34	Helium	Nanomole kilogram^{-1} (nmol·kg^{-1})	OSD
35	Helium-3 (^{3}He)	Percent (%)	OSD
36	Carbon-14 (^{14}C)	Per mille (‰); parts per thousand	OSD
37	Carbon-13 (^{13}C)	Per mille (‰); parts per thousand	OSD
38	Argon	Nanomole kilogram^{-1} (nmol·kg^{-1})	OSD
39	Neon	Nanomole kilogram^{-1} (nmol·kg^{-1})	OSD
40	Chlorofluorocarbon-11	Picomole kilogram^{-1} (pmol·kg^{-1})	OSD
41	Chlorofluorocarbon-12	Picomole kilogram^{-1} (pmol·kg^{-1})	OSD
42	Chlorofluorocarbon-113	Picomole kilogram^{-1} (pmol·kg^{-1})	OSD
43	Oxygen-18 (^{18}O)	Per mille (‰); parts per thousand	OSD

Table 3b. Variable unit standard conversion constants

Description [(1)]	Value
Molar volume of oxygen gas (O_2) at STP[(2)] (liters·mole^{-1})	22.3916
Atomic weight (g·mole^{-1}) of Hydrogen atom	1.0079
Atomic weight (g·mole^{-1}) of Helium atom	4.0026
Atomic weight (g·mole^{-1}) of Carbon atom	12.0110
Atomic weight (g·mole^{-1}) of Nitrogen atom	14.0067
Atomic weight (g·mole^{-1}) of Oxygen atom	15.9994
Atomic weight (g·mole^{-1}) of Neon atom	20.1797
Atomic weight (g·mole^{-1}) of Phosphorus atom	30.9738
Atomic weight (g·mole^{-1}) of Argon atom	39.9480
Atomic weight (g·mole^{-1}) of Silicon atom	28.0855

[(1)] Standard atomic weights scaled to Carbon-12 (Lide, 1992).
[(2)] Garcia and Gordon (1992)

1. Ocean Station Data (OSD)

Historically, Ocean Station Data (OSD) referred to measurements made from an oceanographic research ships using submersible reversing thermometers to measure temperature and collecting water samples to measure other variables such as salinity, oxygen, nutrients, chlorophyll, and others. The OSD dataset includes bottle data (discreet water samples), low-resolution Conductivity-Temperature-Depth (CTD) data, Salinity-Temperature-Depth (STD) data, some surface-only data with specific characteristics, some low-resolution Expendable XCTDs, and plankton taxonomic and biomass measurements.

2. High-Resolution Conductivity-Temperature-Depth (CTD) Data

The CTD dataset contains data from Conductivity-Temperature-Depth instruments as well as STD data measured at high frequency *vs*. depth (pressure). The CTD data are treated according to their resolution. All casts with a depth increment less than two meters are considered high-resolution CTD otherwise, the casts are considered as low-resolution CTD data. The low-resolution CTD data reside within OSD dataset. High-resolution data collected by expendable Conductivity-Temperature-Depth (XCTD) instruments are also included in this dataset.

3. Mechanical/Digital/Micro Bathythermograph (MBT) Data

The MBT instrument was developed in its modern form around 1938 (Spilhaus, 1938). The instrument provides estimates of temperature as a function of depth in the upper water column. The MBT dataset contains data on water temperature profiles obtained from MBTs, Digital Bathythermograph (DBT) and Micro Bathythermograph (micro BT) instruments.

4. Expendable Bathythermograph (XBT) Data

The XBT was first deployed around 1966 and replaced the MBT in most measurement programs. This electronic instrument has a thermistor which measures temperature *vs.* depth.

Depth is calculated using the elapsed time of its free descent through the water column and fall-rate equation (See Section IV for information on XBT fall-rate error).

5. Surface (SUR) Only Data

The SUR dataset contains data collected by any *in situ* means from the surface of the ocean. The majority of the SUR observations were performed along ship routes in the Atlantic and Pacific oceans. In the SUR dataset each cruise is stored in the same form as a cast for other datasets. Each measurement has an associated latitude, longitude, and Julian year-day. The WOD concentrates on subsurface profile data. The NCEI has additional *in situ* and blended ocean surface data products such as the global hourly Integrated Surface Database (ISD), the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), and the Surface Underway Marine Database (SUMD).

6. Autonomous Pinniped (APB) Data

The APB dataset contains *in situ* temperature data from time-temperature-depth recorders (TTDR) and temperature and salinity data from CTD sensors manually attached to marine mammals such as northern elephant seals (*Mirounga angustirostris*).

7. Moored Buoy (MRB) Data

The MRB dataset contains temperature and salinity measurements collected from moored buoys located in the Tropical Pacific, tropical Atlantic, Baltic and North Seas, and other locations (*e.g.*, major ongoing equatorial buoy arrays, TAO/TRITON, PIRATA, and RAMA).

8. Profiling Float (PFL) Data

The PFL dataset contains temperature, salinity, dissolved O_2, nitrate, pH, and chlorophyll data collected from drifting profiling floats such as Profiling Autonomous Lagrangian Circulation Explorer (P-ALACE), PROVOR (free-drifting hydrographic profiler), SOLO (Sounding Oceanographic Lagrangian Observer), and APEX (Autonomous Profiling Explorer). The main source of the PFL data in the WOD is the Argo core program and the BioGeoChemical Argo (BGC-Argo), an extension of the Argo core program. Deep Argo project also provides data in the deep ocean (up to 6000m) in recent years.

9. Drifting Buoy (DRB) Data

The DRB dataset contains data collected from surface drifting buoys and drifting floats with subsurface thermistor chains. The major sources of this data include the Global Temperature and Salinity Profile Programme (GTSPP) project and Arctic buoy projects such as the Woods Hole Oceanographic Institution (WHOI) Ice Tethered Profiler (ITP) data.

10. Undulating Oceanographic Recorder (UOR) data

The UOR dataset contains data collected from a Conductivity-Temperature-Depth (CTD) probe mounted on a towed undulating vehicle.

11. Glider (GLD) Data

The GLD dataset contains data collected from reusable autonomous underwater vehicles (AUV) designed to glide from the ocean surface to a programmed depth and back while measuring temperature, salinity, depth-averaged current, and other quantities along a saw-toothed trajectory through the water.

E. CAST DESCRIPTION

In the WOD, an oceanographic cast includes seven metadata descriptors to aid searching and accessing the data according to user needs. The first five are metadata that describes the characteristics of the cast such as location, time, dates, methods, country, units, platform, institutions, investigators. Metadata use the WOD numerical identification codes. The second two set of metadata descriptors identify the measured variables and provide plankton-specific information.

(1) Primary Header: Information vital to the identification of an individual cast, such as date, time, location, International Organization for Standardization (ISO) country code, cruise code, and a unique cast number.

(2) Secondary Header: Information such as meteorological data, sea floor depth, instrument, ship (platform), institute, project, etc.

(3) Variable specific secondary header: Information specific to each individual measured variable such as originator's units, scales, instrument used, methods, etc.

(4) Character Data: Originator's cruise codes, originator's cast codes, and Principal Investigator's code.

(5) Biological Header: Information necessary to understand how biological data were sampled. "Biological" data are defined as plankton biomass (weights or volumes) and taxa-specific observations.

(6) Taxa-specific and Biomass Data: Plankton weights, volumes, and/or concentrations, for an entire sample (biomass) or for individual groups of organisms (taxa-specific).

(7) Measured Variables (Table 3a): Temperature, salinity, oxygen, phosphate, silicate, nitrate, nitrite, nitrate + nitrite, pH, chlorophyll, alkalinity, partial pressure of carbon dioxide, dissolved inorganic carbon, transient tracers, gases, and pressure data *vs*. depth. Table 3a also includes Air temperature and Air pressure variables in the SUR dataset and Latitude, Longitude, and Julian year/day variables in the SUR, APB, and UOR datasets.

1. Primary Header

The WOD primary metadata header contains information about the number of digital bytes in the cast, a unique number which identifies each cast, the International Organization for Standardization (ISO) country code, a cruise number, date, time, position, and the number and type of variables in the cast. Please note that some data have been submitted with a day of zero (0) and we have kept these in the database as such in case the WOD Team gets additional/updated information. Time and location are all written in the same format:

a) Number of significant digits after the decimal point
b) Total number of digits
c) Precision of the measurement as submitted
d) Data value

Total digits will be one more than significant digits if the value is a negative number. Total digits will also be different than significant digits if a value has been converted or identified as a trace value. The station type identifies whether the stored data are collected at observed depth levels (0) or interpolated to standard levels (1). The number and type of variables identifies the depth-dependent variables in a cast. Depth-dependent variables are listed online on the WOD code tables with their numerical identification codes (Table 3a).

2. Secondary Header

The secondary header contains metadata (information about the data) and meteorological information associated with each cast. Table 4a lists the different types of secondary header data included for each cast. A Description of the secondary headers listed in Table 4a is provided in Table 4b. All of the WOD code tables and files can be found online on the WOD code tables. Note: file names preceded by the letter "s" (*e.g.* s_1_accession) denotes a secondary header file.

Many of the meteorological variables and parameters in the WOD have World Meteorological Organization (WMO) or the NCEI code tables associated with them. The complete listings of accession numbers (secondary header 1), project codes (secondary header 2), platform codes (secondary header 3), and institution codes (secondary header 4) are quite large and therefore are placed in individual files. All files and codes can be found in the WOD code tables section. The WOD secondary header information is always in numeric format. Table 4c lists WOD metadata for WMO international codes for meteorological data and other geophysical data relating to meteorology listed in WMO (2019).

Table 4a List of secondary header variables.

ID(1)	DESCRIPTION	App(2)	ID(1)	DESCRIPTION	App(2)
1	Accession Number		**37**	Data Treatment and Storage Method (NCEI 0614)	2.17
2	Project Code		**38**	Trace Correction	
3	Platform Code		**39**	Temperature Correction	
4	Institution Code		**40**	Instrument for reference temperature (NCEI 0615)	2.18
5	Cast/Tow number		**41**	Horizontal visibility (WMO Code 4300)	2.19
7	Originator's station number		**45**	Absolute Humidity (g/m^3)	
8	Depth Precision		**46**	Reference/Sea Surface Temperature	
9	Ocean Weather Station	2.1	**47**	Sea Surface Salinity	
10	Bottom Depth (meters)		**48**	Year in which probe was manufactured	
11	Cast Duration (hours)		**49**	Speed of ship (knots) when probe was dropped	
12	Cast Direction (down assumed)	2.2	**54**	Depth fix	2.20
13	High-resolution pairs		**71**	Real time	
14	Water Color	2.3	**72**	XBT Wait (code no longer used)	
15	Water Transparency (Secchi disk)		**73**	XBT Frequency (code no longer used)	
16	Wave Direction (WMO 0877 or NCEI 0110)	2.4	**74**	Oceanographic measuring vehicle	2.21
17	Wave Height (WMO 1555 or NCEI 0104)	2.5	**77**	Mole fraction of CO_2 in the headspace (xCO_2) in ppm.	
18	Sea State (WMO 3700 or NCEI 0109)	2.6	**81**	Partial pressure of CO_2 calculation method	2.22
19	Wind Force (Beaufort scale or NCEI 0052)	2.7	**82**	Partial pressure of CO_2 equilibrator type	2.23
20	Wave Period (WMO 3155 or NCEI 0378)	2.8	**84**	ARGOS fix code	2.24
21	Wind Direction (WMO 0877 or NCEI 0110)	2.9	**85**	ARGOS time (hours) from last fix	
22	Wind Speed (knots)		**86**	ARGOS time (hours) to next fix	
23	Barometric Pressure (millibars)		**87**	Height (meters) of XBT launch	
24	Dry Bulb Temperature (°C)		**88**	Depth of sea surface sensor	
25	Wet Bulb Temperature (°C)		**91**	Database ID	2.25
26	Weather Conditions (WMO 4501/4677)	2.10	**92**	UKHO Bibliographic Reference Number	2.26
27	Cloud Type (WMO 0500 or NCEI 0053)	2.11	**93**	Consecutive profile in a tow segment	
28	Cloud Cover (WMO 2700 or NCEI 0105)	2.12	**94**	WMO Identification Code	
29	Probe Type	2.13	**95**	Originator's Depth unit	2.27

ID[1]	DESCRIPTION	App[2]	ID[1]	DESCRIPTION	App[2]
30	Calibration Depth		**96**	Originator's flags	**2.28**
31	Calibration Temperature		**97**	Water Sampler	**2.29**
32	Recorder (WMO 4770)	**2.14**	**98**	ARGOS ID number	
33	Depth Correction		**99**	Time stamp (YYYYJJJ, Y=year, J= year day) to indicate when ASCII version of cast was created	
34	Bottom Hit				
35	Digitization Method (NCEI 0612)	**2.15**			
36	Digitization Interval (NCEI 0613)	**2.16**			

(1) "ID" column represents the code assigned to each secondary header. Some values are provided by the data originator or assigned by the OCL Team.
(2) "App" indicates the Appendix where the code list is found and available on line the WOD code table. If the App is missing, see Table 4b for a description.

Table 4b Description of the secondary header variables listed in Table 4a.

Code	Description (1)
1	Accession number: a unique number assigned to each group of oceanographic data received at NCEI for long-term archival (s_1_accession in CSV, comma-separated values)
2	Project: identifies the program or project (s_2_project in CSV, comma-separated values)
3	Platform: identifies the platform (*e.g.,* research ship) used to collect the data (s_3_platform in CSV, comma-separated values)
4	Institution: code identifies the institution which sampled the data (s_4_institute in CSV, comma-separated values)
5	Cast/Tow Number: sequential number representing each over-the-side operation or discrete sampling at a cast or continuous tow. This is assigned by the OCL Team.
7	Originator's station number: numeric station number assigned by the data submitter or data originator
8	Depth Precision: precision of the depth field (number of digits to the right of the decimal)
9	Weather Station: identifies data from the various ocean weather stations; a list of Ocean Weather Stations are found in Appendix 2.1 (s_9_weather_station in CSV, comma-separated values)
10	Bottom depth: depth from water surface to the bottom, in meters
11	Cast duration: duration of the cast, in hours
12	Cast Direction: if a direction is not present, down is assumed, description of codes found in Appendix 2.2 (s_12_cast_direction in CSV, comma-separated values)
13	High-resolution pairs: unique cast number identifying where high-resolution CTD and low-resolution OSD data are both available
14	Water Color: a modified Forel-Ule color scale is used (Appendix 2.3). Codes include values that are not in the Forel-Ule Scale (values > 21) (s_14_water_color in CSV, comma-separated values)
15	Water transparency: Secchi disk visibility depth, in meters

Code	Description [1]
16	Wave Direction (WMO 0877): description in Appendix 2.4 (s_16_wave_direction in CSV, comma-separated values)
17	Wave Height (WMO 1555): description in Appendix 2.5 (s_17_wave_height in CSV, comma-separated values)
18	Sea State (WMO 3700): description in Appendix 2.6 (s_18_sea_state in CSV, comma-separated values)
19	Wind Force (Beaufort Scale): description in Appendix 2.7 (s_19_wind_force in CSV, comma-separated values)
20	Wave Period (WMO 3155 or NCEI 0378): description in Appendix 2.8; note that NCEI code 0378 is not equivalent to WMO 3155, therefore these data need to be used with caution unless the users can identify which code was reported (s_20_wave_period in CSV, comma-separated values)
21	Wind Direction (WMO 0877): description in Appendix 2.9 (s_21_wind_direction in CSV, comma-separated values)
22	Wind speed: surface or near-surface wind speed, in knots
23	Barometric pressure: the atmospheric pressure at sea level due to the gravitational force on the column of air above it (milli-bar)
24	Dry bulb temperature: identical to air temperature, in °C
25	Wet bulb temperature: the temperature a parcel of air would have if it were cooled adiabatically with no heat transfer, in degrees Celsius (°C)
26	Weather Condition (WMO 4501 and WMO 4677): description in Appendix 2.10 (s_26_weather_condition in CSV, comma-separated values)
27	Cloud Type (WMO 0500): description in Appendix 2.11 (s_27_cloud_type in CSV, comma-separated values)
28	Cloud Cover (WMO 2700): description in Appendix 2.12 (s_28_cloud_cover in CSV, comma-separated values)
29	Probe Type: list of sampler types; listing in Appendix 2.13 (s_29_probe_type in CSV, comma-separated values)
30	Calibration Depth: deviation on a bathythermograph (BT) from the zero depth. This difference between points was used to adjust the profile when it was digitized
31	Calibration Temperature: deviation on a BT from a 16.7°C reference point. This difference between points was used to adjust the profile when it was digitized
32	Recorder Type (WMO 4770): description in Appendix 2.14 (s_29_probe_type in CSV, comma-separated values)
33	Depth Correction: a second header code 33 is set to zero (0) if the original depth time equation was used for the XBT data collected after a corrected depth time equation was introduced; a one (1) is assigned if a corrected depth time equation was used; a -1 if the depth-time equation used is unknown (see XBT depth-time correction section)
34	Bottom Hit: a one (1) is assigned if the probe hits the bottom
35	Digitization Method (NCEI 0612): description in Appendix 2.15 (s_35_digitization_method in CSV, comma-separated values)
36	Digitization Interval (NCEI 0613): description in Appendix 2.16 (s_36_digitization_interval in CSV, comma-separated values)

Code	Description (1)
37	Data Treatment and Storage (NCEI 0614): See Appendix 2.17 (s_37_data_storage in CSV, comma-separated values)
38	Trace Correction: average difference between the surface trace and the surface depth line of the grid for a BT
39	Temperature Correction (°C): correction for difference between reference temperature and BT reading or correction to the original data by the submitter – in some cases the correction has already been applied
40	Instrument for Reference Temperature (NCEI 0615): description in Appendix 2.18 (s_40_ref_instrument in CSV, comma-separated values)
41	Horizontal Visibility (WMO 4300): description in Appendix 2.19 (s_41_visibility in CSV, comma-separated values)
45	Absolute Humidity ($g \cdot m^{-3}$): sometimes referred to as the vapor density, the ratio of the mass of water vapor present to the volume occupied by the moist air mixture present in the atmosphere
46	Reference/Sea Surface Temperature: temperature used to check the probe or a separate measure of sea surface temperature
47	Sea Surface Salinity of the layer of sea water nearest to the atmosphere
48	Year: in which probe was manufactured
49	Speed: ship speed (knots) when probe was dropped
54	Depth Fix: equation needed to calculate correct depth described in Appendix 2.20. (s_54_needs_depth_fix in CSV, comma-separated values)
71	Real time: identifies data received over the WMO Global Telecommunication System within 24 hours of measurement. Real time data is identified with the number one (1)
72	XBT Wait: is the time difference between the launch of the probe and the time it begins recording data (NB: this code is no longer used)
73	XBT Frequency: is the sampling rate of the recorder (NB: this code is no longer used)
74	Oceanographic Measuring Vehicle: Appendix 2.21 lists the different types of vehicles which carry oceanographic instruments (s_74_ocean_vehicle in CSV, comma-separated values)
77	Mole fraction of CO_2 in the headspace (xCO_2)
81	Partial pressure of pCO_2 calculation method: Appendix 2.22 (s_81_pCO2_calc_method in CSV, comma-separated values)
82	Partial pressure of pCO_2 equilibrator type: Appendix 2.23 (s_82_equilibrat_type in CSV)
84	ARGOS Fix Code: ARGOS satellite fix and location accuracy, description in Appendix 2.24 (s_84_argos_fix in CSV, comma-separated values)
85	ARGOS time (hours) from last fix: used to calculate position of APB
86	ARGOS time (hours) to next fix: used to calculate position of APB
87	Height (meters) of XBT launcher
88	Depth of sea surface sensor (meters)
91	Database ID: Identifies source of data description in Appendix 2.25 (s_91_database_id in CSV)
92	United Kingdom Hydrographic Office (UKHO) Bibliographic Reference number: source for digitized cards from the UKHO (vessels, institutes, sea area); description in Appendix 2.26 (s_92_ukho_ref in CSV, comma-separated values)
93	Consecutive profile in tow segment: used to identify one up or down half cycle in underway data
94	WMO Identification code: code assigned to buoys or profiling floats by WMO
95	Originator's Depth Unit: units used by the data originator to report depth values. If code is

Code	Description [1]
	absent, depths were reported in meters; description in Appendix 2.27 (s_95_depth_unit in CSV, comma-separated values)
96	Originator's Flags: Appendix 2.28 lists the data quality flags submitted by the data originator. These flags are assigned only to the observed depth data. If this code is absent, there are no originator's flags (s_96_origflagset in CSV, comma-separated values)
97	Water Sampler: devices used to capture water sample (bucket, specific bottle type) described in Appendix 2.29 (s_97_sampler in CSV, comma-separated values)
98	ARGOS ID number: assigned by the ARGOS project office
99	Time Stamp: in format YYYYJJJ (where YYYY=year, JJJ=Julian year day) time stamp when the ASCII version of a cast was created

[1] The WOD codes can be found online in the WOD Code Tables web page

Table 4c. WMO international codes

WMO Code	Description [1]
0200	Characteristic of Pressure tendency
0439	Ice of land origin
0509	Type of high cloud
0513	Type of Low cloud
0515	Type of Middle cloud
0639	Concentration or arrangement of sea ice
0700	Direction or bearing in one figure
0739	True bearing of principal ice edge
0877	Direction in two figures
1600	Cloud base height
1751	Ice accretion on ships
1819	Indicator for inclusion or omission of precipitation data
2700	Cloud amount
3333	Quadrant of the globe
3551	Ice accretion rate
3590	Amount of precipitation
3739	Stage of development of sea ice
4019	Duration of period of reference for amount of precipitation
4377	Horizontal visibility
4451	Ship's average speed
4561	Past weather
4677	Present Weather
5239	Present ice situation and trend

[1] Details available in WMO (2019)

3. Variable specific Secondary Header

The variable specific secondary headers contain metadata explicitly associated with each variable. Table 5a lists the different types of variable specific secondary header information included for each cast. The "App" Column indicates the Appendix where the code list is found; the "ID" column represents the code number assigned to each variable specific second header. Table 5b provides a description of the variable specific secondary headers listed in Table 5a.

Table 5a. List of Variable specific Second Headers.

ID[1]	DESCRIPTION	App[2]	ID[1]	DESCRIPTION	App[2]
1	Accession number		12	Incubation time	3.7
2	Project		13	CO_2 sea warming	
3	Scale	3.1	15	Analysis temperature	
4	Institution		16	Uncalibrated	
5	Instrument	3.2	17	Contains nitrite	
6	Methods	3.3	18	Normal Standard Seawater batch	
8	Originator's units	3.4	19	Adjustment	
10	Equilibrator type	3.5	23	Primary minimum depth (not in use)	
11	Filter type and size	3.6	24	Mode	

(1) "ID" column represents the code assigned to each secondary header
(2) "App" indicates the Appendix where the code list is found and available on line in the WOD code table. If the App is missing, see Table 5b for a description.

Table 5b. Description of the variable specific second headers in Table 5a

Code	Description [1]
1	**NCEI accession number**: unique number assigned by NCEI to each batch of data received (v_1_accession). Sometimes the variables for a cast are received at different times or from different sources and therefore may have different accession numbers. We have attempted to merge these casts together and kept the source information intact
2	**Project**: identifies the research project associated with the data collection. See v_2_project for a list of projects in the WOD
3	**Scale**: The units for temperature and salinity are based on the internationally agreed referenced measurement standards (*i.e.* ITS Temperature Scale, Practical Salinity Scale, and pH scales). Table 3a provides the detailed list of variables and units. Appendix 3.1 provides the list of scale codes
4	**Institution**: identifies institution (*e.g.*, organization, university, center) associated with the investigator who sampled the specific variable (v_4_institute)
5	**Instrument**: Appendix 3.2 provides a list of instruments (*e.g.*, tool, apparatus, measuring device) used (v_5_instrument)
6	**Methods**: Appendix 3.3 lists methods (*e.g.*, procedure, measuring protocol, technique) associated with each variable measured. This list represents the methods reported with the data submitted and is not a comprehensive list of available variable methods (v_6_measure_method)
8	**Originator's units**: Appendix 3.4 identifies the submitter's original measurement units (v_8_orig_units)

Code	Description [1]
10	**Equilibrator type**: describes the design or type of instrument used for equilibrating seawater with air in preparation for measuring CO_2 concentrations (Appendix 3.5)
11	**Filter type and size** (Appendix 3.6)
12	**Incubation time**: 25 is dawn to noon, 26 is noon to dusk; otherwise, value is in hours (Appendix 3.7)
13	**CO_2 sea warming**: temperature difference between the sea surface temperature (SST) and that inside the CO_2 equilibrator.
15	**Analysis temperature**: Temperature of the seawater at the time of CO_2 analysis;
16	**Uncalibrated**: set to 1 if instrument is uncalibrated;
17	**Contains nitrite**: Set to 1 if nitrate value is actually the sum of nitrate + nitrite;
18	**Standard Seawater batch**: the code gives the International Association for the Physical Sciences of the Oceans (IAPSO) normal standard seawater batch number, P-Series (*i.e.* code 78 means normal standard seawater batch P78).
19	**Adjustment**: this is a data adjustment (*e.g.*, correction, calibration) value made to Argo profiling floats by the Argo project data management. The adjustment is a real value (*i.e.* decimal number) and is the mean difference between original (real-time) and adjusted (delayed-mode) profile of temperature, salinity, oxygen, or pressure for all values below 500 meters depth. If a profile has an adjustment value (even if this value is 0.0, it indicates that the profile has gone through additional quality control by the Argo project and is considered either adjusted real-time or delayed-mode data. Note that Argo and BGC Argo provide data in real time, adjusted real-time, and delayed mode (see variable specific second header 24; mode).
22	**Reported uncertainty**: The Argo data management provides a statistical uncertainty assigned to each observation based on both the sensor accuracy and the correction accuracy
23	**Primary minimum depth (not in use):** For a period of time Argo profilers had two sensor packages, one which switched off around 5 meters depth from the surface to preclude biofouling and another which switched on at 20 meters from the surface and continued measuring until the surface was broken. We combined this information from the two sensor packages, with the primary minimum depth the shallowest depth at which the primary sensor information was used, with the remaining shallower depths from the surface sensor. Primary sensor information was used when both sensors were measuring. This variable is no longer needed since Argo now does the sensor data combinations themselves, but is still available for some older floats.
24	**Mode:** Argo and BGC Argo provide data in real-time (mode 1), delayed (mode 2), and adjusted real-time (mode 3). Real-time data, including adjusted real-time, are quality-controlled and flagged using an automated procedure and are typically available/distributed within 24 hours of the observation Delayed-mode data are often available 12-18 months later. The Argo user's manual provides additional information (Argo data management, 2022).

[1] The WOD codes can be found in the WOD Code Tables web page

4. Character Data and Principal Investigator Code

Character data are used to report the originator's cruise identification and the originator's station identification, if provided, which could be in alphanumeric format. If the originator's code is purely numeric, it will be found in second header code 7.

The Principal Investigator (PI), if present, is also identified by numeric code and by variable code. The PI is the person (or persons), responsible for data collection and this information is included whenever available. A list of the numeric codes associated with each PI can be found in the WOD code tables (primary_investigator_list). For the purpose of assigning PI codes, plankton data are identified as variable 14 for all plankton, -5002 for zooplankton, and -5006 for phytoplankton.

5. Biological Header

The biological header section contains information on the sampling methods used for collecting taxonomic and biomass data (Appendix 4). The different types of biological header information included for each cast, if the metadata was available, are listed in Table 6a. Table 6b describes in more detail the biological header variables

Table 6a. List of biological header variables.

ID[1]	DESCRIPTION	App[2]	ID[1]	DESCRIPTION	App[2]
1	Water volume filtered (m^3)		**14**	Tow distance (meters)	
2	Sampling duration (minutes)		**15**	Average towing speed (knots)	
3	Mesh size (micro-meter)		**16**	Sampling start time (Greenwich Mean Time, GMT)	
4	Type of tow	4.1	**18**	Flowmeter type	4.3
5	Large removed volume (milli-liter)		**19**	Flowmeter calibration	4.7
6	Large plankters removed	4.2	**20**	Counting institution	
7	Gear code	4.3	**21**	Voucher Institution	
8	Sampler volume (liters)		**22**	Wire angle start (degrees)	
9	Net mouth area (squared meter)		**23**	Wire angle end (degrees)	
10	Preservative	4.4	**24**	Depth determination method	4.8
11	Weight method	4.5	**25**	Volume method	4.9
12	Large removed length (centimeter)		**30**	Accession number for the biology	
13	Count method	4.6			

[1] "ID" column represents the code assigned to each secondary header.
[2] "App" indicates the Appendix where the code list is found and available on line in the WOD code table. If the App is missing, see Table 6b for a description.

Table 6b. Description of the biological header codes in Table 6a

Code	Description[1]
1	**Water volume filtered**: total volume of water filtered by the sampling gear (m^3)
2	Sampling duration: time over which the sampling gear was towed, in minutes;
3	**Mesh size**: pore size of the sampling device, in micrometers;
4	**Type of tow**: towing method used (*e.g.*, horizontal, vertical, oblique) – Appendix 4.1;
5	Large removed volume: the minimum volume criteria for removing large plankters, in ml, see also code 12;
6	**Large plankters removed**: if large plankters were specified as being removed (1) or not removed (2), this code is added. See codes 5 and 12 in Appendix 4.2;
7	**Gear code**: type of gear used (*e.g.*, plankton net, bottle, MOCNESS) – Appendix 4.3;
8	**Sampler volume**: internal volume of the sampling gear (*e.g.,* Niskin bottle), in liters;
9	**Net mouth area**: mouth or opening area of the sampling gear, in m^2. If mouth diameter was provided, area was calculated as: area = π (0.5 diameter)^2;
10	**Preservative**: type of preservative used for the plankton sample (Appendix 4.4);
11	**Weight method**: method used for weighing the plankton sample (Appendix 4.5);
12	**Large removed length**: the minimum size/length criteria for removing large plankters, in cm, see also code 5;
13	**Count method**: method used for counting the plankton sample (Appendix 4.6);
14	**Tow distance**: distance over which sampling gear was towed, in meters;
15	**Average tow speed**: average speed used to tow the sampling gear, in knots;
16	**Sampling start time**: GMT;
18	**Flowmeter type**: the brand and/or model of the flowmeter used (Appendix 4.3);
19	**Flowmeter calibration**: the calibration frequency for the flowmeter (Appendix 4.7);
20	**Counting Institution**: the Institution responsible for identifying and counting the taxa-specific sample (b_21_institutes);
21	**Voucher Institution**: the location (Institution) of the taxa-specific sample voucher (b_21_institutes; same as institute code);
22	**Wire angle start**: wire angle of the towing apparatus at sampling start, in degrees;
23	**Wire angle end**: wire angle of the towing apparatus at sampling end, in degrees.
24	**Depth determination method**: a code indicating that depth was calculated from wire angle and length or a PI-specific "target depth" (Appendix 4.8);
25	**Volume method**: the method used for measuring the volume of the plankton sample (Appendix 4.9);
30	**Accession number for biology**: NCEI dataset identification for the biological component of the current cast (v_1_accession).

[1] The WOD codes can be found online in the WOD Code Tables web page

6. Taxa-specific and Biomass Data

The typical plankton cast, as represented in WOD, stores taxon specific and/or biomass data in individual sets of unique observations, called "Taxa-Record". Each "Taxa-Record" contains a taxonomic description, depth range (the upper and lower depth) of observation, the original measurements (*e.g.*, abundance, biomass or volume), and all provided qualifiers (*e.g.*, life stage, sex, size, etc.) required to represent that plankton observation.

Each unique taxonomic description, depth range, or measurement has its own "Taxa-Record". For example:

- Biomass (displacement volume) measured from 0-100m, and 200-500m, will have two "Taxa-Records", one for each depth range,
- Biomass (displacement volume and wet weight) measured from 0-250m will have two "Taxa-Records", one for each type of biomass measurement,
- A taxa-specific measurement of a single species, counted at five bottle depths, will have five "Taxa-Records", one for each depth,
- A taxa-specific measurement of ten species, counted at five bottle depths, will have 50 "Taxa-Records", five depths multiplied by ten species.

Note that taxa with different taxonomic descriptors (*e.g.,* life stage, sex code) are treated as different unique taxonomic descriptions, and are stored in different Taxa-Records. For example: *Calanus* eggs, *Calanus* juveniles, *Calanus* adults (male), and *Calanus* adults (female) would be stored as four separate observations, each with the same genus, but differing in their taxon life stage and/or taxon sex.

Table 7a lists the different types of taxa-specific and biomass data fields for each Taxa-Record, if the information is available (See Table 7b for descriptions of the data fields). Each cast can have multiple Taxa-Records, and each Taxa-Record can contain any of the fields in Tables 7a (See Appendix 5 for taxonomic data). Similar to the biological header information, much of the information is represented by codes. The codes for these variables are listed in Appendices 3.4, 5.1 through 5.11, and 6 as well as in the WOD code tables. The "App" column indicates the Appendix where the code table is found; the "ID" column represents the code number assigned to each biomass and taxon-specific variable. The term "UNIT" refers to the originator's units (code 20).

Scientific taxonomic names in the plankton description follow the Integrated Taxonomic Information System (ITIS) as an authority table, and are represented in WOD under the ITIS taxonomic serial number (t_1_taxa_list). This approach was not applied for all plankton descriptions. For example, non-scientific descriptions such as "gelatinous organisms", combinations of multiple species in a single description, and "total haul biomass" measurements cannot be represented using ITIS. Therefore, ancillary codes were developed to preserve these original descriptions. Table 8 provides a list of value ranges for all Variable number code values present in WOD.

Table 7a. List of biomass and taxa-specific variables.

ID[1]	DESCRIPTION	App[2]	ID[1]	DESCRIPTION	App[2]
1	Variable number (> 0 ITIS taxon code, < 0 WOD taxon or group code)		**15**	Taxon ash-free weight (mg or ng·UNIT^{-1})	
2	Upper depth (meters)		**16**	Taxon feature	5.6
3	Lower depth (meters)		**17**	Taxon modifier	5.7
4	Biomass value		**18**	Size min (milli-meter)	5.8
5	Taxon life stage	5.1	**19**	Size max (milli-meter)	5.8
6	Taxon sex code	5.2	**20**	Originator's Unit	3.4
7	Taxon present	5.3	**21**	Taxon radius (micro-meter)	
8	Taxon trophic mode	5.4	**22**	Taxon length (micro-meter)	
9	Taxon realm	5.5	**23**	Taxon width (micro-meter)	
10	Taxon count (count of taxon·UNIT^{-1})		**25**	Taxon carbon content (mg or ng·UNIT^{-1})	
11	Sample-specific sample volume (m^3 or ml·UNIT^{-1})		**26**	Count method	5.9
12	Taxon volume (ml or pl·UNIT^{-1})		**27**	Common Base-unit Value (CBV)	5.10
13	Taxon wet weight (g or µg·UNIT^{-1})		**28**	CBV calculation method	5.11
14	Taxon dry weight (g or µg·UNIT^{-1})		**30**	Plankton Grouping Code (PGC)	6

[1] "ID" column represents the code assigned to each secondary header

[2] "App" indicates the Appendix where the code list is found and available on line the WOD code tables. If the App is missing, see Table 7b for a description.

Table 7b. Description of biomass and taxa specific variables

Code	Description (1)
1	**Variable number**: identifies the type of taxon or biomass sampled. See Table 8 for a breakdown of these codes and complete numerically sorted taxonomic list available on-line
2	**Upper depth**: the shallowest depth of the sample, in meters
3	Lower depth: the deepest depth of the sample, in meters
4	**Biomass value**: contains biomass value measured, units are specified by the biomass variable code (Table 8 and Appendix 5.8)
5	**Taxon life stage**: a specific life stage indicated for a taxonomic observation (*e.g., Calanus finmarchicus,* nauplii) – Appendix 5.1
6	**Taxon sex code**: a specific sex indicated for a taxonomic observation (*e.g., Calanus finmarchicus,* female) – Appendix 5.2
7	**Taxon present**: a non-numeric description of the relative abundance, presence indicator (*e.g.,* "rare", "common", "dominant") – Appendix 5.3
8	**Taxon trophic mode**: a specific trophic description for a taxonomic observation (*e.g.,* autotrophic *picoplankton*) – Appendix 5.4
9	**Taxon realm**: a specific realm description for a taxonomic observation (*e.g.* bathypelagic *fish*) – Appendix 5.5
10	**Taxon count**: the number of an individual taxon counted, in count per unit (as specified by code 20)
11	**Sample-specific sample volume**: used only when each sample within a tow has a different sample volume (*e.g.,* the different volumes filtered by each net of a MOCNESS net). If the value is > 0, the units are in "m^3 per UNIT". If the value is < 0, the units are in "ml per UNIT", where UNIT is specific by code 20
12	**Taxon volume**: the volume of an individual taxon counted. If the value is > 0, the units are "ml per UNIT". If the value is < 0, the units are "nl per UNIT", where UNIT is specific by code 20
13	**Taxon wet weight**: the wet weight of an individual taxon counted. If the value is > 0, the units are "g per UNIT". If the value is < 0, the units are "mg per UNIT", where UNIT is specified by code 20
14	**Taxon dry weight**: the dry weight of an individual taxon counted. If the value is > 0, the units are "g per UNIT". If the value is < 0, the units are "mg per UNIT", where UNIT is specific by code 20
15	**Taxon ash-free dry weight**: the ash-free dry weight of an individual taxon counted. If the value is > 0, the units are "mg per UNIT". If the value is < 0, the units are "ng per UNIT", where UNIT is specific by code 20
16	**Taxon feature**: a specific feature or shape indicated in a taxonomic observation (*e.g.,* athecate *Dinoflagellate*) – Appendix 5.6
17	**Taxon modifier**: a specific taxonomic identity description for a taxonomic observation (*e.g., Calanus* spp., *Ceratium* sp. A, *Ceratium* sp. B, *Ceratium* spp., other) – Appendix 5.7
18	**Minimum size range description**: the smaller size range used in a taxonomic description. If the value is > 0, the units are "mm". If the value is < 0, it is a code (-1 = small, -2 = medium, -3 = large, -4 = very small, as provided in the original taxonomic description – Appendix 5.8
19	**Maximum size range description**: the larger size range used in a taxonomic description, in mm– Appendix 5.8
20	**Originator's Unit**: additional unit identifier for biomass and taxa-specific measurements (Appendix 3.4)
21	**Taxon radius description**: the radius (0.5 diameter) used in a taxonomic description, in µm

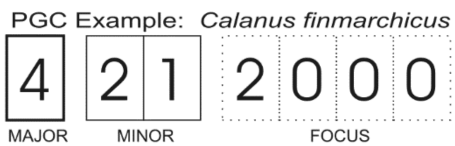
Code	Description [1]
22	**Taxon length description**: the length or height used in a taxonomic description, in micro-meter (µm);
23	**Taxon width description**: the width or shortest-dimension used in a taxonomic description, in micro-meter (µm)
25	**Taxon carbon content**: the carbon content of the individual taxon counted. If the value is > 0, the units are "gr per UNIT". If the value is < 0, the units are "mg per UNIT", where UNIT is specific by code 20
26	**Count method**: used only when multiple methods are used within a single measurement (*e.g.* to distinguish bacterial groups discerned and counted by different staining and/or fluorescent techniques within a single sample) – Appendix 5.9
27	**Common Base-unit Value (CBV)**: a "per-unit-volume" common base-unit value calculated from original value using sampling metadata (*e.g.,* towing distance, water volume filtered) – Appendix 5.10
28	**CBV calculation method**: method used for calculating the CBV – Appendix 5.11
30	**Plankton Grouping Code (PGC)**: A Smart-Index indicates a plankton taxa's membership in up to four tiered groups (O'Brien 2007)

[1] The WOD codes can be found online in the WOD Code Tables web page

Table 8. Summary of Taxa Variable Number Codes.

Value Range	Description
1 to 700000	Official ITIS Code (*Full taxonomic detail are available on the ITIS web site.)*
-400 to -405 **-500 to -503**	Biomass Code (*e.g., All Biomass Types, Total Displacement Volume, Total Wet Mass, etc.)*
-1000 to -1999	"Failed ITIS Review" Code *(ITIS was unable to verify its validity. Description may be non-existent, non-taxonomic, or unidentified)*
-5000 to -5999	"Non-taxonomic Group" Code (*e.g., "gelatinous organisms")*
-6000 to -6999	"Multiple taxa group" Code *(e.g., "Foraminifera & Radiolaria")*
-7000 to -9999	"Pending ITIS Review" Code *(ITIS verification in-progress as of WOD release)*

In addition to the original plankton descriptions, each "Taxa-Record" also contains a supplemental WOD grouping index – Plankton Grouping Code (PGC) code 30 (O'Brien, 2007). The PGC code follows the taxonomic hierarchy presented in *The Five Kingdoms* (Margulis and Schwartz 1998). It places each taxon into broader groups (*e.g., "*phytoplankton", "diatoms", "zooplankton", "copepods") which allows the WOD user access to hundreds of individual taxons by using a single PGC code. Appendix 6 lists the PGC groups and codes available in WOD. Earlier versions of the *World Ocean Database* (2005, 2001) used a PGC precursor index called the Biological Grouping Code (O'Brien *et al.* 2001). The PGC combines the BGC's separate "protist" grouping with the "phytoplankton" group. The latest WOD contains PGC codes that replaced the corresponding BGC codes.



The PGC is a 7-digit code divided into Major (*e.g. Bacteria, Phytoplankton, Zooplankton*), Minor (*e.g. cyanobacteria, diatoms, crustaceans*), and Focus Groups (*e.g., copepods*). For example, the copepod *Calanus finmarchicus* has a PGC code of "4212000", specifying that it is in Major Group "4" (zooplankton), Minor Group "21" (crustaceans), and Focus Group "2000" (copepods). Using the PGC code requires the multiplication of the PGC code value, outlined in Table 9, to specify the exact grouping level desired (*e.g., "all zooplankton", "all crustaceans", or "all copepods"*).

Table 9. Operational example of the Plankton Grouping Code (PGC).

Group	PGC Value	Multiply by	Result	PGC Equivalent (See Appendix 6)
MAJOR GROUP	4212000	10^{-6}	4	zooplankton
	4218000		4	zooplankton
	2160000		2	phytoplankton
MINOR GROUP	4212000	10^{-4}	421	crustacean
	4218000		421	crustacean
	2160000		216	diatoms
FOCUS GROUP	4212000	10^{-2}	42120	copepods
	4218000		42180	euphausiidae

7. Measured Variables

The number of measured variables, their type, as well as quality control flags for each variable (if all values of that variable have been flagged for that cast) are identified in the primary header. Table 3a lists the variables and their identifying codes. Table 12 lists the types of the WOD quality flags that can be assigned to each variable.

Casts with measured data on pressure surfaces have their depths computed, so depth is always present and the pressure value is stored as a variable. Some data were submitted with both depth and pressure values in which case both are stored. Some casts may be reported on standard depth levels (see Appendix 9) such as most of the Japanese and Former Soviet Union (FSU) data. It is uncertain whether these data were originally measured at standard levels or interpolated to standard depth levels.

The SUR, APB, and UOR datasets are discussed in more detail below in sections 7a-c since these include additional information so as to fit the WOD format.

7a. Surface-only Data (SUR)

Surface-only data are treated differently than profile data. For such data, each cruise is presented as a single cast with depth, latitude, longitude, and Julian year-day associated with each set of measured values. The Julian year-day 0.00 is defined as time 0.00 on January 1st of the year of the first measurement in the cruise. For cases in which the cruise spans 2 calendar years, the year-day is consecutive. For example, if the first measurement was taken at time 0:00 on 31 Dec. 1965 (not a leap year), the year day for that observation is 365.00. If the last measurement on the same cruise was taken at time 12:00 on 1 January 1966, the year-day is 366.5. An example of data from a surface cast is shown below:

Longitude	Latitude	Year	Month	Day	Time	Cruise#	CC	Prof_#
-30.026	62.666	1991	9	3	20.33	9810	06	7819341

Num	Depth	Temp	Sal	pCO2	Lat	Lon	Jday
1	0.00	9.130	34.940	294.300	62.666	-30.026	245.847
2	0.00	9.300	34.930	303.400	62.660	-30.057	245.851
3	0.00	9.400	34.913	305.300	62.640	-30.151	245.861
4	0.00	9.370	34.927	307.900	62.655	-30.088	245.854
5	0.00	9.400	34.915	306.600	62.648	-30.120	245.858

cast continues with a total of 2097 observations ...

Access#	113
Platform	335
Institution	388
pCO2 Instrument	8.000
pCO2 Method	1233.000
pCO2 Orig_Units	81.000

Note that the primary header information contains the same longitude, latitude and date/time information as the first observation in the listing.

7b. Autonomous Pinniped Data (APB)

Autonomous Pinniped Data (APB) are the temperature (salinity) data recorded by temperature-depth recorders (TDRs) or conductivity-temperature-depth satellite relay data loggers (SRDLs) manually attached to large marine mammals (*e.g.* northern elephant seals *Mirounga angustirostris*).

Depth and temperature (salinity) are recorded by the TDR or CTD-SRDL as the mammal ascends and descends through the water column while swimming. When the mammal returns to the surface, its position is transmitted to the ARGOS unit. During the seals multi-month migration, the seals dive continuously, night and day, capturing thousands of profiles along their migration route (*e.g.*, Boehlert *et al.* 2001).

7c. Undulating Oceanographic Recorder (UOR)

Undulating Oceanographic Recorder (UOR) is the generic name given to towed vehicles carrying measuring devices (*e.g.*, CTDs, plankton recorders, transmissometers) which ascend and descend through the water column in a more or less regular pattern, giving a two-dimensional view of the water column along the towing path.

UOR measurements are usually close together in time and space, and are near continuous, from the near surface layer to a maximum depth of about 500 m. To fit this dataset into the WOD format, the undulations are broken into distinct up and down casts, and all the measurements between the breaks are averaged on a minimum pressure increment of 1.0 decibar. The latitude and longitude are also averaged for each measurement, as is the date/time (preserved as Julian year-day). This averaged metadata value is kept with each measurement of the oceanographic variables. The coordinates stored in the cast header is the position of the portion of the tow when the vehicle is at the exact middle of its ascent or descent (based on the averaged decibar increments). Some of the data received was already processed to some extent by originators and did not include latitude, longitude, or Julian year-day. A tow can be broken into either a few up or down segments or thousands of segments. The tow number (secondary header 5) along with the Segment Number (secondary header 93) can be used to follow the progression of a tow in time, as the segment numbers correspond to the sequence of up or down undulations.

II. FILE STRUCTURE/FORMAT

The World Ocean Database (WOD) archive version is available online in ragged array NetCDF format following Climate-Forecast (CF) conventions. The CF format for contiguous ragged array and profile data representation is optimal for WOD which aggregates oceanographic casts (collections of ocean profiles for one or more variables taken at the same date, time, geographic location, and depth or pressure). Each cast may have one or more profiles for each measured variable. Different casts can have very different counts of depth/variable pairs for each profile (from 2 to 24,000 in the WOD), and from 1 to 26 variables with separate profiles in each cast. Appendix 12 provides additional description.

All files which contain observed and standard level data are also written as a series of 80-character length ASCII records. A detailed record layout for the data can be found in Tables 10a, 10b, and 10c (primary header format; character data, secondary and biological header; and integrated, taxonomic and profile). There is a 'carriage return-line feed' code (CR-LF) after each 80 bytes. Each cast begins on a new line. Starting with WOD01, the first byte in a cast is a character which identifies the World Ocean Database product release version. The WOD web page provides access to the most current as well as the most recent versions. If the first byte is character "C", it refers to the WOD23 or WOD18 format, a "B" refers to WOD09 or WOD05 format, and "A" refers to WOD01 format. If the first byte is numeric, it identifies WOD98. There is one ASCII format change between WOD09 and WOD18, and only for standard level data files. Since standard levels have changed for WOD13, WOD18, and WOD23 compared to all previous releases, depths are now explicitly given for each depth level, rather than implicit as for previous WOD formats. Each section of a cast (*e.g.,* primary header and variable specific second header, character data, secondary header, biological header) begins with the number representing a total byte count for that section. If there are no data for that section, the byte count is zero. If there are data for that section which are of no interest to the user, the byte count can be used to skip over this section.

The header includes the ISO country code, cruise number, position, date, time, internal unique cast number, the number of observed or standard depth levels, an identifier for observed or standard level data, number of variables, variable codes, originator's flag for observed level data only, and a flag if all of a variable's data in that cast fails a quality control check (see Table 12 for a description of the quality control flags).

Table 10a. ASCII Format for Primary Header

FIELD	LENGTH	FORMAT	DESCRIPTION
1. **WOD Version identifier**	1	A1	WOD13, WOD18, WOD23 = "C"; WOD05, WOD09 = "B"; WOD01 = "A"; if field is numeric, WOD98.
2. **Bytes** in next field	1	I1	
3. **Bytes** in profile	from (2)	Integer	
4. **Bytes** in next field	1	I1	
5. **WOD** unique **cast number**	from (4)	Integer	Cast identification
6. **Country Code**	2	A2	ISO country codes (App 1)
7. **Bytes** in next field	1	I1	
8. **Cruise Number**	from (7)	Integer	cruise number identification
9. **Year**	4	I4	
10. **Month**	2	I2	
11. **Day**	2	I2	may have a zero value
12. **Time** - if time is missing it's denoted as (-) in the Significant digits field - if so, skip to (13)			
a. Significant digits	1	I1	"-" if time missing
b. Total digits	1	I1	not present if (a) is negative
c. Precision	1	I1	not present if (a) is negative
d. Value	based on (b)	based on (a-c)	not present if (a) is negative
13. **Latitude** - if latitude is missing it's denoted as (-) in the Significant digits field - if so, skip to (14)			
a. Significant digits	1	I1	"-" if missing
b. Total digits	1	I1	not present if (a) is negative
c. Precision	1	I1	not present if (a) is negative
d. Value	based on (b)	based on (a-c)	not present if (a) is negative
14. **Longitude** - if longitude is missing it's denoted as (-) in the Significant digits field, if so, skip to (15)			

FIELD	LENGTH	FORMAT	DESCRIPTION
a. Significant digits	1	I1	"-" if missing
b. Total digits	1	I1	not present if (a) is negative
c. Precision	1	I1	not present if (a) is negative
d. Value	based on (b)	based on (a-c)	not present if (a) is negative
15. Bytes in next field	1	I1	
16. Number of Levels **(L)**	from (15)	Integer	Number of depths
17. Profile **type**	1	I1	"0" Observed "1" Standard level
18. # Variables in profile **(N)**	2	I2	
Next section repeated based on number of variables in the profile (read fields 19-23 ***N*** *times)*			
19. Bytes in next field	1	I1	read fields 19-23 N times
20. Variable code	from (19)	Integer	variable codes (Table 3a)
21. Quality control flag for variable	1	I1	see Table 12
22. Bytes in next field	1	I1	
23. Number of secondary header *metadata* ***(M)***	from (22)	Integer	if zero go to 19, otherwise read fields 24-25 **M** times
Next section repeated based on number of variable specific metadata (read fields 24-25 ***M*** *times for each variable* ***(N))***			
FIELD	**LENGTH**	**FORMAT**	**DESCRIPTION**
24. Bytes in next field	1	I1	if zero go to 19
25. Variable specific code	from (24)	Integer	see Table 5
a. Significant digits	1	I1	"-" if missing
b. Total digits	1	I1	not present if (a) is negative
c. Precision	1	I1	not present if (a) is negative
d. Value	based on (b)	based on (a-c)	not present if (a) is negative

Table 10b. ASCII format for character data, secondary, and biological header

FIELD	LENGTH	FORMAT	DESCRIPTION
CHARACTER DATA AND PRINCIPAL INVESTIGATOR - entries 4-9 repeated using the number in (3)			
1. Bytes in next field	1	I1	if “0” go to Second Header
2. Total bytes for character data	from (1)	Integer	
3. Number of entries **(C)**	1	I1	
IF FIELD (4) IS 1=Originators Cruise, OR 2=Originators station code (read fields 4-6 **C** times)			
4. Type of data	1	I1	“1” orig. cruise; “2” orig. cast
5. Bytes in next field	2	I2	
6. Character data	from (5)	A	
IF FIELD (4) IS 3=Principal Investigator			
4. Type of data	1	I1	always “3”
5. Number of PI names **(P)**	2	I2	read fields 6-9 **P** times
6. Bytes next field	1	I1	
7. Variable code	from (6)	Integer	WOD code (see Table 3a)
8. Bytes in next field	1	I1	
9. P.I. code	based on (8)	Integer	WOD code (see primary_investigator_list)
SECONDARY HEADER - entries 5-10 repeated based on number read in (4)			
1. Bytes in next field	1	I1	if “0” go to Biological Header
2. Total bytes for second headers	based on (1)	Integer	
3. Bytes in next field	1	I1	
4. Number of entries **(S)**	based on (3)	Integer	read fields 5-10 **S** times
5. Bytes in next field	1	I1	
6. Second header code	based on (5)	Integer	
7. Significant digits	1	I1	
8. Total digits	1	I1	
9. Precision of value	1	I1	
10. Value	based on (8)	Using (7-9)	
BIOLOGICAL HEADER - entries 5-10 repeated based on number read in (4)			
1. Bytes in next field	1	I1	if “0” go to Profile Data
2. Total bytes for biology	based on (1)	Integer	
3. Bytes in next field	1	I1	
4. Number of entries **(B)**	based on (3)	Integer	read 5-10 **B** times
5. Bytes in next field	1	I1	
6. Biological header code	based on (5)	Integer	WOD code (see Table 6)
7. Significant digits	1	I1	
8. Total digits	1	I1	
9. Precision of value	1	I1	
10. Value	based on (8)	Using (7-9)	

Table 10c. ASCII text format for integrated, taxonomic, and profile Data

FIELD	LENGTH	FORMAT	DESCRIPTION
TAXONOMIC DATASETS AND INTEGRATED PARAMETERS - entries 3-12 repeated based on number read in (2)			
1. Bytes in next field	1	I1	if "-" go to next to next section
2. Number of taxa sets **(T)**	based on (1)	Integer	
3. Bytes in next field	1	I1	read fields 3-12 **T** times
4. Number of entries for each taxa set ***(X)***	based on (3)	Integer	
5. Bytes in next field	1	I1	read fields 5-12 **X** times
6. Taxa or integrated parameter code	based on (5)	Integer	WOD code (see Table 7)
7. Significant digits	1	I1	
8. Total digits	1	I1	
9. Precision	1	I1	
10. Value	based on (5)	Using (7-9)	
11. Quality control flag for value	1	I1	see Table 12
12. Originator's flag	1	I1	always "0" in WOD
PROFILE DATA - all steps repeated based on number of levels **(L)** listed in the primary header			
1. Number depth significant digits	1	I1	if "-", the entire standard level data is missing skip steps 2-12 for the given level
2. Total digits in depth	1	I1	
3. Precision of depth value	1	I1	
4. Depth value	based on (2)	Using (1-3)	
5. Depth error code	1	I1	see Table 12
6. Originator's depth error flag	1	I1	see flags for project (Appendix 2.25)
7. Value significant digits	1	I1	steps 7-12 are repeated for each variable or **N** times. If "-", the measured variable is missing from the level, skip steps 8-12 for the variable.
8. Total digits in value	1	I1	
9. Precision of value	1	I1	
10. Value	based on (8)	Using (7-9)	
11. Value quality control flag	1	I1	see Table 12
12. Originator's flag	1	I1	see flags associated with project (Appendix 2.28)

Appendix 8 shows a sample data output from the WOD Cast 67064 (using the program wodFOR.f). This sample output contains temperature, salinity, oxygen, phosphate, silicate, and taxonomic / biomass data ("f" denotes the flag assigned to the variable and "o" denotes the originator's quality flag); numbers in parenthesis represent the number of significant digits in the value; "VarFlag" identifies whole profile flags for each variable).

For compactness, each variable is written as follows: `STPVVVVVV[F][O]`, where:

- `S` = Number of significant digits in a value;
- `T` = Total number of digits in a value. This is usually the same as [S], but can vary in cases of negative numbers, converted values, and data in which the values are reported with more precision than an instrument is capable of recording;
- `P` = Precision of a variable (number of places to the right of the decimal point);
- `V` = The actual value. This is read in using [T] and [P];
- `F` = WOD quality control flag;
- `O` = Originators flag.

For example: a salinity value, written as [5533389100] means that `S = 5, T = 5, P = 3`. Using this information, there are five bytes in the salinity reading, with a precision of three, so `V(sal) = 33.891`, `F = 0, O = 0`. A missing value in this data format is always represented with an `S = '-'` (the minus character). That is, when the number of significant digits is read in, the character encountered will be a negative sign. This tells the user that no value was recorded and to skip to the next value.

A. DESCRIPTION OF WOD WEBSITE PAGES AND FILES

The WOD web page provides access to data, documentation, and quality control. The WOD dataset landing page provides additional information and data access options. What follows are the Internet page names and the contents of each page:

Online data access, documentation, tools	**Description**
WODSelect	Web application of the WOD data retrieval (user-specified search criteria). The WODSelect online retrieval system allows a user to search the WOD including quarterly updated/added data. Data exported in the WOD text native format, CSV, and NetCDF.
Data sorted by year	Data organized by years
Data sorted by geographic location	Data are organized by World Meteorological Organization (WMO) 10-degree squares (Appendix 7). Within each WMO square, data are separated by dataset and depth.
Data updates	WOD data and metadata quarterly updates (new data/metadata and corrections)
Documentation	Contains information and documentation about the WOD
Code Table Library	Codes associated with the secondary header, variable specific header, biological header, and taxa data
Masks: Data masks delineating ocean areas, range basins, and 5-degree standard deviation.	range_area.msk: Ocean areas for each set of variable min/max ranges range_basin_list.msk: Range basins list sd_multiplier.msk: 5-degree standard deviation multiplier
Sample programs	Code in FORTRAN, C, and Python for reading the data and allow the user to convert the data to the comma-separated values format so it can be read into Matlab or any other tabular programs.

1. WODselect data search and retrieval system

The WODSelect is a web interface which allows a user to search the WOD and new (quarterly updated/added) data using a variety of user-specified search criteria (Figure 1). The query results based on user customized search criteria will provide a distribution map, cast count, and the option for selecting output format of the data files: WOD native ASCII format; comma-separated values (.csv) format; or NetCDF (.nc) format. The data user builds a data retrieval request based on selected options such as geographic coordinates, dataset (*e.g.* OSD, CTD, XBT), measured variables (*e.g.* temperature, salinity, nutrients), biology (*e.g.* phytoplankton, zooplankton), deepest measurement, country, platform, project, institute, and data exclusion using WOD quality control flags.

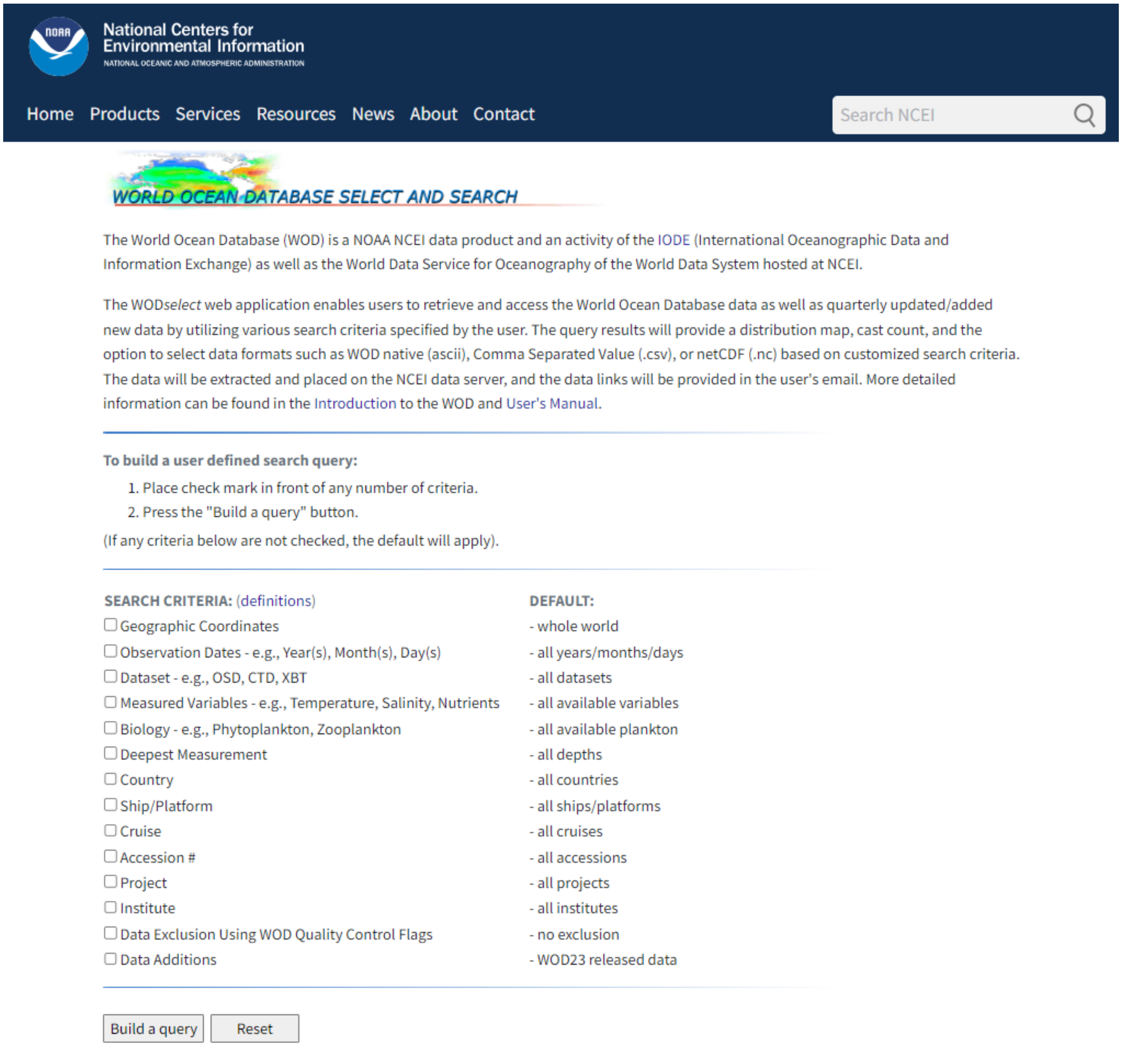


Figure 1. The WODSelect data search and retrieval system enables a user to search and access WOD and new (quarterly updated) data using specified criteria.

2. Data Access

The WOD web page provides several options to search and access data. Users can create a customized dataset using the WODSelect application with user-specified criteria, or they can access pre-sorted datasets based on geographical location (sorted geographically or date (sorted by year). The geographically sorted data are organized by WMO 10-degree squares. A world map with the WMO codes in each 10-degree square is provided in Appendix 7. In both the geographically sorted and the year sorted datasets provide options to retrieve data based on dataset type (see Table 2) as well as data at observed or standard depth levels. We note that WOD is updated quarterly with new and updated data. In addition to WODSelect, WOD data can be accessed via NCEI THREDDS, HTML, WOD Landing Page, WOD web page, as well as at the U.S. Government's Open Data (data.gov) catalog.

The WOD data can be imported into the Ocean Data View (ODV) and other applications supporting NetCDF. The latest ODV version at the time of this writing is ODV 5.6.7 (version date October 25, 2023). The ODV Ocean Data collection includes the WOA23 as well as previously released WOA climatologies (*e.g.,* WOA01, WOA05, WOA09, WOA13, and WOA18).

3. Documentation

The WOD documentation provides information for discovering, selecting, accessing, reading, and using the WOD data. For any questions about this product, please e-mail ncei.info@noaa.gov.

4. Code tables

The directory WOD code tables contain all files describing the metadata in secondary header, variable specific header, biological header, and taxa data. All code file links are listed in the appendices of this document. In addition, the WOD code tables includes links to the tables in comma-separated values (.csv) format.

File structure is as follows:

- Secondary Header Files are prefixed with the letter "**s**" (*e.g.*, s_1_accession)
- Variable Secondary Header Files are prefixed with the letter "**v**" (*e.g.*, v_6_methods)
- Biological Header files have the prefix "**b**" (*e.g.*, b_4_type_tow)
- Taxa specific codes have the prefix "**t**" (*e.g.*, t_1_taxa_list)
- All other files are given their unique names (*e.g.* country list)

5. Sample programs and resources

WOD sample code programs written in FORTRAN (Formula Translation general-purpose programming language), C programming language, and Python are available for reading the WOD data. The FORTRAN and C codes have been tested on a Linux operating system using the freely available GNU Compiler Collection (GCC). Sample code provide options to output the sample data in either tabular column or comma-separated columns (also known as comma-separated values, .csv) format which can be read by commercial programs (*e.g.*, MATLAB, Golden Software

Surfer), Generic Mapping Tools (GMT), and other graphics-capable packages. The Ocean Data View (ODV) software can read both the compressed WOD native format and NetCDF.

Sample program code converters and resources.

Sample Programs, Output, and Instructions	Description
wod_nc.f	Sample FORTRAN program for reading WOD ragged array NetCDF files
readFOR.txt	Readme file describes the wodFOR programs
wodFOR.f	Sample FORTRAN program for reading the data
sampFOR.txt	Sample of output from wodFOR.f
readASC.txt	Describes the use of wodASC.f
wodASC.f	Outputs a user selected variable in either tabular or comma-separated columns
sampASC.txt	Sample output data from wodASC.f
wodSUR.f	Sample FORTRAN program to write surface only data out in a comma-separated value (.csv) format
sampSUR.txt	Sample of output from wodSUR.exe
Converting WOD to csv	Instructions to convert WOD format to ArcMap readable 'csv' format
csvfromwod.c (β version)	Sample C program for conversion data from WOD format to ArcMap readable 'csv' format
ArcGIS tutorial	Tutorial to convert 'csv' files in to shapefiles and upload it in ArcMap
readC.txt	Readme file describing the wodC program
wodC.c	Sample C program for reading the data
wodtodepthmatrix_info.txt	Text file describing the wodtodepthmatrix.c program
wodtodepthmatrix.c	Sample C program for reading the data
IQuOD/wodpy	Python program to extract WOD data in native format (ASCII). It is a NetCDF parser, intended to consume NetCDF files and make a close-as-possible analogous profile class to the ASCII representation (IQuOD github)

6. Data Masks

The following data masks are used as part of the WOD information:

Mask (CSV format)	Description
range_area.msk	Ocean geographic areas listed in the range_basin_list.msk for each set of variable min/max data ranges

range_basin_list.msk	List of ocean basins with ranges
sd_multiplier.msk	5-degree standard deviation of the mean multiplier

B. OPERATING SYSTEM REQUIREMENTS

There are no specific requirements. The WOD data are in a non-commercial uniform digital format to facilitate ease of open use and FAIR-compliance. All of the data and metadata are openly available for use without restrictions.

III. QUALITY CONTROL PROCEDURES

All possible global and U.S. originated oceanographic profile data openly shared with NCEI for long-term archival are added to the WOD. The data are put through a set of quality control (QC) procedures. By QC, we mean that the observations in WOD are of approximately internally consistent science quality. In this way, we also help ensure a consistent quality assurance process at all steps of the QC. The WOD applies a uniform set of automated quality control tests to each data set as it is aggregated into the larger data set. The QC process aims to ensure that (1) the data are converted to the WOD format correctly, (2) the data format provided with the data is correct and the data have not been corrupted in transmission, (3) only one copy of data at each cast is retained in the WOD format, and (4) the data, as initially collected and processed, are of research quality. The OCL Team continues to quality control the data and requests input from the data providers and users as to possible problems identified when using the data. As these problems are identified and corrected, the updated casts will be updated in the WOD, published online, and the changes/corrections documented.

Performing both primary and secondary QC on the data is a critical task of the WOD and WOA data processing protocol. The historical measurements were collected for different scientific purposes and in some cases, employing methods and instruments that are no longer in use or have evolved over time. Thus, the measuring precision, reproducibility, and uncertainty of the observations collected over time are not expected to be nominally uniform. Because the uncertainty of the measurements is not always known *a priory* or provided in the primary data source metadata archived at NCEI, we use an internally consistent variable-specific QC process irrespective of the year of data collection. The WOD data QC is performed using quantitative metrics at both the observed and standard depth levels as well as Subject Matter Expert (SME) assessment of the data. We note that QC of the data should not rely solely on automated QC tests. For example, standard deviation statistical checks often assume a data population distribution (*e.g.*, gaussian, normal) which sometimes lead to not flagging data as questionable when it should and flagging data when it should not have been (*e.g.*, type I and type II errors). The QC methods should help address the specific data science quality requirements for a particular purpose or use.

The WOD includes quality control flags (QCF) that are set during automatic and SME QC steps in the calculation of the WOA data product climatologies and when the data are first added to the database. There are QCF with each measurement and for each profile at observed and standard depth levels. A complete list of the WOD QCFs and their definitions is provided in Table 12. The WOD QCF do not qualifies data values as good or erroneous. We note that in addition to the WOD QCFs, there are QCFs that were originally submitted by data providers (*i.e.*, originator's quality flags). Appendix 2.28 lists the originators quality flags and their associated project or accession number. The originator's quality flags are included with the observed level data only. In some cases, the originator QCF has been assigned by the original data collector. In other cases, QCF maybe assigned by group of SMEs. The definitions of the originator's flags may be different from the WOD flag definitions, and often different from other originator's flags. The WOD data users can select which QCF to use and conduct their own fit-for-purpose data QC.

Some measured variables are included in the WOD even though all the QC steps were not fully applied as is the case for temperature, salinity, dissolved oxygen, and dissolved nutrients (phosphate, nitrate and nitrate + nitrite, silicate). Prior to WOD23, full QC on dissolved oxygen was only done on observations in the OSD dataset. Starting with WOD23, full QC on dissolved oxygen was done for observations in the OSD, CTD, and PFL datasets. Previous versions of WOD included full QC of observations in the OSD dataset. Dissolved nutrient full QC was performed on observations in the OSD dataset in all previous WOD versions including WOD23. The variables that do not receive all of the QC steps include partial pressure of carbon dioxide, dissolved inorganic carbon, pH, alkalinity, tracers, and chlorophyll. For these variables, the WOD uses a global and regional data range check as a function of depth. In addition, nitrite was excluded from the online database since the data were not examined to ensure their science quality. Air pressure, Julian year-day, latitude, and longitude, included as variables and parameters for the sole purpose of identifying the surface-only, APB and UOR data, were not quality controlled beyond basic data range checks.

If the archived data at NCEI includes metadata, the information is added as primary, secondary (Tables 4a, 4b), and variable-specific metadata (Tables 5a, 5b). Older historical data may not include some information about the measurements. If metadata are available in the archive, WOD variables include originator's metadata such as for example, originator quality flags (Appendix 2.28), measurement scale (Appendix 3.1), instruments (Appendix 3.2), methods (Appendix 3.3), originator units (Appendix 3.4). The OCL Team aims at adding to WOD as much metadata as possible. We invite the ocean community to helps us document the data in WOD.

A. QUALITY CONTROL OF OBSERVED LEVEL DATA

1. Digital format conversion

When data are shared and archived at the NCEI long-term data archive and merged into the WOD the first step, after assigning a NCEI accession number and a Digital Object Identifier (DOI) as appropriate if one is not already available, is to convert the data into the WOD internal data format. A significant number of the historical oceanographic data are in non-interoperable heterogenous formats requiring programming to read and convert the data and metadata to the WOD format. Some of the QC checks performed during format conversion include calculation of the number of significant digits, identification of time zone used (*i.e.*, Greenwich Mean Time GMT or local), and checking the consistency of the originator's data format including variable name nomenclature. Additionally, where originator's variable units differ from the standard WOD units, data are converted to the standard WOD variable units (Table 3a). The conversion of biochemical units is based on standard atomic weights (Table 3b). After the data has been converted to the WOD format, they are checked and compared with the original data to verify the accuracy of the data conversion. If problems or questions with the data are noted, the data originator is contacted whenever possible. As a result of the GODAR effort, a significant amount of data in paper form were digitized and added to WOD, as for example, historical WHOI MBT data.

2. Check cast position/date/time

Converted data are checked for metadata accuracy and integrity including incorrect or missing latitudes, longitudes, time, and dates (day, month, and year). Questionable metadata and values are compared with the original data to make sure that problems are not introduced during the data conversion process. If the incorrect datum is found in the original data, the data submitter or principal investigator (PI) is notified of the error and a correction is requested when possible.

3. Assignment of cruise and cast numbers

Once cast positions and dates are checked, unique cruise numbers are assigned. In some cases, data cannot be clearly identified as having been collected on a single cruise (*e.g.* data collected by a single ship over a prolonged period of time). In these cases, cruises are defined by the OCL Team. when not provided or request by the data originator. A general definition is that a cruise is comprised of casts for which the time difference between any two casts is < 20 days. This definition is a guideline, as some datasets necessitate a smaller break period, and others a longer period. Some data which have nonspecific platforms (*e.g.* airplane or ice-camp) are not amenable to this treatment. If no platform or primary investigator information is provided, a cruise number of zero (0) is assigned to denote the absence of verifiable cruise information.

All oceanographic casts added to the WOD are assigned a sequential number which is unique to each cast. This unique cast number allows the OCL Team to identify and record any changes or updates made to the cast overtime, as well as cast deletion. Note, this internal unique cast number is not the originator's cast number. The originator's cast number is kept in its original form as part of the metadata.

4. Platform speed check

Following the assignment of cruise numbers, the entire cruise is mapped out and the speed between casts is calculated. If the speed between adjoining casts is unrealistic, it might indicate errors in the date/time, incorrect position, or the cast may not belong to this cruise/platform. These issues, when encountered, are noted, and the data submitter contacted to determine the appropriate course of action. Due to lack of time and resources, not every single cruise was checked and therefore some groupings of casts may not represent a cruise as defined here.

5. Duplicate cast checks

Upon completion of these preliminary quality control checks, extensive duplicate checks are performed – first internal to the new dataset, and then the data is checked against the existing WOD database. Data duplicates are a continuous problem with any historical database. While exact duplicate profiles are easy to identify and remove, "near" duplicates are more difficult to detect. Such duplicates can result from receiving the same data via different sources, where key metadata variables such as latitude, longitude, or date/time were treated differently. As the procedures for identifying duplicate casts improve, more of these "near" duplicate casts continue to be identified and eliminated.

Duplicate checks involve identifying casts with:

- same position/date/time
- position/date/time within some small offset
- same originator's cast numbers within a cruise
- same profile data
- same taxonomic data

Below are the general types of data duplicates which were found to occur:

Identical or nearly identical profiles – two or more profiles which contain the same variable with identical *values* at each depth. Frequently, positions or times of such profiles may be slightly different (depending on the accuracy to which latitude/longitude/time were provided in the original data submissions). Sometimes larger differences in time (up to a one day offset) may also take place when time is provided in GMT in one dataset and in local time for the other.

Identical casts – two or more casts from the same location, date and time, but with different variables or different values. When values are different, the casts may contain identical profiles that were handled differently by an intermediate data center or investigator (*e.g.* using different storage criteria with XBT's or CTD's, or interpolating the observed data to standard levels). When variables are different between two casts which are otherwise identical, this may be due to cases in which data were submitted separately. Therefore, variables from these casts are combined (see *Special Case: merging profiles* below).

Overlapping Cruises – two or more cruises with the same platform code that overlaps in their starting and ending dates. In most cases, the overlapping cruises are duplicated and have already been detected by the previous two checks. In others cases, the difference in positions is so great that the standard position check does not detect the duplicated casts (*e.g.* a missing "+/-" for latitude would give two casts (or set of casts), collected from the same platform with the same times and data values, in both the northern/southern or eastern/western hemispheres).

When duplicates are found, the "better" cast is retained within the database, and the other cast is marked for removal. In general, the retained (*i.e.* "better") cast has more depth levels, additional variables, or data at a higher precision. Preference is given to the original observed level data over interpolated. As a rule, data obtained directly from the originator have preference over data that have passed through many users/processors, and possibly lost/changed precision or other information along the way.

Special Case: merging profiles within the same cast

In some cases, different variables from the same oceanographic cast have been submitted to the NCEI at different times or from different sources. The most common example of this is when biological data (*e.g.,* pigments, plankton measurements) are submitted for previously processed ocean cast data, which has already been loaded into WOD databases. Through the efforts of the World Data Service for oceanography of the World Data System, and the GODAR and Global Ocean Database projects, many casts containing chlorophyll, nutrient, and plankton data have been acquired from the source Institutions and/or digitized, and combined with existing data in the WOD.

Metadata information such as date, position, time, platform, and originator's cast number and/or cruise identifier is used to match up incoming casts with existing casts. Frequently, the match-up is obvious (*e.g.* the same ship is in the exact position on the same day, and the depth levels of the existing data correspond exactly to the incoming data). When the match-up is less obvious, efforts are made to determine whether this match is appropriate or not by reviewing the documentation, comparing cruise tracks, or contacting the data originator, if possible.

When an appropriate match is found, the data are merged into one single cast which contains all the data and metadata of the previous two casts. When a match is uncertain, but platform, position and dates are very close, the casts are left separate and assigned the same WOD cruise number so the data will at least remain grouped by cruise number.

6. Depth inversion and depth duplication checks

Depth inversions and duplication of depths were found in some profiles. A depth inversion occurs when an observation has a shallower depth than the observation directly preceding it. A depth duplicate is a reading which has the same depth as the reading immediately before it. In either case the second observation was always flagged, rather than trying to evaluate the data. Table 12 lists the QCF assigned to the data. If, after an inversion or duplication, the next two depth observations were still shallower than the first reading, this observation and all subsequent observations were flagged. This usually occurred when two or more profiles have been sequentially entered together into a digital file with no separating header information between them. After this check, casts submitted with depths in reverse order (deeper depth first) were sorted so shallowest depth will appear first.

Depth error flags are assigned if:

a) The second of two successive depths is shallower than the first (a depth inversion), the second depth will be marked with a flag value = 1.

b) Three successive depths are shallower than the first depth, every depth reading in the profile following the first will be marked with a flag value = 1.

c) Two successive depth readings are equal, the second reading will be marked with a flag value = 1. All correct depths are marked with a flag value = 0.

7. High-resolution pairs check

The high-resolution pairs check is implemented to ensure whether or not any incoming data have matches in the existing bottle (OSD) and/or high-resolution (CTD) datasets. This check is performed to link the data acquired during the oceanographic cast when bottle samples and CTD data taken at the exact same time and location (*e. g.* from the same CTD-rosette). The check is done on incoming OSD or CTD data with temperature, salinity, and/or oxygen. The measured parameters themselves are not checked. If there are high-resolution pairs found, the necessary secondary header code for "High-Res Pair" (see Table 4a, code 13) is placed in both OSD and CTD datasets for paired casts.

8. Range checks on observed level data

Data range checks are used to screen the data for extreme values for each variable. Broad ranges have been established as a function of depth and oceanic basins (Figure 2) for each variable. The range for a variable, in each region, is set large enough to encompass variations for all seasons and years. Ranges were determined using frequency distributions, statistical analysis, literature values, and atlases (*e.g.* GEOSECS, Banbridge, 1980; Craig *et al.* 1981, Spencer *et al.* 1982), Southern Ocean Atlas (Gordon *et al.* 1982, Wyrtki, 1971), and previous World Ocean Atlases. The observed level data were compared with these ranges, and outliers were flagged with a range outlier flag. Table 11 lists the variables contained in the WOD, the standard WOD units, and the Appendices containing the ranges set for these variables. The ranges in these appendices do not represent the minimum and maximum values in the basins, but rather indicates extent of values beyond which the data are believed to be erroneous. The range area mask (range_area.msk) and range basin list (range_basin_list.msk) are available as ASCII text files on the WOD web page.

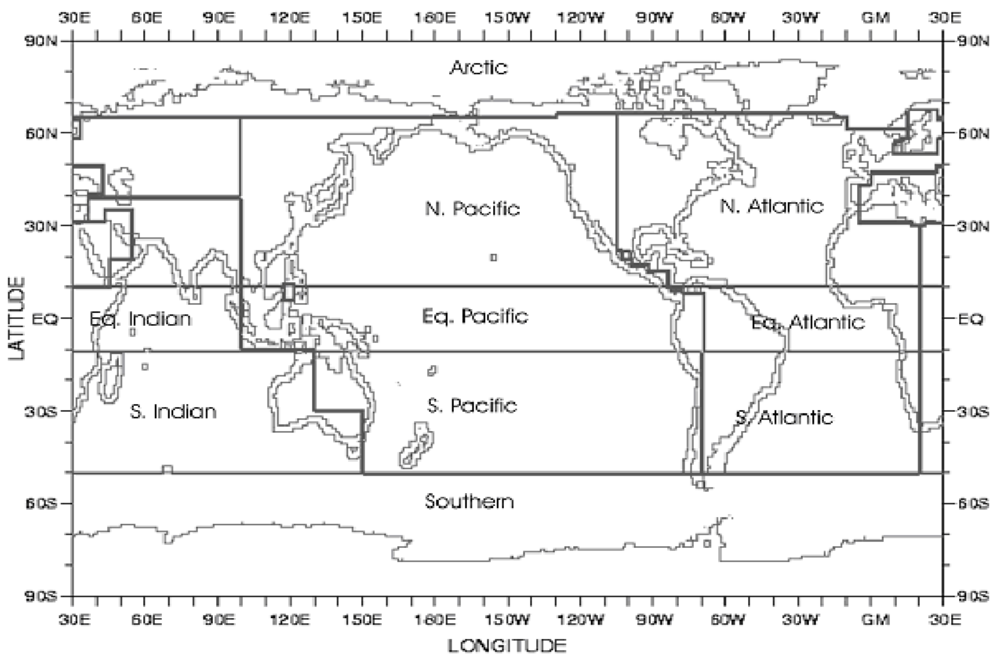


Figure 2. Geographic boundaries of ocean basin definitions

9. Excessive vertical gradient checks

For each variable in Table 11, a quantitative check was made for "excessive decreases and increases in a value over a depth range", or excessive gradients. A gradient was defined as:

$$gradient = \frac{v_2 - v_1}{z_2 - z_1} \quad \text{(Equation 1)}$$

where

v_1 = the value of the variable at the current depth level

v_2 = the value of the variable at the next depth level

z_1 = the depth (meters) of the current depth level
z_2 = the depth (meters) of the next depth level

Table 11. Data ranges for quality control of individual variables

Code	Variable	Standard unit (nominal abbreviation)	See Appendix
1	Temperature	Degree Celsius (°C)	11.1
2	Salinity	Dimensionless (unitless)	11.2
3	Oxygen	Micromole kilogram^{-1} (μmol·kg^{-1})	11.3
4	Phosphate	Micromole kilogram^{-1} (μmol·kg^{-1})	11.4
6	Silicate	Micromole kilogram^{-1} (μmol·kg^{-1})	11.5
8	Nitrate and Nitrate + nitrite	Micromole kilogram^{-1} (μmol·kg^{-1})	11.6
9	pH	Dimensionless (unitless)	11.7
11	Total Chlorophyll unless specified	Microgram liter^{-1} (μg·l^{-1})	11.8
17	Alkalinity	Millimole liter^{-1} (mmol l^{-1})	11.9

Two types of gradients were checked, and marked as follows:

- *Excessive Gradients* - a negative gradient, *i.e.* an excessive decrease in the value over depth. The criteria used to define "excessive" for each variable are listed in Table 13. Any value which exceeded this "maximum gradient value" (MGV) was marked with a gradient flag.
- *Excessive Inversions* - a positive gradient, *i.e.* an excessive increase in value over depth. These criteria are presented in Table 13. Data which exceeded the "maximum inversion value" (MIV), were marked with an inversion flag.

MGV/MIVs were determined from literature and/or by objectively reviewing the trends of the variable within the data. To better accommodate the differences in gradient ranges between surface and deep water (*e.g.* due to physical or biochemical influence), a different set of MIV/MGVs were used for depths above and below 400 meters. When dealing with high-resolution instruments (*e.g.* HCTD, XBT), a minimum depth difference of 3.0 meters was used when calculating the gradients (Equation 1).

In addition, data were checked to distinguish *zero as a value* versus *zero as a missing-value- indicator*, particularly in the historical nutrient data. The zero-sensitivity check will flag a zero value if a gradient decrease to zero at a rate greater than the MGV * ZSI (zero sensitivity indicator). For example, if ZSI is 2.00, the gradient must be twice as large as the MGV for that depth range. These values were assigned a flag = 4, equivalent to an observed level flag.

10. Observed level density checks

Sea water density checks were run on the observed level data to locate density inversions. This check was not used to flag temperature and salinity data from subsequent quality control, but was used to get an estimate of data quality prior to interpolation to standard levels. The check is the same as described in Section B.12, *Standard level density check*, except the values are divided by the depth difference between adjacent levels unless the difference is less than 3 meters, in which case a difference of three 3 meters is used.

Table 12. Definition of the quality control flags.

(1) FLAGS FOR ENTIRE CAST (AS A FUNCTION OF VARIABLE)	
0	accepted cast
1	failed annual standard deviation check
2	two or more density inversions (Levitus, 1982 criteria)
3	flagged cruise
4	failed seasonal standard deviation check
5	failed monthly standard deviation check
6	failed annual and seasonal standard deviation check
7	bullseye from standard level data or failed annual and monthly standard deviation check
8	failed seasonal and monthly standard deviation check
9	failed annual, seasonal and monthly standard deviation check
2) FLAGS ON INDIVIDUAL OBSERVATIONS	
	(a) Depth Flags
0	accepted value
1	duplicates or inversions in recorded depth (same or less than previous depth)
2	density inversion
	(b) Observed Level Flags
0	accepted value
1	range outlier (outside of broad range check)
2	failed inversion check
3	failed gradient check
4	observed level "bullseye" flag and zero gradient check
5	combined gradient and inversion checks
6	failed range and inversion checks
7	failed range and gradient checks
8	failed range and questionable data checks
9	failed range and combined gradient and inversion checks
	(c) Standard Level Flags
0	accepted value
1	bullseye marker
2	density inversion
3	failed annual standard deviation check
4	failed seasonal standard deviation check
5	failed monthly standard deviation check
6	failed annual and seasonal standard deviation check
7	failed annual and monthly standard deviation check
8	failed seasonal and monthly standard deviation check
9	failed annual, seasonal and monthly standard deviation check
(d) Biological data flags (applied only to Comparable Biological Value - CBV Taxa code 27)	
0	accepted value
1	range outlier (outside of broad range check)

2	questionable value ("bullseye flag")
3	group was not reviewed
4	failed annual standard deviation check

Table 13. Maximum depth gradient and inversion factors

VARIABLE	MIV (Z<400m)	MGV (Z<400m)	MIV (Z>400m)	MGV (Z>400m)	ZSI
Temperature	0.300	0.700	0.300	0.700	5.000
Salinity	9.000	9.000[1)]	0.050	0.050	5.000
Oxygen	43.570	43.570	32.677	32.677	87.140
Phosphate	0.967	0.967	0.488	0.488	2.439
Silicate	4.878	4.878	3.415	3.415	2.927
Nitrate	0.976	0.976	0.488	0.488	2.439
pH	0.400	0.400	0.200	0.200	2.000
Chlorophyll	1.000	1.000	0.250	0.250	2.000
Alkalinity	0.300	0.100	0.050	0.050	2.000
Nitrate + Nitrite	0.976	0.976	0.488	0.488	2.439

[1)] For all variables, the MGV/MIV ranges (Z<400m), where Z denotes depth, were set high enough to exclude only values which are grossly incorrect. For salinity, these ranges are so large as to be nearly irrelevant for these checks.

11. Vertical depth interpolation method

Prior to the next step in the quality control procedure, the data are interpolated from observed levels to standard depth levels (listed in Appendix 9). Any data flagged as range outliers, excessive gradients, inversions, or depth errors are not used during interpolation to standard levels. This was applied when possibly during interpolation to standard levels. The interpolation scheme used is a modification from that described by Reiniger and Ross (1968) and noted by UNESCO (1991) as being in common usage. This scheme uses four observed values surrounding the standard level in question – the two closest shallower values and the two closest deeper values. The closest shallower and deep values ("inside" values) and the two farthest shallow and deep values ("outside" values) must be within the depth difference criteria shown in Appendix 10. The first set of depths in this table is the maximum distance between the depths of the "inside values".

The second set of depths applies to the maximum distance between the depths of the "outside values". This interpolation scheme has the advantage over three-point Lagrangian interpolation of being less susceptible to extremes when a large gradient is encountered since two separate three-point Lagrangian interpolations are averaged and then fit to a reference curve.

If all the above criteria are met, the variable value at the standard depth level is set by the Reiniger and Ross (1968) interpolation method. If there are not enough surrounding values within acceptable distances, three-point Lagrangian interpolation is performed on the value above and two values below the level in question, or on the two values above and one value below depending on the number of observations above or below the selected depth.

Modifications to the Reiniger and Ross (1968) method are the following:

a) If the Reiniger and Ross interpolated value does not fall between the observed values directly above and below it, linear interpolation is substituted;

b) If any observed value is recorded within 5 meters of the sea surface, this value is used as the surface value;

Direct substitution (observed level depth equals the standard level depth) and the Reiniger and Ross (1968) interpolation account for most of the standard level values.

B. QUALITY CONTROL OF STANDARD LEVEL DATA

12. Standard level density check

A standard level density check was used to eliminate spurious inversions due to interpolation (Levitus *et al.* 1994). Each profile was checked for static stability using Hesselberg and Sverdrup's (1914) definition. The computation is a local one in the sense that adiabatic displacements between adjacent temperature-salinity measurements in the vertical are considered rather than displacements to the sea surface. The procedure for stability (E) computation follows that used by Lynn and Reid (1968):

$$E = \lim_{\delta_z \to 0} \frac{1}{\rho_0} \frac{\delta\rho}{\delta z}, \qquad \text{(Equation 2)}$$

where $\rho_0 = 1.02$ g·cm^{-3} and z is depth in meters. As noted by Lynn and Reid (1968) the term is "the individual density gradient defined by vertical displacement of a water parcel". For discrete samples, the density difference ($\delta\rho$) between two samples is taken after the deeper sample is adiabatically displaced to the standard level of the shallower depth. $\delta\rho$ is then simply the displaced sample's density minus the shallower sample's density. Densities were calculated using the IGOSS standard density equation (Fofonoff and Millard, 1983) on interpolated temperature and salinity data. An inversion was defined as anywhere the $\delta\rho$ was less than zero. For observations with a shallow sampling depth of 30 meters or less, an inversion of 3×10^{-5} g·cm^{-3} was considered an indication of a problem with the data. The temperature and salinity at both of these depths were flagged. For observations with a deeper sampling depth between 50 and 400 meters an inversion of 2×10^{-5} g·cm^{-3} was considered excessive. For depths greater than 400 meters any inversion greater than 10^{-6} g·cm^{-3} was considered excessive. If two or more such density inversion was found in one profile, all temperature and salinity values were flagged as unusable for this profile.

13. Statistical analysis of data at standard depth levels

Observed level data were interpolated to 102 standard depth levels, averaged by five-degree longitude-latitude squares, and simple statistics (mean, standard deviation, and number of observations) were computed for each depth level. Each five-degree square box was designated as coastal, near coastal, or open ocean, depending on the number of one-degree by one-degree latitude-longitude grid boxes in the five-degree box which were land areas. The five-degree standard deviation multiplier file (sd_multiplier.msk) is available on the WOD website.

Standard level data were flagged as follows:

a) Coastal: The standard level data value exceeds 5 standard deviations computed within the 5x5 grid in the upper 50 m;
b) Near-coastal: The standard level data value exceeds 4 standard deviations computed for 5x5 the grid in the upper 50 m;
c) Open ocean: The standard level data value exceeds three standard deviations computed for the 5x5 grid, except when a profile was at or below the average depth level for the one-degree box in which it was contained, or any of the adjacent one-degree boxes, then 4 standard deviations were used;
d) If a cast contains four or more standard deviation failures, the whole cast is flagged.

The reason for varying the standard deviation criterion is the expected high variability in shallow coastal areas due to river runoff and other factors. Also, high variability within a five-degree box near the ocean bottom can occur if the five-degree square box contains portions of two basins, *e.g.*, the mid-Atlantic ridge separating east and west Atlantic waters. This check was only performed if there were five or more observations at this depth in the grid box. The standard deviation check was applied twice to the data and then new five-degree square statistics were computed to produce a new "clean" dataset.

14. Data objective analysis

Following statistical checks, standard level data were averaged by one-degree squares for input to the objective analysis (Boyer *et al.* 1998). The initial objective analyses for each variable at standard depth levels usually contained some large-scale gradients over a small area, or so-called "bullseyes". These unrealistic features generally occurred because of the difficulty in identifying non-representative values in data sparse areas. "Bullseyes" and other questionable features are investigated and are flagged by identifying the profile or individual data points that created each unrealistic feature. In some extreme cases, entire cruises were flagged. These flags were applied to both the observed and standard level data. "Bullseyes" were investigated using property-property plots (*e.g.* temperature against dissolved oxygen), or variable as a function of depth and season within regional basins, surrounding data.

The objective analyses and the statistical analysis of data at standard depth levels are an iterative quality control conducted for each major release of the WOD and WOA (Figure 3). The WOD contains both observed and standard depth level profile data with various QC flags applied during QC (Table 12). The flags mark individual measurements or entire profiles which were not used in the next step of the procedure, either interpolation to standard depth levels for observed level data or calculation of statistical means in the case of standard depth level data for the WOA. Table 1a provides references to the WOA23 data products that describe the statistical and objective analysis process.

We note that in addition to WOD QC flags (Table 12), the WOD preserves the QC flags by the data provider, if available (See secondary header 96: Originator's Flags; Table 4b). Thus, individual investigators can make their own decision regarding the quality and representativeness of the data. Investigators studying the distribution of features such as eddies or fronts will be interested in those data flagged that we may regard as unrepresentative or questionable. In some cases, we may have marked a measurement as questionable when we should not, and not have marked as questionable when we should.

Although we have attempted to identify and flag as many of the questionable values during the WOD QC process, some obviously could remain. Some may eventually turn out not to be real ocean features, not yet capable of being described in a meaningful way by our analysis due to lack of a more uniform 4-D data coverage, our QC procedures, and objective analysis. We welcome the ocean community comments that would improve the usefulness of WOD and WOA as well as for their help identify questionable data that we may have missed, data that we flagged erroneously, newer data set versions of what is in WOD, duplicate data, additional metadata, or new QC metrics and methods.

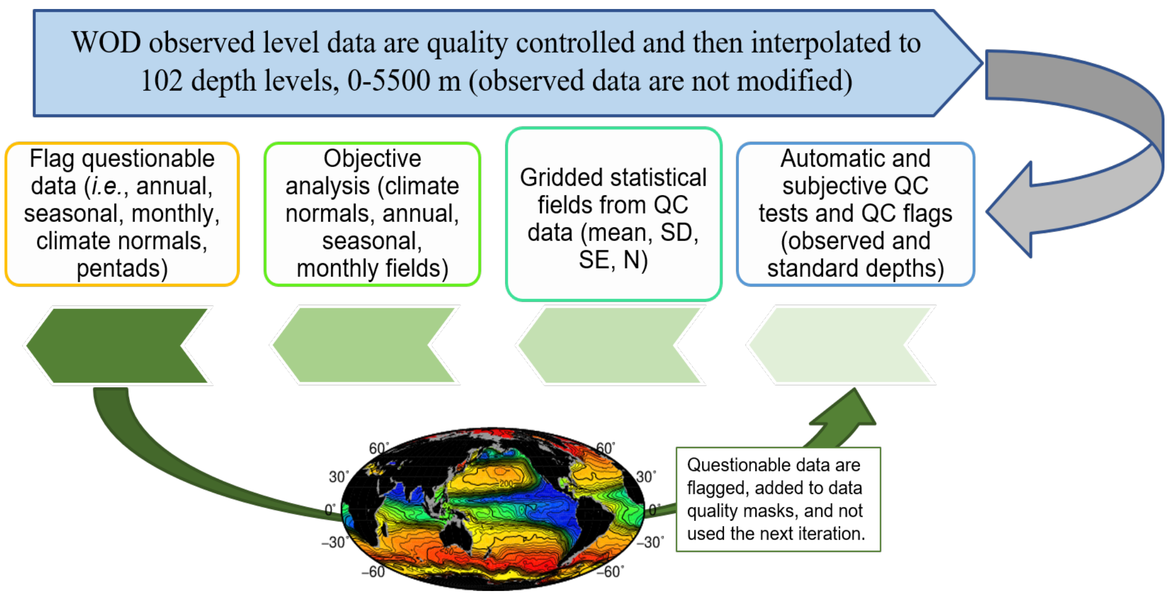


Figure 3. Conceptual WOD and WOA iterative quality control process.

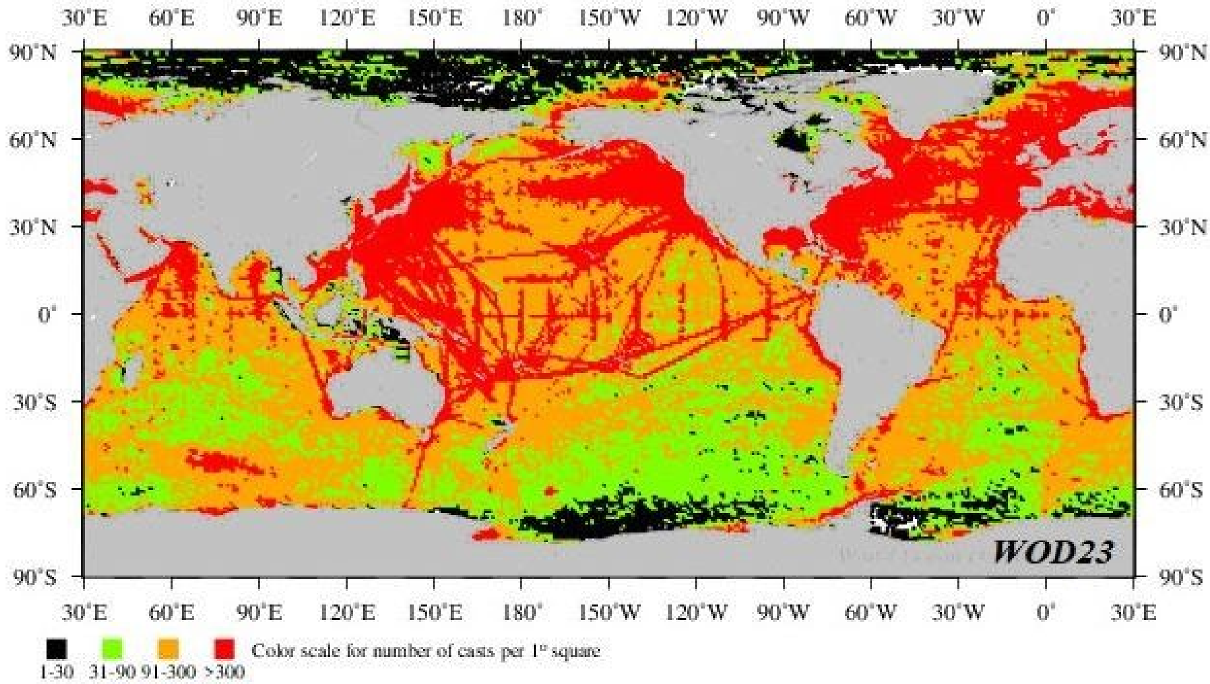


Figure 4. WOD23 number of profiles per 1-degree square

C. XBT DEPTH-TIME EQUATION

Since the current XBT system does not measure depth directly, the precision of the depth associated with each temperature measurement is dependent on the equation that converts the time elapsed since the probe first enters the water to a specific depth (*i.e.*, depth-time equation). The equation is also referred to as the Fall Rate Equation (FRE). Locarnini *et al.* (2024b) provides a detailed description of the XBT data in WOD.

The XBT data at observed levels retain the depths received from the data submitter. Secondary header 33 is added when metadata is provided. It is set to 0 if the Sippican depth-time equation was used, and it is set to 1 if the Hanawa *et al.* (1995) or another amended depth-time equation (Table 4a, 4b). Secondary header 33 is absent if the depth-time equation used is unknown. Data taken before the introduction of corrected depth-time equations in 1996 usually have unknown depth-time equation, and it is assumed the original equation was used unless otherwise noted.

The XBT data at standard levels were adjusted, when needed and possible, using a corrected depth-time equation. Secondary header 54 contains information on whether a depth correction is necessary as well as which corrected depth-time equation should be used to recalculate the reported depth values. Second header 54 is set to "-1" if there is not enough information to know whether a correction is necessary, "0" if no correction is necessary, 1 if the Hanawa *et al.* (1994) correction needs to be applied, 2 if the Kizu et al. (2005) correction needs to be applied, 3 if the Hanawa et al. (1994) was applied (XBT). There are additional secondary 54 header codes which can be found online in s_54_needs_depth_fix

The WODSelect tool allows download of data using each of the corrections detailed in s_54_needs_depth_fix for observed level data. No bias corrections were made to observed level data in the yearly or geographically sorted data.

IV. FREQUENTLY ASKED QUESTIONS AND CITATIONS

The WOD web page includes information about data access, documentation, quality control for each major release. The page also includes answers to frequently asked questions about data access, data specifics, Global Ocean Heat and Salt Content. The World Ocean Database and World Ocean Atlas series are available for public use without restrictions. Additional documentation and access methods, visit the WOD web page and the WOD dataset landing page. For additional questions, please contact ncei.info@noaa.gov.

When the WOD23 data are used, please cite as:

- Mishonov, A.V., T.P. Boyer, O.K. Baranova, C.N. Bouchard, S.L. Cross, H.E. Garcia, R.A. Locarnini, C.R. Paver, J.R. Reagan, Z. Wang, D. Seidov, A.I. Grodsky, J. Beauchamp (2024). World Ocean Database 2023. C. Bouchard, Tech. Ed. *NOAA Atlas NESDIS 97*, https://doi.org/10.25923/z885 h264

When the WOD23 user manual is used (this document), please cite as:

- Garcia H.E., T.P. Boyer, R.A. Locarnini, J.R. Reagan, A.V. Mishonov, O.K. Baranova, C.R. Paver, Z. Wang, C.N. Bouchard, S.L. Cross, D. Seidov, and D. Dukhovskoy (2024). World Ocean Database 2023: User's Manual. A.V. Mishonov, Technical Ed., *NOAA Atlas NESDIS 98*, https://doi.org/10.25923/j8gq eee82

The views, findings, and any errors in this document are those of the authors and do not reflect any position of the U.S.A. Government, the Department of Commerce, or the National Oceanic and Atmospheric Administration (NOAA).

V. DATA SHARING WITH THE WORLD DATA SERVICE FOR OCEANOGRAPHY

The World Data Service for Oceanography (WDSO) is part of the World Data System. NCEI hosts the WDSO; a non-governmental organization (NGO). All data shared with the WDSO are archived and made openly available in the NCEI long-term ocean data archive as soon as practical. WOD is managed at NOAA and is an activity of the IOC IODE. NCEI also acquires and archives oceanography data from data centers and global data acquisition centers by means of automated machine and manual archival means with permission for the data contributors. While WOD includes a significant portion of the historical oceanographic data, additional data resides at worldwide locations. The World Database and World Data Atlas would not be possible without global data sharing for and by all countries.

How to share oceanographic data? Data sharing can be done using the NCEI Send2NCEI (S2N) archival tool. The S2N tool enables individual data providers to upload their data files and related documentation to NCEI up to 20 Gb per submission. Data providers can upload data in one or in as many more submissions. Appendix 14 provides a step by step description of how to upload data and request a DOI if one does not already exist.

VI. LIST OF ACRONYMS USED IN THE DOCUMENTATION

Acronym	Expanded Term
ASCII	American Standard Code for Information Interchange
APB	Autonomous Pinniped Bathythermograph
AWI	Alfred Wegener Institute for Polar and Marine Research
ARGOS	Global satellite comms system for collecting and relaying meteorological and oceanographic data around the world
Argo	Core Argo program floats
BGC-Argo	BioGeoChemical Argo float, an extension of the Argo core program
BT	Bathythermograph
CF	Climate and Forecast Metadata or CF Convention
CRM	Certified Reference Material

Acronym	Expanded Term
CSV	Comma-Separated Values
CTD	Conductivity Temperature Depth dataset in the WOD
DBT	Drifting Bathythermograph
DIVA	Data-Interpolating Variational Analysis
DOC	Department of Commerce
DOE	Department of Energy
DRB	Drifting Buoy dataset in the WOD
ENSO	El Niño-Southern Oscillation,
ERL	Earth Research Laboratory
EOV	Essential Ocean Variable
ETOPO2	Earth Topography 2 arc minute
FAIR	Findable, Accessible, Interoperable, and Reusable
GLD	Glider dataset in the WOD
GMT	Greenwich Mean Time, or Generic Mapping Tools
GTSPP	Global Temperature-Salinity Profile Program
HDF	Hierarchical Data Format
IAPSO	International Association for the Physical Sciences of the Oceans
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODE	International Oceanographic Data Exchange of IOC
IUPAC	International Union of Pure and Applied Chemistry
JPOTS	Joint Panel on Oceanographic Tables and Standards
MBT	Mechanical Bathythermograph dataset in the WOD
MRB	Moored Buoy dataset in the WOD
NCEI	National Centers for Environmental Information
NESDIS	National Environmental Satellite, Data, and Information Service
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
OA	Objective Analysis
OSD	Ocean Station Data dataset in the WOD
OCL	Ocean Climate Laboratory Team
ODV	Ocean Data View (product developed by Dr. Reiner Schlitzer, AWI)
PFL	Profiling Float dataset in in the WOD
PDO	Pacific Decadal Oscillation
QC	Quality Control
QCF	Quality Control Flags
SST	Sea Surface Temperature
SME	Subject Matter Expert
SUR	Surface dataset in the WOD
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UOR	Undulating Oceanographic Recorder dataset in the WOD
USA	United States of America
WDS	World Data System
WDS Oceanography	World Data Service for Oceanography of WDS hosted at NCEI

Acronym	Expanded Term
WOA	*World Ocean Atlas* series (WOA1994, 1998, 2001, 2005, 2009, 2013, 2018, and 2023)
WOA23	*World Ocean Atlas* 2023. WOA23 uses WOD23
WOCE	World Ocean Circulation Experiment
WOD	World Ocean Database series (WOD 1994, 1998, 2001, 2005, 2009, 2013, 2018, and 2023)
WOD23	World Ocean Database 2023 used for WOA23
XBT	Expendable Bathythermograph in the WOD
XCTD	Expendable Conductivity Temperature Depth in the WOD

VII. REFERENCES

Banbridge, A.E. (1980). GEOSECS Atlantic Expedition, vol. 2, Sections and Profiles, 196 pp., *National Science Foundation*, U.S. Government Printing Office, Washington, D.C.

Bane, J.M. (1984). A field performance test of the Sippican deep aircraft-deployed expendable bathythermograph. *Journal of Geophysics Research*, 89: 3615-3621.

Boehlert, G.W., D.P. Costa, D.E. Crocker, P. Green, T. O'Brien, S. Levitus, and B.J. Le Boeuf (2001). Autonomous Pinniped Environmental Samplers: Using Instrumental Animals as Oceanographic Data Collectors. *Journal of Atmospheric and Oceanic Techniques*, 18: 1882-1893.

Boyd, J.D. (1987). Improved depth and temperature conversion equations for Sippican AXBTs. *Journal of Atmospheric and Oceanic Techniques*, 4: 545-551.

Boyd, J.D. and R.S. Linzell (1992). The temperature and depth accuracy of Sippican T-5 XBTs. *Journal of Atmospheric and Oceanic Techniques*, 10: 128-136.

Boyer, T.P., S. Levitus, J. Antonov, M. Conkright, T. O'Brien, and C. Stephens (1998). *World Ocean Atlas* 1998: Vol. 4: Salinity of the Atlantic Ocean. *NOAA Atlas NESDIS 30*, U.S. Government Printing Office, Washington, D.C. 166 pp.

Boyer, T.P., J.I. Antonov, H.E. Garcia, D.R. Johnson, R.A. Locarnini, A.V. Mishonov, M.T. Pitcher, O.K. Baranova, I.V. Smolyar (2006). World Ocean Database 2005. S. Levitus, Ed. *NOAA Atlas NESDIS 60*, U.S. Government Printing Office, Wash., D.C., 190 pp., DVDs.

Boyer, T.P., J.I. Antonov, O.K. Baranova, H.E. Garcia, D.R. Johnson, R.A. Locarnini, A.V. Mishonov, D. Seidov, I.V. Smolyar, M.M. Zweng (2009). World Ocean Database 2009. Ed. S. Levitus. *NOAA Atlas NESDIS 66*, U.S. Gov. Printing Office, Wash., D.C., 216 pp., DVDs.

Boyer, T.P., J.I. Antonov, O.K. Baranova, C. Coleman, H.E. Garcia, A. Grodsky, D.R. Johnson, R.A. Locarnini, A.V. Mishonov, T.D. O'Brien, C.R. Paver, J.R. Reagan, D. Seidov, I.V. Smolyar, M.M. Zweng (2013). World Ocean Database 2013. S. Levitus, Ed., A. Mishonov, Tech. Ed. *NOAA Atlas NESDIS 72*, 209 pp., doi:10.7289/V5NZ85MT.

Calvert J.G. (1990). Glossary of atmospheric chemistry terms (Recommendations 1990). *Pure and Applied Chemistry*. Vol. 62, No. 11. https://doi.org/10.1351/pac199062112167

Copin-Montegut C. (1988). A new formula for the effect of temperature on the partial pressure of CO2 in seawater. Marine Chemistry https://doi.org/10.1016/0304-4203(88)90012-6

Craig, H., W.S. Broecker, and D. Spencer (1981). GEOSECS Pacific Expedition*:* Vol. 4: Sections and Profiles, 251 pp, *National Science Foundation*, U.S. Government Printing Office, Washington, D.C.

Flierl, G. and A.R. Robinson (1977). XBT measurements of the thermal gradient in the MODE eddy. *Journal of Physical Oceanography*, 7: 300-302.

Fofonoff, N.P. and R.C. Millard (1983). Algorithms for computation of fundamental properties of seawater, *UNESCO Tech. Rep. Mar. Sci*., 44.

Forster G. (1777). *A Voyage Round The World in His Britannic Majesty's Sloop, Revolution, commanded by Capt. James Cook, during the Years 1772, 3, 4, and 5*. (George Forters, F.R.S.) Vol 1. London, Printed for B. White, Fleet-Street; J. Robson, Bond Street; P. Elmsly, Strand; and G. Robinson, Paternoster-Row.

Garcia, H.E. and L.I. Gordon (1992). Oxygen solubility in seawater: Better fitting equations. Limnol. Oceanogr., 37, 1307 1312, https://doi.org/10.4319/lo.1992.37.6.1307

Garcia, H. E., T. P. Boyer, R. A. Locarnini, O. K. Baranova, M. M. Zweng (2019). World Ocean Database 2018: User's Manual (prerelease). A.V. Mishonov, Tech. Ed., NOAA, Silver Spring, MD. [PDF]

Garcia H. E., Z. Wang, C. Bouchard, S.L. Cross, C.R. Paver, J.R. Reagan, T.P. Boyer, R.A. Locarnini, A.V. Mishonov, O.K. Baranova, D. Seidov, and D. Dukhovskoy (2024a). *World Ocean Atlas* 2023, Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, Dissolved Oxygen Saturation, and 30 year Climate Normal. A. Mishonov Tech. Ed. *NOAA Atlas NESDIS* 91, 98 pp. https://doi.org/10.25923/rb67-ns53

Garcia, H.E., C. Bouchard, S.L. Cross, C.R. Paver, Z. Wang, J.R. Reagan, T.P. Boyer, R.A. Locarnini, A.V. Mishonov, O. Baranova, D. Seidov, and D. Dukhovskoy (2024b). *World Ocean Atlas* 2023, Volume 4: Dissolved Inorganic Nutrients (phosphate, nitrate, silicate). A. Mishonov, Tech. Ed. *NOAA Atlas NESDIS 92*. https://doi.org/10.25923/39qw-7j08

Gordon, A.L., E.J. Molinelli, and T.N. Baker (1982). *Southern Ocean Atlas*, 266 pp., Columbia University Press, New York.

Gordon L. and L.B. Jones (1973). The effect of temperature on carbon dioxide partial pressures in seawater. Marine Chemistry https://doi.org/10.1016/0304-4203(73)90021-2

Gouretski, V. and K.P. Koltermann (2007). How much is the ocean really warming? *Geophys. Res. Lett*, 34, L01610, 10.1029/2006GL027834.

Hanawa, K.P., P. Rual, R. Bailey, A. Sy, and M. Szabados (1995). Calculation of New Depth Equations for Expendable Bathythermographs Using a Temperature-Error-Free Methods (Application to Sippican/TSK T-7, T-6 and T-4 XBTs), *Intergovernmental Oceanographic Commission Technical Series*, 42: 1-46.

Hesselberg, T. and H.U. Sverdrup (1914). Die Stabiliütsverhältnisse des Seewassers bei Vertitalen Verschiebungen. *Aar. Bergen Mus.*, No. 14, 17 pp.

Kizu, S., H. Yoritaka, and K. Hanawa (2005). A new fall-rate equation for T-5 Expendable Bathythermograph (XBT) by TSK. *Journal of Oceanography*, 61: 115-121.

Levitus, S. (1982). Climatological Atlas of the World Ocean, *NOAA Professional Paper 13*, U.S. Government Printing Office, Washington, D.C. (NTIS PB83 184093)

Levitus, S., R. Gelfeld, T. Boyer, and D. Johnson (1994). Results of the NCEI Oceanographic Data and Archaeology and Rescue Project, 73 pp., *Key to Oceanographic Records Documentation 19*. U.S. Government Printing Office, Washington, D.C.

Levitus S., T.P. Boyer, M.E. Conkright, T. O'Brien, J. Antonov, C. Stephens, L. Stathoplos, D. Johnson, and R. Gelfeld (1998). World Ocean Data Base 1998. Vol. 1: Introduction, 346 pp., *NOAA Atlas NESDIS 18*, U.S. Government Printing Office, Washington, D.C.

Levitus, S, J.I. Antonov, T.P. Boyer, R.A. Locarnini, H.E. Garcia, and A.V Mishonov (2009), Global ocean heat content 1955-2008 in light of recently revealed instrumentation problems. *Geophys. Res. Lett.*, 36, L07608, doi:10.1029/2008GL037155.

Levitus, S. (2012). The UNESCO-IOC-IODE "Global Oceanographic Data Archeology and Rescue" (GODAR) and "World Ocean Database" projects. *Data Science Journal*, Volume 11. https://datascience.codata.org/articles/10.2481/dsj.012-014

Lide, D. R. (1992*). CRC handbook of chemistry and physics, 1992-1993: a ready-reference book of chemical and physical data*; 73rd edition, CRC Press

Locarnini, R.A., A.V. Mishonov, O.K. Baranova, J.R. Reagan, T.P. Boyer, D. Seidov, Z. Wang, H.E. Garcia, C. Bouchard, S.L. Cross, C.R. Paver, and D. Dukhovskoy (2024a). *World Ocean Atlas* 2023, Volume 1: Temperature. A. Mishonov Tech.Ed. *NOAA Atlas NESDIS 89.* https://doi.org/10.25923/54bh-1613

Locarnini *et al.* (2024b). Chapter 4: Expendable Bathythermograph data (XBT). In Mishonov *et al.* (2024).

Lynn, R.J. and J. L. Reid (1968). Characteristics and circulation of deep and abyssal waters, *Deep Sea Research*, 15, 577-598.

Margulis, L. and K.V. Schwartz (1998). Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth. W.H. Freeman & Company (New York), 520 pp.

Mishonov, A.V., T.P. Boyer, O.K. Baranova, C.N. Bouchard, S.L. Cross, H.E. Garcia, R.A. Locarnini, C.R. Paver, J.R. Reagan, Z. Wang, D. Seidov, A.I. Grodsky, J. Beauchamp (2024). World Ocean Database 2023. C. Bouchard, Tech. Ed. *NOAA Atlas NESDIS 97*, https://doi.org/10.25923/z885-h264

O'Brien, T.D. (2007). COPEPOD: The Global Plankton Database. A review of the 2007 database contents and new quality control methodology. U.S. Dep. of Commerce, *NOAA Tech. Memo. NMFS-F/ST-34*, 28 p.

Prestwich, J., XXI. Tables of temperatures of the sea at different depths beneath the surface : reduced and collated from the various observations made between the years 1749 and 1868, discussed. With Map and Sections. By Joseph Prestwich, M.A., F.R.S, F.G.S.. Philosophical Transaction of the Royal Society of London, Vol. 165, part 2, pp. 587-674. Royal Society of London 1875. https://wellcomecollection.org/works/t8qaurkf

Reagan, J.R.; Boyer, T.P.; García, H.E.; Locarnini, R.A.; Baranova, O.K.; Bouchard, C.N.; Cross, S.L.; Mishonov, A.V.; Paver, C.R.; Seidov, D.; Wang, Z.; Dukhovskoy, D. (2024). *World Ocean Atlas* 2023. NOAA National Centers for Environmental Information. Dataset: NCEI Accession 0270533

Reagan, J.R., D. Seidov, Z. Wang, D. Dukhovskoy, T.P. Boyer, R.A. Locarnini, O.K. Baranova, A.V. Mishonov, H.E. Garcia, C. Bouchard, S.L. Cross, and C.R. Paver. (2024). *World Ocean Atlas* 2023, Volume 2: Salinity. A. Mishonov, Tech. Ed., *NOAA Atlas NESDIS 90* https://doi.org/10.25923/70qt-9574

Reiniger, R.F. and C.K. Ross (1968). A method for interpolation with application to oceanographic data, *Deep-Sea Research*, 15: 185-193.

Rual, P., A. Dessier, and J.P. Rebert (1995). New depth equation for 'old' Sparton XBT-7 expendable bathythermographs. *International WOCE newsletter*, 19: 33-34.

Rual, P., A. Dessier, J.P. Rebert, A. Sy, and K. Hanawa (1996). New depth equation for Sparton XBT-7 expendable bathythermographs, preliminary results. *International WOCE newsletter*, 24: 39-40.

Spencer, D., W.S. Broecker, H. Craig and R.F. Weiss (1982). GEOSECS Indian Ocean Expedition: Vol. 6, Sections and Profiles, 140 pp., *National Science Foundation*, U.S. Government Printing Office, Washington, D.C.

Takahashi, T., Olafsson, J., Goddard, J., Chipman, D.W. and Sutherland, S.C. 1993 Seasonal variation of CO2 and nutrients in the high-latitude surface oceans: a comparative study. *Global Biogeochem. Cycle*s 7, 843-8

Thadathil, P., A. K. Saran, V.V. Gopalakrishna, P. Vethamony, N. Araligidad, and R. Bailey (2002). XBT fall rate in waters of extreme temperature: A case study in the Antarctic Ocean. *Journal of Atmospheric and Oceanic Techniques*, 19: 391-396. https://doi.org/10.1175/1520-0426-19.3.391

UNESCO (1991). *Processing of oceanographic station data*, 138 pp., Imprimerie des Presses Universitaires de France, United Nations Educational, Scientific and Cultural Organization, France.

Weiss, R., Jahnke, R. & Keeling, C. (1982)Seasonal effects of temperature and salinity on the partial pressure of CO2 in seawater. Nature 300, 511–513. https://doi.org/10.1038/300511a0

Wilkinson, M., M. Dumontier, I. Aalbersberg, I. *et al* (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018. https://doi.org/10.1038/sdata.2016.18

Willis, J.K., D. Roemmich, and B. Cornuell (2004). Interannual variability in upper ocean heat content, temperature, and thermosteric expansion on global scales. *Journal of Geophysics Research*, 109, C1203., https://doi.org/10.1029/2003JC002260

WMO, World Meteorological Organization (2019) Basic Documents No. 2, Manual on Codes, Volume I.1 – International Codes, Annex II to the WMO Technical Regulations Part A – Alphanumeric Codes, WMO-No. 306 (https://library.wmo.int/idurl/4/35713)

Wyrtki, K. (1971). Oceanographic Atlas of the International Indian Ocean Expedition. 531 pp., National Science Foundation, U.S. Government Printing Office, Washington, D.C.

APPENDIX 1. ISO country codes (sorted by Code in alphabetical order)

##	CODE	COUNTRY NAME	##	CODE	COUNTRY NAME
1	**99**	Unknown	48	**LR**	Liberia
2	**AG**	Antigua	49	**LT**	Lithuania
3	**AO**	Angola	50	**LV**	Latvia
4	**AR**	Argentina	51	**MA**	Morocco
5	**AT**	Austria	52	**MC**	Monaco
6	**AU**	Australia	53	**MG**	Madagascar
7	**BB**	Barbados	54	**MH**	Marshall Islands
8	**BE**	Belgium	55	**MR**	Mauritania
9	**BG**	Bulgaria	56	**MT**	Malta
10	**BR**	Brazil	57	**MU**	Mauritius
11	**BS**	Bahamas	58	**MX**	Mexico
12	**CA**	Canada	59	**MY**	Malaysia
13	**CD**	Congo; Democratic Republic of the	60	**NC**	New Caledonia
14	**CI**	Cote D'ivoire	61	**NG**	Nigeria
15	**CL**	Chile	62	**NL**	Netherlands
16	**CN**	China	63	**NO**	Norway
17	**CO**	Colombia	64	**NZ**	New Zealand
18	**CR**	Costa Rica	65	**PA**	Panama
19	**CU**	Cuba	66	**PE**	Peru
20	**CY**	Cyprus	67	**PH**	Philippines
21	**DE**	Germany	68	**PK**	Pakistan
22	**DK**	Denmark	69	**PL**	Poland
23	**DU**	East Germany	70	**PT**	Portugal
24	**DZ**	Algeria	71	**RO**	Romania
25	**EC**	Ecuador	72	**RU**	Russian Federation
26	**EE**	Estonia	73	**SA**	Saudi Arabia
27	**EG**	Egypt	74	**SC**	Seychelles
28	**ES**	Spain	75	**SE**	Sweden
29	**EU**	European Union	76	**SG**	Singapore
30	**FI**	Finland	77	**SL**	Sierra Leone
31	**FJ**	Fiji	78	**SN**	Senegal
32	**FR**	France	79	**SU**	Soviet Union
33	**GB**	Great Britain	80	**TH**	Thailand
34	**GH**	Ghana	81	**TN**	Tunisia
35	**GR**	Greece	82	**TO**	Tonga
36	**HK**	Hong Kong	83	**TR**	Turkey
37	**HN**	Honduras	84	**TT**	Trinidad and Tobago
38	**HR**	Croatia	85	**TW**	Taiwan
39	**ID**	Indonesia	86	**UA**	Ukraine
40	**IE**	Ireland	87	**US**	United States
41	**IL**	Israel	88	**UY**	Uruguay
42	**IN**	India	89	**VC**	Saint Vincent and Grenadines
43	**IS**	Iceland	90	**VE**	Venezuela
44	**IT**	Italy	91	**WS**	Samoa; Western
45	**JP**	Japan	92	**YE**	Yemen
46	**KR**	Korea; Republic of	93	**YU**	Yugoslavia
47	**KW**	Kuwait	94	**ZA**	South Africa
48	**LB**	Lebanon	95	**ZZ**	Misc. Organization

Data from Russia include data from USSR (the FSU).
Data from Germany include the Federal Republic and the Democratic Republic
See the WOD ISO country code. (See online all of the WOD code tables)

APPENDIX 2. Secondary header code tables

The prefix ‘s’ in front of the following code tables denotes secondary header code tables. The first column in the tables contains the code used by the WOD to identify the variable. Sometimes, the second column contains the code used by NCEI. The final column contains the code description. All of the WOD codes are found online.

2.1. Ocean Weather Station (code 9): s_9_weather_station

2.2. Cast Direction (code 12): s_12_cast_direction

2.3. Water Color (code 14): s_14_water_color; Source: Extended Forel-Ule Scale

2.4. Wave Direction (code 16): s_16_wave_direction; Source: WMO code 0877

2.5. Wave Height (code 17): s_17_wave_height; Source: WMO code 1555

2.6. Sea State (code 18): s_18_sea_state; Source: WMO code 3700

2.7. Wind Force (code 19): s_19_wind_force; Source: Beaufort Scale

2.8. Wave Period (code 20): s_20_wave_period

2.9. Wind Direction (code 21): s_21_wind_direction; Source: WMO code 0877

2.10. Weather Condition (code 26): s_26_weather_condition; Source: WMO code 4501 (if ≤ 0) or WMO code 4677 (if > 0)

2.11. Cloud Type (code 27): s_27_cloud_type; Source: WMO code 0500

2.12. Cloud Cover (code 28): s_28_cloud_cover; Source: WMO code 2700

2.13. Probe Type (code 29): s_29_probe_type

2.14. Recorder (code 32): s_32_recorder; Source: WMO code 4770

2.15. Digitization Method (code 35): s_35_digitization_method; Source: NCEI code 0612

2.16. Digitization Interval (code 36): s_36_digitization_interval; Source: NCEI code 0613

2.17. Data Treatment and Storage (code 37): s_37_data_storage; Source: NCEI code 0614

2.18. Reference Instrument (code 40): s_40_ref_instrument; Source: NCEI code 0615

2.19. Horizontal Visibility (code 41): s_41_visibility; Source: WMO code 4300

2.20. Needs Depth Fix (code 54): s_54_needs_depth_fix.

- Note: Values 3-12 are only available through the WODSelect retrieval tool. In addition, values 1, 2, 103, 104, have corrections applied (ignore the word ‘needs’).

2.21. Ocean Vehicle (code 74): s_74_ocean_vehicle

2.22. Partial pressure CO_2 calculation method (code 81) s_81_pCO2_calc_method

Code table s_81_pCO2_calc_method

Code	Partial pressure of CO_2 Calculation Method (code 81) description
Units	See Table 3a
1500	Warming (°C), or temperature of analysis (°C)
1520	Standard atmospheric pressure used in calculations, or measured
1540	Warming correction method
1541	Warming correction method Weiss *et al.* (1982)
1542	Warming correction method Takahashi *et al.* (1993)
1543	Warming correction method Goyet *et al.* (1993)
1544	Warming correction method Copin-Montegut (1988)
1545	Warming correction method Gordon and Jones (1973)

2.23. Partial pressure of CO_2 equilibrator type (code 82): s_82_equilibrat_type

Code table s_82_equilibrat_type

CODE	DESCRIPTION
1600	Showerhead design
1601	Showerhead, large volume > 10 L
1602	Showerhead, small volume < 10 L
1630	Laminar flow design
1640	Rotating disk design
1650	Bubbling design
1660	Tandem design (combined showerhead and bubbling)
1670	Membrane design
1680	Aspirator design
1690	Discrete sample closed loop equilibration

2.24. ARGOS Fix (code 84): s_84_argos_fix

2.25. Database ID (code 91): s_91_database_id

2.26. U.K. Hydrographic Office Profile Data Reference (code 92) s_92_ukho_ref

2.27. Originator's Depth Unit (code 95): s_95_depth_unit

2.28. Originator Flag Set (code 96): s_96_origflagset

2.29. Water Sampler (code 97): s_97_sampler

APPENDIX 3. Codes for variable specific secondary headers

The prefix 'v' in the following tables denotes variable specific header codes (see WOD codes online)

3.1. Scale (code 3): v_3_scale
3.2. Instrument Codes (code 5): v_5_instrument
3.3. Methods (code 6): v_6_methods
3.4. Originator's Units (code 8): v_8_orig_units
3.5. Equilibrator Type (code 10): v_10_equilibrator_type
3.6. Filter Type and Size (code 11): v_11_filter_type_and_size
3.7. Incubation Time (code 12): v_12_incubation_time

APPENDIX 4. Biological header code tables

The prefix 'b' in the following tables denotes biological header codes. All of the WOD codes are found online.

4.1. Type of Tow (code 4): b_4_type_tow
4.2. Large Removed (code 6): b_6_large_removed
4.3. Gear and Flowmeter (code 7 and code 18): b_7_gear_and_flowmeter_codes
4.4. Preservation Method (code 10): b_10_preservative_method
4.5. Weight Method (code 11): b_11_weight_method
4.6. Count Method (code 13): b_13_count_method
4.7. Flowmeter Calibration (code 19): b_19_flowmeter_calibration
4.8. Depth Determination (code 24): b_24_depth_determined
4.9. Volume Method (code 25): b_25_volume_method

APPENDIX 5. Taxonomic data

The prefix 't' es denotes taxonomic data codes. All of the WOD codes are found online.

5.1. Life stage (code 5): t_5_taxon_lifestage; TSN = taxonomic serial number
5.2. Gender (code 6): t_6_taxon_sex_code
5.3. Presence/abundance (code 7): t_7_taxon_presence_abundance_codes
5.4. Trophic Mode (code 8): t_8_taxon_trophic_mode
5.5. Realm (code 9): t_9_taxon_realm
5.6. Features (code 16): t_16_taxon_features
5.7. Modifier (code 17): t_17_taxon_modifier
5.8. Size (codes 18 and 19): t_18_size_min and t_19_size_max
5.9. Count Method (code 26): t_26_count_method
5.10. Common Base-Unit Value (code 27): t_27_cbv_value
5.11. Common Base-Unit Value Calculation Method (code 28): t_28_cbv_calculation_method

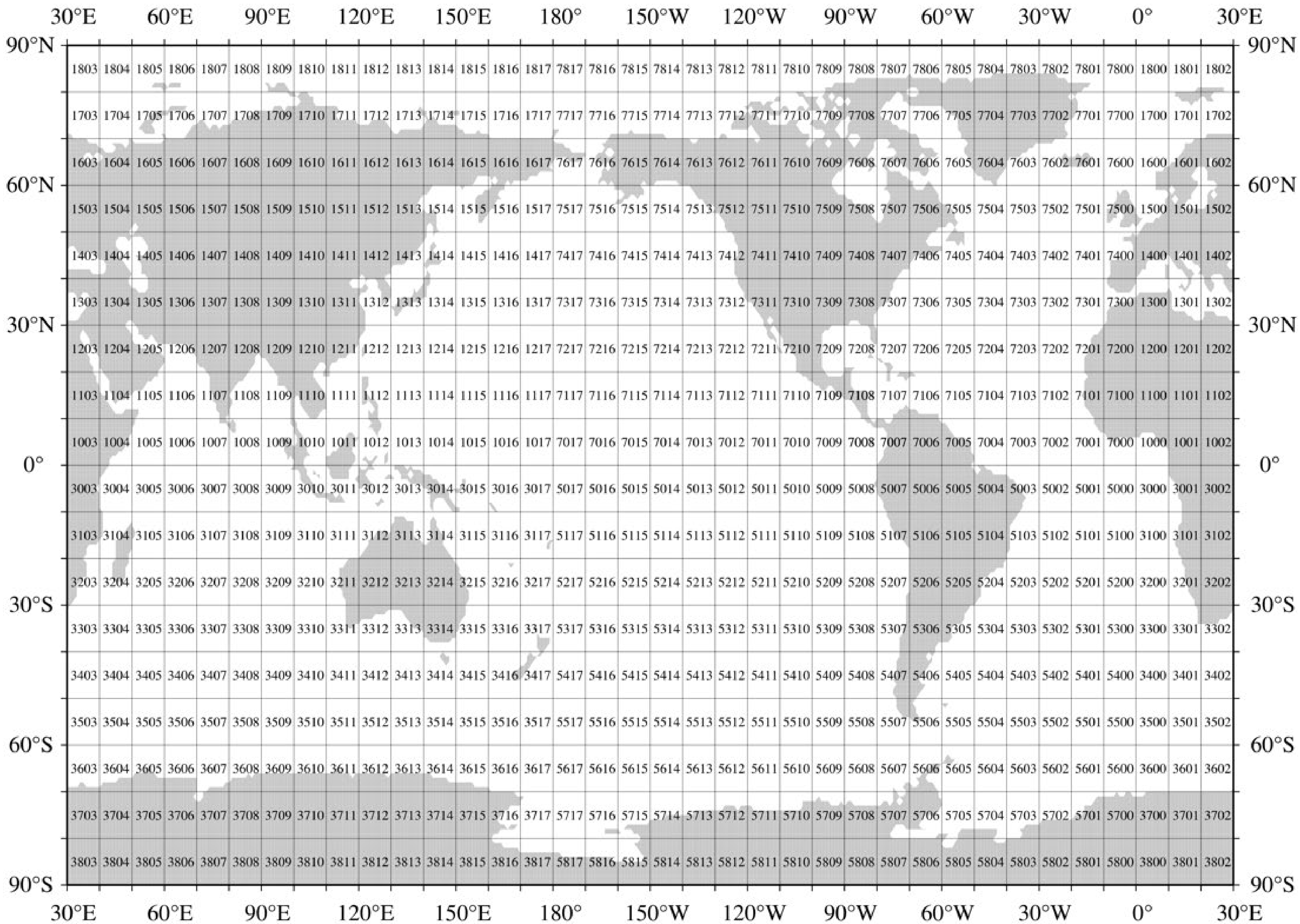
APPENDIX 6. Plankton grouping codes

All of the WOD codes are found online.

CODE	DESCRIPTION
1000000	**BACTERIA (*all sub-groups*)**
1050000	Cyanobacteria
	PHYTOPLANKTON (*all sub-groups*)
2030000	Amoebida
2040000	Granuloreticulosa (Foraminifera)
2070000	Dinomastigota (Dinoflagellata)
2080000	Ciliophora (ciliates)
2100000	Haptomonada (Coccolithophorids)
2110000	Cryptomonada (Chrytophyta)
2120000	Discomitochondria
2130000	Chrysomonada (Chrysophyta)
2160000	Diatoms (Bacillariophyta)
2270000	Actinopoda (amoeba)
2280000	Chlorophyta (green algae)
2300000	Ebriida
4000000	**ZOOPLANKTON (*all sub-groups*)**
4020000	Porifera
4030000	Cnidaria (coelenterates)
4032000	Hydrozoa
4036000	Stauromedusae
4038000	Antipatharia
4040000	Ctenophora (comb jellies)
4050000	Platyhelminthes (flat worms)
4090000	Nemertina (ribbon worms)
4100000	Nematoda
4130000	Rotifera (rotifers)
4180000	Entoprocta
4190000	Arthropoda: Chelicerata
4200000	Arthropoda: Mandibulata ("insects")
4210000	Arthropoda: Crustacea (*all sub-groups*)

CODE	DESCRIPTION
4211000	*Crustacea*: Ostracoda
4212000	*Crustacea*: Copepoda
4213000	*Crustacea*: Cirripedia (barnacles)
4214000	*Crustacea*: Mysidacea
4216000	*Crustacea*: Isopoda
4217000	*Crustacea*: Amphipoda
4218000	*Crustacea*: Euphausiacea
4219000	*Crustacea*: Decapoda
4220000	Annelida (segmented worms)
4230000	Sipuncula
4260000	Mollusca (*all sub-groups*)
4262500	*Mollusca*: Gastropoda (snails & slugs)
	ZOOPLANKTON (*all sub-groups*)
4265000	*Mollusca*: Bivalvia (bivalve molluscs)
4266000	*Mollusca*: Scaphopoda (tusk shell)
4267500	*Mollusca*: Cephalopoda
4300000	Brachiopoda (lamp shells)
4310000	Phoronida
4320000	Chaetognatha (arrow worms)
4330000	Hemichordata
4340000	Echinodermata
4350000	Urochordata (*all sub-groups*)
4352500	*Urochordata*: Ascidiacea (sea squirts)
4355000	*Urochordata*: Thaliacea (salps & doliolids)
4357500	*Urochordata*: Larvacea / Appendicularia
4360000	Cephalochordata / Leptocardia

APPENDIX 7. WMO squares



APPENDIX 8. Sample output for observed level data in WOD18.

The World Ocean Database (WOD) officially archived version for observed and standard level data is provided in ragged array Network Common Data Form NetCDF format which follows the Climate-Forecast (CF) conventions (See Appendix 12).

Sample from WOD18/DATA/NPAC/OSDO7617.gz CAST #: 67064

C41303567064US5112031934 8 744210374426193562-17227140 611010120101301118220581
01118220291601118220291901024721 8STOCS85A3 41032151032165-500632175-50023218273
18117709500110134401427143303931722076210220602291107291110329977020133023846181
24421800132207614110217330103192220521322011216442103723077095001101818115508527
20012110000133312500021011060022022068002272214830228442684000230770421200000191
15507911800121100001333125000151105002103302270022022068002274411816302284426840
00230770426500000191155069459001211000013331250001511050021033011300220220680022
73319043022844268400023077042620000019116601596680012110000133312500021022016002
17110100220220680022733112830228442684000230770435700000181155088803001211000013
33125000210220160022022068002273311283022844268400023077042120000019115508880300
12110000133312500015110200210330535002202206800227441428030228442684000230770421
20000019115508880300121100001333125000152204300210220320022022068002273312563022
84426840002307704212000001911550853710012110000133312500015110200210220160022022
06800227331128302284426840002307704212000001100003328960044230900033267500222650
03312050033281000220100033289500442309000332670002227100331123003328100022025002
22900044231910033286200222900033115400332810002205000342-123004423241003327280003
32117003312560033280500

Sample output using wodFOR.f

```
 -------------------------------------------------------
Output from ASCII file,  cast#        273
-------------------------------------------------------
CC  cruise  Latitude  Longitude  YYYY  MM  DD   Time   Cast   #levels
US  11203   61.930  -172.270  1934     8    7  10.37   67064     4

Number of variables in this cast:          6

Originators Cruise Code: STOCS85A

Primary Investigator:  215  ... for variable #:  0
Primary Investigator:  216  ... for variable #:  0
Primary Investigator:  217  ... for variable #:  -5006
Primary Investigator:  218  ... for variable #:  -5007

   z    fo    1          fo     2           fo     3          fo     4          fo     6          fo     9      fo

   0.0  00    8.960 (3)  00   30.900 (4)  00    6.750 (3)  00    0.650 (2)  00   20.500 (3)  00    8.100 (3) 00
  10.0  00    8.950 (3)  00   30.900 (4)  00    6.700 (3)  00    0.710 (2)  00   12.300 (3)  00    8.100 (3) 00
  25.0  00    0.900 (2)  00   31.910 (4)  00    8.620 (3)  00    0.900 (2)  00   15.400 (3)  00    8.100 (3) 00
  50.0  00   -1.230 (3)  00   32.410 (4)  00    7.280 (3)  00    1.170 (3)  00   25.600 (3)  00    8.050 (3) 00

VarFlag:            0                0               0               0                0               0

 Secondary header #  1    9500110. (7)
 Secondary header #  3       1427. (4)
 Secondary header #  4        393. (3)
 Secondary header #  7         76. (2)
 Secondary header # 10         60. (2)
 Secondary header # 29          7. (1)
 Secondary header # 91          3. (1)
 Secondary header # 99   2013302. (7)

 Measured Variable #  3 Information Code #  8       58. (2)
 Measured Variable #  4 Information Code #  8       29. (2)
 Measured Variable #  6 Information Code #  8       29. (2)
 Biological header   #  2            18.000 (4)
 Biological header   #  3            76.000 (2)
 Biological header   #  4             2.000 (1)
 Biological header   #  7           103.000 (3)
 Biological header   #  9             0.050 (2)
 Biological header   # 13            11.000 (2)
 Biological header   # 16            10.370 (4)
 Biological header   # 30       9500110.000 (7)

 Taxa-set  1 :    Taxonomic Code [1]#       85272 (5)
           Code #   2                  0.000 (1) 00
           Code #   3                 25.000 (3) 00
           Code #  10                  6.000 (1) 00
           Code #  20                 68.000 (2) 00
           Code #  27                  4.800 (2) 30
           Code #  28                 68.400 (4) 00
           Code #  30            4212000.000 (7) 00

 Taxa-set  2 :    Taxonomic Code [1]#       79118 (5)
           Code #   2                 0.000 (1) 00
          Code #   3               25.000 (3) 00
                Code #   5                  5.000 (1) 00
                Code #  10                227.000 (3) 00
           Code #  20              68.000 (2) 00
```

Code # 27 181.600 (4) 30
Code # 28 68.400 (4) 00
Code # 30 4265000.000 (7) 00

Taxa-set 3 : Taxonomic Code [1]# 69459 (5)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 5 5.000 (1) 00
Code # 10 113.000 (3) 00
Code # 20 68.000 (2) 00
Code # 27 90.400 (3) 30
Code # 28 68.400 (4) 00
Code # 30 4262000.000 (7) 00

Taxa-set 4 : Taxonomic Code [1]# 159668 (6)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 10 16.000 (2) 00
Code # 17 1.000 (1) 00
Code # 20 68.000 (2) 00
Code # 27 12.800 (3) 30
Code # 28 68.400 (4) 00
Code # 30 4357000.000 (7) 00

Taxa-set 5 : Taxonomic Code [1]# 88803 (5)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 10 16.000 (2) 00
Code # 20 68.000 (2) 00
Code # 27 12.800 (3) 30
Code # 28 68.400 (4) 00
Code # 30 4212000.000 (7) 00

Taxa-set 6 : Taxonomic Code [1]# 88803 (5)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 5 2.000 (1) 00
Code # 10 535.000 (3) 00
Code # 20 68.000 (2) 00
Code # 27 428.000 (4) 30
Code # 28 68.400 (4) 00
Code # 30 4212000.000 (7) 00

Taxa-set 7 : Taxonomic Code [1]# 88803 (5)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 5 43.000 (2) 00
Code # 10 32.000 (2) 00
Code # 20 68.000 (2) 00
Code # 27 25.600 (3) 30
Code # 28 68.400 (4) 00
Code # 30 4212000.000 (7) 00

Taxa-set 8 : Taxonomic Code [1]# 85371 (5)
Code # 2 0.000 (1) 00
Code # 3 25.000 (3) 00
Code # 5 2.000 (1) 00
Code # 10 16.000 (2) 00
Code # 20 68.000 (2) 00
Code # 27 12.800 (3) 30
Code # 28 68.400 (4) 00
Code # 30 4212000.000 (7) 00

WOD native ASCII format example

Example of data output queried for unique cast # 8577625 in WOD native format. The World Ocean Database (WOD) officially archived version for observed and standard level data is provided in ragged array Network Common Data Form NetCDF format which follows the Climate-Forecast (CF) conventions (See Appendix 12).

```
B41212785776259051417019911 1 13322254422950441137022000 611010120101301014011182 2
```

WOD comma-separated values (.csv) format
Example of data output queried for unique cast #8577625 in .csv format

```
#--------------------------------------------------------------------------------
----,,,,,
CAST                         ,,8577625,WOD Unique Cast Number,WOD code,
NODC Cruise ID               ,,90-14170       ,,,
Originators Station ID       ,,173,,,integer
Originators Cruise ID        ,,24,,,
Latitude                     ,,29.5,decimal degrees,,
Longitude                    ,,137,decimal degrees,,
Year                         ,,1991,,,
Month                        ,,1,,,
Day                          ,,1,,,
Time                         ,,2.25,decimal hours (UT),,
METADATA,,,,,
Country                      ,,90,NODC code,UNION OF SOVIET SOCIALIST
REPUBLICS,
Accession Number             ,,473,NODC code,,
Platform                     ,,6352,OCL code,PROFESSOR KHROMOV,
Institute                    ,,930,NODC code,FAR EAST SCIENTIFIC RESEARCH
INSTITUTE (FERI) (formerly DVNIGMI; now,
Bottom depth                 ,,2000,meters,,,,,,,,,,,,,,,,,
Cast duration                ,,1.08,hours,,,,,,,,,,,,,,,,,
Wind Direction               ,,16,WMO code 0877,155 DEGREES - 164
DEGREES,,,,,,,,,,,,,,,,,
Wind speed                   ,,21,knots,,,,,,,,,,,,,,,,,
Barometric pressure          ,,1008,millibars,,,,,,,,,,,,,,,,,
Air temperature (dry bulb)   ,,19.1,degrees Celsius,,,,,,,,,,,,,,,,,
Weather condition            ,,25,WMO Code 4677,SHOWER(S) OF RAIN - NOT
FALLING AS SHOWER(S),,,,,,,,,,,,,,,,,
Cloud cover                  ,,6,WMO code 2700,6 OKTAS
7/10-8/10,,,,,,,,,,,,,,,,,
probe_type                   ,,7,OCL_code,bottle/rossette/net,,,,,,,,,,,,,,,,,
Absolute humidity            ,,18.5,g/m^3,,,,,,,,,,,,,,,,,
Database origin              ,,3,WOD code,GODAR Project,,,,,,,,,,,,,,,,,
Original units     ,Phosphate,36,NODC code,ug/l               mg/m3    ppb
g/1000m3,,,,,,,,,,,,,,,,,
Original units      ,Silicate,36,NODC code,ug/l               mg/m3    ppb
g/1000m3,,,,,,,,,,,,,,,,,
VARIABLES ,Depth     ,F,O,Temperatur,F,O,Salinity  ,F,O,Oxygen
,F,O,Phosphate ,F,O,Silicate  ,F,O,pH        ,F,O
UNITS     ,m         , , ,degrees C , , ,PSS       , , ,ml/l      , , ,umol/l
, , ,umol/l    , , ,(n/a)     , ,
Prof-Flag ,          ,0, ,          ,0, ,          ,0, ,          ,3, ,
,0, ,          ,3, ,          ,0,
1,0,0, ,20.95,0, ,34.794,0, ,5.01,0, ,0.126,0, ,0.55,0, ,8.23,0,
2,8,0, ,20.96,0, ,34.792,0, ,4.99,0, ,   ---.---,0, ,   ---.---,0, ,8.23,0,
3,17,0, ,20.96,0, ,34.792,0, ,4.97,0, ,0.111,0, ,0.55,0, ,8.23,0,
4,27,0, ,20.96,0, ,34.789,0, ,4.98,0, ,   ---.---,0, ,   ---.---,0, ,8.23,0,
5,51,0, ,20.97,0, ,34.787,0, ,4.99,0, ,0.122,0, ,0.64,0, ,8.23,0,
6,76,0, ,20.97,0, ,34.787,0, ,5.01,0, ,   ---.---,0, ,   ---.---,0, ,8.23,0,
7,101,0, ,20.98,0, ,34.783,0, ,4.97,0, ,0.126,0, ,0.69,0, ,8.21,0,
8,125,0, ,20.96,0, ,34.795,0, ,   ---.---,0, ,   ---.---,0, ,   ---.---,0,
,   ---.---,0,
9,156,0, ,19.86,0, ,34.838,0, ,4.72,0, ,0.134,0, ,0.89,0, ,8.21,0,
10,200,0, ,19.12,0, ,34.837,0, ,4.6,0, ,0.147,0, ,1.2,0, ,8.18,0,
```

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11,255,0, ,18.4,0, ,34.836,0, ,4.52,0, ,0.21,0, ,2.49,0, ,8.15,0,
12,303,0, ,17.62,0, ,34.804,0, ,   ---.---,0, ,   ---.---,0, ,   ---.---,0,
,   ---.---,0,
13,401,0, ,15.91,0, ,34.704,0, ,   ---.---,0, ,   ---.---,0, ,   ---.---,0,
,   ---.---,0,
14,499,0, ,13.25,0, ,34.519,0, ,3.97,0, ,0.378,0, ,7.22,0, ,8.04,0,
15,604,0, ,10.33,0, ,34.326,0, ,   ---.---,0, ,   ---.---,0, ,   ---.---,0,
,   ---.---,0,
16,705,0, ,7.77,0, ,34.245,0, ,   ---.---,0, ,   ---.---,0, ,   ---.---,0,
,   ---.---,0,
17,797,0, ,6.18,0, ,34.258,0, ,2.13,0, ,0.805,0, ,26.07,0, ,7.86,0,
18,998,0, ,4.18,0, ,34.36,0, ,1.79,0, ,0.908,0, ,41.26,0, ,7.8,0,
19,1201,0, ,3.22,0, ,34.464,0, ,1.62,0, ,   ---.---,0, ,   ---.---,0, ,7.8,0,
20,1507,0, ,2.59,0, ,34.533,0, ,2.01,0, ,0.938,0, ,53.19,0, ,7.81,0,
END OF VARIABLES SECTION,,,,,,,,,,,,,,,,,,,,,
#---------------------------------------------------------------------------
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APPENDIX 9. Standard vertical levels and depths (meters)

Depth (m)	Level #	Depth (m)	Level #	Depth (m)	Level #
0	1	1250	52	5600	103
5	2	1300	53	5700	104
10	3	1350	54	5800	105
15	4	1400	55	5900	106
20	5	1450	56	6000	107
25	6	1500	57	6100	108
30	7	1550	58	6200	109
35	8	1600	59	6300	110
40	9	1650	60	6400	111
45	10	1700	61	6500	112
50	11	1750	62	6600	113
55	12	1800	63	6700	114
60	13	1850	64	6800	115
65	14	1900	65	6900	116
70	15	1950	66	7000	117
75	16	2000	67	7100	118
80	17	2100	68	7200	119
85	18	2200	69	7300	120
90	19	2300	70	7400	121
95	20	2400	71	7500	122
100	21	2500	72	7600	123
125	22	2600	73	7700	124
150	23	2700	74	7800	125
175	24	2800	75	7900	126
200	25	2900	76	8000	127
225	26	3000	77	8100	128
250	27	3100	78	8200	129
275	28	3200	79	8300	130
300	29	3300	80	8400	131
325	30	3400	81	8500	132
350	31	3500	82	8600	133
375	32	3600	83	8700	134
400	33	3700	84	8800	135
425	34	3800	85	8900	136
450	35	3900	86	9000	137
475	36	4000	87		
500	37	4100	88		
550	38	4200	89		
600	39	4300	90		
650	40	4400	91		
700	41	4500	92		
750	42	4600	93		
800	43	4700	94		
850	44	4800	95		
900	45	4900	96		
950	46	5000	97		
1000	47	5100	98		
1050	48	5200	99		
1100	49	5300	100		
1150	50	5400	101		
1200	51	5500	102		

APPENDIX 10. Table of acceptable depth differences for "inside" and "outside" values used in the Reiniger-Ross scheme for interpolating observed level data to standard levels.

Four observed depth level values surrounding the standard depth level value were used, two values from above the standard level and two values from below the standard level. The pair of values furthest from the standard level is termed “exterior” points and the pair of values closest to the standard level are termed “interior” points. Paired parabolas were generated via Lagrangian interpolation. A reference curve was fitted to the four data points and used to define unacceptable interpolations caused by “overshooting” in the interpolation. When there were too few data points above or below the standard level to apply the Reiniger and Ross technique, we used a three-point Lagrangian interpolation. If three points were not available (either two above and one below or vice versa), we used linear interpolation. In the event that an observation occurred exactly at the depth of a standard level, then a direct substitution was made (*i.e.*, no interpolation needed).

Appendix 10. Acceptable depth differences for "inside" and "outside" values used in the Reiniger Ross scheme for interpolating observed level data to standard levels

Standard Levels	Standard Depth (m)	Acceptable depth (m) differences for "inside values"	Acceptable depth (m) differences for "outside values"	Standard Levels	Standard Depth (m)	Acceptable depth (m) differences for "inside values"	Acceptable depth (m) differences for "outside values"
1	0	5	200	72	2500	1000	1000
2	5	50	200	73	2600	1000	1000
3	10	50	200	74	2700	1000	1000
4	15	50	200	75	2800	1000	1000
5	20	50	200	76	2900	1000	1000
6	25	50	200	77	3000	1000	1000
7	30	50	200	78	3100	1000	1000
8	35	50	200	79	3200	1000	1000
9	40	50	200	80	3300	1000	1000
10	45	50	200	81	3400	1000	1000
11	50	50	200	82	3500	1000	1000
12	55	50	200	83	3600	1000	1000
13	60	50	200	84	3700	1000	1000
14	65	50	200	85	3800	1000	1000
15	70	50	200	86	3900	1000	1000
16	75	50	200	87	4000	1000	1000
17	80	50	200	88	4100	1000	1000
18	85	50	200	89	4200	1000	1000
19	90	50	200	90	4300	1000	1000
20	95	50	200	91	4400	1000	1000
21	100	50	200	92	4500	1000	1000
22	125	50	200	93	4600	1000	1000
23	150	50	200	94	4700	1000	1000
24	175	50	200	95	4800	1000	1000
25	200	50	200	96	4900	1000	1000
26	225	50	200	97	5000	1000	1000
27	250	100	200	98	5100	1000	1000
28	275	100	200	99	5200	1000	1000
29	300	100	200	100	5300	1000	1000
30	325	100	200	101	5400	1000	1000
31	350	100	200	102	5500	1000	1000
32	375	100	200	103	5600	1000	1000

Standard Levels	Standard Depth (m)	Acceptable depth (m) differences for "inside values"	Acceptable depth (m) differences for "outside values"	Standard Levels	Standard Depth (m)	Acceptable depth (m) differences for "inside values"	Acceptable depth (m) differences for "outside values"
33	400	100	200	104	5700	1000	1000
34	425	100	200	105	5800	1000	1000
35	450	100	200	106	5900	1000	1000
36	475	100	200	107	6000	1000	1000
37	500	100	400	108	6100	1000	1000
38	550	100	400	109	6200	1000	1000
39	600	100	400	110	6300	1000	1000
40	650	100	400	111	6400	1000	1000
41	700	100	400	112	6500	1000	1000
42	750	100	400	113	6600	1000	1000
43	800	100	400	114	6700	1000	1000
44	850	100	400	115	6800	1000	1000
45	900	200	400	116	6900	1000	1000
46	950	200	400	117	7000	1000	1000
47	1000	200	400	118	7100	1000	1000
48	1050	200	400	119	7200	1000	1000
49	1100	200	400	120	7300	1000	1000
50	1150	200	400	121	7400	1000	1000
51	1200	200	400	122	7500	1000	1000
52	1250	200	400	123	7600	1000	1000
53	1300	200	1000	124	7700	1000	1000
54	1350	200	1000	125	7800	1000	1000
55	1400	200	1000	126	7900	1000	1000
56	1450	200	1000	127	8000	1000	1000
57	1500	200	1000	128	8100	1000	1000
58	1550	200	1000	129	8200	1000	1000
59	1600	200	1000	130	8300	1000	1000
60	1650	200	1000	131	8400	1000	1000
61	1700	200	1000	132	8500	1000	1000
62	1750	200	1000	133	8600	1000	1000
63	1800	200	1000	134	8700	1000	1000
64	1850	200	1000	135	8800	1000	1000
65	1900	200	1000	136	8900	1000	1000
66	1950	200	1000	137	9000	1000	1000
67	2000	1000	1000				

Standard Levels	**Standard Depth (m)**	**Acceptable depth (m) differences for "inside values"**	**Acceptable depth (m) differences for "outside values"**	**Standard Levels**	**Standard Depth (m)**	**Acceptable depth (m) differences for "inside values"**	**Acceptable depth (m) differences for "outside values"**
68	2100	1000	1000				
69	2200	1000	1000				
70	2300	1000	1000				
71	2400	1000	1000				

Note: Since many XBT data were reported only at “inflection points” (depth at which temperature changed by a specified amount from previous recorded value) interpolation limits were not used for XBTs.

APPENDIX 11. Tables of acceptable measurement ranges of observed variables as a function of depth and basin

The range values provided have minimum and maximum values for temperature, salinity, oxygen, phosphate, silicate, nitrate and nitrate + nitrite, pH, chlorophyll, and alkalinity (See Table 3a for units). The range values in the tables are used to help identify the most obvious questionable values for these variables. For simplicity, please note that ranges are given on 102 standard levels (+ one for depths deeper than 5500 m). All standard depths in between given standard depths have the same values as the nearest standard depth shown (for example, 90m standard depth uses 100m range values. If a standard depth is equidistance between two shown standard depths, the ranges values will be the same as the shallower shown standard depth (*i.e.* 5 m range values will be the same as 0 m shown values, not 10 m shown values).

11.1. Variable: Temperature

Standard unit: Degrees Celsius or centigrade (°C)

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
10	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
20	-2.10	32.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
30	-2.10	32.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
50	-2.10	32.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
75	-2.00	30.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	32.00	-2.10	35.00	-2.10	35.00	-2.10	35.00	5.00	35.00	5.00	35.00
100	-2.00	30.00	-2.10	30.00	5.00	30.00	5.00	30.00	0.00	32.00	-2.10	30.00	-2.10	30.00	-2.10	30.00	5.00	30.00	5.00	30.00
125	-2.00	28.00	-2.10	30.00	5.00	30.00	5.00	30.00	-1.50	30.00	-2.10	30.00	-2.10	30.00	-2.10	30.00	3.00	30.00	3.00	30.00
150	-2.00	28.00	-2.10	30.00	5.00	30.00	5.00	30.00	-1.50	30.00	-2.10	30.00	-2.10	30.00	-2.10	30.00	3.00	30.00	3.00	30.00
200	-2.00	28.00	-2.10	30.00	5.00	30.00	5.00	30.00	-1.50	30.00	-2.10	30.00	-2.10	30.00	-2.10	30.00	3.00	30.00	3.00	30.00
250	-1.70	28.00	-2.10	28.00	5.00	28.00	0.00	28.00	-1.50	28.00	-2.10	28.00	-2.10	28.00	-2.10	28.00	3.00	28.00	3.00	28.00
300	-1.70	28.00	-2.10	28.00	3.00	28.00	0.00	28.00	-1.50	28.00	-2.10	28.00	-2.10	28.00	-2.10	28.00	3.00	28.00	3.00	28.00
400	-1.50	20.00	-2.10	28.00	3.00	28.00	0.00	28.00	-1.50	28.00	-2.10	28.00	-2.10	28.00	-2.10	28.00	3.00	28.00	3.00	28.00
500	-1.50	20.00	-2.10	28.00	3.00	28.00	0.00	28.00	-1.50	28.00	-2.10	28.00	-2.10	28.00	-2.10	28.00	0.00	28.00	0.00	28.00
600	-1.50	20.00	-2.10	20.00	3.00	20.00	0.00	20.00	-1.50	20.00	-2.10	20.00	-2.10	20.00	-2.10	20.00	0.00	20.00	0.00	20.00
700	-1.50	20.00	-2.10	20.00	3.00	20.00	0.00	20.00	-1.50	20.00	-2.10	20.00	-2.10	20.00	-2.10	20.00	0.00	20.00	0.00	20.00
800	-1.50	20.00	-2.10	20.00	-0.50	20.00	0.00	20.00	-1.50	20.00	-2.10	20.00	-2.10	20.00	-2.10	20.00	0.00	20.00	0.00	20.00
900	-1.50	20.00	-2.10	20.00	-0.50	20.00	0.00	20.00	-1.50	20.00	-2.10	20.00	-2.10	20.00	-2.10	20.00	0.00	20.00	0.00	20.00
1000	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1100	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1200	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1300	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1400	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1500	-1.50	18.00	-2.10	18.00	-0.50	18.00	0.00	18.00	-1.50	18.00	-2.10	18.00	-2.10	18.00	-2.10	18.00	0.00	18.00	0.00	18.00
1750	-1.50	13.00	-2.10	13.00	-0.50	13.00	0.00	13.00	-1.50	13.00	-2.10	13.00	-2.10	13.00	-2.10	13.00	0.00	13.00	0.00	13.00
2000	-1.50	13.00	-2.10	13.00	-0.50	13.00	0.00	13.00	-1.50	13.00	-2.10	13.00	-2.10	13.00	-2.10	13.00	0.00	13.00	0.00	13.00
2500	-1.50	13.00	-2.10	13.00	-0.50	13.00	-1.00	13.00	-1.50	13.00	-2.10	13.00	-2.10	13.00	-2.10	13.00	0.00	13.00	0.00	13.00
3000	-1.50	7.00	-2.10	7.00	-0.50	7.00	-1.00	7.00	-1.50	7.00	-2.10	7.00	-2.10	7.00	-2.10	7.00	0.00	7.00	0.00	7.00
3500	-1.50	7.00	-2.10	7.00	-0.50	7.00	-1.00	7.00	-1.50	7.00	-2.10	7.00	-2.10	7.00	-2.10	7.00	0.00	7.00	0.00	7.00
4000	-1.50	7.00	-1.50	7.00	-0.50	7.00	-1.00	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00
4500	-1.50	7.00	-1.50	7.00	-0.50	7.00	-1.00	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00
5000	-1.50	7.00	-1.50	7.00	-0.50	7.00	-1.00	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00
5500+	-1.50	5.00	-1.50	3.00	-0.50	3.00	-1.00	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00

11.1. Variable: Temperature (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	20.00
10	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	20.00
20	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	20.00
30	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	14.00
50	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	14.00
75	-2.00	32.00	-2.10	35.00	3.00	35.00	-2.10	35.00	5.00	35.00	5.00	35.00	0.00	35.00	-2.10	35.00	-2.40	15.00	-3.00	14.00
100	-2.00	30.00	-2.10	30.00	3.00	30.00	-2.10	30.00	5.00	30.00	5.00	30.00	0.00	30.00	-2.10	30.00	-2.40	15.00	-3.00	14.00
125	-2.00	30.00	-2.10	30.00	3.00	30.00	-2.10	30.00	3.00	30.00	3.00	30.00	0.00	30.00	-2.10	30.00	-2.40	15.00	-3.00	14.00
150	-2.00	30.00	-2.10	30.00	3.00	30.00	-2.10	30.00	3.00	30.00	3.00	30.00	0.00	30.00	-2.10	30.00	-2.40	15.00	-3.00	10.00
200	-2.00	30.00	-2.10	30.00	3.00	30.00	-2.10	30.00	3.00	30.00	3.00	30.00	0.00	30.00	-2.10	30.00	-2.40	15.00	-3.00	10.00
250	-2.00	28.00	-2.10	28.00	3.00	28.00	-2.10	28.00	3.00	28.00	3.00	28.00	0.00	28.00	-2.10	28.00	-2.40	15.00	-3.00	10.00
300	-2.00	28.00	-2.10	28.00	3.00	28.00	-2.10	28.00	3.00	28.00	3.00	28.00	0.00	28.00	-2.10	28.00	-2.40	15.00	-3.00	10.00
400	-2.00	28.00	-2.10	28.00	3.00	28.00	-2.10	28.00	3.00	28.00	3.00	28.00	0.00	28.00	-2.10	28.00	-2.40	15.00	-3.00	10.00
500	-2.00	28.00	-2.10	28.00	3.00	28.00	-2.10	28.00	0.00	28.00	0.00	28.00	0.00	28.00	-2.10	28.00	-2.40	15.00	-3.00	10.00
600	-2.00	20.00	-2.10	20.00	0.00	20.00	-2.10	20.00	0.00	20.00	0.00	20.00	0.00	20.00	-2.10	20.00	-2.40	10.00	-3.00	9.00
700	-2.00	20.00	-2.10	20.00	0.00	20.00	-2.10	20.00	0.00	20.00	0.00	20.00	0.00	20.00	-2.10	20.00	-2.40	10.00	-3.00	9.00
800	-2.00	20.00	-2.10	20.00	0.00	20.00	-2.10	20.00	0.00	20.00	0.00	20.00	0.00	20.00	-2.10	20.00	-2.40	10.00	-3.00	9.00
900	-2.00	20.00	-2.10	20.00	0.00	20.00	-2.10	20.00	0.00	20.00	0.00	20.00	0.00	20.00	-2.10	20.00	-2.40	10.00	-3.00	9.00
1000	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	10.00	-3.00	8.00
1100	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	10.00	-3.00	8.00
1200	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	7.00	-3.00	8.00
1300	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	7.00	-3.00	8.00
1400	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	7.00	-3.00	8.00
1500	-2.00	18.00	-2.10	18.00	0.00	18.00	-2.10	18.00	0.00	18.00	0.00	18.00	0.00	18.00	-2.10	18.00	-2.40	7.00	-3.00	8.00
1750	-2.00	13.00	-2.10	13.00	0.00	13.00	-2.10	13.00	0.00	13.00	0.00	13.00	0.00	13.00	-2.10	13.00	-2.40	7.00	-3.00	8.00
2000	-2.00	13.00	-2.10	13.00	0.00	13.00	-2.10	13.00	0.00	13.00	0.00	13.00	0.00	13.00	-2.10	13.00	-2.40	7.00	-3.00	8.00
2500	-2.00	13.00	-2.10	13.00	0.00	13.00	-2.10	13.00	0.00	13.00	0.00	13.00	0.00	13.00	-2.10	13.00	-2.40	3.00	-3.00	8.00
3000	-2.00	7.00	-2.10	7.00	0.00	7.00	-2.10	7.00	0.00	7.00	0.00	7.00	0.00	7.00	-2.10	7.00	-2.40	3.00	-3.00	7.00
3500	-2.00	7.00	-2.10	7.00	0.00	7.00	-2.10	7.00	0.00	7.00	0.00	7.00	0.00	7.00	-2.10	7.00	-2.40	3.00	-3.00	7.00
4000	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	3.00	-1.50	7.00
4500	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	3.00	-1.50	7.00
5000	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	7.00	-1.50	3.00	-1.50	7.00
5500+	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00	-1.50	3.00

11.1. Variable: Temperature (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Sea of Japan		Seto Inland Sea	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	34.00	0.00	27.00	-2.00	25.00	-3.00	35.00	14.00	35.00	0.00	35.00	-3.00	33.00	-2.00	32.00	-3.00	32.00	3.00	32.00
10	0.00	34.00	0.00	27.00	-2.00	25.00	-3.00	35.00	14.00	35.00	0.00	35.00	-3.00	33.00	-2.00	31.50	-3.00	31.00	3.50	30.00
20	0.00	34.00	0.00	27.00	-2.00	25.00	-3.00	35.00	14.00	34.00	0.00	35.00	-3.00	33.00	-2.00	31.00	-3.00	30.00	4.00	29.00
30	3.00	30.00	0.00	27.00	-2.00	25.00	-3.00	35.00	14.00	34.00	0.00	35.00	-3.00	32.00	-2.00	30.50	-3.00	29.00	4.50	28.00
50	3.00	30.00	3.00	30.00	-2.00	25.00	-3.00	35.00	13.00	32.00	0.00	35.00	-3.00	30.00	-2.00	30.00	-3.00	29.00	5.00	27.00
75	3.00	28.00	3.00	30.00	-2.00	25.00	-3.00	35.00	13.00	30.00	0.00	35.00	-2.00	29.00	0.00	29.00	-3.00	25.00	7.50	25.00
100	3.00	26.00	3.00	30.00	-2.00	25.00	-3.00	32.00	13.00	30.00	0.00	30.00	-1.00	28.00	3.00	28.00	-3.00	23.00	10.00	24.00
125	3.00	26.00	3.00	30.00	-2.00	25.00	-3.00	32.00	13.00	30.00	0.00	30.00	0.00	27.00	3.00	26.50	-2.00	21.00	10.00	22.00
150	3.00	26.00	5.00	30.00	-2.00	25.00	-3.00	32.00	13.00	30.00	0.00	30.00	0.00	26.00	3.00	25.00	-1.00	18.00	10.00	20.00
200	3.00	22.00	5.00	30.00	-2.00	16.00	-3.00	32.00	13.00	28.00	0.00	30.00	0.00	24.50	3.00	24.00	-1.00	14.00	8.00	17.00
250	3.00	22.00	5.00	25.00	-2.00	16.00	-3.00	32.00	13.00	28.00	0.00	28.00	0.00	23.00	5.00	22.50	-1.00	12.00	7.00	14.00
300	3.00	22.00	5.00	25.00	-2.00	16.00	-3.00	32.00	10.00	28.00	0.00	28.00	0.00	21.50	7.00	21.00	-1.00	10.00	6.00	11.00
400	3.00	20.00	5.00	20.00	-2.00	16.00	-3.00	32.00	10.00	28.00	0.00	28.00	0.00	20.00	6.00	18.00	-1.00	3.00	5.00	10.00
500	3.00	20.00	5.00	20.00	-2.00	16.00	-3.00	32.00	10.00	28.00	0.00	28.00	1.00	19.00	5.50	15.00	0.00	1.10	5.00	10.00
600	3.00	20.00	5.00	17.00	-2.00	16.00	-3.00	32.00	10.00	26.00	0.00	20.00	1.80	16.50	5.00	12.50	0.00	1.00	5.00	10.00
700	3.00	20.00	5.00	17.00	-2.00	16.00	-3.00	32.00	10.00	26.00	0.00	20.00	2.00	14.00	4.50	10.00	0.00	0.80	5.00	10.00
800	3.00	20.00	5.00	17.00	-2.00	16.00	-3.00	32.00	10.00	26.00	0.00	20.00	2.00	11.00	4.00	7.60	0.00	0.62	5.00	10.00
900	3.00	20.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	26.00	0.00	20.00	2.00	8.00	3.70	7.30	0.00	0.52	5.00	10.00
1000	3.00	20.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	2.00	6.50	3.50	7.00	0.00	0.44	5.00	10.00
1100	3.00	20.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	2.00	5.30	3.40	6.00	0.00	0.40	5.00	10.00
1200	3.00	18.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	1.95	4.70	3.30	5.00	0.00	0.37	5.00	10.00
1300	3.00	18.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	1.90	4.10	3.20	4.90	0.00	0.34	5.00	10.00
1400	3.00	18.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	1.85	3.70	3.10	4.60	0.00	0.31	5.00	10.00
1500	3.00	18.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	23.00	0.00	18.00	1.80	3.50	3.00	4.50	0.00	0.28	5.00	10.00
1750	3.00	16.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	34.00	0.00	13.00	1.60	3.10	3.00	4.50	0.03	0.25	5.00	10.00
2000	3.00	16.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	34.00	0.00	13.00	1.40	2.60	3.00	4.50	0.05	0.25	5.00	10.00
2500	3.00	16.00	5.00	16.00	-2.00	16.00	-3.00	32.00	10.00	34.00	0.00	13.00	1.30	2.10	3.00	4.50	0.10	0.30	5.00	10.00
3000	3.00	16.00	5.00	16.00	-2.00	16.00	-3.00	13.00	10.00	34.00	0.00	12.00	1.25	1.90	3.00	4.50	0.15	0.35	5.00	10.00
3500	3.00	16.00	5.00	16.00	-2.00	16.00	-3.00	13.00	10.00	20.00	0.00	12.00	1.20	1.80	3.00	4.50	0.20	0.40	5.00	10.00
4000	3.00	16.00	5.00	16.00	-2.00	16.00	-1.50	7.00	10.00	20.00	-1.50	12.00	1.20	1.80	3.00	4.50	0.30	0.45	5.00	10.00
4500	3.00	16.00	5.00	16.00	-2.00	16.00	-1.50	7.00	10.00	20.00	-1.50	12.00	1.25	1.85	3.00	4.50	0.30	0.45	5.00	10.00
5000	3.00	16.00	5.00	16.00	-2.00	16.00	-1.50	7.00	10.00	20.00	-1.50	12.00	1.30	1.90	3.00	4.50	0.30	0.45	5.00	10.00
5500+	3.00	16.00	5.00	16.00	-2.00	16.00	-1.50	7.00	10.00	20.00	-1.50	12.00	1.40	2.00	3.00	4.50	0.30	0.45	5.00	10.00

11.2. Variable: Salinity

Standard unit: unitless

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00
10	27.00	38.20	0.00	40.00	20.00	37.60	0.00	40.00	28.00	38.50	0.00	40.00	25.00	37.00	0.00	40.00	28.60	37.00	0.00	40.00
20	28.30	38.20	0.00	40.00	28.00	37.40	0.00	40.00	28.00	38.00	0.00	40.00	30.00	36.50	0.00	40.00	29.00	37.00	0.00	40.00
30	28.50	38.20	0.00	40.00	31.00	37.40	0.00	40.00	30.60	38.00	0.00	40.00	30.00	36.50	0.00	40.00	29.60	37.00	0.00	40.00
50	28.90	38.00	20.00	40.00	31.40	37.40	20.00	40.00	31.00	38.00	20.00	40.00	31.00	36.00	20.00	40.00	30.20	37.00	20.00	40.00
75	28.90	38.00	20.00	40.00	31.80	37.40	20.00	40.00	31.20	38.00	20.00	40.00	31.00	36.00	20.00	40.00	31.00	37.00	20.00	40.00
100	29.40	38.00	20.00	40.00	31.80	37.40	20.00	40.00	31.40	38.00	20.00	40.00	31.50	36.00	26.00	40.00	31.50	37.00	30.00	40.00
125	29.40	38.00	20.00	40.00	31.80	37.40	20.00	40.00	31.40	37.80	20.00	40.00	31.50	36.00	26.00	40.00	31.50	36.80	30.00	40.00
150	29.60	37.60	20.00	40.00	31.80	37.20	20.00	40.00	31.40	37.40	20.00	40.00	32.00	35.80	26.00	40.00	31.50	36.80	30.00	40.00
200	29.90	37.40	20.00	40.00	31.80	37.00	30.00	40.00	31.40	36.60	30.00	40.00	32.00	35.80	26.00	40.00	31.50	36.70	30.00	40.00
250	30.30	37.10	30.00	40.00	32.00	37.00	30.00	40.00	31.40	36.20	30.00	40.00	32.00	35.80	26.00	40.00	31.80	36.30	30.00	40.00
300	30.80	36.80	30.00	40.00	32.20	36.80	30.00	40.00	31.60	36.00	30.00	40.00	32.00	35.80	30.00	40.00	31.80	36.30	30.00	40.00
400	30.80	36.70	33.00	40.00	32.40	36.60	33.00	40.00	32.00	35.80	33.00	40.00	32.20	35.50	30.00	40.00	31.80	36.20	33.00	40.00
500	31.20	36.60	33.00	40.00	33.70	36.50	33.00	40.00	34.00	35.50	33.00	40.00	32.40	35.25	30.50	40.00	32.75	36.10	33.00	40.00
600	32.20	36.60	33.00	40.00	33.70	36.00	33.00	40.00	34.10	35.10	33.00	40.00	32.60	35.25	30.50	40.00	33.00	36.00	33.00	40.00
700	33.00	36.60	33.00	40.00	33.60	35.80	33.00	40.00	34.10	35.10	33.00	40.00	32.60	35.25	32.00	40.00	33.00	35.90	33.00	40.00
800	33.00	36.60	33.00	40.00	33.60	35.60	33.00	40.00	34.10	35.00	33.00	40.00	33.20	35.25	33.00	40.00	33.75	35.80	33.00	40.00
900	33.00	36.60	33.00	40.00	33.60	35.60	33.00	40.00	34.10	34.90	33.00	40.00	33.60	35.25	33.00	40.00	33.80	35.50	33.00	40.00
1000	33.00	36.60	33.00	40.00	33.60	35.40	33.00	40.00	34.20	34.90	33.00	40.00	33.70	35.15	33.00	40.00	34.20	35.30	33.00	40.00
1100	33.00	36.60	33.00	38.00	33.60	35.40	33.00	38.00	34.20	34.90	33.00	38.00	33.70	35.15	33.00	38.00	34.20	35.30	33.00	38.00
1200	33.00	36.60	33.00	38.00	33.60	35.40	33.00	38.00	34.20	34.90	33.00	38.00	33.70	35.15	33.00	38.00	34.20	35.30	33.00	38.00
1300	33.00	36.60	33.00	38.00	33.60	35.40	33.00	38.00	34.30	34.90	33.00	38.00	33.70	35.15	33.00	38.00	34.20	35.30	33.00	38.00
1400	33.00	36.60	33.00	38.00	33.60	35.40	33.00	38.00	34.30	35.00	33.00	38.00	33.70	35.15	33.00	38.00	34.20	35.20	33.00	38.00
1500	33.00	36.60	33.00	38.00	33.80	35.40	33.00	38.00	34.40	35.00	33.00	38.00	33.80	35.00	33.00	38.00	34.40	35.20	33.00	38.00
1750	33.00	36.60	33.00	38.00	34.60	35.20	33.00	38.00	34.50	35.00	33.00	38.00	33.80	35.00	33.00	38.00	34.40	35.20	33.00	38.00
2000	33.00	36.00	33.00	38.00	34.70	35.15	33.00	38.00	34.60	35.00	33.00	38.00	34.00	35.00	33.00	38.00	34.40	35.10	33.00	38.00
2500	34.70	35.50	33.00	35.50	34.80	35.10	33.00	35.50	34.60	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.40	35.10	33.00	35.50
3000	34.80	35.40	33.00	35.50	34.80	35.10	33.00	35.50	34.66	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.20	35.10	33.00	35.50
3500	34.80	35.40	33.00	35.50	34.70	35.10	33.00	35.50	34.64	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.00	35.10	33.00	35.50
4000	34.80	35.40	33.00	35.50	34.50	35.10	33.00	35.50	34.62	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.00	35.50	33.00	35.50
4500	34.80	35.40	33.00	35.50	34.50	35.10	33.00	35.50	34.62	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.00	35.50	33.00	35.50
5000	34.80	35.40	33.00	35.50	34.50	35.10	33.00	35.50	34.62	35.00	33.00	35.50	34.00	35.00	33.00	35.50	34.00	35.50	33.00	35.50
5500+	34.80	35.40	34.30	35.50	34.50	35.10	34.30	35.50	34.62	35.00	34.30	35.50	34.00	35.00	34.30	35.50	34.00	35.50	34.30	35.50

11.2. Salinity (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	5.00	40.00	0.00	40.00	0.00	40.00	0.00	40.00
10	28.00	37.00	0.00	40.00	28.00	38.00	0.00	40.00	26.00	38.00	0.00	40.00	30.00	36.40	0.00	40.00	26.00	36.75	0.00	40.00
20	28.00	37.00	0.00	40.00	29.80	38.00	0.00	40.00	31.00	37.40	0.00	40.00	31.40	36.40	0.00	40.00	28.00	36.75	0.00	40.00
30	29.00	37.00	0.00	40.00	30.20	38.00	0.00	40.00	31.20	37.00	0.00	40.00	31.60	36.40	0.00	40.00	29.00	36.50	0.00	40.00
50	30.00	36.70	20.00	40.00	31.20	38.00	20.00	40.00	31.60	36.80	20.00	40.00	31.90	36.30	20.00	40.00	30.00	36.50	0.00	40.00
75	31.00	36.70	20.00	40.00	32.20	38.00	20.00	40.00	31.60	36.80	20.00	40.00	32.00	36.30	20.00	40.00	30.50	36.50	0.00	40.00
100	31.00	36.70	30.00	40.00	32.40	37.00	30.00	40.00	31.80	36.60	20.00	40.00	32.00	36.20	30.00	40.00	30.50	36.50	26.00	38.00
125	31.00	36.70	30.00	40.00	32.40	37.00	30.00	40.00	31.80	36.50	20.00	40.00	32.00	36.20	30.00	40.00	30.50	36.50	26.00	38.00
150	31.00	36.70	30.00	40.00	32.60	37.00	30.00	40.00	31.80	36.40	20.00	40.00	32.00	36.10	30.00	40.00	31.00	36.50	26.00	38.00
200	31.20	36.00	30.00	40.00	33.40	37.00	30.00	40.00	31.80	36.40	30.00	40.00	32.00	36.00	30.00	40.00	31.00	36.25	26.00	38.00
250	31.50	36.00	30.00	40.00	33.60	37.00	30.00	40.00	32.00	36.30	30.00	40.00	32.20	36.00	30.00	40.00	31.00	36.00	26.00	38.00
300	32.00	36.00	30.00	40.00	33.70	37.00	30.00	40.00	32.00	36.20	30.00	40.00	32.20	35.80	30.00	40.00	31.00	36.00	30.00	38.00
400	32.00	36.00	33.00	40.00	34.00	36.50	33.00	40.00	32.40	36.20	33.00	40.00	32.40	35.60	33.00	40.00	31.50	35.75	33.00	37.00
500	34.20	35.50	33.00	40.00	34.60	36.50	33.00	40.00	34.30	36.00	33.00	40.00	34.10	35.40	33.00	40.00	32.00	35.50	33.00	37.00
600	34.20	35.25	33.00	40.00	34.85	36.30	33.00	40.00	34.40	36.00	33.00	40.00	34.15	35.30	33.00	40.00	33.00	35.50	33.00	37.00
700	34.20	35.00	33.00	40.00	34.85	36.30	33.00	40.00	34.40	35.75	33.00	40.00	34.20	35.20	33.00	40.00	33.80	35.25	33.00	37.00
800	34.20	35.00	33.00	40.00	34.85	36.20	33.00	40.00	34.45	35.75	33.00	40.00	34.20	35.00	33.00	40.00	33.80	35.00	33.00	37.00
900	34.20	35.00	33.00	40.00	34.85	36.00	33.00	40.00	34.45	35.75	33.00	40.00	34.20	35.00	33.00	40.00	34.00	35.00	33.00	37.00
1000	34.20	35.00	33.00	40.00	34.85	36.00	33.00	40.00	34.50	35.75	33.00	40.00	34.25	34.90	33.00	40.00	34.00	35.00	33.00	37.00
1100	34.30	35.00	33.00	38.00	34.80	35.90	33.00	38.00	34.50	35.75	33.00	38.00	34.25	34.90	33.00	38.00	34.00	35.00	33.00	36.00
1200	34.30	34.70	33.00	38.00	34.80	35.80	33.00	38.00	34.50	35.75	33.00	38.00	34.25	34.90	33.00	38.00	34.00	35.00	33.00	36.00
1300	34.30	34.70	33.00	38.00	34.80	35.60	33.00	38.00	34.55	35.60	33.00	38.00	34.30	34.90	33.00	38.00	34.00	34.90	33.00	36.00
1400	34.40	34.70	33.00	38.00	34.80	35.60	33.00	38.00	34.55	35.30	33.00	38.00	34.30	34.90	33.00	38.00	34.30	34.90	33.00	36.00
1500	34.40	34.80	33.00	38.00	34.75	35.60	33.00	38.00	34.55	35.20	33.00	38.00	34.35	34.90	33.00	38.00	34.30	34.90	33.00	36.00
1750	34.40	34.80	33.00	38.00	34.75	35.50	33.00	38.00	34.57	35.10	33.00	38.00	34.45	34.90	33.00	38.00	34.40	34.90	33.00	36.00
2000	34.40	34.80	33.00	38.00	34.70	35.40	33.00	38.00	34.60	35.00	33.00	38.00	34.55	34.90	33.00	38.00	34.40	34.90	33.00	36.00
2500	34.50	34.80	33.00	35.50	34.65	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
3000	34.50	34.80	33.00	35.50	34.65	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
3500	34.60	34.80	33.00	35.50	34.60	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
4000	34.60	34.80	33.00	35.50	34.60	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
4500	34.60	34.80	33.00	35.50	34.60	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
5000	34.60	34.80	33.00	35.50	34.60	35.40	33.00	35.50	34.60	35.00	33.00	35.50	34.60	34.90	33.00	35.50	34.40	34.90	33.00	35.50
5500+	34.60	34.80	34.30	35.50	34.60	35.40	34.30	35.50	34.60	35.00	34.30	35.50	34.60	34.90	34.30	35.50	34.40	34.90	34.30	35.50

11.2. Salinity (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Sea of Japan		Seto Inland_Sea	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
0	0.00	40.00	0.00	25.00	0.00	35.00	0.00	42.00	0.00	44.00	0.00	40.00	27.00	35.30	2.00	35.05	27.00	35.00	2.00	35.00
10	0.00	40.00	0.00	25.00	0.00	35.00	0.00	42.00	0.00	44.00	0.00	40.00	27.50	35.30	6.00	35.05	28.00	35.00	12.00	35.00
20	0.00	40.00	0.00	25.00	0.00	35.00	0.00	42.00	0.00	44.00	0.00	40.00	28.00	35.30	20.00	35.05	29.00	35.00	22.00	35.00
30	0.00	40.00	0.00	25.00	0.00	35.00	0.00	42.00	0.00	44.00	0.00	40.00	29.00	35.30	25.00	35.05	30.00	35.00	25.00	35.00
50	12.00	40.00	10.00	40.00	0.00	35.00	20.00	42.00	20.00	43.00	20.00	40.00	31.00	35.30	30.00	35.05	32.50	35.00	31.00	34.90
75	12.00	40.00	10.00	40.00	0.00	35.00	20.00	42.00	20.00	43.00	20.00	40.00	31.50	35.30	31.00	35.05	33.00	35.00	32.00	34.85
100	31.00	40.00	12.00	40.00	0.00	35.00	30.00	42.00	30.00	43.00	30.00	40.00	32.00	35.30	32.00	35.05	33.50	34.90	33.00	34.85
125	31.00	40.00	12.00	40.00	0.00	35.00	30.00	42.00	30.00	43.00	30.00	40.00	32.25	35.30	33.50	35.05	33.50	34.80	34.00	34.80
150	31.00	40.00	12.00	40.00	0.00	35.00	30.00	42.00	30.00	43.00	30.00	40.00	32.50	35.30	34.00	35.05	33.50	34.70	34.00	34.80
200	31.00	40.00	12.00	40.00	1.00	25.00	30.00	42.00	30.00	43.00	30.00	40.00	33.00	35.30	34.10	35.00	33.50	34.50	34.00	34.75
250	31.00	40.00	12.00	40.00	1.00	25.00	30.00	42.00	30.00	43.00	30.00	40.00	33.05	35.30	34.10	34.95	33.60	34.50	34.00	34.70
300	31.00	40.00	12.00	35.00	1.00	25.00	30.00	42.00	30.00	43.00	30.00	40.00	33.10	35.25	34.10	34.90	33.70	34.50	34.00	34.70
400	31.00	40.00	12.00	33.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.20	35.20	34.10	34.70	33.80	34.30	34.00	34.70
500	31.00	40.00	12.00	30.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.30	35.15	34.10	34.60	33.96	34.25	34.00	34.70
600	33.00	40.00	12.00	30.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.50	35.10	34.10	34.59	33.97	34.24	34.00	34.70
700	33.00	40.00	15.00	30.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.70	35.05	34.10	34.58	33.97	34.23	34.00	34.70
800	33.00	40.00	15.00	28.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.80	35.00	34.15	34.57	33.98	34.22	34.00	34.70
900	33.00	40.00	15.00	28.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.90	34.90	34.20	34.56	33.98	34.21	34.00	34.70
1000	33.00	40.00	15.00	28.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	40.00	33.95	34.90	34.30	34.55	33.99	34.20	34.00	34.70
1100	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	38.00	34.00	34.90	34.32	34.55	33.99	34.19	34.00	34.70
1200	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	38.00	34.05	34.85	34.33	34.55	34.00	34.18	34.00	34.70
1300	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	38.00	34.10	34.80	34.34	34.55	34.00	34.17	34.00	34.70
1400	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	38.00	34.15	34.80	34.35	34.55	34.01	34.16	34.00	34.70
1500	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	43.00	33.00	38.00	34.20	34.80	34.35	34.55	34.01	34.15	34.00	34.70
1750	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	50.00	33.00	38.00	34.30	34.80	34.35	34.55	34.02	34.14	34.00	34.70
2000	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	50.00	33.00	38.00	34.40	34.80	34.35	34.55	34.03	34.13	34.00	34.70
2500	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	50.00	33.00	35.50	34.55	34.77	34.35	34.55	34.04	34.12	34.00	34.70
3000	33.00	40.00	18.00	25.00	1.00	25.00	33.00	42.00	33.00	50.00	33.00	35.50	34.58	34.75	34.35	34.55	34.05	34.11	34.00	34.70
3500	33.00	40.00	18.00	25.00	1.00	25.00	33.00	35.50	33.00	50.00	33.00	35.50	34.60	34.75	34.35	34.55	34.05	34.11	34.00	34.70
4000	33.00	40.00	18.00	25.00	1.00	25.00	33.00	35.50	33.00	50.00	33.00	35.50	34.61	34.75	34.35	34.55	34.05	34.11	34.00	34.70
4500	33.00	40.00	18.00	25.00	1.00	25.00	33.00	35.50	33.00	50.00	33.00	35.50	34.63	34.73	34.35	34.55	34.05	34.11	34.00	34.70
5000	33.00	40.00	18.00	25.00	1.00	25.00	33.00	35.50	33.00	50.00	33.00	35.50	34.63	34.73	34.35	34.55	34.05	34.11	34.00	34.70
5500+	34.30	40.00	18.00	25.00	1.00	25.00	34.30	35.50	34.30	50.00	34.30	35.50	34.63	34.73	34.35	34.55	34.05	34.11	34.00	34.70

11.3. Variable: Dissolved Oxygen

Standard unit: Micromole kilogram^{-1} (µmol·kg^{-1})

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0	479	0	436	0	305	0	392	0	392	0	392	0	436	0	436	0	349	0	305
10	0	479	0	436	0	305	0	392	0	392	0	392	0	436	0	436	0	349	0	305
20	0	479	0	436	0	305	0	392	0	392	0	392	0	436	0	436	0	349	0	305
30	0	479	0	436	0	305	0	392	0	392	0	392	0	436	0	436	0	349	0	305
50	0	479	0	392	0	261	0	392	0	392	0	349	0	436	0	349	0	349	0	261
75	0	479	0	392	0	261	0	261	0	392	0	349	0	392	0	349	0	349	0	261
100	0	436	0	392	0	261	0	261	0	349	0	349	0	392	0	349	0	261	0	261
125	0	436	0	392	0	261	0	261	0	349	0	349	0	392	0	349	0	261	0	261
150	0	436	0	392	0	261	0	261	0	349	0	349	0	349	0	349	0	261	0	218
200	0	436	0	392	0	261	0	261	0	349	0	349	0	349	0	349	0	218	0	218
250	0	436	0	349	0	261	0	261	0	349	0	349	0	349	0	349	0	218	0	218
300	0	392	0	349	0	218	0	261	0	349	0	305	0	305	0	349	0	218	0	218
400	0	392	0	349	0	218	0	261	0	349	0	305	0	305	0	349	0	218	0	218
500	0	392	0	349	0	218	0	261	0	349	0	305	0	305	0	349	0	218	0	218
600	0	392	0	349	0	218	0	305	0	305	0	305	0	305	0	305	0	218	0	218
700	0	392	0	349	0	218	0	305	0	305	0	305	0	261	0	305	0	218	0	218
800	0	392	0	349	0	218	0	305	0	305	0	305	0	261	0	305	0	218	0	218
900	0	392	0	349	0	218	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1000	0	392	0	349	0	261	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1100	0	392	0	349	0	261	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1200	0	392	0	349	0	261	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1300	0	392	0	349	0	261	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1400	0	392	0	349	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1500	131	392	0	349	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	218
1750	131	392	0	305	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	218
2000	131	392	0	305	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	218
2500	131	349	0	305	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	218
3000	131	349	0	305	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	174
3500	131	349	0	305	0	305	0	305	0	305	0	305	0	261	0	305	0	218	0	174
4000	131	349	0	305	0	305	0	305	0	261	0	305	0	261	0	218	0	218	0	174
4500	131	349	0	305	0	261	0	305	0	261	0	305	0	261	0	218	0	218	0	174
5000	131	349	0	305	0	261	0	305	0	261	0	305	0	261	0	218	0	218	0	174
5500+	131	349	0	305	0	261	0	305	0	261	0	305	0	261	0	218	0	218	0	174

11.3. Variable: Dissolved Oxygen (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0	349	0	349	0	305	0	305	0	436	0	261	0	436	0	392	229	479	0	479
10	0	349	0	349	0	305	0	305	0	436	0	261	0	436	0	392	229	457	0	479
20	0	349	0	349	0	305	0	305	0	436	0	261	0	436	0	392	229	436	0	479
30	0	349	0	349	0	305	0	305	0	436	0	261	0	436	0	392	218	436	0	479
50	0	349	0	305	0	305	0	305	0	436	0	261	0	436	0	392	174	436	0	479
75	0	349	0	305	0	305	0	305	0	436	0	261	0	349	0	392	163	414	0	436
100	0	349	0	305	0	305	0	305	0	305	0	261	0	349	0	392	152	403	0	436
125	0	349	0	305	0	218	0	218	0	305	0	218	0	349	0	392	152	392	0	436
150	0	349	0	305	0	218	0	218	0	305	0	218	0	349	0	392	152	381	0	436
200	0	305	0	305	0	218	0	218	0	218	0	218	0	349	0	392	152	370	0	436
250	0	305	0	305	0	218	0	218	0	218	0	218	0	349	0	305	152	370	0	436
300	0	305	0	305	0	218	0	174	0	218	0	218	0	305	0	305	152	359	0	436
400	0	305	0	305	0	218	0	174	0	218	0	218	0	305	0	305	152	349	0	436
500	0	305	0	305	0	218	0	174	0	218	0	218	0	305	0	305	152	349	0	436
600	0	305	0	305	0	218	0	174	0	218	0	218	0	305	0	261	152	338	0	392
700	0	305	0	261	0	218	0	174	0	218	0	218	0	305	0	261	152	338	0	392
800	0	305	0	261	0	218	0	174	0	218	0	131	0	261	0	261	152	338	0	392
900	0	305	0	261	0	218	0	174	0	218	0	131	0	261	0	261	152	327	0	392
1000	0	261	0	261	0	218	0	174	0	218	0	131	0	261	0	261	152	327	0	392
1100	0	261	0	218	0	218	0	174	0	218	0	131	0	261	0	261	142	327	0	392
1200	0	261	0	218	0	218	0	174	0	218	0	131	0	261	0	261	142	327	0	392
1300	0	261	0	218	0	218	0	174	0	218	0	131	0	261	0	261	131	327	0	392
1400	0	261	0	218	0	218	0	174	0	218	0	218	0	261	0	261	131	327	0	392
1500	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	131	316	0	392
1750	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	131	316	0	392
2000	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	131	316	0	392
2500	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	142	316	0	392
3000	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	152	316	0	392
3500	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	163	305	0	392
4000	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	174	283	0	392
4500	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	174	283	0	392
5000	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	185	283	0	392
5500+	0	218	0	218	0	218	0	174	0	218	0	218	0	261	0	261	196	283	0	392

11.3. Variable: Dissolved Oxygen (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Sea of Japan		Seto Inland_Sea	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
0	0	349	0	436	0	523	0	523	0	523	0	218	0	436	0	436	0	436	0	436
10	0	349	0	436	0	523	0	523	0	523	0	218	0	436	0	436	0	436	0	436
20	0	349	0	436	0	523	0	523	0	523	0	218	0	436	0	436	0	436	0	436
30	0	349	0	436	0	523	0	523	0	523	0	218	0	436	0	436	0	436	0	436
50	0	349	0	436	0	523	0	523	0	523	0	218	0	436	0	436	0	436	0	436
75	0	305	0	349	0	414	0	414	0	414	0	218	0	392	0	392	0	392	0	392
100	0	305	0	349	0	414	0	414	0	414	0	174	0	392	0	392	0	392	0	392
125	0	305	0	349	0	414	0	414	0	414	0	174	0	392	0	392	0	392	0	392
150	0	305	0	349	0	414	0	414	0	414	0	174	0	349	0	349	0	349	0	349
200	0	305	0	218	0	392	0	392	0	392	0	131	0	349	0	349	0	349	0	349
250	0	305	0	218	0	392	0	392	0	392	0	131	0	349	0	349	0	349	0	349
300	0	305	0	218	0	349	0	349	0	349	0	131	0	305	0	305	0	305	0	305
400	0	305	0	87	0	349	0	349	0	349	0	131	0	305	0	305	0	305	0	305
500	0	305	0	87	0	349	0	349	0	349	0	131	0	305	0	305	0	305	0	305
600	0	305	0	87	0	309	0	309	0	309	0	131	0	305	0	305	0	305	0	305
700	0	305	0	87	0	309	0	309	0	309	0	131	0	261	0	261	0	261	0	261
800	0	305	0	87	0	309	0	309	0	309	0	131	0	261	0	261	0	261	0	261
900	0	305	0	87	0	309	0	309	0	309	0	131	0	261	0	261	0	261	0	261
1000	0	261	0	87	0	309	0	309	0	309	0	131	0	261	0	261	0	261	0	261
1100	0	261	0	87	0	309	0	309	0	309	0	131	0	261	0	261	0	261	0	261
1200	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
1300	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
1400	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
1500	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
1750	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
2000	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
2500	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
3000	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
3500	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
4000	0	261	0	87	0	309	0	309	0	309	0	87	0	261	0	261	0	261	0	261
4500	0	261	0	87	0	261	0	261	0	261	0	87	0	261	0	261	0	261	0	261
5000	0	261	0	87	0	261	0	261	0	261	0	87	0	261	0	261	0	261	0	261
5500+	0	261	0	87	0	261	0	261	0	261	0	87	0	261	0	261	0	261	0	261

11.4. Variable: Dissolved phosphate

Standard unit: Micromole kilogram^{-1} (µmol·kg^{-1})

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
10	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
20	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
30	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
75	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
100	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
125	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
150	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
200	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
250	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
300	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
400	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
500	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
600	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
700	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
800	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
900	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1100	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1200	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1300	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1400	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1750	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
2000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
2500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
3000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
3500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
4000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
4500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
5000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
5500+	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50

11.4. Variable: Dissolved phosphate (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
10	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
20	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
30	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
75	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
100	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
125	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
150	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
200	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
250	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
300	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
400	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
500	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50	0.00	4.50
600	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
700	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
800	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
900	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1100	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1200	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1300	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1400	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
1750	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
2000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
2500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
3000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
3500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
4000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
4500	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
5000	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50
5500+	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50	0.01	4.50

11.4. Variable: Dissolved phosphate (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Se of Japan		Seto Inland_Sea	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	30.00	0.00	30.00	0.00	60.00	0.00	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
10	0.00	30.00	0.00	30.00	0.00	60.00	0.00	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
20	0.00	30.00	0.00	30.00	0.00	60.00	0.00	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
30	0.00	30.00	0.00	30.00	0.00	60.00	0.00	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
50	0.00	30.00	0.00	30.00	0.00	60.00	0.00	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
75	0.00	5.00	0.00	15.00	0.00	60.00	0.02	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
100	0.00	5.00	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
125	0.00	5.00	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
150	0.00	5.00	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
200	0.00	5.00	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
250	0.00	2.50	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
300	0.00	2.50	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
400	0.00	2.50	0.00	15.00	0.00	20.00	0.02	1.50	0.00	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
500	0.00	2.50	0.00	15.00	0.00	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
600	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
700	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
800	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
900	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1000	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1100	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1200	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1300	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1400	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1500	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
1750	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
2000	0.01	2.50	0.01	15.00	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
2500	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
3000	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
3500	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
4000	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
4500	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
5000	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75
5500+	0.01	2.50	0.01	4.50	0.01	20.00	0.02	1.50	0.10	4.50	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75	0.50	2.75

11.5. Variable: Dissolved silicate

Standard unit or scale: Micromole kilogram^{-1} (µmol·kg^{-1})

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
0	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
10	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
20	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
30	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
50	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
75	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
100	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
125	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	100.00	0.00	250	0.00	150.00	0.00	250
150	0.00	150	0.00	250	0.00	80	0.00	250	0.00	150	0.00	250	0.00	110.00	0.00	250	0.00	150.00	0.00	250
200	0.01	150	0.01	250	0.01	80	0.01	250	0.01	150	0.01	250	0.01	120.00	0.01	250	0.00	150.00	0.01	250
250	0.01	150	0.01	250	0.01	80	0.01	250	0.01	150	0.01	250	0.01	125.00	0.01	250	0.01	150.00	0.01	250
300	0.01	150	0.01	250	0.01	80	0.01	250	0.01	150	0.01	250	0.01	130.00	0.01	250	0.01	150.00	0.01	250
400	0.01	150	0.01	250	0.01	80	0.01	250	0.01	150	0.01	250	0.01	140.00	0.01	250	0.01	150.00	0.01	250
500	0.01	150	0.01	250	0.50	80	0.01	250	0.50	150	0.01	250	0.50	150.00	0.01	250	0.50	150.00	0.01	250
600	0.01	150	0.01	250	1.00	80	0.01	250	2.50	150	0.01	250	5.00	160.00	0.01	250	2.00	150.00	0.01	250
700	0.01	150	0.01	250	2.00	80	0.01	250	5.00	150	0.01	250	5.00	165.00	0.01	250	5.00	150.00	0.01	250
800	0.01	150	0.01	250	2.00	80	0.01	250	5.00	150	0.01	250	5.00	170.00	0.01	250	5.00	155.00	0.01	250
900	0.01	150	0.01	250	5.00	80	0.01	250	10.00	150	0.01	250	10.00	175.00	0.01	250	5.00	160.00	0.01	250
1000	2.50	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	10.00	180.00	1.00	250	5.00	165.00	1.00	250
1100	2.50	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	10.00	190.00	1.00	250	10.00	165.00	1.00	250
1200	2.50	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	20.00	200.00	1.00	250	10.00	170.00	1.00	250
1300	2.50	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	20.00	200.00	1.00	250	10.00	170.00	1.00	250
1400	2.50	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	20.00	200.00	1.00	250	10.00	170.00	1.00	250
1500	5.00	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	20.00	225.00	1.00	250	10.00	175.00	1.00	250
1750	5.00	150	1.00	250	5.00	80	1.00	250	10.00	150	1.00	250	20.00	225.00	1.00	250	10.00	180.00	1.00	250
2000	5.00	150	1.00	250	10.00	80	1.00	250	10.00	150	1.00	250	20.00	250.00	1.00	250	10.00	200.00	1.00	250
2500	5.00	150	1.00	250	10.00	80	1.00	250	10.00	150	1.00	250	20.00	250.00	1.00	250	10.00	200.00	1.00	250
3000	5.00	150	1.00	250	10.00	80	1.00	250	10.00	150	1.00	250	20.00	250.00	1.00	250	10.00	200.00	1.00	250
3500	5.00	150	1.00	250	10.00	150	1.00	250	10.00	150	1.00	250	20.00	250.00	1.00	250	10.00	200.00	1.00	250
4000	5.00	150	1.00	250	10.00	150	1.00	250	10.00	150	1.00	250	20.00	200.00	1.00	250	10.00	200.00	1.00	250
4500	10.00	150	1.00	250	10.00	150	1.00	250	10.00	150	1.00	250	20.00	200.00	1.00	250	10.00	200.00	1.00	250
5000	10.00	150	1.00	250	10.00	150	1.00	250	10.00	150	1.00	250	20.00	190.00	1.00	250	10.00	200.00	1.00	250
5500+	15.00	150	1.00	250	10.00	150	1.00	250	10.00	150	1.00	250	20.00	180.00	1.00	250	10.00	200.00	1.00	250

11.5. Variable: Dissolved silicate (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
10	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
20	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
30	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
50	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
75	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
100	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
125	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
150	0.00	140.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	250.00	0.00	180.00	0.00	250.00	0.00	200.00	0.00	200.00
200	0.01	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
250	0.01	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
300	0.01	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
400	0.50	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
500	2.00	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
600	3.00	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
700	4.00	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	200.00
800	5.00	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	1.00	200.00	0.01	200.00
900	7.00	140.00	0.01	250.00	0.01	180.00	0.01	250.00	0.01	200.00	0.01	250.00	0.01	180.00	0.01	250.00	1.00	200.00	0.01	200.00
1000	10.00	150.00	1.00	250.00	1.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	1.00	180.00	1.00	250.00	1.00	200.00	0.01	200.00
1100	20.00	150.00	1.00	250.00	1.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	1.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
1200	25.00	150.00	1.00	250.00	1.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	1.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
1300	30.00	155.00	1.00	250.00	1.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
1400	35.00	160.00	1.00	250.00	5.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
1500	40.00	165.00	1.00	250.00	5.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
1750	50.00	165.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
2000	60.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
2500	65.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
3000	75.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
3500	80.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
4000	85.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
4500	90.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
5000	100.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00
5500+	100.00	170.00	1.00	250.00	10.00	180.00	1.00	250.00	1.00	200.00	1.00	250.00	5.00	180.00	1.00	250.00	10.00	200.00	0.01	200.00

11.5. Variable: Dissolved silicate (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Sea of Japan		Seto Inland_Sea	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0	80	0	360	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
10	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
20	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
30	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
50	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
75	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
100	0	80	0	355	0	200	0	25	0	150	0	100	0	100	0	100	0	100	0	100
125	0	40	0	320	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
150	0	40	1	315	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
200	0	40	1	305	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
250	0	40	3	295	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
300	0	40	3	295	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
400	0	40	10	195	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
500	0	40	20	205	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
600	0	40	90	205	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
700	0	20	100	240	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
800	0	20	105	250	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
900	0	20	110	270	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
1000	0	20	110	270	0	150	0	25	0	150	0	100	0	100	0	100	0	100	0	100
1100	0	20	135	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
1200	0	20	135	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
1300	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
1400	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
1500	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
1750	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
2000	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
2500	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
3000	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
3500	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
4000	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
4500	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
5000	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150
5500+	0	20	150	270	0	150	0	25	0	150	0	150	0	150	0	150	0	150	0	150

11.6. Variable: Dissolved nitrate and nitrate + nitrite

Standard unit: Micromole kilogram^{-1} (µmol·kg^{-1})

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
0	0.00	18.00	0.00	500.00	0.00	18.00	0.00	30.00	0.00	22.00	0.00	60.00	0.00	26.00	0.00	50.00	0.00	22.00	0.00	100.00
10	0.00	18.00	0.00	500.00	0.00	18.00	0.00	30.00	0.00	26.00	0.00	60.00	0.00	26.00	0.00	50.00	0.00	22.00	0.00	100.00
20	0.00	18.00	0.00	500.00	0.00	18.00	0.00	30.00	0.00	26.00	0.00	60.00	0.00	26.00	0.00	50.00	0.00	22.00	0.00	100.00
30	0.00	18.00	0.00	500.00	0.00	18.00	0.00	30.00	0.00	30.00	0.00	60.00	0.00	30.00	0.00	50.00	0.00	26.00	0.00	100.00
50	0.00	26.00	0.00	500.00	0.00	26.00	0.00	30.00	0.00	30.00	0.00	60.00	0.00	30.00	0.00	50.00	0.00	34.00	0.00	100.00
75	0.00	30.00	0.00	500.00	0.00	30.00	0.00	30.00	0.00	34.00	0.00	60.00	0.00	34.00	0.00	50.00	0.00	34.00	0.00	100.00
100	0.00	30.00	0.00	500.00	0.00	30.00	0.00	30.00	0.00	34.00	0.00	60.00	0.00	34.00	0.00	50.00	0.00	34.00	0.00	100.00
125	0.00	30.00	0.00	500.00	0.00	30.00	0.00	40.00	0.00	34.00	0.00	60.00	0.00	42.00	0.00	50.00	0.00	34.00	0.00	100.00
150	0.00	30.00	0.00	500.00	0.00	30.00	0.00	40.00	0.00	34.00	0.00	60.00	0.00	42.00	0.00	50.00	0.00	38.00	0.00	100.00
200	0.00	30.00	0.00	500.00	0.00	30.00	0.00	40.00	0.00	38.00	0.00	60.00	0.00	46.00	0.00	50.00	0.00	38.00	0.00	100.00
250	0.00	34.00	0.00	500.00	0.00	34.00	0.00	45.00	0.00	38.00	0.00	60.00	0.00	46.00	0.00	75.00	0.00	42.00	0.00	100.00
300	0.00	34.00	0.00	500.00	0.00	34.00	0.00	45.00	0.00	38.00	0.00	60.00	0.00	46.00	0.00	75.00	0.00	42.00	0.00	100.00
400	0.00	42.00	0.00	500.00	0.00	42.00	0.00	45.00	2.00	42.00	0.00	60.00	2.00	46.00	0.00	75.00	2.00	42.00	0.00	100.00
500	0.00	42.00	0.00	500.00	0.00	42.00	0.00	45.00	2.00	46.00	0.00	60.00	2.00	46.00	0.00	75.00	2.00	46.00	0.00	100.00
600	0.00	42.00	0.00	500.00	0.00	42.00	0.00	45.00	2.00	46.00	0.00	60.00	2.00	50.00	0.00	75.00	2.00	46.00	0.00	100.00
700	6.00	46.00	0.00	500.00	0.00	46.00	0.00	45.00	2.00	46.00	0.00	60.00	2.00	50.00	0.00	75.00	2.00	50.00	0.00	75.00
800	6.00	46.00	0.00	500.00	0.00	46.00	0.00	45.00	2.00	46.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	56.00	0.00	75.00
900	6.00	46.00	0.00	500.00	0.00	46.00	0.00	45.00	2.00	46.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	56.00	0.00	75.00
1000	6.00	46.00	0.00	500.00	0.00	46.00	0.00	40.00	2.00	46.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	56.00	0.00	75.00
1100	6.00	46.00	0.00	500.00	0.00	46.00	0.00	40.00	2.00	46.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	56.00	0.00	75.00
1200	6.00	48.00	0.00	500.00	0.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	56.00	0.00	75.00
1300	6.00	48.00	0.00	500.00	0.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
1400	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
1500	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
1750	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
2000	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
2500	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	54.00	0.00	75.00	2.00	50.00	0.00	75.00
3000	6.00	48.00	0.00	500.00	6.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	50.00	0.00	75.00	2.00	46.00	0.00	75.00
3500	10.00	48.00	0.00	500.00	10.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	46.00	0.00	75.00	2.00	46.00	0.00	75.00
4000	10.00	48.00	0.00	500.00	10.00	48.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	46.00	0.00	75.00	2.00	46.00	0.00	75.00
4500	10.00	46.00	0.00	500.00	10.00	46.00	0.00	40.00	6.00	42.00	0.00	60.00	2.00	42.00	0.00	75.00	2.00	46.00	0.00	75.00
5000	10.00	44.00	0.00	500.00	10.00	44.00	0.00	40.00	10.00	42.00	0.00	60.00	10.00	42.00	0.00	75.00	2.00	46.00	0.00	75.00
5500+	14.00	42.00	0.00	500.00	14.00	42.00	0.00	40.00	14.00	34.00	0.00	60.00	14.00	42.00	0.00	75.00	2.00	46.00	0.00	75.00

11.6. Variable: Dissolved nitrate and nitrate + nitrite (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	18.00	0.00	40.00	0.00	14.00	0.00	30.00	0.00	4.00	0.00	35.00	0.00	18.00	0.00	50.00	0.00	46.00	0.00	18.00
10	0.00	18.00	0.00	40.00	0.00	18.00	0.00	30.00	0.00	6.00	0.00	35.00	0.00	18.00	0.00	50.00	0.00	46.00	0.00	18.00
20	0.00	18.00	0.00	40.00	0.00	18.00	0.00	30.00	0.00	6.00	0.00	35.00	0.00	18.00	0.00	50.00	0.00	46.00	0.00	18.00
30	0.00	22.00	0.00	40.00	0.00	18.00	0.00	30.00	0.00	14.00	0.00	35.00	0.00	18.00	0.00	50.00	0.00	46.00	0.00	18.00
50	0.00	26.00	0.00	40.00	0.00	30.00	0.00	30.00	0.00	18.00	0.00	35.00	0.00	18.00	0.00	50.00	0.00	46.00	0.00	18.00
75	0.00	30.00	0.00	40.00	0.00	30.00	0.00	40.00	0.00	26.00	0.00	35.00	0.00	22.00	0.00	50.00	0.00	46.00	0.00	18.00
100	0.00	30.00	0.00	40.00	0.00	30.00	0.00	40.00	0.00	30.00	0.00	45.00	0.00	22.00	0.00	50.00	0.00	46.00	0.00	22.00
125	0.00	30.00	0.00	40.00	0.00	42.00	0.00	40.00	0.00	34.00	0.00	45.00	0.00	26.00	0.00	50.00	0.00	46.00	0.00	22.00
150	0.00	30.00	0.00	40.00	0.00	42.00	0.00	40.00	0.00	34.00	0.00	45.00	0.00	30.00	0.00	50.00	0.00	46.00	0.00	22.00
200	0.00	38.00	0.00	40.00	0.00	42.00	0.00	40.00	0.00	38.00	0.00	45.00	0.00	30.00	0.00	50.00	0.00	46.00	0.00	26.00
250	0.00	38.00	0.00	40.00	2.00	42.00	0.00	40.00	2.00	38.00	0.00	50.00	0.00	30.00	0.00	50.00	0.00	46.00	0.00	26.00
300	0.00	38.00	0.00	60.00	2.00	50.00	0.00	40.00	2.00	46.00	0.00	50.00	0.00	30.00	0.00	50.00	0.00	46.00	0.00	26.00
400	4.00	42.00	0.00	60.00	2.00	50.00	0.00	40.00	2.00	46.00	0.00	50.00	0.00	34.00	0.00	50.00	4.00	46.00	0.00	28.00
500	6.00	46.00	0.00	60.00	2.00	50.00	0.00	40.00	2.00	46.00	0.00	50.00	0.00	34.00	0.00	50.00	6.00	46.00	0.00	28.00
600	6.00	50.00	0.00	60.00	2.00	50.00	0.00	40.00	2.00	46.00	0.00	50.00	0.00	38.00	0.00	50.00	6.00	46.00	0.00	32.00
700	6.00	50.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	6.00	46.00	0.00	32.00
800	10.00	50.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	46.00	0.00	42.00
900	10.00	50.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	46.00	0.00	42.00
1000	10.00	50.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	50.00	0.00	46.00
1100	10.00	50.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	50.00	0.00	46.00
1200	10.00	54.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	50.00	0.00	46.00
1300	10.00	54.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	50.00	0.00	50.00
1400	10.00	54.00	0.00	60.00	2.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	0.00	46.00	0.00	50.00	14.00	50.00	0.00	50.00
1500	10.00	54.00	0.00	60.00	20.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	50.00	0.00	50.00
1750	10.00	54.00	0.00	60.00	20.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	50.00	0.00	50.00
2000	10.00	54.00	0.00	60.00	20.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	50.00	0.00	54.00
2500	10.00	54.00	0.00	60.00	20.00	54.00	0.00	40.00	2.00	54.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	50.00	0.00	54.00
3000	10.00	54.00	0.00	60.00	20.00	54.00	0.00	40.00	2.00	46.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	50.00	0.00	54.00
3500	10.00	54.00	0.00	60.00	20.00	46.00	0.00	40.00	2.00	46.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	46.00	2.00	54.00
4000	10.00	54.00	0.00	60.00	20.00	46.00	0.00	40.00	2.00	46.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	46.00	2.00	46.00
4500	10.00	42.00	0.00	60.00	20.00	46.00	0.00	40.00	2.00	46.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	42.00	2.00	46.00
5000	10.00	38.00	0.00	60.00	20.00	46.00	0.00	40.00	2.00	46.00	0.00	50.00	2.00	46.00	0.00	50.00	14.00	42.00	2.00	46.00
5500+	14.00	38.00	0.00	60.00	20.00	46.00	0.00	40.00	2.00	46.00	0.00	50.00	10.00	46.00	0.00	50.00	18.00	42.00	2.00	46.00

11.6. Variable: Dissolved nitrate and nitrate + nitrite (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea		NW Pacific		Yellow Sea		Sea of Japan		Seto Inland Sea	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
0	0.00	30.00	0.00	125	0.00	50.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
10	0.00	30.00	0.00	125	0.00	50.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
20	0.00	30.00	0.00	75.00	0.00	50.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
30	0.00	30.00	0.00	75.00	0.00	50.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
50	0.00	30.00	0.00	50.00	0.00	50.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
75	0.00	30.00	0.00	35.00	0.00	30.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
100	0.00	30.00	0.00	35.00	0.00	30.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
125	0.00	20.00	0.00	35.00	0.01	20.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
150	0.00	20.00	0.00	35.00	0.01	20.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
200	0.00	20.00	0.00	30.00	0.01	20.00	0.00	10.00	0.00	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
250	0.00	20.00	0.00	15.00	0.01	20.00	0.00	10.00	0.01	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
300	0.00	20.00	0.00	15.00	0.01	20.00	0.00	10.00	0.01	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
400	0.00	20.00	0.00	5.00	0.01	20.00	0.00	10.00	0.01	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
500	0.00	20.00	0.00	5.00	0.01	20.00	0.00	10.00	0.01	35.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00	0.00	45.00
600	0.00	20.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00
700	0.00	20.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00
800	0.00	20.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00
900	0.00	20.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00
1000	0.00	20.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00	5.00	45.00
1100	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
1200	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
1300	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
1400	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
1500	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
1750	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
2000	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
2500	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
3000	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
3500	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
4000	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
4500	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
5000	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00
5500+	0.01	15.00	0.00	2.50	0.01	15.00	0.00	10.00	0.01	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00	5.00	40.00

11.7. Variable: pH

Standard unit: unitless

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
0	7.50	8.70	6.30	9.20	7.30	8.50	6.20	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.90	7.30	8.60	6.00	8.80
10	7.50	8.70	6.60	9.00	7.30	8.50	6.20	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	8.90
20	7.50	8.70	6.80	9.00	7.30	8.50	6.60	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	9.00
30	7.50	8.70	6.80	9.00	7.30	8.50	6.60	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	9.00
50	7.50	8.70	6.80	9.00	7.30	8.50	7.20	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	9.00
75	7.50	8.70	7.00	9.00	7.30	8.50	7.40	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	9.00
100	7.50	8.70	7.00	8.80	7.30	8.50	7.40	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	6.00	9.00
125	7.50	8.70	7.00	8.80	7.30	8.50	7.40	8.70	7.40	8.50	7.10	8.80	7.30	8.60	7.00	8.80	7.30	8.60	7.00	8.70
150	7.50	8.70	7.00	8.80	7.30	8.50	7.40	8.70	7.40	8.50	7.20	8.80	7.30	8.60	7.00	8.70	7.30	8.60	7.00	8.70
200	7.50	8.70	7.00	8.80	7.30	8.50	7.50	8.70	7.40	8.50	7.30	8.80	7.30	8.60	7.00	8.60	7.30	8.60	7.00	8.70
250	7.50	8.70	7.00	8.80	7.30	8.50	7.50	8.70	7.40	8.50	7.40	8.80	7.30	8.60	7.00	8.60	7.30	8.60	7.00	8.70
300	7.50	8.70	7.00	8.80	7.30	8.50	7.50	8.70	7.40	8.50	7.40	8.80	7.30	8.60	7.00	8.50	7.30	8.60	7.00	8.70
400	7.50	8.70	7.10	8.80	7.30	8.50	7.50	8.70	7.40	8.50	7.40	8.80	7.30	8.60	7.00	8.50	7.30	8.60	7.00	8.50
500	7.30	8.50	7.10	8.80	7.20	8.40	7.50	8.70	7.30	8.40	7.40	8.60	7.20	8.50	7.00	8.50	7.20	8.30	7.00	8.50
600	7.30	8.50	7.10	8.80	7.20	8.40	7.50	8.70	7.30	8.40	7.40	8.60	7.20	8.50	7.00	8.50	7.20	8.30	7.00	8.50
700	7.30	8.50	7.20	8.80	7.20	8.40	7.50	8.70	7.30	8.40	7.40	8.60	7.20	8.50	7.00	8.50	7.20	8.30	7.00	8.40
800	7.30	8.50	7.20	8.80	7.20	8.40	7.60	8.70	7.30	8.40	7.40	8.60	7.20	8.50	7.10	8.50	7.20	8.30	7.00	8.40
900	7.30	8.50	7.20	8.80	7.20	8.40	7.60	8.70	7.30	8.40	7.40	8.50	7.20	8.50	7.20	8.50	7.20	8.30	7.00	8.40
1000	7.30	8.50	7.20	8.60	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.50	7.20	8.50	7.20	8.50	7.20	8.30	7.00	8.40
1100	7.30	8.50	7.20	8.60	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.40	7.20	8.30	7.10	8.40
1200	7.30	8.50	7.20	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.40	7.20	8.30	7.10	8.30
1300	7.30	8.50	7.70	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.20	7.20	8.30	7.10	8.30
1400	7.30	8.50	7.70	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.20	7.20	8.30	7.20	8.30
1500	7.30	8.50	7.70	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.20	7.20	8.30	7.20	8.30
1750	7.30	8.50	7.70	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.20	8.20	7.20	8.30	7.30	8.30
2000	7.30	8.50	7.70	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
2500	7.30	8.50	7.80	8.50	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
3000	7.30	8.50	7.80	8.40	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
3500	7.30	8.50	7.80	8.30	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
4000	7.30	8.50	7.80	8.30	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
4500	7.30	8.50	7.80	8.30	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
5000	7.30	8.50	7.80	8.30	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30
5500+	7.30	8.50	7.80	8.30	7.20	8.40	7.60	8.70	7.30	8.40	7.50	8.40	7.20	8.50	7.40	8.20	7.20	8.30	7.40	8.30

11.7. Variable: pH (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
0	7.30	8.60	7.30	9.00	7.30	8.60	7.10	8.80	7.50	8.50	7.20	8.90	7.30	8.40	7.30	8.50	7.30	8.40	7.20	8.60
10	7.30	8.60	7.30	9.00	7.30	8.60	7.10	8.80	7.50	8.50	7.20	8.90	7.30	8.40	7.30	8.50	7.30	8.40	7.20	8.60
20	7.30	8.60	7.30	9.00	7.30	8.60	7.10	8.80	7.50	8.50	7.20	8.80	7.30	8.40	7.30	8.50	7.30	8.40	7.20	8.60
30	7.30	8.60	7.30	9.00	7.30	8.60	7.10	8.80	7.50	8.50	7.20	8.60	7.30	8.40	7.30	8.50	7.30	8.40	7.20	8.60
50	7.30	8.60	7.30	9.00	7.30	8.60	7.10	8.70	7.50	8.50	7.20	8.60	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
75	7.30	8.60	7.30	8.90	7.30	8.60	7.10	8.70	7.50	8.50	7.20	8.50	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
100	7.30	8.60	7.30	8.90	7.30	8.60	7.10	8.60	7.50	8.50	7.20	8.50	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
125	7.30	8.60	7.30	8.90	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.40	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
150	7.30	8.60	7.30	8.90	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.30	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
200	7.30	8.60	7.30	8.70	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.30	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
250	7.30	8.60	7.30	8.70	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.30	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
300	7.30	8.60	7.30	8.70	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.30	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
400	7.30	8.60	7.30	8.70	7.30	8.60	7.10	8.40	7.50	8.50	7.20	8.30	7.30	8.40	7.40	8.50	7.30	8.40	7.20	8.60
500	7.20	8.40	7.40	8.60	7.20	8.30	7.10	8.30	7.40	8.40	7.40	8.30	7.20	8.30	7.60	8.40	7.20	8.30	7.50	8.30
600	7.20	8.40	7.50	8.60	7.20	8.30	7.10	8.30	7.40	8.40	7.40	8.30	7.20	8.30	7.60	8.40	7.20	8.30	7.50	8.30
700	7.20	8.40	7.50	8.50	7.20	8.30	7.10	8.30	7.40	8.40	7.40	8.30	7.20	8.30	7.60	8.40	7.20	8.30	7.50	8.30
800	7.20	8.40	7.50	8.50	7.20	8.30	7.10	8.30	7.40	8.40	7.40	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
900	7.20	8.40	7.50	8.50	7.20	8.30	7.30	8.30	7.40	8.40	7.50	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1000	7.20	8.40	7.50	8.40	7.20	8.30	7.30	8.30	7.40	8.40	7.50	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1100	7.20	8.40	7.50	8.40	7.20	8.30	7.30	8.30	7.40	8.40	7.50	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1200	7.20	8.40	7.50	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.50	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1300	7.20	8.40	7.50	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1400	7.20	8.40	7.50	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1500	7.20	8.40	7.60	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
1750	7.20	8.40	7.60	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
2000	7.20	8.40	7.60	8.30	7.20	8.30	7.40	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
2500	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
3000	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
3500	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
4000	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
4500	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
5000	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30
5500+	7.20	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.40	8.40	7.60	8.30	7.20	8.30	7.60	8.30	7.20	8.30	7.50	8.30

11.7. Variable: pH (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	7.40	8.70	7.00	9.00	6.70	9.20	6.00	9.30	7.40	8.50	7.60	8.40
10	7.40	8.70	7.00	8.90	6.70	9.20	6.00	9.30	7.40	8.50	7.60	8.40
20	7.40	8.70	7.00	8.90	6.70	9.20	6.00	9.30	7.40	8.50	7.60	8.40
30	7.40	8.70	7.10	8.90	6.70	9.20	6.00	9.30	7.40	8.50	7.60	8.40
50	7.40	8.70	7.10	8.80	6.70	9.20	6.00	9.30	7.40	8.50	7.60	8.40
75	7.40	8.70	7.10	8.50	6.70	9.00	6.00	9.30	7.40	8.50	7.60	8.40
100	7.40	8.70	7.10	8.50	6.70	8.60	6.00	9.30	7.40	8.50	7.60	8.40
125	7.40	8.60	7.10	8.40	6.70	8.60	6.00	8.60	7.40	8.50	7.60	8.40
150	7.40	8.60	7.10	8.40	6.70	8.60	6.00	8.60	7.40	8.40	7.60	8.40
200	7.40	8.60	7.10	8.30	6.70	8.40	6.00	8.60	7.40	8.40	7.60	8.40
250	7.40	8.60	7.20	8.30	6.70	8.40	6.70	8.20	7.40	8.40	7.60	8.40
300	7.40	8.60	7.20	8.30	6.70	8.40	6.70	8.20	7.40	8.40	7.60	8.40
400	7.40	8.60	7.20	8.30	6.70	8.40	6.70	8.20	7.40	8.40	7.60	8.40
500	7.40	8.60	7.20	8.30	7.50	8.40	6.70	8.20	7.40	8.40	7.60	8.40
600	7.40	8.60	7.20	8.30	7.50	8.40	7.50	8.40	7.40	8.40	7.60	8.40
700	7.40	8.50	7.20	8.30	7.50	8.40	7.50	8.40	7.40	8.40	7.60	8.40
800	7.40	8.50	7.20	8.30	7.50	8.40	7.50	8.40	7.40	8.40	7.60	8.40
900	7.40	8.50	7.20	8.30	7.50	8.40	7.50	8.40	7.40	8.40	7.60	8.40
1000	7.40	8.50	7.20	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1100	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1200	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1300	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1400	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1500	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
1750	7.40	8.50	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.40
2000	7.40	8.40	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.60	8.20
2500	7.40	8.40	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
3000	7.40	8.40	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
3500	7.40	8.30	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
4000	7.40	8.30	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
4500	7.40	8.30	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
5000	7.40	8.30	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20
5500+	7.40	8.30	7.40	8.30	7.50	8.40	7.50	8.40	7.60	8.40	7.70	8.20

11.8. Variable: Chlorophyll

Standard unit: Microgram liter^{-1} (µg l^{-1})

Depth (m)	North Atlantic		Coastal N. Atlantic		Equatorial Atlantic		Coastal Eq. Atlantic		South Atlantic		Coastal S. Atlantic		North Pacific		Coastal N. Pacific		Equatorial Pacific		Coastal Eq. Pacific	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0.00	3.00	0.00	50.00	0.00	1.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.50	0.00	50.00	0.00	1.00	0.00	50.00
10	0.00	3.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.50	0.00	50.00	0.00	1.00	0.00	50.00
20	0.00	3.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.50	0.00	50.00	0.00	1.00	0.00	50.00
30	0.00	2.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.80	0.00	50.00	0.00	1.50	0.00	50.00	0.00	1.00	0.00	50.00
50	0.00	2.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.80	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.75	0.00	50.00
75	0.00	1.50	0.00	50.00	0.00	0.80	0.00	50.00	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.60	0.00	50.00
100	0.00	1.00	0.00	50.00	0.00	0.60	0.00	50.00	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00
125	0.00	0.50	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.75	0.00	50.00	0.00	0.40	0.00	50.00
150	0.00	0.50	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.75	0.00	50.00	0.00	0.40	0.00	50.00
200	0.00	0.50	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.40	0.00	50.00
250	0.00	0.50	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.10	0.00	50.00
300	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.10	0.00	50.00
400	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.10	0.00	50.00
500	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.05	0.00	50.00
600	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.05	0.00	50.00
700	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.05	0.00	50.00
800	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
900	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1000	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1100	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1200	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1300	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1400	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1500	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00
1750	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
2000	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
2500	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
3000	0.00	0.30	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
3500	0.00	0.30	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
4000	0.00	0.30	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
4500	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
5000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00
5500+	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00

11.8. Chlorophyll (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
0	0.00	0.80	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	4.50	0.00	15.00
10	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	4.50	0.00	15.00
20	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	4.50	0.00	15.00
30	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	4.50	0.00	15.00
50	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	4.50	0.00	15.00
75	0.00	0.50	0.00	50.00	0.00	1.00	0.00	50.00	0.00	1.00	0.00	50.00	0.00	0.50	0.00	50.00	0.00	2.00	0.00	15.00
100	0.00	0.50	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.75	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.50	0.00	15.00
125	0.00	0.40	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.50	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.50	0.00	4.00
150	0.00	0.30	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.30	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.50	0.00	4.00
200	0.00	0.20	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.50	0.00	4.00
250	0.00	0.10	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.10	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.50	0.00	4.00
300	0.00	0.10	0.00	50.00	0.00	0.40	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.50	0.00	4.00
400	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.50	0.00	4.00
500	0.00	0.10	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.20	0.00	50.00	0.00	0.50	0.00	4.00
600	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
700	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
800	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
900	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1100	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1200	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1300	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1400	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1500	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
1750	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
2000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
2500	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
3000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
3500	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
4000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
4500	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
5000	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00
5500+	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.05	0.00	50.00	0.00	0.50	0.00	4.00

11.8. Chlorophyll (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	5	0	5	0	12	0	5	0	5	0	5
10	0	5	0	5	0	12	0	5	0	5	0	5
20	0	5	0	5	0	12	0	5	0	5	0	5
30	0	5	0	5	0	8	0	5	0	5	0	5
50	0	5	0	5	0	8	0	5	0	5	0	5
75	0	5	0	5	0	5	0	5	0	5	0	5
100	0	5	0	5	0	5	0	5	0	5	0	5
125	0	5	0	5	0	5	0	5	0	5	0	5
150	0	5	0	5	0	5	0	5	0	5	0	5
200	0	5	0	5	0	5	0	5	0	5	0	5
250	0	5	0	5	0	5	0	5	0	5	0	5
300	0	5	0	5	0	5	0	5	0	5	0	5
400	0	5	0	5	0	5	0	5	0	5	0	5
500	0	5	0	5	0	5	0	5	0	5	0	5
600	0	5	0	5	0	5	0	5	0	5	0	5
700	0	5	0	5	0	5	0	5	0	5	0	5
800	0	5	0	5	0	5	0	5	0	5	0	5
900	0	5	0	5	0	5	0	5	0	5	0	5
1000	0	5	0	5	0	5	0	5	0	5	0	5
1100	0	5	0	5	0	5	0	5	0	5	0	5
1200	0	5	0	5	0	5	0	5	0	5	0	5
1300	0	5	0	5	0	5	0	5	0	5	0	5
1400	0	5	0	5	0	5	0	5	0	5	0	5
1500	0	5	0	5	0	5	0	5	0	5	0	5
1750	0	5	0	5	0	5	0	5	0	5	0	5
2000	0	5	0	5	0	5	0	5	0	5	0	5
2500	0	5	0	5	0	5	0	5	0	5	0	5
3000	0	5	0	5	0	5	0	5	0	5	0	5
3500	0	5	0	5	0	5	0	5	0	5	0	5
4000	0	5	0	5	0	5	0	5	0	5	0	5
4500	0	5	0	5	0	5	0	5	0	5	0	5
5000	0	5	0	5	0	5	0	5	0	5	0	5
5500+	0	5	0	5	0	5	0	5	0	5	0	5

11.9. Variable: Alkalinity

Standard unit: Millimole liter^{-1} (mmol l^{-1})

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80
10	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80
20	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80
30	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80
50	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80	1.80	2.80	0.00	2.80	2.00	2.80	0.00	2.80
75	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
100	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
125	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
150	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
200	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
250	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
300	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
400	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
500	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	2.00	2.80	1.80	2.80	1.60	2.80	2.00	2.80	1.60	2.80
600	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
700	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
800	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
900	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1100	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1200	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1300	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1400	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
1750	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
2000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
2500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
3000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
3500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
4000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
4500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
5000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
5500+	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80

11.9. Alkalinity (continued)

Depth (m)	South Pacific		Coastal S. Pacific		North Indian		Coastal N. Indian		Equatorial Indian		Coastal Eq. Indian		South Indian		Coastal S. Indian		Antarctic		Arctic	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
0	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.40	2.60
10	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.40	2.60
20	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.40	2.60
30	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.40	2.60
50	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.00	2.80	2.00	2.80	0.40	2.60
75	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
100	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
125	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
150	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
200	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
250	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
300	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
400	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
500	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.60	2.80	2.00	2.80	1.40	2.80
600	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
700	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
800	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
900	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1100	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1200	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1300	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1400	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
1750	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
2000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
2500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
3000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
3500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
4000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
4500	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
5000	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80
5500+	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	1.80	2.80

11.9. Alkalinity (continued)

Depth (m)	Mediterranean		Black Sea		Baltic Sea		Persian Gulf		Red Sea		Sulu Sea	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	1.80	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
10	1.80	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
20	1.80	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
30	1.80	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
50	1.80	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
75	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
100	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
125	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
150	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
200	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
250	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
300	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
400	2.00	3.10	0.00	2.80	0.40	2.80	2.00	2.80	2.00	2.80	0.40	2.80
500	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
600	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
700	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
800	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
900	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1000	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1100	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1200	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1300	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1400	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1500	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
1750	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
2000	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
2500	2.00	3.10	0.00	2.80	1.70	2.80	2.00	2.80	2.00	2.80	1.70	2.80
3000	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
3500	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
4000	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
4500	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
5000	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80
5500+	2.00	3.10	0.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80	2.00	2.80

APPENDIX 12. World Ocean Database ragged array NetCDF format description

The World Ocean Database (WOD) officially archived version for observed and standard level data is provided in ragged array Network Common Data Form NetCDF format which follows the Climate-Forecast (CF) conventions. The CF format for contiguous ragged array and profile data representation is optimal for WOD which aggregates oceanographic casts (collections of ocean profiles for one or more variables taken at the same date, time, geographic location, and depth or pressure). Different casts can have very different counts of depth/variable pairs for each profile (from 2 to 24,000 in the WOD), and from 1 to 26 variables with separate profiles in each cast. This renders standard array representation (`max_depth_count` x `max_variable_count` x `number_of_casts`) inefficient for oceanographic casts. Ragged array form has single dimension arrays for each profile variable which contain all the measurements for the given variable.

Ragged array form has a second array, a counting array (called `VAR_row_size` where `VAR` is the variable name), which gives the number of variable measurements for each cast. To get to the variable measurements for cast N, the (N-1) `VAR_row_size` counts are summed, and the pointer in array `VAR` is moved to this element position. The next `VAR_row_size` (N) elements in array `VAR` are the variable measurements for cast N. Note that variable `z` (depth) is always present and the indexed variable measurements for a particular cast are always associate with the same index for depth.

A trivial example: A file contains five oceanographic casts, each of which has profiles of depth/temperature and depth/salinity, one of which contains a profile of depth/oxygen. Only the fourth cast contains a profile of oxygen. The file has the following:

```
netcdf wod_example {
dimensions:
        casts = 5 ;
        z_obs = 25 ;
        Temperature_obs = 25 ;
        Salinity_obs = 25 ;
        Oxygen_obs = 5 ;

: : : : : : : : : :
variables:
     float lat(casts) ;
      float lon(casts) ;
       double time(casts) ;
        float z(z_obs) ;
        int z_row_size(casts) ;
        float Temperature(Temperature_obs) ;
        int Temperature_row_size(casts) ;
        float Salinity(Salinity_obs) ;
         int Salinity_row_size(casts) ;
        float Oxygen(Oxygen_obs) ;
        int Oxygen_row_size(casts) ;

: : : : : : : : : : : :

z_row_size =  5, 5, 5, 5, 5 ;
Temperature_row_size = 5, 5, 5, 5, 5 ;
Salinity_row_size = 5, 5, 5, 5, 5 ;
Oxygen_row_size = _, _, _, 5, _ ;
```

Note that '_' for `VAR_row_size` is a missing value. Fill value is set to zero (0).

To read in the fourth cast (N=4), skip the first 15 elements in variables z, Temperature, and Salinity. (N-1)=3, `VAR_row_size(1)+VAR_row_size(2)+VAR_row_size(3)=5+5+5=15` for `VAR=z, Temperature, Salinity.`

For Oxygen, Oxygen_row_size(1)=Oxygen_row_size(2)=Oxygen_row_size(3)=0, so read from the first value in array Oxygen (position 0 in the array).

For all variables, VAR_row_size(4)=5, so the next 5 values are read from each VAR array (elements 16-20 in arrays z, Temperature, Salinity; elements 1-5 in array Oxygen). VAR_row_size(N) will always be either equal to z_row_size(N) or equal to 0, the latter only in cases where the particular variable was not measured in cast N.

All variables present in a cast will have a one-to-one correspondence with the depth (z) for that cast: z(cast=4,element=1) corresponds to Temperature(cast=4,element=1), Salinity(cast=4,element=1), Oxygen(cast=4,element=1).

In the ragged array representation then, z(16) corresponds to Temperature(16), Salinity(16), Oxygen(1) – the separate `VAR_row_size` must be accounted for.

Describing the ocean environment requires multiple profile variables associated with depth (z). But all profile variable elements must be associated not only with depth (z), but with cast specific variables such as latitude, longitude, date/time. Further, other cast-specific measurements such as bottom depth, wave height, wind speed, etc. help to contextualize the ocean profile variables to describe the ocean environment. Other information, such as ship name, primary investigator, cruise identifier, etc. are important to identify and assess the ocean profile data. It is important to keep all of this information together for each cast and so for the aggregate oceanographic cast file provided to users. It is also important, even with today's system capacities, to minimize file size when possible. This is the reason behind using a ragged array format. It is also important to use accepted standards in order to make sure the data are widely accessible. This is why the CF standard has been followed. Two points of the CF standard for contiguous ragged array NetCDF are problematic for the efficient arrangement of oceanographic cast, file size, and inclusion of all necessary variables together and are not followed. The first is that all ocean profile variables do not have the same array size, each ocean profile variable has an array size (`VAR_obs`) commensurate with the number of measurements of the variable itself (`VAR`). All variables are still associated with the cast depth through the `VAR_row_size` counter. The second is that there are arrays of variables – both ocean profile and other ocean environment descriptors with different axes. For instance, the ocean profile variables are arranged along the depth axis (and the cast axis) while ocean state variables are arranged only along the cast axis.

APPENDIX 13. Ocean basins defined for objective analysis and the shallowest standard depth level for which each ocean basin is defined

Code	Basin Name	Standard Depth Level	Code	Basin Name	Standard Depth Level
1	Atlantic Ocean[1]	1	**31**	West European Basin	82
2	Pacific Ocean[1]	1	**32**	Southeast Indian Basin	82
3	Indian Ocean[1]	1	**33**	Coral Sea	82
4	Mediterranean Sea[1]	1	**34**	East Indian Basin	82
5	Baltic Sea	1	**35**	Central Indian Basin	82
6	Black Sea	1	**36**	Southwest Atlantic Basin	82
7	Red Sea	1	**37**	Southeast Atlantic Basin	82
8	Persian Gulf	1	**38**	Southeast Pacific Basin	82
9	Hudson Bay	1	**39**	Guatemala Basin	82
10	Southern Ocean[1]	1	**40**	East Caroline Basin	87
11	Arctic Ocean	1	**41**	Marianas Basin	87
12	Sea of Japan	1	**42**	Philippine Sea	87
13	Kara Sea	22	**43**	Arabian Sea	87
14	Sulu Sea	25	**44**	Chile Basin	87
15	Baffin Bay	37	**45**	Somali Basin	87
16	East Mediterranean	41	**46**	Mascarene Basin	87
17	West Mediterranean	47	**47**	Crozet Basin	87
18	Sea of Okhotsk	47	**48**	Guinea Basin	87
19	Banda Sea	55	**49**	Brazil Basin	92
20	Caribbean Sea	55	**50**	Argentine Basin	92
21	Andaman Basin	62	**51**	Tasman Sea	87
22	North Caribbean	67	**52**	Atlantic Indian Basin	92
23	Gulf of Mexico	67	**53**	Caspian Sea	1
24	Beaufort Sea	77	**54**	Sulu Sea II	37
25	South China Sea	77	**55**	Venezuela Basin	37
26	Barents Sea	77	**56**	Bay of Bengal[1]	1
27	Celebes Sea	62	**57**	Java Sea	16
28	Aleutian Basin	77	**58**	East Indian Atlantic Basin	97
29	Fiji Basin	82	**59**	Chiloe	1
30	North American Basin	82	**60**	Bransfield Strait	37

[1]Basins can interact with adjacent basins in the WOA objective analysis.

APPENDIX 14. How to share or submit oceanographic profile data for archival and open access with NCEI, the WDS-Oceanography, and WOD

All oceanographic data shared with the World Data Service of Oceanography of the World Data System (WDS) hosted at NCEI and the WOD are first archived in their original format and data and metadata content and made openly available to the public. The NCEI also receives data from many different disciplines, sources, including individual researchers, government and non-governmental organizations, global data acquisition centers, and research institutions from all over the world. Data shared with NCEI should ideally be in the public domain. For example, NCEI can archive data using internationally recognized licenses from Creative Commons. NCEI encourages data submitters to assign Creative Commons 1.0 Universal Public Domain Dedication (CC0-1.0) onto their data (preferred), which ensures maximum usage of the data throughout the industry, for anyone's use and for any purpose, or CC BY 4.0.

The Send2NCEI (S2N) data sharing tool can be used for sharing and uploading oceanographic datasets to NCEI that are less than 20 gigabytes (GB) in size total. Multiple datasets (< 20 GB) can be shared via S2N. The S2N is an archiving tool that allows you to share your data files and related documentation (metadata) for long term preservation, stewardship, and access at the NCEI data archive. If you have a data set greater than 20 GB, you may consider submitting the data in more than one submission. NCEI can also archive datasets greater than 20 GB using the Advanced Tracking and Resource Tool for Archive Collections (ATRAC) tool. The data received are subject to an appraisal. For questions please reach out to ncei.info@noaa.gov

Ideally, oceanographic data (and metadata) should be made available in a format that allows data machine manipulation in tabular form such as comma-separated values (.csv), Tab-separated values (.tsv), NetCDF with CF conventions (.nc), Hierarchical Data Format (.HDF), UTF-8 and ASCII (.txt). Metadata can also be submitted using ISO 191xxx (series of international Geographic Metadata); preferably using eXtensible Markup Language (.xml). While documentation about the data such as cruise reports can be in PDF format, sharing data in PDF format is discouraged. Once the data are in the archive, the data are made openly available for discovery and access. If the data does not already include a Digital Object Identifier (DOI), one can be freely requested as part of the S2N data submission process. The OCL Team integrates a copy of the archived data into the WOD data format and includes a web link to the original data in the archive to ensure data provenance.

Below are step by step instruction to share (*e.g.*, upload, submit) ocean data using the S2N tool:

Step 1: Create an account with login.gov. If you already have one, go to step 2. If you have never used S2N before, you will first need to create an account with login.gov (https://login.gov/). Login.gov is a U.S. secure sign in service used by the public to sign in to participating U.S. government agencies such as NOAA. Anyone can create an account. Creating an individual login.gov account is straight forward (step by step instructions are provided). You will need an email address, a password at least 12 characters long and should not include commonly used words or phrases, and an online authentication method (*e.g.*, an authentication application).

Step 2: Log into S2N: On your web browser, go to https://www.nodc.noaa.gov/s2n/. If you haven't used S2N before, you will need to create a new login account before you can use S2N (Figure 14.1).

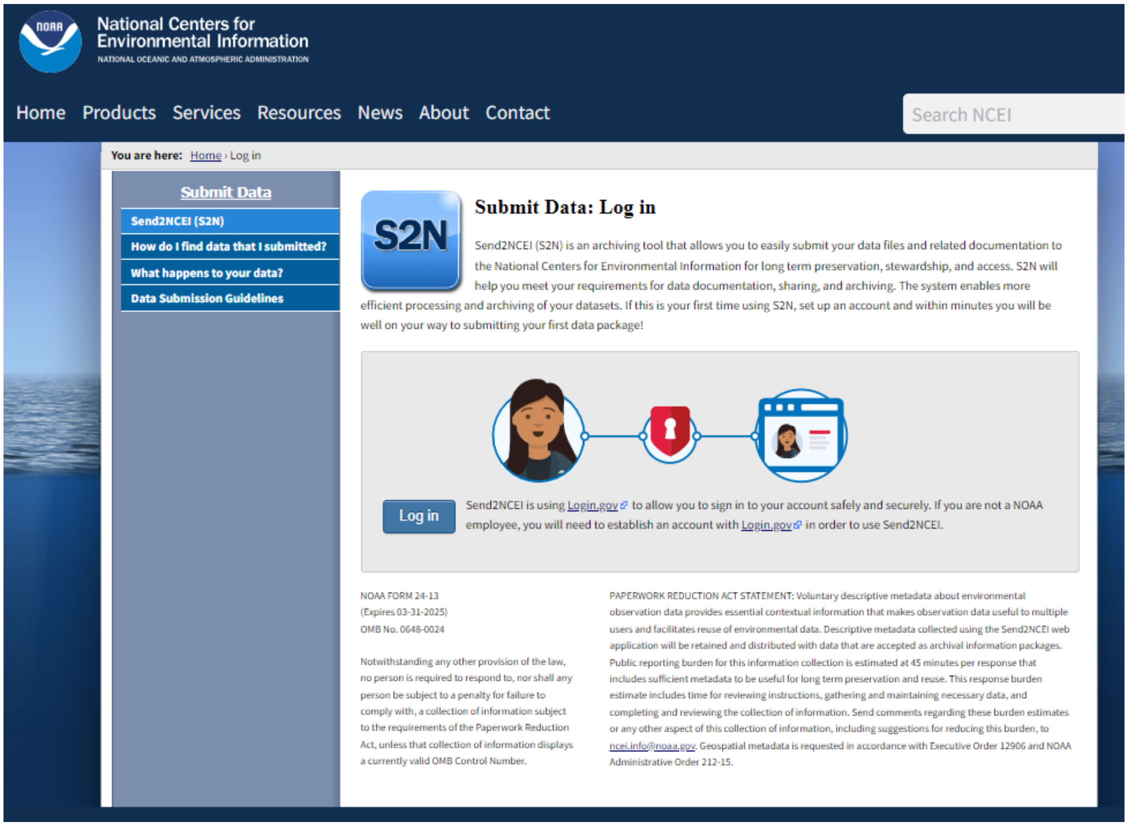

Figure 14.1 Send2NCEI (S2N) entry page (https://www.ncei.noaa.gov/archive/send2ncei/)

Step 3: Once you log into S2N you will be taken to a dashboard page. You can create a new Data Submission Package and/or edit one that you are working on. To create a new data submission, click the "**Create A New Submission Package**". To edit any of your submission packages listed in the "**Submission Packages I am Working On**", click on the package of interest (Figure 14.2).

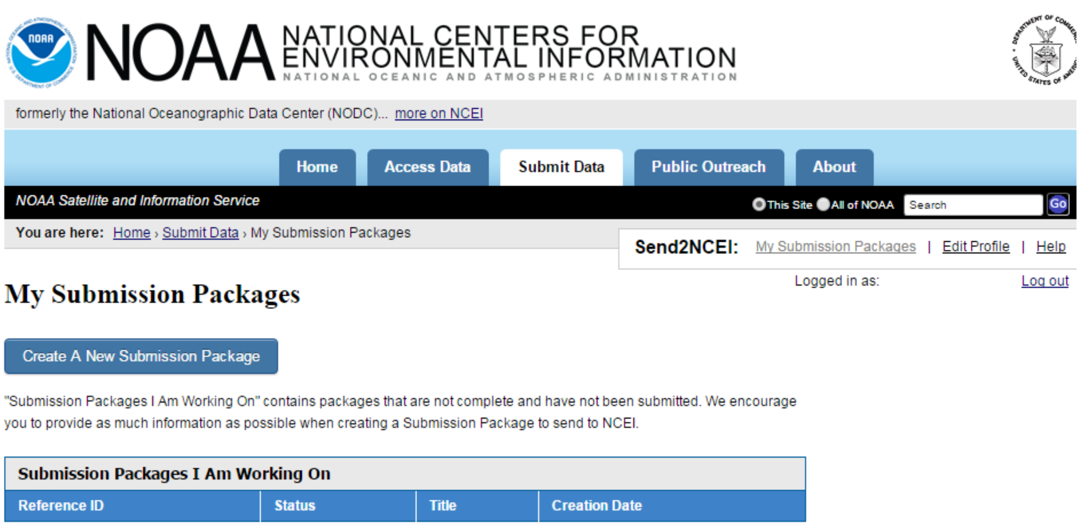

Figure 14.2. S2N dashboard

After you create a new submission package, you will be directed to add information about the data.

- <u>People and Projects</u> - Enter information about one or more people's names (*e.g.*, scientists or data submitter) and projects involved in the collection of the data if any (see figure 14.3).

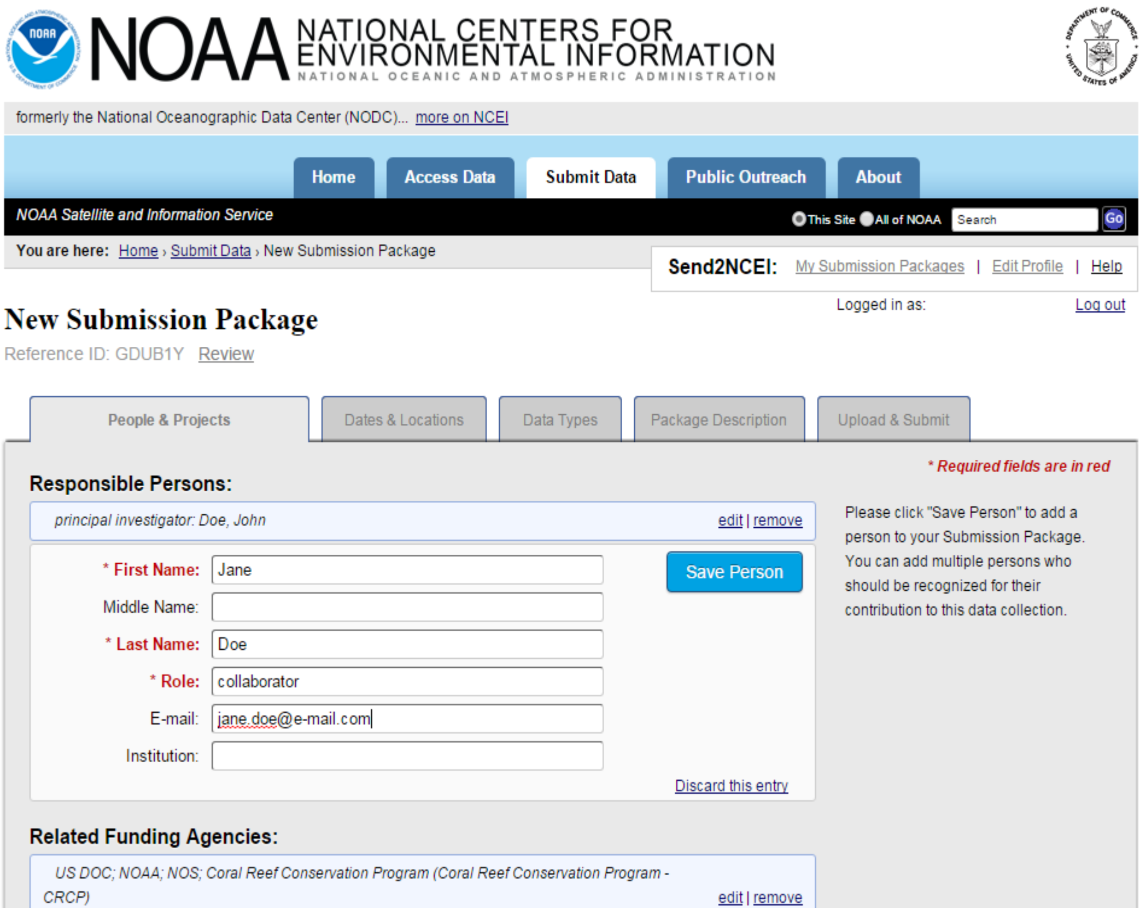

Figure 14.3. Responsible person and project information

a) **Responsible Persons**: This is a mandatory field. Add <u>at least one person's name</u> responsible for the collection of the data such as for example, the chief scientist and/or point of contact. Click on the "**Save Person**" button after it is done. You can enter as many people as you wish. Some names are already in the archive and when you start typing autocomplete options might appear.

b) **Related Funding Agencies:** This is an optional field. You can add one or more funding agencies. Some agency names are already in the archive. If so, then when you start typing, autocomplete options will appear. If the name of the agency already exists, then select it and click "**Save Agency**". If the funding agency does not appear, add the agency's name and click "**Save Agency**"

c) **Related Projects and/or Programs**: This is an optional field. You can add one or more projects and/or program names associated with your field work.

- **Dates and Locations:** These are the dates and geographic locations of all of the data to be submitted (Figure 14.4)

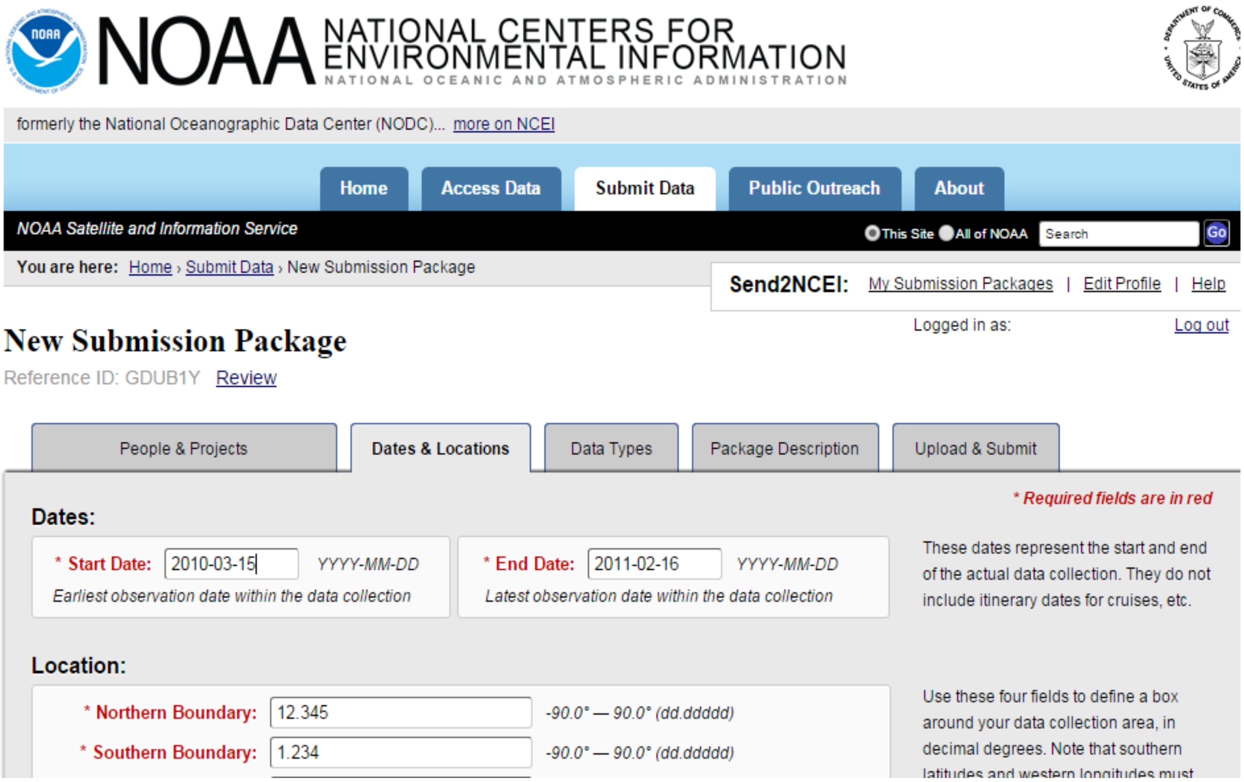

Figure 14.4 Data dates, latitude and longitude geographic boundaries, ship or platform, sea area or regions

a) **Dates:** This is a mandatory field. These are the start and end dates of the entire data collection irrespective of variable: Enter the dates in YYYY-MM-DD format (*e.g.*, 2021-03-19 for Year: 2021; Month: March; Day: 19)

b) **Location**: This is a mandatory field. Enter in the geographic northernmost, easternmost, southernmost and westernmost coordinates in decimal degrees where data were collected irrespective of variable.

c) **Ship Names or Platform:** Enter the name of the research vessel or platform used in the collection of the data. Use the autocomplete if appropriate.

d) **Sea Areas or Regions** - Enter the oceanic region where the data was collected (*i.e.*, North Pacific). You can enter as many entries as appropriate. Use the autocomplete if appropriate.

- **Data Types** - Enter if the data you are submitting are measurements (*i.e.*, *in situ*, remote sensing) or calculated values derived from measurements (Figure 14.5)

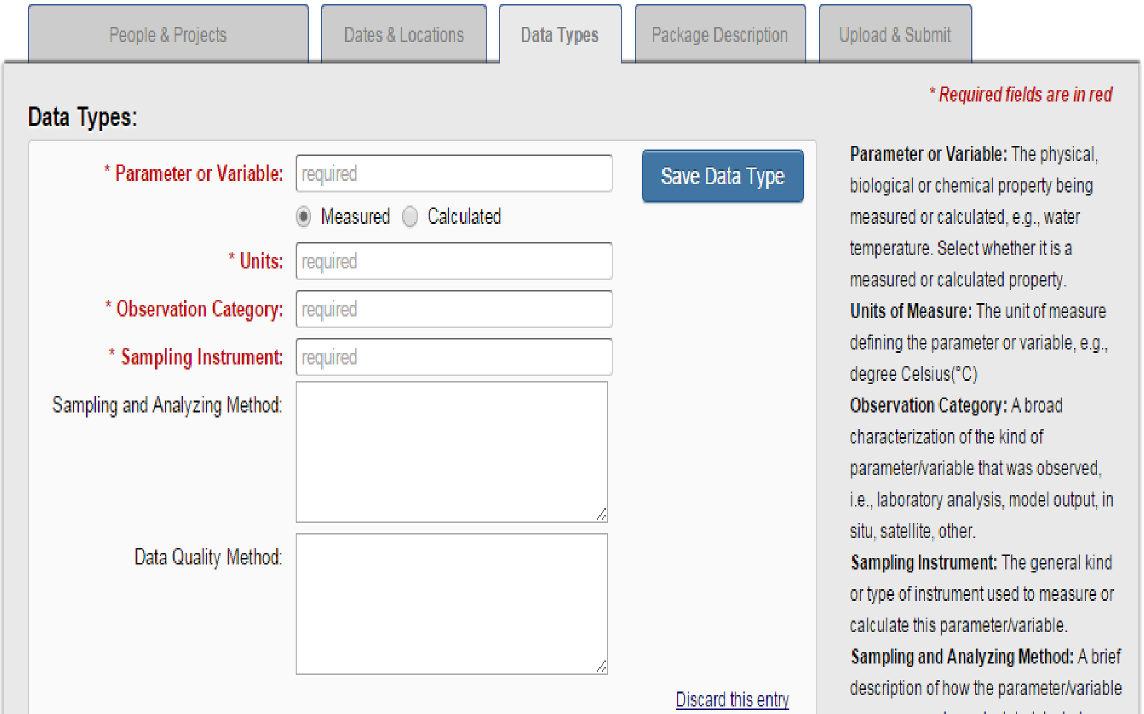

Figure 14.5 Information about the type of measured variable or calculated parameter

a) **Parameter or Variable**: This is a mandatory field. Enter at least one measured variable or calculated parameter (*e.g.*, coral, salinity, tritium, chlorophyll A). You can enter as many variables and/or parameters as you wish. Use the autocomplete if appropriate. If you don't see one that fits the name of your variable or parameter, you can enter in a new one of your choice (See Figure 14.6).

b) **Units/Observation Category/Sampling instrument:** These are mandatory fields. You must enter the units of each measurement, observation type, or sampling instrument added in the previous step. If you have many types of variables, enter at least one variable. If your data has no units of measurement or other fields, then enter "NA" (for not applicable). Click on "**Save Data Type**" when you are done.

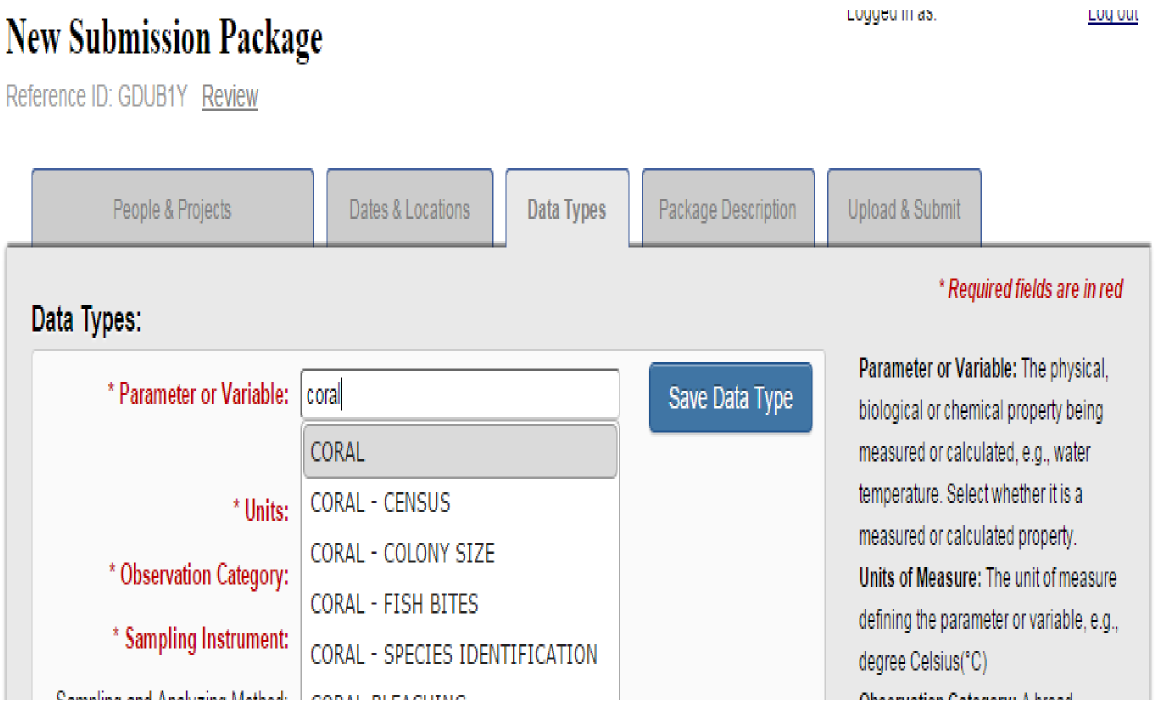

Figure 14.6 Information about the measured variable or calculated parameter

- **Package Descriptions:** This is a mandatory field. This is a description of your data (Figure 14.7)

  a) **Data Set Title**: S2N will suggest a general title based on the metadata you provided in other fields. You can accept, edit, or write your own data set tittle if you wish. The title should describe the data in general (*e.g.*, Temperature and salinity measurements taken by CTD from the research vessel Ronald Brown in the Caribbean Sea from 2010-05-06 to 2010-06-20)

  b) **Abstract:** The abstract provides a summary of the entire data collection (*e.g.*, the purpose of the project or research cruise and other relevant information (*e.g.*, Physical and biological oceanographic time series measurements were collected to study the diurnal migration of copepods). You can add any relevant information that you wish to add.

  c) Suggested author list: Enter authors of the dataset (*e.g.*, chief scientist, and/or other personnel). Enter at least one data author. You can add as many authors as you wish. Please enter names as Last name, First name Middle initial. (if any), separate multiple authors by a semicolon ';'.

  d) **Purpose:** An optional field. You are encouraged to add information about the project, funding agency, and any other metadata.

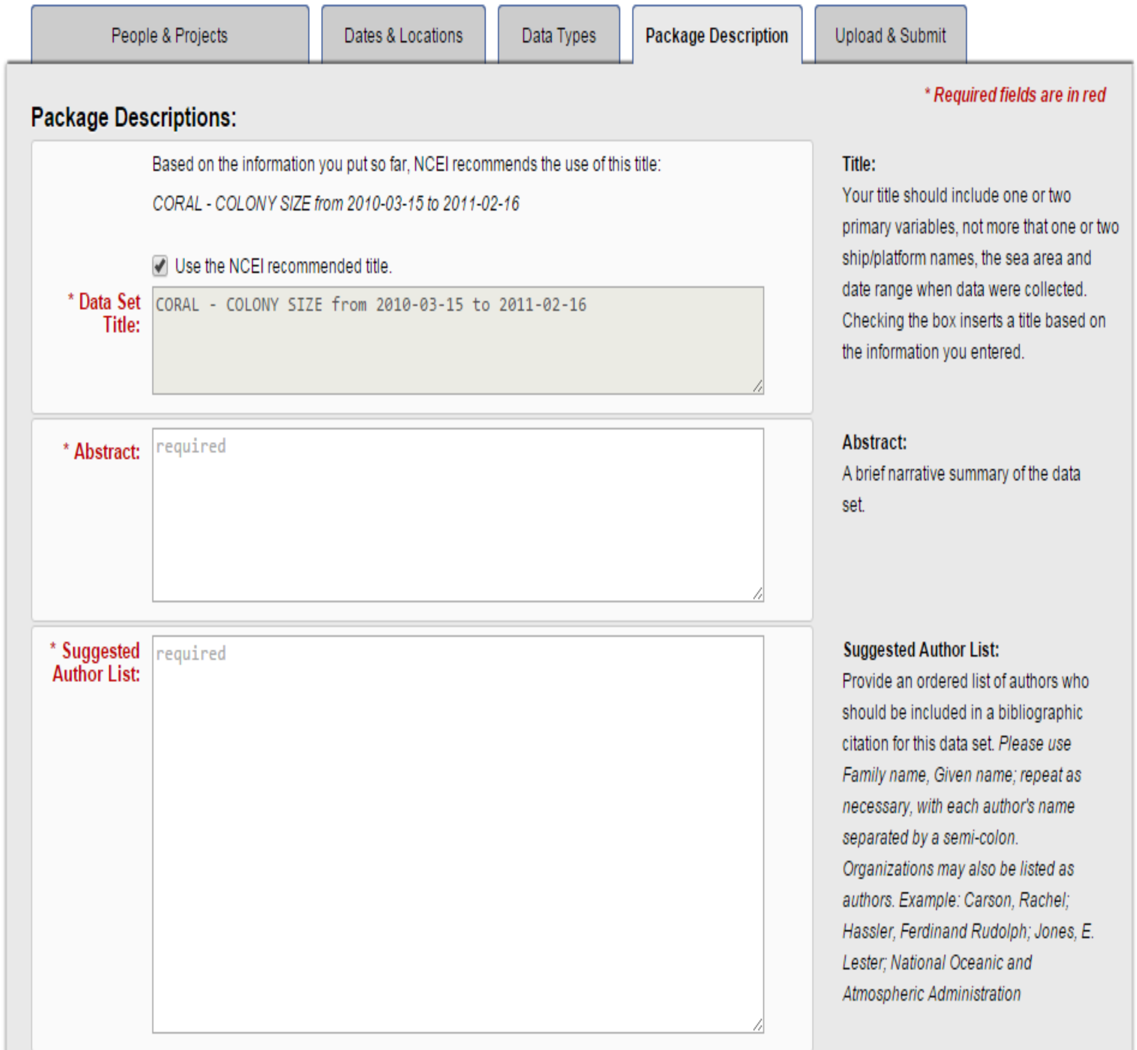

Figure 14.7 Information about the overall dataset

- **Upload data:** Once all of the required S2N fields are entered in previous steps, you are now ready to upload your data for NCEI archival appraisal (Figure 14.8). You can upload data files that all together should be < 20 Gb. Please review your data submission package (metadata) before uploading the data. Once the data files are submitted, you will not be able to easily edit your submission entry. You can upload any type of file associated with the data collection in non-commercial formats, including MatLab.
    - **Cruise reports**: Cruise reports, methods, and other documents can be uploaded in PDF, text.
    - **Data:** Data measurements and parameters can be uploaded via S2N in file formats that allow machine manipulation (*e.g.,* NetCDF, Hierarchical Data Format; HDF, CSV, text). Data in PDF format is discouraged. If the data does not have a DOI

already, you may request one during submission. If a DOI is not already available in the incoming dataset being archived, NCEI staff may nevertheless choose to assign a DOI to the dataset and communicate this to the data provider. Once minted, a DOI provides a unique and persistent identifier that allows users to accurately cite and locate data obtained from NCEI. Data without an assigned DOI can be cited, but may not have a persistent URI or have citation metadata published in the DataCite discovery service.

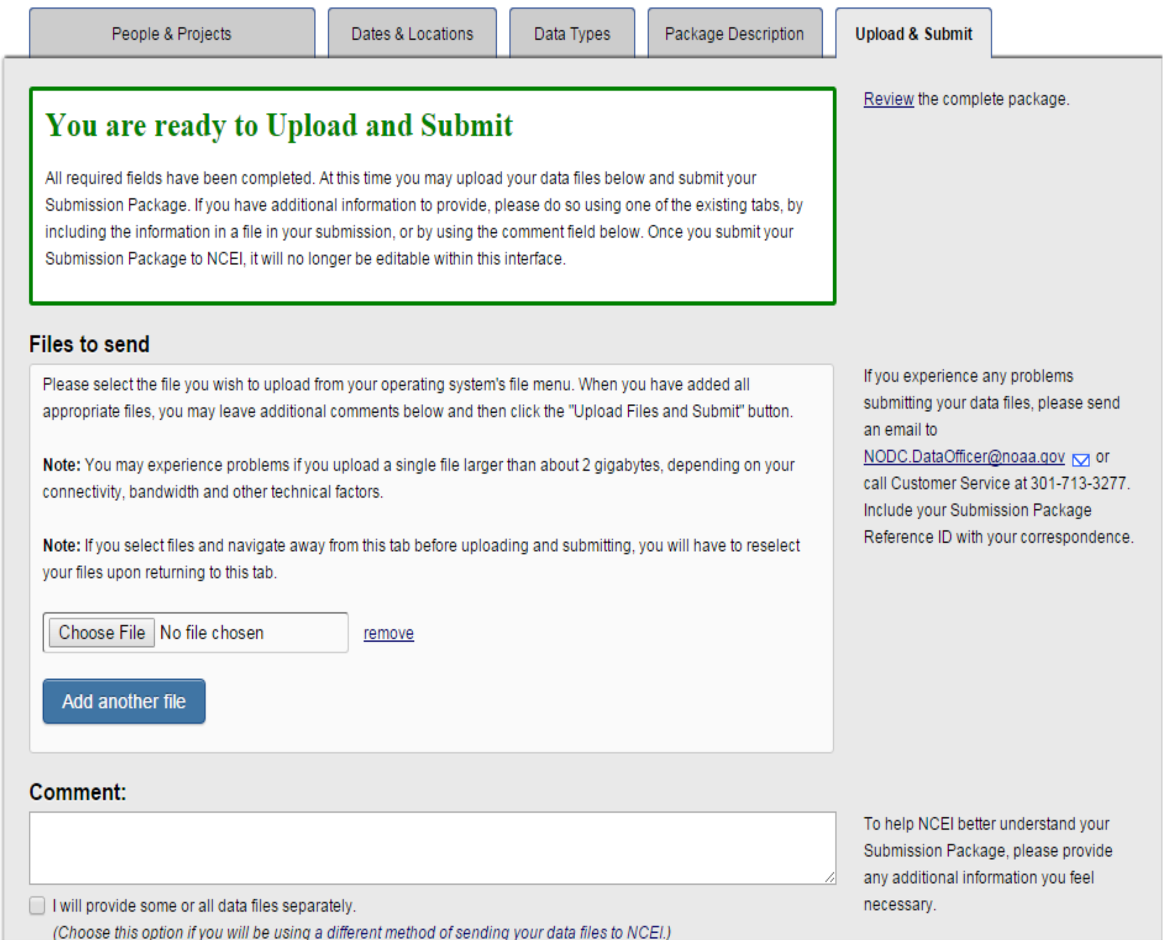

Figure 14.8 Data and metadata upload to the archive.

To upload a file (*e.g.*, cruise report, datasets, metadata) to S2N, click on the "**Choose File**" button (Figure 14.8). You can only upload one file at a time. However, you can repeat this process and upload as many individual files as needed. If you prefer, you can first compress all of the data files (*i.e.*, ZIP) and submit all compressed files as one file (not necessary). If you have a data set greater than 20 GB, you may consider submitting the data in more than one submission. For questions please reach out to ncei.info@noaa.gov

What happens after you share your data?

The data submitter will receive a system-generated email notification stating that the data were received along with an assigned unique "Reference ID" which is a temporary number used internally at NCEI for tracking data submissions. After reviewing your data and metadata, NCEI will update you about the archival status of your submission package with this ID via email. No additional action is required from you at this time. If you have any questions about NCEI archival processes, please contact ncei.archive@noaa.gov. Also, if at any time you wish to update your submission package, please send an e-mail to ncei.archive@noaa.gov with your request. Please remember to include your submission package Reference ID.

You will be later notified via email if NCEI creates an archival information package of your data, including an NCEI unique Accession Number identifier for that archival information package (see glossary). When your data are finally archived, NCEI keeps an exact copy of the data and metadata you sent and will develop necessary tracking and discovery metadata. In addition, NCEI may create additional versions to ensure your data are preserved for long-term access. Upon completion of these archival ingest actions, NCEI will publish your data online.

Figure 14.9a provides an example of a dataset already archived at NCEI with a DOI (NCEI Accession 0241962; https://doi.org/10.25921/tgjj-0s81). For context, this data package contains discrete profile measurements of water temperature, salinity, dissolved oxygen, silicate and phosphate collected during the *R/V Franklin* cruise Fr-10/91 (EXPOCODE 09FA19911115, 09FA1091) WOCE Repeat section PR11 in the South Pacific Ocean from 1991-November-15 to 1991-December-15. The landing page provides information as how to cite the data, metadata (xml, text), documentation, data lineage, where to access and download the data. The data in NCEI Accession 0241962 can be downloaded in individual files or download the complete archive bundle (Figure 14.9b).

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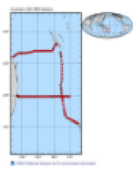
Hydrographic and chemical data collected from profile and discrete sample observations during the R/V Franklin cruise Fr-10/91 (EXPOCODE 09FA19911115, 09FA1091) WOCE Repeat section PR11 in the South Pacific Ocean from 1991-11-15 to 1991-12-15 (NCEI Accession 0241962)



Preview graphic

This dataset includes discrete profile measurements of water temperature, salinity, dissolved oxygen, silicate and phosphate collected during the R/V Franklin cruise Fr-10/91 (EXPOCODE 09FA19911115, 09FA1091) WOCE Repeat section PR11 in the South Pacific Ocean from 1991-11-15 to 1991-12-15.

Dataset Citation
Dataset Identifiers
ISO 19115-2 Metadata

Access Time & Location Documentation Description Credit Keywords Constraints Lineage

Download Data	HTTPS *(download)* Navigate directly to the URL for data access and direct download. FTP *(download)* These data are available through the File Transfer Protocol (FTP). FTP is no longer supported by most internet browsers. You may copy and paste the FTP link to the data into an FTP client (e.g., FileZilla or WinSCP).
Distribution Formats	• Originator data format
Ordering Instructions	Contact NCEI for other distribution options and instructions.
Distributor	*NOAA National Centers for Environmental Information* +1-301-713-3277 NCEI.Info@noaa.gov
Dataset Point of Contact	*NOAA National Centers for Environmental Information* ncei.info@noaa.gov

Figure 14.9a Example archived data set (Accession 0241962; https://doi.org/10.25921/tgjj-0s81).

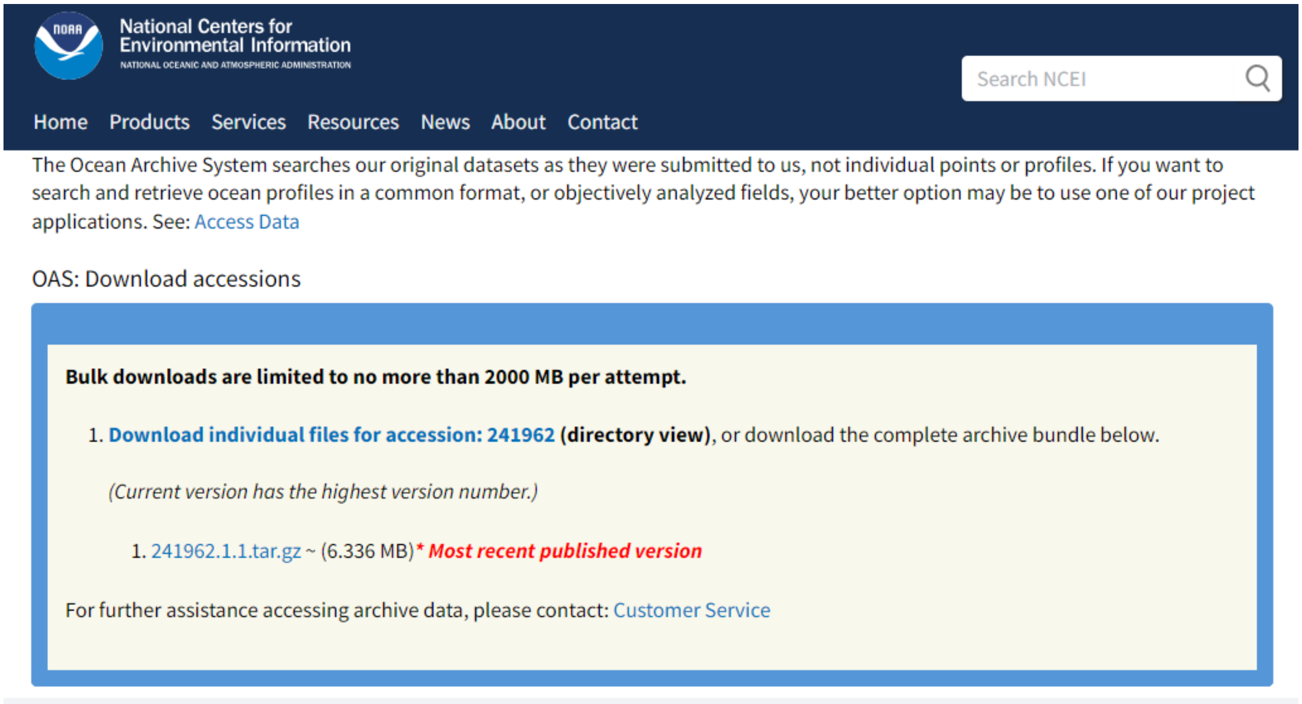


Figure 14.9b Downloading data from the NCEI archive

APPENDIX 15. GLOSSARY

Accession Number – A group of stations received and archived at the U.S. NCEI. Each dataset submitted to NCEI is given a unique accession number. Using this number, a user can get the original data from NCEI as well as information about the data itself. Cruises are not always subsets of accession numbers, as data from the same cruise may come from multiple accession numbers. Each station has an accession number (with a few exceptions). If a station is replaced by higher quality data, the accession number will reflect the new source of the data while the unique station number will remain unchanged. If a profile for a variable not previously stored with a station becomes available, the profile will be added to the existing station, and a profile specific accession number will be added to the station to record the source of the new profile.

Accuracy – ability of a measuring instrument to give responses close to a true known value.

APB – Autonomous pinniped bathythermograph is the name given to temperature data recorded by time-temperature-depth recorders (TTDR) and ARGOS position transmitters attached to pinnipeds (*e.g.* northern elephant seals). See Marine Mammal Center for information on different pinniped species.

Bathythermograph (BT) data – Temperature profile data from mechanical bathythermographs (MBT), and expendable bathythermographs (XBT).

Biological header – The biological header section contains information on the sampling methods used for collecting taxonomic and biomass measurements.

Bullseyes – Bullseyes are unrealistic features found during the initial objective analyses for each variable at standard depth levels and usually contain some large-scale gradients over a small area. The data causing these features are investigated and flagged.

Calibration – A set of operations that establish, under specified conditions, the relationship between the values of quantities indicated by a measuring instrument or measuring system and the corresponding values realized by standards.

Cast – A set of profiles (or a single profile) taken concurrently. Meteorological and ocean condition information are also included for a cast if measurements were taken concurrently with the profile(s). Observations and measurements of plankton from net-tows are included if taken concurrently or in close time proximity to profiles. If there are no profiles in close proximity, a net-tow by itself will constitute a cast. Each cast in the WOD is assigned a unique cast number. If the cast is subsequently replaced by higher quality data, the unique cast number remains the same. If any alteration is made to a cast, this information is noted online, referenced by the unique cast number. For surface-only data in dataset SUR, a cast is defined as a collection of concurrent profiles of surface measurements at discrete latitudes and longitudes over an entire cruise (see definition of cruise below). Profiles of latitude, longitude and Julian year-day are included with profiles of measured oceanographic variables.

Cast/Tow Number – Sequential number representing each over-the-side operation or discrete sampling at a station or section or a cast of a tow.

Character Data – Includes originator's cruise codes, originator's cast codes, and principal investigator integer code.

Comma-Separated Values (.csv) – Also known as "common-delimited" is a text file or flat file format allowing portability of files into any database.

Country code – A two-character code assigned to each country. Each code is unique to a country and is assigned by NCEI. See Appendix 1 for the list of ISO country codes.

Cruise – A set of casts is grouped together if they fit the cruise definition. A cruise is defined as a specific deployment of a unique platform for the purposes of a coherent oceanographic investigation. For an oceanographic research vessel, this deployment is usually well defined with a unique set of scientific investigators collecting data for a specific project or set of projects. In some cases, different legs of a deployment with the same equipment and investigators (*e.g.*, principal investigator, chief scientists, researcher) are assigned different cruise numbers, as per the investigators designation. In the case of merchant ships of opportunity, a cruise is usually defined as the time between major port calls. Profiling floats, moored buoys, and drifting buoys are assigned the same cruise number for the life of the platform. For surface-only data in dataset SUR, a cast and cruise are the same, except for 27 cruises which were split into 2 casts each due to the large number of sets of measurement (> 24,000).

In WOD, a cruise identifier consists of two parts, the ISO 3166-1 country code and the unique cruise number. The unique cruise number is only unique with respect to the country code. The country code is usually assigned based on the flag under which the ship from which the data were measured operates. If the platform from which data were measured was not a ship, (*e.g.* profiling float, moored buoy), the country of the primary investigator or institute which operates or releases the platform is used. For data for which no information on country is present, a country code of 99 is used. For data for which there is no way to identify a specific cruise, a cruise number of zero (0) is used.

The present cruise identifier definition is slightly changed from previous releases of the World Ocean Database. Previously, bathythermograph (BT) data were assigned unique cruise numbers without regard to country in keeping with prior convention at the US NCEI. This made assigning the same cruise number to BT data and other data collected on the same cruise impossible. Now BT cruises are assigned in the same manner as other datasets. To facilitate this change, approximately 5,300 Mechanical Bathythermograph (MBT) cruise numbers were reassigned, along with 22 Expendable bathythermographs (XBT) cruise numbers.

Now, all data for a cruise should be listed under one unique country code/unique cruise number combination. It should be possible to g*et al*l bottle (OSD), high-resolution CTD, BT, and towed-CTD data for a cruise using one unique cruise identifier. However, this is not yet the case for all BT data. It is an ongoing project to match the BT data with the correct bottle and high-resolution CTD data.

Cruise Code – A unique code assigned to all casts completed in the same cruise. It is formed by a country code and an integer number.

CTD – Conductivity-Temperature-Depth. Data contains physical-chemical oceanographic data at discrete pressure levels.

Dataset – All casts from similar instruments with similar resolution. For instance, all bathythermographs (BTs) which are dropped over the side of a ship on a winch and recovered are in dataset MBT, all CTD data stored at high-resolution (small depth increments or large number of measurements) are stored in CTD. A list of all datasets for WOD is found in Table 2. For convenience, data from each dataset are stored in separate files in WOD.

DRB – Drifting Buoy Data

Essential Climate Variable (ECV) – Physical, chemical or biological variables or a group of linked variables that help characterize Earth' s climate (Global Climate Observing System, GCOS.

g77 compiler – g77 is a GNU Fortran (GFortran) compiler that was initially designed to replace the UNIX f77 command, a UNIX compiler. See http://gcc.gnu.org/onlinedocs/gcc-3.4.1/g77/ as well as http://www-rocq.inria.fr/~kern/G77/g77.html for more information.

GLD – Glider Dataset

Global Climate Observing System (GCOS) – GCOS assesses the status of global climate observations of the atmosphere, land and ocean and produces guidance for its improvement. Its co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO), the United Nations Environment Programme (UN Environment), and the International Science Council (ISC).

GTSPP – Global Temperature and Salinity Pilot Project

Institute code – A unique numerical code assigned to each institute which sampled the data.

Intergovernmental Oceanographic Commission (IOC): A body of The United Nations Educational, Scientific and Cultural Organization (UNESCO)

ISO – International Organization for Standardization. It is a widely used coding system and is the largest developer and publisher of International Standards in the world. We see it used everyday: 1) used to ID the Internet country code Top-Level Domains like ".fr", ".jp", ".ru", 2) representation for currencies & funds (United States dollar, Japanese Yen, Euro, Russian Rubble, *etc*.). See http://www.iso.org/iso/home.htm for more information.

MBT – Mechanical Bathythermograph. The data contains temperature-depth profile obtained at discrete depths to a maximum depth less than 300 meters.

Measured Variables – Temperature, salinity, oxygen, phosphate, silicate, nitrate, pH, chlorophyll, alkalinity, pCO_2, dissolved inorganic carbon, Nitrate + nitrite, and pressure data versus depth.

MRB – Moored Buoy Data

µM – Micromolar (micromol per liter)

Observed level/depth – The depth or pressure at which an *in-situ* measurement was collected as reported by the originator of the data.

Ocean Archive System – The Ocean Archive System contains metadata of all of the data received and accessed at NCEI. It assigns unique accession numbers, maintains internal data management information and it maintains a control vocabulary (Principal Investigators, Projects, Institutions, Platforms, etc.).

Originator's Cast Number – Numeric cast number assigned by the data submitter or data originator.

Originator's unit(s) – Units which the data were reported to NCEI.

OSD – Ocean Station Data (also known as Bottle Data). The data contain physical-chemical-biological oceanographic data recorded at discrete depth (or pressure) levels.

PFL – Profiling Float Data

Platform Code – *See Ship code*.

Principal Investigator – Lead scientist or engineer for a particular research cruise or project.

Probe type – OSD, MBT, XBT including XCTD, CTD including STD, SUR, UOR, APB, PFL, DRB, MRB GLD. They correspond to the databases within the WOD main database. Some of the probes are named after the instruments that collected the data.

Profile – A set of measurements for a single variable (temperature, salinity, etc.) at discrete depths taken as an instrument drops or rises vertically in the water column. For surface-only data, the profile consists of measurements taken along a horizontal path. For moored buoys and drifting buoys, the instrument does not move vertically in the water column, so a profile is a discrete set of concurrent measurements from the instruments at different depths attached to the buoy.

Primary headers – The primary header contains information about the number of bytes in the cast, a unique WOD number which identifies each cast, the ISO country code, a cruise number, date, time, position, and the number and type of variables in the cast.

Send2NCEI (S2N) – An archiving tool that allows you to submit your data files and related documentation to NCEI. All data shared with World Data Service for Oceanography are archived at NCEI for inclusion into the World Ocean Database.

Quality Control – Data received by NCEI/OCL are put through a set of quality control procedures to ensure that: 1) the data are converted to the WOD format correctly, 2) the data format provided with the data is correct and the data itself have not been corrupted in transmission, 3) only one copy of data at each cast is retained in the WOD format, 4) the data are of known science quality.

Secondary Header – Contains information such as meteorological data, water column characteristics (*i.e.* depth to bottom), information about the instrument used, ship, institute, and project.

Ship Code – A unique code which identifies the ships associated with the data. Also called platform code.

Significant digits – The total number of digits stored in a WOD parameter value.

Standard level/depth – A depth below the sea surface at which water properties should be measured and reported, either directly or by interpolation, according to the proposal by the *International Association of Physical Oceanography* in 1936.

Station – Data from one or more casts at one geographic location.

SUR – Surface data are surface-only variables which are treated differently from profile data in the database. For surface-only data, each cruise is treated as though it were a single cast with depth, latitude, longitude, and Julian year-day associated with each measurement value.

Taxa-specific and biomass data – Contains plankton weights, volume, and/or concentrations, for an entire sample (biomass) or for individual groups of organisms (taxa-specific).

Unique Cast Number – A number assigned by the WOD database to a cast. This number remains unique to that cast.

UOR – Undulating oceanographic recorder is the generic name given to towed vehicles carrying measuring devices (usually CTDs) which ascend and descend through the water column in a more or less regular pattern, giving a two-dimensional view of the water column along the path in which the vehicle is towed.

Variable – Physical-chemical-biological measurements (*e.g.* temperature, salinity, oxygen, phosphate, nitrate, etc.) as well as latitude, longitude, Julian-day, and other parameters. See Table 3a for a list of variables.

Variable specific secondary header – Contains information specific to each individual variable such as original units and methods for a given cast.

WOD – World Ocean Database

WMO – World Meteorological Organization of the United Nations, Geneva, Switzerland. The WMO Code is an international nomenclature adopted by the World Meteorological Organization based on 10-degree squares.

XBT – Expendable Bathythermograph. It is the successor of the MBT instrument. The data contains temperature-depth profiles taken at discrete depths. Standard XBTs normally obtain profiles to depths of 450 and 760 meters. Other expendable bathythermographs reach a depth of 1830 meters.