

A comprehensive global oceanic dataset of helium isotope and tritium measurements

W.J. Jenkins¹, S.C. Doney^{1,2}, M. Fendrock¹, R. Fine³, T. Gamo⁴, P. Jean-Baptiste⁵, R. Key⁶, B. Klein⁷, J.E. Lupton⁸, M. Rhein⁹, W. Roether⁹, Y. Sano¹⁰, R. Schlitzer¹¹, P. Schlosser¹², C.S. Wong¹³

5 Data organization

We have compiled a comprehensive dataset consisting of helium isotope and tritium measurements in oceanic waters made by numerous laboratories over the past 6 decades. The dataset includes ~58,000 tritium and ~60,000 helium isotope measurements of ocean water taken from 1952 to 2015 (for tritium) and from 1967 to 2015 for helium. In addition to “spot sampling”, there are almost 370 cruises, with sampling from >5,200 locations (5,800 stations) for tritium and ~4700 locations (~4800 stations) for helium. The helium data are from 8 different laboratories and the tritium data from 15 laboratories. In addition to including measurement uncertainties, a data quality flag, and data source, each data point is accompanied by location (latitude, longitude, depth) and time (decimal year) of sampling. When available, water temperature, salinity, and dissolved oxygen measurements are included.

A number of the earlier measurements were obtained from publications. In those cases, the publication source is given. If the data were transcribed from tables, the table number and page is given. In the event that the data were only available graphically, a computer program to digitize the data from plots was used, and in the rare cases where graph quality was sufficiently poor to degrade the precision of the data, the uncertainties were commensurately increased to reflect that issue.

The dataset consists of three tables. The REFERENCES table is a list of the data sources keyed by the text variable “Reference_Code” found in the main data table. This should in principle provide attribution and/or more information regarding the data origin. The METHODS table provides a more complete description of the methods fields “Tritium_Method” and

¹ Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

² Now at University of Virginia, Charlottesville, VA 22904, USA

³ RSMAS, University of Miami, Miami, FL 33149, USA

⁴ University of Tokyo, Kahiwa, Chiba 277-8564, Japan

⁵ LSCE, CEA-CNRS-UVSQ, CEA/Saclay, 91191 Gif-sur-Yvette cedex, France

⁶ Princeton University, Princeton, New Jersey, USA

⁷ BSH, 20359 Hamburg, Germany

⁸ NOAA Pacific Marine Environmental Laboratory, Newport, Oregon, USA.

⁹ University of Bremen, D28359 Bremen, Germany

¹⁰ CAMR-ORI, University of Tokyo, Nakano, Tokyo 164-8639, Japan

¹¹ Alfred Wegener Institute, 27568 Bremerhave, Germany

¹² LDEO, Columbia University, Palisades, NY, USA

¹³ IOS, Fisheries and Oceans Canada, Sidney, BC V8L 4B2, Canada

- “Helium_Method” in the main data table. This is intended to provide useful interpretive information regarding how the sampling and/or measurements were accomplished. The main data table fields are described in the Table 1. Most data fields have an associated quality flag field whose meaning is summarized in Table 2. Normal, acceptable data are associated with a quality flag of 2, whereas questionable data have a flag of 3. When fields are missing for a given record, the data is entered as -999 and the corresponding quality flag is 9. The tritium, helium, and neon data also have an associated uncertainty field (e.g., “Tritium_Error”) which is the estimated uncertainty in the data points. This is either provided by the data measurer or an estimate based on described procedures, and can vary greatly between methods and laboratories so the user is advised to be aware of this value.
- 10 In the spirit of the WOCE/CLIVAR/GO-SHIP¹⁴ convention, the combination of ExpoCode, Station, CastNo, and Bottle should uniquely define a sample. That is, no two data records should have the same combination of these values. This has been followed with most of the information here: when a sample’s station, cast, or bottle number were not provided (in the case of literature data), arbitrary but unique numbers were assigned. In order to supplement this identification we added a unique integer record ID number.
- 15 **Data formats and availability**
- The data is available for download at the web site <http://www.whoi.edu/IGF> (select the **Data** button on the lower left side of the web page) in a number of formats for maximum flexibility. For maximum flexibility, we suggest one of the following three database formats: Microsoft Access®, PostgreSQL, or ODV (Ocean Data View). The three tables are available as 4 files (the main data table is split in two to avoid spreadsheet limitations) in Microsoft Excel® or as a comma separated plain text files.
- 20 Finally, the data table is available for download as a MATLAB® binary data file. The dataset will also be submitted to an international data repository (most like BODC) in the final stages of manuscript preparation.

Tables

Table 1: Fields (columns) in the main data table

Field Name	Field Type	Field Description
ExpoCode	Short Text	Unique string identifying cruise/expedition
Sect_ID	Short Text	String identifying Ocean Section (WOCE/CLIVAR/GEOTRACES)
Station	Short Text	Station name or number
CastNo	Short Text	Cast name or number at that Station

¹⁴ WOCE is the World Ocean Circulation Experiment (e.g., see <https://www.nodc.noaa.gov/woce/>), CLIVAR is the Climate and Ocean – Variability, Predictability, and Change (e.g., see <http://www.clivar.org/about>), and GO-SHIP is the Global Ocean Ship-Based Hydrographic Investigations Program (see <http://www.go-ship.org/>)

Bottle	Short Text	Bottle name or number on that cast
StaDate	Number	Decimal year of sampling
Latitude	Number	North latitude in decimal degrees (from -90 to +90)
Longitude	Number	East longitude in decimal degrees (from -180 to +180)
StaDepth	Number	Bottom depth at station location in meters
Pressure	Number	Bottle depth (actually pressure) measured in dbar
Temperature	Number	In Situ temperature in degrees centigrade
Temperature_Flag	Integer	Temperature quality flag (see QF table)
Salinity	Number	Sample salinity in PSU
Salinity_Flag	Integer	Salinity quality flag (see QF table)
Oxygen	Number	Dissolved oxygen in umol/kg
Oxygen_Flag	Integer	Dissolved oxygen flag (see QF table)
Silicate	Number	Dissolved silicate in umol/kg
Silicate_Flag	Integer	Dissolved silicate flag (see QF table)
Phosphate	Number	Dissolved phosphate in umol/kg
Phosphate_Flag	Integer	Dissolved phosphate flag (see QF table)
Nitrate	Number	Dissolved nitrate in umol/kg
Nitrate_Flag	Integer	Dissolved nitrate flag (see QF table)
Nitrite	Number	Dissolved nitrite in umol/kg
Nitrite_Flag	Integer	Dissolved nitrite flag (see QF table)
Tritium	Number	Tritium in TU at time of sampling
Tritium_Error	Number	Uncertainty in TU at time of sampling
Tritium_Flag	Integer	Tritium quality flag (see QF table)
Tritium_PI	Short Text	Principle investigator or measurer of tritium
Tritium_PI_Inst	Short Text	Institution or laboratory where tritium was measured
Tritium_Method	Short Text	Short descriptor of tritium sampling/analysis method
DelHe3	Number	Helium isotope ratio anomaly relative to atmosphere in percent
DelHe3_Error	Number	Uncertainty in helium isotope ratio anomaly
DelHe3_Flag	Integer	Helium isotope ratio anomaly quality flag (see QF table)
Helium	Number	Dissolved helium concentration in nmol/kg
Helium_Error	Number	Uncertainty in dissolved helium concentration in nmol/kg
Helium_Flag	Integer	Dissolved Helium quality flag (see QF table)

Neon	Number	Dissolved neon concentration in nmol/kg
Neon_Error	Number	Uncertainty in dissolved neon concentration in nmol/kg
Neon_Flag	Integer	Dissolved neon quality flag (see QF table)
Helium_PI	Short Text	Principle investigator or measurer of helium (and neon)
Helium_PI_Ins	Short Text	Institution or laboratory where tritium was measured
Helium_Method	Short Text	Short descriptor of helium sampling/analysis method
Reference_Code	Short Text	Data origin or link to paper discussing data
Reference_Source	Short Text	Data Source within reference (e.g., table, figure) if relevant
DOI	Short Text	Digital Object Identifier of original data set (if existing)
Comment	Short text	Additional information or comments
Record_ID	Long Integer	Unique record identifier number

Table 2: Quality flag meaning

Quality Flag Number	Meaning
2	Normal data, no problems reported
3	Questionable data: may not fit profile or some other doubt
6	Average of 2 or more measurements
9	Missing (null) data