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**Ocean monitoring indicator (OMI) of the copernicus
marine environment monitoring service global yearly pH
time series**

GLOBAL_OMI_HEALTH_carbon_ph_area_averaged

Thi Tuyet Trang Chau, Marion Gehlen, Frederic Chevallier

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Quality Information Document

Ocean Monitoring Indicator (OMI) of the
Copernicus Marine Environment Monitoring Service

Global yearly pH time series

Issue: 5.0

Contributors : Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier

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MERCATOR OCEAN
INTERNATIONAL

2 avenue de l'Aérodrome de Montaudran, 31400 Toulouse, FRANCE

Tél : +33 5 61 39 38 02 - Fax : +33 5 61 39 38 99

Société civile de droit français au capital de 2 000 000 € - 522 911 577 RCS Toulouse - SIRET 522 911 577 00016

marine.copernicus.eu

mercator-ocean.eu

CHANGE RECORD

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1.0	2019/10	all	Creation of the document	Marion Gehlen, Thi Tuyet Trang Chau	
1.1	2019/10	/	Update of Figure 1	Thi Tuyet Trang Chau	
2.0	2019/12	/	Update of Figure 1 (temporal extension)	Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier	
3.0	2020/09	/	Update of Figure 1 (temporal extension and uncertainty quantification)	Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier	
4.0	2021/09	/	Update of Figure 1 (temporal extension)	Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier	Stéphanie Guinehut
4.1	2021/11		Correction following MOi review	Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier	Sandrine Mulet
5.0	2022/09	/	Update of Figure 1 (temporal extension)	Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier	M. Drevillon

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I INTRODUCTION

I.1 Product name

GLOBAL_OMI_HEALTH_carbon_ph_area_averaged

I.2 Indicator evaluation method

The OMI yearly mean surface sea water pH reported on total hydrogen ion scale is computed from monthly pH values which are distributed as part of the CMEMS product MULTIOBS_GLO_BIO_CARBON_SURFACE_REP_015_008.

At each grid cell and monthly resolution, monthly uncertainty (σ_m) is evaluated from the contributions of (1) model randomness, (2) systematic errors. The uncertainty of (1) is derived from the standard deviation of 100 ensemble members of the reconstructed spco2 (Chau et al. 2022a). Systematic uncertainty (2) is evaluated through uncertainty propagation following Orr et al. (2018) within the speciation software CO2sys (Lewis and Wallace, 1998; Van Heuven et al., 2011). Inputs to the CO2sys uncertainty propagation routine are default values for dissociation constants, systematic errors, ensemble-based uncertainty estimates of spco2, and analysis errors from temperature, salinity, and nutrients (see Chau et al, 2022b for further details). Taking these propagated uncertainties results in standard uncertainties (σ_m) of monthly pH fields.

The OMI corresponds to the global average of yearly mean pH values. The associated total uncertainty is first computed by

$$\hat{\sigma} = \sqrt{\frac{\sum \sigma_m^2}{N^2}}$$

where N is total number of grid cells (N_{cell}) multiplied by 12. This biased uncertainty estimate of the global average of the yearly mean pH values is then corrected by a number of effective degrees of freedom N_{eff} involved in space and time:

$$N_{\text{eff}} = \frac{dx dy}{(c^{dr})^2} N_{\text{cell}} \times \frac{12}{c^{\Delta t}}$$

where dx , dy are the mean zonal and meridional grid size in km, c^{dr} and c^{dt} are respectively the spatial and temporal decorrelation length scales. The spatial decorrelation length scale of pH is assessed based on the 12-month pH fields for each year. A semivariogram is used to estimate this quantity. For a temporal decorrelation length scale, the effect of seasonal cycles is considered, and that yields data dependency within 3-month window. The method provides yearly N_{eff} values varying in [99, 133]. The correction with N_{eff} results in a final estimate of yearly uncertainty as,

$$\sigma = \hat{\sigma} \sqrt{\frac{N}{N_{eff}}}$$

I.3 CMEMS products used as input for the computations

Product name (and Type)	Documentation
MULTIOBS_GLO_BIO_CARBON_SURFACE_REP_015_008	QUID: https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-MOB-QUID-015-008.pdf PUM: https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-MOB-PUM-015-008.pdf

II SCIENTIFIC EVALUATION

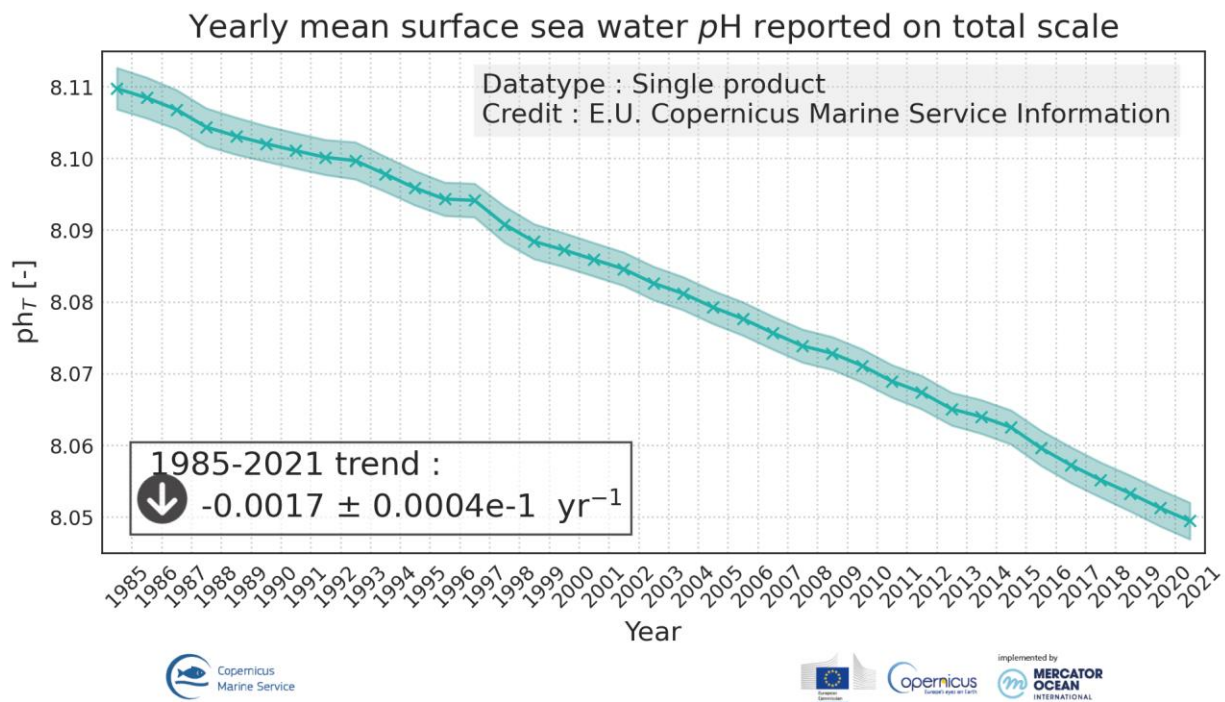


Figure 1. Time series of annual global mean surface sea water pH over the period 1985-2021 using a reconstruction methodology (see indicator evaluation method). Trend and uncertainty are defined as the slope and its residual standard deviation estimated with a linear least-squares regression.

The OMI yearly mean surface sea water pH reported on total hydrogen ion scale is computed from monthly pH values which are distributed as part of the CMEMS product MULTIOBS_GLO_BIO_CARBOON_SURFACE_REP_015_008. The associated quality information document provides details on the evaluation of pH fields.

In Figure 1, the amplitude of the uncertainty envelop ($\pm 1\sigma$) of yearly mean surface sea water pH varies within the range of [0.0023, 0.0029] pH unit. In comparison with the first release of the OMI pH (Gehlen et al., 2020), this number reflects the total uncertainties derived from the ensemble-based approach and model errors.

The average surface water pH decreased by 0.0016 pH units between 1985 and 2021 (Figure 1). Although the time interval covered by the OMI differs from that of published trend estimates from Eulerian time series data, it falls within the full range ($\pm 3\sigma$) of these data-based estimates: (1) station ALOHA (1988-2009, 22.75°N, 158°W) = 0.0019 ± 0.0002 pH units/yr (Dore et al., 2009); (2) station BATS (1983-2005, 31.72°, 64°17'W) = 0.0017 ± 0.0003 pH units/yr (Bates, 2007); (3) station ESTOC (1995-2004, 24.04°N, 15.50°W) = 0.0018 ± 0.0003 pH units/yr (Santana-Casiano et al., 2007; González-Dávila et al., 2010).

A full discussion regarding this OMI can be found in section 2.10 of the Ocean State Report 4 (Gehlen et al., 2020).

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