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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**

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**COPERNICUS**  
MARINE ENVIRONMENT MONITORING SERVICE

# QUALITY INFORMATION DOCUMENT

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

### **Global yearly pH time series**

### **GLOBAL\_OMI\_HEALTH\_carbon\_ph\_area\_averaged**

**Issue: 4.0**

**Contributors: Trang Chau, Marion Gehlen, Frederic Chevallier**

**Approval date by the CMEMS product quality coordination team:**

|                                                                  |        |                                                   |
|------------------------------------------------------------------|--------|---------------------------------------------------|
| QUID for CMEMS OMI:<br>GLOBAL_OMI_HEALTH_carbon_ph_area_averaged | Ref:   | CMEMS-OMI-QUID-GLO-HEALTH-carbon-ph-area-averaged |
|                                                                  | Date:  | September 2021                                    |
|                                                                  | Issue: | 4.0                                               |

## CHANGE RECORD

| Issue | Date           | §   | Description of Change                                                  | Author                                                   | Validated By |
|-------|----------------|-----|------------------------------------------------------------------------|----------------------------------------------------------|--------------|
| 1.0   | January 2019   | all | Creation of document                                                   | Marion Gehlen, Thi Tuyet Trang Chau                      |              |
| 1.1   | October 2019   | /   | Update of Figure 1                                                     | Thi Tuyet Trang Chau                                     |              |
| 2.0   | December 2019  | /   | Update of Figure 1 (temporal extension)                                | Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier |              |
| 3.0   | September 2020 | /   | Update of Figure 1 (temporal extension and uncertainty quantification) | Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier |              |
| 4.0   | September 2021 | /   | Update of Figure 1 (temporal extension)                                | Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier |              |

**Product name:** GLOBAL\_OMI\_HEALTH\_CARBON\_PH\_AREA\_AVERAGED

**Dataset name:** GLOBAL\_OMI\_HEALTH\_carbon\_ph\_area\_averaged

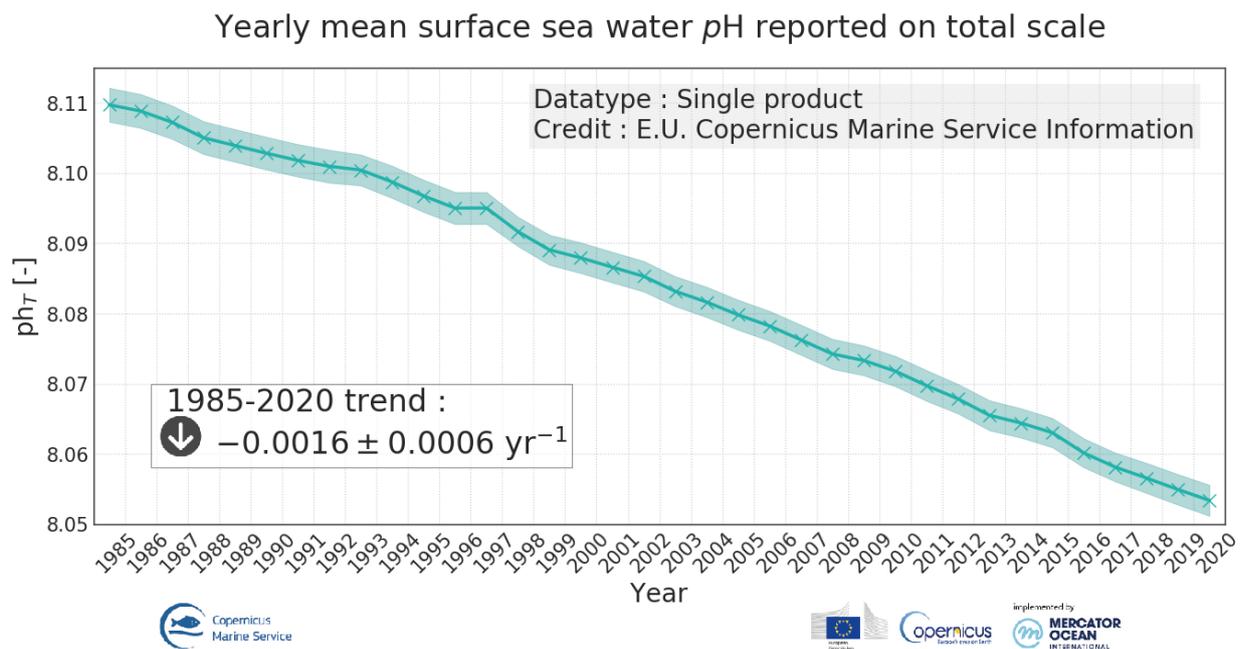
### **Indicator evaluation method:**

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. The associated quality information document provides details on the evaluation of pH fields.

|                                                                  |                         |                                                                            |
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### Scientific evaluation:

The average surface water pH decreased by 0.0016 pH units between 1985 and 2020 (Figure 1 Time series of annual global mean surface sea water pH over the period 1985-2020 using a reconstruction methodology (see method). The trend and its variation are computed as the mean and standard deviation of the differences between consecutive estimates.). 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) =  $0.0019 \pm 0.0002$  pH units/yr (Dore et al., 2009); (2) station BATS (1983-2005, 31.72°, 64°17'W) =  $0.0017 \pm 0.0003$  pH units/yr (Bates, 2007); (3) station ESTOC (1995-2004, 24.04°N, 15.50°W) =  $0.0018 \pm 0.0003$  pH units/yr (Santana-Casiano et al., 2007; González-Dávila et al., 2010).



**Figure 1** Time series of annual global mean surface sea water pH over the period 1985-2020 using a reconstruction methodology (see method). The trend and its variation are computed as the mean and standard deviation of the differences between consecutive estimates.

### Product used for indicator evaluation:

|                                                                  |                                 |                                                                                    |
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The OMI yearly mean surface sea water pH reported on total hydrogen ion scale and its yearly uncertainty ( $\sigma$ ) are computed from monthly pH values and uncertainties which are distributed as part of the CMEMS product MULTIOBS\_GLO\_BIO\_CARBON\_SURFACE\_REP\_015\_008.

In Figure 1, the amplitude of the uncertainty envelop ( $\pm 1\sigma$ ) of yearly mean surface sea water pH varies within the range of [0.0021, 0.0024] pH unit. In comparison with the previous release of the OMI pH, this number reflects the total uncertainties derived from the ensemble-based approach and model errors.

At each grid cell and monthly resolution, monthly uncertainty ( $\sigma_m$ ) is evaluated from the contributions of (1) model randomness, (2) systematic errors. The uncertainty of (1) is defined as the standard deviation of the pH ensemble computed by feeding 100 ensemble members of the reconstructed spco2 (Chau et al. 2021) in the speciation software CO2sys (Lewis and Wallace, 1998; Van Heuven et al., 2011). Systematic uncertainty (2) is evaluated through uncertainty propagation following Orr et al. (2018) within the speciation software CO2sys. Inputs to the uncertainty propagation routine are default values for dissociation constants, measurement uncertainty, uncertainty estimates for monthly alkalinity fields from LIAR (Carter et al., 2016; 2018), respectively estimates for mapping errors between spco2 monthly mean fields derived from an ensemble of 100 neural networks and the observations. Taking the squared root of the sum of (1) and (2) squared results in standard uncertainties ( $\sigma_m$ ) 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:

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

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,

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

pH used to compute the OMI global yearly pH time series is derived from CMEMS MULTIOBS\_GLO\_BIO\_CARBON\_SURFACE\_REP\_015\_008 product (<http://marine.copernicus.eu/documents/PUM/CMEMS-MOB-PUM-015-008.pdf>, <http://marine.copernicus.eu/documents/QUID/CMEMS-MOB-QUID-015-008.pdf>).

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[https://doi.org/10.3334/CDIAC/otg.CO2SYS\\_MATLAB\\_v1.1](https://doi.org/10.3334/CDIAC/otg.CO2SYS_MATLAB_v1.1)