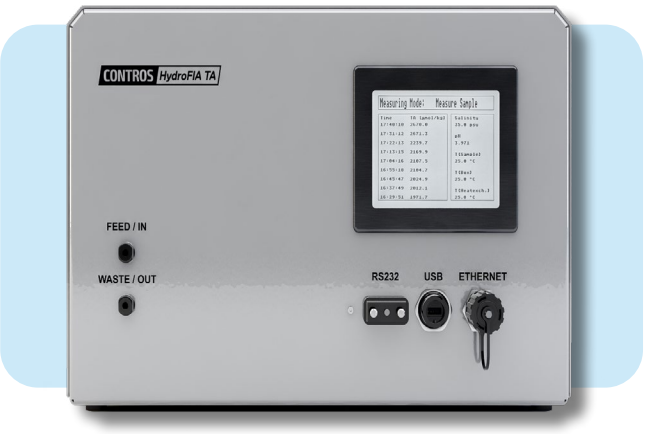
APPLICATION NOTE

Detecting and quantifying the impact of ocean CO_2 levels

-4H-JENA engineering sensors contribute to ocean inorganic carbon system determination, an essential aspect of contemporary climate science.

Full understanding of the carbon cycle can only be achieved by detecting and quantifying the impact of changing CO_2 levels in the atmosphere, in the oceans and on land, all three of which absorb about 1/3 each of the anthropogenically produced CO_2 in the world.

This understanding is a result of decades-long collaborative and international scientific research and today, globally coordinated efforts continue to develop sustainable ocean observation networks – with marine carbon chemistry an essential data set in the fight against the effects of climate change.



At least two of the following four parameters must be known to fully characterize the marine carbonate system, however...

pCO_2 — **Partial pressure of CO_2**
(strictly speaking to account for non-ideal behavior: It is fCO_2 – fugacity of CO_2)

DIC — **Dissolved Inorganic Carbon**
the sum of all dissolved chemical species CO_2, HCO_3^- and CO_3^{2-}

TA — **Total Alkalinity**
the buffer capacity

pH — **A chemical parameter**
indicating how acidic or alkaline a liquid (here: water) is

For many years DIC, TA and pH could only be measured from discrete samples in laboratories, but innovative new sensors and technologies have simplified and reduced the time and financial impact of this process. -4H-JENA engineering has been integral to these developments with the CONTROS HydroC™ CO_2 sensor for the measurement of pCO_2, which is complemented by HydoFIA (Flow Injection Analyzer) systems for measuring TA and pH.

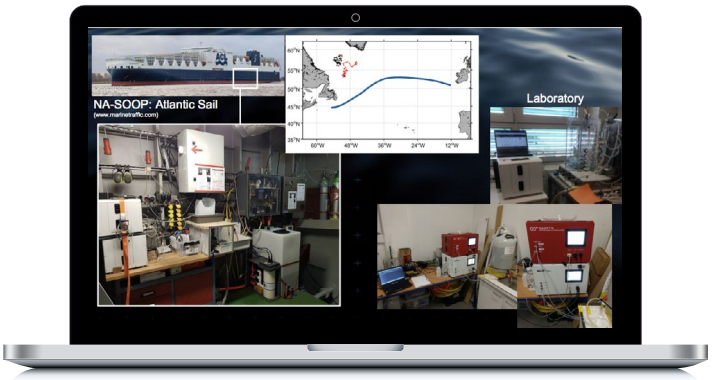
The determination of these three parameters with the specifications reached by HydroC™ sensors and HydroFIAs™ allows characterization of the marine carbonate system to the level of accuracy required by marine scientists.

4H JENA ENGINEERING

DEPLOYMENT

With HydroFIA™ systems, continuous in-situ field monitoring of TA and pH in seawater and brackish water, as well as the measurement of discrete samples in the laboratory are both possible. TA and pH are already common parameters to complement marine carbonate system observations by established and emerging observing networks, such as:

- Biogeochemical-Argo (BGC-Argo) features floats as robotic platforms fitted with diverse submersible sensors, including pH, and is aiming to be a global observation network. The floats are based on a multi-sensor approach with the measurement of other variables including oxygen and nitrates a key aspect of the program.
- The Global 'Ship-Of-Opportunity' (SOOP) network is partly operated in ICOS and is the backbone of the surface ocean CO_2 network. It features autonomous measuring systems on commercial ships like the 4H Jena 'FerryBox', that can be operated easily by non-scientists (seafarers).



A German led extension of the BGC-Argo program, DArgo2025, aims to integrate the work of the project partners. The aim is to unlock quality control, operational approach and interoperability gains in relation to the floats and the data produced. Project partner GEOMAR is comparing and referencing float pH measurements with the HydroFIA™ pH as part of this workflow.

Partnerships with commercial shipping companies are also contributing to improving the amount and quality of ocean CO_2 data. The SOOP network provides continuous measurements, as well as calibration of the BGC-Argo floats, using equipment installed on ships sailing established commercial routes.

A SOOP line across the subpolar North Atlantic (DE-SOOP-Atlantic Sail) is operated by GEOMAR and currently augmented with unattended measurements of TA, pH (both HydroFIA™), pCO_2 and O_2.

These are just a few examples of -4H-JENA engineering's sensors providing datasets for the determination of the marine carbon chemistry and contributing to the complete understanding of the global carbon cycle. The result is actionable climate science that is vital in the fight for sustainability as the effects of man-made warming start to become more visible every year.

Ocean observations using -4H Jena sensors is crucial for reaching the United Nations Sustainable Development Goals (SDGs), especially SDG 13 – Climate Action and 14 – Life Below Water.