

JERICO-NEXT TNA: Intercomparison of instruments for carbonate system measurements (INTERCARBO)

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Continental margins are among the most biologically active areas on Earth. Although they cover only a small portion of the oceans, they contribute up to 15% of ocean primary production, are responsible for over 40% of the total oceanic carbon sequestration and for the vast majority of commercial fisheries.

Carbon fluxes in coastal seas are more complex than those in the open ocean, in part due to high spatiotemporal variability in biological activity and physical processes. In the European coastal areas, complications also rise from the highly variable hydrography: sea surface temperature may vary from below zero degrees on the coast of Spitsbergen up to 30°C in the Mediterranean Sea, while salinity varies from 0 ‰ at the Bothnian Bay, the Baltic Sea, up to more than 38 ‰ in the Mediterranean Sea.

This large variability creates challenges related to instrument accuracy, reliability and maintenance. As there are only a limited number of instruments available for such a highly variable range of environmental conditions, different research groups have often built their own instruments or modified the commercial instruments suitable for their own needs. This has led to a situation which sometimes makes assimilation of the data observed in different areas challenging.

The aim of the INTERCARBO experiment, partly funded by TransNational Access (TNA) of H2020 infrastructure project Joint European Research Infrastructure network for Coastal Observatory – Novel European eXpertise for coastal observaTories (JERICO-NEXT) was to bring together a large number of carbon dioxide partial pressure (pCO₂), pH and total alkalinity sensors used on European coastal seas and to compare measurements using different sensors on the same seawater samples.

During the activity, 17 experiments were carried out in three 1 m³ tanks that were filled with seawater that was obtained from Oslofjord. The seawater was manipulated in order to meet predetermined physical and chemical properties. Three salinity conditions (5, 20, and 35 PSU) were generated by introducing fresh water from a local well. Three carbon dioxide target values of approximately 200, 400, and 800 parts per million (ppm) were targeted by equilibrating the water with the corresponding CO₂ gases (due to high alkalinity and limited duration of the experiment, these target values were not always reached). The measurements were made on seawater at 10 °C and 20 °C.

This data set presented here contains currently available pCO₂ data from the experiment, together with readme file describing the instruments.



1 Three 1 m³ water tanks coated with plastic foil in order to minimize the effect of atmosphere-water exchange

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Readme for different instruments

AA: Ferrybox pCO₂

Abbreviation in data	AA
Instrument producer	Franatech GmbH
Instrument name	FerryBox pCO ₂
Instrument serial number	1311
Instrument measurement method	membrane equilibration/IR absorption spectrometry
Last date instrument calibrated	28-Nov-18
Instrument water flow	1.5-1.8 LPM
Measurement frequency (minutes) during the experiment	0.033 min (2 s)
Other details	
Corrections applied to data	<ol style="list-style-type: none">1. Linear calibration applied based on NOAA/ESRL/GMD calibration gases x3 and UHP N₂.2. Conversion from xCO₂ to fCO₂ using Dickson et al. (2007) SOP5.3. Remove data during equilibration period between treatments.

BB: Contros pCO2

Abbreviation in data	BB
Instrument producer	Kongsberg Maritime Contros GmbH
Instrument name	HydroC CO2 FT
Instrument serial number	CO2FT-0618-001
Instrument measurement method	Gas concentration measured by NDIR
Last date instrument calibrated	8/2018 - received from the manufacturer
Instrument water flow	5.0 LPM (23.-26.11.) 4.75 LPM (26.-27.11.)
Measurement frequency (minutes) during the experiment	5 s
Other details	
Corrections applied to data	Zero calibration

CC: Contros pCO2

Abbreviation in data	CC
Instrument producer	Contros
Instrument name	HydroC / CO2 II
Instrument serial number	CO2-0212-001
Instrument measurement method	equilibration through membrane + FTIR
Last date instrument calibrated	6/14/2018
Instrument water flow	
Measurement frequency (minutes) during the experiment	1 min
Other details	
Corrections applied to data	1 - Correction for the drift of the baseline according to Fietzek et al (2014, https://doi.org/10.1175/JTECH-D-13-00083.1 .) 2 - Removal of data acquired when the the instrument has not reached the equilibrium.

DD: chemini-PH

Abbreviation in data	DD
Instrument producer	IFREMER RDT
Instrument name	Chemini pHt
Instrument serial number	prototype
Instrument measurement method	Spectrophotometric with mcp
Last date instrument calibrated	November 2018 (Checked by TRIS in our lab)
Instrument water flow	10 mL /measurement
Measurement frequency (minutes) during the experiment	3m30s
Other details	
Corrections applied to data	<p>3 intensities are measured at 3 different wavelengths (430 nm: acid form, 576 nm: basic form and 730 nm: reference). the absorbances are calculated for those three wavelengths then the ratio between the basic form and the acid form. This ratio allows to calculate pH. On our system, a temperature sensor (PT100) measures the temperature of the sample during measurement directly into the cell. This temperature as well as salinity (got with Martina Gerhung) are used for calculation of total pH with the seacarb package (pHspec() upgrade by Mueller 2018). To compare with the other systems, we have recalculated pH at 25°C with the 'seacarb' package on R software (pHinsi()). For that we use the total alkalinity measured by Caroline Mengeot. These are the values you will find in the global file.</p>

EE: Contros HydroFIA pH

Abbreviation in data	EE
Instrument producer	Contros Maritime Kongsberg GmbH
Instrument name	HydroFIA pH
Instrument serial number	PH-0218-001 and PH-0515-001
Instrument measurement method	FIA Spectrophotometric pH
Last date instrument calibrated	
Instrument water flow	-
Measurement frequency (minutes) during the experiment	~2min
Other details	pH is unitless given on total scale
Corrections applied to data	extrapolated to zero dye (internally) and corrected for small (<2°C) deviations from intended measurement temperature of 25°C

GG: Contros pCO2

Abbreviation in data	GG
Instrument producer	Kongsberg Maritime Contros GmbH
Instrument name	HydroC CO2 FT
Instrument serial number	CO2FT-0618-002
Instrument measurement method	Gas concentration measured by NDIR
Last date instrument calibrated	7/18/2018 (by Contros)
Instrument water flow	ca. 5 l/min
Measurement frequency (minutes) during the experiment	1min averaged of 1Hz
Other details	Range: 200 μ atm to 1000 μ atm
Corrections applied to data	

HH: Super-CO2

Abbreviation in data	HH
Instrument producer	Sunburst Sensors, LLC
Instrument name	SuperCO2
Instrument serial number	IR009
Instrument measurement method	NDIR absorption spectrometry (LI-840A, LI-COR) + 2 showerhead equilibrator chambers
Last date instrument calibrated	7/2016 - date of manufacture; uses continuously 4 reference gases
Instrument water flow	Max. flow was limited by AFT-pH; 6.0 LPM (22.-23.11.) 5.0 LPM (23.-26.11.) 4.75 LPM (26.-27.11.)
Measurement frequency (minutes) during the experiment	0.25 min (15 s)
Other details	
Corrections applied to data	<ol style="list-style-type: none">1. Calculate dry molar fraction of CO₂ (xCO₂d)2. Linear correction for xCO₂d based on the calibration measurements3. Calculate pCO₂ using total pressure and water vapor pressure4. Remove data if water or gas flows are out of ranges or LI-COR has not reached the steady temperature