

S/Y EUGEN SEIBOLD

MAX PLANCK INSTITUTE
FOR CHEMISTRY



PHOTOPHYSIOLOGY IN THE NORTH ATLANTIC SURFACE OCEAN

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Also on behalf of:

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Maria Ll. Calleja, David Walter, Lena Heins,
Antonis Dragoneas, Ralf Schiebel,
Gerald Haug



THE S/Y EUGEN SEIBOLD



Purpose-built for scientific sampling

- 72ft (~22m)
- 8 berths
- Pivoting A-frame and winch for deployments
- Inlets air and water for continuous underway sampling
- Contamination free sampling

Goals

- Better understanding of modern and past ocean and climate
- Calibrations of planktic paleo-archives
- Detailed characterization surface ocean and atmosphere
- Ocean-atmosphere interactions

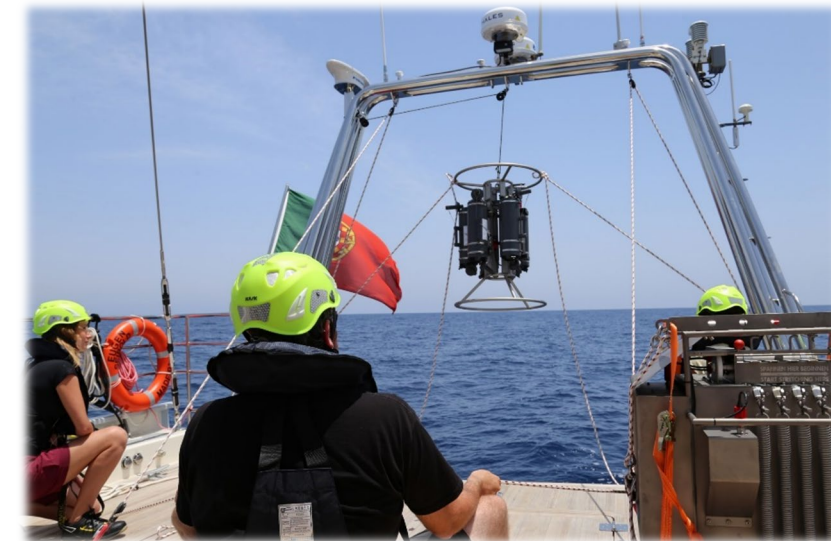


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SAMPLING ON S/Y EUGEN SEIBOLD

Four types of sampling

1. Continuous underway sampling of surface ocean
Ferrybox (Oceanpack, SubCtech) with PTFE lined inlet in keel at ~3 m depth
2. Continuous atmosphere sampling
Marine Boundary layer sampled at ~ 10 m height
3. Discrete sampling from underway lines
Filtering/fixation/freezing until analyses at MPIC or collaborating lab
4. Deployments of the upper 700 m of the water column
CTD sensors, multi net, bongo net, in situ pump, rosette sampler, surface microlayer skimmer, go-flo bottles for TM clean sampling



CONTINUOUS UNDERWAY MEASUREMENTS



Ocean

Physicochemical properties

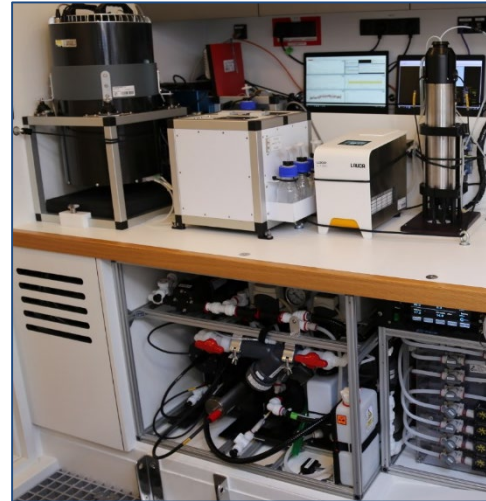
- SBE45 (Temperature, Salinity)
- UV spectrometry (DOC_{eq} , NO_3)
- Particle size distribution (LISST; 1-500 μm)
- pH (Meinsberg)
- FDOM (ECOTriplet)

Dissolved gases

- GE-MI CO_2 infrared LI-840 analyzer
- O_2 optode
- GE-MI mass spectrometry (O_2 , Ar, N_2)

Biological properties

- Chlorophyll *a*/phycocyanin (ECOTriplet)
- Photophysiology (FRRf/LabSTAF)
- Flow cytometry (Cytosense)



Atmosphere

Meteorology

- EUCAWS (Temperature, pressure, humidity)
- Irradiance (PAR; 400-700nm)

Total particle concentration and size distribution

- SMPS (10 – 430 nm)
- APS (0.5 – 20 μm)
- CPC (~5 nm – 2.5 μm)

Gases

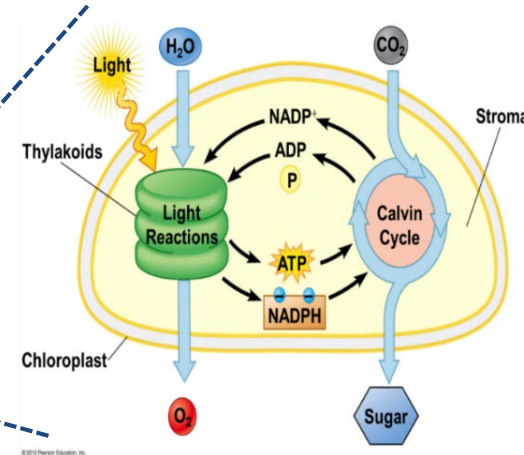
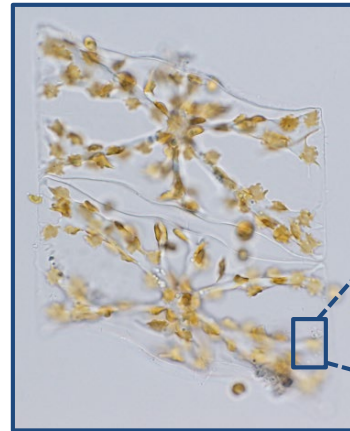
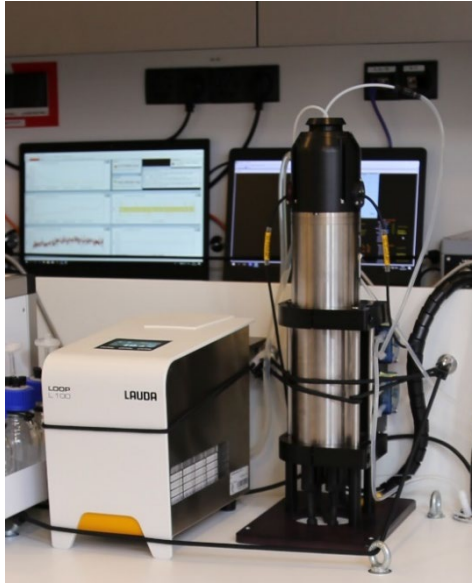
- Picarro Gas Concentration Analyzer (N_2O , CH_4 , CO_2 , NH_3 , H_2O)
- CO_2 infrared LI-840 analyzer

Black Carbon

- SP2 – Single Particle Soot Photometer
- AE33 – Aethalometer (BC monitor)

Bioaerosols

- SIBS (0.3 - 30 μm)



Fast Repetition Rate fluorometry

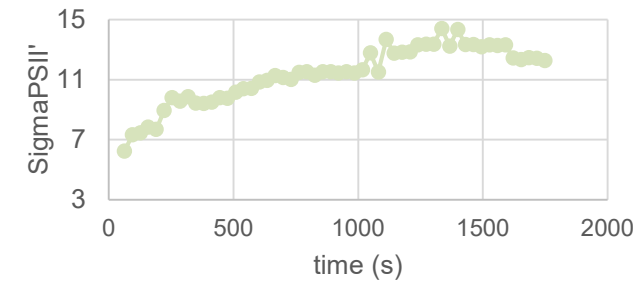
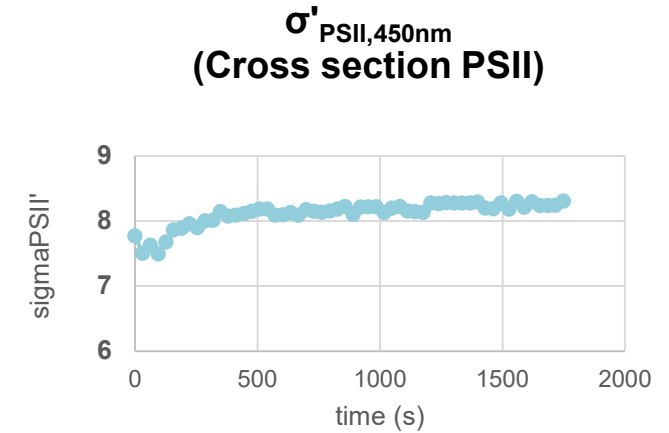
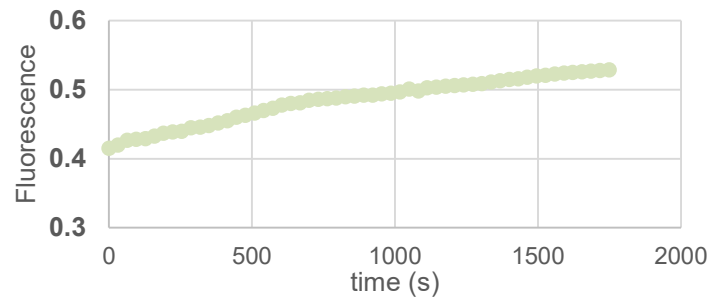
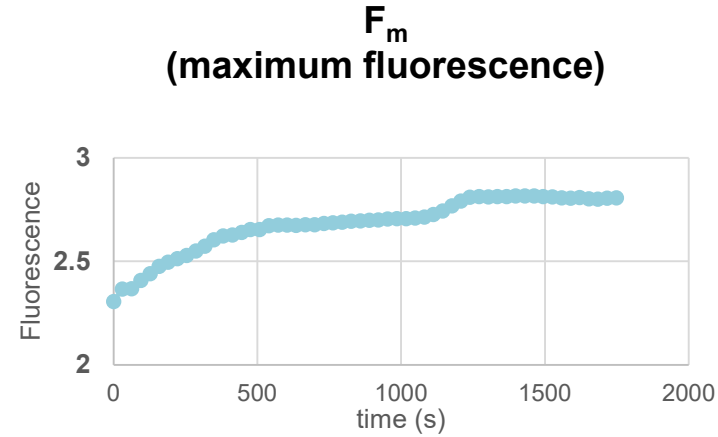
- Chelsea FastOcean FRRf
- Active fluorescence
 - Kinetics of photosystem II
- Fluorescent light curves (increasing background light)
 - Maximum electron transport rate

Flow cytometry

- Cytosense flow cytometer
- Cluster analysis by Slagter et al., (*in prep*)
- Bulk parameters, as proxies for:
 - FLR:FSC -> Chl:Carbon ratio (or Chl:Volume)
 - FLO:FLR -> Pigment composition

FRRf protocol

- Blank manually 2x per day
- Dark regulation time
 - 12 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$
 - 30 minutes
- 12 FLC steps (3-9min per step)

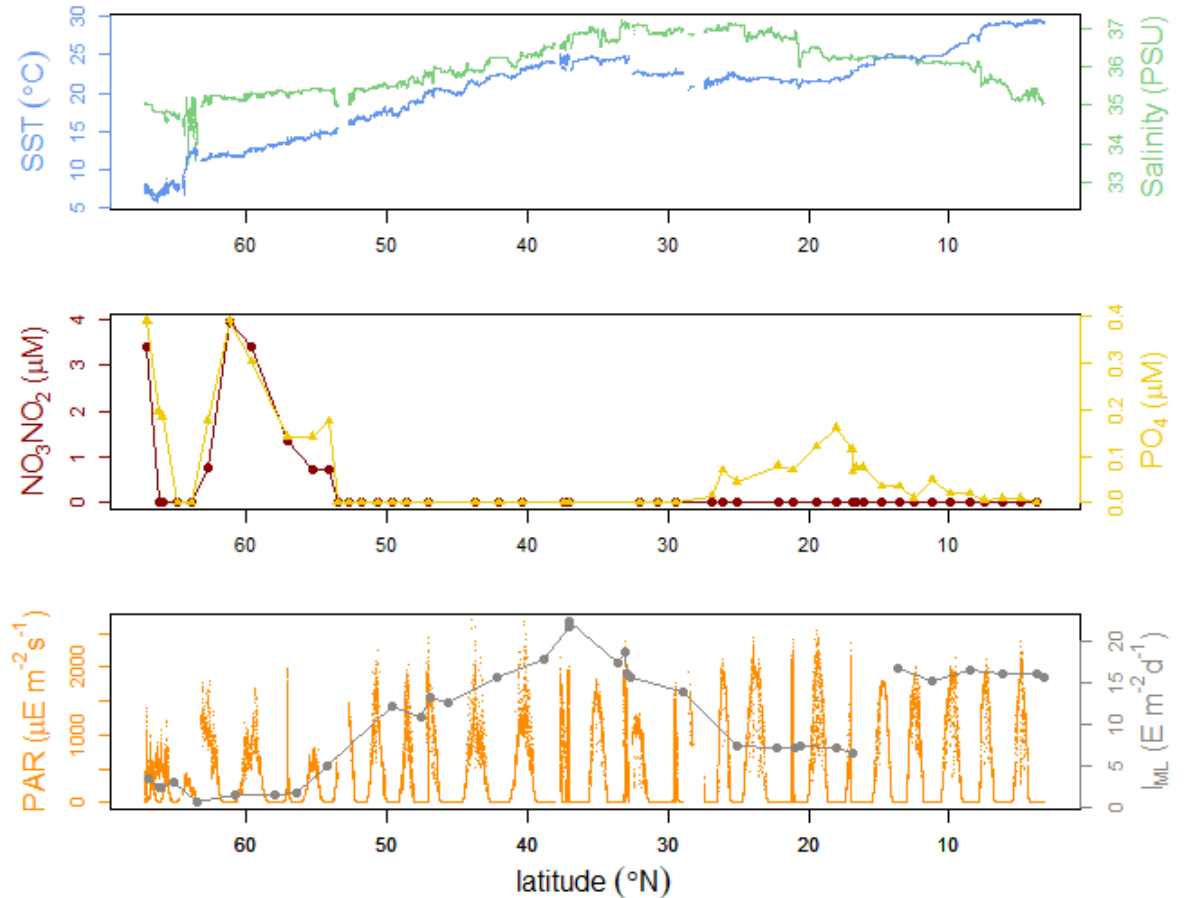
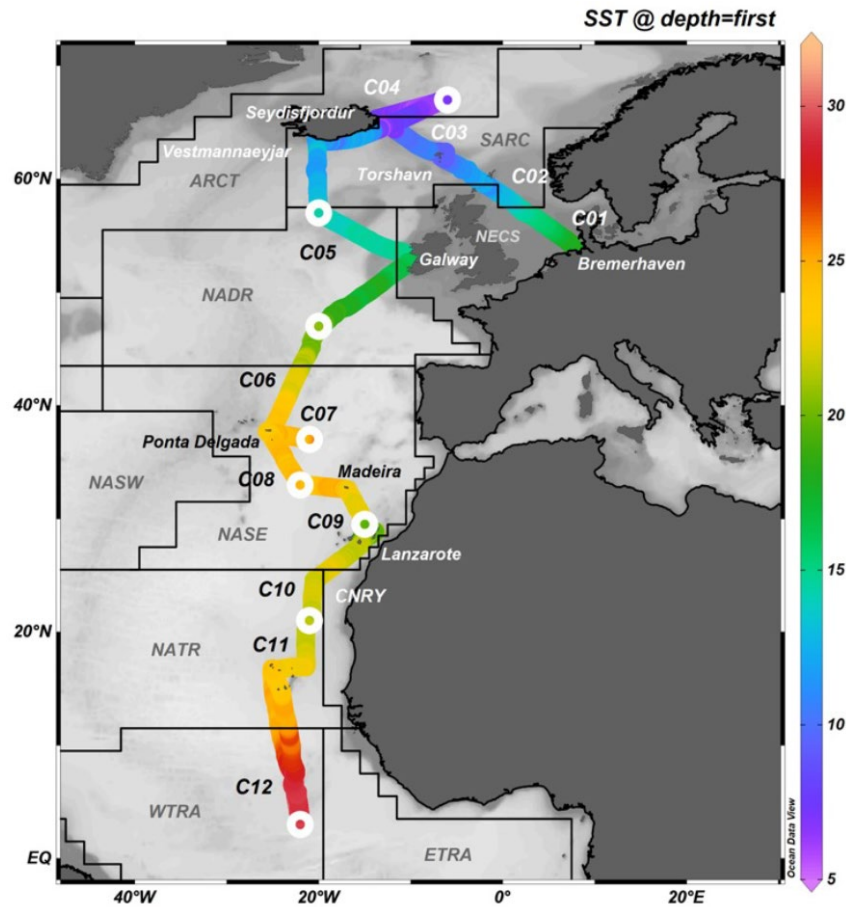


PRELIMINARY RESULTS



Environment

- Transect crosses wide range of environmental conditions

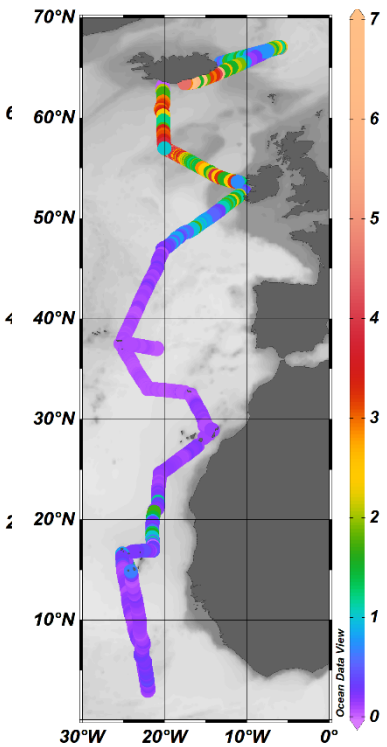


PRELIMINARY RESULTS

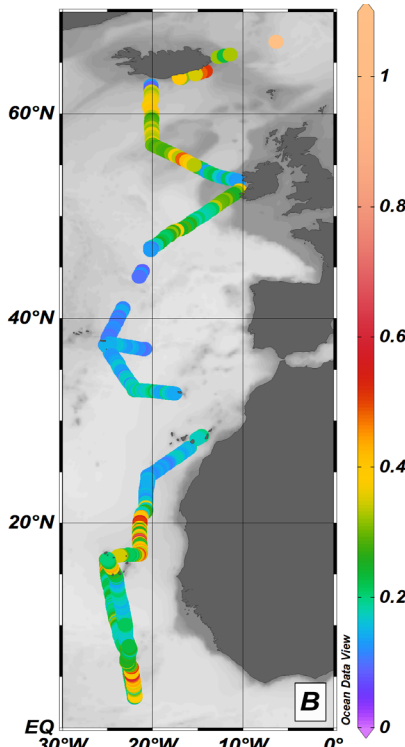
Photophysiology

- Sensitivity not high enough for FLC in oligotrophic gyre
- High spatial variability

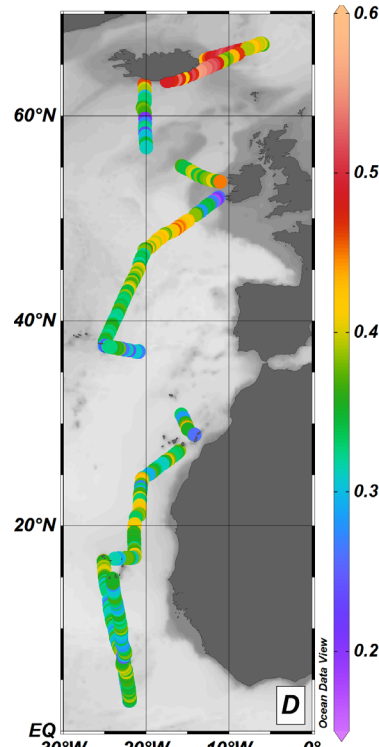
ECOTriplet
Chlorophyll *a*
fluorescence



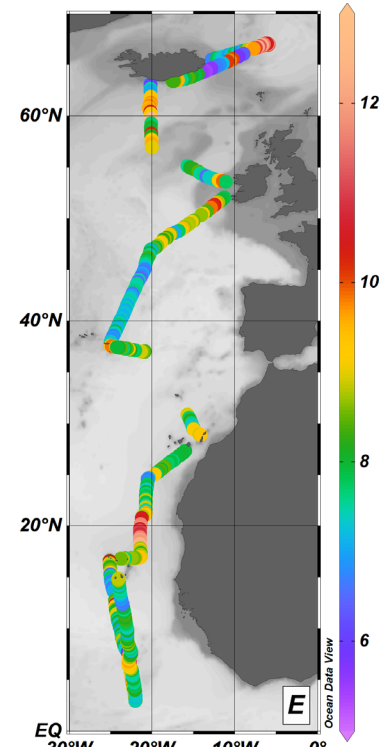
Flow cytometer
FLR:FSC
(Chl:vol ratio)



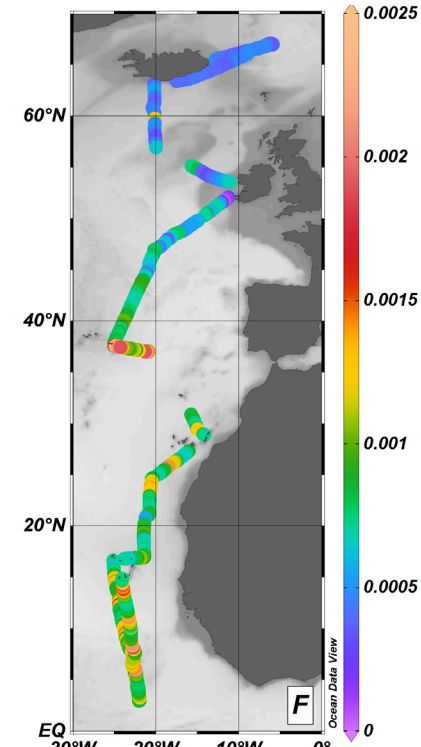
FRRf
 F_v/F_m
(efficiency PSII)



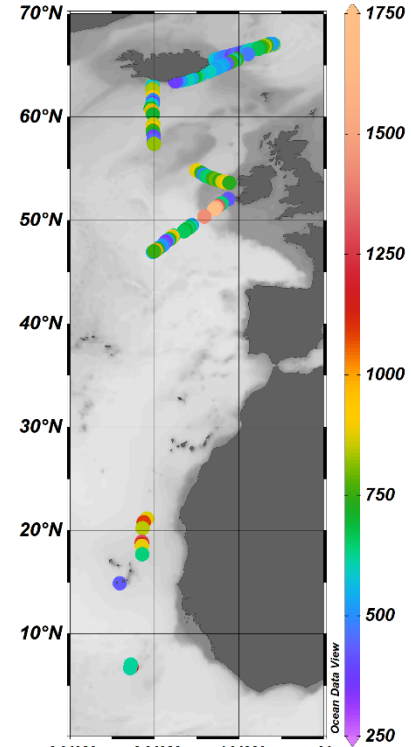
FRRf
 $\sigma_{PSII,450nm}$
(Cross section PSII)



FRRf
 $1/T_{QA}$
(turnover rate PSII)



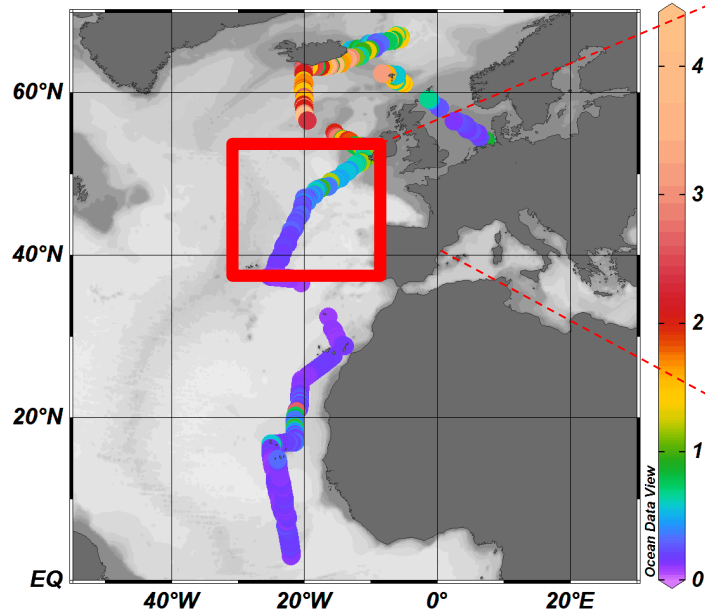
FRRf (FLC)
 P_{max}
(per PSII)



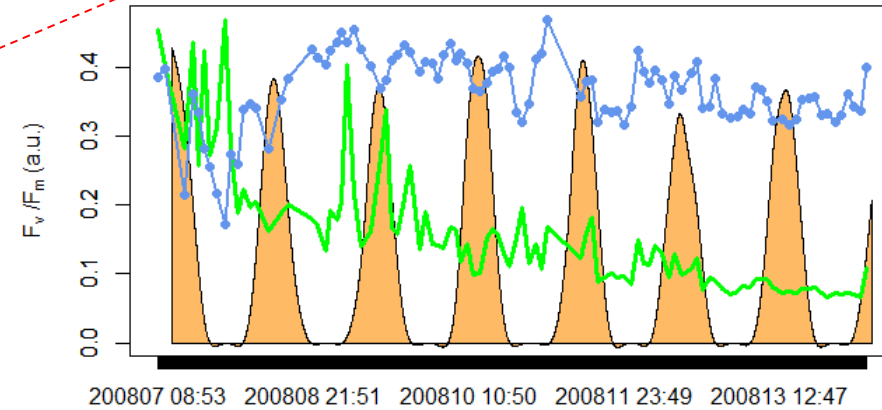
PHOTOPHYSIOLOGY IN THE SURFACE OCEAN



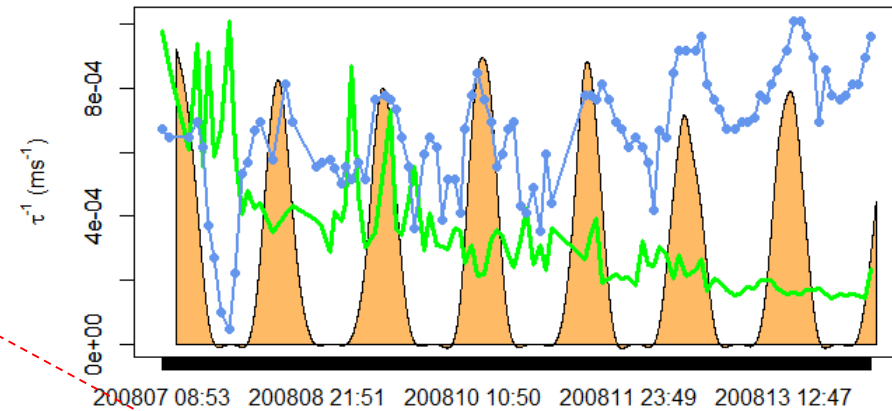
Chlorophyll fluorescence
Estimate of chlorophyll concentration





Quantum efficiency of PSII (F_v/F_m)



Rate of RCII reopening ($1/\tau$)



 [functional PSII reaction centers]
(nmol RCII m⁻³)

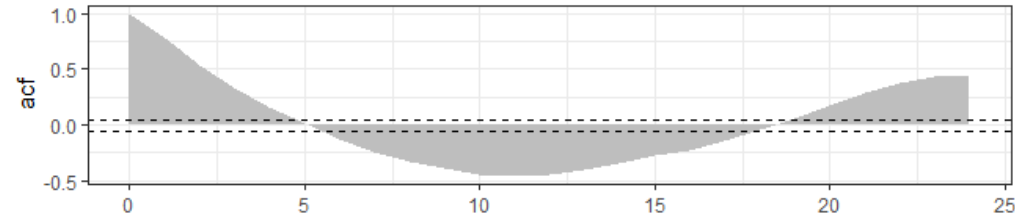
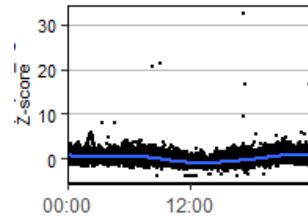
 Irradiance
(μmol photons m⁻² s⁻¹)

PRELIMINARY RESULTS

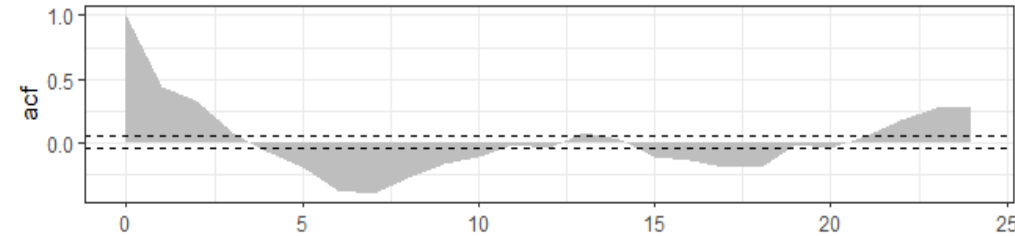
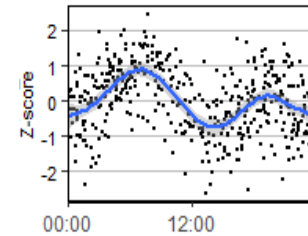


- Auto-correlated diel cycles in photophysiological parameters
- Significant differences between provinces

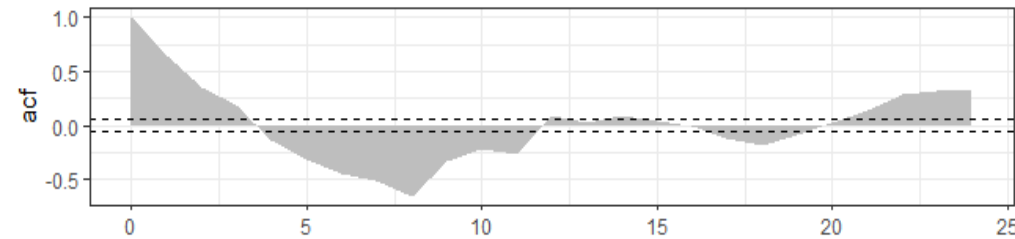
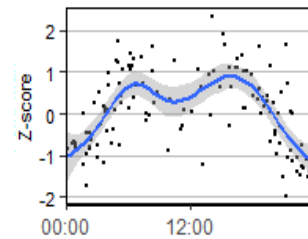
**Chlorophyll *a*
fluorescence**



**F_v/F_m
(efficiency PSII)**



**P_{max}
(maximum electron
transport rate per
PSII)**



Time of day

Lag

CONCLUSION

Photophysiology in the North Atlantic surface waters

- High spatial variability photophysiology
- Instrument sensitivity challenging in oligotrophic ocean
- Diel cycles pronounced in many parameters

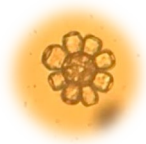
Future works

- LabSTAF replaces FastOcean FRRf
- Crossing the ocean to Panama (MoU with Smithsonian in Panama)
- Sampling oxygen minimum zones and El Niño in eastern Pacific



WSS

WERNER SIEMENS-STIFTUNG



THANK YOU!

QUESTIONS OR COMMENTS?

With many thanks and acknowledgement to:

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Captains Kaarel Kruusmägi and Karl Vahtra, and crew Argo Kruusmägi, Margus Zahharov, Janette Possul, Marge Piirmets, Adeele Kuslap, Marharyta Kalashnikova



PRELIMINARY RESULTS



Parameter	Methods
Temperature	thermistor
Conductivity	oscillator
pH	electrode
Turbidity	Optical – EX 880 nm
CDOM concentration	Optical – EX/EM 370/460 nm
Chlorophyll <i>a</i> concentration	Optical - EX/EM 470/695 nm
Phycocyanin concentration	Optical - EX/EM 630/680 nm
O ₂ concentration	Optical - Dynamic luminescence quenching
CO ₂ concentration	Optical - Dual wavelength (395/426 nm) infrared gas analyzer
Nitrate concentration	Optical - UV excitation; 200-360nm spectral absorbance analysis
Particle size distribution	Optical - Laser In Situ scattering and transmissometry (EX 670 nm, scattering angles)
Polycyclic aromatic compounds	Optical - EX/EM 254/360 nm
CO ₂ isotope ratio	Optical - Isotope ratio infrared spectrometry (Hubert Vonhof)
Photosynthetic activity	Optical - Fast repetition rate fluorometry EX 450/530/624, EM 682 nm
Plankton counts and optical characterization	Optical - Per cell excitation at 488 nm, detection of full pull shape cell scattering and fluorescence
Irradiance	Passive PAR quantum sensor in mast
Dissolved Argon	Mass spectrometry
Dissolved Oxygen	Mass spectrometry
Dissolved Nitrogen	Mass spectrometry

AIR LAB – CONTINUOUS MEASUREMENTS

- SMPS – Scanning Mobility Particle Sizer
particle number size distribution (10 – 430 nm)
- OPC – Optical Particle Counter
particle number size distribution (0.25 – 32 μm)
- CPC – Condensation Particle Counter
total particle concentration (~5 nm – 2.5 μm)
- SP2 – Single Particle Soot Photometer
black carbon in individual aerosol particles
- Spectral Intensity Bioaerosol Sensor
real-time detection of individual particles (0.3 - 30 μm)
- Picarro Gas Concentration Analyzer
gas concentrations of nitrous oxide (N_2O), methane (CH_4), carbon dioxide (CO_2), ammonia (NH_3) and water (H_2O)
- Air CO_2 measurements

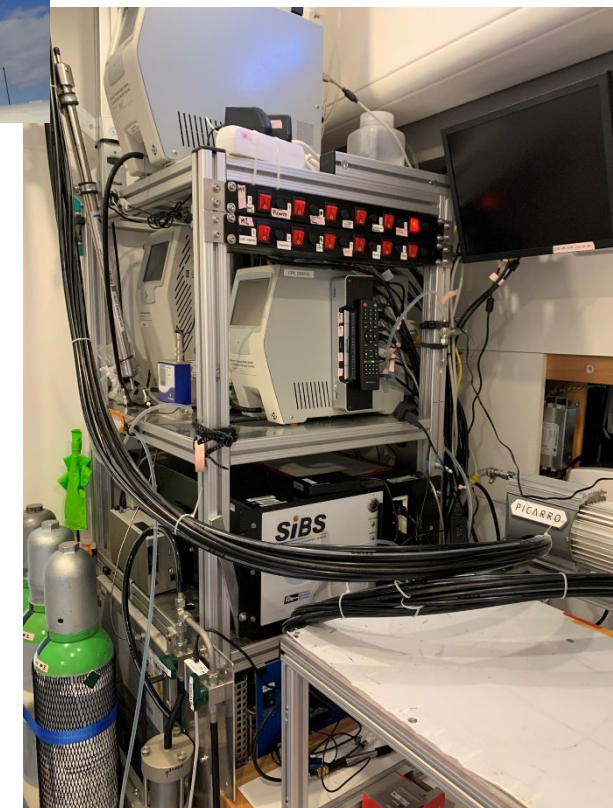
AIR



Total particle concentration and size distribution

Black Carbon

Bioaerosols

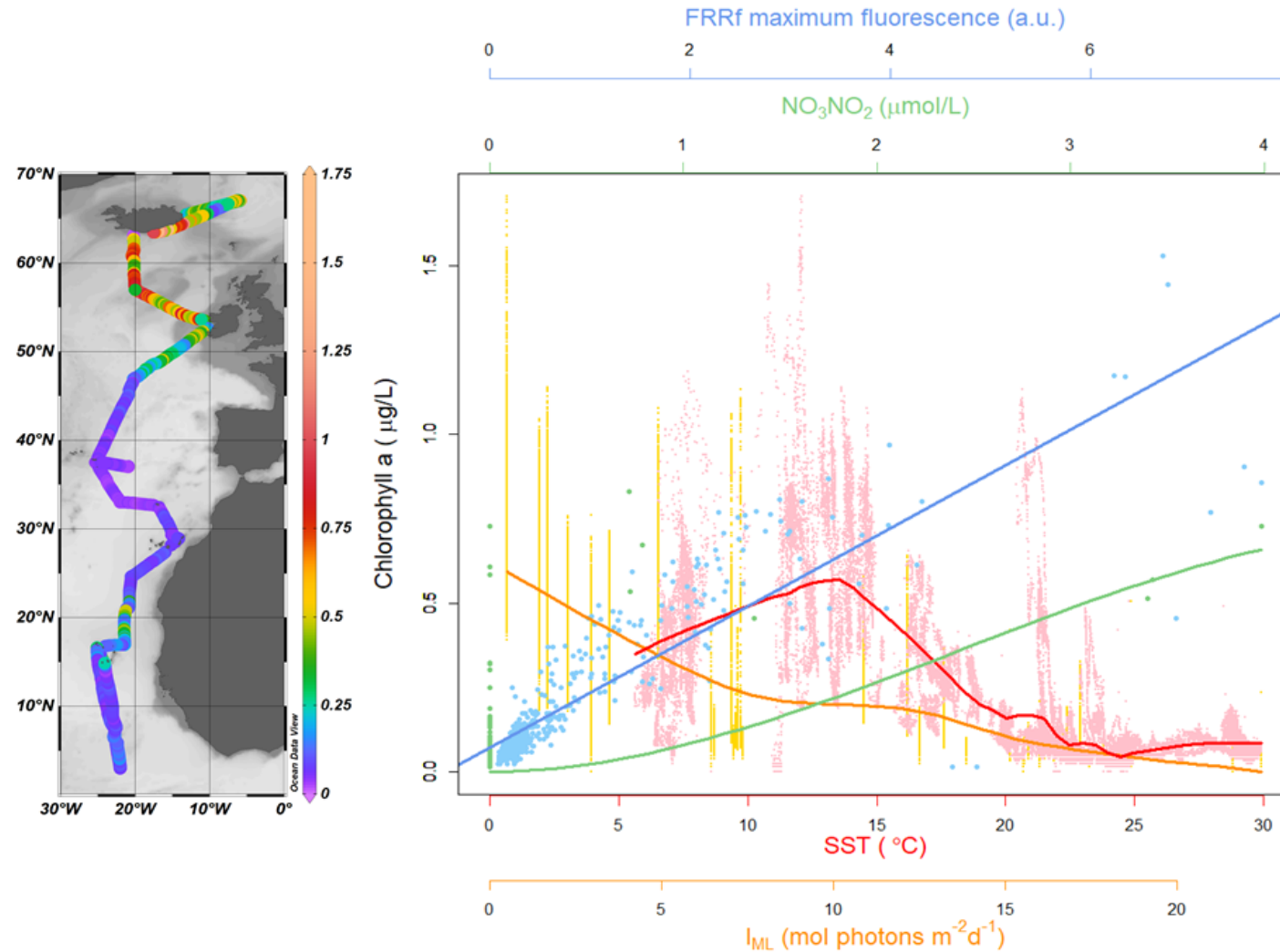


PRELIMINARY RESULTS



Environment

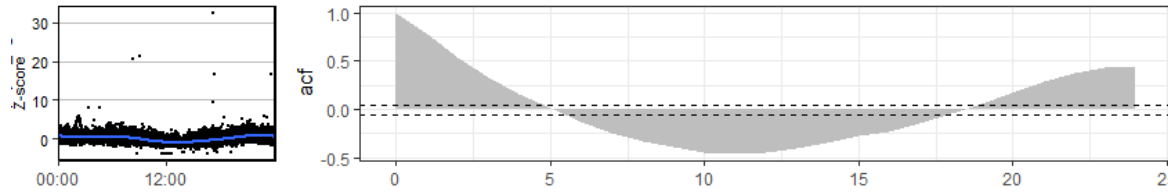
- Transect crosses wide range of chlorophyll concentrations



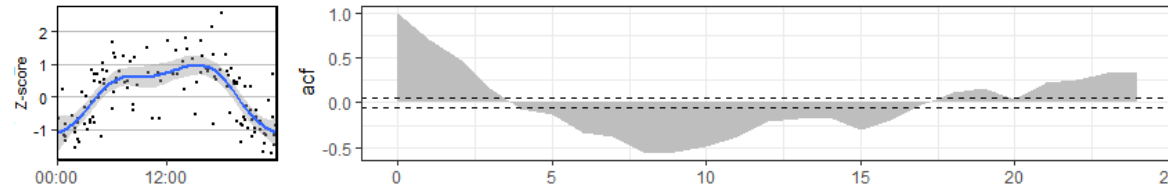
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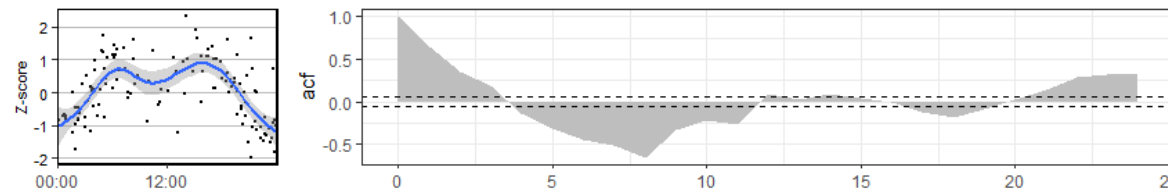
Chlorophyll *a*
fluorescence



$1/T_{QA}$
(turnover rate PSII)

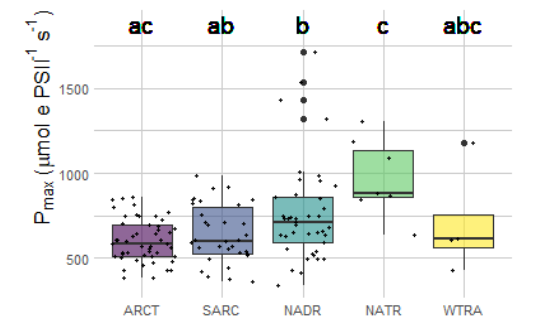
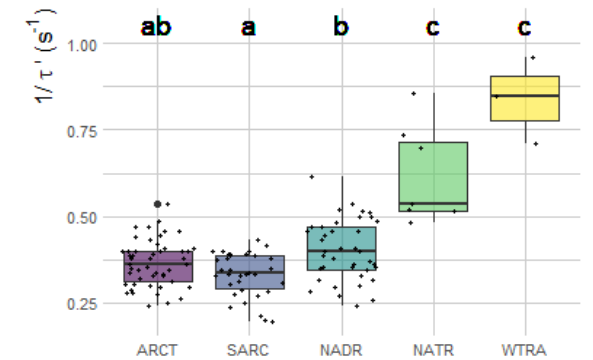


P_{max}
(maximum electron
transport rate PSII)



Time of day

Lag





Layer 1: Headlines

Layer 2: Copy

- Layer 3: Bullet points
- **Layer 4: Highlight bullet points**
 - Layer 5: Indented bullet points
 - Layer 6: Additional bullet points

↳ Layer 7: Additional info

Layer 8: Caption