





National Oceanography Centre

An Alternative Framework to Assess Marine Ecosystem Functioning in Shelf Seas

<u>Dr Matthew Palmer (PI)</u> Charlotte Williams, Matt Toberman, Tom Hull, Anil Akpinar, Anthony Birchill, Jeroen van der Kooij....and many others

WP1: Physical conditioning of the North Sea

WP2: Nutrients, plankton and productivity

WP3: Controls on bottom mixed layer oxygen deficiency

WP4: Delivering an autonomous framework for sustained

Plymouth Marine Cefas UNIVERSITY OF LIVERPOOL

science and monitoring capability





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Timeline

send updates / corrections to tom.hull@cefas.co.uk ; Last updated 2020-04-23 09:48:31

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seaglider					sg620 (Me																	
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	2017			2018										2019								





 East-West transport (across 2°E transect) is correlated with wind stress (r=0.73)

whereas

 North-South transport (across 54°N-57°N transects) is correlated with wind stress curl (r=0.58)

In other words: In the North Sea interior *E-W transport is driven by the wind (stress*) but *N-S transport appears to be driven by the wind stress curl*

• Interannually (filtered with 1-year moving average); Inflow at the Norwegian Trench is correlated with wind stress curl (r=0.49).

In other words, interannually, changes in wind stress curl can generate inflow to the North Sea.

<u>**Circulation</u>**: We examine transport using the NEMO AMM7 and AMM15 models using an expanded version of the NOOS transects.</u>

We focus on exchange at the northern North Sea, exchange between the northern and central north sea regions and zonal transport across the 2°C line to help characterise circulation and exchange between the inner and outer shelf.

SAMS Turbulence and mixing: Autumn breakdown

- Specialist gliders provided insight into critical processes controlling physical, chemical and biological functioning.
- An Ocean Microstructure Glider (OMG) captures how intense wind mixing gradually pushes the surface mixed layer deeper in autumn.
- Deep mid-water mixing is identified associated with a tight pycnocline that exists close to the bed for many weeks into November.
- ADCP data collected on the OMG glider will hopefully help identify the role of wind, tides and convection on the eventual breakdown.

Dissipation rate of turbulent kinetic energy ($\log_{10} \varepsilon$ Wkg⁻¹)



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- The deep stratification in late Autumn effectively isolates the thin bottom mixed layer.
- This effect leads to very low DO concentrations. The gliders observe concentrations <6mgL⁻¹ (<180 umol kg⁻¹), equivalent to <70% saturation and in late November.
- This late breakdown of stratification and subsequent trapping of a low oxygen layer occurred in both 2017 and 2018.
- Calibration of optodes and other sensors was difficult, raising concerns over the use of current platforms and sensors for sustained observing and statutory monitoring purposes.

Oxygen dynamics







Nutrient dynamics:

- AlterEco enabled 11 months of data to be collected using nitrate and phosphate lab-on-a-chip sensors integrated into Seagliders.
- High resolution nutrient dynamics throughout the seasonal cycle will be used to better constrain our understanding of productivity and the oxygen dynamics in the North Sea.



Measuring plankton and assessing productivity





- Dual frequency (70/200kHz), broadband acoustics were fixed to a *Liquid Robotics* Waveglider.
- The method successfully identifies key plankton dynamics processes.
- Provides spatial metrics to identify plankton and fish behaviour inc. centre of mass, inertia, equivalent area, aggregation index, skewness.
- Multi-sensor payload enables links to physical and biogeochemical processes.









Summary:

- AlterEco has provided an 18-month, multidisciplinary time series in a region undergoing seasonal oxygen depletion.
- New sensor technology has been successfully tested, providing
 - Over 11 months of high-density profiles of nutrient data using newly developed lab-on-a-chip technology on ocean gliders.
 - Broad-band, multi-frequency active acoustics on unmanned surface robots for zooplankton and small fish identification and potential stock assessment.
- AlterEco has enabled a sustained ocean observing programme using autonomous vehicles, with the potential to provide EU marine assessment capability.
- Meridional and zonal transport appears well correlated with wind stress curl and wind stress respectively.
- The extent of seasonal depletion of bottom mixed layer oxygen is preconditioned by winterspring transition.
- Depletion continues into late November during both observed years due to persistent, deep stratification. Turbulence data will identify the individual roles of wind, tide and convective processes on the duration of stratification.
- We expect future depletion of North Sea oxygen (see Sarah Wakelin's talk from Tuesday). This unique physical, chemical and biological dataset will be used to better constrain and inform future projections to help better adapt and mitigate to the effects of our changing climate.

