Phytoplankton community structure and trace gas studies

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Why are we interested

- Primary production by plants and algae forms the base of all marine ecosystem processes.
- Phytoplankton are fundamental to climate change studies.
- A wide range of micro and macroalgae are known to produce halogenated trace gases through their metabolic processes.

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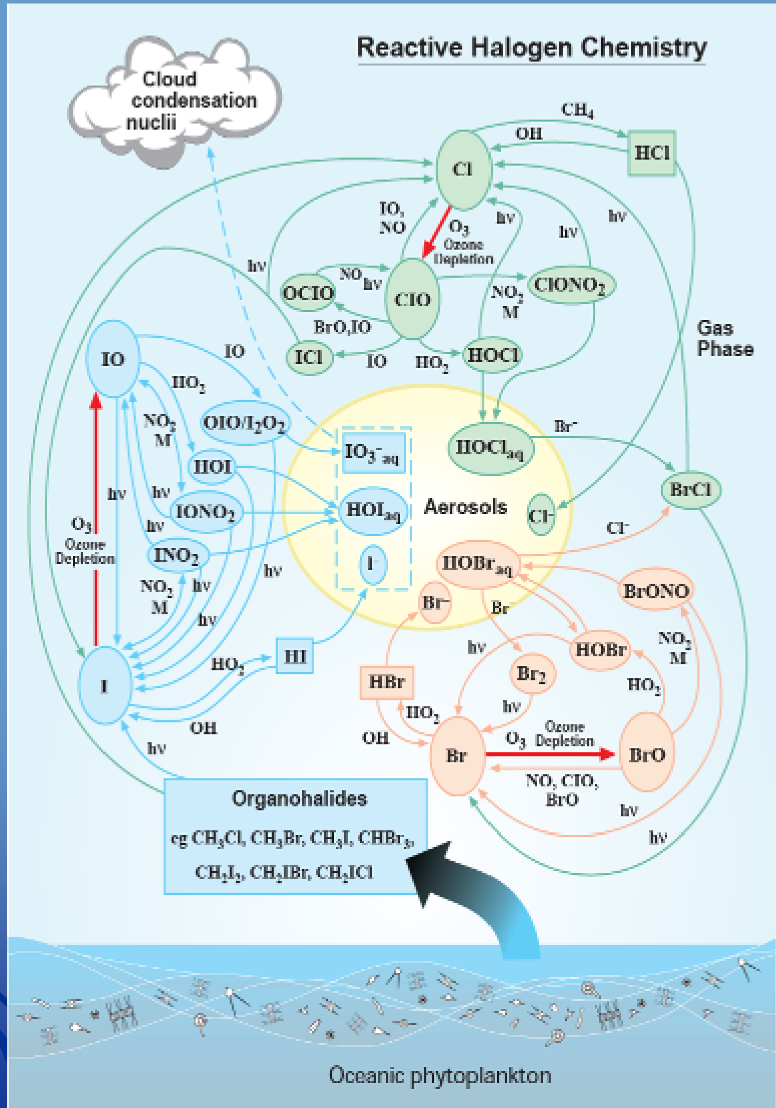
Halogen Chemistry

Once in the atmosphere, these gases provide mechanisms by which chlorine, bromine and iodine species reach the stratosphere and are involved in the catalytic destruction of ozone.

Many of these gases also contribute to Global Warming.

Others are known to instigate the production of cloud condensation nuclei and might help mitigate it.



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Oceanic source

Ocean source is patchy both spatially and temporally.

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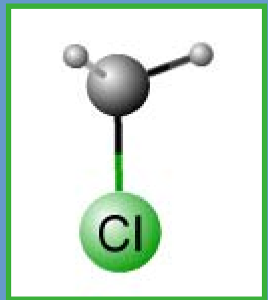
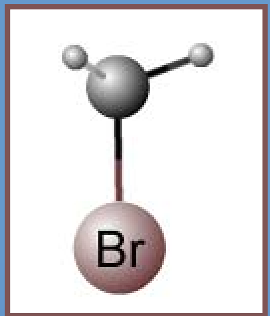
MeCl



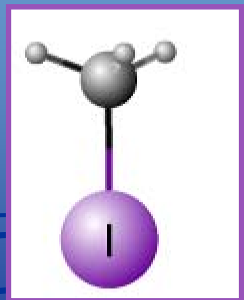
Major ocean source. Related to diatoms and prymnesiophytes. Also chemical interactions

MeBr



Source or sink unclear Related to diatoms in open ocean and culture.

MeI



Coastal source related to macroalgae.
Open-ocean source related to photochemistry and cyanobacteria

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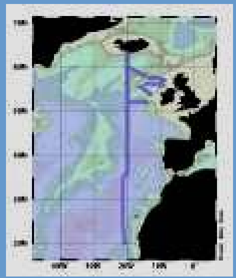
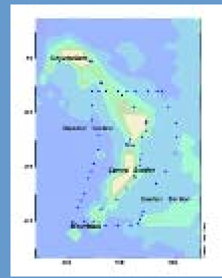
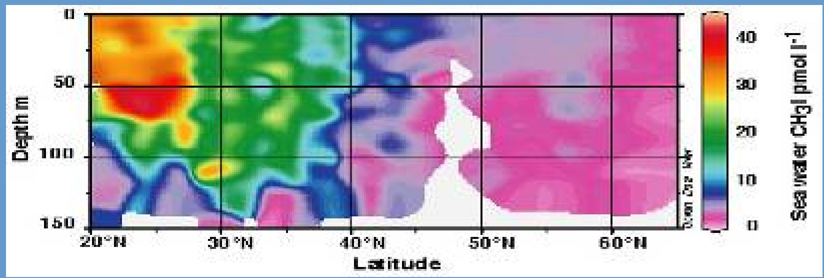
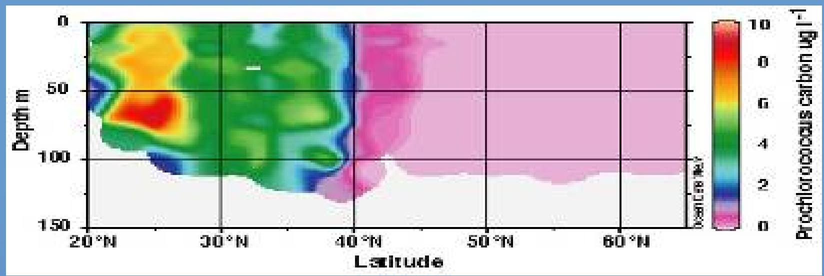
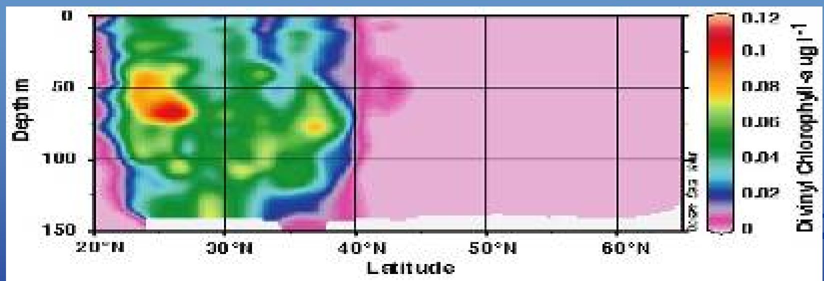


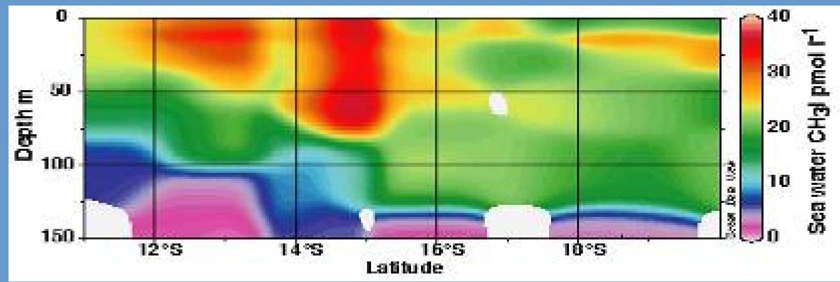
Methyl Iodide and Prochlorococcus

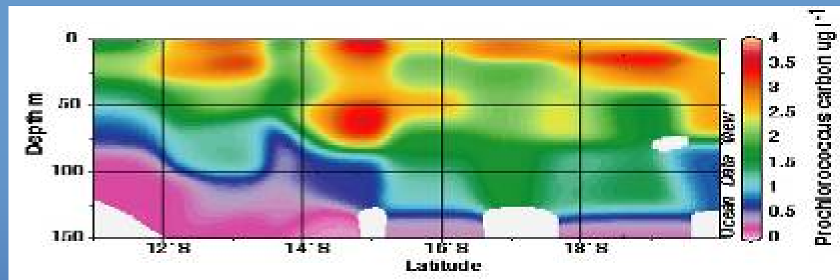












Smythe-Wright et al., 2006

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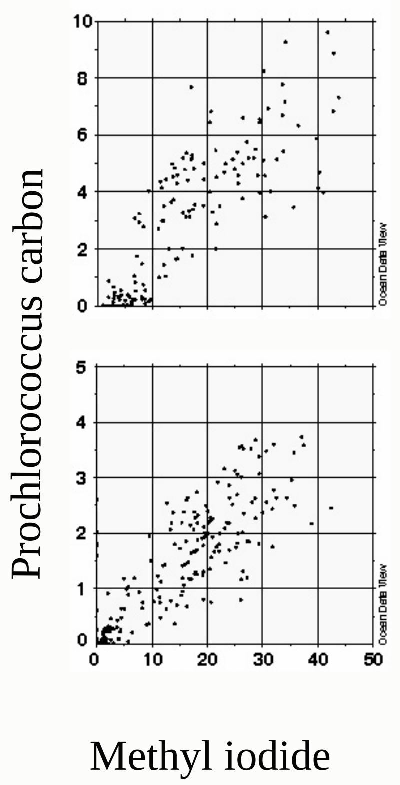
Biological relationship



Studies have shown that biological gas release is not solely related to one species or taxa.

It is more likely to be controlled by community structure and/or environmental conditions.

To further our knowledge of trace gas release it is vital to monitor changes in phytoplankton community structure seasonally, inter-annually and on decadal timescales.

In turn, this will help us better understand how phytoplankton released gases might force or mitigate climate change.

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Automated Equipment

Working alongside a standard Ferrybox system (which logs temperature, salinity, fluorescence and oxygen).

The ferry operates two return journeys per week throughout the year and crosses a number of oceanic and biological provenances, thereby providing data over a variety of temporal and spatial conditions.

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P&O Pride of Bilbao ferry route

Project started April 2002

Online "Web sensors"

@ 1Hz

Conductivity

Temperature

Chlorophyll-fluorescence

@30secs

O_2 (start 2005)

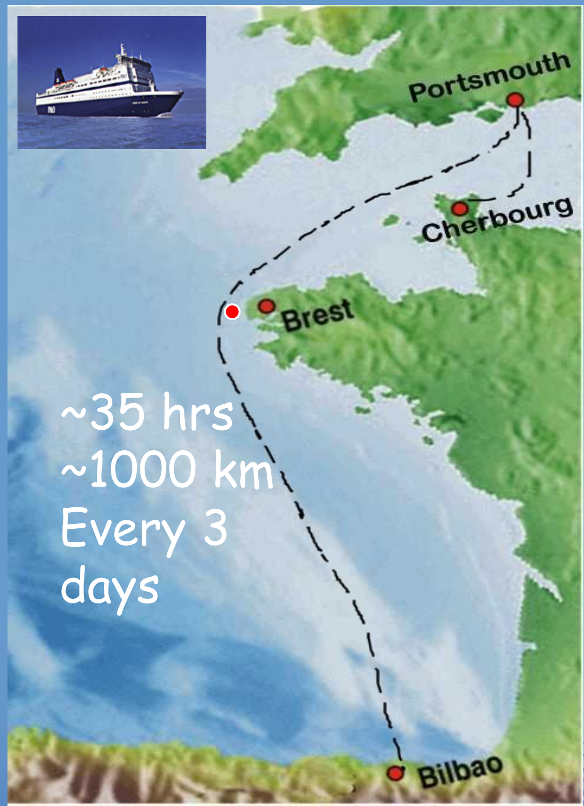
pCO_2 (mid 2005-7)

Monthly water samples

From Feb 2003

NO_3, Si, PO_4, Chl a, Salinity, O_2 (2004 -),

Alkalinity, TCO_2 (2005-), pH (2007-)



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Trace gas equipment

Consists of an autonomous membrane-inlet purge and trap system, taking samples from the ship's seawater intake, coupled to a GC-MS which is installed within a specially designed laboratory area aboard the MV Pride of Bilbao.

Co-axial stainless steel/silicone tubes act as a membrane for the gas transfer from sea water and the gas is trapped and pre-concentrated using a carboxen trap.

All coupled to an Agilent 6890GC/5973 MSD, fitted with a 30 m CB Sil-5, 0.32 mm id column.

The system, including data collection, is PC controlled and the carrier gas is helium throughout.

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Robotic sampler

The robotic arm collects three types of sample.

An injection system fills racks of amber glass bottles and cryovials (containing appropriate preservatives) for taxanomic identification by microscopy and flow cytometry

A filter head which filters seawater samples through a series of filter holders for plant pigment analysis.

Where appropriate the robotic arm moves the samples to -20 °C and -80°C freezers.

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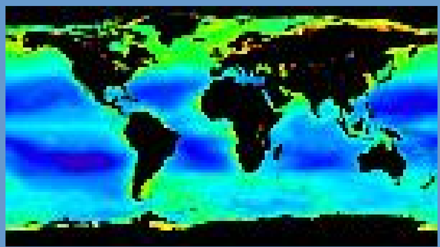
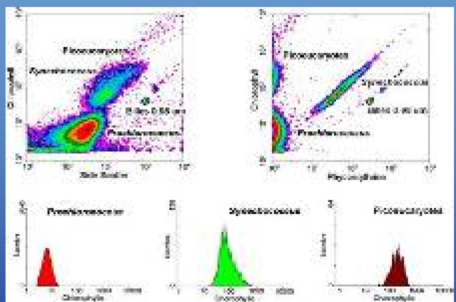
Limitations

Microscope counts -
Time consuming
Limited coverage



Ocean colour -
Near surface only
Large temporal and spatial variability
Uncertainties in algorithms

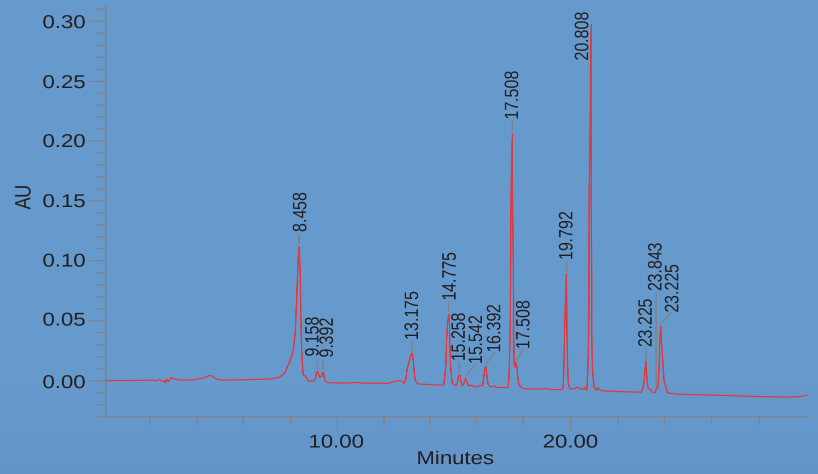


Cytometer counts -
Primarily small organisms
Bulk composition
Little information on species

Advantages of Pigments

Large number of natural pigments.

Can get definitive identification and quantification using HPLC techniques.



Large sample throughput.

Good geographical coverage throughout water column.

Different taxa and species have different pigment compositions.

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Pigment Signatures

PIGMENT	TAXONOMIC SIGNIFICANCE
Chlorophylls	
Chlorophyll a	Phytoplankton biomass
Chlorophyll b	Green algae (Chlorophytes/Euglenophytes)
Divinyl chlorophyll a	Prochlorophytes
Carotenoids	
Peridinin	Photosynthetic dinoflagellates
Zeaxanthin	Cyanophytes/Prochlorophytes/Chlorophytes
Fucoxanthin	Diatoms
Diadinoxanthin	Diatoms and prymnesiophytes
19 Hexanoyloxyfucoxanthin	Prymnesiophytes
19 butanoyloxyfucoxanthin	some prymnesiophytes
Degradation products	
Phaeophorbides	Zooplankton grazing/cell senescence
+ many others	

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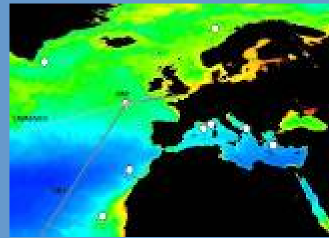
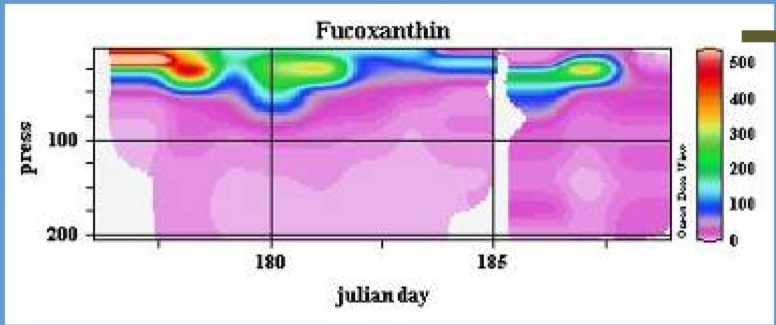
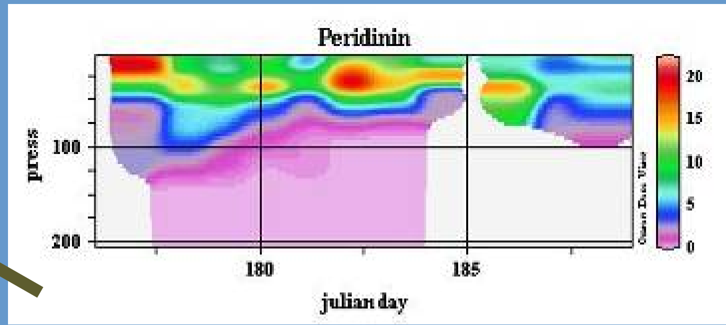
Pigments

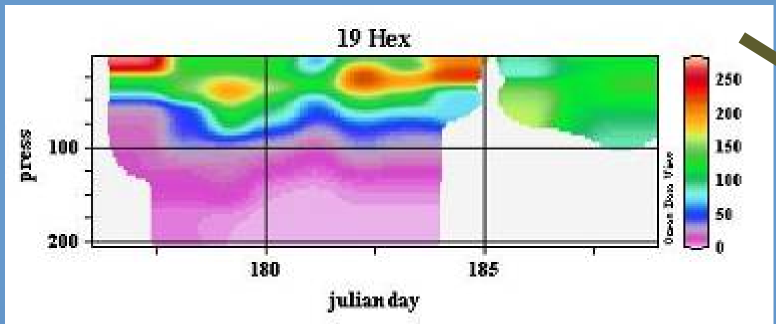




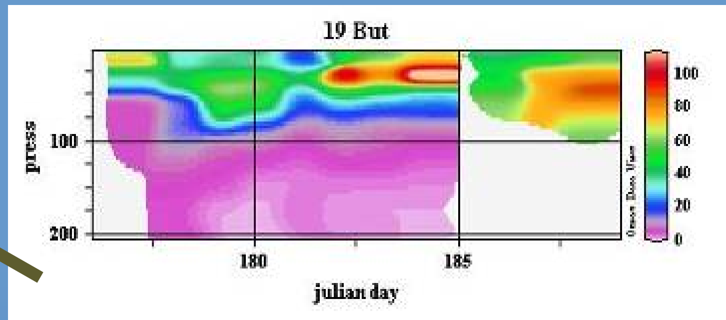
Diatoms

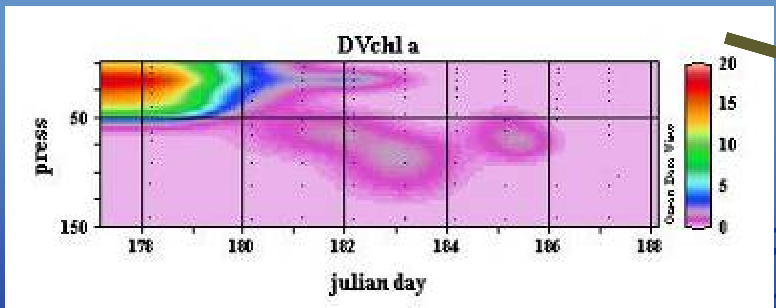
Dinoflagellates



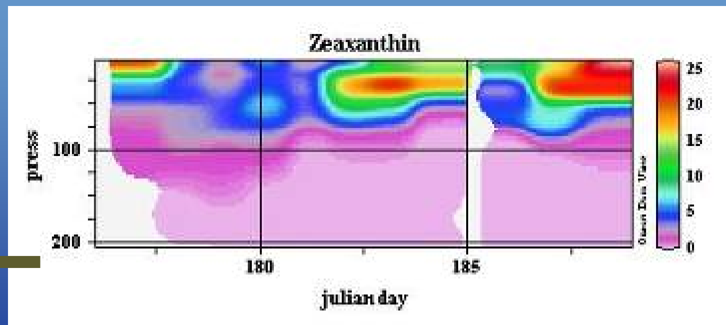


Prymnesiophytes





Prochlorophytes



Cyanophytes
Chlorophytes

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Smythe-Wright *et al.*, 2010

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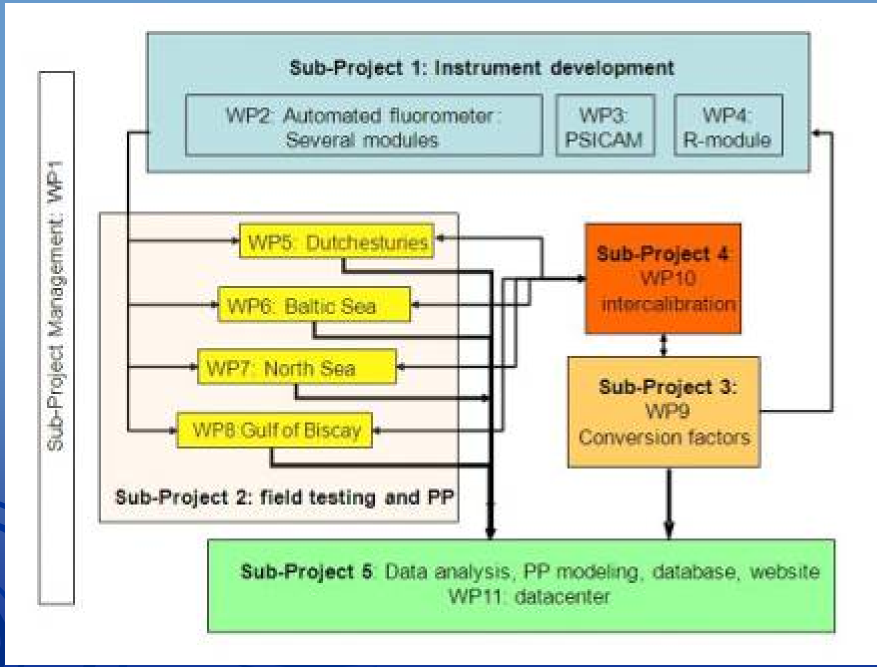
EU PROTOOL Project

PROTOOL stands for PROductivity TOOLs: Automated Tools to Measure Primary Productivity in European Seas.

Three year (2009-2012) project to develop and adapt technology to measure primary production of phytoplankton with automated optical techniques, so that they can be placed on ships of opportunity (SOOP, ferries, container ships).

The project is divided into 5 sub projects and 11 work packages.



http://www.protool-project.eu/project

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Conclusions

We have developed an automated trace gas system and a robotic biological samplers for use on the Pride of Bilbao ferry.

They will be used in assessing how trace gas release and phytoplankton production will impact on and in turn be altered by climate change.

Robotic sampler and pigment analysis part of the PROTOOL EU programme.

We are looking for other routes - particularly across the Atlantic and into the Arctic.

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Thank you

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