Assessment of seasonal and decadal signals in the in-situ Atlantic plankton data

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Abstract: Combining in-situ plankton time series data sets from different research cruises over an ocean-Atlantic scale is particularly challenging. Specifically creating a knowledge base that enables statistical analysis of seasonal and the longer term structure and function of the planktonic presents two challenges: 1) sub-sampling: the underlying trends are not completely represented as not all measures are regularly sampled over time (months & years), and 2) measurement protocols: scientific protocols for individual research expeditions need to be harmonised so that representative long term time series can be constructed. We present the current learning from combining in-situ data across Arctic (1913+), Atlantic (1985+) and Southern Ocean (1992+) waters. To help address these challenges, this in-situ data and the related knowledge is being combined with biogeochemical numerical models and remote sensing data in the GreenSeas Analysis Framework. This novel framework will be briefly discussed to explain how the GSAF and its linkage with the in-situ sampling design provide a systematic capability to construct the longer term time series. Ultimately it enables analyses which help improve the numerical models which are used to give future assessments of climate. We report here the current learning obtained from combining these in-situ data with a focus on phytoplankton abundance, primary production and nutrient metrics. We discuss the seasonal and decadal trends in this data, and present (with relevant statistically simulated data) methods to distinguish seasonal and decadal variation from longer term trends that are typically present in these types of time series.

Keywords : Atlantic, In-Situ, Historical, Longer Term

The Atlantic plankton ecosystem is measured in a range of ways, and one of these: in-situ based ocean scale sampling is a particularly challenging research environment. Our discussion presents the latest learning being combined from a wide range of in-situ types of time series data. We explain how we approach addressing the challenges of interpreting the underlying plankton state and function from irregularly sampled data and discuss data harmonisation protocols.

This work is from the GreenSeas consortium: an EU Framework 7 international consortium explained further in [3] at ICES CM 2012. The part of this study discussed here focusses on creating a knowledge base that enables statistical analysis of seasonal and the longer term structure and function of the plankton ecosystem from Arctic, through Atlantic gyres and to the Southern Ocean. The outcome of this work will provide the opportunity to enhance and improve current biogeochemical model predictions and inform how these are used for future assessments of climate change.

This type of analysis presents two challenges:

1) sub-sampling: the underlying trends are not completely represented as not all measures are regularly sampled over time (months & years), and

2) Measurement protocols: scientific protocols for individual research expeditions need to be harmonised so that representative long term time series can be constructed.

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These two challenges are approached from our analysis perspective through the GreenSeas Analysis Framework discussed in [2] and the schematic description of this is

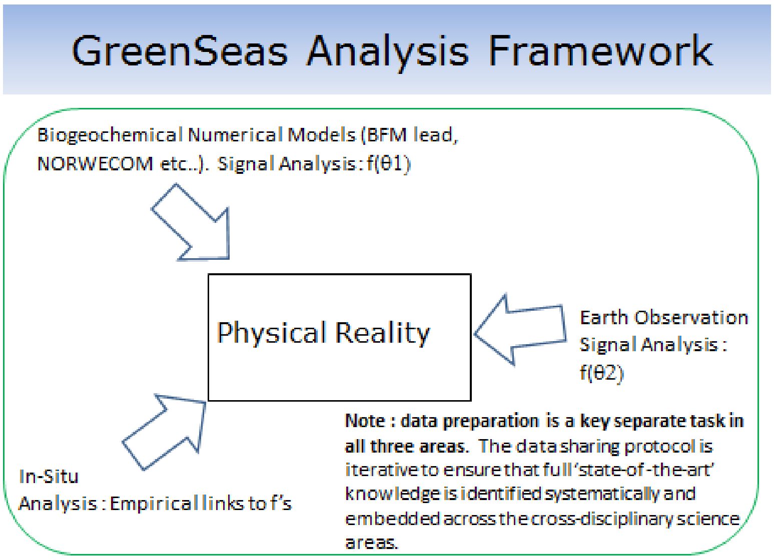
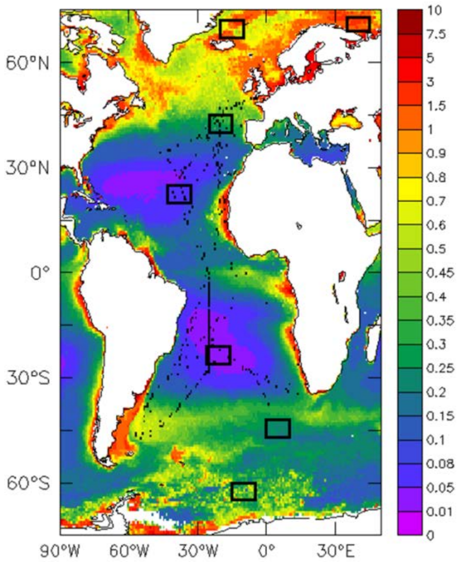


Figure 1

presented in Figure 1 above. The GSAF analysis design, maps this combined knowledge onto the in-situ transect sampling locations and in so helps address both above challenges: 1) utilising information present in regularly sampled numerical models and earth observation measurement and 2) the biogeochemical numerical models help define the measurement metrics required and provide the consistent measure protocol used across the integrated research analysis. All the locations sampled in our current



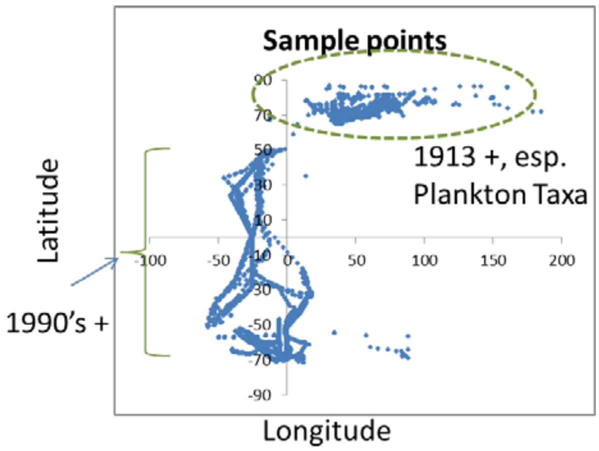


Figure 2(a) **Figure 2(b)**

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database are shown in Figure 2(b) below. For the purpose of analysing the longer term signals, seven locations of initial focus have been selected and are shown as the boxes in Figure 2(a). These boxes have been chosen to give sample analysis locations going from the Arctic, through the Atlantic gyres and south to the Southern Ocean. The small black dots on this figure mark the in-situ samples from the UK Atlantic Meridional Transect (AMT) observatory programme, and the colour map is an example of chlorophyll-a observed with earth observation sampling methods.

In order to assess the potential signal bias and the relative strength of seasonal and longer term variability two aspects of this are discussed.

To identify any issues to temporal sub-sampling in the in-situ signal we utilise information available from the biogeochemical

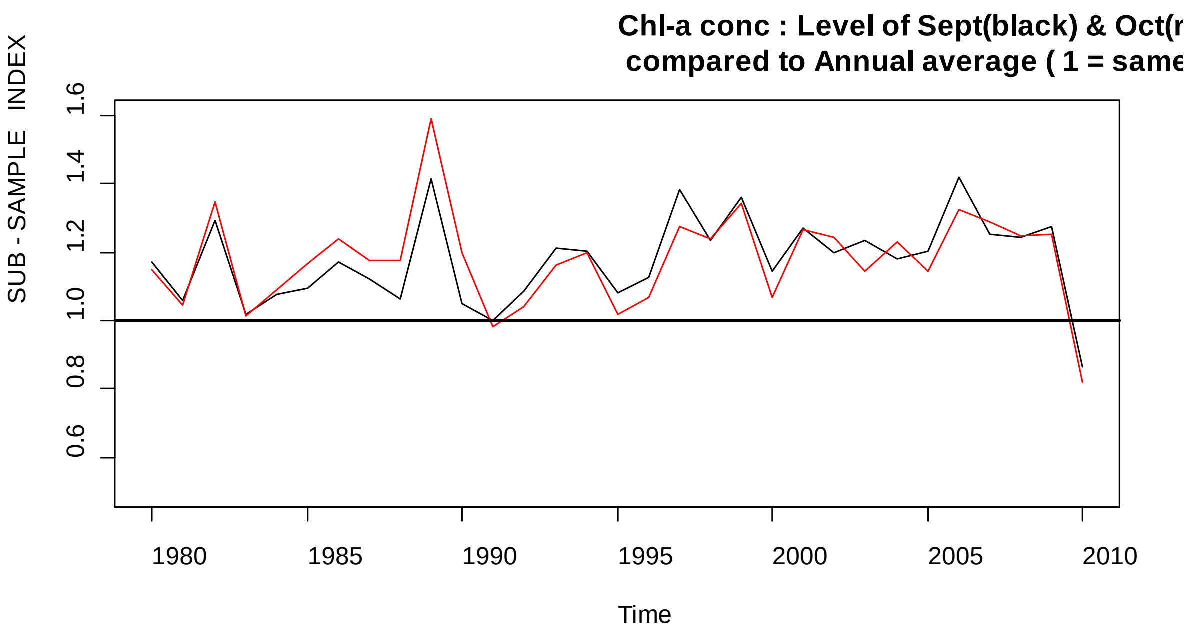

Figure 3

numerical models. An example of this is shown in Figure 3 for the Southern gyre, where we calculate the monthly Sub-Sample Index for the chlorophyll-a concentration. We define the Sub-Sample Index = Chl-a concentration for given month / Average Chl-a concentration for the year. As the AMT observatory measures this region during Sept-Oct-Nov, the months of Sept & Oct are depicted here. The Sub-Sample Index helps us understand the level of temporal subsampling bias can be introduced by observation during specific parts of the year. Here it is suggested that the level of variation could be about + 10 to 20% compared to the overall annual signal.

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To examine the presence of seasonal and longer term trends – statistical time series methods are used as discussed in [1]. An example of this for the Southern gyre is shown in Figure 4 where the regular patterns captured in the biogeochemical numerical models are examined. This example shows how the 30 year monthly chlorophyll time series log(Chlorophyll-concentration) can be decomposed into a regular- annual seasonal and longer term components. In this example (on this log scale) the longer term component exhibits are larger variability compared to the annual cycle. The potential presence of harmonic-regular decadal components will be discussed further in this talk with examples taken from the seven boxes selected in the design and also with simulated data.

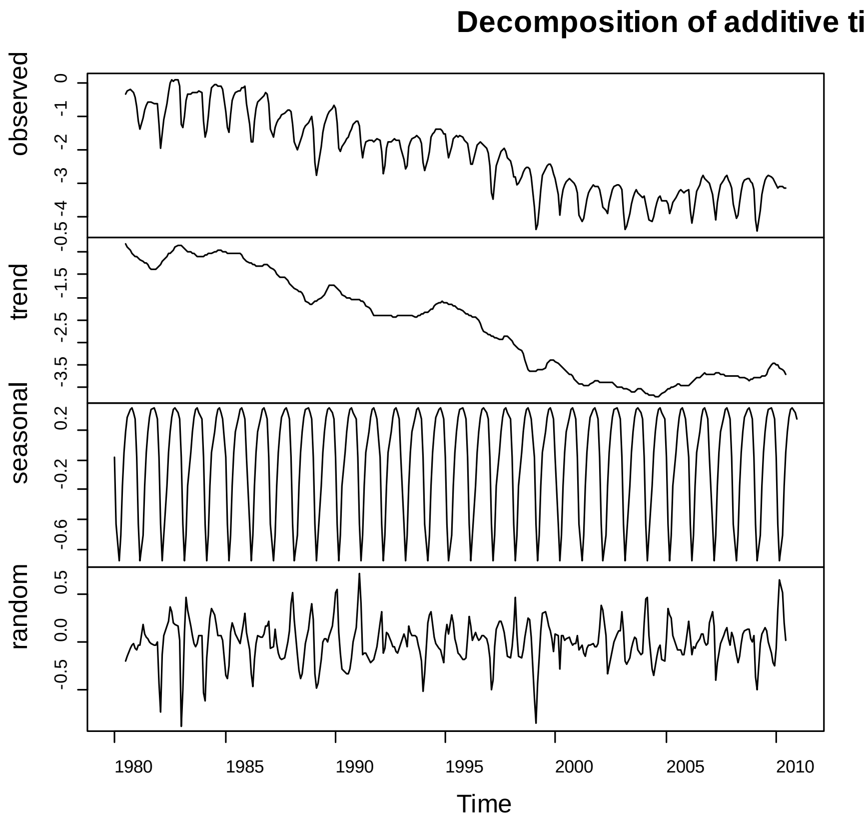

Figure 4

We illustrate our talk with in-situ based examples taken from the Arctic (1913+) time series, the Southern Ocean (1992+) and the Atlantic (1985+) and discuss the protocols of merging this type of data. As an in-situ example, in Figure 5 the annual (Sept/Oct/Nov) phytoplankton concentration time series are exhibited (as box plots) this data is from the Atlantic Meridional Transect. This example focusses on the depth which has the highest chlorophyll concentration- the deep chlorophyll maximum depth (DCM). This exploratory analysis, with the raw in-situ data, suggests that longer term – decadal oscillation could

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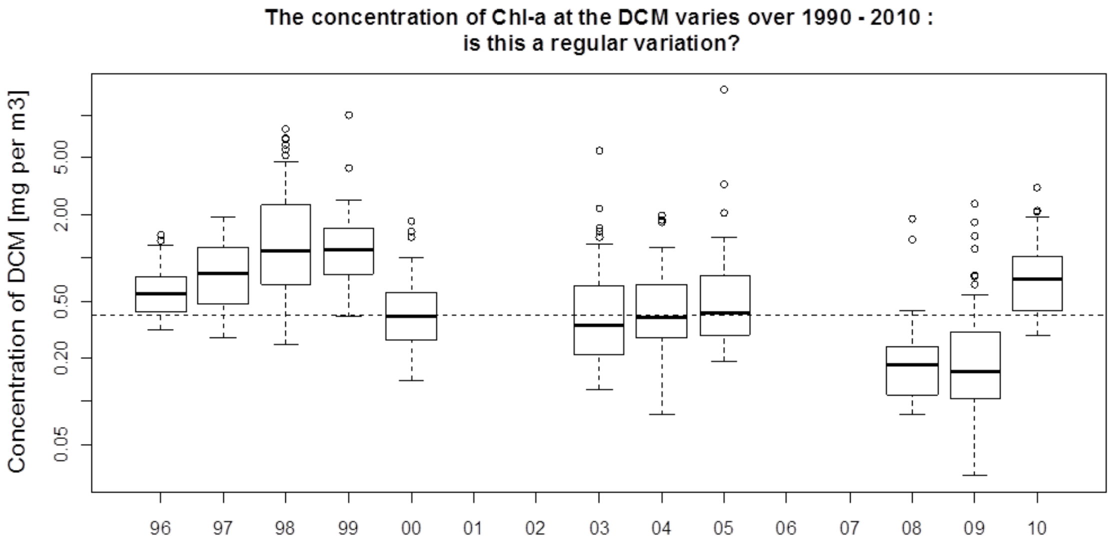

Figure 5

be present. This particular example represents the full coverage of the AMT.

We will report further disaggregate analysis of the in-situ seasonal and potential decadal trends present across the Arctic – Atlantic – Southern Ocean, building in the knowledge we combine from the biogeochemical numerical models and earth observation monitoring platforms.

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Select References:

[1] John Bruun, Paul Somerfield, Icarus Allen (2012), *Applications of Box Jenkins Transfer function methods to identify seasonal and longer term trends in Marine time series*. ICES CM 2012/ R:22.

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[2] John Bruun, Paul Somerfield, Icarus Allen, Marcello Vichi, William McKiver, Marie-Fanny Racault, Johnny Johannessen, Richard Bellerby, Howard Waldron (2012), *New methodologies to build an integrated global plankton database: the GreenSeas Analysis Framework.* ICES CM 2012/ R:10.

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