CARBON AND NUTRIENT CYCLING BETWEEN ESTUARIES AND ADJACENT COASTAL WATERS

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INTRODUCTION

Carbon system in coastal environments

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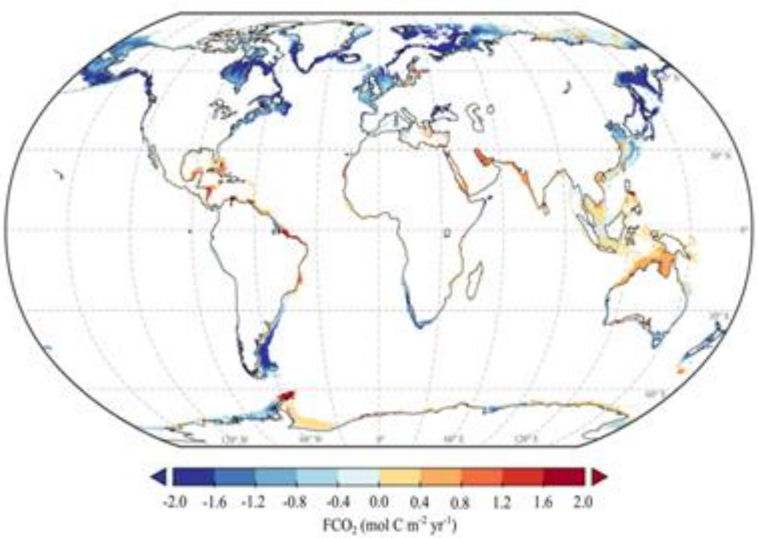
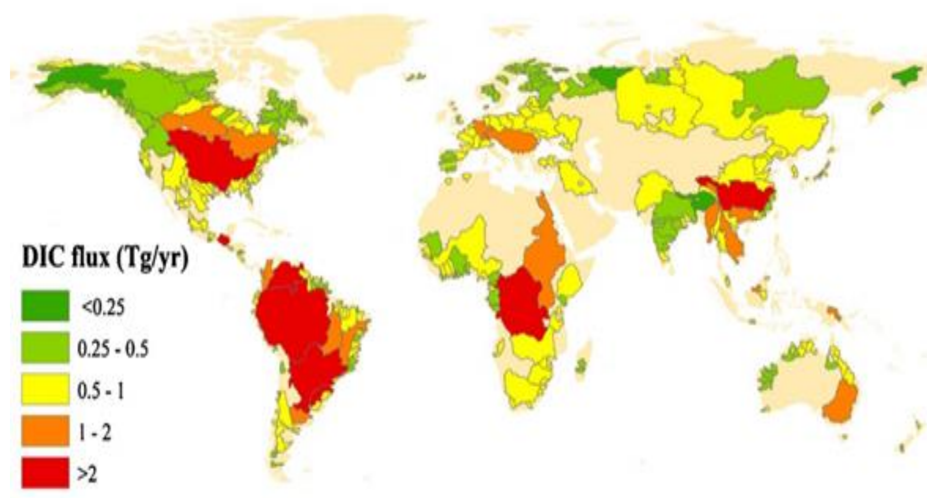
- The coastal environment is an ensemble of connected ecosystems (Bauer et al, 2013).
- Carbon exchange within and between the coastal ecosystems and the atmosphere varies largely (Bauer et al, 2013).
- Carbon dioxide (CO_2) sink regions are mainly found at temperate and high latitudes (Roobaert et al., 2019).



Global distributions of the annually averaged mean air-sea CO2 exchange rate (1998–2015) for the coastal seas (Bauer et al, 2013).



Global riverine DIC flux to oceans (Li et al., 2017).

INTRODUCTION

The complexity of the carbon system in the inner shelf

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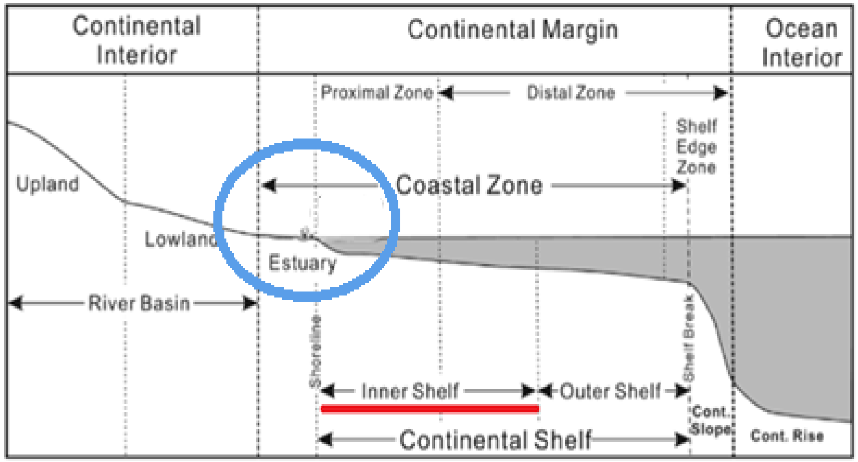
- High biological activity on the inner shelf, driven by estuarine nutrient inputs, can contribute to net CO_2 uptake.
- Inputs of inorganic carbon may increase CO_2 levels in shelf waters.
- Organic carbon inputs can enhance heterotrophic activity and increase CO_2.



Transect of a 2-D continental margin (Liu et al., 2010).

- The influence of estuarine nutrient and carbon exports on the primary production in the coastal zone is still unclear, and hence carbon sources and sinks at the estuary-coastal boundary may not be well accounted for.

KEY OBJECTIVES AND STUDY SITE

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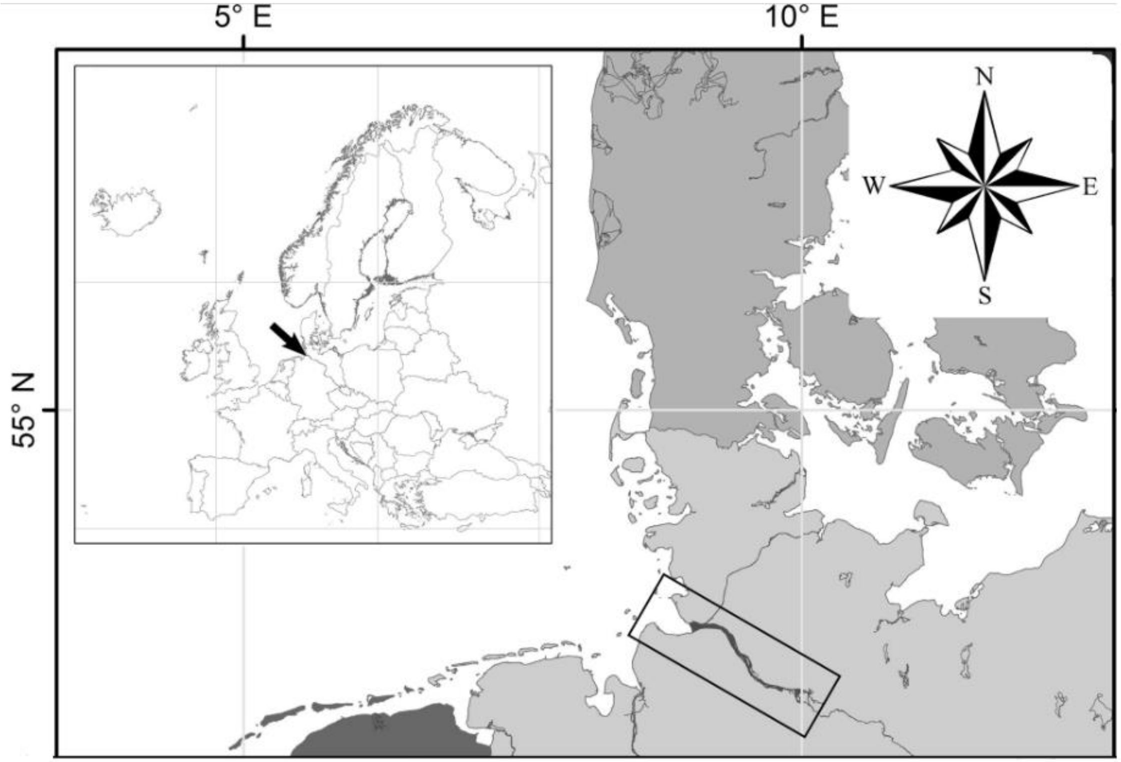
This study aims to identify the seasonal and annual variations in dissolved inorganic carbon (DIC) at the inlet of the Elbe estuary and in the adjacent coastal waters. These DIC changes will be linked to primary production and/or respiration.

- The Elbe River is the 4th largest river basin in central Europe (1,094 km, 148,268 km^2 catchment area), where its estuary extends from Geesthacht to the North Sea.



Location of the Elbe estuary in Northern Germany (Amann et al., 2012)

METHOD

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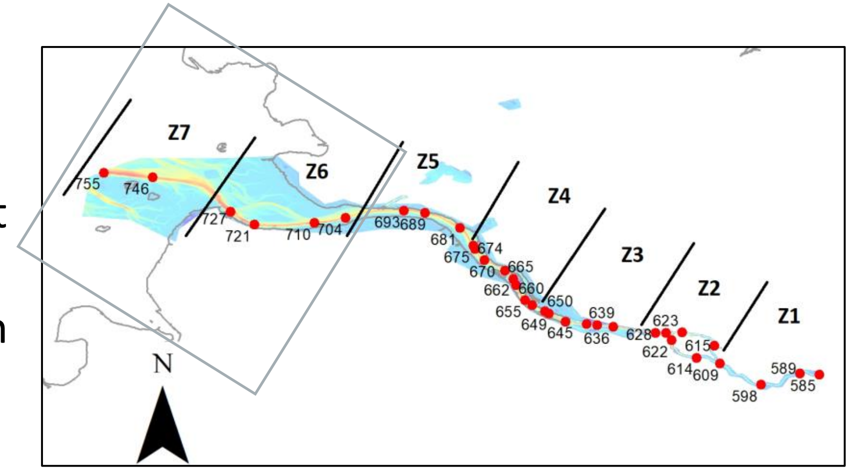
Method

- Utilize FGG Elbe data (1985 – 2018) for the Elbe estuary, North Germany.
- Focus on the lower Elbe estuary and adjacent coastal waters (Z6 and Z7)
- Mean seasonal DIC, pH and Dissolved Oxygen saturation were calculated for each year

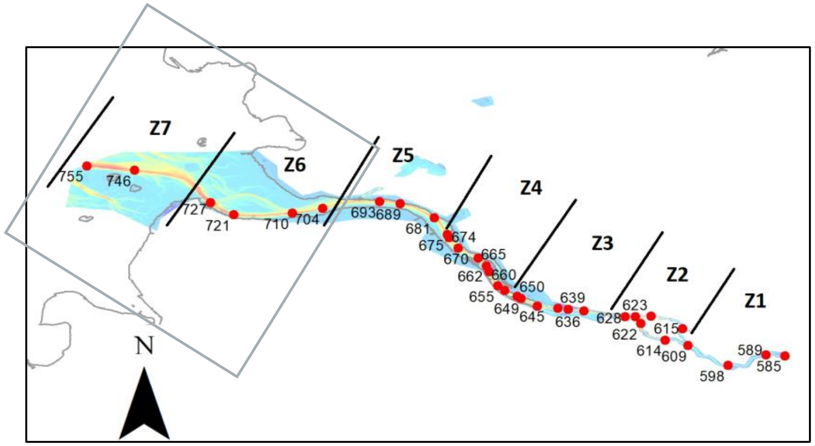


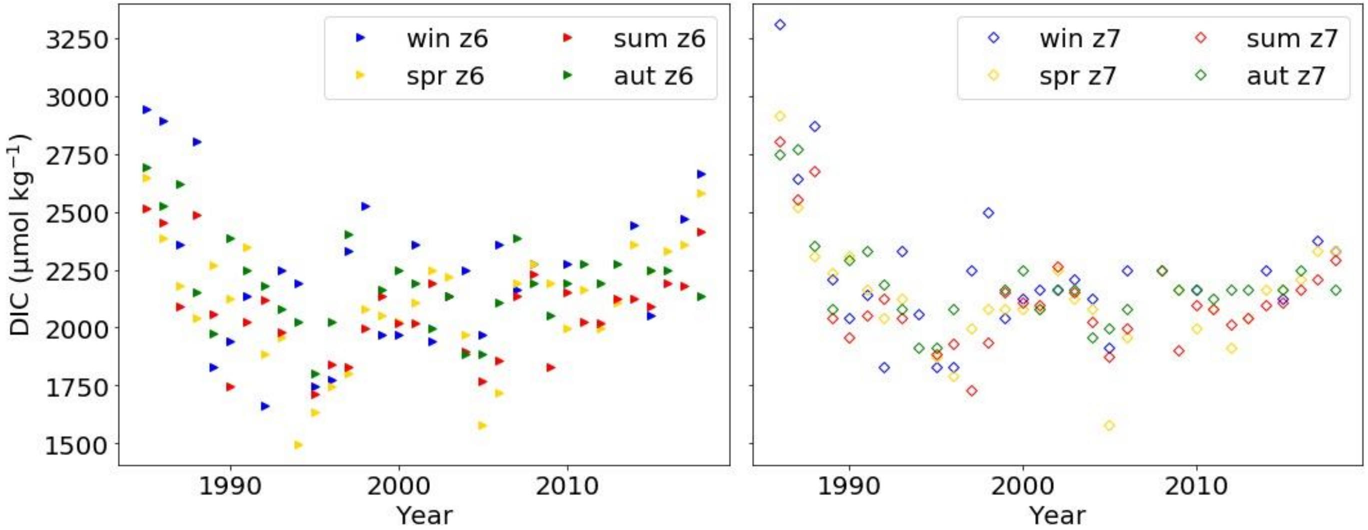
Zone	Elbe-km	Biogeochemistry characteristics	Salinity (psu)
1	586-610	High dissolved oxygen concentration due to upstream primary production imported or in situ primary production. Tidal influence until the weir at Geesthacht (Elbe-km 586).	<0.5
2	610-632	Hamburg harbor, oxygen levels decrease due to the shift from autotrophic to heterotrophic activity.	<0.5
3	632-650	Oxygen minimum zone	<0.5
4-5	650-704	Maximum turbidity zone, highest concentrations of suspended particulate matter.	<0.5-5
6	704-727	Lower estuary, the transitional zone from fresh to marine waters with increasing oxygen values.	>5-18
7	727-757	Outer estuary/coastal waters (German Bight), further increase in oxygen concentration.	>18-30

RESULTS

Seasonal DIC from 1985 to 2018

- DIC decreased from 1985 – 1995
- Fluctuations in DIC 1995 – 2010
- Enhanced DIC after 2010, steeper increase in the lower Elbe estuary (Z6).





Seasonal DIC from 1985 to 2018.

RESULTS

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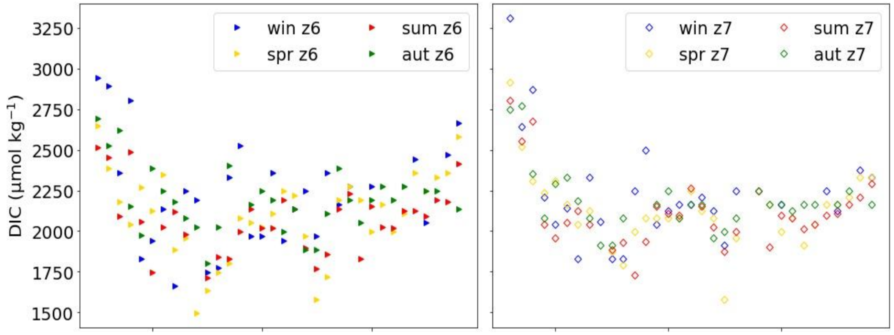
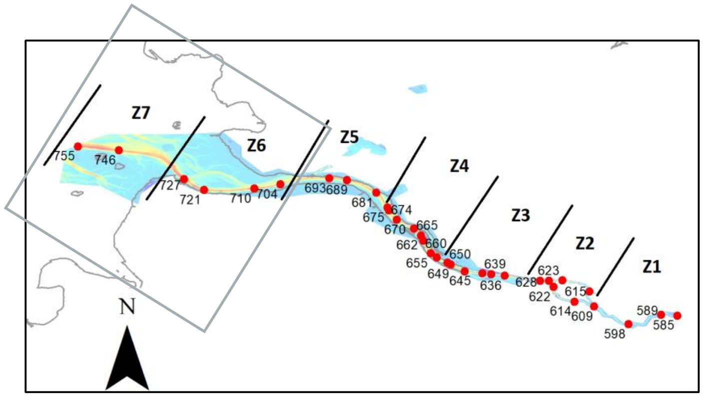
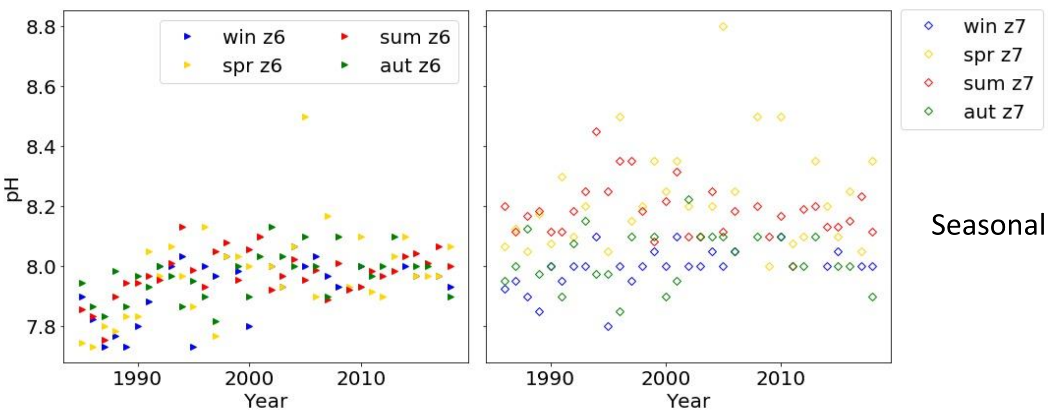
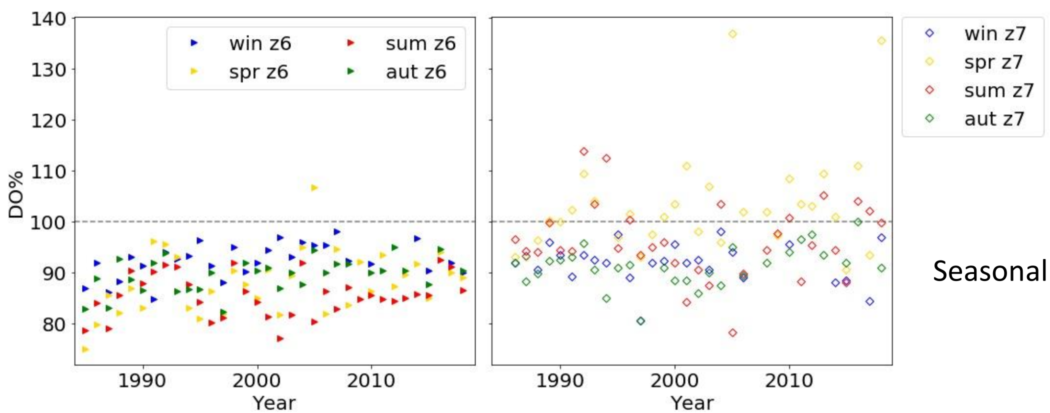


Seasonal DIC from 1985 to 2018.





Seasonal pH from 1985 to 2018.



Seasonal oxygen saturation from 1985 to 2018.

TIME-SERIES AT MOUTH OF ELBE ESTUARY

Spring-summer dissolved oxygen is high, often supersaturated

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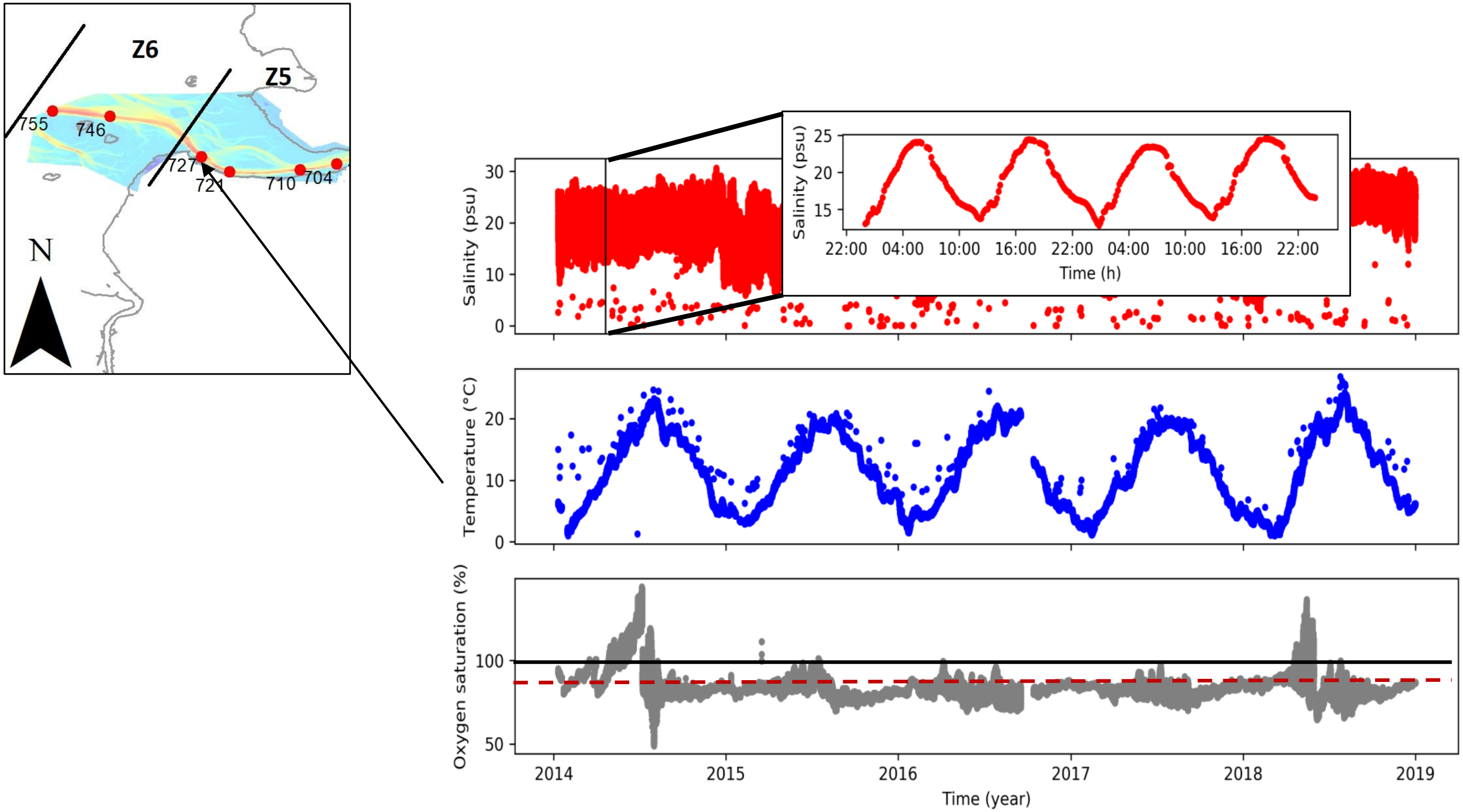

During spring and summer, dissolved oxygen at the Elbe estuary mouth is likely supersaturaled, indicating higher rate of photosynthesis than respiration. This modulates carbon cycling at the estuary-shelf boundary.

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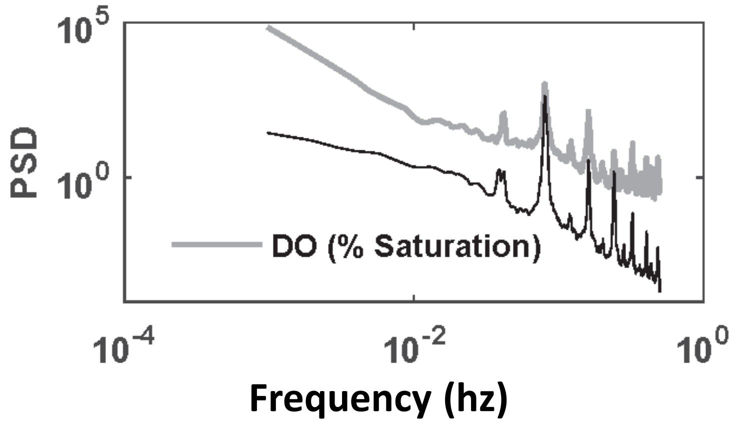
Key Findings

- DIC dynamics in lower Elbe estuary and adjacent inner shelf have dramatically changed over time.
- DIC reduction at the estuary-shelf boundary could be traced back to enhanced photosynthetic activity upstream (Amann et al. 2015) and on the inner shelf, not only during spring, but also in the summer (dissolved oxygen supersaturation and elevated pH).
- After 2010, DIC increased at the mouth of the estuary and slightly in the adjacent shelf region

Future Work

- Conduct time-series analysis to determine the influence of respiration/primary production on changes in DIC
- Incorporate the influence of nutrient loads on primary production



Voynova et al. 2017

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COSYNA monitoring network https://codm.hzg.de/codm/
FGG Elbe https://www.fgg-elbe.de/elbe-datenportal-en.html

COSYNA

SUPPLEMENTARY INFORMATION

FGG ELBE – Helicopter profiles

FGG Elbe data portal has ecosystem parameter readily available from 1985 up to 2018. The FGG Elbe acquired water samples in the estuary at a sample depth between the water surface and about 0.5 m every 5-10 km by helicopter (Figure 1). The survey started at the most downstream location at full ebb stream and was carried onward in upstream direction, ensuring that the measurements represent approximately the mean concentrations of both tidal phases (ARGE Elbe, 2000). Sampling at full ebb stream also ensures a more homogeneous distribution of the suspended matter in water column, compared to other tidal phases. There were almost monthly transects from 1985 to 1993. From 1994 to 2007 data were acquired in February, May, June, July, August and November.

Data includes temperature, conductivity (converted to salinity), oxygen concentration and saturation, nutrients, DIC, POC (1991-2011), DOC, TOC and pH.