FerryBox Workshop, April 7-8, 2016

Biogeochemical changes in the German Bight in response to the extreme June, 2013 Elbe flood

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April 8, 2016 / Heraklion, Crete

http://www.cassen-eils.de/die-reederei/unsere-flotte/ms-funny-girl/

AWI

BSH BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

FerryBox Group, KOI

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June 2013 Floods

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- Widespread flooding
- Danube and Elbe watersheds affected
- Billions of EUR in damages

Ionita et al. 2014
Schröter et al. 2014

http://www.ibnlive.com/news/india/death-toll-hits-10-in-european-flooding-9-missing-613772.html
http://www.theatlantic.com/photo/2013/06/flooding-across-central-europe/100530/

Elbe 2016 Flood Overview: Major System Changes

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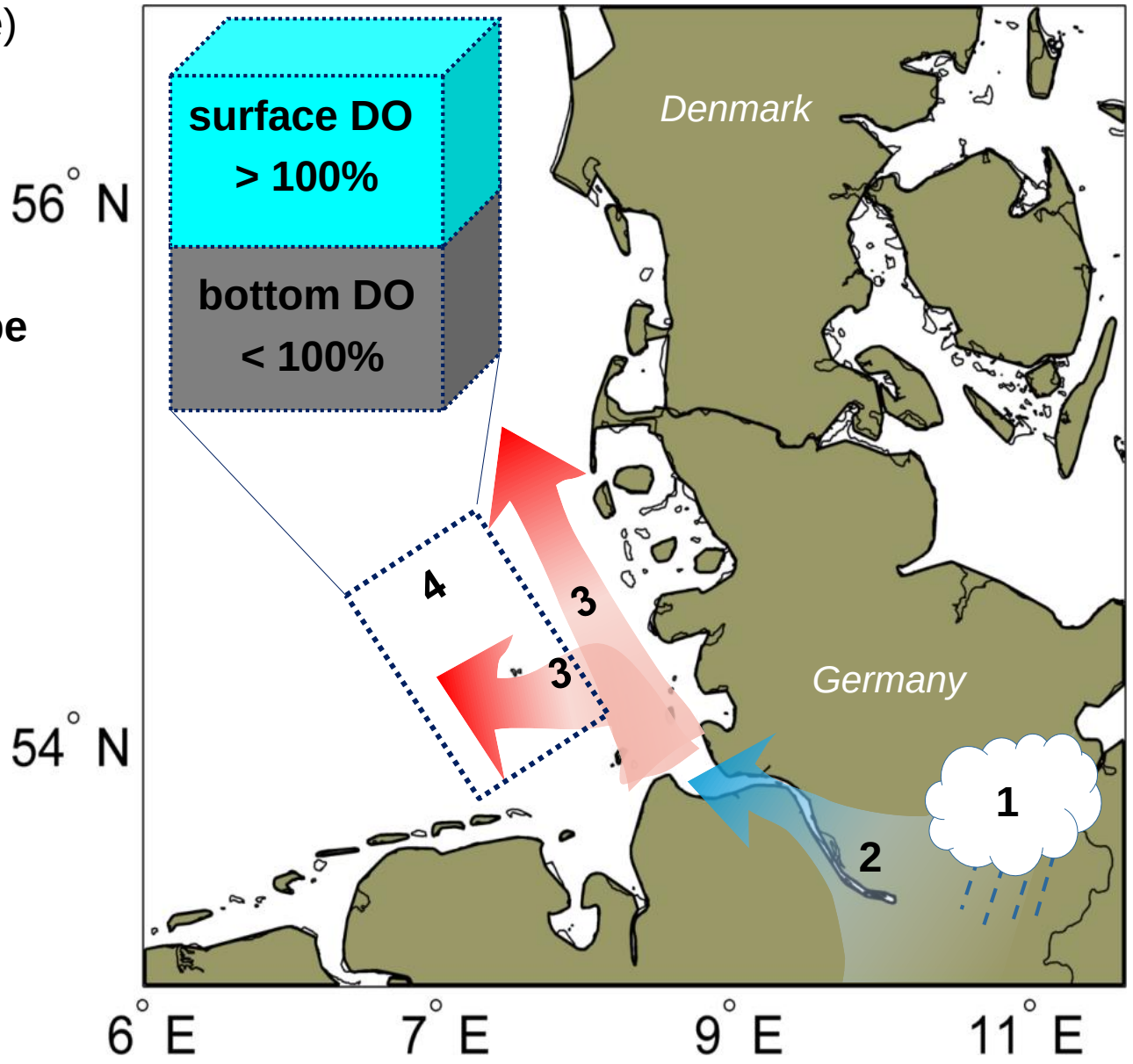
1. **Rain saturated soils:** (May-June)

2. **Extreme Elbe discharge:** June

3. **Large freshwater influx, high nutrients, DOC & POC from Elbe River and onto the German Bight:**(June-July)

4. **2-month stratification; high primary production in surface; widespread DO depletion in bottom waters**



Changes in the Elbe Estuary: two fixed tidal stations

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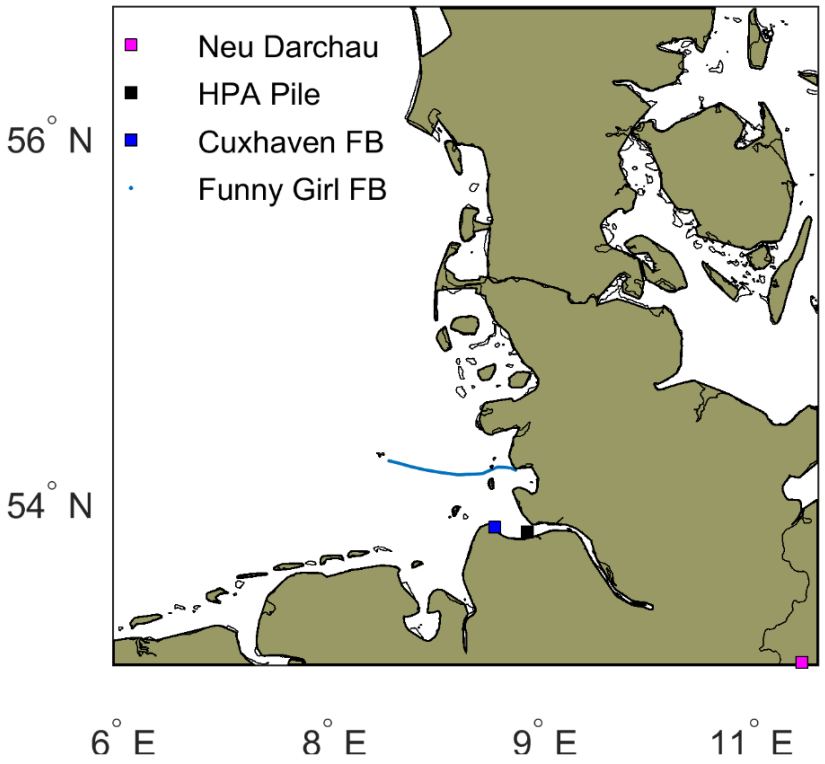

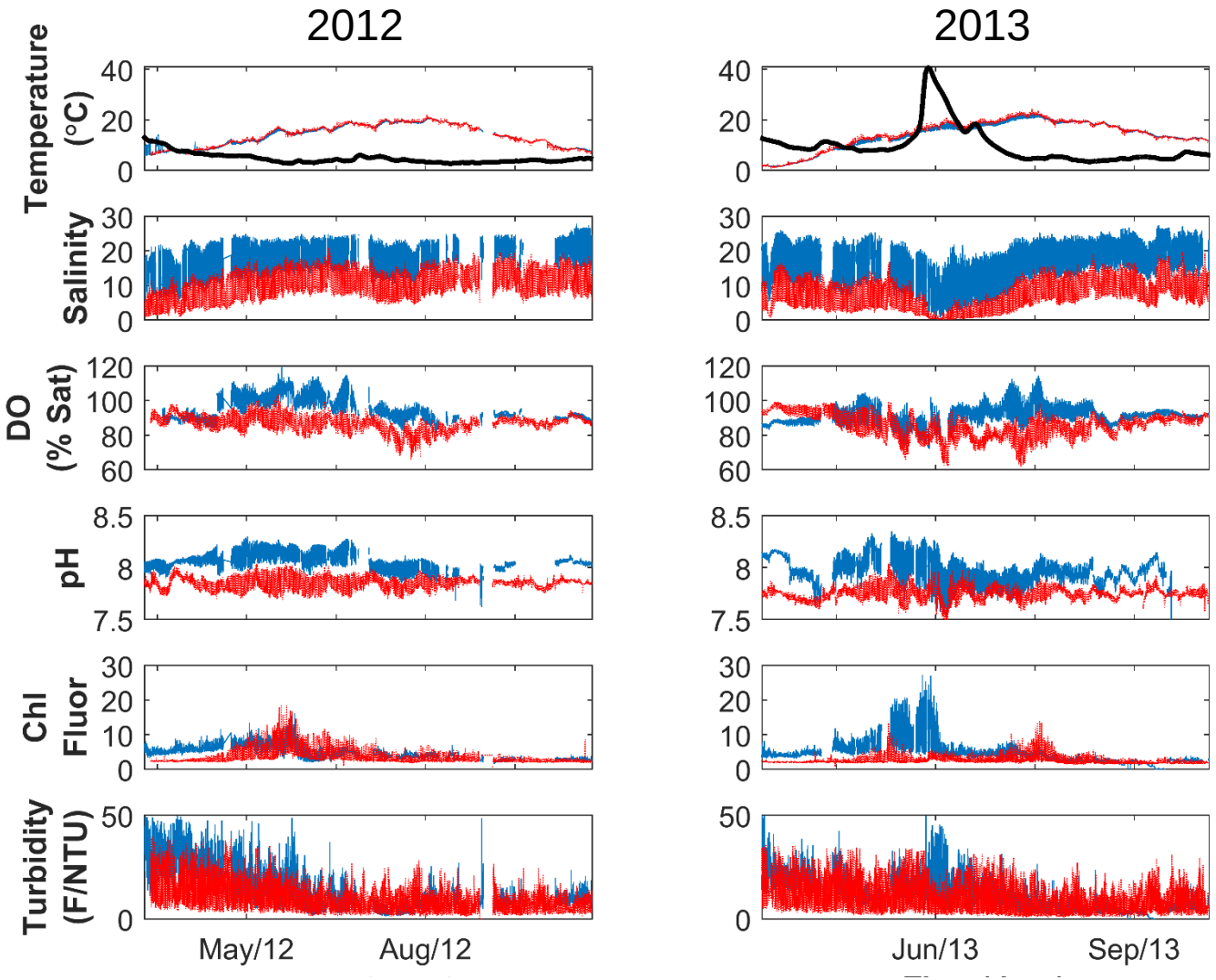

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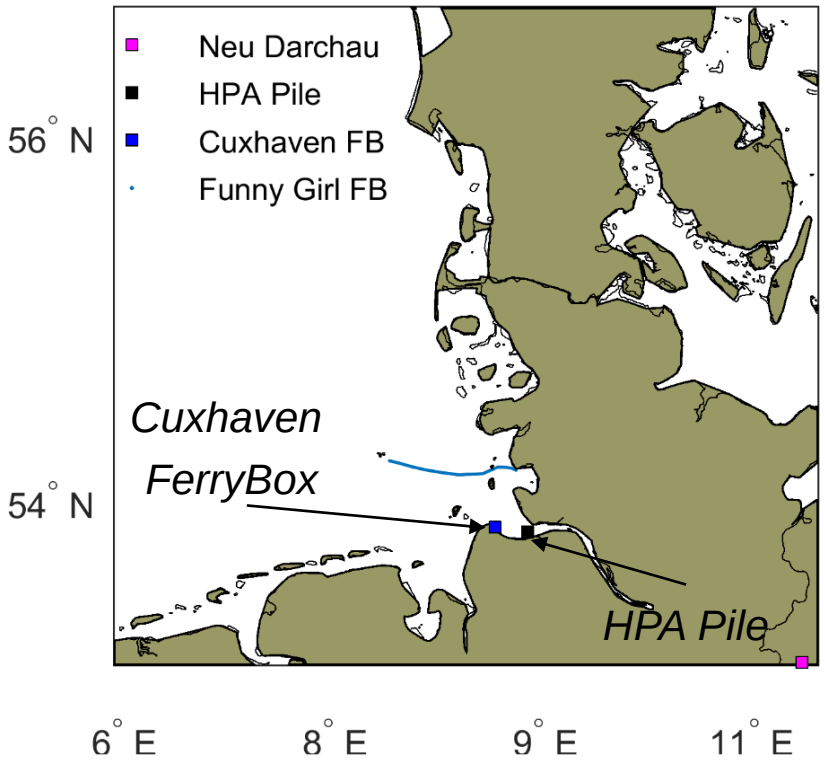

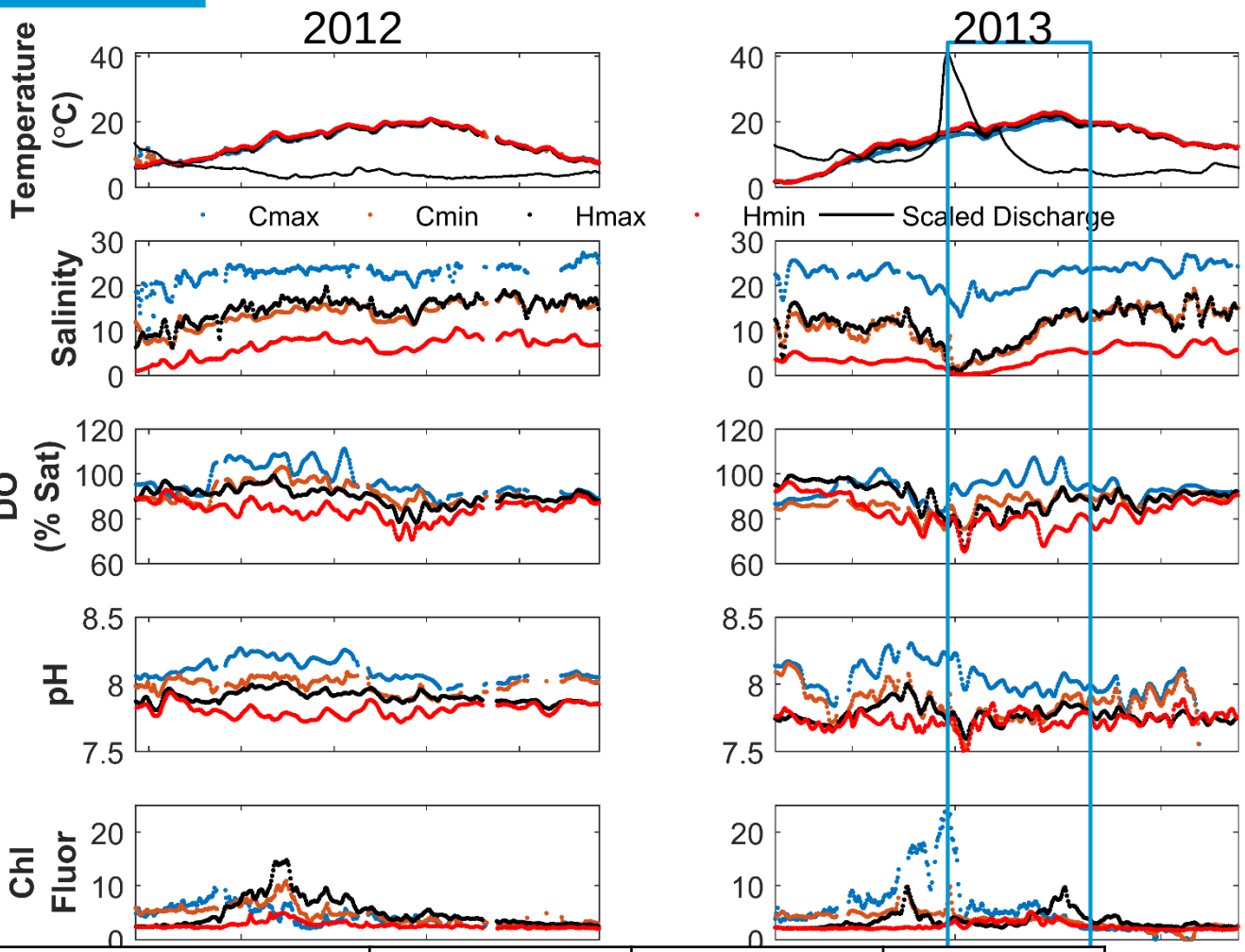

4-5 days after peak Elbe discharge:

- Cuxhaven Salinity ~ 0 at low tide
- Cuxhaven tidal range doubled
- DO
- Cux

1-2 mo

- salir
- Chl

12 June – 8 July 2013	$NO_3 + NO_2$ (t d^{-1})	NH_4 (t d^{-1})	PO_4 (t d^{-1})	Si (t d^{-1})
min	200	5	3	400
max	1100	28	15	1300
June Avg (1996-2005)	105	na	2.3	24

Changes in the German Bight: *Funny Girl* FerryBox

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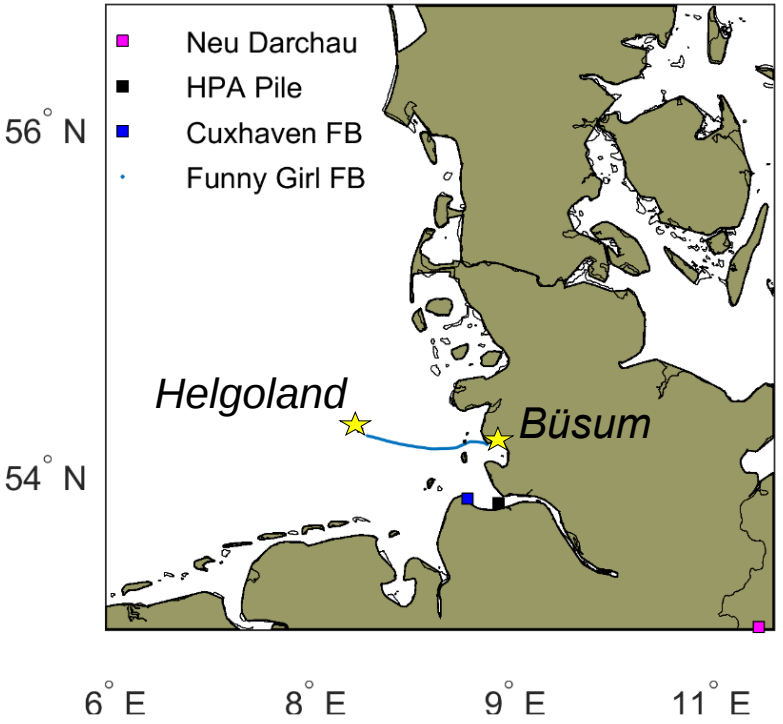

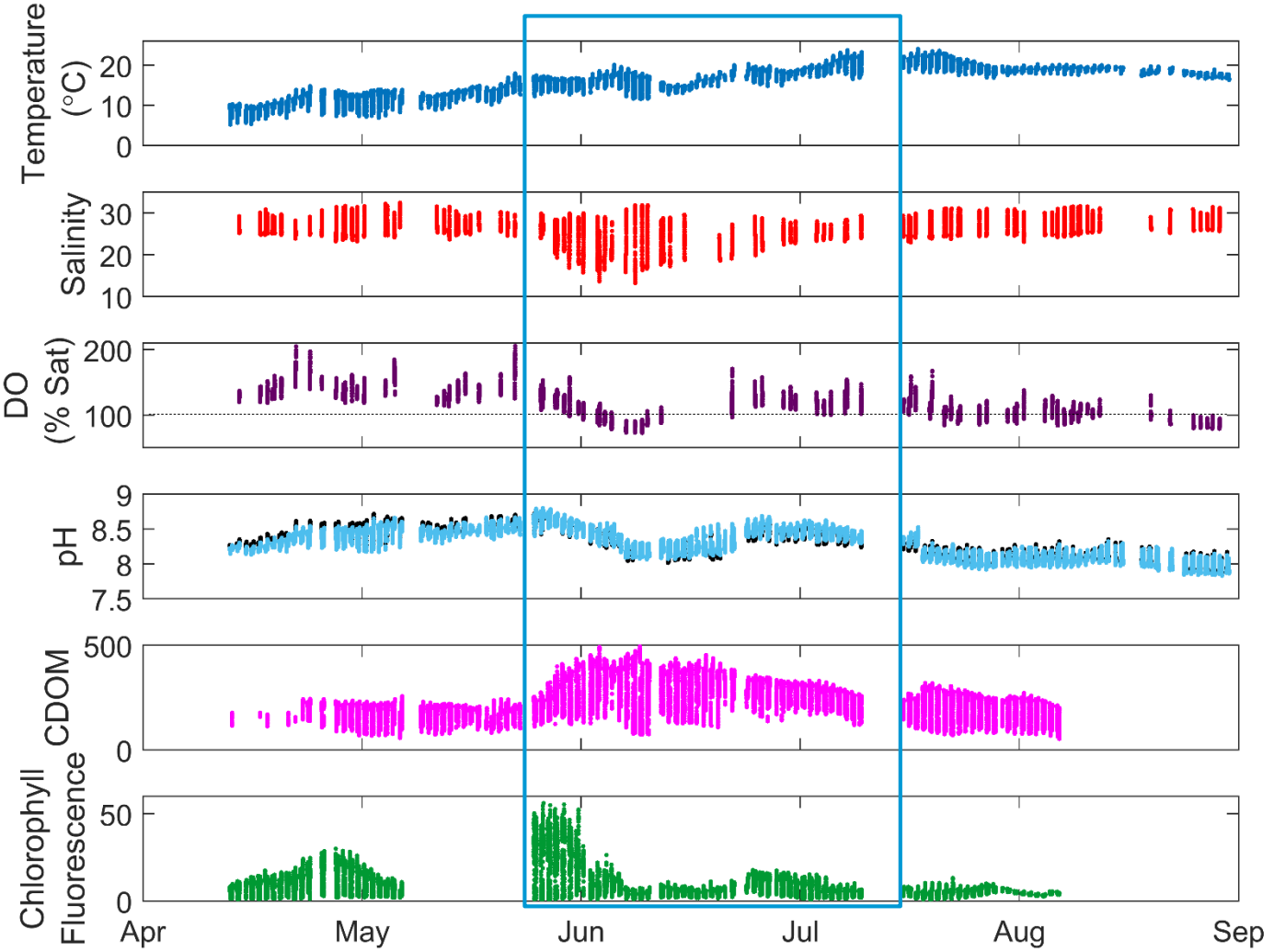

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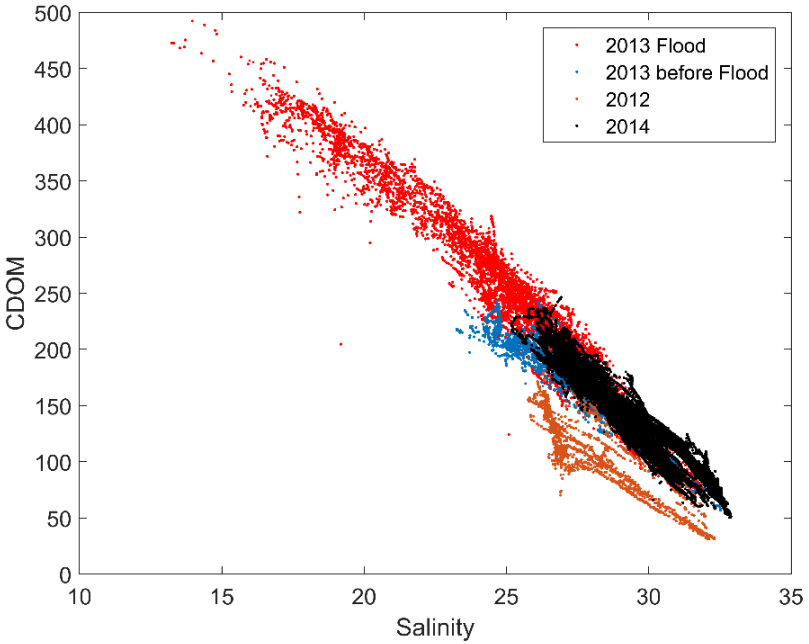

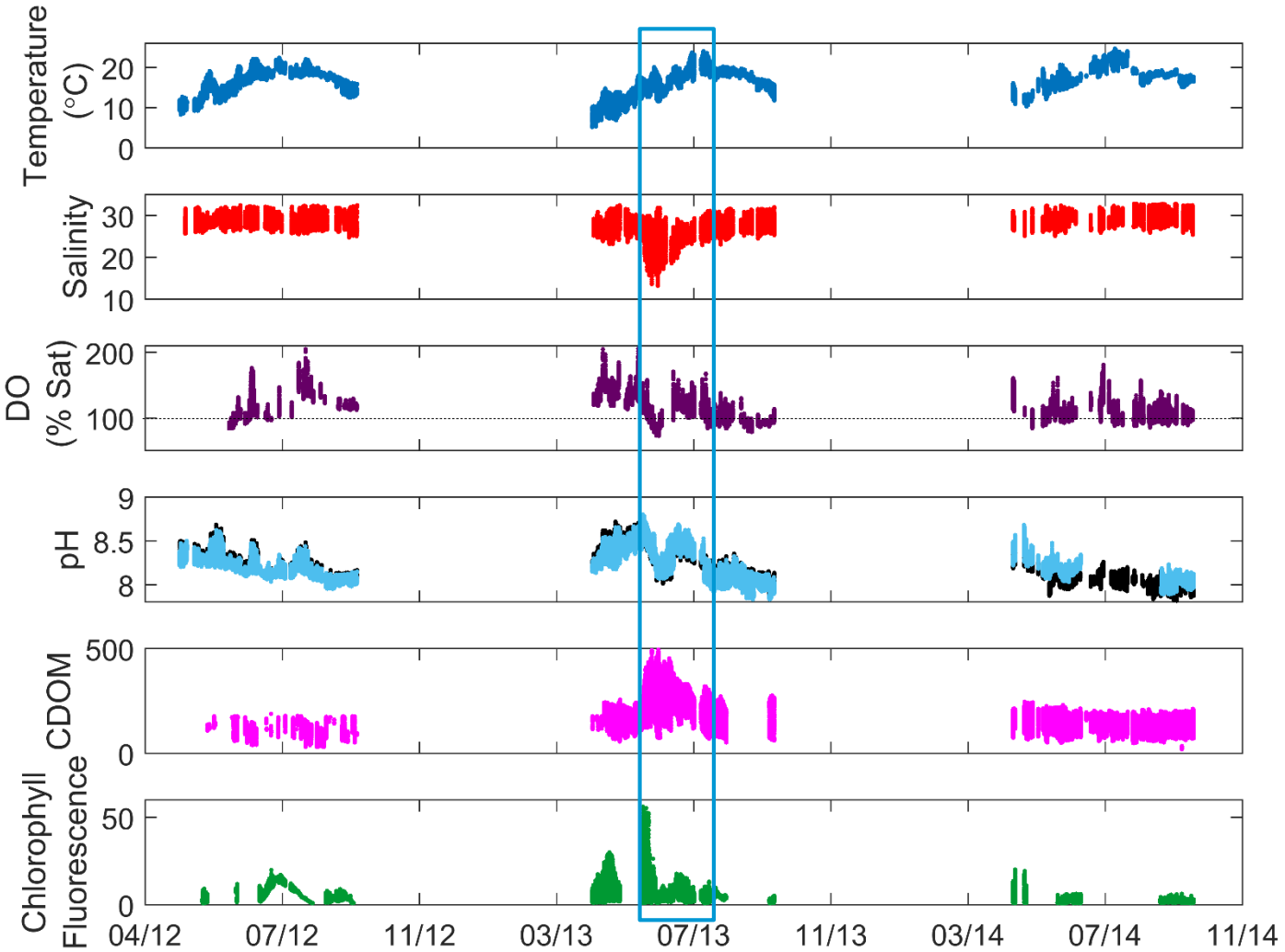

4 days after peak Elbe discharge:

- Salinity decreases below 15
- DO < 100 %, low pH
- DOC doubles
- High Chl fluorescence crashes

1-2 months after:

- salinity over whole transect is depressed
- High pH & DO > 100% Sat indicate a bloom formed after storm

Changes in the German Bight: *Funny Girl* FB

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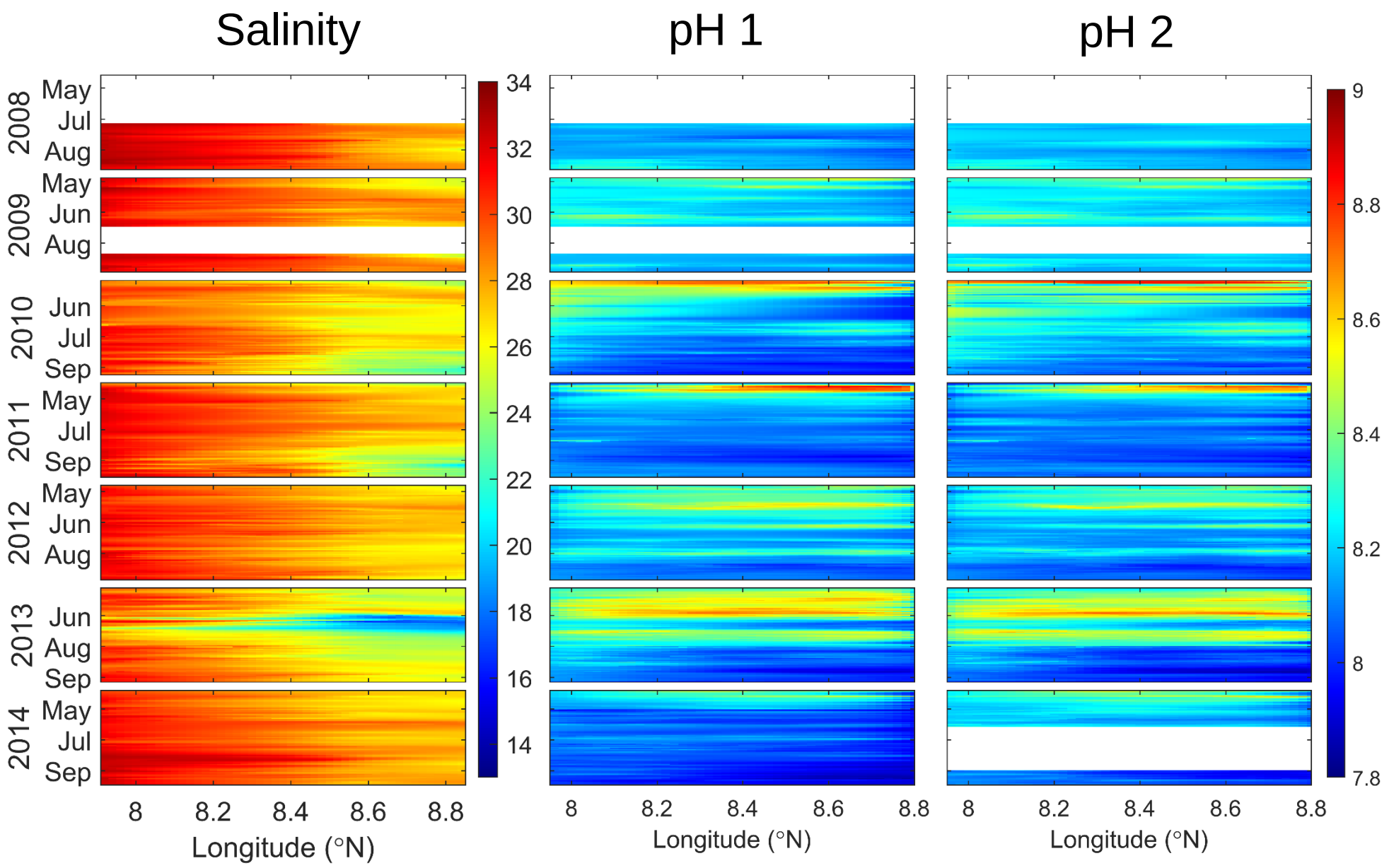

Changes in the German Bight: *Multiple data sources*

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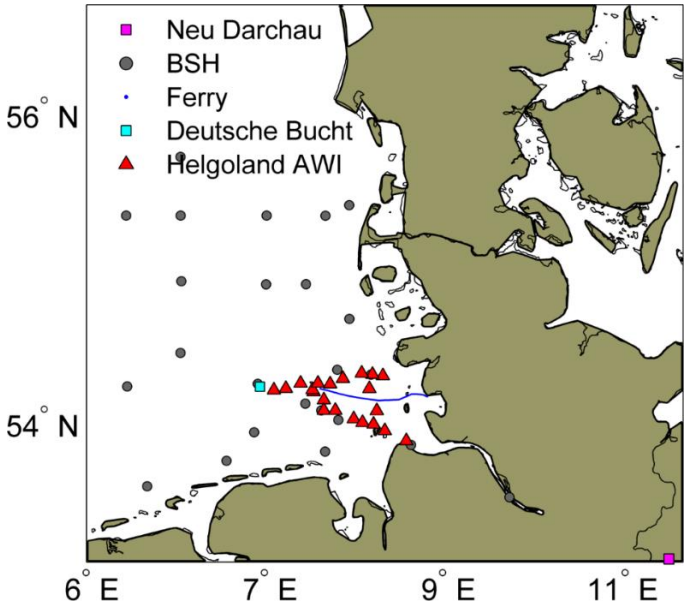

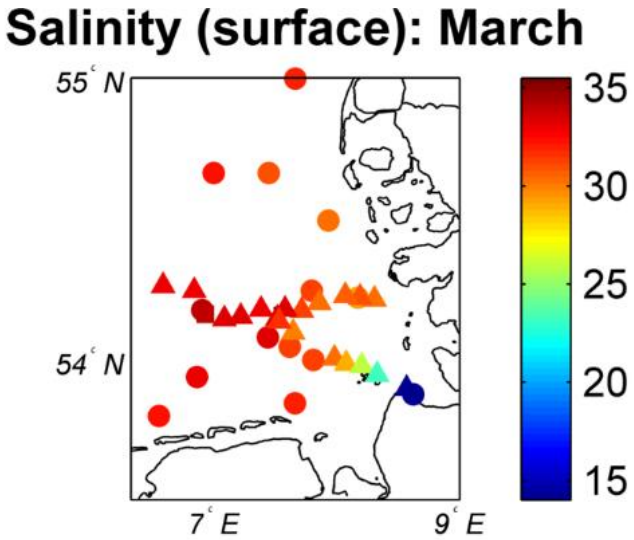

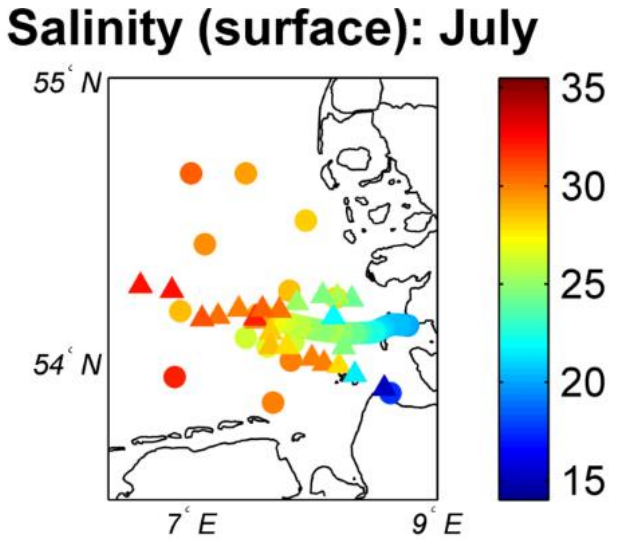

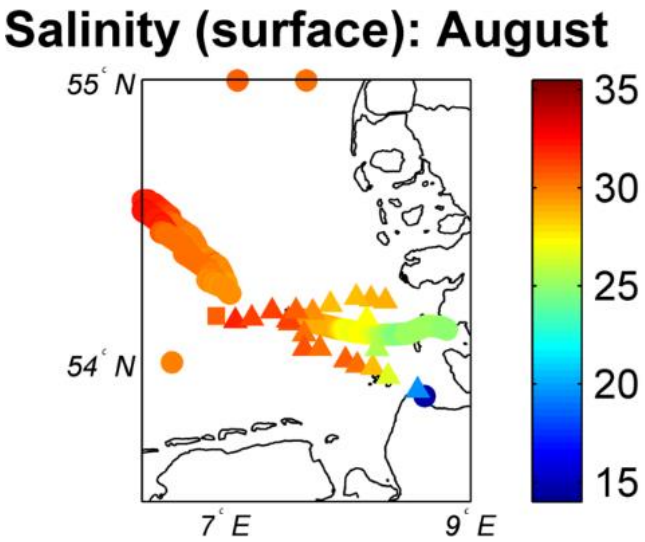

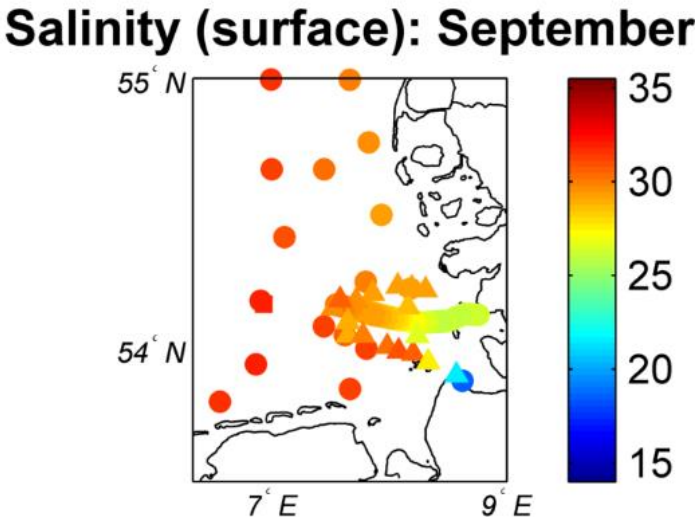

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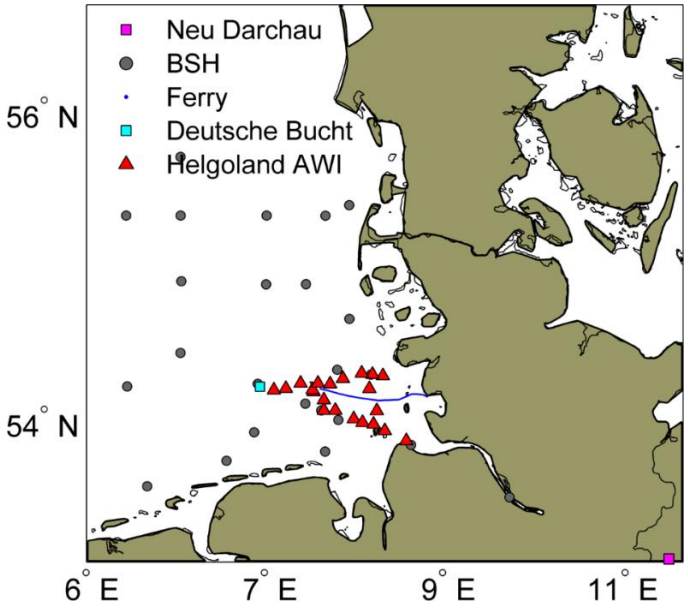
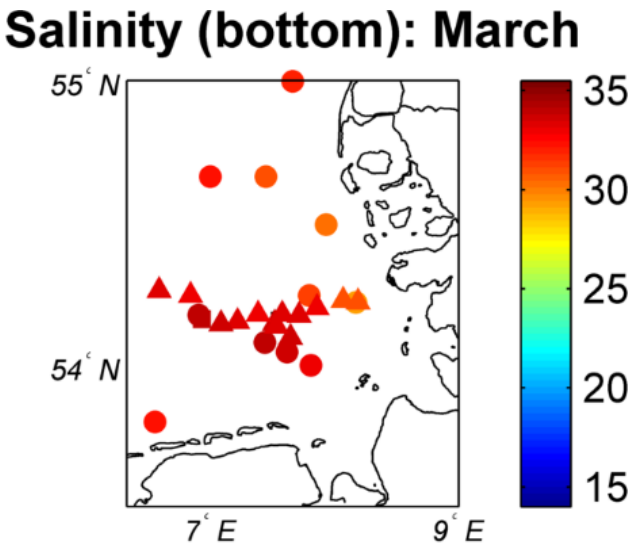
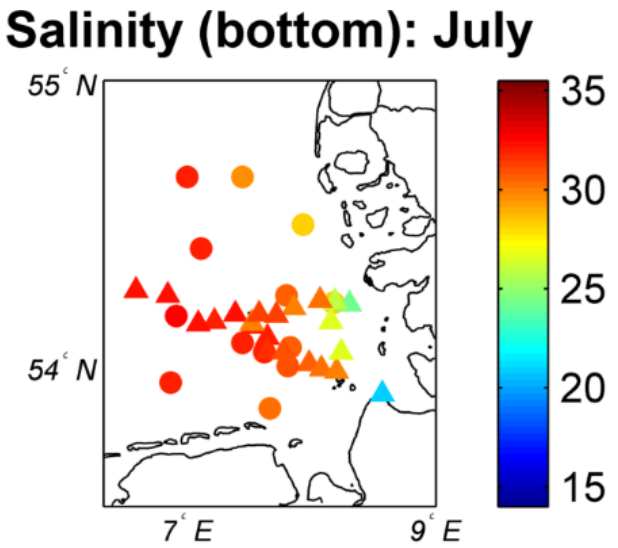
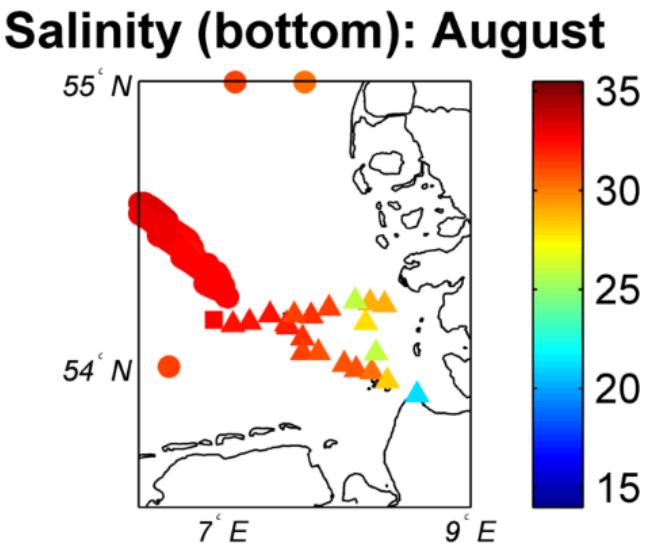


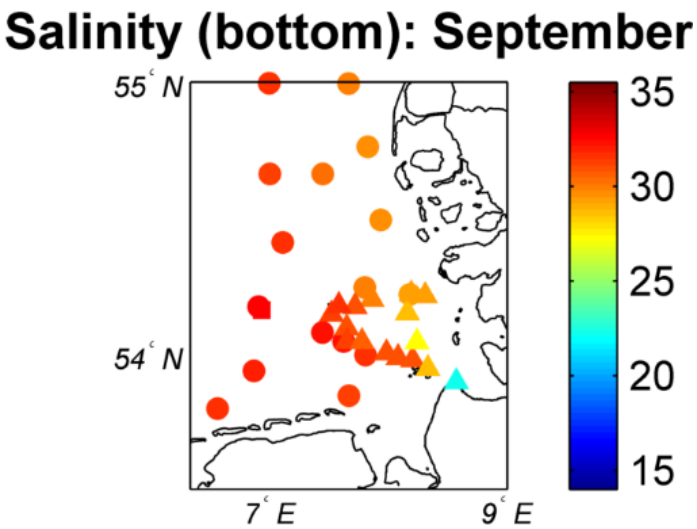




1-2 months after flood:

- Persistent stratification on German Bight





Changes in the German Bight: *Multiple data sources*

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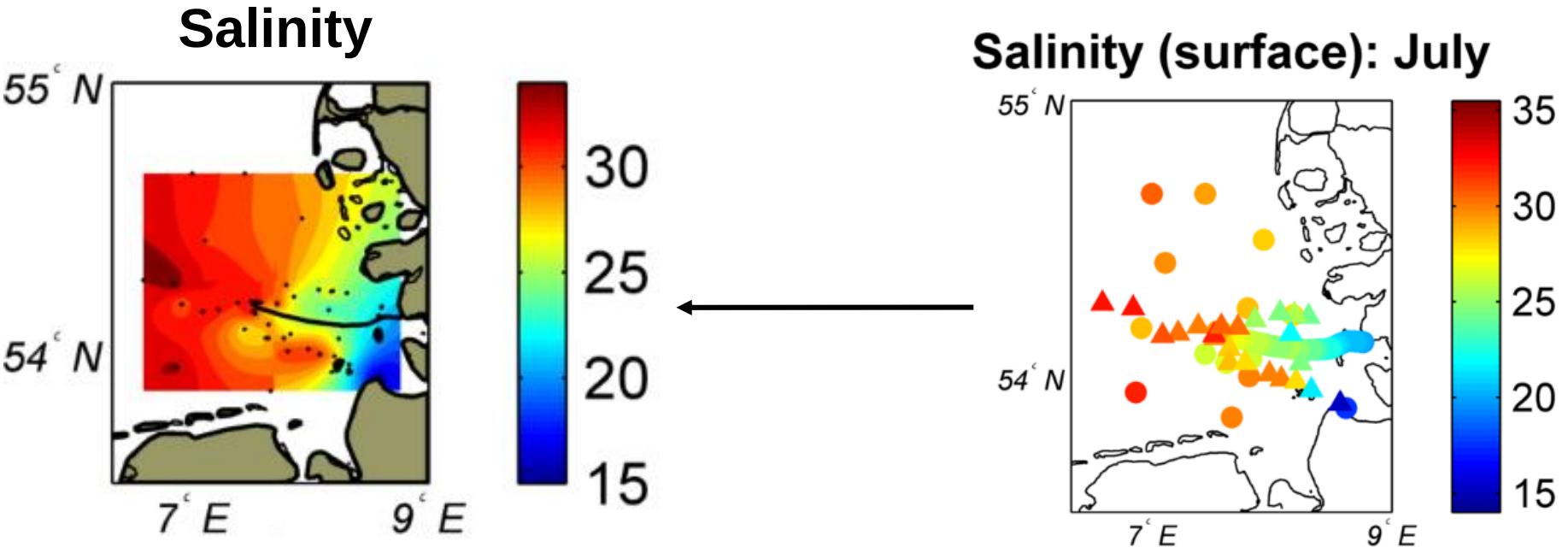

Changes in the German Bight: *Dissolved oxygen*

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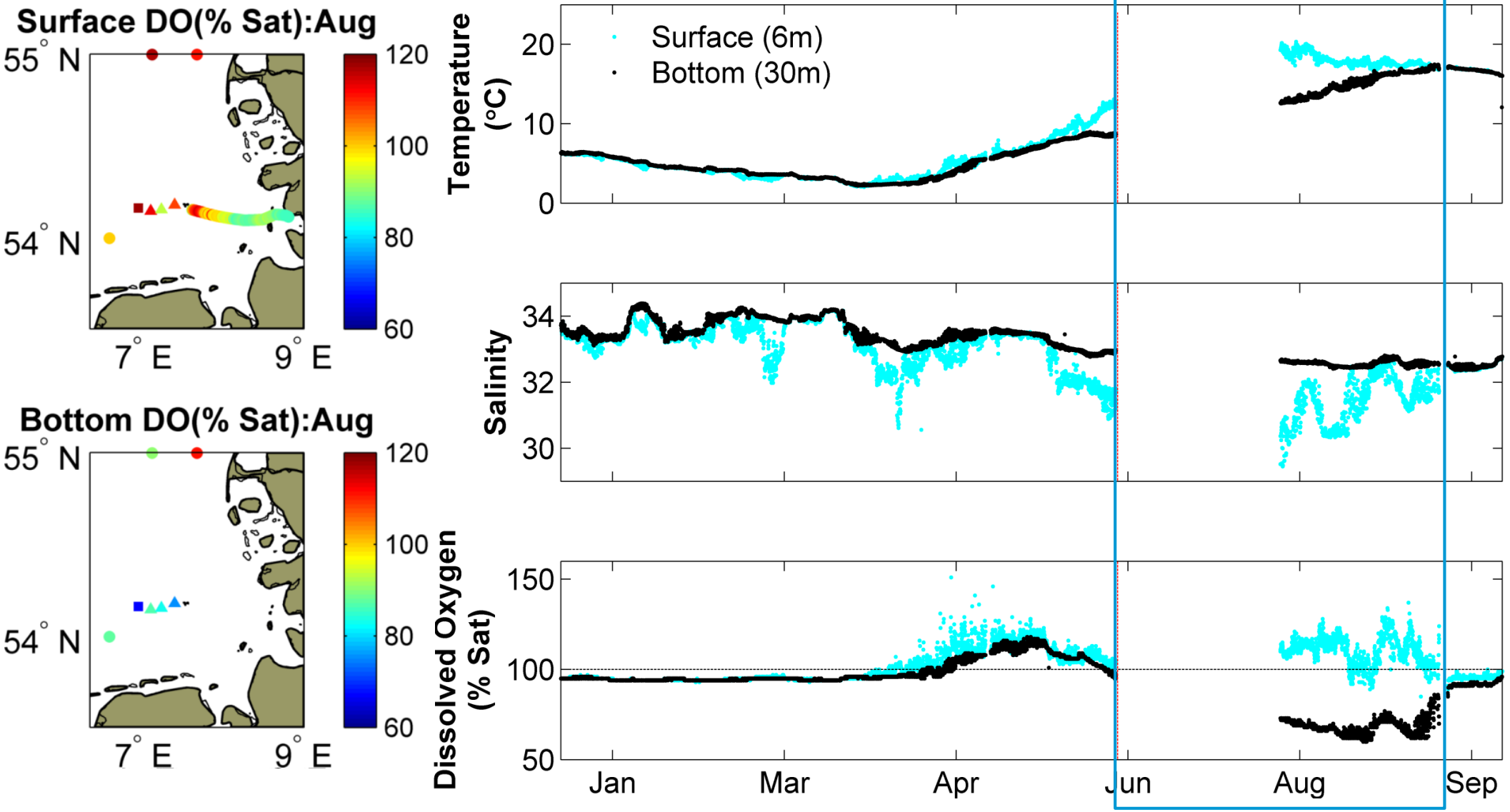

Why do we care?

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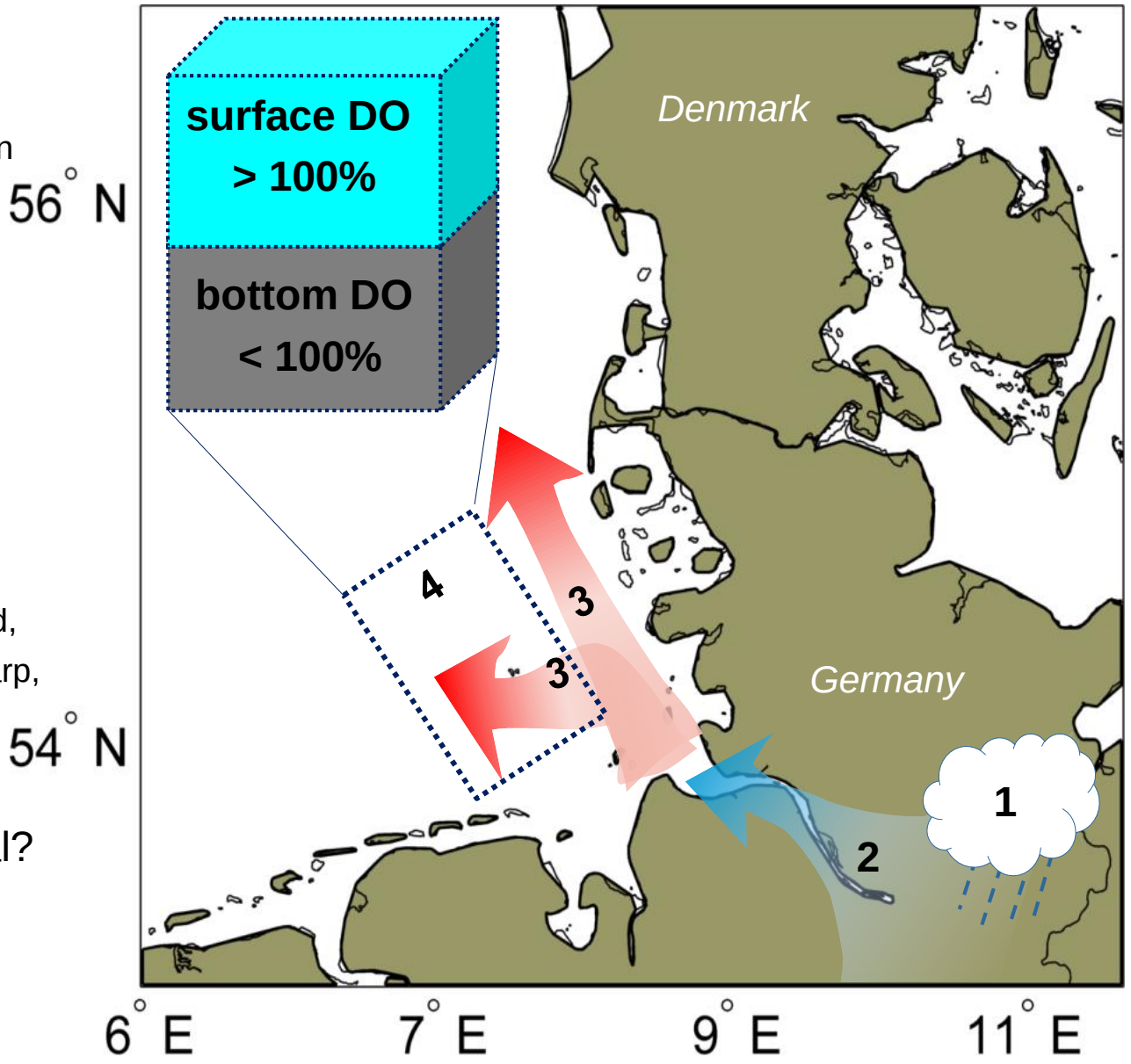
- Increased frequency of extreme rainfall events, particularly during summer months (Karl et al. 1995; Allan and Soden, 2008; Christensen and Christensen, 2015; IPCC, 2014)
- Observed increases in summer temperatures (Luterbacher et al. 2016)
- Floods have major impact on coastal regions (Schubel and Pritchard, 1986; Scavia et al. 2002; Voynova and Sharp, 2012; Wetz and Yoskowitz, 2013)
- Altered conditions the new normal?



June 2016 discharge: Extreme event

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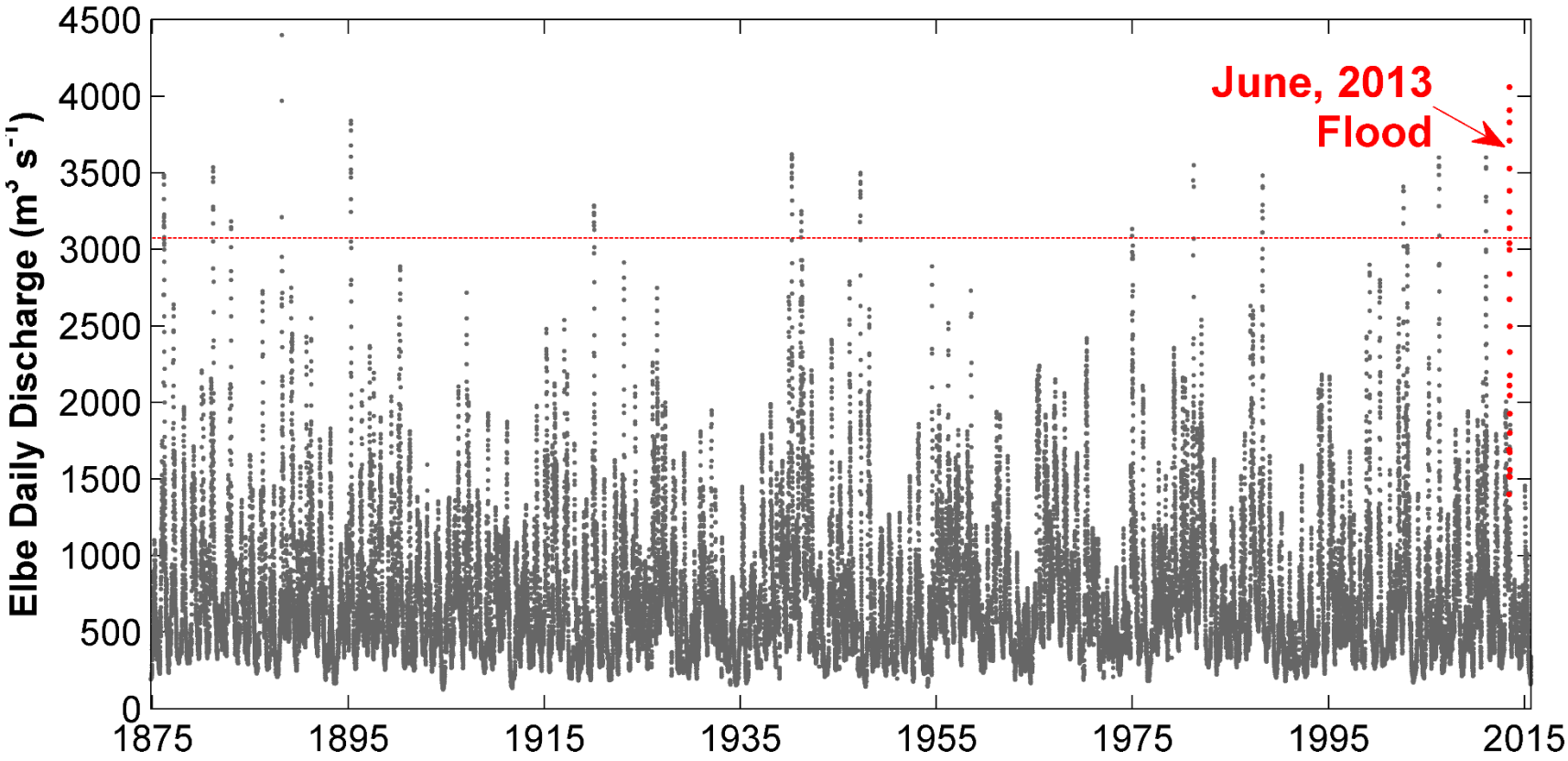

Return Period (years)	Threshold Discharge ($m^3 s^{-1}$)	% Occurrence (last 15 years)
50-year event	3901	**60**
25-year event	3566	**35**
10-year event	3076	**22**
5-year event	2653	**20**

Conclusions

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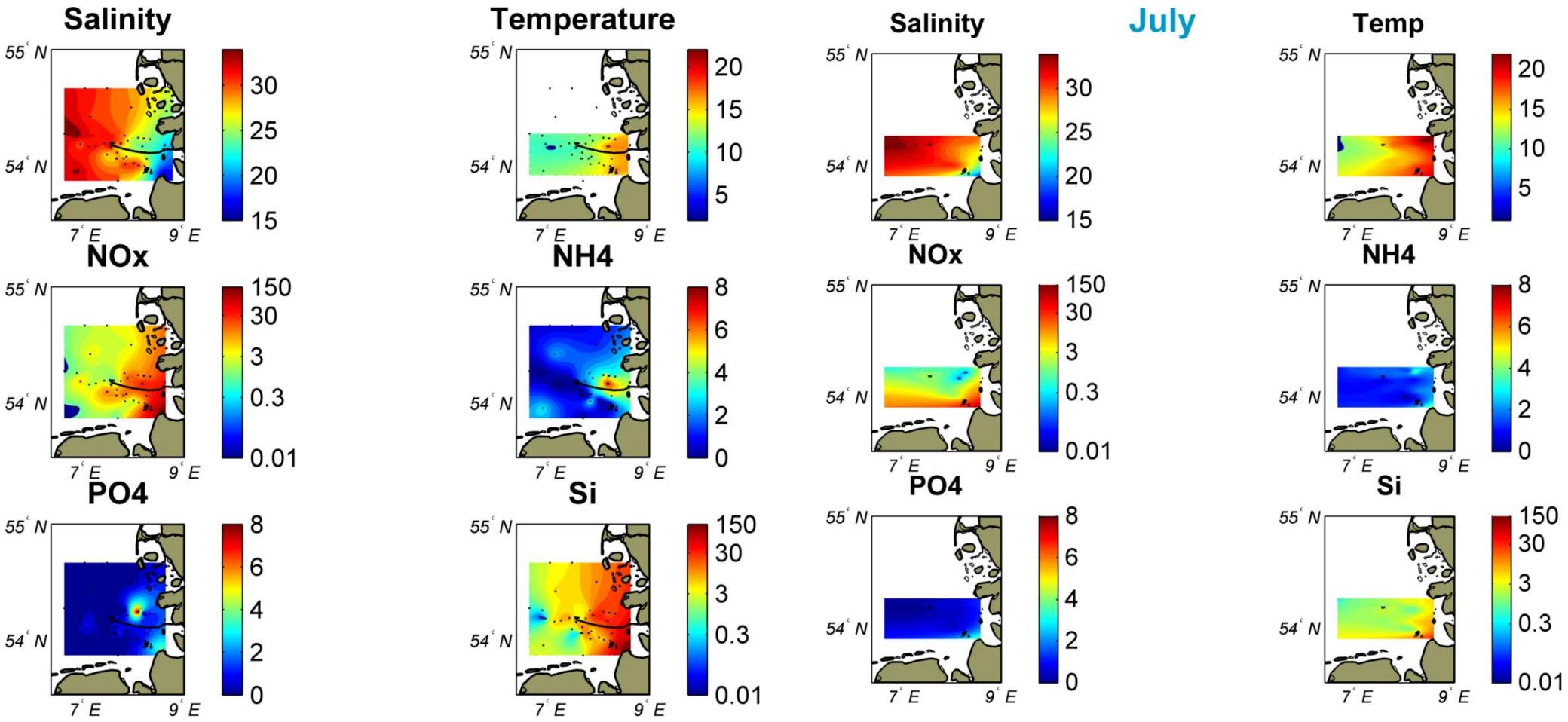
June, 2013 flood was the largest summer discharge over 140 years. It generated:

- large nutrient, dissolved and particulate organic carbon on the German Bight
- prolonged, 2 month-long stratification on the coast, uncharacteristic chlorophyll bloom, dissolved oxygen supersaturation in surface, and undersaturation in bottom waters

These altered biogeochemical patterns may become more prevalent with climate change, since the frequency of large and extreme discharges has increased in the past 15 years.

Implications

- Coastal systems are vulnerable to predicted and observed hydrologic shifts, associated with climate change
- Altered biogeochemical responses in coastal carbon and nutrient cycles may become more prevalent, with increased frequency of large and extreme discharges
- These altered conditions should be considered for future management and modeling of coastal systems


Salinity
Temperature
Salinity
July
Temp
NOx
NH4
NOx
NH4
PO4
Si
PO4
Si
55° N
54° N
7° E
9° E
30
25
20
15
20
15
10
5
150
30
3
0.3
0.01
8
6
4
2
0

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