Decadal phytoplankton biomass variability in two contrasted French coastal ecosystems in a climate change context

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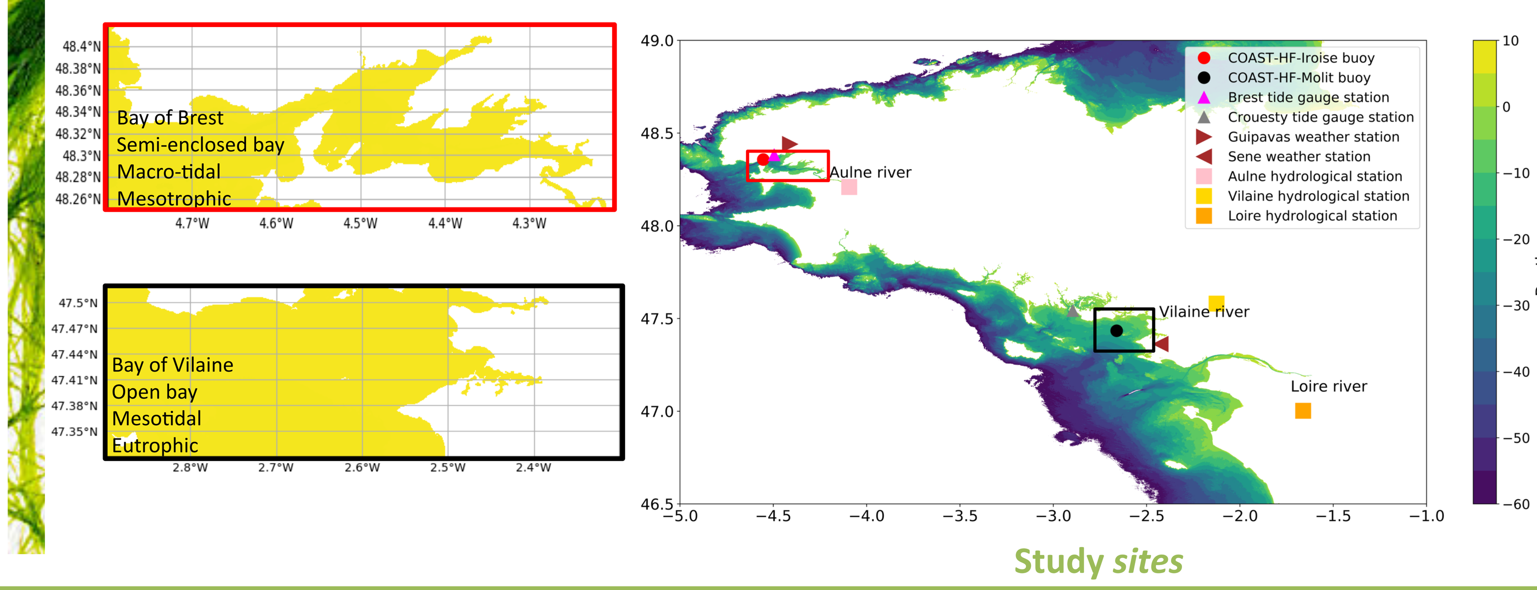
Aims

- ❑ To detect and characterize **phytoplankton blooms** in two **contrasted coastal ecosystems**
- ❑ To describe the **interannual variability** of phytoplankton blooms in a **context of climate change**
- ❑ To explore the impacts of **extreme hydro-meteorological events** such as **cold waves** [3], **exceptional floods** [4] or **wind storms** [5] during the **productive period**

1. *In situ* observations

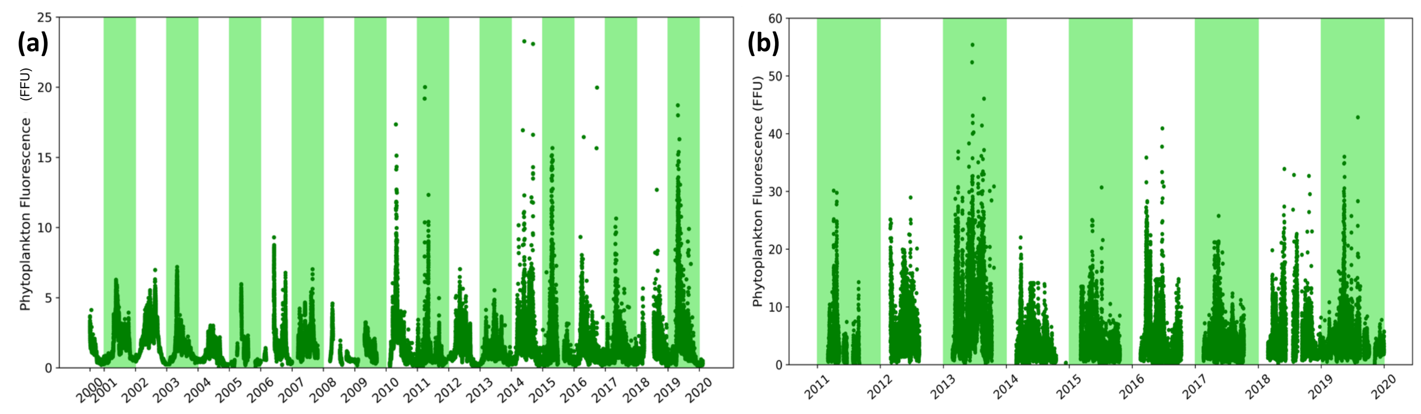


Study sites

- **Ocean *in situ* observations**
  COAST-HF-Iroise and **COAST-HF-Molit**
  High-frequency measurements
  (20 min sampling)
  SOMLIT-Brest and **REPHY-Loscolo**
  Low-frequency measurements
  (15 days sampling)
- **Rivers *in situ* observations**
  Daily average discharge of the Aulne, Vilaine and Loire rivers (Hydro.eauFrance)
- **Meteorological *in situ* observations**
  Mean daily PAR and wind intensity
  Guipavas and Séné station (Météo-France)

2. Processing of the main time series: fluorescence

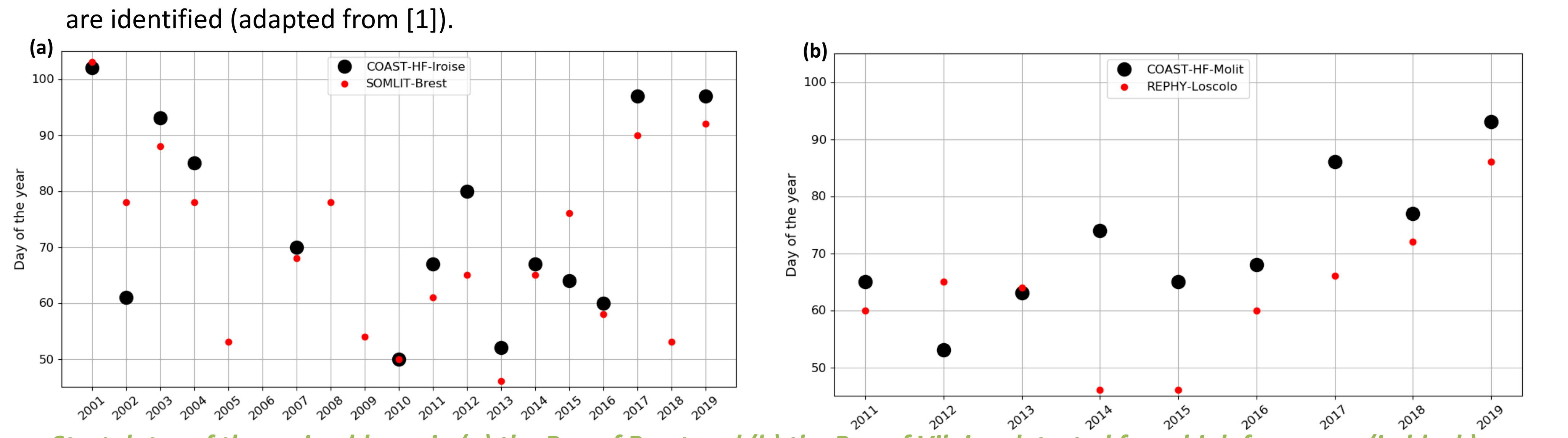
- Analysing **fluorescence** time series as a proxy for chlorophyll concentration (phytoplankton biomass)
- Filtering out the **Quenching effect**: data from 10pm to 5am as defined in [6]
- Focusing on the growing period initiation: **Spring**



Fluorescence time series in (a) the Bay of Brest (2001-2019) and (b) the Bay of Vilaine (2011-2019)

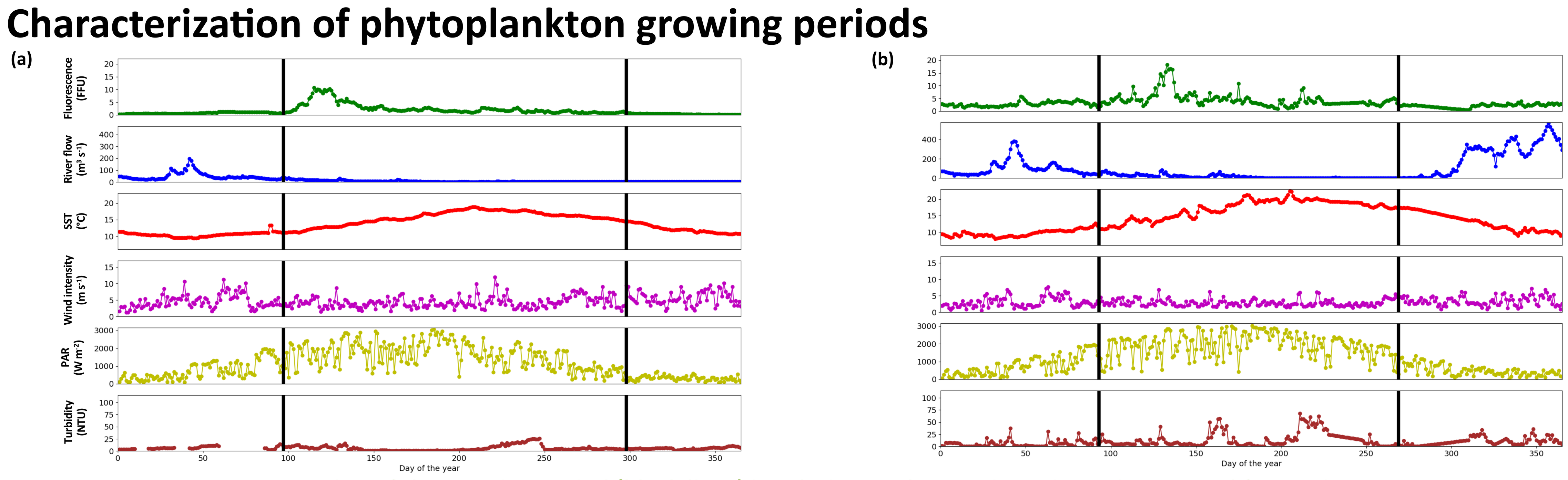
3. Identification of phytoplankton growing periods

Based on the slope gradient variation over a moving 5-days window, the start and end dates of the productive period are identified (adapted from [1]).



Start dates of the spring bloom in (a) the Bay of Brest and (b) the Bay of Vilaine detected from high frequency (in black) and low frequency (in red) time series

4. Characterization of phytoplankton growing periods



Detection of the growing period (black lines) in relation to changes in main environmental factors in 2019 for (a) the Bay of Brest and (b) the Bay of Vilaine

	Start date	End date	Duration	Intensity
Bay of Brest	69	274	200	364
Bay of Vilaine	68	269	179	582

Median feature of phytoplankton growing periods at both sites

	Min PAR (W m^{-2})	Min SST (°C)	Max River flow (m3 s^{-1})	Max Turbidity (NTU)	Max Wind intensity (m s^{-1})	Mean Wind direction
Bay of Brest	915	7.9	100	21.0	6.3	NW
Bay of Vilaine	814	8.0	205	21.6	3.8	SW

Average environmental conditions that influence the start of the phytoplankton pgrowing period

The growing period always start with a minimum of 0.6 and 2.4 FFU for the Bay of Brest and the Bay of Vilaine, respectively.

Spring blooms mostly begin at low tides in accordance with [7]

A large interannual variability of the beginning and ending dates of bloom is detected. Median dates of blooms are similar between both sites, but bloom duration and the cumulative intensity (FFU) are different

The environmental conditions for the onset of the first spring bloom are similar for both sites: a PAR value at least about 800-900 W m^{-2}, a SST of about 8°C, low coastal wind intensity, low river flow and turbidity conditions with a wind direction towards the coast

5. Impact of extreme hydro-meteorological events

Year	Number of events		Duration (days)		Anomaly value (°C)	
2001	0	X	0	X	0	X
2002	0	X	0	X	0	X
2003	1	X	8	X	-0.12	X
2004	1	X	8	X	-0.15	X
2005	0	X	0	X	0	X
2006	1	X	7	X	-0.16	X
2007	0	X	0	X	0	X
2008	0	X	0	X	0	X
2009	1	X	30	X	-0.20	X
2010	1	X	30	X	-0.18	X
2011	1	1	9	10	-0.16	-0.03
2012	0	0	0	0	0	0
2013	0	2	0	12 | 10	0	-0.05 | -0.12
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	1	0	30	0	-0.16
2019	0	0	0	0	0	0

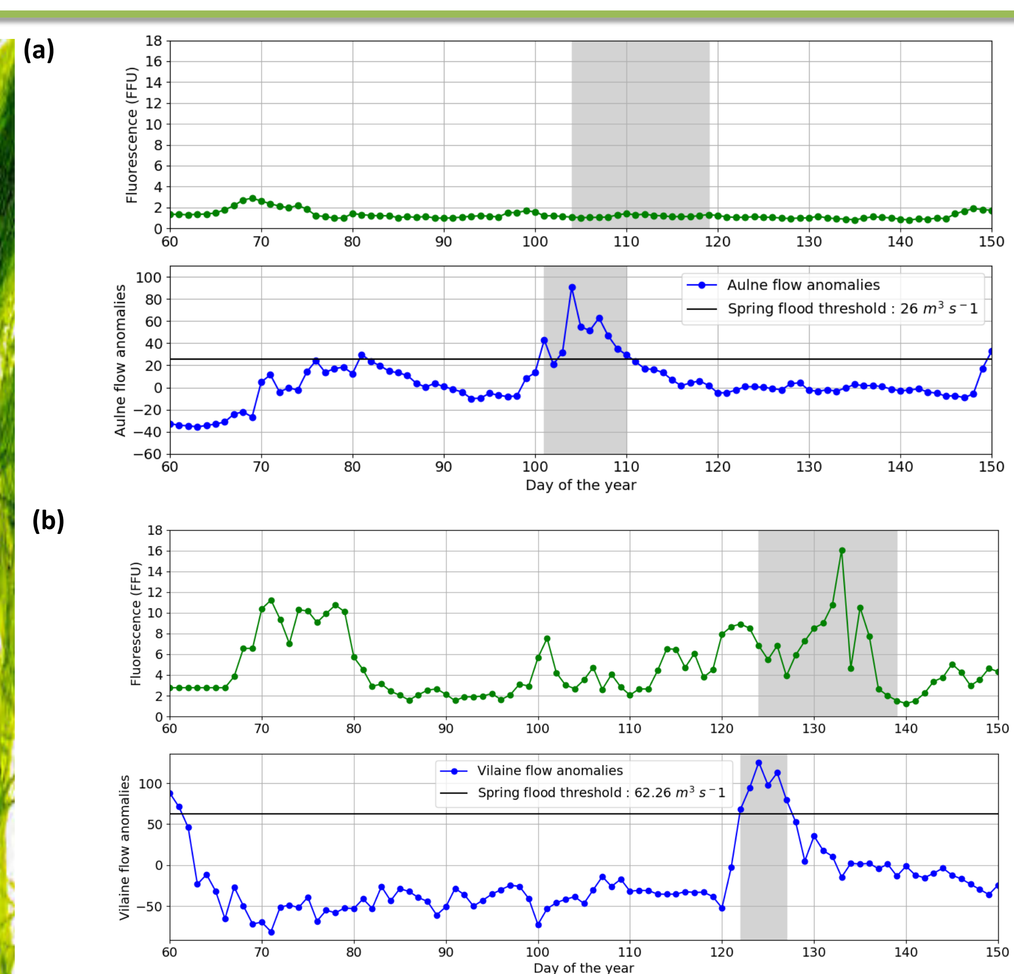
Detected cold waves in February (grey boxes) in the Bay of Brest (red) and in the Bay of Vilaine (black)

Cold waves can influence the phytoplankton biomass [3].

Over the study period, nine cold waves were detected. In 2011, both sites were impacted simultaneously

Long cold waves (30 days in 2009, 2010 and 2018) are the most intense with an anomaly > 0.16°C

Cold waves seem to have no impact on the onset (*Figure section 3*) and intensity of the growing period in both regions. In the north-eastern English Channel, the 2005 cold wave led to an increase in water mixing and delayed the spring bloom [3]



Effect of extreme flooding in (a) the Bay of Brest in 2013 and (b) the Bay of Vilaine in 2016

By comparing both sites, we highlight that exceptional floods do not have the same impact:

In the Bay of Brest (Figure a), a flood does not influence phytoplankton, and no peak is detected during or in the 15 following days of the maximum of the flood event. Fluorescence remains often low (<5 FFU)

In the Bay of Vilaine (Figure b), a flood is associated with nutrient inputs and a peak in fluorescence is always detected within the 15 following days of the maximum peak of river flow anomaly. Fluorescence often reaches 10 FFU

6. Conclusions

- ❑ ***In situ* high frequency observation have a great potential to investigate the long term effects of extreme events on the coastal marine ecosystems** [8]
- ❑ By comparing both sites, we show that **environmental conditions** of the **onset of the spring bloom** are similar
- ❑ A **strong interannual variability** is observed for the **bloom start** in each site. No linear trend nor direct influence of environmental factor is detected, as observed in for the transition zone for temperate waters [2]
- ❑ **Extreme events** such as **cold waves** do not affect the **initiation of the bloom** or its **intensity,** in contrast with a littoral system like in [3]
- ❑ Intense flooding influences the response of phytoplankton in the Bay of Vilaine but not in the Bay of Brest. This can be explained by nutrient-limited conditons, as observed in other regions [4]

Acknowledgments and References:

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