Marine Chemistry at IUEM
an overview of the teaching modules with **on-field activities**

Matthieu Waeles, Peggy Rimmelin, Ricardo Riso, Jean-François Maguer, Emilie Grossteffan, Jérémy Devesa

CORRIENTE XXI Workshop

"Fieldwork as an educational approach for research-based Master programmes"

May 5 - June 2, 2022.

IUEM, Université de Bretagne Occidentale, Brest, France

Co-funded by the Erasmus+ Programme of the European Union

The Program related to marine chemistry

Tuesday

- ***Marine Chemistry at IUEM****: an overview of the teaching modules with on-field activities, Matthieu Waeles*

- ***Observation & time series*** *in coastal waters, learning the specific instrumentation and the standardized methods, Peggy Rimmelin*

Classroom

Wednesday

- ***Introduction to Marine Chemistry*** *part A, on-field activities, Gauthier Schall, Franck Quéré*

- ***The Seamist project****, Matthieu Waeles*

On-field

Thursday

- ***Introduction to Marine Chemistry****: part B, Lab activities, Ricardo Riso*

- ***Segmented-flow for nutrient analysis****, an indispensable tool for our teaching, Jérémy Devesa*

- ***Marine Chemistry for future managers****, M. Waeles, J. Devesa and E. Grosstefan*

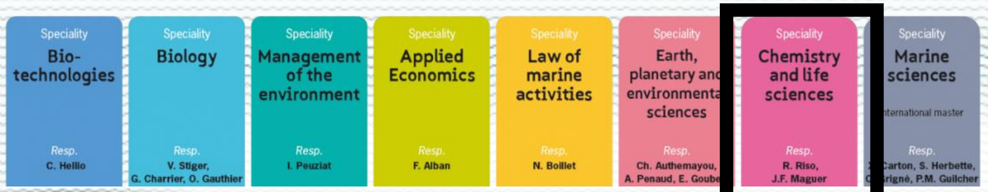
Lab

Teaching modules related to **chemistry** with **on-field activities**

- **Introduction to Marine Chemistry**

- **Functioning of coastal ecosystems**

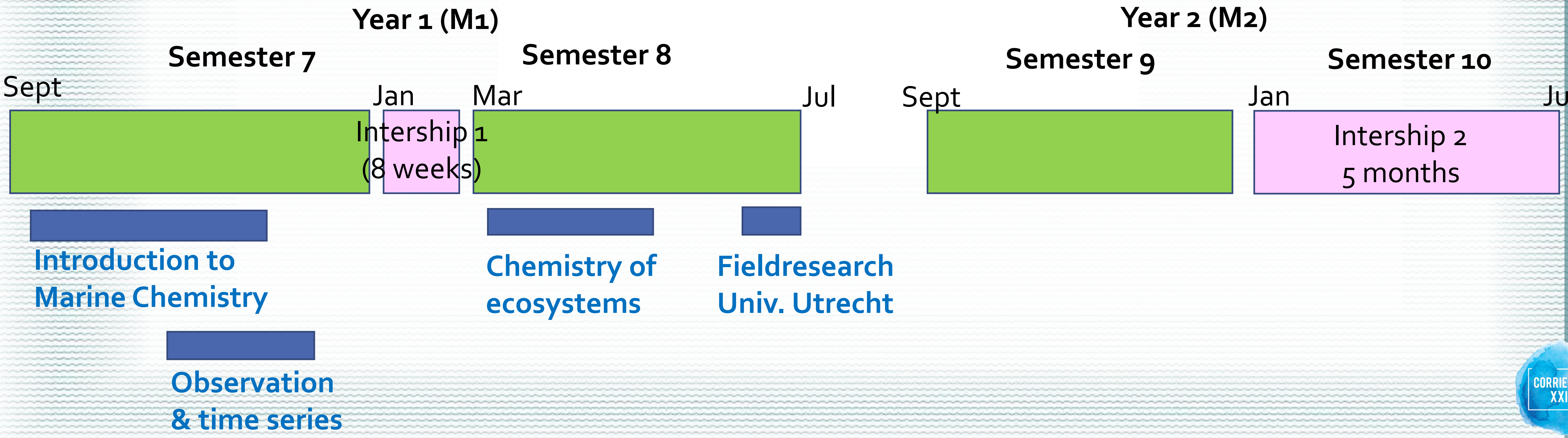
- **Introduction to Marine Chemistry**
- **Observation and time series**
- **Chemistry of ecosystems**
- ***Field research / Univ. Utrecht (optional)***



The Master's degree « Marine Environmental Chemistry»

Objective : to train young scientists for understanding and responding, in a multidisciplinary framework, to the major issues and challenges in the field of marine and coastal sciences by providing them specific skills in **analytical chemistry** and **marine biogeochemistry**

Organisation : 4 semesters



Semester	Course	Analytical Chemistry	Biogeochemistry/ Environmental sciences	Fieldwork	Labwork	Digital tools
Sem. 7	Introduction to Marine Chemistry	■	■	■	■	
	Chemical speciation of elements in seawater (Schema)		■			
	Processing and analysis of oceanographic data (Trafic)		■			■
	Physical Oceanography		■			
	Observation and time series	■	■	■	■	■
	Analytical methods for the environment	■		■		
	Chemometrics	■				■
	Expression techniques and bibliographic research					■
	English 1					
Sem. 8	Intership 1	■	■	■	■	■
	Chemistry of marine ecosystems	■	■	■	■	
	Marine Geochemistry		■			
	Biogeochemistry and ecology of the polar oceans		■			
	Ocean tracers: basics and concepts	■	■			■
	Coaching for the professional project					
	English 2					
	Field research instruction geochemistry / Seamist (optional)	■	■	■	■	
	Floating university (optional)	■	■	■	■	
Sem. 9	Ocean-climate interactions		■			
	Biogeochesmitry and modeling		■			■
	Biogeochemistry of upwellings and western edge currents		■			
	Organic compounds in the marine environment	■	■		■	
	Advanced spectrometric methods	■			■	
	Ocean tracers: new approaches	■	■			■
	Science and society					
	Project engineering					
	Scientific English and critical analysis of the literature					
Sem. 10	Intership 2	■	■	■	■	■

Skill blocks Group A: Disciplinary related

BLOCK 1	**Observation and Experimentation**	Use **sampling and observation tools** for water, sediment and organisms
		Master the specificity of **analytical techniques** dedicated to the marine environment
BLOCK 2	**Expertise in marine chemistry and biogeochemistry**	Formalize the **fundamental concepts of marine chemistry** to understand the mechanisms that govern **the reactivity of chemical elements**
		Mobilize the knowledge and skills of **related disciplines** (physics, biology, geochemistry...)
		Embed key biogeochemical processes that regulate the **cycles and fluxes** in the hydrosphere
BLOCK 3	**Development and integration of highly specialized knowledge**	Mobilize highly specialized knowledge to **answer a management or research question**
		Target the fields of competence of a **scientific article** and extract the relevant information by developing a **critical approach**
		Address a problem by **mobilizing or developing adapted sampling and analytical techniques**
		Make **innovative contributions** in high-level exchanges, and in **international contexts**
		Develop a **comprehensive and multidisciplinary approach** to environmental issues

Skill blocks Group B: Transversal

BLOCK 4	**Advanced and specialized uses of digital tools**	Identify **digital uses in environmental sciences**
		Exploit, with quantitative approaches, experimental data using **numerical representation and modeling tools**
BLOCK 5	**Specialized communication for knowledge transfer**	Identify, select and critically analyze a variety of **specialized resources to synthesize knowledge** within a field and **document a topic** for further use
		Communicate a **scientifically accomplished work** by contextualizing it
BLOCK 6	**Support for transformation in a professional context**	**Manage a study/project** that may involve related expertise (biology, physics, geology) and require new approaches
		Take **responsibilities** within a team to ensure **efficiency** on field and in the lab
		Initiate a project by mobilizing a range of expertise in the field of marine sciences
		Self-evaluate actions to improve practices in a professional context
		Design a project within the principles of **ethics and deontology**

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Sem. 7	**Introduction to Marine Chemistry**	X	X	X	X	
	Chemical speciation of elements in seawater (Schema)		X			
	Processing and analysis of oceanographic data (Trafic)		X			X
	Physical Oceanography		X			
	Observation and time series	X	X	X	X	X
	Analytical methods for the environment	X		X		
	Chemometrics	X				X
	Expression techniques and bibliographic research					X
	English 1					
Sem. 8	Intership 1	X	X	X	X	X
	Chemistry of marine ecosystems	X	X	X	X	
	Marine Geochemistry		X			
	Biogeochemistry and ecology of the polar oceans		X			
	Ocean tracers: basics and concepts	X	X			X
	Coaching for the professional project					
	English 2					
	Field research instruction geochemistry / Seamist (optional)	X	X	X	X	
	Floating university (optional)	X	X	X	X	
Sem. 9	Ocean-climate interactions		X			
	Biogeochesmitry and modeling		X			X
	Biogeochemistry of upwellings and western edge currents		X			
	Organic compounds in the marine environment	X	X		X	
	Advanced spectrometric methods	X			X	
	Ocean tracers: new approaches	X	X			X
	Science and society					
	Project engineering					
	Scientific English and critical analysis of the literature					
Sem. 10	Intership 2	X	X	X	X	X

CORRIENTE XXI

Introduction to Marine Chemistry (S7)

R Riso , JF Maguer and M Waeles

a core course for mastering the sampling and analysis of the chemical parameters

This course presents Marine Chemistry, from the emergence of the discipline in the 17th century through the **evolution of concepts, important definitions** and methodological advances.

Current analytical techniques for the determination of **key parameters** are also taught.

Practical work, at sea and in the laboratory, is an important part of this course.

Theoretical courses: 8h

Fieldwork (on board Albert Lucas): 3h

Labwork: 24 h (6 lab session)

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On-board activities (half-day trip)

Objective: to know how to handle and how to process samples before storage

Each student get back with a set of samples for the following lab courses

Water column sampling

In-situ measurements
Seabird CTD profiler
$+O_2$ +fluo +turbidity

On-board filtration

Glass Fiber filters

MCE filters

The Program related to marine chemistry

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- ***Marine Chemistry for future managers****, M. Waeles, J. Devesa and E. Grosstefan*

Laboratory activities (over 6 weeks)

Objective: to fully master the analytical methods for the key parameters

(methods agreed by the community)

At the end, the students report data and analytical errors, accordance with previously reported values, discussion in a broader context

Absolute Salinity
Titration with Ag^{+} ions

Practical salinity
Conductivity

Dissolved O_2
Winkler method

Nitrate, Nitrite
Segmented-flow analysis

Phosphate, Silicate
Colorimetric methods
Strickland & Parsons
Murphy & Riley

Ammonium
indophenol method

pH
m-cresol method
Clayton & Byrne, 1993

Alkalinity - DIC
Gran method,
« CO2 system » software

Ca^{2+}
EDTA titration

Glass Fiber filters

Chla & phaeopigments
Fluorimetric Lorenzen's method

COP
Back tiration with Fe^{2+} ions after oxidation

MCE filters

Biogenic Si
Alkaline digestion
De Master
kinetic method

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	Marine Geochemistry		■			
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	Ocean tracers: basics and concepts	■	■			■
	Coaching for the professional project					
	English 2					
	Field research instruction geochemistry / Seamist (optional)	■	■	■	■	
	Floating university (optional)	■	■	■	■	
Sem. 9	Ocean-climate interactions		■			
	Biogeochesmitry and modeling		■			■
	Biogeochemistry of upwellings and western edge currents		■			
	Organic compounds in the marine environment	■	■		■	
	Advanced spectrometric methods	■			■	
	Ocean tracers: new approaches	■	■			■
	Science and society					
	Project engineering					
	Scientific English and critical analysis of the literature					
Sem. 10	Intership 2	■	■	■	■	■

Legend:
- Analytical Chemistry
- Biogeochemistry/ Environmental sciences
- Fieldwork
- Labwork
- Digital tools

Semester	Course	Analytical Chemistry	Biogeochemistry/ Environmental sciences	Fieldwork	Labwork	Digital tools
Sem. 7	Introduction to Marine Chemistry	X	X	X	X	
	Chemical speciation of elements in seawater (Schema)		X			
	Processing and analysis of oceanographic data (Trafic)		X			X
	Physical Oceanography		X			
	Observation and time series	X	X	X	X	X
	Analytical methods for the environment	X		X		
	Chemometrics	X				X
	Expression techniques and bibliographic research					X
	English 1					
Sem. 8	Intership 1	X	X	X	X	X
	Chemistry of marine ecosystems	X	X	X	X	
	Marine Geochemistry		X			
	Biogeochemistry and ecology of the polar oceans		X			
	Ocean tracers: basics and concepts	X	X			X
	Coaching for the professional project					
	English 2					
	Field research instruction geochemistry / Seamist (optional)	X	X	X	X	
	Floating university (optional)	X	X	X	X	
Sem. 9	Ocean-climate interactions		X			
	Biogeochesmitry and modeling		X			X
	Biogeochemistry of upwellings and western edge currents		X			
	Organic compounds in the marine environment	X	X		X	
	Advanced spectrometric methods	X			X	
	Ocean tracers: new approaches	X	X			X
	Science and society					
	Project engineering					
	Scientific English and critical analysis of the literature					
Sem. 10	Intership 2	X	X	X	X	X

Analytical Chemistry

Biogeochemistry/ Environmental sciences

Fieldwork

Labwork

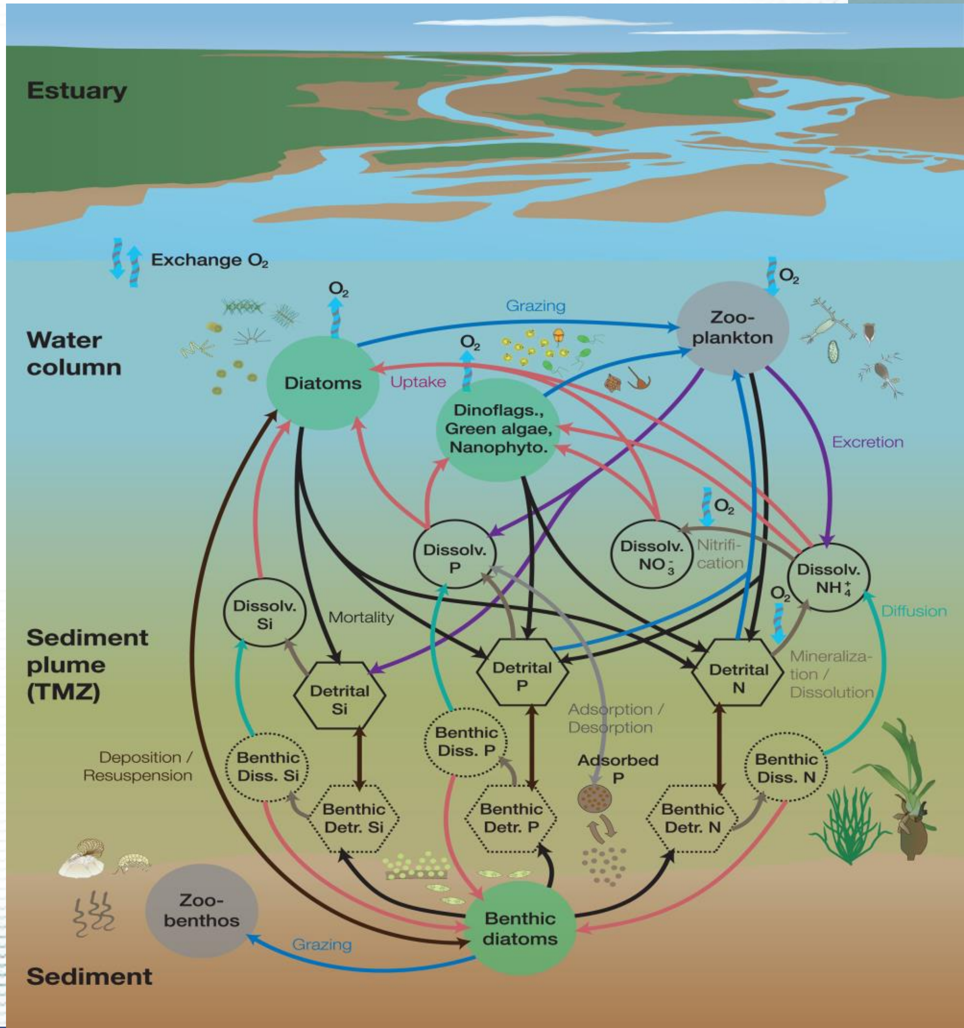
Digital tools

Chemistry of marine ecosystems (S8) JF Maguer and R Riso

This course focuses on the functioning conditions of the main types of coastal and oceanic ecosystems with a perspective on quantifying fluxes of material

- **Case studies** (concrete examples from the scientific literature)
- **Data collected at sea (estuarine salinity gradients)**

Jean-François Maguer, Lemar, UBO
Nitrogen uptake and regeneration in coastal ecosystems: relationships with the mixing regime



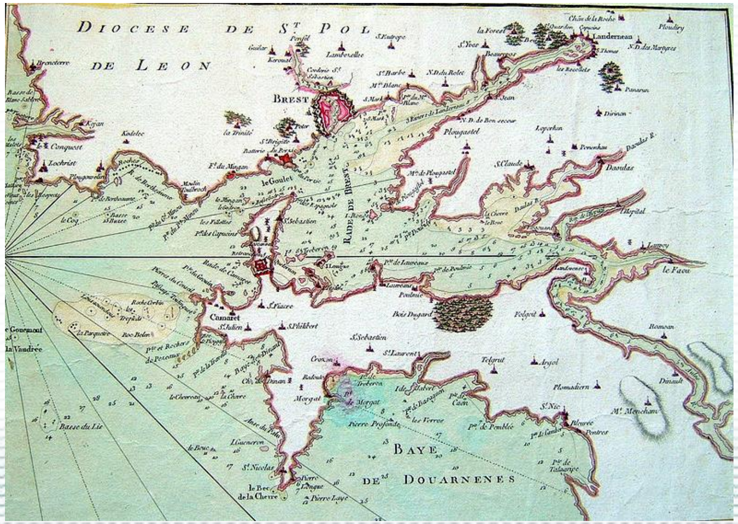
Practical activities

1. On-field activities (1 day for each group of 5 students)

1.1 Sampling along the whole salinity gradient (RV Hesione) **of the main estuaries of the Bay of Brest (Aulne or Elorn)**
Objective: to describe the reactivity of nutrients in the estuaries and assess their impact on nutrient fluxes.

1.2 Sampling and CTD measurements within a tidal cycle at the estuary mouth (RV Albert Lucas)
Objective: understanding the variation of the water column structure and its control on primary production

Note that all methods all the sampling methods learned in S7 are used more autonomously by the students.



Practical activities

2. Lab activities

All the samples are analyzed within 2 full days

the students apply in an autonomous way
- all the analytical methods learned in S7
+ some extra methods described in their manual (e.g. phosphate, silicate)

3. Reports: A global database is created.

Each group of 2 students

- **define a specific question to be addressed (which has to be validated with the teacher)**
- **write a short report by plotting and discussing the appropriate data in a broader context and using the relevant literature**

Functioning of coastal ecosystems and responses to anthropogenic inputs

Theoretical courses (18h), content:

- Coastal ecosystems: functioning principle, establishment of food chains
- Disturbed ecosystems
- Conditions of restoration of coastal systems
- Coastal observation networks

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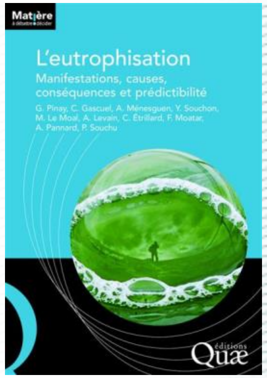
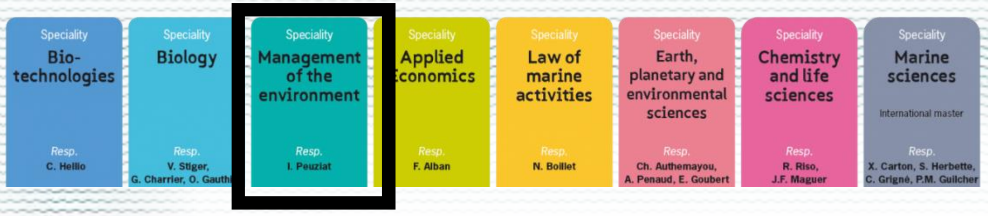


Alain Menesguen, Ifremer.
Specialist in the proliferation of green and brown algae



The EGEL master's degree aims at preparing the future coastal actors, with the ability to understand the environmental and societal management issues

- The first year students acquire the scientific bases necessary for a good knowledge of coastal and marine environments.

- The second year is more directly oriented towards the student's professional or research project

EGEL recruits **students from different backgrounds:** Biology, Environ. Sciences, Geography, Law, Solciology...).

The majority of the students do not have skills in chemistry

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- ***Marine Chemistry for future managers*****, the challenge of teaching in a practical way for students who have never practiced in a chemical laboratory,** *M. Waeles, J. Devesa and E. Grosstefan*

Lab

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Field and labwork (6 h)

A much lighter program

2 Objectives :

- **To give an overview of the equipment to be used and the principles of sampling and measurement of some important parameters**

important for these future managers
e.g. ordering an impact study

- **Obtain data that can be integrated into a broader context or compare to other systems**

Bay of Brest

Le Pape et al., 1996

Resistance of a coastal ecosystem to increasing eutrophic conditions: the Bay of Brest, a semi-enclosed zone

Baltic Sea

Water column sampling

In-situ measurements

Seabird CTD profiler

+O_2 +fluo +turbidity

On-board filtration

Dissolved O_2

Winkler method

Nitrate

Glass Fiber filters

Chla & phaeopigments

Fluorimetric Lorenzen's method

Pergamon

Continental Shelf Research, Vol. 16, No.15, pp. 1885–1907, 1996

0278–4343/96 $15.00 + 0.00
0278–4343(95)00068–2

Resistance of a coastal ecosystem to increasing eutrophic conditions: the Bay of Brest (France), a semi-enclosed zone of Western Europe

OLIVIER LE PAPE,* YOLANDA DEL AMO,†
ALAIN MENESGUEN,* ALAIN AMINOT,*
BERNARD QUEQUINER† and PAUL TREGUER†

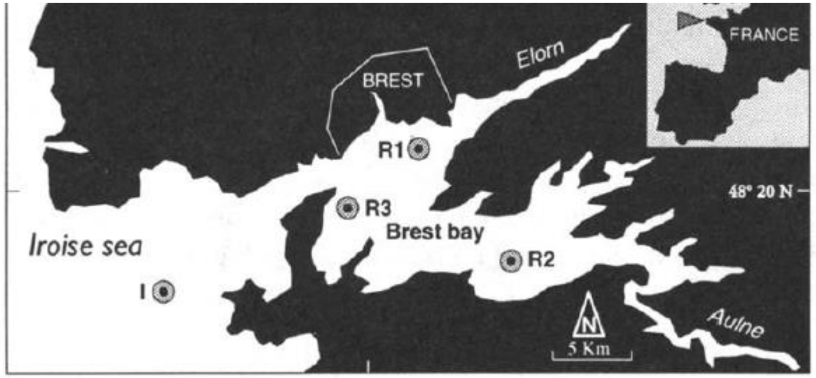


Fig. 1. General situation of the site under study, with location of the sampling stations.

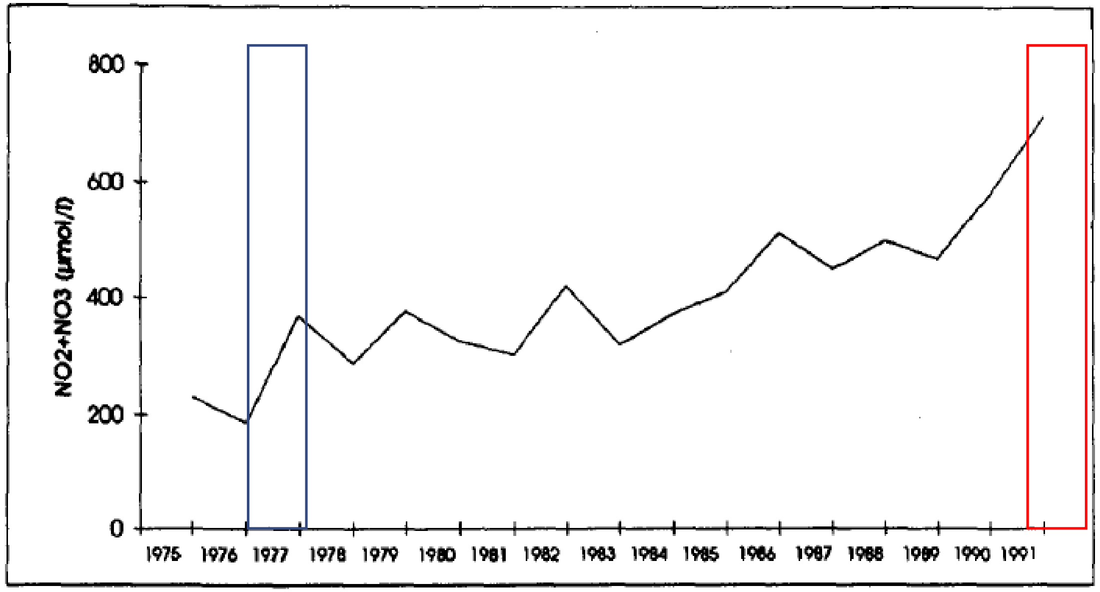


Fig. 2. Time variations of winter nitrate + nitrite concentrations ($\mu mol\ l^{-1}$) in the Aulne River at the limit of the freshwater.

Between <u>1977</u> and <u>1993</u>: the flux of nitrate to the Bay of Brest increased by a factor 2:

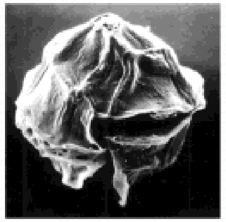
- **Primary production (eutrophication) ??**
- **Oxygen status ??**

Case studies (8h)

Exploring datasets in order to understand: (examples of topics)

- **The physical and chemical features of anoxic areas / dead zones**

Baltic Sea, SMHI dataset



- **Environmental conditions for the development of the toxic dinoflagellate *Alexandrium minutum***

Penzé estuary dataset, Maguer et al. 2004)

- **Environmental conditions for the formation of *Gyrodinium Aureolum* colored waters**

Douarnenez Bay dataset, LeCorre et al., 1992)

- **The contamination of coastal sediments by toxic metallic elements**

ROCCH network dataset

At the end, each group (3 students)....report (oral communication)

Fieldresearch with Utrecht University

Involved students

- About 30 master students from Utrecht and Brest
- Mixed groups (4-6 students)

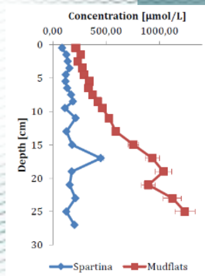
Educational Objectives

- Encourage interactions between students of different nationalities
- Promote exchange of good practices between students of related disciplines (hydrogeology, environmental chemistry, limnology, oceanography…)
- Improve skills (sampling and analytical)
- Develop autonomy in the conduct of a research project

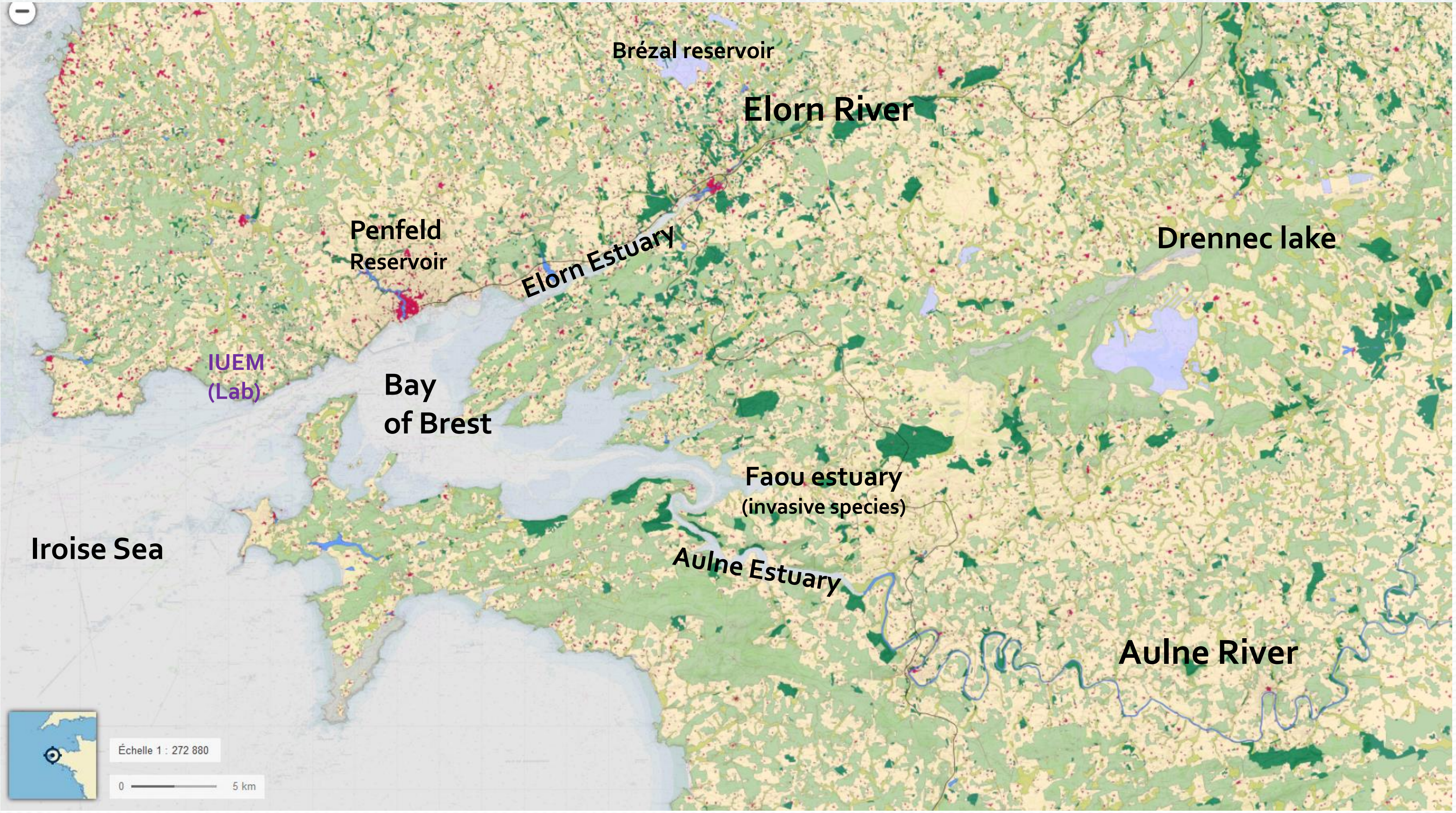
Topic & Scientific questions

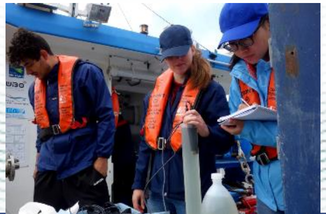
Nutrients in the land-sea continuum

- What is the trophic state of rivers, reservoirs/lakes, estuaries and Bay of Brest?
- What processes control the concentrations and fate of nutrients
- How benthic fluxes (removal/release) affect the overlying water?
- What is the effect of invasive species (*Spartina* and *Gracilaria*) on pore water chemistry?
- How does the phytoplankton community react on perturbations in nutrient supply?



Studied systems





Program

	Group				
	I	II	III	IV	V
Saturday 8 June	Trip to Brest				
Sunday 9 June	Unload busses, groceries, icebreaker BBQ				
Monday 10 June	Roundtrip visiting main field sites				
Tuesday 11 June	Elorn 1	Elorn 2	Half day	Sediment 1 BF-PD	Lab MC1
Wednesday 12 June	Bay of Brest (AL)	Aulne Mix (HS)	Lab BF-PD	Half day	Etang de Brezal 1
Thursday 13 June	Half day	Lac du Drennec 1	Sediment 2 BF-LD	Lab MC 2	Bay of Brest (AL)
Friday 14 June	Lab BF LD	Half day	Lac du Drennec 2	Aulne mining	Sediment 3 anaerob
Saturday 15 June	Sediment 4 PW	Lab BF anoxic	Aulne 1	Le Penfeld	Half day
Sunday 16 June	Off				
Monday17 June	Lab Core 1	Sediment 5 PW	Half day	Half day	Lab Core 2
Tuesday 18 June	Etang de Brezal 2	Half day	Lab Core 3	Lab Core 4	Aulne 2
Wednesday 19 June	Half day	Lab Core 5	Elorn time series (AL)	Elorn mixing (HS)	Lab
Thursday 20 June	Lab	Lab	Lab	Lab	Half day
Friday 21 June	Discussion of results, packing and cleaning				

Daily Organisation

- 9 am: departure to field or lab work
- 5 pm: latest return from field to lab
- 5-7 pm: filtration of samples and preparations for the next day
- 7 -8 pm: Meeting with reports from each groups and discussion
- 8 pm: Diner

every day one group is off to recover, do the laundry, prepare diner food…

Technical and supervising help:

- Jérémy Devesa
- Francien Peters
- Arthur Beusen
- Lauriane Vilmin

Facilities and financial support:

-IUEM/University of Brest (Lab and Sea facilities)
-Utrecht University (Equipment and financial support)
-Isblue (Equipment, accommodation and recreational activities)

CORRIENTE XXI

The Seamist project:

involving undergraduate and postgraduate students in a comprehensive and manageable research project

Nutrients and primary production in the Penfeld estuarine reservoir (Bay of Brest):

Matthieu Waeles,

Emma Kerebel, Kim Rouanet, Clément Lefort, Marie Le Bagousse, Simon Jaffrès, Célestine Morisseau, Pierre Sanlis & Nino Pemartin,

Co-funded by the Erasmus+ Programme of the European Union

1. construction | 2. field and lab work | 3. data exploitation | 4. Preparing a ms | 5. post evaluation

2021

		May			Jun			Jul			Aug			Sep			Oct			Nov			Dec
1	S		1	M	exam	1	J		1	D		1	M	Beginning of S9 (M2)	1	V	exam	1	L		1	M	courses
2	D		2	M	exam	2	V		2	L		2	J	courses	2	S		2	M	courses	2	J	courses
3	L	courses	3	J	exam	3	S		3	M		3	V	courses	3	D		3	M		3	V	
4	M	courses	4	V	exam	4	D		4	M		4	S		4	L	courses	4	J	courses	4	S	
5	M	courses	5	S	exam	5	L		5	J		5	D		5	M		5	V	courses	5	D	
6	J	courses	6	D		6	M		6	V		6	L	courses	6	M	courses	6	S		6	L	courses
7	V	courses	7	L	M1 Intership defense	7	M		7	S		7	M	courses	7	J	courses	7	D		7	M	courses
8	S		8	M	M1 Intership defense	8	J		8	D		8	M	courses	8	V	courses	8	L	courses	8	M	courses
9	D		9	M	End of S8 (M1)	9	V		9	L		9	J	courses	9	S		9	M	courses	9	J	courses
10	L	courses	#	J		#	S		#	M		#	V	courses	#	D		#	M	courses	#	V	exam
11	M	courses	#	V		#	D		#	M		#	S		#	L	courses	#	J		#	S	
12	M	courses	#	S		#	L		#	J		#	D		#	M		#	V	exam	#	D	
13	J		#	D		#	M		#	V		#	L	courses	#	M	courses	#	S		#	L	
14	V	courses	#	L		#	M		#	S		#	M	courses	#	J	courses	#	D		#	M	courses
15	S	courses	#	M		#	J		#	D		#	M	courses	#	V	exam	#	L	courses	#	M	courses
16	D		#	M		#	V		#	L		#	J	courses	#	S		#	M	courses	#	J	exam
17	L	courses	#	J		#	S		#	M		#	V	exam	#	D		#	M		#	V	End of S9
18	M	courses	#	V		#	D		#	M		#	S		#	L	courses	#	J	courses	#	S	then 6 month internship
19	M	courses	#	S		#	L		#	J		#	D		#	M	courses	#	V	courses	#	D	
20	J	courses	#	D		#	M		#	V		#	L	courses	#	M		#	S		#	L	
21	V	courses	#	L		#	M		#	S		#	M	courses	#	J	courses	#	D		#	M	
22	S	courses	#	M		#	J		#	D		#	M	courses	#	V	courses	#	L	courses	#	M	
23	D		#	M		#	V		#	L		#	J	courses	#	S		#	M	courses	#	J	
24	L		#	J		#	S		#	M		#	V	courses	#	D		#	M	courses	#	V	
25	M	courses	#	V		#	D		#	M		#	S		#	L	courses	#	J	courses	#	S	
26	M	courses	#	S		#	L		#	J		#	D		#	M	courses	#	V	exam	#	D	
27	J	courses	#	D		#	M		#	V		#	L	courses	#	M	courses	#	S		#	L	
28	V	courses	#	L		#	M		#	S		#	M		#	J	courses	#	D		#	M	
29	S	courses	#	M		#	J		#	D		#	M	courses	#	V	exam	#	L	courses	#	M	
30	D		#	M		#	V		#	L		#	J	courses	#	S		#	M		#	J	
31	L	exam				#	S		#	M					#	D					#	V	

CORRIENTE XXI

1. construction

Collaborative construction of the research question

Expert insight into current research

News & views

Figure 1 | The weir at Pulteney Bridge, Bath, UK. Belletti *et al.*[1] estimate that more than 1.2 million artificial constructions, such as weirs, dams and locks, alter the flow of Europe's rivers and streams.

Hydrology

Small barriers are a big deal for Europe's rivers

Christiane Zarfl & Bernhard Lehner

An atlas of European river barriers has been made, by curating and correcting existing records, and by surveying 2,700 kilometres of waterways. It reveals that rivers are fragmented by an amazing number of obstructions. See p.436

If you asked a child in Europe to draw a river, what would this picture look like? Would it resemble a natural, wild and scenic river, with braided and meandering flow paths in a vast floodplain, fringed by riverine vegetation? Or would it show a modern, well-managed river with houses lined up along the banks and boats passing by on a confined channel? On page 436 Belletti *et al.*[1] report a remarkably detailed survey of river barriers in Europe, which suggests that the second picture would be much more likely.

Free-flowing rivers have become increasingly rare, because centuries of human activities have altered their passage and channels: dams and levees have been built to protect us from floods; weirs have been added (Fig. 1) to abstract water for irrigation or human use; locks and canals have been used to ensure and expand navigable waters; and river flows have been trapped or diverted for power-generating applications ranging from ancient waterwheels to modern hydroelectricity plants. Diverse in-stream structures have been constructed for these purposes, such as large concrete dams, wooden locks, small weirs and partially submerged fords. All of these interventions fragment the rivers and disturb the flow in various ways across different spatial and temporal scales, affecting the transport and delivery of sediments and nutrients[2,3], and the migration and dispersal of aquatic organisms[4].

Researchers and water managers who want to investigate the consequences – both beneficial and harmful – of these modifications must first ask some fundamental questions. How many barriers have been installed, and what types? And, most importantly, where have they been built?

Perhaps surprisingly, the answers are largely unknown. No comprehensive inventory of barriers has been available on a continental scale that includes structures less than 10 metres high, uses consistent,

Article

More than one million barriers fragment Europe's rivers

https://doi.org/10.1038/s41586-020-3005-2

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Check for updates

Barbara Belletti[1,29], Carlos Garcia de Leaniz[2]✉, Joshua Jones[2], Simone Bizzi[1,30], Luca Börger[2], Gilles Segura[3,4], Andrea Castelletti[1], Wouter van de Bund[5]✉, Kim Aarestrup[6], James Barry[7], Kamila Belka[8], Arjan Berkhuysen[9], Kim Birnie-Gauvin[6], Martina Bussettini[10], Mauro Carolli[11], Sofia Consuegra[2], Eduardo Dopico[12], Tim Feierfeil[13], Sara Fernández[12], Pao Fernandez Garrido[9], Eva Garcia-Vazquez[12], Sara Garrido[14], Guillermo Giannico[15], Peter Gough[9], Niels Jepsen[6], Peter E. Jones[2], Paul Kemp[16], Jim Kerr[16], James King[7], Małgorzata Łapińska[8,17], Gloria Lázaro[14], Martyn C. Lucas[18], Lucio Marcello[19], Patrick Martin[3], Phillip McGinnity[20,21], Jesse O'Hanley[22], Rosa Olivo del Amo[9,31], Piotr Parasiewicz[23], Martin Pusch[11], Gonzalo Rincon[24], Cesar Rodriguez[14], Joshua Royte[25], Claus Till Schneider[26], Jeroen S. Tummers[18], Sergio Vallesi[18,32], Andrew Vowles[16], Eric Verspoor[19], Herman Wanningen[9], Karl M. Wantzen[27,33], Laura Wildman[28] & Maciej Zalewski[8]

All of these interventions fragment the rivers and disturb the flow in various ways across different spatial and temporal scales, affecting the transport and delivery of sediments and nutrients[2,3], and the migration and dispersal of aquatic organisms[4].

What about estuaries ?

very few studies have looked at their impact in terms of nutrient fluxes or eutrophication

CORRIENTE XXI

Plan relief of Brest 1811

Auteur(s) :	Boitard (Martin), dit Boitard aîné
Construction :	1807-1811
Restauration :	-
Echelle :	1/600
Dimensions :	16,45 x 7,93 m
Nombre de tables :	31 tables
Matériaux :	Bois, papier, soie, métal, peinture

Reservoir - Recreationnal area (upstream)

Kervallon gate

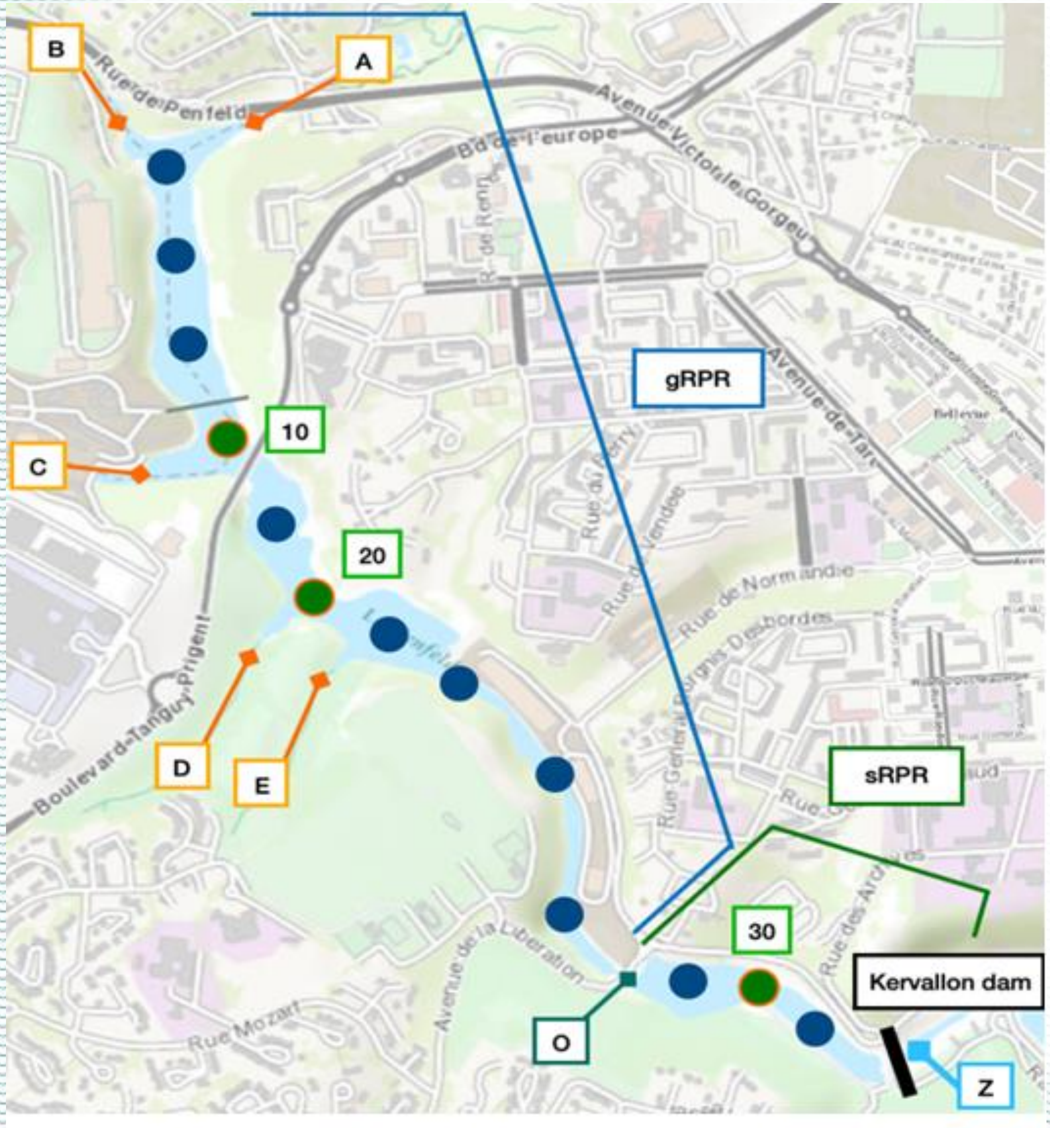
Military area (downstream)

CORRIENTE XXI

2. field and lab work

Priotitize student autonomy

14-15 June 2021 after 15 days of gate closure, high irradiance



Fieldwork 2 days

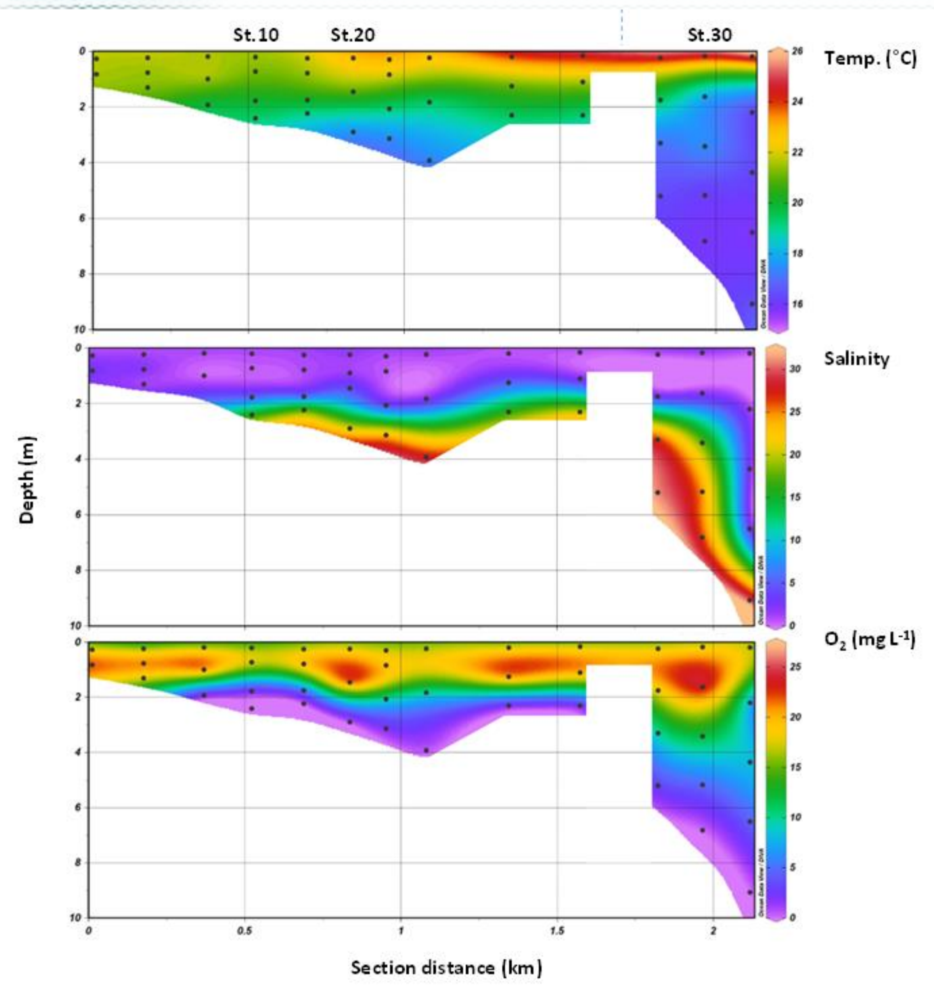
Labwork 4 days

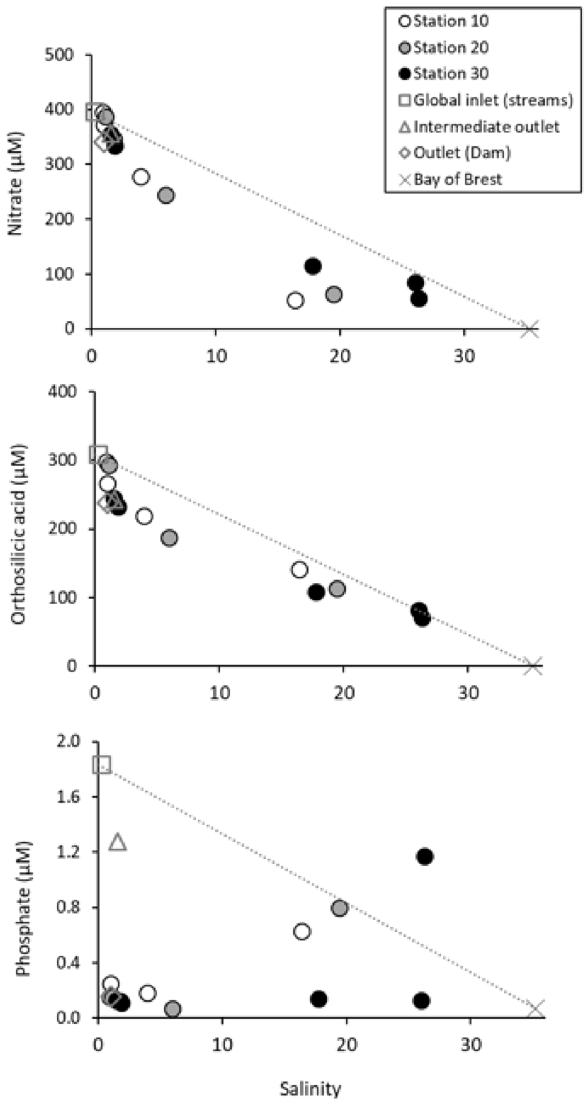
Evening meetings (reporting tasks and results)

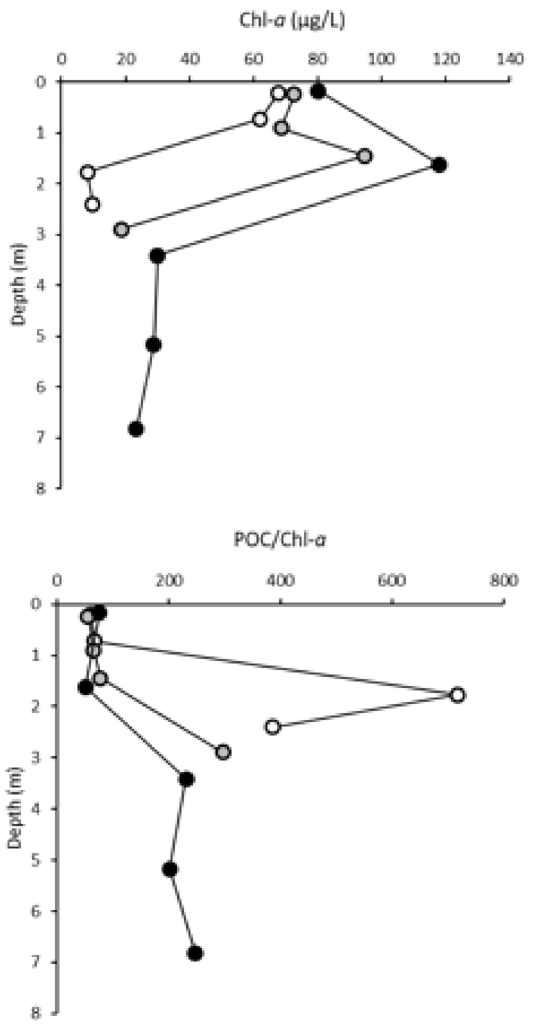
CORRIENTE XXI

3. data exploitation

accompagny the students to identify key processes







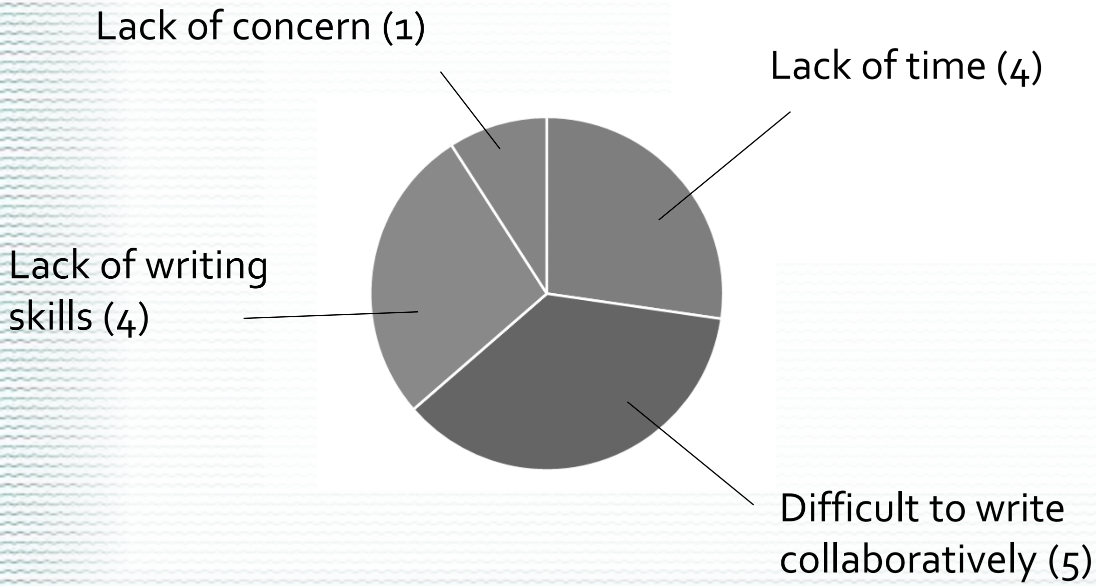
- **Strongly stratified anoxic conditions at the bottom**
- **Important removal of nutrients**
- **High biomass** (chl-*a* up tu 100 µg L-1)
- **Hypertrophic conditions** NPP: 1.7-1.8 gC m^{-2} d^{-1}

4. Preparing a manuscript

Submitted to LHB hydroscience journal (dec-2021)

regular meetings over the oct-dec period

- **selection of figures and tables** ✔
- **selection of points to be discussed** ✔
- **writing** ✘



Eutrophication, oxygen status and nutrient fluxes in a macrotidal estuarine reservoir: the case of the Ria Penfeld, Bay of Brest

S. P. H. Jaffrès[a], E. Kerebel[a], M. M. Le Bagousse[a], C. J. Lefort[a], C. J. Y. Morisseau[a], K. Rouanet[a], N. C. Pemartin[a], P. Sanlis[a], J. Devesa[a,b], J.-F. Maguer[a,b] and M. Waeles[a,b]*

[a]Univ Brest, Master "Chimie de l'Environnement Marin", IUEM, F-29280 Plouzané, France; [b]Univ Brest, CNRS, IRD, Ifremer, LEMAR, F-29280 Plouzané, France

CORRIENTE XXI

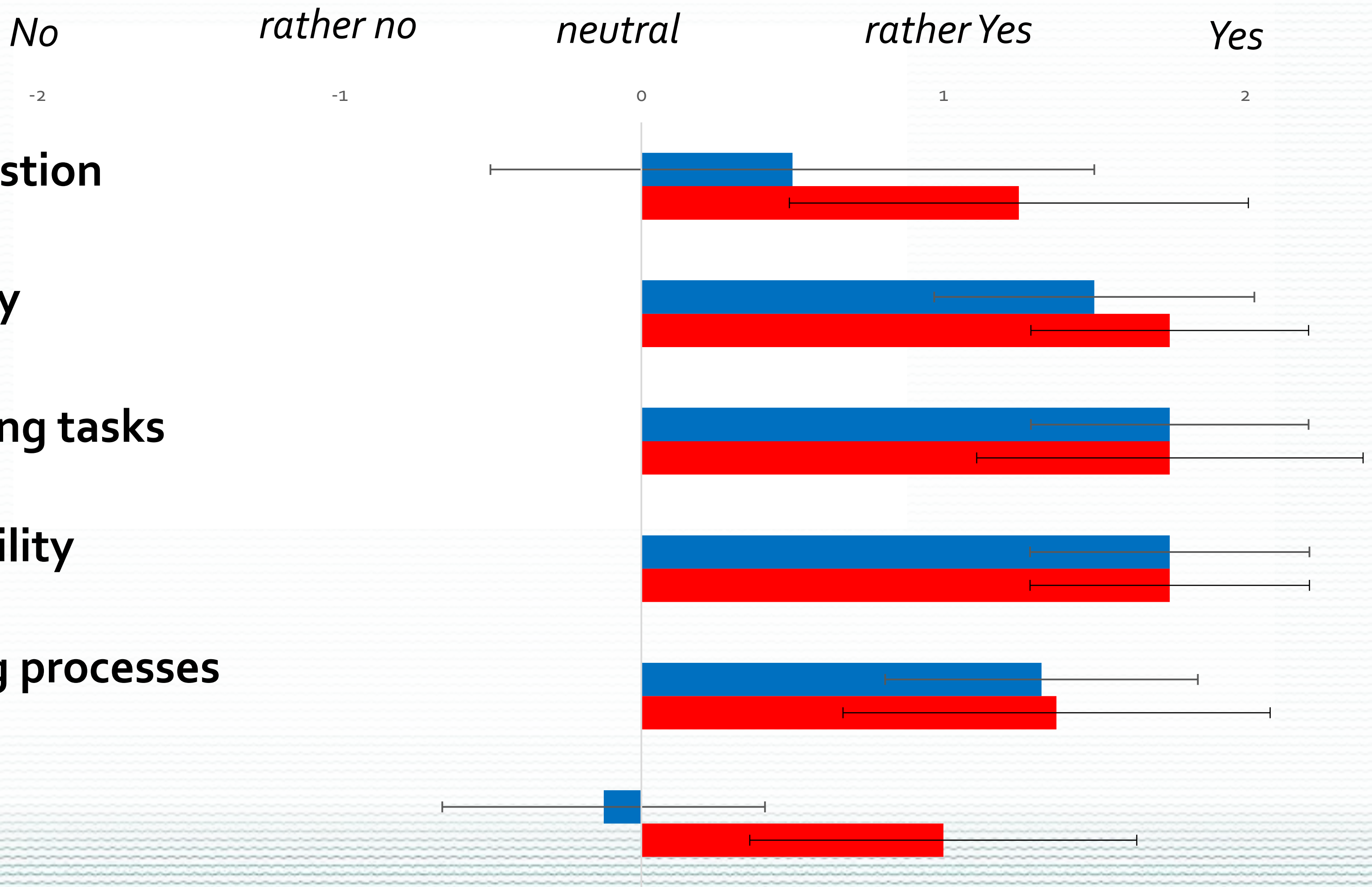
5. post evaluation

[redacted]

Did you sufficiently experienced…

Do you feel now better prepared for…

- Constructing a research question
- Defining a sampling strategy
- Planning, running and sharing tasks
- Taking into account traceability
- Exploiting data/highlighting processes
- Writing



The Program related to marine chemistry

Tuesday

- ***Marine Chemistry at IUEM****: an overview of the teaching modules with on-field activities, Matthieu Waeles*

- ***Observation & time series*** *in coastal waters, learning the specific instrumentation and the standardized methods, Peggy Rimmelin*

Classroom

Wednesday

- ***Introduction to Marine Chemistry*** *part A, on-field activities, Gauthier Schall, Franck Quéré*

- ***The Seamist project****, Matthieu Waeles*

On-field

Thursday

- ***Introduction to Marine Chemistry****: part B, Lab activities, Ricardo Riso*

- ***Segmented-flow for nutrient analysis****, an indispensable tool for our teaching, Jérémy Devesa*

- ***Marine Chemistry for future managers****, M. Waeles, J. Devesa and E. Grosstefan*

Lab

CORRIENTE XXI

Pergamon

Continental Shelf Research, Vol. 16, No.15, pp. 1885–1907, 1996

0278–4343/96 $15.00 + 0.00

0278–4343(95)00068–2

Resistance of a coastal ecosystem to increasing eutrophic conditions: the Bay of Brest (France), a semi-enclosed zone of Western Europe

OLIVIER LE PAPE,* YOLANDA DEL AMO,†
ALAIN MENESGUEN,* ALAIN AMINOT,*
BERNARD QUEQUINER† and PAUL TREGUER†

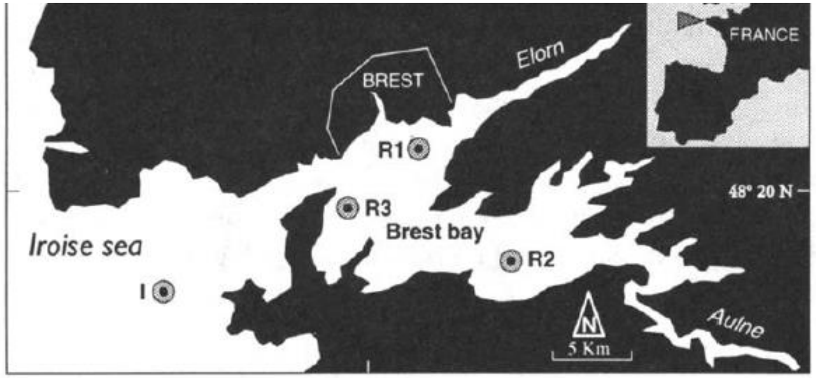


Fig. 1. General situation of the site under study, with location of the sampling stations.

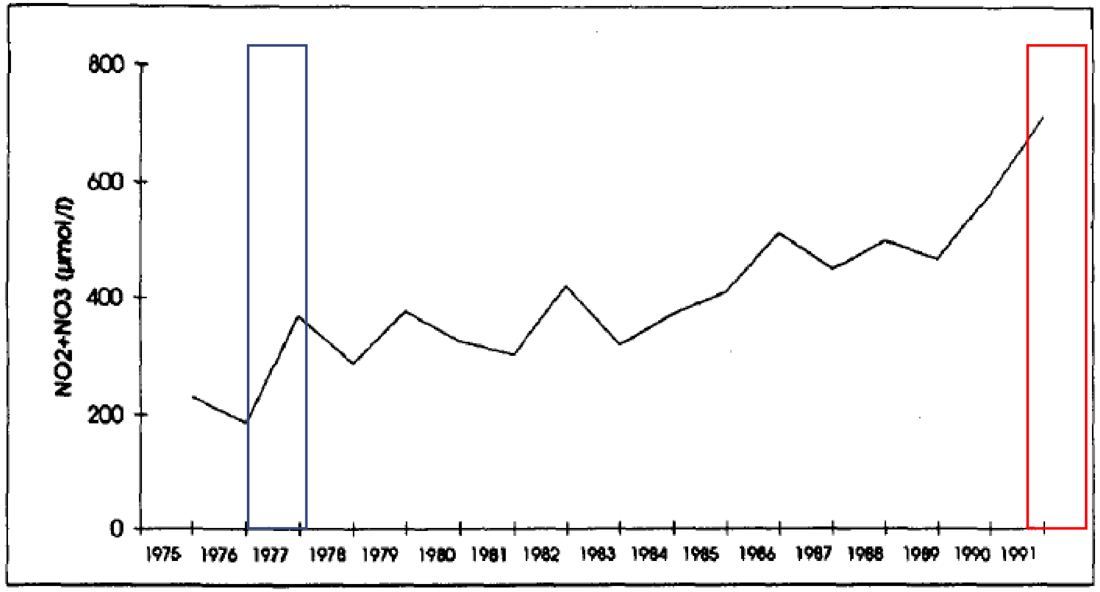


Fig. 2. Time variations of winter nitrate + nitrite concentrations (μmol l^{-1}) in the Aulne River at the limit of the freshwater.

Between <u>1977</u> and <u>1993</u>: the flux of nitrate to the Bay of Brest increased by a factor 2:
- **Primary production (eutrophication) ??**
- **Oxygen status ??**

Elorn mouth

Bay of Brest

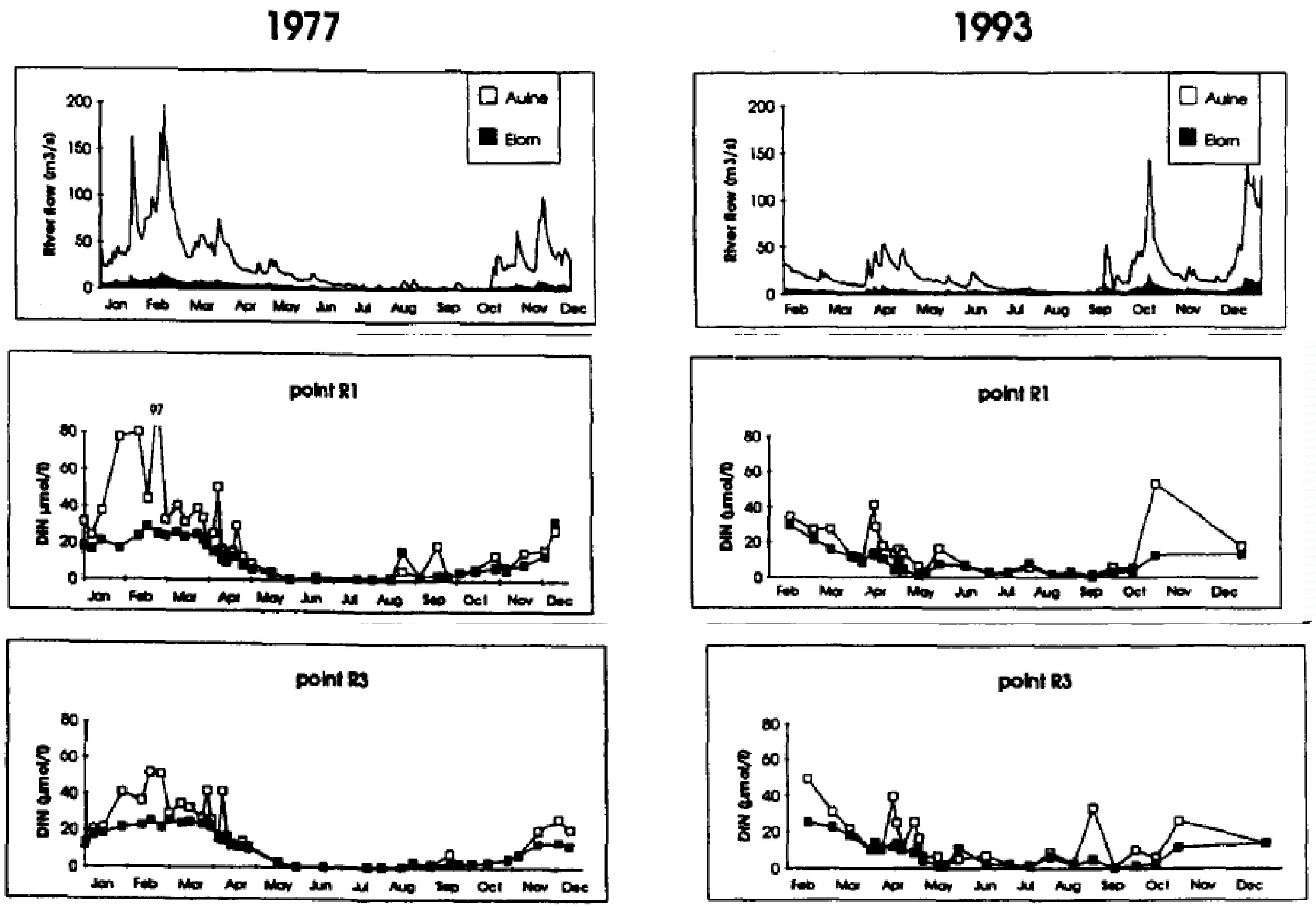


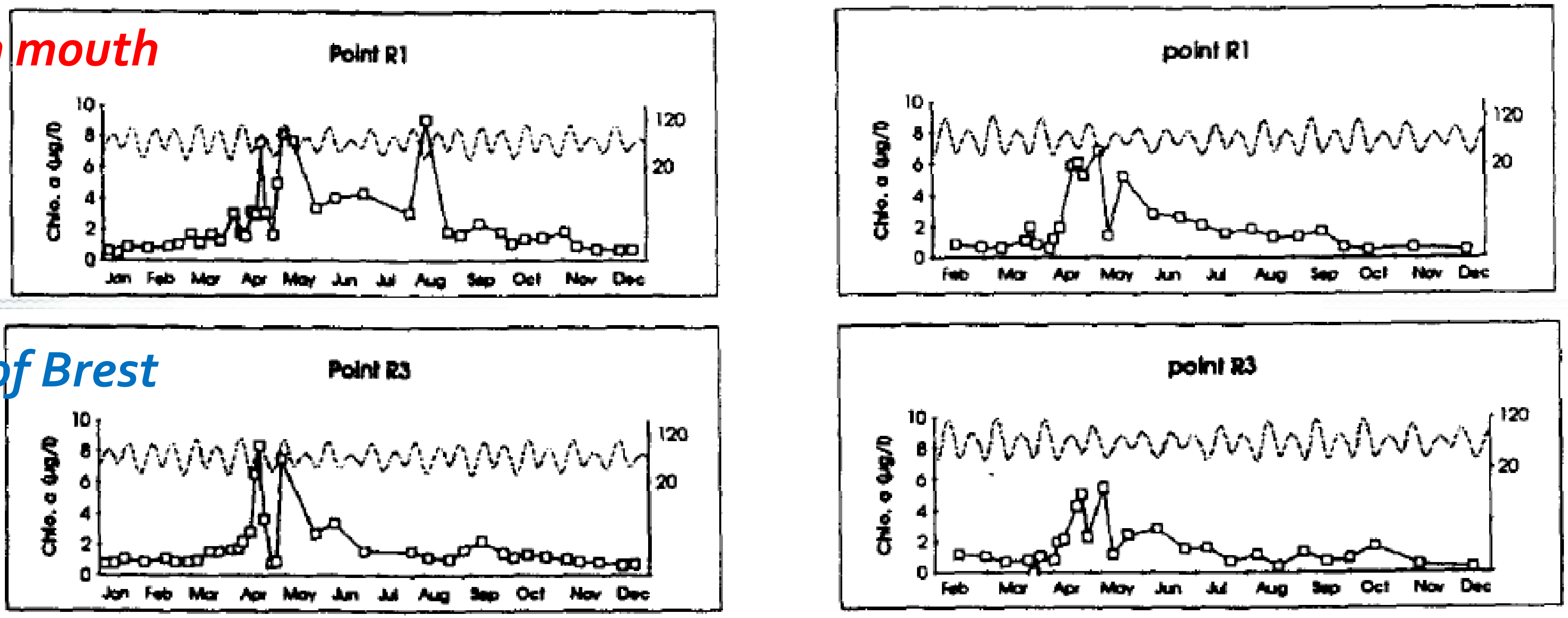
Fig. 7. Daily river flow of the two main tributaries and time variations in surface (□) and bottom (■) DIN concentrations (µmol l^{-1}) at the four studied stations for 1977 and 1993.

depth	Nitrate (µM)
0	35.3
2	28.5
5	17.3
8	11.4
10	7.7

depth	Nitrate (µM)
0	3.5
2	3.6
5	3.8
10	3.5
15	2.9

Nitrate (DIN) concentrations (and salinity) are mainly controlled by the river flow.
Because of the strong mixing, stratification (differences between surface and bottom) occurs only under high river flow or at estuary mouth

1977 | 1993 | Oct. **2017**



depth	chla (µg/L)
0	
2	0.66
5	0.53
8	0.66
10	0.33

depth	chla (µg/L)
0	1.12
2	1.1
5	0.82
10	0.91
15	0.9

Fig. 8. Time variations during 1977 and 1993 in surface (□) chl *a* concentrations (µg l^{-1}) at the four studied stations with overprinted daily tide coefficient.

- *Over a large winter period (Oct-March), primary production is limited by light*
- *First bloom (diatoms) are usually observed in spring (April-May). Note that nutrient concentrations at the onset of the bloom are relatively low because the river flow (usually high in winter) has already decreased and because the high mixing induces important nutrient loss (before the bloom onset).*
- *Over the spring-summer period, primary production is limited by silicic acid then nitrate*

Oct. **2017**

Bay of Brest

1977 1993

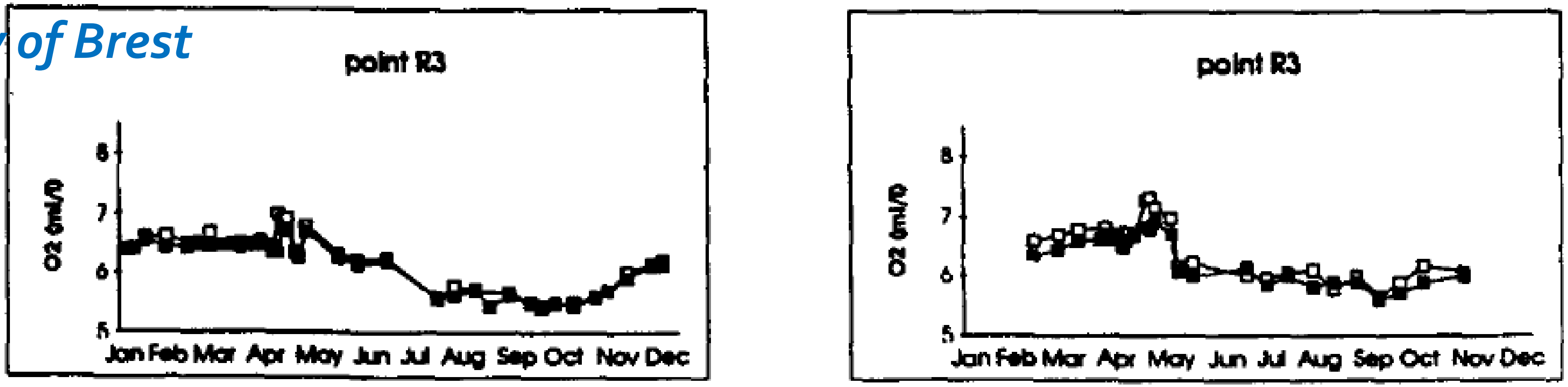


Fig. 9. Time variations during 1977 and 1993 in surface (□) and bottom (■) oxygen concentrations (ml l^{-1}) at points R2 and R3.

depth	ml/l O2	%sat O2
0	5.61	96.5
2	5.14	90.1
5	6.2	108.6
10	5.46	95.7
15	5.49	96.2

Oxygen concentrations in this well-mixed system are always close to saturation and are homogeneous across the water column (no difference between surface and bottom)

Abstract—The Bay of Brest is a semi-enclosed coastal ecosystem receiving high nutrients loading from freshwater inputs. In order to analyse the response of phytoplankton stocks to increasing eutrophic conditions, a survey of the annual cycle of hydrographic properties, nutrients and chlorophyll *a* concentrations, and carbon uptake rates was performed at four stations in 1993. This database has been compared to earlier measurements performed during several comparable surveys within the last 20 years. As compared to the seventies, a doubled nitrate loading is now entering this ecosystem, which is related to increased agricultural activities on the drainage basins, while the geographical origin of the nitrate input has been modified. As a result of these anthropogenic modifications, summer averaged Si/N stoichiometric balance has decreased during the two last decades but, contrary to what has been observed in other coastal ecosystems, phytoplankton stocks have not increased. Several ecological factors have hindered eutrophication: the high hydrodynamic mixing with adjacent marine waters, caused by the macrotidal regime, induces important nutrients losses, temperature and mostly light limit primary production while Si and P high recycling maintain nitrogen limitation in this ecosystem. Conjunction of these non-anthropogenic factors explains the global stability of phytoplankton stocks.

the nutrient ratio has been modified. Nevertheless, our present conclusions do not allow us to say that the Bay of Brest is safe from any danger resulting from increasing eutrophic conditions, although we can preclude that no general increase of phytoplankton stocks is likely to happen. If the decrease in Si/N residual ratio during summer goes on, standing silicate limitation can probably occur with important consequences on the specific phytoplankton composition (Conley *et al.*, 1993).

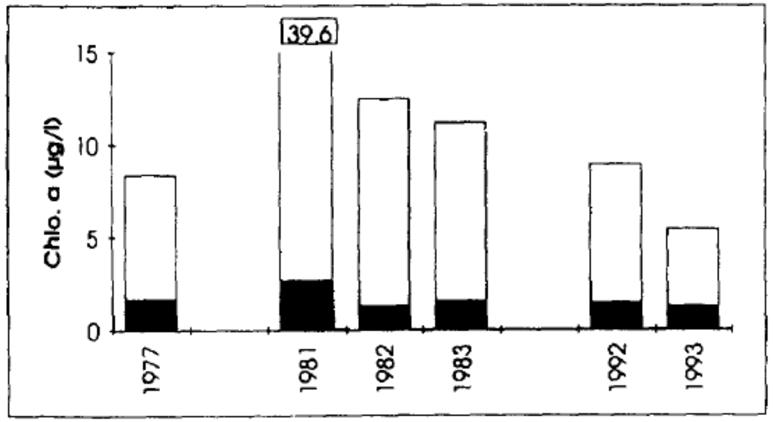


Fig. 3. Maximum (□) and integrated (■) annual chl *a* surface concentrations ($\mu g\ l^{-1}$) at point R3 for different years.

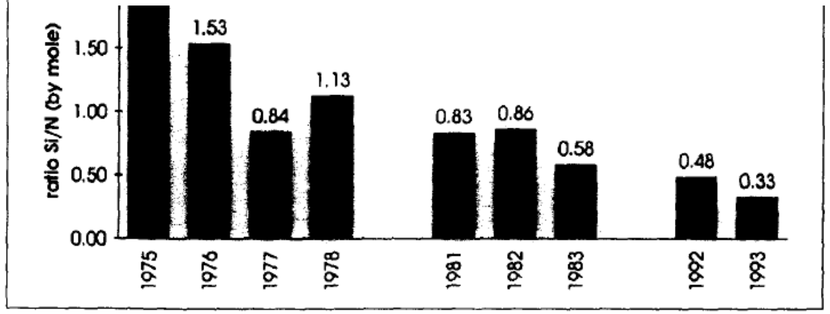


Fig. 4. The Si/N ratio (by mole) for different years, calculated from integrated surface concentrations at point R3 during summer, when nutrients limit primary production.

Vol. 161: 213–224, 1997 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published December 31

Impacts of high-nitrate freshwater inputs on macrotidal ecosystems. I. Seasonal evolution of nutrient limitation for the diatom-dominated phytoplankton of the Bay of Brest (France)

Yolanda Del Amo[1,*], Olivier Le Pape[2], Paul Tréguer[1], Bernard Quéguiner[1], Alain Ménesguen[2], Alain Aminot[2]

This paper from Del Amo also also shows that :

- *the Bay of Brest is a well-mixed system (salinity and temperature distributions are homogeneous excepting during high river flows)*
- *Oxygen concentrations are also homogeneous across the water column and always close to saturation*

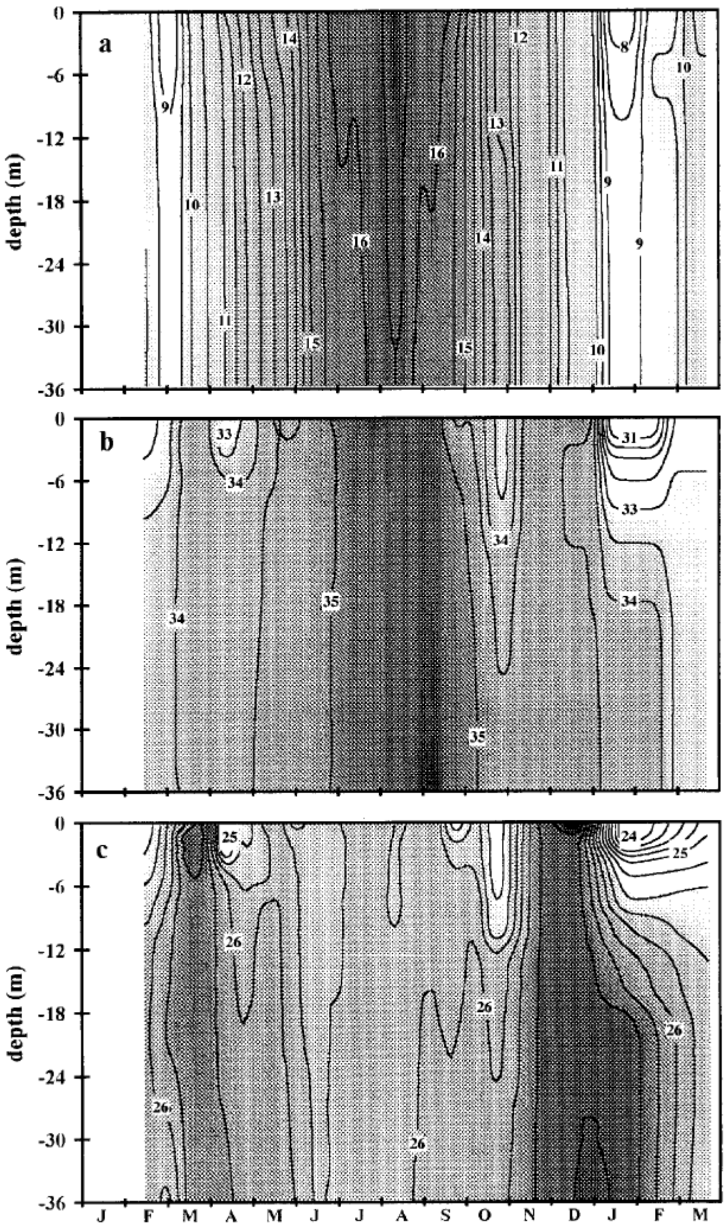


Fig. 3. Seasonal variations of physical parameters at Stn R_3 (Bay of Brest) during 1993–1994 based on CTD profiler measurements. (a) Temperature in °C; (b) salinity in psu; (c) density (σ_t)

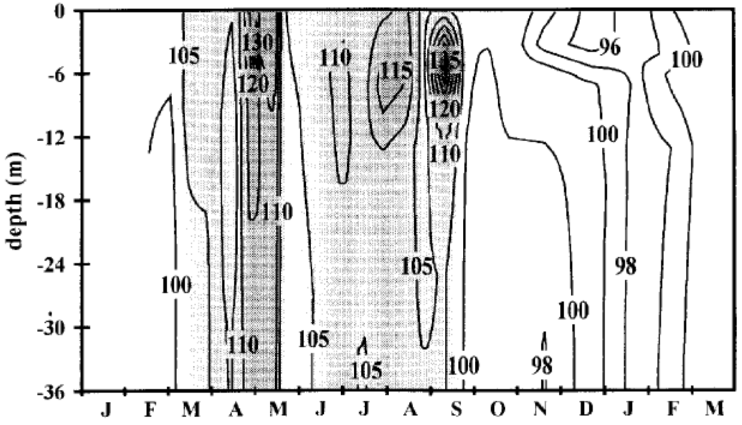


Fig. 7. Seasonal variations of dissolved oxygen saturation values (in %) at Stn R_3 during 1993–1994

Oct. **2017**

depth	salinity	temp.
0	35.1	14.8
2	35.1	14.8
5	35.1	14.8
10	35.1	14.8
15	35.1	14.8