PHYTOPLANKTON COMMUNITIES IN RELATION WITH PHYSICO-CHEMICAL CONDITIONS WITHIN AN OFFSHORE BIVALVE FARMING AREA (NORTH OF SPAIN)

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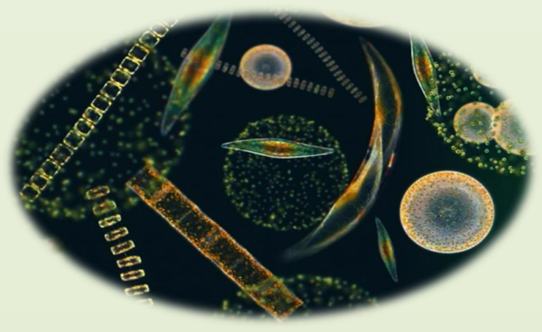

INTRODUCTION

Phytoplankton is the basis of the marine food webs and the main source of energy for filter feeder bivalves.

The spatial and temporal dynamics of phytoplankton are driven by:

- Physico-chemical conditions: mainly, the availability of light and nutrients (quantity and proportion).
- Competition
- Grazing

Some phytoplankton species can cause Harmful Algal Blooms (HABs). HABs involve problems associated to elevated algal biomass in the ecosystems and/or toxins that are transferred to higher trophic levels (including humans). These last are of high concern for bivalve farming.

Thus, the **objective** of this study is to get a better understanding on the dynamics of phytoplankton and their relationship with water physico-chemical conditions, in an offshore mollusc production area specifically.

MATERIAL AND METHODS

- Monthly samplings from May to October 2014 at a pilot-scale bivalve farm ("longline" station).
- Six discrete water depths: 3, 10, 17, 24, 33 and 42 m.
- CTD casts twice a month: vertical profiles of temperature, salinity and chlorophyll "a".
- Determination of size-fractionated chlorophyll "a".
- Phytoplankton identification and abundance (Utermöhl method). DSP, ASP and PSP (i.e., Diarhetic, Amnesic and Paralytic Shellfish Poisoning, respectively) producing taxa were identified.
- Toxins analyses in mussels (*Mytilus galloprovincialis*).

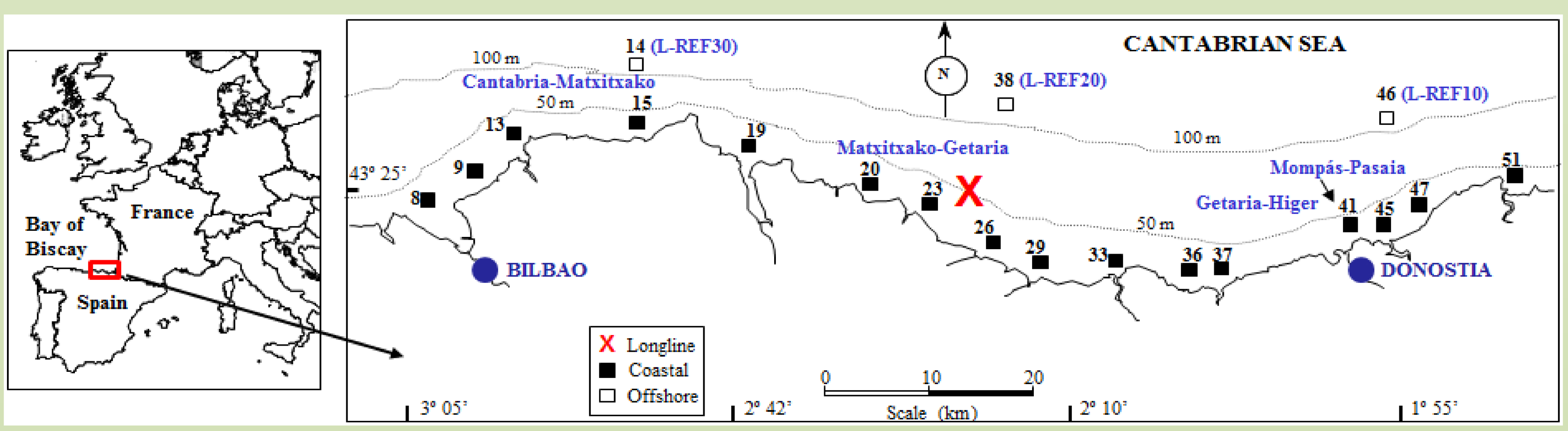

Fig. 1. Map of the Basque coast, in the southeastern Bay of Biscay. The longline station, whose results are shown here, is represented. There are also several coastal and offshore stations with historical data (> 10 years).

Fig. 2. CTD and Niskin bottle were used at discrete depths for the determination of size-fractionated chlorophyll "a", nutrients and phytoplankton abundance

Fig. 3. Pairovet plankton net (20 µm pore size mesh). An integrated sample of the upper 30 m was obtained for the qualitative study of the phytoplankton community.

Fig. 4. Mussel samples were monthly analyzed to determine toxin levels. Mouse bioassay was used for PSP and lipophilic toxins, and HPLC for domoic acid (ASP).

MAIN FINDINGS:

- Thermohaline stratification (May, August and September) alternated with situations of vertical mixing (July and October). Salinity sporadically decreased at surface, probably due to **freshwater inputs** from land, which would increase nutrients availability.

- At late spring, the consumption of nutrients by phytoplankton could have been important: the highest **Chlorophyll "a"** values were observed in May and June, both below 30m, coinciding with the lowest concentrations of dissolved nutrients.

- In May **silicate** followed a decreasing trend with depth, which coincided with an opposite trend in the contribution of **diatoms** to phytoplankton abundance. Although the cell abundance was low, large size diatoms constituted about the 50% of the community at the bottom layer. A change in the size-structure of the community was also revealed by the fractionated chlorophyll.

- **Total phytoplankton abundance** decreased markedly over both time and depth. Nutrient inputs could influence importantly the community during the study period, as the strongest significant Spearman correlations were found with depth (-) and freshwater content (+). **Haptophytes** tended to be more abundant in the upper layer and **diatoms** in the lower layer. **Dinoflagellates** were associated with higher temperatures.

CONCLUSION:

Water variables were important drivers of phytoplankton community structure, abundance and distribution along the water column. During the studied period, freshwater seems to be the strongest influence, given the nutrient input that it involves.

RESULTS

1. Water column structure and phytoplankton biomass (CTD casts)

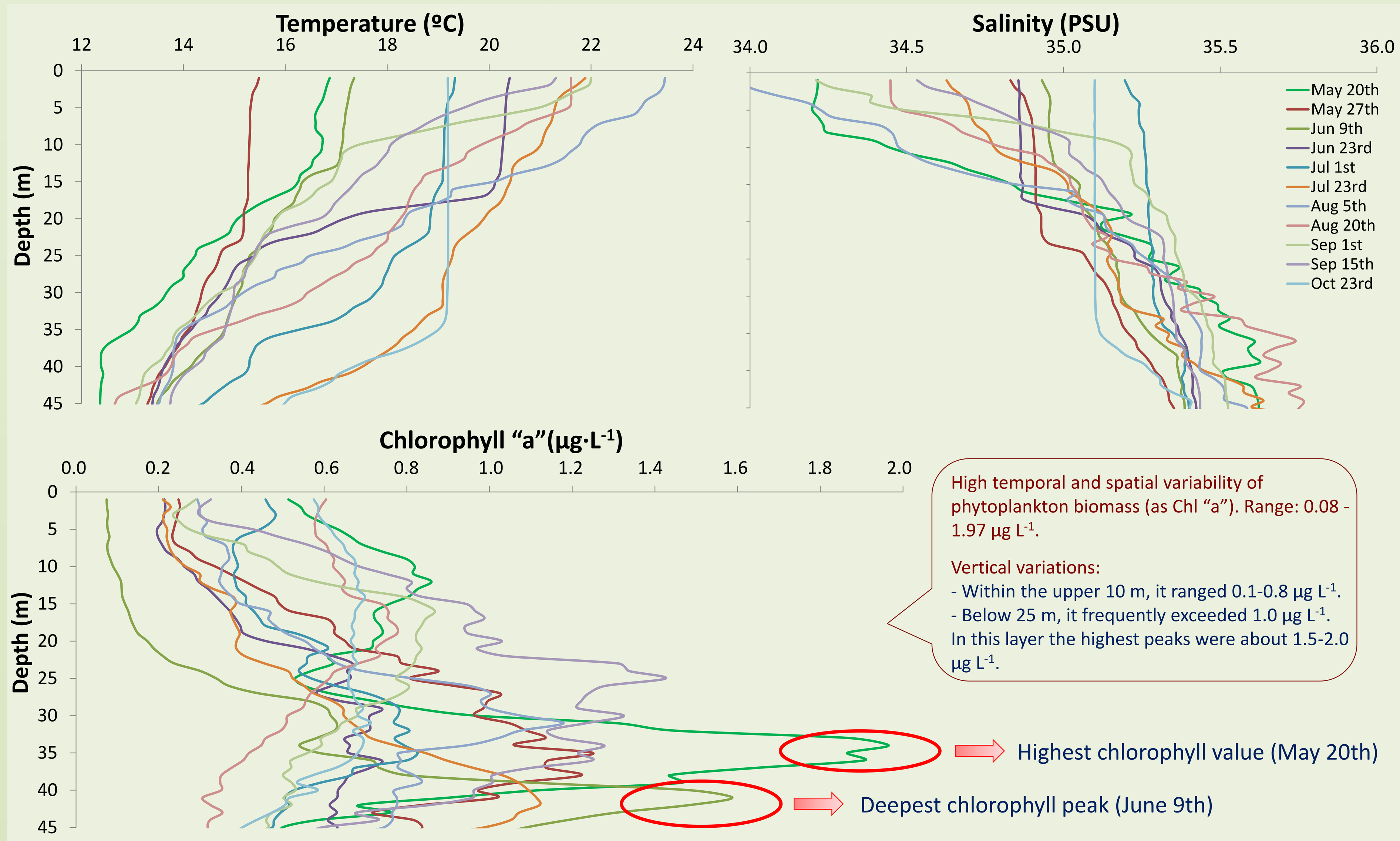

Fig. 5. Temperature, salinity and chlorophyll "a" vertical profiles conducted twice a month (when possible), from May to October 2014.

2. Nutrient concentrations at three depths

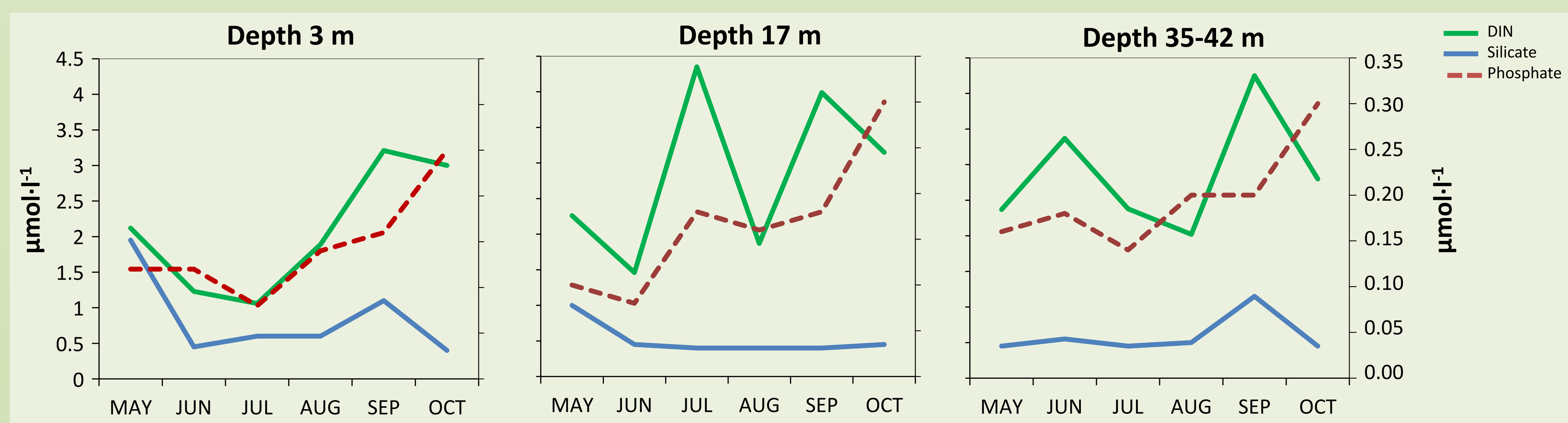

Fig.6. Dissolved inorganic nitrogen (DIN) and silicate concentrations (left axis), and phosphate concentration (right axis). Redfield ratios were usually N:P>16, except in August and October, suggesting phosphate as the limiting nutrient.

	Phytoplankton (total abundance)	Dinoflagellates	Haptophytes	Diatoms
Depth	-0.590*	NS	-0.638**	NS
Temperature	NS	0.560*	NS	NS
Freshwater %	0.501*	NS	0.628**	-0.482*

Table 1. Spearman's rank correlation coefficients (ρ) between phytoplankton abundance and physico-chemical variables. Only significant relations are shown (*p<0.05 and **p<0.01). NS means no significance.

3. Total and size-fractionated chlorophyll "a"

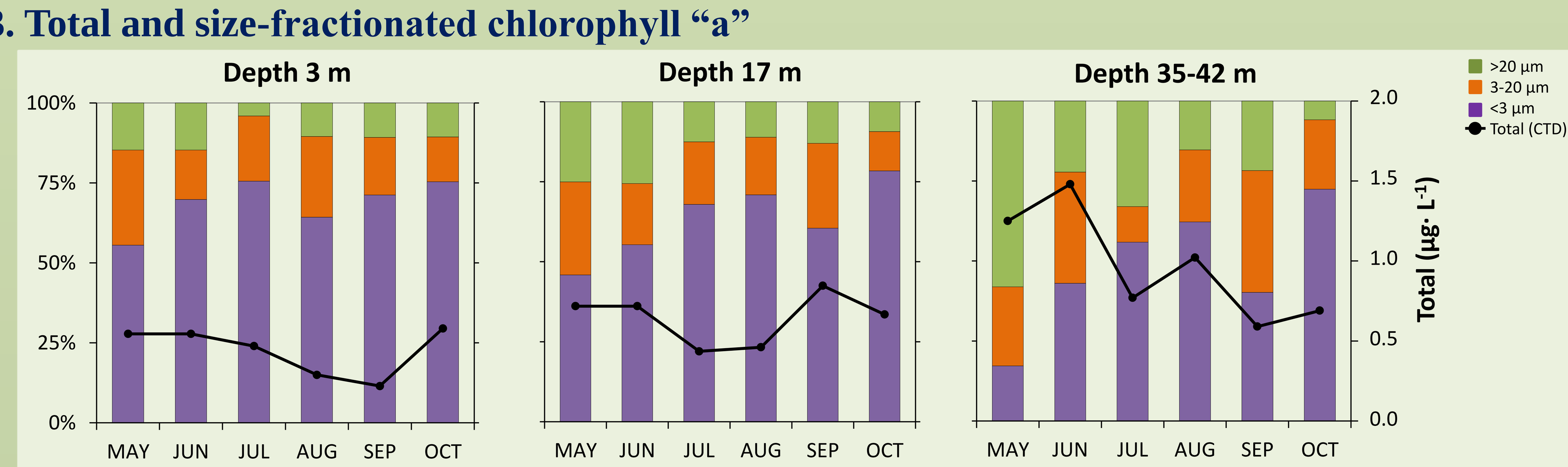

Fig.7. Total chlorophyll (right axis) and percentage contribution of each size fraction (left axis).

4. Phytoplankton abundance and taxonomic composition

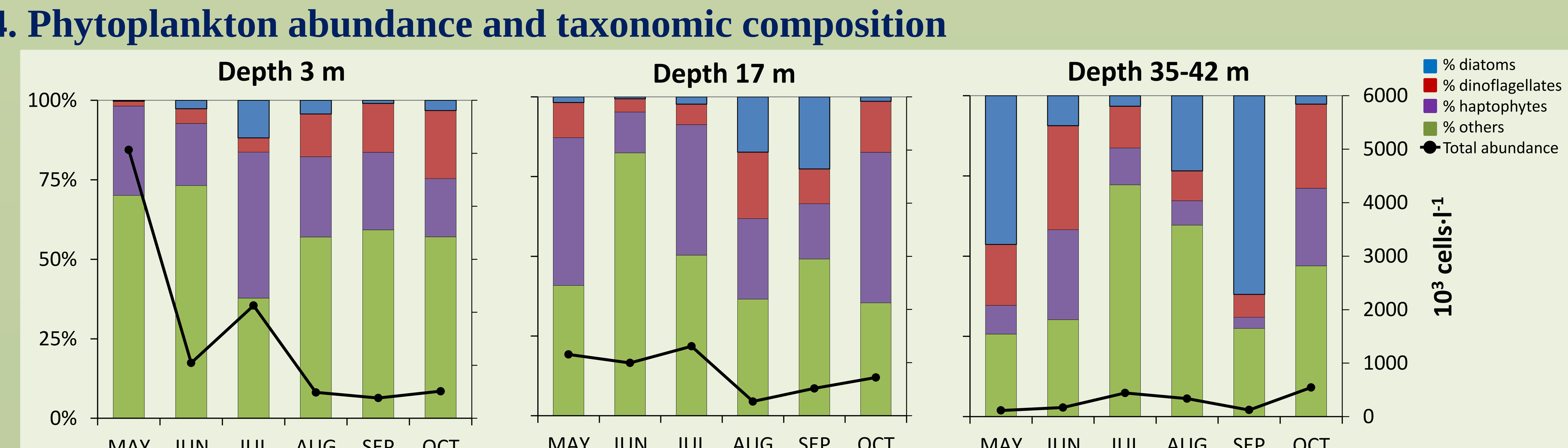

Fig.8. Phytoplankton total abundance (right axis) and percentage contribution of major taxonomic groups (left axis).

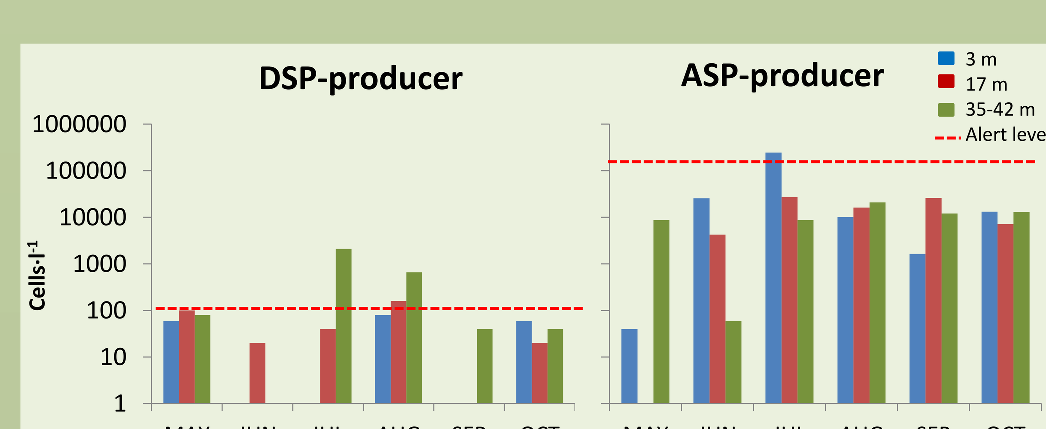

Fig.9. DSP and ASP-producers at three depths each month. PSP-producers are not shown, they were only present in May at 3 m depth (20 cells·l-1). Results for toxin analyses in mussels were below the detection limit, except in May (DSP toxins). The lipophilic toxins coincided with the presence of the DSP producing species *Dinophysis acuminata*, with cell concentrations close to the alert limit (Alert levels taken from the Food Standards Agency). Much higher *Dinophysis* concentrations were observed in the lower layer in July and August, but with *D. tripos* as the responsible species.

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Water column physico-chemical conditions, phytoplankton structure and toxin levels within an open ocean mollusc culture (Southeastern Bay of Biscay)

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ABSTRACT

A pilot-scale longline system (Fig. 1) started in 2012 in the Basque coast (Southeastern Bay of Biscay). In order to study phytoplankton's nutritional quality and potential toxic effect on bivalves, several surveys were carried out from May to September 2014. Data from CTD casts (temperature, salinity, light…), nutrients, size-fractionated chlorophyll "a" and phytoplankton taxonomy were integrated with the purpose of studying the relationships between phytoplankton dynamics and physico-chemical parameters.

Maxima of Chl "a" (1.5-2.0 µg L^{-1}) were observed in late spring, at depths below 30 m. These coincided with low nutrient concentrations, probably due to consumption. A change in community structure was found over time, from the dominance of large organisms (>20 µm), mostly diatoms, to smaller ones (<3 µm). The observed low values of Chl "a" could have been caused by phosphorous limitation, as Redfield ratios were usually >16. Finally, the positive results observed in May for lipophilic toxins in mussels could be explained by the presence of *Dinophysis* spp. and *Phalacroma rotundatum.*

INTRODUCTION

Depletion of natural stocks has motivated a great development in **aquaculture**

Longline systems for bivalves: increased efficiency in offshore areas compared to other culture systems

Study of the suitability of the **Basque coast** → a pilot-scale bivalve farming started in 2012 in front of Mendexa (Bizkaia).

Bivalves (filter feeders) → importance of **phytoplankton** (main source of energy, but also biotoxins producers)

Objectives: to evaluate the potential of offshore aquaculture in the Basque coast through the assessment of the phytoplankton dynamics.

Fig. 1. Longline system with mussel cultures in the area of study (Mendexa, SE Bay of Biscay).

MATERIAL AND METHODS

From May to September 2014 water samples were collected at one point ("longline station") within the pilot-scale bivalve farm. Six discrete water depths (3, 10, 17, 24, 33 and 42 m) were sampled monthly. In addition, CTD casts were conduced twice a month (Fig. 2).

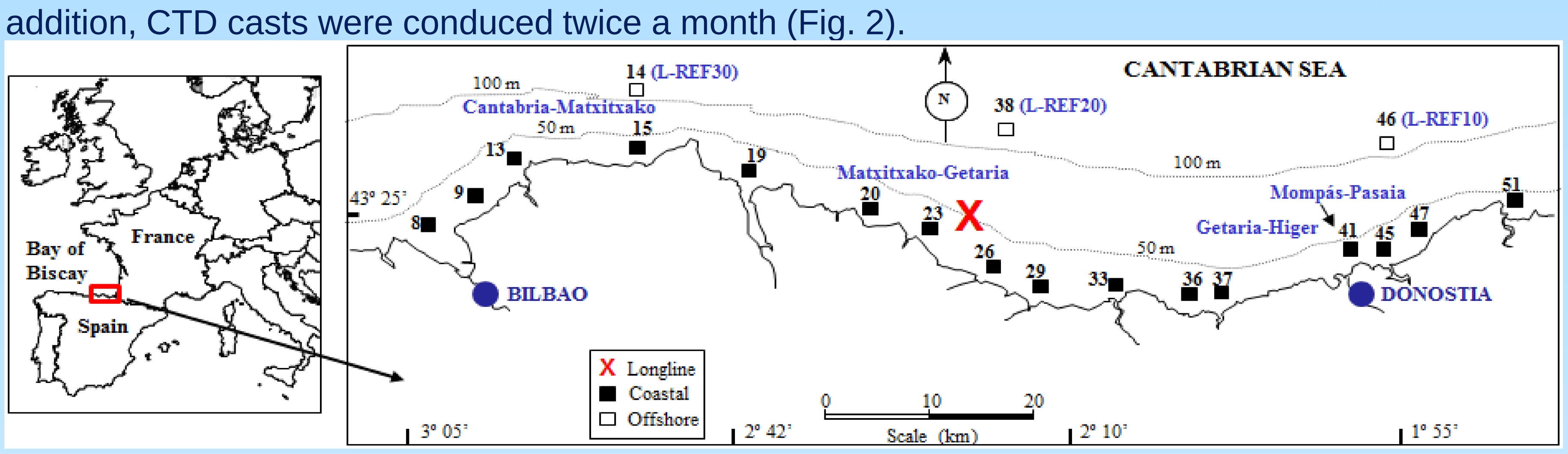


Fig. 2. Map of the Basque coast, in the southeastern Bay of Biscay. The longline station, whose results are presented here, is represented. There are also several coastal and offshore stations with historical data (>10-years).

Fig. 3. CTD to obtain vertical profiles of temperature, salinity and chlorophyll "a". Also, Niskin bottle at discrete depths for determination of size-fractionated chlorophyll "a", nutrients and phytoplankton abundance.

Fig. 4. Pairovet plankton net (20 µm pore size mesh). An integrated sample of the upper 30 m was obtained for the qualitative study of the phytoplankton community.

Fig. 5. Toxins were monthly analysed in mussels. Mouse bioassay was used for PSP and lipophilic toxins, and liquid chromatography with diode array detector for domoic acid (ASP).

DISCUSSION

Some thermal stratification was found in May, but it was stronger in August and September. Salinity lowered sporadically in the surface layer, probably reflecting freshwater inputs from land, which would affect nutrient concentrations.

Historical data from a more offshore located station (L-REF20, Fig. 2) indicate that peaks of Chl "a" are developed below the thermocline, up to 3.5 µg L^{-1} (exceptionally 8 µg L^{-1}). In the longline station this pattern was observed in several occasions, but maxima did not exceeded 2.0 µg L^{-1}.

A change in community structure was observed: large-size phytoplankton (>20 µm) marked the Chl "a" peak in May, whilst picoplankton (<3 µm) dominated for most of the period.

May and June presented the lowest nutrient concentrations, probably due to phytoplankton consumption, agreeing with Chl "a" peaks. The dominance of large diatoms at 35 m, in May, might explain the decrease in SiO_3^{2-} at the deep layer.

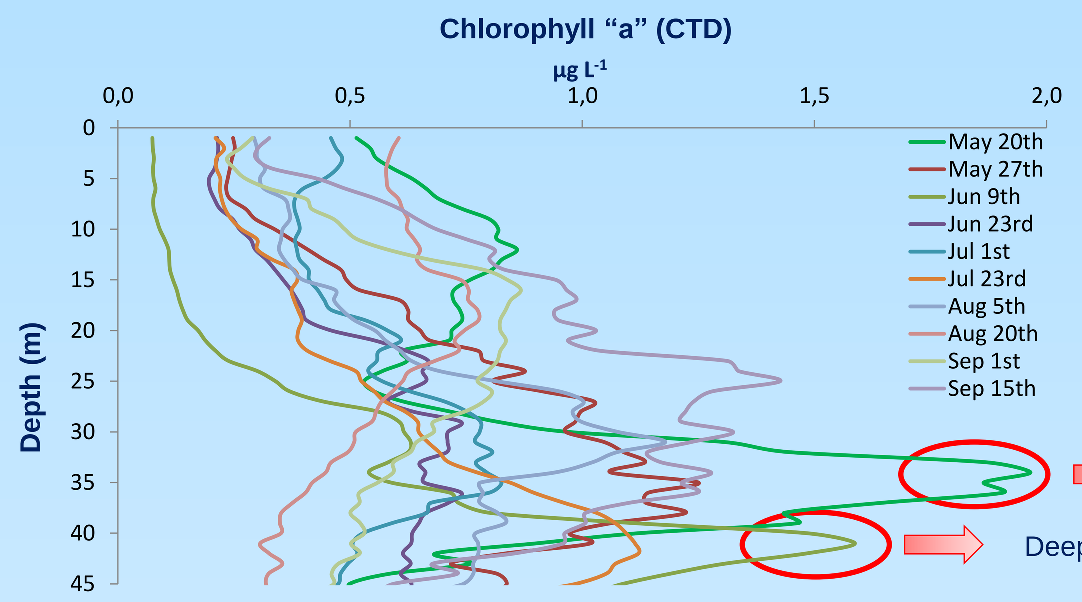
Except in August, the obtained Redfield ratios (N:P>16) suggest P as the limiting nutrient. The increase of NH_4^+ over time can be related to biological processes of organic matter mineralisation, which are enhanced with higher temperatures.

CONCLUSIONS

- The high temporal variability found in the phytoplankton biomass (Chl "a") is coherent with the highly variable hydrographical conditions of this area.
- Chl "a" also showed important variations through the water column. Sporadic peaks were observed at depths below 30 m.
- Although generally the small sized phytoplankton (<3 µm) was the most important contributor to the biomass, larger size-fractions dominated during Chl "a" peaks.
- Toxins (**LP**) found in May coincided with a deep peak of Chl "a". However, this peak was caused by diatoms, whilst the **LipophilicToxin** levels were related to the presence of dinoflagellates (e.g., *Dinophysis* spp.) that contributed very few to the Chl "a".

RESULTS

Phytoplankton biomass (as chlorophyll "a"), general physico-chemical conditions and results from toxin analyses in mussels are shown below, for the studied station within the farming area.



High temporal and spatial variability of phytoplankton biomass (as Chl "a"). Range: 0.08 - 1.97 µg L^{-1}.

Vertical variations:

- Within **the upper 10 m,** it ranged 0.1-0.8 µg L^{-1}.
- **Below 25 m,** it frequently exceeded 1.0 µg L^{-1}. In this layer the highest peaks were about 1.5-2.0 µg L^{-1}.

Fig. 6. Chlorophyll "a" vertical profiles conducted twice a month, from May to September 2014.

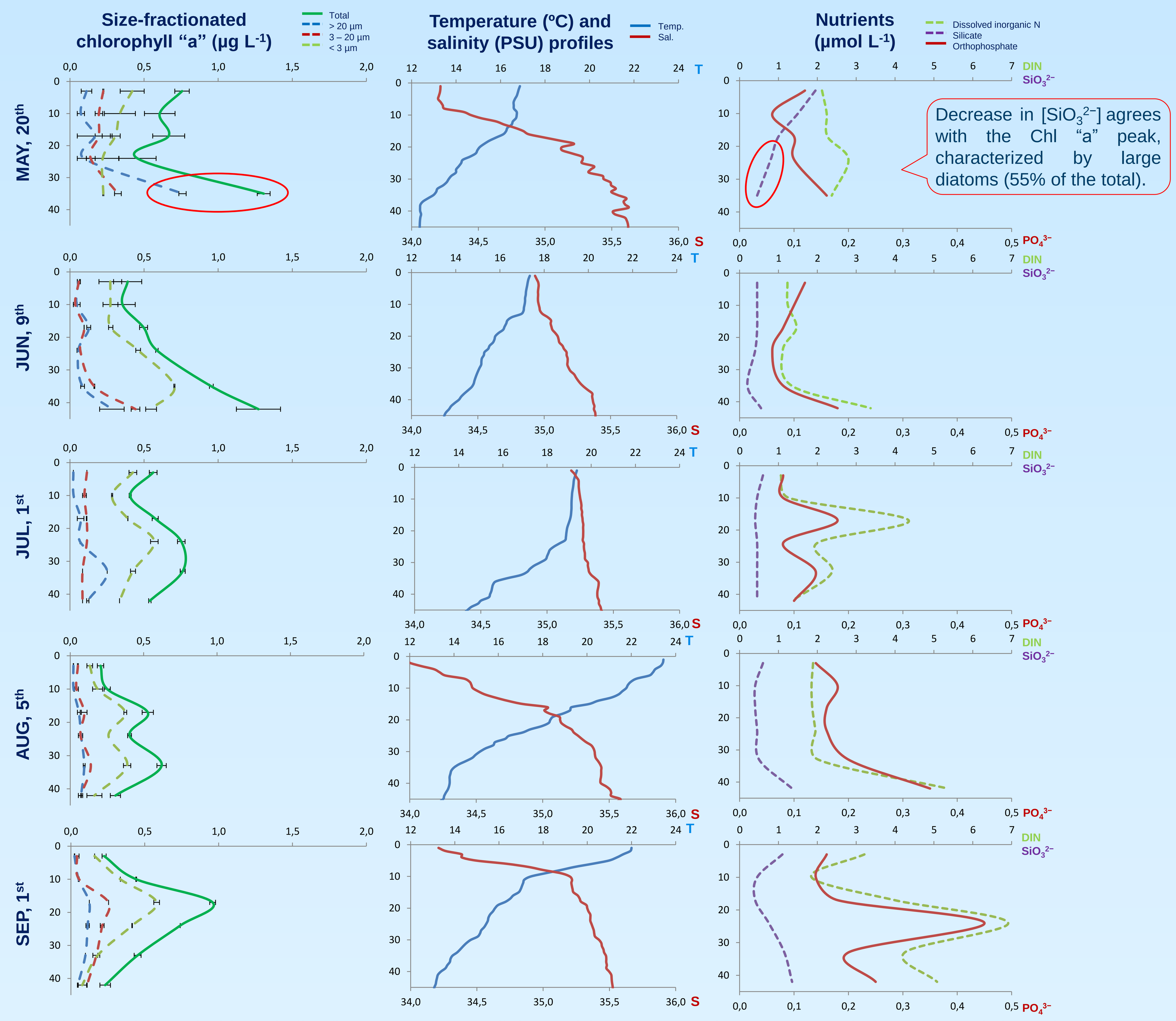


Fig. 7. Size-fractionated chlorophyll "a", temperature, salinity and inorganic nutrient concentrations measured through the water column, for 5 monthly surveys.

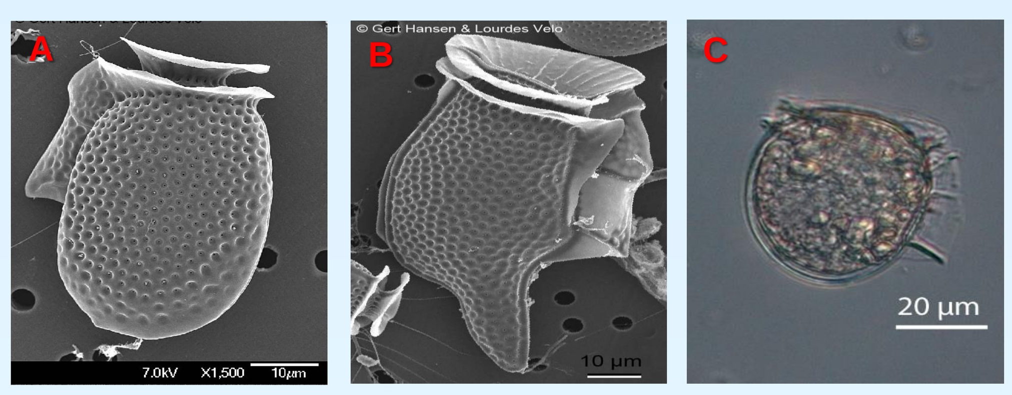


Fig. 8. Toxin values only exceeded the permitted limits **in May**, where the result of the analysis for lipophilic toxins through mouse bioassay was POSITIVE. These toxins cause **Diarrhetic Shellfish Poisoning (DSP)**. Indeed, potentially toxic species, DSP-producers, were identified in the water: *Dinophysis acuminata* (A), *Dinophysis caudata* (B) and *Phalacroma rotundatum* (C). Their abundances were in the order of 10^2 cells L^{-1}.

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