



HAL
open science

Targeted and non-targeted metabolomic analyses of *Heterocapsa cf. bohaiensis* under nickel and iron high concentration and its photophysiology

Vincent Mériot, Gaëtan Herbette, Elnur Garayev, Noémie Coulombier, Loic Le Déan, Thierry Jauffrais, Nicolas Lebouvier

► To cite this version:

Vincent Mériot, Gaëtan Herbette, Elnur Garayev, Noémie Coulombier, Loic Le Déan, et al.. Targeted and non-targeted metabolomic analyses of *Heterocapsa cf. bohaiensis* under nickel and iron high concentration and its photophysiology. 8th European Phycological Congress, Aug 2023, Brest, France. hal-04211842

HAL Id: hal-04211842

<https://hal.science/hal-04211842>

Submitted on 20 Sep 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Targeted and non-targeted metabolomic analyses of *Heterocapsa cf. bohaiensis* under nickel and iron high concentration and its photophysiology

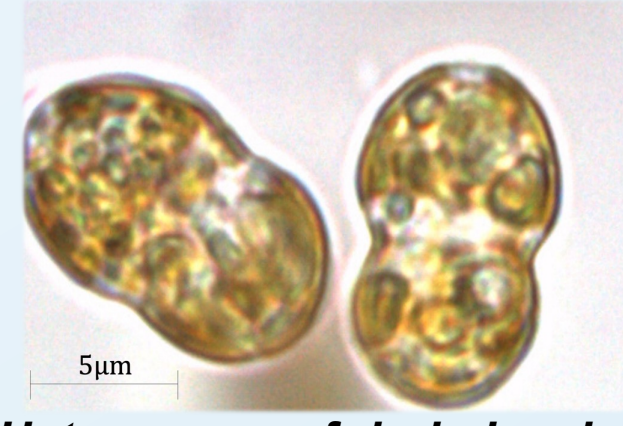
Meriot V.^{1,2*}, Herbet G.³, Garayev E.⁴, Coulombier N.⁵, Le Déan L.², Jauffrais T.², Lebouvier N.¹

1. ISEA EA7484, Univ. Nouvelle-Calédonie, 98851 Nouméa, Nouvelle-Calédonie, France ; 2. Ifremer, UMR Entropie, 101 Promenade Roger Laroque, 98897 Nouméa, Nouvelle-Calédonie, France ; 3. CNRS, Centrale Marseille, FSCM, Spectropole, Aix Marseille Université, Campus de St Jérôme-Service 511, 13397 Marseille, France ; 4. Aix Marseille Univ, CNRS 7263, IRD 237, Avignon Université, IMBE, 27 Blvd Jean Moulin, Service of Pharmacognosy, Faculty of Pharmacy, 13385 Marseille, France ; 5. ADECAL Technopole, 1 Bis Rue Berthelot, 98846 Nouméa, Nouvelle-Calédonie, France

Introduction

❑ **New Caledonian** coastal waters are naturally rich in **metallic trace elements**. (Biscéré et al. 2017; Merrot et al. 2022)

❑ An excess of metallic inputs induce an **oxidative stress**. (Pinto et al. 2016; Danouche et al. 2022)



Heterocapsa cf. bohaiensis

❑ ***Heterocapsa cf. bohaiensis***, a dinoflagellate isolated in New Caledonia, is associated with shrimp and crab mortalities. (Xiao et al. 2018)

❑ Might be a good candidate to study the production of **metabolites of interests** (e.g. carotenoids, biotoxins, fatty acids...)

❑ Does the species **adapted** to this particularly **metal-rich** environment and does it impacted the **photosystem** and **metabolome** by developing **adaptive strategies** ?

Aim: Study the impact of nickel & iron on the photosystem and metabolome

Materials & Methods

Culture in photobioreactors:

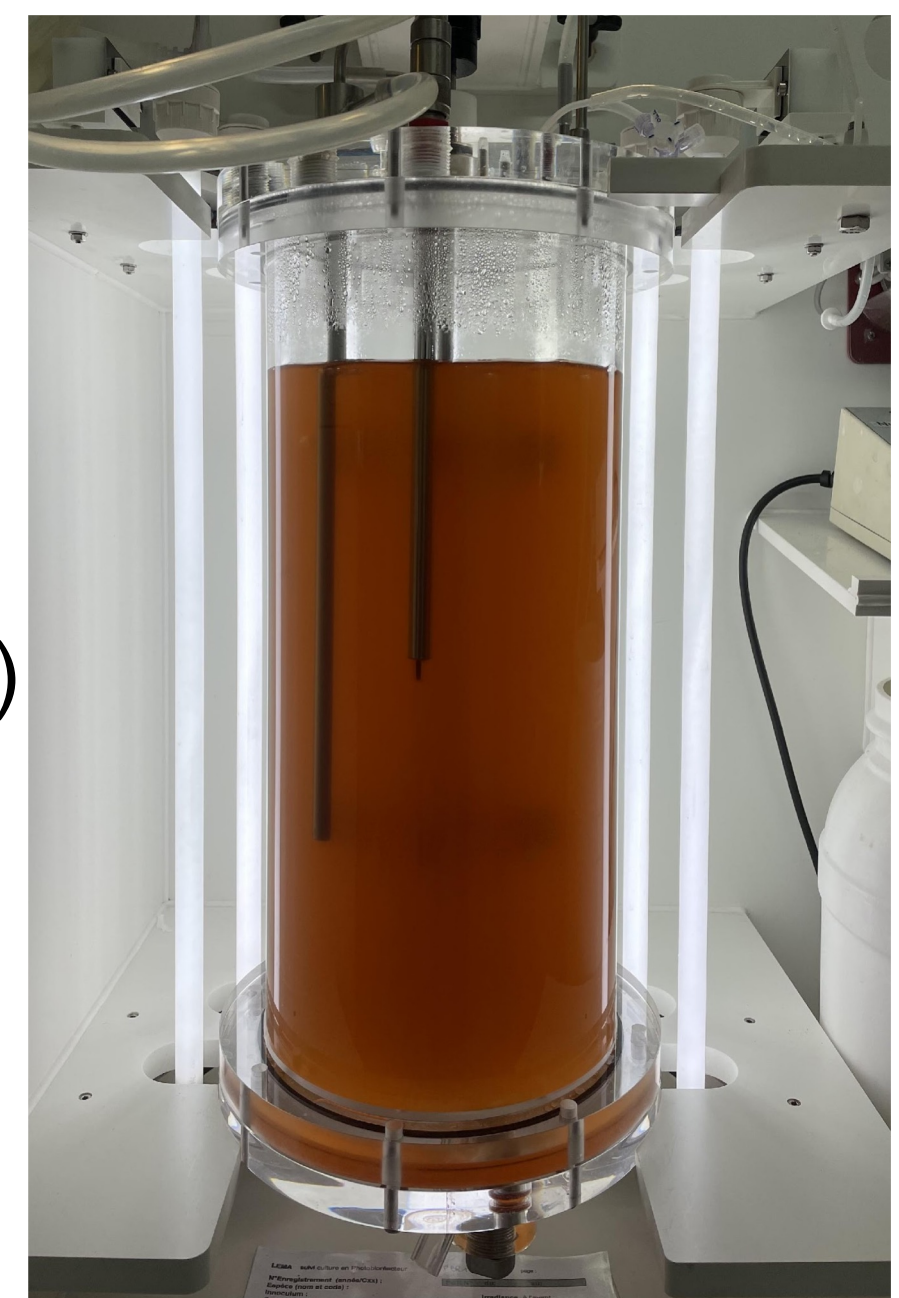
- Continuous culture of *H. cf. bohaiensis*
- Addition of **nickel** and/or **iron** after steady state

Experimental conditions (in triplicate):

- **Metals:** Ni 10^{-3} M ; Fe 10^{-3} M ; Ni+Fe $0.5 \cdot 10^{-3}$ M (of each)
- **Times:** Control t_0 ; t_{24h} ; t_{72h} ; t_f (13 days)

Analyses:

- **Chlorophyll a** fluorescence using PAM (Pulse Amplitude Modulated) fluorometry
- **Bioaccumulation** capacity by ICP-MS/OES
- **Pigment** analyses through HPLC-UV (450 nm)
- **Fatty acids** - GC-MS – (Transesterification)
- **Non targeted metabolites** - NMR



H. cf. bohaiensis in 10L photobioreactor

Results

Photosynthetic efficiency

Maximum Quantum yield

- Maximum photosynthetic efficiency **decreased** by **25%** and **15%** in Fe and Ni+Fe condition, respectively

Rapid Light Curves (RLC)

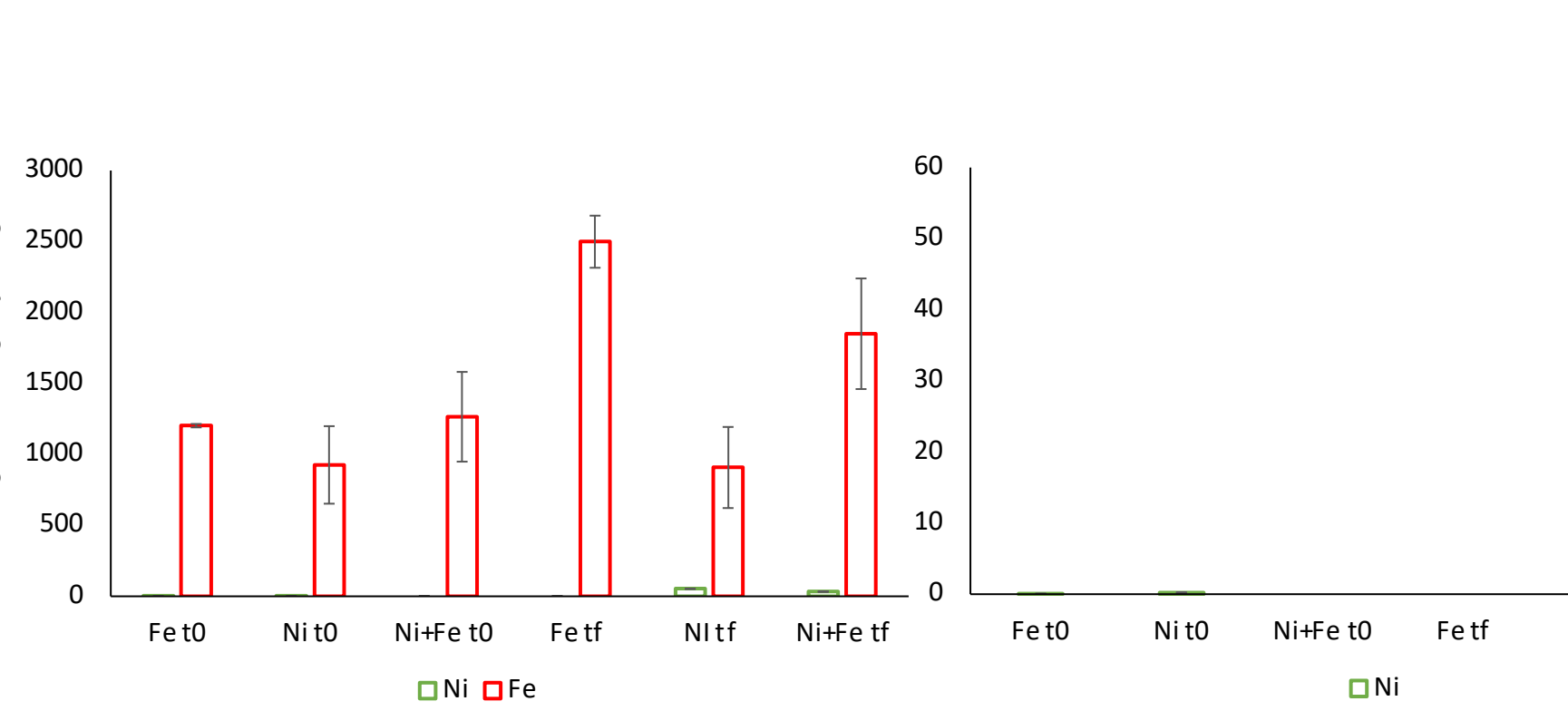
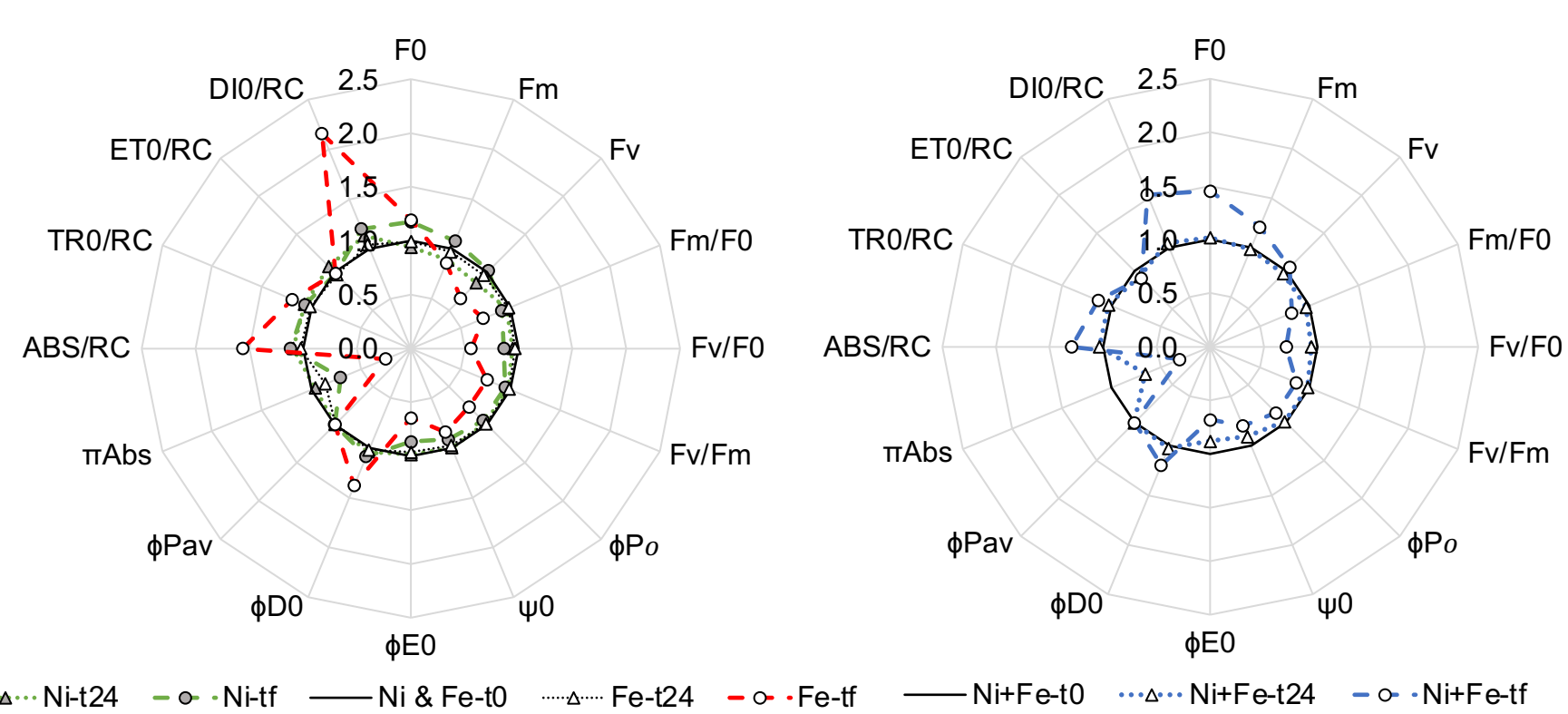
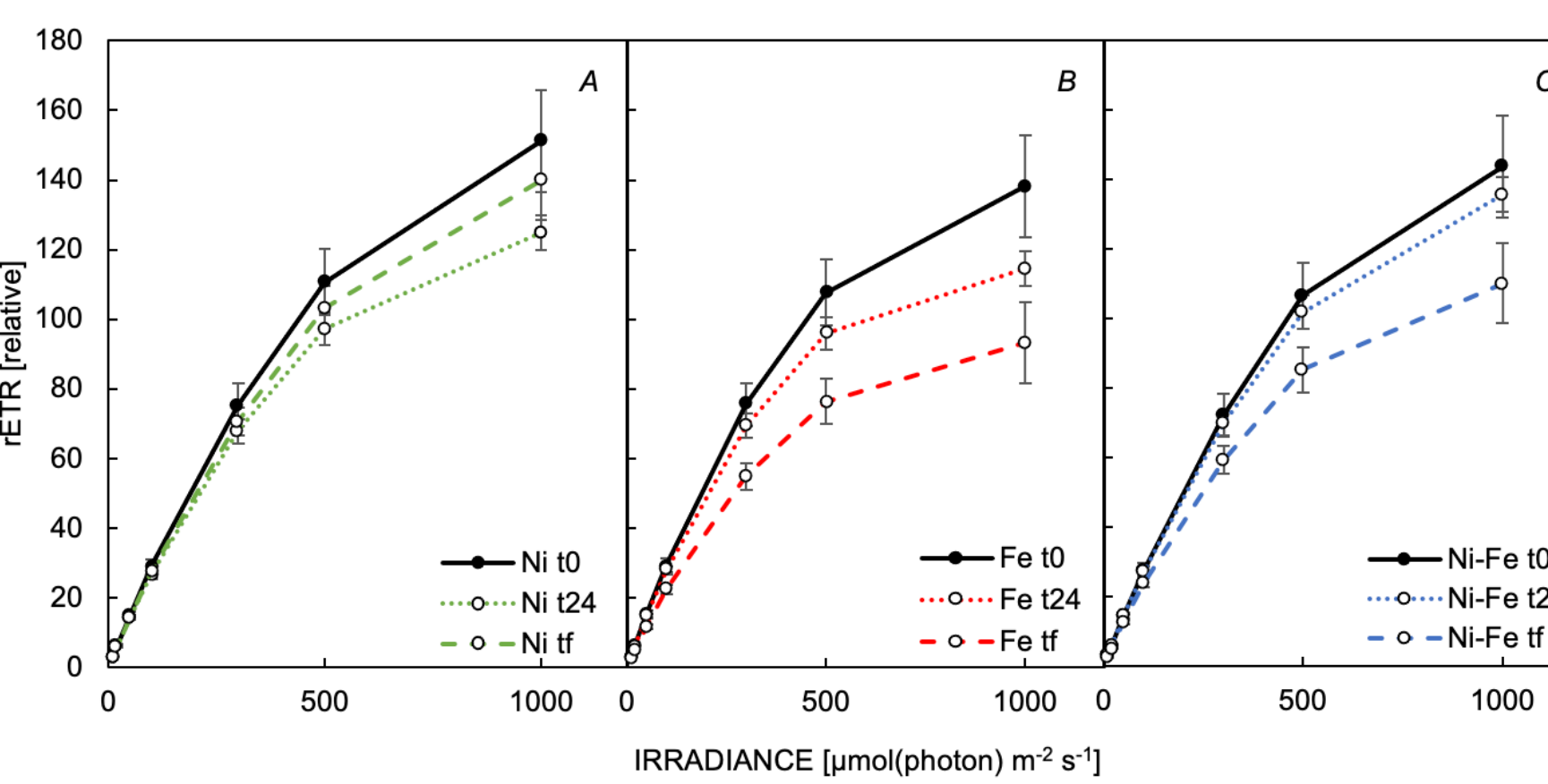
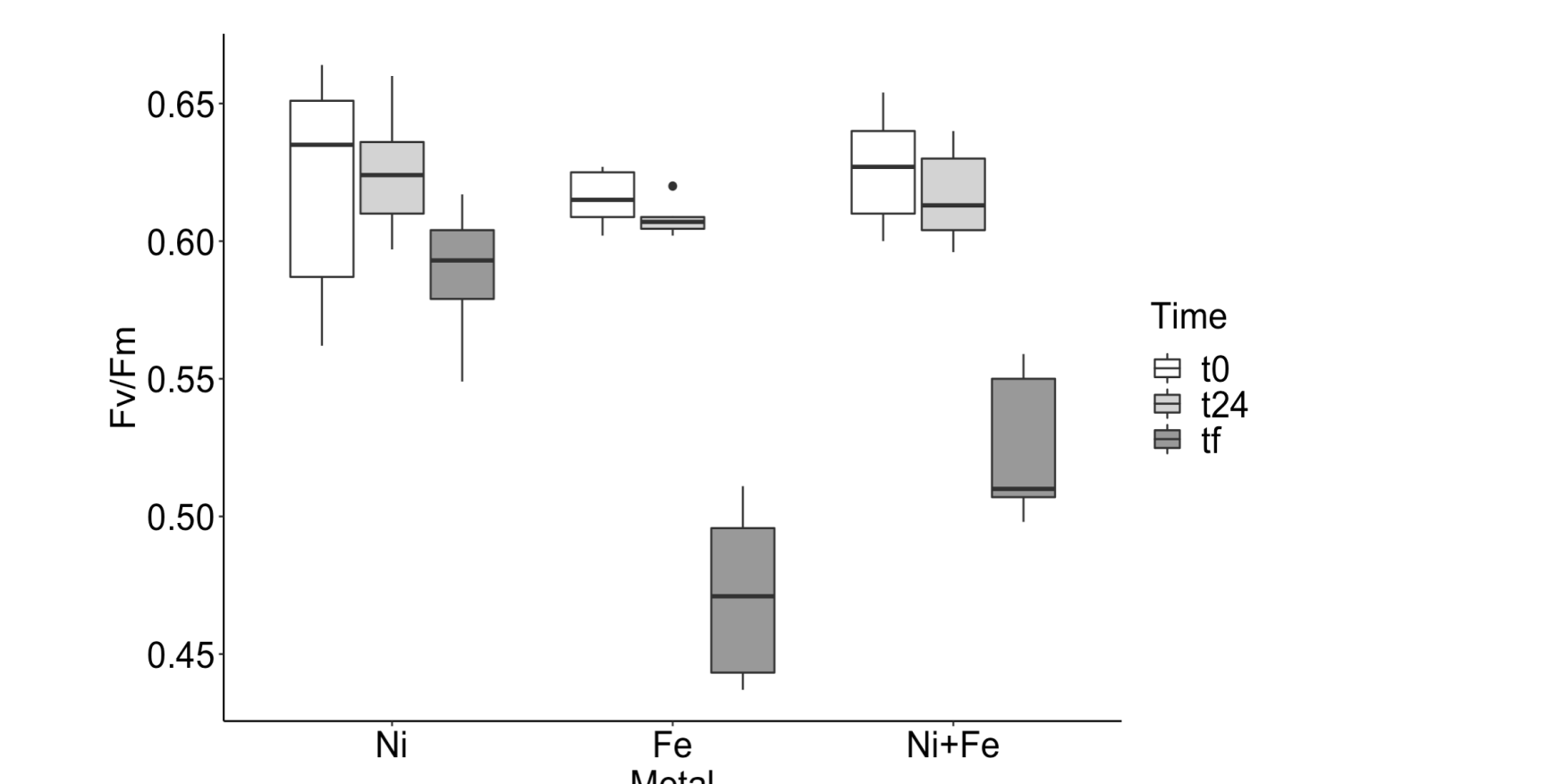
- **Negative** impact on photosynthetic activity due to high iron concentration

OJIP tests

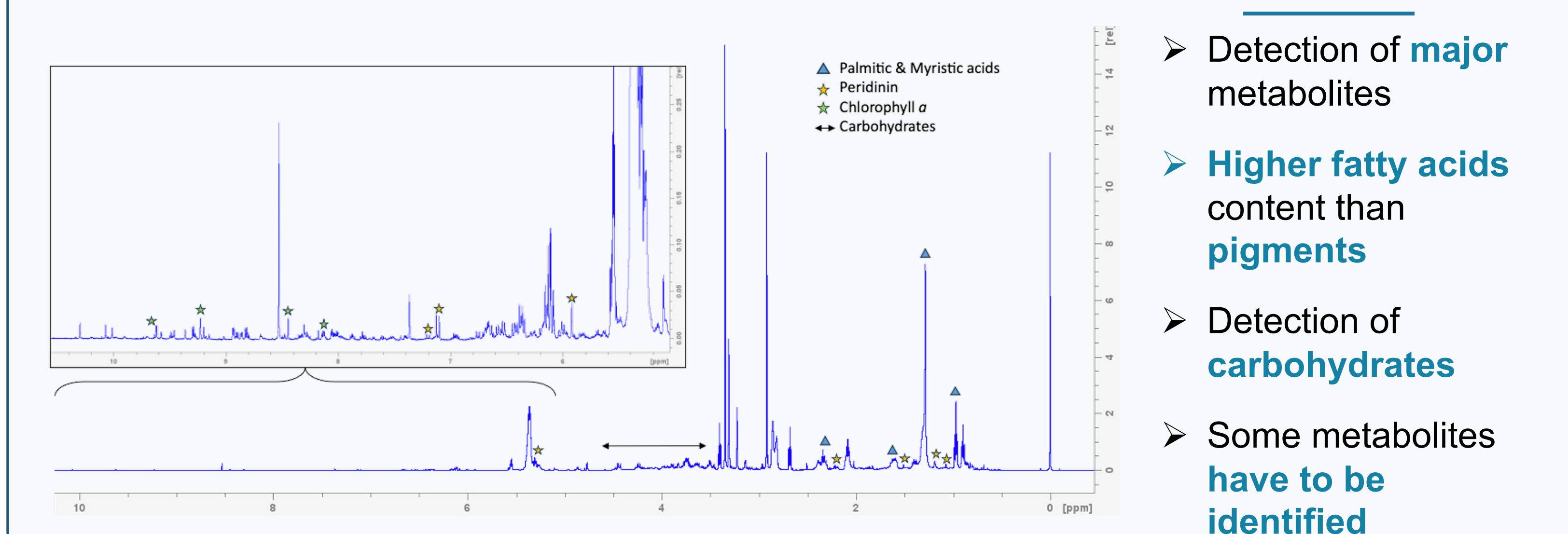
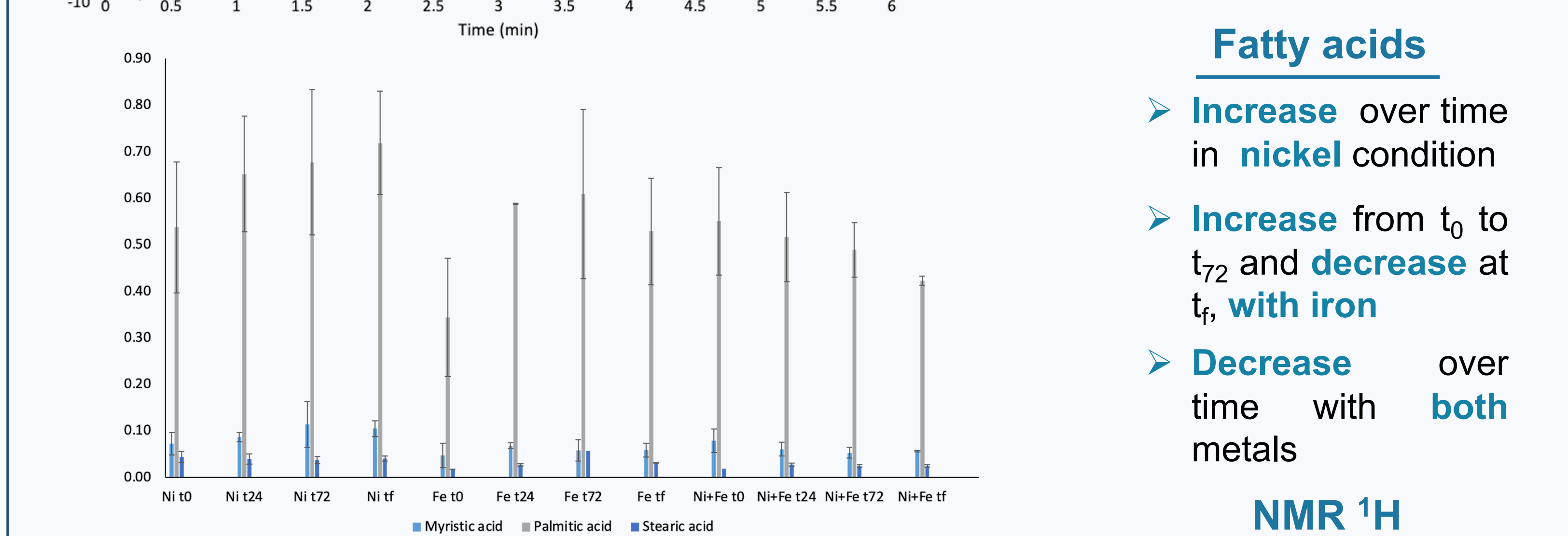
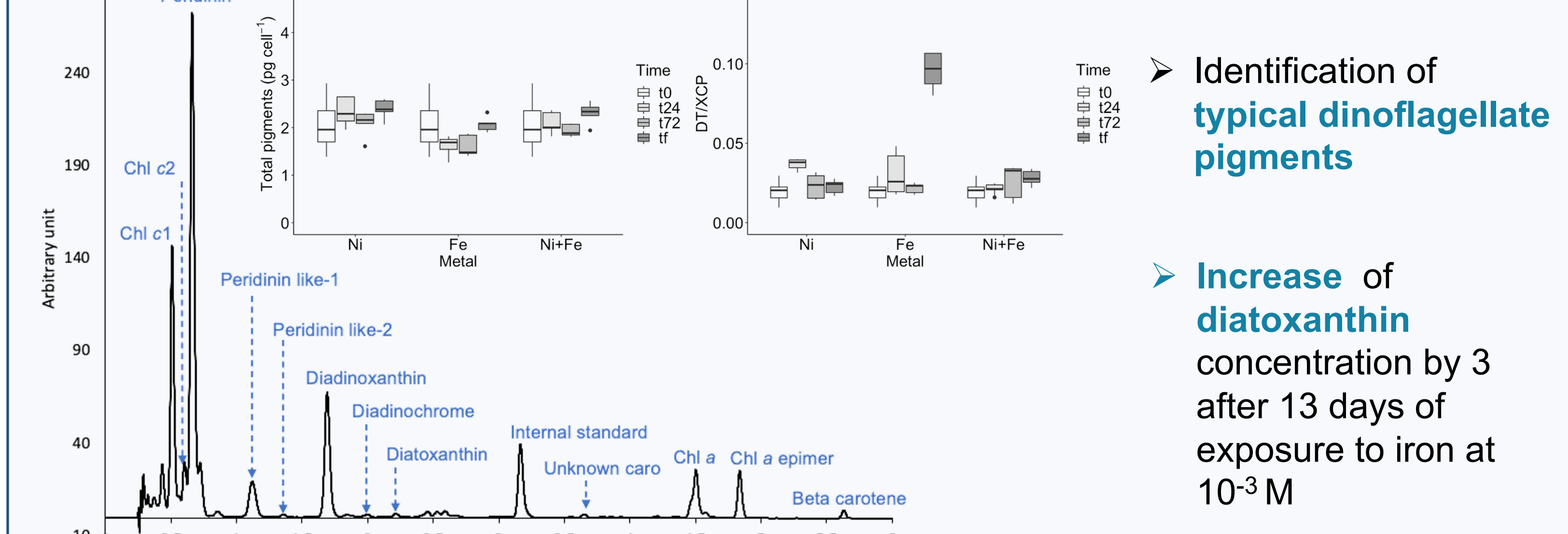
- **Decrease** of quantum efficiency parameters after 13 days with iron
- **Absorption, trapping and dissipation** were **higher** with addition of iron (concentration dependant) after 13 days

Bioaccumulation capacity

- **Higher** accumulation of the specific metal when added at high concentration in the culture



Pigment analyses



➢ Identification of **typical dinoflagellate pigments**

➢ **Increase** of diatoxanthin concentration by 3 after 13 days of exposure to iron at 10^{-3} M

Fatty acids

- **Increase** over time in **nickel** condition
- **Increase** from t_0 to t_{72} and **decrease** at t_f **with iron**
- **Decrease** over time with **both** metals

NMR 1H

- Detection of **major** metabolites
- **Higher fatty acids** content than **pigments**
- Detection of **carbohydrates**
- Some metabolites **have to be identified**

Discussion

Photosynthetic efficiency

- *H. cf. bohaiensis* is **tolerant** to **nickel** at high concentrations
- In Iron conditions:**
 - **Fv/Fm** - *H. cf. bohaiensis* is impacted after a long term exposure
 - **RLC** - Iron reduced the ability to use light
 - **OJIP** - Iron stimulates capture and absorption of light energy & slows down the electron transport rate between photosystem II & I
 - **Increase of specific fluxes** (absorption, trapping and dissipation)

Pigment analyses

- Increase of **diatoxanthin** in iron condition
- Responsible of **dissipation increase**
- **Photosystem protection** against iron induced ROS (Huang et al. 2017)

Fatty acids

- Majority of 3 fatty acids more or less affected by the presence of metals
- Majority of **fatty acids**
- Detection of **other metabolites** than in targeted methods

NMR 1H

- Detection of **major** metabolites
- **Higher fatty acids** content than **pigments**
- Detection of **carbohydrates**
- Some metabolites **have to be identified**

Conclusion

Aim: Study the impact of nickel & iron on the photosystem and metabolome

- ✓ **Toxic** effect of iron dependant of the concentration **on the photosystem**
 - ✓ Iron stress **adaptive strategies** to protect against ROS
 - ✓ Risk of **metal bioaccumulation** in the food chain
- ✓ Identification of specific metabolites by **targeted metabolomics**
- ✓ NMR results show metabolites previously metabolites and new ones
- ❑ **Untargeted** metabolomic data have to be statically analysed to evaluate the metabolome response to metals (NMR & UPLC-HRMS)

References

Biscéré et al. (2017) Nickel and ocean warming affect scleractinian coral growth.
 Danouche et al. (2022) Overview of the management of heavy metals toxicity by microalgae.
 Huang et al. (2017) Occurrence and biosynthesis of carotenoids in phytoplankton.
 Merrot et al. (2022) Bioavailability of chromium, nickel, iron and manganese in relation to their speciation in coastal sediments downstream of ultramafic catchments: A case study in New Caledonia.
 Pinto et al. (2016) Oxidative damage and photosynthetic impairment in tropical rice cultivars upon exposure to excess iron.
 Xiao et al. (2018) *Heterocapsa bohaiensis* sp. nov. (Peridinales: Dinophyceae): a novel marine dinoflagellate from the Liaodong Bay of Bohai Sea, China

Acknowledgments

The authors acknowledge the Province Nord, the Province SUD, the Government of New Caledonia, the Comité Interministériel de l'Outre-Mer (CIOM) and the CRESICA for financial support through the AMICAL and MICROCOMET projects.

