Phytoplankton community response to small scale physical processes (*in situ vis-à-vis* modeling)

Zrinka Ljubešić

Island trapped waves as a driver of primary production – ISLAND, 1 Feb 2021 – 24 Jun 2025, https://www.pmf.unizg.hr/biol/island/en

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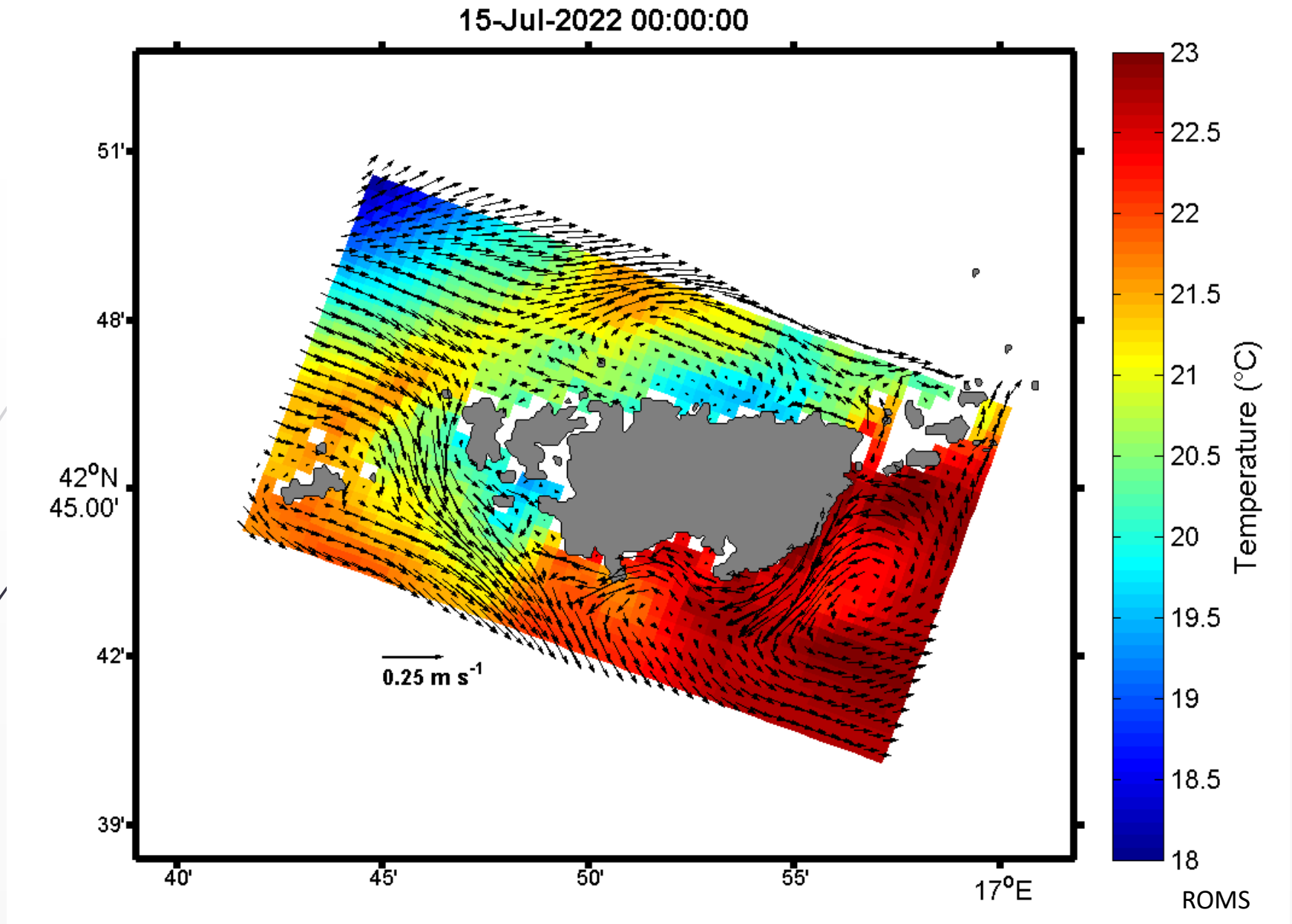
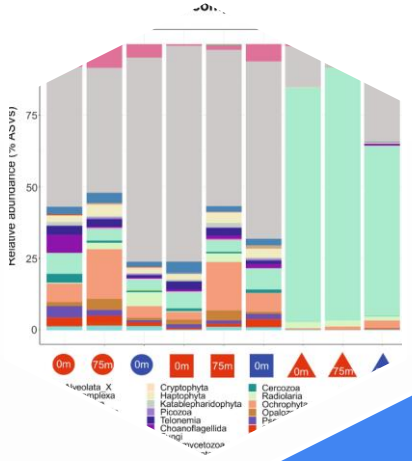
Workshop: Modelling primary production 27.-30.10.2025
Department of Physics, Faculty of Science, University of Split



ROMS animation d = 20m (dt = 3 h) UTC

The ISLAND FIELD adventure

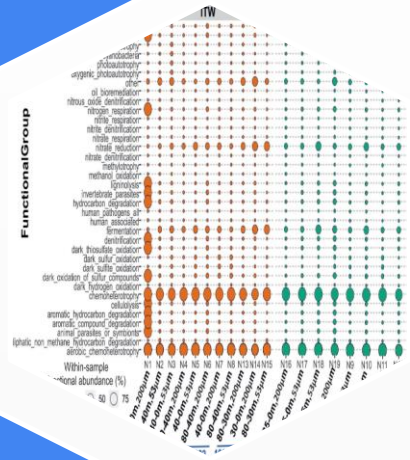


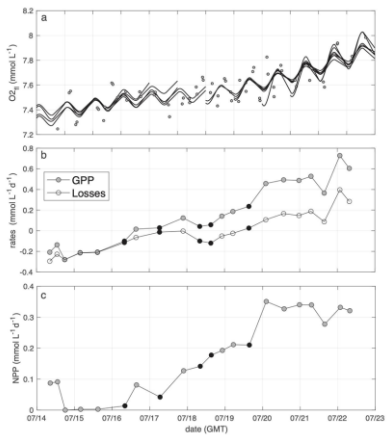
2021

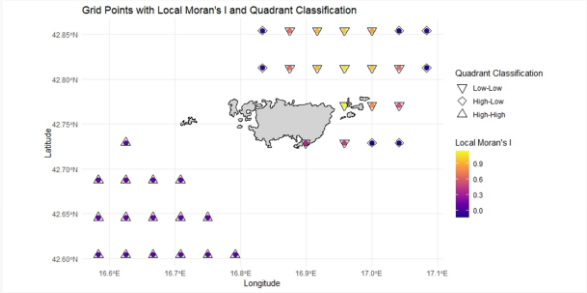
Field fine-tuning, learning & processing

Adaptive methodologies and new findings

2022







2023

Modeling; Processing additional samples – new sequencing and processing methodologies and future perspectives

Moored measurements

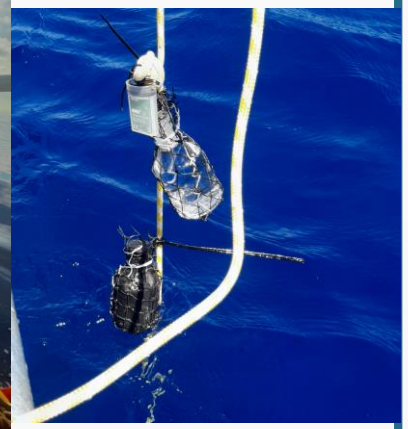
2021

Temperature loggers:

- Prižba (5 m : 5 m: 45 m, except 25 m)
- Maslovnjak (5, 10, 15, 30, 40 and 45 m)
- Struga (5, 10, 20, 30, 35 and 45 m)
- Early June – late September 2021
- dt = 5 min

ADCP (300 kHz):

- Early June – early October 2021
- bin depths: 11 m : 4 m : 83 m
- dt = 10 min



2022

Temperature loggers:

- Prižba (10 m : 5 m : 45 m)
- Maslovnjak (15, 25, 30, 35, 40 and 45 m)
- Struga (5 m : 5 m : 45 m, except 10 m)
- Early June – late September 2022
- dt = 5 min

Light & PAR loggers:

- Struga: 23. July -5. October PAR (10, 40m), dt=5min

Nutrient sensor

- Struga, 29m, 12 – 22 July

ADCP (300 kHz):

- Early June – late September 2022
- bin depths: 9.5 m : 4 m : 85.5 m
- dt = 10 min

NPP in situ incubations

- Prižba: 8 June
-Maslovnjak: 7 June
- Struga: 10 June

2023

Temperature loggers:

- Prižba (15, 20, 25, 35, 40, 45m)
- Maslovnjak (10, 20, 30, 35 and 40 m)
- Struga (10, 15, 20, 25, 30, 35, 45m) + crevice at 35m – 4 T loggers

Early June – early June 2024 (recovered, measured until cca December 2023)

- dt = 5 min

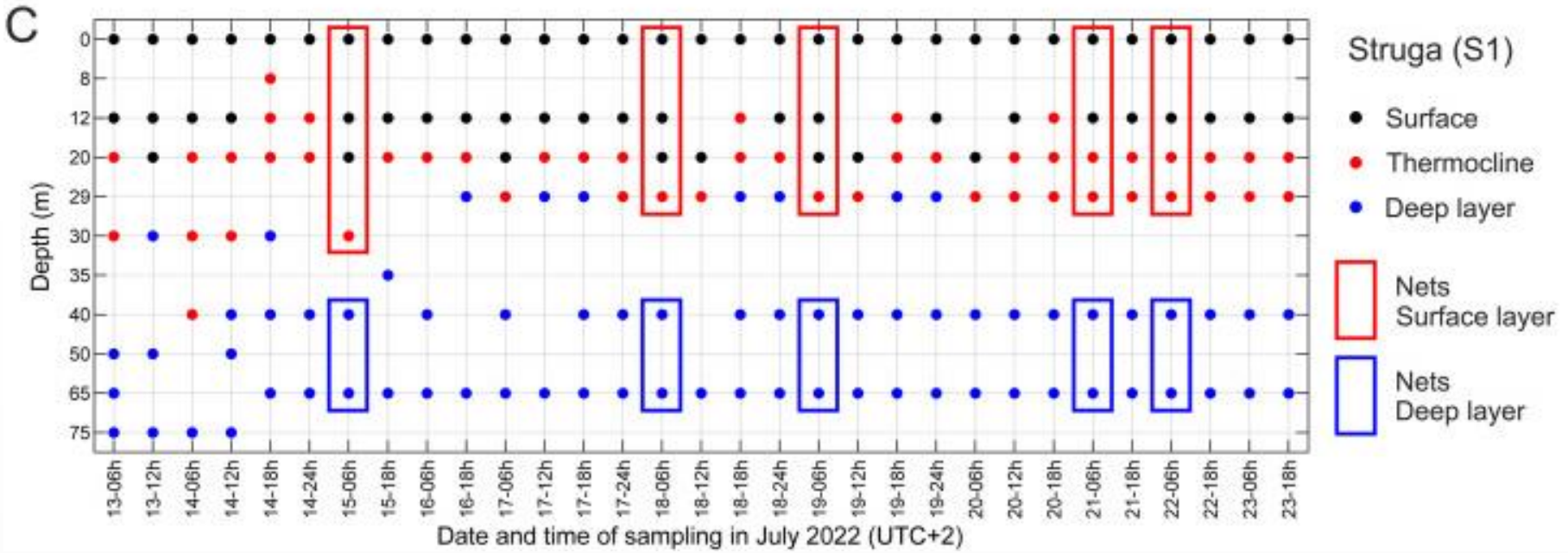
Light & PAR loggers:

- Struga: Light (5, 10, 20, 30m) &PAR (10 &30m) 6. – 23.7

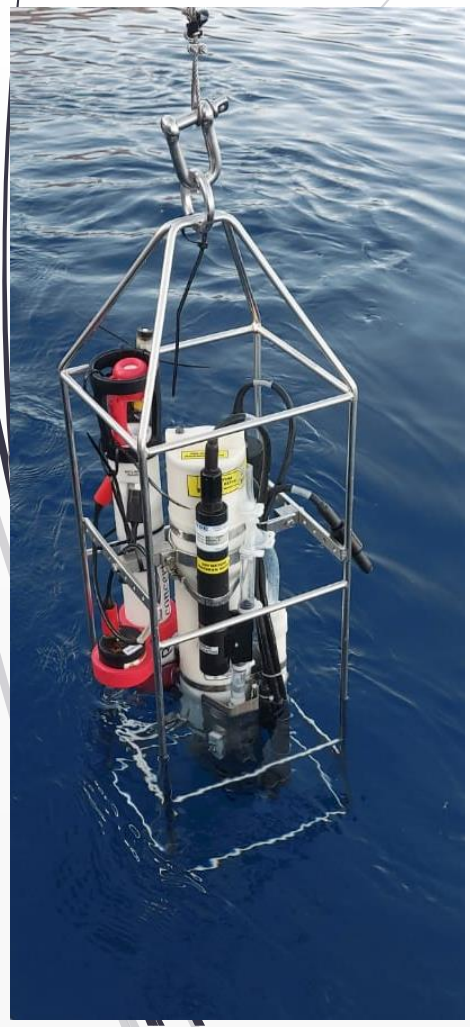
NPP in situ incubations

Struga:4, 8 &16 July

Adaptive sampling strategy in 2022 based on oceanographic and meteorological models



CTD measurments



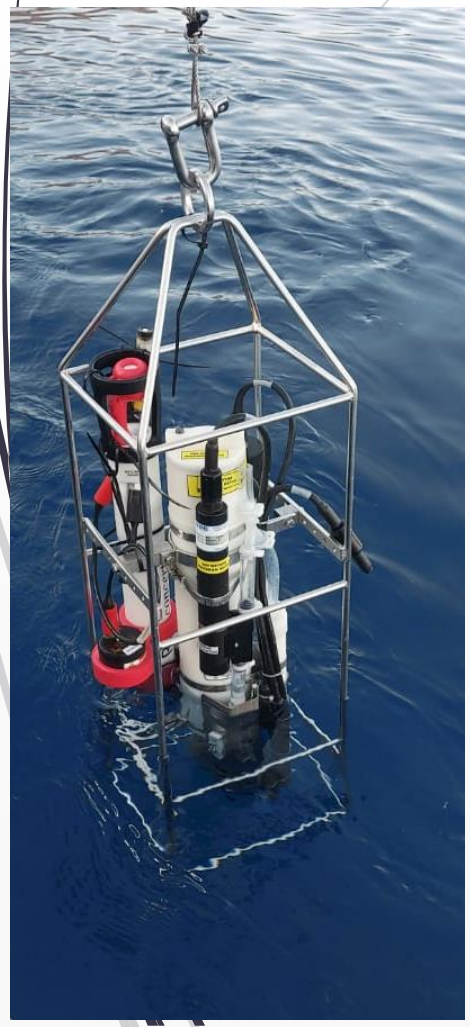
Niskin bottles

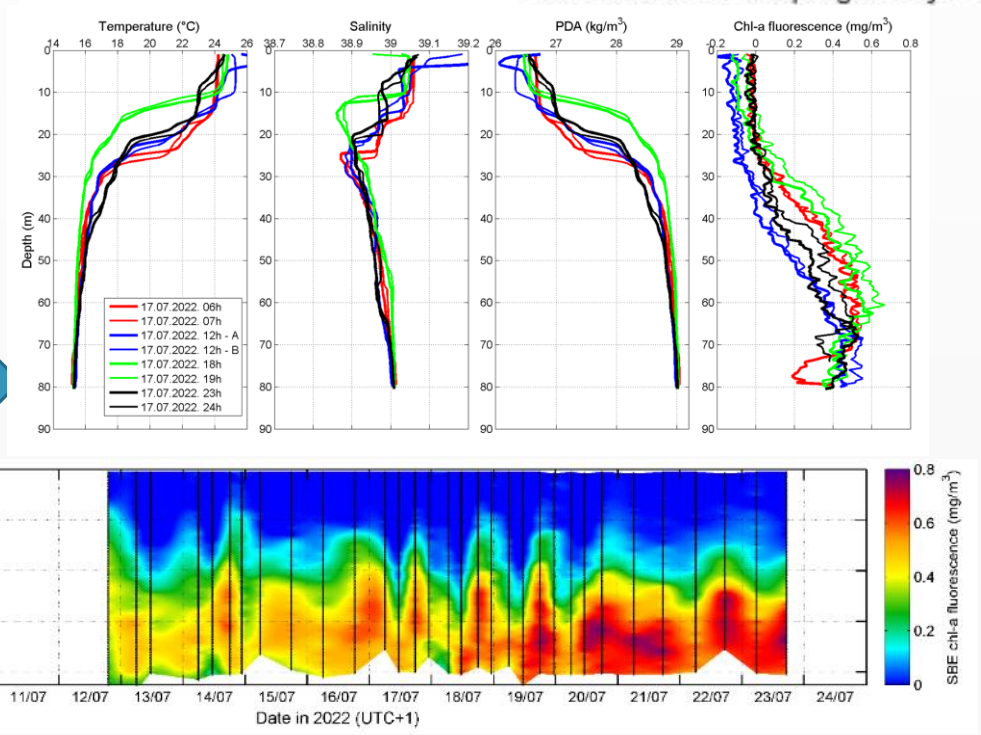
Zooplankton nets

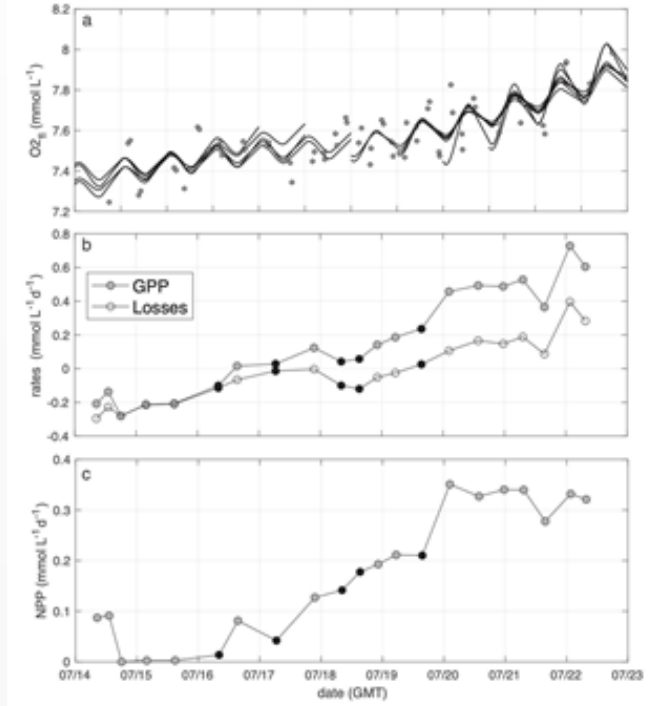
Ljubešić et al, 2024

Adaptive sampling strategy in 2022 based on oceanographic and meteorological models

CTD measurments



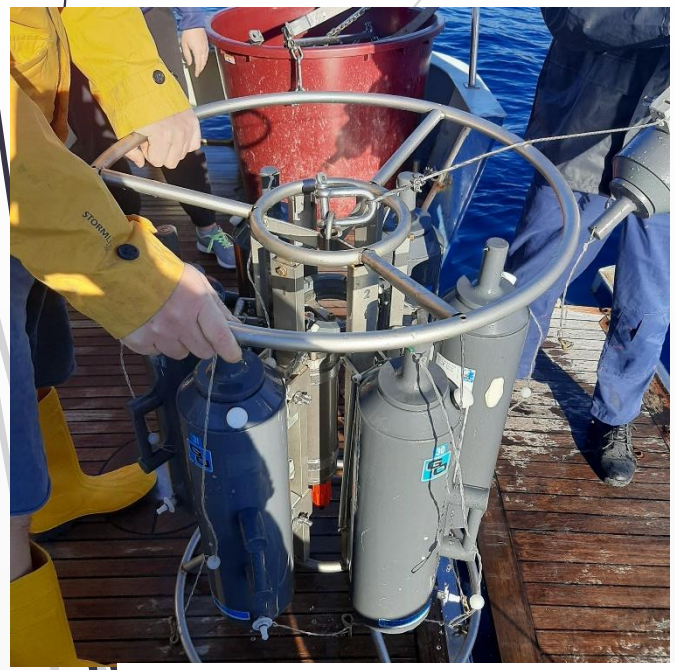


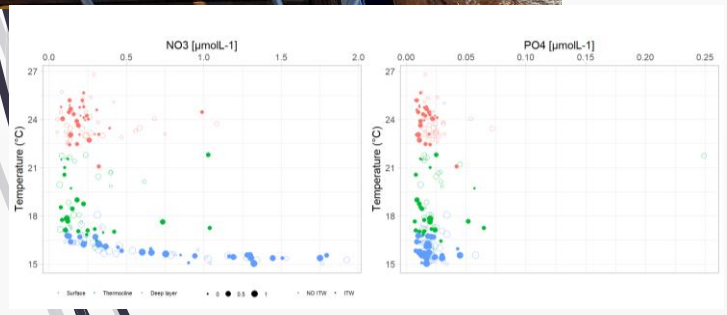


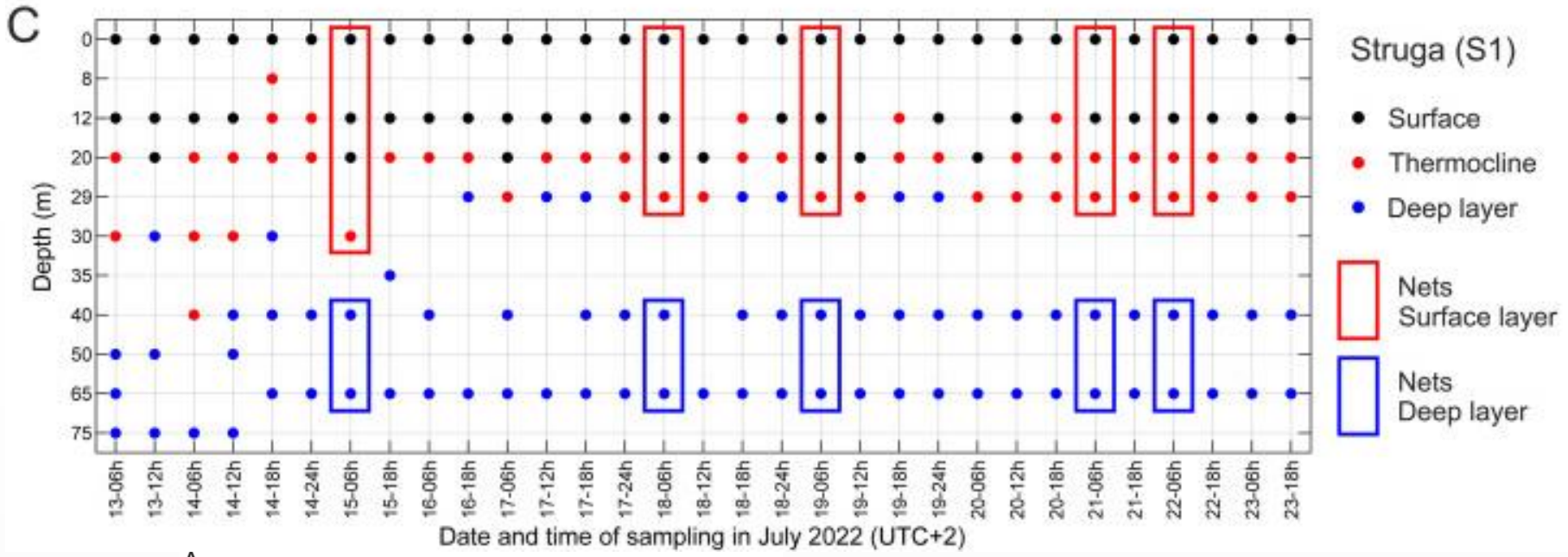
Ljubešić et al, 2024

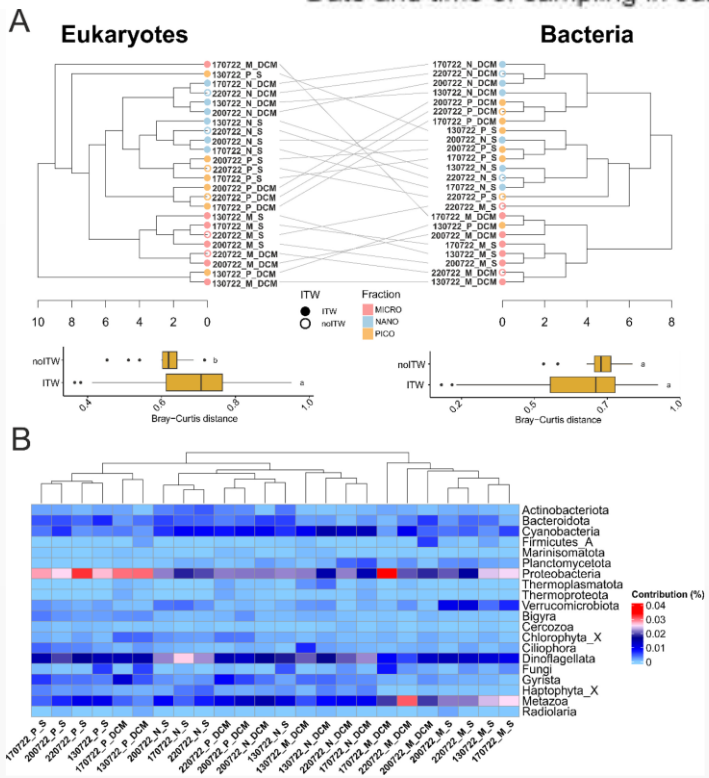
Adaptive sampling strategy in 2022 based on oceanographic and metereological models

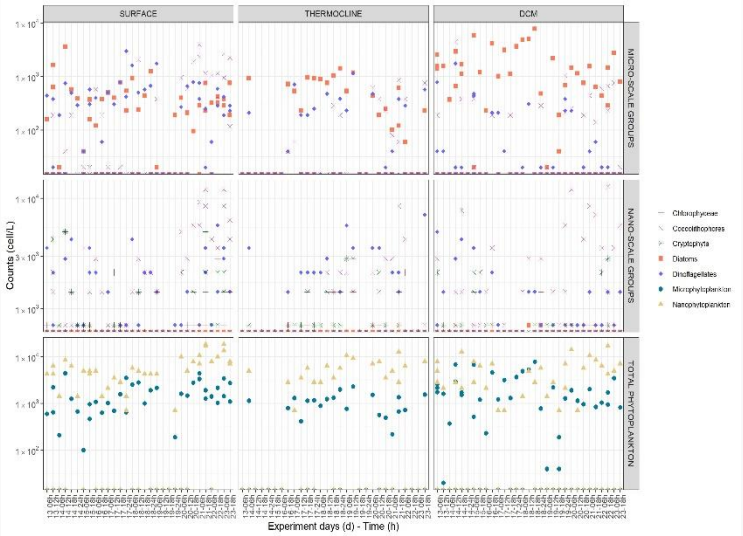
Niskin bottles (LM, Flowcitometry, Chla, Nutrinets, NGS)







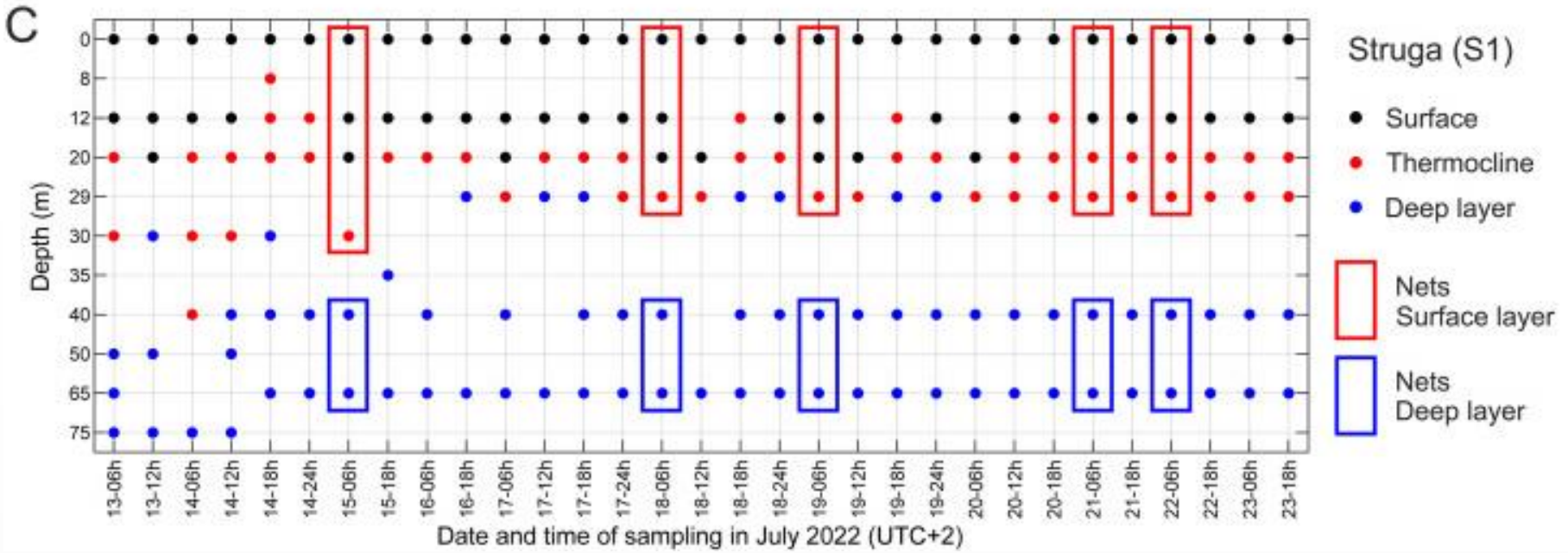


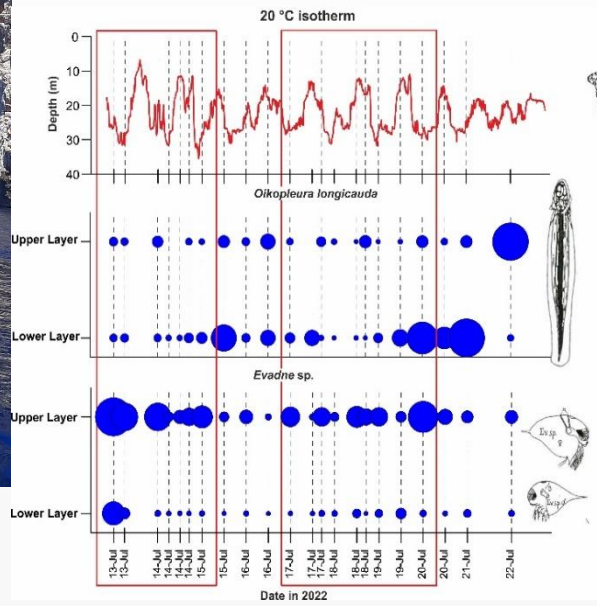


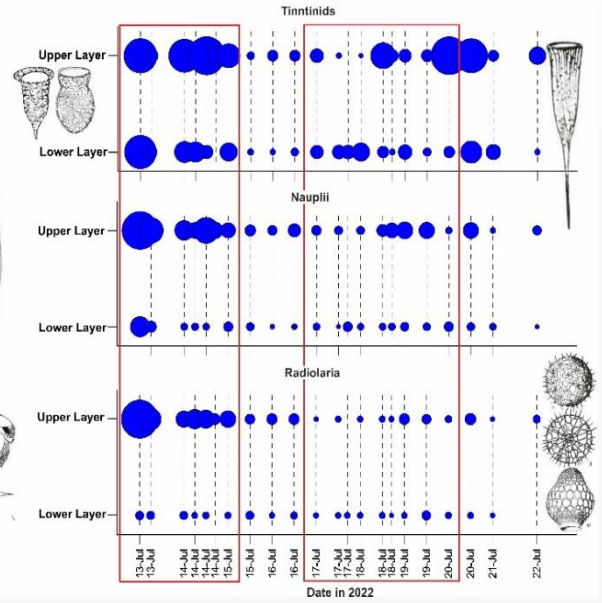
Ljubešić et al, 2024, Mucko et al 2025

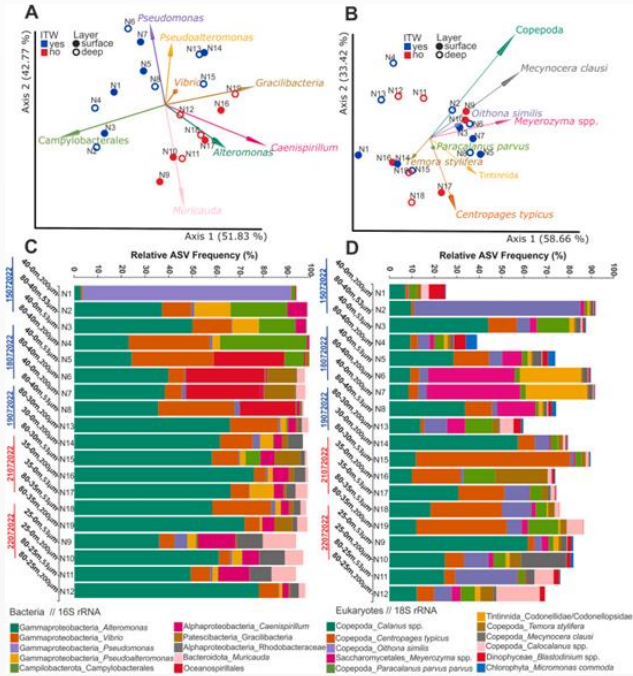
Adaptive sampling strategy in 2022 based on oceanographic and metereological models

Zooplankton nets (LM, NGS)







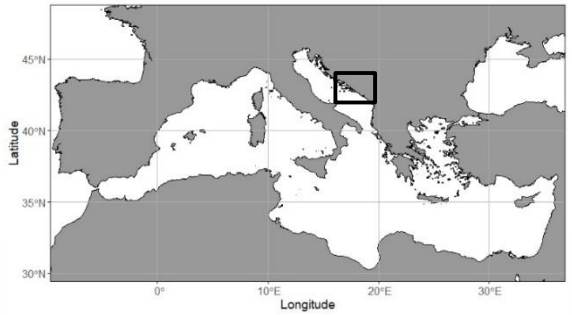


Ljubešić et al, 2024, Pestorić in press

Main Findings from *in situ* experiments:

- **recurring occurrence** of large but intermittent diurnal **internal island-trapped waves** around Lastovo Island during periods with a stratified water column. Their range is highly dependent on background thermohaline properties and physical forcing. The results indicated that Lastovo is an **ideal environment** for physicochemical and biological experiments, particularly when research is coupled with operational meteo-oceanographic forecasts, enabling more adaptive and efficient sampling.
- The use of **operational atmospheric and oceanographic models allowed the prediction** of intense ITW episodes and the rapid adaptation of fieldwork, with four times per day sampling during intense ITW events.
- ITW episodes coincides with **elevated NPP in the thermocline layer**, where enhanced **phosphate** concentrations were also detected. There was no observed response in the community structure or abundance of the eukaryotic plankton community.
- **Bacterioplankton responded** to ITW episodes in terms of their composition and ecological functions. Most bacterial functions represented degradation processes or processes associated with elevated NPP.
- The grazer-decomposer point of view highlights the importance of the heterotrophic fraction of plankton, while **primary production depends on pico-sized cells** that are eaten very quickly, thus generating short but intensive NPP fluxes.
- The enhanced diversity and network complexity observed during ITWs events indicates that these physical disturbances stimulate **short-term restructuring of microbial food webs**.

In situ primary production experiments



Method: ^{14}C incubation

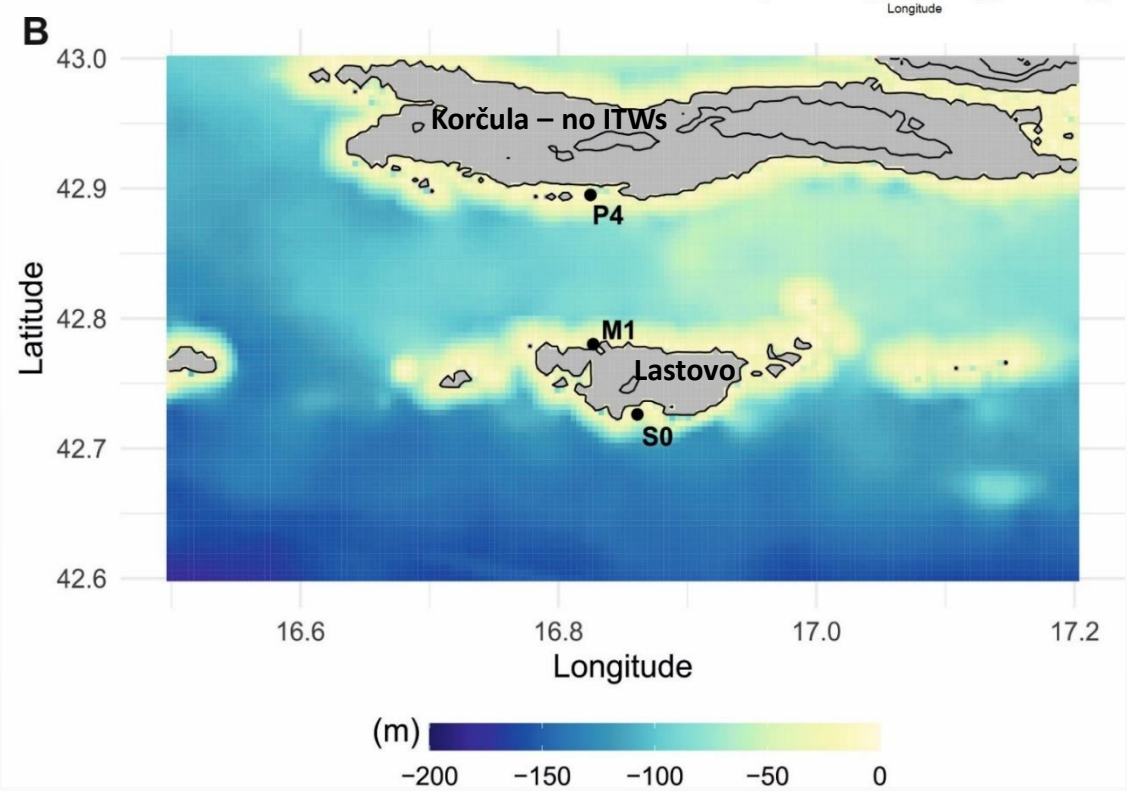
Incubation duration: ~ 6 h

June 2022, three experiments at:

- Struga (**S0**)
- Maslovnjak (**M1**)
- Prižba (**P4**)

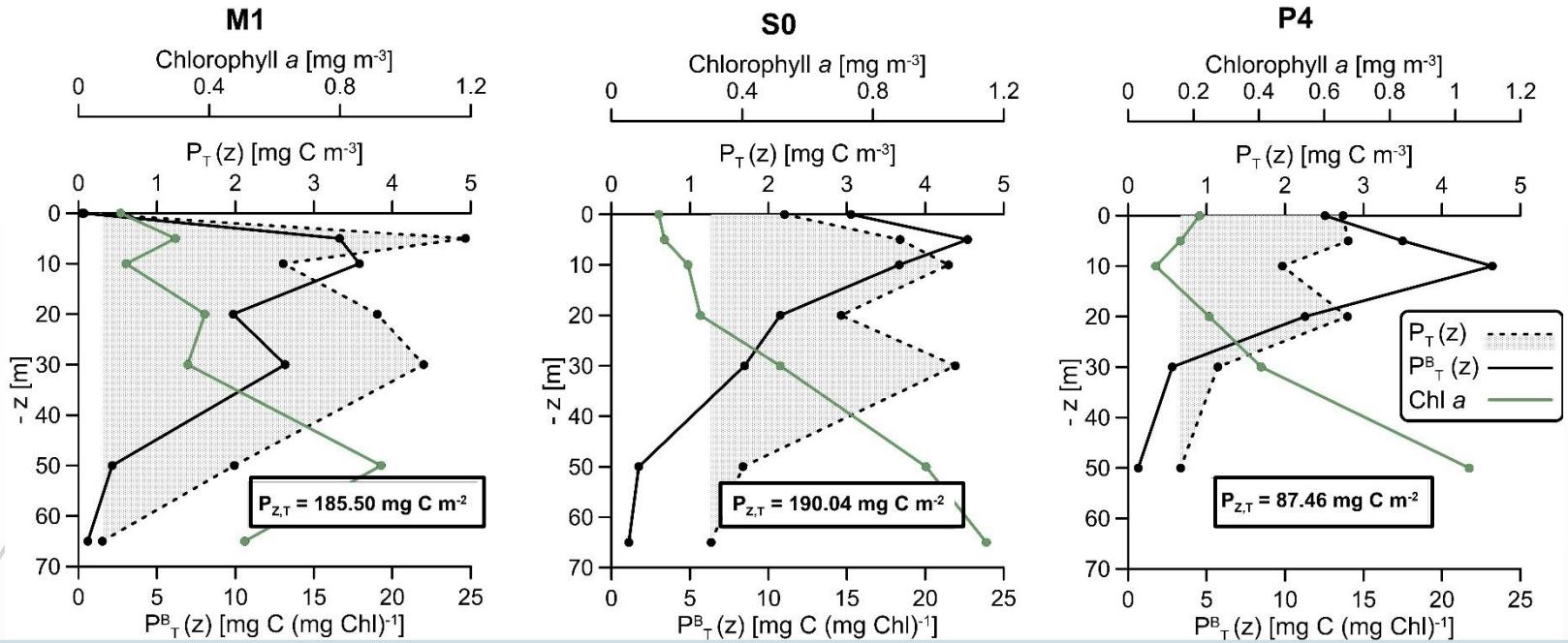
July 2023, three experiments at Struga (S0):

- **S0-04** – before ITWs
- **S0-08** – during ITWs
- **S0-16** – after ITWs



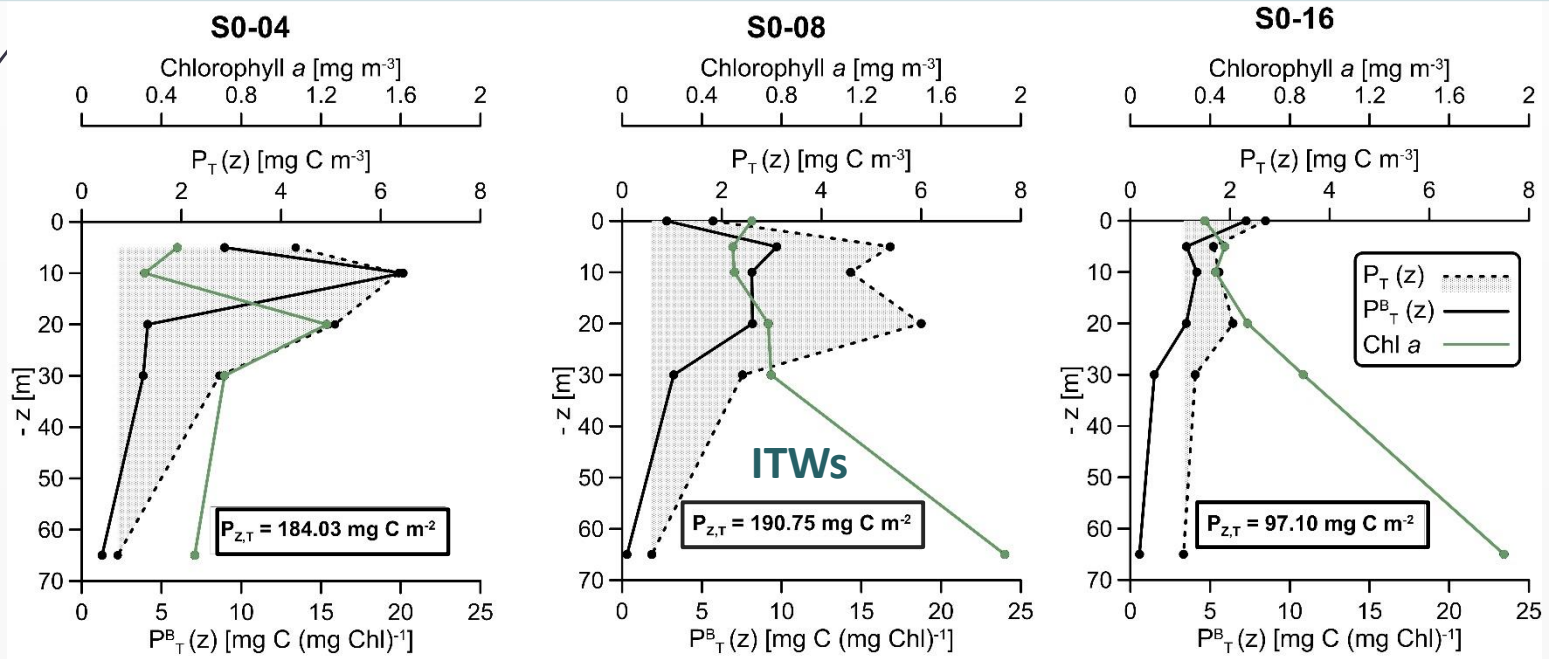
Parallel measurements: chlorophyll *a*, temperature, light intensity (2022, 2023), nutrients (2023)

2022, MASLOVNJAK, STRUGA I PRIŽBA (KORČULA)



NPP is double higher at Lastovo Island compared to Korčula Island

2023, STRUGA

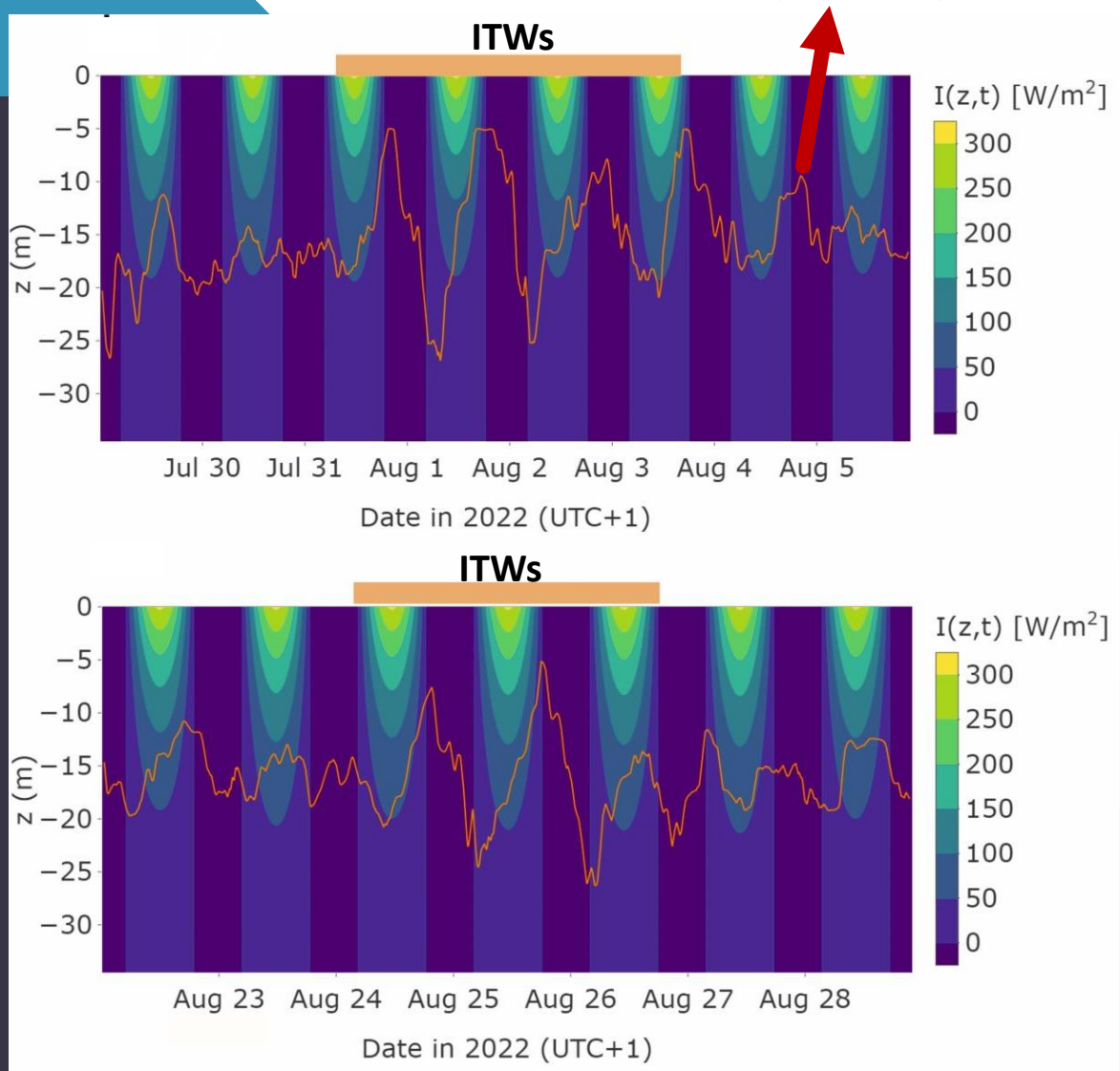


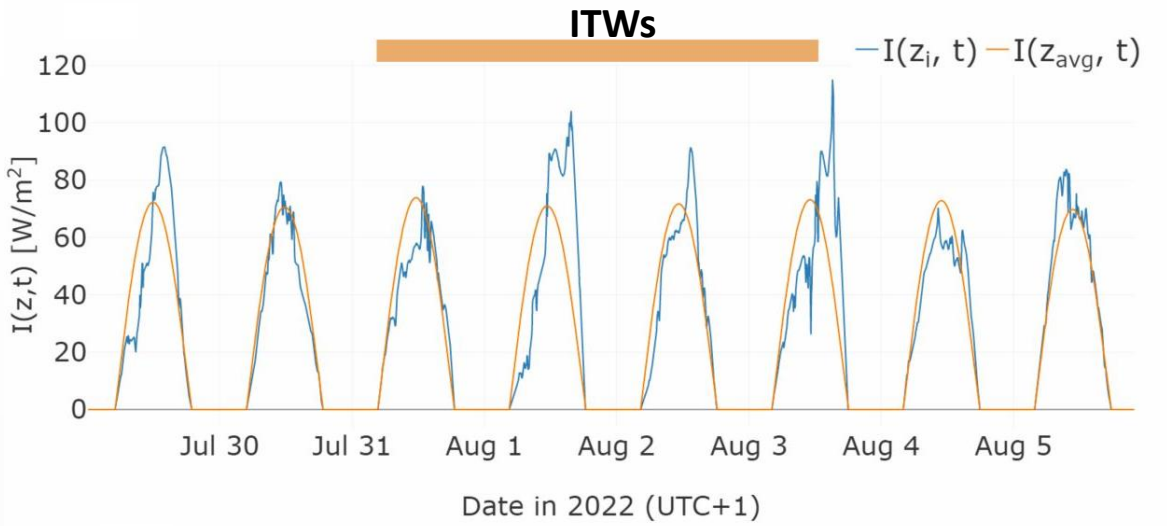
Slight increase of NPP during ITWs, and than decrease for almost double

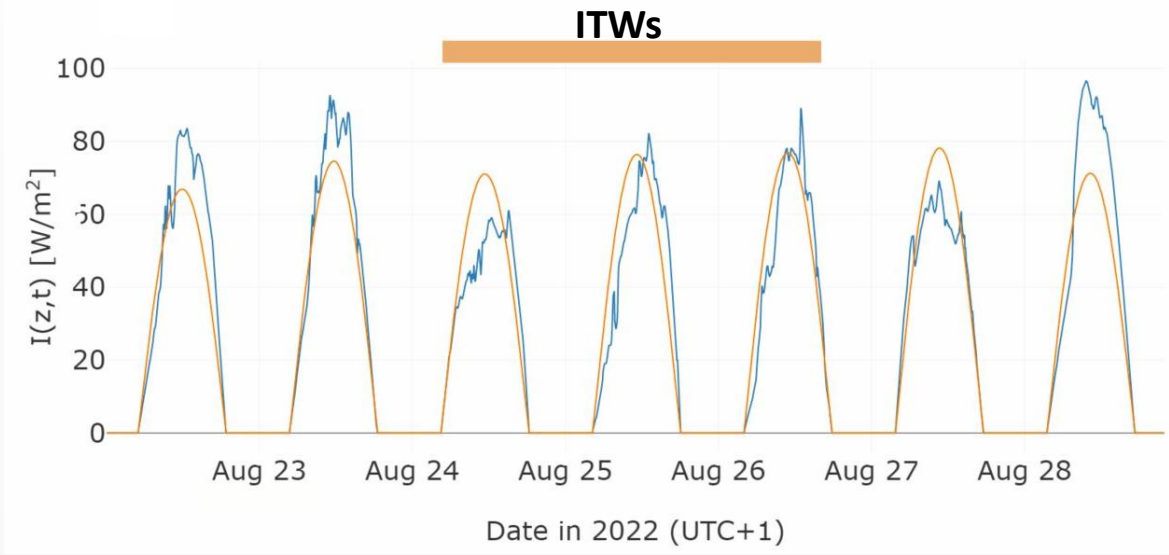
LIGHT MODEL AT STRUGA (2022)

Blue line – phytoplankton in the thermocline is exposed to higher light intensities during ITWs

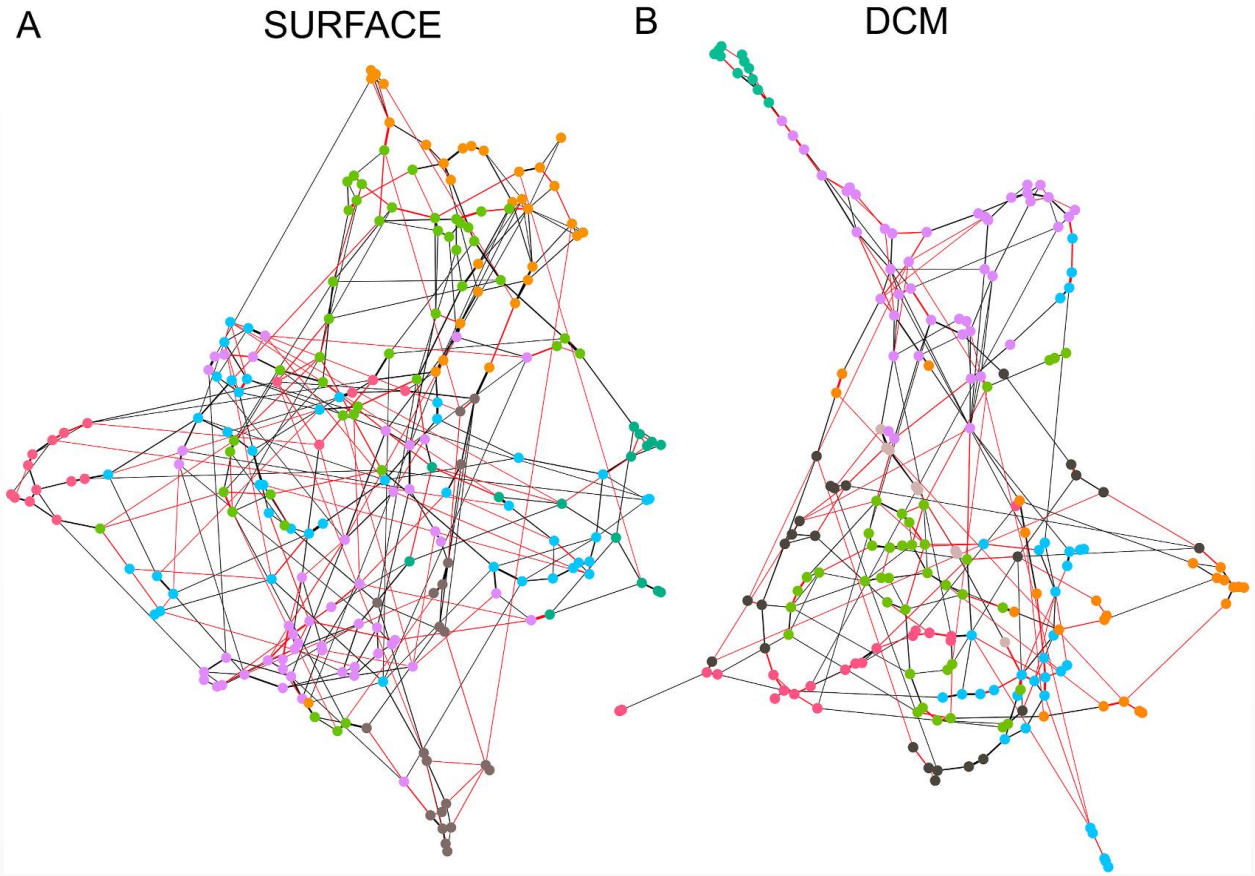
20°C isotherm representing thermocline





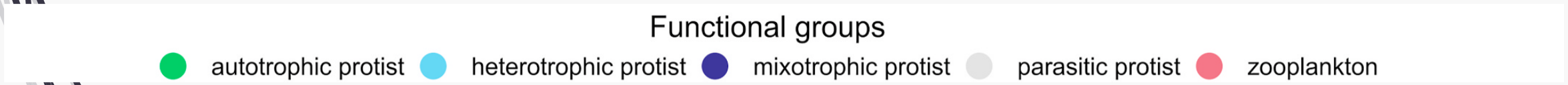


Matek, A., i sur. (2024). Optical properties of the Adriatic Sea: Light the way to the preservation of coastal island ecosystem. CIESM, 43, 311–311.

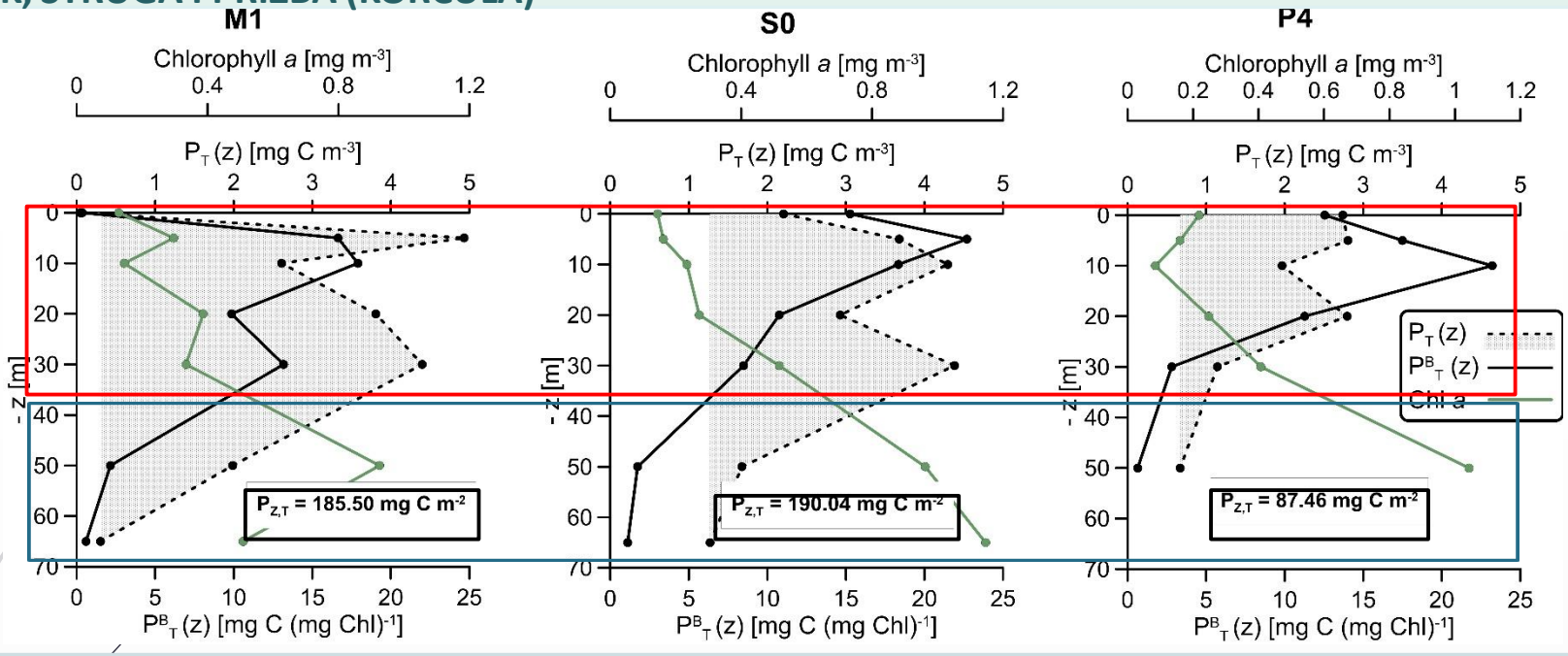


M. Mucko et al. MarineEnvironmentalResearch212(2025)107578

Fig. 5. Co-occurrence networks at the genus level for surface (A) and DCM (B) layers. Nodes' colours represent modules: The width of the edges is scaled from the weak to the strongest correlation value. Red and black edges are putative trophic interactions and non-trophic interactions, respectively. Nodes' labels represent module hubs and connectors and are jittered to visualization purposes. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)



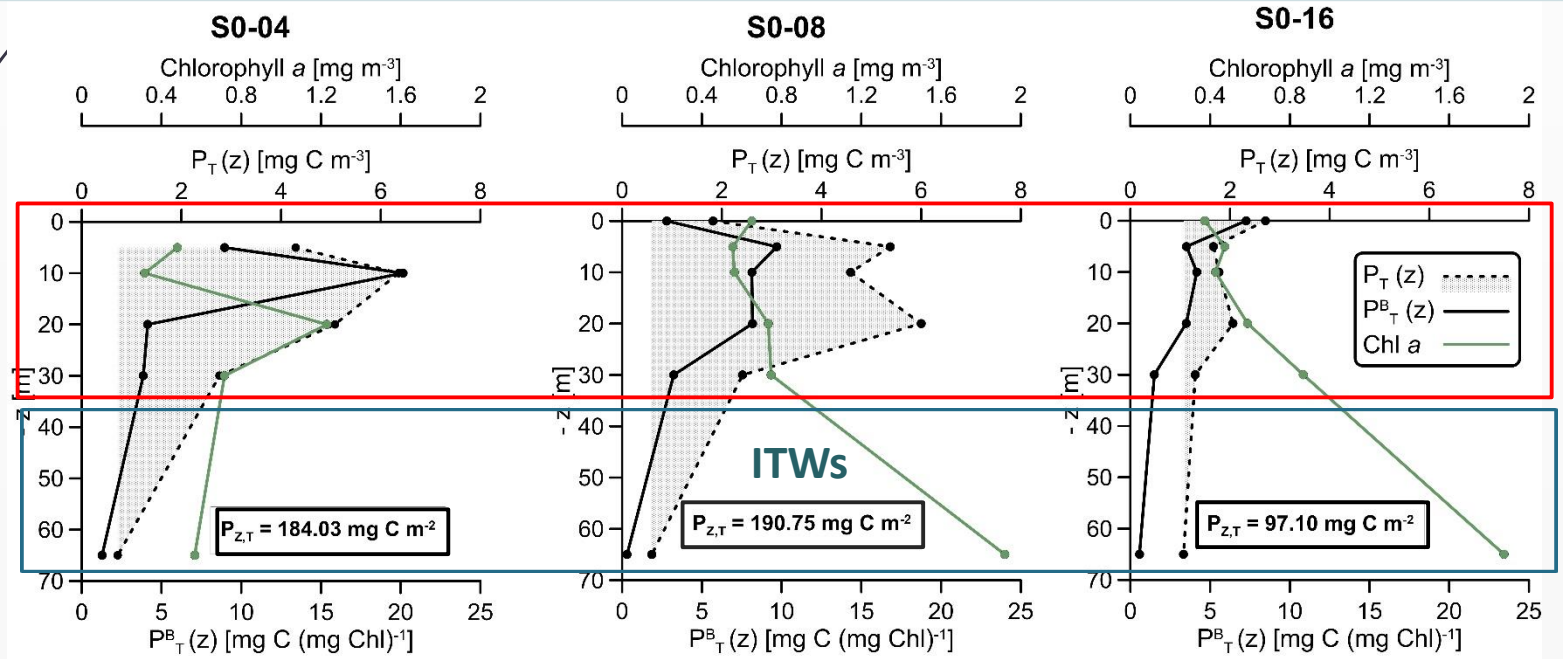
2022, MASLOVNJAK, STRUGA I PRIŽBA (KORČULA)



the nano fraction highest species richness

the micro fraction was most diverse within the DCM

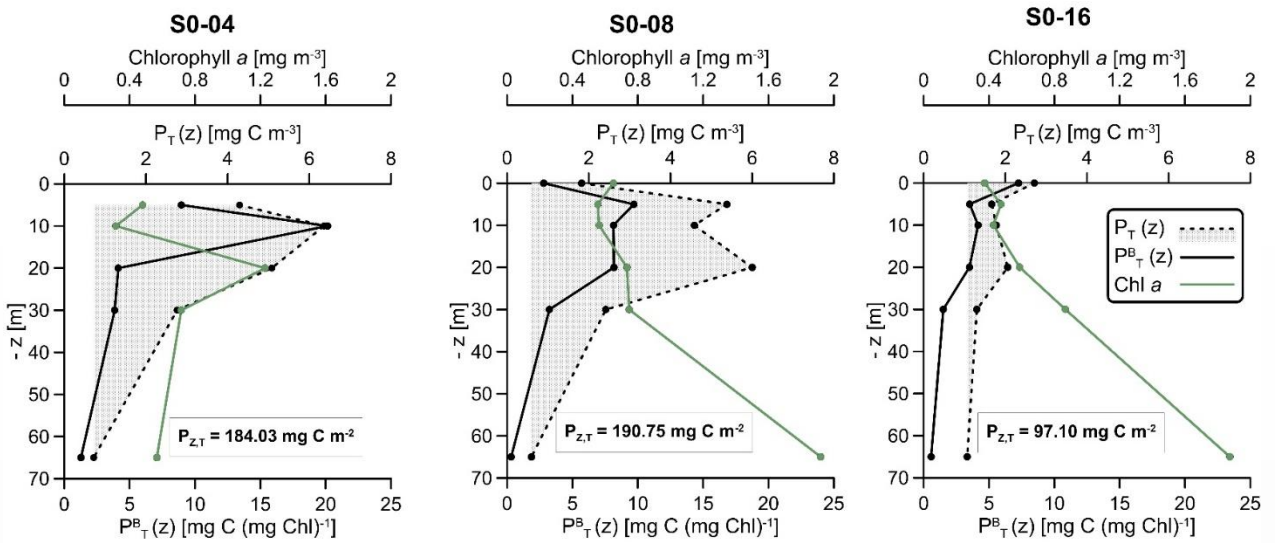
2023, STRUGA



the pico fractions strong vertical gradient, least diverse

Matek et al, in preparation

compositionally similar community during ITW - ITWs-induced mixing may act as a short-term homogenizing force on microbial community

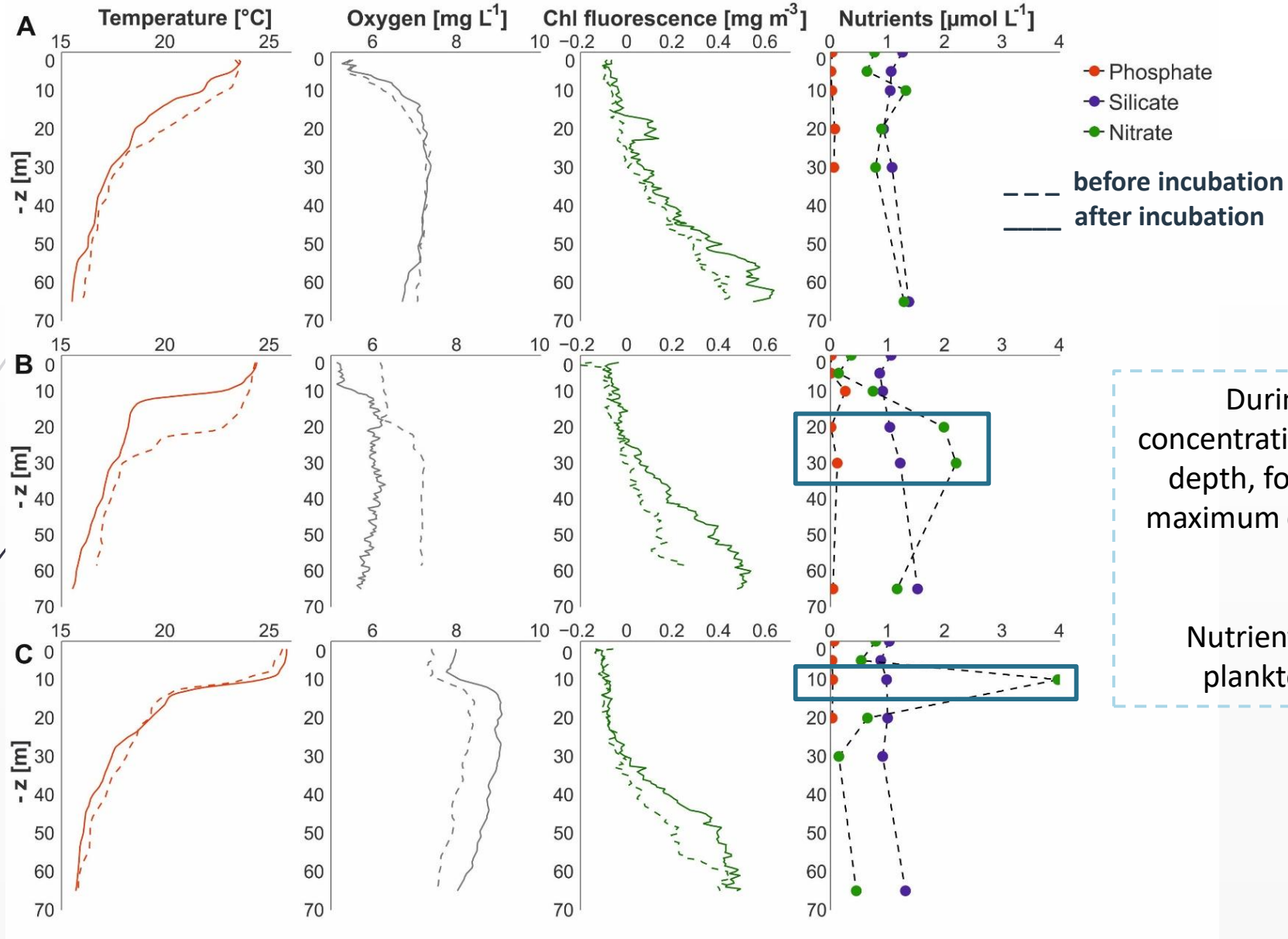


In the surface layers during ITWs:
- pico- and nano-fractions were dominated by Cyanobacteria and Alphaproteobacteria, suggesting **enhanced photoautotrophic activity** linked to the enhanced nutrient flux.
- the micro-fraction showed increased proportions of Bacteroidia, Verrucomicrobiae, and Gammaproteobacteria, indicating elevated contributions of heterotrophic and particle-associated taxa, consistent with a shift toward **degradation of organic matter deposition**.

DCM during ITWs - primary production functions (e.g., oxygenic photoautotrophy, ureolysis) were elevated, especially in pico and nano fractions.

DCM after ITWs: -
an increase in functions associated with nitrogen cycling—particularly aerobic ammonium oxidation and nitrification supported the idea of post-disturbance community reassembly shaped by changing nutrient availability and
nitrogen cycling regimes

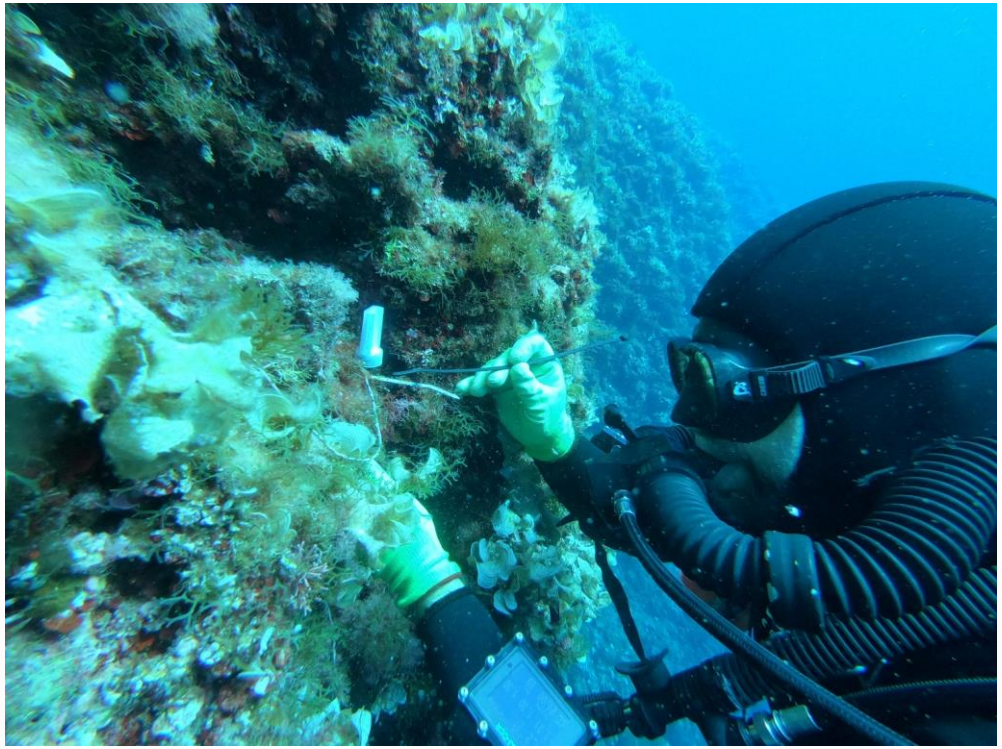
WATER COLUMN PHYSICO-CHEMICAL PROPERTIES IN JULY 2023

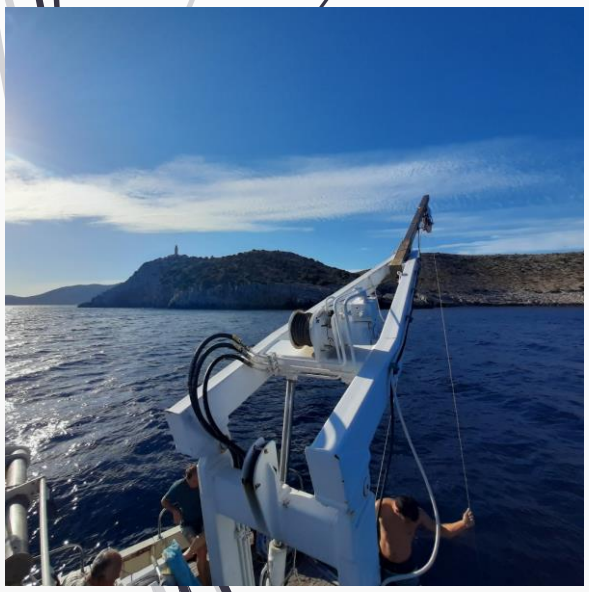


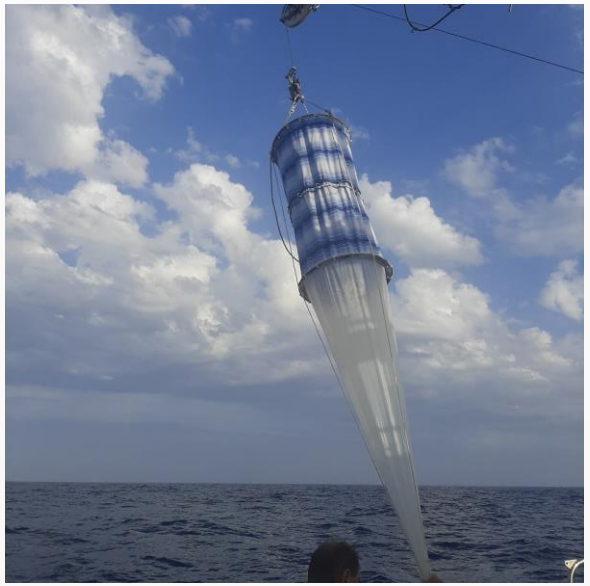
During ITW events, nitrate concentrations increase at 20 and 30 m depth, followed by a decline, while maximum concentrations are retained at 10 m.

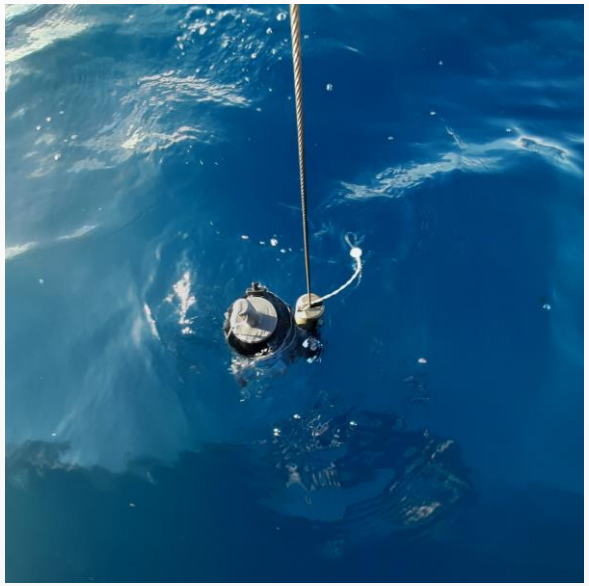
Nutrient dynamics controlled by plankton community activity?

Matek et al, in preparation









September 2023

Thank you for your attention!

and to Croatian Science Foundation