

# The Malina oceanographic expedition: How do changes in ice cover, permafrost and UV radiation impact on biodiversity and biogeochemical fluxes in the Arctic Ocean?

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## **Abstract.**

## **1 Introduction**

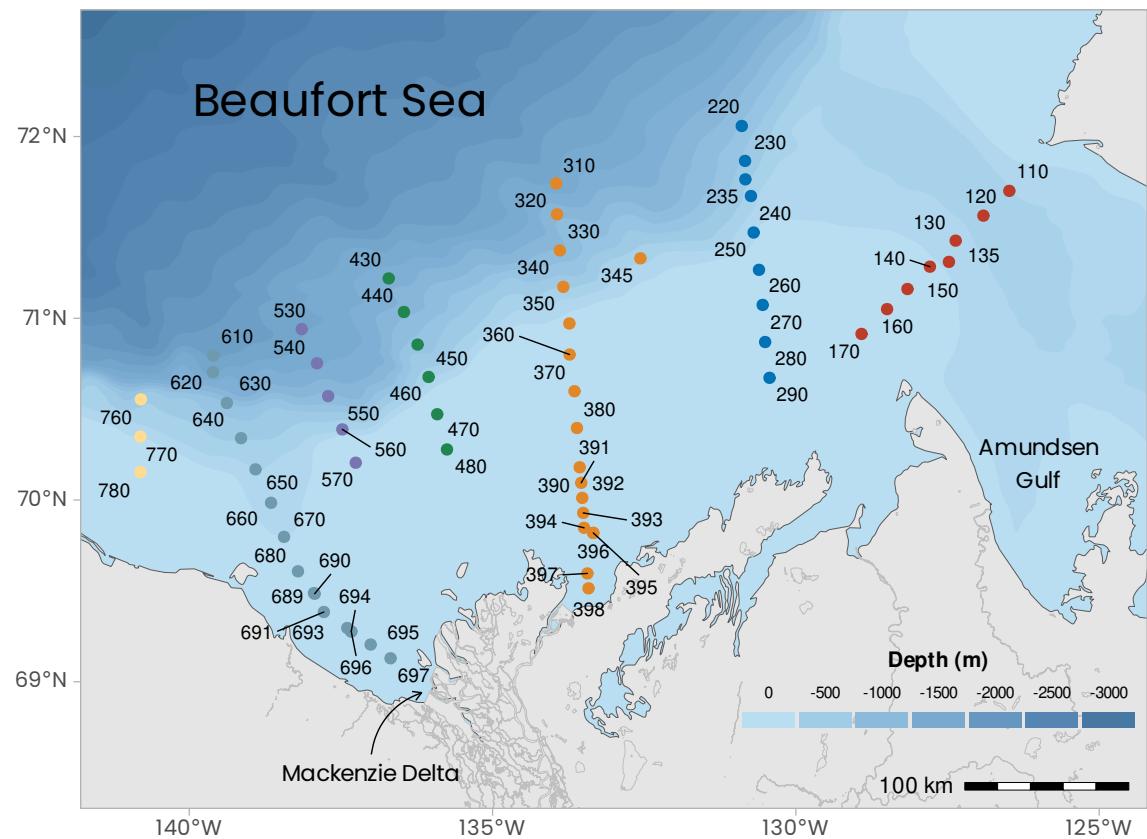
## **2 Study area, environmental conditions and sampling strategy**

### **2.1 Study area and environmental conditions**

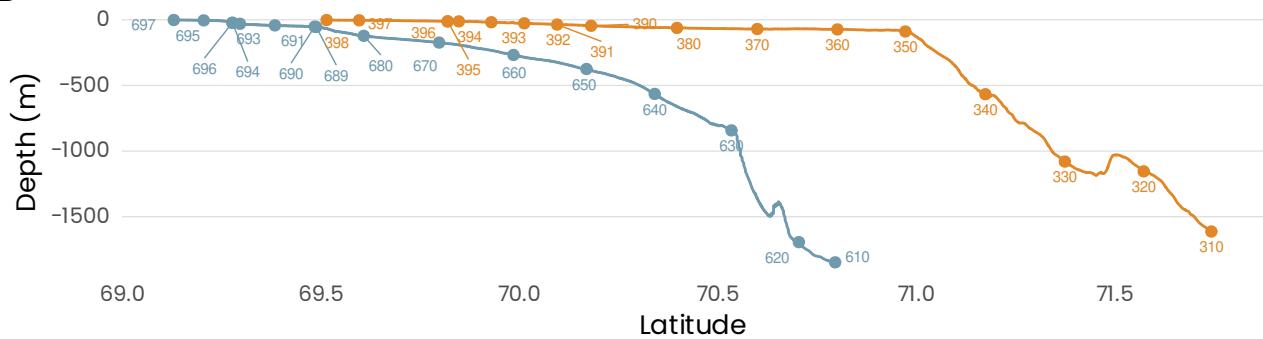
#### **5 2.1.1 CTD and rosette deployments**

### 3 Figures

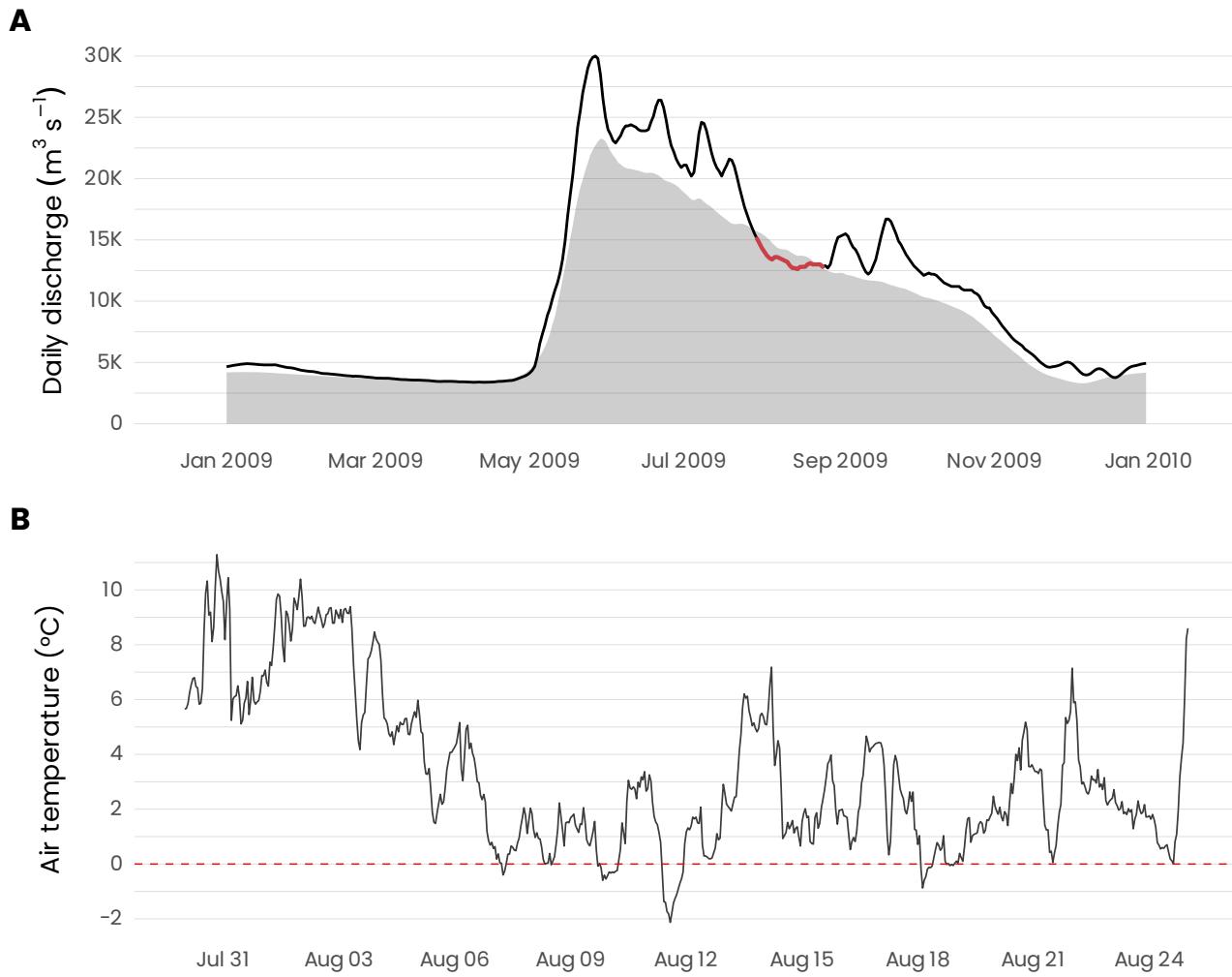
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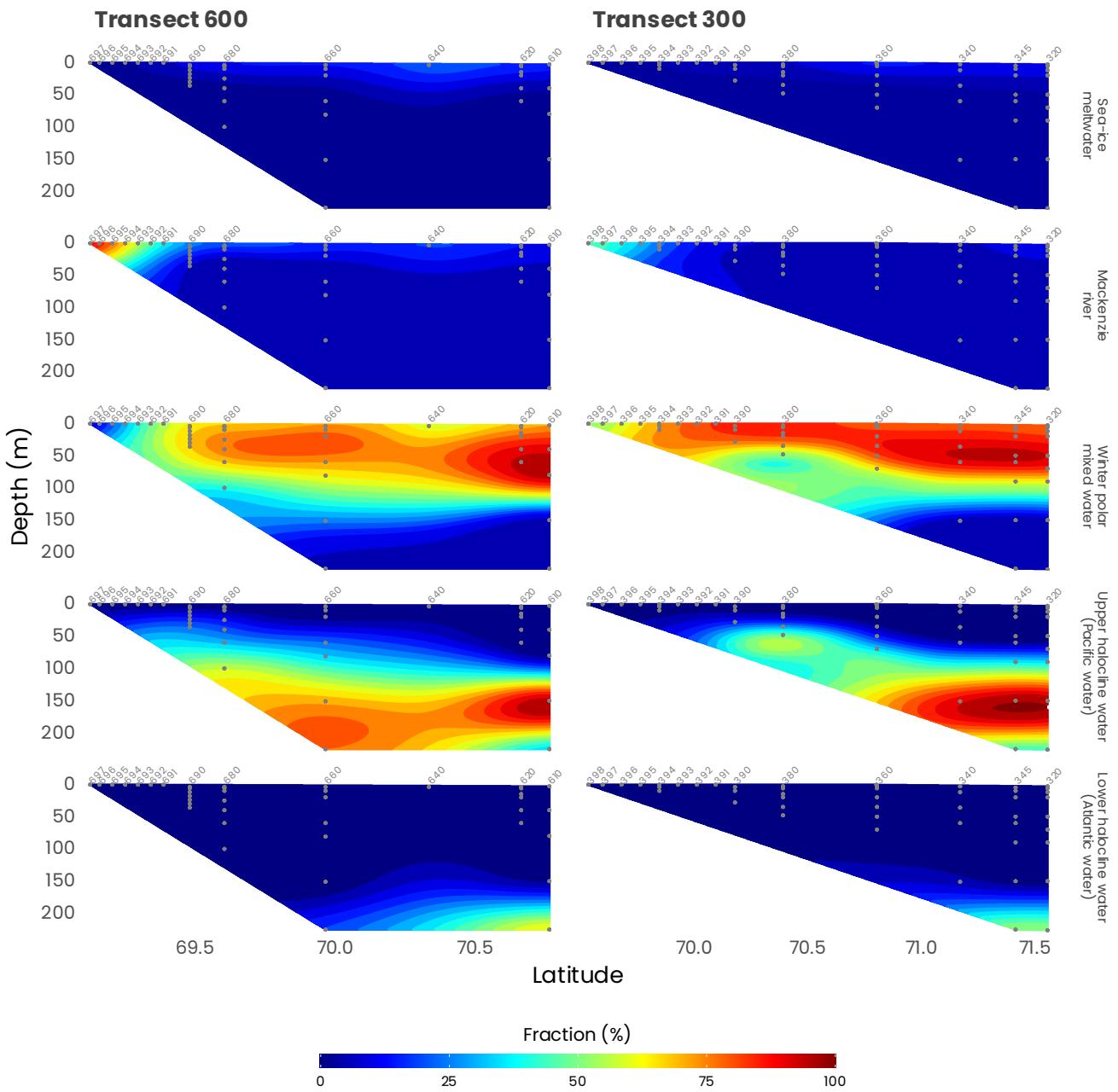
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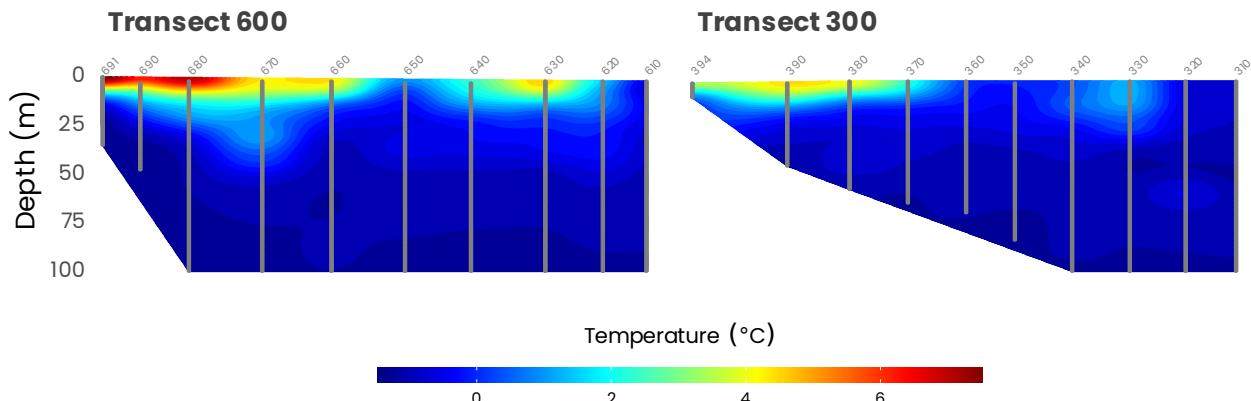
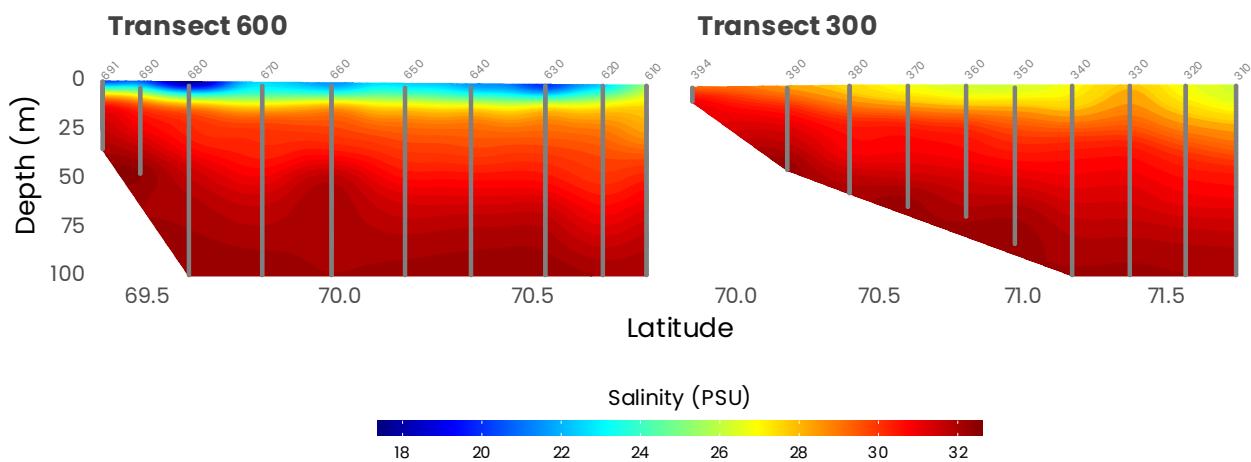
**Figure 1.** (A) Localizations of the sampling sites visited during the MALINA 2009 campaign. The colors of the dots represent the seven transects visited during the mission. (B) Bathymetric profiles for transects 600 and 300. Bathymetric data from GEBCO (<https://download.gebco.net/>).



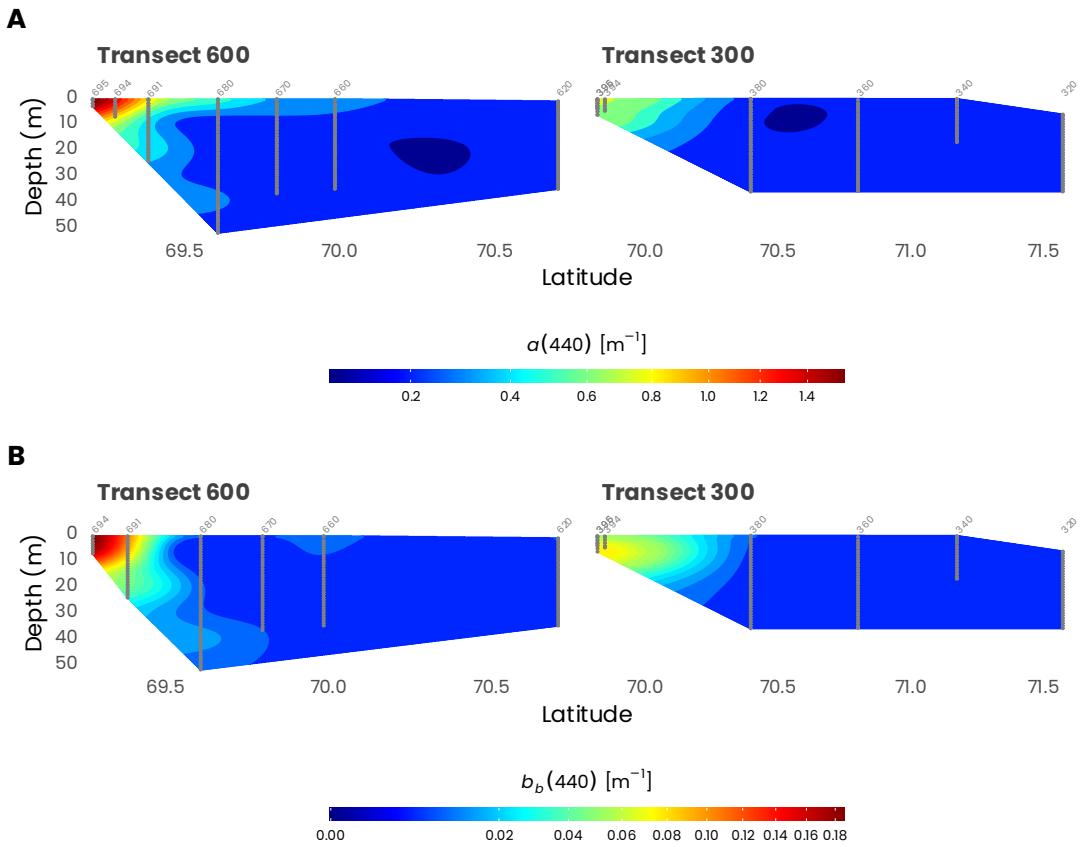
**Figure 2.** (A) Daily discharge of the Mackenzie River at the Arctic Red River junction (station 10LC014). The black line corresponds to the 2009 discharge whereas the coloured segment identifies the period of the MALINA campaign. The shaded area is the mean discharge calculated between 1972 and 2016. Discharge data from the Government of Canada ([https://wateroffice.ec.gc.ca/search/historical\\_e.html](https://wateroffice.ec.gc.ca/search/historical_e.html)). (B) Hourly air temperature recorded from the Amundsen's foredeck meteorological tower during the campaign.



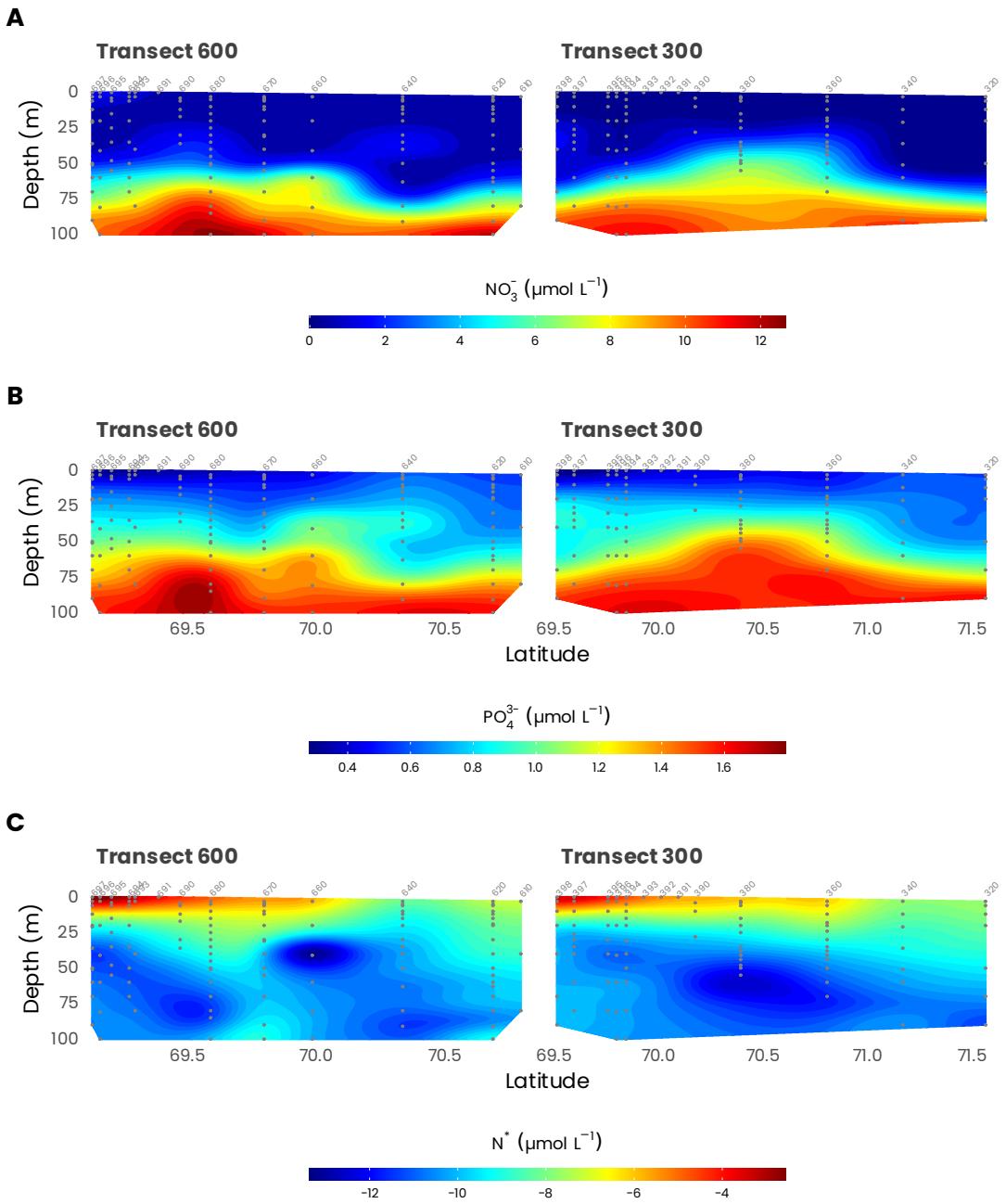
**Figure 3.** Distribution of source water types along transects 600 and 300 (see Fig. 1). Station numbers are identified in light gray on top of each panel.

**A****B**

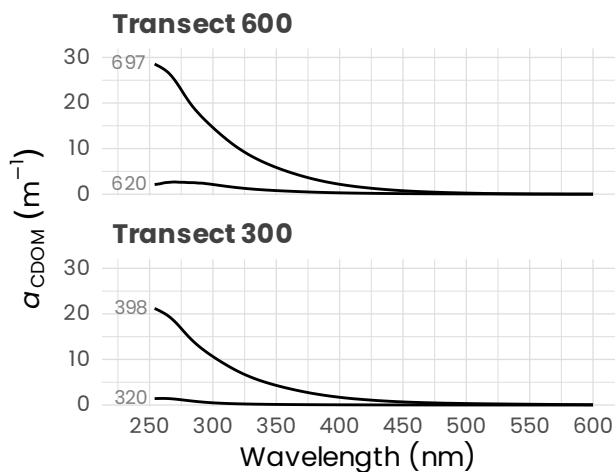
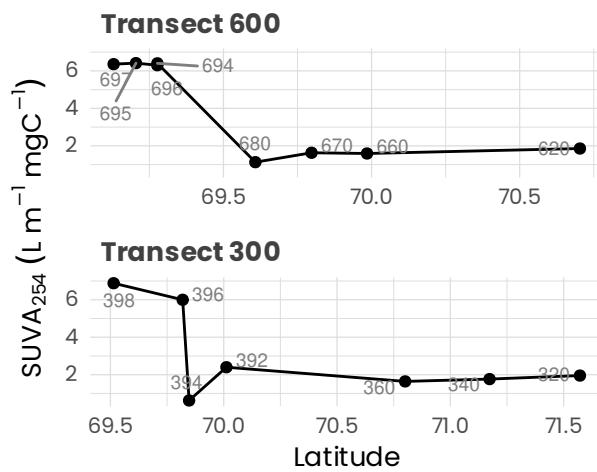
**Figure 4.** Cross-sections of temperature (A) and salinity (B) measured by the CTD (gray dots) along transects 600 and 300. Station numbers are identified in light gray on top of each panel.



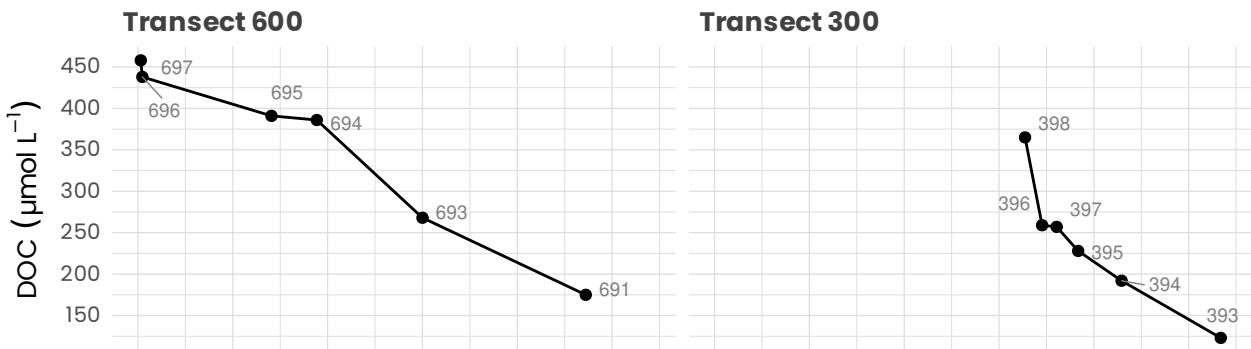
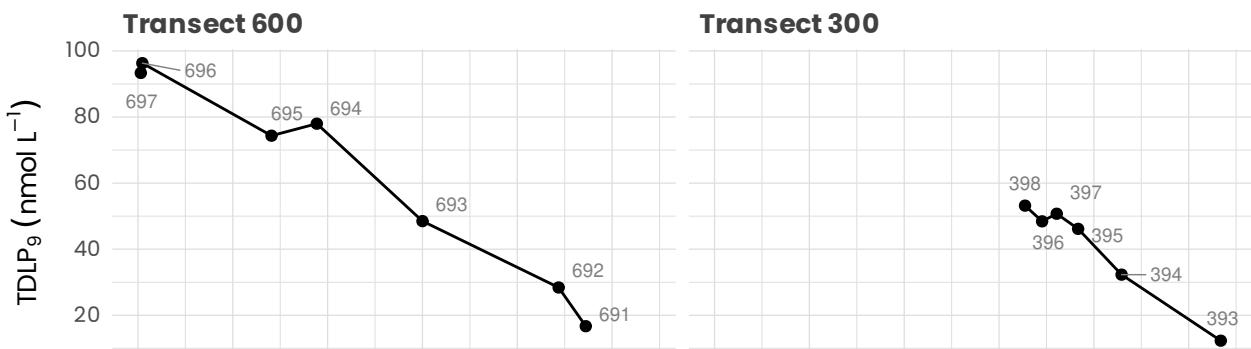
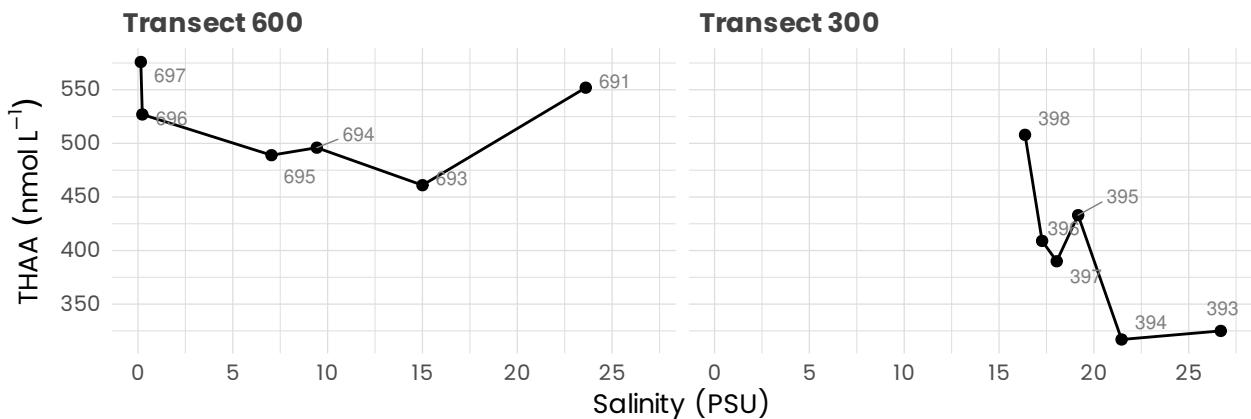
**Figure 5.** Cross-sections of **(A)** absorption ( $a(440)$ ) and **(B)** total scattering ( $b_b(440)$ ) measured from the barge at 440 nm with an AC9 and BB9 respectively along transects 600 and 300. Station numbers are identified in light gray on top of each panel. Note that the data has been square-root transformed for the visualization.



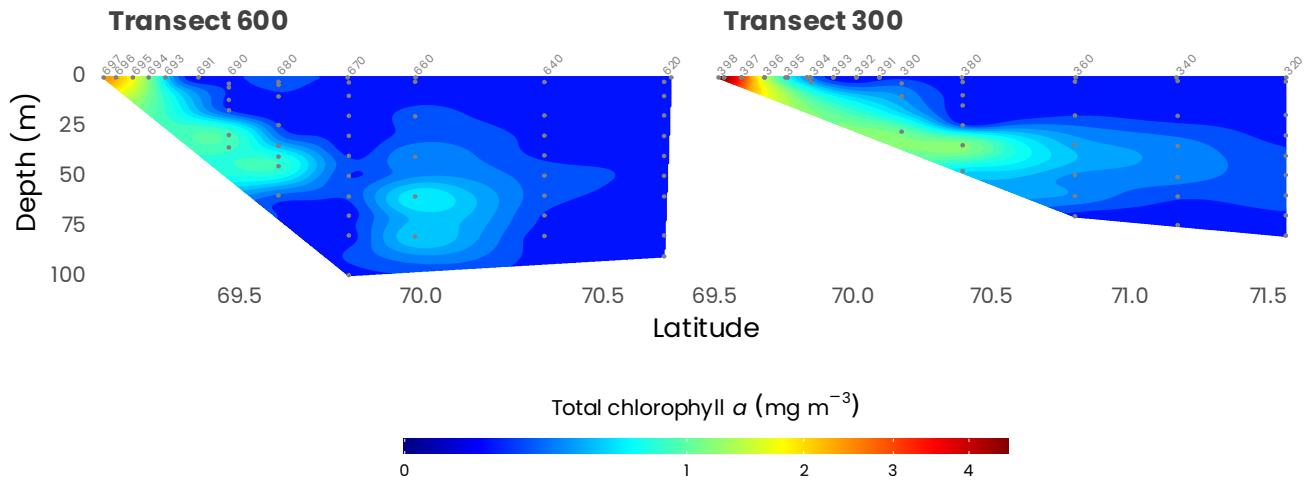
**Figure 6.** Cross-sections of (A)  $\text{NO}_3^-$  and (B)  $\text{PO}_4^{3-}$  measured from Niskin bottles (gray dots) along transects 600 and 300. (C)  $\text{N}^*$  defined as  $\text{N} - \text{rP}$  with  $\text{r} = \text{N/P} = 13.1$  (see the text for the details). Station numbers are identified in light gray on top of each panel.

**A****B**

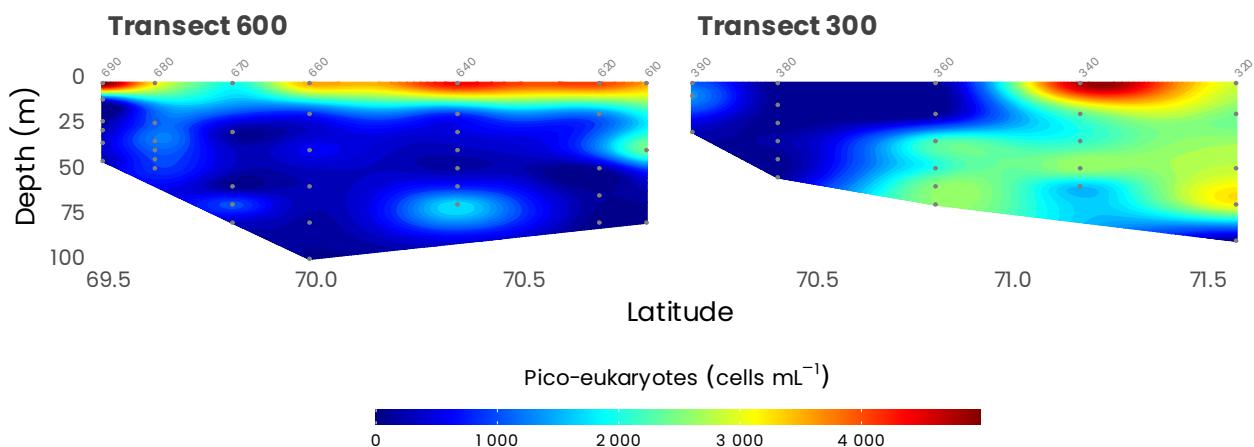
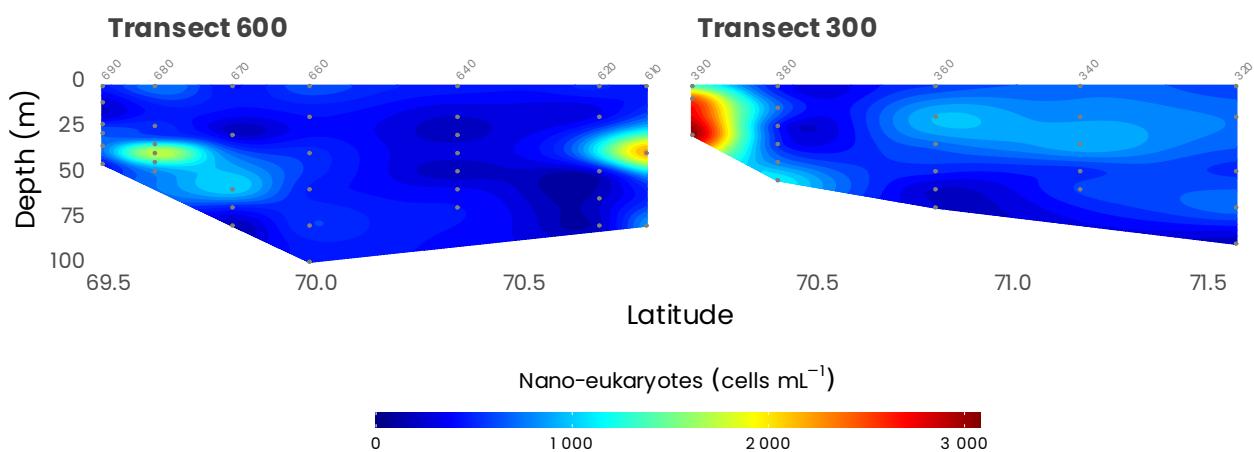
**Figure 7.** **(A)** Absorption spectra between 254 and 600 nm of chromophoric dissolved organic matter ( $\alpha_{CDOM}$ ) measured at the surface for the northern and southern stations of the transects 600 and 300. **(B)** Specific UV absorbance at 254 nm ( $SUVA_{254}$ , i.e. absorption of light at 254 nm per unit of carbon) at surface for stations along transects 600 and 300. Stations are identified in light gray.

**A****B****C**

**Figure 8.** Concentrations of (A) dissolved organic carbon (DOC), (B) total dissolved lignin phenols (TDLP<sub>9</sub>), and (C) total hydrolysable amino acids (THAA) measured along transects 600 and 300, and plotted against salinity.



**Figure 9.** Cross-sections of total chlorophyll-a measured from HPLC (gray dots) along transects 600 and 300. Station numbers are identified in light gray on top of each panel. Note that the data has been square-root transformed for the visualization.

**A****B**

**Figure 10.** Concentrations of photosynthetic (A) pico- and (B) nano-eukaryotes measured by flow cytometry during the MALINA cruise on transects 600 and 300.

**A**

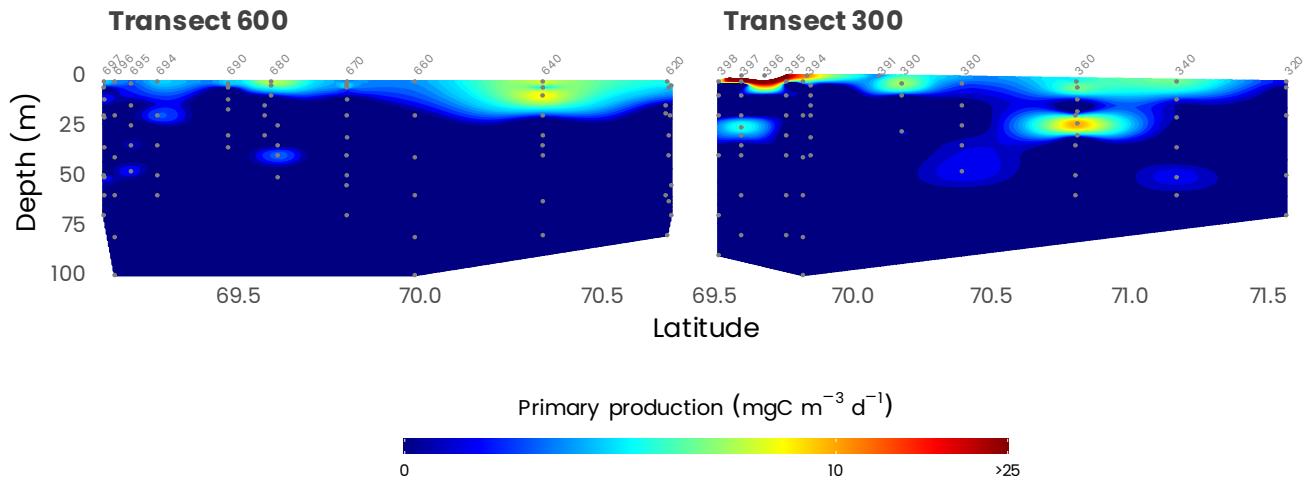
## Clone libraries

**B**

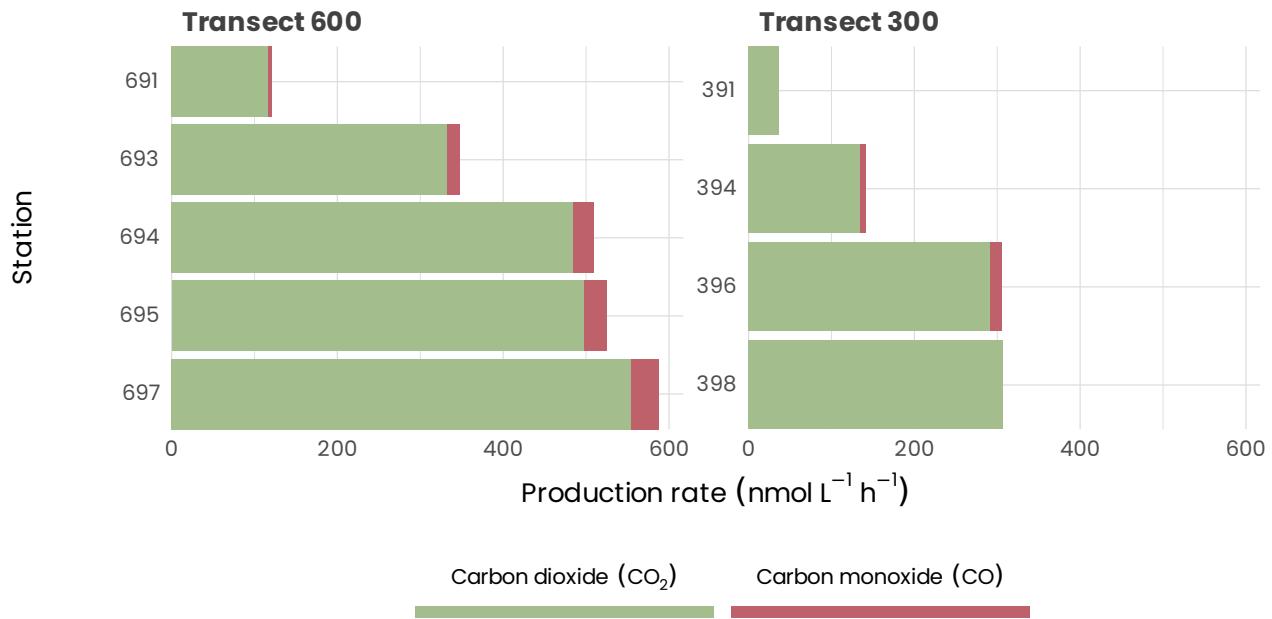
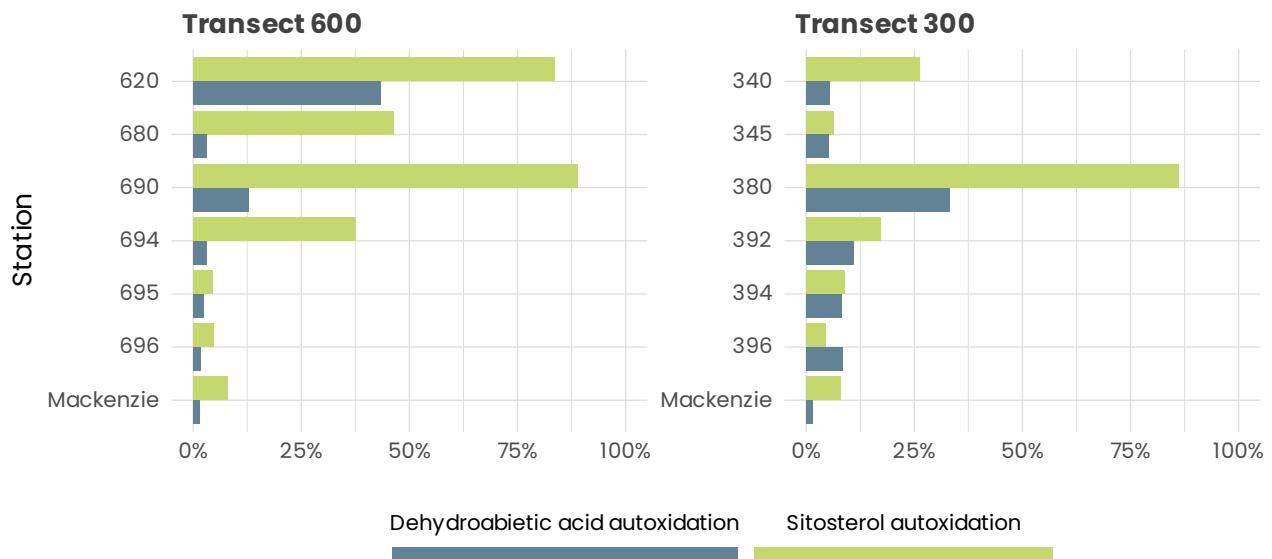
## Cultures



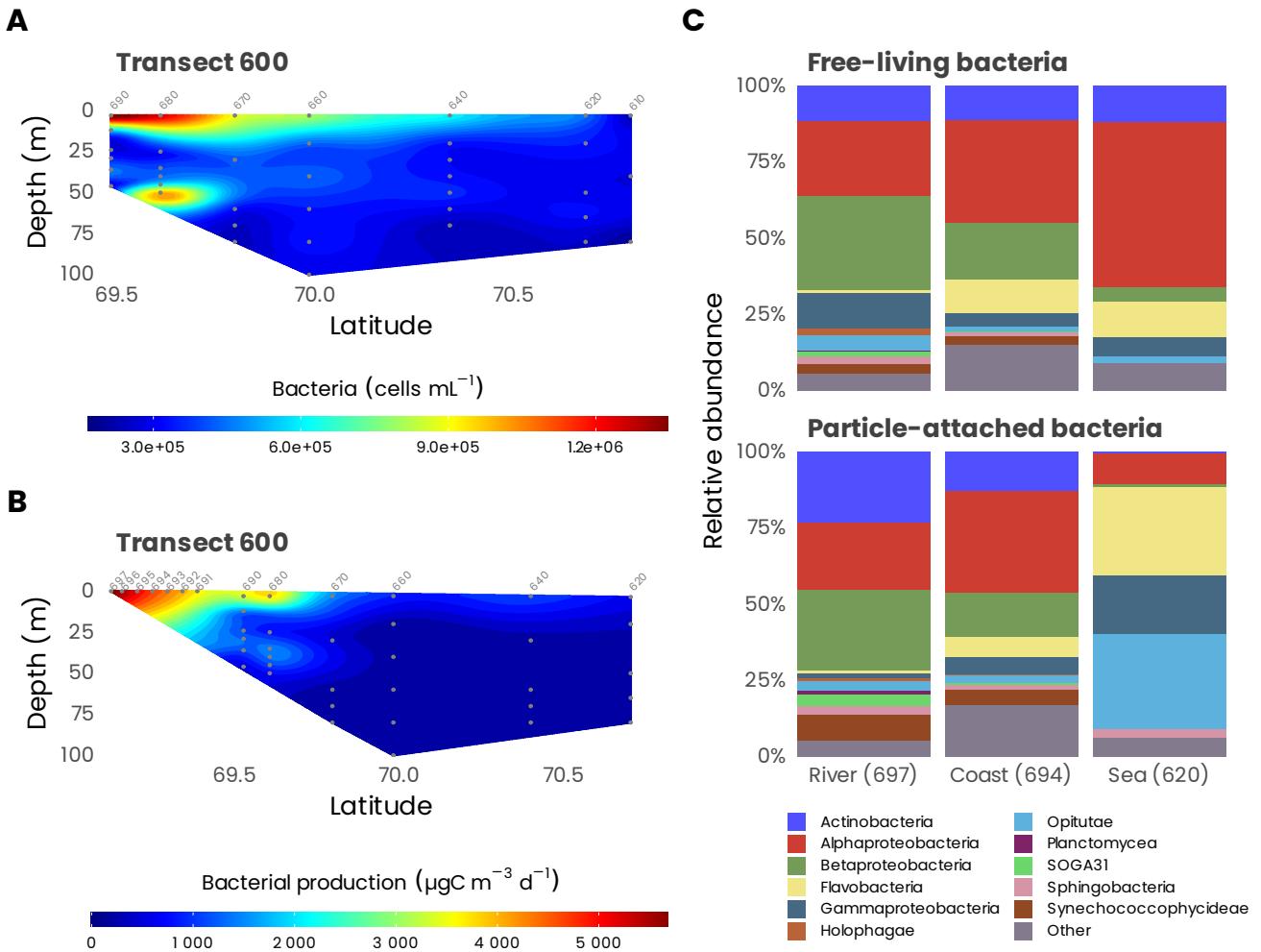
**Figure 11.** (A) Taxonomic composition of populations of photosynthetic pico- and nano-eukaryotes sorted flow cytometry from clone library sequences (Balzano et al., 2012b). (B) Taxonomic composition of cultures of phytoplankton isolated during the MALINA cruise (Balzano et al., 2012a).



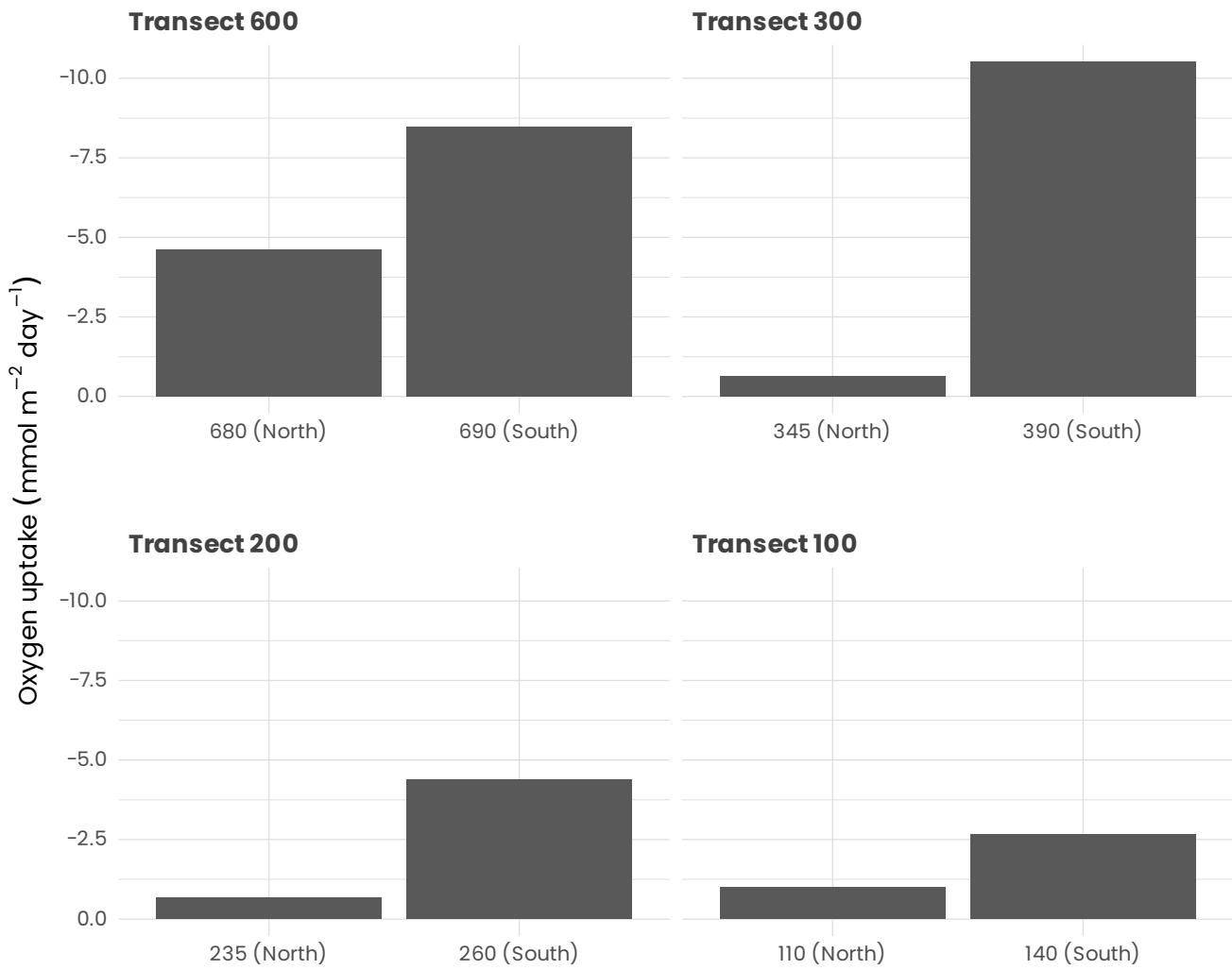
**Figure 12.** Cross-sections of primary production (gray dots) along transects 600 and 300. Station numbers are identified in light gray on top of each panel. Note that the color scale is presented on a log10 scale.

**A****B**

**Figure 13.** (A) CO and  $\text{CO}_2$  production measured at 295 nm at surface for stations of transects 600 and 300. (B) Autoxidation of suspended particulate material for stations of transects 600 and 300.



**Figure 14.** (A) Cross-sections of bacterial abundance measured from flow cytometry and (B) bacterial production measured along transect 600. Station numbers are identified in light gray on top of each panel. (C) Cumulative bar charts comparing the relative class abundances in particle-attached (PA) and free-living (FL) for a selected number of samples in transect 600.



**Figure 15.** xxx

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order.

Parameter	Method	Sampling device	Principal investigators
137Cs datation of core samples	Gamma spectrometry	Box corer	Rochon A./Schmidt
137Cs datation of core samples	Gamma spectrometer	CASQ corer	Rochon A./Schmidt
14C datation of core samples	Accelerator Mass Spectrometry	Box corer	Rochon A.
14C datation of core samples	Accelerator Mass Spectrometry	CASQ corer	Rochon A.
15N-Ammonium assimilation	15N Spiking - incubation - mass-spectrometry	Rosette - Deck incubations	Tremblay J.E./Raimbault P.
15N-Ammonium oxidation (Nitrification)	15N Spiking - incubation - mass-spectrometry	Rosette In-situ production line	Tremblay J.E./Raimbault P.
15N-Ammonium oxidation (Nitrification)	15N Spiking - incubation - mass-spectrometry	Rosette - Deck incubations	Tremblay J.E./Raimbault P.
15N-Ammonium primary production (13C)	15N Spiking - incubation - mass-spectrometry	Rosette In-situ production line	Tremblay J.E./Raimbault P.
15N-Ammonium regeneration	15N Spiking - incubation - mass-spectrometry	Rosette - Deck incubations	Tremblay J.E./Raimbault P.
15N-Ammonium regeneration	15N Spiking - incubation - mass-spectrometry	Rosette - Deck incubations	Tremblay J.E./Raimbault P.
15N-N2 fixation	15N Spiking - incubation - mass-spectrometry	Rosette In-situ production line	Tremblay J.E./Raimbault P.
15N-Nitrate assimilation	15N Spiking - incubation - mass-spectrometry	Rosette In-situ production line	Tremblay J.E./Raimbault P.
15N-Nitrate assimilation	15N Spiking - incubation - mass-spectrometry	Rosette Niskin water sample	Tremblay J.E./Raimbault P.
15N-Urea Photosynthetic parameters	15N incubations mass spectrometry		
210Pb geochronology of core samples	209Po alpha spectrometry	Box corer	Rochon A.
210Pb geochronology of core samples	209Po alpha spectrometry	CASQ corer	Rochon A.
226Ra (particulate)	Gamma spectrometry	Foredock In-situ pump	Gasser B.
226Ra/228Ra	Gamma spectrometry	Discrete Sample on Continuous System.	Gasser B.
234Th (1 micron < particles > 70 micron)	Beta-counting	Foredock In-situ pump	Gasser B.
234Th (particles > 70 micron)	Beta-counting	Foredock In-situ pump	Gasser B.
234Th (Particulate)	Beta-counting	Drifting Sediment trap	Gasser B.
234Th (total)	Beta-counting	Rosette water sample	Gasser B.
238U (Dissolved)	Derived parameter	Rosette water sample	Gasser B.
238U (total)	Alpha-counting	Rosette water sample	Gasser B.
AAPB (abundance)	IR microscopy, fluorimetry, FISH	Rosette water sample	Jeanthon C./Boeuf D.
AAPB (abundance)	IR microscopy, fluorimetry, FISH	Zodiac water sample	Jeanthon C./Boeuf D.
Absorption (particulate)	PSICAM	Barge water sample	Leymarie E.
Absorption (particulate)	Spectrophotometer (filters)	Barge water sample	Belanger S.
Absorption (particulate)	Spectrophotometer (filters)	Continuous on way	Leymarie E.
Absorption (particulate)	PSICAM	Rosette water sample	Leymarie E.
Absorption (particulate)	Spectrophotometer (filters)	Rosette water sample	Belanger S.
Absorption (particulate)	Spectrophotometer (filters)	Zodiac profiler	Leymarie E.
Absorption (total)	PSICAM	Barge water sample	Belanger S.
Absorption (total)	HOBi-Labs a-sphere	Rosette water sample	Leymarie E.
Absorption coefficient (total)	Wetlabs AC9 Serial# 156	Barge profiler	Wright V./Hooker S.
Absorption coefficient (total)		Rosette profiler	Ehn J.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method	Sampling device	Principal investigators
Absorption coefficient (total)(9 wavelengths in IR	Wetlabs AC9 Serial# 303	Barge profiler	Doxaran D.
Absorption coefficient (total)(9 wavelengths)	Wetlabs AC9 Serial# 279	Barge profiler	Doxaran D.
Air Relative Humidity	Humidity Sensor	Foredock Meteorological Tower	Papakyriakou T.
Alkalinity total (TA)			Mucci A./ Lansard B.
Alkalinity total (TA)	Potentiometry	Barge water sample	Mucci A./ Lansard B.
Alkalinity total (TA)	Potentiometry	Rosette	Mucci A./ Lansard B.
Alkanes	Potentiometry	Zodiac water sample	Mucci A./ Lansard B.
	GC-MS	Box corer	Bouloubassi I.
	GC-MS	CASQ corer	Bouloubassi I.
Ammonium ( $\text{NH}_4^+$ ) photo-production apparent quantum yield (AQY)	sun simulator - fluorimetry	Rosette water sample	Xie H./ Tremblay J.E.
Ammonium ( $\text{NH}_4^+$ ) photo-production apparent quantum yield (AQY)	sun simulator - fluorimetry	Zodiac water sample	Xie H./ Tremblay J.E.
Aragonite : saturation state	Derived parameter	Barge water sample	Mucci A./ Lansard B.
Aragonite : saturation state	Derived parameter	Rosette water sample	Mucci A./ Lansard B.
Aragonite : saturation state	Derived parameter	Zodiac water sample	Mucci A./ Lansard B.
Archaea (diversity)	CE-SSCP and DNA clone library	Rosette water sample	Joux F.
Attenuation coefficient (total)(9 wavelengths in IR)	Wetlabs AC9 Serial #0303	Barge profiler	Doxaran D.
Attenuation coefficient (total)(9 wavelengths)	Wetlabs AC9 Serial #279	Barge profiler	Doxaran D.
Attenuation coefficient (total)(9 wavelengths)	Wetlabs AC9 Serial #156	Rosette profiler	Ehn J.
Attenuation coefficient at 660nm	Wetlabs (CRover) transmissometer	Drifting profiling float	Doxaran D.
Backscattering 532 nm	Wetlabs ECO-BB3 backscatterometer	Drifting profiling float	Doxaran D.
Backscattering coefficient (3 wavelengths in IR)	Wetlabs ECO-BB3 serial #538	Barge profiler	Doxaran D.
Backscattering coefficient (3 wavelengths)	Wetlabs ECO-BB3 serial #028	Barge profiler	Doxaran D.
Backscattering coefficient (6 Wavelength)	HOBi-Labs HydroScat-6 serial #	Barge profiler	Wright V./ Hooker S.
Backscattering coefficient (8 wavelengths, spectral)	HydroScat-6(serial#97074) and two a-Beta (HOBi-Labs)	Barge profiler	Reynolds R.
Backscattering coefficient (8 wavelengths, spectral)	HydroScat-6(serial#97074) and two a-Beta (HOBi-Labs)	Foredock	Reynolds R.
Backscattering coefficient (9 wavelengths)	Wetlabs ECO-BB9 serial# 274	Rosette profiler	Ehn J.
Bacterial abundance	Flow cytometry	Rosette water sample	Vaulot D.
Bacterial abundance	Flow Cytometry	Rosette water sample	Joux F./ Ortega E.
Bacterial abundance	FISH-TSA	Rosette water sample	Joux F.
Bacterial bio-volume		Box corer	Joux F./ Ortega E.
Bacterial diversity		Rosette water sample	Link H./ Archambault P./ Chailiou G.
Bacterial Eco-enzymatic activity	CE-SSCP and DNA clone library	Rosette water sample	Joux F./ Jeffrey W.
Bacterial growth (limitation by nutrients)	Spectrofluorimetry	Rosette water sample	Joux F./ Jeffrey W./ Ortega E.
Bacterial production	Leu-3H incubations - cells counts	Rosette water sample	Joux F./ Jeffrey W.
Bacterial production	Leucine-3H incorporation	Zodiac water sample	Joux F./ Jeffrey W.
Bacterial production	Leucine-3H incorporation - cell counts	Rosette water sample	Joux F./ Jeffrey W./ Ortega E.
Bacterial production (effects of UV radiation)	Leucine-3H incorporation	Rosette water sample	Joux F./ Jeffrey W.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method	Sampling device	Principal investigators
Bacterial respiration (whole community)	O2 consumption - Winkler - Incubations	Rosette water sample	Joux F./Ortega E.
Benthic ammonium flux	Incubations - Colorimetry	Box corer	Link H./Archambault P./Chailhou G.
Benthic DOC remineralisation	Incubations - wet oxidation	Box corer	Link H./Archambault P./Chailhou G./Charrie
Benthic Macrofauna abundance	Microscopy	Box corer	Link H./Archambault P./Chailhou G.
Benthic Macrofauna biomass	Wet weight	Box corer	Link H./Archambault P./Chailhou G.
Benthic Macrofauna diversity	Microscopy	Box corer	Link H./Archambault P./Chailhou G.
Benthic nitrate flux	Incubations - Colorimetry-Autoanalyzer	Box corer	Link H./Archambault P./Chailhou G.
Benthic nitrite flux	Incubations - Colorimetry-Autoanalyzer	Box corer	Link H./Archambault P./Chailhou G.
Benthic phosphate flux	Incubations - Colorimetry-Autoanalyzer	Box corer	Link H./Archambault P./Chailhou G.
Benthic respiration	Incubations - Optic - Oxygen probe	Box corer	Link H./Archambault P./Chailhou G.
Benthic silicic acid flux	Incubations - Colorimetry - Autoanalyzer	Box corer	Link H./Archambault P./Chailhou G.
Bioturbation of sediments	Incubation with luminophores	Box corer	Link H./Archambault P./Chailhou G.
Calcite : saturation state	Derived parameter	Barge water sample	Mucci A./Lansard B.
Calcite : saturation state	derived parameter	Rosette water sample	Mucci A./Lansard B.
Calcite : saturation state	Derived parameter	Zodiac water sample	Mucci A./Lansard B.
Campesterol, cholesterol and products of degrad	GC-MS	Rosette water sample	Sempere R.
CDOM absorption	PSICAM	Barge water sample	Leymarie E.
CDOM absorption	Spectrophotometer	Barge water sample	Matsuoka A./Bricaud A.
CDOM absorption	Spectrophotometer	Barge water sample	Wright V./Hoover S.
CDOM absorption	Ultrapath	Barge water sample	Bricaud A.
CDOM absorption	PSICAM	Rosette water sample	Leymarie E.
CDOM absorption	Spectrophotometer	Rosette water sample	Matsuoka A./Bricaud A.
CDOM absorption	Ultrapath	Rosette water sample	Bricaud A.
CDOM absorption	PSICAM	Zodiac water sample	Leymarie E.
CDOM absorption	Spectrophotometer	Zodiac water sample	Matsuoka A./Bricaud A.
CDOM absorption	Ultrapath	Zodiac water sample	Bricaud A.
CDOM fluorescence	HOBi-Labs Hydrosat-6 ser# HS080542	Barge profiler	Wright V./Hoover S.
CDOM fluorescence	Wetlabs WetStar WSCD	Barge profiler	Doxaran D.
CDOM fluorescence	Wetlabs (ECO3) fluorometer	Drifting profiling float	Doxaran D.
CDOM fluorescence	Haardt fluorometer	Rosette profiler	Belanger S./Amon/ Sempere R.
CDOM fluorescence EEM (excitation-emission-matrix)	Spectrofluorimetry	Rosette water sample	Belanger S./Amon/ Sempere R.
Chlorophyll a and Phaeopigments (concentration)	Spectrofluorimetry	Zodiac water sample	Gosselin M./Belanger S.
Chlorophyll a and Phaeopigments(benthic)	Fluorimetry Size fractionned	Rosette water sample	Link H./Archambault P./Chailhou G.
Chlorophyll a fluorescence [Fchl(z)]	Fluorometric analysis	Box corer	Doxaran D.
Chlorophyll a fluorescence [Fchl(z)]	Chelsea Mini-Track all fluorometer	Barge profiler	Wright V./Hoover S.
Chlorophyll a fluorescence [Fchl(z)]	HOBi-Labs Hydrosat-6 fluorometer	Barge profiler	Doxaran D.
Chlorophyll a fluorescence [Fchl(z)]	Wetlabs (ECO3) fluorometer	Drifting profiling float	

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method		Sampling device	Principal investigators
Chlorophyll a fluorescence [F(rha(z)]	SeaPoint fluorometer		Rosette profiler	Gratton Y./Prieur L./Tremblay J.E.
CO photo-prod. apparent quantum yield for CDOM	Sun simulator - reduction gas analyzer		Rosette water sample	Xie H.
CO photo-prod. apparent quantum yield for CDOM	Sun simulator - reduction gas analyzer		Zodiac water sample	Xie H.
CO photo-prod. apparent quantum yield for particulate matter	Sun simulator - reduction gas analyzer		Rosette water sample	Xie H.
CO2 (atm) concentration	Infra Red		Zodiac water sample	Papakyriakou T.
CO2 (seawater) concentration	Infra Red		Foredeck Meteorological Tower	Papakyriakou T.
CO3 2-concentrations	Derived parameter		Foredeck Meteorological Tower	Mucci A./Lansard B.
CO3 2-concentrations	Derived parameter		Barge water sample	Mucci A./Lansard B.
CO3 2-concentrations	Derived parameter		Rosette water sample	Mucci A./Lansard B.
Coccolithophorids	Microscopy		Zodiac water sample	Mucci A./Lansard B.
Conductivity (z)	Sensor on SBE Fascat CTD serial #		Rosette water sample	Couvel P.
Conductivity (z)	Sensor on SBE Fascat CTD serial #		Barge profiler	Doxaran D.
Conductivity (z)	Sensor SeaBird 4c on CTD SBE911		Barge profiler	Wright V./Hoover S.
CTD	Seabird		Rosette profiler	Gratton Y./Prieur L.
Cultures of sorted populations	Sorted by flow cytometry, serial dilution and single cell pipetting		Drifting profiling float	Doxaran D.
Current Profile [U(z)]	ADCP (LADCP) RD Instrument 300 KHz		Rosette water sample	Vaulot D.
delta 13C	Mass Spectrometry		Rosette profiler	Marec C./Gratton Y./Prieur L.
delta 13C on suspended particulate matter	Mass Spectrometry		Zodiac water sample	Mucci A./Lansard B.
delta 15C on suspended particulate matter	Mass Spectrometry		Rosette water sample	Tremblay J.E./Raimbault P.
delta 18O - water	Mass Spectrometry		Rosette water sample	Tremblay J.E./Raimbault P.
delta 18O - water	GC/MS		Rosette water sample	Mucci A./Lansard B.
delta13C	Mass Spectrometer		Zodiac water sample	Mucci A./Lansard B.
delta13C	Mass Spectrometer		Barge water sample	Mucci A./Lansard B.
delta13C	Mass Spectrometry		Rosette water sample	Mucci A./Lansard B.
delta18O - water	Mass Spectrometry		Barge water sample	Mucci A./Lansard B.
Diadids composition	GC/MS		Rosette water sample	Sempere R.
Diadids composition	Sun simulator - GC/MS		Zodiac water sample	Sempere R.
Diadids photo-production apparent quantum yield (AQY)	Microscopy		Zodiac water sample	Sempere R.
Dinoflagellates cysts Abundance	Microscopy		Box corer	Rochon A.
Dinoflagellates cysts Abundance	Microscopy		CASQ corer	Rochon A.
Dinoflagellates cysts Identification	Microscopy		Box corer	Rochon A.
Dinoflagellates cysts Identification	Microscopy		CASQ corer	Rochon A.
Dissolved Inorg. Carbon photo-prod. apparent quantum yield	Sun simulator - infrared CO2 analyzer		Rosette water sample	Xie H./Belanger S.
Dissolved Inorg. Carbon photo-prod. apparent quantum yield	Sun simulator - infrared CO2 analyzer		Zodiac water sample	Xie H./Belanger S.
Dissolved Organic Carbon (DOC)	High Temperature Catalytic Oxidation		Barge water sample	Wright V./Hoover S.
Dissolved Organic Carbon (DOC)	High Temperature Catalytic Oxidation		Rosette water sample	Sempere R.
Dissolved Organic Carbon (DOC)	High Temperature Catalytic Oxidation		Rosette water sample	Benner R.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method	Sampling device	Principal investigators
Dissolved Organic Carbon (DOC)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
Dissolved Organic Carbon (DOC)	High Temperature Catalytic Oxidation	Zodiac water sample	Sempere R.
Dissolved Organic Carbon (DOC)	High Temperature Catalytic Oxidation	Zodiac water sample	Benner R.
Dissolved Organic Nitrogen (DON)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
Dissolved Organic Nitrogen (Total) (TDON)	High Temperature Catalytic Oxidation	Rosette water sample	Benner R.
Dissolved Organic Nitrogen (Total) (TDON)	High Temperature Catalytic Oxidation	Zodiac water sample	Benner R.
Dissolved Organic Phosphorus (DOP)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
Ed, LU, Eu, Es	C-OPS package (320, 340, 380, 395 nm)	Barge profiler	Hooker
Electric resistivity (sediment core physical properties)	Geotek Multi Sensor Core Logger	Box corer	Rothon A.
Electric resistivity (sediment core physical properties)	Geotek Multi Sensor Core Logger	CASQ corer	Rothon A.
Eukaryotes (abundance)	DAPI epifluorescence microscopy	Rosette water sample	Lovejoy C.
Eukaryotes (abundance)	FISH-TSA	Rosette water sample	Lovejoy C.
Eukaryotes (biomass)	DAPI epifluorescence microscopy	Rosette water sample	Lovejoy C.
fCO2	Derived parameter	Barge water sample	Mucci A./ Lanskard B.
fCO2	Derived parameter	Rosette water sample	Mucci A./ Lanskard B.
fCO2	Derived parameter	Zodiac water sample	Mucci A./ Lanskard B.
Foraminifera abundance	Microscopy	Box corer	Rothon A.
Foraminifera abundance	Microscopy	CASQ corer	Rothon A.
Foraminifera identification	Microscopy	Box corer	Rothon A.
Foraminifera identification	CASQ corer	Box corer	Rothon A.
Gamma density (sediment core physical properties)	Geotek Multi Sensor Core Logger	CASQ corer	Rothon A.
Gamma density (sediment core physical properties)	Geotek Multi Sensor Core Logger	In-water profiler	Papakyriakou T.
H2O (atm) concentration	Infrared gas analyzer	Foredock Meteorological Tower	Mucci A./ Lanskard B.
HCO2- concentration	Derived parameter	Barge water sample	Mucci A./ Lanskard B.
HCO2- concentration	Derived parameter	Rosette water sample	Mucci A./ Lanskard B.
HCO2- concentration	Derived parameter	Zodiac water sample	Mucci A./ Lanskard B.
Hydro SCAMP (Temp, Salin, Chlorophyll, turb, ...)	SCAMP profiler	In-water profiler	Gratton Y.
Hydrolyable Amino Acids (Total) (THAA)	HPLC	Rosette water sample	Benner R.
Hydrolyable Amino Acids (Total) (THAA)	HPLC	Zodiac water sample	Benner R.
Hydroxyl Radicals (OH)	HPLC	Rosette water sample	Sempere R.
Hydroxyl Radicals (OH)	HPLC	Zodiac water sample	Sempere R.
Hydroxyl radicals (OH) photo-prod. apparent quantum yield	Sun simulator - HPLC	Rosette water sample	Sempere R.
Hydroxyl Radicals (OH) photo-prod. apparent quantum yield	Sun simulator - HPLC	Zodiac water sample	Sempere R.
IP25 (C25 Monounsaturated Hydrocarbon)	GC	Box corer	Masse G.
IP25 (C25 Monounsaturated Hydrocarbon)	CASQ corer	CASQ corer	Masse G.
Irradiance	Foredock	Foredock	Sempere R.
Irradiance (412, 490 555 nm)	Drifting profiling float	Drifting profiling float	Doxaran D.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method		Sampling device	Principal investigators
Lignin phenols (dissolved)	GC/MS		Rosette water sample	Benner R.
Lignin phenols (dissolved)	GC/MS		Zodiac water sample	Benner R.
Lipid biomarqueurs	GC-Flamme Ionization Detection / GC-MS		Box corer	Tolosa I.
Lipid biomarqueurs	GC-Combustion Ionization Detection / GC-MS	CASQ corer		Tolosa I.
Lipid biomarqueurs d13C	GC-Combustion Isotope ratio MS	Box corer		Tolosa I.
Lipid biomarqueurs d13C	GC-Combustion Isotope ratio MS	CASQ corer		Tolosa I.
Long-Wave radiation (Lwin)	Pygeometer		Wheel-house radiation platform	Papakyriakou T.
Magnetic susceptibility (sediment core physical properties)	Geotek Multi Sensor Core Logger	Box corer		Rochon A.
Magnetic susceptibility (sediment core physical properties)	Geotek Multi Sensor Core Logger	CASQ corer		Rochon A.
Nanoeukaryotes (abundance)	Flow cytometry	Rosette water sample		Vaulot D.
NH <sub>4</sub> <sup>+</sup>	Fluorescence	Rosette water sample		Tremblay J.E./Raimbault P.
Nitrate (concentration)	Salinatic ISUS	Rosette profiler		Gratton Y./Prieur L./Tremblay J.E.
NO <sub>2</sub> <sup>-</sup>	Colorimetry/Autoanalyzer	Rosette water sample		Tremblay J.E./Raimbault P.
NO <sub>3</sub> <sup>-</sup>	Colorimetry/Autoanalyzer	Rosette water sample		Tremblay J.E./Raimbault P.
Organic Compounds High Molecular Weight (HMW)	Sun simulator incubations - HPLC	Rosette water sample		Xie H.
Organic Compounds High Molecular Weight (HMW)	Sun simulator incubations - HPLC	Zodiac water sample		Xie H.
Organic Compounds Low Molecular Weight (LMW)	Sun simulator incubations - HPLC	Rosette water sample		Xie H.
Organic Compounds Low Molecular Weight (LMW)	Sun simulator incubations - HPLC	Zodiac water sample		Xie H.
Oxygen (dissolved)	Discrete samples Winkler Method	Barge water sample		Prieur L.
Oxygen (dissolved)	Discrete samples Winkler Method	Continuous horizontal		Papakyriakou T.
Oxygen (dissolved)	SeaBird SBE-43 sensor	Rosette profiler		Gratton Y./Prieur L.
Oxygen (dissolved)	Discrete samples Winkler Method	Rosette water sample		Prieur L.
Oxygen (dissolved)	Discrete samples Winkler Method	Zodiac water sample		Prieur L.
P waves speed (sediment core physical properties)	Geotek Multi Sensor Core Logger	Box corer		Rochon A.
P waves speed (sediment core physical properties)	Geotek Multi Sensor Core Logger	CASQ corer		Rochon A.
Paleomagnetism	Cryogenic magnetometer	Box corer		Rochon A.
Paleomagnetism	Biospherical sensor	CASQ corer		Rochon A.
PAR	Biospherical sensor	Barge profiler		Wright V./Hooker S.
PAR	Biospherical sensor	Rosette profiler		Gratton Y./Prieur L./Tremblay J.E.
PAR	PARLite sensor	Wheel-house radiation platform		Papakyriakou T.
Particle Size Distribution	LISST-100X	Barge profiler		Reynolds R.
Particle Size Distribution	Coulter counter	Barge water sample		Reynolds R.
Particle Size Distribution	UVP-5	In-water profiler		Picheral M.
Particle Size Distribution	LISST-100X	Rosette profiler		Reynolds R.
Particle Size Distribution	Coulter counter	Rosette water sample		Reynolds R.
Particulate Organic Carbon (POC)	CHN analyzer	Barge water sample		Wright V./Hooker S.
Particulate Organic Carbon (POC)	CHN analyzer on SPM filters	Barge water sample		Doxaran D./Ehn J./Babin M.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method	Sampling device	Principal investigators
Particulate Organic Carbon (POC)	CHN analyzer on SPM filters	Rosette water sample	Doxaran D./ Ehni J./ Babin M.
Particulate Organic Carbon (POC)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
Particulate Organic Carbon (POC)	CHN analyzer on SPM filters	Zodiac water sample	Doxaran D./ Ehni J./ Babin M.
Particulate Organic Matter (POM)	CHN analyzer on SPM filters	Barge water sample	Wright V./ Hooker S.
Particulate Organic Nitrogen (PON)	CHN analyzer	Barge water sample	Wright V./ Hooker S.
Particulate Organic Nitrogen (PON)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
Particulate Organic Phosphorus (POP)	Wet oxidation	Rosette water sample	Tremblay J.E./ Raimbault P.
pH	Spectrophotometry	Barge water sample	Mucci A./ Lanskard B.
pH	SeaBird SBE-18 sensor	Rosette profiler	Gratton Y./ Prieur L./ Tremblay J.E.
pH	Spectrophotometry	Rosette water sample	Mucci A./ Lanskard B.
pH	Spectrophotometry	Zodiac water sample	Mucci A./ Lanskard B.
pH (total proton scale)	Derived parameter	Barge water sample	Mucci A./ Lanskard B.
pH (total proton scale)	Derived parameter	Rosette water sample	Mucci A./ Lanskard B.
pH (total proton scale)	Derived parameter	Zodiac water sample	Mucci A./ Lanskard B.
Photosynthetic eukaryotes (morphology)	Scanning Electron Microscopy	Rosette water sample	Vaulot D.
Photosynthetic eukaryotes (diversity)	DNA clone library and TRFLP of sorted populations	Rosette water sample	Vaulot D.
Photoheterotrophs (delt cycle genes analyses)	RNA expression every 4 hours	Rosette water sample	Jeanthon C./ Boeuf D.
Photoheterotrophs (DNA diversity)	DNA clone library	Rosette water sample	Jeanthon C./ Boeuf D.
Photoheterotrophs (metagenome)	454 sequencing	Rosette water sample	Jeanthon C./ Boeuf D.
Photosynthetic parameters	<sup>14</sup> C incubations	Rosette water sample	Huet Y.
Phytoplankton (abundance)	Inverted microscope	Rosette water sample	Gosselin M./ Belanger S.
Phytoplankton (taxony)	Inverted microscope	Rosette water sample	Gosselin M./ Belanger S.
Phytoplankton pigments	HPLC	Barge water sample	Wright V./ Hooker S.
Phytoplankton pigments	HPLC	Rosette water sample	Ras J./ Claudrie H.
Picoeukaryotes (abundance)	Flow cytometry	Rosette water sample	Vaulot D.
Picoplankton (diversity)	DNA clone library	Rosette water sample	Lovejoy C.
Photosynthetic eukaryotes (diversity)	DNA from filters	Rosette water sample	Vaulot D.
Picoplankton (diversity)	RNA clone library	Rosette water sample	Lovejoy C.
Plankton taxonomy	UVP-5	In-water profiler	Picheral M./ Marec C.
(PO <sub>4</sub> ) <sup>3-</sup>	Colorimetry/Autoanalyzer	Rosette water sample	Tremblay J.E./ Raimbault P.
Pollen and Spores Abundance	Box corer	Box corer	Rochon A.
Pollen and Spores Abundance	CASQ corer	CASQ corer	Rochon A.
Pollen and Spores Identification	Box corer	Box corer	Rochon A.
Pollen and Spores Identification	CASQ corer	CASQ corer	Rochon A.
PR-containing bacteria (abundance)	Rosette water sample	Rosette water sample	Jeanthon C./ Boeuf D.
Pressure (Barometric)	Foredock Meteorological Tower	Foredock Meteorological Tower	Papakyriakou T.
Radiance	Profile mode	Profile mode	Antoine D./ leymarie E.

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (continued)

Parameter	Method		Sampling device	Principal investigators
Radiance	Camera Luminance		Surface mode	Antoine D./Leymarie E.
Radiance (surface leaving radiance)	BIO-SHADE		Barge profiler	Hooker
Radiance (surface leaving radiance)	BIOSORS		Foredock	Hooker
Radiance (surface leaving radiance)	Satlantic HyperSAS		Foredock	Belanger S.
Radiance (surface leaving radiance)	TriOS above water sensor		Foredock	Doxaran D.
Radiance :Sub Product : average cosines	Camera Luminance		Profile mode	Antoine D./Leymarie E.
Radiance :Sub Product : irradiance (E)	Camera Luminance		Surface mode	Antoine D./Leymarie E.
Radiance :Sub Product : irradiance (E)	Camera Luminance		Profile mode	Antoine D./Leymarie E.
Radiance :Sub Product : lnadir	Camera Luminance		Surface mode	Antoine D./Leymarie E.
Radiance :Sub Product : lnadir	Camera Luminance		Profile mode	Antoine D./Leymarie E.
Radiance :Sub Product : Qnadir	Camera Luminance		Surface mode	Antoine D./Leymarie E.
Radiance :Sub Product : Qnadir	Camera Luminance		Profile mode	Antoine D./Leymarie E.
Radiance :Sub Product : scalar irradiance (Escal)	Camera Luminance		Surface mode	Antoine D./Leymarie E.
Radiance :Sub Product : scalar irradiance (Escal)	Camera Luminance		Foredock Meteorological Tower	Papakyriakou T.
Rotational movement (accx, accy, accz,rx,ry,rz)	multi-axis inertial sensing system		Barge water sample	Gratton Y./Prieur L.
Salinity	Salinometer		Rosette water sample	Gratton Y./Prieur L.
Salinity	Salinometer		Continuous horizontal	Papakyriakou T.
Salinity (sea surface) SSS	Thermosalinograph - underway system		Barge profiler	Doxaran D.
Salinity [Sz]	Derived parameter from SBE Fastcat NASA IOP pack.		Barge profiler	Wright V./Hooker S.
Salinity [Sz]	Derived parameter from SBE Fastcat NASA IOP pack.		Rosette profiler	Gratton Y./Prieur L./Tremblay J.E.
Salinity [Sz]	Pyranometer		Wheel-house radiation platform	Papakyriakou T.
Short-Wave radiation (Swin)			Rosette water sample	Tremblay J.E./Rainbault P.
$S'_{\text{H}}(O/H)_4$			Barge water sample	Wright V./Hooker S.
SPM (Suspended Particulate Material)	Colorimetry/Autonalyzer		Barge water sample	Doxaran D./Ehn J./Babin M.
SPM (Suspended Particulate Material)	dry weight (gravimetry)		Rosette water sample	Doxaran D./Ehn J./Babin M.
SPM (Suspended Particulate Material)	dry weight (gravimetry)		Zodiac water sample	Doxaran D./Ehn J./Babin M.
SPM (Suspended Particulate Material)	dry weight (gravimetry)		Rosette water sample	Sempere R.
Sugars	HPLC		Zodiac water sample	Sempere R.
Sugars	HPLC		Rosette water sample	Vailot D.
Synechococcus (abundance)	Flow cytometry		Rosette water sample	Papakyriakou T.
Temperature (Air)			Foredock Meteorological Tower	Papakyriakou T.
Temperature (Sea Surface)			Continuous horizontal	Papakyriakou T.
Temperature (Surface Skin)			Foredock Meteorological Tower	Papakyriakou T.
Temperature [T(z)]	IR transducer		Barge profiler	Doxaran D.
Temperature [T(z)]	Temp sensor on SBE Fastcat CTD serial #		Barge profiler	Wright V./Hooker S.
Temperature [T(z)]	Temp sensor on SBE Fastcat CTD serial #		Rosette profiler	Gratton Y./Prieur L./Tremblay J.E.
	Sensor SeaBird 3plus on CTD SBE-911			

Table 1: Parameters measured during the MALINA oceanographic expedition. Parameters are ordered by alphabetical order. (*continued*)

Parameter	Method	Sampling device	Principal investigators
Total Inorganic Carbon (TIC)	Derived parameter	Barge water sample	Mucci A./Lansard B.
Total Inorganic Carbon (TIC)	Derived parameter	Rosette water sample	Mucci A./Lansard B.
Total Inorganic Carbon (TIC)	Derived parameter	Zodiac water sample	Mucci A./Lansard B.
Total Organic Carbon (TOC)	Wet oxidation	Rosette water sample	Tremblay J.E./Raimbault P.
Total Organic Nitrogen (TON)	Wet oxidation	Rosette water sample	Tremblay J.E./Raimbault P.
Total Organic Phosphorus (TOP)	Wet oxidation	Rosette water sample	Tremblay J.E./Raimbault P.
Trace metals	X-Ray fluorescence spectroscopy	Box corer	Martinez P.
Trace metals	X-Ray fluorescence spectroscopy	CASQ corer	Martinez P.
Urea (concentration)	Spectrophotometry	Rosette water sample	Tremblay J.E./Raimbault P.
Volume Scattering Function (VSF)	Benchtop use of POLVSM	Barge water sample	Chami M.
Volume Scattering Function (VSF)	Benchtop use of POLVSM	Rosette water sample	Chami M.
Volume Scattering Function (VSF)	Benchtop use of POLVSM	Zodiac water sample	Chami M.
Wind direction	Vane	Foredock Meteorological Tower	Papakyriakou T.
Wind speed	Anemometer	Foredock Meteorological Tower	Papakyriakou T.
Major and minor elements	XRF core scanner	CASQ corer	Martinez P.

## 4 Code and data availability

TODO

*Author contributions.*

- 10 *Competing interests.* The authos declar no competing interests.

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15 Thibault) and crews of the Canadian research icebreaker CCGS Amundsen during the Malina cruise in the Beaufort Sea. This study was conducted as part of the Malina scientific program funded by ANR (Agence Nationale de la Recherche), INSU-CNRS (Institut National des Sciences de l'Univers - Centre National de la Recherche Scientifique), CNES (Centre National d'Études Spatiales) and ESA (European Space Agency). The International Atomic Energy Agency is grateful to the Government of the Principality of Monaco for the support provided to its Environment Laboratories.

20 **References**

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