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Long-term observations of hydrography, phytoplankton pigments, and suspended particles in Potter Cove (Antarctica), 1991–2025

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Abstract. Long-term observations are essential for distinguishing seasonal and interannual variability from long-term environmental change, yet sustained coastal monitoring programs remain rare in Antarctica, particularly during winter. Potter Cove, 25 de Mayo/King George Island, is an exceptional case, with observations initiated in the early 1990s through collaboration between the Instituto Antártico Argentino, the Alfred Wegener Institute, and other national and international partners. This dataset compiles more than three decades (1991–2025) of hydrographic and biological observations, including seawater temperature and salinity, chlorophyll-a and other photosynthetic pigments, and total suspended particulate matter (TSPM). It comprises 915 hydrographic profiles, 6,051 chlorophyll-a measurements, and 5,764 TSPM determinations collected at multiple stations and across different seasons. Standardized sampling protocols and quality-control procedures

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support temporal consistency and comparability. The dataset enables investigations of seasonal, interannual, and decadal variability in Antarctic coastal waters undergoing substantial environmental change, including glacier retreat and altered freshwater inputs. Its combined hydrographic, biological, and particulate measurements supported research on phytoplankton dynamics, particle transport, and ecosystem responses to climate forcing, while providing a foundation for model development and validation and comparative studies across Antarctic coastal ecosystems. Data are available at https://zenodo.org/records/23567820.

1 Introduction

Coastal ecosystems of the Western Antarctic Peninsula (WAP) and the South Shetland Islands are among the regions experiencing the most rapid environmental changes in Antarctica. Atmospheric warming, glacier retreat, altered sea-ice dynamics, and changes in freshwater runoff have modified the physical and biological characteristics of numerous coastal habitats over recent decades. These changes are particularly evident in shallow fjord-like embayments, where strong interactions between terrestrial, glacial, and marine processes control water-column structure, light availability, particle dynamics, and biological production (Schloss et al., 2012; Jerosch et al., 2018; Neder et al., 2022; Deregibus et al., 2025).

Potter Cove (62°14′S, 58°38′W, Fig. 1), located on the southeastern coast of Isla 25 de Mayo/King George Island, is one of the best-studied Antarctic coastal ecosystems. The cove is characterized by strong spatial gradients generated by glacier meltwater, suspended sediments, tidal forcing, and exchanges with the adjacent Maxwell Bay system. Hydrographic conditions are highly variable and are shaped by the interaction of atmospheric forcing, freshwater inputs, circulation patterns, and seasonal glacier melt (Neder et al. 2022). Early studies described the hydrographic structure of the cove and demonstrated the importance of wind forcing and glacial runoff in determining circulation patterns and suspended sediment transport and the photic environment (Kloser et al. 1993; 1994; Roese & Drable, 1998).

Over recent decades, the retreat of Fourcade Glacier has transformed the physical environment of Potter Cove. Enhanced freshwater discharge and sediment delivery have modified stratification patterns, turbidity, and underwater light availability, with important implications for pelagic and benthic communities (Quartino et al. 2013, Campana et al. 2018, Meredith et al., 2018; Deregibus et al., 2023). These environmental changes have been documented through a wide range of physical, biological, and ecological studies conducted in the cove (Schloss et al. 2012; Campana et al. 2018; Jerosch et al. 2019; Ruiz-Barlett et al. 2021; Neder et al. 2024; Deregibus et al. 2025). Hydrographic variability is closely linked to changes in phytoplankton biomass and suspended particulate matter concentrations, two variables that integrate the combined effects of physical forcing, biological production, sediment resuspension, and glacier-derived inputs (Schloss et al., 2012; 2014; Neder et al. 2022). Increased sedimentation reduces underwater irradiance, which can constrain the distribution and development of benthic primary producers, while also contributing to changes in zoobenthic community composition (Quartino et al. 2013; Campana et al. 2018; Sahade et al. 2015).

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Long-term observations are essential for distinguishing seasonal variability from interannual fluctuations and long-term environmental change. However, sustained coastal monitoring programs remain rare in Antarctica (Kim et al., 2018), and especially during the winter season because of the logistical challenges associated with sampling in remote polar regions. Potter Cove constitutes a notable exception. Since the early 1990s, the Instituto Antártico Argentino (Argentine Antarctic Institute), in collaboration with the Alfred Wegener Institute and other national and international partners, has maintained regular observations of hydrographic and biological variables in the cove. These efforts have generated one of the longest and most comprehensive coastal Antarctic observational records currently available (Schloss et al. 2008; 2012; 2014; Kim et al. 2018).

The present monitoring program is one of the few Antarctic coastal time series combining long-term measurements of hydrographic conditions, phytoplankton biomass, and total suspended particulate matter over more than three decades. Several studies have used subsets of these observations to investigate hydrographic variability (see list below), climate-related changes in phytoplankton dynamics (Schloss et al. 2012), particle fluxes and sedimentation processes (Schloss et al., 1999), and suspended particulate matter dynamics associated with glacier retreat (Neder et al., 2020, 2022), among others.

The present dataset compiles more than 30 years of observations of seawater temperature, salinity, chlorophyll-a and other pigment concentrations (including chlorophyll-b, chlorophyll-c, carotenoids, and phaeopigments), and total suspended particulate matter (TSPM) collected in Potter Cove. Temperature and salinity measurements characterize the hydrographic structure of the water column, chlorophyll -a provides a proxy for phytoplankton biomass, and TSPM quantifies the concentration of suspended particles resulting from biological, oceanographic, and glaciological processes. The observations were obtained using standardized protocols and quality-control procedures that have been maintained throughout the monitoring programme, ensuring the consistency and comparability of the record.

The dataset spans the period from 1991 to 2025 and comprises 915 hydrographic profiles, 6051 chlorophyll-a measurements, and 5764 TSPM determinations collected across multiple stations and seasons. Covering more than three decades of environmental change, including glacier retreat, variations in freshwater influence, and shifts in hydrographic conditions, the dataset provides an exceptional opportunity to investigate seasonal, interannual, and decadal variability in a rapidly changing Antarctic coastal ecosystem.

Beyond its value for local studies, this dataset constitutes an essential baseline for understanding ecological, biogeochemical, and oceanographic processes in Antarctic coastal environments. Long-term records of comparable duration are uncommon in Antarctica, making this dataset a valuable resource for detecting environmental change, evaluating ecosystem responses to climate forcing, supporting model development and validation, and facilitating regional and circumpolar comparisons.

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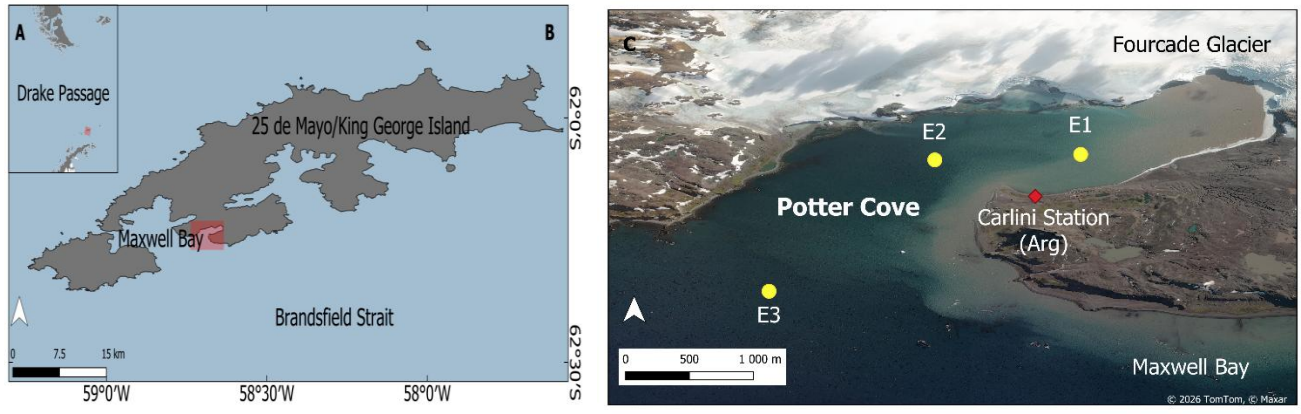


Figure 1. Study site. A) General location. B) 25 de Mayo/King George Island. C) Detailed view of Potter Cove. Map created in QGIS (3.28.6-Firenze version) using satellite images from Bing Satellite (2026). Copyright 2025 TomTom.

2 Materials and methods

2.1 Study site. Potter Cove (PC), located at the southwestern end of 25 de Mayo/King George Island (62°14′ S, 58°38′ W; South Shetland Archipelago; Fig. 1), is a small (~9 km²), wide, and relatively shallow fjord-like embayment that has been described in detail by previous studies (e.g., Klöser et al., 1993; Schloss et al., 2002, Neder 2023). Is a highly dynamic coastal environment profoundly shaped by the rapid, climate-induced retreat of the adjacent Fourcade Glacier. As the glacier increasingly becomes land-terminating, it continuously alters the fjord's geomorphology by exposing new ice-free areas and depositing underwater moraines that divide the cove into distinct inner, central, and outer bathymetric zones. A shallow transversal sill (<30 m) separates the cove into two distinct sectors: an inner cove characterized by soft, fine-grained substrates like silt and clay sediments and depths generally <50 m, and an outer cove with predominantly rocky bottoms and depths exceeding 100 m. Potter Cove opens into Maxwell Bay (Fig. 1), a 14-km-long and 6-km-wide embayment with maximum depths reaching 520 m, which in turn connects to the Bransfield Strait. Water circulation within Potter Cove is strongly influenced by the general cyclonic circulation of Maxwell Bay (Schloss et al., 2002) and seasonal fluxes of sediment-laden meltwater streams, subglacial meltwater, waterfalls, and meltwater streams (see Fig. 1 & 2 in Neder et al., 2022), which transport massive amounts of suspended particulate matter (SPM) into the marine system. This intense coastal runoff significantly modifies the local physicochemical regime, generating a pronounced environmental gradient characterized by high turbidity, lowered salinity, and decreased water temperatures near the glacier front. Furthermore, the glacial meltwater alters local biogeochemical cycles by releasing nutrients like iron and silica into the water column and sediments, ultimately creating a sharp environmental transition from a highly impacted, turbid inner fjord to more stable, open marine conditions in

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the outer cove. Hence, Potter Cove is highly sensitive to glacial retreat and meltwater-driven environmental change (Eraso and Dominguez, 2007), with different identified spatial influences (Jerosch et al., 2019; Neder et al., 2022).

2.2 Oceanographic sampling. Oceanographic sampling was conducted at three stations located in the inner, middle and outer sectors of Potter Cove, near Carlini Station (E1: 62.232° S, 58.666° W (maximum sampling depth: 40 m); E2: 62.232° S, 58.688° W (maximum sampling depth: 60 m); E3: 62.253° S, 58.71° W (maximum sampling depth: 70 m, Fig. 1). Sampling is part of a long-term monitoring program initiated in 1991, whereas sampling at Station E3 began in 2010. Weather permitting, the water column was sampled every two weeks during the austral summer and once per month during winter. Vertical profiles of temperature and conductivity were recorded using the profilers listed in Table 1, salinity was calculated from conductivity measurements. Seawater samples were collected at five depths (0, 5, 10, 20, and 30 m) using 4.7-L Niskin bottles.

2.3 CTD profiling. At each sampling event, vertical profiles of temperature and salinity were recorded using a Conductivity–Temperature–Depth (CTD) profiler. Temperature and salinity sensors were calibrated using certified reference standards manufacturer's recommendations. Profiles recorded with Sea Bird Electronics SBE 911plus were processed in SBE Data Processing using the manufacturer's recommended routines. The column order was standardized across all files, and they were compiled into CSV format.

Table 1. Sensors used to record seawater temperature and salinity data in Potter Cove during the 1991-2025 period.

Year	**Temperature**	**Salinity**
1991-1992	Inversion thermometer	Beckman RS9 induction salinometer
1993-1996	ME-ECO219 miniCTD	ME-ECO219 miniCTD
1998-2001	SBE 911*plus*	SBE 911*plus*
2006-2025	SBE 911*plus*	SBE 911*plus*

2.4 Chlorophyll-a. Seawater samples (0.25–2 L) were filtered through Millipore membrane filters during the 1991/1992 field season and through Whatman GF/F filters in all subsequent field seasons. These filters differ in nominal pore size (0.45 µm and 0.7 µm, respectively), and no correction for this methodological difference was applied to the dataset. Photosynthetic pigments were extracted in 90% acetone for 24 h at 4°C in the dark. Chlorophyll-a (Chl-a) concentrations were determined spectrophotometrically from pigment extracts using a Hitachi Perkin-Elmer UV-VIS 139 spectrophotometer from 1991 to 1999 and a Shimadzu RF-1501 spectrophotometer from 2000 to 2025. Pigment concentrations were calculated according to the SCOR-Unesco formulae as in Strickland and Parsons (1972). For samples collected from 1993 onwards, Chlorophyll-a concentrations were corrected for phaeopigment content.

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2.5 Total suspended particulate matter. Total suspended particulate matter (TSPM) concentrations were determined gravimetrically by filtering 0.25–2 L of seawater through pre-combusted, pre-weighed 25-mm Whatman GF/F filters. Following filtration, filters were rinsed twice with distilled water to remove residual salts, dried at 60°C for 24 h, and subsequently reweighed. TSPM concentrations were calculated from the difference between the initial and final filter weights.

3 Data curation, classification and nomenclature

The dataset was curated to provide a consistent long-term record of hydrographic, pigment and suspended-particle observations from Potter Cove. Original measurements were harmonized into a common tabular structure using shared event, station, depth and geographic fields, followed by variable-specific measured values and their associated quality-control metadata. Parameter names, units and quality flags were standardized to improve interoperability with oceanographic data systems and to support reuse by both domain specialists and data repositories. This curation strategy follows established best practices for documenting and managing marine chemical data and metadata to improve their readability, discoverability, interoperability and reusability (Adjou and Moncoiffé, 2023).

Variables were classified using controlled vocabularies from the NERC Vocabulary Server. Measured parameters were assigned as SeaDataNet/BODC P01 parameter codes, units were mapped to P06 unit codes.

4 Quality flagging approach

Quality control was applied at the measurement level followed the SeaDataNet L20 measurand qualifier flag scheme. Each measured value is associated with a SeaDataNet quality flag indicating whether the value is good, probably good, probably bad, bad, below detection, or missing. The quality-control process included checks for missing values, physically impossible negative values, values below analytical detection limits, and parameter-specific consistency rules. The flags are intended to qualify individual measurements and should not be interpreted as excluding entire sampling events. This approach provides persistent, machine-readable identifiers for the main variables while retaining human-readable labels in the dataset and manuscript.

The following SeaDataNet L20 flags are used to document the measurement-level quality status in the curated dataset (Table 2).

Table 2. SeaDataNet L20 quality flags used for measurement-level quality control. The same coding has been used for SPM and SPIM data.

SeaDataNet flag	Interpretation	Use in this dataset
1	Good value	Measurement passed the applicable checks and is suitable for normal use.
2	Probably good value	Measurement is plausible, but one required contextual or cross-variable check could not be completed.

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3	Probably bad value	Measurement is suspicious because it failed a consistency or range check, but is retained for traceability.
4	Bad value	Measurement is invalid according to a physical or analytical rule, such as a negative concentration where this is not possible.
6	Value below detection	Reported value is at or below the adopted detection threshold.
9	Missing value	No reported value is available for the measurement.

For pigment observations, chlorophyll-a concentrations at or below 0.05 µg l^{-1} are treated as below the detection limit. For suspended particulate matter variables, concentrations at or below 0.1 mg l^{-1} are treated as below the detection limit. These thresholds were used solely for the quality-flagging interpretation and did not alter the reported measured values.

Suspended particulate matter was checked using both single-variable and paired-variable rules. Total suspended particulate matter (SPM) and inorganic suspended particulate matter (SPIM) are non-negative concentration variables; therefore, negative values were flagged as bad values. Values at or below 0.1 mg l^{-1} were flagged as below detection (e.g., below the detection limit). In addition, because SPIM represents the inorganic fraction of total suspended particulate matter, SPIM should not exceed SPM under normal mass-balance constraints. Cases where SPIM exceeded SPM were therefore flagged as probably bad values, unless one of the variables was already missing or invalid.

Very high suspended-matter concentrations were retained in the dataset but flagged as probably bad values when they exceeded 3000 mg l^{-1}. This rule documents likely outliers while preserving the original reported values for transparent review. A controlled reason term was recorded for each SPM/SPIM pair so that each SPM and SPIM status was explicitly documented in the quality-control explanation (Table 3). Table 3 links the main variables described in the paper to controlled vocabulary concepts. These links provide stable semantic identifiers for measured parameters and units while keeping manuscript terminology readable.

Finally, Artificial intelligence (AI) tools were used exclusively for language editing and improving the clarity and readability of the manuscript. No AI tools were used for data generation, data analysis, interpretation of results, or the development of scientific conclusions. The authors take full responsibility for the content and accuracy of the manuscript.

Table 3. Controlled-vocabulary mapping of measured variables and units.

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Variable in the paper	Dataset label	Unit	P01 concept link	P06 unit link	Controlled-vocabulary meaning
Seawater temperature	Temperature	deg C	https://vocab.nerc.ac.uk/collection/P01/current/TEMPS901/	https://vocab.nerc.ac.uk/collection/P06/current/UPAA/	Temperature (ITS-90) of the water body by CTD or STD
Conductivity	Conductivity	S m^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/CNDCST01/	https://vocab.nerc.ac.uk/collection/P06/current/UECA/	Electrical conductivity of the water body by CTD
Practical salinity	Practical salinity	PSU	https://vocab.nerc.ac.uk/collection/P01/current/PSALTC01/	https://vocab.nerc.ac.uk/collection/P06/current/PSUX/	Practical salinity of the water body
Chlorophyll-a	Chl-a	µg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/CHLTVOLU/	https://vocab.nerc.ac.uk/collection/P06/current/UGPL/	Concentration of chlorophyll-a per unit volume of the water body
Chlorophyll-b	Chl-b	µg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/CHLBXXPX/	https://vocab.nerc.ac.uk/collection/P06/current/UGPL/	Concentration of chlorophyll-b per unit volume of the water body
Chlorophyll-c	Chl-c	µg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/CHLCXXPX/	https://vocab.nerc.ac.uk/collection/P06/current/UGPL/	Concentration of chlorophyll-c per unit volume of the water body
Carotenoid pigments	Carotenoids	µg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/SCARSSPM/	https://vocab.nerc.ac.uk/collection/P06/current/UGPL/	Concentration of carotenoid pigments per unit volume of the water body
Phaeopigments	Phaeopigments	µg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/PHAEGFSP/	https://vocab.nerc.ac.uk/collection/P06/current/UGPL/	Concentration of phaeopigments per unit volume of the water body

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Total suspended particulate matter	SPM	mg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/TSEDGVP1/	https://vocab.nerc.ac.uk/collection/P06/current/UMGL/	Concentration of suspended particulate material per unit volume of the water body by filtration, drying and gravimetry
Inorganic suspended particulate matter	SPIM	mg l^{-1}	https://vocab.nerc.ac.uk/collection/P01/current/ISEDGVP1/	https://vocab.nerc.ac.uk/collection/P06/current/UMGL/	Concentration of inorganic suspended particulate material per unit volume of the water body by filtration, combustion and gravimetry
Measurement-level quality flag	Quality flag	dimensionless	https://vocab.nerc.ac.uk/collection/L20/current/	https://vocab.nerc.ac.uk/collection/L20/current/	SeaDataNet measurand qualifier flags

5. Data availability

All data are presently, and only for review purposes available at https://zenodo.org/records/23567820?preview=1&token=eyJhbGciOiJIUzUxMiJ9.eyJpZCI6IjQ1ZmVkNzFkLWZhYWMtNGMyMS1iNGI4LTE0YmNiNGUxYWMxMCIsImRhdGEiOnt9LCJyYW5kb20iOiJlNjQxNjBhODIzZGViMzg0YTU4MmU3MWMyMTk5MWY1NyJ9.k4RYWSDHzJMpWH4o6CCP80Bj9OXE9ljpJNg2IhEavo15eIQeihQbWsaMGU64el03iwkFFc5IAMo6wDP8rsrxWA. The final link, which is embargoed so far, will be: https://zenodo.org/records/23567820. (Schloss et al. 2026).

6. Data set overview and research outputs

Figures 2 and 3 show the temporal coverage of CTD, pigment and suspended particulate matter observations at stations E1, E2 and E3 in Potter Cove from the early 1990s to 2025. Sampling was longest at stations E1 and E2, whereas station E3 started later and became consistently represented after 2010. The plot highlights the complementary timing of hydrographic profiles, pigment measurements and suspended-particle observations across the long-term monitoring programme.

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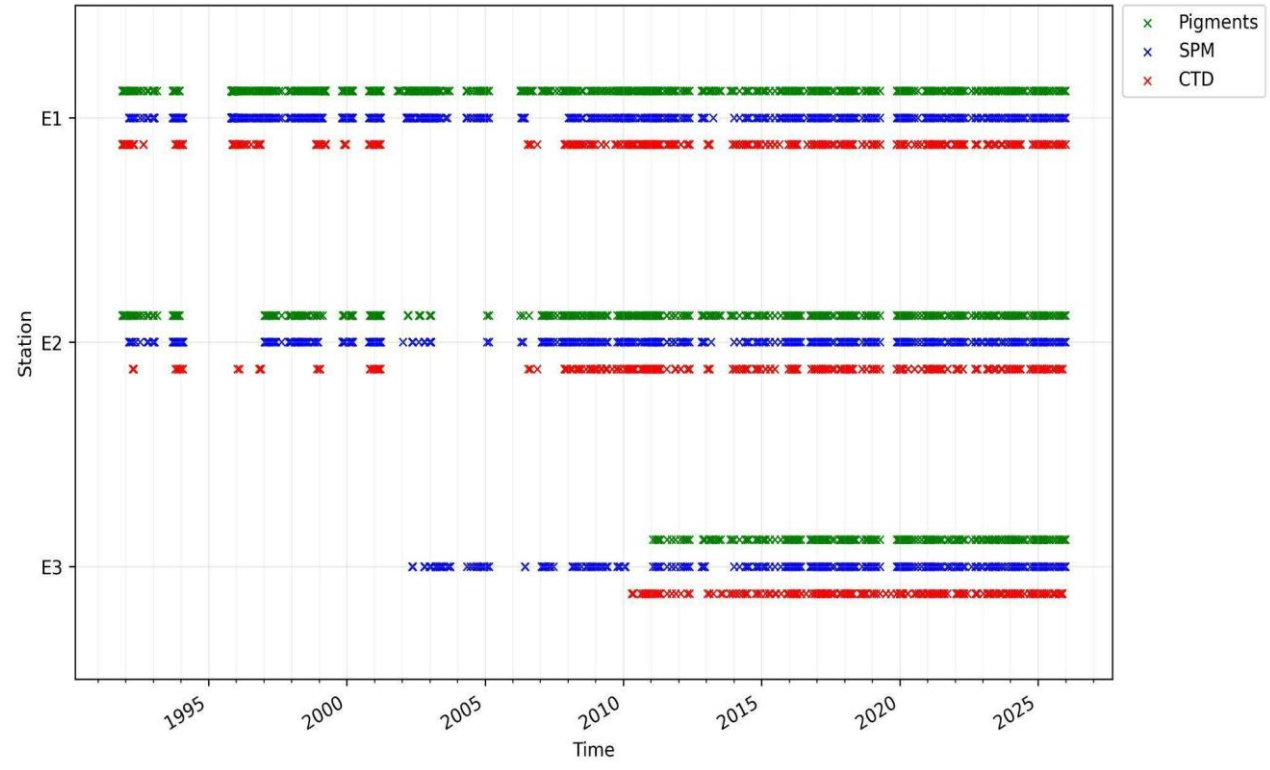
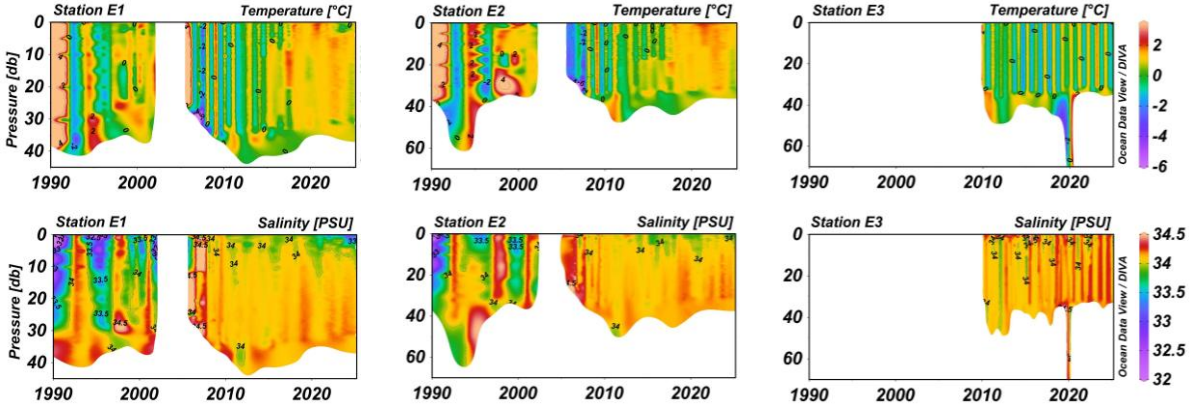


Figure 2. Time series coverage of hydrographic, pigment and suspended-particle observations in Potter Cove



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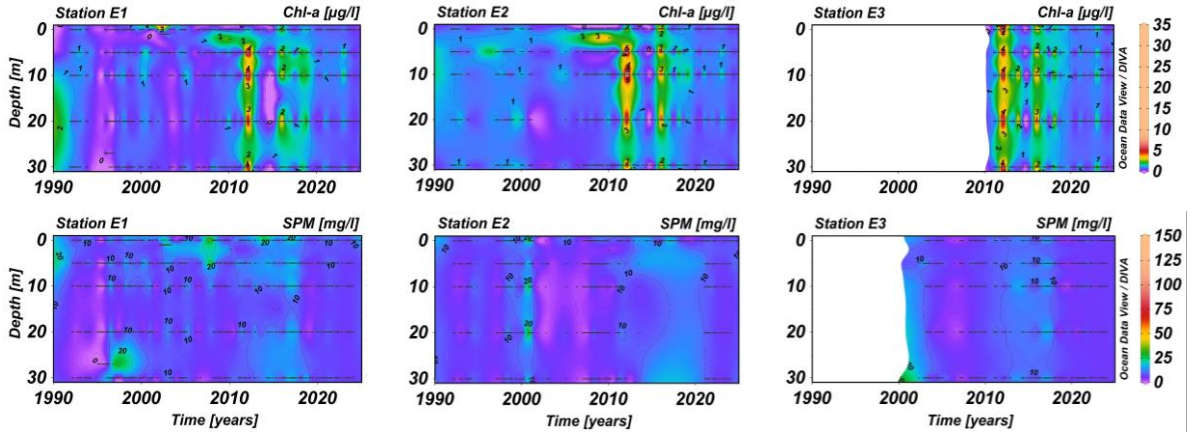


Figure 3. Temperature, salinity, chlorophyll-a and suspended particulate matter in stations E1, E2 and E2 in Potter Cove from 1991 to 2025.

The data presented here were in part used for several publications over the years, among which:

Alurralde, R. Gastón (2018); Enlace bento-pelágico en un ecosistema costero antártico afectado por el deshielo: Una aproximación ecológica. Universidad Nacional de Córdoba. http://hdl.handle.net/11336/110347

Antoni, J.S., Almandoz, G.O., Goldsmit, J., Garcia, M.D., Flores-Melo, X., Hernando, M.P., Schloss, I.R. (2024) Long-term studies on West Antarctic Peninsula phytoplankton blooms suggest range shifts between temperate and polar species. Global Change Biology, 30, https://doi.org/10.1111/gcb.17238

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Braeckman, Ulrike, Karline Soetaert, Francesca Pasotti, Maria Liliana Quartino, Ann Vanreusel, Leonardo A. Saravia, Irene R. Schloss, and Dick van Oevelen. (2024). Glacial Melt Impacts Carbon Flows in an Antarctic Benthic Food Web. Frontiers in Marine Science 11. https://doi.org/10.3389/fmars.2024.1359597.

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IRS contributed to conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, visualization, and writing of the original draft. MLQ contributed to conceptualization, funding acquisition, investigation, project administration, resources, and supervision. GAF contributed to conceptualization, funding acquisition, investigation, methodology, resources, supervision, and validation. LMS contributed to data curation, formal analysis, visualization, and writing of the original draft. FB contributed to formal analysis, funding acquisition, investigation, methodology, project administration, and resources. KJ contributed to conceptualization, funding acquisition, investigation, methodology, and resources. OG contributed to data curation, methodology, and validation. AU contributed to data curation and methodology. ERB and CN contributed to data curation. GT contributed to data curation and formal analysis. GC and DG contributed to formal analysis. MA contributed to data curation, visualization, and writing of the original draft. All authors contributed to writing through review and editing.

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Competing interests

The authors declare that they have no conflict of interest.

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The review statement will be added by Copernicus Publications listing the handling editor as well as all contributing referees according to their status anonymous or identified.

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