# IODP Proposal Cover Sheet

Weddell Sea History

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| Title | Late Neogene ice-sheet and sea-level history of the Weddell Sea, Antarctica | | |
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| Keywords | ice-sheet dynamics<br>sea-level history | Area | Weddell Sea |

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## Abstract


Drilling Late Neogene sites from the Weddell Sea will address critical questions of EAIS and WAIS stability. As the southern extension of the Atlantic Ocean, the Weddell Sea is a key area to study Earth's past climate variability. It constitutes a major source of Antarctic Bottom Water formation, which influences the Atlantic Meridional Overturning Circulation. Moreover, the Weddell Gyre is an important cyclonic circulation system for water-mass communication between the Antarctic Ice Sheet and the Southern Ocean. One of the world's two largest ice shelves, the Filchner-Rønne Ice Shelf, drains into the Weddell Basin. Ice-sheet dynamics in the Weddell Sea sector of the EAIS are highly susceptible to far-field changes in sea level. Practically all icebergs from the EAIS merge in the Weddell Sea before they exit Antarctica through the Scotia Sea, thereby providing a unique location to study AIS dynamics. Despite these paramount scientific issues that have, over the last two decades, identified the Weddell Sea as a key area to study past and present climate change, there has been no deep scientific drilling for high-resolution reconstruction of the Plio-Pleistocene.

Our scientific objectives –relating to the IODP Science Plan 2013-2023 Challenge 1 (elevated $CO_2$) and Challenge 2 (ice-sheets and sea level) –hence aim at achieving the first complete Late Neogene reconstruction for the Weddell Sea. We will address the overarching questions mentioned above on changing ice-sheet dynamics, interhemispheric phasing of ice-sheet and climate events, ocean circulation, and bottom-water production. Specifically, we wish to address the following questions: Was the formation of the contourite ridges north of Crary Fan associated with a sea-level drop initiated through intensification of Northern Hemisphere glaciation during the Pliocene? Did the drainage pattern change during the Mid-Pleistocene Transition? Can we decipher ice-sheet dynamics on glacial-to-interglacial time scales and during the Last Glacial Maximum? Can we detect far-field sea-level effects and rates of sea-level rise from Iceberg Alley? Can we relate varve thickness variations to external (solar) or internal (ocean-atmosphere) variability on decadal-to-centennial time scales? We propose to drill three contourite drifts northeast of Riiser-Larson Ice Shelf that contain high-resolution sections necessary to reconstruct, for the first time, EAIS dynamics through Plio-Pleistocene times. One test site should obtain a complete Cenozoic record from Polarstern Plateau. Alternate sites cover the ridges and one high-resolution Plio-Pleistocene site in the Scotia Sea. Sediment cores and high-resolution seismic data are available for all sites.

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## Scientific Objectives

Our scientific objectives focus on Plio-Pleistocene reconstruction of AIS dynamics, sea-level changes, and ocean circulation in the Weddell Sea. Specifically, we aim to address the following questions:
- Can we test the interhemispheric ice-sheet synchronicity hypothesis for stadial-to-interstadial changes and previous deglaciations and can we determine the response to far-field sea-level changes?
- What is the glacial-to-interglacial record of EAIS dynamics?
- What do provenance studies tell us about changing source signatures of glacially-derived material, and can we infer phases of AIS instability?
- How is the change in orbital forcing recorded in the Weddell Sea sector that accompanied the Mid-Pleistocene Transition?
- Are decadal-scale glacial AIS dynamics caused by solar forcing, atmosphere-ocean interactions, or a combination of both?
- What information can we obtain on sea-ice coverage, biogenic productivity, and sea surface temperatures during the Mid-Pliocene warm period prior to NH glaciation?
- Is the formation of the contourite ridges north of Crary Fan a result of sea-level drop related to the intensification of NH glaciation during the Pliocene?
- Can we detect a Filcher-Rønne Ice Shelf collapse during warmer-than-today interglacials (MIS 5, 11, 31)?
- Can we obtain a signal of AIS mass loss from Iceberg Alley for previous deglaciations and how well can we constrain atmospheric dust transport in the Scotia Sea for the last 800,000 years?
- Can we achieve a complete Cenozoic record in a short test drilling on Polarstern Plateau?

## Non-standard measurements technology needed to achieve the proposed scientific objectives.

## Proposed Sites

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---|---|---|---|---|---|---|
| | | | Sed | Bsm | Total | |
| WS-01 | -74.15, -27.1833 | 2411 | 400 | 2000 | 2400 | This primary site is planned to drill into the southern levee ridge on the continental slope northeast of Crary Fan. It should provide the most complete high-resolution Plio-Pleistocene record deposited closest to the continental shelf, and indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet. |
| WS-02 | -74.05, -27.4167 | 2487 | 500 | 2000 | 2500 | This primary site is planned to drill into the middle levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Plio-Pleistocene records in an intermediate distance to the shelf edge, indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet. |
| WS-12 | -74.1833, -27.5700 | 2450 | 500 | 2000 | 2500 | This is an alternate site for site WS-02 (middle levee ridge) on the continental slope northeast of Crary Fan. It should |

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| - | - | - | - | - | - | provide high-resolution Plio-Pleistocene records in an intermediate distance to the shelf edge, indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet. |
| WS-03 | -73.6667, -26.9 | 3139 | 1500 | 2000 | 3500 | This primary site is planned to drill into the northern levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Mio-Pliocene records in a more distal position to the shelf edge, indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet during times of higher CO2 contents. |
| WS-11 | -73.9222, -26.5372 | 2894 | 400 | 2000 | 2400 | This alternate site is planned to drill into the southern levee ridge on the continental slope northeast of Crary Fan. It should provide the most complete high-resolution Plio-Pleistocene record deposited closest to the continental shelf at the confluence of all three ridges. The site should be indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet. |
| WS-04 | -71.43333, -24.71667 | 3456 | 200 | 2000 | 2200 | This primary site is planned to drill into the central part of Polarstern Plateau. It should provide complete information on the Cenozoic paleoceanographic and glacial history of the Weddell Sea in a distal, low-sedimention area that should be undisturbed. |
| WS-14 | -68.7333, -5.7333 | 2426 | 200 | 2000 | 2200 | This alternate site is planned to drill into Bungenstock Plateau to unravel the long-term evolution from the Eocene greenhouse paleoclimate to the present icehouse world as documented for the Weddell Sea |
| WS-13 | -73.2833, -26.2000 | 3139 | 1500 | 2000 | 3500 | This is an alternate site to site WS-03 for the northern levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Mio-Pliocene records in a more distal position to the shelf edge, indicative for ice-sheet and sea-level dynamics in the Weddell Sea part of the East Antarctic Ice Sheet during times of higher CO2 contents. |
| SCO-01 | -57.4333, -43.4500 | 3103 | 1000 | 2000 | 3000 | This alternate site should be drilled if the primary Weddell Sea sites are inaccessible. Site is on transit route from South America and provides ultra-high resolution record of oceanic and atmospheric circulation in the Southern Ocean (Weber et al., 2012). Located in the center of Iceberg Alley, where virtually all Antarctic icebergs route through, it contains the first high-resolution record of AIS ice mass loss (Weber et al., Nature, in review) during the last deglaciation and is therefore crucial to understand AIS dynamics and its relation to sea-level fluctuations. |

# Late Neogene ice-sheet and sea-level history of the Weddell Sea, Antarctica

## Short title: Weddell Sea


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**Preliminary list of cooperating modelers/scientists**

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