IODP Proposal Cover Sheet

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Campeche Bank Sediment Drifts

Received for:

Title	In the Loop: western boundary current onset and evolution in the southeastern Gulf of Mexico		
Proponents	Christopher Lowery, Ligia Pérez Cruz, James Gibson, James Austin, Gregor Eberli, Elva Escobar, José Isola, Jessica Labonté, Lélia Matos, Bryce Mitsunaga, Uisdean Nicholson, Guillermo Pérez-Drago, Julio Sheinbaum Prado, Kaustubh Thirumalai, Jordan Todes, Jaime Urrutia Fucugauchi, Amy Weislogel, James Wright, Hong Yang, Stacy Yeager, Jorge Zavala, Patricia Standring		
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Proponent Information

Proponent	Christopher Lowery
Affiliation	University of Texas Institute for Geophysics
Country	United States

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Abstract

The North Atlantic western boundary current system is a key part of the Atlantic Meridional Overturning Circulation (AMOC), and an important control on regional climate and sea level in eastern North America and western Europe. Re-analysis of current flow data has shown that the Gulf Stream, the best-known component of the North Atlantic western boundary current, is slowing down, while recent modelling work indicates that AMOC, which has been weakening for decades, is headed for a tipping point. Modern observations of these systems represent a small fraction of their potential variability, over a small fraction of the time in which this variability may play out. Reconstructing the history of the western boundary current during past climate events will provide key context for modern changes observed in this system, and can provide the proxy data of past changes necessary to parameterize and test models of future change.

The Loop Current is the main feeder current for the Gulf Stream and a key component of the western boundary current system. As it flows into the Gulf of Mexico, the Loop Current impinges on the seafloor on the eastern Campeche Bank, leaving a record of its passing in the form of contourite drifts. These drift deposits are sedimentary archives of western boundary current flow which record the inception and evolution of the Loop Current, and can provide an important way to reconstruct western boundary current flow throughout the Cenozoic and how that current changed in response to events on a range of timescales, from millennial-scale events like deglacial transitions to long-termer term climate events across the late Cenozoic, and to tectonic gateway changes like the closure of the Central American Seaway. Understanding the response of the Loop Current to these events can help us better understand the overall evolution of the North Atlantic western boundary current.

We propose an expedition utilizing a standard geotechnical vessel to drill the pelagic carbonates of the eastern Campeche Bank sediment drifts to 1) date key reflectors and tie shifts in depositional regime to the climatic and tectonic history of the Cenozoic, 2) utilize a suite of proxy tools to reconstruct changes in current flow in response to those climatic and tectonic events and 3) reconstruct ecosystem changes in response to changing current properties. This work addresses the Flagship Objective “Ground Truthing Future Climate Change” and a number of related Strategic Objectives.

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Scientific Objectives

The primary objective of drilling on the Campeche Bank is to reconstruct the history of the western boundary current flow through the Gulf of Mexico through time, and then tie that history to key climatic, tectonic, and ecological transitions to understand the drivers and impact of changing western boundary current flow. To achieve this objective we aim to test the following hypotheses:

Hypothesis 1: *Sediment drifts on the Eastern Campeche Bank record the history of Loop Current Flow into the Gulf of Mexico.*

Hypothesis 2: *Climate is a key driver of Loop Current flow, and changes in sedimentary proxies for current flow correspond with late Cenozoic climate events.*

Hypothesis 3: *Unconformities in Campeche Bank drift deposits correspond temporally with unconformities in deep water sediment drifts in the North Atlantic, indicating a relationship between western boundary current flow and AMOC strength.*

Hypothesis 4: *The evolution of Loop Current flow is linked with changes in upwelling dynamics, nutrient cycling, and particulate organic carbon flux that altered local marine ecosystems.*

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

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Science Communications Plain Language Summary

Using simple terms, describe in 500 words or less your proposed research and its broader impacts in a way that can be understood by a general audience.

Ocean currents help distribute heat across the world, and so they play in important role in global and regional climate. In the North Atlantic, warm salty water is transported from the tropics to the polar region by the western boundary current. The best known part of this current is the famous Gulf Stream, which flows from the Florida Straits up along the Atlantic coast of the United States. Recent observations have shown that the Gulf Stream (and by extension, the entire western boundary current system) is weakening due to global warming. While such instrumental observations are a critical way to understand the behavior of current systems, they are limited to the scope of change in the recent past, which likely doesn't represent the full range of changes that can occur. To understand that, we need to reconstruct the history of currents on geologic time scales. Doing so allows us to see how currents behaved under past warm states similar to what is projected to occur under current emissions, and it also allows us to see whether currents respond linearly to change or whether they exhibit threshold behavior. That is, whether a slow accumulation of change eventually causes the current to dramatically shift into a new state.

A good place to study the history of the North Atlantic western boundary current is in the Gulf of Mexico, where the Loop Current flows in from the Caribbean and then out through the Florida Straits, where it joins with several smaller currents to become the Gulf Stream. The Loop Current is also important for Gulf of Mexico climate, as it sometimes spins off warm eddies which drift west, disrupting fisheries and providing a warm water fuel source for hurricanes (notably including hurricanes Katrina and Harvey). It is still unknown whether eddy shedding will become more or less frequent in the future, although this is broadly tied to the strength of the current. As it flows across the seafloor east of the Yucatán Peninsula, the Loop Current pushes sediments around, forming big deposits called contourite drifts. These drifts represent sedimentary archives of the history of the Loop Current. We propose to drill those drifts to reconstruct that history, in order to improve our understanding of how the modern current is changing.

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

This is a revised version of 1015-Full, which was reviewed by SEP in January 2024. SEP made a number of helpful suggestions and encouraged us to resubmit a Full2. However, the following SEP meeting (June 2024) was the final SEP meeting. The next step after a Full2 is for SEP to send it out for external review, and evaluate those reviews in the following meeting, and then make a decision. Since the June 2024 meeting was the last SEP meeting (and thus SEP would not exist to receive any reviews of our proposal after that), we did not submit a revised proposal at this time. Now that IODP3 is accepting proposals, and NSF is establishing a Scientific Ocean Drilling Coordinating Office (SODCO) to review drilling proposal, we feel the time is right to move forward with our revised proposal. We are submitting this to IODP3, and will submit it to NSF when the SODCO is established, with the goal of co-funding this drilling.

Our response to SEP reviews is laid out in detail in a separate document. Briefly, we substantially revised the hypotheses, and thus much of the text of the proposal, to make the focus more concretely the development of the Loop Current, and then building out from there to try to understand western boundary current history more broadly. We rewrote the hypotheses to be more streamlined and less convoluted. We also revised the coring plan to only triple core at the site at which we intend to collect the longest record of Loop Current flow (and thus where a complete composite record will be most impactful), and have revised the other sites to double or single coring. We also corrected a number of minor errors and suggestions that SEP provided. The resulting proposal is much stronger.

1015-Full proposal built off 917-PRE "Revisiting the Mesozoic to Pleistocene in the Southeastern Gulf of Mexico: Plate Tectonics, Ocean Circulation, and Climatic Evolution." SEP highlighted indicated excitement for several aspects of this proposal and recommended submission of a full proposal that addressed the points raised in the review, which were addressed in 1015-Full. Since the site survey conducted after 917-PRE shifted the focus of this proposal from the deep waters north of Cuba to the eastern Campeche Bank, and since none of the sites for this Full proposal were the same as from 917-PRE, SEP renamed our proposal 1015-Full.

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Proposed Sites (Total proposed sites: 7; pri: 6; alt: 1; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CB-01A (Primary)	24.18678 -87.32817	751	385	0	410	Site CB-01A is situated at a thick, continuous succession of contourite drift deposits which will provide an expanded sedimentary archive of the Loop Current through time (Hypothesis 1b-d), and the biotic response to those changes (Hypothesis 2a-b). The onset of drift deposits here is marked by horizon H4; The TD is planned to be 40 m in the underlying predrift sequence to determine the duration of this unconformity (Hypothesis 1a). An internal drift horizon, H5, appears conformable in this location, and drilling here will provide an age for this shift in drift deposition (Hypothesis 1a).
CB-02A (Primary)	22.96684 -86.59342	648	410	0	390	Site CB-02A is the proximal site of a stratigraphic transect along seismic line 1006. This site is chosen because both sequence boundaries H5 and H4 are conformable and thus will record the age of the onset of the drift (H4) and the major reorganization of the current that occurs at the time of the formation of sequence boundary H5 (Hypothesis 1a). In addition, the upper drift sequence above H5 is expanded here and potentially contains a record of current changes related to glacial-interglacial cycles (Hypothesis 1b).
CB-03A (Primary)	23.02050 -86.42609	969	410	5	455	CB-03A forms the middle of our depth transect. The drift here are thin, but separated by conformable sequence boundaries, allowing dating to reconfirm the onset and reorganization of the current deposits (Hypothesis 1a). These drifts overlay a relatively thin pre-drift sequence. Thus, this site is designed to reconstruct early Cenozoic and Late Cretaceous current flow across the Campeche Bank, prior to the development of drift deposits (Hypothesis 1b). This site will also contain a Cretaceous/Paleogene boundary sequence. TD is planned in the underlying platform carbonates, to reconstruct the transition from platform carbonate to pelagic sedimentation (Hypothesis 1a).
CB-04A (Primary)	22.45198 -86.09336	1127	450	0	375	CB-04A is the deepest primary site, located on seismic line 1004 at the far southeast of the survey (Figure 10). This site targets a thick sequence of MSB3 drift deposits in the Yucatan Channel that likely record an earlier phase of deepwater circulation, prior to the onset of modern-day Loop Current activity (Hypothesis 1a-d). TD is planned in the Upper Cretaceous interval, just below the ~75 m thick K-Pg boundary deposit.
CB-05A (Primary)	23.89116 -87.19259	585	250	0	250	CB-05A is located at the intersection of seismic lines 1003 and 1009 at the northern end of the survey. This site has been selected to drill a shallow section (50 m penetration) through CWCs that are developed in this area of the Campeche Bank (Hypothesis 2b). CWCs on the Campeche Bank are directly related to current strength, which shifts with changing sea level between glacial and interglacial times (Hypothesis 1b). In the event we carry out Operational Plan C, we will extend CB-05A to Horizon H3, to provide age constraints on the key bounding unconformities of the contourite sequence.
CB-06A (Primary)	22.2970 -86.3331	690	430	0	450	CB-06A is located on seismic line 1004, updip from CB-04A. It represents a relatively condensed record of the entire pelagic section (MSB and MSC), including a flat-lying K/Pg boundary deposit and underlying Late Cretaceous chalk. Horizons H4 and H5 appear to be conformable here, allowing us to date them. Importantly, it is well to the south of our other sites targeting the sediment drifts, and so will provide evidence of changes in current velocity and upwelling/nutrient flux along the axis of the eastern Campeche Bank.
CB-07A (Alternate)	22.27419 -86.40650	432	560	0	560	CB-07 is an alternative site at which to recover the entire sequence of stratigraphic units on the Campeche Bank