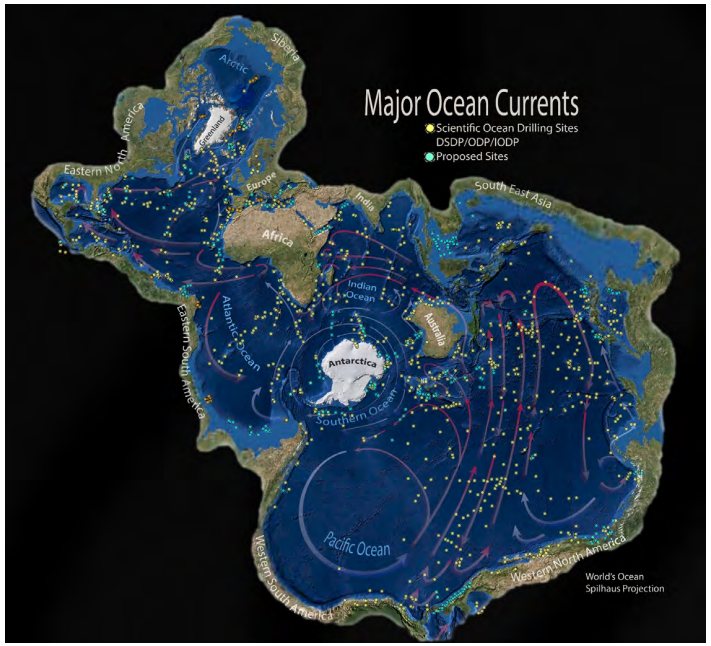
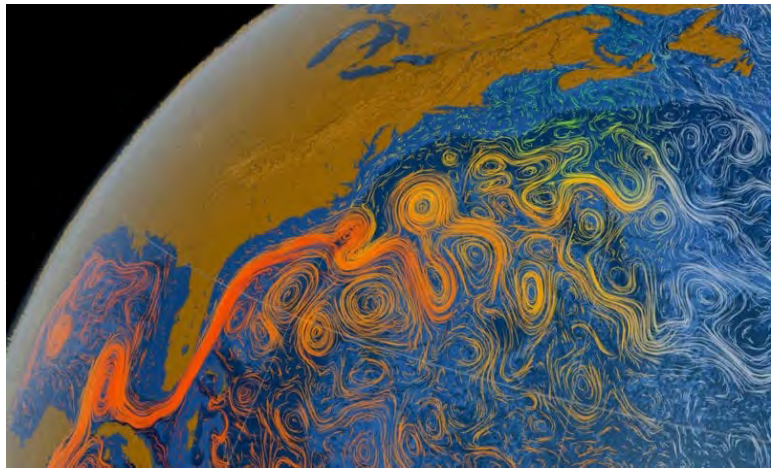
SCIENTIFIC OCEAN DRILLING

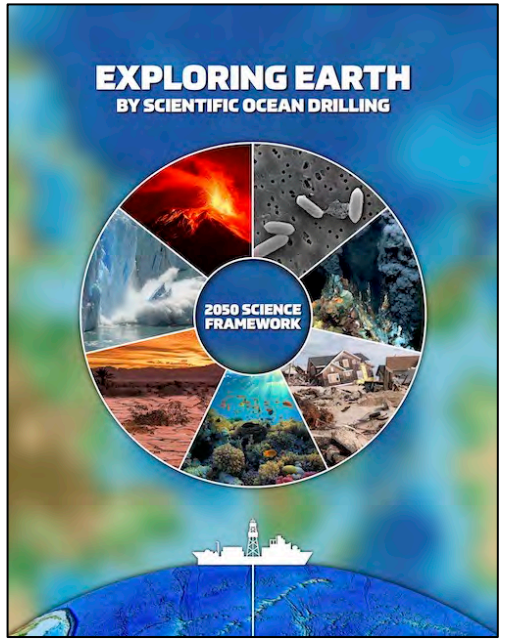
U.S. SCIENCE SUPPORT PROGRAM

FOCUS Virtual Workshop

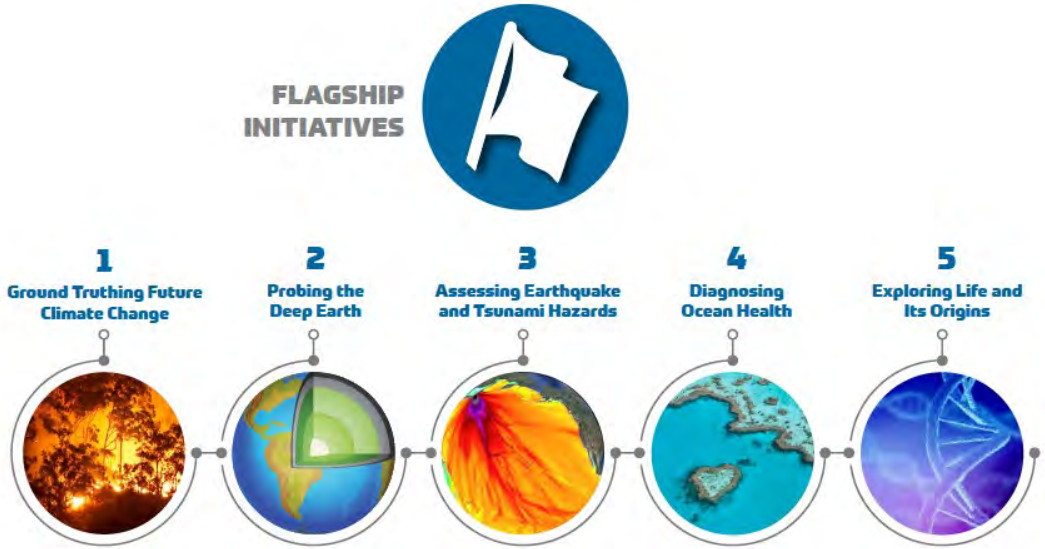
Science Questions and Goals for the Next 5 Years







2050 Science Framework



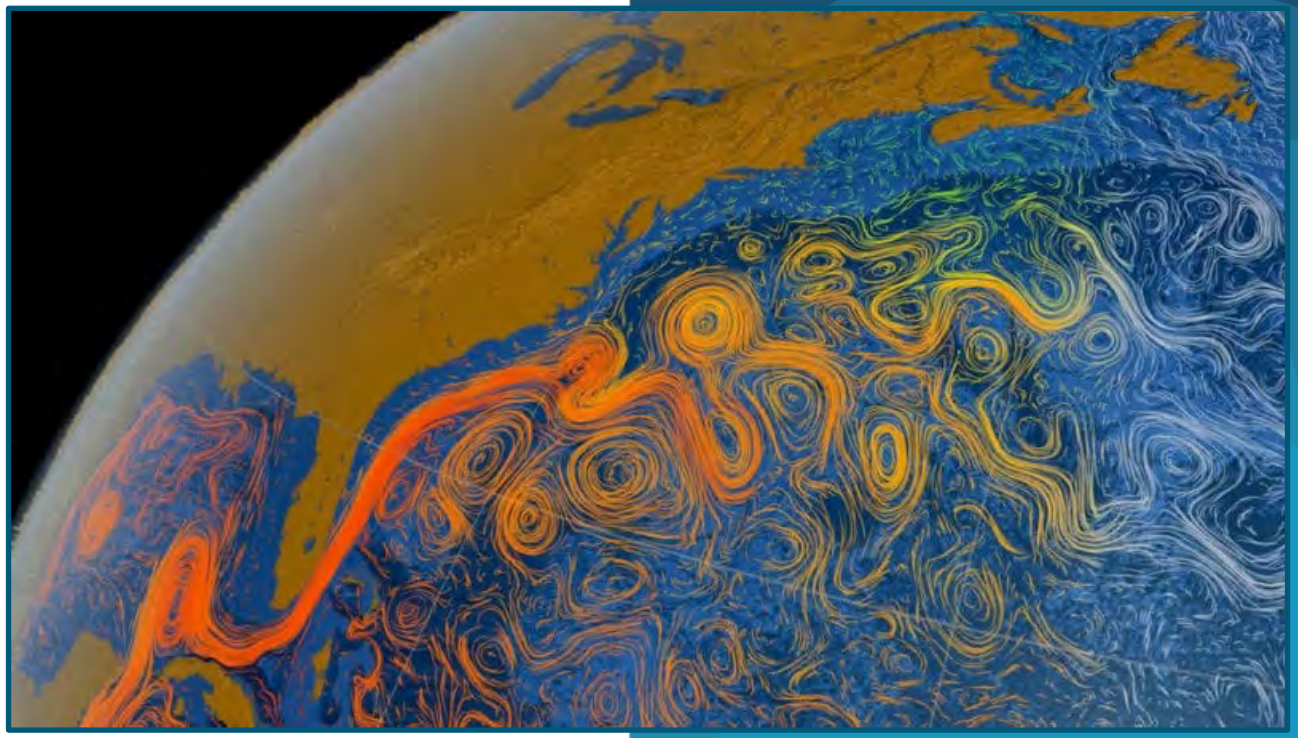
- 2050 Science Framework outlined broad **Strategic Objectives** and **Flagship Initiatives**
- Goal today is to identify Key Science Questions for the **next 5 years**

Koppers, A.A.P., and R. Coggon, eds. 2020. Exploring Earth by Scientific Ocean Drilling: 2050 Science Framework. 124 pp., https://doi.org/10.6075/J0W66J9H.

Science Questions and Goals: Next 5 Years

Example: *A key science priority for US Scientific Ocean Drilling will be reconstructing the history of the* ***Gulf Stream System and AMOC*** *more broadly, with an* ***emphasis on analog warm periods and developing proxy records*** *that can be used to parameterize models.*

Recent time series re-analysis has shown that the Gulf Stream is weakening, while new model results suggest that AMOC as a whole is "on a course to a tipping point". The Gulf Stream system plays an important role in east coast sea level, fisheries, and weather, and is important more broadly in North American and European climate. AMOC, of which the Gulf Stream system is a key part, plays a fundamental role in the global climate system. Understanding how these currents changed in response to past warm periods can provide an essential foundation to efforts to predict how they will respond to ongoing warming and, crucially, help identify Tipping Points in the system.



Science Questions and Goals: Next 5 Years

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Geophysical Research Letters

Research Letter | Open Access

Robust Weakening of the Gulf Stream During the Past Four Decades Observed in the Florida Straits

Christopher G. Piecuch, Lisa M. Beal

First published: 25 September 2023 | https://doi.org/10.1029/2023GL105170 | Citations: 1


Science Advances

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RESEARCH ARTICLE OCEANOGRAPHY

Physics-based early warning signal shows that AMOC is on tipping course

RENÉ M. VAN WESTEN, MICHAEL KLIPHUIS, AND HENK A. DIJKSTRA Authors Info & Affiliations

SCIENCE ADVANCES · 9 Feb 2024 · Vol 10, Issue 6 · DOI: 10.1126/sciadv.adk1189

Science Questions and Goals: Next 5 Years

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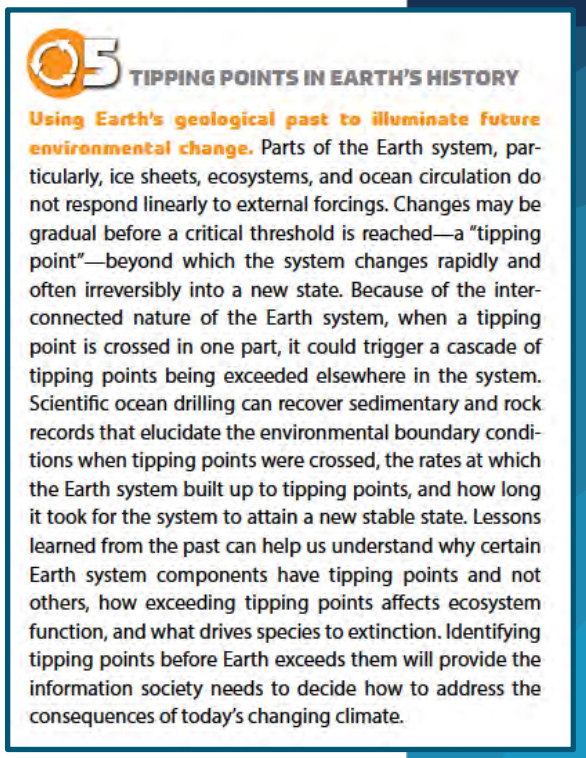


Q5 TIPPING POINTS IN EARTH'S HISTORY

Using Earth's geological past to illuminate future environmental change. Parts of the Earth system, particularly, ice sheets, ecosystems, and ocean circulation do not respond linearly to external forcings. Changes may be gradual before a critical threshold is reached—a "tipping point"—beyond which the system changes rapidly and often irreversibly into a new state. Because of the interconnected nature of the Earth system, when a tipping point is crossed in one part, it could trigger a cascade of tipping points being exceeded elsewhere in the system. Scientific ocean drilling can recover sedimentary and rock records that elucidate the environmental boundary conditions when tipping points were crossed, the rates at which the Earth system built up to tipping points, and how long it took for the system to attain a new stable state. Lessons learned from the past can help us understand why certain Earth system components have tipping points and not others, how exceeding tipping points affects ecosystem function, and what drives species to extinction. Identifying tipping points before Earth exceeds them will provide the information society needs to decide how to address the consequences of today's changing climate.

Connect Science Questions to 2050 Science Framework

Koppers and Coggon, eds. (2020)

Other Examples: Australian and New Zealand IODP Consortium (ANZIC)

Australian National University

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

AuScope | NCRIS

Dr SARAH KACHOVICH
IODP Manager for Australia and New Zealand

Dr Ron Hackney
Director, Australian and New Zealand IODP Consortium
ron.hackney@anu.edu.au

Kachovich et al., 2023, PP24A-05 Future DEEP: Future Drilling to Explore Earth's Past Workshop Report, AGU Fall Meeting, San Francisco, CA.

Science priorities arising from the Future DEEP Workshop

Ground-truthing future climate change, utilising the sedimentary records that preserve past climate records is urgently needed to quantify and reduce uncertainties in future climate and sea level projections and improve understanding of key physical processes.

Progressing understanding of **geohazards**, in particular hazards associated with **subduction zone earthquakes**. Our nations are currently developing pools of seafloor instruments to improve environmental and natural hazard monitoring

Increase the research focus on the **coastal zone**, the poorly-understood **land-to-sea transition** that hosts significant ecosystems, fresh groundwater in sub-seafloor aquifers of unknown extent and is the source of unquantified risks to coastal communities and critical infrastructure.

Advancing **geomicrobiology** as a discipline with significant societal relevance and the potential for generating paradigm shifts in understanding the **habitability of life on Earth** and the **utility of living organisms** in tracking Earth processes and planetary evolution.

Increase ANZIC's engagement with and support for multi-program efforts in **Antarctica and the Southern Ocean**.

Co-ordinate the Australian research community and generate ideas in readiness for **Australian ICDP membership**.

Implementing Legacy Assets Projects (LEAPs) to add value to existing scientific ocean drilling assets, be they cores, samples, data, drill holes that remain open, or installed borehole observatories.

Kachovich et al., 2023, PP24A-05 Future DEEP: Future Drilling to Explore Earth's Past Workshop Report, AGU Fall Meeting, San Francisco, CA.

Read the full Future DEEP Workshop Report

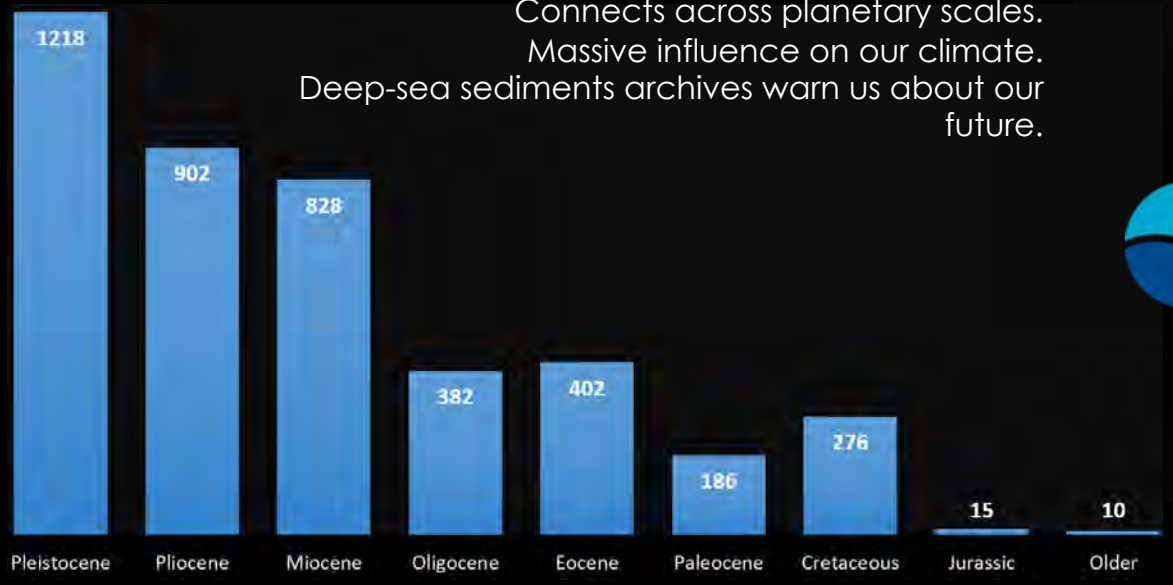
Where have we collected core?

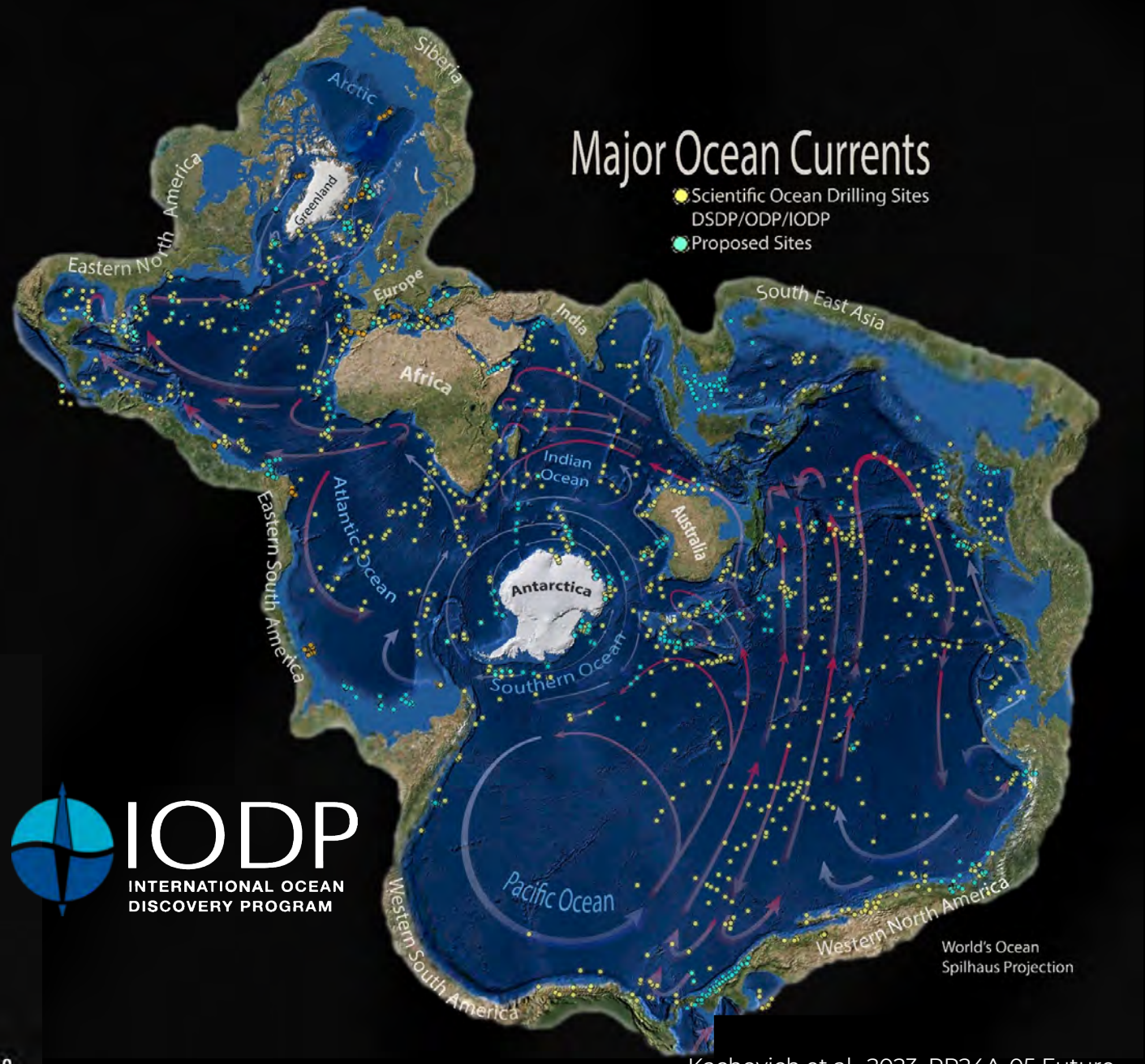
462 km

of drill core!

1681 Sites
3934 Holes

There is only one ocean.
Connects across planetary scales.
Massive influence on our climate.
Deep-sea sediments archives warn us about our future.





IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM

Kachovich et al., 2023, PP24A-05 Future DEEP: Future Drilling to Explore Earth's Past Workshop Report, AGU Fall Meeting, San Francisco, CA.

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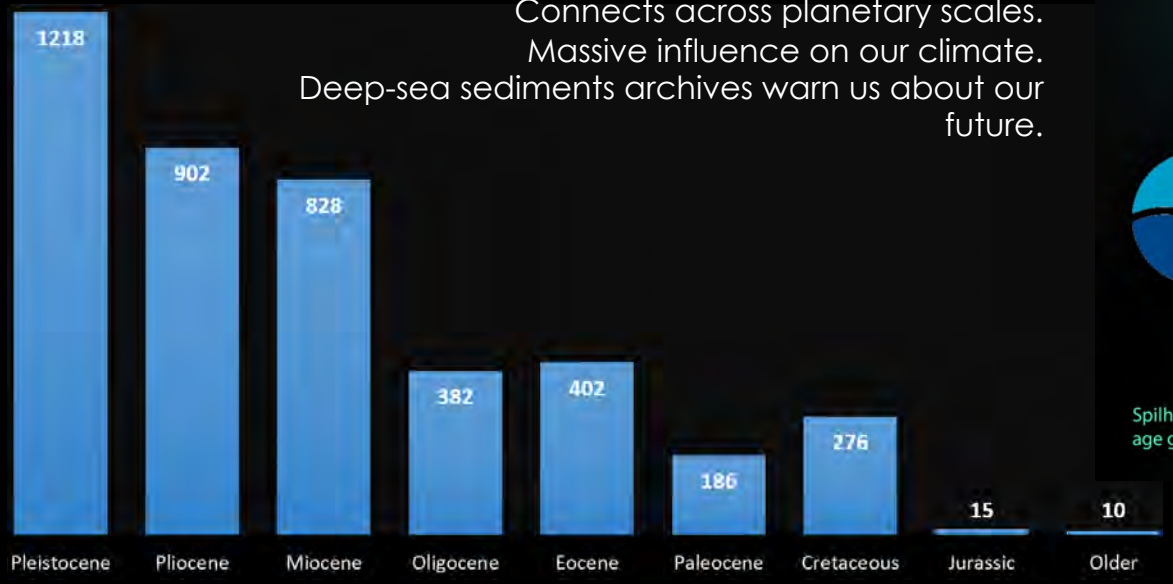

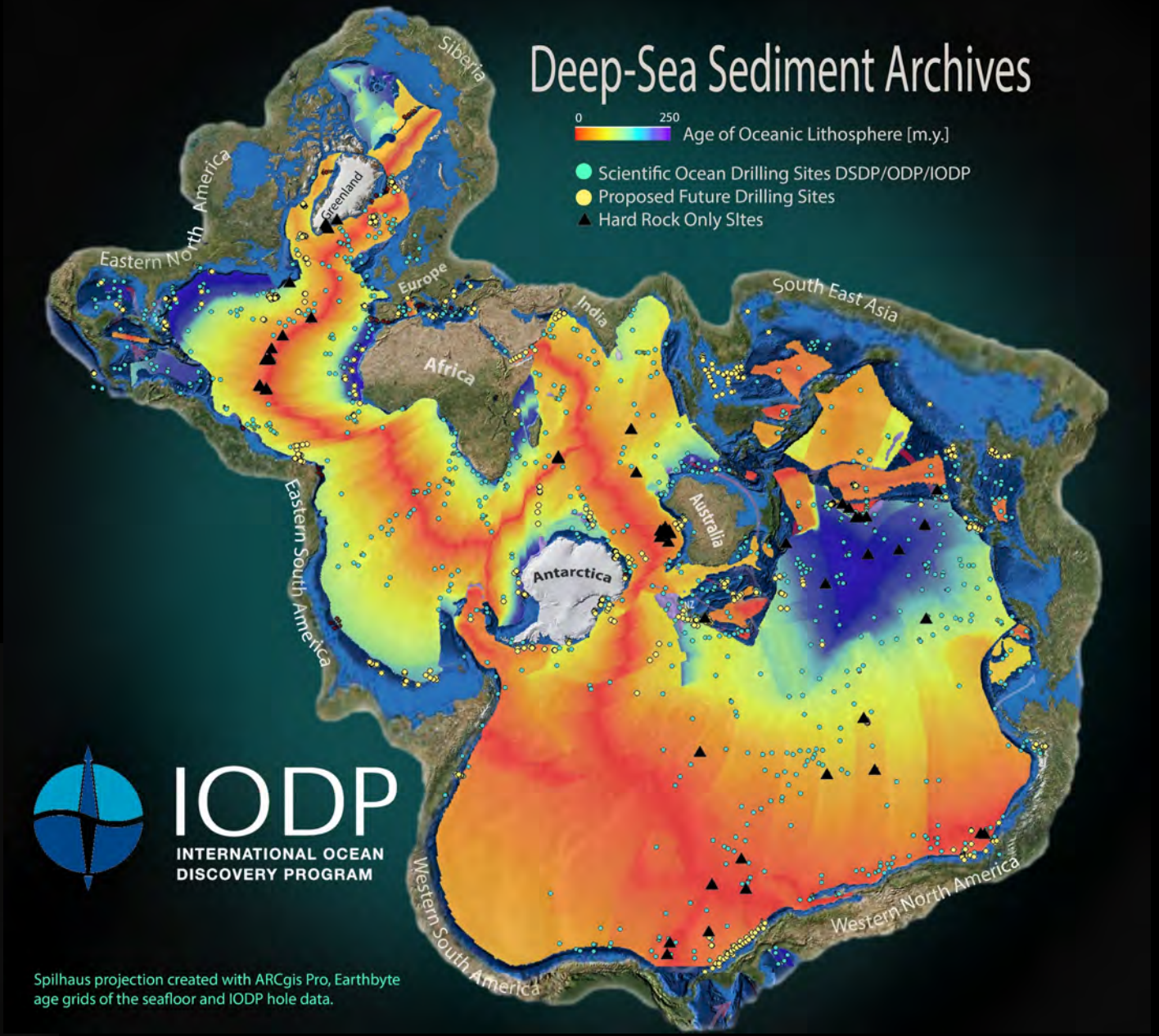

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Antarctica and Southern Ocean Priorities

- The overarching aim is to facilitate the exchange of updates and provide support for existing and new Southern Ocean drilling proposals to respond to future infrastructure opportunities post-2024.

- East Antarctica's Priority
- Antarctic Drilling History and Current Challenges
- Unlocking Deeper Insights with Longer Records
- Synergizing Antarctic Programs

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- **East Antarctica's Priority**
  - IODP East Antarctic drilling proposals (IODP proposals 813, 931 and 1002)
  - prioritised focused efforts to understand East Antarctica's vulnerability to climate warming
  - ANZIC is committed to supporting these critical proposals and similar proposals in East Antarctica that arise in the near future.

Kachovich et al., 2023, PP24A-05 Future DEEP: Future Drilling to Explore Earth's Past Workshop Report, AGU Fall Meeting, San Francisco, CA.

Antarctica and Southern Ocean Priorities

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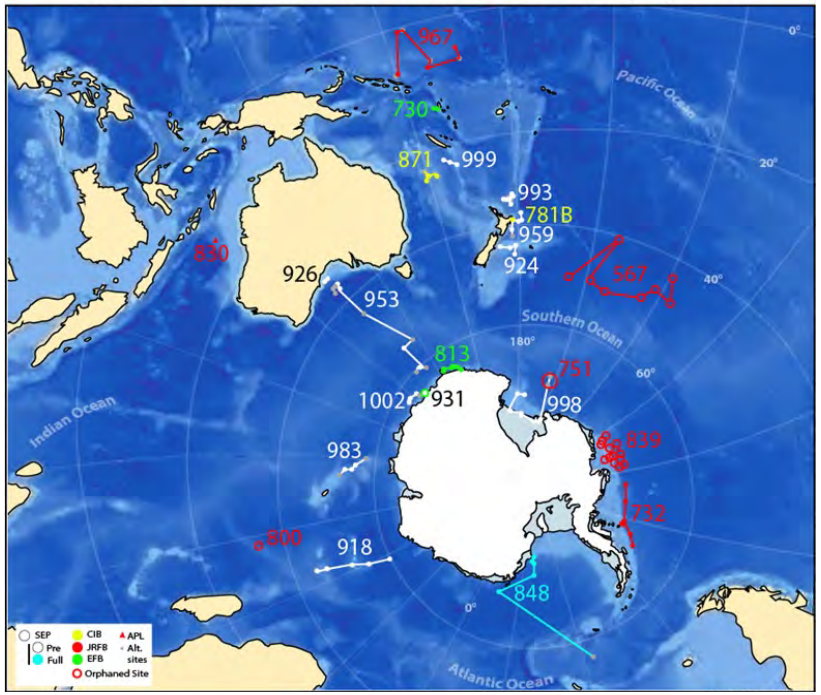
  - East Antarctica's Priority
  - **Antarctic Drilling History and Current Challenges**
    - *piston core on the continental shelf*
    - *ice-based platforms (such as ANDRILL/SWAIS-2C style rigs)*
    - *mission-specific vessels capable of rotary drilling in water depths of less than 2000m*
    - *prioritise solutions for efficient continental shelf drilling in the near term*
    - *A key consideration: use of riserless drilling in shallow waters of less than 2000-3000m vs deeper drilling*

ANZIC waters and Southern Ocean active IODP proposals



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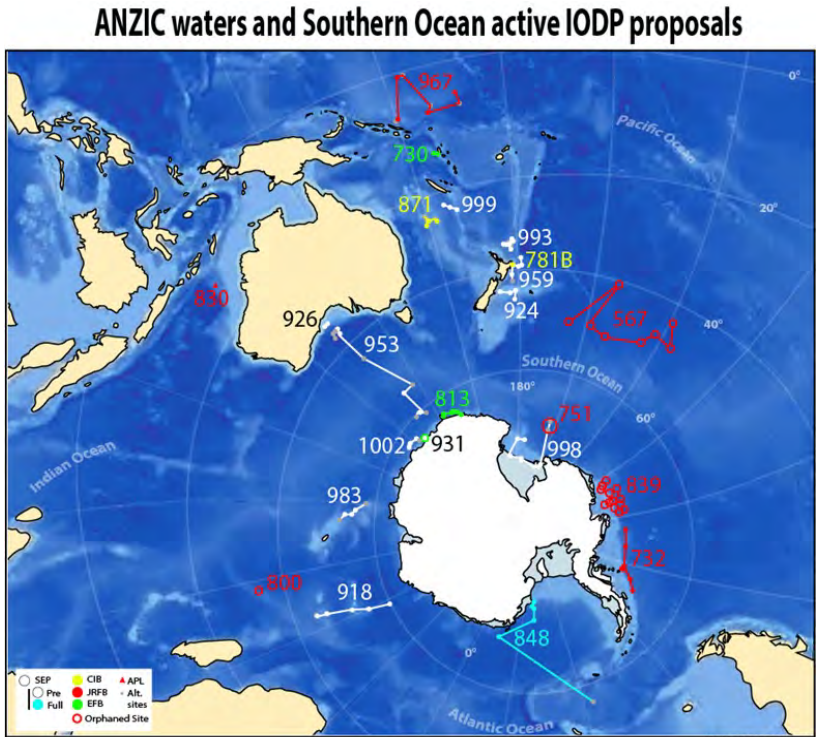

- East Antarctica's Priority
- Antarctic Drilling History and Current Challenges
- **Unlocking Deeper Insights with Longer Records**
  - *deep piston coring for Miocene and older targets*
- **Synergizing Antarctic Programs**
  - land-to-sea transects*/continental drilling projects (e.g., SWAIS 2C)*
  - million-year ice core program

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US Scientific Ocean Drilling: Next 5 Years

- Identify key science questions that should be addressed in the next 5 years
- **In the context of the 2050 Science Framework**
- Specific science questions that need to be addressed

The 2050 Science Framework Structure

STRATEGIC OBJECTIVES

The *Strategic Objectives* comprise broad Earth science research areas that form the foundation of scientific ocean drilling through 2050. Each objective focuses on understanding the interconnections within the Earth system.

Habitability and Life on Earth. Defining the conditions for, and the role of, life in the marine realm.

The Oceanic Life Cycle of Tectonic Plates. Investigating the genesis, aging, motion, and destruction of oceanic plates.

Earth's Climate System. Unraveling ice sheet history, sea level changes, and ocean-atmosphere interactions.

Feedbacks in the Earth System. Constraining the processes that regulate or destabilize the Earth system.

Tipping Points in Earth's History. Using Earth's geological past to illuminate future environmental change.

Global Cycles of Energy and Matter. Determining the role, mechanisms, and magnitude of Earth system cycles.

Natural Hazards Impacting Society. Understanding natural hazards in the marine environment.

ENABLING ELEMENTS

Enabling Elements advance the aims of scientific ocean drilling through numerous and varied broader impacts and outreach initiatives, partnerships and collaborations with organizations that have complementary goals, technology development, and big data analytics.

FLAGSHIP INITIATIVES

The *Flagship Initiatives* comprise long-term, multidisciplinary research endeavors that aim to test scientific paradigms and hypotheses that inform issues of particular relevance or interest to society. They typically combine research goals from multiple Strategic Objectives. Their implementation will be shaped by proposals from the scientific community that develop coordinated strategies that include long-term planning, technology development, and innovative applications of existing and new scientific ocean drilling data products.

Ground Truthing Future Climate Change. By collecting the robust data required for reconstructing global climate evolution over extended geologic time periods, scientific ocean drilling will provide information that is critical for improving climate model performance.

Probing the Deep Earth. By penetrating deep within oceanic crust, scientific ocean drilling will lead to a better understanding of Earth's formation and evolution and the connections between tectonics, earthquake and volcanic hazards, climate, and our planet's habitability.

Assessing Earthquake and Tsunami Hazards. By acquiring samples and deploying instruments in offshore and nearshore fault zones, scientific ocean drilling will enable more reliable assessments of the risks posed by major earthquakes and tsunamis and will facilitate improved hazard preparedness and response.

Diagnosing Ocean Health. By retrieving sedimentary records that preserve key information about past responses of biological activity to natural cycles and catastrophic events, scientific ocean drilling will enable a more informed assessment of the expected rates, duration, and magnitudes of future ocean health deterioration.

Exploring Life and Its Origins. Scientific ocean drilling and monitoring in borehole observatories will advance research into the distribution and limits of deep microbial life, novel microbes and their biotechnological applications, the emergence and evolution of life on Earth, and the possibility of life on other worlds.

Koppers and Coggon, eds. (2020)

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General questions before breakout group discussion?

Koppers and Coggon, eds. (2020)

SCIENTIFIC OCEAN DRILLING

Future Ocean Drilling in the U.S. (FOCUS)

Breakout Group Discussions:

1) What are the high priority, compelling science questions that should be addressed by U.S. scientific ocean drilling efforts in the next 5 years?

2) Please explain why you consider these questions to be high scientific priorities.

3) How do these questions fit more broadly with U.S. scientific and societal priorities?

4) At the end of the discussion, select the top 3-5 science questions that should be addressed in the next 5 years.

2050 Science Framework: https://www.iodp.org/2050-science-framework

SCIENTIFIC OCEAN DRILLING

Future Ocean Drilling in the U.S. (FOCUS)

Breakout Groups

Group #	Steering Committee Member	Breakout Group Topic (Strategic Objectives/Flagship Initiatives)
1	Beth Christensen	Earth's Climate System
2	Chandranath Basak	Diagnosing Ocean Health
3	Chris Lowery	Ground Truthing Future Climate Change
4	Isla Castañeda	Feedbacks in the Earth System
5	Jason Sylvan	Habitability and life on Earth
6	Jeremy Deans	Probing the Deep Earth/Life Cycle of Plates
7	Sonia Tikoo	Exploring Life and Its Origins
8	Justin Dodd	Earth's Climate System
9	Maureen Walczak	Assessing Earthquake and Tsunami Hazards
10	Peter Flemings	Natural Hazards Impacting Society
11	Stefanie Brachfeld	Tipping Points in Earth's History
12	Steve Phillips	Global Cycles of Energy and Matter

2050 Science Framework: https://www.iodp.org/2050-science-framework

The U.S. Science Support Program cordially invites you to participate in a

FOCUS Virtual Workshop Series

Science questions and goals requiring new technology, platforms or vessels

on Wednesday, March 20, 2024
at 12:30 PM Pacific / 3:30 PM Eastern Time

2025-2035 Decadal Survey of Ocean Sciences
National Science Foundation
Public Release Interim Report Briefing on scientific ocean drilling
March 13, 2024 at 10:00 AM Eastern Time
Register at
https://www.nationalacademies.org/events

FOCUS
In-Person Workshop
May 20 – 23

Thank you!

- Looking forward to seeing you at future virtual workshops
- Feel free to provide additional feedback online at:

https://usoceandiscovery.org/focus/

In-Person Workshop
May 20 – 23 (*tentative*)