EXPLORING EARTH
BY SCIENTIFIC OCEAN DRILLING
2050 Science Framework

ANTHONY KOPPERS
Oregon State University

email: anthony.koppers@oregonstate.edu

Scientific Ocean Drilling ***My Involvement***

Some highlights …

1

SciOD-Enabled Research

- Shore-based scientists for 5x expeditions
- Sailed 3x expeditions, 1x as co-chief scientist
- 4x PhD students sailed, 2x Schlanger Fellows
- 21x publications with 3x in Nature/Science
  - Davidson, Koppers, Sano, Hanyu (2023), A younger and protracted emplacement of the Ontong Java Plateau. *Science* 380, 1185-1188 DOI:10.1126/science.ade8666 (cited 1x)
  - Reagan, Heaton, Schmitz, Pearce, Shervais, Koppers (2019), Forearc ages reveal extensive short-lived and rapid seafloor spreading following subduction initiation. *Earth and Planetary Science Letters* 506 DOI:10.1016/j.epsl.2018.11.020 (cited 143x)

2

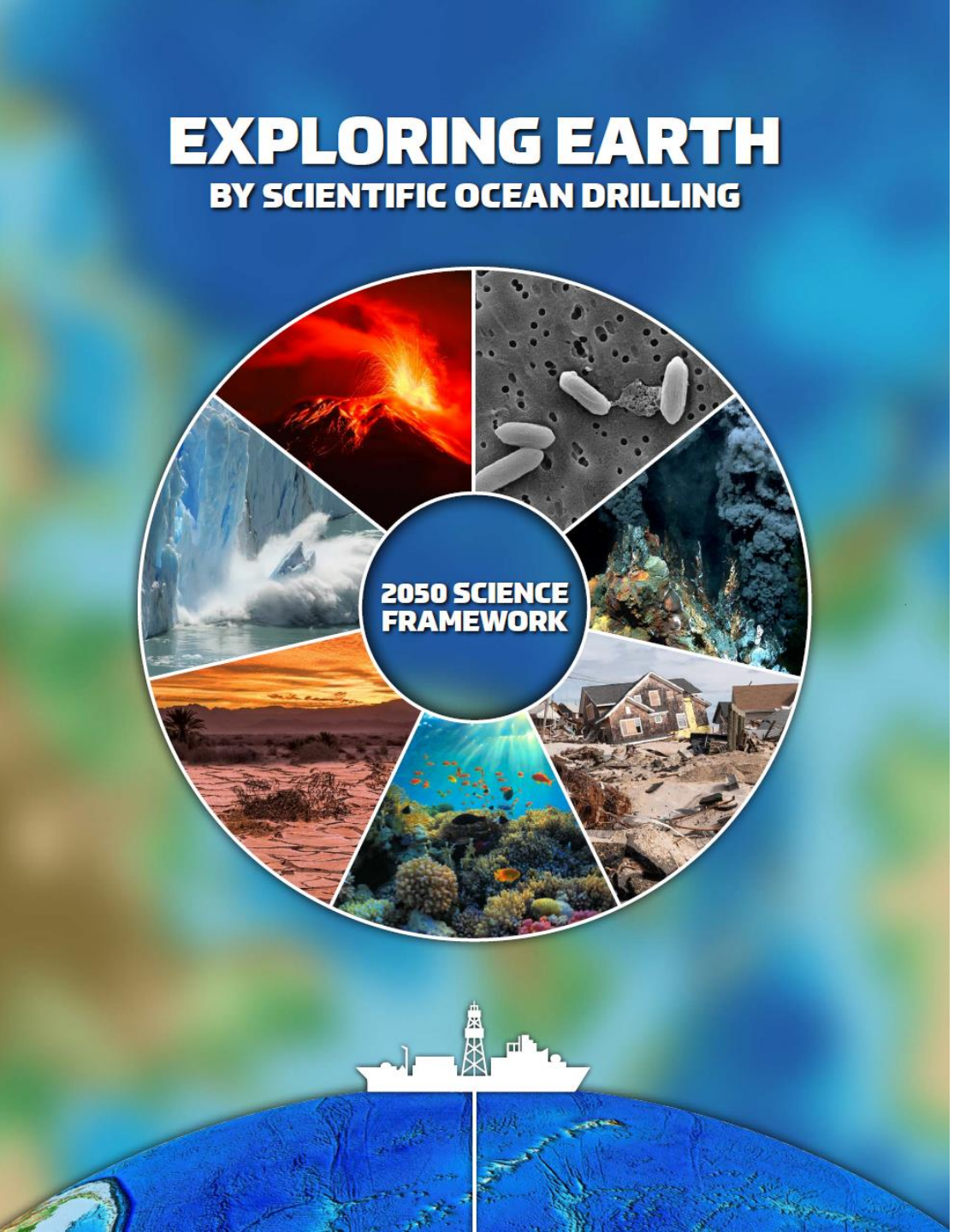
Leadership Contributions

- 2010-2013, Chair – United State Advisory Committee (USAC)
- 2015-2018, Chair – JOIDES Resolution Facility Board (JRFB)
- 2019, Lead Editor – Special Oceanography Volume (206 pages)
- 2019, Co-lead Convener – NEXT Workshop
- 2019, Chair – International Science Framework Working Group
- 2021-2022, Co-lead Editor – 2050 Science Framework (124 pages)
- 2022 and onward, Chair – 15 Institutions represented in the US Scientific Ocean Drilling Alliance (US-SODA.org)

1

Exploring EARTH by Scientific Ocean Drilling

Why the 2050 Science Framework …



Mission

The *2050 Science Framework for Scientific Ocean Drilling* guides multidisciplinary subseafloor research into the interconnected processes that characterize the complex Earth system and shape our planet's future.

- The Framework is neither a science nor implementation plan, but provides the superstructure on top of which new programs and new facilities (ships, core repositories, data repositories, etc.) are built
- The Framework is purposefully broad and open and is built around interconnections, international multi-disciplinary collaboration, and is aspirational with new science goals that have clear societal impact
- The Framework is built by and for the next generation of scientists and is inclusive
- The Framework is long-ranging through 2050, so that science endeavors could be included that would require consistent, even decadal attention, to get it done

Seven Strategic Objectives

- The seven Strategic Objectives are broad areas of scientific inquiry that focus on understanding the interconnected Earth system
- They cover many topics in the earth, ocean, life, geo-physical, physical, biology, polar sciences, and more
- They are designed to allow us to investigate the interconnections in the dynamic earth system, with its climate and environment, and with all life on it
- The new proposed research on those interconnections then will influence our inquiry into and understanding of natural hazards, global cycles and rates, and the health and habitability of our oceans and planet

FLAGSHIP INITIATIVES

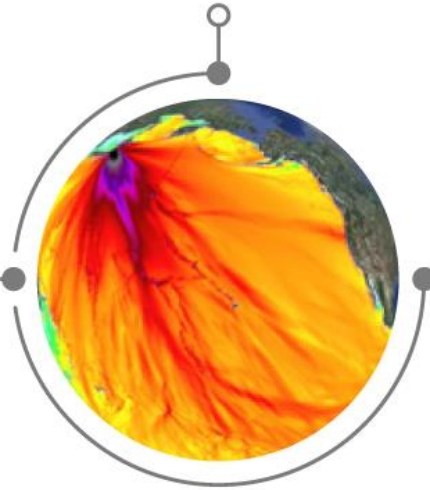
Five Flagship Initiatives

- Flagship Initiatives are long-term drilling endeavors that aim to inform issues of particular interest to society, typically combining goals from multiple Strategic Initiatives
- The new Flagship Initiatives inherently require a coordinated multi-expedition approach
- In particular Flagship Initiatives **1**+**3**+**5** are directly relevant to today's societal challenges and national security risks

1
Ground Truthing Future Climate Change

2
Probing the Deep Earth

3
Assessing Earthquake and Tsunami Hazards



4
Diagnosing Ocean Health

5
Exploring Life and Its Origins

2

2050 Science Framework

All the Science Enabled within the Ocean, Earth, Life, Physical, Polar Sciences …

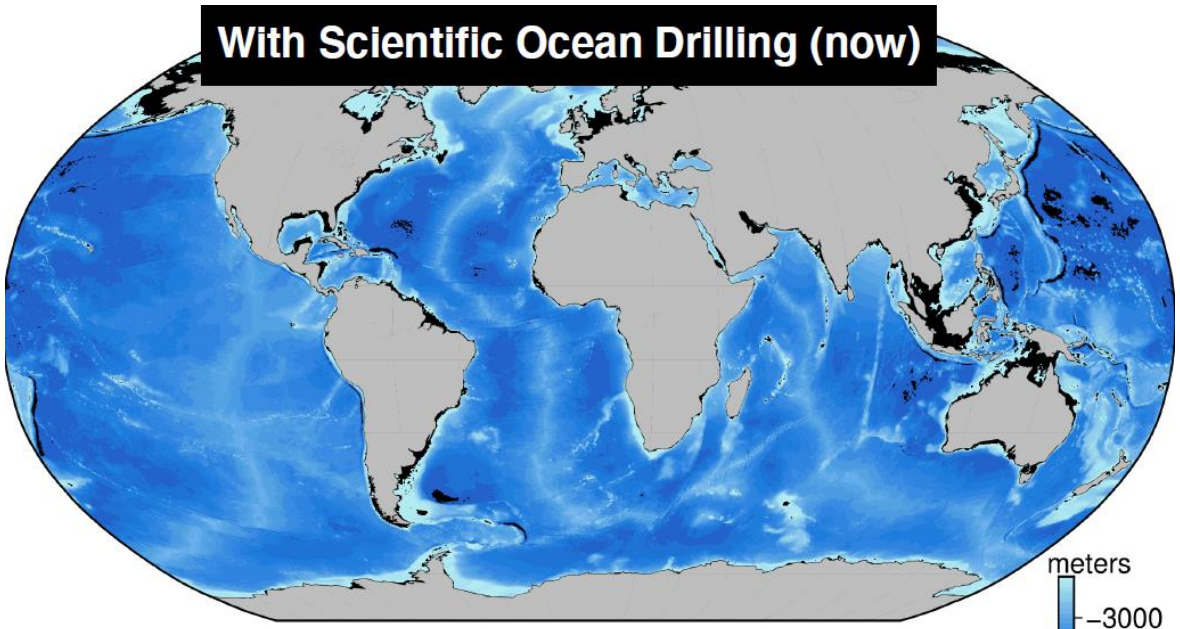
	1st Decadal Survey of the Ocean Sciences (DSOS) in 2012 Sea Change Report								New Research Areas Concerning the Ocean Sciences Partially based on 2050 Science Framework						
	Sealevel Change	Coastal and Estuarine Oceans	Ocean and Climate Variability	Biodiversity and Marine Ecosystem	Marine Food Webs	Ocean Basins	Geohazards	Subsea-floor Environ-ment	Habitability and Micro-biology	Ocean Health	Global Biogeo-chemical Cycles	Energy, Matter and Resources	Tipping Points	Technology and Workforce Develop-ment	Data Sciences, Monitoring and AI
1 **IODP 2012 - ORIGINAL DSOS#1 SEA CHANGE REPORT**	I		I			C	C	C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2 **IODP 2023 - UPDATE AFTER 10 YEARS**	I		C	F		C	C	C	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3 **2050 Science Framework**															
Strategic Initiatives															
Habitability and Life on Earth			F	I	F			C	C	F	I			I	
The Oceanic Life Cycle of Tectonic Plates						C	I	I	F			I			
Earth's Climate System	C		C				I		F	F			C		I
Feedbacks in thet Earth System			C			I			F		C	I	I		
Tipping Points in Earth's History			C	C									C		
Global Cycles of Energy and Matter			I						I	F	C	C	I		I
Natural Hazards Impacting Society	I						C						I	C	C
Flagship Initiatives															
Ground Truthing Future Climate Change	I		C				I			F			C		C
Probing the Deep Earth						C	I	I	C		I	I			
Assessing Earthquake and Tsunami Hazards							C						I	C	C
Diagnosing Ocean Health			I	C	F				I	F				I	
Exploring Life and Its Origins								C	F					I	
Enabling Elements															
Broader Impacts and Outreach														I	
Land to Sea	C	F	C				F								
Terrestrial to Extraterrestrial									F					I	
Technology Development and Big Data Analyses	C		C				C	I	C					I	C

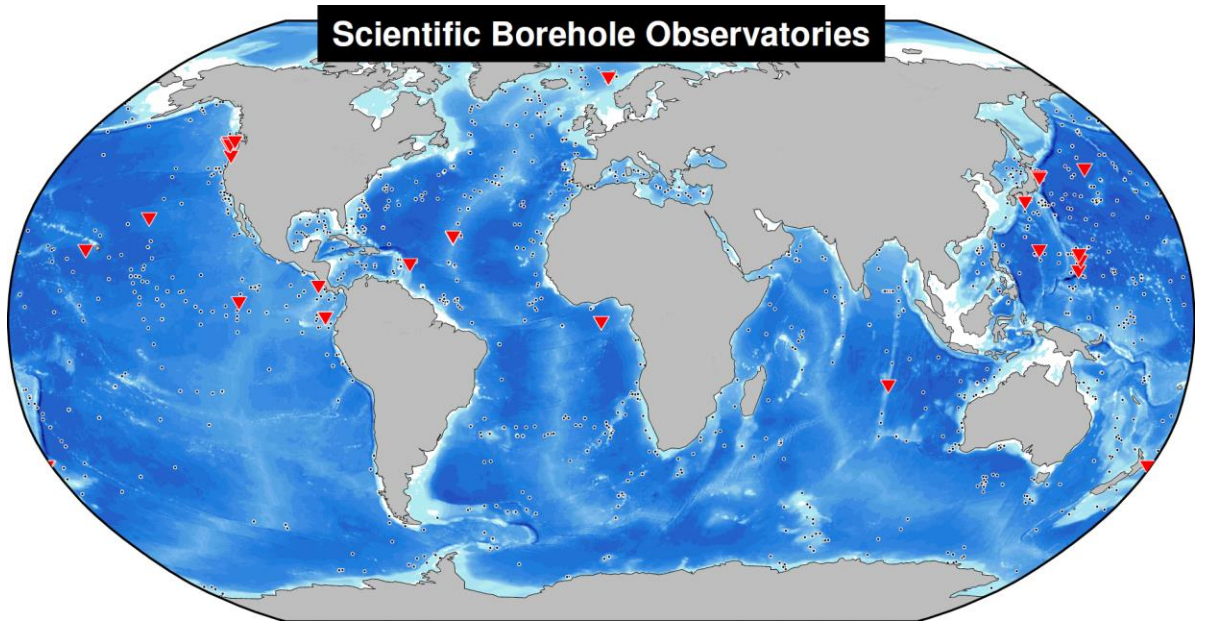
I	Important
C	Critical
F	First work in area

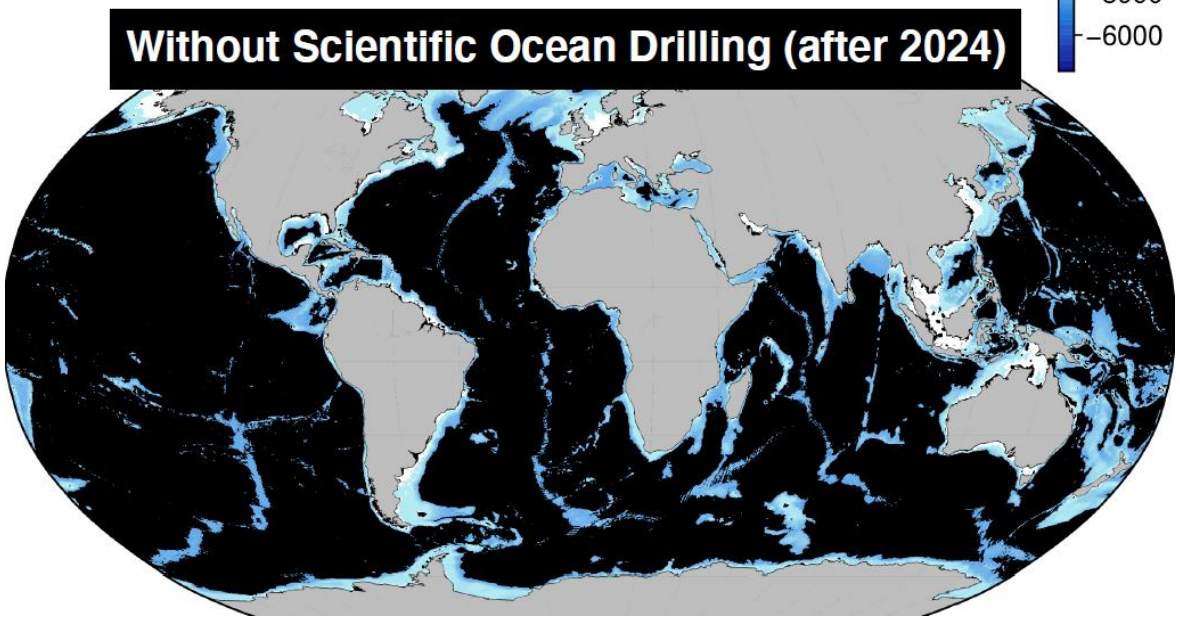
3

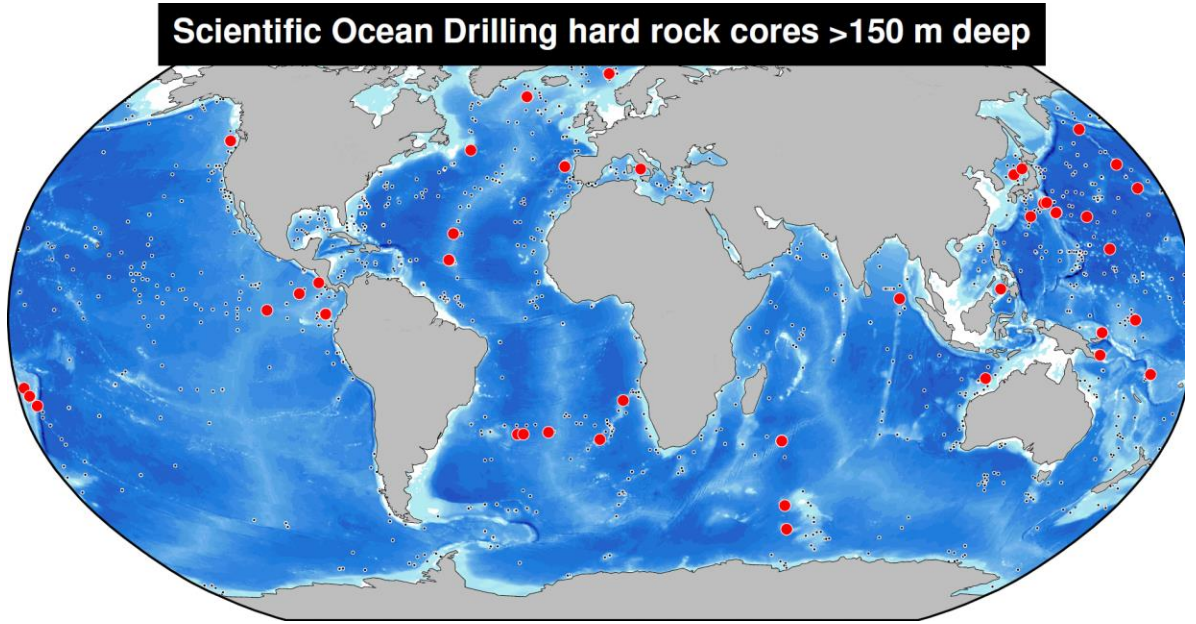
Future Scientific Ocean Drilling

What will we lose without the JR and no immediate replacement …



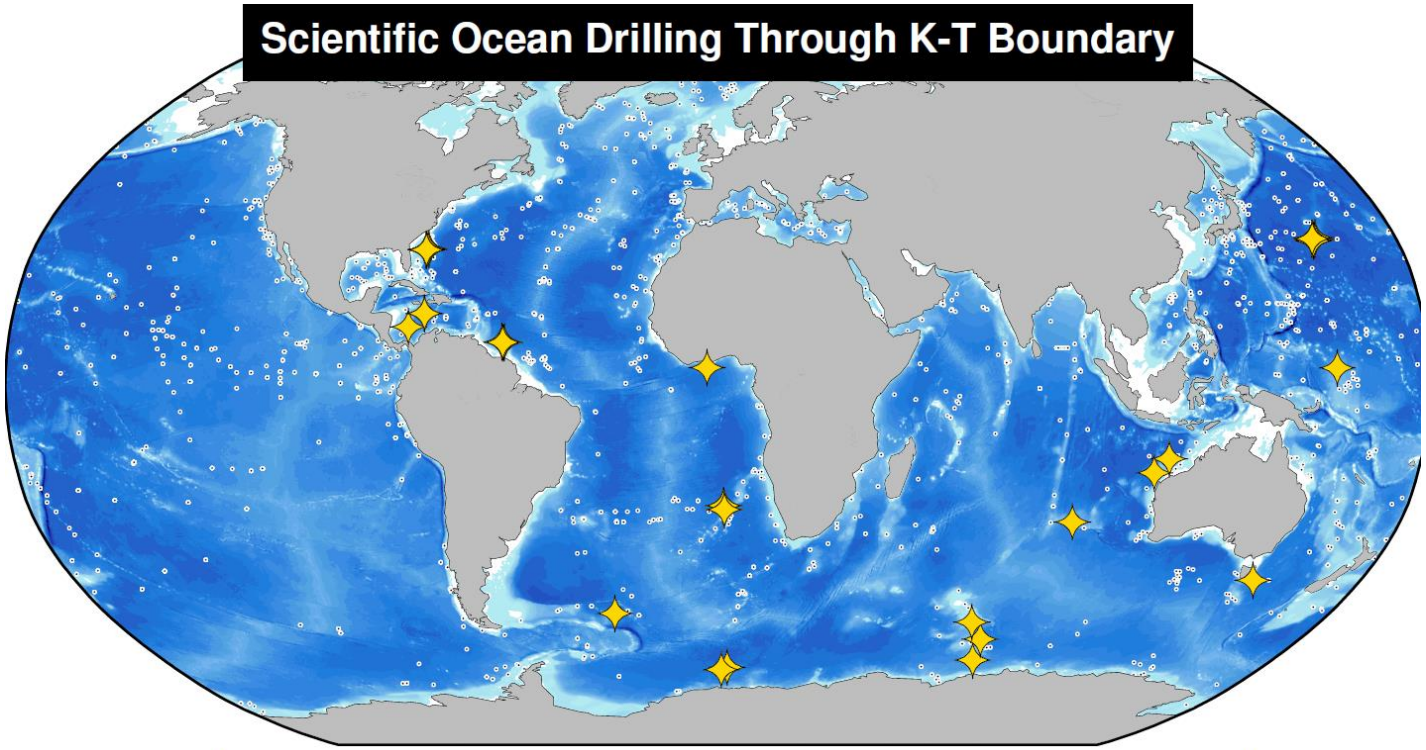


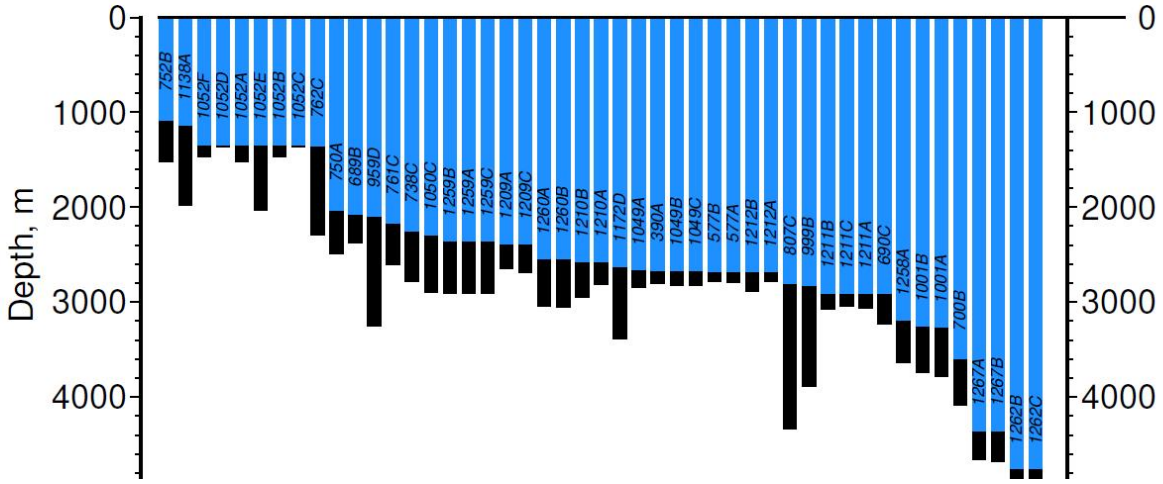


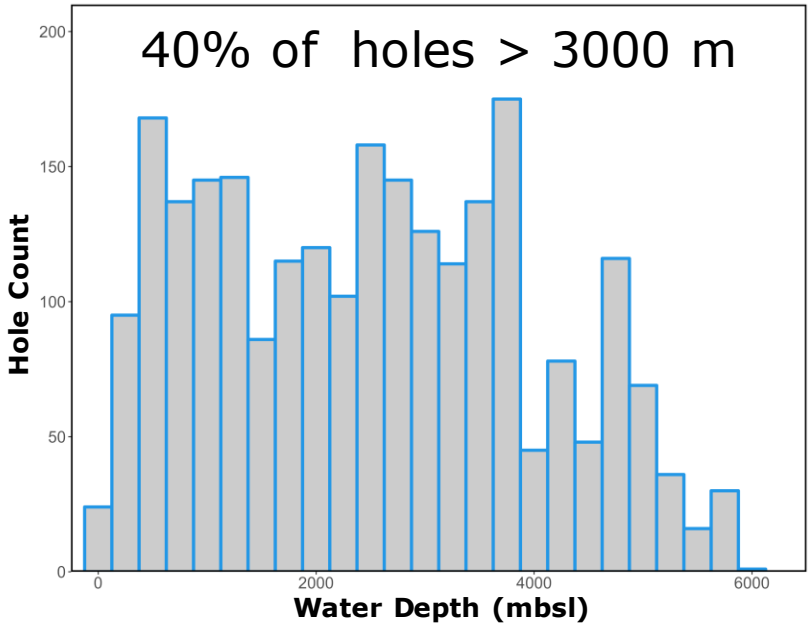


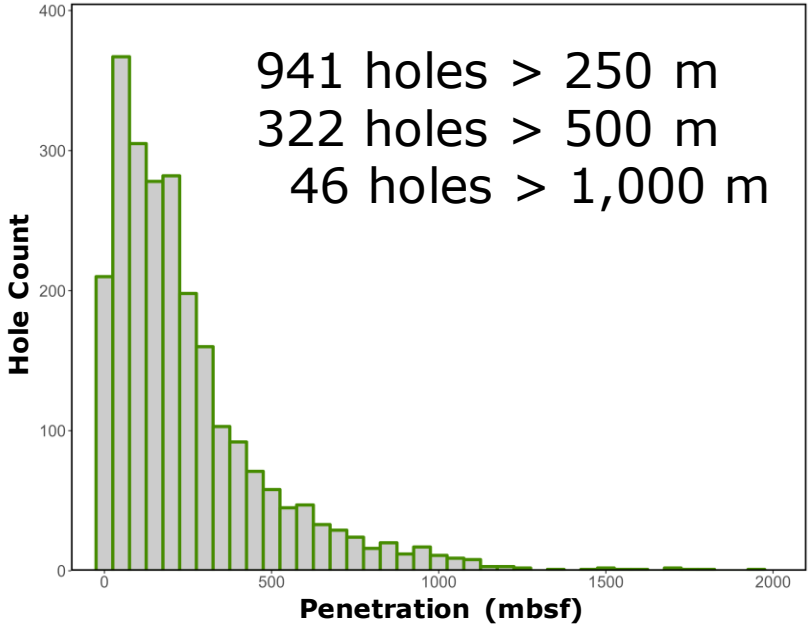
meters
−3000
−6000

W/O JR MOST OCEANS ARE BLACKED OUT WHERE > 3 km WATER DEPTH
DEEP HARD ROCK CORES AND BOREHOLE OBSERVATORIES ARE UNLIKELY







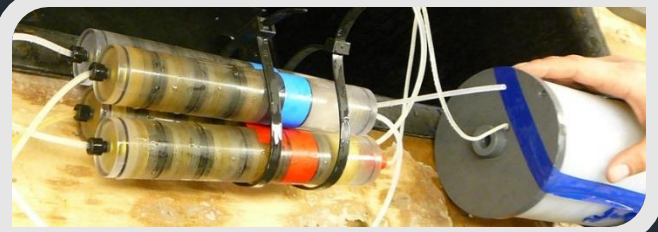


W/O JR CANNOT DRILL HALF OF THE LOCATIONS FOR PETM/KT BOUNDARY DRILLING NEEDING A LOT OF DRILL PIPE WILL BE CLOSE TO IMPOSSIBLE

Many Fundamental Advances in Deep Biosphere Studies

- CORKS installed by JOIDES Resolution have been used to create subseafloor observatories where scientists can sample fluids for geochemistry and microbiology over multiple years
- IODP-based estimates are 10^{29} cells in the deep sedimentary biosphere, as much as in the entire water column (Kallmeyer *et al.* 2012, PNAS)
- Expedition 329 showed that oxygen penetrated down into the top of the oceanic basaltic crust from 9-37% of the seafloor sediments (D'Hondt *et al.* 2015, Nature Geosciences)
- The deep biosphere extends down to at least 2,450 meters below the seafloor (Inagaki *et al*. 2015, Science; Huber 2015, Science)

Enrichment Experiments

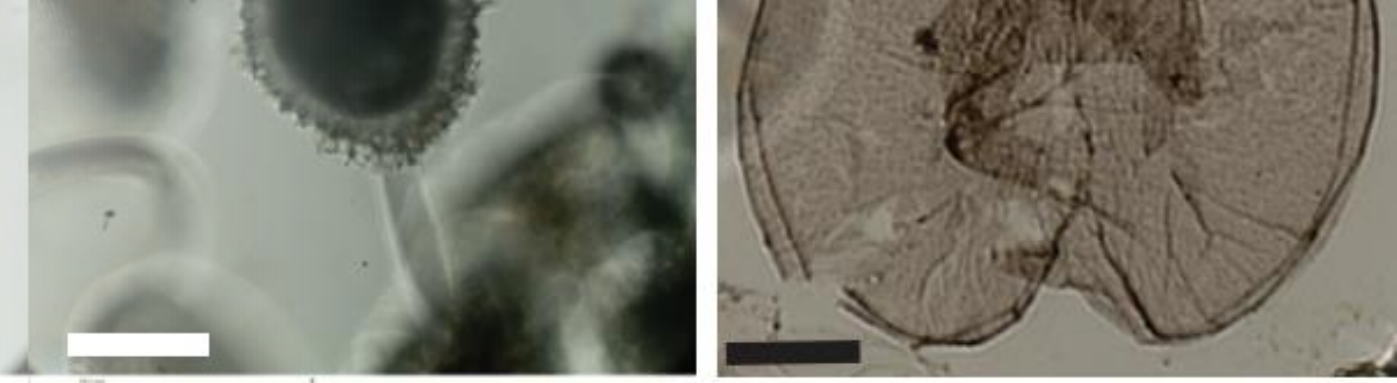


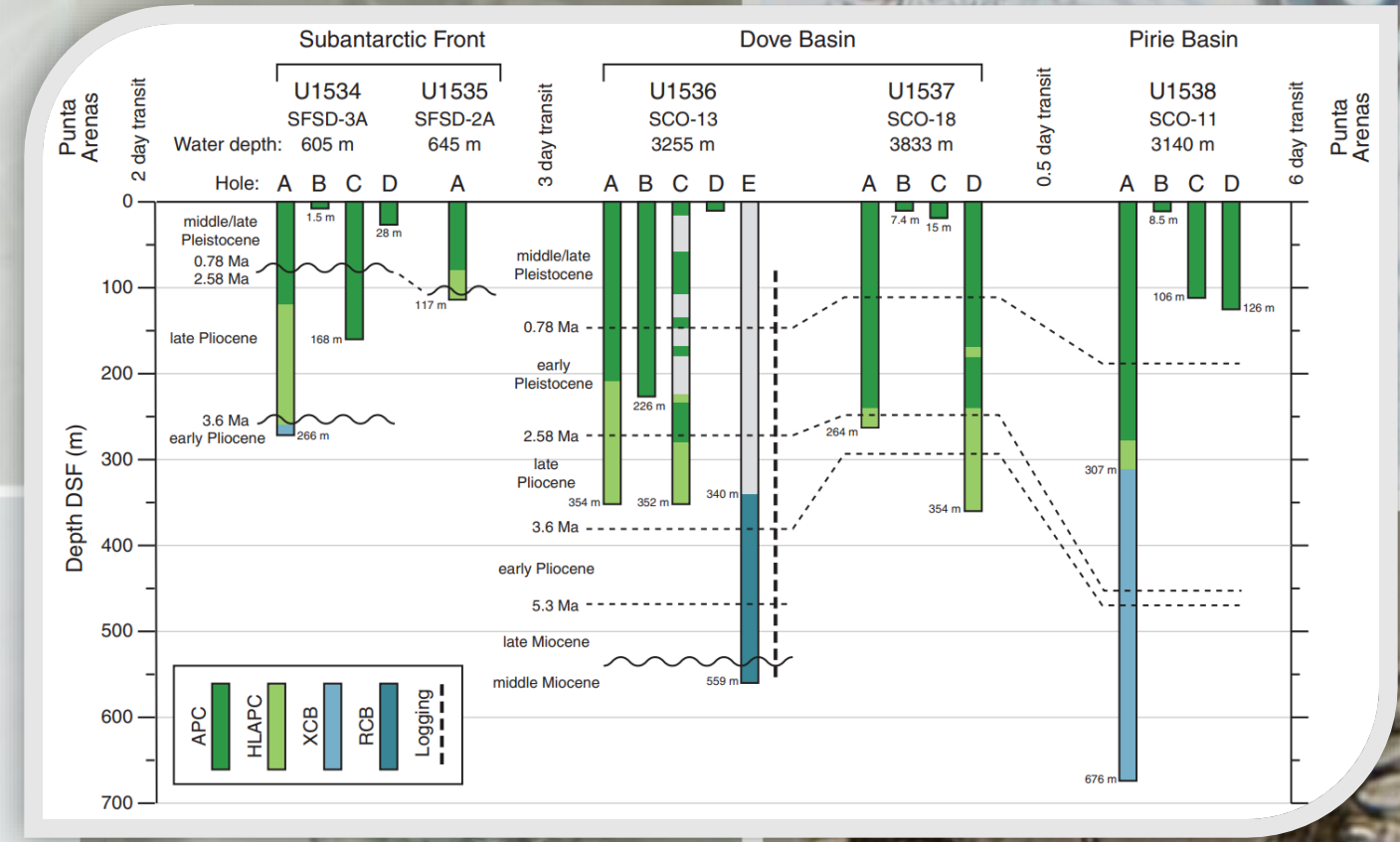
In Situ Mass Spectrometers

Colonization Experiments

Expedition 382 Iceberg Alley and Ice and Ocean Dynamics

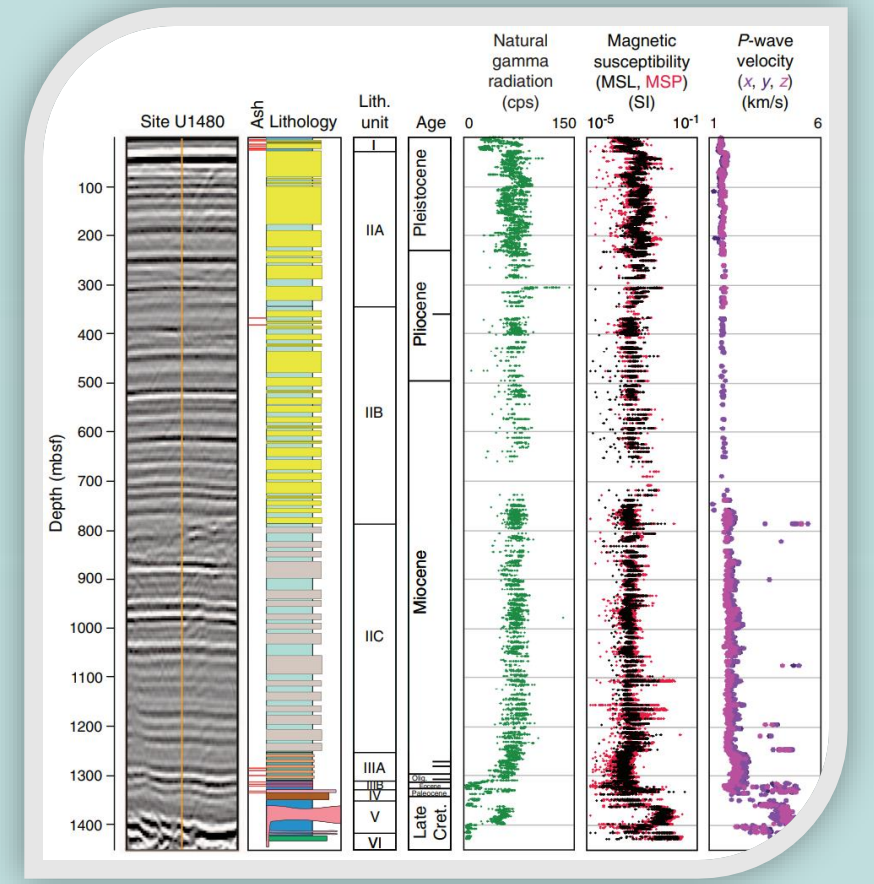
- JOIDES Resolution (JR) recovered part of the long-term climate history of Antarctica, seeking to understand how polar ice sheets responded to changes in insolation and atmospheric CO_2 in the past and how ice sheet evolution influenced global sea level
- Focus on investigating the mid-Pliocene warm period and the late-Pliocene glacial expansion of the West Antarctic Ice Sheet beyond the 800 kyr ice core record
- Water depths are highly variable between 600 and 3800 mbsl with coring depths ranging from 100 to 650 mbsf, resulting in a total of 2.8 km of sediment recovered and 3.7 km of penetration depth





Expedition 362 Sumatra Earthquake Seismogenic Zone

- JOIDES Resolution (JR) drilled the input materials of the north Sumatran subduction zone, where the M9+ earthquake and tsunami originated that devastated coastal communities around the Indian Ocean during Christmas 2004
- The expedition was designed to ground truth the material properties causing unexpectedly shallow seismogenic slip that are not well explained by current models
- Two sites on the Indian oceanic plate were drilled, cored and logged to a maximum depth of 1,500 mbsf and in 4,147-4,178 mbsl water depths, almost using 5.6 km of drill string per hole!



4

Future Scientific Ocean Drilling

A short overview of Scientific Ocean Drilling by the numbers ...

Scientific Ocean Drilling ***By the Numbers***

Impact Through Publications, Community and Novel Science Outcomes …

1 2 3

Publications

- In total 13,081 *Scientific Ocean Drilling*-related publications appeared in the peer-reviewed literature between 1969-2022

13,081

- Since 2003 these include 491 papers in journals like *Nature*, *Science*, *PNAS*, *Earth Sci Review*

491

Citations

- IODP research results have been cited in other research articles more than 67,400 times between 2003 and 2021

67,400

U.S. Community

- Researcher from >600 research institutions in 50 states

>600/50

Scientist's Petition

- Scientists from the U.S. and the world signed the US-SODA petition in support of *Continued, Future Riserless Drilling*

2,225

Countries Involved

- Up to 26 countries have been involved in the drilling programs

26

Scientific Ocean Drilling ***By the Numbers***

By and For Everyone …

1

US-SODA Letters

- US-SODA sent informational letters to the NSF Director and OCE leadership between May 2022 and February 2023

4

Framework Input

- >650 researchers informed the 2050 Science Framework

>650

2

Institutional Letters

- In total 50 letters by Provosts, Vice Presidents, Chancellors from U.S. and international institutions were sent to NSF

50

Framework Writers

- 45 writers with more than half Early Career Scientists

45/50%

3

NSF May Townhall

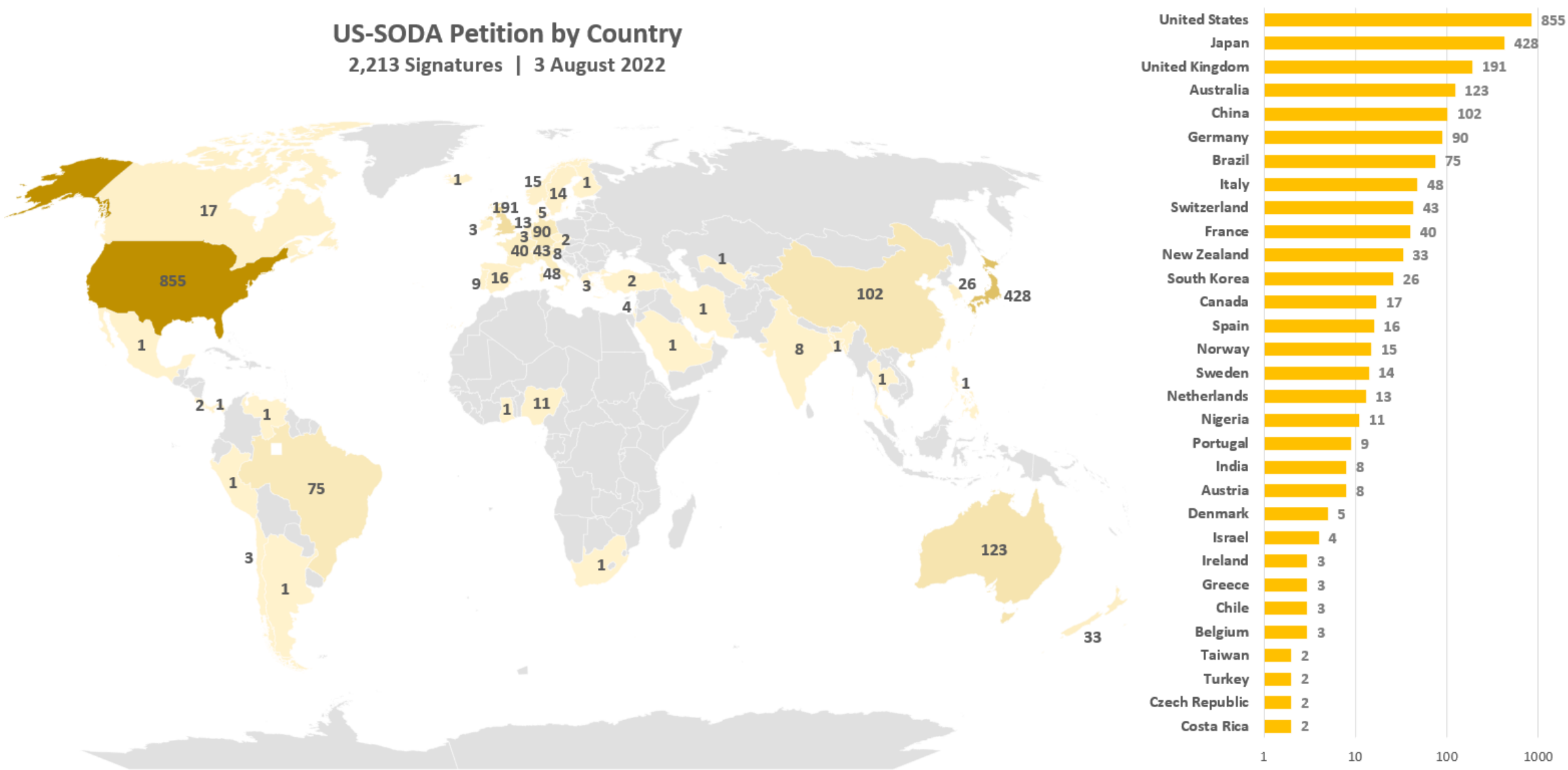
- More than 400 scientists and students listened into the NSF townhall of May 2023 about their decision making and plans

>400

New Disciplines

- Paleoceanography and paleo-climatology would not exist

2



#1 US (855) – #2 ECORD (504) – #3 JAPAN (428) – #4 ANZIC (156)

5

Future Scientific Ocean Drilling

What solutions can start to address the 2050 Science Framework in the next decade …

Scientific Ocean Drilling ***Immediate*** **Steps**

How to ensure that the U.S. can maintain its leadership position …

1

New U.S. Riserless Vessel

- Put into place a university-based program office in FY24 to guide and carry out conceptual design of a new and improved global-ranging riserless U.S. drilling vessel

2

Keeping Community Thriving

- Continue USSSP+USAC and expand their scope of work, funding, membership, and their national and international engagement efforts

3

New US-MSP Office

- Put into place a US-MSP-style office in FY24 to help scientists with logistics, procurement of larger commercial vessels and ice breakers, and programmatic international collaborations and operations, etc.

4

New ODP Grants Program

- Resurrect the now retired ODP solicitation and program at NSF OCE in FY24

6

Future Scientific Ocean Drilling

Summary and take-home messages …

Scientific Ocean Drilling ***Four Take Homes***

Transitioning from the Hubble to the Webb telescope in the Ocean Sciences …

1

Unique Science Field

- *Scientific Ocean Drilling* is a unique science field including many disciplines/subdisciplines and with advanced capabilities that are now lost due to the JOIDES Resolution retirement

2

Broad Science Framework

- However, the *2050 Science Framework* is extremely broad and filling in across the broader interconnected Ocean Sciences themes—and far beyond—as shown earlier in the matrix

3

Seeking Alternate Solutions

- *Scientific Ocean Drilling* supports researchers, students and institutions across the U.S. and the world and we are ready to engage together in finding alternate solutions, while in parallel designing a new riserless drilling vessel

4

Investment Today, Major Returns for Decades

- Investment in *Scientific Ocean Drilling* today will not only yield benefits in the short term but will deliver returns for decades to come

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BY SCIENTIFIC OCEAN DRILLING
2050 Science Framework

THANK YOU!
QUESTIONS? DISCUSSION!