A Brief Overview of US Seafloor Rock Sampling Infrastructure

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Midpac Expedition, 1950
UCSD Libraries

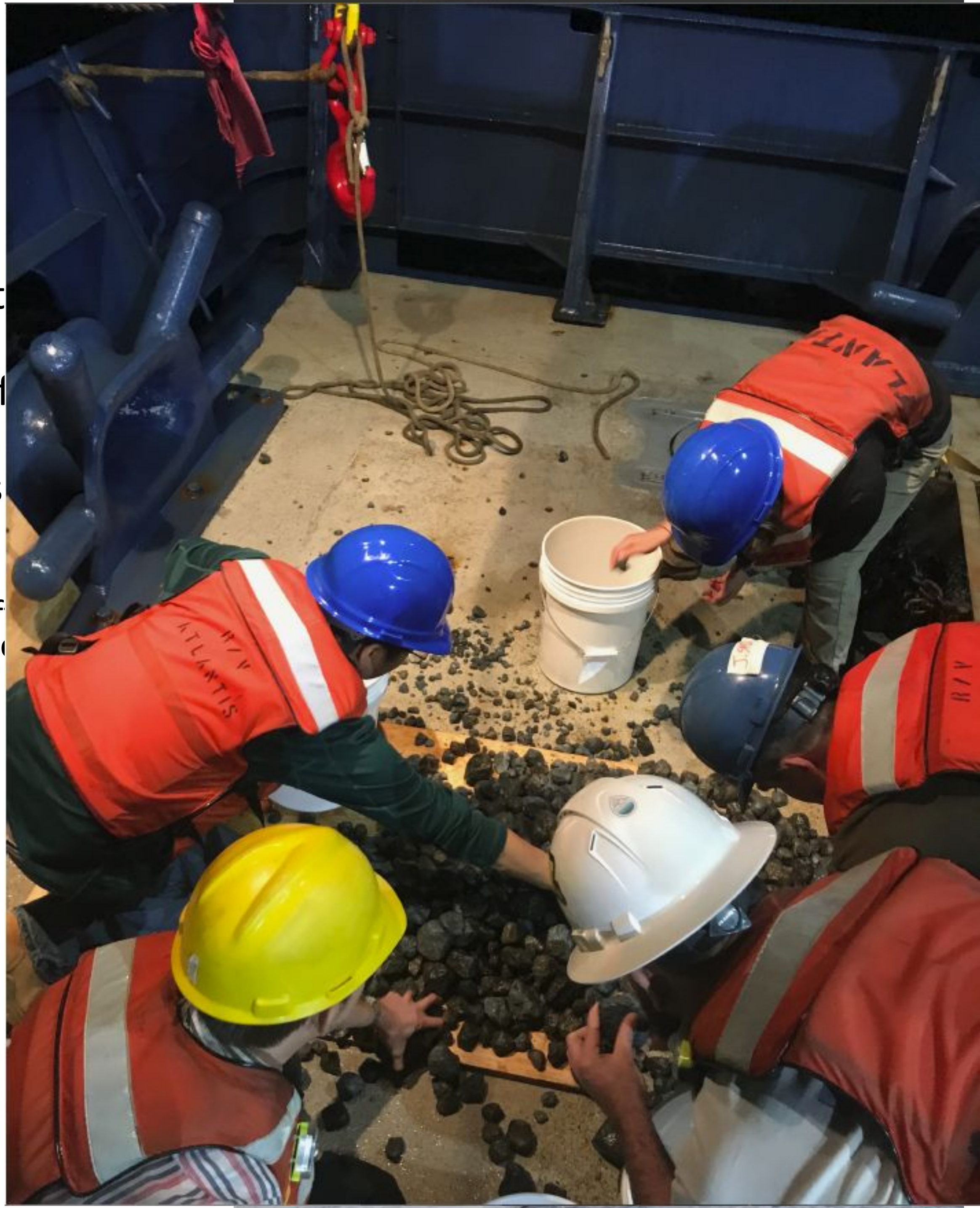
US Federal Seagoing Infrastructure Umbrella

- University-National Oceanographic Laboratory System (UNOLS)
  - A collaboration between US academic institutions and NSF-OCE to maintain and run ship operations
- Academic Research Fleet (ARF)
  - Numerous oceanographic vessels and various ROV/AUV/HOVs owned by NSF, ONW, US Universities and Laboratories- www.unols.org/us-academic-research-fleet-0

- International Ocean Discovery Program
  - Was a 21-nation collaboration
  - A separate funding body that is still supporting drilling expeditions and archived sample use
  - US support for the drill ship (R/V *Joides Resolution*) was not continued
  - Not the focus of this workshop

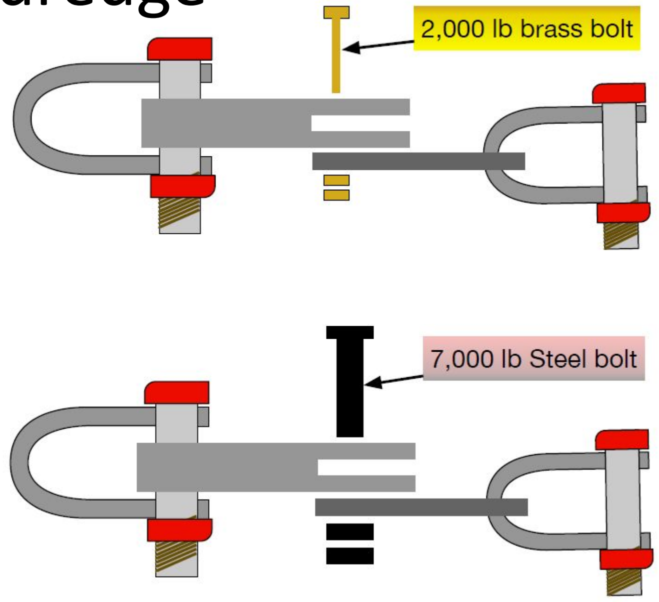
Dredging

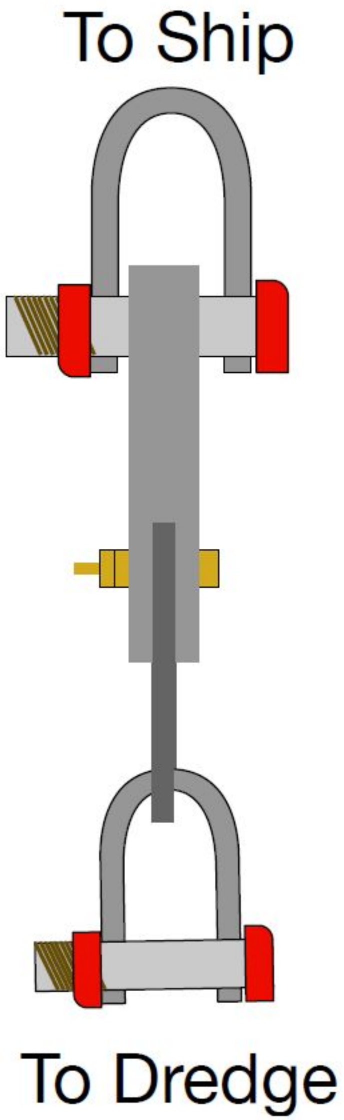
- Comprise of a heavy metal chain bag, ~1m opening wit
box ‘mouth’ of sturdy galvanized steel and teeth
- Designed to collect loose rocks and break rocks off seaf
outcrops
- Attached to a steel trawl wire fair-leaded through the s
A-Frame and connected to a trawl Winch
    - Active dredging = dredge dragged via slow 0.1-0.2 kts ship
    - Passive dredging = dredge dragged via winch movement af
repositioning the ship by a few hundred meters and then r
the dredge wire to pull against seafloor outcrops
- Pros
    - A lot of samples (>100lbs)
    - Quick (lot more targets per expedition)
    - Less expensive (per rock) than ROV expeditions
    - Not particularly weather limited
- Cons
    - Limited spatial/stratigraphic inferences
    - Can get stuck
    - Can come up empty



Dredging

- Shear bolts hold together weaklinks
- If a dredge gets stuck on an outcrop you want to break the links and lose the dredge
- The steel trawl wiring is orders of magnitude more expensive than the dredge





Dredging

- The depth and environment of dredging (e.g., MOR glassy basalts in rift valley or on broad fast spreading crest vs transform faults with 1000s of m relief) results in different tension requirements
- Appendix A of the UNOLS Research Vessel Safety Standards indicates a safety factor of 2.0 (or 1.5 if approved) on the max tension allowance is the upper limits to setting a weak link strength **MARSSAM can help with the appendix A 'waiver'**

Table A.8.4 Wire Rope – Safety Factor From Less Than 2.0 to 1.5 – Minimum Requirements

General	Wire rope of steel construction may be operated to a nominal FS =1.5 on the ABL, including transient and dynamic loads, as long as the following precautions in this section are adhered to.
	Once a FS = 2.0 is reached a regular check on wire loading shall be performed. This will require halting a deployment at regular intervals (~ 500 m) and conducting a slow haul until the nominal and peak tensions are established and verified. A decision on whether to proceed must then be based upon the limiting value of SF = 1.5. The deployment must be halted, when the minimum Factor of Safety of 1.5 is reached.
	Sea conditions and the resulting ship motion will affect the transient loads created on the wire. Thus, the trend in prevailing weather should be assessed before committing to a deployment, which could approach the limits specified above.
	Motion-compensation may be used to reduce the dynamic loads below the permissible limit and/or to reduce the chances of a "zero load" condition.
Tension Monitoring	Tension must be monitored at the winch operator's station with a display refresh rate of at least 10 Hz (every 100mS). The system must also be capable of logging tension data at a minimum frequency of 20 Hz (every 50 mS). Tension must be continuously monitored using a "tension trending" graph at the winch operator's station. The tension measuring system must be calibrated at a minimum of every 6 months at load equal to the imposed load at the selected FS. The tension measuring system must be maintained with an accuracy of 3% of the applied load.
Alarms	The handling system shall be fitted with both audible and visual tension alarms that sound and illuminate at prior to a FS=1.7 of a wire's Assigned Breaking Load (ABL). Alarm conditions must automatically be included in the logged data.
Sheaves & Load Carrying Rollers	The D/d ratio must be at least 40:1 or 400d1 (whichever is greater) throughout. Grooving shall be per Ref A.1.1, Chapter 1, and Section 11.0 to provide adequate support.
Deck Safety	The Operator should identify "Danger Zones" around ropes and wires under tension. To the extent possible, given the nature of operations involved, all personnel shall be excluded from these zones such that a sudden failure cannot result in injury. Warning notices should be displayed at points of access indicating the danger. Physical and/or visual barriers should be erected as needed. Existing doors and accesses to the area should be secured when possible
Testing	Wire Samples from the end closest to the termination shall be sent for testing annually. If a 10% decrease in ABL is detected, then the testing shall be increased to every six months. Alternately, the Owner may cut back to and re-test a new representative length.
Logbooks	At a minimum, the Owner shall maintain logs showing cutbacks, spooling operations, lubrication, wire train description,maximum payout and maximum loading (as determined by monitoring system or by calculation for each cast) for the full service life of the rope or wire. The wire log shall transfer with the wire if it is removed and placed in storage, or transferred to another winch or Owner.
Winch Operator	The Winch Owner must certify that all Winch Operators are competent. By "Certified Competent" it is meant that the Owner must have written documentation in place showing that the operator has been through and successfully passed a formal owner/operator developed training program on the winch, handling apparatus, and monitoring system. The system vendor or the Owner, depending on the complexity of the system, may conduct a formal training program. The certification must be renewed annually. The master shall verify qualifications and designate the approved winch operators. If there are configuration changes to controls or to the hardware then the operator qualifications must be refreshed and documented.

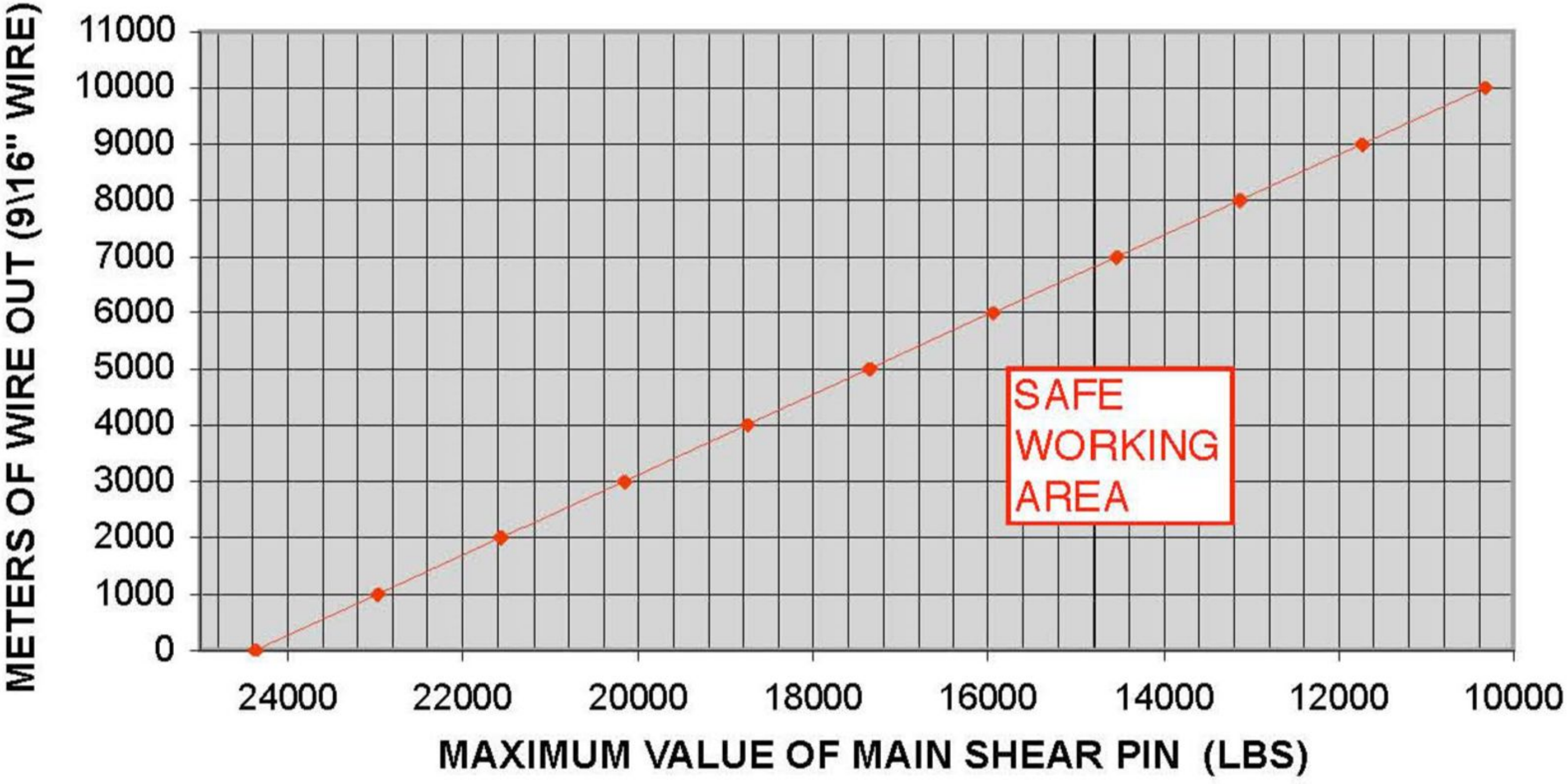
R/V *Sikuliaq* with mounted winch

Dredge Tension

- Most global class winches/wires (9/16”) have a tension limit of ~30k lbs
  - Therefore dredge tension limits are 15-20k

Tables by Ron Comer and John Boaz. May 1985

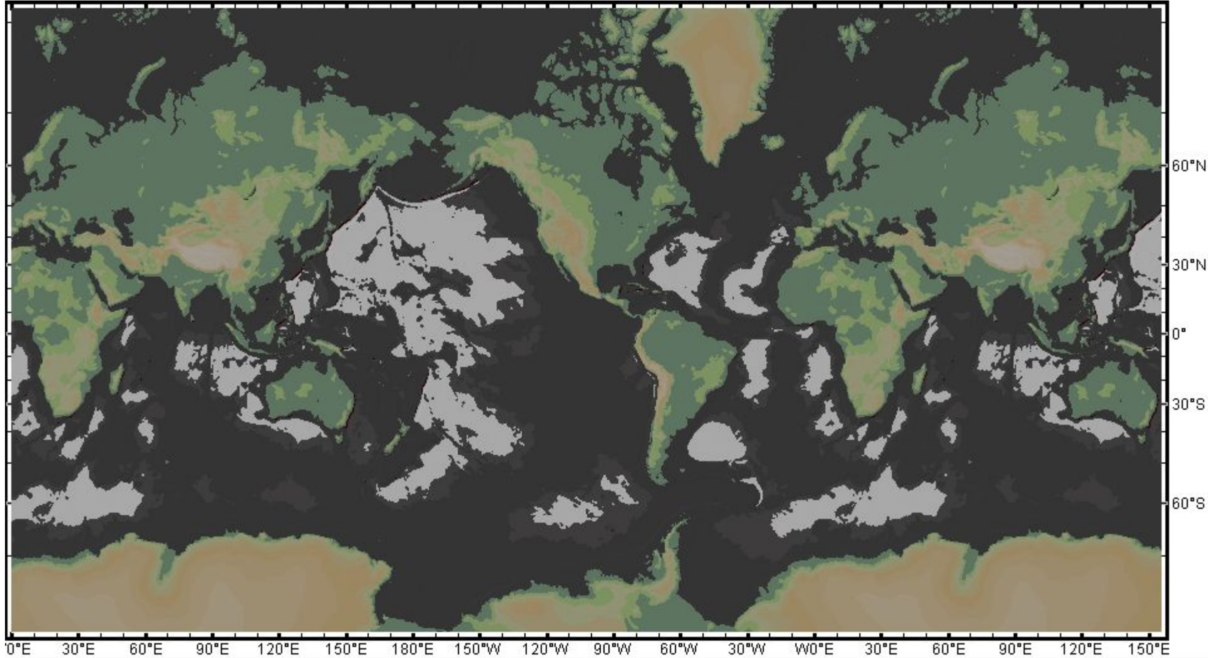
Rev. G.P. and T.E. 13 April 2001.



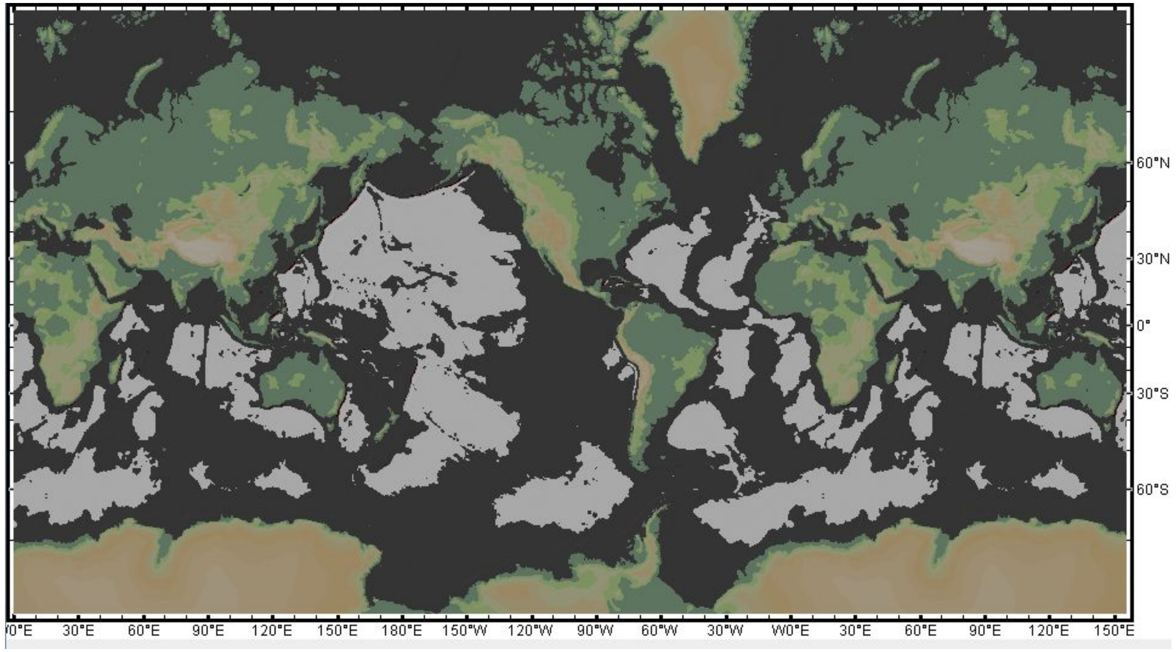
Dredging Tension

Therefore dredge tension limits are 15-20k

- Example: you have a target at 5000 mbsl
- The ‘ambient’ tension at 5000 mbsl is ~15-16k lbs
  - when wire weight, sea state spikes, winch operator tension buffers, shear bolt strength uncertainty is considered
- Therefore, only 4k or so tension is available to pull on an outcrop (typically you want up to 10k) OR MORE….!!!



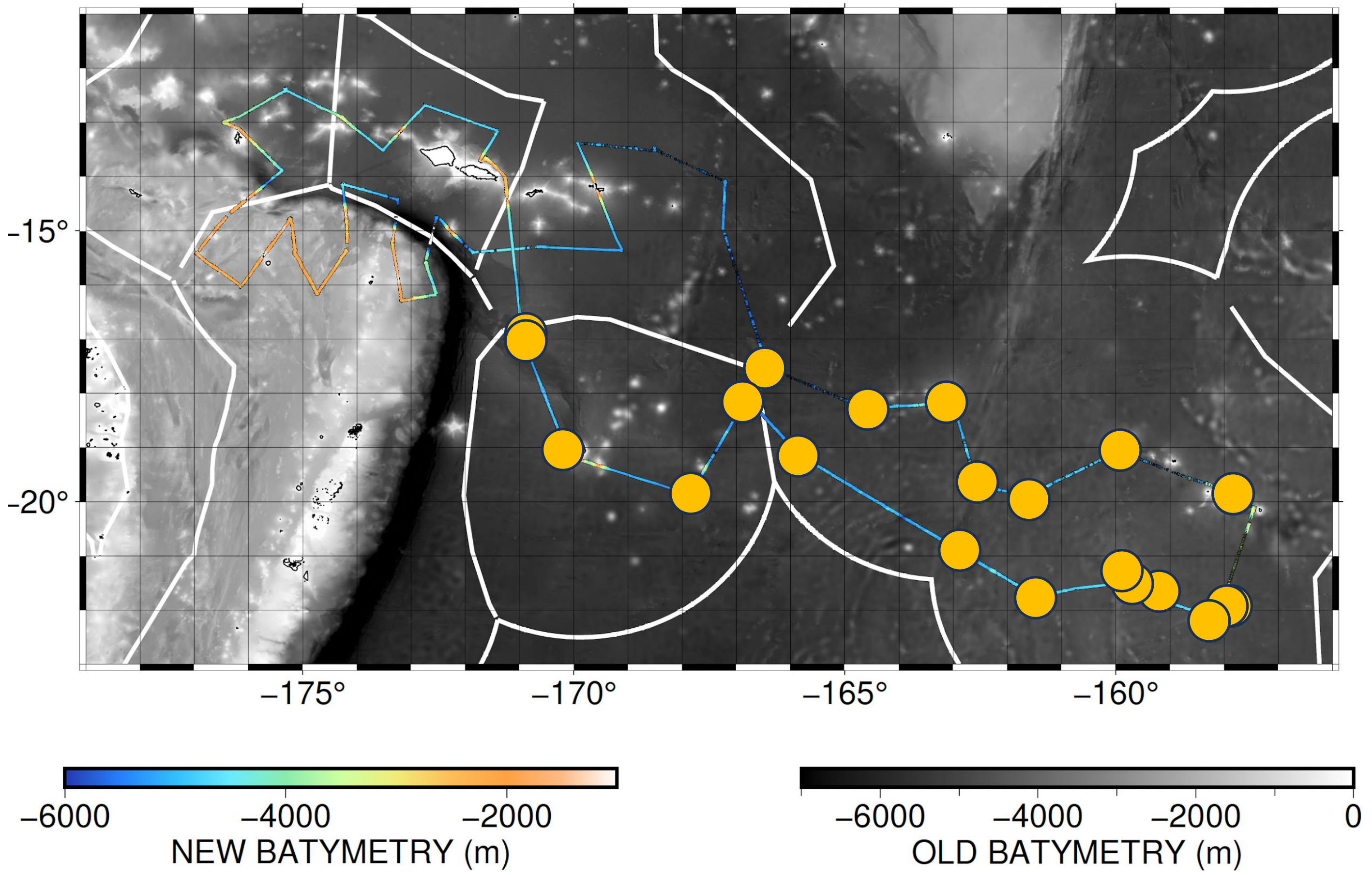
Top: White = seafloor at or below 5000 mbsl
Bottom: 4500 mbsl cut-off



Recent Dredging Example

TN-426: Wei, Jackson, Stegman, Wiens

- Sampling seamounts in the Cook-Australs to Tonga Trench region
- 23 dredges deployed in 13 days
- 20 Dredges recovered rocks. Good rock samples recovered from 18 dredges (78%)
- Depths 4250-2000 mbsl
  - Stuck with passive dredging only
  - Limited to only 0.5 km tracks due to permit limitations
- Supported by MARSSAM



Dredging

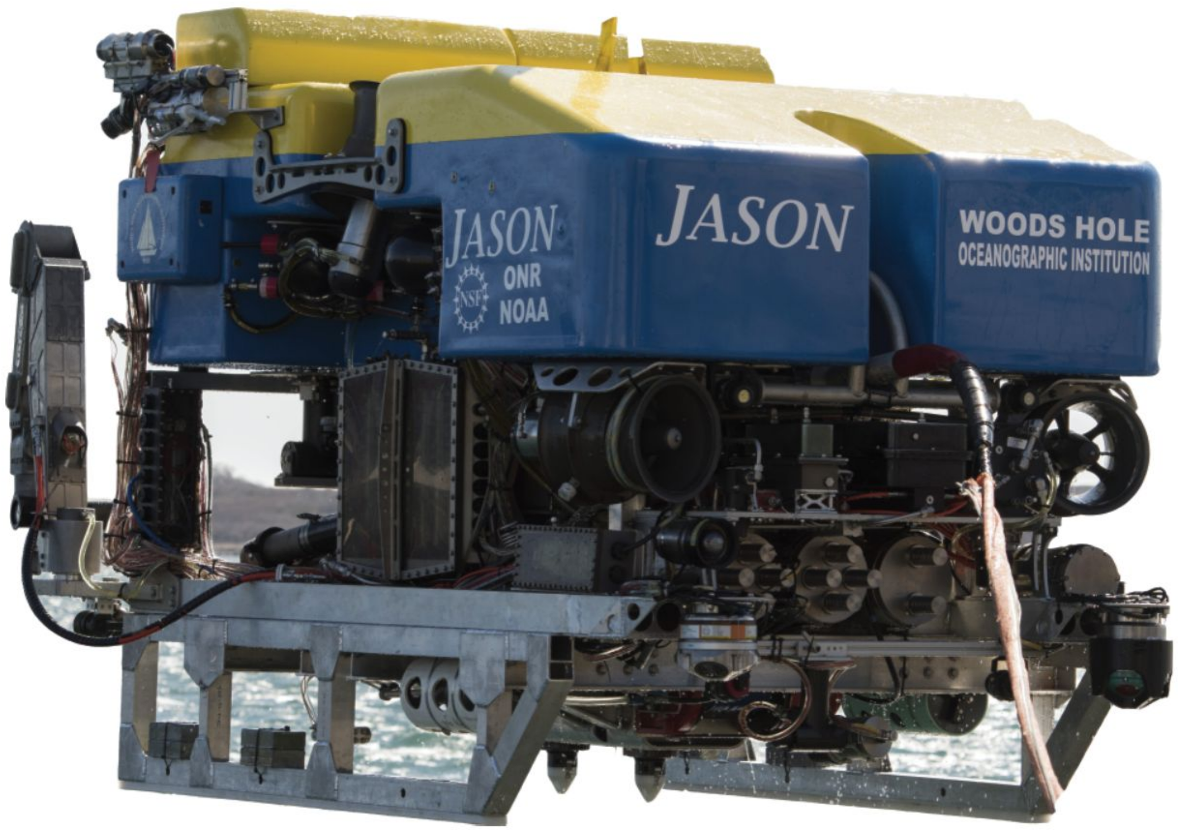
- The MArine Rock and Sediment SAMpling (MARSSAM) Support group now handles dredging support and logistics for all UNOLS vessels with science programs that require seafloor rock dredging
- Includes:
  - Advice on science goal feasibility
  - Providing appropriate technicians
  - Interface between PI and vessel operations and shipboard technicians
  - Supplying all dredging equipment
  - Supplying rock curation equipment (bags; sharpies
    - Can supply curation equipment to ROV rock sampling ex
  - Handling archived sample shipping to NSF reposito

To be discussed in detail Day-2 afternoon

Remote or Human Occupied Submersibles

Jason

- Depth limit 6500 mbsl
- Rock sampling performed through manipulator arm (grabs)
- Pros
  - Highest detail sampling possible
  - Can stay down for long periods of time
  - Recorded video and stills
- Cons
  - Limited sampling (grab only) ~20 samples per dive Or an ELEVATOR/LANDER can be used to ferry samples from the seafloor
    - Elevator time saving is depth dependent
  - Typically, can't break most rocks out of outcrops (e.g. FeMn crusts), however depends on fractures

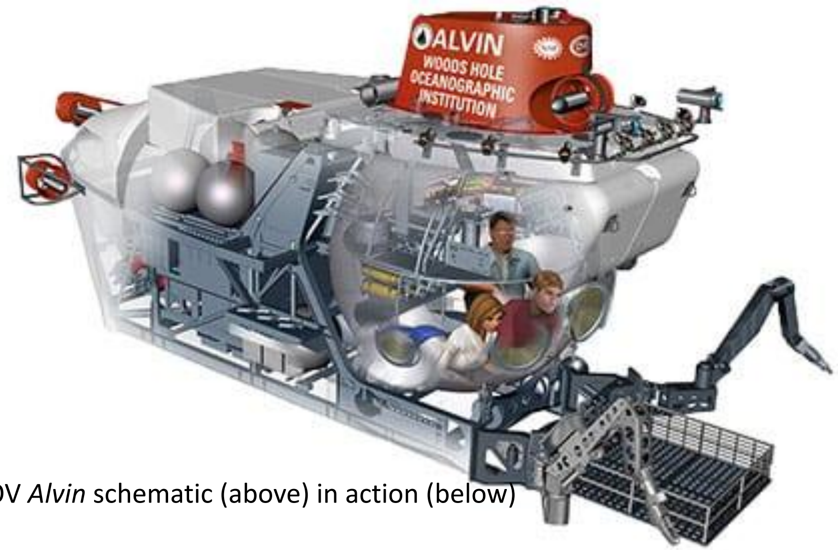


ROV *Jason* being deployed

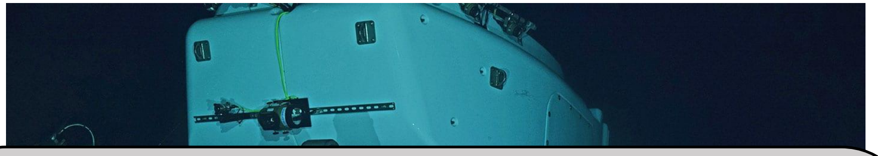
Remote or **Human** Occupied Submersibles

Alvin

- Depth limit 6500 mbsl
- Rock sampling performed through manipulator arm (grabs)
- Pros
    - Highest detail sampling possible
    - Provides an otherwise unavailable 3d view of the seafloor
    - Recorded video and stills
- Cons
    - Limited sampling (grab only)
    - Can’t break rocks out of most outcrops (e.g. FeMn crusts)
    - Dive limited to <10 hrs (5-6 hrs on bottom)
    - Typically, only daytime operation



HOV *Alvin* schematic (above) in action (below)



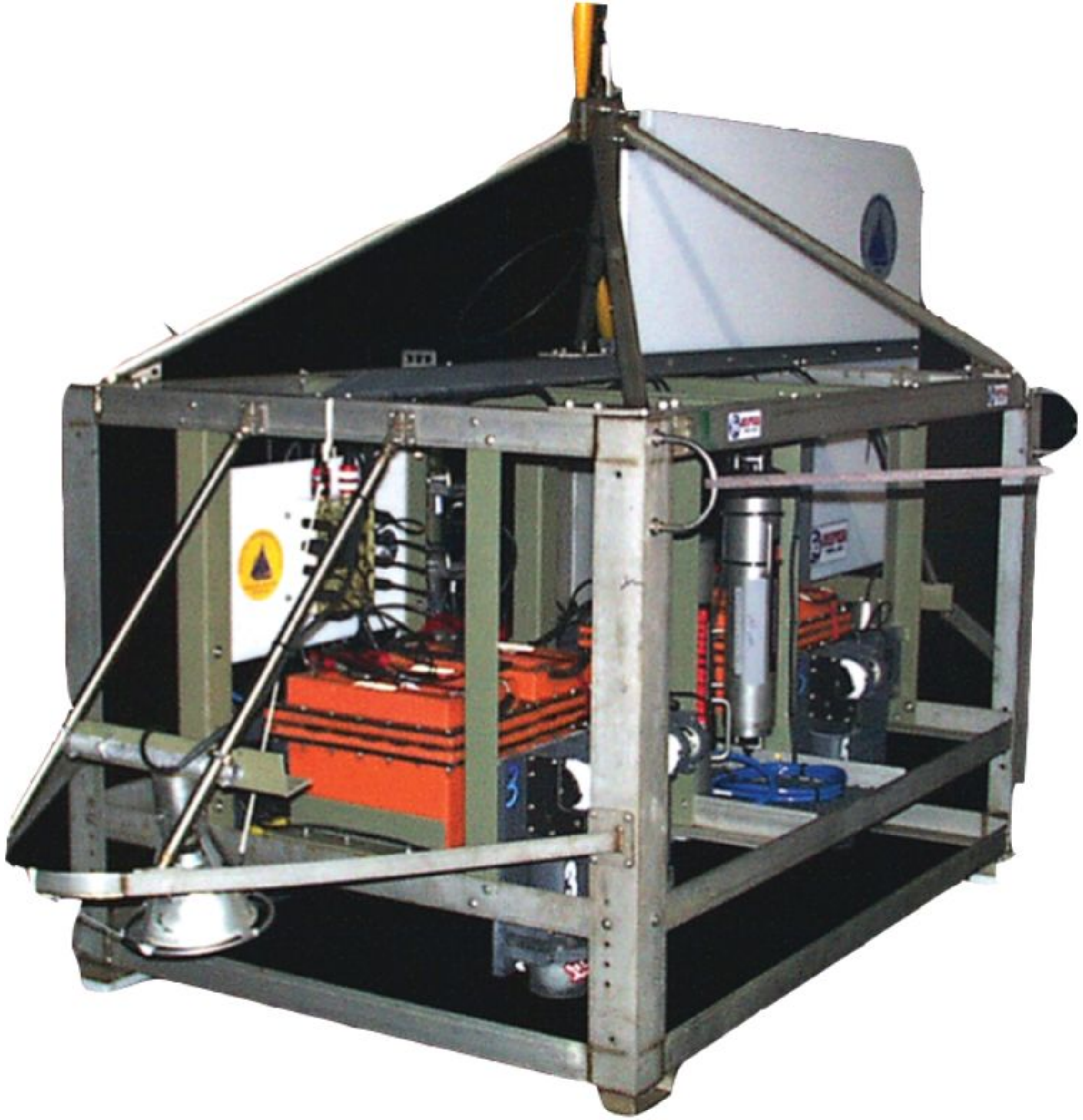
To be discussed in detail Day-2 morning

Wax Coring

- An effective method for recovering volcanic glass from the ridge axis or young seamounts
- A heavy core is dropped on the lava flow, glass is shattered and adhered to recovered wax
- A very rapid and effective means of sampling ridges, particularly valuable for transects

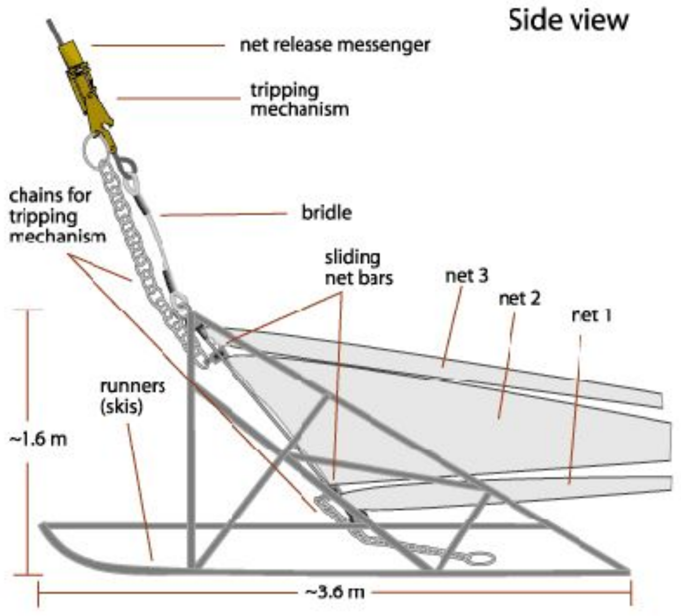
Wax Coring + Towcam

- This was a unique system developed at WHOI
- Allowed for video and still imagery of the seafloor followed by targeted wax coring
- Can be refurbished and rotated back into the UNOLS equipment pool



Epibenthic Sleds

- FeMn Nodule Sampling
- Modern sleds have video and CTD systems
- Uncertain of the status in the UNOLS pool
- Mostly used in biology



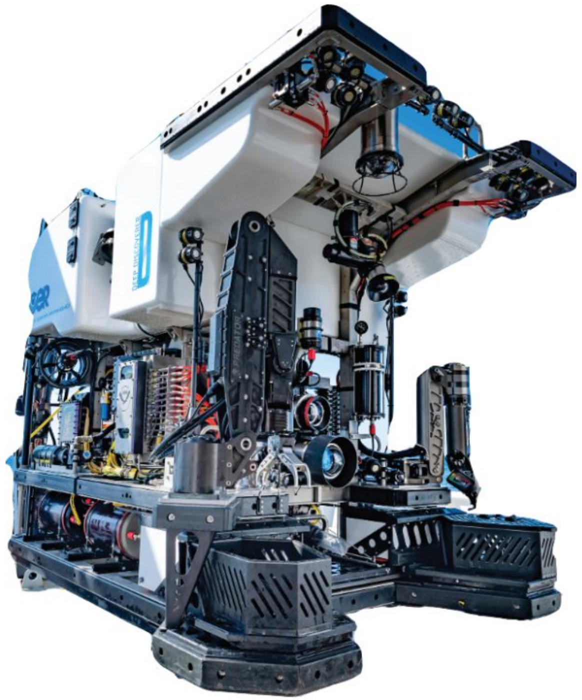
Additional Opportunities for US scientists outside NSF

NOAA

Ocean Exploration (OR).

- Runs R/V *Okeanos Explorer*, which undertakes ROV exploration expeditions to (primarily) US territories
- Provides exploration grants using other ships
- Partners with researchers for sample availability

ROV *D2.* Takes mostly bio samples and water etc, push cores, previously not used much for rock sampling…



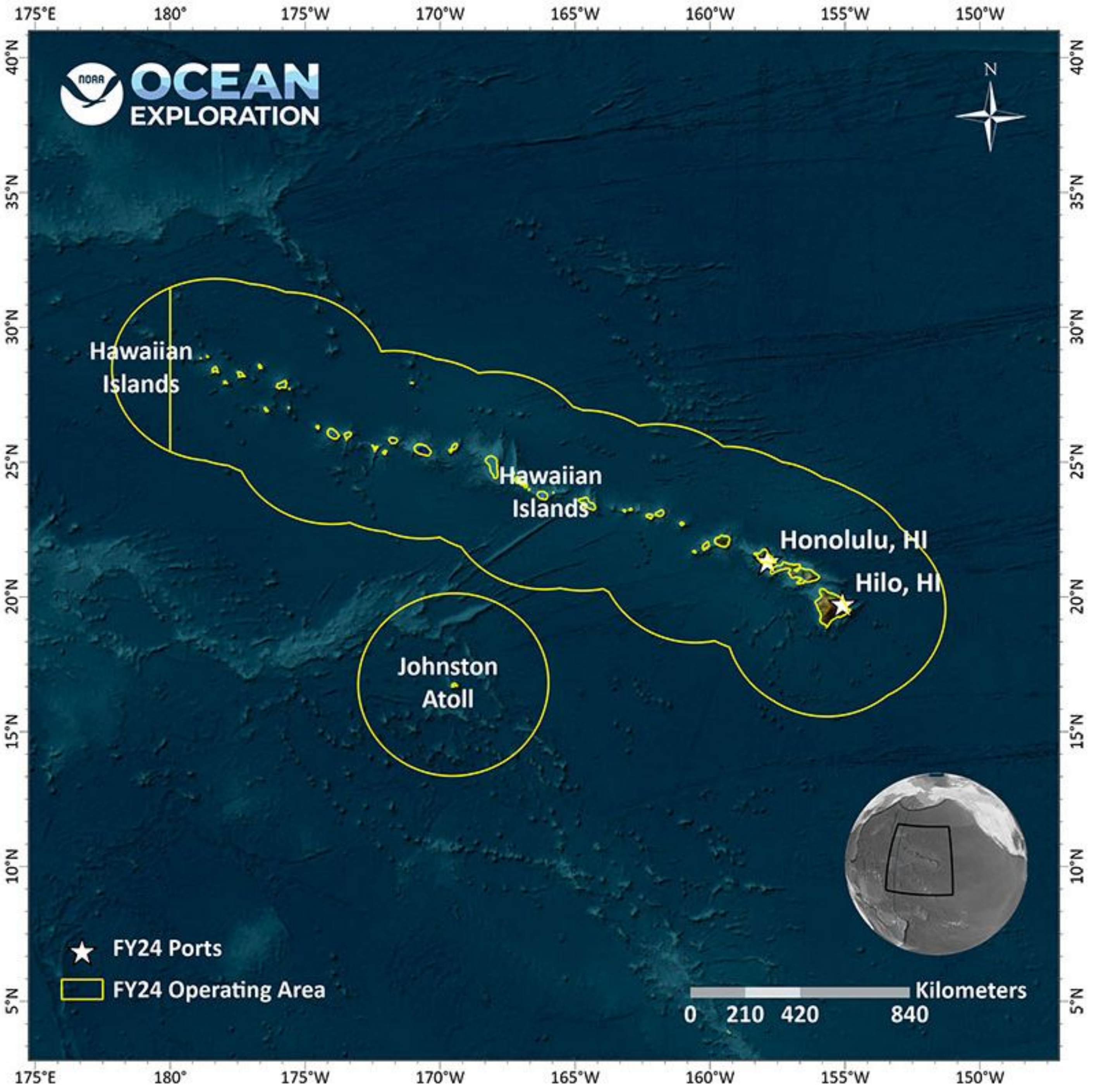
R/V *Okeanos Explorer*

Additional Oppo

NOAA

Ocean Exploration (OR)

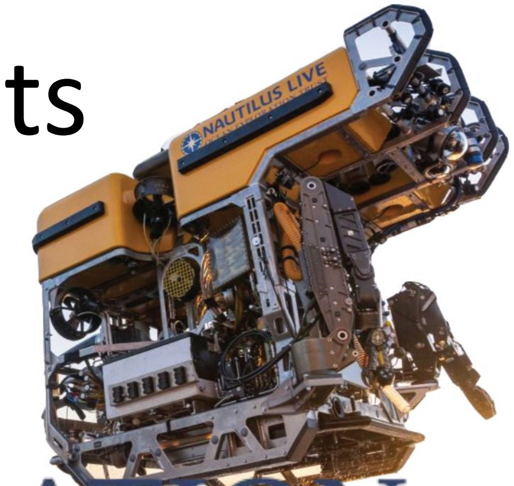
- Current FY24 operations area



Speak to Thomas Morrow for more information

Additional Opportunities for US scientists outside NSF

ROV *Hercules*



Private/Institutional

SCHMIDT OCEAN INSTITUTE

- Runs R/V *Falkor* and ROV *Subastian* which undertakes ROV (and other) cruises through strategic partnerships/Eric and Wendy Schmidt Network
- Provides opportunities for ship use
- Partners with researchers for sample availability

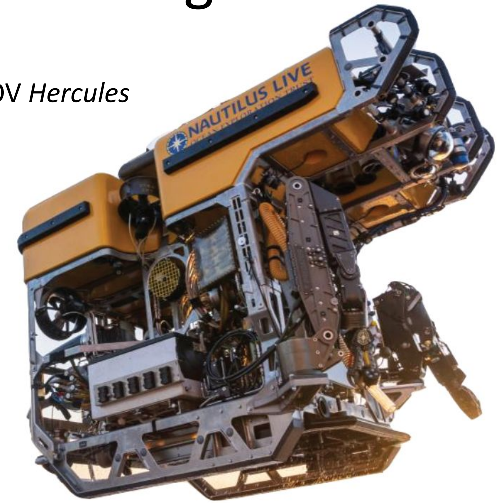
OCEAN EXPLORATION TRUST

- Runs E/V *Nautilus* and ROV *Hercules*
- Run primarily out of the U. of Rhode Island and funded through various partners
- Collects numerous rock samples in the ocean basin that are freely available for use

Additional Opportunities for US scientists outside NSF

OCEAN EXPLORATION TRUST

- 2024 expeditions
  - ROV work:
    - Jarvis Island region
    - US Samoa territories (including Vailulu'u)
    - Palau



ROV *Hercules*

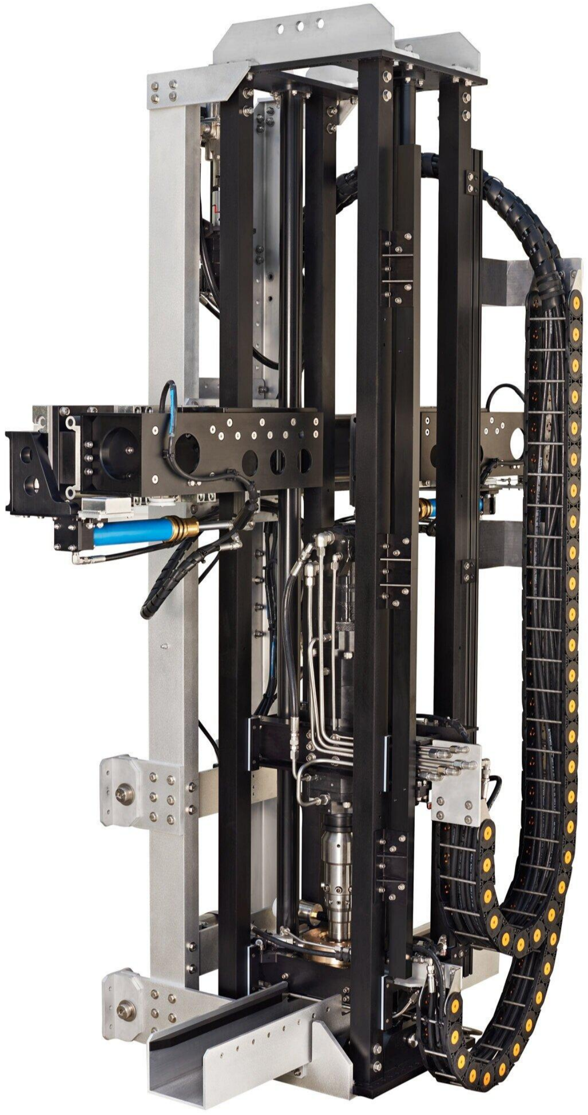
Technology outside the UNOLs system

Remote or Human Occupied Submersibles

- Rock drilling would be an invaluable tool for ROVs
    - Allows for sampling fresher rock materials
    - Allows for sampling FeMn, carbonate and phosphorite *in-situ* for seawater-substrate interface studies
    - Orientated cores could be used in paleomagnetic reconstruction studies

- Natural resource industries have been developing a diverse array of ROVs (see McLean et al. 2020 – *Frontiers* for a great summary)
- Norway and Japan (and other countries) have been developing ROV drilling rigs

ROV Rock Drilling Example

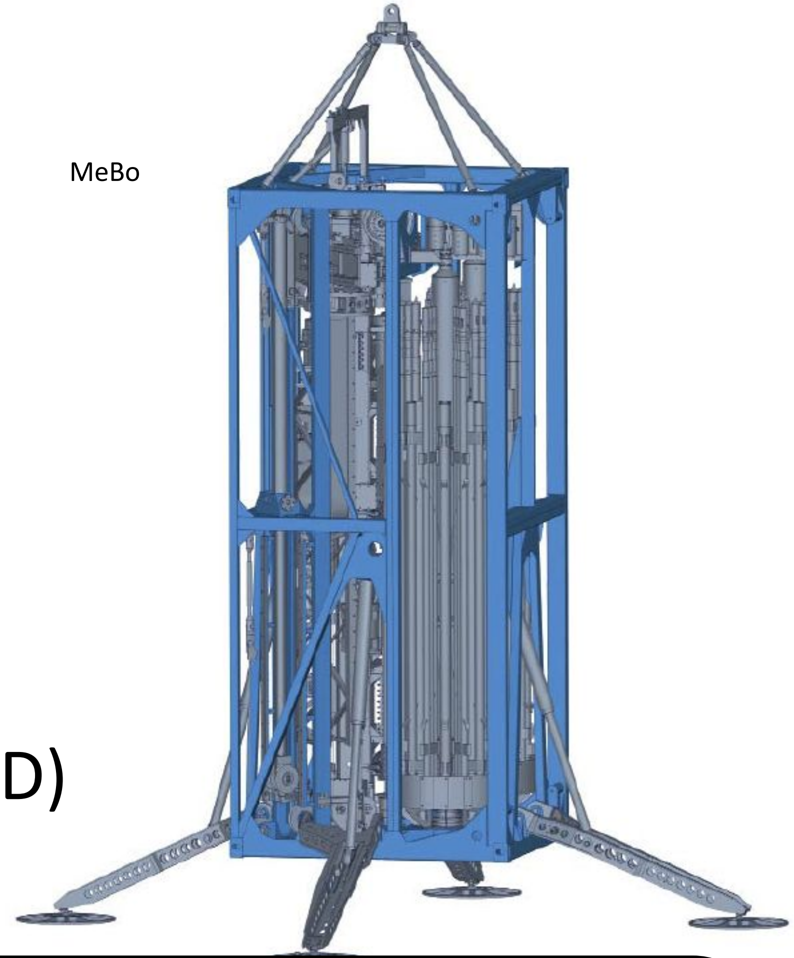


- Williamson & Associates developed some ROV drilling accessories
- Tested recently through JAMSTEC expeditions
- No published reports that indicate consistent reliable recovery

ROV *Hercules*

Over-the-side Lander Drilling

MeBo



Currently not available in the UNOLS system

- British Geol. Survey: RockDrill
- Japanese: Boring Machine Systems (BMS)
- Australian: Portable Remotely Operated Drill (PROD)
- German: MeBo (Meeresboden-Bohrgerät)

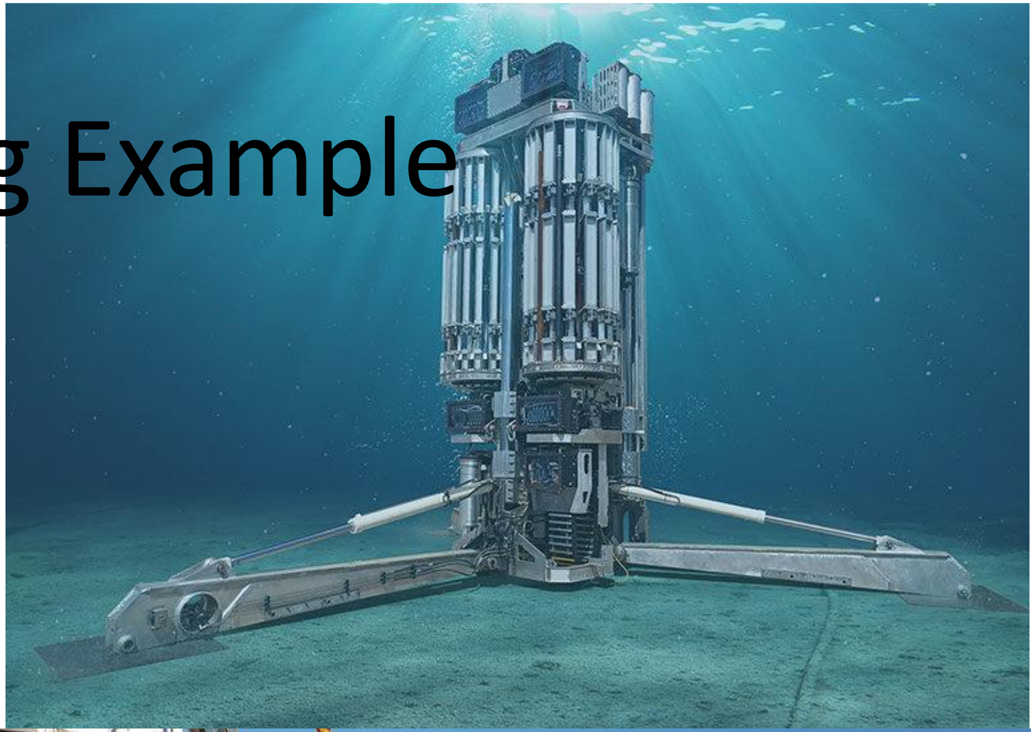
To be discussed in detail Day-2 afternoon

Over-the-side Lander Drilling Example

Over-the-side Lander Drilling

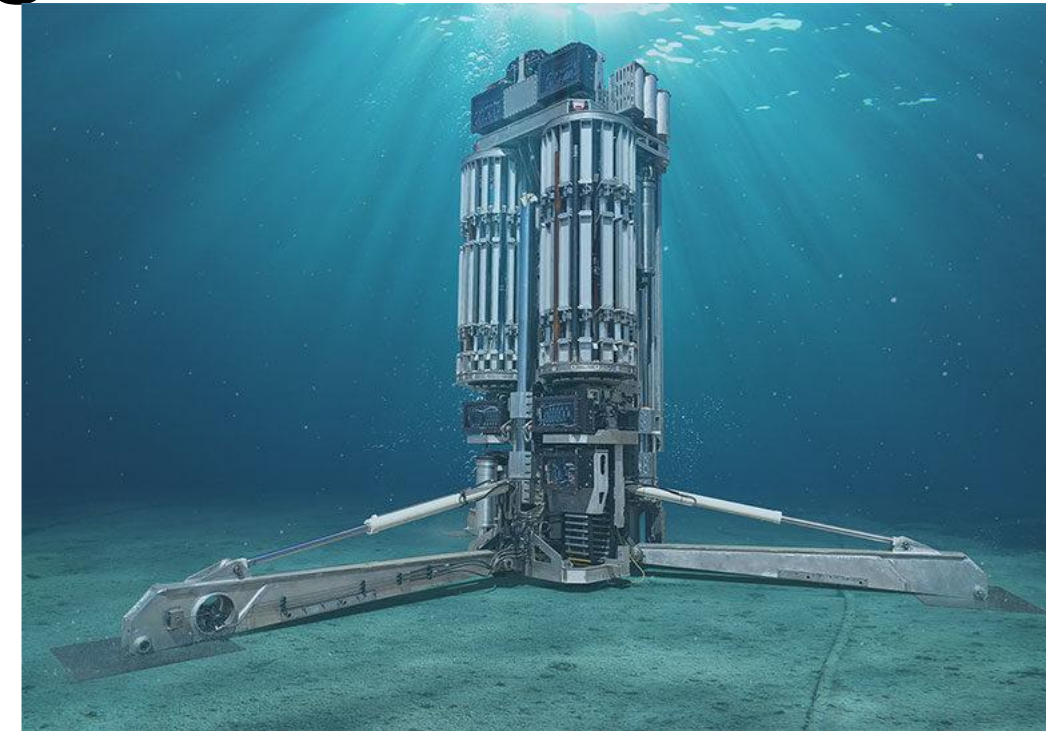
IODP 389

- Mixed (but pretty good) results on coral recovery using PROD
- Great lava flow recovery rates (>90%)!
- Cores lengths got to a little over 50 m
- Drilling in shallow waters



PROD: source Acteon

Over-the-side Lander Drilling



Over-the-side Lander Drilling

- Additional considerations:
- Produces high winch wire tension, and require significant deck space with specific fabrications
- None of the ARF vessels can handle deep water lander drilling
- R/V *Falkor* can potentially handle a wide range of depths but its not part of the ARF and will need to be retrofitted

Contacts and Information for Early Career Scientists Writing Proposals

- WHOI NDSF: https://ndsf.whoi.edu/
- OSU MARSSAM: https://marssam.ceoas.oregonstate.edu/

- Scripps: https://scripps.ucsd.edu/ships/planning
- Lamont: https://lamont.columbia.edu/research-divisions/marine-large-programs/office-marine-operations
- UW: https://www.ocean.washington.edu/story/Cruise_Planning
- UH: https://www.soest.hawaii.edu/UHMC/index.php
- Alaska: https://www.sikuliaq.alaska.edu/ops/
- Other links: https://www.unols.org/ships-facilities/unols-vessels/other-facilities