Sediment sampling aboard the United States University National Oceanographic Laboratory System (UNOLS) Ships

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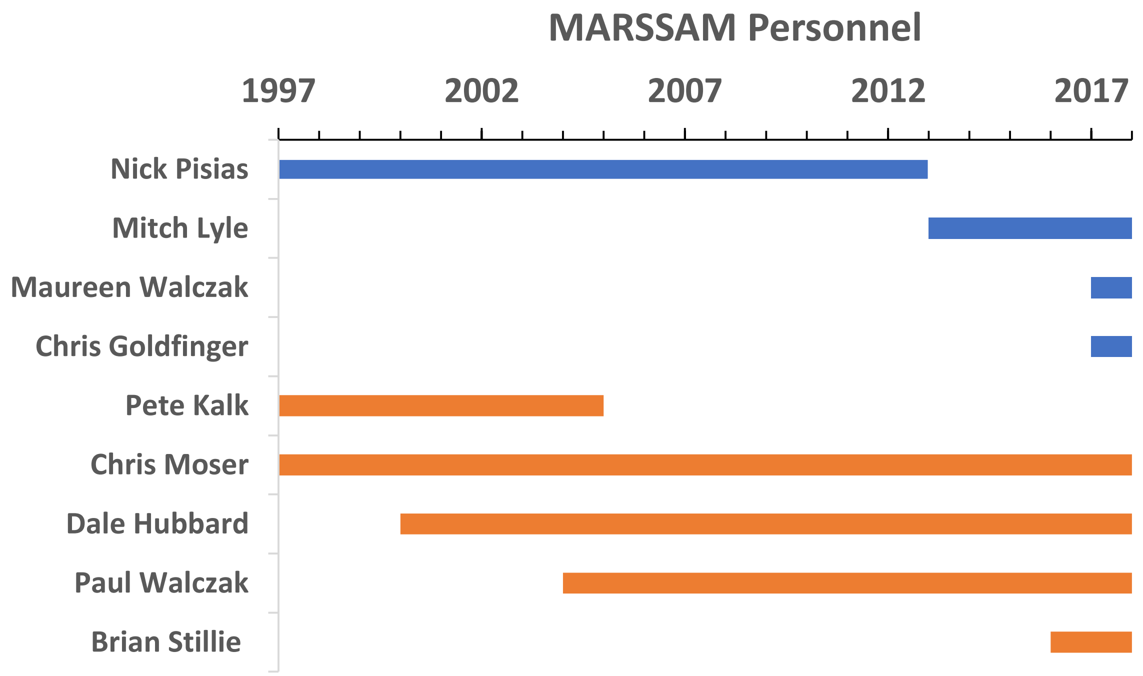
What is the U.S. Marine Sediment Sampling (MARSSAM) Facility?

- Prior to 1997 National Science Foundation (NSF) ***investigators responsible on an individual basis*** for requesting all funding necessary for sediment coring

- However, all sediment cores collected with NSF funding become available to the broad scientific community after brief moratorium

- At 1997 Future of Marine Geoscience (FUMAGEGS) meeting, it was decided that ***a central facility should exist*** to support coring for all NSF-supported PIs

- Now a 25-year-old national facility based at Oregon State University



What are the responsibilities of MARSSAM?

- Maintain, repair, and design new coring equipment suitable for U.S. scientific research platforms (University-National Oceanographic Laboratory System or UNOLS vessels).
- Provide expert advice to PIs seeking marine geology samples for a wide variety of research goals
- Provide logistical support: shipping and staging gear, and returning and archiving samples
- Provide archival materials, multi-sensor track for shipboard logging of sediment physical properties, and training in the operation of that instrument as well as interpretation of physical properties and sub-bottom profile data
- Provide shipboard support for shipboard sampling operations, most importantly complex jumbo piston coring systems

Piston cores

“In order to obtain long cores from the ocean floor two fundamental difficulties have to be overcome: ***first*, the problem of imparting to the coring tube sufficient energy to embed itself in the sediments**; and ***secondly*, the problem of preventing thinning of the sedimentary layers inside the corer by friction between the sediment and the inner surface of the tube**. Dr. Kullenberg's new core-sampler, developed in Sweden during the War, has been designed with the object of overcoming these difficulties.”

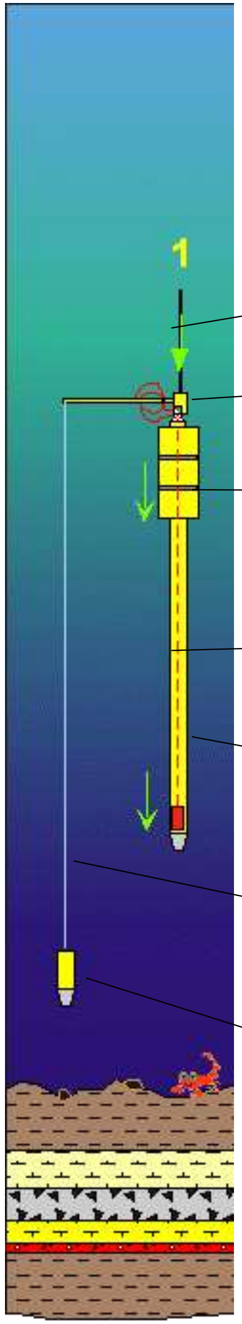
The Piston Core Sampler. By B. Kullenberg. *SvensJca HydrografisJc-Biologiska Rommissionens skrifter.* Tredje Serien: Hydrografl, Band **1**, Hafte 2, 1â46 (1947).

Why does science want longer cores?

High resolution sediment sequences allow us to resolve environmental events at a resolution meaningful to society

More time at higher resolution → need longer cores

Typical Jumbo Piston Coring (JPC) System



Ship’s rope or wire (9/16” trawl or equivalent)

Trigger arm (you could use an acoustic release here if desired). The SCOPE is the coiled part shown attached to the arm – feet of scope = feet free fall

Weight stand (it is hollow so that things can pass through it), loaded with lead ‘pigs’

Pendant (RED – this part comprises the free fall part of the core and runs from the trigger arm to the piston.. The PISTON is the red block at the bottom.)

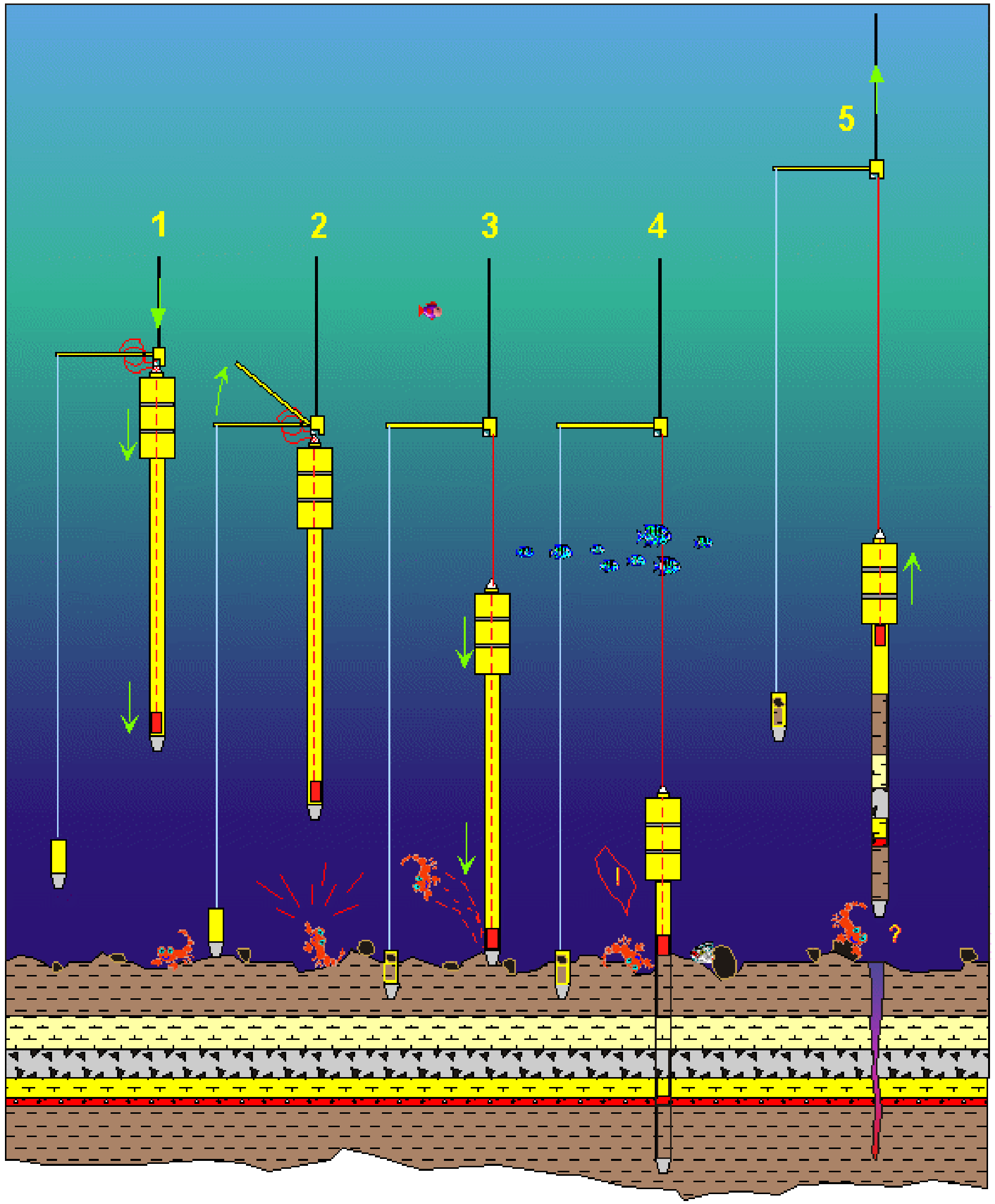
Core barrel (10’ steel barrels lined with PVC for easy extrusion and archiving of sediment sample)

Trigger line (holds trigger core in appropriate position, allows trigger core load transfer)

Trigger core (small gravity core that provides the counterweight holding the jaw of the trigger arm closed – when this weight is slacked due to hitting the bottom the piston core falls freely into the sediment consuming the SCOPE of the pendant)

Figure from: http://geologie.mnhn.fr/Collection_Marine/moyens_mer/Engins_de_prelevements_eng.htm#PISTON_CORER

Typical JPC Coring Sequence



1) Piston core in deployed state.

2) Piston core as trigger core hits the bottom. The trigger arm no longer has weight on it and rotates upward compared to the piston core. BETWEEN STEPS 3 AND 4 THE CORE FREE FALLS

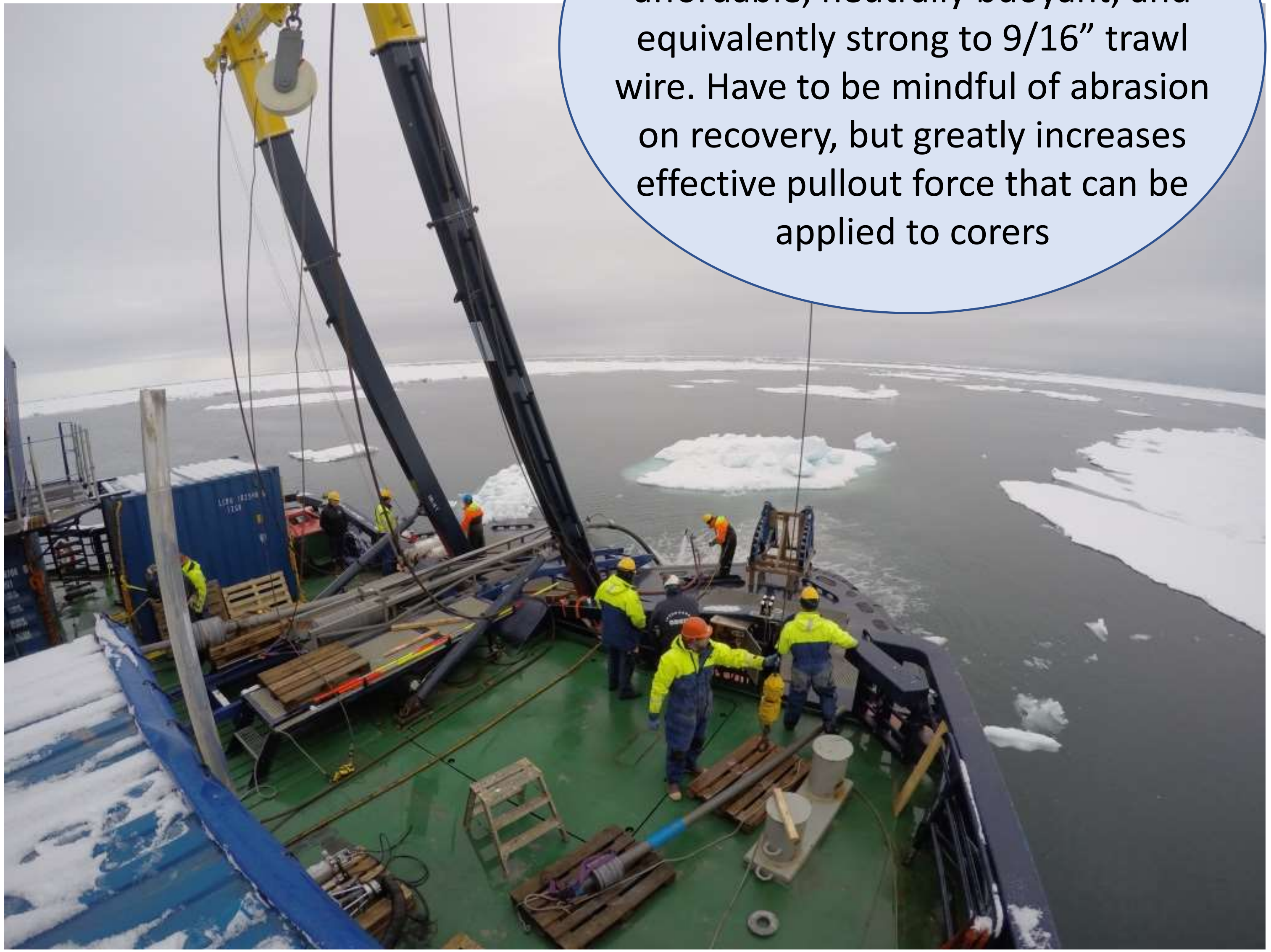
3) Piston core hits the bottom. SCOPE is consumed, piston stops travelling just at the sediment/water interface.

4) Piston core slides into sediment until coming to a stop against the piston (the PISTON STOP internal to the piston core makes contact with the PISTON)

5) Piston and trigger core are pulled out of the bottom by ship's rope/wire and make their way to the surface for recovery

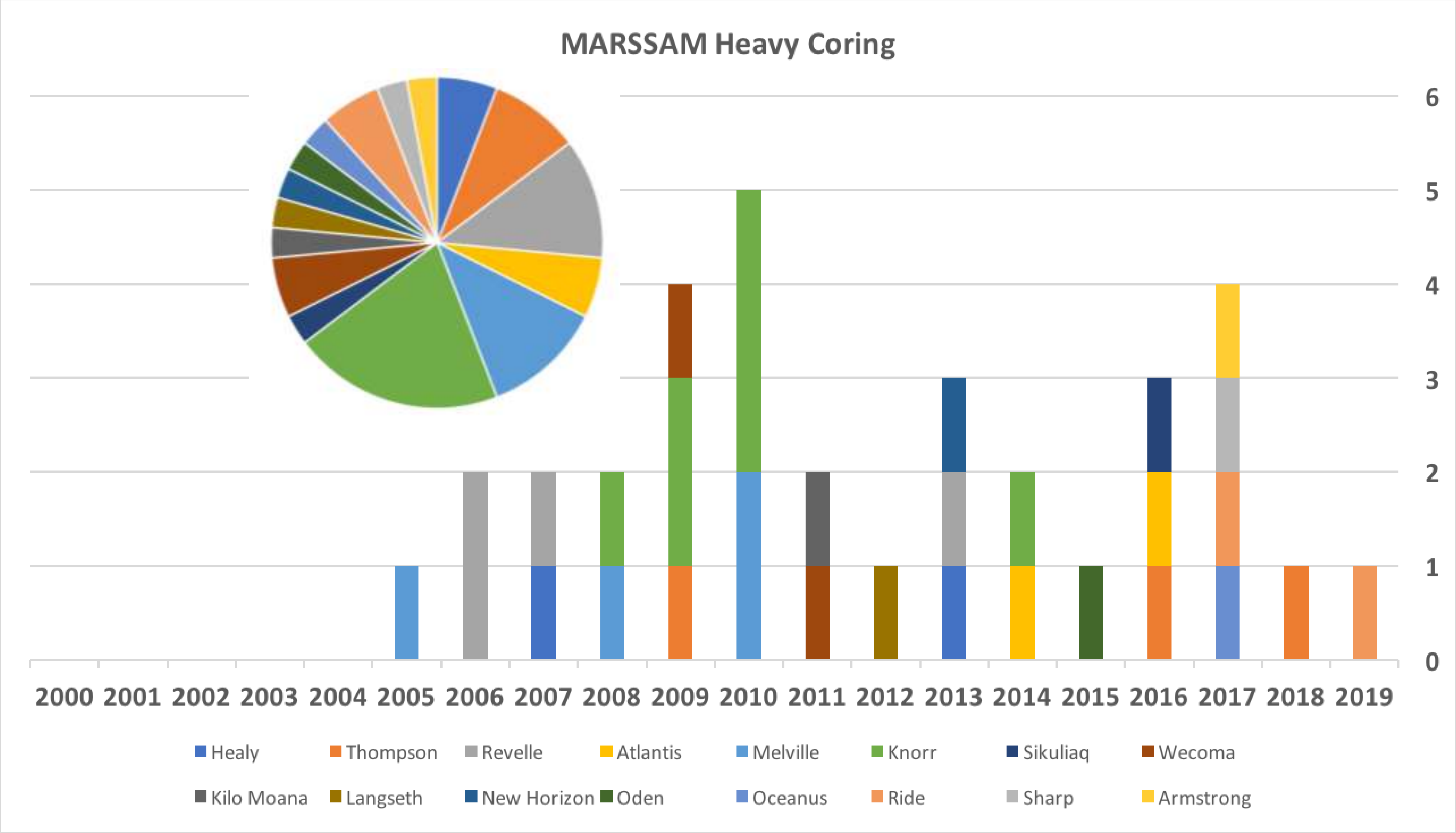
Piston coring limitations:

- Deployment platform (bigger ship=bigger core)
- Wire/rope strength
- Weather
- Sediment type (sand=bad, certain sediments “plug” the corer even with piston)
- Note that **allowable pullout tensions** and **fantail/rail length** are the biggest limitations to what we can accomplish with JPC systems aboard UNOLS ships



Synthetic line (as used for coring from IB Oden in this image) is affordable, neutrally buoyant, and equivalently strong to 9/16” trawl wire. Have to be mindful of abrasion on recovery, but greatly increases effective pullout force that can be applied to corers

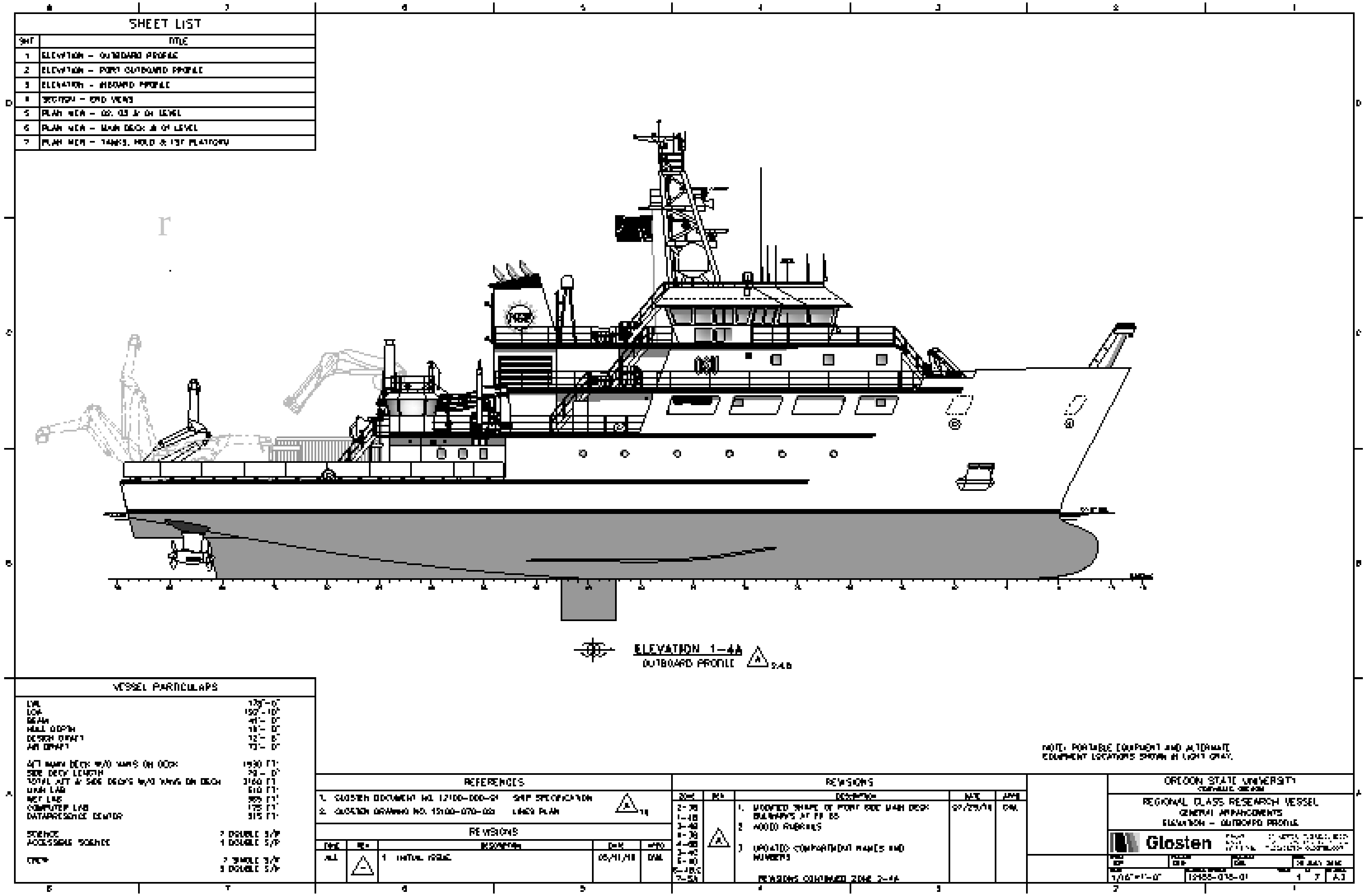
What ships are used the most (2000-2019?)



Ship	Age
Knorr	69
Melville	69
Ewing	65
Endeavor	75
Oceanus	75
Atlantic Explorer	
Langseth	
Thompson	90
Revelle	95
Atlantis	95
Sikuliaq	2012
Armstrong	2014
Ride	2014

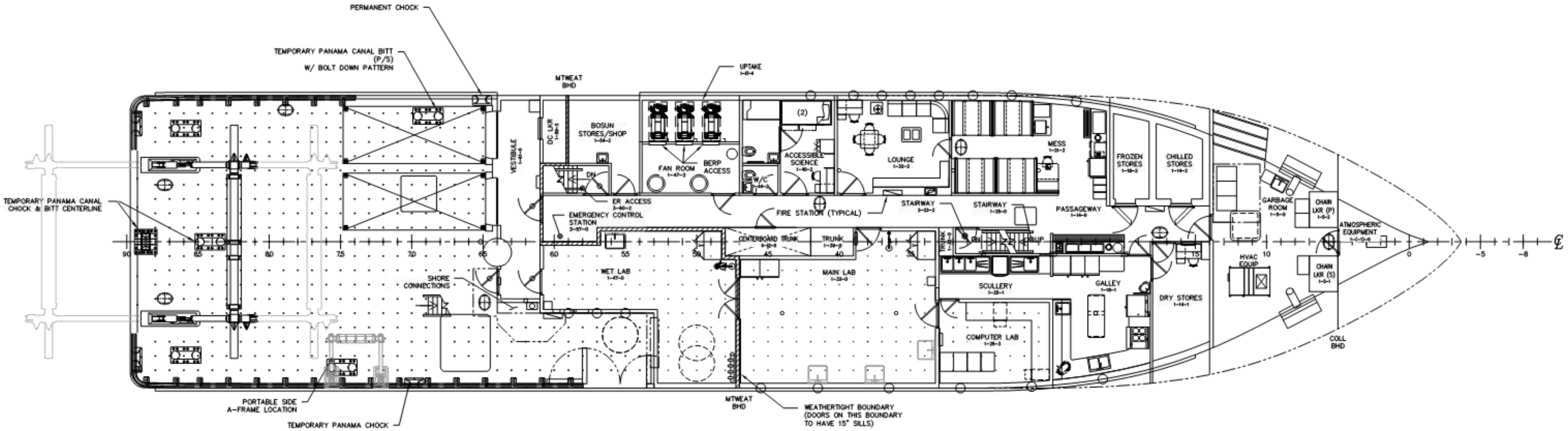
Regional Class Research Vessel(s) (2020?)

Regional Class Research Vessel(s)



What coring can Regional Class do?

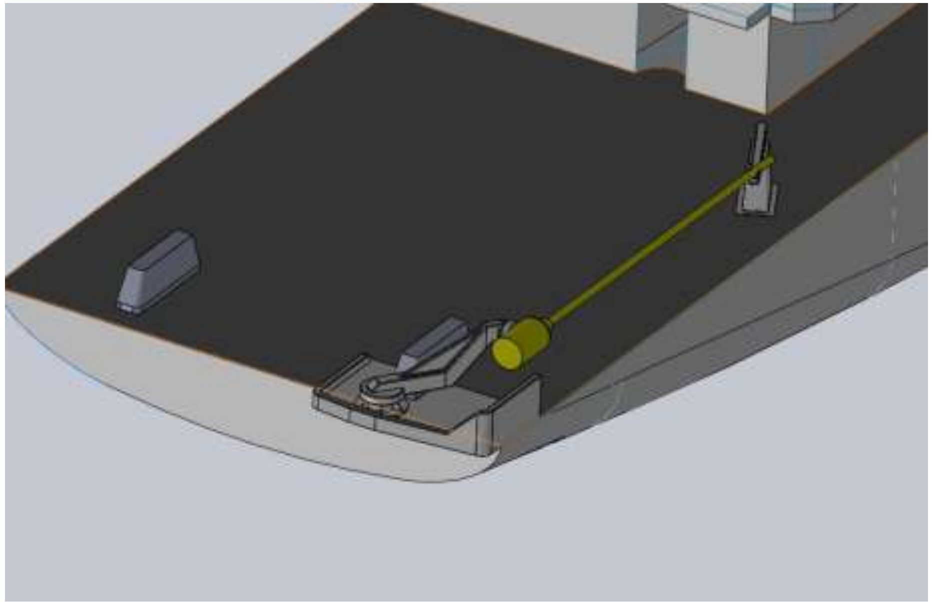
We **cannot** put equipment overboard off the rail on these ships.

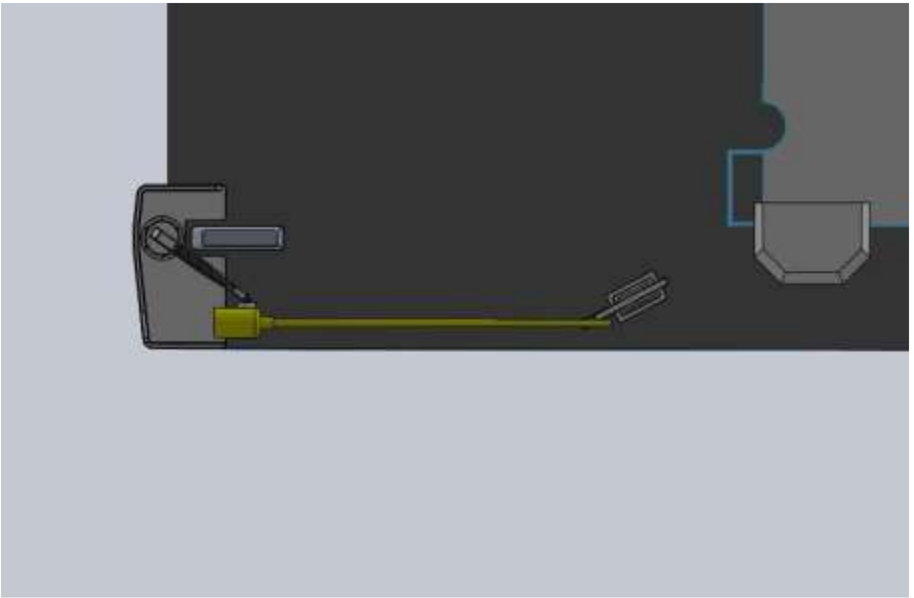


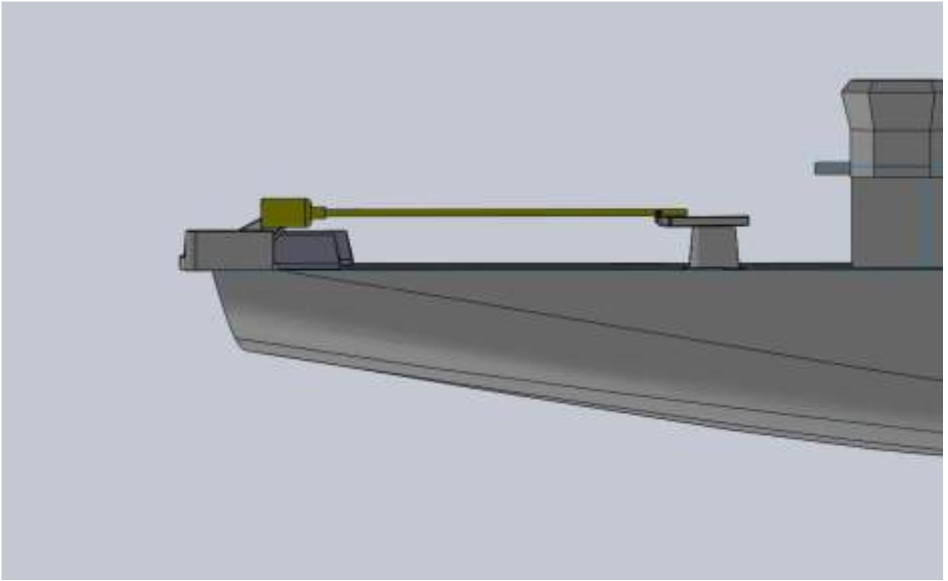
MARSSAM proposed solution to RCRV limitations:

A hydraulic swing arm system that moves the corer from the rail to the A-frame

Position 1: Inboard of starboard rail







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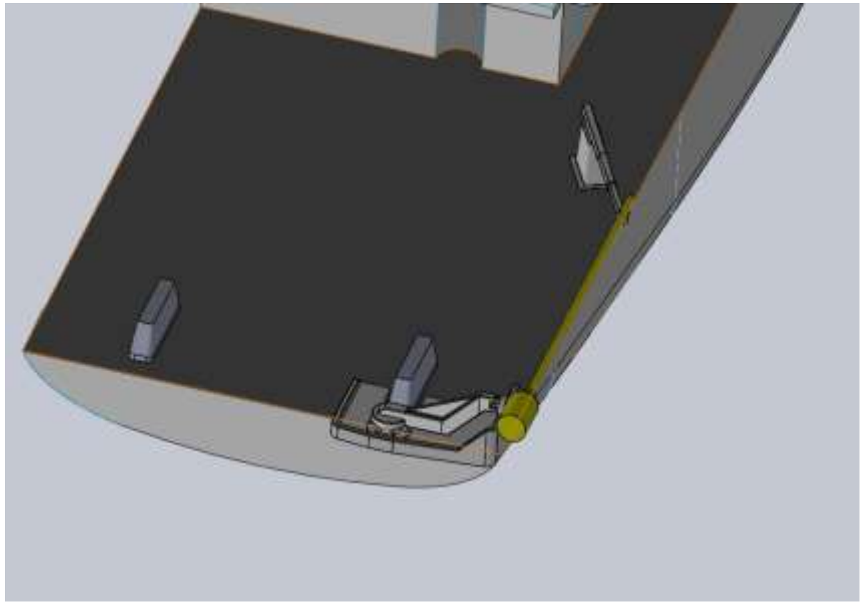
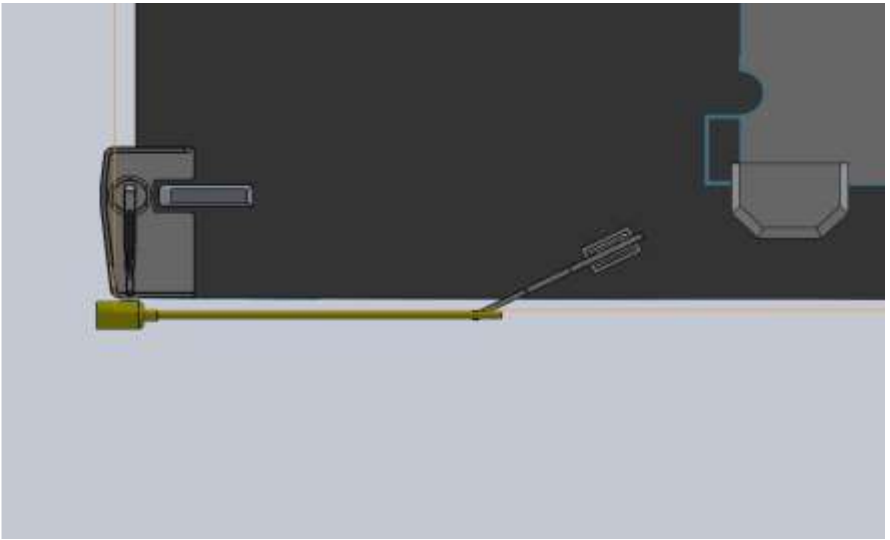
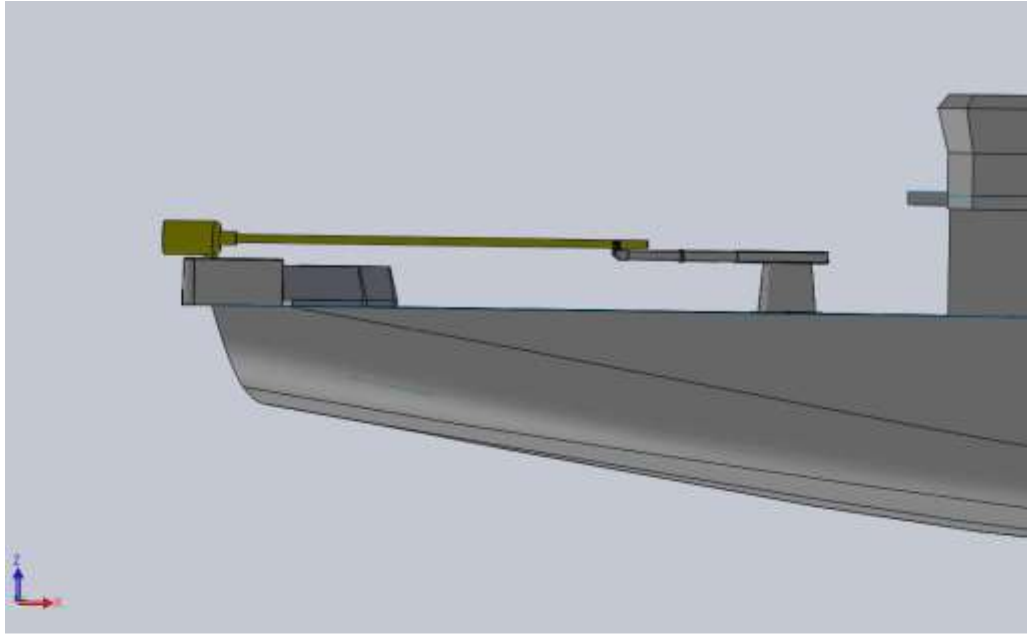
Position 1: Inboard of starboard rail

Position 2: Outboard of starboard rail







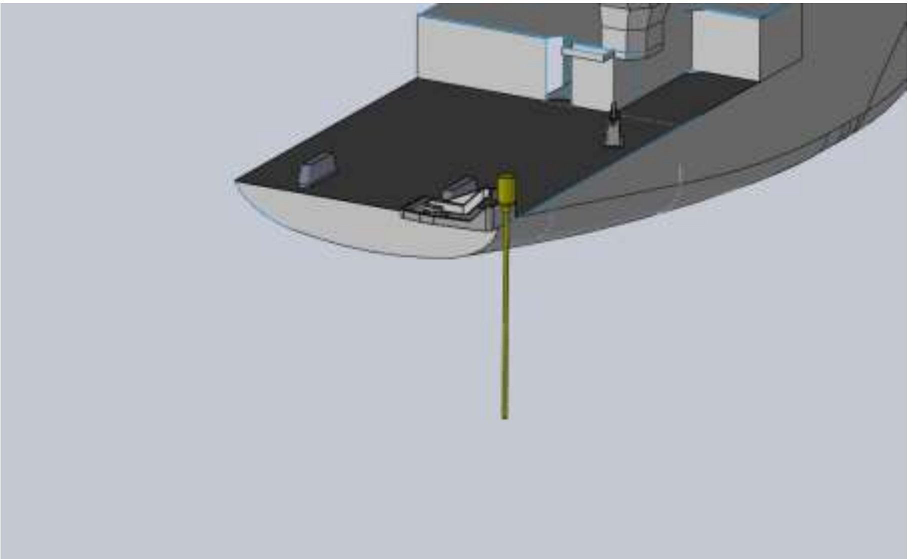
MARSSAM proposed solution to RCRV limitations:

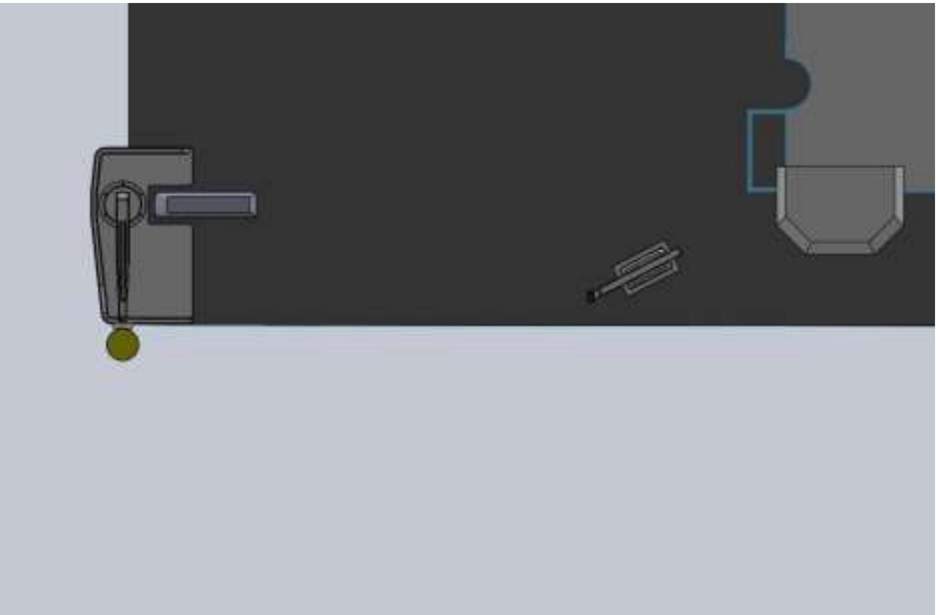
A hydraulic swing arm system that moves the corer from the rail to the A-frame

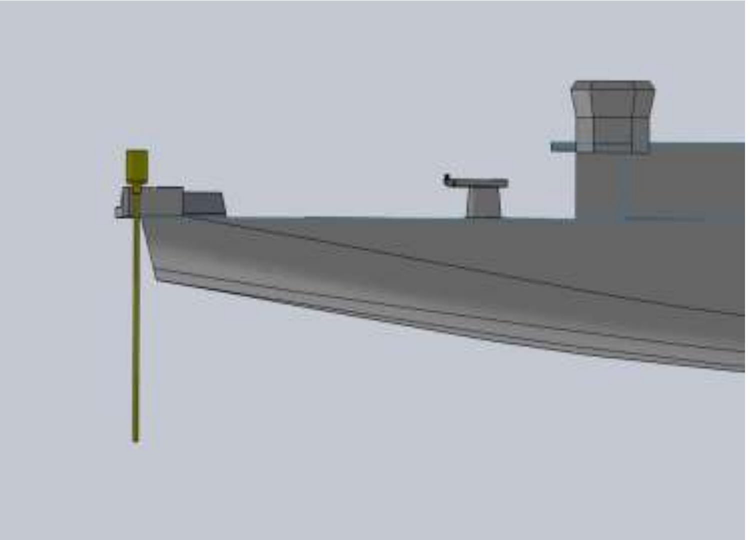
Position 1: Inboard of starboard rail

Position 2: Outboard of starboard rail

Position 3: Vertical off starboard aft quarter







MARSSAM proposed solution to RCRV limitations:

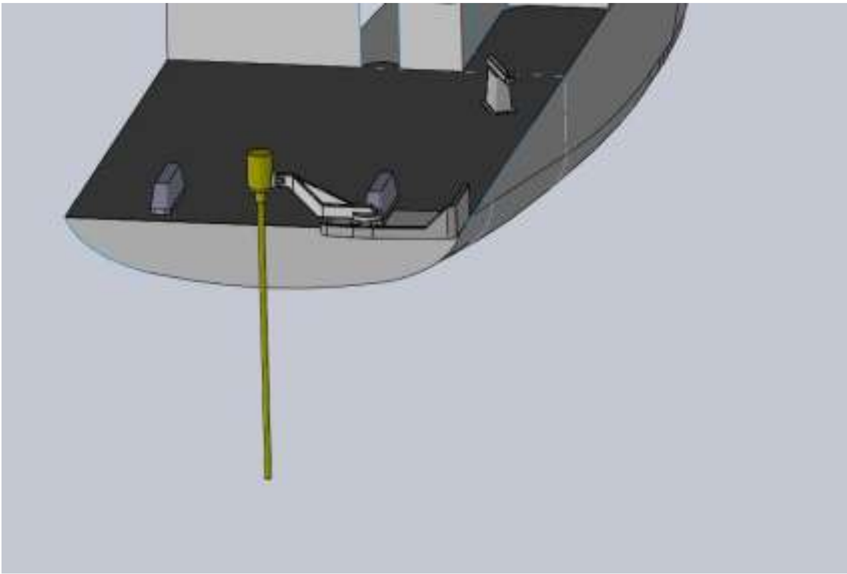
A hydraulic swing arm system that moves the corer from the rail to the A-frame

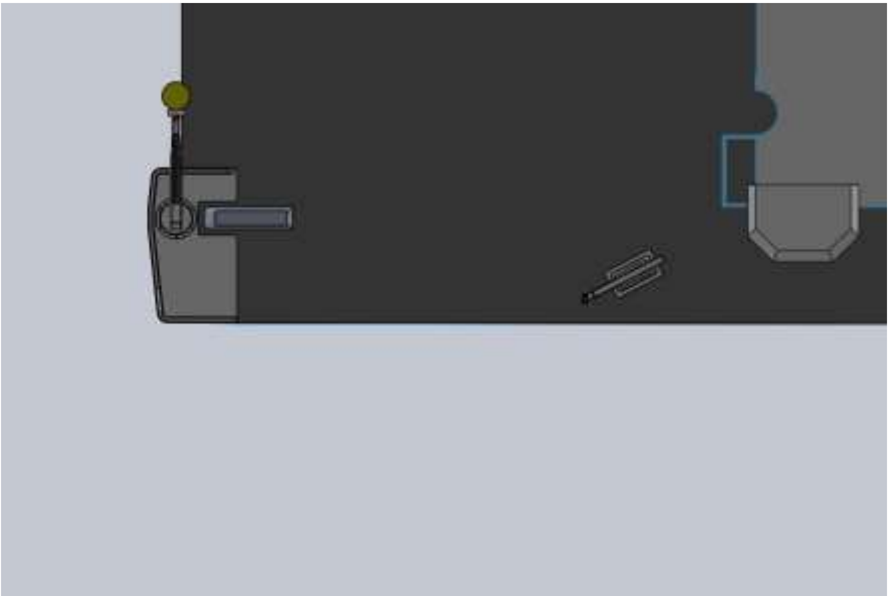
Position 1: Inboard of starboard rail

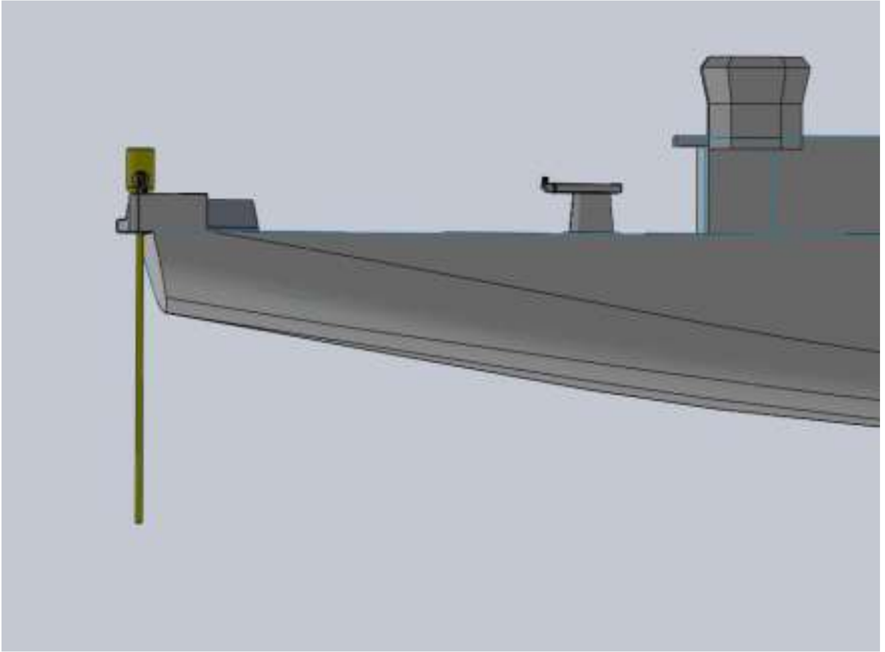
Position 2: Outboard of starboard rail

Position 3: Vertical off starboard aft quarter

Position 4: Vertical off center stern







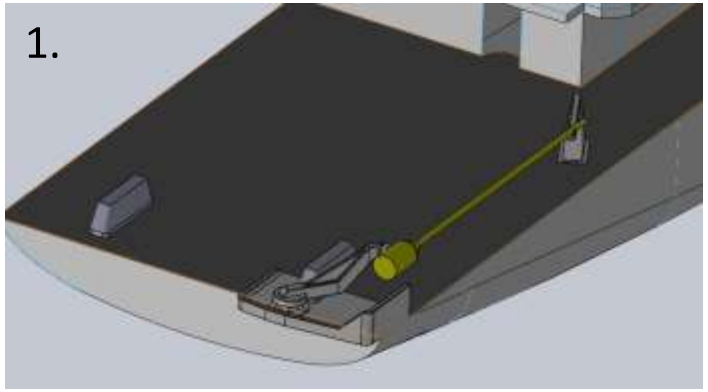
MARSSAM proposed solution to RCRV limitations:

Preliminary examination of concept by Glosten/Einhorn Engineering for functionality and weight suggests it is a feasible design that will have minimum operational impacts

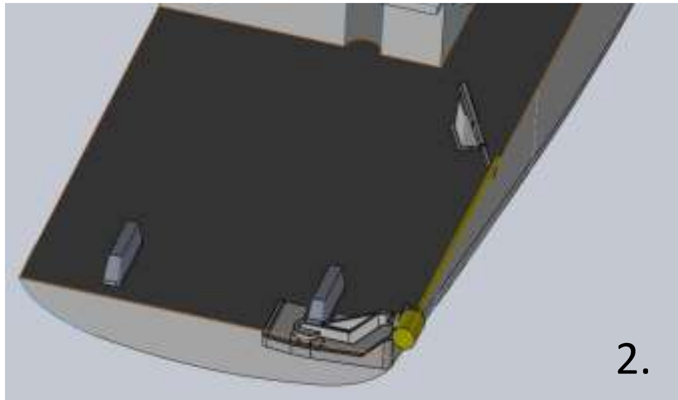
Advantages: Moves coring system entirely out of A-frame allowing for deployment of other equipment, gets corer on supports inboard of starboard rail for ease of core processing, system remains captured in bucket at all points post-recovery

Disadvantages: Simplest solution we could design, but still way more complicated with more potential points of failure (e.g. hydraulics) than just coring off the rail.

Why have we surrendered this capability in our new ships??



1.



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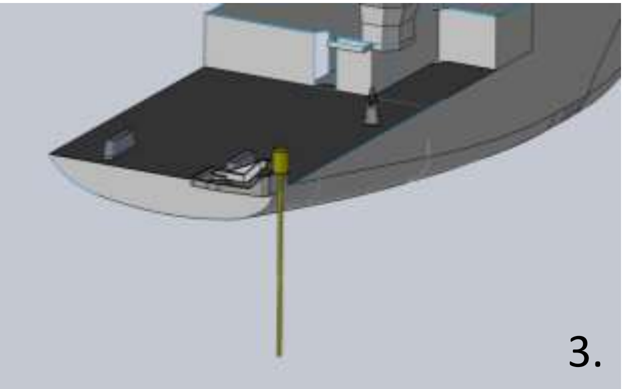

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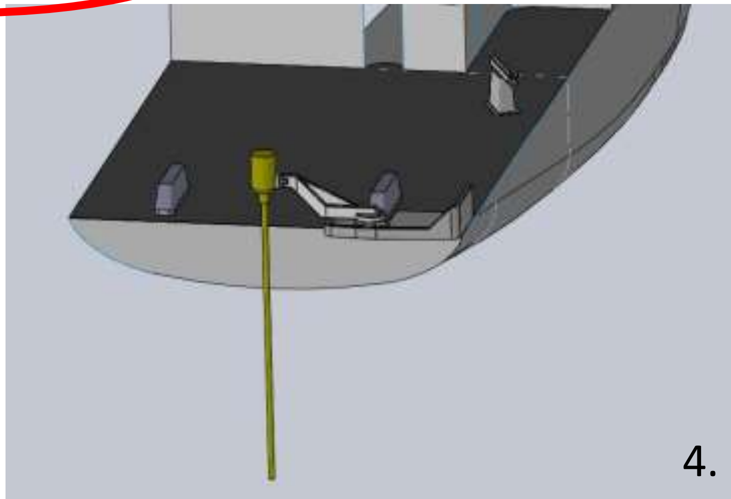
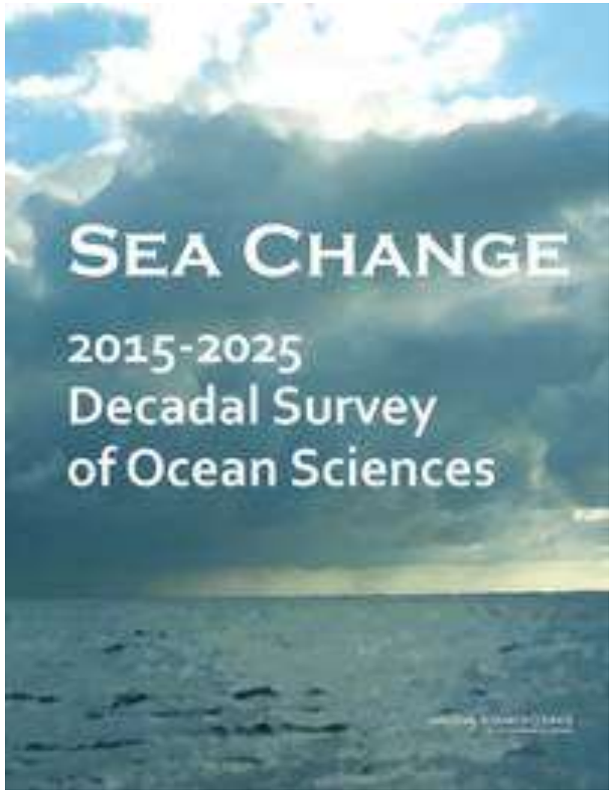


4.

What science may want moving forward: Sea Change 2015-2025



CONTRIBUTORS:

Committee on Guidance for NSF on National Ocean Science Research Priorities

Decadal Survey of Ocean Sciences

Ocean Studies Board

Division on Earth and Life Studies

National Research Council

Sea Change "Priority Science Questions" (8)

1. What are the rates, mechanisms, impacts, and geographic variability of sea level change?
2. How are the coastal and estuarine ocean and their ecosystems influenced by the global hydrologic cycle, land use, and upwelling from the deep ocean?
3. How have ocean biogeochemical and physical processes contributed to today's climate and its variability, and how will this system change over the next century?
4. What is the role of biodiversity in the resilience of marine ecosystems and how will it be affected by natural and anthropogenic changes?

Sea Change “Priority Science Questions” (8)

5. How different will marine food webs be at midcentury? In the next 100 years?
6. What are the processes that control the formation and evolution of ocean basins?
7. How can risk be better characterized and the ability to forecast geohazards like mega-earthquakes, tsunamis, undersea landslides, and volcanic eruptions be improved?
8. What is the geophysical, chemical, and biological character of the subseafloor environment and how does it affect global elemental cycles and understanding of the origin and evolution of life?

What Science may want moving forward:

- Cores from areas that are increasingly marginal to recover cores from
  - *Shallow water depths (<100m and usually sandy or coraline)*
  - *Very deep water depths (>5000m)*
  - *High latitudes (bad weather, ice)*
- Longer cores
- More cros ... ts, buoys)
  - *This* ...
  - *OR* ...
- Free-fa ...
- More ins ... *, compass information,* ...
- Increased reliabili ... *es, heave compensated winches, stronger wire and rope)*

WE NEED TO MEET PEER-REVIEWED NEEDS OF SCIENTIFIC COMMUNITY.

THIS MANDATE IS WHY WE EXIST.

Take Home Points:

- Bones of piston coring system essentially unchanged for decades, **because length of recovered cores is at this point primarily limited by the ships we core from (and their wires/winch systems)**
- Longer cores are easier to achieve on ships with starboard side deployment capabilities with max length of core limited by rail length
- If coring over stern with railroad track cores begin to buckle under own weight at ~50’
- *Paradoxically given priority science goals emphasis on long, high-res records, new UNOLS vessels* ***have largely lost*** *over-the-rail trawl wire working options*
- Maximum pullout tension of core is another hard limit set by the ship, and increases with length of barrel, depth of penetration, sediment type, and **weight of wire**
- Synthetic rope is effectively stronger and lighter, with no elastic limit, we should be making this switch to get the most from our ships.