ARV Science Advisory Sub-Committee of the OPP Advisory Committee

Report on DR #2, September 9, 2022

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INTRODUCTION

In preparation for Design Review #2, we reviewed nearly 60 documents, including performance reports, deck and topside drawings, and system descriptions. In addition, on August 16th and 17th, we listened to two-days of in-depth presentations from the Contractor, detailing the status of ship design, information that added to our understanding of the documents and to the rationale for planned changes in design. Together with committee discussions, the documents and the presentations form the basis for our report, the second of a four part iterative process. We note that the ship design is evolving, as are our recommendations, and emphasize that this is a work in progress.

We focus on (1) changes in design that are needed in order to achieve science mission requirements, (2) General Arrangements / Science Space Arrangements (Main deck and other science spaces, common areas and private space), (3) Handling and Scientific Package Deployment, and (4) Workflow for specific activities (Battery-assisted science missions, Marine Mammal Operations (MMO) science, Science Small Boat Use, Back Deck Operations and Workflow, UAV deck and hangar).

SECTION 1: General Observations on large scale changes to ship design

Based on analytical work completed by the contractor, changes have been made to the ship's design to meet icebreaking capacity, range and endurance requirements, and to comply with seakeeping requirements. The ship design is now at 365 ft LOA and 80 ft beam. In brief, the changes are driven by analyses which documented that the initial smaller ship design was unable to meet the following three objective requirements:

- Icebreaking – to achieve the objective of breaking 4.5 ft ice @ 3 kts the ship needs to have heavier and larger pods and machinery. This necessitates a larger ship to provide the support.
- Fuel Oil Capacity – the volume of the hull and the limit of the draft (based on need to work at the Palmer Station Pier so a 28 ft draft limit) place a limit on the amount of fuel oil. Range and endurance calculations based on all three Design Reference Missions (DRM) fell significantly short of being able to achieve the outlined 90 day missions (only ~57-70 days of the required 90 for each DRM).
- Intact Stability - to meet seakeeping requirements, the length to width ratio has been adjusted, resulting in a wider ship.

Several added benefits resulting from these changes include:

- The ship's superstructure can be reduced in height, with the spaces on the previous 05 level (fan room, bridge electrical room, crew office, emergency generator room, ADA WC) accommodated elsewhere.

- A larger weather deck area will increase the working space available for incubation studies and/or small boats and/or a greater area for more easily accessible van space on the main aft deck.
- The larger ship also enables an increased number of single staterooms, with potentially 6-8 additional single staterooms for the science complement.
- In addition, the increased size may result in the movement of the stack back to the port side instead of a centrally located stack. The central location for the stack was less than optimal, as it resulted in a main deck passageway that would be more difficult to navigate and potentially blocked 360 degree observation from the Marine Mammal Observation space.

We recognize that community members may ask how the increased ship size might impact the possibility of including a helicopter deck and hangar in the updated design, for example through expansion of the UAV deck and hangar. We note the ongoing dialogue, via a letter from the community to NSF Polar Programs, and the continuing conversation between colleagues and the NSF.

SECTION 2: General Arrangements

SECTION 2.1:
Concerns General Arrangements Science Spaces:

We continue to be concerned about the location of many of the science spaces on the main deck, especially their location relative to one another. We recognize that with changes in the length and beam of the proposed ARV and the re-location of the stacks to the port side, the specifics of lab space design will change as well. For this reason, rather than addressing the details presented on the P1 General Arrangements document, we re-emphasize the prioritization of the aft placement of “wetter” labs (Wet Lab, Aquarium Room, Hydro Lab) and the forward locating of “drier” lab spaces (Server space, “Electronics” Lab, Science Office, Forward Dry Lab). Location concerns are based on the ease and efficiency of workflow which depends on how spaces are connected to one another and how these arrangements facilitate safe and easy movement of heavy, awkward and potentially messy instruments and samples. We encourage the placement of more doors between labs to foster flow between labs. We also suggest renaming several of the labs (e.g., the Bio Lab as the Bio-Chem-Analytical Lab), to better reflect the activities that will be housed in those spaces, and to alleviate potential confusion about how we envision each lab will be used. This impacts details of both optimizing locations, and also General Space Arrangements - details of design of individual labs. Some of these details are “hardwired” into the ship design (sinks, hoods, sediment traps, floor drains, temperature control), while others relate to interior arrangements and specifics of materials outfitting each lab. To facilitate organization of our concerns, we provide evolving details in table format for all science-specific spaces; these tables appear at the end of this document. **Table 1** lists each space, recommendations for their relative location and connectivity to other spaces, and considerations for space arrangements within each lab. **Table 2** lists the science spaces and sizes allocated for each space in the 2022 Habitability Study, the 2019 SMR report (https://www.nsf.gov/geo/opp/opp_advisory/meeting_docs/may2019/RV%20Subcommittee%20final%20report%2014AUG2019.pdf), and the size of the space on the RVIB *NB Palmer* (https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/NBP_Systems.pdf).

SECTION 2.2:
General Arrangements Non Science Areas

Here we focus on spaces other than science spaces, addressing the general arrangement of both shared spaces, such as lounges and libraries, hospital, gym and laundry facilities, and private non-science spaces, such as offices and berthing. We recognize the importance of common areas that welcome the ship's crew, technical support staff and scientific party. These spaces encourage mingling during off hours, promote collegial relationships, and provide spaces to both unwind and work outside of staterooms and labs.

The **0-1 Deck Lounge/ Conference Room** is a space that could be used for both quiet activities (space for a conference table) and more social activities (cards, movies, comfortable seating), especially if it has a flexible divider that could be used to separate the two areas when needed. We appreciate that this space has been moved directly across from the mess, so that people would naturally "drift" into this space, an inviting location. This space would promote mingling between crew, science and staff.

Other common areas include:
0-4 Deck crew lounge and crew library –These two crew-only common spaces provide much-needed spaces for the ship's crew to relax and to work.

Three other large common areas are identified on the current deck layouts:
0-3 Deck Science Conference Room; This space could be used for science presentations, and as a common quiet work area, around a central conference table. This space, if large enough, could also function as a primary **muster space f**or the science party.
0-2 Deck Science Library and **02-Deck Science Lounge.** We suggest that these spaces be combined into a single, comfortable, space for quiet activities.

Other common use spaces include:
0-2 Deck Hospital: On the P1 General Arrangements this space is located aft and fairly isolated from other berthing on the 0-2 Deck. The hospital needs to have easy access to accommodate moving a heavy patient on a stretcher. Separation from other quarters would allow patients to be quarantined. Moving the stacks to the port side will help make access to the elevator easier. It is unclear how many individuals can be accommodated in this space.

0-1 Deck Gym: The gym is now aft of the relocated conference room/lounge, a preferred rearrangement of spaces. The gym includes a spa, sauna, 4 showers and an ADA shower that includes a WC. The showers should provide privacy, that is, be fully enclosed and with lockable doors. We suggest that fewer showers are needed, with the extra space used for a larger gym. What is the spa?

Laundry Facilities: Science 0-2 Deck and Crew 0-4 Deck. We question if there are adequate laundry facilities for all, and whether some laundry facilities could be shared between science and crew.

Private/Office Spaces:

- **Private "office" spaces** where sensitive topics may be addressed are necessary for both the **Chief Scientist** and the **MPC**. Currently only the Chief Scientist cabin is associated with an outer room that can be used for small meetings; we suggest adding a similar space for the MPC located directly adjacent to their stateroom. Since many of these conversations may be private, we suggest that both these staterooms be in more private locations, for example, toward the end of passageways. Currently the MPC outer room is not included in the P1 plan.

- **A separate MPC office** is recommended as a space to accommodate the voluminous day-to-day work of the MPC, which includes lots of paperwork associated with travel, cargo, hazardous waste, in addition to duties as liaison between ship's crew, support staff and scientists. This space is separate from an outer room associated with berthing spaces, since the MPC office tends to be a space where small groups gather to discuss a variety of plans related to travel, shipping, and cruise planning. This space could be located on either the main deck or 0-1 deck.

- **Staterooms**: We suggest the addition of ~6 more single-occupancy staterooms, with these allocated to Marine Technicians, and to a co-chief scientist on interdisciplinary cruises where those duties are more likely to be shared. We also note that the 0-3 Deck berthing spaces include both science and crew, divided by starboard and port; this makes sense since science and crew are often on different shift schedules.

- We note that two **science storerooms** are located adjacent to the Science conference room, which is not a necessary use of space on the 0-3 Deck, and that these two storerooms straddle an isolated stateroom. We recommend that most science storeroom space be located on the main deck (aft, as in the P1 plans) with overflow space for less commonly used items located in a space that is easily accessible, including access via elevator, for easier movement of science supplies. Storing science supplies in the hold may be problematic in terms of access, and also in terms of cleanliness and temperature control.

- **Reception office:** close to the gangway to monitor personnel access to the ship while in port.

SECTION 3: Handling and Scientific Package Deployment
The comments listed below highlight specific details to consider regarding handling and scientific package deployment, winches, wires, cranes, and A-frames, the hardware and associated workflow patterns that facilitate safe and efficient science.

Handling and Scientific Package Deployment
- Engineering a space for a portable (boltable) davit (person-rated) for workboats on the main deck (placed forward of any stern hull cutout) so that scientists can load gear conveniently on the main deck near their lab (not so easy on the NBP, seems overly complicated to get people and gear to small boats and to ice). Ease of launching a workboat must be considered. Will we also have zodiac(s)? How will these be loaded with equipment and personnel?
- Ensure there is a place on the main deck for the handling gear of large ROVs (for example, Jason, GEOMARS KIEL 6000) with adequate power for their Launch and Recovery System (LARS).
- Geophysicists asked about towing seismic streamers for 3-D seismic operations - towing off to the side of the ship by mounting small temporary cranes? (page 68 of 2019 report)

Winches, wires
- Dual drums on oceanographic (traction) winch, good to have redundancy.
- The CTD winch and hydro winch should each be able to serve as backup for the other
- Engineer for portable mission-specific winches (foundations, wire fairleads, power) such as mooring spoolers, mooring capstans, trace-metal winches – consider WHOI-style winch turntable to align portable winches with sheaves.
- Enable cable washdown / lubrication to be done cleanly
- Ensure all winches and wires are engineered for compliance with UNOLS Research Vessel Safety Standards (RVSS) Appendix B (which in turn is based on Code of Federal Regulations (CFRs)). This includes but is not limited to:
    - Obtaining the Maximum Capability Documents (MCDs) from the overboard handling system manufacturers as required by Appendix B.
    - Winches are equipped with wire monitoring system as required by Appendix B (LCI-90 or similar)

Cranes and A-frames
- Ensure all cranes that are used for science purposes are engineered for compliance with UNOLS Research Vessel Safety Standards (RVSS) Appendix B (which in turn is based on CFRs)
- Forward crane will be needed for more than “loading stores” – this crane and area will be used for scientific overboarding of things like Vertical Mass Profilers, thermistor chains, and small towfish. Power and data feeds will also need to be considered. Science towing requirements need to be realistically set.
- Ensure cranes are “person-lift” certified to enable scientists and technicians to work aloft in a person-basket
- Ensure CTD handling devices and spaces are adequate for GO-SHIP 36-place rosette. Which always seems to want to get bigger/heavier.
- Consider point-of-use remote controls for cranes
- Consider crane reach to all parts of the aft-deck

SECTION 4: Workflow
Below we address details related to specific activities and workflow, again aimed at maximizing safe and efficient use of space.

- **Batteries and science missions**: In our first design review we indicated the need to re-address the scientific mission role of a "battery bank" to run the ship for periods of low emissions – times when scientists are collecting samples/data that require no (or very low) emissions and/or very quiet operations. Conversations with atmospheric scientists and physical oceanographers highlight two potential science missions that could benefit from running the ship on battery power, for short periods of time. Clean atmospheric sampling while the ship is in motion can generally be achieved by orienting the ship in relation to the wind, such that the stack vents away from the sample intake. However, when the ship is stationary (for example, parked in sea ice), shifts in wind direction can result in contamination of the intake samples. Under those conditions, use of battery power can provide continuity of clean atmospheric sampling. Physical oceanographers noted that passive acoustic sensing ADCP measurements in >1000 m water depth (for example science directed at studies of deep convection) can be improved under acoustically quiet conditions, while stationary or slow speed (1-2 kts). These science benefits are in addition to the benefits of managing energy use.

- **Marine Mammal Observation Space**: Marine mammal observers, required for seismic operations, require a 360 degree observation space. On previous seismic cruises, MMOs have worked from the bridge. From the 2019 report, "Design of pilothouse area and/or flying bridge should include provisions for making a weather-protected, heated, and obstruction free (at least a combined 180 degrees forward of the beam) observations by two to three scientific personnel. Bird and mammal observers will be on watch continuously during daylight hours and observation locations should include secured, but removable chairs, access to the navigation/data network, and a protected location for portable computers and/or logbooks. Mounting locations for big eyes or similar devices may be required for some observers. Observer locations should be free from radiation hazards generated by radars and other communication equipment." It would be possible to achieve these requirements by working on the bridge, but a dedicated space is preferred, to ensure quiet and private working conditions for both scientists and the bridge crew.

- **Science Small Boat Use**: Safe and efficient use of zodiacs and small workboats requires easy loading and unloading of scientists, science gear and samples. To maximize flexibility and "usability", small boat operations from the ARV must be simplified and made nimbler as compared to current operations on the NBP, which are cumbersome and time-consuming. Operations such as working with mammals or small (e.g., gliders) equipment recovery often require speed to take advantage of the presence of animals and weather windows for example. As indicated above in "**Handling and Scientific Package Deployment**", it is imperative that small boat loading/unloading and launching/recovering are efficient and relatively simple. Utilizing a portable (boltable) davit on the main deck (placed forward of any stern hull cutout) so that scientists can load gear conveniently on the main deck near their lab is optimal. Current operations include the main crane which is time consuming and also can be problematic in open water.

- **Working from the sea ice**: Given the greater access to areas of heavier sea ice concentrations, we anticipate scientific work from the sea ice. Options to deploy personnel and gear via a gangway as well as from the crane, through person baskets, will be required depending on the type of ice work. As mentioned, the crane will need to be person-rated.

- **Back Deck Workflow**:

  (1) **Back deck staging bay** - Staging of a variety of over-the-side gear, including but not restricted to AUVs and mooring gear. This could also include a place to secure a trace metal clean rosette. Note that although some instruments can be staged here, without sinks/water access, it doesn't replace a wet lab providing ready access to the main deck. We suggest that the bay have large, garage-door style access. The bay is currently designed with lift machinery in

the overhead to easily get large/heavy equipment into / out of the space. The bay should be heated. The bay is currently designed to be accessible through the MT shop, allowing access when the ship is in transit and/or when decks are secured.

(2) **50 meter Jumbo Piston Core (JPC)** - Working with the 24 meter JPC on the *NB Palmer* is relatively common; doubling the length to a 50 meter core will require special consideration. Perhaps most critically, the winch and other handling equipment must be strong enough to withstand the increased pullout tensions of the longer cores. Consideration of modifications recently made to the French CALYPSO core (RV *Marion Dufresne*, routine 50 m, 75 m maximum) as well as the MARSSAM 30 m JPC will be valuable in designing a safe and reliable system. Synthetic rope (DYNEEMA Synthetic Cable) is used with the CALYPSO core. As with recovering the 24 m JPC, the core barrels must be kept warm during extrusion to prevent freezing of the liner inside the barrel - on the NBP this is accomplished by "watering" the core, with a warm water hose. With marine sediment cores collected in the Southern Ocean now housed at the OSU Marine and Geology Repository (https://osu-mgr.org/), it is likely that cruises with extensive coring requirements may work with MARSSAM (The Oregon State University Marine Sediment Sampling Group; https://marssam.ceoas.oregonstate.edu/) for onboard core logging and packing, via containerized instrumentation, as described in the "Van Table."

(3) **Vans** – the number and kinds of vans that might be used aboard the new ARV was addressed briefly in DR #1, but re-emphasis is needed, noting the science needs for specialized vans for geotechnical drilling, JPC handling, ROVs, AUVs, radioisotope, trace-metal clean, and seismic compressors, for example. **Table 3** (at end of document) lists and describes the suite of vans that we anticipate could be used on the new ARV, and the specifics of those vans in terms of requirements. For example, while some vans might be located in the hold, many must be located on the main deck. The location of doors on vans will dictate how vans can be placed relative to one another and to the structure of the ship, and some vans require water, sinks and hoods or special orientation (coring van with multisensor track has a cesium source that must shoot outward) or isolation (rad van). Where available, we also provide links to descriptions of existing vans that are either part of the UNOLS shared equipment pool (http://marops.cms.udel.edu/uecvp/ and https://ceoas.oregonstate.edu/west-coast-van-pool), or part of the USAP equipment pool (https://www.usap.gov/usapgov/vesselscienceandoperations/). Note that these are only some of the vans that might be brought onboard. In addition, van designs may change after construction of the vessel, so decisions regarding van placement and orientation may change in parallel. Some ships solve this through dedicated vans for a vessel.

- **UAV deck and hanga**r: From P0 to P1, the UAV hangar has been relocated to the centerline of the ship and the flight deck has been enlarged. Continued communication with SCOAR (Scientific Committee for Oceanographic Aircraft Research) will be instrumental in defining space needs for the UAV deck and hangar, and the details of launch and recovery that will guide design for a rapidly evolving technology (https://www.unols.org/committee/scientific-committee-oceanographic-aircraft-research-scoar). Zappa et al. (2019) (https://www.frontiersin.org/articles/10.3389/fmars.2019.00777/full) describe the benefits of vertical takeoff and landing capability (as opposed to a catapult system with net or wing capture). While we anticipate heavy use of UAVs on many cruises, we suggest designing in flexibility so that this space can be used for other science activities when UAVs are not in use. Given the increased length of the vessel, we also suggest reconsideration of the trade-offs of adequate sizing and use of this space for helicopter support.

- **Fold-down mast:** In our first report we also addressed the foremast. Here we stress a design that promotes ease and safety of access for sensor installation (for example, as on the Sikuliaq, which has a protected exterior ladder). We also note that sample intakes need to be located where there is unobstructed air flow and out of the slipstream of the ship. The mast needs to be sturdy to withstand icebreaking conditions and needs not to be an obstruction during takeoff and landing of UAVs (flight path clearance).

- **Freeboard height**: As the proposed vessel has grown, we emphasize that freeboard height continues to be part of the conversation. Instrument deployment and recovery and small boat operations become increasingly difficult as freeboard height increases. (A greater distance of travel in air leads to more swinging and chances of packages hitting the ship). The Sikuliaq (freeboard height 8.76 ft) was complimented in terms of AUV operations from the back deck; the Roger Revelle (Global Class AGORS) has a freeboard height of 9 ft. Many operations are more complicated off the RV Kilo Moana which has a 13 ft freeboard.

- **Incubation deck space**: The following text is modified from the 2019 report: Deck incubator positions (unshaded by structure) with a means for securing to the vessel shall be provided. Seawater delivery to each incubator with a flow capacity of 50 gallons/min (190 liters/min) is required. ….. It should be possible that at least two deck incubators can be used simultaneously side-by-side, with room to accommodate as many as 4-6. Plumbing should include valves that can be fine-tuned to adjust flow rates. Incubator seawater should be within 1C of ambient seawater temperature….. Deck space designated for incubators should preferably be located on the same deck as the CTD station such that researchers conducting experiments that make use of large amounts of seawater collected from the CTD do not have to hand-carry heavy buckets of seawater up stairwells, which increases the risk of falling and injury. We recognize that this would take up a lot of space on the main deck for other operations. The elevator, if conveniently located, will be helpful for carrying bottles of seawater to incubators located on the 0-1 deck.

- **Liquid Nitrogen Plant:** The USAP currently uses a liquid nitrogen plant for large biology cruises that require a lot of liquid nitrogen. The current plant is in a 10ft container which needs power and compressed air with water separators. On the NBP this van sits in the helo hangar. This van (or the equivalent) is expected to be used in the ARV. A protected location with sufficient power will be required.

- **Science seawater systems:** The mission requirements for the science seawater system are extremely specific, as described here: https://future.usap.gov/arv-mission-requirements/. While the following text is quite specific, and lengthy, we include it here, with minor modification. "Flow-through scientific seawater system capable of delivering ≥40 liters/minute to all laboratory spaces. Objective requirement: System capable of delivering 100 liters/minute. The underway system should be designed with the following criteria, which are separated into two sections (1) requirements for the underway seawater system and (2) requirements for seawater pumped to labs like the Aquaria lab.

  (1) Requirements for underway seawater system:
    - The underway seawater sampling system should consist of an intake near the bow and the surface to provide uncontaminated seawater, resistant to ice-clogging, while the ship is underway and/or stationary.
    - Careful attention to system design for operations in ice is necessary to minimize and mitigate ice-clogging drawing on lessons learned from other ice capable research vessels.
    - A secondary intake location further aft for use if the primary intake is compromised by heavy seas or ice clogging, and to accommodate instruments/measurements located further aft that are sensitive to bubbles or destruction of delicate cells, for example.
    - Final location of intakes for underway seawater sampling should be determined following final hull design to minimize thermal contamination, bubbles, intake blockage, and to maximize water flow.
    - Minimize time lag between intake and sampling location (sensor suite and/or lab sinks) with an objective of less than 2 minutes desired. However, the temperature sensor should be located as close to intake as possible to avoid contamination of this measurement by the ship.
    - Include an alarm system for the seawater system if it over pressurizes or shuts off.
    - Anti-icing: develop requirements to deal with de-icing that does not affect seawater requirements.

- Piping material should be corrosion resistant and as chemically neutral as possible within the limits of regulatory requirements.
- If more than one intake is installed ensure that the intake being used is flagged in the data stream.
- This system will support a suite of standard sensors (thermosalinograph (TSG), transmissometer, pCO2, fluorescence, etc.), and include multiple additional ports for science supplied sensors.
- The underway sampling system should include an infrared sensor installed at the bow for measuring sea surface skin temperature.
- Maintenance of the underway sampling system is critical for obtaining high-quality data. The system should be designed to conduct periodic (approximately daily) back-flushes with freshwater or a dilute bleach rinse, to prevent accumulation of growth/biofilms in the underway plumbing.
- The system should have the ability to access coarse strainers for conducting daily rinses. This can be done by bifurcating the inflow so that one side can be taken out of line for cleaning.
- The system should have the ability to swap individual sensors in case of malfunction.

(2) Requirements for seawater pumped to labs

- Provide underway seawater taps at 4 or more sinks in lab-accessible spaces.
- Allow users to configure to either continuous or discrete sampling of underway.
- Additional access points should be provided in sinks in other labs (chem. labs, trace metal labs, wet lab).
- Ability to access underway seawater from labs in vans on deck.
- Design for installation of additional sensors (user-supplied or ship supplied) mounted near the ship's 'standard' TSG, transmissometer, pCO2, and fluorometer package.
- Although these additional sensors could be standalone with their own datalogging, the underway system should be designed to allow the voltage output to be recorded and merged with the ship's underway data feed.

TABLE 1. Science spaces, recommendations for their relative location and connectivity to other spaces, and considerations for space arrangements within each lab.

Space + use (name suggested vs. name in SMR documents	**Location + Connectivity**	**Space Arrangements**
MAIN DECK		
Science Operations Center (Forward Dry lab). "mission control" - day-to-day cruise planning, work with shipboard data; banks of monitors, dedicated workspaces/work surfaces for charts, laptops, workstations for UAV and drone data downloads and processing, marine geophysics (sub-bottom and multibeam data, towed seismics), and work with ROV and satellite imagery.	Dry lab, so aft location, easy connectivity to main passage, clear line of communications to bridge, main lab, UAV deck and back deck, marine mammal observatory.	General purpose tables (not desks), wireless access and numerous (TBD) internet drops; most scientists will bring laptop computers rather than relying on general purpose desktop computers; some space dedicated to workstations for data processing. Telepresence (comms with colleagues, NSF, + outreach efforts that effectively present excitement of scientists at work) might involve 4-6 people on board - accommodated by a temporary partition in aft part of lab. Bookcases and compressed air drops not needed.
Main Lab (Aft Dry Lab). General workspace, multi-purpose lab, with flexible benches and layout configurations, for science equipment and for processing of water, plankton, and sediment samples; instrument programming, charging battery packs, sensor calibrations, filtration + processing of water samples, sorting plankton, setting up incubation experiments, microscopy (that does not require darkness), description / sub-sampling of sediments. Current deck plan: Main Lab will serve the same function as the NBP aft dry lab, which will function as described above.	Ease of moving samples and equipment back and forth between main lab, back deck, + Baltic Room. Easy access to refrigeration + freezer space; water work may include carrying 20 liter carboys from Baltic Room and back deck into main lab; sediment cores 1-6 meters long + will be carried from deck into main lab + later stored in a cold room.	Adequate access to bench space (with benchtop for tie downs), multiple (TBD) sinks, multiple (TBD) hoods, clean water + uncontaminated seawater, working with cores is messy (muddy) - requires sinks w/ sediment traps, and easily cleaned floors and floor drains. Use of nesting tables for increased flexibility of use of space and efficiency of use. P0 plans have 4 double sinks and 3 single sinks, 1 hood; we suggest plywood countertops that are easily replaceable instead of ss Add Milli-Q water, ice makers, freezer space?
Computer/Electronics Lab outreach and telepresence center, also space for working with electronic instruments	forward location, proximal to Science Operations Center, and to ET Shop	space for electronic instrumentation prep/calib/data download; large format printers
Baltic Room CTD operations	Mid-ship location with other "wet" labs proximal to Baltic Room	Space to maneuver easily around rosette, and to carry heavy carboys, and smaller racks of sample bottles out to other labs. Floor shouldn't have lots of tripping hazards. Ample floor drains to facilitate rapid water drainage. Door that has sufficient opening for an extra-large 36 place rosette. Store space for CTD spares and parts should be elsewhere, since this space is open to the elements.
Wet Lab wet, messy activities - receiving and sorting of samples from plankton net tows, fish trawls, dredges, extrusion of multicore sediments, incubation of live animals. Lab may be the site of cleaning moored instruments upon recovery when conditions are unsafe on deck.	Wet Lab and Aquarium Room ideally contiguous; complimentary work, for example, incubating live animals in Aquarium Room and bringing samples into Wet Lab to process. Proximal to Baltic Room and Back Deck. When moored instruments recovered, ready access to main deck key.	access/ hook ups to flowing seawater and freshwater at multiple sites, floor drains, and lots of sink space with sediment traps
Aquarium Room wet, messy activities - receiving and sorting of samples from plankton net tows, fish trawls, dredges, extrusion of multicore sediments, incubation of live animals. Lab may be the site of cleaning moored instruments upon recovery when conditions are unsafe on deck.	same as above	access/ hook ups to flowing seawater at multiple sites, Aquarium Tanks ideally portable, Xactic tanks (# and size to be determined, floor drains, sinks with sediment traps; lights must be controllable to darken space

Space + use (name suggested vs. name in SMR documents**)**	**Location + Connectivity**	**Space Arrangements**
Hydro Lab site of “water wall” for underway surface seawater characterization; collection of samples for [pCO2] work; nutrient analysis; flow-through instrumentation - thermosalinograph, pCO2 system, fluorometer, transmissometer, nitrate analyzer, FlowCam/CytoBot plankton image analysis, flow cytometry. Outlets to add science supplied instrumentation and/or to collect discrete water samples. Pressure regulated so that as instruments are added/removed the pressure to the online instrumentation doesn't change. Other operations could include Nutrient Analysis, other analytical instrumentation.	Samples coming from Baltic room and back deck, access to Chemistry lab	multiple (TBD) sinks, hoods (TBD), bench space for instrumentation, access to clean water and uncontaminated sea water, ice maker. Clean power outlets protected from seawater exposure distributed throughout. Analytical work requires relatively good climate control. Anticipate increase in flow-through instrumentation, so larger hydrology lab may be needed. Image analysis w/plankton directly from seawater line, need for gentle system proximal to intake. Historically this has also had the nutrient analysis and other analytical work. Inner benches should be
Bio-chem / Analytical Lab (Bio Lab) Sensitive biogeochemical analytical work that requires clean space, excellent venting, climate control. Filtration and processing work with water, plankton, and sediment samples that include work with preservatives and/or poisons.	More aft	Note that given the scope of work to be completed in this lab, we suggest increasing the size to 800 sq. ft.; positive pressure and good temperature control; laminar flow hood and chemical hood mandatory; glove box; gas tank racks; sink space (3-4), access to clean water and uncontaminated sea water. Floor drains required. Note that "hazardous" chemicals will be used in this lab space. Refrigerator/Freezers for pickled samples.
Cold Rooms 2 separate rooms for flexibility of temperature control (freezer versus refrigeration), for storage of samples and for analytical work that requires temperature control such as porewater work, work with sea ice cores	3 meter cores need to be maneuvered into cold room from back deck and from main lab	temperature control -30 C to +10 C (-20 F to +50 F), as noted in the ARV Performance Specifications; 1 double sink, countertop, adjustable shelving and countertop space;
Autosal Room space for salinometer, climate control	interior location acceptable	Temperature control of 1-2 C, with range from 21- 23 C (http://www.soest.hawaii.edu/HOT_WOCE/sal-hist-report/2.1.2.html); Ambient temperature measured with digital thermometer near salinity sample boxes away from Autosal to prevent thermometer from being affected by heat of Autosal and allows thermometer to measure temperature of area in which samples have equilibrated.
Microscope Room (currently not in General Arrangements) transmitted and epi-fluorescence microscopy, binocular microscopy	Recommend mid ship location and on the main deck for stability which is important for proper visualization (and to minimize motion sickness). Room will often need to be darkened for proper viewing, so interior location preferred.	Room also be used for fluorometry which requires low light. Space for 3 microscopes, plus associated computers, and fluorometer; 3 microscope desks and a space for at least one fluorometer or other instrument. One space reserved for anti-vibration table. Compressed air connections, water and sink. Suggest increasing size to ~150 sq. ft.
Gravimeter	Newest gravimeters (trying to get to NBP) do not require special security so don't need "special" space	special requirements for mounting instrumentation since this needs to be on a gimble.
Bottom Mapping Transceiver Room / Acoustics	Space located within cable run distance to transducers.	Design for easy access to service hull mounted systems. Suite of sonar and acoustic systems is good but see comments in text regarding ADCPs. Scientists need the ability to easily integrate mission specific transducers/transponders, either as part of a drop keel, or using a transducer tube similar to the SIO approach. We assume all the acoustics can fit in the box/drop keel? Or there will be exchangeable bases? USBL?
Science Stores includes (1) instrumentation and supplies that the ship supplies and (2) PI provided supplies. Ship supplied Science Supplies in a temperature controlled and permanent place, PI provided extra supplies stored in hold	forward location for easy access to lab equipment and general lab supplies - all dry	Room for pallet jack so heavier items easily moved; double doors; all adjustable stainless steel shelving

Space + use (name suggested vs. name in SMR documents**)**	**Location + Connectivity**	**Space Arrangements**
Marine Tech (MT) Shop	Aft location, closest to back deck	This is what is typically the "Bosun's stores" on an ARF vessel - holds everything from hand tools to welders to lifting gear to come-alongs to safety gear.
Marine Lab Tech (MLT) Space	Forward location, close to Science stores	This could be adjacent to or within a Science Stores area. This is an important space as the MLT is often tasked with processing the Hazwaste, samples, the inventory of the ship-supplied lab instrumentation, etc.
ET Shop	Ideally located in or as part of the Electronics Lab.	rack for compressed gas cylinders, 2 tool cabinets, 2 workbenches, bookcase, cabinets (10), chair(s)? Workbench for electronic repairs, computer station, stores for small electronic spares (fuses, cables, wire, etc.)
Electronic Equipment Room location of servers and server HVAC	Forward port location since work in this space does not require access to water or back deck - dry lab space; adjacent to ET Shop and proximal or adjacent to Control Center	Server racks must be accessible from front and back; not oriented adjacent to bulkheads as currently drawn. Sufficient space in the computer racks for future growth or science supplied instrumentation. Small countertop (composition?) and chair. Important that this space is temperature controlled as the servers will generate a lot of heat.
Changing Room/Mud Room float coats and boots	Aft location since wet and muddy	bench, lockers, and hooks, double sink for rinsing
Hazardous Materials Storage	proximal to science stores	May have a locker and a van, need to consider venting requirements
USW Instrument Room (Bow thruster room)		
Transducer Room		need to identify instruments in this space
Gas Bottle Storage Room SMR call outs 5 gas bottle racks but still need gas bottle storage space for easy bottle exchange on longer cruises	where is it?	clarify - storage racks per lab? or a main storage that gets piped into labs?
OTHER DECKS		
Atmospheric Lab	0-2 deck forward; intake location access from foremast	space could house ion chromatographs which need a source of deionized water and a sink; instrumentation requires gas cylinders and compressed air.
Meteorologic Lab	0-7 deck; requirements regarding position relative to stack?	space housing electronics and computers for remote sensing instruments outside on deck
Marine Mammal Observation Platform required during seismic surveys, also stand-alone marine mammal / bird surveys	360 degree observation as high as possible	Weather-protected, heated, and obstruction free (360 degrees) observations 2-3 scientific personnel; removable chairs, access to the navigation/data network, protected location for portable computers and/or logbooks; mounting locations for big eyes. Observer locations should be free from radiation hazards generated by radars and other communication equipment.
DECK SPACES		
AUV Staging Bay Staging of over-the-side gear, including but not restricted to AUVs; also mooring gear, trace metals rosette.	Staging bay accessibility from MT shop when ship is in transit and/or decks secured	Large, garage-door style access; bay currently designed with lift machinery in overhead to easily get large/heavy equipment into / out of the space; heated - helpful for recharging batteries; easy access to freshwater for rinsing instruments.
UAV Hangar and Deck	Forward, clear flight launch and recovery path	Garage-door style access?, heated space for recharging battery banks, tool cabinet, any workbenches?
Aft Winch Control Room for crew handling over-the-side operations, will crew be able to control ship from here? also for science handling and observation of over-the-side operations	back deck with excellent visibility both starboard and aft	adequate space for 4-5 scientists to observe over-the-side operations; space for temporary science instrumentation that may need cable connection to instruments on deck

TABLE 2. List of science spaces and sizes allocated in 2022 Habitability Study, the 2019 SMR report (https://www.nsf.gov/geo/opp/opp_advisory/meeting_docs/may2019/RV%20Subcommittee%20final%20report%2014AUG2019.pdf), and size of these spaces on the RVIB *NB Palmer* (https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/NBP_Systems.pdf).

Space + use (name sugg. vs. name in SMR documents**)**		**Size (all areas ft^2)**	
	2022 Habitability Study	***2019 SMR***	***NBP***
MAIN DECK			
Science Operations Center (Forward Dry lab).	1400	~1100	1150
Main Lab (Aft Dry Lab).	1400	~1100	1036
Computer/Electronics Lab	700	~700	670
Baltic Room	700	~700	680
Wet Lab	580 (more if possible)	~900	416
Aquarium Room	340	~400	298
Hydro Lab	530 (more if possible)	~750	445
Biochem / Analytical Lab (Bio Lab)	500	~400	460
Cold Rooms	2 @ 100 each		86 and 68
Autosal Room		~100	
Microscope Room		~100	
Gravimeter			
Bottom Mapping Transceiver Room / Acoustics	195		
Science Stores	4130 (forepeak main deck), Science Hold (16,000)		375 main deck + 170 lower deck & 4 20-ft containers lower deck
Marine Tech (MT) Shop	250	~150	142
Marine Lab Tech (MLT) Space	260		
ET Shop	100	~100	
Electronic Equipment Room	230		96
Changing Room/Mud Room		~100	100
Hazardous Materials Storage	650		
USW Instrument Room (Bow thruster room)	100		
Transducer Room	200		
Gas Bottle Storage Room			
OTHER DECKS			
Atmospheric Lab	300		
Meteorologic Lab	340		
Marine Mammal Observation Platform	550		
DECK SPACES			
AUV Staging Bay	450		
UAV Hangar and Deck	450 (hangar)		
Aft Winch Control Room			

TABLE 3. List of specialized vans, information concerning location and connectivity to other spaces, and details and links regarding vans.

SPECIALIZED VANS: UNOLS shared equipment pool (http://marops.cms.udel.edu/uecvp/ and https://ceoas.oregonstate.edu/westcoast-van-pool), or part of the USAP equipment pool (https://www.usap.gov/usapgov/vesselscienceandoperations/).	**Location + Connectivity**	**Space Arrangements**
Radioisotope Vans (1-2) depending on which isotopes are being used	Main Deck - exterior location mandatory to limit possibility of radioisotope contamination of interior of ship; consider pathways of use by scientists and limit possibility of contamination of ship - do not recommend allowing direct entry without a contamination control zone at the access point.	https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2001.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2002.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2003.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2004.pdf
Trace Metals Van	Main Deck	https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/TMC%20Van%2007.pdf
Seismic Compressors Vans (2 - 3)	Main deck with accessible connection to air guns	Containerized Compressors and systems that can be easily configured on board. Need to have a regular maintenance facility to ensure equipment remains functional. (Seismic Air Compressors (Borsig-LMF) 2 each 385 scfm at 2,000 psi). Probably need 2 - 3 compressor vans for a seismic cruise (depending on the array size ranges and rep rates) plus a backup; compressor vans can work in cold weather with a few modifications; they already have powered pre-heaters but in really cold conditions an antifreeze injector is needed for the air outlet.
Seismic Gun Shack workshop for air gun maintenance	Back deck - could also use Aquarium Room if cruise conditions permitted	countertops, electric, heated
Seismic Streamer Van	Back deck	streamer and winch
Jumbo Piston Coring Vans (4) archival supplies, Multi-sensor core logger (MSCL), core splitting & processing, core shipping (refrigerated), a 5th container with CT scanner, but this could also be in MSCL container	Archival supplies could be in hold, others on back deck. Refrigerated shipping container instead of storage in cold room, or could have shipping container in port and transfer all cores	Archival supplies in hold, no special needs except routine access; Multi-sensor core logger and core splitting/processing need heat, electric; Shipping van electric; MST van must have tack pointed outboard toward lightly accessed area, because of cesium source
AUV Vans (2)	Back deck with door opening to open back deck for deployment of AUV	specific to each AUV
ROV Vans (4) capability to support Jason, as an example	Back deck	https://ndsf.whoi.edu/; Jason, typically shipped with 5 vans and the team brings 4 vans on board - rigging van, tool van, and 2x control vans. The rigging van can go anywhere on board that has access. The tool van is on the main deck close to Jason, and the 2x control vans are on the main deck on some ships, on the 01 or 02 on some ships. Jason can be operated with a single control van if space dictates.
Liquid Nitrogen Plant	10ft van. Isolated location (not on the back deck)	
Light Incubation Van		https://www.usap.gov/vesselScienceAndOperations/documents/Light%20Incubation%20Van%2014.pdf