Day two – RRS *Sir David Attenborough* science capability

- Biology – Dr Sophie Fielding
- Chemistry – Dr Malcolm Woodward
- Atmospheric science and meteorology – Prof Ian Brooks and Dr Anna Jones

Biology capability

Dr Sophie Fielding

Science trials co-lead, British Antarctic Survey

Biological science and capabilities


COMMUNICATIONS EARTH&ENVIRONMENT

PERSPECTIVE OPEN

Successful ecosystem-based management of Antarctic krill should address uncertainties in krill recruitment, behaviour and ecological adaptation


COMMUNICATIONS BIOLOGY

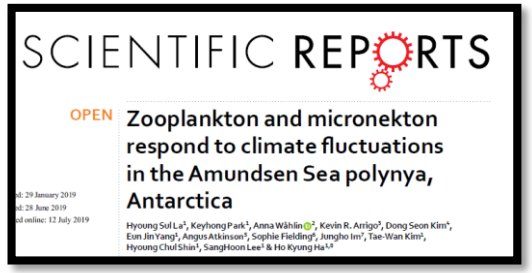
ARTICLE OPEN

Artificial light during the polar night disrupts Arctic fish and zooplankton behaviour down to 200 m depth


nature COMMUNICATIONS

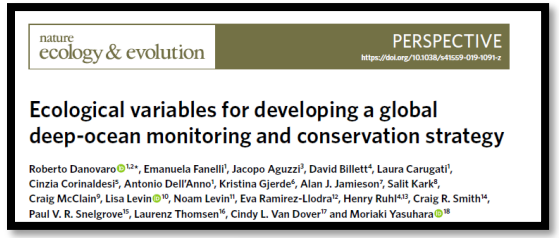
REVIEW ARTICLE OPEN

The importance of Antarctic krill in biogeochemical cycles

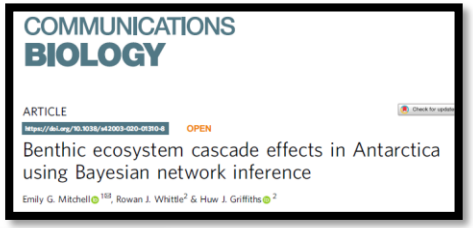

SCIENTIFIC REPORTS

OPEN

Zooplankton and micronekton respond to climate fluctuations in the Amundsen Sea polynya, Antarctica


nature ecology & evolution PERSPECTIVE

Ecological variables for developing a global deep-ocean monitoring and conservation strategy


COMMUNICATIONS BIOLOGY

ARTICLE OPEN

Benthic ecosystem cascade effects in Antarctica using Bayesian network inference


comment

A decade to study deep-sea life

The United Nations Decade of Ocean Science for Sustainable Development presents an exceptional opportunity to effect positive change in ocean use. We outline what is required of the deep-sea research community to achieve these ambitious objectives.

Kerry L. Howell, Ana Hilário, A. Louise Allcock, David Bailey, Maria Baker, Malcolm R. Clark, Ana Colaço, Jon Copley, Erik E. Cordes, Roberto Danovaro, Awantha Dissanayake, Elva Escobar, Patricia Esquete, Austin J. Gallagher, Andrew R. Gates, Sylvie M. Gaudron, Christopher R. German, Kristina M. Gjerde, Nicholas D. Higgs, Nadine Le Bris, Lisa A. Levin, Elisabetta Manea, Craig McClain, Lenaick Menot, Nelia C. Mestre, Anna Metaxas, Rosanna Milligan, Agnes W. N. Muthumbi, Bhavani E. Narayanaswamy, Sofia P. Ramalho, Eva Ramirez-Llodra, Laura M. Robson, Alex D. Rogers, Javier Sellanes, Julia D. Sigwart, Kerry Sink, Paul V. R. Snelgrove, Paris V. Stefanoudis, Paulo Y. Sumida, Michelle L. Taylor, Andrew R. Thurber, Rui Vieira, Hiromi K. Watanabe, Lucy C. Woodall and Joana R. Xavier

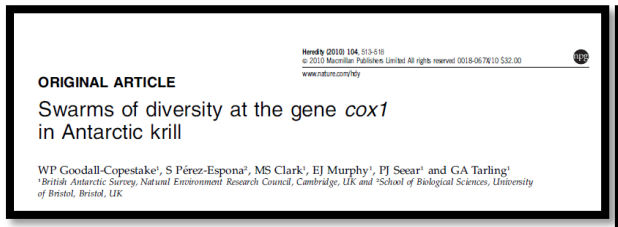
Observing and sampling pelagic organisms:

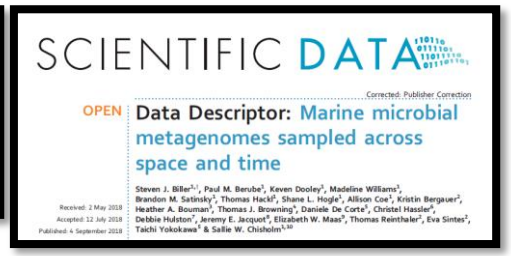
- Nets over stern or side of the vessel
- Acoustic surveys for behavioural research
- Support AUV and ROV operations
- Continuously monitor and log environmental, meteorological, navigational, geophysical, biological data

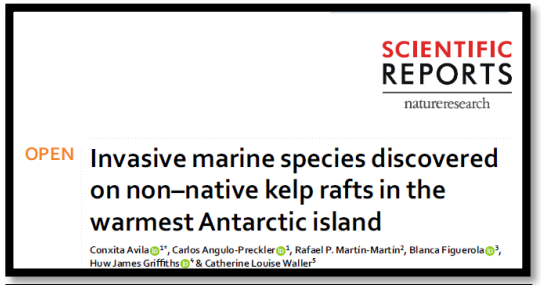
Observing and sampling benthic organisms:

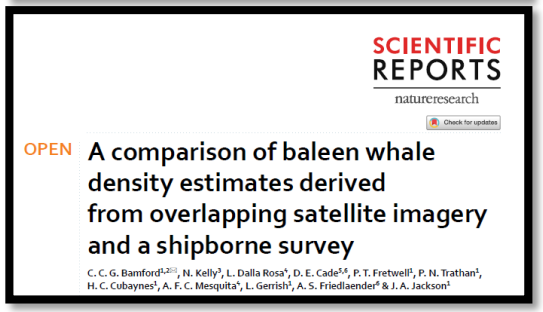
- Trawls and benthic nets to depths >6000m
- Acoustic surveys for seabed mapping
- Support AUV and ROV operations
- Deploy landers, moorings and ocean bottom packages

Biological science and capabilities









Analysing, incubating and communicating

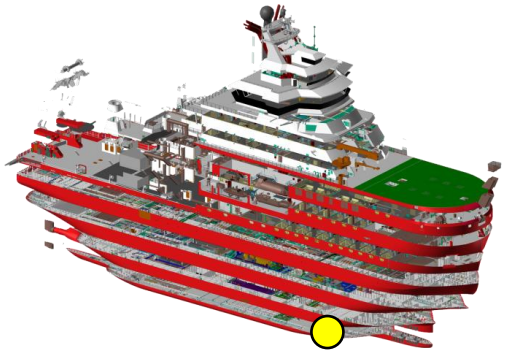
- Have flexible multidisciplinary labs
- Transport live animals
- Store samples and chemicals appropriately (-80°, -20° and 4°C storage, UN appropriate)
- Have multiple constant temperature labs

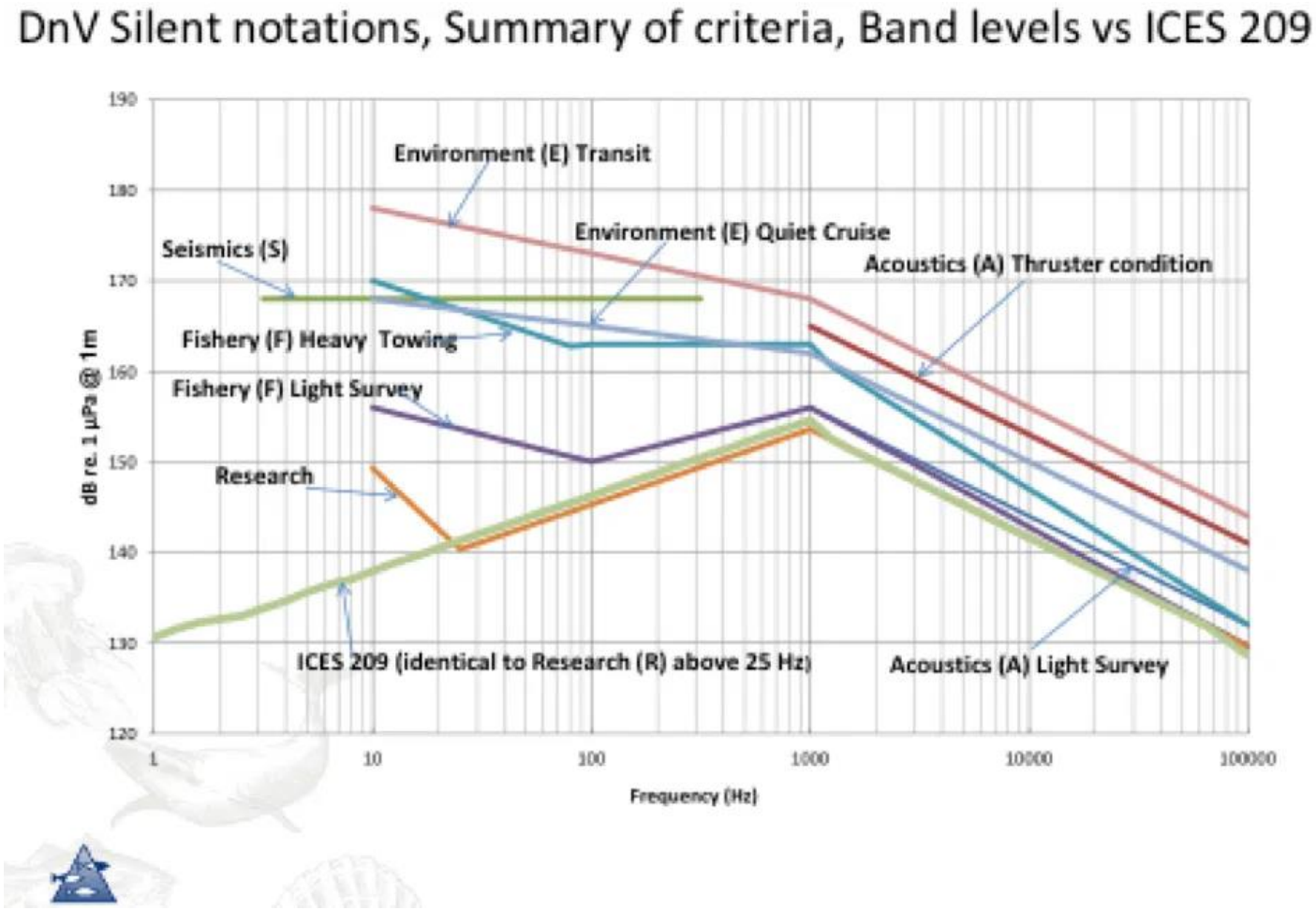
Coastal surveying and marine predator obs

- Conduct shallow water acoustic surveys , support dive activities
- Undertake manned and autonomous marine mammal surveys

Advanced acoustic 3D underwater imaging

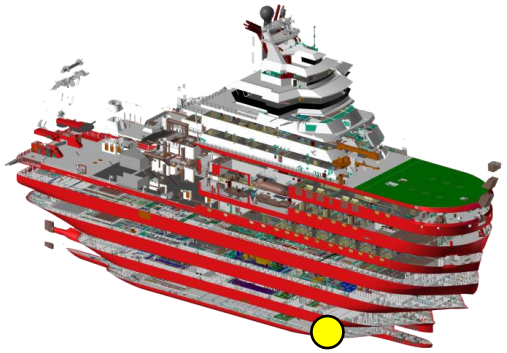
- Silent R specification
- ICES 209
- Minimise Underwater Radiated Noise (URN) to reduce behavioural responses
- Maximise signal to noise ratio

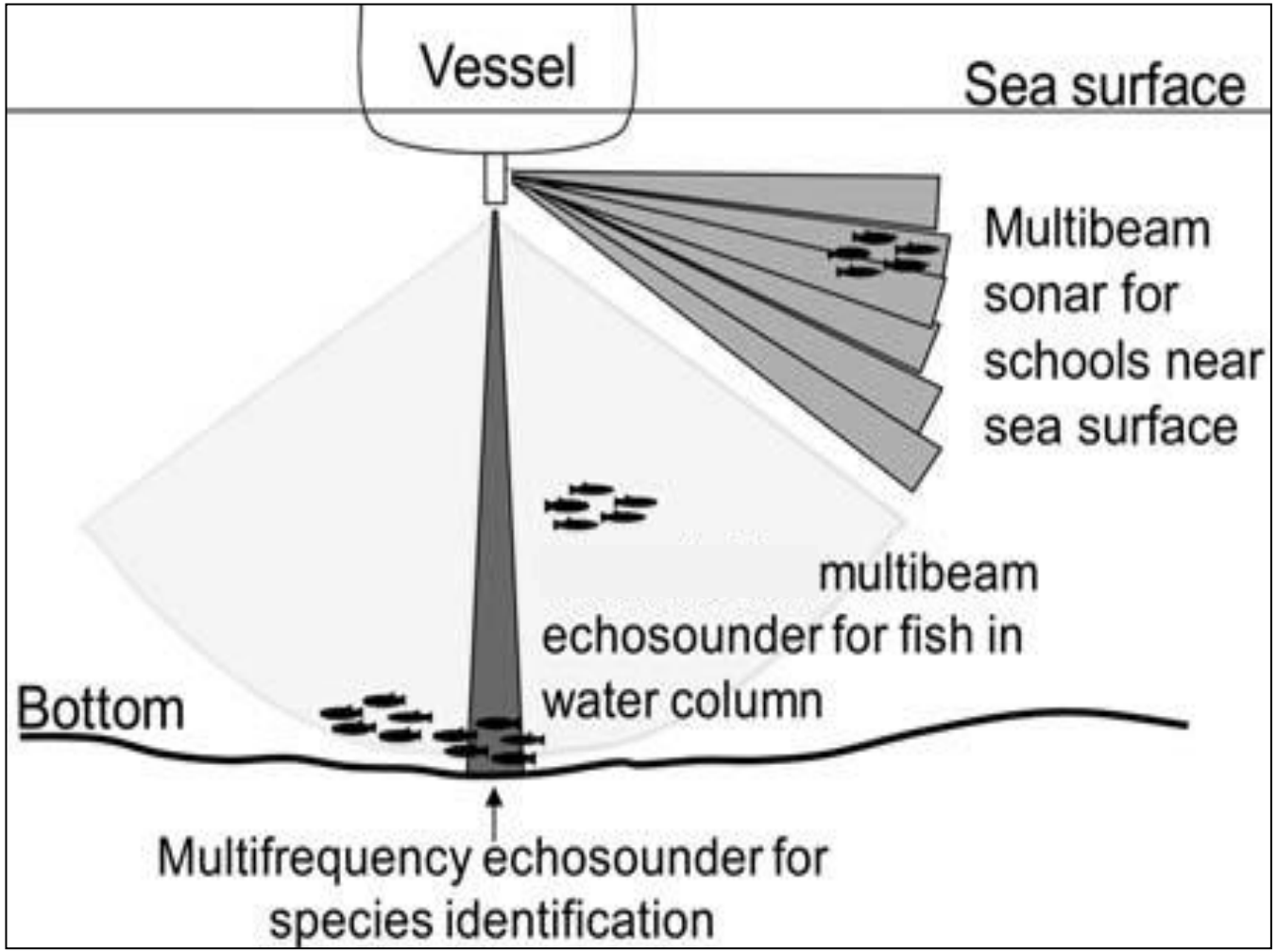




Advanced acoustic 3D underwater imaging

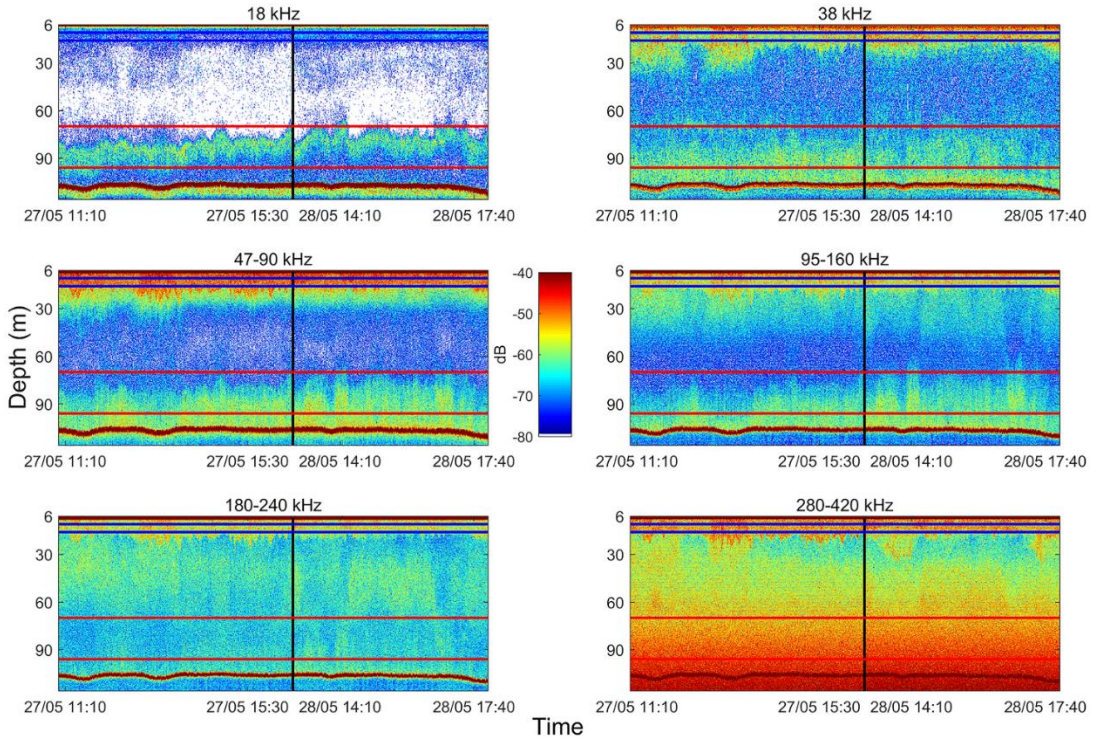
- Hydrographic echosounder (EA640)
- Multibeam swath (EM122, EM712)
- Current meters (ADCP)
- Fisheries broadband echosounder (EK80)
- Fisheries multibeam sonar (MS70)
- Fisheries multibeam echosounder (ME70)
- Omnidirectional sonar (SU94, SC94)





Advanced acoustic 3D underwater imaging

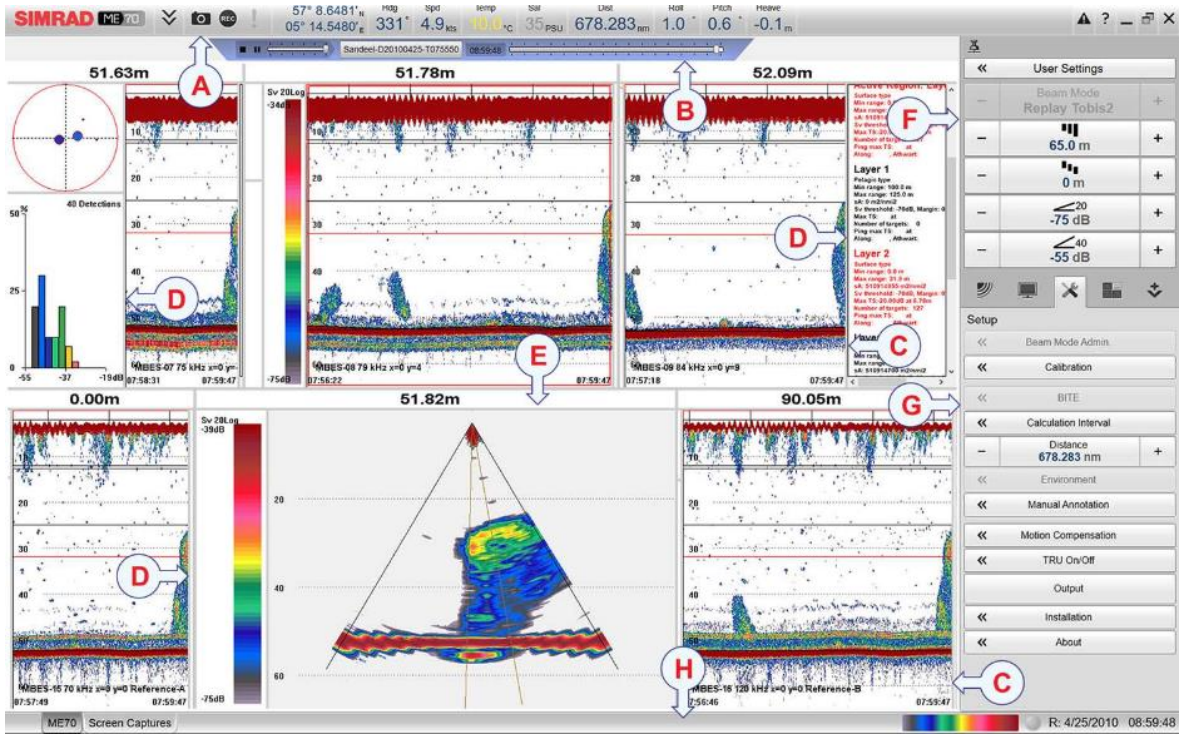
- Simrad EK80 Wideband Echosounder (18, 38, 70, 120, 200, 333 kHz)
- Quantification and identification of zooplankton and fish (and bubbles!)



Blanluet et al. 2019

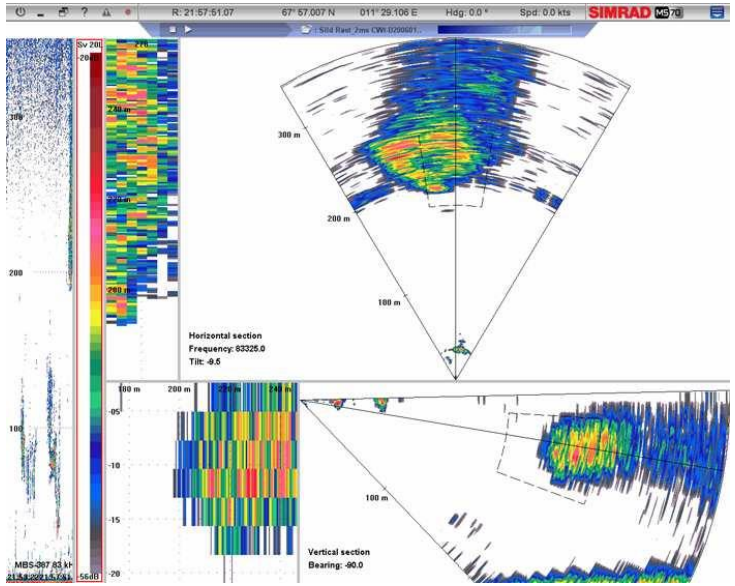
Advanced acoustic 3D underwater imaging

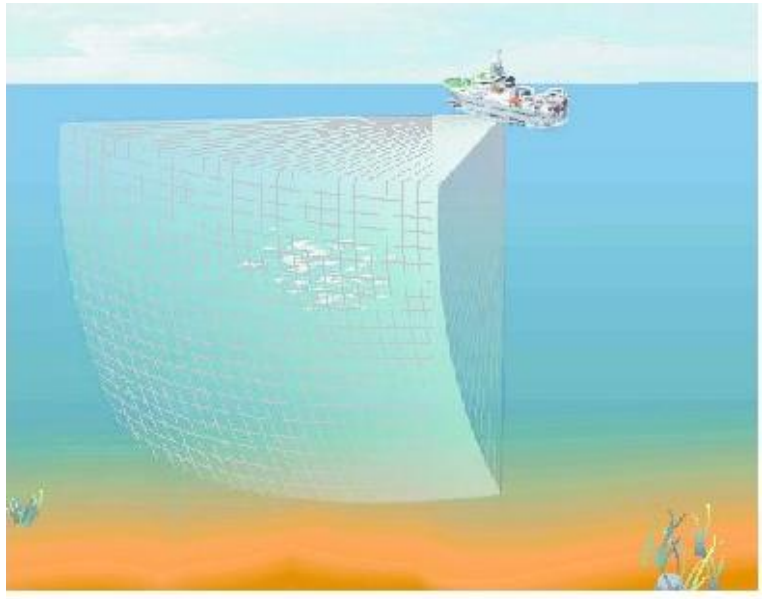
- Simrad ME70 (70-120 kHz multibeam echosounder)
- 3 to 45 stabilized beams (swath of 140°)
- Calibratable echosounder
- Macroplankton school biomass and behaviour research

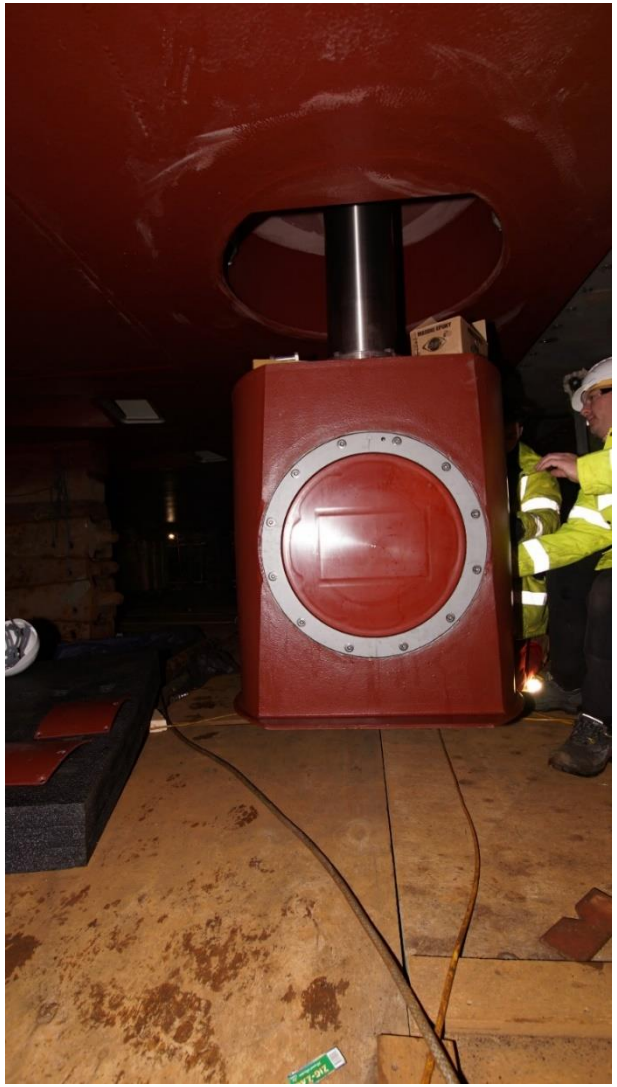


Advanced acoustic 3D underwater imaging

- Simrad MS70 (70-120 kHz multibeam sonar)
- Calibratable sonar – measure a fish school in one transmission
- 500 beams in a 60° (25H) by 45° (20V) fan

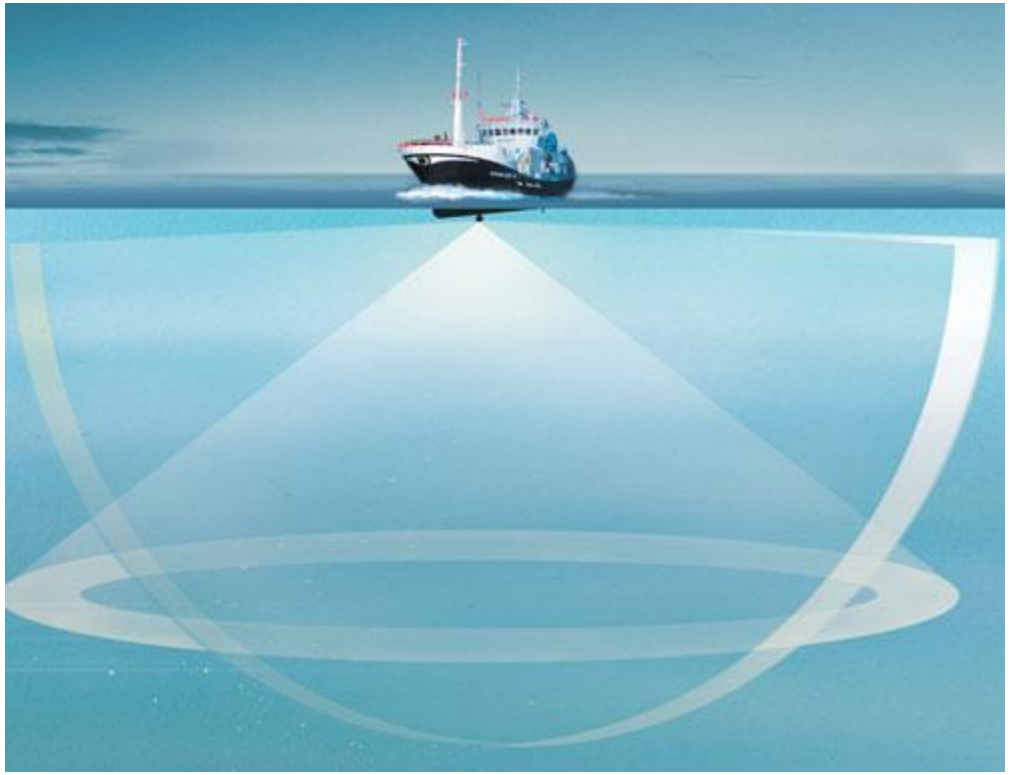


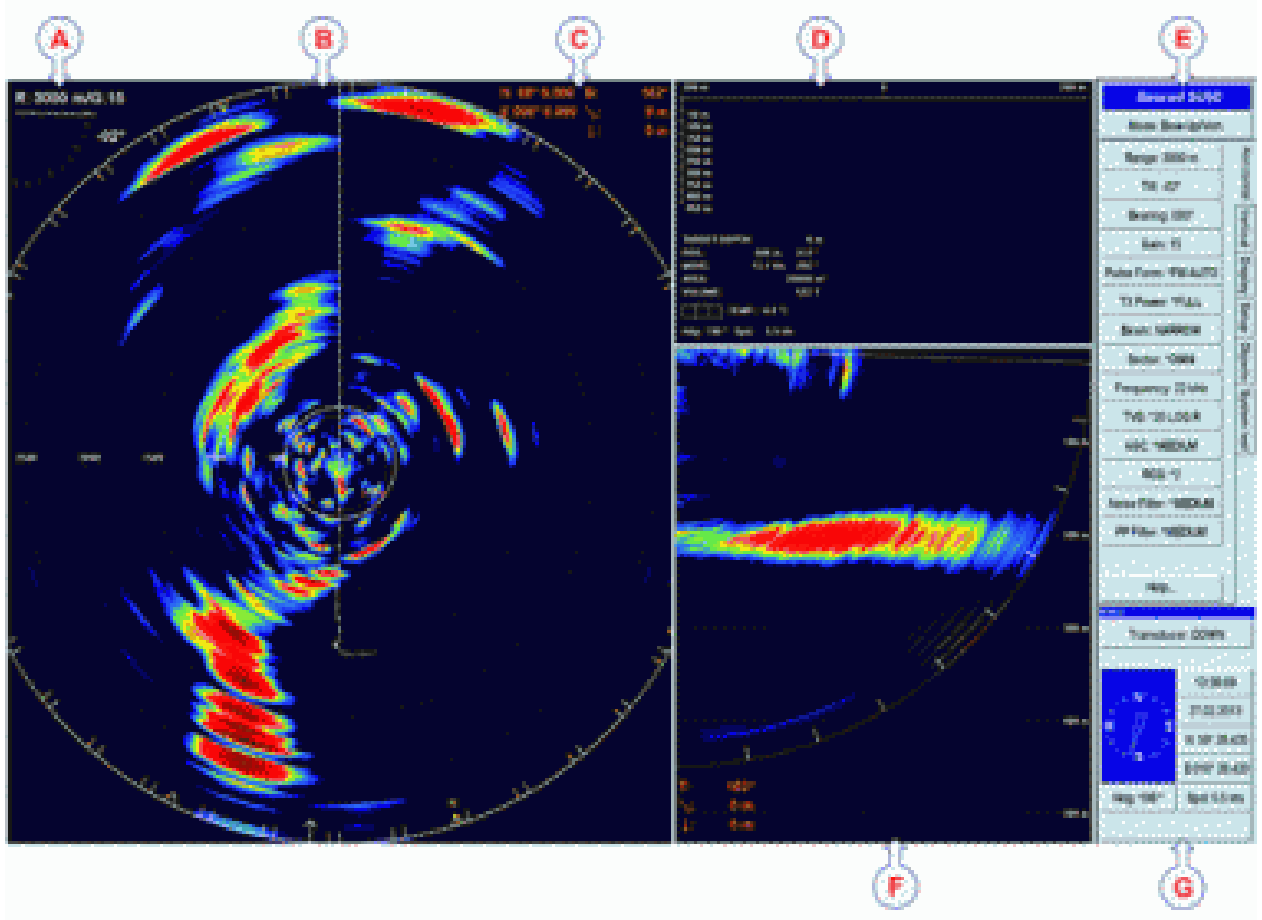




Advanced acoustic 3D underwater imaging

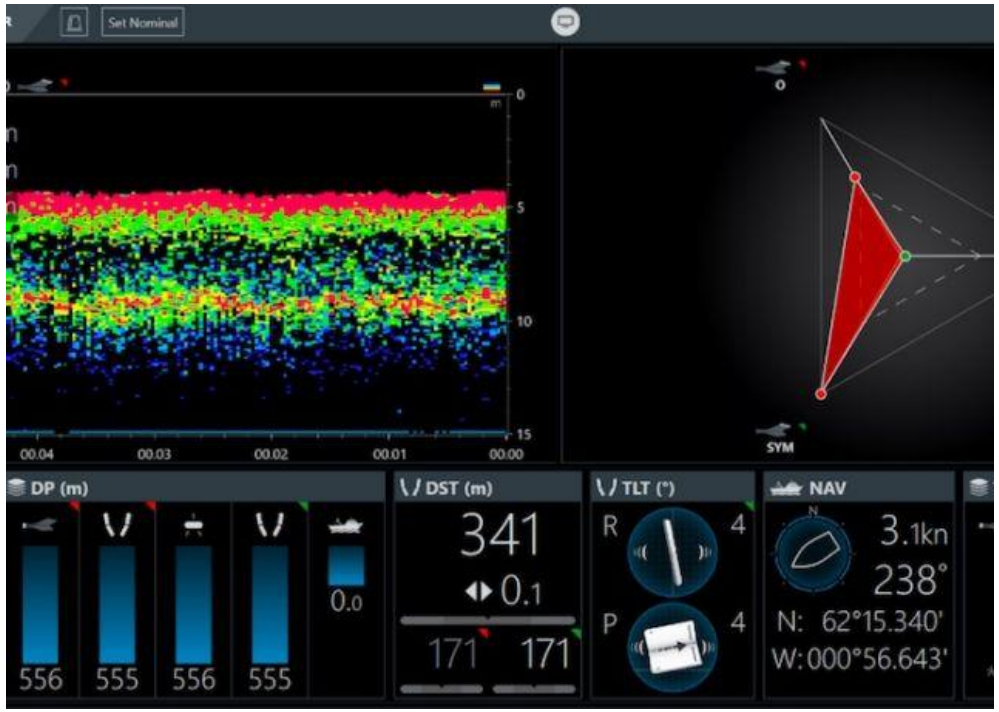
- Omnidirectional sonar (SU94 (20-30 kHz), SC94 (82.5 – 86.5 kHz))
- Ideal for targeting net hauls, viewing underwater obstructions

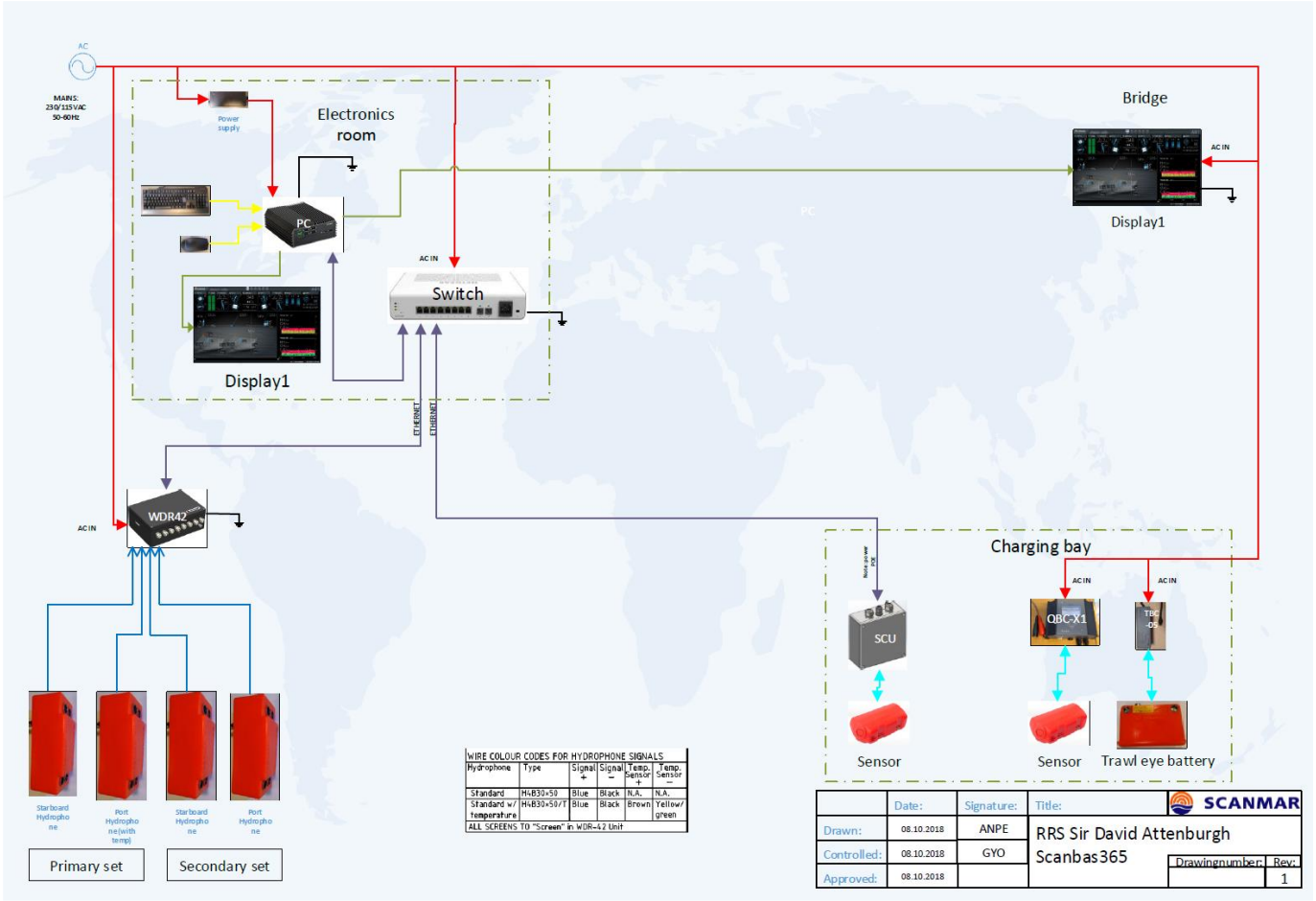




Scanmar trawl monitoring

- Location of towed systems behind vessel





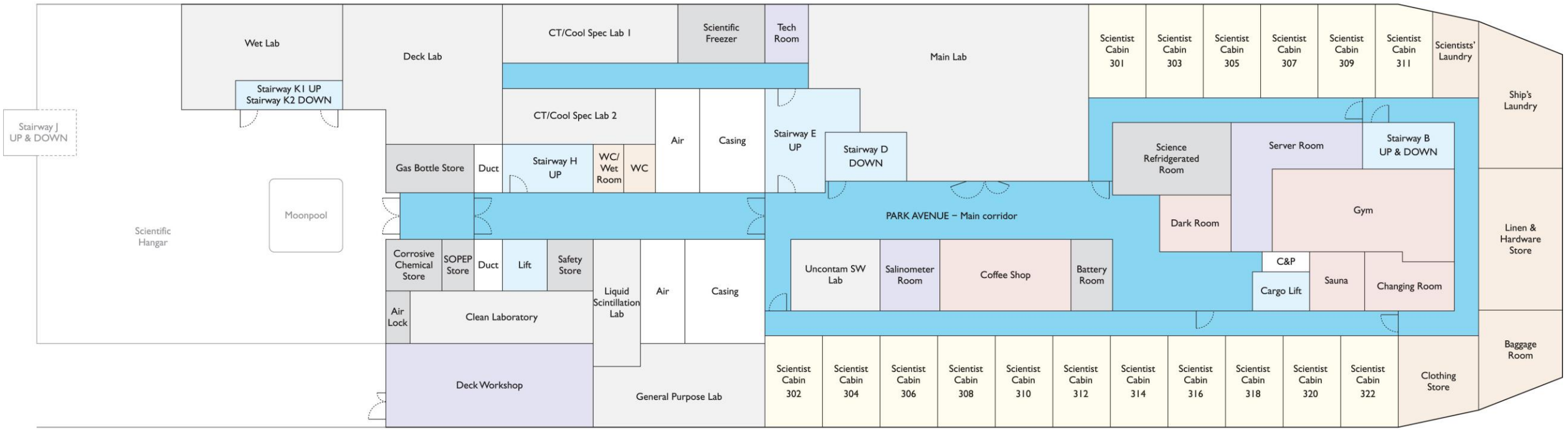
Aft deck workflow

KEY

- Laboratories/Offices
- Accommodation
- Corridors
- Scientific Support
- Facilities
- Stairway/Lift/Lobby
- Technical/Workshops
- Recreational
- Out of bounds
- Doors (only those linking corridors, lobbies, stairways and outside are shown)

RRS *Sir David Attenborough*

Deck 3



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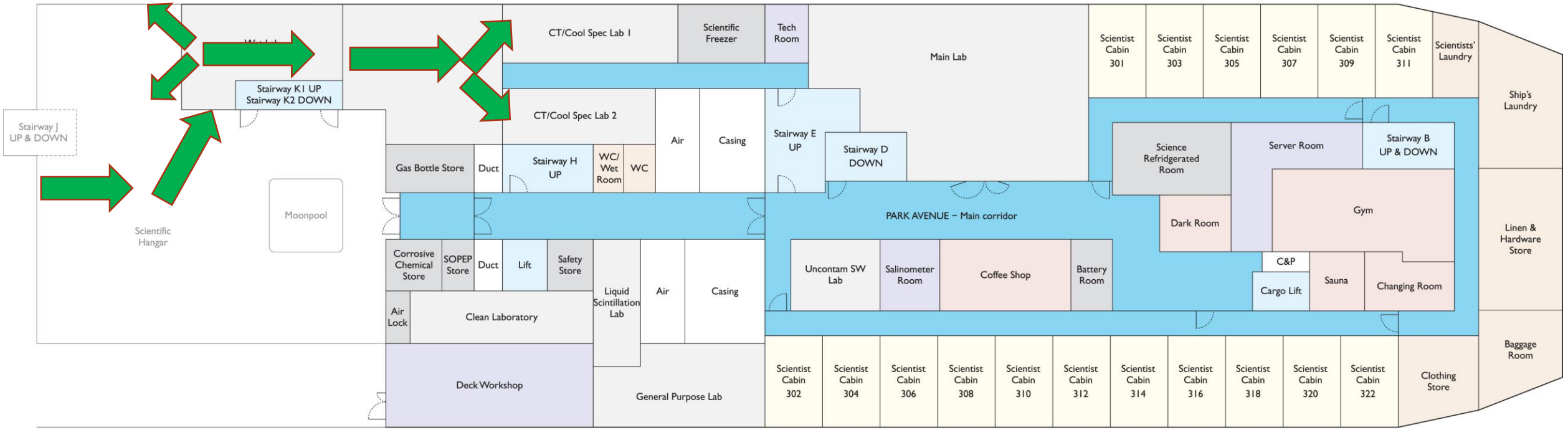
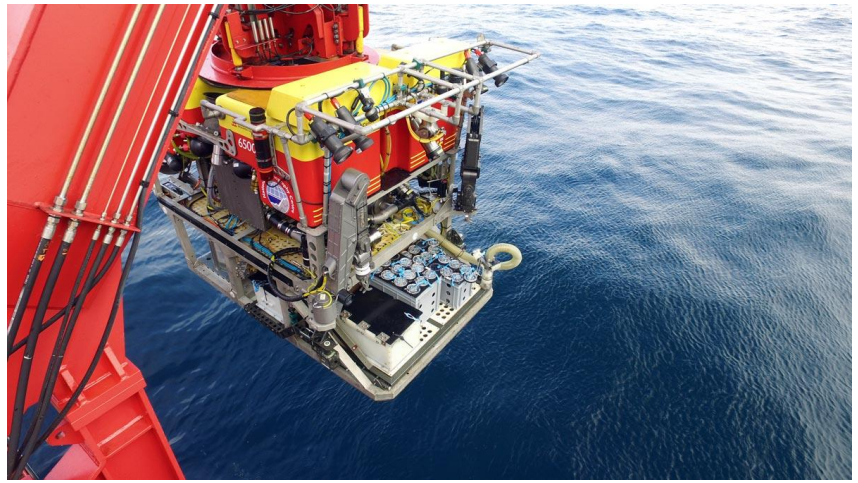
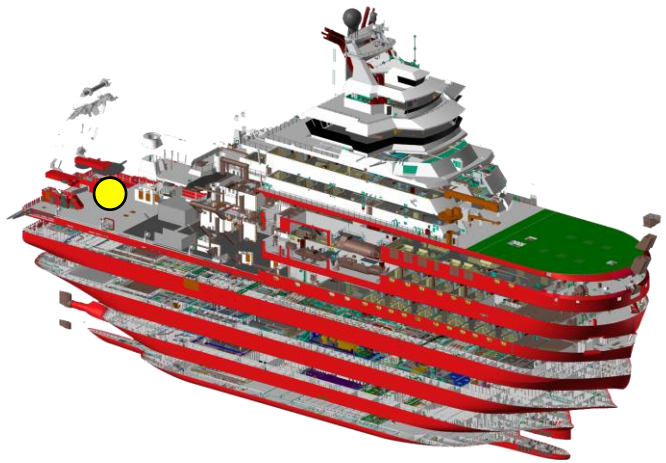
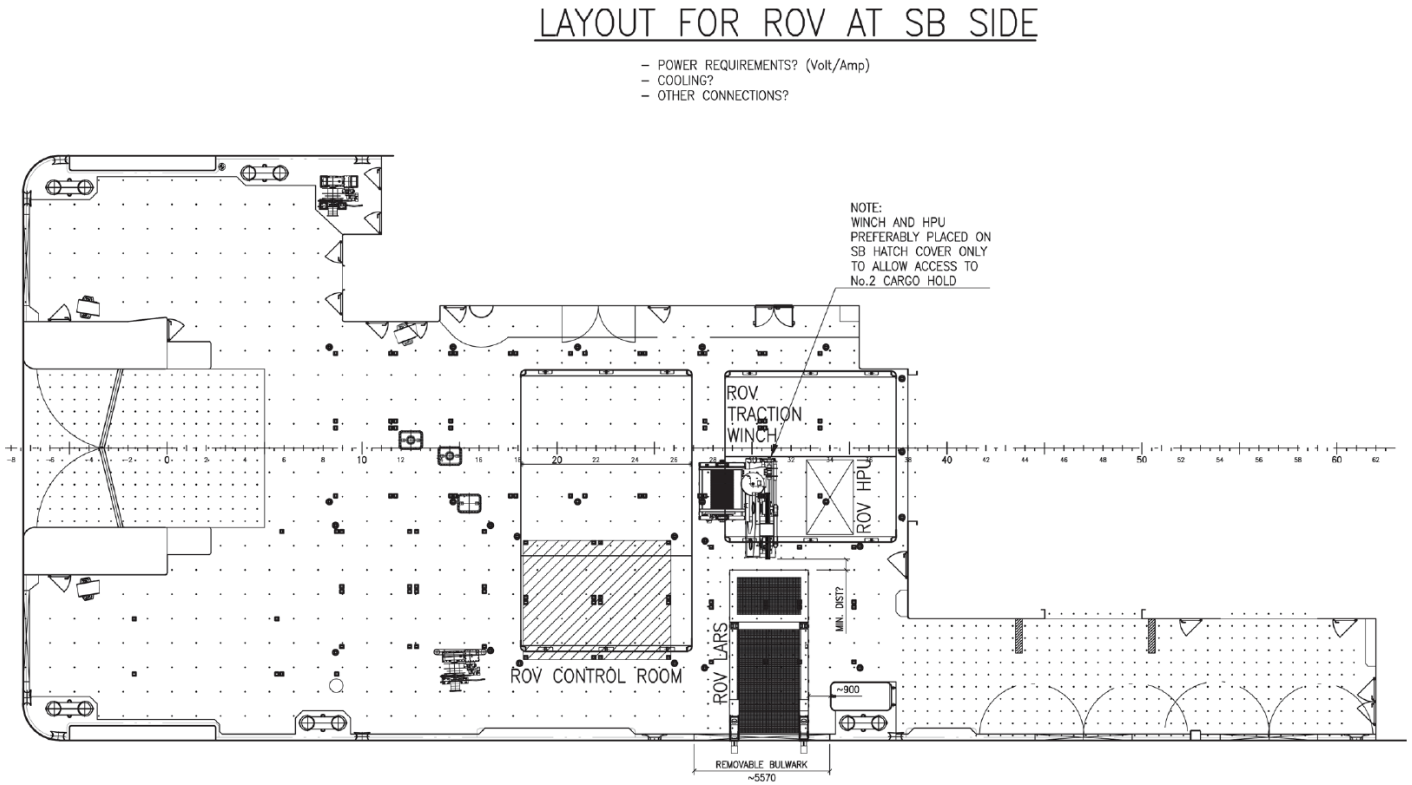


ROV capability

- ROV deck plan
- Ability to transmit video feed around ship
- Small ROVs may go through moon pool
- USBL for tracking

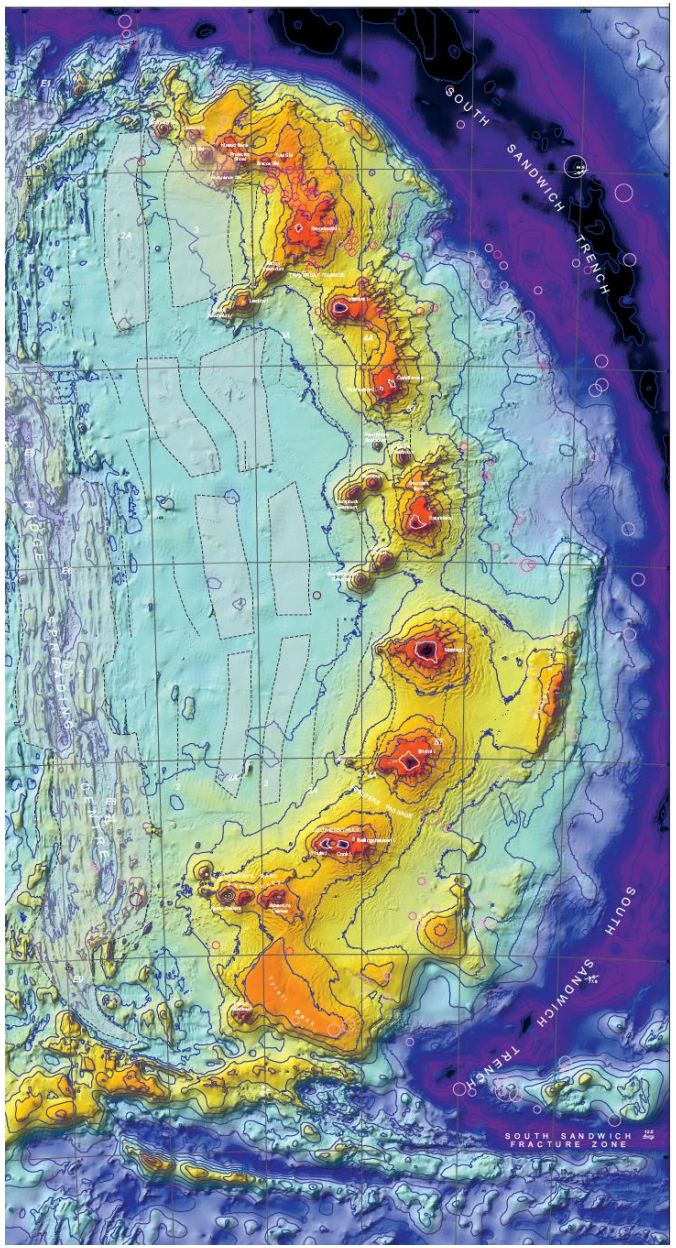






Deep (>6000m) trawl capability

- 12,000m of steel wire rope



Leat et al. 2014

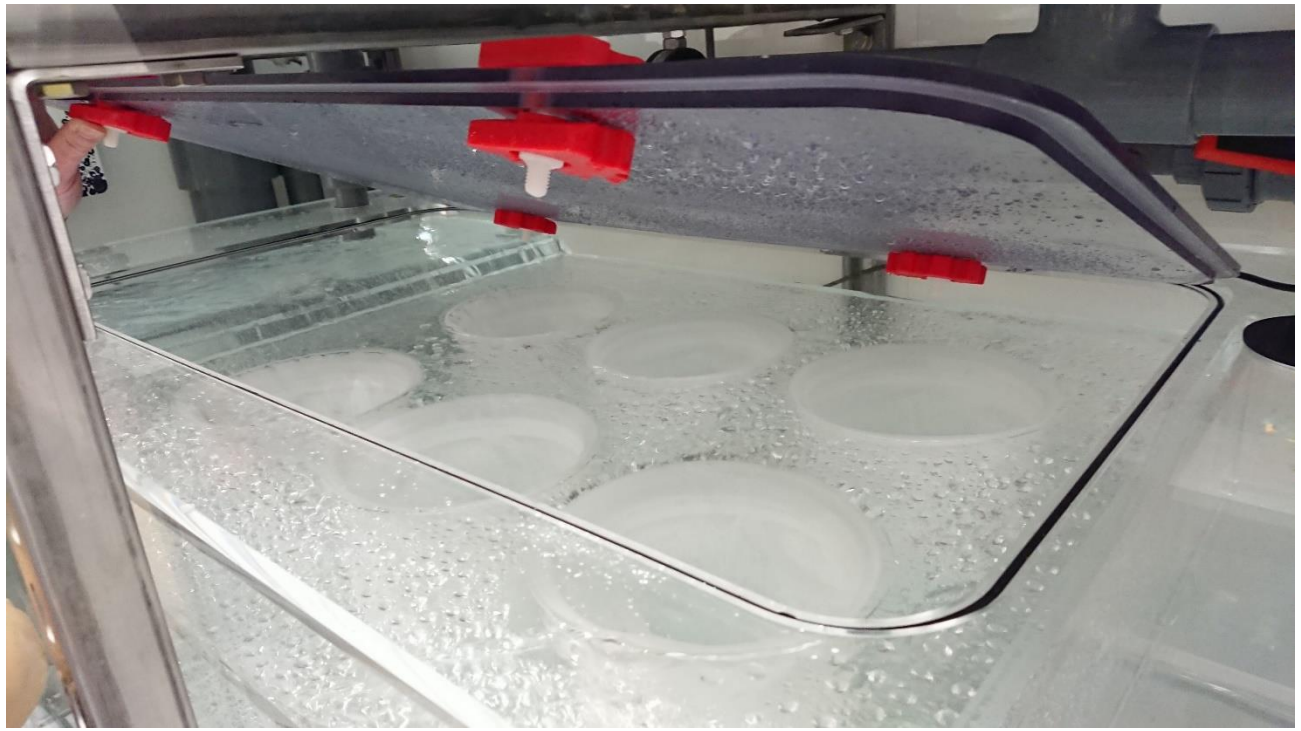
Wet lab, with connections to bespoke container facilities

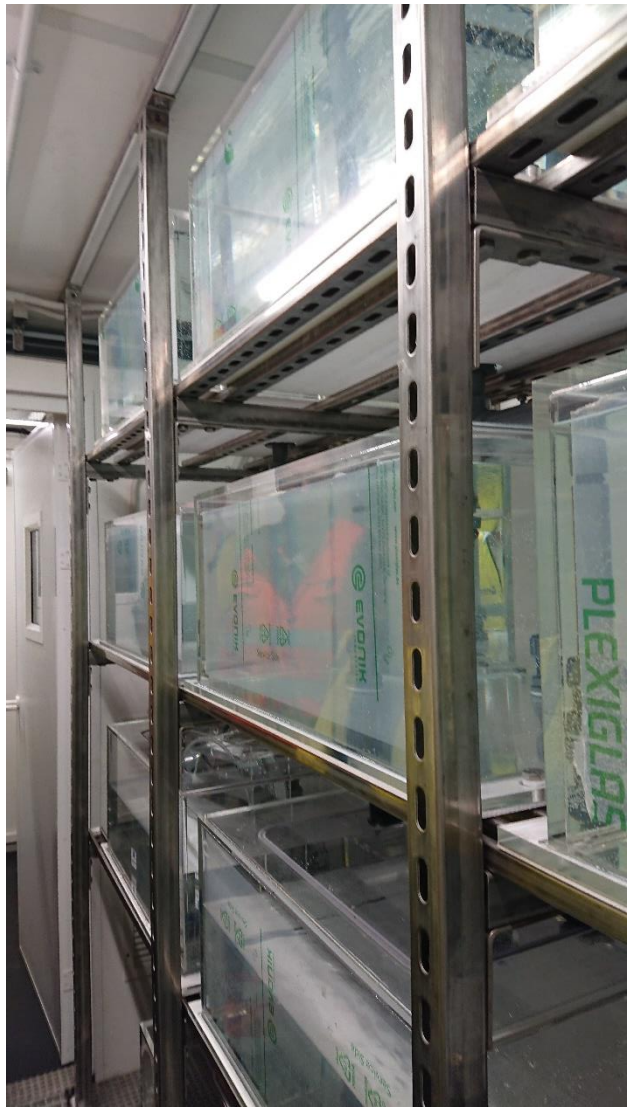
Fresh water sink

Wet lab table

Experimental aquarium container

- Controlled temperature (0 to 30°C)
- Holding, experimental and incubation work
- Cooled seawater to be pumped into





Deck lab

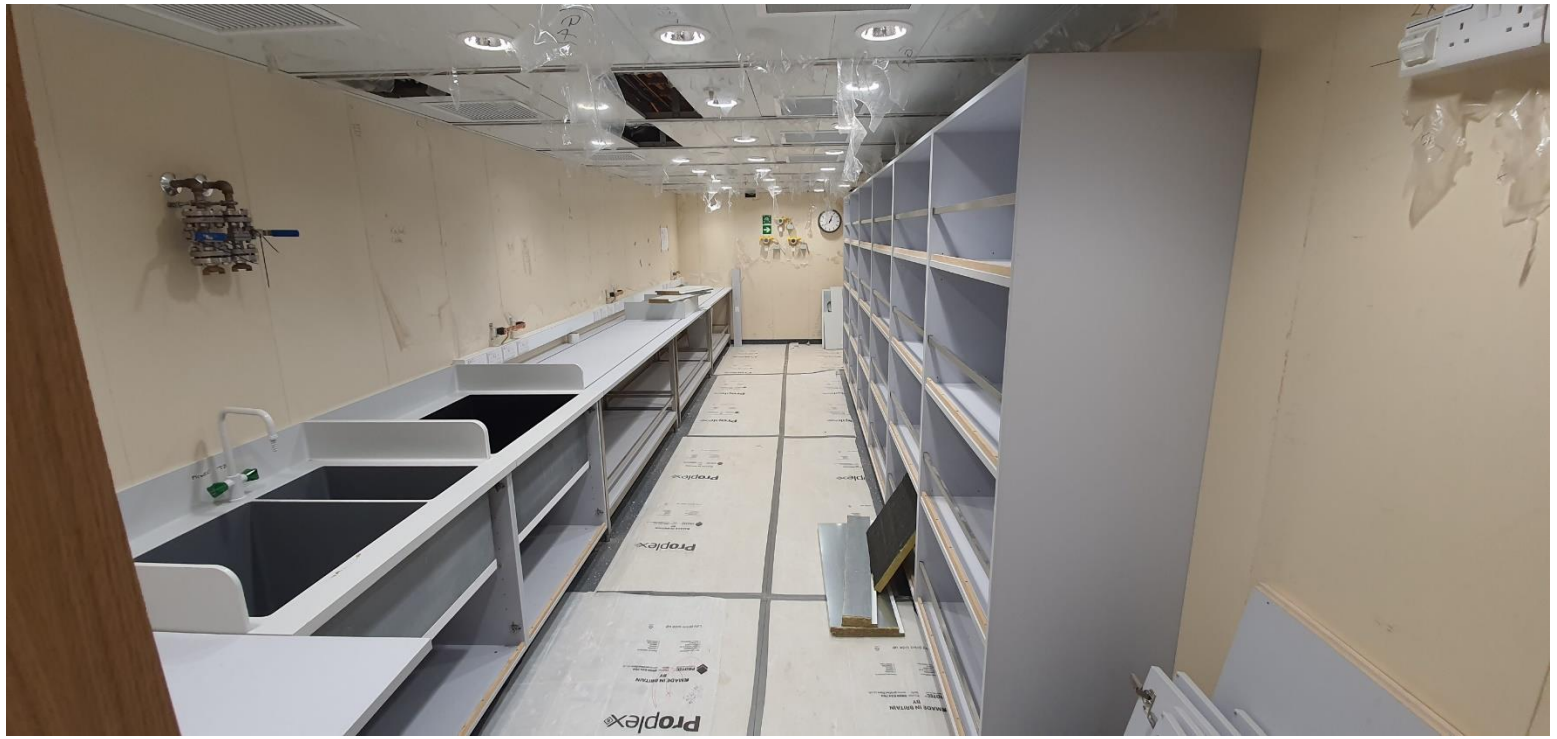
- “Wet” work space, fridge/freezer, fumehood, MilliQ, chem lockers

Deck lab, port side

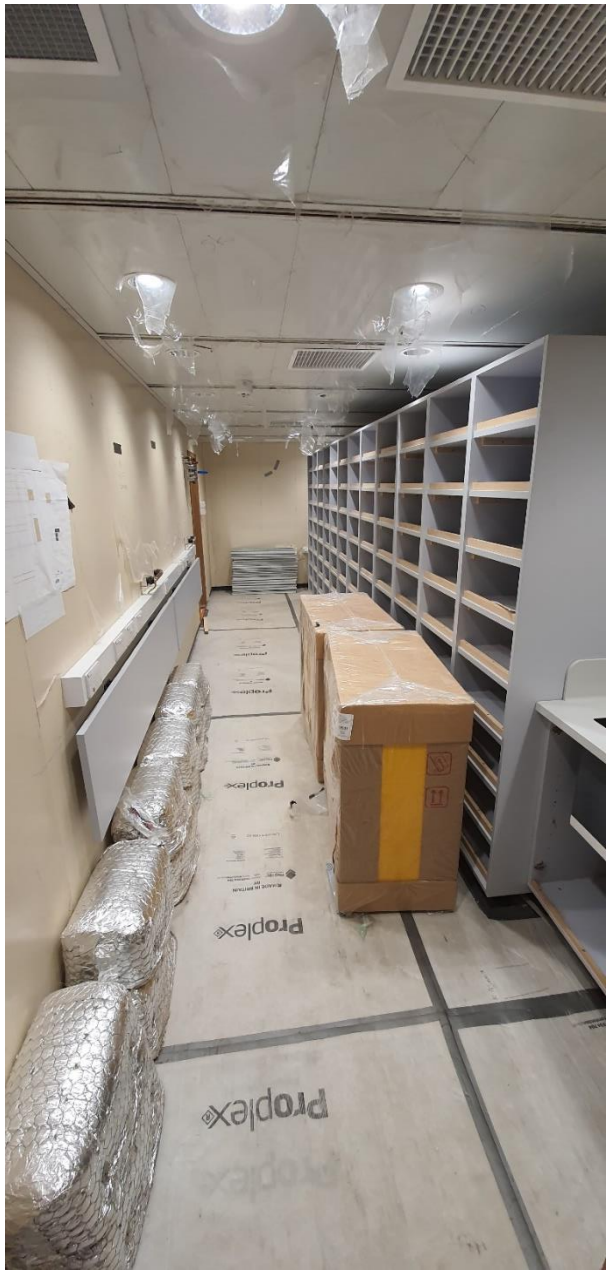
Deck lab workbench

Two controlled environment laboratories

- CT lab (0 to 30°)
- CT store (-2 to 30°)
- Underway seawater to both



CT lab



CT store

Starboard deck workflow

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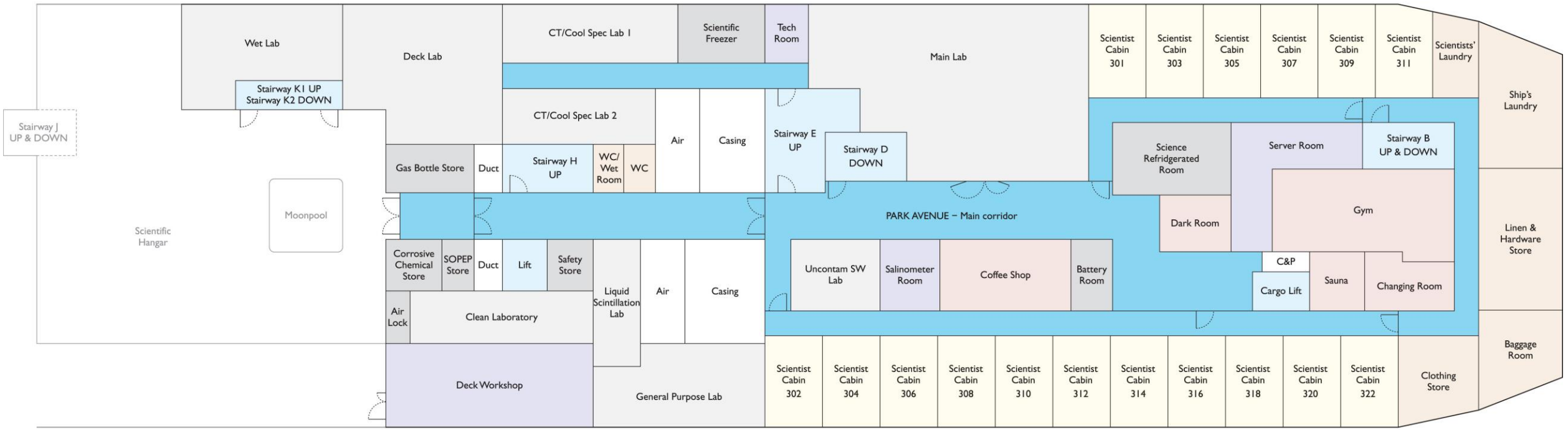
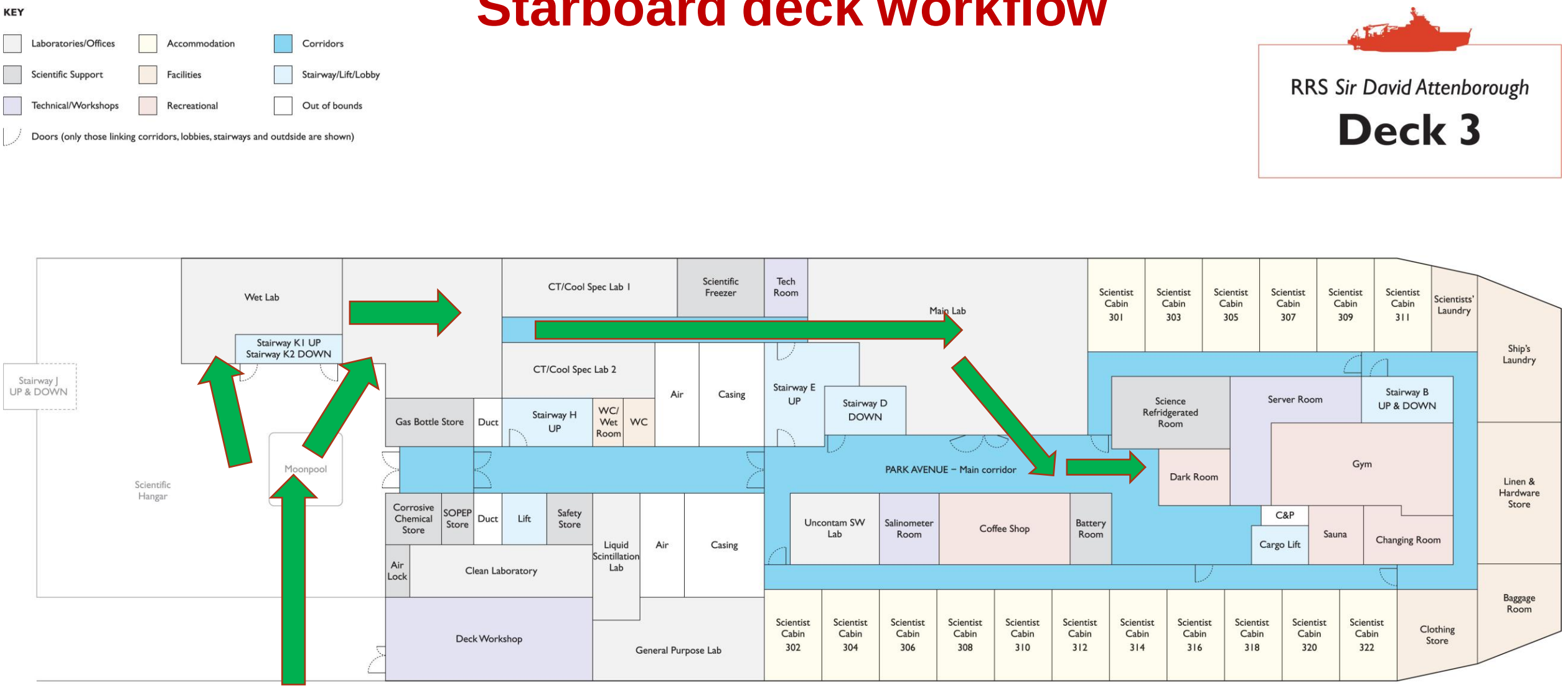
RRS *Sir David Attenborough*

Deck 3



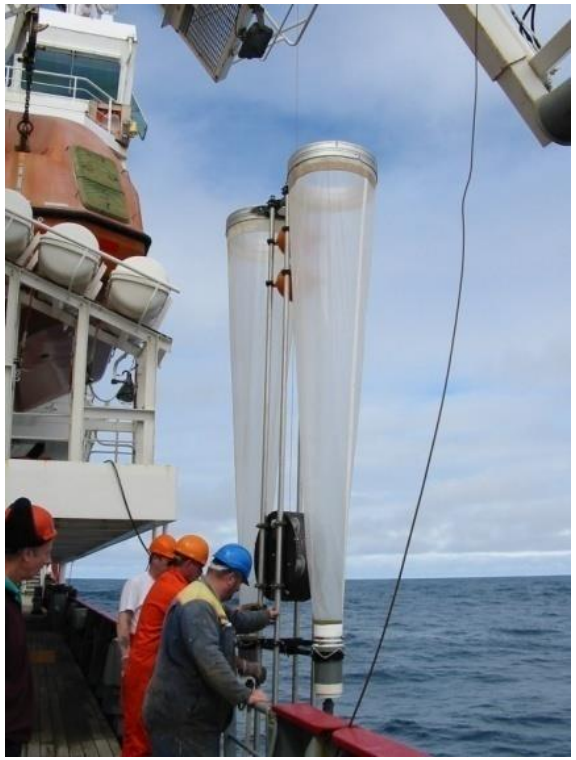
Starboard deck workflow



Sampling equipment

- Equipment request via SME (Ship and Marine Equipment form)

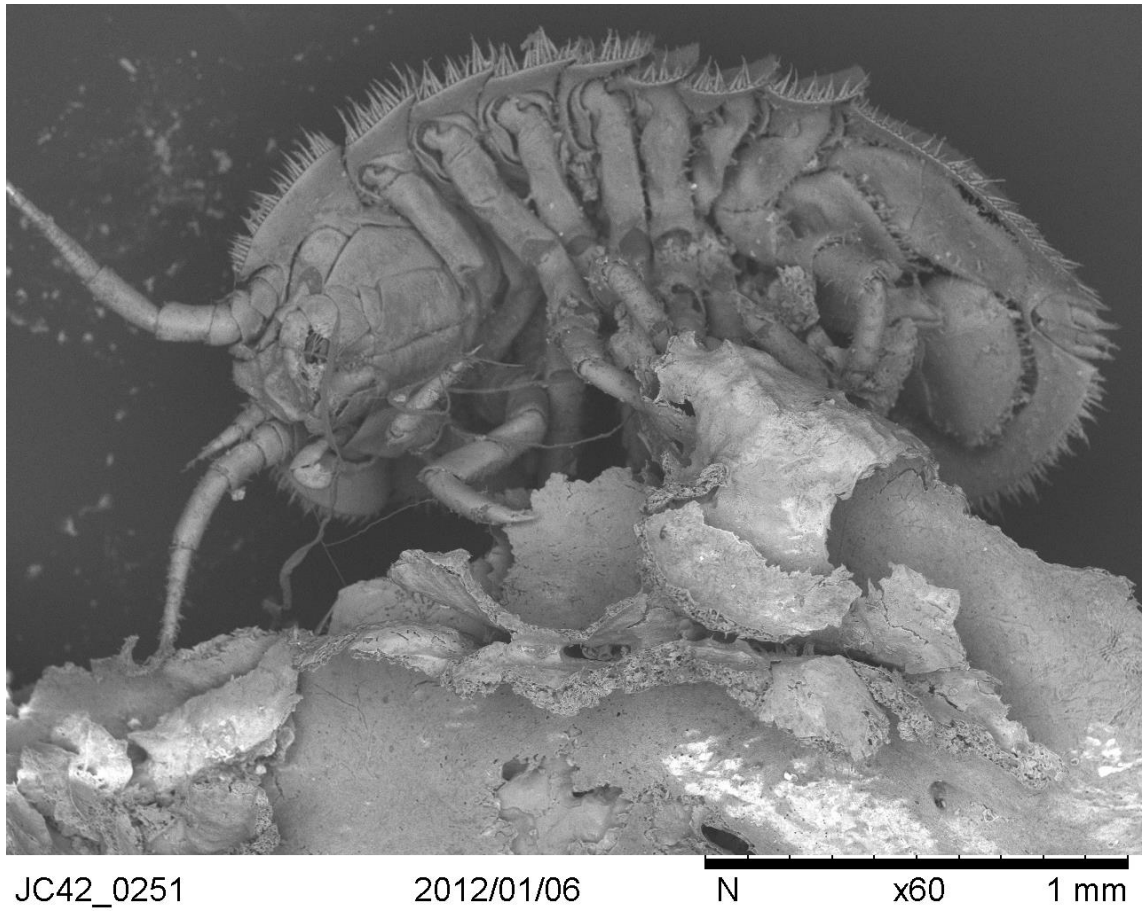
Oktopus multicorer



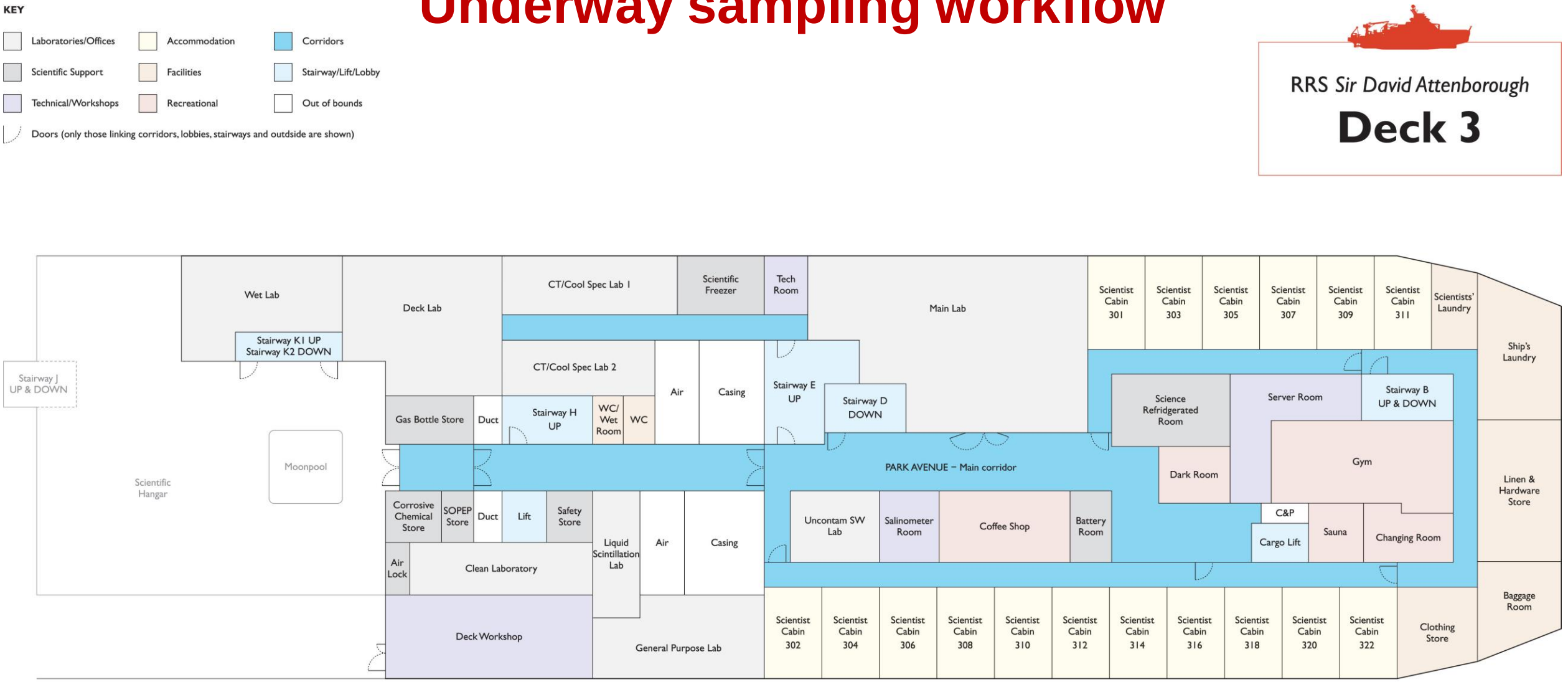
Motion compensated bongo net

Advanced laboratory facilities

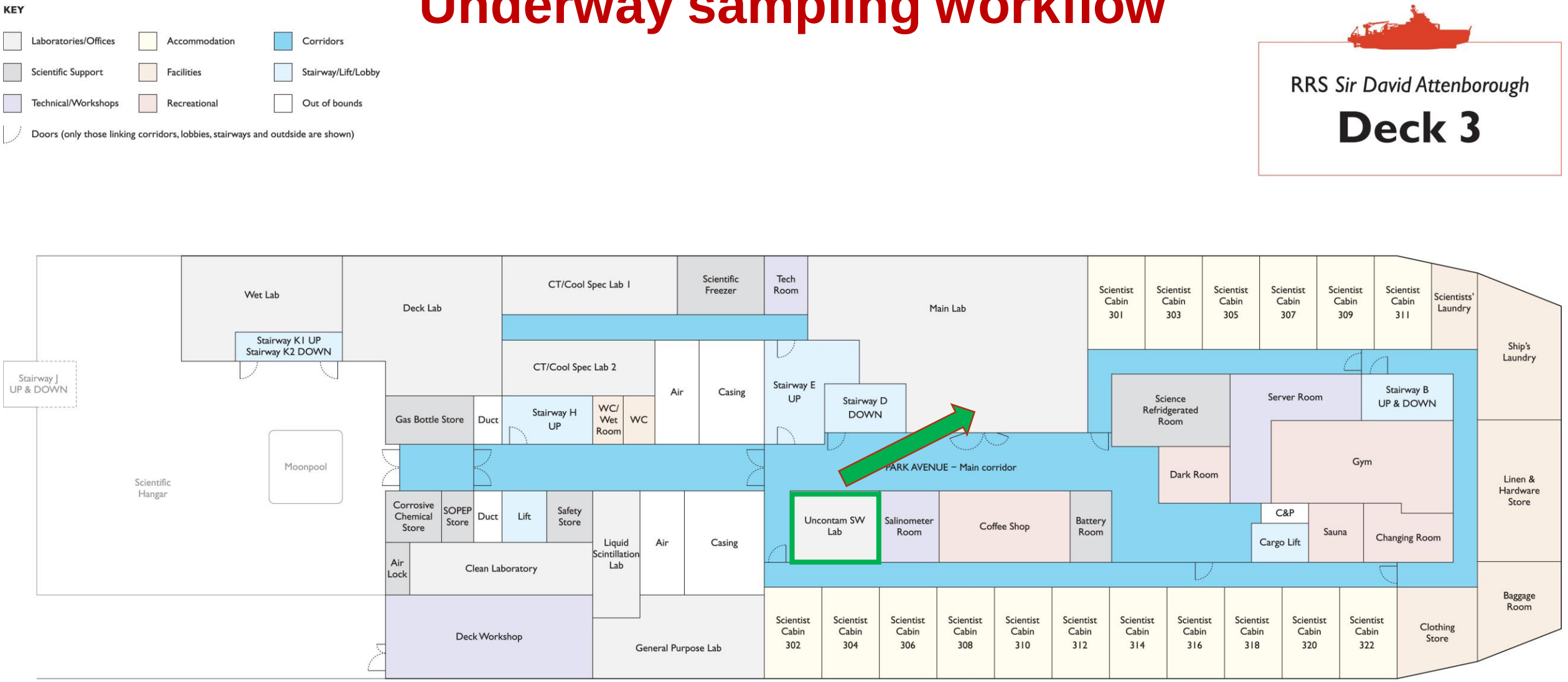
- Scanning Electron Microscope (Hitachi TM4000)



Underway sampling workflow



Underway sampling workflow



Advanced laboratory facilities

- LabStaf FRRF
- Single Turnover Active Fluorometry (STAF) for measuring phytoplankton primary productivity (PhytoPP)

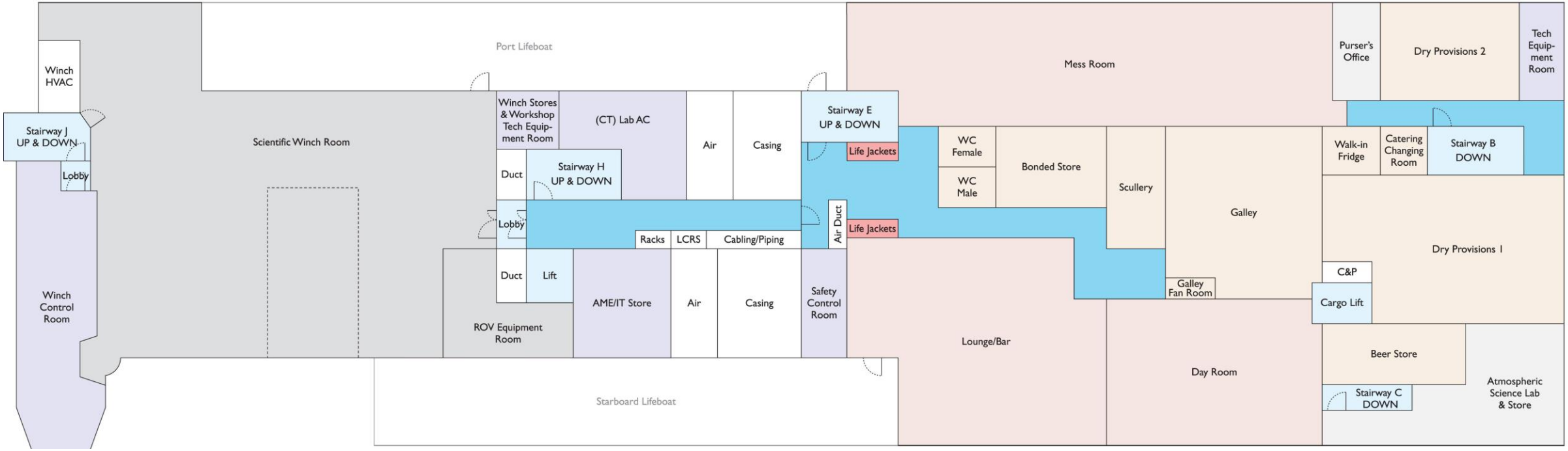
Winch control room

KEY

- Laboratories/Offices
- Accommodation
- Corridors
- Scientific Support
- Facilities
- Stairway/Lift/Lobby
- Technical/Workshops
- Recreational
- Out of bounds
- Doors (only those linking corridors, lobbies, stairways and outside are shown)

RRS *Sir David Attenborough*

Deck 5



Winch control room

KEY

- Laboratories/Offices
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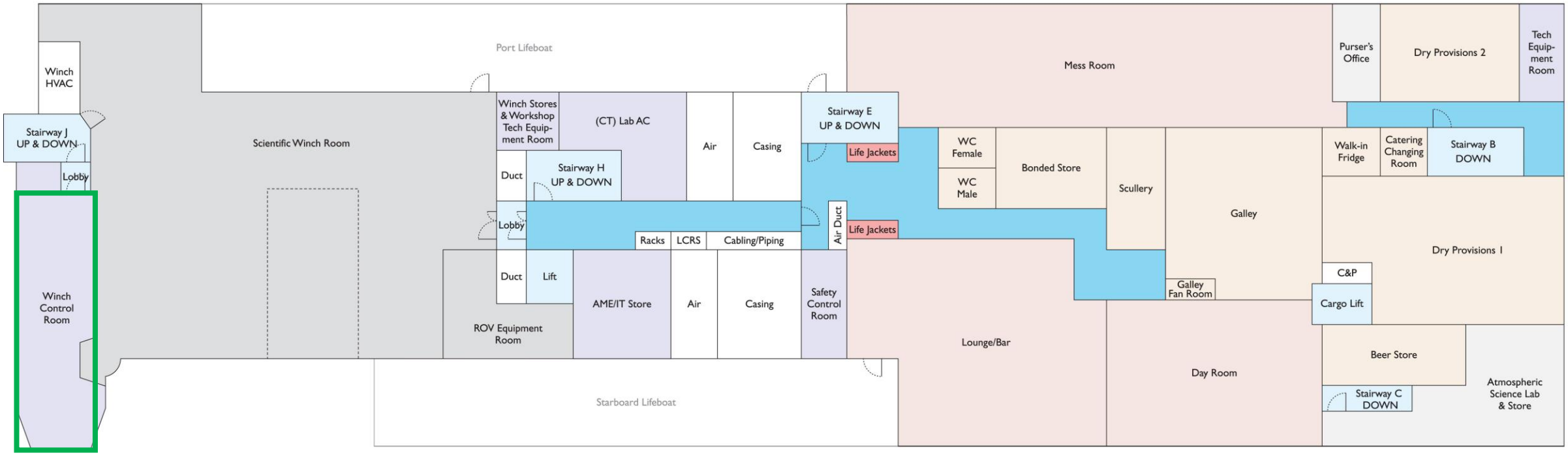
RRS *Sir David Attenborough*

Deck 5



Winch control room

- Starboard and aft winch control desks
- 1 cruise control hub (12 screen video wall)
- 2 system control desks (4 screen multi control)
- Ability to control nets, systems whilst in communication with winch driver

Marine mammal observations

- Outside viewing area with wind baffles
- Inside viewing area with power, warmth and IT

Questions?

Acknowledgements

Thank the UK science community for their input into the specification, back in 2014-15 and for answering subsequent questions since

The ships officers and crew for answering and posing many questions through the build period

Ray Leakey for guiding this process, attention to detail, representing all disciplines

Chemistry capability

Malcolm Woodward

RRS *Sir David Attenborough chemistry representative*

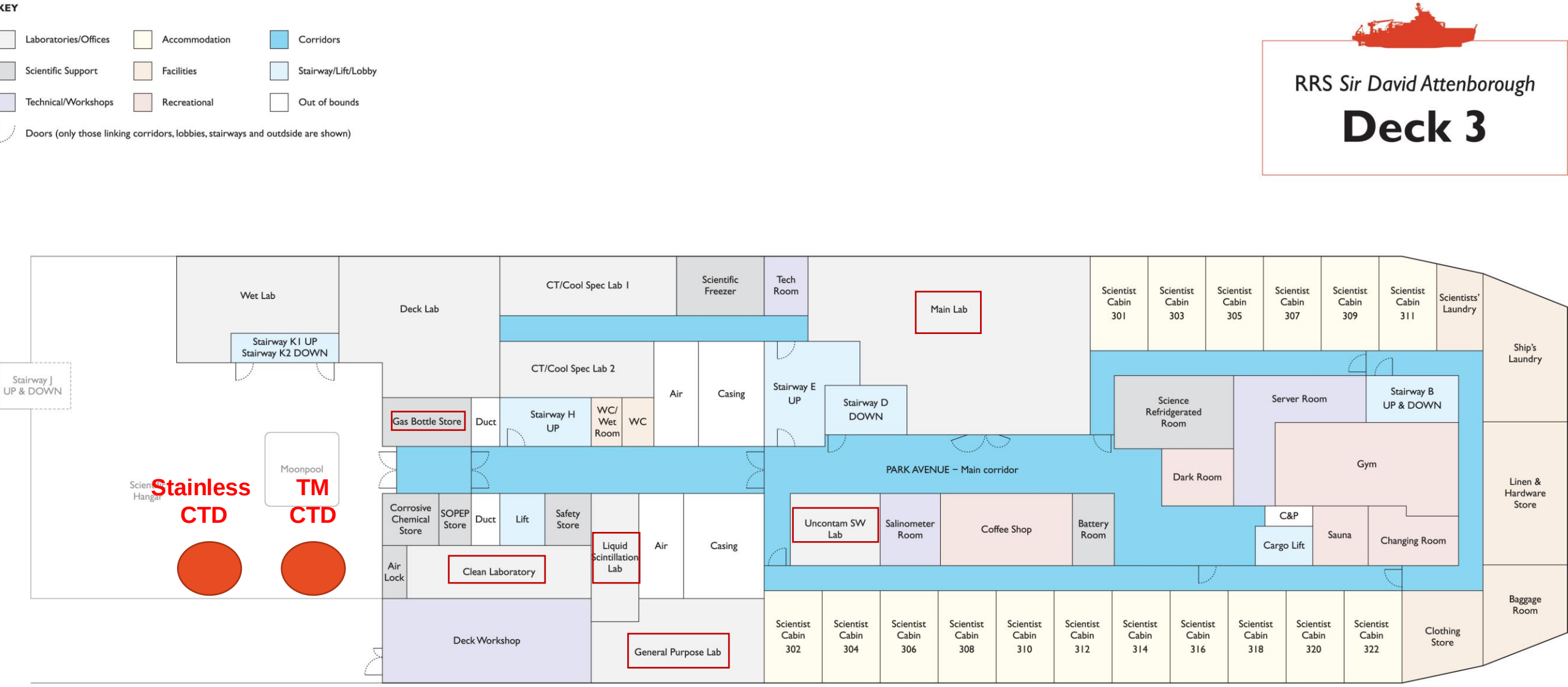
Plymouth Marine Laboratory

RRS Sir David Attenborough Chemistry capability

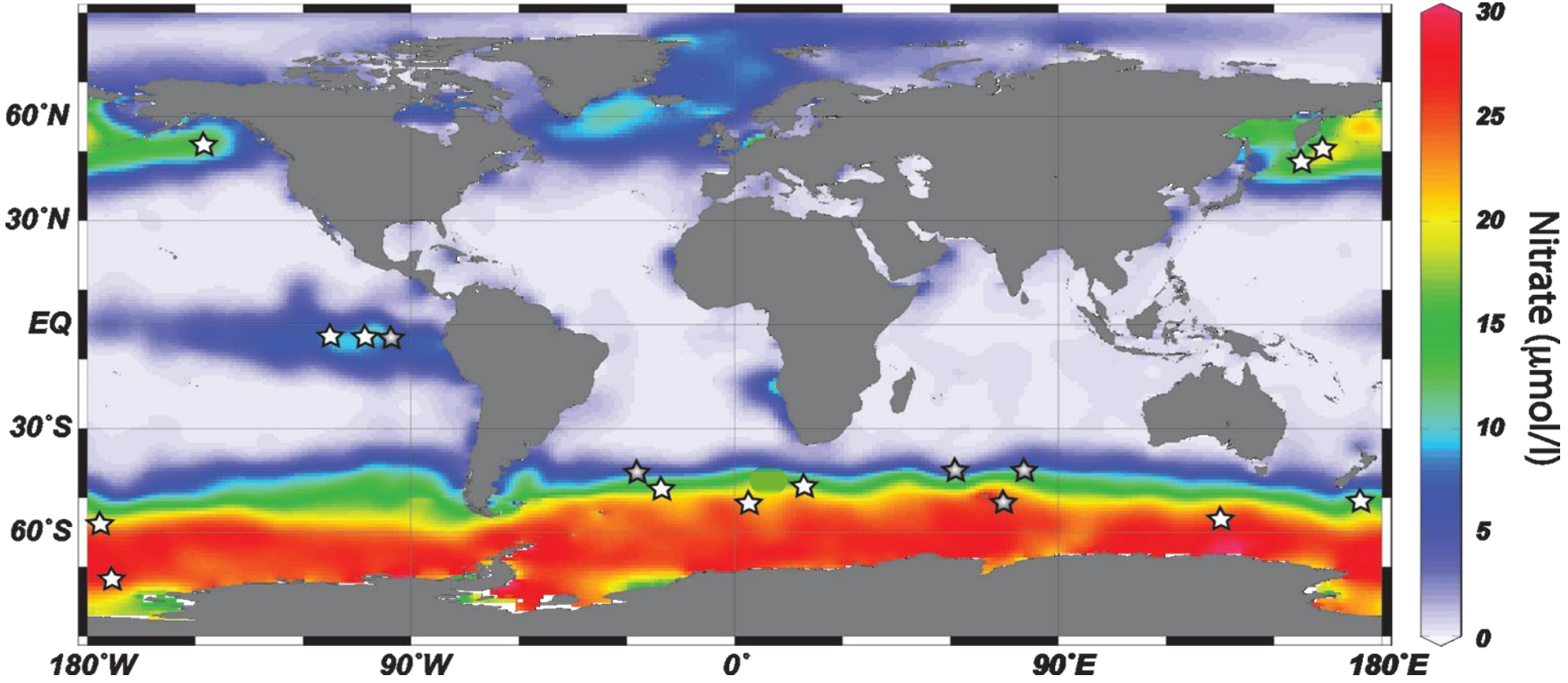
An overview of some aspects of the Chemistry facilities that will be available on the SDA.

- Lab Layouts
- Clean Chemistry capability, trace metals, clean chem lab, CTD
- Experimental Radiochemistry facilities
- Main and General Purpose Laboratories
- Carbon Dioxide and pCO_2
- Other facilities that will be available on board

Science Labs Deck 3



Trace Metals



Adapted from Martinez-Garcia & Winkler (2014) PAGES 22 & Yoon et al. (2018) Biogeosciences 15: 5847-5889

Iron is important as a vital trace nutrient in the ocean, along with Manganese, Cobalt and Zinc
The Southern Ocean is a HNLC (High Nutrient Low Chlorophyll region), excess Nitrate & Phosphate
Iron fertilisation experiments in the 80's and 90's: add iron then primary production was stimulated
Iron was the limiting nutrient

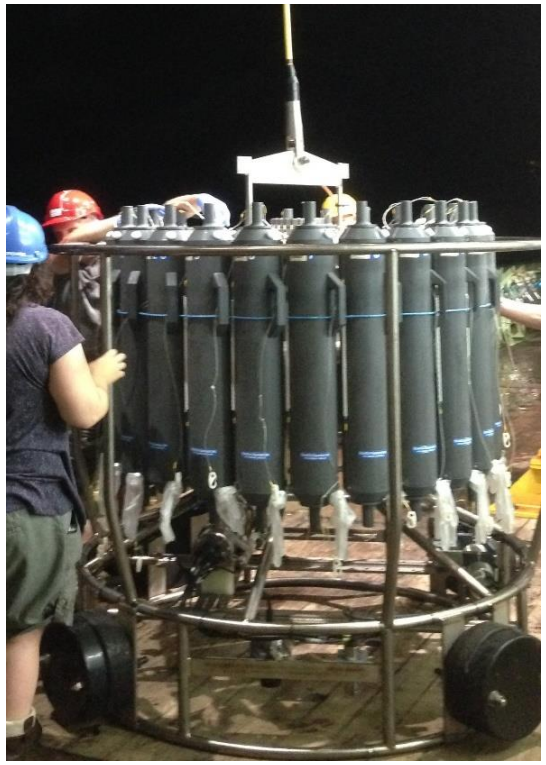
Trace Metals

- Analytical capabilities improved and so the need to have cleaner working facilities
- Improved sensitivities with developing flow injection analytical techniques

- In Antarctic surface waters Iron = ~ 0.1 nanomolar, Cobalt, Zinc and Manganese = picomolar concentrations
- Contrast with up to 30 micromoles/l of Nitrate: 6-7 orders of magnitude greater
- Therefore the requirements for cleaner sampling and working areas
- First items on the SoR in 2014 from the Chemistry community was state-of-the-art clean chemistry facilities

SDA Clean Chemistry CTD: OTE bottles

Titanium 24 bottle CTD Rosette Frame.
All sensors made out of Titanium



OTE Model 114 Niskin-type bottles
Grey PVC
Internal chamber free of contamination
Ball valve activated by external power cord.
(36 x 12 Litres)

There is also the standard Stainless Steel CTD with options of 24 x 12 or 20 litre Niskin bottles plus all the usual sensors

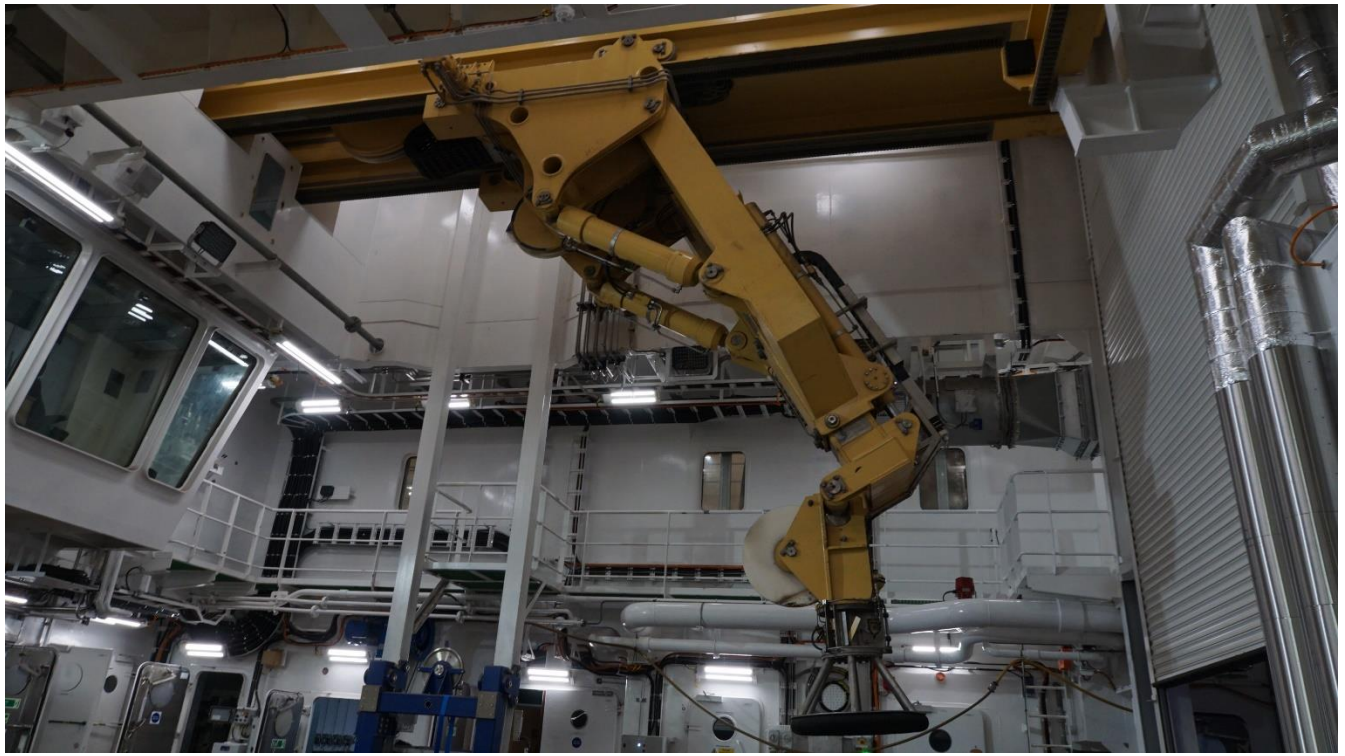
Clean Chem Winch and Cable

With the advent of major international programmes like Geotraces in recent years, researching into trace metal species found at very low levels in the oceans urgent need for clean chemistry sampling systems to avoid the use of metal cables and Stainless steel CTD's.
Elsewhere are portable clean chem winch systems in converted shipping containers, but these are always out on the deck and at the mercy of the ocean waters and atmospheric contamination from the ship and during transport.

SDA has the first in the world state of the art clean chem winch and cable designed as a part of the ships systems.
A dedicated clean winch room with a direct pull winch wound with 10,000 metres of a synthetic conducting cable.

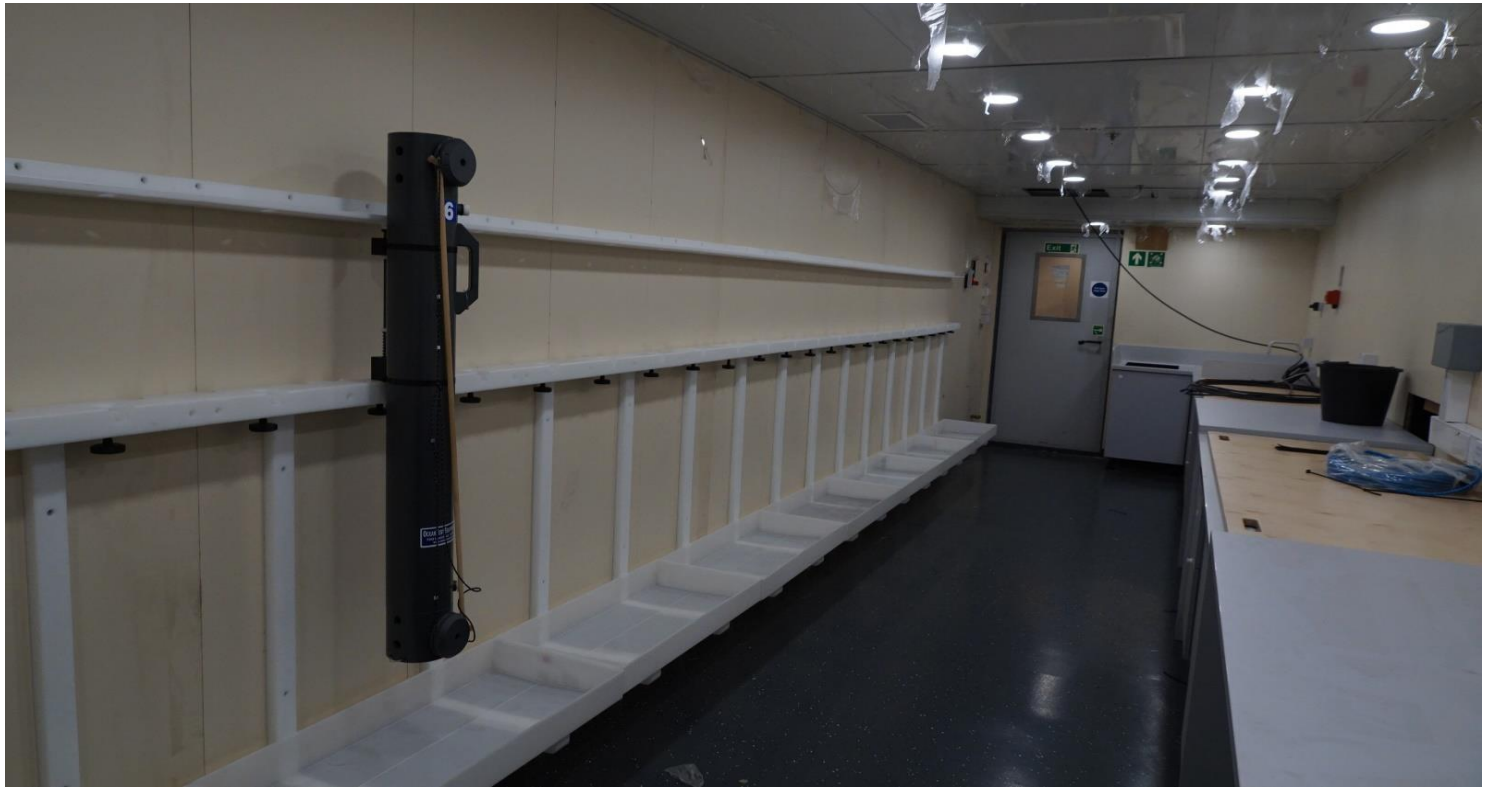
Nexans conducting copper core with thermoplastic polymer layered aramid yarns, forming the armoured CTD cable.

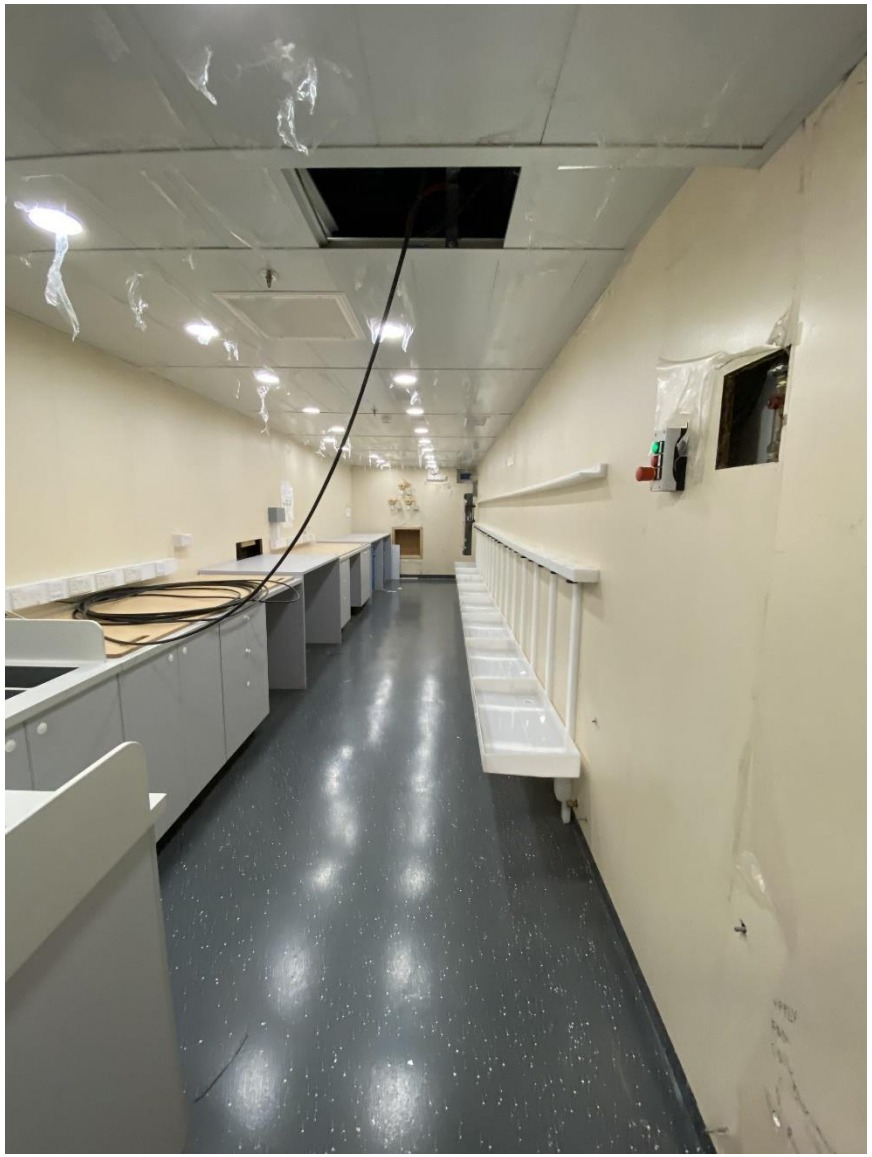
Clean Chem CTD Deployment



Articulated Clean Chem CTD deployment boom
All surfaces are non metallic where cable runs
Design allows close control of CTD, counteracts swinging

Trace Metal Free / Clean Science Lab





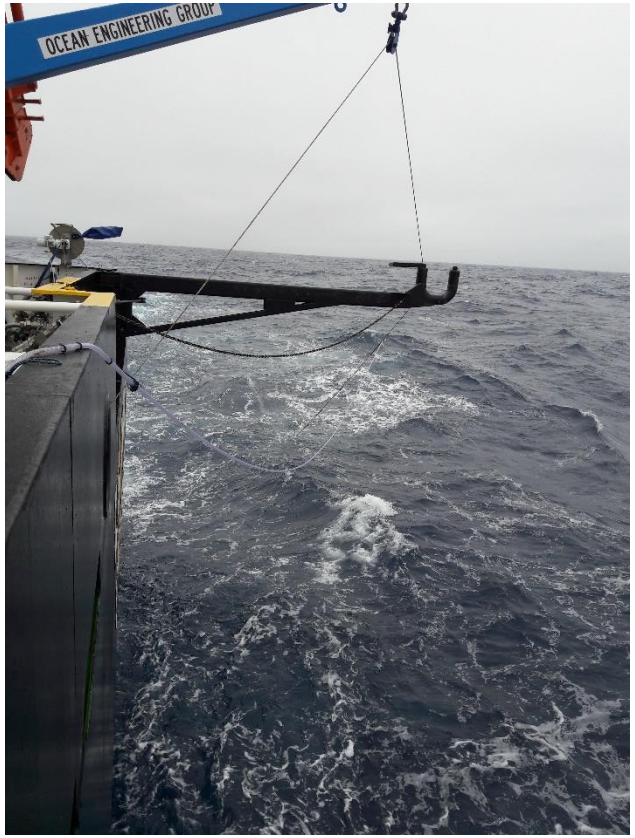
Spacious on-board clean laboratory for sample handling and preparation
Close to the Clean Chem CTD.
A lobby area in which to isolate the lab from outside atmospheric Contamination, and pass bottles in safely.
Hepa filtered air into lab.
Lab and CTD are ideal for clean biological science as well as a chemistry facility.

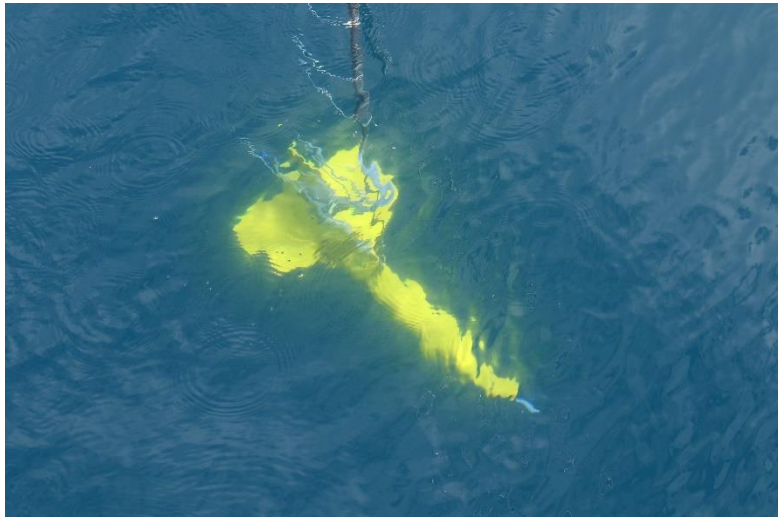
Clean Chemistry

2 x Bassaire Laminar Flow cabinets, made of board and plastics

+Fridge, Freezer, Milli-Q system, chemical cabinets

Oil free compressor for trace metal CTD bottles





Overside Clean chemistry underway ‘fish’, metal free pump

Clean Chem Container

Used for sample processing and at-sea analysis, kept separate from the on-board laboratory.

Laminar Flow cabinet, fridge/freezer, Milli-Q system, air conditioned, Hepa filtered air, positive pressure

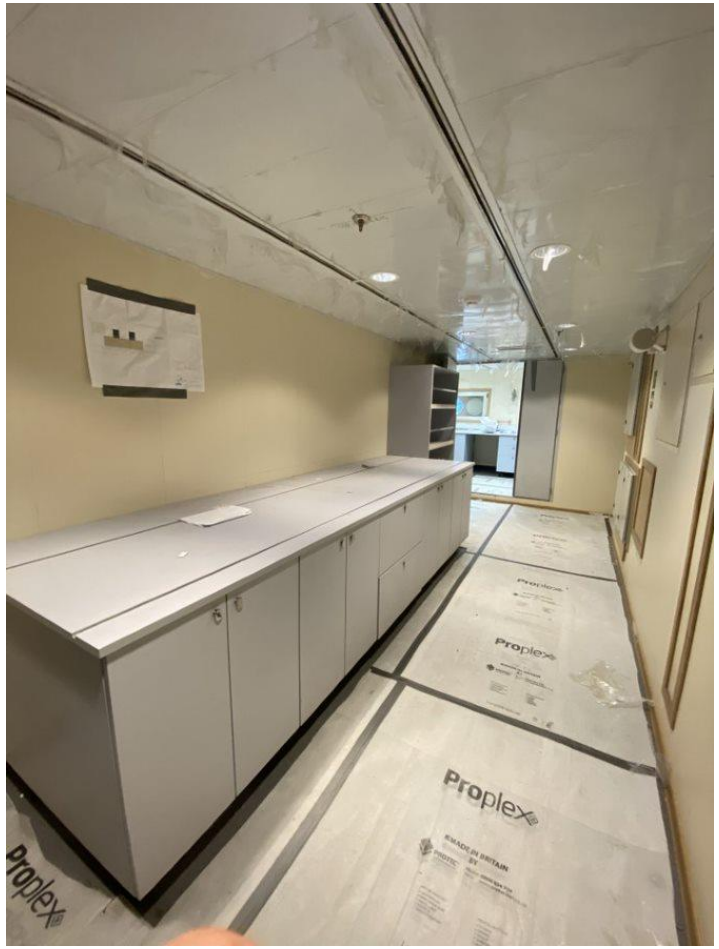
Lab again has lobby to isolate from direct outside air, samples segregated.

Radioactive Lab Container

To carry out radioactive experiments using Carbon 14, for example, to label biological samples for experiments requires a dedicated on deck container so as to contain the radioactive compounds being used, and to be able to isolate this work.
Once the experiment is completed the samples are sealed and taken for measuring in the Liquid scintillation counters.

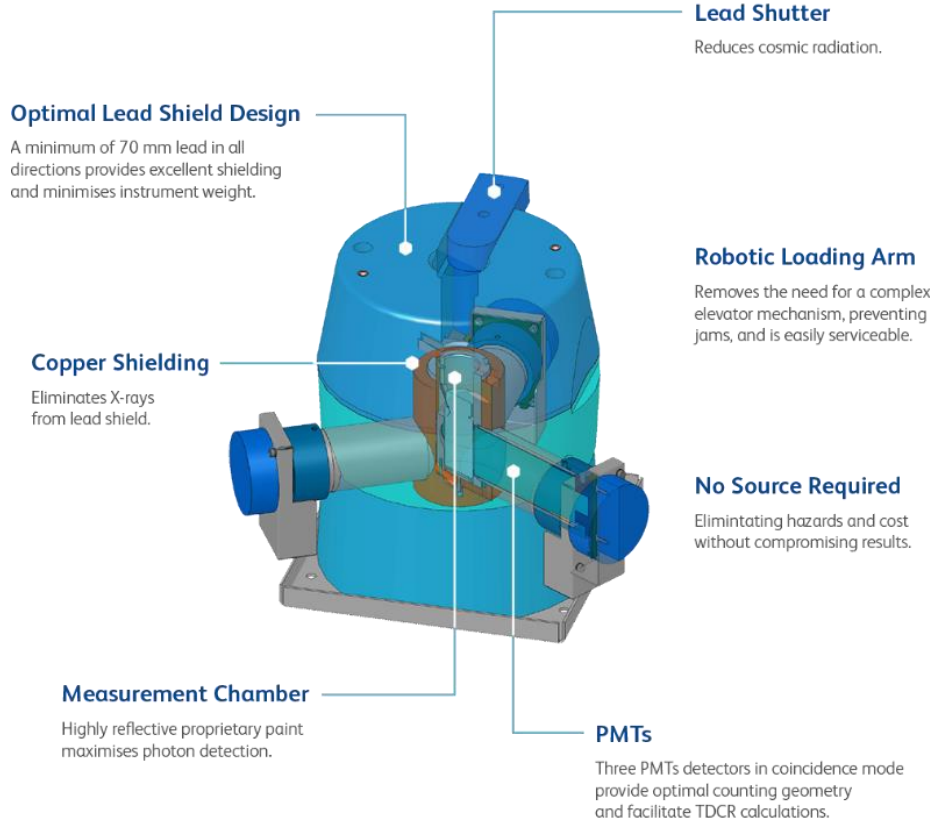
Fume Cupboard
Fridge, Freezer
Chem cabinet

Liquid Scintillation Laboratory



Lablogic 300SL-Super level detection-for dual isotopes

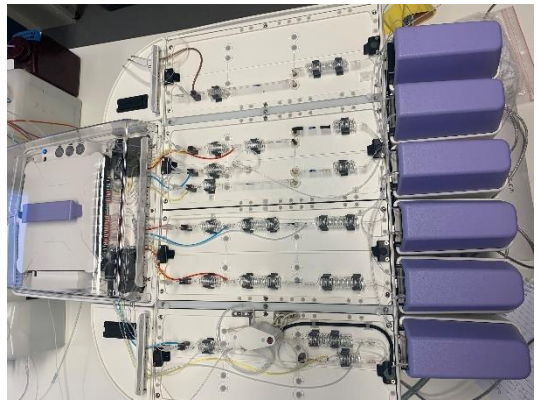
Lablogic Hidex 600SL-high sample throughput

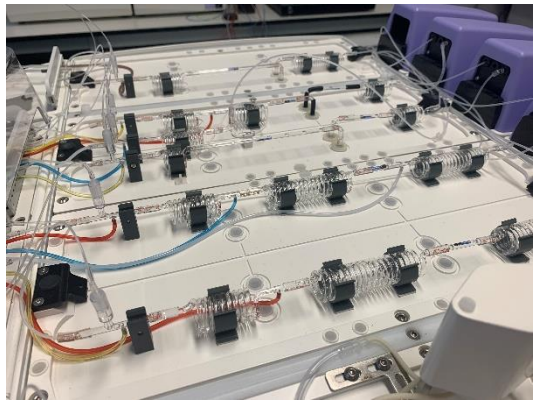


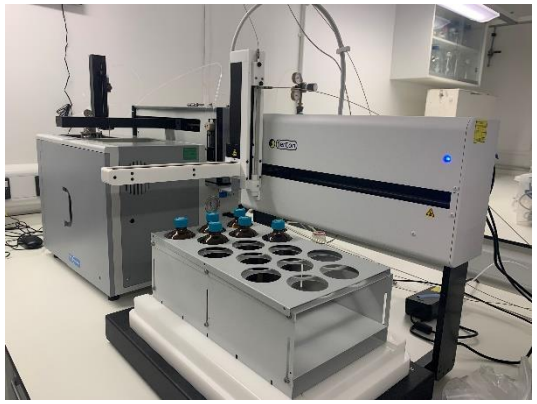
Hidex is relatively new technology-**no internal radioactive source**.
Safer and easier to transport (less paperwork and cost) for service & repairs
Rothera also has one – servicing cross calibrating simplified

General Purpose Laboratory

Recirc fume cupboard
Laminar flow cabinet
Fridge, Chem cabinet
Gas lines, Milli-Q



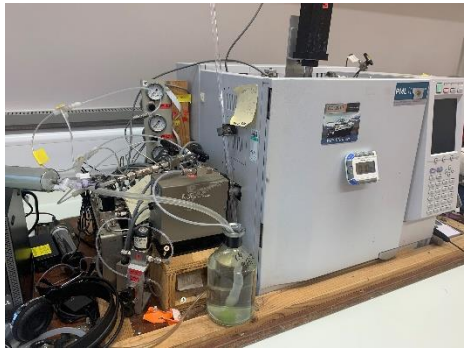


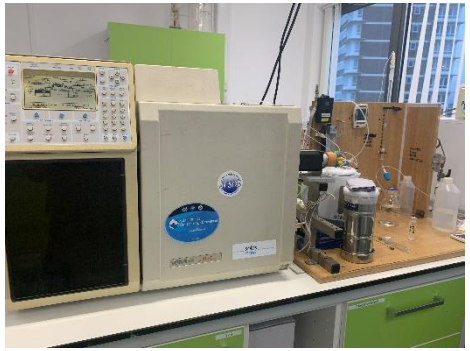


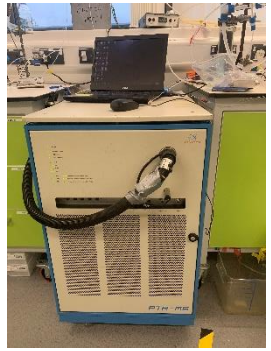
Main Laboratory

Large Multi-user space including one of 3 cruise management areas -12 flat screens, CTD's and deck equipment deployment wall

Extractor Fume Cupboard
Biological Safety Cabinet Class ll
Piped gases
Drying Oven
Ice Machine
Fridge

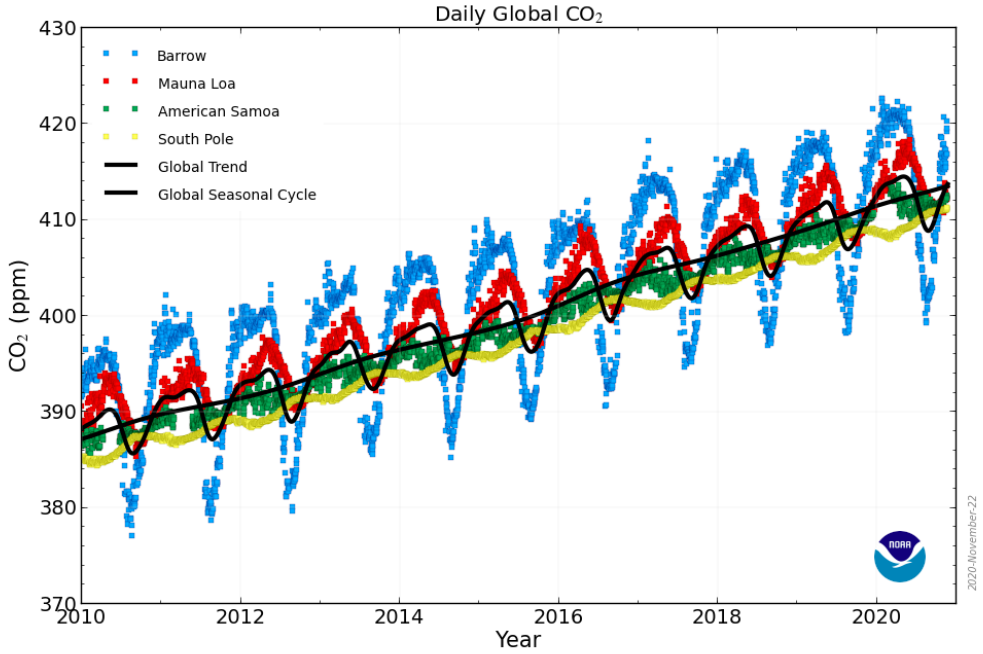






Carbon Dioxide in the Ocean

Since the industrial revolution, the global ocean has absorbed around 30% of anthropogenic (human-produced) CO_2 emissions. Although the Southern Ocean occupies only around 20% of the total ocean area, it absorbs approximately half of the CO_2. Variability and change in the ocean sink of anthropogenic carbon dioxide (CO_2) has implications for future climate and ocean acidification.



Polar air-sea CO_2 fluxes are critical to help understand our climate and the setup on the SDA gives us a great opportunity to better-understand air-sea CO_2 fluxes in the poorly sampled Polar regions.

Direct air-sea CO_2 fluxes by eddy covariance

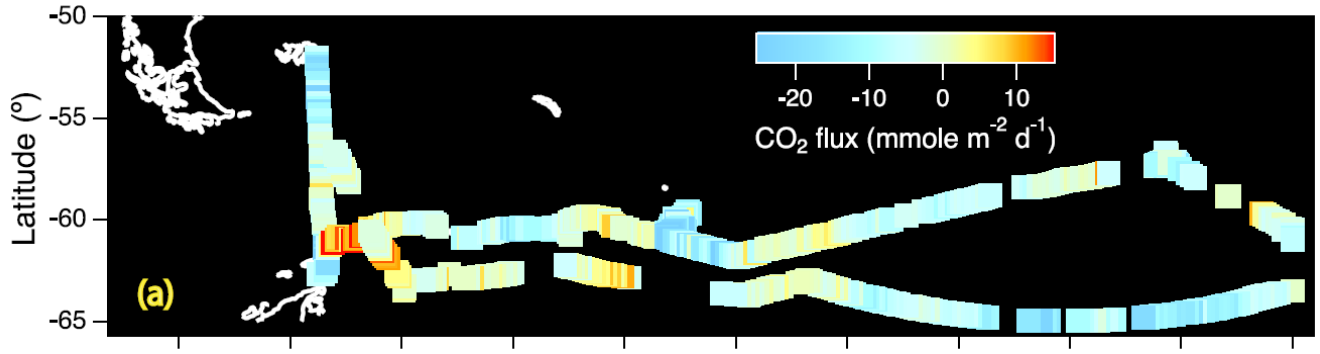
CO_2 Instrument and Data Acquisition

Co_2 Gas analyser

Heated sonic anemometer

Motion sensor

Air/CO_2 inlet



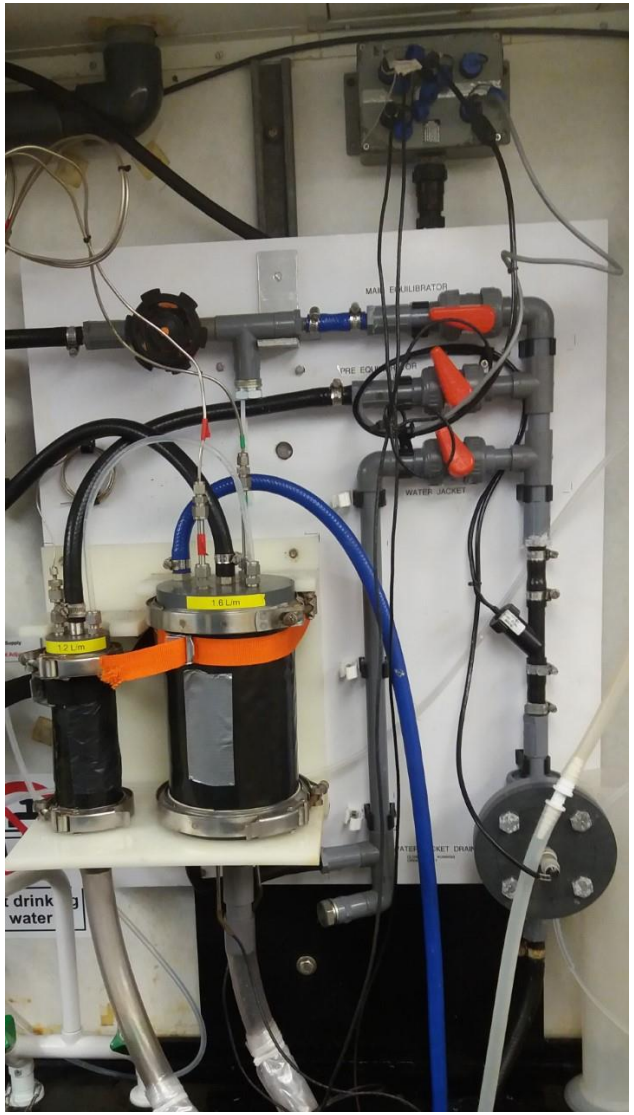
ANDREXII observations, Southern Ocean

Credits Tom Bell, and Ming Yang, PML

pCO2 Analytical system and Sea water equilibrator

Temperature controlled uncontaminated Seawater laboratory + transmissometer, CTD, Fluorometer, FRRF

Electronics, Li-Cor IRGA



Sea Water equilibrator

Measurements of surface seawater CO_2, partial pressure (pCO_2), and wind speed, will be used to calculate high-resolution CO_2 flux time series along the transects of the SDA both in the Polar regions but also on the transects north and south in the Atlantic Ocean each year.

Other ship-installed Laboratory facilities

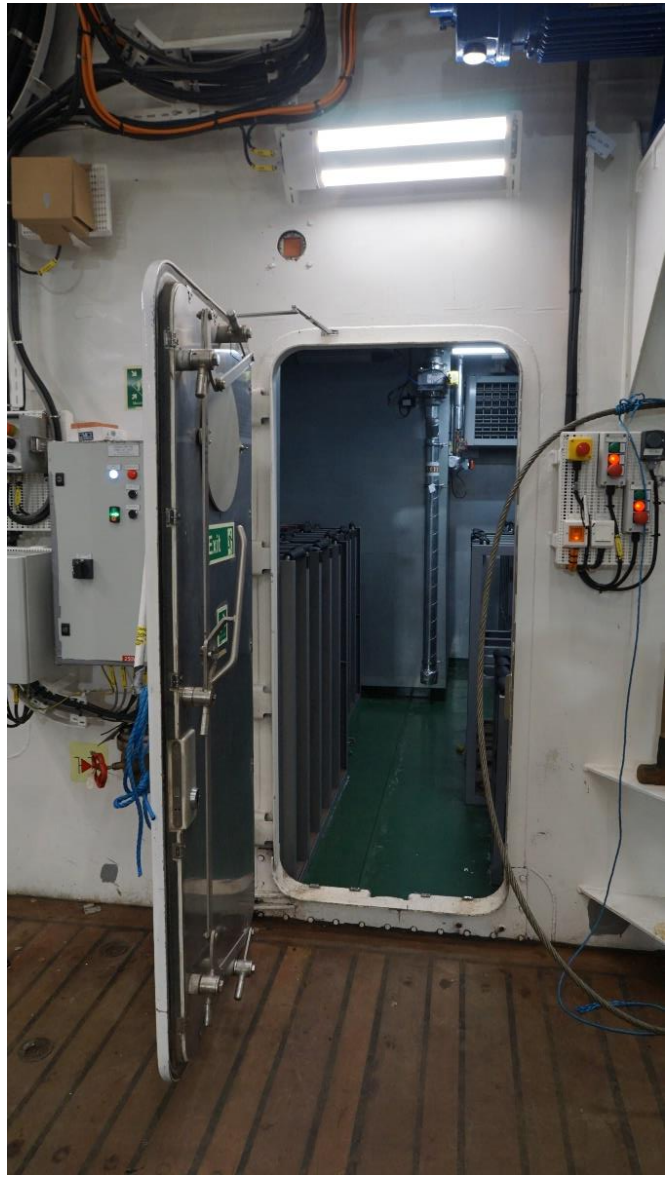
Bench top Elan2
Liquid Nitrogen
Generator

Milli-Q Ultrapure water systems
Latest technology 7015 units:

Fume Cupboards with
Chemical waste disposal system
Extract in Main Lab and Deck Lab
Recirculate in GP and atmospheric Lab

Main Lab, Deck Lab - Controlled Temperature Lab 1, GP lab – Clean Chem Lab, Atmospheric Lab

Other ship-installed Laboratory facilities



Gas store in hanger
N_2, O_2, He, Synthetic air
To Main, Wet, Deck, GP labs

Provision for users to pipe own gas lines - Roxtech glands

Chemical storage

Underway sea water supply from intake in ships hull to all labs

Fridges , Freezers,

Ice Machine and Oven in Main lab

Thank You

Thanks to >90 UK scientists on my ‘NPRV Chemists’ email list way back in 2014 and 2015, many of who all supported and contributed in some way.

Especially to Alex Poulton at Heriot Watt for his wise words about the radioactive operations and lab set ups, and Maeve Lohan at Southampton for all the suggestions, help, and advice with the trace metal facilities on the ship.

And to Ray for leading and guiding us all to where we are now with a world class Research Vessel for Polar science.

Images courtesy of Simon Wright, Sophie Fielding, Angela Milne, Tom Bell and Ray Leakey

Atmospheric science and meteorology capability

Professor Ian Brooks
University of Leeds

Dr Anna Jones
Interim Director of Science, British Antarctic Survey

The journey

Consultation phase (2014) the atmospheric science community requested that attention be given to their science area. Capability for atmospheric science research was not explicitly included in infrastructure of previous UK polar research vessels – this was a clear gap for UK science.

Step-change improvement: SDA has two laboratories dedicated to atmospheric science +4 container slots on helipad for mobile atmospheric science laboratories.

SHIP AHOY!

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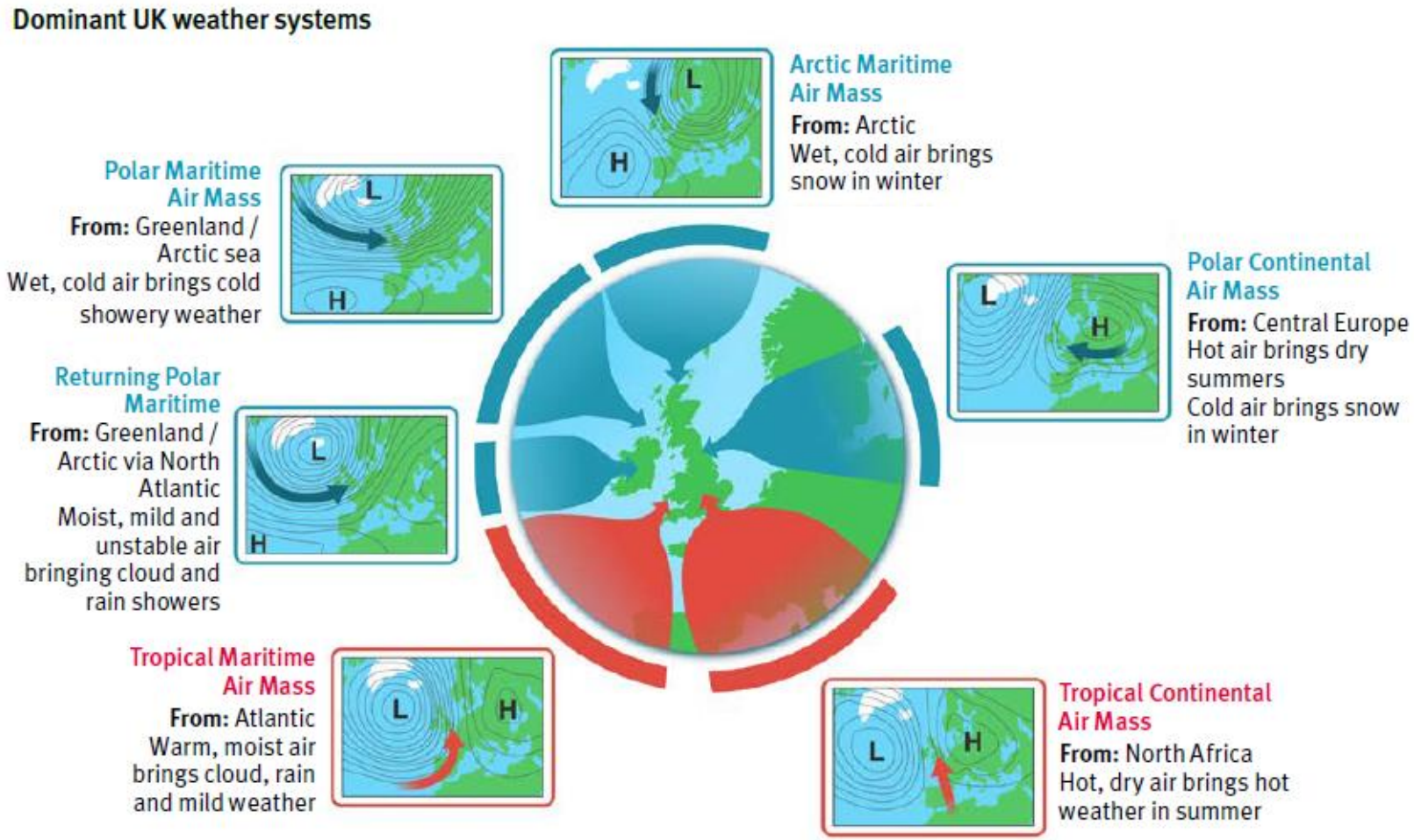
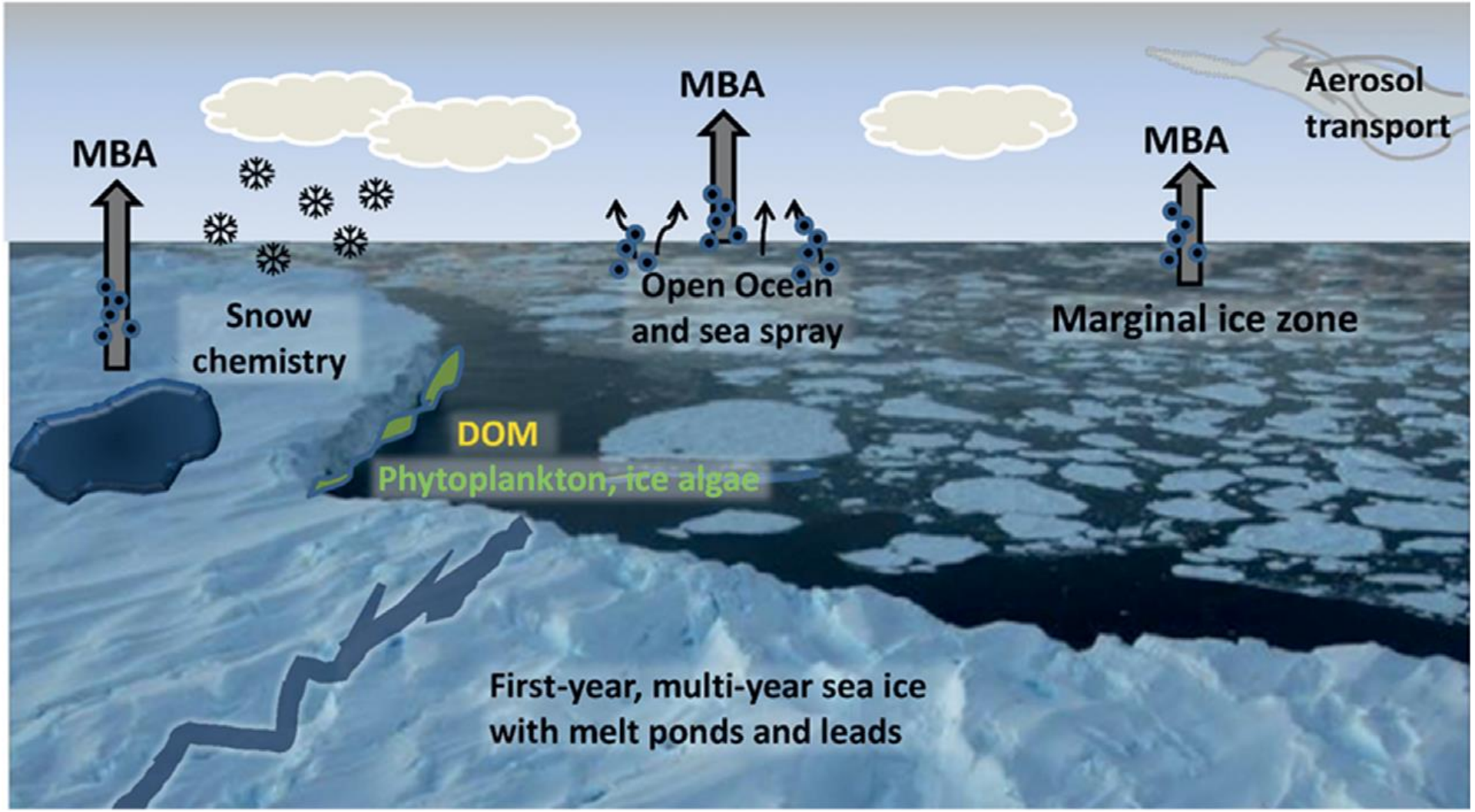


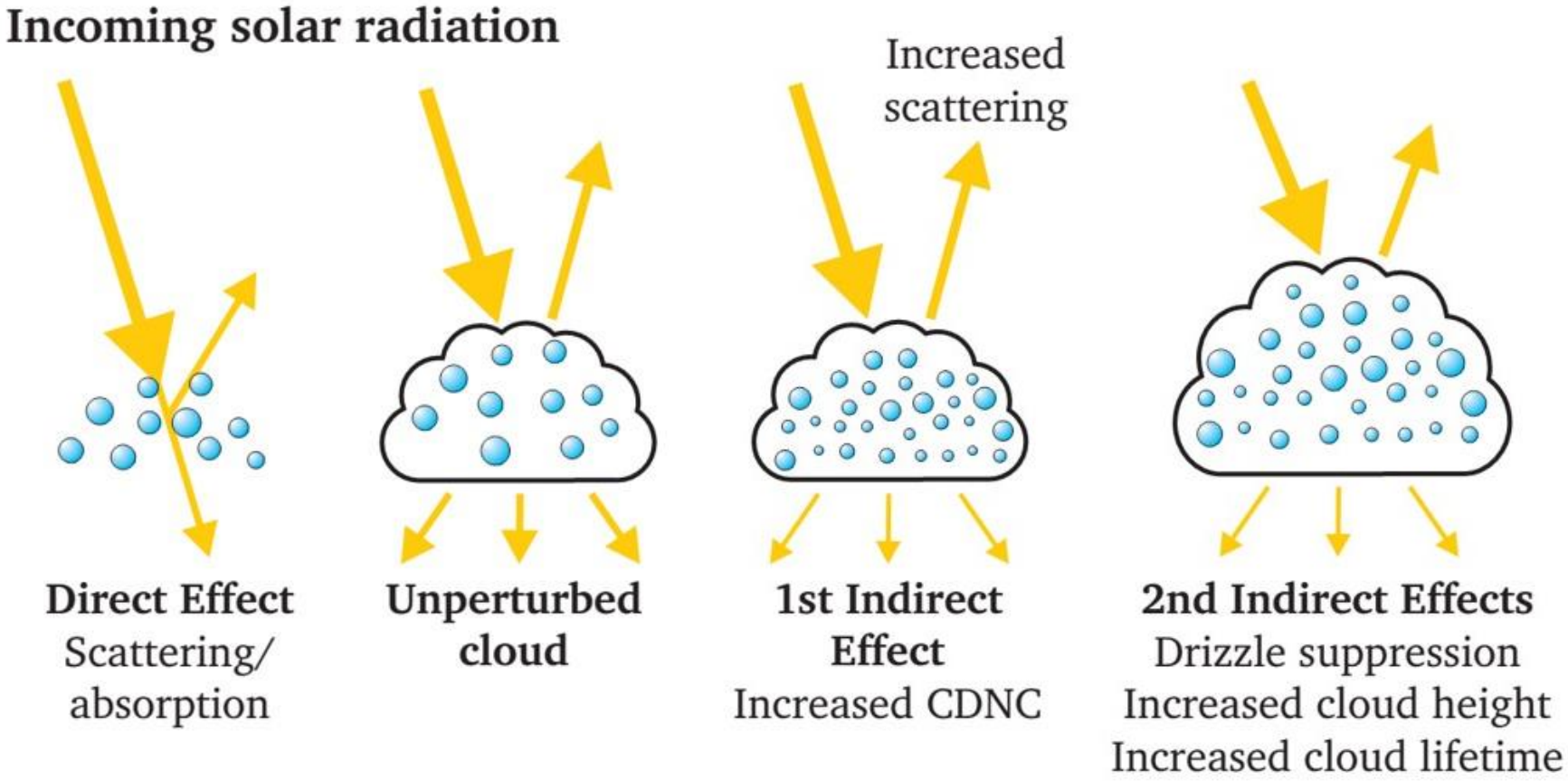
Natural sources of aerosol

Ammonia from sea bird guano



- Direct emission (e.g. sea salt aerosol)
- Secondary production (from e.g. sulphur compounds, ammonia, organics etc)

If you change the number of aerosol, you change the clouds properties, radiation balance, and climate – this system is not currently well understood



SDA will provide capability to make measurements of aerosol, trace gases, and cloud properties, in ice-covered areas

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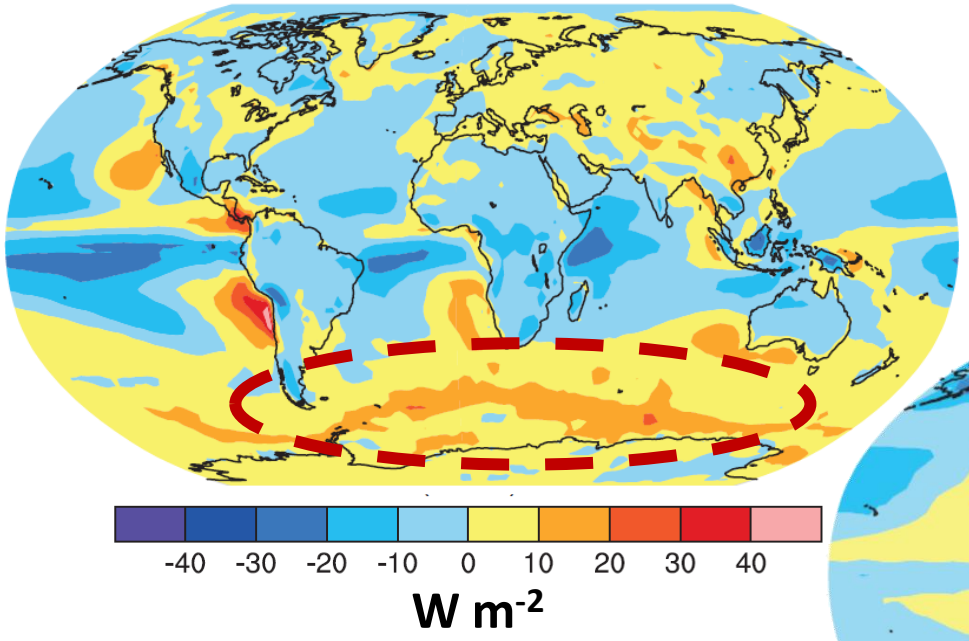
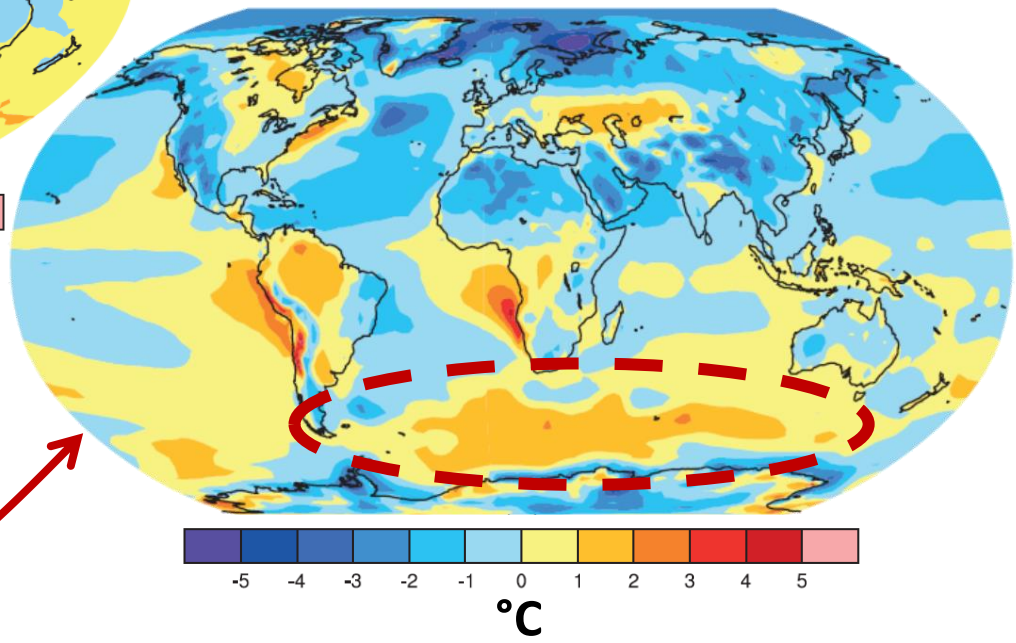
Mean surface solar radiation bias in climate models



Flato et al. (2013)



Resulting sea-surface temperature bias

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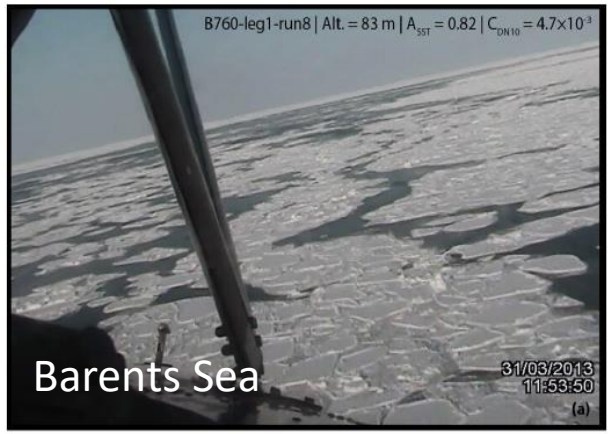
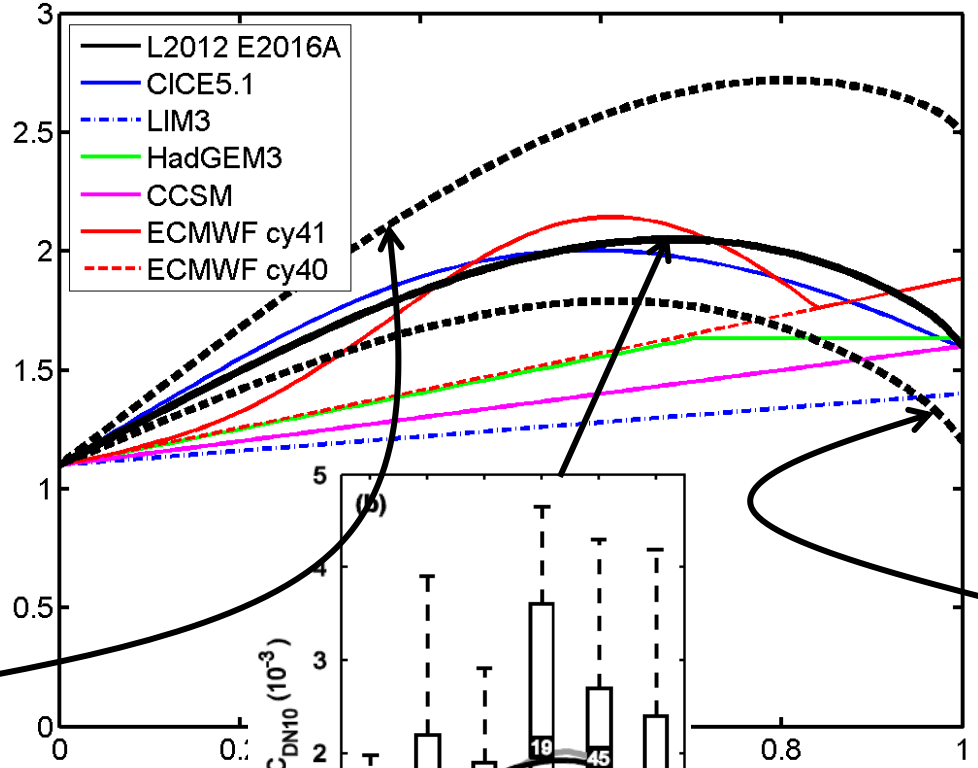
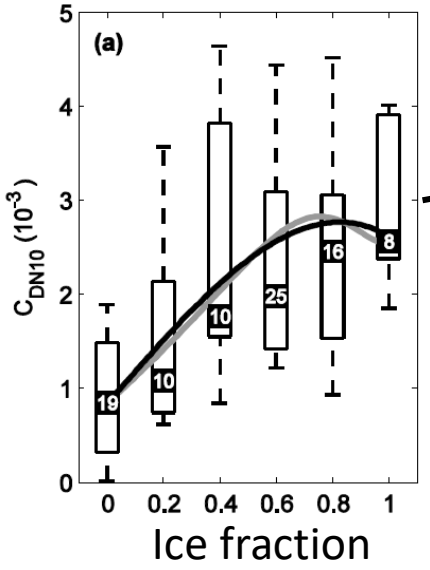
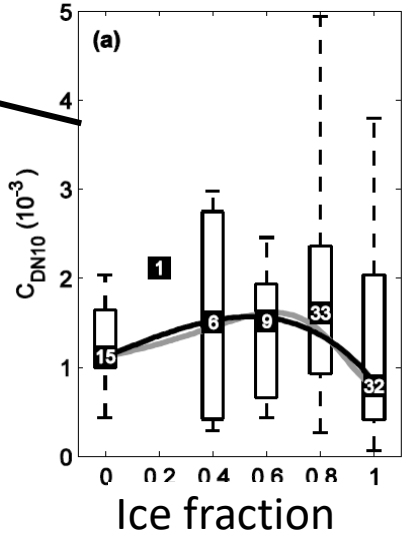


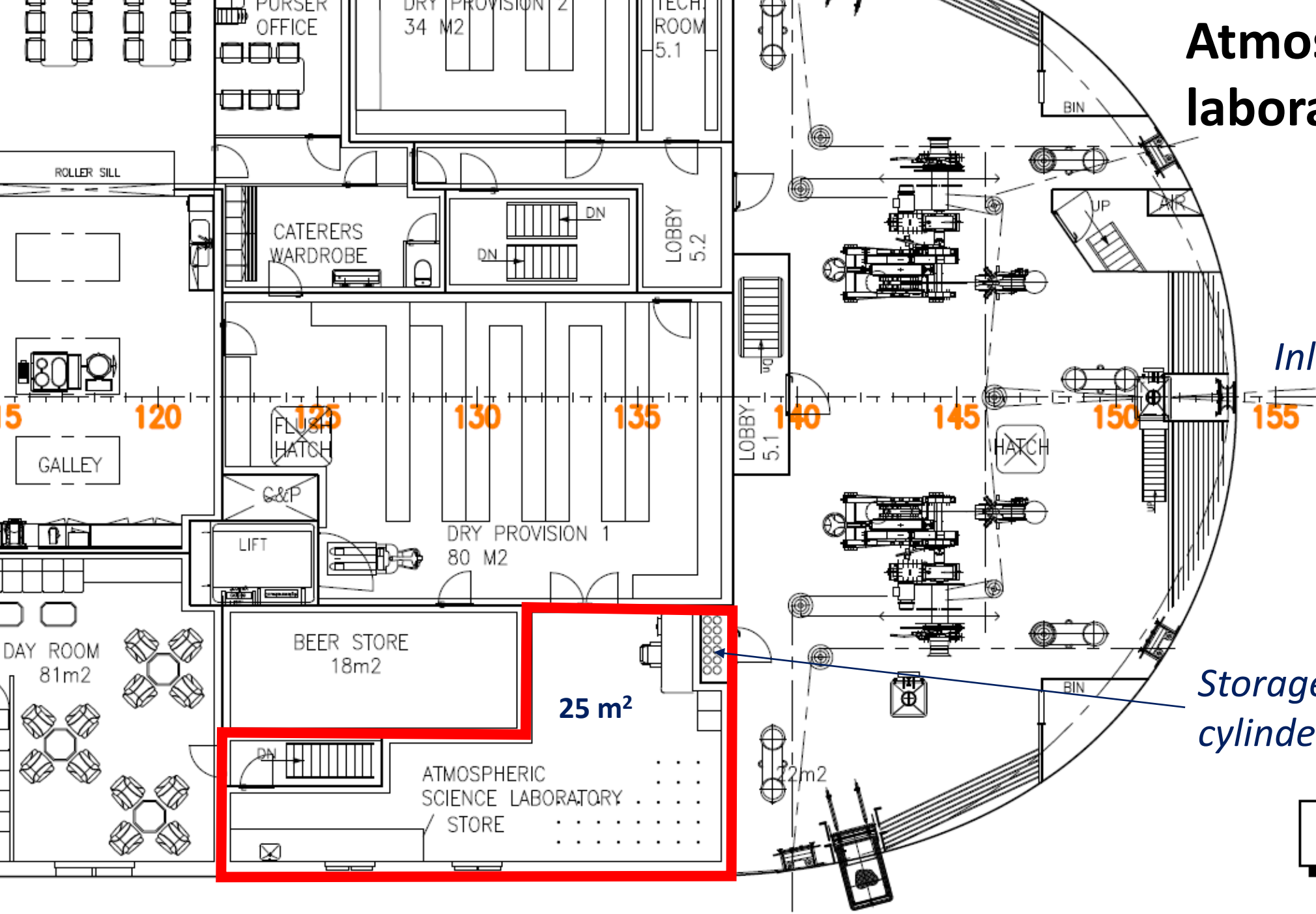






Atmospheric science laboratory

Atmospheric science laboratory



Inlet lines on foremast

Storage for gas cylinder

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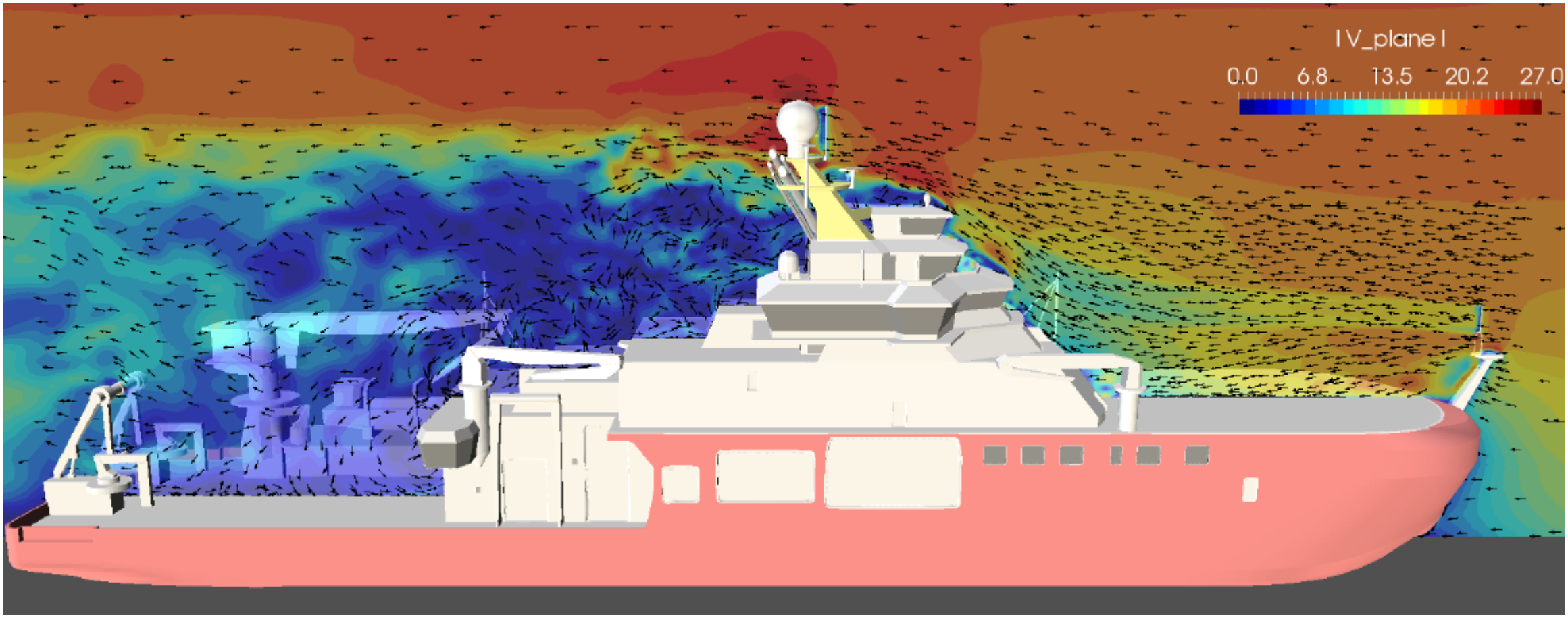
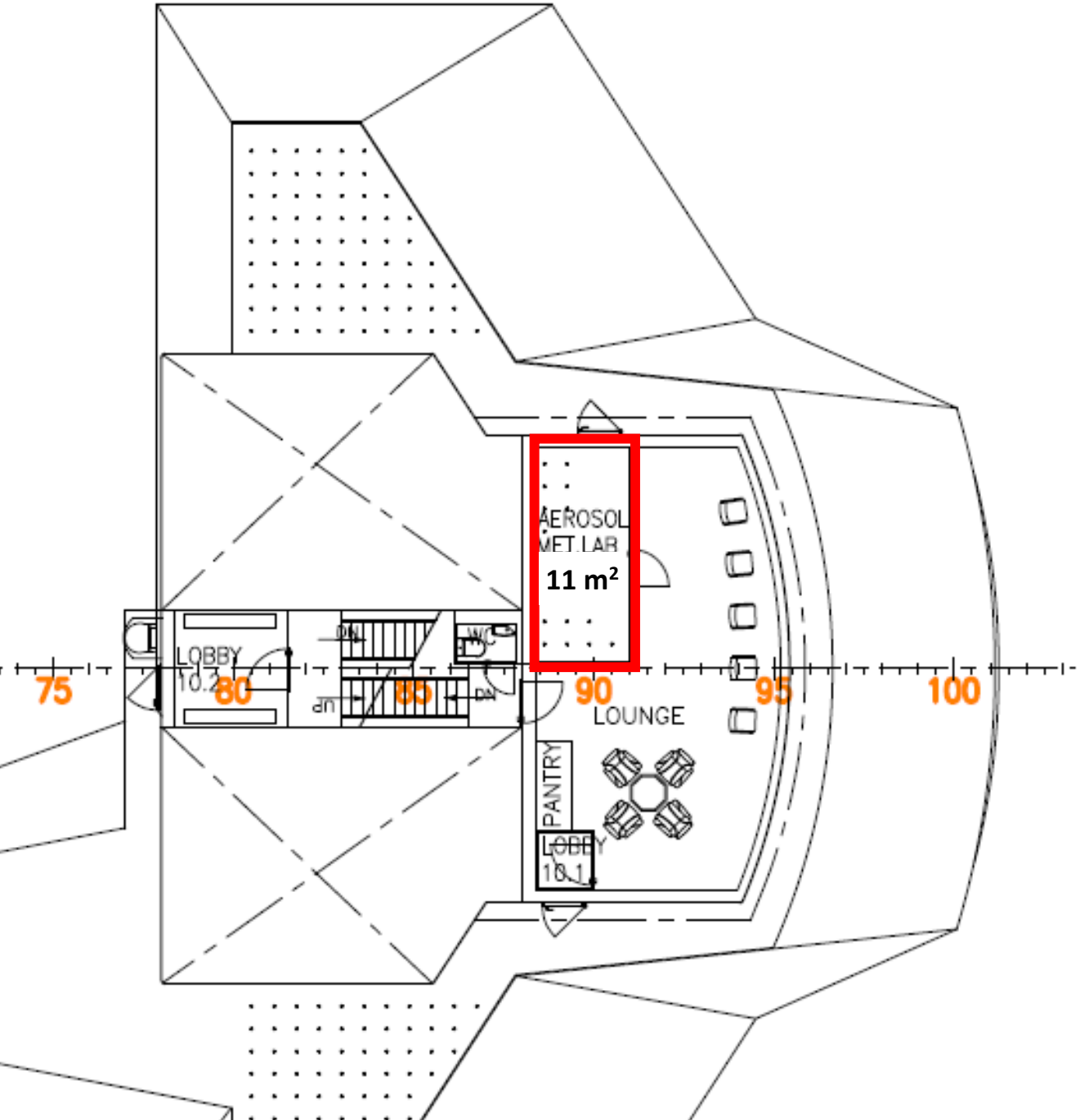


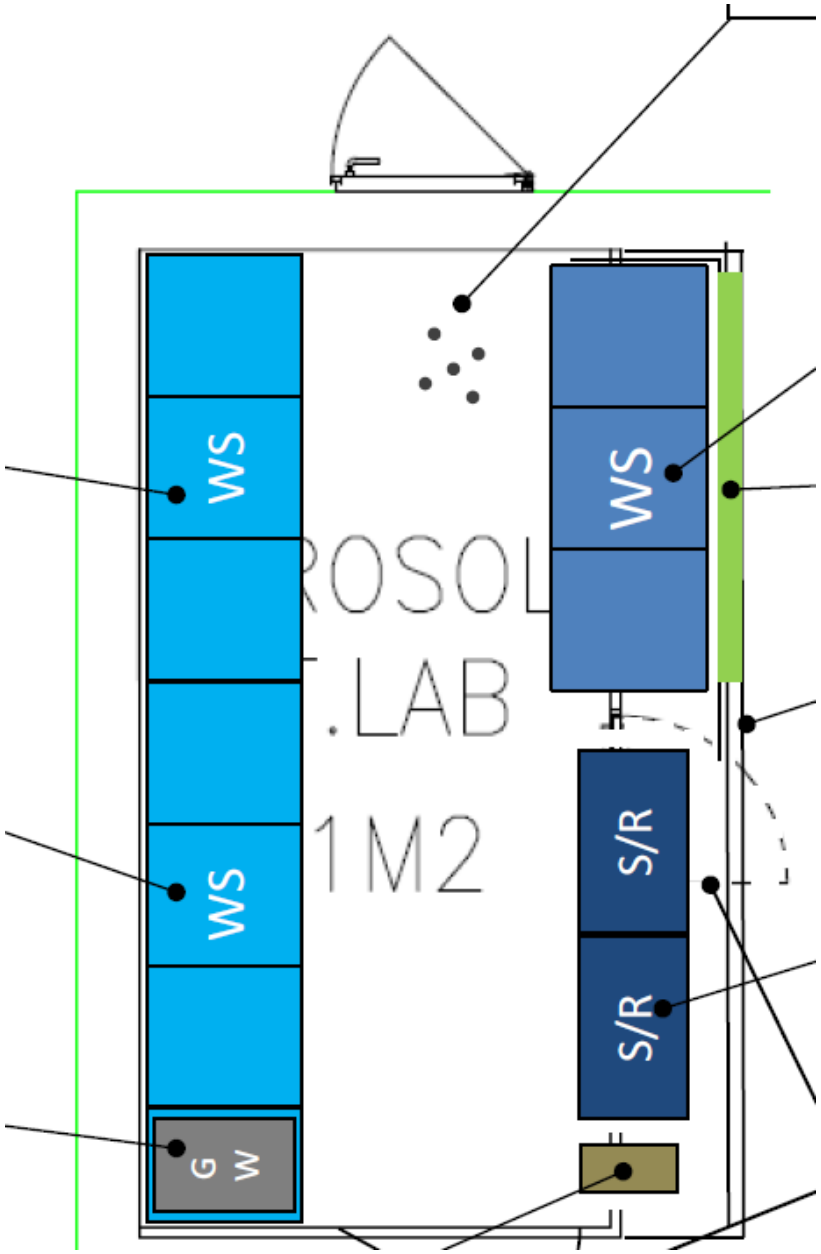
Photo: Mike Gloistein

Foremast extension – gets sensors above level of worst flow distortion. Essential for turbulent flux measurements.

Digital model of the ship available for detailed flow distortion modelling.

Deck 10 – Aerosol lab


AEROSOL
MET LAB
11 m²
LOBBY
10.2
75
80
85
90
95
100
LOUNGE
PANTRY
LOBBY
10.1


WS
WS
WS
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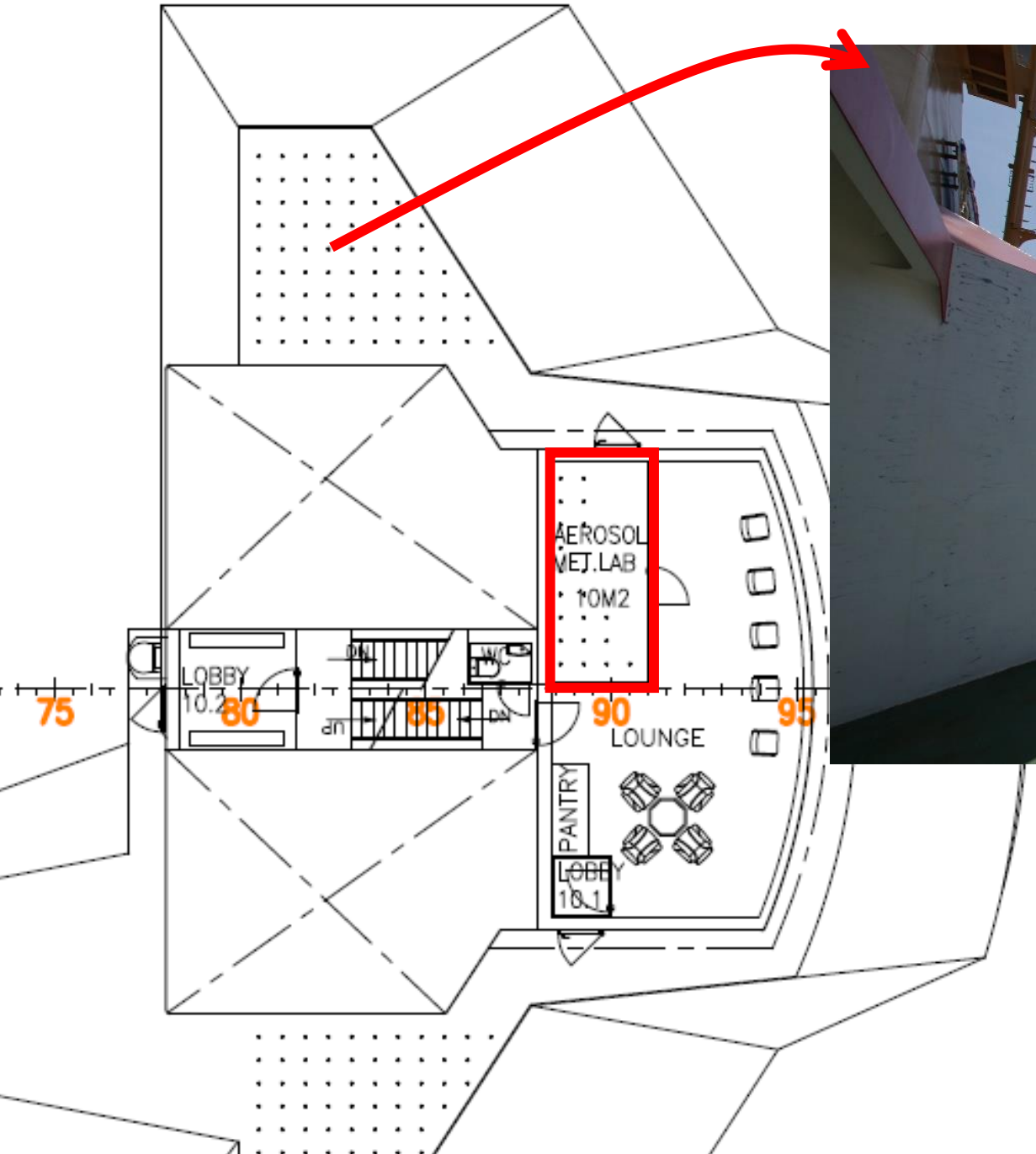

Deck-10 - space for extensive project-specific instrumentation outside lab

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Core measurements for atmospheric science (new to SDA)

- Atmospheric pressure
- Winds – multiple Metek sonic anemometers
- Air temperature and humidity – Vaisalla HMP155
- Dew point sensor
- Solar & IR radiation (downwelling) – Kipp & Zonen radiometers
- Photosynthetically active radiation (PAR) sensor – Seabird PAR sensor
- IR water surface skin temperature – Heitronics IR thermometer
- Underway water temperature – Seabird Electronics sensor
- Visibility sensor (fog)
- Cloud ceilometer
- Precipitation – Thies laser precip monitor / Campbell Scientific freezing rain sensor
- Wave radar
- Underway pCO_2 system
- Picarro 2401 gas concentration analyser for carbon dioxide, methane, carbon monoxide
- Black carbon monitor
- Ambient ozone monitor

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Step-change improvement!

RRS Sir David Attenborough has:

- laboratories dedicated to atmospheric science
- container slots for mobile atmospheric science laboratories
- is well-equipped with core instrumentation for routine observations
- capacity inside labs and on-deck for specialised instrumentation
- overall capability aligned to needs of UK (and international) atmospheric science community.

SHIP AHOY!

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