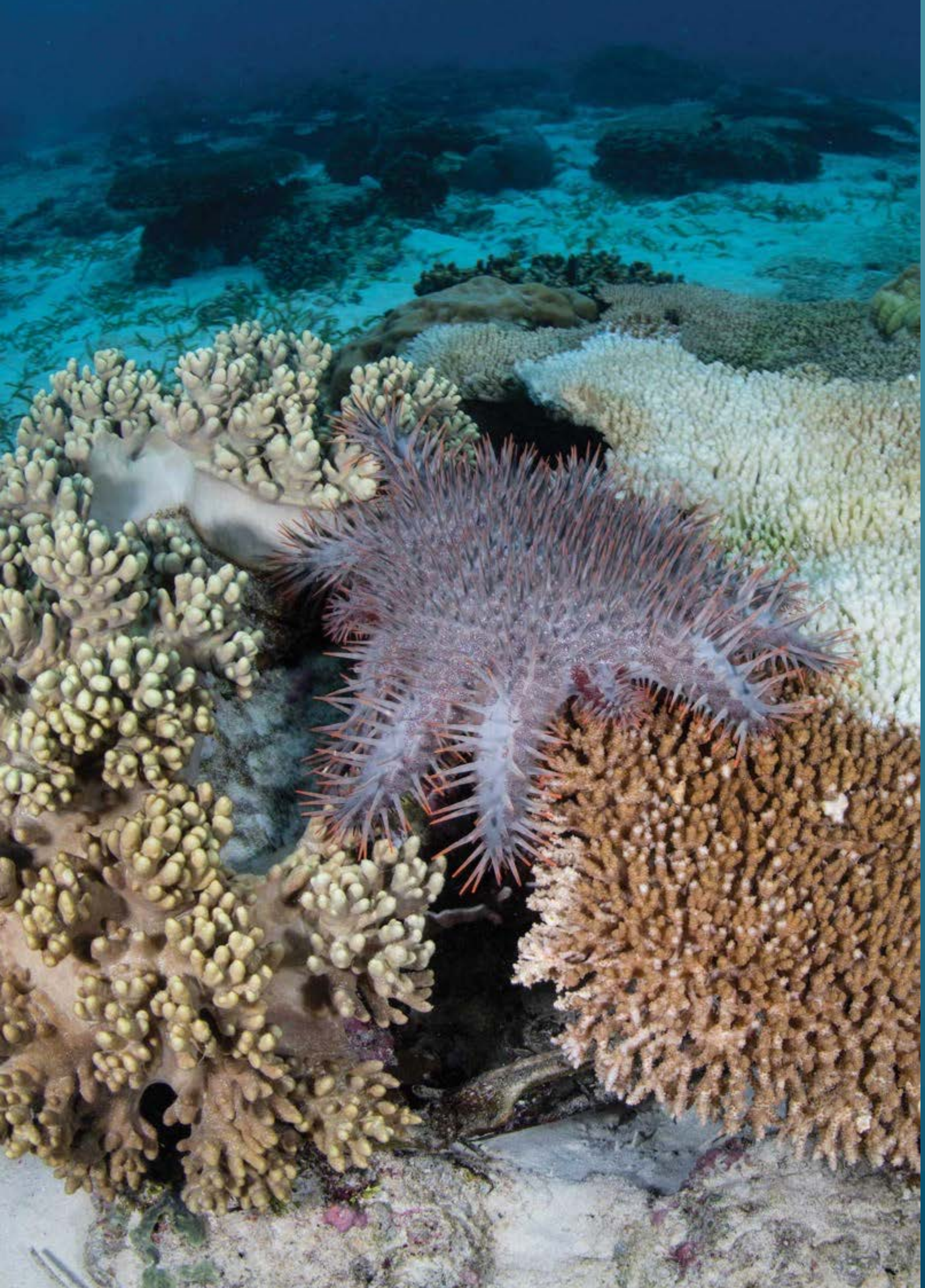
Net Zero Oceanographic Capability



Work Package 1

Future Science Need Workshop feedback

NZOC Work Package 1: Future Science Need

Dr. Kate Hendry (Bristol)
Dr. Eleanor Frajka-Williams (NOC)

Science drivers

Move from broad correlations to understanding connections, processes, and mechanisms in order to have predictive power and confidence.

Approaches to ocean science fall broadly three categories:

1. *Process studies* - understanding the mechanisms behind - and spatial/temporal scales of - oceanic processes, and their interconnections;
2. *Sustained observations* - improving knowledge of system change;
3. *Forecasting* – obtaining data for initialization or assimilation in forward stepping.

Common Themes:

- Ocean-Climate linkages
- Access to under-sampled and under-studied regions (e.g. polar regions, deep sea)
- Ocean interfaces (e.g. air-sea, coasts and seafloor)
- Carbon cycling and biogeochemistry
- Conservation
- Oceans and society
- Geohazards and risk management

Recurring questions:
How do we capture the range of spatial and temporal scales?
How do we most effectively communicate scientific output?

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Data requirements

Modelling:
- Improved model validation
- Better collaboration in study design

Better integration of model and observational data

Observational data:

- Increased data acquisition
- Improved data management and accessibility
- Improved use of existing data

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Transformational technologies

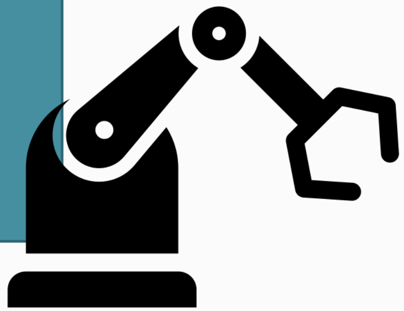
Common Themes:

- High-resolution and fully integrated real time measurements
- Mapping the entire seafloor
- Multidisciplinary timeseries

Subject specific:

Specific requirements for disciplines requiring sampling and sample recovery

Recurring questions:
Can some of the analyses currently requiring sampling be automated and carried out *in situ*?



- Biology (eDNA, omics, acoustics, *in situ* preservation?)
- Sedimentology (sedimentary sensors and probes, resistivity, *in situ* preservation?)
- Hard rock geology and geophysics (robotic OBS, resistivity, use of seafloor holes as *in situ* labs?)

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Transformational technologies

Platforms:

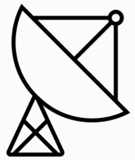
- Underwater Automated Vehicle (UAV) swarms
- Autonomous Surface Vehicle (ASV)
- Underwater observatories
- Airships, high-altitude planes, drones, existing infrastructure (e.g. offshore wind farms)

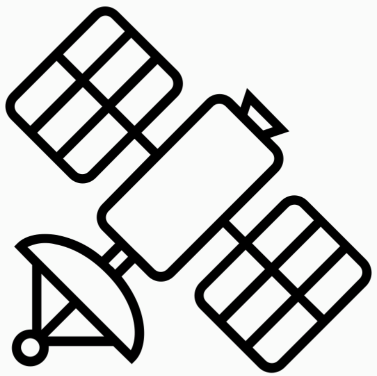
Satellites/remote sensing:

- More use, more products, better calibration…

Sensors:

- New measurements (lab-on-chip/microfluidics) for physical properties, dissolved and gaseous phases (carbonate parameters, methane, micronutrients, eDNA, biomarkers etc.)
    - Miniaturised tags for animals
    - “Biosensors”
- Higher quality measurements
- More sensors per platform





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Interconnection of different technologies

Improving efficiency:

- Do “*more from the ships when the ship is doing things that only ships can do*”
- Smart, adaptable autonomous deployments
- Better planning of observations using models (“digital twins”)
- Widening access to ships

Power and energy:

- New technologies for power supplies
- Making ships more energy efficient (e.g. recycling and heat recovery, use of modular systems)

Links with computer technology/broader automation:

- Improve Human Machine Interfaces (HMI) and data visualisation
- Machine learning/artificial intelligence

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Carbon footprint

Recurring questions:
How do we compute the carbon footprint?

Carbon cost:
- Point-of-use or all stages (manufacture to disposal)
- Role of alternative fuels
- Nuclear powered ships? Sailing ships?
- Not just ships: server farms & satellites

Maximising value while minimising harm:
- Marine litter due to unrecovered equipment
- Environmental cost of batteries – rare metals / mining

Strategies to reduce carbon:
- Regional approach to observations (regional ship planning, marine station as hub, mobile observatories)
- Ships with designated geographic region for the year
- Enabling funding for add-on science

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Gaps created by an autonomous approach

Science disciplines at risk:

- Science requiring heavy infrastructure
- Science requiring manipulation of the environment
- Science requiring high levels of accuracy
- Science requiring particular parameters not likely to be measurable by autonomous sensors (e.g., because the cost to develop the tech is not balanced by the benefit)

Challenges:

- Platform reliability (lack thereof) will endanger science projects
- Platform reliability (lack thereof) will endanger long term records (e.g., time series at moorings)
- Measurements at interfaces are notoriously challenging (air-sea, ocean-ice)
- Technology appropriate for one environment (e.g., Argo in deep sea) may not work in another (e.g., coastal)
- Lack of calibration by established methods will create uncertainty in the measurement – which will decrease the value

Will we limit UK marine science to parameters/disciplines that can be measured autonomously?

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Challenge

Marine science sampling spans a large dynamic range:

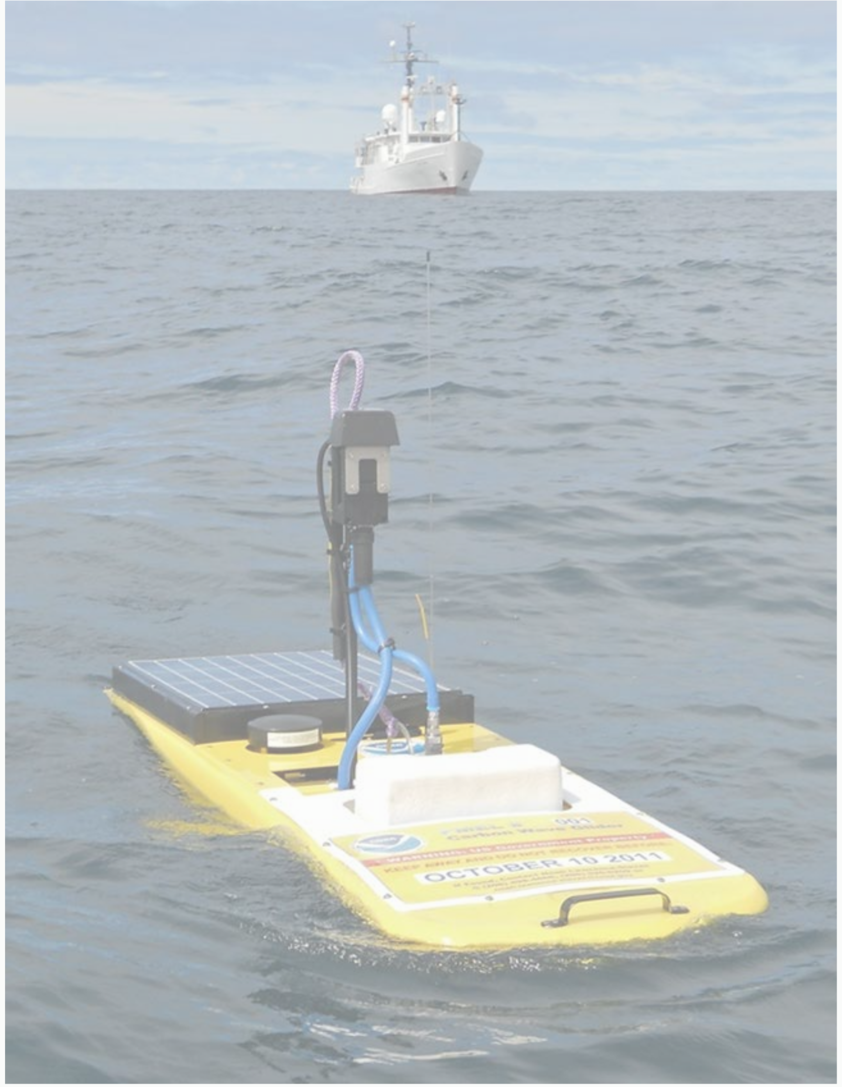
- Seconds to decades
- Microscopic to basinwide

Opportunities to fill space/time scales by autonomous platforms:

- Adaptive sampling to respond to the environment
- Swarms of platforms to increase resolution
- Access to remote environments (rough weather, under ice)

Gaps created by autonomous approaches:

- Slow speeds of platforms mean the ocean changes during the measurement period (myth of synopticity).



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Data collection, processing & storage

Maximising data value not just quantity:

- Data curation – Currently undervalued but will become more important as the data volume increases.
- Data access – needs to be improved (FAIR) with methods that account for increasing data volume
- Quality control / assurance – a challenge with increased volume
- Calibration / validation – new tech needs to be validated to ensure continuity of long term measurements
- Require new best practices to be established

Increased bandwidth from autonomous platforms / ships:

- Enable dynamic decisions on sampling
- Enable a shore-side team to complement the at sea team
- Would require more reliable / faster broadband

Recurring theme:
How to deal with the data explosion?

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Known unknowns

<u>Trends in sectors:</u>

- Decline in oil & gas will have consequences for marine tech dev
- Increase in environmental management – new tech dev?
- Legal implications of autonomy – if an autonomous platform causes a collision, what are the consequences?

<u>Trends in technology:</u>

- Vessel energy systems
- Communication capabilities
- Cloud-based computing
- Robustness in harsh environments
- Low tech vs high tech

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<u>Funding model for autonomy:</u>

- At present, some autonomous costs devolve to the project
- A new funding model analogous to centralised support of ship costs?

<u>Funding the transition:</u>

- In order to build confidence in new methods, they may need to run in parallel to old methods for some time.
- Is there a risk of new technology being overtaken mid-development by newer technology?

<u>Funding to cover carbon cost</u>: Who is responsible? Should the costs of disposal be included in research proposals? A carbon tax?

<u>Funding to improve carbon efficiency of current capability:</u>

- Standard grants are too small to fill berths on ships
- Need a mechanism for 'bolt-on' projects to make more efficient use. NERC small grants used to enable this.
- New communication link between planned expeditions and the world to enable piggy-backing.

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Human implications of autonomous approach

<u>Potential positive:</u>

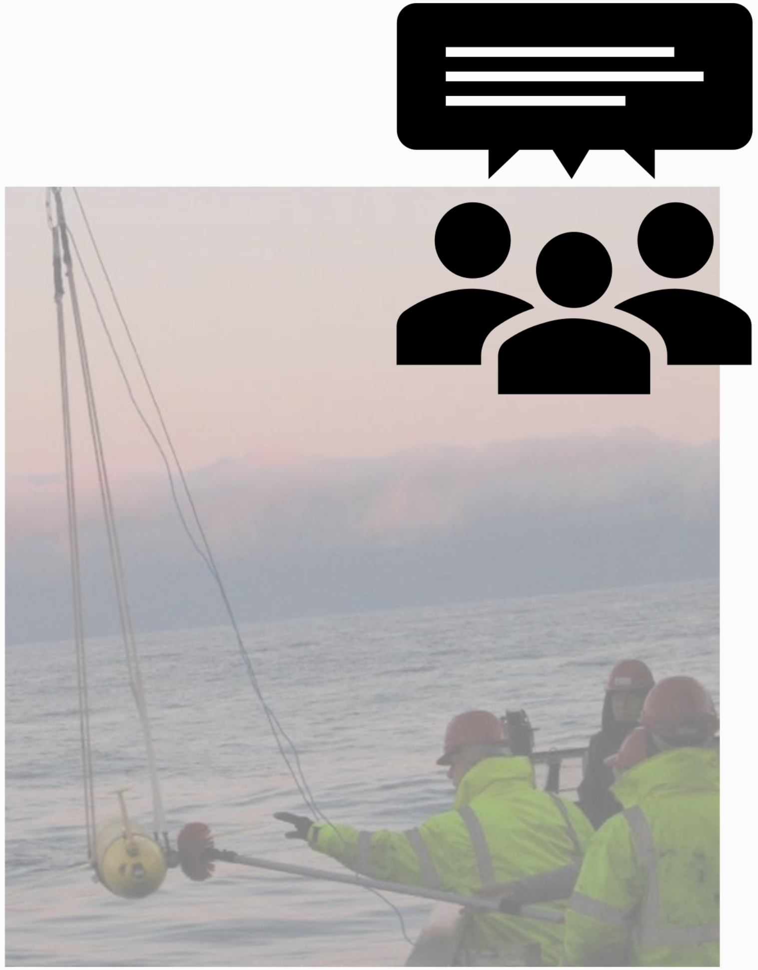
- Broadening access to observational marine science
- Reduced carbon footprint of travel to ships
- Potential increase in data utility

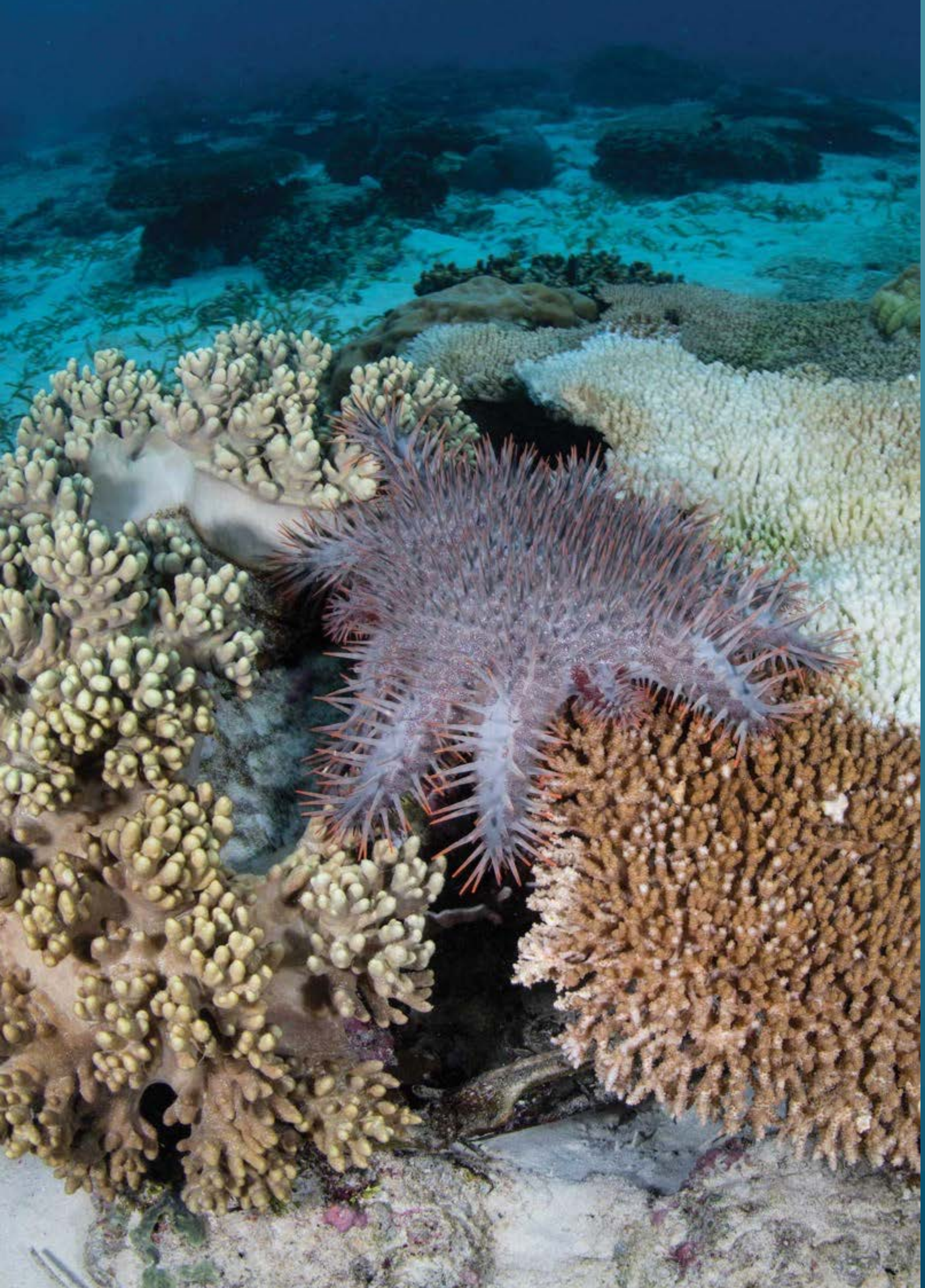
<u>Potential negative:</u>

- Lose human interaction with the environment
- Reduced hands-on training with observational methods
- Reduction in data quality due to reduced scientist interaction with data
- Reduced interaction within the community
- Reduced recruitment potential of seagoing

<u>Shifts in skillset requirement:</u>

- For scientists – shift towards data science
- For techs – staff to operate remotely piloted platforms





THANK YOU for your time in helping us gather the views of the community

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