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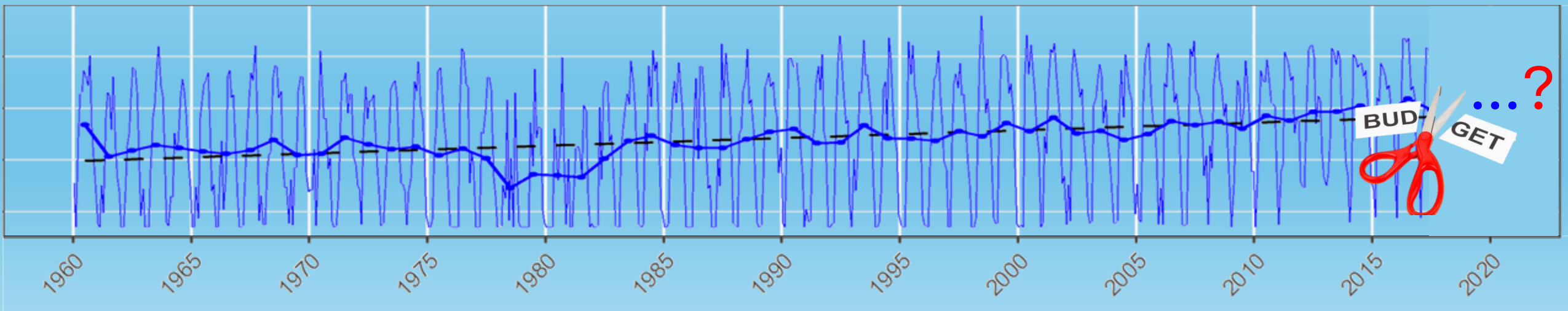
NCEA Natural Capital and Ecosystem Assessment

UK PELAGIC HABITATS EXPERT GROUP

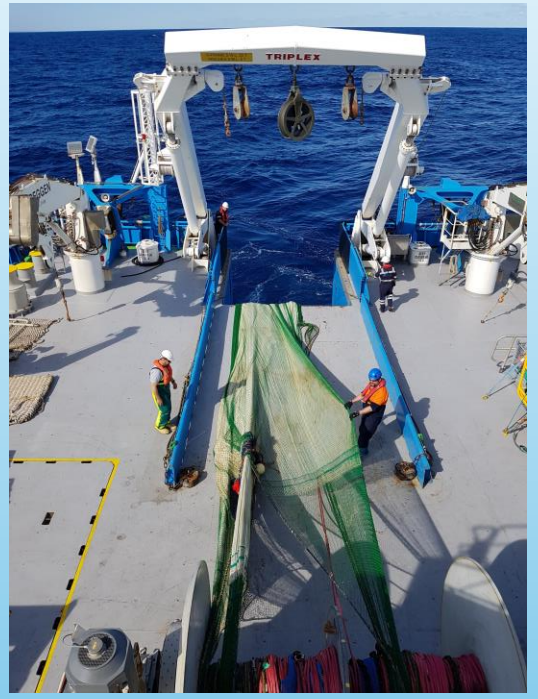
The need to integrate novel plankton methods alongside ongoing long-term monitoring

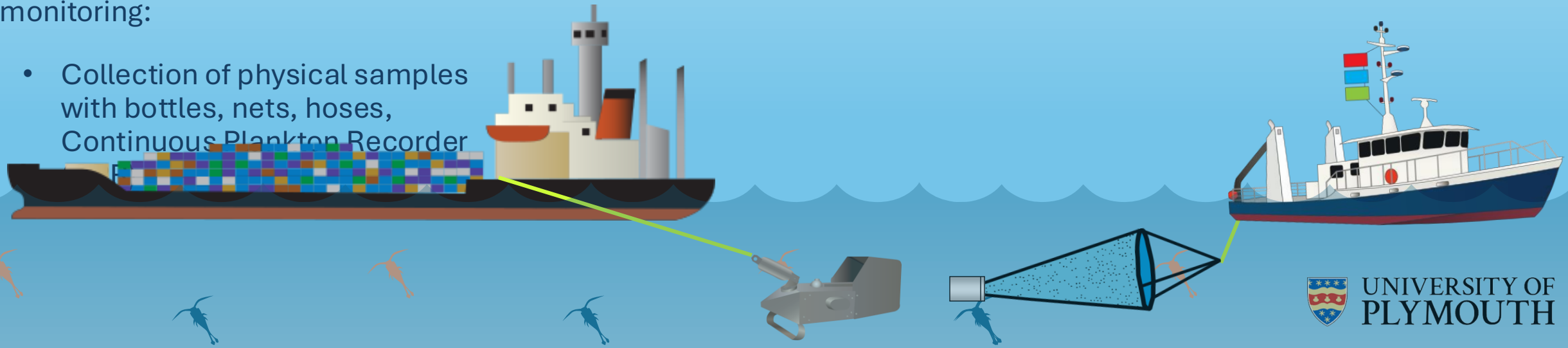
Matthew M. Holland, Luis Felipe Artigas, Angus Atkinson, Mike Best, Eileen Bresnan, Michelle Devlin, Dafne Eerkes-Medrano, Marie Johansen, David G. Johns, Margarita Machairopoulou, Sophie Pitois, James Scott, Jos Schilder, Rowena Stern, Karen Tait, Callum Whyte, Claire Widdicombe & Abigail McQuatters-Gollop



Introduction

- The plankton community provides key ecosystem services:
  - Fisheries
  - Carbon cycling
  - Oxygen production
- Our understanding of plankton is based on historical long-term monitoring:
  - Collection of physical samples with bottles, nets, hoses, Continuous Plankton Recorder





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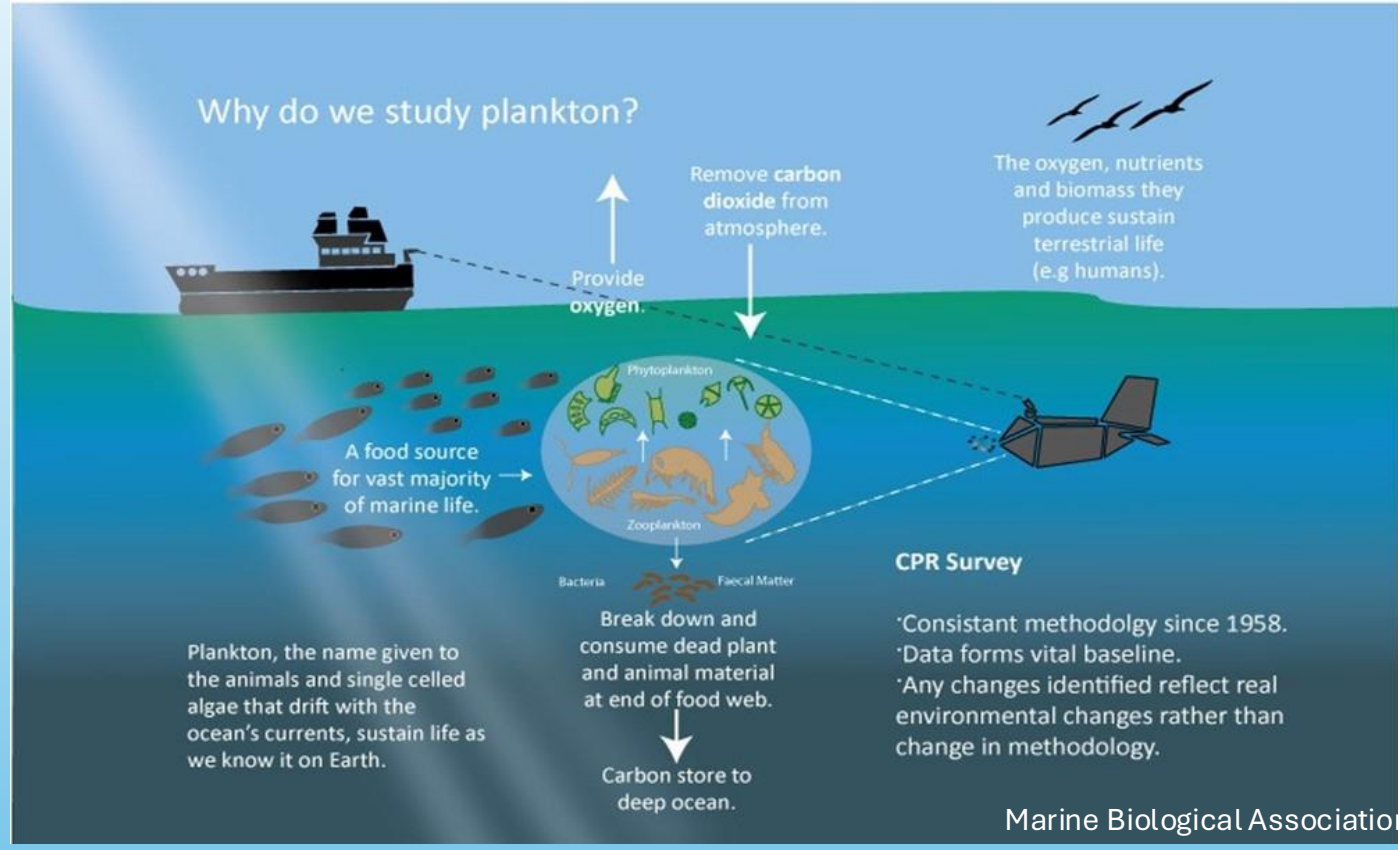
Introduction

Problem:

Long-term plankton monitoring programmes are underfunded, and novel methods need better integration into existing programmes to detect change and support marine biodiversity assessments.

Aims:

1. Compare monitoring methods
2. Explore strategies to maintain long-term monitoring
3. Integration of novel methods into routine marine biodiversity monitoring and assessment.



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Review

Mind the gap - The need to integrate novel plankton methods alongside ongoing long-term monitoring

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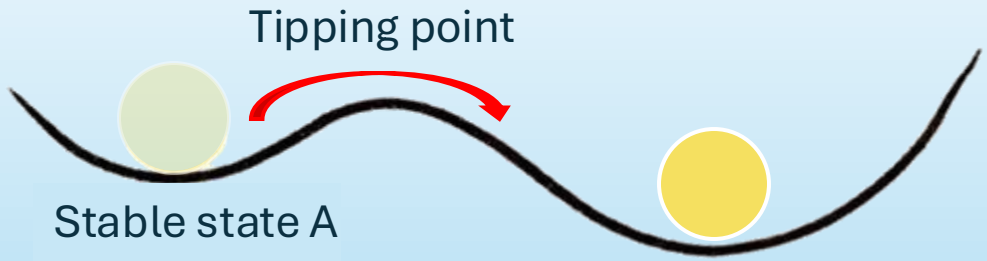
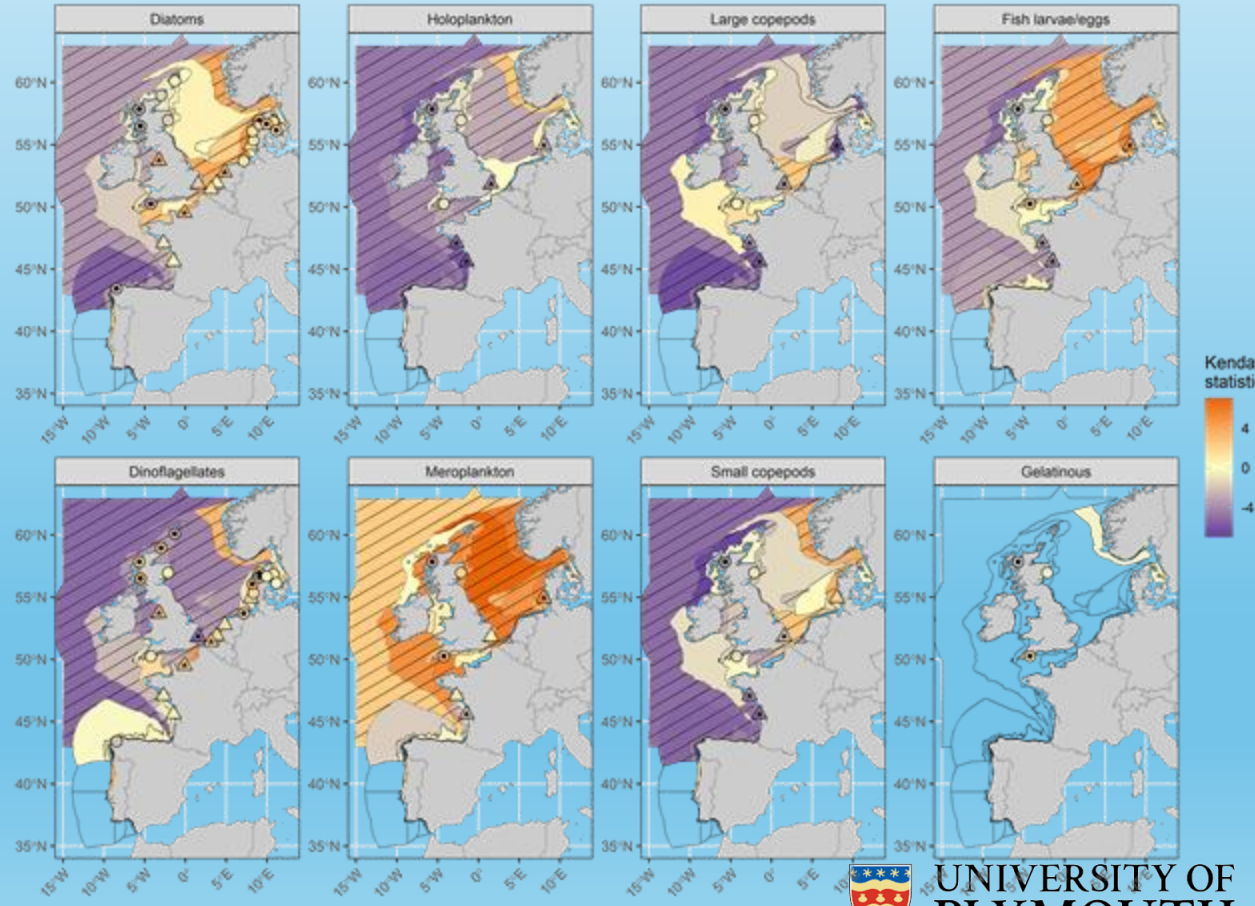
Link to our open-access paper

The role of long-term monitoring in understanding change

- Provides historic baseline information on pelagic biodiversity
- Enables interpretation of changes in ocean nutrient regulation, climate control, and food webs
- Has revealed large-scale declines in plankton abundance in the North-East Atlantic (e.g. Continuous Plankton Recorder Survey)
- Instrumental in detecting and identifying anomalies against background variation
- Helps us understand changes linked to climate change and human pressures
- Informs regional, national, and international statutory policy assessments of biodiversity status (e.g. OSPAR, EU MSFD, UKMS)





Holland et al. (2023)

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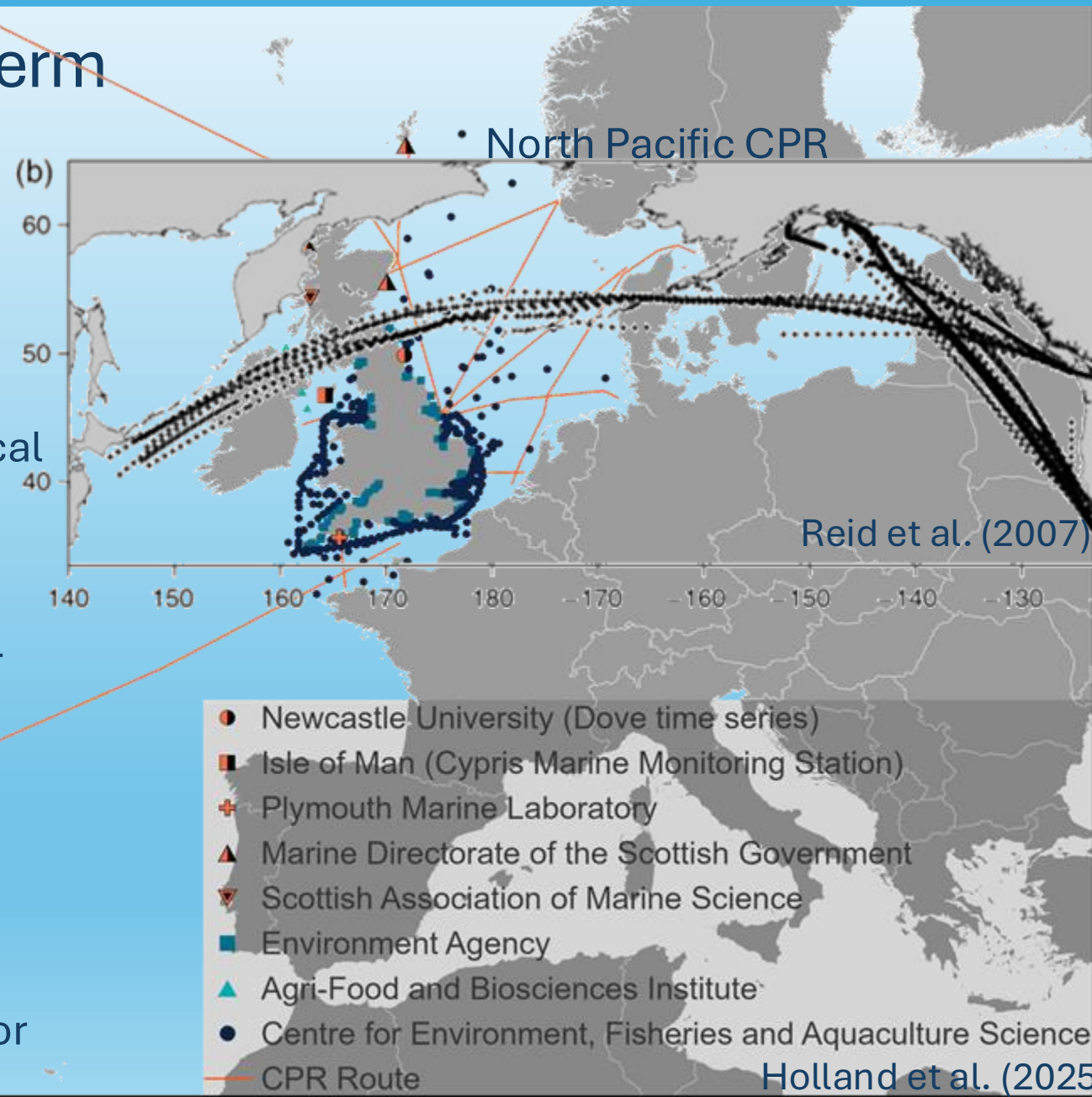
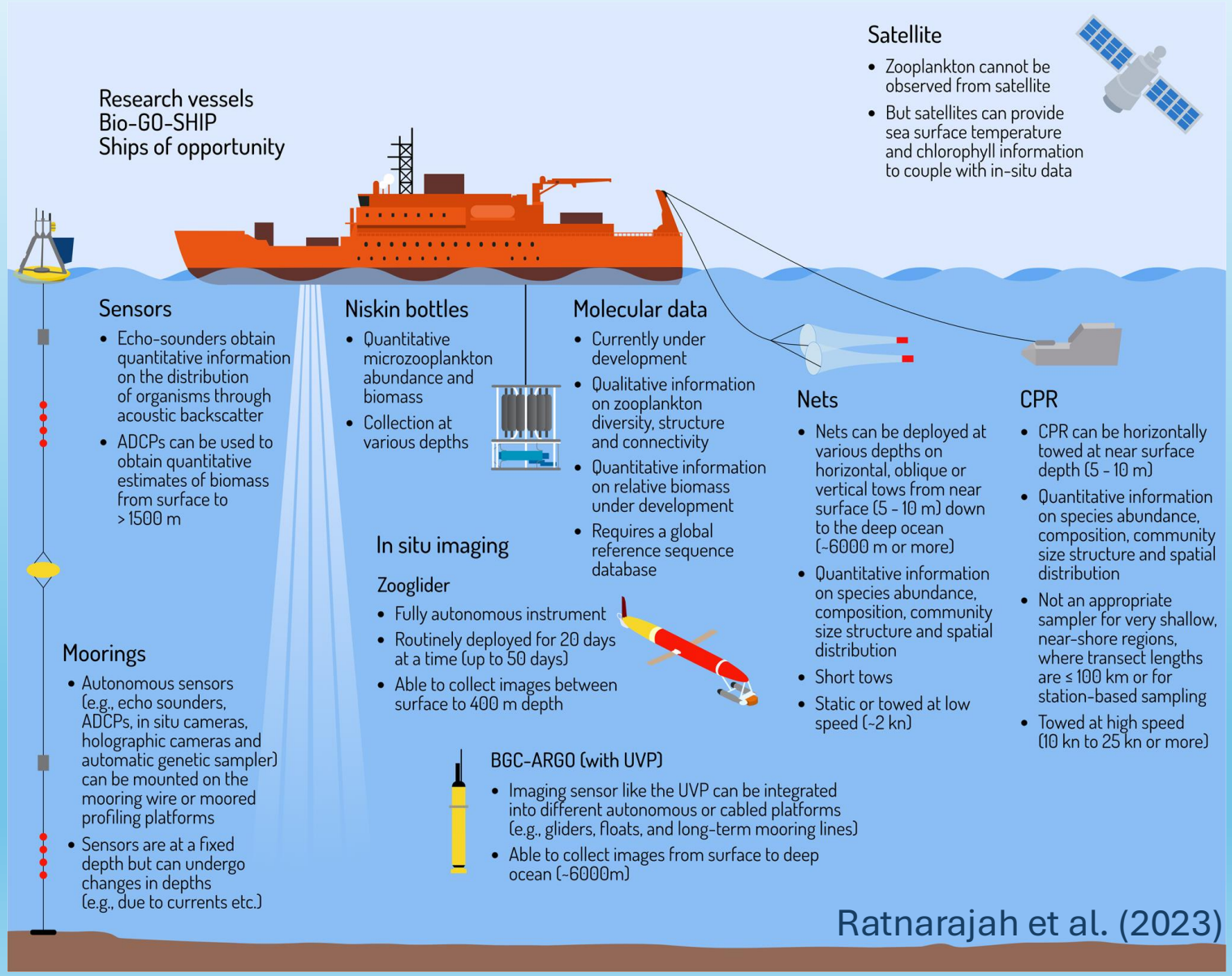
The challenges of maintaining long-term monitoring programmes

- Research funding increasingly allocated for novel studies, potentially at the expense of long-term programmes
- Major funding bodies are cutting long-term ecological research. Little incentive to maintain these programmes.
- Net-zero goals can influence funding towards lower carbon (i.e., less ship-based), more autonomous monitoring
- Erosion of funding contributes to the decline in taxonomic capability
- However, novel methods often carry hidden costs for implementation, maintenance, and validation





Current methods and technologies for plankton monitoring

- Standard methods (net and microscopy-based): Trusted to deliver high-quality, long-term data
- Novel *in situ* methods (imaging, molecular): Enable faster, more targeted data collection and fill knowledge gaps left by standard monitoring
- Satellite remote sensing: Provides large-scale phytoplankton biomass (however, not a focus of our study)
- Integrated approach: Combining standard and novel methods provides a more complete picture of plankton dynamics

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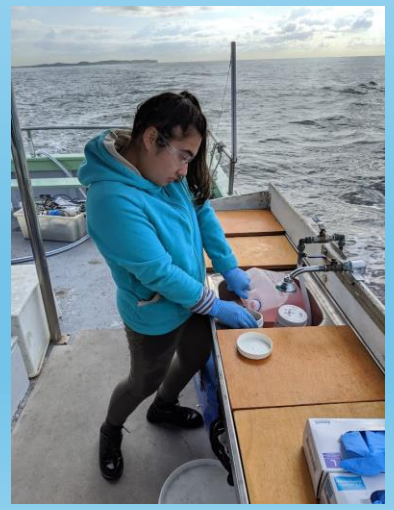


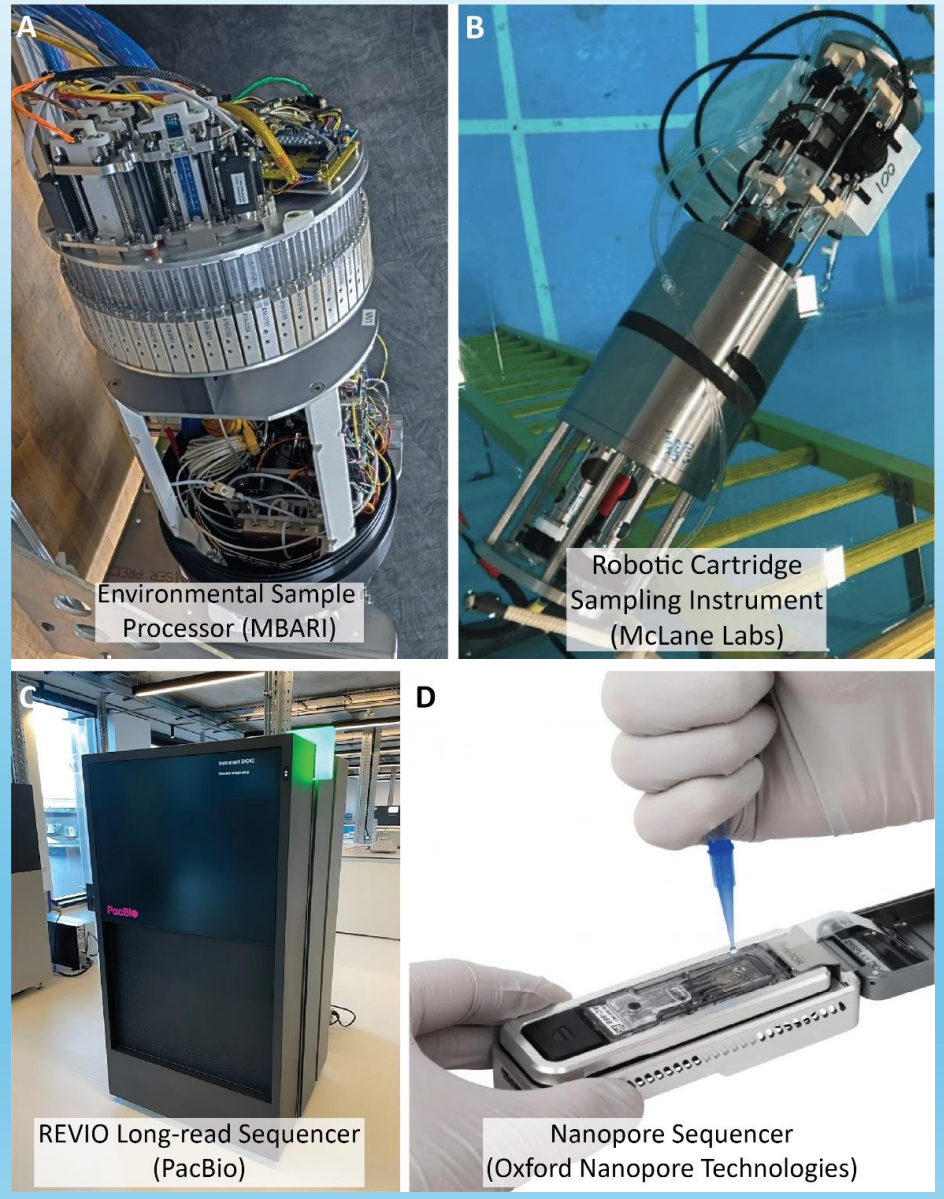
Standard monitoring

- Direct sample collection (nets, bottles, CPR)
- Samples preserved (formalin, Lugol's iodine) and stored for lab analysis, sometimes months or years later
- Identification led by skilled taxonomists using light microscopy
- Provides quantitative abundance and high taxonomic detail
- Enables rapid checks for unusual results or new taxa
- Supported by quality assurance schemes and laboratory intercomparisons
- However, labour-intensive and time-consuming per sample

Automated imaging

- Automatic collection and storage of plankton images and machine learning for automated classification
- Images collected from various platforms (research vessels, buoys, towed bodies, AUVs), autonomy reduces vessel costs/carbon output
- Provides rapid, unbiased, digitally stored data, potentially in near-real-time
- Can enumerate delicate/gelatinous organisms better than nets
- Offers high spatiotemporal resolution
- Challenges include large data volumes, reliance on expert-labelled training libraries, and difficulties with species-level identification and phytoplankton chain enumeration

Holland et al. (2025)



Holland et al. (2025)

Molecular methods

- Uses DNA/RNA markers to identify and quantify plankton
- Uses PCR to amplify DNA for comparison against reference libraries
- Metabarcoding (eDNA analysis) identifies all plankton traces in water samples, revealing "hidden" diversity
- Can detect rare, economically important, or invasive taxa at low abundances (early warning)
- Generally better at providing presence/absence data rather than quantitative abundance/biomass currently
- Quantitative accuracy of metabarcoding is still developing
- Some promising current research linking gene copy number to abundance and biomass

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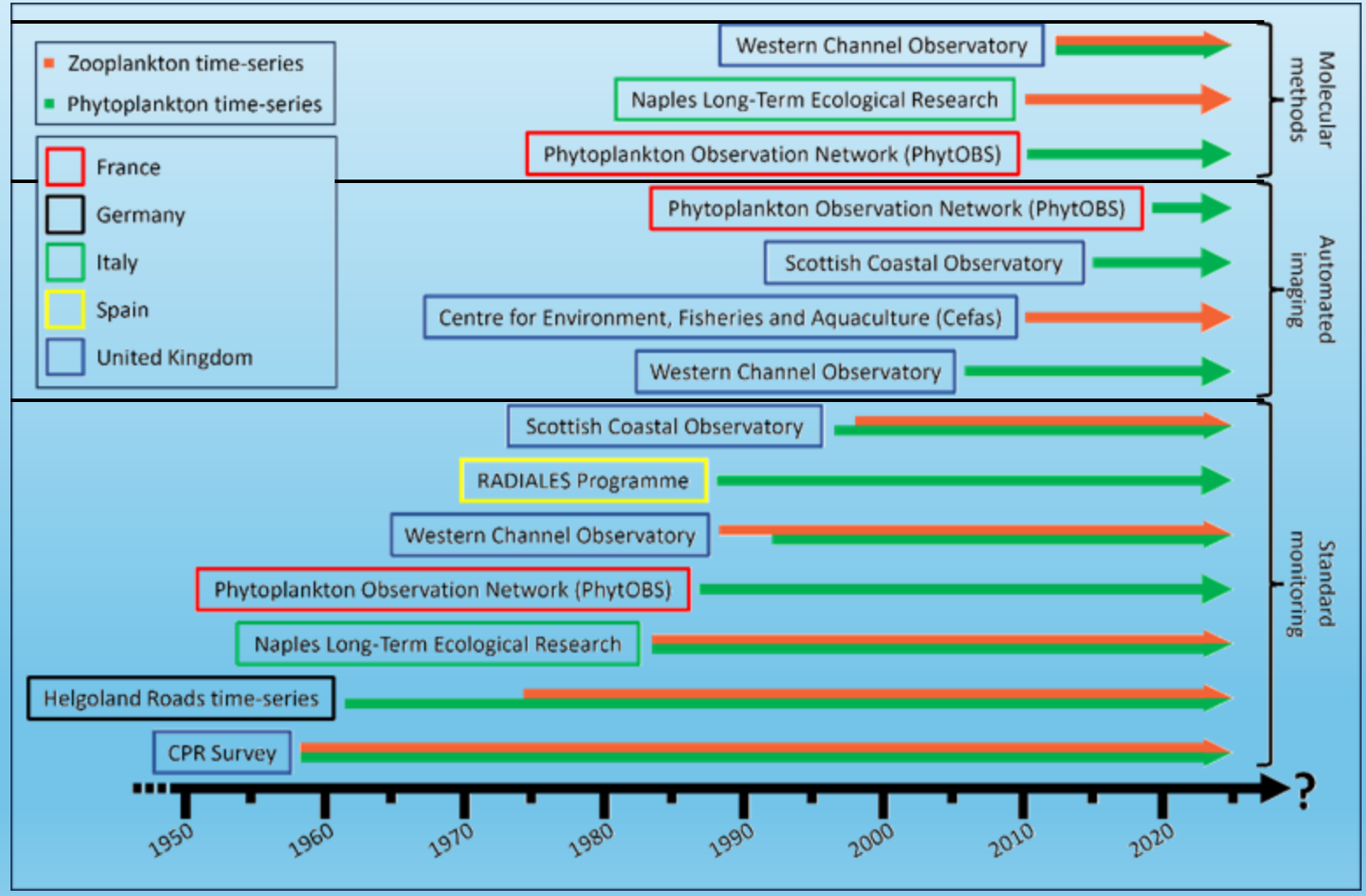
Duration of existing time-series

- Standard plankton monitoring unique in providing long-term (multi-decadal) temporal coverage
- Provides the statistical power needed to detect and understand climate change impacts
- Most plankton time-series using novel methods commenced after 2010
- Novel methods still developing and lack a consistent long-term record needed for biodiversity assessments (e.g. OSPAR, EU MSFD, UKMS)



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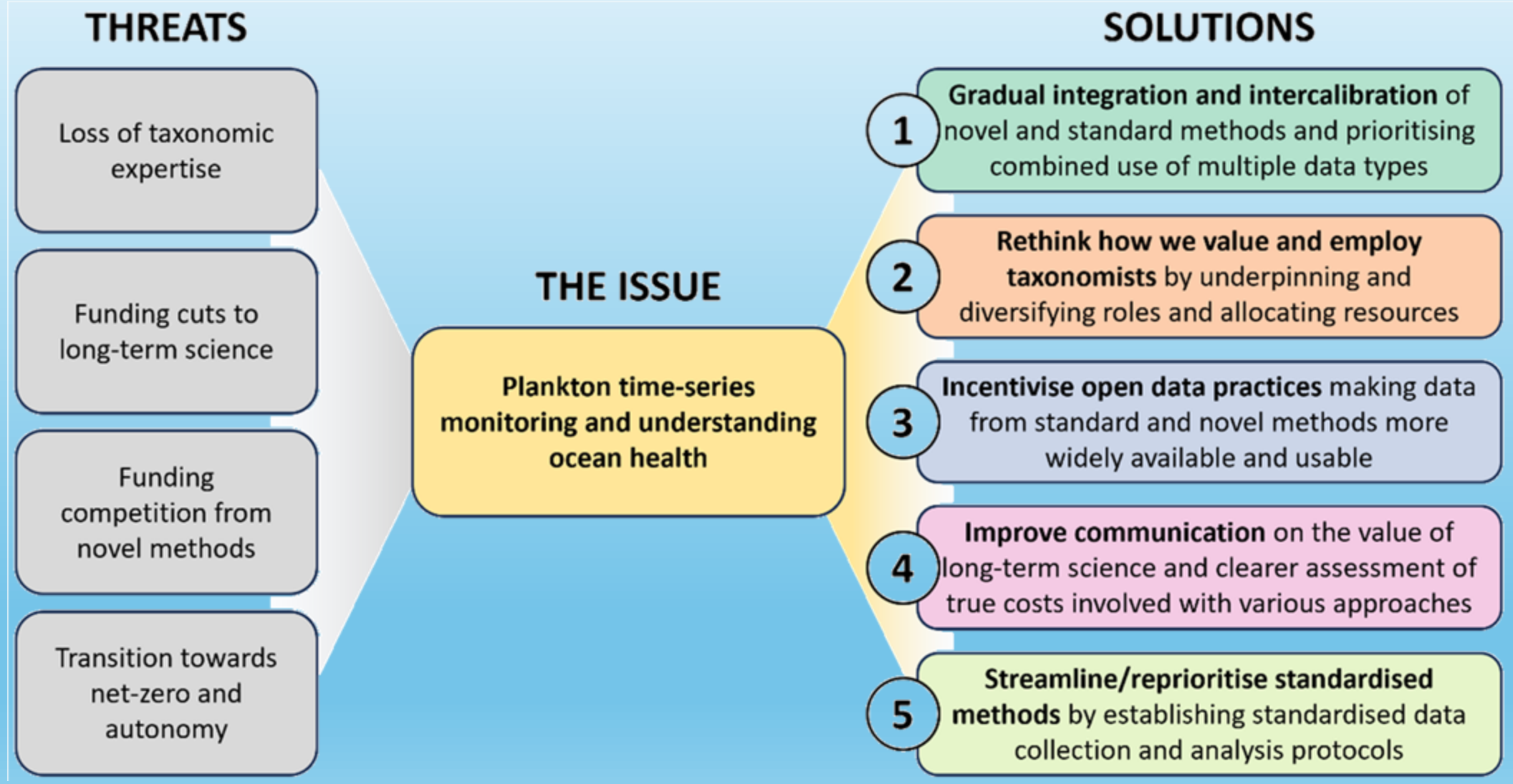
Alarming decline in taxonomic expertise

- Long-term monitoring programmes provide opportunities for taxonomic training
- Loss of experienced taxonomists through retirement and redundancy
- Lack of resources and mentors prevents training of junior taxonomists and development of taxonomic skills
- Loss of taxonomic skills threatens the ability to accurately identify and understand future biodiversity changes
- Future research roles in novel techniques will require strong taxonomic skills (e.g., labelling training libraries, interpreting molecular data)

How can novel technologies can complement standard monitoring to support better understanding?



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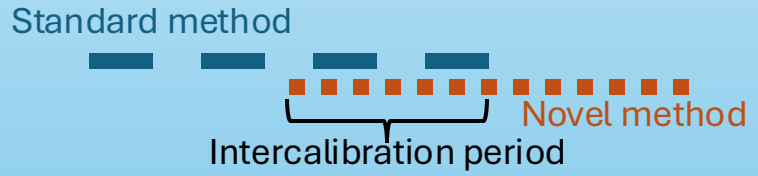
1 **Gradual integration and intercalibration** of novel and standard methods and prioritising combined use of multiple data types

- Run parallel studies applying novel methods alongside standard monitoring to calibrate and verify data
- Ensure taxonomic expertise is central to these efforts
- Combine approaches to leverage strengths of both:
  - Standard = long-term perspective
  - Novel = higher temporal/taxonomic resolution

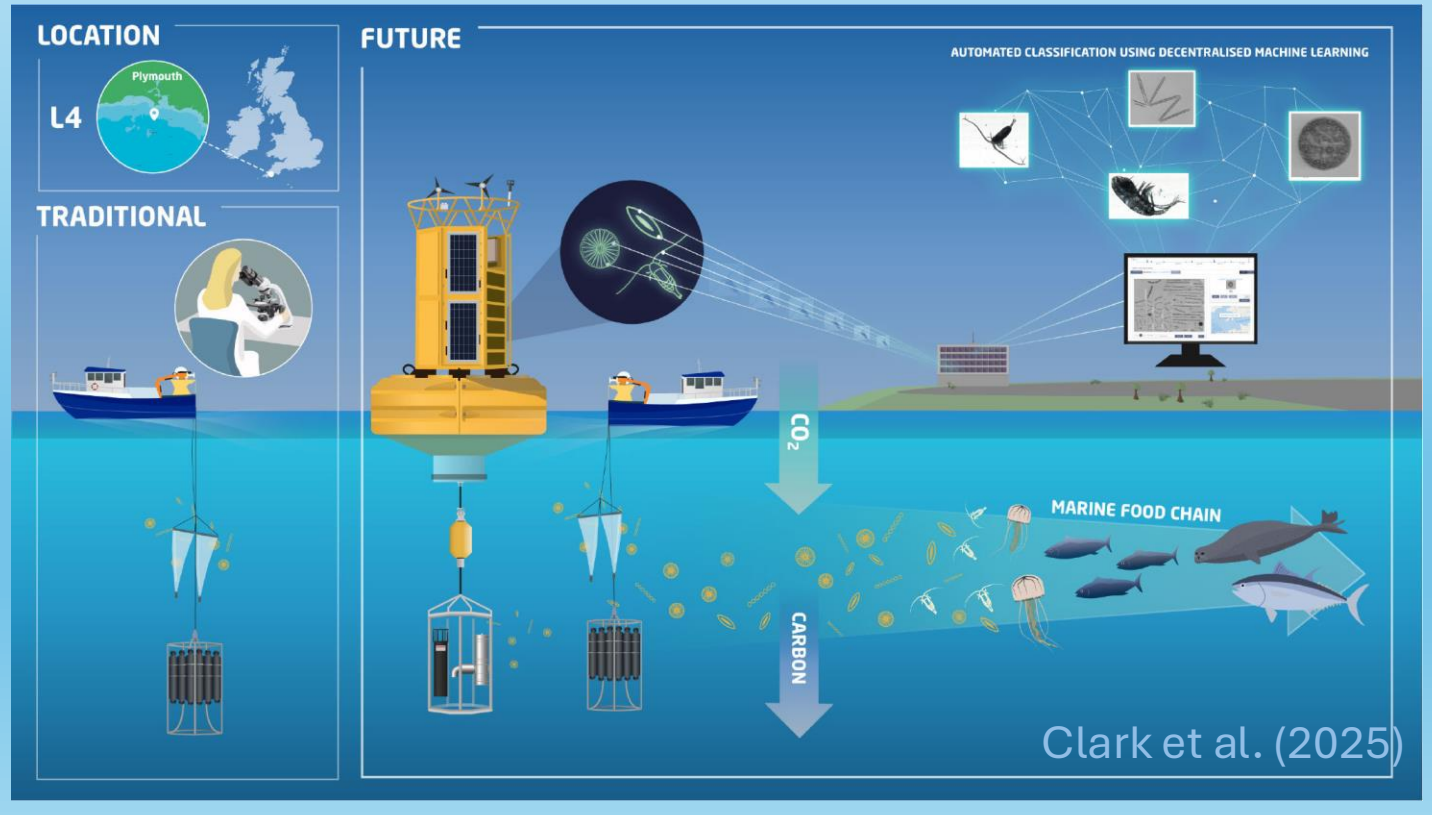


2 **Rethink how we value and employ taxonomists** by underpinning and diversifying roles and allocating resources

- Taxonomists remain essential as their skills underpin both standard and novel methods
- Need broader recognition of this expertise including from funders and research institutes
- Better investment in training in taxonomy and digital skills

3 **Incentivise open data practices** making data from standard and novel methods more widely available and usable

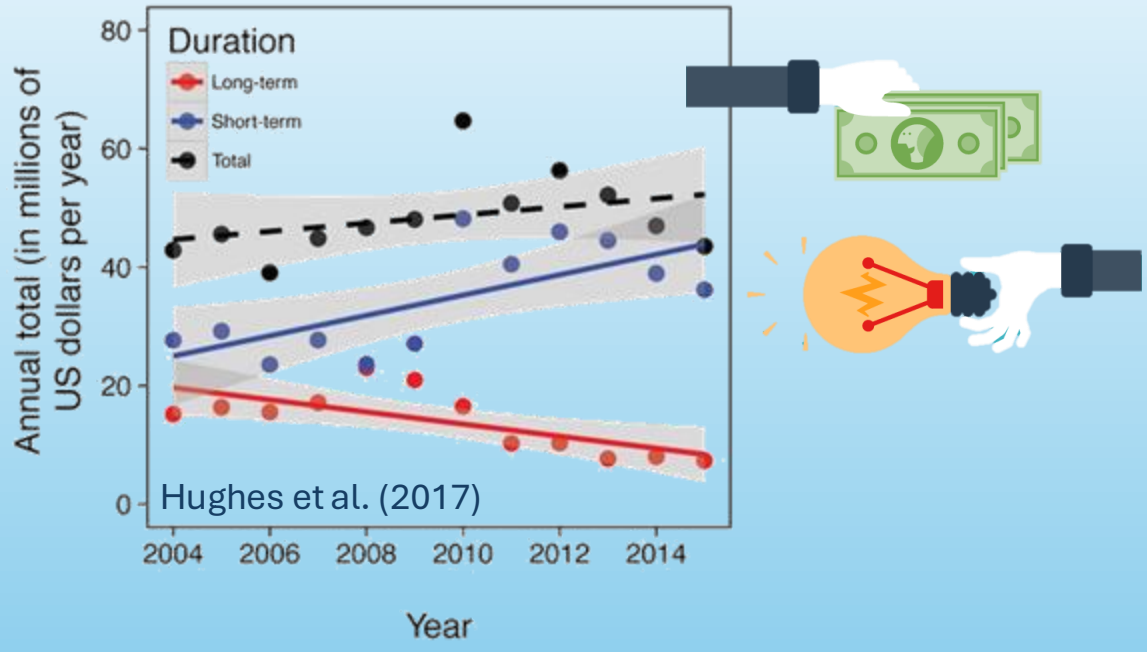
- Make all data openly available for public use
- Reward data sharing through better citation practices and recognition
- Encourage adoption of FAIR principles



Clark et al. (2025)

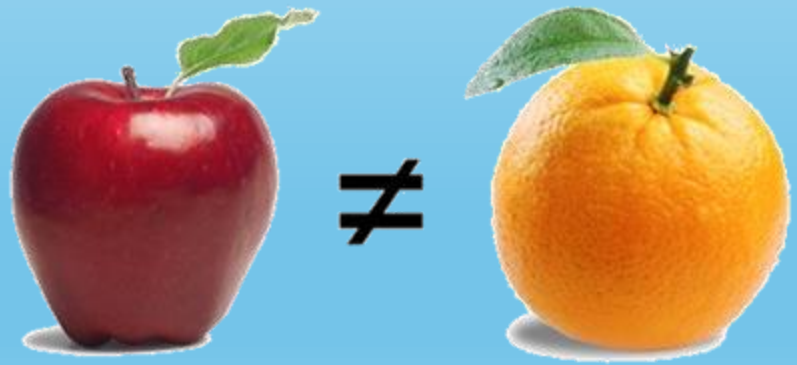
4 **Improve communication** on the value of long-term science and clearer assessment of true costs involved with various approaches

- Long-term research is underfunded and competes with novel research
- Need to better communicate to funders the value of long-term environmental monitoring
- Communicate benefits and true costs of standard vs. novel methods to policymakers, funders, and the public



5 **Streamline/reprioritise standardised methods** by establishing standardised data collection and analysis protocols

- Develop standardised protocols for novel methods to ensure inter-comparable time-series can be established
- Improve communication/collaboration among labs/institutes on the use of novel technologies
- Requires international cooperation to define a set of best practices



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In conclusion:

- **Embrace novel technology:** However, for now we must also ensure the continuity of long-term standard monitoring
- **A simple switch is not yet viable:** Standard methods cannot simply be replaced by novel methods, since historic data would no longer be comparable
- **Complementary approach is key:** Novel methods can enhance standard monitoring, and standard methods can validate novel ones
- **Maintain taxonomic expertise:** Essential for both current and future monitoring approaches

Thank you!

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Environment Agency

PML Plymouth Marine Laboratory

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Scottish Government
Riaghaltas na h-Alba
Marine Directorate

Cefas

SMHI

Rijkswaterstaat
Ministry of Infrastructure and Water Management

cnrs

SAMS Scottish Association for Marine Science

Marine Biological Association

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