REPORTING FORM 2025

Insert Name of Science Team – Atlantic Meridional Transect (AMT)

Operating Period as an IMBeR Member:

- *Start Year: 2012*
- *End Year: 2025*

List of Authors: Andy Rees, Tim Smyth, Glen Tarran, Gavin Tilstone and a large number of others

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1. Ongoing activities, in line with the IMBeR Grand and Innovation Challenges
(Among other uses, information will be used to update the IMBeR Annual Report to SCOR)

1.a. Grand Challenge I
Understanding and quantifying the state and variability of marine ecosystems - with focus on Research Objectives 1 to 3:

Research Objective 1. Evaluate and predict the cumulative effect of multiple stressors
Research Objective 2. Integration of climate change and climate variability
Research Objective 3. Impacts on society – preparation for a changed future

AMT is delivered by the Plymouth Marine Laboratory and was funded until 2025 by the Natural Environment Research Council. Since 1995 the Atlantic Meridional Transect (AMT) has undertaken measurements of oceanographic and atmospheric variables during 30 research cruises on a passage between the UK and destinations in the South Atlantic. This program of observations and novel research activities has collected samples for microbial molecular characterisation since 2009, spans more than 100° of latitude, samples to ocean depths of up to 1000 m and crosses a range of ecosystems from sub-polar to tropical, from eutrophic shelf seas and upwelling systems, to oligotrophic mid-ocean gyres. AMT has enabled the acquisition of repeat measurements of several Essential Ocean Variables and other ecosystem parameters and rate processes at a resolution of ~160 km (over ~13000 km). In delivering these activities AMT has facilitated long-term calibration and validation of satellite ocean colour sensors; deployment of ARGO and Bio-ARGO floats; and has maintained a long-term mooring in the South Atlantic Gyre (2009 to 2023). AMT data is archived and managed by the British Oceanographic Data Centre (BODC), whilst key data are also directed to other focus specific databases.

AMT has enabled extensive investigation of biodiversity and biogeochemical processes and provided the first Atlantic Ocean basin scale measurements of: Prochlorococcus and Synechococcus abundance (Zubkov et al., 2000); plankton net community production (Serret et al., 2001), respiration (Robinson et al., 2002), nitrification (Clark et al. 2007), mixotrophy (Hartman et al., 2012) and distribution of calcifying coccolithophores (Balch et al 2019). By engagement with other global scale programmes AMT contributes to understanding of global metagenome diversity (Larkin et al 2021). Recent activities have seen publications contributing to global updates on Coccolithophore diversity (de Vries et al 2024); phytoplankton pigments related to optical properties (Jordan et al 2025);

elemental stoichiometry (Fagan et al 2024); picophytoplankton cell size (Maranon et al 2024) and the genetic diversity of marine amphipods (Tump et al 2025).

AMT research has contributed to the quantitative understanding of key interactions and feedbacks between the ocean and the atmosphere which have included the role of ammonium in climate control (Jickells et al., 2003); enabled global prediction and model-validation of climate-relevant dimethylsulphide (Bell et al., 2006); provided first ocean basin budget of the global marine sources of atmospheric N2O and CH4 respectively (Forster et al., 2009) and enabled estimates of pCO2 in seawater from net community production measurements (Ford et al 2021). Recent publication by Ford et al (2024) has examined the control of CO2 uptake by temperature gradients.

AMT observations are a key component of the monitoring and detection of long-term changes in the ocean, driven by both natural variability and anthropogenic change. Kitidis et al. (2017) quantify changes in surface ocean CO2 and the carbonate system revealing a basin wide ocean acidification. AMT inputs to the global carbon project and annual carbon budget assessment (https://www.globalcarbonproject.org/). Long-term deployments of ocean moorings have revealed the contribution of atmospheric dust to deep ocean carbon sequestration (Pabortsava et al 2017). Whilst the integration of AMT data with satellites observations and biogeochemical modelling has characterised spatial and temporal variability of dominant oceanic provinces (Smyth et al 2017). More recently Pardo et al (2024) has provided an assessment of global chlorophyll signatures from multiple remote sensors.

Engagement with other organisations including NASA and ESA has been key to the origin and continuation of AMT. Early efforts provided first validation and calibration of SeaWiFS generation satellites (e.g. Aiken & Hooker 1997), recent highlights have included ESA supported projects (www.amt4oceansatflux.org) which continue this work for the current Sentinel Satellites (Tilstone et al 2021), enabling greater characterisation of ocean processes (Lange et al 2020) and oceanatmosphere exchange of climatically important gases (Holding et al 2019). Recent output coordinated by POGO (Partnership for Observations of the Global Ocean) as advised on capacity building activities related to shipboard activities (Krug et al 2025).

Cited references can be found at: Publications (amt-uk.org)

1.b. Grand Challenge II

Improving scenarios, predictions and projections of future ocean-human systems at multiple scales - with focus on Research Objectives 4 to 6:

__Research Objective 4__. Development of integrated data systems and approaches for predictions and projections
__Research Objective 5__. Development of predictive models and projections for use at regional scales
__Research Objective 6__. Development of alternative scenarios to bridge the gap between physical climate sciences and humanities

Since 2012, there have been >250,000 downloads of AMT data by users in >30 countries. Rapid public availability of AMT data has enabled sophisticated model and machine learning outputs: the use of neural networks has linked AMT and remote sensing observations to project accurate fields of pCO2 across the sparsely sampled South Atlantic (Ford et al 2022); AMT observations have validated

the use of optical data in the improvement of biogeochemical models to further mechanistic understanding of phytoplankton diversity (Dutkiewicz et al 2015, 2021). Data assimilation methods are utilised to improve ecosystem simulations (Ciavatta et al 2018) and deep learning methods deployed to improve the resolution and accuracy of chlorophyll concentrations from high frequency optical measurements (Graban et al 2020). In April 2025 AMT was represented at the Ocean Carbon and Biogeochemistry Marine Ecosystem Time Series workshop on FAIR data practises.

Cited references can be found at: Publications (amt-uk.org)

1.c. Grand Challenge III

Improving and achieving sustainable ocean governance - with focus on Research Objectives 7 to 9:

Research Objective 7. *Develop knowledge on best practices for multilevel governance approaches to ocean climate adaptation and mitigation*
Research Objective 8. *Develop understanding on key ingredients for transformation towards more sustainable, equitable and inclusive governance approaches to fisheries and aquaculture*
Research Objective 9. *Support implementation of post-2020 biodiversity targets for marine spatial planning and marine protected areas*

Influence on Policy, Practice, Patients and the Public Processing and validating satellite-derived ocean colour products to monitor for water quality to inform industry and deliver policy directives. AMT has been instrumental in the validation and application of satellite data and the computation of comprehensive uncertainty budgets on in situ measurements, referenced by inter-comparisons to firmly establish them as Fiducial Reference Measurements (FRM's) for satellite validation. During the AMT4CO2Flux contract, AMT was instrumental in developing a Chl-a algorithm that significantly improved the performance of the standard ESA-EUMETSAT Chl-a algorithm in open-ocean waters. In addition, installation of state-ofthe-art eddy covariance CO2 flux systems on two different ships (RRS James Clark Ross and RRS Discovery), accompanied by detailed measurements of the surface ocean on two Atlantic Meridional Transect (AMT) field campaigns (AMT28 & 29) and one Arctic Ocean campaign (DY151) provided near-fiducial data sets for gas flux and ocean acidification studies. These data verified the accepted uncertainties in global estimates of the air-sea flux of CO2 and provided ocean acidification parameters calculated from a suite of satellite products over a range of Atlantic and Arctic locations.

1.d. Innovation Challenge 3

To advance understanding of ecological feedbacks in the Earth System

Add text…

1.e. Innovation Challenge 4

To advance and improve the use of social science data for ocean management, decision making and policy development

Add text…

1.f. Innovation Challenge 5
Interventions to change the course of climate impacts

Add text…

1.g. Innovation Challenge 6
Sustainable management of Blue Carbon ecosystems

Add text…

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2. Selected highlights

2.a. Selected scientific highlights since last report (1-5)
Last report was submitted to SCOR, August 2024

Delivery of AMT research cruise number 31 The Atlantic Meridional Transect

Publication of AMT31 cruise report

Not a highlight but very significant – Termination of current round of funding

2.b. Publications since last report
Please add all publications since last report to the table below (see notes for details on "Class" and "Activity" fields).

Publication with DOI	Class 1, 2, 3	Activity*
de Vries, J., Poulton, A.J., Young, J.R. et al. CASCADE: Dataset of extant coccolithophore size, carbon content and global distribution. Sci Data 11, 920 (2024). https://doi.org/10.1038/s41597-024-03724-z	3	
D. Gilliard, D.J. Janssen, N. Schuback, S.L. Jaccard, Controls on the distribution of dissolved Cr in the upper water column of the Atlantic Basin, Geochimica et Cosmochimica Acta, Volume 390, 2025, Pages 57-69, ISSN 0016-7037, https://doi.org/10.1016/j.gca.2024.10.017	3	
Jordan, T. M., Dall'Olmo, G., Tilstone, G., Brewin, R. J. W., Nencioli, F., Airs, R., Thomas, C. S., and Schlüter, L.: A compilation of surface inherent optical properties and phytoplankton pigment concentrations from the Atlantic Meridional Transect, Earth Syst. Sci. Data, 17, 493–516, https://doi.org/10.5194/essd-17-493-2025, 2025.	3	
Ford, D.J., Shutler, J.D., Blanco-Sacristán, J. et al. Enhanced ocean CO_2 uptake due to near-surface temperature gradients. Nat. Geosci. 17, 1135–1140 (2024). https://doi.org/10.1038/s41561-024-01570-7	3	
Tump, M., Vonk, R., Burridge, Alice K., Beentjes, K., Goetze, E., & Peijnenburg, K. (2025). Genetic diversity of hyperiid	3	

amphipods along a meridional transect in the Atlantic Ocean. Contributions to Zoology, 2025, 1–31. doi:10.1163/18759866-bja10079		
Marañón, E., Fernández-González, C., & Tarran, G. A. (2024). Effect of temperature, nutrients and growth rate on picophytoplankton cell size across the Atlantic Ocean. Scientific reports, 14(1), 28034. https://doi.org/10.1038/s41598-024-78951-w	*3*	
Fagan, A. J., Tanioka, T., Larkin, A. A., Lee, J. A., Garcia, N. S., and Martiny, A. C.: Elemental stoichiometry of particulate organic matter across the Atlantic Ocean, Biogeosciences, 21, 4239–4250, https://doi.org/10.5194/bg-21-4239-2024, 2024.	*3*	
Krug, L.A., F. Beckman, A.P. Rees, A. Dummermuth, C. Stymiest, E.-M. Brodte, K.H. Wiltshire, P. Croot, and S. Seeyave. 2025. All aboard! Providing shipboard technical skills while building capacity in ocean observations. Oceanography 38(1):20–25, https://doi.org/10.5670/oceanog.2025.123.	*3*	
Pardo, Silvia and Tilstone, Gavin H. and Dall'Olmo, Giorgio and Jordan, Thomas M. and Brewin, Robert J.W. and Casal, Tania, Global Assessment of Merged Multi-Sensor Ocean Colour Chlorophyll a Products. Available at SSRN: https://ssrn.com/abstract=4903271 or http://dx.doi.org/10.2139/ssrn.4903271	*3*	
[Add more rows if needed]		

If appropriate, please list the IMBeR activity through / by / from / during which the publication arose

****<u>Notes on publications</u>****

Publications are logged in the IMBeR Zotero library which is publicly accessible online –

Publications since 2016 | Publications prior to 2016

Publications are categorised by "Class" and linked to "Activities":

<u>Class 1 publications</u> are specifically generated through/by/from/during **<u>IMBeR activities</u>** - for example, arising from IMBIZOs and IMBeR conferences such as the IMBeR open science meeting and the IMBeR West Pacific symposia and from the activities of the working groups, regional programmes and the SPIS scoping teams.

<u>Class 2 publications</u> are on topics relevant to the IMBeR Science Plan that benefitted from some interaction with IMBeR or **<u>IMBeR activities</u>**, for example by IMBeR symposium attendees, past and

present SSC members, working group, regional programme and endorsed project members, or national contacts.

Class 3 publications are on topics relevant to the IMBeR Science Plan but for which there is no direct link to or benefit from an IMBeR activity. These might include publications by SSC members, working group, regional programme or endorsed project members or members of the IMBeR international community that were written as part of the normal scientific activity of the authors and would have occurred irrespective of IMBeR's existence. You can report Class 3 publications, but they will no longer be logged in the IMBeR database.

[See "What is an IMBeR publication?" for further information]

Why list 'Class' and 'Activity'? This helps us to declare authentically which publications IMBeR has helped to generate, and it makes it easier for us to demonstrate the value of the Regional Programmes, the Working Groups, and IMBeR in general, and it helps us to justify support for IMBeR activities when we can list tangible outputs.

2.c. Events, Meetings, and Workshops

List all international and national events, meetings and workshops. Describe the level of participation: e.g. chairing session/workshop, organising meeting. Include Endorsed Projects committee meetings and workshops.

Format: Title of event. Date. Location. Description of participation. Any other pertinent details.

- *Ocean Optics Conference, 06-11 Oct 2024, Oral presentation: Tilstone et al. Radiometric field inter-comparison of fiducial reference measurements using an open source community processor.*

- *Living Planet Symposium, 23 – 27 June 2025, Poster presentation: Warren, Tilstone, Jordan, Dierssen. Comparison in atmospheric correction approaches of PACE imagery using ship-based radiometry across the open ocean Atlantic.*

3. International collaboration and links

Visit of Xavier Warren, University of Connecticut, USA, *9 – 20 June 2025, to PML for collaborative work on NASA PACE validation.*

Ben Knight, Cawthron, New Zealand. *20 June 2025, Submission of grant proposal to UKRI STFC UK-NZ ISBF that will utilize AMT31 optics data (Detection of phytoplankton communities and harmful algal blooms from next-generation hyperspectral reflectance algorithms, phytoHAB-EO4NZ).*

AMT31 personnel:

- *Rafael Mendes, FURG, Brazil. HPLC, Size fractionated chl-a, coccolithophores.*

- *Raul Costa, FURG, Brazil. HPLC, Size fractionated chl-a, coccolithophores.*

- *Jan Kaiser, UEA. MIMS O_2/Ar.*

- *Peter Croot, University of Galway, Ireland. NCP*

- *Francielle de Holtz Santos. POGO fellow.*

4. Input to management, policy and SOCIETY* over the last year
Add anything that is not covered under "1.c. Grand Challenge III"
*As previous reporting forms requested 'input to management and policy' only, please add any 'input to society' not captured in previous reports
Add text…

5. Education, outreach and Capacity Development

- *AMT/POGO sponsored fellow during AMT31 cruise: Francielle de Holtz Santos (Brazil)*

- *Publication: Krug, L.A., F. Beckman, A.P. Rees, A. Dummermuth, C. Stymiest, E.-M. Brodte, K.H. Wiltshire, P. Croot, and S. Seeyave. 2025. All aboard! Providing shipboard technical skills while building capacity in ocean observations. Oceanography 38(1):20–25, https://doi.org/10.5670/oceanog.2025.123.*

6. Planned activities

6.a. Activities and Outreach and how they link to the Challenges (including, but not limited to convening sessions, meetings, summer schools, workshops, etc)
Add text…

6.b. Upcoming papers (Community-Position-Review-etc)
Add text…

8. Changes to Organisational Structure
Funding withdrawn. Organisational structure will remain in place whilst future funding is sought

9. Images / Figures
*****It is always good to have some recent photos / figures / infographics to create more exposure for the Regional Programmes, Working Groups, etc. These can range from those suitable for a very scientific audience, to those that would engage the general public. IMBeR would use these, on the*

10. Notable achievements over the IMBeR decade (2016-2025)

- *10.1… Unique decadal series of observations over 100° of latitude. 1995 - 2025*
  10.2… Revealed distinct differences between North & South Atlantic Gyres

  10.3… Sustained measurements of fundamental indicators of ocean health: Biodiversity, Ocean Acidification, Warming etc.

  10.4… Ship observations, autonomous instrumentation, models & satellites. NASA and ESA validation and calibration

  10.5… Provides baseline for measuring and understanding changes in marine environment

  10.6… Next generation training programme and opportunities for developing nations

11. A list of Synthesis Products

Research Topic in frontiers in Marine Science:

The Atlantic Meridional Transect Programme (1995-2023) | Frontiers Research Topic

Special Issue in Progress in Oceanography:

Progress in Oceanography | The Atlantic Meridional Transect programme (1995-2016) | ScienceDirect.com by Elsevier

11. Reflections
Add text…

12. Recommendation for future work
Add text…

13. Anything not covered above
Add text…

14. Appendices

Add appropriate meeting / workshop reports and include URLs (this helps to track where online content is missing)

Add text…