Environment and Climate

Vision Statement:
The marine microbiome will be at the heart of understanding ocean ecosystems and the sustainability of the services they provide to society

Background

Just as the human microbiome is central to our health, the ocean microbiome is key to a healthy and resilient biosphere

Microbes permeate the ocean and their activities deeply influence its chemistry, physics, and underpin all marine life. The marine microbiome is sensitive to environmental stress and shapes ecosystems across the entire planet. Vitally, this also affects our planet's climate system, as marine microbes are responsible for pumping atmospheric carbon into the oceans and preventing the release of methane from the ocean's depths into the atmosphere. They are also key to sustaining the ecosystem services that humans rely on and thus highly relevant to multiple aspects of the Sustainable Development Agenda. For example, their diverse metabolic abilities can deactivate and recycle waste products and pollutants while provisioning food webs and fisheries with essential nutrients. Simultaneously, some kinds of marine microbes pose significant threats to living systems through their ability to cause disease, produce toxins, resist antibiotics, and form harmful algal blooms and oxygen-depleted dead zones. These roles also make microbiomes sensitive and broad indicators of the state, functions, changes, and health of marine ecosystems.

Despite the importance of the marine microbiome to both science and society, our ability to observe it at scale is underdeveloped and under-coordinated compared to current physio-chemical ocean observation efforts. However, recent advances and the falling costs of technologies such as high-throughput sequencing, e.g. of eDNA, remote sensing and autonomous sampling, and emerging coordination networks are a game changer.

We are now capable of mainstreaming microbiome observations in ocean science and operations at large, complementing existing capacities with new biological and ecological perspectives. Integrating microbiomes within ecosystem models will help to improve our ability to better predict and respond to climate variation and ecological hazards. It allows us further to investigate the microbiome of global Marine Protected Areas in order to fully understand these systems from the microbes up. Indeed, in 2018, the Global Ocean Observing System (GOOS) established a Microbial Biomass and Diversity Essential Ocean Variable (EOV), acknowledging the key role of microbes in the Global Ocean. Within AORA, we seek to catalyze the mainstreaming of marine microbiome research and application, integrating these with existing programmes in environmental monitoring and science.

Goals

- Map the Atlantic microbiome and its connectivity and variation in time and space
- Identify novel microbial indicators of ocean health and change
- Improve capacities for the prediction of the future state of ocean health
- Characterize and quantify the microbiome-related ecosystem services to societies, and provide insight into their drivers and their future trajectories
- Provide responses to challenges identified by the Intergovernmental Panel for Climate Change (IPCC) and the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES)

Specific objectives

- Develop and disseminate best practices to assess microbiomes across the Atlantic's diverse ecosystems
- Broaden spatiotemporal coverage of Atlantic microbiome observations and experiments (mm to km and minutes to years) to characterize its core features and behavior
- Define baselines for different microbiome states (e.g. pristine, impacted by pollution) and indicators to detect deviations and risks of exceeding ecological tipping points
- Monitor and measure spatiotemporal variations in microbiome composition, function and health status
- Improve the understanding of how microbiomes within and between ocean regions connect with and influence one another
- Enhance capacities in data science (especially artificial intelligence (AI) technologies and distributed processing of complex data) to accelerate the production of data, information, and knowledge products suited to a wide range of stakeholders
- Improve the transfer of basic science into the development of predictive models used for the response of the microbiomes to environmental change, e.g. biogeochemical cycling, ecosystem structure, trophic status, and environmental hazards

Action Items

Short Term

- Align existing Atlantic microbiome initiatives through the support of collaborative networks, standards, and best practices to promote greater interoperability and basin-scale cooperation
- Select sites or areas - along and across the Atlantic - to conduct repeated and long-term sampling, augmenting our capacity to monitor marine microbiomes
- Across the Atlantic, strongly improve the bridge between environment observations, controlled experiments (lab based, mesocosms, cultivation of mixed microbiomes), data science, and predictive modelling to create deep and validated understanding

Medium Term

- Map the Atlantic microbiome, emphasizing the variability in its diversity, functions, and the services it provides to human society
- Building on increased data availability, build and integrate predictive models across the ocean value chain and contribute to predictions of global ecosystem state (e.g. climate variation, biodiversity loss and gain)
- Develop robust financial concepts to maintain coordinated, long-term microbiome observation and research in the Atlantic
- Improve - across sectors - the crediting of rapid microbiome data release
- Develop, test and deploy sensors and samplers for broadscale, near real time synoptic observations of microbiomes and their physical and chemical environments

Long Term

- Collaboratively and continuously update and maintain quality-controlled maps of the Atlantic microbiome, fully integrated with other ocean data layers
- Provide a global understanding of the role of microbiomes in the ecosystem's state, change, and health
- Promote rapid and automated reuse of microbiome data (assisted by AI solutions) and delivery of tailored information products across ocean stakeholders