ARCTIC SCIENCE AND INNOVATION

FOR A CHANGING WORLD

National Oceanography Centre

ARCTIC SCIENCE AND INNOVATION

FOR A CHANGING WORLD

We live on a blue planet. The ocean is our planet's life support system, but so much of it is yet to be discovered and its value is often overlooked and misunderstood.

The National Oceanography Centre (NOC) is the UK's largest ocean research charity and has existed in various forms for over six decades. Our mission is to gain a deeper understanding of the ocean, to help every living thing on our planet flourish.

We are a unique institute with a wide breadth of multi-disciplinary marine science and technology expertise. We work with local communities, NGOs, government, science and industry partners around the world, to turn research advances and technological innovation into value for society.

NOC HAS FOUR OCEAN-RELATED MISSIONS:

Climate
Enabling society to plan for, adapt to, and mitigate against environmental change.

Biodiversity
Ensuring marine biodiversity is protected and thrives.

Hazards and Pollution
Protecting people, infrastructure and ecosystems from hazards and pollution.

Sustainable Marine Economy
Driving sustainable marine-based economic activity to protect the ocean's future health.

THE ARCTIC

The Arctic is one of the most rapidly changing environments on our planet. The opportunities and risks posed to climate, biodiversity, human wellbeing, marine-economies and geopolitical stability are global. At the National Oceanography Centre we have identified priority research themes, that are addressed by our experts, in collaboration with partners and stakeholders. The Arctic is one of our priority research areas.

RAPID ARCTIC CHANGE

The Arctic plays a fundamental role in the Earth's climate system and its unique sea ice environment and ecosystems provide resources and a way of life to Indigenous and local Arctic communities.

The Arctic, however, is rapidly changing, threatening our global climate, weather and biodiversity.

Warming in the Arctic is occurring up to four times faster than the global average, driving rapid losses of sea ice, glaciers and permafrost. The Arctic could be sea ice free in the summer by the middle of this century. These changes have profound implications, not only for the local ecosystem and the health and livelihoods of the Indigenous and local communities that call the Arctic home, but for every person on our planet.

CLIMATE AND WEATHER

Arctic Ocean and atmosphere circulation changes could disrupt global climate stability and modify regional weather patterns and extremes worldwide, exposing people and infrastructure to increasing hazards.

BIODIVERSITY

Shifts in Arctic marine biodiversity could destabilise the food resources that the ecosystem provides, reduce its ability to withstand environmental change, threaten vulnerable species, as well as the health and livelihoods of communities that rely on the ocean.

SEA LEVEL

Ice melt from Arctic glaciers and the Greenland Ice Sheet contributes to global sea-level rise, impacting coastal communities worldwide.

ARCTIC OCEAN ECONOMY

As the Arctic becomes more accessible, its ocean economy will continue to grow.

The emerging opportunities for

- resource and energy extraction
- tourism
- shipping and communications
- fisheries

will need to be carefully managed against risks to

- environment and biodiversity
- safety of people and infrastructure
- geopolitical stability
- Indigenous culture and way of life

It is essential that the growth of marine-based economies in the Arctic takes place sustainably and that the health, wellbeing and cultural practices of Arctic communities are protected.

As the attention of policy makers and governments worldwide focuses on the Arctic, and the 5th International Polar Year 2032/2033 gains momentum, the need for innovative, multi-disciplinary marine science and technology, co-designed and delivered with Indigenous and local Arctic communities, to observe, understand and predict Arctic change and its impacts, has never been greater.

NOC IN THE ARCTIC

RESEARCH THEMES

NOC is a world-leader in ocean modelling and climate, biodiversity and ecosystems, marine geohazards, remote and in-situ sensors, marine autonomy and digital technologies. We have been delivering high-impact Arctic research for decades.

In collaboration with diverse and international partners, we aim to leverage our multi-disciplinary science and technology expertise to deliver multi-platform, multi-sensor, and multi-season field programmes - with a focus on under - ice exploration - and harness the power of our ocean models and digital tools to provide critical new knowledge for the 5th International Polar Year.

We seek to work alongside Arctic communities to facilitate research that is co-designed with those most impacted by Arctic change.

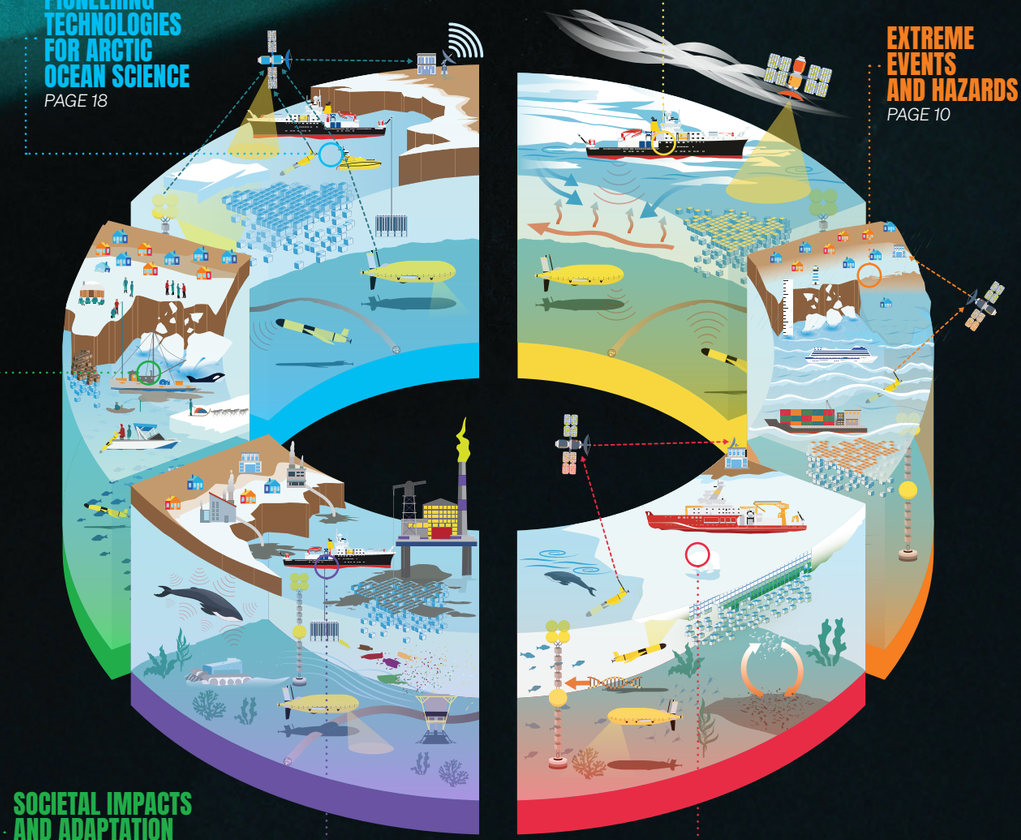
We endeavour to advocate for the Arctic Ocean by raising public, industrial and political awareness of the risks and opportunities presented by a rapidly changing Arctic environment.

ARCTIC THEMES

Our ability to integrate observational, modelling and digital approaches in one of the world's most challenging environments, will help us address knowledge and capability gaps across six themes

1. Ice-free Arctic and Global Climate
2. Extreme Events and Hazards
3. Arctic Marine Biodiversity and Ecosystems
4. Human Stressors and Arctic Pollution
5. Societal Impacts and Adaptation to Arctic Change
6. Pioneering Technologies for Arctic Ocean Science

In partnership, NOC can help provide society with the knowledge and technology innovation needed to tackle Arctic change - helping communities adapt and build resilience, safeguarding the health and wellbeing of people within and beyond the Arctic, and driving sustainable growth of the Arctic Ocean economy while protecting essential marine ecosystem services.



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ICE-FREE ARCTIC AND GLOBAL CLIMATE

SEA ICE
HEAT AND FRESHWATER
CIRCULATION AND MIXING

CLIMATE RISKS
EARLY-WARNINGS
RESILIENCE PLANNING

As Arctic sea ice, ice sheets and permafrost are lost, the ocean, atmosphere, and land are becoming more tightly linked.

This is altering Arctic Ocean and atmosphere circulation patterns, the strength of ocean mixing and the pathways of water into and out of the Atlantic. Sea ice loss may even accelerate if reservoirs of warm, deep water in the Arctic are disturbed.

What happens in the Arctic influences the large-scale ocean and atmosphere systems at lower latitudes. Through heat and freshwater transport and ocean-atmosphere connections, they regulate global climate stability and extremes, with implications for health and wellbeing, food and water security, global economies and geopolitical stability.

The future trends and climate impacts of changes in circulation, mixing, heat and freshwater, both within and beyond the Arctic, are uncertain. This limits our ability to assess climate risks, provide early-warnings of sudden change and strengthen adaptation and resilience planning, locally and globally.

RESEARCH QUESTIONS

- How close are we to an ice-free Arctic?
- How will Arctic Ocean circulation and mixing change as ice is lost?
- Will an ice-free Arctic reshape Earth's climate trajectory and push the planet toward a global tipping point?

NOC CAPABILITIES AND FOCUS

NOC develops world-leading global and regional ocean-ice -atmosphere models that help us understand sea ice loss and Arctic Ocean circulation. They project how Arctic change may influence global climate stability within the coming decades of the 21st century.

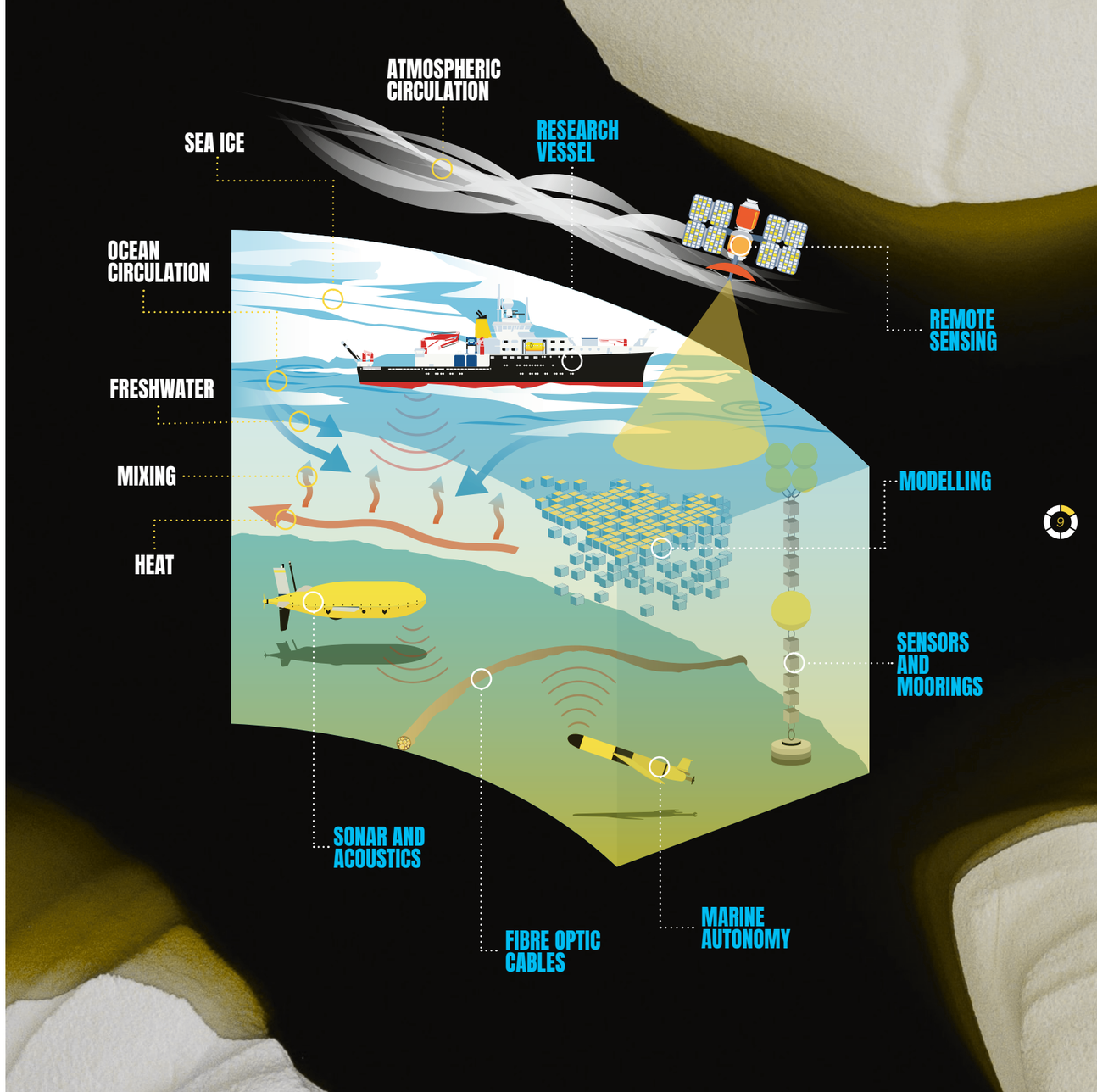
Autonomous underwater vehicles (AUV) can collect measurements of temperature, salinity, currents and mixing in ice-covered regions, and at locations where the Arctic connects with global ocean circulation. NOC designs and builds an AUV that is capable of sampling, over many months, areas covered in sea ice that we know very little about.

Observations NOC makes from satellites, drones and radar systems offer unprecedented views of surface ocean and ice conditions. Beneath the surface, we are advancing the use of sonar on AUVs and fibre-optic cable systems that will help us observe critical ocean and ice properties.

NOC scientists are combining observations, remote sensing and modelling with artificial intelligence and machine learning approaches to better detect when the climate may be approaching 'tipping points' beyond which change will be much more rapid and possibly irreversible.

UNIQUE VALUE

This combination of world-leading modelling and observational capabilities means that NOC is uniquely placed to improve our understanding of the climate risks posed by Arctic sea ice loss, explore the potential for early-warnings and to inform mitigation, adaptation and resilience planning.



EXTREME EVENTS AND HAZARDS

STORMS AND WAVES
FLOODING AND EROSION
SEA LEVEL RISE

FORECASTING
MARITIME SAFETY
EXTREME EVENT RESILIENCE

Photo: Peter Brown

Warming and sea ice loss in the Arctic is fuelling increasingly frequent and severe storms and extreme waves. Coupled with the hazards posed by drifting sea ice, shipping, resource extraction and tourism will become increasingly dangerous activities.

At the coast, amplified by sea-level rise and permafrost thaw, communities are already threatened by flooding and erosion, and the increasing risks of landslides and tsunamis. At the seafloor, the stability of frozen methane stores is decreasing, raising the risk of sudden greenhouse gas releases.

These hazards and extreme events are not confined to the Arctic. Storms, heatwaves, droughts, and shifting monsoon systems around the world are increasingly connected to Arctic change.

Our current ability to predict where multiple environmental hazards converge into 'risk hotspots' is insufficient. This impedes providing reliable operational forecasts and early-warnings, suitable risk assessments or long-term mitigation strategies to protect lives and livelihoods.

RESEARCH QUESTIONS

- How is Arctic change fuelling extreme ocean and weather conditions within and beyond the Arctic?
- Where are the risk hotspots, when will they emerge and what threats are posed to people, infrastructure and ecosystems?
- How will a melting Arctic re-map the world's coastlines?

NOC CAPABILITIES AND FOCUS

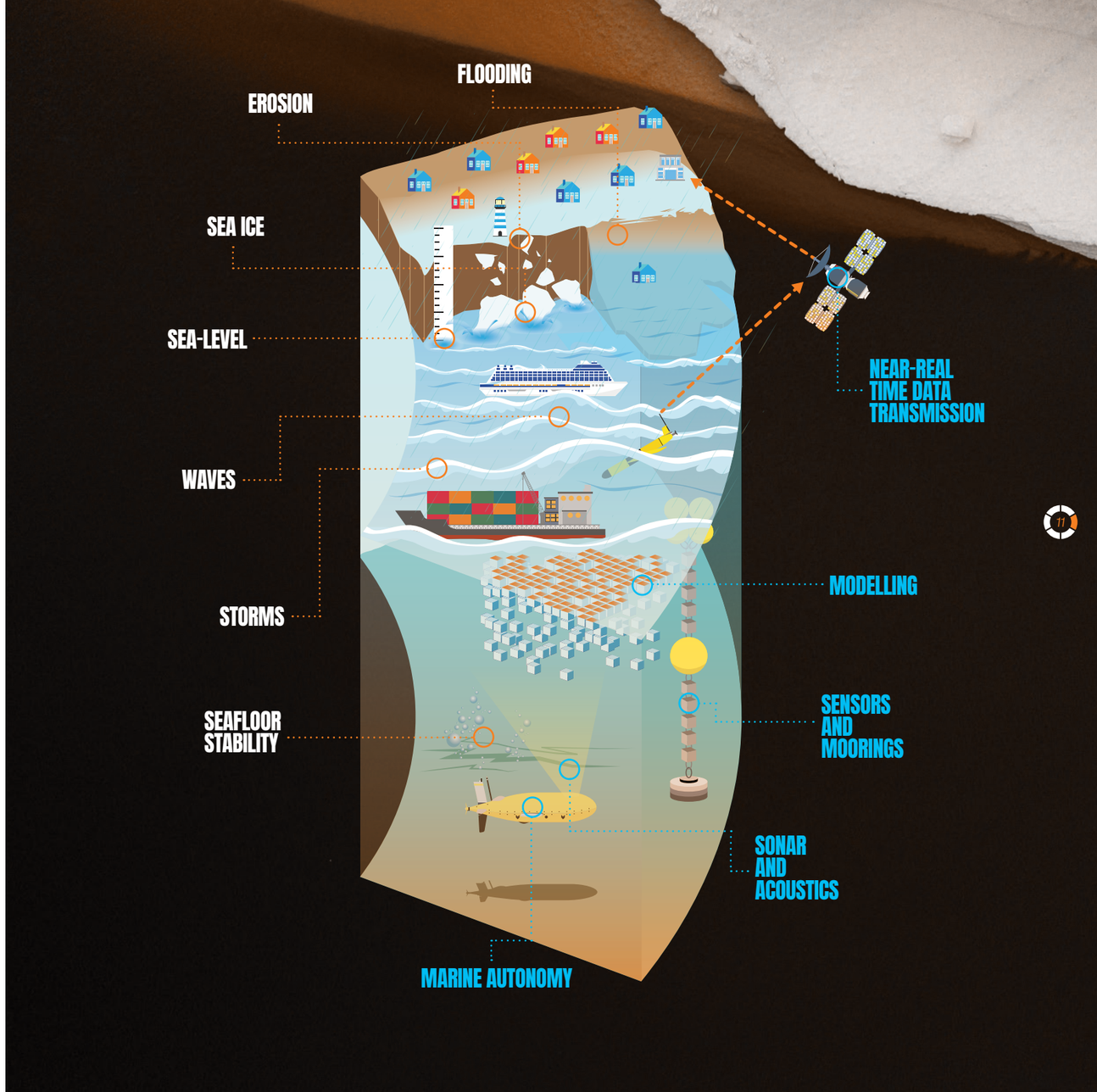
NOC's ocean-ice-atmosphere and wave models identify emerging risks posed by extreme weather and ocean conditions, sea-level rise, flooding and coastal erosion. NOC has a long-history of observing and interpreting sea-level change, including designing and deploying tide gauges and developing innovative, low cost, satellite-based approaches to measure sea-level.

NOC researchers use a range of acoustic instrumentation to detect and make assessments of submarine landslides and tsunamis, ice-properties and stability. Seafloor coring is used by NOC researchers to look at the history of geological hazards and the current stability of methane stores.

The ability to relay information about ocean conditions collected by autonomous underwater vehicles in near real-time improves short-term ocean and weather forecasting and provides timely information for early-warnings of hazards that may threaten lives, livelihoods, navigation and maritime operations.

UNIQUE VALUE

By combining world-class modelling with an array of observations made from the coast, remote sensing, ships, moorings and autonomous underwater vehicles, NOC innovatively delivers new knowledge and technologies that support safe maritime operations, resilience of coastal communities and marine industry, and improved future sea level and hazard risk assessments.



ARCTIC MARINE BIODIVERSITY AND ECOSYSTEMS

NUTRIENTS
CARBON
HABITATS

ECOSYSTEM MANAGEMENT
HABITAT PROTECTION
FOOD SECURITY

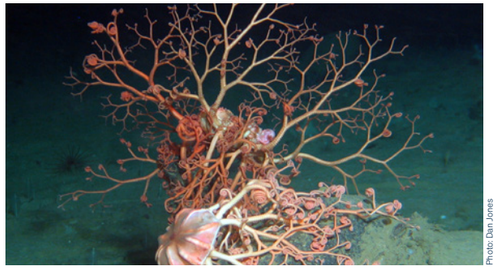


Photo: Dan Jones

Arctic change is predicted to disrupt Arctic biodiversity and the ecosystem services it provides, including carbon storage and food security. We are already observing loss of sea ice habitats, changing nutrient availability impacting the growth of marine life and carbon storage, and climate-driven ecosystem shifts.

We don't yet have enough knowledge of the diverse habitats and ecosystems in the Arctic, especially in winter, which limits our ability to understand how they will cope with future warming and sea ice loss, and the changing inputs from rivers, sea ice, glaciers and land. Indeed, critical ecosystem services may exist in remote and inaccessible parts of the Arctic that we have not yet discovered, particularly in the deep sea.

Without better understanding and forecasting of Arctic ecosystem change, biodiversity, carbon and nutrient cycling, we cannot develop effective conservation strategies, predict ecosystem regime shifts, or strengthen adaptation and resilience plans.

RESEARCH QUESTIONS

- What is the present-day state of Arctic biodiversity?
- How will Arctic change reshape how the ecosystem functions, from the sea-surface to the sea-floor?
- What are the global consequences of Arctic ecosystem change?

NOC CAPABILITIES AND FOCUS

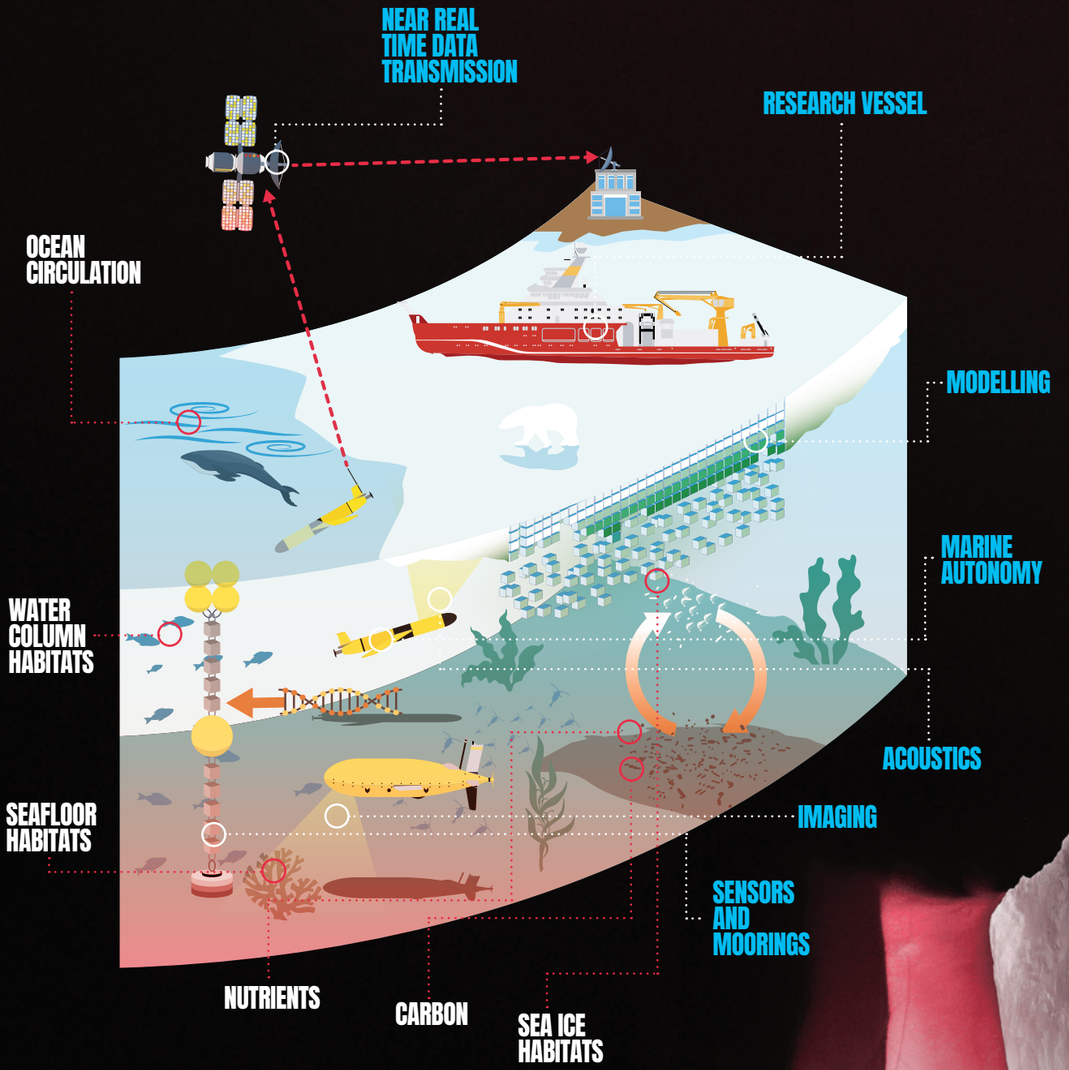
NOC has strong capability in mapping biodiversity and in making observations of ecosystem function in key, rapidly changing areas of the Arctic, helping to understand and quantify the role of biology in regulating climate, carbon storage, nutrient export and how these roles may shift in the future.

By integrating nutrient and carbon sensors, environmental DNA samplers, and imaging systems developed at NOC into ice-capable autonomous underwater vehicles, NOC can map and understand the Arctic's diverse ecosystems from the sea-surface to the sea-floor, even in the remotest and least accessible parts of the Arctic Ocean. New sensors being developed will provide information about diversity and growth of plankton - the base of the Arctic ecosystem.

Our Artificial Intelligence algorithms can link biodiversity to the different Arctic habitats. NOC's ecosystem models predict how the base of the Arctic ecosystem will change over the coming decades of the 21st century and what the impact will be on the global carbon cycle.

UNIQUE VALUE

By integrating sensing, sampling and imaging technologies, ecosystem modelling, and AI-driven analysis, NOC offers a comprehensive suite of capabilities to map, understand and predict Arctic ecosystem change and its global impacts. In this way we can inform adaptive, sustainable management and conservation efforts and resilience planning.



HUMAN STRESSORS AND ARCTIC POLLUTION

PLASTICS
NOISE
DISTURBANCE

ENVIRONMENTAL IMPACT ASSESSMENTS
REGULATORY GUIDANCE
CONSERVATION AND PROTECTION

As human activity in the Arctic increases, so too does the threat from pollution. Shipping, tourism, offshore operations and industrial land run-off are all introducing pollutants, including plastics into the Arctic Ocean.

Plastics are transported by ocean currents, accumulate in critical habitats and enter the food chain, posing risks to wildlife and food security. Underwater noise from shipping, seismic surveys, sonars and offshore industry is also increasing, disrupting how marine mammals communicate, migrate and hunt. Extraction industries, bottom-trawling and future deep-sea mining activities can disturb valuable habitats and carry risks of oil spills and heavy metals polluting the environment.

This is complicated by uncertainty over whether climate driven changes in ocean temperature, salinity, circulation, and ecosystems will exacerbate the impacts of pollution, including modifying the underwater sound channels used by wildlife and humans for communication and navigation.

The combined effects of these stressors on water quality, sea surface to seafloor habitats, wildlife migrations, underwater communication and human health is unknown.

RESEARCH QUESTIONS

- How are plastic, noise, and sea-bed disturbances affecting Arctic habitats?
- Do these pressures and sources of pollution overlap with important wildlife corridors?
- Where do human stressors and climate change intersect to threaten Arctic ecosystem services?

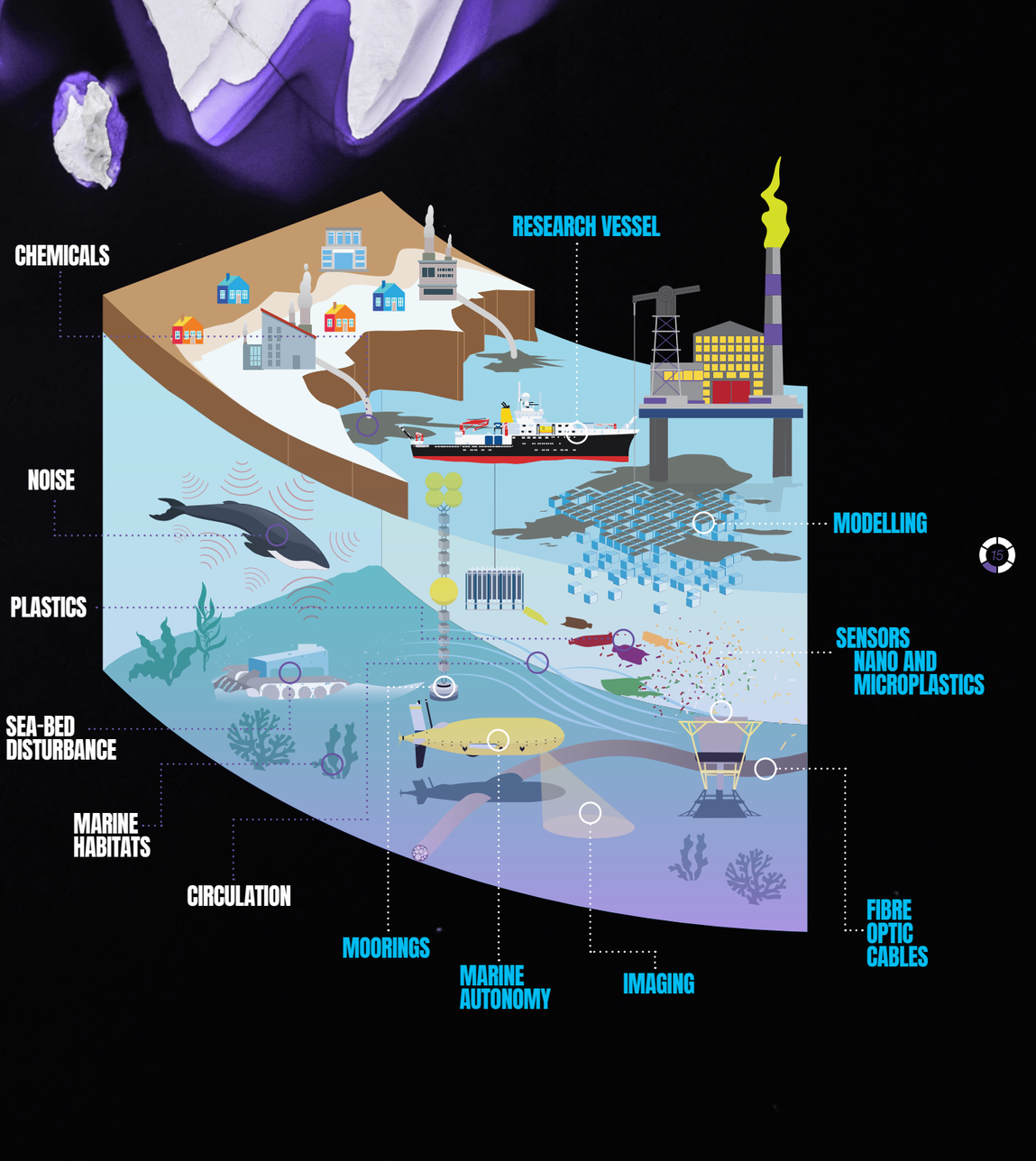
NOC CAPABILITIES AND FOCUS

NOC can sample and analyse the tiny plastic fragments in water, sediments, and marine life, using automated samplers and detectors developed by our technologists. NOC modelling can predict the transport and distribution of chemicals and plastics.

Seabed mapping and imagery provide understanding of habitat disturbance and recovery caused by the extraction industry. Fibre optic acoustic sensing techniques being developed at NOC offer continuous acoustic monitor solutions and will augment the range of instruments already used by our research teams to detect different sound sources in the marine environment.

UNIQUE VALUE

NOC combines world-leading expertise on plastics sampling, a range of acoustic and other seafloor survey technologies and modelling tools. These capabilities can be applied to understand the sources of pollutants and disturbances in the Arctic and assess the environmental and ecosystem consequences. This helps inform environmental impact assessments, policy development, regulatory guidance, and conservation and management efforts.



SOCIETAL IMPACTS AND ADAPTATION TO ARCTIC CHANGE

COMMUNITY
ECOSYSTEM SERVICES
OCEAN ECONOMY

COMMUNITY HEALTH
SUSTAINABLE LIVELIHOODS
ADAPTIVE RESILIENCE

As climate change accelerates and industrial activities grow in the Arctic, communities - particularly Indigenous and coastal populations that rely on the Arctic's sea ice and diverse ecosystem services for food, transport and communication - face increasing risks to their health, livelihoods, and cultural heritage.

To identify and fully understand the potential impacts of change on the ocean ecosystem services that Arctic communities rely upon, observational and modelling tools must be used equitably and respectfully alongside local knowledge.

Through engagement and co-creation, NOC endeavours to support capacity in Arctic researchers and communities, listening to diverse voices and co-developing targeted strategies to build long-term resilience to a changing environment.

RESEARCH QUESTIONS

- What are the key risks to Arctic communities and marine ecosystem services from accelerating climate change and expansion of ocean economy activities?
- How can we meaningfully engage to co-create projects that help strengthen the capacity of Arctic communities to adapt to Arctic change?
- How can marine observations and modelling help identify areas of high risk, and support adaptive responses for Arctic societies?

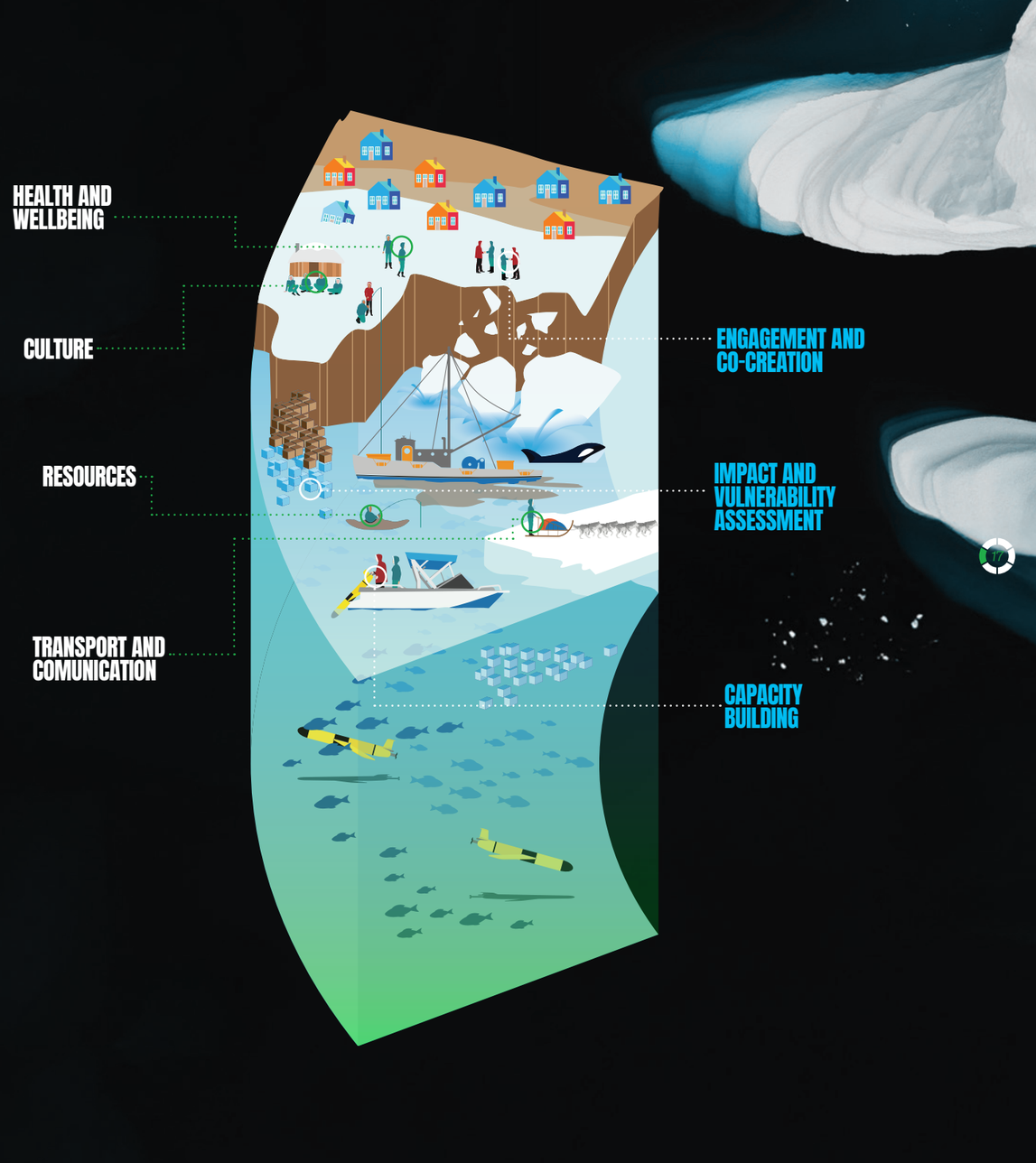
NOC CAPABILITIES AND FOCUS

To help identify where the greatest future risks are, NOC offers expertise in Climate Change Impact, Risk, and Vulnerability assessment. We have experience in engaging with coastal communities on the use of autonomous marine vehicles, new sensors and remote sensing to compliment traditional sampling methodologies and knowledge systems.

By combining these capabilities with co-designed research and data-supported storytelling methods to explore future change through a novel lens, NOC aims to support more inclusive and adaptive approaches to Arctic science.

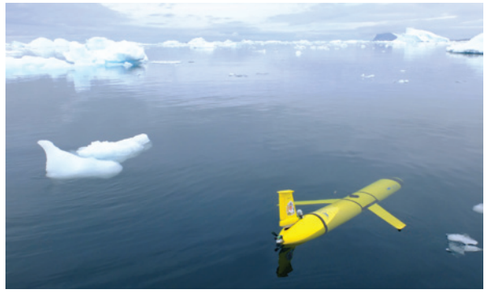
UNIQUE VALUE

Our experience of engaging with multiple partners, co-designing and co-delivering research with local communities, ensures we are well-placed to provide complementary knowledge to that existing in local communities and governing bodies, to support adaptive resilience to Arctic change.



PIONEERING TECHNOLOGIES FOR ARCTIC OCEAN SCIENCE

MARINE AUTONOMY
SENSORS AND SAMPLERS
OCEAN MODELLING
REMOTE SENSING



Understanding and predicting rapid change in the remote Arctic Ocean, with its freezing temperatures and challenging sea ice and weather conditions, requires the development and integration of multiple observing platforms, including physical, chemical, and biological sensors, as well as remote sensing, numerical modelling and digital tools.

NOC offers pioneering technology solutions to meet these needs.

MARINE AUTONOMY

NOC designs and operates autonomous underwater vehicles (AUVs) and gliders engineered for extended under-ice missions, pioneering new navigation methods to ensure safe operation, mapping, and obstacle avoidance. Artificial Intelligence is used onboard our AUVs to optimise and adapt their sampling routines in real-time based on the observations the sensors they are carrying are making. We develop digital solutions to control and co-ordinate fleets of autonomous vehicles and to make the data that is collected available in near-real time, improving operational model forecasting and supporting quick decision making.

SENSORS AND SAMPLERS

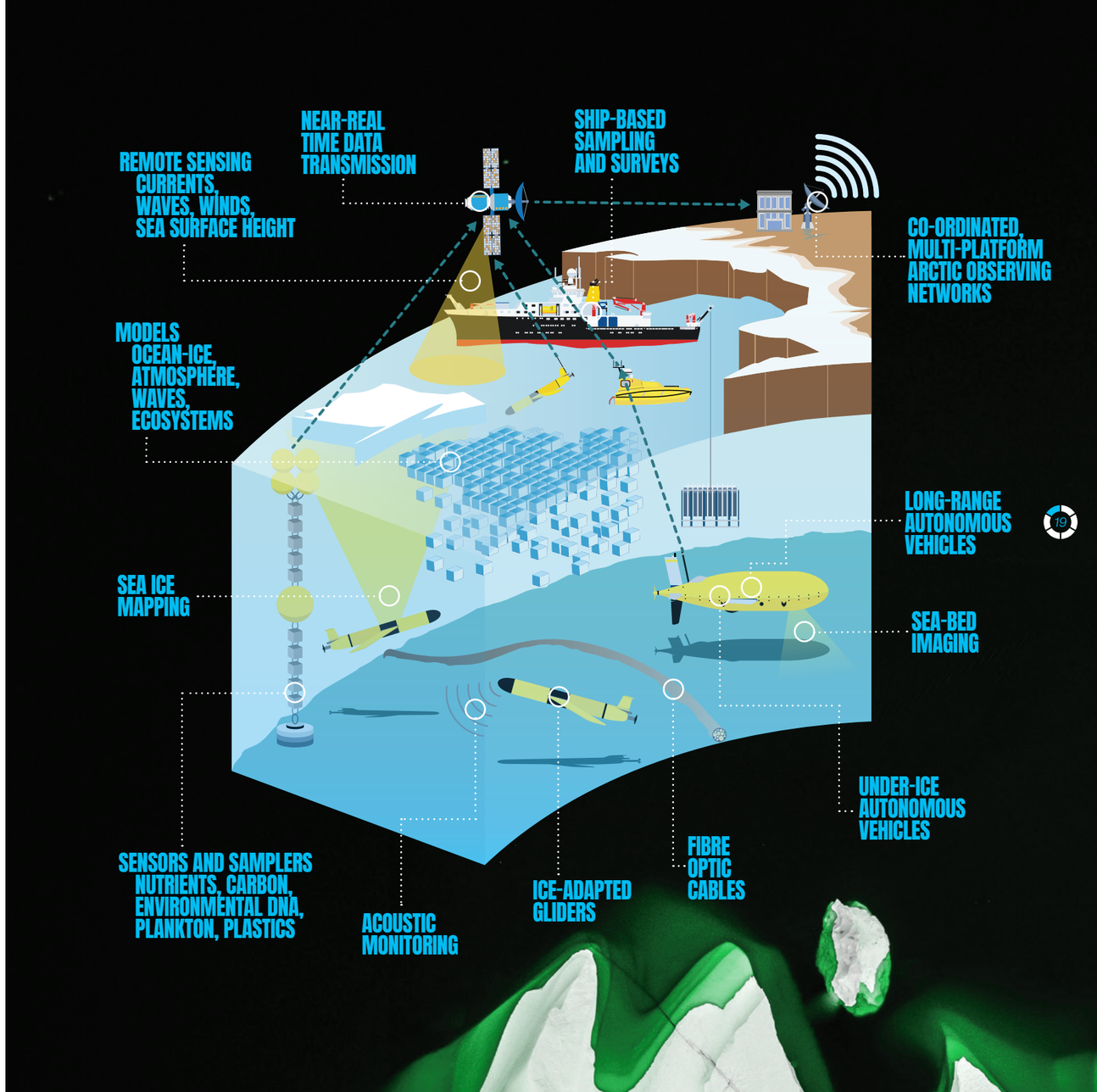
NOC develops next-generation sensors tailored for polar use, including miniaturised sensors for nutrients, pH, and carbonate chemistry, gases and environmental DNA samplers that can be deployed on moorings or carried by AUVs. Sensors for plankton species identification and understanding of how they function, and for measuring marine primary productivity are being developed. Alongside imaging and acoustic instruments, they enable high-resolution observations of Arctic biodiversity and ecosystems across multiple seasons.

OCEAN MODELLING

NOC develops suites of world-leading ocean-atmosphere -ice, wave and biogeochemical models, on local to global scales. They simulate present-day Arctic Ocean changes and make projections 10 to 100 years into the future, helping us understand how, where, why, and when the Arctic's Climate and Ecosystem are changing and what the impacts will be.

REMOTE SENSING

NOC pioneers the development and use of remote sensing, particularly altimetry, radar and drones from which high -resolution currents, wind fields, sea surface heights and even the shape and movement of the coastline can be mapped.



CALL TO ACTION AND PARTNERSHIP

The Arctic is one of the most rapidly changing environments on our planet. It is a sentinel of climate change. The opportunities and risks posed to climate, biodiversity, human wellbeing, marine-economies and geopolitical stability are global.

The National Oceanography Centre is a multi-disciplinary ocean science and technology institute with world-leading capabilities in ocean modelling and climate, biodiversity and ecosystems, marine geohazards, remote and in-situ sensors, marine autonomy and digital technologies.

We welcome partnerships and collaborations that will help us provide society with the knowledge and technology innovation needed to tackle Arctic change - protecting the environment through robust scientific evidence, working with Indigenous and local communities to build resilience, and supporting sustainable and responsible growth of the Arctic Ocean economy, while safeguarding essential marine ecosystem services

The 5th International Polar Year 2032/2033 provides a crucial and timely platform from which real progress in understanding and action can be made.

National Oceanography Centre

For collaborative opportunities, please contact NOC at;

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NOC.AC.UK/SCIENCE/ARCTIC-RESEARCH

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