Ocean Science and Ocean Worlds

Bringing together a new community of Earth, Ocean and Planetary scientists to explore how oceans function elsewhere in our Solar System and to provide fresh perspectives on how essential the oceans are to maintaining a healthy climate and sustaining life on our own planet.

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Network for Ocean Worlds

Abstract

Since the turn of the millennium, oceans have been demonstrated to be widespread throughout our solar system and to have the potential to reveal life beyond Earth within the lifetime of current human generations. These exciting, potentially civilization-changing discoveries come just as our own oceans reach a tipping point that threatens the health and welfare of society here on Earth.

But these two challenges are intimately related. How can we hope to characterize other oceans when we have not yet managed to provide baseline characterization of our own? One potential lies in a massive acceleration in the development and utilization of advanced robotic technologies that have the endurance to span entire ocean basins and to loiter in place for timescales of years or even decades, with improved *in situ* sensing capabilities to characterize the health and life-sustaining capabilities of those oceans, and to have sufficient on-board decision-making autonomy to "know" when and to what extent to request humans to "enter the loop" in decision making processes.

Blending space and ocean technologies in pursuit of this common goal offers a win-win outcome: for Ocean Sciences and for Ocean Worlds.

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Challenges addressed

Recruiting planetary scientists into ocean research brings a promise of fresh perspectives on urgent problems. In Challenge 7, for example, new studies of ocean tidal forces that drive fracturing of ice shells on Jupiter's moon Europa and Saturn's moon Enceladus are providing unique and timely insights into the break-up of the Antarctic ice-sheet.

Foremost, however, we believe that articulating the case for, and pursuing evidence that life could exist right here in our own solar system because of processes that are common to our own oceans, could have a transformative effect in raising the appreciation, across all of society, in the multiple values and services that the oceans bring to human well-being.

This project would seek to answer the profound question "are we alone" through an aspirational program that simultaneously advances the case for a massive advancement in our capability and motivation to understand and cherish our own oceans.

Challenge 7: *Ensure a sustainable ocean observing system across all ocean basins that delivers accessible, timely, and actionable data and information to all users.*
Challenge 10: *Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behavior change required for a step change in humanity's relationship with the ocean.*

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Vision & transformative impact

There is perhaps no greater question that has persisted throughout human culture, in all nations and all philosophies, than whether we are alone in the Universe. The discovery in the past two decades of ocean worlds in our own solar system, some with rocky seafloors and even evidence for hot-springs akin to those on our own planet, has been revolutionary. We now sit on the brink of a first opportunity to search, meaningfully, for extant life (which would most probably represent a second origin of life) right here in our own solar system: much closer to home than our farthest travelling spacecraft have already reached.

That such is the stuff of modern planetary science rather than science fiction is because of knowledge already gained in the study of Earth's oceans. But there is so much more to discover here on Earth and time is pressing if we are to achieve a more perfect baseline understanding before the system is irrecoverably perturbed. This project seeks to pursue a significant acceleration in investments in technologies to study ocean worlds to the benefit of Earth as well as elsewhere.

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Connections inside and outside of traditional ocean science

The US is at the cutting edge in developing ocean technologies that can work in extreme environments. While other important nations are also engaged in such ocean research, the US is currently leading the international stage in drawing ocean and space research together even as other nations in Asia (e.g. Japan) and Europe (e.g. Germany) begin to recognize the importance of this joined-up approach for studying Ocean Worlds. The implications of this project extend well beyond national boundaries and, as such, so would its capacity to access infrastructure and partnerships much greater than any single organization—from oceanographic ships to ice-stations, from satellites to seafloor installations and, like the oceans themselves, connecting multiple nations together. Within the US, major Federal Agencies already engaged in this work include NASA Planetary Sciences, NASA Earth Sciences, NSF Office of Polar Programs, NSF Division of Ocean Sciences and NOAA Office of Ocean Exploration and Research.

The most obvious scientific/technological sector engaged in this work outside of traditional ocean sciences is NASA. While NASA's Earth Science Directorate has always included studies of the Oceans, the emerging field of ocean worlds research is also attracting support from NASA-ESD's cryosphere program, from NASA's Planetary Sciences Division and NASA’s Astrobiology program. The same is being reflected internationally, including in Germany where the Federal Aerospace Center (DLR) has already been engaging with marine scientists in their ROBEX (Robotics for Extreme Environments) program joint with the Alfred Wegener Institute and in Japan where JAXA and JAMSTEC have begun pursuing similar activities.

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Create opportunities for collaboration and capacity-building

We do not yet know what all the most interesting processes active in Earth's oceans are nor where they are to be located—during the careers of the most senior current generation of researchers, rates of discovery have continued unabated and the impetus for continuing exploration remains undiminished. While there is much left to discover, the least explored areas are in international waters furthest from the most established ocean research nations of the past century. The opportunities for expanded and meaningful international participation are profound and the approaches required to achieve that should break free of historic models.

Preparing for the study of ocean worlds will require a drive to smaller and more effective robotic systems and a corresponding drive away from a dependency on large ocean-going vessels. It will also require a drive toward more expendable technologies that can be generated in large numbers which, at scale, will drive down unit costs and render state-of-the-art capacity in ocean sciences more readily affordable to a broader range of ocean nations and a greater diversity of communities. The concept proposed here, implemented at the scale of entire ocean basins, would contribute significantly toward the democratization of ocean science.

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Collaborators

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