The Ocean Worlds Working Group

Linking ocean world science to technology development

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What is the OWWG and what is its goal?

- The OWWG is a cross-AG working group chartered by OPAG, SBAG, and NOW to “create an actionable Ocean Worlds exploration strategy”.

- From *Origins, Worlds, and Life* (p. 568):
  - “Recommendation: NASA should develop scientific exploration strategies, as it has for Mars, in areas of broad scientific importance, for example, Venus and ocean worlds that have an increasing number of U.S. missions and international collaboration opportunities.”
- From *NASA’s 90-Day Response to the 2023-2033 Decadal Survey* (p. 20):
  - “Response: NASA does not concur with this recommendation and asserts that specific scientific exploration strategies should be community-generated by bodies such as the Analysis Groups, advisory committees, and NASEM’s standing boards and commissioned studies.”

Driving Science Questions* for Ocean Worlds Exploration:

**Preliminary wording*

1. Which outer solar system bodies contain liquid water in their interior?

2. How do Ocean Worlds form and evolve over time?

3. Do Ocean Worlds have past or present environments suitable for life? Which Ocean Worlds are habitable?

4. Does past or present life exist on Ocean Worlds?

1. Do water oceans exist in the interiors of outer solar system bodies?
    - Reveal the interior structure of ocean worlds
    - Explore the atmospheres, exospheres, and toruses of ocean worlds
    - Investigate the surfaces of ocean worlds

2. How do ocean worlds form and evolve?
    - Understand how giant planet and satellite formation occurs. Understand how KBOs form
    - Determine the composition of the primordial material (source regions) that formed ocean worlds, the bulk composition of ocean worlds today
    - Determine the sources and magnitude of heat and energy within ocean worlds, and how Heat/energy is transport through ocean worlds
    - Characterize how the physical and chemical structure of ocean worlds has changed through time
    - Investigate how the presence and characteristics of the ocean are expressed on the surface of ocean worlds

3. Do ocean worlds have past or present environments suitable to life?
    - Determine the chemical properties of the ocean
    - Determine the physical properties of the ocean
    - Determine the chemical sources and sinks in the ocean (chemical gradients)
    - Properties of near-surface liquids (brine pockets)

4. Does past or present life exist on this ocean world?
    - Search for possible biosignatures in plumes
    - Search for biosignatures on the surface
    - Search for past or present life at the ice-ocean interface
    - Search for past or present life at the seafloor

Linking the OWWG to the Decadal Survey

Investigate how the presence and characteristics of the ocean are expressed on the surface of ocean worlds	Q5.3 How have surface/near-surface characteristics and compositions of solid bodies been modified by, and recorded, interior processes?
	Q5.3a What Internal Processes Control Surface Topography and Produce Tectonic Features?
	Q8.2c What Is the Expression of Tectonic Activity on Planetary Satellites, and Why Is It So Varied Between Circumplanetary Systems?
	Q8.2e What Causes Plumes, (Cryo)Volcanism, Hydrothermal Activity, and Magmatism in Planetary Satellites?
	Q5.3b What Controls (Cryo)Volcanic Eruptions on Bodies with Solid Surfaces, and How Does the Composition of Erupted Materials Vary?
	Q5.3c How Have Diverse (Cryo)Volcanic Processes Shaped Solid Body Surfaces, Physically and Chemically?
	Q5.3d Where and How Are Surfaces Modified by Hydrothermal/Geothermal Processes?
	Q5.6 What drives active processes occurring in the interiors and on the surfaces of solid bodies?
	Q5.6a Where and How Are Convection and/or Crustal Recycling Taking Place?
	Q5.6b Where and How Are Active Melt Generation, Outgassing and Plume/(Cryo)Volcanic Activity Taking Place, and What Melt and Gas Compositions Are Produced?
	Q5.6c Where and With What Intensity Are Tectonic Processes and Deformation Currently Occurring?

Linking Science and Technology Development

Example Traceability: Question 2 (Working Draft)

							Mission Architecture							Ocean Worlds											
Science Question	**Science Goal**	**Investigation**	**Measurements**	**Instrument**	**Instrument Tech Gap**	**Potential strategic approach to address instrument tech gap**	Flyby	Orbit	Lander	Rover	Melt Probe	Submarine	Sample Return	Europa	Enceladus	Titan	Triton	Ceres	Pluto	Uranian Satellites	Mid-sized Saturnian Sats	Ganymede/Callisto	Other KBOs	**Mission Tech Gap**	**Potential Strategic Approach to Address Mission Tech Gap**
2. How do ocean worlds form and evolve	Determine the sources and magnitude of heat and energy within ocean worlds, and how Heat/energy is transport through ocean worlds (geophysics)	Measure the current surface heat flux of known ocean worlds	Remote Sensing heat flow measurements via Microwave radiometry	Microwave radiometer	TRL level? Improvements relative to Juno		X	X						X	X	X	X	X	X	X	X	X	X	Power and accommodation of MWR	

Linking Science and Technology Development

Example Traceability: Question 4 (Working draft)

							Mission Architecture							Ocean Worlds											
Science Question	**Science Goal**	**Investigation**	**Measurements**	**Instrument**	**Instrument Tech Gap**	**Potential strategic approach to address instrument tech gap**	Flyby	Orbit	Lander	Rover	Melt Probe	Submarine	Sample Return	Europa	Enceladus	Titan	Triton	Ceres	Pluto	Uranian Satellites	Mid-sized Saturnian Sats	Ganymede/Callisto	Other KBOs	**Mission Tech Gap**	**Potential Strategic Approach to Address Mission Tech Gap**
4.Does past or present life exist on ocean worlds	Determine whether biosignatures are found in plume material	amino acid type and abundance	mass spectrometry on samples directly during the flyby process	mass spectrometer operated during fast flyby (3-7km/s): Impact Ionization Mass Spec (SUDA-like)	relevant limit of detection not demonstrated yet		X							X	X		X							sterile collection of milligram quantities of material from plumes, pre-processing and transfer to instruments	

Moving Forward

- OWWG Leads are finalizing the draft traceability
  - Fall 2024
- OWWG Leads are reaching out to community members for specific input
  - Winter 2025
- Preliminary draft traceability released to the community for comment
  - Spring 2025

Searching for a new Science Subgroup Co-Lead

Current Leads:

Science: Angela Marusiak, Misha Zolotov (outgoing)
Technology: Kate Craft, Peter Willis, Paula do Vale Pereira

Apply by December 15th

Apply at
https://docs.google.com/forms/d/e/1FAIpQLSclxY6hYGqElCbrvBNtldR3OcCokJ-N6NMlY719oSxohZFY1w/viewform

All are encouraged to apply regardless of institution and career stage.

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