

Ocean Worlds

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A Report from the National Geographic Ocean Worlds Exploration Meeting
Held on October 23, 2015 in Washington D.C.

Ocean Worlds

Science

- Ocean worlds are possibly the best place to search for extant life and a second, independent origin
- Comparative oceanography (e.g., Earth, Europa, Enceladus, Titan) will likely spark new discoveries and insights and inform our search for Earth-like worlds around other stars

Technology

- Convergence of launch vehicle, propulsion, landing, communication and instrumentation advances makes such missions possible with regularity and consistency of purpose
- Wide diversity of possible mission options: small, medium and large

Innate Public Interest

- Ocean worlds theme integrates Earth and Solar System exploration.
- Fundamental science and new vistas associated with such missions will attract significant public interest

It is surprising that there are no planned missions in NASA's planetary science portfolio to directly access the water in locales where we know it to exist

Ocean Worlds 2015: October 23rd @ NGS, DC

Goals:

1. Raise awareness about the exploration of ocean worlds (moons) in our solar system and the connection to the exploration of Earth's ocean.
2. Discuss current capabilities for the exploration of oceans on Earth and beyond.
3. Discuss converging science investigations, technologies and enabling capabilities ranging from launch vehicles to robotics and instrument payloads.
4. Identify potential studies for the next decadal survey and pathways for implementation.
5. Work to bridge the ocean exploration goals of agencies, institutes, and foundations.

Organized by R. Braun (GT), J. Lunine (Cornell), K. Hand and C. Sotin (JPL)

Ocean Worlds in the Timeframe of the Next Two Decades

- Approximately 50 scientists, engineers and policymakers gathered to discuss the common scientific objectives, technologies and capabilities of ocean world exploration.
- Five targeted sessions: Europa, Enceladus, Titan, Earth's Deep Ocean, Earth's sub-glacial lakes
- 5-10 min intro by discussion lead. Remaining time (15+ minutes) for discussion and brainstorming.
- Key questions to frame the discussion:
 - Twenty years from now, what science questions and missions should we be pursuing for each target and how do we get from here (2015) to there?
 - What ocean world missions should we position as input to the next decadal survey?
 - For each of the targets, are there key links back to the exploration of Earth's ocean and cryosphere?

Summary, Conclusions and Future Actions

- There is strong scientific motivation for exploration of the solar system's ocean worlds. This motivation includes **multiple science objectives with a central focus on the search for life and its origins**. Action: Develop a 3-5 page community-led science goals and objectives document. Led by K. Hand and J. Lunine.
 - Draft in work. Somewhat overtaken by OPAG plans (next presentation).
- **Mission formulation work is required** to understand the next two logical steps at each potential science target. Laying out these steps in the next year or two would significantly **help the community prepare for the next Decadal survey**. These concepts should consider approaches to maximize science/\$. Action: Work with NASA HQ to put in place study teams to formulate two mission concepts at Enceladus, Europa and Titan. Led by R. Braun.
 - Partially overtaken by NF announcement. Discussed further on slide 7.
- **Early investment is needed in life detection instrumentation and sample acquisition and processing systems**. Action: Develop roadmap and advocate for technology funding in these areas. Led by K. Hand.
 - In progress. Sampling system is focus of ongoing activities

Summary Conclusions and Future Actions

- There is considerable **synergy between the planetary and Earth ocean exploration communities**. Action: Develop a two-page white paper about what the search for life entails. Synthesize work on vent, ocean surface science and exploration and seek archival publication over the next year. Led by C. Sotin.
 - In work. Focus of Ocean Worlds 2016.
- **Creating a program** is about building a consensus around a series of interconnected missions with a common scientific theme and common goals. Life detection can be the primary science goal, but not the only goal. These are worlds, interesting in and of themselves. Emphasize the coupling to Earth ocean exploration. **A balanced approach among flagship, intermediate and small missions is possible. Cadence is crucial; we must increase the pace of outer planet exploration.** Heavy-lift launch vehicle capability and a number of technologies under development within the Space Technology Mission Directorate bring these missions within our grasp. Longer-term action: **Work with NASA HQ to develop Ocean Worlds exploration plan.**
 - In progress.

Ocean Worlds Missions Presently in Formulation

- Europa Flyby Mission (+Lander, Plume Probe?)
- ESA's JUICE Mission (Ganymede, Callisto, Europa)
- New Frontiers (now includes Titan, Enceladus)
- Triton?

- Given the recent additions to NF, is the community interested performing additional mission studies in preparation for the next Decadal. Possibilities include:
 - Discovery-class?
 - Farther-term (second logical step in sequence)?
 - Mission sequence?
 - Directed or competed studies?

Ocean Worlds 2016: Seafloor Cycling on Earth and Beyond

- August 25-26 at the Woods Hole Oceanographic Institute
- Please plan to attend