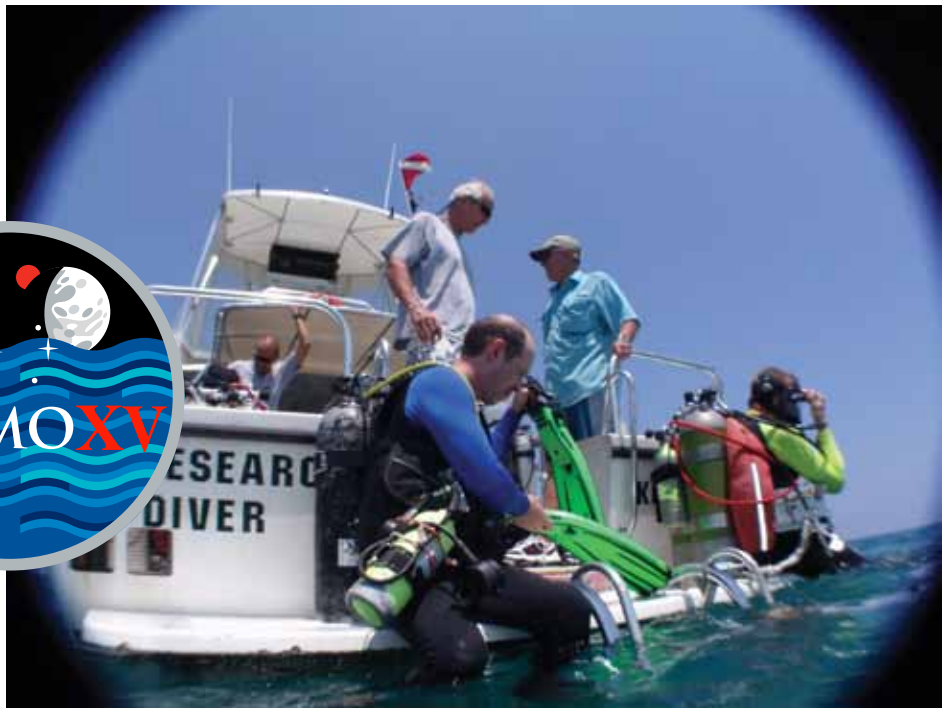
NASAfacts

# NASA Extreme Environment Mission Operations Project (NEEMO) 15




Space exploration presents many unique challenges to humans. In order to prepare astronauts for these extreme environments in space, NASA engineers and scientists use comparable environments on Earth. One of the most extreme environments is the ocean. Not only is the ocean a harsh and unpredictable environment, but it has many parallels to the challenges of living and working in space – particularly in destinations with little or no gravity, such as asteroids.

The NASA Extreme Environment Mission Operations project, known as NEEMO, sends groups of astronauts, engineers, doctors and professional divers to live in an underwater habitat for up to three weeks at a time. These crew members, called aquanauts, live in the world's only undersea laboratory, the Aquarius, located 3.5 miles off the coast of Key Largo, Fla.

Most underwater activities are accomplished by traditional scuba diving, but divers are limited to specific amounts of time because of the risk of decompression sickness (often called the "bends"). Based on the depth and the amount of time spent underwater, inert gases such as nitrogen will build up in the human body. If a diver ascends out of the water too quickly, the gases that were absorbed can create bubbles within the diver's body as the surrounding pressure reduces.

A technique known as saturation diving allows people to live and work underwater

for days or weeks at a time. After twenty four hours at any underwater depth, the human body becomes saturated with dissolved gas. Therefore, the diver can accurately predict exactly how much time is needed to decompress before returning to the surface, which limits the risk of decompression sickness. By living in the Aquarius habitat and working at the same depth on the ocean floor, NEEMO crews are able to remain underwater for the duration of their mission.

## Aquarius

Aquarius provides NASA a convincing analog for space exploration. Much like space, the undersea world is a hostile, alien place for humans to live. NEEMO crew members experience some of the same

tasks and challenges underwater that they would in space. For example, working in space and underwater environments requires extensive planning and sophisticated equipment. Working underwater also has a strong benefit to NASA because the aquanauts can be weighted to simulate different gravity environments.

Aquarius is owned by the National Oceanic and Atmospheric Administration (NOAA) and managed by the University of North Carolina at Wilmington (UNCW) via the NOAA Undersea Research Center (NURC) in Key Largo, Florida. The laboratory is located in the Florida Keys National Marine Sanctuary and is on the ocean floor next to deep coral reefs 62 feet below the surface.

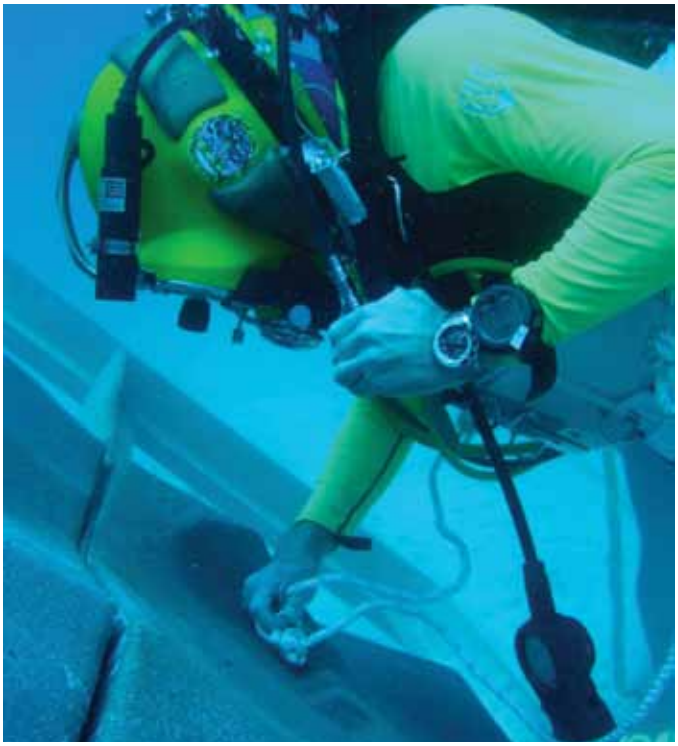
The Aquarius system has three elements: a life-support buoy at the surface, the habitat module and a base plate that secures the habitat to the ocean floor. The Aquarius habitat has about 400 square feet of living and laboratory space. This size is similar to that of the Zvezda Service Module of the International Space Station, which has served as the living quarters for Expedition crew members.

While underwater, NEEMO participants are able to simulate living on a spacecraft such as the International Space Station or to test extravehicular activities for future space missions. NASA sent its first set of NEEMO aquanauts to Aquarius in October 2001. There is always a NASA crew of four and two habtechs from UNCW on each mission.

## NEEMO 15 Mission:

### Life on an Asteroid

NASA is actively making plans to expand the horizons of exploration, and with the Space Launch System and Multi-Purpose Crew Vehicle, humans will soon have a



way to travel beyond low Earth orbit, to such distant destinations as the moon, Mars, Mars' moons and asteroids. Although many of the questions being asked as part of the NEEMO 15 mission will be applicable in any of those scenarios, the primary focus for 2011 is asteroid exploration.

Asteroid missions present a particular challenge. Unlike a planetary or lunar surface, asteroids have no gravity to anchor vehicles, astronauts and tools to the ground. In that way, a spacewalk on an asteroid is somewhat similar to a spacewalk at the International Space Station. But unlike the space station, the asteroid wasn't built

with an astronaut's convenience in mind: there will be no handholds spaced to correspond a spacewalker's reach, or existing interfaces to which foot restraints can be connected.

To work in such an environment, NASA will need to come up with innovative exploration techniques, and analog missions such as NEEMO 15 are the first step in doing so. Simulating a mission to an asteroid in a weightless underwater environment will help NASA understand the nuts and bolts of how to explore and live on an asteroid now, rather than waiting until the first asteroid landing – when to the lessons would be much more difficult and costly to learn – to try out the concepts.

**Spacewalk and Anchoring Operations:**

One of the first questions to be answered as NASA prepares to visit an asteroid is how to enable astronauts to explore an asteroid's surface. Without gravity to hold them on the surface, they will need to either anchor themselves to the surface or stay attached to their ship. Although NEEMO won't identify the type of anchor to eventually be used, it will allow engineers and scientists to evaluate various anchoring techniques and concepts for moving around on the asteroid, so that they can determine the operational implications of the different strategies. Ideas to be tested include an excursion line device, hand-over-hand tethers, a deployable boom and jet packs. The results of these tests, combined with information gathered during robotic precursor missions, will enable engineers to develop anchoring techniques and eventually lead to a solution for securely anchoring to an asteroid.

**Communications**

Whether traveling to an asteroid or to Mars, as human exploration moves farther from Earth, the communication between the astronauts and their support back home will have to change. Thus far, being only a matter of days, at most, from the Earth, astronauts have only had to wait fractions of a second to receive the messages sent up to them from Mission Control. When the travel time increases to weeks and months, the travel time for data and voice messages will also increase to seconds or even minutes. The NEEMO 15 aquanauts and their support team will experience what the impacts of such a delay will be by incorporating a 50-second delay in communications to and from Mission Control. A behavioral health and performance study will examine the impacts of communication delays on the crew's performance. Results will be used to develop procedures for a future communications delay test on the International Space Station.

**Habitability**

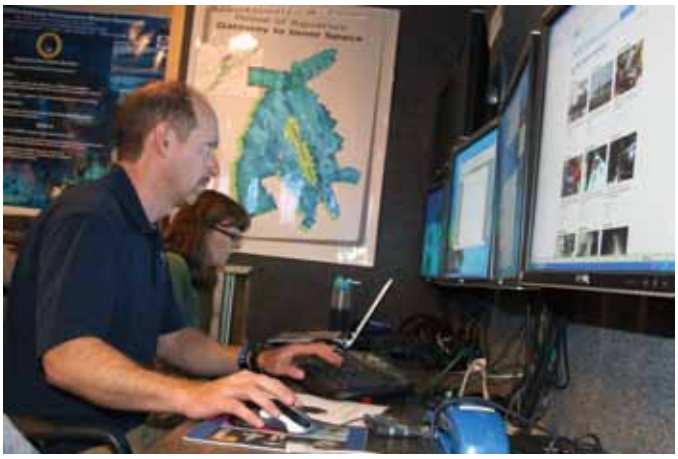
For future exploration missions, astronauts will be required to travel long distances in cramped quarters. Inside Aquarius, the isolation, confined space, harsh environment and reduced gravity (on spacewalks) will challenge aquanauts to perform mission operations in extremely formidable conditions – conditions similar to what they would experience on the journey to an asteroid or other distant destination. A space human factors engineering study will work to develop a tool to assess human factors and habitability.

**Science Collection**

Asteroids are the left over building blocks of the solar system; they represent and record material from the earliest times of the solar system's formation. Getting a closer look at those building blocks is one of the main reasons for visiting an asteroid. As such, the astronauts who make the trip will need to know how to collect data and samples on behalf of the eager scientists back on Earth. And the methods they'll use will be similar to how marine biologist collect data from coral reefs such as those near Aquarius. By practicing on the reefs, NASA science teams will learn from the different data collection and sampling techniques and will use the information to develop future methods to be used on asteroids.

## NEEMO Teams and Key Personnel

In addition to the participants in NEEMO saturation dives, teams of technicians and scientists work above the surface. They monitor Aquarius' systems and stay in contact with the underwater crew.



## Surface Support Team

The Surface Support Team includes the NEEMO project lead, the mission lead, and the dive medical officer and support personnel. This team resides at the National Undersea Research Center, or NURC, during the mission and training. Overall responsibility and authority for NASA objectives during NASA missions resides with the NEEMO mission lead on this team.

## Aquanaut Crew

This team consists of the three aquanaut personnel from NASA, the Japan Aerospace Exploration Agency and the Canadian Space Agency that go into "saturation," living aboard Aquarius for the duration of the dive.

## DeepWorker Submersible Pilots

Although they won't be living underwater with the rest of the crew, three NASA astronauts will also participate in the NEEMO 15 mission from below the surface. They'll be piloting the DeepWorker submersible, a small submarine that will stand in as an underwater version of the Space Exploration Vehicle, which might someday be used to explore the surface of an asteroid.

## Habtechs

Three NURC employee/aquanauts accompany the NEEMO crew into saturation. Their primary responsibilities are the operation of the Aquarius on-board systems and the safety of the aquanauts.

## Watch Desk

The watch desk is the NURC version of NASA's Mission Control Center. It is located onshore and is staffed by a team of two employees 24 hours a day during the mission. Watch desk personnel are primarily responsible for the overall safety of the mission, monitoring the telemetry of the facility and approving all of the aquanaut dive plans. The watch desk lead is the ultimate authority on safety issues such as storm evacuation, medical emergencies, habitat system contingencies and dive plan approval.

## Principal Investigators

These individuals are responsible for developing much of the science conducted by the aquanauts. They monitor the mission from a remote control center or in some instances from the NURC facilities. They periodically interface with the crew real-time during the mission to facilitate the science needs.

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