

Aquarius User Manual

Welcome to the Aquarius underwater habitat. Below is information that all aquanauts must read. It is the basic manual for scientists who use the facility. We provide it here as a reference for others to look at, but in no way is it to be used by any facility as the basis for training material. It is for reference only.

Introduction

You are about to embark on a unique journey. A research proposal of high scientific merit and relevance was your ticket. Your Aquarius experience will include adventure — in the classic expedition mode. You will experience the ocean as few people ever have. Your daily work routine will include underwater excursions measured in hours, instead of minutes. Inside Aquarius you will live in close but comfortable quarters, and you will have work space and electronic capabilities similar to any university lab bench. Your home for ten days is part of the reef itself, with substantial growth on its outer skin and incredible numbers of fishes that hover around all sides. After ten days underwater your return to the surface will provide contrast and perspective that may forever change your view of the ocean and our planet.

Aquarius is the latest, and only remaining, underwater laboratory dedicated to research, in a long line of underwater living environments that date from the 1960s. Good science, conscientious administration, and a sound safety culture characterize the program. We hope that you will find this manual, compiled to provide you with information on all aspects of conducting scientific research from the Aquarius undersea research laboratory, helpful as you prepare for your mission. The manual is organized to match the sequence of events that make up a mission, from preparations and training, through mission operations, to decompression, and end-of-mission activities.

The Aquarius Reef Base is owned and operated by [Florida International University \(FIU\)](#). We take great pride in what we do and we hope that you will come away from this experience impressed with the amount of work you accomplished and the benefits of undersea living.

Situation and Need

In 1991, the Aquarius Program expanded its Florida science program in response to widespread concern about the health of nearshore ecosystems in the Florida Keys, especially coral reefs. Scientists and resource managers were unwavering in their call for information to better understand and protect this economically significant national treasure. Surprisingly, prior to 1990 few data existed to describe the condition of nearshore ecosystems in the Florida Keys. Scientists were unable to explain the causes of widespread coral bleaching, increases in the distribution and abundance of coral diseases, and epidemic regional die-offs of sea urchins. Even the most basic descriptive baseline information was missing, both for benthic communities and related to water quality.

From the beginning, the Aquarius Program worked closely with the Florida Keys National Marine Sanctuary Program to support research to help meet relevant science and management needs. Examples of projects supported by Aquarius that are useful to management of the

sanctuary include, long-term benthic and physical oceanographic monitoring, evaluation of fisheries and proposed replenishment zones, documentation of water quality and nutrient pollution, coral recruitment and coral feeding studies, coral disease distribution and abundance research, coral bleaching studies, and geological investigations to document reef growth and history to better interpret the kinds of changes observed today. The Florida Keys research program provides state-of-the-art diving technology (including manned submersibles, ROVs, nitrox and air diving, and the Aquarius undersea laboratory), boats, and shore-based support. Over 200 research projects were conducted between 1991 and 2002.

Aquarius provides scientists with state-of-the-art diving technology and advanced undersea capabilities. Aquarius is especially valuable to researchers in the Florida Keys because an extensive amount of living coral reef resource lies in water too deep to be reached by conventional surface-based diving methods. And if you want to study coral reefs you need to work underwater. Working from Aquarius, scientists have up to nine hours per day of bottom time to conduct their studies. They also have access to a world-class underwater laboratory from which to set up and monitor sophisticated research projects. Aquarius provides a vehicle to conduct underwater research that could not be accomplished any other way.

Significant discoveries from Aquarius missions include: ultraviolet radiation as damaging to coral reef environments; factors that affect water quality and pollution in the Florida Keys National Marine Sanctuary; biology of how corals feed, which is important for understanding coral bleaching, disease epidemics, and water quality; explanations from fossil reefs of difficult-to-explain long-term events such as disease epidemics and global climate change that reshape the way reefs look and function; long-term studies of coral reef change; dynamics of sponge growth; seaweed population biology and physiology; and chemicals produced by marine organisms that affect the distribution and abundance of those organisms and that also have pharmacological potential. Aquarius has revolutionized the way scientists work in the sea, and Aquarius scientists are reshaping the way we think about coral reefs and our oceans.

Description of the Research Site

Aquarius is located at Conch Reef approximately nine miles south of Key Largo, in the Florida Keys. Aquarius is located in a sand patch approximately 63 feet deep that is surrounded by spur and groove coral formations. Conch Reef is loosely described as a bank reef, with a shallow platform inshore and several deep reef formations found to depths of approximately 115 feet. The seaward spur and groove formations are located a relatively long distance from the shallow reef flats and appear to be antecedent formations with thin Holocene coral cover. A high-resolution bathymetric map of the site is available. A good general description of reefs in Florida was compiled by Jaap (1984) and geological considerations are available in Shinn et al. (1989). Aronson et al. (1994) provides benthic community descriptions of Conch Reef and other sites in the upper Keys. A summary of research supported by the Center in Florida is available.

The fragility of the reef is a major consideration at the research site. Great care is taken to conduct research from Aquarius in ways that help conserve the environment for long-term science use. The site is identified in the Florida Keys National Marine Sanctuary Management Plan as a Research Only Area. While specimen collecting and manipulative experiments are not discouraged, we work with scientists to minimize environmental impacts. Research permits are required and we work to facilitate the permitting process with each investigator.

Fauna

Species lists for scleractinians, gorgonians, sponges, and fishes at Conch Reef are available. Long-term benthic monitoring stations were established in 1994 at 30, 60, 90, and 105 foot depths. The monitoring stations were resampled in 1998 and 2000.

Meteorology / Oceanography

Meteorological and oceanographic data are available for Conch Reef. Meteorological data are collected from the tower at Molasses Reef and are telemetered via satellite to NOAA's National Data Buoy Center (NDBC) on an hourly basis. Hourly weather and oceanographic data at Molasses Reef is available.

The Aquarius Research Team

In the history of underwater habitats only a small subset of scientists who dive have ever achieved aquanaut designation by living and working underwater for more than 24 hours. A key element in the success of any mission is advance planning. There are also chain-of-command protocols we follow that help prevent misunderstanding or miscommunication. The opportunity for others to follow in your footsteps depends on your success and achievement of a safe and productive mission. This manual is not meant as the definitive statement about protocols for Aquarius diving, but it will give you an idea of what to expect when you arrive in Islamorada for your mission. It is the field training, and your seriousness to tasks at hand, which will ultimately prepare you for a safe journey.

Aquarius houses a team of six that includes four scientists and two center staff onboard technicians. The Principal Investigator (PI) has overall responsibility for coordination and supervision of the research effort. The primary contact for the PI prior to the saturation mission is the Aquarius Director of Operations. If the PI does not saturate during the mission, an Aquanaut Team Leader is selected by the PI from the aquanaut research team. The Aquanaut Team Leader is always a senior-level scientist. However, the PI is ultimately responsible for the conduct of the entire scientific crew.

The Onboard Technicians are from our staff and they saturate with the research team. The Onboard Technicians primary tasks involve monitoring and maintaining all on-board Aquarius systems. The technicians also help the science team prepare for excursions.

Aquarius missions usually include surface-based support divers. Surface-support divers, called Scientific Divers by the program, are often exposed to more physical exertion and sometimes require greater watermanship skills than aquanauts. Criteria for selection of a surface-support team includes good diving skills, ability to work independently, responsibility, and thorough knowledge of the overall mission objectives. A Topside Scientific Team Leader is responsible for coordination and communication with the aquanauts and our staff to ensure smooth operations.

Pre-mission Planning and Coordination

When a mission is approved and scheduled, the Aquarius Director of Operations contacts the Principal Investigator to begin mission planning. This is when equipment needs, and special logistics of the project are discussed.

The Aquarius Operations Director reviews the entire Mission Plan with the Principle Investigator prior to saturation. The review includes general dive plans for each day and overall objectives. All research equipment and supplies are checked for possible safety hazards. Electronic, Marine, and Dive Technicians are available to assist with equipment deployment and testing prior to start of the mission. Principal Investigators are encouraged to work with Aquarius staff far in advance of their mission to help ensure smooth operations once they arrive in Islamorada.

This is particularly important when plans include underwater use of electronics and computers. Our staff have extensive experience with complicated equipment designed to work underwater. In many ways, they have seen it all and can usually provide significant contributions as you develop and build your experimental gear.

Qualifications

All medical forms and other paperwork are provided to the Principle Investigator well before the mission. Completed medical forms should be returned to the Aquarius Operations Director at least two months prior to the start of the mission for review and to check for completeness. Prerequisites to training for an Aquarius mission are what you would expect for any extended diving program, and include:

- SCUBA certification by a nationally recognized sport diving agency, NOAA, or military equivalent;
- A minimum of 50 logged SCUBA dives to similar depths at which your planned research will be conducted are recommended (permission to waive this requirement under exceptional circumstances must be approved by the Aquarius Operations Director); and
- Successfully passing a AAUS Medical Examination.
- Successful completion of Aquarius Aquanaut Training and sign-off by the Aquarius Director of Operations.

There is also paperwork to be completed prior to your arrival in Islamorada. Aquanauts and surface support divers provide their own personal dive equipment, including mask, snorkel, fins, wet suit boots, watch, dive knife and wet suit. Aquanauts are strongly encouraged to wear “dive skins” under their wet suits to minimize skin abrasions and for added warmth. The program provides buoyancy compensators, tanks, weights, regulators, and other specialized equipment. A pre-saturation medical exam is performed by the Diving Medical Officer and Lead Diver Medical Technician for each Aquanaut candidate during training to determine final fitness for participation in the mission.

Training

Aquanaut training consists of briefings, pool training, open water training, and orientation dives to the reef area and Aquarius. Topside science staff, who dive, participate in certain briefings. You must show evidence of good watermanship during pool and open water training and

demonstrate a safe attitude to qualify for participation in the program.

Several aquanaut briefings are presented that include information about equipment, dive protocols, and Aquarius. During training, safety is emphasized and aquanaut candidates are familiarized with the special requirements of saturation diving. Open water orientation dives take place that allow aquanauts to become familiar with equipment and work sites located around Aquarius. A big difference between saturation diving and surface-based diving is that in saturation diving the surface is not an option — if you have a problem you will need to solve it on the bottom. Questions are encouraged during all aspects of training.

Aquarius Dive Training Schedule: Day One

- 08:30AM: Introduction Briefing
- 09:00AM: Swim Evaluation (pool / offshore)
 - 400 yards free style (no fins, no snorkel): finish in less than 12 minutes
 - 10-minute tread (no fins, no mask)
 - Underwater Swim Evaluation: one breath 25 yds
 - Ditch / Don mask and snorkel and clear (pool)
 - Rescue breathing practice
- 10:00AM: Dive Equipment Briefing
 - Equipment / Configuration Briefing
 - Harness Adjustment
 - Source Drill
 - Shut Down Drill
 - Safety (S) Drill
 - Air Sharing / Buddy Breathing Briefing
 - Buddy Awareness Briefing
- 12:00PM: Habitat Site (Conch Reef) Orientation Briefing
 - Dive #1 Checkout Dive (Fuel Mooring at 45 ft./45 min.)
 - S-Drills
 - Buoyancy Control
 - Mask Clearing (partial and total removal)
 - Regulator Clearing
 - Regulator Retrieval
 - Buddy Breathing (stationary)
 - Air Sharing (stationary)
 - Buddy Breathing (swimming)
 - Air Sharing (swimming)
 - Shut Down Drills (x 2)

Aquarius Dive Training Schedule: Day Two

- 08:00AM: Safety and Procedures Briefing
- 09:00AM: Excursion Emergency Procedures Briefing
- 10:00AM: Dive Equipment Briefing
 - Add 2 reels to gear (1 primary, 1 safety)

- Night Dive Briefing
- Excursion/Boundary Line Orientation
- Line Exercise #1 (Parking Lot)
- Line Exercise #2 (Parking Lot)
- Compass Navigation Exercise (Parking Lot)
- 13:00PM: Dive #2 (Fuel Mooring Site 50 ft./45 min.)
 - S-Drills
 - Line Exercise #1 (tie-off, running, placement, secondary tie-off, search, return) Shut Down Drills (mask off)
- 14:00PM: Dive #3 (Conch Reef / Fuel Mooring 50 ft./45 min.)
 - S-Drills
 - Line Exercise #2 (directional line exercise with eyes closed, mask off) Shut Down Drills (mask off)
- 18:00PM: Fill tanks and rinse gear.

Aquarius Dive Training Schedule: Day Three

- 08:00AM: Food/Provisioning Briefing
- 08:15AM: Potting Briefing
- 08:30AM: Camera/Video Housing Briefing — Effects of pressure differential
- 09:00AM: Dive Equipment Briefing
 - Add 1 pouch to gear (contains 1 primary light, 1 secondary light, strobe, sausage buoy)
 - Sausage Buoy Deployment Briefing
 - VHF Briefing (exercise/comm. check)
- 12:00PM: Dive #4 (Fuel Mooring Site 50 ft./45 min.)
 - S-Drills
 - Lost Line Exercise (mask off)
 - Shut Down Drills (mask off)
 - Diver Rescue On Surface (airway, rescue breathing)
- 13:00PM: Dive #5 (Fuel Mooring Site 50 ft. / 45 min.)
 - S-Drills
 - Deploy Sausage Buoy (x2)
 - Shut Down Drills (mask off)
- 15:00PM: Fill tanks and rinse gear
- 16:00PM: Shopping at Publix

Aquarius Dive Training Schedule: Day Four

- 08:00AM: Aquarius Orientation Briefing
- 09:00AM: Aquarius Emergency Procedures Briefing
- 10:00AM: Dive Equipment Briefing
 - Add 1 VHF Canister to gear (contains canister and VHF handheld radio)
 - Fill Panel Orientation
- 12:00PM: Dive #6 (Pinnacle Site or NE Site 60 ft./50 min.)
 - S-Drills
 - Site Orientation

- Fill tanks and test communications at Site fill station
 - Swimming Air Sharing from site to Habitat (mask off)
- 13:00PM: Dive #7 (Aquarius Habitat Orientation)
 - S-Drills
 - Habitat Orientation
 - Aquarius Emergency Procedures and Lockout/Ascent Briefings
 - Habitat Exterior Orientation
- 15:00PM: Physical Review
- 16:00PM: Excursion Tables
- 17:00PM: Chamber Briefing
- 17:30PM: What if Review
- 18:30PM: Fill tanks and rinse gear

Aquarius Dive Training Schedule: Day Five

- 08:00AM: Science Briefing
- 10:00AM: Dive #8 (Optional) Equipment and Situation dependent - Reserved for missed exercises (bad weather day) and or training for specialized gear, such as Aga masks and Hooka rigs.

Important Instructions

Do not plan science activity during training. Rather, schedule your research with sufficient time in advance of your mission to test equipment, conduct preliminary studies, or prepare field sites. If you don't plan to use tethered diving, day four of training includes time for equipment deployment and tests. However, day four is also set aside for make-up if any orientation dives are missed due to weather.

The use of the tethered diving system requires a special training session and an open water qualification dive.

Aquarius Scientific Support Systems

The FIU Medina Aquarius Program does not provide surface or underwater photographic equipment. Aquanauts must bring their own cameras and strobes. Aquarius staff will provide briefings and instructions on protocols for use of cameras and video systems out of Aquarius.

Aquanauts should bring their own personal computers for use in Aquarius, provided that they are LCD equipped. No CRTs are allowed in Aquarius. Questions related to data acquisition and storage should be handled far in advance of your arrival to Islamorada.

Mission Safety

The operational phase of this program is conducted in accordance with the FIU Diving Operations Manual and the Habitat Operating and Procedures Manual. The Aquarius Director of Operations, Mr. Roger Garcia has overall responsibility for mission operations. **SAFETY IS PARAMOUNT IN ALL OPERATIONS.**

The undersea environment presents some element of risk. Most accidents, however, are preventable by using well–designed and properly maintained equipment, thoughtful prior planning, and careful mission execution. Caution and common sense must be exercised at all times. It is expected that all persons will follow accepted safety practices while engaged in any activity. A few moments spent to get the correct tool, or to put on a piece of protective gear might prevent an injury that cancels an entire research effort.

It is the intention of the FIU Medina Aquarius Program to limit activities as little as possible within the constraints of sound safety practices. In all cases, however, safety is our first consideration. Many procedures are based on diving regulations and are not negotiable.

The following rules are in effect at all times:

- No deviations from procedures outlined in the aquanaut training and the Aquarius Operations Manual.
- No medications are to be taken by the aquanauts without prior approval of the Aquarius Diving Medical Officer.
- No smoking or open flames are permitted in Aquarius.
- Mission Control must be informed whenever an aquanaut leaves Aquarius, regardless of the purpose or expected duration.
- All equipment malfunctions are reported to the Watch Desk immediately.
- All medical problems are reported to the Watch Desk immediately.
- No alcoholic beverages or “social” drugs are allowed.

Sea Conditions

Sea conditions that can affect operations include: sea state, water visibility, currents, and the presence of hazardous marine life. The Shift Duty Officer has final say with regard to safe operating conditions. As a general guideline, the maximum sea state should not exceed six to eight feet, and currents should not exceed one knot. Diving in conditions of reduced visibility take place only if aquanauts can maintain buddy contact, orientation to Aquarius or way stations, or positive contact with navigation lines during the entire dive. Sometimes, sea conditions that limit surface–based operations do not affect tethered diving operations from Aquarius.

Weather Considerations

Mission Control monitors the NOAA Marine Weather Broadcasts on a daily basis, records the forecast in the mission log book, and alerts the Aquarius Operations Director of any threatening weather. Aquarius is designed to operate under severe weather conditions. The primary factor that limits operations is the ability to provide safe topside emergency support. The Aquarius Operations Director may delay, curtail diving activities, or terminate a mission because of weather. In some instances, termination of a mission will be done on the basis of weather forecasts rather than actual conditions.

Hours of Operation

Hours of operation are detailed in the Diving Operations and Procedures Manual. All staff and all topside scientists who participate in diving are required to get a minimum of eight continuous

hours of sleep each day. In general, staff are scheduled for no more than twelve hours of continuous duty during any 24-hour period. Aquanauts should be diligent about getting adequate rest and sufficient sleep each day to avoid fatigue, which could lead to more serious problems.

Aquarius Saturation Diving Procedures

Divers from Aquarius must always know their location, tank pressures, and excursion time limits. Solid “buddy” skills are essential to safe diving from Aquarius. As in conventional SCUBA diving, many problems are prevented by adequate planning. Careful execution of the dive plan and modifications to the plan in response to changing underwater conditions, such as an increase in current speed or a drop in visibility, will prevent buddy separation, lost divers, and low air situations.

Generally speaking:

- be conservative;
- pay attention;
- maintain good buddy contact; and
- stay oriented with on–bottom navigation lines and landmarks

All dives are planned and reported to the Watch Desk using the Dive Plan Work Sheet. Information includes: names of the aquanaut teams, planned times out, destination, depth, route, expected times of return, air requirements, and any additional scientific or support materials required at work sites, such as cameras, lights, or scientific gear.

General Considerations for Planned Excursions

- For all dives, bottom time is measured as time of departure from storage depth (or hatch depth of Aquarius) to return to storage depth;
- It is advisable to make deep excursions first, and shallower excursions later;
- Dive plans must be relayed to the Watch Desk on the evening prior to the planned excursion;
- Aquanauts may not leave sight of the excursion navigation lines without the use of a reel line;
- During periods of high current, aquanauts should be extremely careful to insure an adequate air supply for return to Aquarius;
- If symptoms of any kind develop during an excursion, aquanauts return immediately to Aquarius, lie at rest, and report the incident to the on-board technician, who will notify the Watch Desk.

A typical dive day (at 95 ft or less) usually includes a three to six hour dive (maximum) in the morning to early afternoon, followed by an interval in Aquarius (four hours are required to obtain maximum bottom time on the second dive), followed by a second dive of up to three hours. Each mission usually has unique requirements related to the science conducted and the PI is encouraged to work with the Aquarius Operations Director to ensure that sufficient dive time is available to accomplish the mission goals. Diving is allowed throughout the day and night and is limited only by the dive tables. Additional dive time is available by working at hatch–depth around Aquarius. Placement of equipment at hatch–depth adjacent to Aquarius provides easy 24-hour access.

Normal Decompression Procedures

Decompression takes place in Aquarius and consists of slowly reducing the interior Aquarius pressure over a period of approximately 17 hours, until surface pressure is reached. Aquanauts then move to the Entry Lock and are quickly recompressed to ambient water pressure. Aquanauts exit Aquarius, by way of the Wet Porch where they are escorted to the surface by staff. All of the Aquarius systems are operational during decompression, except the toilet in the Entry Lock, which can be used in the normal fashion until compartment pressure is reduced to a 5-foot depth. On the next to the last day of the mission, the Aquarius Operations Director contacts the Onboard Technicians and Principal Investigator to review the tasks to be performed prior to decompression.

These procedures include:

- A review of the schedule. No excursions are allowed below 95 feet or for longer than two hours after 2200 on the next to last day of the mission. Aquanauts return to storage depth by 1000 on their last work day. Aquanauts are restricted to Aquarius by 1200 on the last day of saturation.
- Final dives include packing up deployed equipment and carefully checking reef areas for equipment or debris left behind. The surface team can assist with site clean-up.
- A pre-decompression medical check and briefing is scheduled for 1300 on the last day of saturation, one hour before decompression begins.

End of Mission

After decompression, aquanauts are transferred to shore to complete a twelve hour post-saturation observation period. Aquanauts refrain from stressful activities such as running or taking hot showers. No vigorous activity is allowed. Aquanauts may not fly for 48 hours after surfacing from saturation. Before leaving Islamorada, the PI must submit a Project Summary Report to the Aquarius Operations Director.

Final Comments

The legacy of our program will be written based upon the skill, hard work, and dedication of its participants. We hope that the program operates for many years in the Florida Keys and beyond, where each operating site is used to establish a coral reef superstation for researchers. We encourage you to tell others about what you did and what you saw. It is not sufficient that your Aquarius experience be only a personal or professional benchmark in your career. We hope that you will use your Aquarius experience as a vehicle to express your feelings about the ocean and the value of your science, and to explain and justify your work in public forums.

We believe that the FIU Medina Aquarius Program helps scientists advance their research in significant ways, it should also be used to help capture the imagination of our nation about the value and wonders of the underwater realm. After your mission, please pause to think about what you did in larger terms. One of our products is related to education, however, not as you might expect. We invested in you, the scientist, and the results of your time and effort in terms of developing your expertise is as much an educational product as any other. Taxpayers pay for your education, they deserve to hear about how and why their money was spent. This could mean writing about your work for a local newspaper or favorite magazine, or it might mean

getting more involved in management and resource issues. Of course, you are also required to publish your results in scientific journals, and in a timely manner too. Aquarius has revolutionized the way scientists work in the sea, and Aquarius scientists, such as yourself, are reshaping the way we think about coral reefs and our oceans. We look forward to working with you. Good luck as you prepare for your mission.