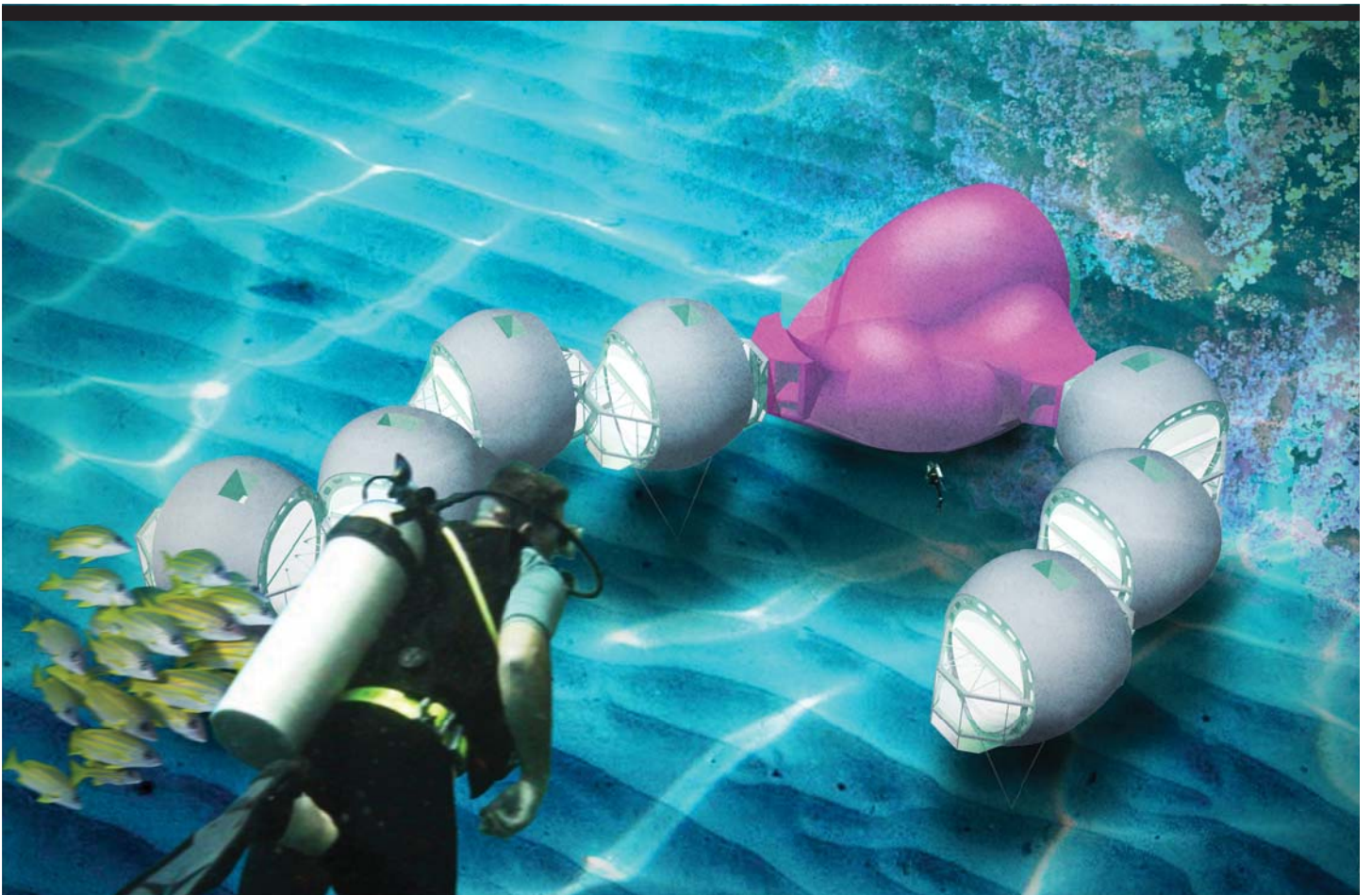


UNDERSEA HAB/LAB

JENNIFER CAHILL



ARCHITECTURE FOR EXTREME ENVIRONMENTS:
CHALLENGES IN UNDERSEA DESIGN

A Thesis

Submitted to the

Faculty of Miami University

In partial fulfillment of

The requirements for the degree of

Master of Architecture

Department of Architecture and Interior Design

By

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PAPER

Architecture for Extreme Environments: Design Challenges in the Realm of the Uncommon

INTRODUCTION

When I was seven years old, I taped pictures of Sally Ride around my bedroom and dreamed that I, too, would one day explore the farthest frontiers of our civilization. Passions change, and my career as an astronaut was not to be. Yet I am still fascinated by the exploration of extreme environments, drawn by the allure of the dangerous and the unknown. From the poetry of an Arctic sunrise to the gossamer framework of a coral reef, nature's beauty belies its peril, luring the brave beyond the edges of the built environment. But what is the role of the architect outside these borders? As designers we have something to offer, and we may find that the extreme environment has something to teach *us* as well.

Methodology

Environments are not divided into two discreet categories, the familiar and the extreme. Rather, the label of 'extreme' can suggest a range of conditions. This paper examines habitats in the polar regions, undersea, and outer space. Methodology consisted of studying existing documentation of these habitats and interpreting it from an environmental psychology and an architectural design perspective, supplementing with personal reflections from a trip to Jules' Undersea Lodge and the Aquarius Reef Base in Key Largo, FL.

Site

The Earth's Polar Regions, although lacking neither gravity nor oxygen, constitute one type of extreme condition. In these 'Lands of the Midnight Sun,' snow and ice dominate the natural landscape, and humans are subject to both physical containment and deprivation of sensory stimuli. Undersea design, on the other hand, must take buoyancy into consideration, altering the way in which inhabitants experience the vertical dimension of the space.¹ As habitat designer Dennis Chamberland reminds us, "The world of the Aquatican is not bound by a surface. It is shaped not only by X and Y [axes], but by the added dimension of Z."² Atypical daylight qualities, physical confinement, and potential for danger add to the already unusual framework for undersea design. At the farthest end of the spectrum, in the vacuum of Outer Space, the usual parameters for design simply don't apply. There is no gravity, no north arrow, no atmospheric weather – not even a designated up and down.

These three frontiers of civilization, as vastly different as they are, present surprisingly similar obstacles. They are places that, while beautiful, can truly challenge the human mind and body.³ In each, architecture has the opportunity to mitigate extreme conditions such as disorientation, atypical daylight, containment, and lack of familiar sensory stimuli. As architects, we must determine our role in places where engineering usually takes precedence, and study the built environment where the natural environment is completely unfamiliar.

Foundation

Besides being aesthetically pleasing, a *habitat* must meet psychological needs for orientation, daylight, privacy, sound (or silence), and visual stimulation, among others. Environmental psychologist Sally Augustin contends that there are five major attributes of well-designed spaces, one being that they *comfort* their inhabitants.⁴ Comforting qualities are often overlooked in extreme environments, both because of budget limitations and lack of designer involvement.

To create comforting spaces, we first need to identify our user. The explorers and scientific researchers that currently constitute the entire population of the poles, seabed, and low earth orbit are not necessarily our only clients. While the fearless adventurer or trained scientist may be willing to accept hostile living conditions, architectural design could give a larger share of the population access to our vast, uncharted frontiers. Many of these future 'tourists' will lack the tenacity of today's explorer, and demand greater comforts than are currently available. They need reassurance that their needs – both physical and psychological – will be met in their new environment.

Outer Space has already seen a boom in wealthy visitors, including seven passengers who have traveled on the Russian Soyuz spacecraft to visit the International Space Station. Richard Branson's Virgin Galactic has over 430 tourists signed up to participate in its (relatively) cheaper suborbital missions, which it hopes to begin in 2013.⁵ Tourism seems to be the next phase for undersea exploration as well. One particularly high-profile example, the Poseidon Undersea Resort, is planned off the coast of Fiji.⁶ In the United States, Jules' Undersea Lodge in Florida accommodates up to six guests in an adapted undersea research habitat. Even the sub-zero temperatures of Antarctica draw people seeking nature's beauty. Eventually, all three environments could be home to tourist facilities, and perhaps even permanent colonies.⁷

Many worry that such development would adversely affect the ecology of an extreme environment. Sadly, avoiding a place doesn't necessarily equate to protecting it; although we may not travel to the bottom of the seas or the top of the earth's atmosphere, our trash and debris certainly does. In many cases isolated and extreme environments have simply slipped under the radar of environmental stewardship. Precisely because of their unpopulated nature, they tend to become an easy dumping ground for waste and debris. In 1997, oceanographer and racing boat captain Charles Moore discovered a floating garbage patch twice the size of Texas in the central Pacific Ocean.⁸ Located in a high-pressure system avoided by most seafarers, the area had accumulated an unbelievable volume of plastic waste. In Outer Space, the problem takes on a new dimension, as debris does not simply float in place but continues orbiting at high speeds and can lead to potentially catastrophic collisions. Debris currently in space includes 15 years' worth of trash bags from Russia's Mir space station.⁹ One theorem predicts the eventual formation of a self-perpetuating debris field, as new objects entering the system collide with existing objects and create new debris faster than it can fall out of orbit.¹⁰ Were this to occur, it could render all Low Earth Orbits unsafe for human travel or habitation. In effect, humanity is at a greater risk of damaging environments that *aren't* in use – nobody would allow such things to happen in their own backyards. Encouraging more people to experience these unfamiliar environments is the only way to generate advocates for their protection.

CASE STUDY ANALYSIS

Polar Regions

An infinitesimal percentage of the Earth's population lives in so-called 'extreme' environments, making case studies hard to come by. From 1997 to 1998, the designers of an Arctic research station in Greenland analyzed its performance by surveying inhabitants. Researchers Xiaoying Yan and Marijane England asked three winter-over participants to periodically evaluate the physical attributes of the habitat, as well as their own satisfaction with the structure and the status of their personal well-being.^{11,12} From this they were able to determine which aspects of their design were successful.

The surveys focused on six elements of the habitat: perception of safety, use of color, lighting conditions, separation between private and public space, noise conditions, and ease of personalization. As the study notes, "the physical built environment often becomes one of the few resources available to help inhabitants better cope with and adapt to the...conditions in polar regions."¹³

When a building is so isolated from other stimuli, the smallest detail can make a remarkable difference in one's perception of it. For example, in an environment entirely devoid of color, Arctic researchers spoke fondly of their deep green building – which they nicknamed the 'Green House.'¹⁴ The expanse of glacial ice lacks not only color but also the scents, sounds, and variety with which the mind is familiar. Yan and England suggest greater integration of color in future designs.¹⁵ This could be expanded to include digital and kinetic elements, which provide more complex visual stimuli.

Because of its latitude, the winter-over station experiences perpetual darkness in the middle of winter and endless sunlight during the summer months. This condition not only disturbed inhabitants' sleeping patterns but also affected their sense of time. According to one lighting organization, "Too little light can cause a delayed reaction in our internal clock or make sleep/wake phases less pronounced. In both instances, the effect on chronobiological rhythm is negative and can cause health problems."¹⁶ At the end of their study, Yan and England concluded that similarly sited habitats should focus on intelligent window placement and careful attention to interior lighting.¹⁷

The research team also found that flexibility of interiors was key to user well-being. The ability to personalize one's space, from moving furniture to changing color and lighting schemes, helps humans adapt to a perceived sameness of environment.¹⁸ Yan and England linked personalization not only to increased user satisfaction, but also greater levels of productivity. Author C. A. Berry goes so far as to suggest that monotonous, nonflexible interiors may dull the mind as well as damage user morale.¹⁹

At the same time, continuance has its place. A permanent habitat such as Summit Station's 'Green House' has significant advantages over a site-less canvas tent. A stable structure has orienting properties, providing an invariable location and a psychological sense of 'coming home.'²⁰ Alaska's Toolik Field Station also tries to offer Arctic researchers a comforting permanent environment. In addition to construction permanence, common areas have high ceilings and large windows that provide stunning views of the nearby Brooks Range Mountains – a wonderful reminder that architecture must not insulate its inhabitants to the extent that it severs their connection with the surrounding environment.²¹

Undersea Environments

Man has long been fascinated with the world below the ocean's surface. Alexander the Great is purported to have submerged in a diving bell, and Leonardo da Vinci counted a SCUBA-like contraption among his many inventions.²² Beginning in 1961, the creation of new technologies paired with the political atmosphere of the Cold War created a sense of excitement and urgency surrounding the exploration of new frontiers. Between 1962 and 1977, over 60 habitats were constructed in the Earth's oceans.²³ In 2007, author and aquanaut Dennis Chamberland published *Undersea Colonies*, which presents a contemporary viewpoint on undersea design: "In every exploration system, we must require the systems we build to adapt to the human standard rather than expect the human to adapt to the machine or the environment."²⁴ In other words, the architecture should do all it can to *comfort* and accommodate inhabitants in their unusual surroundings.

The underwater world is not a two-dimensional place, and thanks to buoyancy both humans and their habitats can explore the vertical dimension of the oceans. One may not need to enter a building from the 'first floor,' and for habitats not resting on the seafloor, there would be no horizontal datum like we experience on land. Furthermore, undersea habitats are generally entered from what we would consider the floor plane rather than a wall. This affects all aspects of the entry sequence, prohibiting visitors from seeing the entry as they approach and creating a porch- or lobby-like space underneath the habitat. Architects must design visual cues that will lead visitors into the habitat without confusion. Clearly, the ocean's unique third axis suggests the transformation of traditional spatial relationships.

Like buoyancy, natural lighting beneath the seas is both challenge and opportunity. Undersea habitats receive sunlight from almost directly above, never from their sides like land-based habitats. To accommodate this, daylighting schemes must provide plenty of upward facing windows. Furthermore, the color spectrum of natural light is quite narrow, limiting perception of reds, oranges, and yellows at certain depths.²⁵ This may limit exterior color choices for habitats, depending on where they are placed. Yet despite its limitations, sunlight beneath the ocean's surface can be startlingly beautiful, shimmering gently or piercing through the water in brilliant rays of light. A good lighting design should navigate the constraints while maximizing the assets of undersea daylight. For example, installing exterior lighting can showcase marine creatures' nighttime activities – another opportunity for architecture to enhance rather than insulate from the surrounding site.²⁶

Noise from HVAC systems can be another stressor.²⁷ Chamberland reminds us, however, that these are essentially the sounds of safety: "each noise represents the same effect: life being supplied to the aquanaut, enabling him to live and work beneath the surface of the ocean."²⁸ Fortunately, studies show that people are less aggravated by noise when they believe that the source of the sound is related to their own well-being.²⁹ Architects should take this into consideration, making such systems an integrated and visually comprehensible aspect of habitat design.

In undersea environments, inhabitants must frequently cede control of their lives to trained technicians or natural forces.³⁰ To retain some feeling of control and personalization, each bunk in the Aquarius reef base is fitted with its own reading light and has a cubby for storing personal belongings. Unfortunately, in many undersea habitats, built-in furniture and size limitations impede flexibility.³¹ Large control panels in Aquarius lend the space an 'operational feel' and may decrease participants' feelings of control, since they have neither the training nor permission to operate them. Even command over one's personal appearance may feel constricted, as in the case of Aquarius' hairdryer ban.³² User experience could be improved by offering more opportunities for personalization, hiding complicated controls, and allowing visitors to participate in making other decisions to compensate for lack of spatial control.³³

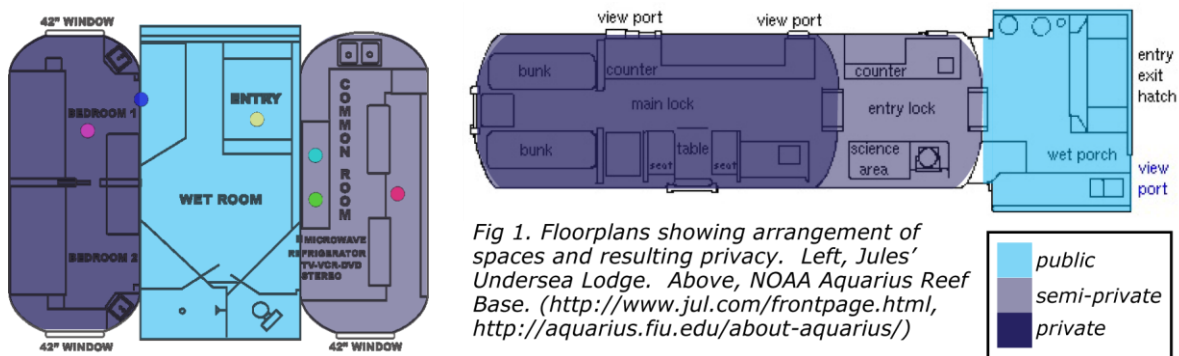


Fig 1. Floorplans showing arrangement of spaces and resulting privacy. Left, Jules' Undersea Lodge. Above, NOAA Aquarius Reef Base. (<http://www.jul.com/frontpage.html>, <http://aquarius.fiu.edu/about-aquarius/>)

Controlling one's environment includes being able to choose when we interact with others.³⁴ The arrangement of spaces and the barriers between them can determine whether a small facility allows for proper visual and auditory privacy. For example, in Jules' Undersea Lodge, the wet porch and a change in floor level separate public and private spaces, and the private side is divided into two separate sleeping rooms. At the Aquarius Reef Base, on the other hand, sleeping bunks are in one room directly adjacent to the kitchen area. Auditory privacy is also difficult to control at Aquarius. Conversation is transmitted via intercom from one pressure lock to another, leading Operations Director Saul Rosser to opine that one is "essentially never alone."³⁵

Finally, control means being able to decide how long we remain in an environment. Unfortunately, most extreme environments require an element of containment. You cannot simply step out the door of an undersea habitat and go somewhere else; you must wear a mask, breathe from a

regulator and tank, ascend slowly and go through decompression if necessary. Chamberland proposes using elevators and submarines for accessing future habitats, reducing the feeling of confinement.³⁶

In such a high-tech environment, designers should never discount the impact of a relatively low-tech solution. Comfortable seating areas allow overworked scientists and divers to enjoy what Augustin would call 'restorative views' of the sea.³⁷ Such experiences allow people to recharge mentally and continue to work at the exceptionally high levels required.³⁸

Outer Space

Two hundred miles above our heads, the International Space Station soars past at a rate of almost 16 orbits a day. It's a conspicuous member of the built environment, but from an aesthetic point of view, it's no more attractive than the drum of a washing machine. Between safety concerns, financial constraints, and structural issues, there's little room in outer space for the 'luxury' of architecture. Taseer Ahmad, co-director of the Extreme Environments Laboratory, describes current space stations as "modules like tin cans, either full of Heath Robinson contraptions or monochrome and sterile."³⁹ We cannot continue to disregard the livability of these habitats. Architecture should help orient and comfort astronauts, relieving mental stress and ensuring the success of a lengthy mission.

In order to orient users, many designs impose an artificial gravity to imitate Earth's pull.⁴⁰ Angel Marie Seguin proposed such a project in 2005. The habitat's form consists of a primary and secondary torus positioned at right angles to each other, the rotations of which provide, respectively, an artificial gravity of 0.56G and a light/dark cycle of 8 hours. Since gravity is the result of rotation and centripetal forces, people are pulled 'downward' toward the outside of the habitat, with 'up' being toward the center.

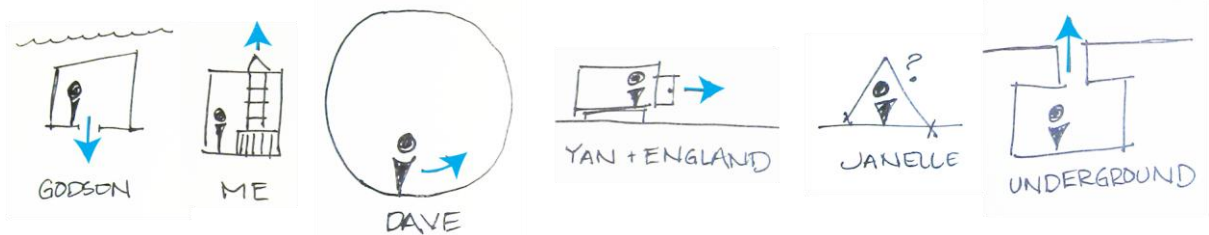


Fig 2. Diagramming feelings of orientation in various environments. From left to right: undersea, roof access, space station, arctic station, arctic tent, underground.

To orient users, Seguin suggests using visual cues to distinguish between prograde (with the direction of rotation) and retrograde (against the direction of rotation). Something as simple as color choices could indicate to occupants whether they would experience more, or less gravity by moving in that direction.⁴¹

In addition to solving orientation and lighting challenges, the almost-complete shape of the primary torus also allows for effective programming, with work, home, and recreation placed as far apart as possible. According to Seguin, "the notion of 'going somewhere' is important to the human psyche...because it suggests to the occupants a scale and volume in their habitat that would abate feelings of confinement and isolation."⁴² In section, the torus provides spaces that vary in height and views, even allowing inhabitants to view the station itself. What makes Seguin's architecture so successful, therefore, is not merely a fascinating form but rather the form's ability to meet psychological and functional needs.

CONCLUSION

Armed with an insatiable desire to explore new frontiers, and facing growing environmental challenges at home, man will no doubt find himself increasingly inhabiting the Polar Regions, Undersea, and Outer Space. It is the role of the architect to design structures that optimize his experience, sheltering his body and psyche without curtailing his adventure.

This means finding creative ways to mitigate those environmental stressors faced at each site. Future research might investigate more specific solutions for identified stressors (disorientation, atypical daylight, containment, lack of stimuli, and lack of control). Fortunately, architects are uniquely equipped to meet the challenges of extreme environments; in the words of Professor Brian Davies, we can "visualize [solutions] that are difficult for non-designers to imagine or believe."⁴³ We have a singular understanding of that physical landscape which draws people out of their comfort zone and into extreme surroundings. To designers, the inherent challenges of these environments are catalysts for exploration and invention, forcing us to try new things and fueling our creativity. For our own sake and for the well-being of potential clients, it's time that architects join the dialogue of extreme environments.

¹Throughout this paper I will use the term 'undersea' rather than 'underwater,' not only because it is the term employed by professional divers and habitat designers, but also because the latter seems to imply that one might be submerged in one's swimming pool.

² Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 18.

³ DialogProjects, "Future Fellows: Brian Davies," Accessed August 10, 2012. <http://www.dialog-projects.com/davies>.

⁴ Sally Augustin, *Place Advantage: Applied Psychology for Interior Architecture*, (Hoboken, NJ: John Wiley & Sons, Inc., 2009), 21-22.

⁵Peter Pachal, "Virgin Galactic Keeps Inching Toward Space, but When Will It Get There?" *Mashable*. Feb 3, 2012, Accessed March 28, 2012, <http://mashable.com/2012/02/03/virgin-galactic-rocket-test>.

⁶ Unfortunately, construction is currently on hold until funding can be secured .

Felix Chaudhary, "Underwater Resort," *The Fiji Times Online*, July 30, 2012, <http://www.fijitimes.com/story.aspx?id=207922>.

⁷ If the concept of long-term habitation still seems a figment of science fiction, keep in mind that as early as 1985, a NASA publication on extended spaceflight began with this caveat: "We are now entering an era when the new astronaut must forsake his short-term approach to space travel and begin to deal with the space environment as a continuing condition. When this occurs, the space traveler will truly begin to live in space."

Mary M. Connors, Albert A. Harrison, and Faren R. Akins, *Living aloft: Human requirements for extended spaceflight* (NASASP-483), (Washington,DC: National Aeronautics and Space Administration, 1985.), 17.

⁸ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 292-293.

⁹Julian Smith, "Space Junk," *USA Weekend*, 26 August 2007, accessed March 30, 2012, http://159.54.226.237/07_issues/070826/070826space.html.

¹⁰Donald Kessler, "The Kessler Syndrome," March 8, 2009, Accessed March 30, 2012, <http://webpages.charter.net/dkessler/files/KesSym.html>.

¹¹One who remains at a base in the Polar Regions for the hostile winter season.

¹²Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 457.

¹³ Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 450.

¹⁴ Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 459.

¹⁵ Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 468.

¹⁶licht.de, "licht.wissen 19: Impact of Light on Human Beings," Accessed March 11, 2012, <http://www.licht.de/en/info-and-service/publications-and-downloads/lichtwissen-series-of-publications>, 15.

¹⁷ Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 468.

¹⁸ Xiaoying Winston Yan and Marijane E. England, "Design Evaluation of an Arctic Research Station From a User Perspective," *Environment and Behavior*, v.33, no. 3 (2001), 467.

¹⁹ C. A. Berry, "A view of human problems to be addressed for long duration space flights," *Aerospace Medicine*, 44, 1136-1146 (1973).

²⁰ Janelle Sikorski, (Lecturer, Miami University), interview by Jennifer Cahill, Oxford OH, March 1, 2012.

²¹ Janelle Sikorski, (Lecturer, Miami University), interview by Jennifer Cahill, Oxford OH, March 1, 2012.

²² Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 54-56.

²³ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 86.

²⁴ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 5.

²⁵ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 135.

²⁶ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 49.

²⁷ During my stay at Jules' Undersea Lodge, I was constantly aware of the electrical hum of life support systems and the noisy slurping of the moon pool intake.

²⁸ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 30.

²⁹ Mary M. Connors, Albert A. Harrison, and Faren R. Akins, *Living aloft: Human requirements for extended spaceflight* (NASASP-483), (Washington,DC: National Aeronautics and Space Administration, 1985.), 72.

³⁰ Sally Augustin, *Place Advantage: Applied Psychology for Interior Architecture*, (Hoboken, NJ: John Wiley & Sons, Inc., 2009), 29.

³¹ Size constraints, unfortunately, will always be a reality for undersea habitats. Not only do larger habitats require more materials, they require larger life support systems, greater volumes of mixed breathing gases (when used), more ballast to create negative buoyancy, and are costlier to move into place and maintain.

Saul Rosser, (Operations Director, Aquarius Reef Base), interview by Jennifer Cahill, Key Largo FL, August 6, 2012.

³² Saul Rosser, (Operations Director, Aquarius Reef Base), interview by Jennifer Cahill, Key Largo FL, August 6, 2012.

³³ Aquarius, for example, allows visitors to make food requests for their 10-day missions.

Saul Rosser, (Operations Director, Aquarius Reef Base), interview by Jennifer Cahill, Key Largo FL, August 6, 2012.

³⁴ Sally Augustin, *Place Advantage: Applied Psychology for Interior Architecture*, (Hoboken, NJ: John Wiley & Sons, Inc., 2009), 29.

³⁵ Saul Rosser, (Operations Director, Aquarius Reef Base), interview by Jennifer Cahill, Key Largo FL, August 6, 2012.

³⁶ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 202-209.

³⁷ Dennis Chamberland, *Undersea Colonies: The Future of Permanent Undersea Settlement*, (Quantum Editions, 2007), 49.

³⁸ Sally Augustin, *Place Advantage: Applied Psychology for Interior Architecture*, (Hoboken, NJ: John Wiley & Sons, Inc., 2009), 31.

³⁹ Taseer Ahmad, "My future," *Architects' Journal*, 198. no. 4 (1993), 50.

⁴⁰ Interestingly, in virtual reality, the common practice is to create a 'false gravity' that allows us to quickly and easily orient ourselves within the constructed environment. Even an avatar within a virtual environment has to obey the physical laws of Earth – it can't walk on the walls, or float up to the ceiling. There is a clearly defined horizontal plane. So although it isn't a physical reality, gravity becomes a parameter even within the virtual world.

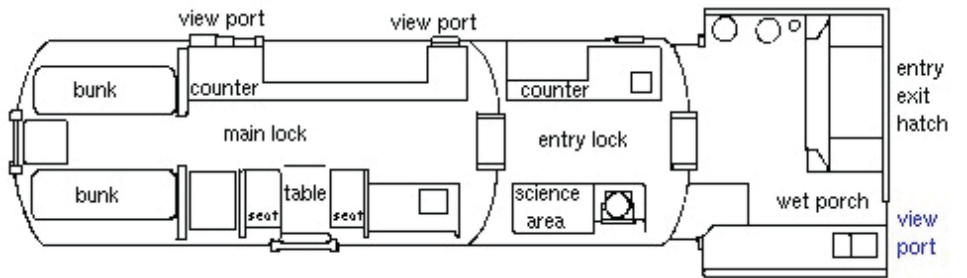
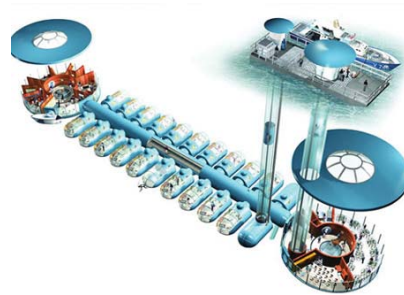
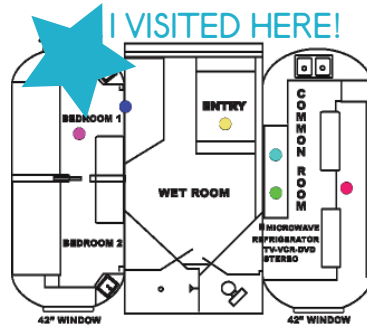
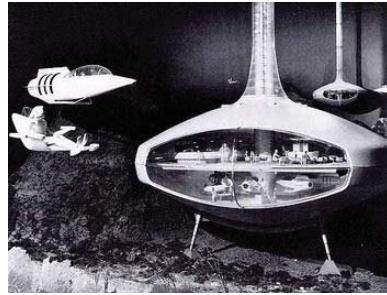
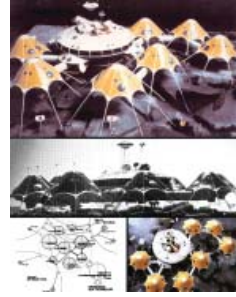
⁴¹ Angel Marie Seguin, "Engaging space: extraterrestrial architecture and the human psyche," *Acta Astronautica*, 56 (2005): 980-995, 983-989.

⁴² Angel Marie Seguin, "Engaging space: extraterrestrial architecture and the human psyche," *Acta Astronautica*, 56 (2005): 980-995, 988.

⁴³ DialogProjects, "Future Fellows: Brian Davies," Accessed August 10, 2012. <http://www.dialog-projects.com/davies>.

DESIGN PROCESS

Precedents



Undersea colony

British and Chinese governments of Hong Kong want to establish the first human undersea colony by 2015, possibly off the British Channel coast. It would be called Atlantis, and located in the East Stream with the primary task of researching ocean health.

Challenge Station

Although in early completion, early designs call for four "fish-beds" that would house three researchers each. The station will also house a community center and engineering space.

Dry run: July 4, 2012

The Chinese medical clinic enable three people to live and work for 30 days, in and allow one of two more occupants to join later for 24 to 72 hours.

A diagram showing a central station with four surrounding modules, each labeled 'Challenge Station'.



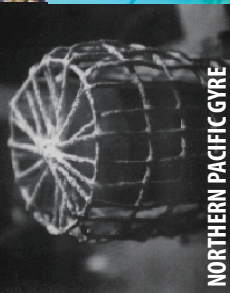
SIMULATING ASTEROID EXPLORATION



BLEACHED CORAL



NORTHERN PACIFIC GYRE



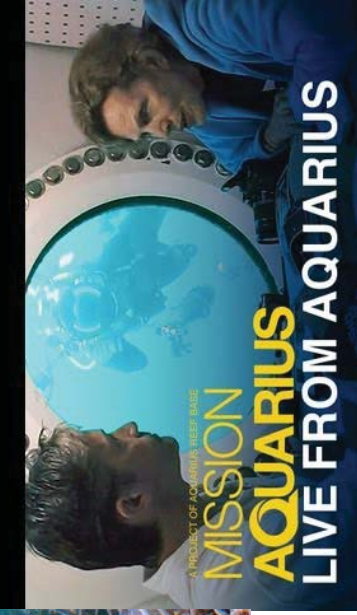
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NAVY SEALAB I

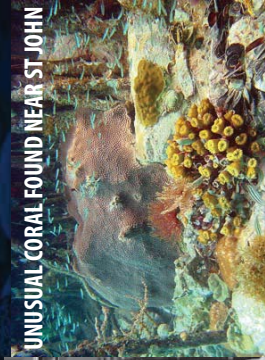


- CLIMATE CHANGE
- DOCUMENTARY PRODUCTION
- NASA TRAINING
- POLLUTION/WATER QUALITY
- INDIGENOUS PLANTS AND ANIMALS
- 'SEAMENT'/CONSTRUCTION
- NAVY TRAINING
- DIVING TECHNOLOGY DEVELOPMENT
- ARCHAEOLOGY
- ANTHROPOLOGY
- LIVE-STREAM TEACHING EXPERIENCES
- PHYSIOLOGICAL STUDIES
- PHOTOGRAPHY
- INTERNATIONAL CONFERENCES

FABIEN COUSTEAU & SYLVIA EARLE



MISSION
AQUARIUS
LIVE FROM AQUARIUS

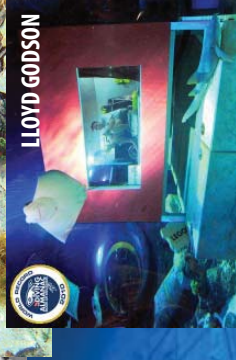


UNUSUAL CORAL FOUND NEAR ST JOHN

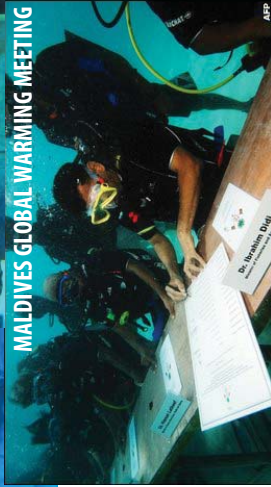


GEORGE F. BOND

SHIPWRECK SITE, FL



LLOYD GODSON

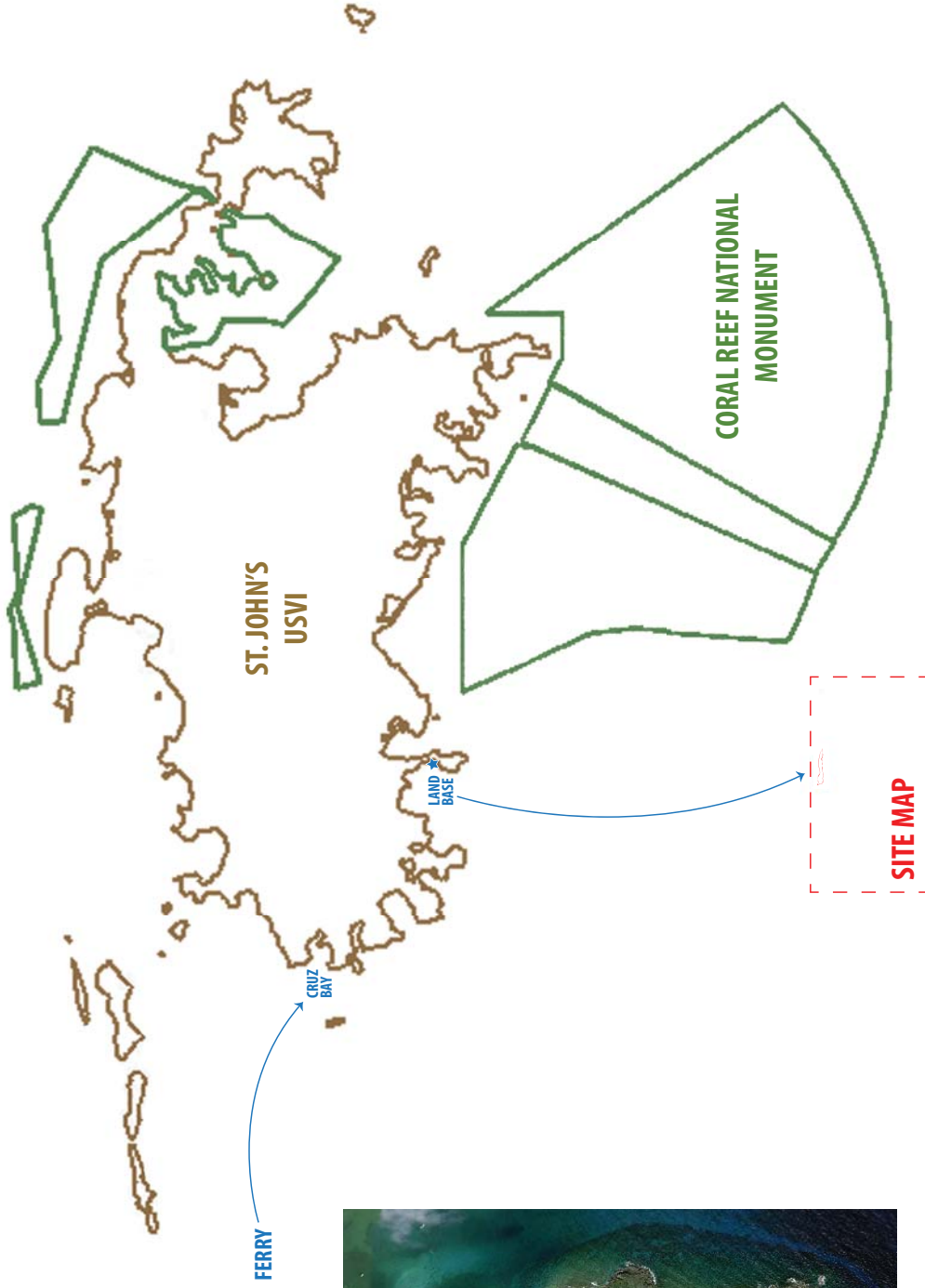


MALDIVES GLOBAL WARMING MEETING

UNDERSEA RESEARCH

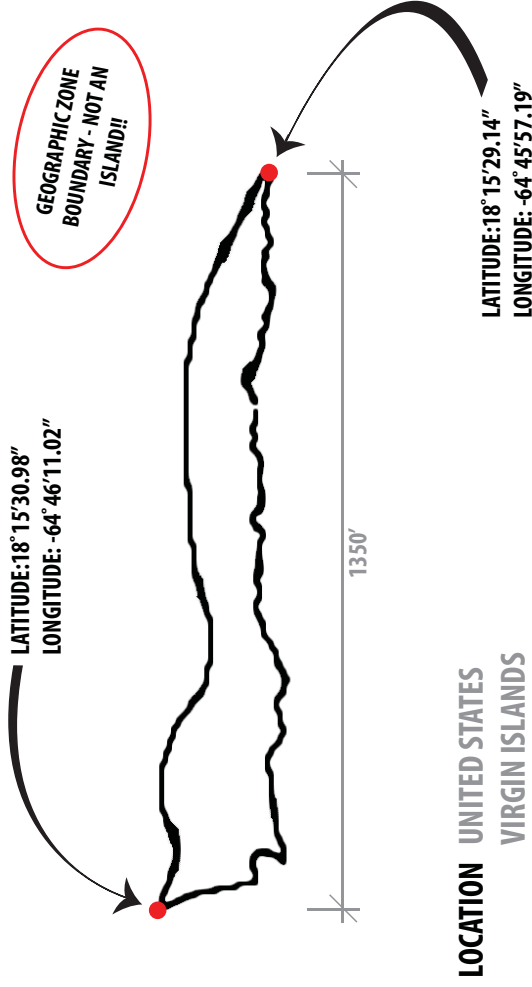
STEVE GITTINGS





LAND BASE:

MACRO SITE 1IN = 1MILE



LOCATION UNITED STATES
VIRGIN ISLANDS
3.6 MILES SOUTH OF ST. JOHN

ZONE ST. JOHN/ST. THOMAS SHELF

LATITUDE 18.26°

LONGITUDE -64.77°

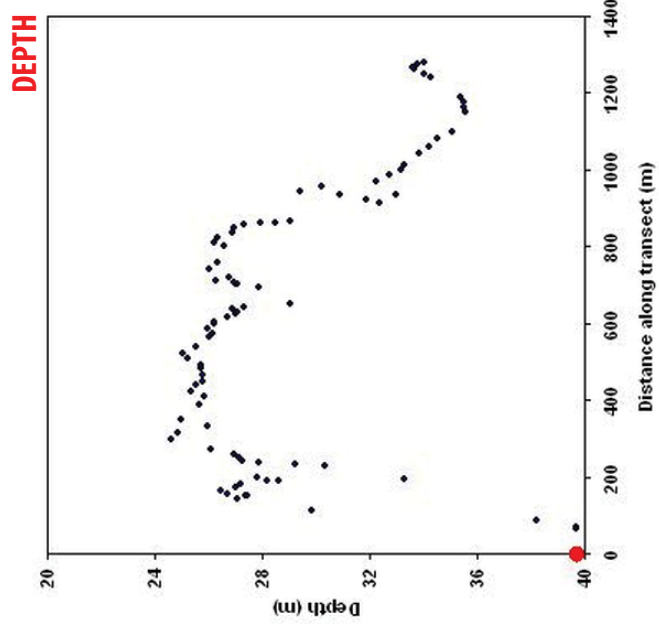
DEPTH 40m

RUGOSITY 1.00

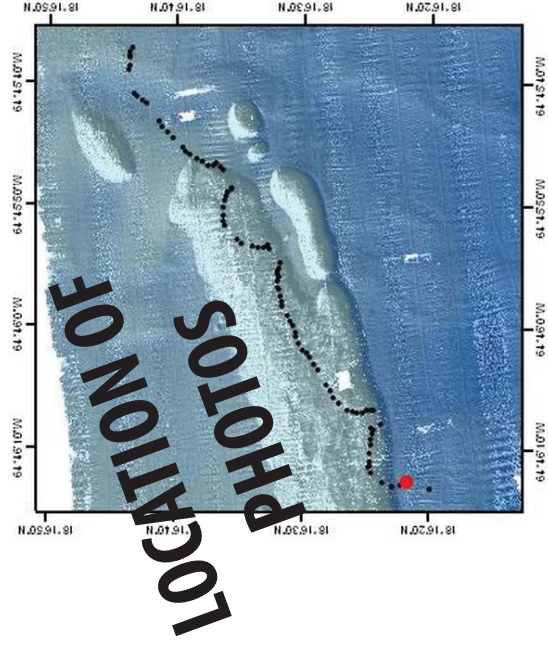
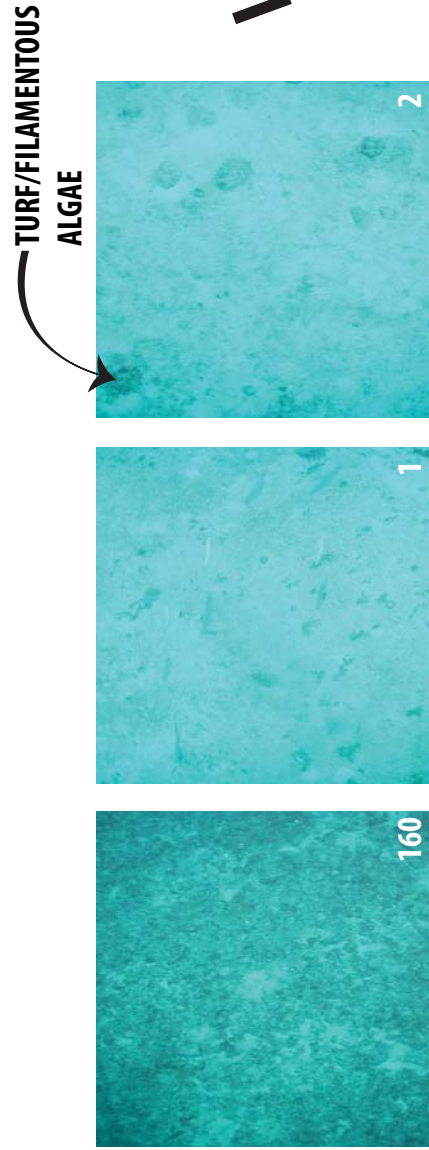
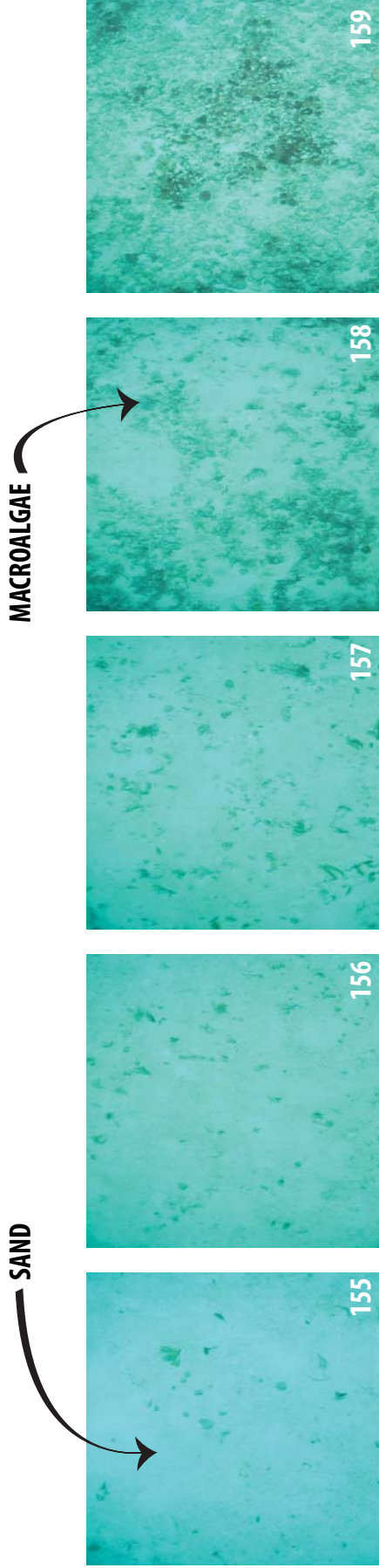
STRUCTURE SAND

SLOPE 1.05

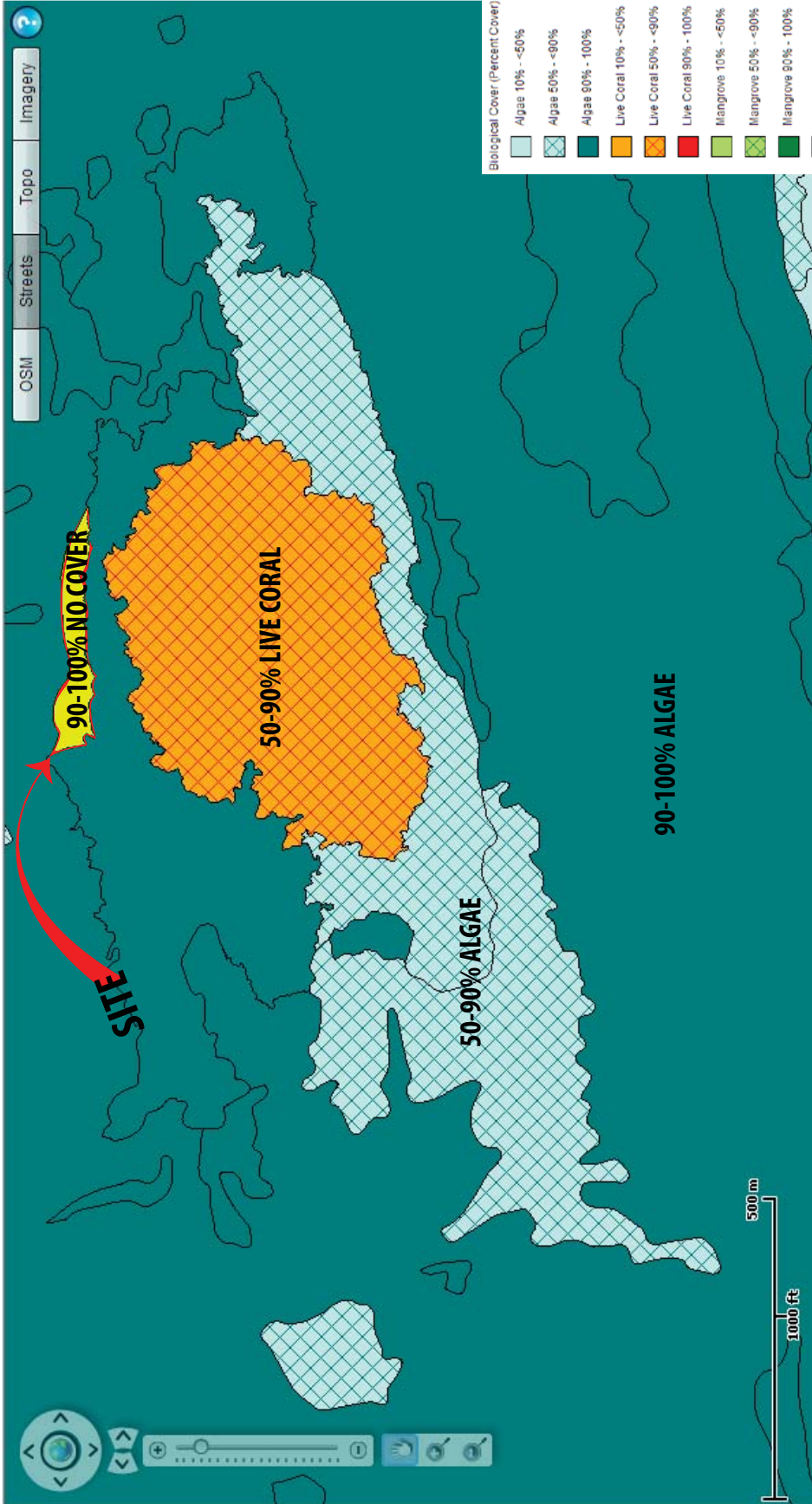
RUGOSITY INDICATES THE ROUGHNESS OF THE GROUND!



SITE INFO & LOCATION



SITE PHOTOS



BIOLOGICAL COVER 1IN = 500FT



CORALS, SPONGES, AND FEATHER DUSTER WORMS



OCTOPIUS

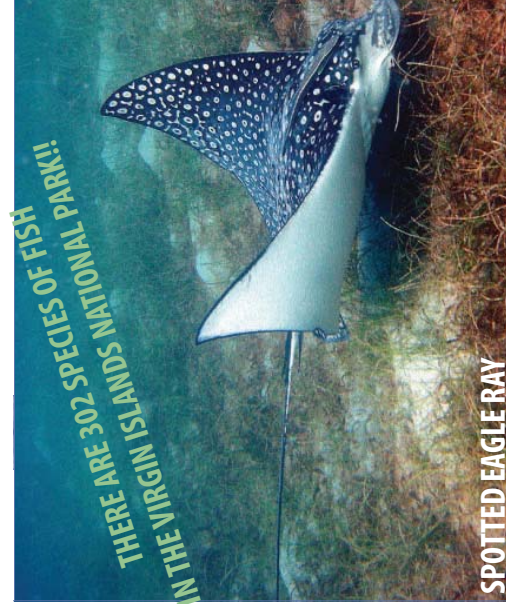


HAWKSBILL TURTLE



CORAL MONITORING

MOUNTAINOUS STAR CORAL
MONTASTRAEA FAVEOLATA



IN THE VIRGIN ISLANDS NATIONAL PARK!!
THERE ARE 302 SPECIES OF FISH

SPOTTED EAGLE RAY

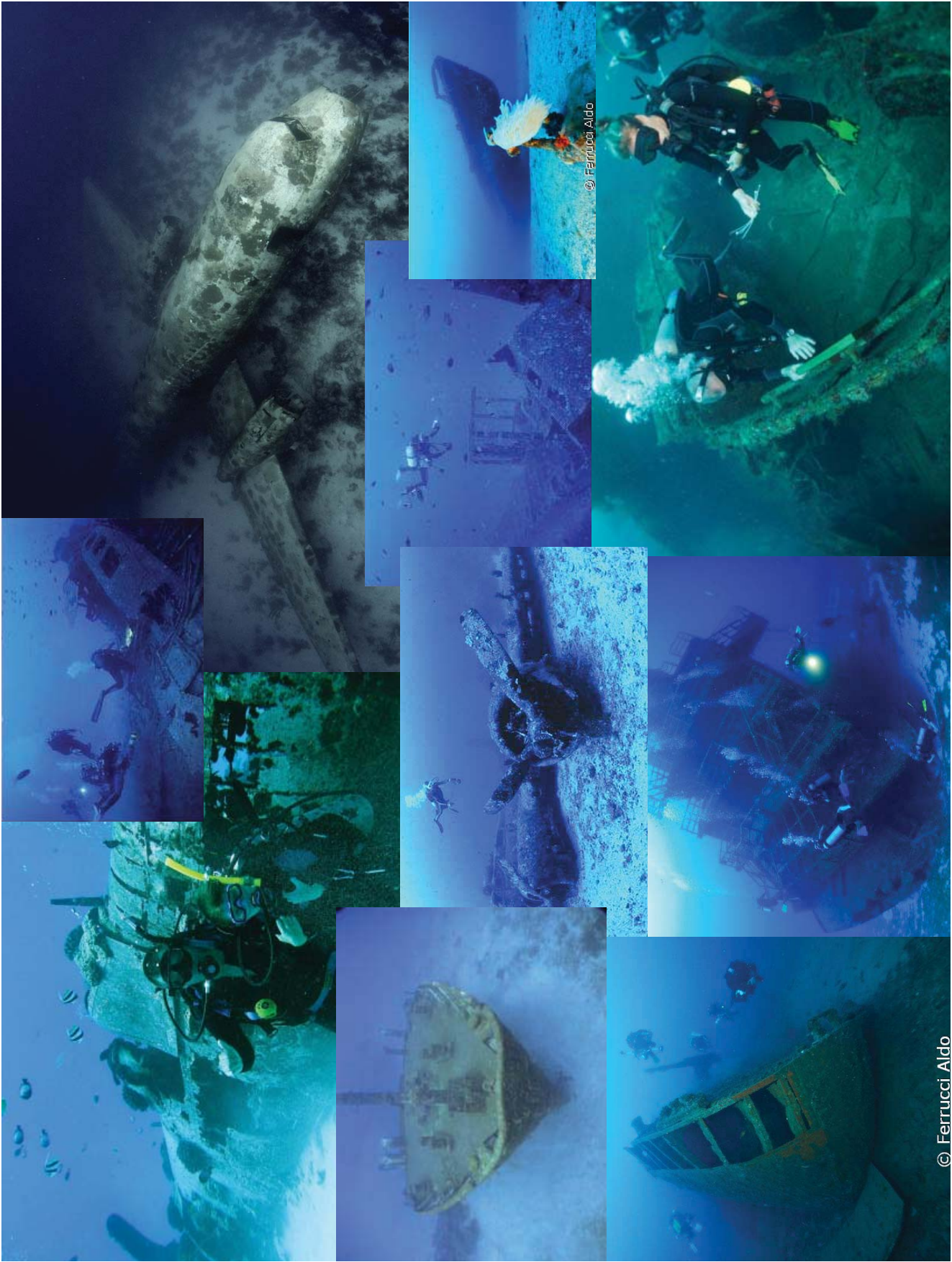


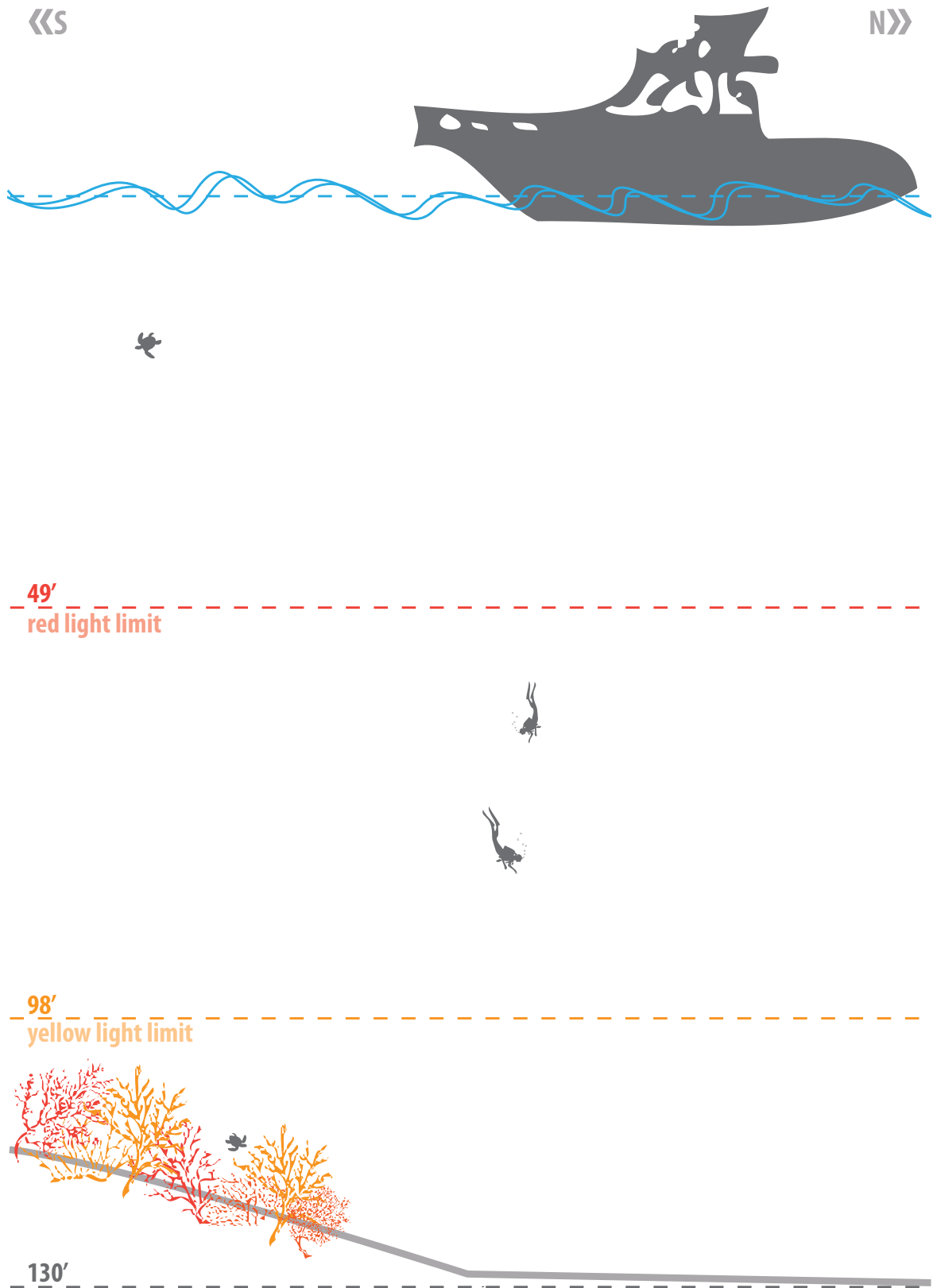
FLOWER CORAL EUSMILIA FASTIGIATA



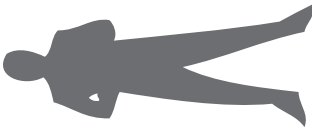



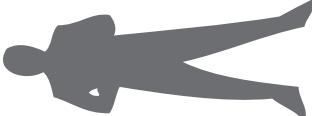





NASSAU GROUPE

FAUNA OF THE CORAL REEF NATIONAL MONUMENT





SITE SECTION 1" = 10'

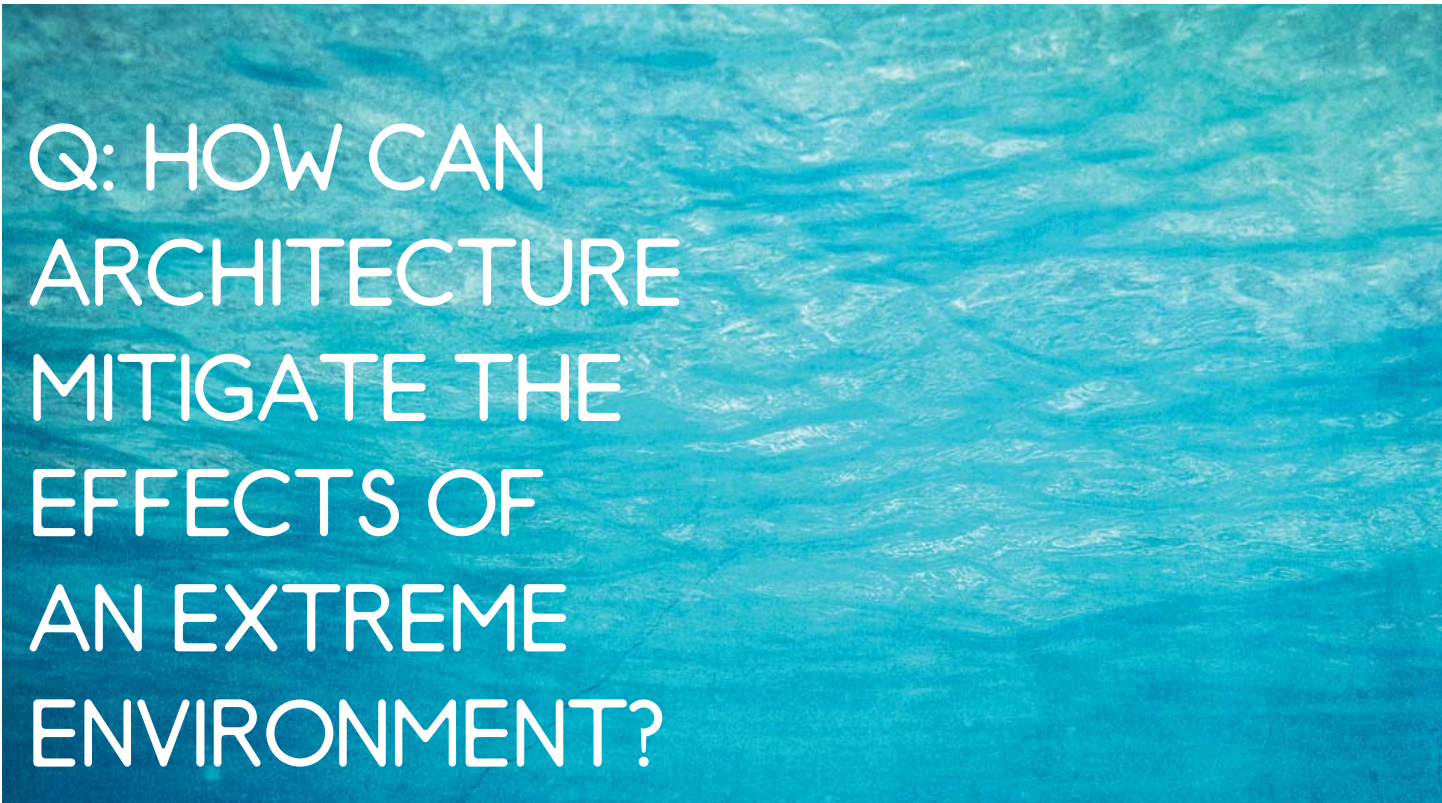
PRE-MISSION			N/A
ENTRY DIVE			15 MINS
IN HABITAT			4 HRS BETWEEN EXPEDITIONS
EXPEDITIONS			9 HRS/DAY
DECOMPRESSION			26 HRS

1 hr/ft depth (indicated by a red arrow pointing from the 26 HRS value to the 1 hr/ft depth text)

TIME LAPSE FOR MISSION

Process

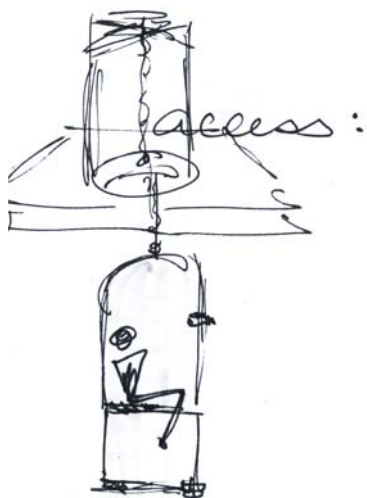
My design process focused on answering the overarching question below, as well as many others: how do you get to the site? How is circulation different underwater? What are the views like? How much flexibility is needed, and how can we provide it?



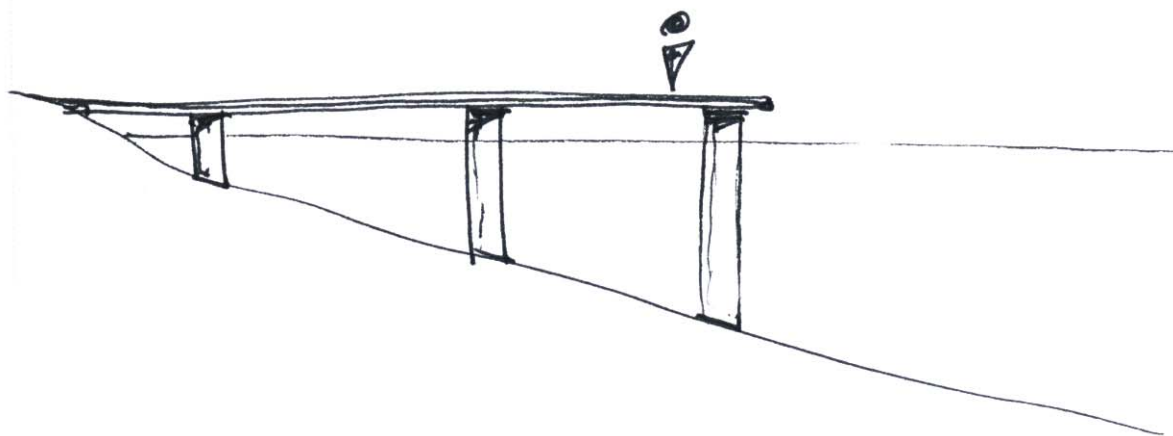
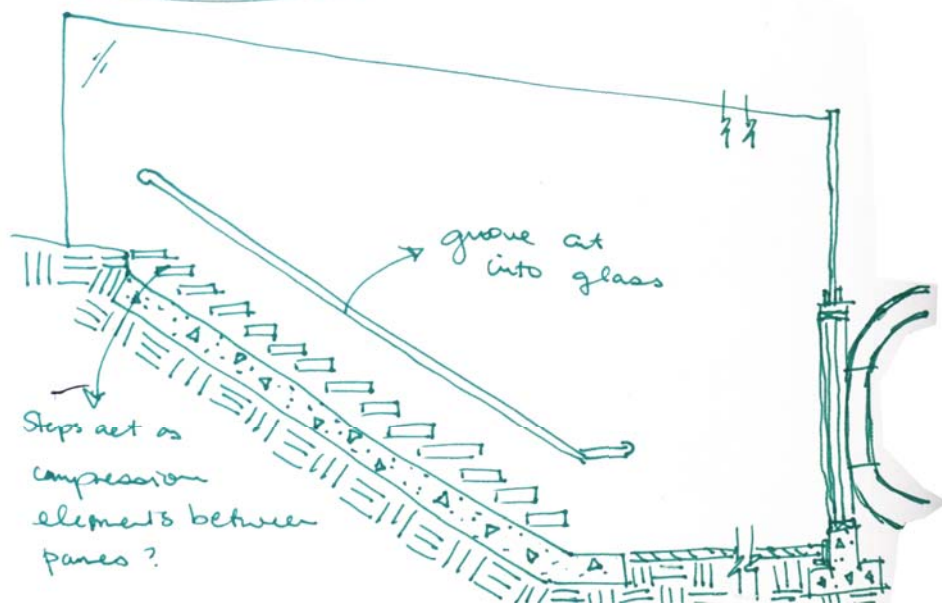
Q: HOW CAN
ARCHITECTURE
MITIGATE THE
EFFECTS OF
AN EXTREME
ENVIRONMENT?

IN AN UNDERWATER
DESIGN, HOW CAN WE
MAXIMIZE AN EXCITING &
BEAUTIFUL EXPERIENCE
WHILE MINIMIZING
STRESSORS?

Contemplating site access and the drawbacks of various methods, from submarine and diving bell to direct dive access.

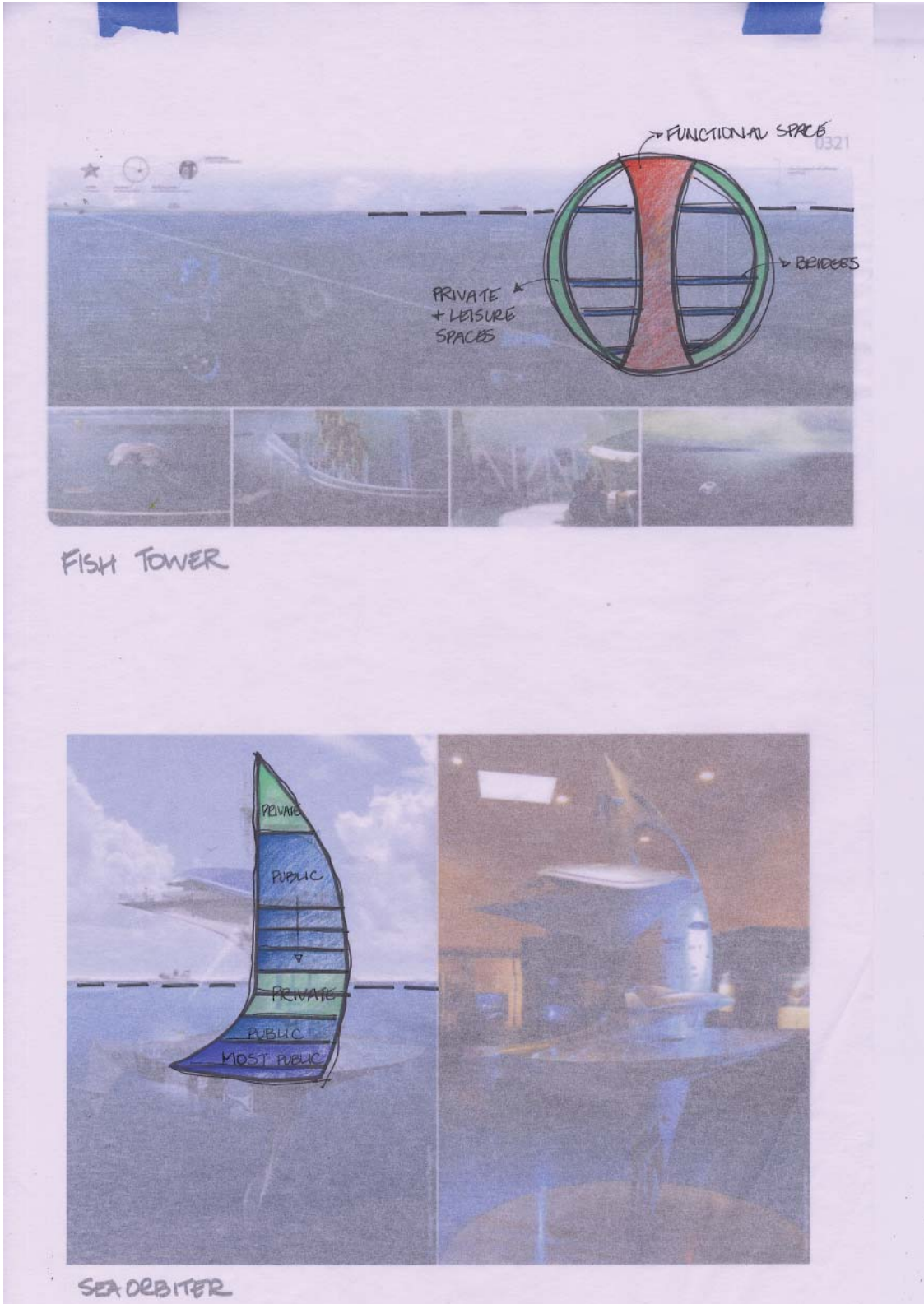


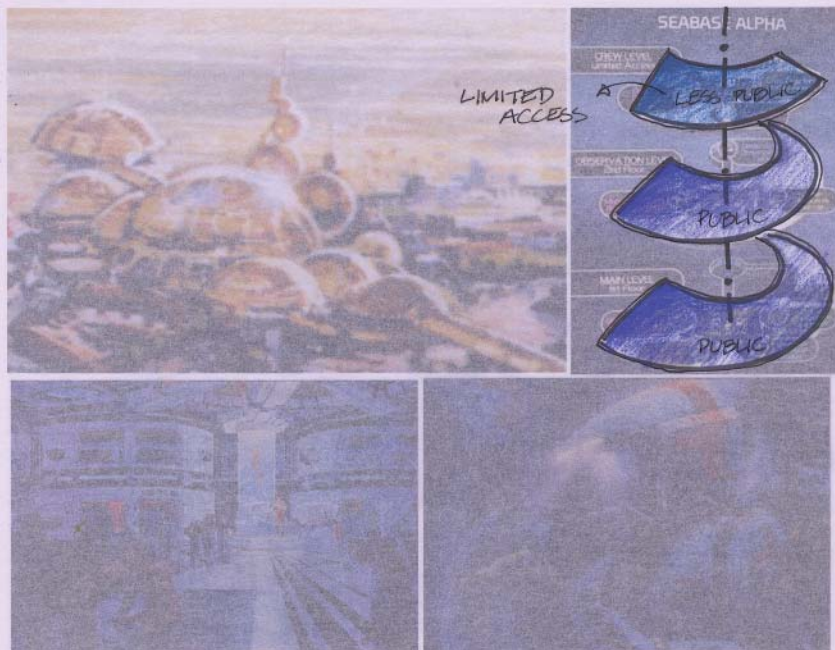
Submarine gate:



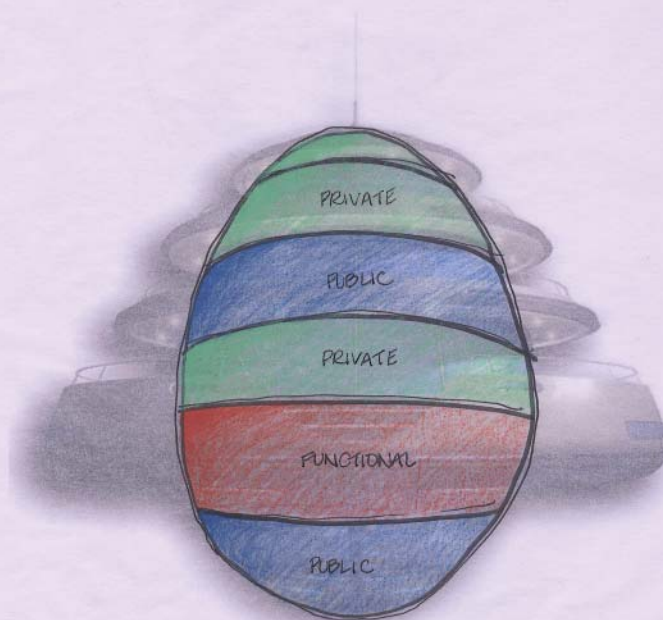
Process

Analyzing undersea precedents.





SEABASE ALPHA



JELLY-FISH 45

Undersea colony

Dennis and Claudie Chamberland of West Cocoa want to establish the first human undersea colony by 2015, possibly off the Brevard County coast. It would be called Atlantica, and located in the Gulf Stream with the primary task of monitoring ocean health.

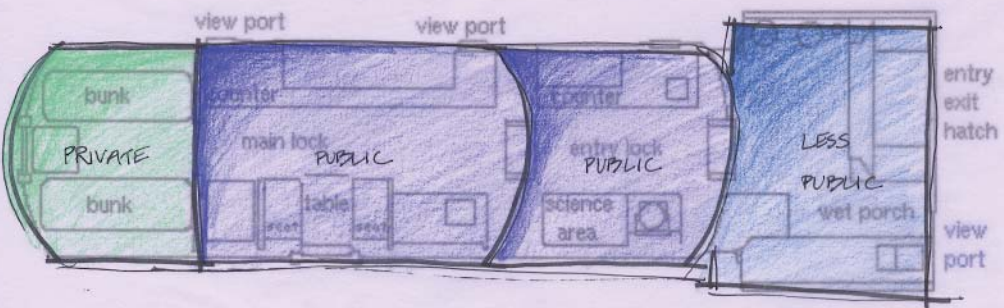


Challenger Station
Although a work in progress, early designs call for four "cylinders" that branch out from a three-story central structure. The center hub would house a community center and engineering space.

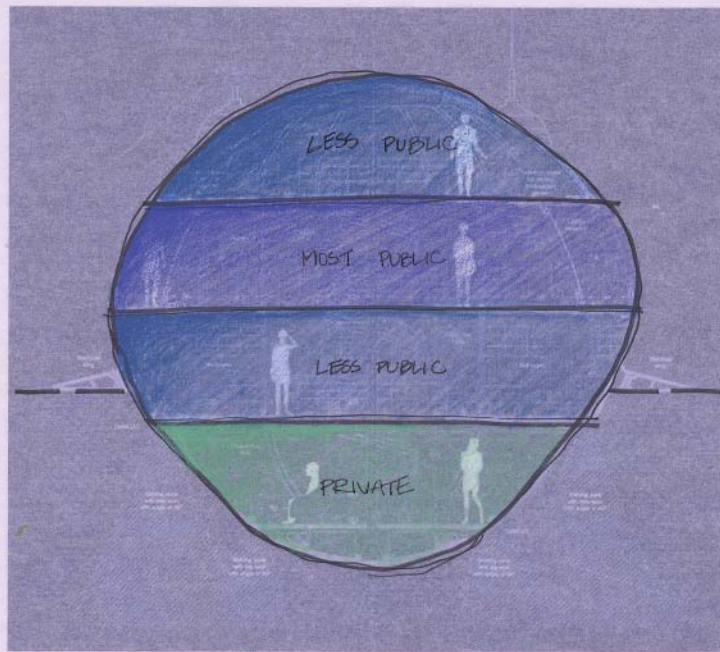
Dry run: July 4, 2012
The Leviathan Habitat could enable three people to live onboard for 90 days, as well as allow one or two more aquanauts to join them for 24 to 72 hours.

The diagram shows a map of the Gulf of Mexico with the Gulf Stream highlighted. A red arrow points to the location of the Challenger Station off the coast of Brevard County, Florida. A vertical scale bar indicates depth from 0 to 10000 feet. A central hub is labeled '40-foot raft center hub' and is surrounded by four '40-foot arms'. Each arm is divided into 'PUBLIC' (blue) and 'PRIVATE' (green) sections. A '30-foot tank' is also shown. Text notes that living space would be under the same pressure as land and that only professional divers would venture outside using an airlock. Source: Dennis Chamberland. E. GARDNER, FLORIDA TODAY.

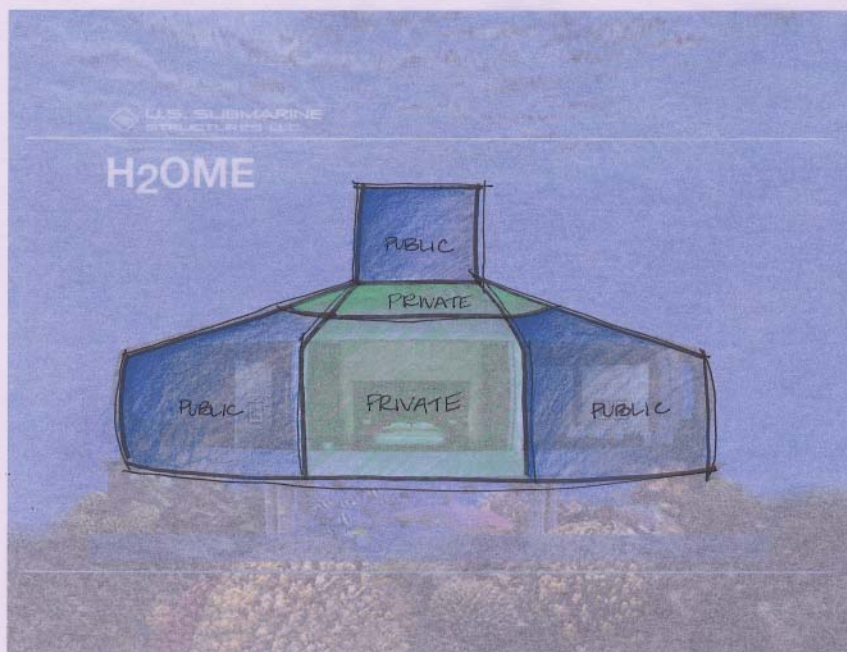
ATLANTICA / CHALLENGER STATION



AQUARIUS

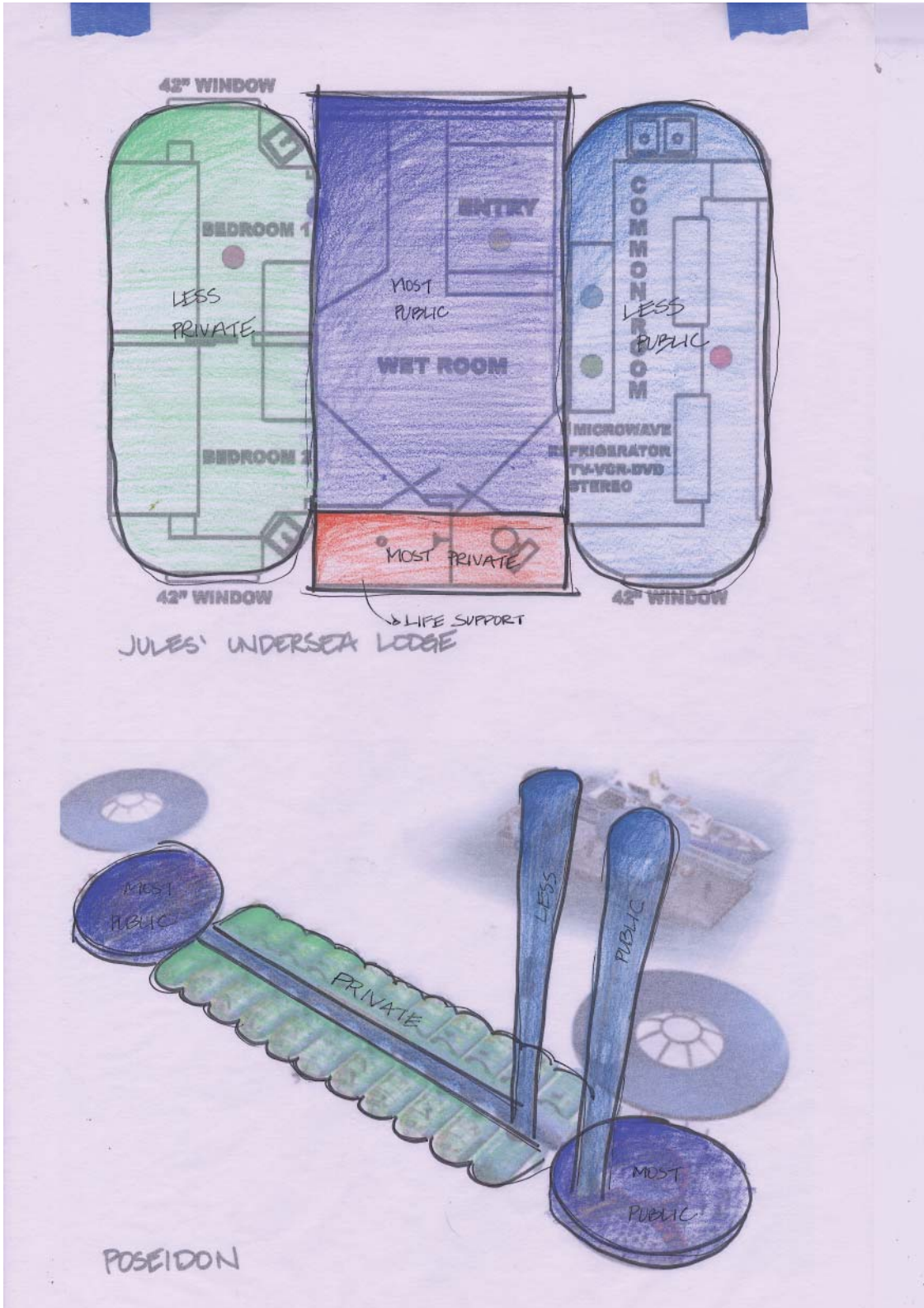


TRILOBIS

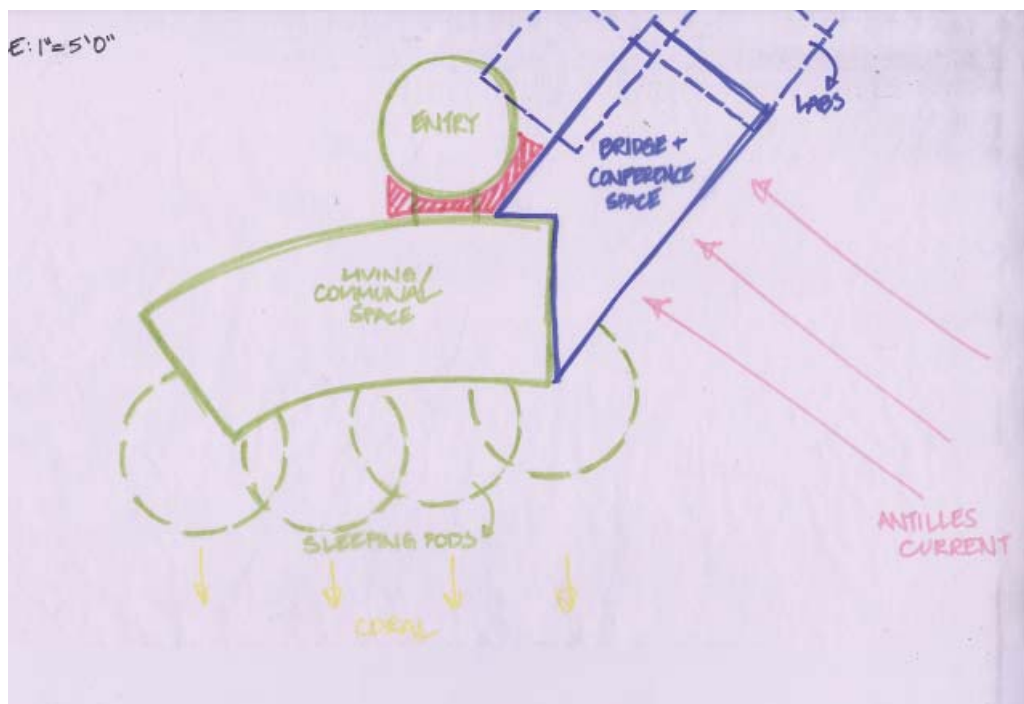
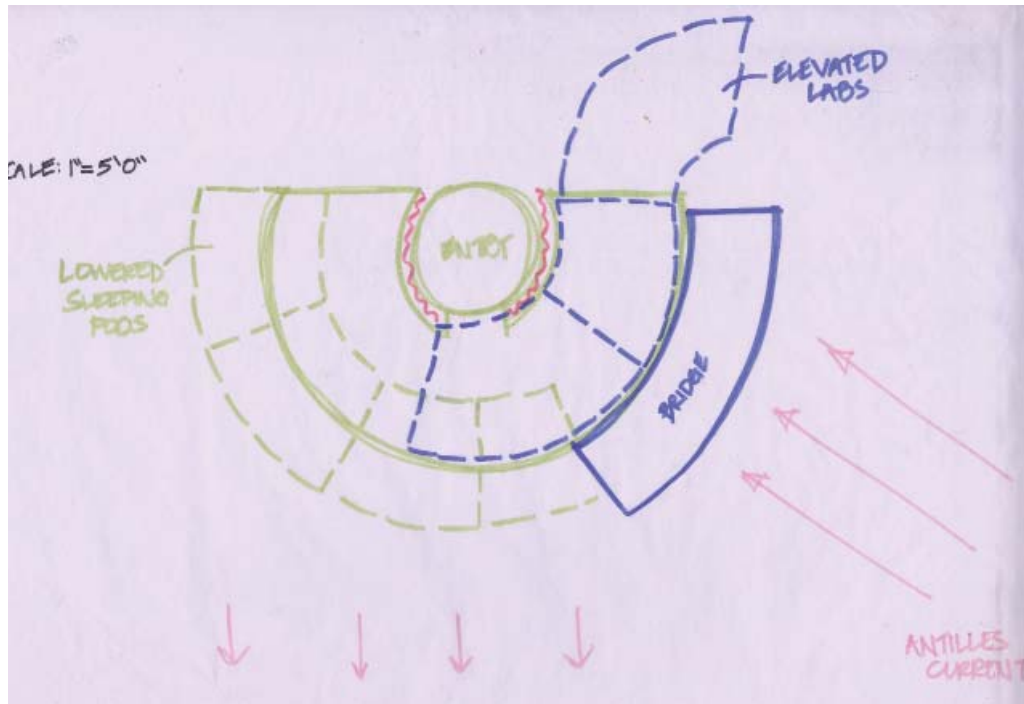


H₂OME

Process

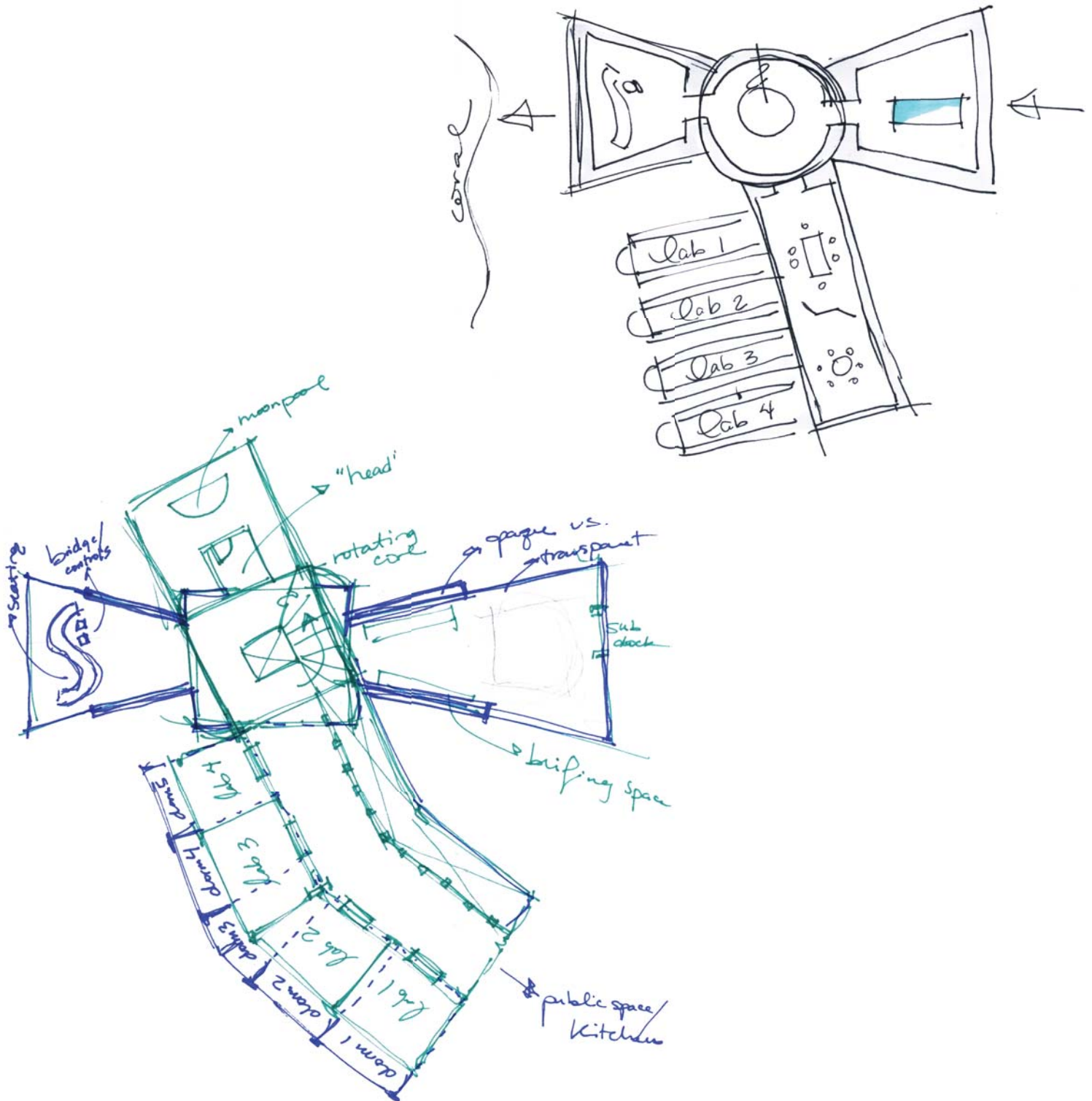


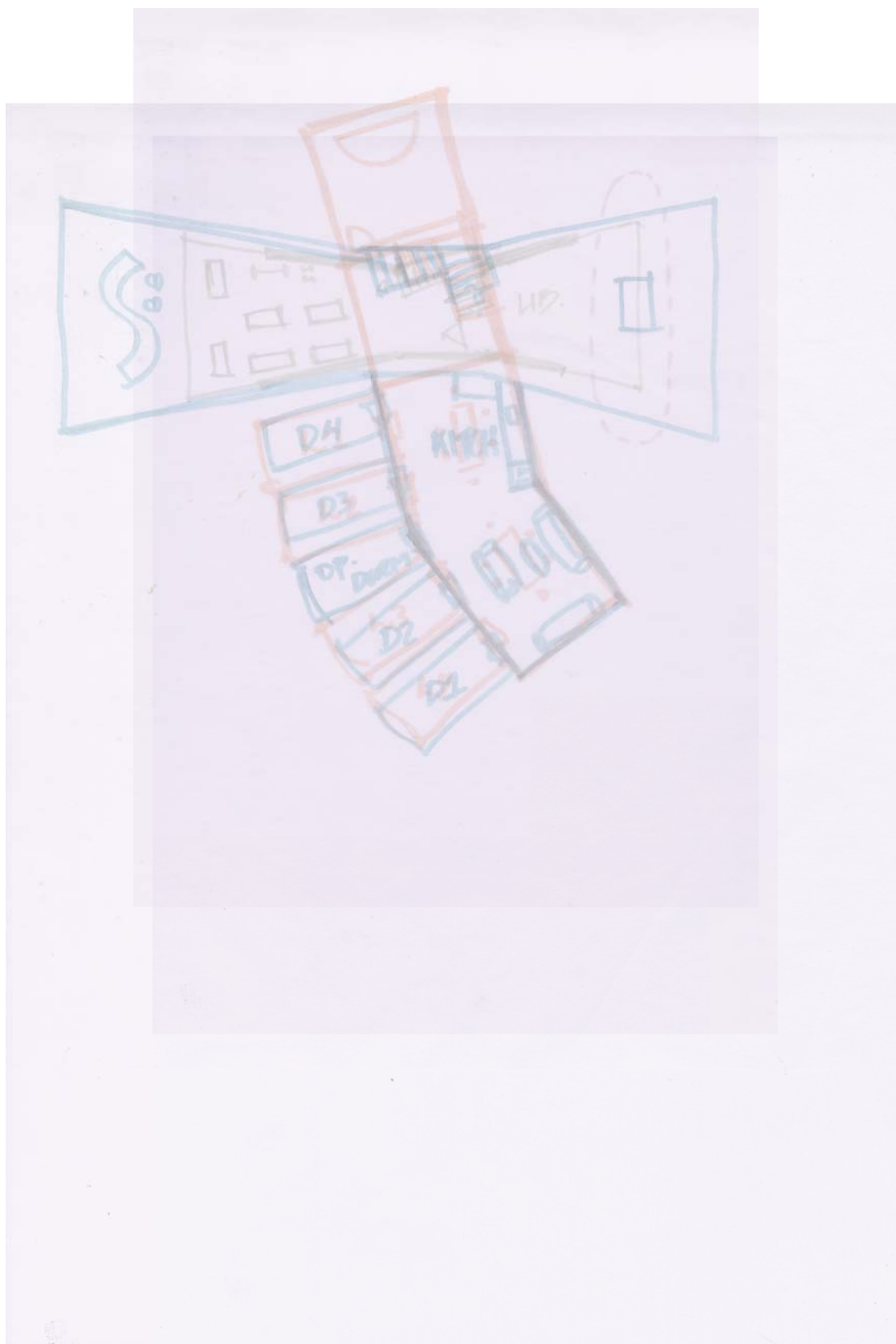
Experimenting with spatial arrangements in plan.



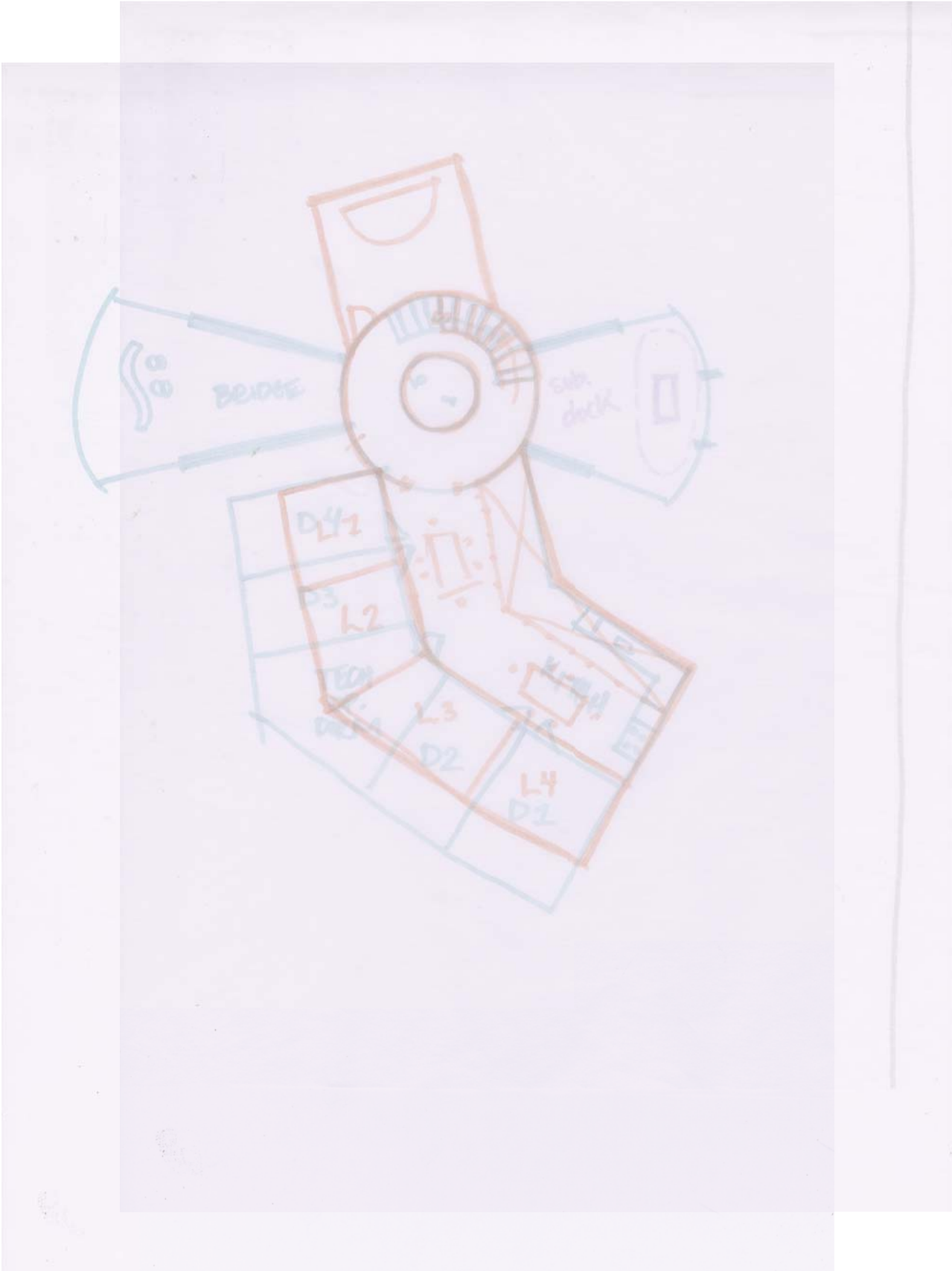
Process

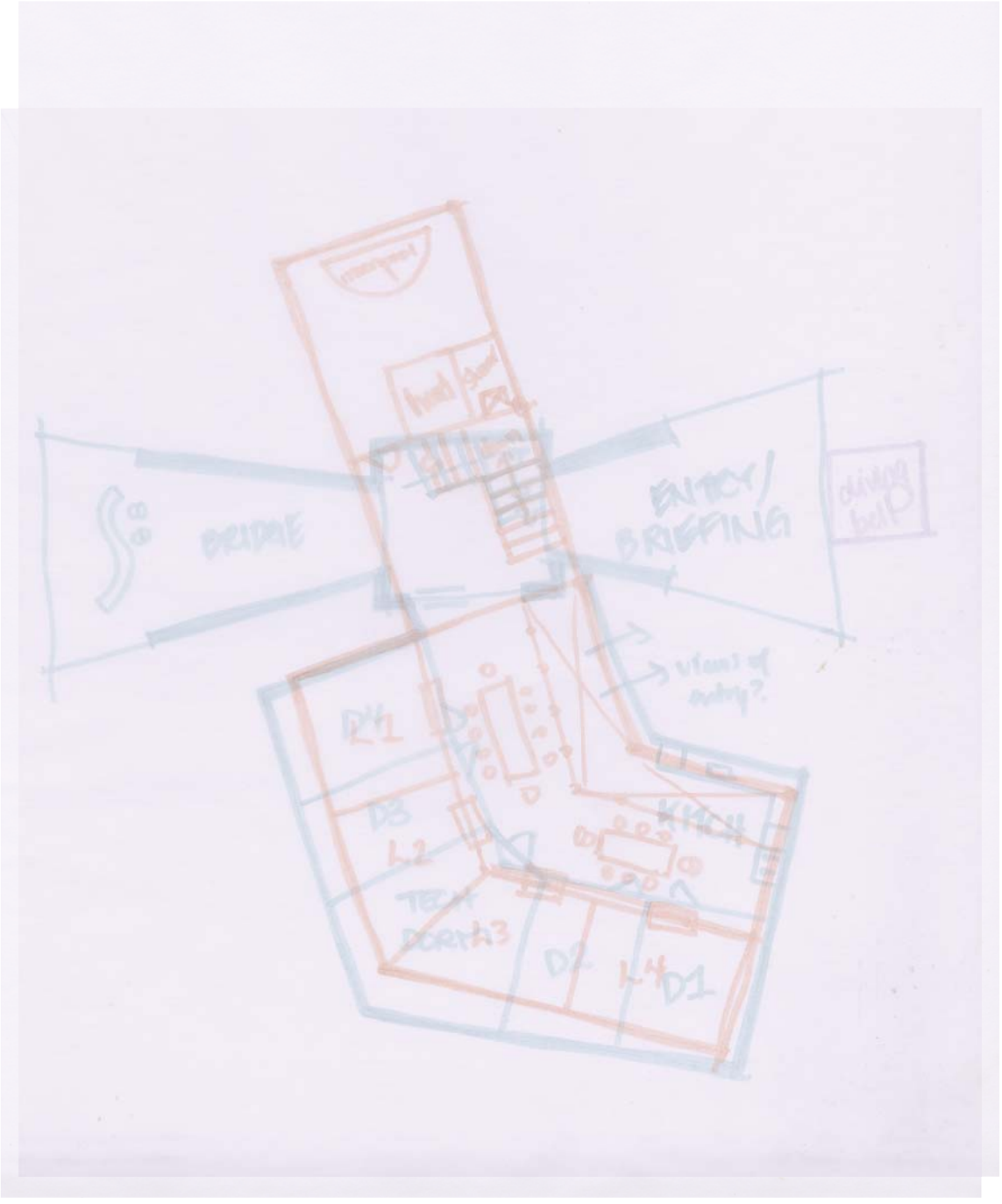
Working out a floorplan that will allow for ample top-lighting and the necessary separation of work and play.





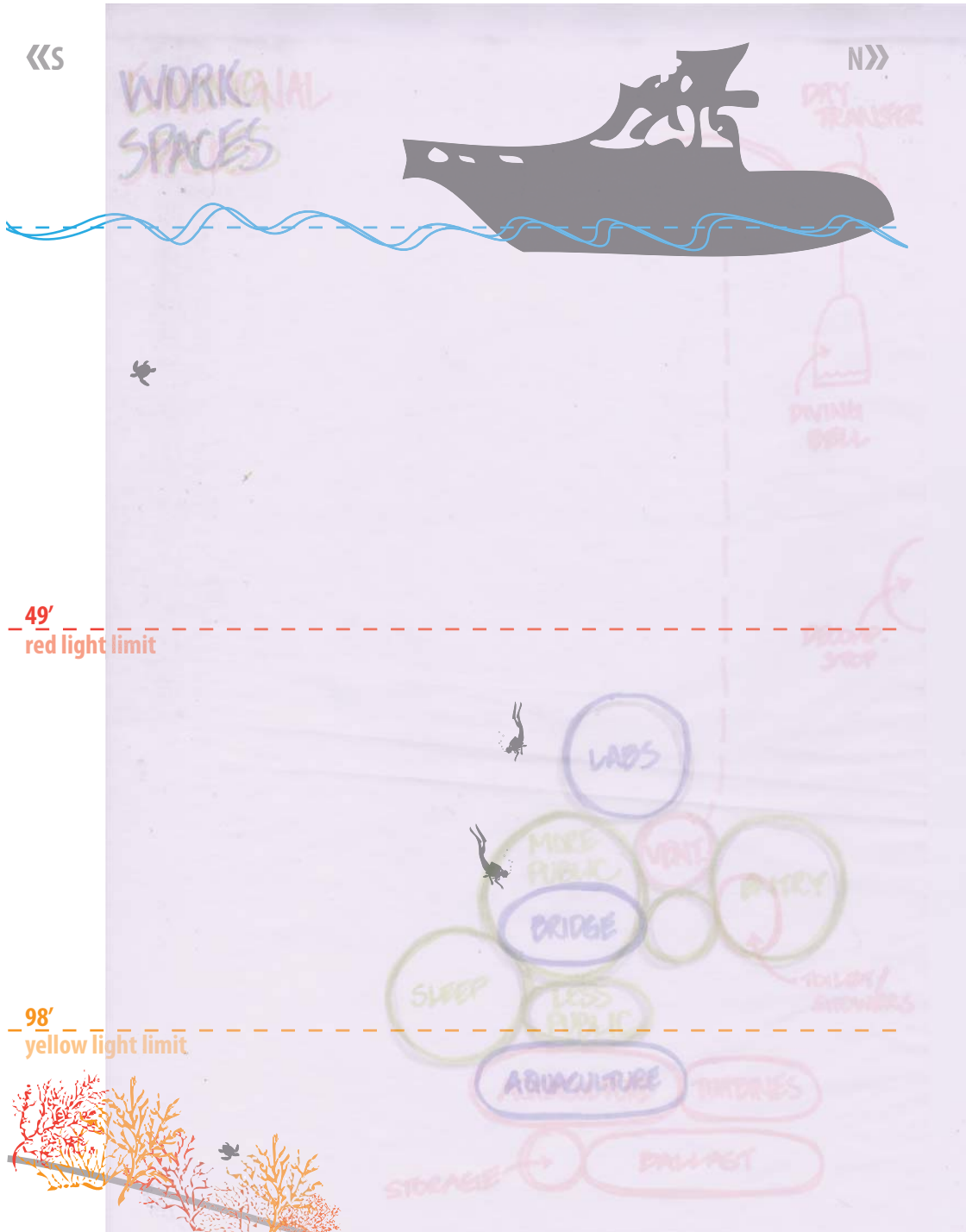
Process





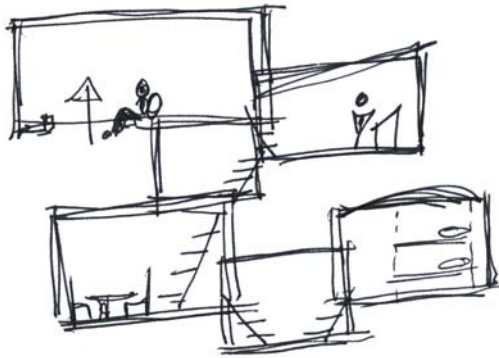
Process

Arranging spaces in section to allow for light, access, and centralized HVAC systems.

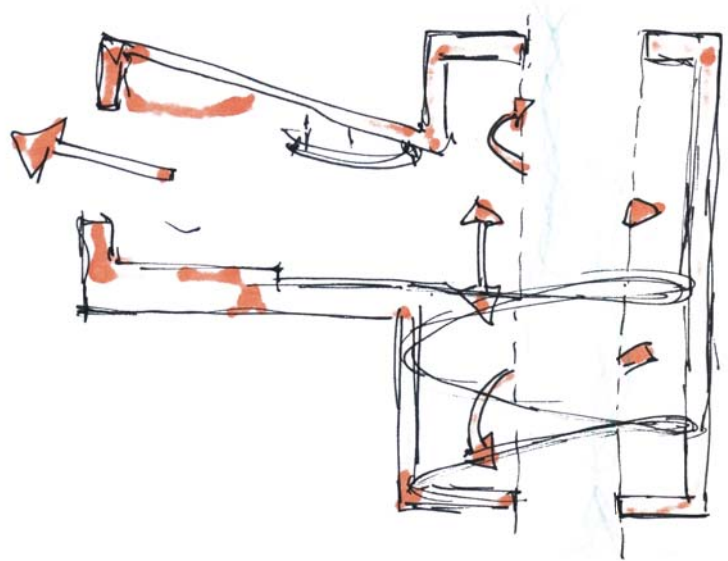
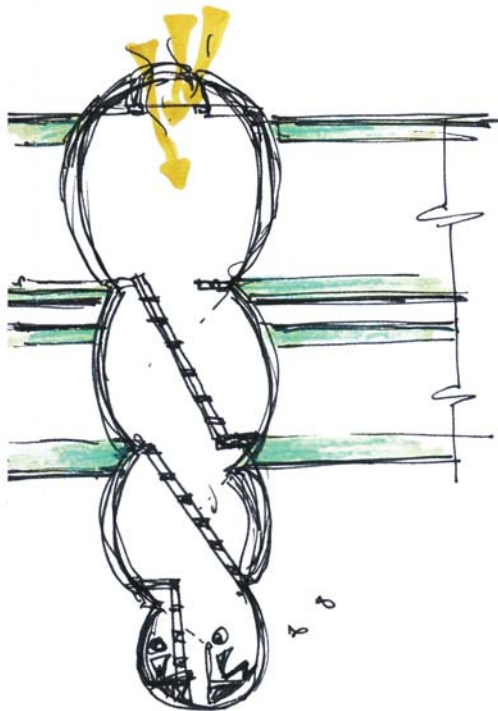


130'
SITE SECTION 1" = 10'

Considering different methods of vertical circulation.

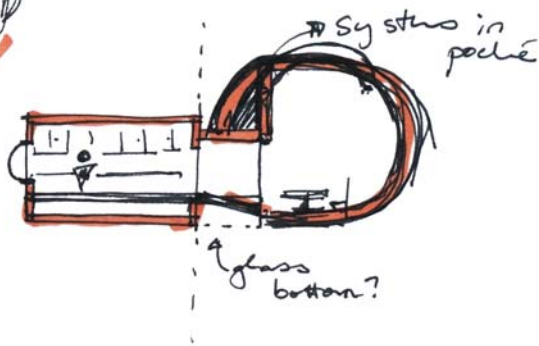
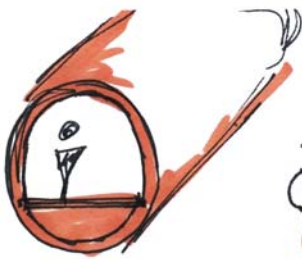
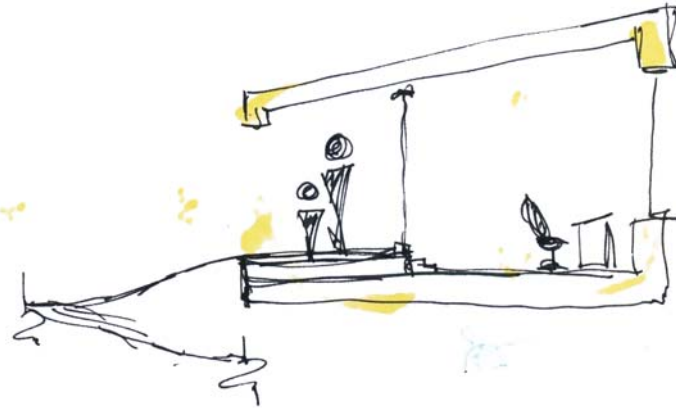


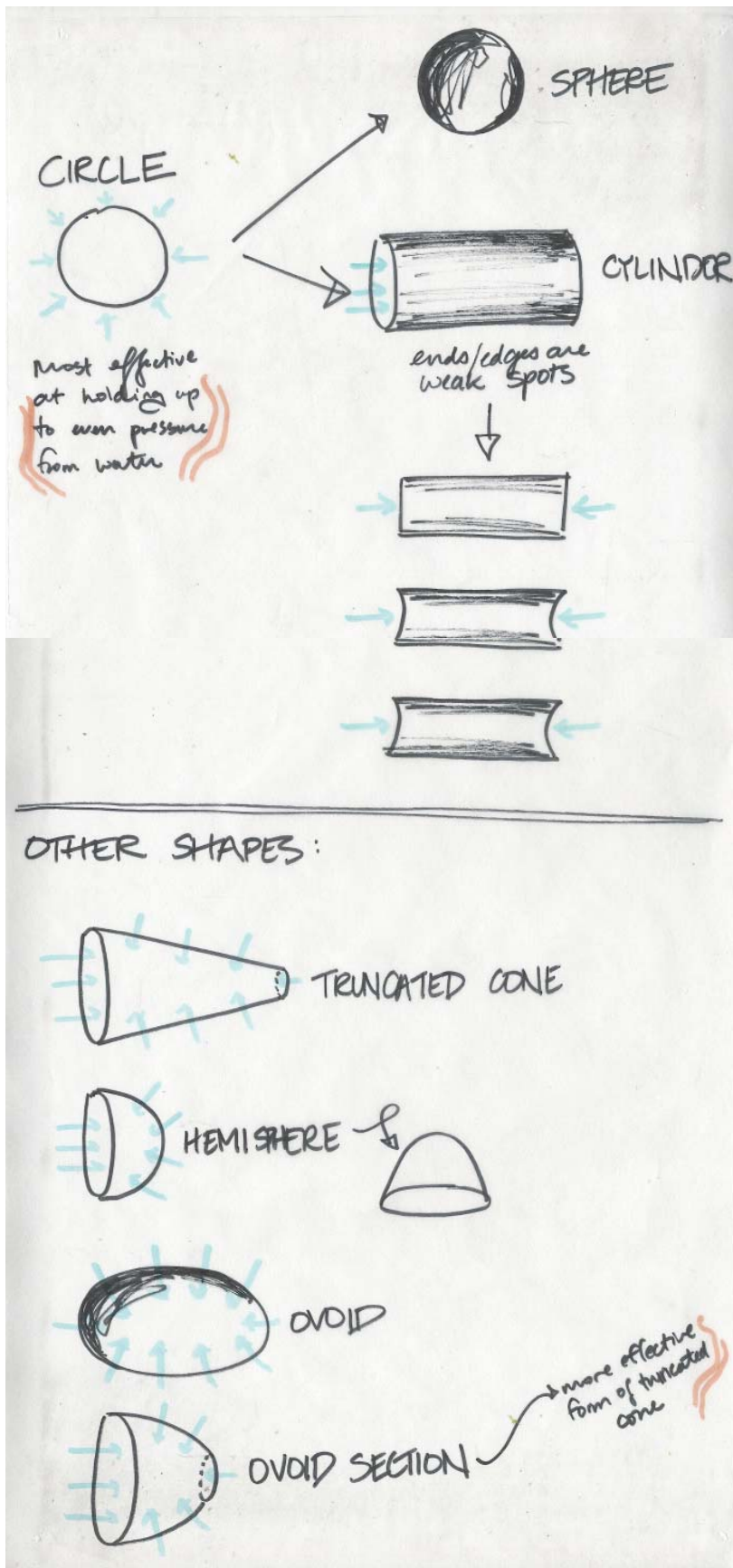
don't need
a stacked
circulation
core...



Process

Studying sectional properties of spaces in different shapes and positions.

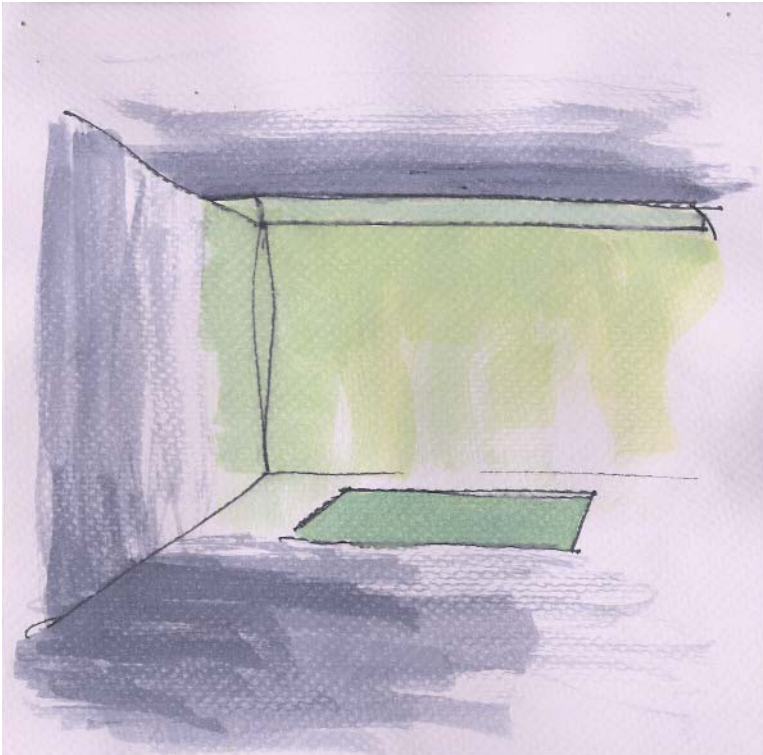




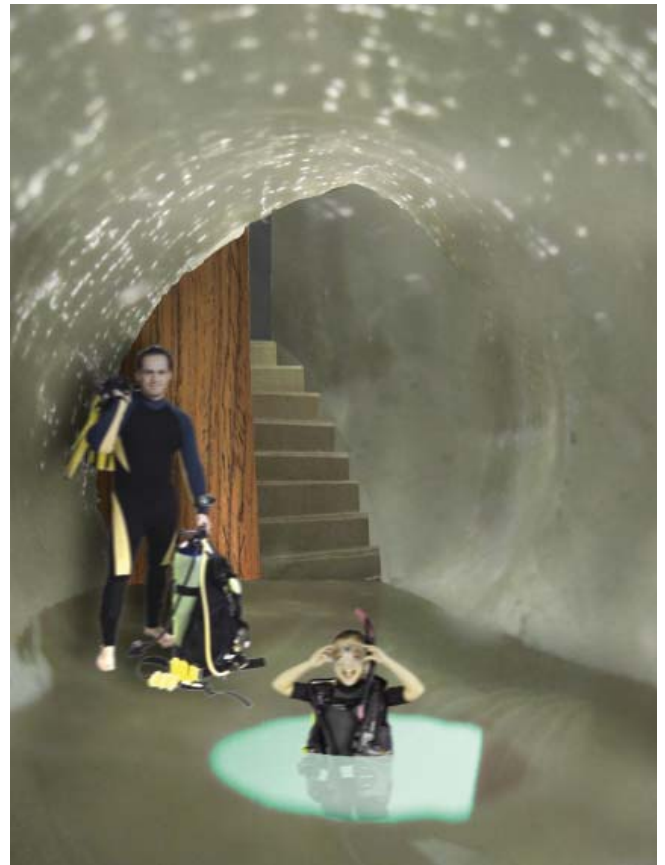
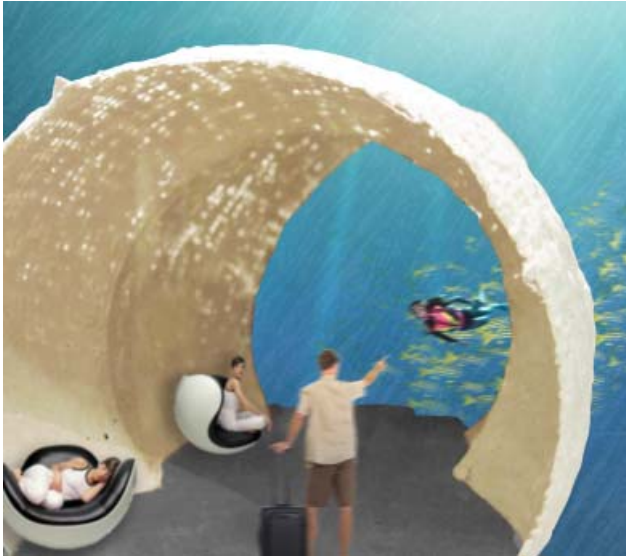
Determining which shapes are best-suited to withstand undersea pressures.

Process

Watercolor lighting study.

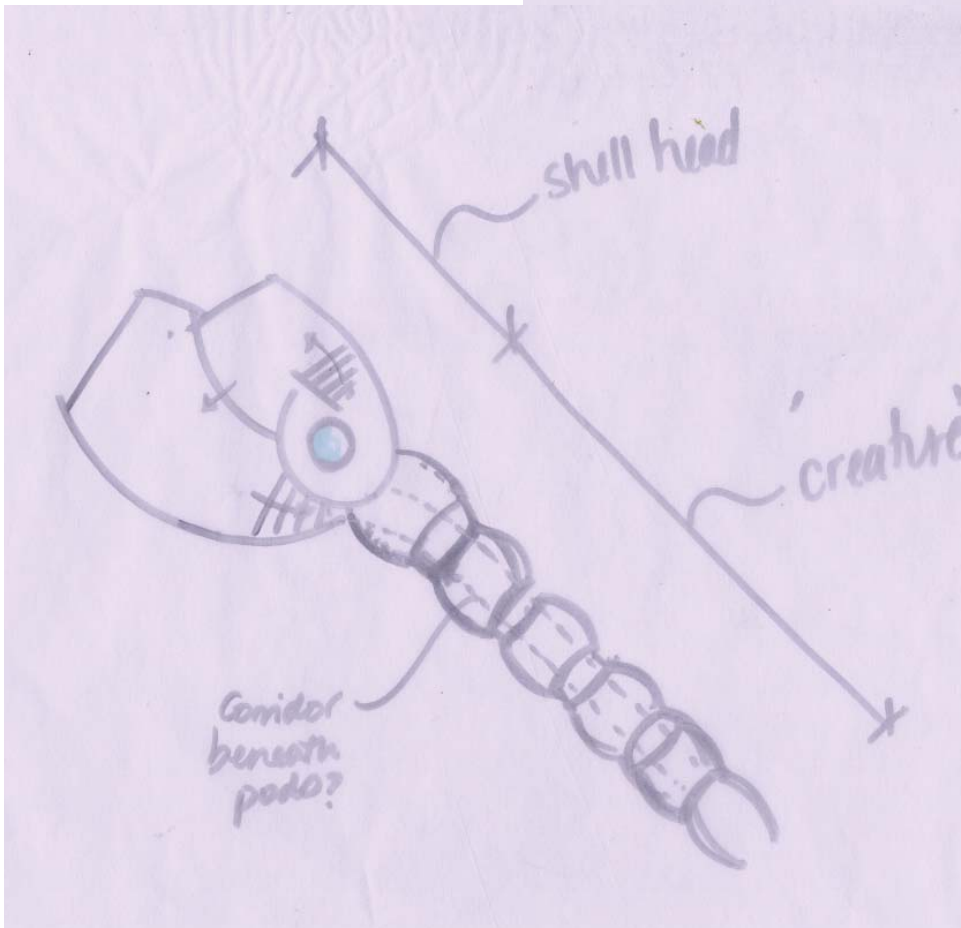
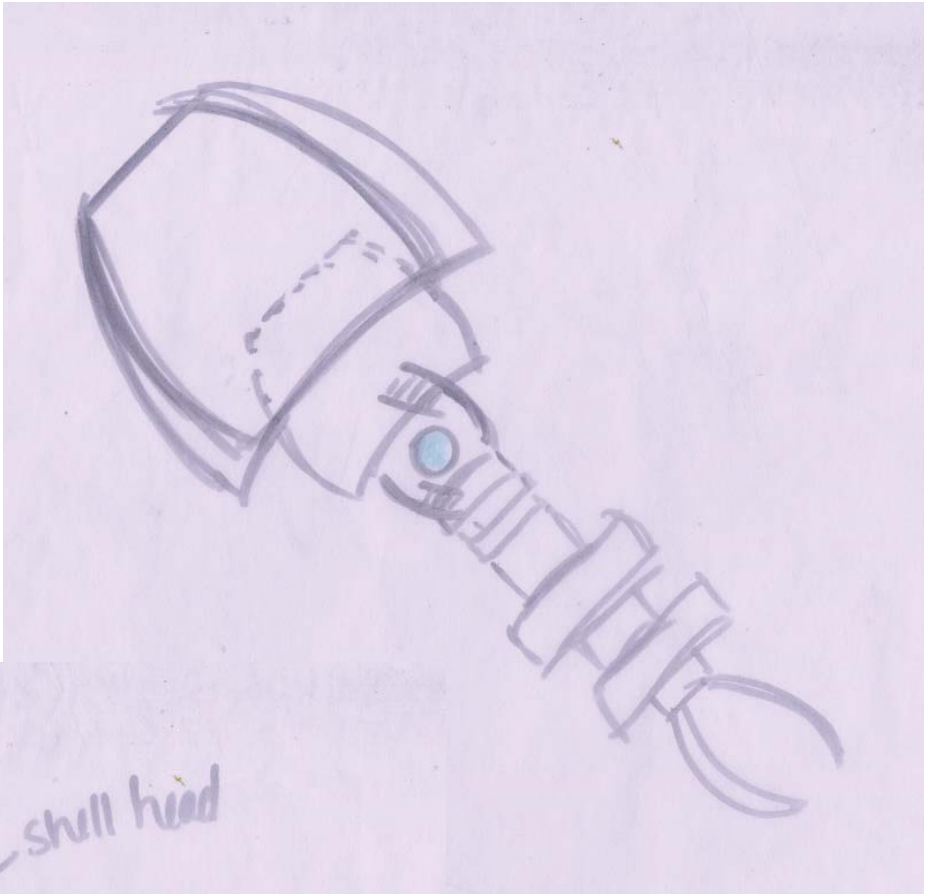


Experimenting with lighting qualities in Photoshop.

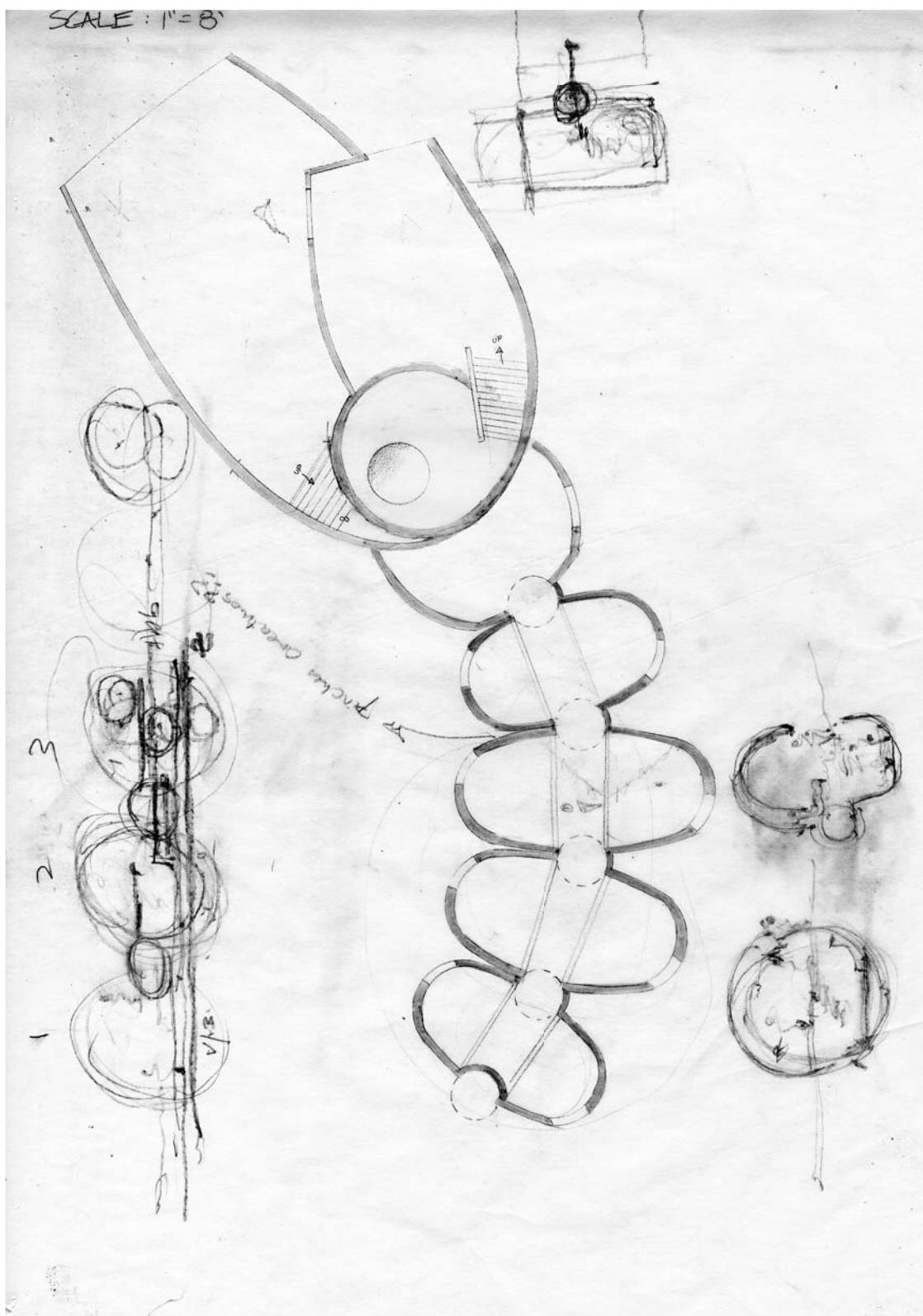


Process

New floorplan emerges, inspired by the organization of sea creatures.

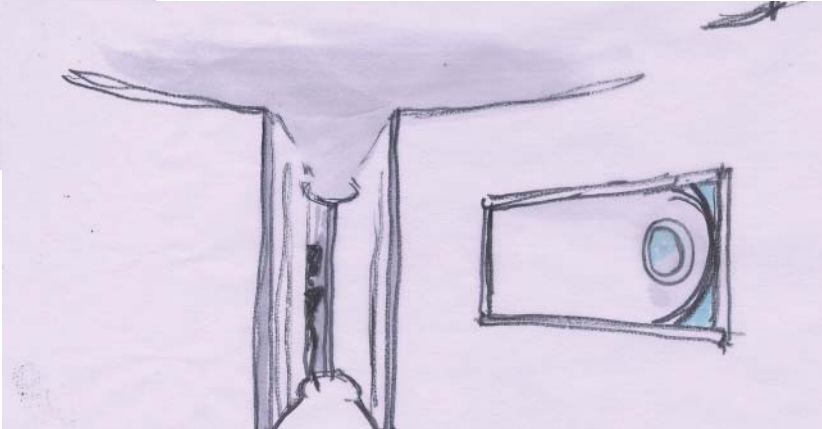
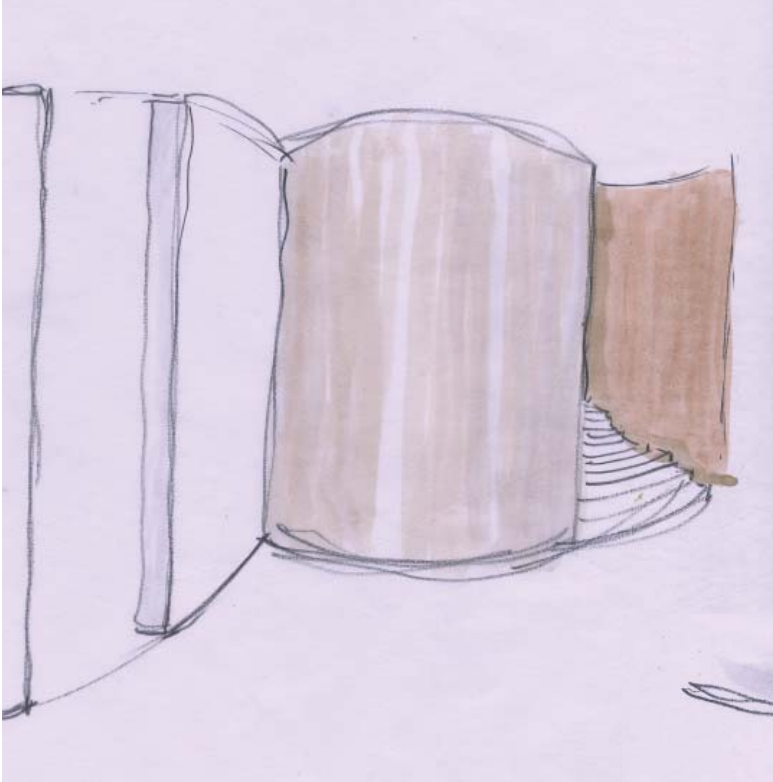
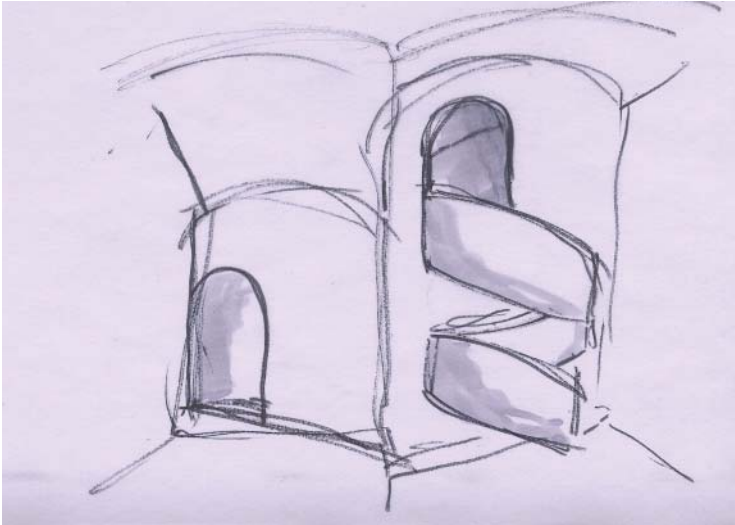


Developing floor plan.

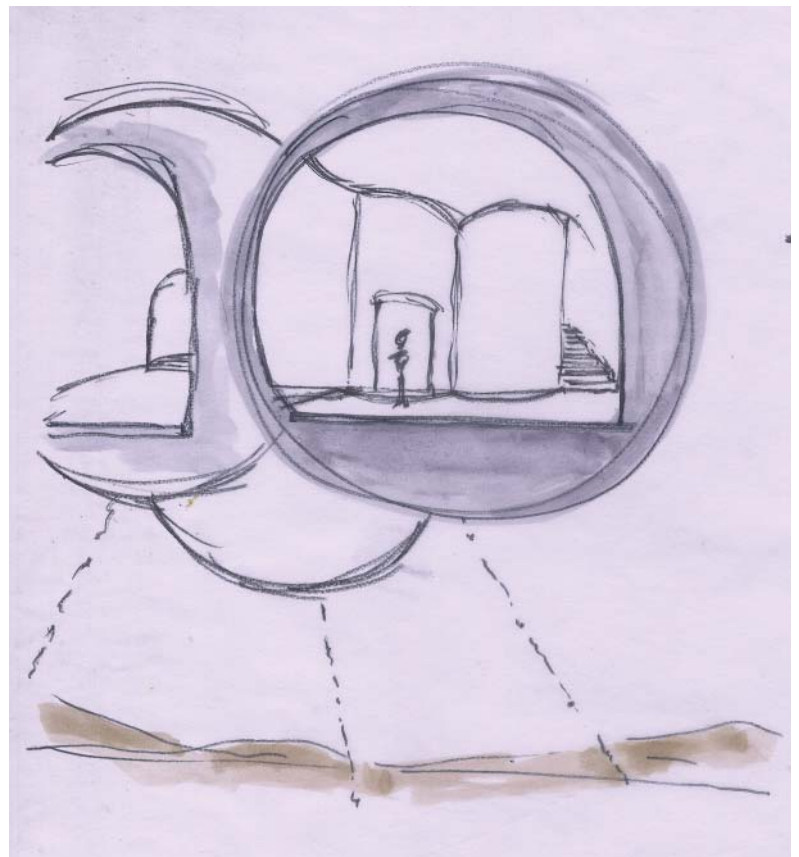
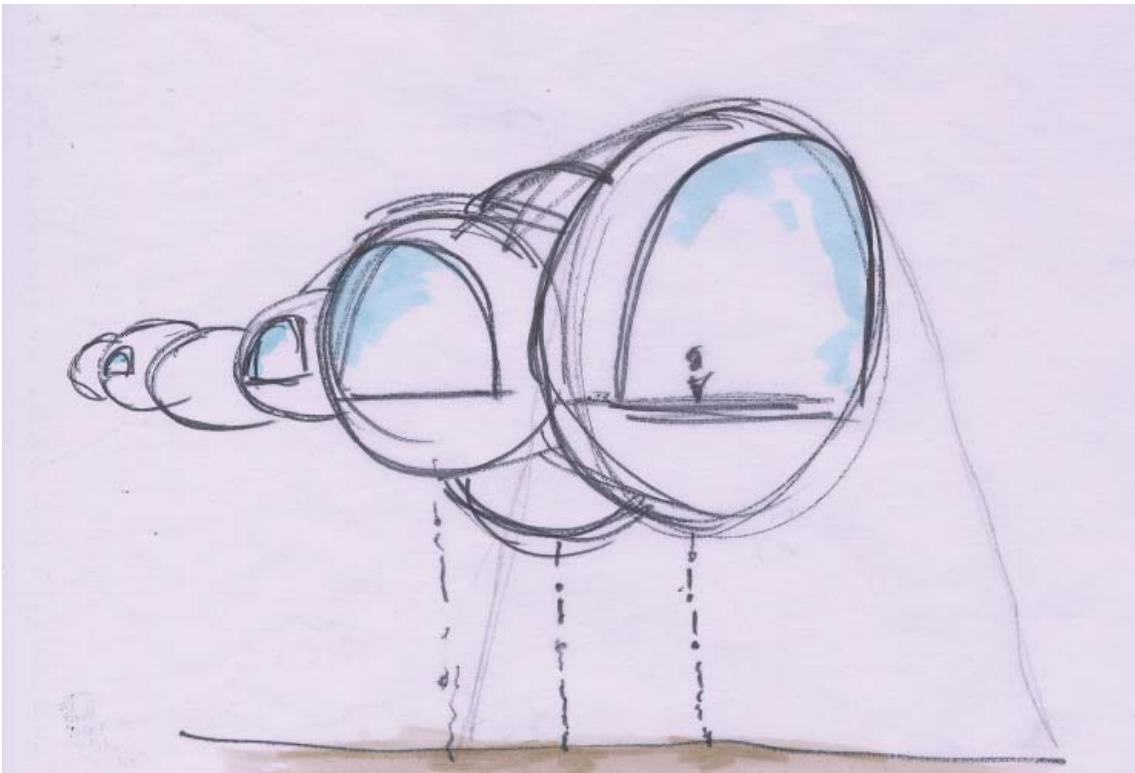


Process

Interior vignettes.

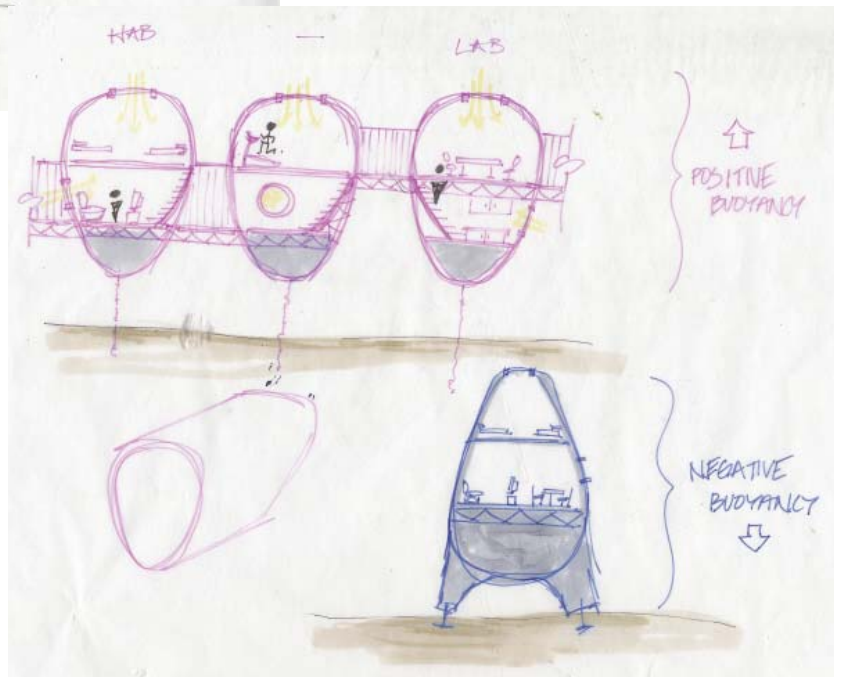
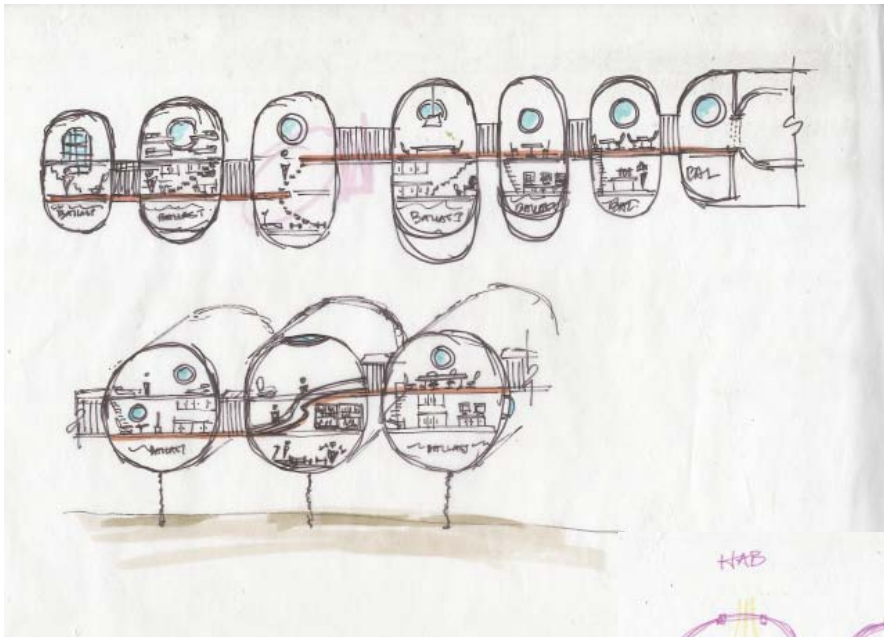
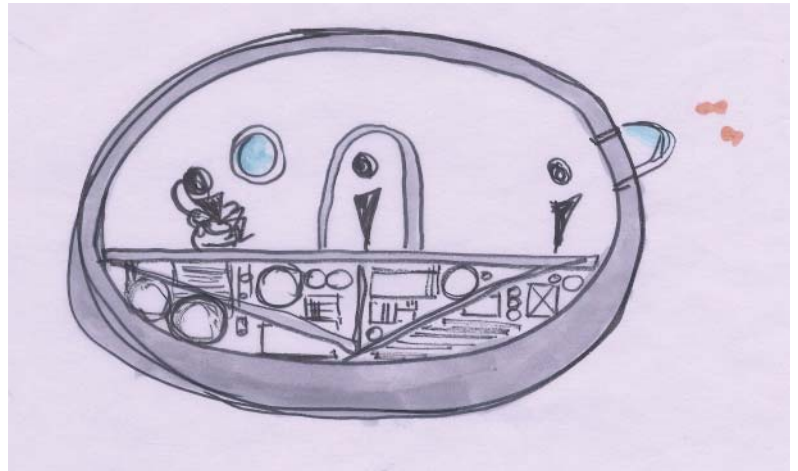


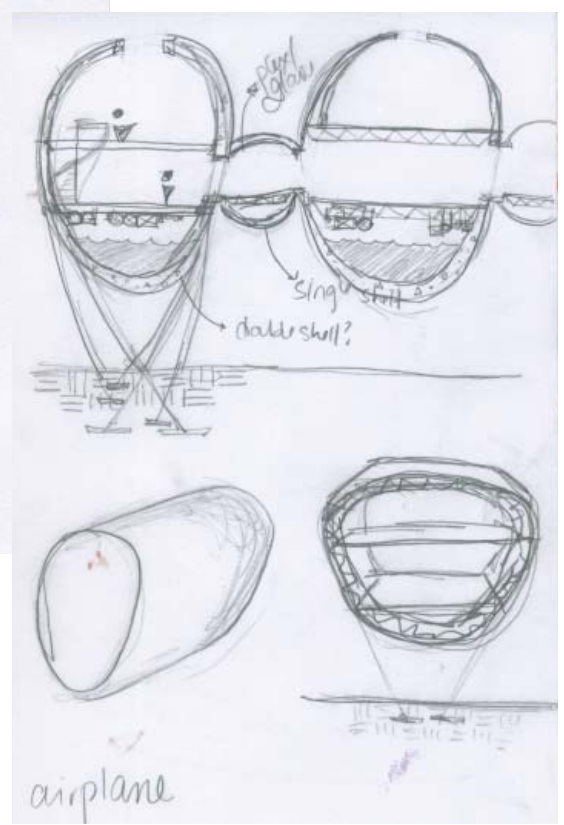
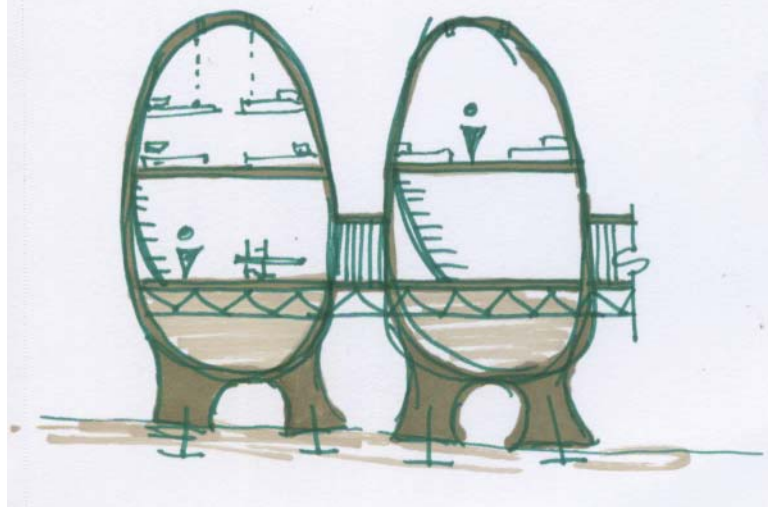
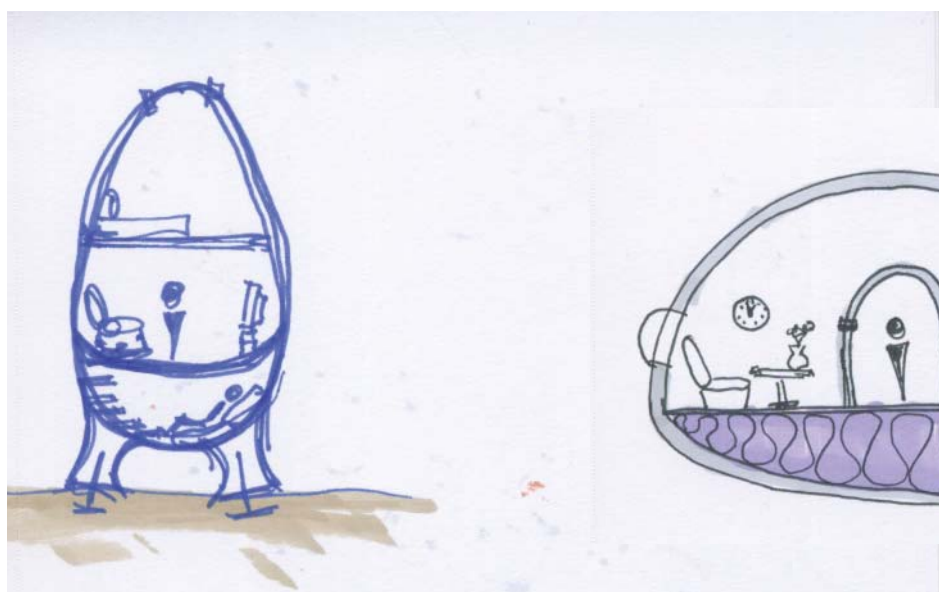
Exterior vignettes.



Process

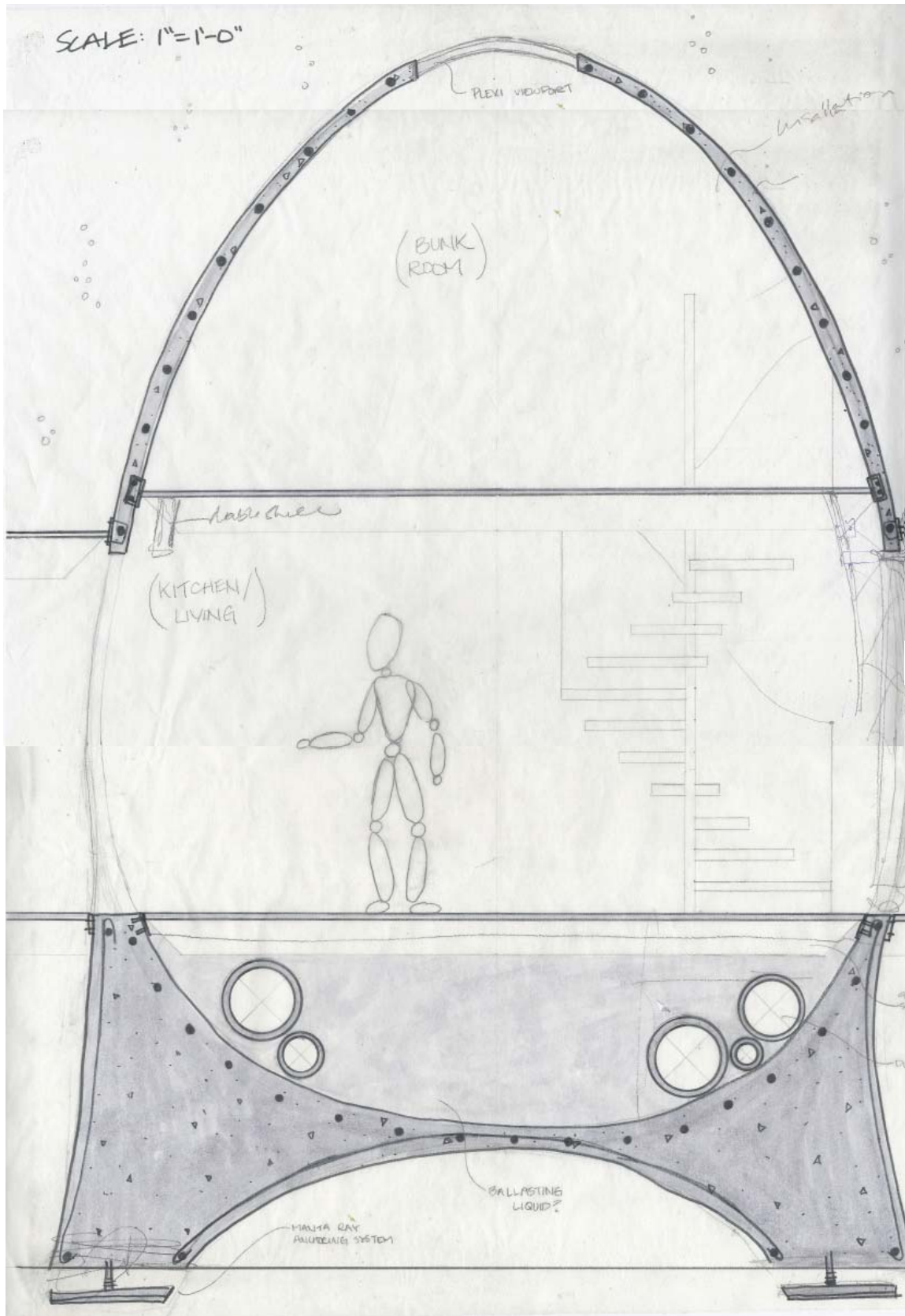
Developing section of pod.



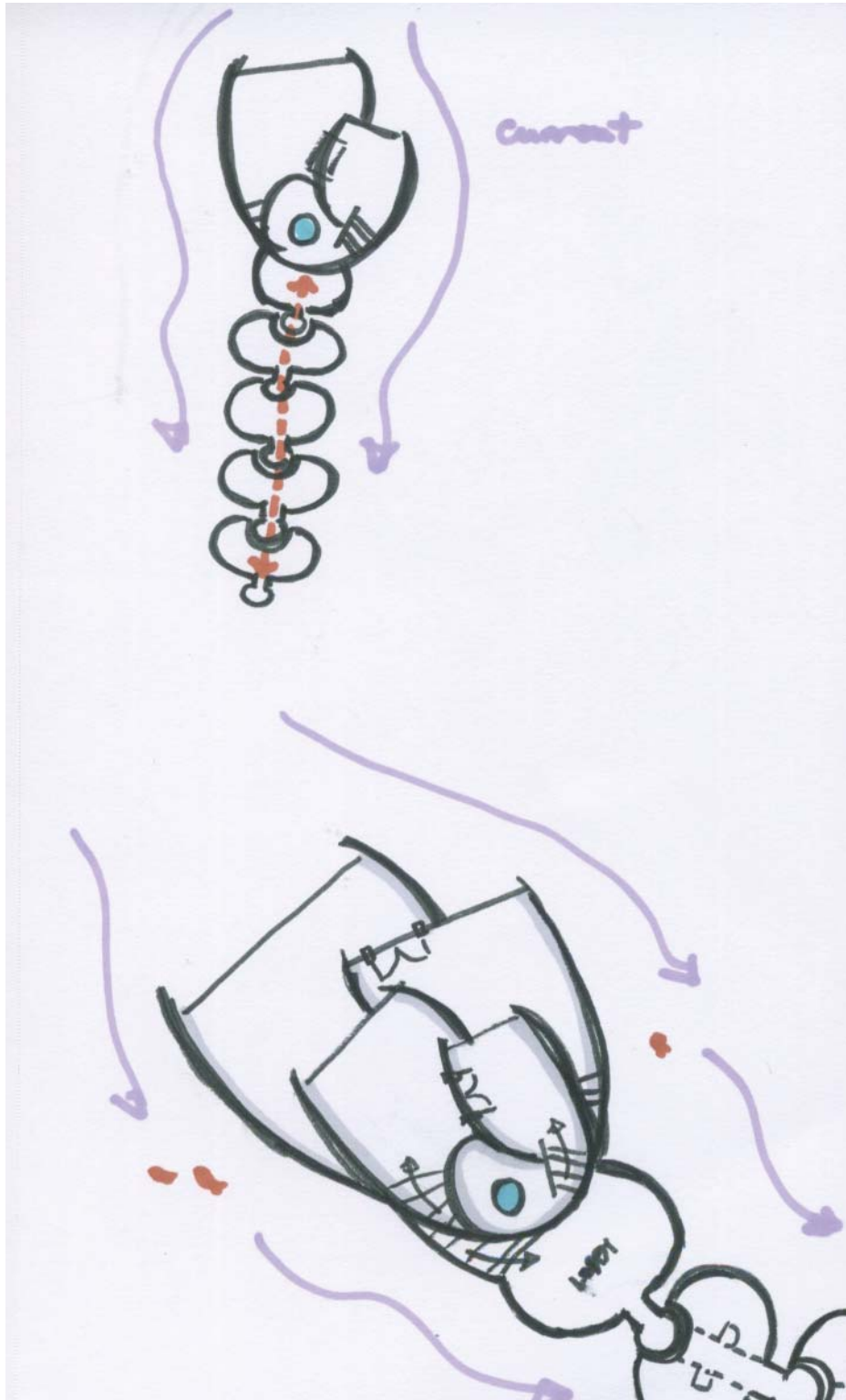


Process

Developing section of pod.

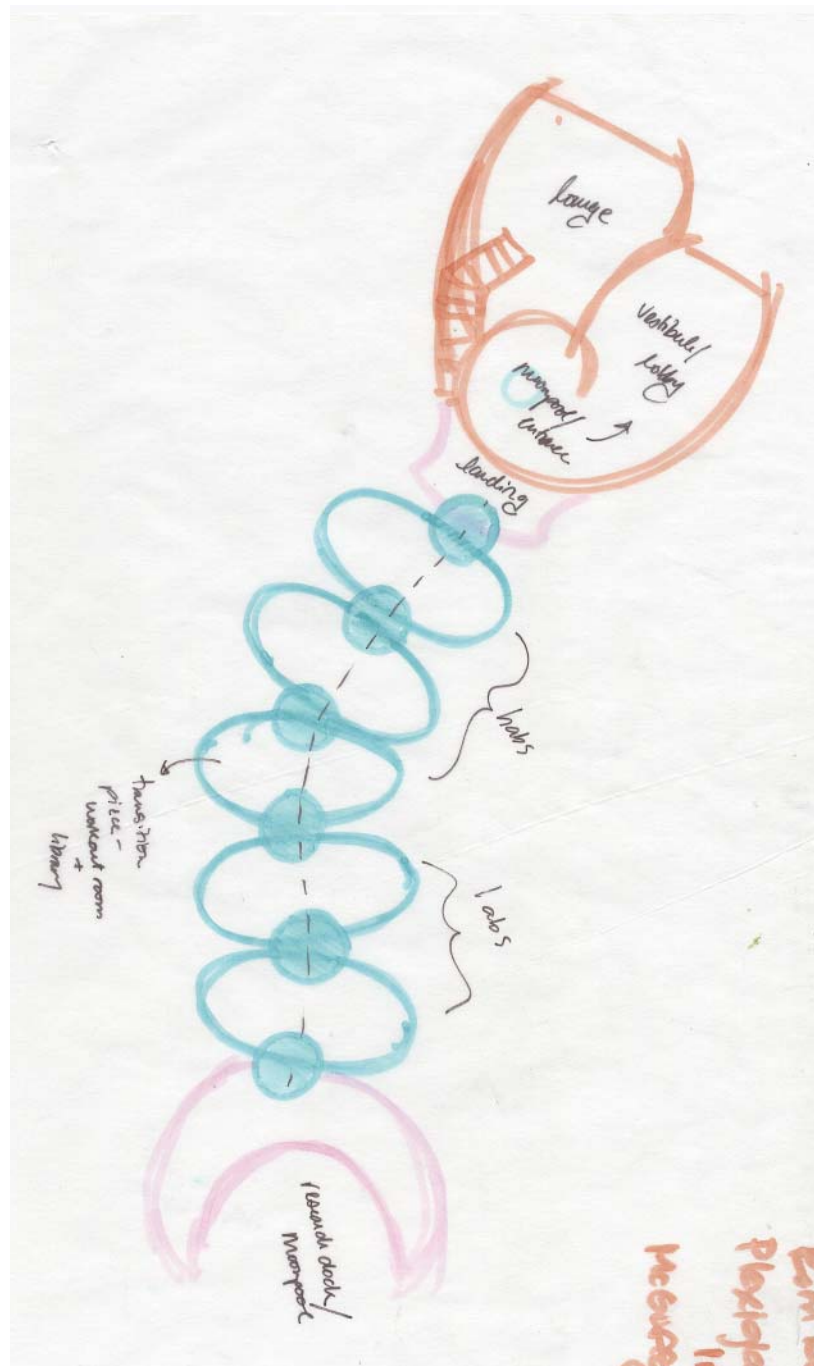
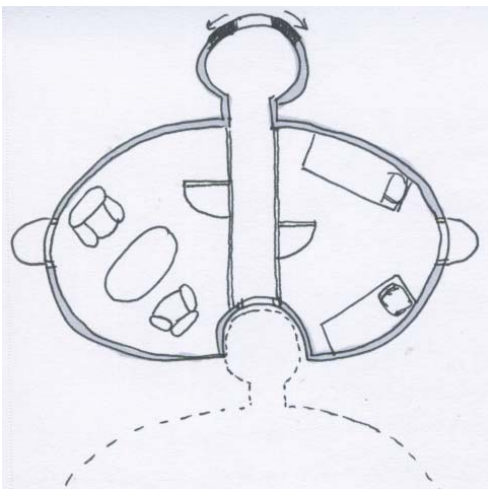


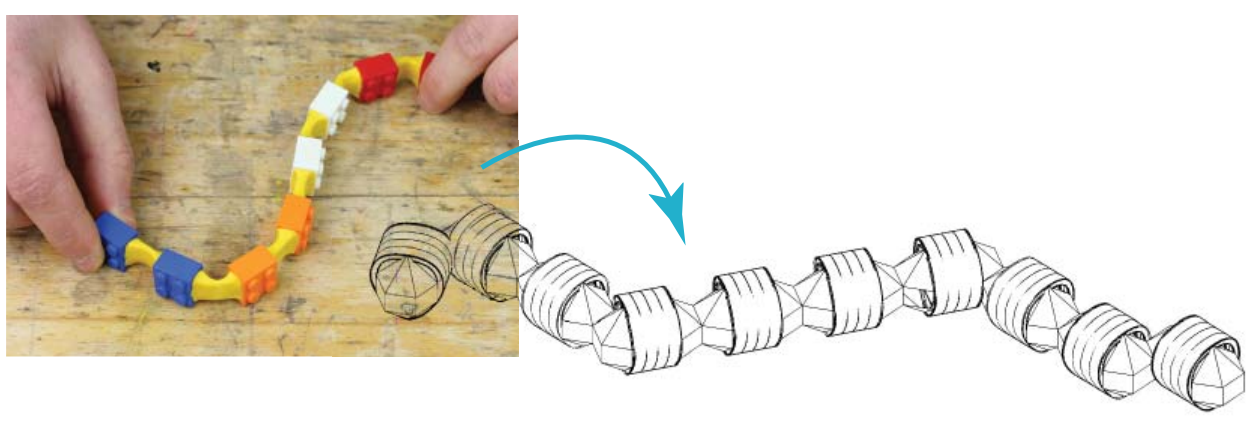
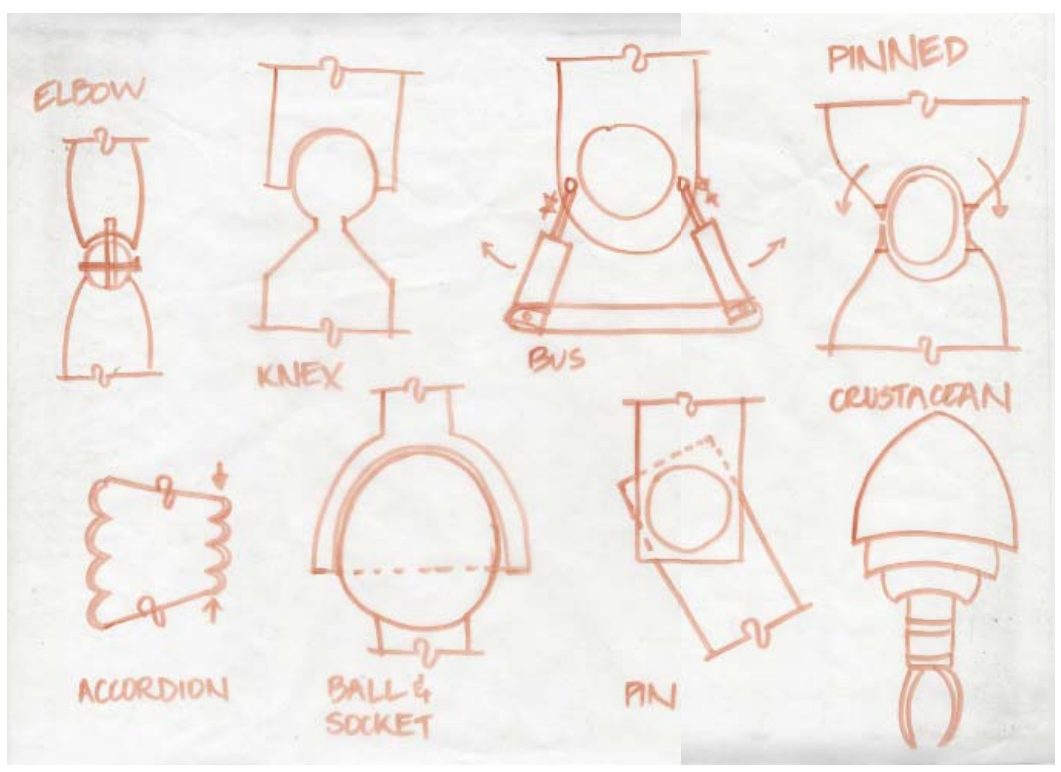
Layering 'shell' spaces in plan.



Process

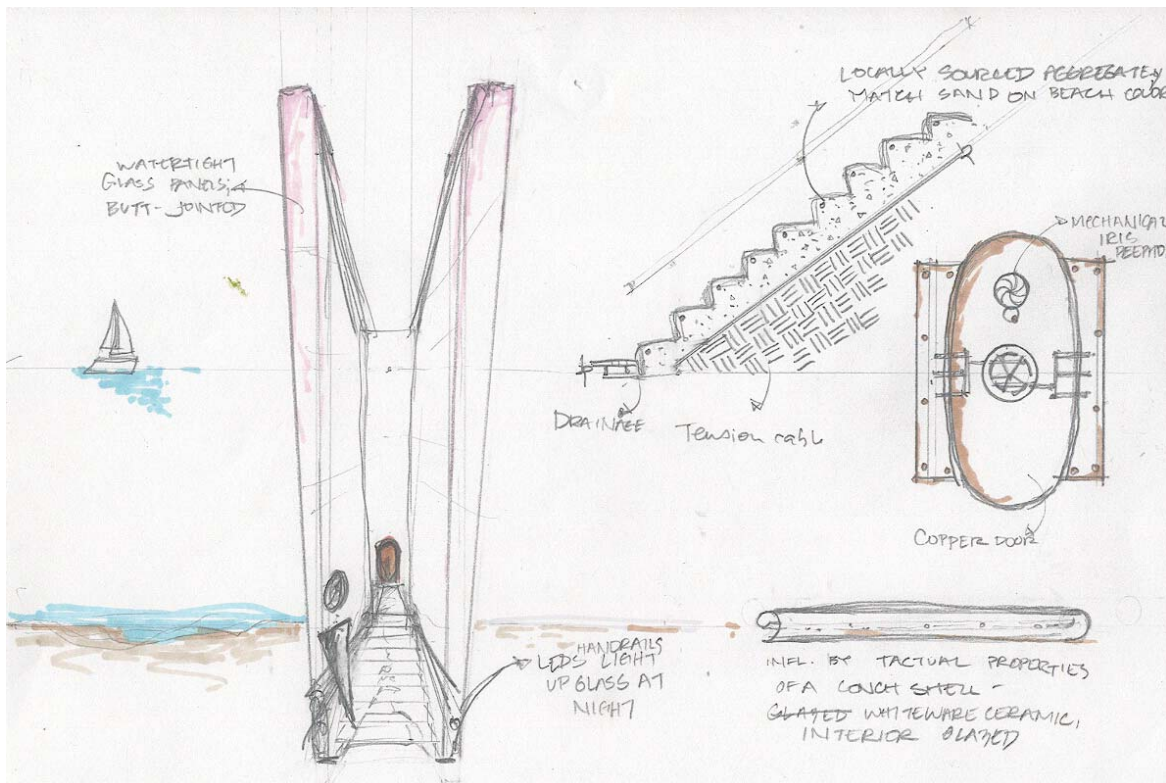
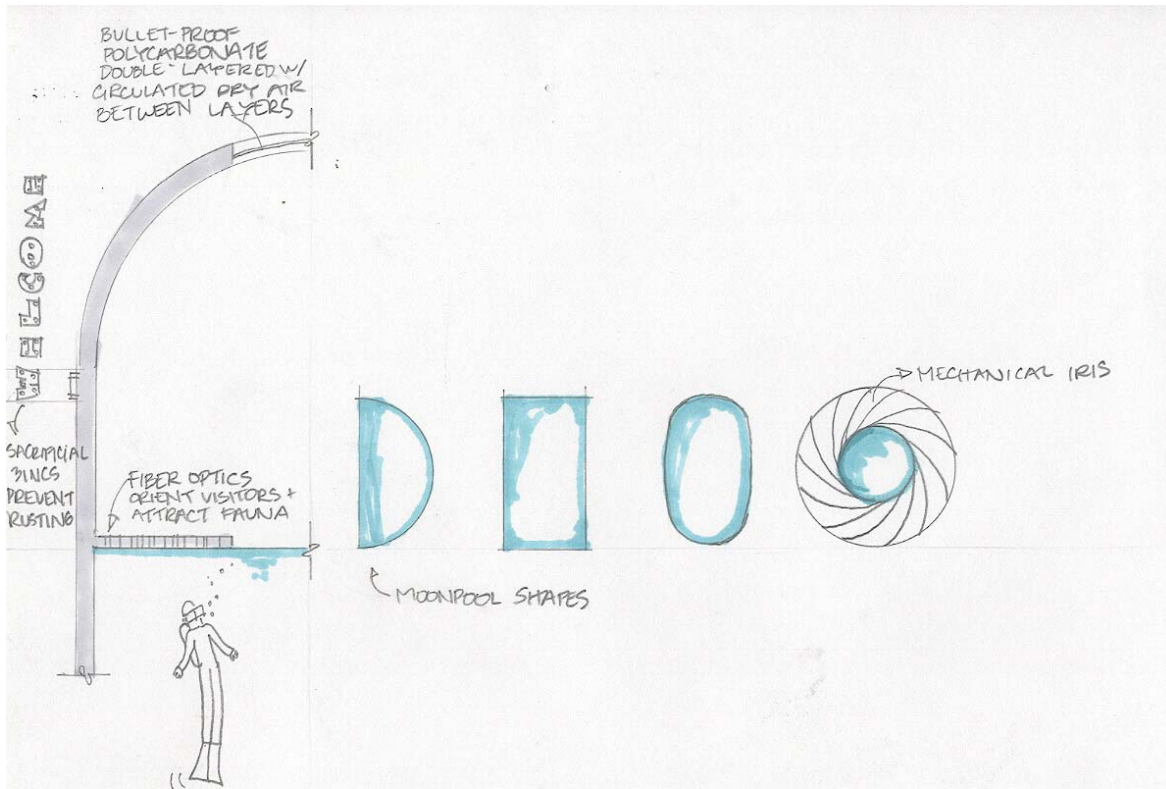
Developing joints between pods.



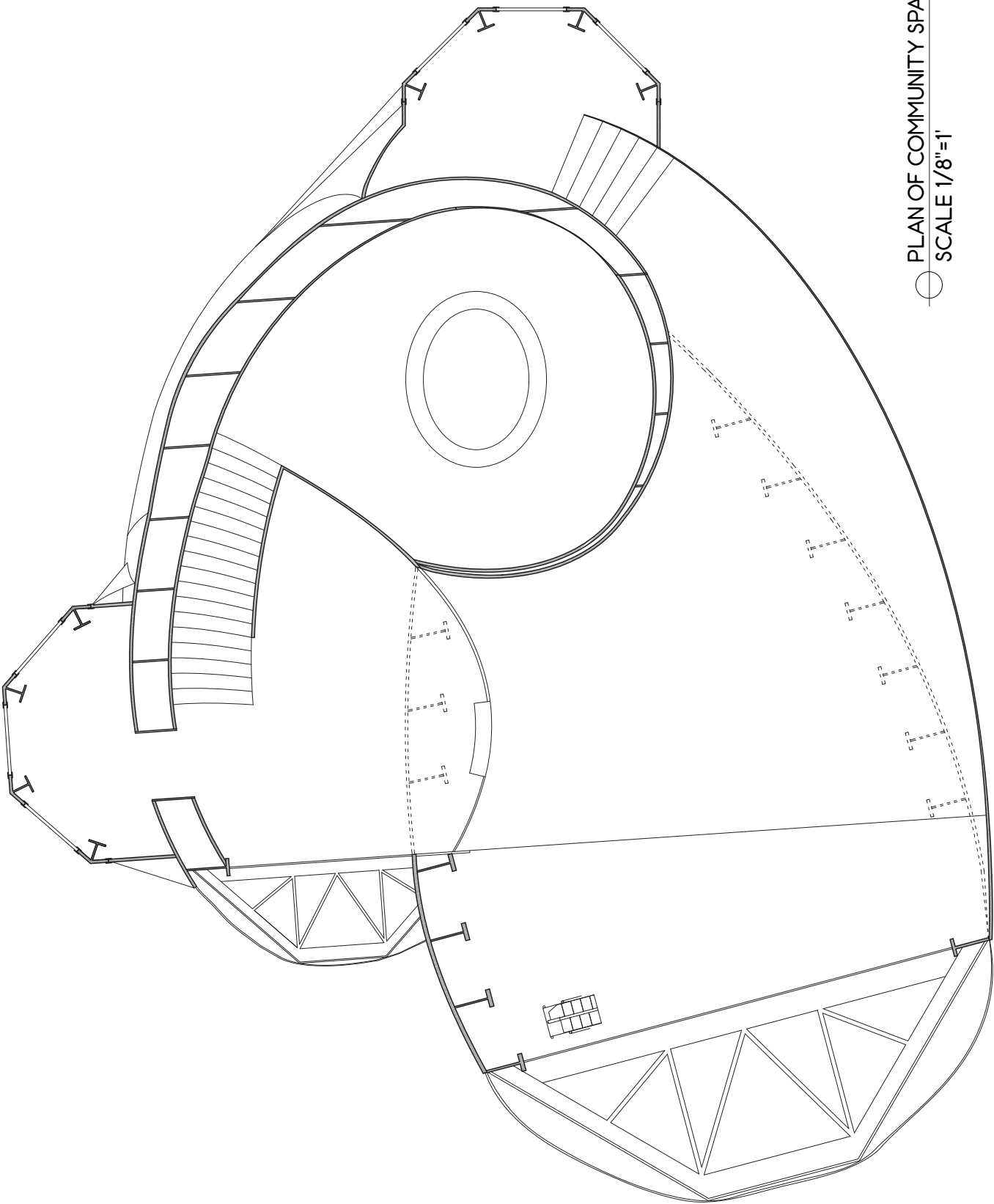


Process

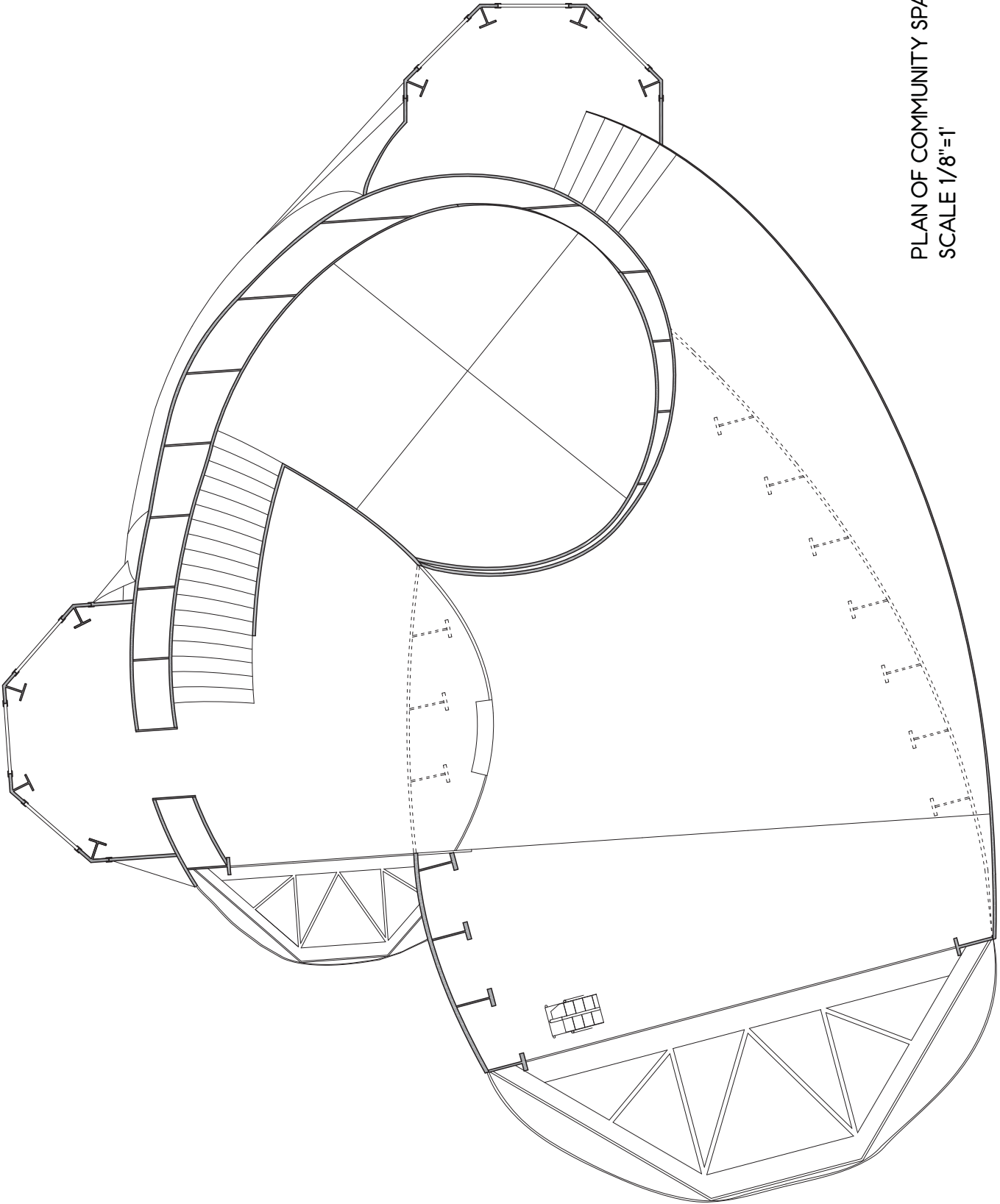
Working out details of moonpool and shore dock.



FINAL DRAWINGS

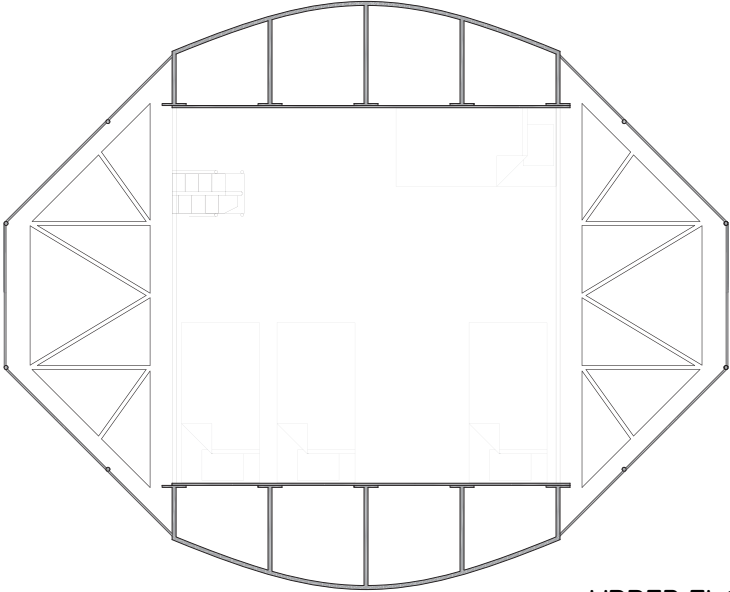


PLAN OF COMMUNITY SPACES
SCALE 1/8"=1'

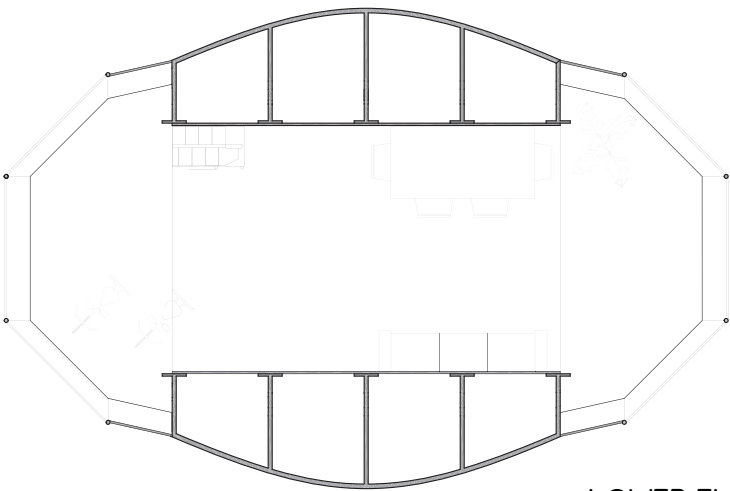


PLAN OF COMMUNITY SPACES
SCALE 1/8"=1'

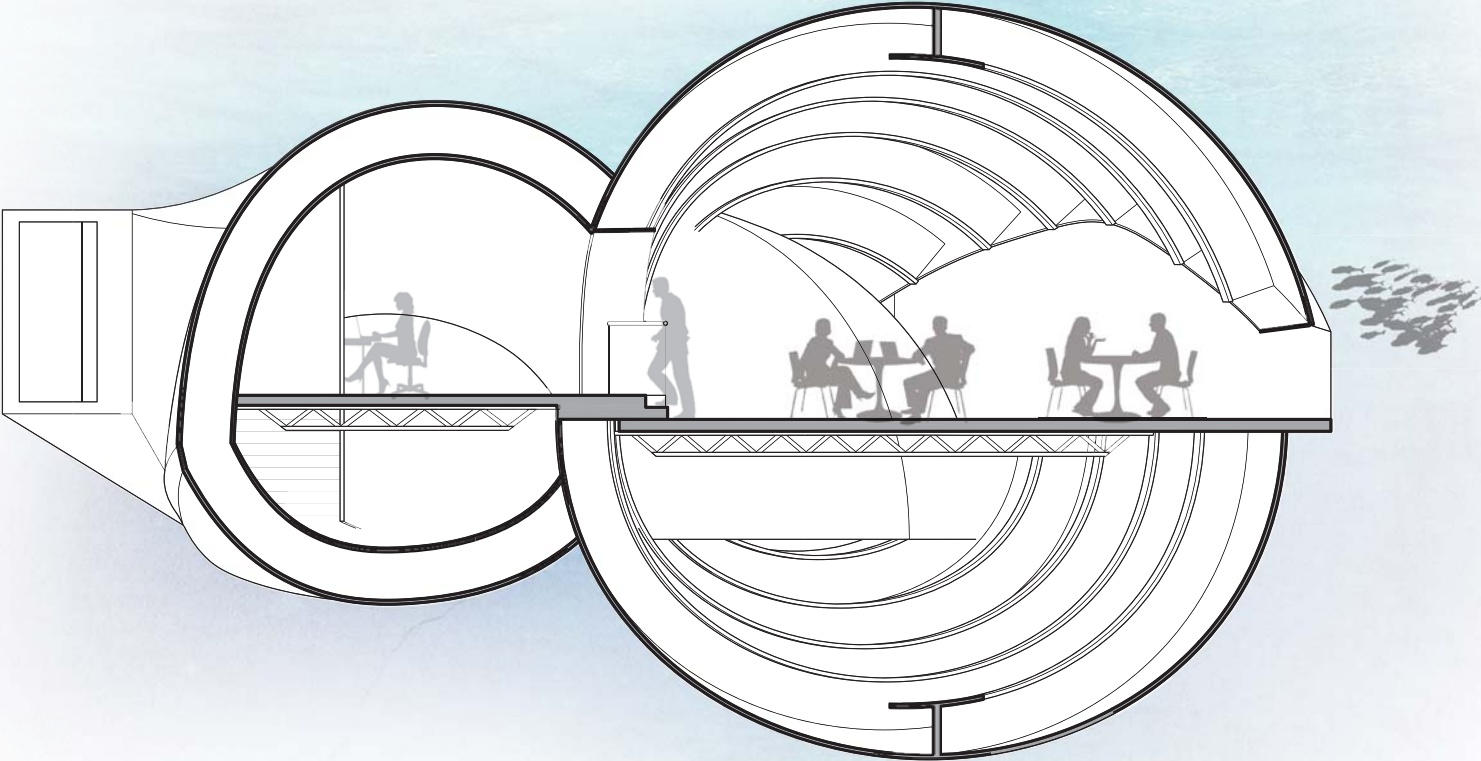
Plans



○ UPPER FLOOR OF POD
SCALE 1/8"=1'

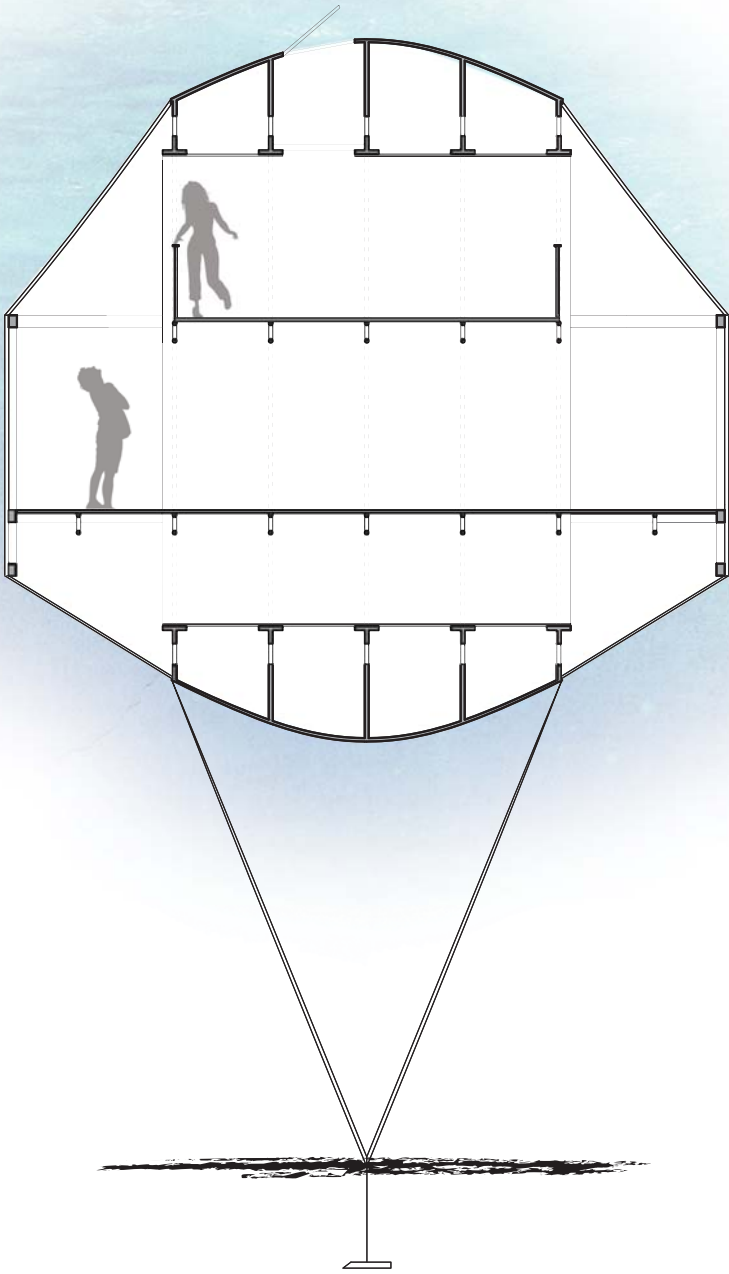


○ LOWER FLOOR OF POD
SCALE 1/8"=1'

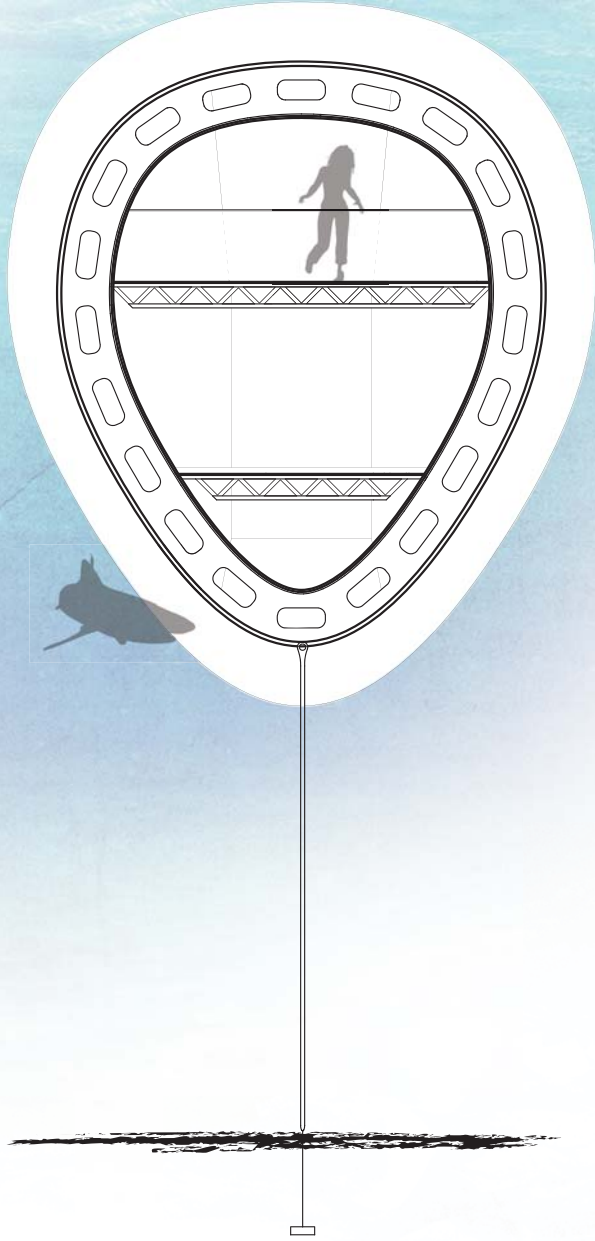


SECTION OF COMMUNITY SPACES
SCALE 1/8"=1'

Sections

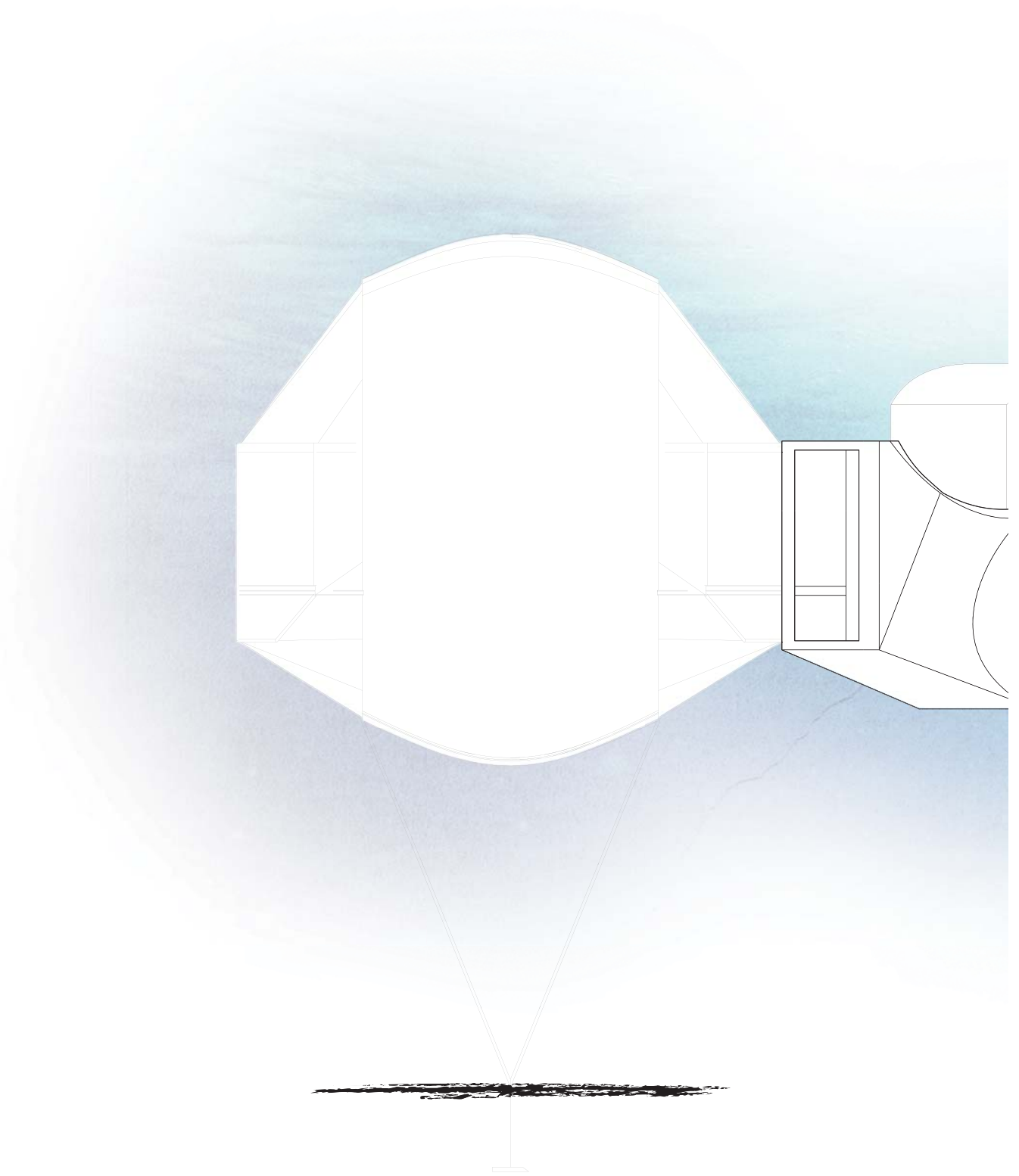


○ TRANSVERSE SECTION OF POD
SCALE 1/8"=1'

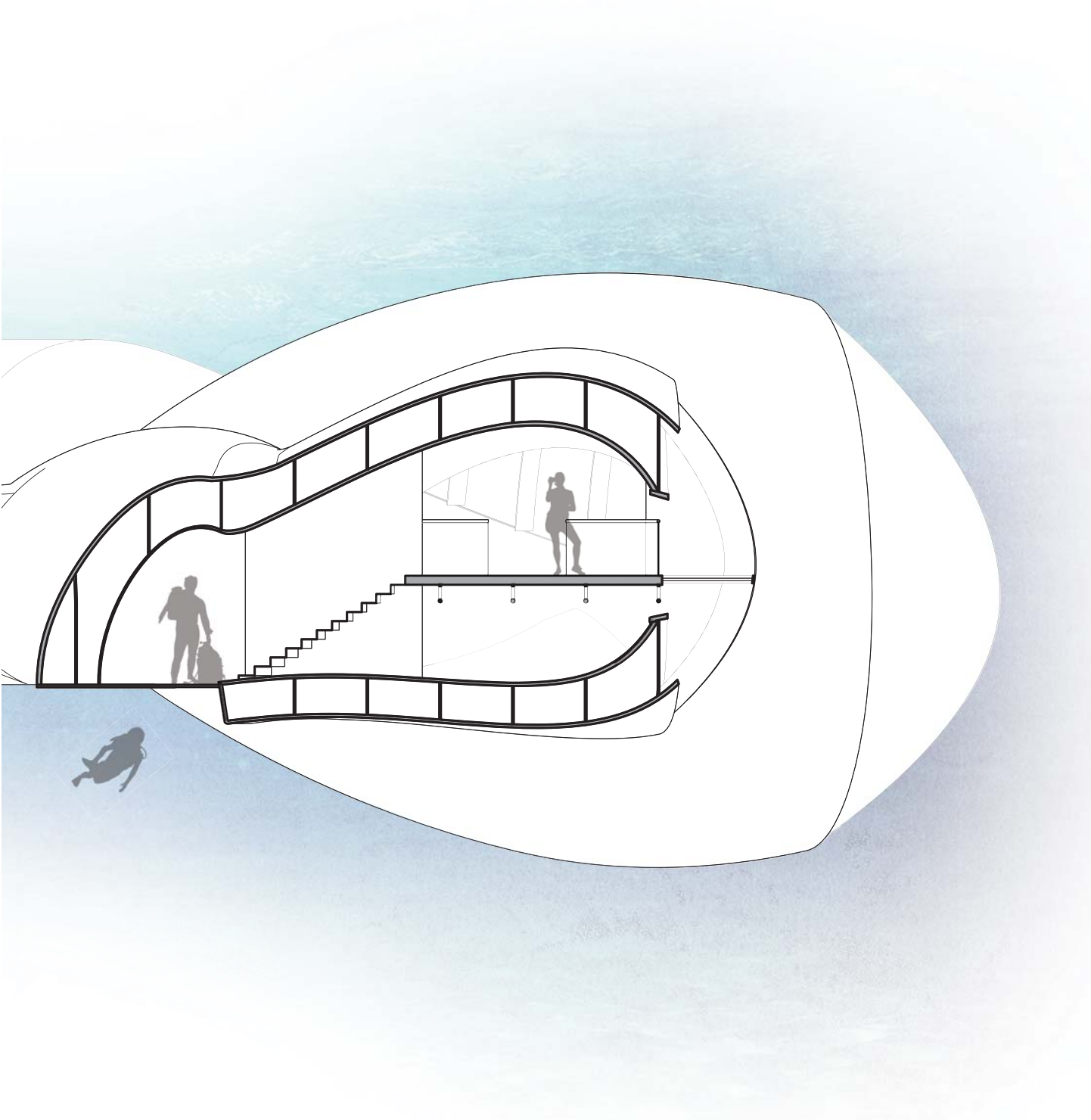


⊙ CROSS SECTION OF POD
SCALE 1/8"=1'

Sections

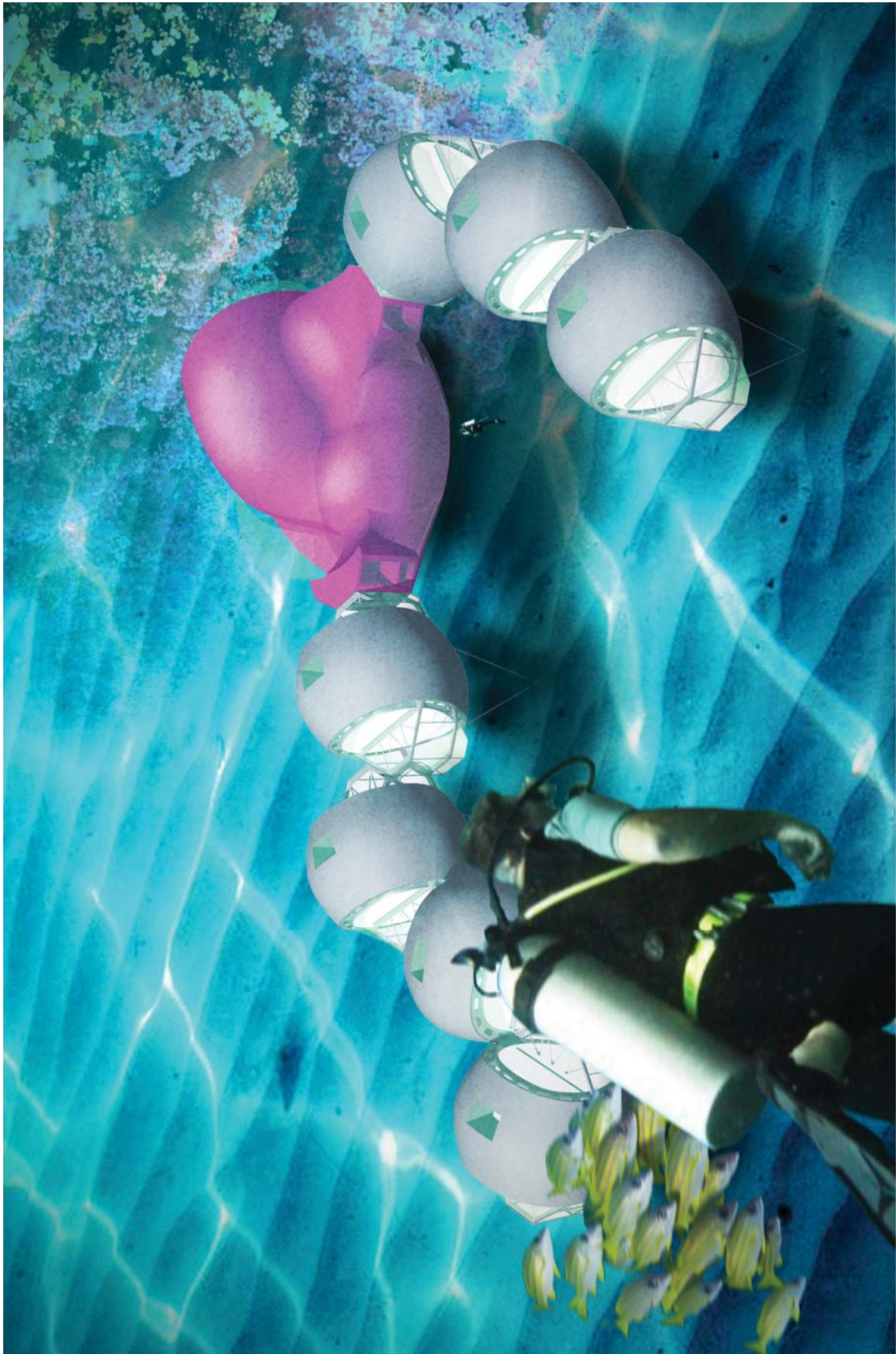


SECTION OF ENTRY
SCALE 1/8"=1'



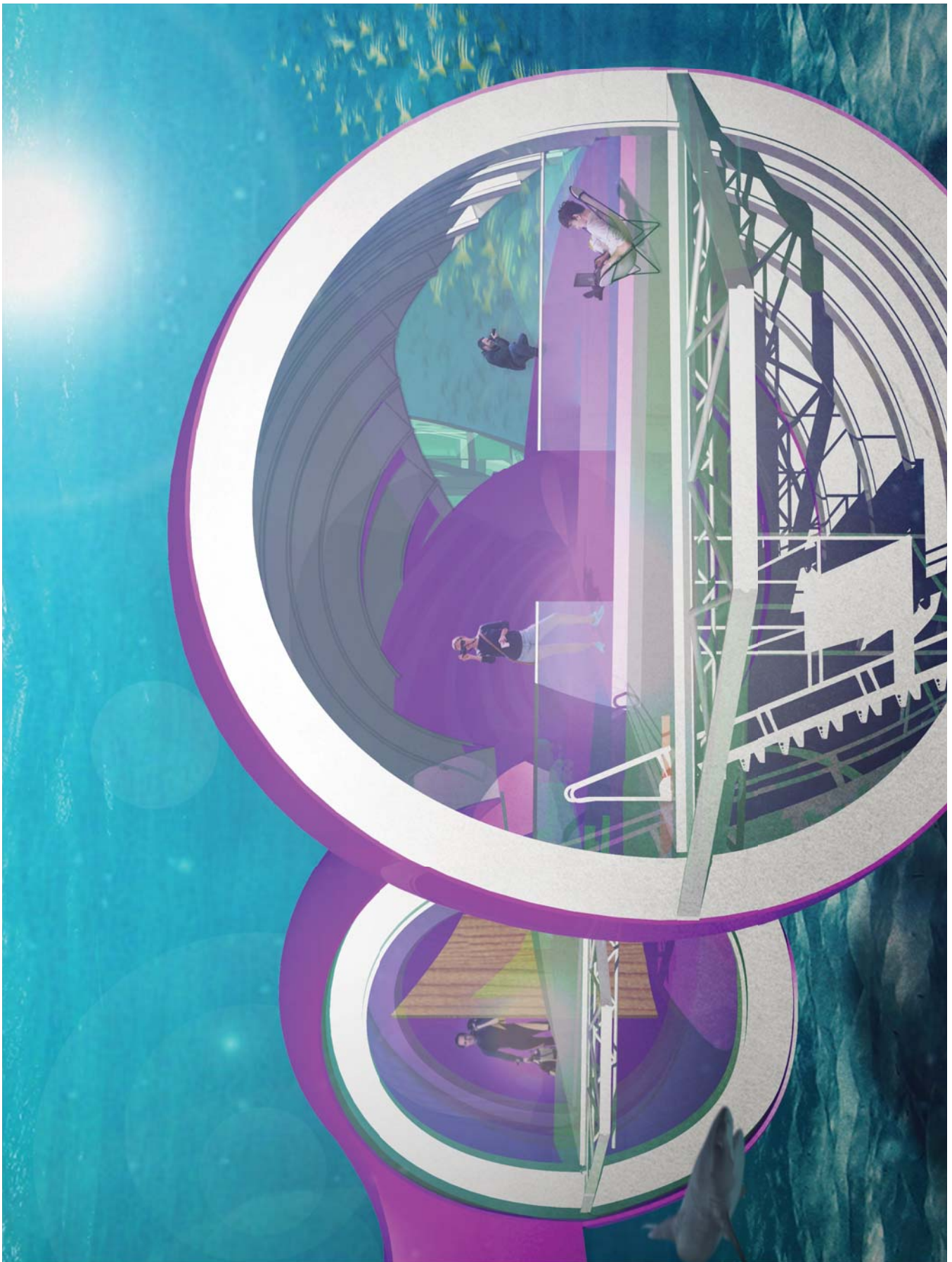
Renderings



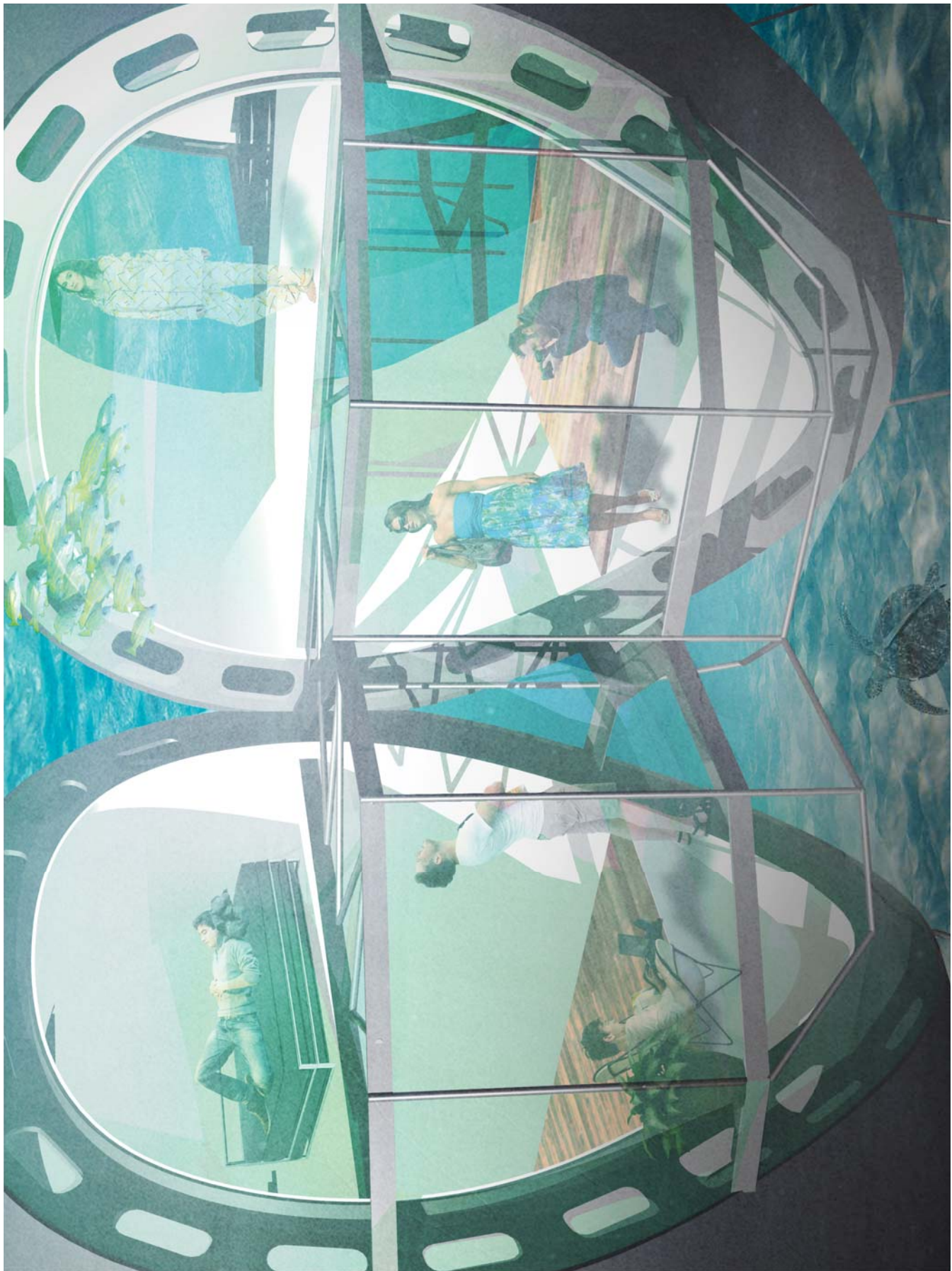


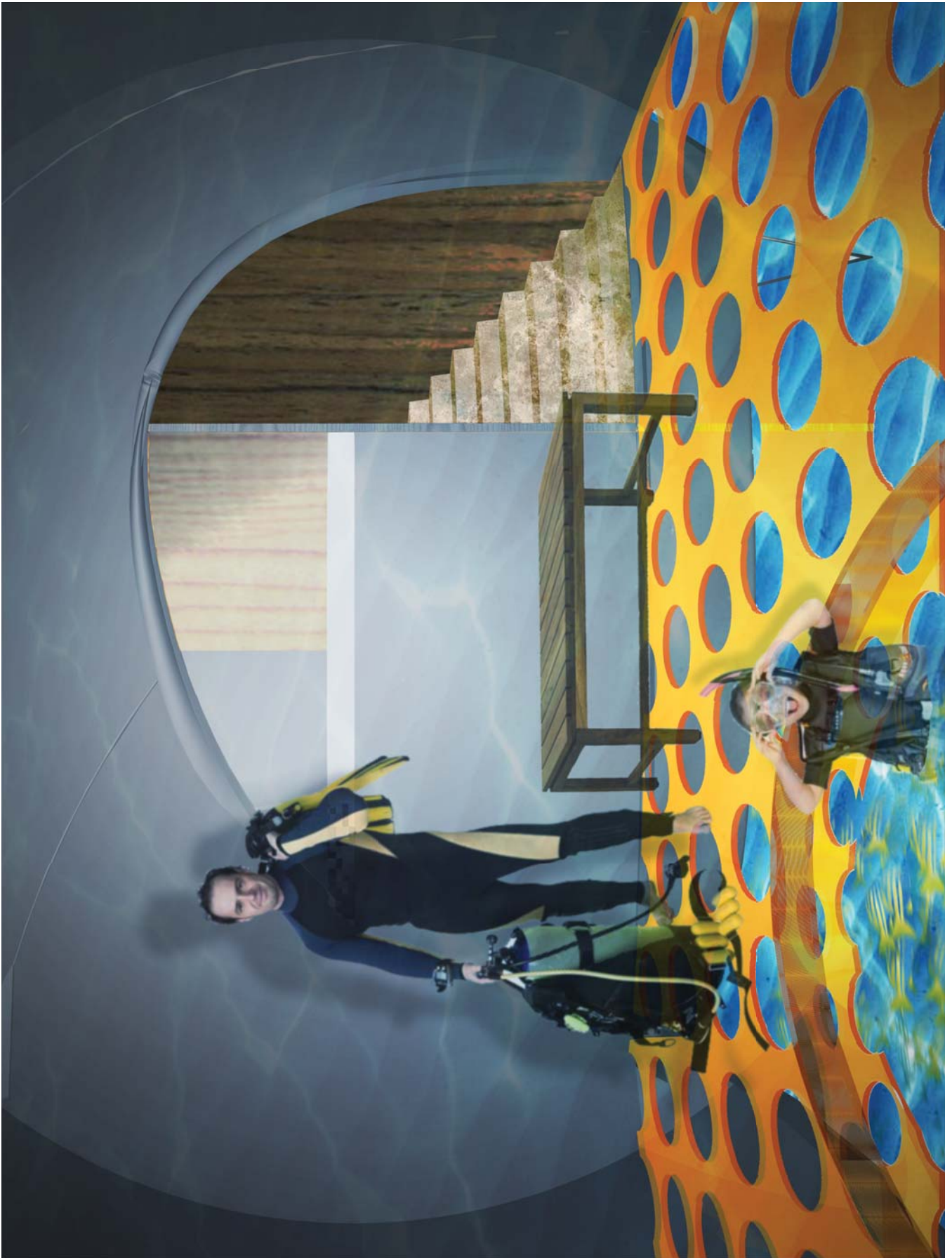
Renderings





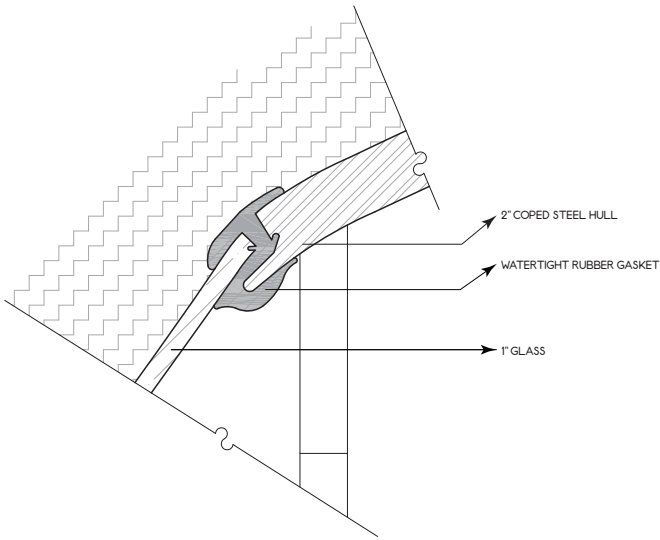
Renderings



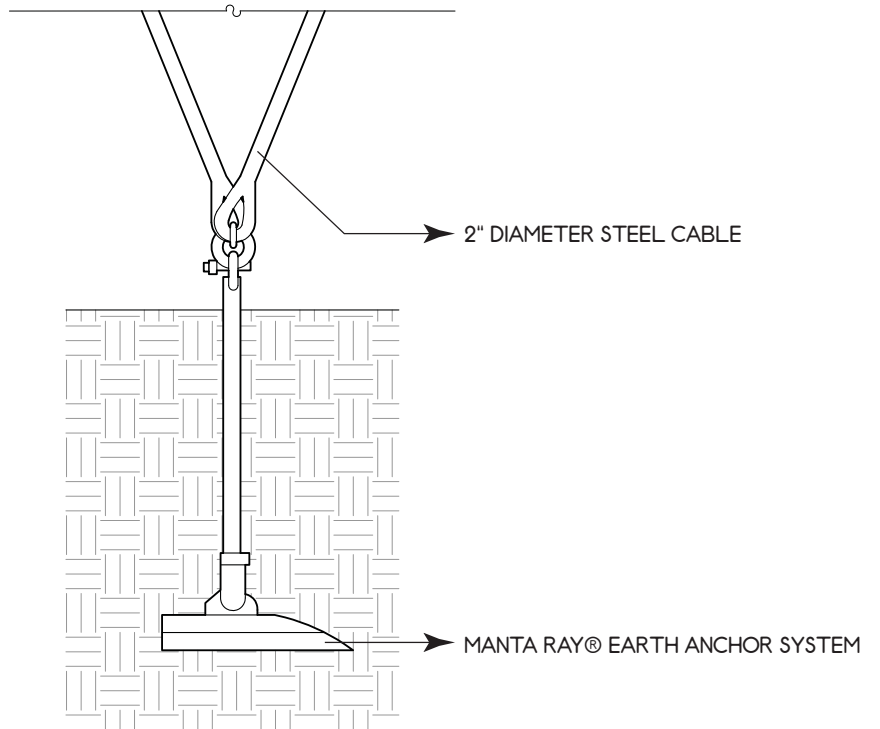
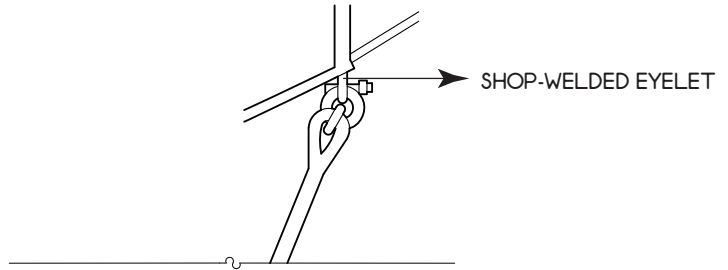


Renderings



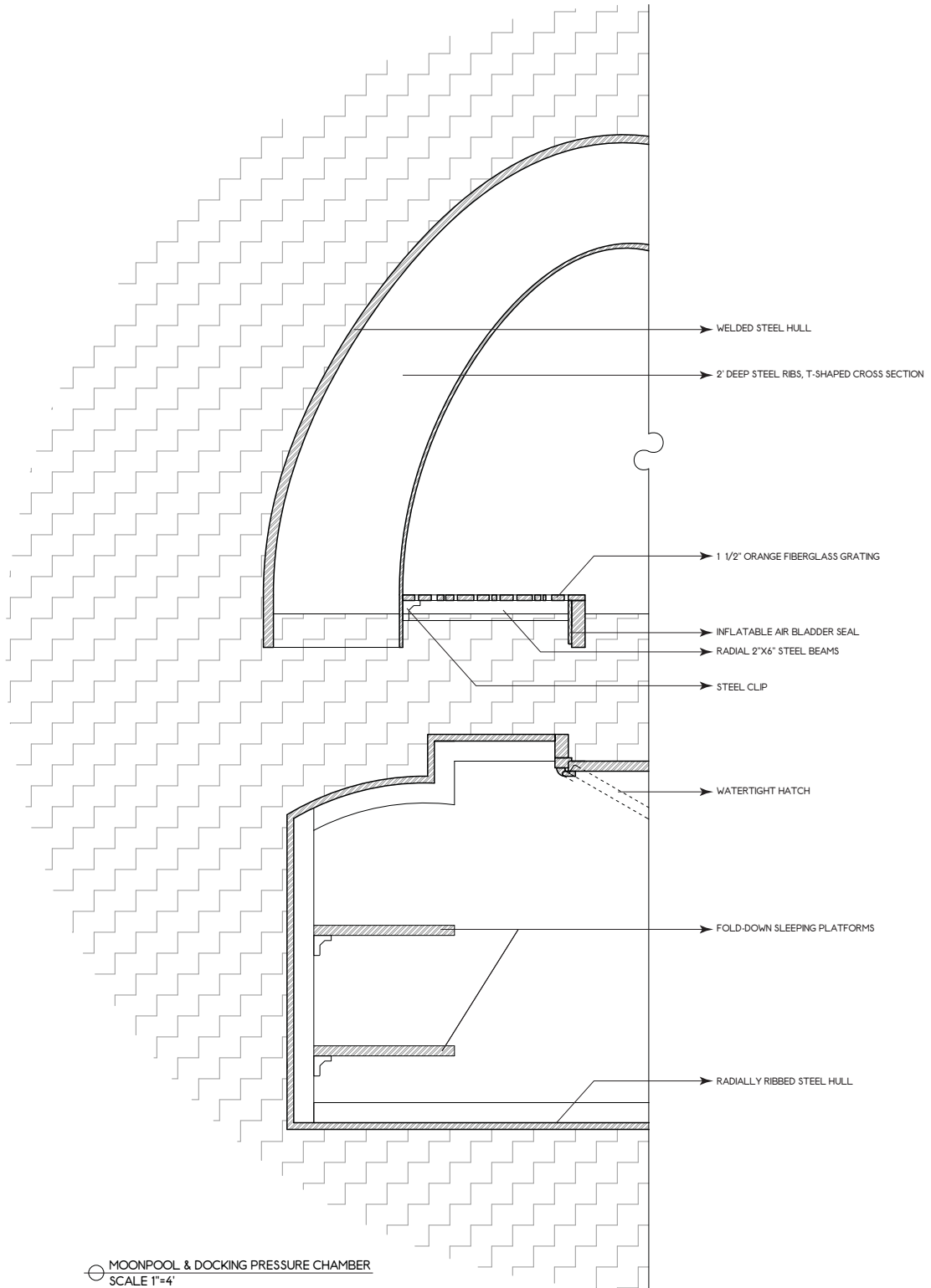


○ GLASS TO HULL CONNECTION
SCALE 1"=8"

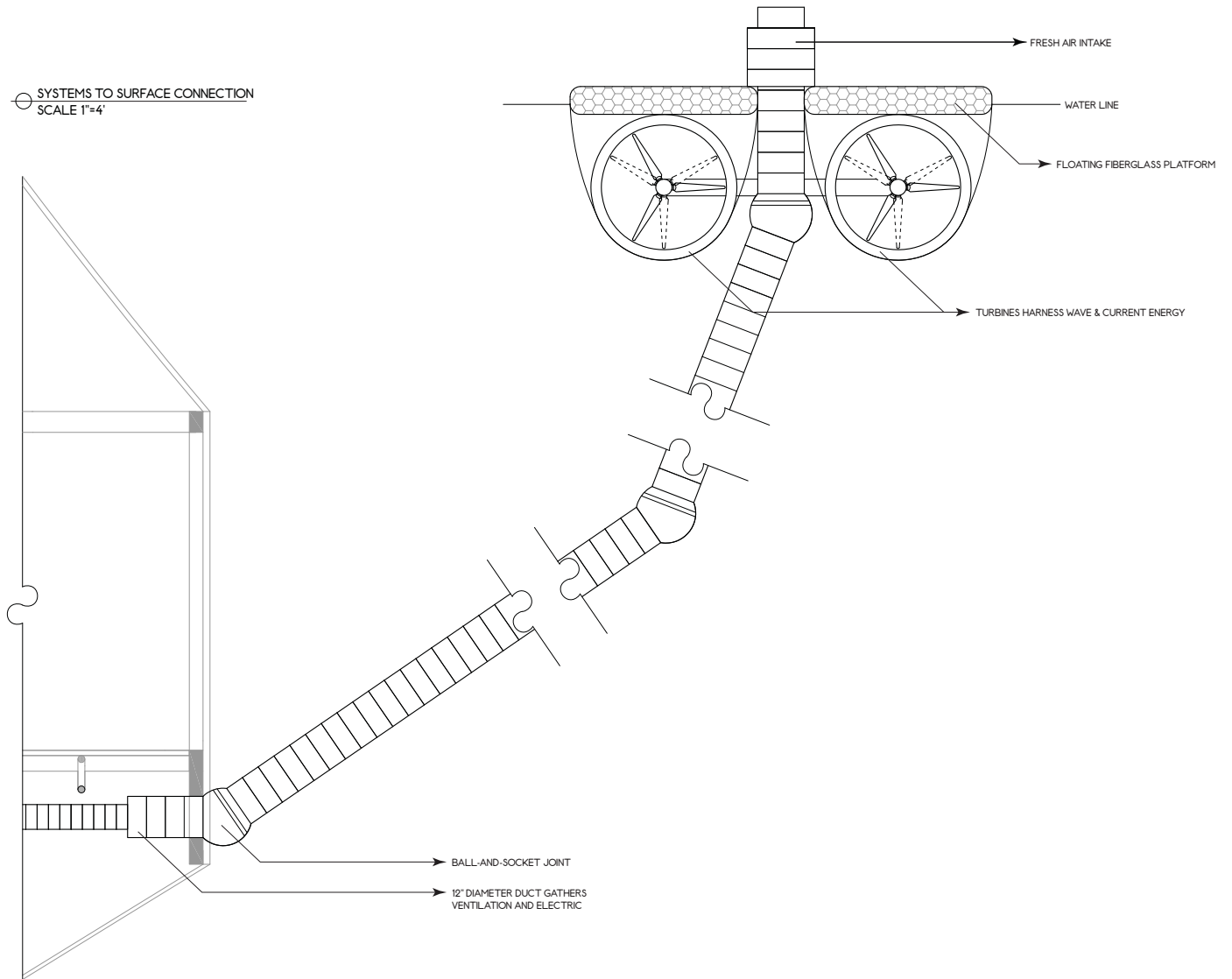


○ POD ANCHORING
SCALE 1"=4'

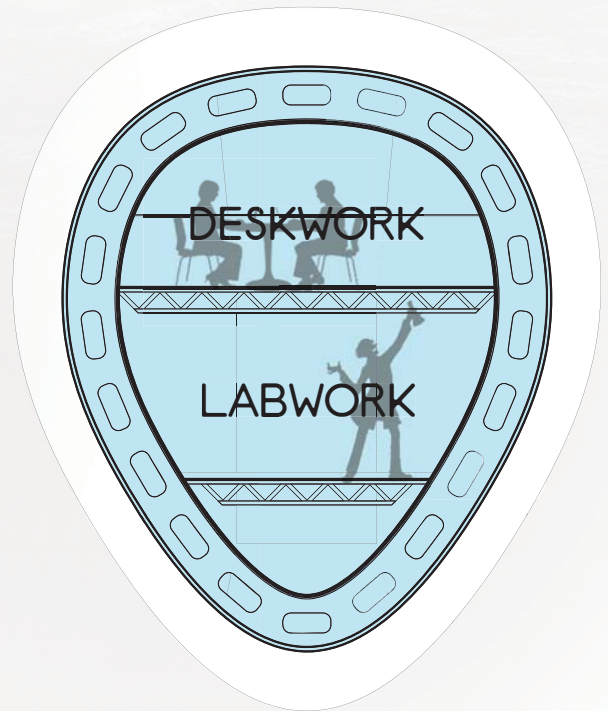
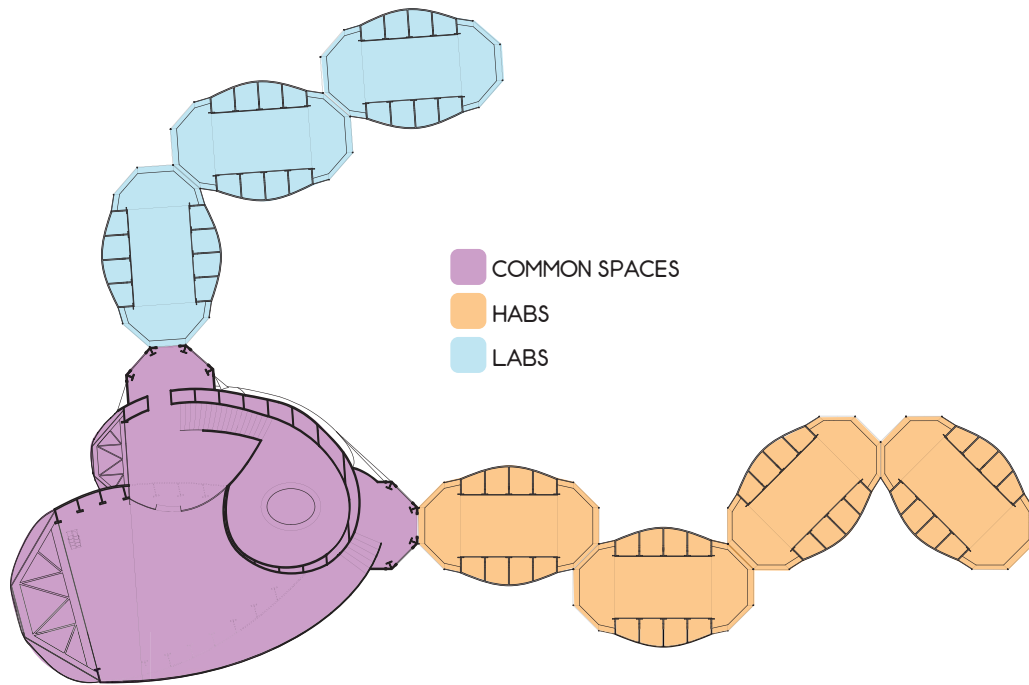
Details

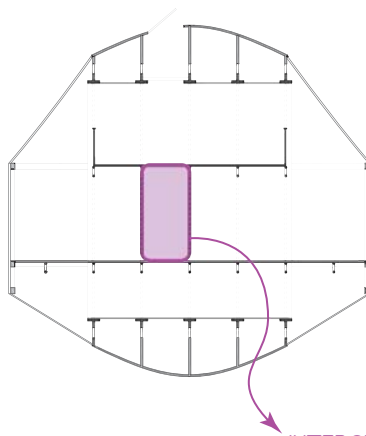
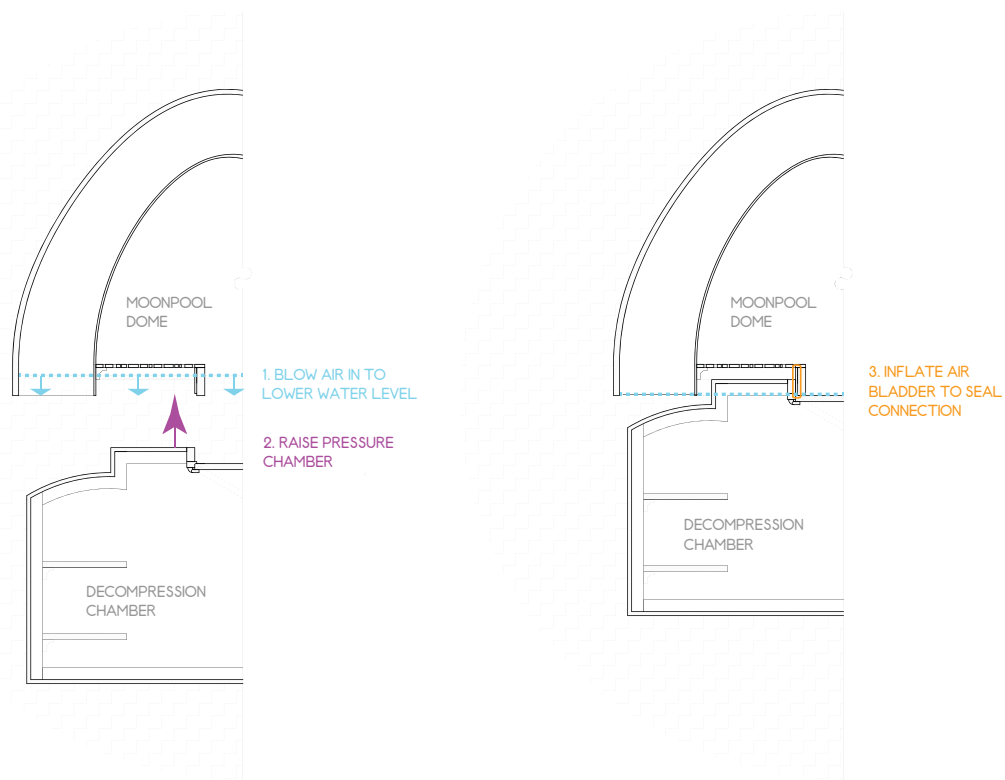


○ SYSTEMS TO SURFACE CONNECTION
SCALE 1"=4'



Diagrams



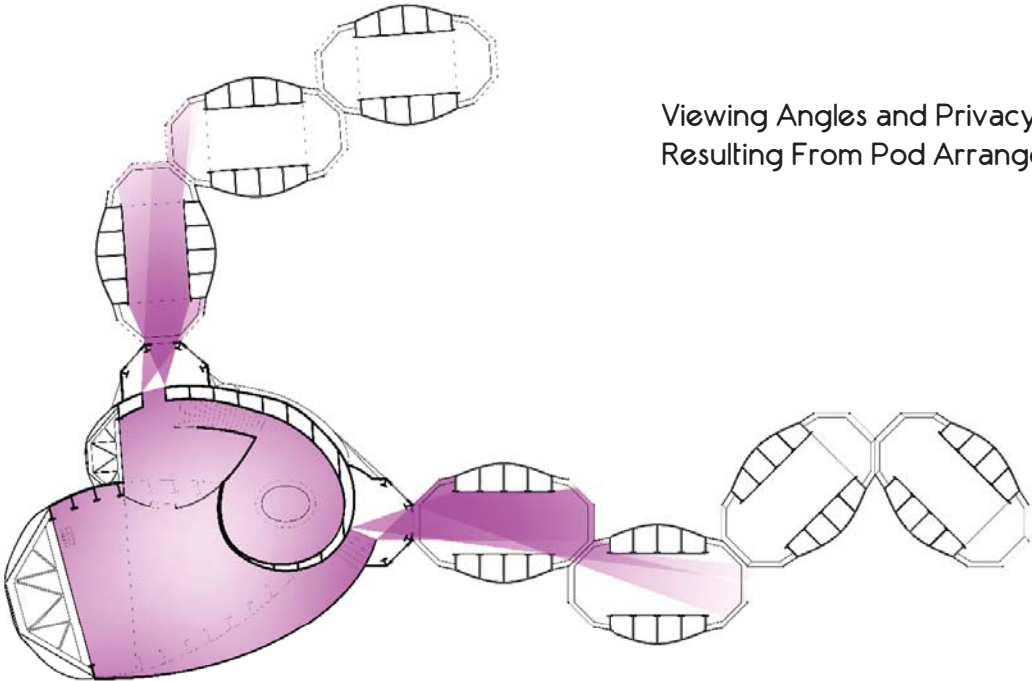


INTERCHANGEABLE 4' PANEL SYSTEM:



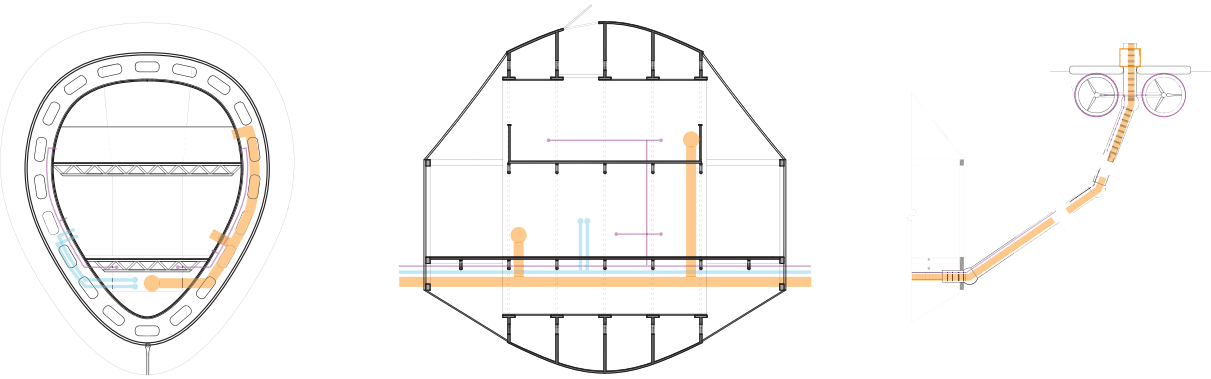
[FURNITURE & EQUIPMENT ARE BUILT INTO PANEL, PREVENTING SHIFTING DURING TRANSPORT OR TURBULENCE]

Diagrams

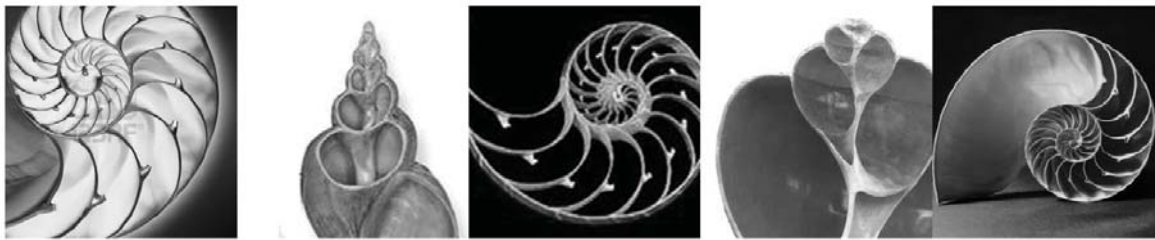
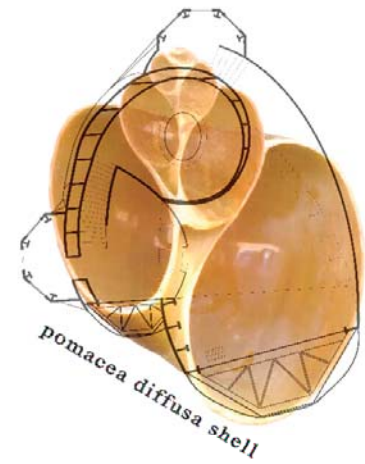


Viewing Angles and Privacy Resulting From Pod Arrangements

Path of Systems Through Pods



- ELECTRIC
- PLUMBING
- HVAC



shell sections

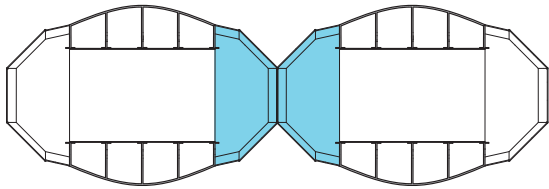
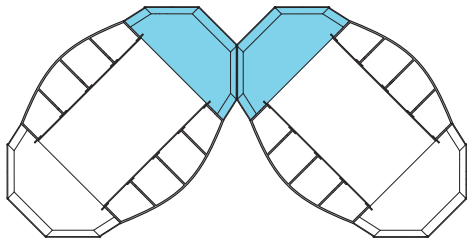
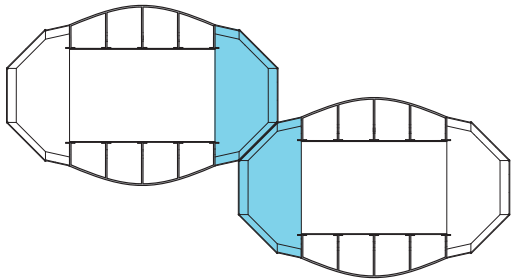
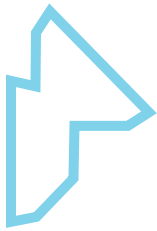
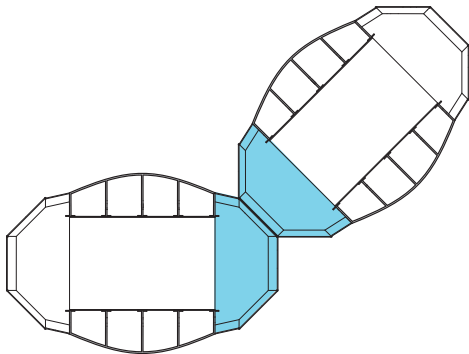


deep ocean creatures



spinal vertebrae

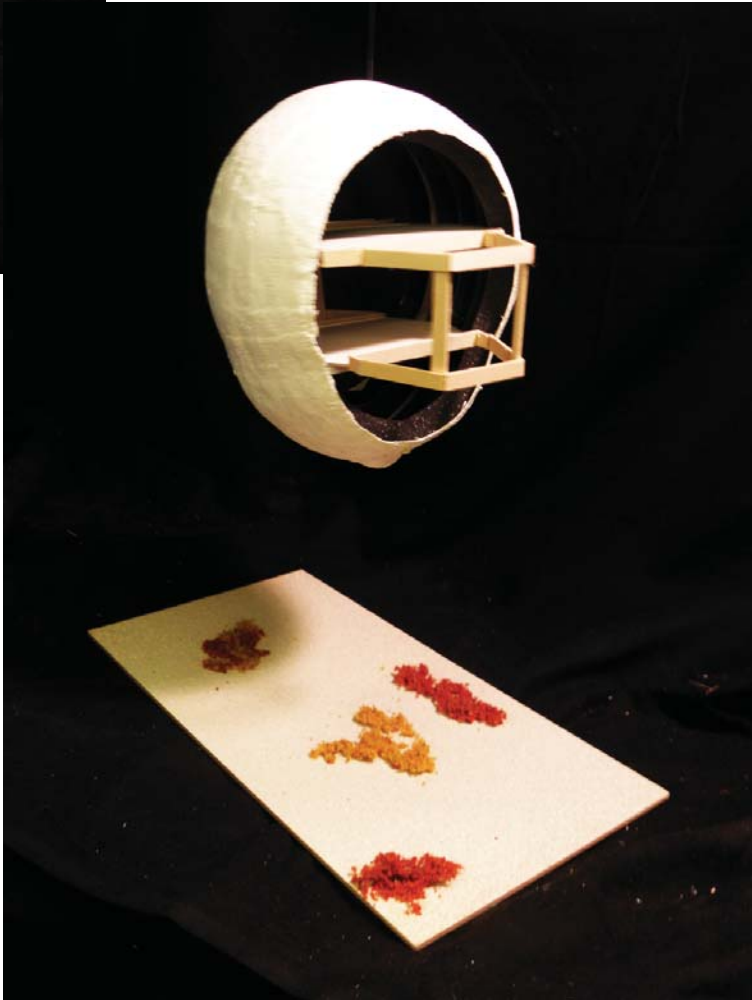
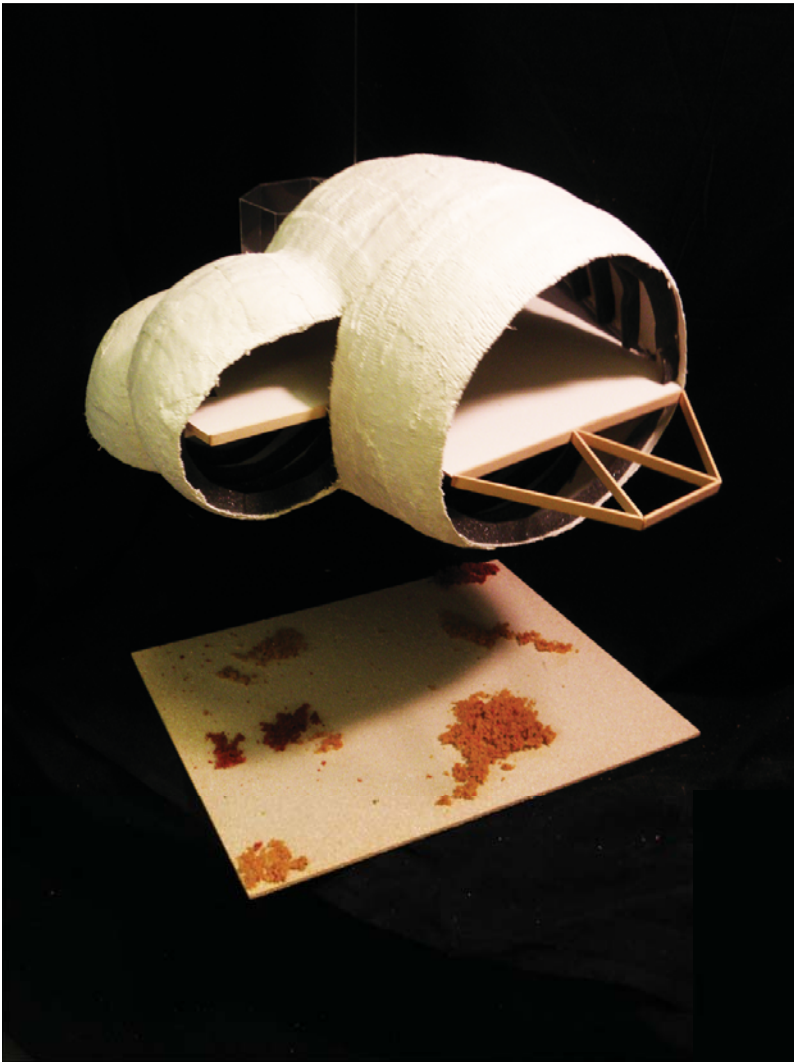
Diagrams

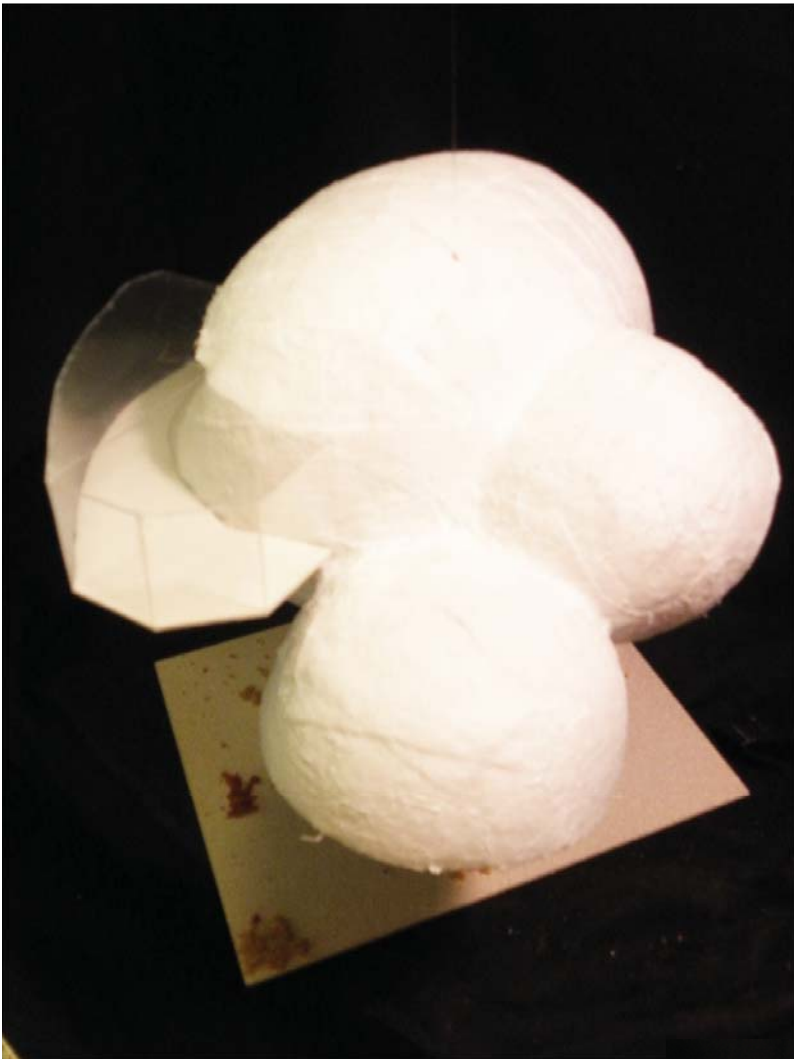


Atrial Shapes Resulting from Possible Pod Arrangements

MODEL

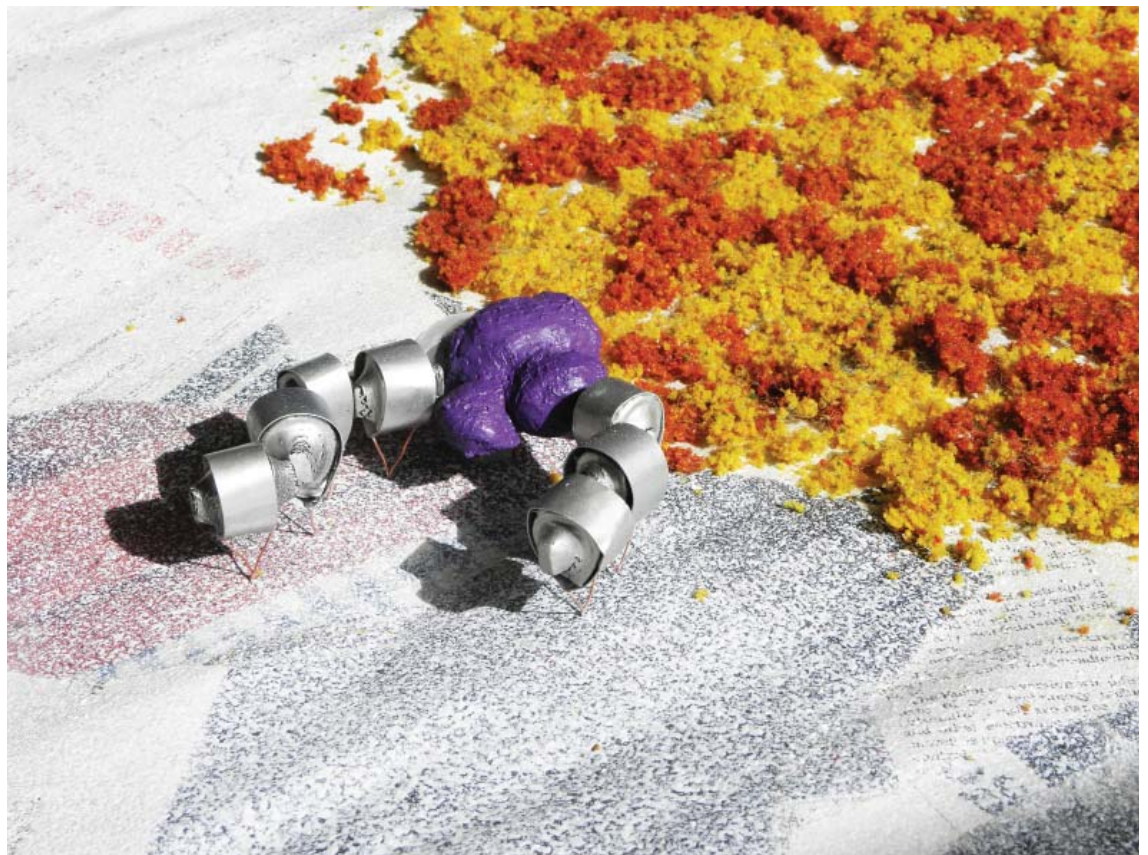
Model





Model









REFLECTION



Reflection

Looking to the future, it's clear that architecture for 'extreme environments' will soon be more than the purview of science fiction. Projects like this, and those of others in my graduating class, are beginning to address an environmental need to inhabit the indistinct borderland between man and nature. I expect to see more architects like Taseer Ahmad and Brian Davies, who are exploring the potential of the built environment in some very extreme sites.

One thing I struggled with, and ultimately learned from, in this project was setting parameters for my design. In extreme environments there are a number of unique physical, social, financial, and psychological constraints that need to be recognized and addressed. This is not to say that an extreme site has to limit design, rather, the site provides a framework of challenges that can inspire or restrict depending on one's perspective. Personally, I know that setting clearer parameters for myself would have allowed me more creativity in finding solutions to whatever challenges arose. Leaving the rules vague (what can engineering achieve? what kind of budget does this project have? who will inhabit this building and when?) made it difficult to make any design moves that would purposely break or push those limits.

The 'system tail' at the end of my building is one aspect of the design that I would have liked to push farther. In a conversation with marine biologist Hays Cummins, I learned about the importance of visibility for research facilities such as this. Right now, undersea labs like the Aquarius Reef Base are in danger of closing due to loss of government funding, which corresponds with reduced public interest in exploratory projects. One problem is visibility - if people can't see it, they may lose interest. Even the International Space Station orbits overhead where we can catch a glimpse every once in a while! How can a research facility 130ft under water be in the public eye? Were I to spend more time developing this project, I would focus in on this issue. I believe the solution is two-fold: shore-based and sea-based. Architecture could highlight the location where visitors first step off land and head out to sea, which should be sited to draw both local attention and a broader audience. Examples of this are seen in my process work when I looked at designing a submarine docking station on the St. John beachfront. The second part of the equation is to have the building itself, submersed deep below the ocean's surface, emerge in some way and pique the interest of any marine passerby, as well as those who might only see the facility on television or the web. In the sketches to the right, the systems umbilical that provides ventilation, energy, and fresh water to inhabitants becomes a monumental statement that rises above the water, perhaps terminating in a bundle of glowing microalgae that provides a percentage of the energy required to operate the facility.

From beginning to end, this project was mentally stimulating and - yes - fun. How many people can say they went scuba diving for their site research? As I begin my career, I look forward to facing many more challenging projects and extreme sites. As they say...

"The absence of limitations is the enemy of art."

-Orson Welles

