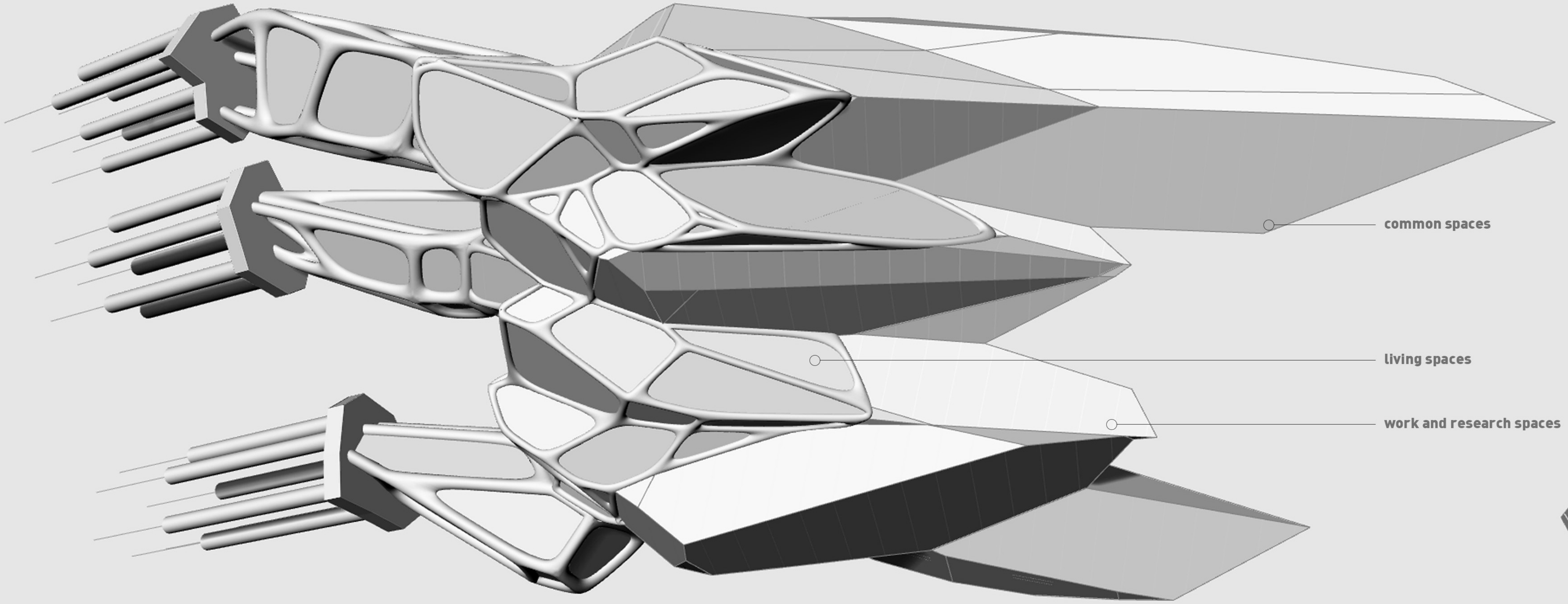
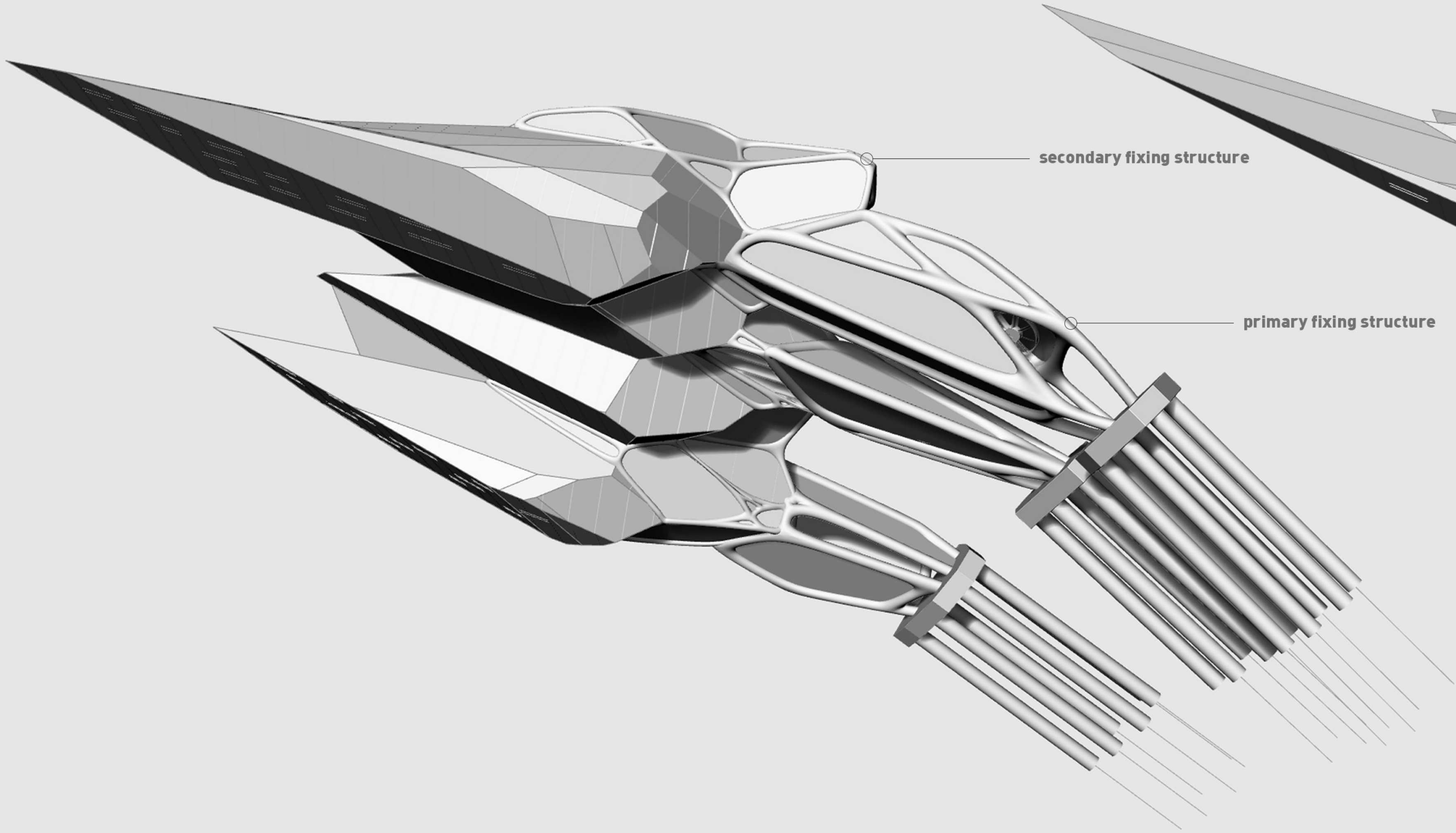


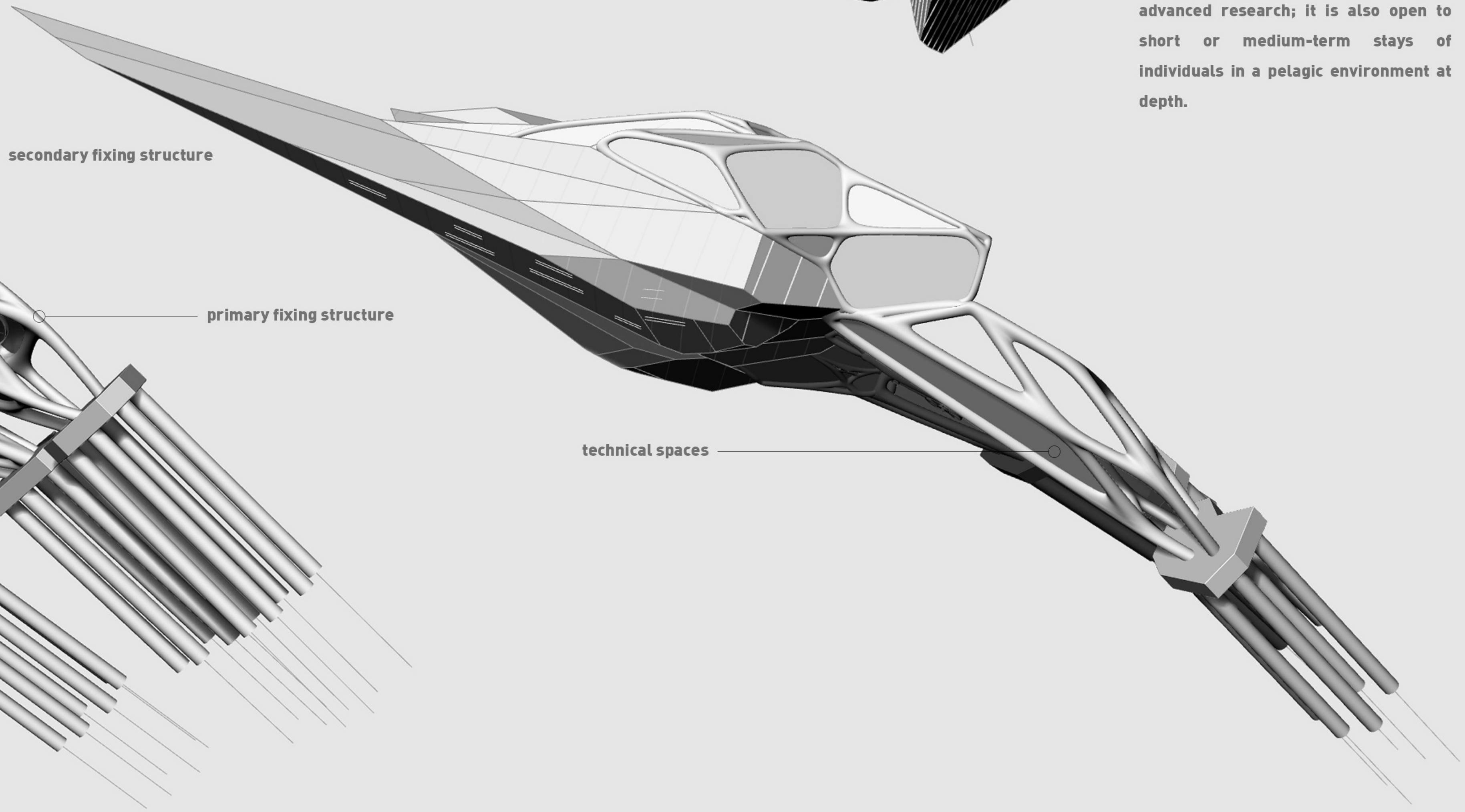
GUP - Grace Under Pressure - is a self-sufficient underwater habitat suitable for accommodating people engaged in work and research in the depths of the sea. It is designed to ensure energy and productive autonomy, minimizing external inputs.

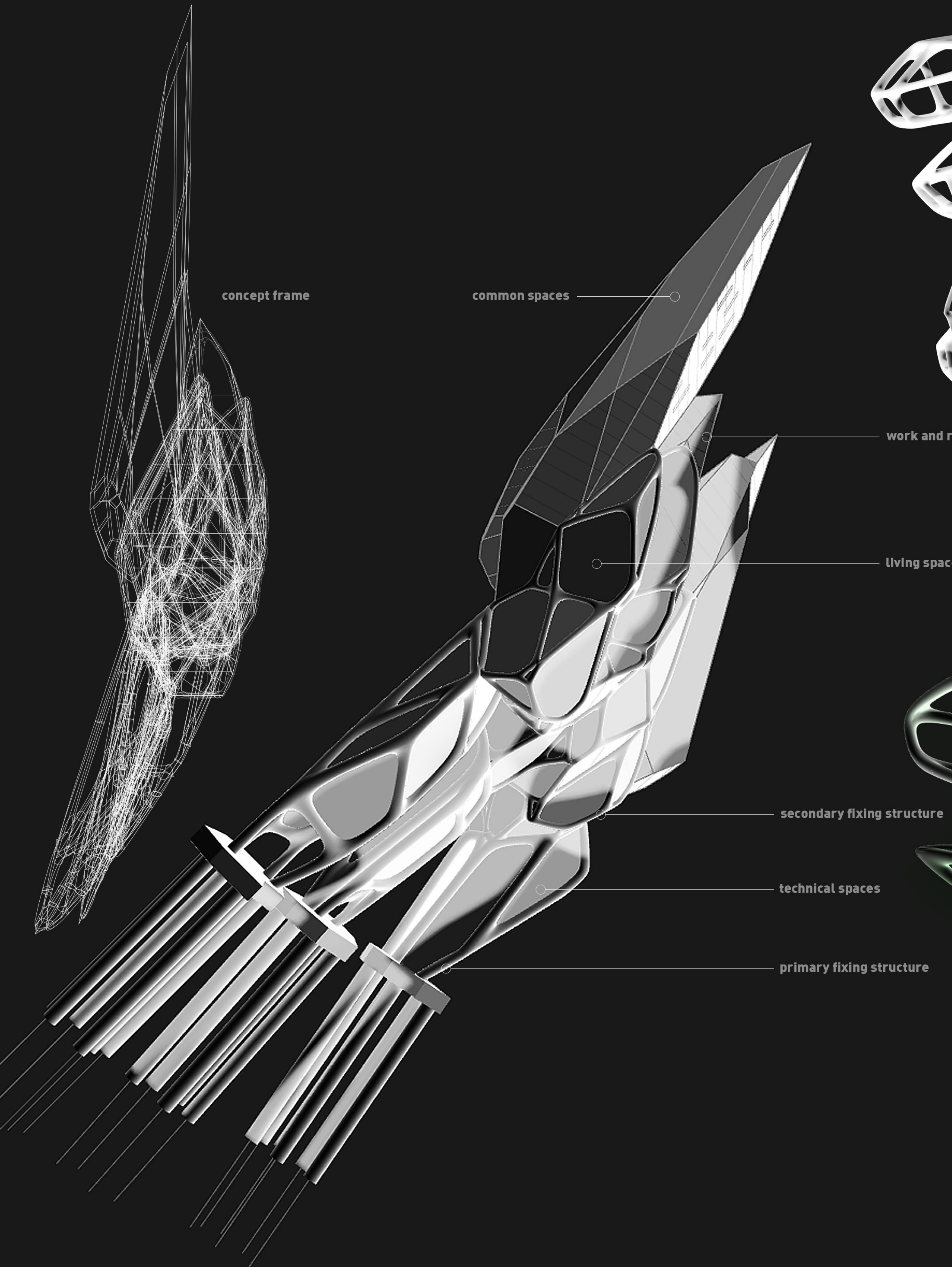
Gup can be placed in still largely unexplored environments, particularly on the slopes of underwater mountains, at depths ranging from 400 to 1,000 meters.
Gup is divided into six main components:

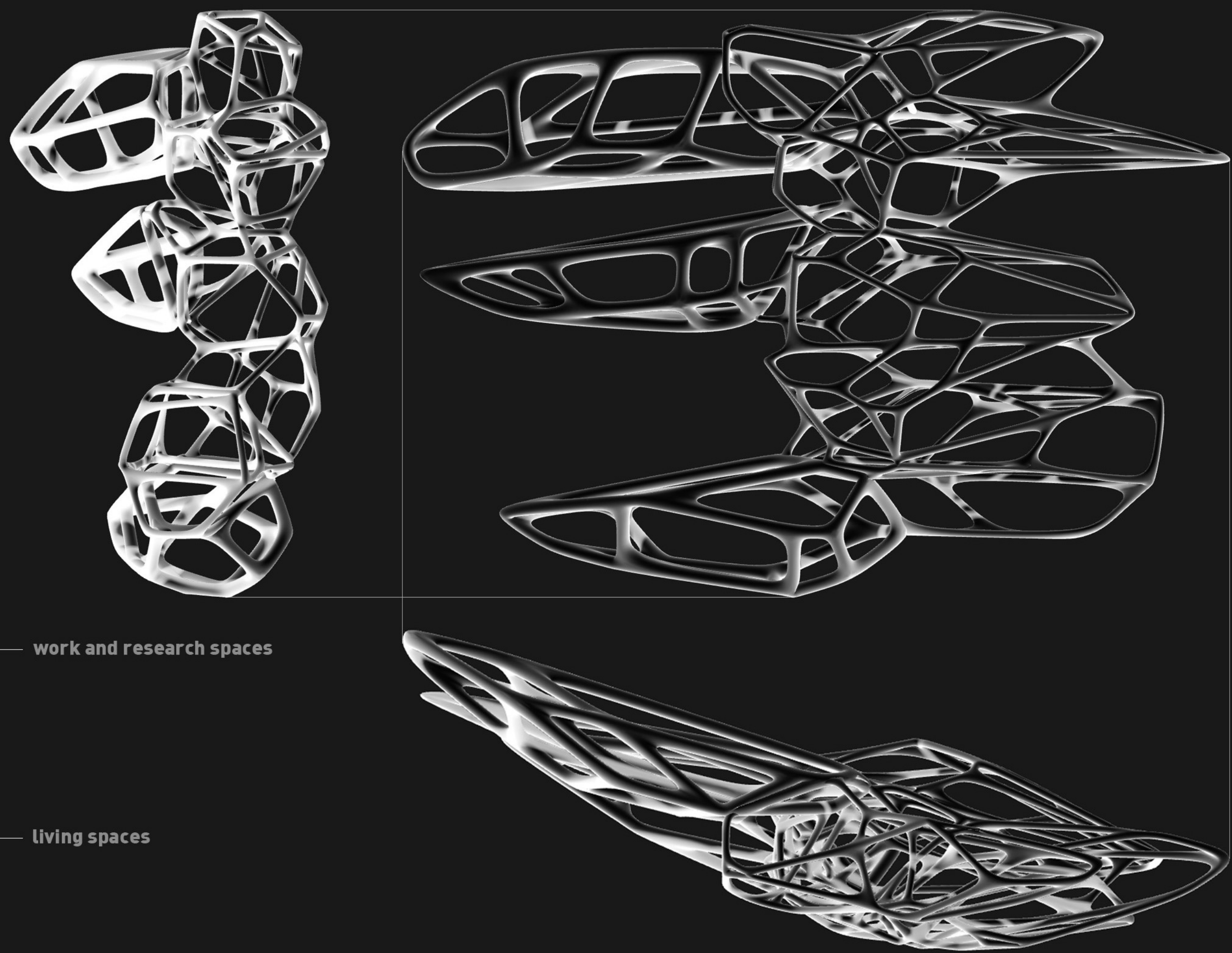
- Primary fixing structure
- Secondary fixing structure
- Living spaces
- Work and research spaces
- Common spaces
- Technical spaces

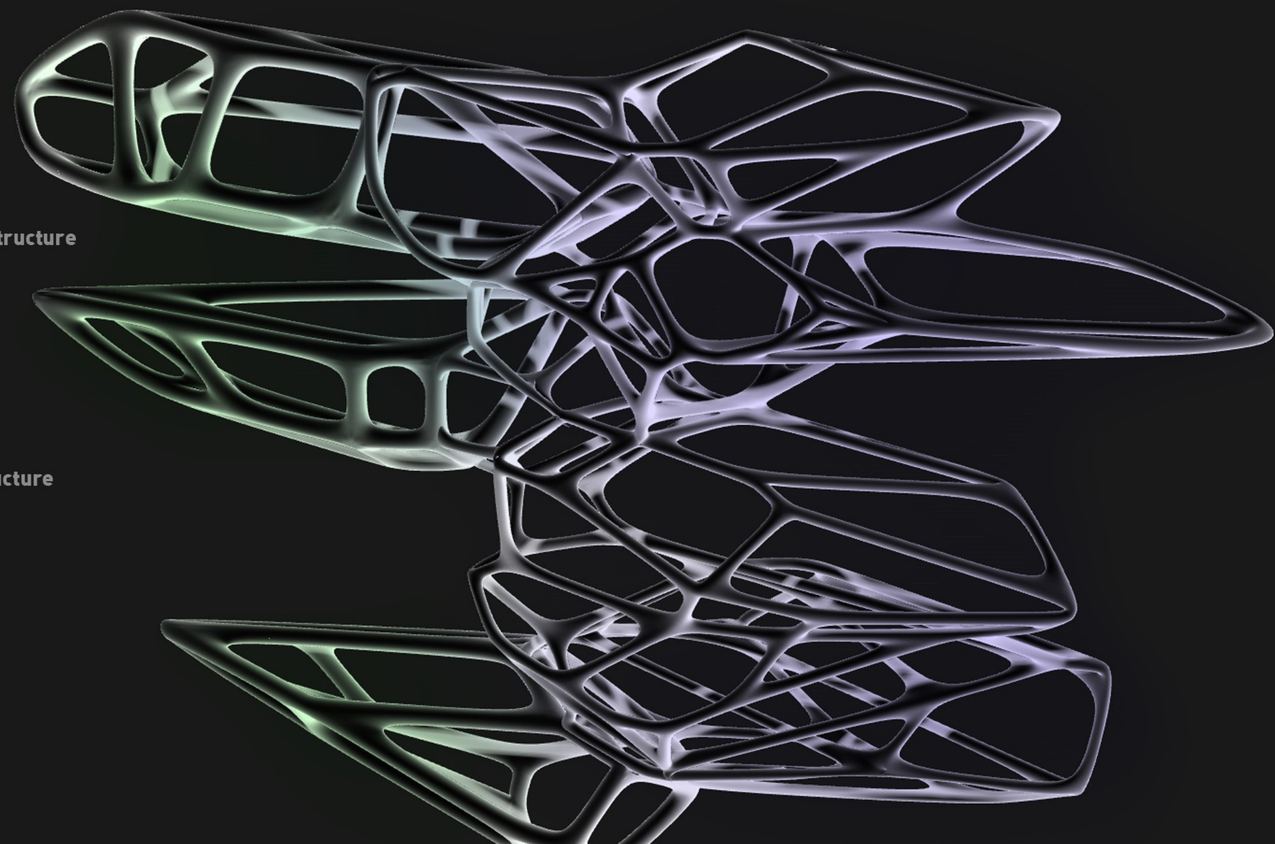
The colony has a hybrid configuration because it is not exclusively limited to advanced research; it is also open to short or medium-term stays of individuals in a pelagic environment at depth.











concept solid structure

It is estimated that there are about 30,000 underwater mountains on our planet, and only very few are known. In most cases, they are made up of volcanoes, either extinct or active, which usually rise sharply from the ocean floor from depths of 1,000 to 4,000 meters, sometimes just a few meters below the surface. GUP is designed to be placed along the steep sides of these mountains, particularly near the surface manifestations of hotspots, and in the presence of constant slope currents, often caused by canyons or narrowing of the seabed. In particular, the most suitable formations for placing GUP are the so-called submarine peaks: cone-shaped elevations over 1,000 meters high with very steep sides.

The sustaining energy for the colony is obtained from a hybrid combination of renewable sources, set up according to the potential of the location. The main processes used for transforming marine energy sources are:

- Conversion of thermal energy from hydrothermal emissions into electricity. Hydrothermal vents host some of the most fascinating ecosystems on our Planet. Despite the fact the water that emerges from them has temperatures of over 400 degrees Celsius, there is intense vital activity near the vent openings. Unlike most terrestrial life that relies on photosynthetic food chains, in the dark abyssal depths (between 1,000 to 4,000 meters), life is sustained through chemosynthesis, utilizing chemical reactions rather than sunlight to produce energy.

The production of electricity uses the Seebeck effect. That is a thermoelectric effect thanks to which a temperature difference generates a potential difference in a circuit made of metallic or semiconducting conductors.

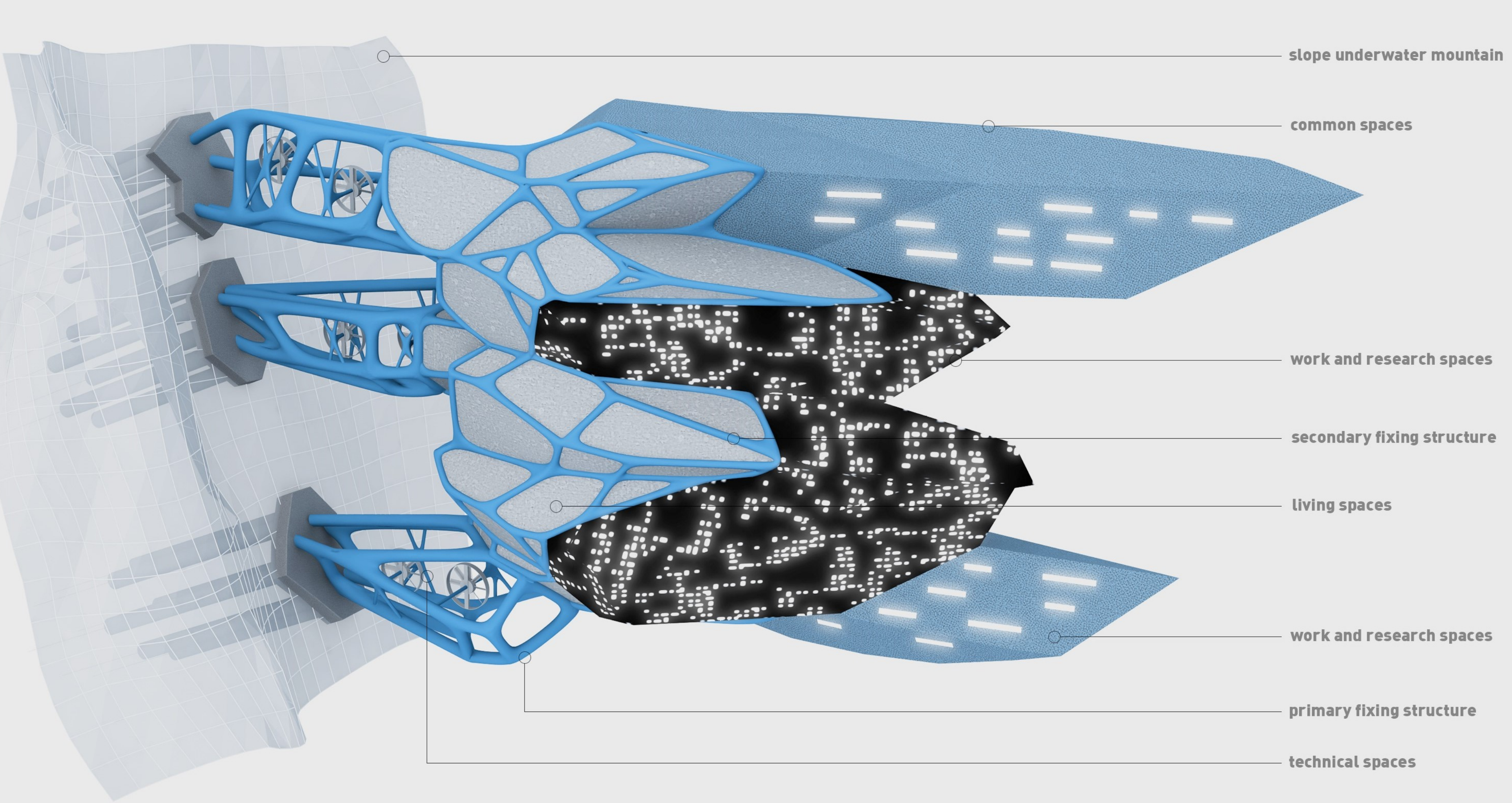
2023 JACQUES ROUGERIE FOUNDATION AWARDS

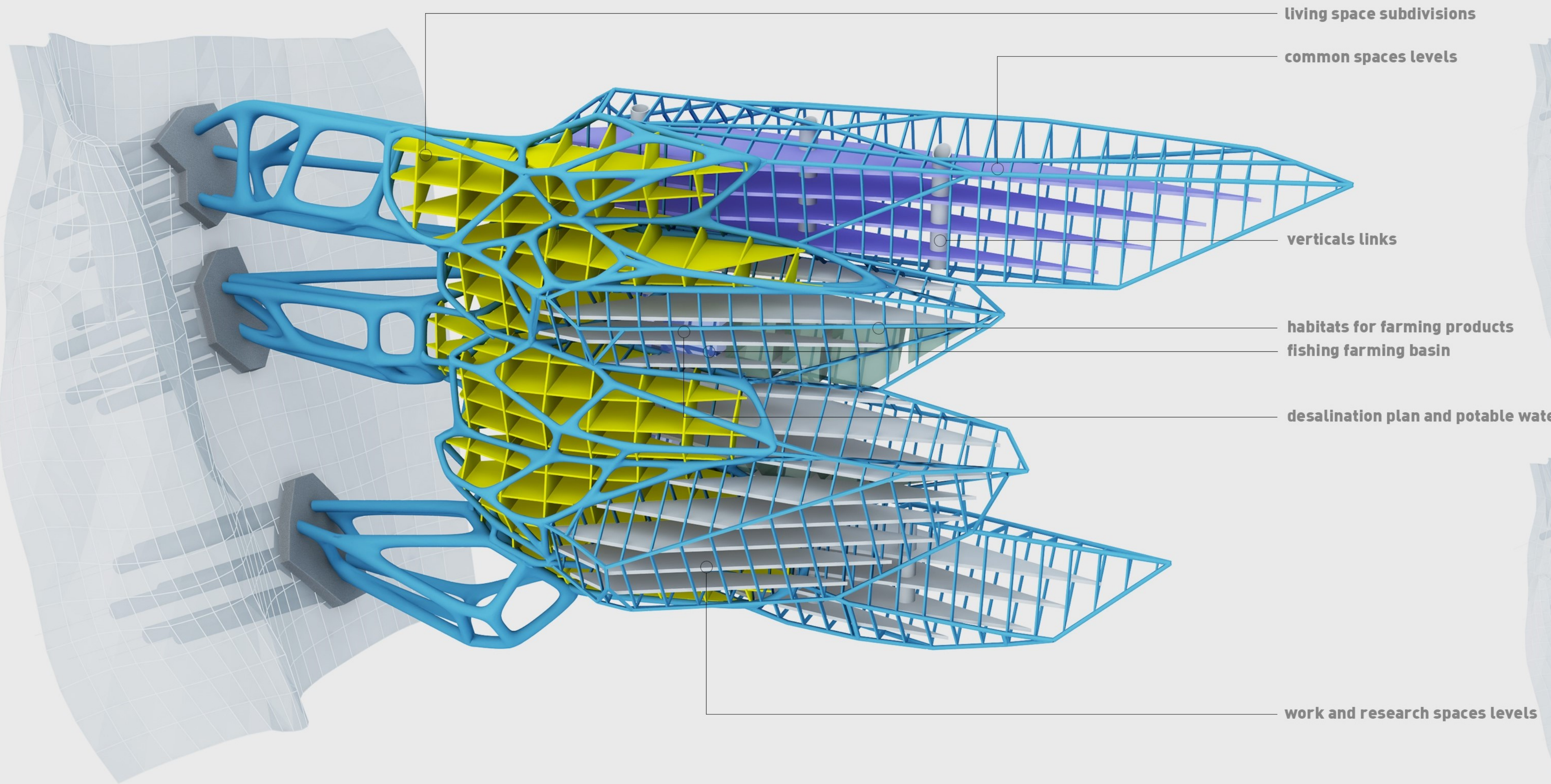
Award's category : **Architecture and Innovation for the Sea**

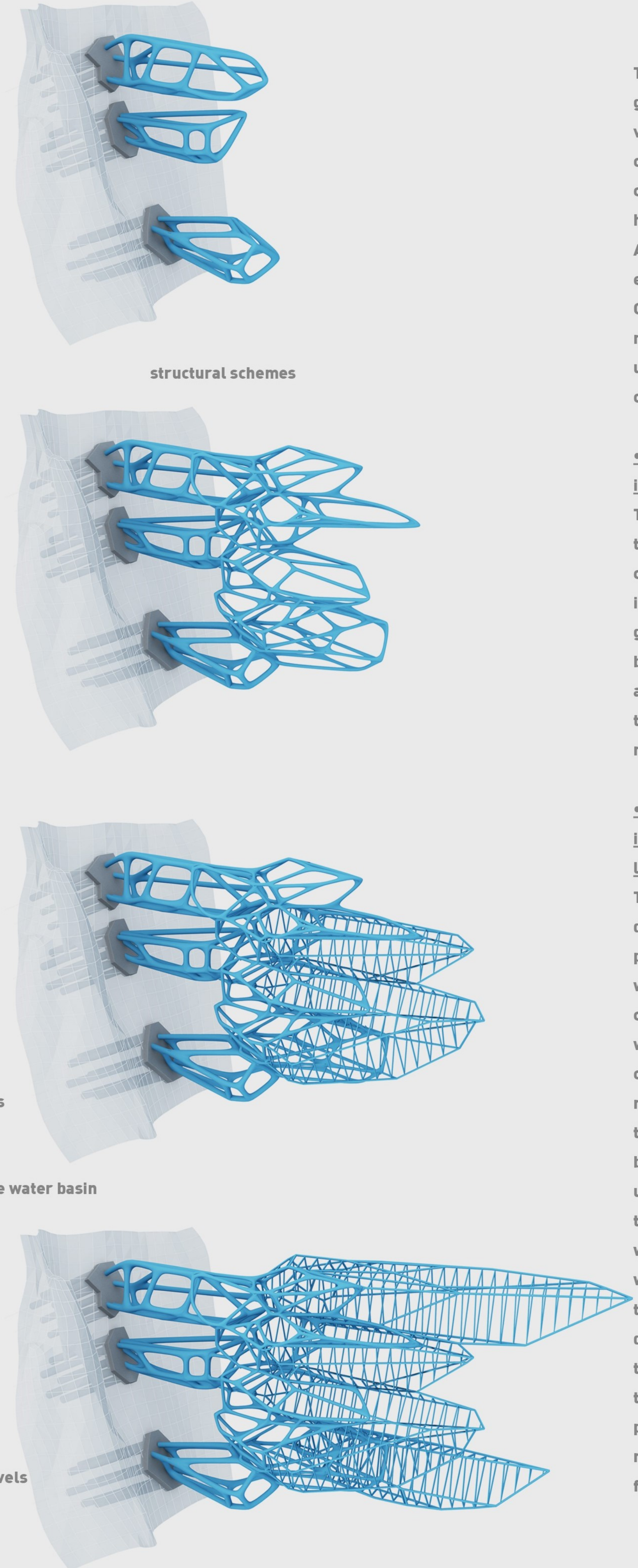
Project's Name **GUP - Grace Under Pressure**

Description **Concept and sketches - 02**

FONDATION JACQUES ROUGERIE GÉNÉRATION ESPACE MER ACADÉMIE DES BEAUX-ARTS



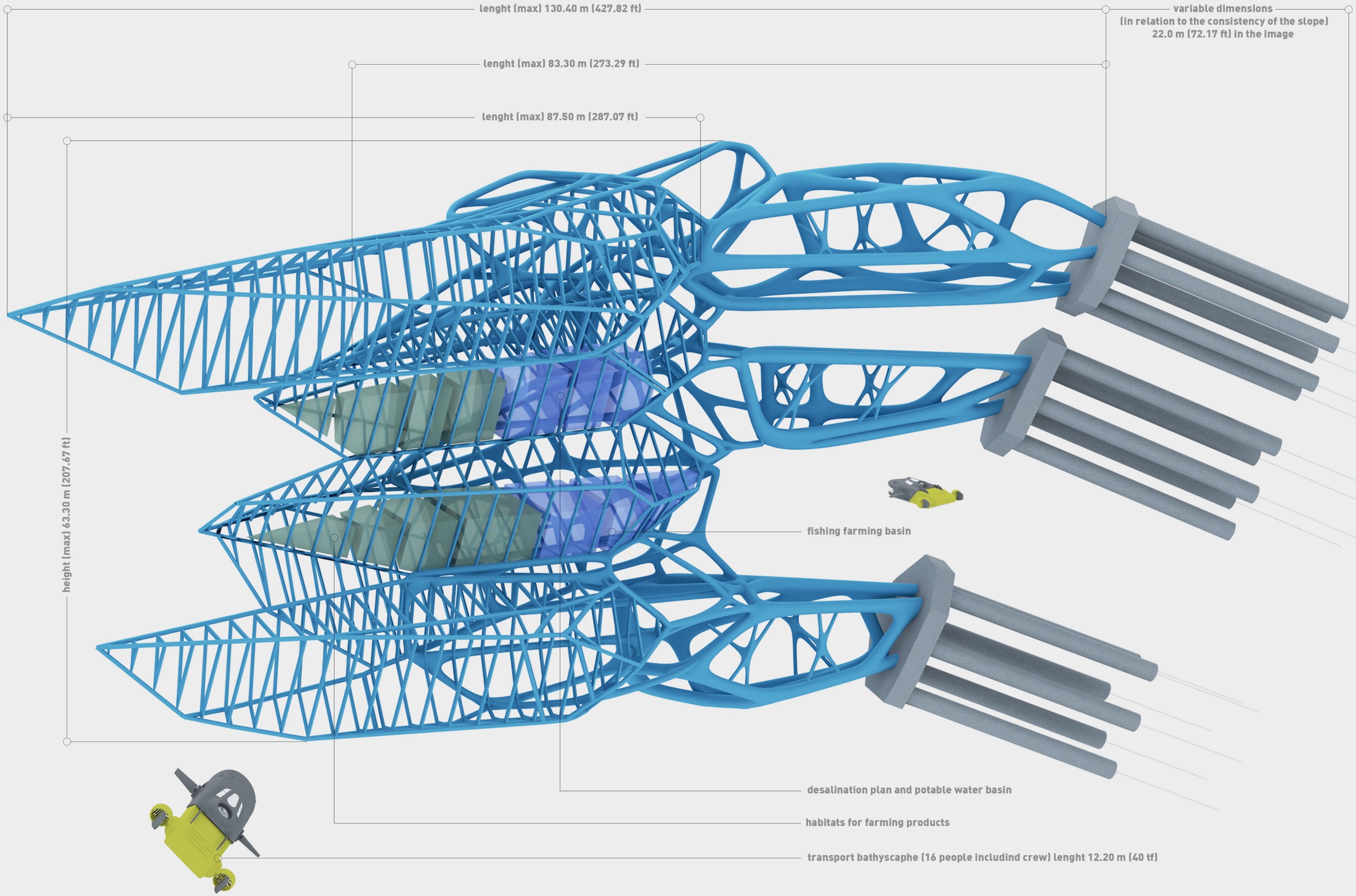




This effect is used by thermoelectric generators, which, while having relatively low efficiency (converting about 7% of thermal power into electric power), can access a continuous flow of hot high-temperature water.
Advanced studies of these hydrothermal emissions would be carried out in the GUP in order to discover unknown nearby volcanic areas and to better understand the chemical mechanisms occurring within Earth's oceans.

• Conversion of deep-sea current motion into electricity.
The principle of operation is analogous to that of wind energy, deriving electricity from the mechanical movement induced by water flow through submerged turbines consisting of rotating blades. The rotation of the blades around their axis and around the hub of the propeller generates excellent results.

• Conversion of water column energy into electricity (underwater hydroelectricity).
The operation of this type of device is directly inspired by that of hydroelectric power plants that harness the power of water and gravity. The principle involves creating a deep reservoir containing water stored at low pressure. A system of pumps and turbines connects this reservoir to a flexible air chamber positioned above. The electricity generated by the other transformation systems is used to pump water from the reservoir to the upper chamber and then release it when needed under the pressure of the water column above the chamber. This transition from the top to the bottom drives hydroelectric turbines, generating electricity again. The efficiency of these devices ranges between 70 and 80 percent and can rely on an unlimited number of charge and discharge cycles for long operational life.

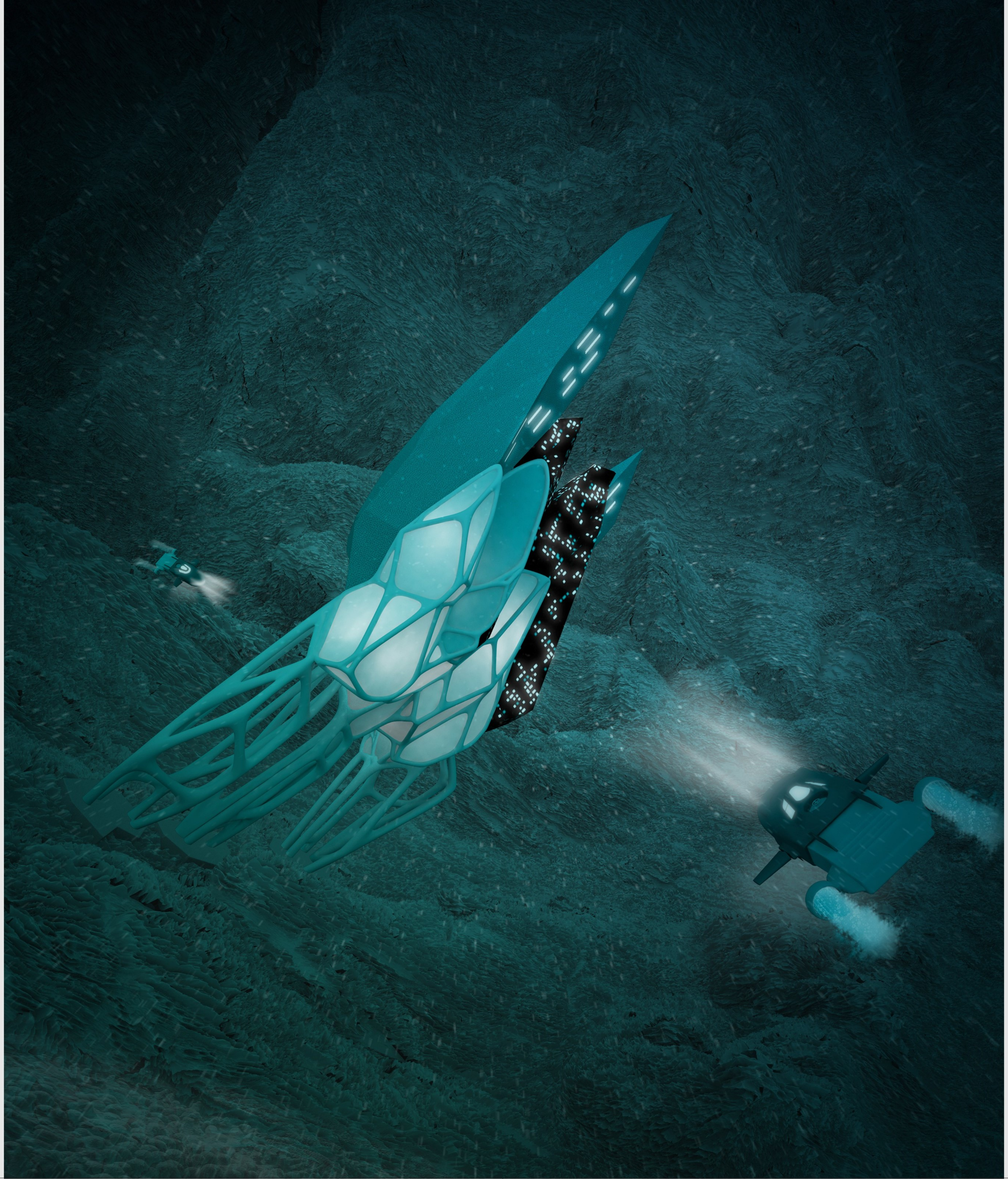


• Conversion of wave motion into electricity.

The hybrid energy system can also be supplemented by a surface field consisting of modules for generating electricity from wave motion.

Water Production

The production of drinkable water is achieved through a desalination plant that removes the saline fraction from seawater. The saltwater is initially taken from the sea and passes through a pre-filtration process in three stages (removing sand, bacteria and sulphates). Subsequently, the water is pushed at pressures between 55 and 70 bars (greater than osmotic pressure) through a membrane with pores (0.1 nm), allowing only water molecules to pass through, but not salts. Of course, the composition of brackish water varies depending on the geographic area and environmental conditions, but the percentage of dissolved salts present is relatively constant, averaging 35 g/L. Since drinkable water does not need to be completely salt-free, the treatment leaves a modest amount of saline carryover, around 25-50 mg/L. The remaining undistilled water is called brine and represents a product that cannot be directly discharged into the sea as it disrupts marine biodiversity.
The effluents from desalination plants undergo additional treatments to produce new by-products for use in aquaculture, irrigation of salt-tolerant plants, recycling of salt (sodium chloride), and metals (magnesium, gypsum, sodium, calcium, potassium, chlorine, bromine). In the GUP, some laboratories could be activated for in-depth research to recover other important resources for the industrial sector (IT, automation, robotics) such as lithium, strontium, rubidium and uranium.



<u>Air Production</u>

The oxygen production system is the most delicate aspect of GUP because, in addition to providing breathable air, it must prevent the accumulation of toxic substances produced by the inhabitants. Most of the oxygen can be derived through the process of electrolysis, using electricity provided by the GUP hybrid system to separate the hydrogen and oxygen that make up the water obtained from the desalinators. By passing electrical energy through water, atoms separate and recombine in gaseous forms. However, hydrogen cannot be released directly into the sea; therefore, it will feed fuel cells that produce new energy in a closed cycle. In other words, fuel cells (similar in their operation to those used in automobiles) will use the waste H2 from electrolysis to produce new electricity and water as a new waste product.

To avoid the accumulation of toxic substances, carbon filters are installed to eliminate gases emitted by humans (methane, carbon dioxide, and ammonia exhaled from uric acid suspended in sweat). The air is also stored in buoyancy tanks that provide hydrostatic balance to the GUP, which can partly be used to allow occupants to breathe in case of emergencies. As a safety device, a snorkel tube can be raised and through it air is directly drawn from above the sea surface.

Technical sheet 1

Name: GUP (Grace Under Pressure)
Type: Underwater habitat
Place: Slopes underwater mountains

Length (max):	130.40 m	(427.82 ft)
Beam (max):	29.60 m	(97,11 ft)
Height (max):	63.30 m	(207.67 ft)
Volume:	50,550 m3	
Floor area:	9,650 sqm	

Estimated construction cost:
450 million euros

Depth: 400 - 1000 m
Decks: 18

Estimated energy production
- conversion of thermal energy from hydrotermal emission: 5,000 kW
- conversion of deep-sea current motion: 6 turbines (5.6 m in diameter) x 400 kW = 2,400 kW
- conversion of water column energy (underwater hydroelectricity) - estimated: 8,000 kW
- conversion of wave motion: 4 trips (with 7 oscillating sensors each) x 2,000 kW = 8.000 kW

Total power on-board electricity supply:
23.4 MW

Estimated electric requirements
- 6,000 kW accommodation units
- 2,500 kW air and ventilation
- 1,800 kW laboratories
- 4,500 kW machinery and instruments
- 1,000 kW lighting
- 3,600 kW production plants, farming and fish farming
- 2,000 kW emergency reserve

Total electric requirement:
21.4 MW

Technical sheet 2

Fresh water tank capacity:
400,000 l

Air emergency reserve (8h autonomy for 180 people):
700.000 l (9 m3 at 80 bar)

Air reserve:
40 m3 at 80 bar

Capacity oh the habitat:
180 people (max) including the minimum crew of 30 people

Transport bathyscape:
n. 7 (capacity of 16 people including crew of 2)

Total evacuation time with max capacity:
4 h (istallation depth 500 m)

Minimum crew:
- 1 commander
- 1 deputy commander
- 4 pilots
- 2 bathyscaphe maintainers
- 3 sector directors
- 1 doctor
- 1 medical assistant
- 4 control/mantenaince teams (2 people each)
- 4 system engineering
- 1 cook
- 1 cook assistant
- 1 storeman
- 2 cleaners

<u>Air Production</u>

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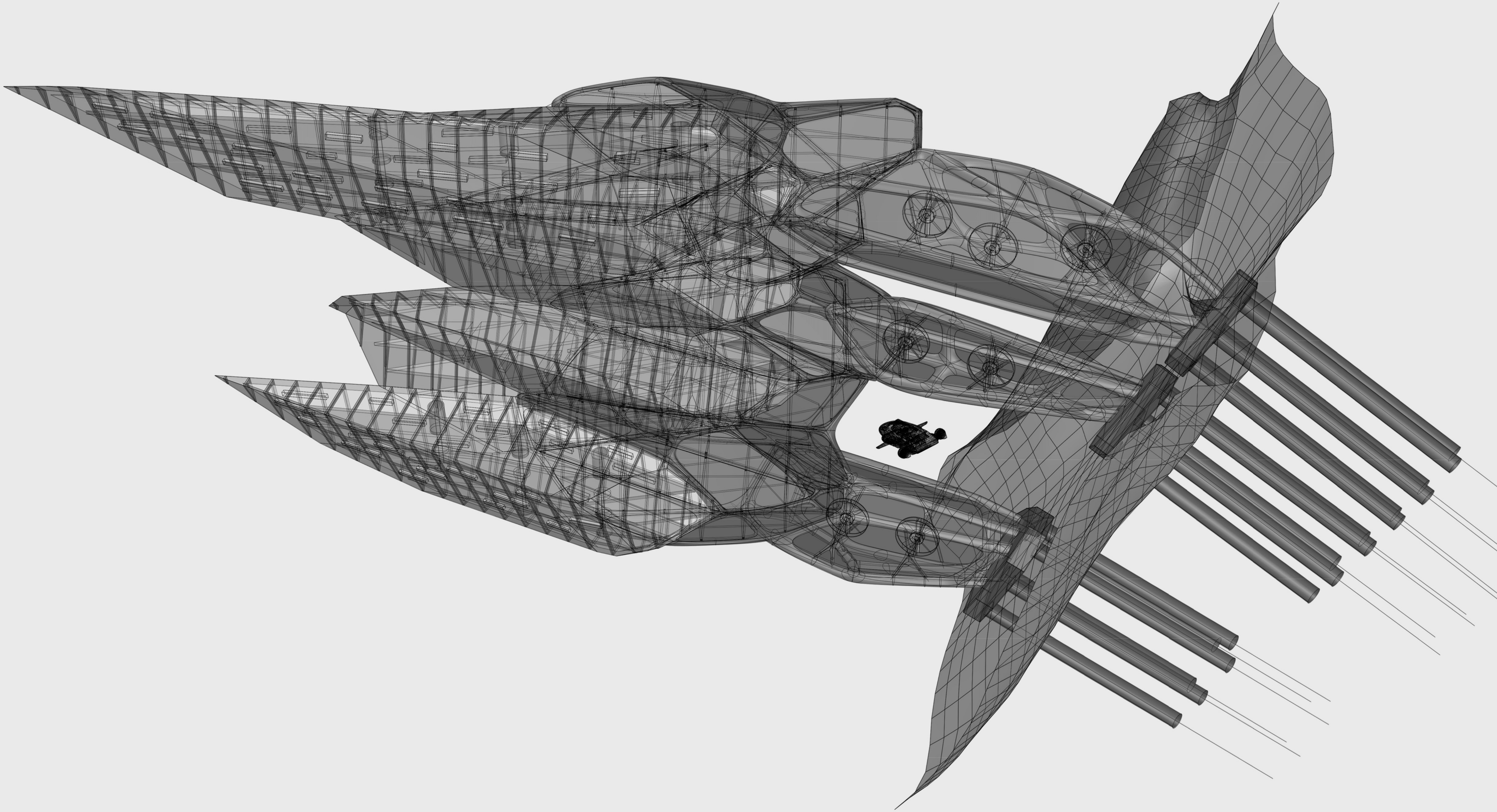

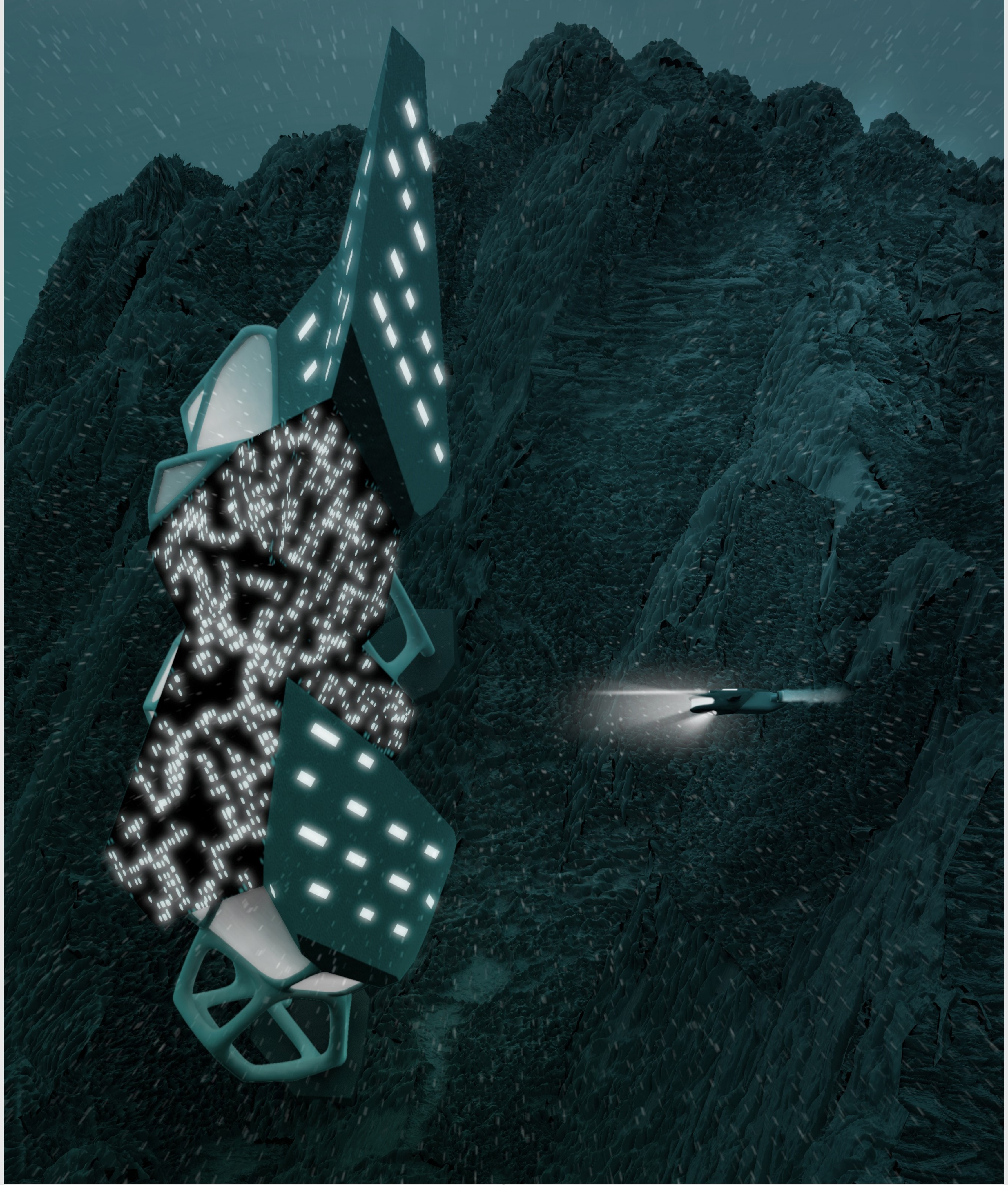

GUP - Grace Under Pression - est un habitat sous-marin autosuffisant conçu pour accueillir des personnes dédiées au travail et à la recherche dans les profondeurs des océans. Il est conçu pour assurer l'autonomie énergétique et productive, en limitant au minimum les apports de l'extérieur.

GUP peut être placé dans des environnements largement inexplorés, en particulier sur les pentes des montagnes sous-marines, à des profondeurs variant de 400 à 1000 mètres. GUP est divisé en six éléments constitutifs principaux :

- Structure de fixation primaire
- Structure de fixation secondaire
- Espaces de vie
- Espaces de travail et de recherche
- Espaces communs
- Espaces techniques

La colonie a une configuration hybride car elle n'est pas exclusivement réservée à la recherche avancée, elle est également ouverte à des séjours de courte ou moyenne durée de personnes dans un environnement pélagique en profondeur.

On estime qu'il existe environ 30 000 montagnes sous-marines sur notre planète, dont très peu sont connues. Dans la plupart des cas, elles sont constituées de volcans, éteints ou actifs, qui s'élèvent généralement du fond océanique à partir d'une profondeur de 1000 à 4000 mètres et montent brusquement, parfois jusqu'à quelques mètres de la surface. GUP est conçu pour être placé le long des flancs escarpés de ces montagnes, en particulier à proximité des manifestations superficielles de points chauds (hot spots) et en présence de courants constants de pente, souvent causés par des canyons ou des rétrécissements du fond. En particulier, les formations les plus appropriées à l'emplacement de GUP sont les soi-disant sommets sous-marins : des reliefs coniques de plus de 1000 mètres de haut aux flancs très abrupts.

- Deepseanews - https://www.deepseanews.com
- USGS, U.S. Geological Survey - https://www.usgs.gov
- NOAA, National Oceanic and Atmosfheric Administration - https://www.noaa.gov
- Usa Science & Engineering Festival - https://usasciencefestival.org
- NASA, National Aeronautics and Space Administration- https://seawifs.gsfc.nasa.gov
- UNESCO, United Nations Educational, Scientific and Cultural Organization - https://unesdoc.unesco.org
- National Geographic - https://www.nationalgeographic.com
- PLOS - https://journals.plos.org
- MarineBio, https://www.marinebio.org
- NPR, https://www.npr.org
- Smithsonian Magazine - https://www.smithsonianmag.com
- BBC Science Focus Magazine, "How underwater cities could solve Earth's overpopulation problem" by Stephen Kelly, issue 384, November 2022
- CNR, Consiglio Nazionale delle Ricerche - https://almanacco.cnr.it
- OGS, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - https://www.ogs.it