The deep sea, defined as the portion of the ocean below 200 meters, accounts for 90% of the ocean’s volume and represents the largest and least explored ecosystem on the planet. It plays a fundamental role in sustaining life on Earth, providing critical ecosystem services such as nutrient cycling, CO₂ absorption, and global climate regulation. Due to its vast expanse, the deep sea is the most extensive habitat on Earth, encompassing a highly diverse range of environments and ecosystems including seamounts, cold-water coral reefs, hydrothermal vents, cold seeps, submarine canyons, open slopes, and deep basins. This remarkable variety of habitats supports unique organisms that exhibit extraordinary adaptations to survive under extreme conditions. The continuous interplay between geological and biological processes shapes the structure and functioning of the deep sea. In particular, complex geological dynamics play a key role in oceanic life, influencing both the physical environment and marine ecosystems. Plate movements, resulting in new crust formation and subduction, drive large-scale, long-term morphological evolution of the seafloor and create unique environments characterized by total darkness, high hydrostatic pressure, low temperatures, and fluid emissions.

Among these, hydrothermal vent systems, often considered relatively pristine, are of significant interest for genomic studies of resident organisms, for the development of biotechnologies in sectors such as pharmaceuticals and cosmeceuticals, and for their potential industrial value due to their richness in metals. Meanwhile, high-energy geological processes that occur on near-instantaneous timescales can have immediate impacts on both humans and marine ecosystems.

Pressures and threats to these fragile deep-sea ecosystems are steadily increasing. Cumulative impacts are compromising their stability and resilience. A review of the current scientific literature highlights considerable knowledge gaps regarding this crucial environment and underscores the urgent need for targeted research programs. These should aim to: (i) investigate the processes and phenomena regulating deep-sea ecosystem functioning, (ii) assess the risks posed by human activities to the delicate balances sustaining these ecosystems, and (iii) explore sustainable approaches to the use of the deep sea’s biological and abiotic resources.

The research program presented here focuses on advancing scientific knowledge of the deep Mediterranean Sea, an ecosystem under significant pressure. The Mediterranean Basin is heavily impacted by intense urbanization and a wide range of human activities, including pollution, overfishing, habitat destruction, and the introduction of alien species. Additionally, the Mediterranean has been identified as a climate change hotspot and as one of the regions where climate impacts are expected to be particularly severe. This makes it a key observatory for studying the current and future effects of environmental change, offering unique opportunities to analyze how deep-sea ecosystems respond to such pressures.

Despite its relatively small size, the Mediterranean is often considered a "miniature ocean," as it encapsulates dynamic processes similar to those of the global oceans, while exhibiting unique characteristics. Its configuration makes it an exceptional natural laboratory for studying the oceanographic, ecological, and biogeochemical processes described, providing a unique opportunity to investigate deep-sea dynamics with fewer logistical challenges compared to larger ocean basins.

Access to CNR’s state-of-the-art research vessel *Gaia Blu*, equipped with cutting-edge instrumentation, enables high-resolution, multidisciplinary exploration of deep-sea environments, offering valuable research opportunities for the broader scientific community. The research program addresses key knowledge areas in deep-sea exploration by integrating disciplines such as geology, biology, ocean physics, and chemistry. Particular emphasis will be placed on technological innovation, including the design and development of new sensors and robotic systems for monitoring critical environmental parameters. Furthermore, the project will apply artificial intelligence techniques for big data management and the development of numerical models across the various areas of investigation.

Special attention will also be dedicated to the archaeological exploration of artifacts and shipwrecks lying on the seabed, remnants of vessels and carriers dating back over 4,000 years. These millennia of history will be studied using the most advanced experimental techniques, allowing reconstruction of ancient trade routes and the geographical development of what is considered the cradle of civilization.

The research program will also focus on technology transfer activities, particularly in underwater robotics, the discovery of new molecules, and the development of AI systems dedicated to big data management in seafloor exploration. Strong synergies are envisioned with ongoing PNRR projects (NBFC, RAISE, HPC, EMBRC+, etc.), which have already developed or are in the process of developing knowledge and prototypes that will serve as key references for the research activities outlined in this program.