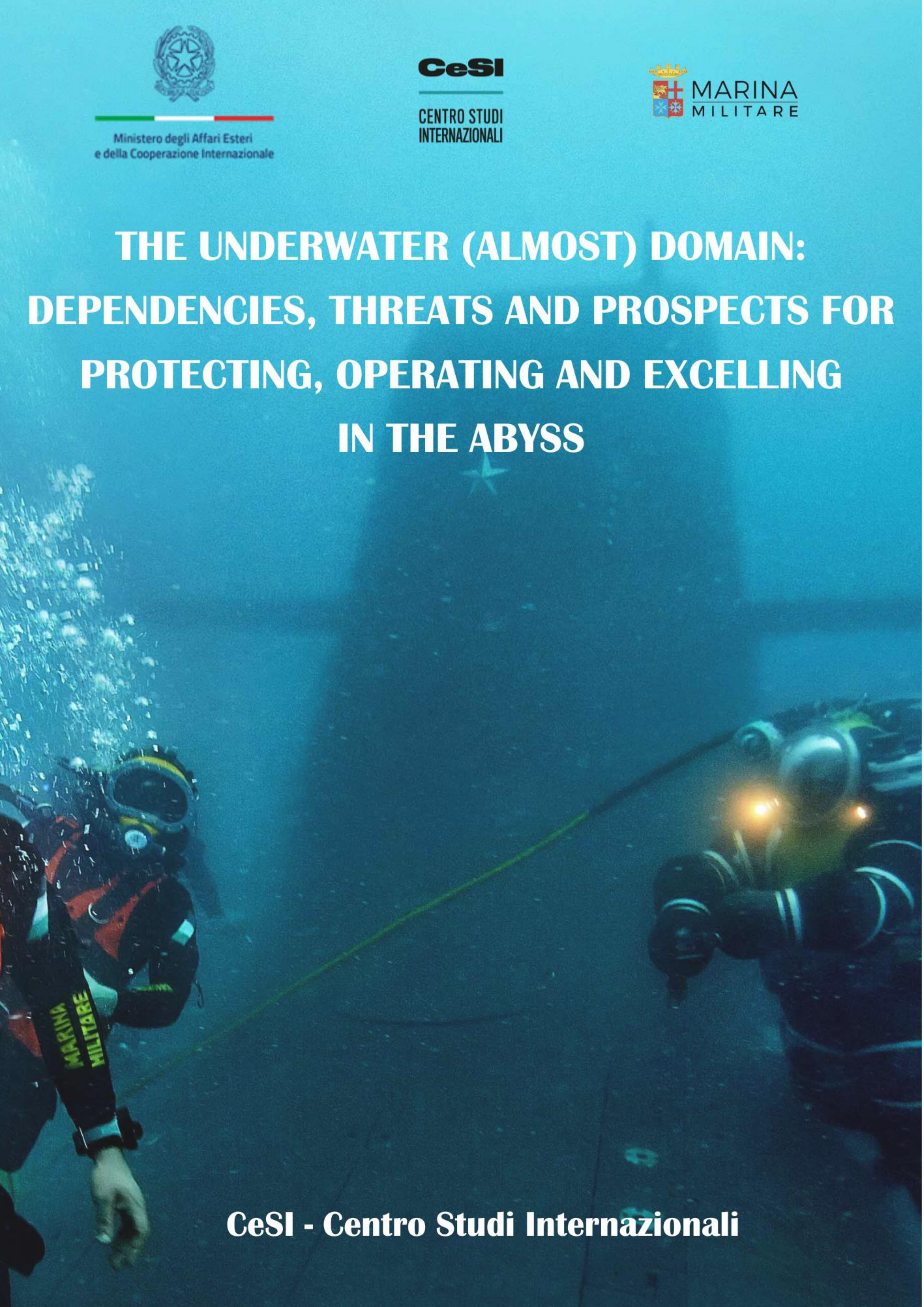
Ministero degli Affari Esteri
e della Cooperazione Internazionale

CeSI
CENTRO STUDI
INTERNAZIONALI

MARINA
MILITARE

THE UNDERWATER (ALMOST) DOMAIN: DEPENDENCIES, THREATS AND PROSPECTS FOR PROTECTING, OPERATING AND EXCELLING IN THE ABYSS



CeSI - Centro Studi Internazionali

THE UNDERWATER (ALMOST) DOMAIN: DEPENDENCIES, THREATS AND PROSPECTS FOR PROTECTING, OPERATING AND EXCELLING IN THE ABYSS

June 2024

Introduction by **Marco Di Liddo** – CeSI Director

Authors

Emmanuele Panero – Head of Defence & Security desk at CeSI

Commander (OF-4) Stefano Oliva – Head of Combat System section at the Submarines Department of the Italian Navy General Staff

Commander (OF-4) Marco Cassetta – Officer specialized in Underwater warfare and Explosive Ordnance Disposal

Translation edited by **Andrea Russo**

This (project/workshop/volume/article etc.) is realized with the support of the Unit for Analysis, Policy Planning, Statistics and Historical Documentation - Directorate General for Public and Cultural Diplomacy of the Italian Ministry of Foreign Affairs and International Cooperation, in accordance with Article 23 – bis of the Decree of the President of the Italian Republic 18/1967.

CONTENTS

ABSTRACT

In recent years, the submarine environment has become increasingly important, especially in the Indo-Pacific region, with the emergence of the concept of Underwater Domain Awareness. This relates to an awareness of the security risks associated with increasing human dependence and activity in the deep sea and the possibility that they may be subject to malicious surveillance or attack. Moreover, it relates to the opportunities that adversary actors could take, operating below the surface, in the absence of adequate control of the submarine environment, conducting actions contrary to national security and interests, thus affecting the performance of economic, commercial, civil and military activities. Corridors related to energy supply, mineral resources, connectivity, gas and oil pipelines, and data traffic transmission backbones make the underwater environment strategic in many aspects and as such vulnerable to the influence of competitors. The return of a high-intensity conventional conflict with effects and lessons learned also in the maritime domain, as well as the sabotage of the Nord Stream gas pipelines in the Baltic Sea or the digital communication cables in the Barents Sea, have made clear the relevance of this (almost) domain also for the coastal countries of the European region. This implies an appropriate reflection on the vulnerabilities of strategic assets located on the seabed, the threats (espionage, hybrid or kinetic) to which these infrastructures are exposed, and the new requirements needed to operate, monitor and project capabilities below the surface.

Indeed, the Mediterranean is increasingly a contested and chaotic sea, where numerous regional actors aspire to control and exploit increasing portions of the deep sea, and where disagreements between some states over their respective Exclusive Economic Zones (EEZs) are driving growing activity of surface and especially submarine assets to monitor activities below and above the sea. Finally, the increase in the number and activities of the Russian fleet in the *Mare Nostrum* poses significant questions of effective deterrence and the scalability of surveillance and potential competition tools, posing an undeniable threat to national, European and Atlantic security. In line with the challenges posed by acting in the underwater environment, the Budget Act has provided for the annual allocation of 2 million euro from 2023 for the construction and development of a National Centre of Excellence in La Spezia, under the supervision and control of the Italian Navy. The ultimate objective of the newly established centre is the enhancement of the national underwater sector, also implying the updating of the Code of Military Regulations, assigning the Navy the task of promoting the sector's potential and competitiveness while fostering its related technical-scientific research activities, as well as supporting its innovations and intellectual property. In fact, the subsurface dimension is of great importance to the Italian Republic due to the presence of key civil infrastructures, with the Navy playing an essential role in protecting communication routes and underwater infrastructures through submarines and other means, including unmanned ones such as underwater drones, which represent a leading high-tech and defence-industrial achievement. Undersea environment then offers a possible sphere of action and manoeuvre, in which the dedicated

components of the Armed Forces, especially the Navy, can extend their projection capabilities, developing doctrines and instruments suitable for controlling and influencing, if necessary, what lies below and above the surface or overlooking it from the coast. Determining the level of dependence on submarine infrastructure is therefore a fundamental prerequisite for an analysis of the different threats that can disrupt or damage these assets, and at the same time a starting point for identifying the capacity requirements to operate and excel in the underwater (almost) domain as Armed Forces, Defence Industry and Country-System.

INTRODUCTION

by Marco Di Liddo

Italy consistently ranks among the top-thirty most globalised countries according to the KOF Globalisation Index, reflecting the Republic's significant role within the global market, but also a high degree of dependence. Imports, exports, investment flows and financial transactions are indeed a central element of national economic dynamics and are often enabled by access to and use of critical infrastructure. From motorway and rail connections to multi-modal logistics nodes, from power plants to transmission lines to the country's digital architecture, these are the fundamental enablers not only for productive activities, but also for the everyday life of its millions of citizens.

A historically privileged route to connect states is, however, the sea, with the absence of orographic obstacles, volumetric transport capabilities and accessibility, constituting an important advantage for the naval instrument as a connection vector especially in the Italian topographical landscape. The advent of the age of digital industrialisation has further strengthened the role of the maritime domain in international relations, particularly with the progressive transformation of the seabed into pathways for the rapid transfer of goods essential to economic growth. Electricity, hydrocarbons and data flow constantly along the lines that run deep under the sea, fuelling the productivity of the Republic and ensuring the functioning of the country's system.

Boundlessness, poor accessibility and extreme physical-environmental conditions have for decades underpinned the assumption that these underwater infrastructures were per se protected from any threat, in a dimension, such as that below the surface of the sea, essentially excluded from competition between states. Technological advancement and the changing international political and strategic environment have, however, refuted such assessments, revealing the profound vulnerability of seabed installations and opening up a new operational domain located between 0 and 10,994 metres below sea level[1]. A broad, vertically diverse and inherently hostile *milieu*, closer to the challenges and limits posed by outer space than to the dynamics existing on land or in the air. An inductive situation of an ongoing technological and industrial race to develop advanced intelligence, surveillance and reconnaissance capabilities, denial of area access (A2/AD – Anti Access/Area Denial), monitoring and defence of critical infrastructures (Physical Infrastructure Security), as well as planning and conducting kinetic and non-kinetic actions. The specificities that characterise the underwater environment and the rapid development of doctrinal concepts, courses of action and technical tools inherent to it have therefore significantly increased and structured the understanding of the importance of the underwater dimension, elevating it almost to become a sixth operational domain. Regardless of the future success of such a classification, the considerable focus on

[1] The Mariana Trench is the deepest known oceanic depression in the world, located in the Pacific Ocean east of the Mariana Islands, between Japan to the north, the Philippines to the west and New Guinea to the south. Its deepest point, the Challenger Abyss, lies about 11,000 m below sea level.

dependencies on infrastructure on the seabed, potential threats from below the water surface, and the opportunities offered by manoeuvring in the depths make the underwater (almost) domain itself an object of strategic interest in ensuring national security.

This report, through an in-depth research, analysis and comparison activity, as well as relying on the constant comparison and contribution of institutional and industrial realities active both in the construction, maintenance and management of critical underwater infrastructures, and in the development and implementation of capabilities in and from the abyss, aims to lay the foundations for the definition of a National Underwater Strategy. To this end, the study begins by outlining the evolution of the "anthropisation" of the seabed and the progressive expansion of the human presence in the underwater depths especially in the military field, observing the main prospects of transformation in terms of both economic and resource exploitation and operational activities. Subsequently, the report details the main scenario for the development of the reflection on the underwater (almost) domain, addressing the issues of Underwater Domain Awareness and submarine competition in the regional theatre, but with global implications, of the Indo-Pacific. Building on these foundations, the analysis explores Italy's dependence on critical underwater infrastructures, investigating their qualitative and quantitative characteristics and relevance. The identification of these infrastructure vulnerabilities, with specific reference to opposing actors' malicious conducts, as well as the possible impact of a disruption in their functioning are therefore addressed, allowing a brief assessment of the risks to the security of the Country-System to be sketched out. The increasingly congested, contested and disputed nature of the underwater (almost) domain in the Mediterranean is therefore addressed in detail, assessing the shipbuilding initiatives of the main riparian countries and framing it within the relative strategic interests in the basin. The set of observations that emerged is finally at the basis of the identification of the new capability requirements imposed directly on the Navy, according to its specific institutional tasks, and transversally on the Defence Industries active in the shipbuilding sector.

In summary, the report, through its structured and comprehensive multi-level analysis of the central themes and factors pertaining to the (almost) underwater domain, aims to answer precisely to the following questions:

- How dependent is Italy on its critical underwater infrastructures?
- Which threats to their security and reliability can be outlined?
- What challenges do peer and near-peer competitors pose in the underwater dimension?
- What capability requirements the underwater (almost) domain dictates for the underwater component of the Italian Armed Forces?

The identification of these relevant answers is the foundation for the elaboration of a National Submarine Strategy, whose general guidelines, inspired by the principles of safeguarding security and the national interest and oriented towards enabling the Country-System to protect, operate and excel in the abyss, are outlined in the conclusion to this report.

CHAPTER I: THE UNDERWATER DOMAIN CONCEPT, EMERGENCE, HISTORY AND PROSPECTS

by Emmanuele Panero

The hostile nature of the deep sea has required the progressive development of cutting-edge technological solutions both to exploit the seabed for economic and commercial purposes and to manoeuvre effectively in the overlying water column. The first attempts to explore the possibilities offered by the abyss can be traced back to the 17th and 18th centuries, when the first, extremely rudimentary, experimental submersible vessels began to be built, with the intention, common to every historical age, of expanding the frontiers of human accessibility. The first underwater cable to transfer electricity dates back to 1811, installed not under the sea, but along the bed of the river Isar in Bavaria. It was only between the late 19th and early 20th century, however, that the technologies developed in the previous centuries came to fruition, with civil and military applications. In 1850, the first submarine telegraph cable was laid to connect France and the United Kingdom; in 1862, the US Navy's first submarine, the USS Alligator, was launched in the midst of the American Civil War; and Italy built its first underwater vessel, the *Delfino*, in 1896. The Navy would only equip itself with assets with military functions from 1905 onwards, deploying sequentially the vessels *Glauco*, *Squalo* and *Narvalo*. The first offshore pipeline for the transport of hydrocarbons, built by the Allies across the English Channel during the Second World War, was laid between 1942 and 1944.

Technological evolution has also allowed significant upgrades and advances in the possibilities of exploiting the immense submarine spaces for both civil and military purposes. Since 1956, telegraph cables were firstly flanked and then progressively replaced by telephone cables, before the advent of fibre optic telecommunication systems which, after a gradual phase of preliminary laying in the early 1990s, saw exponential growth in the 21st century. The sector of offshore pipelines for the transport of hydrocarbons and underwater cables for electricity has seen a gradual refinement of the materials used and the construction techniques, aimed on the one hand at making their installation more efficient and on the other hand at ensuring adequate safety standards. Similarly, the military has made major investments in submarine technologies, particularly, as far it concerns atomic powers, with the latter becoming an essential element of the nuclear deterrence triad. The advent first of nuclear-powered submarines, with the launch of the USS *Nautilus* in 1954, then the installation of ballistic missile carriers with unconventional warheads on them, with the deployment of the American USS *George Washington* in 1958, made the submarine component one of the most competitive areas during the Cold War, with significant investments also in conventional propulsion and weaponry. The subsequent development of anaerobic motors (AIP – Air-Independent Propulsion), through various engineering solutions, has actually favoured the latter, allowing the construction of submarines with smaller dimensions and costs, but extremely quiet and stealthy.

Over the decades, the economic advantages in terms of efficiency, durability and reach resulting from the use of submarine cables and ducts have promoted exponential growth in dedicated infrastructure, connecting continents, countries and societies. Similarly, the benefits of concealment, projectability and lethality offered by underwater manoeuvres in the military have favoured the expansion of underwater operational capabilities, making submarine fleets one of the most secretive and valuable components of naval forces worldwide, capable of reaching increasing depths, staying submerged for longer and generating effects below and above the surface. The relevance achieved by the deep sea and the activities carried out there is plastically represented by the more than 1.4 million kilometres of submarine cables and 1.2 million kilometres of offshore pipelines stretching along the Globe's seabed, while 43 countries have equipped themselves with underwater means, with 505 submarines deployed at the beginning of 2023[2].

The number of infrastructures and assets permanently active in the approximately 1.35 billion cubic kilometres of sea and ocean water, a measure of the immensity of the underwater (almost) domain and the inherent difficulties of tracking, surveying and conducting activities in it is not sufficient to express the significance of the abyss. By contrast, an estimate of the economic values related to their efficiency and security can provide an index of the dependence on these assets. Excluding the fact that over 80 % of global trade is by sea and it is hence vulnerable to what operates below the surface, the constant energy, hydrocarbons and data flows, from communications via social media to international financial connections, make it essentially impossible to determine an all-inclusive figure with any accuracy. However, it is relevant to note that more than 98% of the global web traffic travels, at least in part, through submarine cables, while by 2022 it was estimated that more than 10 trillion US dollars in financial transactions were carried through the same mean[3].

The growing dependence of the international economy and, in some respects, of contemporary societies on the seabed does not in itself exhaust the emergence of the concept of the underwater domain, but rather it is the association between this and the unique characteristics of the underwater environment, postulating the need of a strategic, doctrinal, capacitive, technical and technological reflection specifically dedicated to it. The underwater (almost) domain presents a considerable range of relevant obstacles: impenetrability through water of radio, infrared and electromagnetic waves, the need to employ sound as detection and tracking vector, the endemic darkness of the abyss, the variable density of water, the strength of stratified currents and the impact of pression and temperature on different types of surfaces and materials. The naturally hostile character of the abyss is also associated with the limits that still exist for human operations in the submarine depths. As of 2023, only 24.9% of the seabed surface has been mapped with sufficient resolution, and significant limits in underwater staying time and in depth reaching still persist, with negative altitudes rarely exceeding 900 metres and more usually close to 300 metres for the majority of submarines[4]. It

[2]Global Fire Power, *Submarine Fleet Strength by Country (2023)*, 2023, https://www.globalfirepower.com/navy-submarines.php

[3] Anna Gross, Alexandra Heal, Chris Campbell, Dan Clark, Ian Bott and Irene de la Torre Arenas*, How the US is pushing China out of the internet's plumbing*, in Financial Times, June 13th, 2023, https://ig.ft.com/subsea-cables/

[4] Dorian Archus, *How deep can a submarine dive?*, in Naval Post, April 26th, 2021, https://navalpost.com/how-deep-can-a-submarine-dive/

follows that surveillance of the deep, as well as the possibility of conducting benevolent or malevolent operations on underwater critical infrastructures represents a complex and inductive challenge of significant innovative efforts. Technological and capacitive primacy is in fact a decisive competitive advantage in the emergence of a potential new frontier domain, in order to act as a deterrent and to dictate industrial standards for the development of underwater shipbuilding and sensor technology. The effects therefore not only have a military impact, but also and above all a civil one, ensuring the targeted advancement of national and international submarine infrastructure and the related production, laying and maintenance sector, as well as the resulting benefits for the surface economy.

The competition between institutional and industrial players has therefore already outlined new perspectives for the underwater (almost) domain with parallel lines of development in both the military and civil spheres. As far it concerns communication cables, data flow speed, adaptability to transmission protocols, continuous geolocation of networks and routine and emergency maintenance are the priorities for the value-chain action. Similar needs are perceived for electric energy cables, whereas a different future is outlined for offshore oil and gas pipelines. Indeed, despite their persisting importance, energetic transition policies and the vast changing of international contexts dampened the innovation and maintenance of infrastructures and of their technologies, nevertheless inspired by rigid principles of security and maintainability of pipelines. Moreover, the gradual emergence of the underwater (almost) domain fostered a widespread modernisation of naval forces, especially in the Western hemisphere. The apparently sophisticated capabilities achieved by the Russian Federation to implement covert operations in the sea depths and the consistent investments undertaken by the Popular Republic of China in its underwater component, respectively associated to an increasingly aggressive posture adopted by Moscow and a more assertive stance adopted by Beijing, sensitively promoted the development of new solutions capable to operate longer and deeper. On the one hand, the research of new designs with low acoustic signature, multi-mission effectors and sensors and more silent propulsion systems capable of sustaining prolonged diving periods concerned the manned submarines fleets. On the other hand, an entirely new kind of capabilities related to remotely controlled and potentially autonomous assets has emerged. These latter overcome a series of obstacles and restraints concerning the designing and the employment of underwater assets, allowing to develop and deploy smaller and cheaper vessels featuring superior performances in terms of deepness and persistence. The integration of Artificial Intelligence (AI) in Underwater Unmanned Vehicles (UUV) provides a possible solution to the problems related to their remotization, eliminating the need for a physical connection between the asset and the mother platform, so to erase the necessity of resorting to complex and cumbersome transmission systems. At the same time, the exclusivity of the sound as the only tracking and surveillance vector is the object of a consistent innovation process aim to hone the range and the precision of multi-layered acoustic detection systems, so to increase their reliability regardless of water temperature and density.

The quantitative increasing and the upgrading of functions and performances delivered by underwater infrastructures and assets further contributes to highlight the role that the underwater (almost) domain is going to assume, together with the return of the intense confrontation between peer and near-peer competitors. According to this perspective, the rising of the underwater competition is affected by the progressive evolution of the Indo-Pacific scenario, from which the concept of Underwater Domain Awareness originates.

CHAPTER II: THE INDO-PACIFIC SCENARIO AS AN APPLICATION THEATRE OF UNDERWATER DOMAIN AWARENESS

by Emmanuele Panero

Since more than a decade, the Indo-Pacific is the stage of regional and global competition dynamics aimed at the control of areas of influences, natural resources and commercial routes. Besides the complex network of relationships among the regional countries and the states bearing interests in the area, the underwater dimension plays a primary role from which the concept of Underwater Domain Awareness gained the limelight, especially in the Indian strategic debate.

The term originates in the United States of America, where in late 2005 the concept of Maritime Domain Awareness (MDA) was presented as the fundamental precondition of the implementation of every capability in the maritime domain through the publication of the *National Plan to Achieve Maritime Domain Awareness for the National Strategy for Maritime Security*[5]. Being essentially focused on asymmetric threats, especially the terrorist ones, the plan did not make any significant reference to the underwater environment or to the strategies to decrease the odds or mitigate the effects of malicious actions against underwater infrastructures. Indeed, Washington did not consider the abyss relevant for the 21st Century Maritime Domain Awareness structure according to the Global War on Terror perspective. The first reference to the Underwater Domain Awareness is found in a study by the Royal Canadian Navy Lieutenant Commander David Finch, published in 2011 on the *Canadian Naval Review* with the title *Comprehensive Underwater Domain Awareness: A Concept Model*[6]. Curiously, the same made no reference to Maritime Domain Awareness, but emphasised the need to acquire greater situational awareness on the seabed to protect Sea Lines of Communication (SLOC) and prevent the restriction of freedom of movement in the seas and coastal waters by underwater assets and adversary naval mines. The paper noted in particular how acoustic surveillance capabilities developed in the military, industrial and scientific sectors pursued different and highly specialised objectives, but they could be integrated to foster a better understanding of what was happening on the seabed and in the water column above it. The central role of the sonar system (acronym of Sound Navigation and Ranging) both in the active version (sound wave emission and echo reception), and in the passive one (collection of sounds emitted in water) and their possible combinations, was addressed in detail, thus emphasising their instrumentality to civil and military implementations of the process of search, detection, classification, localisation and possibly attack/production of effects (SDCL-A - Search, Detect, Classify and Localize to Attack). The paper concluded by highlighting how the Underwater Domain Awareness, to be achieved through the fusion of data gathered by platforms of different nature and purpose, could enable the maritime environment to be comprehensively monitored, from the seabed, through the water column

---

[5] U.S. Department of Homeland Security, *National Strategy for Maritime Security: National Plan to Achieve Maritime Domain Awareness*, October 2005, https://www.dhs.gov/sites/default/files/publications/HSPD_MDAPlan_0.pdf

[6] Lieutenant-Commander David Finch, *Comprehensive Underwater Domain Awareness: A Concept Model*, in Canadian Naval Review, 2011.

and up to the surface. This would have made it possible to monitor, measure and evaluate a plurality of geophysical, biological and industrial activity parameters, while achieving national security objectives.

The issues and arguments developed in the paper did not, however, receive particular attention for almost a decade, as a result of both reduced perception of the underwater threat and the significant technological development required to implement effective multi-sensor integration in the seabed. The concept of Underwater Domain Awareness has therefore re-emerged in the Indian strategic context, where it has been interpreted as a multi-faceted framework of industrial consolidation in the submarine sector and strengthening national security instruments. On the one hand, New Delhi aspired to excel in abyss-related innovations, so to foster the development of a significant manufacturing industry; on the other hand, it feared being marginalised in the Indo-Pacific competition. In fact, the regional theatre, which is large, fragmented and predominantly insular, is characterised by the clear predominance of the maritime domain with the key importance of SLOCs and underwater resources and infrastructure at the centre of temporary balances. Although India is not directly involved in the territorial disputes related to the spaces claimed by the People's Republic of China within the so-called nine-dash line[7] in the South China Sea, the tactics employed by Beijing in this area have greatly heightened India's perception of its need to guard its own seabed to prevent the occurrence of malicious actions. In fact, China has implemented the gradual expansion of a multifaceted series of activities, both civil and military, in the seabed to promote its national interests, leading to a widespread realisation of the relevance of the underwater (almost) domain. In detail, over the years, Beijing has undertaken and pursued actions involving the deep sea in at least three respects. Within the South China Sea and particularly in the vicinity of disputed territories, including the better-known Spratly and Paracelsus Islands, the People's Republic has made widespread use of massive seabed dredging operations with a twofold purpose. While some of the material collected has been used by the continental industry, the majority of it has been used to bring about profound morphological changes in some coastal areas, expanding portions of land and building surveillance and naval defence installations. In parallel, China has challenged the hegemony of French, US and Japanese companies in the submarine cable sector since 2009, with the prospect of consolidating its position at the tail end of these by 2025, with some 75,000 kilometres of lines laid[8]. Chinese activism in this area has also expressed itself through significant business clashes, especially with American companies, over the awarding of major contracts promoted by the countries in the region, in tenders often marked by cross-accusations over the privacy of data transmitted through their respective networks. The People's Liberation Army Navy

[7] The nine-dash line is a demarcation line drawn by the governments of the People's Republic of China and the Republic of China (Taiwan) around their claimed territories in the South China Sea. The line, which consists of nine distinct stretches arranged in a U-shape from the southern coast of China, encloses most of the waters of the South China Sea and a series of archipelagos, atolls and shoals, including the Paracelsus Islands, the Spratly Islands, Pratas Island, Macclesfield Bank and Scarborough Shoal. Beijing's or Taiwan's sovereignty over these territories is not internationally recognised and is indeed contested by the other riparian states in the region, notably Brunei, the Philippines, Malaysia and Vietnam.

[8] Anna Gross, Alexandra Heal, Chris Campbell, Dan Clark, Ian Bott and Irene de la Torre Arenas, op. cit.

(PLAN) also expanded its underwater component, building and deploying an increasing number of assets and increasing their operational depth and range.

The perception of a growing and increasingly technological Chinese underwater assertiveness has thus constituted the prerequisite for the development of a profound strategic reflection not limited to India regarding the ability to watch its territorial waters and infrastructures therein to deny conducts contrary to national interests and security. The perceived threat is in fact emphasised by the impossibility, given the quality and quantity of existing technical tools, of even detecting malicious actions. On the one hand, the main concerns relate to covert intelligence-gathering activities conducted by underwater assets both with respect to information flows through cables on the seabed and through multi-sensor ISR operations near the coast. On the other hand, the execution of kinetic actions aimed at disabling critical underwater infrastructures or degrading the freedom of movement of surface vessels, both civil and military, especially by means of naval mines, again with the aid of underwater means. A number of events that took place in the region over the past two years have also materialised some of the risks envisaged, showing how not only clearly malicious events can cause damage beneath the waves. Notably, in January 2022, the eruption of a submarine volcano damaged the only underwater internet cable connecting Tonga with the global network, isolating the island for several weeks[9]. In April 2023, the island of Matsu, belonging to the Republic of China and located in the Taiwan Strait, has lost its connections, following the apparently accidental severing of the two cables connecting its territory to Taipei[10]. Other similar incidents have taken place in the Indo-Pacific region in at least 27 cases between 2018 and 2023[11], with civilian vessels, either engaged in trawling or anchoring along the coast, held responsible. These events, whose accidental nature is in some cases questionable, further underlined how a lack of awareness of the vulnerabilities to which critical underwater infrastructures are exposed can generate extremely significant problems for a country, slipping into an area of possible hybrid conflict.

Hence, the Underwater Domain Awareness outlines the objective of establishing an architecture of systems and installations capable of monitoring the abyss, ensuring the early detection of any activity and enabling the decision-making process to take appropriate response initiatives. Despite being perceived as a simple result to be achieved, the intent is still held back by the very two aspects characterising the underwater (almost) domain: the immensity of the volumes, more than the surfaces, to be monitored and the inherent hostile complexity of the underwater environment. The former in fact imposes extremely high costs, requiring the combined use of high-performance surface platforms and of the related technological research and development process to implement them, and a plurality of remotely controlled or autonomous systems, constantly active in scouring the seabed. The latter represent one of the only lines of development capable of overcoming the engineering limitations posed by the necessary attention to the safety of sailors operating under the

---

[9] Simon Scarr, Wen Foo, Vijdan Mohammad Kawoosa, Anand Katakam and Aditi Bhandari, *The race to reconnect Tonga*, in Reuters, January 28th, 2022, https://www.reuters.com/graphics/TONGA-VOLCANO/znpnejbjovl/

[10] Huizhong Wu and Johnson Lai, *Taiwan suspects Chinese ships cut islands' internet cables*, in Associated Press, April 18th, 2023, https://apnews.com/article/matsu-taiwan-internet-cables-cut-china-65f10f5f73a346fa788436366d7a7c70

[11] Ibidem

waves and their vulnerability to the harmful effects of extreme temperatures, high pressures and rapid changes in depth. The constant challenge posed to Anti-Submarine Warfare (ASW) between detection capability and exposure to it, resulting from the inverse relationship between active sonar systems and passive sensor equipment, further complicates the scenario. Indeed, attempting to detect a submarine exposes the asset engaged in the task to detection, precisely because of the sound waves it emits, in a constant dilemma between detecting the adversary and evading the reach of enemy detection systems. Magnetic anomaly detectors and bathymetric light detection and measurement equipment have been tested with the aim to improve ASW capabilities, yielding however mixed results. Moreover, they have already been partly neutralised by the application of specific countermeasures, in terms of materials and equipment, integrated in new submarine assets.

Despite significant difficulties in the concrete implementation of the concept, Underwater Domain Awareness encompasses the principle that the underwater (almost) domain shares an intrinsic dual civil-military nature with the two most recently recognised operational domains, namely the space and cyber domains. Consequently, a purely military approach to the issue would generate suboptimal results, thus reinforcing the proposition of a pragmatic horizontal and vertical cooperation. Underwater situational awareness, although it is hard to attain and it is essentially subordinated to the eternal technological race between detection systems and concealing devices, can contribute decisively to one country’s national security only combining skills, capabilities and needs of multiple realities, both public and private, operating in the abyss.

The development of Underwater Domain Awareness, particularly in its conception as a detection, tracking and identification architecture intended to make the seabed and the water columns above it metaphorically transparent, therefore proposes the implementation of regulations, the carrying out of risk analyses and the establishment of sensor networks. The security sector, encompassing not just the military but also environmental protection institutions, shipbuilding industries, oil transport, communications and offshore wind sectors and of course the academic and scientific research institutions should synergically converge towards a coordinated, efficient and decisively innovation-driven framework.

The inherent difficulty of distinguishing between set objectives and concrete capabilities, at least in a scenario as broad as the Indo-Pacific, is currently one of the elements that has most prevented the effective transformation of the Underwater Domain Awareness model into reality. The purely defensive assumption of the concept has also contributed to its partial marginalisation towards more localised and distributed approaches, with a significant military bias. The US Navy in particular, referring to the same theatre and with a view to operations away from its own national territory, has developed reflections mostly focused on the ability to create dispersed bubbles structured on combinations of sensors and effectors to prevent the adversary from acting in certain areas within specific time windows, thus enabling a time- and space-sensitive selective interdiction.

The concept of Underwater Domain Awareness, however, is a functional prospect to promote accurate strategic thinking about a country’s posture towards the underwater (almost) domain, but to define this stance properly it is first essential to determine the dependencies on the same.

CHAPTER III: THE ITALIAN DEPENDENCY ON THE UNDERWATER (ALMOST) DOMAIN

by Marco Di Liddo

Over the years, the geographical location of Italy in the centre of the Mediterranean Sea and the considerable length of its coastline fostered and still promote the widespread construction of infrastructures in the underwater (almost) domain within the water surrounding the Peninsula. The consistency of this network of cables and pipelines, with their respective routes and terminals, and the analysis of the industrial capabilities behind their construction, maintenance and management, as well as the economic significance of the flows through them, are therefore central to the definition of the vulnerabilities and impacts that eventual damages to them could cause. The understanding of the operational environment and the consequent identification of the nature and the extent of potential attack surfaces are indeed fundamental prerequisites of a possible National Submarine Strategy.

Italy's critical underwater telecommunication infrastructures represent the most consistent share among those deployed in the seabed. Specifically[12], approximately 1,139 kilometres of cables are registered along the Adriatic side, connected to Croatia, Albania and Greece, of which approximately 60% pass through Italian territorial waters. All the relevant terminals on the national side in this quadrant converge on Bari, except for the Italy-Croatia cable which emerges in Mestre. There are three connections between Italy and Greece, the first of which is divided into two cables ending respectively in Bari and Kokkini; the second and the third ones are located on the Ionian side and depart from Ethos and Prevesa, to reach Italy in Otranto and Crotone. Also, two large-scale backbones, the *Jonah* and *Asia Africa Europe-1* (AAE-1), arrive near Bari. The former, with an overall length of 2,297 kilometres, is a direct cable that starts in Tel Aviv, Israel, and stretches across the Eastern and Central Mediterranean. The second, with a total length of 25,000 kilometres, spans across several continents, starting at Cape d'Aguilar, in the Chinese Special Administrative Region of Hong Kong, and crossing the Indian Ocean, the Suez Canal and the Mediterranean Sea.

In the Tyrrhenian quadrant, Genoa and Savona serve as the main entry points, with the *BlueMed* and *2Africa* cables, representing two of the most important infrastructure projects under construction in the Tyrrhenian Sea. The former, in its full extent, will in fact cover a total distance of 4,696 kilometres along the entire Mediterranean Sea, reaching as far as Aqaba in Jordan. The latter is expected to reach 45,000 kilometres, circumnavigating the entire African continent, all the way to North Central Europe. Genoa also marks the end of both the 162-kilometre-long cable connecting Italy to the Principality of Monaco and the *Medloop*, a 1,360-kilometre-long backbone connecting Italy, France and Spain. Also, within the Tyrrhenian sector, the initial operation capability of the

[12] Mileage and track data are extracted and processed from Submarine Cable Map, in TeleGeography, https://www.submarinecablemap.com/

India Europa Xpress (IEX) intercontinental cable and the Italian interregional infrastructure project *Minor Islands Plan* are planned for 2024. To this must be added the *Unitirreno* backbone, expected to be operational by 2025, which will connect the entry points of Mazara del Vallo, Rome and Genoa.

However, Sicily is the Italian region with the greatest convergence of submarine telecommunications cables, belonging to both regional and intercontinental networks. The *MedNautilus* is one of the main ones, with its route passing through several Mediterranean nerve centres, including Israel, Turkey, Greece and Cyprus and totalling an overall length of 7,000 kilometres. Catania is the national terminal for this backbone, together with the *Imewe* and *SeaMeWe-5* intercontinental cables, extending respectively for 12,091 and 20,000 kilometres. *Imewe* reaches the Indian city of Mumbai, while *SeaMeWe-5* proceeds as far as Malacca, Malaysia, one of the main international choke points also for underwater infrastructures. Palermo, on the other hand, hosts the junction point of the *Flag Europe-Asia* (FEA) backbone, which stretches 28,000 kilometres through the Mediterranean Sea, the Suez Canal, and taps the coasts of the People's Republic of China, South Korea and Japan. Finally, Palermo is the terminal of the *SeaMeWe-4* cable, which essentially duplicates the *SeaMeWe-5* in capacity and routing. In the Central Mediterranean and along the Strait of Sicily, direct connections between Italy, Malta, Libya and Tunisia are also concentrated, for an overall total of 2,107 kilometres, with national anchorage points at Catania, Marina di Ragusa, Trapani and Mazara del Vallo. The latter location is a crucial terminal for the landing of underwater backbones passing through the Central Mediterranean, being the Italian landing point for the *SeaMeWe-3* and *Gulf Bridge International* cables, two intercontinental connections of 39,000 and 8,000 kilometres from Australia and the United Arab Emirates respectively. Lastly, connections between the islands and the continental platform are ensured by the cable *Janna*, 637-kilometers long, emerging in Mazara del Vallo, Olbia, Cagliari and Civitavecchia.

The overview in Figure 1 outlines a summary encompassing the aforementioned critical infrastructures, amounting to 40,000 kilometres of communication cables in the whole Mediterranean Basin. Adopting a strictly national perspective, the role of the city of Bari as primary terminal for the incoming data traffic on the Adriatic and Ionic side, whereas the other connections in the field performing mostly regional tasks. In this quadrant, the overall length of underwater cables is rather short, totalling no more than 2,000 kilometres of backbones. The connections in the Tyrrhenian quadrant, mostly converging on Genoa, are essentially local and regional in nature. 2,500 kilometres of cables are currently operational, without considering future possible

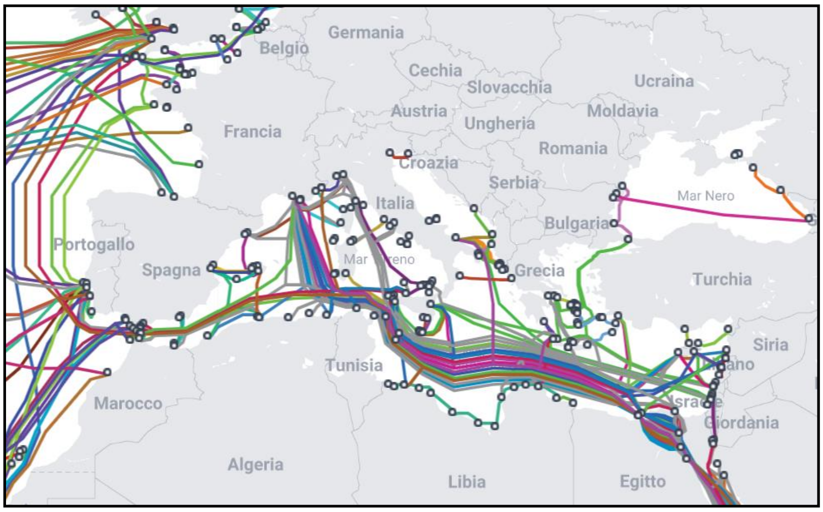


Figure 1: Underwater IT backbones in the Mediterranean Sea.
Source: Submarine Cable Map

investments for increasing the number of underwater telecommunications infrastructures in the area. On the contrary, Sicily constitutes one of the major global connectivity hubs, both as a European terminal and as a transit point for intercontinental backbones to Spain, France and Northern Europe. The cables that run there also ensure a large part of national data traffic. Significantly, 60% of Italian internet connections originate or emerge in the cities of Mazara del Vallo, Catania and Bari[13]. The relevance of these infrastructures can hardly be overestimated, with more than 90% of Big Data passing through them, totalling a national value close to 2,500 billion euros per year and growing steadily by 2030[14].

The Italy's significant dependence on the underwater (almost) domain and the relevant expansion of the related civil market fostered the development of entrepreneurial and industrial realities in the field, especially through the establishment of joint ventures among telecommunication companies, cable-lying specialized firms and Big Tech companies. The latter still retain more than 66% of the shares for the implementation, the maintenance and the management of seabed cables[15]. Nationally speaking, *Telecom Italia Sparkle* is the first service provider, thus being listed among those companies subjected to the Golden Power[16] regulation since 2017[17]. The national manufacturing sector includes *Prysmian Group*, an international pioneer in the

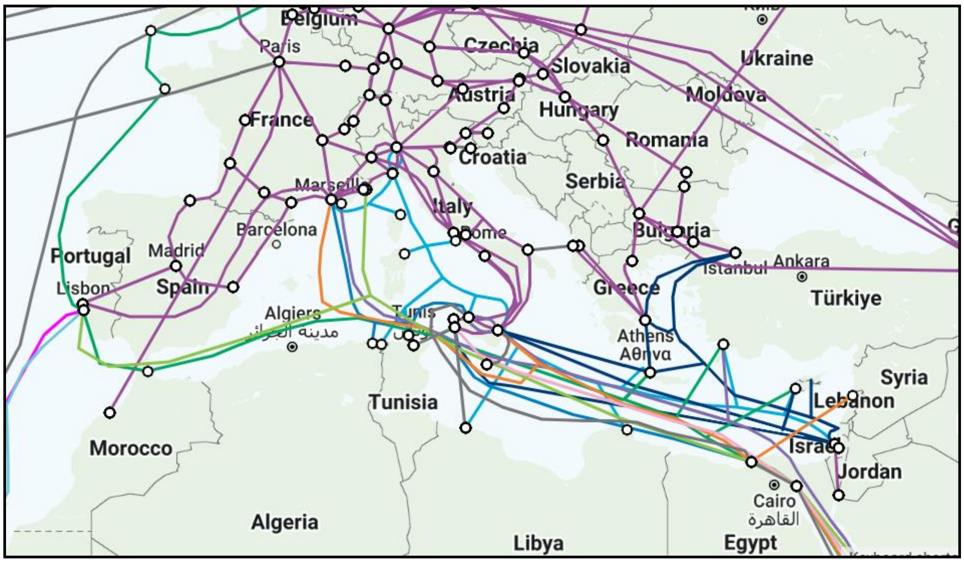


Figure 2: The backbone network belonging to Team Sparkle.
Source: Sparkle

[13] Emanuele Oddi, *Sicurezza e rilevanza geopolitica dei cavi sottomarini in Italia*, in Eurispes, June 5th, 2023, https://www.leurispes.it/cavi-sottomarini-di-grande-rilevanza-geopolitica-in-italia/

[14] Alessandro Ruocco, *I pagamenti digitali ormai (quasi) eguagliano quelli in contanti*, in Credit News, October 18th, 2023, https://www.creditnews.it/pagamenti-digitali-eguagliano-contanti/#:~:text=Secondo%20le%20previsioni%20di%20Banca,addirittura%20superarli%20nei%20prossimi%20anni

[15] Michele Calamaio, *La rete di cavi internet nel Mediterraneo è piuttosto ingarbugliata*, in Wired, November 20th, 2023, https://www.wired.it/article/internet-cavi-sottomarini-mediterraneo-ambiente/

[16] Golden Power is a discipline found in Decree-Law No. 21 of 2012 and is aimed at safeguarding the ownership structures of companies operating in sectors deemed strategic and of national interest. Mainly exercisable in the defence and national security sectors, as well as in certain areas of activity defined as strategically important in the energy, transport and communications sectors, the Golden Power implies, inter alia, the power to dictate specific conditions to the acquisition of shareholdings, to veto the adoption of certain company resolutions and to oppose the acquisition of company shares.

[17] TIM Group, *TIM: Ricevuta Notifica del Provvedimento "Golden Power"*, October 16th, 2017, https://www.gruppotim.it/it/archivio-stampa/corporate/2017/TIM-CS-Golden-Power-16-10-17.html

production and laying of telecommunication and fibre optic cables, which also has its own fleet of specialised vessels capable of operating at depths up to 3,000 metres[18].

For what it concerns the field of electric energy, Italy is less dependent on the underwater (almost) domain, with a total of 1,762 kilometres of underwater power lines, of which 1,445 kilometres are very high voltage (380 kV) and 317 kilometres are high voltage (220 kV and 150 kV)[19]. Figure 3 summarises the Italian currently operational power lines, indicating the terminals, route length and laying depth. With the remarkable exception of the direct links with Serbia and Montenegro, all remaining national power lines work as internal connectors between different areas of the country, passing through waters under exclusive Italian jurisdiction. Moreover, the power cable between Italy and Greece is one of the ten longest and most powerful direct current submarine cables in the world, with a peak power transmission of 500 MW and a maximum voltage of 400 kV[20]. Its route stretches for 160 kilometres, completed by a further 43 kilometres on land, starting from the Galatina power station, and reaching the Greek power station of Arachthos, passing through the Otranto Channel. The power line between Italy and Montenegro, on the other hand, represents a key junction towards the Balkans, and is currently the longest High Voltage Direct Current (HVDC) link ever built by *Terna*. Its route, which passes through the waters of the Adriatic Sea, spans 423 kilometres underwater and 22 kilometres on land. The most relevant national power line, however, is the *SA.PE.I*, considered the deepest operational submarine power cable in the world, reaching a negative laying altitude of around 1,640 metres below sea level. Its 420-kilometre route connects Sardinia with Lazio via two lines capable of supporting 500 kV of voltage for 1,000 MW of power.

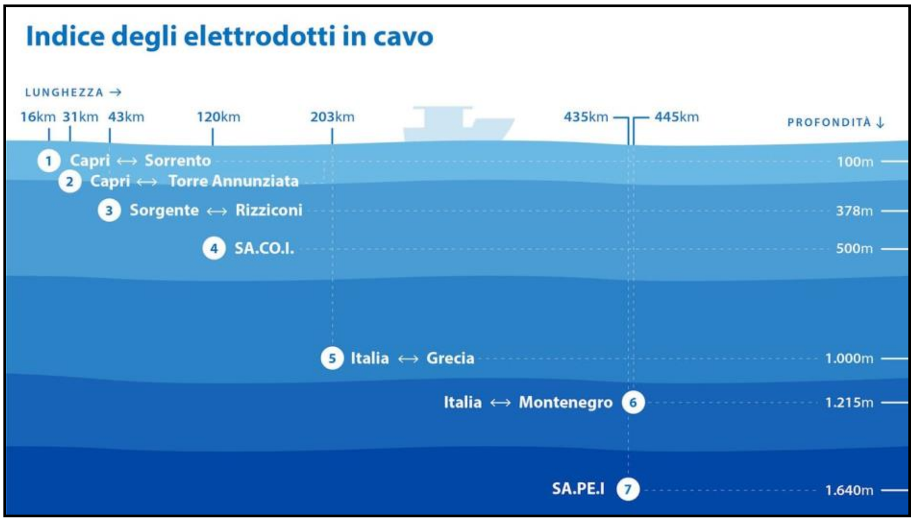


Figure 3: Summary of power lines.
Source: Terna

Underwater electricity infrastructure is also experiencing a phase of growing interest, with the planning and implementation of additional power lines, as reported in the 2023 Development Plan published by *Terna* and illustrated in Figure 4. At the intra-national level, the two main programmes, both with an operational horizon of 2028[21], are the *Tyrrhenian Link* and the *Adriatic Link*, which are

[18] Prysmian Group, https://it.prysmiangroup.com/mercati/generazione-trasmissione-distribuzione
[19] Terna, *Piano di Sviluppo 2023*, 2023, https://download.terna.it/terna/Terna_Piano_Sviluppo2023_Stato_Sistema_Elettrico_8db254887149b77.pdf
[20] Terna, *L'energia che scorre sott'acqua*, January 18th, 2021, https://lightbox.terna.it/it/in-prima-linea/cavi-sottomarini-record
[21] Terna, *Terna: 2023 Develompment Plan for the National Electricity Grid Presented*, March 15th, 2023, https://www.terna.it/en/media/press-releases/detail/2023-development-plan

going to be respectively an HVDC with 500 kV voltage between Sicily, Campania and Sardinia, and a 1,000 MW HVDC between Abruzzo and Marche, with a track length of approximately 250 kilometres, 210 of which are below the sea surface. By contrast, the most important planned international links are the 200-kilometres long, 500 MW voltage electric pipeline with Greece, which is going to double the energetic exchange capability between the two countries[22]; and a 600 MW voltage power bridge with Tunisia built by *Terna* and *Steg*, the Tunisian electricity grid operator, with a total investment of 850 million euros.

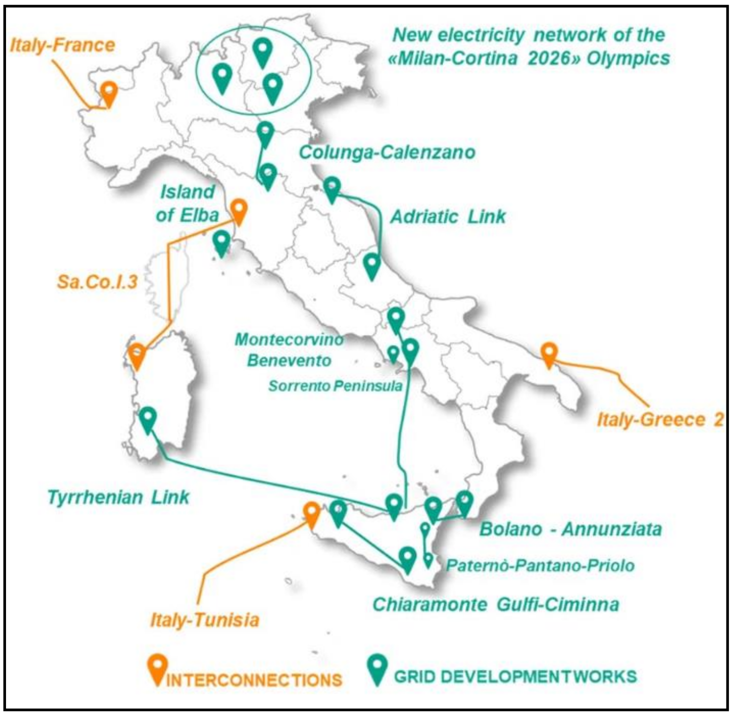


Figure 4: Terna Development Plan 2023.
Source: Terna

Overall, the underwater electricity network is small if compared to that on land, with the only routes to foreign countries being along the lower Adriatic and the Central Mediterranean. Furthermore, the data show that the national electricity supply is marginally dependent on infrastructures located outside the national perimeter. Terna's report for the year 2022[23] stresses that electricity demand in Italy amounted to 315 TWh, 86.4% of which was met by domestic production for consumption and the remainder by net imports from abroad, amounting to 43 TWh.

In contrast to energy supply, pipelines along the seabed are important in relation to the transport of light hydrocarbons. In fact, Italy is highly dependent on imports of natural gas, that following the supply cut from the Russian Federation due to the aggression to Ukraine is shifted to other supplier countries, promoting the use of underwater lines, which feed three of the six national entry points for imported gas. More specifically, Melendugno, in the Province of Lecce, is the landing point of the *Trans Adriatic Pipeline* (TAP), which transports natural gas from Azerbaijan to Europe, Mazara del Vallo is the terminal of *TransMed*, which connects Algeria to Italy via Tunisia, and Gela is the arrival point of *GreenStream*, coming from Libya[24]. The first pipeline extends, in its

[22] Ibidem

[23] Terna, *Pubblicazioni Statistiche 2022*, https://www.terna.it/it/sistema-elettrico/statistiche/pubblicazioni-statistiche#:~:text=La%20potenza%20efficiente%20lorda%20di,2021%20del%205%2C3%25.

[24] Chamber of Deputies, *Il Sistema Gas Italiano*, March 7th, 2023, http://documenti.camera.it/leg19/dossier/pdf/AP0021.pdf

national section, along the Otranto channel for 105 kilometres and reaching a maximum depth of 810 metres; the second has a course of 160 kilometres along the Sicilian Channel at a negative altitude of 610 metres[25], whereas the third one stretches 516 kilometres over depths up to 1,150 metres [26]. On aggregate, approximately 781 kilometres of pipelines pass through Italian territorial waters, located at an approximate average depth of 850 metres.

Italy depends on imports for more than 96% of the gas consumed, corresponding to about 70 billion cubic metres per year, compared to an approximate national production of 3 billion cubic metres[27]. Currently, approximately 49% of the gas entering Italy transits through subsea pipelines, divided as follows: 32% by *TransMed*, which transports approximately 22.4 billion cubic metres, 13% by TAP, with a volume of approximately 9.1 billion cubic metres of gas per year, and 4% by *GreenStream*, with approximately 2.8 billion cubic metres[28]. According to an industrial perspective, all three pipelines have a significant Italian shareholding with *Eni* and SNAM holding 50% of the shares for the *TransMed* pipelines[29] and *GreenStream* pipelines and 20% for TAP[30].

Figure 5: National Gas Pipeline Network.
Source: SNAM

Lastly, for what it concerns oil supply, there are no dependencies on underwater infrastructures, with the three oil pipelines passing through the country, respectively the *Monte Alpi* crude oil, the *NATO pipeline system* and the *Transalpine* pipeline, running almost entirely on land. Indeed, only the last one makes a short transit along the upper Adriatic coast to reach the port of Trieste. The reason for this configuration is that approximately 70% of the total national crude oil traffic transits by ship and is handled by the ports of Trieste, Cagliari, Augusta, Milazzo and Genoa[31].

---

[25] Ministry of the Economic Development, *Decreto Ministeriale*, May 22nd, 2020, https://www.mimit.gov.it/images/stories/normativa/Deroga_Trasmed_22_maggio_2020.pdf

[26] GreenStream, *Il Sistema di Trasporto LGTS (Libyan Gas Transmission System)*, https://www.greenstreambv.com/it/gasdotto-greenstream.html

[27] Chamber of Deputies, op. cit.

[28] Elaboration of Data extracted from Chamber of Deputies, op. cit.

[29] Transmed, https://www.transmed-spa.it/#:~:text=La%20societ%C3%A0%20%C3%A8%20una%20societ%C3%A0,e%20della%20societ%C3%A0%20algerina%20Sonatrach

[30] Trans Adriatic Pipeline, *Azionariato di TAP*, https://www.tap-ag.it/informazioni-su-tap/azionariato-di-tap#:~:text=L'azionariato%20TAP%20%C3%A8%20composto,%2C%20e%20Enag%C3%A1s%20(20%25)

[31] SRM, ITALIAN Maritime Economy, October 1st, 2020, https://www.sr-m.it/wp-content/uploads/2020/10/RS-MARITIME-2020-OTTOBRE.pdf

In conclusion, the mapping of national submarine infrastructures and their dependencies shows Italy's exposure to the underwater (almost) domain concentrated mainly in the telecommunication and light hydrocarbon sectors. Quadrants with a higher density of cables and pipelines are located in the central Mediterranean Sea and in the Sicily channel. Indeed, Sicily is a crucial hub for both Italian digital connectivity and energetic supply, being the convergence of a great number of telecommunication cables from Asia and pipelines coming from North Africa. Another area of relevance can be found in the Adriatic Sea quadrant, especially the Otranto Channel, where the TAP gas pipeline, some intercontinental cables and power lines to foreign countries transit. Considering the overall routing of these infrastructures, particularly for telecommunication cables, the importance of the entire Mediterranean Sea becomes clear with specific regard to the choke point represented by the Suez Canal. Finally, on the national soil, 60% of telecommunication cable junctions, around 50% of submarine gas pipelines and the entirety of transnational power lines (operational and in the implementation phase) land in only two regions: Sicily and Apulia.

The large and diversified attack surface outlined, the economic and general relevance of underwater cables and ducts for the Country-System, as well as the exiguity and concentration of outlets highlight the importance of detecting vulnerabilities and potential impacts of malicious actions. From this perspective, defining the threats posed to critical underwater infrastructures is the next step.

CHAPTER IV: THE THREATS TO NATIONAL UNDERWATER CRITICAL INFRASTRUCTURES

By Commander Marco Cassetta[32]

Threat to underwater critical infrastructure: evolution and causes of the phenomenon.

Recent Russian assertiveness and the events related to the war in Ukraine have radically altered the threat landscape in Europe, marking a turning point in the way wars are fought. While the Alliance remains focused on supporting Ukraine and strengthening its eastern flank, the Mediterranean increasingly appears to be a highly unstable, uncertain, and crisis-ridden environment, revealing, especially in the underwater dimension, vulnerabilities that will not be easily resolved. The sabotage of the *Nord Stream* pipeline in September 2022 forced European governments to confront the limited capacity to defend against hybrid tactics in the submarine domain[33]. Furthermore, at present, it is not yet possible to ascertain whether the subsequent damage to the *Balticconnector* pipeline and a data cable between Finland and Estonia, which occurred in October 2023, was in fact intentional or happened by chance[34].

In this context, the intricate web of critical underwater infrastructures would seem to be the perfect scenario for the conduct of malicious actions with conventional assets, special forces, hybrid warfare deeds or, in the case of non-state actors, terrorist actions[35]. Indeed, hybrid warfare tactics aim to cause significant damage by acting below the detection threshold, i.e. in the "grey zones" that increasingly characterise the blurred boundaries between competition - crisis - war[36]. The recent evolution of this threat in the underwater environment is further aggravated by difficult conceptual challenges:

- the lack of accurate definitions governing the protection and protection of critical infrastructures, effectively allowing malicious actors to operate in the regulatory gaps of lawfare;
- a dimension, the underwater one, intrinsically difficult to explore and largely unknown;

---

[32] Commander Cassetta is an Officer Specialised in Diving and Explosive Ordnance Disposal. He was Head of the Unmanned Vehicles Section at the Mine Countermeasures Force Command, Head of the Operations Department of the Submarine Rescue Ship and Underwater Operations Ship *Nave ANTEO*, Head of the Operations Department of the COMSUBIN Underwater Operations Group. Commanded the Coastal Patrol Vessel *Nave VEDETTA* deployed in Egypt at the Multinational Force and Observers as part of the monitoring actions of the peace treaty between the Arab Republic of Egypt and the State of Israel (Camp David Accords - 1978). He participated in various NATO, EU and national activities. In 2022, he contributed to the planning and conduct of the newly established Operation *Fondali Sicuri* at CINCNAV, for the monitoring, protection and protection of critical underwater infrastructure of national interest. He is currently serving in the Special Forces and Underwater Departments Office of the Navy General Staff.

[33] Sean Monaghan, *Five Steps NATO Should Take after the Nord Stream Pipeline Attack*, CSIS, Commentary, October 6th, 2022. https://www.csis.org/analysis/five-steps-nato-should-take-after-nord-stream-pipeline-attack

[34] Richard Milne, *Finland Investigates Potential Sabotage to Baltic Gas Pipeline*, in Financial Times, October 10th, 2023. https://www.ft.com/content/8d9baf58-22c2-4456-905c-15fd7f9dcd69

[35] Christian Bueger e Tobias Liebetrau, *Critical Maritime Infrastructure Protection: What's the Trouble?*, in Marine Policy 155 (September 2023) https://www.sciencedirect.com/science/article/pii/S0308597X23003056

[36] Defence General Staff, *Approccio della Difesa alle Operazioni Multidominio*, 2022. Chapter I, Cfr. "Continuum of Competition", p. 6-7.

- a multitude of potential threats, quantitatively and qualitatively inferior only to the imagination of the malicious actor;
- the possibility, common to all forms of underwater fighting, of inflicting enormous damage by means that, in some cases, could be simple to carry out (think, for example, of how cost-effective it is to use a mine to damage a ship).

Indeed, it should come as no surprise that today, in many forms of struggle and especially in the conduct of hostile actions, the rules of the game are changing. As a mere example, Ukraine, whose critical capacity is certainly not its fleet assets, managed to prevent the Russian Navy from landing on its Black Sea coast. Also extending the analysis to the Red Sea, the Houthis, despite not having an air force, manage to act effectively in the air domain, employing missiles and unmanned systems of negligible cost if compared to the damage they are inflicting. In broader terms, and referring to current potentially hostile actors, Russia's ability to strike critical infrastructure at short notice so to impose economic costs to deter NATO intervention in regional conflicts, is an important component of Moscow's doctrine and thinking on escalation management[37]. Hybrid tactics have been used for years by the Kremlin, which sees itself as being in perpetual conflict with the West, because they allow it to stand up to NATO by overcoming the Russian Federation's current condition of weakness in conventional military terms[38]. Russia has probably been targeting critical underwater infrastructure across Europe with increasing frequency[39] and dedicated resources to map and threaten Europe's energy and communications infrastructure[40].

As a response to this threat, Italy launched Operation *Fondali Sicuri* ("Safe Seabed") to monitor the status of pipelines and of national critical infrastructures within the broader framework of Maritime Vigilance (operation currently ongoing), France promulgated a new strategy of Seabed Warfare and announced[41] investments in the defence of ocean sea bottoms, while the United Kingdom has established a Centre for Seabed Mapping and started the naval programme of two dedicated vessels, Multi-Role Ocean Surveillance[42].

---

[37] Michael Kofman, Anya Fink and Jeffrey Edmonds, *Russian Strategy for Escalation Management: Evolution of Key Concepts*, Center for Naval Analyses, April 2020. https://www.cna.org/reports/2020/04/DRM-2019-U-022455-1Rev.pdf

[38] *Russian President's Decree about National Security Strategies*, Russian Military and Security Research Group, July 2nd, 2021. https://rusmilsec.files.wordpress.com/2021/08/nss_rf_2021_eng_.pdf. Vds. inoltre il recente documento strategico edito da MFA Russia, *Concept of Foreign Policy of Russian Federation*, March 2023.

[39] Pillai, *Protecting Europe's Critical Infrastructure*, https://www.cer.eu/publications/archive/policy-brief/2023/protecting-europes-critical-infrastructure-russian-hybrid

[40] Ibidem.

[41] Ministère des Armées, *Ministerial Strategy for Seabed Warfare* (Parigi: Ministère des Armées, February 2022). https://archives.defense.gouv.fr/content/download/636000/10511901/file/20220214_FRENCH%20SEABDED%20STRATEGY_key %20points.pdf

[42] Naval News Staff, *First of Two MROS Ships Arrives in the UK*, in Naval News, January 19th, 2023. https://www.navalnews.com/naval-%20news/2023/01/first-of-two-mros-ships-arrives-in-the-uk/

Types of critical underwater infrastructures.

Maritime infrastructures are essential to emsure basic social functions, energy supply, security and defence, communications, and, more generally, to protect the national interest[43]. For this reason, the most important infrastructures are considered "critical", in the sense that without them the country could not function with the same standards of efficiency. Given that each nation weighs its critical infrastructures differently - being some economies more dependent on fishing or tourism, while others rely purely on maritime trade, energy infrastructures or data cables - the determination of critical infrastructures of strategic interest is often the result of an assessment of the political level.

Critical infrastructures can be classified by sector and divided into at least five types: transport, energy, communications, fisheries and marine ecosystems[44]. Maritime infrastructure security policies traditionally focus on maritime transport (sea bases and ports) and the transport of energy sources (gas, oil and hydrocarbons in general). However, in recent years the number of submarine cables for data transfer has increased rapidly, while offshore renewable energy technologies (wind and tidal systems) are expected to spread incrementally to support nations in meeting global carbon reduction targets[45].

The future proliferation of unmanned assets and the consequent increase in seabed exploration for energy resources, military applications, together with the disruptive effect of artificial intelligence, could give rise to both new types of critical underwater infrastructure and new related threats. Indeed, NATO and the EU have predicted that the submarine energy infrastructure network in the Euro-Atlantic area will grow with the increase of offshore energy platforms[46].

Types of threats to underwater critical infrastructures.

The classification of critical infrastructures, as analysed in the previous section, depends on their respective importance for the functioning of society. However, governments tend to define "critical" as an infrastructure that is more vulnerable to external actors. Indeed, although the range of threats to critical information infrastructures is probably the broadest, acts of sabotage conducted against gas pipelines in the Baltic Sea have caused a stir in recent years. Since the invasion of Ukraine, Russia has become the most significant and direct threat to Allied security, being capable to strike at our critical infrastructures, including those in the underwater dimension[47]. In this regard, NATO's new Strategic Concept includes attacks against critical infrastructure among the cases that can

---

[43] "The national interest is the set of objectives, ambitions and aspirations of a State, defined within a geographical area, made explicit in the 4 dimensions: Political, Cultural, Economic and Military" cit. M. Cassetta, *Interesse Nazionale: un'espressione difficile da pronunciare*, Centro Studi Geopolitica.info, 2021. https://www.geopolitica.info/interesse-nazionale-unespressione-difficile-da-pronunciare/

[44] C.Bueger e T. Liebetrau, *Critical Maritime Infrastructure Protection: What's the trouble?*, Elsevier, Marine Policy, 2023. https://www.sciencedirect.com/science/article/pii/S0308597X23003056

[45] European Commission, *An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future*, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:741:FIN&qid=1605792629666 Abstract al link: https://energy.ec.europa.eu/topics/renewable-energy/offshore-renewable-energy_en.

[46] EU-NATO Task Force on the resilience of critical infrastructure, *Final Assessment Report*, 2023. https://commission.europa.eu/system/files/2023-06/EU-NATO_Final%20Assessment%20Report%20Digital.pdf

[47] *NATO 2022 Strategic Concept*. https://www.nato.int/strategic-concept/

trigger Article 5 for collective defence[48] and underwater critical infrastructures are probably among those more vulnerable to hybrid threats[49].

Malicious actors may cause damage to critical underwater infrastructures by using fishing vessels, merchant ships or even small, unregistered vessels that are more difficult to identify. The recent spread of unmanned assets, which can even operate in covert mode, further aggravates the issue. Russia itself has a fleet of dedicated submarines designed for infrastructure sabotage[50] and the GUGI[51]-managed research vessels are suspected of mapping undersea infrastructure networks in all Europe[52].

Pushing the analysis to the possible options for damaging a critical underwater infrastructure, it can be stated that malicious actions can be carried out primarily by countries with submarine assets and Special Forces assets. Moreover, malicious actions against underwater infrastructures can also be carried out by non-state actors, i.e. by terrorist organisations equipped with commercial unmanned platforms[53]. Regardless of the type of actor carrying out a hostile action and without addressing the question of the type of carrier (manned or unmanned), it is possible to identify two macro-categories of malicious actions against an underwater critical infrastructure:

- use of explosive material;
- damage by mechanical action.

Use of explosive material.

As an illustrative event of the use of explosives to damage a critical underwater infrastructure, reference will be made to the acts of sabotage that occurred at the North Stream[54] pipeline on September 26th, 2022. In this regard, considerations will be presented on the quantity of explosives and the possible characteristics of an underwater device, sized to cause physical damage to critical gas transport infrastructure, quite similar to the three gas pipelines serving Italy (*Transmed*, *Greenstream*, TAP). At the time of the sabotage, the pipeline consisted of four independent lines (two lines on *Nord Stream* 1 and two lines on *Nord Stream* 2) on mostly parallel routes along the

---

[48] Ibidem. Cfr. Article 27.

[49] Hybrid CoE Paper 16, *Handbook on maritime hybrid threats: 15 scenarios and legal scans*, 2023, p.12. https://www.hybridcoe.fi/wp-content/uploads/2023/03/NEW_web_Hybrid_CoE_Paper-16_rgb.pdf

[50] Dr Sidharth Kaushal, RUSI, *Stalking the seabed: How Russia targets critical underwater infrastructures*, 2023. https://rusi.org/explore-our-research/publications/commentary/stalking-seabed-how-russia-targets-critical-undersea-infrastructure

[51] The acronym, standing for *Glavnoye Upravlenie Glubokovodnikh Issledovanii*, identifies the Directorate for Underwater Research that answers to the Defence apparatus of the Russian Federation, responsible for the main underwater research systems.

[52] Morten Soendergaard Larsen, Foreign Policy, *Russian Ghost Ships are turning the seabed into future battlefield*, 2023. https://foreignpolicy.com/2023/05/02/russia-europe-denmark-spy-surveillance-ships-seabed-cables/

[53] Saverio Lesti, Alessandro Zacchei, MInter Group srl, *La sicurezza marittima e le infrastrutture critiche subacquee*, 2023, p. 23.

[54] NATO recognised the damage to the Nordstrem pipelines as an act of sabotage. Vds. Press Release 129 (2022) issued on September 29th, 2022, available at the following link: https://www.nato.int/cps/en/natohq/official_texts_207733.htm#:~:text=The%20NATO%20Invitees%20associate%20themselves,and %20irresponsible%20acts%20of%20sabotage.

Figure 6: Laying of pontoon pipeline, with detail of the joint between each 12-metre-long module.

route plan that cuts the Baltic Sea from Nort-East to South-West, with an overall length of 1,224 kilometres. The pipeline consists of 12-metre modules (Figure 6) with an internal diameter of 1,153 mm (45.3 inches) and a steel thickness of up to 41 mm. Each module is obtained from a SAWL-485-I-FD (X70) steel sheet specifically for underwater applications with high values of elastic tension and breaking strength, tube-welded and internally coated with anti-friction epoxy paint. On the outside, a triple anti-corrosion layer of polyethylene (3LPE) is applied and, finally, a layer of Portland marine concrete[55] (Figure 7). The different modules are then welded together on board dedicated pipelay pontoons, inspected and then spun on the seabed. Moreover, Italy represents world excellence in this field: Saipem's *Castoro 6* and *Castoro 10* pontoons have indeed positioned the 12-metre modules of the North Stream 1 pipeline.

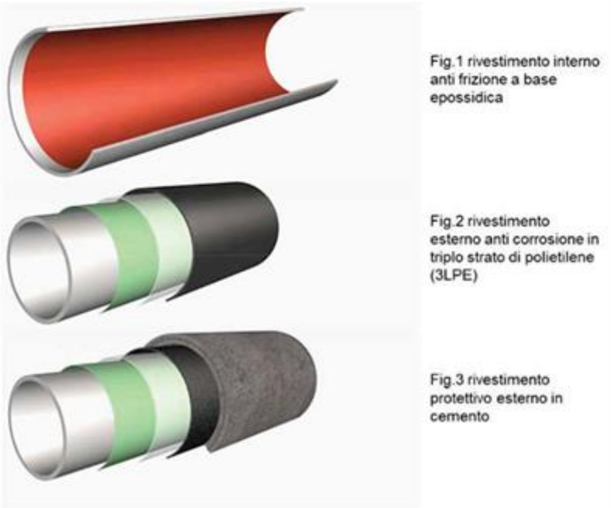


Figure 2: Nord Stream pipeline composition.

A few hours after the pipeline was damaged, seismographs from the Swedish National Centre at Uppsala University reported seismic anomalies of magnitude ML 2.7 near the location of the first surface gas leak and ML 3.1 in vicinity of the location of the second leak (seismograph-detected magnitude shown in Figure 10). Seismic detection of man-made explosions is a study that dates back to the Cold War, when nuclear explosions were monitored by both nuclear-capable superpowers. Coincidentally, the NORSAR underwater sensor array[56] which detected the seismic anomalies, was designed precisely for this task. In the following months, specialized academic

---

[55] Official wbesite *Nordstream Secure Gas Supply for Europe – Library* https://www.nord-stream.com/press-info/library/

[56] *Norwegian National Data Center (NDC) for verification of the Comprehensive Nuclear-Test-Ban Treaty*.

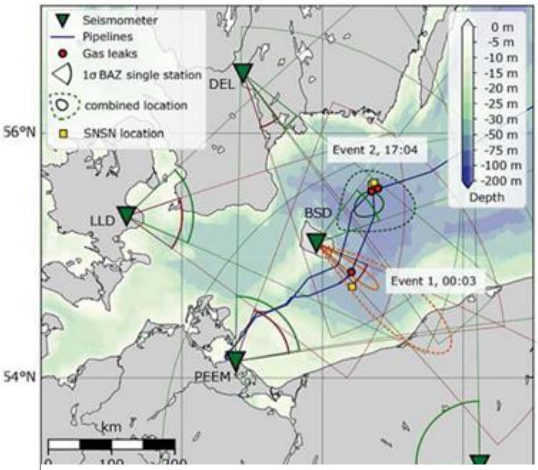


Figure 3: Triangulation diagram of blast points
11 using seismographs

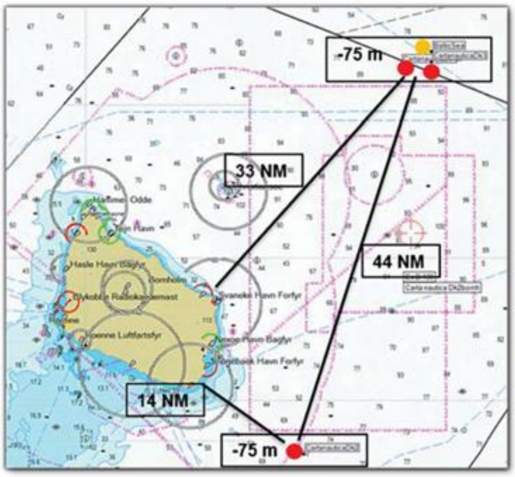


Figure 4: Chart representation of blast points with approximate distances and elevations.

sources of seismology and earthquake science[57] confirmed that the seismic anomalies detected can be traced back to the location where the pipelines were damaged (Figures 8-9-10), effectively explaining the events recorded with underwater explosions.

Sweden has launched official investigations, while several non-governmental agencies have conducted underwater inspections and made video-photographic documentation available mostly on social networking platforms[58]. The underwater footage in question, although not georeferenced, is clearly traceable to the *Nord Stream* pipeline.

A study by Saipem drew interesting inferences by developing a model on the effects of underwater explosions on critical infrastructure[59]. The Saipem model is developed on a steel pipe of quite similar dimensions and characteristics to the *Nord Stream*'s. The explosion, probably sized on the accidental activation of a remnant of war, considers a 600 kilograms charge of TNT at a distance of 4 meters from the pipeline. A comparison between the Saipem model and what was gathered about the acts of sabotage in 2022 reveals an interesting similarity: the effects generated by the bubble and shock wave in the simulation show a 3D model with effects on the structures very similar to those observed on *Nord Stream*. The hypothesis concerning the use of explosives is fully supported by the confirmation that the Swedish authorities gave in November 2022, revealing, in fact, the discovery of traces of explosive material on many recovered pipeline fragments[60].

[57] S. C. Stähler, G. Zenhäusern, J. Clinton, D. Giardini, Seismica.org, *Locating the Nordstream explosions without a velocity model using polarization analysis*, 2022 https://seismica.library.mcgill.ca/article/view/253/270

[58] Blueyerobotics and Greenpeace, ispezione subacquea a mezzo ROV. Video disponibile al seguente link: https://www.youtube.com/watch?app=desktop&v=AkvXJRNunW8&embeds_referring_euri=https%3A%2F%2Fwebtribune.rs%2F& feature=emb_imp_woyt

[59] Lorenzo M. Bartolini, Lorenzo Marchionni, Caterina Molinari, Antonio Parrella, Saipem, *Effects of underwater explosion on pipeline integrity*, 2015. https://www.researchgate.net/publication/276241513_Effect_of_Underwater_Explosion_on_Pipeline_Integrity

[60] Andrew Roth, *Sweden to drop inquiry into Nord Stream pipeline explosions*, in The Guardian, hΣps://www.theguardian.com/business/2024/feb/07/sweden-drop-inquiry-nord-stream-pipeline-explosions

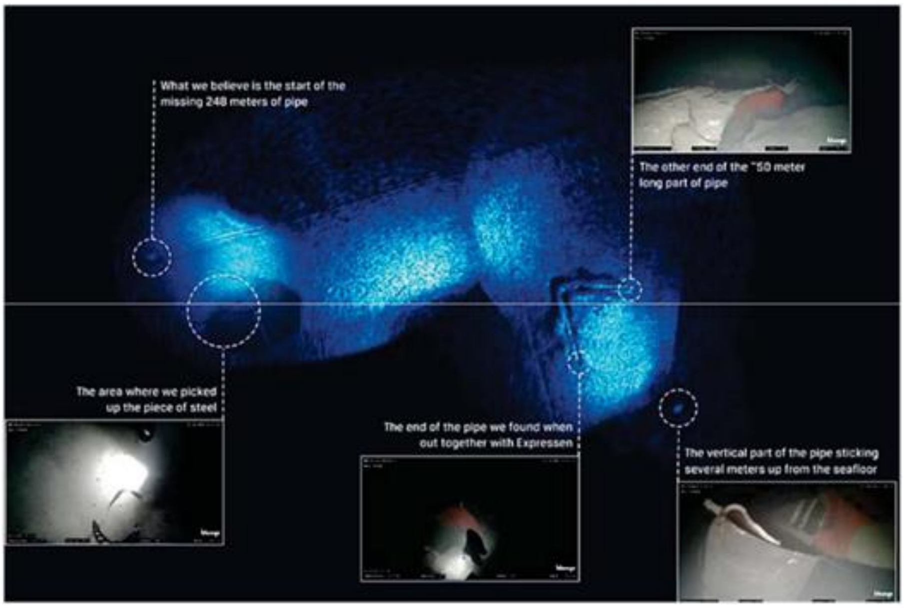


Figure 5: Sonar image from Blueyerobotics on Nord Stream with description of areas observed by ROV.

	Event 1		Station	P arrival	S arrival	Back-azimuth [deg]
Origin time	00:03:24.5		UP.DEL	00:03:55	00:04:25	153 [142-165]
Latitude	54.768		PL.GKP	00:04:37	00:04:48	-
Longitude	15.431		DK.BSD	00:03:32	-	125 [111-139]
Magnitude	2.7		DK.LLD	00:04:00	-	100 [71-125]
			KQ.PEEM	00:03:50	00:04:08	54 [20-81]
	Event 2A	Event 2B				
Origin time	17:03:50.4	17:03:58.5	UP.DEL	17:04:15	17:04:37	135 [128-143]
Latitude	55.6	55.617	PL.GKP	17:04:27	-	325 [265-2]
Longitude	15.71	15.745	DK.BSD	17:04:03	17:04:11	55 [37-70]
Magnitude	3.1	3.1	DK.LLD	17:04:30	-	85 [46-113]
			KQ.PEEM	17:04:20	17:04:45	33 [356-76]

Figura 6: Data processed by seismographs following the explosion events underwater on Nord Stream.

Wanting to extend the analysis to the sizing of an explosive charge, we can state that a hypothetical 200 kilograms of TNT explosive equivalent, placed at a distance of 1 m from the pipeline would be perfectly capable of causing the physical rupture of the infrastructure, either through the direct effect of the shock wave or through the creation of the underwater bubble. Indeed, the bubble generated during the underwater explosion in these circumstances collapses close to the solid walls of the pipeline, generating asymmetries (toroidal bubble) with micro-jets of water colliding at high speed and acceleration against the pipeline structures, intensifying and extending the rupture phenomena. The simultaneous leakage of the gas contained in the pipeline, although by purely mechanical effect, contributes to the disruptive effects on the physical structure, fortunately without participating in the violent oxidation of the explosive reaction: in fact, the ejected flow fails to combust due to a lack of sufficient oxygen in the underwater environment. As evidence of this, it is interesting to note that the seismographs detected a vibration following the explosion that lasted over 10 minutes. It would precisely be attributable to the leakage of the large quantity of gas following the rupture of the pipeline. The described explosion, also detected by the study model of Saipem, generates a small dome of water on the surface, immediately followed by the methane gas bubble of a radius close to 20 m, pulsating on the water surface disperses in the atmosphere. The observed study pattern actually coincides with what was found following the acts of sabotage. The cutting explosive charges and hollow charges currently available on the market appear to be only partially or, in most cases, totally incompatible with the *Nord Stream* scenario. This is attributable to the limited quantity of explosives employed, which would be considerably less than any possible estimate and, more importantly, inconsistent with the data recorded by seismographs. In addition, the typical effects of a hollow charge, whether conical or shear, are not compatible with what is

Figura 7: Screenshot da video Blueyerobotics su Nord Stream che mostra un punto di rottura del gasdotto.

observed from ROV video footage (Figure 15). More plausible, however, would be the use of a large omnidirectional explosive charge[61], sized on 200 kilograms of TNT equivalent. This type of ordnance is readily available from the arsenals of many countries and is usually used in the maritime domain in an anti-ship function. Indeed, its disruptive effect against a critical infrastructure could be further enhanced by making use of explosives optimized for the employment in water, such as those enhanced by the presence of aluminium[62].

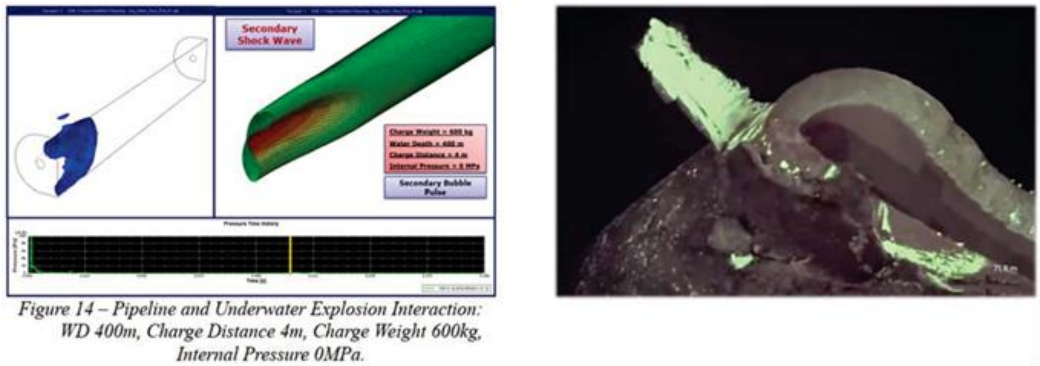


Figure 8: (left) Saipem model 'effect of underwater explosions on pipeline integrity', (right) screenshot from GreenpeaceGER video on Nord Stream.

In any case, comparison with experimental models and the results of underwater inspections and investigations carried out by Sweden confirm, to date, that sabotage was conducted through the use of explosive. Operationalizing this analysis in the current geopolitical context, it is likely to infer that the malicious action was carried out by a state actor capable to operate in the underwater environment and with adequate technical and technological readiness, employing a large omnidirectional charge, approximately 200 kilograms of TNT equivalent.

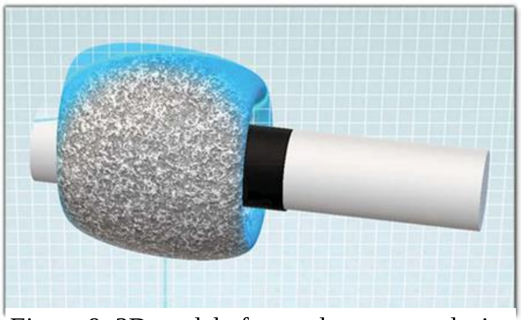


Figure 9: 3D model of an underwater explosion in the vicinity of a gas pipeline with a bubble radius smaller than the charge-pipeline distance and related 'toroidal bubble' formation.

Damage by mechanical actions.

Mechanically damaging submarine cables is a tactic more than a century old. In fact, by way of example, at the beginning of the Great War, one of the first offensive actions conducted by the British was precisely the cutting of German submarine communication cables, carried out in the English Channel by the small naval unit

[61] An omnidirectional charge consists of a large quantity of explosive capable of expressing potential equally in each direction.

[62] For example, Tritonal and Tritolital explosives (mixtures consisting of trinitrotoluene and metallic aluminium powder).

HMS Alert, on the night between August 4th and 5th, 1914[63]. Although it may be intuitive that a data cable - quite thin by nature - can easily be damaged by mechanical action, in reality, pipelines are also subject to this type of threat.

In this regard, a case in point is the damage to the "*Enrico Mattei* Gas Pipeline", better known as *Transmed*, which connects Algeria and Italy via Tunisia. The incident at *Transmed* occurred on December 19th, 2008[64] due to a merchant ship erroneously dropping anchor near the critical infrastructure and subsequently causing the rupture and a gas leak. Figure 16 shows the extent of this damage that led to the abnormal detour of the five pipelines. A blessing, in disguise: this damage was promptly repaired by underwater intervention (Figure 17) and allowed Italy to gain experience for the eventual handling of similar events.

Cariche esplosive commerciali	Effetti tipici sulle strutture	Penetrazione su spessore di acciaio	Posa subacquea	Probabile compatibilità causa/effetti
Carica cava conica	Foro	> 7 cm	‰ *Tech Diver* ‰ ROV	
Carica da taglio flessibile	Taglio	< 7 cm	‰ *Tech Diver*	
Carica omnidirezionale	Deformazioni plastiche/cratere	h cratere < 1 m	‰ *Tech Diver* ‰ ROV	

Figure 10: Experienced analysis of the most popular explosive charges available on the market

The year 2008 was particularly rich in incidents of damage to underwater critical infrastructure. Between January 23rd and February 4th, five undersea telecom cables ruptured in the Mediterranean Sea, causing internet traffic disruption and slowdowns for more than 1 million users in the Middle East[65]. At the end of February, there was another incident that caused the fibre-optic connection between Singapore and Jakarta to break down[66]. Several other critical underwater infrastructures broke down in December:

- *Fiber-Optic Link Around the Globe* (FLAG), the 28,000 kilomters long undersea telecommunications cable connecting North America with Japan[67];
- GO1, the underwater telecommunications cable connecting Sicily with Malta [68];

[63] Amm. J.S. Corbett (Royal Navy), *History of the Great War. Naval Operation, based on official documents*, Longmans Green&Co1920, p. 128. Oppure C.R.M.F. Cruttwell, *A History of the Great War. Naval Operations*, Oxford University Press, 1934, p. 187 e ss. https://ia902903.us.archive.org/29/items/in.ernet.dli.2015.57902/2015.57902.History-Of-The-Great-War-1914-1918_text.pdf

[64] Parliamentary Enquiry 4/02010 by A.E. Quartiani in session no. 114, on January 14th, 2009 https://dati.camera.it/ocd/aic.rdf/aic4_02010_16 and https://documenti.camera.it/_dati/leg16/lavori/stenografici/sed114/bt54.htm

[65] Asma Ali Zain, *Cable damage hits one million Internet users in UAE*, in Times online, 2008. https://web.archive.org/web/20080209140523/http://www.khaleejtimes.com/DisplayArticleNew.asp?section=theuae&xfile=data%2Ft heuae%2F2008%2Ffebruary%2Ftheuae_february121.xml

[66] The Jakarta Post, *Internet capacity down to 10%*, 2008. https://www.thejakartapost.com/news/2008/02/29/internet-capacity-down-10.html

[67] Malcolm Fried and Lars Klemming, *Several Cables in Mediterranean disrupt communications*, Bloomberg, 2008. https://www.bloomberg.com/news/articles/2008-12-19/severed-cables-in-mediterranean-disrupt-communication

[68] Times Malta, *GO submarine cable fault part of wider disruption between Italy and Egypt*, 2008. https://www.timesofmalta.com/article/go-submarine-cable-fault-part-of-wider-number-between-italy-and-egypt.237909

- SEA-ME-WE 3, the world's longest underwater cable (39,000 kilometers) connecting Australia with Northern Europe [69].

Due to such incidents, in 2009, the US Air Force 50th Communication Squadron admitted that the drastic decrease in telecommunications capabilities in the Mediterranean had greatly reduced UAV sorties from the Balad base in Iraq "from hundreds to a few dozen per day"[70]. The two methods of damage illustrated (damage with explosives and with mechanical means), place the public in a strong dilemma as to what might have caused the recent cutting of the internet cables crossing the Red Sea[71]. In fact, although the Houthis are the main suspects of a deliberate act of sabotage, it seems plausible to assume that the *Rubymar* merchant ship, attacked by a missile on 18 February, during its slow drift of about two weeks, may have run into the cables in question and consequently damaged it.[72].

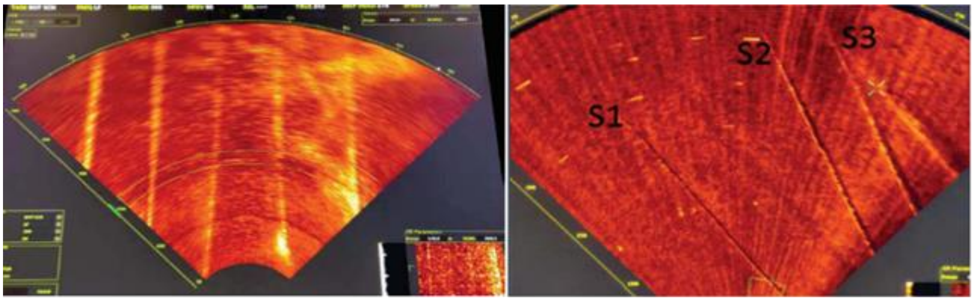


Figure 11: Sonar images acquired by Italian Navy Naval Units on the *Transmed* gas pipeline. The images show the extent of the damage that occurred as a result of the accidental sinking of a merchant ship's anchor on December 19th, 2008. It is possible to see the normal course of the five pipelines running parallel (left photo) and the anomalous deviation of the same following the accident (right photo). Navy Archive.

The reported cases show that damage to critical underwater infrastructures through mechanical action is not only possible, but even very frequent in the Mediterranean area. This threat becomes even more critical considering that all underwater infrastructures are graphically represented on the main nautical charts, accessible to any yachtsman or private sailor. The rationale for such publicity lies in the need to avoid accidental clashing and to

Figure 12: Image acquired with ROV of the Italian Navy, representing the concrete pour deposited to restore the accidental damage that occurred on the *Transmed* on December 19, 2008. Navy Archives.

[69] Telocompaper, *Mediterrean submarine cables are cut, affecting internet*, 2008. https://www.telecompaper.com/news/mediterrean-submarine-cables-are-cut-affecting-internet--650982

[70] Saverio Lesti, Alessandro Zacchei, MInter Group srl, *La sicurezza marittima e le infrastrutture critiche subacquee*, 2023, p. 31.

[71] Hanna Ziadi, *Red Sea cables have been damaged, disrupting internet traffic*, March 4th, 2024. https://edition.cnn.com/2024/03/04/business/red-sea-cables-cut-internet/index.html

[72] Olivia Solon e Mohammed Hatem, *Houthi Sunk Ship Anchor Likely SeveredSea Internet Cables*, Bloomberg, March 7th, 2024. https://www.bloomberg.com/news/articles/2024-03-06/anchor-from-houthi-sunk-ship-likely-damaged-undersea-cables

establish unequivocally sea areas where anchoring and related activities are prohibited. However, unlike damage to critical infrastructure by means of explosives, for which it is reasonable to assume that the malicious actor must necessarily have a minimal capability to engineer the explosive charge, damage by means of mechanical aids could also be carried out by non-state actors. One thinks, for example, of the relative ease with which one could snag a critical underwater infrastructure by dropping an anchor from any vessel. In such a situation, as far as underwater cables are concerned, mechanical failure of the critical infrastructure would occur with reasonable certainty.

In the case of pipelines, which are larger in size and strength, damage could be sought by exploiting vessels of high tonnage, such that momentum conservation imparts considerable force, or alternatively even with naval platforms of low tonnage, simply by using propulsion systems and pulling steel cables.

CHAPTER V: MEDITERRANEAN UNDERWATER, A CONTESTED AND DISPUTED ENVIRONMENT

by Emmanuele Panero

The Mediterranean Sea is a central maritime communication line in international trade dynamics, excluding the new oceanic routes, and is traversed by an increasing number of ships. Indeed, it is estimated that an average of 3,000 vessels sail its waters every day, corresponding to approximately 15% of global maritime traffic and a countervalue of 70 billion euros, amounting to 5% of global industry revenues[73]. These data add up to those pertaining to the resources and economic flows that pass through the pipelines and cables silted up or lying on the seabed, which connect not only Italy, but connect all the countries that border with it in a dense multidirectional network.

The Mediterranean region, and even more so the Wider Mediterranean region, in addition to being in itself characterised by widespread competition for control and exploitation of the vast and diverse resources of disputed EEZs and continental shelves, also intersect a wide arc of territories characterised by instability, crises and conflicts. The continuing hostilities between the Russian Federation and Ukraine, resulting from Moscow's aggression against Kiev territory, has in fact also involved the maritime domain, both with the dangerous drift of naval mines up to the Dardanelles Strait and with a significant change of posture by the Russian fleet in the Mediterranean. The crisis in the Middle East then led to problematic disruptions in trade and resulted in the deployment of a substantial military air and sea force in the eastern part of the basin. The persistence of unstable situations then plagues countries such as Libya, with consequences in terms of the penetration of the terrorist threat and other potentially malevolent non-state actors.

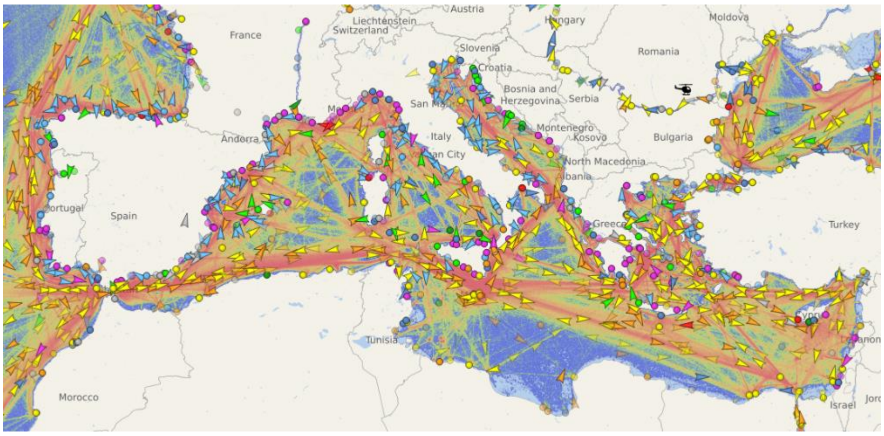


Figure 18: Freeze-frame of daily routes tracked by civil vessels in the Mediterranean Sea.
Source: VesselFinder

The area is also increasingly affected by the growing presence and assertiveness of the Russian Federation's naval and submarine assets, enabled by the concession to the Kremlin of the Syrian naval base in Tartus since 2017. The conflict in the Middle Eastern country has also offered Moscow the opportunity to test the deployment of cruise missiles from submarines diving in the Mediterranean Sea to strike Daesh-linked targets under actual combat conditions. Over the last five

[73] Mediterranean Posidonia Network, *Key Network*, https://medposidonianetwork.com/key-numbers/

years, the Russian presence in the region has expanded with the frequent deployment and transit in the Central Mediterranean of several *Kilo*-class submarines, the *Kasatonov* and *Grigorovich* frigates, the *Akademik Pashin* supply vessel[74], of the intelligence ship *Yuri Ivanov* and the corvettes *Stoikiy* and *Soobrazitelny*[75]. The People's Republic of China has also consolidated its presence in the Mediterranean basin, both through significant economic penetration in the port infrastructure segment and the occasional deployment of naval platforms such as the *Type 636* hydrographic research vessels, capable of collecting critical information on the seabed.

Generally speaking, the combination of geopolitical and geo-economic interests in the area, the consequent strategic competition for their control and the insecurity profiles that characterise it are therefore at the basis of important investments and capacitive upgrades in the defence sector, including above all the submarine component, functional to maintaining an advanced situational awareness thanks to pervasive covert ISR operations. Similarly, the aforementioned pushing factors fostered considerable investments in infiltration or exfiltration of special operators for special reconnaissance tasks or direct action, and eventually to generate effects in the physical dimension both at sea and on land. From this perspective, in fact, many countries have developed relevant capabilities from the analysis of which it is possible to deduce not only the threat profile posed by potential competitors, but above all the requirements and directions identified and pursued in the underwater (almost) domain by the navies of partner, friendly or allied countries.

Algeria has been one of the first actors that have most strengthened its underwater military component, especially on the basis of a substantial and exponentially increased defence budget in the last two years. Algerian capacitive development was enabled by strong and persistent relations with the Russian Federation, from which the country acquired technology and expertise in the segment. The *Al-Bahriyya al-wataniyya al-Jaza'iriyya* (Algerian Navy) is endowed with six attack submarines, two *Paltus* class and four *Varshavyanka* class, derived respectively from the Russian *Kilo* and *Improved Kilo* classes[76]. The first two Soviet-made vessels entered service in the late 1980s and were modernised in the early 2000s in Russian shipyards. The other four were launched during the last 15 years[77] and received an upgrade of both active and passive radio-electronic and hydro-acoustic equipment and payloads[78]. The latter are also capable of carrying and deploying both 3M14E *Klub-S* Land Attack Cruise Missile (LACM) and 3M54E1 *Klub-S* anti-ship cruise missiles, both export variants of the Russian *Kalibr*. Moscow and Algiers also carried out regular exercises in the Mediterranean Sea, with the aim of sharing tactics, techniques and procedures, as well as fostering interoperability between their respective fleets.

---

[74] Grzegorz Kuczyński, *Russian Navy Boosts Presence in the Mediterranean*, in Warsaw Institute, March 25th, 2023, https://warsawinstitute.org/russian-navy-boosts-presence-in-the-mediterranean/

[75] Itamilradar, *Russian Navy in the Mediterranean today*, https://www.itamilradar.com/2023/05/10/russian-navy-in-the-mediterranean-today/

[76] Military Balance 2023, p. 316.

[77] Maddalena Ingrao, *ALGERIA. Nuovi Kilo per Algeri*, in AGC Communication, January 23rd, 2019, https://www.agcnews.eu/algeria-nuovi-kilo-per-algeri/

[78] Davide Bartoccini, *Cosa sono i "Buchi neri" dell'oceano che preoccupano la NATO*, in InsideOver, March 19th, 2019, https://it.insideover.com/guerra/cosa-sono-i-buchi-neri-delloceano-che-preoccupano-la-nato.html

Egypt, on the other hand, is the first country on the southern shore of the Mediterranean in terms of the size of its submarine fleet, which consists of eight attack boats. In detail, the *Al-Quwwāt al-Baḥriyya al-Miṣriyya* (Egyptian Navy) has four *Type 033*, produced in the People's Republic of China based on the design of the Soviet *Romeo* class and four *Type 209/1400s*, made by the German Howaldtswerke-Deutsche Werft[79]. Both types of vessels were later modified to accommodate US-made UGM-84C Harpoon Block 1B anti-ship missiles in the first case and UGM-84L Harpoon Block II in the second. Similar to the multi-supplier approach characterising procurement, Cairo maintains military cooperation relations for training and education purposes with various regional and non-regional actors, conducting regular activities in the Mediterranean basin with units and naval personnel from China, the United States, Greece, Cyprus and the United Arab Emirates[80].

Turkey is also the country that has focused its strategic approach in the area more on maritime dominance, pursuing the *Mavi Vatan* ("Blue Homeland") concept, introduced by President Recep Tayyip Erdoğan in 2019. Embracing this perspective, Ankara has pursued a consolidation of its submarine component that is profoundly oriented towards acquiring skills in the technological-industrial sector even before the operational one, with the main purpose of increasing the degree of indigenisation of its military procurement. Despite the general nature of this trend, which has led to a reduction in dependence on foreign imports of around 75% over the last two decades[81] while at the same time fostering a penetration of Turkish defence industries in the international market, the underwater dimension has been particularly affected by it. The *Türk Deniz Kuvvetleri* (Turkish Navy) currently deploys twelve attack submarines (SSKs), all built in Germany and with a service life of several decades, net of modernisation programmes carried out over time. Specifically, Ankara has four *Atilay* class, four *Gür* class and four *Preveze* class, all locally adapted variants of the Howaldtswerke-Deutsche Werft Type 209/1400 project[82], the last two of which are capable of deploying UGM-84 Harpoon anti-ship missiles. Turkey, however, launched a programme called National Submarine *MİLDEN* in 2022, which aims to build and incorporate up to six new *Reis*-class submarines into Ankara's fleet by 2030. These assets will be equipped with an AIP diesel-electric propulsion system and will be produced under licence in Turkey, adapting the Type 214 export vessel model of Howaldtswerke-Deutsche Werft GmbH to local requirements. National programmes to strengthen the underwater component also involve the development of the *Akya* heavy torpedo and the *Müren* combat system. The *Akya* torpedo is deployable against underwater and surface targets, capable of operating with high degrees of autonomy and equipped with a fibre-optic guidance system as well as active and passive acoustic sensors, while the *Müren* is an upgraded local version of the previous on-board system installed on the *Preveze* class submarines[83]. At the same time as its goals

[79] Military Balance 2023, p. 321.
[80] Darek Liam, *Esercitazione militare Medusa-12 in corso nel Mar Mediterraneo*, in Military Africa, November 25th, 2022, https://www.military.africa/2022/11/medusa-12-military-exercise-underway-in-the-mediterranean-sea/
[81] Ali Bakir, *Turkey's defense industry is on the rise. The GCC is one of its top buyers*, in Atlantic Council, August 4th, 2023, https://www.atlanticcouncil.org/blogs/menasource/turkey-defense-baykar-gcc-gulf/
[82] Military Balance 2023, p. 142.
[83] Michele Cosentino, *La «nuova» Turchia: scenari geopolitici e potenziamento navale*, in Rivista Marittima, October 2022.

of nationalising military production, the Turkish company Rockestan is pursuing a project for a naval version of the *Atmaca* cruise missile[84], with the final aim of replacing the US-made vectors currently embarked on Turkish vessels. Emblematic of the depth and diversity of the research and development programmes in the underwater (almost) domain pursued by Turkey is the realisation by Aselsan and STM of the UUV *Deringöz*, potentially interoperable with the mini-submarine STM500. The latter should provide the Turkish Navy with a spectrum of advanced operational capabilities particularly in coastal areas and shallow waters, being able to covertly infiltrate and exfiltrate special operators, deploy UUVs and launch both heavy torpedoes and missile launchers[85].

On the northern shore of the Mediterranean, France is the country with the most significant submarine capabilities, partly due to the underwater component of its strategic deterrent. In fact, Paris deploys nine nuclear-powered submarines, four of which are *Le Triomphant*-class ballistic missiles (SSBN), armed with M51 intercontinental missiles with atomic warheads (SLBM - Submarine Launched Ballistic Missile) and five attack submarines (SSN)[86]. These are divided into four *Rubis* class and one *Suffren* class, with the former equipped with SM39 *Exocet* anti-ship missiles, and the fifth with *SCALP Naval* land attack cruise missiles. As part of the *Barracuda* programme, then, between 2024 and 2029, a further five *Suffren*-class vessels are scheduled to be launched, which appear to be configured with a focus on special forces operations support capabilities[87]. With this in mind, the *Marine Nationale* intends to upgrade its Swimmer Delivery Vehicle (SDV) component by deploying Dry Deck Shelters (DDS) on board the new assets, capable of accommodating both UUVs and the Special Warfare Underwater Vehicle (SWUV) PSM3G[88], produced by Exail, for the transport of up to six special operators. The *Direction Générale de l'Armement* (DGA) finally awarded Naval Group the design and testing of a future Unmanned Combat Underwater Vehicle (UCUV)[89]. The platform, named D19, will in fact be equipped with a modular front-end payload, functional to host ASW, Mine CounterMeasures (MCM) and Electronic Warfare (EW) systems[90].

Despite lower investment in the segment and an apparent lower propensity for innovation in the short term, Spain and Greece also have conventional submarine fleets, with the *Armada Española* equipped with two *Galerna*-class attack boats[91] and the *Polemikó Nautikó* (Greek Navy) endowed

---

[84] Tayfun Ozberk, *Turkish Navy To Outfit 11 Platforms With Atmaca AShMs Until 2027*, in Naval News, August 10th, 2023, https://www.navalnews.com/naval-news/2023/08/turkish-navy-to-outfit-11-platforms-with-atmaca-ashms-until-2027/

[85] Ibidem

[86] Military Balance 2023, p. 91.

[87] *French Navy Receives its Second Next-Generation Nuclear-Powered Submarine*, in The Maritime Executive, August 18th, 2023, https://maritime-executive.com/article/french-navy-receives-its-second-next-generation-nuclear-powered-submarine

[88] *Analysis: French Suffren-Class Submarine Empowers Special Forces with PSM3G swimmer delivery vehicle*, in Navy Recognition, August 1st, 2023, https://navyrecognition.com/index.php/focus-analysis/naval-technology/13400-french-suffren-class-submarine-empowers-commando-operations-with-psm3g-mini-submersible.html?utm_content=cmp-true

[89] Xavier Vavasseur, *France's Naval Group Starts XLUUV Qualification Trials*, in Naval News, September 19th, 2023, https://www.navalnews.com/naval-news/2023/09/frances-naval-group-starts-xluuv-qualification-trials/

[90] Xavier Vavasseur, *Euronaval: French Navy Becomes Launch Customer Of Naval Group's D-19T UUV*, in Naval News, October 26th, 2020, https://www.navalnews.com/event-news/euronaval-2020/2020/10/euronaval-french-navy-becomes-launch-customer-of-naval-groups-d-19t-uuv/

[91] Military Balance 2023, p. 134.

with ten, German-made assets, for of which derived from *Type-209/1200*, two from *Type-209/1100* and four from *Type-214*. Madrid also planned to acquire four new domestically produced *Isaac Peral* class submarines, one of which has already been built. Built at the Cartagena shipyards, they are equipped with an AIP propulsion system and will also be able to embark and deploy UGM-84 Harpoon Block II anti-ship missiles. Similarly, the upgrade programmes implemented by Athens enabled it to arm its last six vessels with surface anti-ship launchers, with the adoption of the UGM-84C Harpoon Block 1B[92].

Finally, in the Eastern Mediterranean, Israel has significant submarine capabilities related to both strategic deterrence and force projection in areas of interest. The *Heil HaYam HaYisraeli* (Israelian Navy) deploys three submarines of the Dolphin class and two *Tanin* class, all having land attack capability by cruise missiles. A further three Dolphin II-class vessels, commissioned from the German company Howaldtswerke-Deutsche Werft and intended to replace the previous generation of vessels, are scheduled to enter service by 2027.[93]. These will be designed both for the launch of cruise missiles and for the infiltration and exfiltration of special operators from beneath the surface [94]. Tel Aviv has also invested in the development of UUVs, in particular with Israel Aerospace Industries' BlueWhale programme[95], a mini submarine designed for ASW and ISR tasks. Israelian capabilities in the underwater (almost) domain are constantly trained[96] by frequent combined activities with US and France[97].

The significant investments in the underwater component in many of the countries bordering the basin highlight the prominence that the underwater (almost) domain holds in the growing strategic competition for the Mediterranean. At the same time, they outline some of the decisive requirements to maintain an advantage in the confrontation for industrial, technological and military primacy, while defining what challenges lie ahead for the Navy, as well as potentially for the entire Country-System.

---

92 Military Balance 2023, p. 99.

93 *Israel Submarine Capabilities*, in NTI, March 2nd, 2023, https://www.nti.org/analysis/articles/israel-submarine-capabilities/

94 H I Sutton, *Israel Launches New Submarine, First In World With Modern Missiles In Sail*, in Naval News, August 14th, 2023 https://www.navalnews.com/naval-news/2023/08/israel-launches-new-submarine-first-in-world-with-modern-missiles-in-sail/#prettyPhoto

95 Seth J. Frantzman, *Israeli firm reveals unmanned submarine BlueWhale*, in Defense News, May 5th, 2023, https://www.defensenews.com/unmanned/2023/05/05/israeli-firm-reveals-unmanned-submarine-bluewhale/

96 *Israeli Navy completes 'complex' submarine drill in Red Sea*, in i24 News, June 2nd, 2022, https://www.i24news.tv/en/news/israel/defense/1654175764-israeli-navy-completes-complex-submarine-drill-in-red-sea

97 *Israel, US and France in joint underwater exercise*, in The Jerusalem Post, July 27th, 2017, https://www.jpost.com/israel-news/watch-israel-us-and-france-in-joint-underwater-exercise-500915

CHAPTER VI: MONITOR, PROTECT AND PROJECT IN THE UNDERWATER (ALMOST) DOMAIN

By Commander Stefano Oliva[98]

The underwater operational environment: technology, risks and opportunities. The new theatre of competition

Thinking about the 70% water surface that characterises our planet[99] (which we curiously call Earth), we have to take into account the immense volume of water underneath and its depths, more than 80% of which remain unexplored to date. The third dimension of the maritime domain, the submarine one, is gaining increasing importance due to the multiplicity of interests that reside there and the increased usability of underwater spaces thanks to technological progress. The focus on the seabed is constantly increasing, as well as investments in research and development of technologies to access the abyss, in order to seize the opportunities and at the same time protect the intrinsic fragility, both physical and cybernetic.

More and more frequently we hear about an ocean gold rush. Indeed, the underwater environment is a fundamental source of wealth for humanity. According to a recent OECD statistic, the ocean-related economy is expected to grow from the current 1.5 trillion dollars to about 3.000 billion dollars by 2030[100]. In addition to natural gas and oil, we think about the strategic potential of the oceans by virtue of the presence of polymetallic nodules, which are rich in manganese, nickel, cobalt, copper and rare earth. Moreover, the seabed hosts important infrastructures of strategic value for the functioning of the world in which we live, vital for the current societies as the vascular system is vital for the human body. They appear crucial in ensuring energy supply and digital communications. In general, the underwater world encloses an enormous potential of development, still more important for littoral Countries like Italy representing a natural bridge between Europe and the so-called Global South. Not only strategic infrastructure and mineral resources, but also genetic resources, renewable energy, underwater tourism, biotechnology and underwater agriculture.

[98] Submariner, Commander Oliva is Chief of Combat Systems at the Submarine Department of the Navy General Staff. He has held various assignments on board the national submarines and has been Commander of the Submarine *Pietro Venuti*.

[99] The total volume of water on Earth is estimated at 1,358 billion km^3, with 97.18% represented by sea waters and oceans, and only 2.5% of the entire body of water is freshwater, mainly located in Antarctica and Greenland.

[100] This growth will be fuelled by several factors, including the expansion of the world's population, economic growth, increased trade, improved income levels, as well as technological advances. However, there are significant challenges related to ocean health, including acidification, rising temperatures and sea levels, changes in ocean currents, loss of biodiversity, and plastic pollution and agricultural discharges, that represent significant threats to the future of ocean resources.

Last but not least, the underwater environment provides indispensable food support[101] and preserves an invaluable archaeological heritage[102]. The opportunities are many and destined to grow over time. These interests are closely intertwined with the growing implications for defence and security. The evolution of the technology, with increasing standards at inversely proportional costs, is favouring the acquisition of the ability to operate in the underground world, today no longer prerogative of the greater powers. Moreover, less impracticable access, even by non-State entities, underlies greater vulnerability of critical infrastructure, as highlighted by events related to the war in Ukraine, such as the attack on the *Nord Stream* pipelines in 2022.

Evolution of the fight below the surface: the role of the submarine

The evolution of the role of submarines from the Cold War to today represents an important paradigm shift in military strategy and the conception of naval operations. During the Cold War, submarines were primarily seen as tools for anti-submarine warfare and as a strategic deterrent through the launch capability of intercontinental ballistic missiles. This view was in line with the military doctrine of the time, which emphasized nuclear deterrence and direct confrontation between the superpowers.

However, since the end of the Cold War, there has been a progressive reconsideration of the role of submarines, which have started to be seen increasingly as versatile tools capable of operating in a wide range of scenarios and performing multidisciplinary tasks[103]. Even in a strategic context that envisaged the "end of history"[104] more than once, indeed, the number of submarines did not decrease.

The balances in the Mediterranean, whose stability is of fundamental strategic value for the security of our Country, of Europe and of the Atlantic Alliance, are rapidly evolving. The submarines, with their exclusive ability to dominate the underwater dimension, maintain the traditional ability to prevent hostile actions against national interests. Moreover, they contribute to the wider control of the maritime domain, activity that is currently developed also through the Maritime Security Operations that include the control of the smuggling of migrants, drugs, smuggling or terrorism.

Further, submarines continue to be the main element of deterrence, a fundamental ingredient of the international balance, true basis on which peace, security and global stability rest. Many are the tasks that the Italian submarines carry out daily in favour of the security of the Country and of the Alliances which it is part of, all carried out in a concealed way and far from the media spotlight. In addition to the purely military missions, there are those relating to freedom of navigation, anti-

[101] FAO (Food and Agriculture Organization), *The State of World Fisheries and Aquaculture*: the report highlights how fisheries and aquaculture are critical to the nutrition and economy of billions of people.

[102] UNESCO, through the Convention on the Protection of Underwater Cultural Heritage (2001), recognises the importance of protecting underwater archaeological sites as unique witnesses of human history, including ancient trade routes, underwater cities and wrecks.

[103] Hooton, E. R. (2016). *Submarines of the 21st Century: The Changing Face of Underwater Warfare*. Barnsley, South Yorkshire: Pen & Sword Maritime.

[104] Francis Fukuyama, *The End of History and the Last Man*, 1992.

piracy, security of energy supply routes, respect for international law, fight against international terrorism, protection of external borders, protection of the marine environment and safeguarding of maritime infrastructure including offshore and underwater ones. Within such missions the submarine is placed like an asset capable of operating in isolated way or to constitute a crucial instrument for complex, large-scale aeronaval or amphibious operations. Since submarines can provide long-term intelligence-gathering and surveillance activities in a covert manner even in a high-threat coastal environment, they represent an instrument of considerable strategic value, unique in its kind in the entire Defence landscape.

Its ability to remain in the sea in an "invisible" way for a consistent time without necessarily having to emerge makes it an ideal tool to collect information without altering the environment and without affecting or alerting the subject observed. This peculiar ability to monitor, unseen, the behaviour of the actors in play, helps to better understand the abilities, intentions and vulnerabilities of others, with the intent to identify and manage in advance the causes of potential conflicts even before they can manifest. All without the risk of triggering dangerous escalation following the presence of obvious forces.

To summarise, the combined capabilities of deterrence, intelligence gathering and advanced defence with power projection (weapons and special forces) of submarines ensure constant surveillance and defence of maritime spaces, to protect the national interest and the legitimate use of the sea and the entire maritime, coastal, offshore and underwater cluster.

Investments in submarine fleets and unmanned vessels

An indicator of the relevance enjoyed today by the underwater dimension and related interests can be represented by the size of the submarine fleets worldwide. 43 Countries out of 162 having a littoral border have at least one submarine, with China driving this growing trend with about 80 units, followed at short distance from Russia and the United States.

Another indicator is investment in the development of underwater drones, autonomous vehicles of various sizes, which without crew on board can operate even at very deep altitudes and be difficult to detect in a complex environment such as the underwater one. Currently the total economic volume of the market for both autonomous and remotely controlled unmanned systems is around 3 billion dollars[105]. Although the data itself is not so significant, the projected estimates towards a strong growth of the sector unveil the true value of this trend. About a third of the investments are concentrated in North America (USA in the lead) and Asia (China in the lead) and it is substantially polarized between these two Big Players, with the remaining investments of the order of tens/hundreds of millions of dollars in Europe and in the remaining countries.

[105] The sources are various private or state research institutes available on the web: Centre for International Maritime Security CIMSEC - statista.com - Worldbank.org - ICAO.int.

Acquisition of the Underwater Situational Awareness (UWSA)

Potential defence measures against emerging threats in the underwater dimension may include advanced surveillance systems to detect and monitor suspicious activity, technologies and active defence strategies to neutralize hostile drones, surveillance by surface vessels, aircraft and submarines to obtain what the experts call Underwater Situational Awareness (UWSA).

To increase the ability to control and protect the underwater operational environment, the Italian Navy is devoting much importance to technological development following an incremental approach to develop new structures and promoting innovative models of technological development in collaboration with companies and universities.

In detail, efforts are being made to improve existing capabilities by developing new conventional platforms, such as the U212 NFS submarines, the FREMM frigates and the new generation minehunters. The next step, already under way, is to upgrade capabilities by developing unmanned vehicles and integrating them with conventional platforms. The last phase of this path involves the development of networks of fixed and mobile sensors and actuators, capable of extending and making the control capabilities of the underwater dimension persistent, with the final aim of monitoring large areas, especially in proximity of critical infrastructures.

By enhancing national expertise, technological innovation on the one hand will offer enormous opportunities for the preservation, enhancement and exploration of the deep and the seabed, while on the other hand it will allow to mitigate the risks to which the strategic underwater infrastructures are exposed. It is therefore essential to maintain an adequate technological advantage.

At the international level the Navy has promoted a new project proposal within the framework of the Permanent Structured Cooperation (PESCO) initiative, called Critical Seabed Infrastructure Protection (CSIP). With the participation of France, Germany, Portugal, Spain and Sweden (Bulgaria, Finland and Ireland as observers), the project was approved by the European Council in May 2023. In the long term, the goal is to obtain an Advanced Underwater Situational Awareness through the establishment of a suitable Command and Control structure capable of managing an underwater communication network, consisting of UxV nodes, buoys and ships capable to work together in swarming (according to swarm logics) and teaming (cooperating by dividing tasks). This project involves highly sophisticated technologies and will be used both for the form of ASW fight and for the protection of underwater infrastructure.

Capability Development Guidelines of the National Underwater Component

The submarine is a highly technological means that has always played a strategic role for the protection of the vital interests of the country and for national security. The employment of the submarines in the next decades will continue to represent a strategic activity of our Defence. The design and construction of a modern submarine and its subsequent maintenance are, at present, one of the enterprises of far greater technological content in the military and civil world. An underwater unit is in fact the sum of hundreds of equipment and systems that must work simultaneously and in harmony despite adverse environmental conditions, with a reliability comparable only to the space domain. Currently, Italy employs 8 submarines, 4 of which of the *Sauro* class and 4 of the *Todaro* class, type U212A.

The submarines U212A are the result of an Italian-German cooperation and of the industrial agreement between the group tkMS and the Italian Fincantieri and have represented a turning point in the field of the conventional submarines at the global level. The next project U212 NFS (Near Future Submarine) originated from the need to replace the 4 units of the *Sauro* Class dating back to the 1980s-1990s, with the aim of having an even more performing asset for underwater dimensional control. The U212 NFS Program is based on the technological evolution of the U212A design and provides for the further increase of specific performance using innovative technology prioritized with national connotation. Near Future Submarine submarines will change the approach to the underwater world: today, in fact, the underwater units act in a timely and often isolated in complex covert surveillance activities for data collection operations as well as for underwater space control. However, this valuable and unique capability must be extended and integrated by increasing the range, persistence and quality of the data collected. In the future, the submarine will have to be part of a wider system of contrast to new types of threats, included those towards energetic and commercial interests on the seabed.

The new Italian submarine, therefore, maintaining the traditional operational capabilities, will represent the hub of a widespread network of sensors (fixed on the bottom and mobile, mounted on unmanned underwater vehicles) for underwater dimension surveillance. In synthesis, the new vessels will represent a sort of "underwater operating centre" in a position to monitor and to protect the interests of the Nation above and beneath the surface of the sea. All this must be attained while maintaining submarines' most important feature and strength: invisibility.

The implementation of the 4 U212 NFS is characterized by important innovations, including the implementation of lithium-ion batteries, integrated in the green economy supply-chain linked to decarbonisation and electrification of large industrial sectors. U212 NFS will be the first submarine in Europe to be equipped with this technology, integrally designed and built in Italy. The innovations of the U212 NFS submarines will also integrate the Command-and-Control system, also for the first time nationally produced and equipped on a submarine. Another feature of the U212NFS is its concept of "system systems" that coordinates and manages other autonomous underwater vehicles and interacts with underwater sensor networks, to implement a full-spectrum vertical surveillance of the water column and the seabed. NFS submarine can launch, deploy and recover underwater drones that will increase the ability of surveillance and deep intervention (both in terms of horizontal projection, even in very low waters otherwise unreachable by submarines, and vertical projection, towards the abyssal depths), ensuring the confidentiality of operations. The new submarines will be even more perfectly integrated in the national military devices and they will dialogue in the wider networks of satellite communication of the Defence, overcoming the traditional limits of older means.

According to the current programs, the first unit will enter in service in the first semester of 2028, while the successive ones will be delivered on an annual basis until the completion of the program in 2031. In the long term, the Italian Navy is oriented towards an evolution of its submarine component along innovative parameters through the Next Generation Submarine Project (NGS), launched in 2022 to achieve, with the necessary time edge, the development of the technologies that will characterize the submarines entering in service in a temporal horizon comprised between 2040 and 2050. First objective of the project is the so-called technological scouting, aimed at identifying the most promising and potentially integrable disruptive technologies in new generation submarines. NGS will have to aim at a new paradigm shift in the underwater field, pursuing the evolution of the submarine towards an Underwater Capability Carrier capable of deploying and controlling a wide range of sensors and capabilities to be integrated with on-board sensors.

This set of capabilities can be achieved by immediately addressing the development and application to the submarine environment of so-called Disruptive Technologies (primarily Artificial Intelligence, Big Data, quantum technologies) and, to this purpose, the role of the National Underwater Dimension Pole will be fundamental. A further line of action is related to the world of basic research through the use of the National Military Research Plan, thanks to which several initiatives and research projects have already been launched.

The underwater ecosystem

While the national scene boasts a valuable range of initiatives and expertise in the diving sector, there is a structural lack of cohesion among the various realities. In order to protect vital national interests, the need to adopt an organic approach was recognised and the National Underwater Dimension Centre was created (PNS - *Polo Nazionale della Subacquea*). It derives from Article 658 of the Budget Law 2023 and was established by Decree of the Minister of Defence in 2023. The latter, among other things, states: "The PNS promotes, facilitates and coordinates the cooperation of the multiple articulations operating in the underwater sector, in order to achieve the enhancement of technical-scientific research and technological innovation, the increase of the competitiveness of the national industry and the protection of the related intellectual property". Therefore, the PNS was created to be an unprecedented technological hub model and an incisive expression of the Country-System aimed at aggregating national excellence, both public and private, operating in the underwater innovation sector, promoting synergy, growth and competitiveness. In fact, the National Underwater Dimension Pole has a distinct inter-ministerial, inter-disciplinary and inter-agency character, acting as a catalyst and integrator of the so-called underwater cluster (understood as a combination of institutions, industry, start-ups, academia and research centres).

The functioning of the PNS is governed by a multi-level governance composed of representatives from the participating Ministries (Defence, Enterprise and Made in Italy, University and Research, Civil Protection and Sea Policy), the Defence sector, industry, through the Federation of Italian Aerospace, Defence and Security Companies (AIAD – *Agenzie Italiane per l'Aerospazio, la Difesa e la sicurezza*), academia and research.

The National Underwater Dimension Centre was inaugurated on December 12th, 2023. The location of the PNS in La Spezia allows the capitalisation of the intrinsic advantages deriving from the vocation of this centre. These include the possibility of carrying out experimental activities at sea, the proximity to the major industrial and shipbuilding centres in the sector, the specialised know-how, the network of collaborations with universities and research institutes, the connection with the Navy Hydrographic Institute, which in turn also has a solid network in the meteorological-oceanographic, geological and geophysical sectors, as well as the expertise of specialists including submariners, divers and special forces, mine experts and subsurface operations experts. The La Spezia site acts as a hub for the synchronisation of initiatives across the country, providing infrastructural resources, testing and evaluation capabilities, laboratories, space for lectures, conferences, meeting rooms, etc. In this way, even small entities in the sector will be able to operate with tools consistent with their ambitions, facilitated by a structure capable of shortening the path between the formulation of requirements and the verification/evaluation of the products of innovation activities. In addition, by leveraging the agility of SMEs and emerging realities - such as spin-offs and start-ups - in coordination with large national companies, the PNS acts as an incubator to enable those involved to quickly acquire skills and competencies. Last but certainly not least, the PNS will seek collaborations with international entities, including the aforementioned Centre for Maritime Research and Experimentation (CMRE)[106]. The Naval Support and Experimentation Centre of the Italian Navy is located in the same site.

Furthermore, in view of the presence of these centres, the Italian Navy is developing a proposal to establish a NATO underwater Centre of Excellence within the Atlantic Alliance framework. This initiative represents an important opportunity to strengthen NATO's capabilities and expertise, from technological research to the development of underwater capabilities. Taking advantage of the presence of NATO's CMRE and the Italian National Underwater Dimension Centre, the NATO Centre of Excellence will be able to act as a bridge between technological research and the effective development of Alliance doctrine and capabilities in the underwater operational environment.

New forms of governance

It is important to develop an appropriate legal framework at the national level and to promote new rules also at the international level in order to ensure safe access to the underwater operating environment. It is evident that the simultaneous proliferation of submarine activities capable of operating at depth and the growing need for access to the underwater environment for research and exploitation of energy and mineral resources, for the laying of communication infrastructures, for scientific or military purposes, will make the underwater dimension increasingly crowded. Therefore, it is necessary to establish procedures and rules to coordinate and control all these undersea activities. This task should be handled by a single operations centre responsible for all submarine activities in waters under national authority, including the Exclusive Economic Zone. This centre will play the role of the National Authority for the Supervision of Underwater Activities (ANCAS – *Autorità Nazionale per il Controllo delle Attività Subacque*) with the task of centralising

[106] The CMRE is a NATO body dependent on the globally established Science and Technology Organisation (STO); it deals with research, scientific experimentation and technological development in the maritime field.

all requests for access to underwater spaces, issuing authorisations and resolving interferences between adjacent activities. Thanks to this unique organisation, submarine operations will be safer and it will also be possible to establish a recognised picture, in order to be able to detect any anomalies and act quickly, especially near critical infrastructures.

Conclusions

The need to control and protect the underwater dimension and the vast network of strategic interests it encompasses, especially in the face of the growing risks to which they are exposed, makes indispensable to support a unified national approach by acting on several levels. Investment in underwater technologies, while promoting synergies in the sector and avoiding dispersive duplication, is a first fundamental aspect to be pursued to enable Italy both to mitigate the risks to which its interests are exposed and to seize the important opportunities that developments in the underwater sector will open up. The promotion of a new governance of underwater spaces, tailored for the times and modern threats, is a parallel but equally important path to the technological one. The Navy is a key player in this new approach and it is ready to offer its expertise and constant commitment at sea, above and below the surface, to protect national interests.

CONCLUSIONS: A NATIONAL UNDERWATER STRATEGY

by Emmanuele Panero

The systematic analysis of the dependencies, vulnerabilities, threats and requirements emerging in the underwater (almost) domain highlights the crucial importance that it will incrementally hold for the entire Country System, both in terms of civil infrastructure and economy, and in terms of the Defence industrial and military sector. However, the emergence of a multipolar international context marked by deep interdependencies, the pervasive widening of global and regional strategic competition, and the assertiveness of certain state and non-state actors, increasingly involves the seabed and the water column above it. In order to acknowledge and address the resulting challenges, the development of a civil and military National Underwater Strategy (SSN – *Strategia Sottomarina Nazionale*) aimed at both ensuring the security and resilience of national underwater assets and consolidating and enhancing power projection capabilities from and below the surface appears therefore essential.

The resulting policy document should pursue an approach that is not only inter-ministerial and inter-agency, but also based on a substantial implementation of structural public-private coordination and cooperation. Combining a holistic and sectoral approach, it should outline vision, needs and tools to ensure the protection and promotion of national interests in the underwater domain, with specific references to the development and management of critical national infrastructures, the Navy's capabilities upgrading and the strengthening of related industrial bases.

Assuming, to consolidate a regulatory reference framework, the advisability of a full and complete implementation of the provisions of Law 91/2021, envisaging a national Exclusive Economic Zone (EEZ) without formally establishing it, the Underwater Strategy should promote advanced multi-platform and multi-sensor situational awareness within its geographical limits. The data and information collected by the most diverse private stakeholders, public bodies and scientific and research institutes should in fact be integrated with those collected by the Navy to form a constantly updated National Submarine Prospectus (PSN – *Prospetto Sottomarino Nazionale*) under the Navy's control and management. It would inform and enable the protection of critical national infrastructures under the coordination of the Prime Minister's Office, while a version of the document, removing classified elements, would be made available to all institutional, industrial and academic stakeholders participating in the original information sharing.

This second document would also be a fundamental aid to support the analyses, evaluations and decisions of a newly-formed Interministerial Table for the Underwater Development (TISS – *Tavolo Interministeriale per lo Sviluppo Sottomarino*), including representatives of the Ministry of Foreign Affairs, the Ministry of Defence, the Ministry of the Interior, the Ministry of Economy and Finance, the Ministry of Business and Made in Italy, the Ministry of the Environment and Energy Security and the Ministry of Infrastructures and Transportation. The TISS would be responsible for directing and coordinating the sustainable exploitation and infrastructures of the seabed and the underwater space falling within the Italian EEZ, interfacing periodically in meetings in an enlarged format (TISS+) with a permanent delegation of private economic stakeholders operating or having interests in the underwater sphere. Underwater Domain Awareness would thus take the form both of a technical, constantly updated document, always available and prepared for the prevention and management of emergencies including imminent threats to national security, and of a constant public-private confrontation aimed at supporting a coordinated evolution of national dependency on the underwater (almost) domain. Bearing this in mind, a careful assessment of the disclosure requirements pertaining to both the related operational activities and technology divestments by companies in the industrial and underwater services segment should be carried out, coordinating their outcomes with the Golden Power legislation with particular reference to the amendments made to it by Law 133/2019[107]. Similarly, common standards collectively identified by industry companies under the mandate of the TISS, should be actively promoted along the lines of international best practices, with reference to infrastructure resilience and information security. The overall monitoring, coordination and guiding activity outlined would also target cable and pipeline entry points, with the dual aim of pursuing a greater diversification of the geographical areas concerned, on the one hand, and reinforcing the sub-shore and onshore protection of the same, on the other.

Domestic initiatives could then be integrated with a multilateral approach with the main countries with which Italy shares critical underwater infrastructure, with specific reference to telecommunications cables. In particular, the situational awareness guaranteed by the PNS and the widespread public-private competences integrated in the TISS+ would guarantee Italy the possibility of acting as a leader in the constitution of a Common Mediterranean Underwater Framework shared primarily with the other states, mostly belonging to the European Union and/or the Atlantic Alliance, of the northern shore of the Mediterranean Sea. This platform would be geared towards enabling greater coordination in the coordinated development of regional underwater infrastructure, the analysis of imminent threats, and the timely response and investigation of incidents. Such an instrument would in fact be central to an extension of the surveillance radius of both submarine cables and pipelines that extend far beyond the theoretical national EEZ, and the potentially malicious presence and activity of civil or military assets.

The consolidation and development of advanced submarine capabilities by the Navy would then constitute the second pillar of the SSN, oriented to support the refinement of the Underwater Domain Awareness and to strengthen the Armed Force's projectability from and below the surface in the Wider Mediterranean. Close coordination with the defence industry would therefore be a key component in helping to identify and meet new technical-operational requirements, implementing constant research, development and testing activities. The establishment, under the leadership of the

[107] Law No. 133 of 18 November 2019, converted, with amendments, Decree-Law No. 105 of 21 September 2019, extending the operational scope of the rules on special powers that can be exercised by the Government in strategic sectors, in coordination with the implementation of Regulation (EU) 2019/452 on the control of foreign direct investment in the European Union. Energy, transport and communications are some of the relevant sectors provided for in Art. 4, para. 1 of the aforementioned Regulation, extending the exercise of special powers in these areas on the basis of the existence of a threat of serious prejudice to public interests relating to the security and operation of networks and facilities and the continuity of supply.

Italian Navy, of the National Underwater Centre in La Spezia coherently represents an action in this perspective, oriented to implement a fusion centre of scientific, engineering, technological, industrial and operational competences in the sector in favour of both the effectiveness of the Armed Force and the national, European and global competitiveness of the Italian military-industrial sector. Innovative efforts would be appropriately optimised by prioritising, alongside solutions capable of reaching increasing depths and providing increasingly accurate sonar-acoustic imaging, even at great distances. The gradual convergence of robotics and AI into assets capable of completing increasingly complex tasks in environments inherently hostile to human presence guarantees the possibility of operating at previously inaccessible depths, with high dwell times. The plurality of missions to be carried out (in particular ISR ones) also in favour of critical national infrastructures clearly demonstrate an appreciable incentive for the realisation of a complementary spectrum of classes of submarine assets with different dimensions, performance, dive rates, technical characteristics and payloads. The significant advantages in terms of scalability, persistence and potential pervasiveness of unmanned and autonomous assets should therefore be addressed within the SSN, promoting adequate public investment and research incentives from private stakeholders, including through an enhancement of the National Military Research Plan (PNRM). Moreover, the resources committed to these initiatives should be a reinforcement to those already allocated to pre-existing MCM and ASW capabilities, in particular by consolidating fleets of dedicated ships, including an upgrading of assets such as European Multi-Mission Frigates in ASW configuration.

With regard to the submarine component and the emerging requirements for their deployment in the Wider Mediterranean, in addition to the constant improvement of their inherent acoustic and sonar concealment and hydrophone detection capabilities as well as optical ISR along the coast and possible anti-ship torpedoing, the possibility of generating effects in the terrestrial domain and that of operating on the seabed represent two main strands of development. The challenges posed by growing instability in various areas of national strategic interest and the re-emergence of high-intensity warfighting in a scenario of confrontation between peer and near-peer competitors call for a parallel consolidation of the valuable delivery capabilities of special forces through underwater vectors and the evaluation of the opportunity to include Submarine Launched Missiles (SLM) within the armament of the Navy's submarine component. Similarly, the aforementioned extension of the majority of critical national underwater infrastructures far beyond the theoretical Italian EEZ implies the development of assets capable of approaching and possibly operating in their vicinity with suitable instruments. The adaptation of assets to these tasks would indeed provide the Navy with a significant advantage in terms of capability, helping it to promote its role in the European and Atlantic arena.

The development and acquisition of the U212 Near Future Submarine (NFS) is central to the Navy's submarine capabilities and to the national competitiveness of the Italian defence industry: this asset is going to be entirely built in the Country with the participation of large, medium and small national companies for its components. Constant investment and orientation towards a platform open to further innovation during the vessels' operational period would therefore be essential to keep the military-industrial sector at the forefront.

The development and implementation of the general guidelines outlined by the SSN, based on the guiding principles of the protection of security and national interests both in the EEZ and in the Enlarged Mediterranean as a whole, as well as the consolidation of the related industrial and service sectors in an integrated Country System perspective will enable Italy to protect, operate and excel in the future of the underwater (almost) domain.

Bibliography

Abhijit Singh, *The Promise and Pitfalls of Underwater Domain Awareness*, in War on the Rocks, February 10th, 2023, https://warontherocks.com/2023/02/the-promise-and-pitfalls-of-underwater-domain-awareness/

Alessandro Ruocco, *I pagamenti digitali ormai (quasi) eguagliano quelli in contanti*, in Credit News, October 18th, 2023, https://www.creditnews.it/pagamenti-digitali-eguagliano-contanti/#:~:text=Secondo%20le%20previsioni%20di%20Banca,addirittura%20superarli%20nei%20prossimi%20anni.

Alexandre Jubelin and Camille Morel, *Les câbles sous-marins, artères stratégiques*, in Le Collimateur Podcast, June 2023, https://soundcloud.com/le-collimateur/les-cables-sous-marins-arteres-strategiques

Ali Bakir, *Turkey's defense industry is on the rise. The GCC is one of its top buyers*, in Atlantic Council, August 4th, 2023, https://www.atlanticcouncil.org/blogs/menasource/turkey-defense-baykar-gcc-gulf/

Amm. J.S. Corbett (Royal Navy), *History of the Great War. Naval Operation, based on official documents*, Longmans Green&Co, 1920.

Analysis: French Suffren-Class Submarine Empowers Special Forces with PSM3G swimmer delivery vehicle, in Navy Recognition, August 1st, 2023, https://navyrecognition.com/index.php/focus-analysis/naval-technology/13400-french-suffren-class-submarine-empowers-commando-operations-with-psm3g-mini-submersible.html?utm_content=cmp-true

Andrew Roth, *Sweden to drop inquiry into Nord Stream pipeline explosions*, in The Guardian, hΣps://www.theguardian.com/business/2024/feb/07/sweden-drop-inquiry-nord-stream-pipeline-explosions

Anna Gross, Alexandra Heal, Chris Campbell, Dan Clark, Ian Bott and Irene de la Torre Arenas, *How the US is pushing China out of the internet's plumbing*, in Financial Times, June 13th, 2023, https://ig.ft.com/subsea-cables/

Antonio Perrucci and Franco Bassanini, *Industria dei cavi sottomarini. Tendenze di mercato e geopolitica*, Passigli, June 10th, 2022.

ARERA, Autorità di Regolazione per Energia, Reti e Ambienti, Dati e Statistiche, https://www.arera.it/it/dati/bilancio_en.htm

Arnab Das, *The Underwater Domain Awareness Framework: Infinite Possibilities in the New Global Era*, in India Foundation, September 6th, 2021, https://indiafoundation.in/articles-and-commentaries/the-underwater-domain-awareness-framework-infinite-possibilities-in-lthe-new-global-era/

Arnab Das, *Underwater Domain Awareness – A New Perspective in the Indo Pacific*, in UDA Digest, February 14th, 2022, https://digest.foundationforuda.in/2022/02/14/underwater-domain-awareness-a-new-perspective-in-the-indo-pacific/

Asma Ali Zain, *Cable damage hits one million Internet users in UAE*, in Times online, 2008. https://web.archive.org/web/20080209140523/http://www.khaleejtimes.com/DisplayArticleNew.asp?section=theuae&xfile=data%2Ft heuae%2F2008%2Ffebruary%2Ftheuae_february121.xml

Bellezza, M., & Fioravanti, C. (2018). *The Role of Advanced Sonar Systems in Submarine Warfare*, in Naval Engineering Journal.

Christian Bueger and Tobias Liebetrau, *Critical Maritime Infrastructure Protection: What's the trouble?*, in Marine Policy, 2023. https://www.sciencedirect.com/science/article/pii/S0308597X23003056

C.R.M.F. Cruttwell, *A History of the Great War. Naval Operations*, Oxford University Press, 1934.

Chamber of Deputies, *Il Sistema Gas Italiano*, March 7th, 2023, http://documenti.camera.it/leg19/dossier/pdf/AP0021.pdf

Camille Morel, *Câbles sous-marins*, CNRS Editions, 2023.

Charlotte Le Breton and Hugo Decis, *France's Deep Dive into seabed warfare*, in International Institute for Strategic Studies, February 25th, 2022, https://www.iiss.org/online-analysis/military-balance/2022/02/frances-deep-dive-into-seabed-warfare/

European Commission, *An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future*, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:741:FIN&qid=1605792629666

European Commission, *PCI Transparency platform Projects of common interest – Interactive map*, in Climate, Infrastructure and Environment Executive Agency / Energy, https://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/main.html

Darek Liam, *Esercitazione militare Medusa-12 in corso nel Mar Mediterraneo*, in Military Africa, November 25th, 2022, https://www.military.africa/2022/11/medusa-12-military-exercise-underway-in-the-mediterranean-sea/

Davide Bartoccini, *Cosa sono i "Buchi neri" dell'oceano che preoccupano la NATO*, in InsideOver, March 19th, 2019, https://it.insideover.com/guerra/cosa-sono-i-buchi-neri-delloceano-che-preoccupano-la-nato.html

Dorian Archus, *How deep can a submarine dive?*, in Naval Post, April 26th, 2021, https://navalpost.com/how-deep-can-a-submarine-dive/

Dr Sidharth Kaushal, RUSI, *Stalking the seabed: How Russia targets critical underwater infrastructures*, 2023. https://rusi.org/explore-our-research/publications/commentary/stalking-seabed-how-russia-targets-critical-undersea-infrastructure

Egypt State Information Service, *Egypt, China conduct joint naval drill in Mediterranean Sea*, August 21st, 2019.

Egypt State Information Service, *Egyptian-US military exercises 'Bright Star 2023' continue activities*, September 15th, 2023, https://www.sis.gov.eg/Story/185785/Egyptian-US-military-exercises-'Bright-Star-2023'-continue-activities?lang=en-us

Emanuele Oddi, *Sicurezza e rilevanza geopolitica dei cavi sottomarini in Italia*, in Eurispes, June 5th, 2023, https://www.leurispes.it/cavi-sottomarini-di-grande-rilevanza-geopolitica-in-italia/

EU-NATO Task Force on the resilience of critical infrastructure, *Final Assessment Report*, 2023. https://commission.europa.eu/system/files/2023-06/EU-NATO_Final%20Assessment%20Report%20Digital.pdf

FAO. (2020). *The State of World Fisheries and Aquaculture 2020*. Food and Agriculture Organization of the United Nations.

Fondazione Leonardo, *RAPPORTO CIVILTÀ DEL MARE Geopolitica, strategia, interessi nel mondo subacqueo - Il ruolo dell'Italia*

Frank Hoffman, *Extending that 'Loving Feeling' to Undersea Warfare*, in War on the Rocks, November 3rd, 2021, https://warontherocks.com/2021/11/extending-that-loving-feeling/

French Navy Receives its Second Next-Generation Nuclear-Powered Submarine, in The Maritime Executive, August 18th, 2023, https://maritime-executive.com/article/french-navy-receives-its-second-next-generation-nuclear-powered-submarine

Friedman, N. (1994). *U.S. Submarines Since 1945: An Illustrated Design History*. Annapolis.
Frost & Sullivan, *Global Unmanned Underwater Vehicles Market Forecast*.

Garantire acque pulite per le persone e per la natura. Agenzia europea dell'ambiente. https://www.eea.europa.eu.

Global Fire Power, *Submarine Fleet Strength by Country (2023)*, 2023, https://www.globalfirepower.com/navy-submarines.php

Global Gas Infrastructure Tracker, in Global Energy Monitor, https://globalenergymonitor.org/projects/global-gas-infrastructure-tracker/

Global Oil Infrastructure Tracker, in Global Energy Monitor, https://globalenergymonitor.org/projects/global-oil-infrastructure-tracker/

GreenStream, *Il Sistema di Trasporto LGTS (Libyan Gas Transmission System)*, https://www.greenstreambv.com/it/gasdotto-greenstream.html

TIM Group, *TIM: Ricevuta Notifica del Provvedimento "Golden Power"*, October 16th, 2017, https://www.gruppotim.it/it/archivio-stampa/corporate/2017/TIM-CS-Golden-Power-16-10-17.html

Grzegorz Kuczyński, *Russian Navy Boosts Presence in the Mediterranean*, in Warsaw Institute, March 25th, 2023, https://warsawinstitute.org/russian-navy-boosts-presence-in-the-mediterranean/

H I Sutton, *Israel Launches New Submarine, First In World With Modern Missiles In Sail*, in Naval News, August 14th, 2023 https://www.navalnews.com/naval-news/2023/08/israel-launches-new-submarine-first-in-world-with-modern-missiles-in-sail/#prettyPhoto

Hanna Ziadi, *Red Sea cables have been damaged, disrupting internet traffic*, March 4th, 2024. https://edition.cnn.com/2024/03/04/business/red-sea-cables-cut-internet/index.html

HM Government, *National Strategy for Maritime Security*, August 2022, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1100525/national-strategy-for-maritime-security-web-version.pdf

Hooton, E. R. (2016). *Submarines of the 21st Century: The Changing Face of Underwater* https://beta.sis.gov.eg/en/media-center/news/egypt-china-conduct-joint-naval-drill-in-mediterranean-sea/

Huizhong Wu and Johnson Lai, *Taiwan suspects Chinese ships cut islands' internet cables*, in Associated Press, April 18th, 2023, https://apnews.com/article/matsu-taiwan-internet-cables-cut-china-65f10f5f73a346fa788436366d7a7c70

Hybrid CoE Paper 16, *Handbook on maritime hybrid threats: 15 scenarios and legal scans*, 2023, https://www.hybridcoe.fi/wp-content/uploads/2023/03/NEW_web_Hybrid_CoE_Paper-16_rgb.pdf

International Institute for Strategic Studies (IISS). *The Military Balance. Annual publication.*

Parliamentary Enquiry 4/02010 presented by A.E. Quartiani in session nr. 114, January 14th, 2009 https://dati.camera.it/ocd/aic.rdf/aic4_02010_16 and https://documenti.camera.it/_dati/leg16/lavori/stenografici/sed114/bt54.htm

Israel Submarine Capabilities, in NTI, March 2nd, 2023, https://www.nti.org/analysis/articles/israel-submarine-capabilities/

Israel, US and France in joint underwater exercise, in The Jerusalem Post, July 27th, 2017, https://www.jpost.com/israel-news/watch-israel-us-and-france-in-joint-underwater-exercise-500915

Israeli Navy completes 'complex' submarine drill in Red Sea, in i24 News, June 2nd, 2022, https://www.i24news.tv/en/news/israel/defense/1654175764-israeli-navy-completes-complex-submarine-drill-in-red-sea

Itamilradar, *Russian Navy in the Mediterranean today*, https://www.itamilradar.com/2023/05/10/russian-navy-in-the-mediterranean-today/

Joe Brock, *Inside the subsea cable firm secretly helping America take on China*, in Reuters, July 6th, 2023, https://www.reuters.com/investigates/special-report/us-china-tech-subcom/

Joe Brock, *U.S. revives Cold War submarine spy program to counter China*, in Reuters, September 21st, 2023, https://www.reuters.com/investigates/special-report/usa-china-tech-surveillance/

Jonathan Bentham and Nick Childs, *Seabed security after Nord Stream: in search of a clear vision*, in International Institute for Strategic Studies, October 14th, 2022, https://www.iiss.org/online-analysis/military-balance/2022/10/seabed-security-after-nord-stream-in-search-of-a-clear-vision/

Jonathan Bentham, *Naval mine countermeasures, clearing up misconceptions*, in International Institute for Strategic Studies, February 18th, 2022, https://www.iiss.org/online-analysis/military-balance/2022/02/naval-mine-countermeasures-clearing-up-misconceptions/

KOF Swiss Economic Institute, *KOF Globalisation Index*, December 6th, 2023, https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html

Lieutenant-Commander David Finch, *Comprehensive Underwater Domain Awareness: A Concept Model*, in Canadian Naval Review, 2011.

Lorenzo M. Bartolini, Lorenzo Marchionni, Caterina Molinari and Antonio Parrella, Saipem, *Effects of underwater explosion on pipeline integrity*, 2015. https://www.researchgate.net/publication/276241513_Effect_of_Underwater_Explosion_on_Pipeline_Integrity

Maddalena Ingrao, *ALGERIA. Nuovi Kilo per Algeri*, in AGC Communication, January 23rd, 2019, https://www.agcnews.eu/algeria-nuovi-kilo-per-algeri/

Malcolm Fried and Lars Klemming, *Several Cables in Mediterranean disrupt communications*, Bloomberg, 2008. https://www.bloomberg.com/news/articles/2008-12-19/severed-cables-in-mediterranean-disrupt-communication

Mediterranean Posidonia Network, *Key Network*, https://medposidonianetwork.com/key-numbers/

Megan Eckstein, *Navy Undersea Warfare Priorities: Strategic Deterrence, Lethality and Networked Systems*, in USNI News, November 8th, 2019, https://news.usni.org/2019/11/08/navy-undersea-warfare-priorities-strategic-deterrence-lethality-and-networked-systems

MFA Russia, *Concept of Foreign Policy of Russian Federation*, March 2023.

Michael Kofman, Anya Fink and Jeffrey Edmonds, *Russian Strategy for Escalation Management: Evolution of Key Concepts*, Center for Naval Analyses, April 2020. https://www.cna.org/reports/2020/04/DRM-2019-U-022455-1Rev.pdf

Michele Calamaio, *La rete di cavi internet nel Mediterraneo è piuttosto ingarbugliata*, in Wired, November 20th, 2023, https://www.wired.it/article/internet-cavi-sottomarini-mediterraneo-ambiente/

Michele Cosentino, *La «nuova» Turchia: scenari geopolitici e potenziamento navale*, in Rivista Marittima, October 2022.

Ministère des Armées, *Les armées se dotent d'une stratégie ministérielle de maîtrise des fonds marins*, in Ministère des Armées, February 18th, 2022, https://www.defense.gouv.fr/actualites/armees-se-dotent-dune-strategie-ministerielle-maitrise-fonds-marins

Ministère des Armées, *Seabed Warfare Strategy*, February 2022, https://www.archives.defense.gouv.fr/content/download/636001/10511909/file/20220214_FRENCH%20SEABED%20STRATEGY.pdf

Italian Ministry of Defence. *Libro Bianco per la Sicurezza Internazionale e la Difesa*.

Ministry for the Economic Development, *Decreto Ministeriale*, May 22nd, 2020, https://www.mimit.gov.it/images/stories/normativa/Deroga_Trasmed_22_maggio_2020.pdf

Morten Soendergaard Larsen, Foreign Policy, *Russian Ghost Ships are turning the seabed into future battlefield*, 2023. https://foreignpolicy.com/2023/05/02/russia-europe-denmark-spy-surveillance-ships-seabed-cables/

NATO 2022 Strategic Concept. https://www.nato.int/strategic-concept/

Naval Group to study unmanned combat underwater vehicle, in Naval Group, June 7th, 2023, https://www.naval-group.com/en/naval-group-study-unmanned-combat-underwater-vehicle

Naval News Staff, *First of Two MROS Ships Arrives in the UK*, in Naval News, January 19th, 2023. https://www.navalnews.com/naval-%20news/2023/01/first-of-two-mros-ships-arrives-in-the-uk/

Nick Childs, *New EU maritime security strategy: adjusting the compass?*, in International Institute for Strategic Studies, April 11th, 2023, https://www.iiss.org/online-analysis/military-balance/2023/04/new-eu-maritime-security-strategy-adjusting-the-compass/

Nick Ferris, *Weekly data: One million kilometres of new fossil pipelines poses stranded asset risk*, in Energy Monitor, February 14th, 2022, https://www.energymonitor.ai/risk-management/weekly-data-one-million-kilometres-of-proposed-fossil-fuel-pipelines-poses-stranded-asset-risk/?cf-view

Norwegian National Data Center (NDC) for verification of the Comprehensive Nuclear-Test-Ban Treaty.

OCSE - *L'economia degli oceani nel 2030*.

Olivia Solon and Mohammed Hatem, *Houthi Sunk Ship Anchor Likely SeveredSea Internet Cables*, Bloomberg, March 7th, 2024. https://www.bloomberg.com/news/articles/2024-03-06/anchor-from-houthi-sunk-ship-likely-damaged-undersea-cables

O'Rourke, Ronald. *Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress*. Congressional Research Service.

Percentuale di acqua sulla Terra. Chimica-online.it. Disponibile su: https://www.chimica-online.it.

Phil Gervasi, *Diving Deep into Submarine Cables: The Undersea Lifelines of Internet Connectivity*, in Kentik, March 28th, 2023, https://www.kentik.com/blog/diving-deep-into-submarine-cables-undersea-lifelines-of-internet-connectivity/#:~:text=There%20are%20approximately%201.4%20million,cable%20at%2045%2C000%20km%20long

Pillai, *Protecting Europe's Critical Infrastructure*, https://www.cer.eu/publications/archive/policy-brief/2023/protecting-europes-critical-infrastructure-russian-hybrid

Polmar, N. and Moore, K. J. (2004), *Cold War Submarines: The Design and Construction of U.S. and Soviet Submarines, 1945-2001*. Dulles, Virginia: Potomac Books.

Prakash Panneerselvam, Rajaram Nagappa e R Ganesh, *Underwater Domain Awareness: Case for India*, Routledge India, May 10th, 2022.

Prysmian Group, https://it.prysmiangroup.com/mercati/generazione-transmissione-distribuzione

Quanta acqua c'è sulla Terra? - Info Data, in Il Sole 24 Ore. Disponibile su: https://www.infodata.ilsole24ore.com.

Richard Milne, *Finland Investigates Potential Sabotage to Baltic Gas Pipeline*, in Financial Times, October 10th, 2023. https://www.ft.com/content/8d9baf58-22c2-4456-905c-15fd7f9dcd69

S. C. Stähler, G. Zenhäusern, J. Clinton and D. Giardini, Seismica.org, *Locating the Nordstream explosions without a velocity model using polarization analysis*, 2022 https://seismica.library.mcgill.ca/article/view/253/270

Saverio Lesti and Alessandro Zacchei, MInter Group srl, *La sicurezza marittima e le infrastrutture critiche subacquee*, 2023.

Scott Savitz and Scott C. Truver, *Invisible Blockades and Strategic Coercion*, in War on the Rocks, November 23rd, 2022, https://warontherocks.com/2022/11/invisible-blockades-and-strategic-coercion/

Sean Monaghan, *Five Steps NATO Should Take after the Nord Stream Pipeline Attack*, in CSIS, Commentary, October 6th, 2022. https://www.csis.org/analysis/five-steps-nato-should-take-after-nord-stream-pipeline-attack

Seth J. Frantzman, *Israeli firm reveals unmanned submarine BlueWhale*, in Defense News, May 5th, 2023, https://www.defensenews.com/unmanned/2023/05/05/israeli-firm-reveals-unmanned-submarine-bluewhale/

Sidharth Kaushal and Kevin Rowlands, *Tackling the Underwater Threat: How Ukraine Can Combat Russian Submarines*, in Royal United Services Institute, March 7th, 2023, https://rusi.org/explore-our-research/publications/commentary/tackling-underwater-threat-how-ukraine-can-combat-russian-submarines

Simon Kemp, *Digital 2023: Italy, in Datareportal*, February 9th, 2023, https://datareportal.com/reports/digital-2023-italy

Simon Scarr, Wen Foo, Vijdan Mohammad Kawoosa, Anand Katakam and Aditi Bhandari, *The race to reconnect Tonga*, in Reuters, January 28th, 2022, https://www.reuters.com/graphics/TONGA-VOLCANO/znpnejbjovl/

SRM, *ITALIAN Maritime Economy*, October 1st, 2020, https://www.sr-m.it/wp-content/uploads/2020/10/RS-MARITIME-2020-OTTOBRE.pdf

Defence General Staff, *Approccio della Difesa alle Operazioni Multidominio*, 2022.

Submarine Cable Map, in TeleGeography, https://www.submarinecablemap.com/

Tayfun Ozberk, *Turkish Defence Industry Now Focuses On UUV Projects*, in Naval News, September 4th, 2023 https://www.navalnews.com/naval-news/2023/09/turkish-defence-industry-focuses-on-uuv-projects/

Tayfun Ozberk, *Turkish Navy To Outfit 11 Platforms With Atmaca AShMs Until 2027*, in Naval News, August 10th, 2023, https://www.navalnews.com/naval-news/2023/08/turkish-navy-to-outfit-11-platforms-with-atmaca-ashms-until-2027/

Telocompaper, *Mediterrean submarine cables are cut, affecting internet*, 2008. https://www.telecompaper.com/news/mediterrean-submarine-cables-are-cut-affecting-internet--650982
Terna, https://cieloterramare.terna.it/it/mare

Terna, *L'energia che scorre sott'acqua*, January 18th, 2021, https://lightbox.terna.it/it/in-prima-linea/cavi-sottomarini-record

Terna, *Piano di Sviluppo 2023*, 2023, https://download.terna.it/terna/Terna_Piano_Sviluppo2023_Stato_Sistema_Elettrico_8db254887149b77.pdf

Terna, *Pubblicazioni Statistiche 2022*, https://www.terna.it/it/sistema-elettrico/statistiche/pubblicazioni-statistiche#:~:text=La%20potenza%20efficiente%20lorda%20di,2021%20del%205%2C3%25

Terna, *Terna: 2023 Develompment Plan for the National Electricity Grid Presented*, March 15th, 2023, https://www.terna.it/en/media/press-releases/detail/2023-development-plan

The Jakarta Post, *Internet capacity down to 10%*, 2008. https://www.thejakartapost.com/news/2008/02/29/internet-capacity-down-10.html

Times Malta, *GO submarine cable fault part of wider disruption between Italy and Egypt*, 2008. https://www.timesofmalta.com/article/go-submarine-cable-fault-part-of-wider-number-between-italy-and-egypt.237909

Trans Adriatic Pipeline, *Azionariato di TAP*, https://www.tap-ag.it/informazioni-su-tap/azionariato-di-tap#:~:text=L'azionariato%20TAP%20%C3%A8%20composto,%2C%20e%20Enag%C3%A1s%20(20%25)

Transmed, https://www.transmed-spa.it/#:~:text=La%20societ%C3%A0%20%C3%A8%20una%20societ%C3%A0,e%20della%20societ%C3%A0%20algerina%20Sonatrach

U.S. Department of Homeland Security, *National Strategy for Maritime Security: National Plan to Achieve Maritime Domain Awareness*, October 2005, https://www.dhs.gov/sites/default/files/publications/HSPD_MDAPlan_0.pdf

Ulrich Jochheim and Rita Barbosa Lobo, *Geopolitics in the Indo-Pacific: Major players' strategic perspectives*, European Parliamentary Research Service, July 2023, https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/751398/EPRS_BRI(2023)751398_EN.pdf

UNESCO. (2001). *Convention on the Protection of the Underwater Cultural Heritage*. United Nations Educational, Scientific and Cultural Organization.

United Nations Conference on Trade and Development, *Review of Maritime Transport*, 2022, https://unctad.org/system/files/official-document/rmt2022_en.pdf

Russian President's Decree about National Security Strategies, Russian Military and Security Research Group, July 2nd, 2021. https://rusmilsec.files.wordpress.com/2021/08/nss_rf_2021_eng_.pdf.

Water Science School, *How Much Water is There on Earth?*, in U.S. Geological Survey, November 13th, 2019, https://www.usgs.gov/special-topics/water-science-school/science/how-much-water-there-earth

WWF, *Maritime Traffic*, https://www.wwfmmi.org/medtrends/shifting_blue_economies/maritime_traffic/

Xavier Vavasseur, *Euronaval: French Navy Becomes Launch Customer Of Naval Group's D-19T UUV*, in Naval News, October 26th, 2020, https://www.navalnews.com/event-news/euronaval-2020/2020/10/euronaval-french-navy-becomes-launch-customer-of-naval-groups-d-19t-uuv/

Xavier Vavasseur, *France's Naval Group Starts XLUUV Qualification Trials*, in Naval News, September 19th, 2023, https://www.navalnews.com/naval-news/2023/09/frances-naval-group-starts-xluuv-qualification-trials/

Yimou Lee, *China's latest weapon against Taiwan: the sand dredger*, in Reuters, February 5th,2021, https://www.reuters.com/graphics/TAIWAN-CHINA/SECURITY/jbyvrnzerve/

AUTHORS

Marco Di Liddo – At CeSI since 2011, he held the position of Analyst and Head Analyst before taking on the role of Director. Subject Matter Expert in History of Eastern Europe at the University of Trieste, he is an adjunct lecturer at the Geopolitics Course of the *Guardia di Finanza*'s Economic and Financial Police School, lecturer at the Department of Information for Security (DIS) School and contributor for the magazine *Formiche* and for the *Rivista Italiana Difesa* (RID). His topics of analysis include Russia and the post-Soviet space, sub-Saharan Africa, jihadist warfare techniques and methodologies in Africa.

Emmanuele Panero – Head of the Defence and Security desk, he holds a Master's Degree in Strategic Sciences with Honours and Mention at the SUISS - Interdepartmental University School of Strategic Sciences of the University of Turin. He completed the entire five-year course, including a Bachelor's Degree in Strategic and Security Sciences, at the Army Application School of Turin. He then obtained a second-Level University Master's Degree in International Strategic-Military Studies cum laude, attending the 25th Joint Service Staff College Course at the Centre for High Defence Studies in Rome.

C.F. Marco Cassetta - Commander Cassetta is an officer specialised in diving and Explosive Ordnance Disposal. He was Head of the Unmanned Vehicles Section at the Mine Countermeasures Force Command, Head of the Operations Department of the Submarine Rescue Ship and Underwater Operations Ship *Nave ANTEO*, Head of the Operations Department of the COMSUBIN Underwater Operations Group. Commanded the Coastal Patrol Vessel *Nave VEDETTA* deployed in Egypt at the Multinational Force and Observers as part of the monitoring actions of the peace treaty between the Arab Republic of Egypt and the State of Israel (Camp David Accords - 1978). He participated in various NATO, EU and national activities. In 2022, he contributed to the planning and conduct of the newly established Operation *Fondali Sicuri* at CINCNAV, for the monitoring, protection and protection of critical underwater infrastructure of national interest. He is currently serving in the Special Forces and Underwater Departments Office of the Navy General Staff.

C.F. Stefano Oliva - Submariner, Combat Systems Section Chief at the Submarine Department of the Navy General Staff. He held various positions on board national submarines and was Commander of the Submarine *Pietro Venuti*.

CeSI | CENTRO STUDI INTERNAZIONALI

CeSI - Center for International Studies is an independent think tank founded in 2004 by Andrea Margelletti, who has been its President ever since.

The activity of the Institute has always focused on the analysis of international relations and the dynamics of security and defense, with particular attention devoted to areas of crisis and the dynamics of radicalization and extremism, afterwards expanding its analytical tools also in the field of geoeconomics and conflict prevention.

The flagship of CeSI is certainly its analytical methodology which is based on an in-depth knowledge of the analyzed context, on a daily and transversal information research and on a periodic visit in the areas of interest, which allows the analysts of the Institute to carry out timely and dynamic work. Furthermore, the Institute has created a wide network of collaborations and partnerships with other think tanks, universities, institutional and non-institutional stakeholders in the reference countries.

The goal is to provide tools which will contribute to help to better understand the reality and provide useful elements for decision making. What the CeSI intends to provide is a multifaceted approach which, in the complexity of the contemporary world, is based on an understanding at 360° of the dynamics in action by the actor.

Contacts

Via Nomentana, 251
00161 Rome, Italy
+39 06 8535 6396
info@cesi-italia.org

Website

www.cesi-italia.org

Social Media

Fb: Ce.S.I. Centro Studi Internazionali
X: @CentroStudiInt
LinkedIn: Ce.S.I. Centro Studi Internazionali
IG: cesi_italia
Telegram: Ce.S.I. Centro Studi