

Bridging Strategy and Technology Beneath the Waves

Lessons from France's Seabed Warfare Strategy

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“When we talk about seabed warfare, always consider that from a French perspective there are two main goals: first is to protect critical underwater infrastructure and second is to ensure freedom of manoeuvre for naval forces.”

Rear Admiral Cedric Chetaille, French Navy's Deputy Chief for Operations and Director of Seabed Capability Development

INTRODUCTION

While the ocean floor had been predominantly associated with scientific exploration and energy exploitation in the past, today it has evolved into a critical strategic domain where national security, economic sovereignty and technological supremacy intersect. This transformation is being driven by the growing vulnerability of Critical Underwater Infrastructure (CUI), which include submarine communication cables, energy transmission systems and sensor networks. The sabotage of Nord Stream gas pipelines in September

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2022 served as a watershed moment, conclusively demonstrating that CUI have become primary targets due to changing geopolitics.¹ Essentially, the seabed has become a strategic domain that demands a national security posture transcending beyond conventional surface and sub-surface operations. The 'Seabed Warfare Strategy' of France is a convincing example in this regard, which integrates scientific research with military objectives with the core essence of 'Know, Monitor and Act' functions.² France's approach serves as a template for nations seeking to develop sovereign capabilities in robust protection mechanisms for CUI.

For India, which commands a 11,098.81 km coastline³ and an Exclusive Economic Zone (EEZ) of 2.02 million sq. kms,⁴ development of strategic capabilities for a robust seabed is not a policy aspiration but an urgent national security imperative. As a case in point, India has a vast digital economy but it manages merely 17 undersea cables that terminate within its territorial seas.⁵ In contrast, Alphabet, Meta and Microsoft manage more than 500 sub-sea cables and 1,300 Cable Landing Stations (CLS) globally.⁶ The situation is further exacerbated by increasing Chinese assertions of seabed mapping in Indo-Pacific region. Therefore, there is a need to recalibrate India's approach in the seabed domain by augmenting its capabilities beyond infrastructure protection to robust deterrence, taking a cue from the French doctrine.

ANALYSIS OF FRANCE'S APPROACH IN THE SEABED DOMAIN

France has the largest EEZ in the world, approximately 10.7 million sq. kms, spread across all oceans. This massive EEZ offers France significant sovereign rights over exploration and exploitation of marine resources and acts as an enabler in France's geopolitical influence across the world. It was therefore obligatory for France to recognise the significance of the seabed, and it did so by ratifying the United Nations Convention on the Law of the Sea (UNCLOS) in 1996.⁷ This aided in establishing a legal framework for its claims. However, the strategic and security implications of the seabed gained formal recognition when President Emmanuel Macron announced the 'France 2030' plan, which included 'exploring the seabed' as a key objective. Thereafter, France publicly released its 'Seabed Warfare Strategy' in February 2022, which is structured around three interdependent functions, i.e., 'Know, Monitor and Act'.⁸ It outlines a roadmap for augmenting the information about the seabed and developing defensive and offensive capabilities to act in this domain.

THE 'KNOW, MONITOR AND ACT' DOCTRINE

The core of the French approach to the seabed domain is the 'Know' function, which involves improving the current understanding of the deep seabed to obviate the strategic knowledge gap, which directly hampers threat detection, identification and intervention in underwater environments. The 'Monitor' function focuses on creating long-lasting surveillance capabilities to observe activities that take place in or from the seabed and defending important underwater infrastructure. The 'Act' function refers to the ability to execute search operations to retrieve objects from the seabed to undertake offensive operations like mining. This is a proactive function, which enables France to execute credible responses to diverse, evolving and hybrid actions in this domain.⁹ Together, these three functions leverage scientific research for critical information on national security, where every new information or mapping detail provides a strategic edge.

RESEARCH AND DEVELOPMENT (R&D) EFFORTS BY IFREMER

The French Research Institute for Exploitation of the Sea (IFREMER) is dedicated to R&D in ocean sciences and has developed advanced expertise in the deep-sea domain. In 1984, IFREMER commissioned a deep-sea submersible 'Nautile' for scientific exploration up to a depth of 6,000 metres. This made France the only country in the European Union to design, maintain and operate a manned submersible, capable of operating at such depths. Over the past 40 years, it has completed 2,122 dives, placing France alongside the US, Japan, China and Russia that have submarines with these capabilities.¹⁰ The operation of 'Nautile' provided significant learnings about advantages and constraints of manned deep-sea diving. Building upon this knowledge, the IFREMER has developed and demonstrated the Autonomous Underwater Vehicle (AUV) 'Ulyx', which is capable of diving up to 6,000 metres. The architecture of 'Ulyx' is being used by the French defence firm Exail Technologies, for developing the A6K-M AUV. This programme underlines the pursuit to acquire maritime freedom of action and national sovereignty by conducting seabed research and continuous surveillance of vital underwater infrastructures at 6,000 metres. The A6K-M AUV emphasises the 'Know' and 'Monitor' functions of seabed warfare strategy and highlights how effectively France is leveraging the technological advancement meant for civilian research in military applications.

ROLE OF THE FRENCH NAVAL HYDROGRAPHIC AND OCEANOGRAPHIC SERVICE (SHOM)

SHOM is the national hydrographic service which is an administrative establishment under the supervision of French Ministry of Armed Forces. It has an explicit mandate of providing essential defence expertise and operational support on the aero-maritime environment. It provides updated and precise Hydrographic, Oceanographic and Meteorological (HOM) environmental intelligence, which is indispensable for the safety and functioning of modern command and weapons systems and submarine navigation. To meet its objectives, SHOM develops efficient tools and services, which are tailored to various types of warfare, sensors and weapons systems, in order to measure, describe and forecast the HOM environment.¹¹ Essentially, SHOM emphasises on improving the knowledge of the seabed to execute the 'Know' function, which is a continuous and iterative process.

CONTRIBUTIONS OF ACADEMIA

In order to transform the raw and complex underwater data into actionable intelligence, it is necessary to build advanced data processing capabilities. This gap is being addressed by French universities. The Naval Academy Research Institute (IRENav) is focused on studying underwater acoustics and signal processing. It is also a member of 'Europole Mer', the national scientific cluster comprising engineering schools and universities inclined towards study of the maritime environment.¹² Additionally, the College of Naval Sciences (CSN) was established on 25 June 2025, for undertaking dedicated research in the field of undersea robotics, drones, autonomous marine and submarine systems.¹³ The involvement of academic institutions is aligned with a dual-use philosophy as it addresses both military and civilian issues.

ROBUST INDUSTRIAL CAPACITY

The involvement of firms like Exail and Thales is aimed at fostering robust industrial capacity tailored to the needs of the envisaged underwater capability. Thales and Exail have been selected by the French defence procurement agency (DGA) to deliver eight A18-M AUVs with mine warfare capabilities. Exail has been entrusted with developing the fully autonomous capability of AUV, while Thales will integrate the AUVs with SAMDIS 600

sonar for superior performance. This industrial collaboration resonates with the definition of the 'Monitor' function, as it will contribute to the SLAMF programme wherein the French Navy is looking at mine warfare capabilities using unmanned systems.¹⁴

OPERATIONALISATION OF SCIENTIFIC AND TECHNOLOGICAL ADVANCEMENTS

France has been advancing the integration of academia, industries and R&D institutes' technological output into its operational doctrine by conducting and participating in simulated combats. This move represents the 'Act' function of the seabed warfare strategy; the case in point being, Operation Calliope, which was initiated in 2022 to rigorously test off-the-shelf technologies of AUVs and ROVs, impart training to the Navy in the deep-sea domain. Operation Calliope simultaneously delivers experimental data and operational results, demonstrating how scientific learning directly affects military practice.¹⁵ Further, the French Navy regularly participates in NATO exercises to refine its operational doctrine in the seabed domain. Participation in 'Polaris-25', which was held between 12 May and 17 June 2025, is illustrative in this regard. During this exercise, the French Navy undertook simulated manoeuvres and confrontation on the seabed to tackle hybrid and non-linear threats.¹⁶ France also participated with Italy in the exercise 'Mare Aperto' in 2025, to hone the tactics of protecting underwater infrastructure and lines of communication. It included mine countermeasure operations involving manned and unmanned assets in simulated training scenarios. During real-time clearance activities, 13 unexploded ordnances dating back to the Second World War were discovered.¹⁷ Therefore, it is evident that these operations transcend mere testing of technology and function as a dynamic real-world laboratory for developing and refining France's seabed warfare doctrine.

OCEAN SCIENCES IN INDIAN CONTEXT

Ocean sciences in India traces back to the establishment of the CSIR–National Institute of Oceanography (NIO) in Goa in 1966. It was one of the first oceanographic centres in Asia. Subsequently, other institutes were established viz. the Indian National Centre for Ocean Information Services (INCOIS), the National Institute of Ocean Technology (NIOT) and the National Centre for Polar and Ocean Research.¹⁸ This multi-institutional

framework has steadily increased India's ability to map the seabed, assess biodiversity and provide real-time data services. The creation of the Ministry of Earth Sciences (MoES) in 2006 with the mandate of ocean research and exploration laid the groundwork for strategic and commercial uses of ocean sciences.

SCIENTIFIC EXPLORATION AND ECONOMIC AMBITION

In 1981, CSIR-NIO commanded the Indian programme to collect the first polymetallic nodule samples from the Arabian Sea. This initial breakthrough inspired subsequent surveys by several research ships between 1982 and 1987. As a result of these efforts, the International Seabed Authority (ISA) recognised India as a pioneer investor in the Central Indian Ocean Basin (CIOB) for exploration and future exploitation of these minerals.¹⁹ In 2021, MoES launched the Deep Ocean Mission (DOM) with primary goals of developing technology for deep-sea mining, underwater robotics, manned submersible and understanding the role of the ocean in climate change.²⁰ Indigenous development of manned deep-submergence vehicle (Matsya 6000) under the Samudrayaan project is a significant landmark for the DOM. It is being developed with the primary aims of identification of polymetallic nodules, study of ecosystems, biodiversity and geological formations in the abyssal environment at 6,000 metres. Maiden wet harbour trials which included both manned and unmanned dives, were conducted in 2025 to assess stability, manoeuvrability, power management, communication, control devices and human support systems.²¹ Shallow water demonstrations were scheduled for end 2025 and descent to 6,000 metres expected by 2026. This noteworthy progress signifies a major technological leap that has the potential to be leveraged beyond scientific or economic pursuits to aid and augment the 'Know' and 'Act' functions of seabed warfare.

STRATEGIC SIGNIFICANCE OF THE DOM

The DOM aims at ensuring sustainable exploration of approximately 380 million tonnes of polymetallic nodules in 75,000 sq. kms of CIOB allocated by the ISA.²² Therefore, DOM establishes a direct link with India's Blue Economy vision. Economic imperatives of Blue Economy coupled with critical mineral security as ensured by DOM, provides a powerful civilian justification for funding development of deep-sea technologies. However, these technologies have direct military utility as seen in the case of France;

therefore, if India follows the same path, the DOM will become a strategic national asset that will underpin economic prosperity and future defence capabilities. This dual benefit will facilitate greater public and private investment and political will, compared to a purely military programme.

INADEQUACIES IN INDIA'S APPROACH TO SEABED DOMAIN

India's approach to seabed domain displays significant strategic vulnerabilities that jeopardises its digital sovereignty, vision of blue economy and national security. The convergence of the factors outlined below calls for an urgent need for a robust undersea strategic capability.

Institutional Fragmentation and Limited Strategic Coordination

India's capability in seabed domain is scattered across multiple organisations operating with limited coordination and divergent objectives. For instance, the National Physical and Oceanographic Laboratory successfully deployed the moored autonomous underwater sonar system in 2025.²³ However, this feat is organisationally isolated from the Matsya 6000 programme. This is unlike France's integrated approach under a unified ministerial ship which ensures coordinated institutional development. Lack of unified endeavours in the Indian context undermines the development of a coherent seabed strategic capability.

Dependency of Digital Economy on Underwater Assets

India's digital economy was valued at more than US\$ 190.7 billion in services exports in 2023–24 and was expected to reach US\$ 618 billion by 2030.²⁴ However, it remains significantly reliant on underwater cable infrastructure, owned, controlled and maintained primarily by foreign corporations. As per an ORF report endorsed by Rear Admiral Monty Khanna (Retd), 'India consumes 20 percent of global internet traffic; yet, it hosts only 17 trans-oceanic cables i.e. 3 percent of global subsea cables terminating at 14 distinct landing stations across five cities'.²⁵ The Chinese owned HMN Technologies in comparison maintains and repairs 25 per cent of the world's sub-sea infrastructure. Further, corporations in the United States, Japan and Finland control 90 per cent of the global sub-sea cable production industry.²⁶ This external dependency creates vulnerability to cyberattacks, espionage and purposeful sabotage during international crises. Moreover, 95 per cent of cable landing points in India are amassed within

a 6-km coastal sector near Mumbai which makes it vulnerable to targeted assaults or natural calamities.²⁷

TECHNOLOGY GAPS IN REPAIR CAPABILITY OF SUBMARINE CABLES

India currently lacks a specialised fleet of undersea cable repair vessels, relying on international consortia for laying and maintenance activities. The lack of indigenous cable-repair assets exposes crucial digital and financial infrastructure to extended outages in the event of a cable break or damage. For instance, disruption of three undersea cables connecting India to global telecom networks, i.e., Asia–Africa–Europe-1, Europe India Gateway and Tata Global Network forced the telecom operators like Bharti Airtel Ltd, Reliance Jio Infocomm Ltd and Tata Communications Ltd to reroute traffic to other cable systems.²⁸ Further, repair for the same was time-consuming and expensive as seen in the case of restoration of Asia–Africa–Europe-1 cable in the Red Sea which took four months to restore.²⁹ These prevailing vulnerabilities to sub-sea cables underscore the need for a swift repair capability.

EMERGING THREATS TO CUI

Recent global accidents have shown that undersea infrastructure is vulnerable to both accidental damage and intentional sabotage. On 26 September 2022, powerful underwater explosions and the subsequent release of natural gas were reported in the Nord Stream Pipelines laid out in Denmark and Sweden's EEZ.³⁰ Following the incident, Russia had asked for an independent international investigation at the United Nations Security Council (UNSC), however, it was rejected, citing that independent investigations were underway by Danish, German and Swedish authorities.³¹ These investigations could not conclusively identify the perpetrators, however, they could establish the fact that it was an act of deliberate sabotage.³² Later, an investigative piece published in *The Wire* by French investigative journalist Freddie Ponton, hinted at use of C4 explosives and detonation by NATO. Ponton pointed to strong proof of underwater demolition and seabed mine warfare.³³ The Nord Stream pipeline catastrophe and the claims that came with it, are a persistent concern. They changed people's thinking about the ocean floor in terms of resource extraction or scientific curiosity. The ocean floor is now a place where countries compete strategically, just like outer space and cyberspace. This incident has resulted in increased efforts by

nations to build their seabed warfare capabilities to protect their economic and national interests.

GEOPOLITICAL COMPETITION IN THE INDO-PACIFIC

The Indo-Pacific region has been experiencing heightened submarine operations and threats to underwater infrastructure. One particular illustrative incident occurred in 2023, when Taiwan accused China of damaging the sub-sea cables giving internet access to Matsu Islands. This had resulted in digital isolation of 14,000 residents for six weeks.³⁴ Similarly, in the context of India, there are growing concerns about Chinese maritime activities. China has been undertaking seabed mapping, current profiling and unmanned underwater vehicle deployment masked as oceanographic and climatic investigations. The presence of Chinese research vessels in the Indian Ocean Region (IOR) often coincides with Indian naval drills and missile tests. As per media reports of July 2025, a Chinese research vessel was involved in seabed mapping and acoustic analysis in the Bay of Bengal adjacent to Indian waters. The vessel was attempting to obscure its whereabouts by deactivating its Automatic Identification System (AIS).³⁵ Audaciously, China is not shying away from disclosing its deep-sea cable cutting technology which can paralyse high-speed connectivity and affect the modern financial system adversely.³⁶ China is seeking to assert its deterrence capabilities by projecting power and maritime outreach without actual conflict.

FUTURE OUTLOOK: POLICY RECOMMENDATIONS FOR INDIA'S SEABED SECURITY STRATEGY

The rising threats, lack of specialised units for undersea cable protection and inadequate undersea cable repair capability underscores significant deficiencies in India's strategic readiness. Though India has emphasised economic and scientific imperatives in the seabed domain, the strategic implications are not as overtly acknowledged as by France. However, opportunities exist for India to develop a strategic capability based on existing technological foundations and institutional capabilities. It will be prudent for India to draw relevant lessons from France's 'Seabed Warfare Strategy' to embrace a strategic outlook. Recommendations in the subsequent paragraphs are aimed at mitigating prevailing vulnerabilities in digital sovereignty, institutional coordination and underwater domain awareness due to lack of a seabed security roadmap.

Establishment of Unified Seabed Security Institutional Architecture

The Government of India can consider establishment of a Seabed Security Strategy Cell under a National Maritime Security Coordinator. Members from the DRDO, Ministry of Defence, Indian Navy, Ministry of Earth Science and the Department of Telecommunications could be the proposed stakeholders in this Cell. This unified mechanism will obviate current institutional fragmentation and limited strategic coordination amongst individual stakeholders. The Cell should focus on integrating the NPOL's sensor capabilities with NIOT's deep-sea exploration systems, leveraging INICOIS' ocean observation networks with the Indian Navy's surveillance requirements in the Indo-Pacific and the application of DOM's technological advancements, to augment strategic capability. This integrated approach will result in optimal utilisation of resources to improve underwater domain awareness and threat detection capabilities.

Adoption of a Formal Seabed Security Strategy

The Seabed Security Strategy Cell can be tasked with the formulation of India's seabed security strategy, based on France's 'Know, Monitor and Act' framework, adapted to India's strategic outlook and technological development. The formulation of the strategy can be based on varied terms of references, viz. integration of existing civilian deep-sea capabilities with the emerging strategic implications of the seabed domain, protection of subsea cables and development of human capital. The proposed strategy will emulate 'Know and Monitor' functions by integrating NPOL's sonar and sensor capabilities with NIOT's seabed mapping capabilities and INICOIS' ocean observation networks. Leveraging NSTL's underwater weapons capabilities will enable the 'Act' Function. Adoption of a formalised strategy will provide clarity of intent, streamline allocation of resources and signal India's commitment to the seabed domain to adversaries and allies. This strategy could include a defensive posture to protect CUI as well as offensive measures to counter any threat.

Addressing Vulnerabilities of Digital Infrastructure

In the short term, India's reliance on foreign-flagged vessels for repairs of subsea cables can only be mitigated through the immediate procurement of Indian-flagged cable repair vessels. As a long-term measure, India should aim at building sovereign repair capabilities, which can include vessel operations at depths more than 6,000 metres, contemporary cable repair techniques and trained manpower. Further, to address the single point failure risk of amassed

sub-sea cables at Mumbai, the Seabed Security Strategy Cell can explore alternate cable landing stations to diversify the submarine communication cables geographically. Lakshadweep Islands will provide redundancy for west coast infrastructure. Similarly, Andaman and Nicobar Islands is a suitable alternative to Chennai as it provides the strategic advantage to monitor ISLs and cable routes in the Bay of Bengal and the Andaman Sea. Private players like Larsen & Toubro, Bharti Airtel and Reliance can be engaged for cable infrastructure development. Members from the Department of Telecommunications shall have dedicated authority within the Seabed Security Strategy Cell to oversee protection, threat assessment, coordination of repairs, diversification of sub-sea cables and coordination between the Indian Navy and telecom operators.

ROADMAP FOR TECHNOLOGICAL DEVELOPMENT

Initial testing of Matsya 6000 has laid the groundwork for military adaption akin to 'Ulyx' to A6K-M model. However, its existing underwater surveillance capabilities are insufficient for high-resolution seabed mapping and continuous monitoring, which are prerequisites for effective seabed warfare. This gap can be addressed by leveraging the initiatives of the DRDO-led National Quantum Mission. The Seabed Security Strategy Cell can task the Quantum Technology Research Centre at New Delhi, to explore the application of indigenous quantum sensing capabilities for Matsya 6000.

PUBLIC-PRIVATE COLLABORATION

Indian industries have fragmented deep-sea and underwater capabilities scattered across public sector undertakings (PSUs) and private firms. While Keltron builds indigenised capabilities in underwater sensing and communications technology,³⁷ Bharat Forge has strategic equity in the Italian firm Edgelab, to acquire AUV technology.³⁸ Indian private firms such as EyeROV offer remotely operated vehicles (ROVs) with an operational depth of about 300 metres for use in oil and gas, maritime research and defence.³⁹ Still, the overall ecosystem for deep-sea robotics has not yet reached the level of industrial depth achieved by France. It can be accomplished through collaboration between the DRDO, PSUs and private firms, to create end-to-end Intelligence, Surveillance and Reconnaissance (ISR) capabilities. Members from the DRDO can be the coordinating authority for industrial

collaboration, focusing on developing indigenous capabilities in AUV propulsion systems, sensor integration and data processing.

FORMULATION OF LEGAL FRAMEWORK

India's strategic location along the IOR offers significant potential to harness rare earth minerals and polymetallic nodules. However, this potential is tempered by significant regulatory gaps to monitor seabed mining activities.⁴⁰ Therefore, the Seabed Security Strategy Cell will have to develop a comprehensive legislation and regulatory framework for all activities in the seabed domain. This framework must include establishment of protection zones for CUI, an authorisation mechanism for seabed activities in the EEZ, an overseeing mechanism for AUV operations and coordination protocols between civil and military organisations for seabed security issues. The legal framework should establish a well-defined hierarchy, standard operating procedures and accountability suited for peacetime and wartime scenarios.

COUNTERING CHINESE POSTURE IN THE IOR

India needs to be more assertive in the IOR to counter existing Chinese threats. The Seabed Security Strategy Cell may consider the establishment of a seabed surveillance network to monitor critical chokepoints. The surveillance network can comprise AUVs for reconnaissance missions and arrays of sensors in the seabed for persistent area monitoring. If the network is designed as redundant and resilient so that it can function even during disruption or targeted damage, it will augment real-time response mechanisms based on the threat assessment. INICOIS' existing ocean observation capabilities, coupled with DRDO's or Keltron's military-grade sensors can be the backbone of this surveillance network.

INTERNATIONAL COLLABORATION

India should seek international collaborative operational missions, which can encompass seabed mapping, infrastructure monitoring and tactical response simulations. This will foster a collective deterrence mechanism while sharing technology transfer and best practices, as seen in *Polaris-25* and *Mare Aperto*. The existing framework of the Quadrilateral Security Dialogue (QUAD) and bilateral naval exercises offers suitable platforms for such collaboration. It will

enhance India's learning curve and strengthen its position in the Indo-Pacific. Interoperability will also aid in building human resource capital which will meet the requirement of a specialised workforce capable of operating complex deep-sea robotics.

CONCLUSION

The sabotage of Nord Stream Pipelines has established the fact that future wars will extend to and from the seabed and protecting the seabed will be essential for national security and strategic autonomy. India should acknowledge this truth and change its thought process about the seabed domain from *exploration* to *strategic posture*. Adoption of a seabed security strategy is poised to bolster India's economic ambitions and security framework. The establishment of the Seabed Security Strategy Cell will integrate diverse expertise scattered across multiple institutions, promoting a whole-of-government approach. A seabed security strategy can establish technological and operational superiority to counter China's posture in the Indian Ocean Region.

NOTES

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