

ADVANCING UNDERWATER DOMAIN AWARENESS (UDA) FRAMEWORK FOR INDIA'S **MAHASAGAR VISION** AND ITS REALISATION

A Two-Day National Conference

17–18 August 2026 | Pune

CONFERENCE REPORT



Organised by :

Maritime Research Center (MRC), Pune

in collaboration with

Indian Council of World Affairs (ICWA), New Delhi

Technology Partner :



MARITIME RESEARCH CENTER (MRC), PUNE

in collaboration with

INDIAN COUNCIL OF WORLD AFFAIRS (ICWA), NEW DELHI

CONFERENCE REPORT

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Underwater Domain Awareness (UDA)
Framework for India's MAHASAGAR Vision
and its Realisation**

A National Conference

August 17–18, 2026
Pune, India

Foreword

The MRC–ICWA National Seminar on Advancing the Underwater Domain Awareness Framework for India’s MAHASAGAR Vision and its Realization, held in Pune on 17–18 August 2026, was conceived with a clear purpose: to move the Underwater Domain Awareness (UDA) framework from a specialised technical discussion to the centre of India’s strategic, developmental and diplomatic agenda. India’s transition from SAGAR to MAHASAGAR—

Mutual and Holistic Advancement for Security and Growth Across Regions—articulates an expansive vision of maritime cooperation with the Indian Ocean Region (IOR) and the wider Global South. Realising this vision, however, requires an informed, decision-ready understanding not only of the ocean’s surface but also of the complex, largely unseen domain beneath it.

The seminar was therefore designed as a structured platform for disciplines and institutions that do not always engage with one another. Across eight thematic sessions, the deliberations moved from the strategic foundations and global relevance of the UDA framework to modelling and simulation-based Marine Spatial Planning (MSP); capacity-building and skilling; sediment management and navigational safety; blue accounting; biofouling and anthropogenic noise; and sustainable fisheries, aquaculture and marine bioresources. These subjects were examined through the four mutually reinforcing pillars of the UDA framework: maritime security, the Blue Economy, marine environment and disaster management, and science and technology. This architecture demonstrated that the UDA framework is not a collection of isolated sectoral applications but an integrated capability through which the same knowledge, infrastructure, and analytical tools can serve security, economic, ecological, and social objectives.

The importance of the UDA framework lies precisely in its integrative potential. The underwater domain is simultaneously a strategic space, an economic resource, an ecological system and a repository of critical infrastructure. It must therefore be understood through physical, chemical, biological, and economic indicators, rather than through any single technological or institutional lens. For India, this capability must also be “tropical by design”. Technologies and models developed for temperate waters cannot simply be transferred to the warm, sediment-rich, biologically active, and monsoon-influenced conditions of the Indian Ocean. Indigenous datasets, validated models, interoperable systems and sustained research capacity are consequently essential to technological self-reliance and credible maritime leadership.

The policy recommendations emerging from the seminar provide a clear direction of travel. First, India should establish an Indian Ocean-focused UDA capability grounded in tropical datasets, models and field validation. Second, UDA should be developed as shared, multi-use national infrastructure, supported by effective institutional coordination and an appropriate open, controlled and classified data architecture.



Dr. (Cdr) Arnab Das

*Founder & Director,
Maritime Research Center*



Third, indigenous and affordable capabilities should be extended through MAHASAGAR, a capacity-building and technology-sharing initiative for the Indian Ocean littorals, Small Island Developing States and the Global South. Fourth, procurement should shift from acquiring individual platforms to securing outcomes, with modelling and simulation-based MSP at its core. Fifth, validated traditional and community knowledge should become an additional data layer within modern scientific and AI-enabled systems. These shifts are complemented by two practical proof points—one focused on critical subsea infrastructure and another on the sustainable Blue Economy—and by a Blue Accounting framework that demonstrates the economic, environmental and social value generated by the UDA framework.

An important achievement of the seminar was the breadth of the constituency it brought into this conversation. Defence leaders and strategic practitioners engaged with diplomats, public policy experts, economists, marine scientists, engineers, technologists, industry representatives, research fellows, and young scholars. The discussions addressed the needs of national ministries and maritime-security agencies, ports and waterway authorities, technology companies and start-ups, universities and research institutions, regional partners, and coastal and fishing communities. By connecting senior experience with emerging scholarship and technical research with policy judgement, the seminar helped build a common vocabulary across communities that often approach the ocean from very different starting points.

The broader significance of this exercise lies in its comprehensiveness and inclusiveness. It considered the UDA framework at multiple levels—from national strategy and regional cooperation to institutional governance, operational applications, local livelihoods, and individual career pathways. It brought security imperatives into conversation with the greater public good; placed modern science alongside Traditional Ecological Knowledge; and linked indigenous capability-building with the sharing of appropriate technologies across the Global South. In this context, inclusiveness concerns not only who participates, but also whose knowledge is recognised, who can use the resulting information, and who ultimately benefits from the capability created.

This report is both a record of the seminar and a foundation for continued action. It affirms that the UDA framework can enable India to move from reactive observation to predictive, evidence-based decision-making and to translate MAHASAGAR from a statement of intent into a practical framework for security, sustainability, growth, and cooperation.

The Maritime Research Center records its sincere appreciation for the Indian Council of World Affairs' support as co-convener and institutional sponsor of this national seminar. ICWA's partnership and engagement were instrumental in bringing foreign policy and strategic perspectives into dialogue with the scientific, technological, economic and societal dimensions of the UDA framework. We look forward to advancing this collaboration in service of India's maritime interests and its broader commitment to the IOR and the Global South.

DISTINGUISHED LEADERSHIP



**Amb. Anup Mudgal
(Retd.)**

*Former Diplomat | Blue
Economy Expert*



Adm. Karambir Singh
PVSM, AVSM, IN (Retd.)

Former Chief of the Naval Staff



Gen. Manoj Pande
PVSM, AVSM, VSM (Retd.)

Former Chief of Army Staff



Vice Admiral D. S. P. Varma
PVSM, AVSM, VSM (Retd.)

Former DG of the ATV Programme



**Vice Admiral Anil Jaggi
AVSM**

Commandant, NDA



**Lt. Gen. A. K. Ramesh,
SM**

*Commandant, CME,
Pune*



Dr. Ajit Ranade

*Economist & Former
Vice-Chancellor, GIPE*



Dr. Varsha Kelkar-Mane

*Professor & Deputy
Director, CEMAS*



**Mr. Vish
Sahasranamam**

*Co-Founder & CEO,
Forge*



Mr. Rakesh Kumar

General Manager, BEL



Shri Pravin Kumar Roy

*DDG (Tech), Maritime
Administration*



Mr. Hrishikesh Dhande

*Deputy Director, Pune
International Centre*



Mr. Araudra Singh

*Research Associate,
ICWA*



Dr. (Cdr) Arnab Das

*Founder & Director,
MRC*



MRC Research Team & Presenters



Mr. Callistine Lewis

*Head of Publications,
Maritime Research
Center (MRC)*



**Mr. Shridhar
Prabhuraman**

*Deputy Director,
Maritime Research
Center (MRC)*



Ms. Catherine J

*Head of Research,
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Mr. Romit Kaware

*Research Fellow,
Maritime Research
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Mr. Suchir Mamidala

*Research Fellow,
Maritime Research
Center (MRC)*



Mr. Ashwani Singh

*Research Fellow,
Maritime Research
Center (MRC)*

Conference Programme Schedule

Day 1: Strategic Foundations of UDA (August 17)

Session & Topic	Panelists / Key Speakers
Welcome Remarks	Dr. (Cdr) Arnab Das, <i>Founder & Director, MRC</i>
Keynote Address	Vice Admiral Anil Jaggi AVSM, <i>Commandant of the National Defence Academy</i>
Concluding Remarks	Mr. Araudra Singh, <i>Research Associate, ICWA</i>
Session 1: Evolution of UDA Framework & Global Relevance	Main Presenter: Dr. (Cdr) Arnab Das (<i>Founder & Director, MRC</i>); Session Chair: Admiral Karambir Singh PVSM, AVSM, IN (Retd.) - <i>Former Chief of Naval Staff</i>
Session 2: Building the Blue Sun - UDA and its Place in an Evolving World Order	Main Presenter: Mr. Callistine Lewis, <i>Head of Publications, MRC</i> Session Chair: Amb. Anup Mudgal (Retd.) - <i>Former Indian Diplomat & Member of the Blue Economy Task Force at FICCI, India</i>
Session 3: Modelling & Simulation based Maritime Spatial Planning (MSP)	Main Presenter: Mr. Shridhar Prabhuraman, <i>Deputy Director, MRC</i> Session Chair: Vish Sahasranamam, <i>Co-Founder & CEO, Forge Innovation & Ventures</i>
Keynote Speech: "Instrument & Institution: Defining, Developing, Acquiring and Operating UDA as a Military Capability"	Speaker: Vish Sahasranamam, <i>Co-Founder & CEO, Forge Innovation & Ventures</i>
Session 4: Career Opportunities, Skilling & Capacity Building in UDA	Main Presenter: Mr. Callistine Lewis; <i>Head of Publications, MRC</i> Session Chair: Mr. Hrishikesh Dhande, <i>Deputy Director, Pune International Center</i>



DIGITAL VERSIONS



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Conference Programme Schedule

Day 2: Blue Economy, Ecology & Sustainability (August 18)

Session & Topic	Panelists / Key Speakers
<i>Opening Remarks</i>	Gen. Manoj Pande PVSM AVSM VSM (Retd) - <i>Former Chief of Army Staff of the Indian Army</i>
Session 5: Sediment Management & Navigational Safety	Main Presenter: Mr. Romit Kaware, <i>Research Fellow, MRC</i> Session Chair: Lieutenant General AK Ramesh SM, <i>Commandant of the College of Military Engineering, Pune</i>
Session 6: Blue Accounting & Marine Environmental Economics	Main Presenter: Ms. Catherine J, <i>Head of Research, MRC</i> Session Chair: Dr. Ajit Ranade, <i>Economist and Former Vice-Chancellor of Gokhale Institute of Politics and Economics, Pune</i>
Keynote Address: "IMO GloNoise and Maritime Decarbonization Initiative"	<i>Shri Pravin Kumar Roy, Deputy Director General of Maritime Administration DDG (Tech)</i>
Session 7: Biofouling, Anthropogenic Noise & Ecological Resilience	Main Presenter: Mr. Suchir Mamidala, <i>Research Fellow, MRC</i> Session Chair: Dr. Varsha Kelkar-Mane, <i>Professor & Head, Department of Biotechnology; Deputy Director, Centre for Excellence in Marine Studies (CEMAS), University of Mumbai.</i>
Session 8: Sustainable Fisheries, Aquaculture & Marine Bioresources	Main Presenter: Mr. Ashwani Singh, <i>Research Fellow, MRC</i> Session Chair: Mr. Rakesh Kumar, <i>General Manager, Bharat Electronics Limited</i>
<i>Closing Report</i>	Mr. Araudra Singh, <i>Research Associate, ICWA</i>
<i>Concluding Remarks</i>	Vice Admiral D. S. P. Varma PVSM AVSM VSM (Retd.) <i>Former Director General of the Advanced Technology Vessel (ATV) Programme</i>



Fig 9.1 Vice Admiral Anil Jaggi AVSM, Commandant NDA addressing the gathering

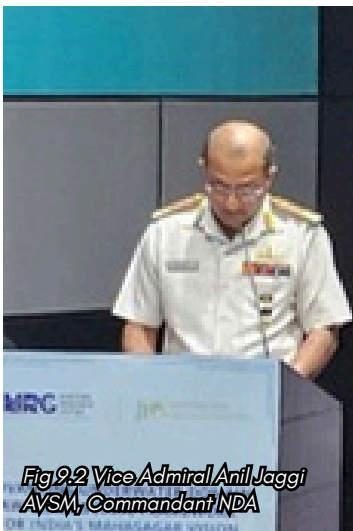


Fig 9.2 Vice Admiral Anil Jaggi AVSM, Commandant NDA



Fig 9.3 Mr. Araudra Singh, Research Associate, ICWA delivering remarks at the opening session touching upon streamlining certification pathways for Deep Tech



Events in Perspective – Speakers and Sessions

I. Keynote Address: Underwater Domain Awareness as a Strategic National Imperative

Speaker: Vice Admiral Anil Jaggi AVSM, Commandant, National Defence Academy (NDA)

1. The Oceanic Reality: High Value, Hidden Vulnerabilities

The keynote opened by establishing the absolute primacy of the ocean in modern geopolitics and economic security:

- **The Global Footprint:** Approximately 75% of the world's population lives in littoral zones, over 80% of global trade by volume travels across sea lanes, and subsea fibre-optic cables carry an astounding 99% of international digital data traffic.
- **The Knowledge Gap:** Despite its critical importance, over 80% of the world's oceans remain unmapped, unexplored, and unmonitored, creating a massive observational vacuum that adversaries can exploit.

2. Evolving Subsea Threats & Grey-Zone Warfare

The address highlighted the growing complexity of underwater threats across the Indian Ocean Region (IOR):

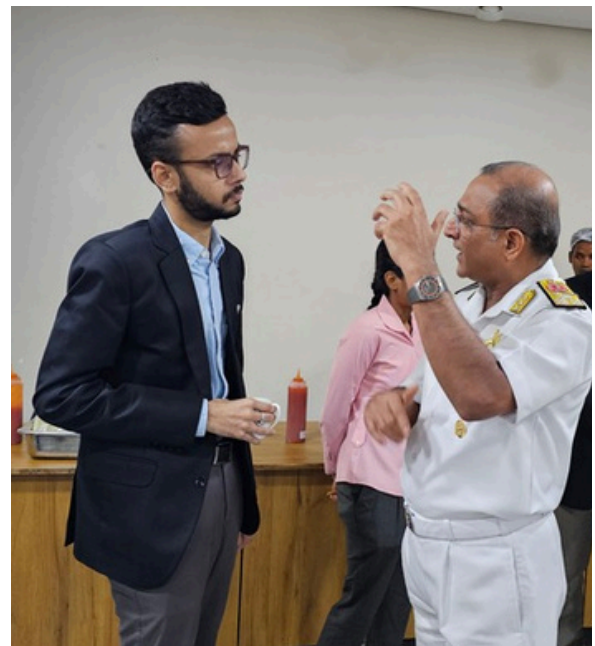
- **Extra-Regional Presence:** Increased activity by extra-regional forces, particularly Chinese oceanographic survey vessels operating under the guise of dual-use scientific research, as well as the deployment of Autonomous Underwater Vehicles (AUVs), deep-sea gliders, and SSBN/SSN submarine patrols.
- **Grey-Zone Sabotage:** Modern conflict is increasingly shifting toward underwater infrastructure, where attribution is difficult. Recent incidents—such as the sabotage of subsea communications cables and energy pipelines in the Baltic Sea amid the Russia-Ukraine conflict—demonstrate the urgent need to monitor and secure Subsea Critical Infrastructure and Sea Lines of Communication (SLOCs).

The UDA Imperative: Developing multi-layered Underwater Domain Awareness (UDA) is no longer optional; it is essential for detecting, tracking, and countering subsurface threats before they disrupt national security or critical commerce.



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3. Deep-Sea Geopolitics & Resource Security

Beyond military defence, the ocean bed has become the premier frontier for economic and scientific dominance:

- **The Deep-Sea Race:** Highlighted foreign breakthroughs, such as China's manned submersible Fendouzhe exploring extreme-depth environments like the Mariana Trench. Discoveries of extremophile life forms offer massive breakthroughs in biotechnology and medical research, while seabed geological mapping secures future resource claims.
- **Critical Minerals & Rare Earth Elements:** The transition to green energy and strategic technology depends heavily on seabed resources, particularly Polymetallic Nodules (PMNs) rich in cobalt, nickel, copper, and manganese.
- **India's Strategic Advantage:** India was the first pioneer nation to receive exploration contracts from the International Seabed Authority (ISA) in the Central Indian Ocean Basin, making deep-sea resource extraction, sustainable fisheries, coastal disaster management, and offshore energy a central national imperative.

4. The Way Ahead: Building Integrated National Capability

To safeguard maritime interests and transition from regional cooperation under the **SAGAR (Security and Growth for All in the Region)** vision toward the expanded **MAHASAGAR framework**, Vice Admiral Jaggi outlined a clear strategic roadmap:

J-A-I Framework:

- **Jointness:** Seamless operational integration across the Army, Navy, Air Force, and civilian oceanographic agencies.
- **Atmanirbharta:** Achieving true self-reliance in designing and manufacturing indigenous hydro-acoustic sensors, AUVs, and defence software.
- **Innovation:** Actively partnering with private industry, startups, and academic institutions to accelerate technology adoption.

Citing pioneering strategist Sardar K.M. Panikkar, the Vice Admiral reminded the audience that maritime vision must never be merely coastal; it must be genuinely oceanic. Looking beneath the ocean surface is the core obligation of modern statecraft, echoing the ancient dictum: "*Jalamev Yasya, Balamev Tasya*" — *He who rules the sea commands all.*



Fig 16: Admiral Karambir Singh PVSM, AVSM, IN (Retd.)





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Session 1: Evolution of the UDA Framework & Global Relevance

Main Presenter: Dr. (Cdr) Arnab Das (Founder & Director, MRC);

Session Chair: Admiral Karambir Singh PVSM, AVSM, IN (Retd.) - Former Chief of Naval Staff

1. Context & The "Cylinder of Awareness"

The session established that tropical littoral waters, high population density, and immense undersea mineral resources predominantly shape the Indo-Pacific's strategic space. However, conventional Maritime Domain Awareness (MDA) has historically remained surface-centric, creating a critical blind spot. *Admiral Karambir Singh* conceptualised the necessary shift as building a **"cylinder of awareness"**: a volumetric governance model that integrates space, air, surface, and the underwater domain to correlate disparate activities, such as tracking "dark fleets" or illegal Chinese trawlers.

This volumetric approach is essential to address the opacity and complexity of the underwater domain, which is increasingly populated by asymmetric threats, including over 50 submarines in the Indian Ocean Region (IOR), autonomous underwater warfare systems, and untraceable seabed mines. Furthermore, critical infrastructure—such as the subsea fibre-optic cables that carry 99% of global data and energy pipelines—remains highly vulnerable.

2. The Tropical Acoustic Challenge & Legacy Tech Failures

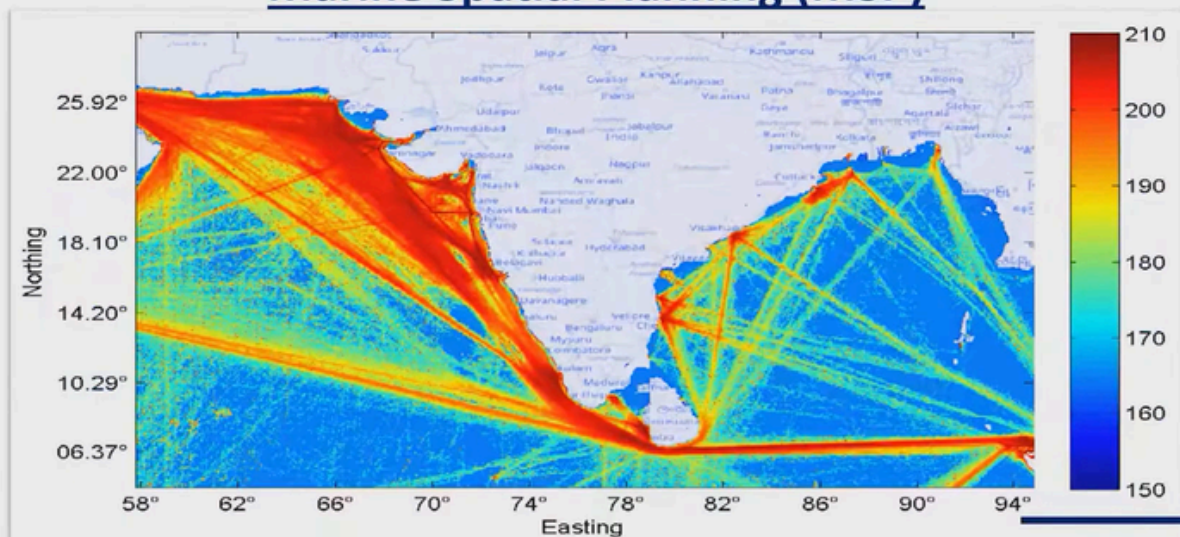
A central theme of the session was the fundamental incompatibility of imported "cold water" acoustic technology in the tropical waters of the Global South. The physics of tropical sound propagation—characterised by warm temperatures and high ambient biological noise—can degrade sonar performance by up to 60% when legacy systems designed for temperate zones are used.

- **Biological Interference:** The acoustic reality of the Indian Ocean is incredibly complex; for instance, a bed of snapping shrimp can generate noise levels up to 200 decibels, masking the presence of strategic submarines and complicating habitat mapping.
- **Operational Consequences:** The reliance on imported, temperate-optimised hardware has led to severe operational consequences, exemplified by historical sonar blackouts during strategic submarine deployments (e.g., INS Chakra) and the USS Connecticut collision in the South China Sea.
- **Sedimentation:** Navigability and acoustic profiling are further complicated by heavy sediment transport in tropical rivers like the Brahmaputra, rendering reactive dredging suboptimal and ecologically damaging.





Modelling & Simulation (M&S) based Marine Spatial Planning (MSP)



3. Navigating Strategic Security and the Greater Public Good

Dr Das highlighted the historical divergence between military-driven technology and broader societal needs. Event-driven pivots such as 9/11 and 26/11 have historically triggered security-centric responses that ignored the underwater component. The Cold War era spurred massive investments in systems such as SOSUS and SURTASS, but today's multi-polar world—particularly for Small Island Developing States (SIDS)—requires a balanced approach. The session discussed multilateral forums arguing that the Global South needs UDA for the "greater public good," such as managing biofouling, blue accounting, and mitigating the environmental costs of aquaculture. The unchecked expansion of international shipping and poor noise management have already caused severe ecological damage, including marine mammal strandings off northern Sri Lanka.

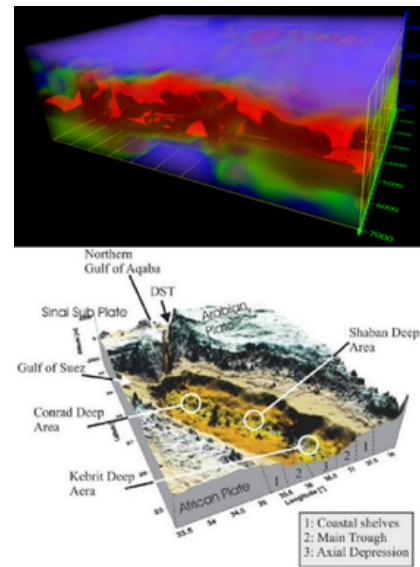
4. Data Democratisation & Solutions Architecture

To move forward, the UDA framework must transition from accumulating capital-intensive "products" (hardware) to delivering customised "solutions" (data and services).

- **Bridging the Classification Gap:** A significant barrier to UDA is the friction between military classification and academic access. The panel proposed utilising open-source data to build baseline modelling prototypes, which can subsequently be populated with classified data by national security agencies.
- **Integrating Traditional Ecological Knowledge (TEK):** Modern science must be scaled up carefully to incorporate the highly localised, site-specific knowledge of coastal communities without causing unsustainable outcomes.
- **Digital Transformation:** The deployment of AI tools (such as the SARVAM initiative) and advanced data analytics is crucial for automating decision-making and standardising multi-agency collaboration across the four pillars of the UDA cube: Security, Blue Economy, Environment, and Science & Technology.



Fig 20: Amb. Anup Mudgal (Retd.).



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Session 2: Building the Blue Sun UDA and its Place in an Evolving World Order

Main Presenter: *Mr. Callistine Lewis, Head of Publications, Research Fellow, MRC*

Session Chair: *Amb. Anup Mudgal (Retd.), Former Indian Diplomat & Member of the Blue Economy Task Force at FICCI, India*

1. Historical Context & De-colonial Ocean Governance

The session opened by reframing the ocean not merely as a geographic boundary, but as the historical engine of civilizational progress. Ancient maritime networks, such as the Bali Yatra of Kalinga, relied on the monsoon as "the engine before the engine" for precise, day-specific navigational planning across the Indian Ocean. However, colonial powers subsequently imposed a structural "sea-blindness" on India, reducing water bodies to mere territories claimed via naval force.

Moving forward, India's maritime posture must transition from a traditional security model to the MAHASAGAR vision. Ambassador Mudgal emphasised that the ultimate security guarantee in the Global South is not the accumulation of naval hardware, but the goodwill of potential opponents. This goodwill is strengthened through shared economic growth, sustainability, and the Development Partnership Administration, showing that collaboration builds regional peace and stability.

2. Re-conceptualising Security: Beyond Westphalian Terrestrialism

The presentation challenged the "Westphalian terrestrialism" that dominates modern statecraft. Standard 2D land maps effectively read only the "floor and ceiling of a room," leaving the vast, three-dimensional volumetric water column invisible. This terraqueous blindness leaves critical sub-surface infrastructure—such as the subsea fibre-optic cables that carry over 95% of global internet traffic and international finance—highly vulnerable to grey-zone tactics and UNCLOS legal ambiguities.

The panel underscored the necessity of bridging "hard security" (combating piracy and trafficking) with "soft security". Environmental degradation must be treated as a hard security threat. The ocean is the planet's primary life-support system, providing 50% of global oxygen (roughly 11 out of every 22 breaths we take) and absorbing 33% of anthropogenic CO₂.

3. Demography, Youth Capital, & The Blue Economy

The geopolitical centre of gravity is decisively shifting toward the Indian Ocean Region (IOR), which is projected to host 40% of the global population by 2050. With 4.15 billion people already living within 100 miles of a coast, and regions like India, Africa, and Southeast Asia possessing the world's largest youth workforces, there is a massive demographic advantage waiting to be harnessed.





To absorb this youth capital, the Global South must transition marginalised coastal communities toward high-value, tech-driven "green and blue" sectors (e.g., offshore renewable energy, marine conservation). Implementing standardised, transparent sub-surface data architectures and Marine Spatial Planning (MSP) is essential to attract sustainable blue capital and resolve spatial conflicts between deep-sea mining, shipping lanes, and traditional fisheries.

4. The Ocean MRI, Digital Twins & Data Governance

A critical technical intervention in the session was the concept of deploying UDA as a "diagnostic MRI scanner" for the planet. Passive acoustic monitoring (PAM) networks can track sub-surface temperature shifts, ocean acidification, and ecological changes in real time. The fundamental language of the ocean is physics, sound, and temperature; translating this requires the "virtual twinning" of ocean spaces. Unlike static industrial digital twins (e.g., modelling a nuclear power station's fixed components), an ocean digital twin must continuously adapt, recognising that dynamic underwater chemistry directly dictates atmospheric weather and cloud formations above water.

5. Deep Ocean Exploitation & Infrastructure Impacts (Q&A Interventions)

The Q&A segment tackled the immediate challenges of seabed governance, exploration, and the ecological footprint of technology:

- **The Mapping Deficit & Deep Ocean Mission (DOM):** It was highlighted that the Indian Ocean remains severely under-mapped (only 17% of it is mapped). Concerns were raised regarding the classification of seamounts, which often relies on destructive sampling methods rather than deploying non-invasive ROVs (Remotely Operated Vehicles) and video footage to study the rich biodiversity surrounding polymetallic nodules.
- **Subsea Infrastructure Impacts:** Addressing the biodiversity impacts of subsea cables and underwater data centres, the panel stressed the urgent need for localised Environmental Impact Assessments (EIAs). As the BBNJ (Biodiversity Beyond National Jurisdiction) treaty framework evolves, developing indigenous scientific capacity to map and monitor these changes is paramount to ensure blue economic development does not destroy vital marine ecosystems.

The session ultimately pointed towards UDA Framework as a "*Blue Sun*": illuminating the dark depths, becoming a source of energy and allowing us to see into spaces Humanity has not foraged in before. The vast expanse of underwater seabeds will be the consequential frontier where 21st century world power will be decided. For India to assert its credentials as a voice of the Global South; building the architecture to safeguard subsea resources and areas from adversarial global hegemony, while building cooperation with other littoral states, is paramount to fully unlock the potential that the Blue Economy offers.



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Marine Spatial Planning, Simulated.

A modelling & simulation-driven decision platform for India's Exclusive Economic Zone — turning fragmented ocean data into forecasting foresight for sustainable governance of the Indian Ocean Region.

KNOWLEDGE PARTNER
Maritime Research Centre, Pune

TECHNOLOGY PARTNER
NirDhwani Technology Pvt Ltd

- 6 simulation-driven initiatives spanning the acoustic, physical & living ocean
- 2M+ km² of Indian EEZ — the modelling domain, validated by targeted sensing
- 4 modules already live on the NirDhwani MSP platform today

1 Underwater Noise Mapping Wind, rain & shipping acoustics into a cumulative stress map. +3.3 dB /decade rise	2 Coastal & Riverine Flood Risk Compound surge + riverine flooding under sea-level rise. \$14B Amphan, costliest ever	3 Coral Bleaching Forecasting Thermal + multi-stressor risk and refugia mapping. 84% of reefs bleached, 2023-25
4 Oil Spill Drift Simulation Monsoon-aware trajectories & cross-layer impact alerts. ~25% seaborne oil via Hormuz	5 Blue Carbon Health Mangrove & seagrass carbon stock and protection value. 67 Tg C India blue-carbon stock	6 Biodiversity & Habitat Species distribution + acoustic habitat suitability. 0.905 whale model AUC

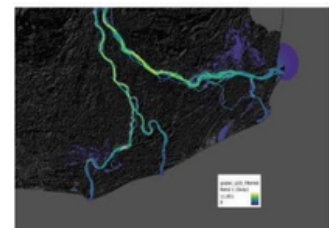


Figure 1. Godavari basin — simulated maximum inundation extent, Q10 design flood.

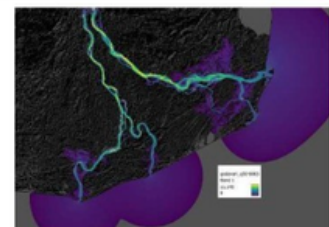


Figure 2. Godavari basin — simulated maximum inundation extent, Q50 design flood.



Figure 3. Godavari basin — simulated maximum inundation extent, Q100 design flood.





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Session 3: Modelling & Simulation for Maritime Spatial Planning (MSP)

Main Presenter: Mr. Shridhar Prabhuraman, Deputy Director, MRC

Session Chair: Mr. Aditya Kumar Sinha, Executive Director, CDAC Mumbai

1. The Limitations of Traditional MSP

- **The Static Trap:** Traditional Marine Spatial Planning (MSP) plots where assets and ecosystems are today, but fails to forecast where they will be tomorrow. It treats a dynamic ocean as a static map, leading to uncoordinated plans built on fragmented data silos across various government agencies.
- **Reactive Consequences:** Without predictive "what-if" modelling, risks are only discovered after development begins. For example, un-modelled sea walls in Tamil Nadu shifted coastal erosion downstream (contributing to 42.7% of the state's coastline actively eroding). At the same time, the \$900M Vizhinjam port in Kerala faced years of delays due to unaccounted community and shoreline impacts.

2. The Simulation-Driven Paradigm Shift

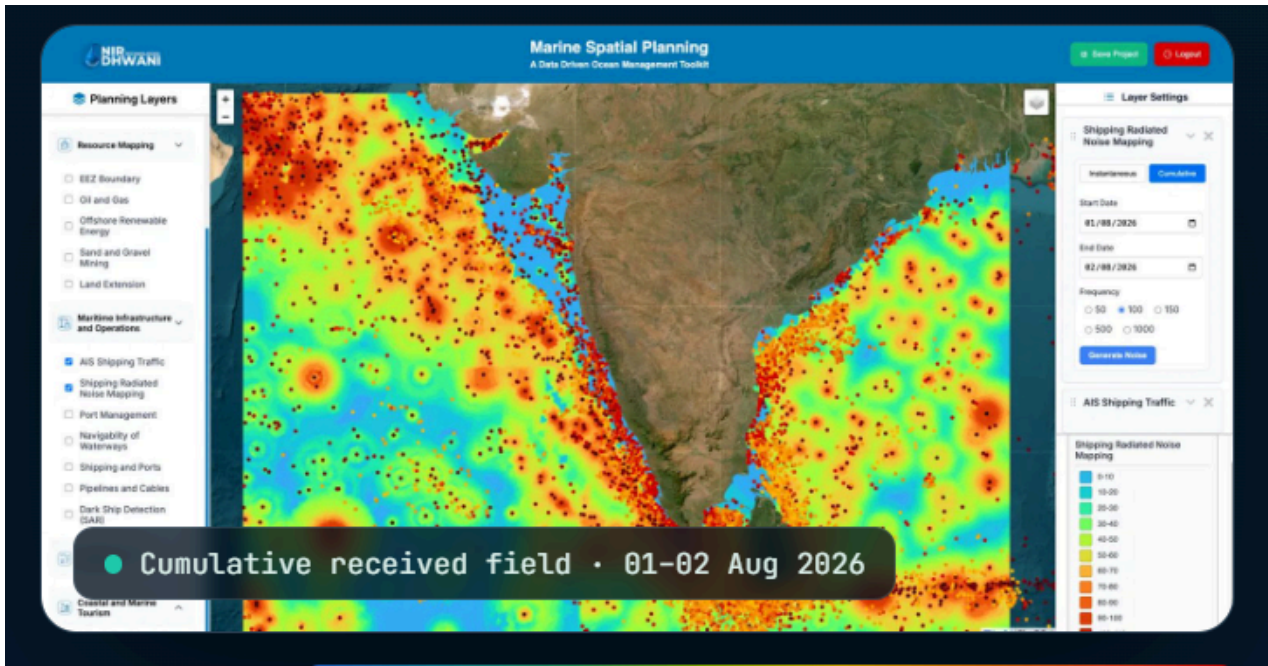
- **Dynamism & Impact Modelling:** The MSP platform shifts the paradigm from descriptive mapping to predictive decision-support. It continuously ingests real-time environmental data to run computational scenarios, revealing the downstream costs of an action (e.g., dredging or opening new shipping lanes) before resources are committed.
- **Continuous Feedback Loop:** The architecture processes historical data and community knowledge through simulation engines, which then generate impact analyses and a unified decision-support interface. This loop continuously re-feeds new data upstream to adapt the plan over time.
- **Strategic Imperative for India:** With a massive 2 million+ km² Exclusive Economic Zone (EEZ) and a goal of generating a \$1 trillion Blue Economy by 2030, India requires this unified framework to overcome extreme seasonal variability and overlapping governance mandates.

3. The Six Simulation Initiatives

The platform operates six interconnected simulation layers, with four foundational modules currently live across the Indian EEZ:

1: Underwater Noise Mapping (Live): Creates a cumulative acoustic stress map by combining wind, rain, and shipping noise. Tracking a +3.3 dB/decade rise in low-frequency ambient ocean noise, this tool allows the Navy to identify quiet windows for passive sonar operations while helping environmental agencies protect marine mammal habitats.





Ocean science & data

- **MoES** — Ministry of Earth Sciences; ocean observation & the Blue Economy Policy
- **INCOIS** — ocean state forecasting, storm-surge & PFZ advisories
- **NIOT** — ocean-technology & sensing platforms
- **NCCR** — shoreline change & coastal-vulnerability mapping



Environment & conservation

- **MoEFCC** — coastal-regulation zones, MPAs & biodiversity
- **State forest & environment depts** — mangrove & reef management
- **Coastal states & UTs** — shoreline management plans
- **Fisher communities** — local knowledge & catch reports as data inputs



Ports, shipping & trade

- **MoPSW** — Ports, Shipping & Waterways; Sagarmala & port siting
- **DG Shipping** — IMO compliance, URN & decarbonisation
- **Port authorities** — infrastructure-resilience planning



Defence & industry

- **Indian Navy** — maritime domain awareness & UDA
- **BEL** — sonar & sensing systems; passive-sonar programmes
- **MRC & NirDhwani** — knowledge & technology partners



2: Coastal & Riverine Flood Risk: Simulates compound flooding by running a 56-day design hydrograph to reach a steady-state inundation extent. Validated across four major basins (Mahanadi, Godavari, Krishna, Irrawaddy), it enables disaster authorities to pre-stage relief assets before peak monsoons.

3: Coral Bleaching Risk Forecasting: Goes beyond standard temperature tracking by weighting thermal stress alongside physical contexts like depth and cyclone exposure. This generates ranked risk scores and thermal refugia maps to prioritise conservation efforts for reefs most likely to survive warming.

4: Oil Spill Drift Simulation: Utilises a 3-D Lagrangian run to predict monsoon-aware spill trajectories. It provides rapid-response landfall forecasts for the Coast Guard while flagging intersections with sensitive ecology.

5: Blue Carbon Ecosystem Health: Maps the 67 Tg C stored in India's coastal habitats. By quantifying surge attenuation and carbon stock, it connects directly to flood risk models and provides critical data for carbon-credit markets and infrastructure screening.

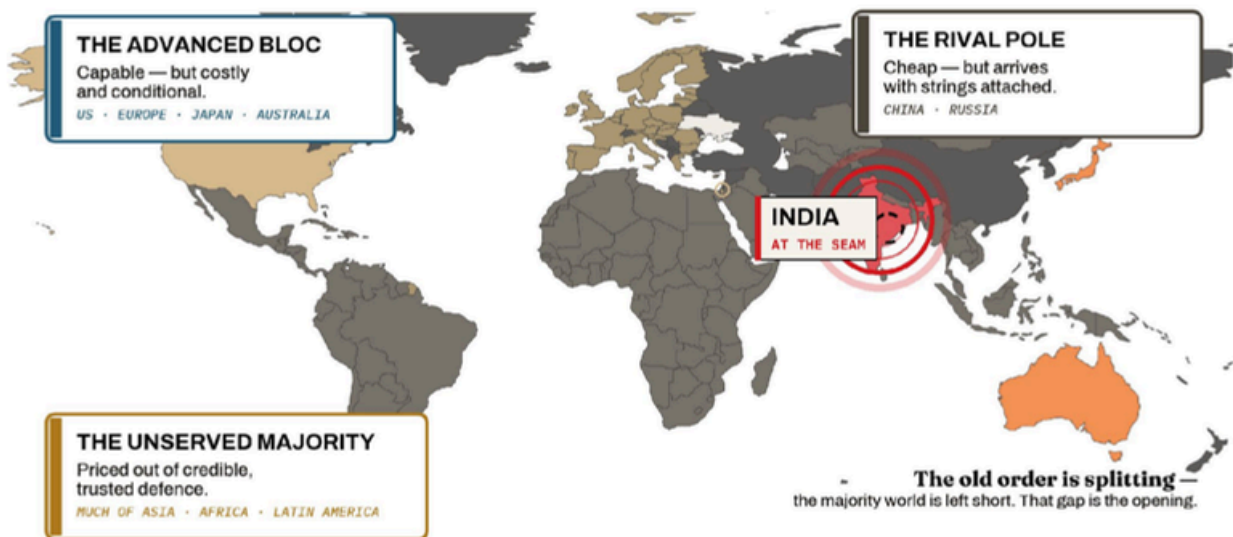
6: Marine Biodiversity & Habitat Suitability: Uses acoustic data and machine-learning classifiers—such as a blue-whale habitat model—to map species distribution. This allows planners to design Marine Protected Areas based on where species will be under future climate scenarios, not just where they are today.

4. Ecosystem Integration & Roadmap

- **Interconnected Outputs:** The true power of the toolkit lies in cross-layer communication. For instance, mangrove degradation (Initiative 5) automatically updates the coastal flood risk model (Initiative 2), while spill trajectories (Initiative 4) cross-reference biodiversity hotspots (Initiative 6).
- **Timeline to 2029:** Built entirely on open-source data and validated against historical events, the platform is scaling from its current operational foundation toward a fully unified, IOR-wide adaptive decision-support system by 2029.



Fig 23: Mr. Vish Sahasranamam, Co-Founder & CEO, Forge Innovation & Ventures



Keynote Address II: Instrument & Institution Defining, Developing, Acquiring, and Operating MUDA as a Military Capability



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to watch the session](#)

*Keynote Speaker: Mr. Vish Sahasranamam, Co-Founder & CEO, Forge Innovation & Ventures;
Executive Advisor - Strategic-Sector Innovation, Ventures & Capability Institutions*

The Global Rearmament & The \$992 Billion Opportunity

The global defence architecture is splitting. With NATO pushing towards significant rearmament and Western suppliers absorbed by their own commitments, the "Unserved Majority" across Asia, Africa, and Latin America is priced out of access to trusted, high-grade defence equipment.

- **Geopolitical Pivot & Trusted Supply Chains:** As democratic nations seek trusted partners to contain regional overreach in the Indo-Pacific (via QUAD, AUKUS, and bilateral partnerships), India stands at the seam. Countries like Armenia (\$1.5B in purchases), Indonesia, Morocco, Brazil, and Argentina are already buying Indian systems.
- **Phygital Twins in the Maritime Domain:** Commercial and defence markets increasingly demand accessible, scalable "Phygital Twins"—coupling deep physics-based modelling with digital sensor arrays to streamline the entire pipeline from underwater sensing to kinetic/non-kinetic end-effects (e.g., Sagarmala S2I2 / MIF port-startup initiatives).

The 5 Capability Thrust Areas (CTAs):

- *Autonomous Systems & Multi-Domain Operations (MDO):* \$191B (27.9%)
- *Domain Awareness & Sensor Grids:* \$185B (27.1%)
- *C4ISTAR & Decision-Centric Warfare:* \$139B (20.3%)
- *Maritime Domain Superiority:* \$94B (13.7%)
- *Cognitive & Algorithmic Warfare:* \$75B (11.0%)

The Cost of Inaction: Without early demand signals, private risk capital stays on the sidelines. When the operational need arises, domestic industrial depth is lacking, forcing the state to resort to expensive emergency procurements, "buy-and-make" imports, or late-stage indigenisation.

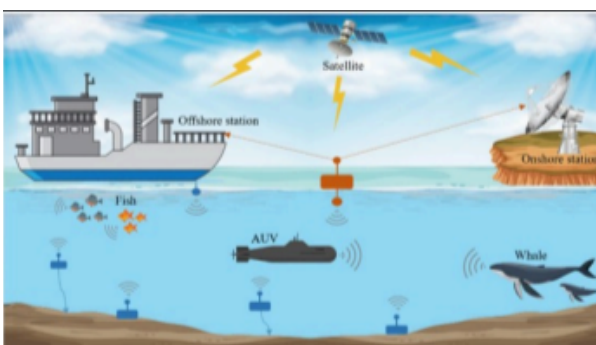
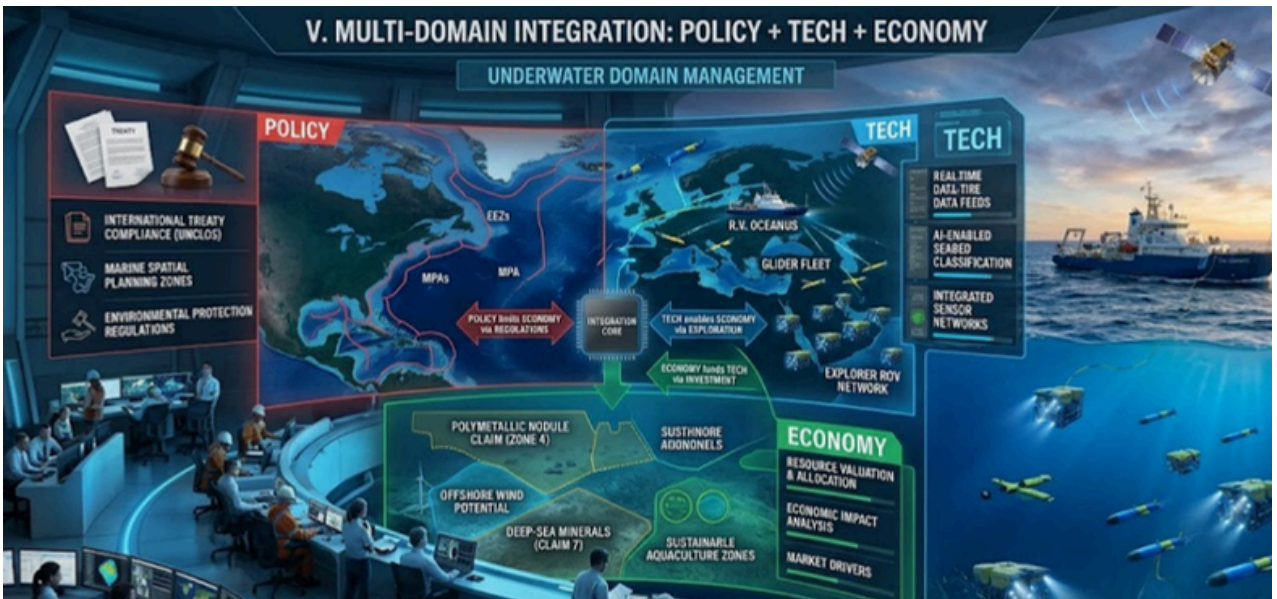
Dismantling the Classification Myth: Defence planners often withhold Integrated Capability Development Plans (ICDP) for classified reasons. However, the speaker stressed that **Quantification** (force size, stock numbers, operational readiness) is the true secret, whereas **Qualification** (fielded equipment categories, functional capabilities, and underlying technology domains) is already presumed by adversaries and must be communicated to industry to enable cross-sectoral synergy.

To operationalise this, the speaker proposed setting up a **Defence Technology WatchTower** to identify, commission, and transition critical technologies.





Fig 30: Mr. Hrishikesh Dhande, Deputy Director, PIC





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Session 4: Career Opportunities, Skilling & Capacity Building in UDA

Main Presenter: *Mr. Callistine Lewis; Head of Publications, MRC*

Session Chair: *Mr. Hrishikesh Dhande, Deputy Director, Pune International Center*

1. Overcoming the Land-Centric Bias & India's Strategic Reality

- The global economy is currently suffering from a saturation of resource extraction, employment creation, and industrial output due to an overwhelmingly land-centric approach to development.
- India's Exclusive Economic Zone (EEZ) covers 2.37 million square kilometres, so we need to move from traditional, surface-focused maritime models to technology-led marine exploration and continuous underwater monitoring.
- Achieving the "Viksit Bharat" and "Blue Economy 2047" visions depends on responsibly managing the underwater domain, securing key trade routes, and protecting strategic choke points across the Indian Ocean Region.

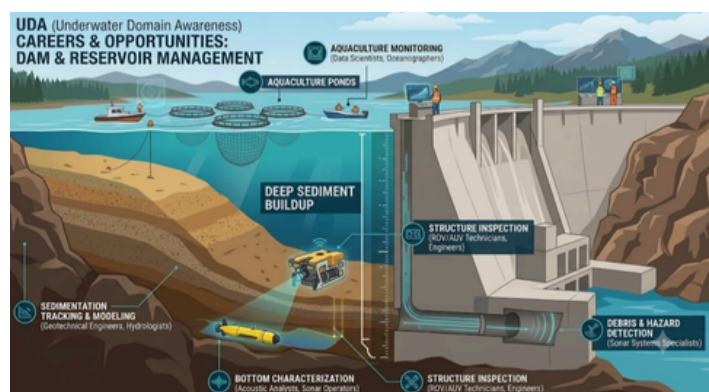
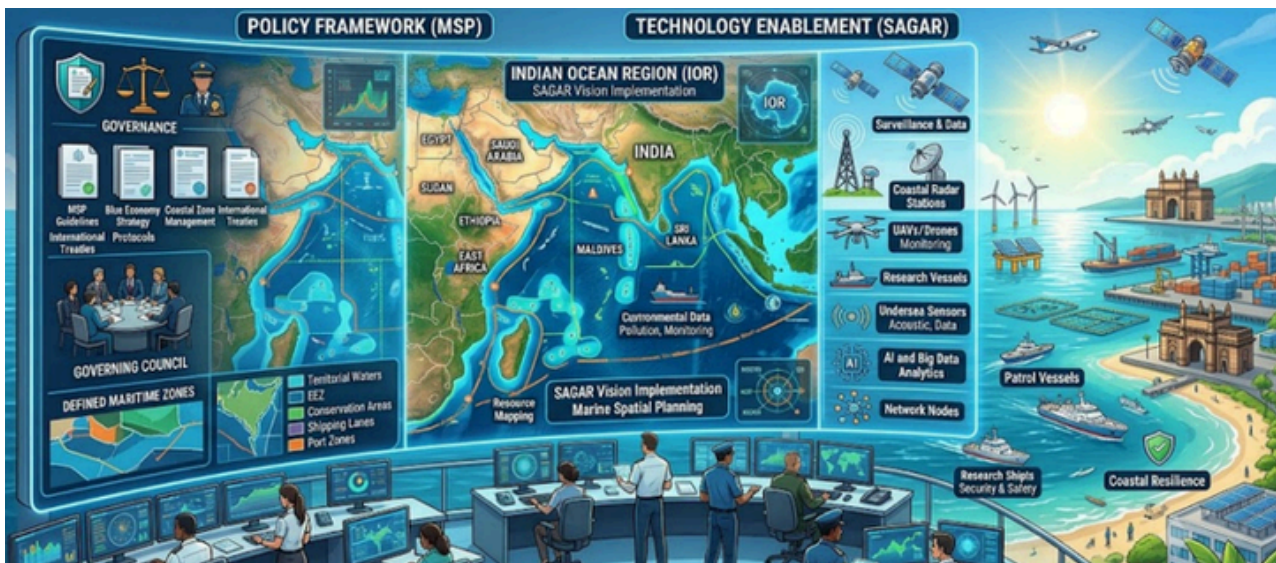
2. Bridging the Structural Capability & Skilling Deficit

- Currently, India's maritime capabilities face severe structural gaps, most notably a critical shortage of professionals cross-skilled in Artificial Intelligence (AI), data science, and marine biology.
- There is a high dependence on imported technology, including high-end sonar systems, precision sensors, and advanced Autonomous Underwater Vehicles (AUVs), which introduces global supply chain risks and degrades domestic operational capability.
- We're still largely unable to use operational data, with raw ocean data trapped in inter-departmental silos, leaving a gap in actionable intelligence at the policy and defence decision tables.
- Inter-agency coordination remains weak and fragmented, creating operational friction and policy incoherence among naval commands, port authorities, and climate regulatory bodies.
- Furthermore, as commercial shipping traffic increases, there is a growing compliance gap in Underwater Radiated Noise (URN) regulations, which standard acoustic monitoring currently fails to address.

3. High-Growth Career Pathways & Cross-Sectoral Employment

- **Government & Defence:** Building indigenous sovereign capability requires specialised roles such as Acoustic Intelligence & AI Surveillance Officers for the Navy, and Underwater Surveillance Analysts to support the Coast Guard and DRDO laboratories.





- **Blue Economy & Private Industry:** To support offshore energy, logistics, and marine tech startups, the maritime industry urgently needs ROV/AUV Technicians, Marine GIS Bathymetry Specialists, and Smart Port Digital Twin Engineers.
- **Environment & Climate Policy:** There is growing demand for ESG Analysts, Marine Environmental Consultants, and Freshwater Sediment Management Specialists to conduct biodiversity conservation projects and execute Environmental Impact Assessments (EIAs).

4. Engineering the Digital Ocean: Digital Twin Architectures

- **Critical Subsea Infrastructure:** Digital twins are essential to bridge the physical and cyber models of subsea cables and pipelines. Real-time data transmission allows engineers to detect micro-fractures, monitor internal pressure, and assess seafloor stability before catastrophic failures occur.
- **Marine Renewable Energy:** Offshore wind farms require advanced cyber models to continuously track turbine structural fatigue, measure wave-induced forces, and monitor underwater acoustic noise generated by the infrastructure.
- **Smart Ports & Disaster Resilience:** Digital models of coastal cities and ports enable dynamic storm-surge predictions, real-time seawall-integrity monitoring, and optimised evacuation routes, directly enhancing coastal disaster resilience to climate risks.
- **Sustainable Aquaculture & Dams:** Cyber models are similarly critical for monitoring biomass density and dissolved oxygen levels in smart aquaculture fisheries, as well as tracking sub-bottom sediment build-up and structural strain in inland dam reservoirs.

5. Humanities, Social Sciences, & Grassroots Integration

- UDA is not exclusively a STEM domain; it requires deep integration with the humanities, including careers in maritime heritage, underwater archaeology, ocean governance, and the International Law of the Sea (UNCLOS).
- Crucially, the framework must incorporate Traditional Ecological Knowledge (TEK) from coastal and riverine populations, ensuring that the deployment of technology does not marginalise traditional livelihoods.
- The "*100 Coastal Warriors*" initiative by MRC exemplifies this grassroots integration, empowering local community members to serve as field deployment specialists, socio-economic validators, and active participants in site-specific marine governance.





Fig 34 : General Manoj Pande PVSM, AVSM, VSM, ADC (Retd) Former Chief of Army Staff of the Indian Army



Opening Remarks Day 2

The Strategic and Ecological Imperative of Underwater Domain Awareness

General Manoj Pande PVSM AVSM VSM ADC (Retd)

Former Chief of Army Staff of the Indian Army

General Manoj Pande opened the second day of the seminar by emphasising the foundational role of the oceans in India's national growth, strategic positioning, and environmental security. Noting the increasing complexities of a contested and environmentally vulnerable maritime domain, he argued that Underwater Domain Awareness (UDA) must evolve beyond traditional security and surveillance paradigms.

Traditional maritime awareness has historically prioritised surface-level tracking and identification. However, the underwater domain remains largely invisible, highly dynamic, and notoriously difficult to monitor. Because "you cannot secure what you do not understand, and you cannot manage effectively what you cannot adequately observe," a paradigm shift is required. General Pande framed UDA as a comprehensive, shared knowledge framework that must actively encompass the health of the marine environment, resource sustainability, and navigational safety.

Moving Toward an Integrated, Inter-agency Framework

A central theme of the address was the necessity of multi-sectoral collaboration. UDA cannot be the siloed responsibility of a single organisation or agency. It fundamentally intersects with defence, shipping, port management, fisheries, environmental protection, and scientific research.



To build a comprehensive understanding, the UDA framework must promote:

- **Inter-agency Coordination:** Bridging gaps between defence, scientific, academic, and industrial stakeholders.
- **Information Sharing:** Moving from specialised, isolated datasets to a common operating picture.
- **Actionable Knowledge:** Transforming raw data into operable intelligence, reinforcing the principle that "what gets measured gets managed."

[Scan or click here to watch the session](#)





The Blue Economy and Marine Ecological Security

General Pande redefined the Blue Economy, emphasising that it is not merely about extracting value from the seas. Rather, it is about creating economic value while rigorously preserving the ecological systems that make such value possible.

He highlighted that security, economic prosperity, and ecological sustainability cannot be compartmentalised. Environmental degradation is inextricably linked with resource depletion, which in turn fuels economic and social tensions. Damage to marine infrastructure carries cascading effects on global trade and connectivity. Conversely, a healthy marine ecosystem directly supports coastal communities, sustainable fisheries, and tourism. Marine ecological security is, therefore, a critical component of overall national resilience.

Technology, Navigation, and the MAHASAGAR Vision

Addressing the practical applications of UDA, General Pande noted its role in ensuring safe navigation—particularly regarding sedimentation, seabed changes, and inland water conditions—and highlighted untapped potential in India's Northeastern region. UDA supports long-term resource conservation by providing the technological and scientific understanding necessary to manage ocean resources, which provide food and livelihoods for millions.

General Pande aligned UDA with the broader MAHASAGAR Vision, focusing on three key pillars:

- **Integration:** Consolidating multidisciplinary datasets.
- **Use of Technology:** Leveraging sensors, autonomous systems, Artificial Intelligence, data analytics, and seabed mapping.
- **Sustainability:** Ensuring ecological considerations are integrated into the core of the planning process.

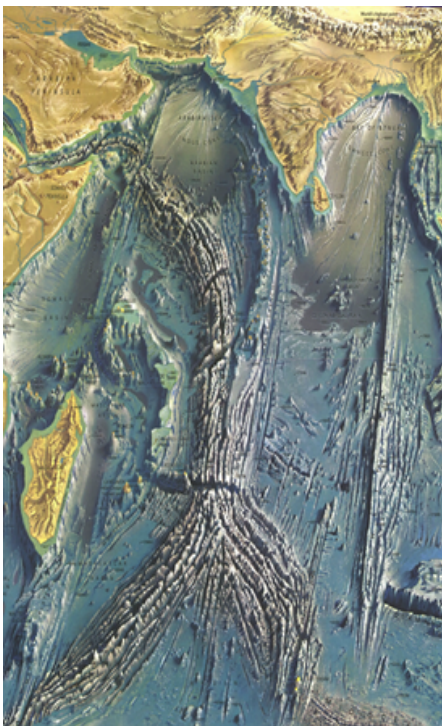
He concluded by noting that while technology is a critical enabler, it is not an end in itself; its value lies in the decisions it empowers us to make. For a maritime nation like India—with its expansive coastline, island territories, and deep economic dependence on the oceans—the future relies heavily on what lies beneath the surface.

Gen. Pande commended the seminar as a vital, multidisciplinary endeavour successfully connecting scientific research with policy, technological innovation with operational development, and security with ecological responsibility.





Fig 38 : Lt. General AK Ramesh SM, Commandant of the College of Military Engineering, Pune



Session 5: Sediment Management in the Tropical Waters of Indian Ocean



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watch the session

Main Presenter: *Mr. Romit Kaware, Research Fellow, MRC*

Session Chair: *Lieutenant General AK Ramesh SM, Commandant of the College of Military Engineering, Pune*

1. The Strategic & Ecological Imperative

Despite being the third-largest ocean globally, the Indian Ocean Region (IOR) remains the least sampled in space and time compared to the Pacific and Atlantic. This observational gap creates strategic vulnerabilities—highlighted by extensive mapping of Chinese research vessels near vital chokepoints like the Strait of Malacca—while a severe internal ecological crisis unfolds across South Asian river basins.

- **Sediment Volumes & Climate Impact:** The Ganga and Brahmaputra rivers alone deliver approximately 1 billion tons of sediment annually to the Bay of Bengal. Intensifying monsoons and climate change are projected to increase this delivery by 34% to 60% in the 21st century.
- **Reservoir Storage Crisis:** Over 3,700 dams in India are projected to lose 26% of their total storage capacity by 2050 due to unchecked siltation. Central Water Commission data shows that a quarter of 141 surveyed major reservoirs (>50 years old) have already lost over 30% of their initial capacity.

2. Unique Tropical Acoustic & Hydrodynamic Challenges

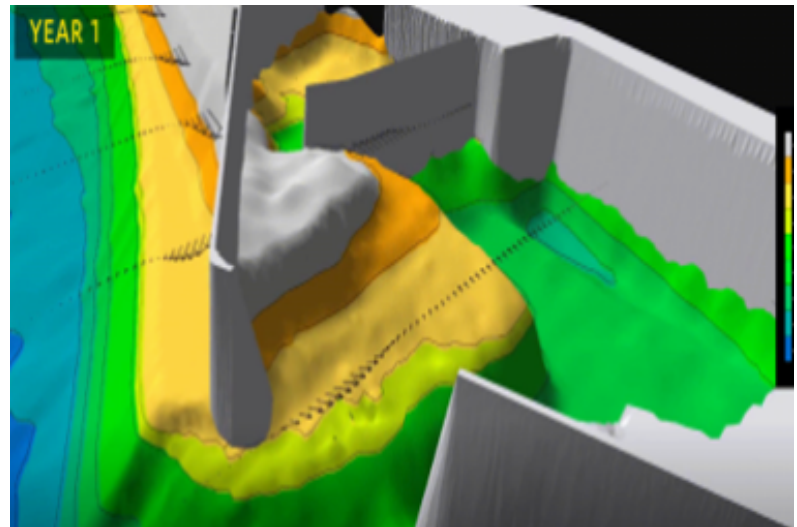
Standard Western oceanographic and sonar hardware fails to perform reliably in IOR tropical waters, experiencing a performance degradation of 60% to 70%.

- **Acoustic Signal Distortion:** High turbidity and suspended sediment alter acoustic attenuation and scattering. Heavy biological activity (plankton, fish, reefs) introduces ambient noise. At the same time, strong seasonal surface heating distorts the Sound Speed Profile (SSP) and creates an unstable sound channel axis, limiting long-range propagation.
- **Erosion vs. Structural Intervention:** Nearly 40% of India's coastline is experiencing erosion (with severe hotspots in Tamil Nadu, Kerala, West Bengal, and Gujarat). Uncoordinated coastal armouring—such as seawalls, breakwaters, and jetties—often generates a "Cape Effect," trapping sediment locally while severely accelerating downstream shoreline erosion.

3. Strategic Defence, Port Infrastructure & Benthic Impact

- **Amphibious & Defence Operations:** Silt-clay beds with low sediment-bearing capacity create severe bogging risks for heavy armoured vehicles (e.g., BMP-2 IFVs, tanks), supply trucks, hovercraft, and temporary bridging equipment. Critical operational zones such as Sir Creek and the Rann of Kutch (tidal mudflats), East Coast deltas (soft clay), and the Andaman & Nicobar Islands (coral rubble/sand) require precise sediment classification to evaluate trench stability, mine burial, and anchor holding ground.





- **The Inefficiency of Reactive Dredging:** Capital and maintenance dredging account for roughly 30% of new port setup costs. Without site-specific sediment dynamics modelling, dredging becomes reactive, expensive, and environmentally disruptive—causing benthic smothering, nutrient imbalances, and fish habitat destruction.

4. MRC's Data-Driven Framework & Case Studies

To move away from de facto dredging and static management, the Maritime Research Centre (MRC) advocates an integrated Underwater Domain Awareness (UDA) framework that combines hydroacoustics, satellite remote sensing, and machine learning.

- **Ujjani Reservoir Siltation Mapping:** Utilising Sentinel-2 Near-Infrared (NIR) band ratios (Red/Green and Red/NIR), MRC tracked a 63.3% rise in surface reflectance from pre- to post-monsoon, accurately mapping turbid sediment plumes and water volume loss.
- **Khadakwasla Field Validation:** In situ acoustic propagation studies used Sub-Bottom Profilers (SB-216S) to measure channel impulse responses, sound speed profiles, and reflection coefficients across varying sediment stacks (clay vs. fine/medium silt).
- **Brahmaputra Riverine System:** Applied shallow-water acoustic tomography and multi-spectral satellite imagery (MNDWI/AWEI) paired with U-Net (ResNet-34) segmentation and Dijkstra 16-node connectivity algorithms to generate real-time navigation channel cost maps and urban flood forecasting.
- **Kochi Port Predictive Dredging Model:** Modelled spatio-temporal sediment accumulation within the Ernakulam and Mattancherry channels by coupling tidal Krone deposition parameters and bed shear stress. This predictive approach forecasts exact siltation hotspots and dredging volumes, reducing vessel fuel consumption and supporting green shipping targets.





THE FIVE PILLARS OF BLUE ACCOUNTING

An Integrated Framework for a Sustainable Blue Economy

Blue Accounting provides a holistic measurement of ocean wealth by integrating environmental, economic, social, and governance dimensions to support informed decision-making and sustainable ocean management.

1 NATURAL CAPITAL



Measures the ocean's natural assets and their ecological health.

2 OCEAN ECONOMY



Captures the economic value generated from ocean-based sectors and industries.

3 ECOSYSTEM SERVICES



Quantifies the direct and indirect benefits provided by marine ecosystems.

4 SOCIAL & EQUITY DIMENSION



Evaluates the human and social dimensions of the blue economy.

5 GOVERNANCE & SUSTAINABILITY



Assesses the effectiveness of institutions, policies, and sustainability mechanisms.

01

BLUE ACCOUNTING

What assets exist? What services do they provide? What is their economic contribution?

02

UDA

What is happening underwater — now, where, and at what intensity?

03

M&S-MSP

What happens if we choose one marine-use scenario over another?



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Session 6: Blue Accounting & Marine Environmental Economics

Main Presenter: Ms. Catherine J, Head of Research, MRC

Session Chair: Dr. Ajit Ranade, Economist and Former Vice-Chancellor of Gokhale Institute, Pune

1. The Limitations of Conventional Ocean Economics

The session opened by identifying a critical flaw in traditional economic models: they easily capture economic flows (like shipping revenues and fisheries output) but fail to account for the degradation of the natural capital that sustains them. This allows short-term economic gains to mask long-term ecological depletion.

In high-value, high-velocity tropical systems characterized by intense monsoon dynamics, informal coastal livelihoods, and climate shocks, a region-specific framework is required. "Blue Accounting" solves this by making ecological conditions and ecosystem services visible alongside economic performance, shifting the paradigm from merely tracking what the ocean produces to safeguarding the assets that sustain that production.

2. The Integrated Architecture & The Five Pillars

Blue Accounting (BA) operates through a continuous, integrated loop: It relies on three core capabilities:

1. **Blue Accounting:** Quantifies what assets exist and their economic contribution.
2. **Underwater Domain Awareness (UDA):** Acts as the dynamic information backbone (via sensors, AI, and hydrographic surveys) to observe what is happening underwater in real-time.
3. **Modelling & Simulation-Based Marine Spatial Planning (M&S-MSP):** Tests alternative marine-use scenarios to evaluate trade-offs before implementation.

This architecture supports the **Five Pillars of Blue Accounting:**

- **Natural Capital:** Biomass levels, habitat extent, and ecosystem health.
- **Ocean Economy:** GDP contribution, employment, and trade.
- **Ecosystem Services:** Coastal protection, blue carbon sequestration, and climate regulation.
- **Social & Equity Dimension:** Livelihood dependency, food security, and indigenous rights.
- **Governance & Sustainability:** Policy frameworks, compliance, and institutional capacity.





The ocean is productive — but poorly accounted for

Conventional accounts capture economic flows more easily than the natural capital sustaining them.

ECONOMY

Fisheries • tourism • shipping • aquaculture

ECOSYSTEM

Reefs • mangroves • seagrass • biodiversity

SOCIETY

Food security • livelihoods • equity



3. The Total Ocean Value (TOVA) Framework

To capture the true balance sheet of marine development, the MRC introduced the Total Ocean Value Assessment equation, which subtracts value degraded from value created: Where the Value Created includes Market Value, Indirect Value, Avoided Cost Value, Strategic Value, and Ecosystem Service Value. The Liability/Value Lost encompasses Environmental Degradation, Opportunity Cost, and Degradation/Restoration Cost.

4. Practical Implementation: Case Studies in Maharashtra

The session demonstrated the TOVA framework through highly interconnected coastal case studies:

- **Vadhvan Port & Biofouling Management:** Conventional economics asks only how much money hull-cleaning saves. Blue Accounting evaluates the avoided liabilities—such as excess emissions, invasive species transfer, and ecological damage—against the costs of management. This proves that biofouling intervention creates systemic value far beyond fuel savings.
- **Ports vs. Social/Environmental Liabilities:** While entities like JNPA boast massive net worth and operating margins (66.7%), conventional ledgers ignore the 4,550 mangroves (4.5 ha) destroyed at JNPT or the 5,333 fishing households affected by Vadhvan's proposed 1,448 ha reclamation.
- **Mangrove Natural Capital & The "Double-Counting" Challenge:** Maharashtra's mangroves hold an estimated blue carbon stock of ₹54,000–1,12,800 crore, making them strictly an Ecosystem Service Value (ESV)-led asset. The presenter highlighted a critical accounting risk: one must not double-count the value of a mangrove nursery, the intermediate fish recruitment it supports, and the final market value of the landed fish. Blue Accounting distinctly separates the natural capital stock from the economic output to maintain a defensible balance sheet.

By calculating the difference between a managed scenario and a baseline, policymakers can clearly quantify the exact economic and ecological value of an intervention. Ultimately, establishing this common evidence base ensures that future Blue Economy growth is balanced with ecological integrity and social equity.





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Keynote Address III: IMO GloNoise and Maritime Decarbonization Initiative

Keynote Speaker: Shri Pravin Kumar Roy, Deputy Director General of Maritime Administration DDG (Tech), Directorate General of Shipping, Ministry of Ports, Shipping & Waterways, Government of India

1. Strategic Context & IMO Global Partnerships

The keynote address highlighted India's proactive role in advancing international maritime environmental standards through key global initiatives led by the International Maritime Organisation (IMO):

- **GloLitter Partnerships:** A US\$ 4.5 million global project funded by Norad and executed in collaboration with the FAO to tackle sea-based marine plastic litter originating from shipping and fisheries.
- **GreenVoyage2050:** A US\$ 7.15 million initiative funded by the Norwegian Ministry of Climate and Environment supporting developing nations in implementing the Initial IMO GHG Strategy and MARPOL Annex VI commitments.
- **GloNoise Partnership:** A global framework executed in partnership with the UNDP and Global Environment Facility (GEF) to implement the IMO Revised Guidelines for the reduction of Underwater Radiated Noise (URN) from commercial shipping (MEPC.1/Circ.906/Rev.1) to protect marine biodiversity.

2. GloNoise Partnership & India's Leadership Role

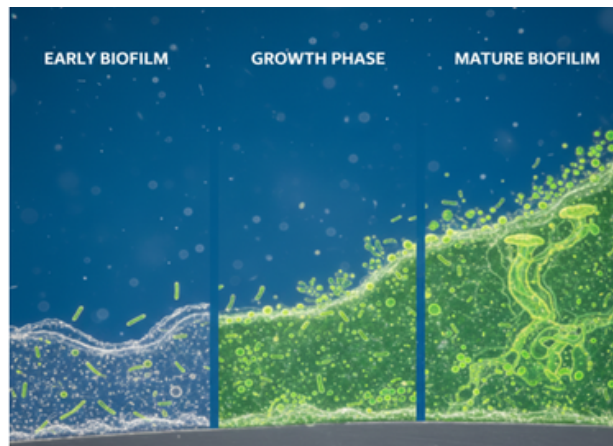
India serves as a **Lead Pilot Country** under the GloNoise Partnership (alongside Argentina, Chile, Costa Rica, South Africa, and Trinidad & Tobago). In this role, India is actively driving regional capacity building, having hosted the URN Toolkit Workshop in Mumbai in April 2026.

3. National Maritime Decarbonization Policy Framework

To align India's domestic maritime sector with global net-zero targets, the Ministry of Ports, Shipping & Waterways outlined the **8 Pillars of the National Maritime Decarbonization Policy Framework**: 1. Green Shipbuilding & Retrofits | 2. Green Ports | 3. Green Ship Recycling | 4. Green Finance | 5. Green Skills | 6. Alternate Fuels | 7. Green Technology | 8. Pollution Prevention

India's forward-looking maritime transition focuses on training a future-ready workforce for alternative fuels and digital systems, scaling up LNG, methanol, green ammonia, and hydrogen supply chains, and accelerating local green tech like AI and IoT integration alongside strict MARPOL pollution controls. By blending global frameworks like GloNoise with domestic strategies like the 8-Pillar Decarbonization Framework, the sector is successfully aligning with international regulations while cementing its leadership across the Indian Ocean Region.







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to watch the session](#)

Session 7: Biofouling Management in the Maritime Industry – *Understanding the Challenges, Solutions and Innovation*

Main Presenter: *Mr. Suchir Mamidala, Research Fellow, MRC*

Session Chair: *Dr. Varsha Kelkar-Mane, Professor & Head, Department of Biotechnology;
Deputy Director, Centre for Excellence in Marine Studies (CEMAS), University of Mumbai.*

1. The Biofouling Crisis & Economic Impact

Biofouling—the undesired accumulation of biological organisms on submerged surfaces—imposes massive operational and economic penalties on the maritime industry.

- **Hydrodynamic Drag & Fuel Consumption:** Even a light layer of slime increases hydrodynamic drag by 10–15%, while heavy macrofouling increases it by 30–60%. This translates to a 15–30% fuel penalty for moderately fouled hulls, with extreme fouling pushing fuel consumption increases beyond 40%.
- **Operational & Economic Costs:** Biofouling causes speed losses of 1–2 knots, directly affecting schedule reliability. It also accelerates Microbiologically Influenced Corrosion (MIC) and acts as a vector for invasive, non-native species. Globally, the industry spends \$5.7 billion annually on prevention and control, while fouling can cost up to \$1 billion over the 15-year lifecycle of a destroyer-class naval vessel.

2. The Tropical Accelerator

Biofouling dynamics in the Indian Ocean Region (IOR) are far more severe than in temperate waters.

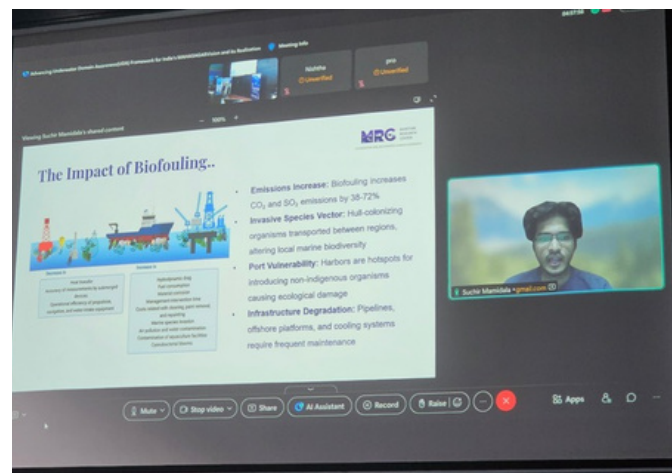
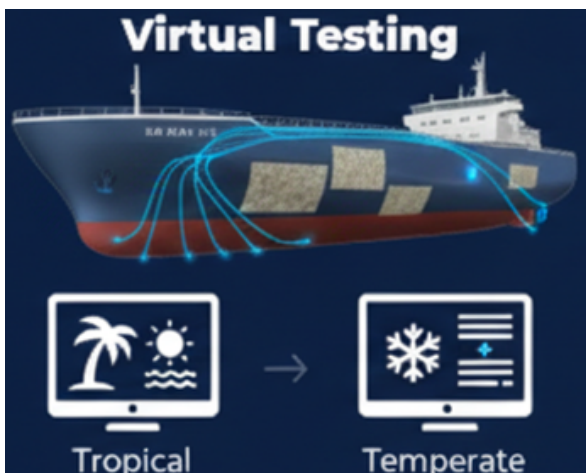
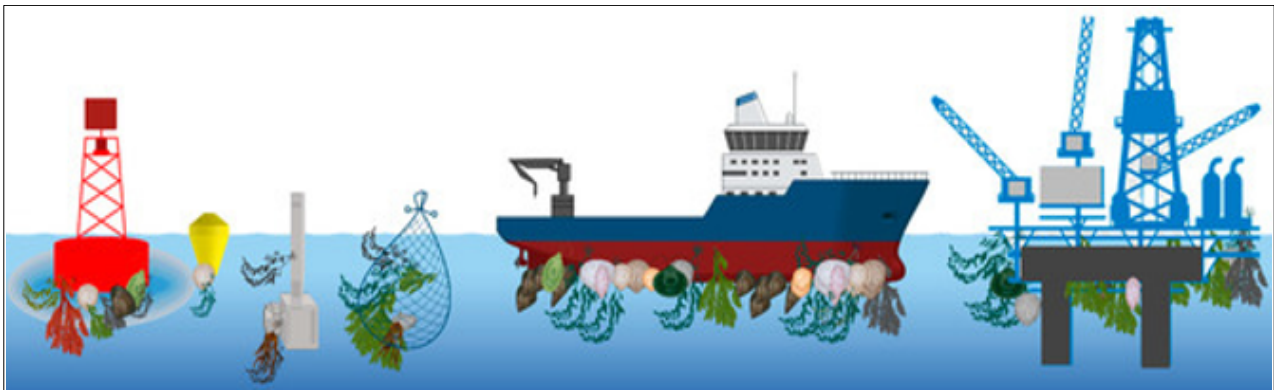
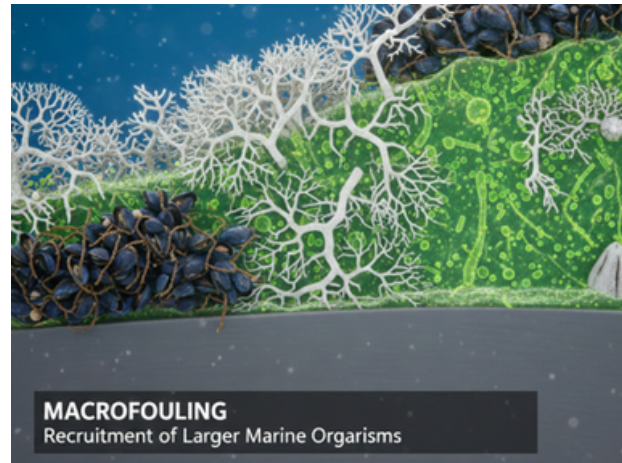
- **Metabolic Acceleration:** Warm tropical temperatures (25–32 °C) accelerate microbial growth rates by 2–3 times. Microbes can reproduce in just 20 to 30 minutes under these conditions.
- **Persistent Growth:** The tropical environment features high nutrient availability, greater species diversity, and the absence of cold winters. Without a natural winter "die-off," fouling layers persistently thicken over time, leading to rapid, multi-species colonisation.

3. Limitations of Current Antifouling Methods

Current antifouling strategies rely on biocidal coatings (such as copper and zinc), self-polishing copolymers (SPCs), and foul-release silicone coatings, as well as mechanical in-water cleaning and emerging physical systems (ultrasonic, UV, air lubrication). However, these methods face severe limitations:

- **Environmental & Regulatory:** Biocidal coatings release toxic substances that harm non-target marine life, leading to increasingly strict environmental regulations that complicate global operations.





4. MRC's Machine Learning Surrogate: Because traditional modelling is computationally heavy, the MRC used Latin Hypercube Sampling to synthesise an 80,000-scenario dataset covering extreme IOR conditions. The simulation revealed that in extreme IOR heat, biofilm and microfouling hit their biological carrying capacity in just 5–7 days. A Random Forest machine-learning surrogate was trained on this data, successfully replicating the physics engine to predict Day 90 drag increases, enabling instant, fleet-wide fuel-penalty predictions.

5. Session Chair Remarks & Q&A

Dr Varsha Kelkar-Mane expanded the discussion by introducing a biochemical and ecological perspective on biofouling.

- **The Biochemistry of Adhesion:** The proteins that allow marine organisms to stick to hulls are biologically similar to amyloid plaques found in Alzheimer's disease—proteins that agglomerate to form rigid structures. Marine organisms use specific amino acids (such as DOPA) to create powerful organic glues that effectively stick two surfaces together underwater.
- **The Ecological Benefits of Fouling:** Approaching the topic from a purely scientific (rather than economic) perspective, Dr Kelkar-Mane highlighted that biofouling serves as a critical habitat-creation mechanism.. Hulls become floating ecosystems—a "3-dimensional habitat"—that support local biodiversity. Sponges, mussels, and oysters attached to hulls filter suspended particles, regulating local water quality and contributing immensely to nutrient and carbon cycling. They serve as ecosystem engineers and bio-indicators of a region's physico-chemical characteristics.
- **Bio-Inspired Solutions:** Instead of toxic paints, the future of antifouling lies in biotechnology and preventative design. Dr Kelkar-Mane pointed to the "lotus leaf" effect—creating superhydrophobic nanopolymer layers that reduce the water contact angle, preventing the very first layer of colonisation (the conditioning film) from forming. She warned that simply scraping biological matter off hulls into foreign ports during cleaning loops the contaminants and bio-matter back into the local environment.

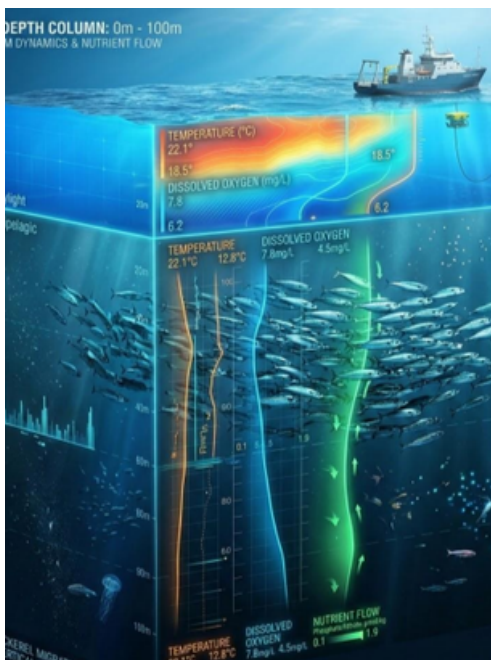
Q&A Highlights:

- The "Submerged Metropolis": The audience discussed how international shipping routes serve as transcontinental highways for microbial passengers, creating floating, submerged civilisations. This necessitates a coexistence strategy rather than pure eradication. The conversation drew parallels between hull fouling and ballast water discharge, questioning if new international treaties are required to manage the massive transfer of biodiversity via ship hulls, potentially involving phytosanitary certifications.
- Addressing chemical interventions, it was noted that marine bacteria are highly adaptable. In some instances, where copper compounds were used for antifouling, bacteria evolved to produce copper-iron complexes, rendering the antifouling paint non-toxic and enabling them to survive the treatment. Understanding this biochemistry is essential to designing better "drugs" (coatings) against fouling.





Fig 52: Mr. Rakesh Kumar, General Manager, Bharat Electronics Limited



Session 8:

Ocean Intelligence for the Indian Coast

Biogeochemical Modelling, Dark-Fleet Detection, Mariculture Mapping and Marine Heatwave Analysis



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session

Main Presenter: Mr. Ashwani Singh, Research Fellow, MRC

Session Chair: Mr. Rakesh Kumar, General Manager, Bharat Electronics Limited

1. The Ocean's Four Blind Spots & 3D Ecosystem Modelling

Four critical blind spots currently paralyse effective marine governance: tracking where the fish are, identifying who is fishing, mapping what is being farmed, and understanding how environmental baselines are changing.

To resolve the biological tracking gap, the MRC transitioned from static surface mapping to a dynamic **Decision Intelligence System** for Potential Fishing Zone (PFZ) mapping.

- **0-100m 3D Integration:** Using five parameters from the Copernicus Marine Service, the model analyses the entire euphotic zone. By applying trapezoidal numerical integration, it calculates the total biological productivity across the water column rather than just the surface.
- **The Dual Bloom System & Oxygen Paradox:** The model tracks three primary suitability curves: thermal, oxygen, and nutrient gradients. This revealed a "Dual Bloom" system (Winter vs. Summer/Fall). It also uncovered a severe "Oxygen Paradox"—while nutrients were abundant, dissolved oxygen at a depth of 50m dropped to 116 units (below the critical stress threshold of 120 units). This localised hypoxia drastically reduced grazing efficiency, a nuance completely missed by surface-only satellites.

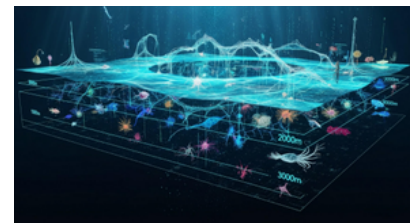
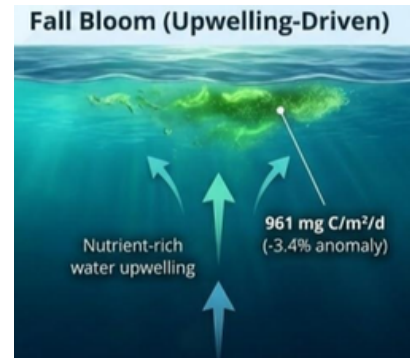
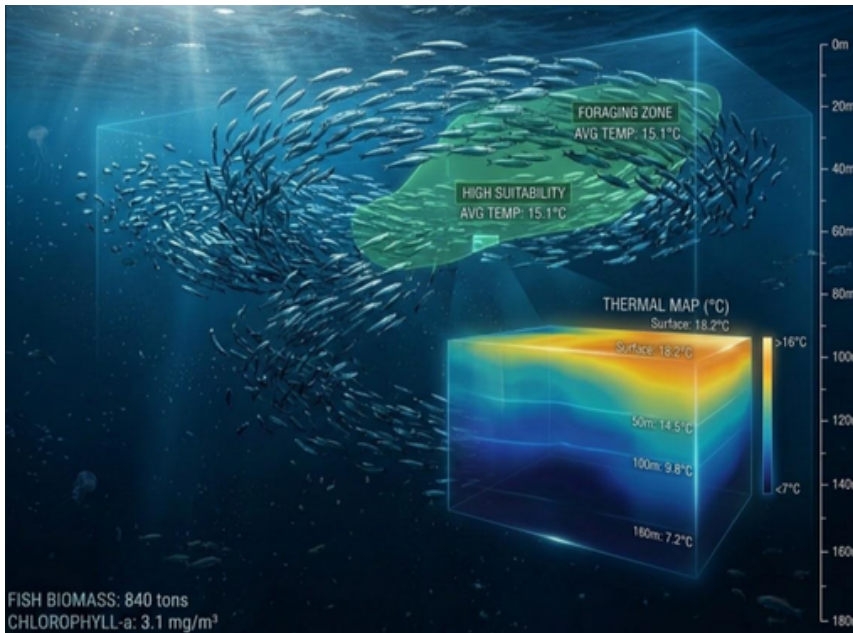
2. Maritime Security & The "Dark Fleet"

India cannot see its own fishing fleet. Currently, only about 17% of the fleets operating in the Indian Exclusive Economic Zone (EEZ) are equipped with Automatic Identification Systems (AIS). This massive "AIS Invisibility" creates a surveillance vacuum that dark fleets exploit.

To counter this, the MRC advocates for a **Multi-Sensor Fusion Framework**, drawing on successful methodologies previously used to track dark fleets in regions like North Korea (which successfully tracked 900+ hidden vessels). The framework integrates:

- **AIS:** For baseline tracking of compliant vessels.
- **SAR (Synthetic Aperture Radar):** Satellite microwave systems that penetrate clouds to pinpoint metallic vessel structures.
- **VIIRS (Visible Infrared Imaging Radiometer Suite):** Night-light detection to expose nocturnal operators, such as squid boats.
- **Optical Imagery:** High-resolution photography for positive visual identification.





3D Ecosystem Modelling

- Depth-integrated productivity (0–100m)
- Multi-parameter ocean signals
- Hidden biological patterns



3. India's Unmapped Aquaculture

Despite holding the #2 global rank as an aquaculture producer, India has an officially recorded offshore mariculture area of zero. This discrepancy stems from severe environmental and geographical hurdles that break standard global mapping pipelines:

- **Monsoon Clouds & Turbidity:** Persistent cloud cover can block optical satellites for months, while heavy sediment can mimic seaweed farms, causing false positives and false negatives.
- **Geography & Scale:** India's straight coastlines expose farms to raw ocean forces, and the highly localised, artisanal scale of these farms slips completely below the threshold of global sensors.

The MRC Solution: With an "India-First" focus, the team is tailoring algorithms for the Indian coast, deploying monsoon-resilient SAR paired with optical data to detect and map micro-mariculture.

4. Session Chair Remarks: Strategic Tech & Market Positioning

In his closing remarks, Mr Rakesh Kumar (BEL) bridged marine science with defence technology strategy, emphasising the role of AI, ML, and AUVs in meeting Environmental, Social, and Governance (ESG) mandates. He framed the future of Underwater Domain Awareness through distinct strategic lenses:

- **Blue Sky Research:** Essential for long-term viability, this entails R&D investments with 5+ year timelines. He noted that true market disruptions rarely come from within the established sector; they emerge from forward-looking, cross-disciplinary Blue Sky investments.
- **Blue Ocean vs. Red Ocean Strategy:** Mr Kumar urged the maritime sector to adopt a "Blue Ocean" mindset—creating entirely new, uncontested markets (such as predictive ocean intelligence)—rather than fighting in a "Red Ocean" characterised by heavy competition, intense cost-cutting, and fierce competition.
- **The Threat of Foreign Dependency:** The panel warned against relying too heavily on foreign players or institutions to fund or build domestic capabilities, noting that the ultimate "cost of help" is often prohibitively high for national sovereignty. Instead, he advocated for domestic "co-opetition"—where local entities collaborate to build indigenous marine technological capacity.



Fig 56: Mr. Araudra Singh, Research Associate, Indian Council for World Affairs



Closing Report



Scan or click here to
watch the session

Speaker: Mr. Araudra Singh, Research Associate, ICWA

Doctrinal and Institutional Challenges

- **Naval Doctrine vs. Reality:** Current naval doctrines still treat Underwater Domain Awareness (UDA) merely as a subset of Maritime Domain Awareness (MDA). Mr Singh argued that UDA must be conceptualised as a unique domain due to the highly opaque and distinct operating conditions of the underwater environment.
- **Threat Perceptions:** A primary area of strategic interest remains the deployment of Pakistan's Hangor-class submarines.
- **Institutional Fragmentation:** UDA efforts span multiple domains—critical infrastructure, security, and the economy—but are hindered by a disconnect among multiple ministries. Institutions and joint planning for acoustic, civil, and anti-submarine warfare applications must be synergised.
- **The Proposed Solution:** Establishing a centralised **National Nodal UDA Authority** is essential to unify these fragmented efforts.

Technological Capabilities and Operational Gaps

- **Unmanned Systems:** While technological gaps persist regarding UUV autonomy software and mission diversification, collaborative efforts are showing promise. For example, the coordinated development of the Vamana Unmanned Surface Vehicle (USV) by GRSE and BEL aims to field platforms capable of withstanding high-monsoon conditions in tropical waters.
- **Overlapping Acoustic Networks:** Relying on a single asset is risky; if a submarine manoeuvres outside a sensor's coverage or an asset takes a hit, awareness is lost. The focus must shift to **multi-static sonar capabilities**, creating an overlapping acoustic node network that links seabed sensors, surface ships, and helicopters.
- **Cross-Sectoral Capability Integration:** MoES and MoD should consider pooling of resources and expertise of NIOT and NPOL for introducing a joint NIOT-NPOL programme for IOR acoustic database development, ambient noise measurement, analysis system technologies, and deep-sea sensor placement under a formal MoU.
- **Adversary Advancements:** The urgency of these technologies is underscored by emerging threats such as weaponised boat swarms, ROVs, and Chinese UUV gliders already operating at depths beyond 6,000 meters.

The Policy Ecosystem

- **Reinvigorating Defence Innovation:** The ecosystem requires stronger synergy between Defence Public Sector Undertakings (DPSUs) and startups. Initiatives like iDEX must be broadened to include dual-use technologies to foster this collaboration.
- To accelerate indigenisation, we need to streamline certification pathways and mandate equitable contracting terms between large DPSUs and smaller tech startups.
- **Dual-Use Synergies:** National initiatives like the Deep Ocean Mission should actively integrate civil oceanographic data with dual-use defence technologies to build a comprehensive UDA framework.





*Fig 58: Vice Admiral D. S. P. Varma PVSM AVSM VSM (Retd.)
Former DG of the Advanced Technology Vessel (ATV) programme*



Concluding Remarks



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[click here to
watch the session](#)*

Vice Admiral D. S. P. Varma PVSM AVSM VSM (Retd.)

Former DG of the Advanced Technology Vessel (ATV) programme

Transitioning from Discourse to Action in the Underwater Frontier

Vice Admiral D. S. P. Varma delivered the closing remarks for the seminar, expressing strong optimism about the vibrant participation of young scholars and cadets from the National Defence Academy (NDA). Acknowledging the presence of representatives from the Army and Air Force alongside naval personnel, he commended the creation of a truly multi-service and multidisciplinary space to discuss the future of the maritime domain.

Exploring a Vast and Tactile Domain: Reflecting on the physical realities of the oceans, Vice Admiral Varma reminded the audience that "below the submarine, there is a whole world to explore." He described the underwater region as a vast and exciting frontier characterised by unique sensory challenges—a dark environment where traditional vision fails, and operators must instead rely on technology and acoustics to "feel" their way through. He issued a strong call to action to the next generation, emphasising that India urgently needs more young professionals to enter and specialise in this underwater space.

Aligning with Vision 2047 and overcoming funding hurdles, Vice Admiral Varma posed the critical question to the delegates—"What should we do with what we have learned?"—and stressed that all initiatives in the underwater domain must ultimately align with India's national developmental goals, specifically Vision 2047.



Fig 59: Vice Admiral D. S. P. Varma (Retd.), Former DG of the Advanced Technology Vessel (ATV) programme

He highlighted the operational challenges of realising this vision, noting that while it is easy to produce theoretical papers, the primary hurdle in transitioning from the "paper level to the project level" is securing capital. However, he expressed confidence in the ecosystem's trajectory, citing the seminar's sessions on deep-tech investments and the underwater investment environment as vital, positive steps toward addressing the funding challenge.

Vice Admiral Varma concluded the seminar by reiterating the sheer volume of work still to be done and encouraging the young attendees to take up the mantle of advancing India's underwater capabilities.



PARTICIPANT INTERACTIONS



Analytical Impressions:

Viewing the Conference through a Comprehensive, Structured, and Inclusive UDA Paradigm

The National Conference on Advancing the Underwater Domain Awareness (UDA) Framework demonstrated that the central challenge of UDA is not simply the acquisition of greater underwater visibility, but the development of an architecture capable of converting fragmented observations into coordinated national capability. Across its sessions, the conference brought together questions of maritime security, marine science, environmental resilience, blue-economy development, technology, infrastructure, livelihoods and institutional governance. In doing so, it positioned UDA as a framework for understanding the underwater domain as an interconnected physical, ecological, economic and strategic space rather than as a collection of isolated sectoral concerns.

Viewed through this lens, the conference reflected three mutually reinforcing characteristics of the UDA framework: **comprehensiveness** in the scope of what is observed and integrated; **structure** in the mechanisms through which data is converted into analysis, planning and institutional action; and **inclusivity** in the range of ecological systems, communities, disciplines and economic interests incorporated into governance.

These three dimensions provide an analytical lens through which the discussions and interventions of the conference can be understood:

Dimension	Core question	UDA Interaction
I. Comprehensive	<i>What does UDA bring together?</i>	<i>Domains, scales, systems, geography, threats</i>
II. Structured	<i>How does UDA organise knowledge into action?</i>	<i>Data → models → valuation → institutions → policy</i>
III. Inclusive	<i>Who participates and who benefits?</i>	<i>Communities, ecology, economy, academia, industry, youth</i>

I. *Comprehensive*: Expanding the Scope of UDA

The conference demonstrated that UDA cannot be treated as belonging exclusively to defence, oceanography or maritime technology. It emerged instead as a framework capable of bringing together security, environmental science, economic valuation, infrastructure and scientific observation within a common architecture. By being *Comprehensive*; UDA expands the object of governance.

1. From Sectoral Awareness to a Unified UDA Paradigm: The conference demonstrated that Underwater Domain Awareness cannot be approached as a specialised extension of maritime defence or oceanographic observation alone. Rather, the UDA framework brings together security imperatives, environmental processes, economic activity, critical infrastructure and scientific enquiry within a common analytical architecture. This comprehensive conception recognises the underwater domain as an interconnected physical, ecological, economic and strategic space, in which developments in one domain can generate consequences across others. The conference's discussions on subsea infrastructure, marine ecosystems, fisheries, sediment dynamics, blue accounting and maritime security consequently illustrated the need to move beyond fragmented sectoral approaches toward a unified understanding of the underwater environment.

2. From Surface-Centric MDA to Volumetric Domain

Awareness: A defining feature of the comprehensive UDA paradigm was the expansion of maritime awareness from a predominantly surface-oriented framework toward a volumetric understanding of the maritime environment. The concept of a "cylinder of awareness" presented during the conference illustrates this shift by seeking to correlate activities across space, air, surface and subsurface environments. Such an approach recognises that critical infrastructure, vessels,

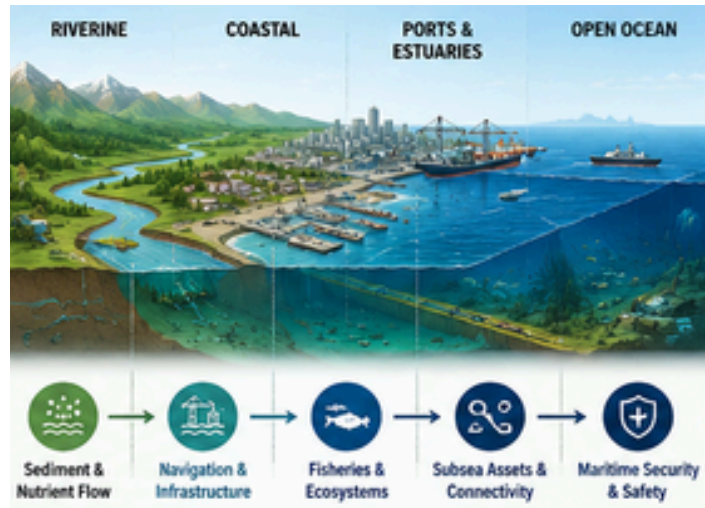


Ecological processes and security threats operate across different layers of the maritime space and cannot be adequately understood through surface observations alone. Comprehensive UDA, therefore, implies not merely an expansion in the quantity of information collected, but also an expansion in the spatial dimensions through which the maritime domain is observed and interpreted.

3. From Isolated Water Bodies to an Interconnected Riverine-Coastal-Marine System: The conference also broadened UDA's geographical scope beyond its conventional focus on open-ocean and naval environments. Discussions on riverine sedimentation, reservoir siltation, coastal erosion, port infrastructure, navigation and offshore systems demonstrated the interconnectedness of India's riverine, coastal and marine environments. Processes originating upstream can alter sediment regimes, navigation conditions, coastal morphology and port operations downstream, while interventions in one part of the system may generate consequences elsewhere.



A comprehensive UDA framework therefore requires awareness across the full continuum of underwater environments rather than treating rivers, coasts and marine spaces as administratively or analytically separate systems. The integrated approach needed to map out hydrosocial relations is a central feature of the UDA Framework.



4. Interdisciplinary Integration for Complex Problem-Solving: The conference demonstrated that the complexity of the underwater domain exceeds the analytical capacity of any single discipline. Physical oceanography provides an understanding of water-column and sediment dynamics; hydroacoustics enables subsurface observation; artificial intelligence and modelling convert observations into predictive assessments; economics evaluates the value and liabilities associated with marine activity; while defence and policy institutions translate these assessments into strategic and regulatory decisions. The interaction of these disciplines, therefore, represents more than academic collaboration: it is a necessary condition for developing actionable UDA. The conference's movement between security, environmental, technological and economic questions illustrated the value of treating these fields as mutually reinforcing components of a common analytical framework.

5. From National Awareness to Indian Ocean Regional Architecture: Finally, the comprehensive character of UDA extends beyond India's territorial waters and national institutions to the wider Indian Ocean Region. The conference situated underwater awareness within a regional environment shaped by critical subsea infrastructure, maritime trade, extra-regional activity, resource competition and shared ecological vulnerabilities. This creates a basis for moving from nationally isolated data and capabilities toward information-sharing, interoperable systems and Collaborative approaches with littoral partners. The comprehensive UDA paradigm is multi-sectoral and multi-dimensional, and it is also regional, supporting India's MAHASAGAR vision by building shared maritime resilience and cooperative capacity across the Indian Ocean.



II. *Structured*: Converting Awareness into Decision-Making

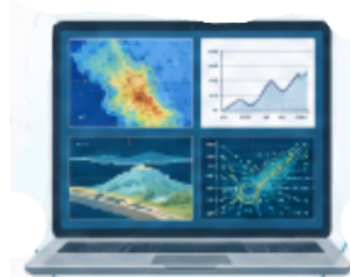
If *comprehensiveness* defines the breadth of the UDA paradigm, its *structured* character determines how that breadth can be converted into usable knowledge, coordinated planning and institutional action. The conference demonstrated that underwater awareness cannot be achieved by accumulating isolated datasets, technologies, or capabilities. It requires an architecture in which observations are *systematically generated, modelled, spatially interpreted, economically evaluated and ultimately translated into policy and operational decisions*. The discussions across the conference therefore revealed a progression from **observation to modelling, from modelling to valuation, from valuation to institutional coordination, and from institutional coordination to implementation**. This layered architecture provides the basis for transforming UDA from an awareness objective into a functioning decision-support ecosystem.

1. Science-Based Observation and Data Generation: The foundation of a structured UDA architecture is the generation of reliable, context-specific and continuously updated information about the underwater environment. The conference highlighted that tropical waters present distinct physical and environmental conditions, including complex acoustic propagation, high biological activity, sediment dynamics and changing temperature and oxygen profiles. These characteristics make generic or static datasets insufficient for effective underwater governance. Hydro-acoustic observations, satellite imagery, environmental sensing, bathymetric surveys, and other forms of field data must therefore be organised into a common evidence base that represents the physical and ecological realities of India's riverine, coastal, and marine environments. The emphasis on India-specific data generation, particularly in relation to sediment management, fisheries, mariculture and tropical acoustics, demonstrates that structured UDA begins with building an accurate and context-sensitive picture of the underwater domain.



2. Algorithmic Modelling and Predictive Decision Support: The second layer involves transforming raw observations into predictive intelligence. The conference's discussions on Modelling and Simulation (M&S) demonstrated a shift from descriptive mapping towards scenario-based decision support, in which environmental and operational data can be used to model possible future outcomes before interventions are undertaken.

The MSP toolkit presented during the conference illustrated this approach through interconnected simulations covering underwater noise, flood risk, coral bleaching, oil-spill trajectories, blue-carbon ecosystems and marine biodiversity.



- Similarly, the five-stage biofouling simulation and its machine-learning surrogate demonstrated how computationally intensive physical models can be translated into faster predictive tools for operational use. The structured UDA paradigm therefore places modelling and simulation between observation and action, enabling policymakers and operators to ask not only what is happening underwater, but what is likely to happen under different interventions.
- 3. Spatial and Economic Valuation:** The conference further demonstrated that underwater information becomes meaningful for governance when it can be translated into spatial and economic terms. *Marine Spatial Planning (MSP)* provides a mechanism for understanding how different activities and ecological systems occupy and interact within the same marine space, while *Blue Accounting* and the *Total Ocean Value Assessment (TOVA) framework* extend this analysis into the economic domain. The Blue Accounting framework presented at the conference integrates UDA as an information backbone with M&S-MSP and economic valuation, incorporating natural capital, ocean activity, ecosystem services, social equity and governance within a common accounting structure. This creates the possibility of assessing not only the economic value generated by marine development, but also the environmental degradation, opportunity costs and restoration liabilities associated with it. Structured UDA thus provides a common evidentiary basis for comparing competing uses of underwater space before decisions are implemented.
- 4. Institutional and Governance Architecture:** Data, models, and valuation frameworks can only produce public value when institutions have the capacity to absorb and act on them. A recurring concern throughout the conference was the fragmentation of underwater responsibilities among ministries, agencies, and sectors. The discussions therefore moved beyond technological capability towards institutional mechanisms capable of coordinating information, defining requirements and aligning national priorities. Proposals such as the MCDD-01 capability-definition framework, the *Defence Technology WatchTower* and a *National Nodal UDA Authority* represent different components of an emerging institutional architecture for UDA. The concluding ICWA discussion identified multi-ministry fragmentation as a major obstacle. It proposed a centralised nodal mechanism to bring together efforts across security, critical infrastructure, the economy, and ocean science. The structured character of UDA consequently requires not only technological integration but also institutional arrangements that enable knowledge to move across organisational boundaries.

5. **From Architecture to Implementation: Linking Policy, Industry and Capability:**

The final component of a structured UDA framework is its ability to move from analytical systems into operational capability. The conference repeatedly highlighted the importance of connecting scientific research, defence requirements, government policy and private-sector innovation so that emerging technologies do not remain confined to research laboratories or isolated institutional programmes. Discussions on indigenous sensors, autonomous systems, digital twins, defence innovation, and startup-industry collaboration showed the need to establish pathways to turn identified requirements into technologies, standards, services, and deployable capabilities. Similarly, the conference's emphasis on stronger coordination between Defence Public Sector Undertakings and startups highlighted the need to streamline certification, contracting and adoption pathways. A structured UDA ecosystem depends on a continuous feedback loop: data informs analysis, analysis informs planning, planning informs institutional action, and operational experience generates new data for the next cycle of decision-making.

III. *Inclusive:* Expanding the Constituency of Ocean Governance

The conference demonstrated that an effective UDA framework cannot be limited to state agencies, defence institutions and technology providers. The underwater domain is simultaneously an ecological space, an economic resource, a livelihood base, a scientific field and a site of cultural and social significance. An inclusive UDA paradigm must therefore recognise the plurality of actors, knowledge systems and interests that interact with the underwater environment. Inclusion, in this sense, is not merely participation in UDA programmes but the incorporation of diverse forms of knowledge, ecological considerations, livelihood concerns, and future human resource requirements into the architecture of underwater governance.

- 1. Ecological Systems as Stakeholders:** The conference discussions indicate that the underwater domain should not be conceptualised as an empty operational environment available solely to humans. Marine and freshwater ecosystems constitute active components of the domain whose condition directly affects security, economic activity and human wellbeing. Discussions on mangroves, biofouling, biodiversity and ecological processes therefore broaden the meaning of UDA beyond surveillance and infrastructure protection. The treatment of biofouling was particularly significant in demonstrating that ecological processes can simultaneously create operational challenges and contribute to complex underwater habitats. This suggests that ecological intelligence should be an integral component of UDA rather than an auxiliary environmental concern. Understanding habitats, biodiversity, sedimentation, water quality and ecological change can strengthen both environmental resilience and strategic decision-making.

- 2. Coastal and Riverine Livelihoods:** An inclusive UDA framework must also account for the communities whose livelihoods depend directly on underwater and coastal environments. Fisherfolk, coastal populations, and other resource-dependent communities possess forms of *Traditional Ecological Knowledge* (TEK) that can complement technology-generated datasets. The conference explicitly identified the value of incorporating localised traditional knowledge alongside modern scientific approaches. This has particular significance for fisheries management, detection of illegal, unreported and unregulated fishing, climate vulnerability and coastal resilience. Incorporating such knowledge does not imply substituting local knowledge for scientific or technological systems. Rather, it creates the possibility of a more grounded UDA architecture in which technological observation and lived experience can inform one another.
- 3. Distribution of Economic Value and Liability:** Inclusivity also requires asking not simply how much value the ocean generates, but who receives that value and who bears the associated costs. The conference's discussion of Blue Accounting provides an important basis for this perspective by connecting the ocean economy with natural capital, ecosystem services, social dimensions and governance. Large-scale infrastructure and blue-economy projects can generate substantial economic benefits while simultaneously producing ecological degradation or imposing costs upon particular communities. An inclusive UDA framework should therefore support forms of accounting that can recognise these distributional consequences. This shifts the focus from economic output alone towards a more comprehensive assessment of value, dependency, ecological liability and social equity.
- 4. Interdisciplinary and Knowledge Inclusion:** The conference further demonstrated that UDA cannot be treated as an exclusively STEM or defence-oriented field. Its advancement requires interaction between ocean sciences, engineering, artificial intelligence, and data science, alongside social sciences, law, policy, governance, archaeology, maritime heritage, and the humanities. The discussions around UNCLOS, maritime heritage and ocean governance particularly illustrate this expanded intellectual constituency. Such interdisciplinarity is important because the problems encountered underwater are rarely confined to a single disciplinary category. Questions concerning subsea infrastructure, fisheries, maritime boundaries, environmental change or underwater heritage can simultaneously involve technological, legal, ecological, economic and social dimensions. UDA therefore benefits from treating disciplinary plurality as an institutional strength rather than an organisational complication.

5. Youth, Skills and Future Capability: Finally, inclusivity must extend across generations. A UDA framework cannot remain sustainable if the knowledge and technological capabilities required to operate it are concentrated within a narrow group of existing institutions and specialists. The conference's discussions on professional shortages across areas such as AI, data science, and marine biology highlight the need to build a broader and more diverse human resource base. This makes capacity-building, skilling and career development strategic components of UDA rather than peripheral educational concerns. Creating pathways for young professionals, researchers, engineers, policy specialists and multidisciplinary practitioners can expand the talent pool available to India's emerging underwater ecosystem. In this sense, inclusivity is also an investment in future capability: the UDA architecture being developed today must create the expertise required to sustain and evolve it tomorrow.

The UDA Framework developed by MRC represents not only strategic interests and technological capabilities, but also ecosystems, communities, livelihoods, knowledge systems and future generations.

- Comprehensive UDA seeks to see the whole system.
- Structured UDA seeks to make that system intelligible and actionable.
- Inclusive UDA seeks to ensure that those who inhabit, depend upon and shape that system are represented within its governance.



Way Forward

An Outreach–Engage–Sustain Framework

The policy recommendations emerging from the seminar provide a substantive basis for moving from strategic intent to implementation. Together, they call for a UDA capability that is tropical by design, multi-use in application, indigenous and interoperable, outcome-oriented rather than platform-oriented, and able to combine modern science with validated traditional and community knowledge. From this framework emerge two practical proof points — critical subsea infrastructure protection and a sustainable Blue Economy application — each underpinned by a clear economic case built through Blue Accounting.

Most speakers at the seminar offered substantive, actionable suggestions that spoke directly to them, contributing technical evidence, policy validation, and practitioner perspectives that reinforced the seminar's original vision and purpose. Taken together, the discussions confirmed that the principal challenges facing UDA are not solely technological — they are equally institutional, spanning coordination across agencies, data governance, human capacity, financing, field validation, and the translation of research into usable decision-support systems.

MRC's 2021 report for NITI Aayog, [*Underwater Domain Awareness and Acoustic Capacity Building – A National Capacity and Capability Building Initiative*](#), had already framed UDA as a whole-of-nation effort to achieve safe, secure, and sustainable growth across India's marine and freshwater systems. In highlighting the distinctive conditions of tropical littoral waters, it called for site-specific indigenous research, coordinated policy and technology interventions, and stronger partnerships between users, academia, and industry — proposing UDA fellowships, specialised skilling curricula, Centres of Excellence, project-based learning, innovation challenges, and structured stakeholder participation as the institutional and human-capacity foundations on which UDA would need to be built.

The seminar builds directly on this foundation, aligning it with the MAHASAGAR vision and translating it into a specific set of priorities: tropical validation, multi-use data infrastructure, modelling and simulation-based Marine Spatial Planning, subsea infrastructure protection, Blue Accounting, and the integration of community knowledge. Its Way Forward carries this alignment into action through an Outreach–Engage–Sustain approach — broadening thematic awareness through outreach, deepening participation through fellowships, internships, ECOP networks and research partnerships, and sustaining progress through the UDA Skilling Document, the "100 Warriors" initiative, and application-oriented projects.



I. Outreach: Build Thematic Constituencies for the UDA framework

Outreach should move beyond general awareness-building and be organised around the specific themes identified in the policy recommendations. Each thematic stream should bring together the institutions that generate data, develop technology, frame policy, operate maritime infrastructure, and use UDA framework -derived information.

The following thematic outreach streams are proposed:

- 1. Tropical UDA and Indian Ocean Data:** Convene technical consultations with ocean-science institutions, defence organisations, universities and industry to identify gaps in Indian Ocean bathymetric, sediment, sound-speed, water-quality, biodiversity and bio-noise data. These consultations should identify candidate field-validation sites and define the minimum common datasets required for indigenous physical, chemical and biological models.
- 2. Multi-use UDA Architecture and Data Governance:** Initiate structured dialogue among the Navy, Coast Guard, relevant ministries, scientific agencies, port and waterway authorities, telecommunications providers, and industry. This stream should assess the feasibility of a national UDA coordination mechanism based on the UDA framework and develop principles for an open, controlled, and classified three-tier data architecture
- 3. Modelling and Simulation-based Marine Spatial Planning (MSP):** Conduct problem-definition workshops with maritime boards, ports, technology companies, start-ups, research institutions, and procurement agencies. The immediate objective should be to define outcome-based requirements for an integrated modelling and simulation platform that supports navigational safety, security planning, fisheries, environmental monitoring, and infrastructure development.
- 4. Critical Subsea Infrastructure:** Establish a dedicated engagement platform comprising cable owners, cable-laying companies, telecommunications operators, maritime security agencies, and seabed data specialists. This should lead to the selection of a single cable corridor or landing zone for a pilot that integrates cable mapping, acoustic monitoring, AIS data, seabed conditions, and anomaly detection.
- 5. Sustainable Blue Economy and Blue Accounting:** Organise sector-specific consultations on predictive sediment management, sustainable dredging, fisheries and aquaculture, biofouling, underwater noise, marine natural capital, and ecosystem services. Identify a port, coastal state, or economic sector for an initial Blue Accounting exercise to measure avoided losses, reduced operating costs, ecological value, and livelihood benefits.

6. Traditional Knowledge and Community Participation: Conduct district-level outreach with fishing communities, coastal organisations and local institutions. The aim should be to identify practical mechanisms for integrating community observations with satellite, buoy, hydrophone and oceanographic data, while ensuring that validated findings are returned to communities through accessible local-language advisories.

7. MAHASAGAR and the Global South: Initiate targeted exchanges with Indian Ocean littoral states and Small Island Developing States to understand their priority requirements. These exchanges should inform the development of a low-cost UDA technology and capacity-building package for applications such as dark-fleet detection, fisheries monitoring, disaster warning and marine environmental assessment.

The immediate outputs of the outreach phase should include thematic policy briefs, stakeholder maps, data gap assessments, pilot concept notes, and clearly defined research and technology problem statements.

II. Engage: Create Long-term Pathways for Participation

Engagement should convert the interest generated by the seminar into sustained participation from researchers, institutions, practitioners and communities. This requires mechanisms that enable individuals and organisations to contribute to defined UDA framework workstreams.

Fellowships should be established in priority areas such as tropical acoustic modelling, integrated physical-chemical-biological datasets, UDA data governance, MSP, Blue Accounting, subsea infrastructure protection, and the integration of Traditional Ecological Knowledge. Fellows should work with both technical and policy mentors so that their outputs can inform policy briefs, models, standards, or pilot projects.

Internships should be linked to clearly defined research and field assignments rather than stand-alone academic exercises. Interns may contribute to data curation, field validation, sediment and water-quality monitoring, fisheries modelling, ecological assessments, policy analysis, and the development of regional-language communication materials.

Academic and research partnerships should integrate the UDA framework into curricula across marine science, engineering, data science, economics, international relations, and public policy. Joint research projects, shared datasets, co-supervised dissertations, visiting fellowships, and institutional research chairs can help bridge the divide between technical and strategic education.

A dedicated Early Career Ocean Professionals (ECOP) network should connect young scientists, engineers, economists, policy researchers and maritime practitioners. Mentorship from seminar speakers and senior professionals, an annual ECOP colloquium, collaborative publications and cross-institutional placements would create a clear pathway into UDA-related careers.



Training programmes should be tailored to the audience. Short executive modules can familiarise policymakers and administrators with UDA framework applications and data requirements; specialised programmes can serve port personnel, maritime operators, researchers and industry; and foundational training can prepare students and coastal participants for field observation and data collection.

Together, these mechanisms should enable deeper penetration and mainstreaming of the UDA framework across government, academia, industry, think tanks and coastal institutions. The two proposed pilots should serve as practical engagement platforms, with multidisciplinary teams working towards defined deliverables and measurable security, economic and ecological outcomes.

III. Sustain: Build Skills, Institutions and Demonstrable Practice

Sustaining the UDA framework will require a long-term human-capacity pipeline and repeated opportunities to apply knowledge to real-world problems.

The Maritime Research Center has developed the UDA Skilling handbook as a living competency and implementation roadmap. It identifies foundational, intermediate and advanced competencies; maps relevant occupational roles; recommends curricula and certification pathways; and aligns training institutions with government, research and industry requirements. It should also be periodically revised to reflect technological developments and lessons from field projects.

MRC's "**100 Warriors**" initiative can provide the grassroots foundation for this effort. Participants should be trained to observe and record basic physical, acoustic, chemical and biological indicators, including sediment conditions, water quality, ecological changes and unusual underwater activity. Initial cohorts may be formed in selected coastal districts, with observations incorporated into formal systems only after scientific validation. Information should then be returned to participating communities through useful advisories and in local languages.

Project-based learning should become the primary method for translating training into capability. Multidisciplinary teams of students, fellows, professionals and community participants should work on defined UDA challenges using real datasets and field conditions. Projects could include tropical model validation, sediment forecasting, cable corridor risk assessment, fisheries suitability mapping, underwater noise monitoring, or a pilot Blue Accounting exercise. The strongest projects should advance to prototypes, policy studies, start-up opportunities, or components of the two national proof points.

Sustainability will also require a shared knowledge repository, alumni and mentor networks, periodic institutional working groups, train-the-trainer programmes, and an annual review of progress. Evaluation should track not only the number of people trained but also the number of models validated, datasets created, curricula adopted, community observations integrated, prototypes developed, and measurable value demonstrated through pilots.

It is recommended that a national Data Analysis Centre be established as the institutional and analytical backbone of the country's UDA architecture. The Centre should collect, integrate, analyse, and securely disseminate data on underwater activity, fixed subsea infrastructure, and seabed topography. Subject to national-security and data-sharing protocols, appropriate analytical products should also be incorporated into UDA offerings for littoral partner countries, thereby strengthening regional maritime security, infrastructure protection, environmental management, and long-term institutional sustainability.

Through this Outreach–Engage–Sustain framework, the seminar's recommendations can evolve into a cumulative implementation process—one that builds awareness of specific challenges, engages the right institutions and people in practical work, and sustains capability through skills, evidence, partnerships, and demonstrable outcomes. An initial sequence could begin with thematic outreach, stakeholder and data mapping, implementation of the UDA Skilling, and selection of pilot locations. Fellowships, internships, ECOP engagement, and academic partnerships can then be aligned with the selected pilots. Evidence generated through these activities should inform the gradual institutionalisation of data governance arrangements, outcome-based procurement, and regional capacity sharing under MAHASAGAR.

MEDIA COVERAGE REPORT

Overview

This report presents screenshots and links to media stories published across leading national and regional publications, including *The Times of India*, *The Indian Express*, *The Financial Times*, and *Mirror Now*. The National Seminar on “Advancing Underwater Domain Awareness (UDA) Framework for India’s MAHASAGAR Vision and its Realisation” also received extensive coverage in leading print and digital media outlets, including *The Times of India*, *The Indian Express*, *Democracy Now*, *Maharashtra Times*, and *Loksatta*. The breadth of this coverage reflects the significance and relevance of the National Seminar to India’s evolving strategic and security landscape, as well as to stakeholders across industry, academia, think tanks, government, and the broader maritime ecosystem.

Key Themes Highlighted in the Media Coverage

The media coverage largely focused on three key aspects that emerged from the discussions and deliberations at the National Seminar:

1. Vulnerability of Undersea Cables and the Need for Robust UDA Capabilities

The increasing vulnerability of undersea cables to disruption and the need for India to develop stronger Underwater Domain Awareness (UDA) capabilities to safeguard critical underwater infrastructure.

2. Emerging Career Opportunities for Young Professionals in UDA

The growing scope for employment, skilling, research, and professional opportunities for young people in the emerging field of Underwater Domain Awareness.

3. Expanding UDA Beyond Security and Surveillance

The need to evolve UDA beyond a conventional security and surveillance framework and adopt a more comprehensive, multidisciplinary approach encompassing environmental, economic, technological, scientific, governance, and societal dimensions.

Undersea cables vulnerable to disruption, India needs robust underwater domain awareness: Admiral Karambir Singh (Retd)

Pune, Correspondent : With undersea communication cables carrying a growing share of the world's internet traffic and data, India must urgently strengthen its underwater domain awareness and develop seabed warfare capabilities to protect critical maritime infrastructure, former Chief of Naval Staff Admiral Karambir Singh (Retd) said on Monday.

Undersea cables are already 80 to 90 per cent utilized, with demand continuously rising. Given this high utilization, even a single severed cable can cause severe, widespread disruption," Singh said, highlighting the growing vulnerability of India's subsea networks.

He was speaking at a program titled 'Advancing Underwater Domain Awareness: Framework for India's Mahasagar Vision and its Realization', organized by the Maritime Research Center (MRC), Pune, and the Indian Council of World Affairs (ICWA), New Delhi.

Vice Admiral Anil Jaggi, Commandant of the National Defense Academy, Dr. (Cdr) Arnab Das from MRC and Arundha Singh from ICWA were also present on the dais.

Singh said the protection of undersea cables must become a strategic priority, noting that the United Nations General Assembly has recognized undersea cables as critical information infrastructure requiring protection.

He called for India to proactively develop seabed warfare strategies, drawing lessons from the French and Royal Navy, while also supporting international cooperative frameworks such as Singapore's Guidance for Underwater Infrastructure Defense

Exchange.

Managing the unique challenges of the Indian Ocean Region requires transforming our naval approach towards comprehensive underwater domain awareness," Singh said.

He pointed out that the concentration of entry and exit routes through vulnerable choke points, coupled with extensive shallow waters, creates complex operational challenges for sonar and mine warfare.

During his inaugural keynote address, Vice Admiral Anil Jaggi, Commandant of the National Defense Academy, said the need for UDA had become increasingly important as India's maritime vision evolved from the Sagor doctrine to the expanded Mahasagar framework. The ocean beneath the surface will define future security and prosperity," he said.

Jaggi noted that seas account for 80pc of global merchandise trade by volume, while nearly 99pc of the world's data, including internet traffic, is carried through submarine networks.

Despite the strategic and economic importance of the underwater domain, more than 80pc of the world's underwater environment remains unexplored, unobserved and unmapped, he said.

Flagging emerging security challenges in the Indian Ocean Region, Jaggi pointed to increasing extra-regional activity, particularly by China.

He said China operates approximately 64 ocean-surveying vessels for seabed, hydrographic and oceanographic data collection. Chinese-origin autonomous underwater vehicles and gliders have also been recovered in Indonesia and the Philippines near

strategic sea lanes and choke points.

Jaggi proposed a 'JAI' framework for India's UDA efforts, J for Jointness across services, agencies and partners, A for Atmanirbharta or self reliance in technologies and platforms, and I for Innovation.

He said such an approach would strengthen India's ability to detect and counter underwater threats, protect maritime infrastructure and communication networks, secure sea lanes and support credible deterrence.

The underwater domain also presents significant economic opportunities, Jaggi said, highlighting deep-sea exploration, critical minerals and the blue economy.

India has deep-sea exploration contracts covering more than 90,000 sq km in the Central Indian Ocean Basin and along the Carlsberg Ridge, giving it access to polymetallic nodules and rare earth elements.

Drawing attention to China's 2020 Fendouzhe crewed-submersible dive to the Challenger Deep, Jaggi said India must accelerate its own capabilities in extreme depth exploration.

He also called for greater focus on fisheries, maritime transport, coastal tourism, offshore renewable energy and underwater infrastructure.

Dr (Cdr) Arnab Das, Founder, MRC, said India's UDA framework should adopt a regional approach involving all relevant stakeholders, while accelerating capacity and capability building, localised research and development and innovation.

"Security and growth have to be integrated while addressing classified data concerns and keeping the greater public good in mind," he said.

Democracy Now

समुद्राखालील धोक्यांविषयी अधिक सजगतेची गरज

संक्षेप

पुणे : 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' असे माजी नौदलप्रमुख अॅडमिरल कर्मवीर सिंह यांची अपेक्षा आहे. त्यांनी पुणे येथील 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' या विषयावर एक कार्यक्रम आयोजित केला. या कार्यक्रमात अॅडमिरल कर्मवीर सिंह यांनी आपल्या भाषणात समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली. त्यांनी म्हटले की, समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देणे हे भारताच्या सुरक्षा आणि आर्थिक स्थिरतेसाठी अत्यंत महत्वाचे आहे. त्यांनी यावेळी समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली.

संक्षेप

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Loksatta

समुद्राखालून जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे

प्रधान वृत्तसंवा

पुणे, दि. १० - 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' असे माजी नौदलप्रमुख अॅडमिरल कर्मवीर सिंह यांची अपेक्षा आहे. त्यांनी पुणे येथील 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' या विषयावर एक कार्यक्रम आयोजित केला. या कार्यक्रमात अॅडमिरल कर्मवीर सिंह यांनी आपल्या भाषणात समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली. त्यांनी म्हटले की, समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देणे हे भारताच्या सुरक्षा आणि आर्थिक स्थिरतेसाठी अत्यंत महत्वाचे आहे. त्यांनी यावेळी समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली.

संक्षेप

पुणे : 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' असे माजी नौदलप्रमुख अॅडमिरल कर्मवीर सिंह यांची अपेक्षा आहे. त्यांनी पुणे येथील 'समुद्राखाल जाणाऱ्या डेटा केबल्सच्या सुरक्षेला प्राधान्य द्यावे' या विषयावर एक कार्यक्रम आयोजित केला. या कार्यक्रमात अॅडमिरल कर्मवीर सिंह यांनी आपल्या भाषणात समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली. त्यांनी म्हटले की, समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देणे हे भारताच्या सुरक्षा आणि आर्थिक स्थिरतेसाठी अत्यंत महत्वाचे आहे. त्यांनी यावेळी समुद्राखालील डेटा केबल्सच्या सुरक्षेला प्राधान्य देण्याची गरज व्यक्त केली.

Prabhat

ONLINE MEDIA COVERAGE

TOI The Times of India

Underwater data crucial for India's interests, says former Army chief



Former Chief of Army Staff General Manoj Pande delivers a talk during a seminar organised by Maritime Research Center in Pune on Tuesday

Pune: Former Chief of Army Staff General Manoj Pande on Tuesday said India must harness underwater information, gleaned from a specialist data set, to improve maritime security, navigational safety, protection of critical infrastructure and sustainable use of marine resources.

Speaking at a seminar organised by Maritime Research Center here, Pande said the underwater domain was largely invisible, dynamic and difficult to monitor, but contained critical infrastructure, ecosystems, natural resources and activities that have a direct bearing on

India's security and economic interests. "Underwater information needs to move from being a specialist data set to becoming actionable operational knowledge," he said.

The objective of Underwater Domain Awareness (UDA) should not be merely to collect more data, but to ensure that information enables authorities to take better, faster decisions. "The real question should be, what decisions will this information enable us to take," he said.

Pande said UDA should be developed as a shared knowledge framework — encompassing information, technology, institutions and expertise — to build a complete picture of underwater activities.

The Times of India



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TOI The Times of India

A single undersea cable cut could cause widespread disruption, warns former Navy chief



Former Navy chief Admiral Karambir Singh delivers a talk organised by Maritime Research Centre

Pune: A single cut in an undersea communication cable could cause severe and widespread disruption to India's digital and communications infrastructure, former Chief of Naval Staff Admiral Karambir Singh (Retd) warned on Monday, stressing the urgent need to strengthen underwater surveillance and develop capabilities to protect the seabed.

"Undersea cables are already 80-90% utilized, with demand continuously rising. Given this high utilization, even a single severed cable can cause severe, widespread disruption," Singh said. He was speaking at

a programme, Advancing Underwater Domain Awareness Framework for India's Mahasagar Vision and its Realization, organised by the Maritime Research Centre (MRC), Pune, and the Indian Council of World Affairs (ICWA), New Delhi.

Singh said the protection of undersea cables must become a strategic priority as submarine networks carry a substantial share of the world's internet traffic and data. He noted that the United Nations General Assembly has recognised undersea cables as critical information infrastructure requiring protection. He called for India to proactively develop seabed warfare capabilities, drawing lessons from the French and Royal Navy, and to strengthen international cooperation for protecting underwater infrastructure.

The Times of India



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Undersea cables vulnerable to disruption — Why India needs seabed warfare capabilities

India must prioritize the protection of undersea cables by enhancing underwater domain awareness and developing seabed warfare capabilities to safeguard critical maritime infrastructure and counter emerging security threats.

Written by **FE Bureau**

Updated: August 18, 2026 09:05 IST



Vice Admiral Anil Jaggi, Commandant of the National Defence Academy, flagged emerging security challenges in the Indian Ocean Region.

Prefer **FE**     

Protection of undersea cables must become a strategic priority for India, and it must urgently strengthen its underwater domain awareness and develop seabed warfare capabilities to protect critical maritime infrastructure, former Chief of Naval Staff, Admiral Karambir Singh (Retd), said on Monday.

Undersea cables are part of the critical information infrastructure, requiring protection, so the country must proactively develop seabed warfare strategies, drawing lessons from the French and Royal Navy, while also supporting international cooperative frameworks such as Singapore's Guidance for underwater infrastructure defence exchange, Singh said at the Advancing Underwater Domain Awareness Framework conference organised by the Maritime Research Center (MRC), Pune, and the Indian Council of World Affairs (ICWA), New Delhi.

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HOME / PUNE / NEW CAREER OPPORTUNITIES FOR YOUNGSTERS IN UNDERWATER DOMAIN

New Career Opportunities for Youngsters in Underwater Domain



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Pune, 18th August 2026: India's rapidly expanding underwater and blue economy sectors could create several lakh employment opportunities for young professionals by 2030 and beyond, with emerging areas such as artificial intelligence, underwater data analytics, climate change, aquaculture, freshwater **El management**, sediment management and marine infrastructure opening up new **El career** pathways, said Dr. (ICdr) Anub Das, Founder of the Maritime Research Centre, Pune.

He was speaking at the Advancing Underwater Domain Awareness Framework for India's Mahasagar Vision and its Realization, organized by Maritime Research Centre in association with the Indian Council of World Affairs at the Sumant Moolgaonkar Auditorium at MCCIA on Senapati Bapat Road.

Highlighting the need to prepare youngsters for these emerging opportunities, Dr. Das said India required a skilled workforce capable of combining domain knowledge with advanced technologies to solve real-world problems.

"How we can use AI to solve these real-world problems is what we need to look at. Domain knowledge is going to make it more real-world problem-solving rather than just administrative," he said.

According to Dr. Das, several sectors offer significant opportunities for young professionals. Freshwater systems and management will require expertise to address water quality, urbanization, siltation and urban flooding. He pointed out that cities such as Pune spend nearly Rs.900 crore on managing urban floods, underlining the scale of the challenge and the need for specialized professionals.

The marine sector and aquaculture also offer considerable scope for the application of advanced science, technology and digital solutions to improve productivity, sustainability and resilience to climate change. Deep-sea mining is another emerging area where India needs to develop domestic expertise and reduce its dependence on external capabilities.

The Financial Express



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Puneekar News



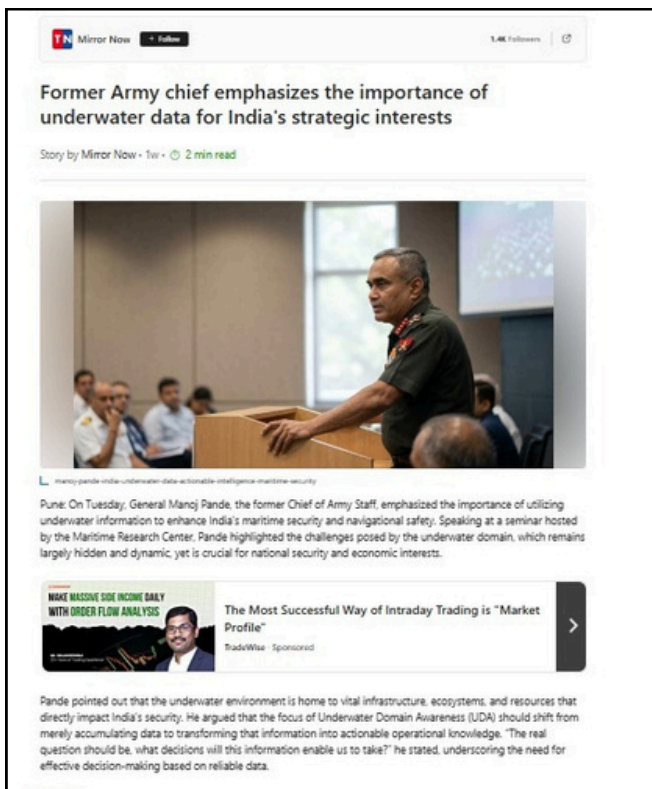
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Former Navy chief cautions that a single severed undersea cable could lead to significant disruptions

Story by Mirror Now • 2w • 2 min read



In a stark warning regarding the fragility of India's digital infrastructure, former Chief of Naval Staff Admiral Karambir Singh (Retd) emphasized the critical need for enhanced underwater surveillance and protective measures for undersea communication cables. Speaking at a recent event in Pune, Singh highlighted that a single cut in these cables could lead to significant disruptions across the nation's communications and digital services.

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During the program titled "Advancing Underwater Domain Awareness Framework for India's Mahasagar Vision and its Realization," organized by the Maritime Research Centre (MRC) and the Indian Council of World Affairs (ICWA), Singh pointed out that undersea cables are currently operating at 80-90% capacity, with demand on the rise. He stated, "Given this high utilization, even a single severed cable can cause severe, widespread disruption." This assertion underscores the urgency of addressing vulnerabilities in the underwater communication network.

Mirror Now

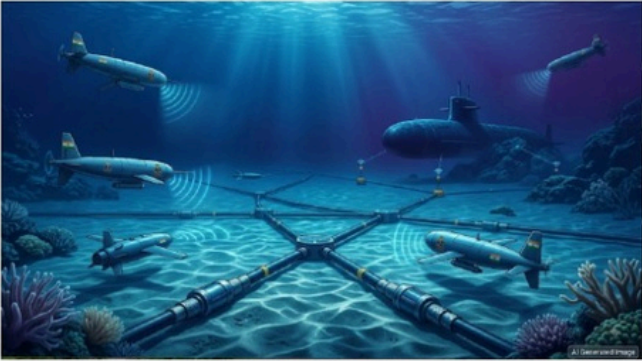


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Underwater Domain : भारताच्या समुद्राखालील नेटवर्कसमोरील वाढता धोका, हिंद महासागरात चीनचे आव्हान !

पुण्यातील विशेष कार्यक्रमात त्यांनी या सुरक्षेच्या आव्हानांकडे लक्ष वेधले.

Written by **लोक्सत्ता टीम**
August 18, 2026 12:26 IST



भारताच्या समुद्राखालील नेटवर्कला धोका (ai generated images)

पुणे : 'समुद्रातून जाणाऱ्या केबलचा वापर सध्या ८० ते ९० टक्क्यांपर्यंत होत असून, भविष्यात त्याच्या मागणीत सातत्याने वाढ होणार आहे. त्यामुळे एखादी केबल तुटली किंवा निष्क्रिय झाल्यास त्याचा गंभीर परिणाम होऊ शकतो,' असे सांगून माजी नौदलप्रमुख अॅडमिरल करमबीर सिंह यांनी भारताच्या समुद्राखालील नेटवर्कसमोरील वाढत्या धोक्याकडे लक्ष वेधले. भारताने पाण्याखालील क्षेत्राविषयीची जागरूकता (अंडरवॉटर डोमेन अव्हेरनेस) तातडीने अधिक सक्षम करणे, महत्त्वपूर्ण सागरी पायाभूत सुविधांच्या सुरक्षेसाठी समुद्रतळावरील युद्धतंत्राची क्षमता विकसित करण्याची गरजही त्यांनी व्यक्त केली.

Loksatta



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New Undergraduate Course : 'अंडरवॉटर डोमेन'मधील संधींसाठी चार वर्षांचा पदवी अभ्यासक्रम; राज्य कौशल्य विद्यापीठाची मान्यता

पाण्याखालील क्षेत्रातील वाढत्या संधी आणि रोजगार लक्षात घेता पुण्यातील मेरिटाइम रिसर्च सेंटरने चार वर्षांचा विशेष पदवी अभ्यासक्रम विकसित केला आहे.

Written by **दीक्षा दास**

August 19, 2026 11:35 IST



अंडरवॉटर डोमेन क्षेत्रातील चार वर्षांचा नवीन पदवी अभ्यासक्रम (एआयएमईल छायाचित्र)



पुणे : भारतात अंडरवॉटर डोमेन अर्थात पाण्याखालील क्षेत्रातील वाढत्या संधी विचारात घेऊन पुण्यातील मेरिटाइम रिसर्च सेंटरने चार वर्षांचा पदवी अभ्यासक्रम विकसित केला आहे. या अभ्यासक्रमाला रतन टाटा महाराष्ट्र राज्य कौशल्य विद्यापीठाची मान्यता मिळाली आहे.

मेरिटाइम रिसर्च सेंटरचे संस्थापक, कमांडर डॉ. अर्नब दास यांनी ही माहिती दिली. अॅडव्हान्स्ड अंडरवॉटर डोमेन अवेअरनेस फ्रेमवर्क फॉर इंडियाज महासागर किंज अँड इट्स रिअलप्लेस या कार्यक्रमात ते बोलत होते. पदवी अभ्यासक्रमात नील अर्थव्यवस्था (ब्ल्यू इकॉनॉमी), हवामान बदल, गाळ व्यवस्थापन, गोड्या पाण्याचे व्यवस्थापन, पाण्याखालील ध्वनी व्यवस्थापन आणि एआय व पाण्याखालील डेटा विश्लेषण अशा सहा विशेष अभ्यासक्रमांचा समावेश आहे. रोजगाराच्या संधी आणि उद्योगाच्या गरजा लक्षात घेऊन विद्यार्थ्यांना रोजगारासाठी सक्षम करण्याच्या दृष्टीने अभ्यासक्रमाची रचना करण्यात आली आहे. तसेच 'एआय आणि अंडरवॉटर डेटा अॅनलिटिक्स' या विषयातील सहा महिन्यांचा विशेष अभ्यासक्रमही सुरू करण्यात आला आहे. पुण्यातील कोरेगाव भीमा येथील 'सेंटर ऑफ एक्सलन्स'च्या माध्यमातून हा अभ्यासक्रम ऑनलाइन, ऑफलाइन आणि हायब्रिड पद्धतीने उपलब्ध करून देण्यात आला आहे.

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एआय आणि अंडरवॉटर डेटा अॅनलिटिक्स हा विशेष अभ्यासक्रम सादर

पदवी अभ्यासक्रम देखील तयकरत **नवीन भाषा शिक्षणसंस्था संस्थाने खोले**

पुणे : भारतातील ह्याक्टचे विस्तारत असलेल्या अंडरवॉटर डोमेन अर्थात पाण्याखालील आणि नील अर्थव्यवस्था क्षेत्रात २०३० पर्यंत आणि त्यानंतर तरुणांसाठी तांत्रिक रोजगाराच्या संधी निर्माण होण्याची वाक्यत आहे. कृत्रिम बुद्धिमत्ता, पाण्याखालील डेटा विश्लेषण, हवामान बदल, मत्स्यपालन, गोड्या पाण्याचे व्यवस्थापन, गाळ व्यवस्थापन आणि सागरी पायाभूत सुविधा यासारख्या नव्या क्षेत्रांमुळे करिअरच्या अनेक नव्या वाटा खुलू शकत आहेत. असे मेरिटाइम रिसर्च सेंटर, पुणे या संस्थेचे संस्थापक डॉ. (कमांडर) अर्नब दास यांनी सांगितले.

पुण्यातील मेरिटाइम रिसर्च सेंटर आणि नवी दिल्लीतील इंडियन कॉन्सिल ऑफ वर्ल्ड अफेयर्स यांच्या संयुक्त विद्यमाने आयोजित अॅडव्हान्स्ड अंडरवॉटर डोमेन अवेअरनेस फ्रेमवर्क फॉर इंडियाज महासागर किंज अँड इट्स रिअलप्लेस या कार्यक्रमात ते बोलत होते. सेनापती ब्रायट रस्तावरील एमसीसीआयएच्या सुमेल मुखागळकर संभागात सादर कार्यक्रम संपन्न झाला.

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पुणे : ‘अंडरवॉटर डोमेन अवेअरनेस’ ही संकल्पना केवळ सुरक्षा आणि देखरेखीच्या चौकटीपुरती मर्यादित न राहता सागरी पर्यावरण, जलवाहतुकीची सुरक्षितता, सागरी संसाधनांचा शाश्वत वापर आणि महत्वाच्या पायाभूत सुविधांचे संरक्षण यांचा समावेश असलेल्या व्यापक स्वरूपात विकसित होणे आवश्यक आहे, असे भारताचे माजी लष्कर प्रमुख जनरल मनोज पांडे यांनी मंगळवारी सांगितले. यावेळी मेरीटाइम रिसर्च सेंटरचे संस्थापक डॉ. (कमांडर) अर्नब दास उपस्थित होते.

पुण्यातील मेरीटाइम रिसर्च सेंटर आणि नवी दिल्लीतील इंडियन कॉन्सिल ऑफ वर्ल्ड अफेयर्स यांच्या संयुक्त विद्यमाने आयोजित अॅडव्हान्स्ड अंडरवॉटर डोमेन अवेअरनेस प्रेमिअर फॉर इंडियाज महासागर विज्ञान अँड इट्स रीअलायझेशन भारताची समुद्रावरील वाढती अवलंबित्वाची गरज आणि त्याचेवेली अधिकाधिक गुंतणुकीचे, आखनात्मक तसेच पर्यावरणीयदृष्ट्या असुरक्षित होत घातलेले सागरी क्षेत्र याकडे पांढे लक्ष वेधले. सदर कार्यक्रम सेनापती बापट रस्त्यावरील सुमंत मुलगावकर सभागृहात संपन्न झाला. [नकाशे अभ्यासावे](#)

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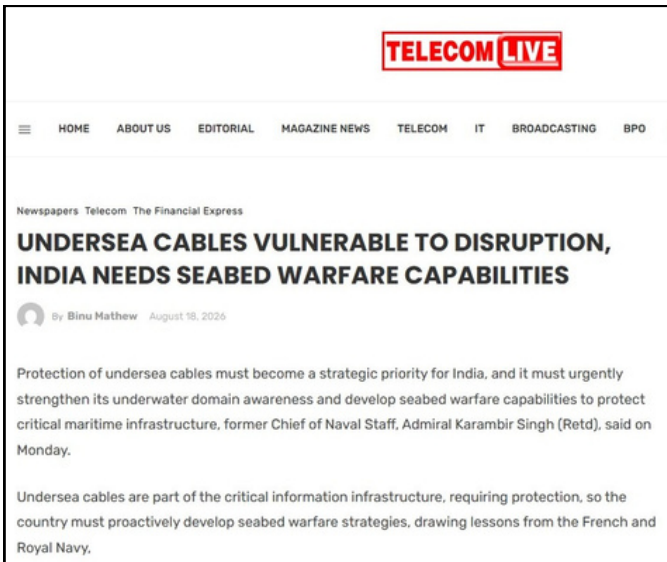
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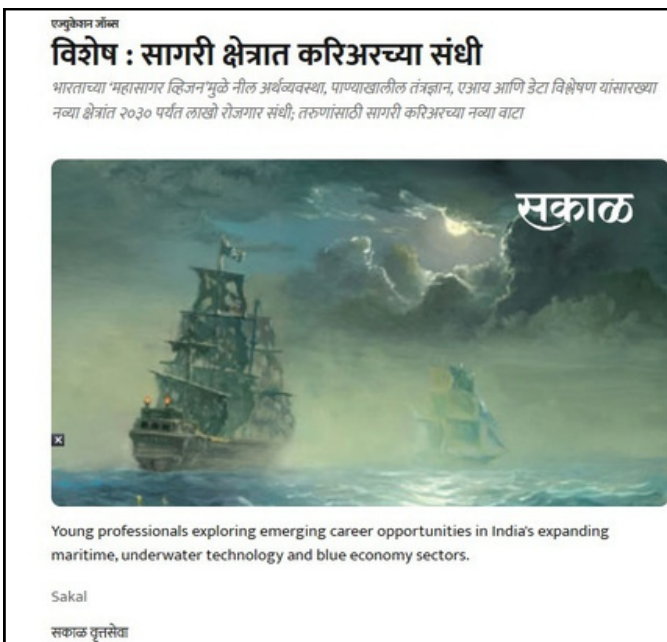
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अंडरवाटर डोमेन अवेअरनेस यह संकल्पना सिर्फ सुरक्षा और देखरेख के दायरे तक सीमित नहीं होनी चाहिए, बल्कि सागरी पर्यावरण, जलवायुतक सुरक्षा, सागरी संसाधनों का शाश्वत उपयोग और पायाभूत सुविधाओं के विकास के नजरिए से देखना चाहिए, यह विचार भूतपूर्व लश्कर प्रमुख जनरल मनोज पांडे ने व्यक्त किए। मैरीटाइम रिसर्च सेंटर और नई दिल्ली स्थित इंडियन काउन्सिल ऑफ वर्ल्ड अफेयर्स द्वारा आयोजित, कार्यक्रम में वे बोले रहे थे। इस मौके पर मैरीटाइम रिसर्च सेंटर के फाउंडर डॉ. (कमांडर) अर्नब दास मौजूद थे। यह कार्यक्रम सेनापति बापट रोड पर सुमंत मुलगावकर सभागार में संपन्न हुआ। जनरल पांडे ने कहा कि अंडरवाटर डोमेन अवेअरनेस एक शेपई नौलैज सिस्टम है जो जानकारी, टेक्नोलॉजी, संस्थानों और एक्सपर्टीज को एक साथ लाता है। यह समुद्र की सतह के नीचे हो रहे डेक्सप्लेट की पूरी तस्वीर दे सकता है। हालांकि, ऐसा सिस्टम किसी एक संगठन की जिरमेदारी नहीं हो सकता। क्योंकि अंडरवाटर डोमेन डिफेंस, सिफिंग, पोर्ट, फिशरीज, पर्यावरण सुरक्षा, साइबरसेफ्टी, मरीन इंफ्रस्ट्रक्चर और बड़ी भू-इकोनॉमी से जुड़ा है। उन्होंने कहा कि अंडरवाटर डोमेन के बारे में अयाद स्टैंड जानकारी से सुरक्षित सिफिंग, समुद्री संसाधनों का अयाद कुशल इस्तेमाल, जलवायु परिवर्तन की सुरक्षा और पर्यावरण से जुड़े अयाद अस्तरदार फैसले लेने में मदद मिलेगी। उन्होंने कहा कि यह तरीका नॉर्थ ईस्ट इंडिया में इनलैंड वॉटरवे प्रोजेक्ट्स के लिए खास तौर पर जरूरी हो सकता है।

‘अंडरवॉटर डोमेन अवेअरनेस’ केवल सुरक्षा आणि देखरेखीपुरते मर्यादित न राहता व्यापक स्वरूपाचे असावे – जनरल मनोज पांडे

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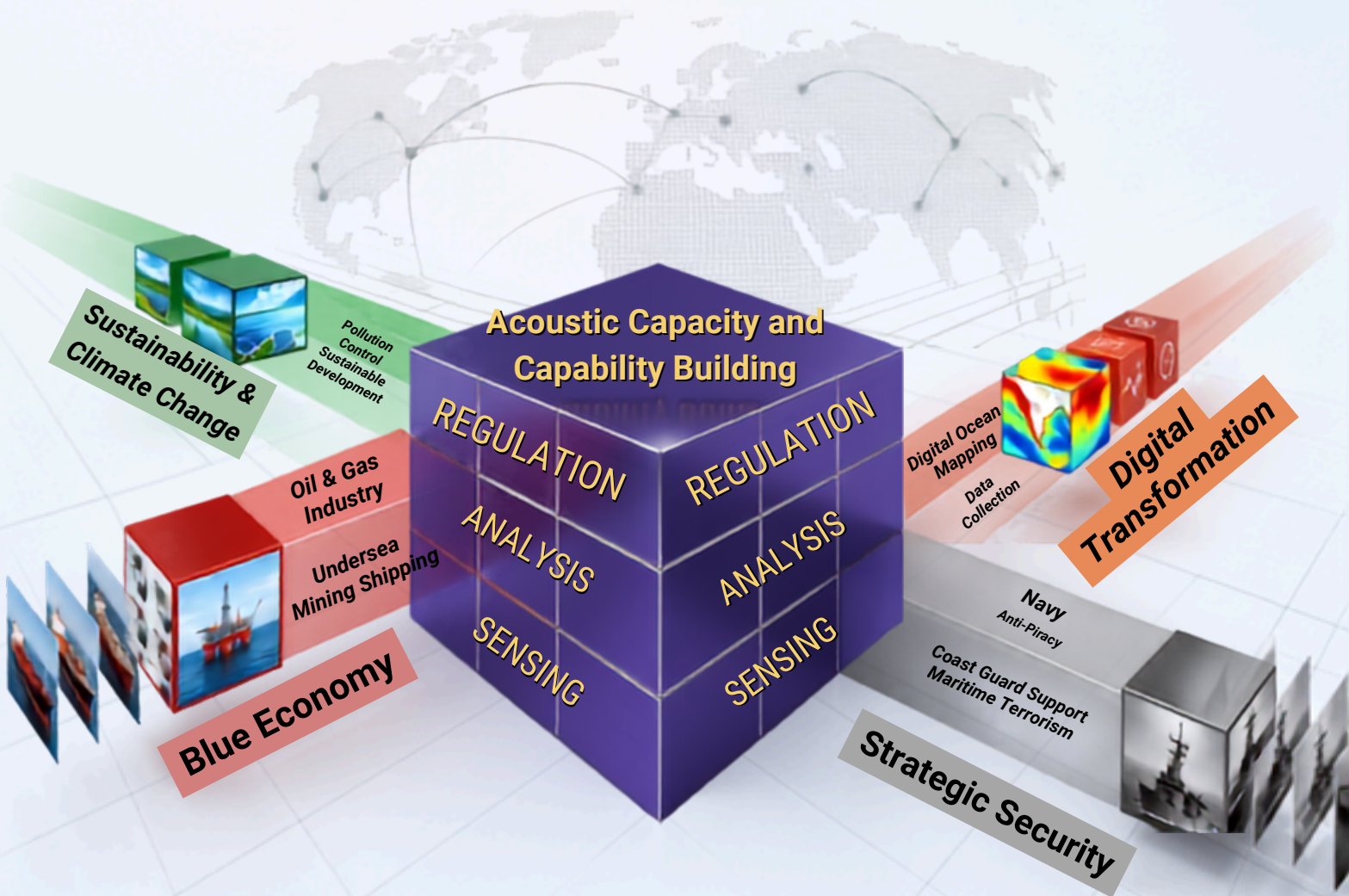
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