

**MARITIME RESEARCH CENTER (MRC), PUNE**  
*in collaboration with*  
**INDIAN COUNCIL OF WORLD AFFAIRS (ICWA), NEW DELHI**

**CONCEPT NOTE**

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

*A National Seminar*  
**August 17–18, 2026**  
**Sumant Moolgaokar Auditorium,  
MCCIA Trade Tower, Pune - 411016**

## 1.1 Introduction

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The underwater domain remains one of the least understood frontiers of the modern era. The strategic decisions made in this space over the coming decade will directly propel the Blue Economy, reinvigorate national infrastructure resilience, inform resource planning, and determine sustainable co-existence between human activity and marine ecosystems. Positioned at a critical geopolitical and technological juncture, the world faces both unprecedented sub-surface volatility and vast strategic opportunities. This national seminar provides a dedicated platform to examine the complex security, economic, and scientific dynamics of our oceans; domains we are only beginning to comprehensively decode.

India's maritime doctrine has progressively evolved from SAGAR (Security and Growth for All in the Region) to the MAHASAGAR vision (Mutual and Holistic Advancement for Security and Growth Across Regions). MAHASAGAR projects India's strategic, economic, and technological leadership across the broader Indian Ocean Region (IOR) and the Global South. However, realizing this ambitious vision requires bridging a fundamental operational gap: Underwater Domain Awareness (UDA). The sub-surface environment—encompassing acoustic tracking, seabed infrastructure protection (such as submarine communication cables), marine biodiversity preservation, port noise management, and sustainable blue economy monitoring; remains heavily under-monitored in the absence of a unified, multidisciplinary framework.

Jointly organized by the Maritime Research Center (MRC), Pune, and the Indian Council of World Affairs (ICWA), New Delhi, this two-day national seminar brings together policy strategists, defense leadership, economists, marine scientists, and research fellows. The dialogue aims to align technical research in underwater acoustics and marine science with high-level geopolitics and national security strategy.

## 1.2 Objectives

- **Strategic Alignment:** Map the MRC UDA framework directly onto the key pillars of India's MAHASAGAR vision.
- **Stakeholder Convergence:** Foster dialogue across the four core UDA pillars: Maritime Security, Blue Economy, Marine Environment/Disaster Management, and Science & Technology (Research & Innovation).
- **Capacity Building:** Highlight career paths, academic fellowships, and skilling avenues for the next generation of ocean policy leaders and underwater technologists.
- **Policy Deliverables:** Synthesize actionable policy recommendations for subsea governance, marine biofouling standards, acoustic mapping, and blue accounting frameworks.

**Dates:** August 17–18, 2026

**Venue:** Sumant Moolgaokar Auditorium, MCCIA Trade Tower, Pune - 411016

## Seminar Programme Schedule

### Day 1: Strategic Foundations of UDA (August 17)

| Time          | Session & Topic                                                                                                               | Panelists / Key Speakers                                                                                                                                                                                                    |
|---------------|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9:30 – 9:35   | Welcome Remarks                                                                                                               | Dr. (Cdr) Arnab Das, <i>Founder &amp; Director, MRC</i>                                                                                                                                                                     |
| 9:35 – 9:50   | Keynote Address                                                                                                               | Vice Admiral Anil Jaggi AVSM, <i>Commandant of the National Defence Academy</i>                                                                                                                                             |
| 9:50 – 10:00  | Concluding Remarks                                                                                                            | ICWA Representative                                                                                                                                                                                                         |
| 10:00– 11:00  | <b>Session 1:</b> Evolution of UDA Framework & Global Relevance                                                               | <b>Main Presenter:</b> Dr. (Cdr) Arnab Das ( <i>Founder &amp; Director, MRC</i> );<br><b>Session Chair:</b> Admiral Karambir Singh PVSM, AVSM, IN (Retd.) - <i>Former Chief of Naval Staff</i>                              |
| 11:00 – 11:30 | High Tea                                                                                                                      |                                                                                                                                                                                                                             |
| 11:30– 13:00  | <b>Session 2:</b> Building the Blue Sun - UDA and its Place in an Evolving World Order                                        | <b>Main Presenter:</b> Mr. Callistine Lewis, <i>Head of Publications, MRC</i><br><b>Session Chair:</b> Amb. Anup Mudgal (Retd.) - <i>Former Indian Diplomat &amp; Member of the Blue Economy Task Force at FICCI, India</i> |
| 13:00 – 14:00 | Lunch Break                                                                                                                   |                                                                                                                                                                                                                             |
| 14:00 – 15:30 | <b>Session 3:</b> Modelling & Simulation based Maritime Spatial Planning (MSP)                                                | <b>Main Presenter:</b> Mr. Shridhar Prabhuraman, <i>Deputy Director, MRC</i><br><b>Session Chair:</b> Mr. Aditya Kumar Sinha, <i>Executive Director, CDAC Mumbai</i>                                                        |
| 15:30 – 15:45 | <b>Keynote Speech:</b> "Instrument & Institution: Defining, Developing, Acquiring and Operating UDA as a Military Capability" | <b>Speaker:</b> Vish Sahasranamam, <i>Co-Founder &amp; CEO, Forge Innovation &amp; Ventures</i>                                                                                                                             |
| 15:45 – 16:15 | Evening Tea                                                                                                                   |                                                                                                                                                                                                                             |
| 16:15 – 17:30 | <b>Session 4:</b> Career Opportunities, Skilling & Capacity Building in UDA                                                   | <b>Main Presenter:</b> Mr. Callistine Lewis; <i>Head of Publications, MRC</i><br><b>Session Chair:</b> Mr. Hrishikesh Dhande, <i>Deputy Director, Pune International Center</i>                                             |

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

| Time          | Session & Topic                                                            | Panelists / Key Speakers                                                                                                                                                                                                                                                   |
|---------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9:30 – 9:40   | Opening Remarks                                                            | Gen. Manoj Pande PVSM AVSM VSM (Retd) -<br><i>Former Chief of Army Staff of the Indian Army</i>                                                                                                                                                                            |
| 9:40 – 10:40  | <b>Session 5:</b> Sediment Management & Navigational Safety                | <b>Main Presenter:</b> Mr. Romit Kaware, <i>Research Fellow, MRC</i><br><b>Session Chair:</b> Lieutenant General AK Ramesh SM, <i>Commandant of the College of Military Engineering, Pune</i>                                                                              |
| 10:40 – 11:10 | High Tea                                                                   |                                                                                                                                                                                                                                                                            |
| 11:10 – 12:40 | <b>Session 6:</b> Blue Accounting & Marine Environmental Economics         | <b>Main Presenter:</b> Ms. Catherine J, <i>Head of Research, MRC</i><br><b>Session Chair:</b> Dr. Ajit Ranade, <i>Economist and Former Vice-Chancellor of Gokhale Institute of Politics and Economics, Pune</i>                                                            |
| 12:40 – 13:40 | Lunch Break                                                                |                                                                                                                                                                                                                                                                            |
| 13:40 – 15:10 | <b>Session 7:</b> Biofouling, Anthropogenic Noise & Ecological Resilience  | <b>Main Presenter:</b> Mr. Suchir Mamidala, <i>Research Fellow, MRC</i><br><b>Session Chair:</b> Dr. Varsha Kelkar-Mane, <i>Professor &amp; Head, Department of Biotechnology; Deputy Director, Centre for Excellence in Marine Studies (CEMAS), University of Mumbai.</i> |
| 15:10 – 15:40 | Evening Tea                                                                |                                                                                                                                                                                                                                                                            |
| 15:40 – 17:10 | <b>Session 8:</b> Sustainable Fisheries, Aquaculture & Marine Bioresources | <b>Main Presenter:</b> Mr. Ashwani Singh, <i>Research Fellow, MRC</i><br><b>Session Chair:</b> Mr. Rakesh Kumar, <i>General Manager, Bharat Electronics Limited</i>                                                                                                        |
| 17:10 – 17:25 | Workshop Report                                                            | Dr. (Cdr) Arnab Das, Mr. Callistine Lewis                                                                                                                                                                                                                                  |
| 17:25 – 17:30 | Closing Remarks                                                            | ICWA Representative                                                                                                                                                                                                                                                        |



## 2. Theoretical & Strategic Foundations

### 2.1 From SAGAR to MAHASAGAR

SAGAR, articulated in 2015, framed India's maritime engagement primarily around security cooperation and capacity-building with immediate IOR neighbours. MAHASAGAR broadens this framing along two axes: it extends India's ambit of engagement across the wider Indian Ocean Region and into the Global South more generally, and it recasts India's role from a regional security partner into a holistic development, governance, and technology partner. This shift is deliberate — it responds to a Global South increasingly wary of great-power competition and looking instead for partners who can offer capacity rather than dependency.

This broader diplomatic ambition creates an operational requirement that has so far gone under-examined: subsurface visibility. Diplomatic commitments to maritime security, disaster resilience, and sustainable blue economy growth are difficult to substantiate without the underlying capability to see, track, and understand what is happening beneath the surface of the ocean India seeks to help govern. A vision built on holistic maritime leadership cannot rest on a surface-only picture of the maritime domain. Underwater Domain Awareness is, in this sense, not a niche technical add-on to MAHASAGAR but a precondition for its credibility.

### 2.2 The Four Pillars of the UDA Framework

- **Maritime Security:** acoustic tracking, subsea asset protection, and anti-submarine warfare (ASW) advantages.
- **Blue Economy:** resource exploration, deep-sea mining, sustainable energy, and marine spatial planning.
- **Environment & Disaster Management:** seismic monitoring, tsunami early warning, the impact of climate change on acoustic propagation, and biodiversity preservation.
- **Science & Technology:** indigenous hardware and software, acoustic modelling, skilling, and R&D infrastructure.

These four pillars are treated throughout this seminar not as independent silos but as mutually reinforcing dimensions of a single UDA capability. A hydrophone array built for anti-submarine warfare, for instance, generates data equally useful for tsunami early warning and biodiversity monitoring; an acoustic model built for naval sonar prediction underpins both ASW planning and sustainable dredging schedules. The seminar's eight sessions are each mapped explicitly against all four pillars precisely to surface these cross-cutting synergies rather than treat them as coincidental.

### 2.3 The Rationale for the Seminar

The single greatest obstacle to a coherent national UDA capability is institutional, not technical. The Indian Navy and Coast Guard, marine-science academia, defense and commercial industry (dredging, offshore energy, shipbuilding), and policy think tanks each hold a piece of the UDA puzzle. Naval hydrographic data, university acoustic research, industry operational experience, and foreign policy strategies each develop separate tracks, with few structured mechanisms for cross-pollination.

Each session pairs a technical research fellow with a senior policy, defence, or industry figure as chair or co-panellist, allowing technical material to be translated into policy language in real time, and allowing policy assumptions to be tested against technical reality. The seminar's outputs, draft frameworks, policy briefs, and proposed working groups, are designed to be able to be submitted to national security and foreign-policy institutions, rather than as an academic proceedings volume alone.

## Day 1: MRC-ICWA National Seminar on Underwater Domain Awareness

*Day 1 • August 17, 2026 • 10:00 AM – 11:30 AM*

### Session 1: Evolution of the UDA Framework & Global Relevance

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**Main Presenter:** Dr. (Cdr) Arnab Das, *Founder and Director, MRC* ·

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

**Session Focus:** Global strategic relevance of underwater acoustic monitoring and cross-border maritime situational awareness.

#### *1. Context & Problem Statement*

India's traditional maritime security and ocean policy frameworks have historically operated under a surface-centric paradigm. While the SAGAR doctrine and its evolved iteration, MAHASAGAR, establish a clear diplomatic and strategic vision for leadership in the Indian Ocean Region (IOR), they face a critical operational limitation at the subsurface level: the UDA blind spot.

The underwater environment of the Indian Ocean presents unique challenges that distinguish it from temperate, deep-water ocean domains where legacy underwater acoustic frameworks were developed. Tropical water dynamics — warm temperatures, variable salinity profiles, high ambient biological noise, and complex bathymetry — severely distort acoustic signal propagation, rendering standard Western sonar models inaccurate when applied without modification to the IOR. Shallow, sediment-heavy littorals fed by monsoon river systems alter seabed absorption characteristics, complicating acoustic tracking, bathymetric mapping, and subsea asset protection.

Compounding this technical gap is a governance gap: maritime security (Navy/Coast Guard), economic exploitation (dredging, offshore energy), environmental monitoring (marine biology), and science and technology (indigenous R&D) currently operate in institutional silos, without a unified data-sharing architecture. To translate the MAHASAGAR vision into tangible regional leadership, India requires a standardized, indigenous UDA framework. Session 1 establishes the theoretical foundation, scientific rationale, and global strategic necessity of UDA as a prerequisite for holistic ocean governance as well as how the global evolution of UDA technology and analysis frameworks have been developed. It will also interrogate the pitfalls and obstacles that India, as a member of the Global South, will need to take note of while charting its own course on the world's waters.

#### *2. Core Themes & Sub-Topics for Deliberation*

##### **A. Unique Environmental Dynamics — Tropical vs. Temperate Waters**

- **Physics of Tropical Sound Propagation:** Analyzing high acoustic attenuation, extreme SSP variability, and monsoon-driven stratification in the IOR.
- **Overcoming Acoustic Blind Spots:** Mitigating high biological ambient noise and sediment absorption that degrade imported sonar performance.
- **Indigenous Algorithm Modeling:** Developing localized acoustic propagation software tailored to shallow-water tropical littorals to ensure technological independence.

## **B. Transitioning from "Products" to "Solution-Driven" Architectures**

- **Data Fusion over Capital Hardware:** Moving away from reliance on expensive standalone hardware toward integrated sensor networks, AUVs, gliders, Distributed Acoustic Sensing (DAS), and AI-driven data modelling.
- **Democratized Digital Tools:** Applying low-capital, data-driven frameworks—exemplified by MRC's Area–Production–Yield (APY) Tool for aquaculture and INCOIS's Potential Fishing Zone (PFZ) advisories—to maximize socioeconomic impact with minimal hardware investment.
- **Data Interoperability:** Establishing standardized subsea data formats across littoral agencies to resolve information fragmentation.

## **C. Bridging Strategic Security and the Greater Public Good (3D "Volumetric" Governance)**

- **Extending MDA Beneath the Surface:** Expanding traditional, 2D surface-centric Maritime Domain Awareness into 3D vertical ocean space.
- **Critical Maritime Infrastructure Protection (CMIP):** Safeguarding submarine communication cables, offshore platforms, and subsea pipelines against gray-zone threats, anchor damage, and sabotage.
- **Dual-Use Sensor Infrastructure:** Utilising passive acoustic monitoring (PAM) networks simultaneously for Anti-Submarine Warfare (ASW), tsunami early warning, and marine biodiversity mapping.

## **D. Overlaying Traditional Ecological Knowledge (TEK) with Modern Science & AI**

- **Integrating Local Knowledge:** Leveraging the generational ecological observations of coastal and fishing communities as empirical data streams for formal scientific research.
- **AI & Big Data Analytics:** Fusing TEK with oceanographic buoy data, satellite observations, and hydrophone inputs using AI models to validate ecosystem shifts, fish aggregation, and illegal activities.
- **Participatory Ocean Governance:** Positioning coastal communities as active contributors to national underwater situational awareness rather than passive observers.

## **E. Addressing Global South Priorities & Technological Independence**

- **Closing the Global North–South Capability Gap:** Reducing reliance on foreign proprietary oceanographic software and imported hardware built for temperate zones.
- **Sovereign Oceanographic Databases:** Building regional, tropical-specific ocean databases across Indian Ocean littoral states to foster scientific independence.
- **Extending Coalition Logic (Quad/IPMDA):** Building on surface frameworks like the Quad's *Indo-Pacific Partnership for Maritime Domain Awareness (IPMDA)* to create subsurface data-sharing mechanisms for small island developing states (SIDS) and LDCs in the IOR.

### 3. Alignment with the Four Pillars of UDA

| UDA Pillar                        | Strategic Session Focus                                    | Operational Application                                                                                             |
|-----------------------------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Maritime Security</b>          | Subsurface threat detection & Anti-Submarine Warfare (ASW) | Enhancing sonar detection ranges; identifying non-cooperative subsea vessels in tropical waters.                    |
| <b>Blue Economy</b>               | Safe navigation & subsea resource exploration              | Providing accurate acoustic bathymetry for offshore platform installation and deep-sea mineral exploration.         |
| <b>Disaster &amp; Environment</b> | Seismic activity & marine ecosystem monitoring             | Utilizing passive acoustic monitoring (PAM) for tsunami early warnings and mapping marine biodiversity soundscapes. |
| <b>Science &amp; Technology</b>   | Indigenous hardware & acoustic software modelling          | Reducing dependence on imported oceanographic software by developing indigenous tropical acoustic models.           |

*Day 1 • August 17, 2026 • 12:00 PM – 1:30 PM*

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

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**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,*

**Session Focus:** Geopolitical shifts in the IOR, subsea cable vulnerabilities, seabed governance, and India's role in Global South security architecture.

### ***1. Context & Problem Statement***

The ocean dictates the structural foundation of planetary life and human civilisation: covering 71% of the Earth's surface, it governs biodiversity, food security, climate regulation, global trade, internet communications, international finance, cultures, livelihoods, and statecraft. Yet, as the global balance of power undergoes a historical realignment, traditional statecraft remains constrained by a land-centric, Westphalian bias. India's MAHASAGAR doctrine offers a transformative framework for the Global South, expanding India's maritime posture from regional security partner to a global leader in holistic ocean governance, trade, and technology sharing. However, operationalising MAHASAGAR across the Indian Ocean Region (IOR) and beyond requires confronting five interconnected world order dimensions. Firstly, Ocean geopolitics forms the bedrock of the modern world order. Yet, Westphalian concepts of rigid terrestrial borders dissolve at sea, where control over subsea cables, maritime choke points, and subsurface resources dictates strategic supremacy. While traditional Westphalian sovereignty relies on two-dimensional land maps; effectively reading only the floor and ceiling of a room: it leaves our vast, three-dimensional maritime territorial space entirely invisible, obscuring the critical water column where modern geopolitical, economic, and ecological realities unfold.

Secondly, over 80% of global trade by volume travels by sea, and international financial systems rely entirely on underwater data cables, making the sub-surface the ultimate backbone of global supply chains and economic stability. Thirdly, ecological collapse is an existential threat to world order; while marine spaces have suffered severe exploitation, they possess rapid regenerative capacity: acting as the planet's vital "lungs" and carbon reserves. Fourth, with over 50% of humanity or 4.15 billion people living within 100 miles of a coast and rapid demographic expansion across South Asia and Africa, the geopolitical center of gravity is shifting toward the Indian Ocean, projected to host over 3.9 billion people or 40% of global population by 2050. And finally, power projection rests on technological capability, yet current sub-surface technology, developed in the Global North for cooler, calmer, shallower waters, faces severe degradation when deployed in the warmer, deeper, acoustically complex, and biologically dense tropical waters of the Global South.

Realizing the MAHASAGAR vision requires moving beyond surface-level presence. Underwater Domain Awareness (UDA) provides the operational backbone for this doctrine, converting raw sub-surface data into strategic clarity, sustainable blue growth, and inclusive global governance.

## ***2. Core Themes & Sub-Topics for Deliberation***

### **A. Politics & Statecraft: Beyond Westphalian Terrestrialism**

- Reconceptualizing Maritime Sovereignty: Re-evaluating traditional, land-centric Westphalian governance in fluid, 3D sub-surface spaces where UNCLOS legal ambiguities leave critical subsea infrastructure vulnerable.
- Sub-Surface Geopolitics & Infrastructure Security: Countering grey-zone tactics, unattributed sub-surface activity, and safeguarding submarine fiber-optic cables and seabed energy pipelines across strategic choke points.
- Plurilateral Leadership under MAHASAGAR: Positioning India's UDA framework as an exportable public good, fostering flexible plurilateral security and data-sharing coalitions with Global South littorals and Small Island Developing States (SIDS).

### **B. Economics & the Blue Economy: Securing Global Financial Arteries**

- Safeguarding Commercial Backbones: Protecting the physical and digital sub-surface infrastructure—from oceanic trade routes to subsea internet cables—that anchors international trade, banking, and supply chain resilience.
- MAHASAGAR-Driven Marine Spatial Planning (MSP): Resolving spatial conflicts between offshore energy, deep-sea mining, shipping lanes, and traditional fisheries to ensure long-term economic stability across the Global South.
- Attracting Blue Capital: Creating standardized, transparent sub-surface data architectures that attract global green and blue investment while preventing predatory resource extraction.

### **C. Environment & Climate Resilience: The Ocean's Diagnostic MRI**

- UDA as the Planet's Diagnostic Scanner: Deploying passive acoustic monitoring and sub-surface sensors as a diagnostic "MRI scanner" to assess, monitor, and restore ocean ecosystems, carbon sequestration sinks, and atmospheric oxygen generation.
- Pre-Emptying Climate Tipping Points: Tracking rising sub-surface temperatures, ocean acidification, and shifting current dynamics in real time before marine systems cross irreversible tipping points.
- Regenerative Ocean Governance: Capitalizing on the rapid natural regenerative capacity of underwater ecosystems to offset terrestrial environmental degradation under the ecological pillar of MAHASAGAR.

### **D. Demography & Human Capital: Blue Jobs for Global South Youth**

- Absorbing Underutilized Youth Demographics: Leveraging the massive youth demographic in India and the Global South to meet expanding labor demands in offshore renewable energy, sustainable aquaculture, bio-conservation, and maritime logistics.
- Empowering Coastal & Marginalized Communities: Transitioning coastal youth from vulnerable, declining traditional fishing toward high-value "green and blue" sectors through UDA-linked technical skilling.
- Social Stability & Regional Security: Mitigating youth discontent, illegal migration, and maritime piracy by generating sustainable, ocean-derived economic opportunities along tropical coastlines.

### **E. Technology & Sovereignty: Tailoring Innovation to Tropical Waters**

- Overcoming Northern Technological Bias: Moving away from imported oceanographic hardware built for cold, shallow northern waters, and developing indigenous algorithms optimized for warm, acoustically complex, and biologically dense tropical oceans.
- Solution-Driven Architecture over Hardware Accumulation: Shifting from capital-intensive standalone hardware toward integrated, data-driven frameworks—aligning indigenous R&D (such as India's Deep Ocean Mission) with MAHASAGAR's capacity-building goals.



- Bridging the Global North–South Capability Gap: Fostering technological self-reliance (Atmanirbhar Bharat) while sharing accessible, low-cost digital tools and sub-surface platforms with regional partners.

### 3. Alignment with the Four Pillars of UDA

| UDA Pillar                        | Strategic Session Focus                                                                                           | Operational Application                                                                                                                               |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Maritime Security</b>          | Sub-surface asset protection, choke-point vigilance, and non-Westphalian plurilateral statecraft under MAHASAGAR. | Real-time acoustic tracking of subsea cables, threat discrimination in high-density corridors, and non-cooperative sub-surface target identification. |
| <b>Blue Economy</b>               | Securing global financial flows, trade routes, and blue job creation for Global South youth.                      | Risk-informed subsea infrastructure routing, data-driven marine spatial planning, and workforce integration in offshore renewable energy.             |
| <b>Disaster &amp; Environment</b> | Diagnostic monitoring of ocean health, carbon reserves, and climate-induced tipping points.                       | Deploying passive acoustic monitoring (PAM) networks for ecosystem diagnosis, sub-surface thermal tracking, and early warning systems.                |
| <b>Science &amp; Technology</b>   | Developing localized tropical acoustic tools and bridging North–South technological divides.                      | Indigenous algorithm modeling for high-ambient-noise tropical waters and accessible digital tool deployment under the Deep Ocean Mission.             |

*Day 1 · August 17, 2026 · 2:30 PM – 4:00 PM*

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

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

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

**Session Focus:** Marine Spatial Planning, Acoustic propagation modelling, underwater digital twins, and simulation tools supporting sustainable ocean governance.

### *1. Context & Problem Statement*

India's coastal and Exclusive Economic Zone (EEZ) waters are governed today largely through static, two-dimensional maps that struggle to represent a dynamic, multi-user underwater environment. Naval exercises, commercial shipping lanes, fishing grounds, offshore energy leases, and marine protected areas (MPAs) increasingly compete for the same subsurface and water-column space, and static planning tools cannot resolve these conflicts efficiently or safely.

The emerging alternative is the underwater digital twin: a continuously updated, multi-layered digital representation of bathymetry, acoustic conditions, currents, and biodiversity that allows planners to simulate outcomes before committing resources on the water. Acoustic propagation modelling — predicting sonar detection ranges and mapping underwater noise footprints under tropical sound-speed conditions — forms the technical backbone of such a twin and must be validated against field data gathered specifically in Indian coastal waters rather than imported wholesale from temperate-water models.

Building this capability at national scale requires resolving an institutional question as much as a technical one: which agency owns, updates, and shares digital-twin data across the Navy, the Ministry of Earth Sciences' agencies (INCOIS, NIOT), state maritime boards, and industry users. Session 3 sets out both the technical case for underwater digital twins and a proposed data-governance architecture to sustain them.

### *2. Core Themes & Sub-Topics for Deliberation*

#### **A. Acoustic Propagation Modelling**

- Sonar range prediction under variable tropical sound-speed profiles (SSPs).
- Underwater noise mapping across shipping lanes and port approaches.
- Validating models against field data gathered in Indian coastal waters, rather than imported temperate-water datasets.

#### **B. Underwater Digital Twins for MSP**

- Multi-layered digital-twin architecture integrating bathymetry, acoustics, currents, and biodiversity data.
- Real-time data assimilation from AUVs, moored buoys, and satellite altimetry.
- Priority use cases: naval-exercise deconfliction, shipping-lane optimization, and MPA design.

#### **C. Institutional Data Architecture**

- Common data standards across the Navy, MoES agencies (INCOIS, NIOT), and state maritime boards.
- Data-sharing protocols that balance operational security with planning transparency for industry and researchers.

#### **D. Modelling & Simulation (M&S) Pipeline as the Digital Twin's Engine**



- Coupling physical oceanography, acoustic propagation, and ecological/biodiversity models into a single M&S pipeline, rather than running each in isolation
- Computational infrastructure and coupling standards (grid resolution, model interoperability protocols) needed to run this at national scale.

#### **E. AI/ML-Enabled Decision Layers for Governance**

- Applied use cases like fishing zone detection and coral bleaching risk modelling as examples of the twin moving from passive visualization to active governance tool
- AI/ML-adaptive approaches to compensate for tropical-water acoustic performance degradation, improving detection and classification reliability where temperate-model assumptions break down

#### **3. Alignment with the Four Pillars of UDA**

| UDA Pillar                        | Strategic Session Focus                                               | Operational Application                                         |
|-----------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------|
| <b>Maritime Security</b>          | Deconfliction of naval exercises with commercial and fishing activity | Digital twin overlays of restricted zones and shipping density. |
| <b>Blue Economy</b>               | Efficient marine spatial planning for offshore energy and mining      | Simulation-driven site selection reducing conflict and delay.   |
| <b>Disaster &amp; Environment</b> | MPA design informed by acoustic and ecological modelling              | Dynamic zoning responsive to seasonal biodiversity patterns.    |
| <b>Science &amp; Technology</b>   | Indigenous simulation and digital-twin software                       | Reduced reliance on imported modelling platforms.               |

*Day 1 · August 17, 2026 · 4:15 PM – 5:30 PM*

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

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**Main Presenter:** Mr. Callistine Lewis, *Head of Publications, Research Fellow, Maritime Research Center* ·

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

**Session Focus:** Bridging academia, defense, and industry to build indigenous talent in underwater technology and ocean policy.

### ***1. Context & Problem Statement***

Every technical and policy ambition articulated across this seminar rests on a scarce resource: trained people. India faces a severe deficit of specialised manpower in underwater domain awareness — underwater acousticians, marine signal-processing engineers, and subsea policy analysts capable of translating acoustic data into strategic judgment. This shortage is not confined to the defence establishment; think tanks, ports, and industry face the same gap in different forms.

Part of the problem is structural: STEM curricula in Indian universities rarely include applied ocean-technology content, and international-relations or public-policy programmes rarely engage with the physical realities of the subsurface domain. The result is two parallel talent pipelines — technical and policy — that almost never intersect, producing acoustics graduates unable to communicate with strategists, and strategists unable to interrogate the technical assumptions behind the advice they receive.

Closing this gap requires a deliberate triple-helix model connecting academia, defence R&D (DRDO, the Navy), and indigenous industry, supported by structured fellowship pathways, youth engagement, and vocational training for coastal communities. Session 4 sets out a concrete proposal for building this pipeline, drawing on MRC's own experience running research fellowships that combine technical and policy training.

### ***2. Core Themes & Sub-Topics for Deliberation***

#### **A. The Talent Deficit**

- Shortage of underwater acousticians, marine signal-processing engineers, and subsea policy analysts.
- Mismatch between STEM curricula and applied ocean-technology needs.
- Absence of dedicated subsea-policy career tracks within civil services and think tanks.

#### **B. Curriculum and Institutional Integration**

- Embedding UDA modules into marine science, engineering, and international-relations programmes.
- Joint fellowships linking think tanks and university departments.
- Vocational and skilling pathways for coastal youth in acoustic monitoring and ROV/AUV operation.

#### **C. Triple-Helix Collaboration**

- Structured internship and secondment pipelines spanning the Navy/DRDO, academia, and industry.
- Industry-sponsored research chairs and innovation challenges.
- Mentorship networks connect early-career researchers to policy practitioners.

#### **D. Blue-Tech Entrepreneurship and Innovation Incubation**

- Transitioning acoustic research and UDA technologies from university labs to viable commercial start-ups (e.g., leveraging iDEX or ATAL incubation frameworks).

- Cultivating 'job creators' in the ocean technology sector through targeted seed funding, commercialisation training, and venture partnerships.
- Establishing clear frameworks for intellectual property (IP) sharing and technology transfer between DRDO, academia, and early-career founders.

#### **E. Continuous Professional Development (CPD) and Cross-Sector Mobility**

- Upskilling existing naval personnel, maritime operators, and civil servants in emerging UDA technologies, machine learning, and acoustic data analytics.
- Facilitating lateral entry and cross-domain mobility to bring established professionals from the broader tech sector (e.g., big data, AI) into subsea and marine applications.
- Developing short-term executive certification and immersion modules for policymakers to better grasp the strategic and physical implications of acoustic data

#### **3. Alignment with the Four Pillars of UDA**

| UDA Pillar                        | Strategic Session Focus                                      | Operational Application                                        |
|-----------------------------------|--------------------------------------------------------------|----------------------------------------------------------------|
| <b>Maritime Security</b>          | Building a pipeline of trained acoustic and ASW analysts     | Naval–academic exchange and secondment programmes.             |
| <b>Blue Economy</b>               | Skilled workforce for offshore, dredging, and energy sectors | Industry-linked vocational certification.                      |
| <b>Disaster &amp; Environment</b> | Field-ready personnel for monitoring networks                | Community-based training in coastal early-warning systems.     |
| <b>Science &amp; Technology</b>   | Sustained indigenous R&D talent pipeline                     | Fellowship-to-employment pathways in defense and industry R&D. |

## Day 2: MRC-ICWA National Seminar on Underwater Domain Awareness

*Day 2 · August 18, 2026 · 9:40 AM – 11:10 AM*

### Session 5: Sediment Management & Navigational Safety

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**Main Presenter:** Mr. Romit Kaware, *Research Fellow, Maritime Research Center*

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

**Session Focus:** Acoustic techniques for sediment profiling, sustainable dredging policy, and dual-use navigational readiness.

#### *1. Context & Problem Statement*

India's tropical rivers, estuaries and coastal zones face some of the highest siltation rates in the world, driven by monsoon-fed systems that deposit heavy sediment loads at the coast. Left unmanaged, this siltation reduces navigational draft limits, constrains naval channel mobility, and forces increasingly frequent and costly dredging campaigns — a problem set to intensify as Sagarmala-driven port expansion adds capacity along India's coastline.

Acoustic sediment monitor and quantification offers a path toward predictive rather than reactive management: real-time bathymetric and sub-bottom profiling can track shifting sediment loads through the tropical conditions and monsoon cycle and informed dredging schedules before channels become operationally constrained. But dredging itself carries ecological cost — it's not a long term solution. Disturbance to the seabed/riverbed and resulting sediment redistribution negatively impact fish spawning grounds and mangrove ecosystems. The current regulatory processes often treat Sagarmala expansion targets and environmental clearance regimes as separate, sequential hurdles rather than a jointly optimized system.

There is also an underexploited dual-use opportunity: commercial ports and adjacent naval facilities frequently share the same estuarine system yet rarely share sediment-monitoring infrastructure or data. The lack of a data sharing platform hampers the comprehensive understanding of local dynamics. Session 5 makes the case for acoustic sediment monitoring as shared infrastructure serving navigational safety, port efficiency, and ecological stewardship simultaneously.

#### *2. Core Themes & Sub-Topics for Deliberation*

##### **A. Need for Integrated Sediment Management**

- Sediment accumulation reduces navigational depth and increases the risk of vessel grounding, delays, and channel restrictions.
- Predictive sediment management can reduce emergency dredging costs and improve port and waterway efficiency.
- Monsoons, floods, tides, and coastal processes create continuously changing sedimentation patterns.
- Sediment behaviour should be considered during the planning of ports, waterways, reservoirs, and coastal infrastructure.

##### **B. Applications of Sediment Management**

- Sediment data can optimise the timing, location, frequency, and volume of dredging operations.
- Effective management supports ports, inland waterways, fishing harbours, reservoirs, and strategic navigation channels.

- Sediment bypassing, trapping, channel training, and nature-based solutions can reduce dependence on repeated dredging.
- Dredged sediment can be reused for beach nourishment, reclamation, wetland restoration, and shoreline protection.

### C. Acoustic Sediment Profiling and Quantification

- Bathymetric and sub-bottom surveys can map channel depths, seabed changes, and deposited sediment thickness.
- Acoustic Doppler and backscatter techniques can monitor currents, suspended sediment, and sediment plumes.
- Acoustic data should be calibrated using turbidity sensors, sediment samples, and laboratory analysis.
- Monitoring systems must be adapted to shallow, turbid, saline, and monsoon-affected Indian waters.

### D. Sustainable Dredging and Environmental Management

- Dredging can increase turbidity, disturb seabed habitats, and resuspend contaminated sediment.
- Dredging schedules should protect fish-spawning periods, mangroves, wetlands, and other sensitive habitats.
- Dredging methods should be selected based on sediment type, site conditions, cost, and environmental impact.
- Port development, navigational needs, and environmental clearance should be addressed through integrated planning.

### E. Digital Transformation and Decision Support

- Real-time monitoring can combine acoustic sensors, satellites, drones, turbidity meters, and autonomous platforms.
- Digital twins can simulate sediment transport, channel shoaling, and future dredging requirements.
- Artificial intelligence can identify siltation hotspots, predict deposition, and optimise dredging schedules.
- Shared data platforms can improve coordination among ports, government agencies, researchers, and maritime authorities.

## 3. Alignment with the Four Pillars of UDA

| UDA Pillar             | Strategic Session Focus                        | Operational Application                                       |
|------------------------|------------------------------------------------|---------------------------------------------------------------|
| Maritime Security      | Assured channel depth for naval mobility       | Shared sediment-monitoring data with Navy hydrographic units. |
| Blue Economy           | Port efficiency and reduced dredging costs     | Predictive dredging schedules based on acoustic profiling.    |
| Disaster & Environment | Minimizing ecological disruption from dredging | Environmental-impact-informed dredging windows.               |
| Science & Technology   | Indigenous sediment-profiling instrumentation  | Reduced dependence on imported survey equipment.              |

Day 2 · August 18, 2026 · 11:40 AM – 1:10 PM

## Session 6: Blue Accounting & Marine Environmental Economics

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

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

**Session Focus:** Integrating Blue Accounting, ocean-resource valuation, and marine environmental economics into national policy.

### 1. Context & Problem Statement

Conventional GDP accounting is structurally blind to ocean degradation. It records the revenue from a fishery, a dredged port channel, or an offshore energy lease, but not the depletion of the natural capital that generated that revenue, nor the depreciation of subsea infrastructure, nor the loss of coastal ecosystem services such as storm buffering and carbon sequestration. As India's blue economy ambitions scale up under MAHASAGAR, this blind spot risks systematically overstating the sustainability of ocean-based growth.

Blue Accounting offers a corrective: methodologies for valuing marine natural capital — coastal wetlands, mangroves, deep-sea ecosystems — alongside more conventional economic output, drawing on international precedents such as the UN System of Environmental-Economic Accounting (SEEA) and its ocean-specific extensions. Embedding these methodologies into India's System of National Accounts (SNA) would require sustained coordination between the Ministry of Earth Sciences, NITI Aayog, and the Ministry of Statistics and Programme Implementation, alongside sector-specific ESG metrics tailored to maritime, port, and shipping industries.

Valuation alone does not finance conservation. Blue bonds, blended-finance instruments, and carbon-credit frameworks for blue-carbon ecosystems (mangroves, seagrass) offer mechanisms to convert natural-capital accounting into investable projects, provided risk-sharing structures can de-risk private capital sufficiently to participate at scale. Session 6 lays out both the accounting and financing sides of this agenda.

### 2. Core Themes & Sub-Topics for Deliberation

#### A. Valuing Marine Natural Capital

- Methodologies for valuing coastal wetlands, mangroves, and deep-sea ecosystems.
- Accounting for subsea asset depreciation — cables, pipelines, and other seabed infrastructure.
- International precedents, including UN SEEA and related ocean natural-capital accounting frameworks.

#### B. Integrating Blue Accounting into National Planning

- Pathways to incorporate ocean-asset accounts into India's System of National Accounts (SNA).
- ESG metrics tailored specifically to maritime, port, and shipping industries.
- Coordination requirements across the Ministry of Earth Sciences, NITI Aayog, and the Ministry of Statistics.



### C. Financing Ocean Conservation

- Blue bonds and blended-finance instruments for coastal restoration.
- Carbon-credit frameworks for blue-carbon ecosystems such as mangroves and seagrass.
- Risk-sharing models to de-risk private investment in ocean conservation.

### D. Capacity Building & Digital Transformation

- Utilizing AI, digital twin technologies, and high-end data analytics for Marine Spatial Planning (MSP) and mapping underwater natural capital.
- Skilling coastal communities and local stakeholders (e.g., integrating programs like the MRC's "100 Warriors" grassroots initiative) in data collection, disaster preparedness, and ecological monitoring.
- Addressing the structural deficits in site-specific tropical marine research to build indigenous acoustic capacity and data grids.

### E. Policy Frameworks & Regional Governance

- Harmonizing India's national blue accounting standards with broader regional frameworks across the Indo-Pacific, IORA, and BIMSTEC.
- Formulating regulatory mandates for the maritime industry to assess their subsea footprint and manage ecological stressors like Underwater Radiated Noise (URN).
- Translating environmental accounting and natural-capital data into actionable spatial regulations for coastal zone management and sustainable dredging.

## 3. Alignment with the Four Pillars of UDA

| UDA Pillar                        | Strategic Session Focus                                          | Operational Application                                         |
|-----------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|
| <b>Maritime Security</b>          | Economic case for protecting strategic coastal and subsea assets | Valuation data informing infrastructure protection budgets.     |
| <b>Blue Economy</b>               | Investment-grade metrics for sustainable ocean industries        | ESG-linked financing for ports, shipping, and offshore sectors. |
| <b>Disaster &amp; Environment</b> | Quantifying the cost of ecosystem loss from disasters            | Blue-carbon accounting tied to restoration financing.           |
| <b>Science &amp; Technology</b>   | Data infrastructure for natural-capital accounting               | Indigenous monitoring networks feeding national accounts.       |

*Day 2 · August 18, 2026 · 2:10 PM – 3:40 PM*

## **Session 7: Biofouling, Anthropogenic Noise & Ecological Resilience**

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**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.

**Session Focus:** Managing underwater noise pollution, biofouling management, and port ecosystem health in line with global IMO benchmarks.

### *1. Context & Problem Statement*

Shipping traffic and port operations generate two underappreciated but serious environmental pressures: underwater noise pollution and biofouling-driven invasive species transfer. Rising vessel traffic along India's coast, concentrated around a small number of major ports, is pushing ambient underwater noise levels upward in exactly the shallow, biologically rich waters least equipped to absorb them, even as the International Maritime Organization (IMO) has moved toward voluntary guidelines on ship-radiated noise reduction. Biofouling presents a parallel dilemma. Hull fouling increases drag and fuel consumption, creating a commercial incentive for aggressive anti-fouling coatings — but many of the most effective coatings are also toxic to marine ecosystems, while biofouled hulls themselves are a leading vector for invasive marine species entering Indian port waters from international shipping routes. Balancing hull efficiency, fuel economy, and ecological safety requires both better data and better technology, not a simple trade-off between economics and the environment. Long-term monitoring of port-adjacent ecological zones — tracking biodiversity health alongside noise and biofouling indicators — is the missing feedback loop that would let ports, shipping lines, and regulators calibrate standards against real outcomes rather than assumptions. Session 7 calls for tying underwater noise, biofouling, and ecosystem resilience into a single, IMO-aligned management agenda, with direct industry participation.

### *2. Core Themes & Sub-Topics for Deliberation*

#### **A. Managing Underwater Noise Pollution**

- Alignment with IMO guidelines on reducing underwater radiated noise from commercial shipping.
- Noise budgeting for high-traffic port approaches and shipping lanes.
- Acoustic monitoring as a compliance and enforcement tool.

#### **B. Biofouling Management**

- Trade-offs between hull efficiency, fuel burn, and toxic anti-fouling coatings.
- Invasive-species transfer risk via biofouling at Indian ports.
- Emerging non-toxic and inspection-based biofouling management technologies.

#### **C. Port Ecosystem Health Monitoring**

- Long-term monitoring of sensitive ecological zones near major ports.
- Integrating biofouling and noise data into port environmental management plans.
- Industry engagement in setting ecological resilience standards.

## D. Integrated Data, Policy and Regulatory Frameworks

- Development of standardised methodologies for measuring underwater radiated noise, biofouling intensity, and ecological impacts.
- Integration of monitoring data into port environmental management systems and national maritime policies.
- Defining responsibilities for ports, shipowners, operators, classification societies, and regulatory authorities in line with IMO guidance.

## E. Technology, Research and Industry Collaboration

- Pilot deployment of low-noise vessel technologies, non-toxic antifouling solutions, and advanced hull-cleaning systems.
- Collaboration among ports, shipping companies, research institutions, technology providers, and environmental agencies.
- Establishment of measurable implementation targets, reporting mechanisms, and research priorities for improving long-term ecological resilience.

### 3. Alignment with the Four Pillars of UDA

| UDA Pillar                        | Strategic Session Focus                                                 | Operational Application                                  |
|-----------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Maritime Security</b>          | Naval vessel biofouling and noise-signature management                  | Standards reducing acoustic detectability and hull drag. |
| <b>Blue Economy</b>               | Port competitiveness through environmental compliance                   | IMO-aligned standards attracting green shipping traffic. |
| <b>Disaster &amp; Environment</b> | Ecosystem health monitoring near ports                                  | Long-term biodiversity monitoring frameworks             |
| <b>Science &amp; Technology</b>   | Indigenous biofouling-resistant coatings and noise-reduction technology | R&D partnerships with industry.                          |

*Day 2 · August 18, 2026 · 3:55 PM – 5:25 PM*

## **Session 8: Sustainable Fisheries, Aquaculture & Marine Bioresources**

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

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

**Session Focus:** Multi-parameter environmental intelligence for fisheries governance, climate-driven vulnerability in aquaculture systems, and capacity building through structured UDA-framework research mentorship.

### **1. Context & Problem Statement**

India's marine fisheries sector supports approximately 7 million coastal fisherfolk and a \$12 billion Blue Economy, yet the environmental intelligence guiding daily fishing effort remains structurally limited. Conventional fishing zone advisories rely on only two satellite-derived parameters, sea surface temperature and chlorophyll-a, an approach that cannot detect the oxygen dynamics, thermal habitat compression, and nutrient gradient signals that govern fish availability in the tropical Arabian Sea and Bay of Bengal. This gap is compounded by parallel climate pressures on aquaculture: marine heatwaves are increasingly disrupting shrimp farming, seaweed cultivation, and fish farming operations along both coasts, with limited predictive tools available to anticipate these events.

MRC's response has been twofold. First, the development and field validation of a multi-parameter Fishing Suitability Index (FSI) integrating net primary production, dissolved oxygen, nutrient gradients, and thermal optimality into a single operational advisory layer, now running as a live daily pipeline against Copernicus Marine Service data. Second, the extension of this research capacity through a structured Summer 2026 internship programme, in which student researchers applied the UDA Framework to marine heatwave prediction and its downstream impact on aquaculture across the Arabian Sea and Bay of Bengal. Session 8 presents both threads together: the operational science and the pipeline of researchers being built to carry it forward.

### **2. Core Themes & Sub-Topics for Deliberation**

#### **A. Multi-Parameter Environmental Intelligence for Fisheries**

- Oxygen-aware fishing suitability modelling as a successor to dual-parameter (SST + chlorophyll) advisories
- Detection of compound thermal-oxygen habitat compression events invisible to conventional monitoring
- Cross-validation of environmental indices against ICAR-CMFRI landings data for species-level accuracy

#### **B. Operational Deployment and Technology Pipeline**

- Daily automated ingestion of Copernicus biogeochemical and physical ocean data
- H3 hexagonal grid mapping for scalable, mobile-compatible advisory delivery
- Transition from research index to field-deployable decision support, including in-situ sensor validation and controlled fishing trials

#### **C. Empowering Coastal Communities**

- Translating multi-parameter indices into simple, regional-language advisory formats for fisher adoption

- Cooperative models linking fisher-reported catch data back into index calibration
- Livelihood diversification support through aquaculture and Blue Economy skilling

#### D. Climate-Driven Vulnerability in Aquaculture Systems

- Marine heatwave drivers and predictability across the Arabian Sea and Bay of Bengal
- Downstream impact on shrimp farming, seaweed cultivation, and fish farming operations
- Early-warning indicators linking heatwave onset to aquaculture-sector risk management

#### E. Building Research Capacity through UDA-Framework Mentorship

- MRC's Summer 2026 structured internship programme applying the UDA Framework to open research problems
- Intern-led investigation into marine heatwave predictability and aquaculture impact as a model for scalable, mentorship-driven research
- Pathways for translating student research output into MRC's broader policy and technical publication pipeline

### 3. Alignment with the Four Pillars of UDA

| UDA Pillar                        | Strategic Session Focus                                                                | Operational Application                                                                                                            |
|-----------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <b>Maritime Security</b>          | Fisheries intelligence overlapping with sustainable resource governance in the EEZ     | Multi-parameter advisory data supporting evidence-based zone management and reduced illegal effort concentration                   |
| <b>Blue Economy</b>               | Sustainable fisheries and climate-resilient aquaculture as core Blue Economy pillars   | Oxygen-aware suitability scoring and heatwave early-warning tools raising yield stability across capture fisheries and aquaculture |
| <b>Disaster &amp; Environment</b> | Protecting fish stocks and aquaculture systems from compound climate and oxygen stress | Habitat compression alerts and heatwave predictability models informing seasonal harvest and stocking decisions                    |
| <b>Science &amp; Technology</b>   | Indigenous multi-parameter modelling and structured research capacity building         | Daily Copernicus-to-H3 pipeline deployment paired with intern-led research translating into MRC's technical and policy output      |

## 4. Annexures & Reference Material

### 4.1 Glossary

- UDA — Underwater Domain Awareness: the capability to detect, track, and understand activity and conditions within the underwater environment.
- MAHASAGAR — Mutual and Holistic Advancement for Security and Growth Across Regions: the successor doctrine to SAGAR, extending India's maritime engagement across the IOR and Global South.
- MSP — Maritime Spatial Planning: the process of allocating and managing marine space among competing uses (naval, commercial, ecological).
- SSP — Sound Speed Profile: the variation of underwater sound velocity with depth, critical to acoustic propagation modelling.
- PAM — Passive Acoustic Monitoring: the use of underwater microphones (hydrophones) to detect and analyse ambient and biological sounds.
- SCIP — Subsea Critical Infrastructure Protection: policy and operational measures to secure seabed cables, pipelines, and installations.
- Blue Accounting — methodologies for incorporating the value of marine natural capital and ecosystem services into economic accounts.

### 4.2 Profiles of Collaborating Institutions

#### **Maritime Research Center (MRC), Pune**

MRC is a research institution focused on underwater domain awareness, maritime security, and blue economy policy, combining technical research in underwater acoustics and marine science with policy analysis and publications for national and regional audiences.

#### **Indian Council of World Affairs (ICWA), New Delhi**

ICWA is India's oldest think tank on international affairs, engaging in research, dialogue, and policy advocacy on foreign policy and international relations, and serves as co-convener and institutional sponsor of this seminar.



## 4.3 Profiles of Speakers

### Session 1: Evolution of UDA Framework & Global Relevance

**Dr. (Cdr.) Arnab Das** is a researcher, maritime strategist, and entrepreneur. He is the Founder & Director of the Maritime Research Centre (MRC) under the Foundation for Underwater Domain Awareness (FUDA), Pune, which is working on a unique concept of Underwater Domain Awareness (UDA) as its main focus. He also runs his Start-up, M/S NirDhwani Technology Pvt Ltd which provides consultancies and services for high-end maritime security solutions and marine conservation support. He advises start-ups on underwater technology solutions and defence strategies. He has over 100 publications, a book, and two book chapters to his credit. Arnab was commissioned as an electrical officer in 1994. He was deputed to IIT Delhi in 2001 for his Master's in Underwater Electronics and subsequently appointed as the Project Officer at IIT Delhi to manage the Navy's Underwater R&D. He delivered multiple technology transfers, including for the strategic submarine project related to underwater systems and algorithms. He also completed his PhD from IIT Delhi in 2007 in underwater signal processing. He was invited to Tokyo University in 2014 as a visiting researcher to participate in the design and development of passive acoustic monitoring systems for freshwater dolphins. He was also at the Acoustic Research Laboratory of the Tropical Marine Science Institute at the National University of Singapore in 2015 for a year, post his retirement from the Navy to understand underwater technology development from a global perspective.



**Admiral Karambir Singh, PVSM, AVSM, IN (Retd.)** served as the 24th Chief of the Naval Staff of the Indian Navy, capping a distinguished military career spanning over four decades. Commissioned into the Executive Branch of the Indian Navy in July 1980, he qualified as a helicopter pilot in 1981, extensively flying Chetak and Kamov helicopters. Throughout his career, he held the unique distinction of being the "Grey Eagle," a title conferred upon the senior-most serving naval aviator. An alumnus of the National Defence Academy, Khadakwasla, and the Defence Services Staff College, Wellington, Admiral Singh held numerous critical operational and staff appointments. He commanded four frontline ships, including the guided-missile destroyers INS Rana and INS Delhi. His apex leadership roles included serving as the Flag Officer Commanding-in-Chief of the Eastern Naval Command and Vice Chief of Naval Staff, before taking command of the Indian Navy from May 2019 to November 2021. In recognition of his exceptional service, leadership, and devotion to duty, he was awarded the Param Vishisht Seva Medal (PVSM) and the Ati Vishisht Seva Medal (AVSM) by the President of India. Following his naval retirement, he continued to shape maritime strategic thought, serving as the Chairman of the National Maritime Foundation.



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

**Amb. Anup K. Mudgal:** As India's High Commissioner to Mauritius, Ambassador Anup K. Mudgal, a member of the Indian Foreign Service (IFS), retired in May 2016. His thirty-two-year diplomatic career included three stints at the Ministry of External Affairs' headquarters, where he oversaw matters relating to human resource development as well as relations with countries in India's neighbourhood, the ASEAN region, the Russian Federation, and some countries in Central and Eastern Europe. Amb. Mudgal served in a variety of roles in the Indian Missions in Mexico (including NAFTA matters), Peru, the former Yugoslavia, Belgium (EU matters), Germany, Austria (work relating to: IAEA, UNIDO, UNODC, UNOOSA, UNCITRAL), and Mauritius as part of his eight assignments overseas (including IORA). Among Amb. Mudgal's areas of expertise are maritime security and defence, the ocean economy, particularly the economy within the broader sustainability agenda, trade policy and market access, technology transfer, adaptation, and application, and human resource management, including skill development and development assistance. Amb. Mudgal has participated in a number of voluntary activities, with the most significant ones being: member of the FICCI Task Force on Blue Economy; member of the Steering Committee on Blue Economy under the PMEAC; and guest lecturer at several schools of higher learning



**Callistine Jude Lewis** is a researcher, policy writer, and editor specializing in maritime security, coastal community development, and conflict analysis. He currently serves as the Head of Publishing and Research Fellow at the Maritime Research Center (MRC) in Pune, India. Following his Bachelor of Arts in Political Science and English Literature from St. Stephen's College, Delhi University, he pursued his postgraduate degree of M.A. in Conflict Analysis and Peacebuilding from the Nelson Mandela Centre for Peace and Conflict Resolution at Jamia Millia Islamia, New Delhi where his thesis interrogated the impacts of the 1950s mechanisation of fishing on the Latin Catholic fishing communities of Central Kerala. He directs the end-to-end editorial production of academic journals, policy papers, and gap analysis reports for the center. He also actively works on strategic policy frameworks focuses on the geopolitics of the Indian Ocean Region and Underwater Domain Awareness (UDA) and has authored strategic analyses such as *"The Indo-US Comprehensive Underwater Domain Awareness (UDA) Roadmap: Why Strategic Alignment in the Underwater Space Is Crucial for India"*. Callistine also speaks on environmental policy, blue economy growth, and water governance and as an independent writer, he has documented the severe impacts of coastal erosion and climate vulnerability on local populations, publishing detailed investigative feature pieces regarding the erosion crisis along the Kannamaly coast in Kerala.



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

**Mr. Aditya Kumar Sinha** [Executive Director, C-DAC Mumbai & CEO, MDCoE]: Mr. Aditya Kumar Sinha is a distinguished tech leader and the Executive Director of the Centre for Development of Advanced Computing (C-DAC), Mumbai, a premier R&D organization under the Ministry of Electronics and Information Technology (MeitY), Government of India. Concurrently, he serves as the Chief Executive Officer of the Maritime Digital Centre of Excellence (MDCoE), a strategic initiative under the Ministry of Ports, Shipping and Waterways. With an extensive and impactful career in public-sector technology leadership, Mr. Sinha has previously directed operations at C-DAC Patna and C-DAC Kolkata. He has been instrumental in spearheading national-level digital transformation initiatives, fostering industry-academia collaborations, and building robust technological ecosystems across India. His core areas of expertise encompass High-Performance Computing (HPC), Artificial Intelligence (AI), Cyber Security, and Digital Twin technologies. Under his visionary leadership, C-DAC Mumbai continues to drive cutting-edge research and deploy scalable, high-utility solutions across vital sectors including maritime logistics, digital health, and smart governance.



**Mr. Shridhar Prabhuraman** brings over six years of experience in underwater acoustics at Maritime Research Center, Pune. He holds a Bachelor's degree in Computer Science and a Master's degree in Artificial Intelligence from the University of New South Wales (UNSW), where he was awarded the prestigious International Scientia Scholarship. His academic prowess and deep understanding of AI have been pivotal in advancing MRC's technological capabilities and research outputs. In his current role, Shridhar leads pioneering projects such as the 3D Ambient Noise Mapping in the Indian Ocean Region (IOR) and the Marine Spatial Planning Tool for IOR. These projects aim to bolster maritime situational awareness and support sustainable marine resource management. His research work at Maritime Research Centre, reflected in multiple notable publications, focuses on leveraging AI to enhance Underwater Domain Awareness (UDA) and drive innovation in the field.





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

**Mr. Hrishikesh Dhande** is the Deputy Director of the Pune International Centre. He served as the Former Region Head - Academic Alliances Group - TCS, and did his BE CSE from MIT Pune in 2001. He started his professional career with Tech Mahindra in 2003 and was in the USA from 2006 to 2009. After the stint of Business roles for 13 years, he took up the Region Head role of Academic Interface Program (now called as Academic Alliances Group) out of his passion towards Academia in Apr 2016. With over a decade of experience in building strategic academia–industry collaborations, Mr. Dhande has been instrumental in driving partnerships between Tata Consultancy Services and leading universities across India. His work has focused on enabling employability, digital skilling, and innovation-driven learning frameworks that connects academia with industry.



## Session 5: Sediment Management & Navigational Safety

**Lieutenant General AK Ramesh, SM** is a distinguished military leader currently serving as the 49<sup>th</sup> Commandant of the prestigious College of Military Engineering (CME), Pune. Commissioned into the Corps of Engineers of the Indian Army, he brings decades of extensive operational, instructional, and administrative experience to his leadership roles. Throughout his illustrious career, he has commanded critical engineering formations and held pivotal staff appointments across diverse operational terrains, earning the Sena Medal for his exceptional devotion to duty and gallantry. As the head of CME Pune, the premier tactical and technical training institution of the Indian Army, he spearheads advanced military education, research, and innovation in combat engineering, CBRN defense, and sustainable infrastructure development.



**Mr. Romit Kaware** is a graduate of the Indian Institute of Technology (IIT) Delhi, holding a Bachelor's degree in Civil Engineering. Currently, he is pursuing his PhD in geotechnical engineering from IIT Delhi. He is a research fellow at the Maritime Research Center and his primary focus is on sediment management in the tropical waters of the Pacific. His work highlights the importance of sediment management in different domains like coastal zones, freshwater systems and watershed management while discussing the impacts of sedimentation in the context of people-economy-nature. It gives the context of the unique tropical conditions and the socio-economic challenges faced by the different stakeholders in sediment management. His work also underlines how digital transformation and integration of AI in the current systems can lead to capacity and capability building in sediment monitoring. Romit is also deeply enthusiastic about applying his expertise in civil engineering, especially in the maritime sector to foster sustainable development



## Session 6: Blue Accounting & Marine Environmental Economics

**Dr. Ajit Ranade** has served as Vice Chancellor, Gokhale Institute of Politics and Economics, a deemed University in Pune, from February 4, 2022 till October 29, 2024. He earlier served as Chief Economist of the Aditya Birla Group (2003-2022) and Chief Economist of ABN AMRO Bank, India (2000-2003). His professional career has spanned academic and corporate assignments, including teaching in universities in India and U.S. He has served on many boards of companies, academic institutions and trusts. He has served on various committees of the Reserve Bank of India, most recently in the committee for Fuller Capital Account Convertibility. Dr. Ranade is a trustee of Pune International Centre, Board member of MCCIA and Chairs the Research Advisory Panel of the Indian Institute of Banking and Finance.



**Ms. Jayseelan Cathrine** has a strong interdisciplinary background with a Master's in Water Science and Policy from Shiv Nadar University. Her thesis explored socioeconomic challenges in drought management and climate change. She also completed the Young India Fellowship at Ashoka University (PGD in Liberal Studies) and holds a B.Sc. (Hons) in Physics from St. Stephen's College, Delhi. Professionally, she co-chaired the Underwater Domain Awareness (UDA) session at the World Ocean Summit Conference (WOSC) 2024, authored a position paper on Marine Spatial Planning (MSP), and led the development of a UDA skilling handbook. Currently, she is producing an MSP handbook, designing e-learning modules on the blue economy, and contributing to a monograph on the Indus and Brahmaputra transboundary basins. As Head of Research & Publication at the Maritime Research Center (MRC), she oversees key projects. She is also Co-Editor of the UDA Knowledge Center, demonstrating her commitment to knowledge dissemination, capacity building, and sustainable development research



## Session 7: Biofouling, Anthropogenic Noise & Ecological Resilience

**Dr. Varsha Kelkar-Mane** is a Professor and Head of the Department of Biotechnology at the University of Mumbai, where she also serves as the Deputy Director for the Center for Excellence in Marine Studies (CEMAS). A distinguished academic and researcher, she is a Fellow of the Royal Society of Chemistry (FRSC) and holds extensive expertise spanning environmental microbiology, bio nanotechnology, bioprospecting, and diagnostics. Dr. Kelkar-Mane has been at the forefront of several high-impact national and international research initiatives. Notably, she leads a prestigious project backed by the Ministry of Earth Sciences under India's Deep Ocean Mission, focusing on bioprospecting marine microalgae for the cosmeceutical and pharmaceutical industries. Her diverse research portfolio also features innovative work in archival preservation using advanced biotechnological interventions. With numerous publications in high-impact peer-reviewed journals and a proven track record of institutional leadership, Dr. Kelkar-Mane continues to drive critical advancements at the intersection of biotechnology, marine sciences, and sustainable development.



**Mr. Suchir Mamidala** is a Research Fellow at MRC and a graduate of IIT Madras with a Bachelor's degree in Chemical Engineering and also possess a research interest in computational modeling, maritime sustainability, and data-driven decision support systems. His work is mainly focused on the simulation of marine biofouling processes, integrating engineering principles with computational techniques to address the ever growing challenge of Biofouling in the maritime sector. He is particularly interested in interdisciplinary research at the intersection of engineering, technology, policy, and economic development, and looks forward to engaging in meaningful academic discussions and collaborative research initiatives.





## Session 8: Sustainable Fisheries, Aquaculture & Marine Bioresources

**Mr. Rakesh Kumar** is the General Manager (Software), Bharat Electronics Limited, a PSU under the Ministry of Defence, Government of India. With extensive experience in software engineering, digital innovation, and technology-driven solutions, Mr. Kumar has contributed significantly to advancing indigenous technology capabilities and supporting mission-critical initiatives across strategic sectors.



**Ashwani Singh** is a Research Engineer at C3i Hub IIT Kanpur and research fellow at MRC where he works on applied artificial intelligence and machine learning for real-world decision-making systems. His work includes the development of AI-driven solutions for the maritime sector, with a particular focus on Potential Fishing Zone (PFZ) prediction to support sustainable fisheries and improve operational efficiency for fishing communities. By combining satellite data, environmental parameters, and advanced AI techniques, he aims to build intelligent systems that enhance maritime resource management and decision-making. His broader research interests include geospatial AI, large language models, and trustworthy AI for critical applications.

