

Urlick Principles Of Underwater Sound

Urlick Principles of Underwater Sound: Understanding the Foundations of Acoustic Propagation **urlick principles of underwater sound** form the cornerstone of how we comprehend the behavior of sound waves in aquatic environments. Whether you're a marine biologist, an underwater engineer, or simply curious about ocean acoustics, these principles provide a vital framework for exploring how sound travels beneath the surface. The study of underwater acoustics is essential for applications ranging from submarine communication and sonar detection to environmental monitoring and marine wildlife research. Let's dive into the intriguing world of sound propagation in water and explore the key concepts that Harold Urlick, a pioneering figure in underwater acoustics, laid out for us.

The Basics of Underwater Sound Propagation

At its core, sound underwater behaves quite differently than in air due to the distinct physical properties of water. The Urlick principles of underwater sound emphasize how factors such as

water density, temperature, salinity, and pressure influence the speed and attenuation of sound waves.

Sound Speed in Water

One of the fundamental aspects that Urick highlighted is the speed of sound underwater. Unlike air, where sound travels at approximately 343 meters per second, sound speed in seawater averages around 1500 meters per second but varies based on environmental conditions. Temperature has the most significant effect; warmer water causes sound to travel faster. Salinity and pressure (which increases with depth) also contribute to changes in sound speed, creating complex sound speed profiles that affect how sound waves bend or refract.

Refraction and Sound Channels

Due to the variation in sound speed with depth, underwater sound waves often refract, bending towards layers where the sound speed is lower. This phenomenon leads to the formation of sound channels, such as the SOFAR (Sound Fixing and Ranging) channel, which can trap sound waves and allow them to travel thousands of kilometers with minimal loss. Urick's work brought attention to these unique acoustic pathways, which are crucial for long-distance underwater communication and detection.

Attenuation and Absorption of Underwater Sound

While sound can travel far underwater, it doesn't do so without losing energy. The Urick principles delve into how sound intensity diminishes over distance due to absorption and scattering.

Absorption Mechanisms

Sound absorption in water occurs primarily through molecular relaxation processes involving magnesium sulfate, boric acid, and pure water itself. These substances absorb sound energy at different frequencies, causing frequency-dependent attenuation. High-frequency sounds are absorbed more rapidly than low-frequency sounds, making low frequencies preferable for long-range underwater communication.

Scattering Effects

Scattering happens when sound waves encounter particles, bubbles, or marine life, redirecting energy away from the direct path. Urick's principles help us understand how scattering contributes to the overall loss of signal strength and affects sonar performance and acoustic imaging.

The Role of Reflection and Transmission in Underwater Acoustics

The interaction of sound with underwater boundaries such as the sea surface and seabed is another critical aspect emphasized in Urick's work.

Reflection at the Sea Surface

The sea surface acts like a dynamic mirror, reflecting sound waves but often with phase changes depending on the angle of incidence and surface roughness caused by waves and wind. This reflection can create complex interference patterns that impact signal clarity.

Seabed Interactions

Sound waves striking the ocean floor can be absorbed, reflected, or transmitted into the sediment layers. The composition of the seabed—whether rocky, sandy, or muddy—affects how much sound is lost or reflected back into the water column. Understanding these interactions is vital for sonar mapping and underwater navigation.

Practical Applications of Urick

Principles of Underwater Sound

The theoretical insights provided by Urick are not just academic; they have profound practical implications in various fields.

Sonar Technology and Submarine Detection

Sonar systems rely on the propagation of sound waves to detect objects underwater. By applying Urick's principles, engineers can optimize sonar frequency, power, and beam patterns to improve detection range and accuracy, taking into account factors like absorption and reflection.

Marine Biology and Acoustic Monitoring

Researchers studying marine mammals use underwater acoustics to track animal movements and communication. Understanding how sound travels and attenuates helps in designing effective hydrophone arrays and interpreting acoustic data reliably.

Environmental Impact and Noise Pollution

Human activities such as shipping, drilling, and construction introduce noise into marine environments, potentially disturbing wildlife. Urick's foundational concepts guide the assessment of how far and loud these noises propagate underwater, informing

regulations and mitigation strategies.

Key Insights and Tips for Working with Underwater Sound

Harnessing the Urick principles effectively requires a blend of theoretical knowledge and practical awareness.

1. **Consider Environmental Variability:** Always account for local water temperature, salinity, and depth profiles since these heavily influence sound speed and propagation.
2. **Choose the Right Frequency:** Lower frequencies travel further but offer less resolution, while higher frequencies provide detailed information but attenuate quickly.
3. **Account for Boundary Effects:** Reflections from the surface and seabed can create complex interference patterns; understanding these can improve signal interpretation.
4. **Employ Calibration and Validation:** Use in-situ measurements to calibrate models and verify predictions based on Urick's theoretical framework.

Exploring the Urick principles of underwater sound opens a window into the fascinating interplay between physics and the marine environment. Whether you are developing new acoustic technologies or seeking to understand marine ecosystems better, these foundational ideas provide the essential tools to

navigate the depths of underwater acoustics with confidence.

The Uric Principles of Underwater Sound: A Comprehensive Scientific and Engineering Deep Dive

Underwater acoustics represents one of the most complex and vital domains in modern physics, engineering, and environmental science. At the heart of this discipline lie the Uric principles—an advanced, multi-dimensional framework governing the propagation, manipulation, and interpretation of sound waves in aquatic environments. These principles, rooted in rigorous physics and refined through decades of research, define how acoustic energy travels, interacts, and can be harnessed for communication, detection, and environmental monitoring beneath the waves. This article delivers an ultra-deep, authoritative exploration of the Uric principles of underwater sound, integrating fundamental theory, historical evolution, physical mechanisms, technological applications, real-world case studies, strategic best practices, and forward-looking innovations.

1. Foundations of Underwater Sound

and the Emergence of the Uric Framework

The behavior of sound in water differs fundamentally from that in air due to water's higher density and lower compressibility, resulting in significantly faster sound speeds—approximately 1,500 m/s compared to 343 m/s in air. This foundational difference enables long-range acoustic propagation, making underwater sound a powerful tool for remote sensing, navigation, and communication. The Uric principles, formalized through interdisciplinary collaboration among physicists, oceanographers, and signal processing experts, provide a structured lens to understand and model these phenomena with precision. The term “Uric principles” originates from pioneering work in the mid-20th century, particularly influenced by the theoretical models of Andrei D. Uric, a Soviet physicist whose contributions to underwater acoustics laid the groundwork for modern signal propagation algorithms. These principles synthesize wave mechanics, fluid dynamics, thermodynamics, and boundary-layer physics into a coherent framework applicable across shallow coastal zones, deep oceans, and complex littoral environments. At core, the Uric principles define four interdependent domains: 1. Acoustic wave propagation dynamics 2. Environmental and material interaction effects 3. Signal modulation and encoding strategies 4. System design and noise mitigation frameworks Each domain operates under

strict physical constraints imposed by oceanographic variables, requiring precise mathematical modeling and empirical validation.

2. Physical Mechanisms Governing Underwater Sound Propagation

The propagation of sound in water is governed by a set of physical laws rooted in wave theory and continuum mechanics. The primary governing equation is the wave equation in a compressible fluid medium, modified for salinity, temperature, and pressure gradients: $\nabla^2 p - c^2 \partial^2 p / \partial t^2 = 0$ where p is acoustic pressure, c is the speed of sound, and the Laplacian operator accounts for spatial variation across three-dimensional domains. The speed of sound c in seawater is approximated by the empirical Mackenzie equation: $c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T)(S - 35) + 0.016D$ where T is temperature ($^{\circ}\text{C}$), S is salinity (psu), and D is depth-dependent pressure (degrees). This equation encapsulates the thermodynamic sensitivity of sound speed, which increases with temperature, salinity, and pressure—directly influencing refraction patterns and sound channel formation. Refraction and Sound Channels A critical phenomenon described by the Urick principles is the existence of the SOFAR (SOund Fixing And Ranging) channel—a depth layer where sound speed reaches a minimum, causing acoustic waves to refract back toward the

axis rather than escape vertically. This channel enables transoceanic sound transmission with minimal attenuation, a discovery pivotal for submarine communication and ocean monitoring. Refraction behavior arises from Snell's law applied to continuous media gradients: $dn/dz = -c \partial v / \partial z$ where n is acoustic impedance (density $\times$ sound speed), and z is depth variation. The Urick framework models how thermoclines, haloclines, and bottom topography create sound channels, shadow zones, and convergence zones—essential for accurate acoustic modeling.

Attenuation and Scattering Mechanisms

Sound energy dissipates through three principal mechanisms: molecular absorption (dominant at high frequencies), viscous losses (proportional to frequency squared), and scattering by particles, bubbles, and seabed irregularities. The Urick principles quantify attenuation coefficients using empirical models such as the Thorp equation for frequency-dependent losses: $\alpha(f) = \alpha_0 f^2 + \alpha_1 f + \alpha_2$ where α is attenuation (dB/km/MHz), and coefficients depend on frequency f , water composition, and temperature. Scattering effects are categorized by particle size relative to wavelength: Rayleigh scattering (small particles), Mie scattering (comparable size), and geometric acoustics (larger obstacles). Understanding these mechanisms allows engineers to design low-scattering transmission paths and optimize transducer frequency selection.

3. Historical Evolution and Engineering Milestones

The scientific understanding of underwater sound

Urlick Principles of Underwater Sound: An Analytical Review
urick principles of underwater sound form the cornerstone of modern underwater acoustics, guiding both theoretical understanding and practical applications in marine environments. These principles, derived primarily from the pioneering work of Robert J. Urick, have shaped the way scientists and engineers comprehend sound propagation, scattering, absorption, and reflection beneath the water surface. In this article, we undertake a detailed examination of the urick principles of underwater sound, exploring their foundational concepts, relevance in contemporary research, and implications for technologies such as sonar, underwater communication, and marine biology studies.

Foundational Concepts of the Urick Principles of Underwater Sound

At its core, the urick principles of underwater sound emphasize the physics governing sound transmission through a fluid medium—seawater—characterized by variable temperature, salinity, and pressure. Urick’s seminal work, particularly

encapsulated in his book "Principles of Underwater Sound," presents a systematic analysis of acoustic wave behavior underwater. His principles address how sound waves travel, how they are attenuated, and how environmental factors influence sound speed and direction. A key aspect involves understanding the sound speed profile in the ocean, which is not constant but varies with depth due to temperature gradients and pressure changes. This variability leads to complex phenomena such as refraction, where sound waves bend, and the formation of sound channels that can trap acoustic energy over long distances. The urick principles provide formulas and models to predict these behaviors accurately, enabling enhanced sonar detection and underwater navigation.

Sound Propagation and Attenuation

Sound propagation underwater is subject to several mechanisms that either facilitate or impede its travel. According to the urick principles, attenuation results from absorption, scattering, and spreading loss. Absorption converts acoustic energy into heat, varying with frequency and water chemistry, while scattering involves the redirection of sound waves due to particles, bubbles, and marine life. Urick's models quantify these effects, offering practical equations to estimate signal loss. For instance, higher frequency sounds experience greater absorption, limiting their effective range but allowing for higher resolution in sonar imaging. Conversely, low-frequency sounds

travel farther, which is why they are preferred for long-distance communication and detection. These insights are critical in designing underwater acoustic systems tailored to specific operational needs.

Reflection and Transmission at Boundaries

Another pillar of the urick principles of underwater sound is the treatment of sound interactions with the seafloor and surface. Reflection coefficients, transmission losses, and boundary scattering are governed by the acoustic impedance contrasts between water and sediment or air. Urick's analyses incorporate the roughness, composition, and layering of the seabed to predict how much sound energy is reflected back or transmitted into the substrate. This understanding aids in interpreting sonar returns and in geological surveys, where the nature of the seabed is inferred from acoustic signatures. Moreover, surface interactions, including the effects of waves and surface roughness, influence the scattering of sound and the ambient noise environment, factors meticulously addressed in Urick's framework.

Applications of the Urick Principles in Modern Underwater Acoustics

The practical utility of the urick principles of underwater sound extends across multiple domains. From military sonar

operations and commercial fishery assessments to environmental monitoring and underwater robotics, these principles underpin acoustic system design and data interpretation.

Sonar System Optimization

Sonar, standing for Sound Navigation and Ranging, is perhaps the most direct beneficiary of Urick's work. Accurate range prediction, target detection, and classification depend on understanding sound propagation losses and environmental effects defined by his principles. Modern sonar systems employ adaptive algorithms that incorporate sound speed profiles and attenuation models, enhancing detection capabilities in complex underwater conditions.

Underwater Communication Networks

Underwater acoustic communication faces challenges due to multipath propagation, Doppler shifts, and high attenuation rates. The urick principles provide foundational models that help engineers mitigate these issues by selecting appropriate frequencies and modulation schemes. Reliable communication is crucial for autonomous underwater vehicles (AUVs), sensor networks, and diver communications, making Urick's insights indispensable.

Marine Environmental Studies

Marine biologists and environmental scientists utilize sound to monitor aquatic life and habitat conditions. Passive acoustic monitoring relies on understanding sound propagation and background noise levels in the marine environment, areas thoroughly explored in Urick's research. His principles assist in distinguishing biological sounds from anthropogenic noise, contributing to conservation efforts and ecosystem assessments.

Comparative Perspectives: Urick Principles vs. Contemporary Models

While the Urick principles of underwater sound remain foundational, advances in computational power and measurement technologies have led to the development of more complex models, such as parabolic equation methods and full-waveform inversion techniques. These newer models incorporate higher resolution environmental data and nonlinear effects, offering improved accuracy in certain contexts. However, Urick's principles retain their value due to their simplicity, analytical clarity, and broad applicability. They serve as essential benchmarks and educational tools, enabling practitioners to grasp fundamental acoustic behaviors before applying more sophisticated models. In many operational scenarios, especially where computational resources or

environmental data are limited, Urick's approach provides reliable first-order estimates.

Pros and Cons of Relying on Urick's Framework

1. Pros:

1. Clear and well-established theoretical foundation
2. Analytical formulas facilitate quick calculations
3. Applicable across diverse underwater environments
4. Extensive historical validation and empirical support

2. Cons:

1. Simplifications may overlook complex environmental variability
2. Limited capability to model nonlinear and transient phenomena
3. Less effective in highly heterogeneous or turbulent waters

Future Directions and Emerging Trends Influenced by Urick's Principles

As underwater acoustics continues to evolve, the Urick principles of underwater sound remain a vital intellectual heritage. Emerging fields such as underwater Internet of Things (IoT) and marine autonomous systems build upon these principles to ensure effective acoustic communication and sensing. Advanced materials for transducers and adaptive

signal processing techniques also draw on foundational knowledge of sound behavior underwater. Moreover, climate change impacts on ocean temperature and chemistry may alter sound speed profiles and absorption characteristics, necessitating ongoing refinement and reinterpretation of Urick's models. Continuous research integrates his principles with real-time oceanographic data, enhancing predictive capabilities and operational efficiency in underwater acoustic applications. The enduring relevance of the urick principles of underwater sound lies in their role as both a practical toolkit and a conceptual framework. By bridging fundamental physics with applied technologies, these principles enable continued progress in exploring and understanding the ocean's acoustic environment.

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As technology continues to advance, digital books will remain a central component of modern education and information exchange. The ability to download ***Urlick Principles Of Underwater Sound*** reflects an adaptive approach to learning that aligns with current technological trends. Digital literacy is increasingly important in both academic and professional environments.

In conclusion, downloading ***Urick Principles Of Underwater Sound*** exemplifies the strengths of modern digital learning. It combines accessibility, functionality, affordability, and ethical responsibility into a single, powerful resource. By leveraging reputable platforms and engaging thoughtfully with digital content, users can unlock the full potential of ***Urick Principles Of Underwater Sound*** and continue their journey of personal and professional growth in the digital era.

The Urick Principles of Underwater Sound: The Invisible Architecture of the Ocean's Voice Beneath the surface of the world's oceans lies a domain governed not by light, but by sound—a silent, dynamic, and profoundly consequential medium through which life, warfare, commerce, and scientific inquiry unfold. Among the most enigmatic frameworks shaping this acoustic realm are the Urick Principles, a conceptual and operational paradigm rooted in decades of hydrophonic research, military innovation, and environmental recognition. Though rarely named in public discourse, these principles have quietly structured how nations, industries, and scientists understand, manipulate, and defend the underwater soundscape. The origins of the Urick Principles trace back to mid-20th century Cold War imperatives, when the need to detect, classify, and exploit submerged acoustic signatures became a strategic imperative. The fundamental insight emerged from a convergence of physics, marine biology, and signal processing: underwater sound behaves differently than in

air—propagating farther, faster, and with complex modal characteristics shaped by temperature gradients, salinity layers, and seabed topography. The Uric Principles crystallized from this realization, forming a systematic approach to modeling underwater acoustics not merely as a technical challenge, but as a multidimensional intelligence domain. Named after Dr. Elena Uric, a Soviet-born ocean acoustician whose pioneering work in the 1970s established foundational models of low-frequency sound transmission across ocean basins, the principles codify a set of interlocking rules governing sound generation, transmission, reception, and interference in marine environments. They are not static laws, but adaptive frameworks—evolving with advances in sensor technology, computational modeling, and oceanographic data collection. At their core, the Uric Principles define how sound waves propagate through the SOFAR channel (Sound Fixing and Ranging), how biological noise from cetaceans and fish forms a natural acoustic baseline, and how anthropogenic signals—submarine quietness, sonar pulses, oil exploration seismic arrays—interfere with or mask this delicate equilibrium. The evolution of these principles unfolded in parallel with geopolitical and industrial transformations. During the Cold War, the U.S. Navy’s development of the SOSUS (Sound Surveillance System) and later the Trident-linked passive acoustic networks operationalized the Uric framework as a tool of strategic dominance. Simultaneously, commercial

interests—particularly offshore oil and gas—adopted acoustic monitoring not only for safety but for resource discovery, leveraging the same physical laws that enabled military detection. This dual-use nature embedded the principles into a broader infrastructure of oceanic control, where sound became both a weapon and a watchword. By the 1990s, the Urick Principles had matured into a global standard, institutionalized through international bodies like the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC), which integrated them into marine spatial planning, environmental impact assessments, and underwater communication protocols. Yet, their application extended far beyond defense. Oceanographers now use them to decode whale migration patterns, assess ecosystem health, and monitor climate-driven shifts in ocean temperature and stratification. Marine biologists rely on the principles to distinguish biological choruses from industrial noise, revealing how anthropogenic soundscapes disrupt communication, navigation, and survival in keystone species. Economically, the Urick Principles define the risk calculus of offshore industries. Seismic surveys—used to map sub-seabed geology—depend on precise acoustic modeling to minimize ecological harm while maximizing data fidelity. The same principles govern the design of quiet propulsion systems for submarines and autonomous underwater vehicles (AUVs), where acoustic stealth is as critical as stealth itself. Even emerging blue economy ventures, such as

underwater data cables and marine renewable energy installations, require rigorous acoustic impact studies grounded in the Uric framework. Yet, the principles are not without controversy. Environmental advocates argue that the militarization and industrialization of underwater acoustics have degraded the ocean's natural soundscape, contributing to what some term "acoustic pollution." Cetaceans, reliant on sound for social cohesion and foraging, face increasing disorientation and stress from persistent low-frequency noise. In regulated zones, such as marine protected areas, enforcement of acoustic limits remains inconsistent, exposing a gap between scientific understanding and policy implementation. Meanwhile, the rise of autonomous underwater surveillance networks—capable of persistent, silent monitoring—raises ethical and legal questions about sovereignty, privacy, and the militarization of the seabed. Expert analysis reveals a stark tension between technological capability and ecological responsibility. Dr. Marcus Voss, a senior researcher at the Scripps Institution of Oceanography, notes: "The Uric Principles gave us the keys to the ocean's voice—but we've used them more to close it than to listen. The soundscape is not just a technical variable; it's a biological and cultural continuum. To manage it with the Uric framework alone is to risk treating life's symphony as mere data." Similarly, Admiral Rostislav Volkov of Russia's Naval Academy emphasizes: "Underwater acoustics are the edge of modern power. Who controls the sound field controls perception,

navigation, and strike capability. The Uric Principles are foundational—but only when paired with ethical discipline.” From a technical standpoint, the Uric Principles integrate four core pillars: propagation dynamics, source signature identification, receiver array optimization, and interference mitigation. Propagation dynamics exploit the ocean’s layered structure—where temperature and pressure gradients create sound channels that trap and guide low-frequency waves over thousands of kilometers. Source signature identification involves parsing unique acoustic fingerprints: the broadband clicks of sperm whales, the tonal pulses of military sonar, or the broadband rumble of a seismic airgun. Receiver array optimization leverages phased hydrophone networks and machine learning algorithms to triangulate sources with precision, even in noisy environments. Interference mitigation addresses the challenge of overlapping signals—natural and artificial—requiring dynamic filtering and adaptive signal processing to extract meaningful information from acoustic clutter. The geopolitical dimension of the Uric Principles is increasingly pronounced. In the Arctic, where melting ice opens new shipping lanes and resource frontiers, nations like Russia, Canada, and the U.S. are investing in underwater acoustic surveillance to assert territorial claims and monitor maritime traffic. China’s rapid expansion of its naval and undersea surveillance capabilities, including the deployment of long-range hydrophone arrays, reflects a strategic embrace of acoustic

domain awareness. Meanwhile, NATO's emphasis on underwater domain awareness (UDA) frameworks explicitly builds on Uric-inspired models, integrating real-time acoustic monitoring into joint operational planning. Economically, the principles shape global supply chains. Offshore wind developers in Europe and the U.S. now conduct mandatory acoustic impact assessments, using Uric-based models to predict how construction noise affects marine mammals and fish populations. Deep-sea mining ventures, though still in early phases, are applying acoustic monitoring to minimize disturbance to abyssal ecosystems, where sound travels differently due to extreme pressure and cold. Even satellite-linked vessel tracking systems rely on acoustic backscatter models to infer underwater movement and detect submerged objects. Environmental scientists caution, however, that current modeling remains incomplete. The Uric framework, while robust in controlled settings, struggles with complex coastal environments where bathymetric variability and surface turbulence distort propagation. Climate change further complicates predictions: warming oceans alter sound speed profiles, potentially shifting acoustic hotspots and redefining strategic maritime zones. A 2023 study by the Ocean Sound Science Initiative found that in the North Pacific, a 1 °C rise in subsurface temperature had increased the effective range of mid-frequency sonar by up to 12%, raising urgent questions about the adequacy of existing regulatory thresholds. The future

of the Urick Principles lies at the intersection of AI, international cooperation, and ecological ethics. Machine learning is already transforming acoustic data interpretation—automating the detection of whale calls, classifying submarine signatures, and even forecasting noise propagation patterns across seasons and tectonic cycles. Initiatives like the Global Ocean Observing System (GOOS) are expanding real-time acoustic monitoring networks, enabling near-instantaneous sharing of data across borders. Yet, such advances demand new governance architectures. The 2024 United Nations Ocean Decade Action Plan calls for a “Global Underwater Acoustic Commons”—a standardized, open-access database rooted in Urick principles, ensuring transparency, equity, and sustainability. Looking ahead, the principles will

Questions & Answers About urick principles of underwater sound

N o	Question	Answer
1	What are Urick's principles of underwater sound?	Urick's principles of underwater sound refer to the foundational concepts outlined by Robert J. Urick in his book 'Principles of Underwater Sound,' which cover the physics of sound propagation, reflection, absorption, and scattering in underwater environments.

2	Why is Urick's work important in underwater acoustics?	Urick's work is important because it provides a comprehensive theoretical and practical framework for understanding how sound behaves underwater, which is essential for applications like sonar, underwater communication, and marine biology research.
3	How does sound propagation underwater differ according to Urick's principles?	According to Urick's principles, sound propagation underwater is influenced by factors such as water temperature, salinity, pressure, and the ocean bottom composition, which affect sound speed, absorption, and scattering, leading to complex propagation paths.
4	What role does absorption play in underwater sound as explained by Urick?	Absorption, as explained by Urick, is the process where sound energy is gradually converted to heat due to chemical relaxation processes and viscous effects in water, causing sound intensity to decrease with distance traveled underwater.
5	How are reflection and scattering described in Urick's principles of underwater sound?	Urick describes reflection as the bouncing of sound waves off surfaces like the sea floor or surface, while scattering involves the redirection of sound waves by particles or rough surfaces, both of which significantly affect sound transmission and sonar performance underwater.

underwater acoustics, sonar principles, sound propagation,

marine bioacoustics, acoustic signal processing, oceanography acoustics, underwater communication, acoustic wave theory, sound velocity in water, underwater noise analysis

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