



PART 2

Read the text below and answer questions 14–26.

OCEAN ACOUSTICS AND THE SCIENCE OF SOUND IN THE SEA

A

In the ocean, sound is not merely one sensory channel among others; it is the principal medium through which long-distance information travels. Electromagnetic radiation is rapidly diminished in seawater because scattering and absorption cause strong attenuation, leaving light useful only over short ranges and mainly near the surface. Acoustic energy, by contrast, propagates efficiently, allowing communication, navigation, and measurement across distances that would be impossible with optics alone. This is why biological systems—such as cetacean calls and dolphin clicks—alongside human technologies—such as sonar and ship-borne sensors—are so dependent on how sound moves through the water column. The sea is therefore an acoustic commons: a shared medium whose physical properties shape both ecological interaction and maritime activity.

B

The apparent simplicity of “sound travels far” conceals a complex dependence on ocean structure. The speed of sound in seawater is governed primarily by temperature, pressure, and salinity, and these variables vary systematically with depth and geography. Warmer water generally increases sound speed, while increasing depth raises pressure, which also increases speed; salinity exerts a smaller but still meaningful effect. Because these properties form vertical gradients—often organised around a thermocline—sound paths bend as they cross layers, a process known as refraction. Refraction produces regions where acoustic energy converges and regions where it is depleted, creating “shadow zones” in which a signal may be unexpectedly weak. Practical acoustics therefore depends not just on the source and receiver, but on the stratified physics of the entire water column between them.

C

One striking consequence of refraction is the deep sound channel, often called the SOFAR channel. In many parts of the ocean, sound speed decreases from the surface down to an intermediate minimum and then increases again at greater depths as pressure dominates. This speed minimum acts like a waveguide: sound rays that drift upward or downward are refracted back toward the centre of the channel, effectively trapping acoustic energy. The result is extraordinary range, especially for low-frequency signals, which can travel thousands of kilometres with limited loss. This phenomenon helps explain why some



whale vocalisations are detectable far from their source, and why long-range acoustic monitoring can “hear” events—biological, geological, or anthropogenic—across vast ocean basins.

D

Human use of ocean acoustics emerged from practical and strategic needs, particularly submarine detection and seafloor mapping. Active sonar transmits a pulse and measures echoes, while passive systems listen for existing sources without emitting energy. Echo sounders and multibeam instruments infer depth and seabed structure by measuring travel time and angle, generating bathymetry at resolutions that can reveal ridges, canyons, and sedimentary features. Yet these tools are limited by acoustic geometry and seafloor complexity. Sound reflects differently from soft sediment and hard rock, and irregular terrain can produce ambiguous returns, including multipath echoes and areas where the beam does not illuminate effectively. Moreover, the same refraction that enables long-range travel can also complicate local interpretation by bending paths and producing unexpected gaps in coverage.

E

Beyond mapping and detection, acoustics has become a core instrument for environmental observation. Networks of hydrophones can track marine mammals, register earthquakes, and even record the low-frequency signature of distant storms, enabling researchers to build acoustic baselines over time. Analysts often rely on spectrograms to classify signals by frequency and temporal pattern, distinguishing, for example, biological calls from ship noise or seismic events. However, interpretation remains probabilistic rather than absolute. Background noise varies with weather and season; the same species may alter calls depending on context; and overlapping sources can blur classification. Consequently, acoustic monitoring requires careful calibration, ground-truthing, and methodological transparency to avoid treating patterns as definitive when they are only strongly suggestive.

F

The expansion of anthropogenic activity has also transformed the ocean into a noisier environment, making *noise pollution* a major governance concern. Commercial shipping produces pervasive low-frequency sound, while construction, seismic surveys, and some naval systems can add intense pulses. Chronic noise can mask communication and navigation cues used by marine organisms, and acute exposures may trigger behavioural disruption, avoidance, or stress responses, depending on frequency, duration, and species sensitivity. Because sound can propagate far, the ecological footprint of a source may extend well beyond its immediate location, complicating any attempt to draw neat



boundaries around impact. The ethical question is therefore not only whether a single activity is “too loud,” but how cumulative acoustic loading alters the functioning of marine habitats over time.

G

Mitigation and future change are now intertwined. Some interventions focus on engineering—quieting propellers, reducing cavitation, and redesigning machinery—while others rely on policy tools such as rerouting traffic away from sensitive areas or imposing *speed limits* to reduce noise emissions. These measures can involve trade-offs: rerouting may increase distance travelled and fuel use, and enforcement is challenging in open waters. At the same time, climate change is modifying the ocean’s acoustic conditions. Warming alters temperature profiles and thus refraction patterns, potentially changing long-range *propagation* pathways and the shape of shadow zones. Melting sea ice can raise ambient noise and open new routes, increasing shipping in previously quieter regions. The scientific challenge is to model these interacting pressures, while the governance challenge is to balance scientific, commercial, and ecological needs within a shared acoustic environment.

Questions 14–19

Choose the correct heading for each paragraph.

List of Headings

- i Why sound is especially useful in the ocean
- ii The variables that control sound speed and refraction
- iii A channel that carries sound over huge distances
- iv Practical technologies for mapping and detection, with limits
- v Listening to the sea for environmental signals
- vi Increasing human noise and its potential impacts
- vii The formation and effects of acoustic shadow zones
- viii Changes in ocean acoustics caused by climate change

14 Paragraph B

15 Paragraph D

16 Paragraph F



17 Paragraph C

18 Paragraph A

19 Paragraph E

Questions 20–23

Choose **TRUE** if the statement agrees with the information given in the text, choose **FALSE** if the statement contradicts the information, or choose **NOT GIVEN** if there is no information on this.

20 The passage suggests that sound travels more efficiently through seawater than light does.

21 The passage states that sound speed in seawater is influenced by temperature, pressure and salinity.

22 The passage states that hydrophone networks are more expensive to install than satellite-based monitoring systems.

23 The passage suggests that rerouting ships may increase fuel use.

Questions 24–26

Complete the table below. Choose **NO MORE THAN TWO WORDS** from the text for each answer.

Managing the ocean soundscape

Source of change	Problem or measure	Effect / Comment
Human activity	Increasing noise 24	Can mask biological communication and cause behavioural disruption
	Quieter propellers and reduced cavitation	Engineering measures reduce sound at its source
	Imposing 25	Policy measure intended to reduce noise emissions
Climate change	Warming alters temperature profiles and refraction patterns	Long-range propagation 26 may change



Source of change	Problem or measure	Effect / Comment
	Melting sea ice and new shipping routes	Ambient noise may rise in previously quieter regions

Answer Key

14. ii

15. iv

16. vi

17. iii

18. i

19. v

20. TRUE

21. TRUE

22. NOT GIVEN

23. TRUE

24. pollution

25. speed limits

26. pathways