DOI: 10.37102/1992-4429_2022_39_01_06

IDENTIFICATION OF THE SOUND FIELD MODE STRUCTURE IN SHALLOW WATER IN THE INFRASOUND FREQUENCY RANGE

B.A. Kasatkin, N.V. Zlobina, S.B. Kasatkin

The paper continues the study of the vertical structure of the sound field in a shallow sea using a vertically oriented three-element combined receiving antenna. The sound field was formed by discrete components of the vessel's shaft-blade scale in the infrasonic frequency range of 2–15 Hz. In this frequency range, which is obviously lower than the first critical frequency of Pekeris's model waveguide, the structure of the sound field becomes extremely simple and can be used to identify the normal waves that form the sound field. The experiment conducted in August 2021 in the Ussuriyskiy Bay confirms the earlier conclusion that the sound field at extremely low frequencies of the infrasonic range is formed by both regular and generalized inhomogeneous Rayleigh-Sholte waves. In addition, the increased aperture of the antenna made it possible to separate the contribution of these waves to the spatial structure of the sound field. As the frequency increases, the depth of penetration of the sound wave into the bottom half-space decreases, and the role of inhomogeneous waves of the Pekeris waveguide, excited by the complex angular spectrum of the source, increases. Based on the results of measuring the attenuation coefficients of inhomogeneous waves at the aperture of a vertical antenna, the effective group velocity is determined as the energy transfer velocity in the infrasonic frequency range and its spatial-frequency dependence. Identified mode structure of the sound field is consistent with the performed model calculations.

Keywords: combined receiver, infrasound, inhomogeneous Rayleigh–Scholte waves, generalized (hybrid) waves, group velocity.

References

1. Pekeris C.L. Theory of propagation of explosive sound in shallow water. Geol. Soc. Am. Mem. 1948. N 27. P. 48–156.

2. Brekhovskikh L. M. On the field of a point emitter in a layered-inhomogeneous medium. Izv.AS USSR. Series of physics. 1949. Vol. 13. N 5. P. 505–545.

3. Brekhovskikh L.M. Waves in layered media. Moscow, Publishing House of the USSR Academy of Sciences, 1957. 502 p.

4. Brekhovskikh L.M. Waves in layered media. Moscow, Nauka, 1973. 343 p.

5. Brekhovskikh L.M., Lysanov Yu.P. Theoretical foundations of ocean acoustics. L. Hydrometeoizdat, 1982. 280 p.

6. Brekhovskikh L.M., Godin O.A. Acoustics of layered media. Moscow, Nauka, 1989. P. 278–290.

7. Acoustics of the ocean / Edited by L. M. Brekhovskikh. Moskow, Nauka, 1974. 692 p.

8. Brekhovskikh L.M., Godin O.A. Acoustics of inhomogeneous media. Vol.1 Fundamentals of the theory of reflection and propagation of sound. Moscow, Nauka, 2007. 442 p.

9. Brekhovskikh L.M., Godin O.A. Acoustics of inhomogeneous media. Vol.2. Sound fields in layered and three-dimensional inhomogeneous media. Moscow, Nauka, 2009. 428 p.

10. Kasatkin B.A., Zlobina N.V., Kasatkin S.B., Zlobin D.V., Kosarev G.V. Acoustics of the shallow sea in a scalar- vector description. Theory and experiment. Vladivostok. 2019. 360 p.

11. Kasatkin B.A., Kasatkin S.B. Scalar – vector structure and kinematic characteristics of the sound field in the infrasound frequency range. Fundamental and applied hydrophysics. 2021. Vol. 14, N 3. P. 71–85.

12. Padilla F., de Billy M., Quentin G. Theoretical and experimental studies of surface waves on solid-fluid interfaces when the value of the fluid sound velocity is located between the shear and the longitudinal ones in the solid. J. Acoust. Soc. Am. 1999. Vol. 106(2). P. 666–673.

13. Ansell J.H. The roots of the Stoneley wave equation for liquid-solid interfaces. Pure Appl. Geophys. 1972. V. 194. P. 172–188.

14. Zhuravlev V.A., Kobozev I.K., Kravtsov Yu.A. Dislocations of the phase front in an oceanic waveguide and their manifestations in acoustic measurements// Acoustic. journal. 1989. Vol. 35. N 2. P. 260–265.

15. Kasatkin B.A., Zlobina N.V., Kasatkin S.B. Model problems in acoustics of layered media. Vladivostok: Dalnauka, 2012. 256 p.

16. Kasatkin B.A., Zlobina N.V. Correct formulation of boundary value problems in acoustics of layered media. Moscow. Science, 2009. 406 p.

17. Gao Tain-Fu - Shang E.C. Effect of the branch-cut on the transformation between the modes and rays. J. Acoust. Soc. Amer. 1983. V. 73, N 5, P. 1551–1555.

18. Gordienko V.A. Vector-phase methods in acoustics. Moscow, Fizmatlit, 2007. P. 168–237.

19. Shchurov V.A., Kuleshov V.P., Tkachenko E.S., Ivanov E.N. Signs determining compensation of oncoming energy flows in ocean acoustic fields. Acoustic. journal. 2010. Vol. 56. N 26. P. 835–843.

20. Chuprov S.D. Interference structure of the sound field in the layered ocean. Acoustics of the ocean. Modern state. Moscow, Nauka, 1982. P. 71_91.

Об авторах

KASATKIN Boris Anatolyevich, Doctor of Physical and Mathematical Sciences, Chief Researcger
Institute of Marine Technology Problems of the Far Eastern Branch of the Russian Academy of Sciences
Address: 5a Sukhanova st., Vladivostok, Russia
Research interests: Theoretical and applied hydroacoustics, sound wave propagation in layered waveguides
E-mail: kasatkas@marine.febras.ru
ORCID: 0000-0001-7392-3672

ZLOBINA Nadezhda Vladimirovna, Doctor of Technical Sciences, Scientific Secretary
Institute of Marine Technology Problems of the Far Eastern Branch of the Russian Academy of Sciences
Address: 5a Sukhanova st., Vladivostok, Russia
Research interests: Acoustics of layered media, signal processing
E-mail: zlobina@marine.febras.ru
ORCID: 0000-0003-3314-2163

KASATKIN Sergey Borisovich, Candidate of Physical and Mathematical Sciences, Head laboratory
Institute of Marine Technology Problems of the Far Eastern Branch of the Russian Academy of Sciences
Address: 5a Sukhanova st., Vladivostok, Russia
Research interests: hydroacoustics, signals processing, noise fields, hybrid receiving systems, inhomogeneous generalized waves
Phone: +7(908)440-8854
E-mail: kasatkas@marine.febras.ru
ORCID: 0000-0002-0945-8355

Recommended citation:

Kasatkin B.A., Zlobina N.V., Kasatkin S.B. IDENTIFICATION OF THE SOUND FIELD MODE STRUCTURE IN SHALLOW WATER IN THE INFRASOUND FREQUENCY RANGE. Underwater investigation and robotics. 2022. No. 1 (39). P. 58–71. DOI: 10.37102/1992-4429_2022_39_01_06.