G.I.Doldikh, V.A.Luchin, I.O.Jaroshchuk, E.P.Varlatyj, M.J.Cheranev, A.A. Pivovarov, A.N.Samchenko, A.N.Shvyrev

EXPERIMENTAL RESEARCHES OF SPACE-TIME VARIATIONS PROCESS OF SOUND VELOCITY ON THE SHELF OF THE JAPANESE SEA

Pacific oceanological institute FEB RAS
Russia, 690041, Vladivostok, Baltic, 43
Тел.:8 4232 312-617; the Fax: 8 4232 312-573
E-mail: dolgikh poi.dvo.ru

In the report complex experimental supervision of variations of speed of a sound and various hydrodynamical processes in gulf Posiet (sea of Japan) during various seasons of year are discussed. Hour and daily variations, and also their communication with разномасштабными the meteorological and oceanologic phenomena are analyzed. Results of statistical processing of variations of speed of a sound on depth are resulted.

Speed of a sound is the major characteristic of the oceanic environment. In a number of such oceanologic factors as sea excitement and roughnesses of a sea-bottom, etc., in all practically important problems, its existential variations are defining for formation of fluctuations of a sound. Therefore research of statistical structure and variability of speed of a sound in the field of various spatial and time scales is the major problem of hydrophysics [1].

Shelf zones of world ocean possess especially intensive hydrological variability which besides has strongly pronounced geographical features. Such variability is defined to tidal and wind currents, coastal internal waves and sea inflow which amplitude can be essential greater, than at the open ocean. Known of the literature, researches of fluctuations of speed of a sound on a shelf of sea of Japan were spent, as a rule, during studying fluctuations of a phase and intensity of a voice-frequency signal on stationary lines (see, for example, [2]), and, undoubtedly, they have the important scientific interest. However, the decision of a problem of an actual problem - definition of existential distribution of fluctuations of speed of a sound still far before end. The sequence of stages of the decision of this problem consists in the following. First, quantitative оценивание large-scale and small-scale making fluctuations. Secondly, finding-out of a question on the contribution of internal waves to a statistical field of speed of a sound. And, at last, the third – development of statistical model of a field of speed of the sound allowing in further to carry out direct analytical research, and also randomization of model and numerical statistical modelling of sound fields [3]. Some fragments of researches offered further in a concrete geographical zone – gulf Посьета (a shelf of sea of Japan) also are devoted to consecutive performance of such program.

For realization of tasks in view during the warm period 2007 on investigated water area four complex expeditions (in May, July, September and October) have been realized. For the period of forwarding works it has been executed: about thousand series probe the high sanction on a vertical (from a surface to the bottom) with supervision of temperature, salinity and pressure; about four hundred series зондирований the high sanction on a vertical (from a surface to the bottom) with measurements of speed of a sound; some daily stations of vertical sounding. Currents (during sounding and ground stations), a sea level and meteorological conditions were simultaneously registered. During carrying out of oceanographic supervision background hydrological shootings on all area of range (8×8=64 stations). Supervision on all background shootings were made in the afternoon one day.

Great volume of supervision has been executed on acoustic lines. Simultaneously with oceanologic supervision the acoustic researches including radiations voice-frequency and фазоманипулированных of signals with frequencies of 35 and 240 Hz on various horizons were carried out. Reception was carried out both separate hydrophons (radio buoies), and the vertical aerial.

The technology of oceanologic supervision at multiseries stations consist in the following. After statement of a vessel on an anchor or a stop on drift station, 3 or 5 minutes are strict on a stop watch through everyone began sounding of water thickness. Supervision at each oceanographic station were made with high enough sanction on a vertical (on the average from 0.1 till 0.15) from a surface up to benthonic horizons which of 0.2-0.4 m from a bottom were on distance. At all stations of multiseries supervision instrumental the temperature and salinity of sea water, pressure, and also speed of a sound

were registered. The general duration of supervision at each multiseries station made 1 hour. On figure 1 distributions of multiseries stations, along a set of acoustic lines are shown.

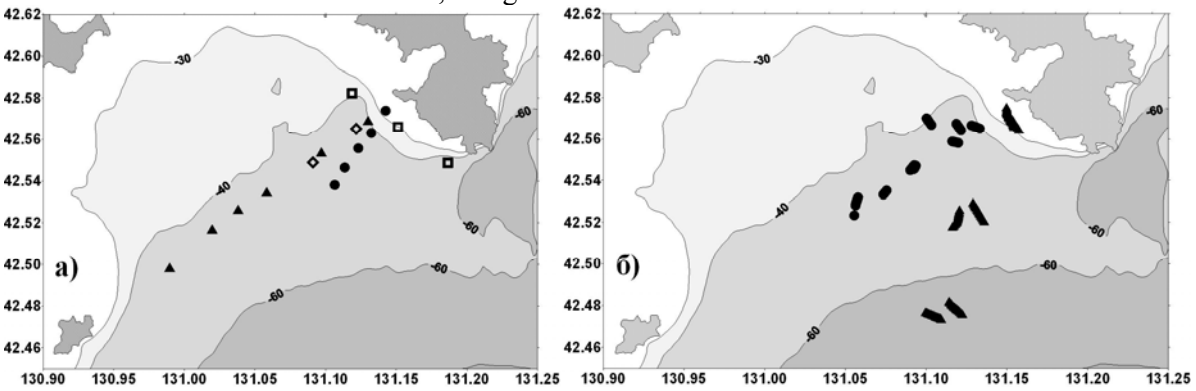

Fig.1. Multiseries supervision (a – ship on anchor; b – from a drifting vessel).

During the warm period 2007 has shown the Analysis of the received forwarding supervision, that the maximal variability of hydrological and acoustic parameters is characteristic for daily scales. The existential structure of these changes, basically, is formed under influence of the tidal phenomena. Tidal currents and fluctuations of a sea level lead to horizontal movings of water weights, and also to generation of internal waves. All listed, and also presence of acyclic currents and changes of weather conditions, leads to essential time changes of vertical stratification and structure of hydrological and acoustic parameters within day. On figure 2 such example is resulted.

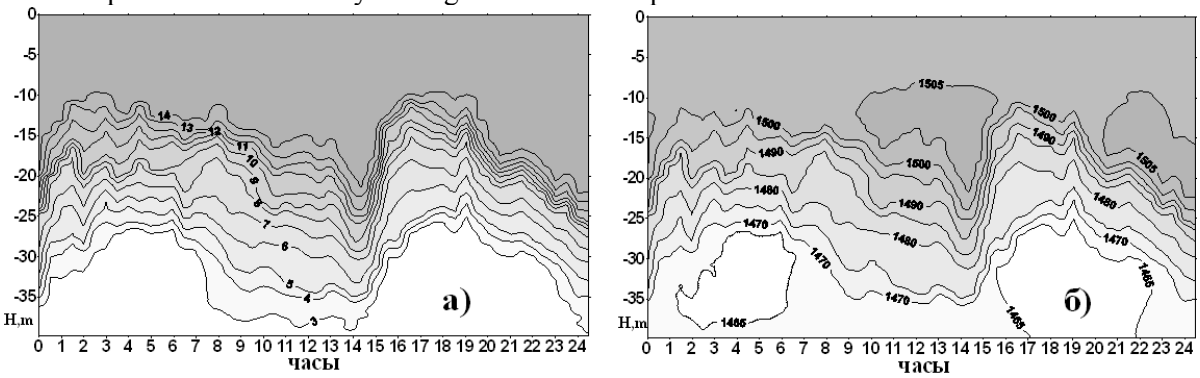

Fig.2. Time changes of temperature of water () and speeds of a sound () in thickness of waters at daily station in October, 2007

Are marked as well seasonal distinctions in daily variability of parameters of waters. For the period of the maximal warming up of thickness of waters of the sea (fig. 2a) are characteristic weak vertical gradients of parameters, practically is absent top quasihomogeneous a layer and vertical displacement of weights of water that is well shown in a floor isolines temperatures of water and speed of a sound are most significant. If to follow изолинии to speed of a sound of 1515 km/s vertical displacement of weights of water in seasonal pyknocline, connected with internal waves, in investigated region reach 25 m. In October when the period of cooling of the top part of an active layer of waters begins, there is an essential reorganization of vertical structure of waters and its time variability. In fields of temperature of water and speed of a sound it is well allocated top quasihomogeneous a layer with temperature more than 14 °C which vertical extent on different phases of the tidal phenomena varies from 10 up to 20 m. The cold benthonic layer which temperature does not exceed 3 °C is well shown also, and the vertical sizes are concluded within the limits of from 1 up to 14 m. the Aggravation seasonal pyknocline leads to essential reduction (in comparison with September) the vertical displacement of weights of water connected with internal waves, 10 m. do not fall outside the limits

From results of daily supervision follows, that time scale of variability of a field of speed of a sound about 1 hour that is in the consent from classifications of time scales of the oceanic phenomena. Usually to shot-period to the phenomena carry the periods from shares of second up to tens minutes [4]. Typical variations of temperature and speed of a sound within one hour are resulted on figure 3.

Such variations, apparently, are connected with display shot-period internal waves (IW). In this case the mechanism of variations of speed of a sound consists that the structure of speed of a sound is displaced together with an internal wave. The size of a variation is described by the elementary expression $\delta c(z) = -dc_0(z)/dz\,\xi$, where ξ - vertical displacement of particles of a liquid.

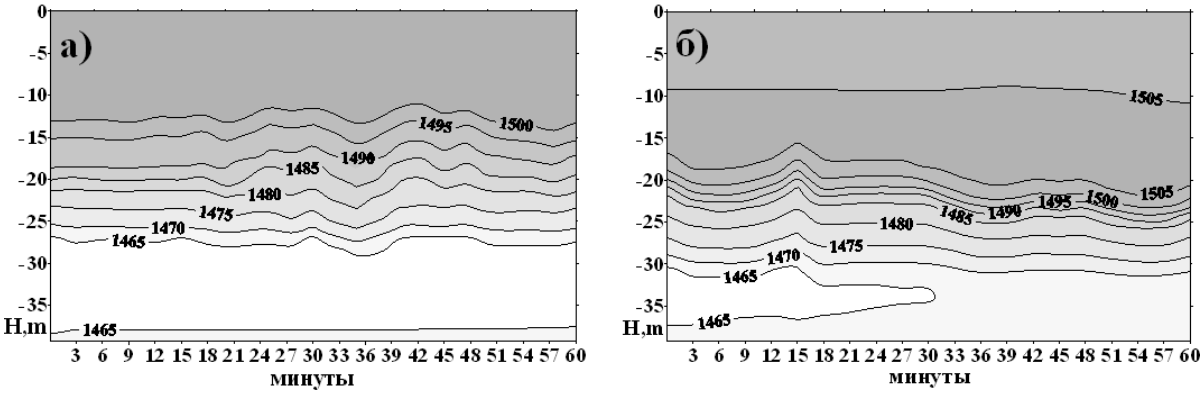

Fig.3. Time changes of speed of a sound at daily station in October, 2007 on different phases of inflow in a point with coordinates 42º 31,351 ' N, 131º 02,103 ' E (time of the beginning of supervision: and – a phase of inflow - 19:00 10/14/2007; – a phase of outflow - 13:00 10/15/2007).

To the statistical analysis of vertical variations of speed of a sound we shall apply a method of orthogonal empirical functions (OEF). It is necessary to notice, that method OEF was initially applied in oceanology only to scales of synoptic scale. However, works, for example, [5] where its substantiation for more shot-period processes at ocean is lead are known. We shall note, also, that some authors already use OEF for the analysis of a field of speed of a sound in a foreshortening of problems of sound emitting, for example, [6].

On figure.4 results of daily supervision are resulted: average for a day (53 realizations with step-type behaviour of 30 minutes) a structure of speed of a sound, a variation (STD) speeds of a sound on various horizons, and also the first and second components of decomposition on OEF (F1, F2) which contribution makes 83.83 and 8.97 %, accordingly.

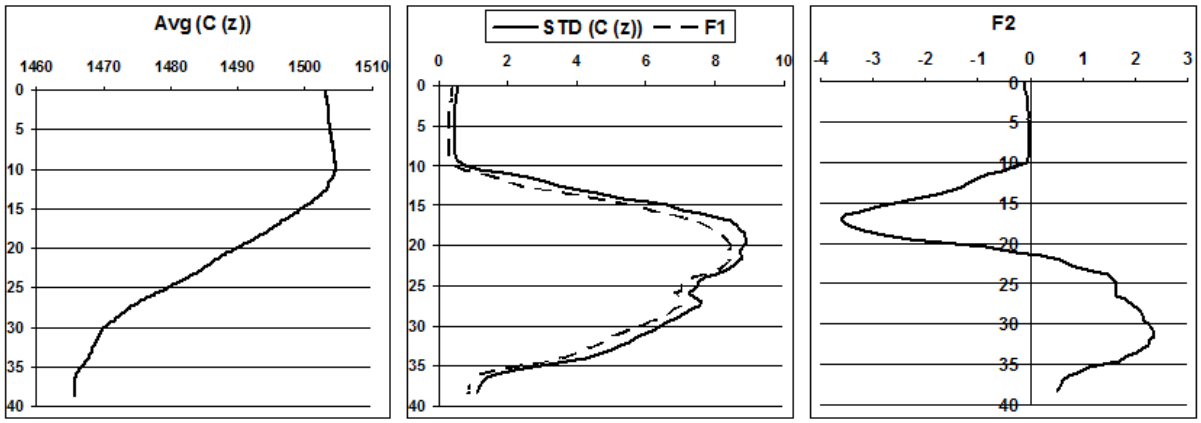

Fig.4. Average for a day a structure of speed of a sound, its variation on various horizons, and also the first and second components of decomposition on OEF (42º 31,351 ' N, 131º 02,103 ' E).

On figure 5 results of the speeded up supervision on a phase of inflow within an hour (with step-type behaviour of 3 minutes) are resulted: average in an hour (21 realization) a structure of speed of a sound, a variation (STD) speeds of a sound on various horizons, and also the first and second components of decomposition on OEF (F1, F2) which contribution makes 70.34 and 16.69 %.

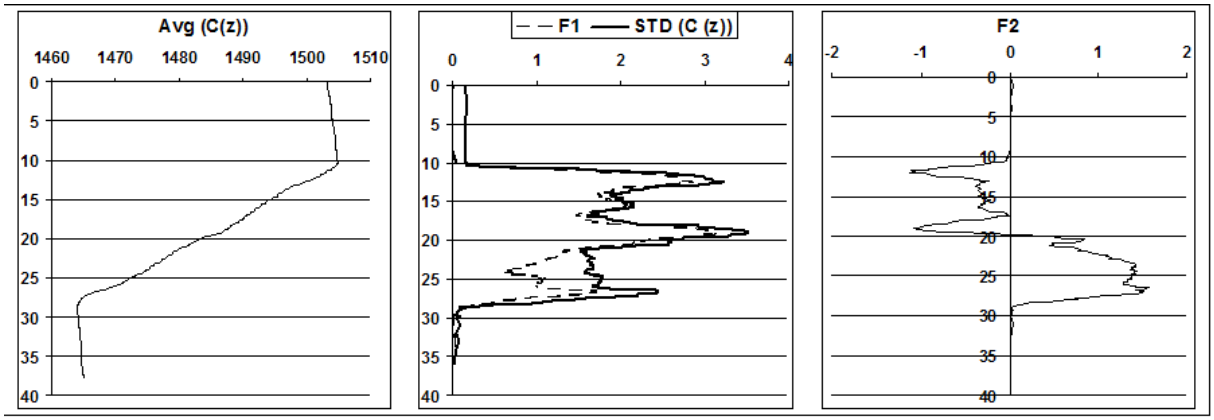

Fig. 5. Average in an hour a structure of speed of a sound, its variation on various horizons, and also the first and second components of decomposition on OEF in October, 2007 on a phase of inflow (time of the beginning of supervision - 19:00 10/14/2007).

On figure 6 results of the speeded up supervision on a phase of outflow within an hour (with step-type behaviour of 3 minutes) are resulted: average in an hour (21 realization) a structure of speed of a sound, a variation (STD) speeds of a sound on various horizons, and also the first and second components of decomposition on OEF (F1, F2) which contribution makes 91.95 and 5.29 %.

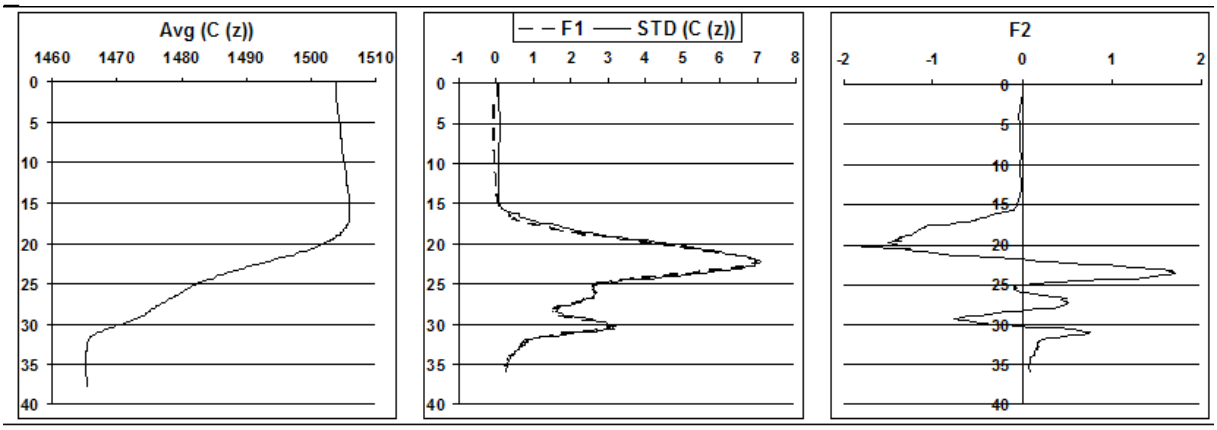

Fig. 6. Average in an hour a structure of speed of a sound, its variation on various horizons, and also the first and second components of decomposition on OEF in October, 2007 on a phase of outflow (time of the beginning of supervision - 13:00 10/15/2007).

As follows from the results resulted on figures4-6, radiuses of correlations spatial (on z) changes of structures of speed of a sound in an hour and for a day are within the limits of from 1-2 up to 8-10 meters. Thus for a day scale of correlation it is essential more.

R E F E R E N C E S

1. Distribution of a sound in fluctuating ocean /Flatter – M.: the world, 1982.–336c.
2. Rutenko A.N. Influence of internal waves on distribution of a sound to a shelf zone of sea of Japan during different seasons of year // Acoustic J. 2005. T.51. 4. c.527-535.
3. Jaroshchuk I.O., Gulin O.E. Method of statistical modelling in problems of hydroacoustics. – Vladivostok, Dalnauka, 2002. – 352c.
4. Monin A.S., Kamenkovich V.M., Court V.G. Variability of the World ocean. Gidromet. 1974. – p. 263. (In Russian)
5. Novotrjasov V.V., Yurasov G.I. Empirical orthogonal functions and vertical structure of internal waves // Oceanology. 1991. T. 31/ 2. p. 395-399.
6. Virovljanskij A.L., Kazarova A.J., Lubavin L.JA. Restoration of average temperature of ocean on measurements of a transit time of sound impulses // Acoustic J. 2007. T. 53.2. p. 216-225.