1J4-1
Proceedings of Symposium on Ultrasonic Electronics, Vol. 36 (2015)
5-7 November, 2015

Analysis of long-distance propagation characteristic by an air gun source
エアガン音源による遠距離伝搬特性の解析

Toshio Tsuchiya[1†], Koji Futa[2], Shinpei Goto[3] ,Fujio Yamamoto[3], Etsuro Shimizu[4],
([1]JAMSTEC/Tokyo Univ. of Marine Sci. and Tech.,[2]Mitsubishi Precision Co.,
[3]JAMSTEC and [4]Tokyo Univ. of Marine Sci. and Tech)
土屋利雄 [1†]，布田浩二 [2]，後藤慎平 [3] ,山本富士夫 [3]，清水悦郎 [4] ([1] 海洋研究開発機構／東京海洋大，
[2] 三菱プレシジョン, [3] 海洋研究開発機構，[4] 東京海洋大)

1. Multi Channel Seismic Survey (MCS) and marine mammal noise environment guidance

MCS is used for purpose of an investigation in a focal region and submarine resource-searching all over the world in recent years. Special vessel for MSC is often also built all over the world. But an environmental protection group shows the suspicion by which a high-power air gun source of MCS has an influence upon ecology of a marine mammal. Therefore the user of MCS is requesting always to watch a marine mammal. So JAMSTEC made a guideline to protect a marine mammal independently. When finding a marine mammal in a watch area, this guideline has decided that an air gun is stopped. But this guideline followed the example of foreign countries. An American researcher was planning a crustal structure investigation in the Hawaii Islands neighborhood jointly with JAMSTEC in 2014. But the opposite of an environmental protection group made them cancel a plan. To check influence to a marine mammal by this research, PE method suitable for long-distance propagation analysis was used. The distribution of the acoustic propagation attenuation and a receiving pulse from the offing in the Hawaii Islands to the Alaska offing were calculated by PE method. The air gun source used for a simulation is loaded into a new research vessel of JAMSTEC "KAIYO". The transmission level is 230dB (re 1μPa/1m), center frequency is 50 Hz band width is about 100 Hz, depth is about 5m

2. Propagation path and sound speed profiles

We set a propagation path (4,532 km in distance) to the Alaskan Prince Williams Sound (60.5°N) many marine mammals live from the offing in the Hawaii Islands (150°W 20°N) as shown in Fig 1. A sound speed profile changes considerably because a sound wave is propagated to the latitude direction in this course.

Along this propagation path, we assumed a total of 46 sound speed profiles of the Levitus Data [2)] for every latitudinal degree (about 111 km) l s shown in Fig 1. A sound speed profile was acquired from Levitus data site [(2)]. A sound speed profile was divided every 100m from surface to depth 1500m to improve the

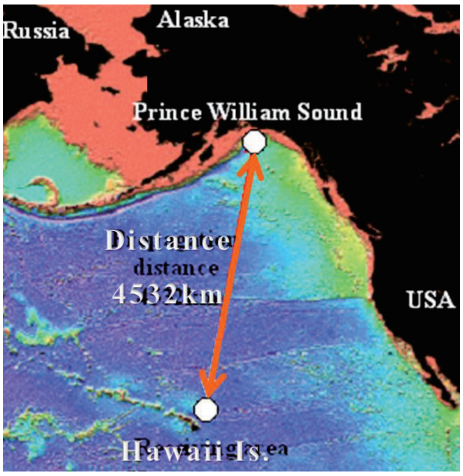

Fig.1 Sound speed profile from Hawaii to Alaska

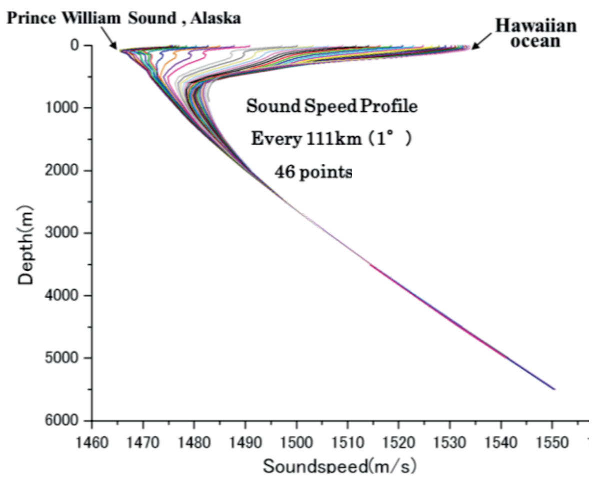

Fig.2 Propagation Path from the Hawaii Islands to Alaska (4523km)[3)]

calculation accuracy, and it was divided every 500m from depth 1500m to the ocean floor. The sound speed to the depth 1000m under the ocean floor was established 1600 m/s as the general value. This propagation path was decided only for the simulation. The transmission spread was made the cylindrical spread by this simulation. There reason are (1) sufficiently low frequency (50Hz), (2) propagated distance is very far (more than 1000 km) compared with depth,(3) the source depth is very shallow (5m).

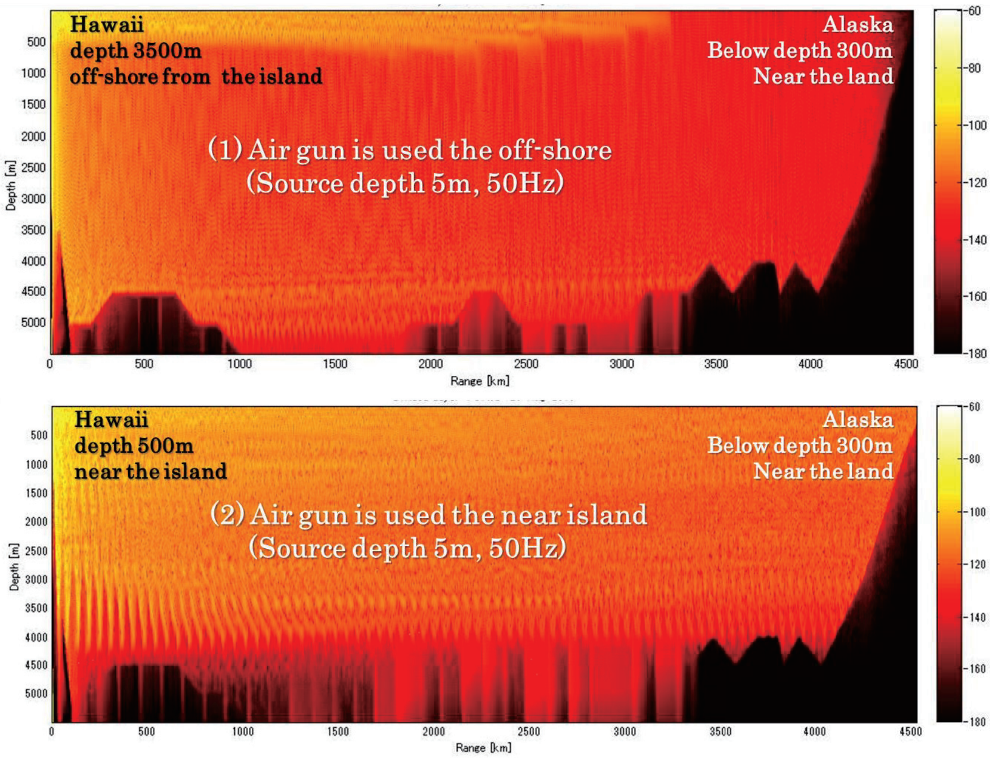

Fig3.Air gun signal propagation sound field from Hawaii to Alaska

3. Analysis by PE method

The Ray theory can calculate only a transmission process of a sound wave and transmission time. So we did simulation calculation using the Parabolic Equation (PE) method suitable for long-distance propagation analysis. PE method was used for the simulation, the computer model of Lee and Schultz was used for the analysis[1]. PE methods are efficient under range-dependent conditions such as sloping bottom and special variations in a sound speed profile. The sound speed was set to 1600m/s to 1000m under the ocean bottom in a simulation. A frequency was changed every 1Hz, and was calculated to 0-200Hz for pulse calculation.

A simulation result is shown to figure 3. A sound field on the distance 4,325km transmission course from an air gun sound wave in the Hawaii Islands to Alaska of a received point shows figure 3 (1). This figure shows that attenuation becomes high around the 3500km for an air gun sound. An environmental standard to a marine mammal has been decided respectively at each USA and Canadian state. Those standard values are different from loose 180dB to severe 110dB. When being used at a Hawaiian offing from figure 3 (1), even the severest environmental standard clears the received level.

But when using an air gun near the Hawaii Islands, the situation is different. An air gun sound reaches a sound channel axis by this situation, and the level becomes high by an Alaskan wave receiving point as shown Fig.3(2). Figure 4 shows a received pulses. When an air gun near the island is used, a received pulse shows that the level also becomes high 60dB compared with a case in the off-shore. A pass of various processes is piled, so a pulse width is stretched by hundreds of times. The received level may reach the severest standard in this case. However this level is calculated by the cylindrical spread, so the level may be quite high. When presuming that even the suitable distance is the spherical spread, the received level consists of source quite lower. A severe environmental standard would be satisfied sufficiently in that case. We'd make a marine experiment using an air gun in the future for simulation inspection. And influence of a noise to a whale would be confirmed.

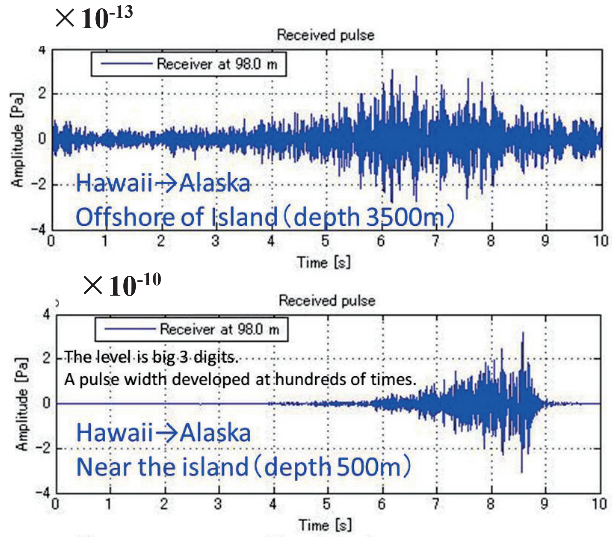

Fig.4 Comparison of a received pulse.

References

1. D.Lee,M.H.Shultz. " NUMERICAL OCEAN ACOUSTIC PROPAGATION IN THREE DIMENSION" , World Scientific,1995
2. http://iridl.ldeo.columbia.edu/SOURCES/.LEVIT
3. Toshio Tsuchiya, etc." Difference of Low Frequency Sound Propagation by the Whale Species",Pro.Symp.,Ultrason,Electron.,Vol.24(2003), pp283-284