

## **Hearing loss with frequent diving (deaf divers)**

**C. EDMONDS**

*Diving Medical Centre, Sydney, Australia*

Edmonds C. Hearing loss with frequent diving (deaf divers). *Undersea Biomed Res* 1985;12(3):315-319.—An audiometric survey was performed on a group of professional abalone divers, all of whom had experienced a great deal of exposure to dysbaric conditions. The results of this survey revealed that, even allowing for the very liberal requirements of the Australian standards for divers, over 60% had an unacceptable sensorineural, high frequency deafness. In half of these cases it was unilateral, and half bilateral. Making allowance for age, over 70% had evidence of hearing loss to a degree considered by the National Acoustic Laboratories to be compensatable.

hearing loss  
abalone divers  
Australian hearing standards

The presence of a permanent hearing loss in caisson workers has long been established, and was described by Bert (1) and Snell (2) last century. In 1913, Boot (3) coined the phrase "caisson worker's deafness" to describe a hearing loss which was either acute or chronic, temporary or permanent. In 1971, Lang et al. (4) investigated caisson workers under 40 yr of age and found that 60% had hearing defects. There was a variety of reasons why caisson workers should be affected with such a high incidence of hearing abnormalities, including barotrauma, decompression sickness, infections, and noise damage.

Although there were isolated case reports of permanent hearing loss with diving, reported intermittently, the major surveys on divers revealed little or no significant permanent hearing loss (5-7). Nevertheless, disorders associated with diving were increasingly being shown to produce permanent hearing loss. These included noise, by Coles and Knight (7) in 1961, decompression sickness by Bühlmann and Waldvogel (8) in 1967, and inner ear barotrauma by Freeman and Edmonds (9) in 1972. Excellent reviews on the development of knowledge of this subject have been made by Farmer (10).

Despite the current acceptance of the disorder of permanent hearing loss as an occupational complication of diving, there is very little evidence of the incidence of this disorder among divers. The inference from the surveys referred to above is that

it is low. However, in 1972 Zannini et al. (11) showed that there was a significant hearing loss, especially in the 4000–8000 Hz range, compared to nondivers. Just as Coles and Knight (7) attributed the permanent high frequency deafness of many of the divers to coincidental noise and gunshot trauma in their earlier years, so has Farmer (10) attempted to explain Zannini's findings.

To ascertain whether there is an appreciably high incidence of hearing loss in professional divers, a survey was performed on a very special group of subjects who had performed a large number of compressed air dives, comparable to the numbers of exposures that would be experienced by caisson workers, and in conditions in which noise exposure was unlikely.

### POPULATION STUDIED

The professional abalone divers of New South Wales, Australia, were mainly ex-fishermen who took up diving when their traditional fishing became unprofitable. The average age was 37.5 (SD = 7.7). All spent in excess of 6 yr full time abalone diving (average = 13.0, SD = 3.8). The diving was mainly 15–20 m depth, 4 h/d, 100 d/yr. Hookah gear was used, with the divers performing strenuous tasks—dragging the long compressed air hoses and transferring the full bags of abalone to the boat.

There were no obvious factors leading to otological pathology, other than diving. Excessive noise exposure was not likely and only one had any experience with the armed services (gunfire, explosives). None had caisson, helmet, or helium diving experience.

### RESULTS

The following results were obtained (Table 1).

Pure tone audiometry was performed after an otological history and examination on 28 of the 30 available professional abalone divers. Two rejected the examination for undisclosed reasons. A recently calibrated Angus and Coote S.A.3 pure tone audiometer was used in a sound-protected area, measuring the hearing loss from 500 Hz to 8000 Hz ISO, in accordance with the Australian Standards Association (12).

In 1974 the National Acoustic Laboratory supplied average hearing standards for the Australian population. It also specified hearing loss that may be considered as abnormal or sufficiently impaired to attract compensation, for various age groups. As an example, in the 35–39 age group, the acceptable degree of hearing loss in dB is 15 at 250–1500 Hz, 20 at 2000 and 3000 Hz, 25 at 4000 Hz, 30 at 6000 Hz, and 35 at 8000 Hz. Levels at the age of 60 yr are 25, 30, 40, 50, and 60 dB, respectively. In relation to these Australian norms, over 70% had hearing below acceptable standards.

The Australian Standards Association (12) has stipulated minimum ISO standards of hearing for divers and compressed-air workers as follows:

Hz	500	1000	2000	4000	6000	8000
dB	40	35	35	45	50	50

The results indicate that less than 40% of the divers conformed with the very liberal standard of hearing required by the Australian Standards Association. Of the remaining 60%, approximately half had unilateral high frequency (sensorineural) deafness,

TABLE 1  
dB HEARING LOSS IN DIVERS (ISO)

		Hertz					
		500	1000	2000	4000	6000	8000
Case 1	R	20	20	15	5	10	15
	L	20	15	10	5	20	10
Case 2	R	30	25	15	10	20	15
	L	30	20	5	20	25	25
Case 3	R	20	10	15	20	30	5
	L	15	10	20	25	35	35
Case 4	R	10	5	5	20	30	15
	L	10	10	10	20	35	15
Case 5	R	10	5	10	25	25	25
	L	15	15	10	25	25	15
Case 6	R	15	10	10	20	20	20
	L	15	10	5	15	20	35
Case 7	R	15	10	0	30	20	10
	L	25	15	5	40	35	20
Case 8	R	20	10	5	15	35	10
	L	15	10	5	5	30	5
Case 9	R	15	20	20	30	45	35
	L	10	15	20	40	40	35
Case 10	R	15	15	15	15	25	50
	L	15	5	10	20	15	25
Case 11	R	25	20	5	15	10	20
	L	15	10	15	30	45	50
Case 12	R	25	20	65	90	90	75
	L	10	15	25	20	25	30
Case 13	R	5	5	5	10	45	10
	L	5	5	0	70	90+	45
Case 14	R	10	15	10	5	30	30
	L	10	5	5	20	90	90+
Case 15	R	15	5	20	10	20	25
	L	15	20	30	75	75	80
Case 16	R	20	30	45	50	35	35
	L	15	30	45	55	55	55
Case 17	R	20	10	5	80	90+	90+
	L	20	15	10	10	30	20
Case 18	R	25	20	20	0	50	50
	L	5	10	10	55	55	50
Case 19	R	30	25	25	15	35	25
	L	30	20	20	25	45	55

TABLE 1 (continued)

		Hertz					
		500	1000	2000	4000	6000	8000
Case 20	R	15	20	10	25	55	45
	L	10	15	15	30	50	45
Case 21	R	20	20	35	70	90+	75
	L	25	25	45	85	90+	90+
Case 22	R	10	15	5	25	45	65
	L	10	15	5	40	60	80
Case 23	R	20	15	10	70	70	65
	L	15	15	30	75	80	70
Case 24	R	30	25	25	40	70	55
	L	20	15	25	50	70	60
Case 25	R	60	55	75	90+	90+	90+
	L	30	35	50	60	65	90+
Case 26	R	35	30	20	55	65	35
	L	35	30	20	60	50	25
Case 27	R	20	10	10	70	80	65
	L	20	20	15	65	80	45
Case 28	R	25	15	25	45	65	75
	L	10	15	20	40	60	75

and half, bilateral. In many cases the hearing losses were extreme in those frequencies, and in most cases the divers were aware of the hearing loss or its associated tinnitus.

Otoscopy was also performed to ensure that there was no evidence of external or middle ear pathology, or of current middle ear barotrauma of descent, causing temporary threshold shift of hearing from recent diving.

## DISCUSSION

This group of divers were analogous in many respects to caisson workers described by previous clinicians. They had undertaken a great deal of exposure to dysbaric conditions, and therefore were more likely to suffer the consequences of decompression sickness and barotrauma than their more conservative counterparts in other professional diving activities—such as navy divers, oil rig divers, etc. Because of their age and their relative freedom of exposure to noise environments and explosives (this group was basically fishermen) and because they did not wear helmets and rarely were exposed to recompression chambers, it is more difficult to dismiss the auditory deficit, as has been done with other diving groups (7,10). There was no recent diving exposure to explain the deficits on the basis of a temporary threshold shift, and no evidence of middle ear barotrauma on otoscopy.

With the above results, we are compelled to agree with the Italian workers, Zannini

and his colleagues, in claiming that high frequency (sensorineural) hearing loss is an occupational disease of compressed air divers, and that its incidence is significantly high. We found this incidence to be equivalent to that described among the caisson workers of earlier years. In this survey there was no attempt to hypothesize on the specific cause of each of the cases of hearing losses. However, the majority of the divers who had demonstrable and significant hearing loss were aware of this disorder, or of its associated tinnitus, and attributed it to a barotrauma incident or incidents in the distant past.

Although 70% of the divers had hearing loss that was classified as compensatable by the National Acoustic Laboratory, in fact this is not relevant to the divers themselves, because they are all self-employed.

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Edmonds C. Perte de l'audition reliée aux plongées fréquentes (plongeurs sourds). *Undersea Biomed Res* 1985; 12(3): 315-319.—Une enquête audiométrique fut entreprise sur un groupe de plongeurs professionnels d'ormeaux lesquels avaient tous été exposés à maintes reprises à des conditions de dysbarie. Tenant compte des exigences très libérales des normes australiennes pour les plongeurs, les résultats de cette enquête révélèrent que plus de 60% avaient un niveau de surdit  sensori-neurale inacceptable dans la bande des hautes fr quences. Dans la moiti  des cas la perte de l'ouie  tait unilat rale, et dans l'autre moiti  bilat rale. En allouant pour l' ge, plus de 70% avait une  vidence de surdit    un degr  consid r  compensatoire par les Laboratoires acoustiques nationaux.

surdit   
plongeurs d'ormeaux

enqu te audiométrique  
dysbarie

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