

ACUTE HEARING LOSS FOLLOWING DIVING INTO AND IN WATER

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SUMMARY

Acute and often permanent inner ear injury from water-related activities involving rapid changes of pressure in the middle ears may be more common than is generally believed.

25 cases are reported to illustrate the relatively minor trauma experienced by victim, which however results in permanent inner ear damage.

Cases are described resulting from diving into water (3), free diving (2), playing underwater polo (free diving) (1), riding an underwater sledge (SCUBA diving) (1), ordinary SCUBA diving (17) and hard hat diving (1).

Decompression sickness was not implicated in these cases. The value of a baseline audiogram is stressed, and a base-line vestibular test is also desirable.

INTRODUCTION

The occurrence of inner ear barotrauma during diving with transient or permanent injury to the cochlea and/or the vestibular apparatus has become widely known during the last decade^{1,3}.

At the invitation of Dr Douglas Walker, The Editor of the SPUMS Journal, I have collected the case histories and audiograms of the 25 patients with diving induced hearing loss which appears to be due to inner ear damage that I have treated over the past ten years. As a result many of the cases have been reported elsewhere, though mostly only in summary. The details of the previously reported cases are as follows.

Cases 1-12 have been published in summary previously in Norwegian (The paper has an English summary).⁶ Cases 13-14 have been described in detail in English elsewhere.⁵ Cases 15-23 also have been published in English previously, case 15 in detail and cases 16-23 summarily in a table.⁷ Cases 1 and 15 also have been briefly mentioned in a short survey article in English.⁸ Case 1 also was described in English in another paper.⁴ Cases 24 and 25 have not been published before.

In the audiograms which accompany the case reports the following conventions apply.

The first audiogram is indicated with crosses, the second with circles, the third with dots, and the fourth with squares. Arrows pointing downwards below a symbol mean that the hearing loss was greater than the loss indicated by the symbol, i.e. beyond the capabilities of the audiometer.

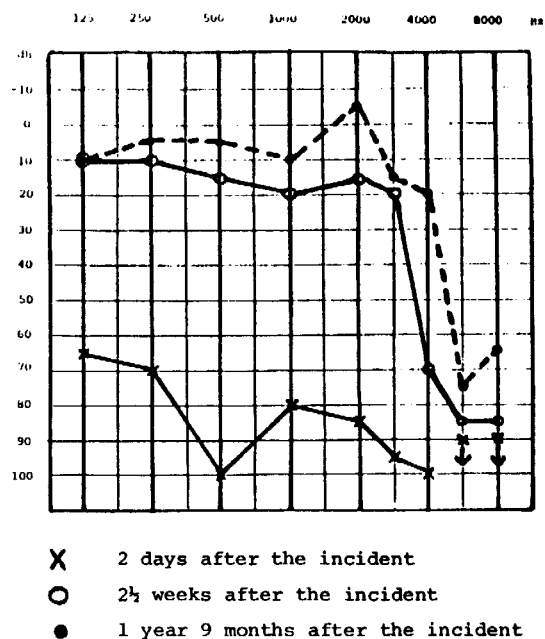
Post operative audiograms have dashed lines.

CASE REPORTS

Case 1

A 21 year old man made a free dive to the bottom of a 4 metre deep swimming pool. At the bottom he experienced fullness and tinnitus in his right ear, but subjectively he became free of symptoms after a while. Before this incident his audiogram was normal and after he had a notch in the high frequency range. In 1974 he did the same dive in the same place and the same thing happened. This time he was examined by an audiologist and his audiogram is shown in Figure 1. After a week he still had a large hearing loss and was admitted to our ward where we kept him in bed for a week. As he still had the bad loss in the high frequency range, which could influence his career as a jet pilot, we explored his right middle ear and found a perilymphatic fistula in the oval window. The fistula was closed surgically, and his hearing became normal through all frequencies up to and including 4 kHz.

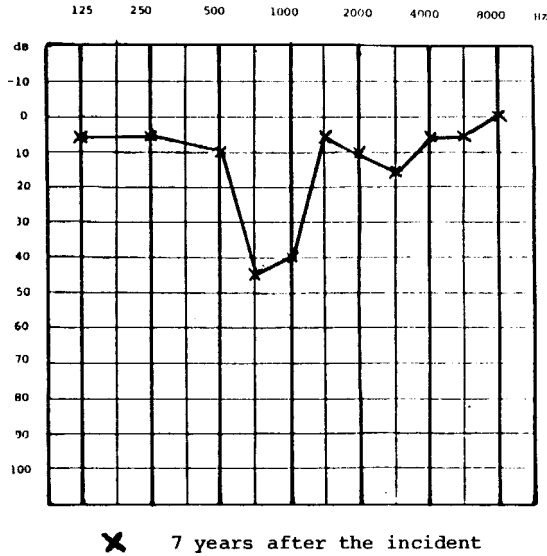
Figure 1 RIGHT EAR CASE 1



Case 2

A 19 year old man experienced left sided tinnitus during ascent from a free dive to about 10 metres depth. Tinnitus lasted for 3 months. Before the dive his audiogram was normal. After the dive he had a sensorineural notch at 1 kHz. His last audiogram, 7 years after the incident had a sensorineural notch between 500 and 1500 Hz (Figure 2).

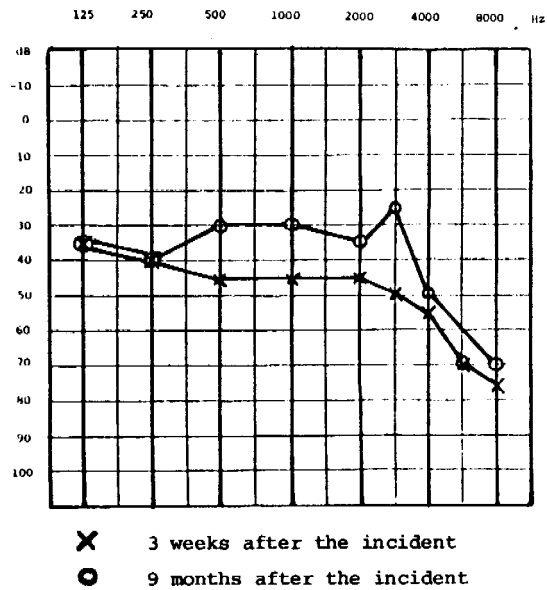
Figure 2 Left EAR CASE 2



Case 3

A 15 year old boy plunged head foremost into the water from 1 metre height. The depth was about 2 metres. He experienced fullness in his right ear, felt unsteady, unwell and nauseated so he took to his bed for a day. After one and a half days he felt well except for the sensation of fullness in his right ear. This still was the case when we saw him three weeks after the incident. His audiogram then showed a sensorineural loss (see Figure 3). Nine months after the incident his audiogram showed some improvement, but still with a sensorineural loss.

FIGURE 3 RIGHT EAR CASE 3

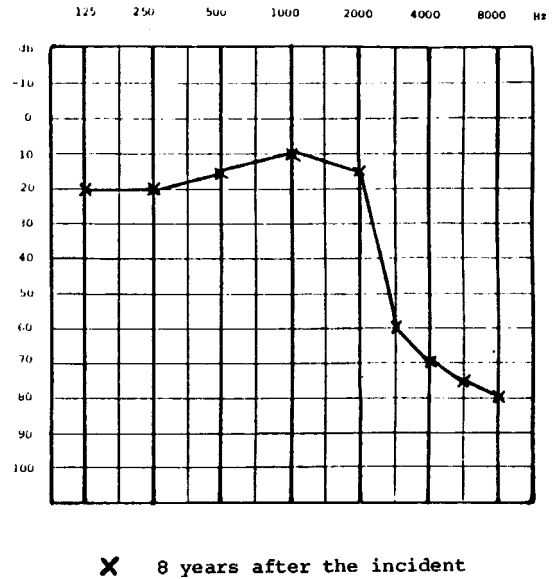


Case 4

A 28 year old man plunged head foremost from 5 to 6 metres height and free dived to the bottom. He does not know how deep he went, but he had difficulties in reaching the bottom. Afterwards

he had a sensation of water in his ears and experienced vertigo. Next day he woke up with left sided tinnitus which persisted. Three months later he saw a doctor who gave him vasodilating tablets without any effect. Ten years later he still has the bothersome tinnitus. Before the dive he judged his hearing as normal and he had no ear symptoms. Now he can no longer hear high frequency sounds in his left ear and audiometry 5 years after the incident showed a sensorineural left sided loss in the high frequency range, unchanged three years later (Figure 4).

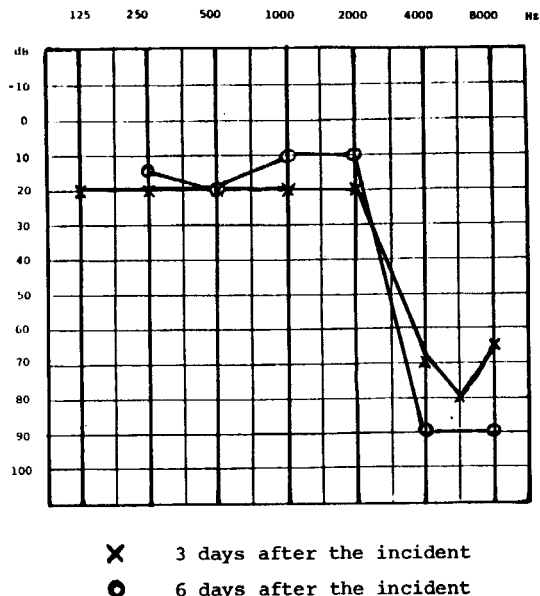
FIGURE 4 LEFT EAR CASE 4



Case 5

A 34 year old man, a sports diver, performed 2 open sea SCUBA dives. The first to 28 metres with a bottom time of 8 minutes. After a surface interval of 10 minutes he went down to 20 metres for 21 minutes. He had difficulties with pressure equilibration to his middle ears, and had to do forceful Valsalva manoeuvres several times. Immediately after surfacing after the last dive he experienced reduced hearing and tinnitus of the right side. Later in the day he became increasingly nauseated, experienced vertigo and vomited. He had to stay in bed the rest of the day. The symptoms ameliorated gradually. When he saw a doctor a couple of days later he still had reduced hearing, tinnitus, nausea and spinning vertigo which became worse when he changed position and closed his eyes. He was unsteady during Romberg's test and the 'finger-nose' test was not completely normal. His eardrums were slightly congested and his audiogram showed a large hearing loss in the high frequency range on the right side (Figure 5). He was treated with hyperbaric oxygen and after 10 minutes the nausea and vertigo became less bothersome and the tinnitus changed character. After the treatment he felt better and Romberg's test was normal as well as the 'finger-nose' test. Three days later he was seen by an audiologist who found a large sensorineural high tone loss on the right side (Figure 5).

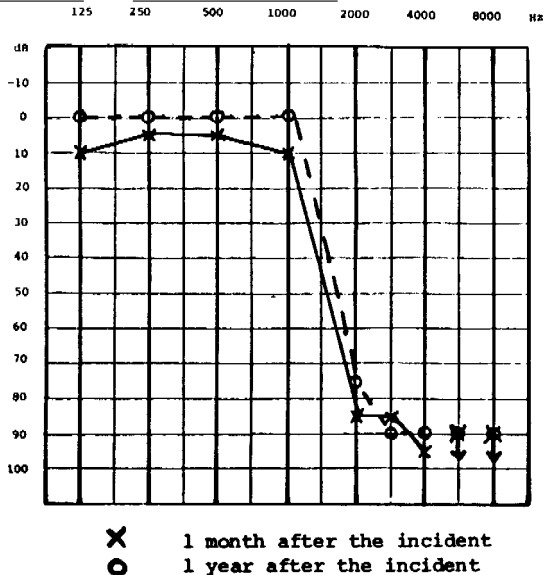
FIGURE 5 RIGHT EAR CASE 5



Case 6

A 25 year old man, a sports diver, did a 20 metre open sea SCUBA dive. At a depth of 2 metres during the descent he experienced pressure in his right ear and could not equalize the pressure in the middle ear. Therefore he returned to the surface and made another attempt. He then reached 20 metres where he remained for less than half an hour before he returned to the surface. When he came ashore he experienced fullness in his right ear and later tinnitus. The next day he saw a doctor who found his right eardrum slightly retracted and some fluid in the middle ear. As the tinnitus and reduced hearing still was present one month later he saw a doctor again and an audiogram showed a big sensorineural high tone loss on the right side (Figure 6). One month later the hearing had not improved and he was admitted to an ENT ward where his right middle ear was explored surgically. No perilymphatic fistula was found, and an audiogram one year after the incident showed no improvement (Figure 6).

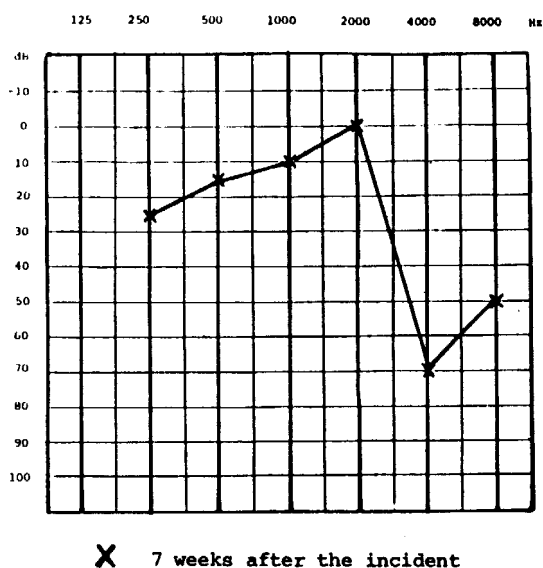
FIGURE 6 RIGHT EAR CASE 6



Case 7

A 36 year old man dived with SCUBA gear to 15 metres in the sea for 60 minutes. He went up and down between the bottom and the surface about 6 times and all the time had difficulties with the pressure equalization to the middle ears. When he reached the surface after the dive he experienced pressure in his right ear, reduced hearing and tinnitus. As the symptoms lasted he saw a doctor a little less than a week later and a sensorineural hearing loss in the high frequency range on the right side to 80 dB at 4kHz was found. He was treated with hyperbaric oxygen and 500 ml of Dextran iv without any effect. Afterwards he was checked by an audiologist who found a sensorineural high tone loss on the right side (Figure 7).

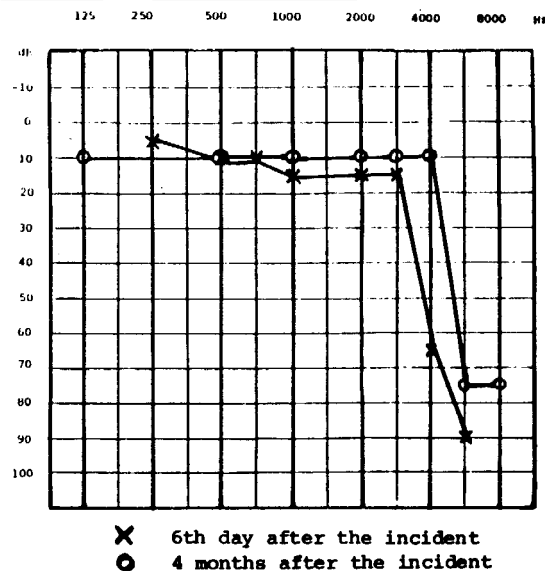
FIGURE 7 RIGHT EAR CASE 7



Case 8

A 29 year old man performed an open sea SCUBA dive to 25 metres. During the dive he got a sensation of fullness and tinnitus in his right ear and experienced transient vertigo.

FIGURE 8 RIGHT EAR CASE 8



As his ear symptoms continued he saw a doctor 6 days later and a large sensorineural hearing loss in the high tone range was found on the right side (Figure 8). One month previously a screening audiogram at 20 dB level had shown normal hearing. Because his trouble did not clear up he was seen by an audiologist a week later and his audiogram was unchanged. Four months after the incident hearing had improved remarkably at 4 kHz, but still he had a big loss for 6 and 8 kHz (Figure 8).

Case 9

A 27 year old man performed an open sea SCUBA dive to 40 metres depth. The bottom time did not require decompression stops according to the diving tables he was using. He had trouble with pressure equalization to his middle ears during the descent and made forceful Valsalva manoeuvres. Before the dive his hearing was normal but afterwards he had a feeling of fullness in his ears, tinnitus and subjectively reduced hearing. A week later he saw a doctor who found a bilateral hearing loss (Figure 9a and 9b).

FIGURE 9a RIGHT EAR CASE 9

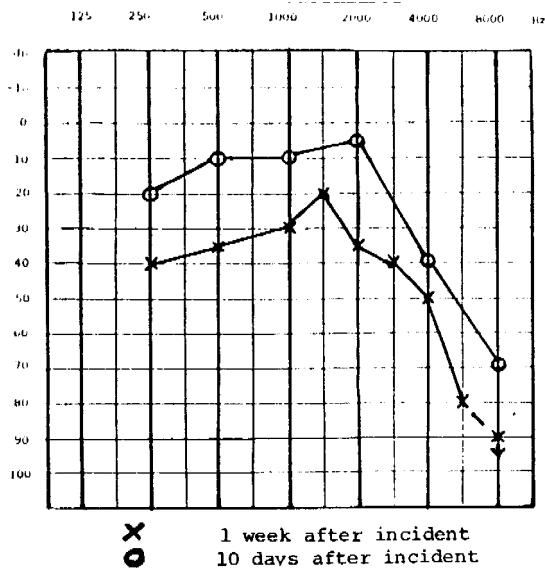
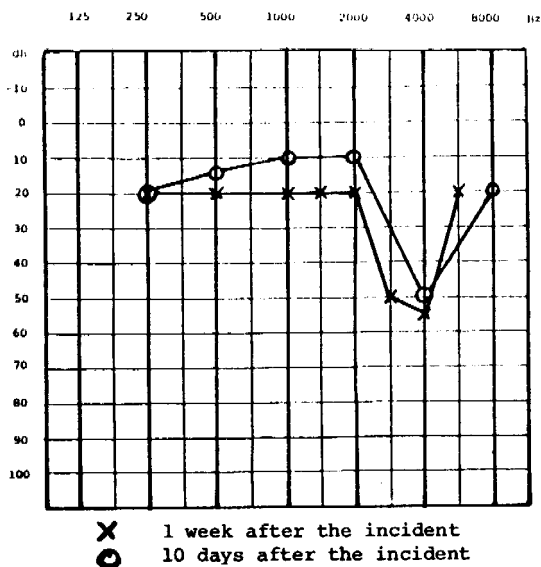


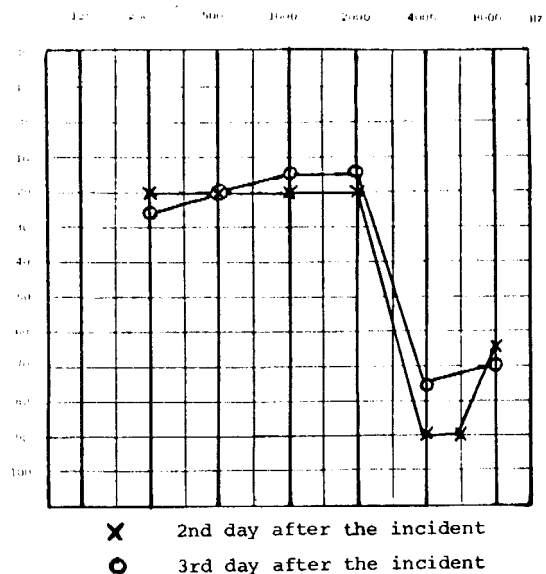
FIGURE 9b LEFT EAR CASE 9



Case 10

A 26 year old professional diver performed 2 sea dives in standard hardhat equipment. The first dive was to 46 metres depth with a bottom time of 9 minutes and surface decompression. Four minutes after surfacing he got a feeling of fullness in his left ear and experienced vertigo. Nevertheless, he dived again one and a half hours later to 9 metres depth for 40 minutes. His symptoms continued. A couple of hours after the last dive he complained of reduced hearing. The next day he experienced transient nausea, variable vertigo and a constant feeling of fullness in his ear. He was seen by a doctor, and 2 days later fullness in the ear was his only symptom and his audiogram showed a big sensorineural high tone loss in the left ear (Figure 10). The loss at the highest frequencies was too large to be measured by the available equipment. He was given hyperbaric oxygen therapy plus 500 ml of Dextran iv. After that his feeling of fullness in the ear was less and his high tone hearing had become measurable (Figure 10). The third day after the dive he was seen by the audiologist who verified the sensorineural high tone loss on the left side. His hearing had been normal before the dive.

Figure 10 LEFT EAR CASE 10



Case 11

A 28 year old man made an open sea SCUBA dive to 30 metres. During descent he experienced difficulties with pressure equalization to the middle ears.

Afterwards he had a feeling of fullness and tinnitus in his ears and performing a Valsalva manoeuvre triggered slight vertigo. When examined 10 days later his pure tone, SRT and Bekesy audiogram were normal, but caloric testing showed right sided canal dysfunction. Three weeks later this had normalised, but even 7 weeks after the incident he still experienced fullness in his ear and tinnitus.

Case 12

A 19 year old diving student in the Navy experienced increasing difficulties with pressure equalisation to the middle ears during a ride on an underwater sledge. Before the dive he had a slight discharge from his nose. The sledge went much up and down between 10 and 15 metres and the greatest depth reached was 20 metres. The bottom time was 26 minutes. No decompression was necessary. Immediately after surfacing he experienced fullness in his right ear and a quarter of an hour later vertigo, slight nausea and increasing tinnitus with high frequency. He thought he had become seasick and went to bed. When his right-sided hearing loss and tinnitus persisted the next morning he saw a doctor and the audiogram showed reduced hearing on both ears (Figure 11 and 12), worse on the right side. He was immediately recompressed with hyperbaric oxygen. During the treatment the hearing loss was subjectively reduced and so was the tinnitus. An audiogram taken shortly after the treatment showed reduction of the hearing loss, which was confirmed by an audiologist the next day (Figures 11 and 12).

FIGURE 11 RIGHT EAR CASE 12

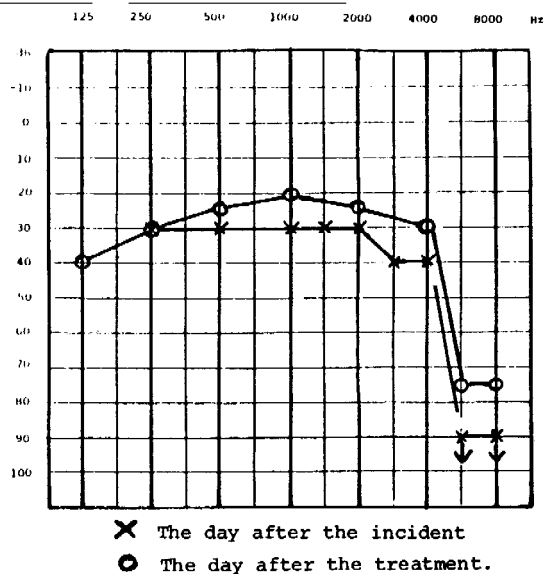
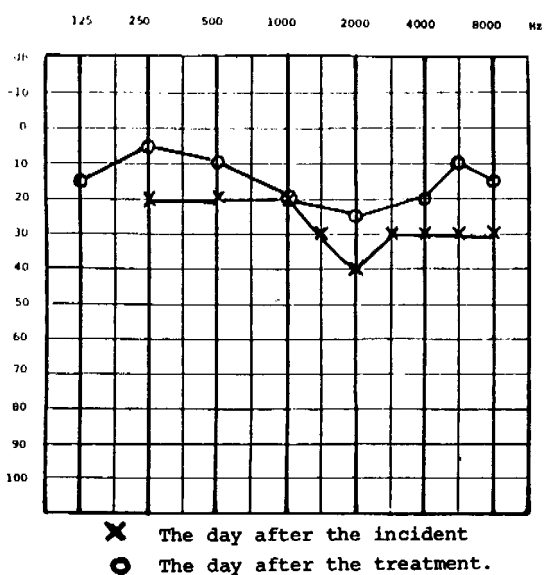


FIGURE 12 LEFT EAR CASE 12

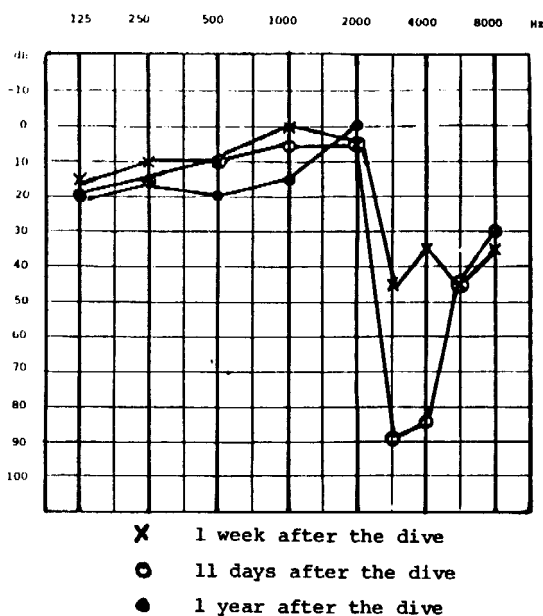


Before the dive a screening audiogram at 20 dB level was normal except for a dip to 25 dB at 8 kHz on both sides.

Case 13 (previously reported as diver 1 in reference 5)

A 21 year old female nurse with 1 year of diving experience performed an open sea, no decompression, SCUBA dive to 37 metres depth. She had trouble with pressure equilibration to the middle ears with pain in the right ear. She made several forceful Valsalva manoeuvres. On coming ashore she experienced spinning vertigo, tinnitus and reduced hearing in her right ear. The vertigo subsided gradually, but the tinnitus and hearing loss persisted. A week later she saw a physician who found a sensorineural high tone loss in her right ear (Figure 13). Four days later the loss was greater (Figure 13) and after a year she had no detectable hearing in the high tone range in that ear (Figure 13). Caloric responses were normal. She has stopped diving.

FIGURE 13 RIGHT EAR CASE 13



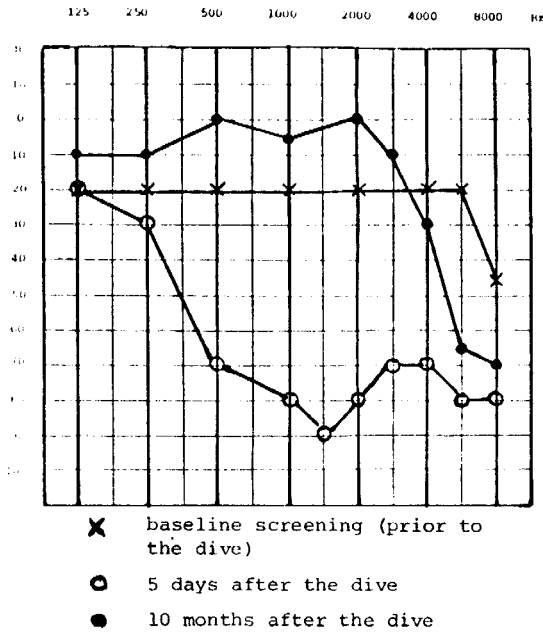
Comment: In this case the hearing loss progressed, while usually it will ameliorate to a certain extent shortly after the acute phase.

Case 14 (previously reported as diver 2 in reference 5)

A 23 year old male Navy SCUBA diver performed an open sea, no decompression, dive to 15 metres. During the dive he suddenly experienced vertigo. His right ear felt plugged combined with tinnitus and reduced hearing. The symptom subsided in the course of the day, but the following night he woke up suddenly with spinning vertigo, retching and a cold sweat. He had horizontal nystagmus grade III to the left, fluid in the right middle ear and a big sensorineural hearing loss (Figure 14). Good caloric responses were obtained from both labyrinths.

His symptoms subsided gradually, but even 10 months after the dive he had tinnitus and hearing loss (Figure 14). He stopped diving.

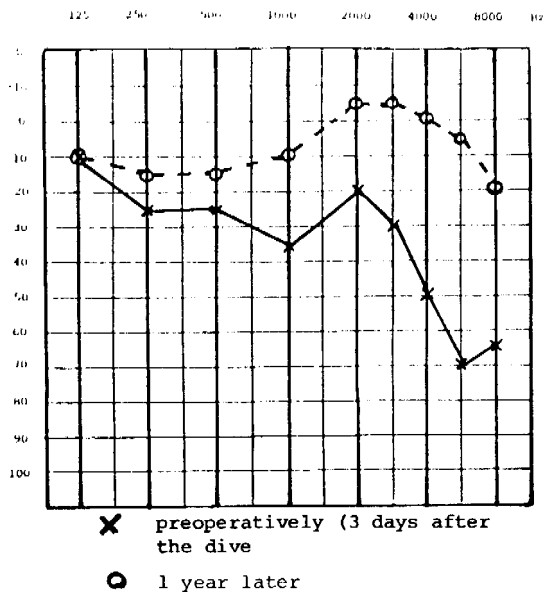
FIGURE 14 RIGHT EAR CASE 14



Case 15 (previously reported as diver 1 in reference 7)

A 21 year old SCUBA student experienced severe difficulty with pressure equilibration to the middle ears during descent during his first open sea dive. He suffered haematotympanon on one side, and rupture of the tympanic membrane and an oval window fistula on the other. Both were successfully repaired surgically with an excellent result (Figure 15).

FIGURE 15 LEFT EAR CASE 15

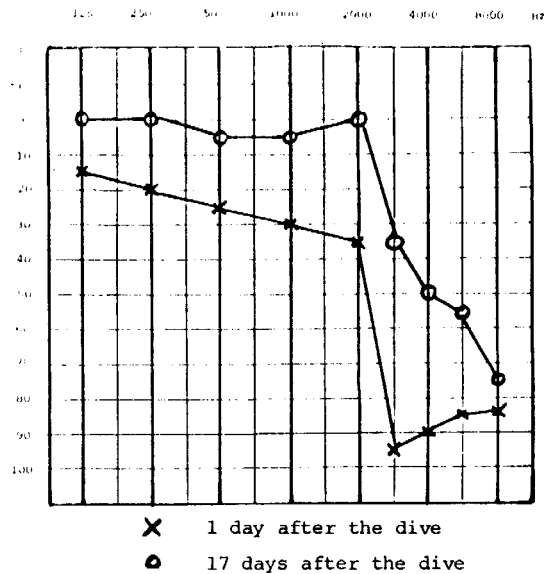


Case 16 (diver 2 in reference 7)

A 23 year old male medical student who suffered from hay fever, had six months experience as a SCUBA diver. He made a series of 3 poorly planned and performed repetitive dives to a maximum depth of 25 metres. There was some trouble with pressure equilibration to the ears during descent. On coming ashore he experienced reduced hearing and tinnitus in his left ear, spinning vertigo, nausea and vomiting. His sensorineural high tone loss improved during bed rest, but the lasting loss was significant (Figure 16). The response to caloric stimulation was slower on the affected side than on the right.

As he used neither a watch nor a depth gauge it is difficult to figure out his exact dive profiles. It is likely that he should have carried out an 8 minute decompression stop at 3 metres on his last dive. This calculation was not made until 5 days after the incident. He had no other symptoms indicating decompression sickness, and symptoms from the inner ear only are very rare (even unheard of?) in decompression sickness from shallow air dives. Consequently we concluded that this was not a case of decompression sickness, and recompression therapy was not tried.

FIGURE 16 LEFT EAR CASE 16

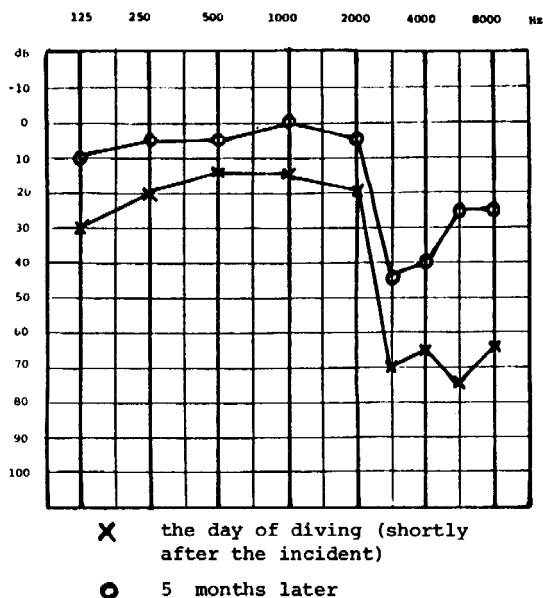


Case 17 (diver 3 in reference 7)

A 33 year old male SCUBA diver who, 3 weeks before the incident that brought him to our notice, experienced marked vertigo with a tendency to fall to the left after diving. This subsided in the course of a couple of days. On the second occasion he experienced acute spinning vertigo after repetitive dives to 18 metres. He needed assistance to get ashore, where he was unable to stand without support. There was no spontaneous nystagmus. There was no sign of barotrauma to the middle ears. However there was sensorineural hearing loss in the right ear (Figure 17). After 1 day of bed rest in hospital ENG showed normal vestibular responses on both

sides, and there was no Rombergism. When discharged after 4 days he still had tinnitus, and even 5 months later an audiogram showed evidence of permanent cochlear injury (Figure 17).

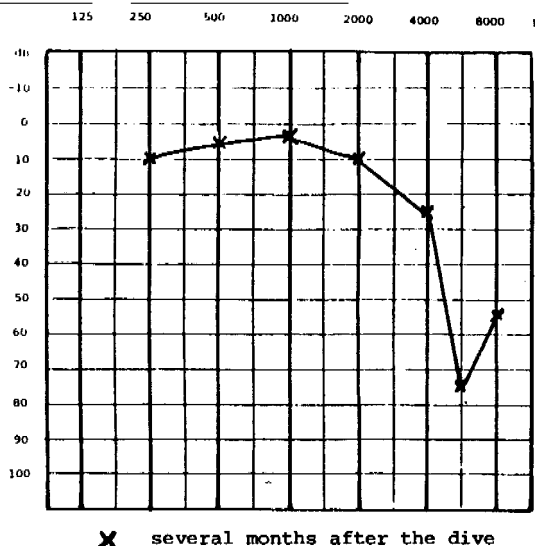
FIGURE 17 EIGHT EAR CASE 17



Case 18 (diver 4 in reference 7)

A fire brigade diver without previous ear symptoms had difficulties with pressure equilibration to the middle ears during a shallow SCUBA descent and performed several forceful Valsalva manoeuvres. He then experienced reduced hearing, vertigo, ringing and pain in his right ear. The tinnitus lasted for 3 months, and his sensorineural high tone loss persisted (Figure 18).

FIGURE 18. RIGHT EAR CASE 18

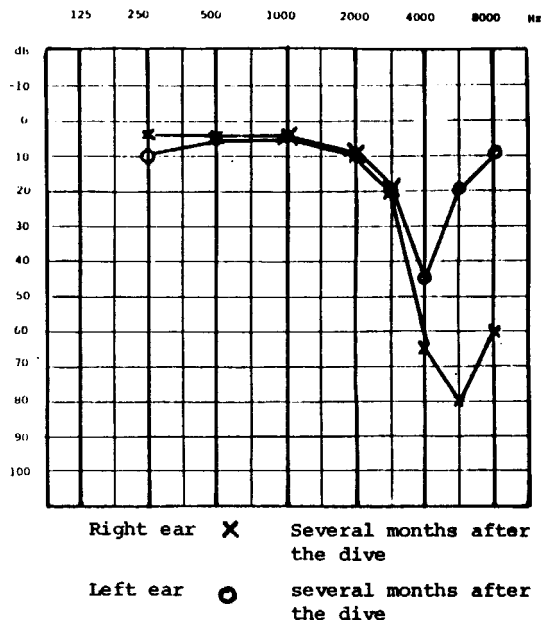


Case 19 (diver 5 in reference 7)

A fire brigade diver without previous ear symptoms had trouble with pressure equilibration to the middle ears during a shallow SCUBA descent, and performed several forceful Valsalva manoeuvres. He experienced lasting tinnitus and reduced

hearing for high frequency tones in both ears. His sensorineural high tone losses are shown in Figure 19.

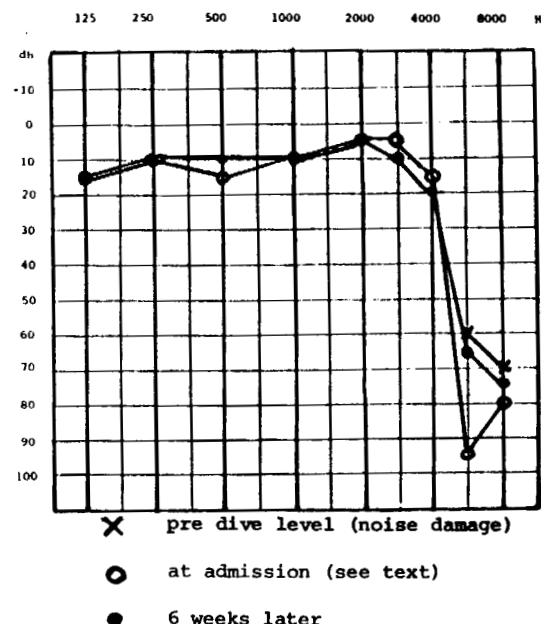
FIGURE 19 EIGHT AND LEFT EARS CASE 19



Case 20 (diver 6 in reference 7)

A professional diver with 10 years experience who already had a "noise notch" in the audiograms for both ears. Five weeks before the hospital admission he experienced acute spinning vertigo shortly after leaving the surface. He continued to dive daily in spite of the same experience each dive. Sometimes the vertigo subsided so that he could perform his task, but sometimes it forced him to abort the dive. The vertigo would now and then last for several minutes after coming ashore. He had the same experience during dry, simulated test dives in a hyperbaric chamber. After one week in hospital he was symptom free and managed well in a shallow test dive.

FIGURE 20 LEFT EAR CASE 20

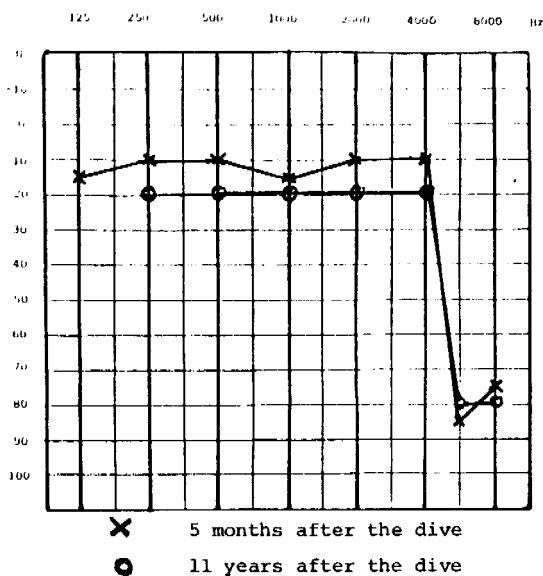


Comment: He had no tinnitus and no Rombergism on admission, and no explanation to his trouble was found. His ears were not explored surgically, so we do not know whether he had a perilymphatic fistula. His main complaints were vestibular, but his hearing deteriorated on the left side during the actual episode, and did not quite recover to the previous level (Figure 20).

Case 21 (diver 7 in reference 7)

A 21 year old Navy diver with a normal screening audiogram at 20dB level when he entered the Navy. He performed a no decompression sea dive with nitrox (20 metres for 20 minutes) in spite of having a cold and had great difficulties with pressure equilibration to his middle ears during descent, wherefore he performed several forceful Valsalva manoeuvres. Suddenly he got a feeling that "something" happened to his right ear. Afterwards he experienced tinnitus and felt as if the ear was plugged. He was not dizzy. He did not see a physician at this time. His next audiogram 5 months later showed a dramatic change (Figure 21) with a severe loss at 6 and 8 kHz. Since then he has experienced tinnitus periodically, and even 11 years after the incident he still had a considerable sensorineural high tone loss in that ear (Figure 21).

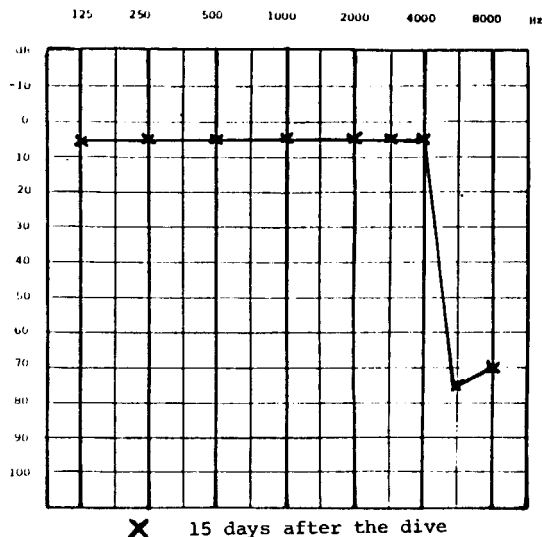
FIGURE 21 RIGHT EAR CASE 21



Case 22 (diver 8 in reference 7)

A 31 year old male underwater polo player who during a game experienced pain and vertigo and felt as if his right ear became plugged. He was forced to surface and abandon the game. The spinning vertigo lasted for the rest of the day, but the plugged sensation, high pitched tinnitus and distortion of hearing continued. He therefore saw a physician 15 days later, and a marked sensorineural high tone loss was found in his right ear (Figure 22).

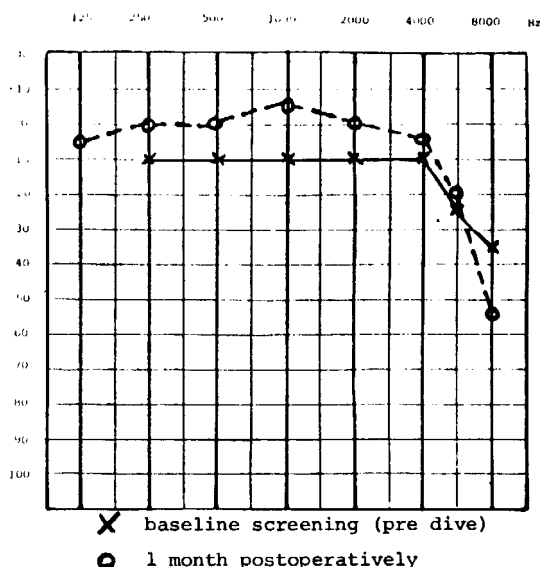
FIGURE 22 RIGHT EAR CASE 22



Case 23 (diver 9 in reference 7)

A 20 year old male dived into the water from a 5 metre high spring-board and experienced acute hearing loss, tinnitus and vertigo which was made worse by Valsalva manoeuvres. An exploratory tympanotomy revealed a round window fistula in his left ear, which was closed with fat. Postoperatively his vertigo disappeared and nystagmus could not even be elicited by the Valsalva manoeuvre. One month later his hearing had still not reached pre-incident level (Figure 23), but his main trouble, the vertigo, had completely disappeared.

FIGURE 23 LEFT EAR CASE 23



Case 24

A 24 year old male professional diver had, because of a cold, severe trouble with pressure equalization to the ears during a 10 minute dive to 30 metres. He experienced vertigo and nausea and coming ashore he could not stand unaided because of spinning vertigo, vomiting and head-

ache. He fell toward the right and had nystagmus of third degree to the left. He also complained of right-sided tinnitus, and had a sensorineural high tone loss in that ear (Figure 24). Although the dive profile did not indicate decompression sickness as likely he received a therapeutic recompression in the nearest hyperbaric chamber, and was then admitted to the local ENT-ward. After 4 days of bed rest he was discharged symptom-free, with normal pure tone hearing (Figure 24) and no loss of speech discrimination. Caloric vestibular tests were also normal.

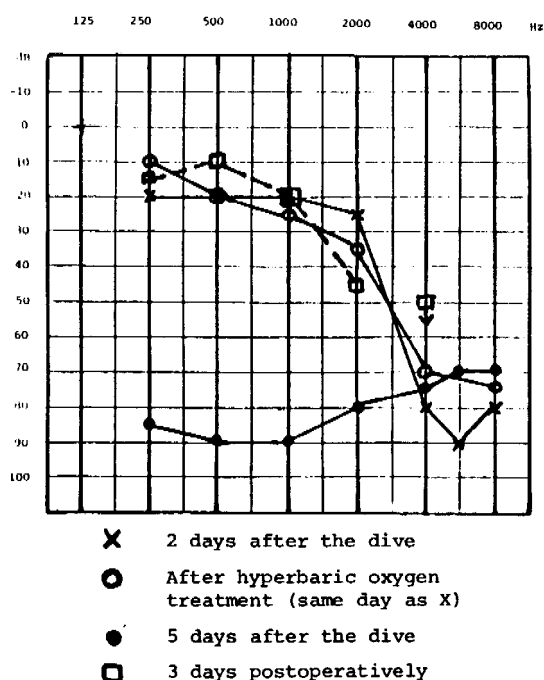
FIGURE 24 RIGHT EAR CASE 24



Case 25

A 26 year old sport SCUBA diver with a couple of years of experience. He had been exposed to noise as an aircraft mechanic. He always had to perform Valsalva's manoeuvre during descent and

FIGURE 25 RIGHT EAR CASE 25



would always experience a feeling of plugs in his ears for a short while after a dive. This specific dive to 15 metres for half an hour was uneventful. The plugged feeling in his right ear did not clear after the dive, and he also experienced tinnitus periodically. Therefore he saw a physician 2 days later, and a marked sensorineural high tone loss was found in his right ear (Figure 25). Hyperbaric oxygenation was tried, but the hearing was little affected by this (Figure 25). After 3 days of bed rest his hearing had deteriorated dramatically in the middle and lower frequencies (Figure 25). He experienced diplacusis, his speech discrimination score was poor and Fowler's ABLB test showed positive recruitment. An exploratory tympanotomy revealed a round window fistula that was closed with lyo-dura. Three days post-operatively his bone conduction hearing (with surgical packing still in his ear canal) showed normal hearing in the low frequencies, but still a considerable sensorineural high tone loss (Figure 25). His speech discrimination score however was 100. (This case is completely "fresh" and will be followed up further).

DISCUSSION

Many of the cases did not see a physician until a long time after the incident, a fact that affects the prognosis unfavourably. The chances are that many others do not see a doctor at all. To evaluate a case of hearing loss properly a baseline audiogram is essential, and a baseline vestibular test is highly desirable.

All these patients will probably benefit from bed rest, and some will need surgical treatment. The place of hyperbaric oxygen treatment in these cases is disputed. In most instances the victim will manage pretty well after a while because both ears seldom are affected, but a residual sensorineural high tone loss is the rule.

An injured inner ear seems to be more vulnerable than a healthy one, and thus a person with for instance a noise damage may be more susceptible than others to diving related inner ear injury. Therefore at least sport divers experiencing diving injuries to their inner ears should consider giving up diving.

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7. Molvær, OI, Natrud E and Edisvik S. Diving Injuries to the Inner Ear. *Arch. Otorhinolaryngol.* 1978; 221: 285-288.
8. Molvær, OI and Natrud E. Ear Damage Due to Diving. *Acta Otolaryngol* (Stockholm), 1979; 360 (Supp): 187-189.

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SPUMS COMMITTEE MEETING

Held at 25 Hastings Road, Frankston, 27th March, 1980 at 1930 hours.

ATTENDANCE: John Knight, Bill Hurst, Victor Brand, Chris Lourey.

APOLOGIES: Bill Rehfish, Douglas Walker, Daryl Wallner.

MINUTES OF PREVIOUS MEETING:

Read and accepted as correct.

BUSINESS ARISING:

Col. Jimmy How (Singapore Armed Forces) coming to Australia in May 1980. Decided to host the visitor at dinner with the committee members.

CORRESPONDENCE: Letters from:

Dr Paul Webb - President-elect UMS
 Dr Ken Kizer - President - HUMA
 Dr C Schilling - Secretary - UMS

Plus general correspondence between the Secretary and participants in the 1980 AGM.

TREASURERS' REPORT:

Current balance as at 21st March, 1980 - \$3,792.27.

The Savings Interest and Investment accounts the same as previous and both with the addition of accrued interest.

PRESIDENT'S REPORT:

Reported correspondence from Vice-Admiral, Sir John Rawlins re attendance at 1980 AGM.

SECRETARY'S REPORT:

1. 1980 AGM plans and attendance progressing satisfactorily.
2. All committee members to give recommendations as to a suitable site for the 1981 AGM. With this in mind Dr A Slark (NZ) to be approached re the consideration of NZ members.
3. Discussion to continue with regard to future conference organization. Suggested that at least one person (not necessarily the secretary) be responsible for organizing the AGM.

NEWSLETTER:

1. The next newsletter is about to launch into print.
2. Dr John Knight to post the previous newsletter to new members.
3. Reported that the current arrangement between the Editor and the President is working well. Decided to continue this arrangement.

4. Dr D Walker (Editor) to be advised to submit application for petty cash to reimburse general expenses as well as postage etc.

DIPLOMA OF DIVING AND HYPERBARIC MEDICINE:

1. Letter from CO HMAS Penguin advising that the course will in future be limited to five civilian members only.

2. Letter from Dr I Unsworth advising that the 1980 one week course in Hyperbaric medicine will not occur.

3. The Secretary reported a phone call from Captain R Grey - Navy Office Canberra, where it was stated that some discussion is being undertaken to consider deleting the Hyperbaric medicine section from the Diploma. No action taken - awaiting documented evidence and discussion from the Navy.

4. Letter from Dr Bruce Logan outlining his experience and enquiring whether this met the requirements of 6 months full time or equivalent part time experience required for the Diploma. Referred to the Diploma Committee.

GENERAL BUSINESS:

The discussion and plans to have a National Network to be raised at the AGM.

FUTURE MEETING:

Date to be decided.

Meeting closed 2200 hours.

DR CHRISTOPHER J LOUREY
 SECRETARY - SPUMS

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FREE ASCENT AND "DUMB" ANIMALS

In the UMS hosted Workshop on Emergency Ascent Training (1977), to be discussed in a later issue, Dr Eric Kindwall included the following information:-

"To demonstrate this point (that the key to successful emergency ascent was to be sufficiently relaxed in the water), Dr Charles Shilling, who was supervisor of Submarine Escape Training at the New London Escape Tower in the 1940s, took a mongrel dog to 100 feet in the roving bell and threw him out into the water. Dr Shilling reports that the dog swam towards the surface, exhaling all the way, as he followed behind in the roving bell. The dog performed beautifully with no previous escape training, did not embolise, and remained Dr Shilling's pet for many months. (Admittedly the dog had been supplied by Harvard University, so he may have been smarter than some)."