PROJECT STICKYBEAK

This project is an on-going investigation seeking to document all types and severities of diving-related incidents. Information, all of which is treated as being CONFIDENTIAL in regard to identifying details, is utilised in reports (such as this) and case reports on non-fatal incidents. Such reports can be freely used by any interested person or organisation to increase diving safety through better awareness of critical factors. Information may be sent, in confidence, to:-

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FIRST AID PRIORITIES FOR DIVERS THE TOBERMORY VIEWPOINT

G Harpur

Due to the large number of divers attracted to the Tobermory area by the clear waters and abundant marine artifacts, we are provided with many opportunities to examine those events surrounding diving accidents which influence their outcome. In the past year approximately 30,000 dives were committed, principally between the 24th May and the Thanksgiving weekend in October, by some 7500 divers of whom 30% were student divers on their initial open water experience. Since 1974, there have been 36 accidents resulting in major injury to divers as well as countless minor incidents with less serious sequelae. In this paper I intend to present a review of the more serious incidents and accidents with particular attention to those factors which contributed to the serious or fatal outcome.

Our figures indicate that on any given dive in the last two years, the diver's chance of being injured was 0.04% and of being killed was 0.003%. These figures do show a higher incidence than is reported elsewhere, eg. the Rhode Island surveys, and may reflect the effects of cold water and the high proportion of novice divers. Training accidents have been rare, with only 1 fatality and 2 serious incidents occurring in the past 7 years.

There have been 16 deaths in the period 1974 to 1981, out of a total of 36 serious accidents. Of these deaths, 11 died before reaching the surface, 3 died after reaching the surface but before reaching the recompression facility and 2 died after completing an initial treatment table. The remaining 20 divers all survived and were entirely intact, so far as could be clinically determined, after one or more treatment runs. There were no survivors who sustained any long term injuries as a result of their accidents. This type of sharp division is probably unusual and can be most likely explained by the unique character of our situation in Tobermory. Most of the diving takes place within the confines of Fathom Five Provincial Park and this area is controlled by both OPP (Ontario Provincial Police) and Park staff routinely, so a very rapid response to any accident is possible. The average time from the victim arriving at the surface until being placed back under pressure, when indicated, is between 30 and 40 minutes. This organization also permits a very detailed investigation of each incident and accident to be carried out at the same time as the victim is being treated. Park staff and OPP dive team members conduct interviews with other members of the diving group. In more serious cases, exhaustive studies are conducted on the equipment and air supply, with the assistance and such technical support as DCIEM (Defence and Civilian Institute of Environmental Medicine) and the Centre for Forensic Science in Toronto.

TABLE 1

FACTORS RESPONSIBLE FOR INCIDENTS WHERE A DIVER FAILED TO SURFACE OR SURFACED WITH ASSISTANCE

DIVER FITNESS

Training

- None or taught by a friend
- Diving alone
- Improper response to:
  - freeze-up
  - emergency ascent
  - buoyancy control
  - shallow water blackout

Psychological State

- Unfit
- Temporary conditions
- Pre-existing long term conditions

Medical Conditions

- Temporary
- Pre-existing long term

EQUIPMENT

- Inadequate
- Malfunction

RESCUE

- Poorly organised or no plan
- Improper technique

If we consider first the group of divers who failed to make the surface on their own, we can divide them into subgroups according to the various factors which accounted for this failure in each case. In some of the accidents, more than one of the factors listed in Table 1 may have been present. The following brief case histories serve to illustrate these points.

DIVER FITNESS

TRAINING

Fortunately we have not encountered many cases of diving without formal instruction which have resulted in problems in Tobermory, although these are common elsewhere. The one example we have illustrates a combination of informal instruction, diving alone and inadequate equipment.

Diving Alone

PH, a 26 year old male, who had just completed his PhD in Maths and Physics, and who was a self taught skin diver, was free diving to 50-60 feet depth in an area off the shore of Georgian Bay which had a flat bottom, sloping gradually to depth in excess of 100 feet. He had no buddy, but there were several groups of scuba divers in the same general area. His friends on shore wandered away for a period, as they were accustomed to his being out for periods up to 90 - 120 minutes. He was not on the shore or visible in the water when they returned. After a period of confusion and trips to his car 1 mile away, the alarm was raised. It was now dusk. His body was located the next morning by OPP divers in 70 feet of water. It was on the bottom with 16 lb of lead in place, a full wet suit, mask and flippers and no buoyancy device. Another weight belt, visible from the surface, with 18 lb of lead on it, lay nearby. Autopsy determined the cause of death to be drowning. His lack of adequate training undoubtedly left this diver unaware of how rapidly shallow water blackout occurs, and his lack of a vest reduced his options.

We have not been able to document a single case in which equipment malfunction directly caused a diver's death or injury. It has always been the diver's response to the problem which results in the pathology. Recognition of the malfunction and effective management of it are part of good diver training. The following cases illustrate areas where the job is still being inadequately done.

Inappropriate Responses: Freeze-Up

Regulator freeze-up is a common event in cold water, which is to say in all water deeper than the thermocline in Canadian lakes at any time of the year. Proper training should reduce unnecessary use of the purge button, anxious panting and heart exertion which encourage this problem. All students should be aware of the problem, exposed to it and taught how to recognize it and how to respond appropriately. That is by breathing off the free flowing regulator to the surface. Failure to do this has been the initiating event in several incidents, two of which resulted in fatality.

In the first of these, the individual who died was an innocent bystander.

JM was an 18 year old male diver who, after qualifying the day before, was persuaded to participate in a badly conceived dive to 70 feet off Flower Pot Island. Four divers took part. Two had previous experience to 70 feet in warm water, and formed one buddy pair. JM's buddy had one previous dive to 100 feet in cold water. None of the divers were familiar with the site. No shot line was dropped to confirm depth, despite the fact that depths in excess of 300 feet are encountered in this area.

Difficulty with buoyancy control was encountered by all the divers during the descent as they had all weighted to neutral trim at the surface and failed to anticipate the effects of wet suit compression. This resulted in a rapid descent and the divers found themselves very unexpectedly at 90 feet, just 20 feet off the bottom in clear 4°C water.

At this point, one of the pair of warm water divers encountered a free flow probably secondary to anxiety and overbreathing. He abandoned his regulator and attempted buddy breathing, but was unsuccessful due to numb lips. His buddy now abandoned him, ascending rapidly. JM's partner, the most experienced diver, took over. The three remaining divers were on the bottom at 110 feet at this point. The CO2 cartridge, a 25 g size on the victim's vest had been pulled with no apparent effect. (See the later section on vests). The attempts to force buddy breathe the victim were moderately successful. This pair of divers swam up after dropping the victim's belt. JM was following in no apparent difficulty. At 50 feet the rescuer ran out of air, pulled his reserve and continued up with the victim. JM was still in attendance. At 30 feet the rescuer completely ran out of air, dropped his weight belt, blew his vest and released the victim who was now positively buoyant. Both divers arrived on the surface where the other diver was waiting. The victim was in fair shape although he underwent prophylactic recompression for possible cerebral embolism at Toronto General Hospital later.

JM never arrived at the surface. Lack of planning led to confusion and delay in the rescue attempts. The body was recovered 4 hours later by OPP divers on the bottom, in full gear with his vest and CO2 cartridge intact (ie. not activated). Autopsy showed death was due to massive air embolism. The degree of mask squeeze present suggested that JM made a breath hold lunge for the surface when the other divers took off from 30 feet. His tank contained air and there was no evidence of equipment malfunction.

Although JM did not encounter free flow, the failure of the initial victim to deal properly with this event initiated the sequence which led to his death.

The second example illustrates a much more direct effect.

SG, also an 18 year old male, was making a dive on the Arabia, which lies in 110 feet of water. He too was a low time diver, but did have several hours of post certification diving at depths of up to 40 feet in cold water. The temperature at 110 feet was 4°C as usual and the visibility 40-50 feet in low light. He encountered a free flow at 100 feet early in the dive, and abandoned his regulator. His buddy commenced buddy breathing with him, but SG refused to return the regulator. The buddy dropped his belt, activated his $C0_2$ vest and swam up, dragging the victim, he thought, by the regulator. When he arrived on

the surface, SG was not with him. The body was recovered several hours later in full gear and with an intact $C0_2$ cartridge. Autopsy showed death had been due to massive air embolism to all major vessels, with damage to both lungs. Panic induced by an inappropriate response and the surprise of an unfamiliar problem had claimed another victim.

There were also many minor incidents which avoided a similar conclusion only by chance. One, which was somewhat amusing, involved a fellow and his girl in 30 feet of water. The girl encountered a free flow and abandoned her regulator. He being chivalrous, gave her his. She refused to relinquish it. As in the last case, he bounced to the surface, dragging her with him, but in this case she was unharmed. The abrupt development of a romance-shattering insight was the only damage done.

The major problem in all these cases arose because of an inappropriate response ie. abandoning the regulator. This indicates a flaw in basic training. Good free flow simulation is possible. OUC have recently published a modification to a standard scuba set, devised at Tobermory, which will permit any student to be exposed to this problem and its management, in the safety of the pool.

Inappropriate Responses: Emergency Ascent

Even with the best of training and planning and equipment, if one dives long enough one will encounter an out of air situation, more frequently if one neglects any of the foregoing.

The inadequacy of the responses currently being taught for use in this situation, are illustrated by the next series of cases.

JK was another 26 year old male diver. The frequency of this age and sex combination begins to look like an ill omen. He was performing an emergency ascent from 30 feet in open water as part of his graduation exercises. The drill to be followed was:

1. remove the mouthpiece

2. undo the weight belt and pass it to your buddy

3. swim up, humming constantly, with the instructor and flare at about 5-10 feet.

JK commenced his drill but fouled up at 2, when he undid his tank strap. He replaced his regulator, refastened his strap and after a brief rest, started again. He completed the exercise correctly and was observed to be exhaling, presumably by humming, throughout the ascent, by his instructor. At the surface he was immediately asked how he felt. He replied, "I feel fine", just before passing out and convulsing. CPR was effectively applied and he was evacuated to the beach and subsequently to the hyperbaric chamber, in approximately 25 minutes, where an immediate table 6A with extensions was commenced. He recovered spontaneous respiration and circulation after drainage of bilateral pneumothoraces, and remained stable without any recovery of cerebral function despite repeated recompression. He died 4 days later of brain infarction. Examination of his equipment and gas analysis revealed no problems.

JK had approximately 10 litre lungs. If we assumed that he near filled his chest before his attempted ascent, the outcome is easy to explain. Humming does not permit a lot of air to escape. The amount necessary to produce a good hum can be as little as 50 ml/second. A hard hummer can get rid of 500 ml to 1 litre/second, but averages are probably around 250 ml/second. From 30 feet to the surface, JK had to clear 9 to 10 litres if he was to avoid disaster and his ascent time was 6 to 7 seconds. Humming obviously could not do the job. Unfortunately the lungs provide little warning of the impending disaster as evidenced by his "fine". The tragic part is that his unimpeded airway had the capacity to handle flows in excess of 10 litre/second, more than 6 to 7 times his requirement. The obvious solution is to teach an ascent technique which keeps the airway open. (See continuous breathing cycle ascent below).

Probably the commonest emergency ascent technique taught is the continuously exhaling pattern. This mode of ascent was definitely used in 8 of our embolism cases who survived, in one of the fatal cases for certain, and it is highly probable it was the technique used in 4 others. This constitutes about 60% of the fatalities and about 75% of the casualties due to ascent technique.

The case of diver TR, a 42 year old male, assistant diving instructor illustrates this very well.

TR had completed a well organized dive with his club on the Arabia and was making the ascent from 110 feet when he decided that since he was ascending a little faster than the normal 60 feet a minute, he should probably do what he taught his students to do during fast or emergency ascents, ie. exhale continuously.

This was the last thing he could recall until he came to in the hyperbaric chamber some hours later. He had arrived at the surface unconscious and not breathing, brought up by his own vest due solely to vest expansion. He had some frothy red sputum coming from his nose. His group followed their emergency training and commenced artificial respiration (AR) with the victim on a 20° head low slant and transported him to the chamber. On arrival there he was breathing spontaneously, coughing up some bloody sputum. He was still very obtunded, responding only to deep pain. Rapid recompression on a table 6A resulted in dramatic recovery within 15 minutes. He was confused for the first 90 minutes after full recovery of consciousness. He kept asking how he could possibly have embolised, as he was so positive about his decision to exhale. We reassured him that although many would doubt him, we did not and explained the mechanism of small airway closure to him and the hazards of exhaling ascents. The sad part is that this diver had adequate air supply and stopped

breathing only because he was misinformed.

The degree of embolism sustained in this case was obviously slight and this is typical of the injury which results from low volume air embolism. The embolism does not usually kill directly, but does alter consciousness and lead to drowning. These cases are often missed at post mortem as not many pathologists are well versed in the mechanics of diving injuries. This problem, like that created by the humming ascent, is avoided by the continuous breathing cycle ascent protocol.

Inappropriate Responses: Buoyancy Control

In many of the cases where the diver died, the cause of death was drowning and the embolism or hypoxia or fatigue which led to this outcome were not in themselves serious. In these instances a failure to get to the surface or a failure to remain there, was the critical factor in determining the outcome. Many critically injured divers survived because they reached the surface. All of those who remained on the bottom or returned to it, died.

This underscores the importance of the diver making certain that he will continue to ascend even if he loses consciousness. None of the divers recovered from the bottom had dropped their weight belt, and none had deployed the $C0_2$ cartridge or otherwise fully inflated their vest.

The case of PH cited earlier, illustrated the effects of hypoxia in free diving. Many scuba divers fail to appreciate that once they are out of air they too can become critically hypoxic during ascent for the same reasons. Calculations show that a diver who runs out of air and then attempts to swim up with no assistance from vest or from dropping a weight belt runs a significant risk of abrupt loss of consciousness during the ascent if he starts deeper than 50 feet. In trial runs from 60 feet in the chamber at Tobermory while exercising at a level equivalent to such a swimming ascent, two subjects were unable to complete a simple secondary task all the way up, both becoming confused at depths greater than 6 to 7 feet. A repeat run from 90 feet resulted in one subject getting into difficulty with confusion at 21 feet, the other at 13 feet. Such confusion under water could result in loss of control and breath holding, with subsequent embolism or aspiration of water and drowning.

A good example of this is the case of LC, a 27 year old diver on her first night dive in the company of an older more experienced diver. The dive was planned to 30 feet, but the area of the dive included depths to 90 feet. Both divers were weighted for a neutral trim at 18-20 feet with 12 lb and 14 lb lead respectively. Some incident led to both women embolizing and neither shed her weight belt or inflated her vest, but one surfaced, the other, LC, was recovered the following day, having drowned following a minimal embolism. I wish I could say the other survived, but she did not for a series of reasons I shall deal with later, but she had a chance, LC had none.

PSYCHOLOGICAL FITNESS

Many of the incidents, especially those which commence with free flow, indicate that the diver involved was under excessive pressure at the time of the incident. Most frequently this stress appears to originate in peer pressure. The low time diver attempts a dive which takes him out of his depth and experience in order to be one of the group and prove that he can hack it thus setting the stage for tragedy. As this factor is apparent in many of the cases cited, I will give no specific example.

This same problem, diving while under excessive duress, has led to two cases of spurious decompression sickness. Both of these cases presented as type two decompression sickness but the findings were inconsistent and the complaints variable. Resolution of one case required a sham chamber treatment with descent to 3 feet on compressed air resulting in an abrupt and total resolution of all symptoms and signs.

MEDICAL CONDITIONS

Temporary

Medical fitness or rather the lack thereof has been a significant factor in both incidents and fatalities. Temporary disability of minor degree has served as the trigger factor in several cases and the commonest example is difficulty with ear clearing. It would appear that we are not doing a very good job of training people in this area. We conducted a survey of novice divers during the summer of 1978 with the results shown in table 2.

TABLE 2

DAMAGE TO THE EARS OF 186 NOVICE DIVERS

No Barotrauma	79
Minimal	29
Moderate	70
Severe	8
(Bilateral)	(11)

The interesting point about this is that despite the fact the two-thirds had significant trauma to their ears, only one or two recognized this fact.

Most of the problems created by this sort of trouble have been minor. We see a steady stream each summer that we refer to as investors. The people leave home 200 or 300 kilometres away without checking that their ears can clear. They arrive in Tobermory, pay for their charter, rent equipment and get teamed up with a buddy, and still have not checked that their ears clear. Finally at 10-15 feet on the first dive, with all their money and time invested, they discover that their ears are going to be difficult. They proceed to try everything known to God and Man to get those ears to work, frequently winding up in our hands with

various types of squeeze or worse.

The effects are not always trivial. There has been one case of a diver, GP, in whom air embolism resulted from panic at 10 to 12 feet over ear pain. He made a breath hold ascent and became confused with bloody cough and voice changes. Response to therapy was excellent and a modified table 6A resulted in his total recovery.

Most serious problems arising as a result of temporary disability are a result of diving while under the influence of drugs, the commonest being alcohol. The partner in the case of LC cited earlier, was a 42 year old female, KC. What event led her to embolize during that night dive was unknown. She came to the surface where she added fresh water drowning to her problems because her face was not supported free of the surface with her weight belt on and the vest was not inflated. She vomited and aspirated during resuscitation attempts. Despite effective CPR and surviving her initial chamber treatment, she eventually died with the following injuries: massive air embolism of the cerebral vessels, aspiration pneumonitis and fresh water drowning. Her blood alcohol was reported as twice the legal limit.

Fatigue, alcohol and decongestants figured in the temporary disability which led to the death of. TR, a 26 year old male diver. TR drove up to Tobermory during the night, arriving at 0600 hours having imbibed liberally en route. During his first dive of the day at 1000 hours he experienced difficulty with his ears. So he took a couple of Sudafed tablets. This was his first experience with this particular medication, and for good measure he washed them down with a couple of ounces of rye. Two hours later he made a dive to 40 feet for 45 minutes. He made an abrupt swimming ascent for reasons which were never elucidated. At the surface, he was confused and could not stay up, succeeding neither in releasing his weight belt nor in inflating his vest. He subsequently lost contact with his buddy and sank. He was recovered by other divers in a few minutes at a depth of 4 feet. He was unconscious and failed to respond to attempts at resuscitation. The cause of death was drowning secondary to minimal air embolism.

Street drugs probably played a significant role in the death of LS. This 23 year old diver approached two other divers at 100 feet with his regulator out. He took the regulator offered him and took one breath, returned it, then refused to take it back. The rescuer had located his octopus and offered the regulator to keep, but it was refused. The victim was now in total panic and holding tightly onto part of the wreck Arabia. The rescuers pried his fingers loose and took him up, squeezing his chest, pounding his gut and doing all the things they had been taught to make him exhale.

Unfortunately an air breathing mammal underwater in severe panic will give you almost anything, his lunch, his blood, but not his air so long as he remains conscious. Thus the diver predictably held his breath and sustained a massive degree of embolism resulting in instant irreversible death. Subsequent investigation showed that hallucinogens and cannabis had both been in use.

A more effective job of educating sport divers to the hazards of diving while impaired physically, emotionally or pharmacologically is the only thing that will reduce the frequency of these occurrences.

Long Term Pre-existing Conditions

The presence of a long term pre-existing medical condition which should contraindicate diving is becoming alarmingly common. What is most disturbing about this is that many of these divers with a history of epilepsy, or asthma, have reported their illness to the physician who did their screening physicals, required to enter Scuba training by most agencies, and were cleared as completely fit to participate in the sport. The consequences of this are well demonstrated by several incidents. I will cite two.

GB was a 42 year old diver with a long history of epilepsy which had been under control for more than 20 years, but which still required that he take Diazepam (Valium) on a regular basis. During a dive to 50 feet, off Lighthouse Point in the Tobermory harbour area, he lost consciousness during ascent while separated from his buddy. Fortunately he was positively buoyant and continued to the surface. His luck at the surface was good as he popped up under the nose of some well trained people who cleared his airway of vomitus and administered effective CPR, which was required. When he arrived at the Hyperbaric facility 20 minutes later he was still comatose and requiring AR, but now had spontaneous heart action present. After 15 minutes at 165 feet he showed no signs of recovery. When placed on a breathing mixture of 50% N_2 and 50% O_2 he responded rapidly. Within 5 minutes he was awake but struggling and confused. He remained confused for 4 hours while an extended table 6A was carried out. He then abruptly recovered totally except for a short period of amnesia surrounding the dive. The difficulty with short term memory persisted for several days. His subsequent course was one of total recovery with no sequelae. He no longer dives.

The second case is that of a 59 year old male, VK, who had pre-existing arteriosclerotic heart disease with a rhythm disturbance, requiring medication, and chronic obstructive lung disease of moderate degree, also requiring medication. At 110 feet on the Arabia this diver became stuporous and confused, but was brought up under control by his smaller female buddy in a truly remarkable display of good diving skills effectively and calmly applied. He was coughing bloody sputum and unconscious at the surface requiring AR. Recovery was rapid but complicated by aggressive behaviour and confusion adding to the problem of his management. At our unit he presented as a case of definite pulmonary barotrauma with bloody, frothy sputum and of fresh water near-drowning of significant degree superimposed on the original maladies. Hew as hypoxic and confused to begin with. This had been clearing during evacuation and with O_2 and a head low position continued to do so. He had no pneumothorax. However X-rays confirmed the presence of near-drowning and the pre-existing emphysema. As he was improving he elected not to use the chamber in the face of the serious pre-existing

disease. Had he been worse or deteriorating our hand would have been forced. He subsequently made a full recovery. I am sure the possibility of a fatal outcome was not missed by much.

To reduce this sort of problem we have just drafted a short article outlining the hazards of scuba diving and listing the factors to be looked for during medical examination to determine fitness for the sport. This is to be reproduced in the journal of Family Medicine and the Medifacts tapes system, which should bring it to the attention of a majority of primary care physicians in Canada.

EQUIPMENT

Regulators

Many of the cases already cited illustrate equipment shortcomings. Regulator freeze-up can be managed. While it cannot be completely prevented by current single hose designs, many companies have produced products which are more resistant than others. To achieve low breathing resistance, high peak flows are required. Many designs have pursued this goal, neglecting the fact that these higher flow rates imply greater cooling and therefore greater risk of freeze-up. Divers should be made aware of those designs which best meet both criteria such as the excellent line by Sherwood which we have found very freeze-up resistant.

$C0_2$ Vest

In cold water the performance of these vests at depth is pitiful (Table 3). Below 60 feet $C0_2$ vests are wholly inadequate in our 4°C waters, even with the largest of cartridges. A vest can be used as a last resort air supply if fitted with the right mouthpiece and if the skill is practiced, but if it is full of $C0_2$ breathing would of course only hasten your demise. A $C0_2$ cartridge with a power inflator does not ease the problem as the one time you really need that vest is when your air supply has gone.

Two young divers, MZ and JS died while diving the wreck of the Forest City. These divers were wearing $C0_2$ vests which at 150 feet would provide 1.25 pound lift when deployed against net negative buoyancies of approximately 10 to 12 pounds. Neither reached the surface nor survived, so the exact role played by this deficiency remains speculative.

The diver TR referred to earlier droned because he failed to inflate his vest on the surface. He was unable to do so because it had a power inflator but he was out of air. It had an oral inflator but he was fighting so hard for breath he could not spare any. It had no $C0_2$ or alternative last ditch fill system.

The solutions are fairly obvious and simple. An independent fill system for the vest. This should be breathable one is diving in cold water deeper than 50 feet. The training required for safe use of the system should be part of all diver courses. There is a new inadequacy in equipment which, as far as I am aware, has yet to produce a casualty that I would like to mention in passing.

TABLE 3

$C0_2$ VEST BUOYANCY

Cartridge size	Lift at 90 feet in 5°C water
38g	5 lb
25 g	2-3 lb
12 g	1.5 lb

(Average Canadian diver-buoyancy at the end of expiration is 4 lb negative. This becomes 6 to 8 lb negative if water is inhaled).

Stabilizing jacket

The stabilizer jacket is being widely promoted as the ideal buoyancy device. While it is compact and comfortable in most circumstances, fully inflated many models cause significant restrictions to respiration and a sensation rather like what I have always imagined the grip of an octopus might feel like. These effects could be devastating if experienced for the first time in an emergency situation. Divers should be cautioned in this regard. Details of the restriction to respiration will be included in a study to be published shortly.

Malfunction

Equipment malfunction was an initiating factor in many cases, including JM, SG and LS and a complicating factor in others, including TR and JG. *I would like to emphasize that the malfunction per se killed none of these divers. It was their reaction to the malfunction that did.*

RESCUE

This brings me to the last area of difficulty, the response to the accident by other divers. The most frequent cause of difficulty in relation to technique was with CPR. In three of four cases where divers reached the surface but died before reaching the recompression units, faulty or no CPR was involved. In the case of TR loose bridge-work lodged in his throat. The rescuers abandoned CPR on RR because the victim vomited. As Resusci-Anne never did that they were totally unprepared. In one case, no CPR was attempted because the victim was cold, blue and had dilated pupils.

Most divers could get 2 out of 3 on that test after any dive at Tobermory. In the case of KC the initial problems were compounded by faulty CPR, which fractured ribs and may have lacerated the lungs.

CPR training for divers needs to emphasize that unconscious divers in a head low position almost inevitably vomit, in a passive way and that to save these people you must be

prepared to clear the airway, spit out the chunks and keep going. Divers must also be taught that the pupillary signs are totally unreliable when dealing with a potential cerebral air embolism.

Organisation and Planning

The following case illustrates almost every factor I have discussed and many more besides.

JG was a 30 year old diver, with low time diving with a group who did not know him or his experience beyond the fact that he possessed a C card. His girl-friend was along as part of the group so the pressure was on as the group decided to dive the Arabia. Dive organisation had been fairly good throughout the weekend, but for some reason which was never clear, it was now let slip. The divers were not in standard buddy teams. On the descent one female diver aborted after crossing the thermocline at 80 feet and was left alone on the descending line. JG continued down. After completing a part of the distance around the wreck one of the more experienced divers noticed that JG was already down to 750 psi and directed him back toward the ascending line. He then turned to signal the rest of the group to follow. The girl left behind was at 70 feet and came to the surface with the rest of the group, having encountered no other diver. At the surface, the captain of the charter boat, an interested bystander, pointed out that the group was a diver short and the search for JG began. There was no-one who had not already dived. So four of those in the water made immediate repetitive dives, one of them twice, using fresh tanks. Finally 20 minutes later JG was brought to the surface, dead. Death was due to massive air embolism of the brain and heart. Subsequent investigation revealed that the diver had encountered a free flow, ascended, embolized and sunk to the bottom where he was found. As a result of the repetitive dives committed, we wound up treating 1 case of type 1 decompression sickness and 4 cases of missed decompression. I do not believe an additional comment is required

The dual fatality of JS and MZ on a dive conducted without a safety diver, reserve air or communication 8 miles off shore, illustrated the same deficiencies. The old maxim, plan your dive and dive your plan really says it all.

LESSONS FOR FIRST AID PRIORITIES

In this review of the accidents at Tobermory I have attempted to review those factors which could be altered to improve the situation and prevent the accidents or improve the outcome.

First aid has obviously got to start with training if the figures are to change much. Of 15 deaths, 11 failed to surface which certainly limits one's options in dealing with these accidents. Universal adoption of the continuous breathing cycle ascent protocol below would eliminate most of the air embolism cases. Details of this protocol are available on request.

1. Do not remove the regulator from your mouth unless you have another to replace it with, or in cases of entanglement. The regulator provides a safety valve, and a possible source of air.

2. Continue to attempt to breathe in and out at all times even if out of air or without your regulator. This ensures an open glottis and larynx, and minimises the chance of small airway closure.

3. Make certain you become positively buoyant by inflating your buoyancy compensator or dropping the weight belt or both. This guarantees that you will reach the surface despite hypoxia.

CPR training is the most critical factor to date in determining the outcome if the diver surfaces.

Good dive organization ensures rapid response and prevents incidents from becoming complicated.

There is no conclusion to this paper, it is in fact merely a beginning in what we hope will become a broader, ongoing review of Canadian diving accidents and incidents leading to improved First Aid for Divers.

SPUMS MELBOURNE MEETING

A very interesting programme was available to members on November 20th. Unfortunately few members took the opportunity to hear Dr Peter Laverick present two cases of spinal decompression sickness and Dr Geoff Macfarlane discuss the pitfalls of histories as given by divers and the newly available recompression chamber stationed at Morwell. They were followed by Dr Harry Oxer discussing decompression accidents in Western Australia and Dr Charles Hackman who presented two cases treated recently at Prince Henry's Hospital. The final speaker was Dr John Knight who outlined "First Steps in First Aid for Diving Accidents" using a chart developed from that presented to the joint SPUMS Singapore Navy meeting in June 1980 by Dr Mike Davis and published in the SPUMS Journal Supplement 1981. The new chart appears opposite.

Those who missed the meeting will not need to miss the information as the papers will be published in the Journal during 1982.