Chapter 6

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DIVING ENVIRONMENTS

When the aspiring diver is given his formal training, it is usually in a controlled and pleasant environment. He is trained to dive in that environment – not in other environments. He often has no concept of the demands and dangers of the other environments. He may subsequently encounter these dangers without an appreciation of the consequences of his actions, until it is too late. A perusal of this chapter may introduce him to some of the problems he could face and that need to be overcome. He needs specialised training and supervision when extending his diving profile to encompass these new environmental situations,

We will present only a brief overview. Reference should be made to diving manuals and texts for further details (see Appendix A). Divers are advised to obtain expert tuition from diving organisations specialising in these environments, before they contemplate venturing into them. Even then, they should be chaperoned by divers with specific experience of these environments

WATER MOVEMENTS

Tidal Currents

Currents of several knots* are commonly found in estuaries and ocean sites frequented by divers. These cannot be matched by the relatively puny swimming speeds achievable by a diver. For a short burst, a diver can manage about 1.5 knots, but a sustained speed of about 1.2 knots is the maximum which a fit diver can reach. For a relatively relaxed dive, a current of less than half a knot is acceptable. The problems posed by currents can be lessened by correct dive planning.

Firstly the diver needs to be aware that specific currents are a factor in any planned diving location. At other times they may be predicted by the tidal charts. This information is best obtained from local divers and/or maritime authorities. Currents can sometimes be identified by the behaviour of the dive boat at anchor, with the bows usually pointing into the current.

* 1 knot = 1 nautical mile per hour = 1.85 km per hour

The "Half Tank Rule". The best technique is to plan to swim into the current for the first half of the dive and use it to drift back to the boat during the second half. The dive is divided into halves on the basis of the air supply. After subtracting the air pressure needed to drive the regulator and as a reserve, allow half the remaining gas for the swim into the current and return using the second half of the supply. In tidal areas, it is necessary to anticipate any change in direction as the tide turns, or both halves of the dive may be into current. The best time to dive in tidal areas, for both ease and visibility, is usually during slack water - between tides.

As an example, if there is 200 ATA (or Bar) in the scuba cylinder, 40 ATA would be needed as a driving pressure for the regulator. That leaves 160 ATA for the dive. Eighty ATA could be used to swim into the current, and that leaves 80 ATA to drift back to the boat, allow for navigational errors and perform a safety stop. If one had allocated gas for emergencies, this would reduce the dive times accordingly.

The **anchor line** can be used to advantage. It is much easier to make headway against a current by pulling along a rope or chain, than by swimming. If a rope is attached loosely to the anchor line at the surface and run around the side of the boat, divers can enter the water holding onto this and use it to pull themselves to the anchor line. By using the anchor line, divers can pull themselves down to within 2 metres of the bottom, where the current is often less strong. Avoid swimming onto or dislodging the anchor, which can cast the boat adrift or lift and injure the diver. Swimming around the anchor allows the diver to check the anchor’s security before continuing upstream.

Another rope (a **floating** or **Jesus line**) should drift with the current from the back of the boat, for 50 metres or more. This should be supported at regular intervals by buoys or floating plastic containers. This line has earned its name by "saving the sinners" who have missed the boat or surfaced down-current.

Another technique used in locations with strong currents is **drift diving**. Because of the fast currents, all equipment should be firmly attached and snagging on environmental hazards and other divers must be avoided. A **float** is towed to mark the diver's position and allow for signals to be sent to the surface craft. A rescue or pickup boat must drift with the divers and the current to another location, where the divers are hopefully recovered. Any such boat should have a **propeller guard** if it is to be used to rescue the divers.

Divers being left and lost at sea is unfortunately not a rare event, and it is often difficult for boatmen to find their divers if the sea surface is choppy (bubbles not detectable) and waves or swells block the diver from the low gunwaled boat. A divers float or a **"safety sausage"** (a long fluorescent inflatable plastic float) is a useful backup for a lost diver after an ocean or drift dive, and can be seen for a kilometre or so. A whistle can be used to attract attention, but is difficult to hear over engine and ocean noises. Other means of attracting attention of boatmen are low pressure horns (with >100dB sounds, for > 1km.), signal mirrors (if the sun is shining, for many km.), and waterproof **smoke flares** (lasting a minute or so, and visible for up to 10 km.). EPIRB and other electronic signalling devices may send emergency signals to commercial transports, including aircraft, over many km. See Chapter 5 for information on equipment.

Surge

In shallow water affected by waves, a **to-and-fro surge** which is too strong to swim against, may be encountered. This is best dealt with by gripping the bottom (with gloves) during the adverse surge, and moving with the favourable one. A diver contending with a powerful surge can become disoriented from the violent movement, injured from impact with rocks and can succumb to panic.

Surf

A surf entry without proper technique can be hazardous. The fully equipped diver presents a large vulnerable target to waves which can quickly divest him of essential equipment while engulfing him in unbreathable, non-buoyant foam.

The recommended technique of surf entry is to approach the water backwards after donning all equipment including fins before entry. The fins and mask must be firmly attached as they are easily lost and the regulator is attached to the vest by a clip in a readily accessible position. The diver watches oncoming waves over his shoulder while keeping an eye on his buddy, who is using the same procedure. Waves in shallow water should be met side-on to present the smallest surface area. The diver adopts a wide stance and leans into the wave. The diver should descend and swim while breathing through the regulator as soon as possible. Thus he avoids turbulence by diving under oncoming waves. After passing the waves break line, ascent allows reconnection with his buddy.

Floats are towed behind the diver on entry, and pushed in front when returning. Exit is achieved by the opposite process and by using incoming waves to help with progress towards the beach.

ENTRAPMENT

A variety of ropes, cords, fishing lines, nets, kelp and other material can easily snare the diver or his bristling array of equipment. Entrapment of this type can be safely dealt with by a calm appraisal of the situation and a sharp knife. Some divers prefer to use scissors (similar to wire cutters) instead of a knife, as they are more effective in cutting through particularly tough lines made of synthetic fibres. The limited field of view inherent with all face masks complicates these problems and makes the assistance of a buddy invaluable in tracing and untangling or cutting the causes of entrapment.

Kelp

This is a giant seaweed growing in forests from as deep as 30 metres and reaching the surface. It has a long trunk with branching fronds near the surface. It occupies cooler waters and provides a fascinating but potentially dangerous diving environment.

A diver can easily become entangled and drowned in kelp, especially near the surface where the fronds are thickest and special diving techniques are necessary for safe kelp diving.

Divers help minimize projections, which cause entanglement, by wearing the knife on the inside of the leg, use flush-fitting buckles and tape over protruding equipment. The scuba cylinder can be worn “upside down” to reduce regulator entanglement. The water is entered feet first and an attempt is made to push a hole in the kelp fronds, through which the diver passes. Divers should avoid twisting and turning in the kelp. A good kelp diver is a slow diver.The area near the bottom of the kelp causes the least likelihood of entanglement.

It is important to return to the surface with an ample reserve of air to ensure that the passage through the surface kelp is careful and unhurried. If entangled, be careful when cutting kelp stalks with a diameter similar to the regulator hose – you never know...

Enclosed Environments

Caves, wrecks, under-ice and even diving beneath large over-hangs are potentially hazardous environments which should not be entered without special training and planning. The following outline is by no means comprehensive. Specialised training and equipment are needed.

- **Caves.**

A diver in a cave usually cannot return directly to the surface in the event of an equipment malfunction or emergency. Even without these problems, it is easy to become lost and be unable to find the surface before the air supply is exhausted. The main problems are – panic, loss of visibility and navigational difficulties. The roof of a cave may collapse after air (expired from scuba) replaces the previously supporting water.

Caves are usually dark and lined with fine silt which is easily stirred into an opaque cloud by the use of fins. This is reduced with small fins, slow movements and avoiding the floors and roof. With silt, the natural or artificial illumination sources become valueless, reflecting the light back towards the diver.

Fig. 6.1

All essential equipment and lights are duplicated. A compass is mandatory. Cave divers carry a spare tank and regulator attached to a manifold, with the spare regulator on a long hose so it can be used by another diver following in a narrow passage, if necessary. Totally separate emergency air supplies are recommended.

Probably the safest diving equipment to use in caves, if not deep and the penetration distance not long, is a surface supply. Then return can follow the hose, which is being withdrawn by the surface tender.

Return to the entrance of the cave is marked by a line which is dispensed from a reel by the dive leader, who goes in first. The diver follows the leader into the cave.

This allows the way-out to be found by following the line, away from the leader. Vertical passage to the surface is marked by a heavier shot line which is less likely to entangle the diver ascending in haste.

- **Wrecks.**

Wreck diving shares many of the problems of cave diving (requiring similar preparations and precautions) as well as presenting some unique problems. In many areas the enduring wrecks are deep, adding the risk of decompression sickness and nitrogen narcosis to the general hazards.

Wrecks frequently contain physically or chemically unstable cargo, explosives and ordinance, toxic chemicals and unfriendly marine animals. Disturbed silt deep in a wreck and sharp jagged metal edges can make navigation through a labyrinth of ladders and passageways difficult. A compass may be of little help as the metal in the wrecks is often magnetised.

- **Ice diving.**

Diving under ice requires special equipment and know-how. It shares many of the hazards and precautions of cave diving but has the added complication of freezing conditions. Being trapped under ice can be an alarming experience for a diver with a frozen and therefore non-functioning regulator. Full reliance should not be placed in specialised "ice diving" regulators – in which the water is replaced by oil, alcohol or air. These can also freeze especially on the surface, using octopus regulators and with over-breathing. Attention has also to be paid to the exit procedure, as holes can "ice-over" rapidly. Protection may also be needed for surface tenders, as they may be exposed to wind and much colder temperatures than the diver, who is only at zero degrees C.

ENVIRONMENTAL VARIANTS

Cold Water

This can disrupt the performance of both the diver and his equipment. Diving in cold water requires the insulating qualities of a thick wet suit or dry suit, with gloves, boots and a hood. The wet suit, unfortunately, loses it efficiency when the insulating air layer is compressed with depth.

The cooling effect of compressed air expanding in the regulator, added to the low temperature of the water, makes freezing of the regulator a significant problem. Modified regulators which reduce these occurrences are available but cannot be fully relied upon.

Night Diving

This is not for everyone. The concept holds real fears for some divers who are perfectly comfortable diving in daylight. Because of the dangers of anxiety reactions and panic, night diving should be avoided by divers who are claustrophobic or feel excessively anxious at the prospect. The lack of visual cues can cause disorientation and imagination runs rife.

Lights well above the waterline, should be displayed on the boat and the shore exit. Torches should not be shone into a diver's face — it blinds him temporaribly (destroys night vision) — but they may be directed to display one's own hand signals.

The problems centre on impaired visibility. Vision is dependent on artificial light which is very restricted and can easily fail. It is important for the night diver to be able to find and use all items of equipment by touch alone.

Detecting and rescuing divers who develop problems and surface some distance away, may be difficult. An emergency flare, strobe light or chemical light stick (e.g."cyalume") attached to the diver's tank valve is worthwhile carrying for this eventuality, as is a whistle.

Deep Diving

Dives deeper than 30 metres have an increasing number of complications, possibly with inappropriate responses to these.

The endurance of the scuba air supply is severely limited at greater depths while the decompression requirements increases almost exponentially, adding a sense of urgency to the dive in the face of a diminishing reserve-air safety margin.

Decompression stops become obligatory for even short dives to depths in excess of 40 metres and requires the provision of extra air for this purpose. Unfortunately, the decompression tables, even if followed exactly, become less reliable as the depth increases, raising the possibility of serious decompression sickness even after a faultlessly executed dive.

Nitrogen narcosis can occur at less than 30 metres (100 feet) and progressively impairs judgement, attention, perception and an appropriate response to adversity as the depth increases. At depths in excess of 45 metres (150 ft.) mental stability, cognition and judgement are seriously impaired. See Chapter 18)

Equipment becomes more difficult to manage at these depths. Breathing through the regulator becomes harder. The buoyancy compensator takes much longer to inflate and uses more of the limited air supply. Wet suit compression reduces its insulating properties at the same time as the diver passes into colder deep water. This compression also progressively decreases buoyancy.

The environment beyond 30 metres is dark, colourless, cold, relatively devoid of marine life (although the fish and sharks are often larger), and replete with physiological hazards. In spite of this, some recreational divers feel compelled to experience it, albeit briefly because of the limited air endurance.

The authors recommend that, in view of the increased hazards and the limited diving satisfaction available in deep dives, recreational divers regard 30 metres (100 ft.) as the maximum recommended safe depth. Uneventful dives beyond this depth often impart a false sense of capability – which is then shattered when one or more things go wrong. It is then that the effects of narcosis are demonstrated.

Altitude Diving

Diving in waters located above sea level (e.g. a mountain lake or dam) introduces some potential hazards which are related to the cold temperatures at altitude and buoyancy problems with fresh water (see below). Other variations with altitude are much more important, but not immediately obvious.

Consider a dive in a mountain lake where the atmospheric pressure is half that at sea level (this would be at an unlikely altitude of about 6000 metres or 18,000 ft. elevation, but it makes the calculations easy). The pressure at the surface of the lake is that of the atmosphere, 0.5 ATA. Assume it is a salt water lake (fresh water is slightly less dense and so exerts slightly less pressure at a given depth).

The water in the lake will exert the same pressure at this altitude as it would at any other altitude.

That is, 10 metres of water will still exert a pressure of 1 ATA.

The pressure at 5 metres depth therefore will be 1 ATA, consisting of 0.5 ATA contributed by the atmospheric pressure, and 0.5 ATA contributed by the water.

The pressure at 10 metres will thus be 1.5 ATA.

One might think initially that this would give the diver a safety margin since the pressure at a given depth in a mountain lake is less than that in the ocean. The critical difference, however, is that the diver in the lake is returning to a lower surface pressure.

This can be illustrated by referring to one of Haldane's hypotheses (see Chapter 13). He indicated that a diver could spend an unlimited time at 10 metres (2 ATA) and return to the surface (1 ATA) without developing decompression sickness. In other words, a diver could return to a pressure of half the original pressure (i.e. a 2 : 1 ratio) without developing nitrogen bubbles in the tissues.

In the mountain lake, because the surface pressure is only half that at sea level (0.5 ATA), the diver need dive to only 5 metres (1 ATA) and return to the surface to encounter the same 2 : 1 “safe” ratio. A 10 metre dive exceeds the “safe” decompression ratio. This makes dive tables designed for sea level unreliable at altitude unless considerable corrections are made.

Decompression at altitude is further complicated by difficulties in estimating depth. Digital electronic gauges must be calibrated for altitude.

A mechanical depth gauge calibrated for sea level is likely to be unreliable at altitude. The gauge simply measures pressure and registers this as depth. Since the pressure at the surface of the lake is 0.5 ATA (half that of sea level), the gauge will be straining its mechanism and possibly bending the needle, trying to get its pointer past the zero stop to register what it interprets as negative depth. The gauge may only start to register a depth after it has returned to 1 ATA. This would not happen in the mountain lake until the water pressure and atmospheric pressure added up to 1 ATA – a depth of about 5 metres.

Even a capillary depth gauge, calibrated at sea level, will not really read accurately. At sea level, the air-to-water interface in the capillary will move half way along the capillary at 10 metres, since the pressure there is twice that at the surface. In the mountain lake with a surface pressure of 0.5 ATA, twice the surface pressure will be encountered at about 5 metres depth. So the capillary gauge will reach the "10 metre depth mark" (the half volume mark) at 5 metres.

The lower surface pressure also means that gas volume changes with depth are different. The gas in a diver's lungs will double in volume between 5 metres and the surface in the lake, instead of between 10 metres and the surface as would occur in the ocean. Ascent rates thus need to be reduced if the risk of barotrauma is not to increase. The gas expansion in a buoyancy vest will also be greater near the surface in the lake, which can lead to buoyancy changes unexpected by a diver used to ocean diving. Hyperventilation is more likely at altitude because the air is less dense, and over-breathing the regulator is more likely.

Flying after Diving

This creates some similar problems to altitude diving. The decompression tables were calculated on the assumption that the diver would be returning to a pressure of 1 ATA. If the diver then goes to altitude either in an aircraft of on a high mountainous road, with nitrogen still in his tissues, bubble formation is more likely because of the lower pressure experienced, and existing bubbles are liable to enlarge. Special "post diving flying rules" apply.

Diving in Freshwater and Dams

Buoyancy is less in freshwater than saltwater. Depth estimations and calculations are similarly disrupted (10 metres of seawater = 10.3 metres of freshwater). Freshwater is often still, and therefore develops dramatic thermoclines. Trees and other sources of entanglement tend to accumulate and not be destroyed as rapidly as in the sea. Some freshwater currents may cause difficulty. Chemical and sewerage pollution can be a major problem, and some specific freshwater organisms are very dangerous (e.g. *Naegleria* causing amoebic encephalomyelitis).

Dams have a specific problem with outflow below the surface. A diver may be unaware of the pressure gradient that can develop if part of the body covers an outflow orifice. Such a gradient will tether the diver underwater and may cause grotesque injuries as it forces the diver into and through the opening.

Conclusion

In this chapter, we have reviewed only some of the problems of diving in various environments and only some of the measures that can be taken to reduce the dangers. It is hoped that the reader will review this information whenever he is invited to join a diving activity different to one for which he has been trained. He may then be encouraged to undertake more specific training appropriate to his proposed dive program.

Fig 6.2 For some divers, there are few safe environments