ADVANCED OPEN WATER

Beginning with:

A Brief History of Diving, From Antiquity to the Present

WHAT IS THE EARLY HISTORY OF DIVING?

Men and women have practiced breath-hold diving for centuries. Indirect evidence comes from thousand-year-old undersea artifacts found on land (e.g., mother-of-pearl ornaments), and depictions of divers in ancient drawings. In ancient Greece breath-hold divers are known to have hunted for sponges and engaged in military exploits. Of the latter, the story of Scyllis (sometimes spelled Scyllias; about 500 B.C.) is perhaps the most famous. As told by the 5th century B.C. historian Herodotus (and quoted in numerous modern texts),

During a naval campaign the Greek Scyllis was taken aboard ship as prisoner by the Persian King Xerxes I. When Scyllis learned that Xerxes was to attack a Greek flotilla, he seized a knife and jumped overboard. The Persians could not find him in the water and presumed he had drowned. Scyllis surfaced at night and made his way among all the ships in Xerxes's fleet, cutting each ship loose from its moorings; he used a hollow reed as snorkel to remain unobserved. Then he swam nine miles (15 kilometers) to rejoin the Greeks off Cape Artemisium.

The desire to go under water has probably always existed: to hunt for food, uncover artifacts, repair ships (or sink them!), and perhaps just to observe marine life. Until humans found a way to breathe underwater, however, each dive was necessarily short and frantic.

How to stay under water longer? Breathing through a hollow reed allows the body to be submerged, but it must have become apparent right away that reeds more than two feet long do not work well; difficulty inhaling against water pressure effectively limits snorkel length. Breathing from an air-filled bag brought under water was also tried, but it failed due to rebreathing of carbon dioxide.

In the 16th century people began to use diving bells supplied with air from the surface, probably the first effective means of staying under water for any length of time. The bell was held stationary a few feet from the surface, its bottom open to water and its top portion containing air compressed by the water pressure. A diver standing upright would have his head in the air. He could leave the bell for a minute or two to collect sponges or explore the bottom, then return for a short while until air in the bell was no longer breathable.

In 16th century England and France, full diving suits made of leather were used to depths of 60 feet. Air was pumped down from the surface with the aid of manual pumps. Soon helmets were made of metal to withstand even greater water pressure and divers went deeper. By the 1830s the surface-supplied air helmet was perfected well enough to allow extensive salvage work.

Starting in the 19th century, two main avenues of investigation - one scientific, the other technologic - greatly accelerated underwater exploration. Scientific research was advanced by the work of Paul Bert and John Scott Haldane, from France and Scotland, respectively. Their studies helped explain effects of water pressure on the body, and also define safe limits for compressed air diving. At the same time, improvements in technology - compressed air pumps, carbon dioxide scrubbers, regulators, etc., - made it possible for people to *stay* under water for long periods.

WHAT ARE THE DIFFERENT TYPES OF DIVING?

There are really four 'mini-histories' in the fascinating story of man's desire to explore beneath the sea; they correspond to four separate methods of diving, of which scuba is but the latest.

a) ***Breath-hold diving (free diving, skin diving).*** This earliest form of diving is still practiced for both sport and commercial purposes (e.g., ama divers of Japan and Korea, pearl divers of the Tuamoto Archipe-lago). The breath-hold diver's compressible air spaces are squeezed by the increased water pressure throughout the dive. Each dive, limited by the individual's tolerance for breath-hold and the risk of drowning from hypoxia, is usually a minute or less.

b) ***Diving in a heavy-walled vessel.*** Heavy-walled vessels can maintain their internal atmosphere at or near sea level pressure ('one atmosphere'or 'one atm.'), and so prevent the surrounding water pressure from affecting the occupants. Such vessels include: the *bathysphere*, an unpowered hollow steel ball lowered from the mother ship by steel cable; the *bathyscaphe*, a bathysphere with buoyancy control so that cable is not needed for descent and ascent; and the *submarine*, which can travel great distances in any direction under its own power. All one-atmosphere vessels require a system to both provide fresh air (usually by adding oxygen to the existing air) and get rid of exhaled carbon dioxide (with soda lime, lithium hydroxide, or a similar compound that takes up CO_2). A modern extension of the one-atmosphere vessel is the self-contained armored diving suit, flexible yet able to withstand pressures at depth: in effect, the diver becomes almost like a small submarine. With these one-atmosphere suits a diver can work at a depth of several hundred meters for hours.

c) ***Diving with compressed air supplied from the surface*.** The diver is separated from the supply of fresh air, which is kept on the surface. Air reaches the diver through a long umbilical, which in its simplest form ends in a regulator and mouthpiece carried by the diver. In more sophisticated systems the umbilical leads into a dive suit or some larger enclosed space containing the diver. Devices in this category include caissons (huge spaces supplied with compressed air, employed mainly for bridge and tunnel work), underwater habitats used for saturation diving, diving bells, and rigid-helmet diving suits. In all these devices the diver breathes air at the same pressure as the surrounding water pressure, and so is at risk for decompression problems (bends, air embolism, etc.) if ascent is too fast. Special 'high tech' mixtures, such as hydrogen-oxygen, helium-oxygen and helium-nitrogen-oxygen, are used to dive deeper than possible with compressed air.

d) ***Diving with compressed air or other gas mixture that is carried by the diver (scuba diving).*** There are two principle types of scuba: open and closed circuit. Open circuit vents all expired air into the water, and is the mode used in recreational diving. Closed circuit systems, in which exhaled air is re-breathed after carbon dioxide is absorbed and oxygen added, were widely used before open circuit became available, particularly by military divers who wished to avoid showing any air bubbles. As with divers using surface-supplied compressed air, scuba divers are at risk for decompression problems if they ascend without proper decompression. Helium-oxygen and other mixtures can be used to go deeper than possible with compressed air.

WHAT ARE SOME IMPORTANT EVENTS IN THE HISTORY OF DIVING?

The remainder of this chapter is a chronologic recounting of some important events in the four mini-histories of diving, with emphasis on scuba. There are many legends attached to diving history, some based on isolated woodcuts or the storyteller's art. This list includes selected inventions, discoveries and achievements documented and accepted by historians as fact. Following each date is the type of diving to which the described event is most relevant. (Events that advanced knowledge of diving physics and decompression sickness are relevant to all compressed air diving). The four types of diving are:

a) Breath-hold diving ("breath-hold")

b) Diving in a heavy-walled vessel ("vessel")

c) Diving with compressed air or other gas supplied from the surface ("surface air")

d) Diving with compressed air or other gas in a container carried by the diver ("scuba")

A BRIEF CHRONOLOGY OF DIVING HISTORY

500 B.C. (breath-hold). Scyllis demonstrates practical use of breath-hold diving by performing military exploits for the King of Persia (see above).

1530 (surface air). First diving bell is invented.

1650 (surface air). *Von Guericke* develops the first effective air pump. With such a pump Robert Boyle is able to undertake experiments in compression and decompression of animals.

1667 (surface air; scuba). *Robert Boyle*, English physicist and originator of Boyle's law, observes gas bubble in eye of viper that had been compressed and then decompressed. He writes: "I have seen a very apparent bubble moving from side to side in the aqueous humor of the eye of a viper at the time when this animal seemed violently distressed in the receiver from which the air had been exhausted." This is the first recorded observation of decompression sickness or "the bends."

1690 (surface air). *Edmund Halley* (of comet fame) patents a diving bell which is connected by a pipe to weighted barrels of air that can be replenished from the surface. Both barrel and bell (the latter with men in it) are lowered to depth; dives to over 60 feet for 90 minutes are recorded. Diving bells are thus shown to be practicable devices.

1715 (surface air). Englishman *John Lethbridge* builds a "diving engine," an underwater oak cylinder that is surface-supplied with compressed air. Inside this device a diver can stay submerged for 30 minutes at 60 feet, while protruding his arms into the water for salvage work. Water is kept out of the suit by means of greased leather cuffs, which seal around the operator's arms. The diving engine is claimed to be used successfully for many years.

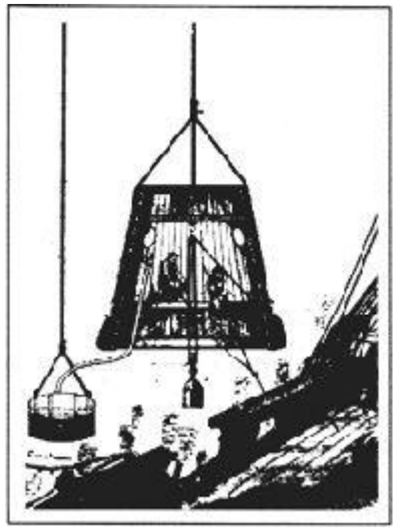

Figure 1. Halley's diving bell, late 17th century. Weighted barrels of air replenished the bell's atmosphere. (U.S. Navy Diving Manual)

1776 (vessel). First authenticated attack by military submarine - American *Turtle* vs. *HMS Eagle*, New York harbor.

1788 (surface air). American *John Smeaton* refines diving bell; incorporates an efficient hand-operated pump to supply fresh compressed air and a non-return valve to keep air from going back up the hose when pumping stops. In 1790 Smeaton's diving bell is used at Ramsgate Harbor, England, for salvage work. In another 10 years his bell is found in all major harbors.

1823 (surface air). *Charles Anthony Deane*, an English inventor, patents a "smoke helmet" for fighting fires. At some point in the next few years it is used for diving as well. The helmet fits over a man's head and is held on with weights; air is supplied from the surface through a hose. In 1828 Charles and his brother *John Deane* market the helmet with a "diving suit." The suit is not attached to the helmet but only secured with straps; thus the diver cannot bend over without risking drowning. Even so, the apparatus is used successfully in salvage work, including the removal of some canon from the *Royal George* in 1834-35 (see also 1839).

1825 (scuba). "First workable, full-time SCUBA" is invented by an English-man, William James. It incorporates a cylindrical belt around the diver's trunk that serves as an air reservoir, at 450 psi. (It is unclear if this equipment was ever actually used for diving; see Marx 1990 and Brylske 1994 in the Bibliography). Other inventors about this time are also working on self-contained underwater breathing apparatus.

1837 (surface air). German-born inventor *Augustus Siebe*, living in England, seals the Deane brothers' diving helmet (see 1823) to a watertight, air-containing rubber suit. The closed diving suit, connected to an air pump on the surface, becomes the first effective standard diving dress, and the prototype of hard-hat rigs still in use today. In his obituary Siebe is described as the father of diving.

Figure 2. Siebe's early diving suit. (U.S. Navy Diving Manual)

1839 (surface air). Seibe's diving suit is used during salvage of the British warship *HMS Royal George.* The 108-gun ship sank in 65 feet of water at Spithead anchorage in 1783. The "Siebe Improved Diving Dress" is adopted as the standard diving dress by the Royal Engineers. During this salvage, which continues through 1843, the divers report suffering from "rheumatism and cold," no doubt symptoms (among the first recorded) of decompression sickness. Also of note in this salvage is the first recorded use of the buddy system for diving.

1843 (surface air). As a result of experience gained salvaging the *HMS Royal George*, the first diving school is set up by the Royal Navy.

1865 (surface air, scuba). Frenchmen *Benoit Rouquayrol* and *Auguste Denayrouse*, a mining engineer and naval lieutenant, respectively, patent an apparatus for underwater breathing. It consists of a horizontal steel tank of compressed air (about 250-350 psi) on a diver's back, connected through a valve arrangement to a mouth-piece. Patented as the "Aerophore," the device delivers air only when the diver inhales, via a membrane that is sensitive to outside water pressure: in effect, the first demand regulator for underwater use. With this apparatus the diver is tethered to the surface by a hose that pumps fresh air into the low pressure tank, but he is able to disconnect the tether and dive with just the tank on his back for a few minutes. The aerophore is a forerunner of modern scuba equipment. The apparatus is used by the French and other navies for several years, and also appears prominently in Jules Verne's 1870 novel, '*20,000 Leagues Under The Sea* '

1873 (surface air). *Dr. Andrew H. Smith* presents his formal report as Surgeon to the New York Bridge Company, builders of the Brooklyn Bridge, about workers who suffered the bends after leaving the pressurized caisson. (The bends was a common problem among caisson workers. The condition also afflicted chief engineer Washington Roebling; he developed a severe, non-fatal case of decompression sickness, permanently impairing his health). By the time of Smith's report, which recommends chamber recompression for future projects, all Brooklyn Bridge caisson work is completed. Smith's report makes no mention of the true cause of decompression sickness: nitrogen bubbles.

1876 (scuba). An English merchant seaman, *Henry A. Fleuss*, develops the first workable, self-contained diving rig that uses compressed oxygen (rather than compressed air). In this prototype of closed circuit scuba, which is the forerunner of modern closed circuit scuba units used by military divers, carbon dioxide is absorbed by rope soaked in caustic potash, so that exhaled air can be re-breathed (no bubbles enter the water). Although depths are limited (pure oxygen is toxic below about 25 feet of sea water, a fact not known at the time), the apparatus allows for relatively long bottom times, up to three hours. In 1880 Fleuss's apparatus is used by the famous English diver Alexander Lambert to enter a flooded tunnel and seal a hatchway door; the hatchway is 60 feet down and 1000 feet back into the tunnel.

Figure 3. Aerophore patented in 1865 by BenoitŒt Rouquayrol and Auguste Denayrouse. (Courtesy Historical Diving Society)

1878 (surface air; scuba). Frenchman *Paul Bert* publishes *La Pression Barometrique,* a 1000-page work containing his physiologic studies of pressure changes. He shows that decompression sickness is due to formation of nitrogen gas bubbles, and suggests gradual ascent as one way to prevent the problem. He also shows that pain can be relieved by recompression. Bert provides the link between Boyle's 17th century observation of decompression sickness in a viper and the symptoms of compressed air workers first recorded in the 19th century.

1908 (surface air; scuba). In 1906 the British Government asks *John Scott Haldane,* an eminent Scottish physiologist, to do research in the prevention of decompression sickness. Two years later Haldane, *Arthur E. Boycott* and *Guybon C. Damant*, publish their landmark paper on decompression sickness (from hyperbaric experiments done on goats). "The Prevention of Compressed-Air Illness" lays the groundwork for staged decompression. Tables based on this work are soon adopted by the British Royal Navy and later the United States Navy, and save many divers from the bends. (See Chapter 9)

1912 (surface air; scuba). The U.S. Navy tests tables published by Boycott, Damant and Haldane.

1917 (surface air). The U.S. Bureau of Construction & Repair first introduces the Mark V Diving Helmet. When attached to a deep sea dress and umbilical, the Mark V becomes the underwater work horse for decades to come. It is used for "practically all salvage work undertaken during World War II...the MK V Diving Helmet becomes the standard U.S. Navy Diving equipment until succeeded by the MK12 in 1980." (U.S. Navy Diving Manual). "So sound was its design that very few modifications were ever incorporated, and recent models vary only slightly from the 1917 version." (Leaney 1993)

1920s (surface air; scuba). Research is begun in United States into the use of helium-oxygen mixtures for deep dives. To the beginning of World War II, the U.S. maintains a monopoly on helium.

1924 (surface air; scuba). First helium-oxygen experimental dives are conducted by U.S. Navy and Bureau of Mines.

1930 (vessel). *William Beebe*, a diving pioneer and "oceanographic naturalist" descends 1426 feet in a round, 4'9" bathysphere; it is attached to a barge by a 7/8" non-twisting steel cable to the mother ship. Of this dive Beebe later writes:

...There came to me at that instant [1426 feet down] a tremendous wave of emotion, a real appreciation of what was momentarily almost superhuman, cosmic, of the whole situation; our barge slowly rolling high overhead in the blazing sunlight, like the merest chip in the midst of the ocean, the long cobweb of cable leading down through the spectrum to our lonely sphere, where, sealed tight, two conscious human beings sat and peered into the abysmal darkness as we dangled in mid-water, isolated as a lost planet in outermost space.

1930s (breath-hold). *Guy Gilpatric*, an American ex-aviator living in southern France, pioneers use of rubber goggles with glass lenses for skin diving. By the mid-1930s, face masks, fins, and snorkels are in common use. Fins are patented by a Frenchman, *Louis de Corlieu*, in 1933 (called "Swimming Propellers") and later popularized world-wide by an American entrepreneur, *Owen Churchill* (see 1940). The modern mask (covering eyes and nose, as opposed to simple eye goggles), evolves from the ideas of various people, including the Russian *Alec Kramarenko*, and the Frenchmen *Yves Le Prieur* and *Maxime Forjot.* In 1934 Gilpatric writes of his Mediterranean exploits for The Saturday Evening Post, and in 1938 publishes *The Compleat Goggler*, the first book on amateur diving and hunting. Among the book's readers: a French naval lieutenant named Jacques Cousteau.

1933 (breath-hold). First sport divers club is started in California, called the Bottom Scratchers; a year later an amateur diving group, Club des Sous-l'Eau, is founded in Paris. A primary purpose of these and similar clubs is underwater spear fishing.

1933 (scuba). French navy captain *Yves Le Prieur* modifies the Rouquayrol-Denayrouse invention by combining a specially designed demand valve with a high pressure air tank (1500 psi) to give the diver complete freedom from restricting hoses and lines. The apparatus contains no regulator; the diver receives a breath of fresh air by opening a tap, while exhaled air escapes into the water under the edge of the diver's mask. (In the late 1930s Cousteau used this apparatus but, as he wrote in *The Silent World*, "the continuous discharge of air allowed only short submersions.") In 1935 Le Prieur's SCUBA is adopted by the French navy.

1934 (vessel). On August 15 William Beebe and *Otis Barton* descend 3028 feet in a bathysphere near Bermuda. This dive sets a depth record that remains unbroken for 14 years.

1936 (scuba). Le Prieur founds the world's first SCUBA diving club, called the "Club of Divers and Underwater Life."

1938 (surface air; scuba). *Edgar End* and *Max Nohl* make the first intentional saturation dive, spending 27 hours at a depth of 101 feet in a Milwaukee hospital hyperbaric chamber. Decompression takes five hours and one of the divers (Nohl) suffers the bends.

1939 (vessel). The first completely successful rescue of submarine-trapped men is carried out. On May 23 the *USS Squalus*, a new 310-foot submarine, sinks in 243 feet of water during a checkout dive in the North Atlantic. Twenty-six of the crew die instantly in the flooded aft compartments. The forward, unflooded area holds 33 men (including the captain) with enough air and water to last several days. Within hours the largest submarine rescue in history is underway. By midnight of May 25 all 33 men are rescued by a new diving bell, the *McCann-Erickson* Rescue Chamber. The chamber fits over an escape hatch on the submarine; when the chamber and submarine hatches are opened the men enter the bell under one atmosphere of pressure. Four separate trips are used to rescue the men. The submarine is later salvaged and renovated, and enters World War II duty as the *USS Sailfish*.

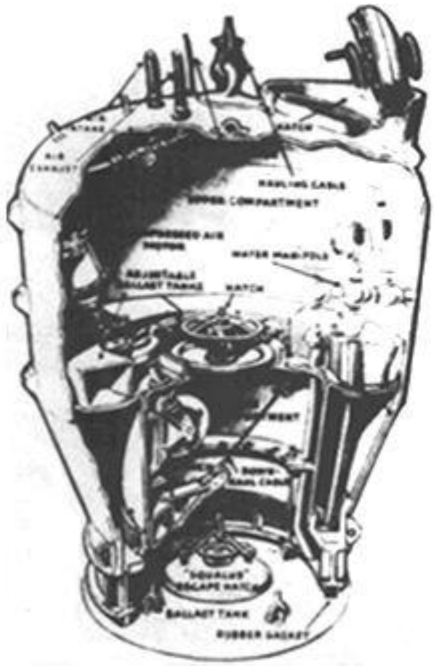

Figure 4. Vertical cross section of the McCann-Erickson Rescue Chamber. (Courtesy U.S. Navy Diving Manual.)

1940 (breath-hold; scuba). First year of production of Owen Churchill's swim fins. Initially, only 946 pairs are sold, but in later years production increases substantially, and tens of thousands are sold to the Allied forces.

1941-1944 (scuba). During World War II Italian divers, working out of midget submarines, use closed circuit scuba equipment to place explosives under British naval and merchant marine ships. Later in the war the British adopt this technology to sink German battleship *Tirpitz*.

1942-43 (scuba). *Jacques-Yves Cousteau* (a French naval lieutenant) and *Emile Gagnan* (an engineer for Air Liquide, a Parisian natural gas company) work together to redesign a car regulator that will automatically provide compressed air to a diver on his slightest intake of breath. (Prior to this date, all self-contained apparatus still in use supplied air continuously, or had to be manually turned on and off. For unclear reasons, the 19th century demand regulator of Rouquayrol-Denayrouse had long been abandoned.) Cousteau and Gagnan attach their new demand valve regulator to hoses, a mouthpiece and a pair of compressed air tanks. In January 1943 Cousteau tests the unit in the cold Marne River outside Paris. After a modification (placing the intake and exhaust valves at the same level), they patent the Aqua Lung...

The Gagnan-Cousteau regulator fundamentally altered diving. Its simple design and solid construction provided a reliable and low-cost unit for sport diving. Air Liquide put the equipment into commercial production, but it couldn't keep up with the demand. Competitors tried to capture the growing market by producing imitations or making slight adjustments... The devices revolutionized man's perception of the planet. Not unlike the Portuguese, Spanish, and Chinese explorers of the fifteenth century who doubled their knowledge of the size of the world, Cousteau and Gagnan helped open a vast portion of the globe to human exploration. They offered the opportunity for extensive undersea investigation to enthusiastic scientists, engineers, and sportsmen.

Summer and fall 1943 (scuba). Cousteau and two close friends, Frederic Dumas and Philippe Tailliez, make over five hundred dives with the aqualung, gradually increasing the depths to which they plunge. They have developed the first workable, open-circuit demand-type scuba apparatus. In October Dumas, in a carefully planned dive, descends to 210 feet in the Mediterranean Sea and experiences *l'ivresse des grandes profondeurs* - rapture of the great depths.

1946 (scuba). Cousteau's Aqua Lung is marketed commercially in France. (It is marketed in Great Britain in 1950, Canada in 1951 and the USA in 1952).

1947 (scuba). In August, Dumas makes a record dive with the Aqua Lung to 307 feet in the Mediterranean Sea.

1948 (vessel). Otis Barton descends in a modified bathysphere to a depth of 4500 feet, off the coast of California.

1950 (scuba). Despite the technical success of the aqua lung, it has yet to catch on in the U.S. So far only 10 aqua lung units have been shipped to the U.S. because, the distributor tells Cousteau, "the market is saturated."

1951 (breath-hold; scuba). The first issue of *Skin Diver Magazine* appears in December.

1950s (breath-hold; scuba). The sport of diving gradually changes from breath-hold to mainly scuba. Dive stores open up around the U.S.

1953 (scuba). *The Silent World* is published. Written in English by Jacques Cousteau, with the assistance of Fr,d,ric Dumas, the book chronicles the development and early testing of the Cousteau-

Gagnan Aqua Lung.

1950s (vessel). Famed Swiss balloonist *August Picard* turns his attention to the deep sea. With son Jacques, he pioneers a new type of vessel called the bathyscaphe (deep boat). The bathyscaphe is completely self-contained (not tethered to the surface), and designed to go deeper than any bathysphere. On February 15, 1954, off the coast of French West Africa, a bathyscaphe containing *Georges S. Houot* and *Pierre-Henri Willm* exceeds Barton's 1948 diving record, reaching a depth of 13,287 feet.

1957 (scuba). First segment of *Sea Hunt* airs on television, starring *Lloyd Bridges* as Mike Hunt, underwater adventurer. The series inspires thousands of people to take up scuba diving.

1959 (scuba). YMCA begins the first nationally organized course for scuba certification.

1960 (vessel). On January 23, *Jacques Picard* and Navy lieutenant *Don Walsh* descend to 35,820 feet (10,916 meters, 6.78 miles) in the August Picard-designed, Swiss-built, US Navy-owned bathyscaphe *Trieste*. This dive takes place in the Pacific Ocean's Mariana Trench, 250 miles southwest of Guam, one of the deepest parts of the world ocean. Water pressure at this depth is 16,883 psi, temperature 37.4°F. Picard observes what he later calls "a flatfish at the very nadir of the earth" but no specimens can be collected. Trieste leaves the surface at 8:22 a.m., reaches maximum depth at 1:10 p.m. and surfaces at 4:30 p.m. No one will ever go deeper (unless, of course, oceanographers discover a deeper spot than the Mariana trench).

1960s (scuba). As accident rates for scuba divers climb, the first national training agencies are formed to train and certify divers; NAUI is formed in 1960, PADI in 1966.

1962 (surface air; scuba). Beginning in 1962 several experiments are conducted whereby people live in underwater habitats, leaving the habitat for exploration (using scuba equipment) and returning for sleeping, eating and relaxing. The habitats are supplied by compressed air from the surface. The first such experiment, Conshelf (Continental Shelf) One, takes place in September 1962. Under the watchful eye of Jacques Cousteau and his team, *Albert Falco* and *Claude Wesley* spend seven days under 33 feet of water near Marseilles, in a habitat they name Diogenes.

Diogenes was an enormous Aqua-lung into which Falco and Wesley retreated for warmth and food, sleep and hygiene. It was like the air *bubble that a water spider takes down to sustain itself in its activities beneath the surface. For our men, the five daily hours outside were more important than the nineteen hours within.* (Cousteau 1963)

1963-1965 (surface air; scuba). In 1963, eight divers live in Conshelf Two under the Red Sea for a month. Other habitats of this period: Sealab I (1964); Sealab II (1965); and Conshelf Three (1965), in which former astronaut *Scott Carpenter* and other divers spend a month at 60 meters off the coast of southern France.

1967 (scuba). PADI, Professional Association of Diving Instructors, trains 3226 divers in its first year of operation.

1968 (scuba). On October 14 *John J. Gruener* and *R. Neal Watson* dive to 437 feet breathing compressed air, off coast of Grand Bahama Island. This record is not broken until 1990 (see Diving Odds N' Ends).

1970s (scuba). Important advances relating to scuba safety that began in the 1960s become widely implemented in the 1970s, including: adoption of certi-fication cards to indicate a minimum level of training and as a requirement for tank refills rental of scuba equipment; change from J-valve reserve systems to non-reserve K valves and adoption of submersible pressure gauges; adoption of the buoyancy compensator and single hose regulators as essential pieces of diving equipment (replacing the dual hose, non-BC equipment initially in widespread use).

1980 (scuba). Divers Alert Network is founded at Duke University as a non-profit organization to promote safe diving.

1981 (scuba). Record 2250 foot-dive is made in a Duke Medical Center chamber. *Stephen Porter*, *Len Whitlock* and *Erik Kramer* live in the eight-foot- diameter spherical chamber for 43 days, breathing a mixture of nitrogen, oxygen and helium. They beat their own previous record set in 1980.

1983 (scuba). The first commercially available dive computer, the Orca Edge, is introduced. In the next decade many manufacturers market dive computers, and they become common equipment among recreational divers.

1985 (vessel). U.S.-French team headed by Woods Hole researcher *Robert Ballard*, using a remote controlled camera attached to the mother ship, finds the wreck of the *Titanic*. The ship sits broken into two sections at 12,500 feet depth, some 400 miles northeast of

New York. On April 15, 1912, five days into its maiden voyage, *Titanic* hit an iceberg and sank in less than three hours. At the time she was the largest ship in the world. A total of 1522 passengers and crew died. Since 1985 both the U.S. and France have revisited the site, and the French have recovered artifacts from the ship.

1993 (scuba). The 50th anniversary of the invention of modern scuba diving is celebrated around the world. PADI, the largest of the national training agencies, certifies 515,000 new divers worldwide.

1990s (scuba). An estimated 500,000 new scuba divers are certified yearly in the U.S., new scuba magazines form, dive computers proliferate, new liveaboards ply the waters and scuba travel is transformed into a big business. In North America alone recreational diving becomes a multi-billion dollar industry. At the same time there is expansion of "technical diving" Ä diving by non-professionals who use advanced technology, including mixed gases, full face masks, underwater voice communication, propulsion systems, etc.

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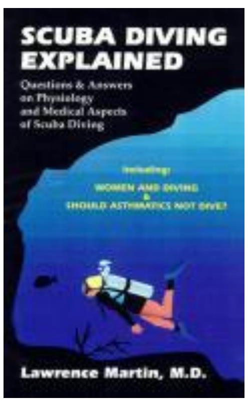


SCUBA DIVING EXPLAINED

Questions and Answers on
Physiology and Medical Aspects of Scuba Diving

Lawrence Martin, M.D. Copyright 1997

Short Scuba Quiz

For each of the following 15 multiple-choice questions choose the SINGLE BEST ANSWER. Answers are at the end of the quiz. If you answer 12 or more questions correctly, you already know quite a bit about scuba diving. After the multiple choice quiz is a "Trivia" quiz based on other information in the book.

1. The gas composition of ordinary air is:

a) 15% oxygen, 20% nitrogen, 5% other ☐

b) 20% oxygen, 75% nitrogen, 5% other ☐

c) 21% oxygen, 78% nitrogen, 1% other ☐

d) 24% oxygen, 79% nitrogen, 3% other ☐

e) 26% oxygen, 81% nitrogen, 3% other ☐

2. Compressed air in a scuba tank filled to capacity, compared to ordinary arie, has:

a) the same composition ☐

b) a greater percentage of oxygen ☐

c) a greater percentage of nitrogen ☐

d) a greater percentage of both oxygen and nitrogen ☐

e) varying composition of oxygen and nitrogen, depending on the tank pressure ☐

3. Compared to seal level ai pressure, aire pressure ina scuba tank with 3000 psi is approximately how many times higher?

a) 10 ☐

b) 50 ☐

c) 100 ☐

d) 200 ☐

e) 400 ☐

4. The total number of atmospheres of pressure on a scuba diver at 99 feet of sea water is:

a) 2 ☐

b) 3 ☐

c) 4 ☐

d) 5 ☐

e) 6 ☐

5. Nitrogen narcosis ("rapture of the deep") results from:

a) nitrogen forming bubbles in the nervous system ☐

b) lack of oxygen to the brain from excess nitrogen pressure ☐

c) a direct effect of high nitrogen pressure on the nervous system ☐

d) diving with an elevated blood alcohol level ☐

e) staying too long under water ☐

6. Which of the following problems is least related to diving deeper than allowed by standard dive tables?

a) nitrogen narcosis ☐

b) type I decompression sickeness (pain only, or "the bends") ☐

c) type II decompression sickness (major physical deficit, such as paralysis) ☐

d) air embolism ☐

e) running out of air ☐

7. The reason scuba divers should never hold breath under water has to do with effects explained by:

a) Boyle's law ☐

b) Daltons's law ☐

c) Henry's law ☐

d) lack of oxygen that occurs when you stop breathing ☐

e) the buildup of carbon dioxide when you stop breathing ☐

8. At a depth of 66 feet sea water, air breathed from a scuba tank as it enters the diver's lungs is how much denser than air breathed at seal level?

a) same density ☐

b) twice as dense ☐

c) three times as dense ☐

d) four times as dense ☐

e) depends on amount of air left in scuba tank at that point ☐

9. Wich one of the following factors is the same for aire embolism

and for decompression sickness?

- a) composition of the gas bubbles ☐
- b) principal location of gas bubbles in the body ☐
- c) cause of the bubbles ☐
- d) time of onset of symptoms in relation to the end of the dive ☐
- 3) method of treatment ☐

10. Aire embolism occurs on:

- a) descent only ☐
- b) ascent or descent, depending on where the diver holds his or her breath ☐
- c) ascent or descent, depending on where the diver runs out of air ☐
- d) ascent only, and only with breath holding ☐
- e) ascent only, and depends on factors such as breath holding and state of the diver's lungs ☐

11. "Shallow-water-blackout," as may be seen in breath-hold dives, is due to:

- a) elevated carbon dioxide from prolonged breath holding ☐
- b) lack of oxygen from prolonged breath holding ☐
- c) both elevated carbon dioxide and lack of oxygen ☐
- d) nitroten buildup from prolonged time under water ☐
- e) siezures brought on by the breath hold in susceptible people ☐

12. First aid treatment for a victim of decompression illness should always include 100% inhaled oxygen because:

- a) it stimulates the heart to pump harder ☐
- b) it hastens the elimination of nitrogen ☐
- c) it hastens the elimination of carbon dioxide ☐

d) it helps to keep victoms from hyperventilating ☐

3) the victim's blood is usually low in oxygen ☐

13. All of the following are forms of barotrauma except one:

a) pneumothorax ☐

b) mask squeese ☐

c) air embolism ☐

d) the bends ☐

e) ear squeeze ☐

14. Dive table s are based on the assumption that:

a) the diver will make no more than three dives a day ☐

b) all bottom time is spent at the deepest depth reached ☐

c) the survace interval will be at least one hour between dives ☐

d) any subsequent dive will be shallower than the one before ☐

e) there will be no multi-level diving ☐

15. The principal reson peoplewith asthma are advised not to dive is the risk of

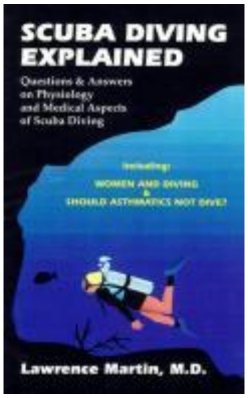
a) the bends ☐

b) running out of air due to over breathing ☐

c) arterial gas embolism ☐

d) an asthma attache from breathing dry compressed air ☐

e) aspirating sea water from caughing at depth ☐



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ANSWERS:

1. c

2. a

3. d

4. c

5. c

6. d

7. a

8. c

9. e

10. e

11. b

12. b

13. d

14. b

15. c

An Introduction to PDIC

Professional Diving Instructors Corporation

During the first thirty years of sport diving there was a free-for-all competition among businesses who authorized instructors to teach. Image-advertising, bad-mouthing and cross-certification were some of the forms of this competition. Instructors were required to create their own courses. There was no accepted way of teaching diving and no agreement about what was needed to produce a diver who would be ready to dive without supervision.

P.D.I.C. started as a school for training instructors to teach the use of scuba. A Copy-right for the course was granted to the Professional Diving Instructor College. Other certifying agencies used portions or all of the course but the copy-right was successfully defended in court. In the 70's the decision was made that P.D.I.C. would enter into the certification business in the world market.

In moving their headquarters from California to Pennsylvania the name was changed to the Professional Diving Instructors Corporation. P.D.I.C. is not the biggest, or the best known agency but instructors in 11 countries teach to exactly the same high standards. Every course is complete. P.D.I.C. Instructors have produced well educated divers. Many other agencies have left many things optional to the instructor (like skin diving skills), allowing for much variance from instructor to instructor in the completeness and quality of scuba courses they teach.

At a P.D.I.C. International Training Facility you are guaranteed a consistently complete and quality course. You will be a safe, comfortable and confident diver when you finish a P.D.I.C. course. You'll have fun doing it too.

PDIC joined with NASDS, NAUI, PADI, SSI, YMCA, IDEA and MDEA to form the Recreational Scuba Training Council. Beginning in mid-1985, more than 700 man-hours were expended in formal meetings and review sessions by a committee representing the agencies. As a result of these meetings a set of standards were officially announced and adopted by all agencies as of January 16, 1986, and were to be implemented by September 1, 1986. This represents an updating of existing standards and is considered the state of the art. It is intended and expected that the use of these standards as the accepted minimum in instructing entry-level divers will further improve both instructional effectiveness and diving's overall safety record. PDIC meets and goes past these standards. PDIC is not only taught widely in the United States and 11 other countries but it is also affiliated with the World Underwater Federation.

Once Certified you should further your diving experience. We teach courses in Advanced Open Water, Dive Supervisor, Rescue, Search and Recovery, Equipment Repair, Deep Diving, Ice Diving, Underwater Hunting, Assistant Instructor, and Instructor. We are interested in working with people who would like to be part of our professional staff. Let us know what further diving experiences and or courses you would like to participate in. Thanks for diving with us. You are going to love it.

TRAINING&SAFETY

Secrets of Better Buoyancy

by Greg Barlow

Professor Scuba demystifies the science behind sinking and floating.

Buoyancy is a concept all divers are familiar with. After all, we strive for neutral buoyancy at depth, positive buoyancy at the surface and negative buoyancy when it's time to start the dive. With all the attention divers pay to controlling buoyancy, you might think the scientific principles behind it would be as clear to us as a Florida spring. Unfortunately, for many divers, buoyancy basics are as murky as the Mississippi.

A Rather Dense Explanation

So what causes an object to be neutrally buoyant, negatively buoyant or positively buoyant? The Greek mathematician Archimedes pondered buoyancy for quite some time before formulating what is known today as Archimedes' Principle: An object immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced. This statement sums up the nature of buoyancy in a concise fashion, but it needs some explanation.

A key factor in buoyancy is the property of density--how heavy an object is for its size. A block of lead has greater density than an identically sized block of wood because the lead particles are packed together more tightly than the wood particles. Another way to conceptualize density is to consider a wadded up piece of paper. If the paper wad is loosely compacted, it takes up more space than if it were crushed into a smaller size, but the paper still contains the same number of particles and the weight remains stable.

To Float or Not To Float

Now, the buoyancy part. The density of an object is expressed by its specific gravity. Pure water has an assigned specific gravity of 1.0 to serve as a handy measuring unit. If an object's specific gravity is greater than 1.0, then the object will be negatively buoyant and will sink. The greater the density, the more an object will sink. An object with a density of 5.0 will be very negatively buoyant, but a substance with a density of 1.1 will just barely drop below the surface.

Conversely, if an object's specific gravity is less than 1.0, it will float. The lower the density, the higher the object will rise above the liquid's surface. Think of two pieces of wood floating in water--a light wood like pine floats higher up than a comparatively denser piece of oak.

Not All Water Is Equal

Specific gravity is based on a comparison to pure water. For the most part, seawater has an average specific gravity of 1.03; that's why fresh water floats on top of salt water.

Looked at another way, salt water weighs more than fresh water. A cubic foot of seawater weighs about 64 pounds, while a cubic foot of fresh water weighs approximately 62.4 pounds.

If a given object weighs 70 pounds for each cubic foot, then it will be negatively buoyant in both fresh and salt water, but slightly less so in salt water. However, if an object weighs less than 60 pounds per cubic foot, it will float in both fresh and salt water, but the object in salt water will be buoyed up with a slightly greater force due to the greater weight of salt water. The difference explains why you must add a small amount of additional weight when switching to the ocean from a freshwater lake (see "Fresh-to-Salt Weight Conversion").

Submarines vs. Your BC

So there you have it: An object floats or sinks because of how heavy it is for its volume in comparison to the same volume of the water it's in. With this bit of information then, it becomes clearer as to how we can control buoyancy.

Take your BC, for example. As air is removed from the bladder, the surrounding water pressure forces the material into a smaller, more compact shape. The bladder still weighs the same, but it takes up less space--its density has increased. When the bladder is filled with air, the external dimensions increase, which gives it an overall weight that is less for its size than the surrounding water.

Now imagine a submarine. Instead of a collapsing bladder, the sub's ballast tanks are rigid. The submarine controls its buoyancy by adding or removing water from solid tanks. If the tanks are filled, the sub weighs more than the surrounding water and it sinks. When compressed air is used to purge the ballast tanks, the sub has a lower weight than the same volume of water, and it rises.

Buoyancy Brain Busters

So, is the concept of buoyancy still floating around in your head? Try this little activity to test your understanding. A watertight metal box has a total volume of 2 cubic feet. It also has a given weight of 140 pounds. If this box were placed in seawater, would it be positively, negatively or neutrally buoyant?

Well, if the box has a volume of 2 cubic feet, then an identical amount of seawater would weigh a total of 128 pounds (64 pounds per cubic foot multiplied by 2). Since the given weight of the box is 140 pounds, it is 12 pounds heavier than the surrounding water and will sink.

Fresh-to-Salt Weight Conversion

Remember that an object in salt water is buoyed up with a greater force due to salt water's greater weight. To convert your weight requirements from fresh water to salt water, determine the total weight of your body and equipment. Multiply that figure by .025 and round the answer up to the nearest whole number. This is the additional weight you'll need to add to dive in salt water. Of course, converting from salt water to fresh water would be a matter of removing the same amount of weight.

Navigation

Navigation principles

One of the most important and valuable abilities of the diver should be the ability to navigate. is the process of knowing where you are and going where you want. The word 'navigation' originates from the Latin word 'navigare', which means 'sailing a ship'. Using navigation the diver finds it way under water and, more important, finds his way back. Being able to navigate has following advantages:

- Knowing where you are and where to go reduces anxiety and stress. Disorientation leads to stress since you do not know whether you are moving to or from your destination.
- It avoids swimming long distances at the surface. Usually, being lost means you have to go to the surface to look where you are or when you run out of air. Swimming at the surface might be undesirable in case of strong currents or in sailing-routes.
- Navigation helps planning your dive. It saves time and air reaching your goals efficiently underwater.

This section describes a number of generic navigation techniques. Next sections apply this to diving. There are a lot of good sites on navigation. Refer to the links for a few of them. Essential ingredients of navigation are

At some point you have to know your position. From this position you travel to other positions.

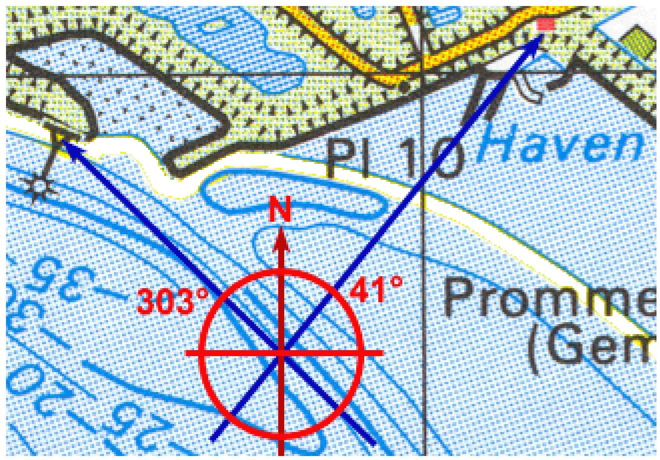
. In some way you have to know the distance you travel.

When you travel, it is in a certain direction or course. You have to know this course.

During traveling you can establish your exact position by referencing. This means you reference your observations with e.g. a map.

Measuring position

Measuring position is not common during diving. For the completeness of this section it is explained though. Using a map and a compass you can pinpoint your position by measuring the angle towards two visible landmarks that can be identified on the map (e.g. church towers). By drawing the lines on the map with the measured angles through the landmarks, the crossing of the lines indicates your position.



In the example to the right the heading is measured towards a buoy (303°) and towards a house on the shore (41°). The lines with the measured angles are plotted on a map. The crossing of the lines indicates the position where the measurement was performed.

Measuring distance

For a diver there are several ways to estimate the distance covered.

In one kick cycle each leg has performed a full stroke cycle. It is necessary to swim in the same tempo.

The time elapsed can be used as a measure for distance. It is necessary to swim the same tempo. If the diver stops for a while, you have to correct the measurement for this. Use a watch for this. Many dive computers stop counting dive time at shallow levels.

The amount of air used is an alternative for measuring dive time, and hence distance if the diver swims at the same tempo continuously. This can only be performed when the diver remains at the same depth, since air usage is depth related. If the diver stops for a while, you have to correct the measurement for this.

Short distances can be measured fairly accurate by using arm span lengths. Swimming close to the bottom, you 'walk' with your hands over the bottom. Reach forward with one arm, put the hand on the bottom and move forward. When the hand is under your upper leg, reach forward with the other arm. One arm span length is measured by a full cycle of each arm. Roughly, one arm length equals the length of the divers body.

The most accurate method is using marked lines or tapes. It is applicable on relatively flat areas and for short to medium distances.

With the exception of the line/tape method, the methods measure distance relatively. This means distances measured in such way can be compared to other distances measured in the same way. It is possible to convert the measurement to absolute distances (measured in meter, miles, etc). For that, the diver has to calibrate himself. For the use of kick cycles following steps are needed:

1. Swim a section of which the distance is known (e.g. in meter) and count the number of kick cycles.
2. Calculate the average-distance-per-kick-cycle the by dividing the distance by the counted number of kick cycles.
3. When an unknown section is covered counting the number of kick cycles, the diver can calculate the distance by multiplying the number of kick cycles by the average-distance-per-kick-cycle.

Following factors may influence the accuracy of the kick cycle, time and pressure measurement methods:

- Current reduces or enhances the speed of the diver. This influences the distance per kick cycle, time unit or pressure drop unit.
- From own experience: the diver swims slightly faster at the end of the dive (i.e. returning to the entrance).
- From own experience: In cold water the diver gradually gets colder during the dive. When the diver gets cold he uses more air.
- Depth heavily influences the amount of air the diver uses.

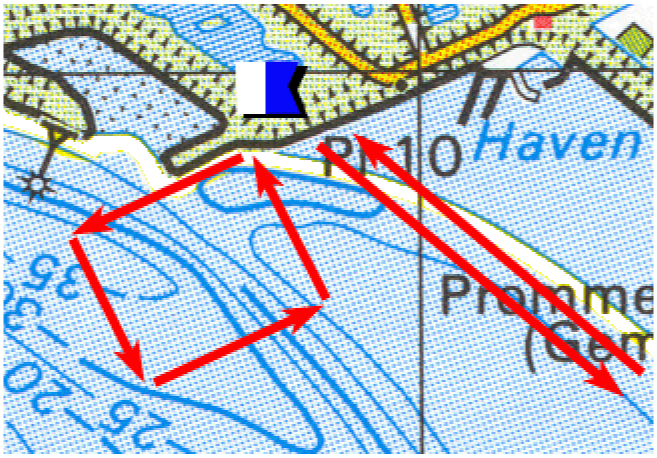
Measuring course

Measuring course is usually performed using a compass. Another chapter is dedicated to Compass Navigation.

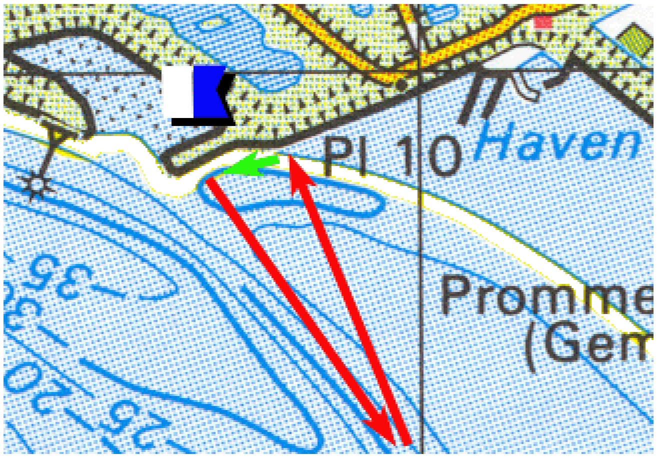
Referencing

Dead Reckoning and swimming patterns

Dead Reckoning is the process of starting at a known position and travel to another position only by measuring distance and course. No other observations are used to establish your position. Traveling at sea typically is done by dead reckoning, since no landmarks (seamarks?) are present.



Dead Reckoning is the method that is often used during diving. Usually the diver swims a pattern, measuring distance and heading of each section. The goal is to return to the starting point again eventually. In the example to the right two famous patterns are shown. The to-and-fro pattern is a fairly simple pattern: just head back in the opposite direction. Swimming the square pattern means the diver changes direction 90° each time after swimming a certain distance. More advanced patterns are possible, but they require some more preparation and calculation.



When you end up at the coast it is often wise to add some extra error to the position where you intend to end up. In this case you are sure to end up left or right to your target. In that case you know in what direction to proceed along the coast. If you would not add error you do not know whether you end up left or right from your target. Hence you do not know which direction will bring you to your target.

In the example on the right, the diver makes sure he ends up to the right of the target. In this case it is important, because if he ended up to far to the left, he would miss the way out entirely. The error is indicated in green.

Natural Navigation is navigation purely based on observations of the environment. No instruments are used.

Observations before the dive

Observation of the dive site before the dive provides a lot of information that is usable for navigation.

- These directions are usually constant during the dive. These directions can be used for referencing direction.
- This direction can be used as reference for direction. It is most usable at the start and end of the day (sun is low) because the direction of the light is most distinguishable.
- Reefs, buoys, piers, sandbanks are references for position. Waves breaking outside the coast indicate presence of shallow sandbanks or reefs.
- Local divemasters can tell a lot. Maps, documentation, depth profiles are other sources provide information as well. The ships sonar can provide bottom contours.

Observations during the dive

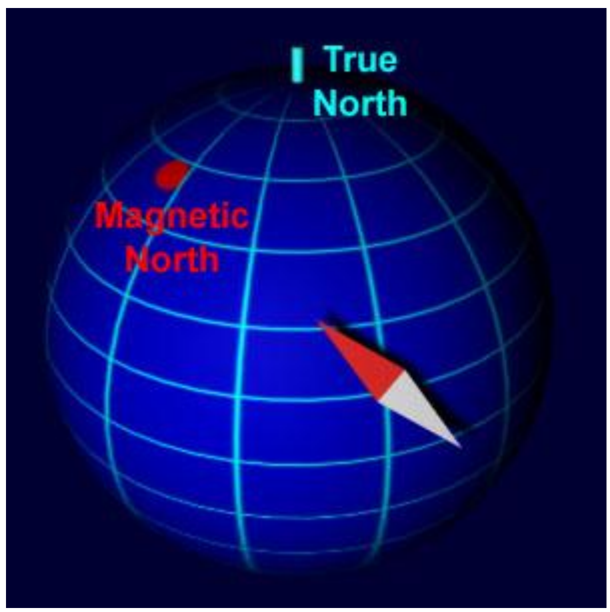
Following natural references can be used for navigation during the dive:

- The direction of the sunlight can be a reference for direction. Sunlight casts shadows. These can be used as well.
- Current can be used as reference for direction. Note that the direction of currents can change. Waves produce swell (movement to and fro) under water. This movement can best be sensed in shallow water. Waves move towards the coast. The to and fro movement is roughly perpendicular to the coast. Moving along this direction to shallower water will generally bring you to the coast. Knowledge about the dive site is required.

- The bottom usually follows a distinctive profile. This profile can be used as reference for direction (and location). You can often swim parallel at the coast by swimming at fixed depth along a slope.
- Bottom composition changes (e.g. coral to sand, sand to vegetation) can be used as references for location. Ribs in the sand near the coast are usually parallel to the coast. These can be used as directional references.
- Sound produced by your boat, buoy or anchor chains may be references for position.
- Landmarks like rocks, wrecks, etc at the bottom can be great references for position. If their depth is known you can even look for them in murky water by following this depth till the landmark is reached.

Compass Navigation

A compass basically is a magnetic needle that can rotate freely. The earth has a magnetic field. The magnetic north and south pole roughly correspond to the earth geographic North and South Pole. Since equal magnet poles repel and opposite magnet poles attract each other, our magnetic needle will align itself with the earth magnetic field: the south pole of the needle will point to the earth's north pole, the north pole of the needle will point to the earth's south pole.



Direction is measured with respect to the North Pole. This is called the *Geographic North* or *True North*. Direction with respect to the True North is called the *True Direction*. Compasses do not exactly point to the True North. A Compass Reading exhibits *Compass Error*. Compass Error is due to following facts:

- *Magnetic Variation* or *Declination*. The earth magnetic north pole is located near the northern islands of Canada, at approximately 78.9°N latitude and 103.8°W, about 1200 km from the geographic North Pole. A compass points to the magnetic north pole and not to the geographic North Pole. The difference between the True Direction and the compass heading is called Magnetic Variation. The amount of variation depends on the location on earth. It even changes in time, since the magnetic north pole moves a few km per year. Variation is expressed as e.g. 2°25' West. This means at this position the compass needle points 2°25' to the west with respect to true direction of the True North. Variations can be as large as 20°
- Ferrous (iron, steel) objects, magnets, flowing electrical current (magnetic field!) influence the reading of the compass. This results in an error in the compass readout. This error depends on the compass heading. Most ships compasses can be adjusted to eliminate entirely or partly the compass deviation. Deviation left is documented on a *deviation card*. For various compass directions the deviation is documented (usually in a deviation vs. heading plot).

Compasses exist for the Northern Hemisphere and Southern Hemisphere. At the Northern Hemisphere the south pole of the compass needle (points to the North) is pulled towards the earth (magnetic north pole) whereas the north pole of the compass needle is pushed upward. At the Southern Hemisphere this is opposite. Good compasses are compensated for this.

In comparison to ship compasses, diving compasses are fairly inaccurate. As a diver we do not worry about compass error. Since a diver only travel small distances the compass error will result in only small absolute deviations in the divers location. Furthermore, a diver usually uses his compass for relative direction (in contrast to using a compass together with a map for absolute directions).

Diving compasses

On a diving compass following parts are discerned:

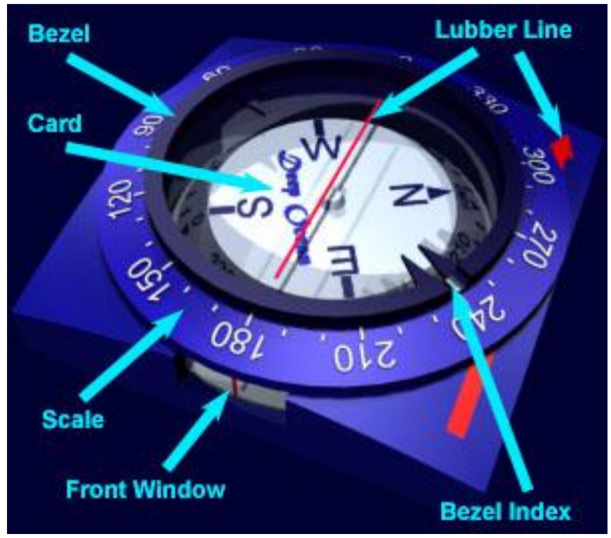
- *Housing*, usually filled with fluid. Two types are usual: a type worn on the wrist and one integrated in the divers console.
- *Magnetic needle or card*, always pointing to North. Though it is common practice to state that the needle or blade rotates in the housing, it is better to think of the needle or blade being steady, always pointing North. The housing rotates around the needle. The card contains an arrow indicating North. Thereby it often contains markings for East, West and South and/or a degree scale.
- *Degree scale* with degree markings on it. It is on the housing or on the rotating bezel, depending on the type of compass.
- *Rotating bezel* containing markers: usually two notches at one side and one notch at the opposite side.
- *Lubber line* indicating the direction of movement. On a diving compass it is usually printed on the window straight over the card. On some compasses it might be an arrow printed besides the window.

Most compasses are filled with fluid. This serves to purposes. First, it dampens the motion of the needle or card. Secondly, it makes the compass withstand the pressure at depth.

Sometimes there is a small window at the front side of the compass. Using an index on this window, the diver can directly read the course from degree markings on the card. For this, the degree markings on the blade have to be inverted: 0 degrees is at the South indicator, whereas 180 degrees is at the North indicator.

Diving compasses come in two flavors:

- *Direct reading compass*. On this type of compass the degree markings increase counter clockwise and fixed on the compass housing. The magnetic needle or card always indicates the direction to which the lubber line points. The rotating bezel only contains an index that points to the degree markings on the housing.
- *Indirect reading compass*. On this type of compass the degree markings increase clockwise and on the rotating bezel. If the rotating bezel is rotated such that the needle corresponds to the zero degree marking, the upper side of the bezel (often indicated by the lubber line) indicates the direction of the lubber line.



Indirect Reading Compass   Direct Reading Compass

Note: there is a bit of confusion in articles on the Internet between 'direct reading' and 'indirect reading'. These terms are not used consistently. I think the definition above is the right one: on a direct reading compass the course can always be read, independent of the position of the bezel: it is indicated on the scale by the North indicator of the needle or card.

Using a diving compass

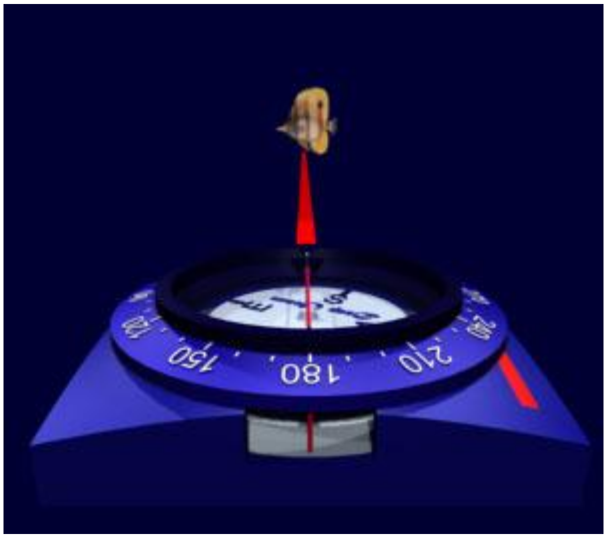
When using an underwater compass following points are important:

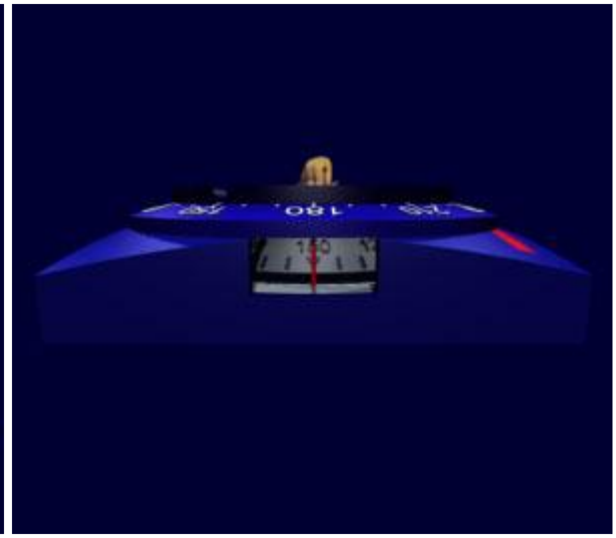
- Make sure to keep ferrous (iron, steel) objects away from the compass. The needle is attracted to ferrous material and the readout is influenced.
- Line up your body with the lubber line. For wrist worn compasses this is accomplished by placing the hand of the arm on which you are wearing the compass on the elbow of the other arm, which is held straight in front of you. Hold the compass at eye level so you are sighting over it instead of down on it. If the compass is in a console, hold it in front of you and line your body up with the lubber line.

Reading out a direction

Often a diver decides which course to swim when he or she is standing at the waterline at the dive site. In many cases the environment defines the course. The diver picks a natural target to swim to, e.g. he wants to swim parallel to the coast. Using a compass the diver measures the course to the target. Under water he swims the to the target.

Direct reading

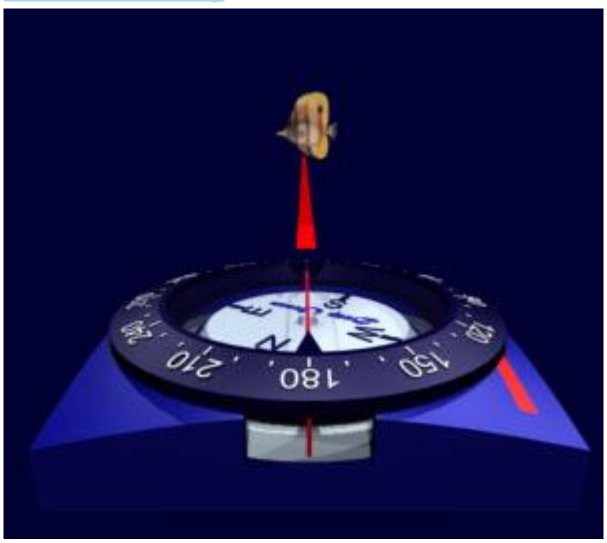


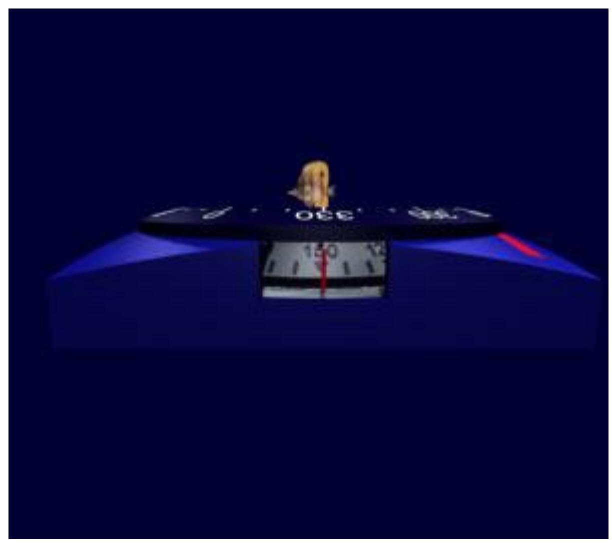


Point the compass to the target. This is done by imaginary extending the lubber line to the target.

On the compass the course can be read by looking through the front window of the compass and using the scale on the card. In this case 150° is read.

Indirect reading





Point the compass to the target. This is done by imaginary extending the lubber line to the target.

On the compass the course can be read by looking through the front window of the compass and using the scale on the card. In this case 150° is read.

On a indirect reading compass the bezel (dark blue) has to be rotated so that the index (double notches) line up with the North indication on the card (or needle). The upper end of the lubber line indicates the course (150°) on the bezel degree scale

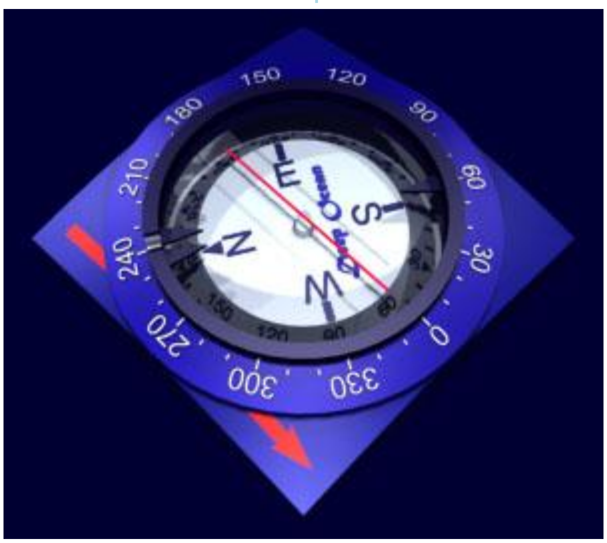
Swimming a course

This section describes the procedure to swim a predefined course. Distinction is made between a direct reading compass and an indirect reading compass. In the examples below, the diver intends to swim a course of 240°.

Direct reading

Direct reading compass: starting position. The magnetic card points to the North, the bezel is in the default position.

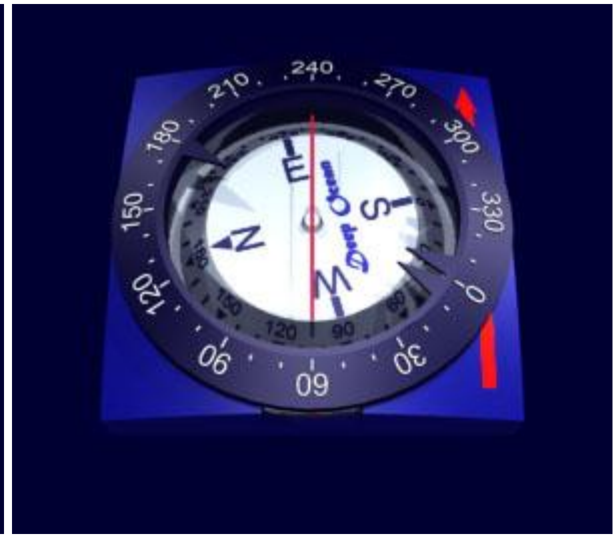
Rotate the bezel such that the double markers points to 240 degrees.



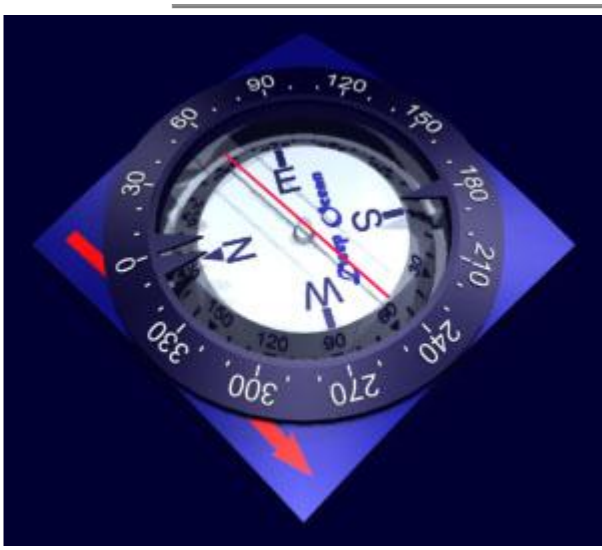
Now rotate the entire compass such that the North Arrow on the magnetic card points between the double markers. The lubber line now points in the 240 degrees direction.

Indirect reading

Indirect reading compass: starting position. The magnetic card points to the North, the bezel is in the default position.



Rotate bezel until the 240 degrees mark on it corresponds to the lubber line.



Now rotate the entire compass such that the North Arrow on the magnetic card points between the double markers. The lubber line now points in the 240 degrees direction

TRAINING&SAFETY

Simple Tricks of Underwater Navigation

Photography by Mark Lawrence

Birds do it, bees do it, even salmon in the sea do it. Here's how to find your way home without bread crumbs or a search-and-rescue helicopter.

- By John Francis

From Topside | Hit Bottom | Into the Wild Blue Yonder | Look Back | Find a Landmark | Reality Check | Back to the Boat

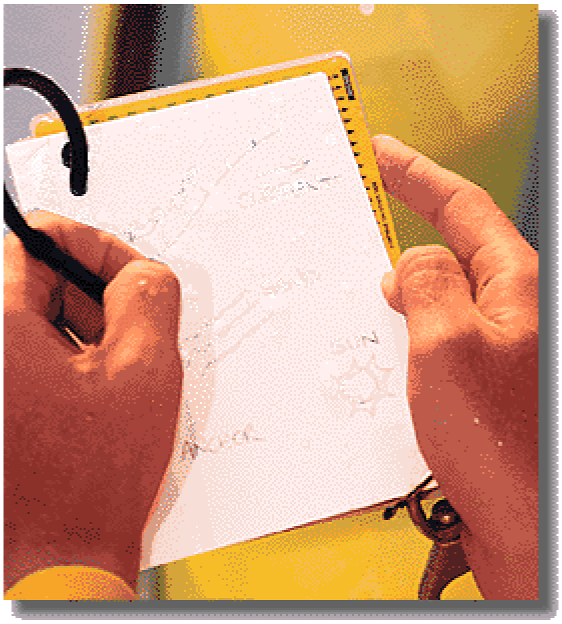
What About Electronics? | **How Far is It?** | **Getting Your Bearings** | **How to Use A Compass**

The navigational sense that enabled ancient Polynesians to find a flyspeck island in the open Pacific is innate in all of us and can be developed at least enough to find one's way around a dive site. The keys are observation and mental imaging. You need to see more of what you're looking at, listen to more of what you hear and take better notice of what touches you. Then use these clues to create a mental map that you will constantly update and keep in the front of your mind.

The process starts before you get wet--on the beach or, let's say, the deck of the dive boat.

From Topside

Look around you and visualize the dive site as if you're Moses doing his sea-parting act. What's the general shape? A bowl? A flat floor with a crescent-shaped reef projecting? There are visible clues. Landforms at the shoreline usually continue their shape and direction under water. A steep cliff above the surface implies a steep wall below. A canyon leading down to the shore probably continues under water, though it may be partially filled with sand. An offshore rock that's steep on one side and gently sloping on the other probably has the same shape below the surface. Water color indicates deep or shallow, sand or grass. Kelp beds will be visible from above. Take time with this, so the image has a chance to fix itself on your memory. Sketching the site on your slate will help you remember it, even if you never refer to the sketch.



Now look for directional clues that will be visible from under water. Where is the sun, and where will it be in another hour or so? Fairly small wave fronts will be visible from below. Which way do they go? They'll generally follow the direction of the wind, but they'll bend around islands and points of land. The current will be easy to feel under water; which way is it running?

Current is tricky. It sometimes, but not reliably, runs with the wind and waves. It can change with depth and tide, and it can be hard to spot from the surface. To identify it at the surface, look for ripples around stationary objects like the anchor chain or a buoy, or notice which way kelp lies.

Superimpose these directional clues on your mental image of the dive site. Draw arrows on your slate for sun, wave direction and surface current.

Take compass bearings to what may be prominent underwater landmarks--the steep side of that offshore rock, for example--and add them to your slate. Reciprocal courses are return routes. Add these, and an arrow for magnetic north, to the sketch on your slate.

Keep in mind, though, that the purpose of drawing the sketch is, as much as anything, to fix the image in your mind. Your goal is to navigate without relying on it.

Next, plan your dive. Decide on a logical route through the dive site and back to the boat, then superimpose it on your mental image of the area. You'll be less likely to get lost than if you just jump in and start following your nose.

(Top)

Hit Bottom

To help you retain your mental image of the dive site, descend head-up, while facing in a constant direction. A head-first descent tends to cause some vertigo and can scramble your mental gyrocompass.

When you reach the bottom, check your compass to verify that you are still facing in the same direction as when you formed your mental image of the dive site. Now look up: Where

is the sun? What do the wave patterns on the surface look like? Look down: In which direction do the sand ripples go? What's the depth? In which direction does the bottom contour trend? Look around: Can you see a reef, a coral head, a clump of kelp? Feel the current: Is it going the same direction as you expected? Integrate all this with the mental image you've already formed of the dive site.

(Top)

Into the Wild Blue Yonder

Usually, you'll have an open-water swim from the boat to the reef, wreck, kelp forest or whatever your first destination is. It may be a short swim, but it may be long enough that you can't see from the reef, say, back to the boat. To help you find the boat again, measure the distance by counting fin kicks (or for another method, see "How Far Is It?"). Even if you return to the boat by a different route, this will calibrate your mental image of the dive site so you can estimate distances.

(Top)

Look Back

Before the boat and its anchor chain have disappeared behind you, stop, turn around and see what the scene will look like when you try to find the boat again. Use visual clues like the position of the sun and the contour of the bottom to give the scene detail. Even a bottom that appears featureless at first will have small but distinctive rocks, plants, holes, shells, a beer can, etc. Record the snapshot in your memory. Do this several times if it's a long swim to the reef. But before you resume your forward direction, be careful that you've returned to the correct heading.

(Top)

Find a Landmark

When you reach the edge of the reef, wreck or whatever, find a landmark to identify the spot as your take-off point for returning to the boat. The landmark need not be large, as long as you can find it again easily. Something that doesn't belong, like a bit of trash, often makes a good landmark. At many dive sites it may be acceptable to stack a few small rocks, hiker-fashion, as a marker. Once again, look back in the direction of the boat and memorize the scene.

(Top)

Reality Check

As you explore the dive site, occasionally position yourself on your mental site plan. Use visual cues to estimate your direction, and verify it with your compass. What's the depth, compared to the depth under the dive boat? Look back occasionally to record the scene for the return trip. These frequent updates keep your mental image of the site fresh, detailed and accurate.

(Top)

Back to the Boat

Whether you retrace your steps or return by another route, you will probably make another open-water swim requiring careful navigation--and this time the target, the anchor line, will be a small one. Take time to verify your take-off position and your course as well as you can. Look at visual clues--sun position, wave patterns, sand ripples, current, etc.--and if they don't jibe with your mental map, satisfy yourself as to why before you take off. Verify this information with your compass.

If you're retracing your route, recall the mental snapshot you took at the end of the outbound leg. Then knock over your pile of rocks, and pick up that beer can that served as a marker.

Once you're as sure as you can be of the direction to the boat, stick to it. A mid-course "correction" is more likely to get you lost. If there's perceptible current, allow for it by angling slightly into it. If the boat doesn't appear after the expected number of fin kicks (or whatever) plus 10 percent, find bottom at the same depth as the anchor and follow the contour. Search up-current first. If you don't find the boat soon, it's probably best to surface and look for it. If it's very far, take a bearing to a point ahead of the boat (that's where the anchor is), then descend and swim to it under water.

Underwater Navigation and Search

When planning a day's diving, especially if the site is unknown, it is beneficial that you :-

- Dive with someone who is familiar with the chosen site
- Check with any available dive guides (either guide books or magazine articles)

- Check branch websites
- Consult an Admiralty Chart

An Admiralty Chart is basically a map of the sea, what you as a diver is looking for are the depths in the area of your planned dive, what the bottom may be, if there is anything charted that may be of interest, i.e wrecks.
Charts are covered more thoroughly in the Basic Seamanship lecture

On arrival to the site, each group that is diving should carry out a compass check to find out where the land is in relation to the sea, just in case you surface and a thick fog has descended after you started your dive.

Compass
A compass can be either console mounted or strapped to your wrist, inside the compass is a round flattish disc with a series of numbers and markings for north, east, south and west. The north bearing always points to magnetic north, This disc sits on a pin and is immersed in a very fine oil, this will allow the compass to rotate as the diver turns.

There are two types of compass, a fixed bezel type and a rotating bezel, the only difference being the numbers on one go the opposite way from the numbers on the other. Some compasses, normally rotating bezel models have a viewing window, which gives the bearing you are heading on.

There are a number of things to remember when using a compass

- Must be kept flat, or the compass will stick,
- Can be deviated by metal and rocks with a high iron content
- Can be deviated by electrical equipment
- Should be held with both hands if possible, which will even up any drag
- Allow for current

Part of the open water training for Master Diver involves a compass course with at least four changes in direction, accurate compass reading is a skill that is developed by practice.

Once underwater we can use a variety of other objects to allow us to navigate around the site

Contours of the seabed
Its fairly obvious that if you are diving on a slope and you go down the slope, you are getting further away from the shore. The only time this would be different is if there was an island close to shore.

Sand ripples,
If the seabed is sand or mud, the ripples in the sand generally run parallel to the shore.

The amount of light,
As the diver descends the less light will penetrate the water. The first thing that may be noticed is the loss of some colours, starting with red. If it gets darker, then you have gone deeper or underneath something.

The position of the sun,
Take note of the suns position when you start the dive, if it is on your left side as you start your dive it should be on your right at the end of the dive. However this doesn’t work well on cloudy days or at night, but there is always the moon

Visual Objects,
The deeper you go, the less kelp there is, or you may pass a certain shaped rock or sand patch, these markers can be used to navigate your way back to the exit point.

Depth,
The obvious marker is your depth gauge, but also remember that loss of buoyancy means you have gone deeper, or that having to clear your ears is another indication that you have increased your depth.

Current,
A gentle current can aid in navigation in as mush as if the current is coming from you left side at the start, it should be on the right side at the end, unless of course it has reached slack water in which there may be no current.

Very seldom will you find that the current will change direction in the space of one dive.

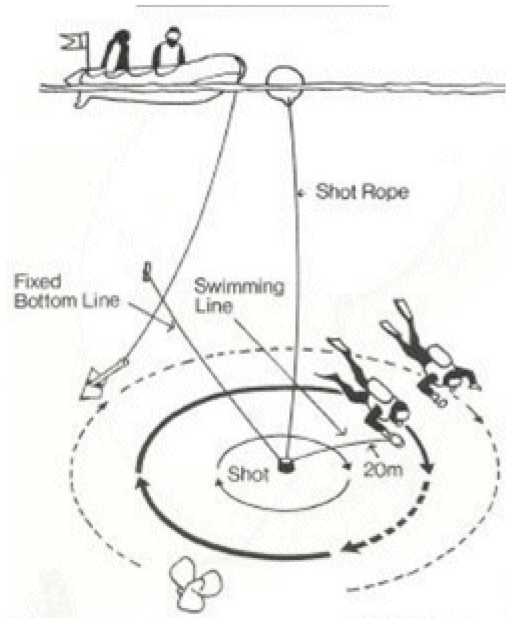
Underwater Searches
Divers are often asked my members of the public, local fisherman or by the police to help in the search in missing items, worse still you may have to search for an overdue diver. Therefore the diver should be able to carry out a good effective search of any given area.

If a member of the public approaches you asks if you could look for a missing item of jewellery, say a wedding ring, you should try and find out roughly where the item went missing, a wedding ring missing in the Firth of Forth is not much good to searching divers, so if possible try and get the search area identified and narrowed down as much as possible.

The type of search you will do depends on the size of the object you are looking for, is it a wedding ring or a battleship (a bit careless to lose one of these), a lot will also depend on the type of seabed is within the search area. The types of underwater searches are as follows

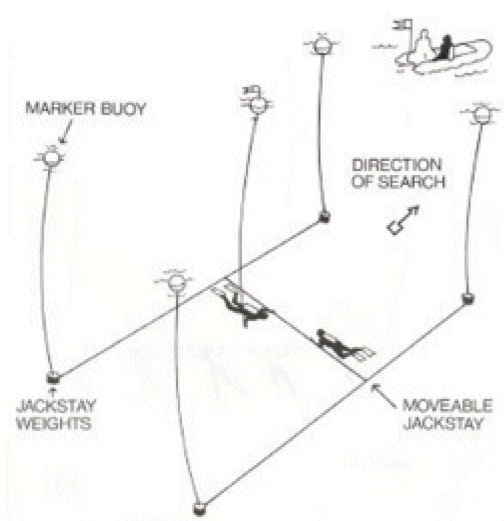
- Sweep search
- Jackstay search
- Snag Line search

Sweep Search
Probably the most common type of search used, as it is quick and easy to set up. A shotline is dropped close to the area the missing item is reported to be in, the divers go down and attach a line to the shot. Depending on visibility the diver moves out about two thirds of the visible distance. The diver then leaves a marker and keeping the line taught swims around the shot until they reach their marker. They then move out again and carry out the same procedure until the item is located, see diagram below.



This type of search is ideal for flat areas, though it can also be carried out in rocky areas as well. The only disadvantage with this type of search is if the bottom is of fine silt, then the visibility will be reduced very quickly. This type of search is not recommended for a steeply sloping seabed. It is also advisable that one of the divers uses a surface marker buoy, so that the boat or shore cover know their position

Jackstay Search
This type of search takes time to set up as a number of shotlines may need to be placed. In the example below four shots have been fitted with Jackstays between each pair of shots, The diver's carry a portable Jackstay which they attach to the fixed lines. With a diver swimming on each side of the Jackstay they can look for small areas over rough terrain. Once they have completed the first pass, they move the Jackstay along and repeat the procedure.



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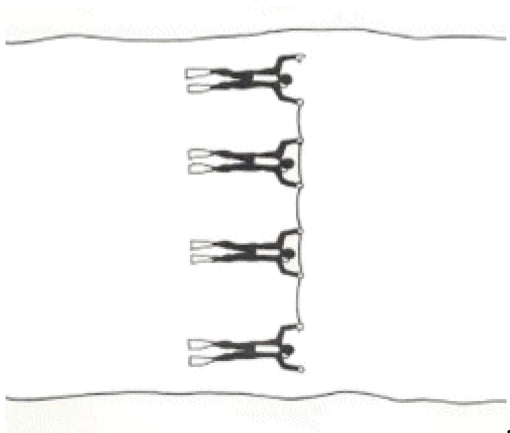
Snag line Search / Swim line search
This type of search has a couple of options, the first and most thorough search involves laying down a grid similar to the jackstay search (above) and each diver swims along the fixed jackstay

with a buddy line between them.
As they progress along the line, the buddy line should snag the object being searched for.

The other type of search can be very easy. The divers can opt to swim on a specific compass bearing or remain at a given depth and follow the contours of the seabed. Both divers will have a buddy line between them (see below)
This type of search is ideal for searching large flat areas for a large object.

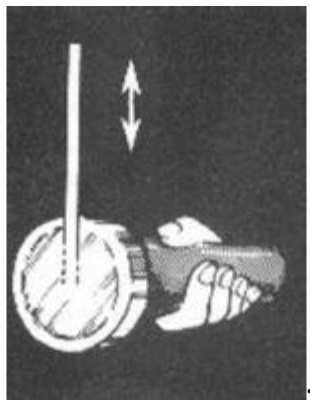
Whichever search method used it is important to remember that each search should overlap the previous search.
Both divers may be beyond the distance of visibility so a system of signals has to be used for the divers to communicate.
Either torch signals or rope signals can do this.



Torch Signals
Torches are generally used to see the marine like that hide in the crevices and gullies at the dive site, however the torch can also be a usefull tool for signalling to your buddy should you become seperated.

The diagram above is one method of giving the OK signal at night or in low visibility, however the diver should be close to their buddy when giving this signal.

If the divers are apart while carrying out a search, the method used to signal would be the same as the above signal for the OK sign.



If however a problem had developed then quickly moving the torch either up or down or from side to side is the distress signal
The two divers and the shore or boat cover should agree the signals before the search commences.

Rope Signals.
There are times when rope signals may be used though in reality Sports Divers generally only use a rope if the visibility is bad.
If commercial divers were diving on their own then they a legally obliged to be roped up in case of incident. The other user would be positioned close to the water edge so that if a problem developed or the shore party received no response from the diver then they could bring the diver back to the surface easily. It should be noted that in the commercial field there is also a stand-by diver wearing full kit ready to go in at all times the diver is submerged.

Signal	Diver	Surface
1 Pull	I am OK	Are You OK
2 Pulls	I have stopped	Stop

3 Pulls	I am going deeper	Go deeper
4 Pulls	I am Surfacing	Surface
Continual pulls	Emergency Pull me up	Emergency Pulling you to the surface

Getting it up - and keeping it up! Lift Bags.

by Rick Poole

At some point in their careers almost all commercial divers' have employed lift bags in salvage or lifting operations. Some have undergone formal training in their use under the experienced eye of an instructor. Others have been left to fend for themselves,usually
with varying degrees of success.

This article is an overview intended to clarify some

key points for those with little or no experience in the use of lift bags; one that may also, perhaps, remind those who are experienced in their use of some of the problems that can arise (lift-bag pun!).
There are several companies around the world who specialise in the manufacture of lift bags. Although sizes normally range between bags with a 50 kilo to 10,000 kilo lifting capability, larger and smaller bags can always be made to order for special applications.

The two most common types of lift bag in use today are the Parachute and the Enclosed. Although each of these types feature models of various shape and design, all lift bags essentially fall within this basic scope.

Parachute Lift Bags

The Parachute Lift Bag is the most common type used by diving contractors. Their main use is to raise objects from the seabed - and in some instances to support items on the surface. The design is, as their name suggests, similar to that of a parachute. They provide buoyancy by virtue of the fact that the air that is used to fill them is trapped at the top of the bag while the bottom of the bag is open to allow excess, or expanded, air to readily escape.

The material used in the fabrication of this type of lift bag is a heavy denier (850 denier and upwards in thickness), abrasion resistant material that offers air tight integrity. Other qualities include resistance to weathering and deterioration caused by oil and grease as well as U.V. stability. Commonly made from polyester materials the seams are usually hot welded together.

The smaller, parachute-type lift bags, up to about 500 kilos, have webbing lifting straps that are usually stitched to bag material pads which are then welded to the sides of the Lift Bag. Smaller bags in this range usually have two straps while the larger bags have up to five straps to ensure the added strength required for heavier lifts.
Larger parachute-type lift bags - 500 kilos and more - employ a heavier denier material and more straps. The webbing-type straps on the larger lift bags usually run up the entire side of the bags through special welded-on pockets and secure together at the bag's crown. This gives enormous strength for heavy lifts and large bags can have up to ten or more of these webbing type straps.

Parachute Lift Bags are usually fitted with a manually operated dump valve controlled by the diver. The size of this valve increases with larger bags to ensure that the air can easily be vented. The valve is connected to a rope long enough to come down to the skirt of the bag, where the diver is carrying out his connection to the job. This allows the diver to pull on the rope and activate the dump valve so that the bag can be trimmed as needed. Parachute Lift Bags should never be used without a dump valve unless there is a very special application and the diver is made aware of this modification.

There are two usual methods of filling the parachute lift bag with air: Either from the open end, or skirt, of the bag or, in some instance, from an air inlet control valve fitted to the crown (top) of the bag with a connection that allows a hose connection. This is an ideal way to fill the bag and allows the surface team to take over control when necessary.

What Size Bag To Select For A Lift?

This is where experience counts. It is of the utmost importance that the correct calculations are applied when selecting the right size bag for a particular lift. Choosing the wrong size of bag can result in the item not lifting from the bottom or, and worse still, being lifted and rising to the surface at an uncontrollable speed.

Before attempting a lift Diver's need to consider the following points:-

1. Size and weight of the item to be lifted?
2. What is its weight in water?
3. The depth of water that the object rests in.
4. What is the best lift bag to use? Or the best chosen from those available at the time.
5. Is there an adequate air supply available for filling the bag?
6. Have you got sufficient shackles, strops, ropes, chains, etc., to assist with the lift?
7. Surface conditions and sea state.
8. DIVER SAFETY.
9. The securing point(s) on the item to be lifted.
10. The nature of the seabed, ie. silt, sand, rock or mud, and the amount of suction to contend with.
11. Never 'ride' a lift bag to the surface.
12. All other important aspects - unique to each job - that relate to the lift.

Founder and Managing Director of Sydney-based, Pro-Diving Services Pty Ltd, Rick Poole has been a professional diver since 1967 and has worked on a wide variety of projects requiring solid underwater experience, meticulous planning and specialised skills. As a leading commercial and salvage diver he has been involved in ship repairs, cutting and welding, deep sea diving, inspections and surveys, cargo recovery and dam and tunnel work. As an Instructor he has trained thousands of recreational and occupational divers. He can be contacted at:

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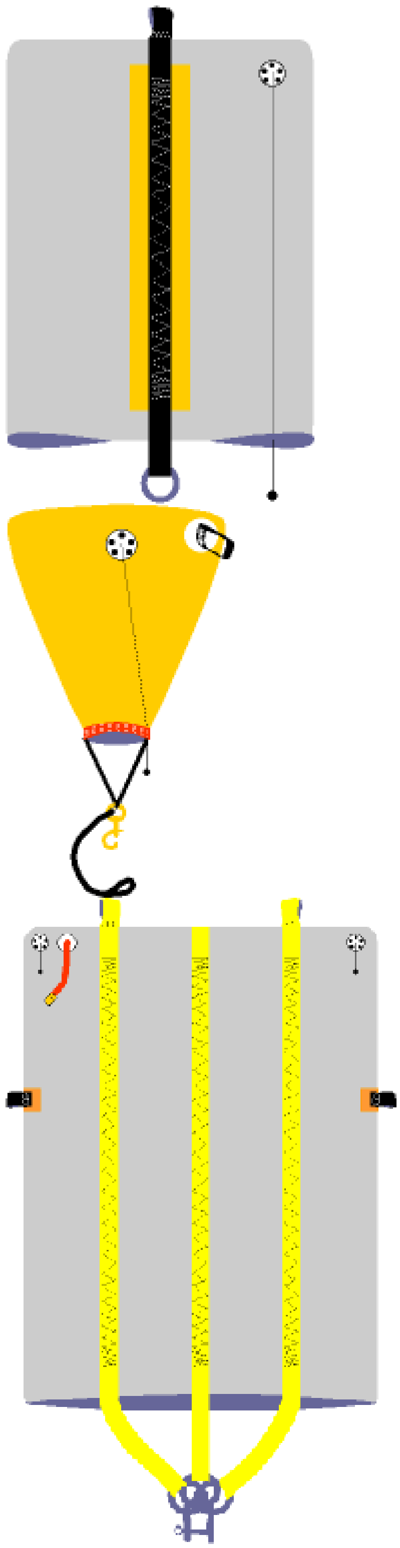
E-mail: allgas@bigpond.com

Techniques

Types and Models



Important:

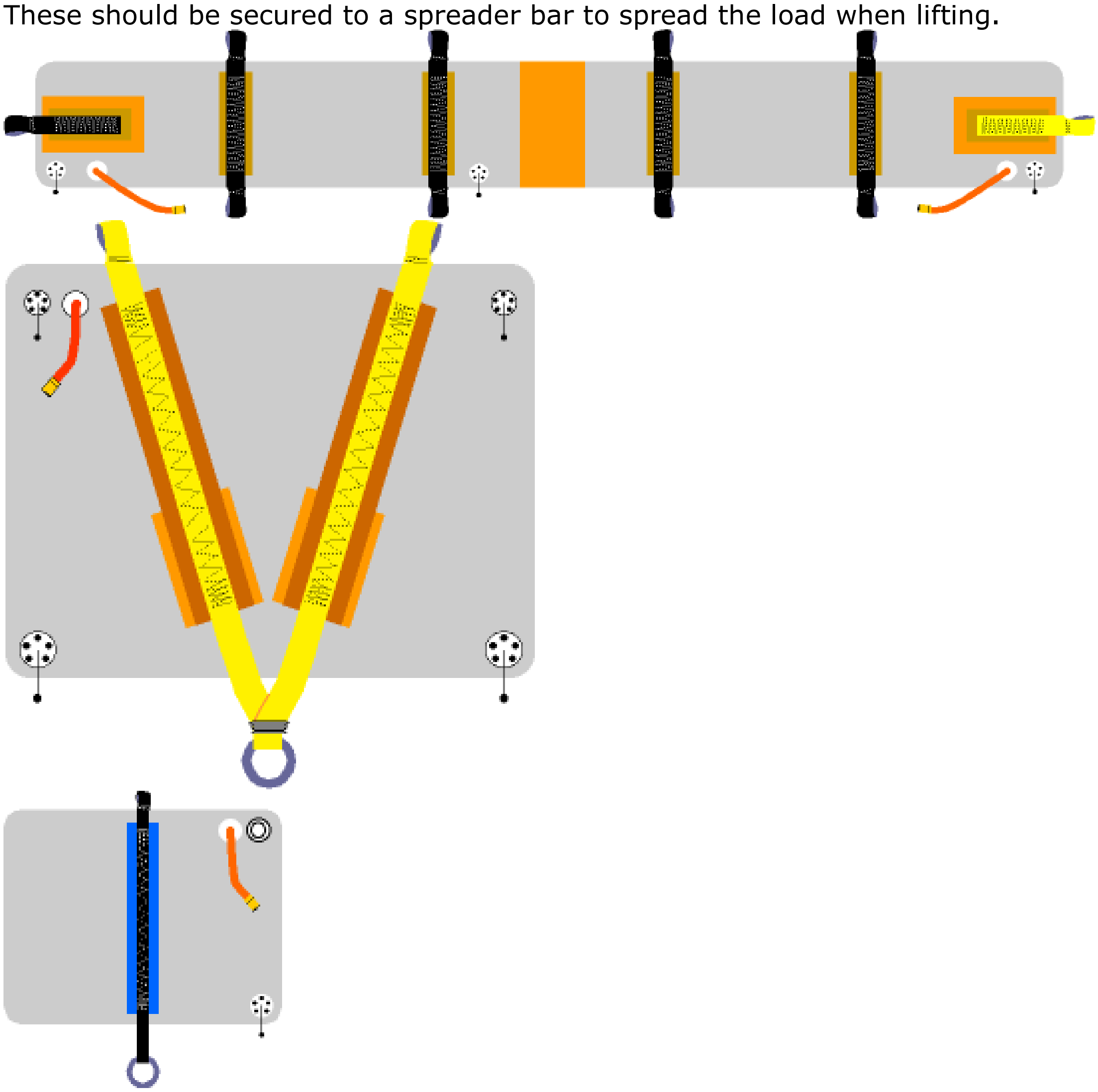
Bringing items up from deep water imposes additional problems. Proper calculations are essential. Divers should take note that using a lift bag with too much lifting capability will - allowing for air expansion in the bag - cause a rapid increase in the ascent rate. This can result in disaster, with the item eventually reaching the surface at great speed where air is spilled from the bag allowing the item to rapidly descend back to the seafloor. Calculate each lift. Use small pilot bags if necessary to ensure that there is MINIMUM spare volume in the main bag once the lift begins. Have a small bag above the larger bags that take the final lift.

Enclosed Lift Bags

Enclosed Lift Bags, sometimes referred to as 'closed', or 'sausage bags', usually come in sizes that range from 250 kilos and upward. Primarily used to support the flotation of items on the surface they are not used to lift items from the sea-bed.

Although made from the same materials as the parachute-type lift bags, these bags, being totally sealed, vary in design. These bags have filling points with valves that allow remote filling. They are also fitted with over-pressurisation valves on the bottom so that the bag does not over-inflate and burst. Most bags have at least two filling points, located at each end of the top of the bag, and several over-pressure valves on the bottom.

The webbing straps run all the way around the bag and are fed through pockets. For example, a 5,000 kilo enclosed bag has around seven straps. These should be secured to a spreader bar to spread the load when lifting.



Because enclosed lift bags usually come into contact with the item that they are supporting it is important to prevent damage to the bag. Always remove any barnacles, welds, jagged metal, rough paint, etc., from the contact surface. Chafing will badly damage the bag. If need be cover the contact area of the bag with canvas, hessian bags or place marine ply between the contact surfaces. Chafing happens quickly.

Procedures To Consider:

Enclosed bags need to be well secured to the lift point. It is equally important that the top of the lift bag also be secured to the item being supported to prevent a possible capsize. When floating a vessel, for example, the bags should not only be connected to the lifting points, but they should also be secured fore and aft at the securing lugs on the top of the bag and also secured inboard to prevent them from moving away from the hull and causing a possible capsize.

Calculations for these bags are also important. The use of Enclosed Lift Bags should be avoided in lifting items from the seabed, especially at depth. The chance of exploding these bags due to rapid air expansion is very real. Use Parachute Bags to lift, and Enclosed Bags to support and tow an item. (Enclosed bags are ideal for towing purposes as there is little or no chance of spillage from the bags, whereas there is a chance of spilling air from open, parachute-type lift bags, when towing an item).

Summary of Lift Bag Use:

1. Be aware of the DANGERS when using lift bags.
2. Have experienced Lift Bag personnel on site.
3. Carry out full calculations on the item to be lifted or supported.
4. Ensure that you have the appropriate combination of bags. And that you know which bags to use.
5. Ensure that you have plenty of support equipment: ie., shackles, ropes, strops, chain, marine ply, canvass, compressed air, hoses, etc..
6. Check the strength of the lifting points on the item you are lifting or supporting.
7. Use Parachute Bags for lifting. Use Enclosed Bags for surface flotation, especially when towing.
8. Be aware of the sea conditions, including sea state, currents, tides and monitor the weather forecast.
9. Take your time, and remove anything that can damage the bags, ie.,barnacles, jagged metal, etc..
10. And finally:

Be prepared for the unexpected!

Calculating The Lift

0.97 litres of air provides 1 kg of lift in seawater.

1 litre of air provides 1 kg of lift in fresh water.

How much air will be required to lift an object weighing 500 kgs from the sea floor in 30 metres (4 ATA's) of water?

0.97 X 4 ATA's = 3.88 litres of air will provide 1 kg of lift at 30 metres.

3.88 X 500 (weight of object to be lifted) = **1,940 litres of air**

Night Diving

Some divers worry about getting separated. You should remind your buddy that you want to stay closer together than normal. Insist that your buddy stay no more than an arm's length away. If he or she doesn't agree, find a different buddy. Once underwater you will be surprised how easy it is to see each other, with the dive lights and a chemical light stick. Chemical light sticks should be tied to the scuba tank. They come ins several different colors and are good for one dive and throw off an amazing amount of light. They even make it easy for dive boat staff to track your progress through the water. Some resorts offer large boats and have the space and equipment to hang generator powered high intensity lights in the water. It's fun to try. because you can shut off your personal light and dive in the glow of the big overhead lights.

One caution: The big light clusters attract marine life like bugs to a porch light. It's wild to see Flying Fish rocket to the surface or squid move like a giant bait ball. As a beginning night diver, you might wonder what big set of teeth look at the squid (and you) like an all you can eat buffet!

Dive Lights: To have a safe and enjoyable night dive, you will need some additional equipment and extra planning.

The most obvious equipment is a dive light. These can range from flashlights for under $30.00 to larger lights with six bolt or multiple battery power sources. The larger lights have a handle (other than the light's barrel) and are powered by dry cell or rechargeable batteries. This style light ranges from $20.00 to $100.00, depending upon the case material, power source and type of bulb assembly.

There is no one right light. It all depends on the amount, location and activities planned for your night dive. You may even want to choose a secondary light that is small enough to take on day dives for hole peeking and color enhancement, plus use a larger model as your primary light.

The one light or two light debate could go on for pages but simple common sense ought to prevail. If several buddy pairs are diving in clear, warm water, then one average light per diver is common practice. On the other hand, if two divers are night/wreck/game diving off the beach, then each diver will want to carry two of the heaviest duty, most reliable lights they can buy and also consider wearing an arm strobe for emergency signaling. The conventional wisdom from the training agencies is take two light sources when ever there is limited visibility.

Features to consider when selecting a dive light:

1. Beam width.
2. Weight. If you face a long hike to the dive site, you might want to consider a lightweight light.
3. Buoyancy. A light that floats could be an advantage or disadvantage depending upon where you dive.
4. The on/off switch. Can the light be turned on and off easily with one gloved hand? Too easily? Will the switch get turned on accidentally?
5. Durability
6. The availability of a wrist lanyard
7. Beam strength. Does the light seem bright enough for the color and clarity of water where you usually dive?
8. Depth limit
9. Warranty period?
10. The frequency of your night diving excursions.
    Dry cell batteries are less expensive, but only if you use the light infrequently.
11. The O-ring seal
    Does it stay in place when opening the light or will it be easy to lose or crimp (and flood) when changing batteries?
12. If most of your night dives are made while traveling
    Which light will be easier, more available and cheaper -- disposable or rechargeable batteries?
13. Does your local dive store stock the common replacement parts?
14. What lights do your buddies use -- would they repurchase the same light?

Techniques and Practices: Buoyancy control is the number one skill to concentrate on while night diving. Improper buoyancy control results in reef damage or in stirring up a silty bottom. If you are kicking wildly, the chances are you are going to break plants and smash animals. So it is critical not to be over-weighted. Ideally, a diver would hover slightly above a reef, never coming in contact with anything alive. If you want to stop and kneel down to watch the life, do it on a bare patch of sand.

Buoyancy control is a little harder at night, because your depth perception may be off a little and your hands are busy with a light. If you are not used to carrying anything while diving, the manipulation of a light can be enough to make your movements awkward. If you have a chance to carry a light during a day dive, it is good preparatory training.

Being positively buoyant is a problem as well. If you keep floating to the surface, your buddy is going to have a hard time staying in close contact. Test your buoyancy during the day dives, so you are confident you have the right amount of weight for the thermal protection and type of tank you plan to use at night.

Some people add one or two pounds to their weight belts the first few times they night dive. You man consumed air faster on your first few night dives, because you over-breathe when anxious or worried. The extra weight helps offset the buoyant effect of taking bigger breaths. When you calm down after a few night dives, return to your normal weight. don't add more than one to two pounds or you will need to add excessive air to your BC.

Even if your buoyancy control is excellent, you will probably brush into something during a night dive. To avoid skin irritation and cuts, wear some type of protective suit. In the warmest waters this may be a Lycra skin. In cooler tropical waters it might be a 3mm suit. If you only have a lightweight shortie, then consider wearing heavy tights and a long sleeved T-shirt.

Once the sun goes down even the warmest tropical climates cool of. You will be more comfortable if you wear a thicker suit night diving than you wore during the day. Also, bring a jacket and warm clothes for the ride back to the shore.

Summary: Night diving is a wonderful underwater experience. Consider plunging into a world where a wave of the hand produces a phosphorescent trail of twinkling light, where the critters come to see you and where you can experience many organisms feeding and looking totally different than they do during the day.

There is also an inner experience that comes with night diving. Your senses come alive and you hear new sounds, such a shrimp clicking and reef fish grunting. You also confront your personal fears about the unknown and gain a new confidence from a successful night dive. Try it on your next tropical vacation for a spectacular underwater experience.

Breathing on Scuba

Breathing. It seems simple, yet it has more impact on diving pleasure and safety than any other aspect of scuba training. Breathing is the only skill performed continuously throughout your in-water activities. It controls becoming and staying relaxed and your ability to react to stress appropriately. Efficient breathing is the key to avoiding panic. How you breathe affects your buoyancy and level of exertion. And it's often the limiting factor in the amount of time spent on a dive.

Although divers are often admonished to "breathe normally," the most effective breathing pattern for diving is not "normal" for most of us. On land, breathing is usually slow, shallow, and through the nose. Occasionally we even hold our breath when in thought or straining. (Test this by pressing your palms together hard and noting your breathing.) For diving, we learn a different pattern that serve us better underwater. We breathe continuously, slowly, deeply, and through the mouth.

Our respiratory cycle begins when we inhale. air passes through the nose and moth and through the airway (trachea), which splits into two bronchial tubes. Each one enters a lung, where it divides into progressively smaller bronchiole. These continue to branch until they reach the alveoli, the millions of microscopic air sacs through which our lungs exchange gases with the circulatory system. Each air sac is surrounded by a network of tiny blood vessels, or capillaries.

The air we breathe on land, and out of a standard scuba tank, is composed of 20 percent oxygen, 79 percent nitrogen, and 1 percent carbon dioxide and other trace gases. A portion of the oxygen in the inspired air goes into solution in our blood by diffusing across the extremely thin membrane separating the alveoli and the capillaries. The oxygenated blood is then carried to the heart, where it's pumped through the arteries to all the body's tissues.

When the oxygen-rich blood reaches the body's cells via the arterial capillaries, each cell takes some oxygen and metabolizes it to produce energy. Carbon dioxide, a by-product of this metabolism, moves from the cells into the blood-stream, where it's carried by the veins back to the lungs. There, the carbon dioxide is diffused into the alveoli. The air in the lungs now contains more carbon dioxide than oxygen, and it's exhaled from the body. Most people are surprised to learn that it is this buildup of carbon dioxide, not the decrease in oxygen, that is the primary stimulus to breathe.

The respiratory cycle is significant in scuba diving because our lungs were not designed to function underwater. Physical differences in the underwater environment, such as increased ambient (surrounding) pressure and the necessity to breathe through scuba equipment, decrease the efficiency of the air exchange process. In addition, there are diver-controlled factors: the increased demand for oxygen placed on the body by moving through the water, and the physical and psychological stresses of functioning in a foreign environment.

Using the proper diving breathing pattern enhances your comfort and safety by maximizing the amount of air exchanged and the time it spends within your system.

Always breathe continuously. This is the most important safety rule in diving. On scuba we are breathing air at increased pressure. As we descend, our air spaces are compressed, as we ascend they expand. To avoid serious injury and discomfort when diving, we equalize the pressure in our lungs, ears, and sinuses.

Correct scuba breathing means we are always either inhaling or exhaling. Our airway must remain open at all times so that expanding air can be exhaled safely. Breath-holding traps expanding air in the alveoli, which might possibly result in a lung overexpansion injury. Air released from a ruptured alveolus may escape into the chest cavity, putting pressure on the heart (mediastinal emphysema), rise to the neck (subcutaneous emphysema), or cause a collapsed lung (pneumothorax). The most serious type of lung overexpansion injury is an air embolism, in which an air bubble penetrates the alveolar membrane and is forced into a capillary, traveling though the circulatory system to the brain.

Skip-breathing (pausing between breaths to save air) is dangerous and should be avoided. It doesn't same air because the increased carbon dioxide level stimulates rapid breathing, and the breath-holding may cause lung injury. Fortunately, overexpansion injuries are easily preventable in healthy divers by avoiding breath-holding and ascending slowly to allow air sufficient time to escape from the lungs.

Learning to breathe continuously seems simple enough. But all mammals, including humans, are born with the instinct to inhale and hold their breath when their face hits the water. Have you ever been unexpectedly splashed in the face with water? If you react normally, you automatically hold your breath.

This instinct explains why some divers (and snorkelers) enter the water in a non-threatening situation and immediately display reactions ranging from mild uneasiness to sheer panic. In new students, instructors often attribute this reaction to fear of the unknown. While this may be a factor, it doesn't adequately explain why a student standing in waist-deep water has trouble keeping his masked face in the water while breathing through a regulator. The instinct to hold one'[s breath causes novice divers to inhale quickly and exhale only when triggered by the impulse to inhale again. Divers need to relearn how to breathe.

The first step in making breathing a learned skill is to become aware of it, to convert breathing from an automatic to a conscious act. A good example is learning to exhale whenever the regulator is out of your mouth. Since you can't inhale with the regulator removed, and it's dangerous to hold your breath, the only choice is to exhale. this keeps the airway open and the lungs safe from overexpansion. Yet many student find it difficult to remember to exhale because it goes against instinct.

The second step in learning to breathe properly on scuba is to make the new breathing pattern automatic. A conscious effort must be made to disassociate "regulator out of the mouth" from "hold breath" and reassociate it with "exhale small bubbles continuously." If this skill is learned just well enough tin class to perform adequately during skill evaluations, it probably hasn't become automatic. In an emergency the diver may revert to breath-holding. continuous breathing must become a habit.

Inhaling and exhaling slowly and deeply increases the amount of air that reaches the alveoli and the time that air remains in the lungs. Slow, deep breaths allow more oxygen to be absorbed into the bloodstream.

Although "breathe deeply" is usually interpreted as "inhale deeply," it is actually just as important, if not more so, to exhale deeply. Divers should exhale to near the bottom of normal lung volume with each breath. Just a few breaths without exhaling adequately will produce sufficient carbon dioxide buildup in the lungs to send "I need air" signals to the brain. These are translated into a command to inhale. But the lungs are still full of unexahled air, making the effective exchange of air impossible. The solution is to concentrate on exhaling fully with each breath.

If a diver, breathing shallowly, inhales 1 pint of air, only about half of that actually reaches the alveoli; the rest fills the "dead air space" of the mouth and trachea. By inhaling deeply, 4 or more pints are drawn into the lungs, and more air reaches the alveoli. Breathing slowly also minimizes air turbulence in regulator hoses.

A note of caution, however. Your lungs should never be filled completely because of air expansion, as you rise a little with each breath. Also, don't try to squeeze all the air out of your lungs when exhaling. This could cause collapse of small airways in the lungs and lead to air trapping.

The pattern of slow, comfortable inhalation followed by slow, full exhalation is analogous to breathing patterns used in various types of relaxation techniques, such a yoga and Lamaze birth training. This pattern also helps calm anxious divers.

The third aspect of proper scuba breathing is to inhale and exhale "through the mouth." Those of us who have the habit of mouth-breathing firmly ingrained sometimes forget that people normally breathe through their noses.

On land, breathing through the mouth is related to strenuous activity or nasal congestion, and therefore associated with discomfort. Considerable mouth-breathing practice may be necessary before you can put on a mask and automatically switch to the correct scuba breathing technique.

Developing the habit of breathing through the mouth is important for underwater comfort. The number one reason for water in the mask is exhaling through your nose. The exhaled air breaks the mask's seal, which lets water seep in, and causes most masks to ride up on your face, further aggravating the problem. Frequent mask clearing fails to solve the problem and encourages shallow breathing. This may cause the diver to revert to reflexive responses and inhale through their nose, sucking water into the nasal passages.

Exhaling through the mouth rather than the nose has other benefits as well. Full exhalation prevents the buildup of carbon dioxide in the lungs and is actually easier because the mouth's larger opening offers less resistance than the nostrils. air exhaled through the mouth exits the regulator second-stage via the exhaust tee, which is specifically designed to shunt exhaled bubbles away from the front of the mask. This keeps the bubbles from pushing the mask up and obstructing your vision. finally, mouth-breathing eliminates nose-exhales air as a cause of mask fogging.

Diving injuries most often result from panic, not the out-of-the-ordinary situation that initiates it. Experienced divers increase their panic resistance by maintaining the proper breathing pattern in all situations. There are several things you can do to reach this skill level.

Practice slow, deep, continuous breathing through the mouth before entering the water. Those familiar with various relaxation techniques usually pick up correct scuba breathing quickly because they are accustomed to controlling their breathing rate and pattern. Wear your mask and put your snorkel in your mouth while practicing.

Be aware of your breathing while you gear up and enter the water. l Make sure your air is one and enter with your regulator in your mouth. While on the surface, keep your face in the water and concentrate on exhaling fully with each breath. If you start to feel like you are not getting enough air, think exhale. l Your brain will take care of the inhale part. After a few full exhalations, you should feel your breathing slow and you will start to relax. Remember, it is an instinctual reflex to hold your breath in the water. The breathless feeling will pass if your concentrate on exhaling slowly and fully.

Once underwater, your attention will naturally shift to the surroundings. As you dive, monitor your breathing pattern and immediately bring your attention back to breathing should the pattern change without your conscious control. You must be aware of a potential problem before you can do anything about it.

Once you are aware of the problem, stop, think, and act. Stop whatever activity you are engaged in, whether it is mask clearing or observing fish. Think about your breathing pattern and concentrate on bringing it back to slow, deep, and through the mouth. Identify what caused the change. Only then resume movement, taking steps to eliminate the cause of the anxiety or overexertion. The whole process may take as little as a few seconds or as long as several minutes.

Breathing is also the "fine-tuning" of buoyancy control. If you feel slightly negatively buoyant, or want to rise over an obstacle, breathe deeper and the added lung volume makes you more buoyant. Or breathe shallower to decrease your buoyancy. Experienced divers develop subconscious control of their breathing to automatically adjust their buoyancy.

Not breathing through the mouth is a problem most divers are unconscious of. Even experienced divers exhale through their noses occasionally. If you are having a problem with water in your mask and have checked the obvious reasons for leakage (hair or hood under mask, strap incorrectly positioned), determine if you are exhaling though your nose. l Check this by pinching your nostrils shut for several breaths. Divers are often surprised to discover that the leakage stops. Holding the nose gives the body time to get used to exhaling through the moth again and often solves the problem.

Maintaining a slow, deep, through-the-mouth breathing pattern with full exhalation is the key to safe, comfortable diving. It is a learned skill which involves overcoming your innate breathing reflexes and replacing them with a new habitual pattern. This can only be accomplished through over-learning, training to the point that when you place a scuba regulator in your mouth you automatically breathe differently, and continue to do so even when under stress. By controlling breathing you render yourself panic-resistant, increase confidence, and make your diving safer and more enjoyable.

Mask Removal and Replacement

The scuba mask is the most basic piece of equipment. It is the viewing window to the underwater world and the first item usually purchased upon deciding to become a diver. During certification class, considerable time is spent practicing mask handling skills. Despite this, many divers are still uncomfortable with their mask, especially removing and replacing it underwater. This is typically one of the skills divers are most anxious about, and yet it's one of the simplest and most important.

The ability to calmly and efficiently remove and replace the mask underwater is a good indication of overall diving comfort. It's also a crucial practical skill. If the mask is accidently dislodged during a dive (and anyone who dives much will experience that)or when removing it to fix a broken strap, divers will be thankful to have practiced mask removal and replacement until it's second nature.

While becoming comfortable having the mask off underwater may take some effort, it can mean the difference between a minor irritation and dangerous panic. As with most scuba skills, being thoroughly familiar with the technique and practicing it conscientiously is the key to safe, enjoyable diving.

Mask Removal Underwater. The biggest trauma in removing the mask underwater is that it is usually unplanned and happens suddenly, without prior warning. Perhaps a buddy accidently kicks the diver in the face, a diver bumps into something or a mask strap breaks. The surprise, plus the shock of water hitting the face (especially if it's cold water), can cause an involuntary gasp which sometimes results in inhaling water through the nose. If not controlled immediately, choking and panic may follow. Many divers also find it difficult to continue breathing slowly and deeply through their mouths with their mask off.

The solution to this unpleasant scenario is to practice removing the mask and breathing underwater for at least a minute at a time, until the diver can do it without altering their breathing rate and pattern. This skill takes active concentration; a diver must maintain positive pressure in the nostrils so that water will not enter as the diver continues to inhale and exhale through their mouth.

If getting water in the nose, or the fear of it, is a source of anxiety, divers should begin a no-mask exercise by pinching the nostrils or by exhaling simultaneously through the nose and mouth. The diver must concentrate on inhaling only through the mouth. Gradually release your nostrils and switch back to exhaling totally through the mouth. Divers must develop the discipline to sustain a slow, deep mouth-breathing pattern without a mask, and when the need arises they will have no problem taking the time to calmly and deliberately replace the mask.

A helpful hint: When purposely removing the mask during a dive, the shock of water hitting the face can be minimized by breaking the seal gradually. Let the water trickle in a little at a time. After the mask is fully flooded, it can be removed with little change in breathing pattern.

Mask Replacement Underwater. The most popular procedure for replacing a mask underwater is to seat the mask on the face and then pull the strap over the head as follows:

1. Arrange the mask, strap and snorkel in the proper positions relative to the face. This sounds obvious, but divers have been known to replace the mask upside down in their rush to get it back on quickly. Divers should make sure that the mask is right side up, the strap is not tangled or twisted and the snorkel is on the left and not wrapped inside the strap. It's just as easy to do this with eyes closed by feel as with eyes open. Divers should take their time and use both hands to examine the entire mask assembly for correct positioning. Use the nose pocket and snorkel as guides.
2. Divers should fold the strap up and forward and seat the mask comfortably against the mask comfortable against the face. Divers should hold the mask in place with one hand while using the other to sweep hair out of the way, move the edge of the hood, smooth down a mustache and generally confirm an unobstructed sealing surface. Some divers prefer to clear the mask of water at this point, other wait until the strap is in place.
3. While pressing the mask against the fact with one hand, lift or slide the mask strap back over the head with other. Divers should be able to accomplish this without dislodging the mask. The next step is to pull the strap down only as far as the widest part of the head. If it is found that the mask is positioned too low, it should not be pushed back up; instead a diver should lift it and start over. Otherwise, especially if a diver has long hair, it will just slide back down.
4. A diver should clear the mask now if they have not already done so. Now both hands are free in case the mask needs reseating or the strap is twisted. If the mask strap is designed with a split in the back then spread it out for a better hold. (Position a split strap above and below a hair know or high pony tail.)

When wearing a hood, the strap may be hard to slide back across the neoprene. The suggested alternative is:

1. Place the mask against the forehead and hold with one hand.
2. slide the strap back over the head with the other hand.
3. Use both hands to pull the mask into place on the face, then clear.

The key to removing and replacing the mask easily and calmly underwater is to maintain a normal breathing pattern and move slowly and deliberately. To reacquaint oneself with no-mask breathing, divers should occasionally practice the maneuver. Of course, it should be done in a secure setting and with the buddy's knowledge.

Donning a Mask Above Water. For many divers, the only attention the mask gets before a dive is defogging. However, the process of preparing to don the mask should begin will before entry, during gear setup. That is the time to make sure that the mask strap is adjusted properly, not when you are about to enter the water or during the dive. Underwater, it is not uncommon for a mask to flood while a hapless diver is tugging on the strap to adjust it.

Divers should preadjust their mask by seating it against the face and pulling the strap over the head as described earlier for mask replacement underwater. The mask strap should be loose enough to pull down easily over the back of the head with one hand. It is difficult to get the strap over the head, it is too tight. A diver should loosen the strap and try again. Once the mask is on, the strap can be snugged slightly by pulling the loose ends.

Divers should not over tighten the mask. Remember, underwater the increased ambient pressure works to keep the mask on the face. As long as a diver does not exhale through the nose, it should remain sealed even without a strap. With the mask correctly preadjusted, divers simply slip it on before enter -- no fiddling or last-minute rush necessary.

To don the mask at entry time, divers simply need to place it against the face, seated comfortably below the now. If the mask is pressing upward on the nose, as soon as you exhale through the nose, equalize or even just move, water is likely to enter. While holding the mask in place with one hand, use the other to check the perimeter of the skirt for obstructions. Strands of hair, the edges of a hood or the end of the mask strap caught underneath the skirt are common sources of leakage.

Before a diver enters, he or she should be sure that the mask strap is positioned across the widest portion of the skull. For most people this is well above the ears. If the strap is too low, it may slide down during the dive, causing the mask to feel loose under the nose. If the strap is too high, it could slip off over the top of the head.

MASK REMOVAL ABOVE WATER - Back on the surface after a dive, the question is not so much how to remove the mask as when. Divers who are not comfortable with their mask have a tendency to remove it as soon as they hit the surface. Think about that -- a diver has been diving for 30 minutes or more, seeing well enough to enjoy the scenery and breathing through the mouth. Why should a diver remove the mask before he or she is out of the water?

There are many reason for leaving the mask on: It saves energy by allowing the diver to rest with his or her face in the water. a diver can see his or her fins for easier removal, when it is on the face a diver can't lose it and it keeps surface chop from getting in the eyes and nose, to name just a few. Divers should strive to be so comfortable with the mask that it becomes part of the face and there is not even an awareness about having it on.

If a diver must remove the mask (perhaps due to fogging or sinus drainage), hold on to it or otherwise anchor it securely. Perching it on the head or letting it dangle from the forearm is inviting its disappearance.

Smooth, calm mask handling above and below water is the mark of a comfortable diver. Divers should invest in a quality mask that seals perfectly on the face. Masks should be defogged thoroughly and adjusted properly. Divers should remove and replace the mask underwater and store it safely. Over time, it will come to feel like a part of the face.

Common Mistakes Divers Make

Poor buoyancy control.
The most frequently discussed diving skill problem is lack of adequate buoyancy control, which is notorious for causing damage to fragile underwater habitats.

Having poor buoyancy control means a diver can't stay neutrally buoyant throughout a dive, which is usually the result of wearing too much weight on the weight belt. Negatively buoyant divers have a tendency to bump into, kick and grab onto whatever is near them, or constantly compensate for the feeling of sinking by putting more air in their Buoyancy Compensator, kicking up and swimming with arms and bent knees. This, in turn, uses more energy, increases breathing rate and air consumption and can initiate the panic cycle. The end consequences are an exhausted diver and a trashed diving environment.

Good buoyancy control is primarily a function of practice, but improvement comes more rapidly if divers wear only as much weight as is absolutely needed, considering the amount of neoprene being worn, the buoyancy characteristics of the tank being worn and the type of diving (i.e., water salinity, depth and movement). Scuba Staff should be alert to help divers determine the exact right amount of weight for them in any particular situation.

At some dive resorts, damage to reefs by divers unable to adequately control their buoyancy has become such a problem that divers are asked to do a checkout dive with an instructor before being turned loose. We need to work more with students in the pool and at Open Water to assist in learning effective buoyancy skills. On open water dives the hover portion of ascent work is a vital part of buoyancy control skills.

Problems on the surface.
Inexperienced or uncomfortable divers often spend excess time bobbing on the surface after entering the water from a boat. When a surface current is present, an unaware diver can quickly be swept away from the dive site. If the buddy team chooses to descend away from the boat, there is a greater chance of navigational difficulties, since the boat is not available as a reference point.

To avoid this situation, both buddies should enter together so one doesn't have to wait on the surface. They should be ready to descend before entering, with all equipment in place. They need to carefully follow the divemaster's instructions and spend as little time as possible on the surface.

During the open water experience students need to be helped to be aware of timing in a buddy team. Each buddy team member needs to watch the other and help each other to become ready to dive at the same time and to work at staying together and functioning as a team.

Mask removal.
Another common diving mistake is removing a mask on the surface or placing it on one's forehead after surfacing from a dive. The reasons for leaving a mask on until a diver is safely out of the water are basic. A diver can see under the surface to remove fins or grab the boat's ladder and the diver will not water in the nose and eyes while doing it. The mask can't get lost if it's on the face, while even small wave is capable of washing it from the forehead.

Removing the mask and placing it on a forehead is a primary indicator of an uncomfortable or distressed diver. If a mask has been in place for 30 minutes or more during a dive, there should be no reason why it can't remain there another couple of minutes while the diver exits the water. If it is uncomfortable, full of water or fogged, these are correctable problems which should be resolved before the next dive. Some experienced divers may remove their masks on the surface. Chances are it is just a bad habit that they have developed and is not something to be copied.

Stress with students in the pool and at open water to place the mask on the face before entering the water and not removing it until they have exited the water.

Not practicing scuba skills.
The reason for learning scuba skills is because a diver might have to use them at some point to preserve their own or their buddy's safety. When that happens divers must react automatically, quickly and calmly to avoid adding stress to an already tense situation. The only way to maintain this level of readiness is regular practice. Divers should periodically devote part of a shallow dive to actually performing safety skills with their buddy. Practicing under the supervision of an instructor is always safest (like having a spotter in gymnastics) but if students choose to practice on their own, they should notify others to avoid causing undue concern.

A diver's ability to effectively and comfortably perform even basic diving skills such as mask clearing or ear equalization with deteriorate significantly if divers don't dive regularly. A refresher is the answer. Divers should be encouraged to regularly practice their scuba skills.

Not monitoring gauges.
Students should be encouraged to prevent out-of-air situations by prevention -- by looking at the pressure gauge every few minutes. Unfortunately divers have so many things to remember, not to mention the engrossing beauty all around, that it's easy to lose track of time.

The fact is, divers can't be responsible for their own safety unless they have a good idea at all times during the dive of their own personal dive information, or what's easy to remember as D.A.T.A.: Depth -- how deep are you now and what was the maximum depth? Air -- how much do I have left? Time --how long have they been down and how much longer is the planned bottom time? Area -- where are they in relation to the exit point? If divers have trouble remembering to check their gauges every three to five minutes, they should pen the acronym D.A.T.A. on their palm or glove. Divers have developed the proper habit when they can give an approximate answer to each of the above question without looking at their gauges at the time. Both in the pool and during the Open Water Experience staff should routinely ask students what their air pressure is and in during the Open Water Experience ask them about depth, time and where they were are.

EQUIPMENT

Scuba is an equipment-intensive sport, consequently a good deal of our training involves learning to use and care for our gear. So it follows that a high percentage of diver mistakes would also involve equipment.

Unfamiliarity with gear being used.

Even if a diver owns their own equipment and has not used it for several months, a review of how each feature works is a smart idea. When divers are renting equipmen they should have the shop personnel provide a thorough briefing on its use.

BCs require practice to operate effectively, and are therefore a prime source of difficulty for new divers. A very common BC usage problem is the failure to deflate adequately when trying to descend. This often leads to the erroneous conclusion that more weight is needed. Divers need to be helped to understand that with most BCs they must be vertical (head up) in the water with the inflater hose stretched above the head for air to flow out of the BC bladder. If they look up at the hose as they descend; they should see bubbles emerging. Squeezing the BC;s air pocket with the other arm will often help force the air out. Some BCs have two or even three air dump valves to assist divers to vacate the air from their BC in a variety of positions. Scuba staff should watch for these alternate dump valves and help divers learn how to use them.

A similar mistake is adding air to the BC while ascending. Provided a diver is neutrally buoyant during the dive, to ascend a diver merely needs to gently begin to kick toward the surface before the BC will begin to expand and it will be necessary to begin venting air from the Bc as it expands. This helps prevent the common error of ascending too fast. Also, divers need to pay close attention to which button on the inflate/deflate mechanism they push. If they are not totally comfortable with using their BC, it is easy to accidentally push the inflate instead of the deflate button. If a diver holds the BC inflate/deflate mechanism wrong they could squeeze the inflate mechanism without realizing it as they try to get a firm grip on the mechanism in order to deflate the BC.

Failure to preadjust, check and stow equipment.

By the time divers arrive at the entry point, whether it is a shore break, dock or boat swim platform, all the equipment should be ready to go. Fins, mask and BC straps should already be the right length so that they can just pull everything on and enter the water. An important part of that readjustment process is checking the equipment for potential maintenance problems before it's too late to fix them. Discover and replace the cracked heel strap or bad hose before entry time. To avoid the embarrassment of having the tank slide out of the BC strap underwater, be sure the buckle is strung correctly and pulled tight.

Once everything is assembled and checked, gear and accessories should be stored in a bag, bin or assigned space where they won't get lost or be in the way (unless divers are immediately gearing up for entry). Weight belts are always kept at ground or deck level to avoid an accident should it fall.

Discovering the omission of a crucial piece of equipment (like a weight belt) can be prevented by divers religiously performing buddy checks before every entry. Students should be assisted in the pool and at the open water site to develop a routine for the gearing-up process which includes each buddy checking each other's gear for completeness and readiness.

Thoroughness in getting ready can prevent a number of common mistakes which could lead to a delayed or aborted dive. Divers will also avoid inconveniencing other divers and help themselves feel more relaxed and confident, decreasing the chances of making additional mistakes in the water.

Poor equipment care.
The list of mistakes in this category is long, but by far the most common one is rinsing a regulator after a dive without replacing the dust cap, which allows water to enter the first stage. The dust cap is attached to the first-stage yoke by a cord or rubber loop, and should always be replace over the valve opening as soon as the regulator is removed from the tank. Also don't push the purge button when rinsing a second-stage unless the regulator is still on a tank and under pressure. Otherwise, water can travel up the low-pressure hose into the first-stage, causing corrosion.

Another common mistake is hanging a regulator by the first-stage. This puts excess stress on the hoses where they connect with the first-stage. It is better to lay a regulator down with the hoses coiled loosely in an unstrained position.

ATTITUDE

Attitude mistakes arise from a diver having either too much or too little confidence, and are just as likely to be committed by longtime divers as novices.

Not asking questions.
Many divers feel that because they have a certification card, regardless of their actual level of experience, they are expected to know everything about diving. They fear the embarrassment of not knowing something when they think they should, and consequently make the mistake of assuming, rather than asking.

Scuba staff should expect divers to be inexperienced and/or unfamiliar with local conditions and protocols, and should be happy to assist and answer questions. That is primarily why they are there; to help with equipment, to refresh skills, to guide dives. It is much easier for scuba staff to answer questions and correct problems early than to solve problems later. The only stupid question is the one not asked.

Not planning the dive.
This is often related to the problem of not asking questions. Many divers figure that when they are diving from a charter boat or in a group, there is no need for a dive plan. Even basic things like depth and time limits are left to chance or to others. Proper dive planning means preparing physically and mentally for a dive with your buddy before you enter the water. Topics that should be addressed when planning a diver include everything from establishing the dive profile and objective, preparing equipment, verifying that each buddy uses similar hand signals to running through predive checklists. Planning also means mentally preparing for the upcoming event by talking through potential dive problems, like running low on air, having equalization troubles or getting separated. Proper pre-dive planning allows divers to visualize the entire dive, and invent solutions to potential problems, before they step in the water. As the saying goes, "Safe dives don't just happen; they're planned." Pre and post dive briefings during the Open Water help students to acquire this habit.

Complacency.
All divers are guilty of this one once in a while. It's the old, ":the rules don't apply to me" lie that divers tell themselves. Divers who have been diving for awhile and who have broken or bent a few rules, even if accidentally -- gone too deep, stayed too long, worn equipment they knew was faulty, not listened to a dive briefing. Then the problem is compounded by concluding, "I got away with it this time, I guess it's OK if I do it again." Unfortunately, that attitude leads to sloppiness, which eventually catches
up with every diver.

The Experienced Diver

Somewhere in the process of conducting a scuba course instructors should say something like: "You are qualified to dive in the environment in which you were trained." Well this really means in the pool used for training and the dive site used for the Open Water Experience.

Most divers are not going to be satisfied limiting their diving to the pool and one specific dive site. They will want to expand their diving horizons. They will want to become experienced divers as soon as possible. Hopefully they will continue their dive training and travel around in hopes of becoming experienced divers. However, the longer a person dives and the more they really understand the more they realize that "experience" is an elusive and relative term.

"Experienced diver" means many things to different people, depending on where you reside in the diving community, your ego, and your outlook on life. To a non-diver, anyone flashing a certification card may be considered "experienced." Yet, an obviously experienced scuba instructor with over 1,00-0 logged warm water dives joins the ranks of the novice when standing in a dry suit at the edge of a hole in the ice, waiting to embark on his or her first ice dive.

Timing is also a factor when determining a diver's level of experience. After checking their C-cards, dive boat captains should ask three questions before they even board the dive boat: When did you last dive? How many dives have you done? And have you dived in this type of environment before? Having a total of 100 dives doesn't mean much if you haven't dived for 10 years. Likewise, if all your diving has been in tropical waters, without additional training you may not be prepared to explore wrecks in New Jersey.

You get interesting answers when you ask divers if they consider themselves "experienced." Often divers with as few as 10 dives feel they are experienced, while more conservative thinkers view themselves as novices although they have completed 25 dives or more. Your personal perspective is often the defining factor in whether or not you consider yourself experienced.

For example, when asked about being experienced, an energetic 24-year-old Californian, who has been diving for six years, responded with a resounding yes. "With over 70 dives I consider myself safe and confident," he stated. "I'm prepared to handle a variety of diving situations. I dive kelp, rocky shores, from boats, and Catalina Island. If faced with diving a new environment, give me a week to research the required techniques and I'll be ready."

This adventurous individual hasn't taken any advanced training but does read about new environments and techniques before trying them. After receiving his entry-level scuba certification he studies advanced diving texts and equipment manuals and has basically learned by doing.

Another active diver from Portland, takes a more conservative view of his diving skills. Certified for 15 months, he answers the "experienced diver" question with qualification. "I have 65 dives, all but two in tropical water. Since we have completed Advanced training and a number of Specialty courses, I feel experienced in those areas, but only in warm water. Put me in cold water and I'm a novice." he said. His outlook is a bit more realistic than his younger peer from California.

Most informed divers and dive professionals agree with the latter rationale. You may be experienced in one type of diving, but when presented with a different type of environment, you have to pause and learn before proceeding. You possess a foundation of basic diving skills but need to acquire the proper techniques to handle each new situation.

Dive industry professionals, instructors, divemasters, and dive store and resort personnel often use slightly different criteria for determining if divers are experienced. Most don't view experience merely by number of dives, but also by the diver's attitude and actions.

The paperwork required from diving guests at one dive destination asks if you are an experienced diver, then defines "experienced" as someone who has done at least 20 dives in the past year. This gives the dive center a feel for the amount of time a diver spends underwater, but if all 20 dives were done from the shore of a shallow, murky lake, this person may not be ready to dive coral walls from a boat -- at least not without a detailed orientation to boat and wall diving.

"Experience is a state of mind reinforced by practical application," is how a dive operator at a popular resort defines the term. "If a diver has done the type of diving being proposed and feels comfortable and confident about it, I consider her experienced at diving that environment. If, however, they are new to this type of diving, most people consider themselves inexperienced."

According to one dive guide as a Pacific resort destination, diving experience is expressed as an attitude. After giving the question careful thought, she offered a definition of an experience diver as one who "respects the underwater environment, is comfortable in the water, has excellent buoyancy control, is open to learning, and is honest when responding to the dive guide's questions."

It's easy to tell if a diver is outside his comfort zone. Just watch the bubbles, If they are huffing and puffing like a train, it's obvious they are not comfortable and probably inexperienced. It's important that divers be honest with the dive staff and themselves. If a diver isn't physically or mentally prepared for the dive being planned, he should let that feeling be known.

Many dive professionals recognize experienced divers by their actions; how they act around the dive store, on a charter boat, and while underwater. As one dive store owner explained, "If a diver stands around my store bragging about how deep he's gone, and how many solo dives he's done, I don't consider him a truly experienced diver." Experienced divers just seem to fit in. They'll discuss their diving adventures if asked, but they don't use their experience as bravado.

On dive charter boats experienced divers are the ones who practice proper boat etiquette. They keep their gear stowed as directed by the boat crew. They pay attention during the boat and dive briefings, even if they've heard it before; and their equipment is assembled, adjusted, and tested long before it's time to enter the water. Experienced divers don't force their diving wisdom upon novice divers. They offer advice and suggestions only when appropriate, and then in a tactful, non-condescending manner.

A feeling shared by a majority of charter boat crews is that truely experienced divers don't assist with boat crew and divemaster duties unless there appears to be a definite need and they first ask permission. And if the help is refused they accept it graciously and are not offended. Experienced divers don't require or demand special attention. They are willing to help if needed, but otherwise they are satisfied to be one of the crowd.

Following the directions of the divemaster is another virtue of experienced divers. On the dive, they adhere to the planned profile and dive guidelines. If they are to be back on the boat in 40 minutes or when their tank reaches 500 psi, you can count on the experienced diver being there. They enter and exit the water as directed and respect the buddy team concept.

Being experienced doesn't mean you are exempt from following the rules. for example, if everyone is directed to remove their tanks and buoyancy compensators in the water before climbing back onto the boat, experience divers follow the instructions that have been given.

Just because the divemaster may climb the boat ladder with equipment in place isn't a reason for a macho, "watch me I'm experienced" diver to try the same thing.

As recognized by most dive professionals, experienced divers are aware and concerned divers. They know what is going on around them underwater and place conservation high on their list of priorities. The truly experienced are considerate of other divers and dive to the experience level of their buddy. If teamed with an inexperienced diver, they dive within the novice's comfort zone, not their own.

In the water, experienced divers possess a certain poise. They are weighted correctly, and descend and ascend slowly and effortlessly. They don't struggle to get below the surface and flail awkwardly to move at depth. They use lung volume to fine-tune buoyancy and require a minimum of air in their buoyancy compensator. They have the hydrodynamic attributes that cause you to think, "There is a good diver," upon seeing them underwater.

The best way to gain diving experience is to dive. Some divers learn from other certified divers, others participate in organized group dive trips, and many take additional training.

Regardless of the method you choose for expanding your comfort zone, if you don't dive, you won't become an experienced diver.

Learning from other certified divers allows you to log additional dives without attending a training session, but it can also be a risky approach. although you will be experiencing new environments and broadening your comfort zone, it's important that you master the correct techniques.

If your mentor learned kelp diving from his buddy, who was taught by a friend, who tagged along with his friend's father, much could have been lost in the transitions. You will be gaining kelp diving experience, but the skills and procedures might be incorrect, outdated, and even unsafe.

The potential pitfalls of learning only from other certified divers became painfully obvious for one diver when she was a novice diver. She had gone to the Bahamas to "dive the wall" with three macho divers who were masquerading at being experienced. The dive plan was 130 feet for 8 minutes with a safety stop before surfacing. They planned to back roll from the small boat and head for the bottom. On cue, they all rolled over the side and began a rapid descent.

The novice diver, doing her first back roll entry and by far the deepest dive of her five-dive career, became slightly disoriented after hitting the water. By the time she regained composure her "experienced" buddies were nearly out of sight. All she could think about was being left behind. so she kicked hard toward their 130-foot rendezvous.

During the excitement of trying to catch her so-called buddies, she forgot about equalizing the pressure inside her mask, which on a 130-foot dive, can become significant. The result: an unbelievable case of mask squeeze. Along with the pain and embarrassment, the entire area covered by her mask remained bloodshot for several weeks. Needless to say, the next time she wanted to try a new diving adventure, she visited the local dive center for a thorough orientation.

Participating in group dive trips organized by a local dive center is a good way to gain experience. There is usually a divemaster or instructor in charge who will watch over you, if necessary. You will also learn by osmosis. Just being around a group of more experienced well-trained divers usually has a positive impact.

Keep your eyes and ears open and ask questions. If you are not sure about something you observe, or encounter conflicting techniques, ask the divemaster leading the group for an opinion.

The safest and surest way of gaining quality diving experience is to enroll in advanced training classes. You will learn new skills and increase your time spent on scuba while under the supervision of trained professionals. As you encounter new situations and become more proficient at buoyancy control and advanced diving techniques, move on to specialty courses and possible leadership training. Whenever diving an unfamiliar environment or experimenting with new techniques or equipment, for the best results, consult a qualified dive professional.

Whether you are a seasoned aquanaut with hundreds of trips beneath the sea or a novice just beginning to appreciate the fascination of the underwater world, numbers alone don't qualify you as an experienced diver. It's an attitude; an awareness which you demonstrate on each dive. Being experienced is the ability to recognize and admit that you don't know it all, and the desire to expand your comfort zone. After all, an experienced diver is always training and beyond just being "experienced" is also "wise."

REMEMBER:

EXPERIENCED DIVERS -

- Have their C-card with them when at the dive site.
- Maintain a log book.
- Have their own dive equipment.
- Maintain their equipment in proper working order.
- Follow safe diving practices.
- Maintain diving fitness.
- Dive whenever possible
- Follow the divemaster's directions.
- Practice proper boat diving etiquette.
- Dive to the level of the buddy's comfort zone.
- Respect the environment and fellow divers.
- Exhibit excellent buoyancy control.
- Dive conservatively.
- Offer advice to novice divers only in a polite, non-condescending manner.
- Know how much weight they require.
- Have an alternate air source.
- Realize that diving deep or solo isn't an indicator of experience.
- Admit that they don't know everything about diving.
- Place safety first.
- Seek professional guidance before diving an environment with which they are unfamiliar.
- Seek professional guidance before using new diving techniques or equipment.
- Move slowly and efficiently through the water.
- Recognize their limitations.
- Go to the person most directly involved if you see or hear of a dive practice that bothers or concerns you and ask them about it.

- Stay abreast of new/updated diving techniques and equipment.

EXPERIENCED DIVERS DO NOT -

- exceed their own comfort zone without preparation.
- exceed the planned dive profile.
- dive over weighted.
- interfere with charter boat crew or divemaster duties.
- mix alcohol and drugs with diving.
- hesitate to ask questions.
- spread stories or rumors about other divers or dive organizations.

Sharks and Divers

Not too long ago , a man snorkeling off the beach in Fort Lauderdale, Florida, was bitten by a small, 3-foot nurse shark. What followed was a brief but intense flurry of publicity and media attention concerning the safety of swimmers and the perceived dangers of sharks.

The fact that the bite was probably a case of mistaken identity -- the man was spearfishing and visibility was extremely poor -- was overlooked by the media, who instead concentrated on the fact that the snorkeler had to swim back to shore with the small shark still attached to his arm, where two police officers then killed the fish.

The sensationalization of the event once again reinforces the public's belief that all sharks are savage attackers, viciously biting anything in their paths.

Since man first entered the sea, the shark has occupied a prominent place in our minds and has served as a source of both reverence and fear. Among some traditional Pacific cultures, the shark is even worshiped as a god.

Around the world, the shark has been depicted as both an emissary of death and a symbol of power. From pictorial representations left on case walls by early man to the hand-written journals of prominent historians and scholars, the shark has been a source of fascination throughout history. This fascination continues today, evidenced by the popularity of books and films such as Jaws.

But unfortunately this fascination doesn't always produce a complete and rational understanding of the shark. For most people, including a surprising numbers of divers, the shark still suffers from a largely unjustified bad reputation.

SURVIVORS:

Compared to our own relatively short existence on earth, sharks have been around since the Devonian period, some 350 million years ago. Of the more than 21,000 species of identified fish in the world's oceans, only several hundred are sharks.

For such a small group they occupy a surprisingly wide range of habitats, including all the oceans, though mostly in the temperate and tropical regions. Their range includes depths of over 3,000 feet and, on occasion, bodies of fresh water.

From the impressive to the bizarre, they come in a wide variety of sizes. At one end of the spectrum is that massive whale shark which can obtain a length of up to 60 feet and is the largest fish in the sea. At the other end of the scale is the tiny male cigar shark, which attains a maximum length at full maturity of about 6 to 7 inches.

Of the approximately 250 known species of shark, fewer than 10 percent are considered truly dangerous. The rest, if left alone, have absolutely no interest in man. And even those in the 10 per-cent category seldom pay any attention to us. Customarily, people are not a normal food source for sharks, but attacks do happen.

On average about 100 person per year -- worldwide -- are attached by sharks, according to the International Shark Attack File (ISAF), first brought to the public's attention by H. David Baldridge, Ph.D., in his 197 book Shark Attack. Fewer than 50 percent of these incidents end in fatality. To place this number in perspective, relative to the millions of people who enter the oceans each day, approximately 300 people per year in the U.S. die from such seemingly unlikely causes such as being struck by lightning or stung by a bee. Surprisingly, most shark attacks (around 95 percent) are not a case of man being preyed upon as a food source. Instead most involve a single bite with the shark letting go and with no further assault attempted by the same animal.

Based on the ISAF and studies conducted by behavioral researchers like Dr. Eugene Clark, John McCosker and Richard Johnson, every shark attack has a reason behind it. Most often, sharks aren't biting because of a hunger for human flesh. Most attacks are thought to be either cases of mistaken identity where the shark mistook the information received (sound, smell or vibrations) as coming from a normal source of prey, or a defensive reaction when the shark was disturbed in some fashion.

Our ability to understand the motive of a given attack is hindered by the abundance of popularly held misconceptions about these predators. The most classic is that sharks are insatiable eating machines and relentless killers. If this were the case, few people entering the sea would return unharmed. William Beebe, a famed ichthyologist of the 1930s and '40s, referred to sharks as nothing more than "chinless cowards." Actually, sharks are less barbarous in dealing death than many other ocean hunters such as billfish, tuna and killer whales. In addition, sharks don't need to eat all the time. Compared to most other types of predators in the world, sharks are actually light eaters, feeding on the average of two to three times a week and needing to take in only five to 14 percent of their body weight at a time.

MASTER HUNTERS:

Sharks are master hunters, equipped with a battery of finely integrated senses for finding food. They are among the most efficient predators in the marine realm, a status which is seldom challenged. For long-range detection and location of potential prey, sharks depend mostly on vibrational stimuli (sound). In numerous studies, the first conducted by field researchers Dr. Donald R. Nelson and Dr. Richard H. Johnson, sharks have demonstrated they're capable of hearing low-frequency vibrations in the 10 to 800 hertz (cycles per second) range, such as those emitted by a struggling, wounded or actively feeding fish.

During controlled tests, sharks repeatedly were drawn from as far away as a thousand feet when recorded sounds similar to those of a wounded fish were played. Once in closer range, the shark's olfactory (smell) and ocular (vision) senses kick in, and it can pinpoint the source of the disturbance. For some time, we have known that sharks can perceive body fluids (blood, urine and so forth) diluted to as much as one part per million. More recently, the popularly conceived notion that a shark has extremely poor eyesight has been rebutted with evidence that it can see basic shapes and patterns quite well. Some species may even distinguish colors. The shark's greatest failing, however, still appears to be its acuity, or the inability to discriminate fine detail, shape or form. In cases of attacks caused by mistaken identity, the victims probably acted in some way that caused them to either appear and/or sound like the shark's normal prey.
The result of this misinformation is often a predatory attack. For example, the silhouette of a surfer on a board seen from below may resemble a seal or turtle floating on the surface. Because the shark is unable to discriminate fine details, it may strike. By the time the shark realizes it has made an error, the victim is injured.

While mistaken identity is considered the most common cause of shark attack, there is sufficient evidence that many of the remaining reported incidents are the result of a shark being provoked. Most animals, when threatened or feeling threatened, instinctively will either flee or fight. The two most common ways to elicit this response from a shark is to attack, molest or corner it, or to infringe on its territory. This is much the same as venturing into someone's backyard where there is a dog. The more you advance, the more the dog becomes agitated to the point of either backing away or biting you.

PERCEPTIONS AND REALITY:

Hollywood and, at times, the media sensationalize and capitalize on the shock value of the shark's "beastly" image. This coverage encourages, the public to regard these magnificent creatures in an unfavorable light. Granted, like any large animal with teeth, sharks can be dangerous. If one were to review all the facts, however, they would indicate that it is only under rare or extenuating circumstances that the shark has been known to attack man. What most people are not aware of, or perhaps don't even care to know, is that when we enter the sea, whether swimming, surfing or diving, at one time or another we probably have encountered a shark. The shark usually sees and/or hears our presence and inadvertently is frightened away or departs due to lack of interest. With such acute senses they know we are there long before we think they do.

As man learns more about sharks, he discovers a little more about himself, most notably his fears. Hopefully, with our new understanding, we can gain a better perspective on sharks and the hazards they can impose, and permit them to be seen as the majestic predators they are. Simultaneously, we might allow the shark to fulfill the role which nature ordained. After all, there are no villains in the sea.

SHARKS COMMONLY SEEN WHILE DIVING:

While a growing number of the sport diving community consider it a rare and rewarding thrill to see a shark during a dive, there's still a majority who consider such an encounter, whether intentional or not, as the least comforting type of confrontation they could experience. The likelihood of seeing sharks under normal diving practices is not all that great; encountering sharks is usually a rare occurrence. Of the variety of sharks in the world, only a moderate number are likely to be seen, whether planned or unplanned. These species are prevalent in reef-type communities at 10 to 150 foot depths. Although other species occasionally will frequent these areas, they are less commonly seen by divers.

Nurse Shark: Reported to reach a maximum length of 14 feet, the nurse shark is seldom larger than 5 to 9 feet. It's perhaps one of the most commonly observed sharks by divers and snorkelers in the tropical and subtropical oceans. With a body coloration varying from light gray to yellow-brown, it's most easily identified by its resemblance to an oversized catfish (broad-shaped head with two barbels hanging from the underside of the snout). Most abundant on sand and mud flats and in shallow reef areas (2 to 60 feet), nurse sharks are typically seen lying under ledges and overhangs. Normally shy around divers and snorkelers, the nurse shark sometimes will lie motionless when approached. Although considered non-threatening, they do have a good reputation for biting when provoked and sometimes hang on with a bulldog-like tenacity. This usually occurs when they've been molested to the point of retaliation. Best advice when you find this shark: Look but don't touch.

California Horn Shark Of the eight species of bullhead sharks in the Pacific and Indian oceans, the one most familiar to California divers is the horn shark. Like all bullheads, the horn shark is identified by its broad, blunt-shaped head with pig-like snout and pronounced crest over each eye. Unlike most sharks, bullheads have an armament of two sharp spines, one in front of each dorsal fin. Seldom exceeding 3 feet, it is a predator of small invertebrates such as crab and shrimp. Sluggish and reclusive, bullheads are a denizen of the shallows, preferring habitats with rocky bottoms for hunting and taking refuge. Because of their size and nature, horn sharks shouldn't cause any concern unless they're seriously provoked. Some people aren't even aware that it's a real shark.

Nurse Sharks: Common from southern Alaska to Southern California, angel sharks are identified by their flattened, ray-like appearance and mottled coloration on their back. Often seen lying partially buried on the sea floor, it hunts by means of ambushing small fish that pass close to it. Shy and secretive, it poses little to no threat to people. The largest angel shark recorded measured close to 7 feet, but its usual maximum length is 5 feet.

Whitetip Reef Shark: Abundant throughout the Pacific and Indian oceans, particularly in the eastern Pacific from Mexico to Colombia, the reef whitetip is one of the most common sharks encountered on all types of reefs. Known to reach a maximum of about 6 feet, they're long, slender sharks with light to dark gray body coloration with conspicuous white tips on the upper tail, dorsal and pectoral fins. Predominantly bottom-oriented, it normally stays close to rock and coral outcroppings. The reef white-tip often can be seen resting under ledges or caves, Unless stimulated with food or aggressive behavior, whitetips tend to treat divers with almost complete indifference.

Graytip Reef Sharks are found widely in tropical and subtropical waters of both the Pacific and Indian oceans. They are one of the most abundant sharks in the central and western Pacific. Seldom exceeding 6 feet, the gray reef prefers to inhabit outer reef edges and drop-offs, where they commonly congregate in packs. As the name implies, they're identified by their basic gray coloration, some dark markings on the fins, a broad black band on the tail and white belly. In disposition, grays are innately curious and bold, sometimes making a pass as close as 3 feet to a diver. Under stimulated conditions such as spearfishing or chumming, grays become highly active and aggressive, making them potentially dangerous. Also territorial, this variety is most known for its defensive and antagonistic posture displays.

Atlantic Or Caribbean Reef Shark: Very similar in build and coloration to the gray reef shark, with the exception of lighter markings on fins and tail, these are fairly common sharks on shallow and deep reef in the tropical Atlantic and caribbean, particularly the Bahamas. Although considered dangerous when in the presence of spearfishing or baiting activities, the Atlantic reef shark is customarily a wary creature. It has been known to move away when approached by divers.

Blacktip Shark : Bearing a similar color pattern as those on grays and Atlantic reefs, the blacktip is most easily identified by a more sharply pointed snout and black tips on the fins. With the Pacific variety, the black tips on the dorsal and peck fins are sometimes reduced. A regular inhabitant of shallows and near shore reefs, they're also frequent visitors to outer lying reefs where they could be mistaken for reef sharks. Found in all tropical and subtropical oceans, blacktips seldom exceed 7 feet. The temperament of this species is more shy and less aggressive, even when stimulated by the presence of food. Yet, because it has been implicated in some attacks on humans, it is considered potentially dangerous.

Bull Shark. When it comes to having a reputation, this fellow is widely known as one of the top three "bad actors." Although it isn't seen sa commonly as the blacktip, the bull shark is most often found in the warm water regions of all three major oceans, While their range extends mostly to coastal areas, bays and estuaries, especially in shallow turbid waters including various rivers and lakes, they may frequent inner and outer reef areas. Bulls are most easily identified by their robust, stocky build, relatively blunt snout, medium to dark gray coloration on the back (sometimes with a touch of bronze), and pale underside with no markings on the fins. Reported to have taken a large number of attacks on swimmers, they're generally considered dangerous.

Blacktip Reef Shark Of all the inshore reef shark belonging the genus Carcharhinus, the blacktip is the most handsome of the lot. The basic coloration of this species is light gray with beige or brownish overtones, and prominent black markings on the tips of their fins; the one on the dorsal is accentuated by a white band underneath. Sometimes seen over outer reef drop-offs, they prefer the clean shallow waters afforded by inner reef structures. Seldom reaching more than 5 feet, blacktips are regarded by many divers as timid and easily frightened, even though some authorities consider them an aggressive and potentially dangerous species.

Lemon Shark. The lemon shark was named, not so much for a sour disposition, but for its yellowish gray/brown color. They are predominantly inshore inhabitants and often take refuge in lagoons, bays and estuaries. Like most inshore sharks, the lemon is capable of resting motionless on the bottom. Found widely throughout the tropical Atlantic and Caribbean, it's believed that the tropical Pacific species may be one in the same. While it's reported to have attacked man, most often in the shallows right off beach areas, the species seems to show a reluctance to approach divers even when baited.

Great Hammerhead Shark. Of the eight or nine species of hammerhead sharks, none save the scalloped hammerhead is as heart-stopping in appearance and size as the great hammerhead. Able to attain a length of more than 20 feet, this open-water shark is widespread throughout the tropical and subtropical oceans of the world. Easily identified by its distinctively hammer-shaped head, the shark's two lateral projections are presumed to serve as a forward plane for greater maneuverability. With eyes located at the ends of these projections, there's no mistaking what it is when seen from above or below. Commonly feeding on rays and tarpon, the hammerhead is a frequent visitor to inshore waters and reefs. Although considered highly dangerous, they are generally wary of diver activity and may move away when approached.

Galapagos Shark Although found throughout the topical and subtropical oceans of the world, the species tends to be insular and coastal in distribution. In the eastern Pacific region from Mexico to Colombia, they're one of the most abundant sharks belonging to the genus Carcharbinus. There's no distinctive coloration on this species, it has a medium to dark gray body with white underparts. Generally an inshore shark, it's also commonly seen near island drop-offs and banks, sometimes traversing large stretches of open water. Like the gray reef shark, the Galapagos shark is often curious and at times brazen. Even without feeding stimuli, they've been known to act aggressively.

Zebra Shark Of all the reef-dwelling sharks in the world, few have as fanciful a physique as that of the zebra shark. The shark's appearance is unmistakable. With the ability tog row up to 9 feet, it has an unusually long tail (almost as long as its body). The frame of the zebra shark is moderately stout with a broad, bluntly rounded head and several dorsal ridges running the length of its back. Although its coloration may vary from light gray to yellowish gray, as an adult, its body is heavily marked with small brown or black dots. Found mainly in depths of 20 to 150 feet in the tropical regions of the western Pacific and Indian oceans, they preferred habitat is around reef areas with large coral heads or gullies and wise sand bottoms. Primarily a bottom predator of small fish, crabs, mollusks, shrimp and other invertebrates, the zebra is shy, retreating from divers if spooked.

Scuba Tanks

Until the late 1940's, a hydrostatic test once every five years was effective in detecting normal wear and tear on high pressure gas cylinders. Then, as scuba diving began its steady ascent into popularity, the situation altered. Along with an increase in the number of scuba divers came an increase in the use and handling of high pressure cylinders around corrosion producing elements and potential sources of contamination.

As a result, today in addition to the hydrostatic test, other maintenance procedures are necessary to insure the integrity and continuing use of high pressure cylinders for scuba diving. Compressed air cylinders require special precautions in maintenance, handling and storing to insure maximum tank life and optimum safety for the diver.

ABOUT STEEL TANKS:

Exterior Coatings - All steel tanks manufactured for scuba today are galvanized (coated with zinc) to prevent rust from forming on the bare steel. This is the best method of exterior tank protection. A zinc coating exhibits a gray to silvery appearance, characteristic of a majority of steel tanks. Epoxy or vinyl coatings are used in conjunction with a zinc coating, since they do not last long enough by themselves to provide adequate protection against rust. They protect the zinc from chipping and also add an eye-appealing coat of color or finish to the tank. Some earlier types of tanks were not protected with galvanization, and they generally require more maintenance since they lack the protective undercoating of zinc.

Interior Linings - To protect the interior of the tank from corrosion caused by moisture entering the tank, some manufacturers lined the interior of the tank with either a white coating of paint, a blue plastic coating, or a reddish-brown epoxy coating. When applied properly and evenly, these coatings were effective in preventing water from coming in direct contact with the interior of the tank walls, thus discouraging the formation of rust. Most of the tanks manufactured between 1954 and 1974 contained some type of interior lining.

Today, however, all manufacturers of scuba cylinders have discontinued the use of interior linings in tanks as a result of maintenance problems generated by the linings. If even the smallest pinhole develops in the lining, moisture can find its way under the lining. Rust will begin to form, eventually working its way under the lining and lifting it loose from the tank as the corrosion spreads. This process is almost unnoticeable to the naked eye.

Also, some linings have a tendency to flake off after just a few years in service. If these tiny particles go undetected, they can travel through the tank valve and into the regulator, causing contamination to both. don't completely trust a lining to protect the interior of a tank. A lined cylinder should be inspected just as frequently as an unlined cylinder, and the lining should be removed at the first sign of deterioration.

Corrosion - Corrosion in steel tanks involves an oxidation process whereby oxygen in the air combine with the iron, causing a deterioration or "eating away" of the metal. The residue formed by this process is called rust, or iron oxide. Rust is the number one enemy of steel tanks. Steel tanks will rust readily, while aluminum tanks do not rust at all)though they do have their own peculiar brand of corrosion called aluminum oxide). Normally, the oxidation process in steel occurs very slowly, or does not occur at all if the metal does not come in direct contact with oxygen. However, when the bare metal is exposed to both oxygen and water vapor, the oxidation process accelerates. and exposure to salt water accelerates the process seven more. Salt water in steel tanks can ruin the tank in less then three months, rendering it useless for compressed air storage.

ABOUT ALUMINUM TANKS

Construction - Aluminum tanks were first introduced commercially into the United States in the early 1970's, although other types were used in Europe as early as 1930. Since pure aluminum is too weak to withstand high pressures, the aluminum used to manufacture scuba tanks is actually an aluminum alloy, whose additive endow the metal with high strength and corrosion resistant properties. Some aluminum tanks are protected with an anodized coating on the outside, and most are painted externally
with a polyurethane enamel.

Corrosion - aluminum tanks are more resistant to corrosion due to characteristics inherent in the metal itself. Rust (iron oxide) will not form on aluminum, and aluminum tanks are not susceptible to the corrosive effects of oxidation found in steel tanks. The corrosion that does take place on aluminum tanks produces a thin, powdery substance called Aluminum Oxide. This thin residue adheres to the bare metal underneath and actually protects the metal from any further corrosion.

EFFECTS OF CORROSION:

Corrosion in steel tanks may range from a light surface coat the consistency of dust, to severe pitting or cratering which can eat its way through the walls of the cylinder very quickly. A light coat of corrosion may be removed by having the tank tumbled by a reputable facility. However, if the damage is too severe, the tank will have to be condemned and can not be used for the storage of pressurized gases.

Besides damaging the tank itself, an accumulation of corrosion in a tank can also cause other problems. Tiny corrosion particles can become lodged in the tank valve or regulator, causing malfunctions to either or both. In severe cases, the amount of oxygen within the tank itself is reduced. A diver using an extremely corroded tank could run the risk of becoming unconscious underwater, since corrosion accumulation in the tank could seriously deplete the oxygen in the air that is being breathed.

Corrosion in aluminum tanks will usually not cause serious deterioration of the tank, since once an adequate coating of aluminum oxide is formed, further corrosion ceases. However, the powdery substance can flake off from the cylinder walls and find its way into the valve or regulator. an aluminum tank should be inspected just as often as a steel tank.

REMOVING CORROSION:

Aluminum Tanks - Aluminum oxide will form on the tank exterior anywhere there is a nick, scratch or gouge in the protective coating, and the bare metal is exposed to the elements. A while, chalk-like deposit will form over the damaged area. The corrosion can be removed by using a small piece of aluminum wool or a square of wet/dry sandpaper of a light grit on the affected area. The edges should be feathered for repainting. If the damage is excessive, the entire tank may be repainted, or the damaged areas may be touched up with a like color of enamel.

A light coating of aluminum oxide in the interior may be removed by rinsing the tank with distilled water, then drying the interior thoroughly using an effective warm air flow source. The tank valve should not be replaced until all traces of moisture and foreign particles have been removed and the tank is completely dry inside.

If the tank is severely corroded, a visual inspector will usually recommend that the tank be sent to a hydro testing facility, where an assortment of different cleaning agents will be used, depending upon the severity of the corrosion. Aluminum tanks are soft and should never be subjected to a "heavy tumble" to remove corrosion. Tumbling the tank with hard abrasive materials (such as is done with steel tanks) may remove the inner anodized coating and can damage the bare metal.

Steel Tanks - Corrosion on the exterior of a steel tank may be removed in a variety of ways, depending upon the extent of the corrosion. The most common method of removing rust from the exterior for light surface corrosion is a light sandblasting. This removes all of the rust from the pores of the metal. The entire tank, or just the affected are, should then be recoated with zinc. If further protection is desired, a paint or epoxy can be applied. a zinc coating provides the best protection, as paint and epoxies may chip easily and don't last as long.

The Story Of A Fatal Dive

3 Youth Dive -- Only One Survives

Mark Roberts was 130 feet underwater when he began feeling the first intoxicating effects of nitrogen narcosis, or "Rapture of the Deep." Mark, 19 recalled looking quickly at his brother, Leonard, 18, on his right, and a close friend, Bill Harper, 18, on his left. They gave each other the A-OK sign and plunged further into the deepening gloom of the popular "Sandy Slide Trench" diving area about 200 yards off San Jose Beach near Carmel.

The three Los Altos area teenagers had been diving almost every weekend for the last two years and had several years of experience before them, but they never had ventured past the 160-foot level. This time -- for the same adventurous reasons mountains are climbed and jungles explorer -- their goal was 175 feet, knowing at that depth the tiniest mistake could be fatal, the effects of nitrogen narcosis unpredictable. Caused by nitrogen under excessive pressure the euphoric effect of nitrogen narcosis has prompted experience divers to rip off masks, spit out air hoses and turn on their backs to sink languidly to their death. At 150 feet, divers say, nitrogen narcosis can have the impact of three martinis on an empty stomach -- at 200 feet four martinis, though the impact differs with each individual.

As the trio descended, the last time Mark remembered checking his depth gauge with Any certainty was at 160 feet, the intoxicating effect of "Rapture of the Deep: already was numbing his senses. Here is his story of the tragic events of "Aug. 5 that followed:

"I knew I was getting nitrogen narcosis, but I thought I could fight it off. It really felt very nice -- peaceful. Everything seemed all right ... so relaxing.

The next time I remember looking at my gauge, my eyes were blurry -- tunnel vision -- I could only see a narrow space ahead of me. I think the gauge read about 180. I knew we had gone too far. Something inside me kept saying. Come up, come up, but I felt so relaxed I kept thinking 'just a little further, a little further -- everything will be OK."

Somewhere around 200 feet Mark started to black out. He jerked his thumb wildly upward to signal the others to surface. He shot toward the surface, his air bubbles streaming behind. At 100 feet Mark's head began to clear and he realized his fast ascent and the rapid pressure change could cause the "bends," or his lungs to burst.

Blood gushed from his nose -- a common danger sign that the lungs had burst.

Bill was hovering a few feet away. Mark gestured desperately for help.

But Bill was pointing frantically behind Mark to where his brother Leonard, should have been. "I turned around and there was nothing -- my brother didn't come up.

"I could see his stream of bubbles drifting up in a crazy pattern.

"I clasped my hands like a prayer to plead for Bill to go down after my brother. I knew I couldn't make it." Bill kicked toward the thinning stream of bubbles. Mark stayed at 50 feet.

"Soon -- I don't know how long -- Bill's bubbles were swirling all around me. It looked like two sets of bubbles." "I kept looking for them to come up." Then he spotted an object rising slowly from the darkness below. It was Bill's flashlight.

"I knew I had to go back down -- something had happened. As I followed the trail of bubbles I realized they were only coming from one person. Then my nose broke open again at 150 feet. My mask filled with blood. I cleared it but it kept filling up again."

"I was weak -- almost out of air. It was either surface or die."

Two diving instructors in the area rescued Mark and rushed him to a recompression chamber where he spent five hour for treatment of the "bends."

Leonard was found lying on a sandy slope at the 214-foot level, a victim of nitrogen narcosis. Bill, apparently delirious from extreme nitrogen narcosis, swam right past Leonard and crashed into the ocean floor at 240 feet, making a furrow in the sand.

Mark said he has been told over and over by well-meaning friends and relatives that the two deaths were not his fault, but he still blames himself. "I organized the dive. Everyone was relying on me to tell them when to come up. If I had only thought a little more -- grabbed my brother's leg to warn him -- not asked Bill to go back down alone -- not gone on the dive without four divers (buddy system) -- that way my brother would have had somebody with him."

"I've cried by heart out. I don't know what else to do. I don't think it has really hit me yet. People who know bill and my brother really well say they are laughing at me for feeling so sorry for myself. Everybody says that life must go on -- I guess it must. But I want to tell the world what happened. Maybe it will help somebody come up alive."

Scuba Fitness

In Scuba, if you are working too hard, you must be doing something wrong. It is essential for divers to have a thorough understanding and mastery of the physical skills required for diving in order to meet challenges that may arise during the dive. working hard when you are diving not only increases your risks, but it defeats the purpose of diving in the first place -- to enjoy yourself.

Divers have been known either to overestimate their abilities or underestimate the diving conditions. we all may have made mistakes in planning form time to time, Even with the right amount of planning, diving conditions may change dramatically after the dive has begun. When faced with the unexpected in diving, we may have to call upon previously untapped, and potentially unavailable, physical reserves in order to cope.

So make time to take a long look at your overall fitness. All divers must have adequate physical reserves which enable them to respond to sudden exertion without premature exhaustion. As a diver, if you have reduced exercise tolerance, you could place yourself, your buddy, or other divers at a significantly increased risk of injury.

As divers pass the age of 30 they begin to lose a part of what is knows as "organ reserve," or the capacity for overloading. In youth, for example, our hearts can pump 10 times the amount of blood required to sustain life; our kidneys are able to excrete six times the waste products that we produce every day. Other organs have similar reserve powers which, like those associated with the heart and kidneys, are fortunately seldom required.

After the age of 30, we begin to lose this reserve at a rate of 1 or 2 percent each year. We don't even notice the loss -- unless we are placed suddenly in a situation where we really need it. The loss of reserve power as you age means that you may find it increasingly difficult to return to "normal" after extreme physical stress.

Being aware of the changes our bodies will undergo as we age -- and taking steps to cope with the process -- is only part of the answer. The other is a thorough review of our personal approach and commitment to safe diving.

Take time to analyze your diving habits to determine if there is anything you are doing which increases the work of diving. It may be as simple as your approach to buoyancy control.

Overweighting, one of the most common technique errors in diving, compounds the work of diving. The overweighted diver compensates by adding air to the BC, which can create a seesaw effect. The resulting change in body position while swimming underwater presents more surface area than necessary, which can increase drag. A doubling of drag increases workload by a factor of four!

Also take time to analyze your limitations -- we all have them. Dive within your limits, so you can enjoy yourself and so you will look forward to your next dive.

Fitness for diving demonstrates that there is an inverse correlation between workload and enjoyment. If you have to work too hard at anything, it removes some of the pleasure you may derive from it. The thrill of diving should come from the experience rather than simply surviving.

Not all diving requires measures of great strength or endurance. Unlike commercial divers, recreational divers may select the time and place for their dives to match them to their own strengths and skills. We all agree, however, that no matter how simple and easy the dive, physical fitness actually adds to the pleasure and safety of the event.

Every dive requires some degree of work and exercise, which is often greater than the everyday demands on a body. This intensified muscular activity in turn increases the work of the heart in delivering oxygen and fuel to the exercising muscles. The heart and blood vessels respond to this increased load by adjusting blood flow and increasing its output via the heart.

Activities associated with diving -- carrying heavy gear, climbing ladders and swimming -- all require increased oxygen consumption. The normal heart has considerable reserve to help meet these demands, but in order to maintain this reserve at high levels you must maintain a program of "physical fitness."

What do we mean by physical fitness? Very simply: It is endurance or aerobic capacity measured by your response in oxygen consumption to an increasing work load. Your fitness level is determined primarily by your cardiovascular system. It is possible to have great musculoskeletal strength (as in a body builder) but still have poor cardiovascular reserve.

Near the age of thirty, both physical strength and exercise capacity begin a decline which continues throughout the remaining lifespan. The body's ability to achieve maximum use of oxygen in energy production reaches a peak in the late 20s and then begins a decline. This deconditioning is the result of many causes. Some are fundamental changes in physiology that come with aging. And if you follow an inactive lifestyle, these changes may be accelerated.

This reduction in physical fitness may be rapid or slow depending on each individual's physical condition and endurance training. the decline in physical endurance can be slowed. however, by certain conditioning programs. Known as the training effect, regular aerobic exercise programs augment and improve general physical performance.

The question "Are you in shape?" may be easy to answer -- or it could be difficult. Begin by asking yourself about several risk factors:

* How do you react to stress? Stress and stress-producing personality behavior patterns may place a strain on the heart. The body's hormonal systems behave today just as they have done since the Stone Age: When faced with a challenge, they speed up the heart rate and increase blood pressure to get you ready for "fight or flight." If you don't fight or flee, these hormones remain in the bloodstream for a time and keep the heart and blood vessels under a constant, low-grade pressure.

* Are you an active person? Inactivity is clearly associated with heart disease, according to many research studies. Active people have better hearts than do sedentary people.

Other equally important factors are high blood pressure an abnormal resting electrocardiogram, obesity, elevated cholesterol and diabetes.

Are you ready to start an exercise program? Here are some guidelines.

If your age is less than 30 you are still not immune to heart disease although your risk is lower than for older persons. You should have a complete medical history and physical examination sometime in the 12 months before you begin your exercise program.

* If your age is between 30 and 35 you should have had a complete history and physical examination including a resting electrocardiogram sometime within six months before you kick off your program.

* If you are over 35 the examination should have been done within three months before beginning your new protocol. The examination should include an exercise test with monitoring by electrocardiogram, or a stress ECG.

If you cannot obtain an "exercise prescription" then you may obtain one of the books on aerobic conditioning found in most bookstores. Kenneth H. Cooper, M.D. has written a series of these books. These books provide detailed instructions on starting an exercise program safely while avoiding injury.

Keep in mind that some recreational activities are enjoyable but have little or no benefit for your cardiovascular system. Approach your program on a gradual, step-by-step basis. Exercise and cardiovascular fitness also affect your mental health. Numerous studies have confirmed a link between physical health and psychological well-being.

If you are out of shape, you are our of sorts with yourself. Take better care of yourself, get fit and enjoy this great sport of ours.

Water Workouts

WATER WORKS:
Exercising in a pool can give your muscles a burn not even water can cool off!

Water is one of the best resistance mediums around, providing all the benefits of a gym and running track without the same risk of injury. You can train both your muscles and cardiovascular systems at high intensity without pounding your joints, tendons and ligaments. Incorporate water exercise into your training.

THE FULL BODY WORKOUT

Depending on how many reps and sets you do, this routine can take 20 minutes or longer. It replicates a high-rep, low-weight resistance workout, and if performed vigorously should take care of your cardiovascular needs as well. Add some water running if you want to extend your workout. Take to the pool three to five times a week, and your body will be in the swim.

Perform this routine in a sequence in chest-deep water. A warm-up isn't really necessary, since the water resistance slows your movements enough to make the risk of injury minimal. For sets and repetitions, follow these guidelines:

* If you have been doing aerobic activities two to three days a week for four months or longer, start with one set of 20 reps of each exercise. Add reps up to 30, then move on.

* If you have been doing aerobic and anaerobic exercise three to four times a week for six months or longer, do one set of 30 reps of each exercise and progress to two sets of 20 reps.

You can always just run in the water, but to get the most benefit from it try anaerobic interval training; those all-out bursts of speed increase the body's ability to transport and use oxygen. Although intervals are primarily used by competitive athletes, they are also a way to create a workout that features high intensity and variety.

For runners, intervals are characterized by an intense, staccato pounding of the feet and legs, and a corresponding jerking of the joints and limbs. All of that is minimized in the water. It also lets cyclists or other athletes who have suffered an injury still get their anaerobic fix.

Lift your knees until they are bent 90 degrees on each stride, and pull your arms directly forward and back, with no lateral movement. Be sure the opposite arm and let work together. Once you have mastered good form, increase your leg speed. If you lose form, slow down, then try to increase speed again. Try this interval session:

* 15-second sprint, 15-second jog;
* 30-second sprint, 30-second jog;
*45-second run, 45 second jog;
* one-minute run, sprinting the last 15 seconds, one-minute jog.

1. LUNGE: In water up to your neck take a forward stride position with your right knee bent, right foot in front. Your left arm is forward for counterbalance. Jump up and switch arm and leg positions so the left leg and right arm are forward. Opposition is the key to this exercise, so make sure your right arm moves with your left leg and vice versa. Emphasis: quadriceps, hip flexors, gluteus maximus, hamstrings, deltoids, pectorals, latissimus dorsi.

2. SIDE-STRADDLE JUMP: Skip this exercise if you have lower-back problems. Begin bounding on both feet, legs together. Jump up, spread your legs apart, then pull them back together before landing. Bend your knees as you land, then immediately start the next straddle jump Emphasis: quads, hip adductors and abductors, glutes and hamstrings.

3. UP/DOWN PULL: Stand with your legs apart and both arms straight out to your sides, palms facing down. Pull your arms down until your hands touch in front of your hips. Then, without changing your hand position, lift your arms back to the starting position. Emphasis: pecs, lats, traps, delts, various upper-back muscles.

4. ARM CURL: Stand with your legs apart and both arms straight out to your sides, similar to the previous exercise, but with palms facing forward. Then forcefully pull your forearms in while keeping your upper arms in a stationary position. Next reverse the motion with vigorous outward thrusts, leading with the back of your hands. Pay attention to balance; it it's a problem, pack up to the side of /the pool to perform the exercise. Emphasis: biceps, triceps, wrist flexors and extensors.

5. POWER FROG JUMP: Bounce on both feet with your legs together and your arms to your sides for stability. Jump and lift both knees toward your chest. At the same time, sweep both hands forward to meet in front of you. As your feet return to the pool bottom, swing your arms back to their starting position. Emphasis: quads, hip flexors, glutes, hamstrings, pecs, biceps, triceps, delts, various upper-back muscles.

6. BICYCLING: So you don't overemphasize the quads, do at least a few minutes of this hamstring-intensive exercise for balance. Sit on a step or brace yourself at the side of the pool. Bend one knee, then the other as you kick in a bicycling movement. Lift each knee as close to your chest as possible and raise each foot out of the water. Emphasis: hamstrings, glutes, quads, hip flexors, hip adductors.

7. FRONT/BACK PULL: Stand with one foot forward for stability, arms stretched out to your sides, fingers together, palms facing forward. Pull your arms through the water to meet in front of you. Without changing your hand position, forcefully push your arms back to the starting position. Emphasis: pecs, trapezius, delts, various upper-back muscles.

POST-WORKOUT STRETCHES:

QUADS: Face the pool edge and place your left hand on the deck for balance. Grasp your right ankle with your right hand and pull your right heel up toward your right buttock. Keep your hips level and knees side by side. Maintain steady pressure while you breathe slowly and deeply five times. Place your right hand on the deck and repeat the exercise for the left leg.

HAMSTRINGS, GLUTES, CALVES, SPINAL ERECTORS, TRAPS: Lift your left foot straight in front of you onto the wall of the pool until you feel a challenging stretch. The more flexible you are, the higher your foot will be on the pool wall. Relax your shoulders, back and neck. Breathe slowly and deeply five times, Each time you exhale, try to relax more and gradually straighten the knee. If your knee is straight, try to get your heel flat on the wall as well. Repeat with your right leg.
