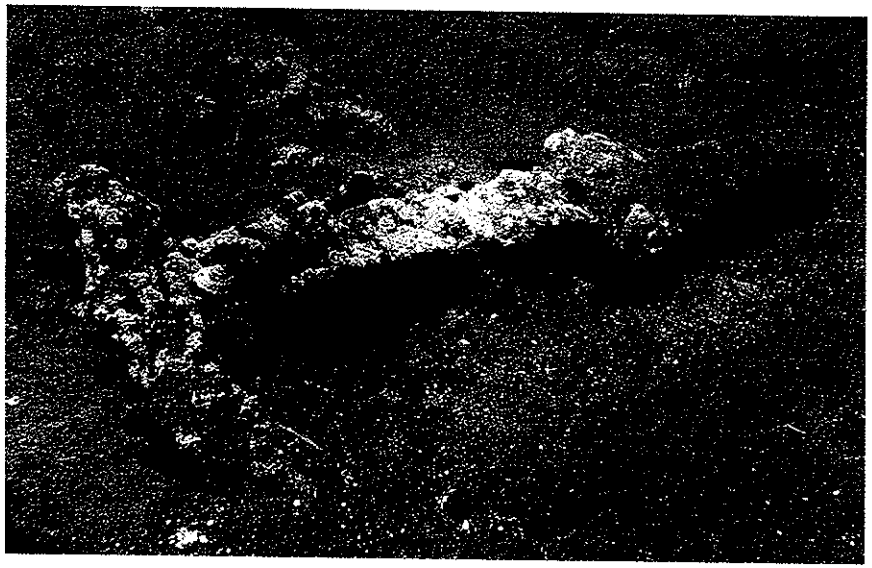
By C. Roger & M. Scott

Chapter 1

Eleven Keys to Natural under water Navigation

Remember; wherever you go, there you are.



Landmarks

One of the most useful techniques in under water navigation may be finding an under water landmark. Under favorable conditions, utilizing

visual markings can greatly increase the ability to find your way around your chosen dive site. Of course, underwater landmarks are not always an option. Under some conditions, such as low visibility caused by currents, rainstorms, suspended particles in the water, and poor lighting, it may be impossible to us this technique.

BOTTOM CONTOUR, such as canyon arches and rocks can assist you in your use of landmark observations. You may find that the dive location you've chosen has a distinctive canyon with which you can quickly become familiar. Similarly, some locations will have distinctive features such as underwater arches, memorable rocks, and/or some type of recognizable bottom markings.

It is possible for one to make their own landmarks. In some circumstances, you may find it is necessary to create some kind of underwater markings. You can pile up a mount of rocks to mark a location or use floating markers, above and below the water. You can mark off an under water location by using rope, twine or some other kind of long line. A dive float, which in some locations is a mandatory piece of diving equipment, could become a good reference point.

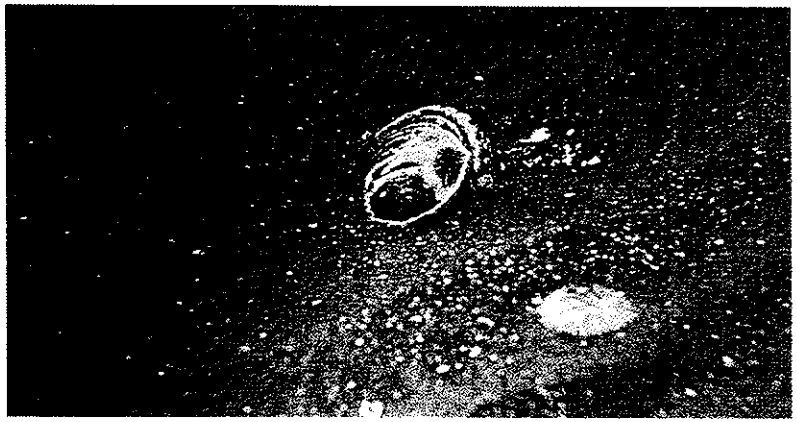


Diagram 1.2 Ripple Marks

RIPPLE MARKS are probably some of the most frequently used identifying marks utilized by beach divers. Ripple marks running parallel to shore are created or the wave's action moving toward shore, which forms

the rippling sand formations. "Ripples," just as it sounds, as they are much like the form of the waves themselves, as they are leading there way to shore. You are most certainly heading in the right direction if you have been following the ripples in the direction of the cresting or crashing waves (see diagram #1.2).

READING THE BOTTOM, especially when nearing the shoreline, is a good indication of direction. As the waves come in to shore, they pull the sand grains on top of one another creating the sand formations. Consequently, these ripples will generally run parallel to the shoreline, close together, with the lip of the ripple heading toward shore. Sometimes, with strong wave action close to the shore, they will take on the appearance of a diamond. The wave, after bouncing back from shore at an angle, will pull sand back with it. As the reflecting wave loses its momentum, the diamond shaped ripples will stop and the single sand ripple will remain. You can also watch for different types of rock, plants, and sea life that live closest to shore as part of reading the bottom. A diver that is familiar with the dive site will fine these factors useful.

LIGHT can also be used as a directional aid. By using the sun as your underwater sundial, you can create a reference point for yourself. Unfortunately, this technique is not very useful for divers in cooler waters. Visibility in colder waters is for the most part rarely clear enough that a diver would be able to determine where the light originates. In addition, in cooler waters that have low visibility, many particles will be presents that reflect the light, giving a misrepresentation of light direction. If you are going to use shadows under water as a reference, keep track of the time, or the shadows will shift and throw you off course.

PHOTOTROPISM refers to the depth at which various plants are found. These observations can be very useful indicators of your surroundings especially true when you are familiar with the diving location. A good example of such indicators is in southern California. The Santa Monica bay area are the sand dollar beds, usually found in around 14 to 20 feet of water. Remember that plants always grow toward the source of light. Therefore, if you get vertigo, you can reference yourself from the direction of the growth of the plants. Plants can also give you a clue about the direction of the current. Plants will always bend in the direction of the

current. If you can't see the kelp beds where you are supposed to dive, you probably don't want to dive because the current is strong.

TIME is another way to guide us from one point to another. By gauging how long it takes getting from one place to another can give you an idea of how far you have gone. To make this more of a science, you can take a given distance and time how long it takes you to go this distance at a relaxed normal diving pace. I suggest that you repeat the exercise four or five times to get the average amount of time. Unfortunately, currents and variances can cause inaccurate results. As a time reference, you can use air consumption as another way to gauge how long and how far you have traveled. Be careful though, this can be very inaccurate if your breathing rate changes during the dive or if there is any current.

DEPTH is a good indication of the direction you are going. The best example of its use is if you are on a beach dive. The closer you get to shore the shallower the water gets. The farther you go away from the shore the deeper the water gets. Your depth is helpful if you get lost and need a little help determining which direction you are going. This can also save you a trip to the surface to see where you are.

KICK CYCLES are a way of estimating the distance you've traveled. The way you perform a kick cycle is to kick once with both legs. That is, one kick with the right leg and one kick with the left leg. This constitutes the completion of one cycle. This is only useful if you know how far you can get with a kick cycle. To do this, take a given distance. Count the number of kick cycles it takes you to get to that distance divide that number of kick cycles into the distance.

Example: Let's take a given distance of 100 feet. Let's estimate that it would take us 28 kick cycles to finish 100 feet. Take that 100 feet and divided it by 28. This means that for every kick cycle you would travel 3.5 feet

This method will give you a good idea of how far you have traveled if not affected by current.

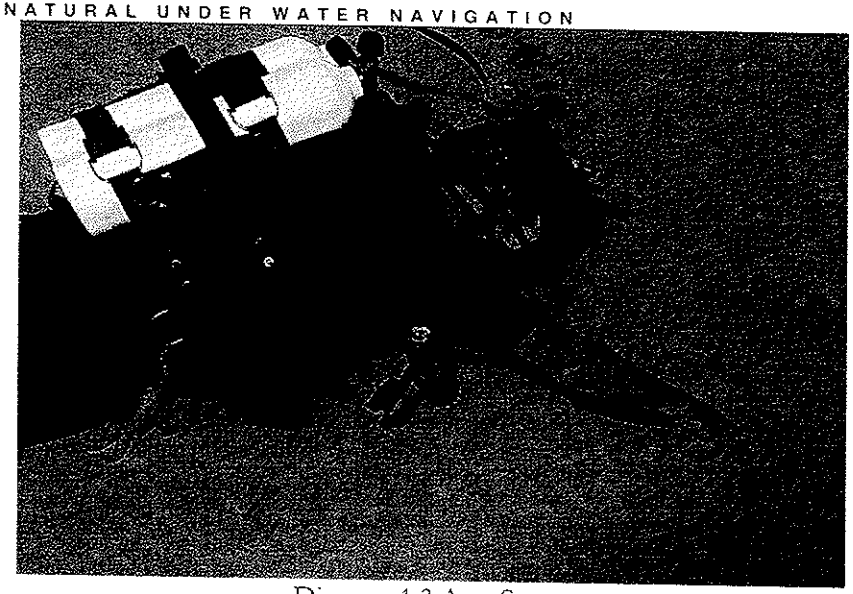


Diagram 1.3 Arm Spans

ARM SPANS can be a way to gauge the distance you have traveled. This is the best method to use if the distance you wish to go is short. If you take your arms and spread them out to your sides, the distance from your left fingertips to you right fingertips comes within an inch or two of your height. Keep this in mind as you perform arm spans. You perform arm spans by taking one of your hands and extending it out in front of you. You place that hand down and extend with your other hand. The distance that you end up with between your hands is about equal to your height. (See diagram 1.3)

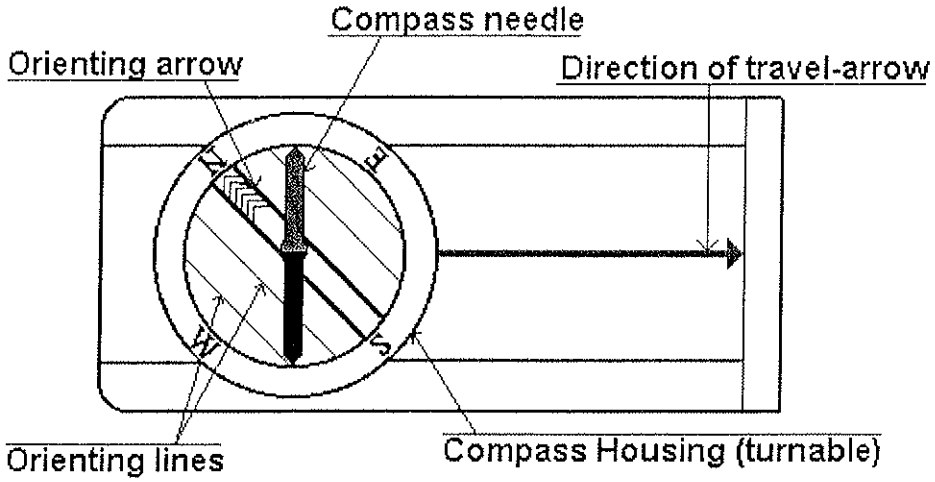
AIR CONSUMPTION rates are important because they to let the navigator know how much time remains to locate an object. Several factors must be taken into consideration for determining how long a tank will last: the volume of the cylinder, and depth required must enter into the diver's calculations.

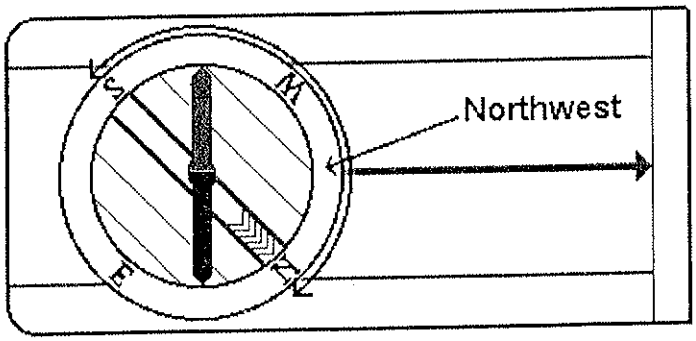
The volume of a tank is determined by the number of cubic feet that it will hold when it is filled to its working pressure. An 80 cubic foot cylinder contains a total of 80 cubic feet of air if it is fully charged to 3000 p.s.i. As the pressure drops, so does the tank's capacity (volume). At a pressure of 2500 p.s.i. the same cylinder now only holds 66.6 cubic feet of air, and then only if the temperature remains the same. If the temperature drops, the air will contract and the volume will be lowered.

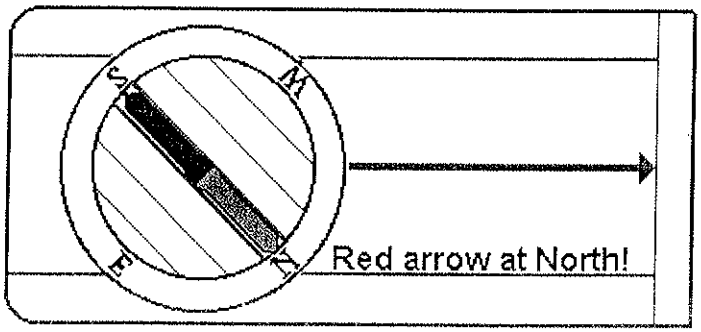
An underwater pressure gauge is necessary to give the diver a constant monitor on the remaining air supply. While the gauge is now being considered as a part of the diver's basic equipment, it must be used if it is to perform its function. It will not reach up and tap the diver on the shoulder and tell him to take a look. The gauge must be referred to throughout the dive.

As the ambient pressure increases on the diver with depth, the more air he will need. At 33 feet, he will require twice as much air as he would at the surface, so depth is also a primary factor in determining consumption rate. Finally, the diver's own personal rate of consumption must be calculated. Generally, the figure of one cubic foot per minute while resting at the surface is considered the norm, but additional work and the diver's own metabolism can easily change this.

This figure of two cubic feet per minute while doing heavy work or swimming rapidly can increase the consumption rate to three cubic feet per minute. Extreme conditions such as ice diving can cause the diver to consume up to four cubic feet per minute. Colder water draws away more heat and the diver's body naturally demands a more rapid respiration rate. Limited visibility can cause anxiety, which leads to an increased respiration rate. Heavier people with greater bulk require more air than a 97-pound diver, and so on.


Compass needle
Orienting arrow
Direction of travel-arrow
N
E
W
S
Orienting lines
Compass Housing (turnable)

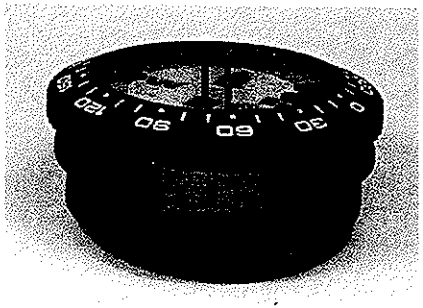

Northwest


Red arrow at North!

Underwater Compass

An under water compass is a specially designed piece of diving equipment and only such a device should be used in underwater navigation. Before we begin navigating, we need to become familiar with the different parts of our compass. The following is a list of the things with which your compass should be equipped.

LIQUID FILLED is the basis for the design of an underwater navigational compass. The difference here from a land compass is that by filling it with water the movement of the directional needle is dampened which keeps it from moving all about, allowing an easier view of your heading. The compass should be filled with a non-freezing liquid such as oil or silicone, to allow the needle to rotate properly and to allow for expansion due to temperature changes. The dampening of the needle allows the needle to rotate and lock into a reading without swinging back and forth once it reaches its position. Over expansion may occur, however if the compass is left in direct sunlight for a short period. The needle may be inaccurate.



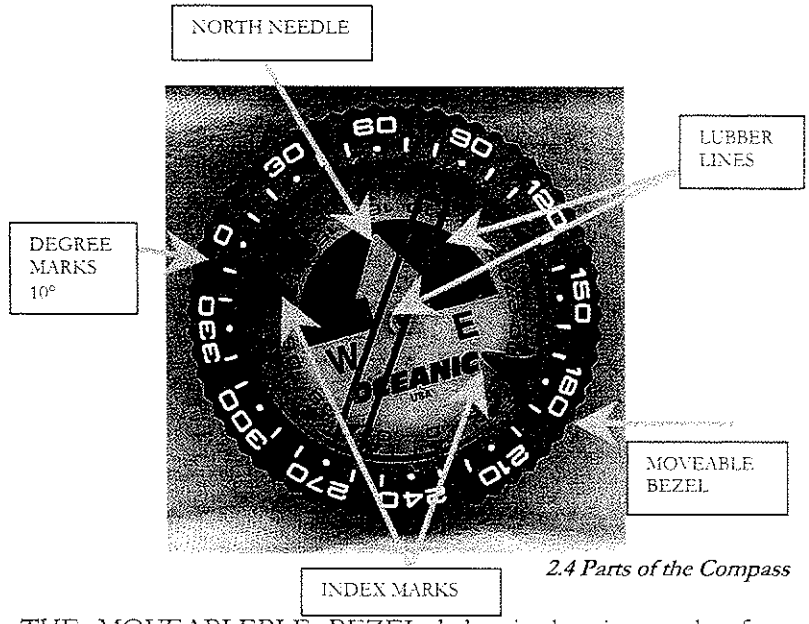
2.3 Side view of Compass

THE NEEDLE within an underwater compass is set in such a position that it will allow you to hold the compass in an uneven position while navigating. The compass should also have the capability of being tilted at a reasonable angle and still give an accurate reading. Some compasses will lock when held at an angle. This feature of the compass

is important because the diver himself is never truly level while swimming or suspended in the water

DEGREE MARKINGS are found on the moving bezel and around the floating needle. The degree markings should be in thirty-degree increments. There should be lines between the degree markings in ten-degree increments. These degree markings will help you stay on an accurate course. A mistake of one-degree will cause you to end up off course and somewhere you don't want to be.

LUBBER LINE is a line on the compass that is used to aid you in following a proper heading. This line will be obvious on your compass. As you dive, your body should be in a straight line with the compass bisecting (breaking it into two parts) it. The lubber line is there to aid you in bisecting your body by bisecting the compass. By using the line, you will be able to stay on the proper course.



2.4 Parts of the Compass

THE MOVEABLEBLE BEZEL helps in keeping track of your direction by allowing you to move the index marks to the location of the directional needle.

Care should be taken to pack it away immediately after use, preferably in a wet suit glove or boot for added insulation. As with any piece of diving equipment, the compass should be rinsed with fresh water and stored away from other gear that may damage it. It should be packed in a separate area from such objects as a weight belt.

USING THE COMPASS

Ok now, let's get to navigating.

POSITION OF THE COMPASS is everything. Unless you truly understand this section of this book, you may as well throw your compass away. Really! The compass is your friend, if you can understand how to use it. Positioning the compass is necessary. Depending on which compass you own will depend on how you hold it.

No matter what style of compass you own you should always imagine a line going through the center of your body and extending in both imaginary directions. Your compass, head, body and feet should all be aligned with this imaginary line. If any part is off, your course will be off.

If your compass is console mounted you, hold the compass in both hands directly if front of you. The compass should be lined up with that imaginary line cutting your body into two equal parts.

If your compass is on your wrist you may choose the method of extending one arm straight out in front of your body, while the other crosses over grasping the straight arm. (See diagram #2.5)

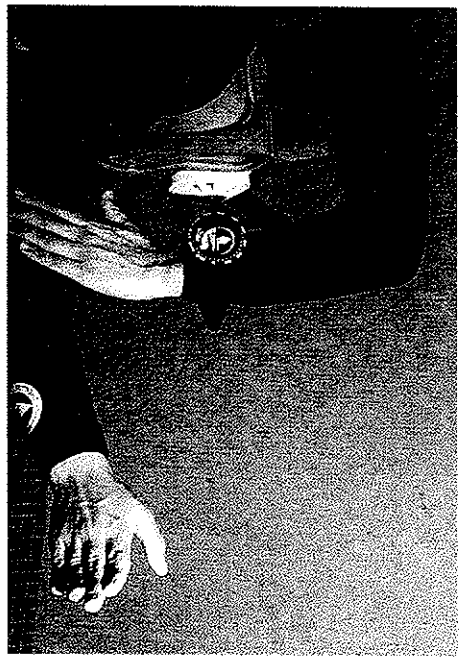
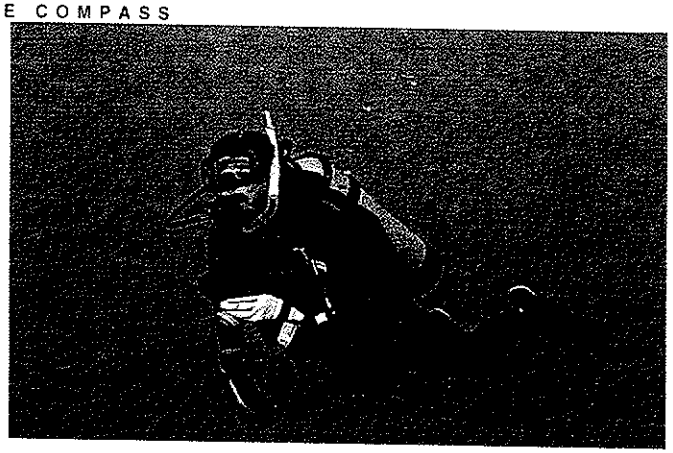


Diagram #2.5

IN SWIMMING WITH A COMPASS, the most important thing is keeping in mind that imaginary line which goes through your body and the compass. The lubber line on the compass is there to help you do this by splitting the compass in to two equal parts. This should coincide with the imaginary line that splits your body into to two equal parts. When looking at the compass do not look directly down at the face. You should be looking over it to give you an accurate reading. The compass should be held as level as possible so the needle won't stick.



SETTING A HEADING

Now that you know how to hold the compass and swim with the compass, you will need to know how to set your heading. This is a simple but important task.

The first thing you have to know is where you want to go. Let's say you have a location where you are going to dive. You locate yourself on the map, which indicates to you that from where the boat sits there is a wreck off the stern. All you have to do is swim at a heading of 180° and you will run smack dab into the wreck. So you get into the water and position yourself off the stern of the boat. You drop down until you are just hovering over the bottom. You turn your body until it faces 180°. Then move your bezel until the arrow is in-between the index marks. As you swim, just make sure your arrow is always between the index marks and in the direction of the lubber line.

Well, you found the wreck but now it is time to go back to the boat. You must find the reciprocal or opposite course of your original heading. A reciprocal is 180° from the original heading. Since we were going 180° the boat will be at 0°heading. You turn until your compass is pointing at 0° and then you move your bezel until the needle is in between the index marks. Swim with the proper position and you will get back to the boat with no problems.

The following chart is a break down of possible combinations one might use while relational diving. See if, after studying this chart, the concept of headings and degree's starts to make scene.

Original Heading	Left 90°	Right90°	Reciprocal
0°	90°	270°	180°
30°	120°	300°	210°
60°	150°	330°	240°
90°	180°	0°	270°
120°	210°	30°	300°
150°	240°	60°	330°
180°	270°	90°	0°
210°	300°	120°	30°
240°	330°	150°	60°
270°	0°	180°	90°
300°	30°	210°	120°
330°	60°	240°	150°

2.6 Combo-Chart

TECHINQUES FOR USING A COMPASS

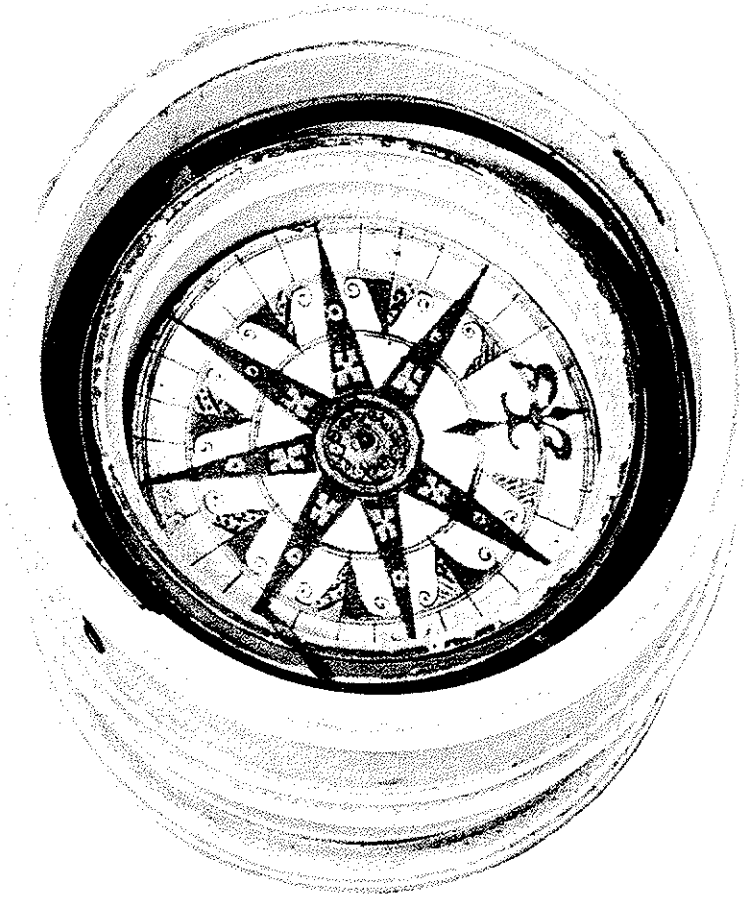
One of the most difficult exercises the underwater navigator must learn to accomplish is maintaining a compass course while at a specified depth. When diving in waters of great depth, such as the ocean or a deep lake, the bottom cannot be used as a reference. If the diver only watches his compass to make sure he is on course, he may experience an elevator effect, either angling up toward the surface or going down to the bottom. If he tries to watch his depth gauge, he will maintain a level attitude but go off course. Trying to keep an eye on both instruments is nearly impossible and ineffective. Since the buddy system is a cardinal rule of diving, both divers should share the responsibility of direction finding. Once the diving partners have used their buoyancy compensator to attain neutral buoyancy, one takes the role of navigator and the other maintains "attitude".

The other thing you have to consider is the compass style that works best for you. Some divers prefer to use the compass mounted in the center of a board with a watch and depth gauge mounted on either side of the compass. Lines coming from the center of the compass toward the top and bottom of the board act as an extended lubber line to more easily align the body for greater accuracy. Usually this compass board is made of Plexiglas that can be roughed up with sandpaper so it can also act as a slate board. This is extremely convenient for making notes to plot a course or write down degree readings. It is also convenient to have the depth gauge and watch mounted close by to record depths and times, as well as trying to keep close to the desired depth. There are other compasses that you can wear around your wrist or clip on your buoyancy compensator. The compass that is easiest for you to use will make your navigating a much more pleasurable experience.

Another helpful technique to use to keep your direction is to descend facing in the direction you want to be traveling. Always descend feet first for orientation sake. When you reach the bottom, stop for a few minutes. Look at the compass and see if you are still facing the desired direction of travel. When you are sure that you have found your orientation then proceed with the dive plan.

There will be times when there is a big rock or other object in your direction of travel, depending on the size of the object or the particular

situation, you might be able to just go over it. However, there are time when that won't be an option. In this case you make a ninety-degree turn and go in that direction until you traveled the length of the object. Then take another ninety-degree turn and swim the width of the object. Then make one more ninety-degree turn until you come back to the same line of direction.



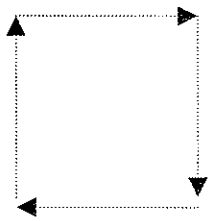
Chapter 3

Applying Navigational Skills

Thinking you know it, proving you show it.

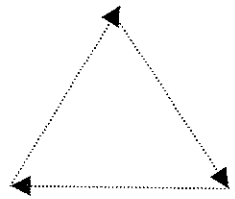
Dive Patterns are useful for a variety of reasons. As mentioned earlier, diving patterns can be used to find lost objects as well as assist a recreational diver in achieving complete fun, dive outings.

SQUARE. You can perform this easy dive pattern. This is because you are using right angles (90-degree angles). A right angle can be preformed without the use of a compass, although you will find using a compass would be far more accurate. Use kicks cycles or arm spans to track the distance you have traveled in each length.



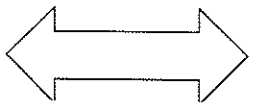
3.1 Seare Pattern

So, try this. Go thirty kick cycles using the compass set at a northern predetermined reading or in this case 0 degrees. At the thirtieth cycle, you'll turn left and take a reading of 90 degrees from the original heading, your compass will be set to 90 degrees west. Thirty more cycles, and another left, taking a reading 90 degrees to the south (180 degrees). After another thirty cycles, an additional left and reading 90 degrees to the east (270 degrees), and a final thirty cycles should put the navigator back to his point of origin.



3.2 Triangle

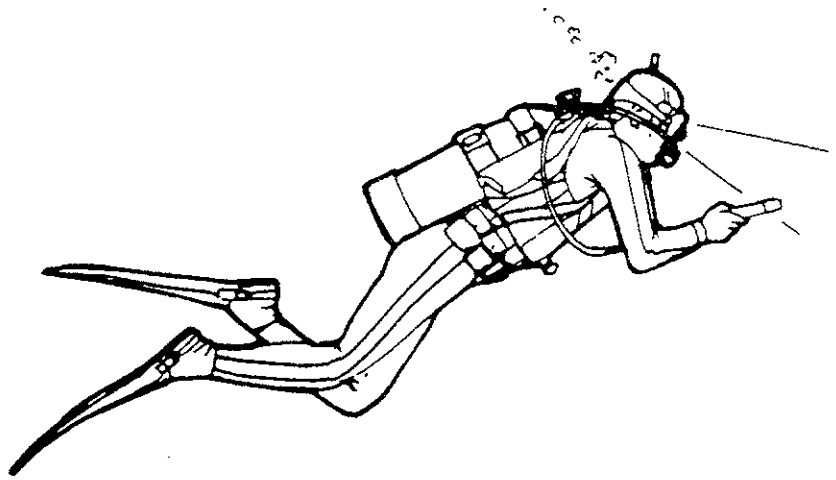
TRIANGLE, this is not your likely choice of dive patterns, as it is only used if your other patterns do not work for the site you have picked. A triangular runs as follows: Starting on a reading of 120° the diver goes fifty kick cycles. Once there, he takes a reading of 240° and goes fifty more cycles. At the end of the second leg, a reading of 360° and fifty kick cycles should bring him back to his point of origin.



3.3 Out & Back

OUT AND BACK, This is the easiest and sometimes the most practical pattern to dive. This is used when you want to get to a specific

point and don't want to take the long way. Either you'll plot your course by a map you saw previously or by surface observations. You have to know what way you want to head. Before you descend, set your bezel to the appropriate course. Descend facing the direction you want to travel. It is easy, but remember that on your way back it is the reciprocal of the original heading.



and have been picked over by previous explorers. Even if the ribs are all that are left of a ship; the dive can still be exciting and enjoyable.

Artifact laws must be considered when removing an object from a ship. Certain states demand that an object not be removed if it is attached to a vessel, and anything found loose on the bottom must be returned to the proper authorities. The laws governing a specific area should be consulted before the dive. Besides losing his find, the diver may also face the penalty of a fine and confiscation of his equipment.

Regardless of the laws of the area, the diver should ponder on one point: If he takes an object, legally or illegally, what will be left for future generations to see? When he removes something, he is denying others the pleasure of exploration and discovery. If each diver took one object from a wreck, whether it was a spike or the ship's clock, there would be little left for others to enjoy. The thought of diving on a ship, regardless of the cargo content and destination, can be considered a visit to a historical vessel, from a time when its supplies were necessary to maintain the mutiny that shaped a part of the past.

NAVIGATION IN LOW VISIBILITY

River diving produces almost a zero visibility situation because the flow of the water carries silt, debris, and pollution along with it.

Areas that have run-offs produced by rain will have a very poor field of vision. Heavy wave action, tide changes and strong winds all contribute to stir the bottom, usually composed of either silt or sand, and cut down the diver's perceptibility. Strong winds blowing out to sea will push surface water away from shore, and colder water from the bottom will replace it. This water cycle is called upwelling, and brings with it plankton. When the plankton blooms as a result of sunlight, there will be a rapid decline in visibility.

Regardless of the reason for poor visibility, if there is water present, divers will enter it. Many times water with limited visibility is all that is available, so certain equipment must be readied and precautions should be taken to make the dive a safe one.

The compass is of the utmost importance in limited visibility diving. Point to point navigation is impossible, since the navigator can only see about six feet or less in front of him. The entire dive has to be plotted from the surface, so readings must be taken on as many references as possible and noted on an underwater slate board. Ideally, the diver should have prior experience in the area under better conditions, but this may not always be the case.

Currents and/or surge should be taken into consideration and compensation should be made. If diving in a river or swift current, a line may be necessary not only for safety, but for use as a reference to avoid vertigo when the diver cannot tell up from down. Even if the diver does have a line, his orientation may be thrown off. If the navigator tries to find out where "up" is by the discharged bubbles from his exhaust, a swiftly moving current may pull the bubbles away from him at a horizontal angle before eventually working their way to the surface. A small amount of water in the mask will always settle at the bottom, giving the diver a constant reminder of where the surface is located regardless of his swimming position.

When diving in low visibility there are fewer references to guide your navigation. Remember the technique for the proper use of a compass and you will have no problems in low visibility. Use the references that you do have. In most cases, you can still make out ripple marks on the bottom in the sand. Don't forget to notice references before you go on your dive. Look at the kelp to see the direction of the current

Other basic pieces of equipment the diver normally carries become more important in poor visibility. The underwater pressure gauge monitors the navigator's remaining air supply. Subconsciously the diver's anxiety is intensified with a restricted view, and his rate of consumption will increase. The diver must remember to look at the gauge occasionally, if it is going to do him any good. A knife with a good serrated edge is also necessary for prying, prodding, cutting, and for being a general, all around tool.

Chapter 5

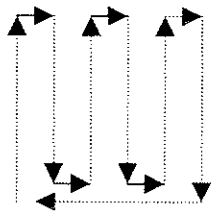
Applying Navigational Skills

Knowing where you are, doesn't always guaranty you'll be able to find you way back.

Search Patterns

Search Patterns are referenced or referred to when discussing search and recovery. Search and recovery is a very useful skill for frequent scuba divers, for the simple fact that at one point or another someone else or you yourself well inevitably lose some item while boating and/or diving. Boy it sure would be nice to find such lost items. Study the following search patterns, and maybe, when the unthinkable accurse it won't become a unfortunate loss .

U PATTERNS are good for calm water and flat terrain. They are fairly simple to use and don't require ropes or weights. To be successful you must use your compass to make straight lines.

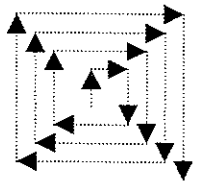


5.1 U Pattern

Procedure

You start by picking a corner of the search area to start in. You swim in a straight line to the other side of the search area. Then make a ninety-degree turn. The length that you go on this stretch depends on the water conditions. Then you make another ninety-degree turn returning to the original side you started from. The pattern repeats itself until you find the object.

EXPANDING SQUARE is for medium objects in rough terrain. This is made for a small search area. The premise of this pattern is based on ninety-degree turns all in the same direction.

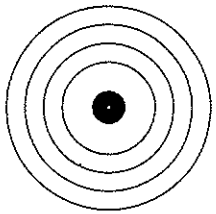


5.2 Expanding Square

Procedure

Start at a central point. Swim a couple of kick cycles and then make a ninety-degree turn. Next swim about double that distance and make another ninety-degree turn in the same direction as the last. You repeat this process of going a bit farther on the lengths and make ninety -degree turns. Remember that these squares should be tight together and that you want to over lap some distance.

A CIRCULAR pattern is the best to use in low visibility, heavy current, and when the terrain is flat. The gear you will need are rope, weight (twenty-five pounds), buoy, and a weight for the buoy.



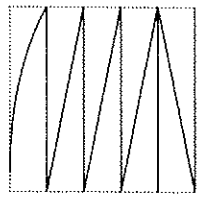
5.3 Circle

Procedure

Set the weight at the buoy to begin the search. The dive team then submerges to the weight, and fastens one end of the guideline to the weight. Then one diver swims to the end the guideline. This distance should be pre-determined and the length of the line should be restricted to the outer perimeter of the search area. The other diver should be at the center of the weight. Using the line as a guide, the diver swims in a circle searching as he proceeds. Upon completing this circle, the diver by the weight moves the other diver inward, and he proceeds to make another circular swim, slightly overlapping the area previously searched. This procedure continues until the circling diver has worked his way back to the base weight. At this point, the dive team moves the base weight to the adjacent area to be searched, placing the weight so that the new area will overlap the previous search area. The search team then repeats the original procedure.

There are several variations to this basic search method. Many teams, for example, prefer to start their search at the base weight and work out. As long as the diver on the outside keeps the excess line coiled in his hand, either way will work.

JACK STAY METHOD. This method is good if you have a long distance to cover. All you need is fifty feet of rope and two fifteen pound weights.



5.4 Jack stay method

Procedure

Place a line on the bottom, with a fifteen-pound weight. Then pull the excess rope about fifty feet from the original weight. Then go five feet over to the left or the right and anchor that end of the rope with another fifteen-pound weight. Now one diver goes back along the rope to the original

anchor. That diver then slides the weight over to the right or the left five feet. Repeat this process until the object is found.

HALF MOON SEARCH is done from a sea wall or from the shore. Other than your regular buddy diving with you will need someone on the surface as a safety diver. Too perform this correctly you need a rope of about a hundred meters long and a minimum of twenty –five pounds to weight the rope down.

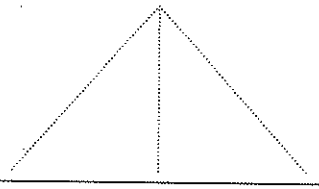
5.5 Half moon search

PROCEDURE

Attach the weight to the line. This line is to be use for surface contact. Place the weight in a prime spot so the search can begin. The dive team takes the rope and enters fifty to seventy feet from the prime spot. The dive team starts at the end of the rope working their way back to shore in semi circles. As they come opposite to the site of the starting point, the diver on shore pulls the rope in just enough to slightly overlap the last semicircle.

Triangulation

This is a good technique to use if you've found an object under water and you want to find the object again. When you find an object underwater, you surface straight up from the object. Once you reach the surface, you find two objects on shore to align yourself with. The alignment of the objects should be about ninety-degrees from each other.



5.6 Triangulation

Pick a distinct part of the objects. An example would be a light pole or a telephone pole. Take compass headings off the objects and write them down on an underwater slate if you have one. Now determine the distance from the under water object to shore. The best way to do this is by making a timed surface swim back to shore, counting your kick cycles, Make sure when you get to shore to write your time and kick cycles information on a slate. You can transfer this to your logbook later.