STUART SCUBA

SCUBA TRAINING

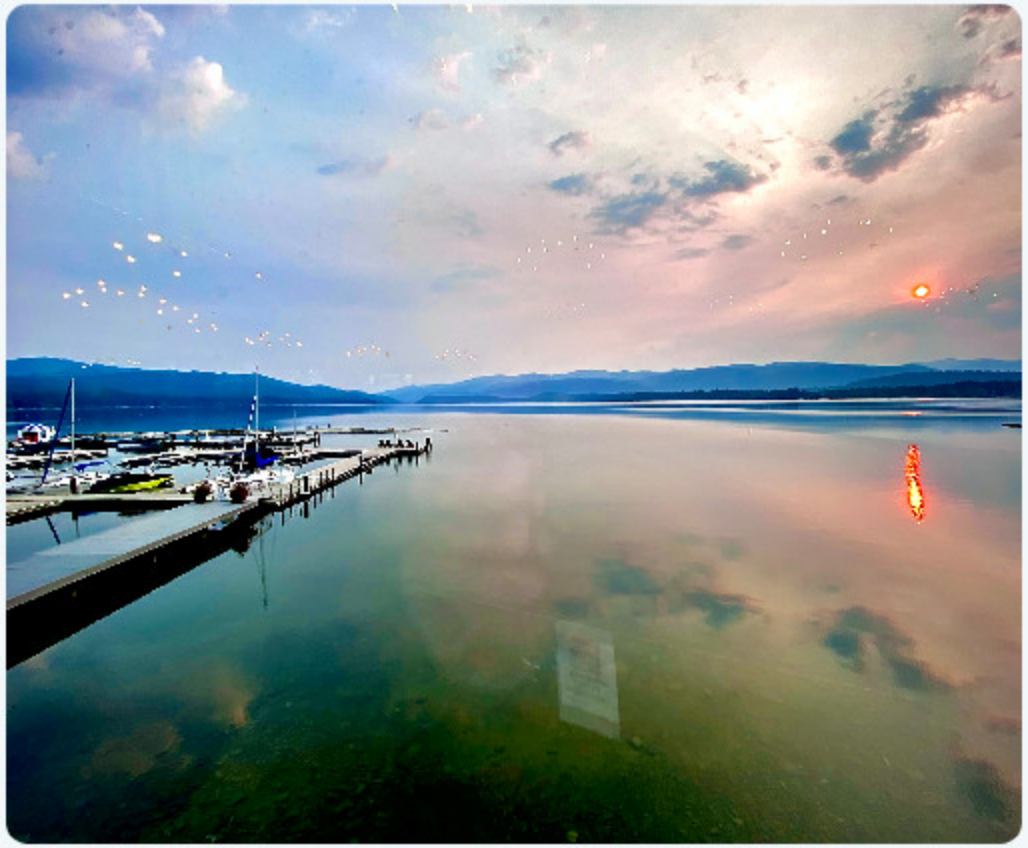
ALTITUDE DIVING

STUART SCUBA TRAINING



Welcome to Stuart Scuba

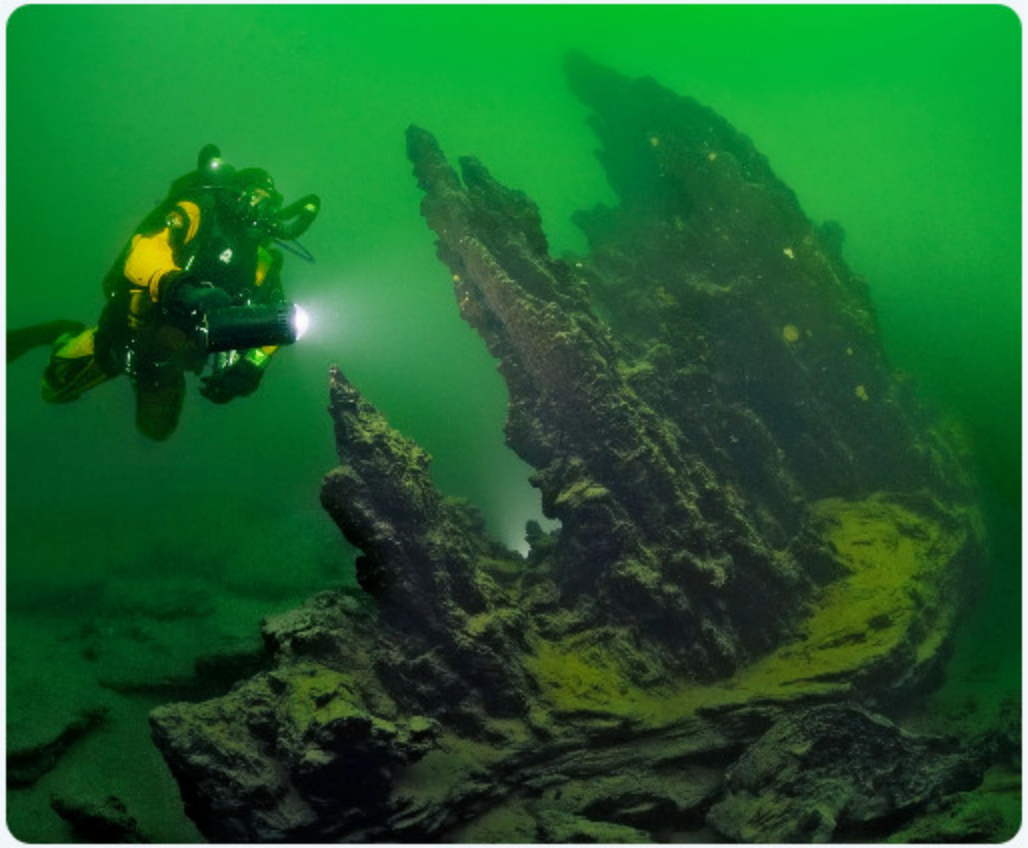
WELCOME
PERSONAL INTRODUCTION
PAPERWORK



McCall Lake, Idaho. About 5,000 ft elevation.

TO BECOME A COMFORTABLE AND CONFIDENT DIVER IT TAKES FOUR INGREDIENTS:

- Proper Knowledge
- Proper Skills
- Proper Equipment
- Proper Experience x2



Yellowstone Lake. THE SPIRES. Elevation 7,700 ft.

Diving at Altitude | Objective

Because of the reduced atmospheric pressure, dives conducted at altitude require more decompression than identical dives conducted at sea level. The standard dive tables cannot be used as written.

Through this class we will learn several alternative approaches to determining safe diving practices for diving at altitude, along with additional safe diving practice and emergency procedures.

Diving at Altitude | Value

A majority of inland diving is at altitude and can present additional risks that may not be as simple as diving at sea level. This course is to prepare divers for these additional challenges and provide them with the ability to safely plan and execute dives at elevations from 1,000' - 10,000'.



Lake Tahoe. Elevation 6,224 ft.

Main Points to Be Covered

- Definitions and benefits of altitude diving
- Review of Boyle's Law and Henry's Law
- Dive planning (Sea Level Equivalent Depths and calculations)
- Adjusting ascent and safety stops
- Thermal protection
- Pre-dive checks and preparation
- Air delivery systems
- Typical conditions in lakes and rivers
- Emergency procedures
- Common altitude-dive maladies and prevention
- After-dive travel

Areas for Altitude Diving

- Mountainous regions above 1,000 feet
- High plains areas that are not as obviously high altitude as mountainous regions that are above 1,000 feet
- The maximum recommended altitude for altitude diving is 10,000 feet.



Road to Redfish Lake, Idaho.

What Does Altitude Diving Mean to You?

Discussion

Lake Tahoe
191.1 square miles | Maximum depth 1,644' | Elevation 6,224'

Redfish Lake
5.1 square miles | Maximum depth 387' | Elevation 6,547' | 110' visibility



Little Redfish Lake, Idaho.

Marcel Korkuś Sets an Altitude Diving Record

On December 13, 2019, the Polish diver Marcel Korkuś dived at an altitude of 6,395 m (20,981 feet) above sea level, setting an absolute world record in altitude diving. He is the first person to dive at such a high altitude. The dive was experimental, as the dive planning tables end at 3000 meters (10,000 feet).

On 7th March 2016, he discovered the highest lake on Earth (Cazadero at 5985 m above sea level) and thereby set the Guinness record in diving, confirmed by an official certificate.





Benefits of Diving High-Altitude Waters

- The opportunity to find preserved artifacts
- New varieties of underwater life
- Allows for more local diving activities
- Extends diving experience



Benjamin surveying THE SPIRES in Yellowstone Lake.

Specialized Accident Insurance Coverage for Divers

DAN dive accident insurance* is an affordable way for divers to obtain insurance against the costs of dive injuries that are often left uncovered by typical health insurance.

- Covers diving, non-diving and named water sports accidents and injuries
- Pays 100% of eligible accident medical expenses up to US$500,000
- Available for divers age 70 and over in the U.S. and Canada
- Plans recognized worldwide
- Annual coverage

Discussion: Will DAN.org or any other insurance provider cover a dive accident if you are diving outside of your certification?

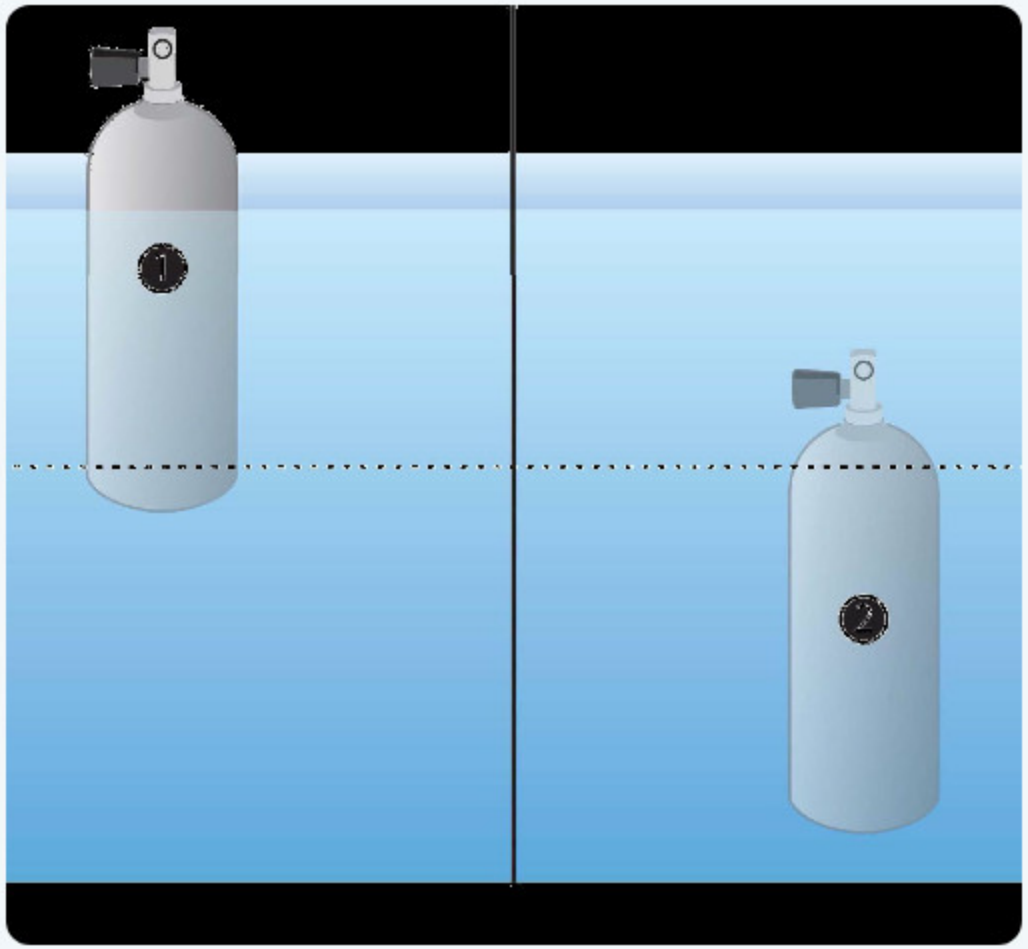
When Is the Scuba Cylinder Empty?

Your scuba cylinder is “empty” when the pressure is equal to the absolute pressure. There must be a difference in pressure for air to flow in or out of the cylinder.

Your scuba cylinder is also considered “empty” at the surface when the pressure reaches 1 ata.

Take the same “empty” cylinder to an altitude of 16,000 ft (1/2 ATA), open the valve and air will flow out (pressure decrease, volume increase) until the cylinder is equalized. At depth, your dive cylinder is also “empty” at 16 ft when the air pressure reaches 1.5 ata, equaling the absolute pressure.

SAFETY POINT
During an out-of-air ascent, keep the primary regulator in your mouth. As you ascend (pressure decrease, volume increase), air should flow into the Delivery System providing you some air on ascent.



Pressure, Atmospheric Pressure and Hydrostatic Pressure

Pressure describes a force per unit area. The mathematical representation is:
Pressure = Force / Area, or P = F / A

Atmospheric pressure
Air pressure at sea level is known as atmospheric pressure. The common unit of atmospheric pressure in the imperial measurement system is ATA. At sea level, one atmospheric pressure is defined as 1 ata.

Hydrostatic pressure
Hydrostatic pressure is the weight exerted by a fluid (water) due to gravity. It comes from the weight of water, excluding air pressure, and is commonly expressed as pressure per unit of depth.

Depth fsw	*ATA*	*Ambient Pressure psi/bar*	*Volume*	*Density*
Surface	1	14.7/1	1	1×
33 fsw	2	29.4/2	1/2	2×
66 fsw	3	44.1/3	1/3	3×
99 fsw	4	58.8/4	1/4	4×

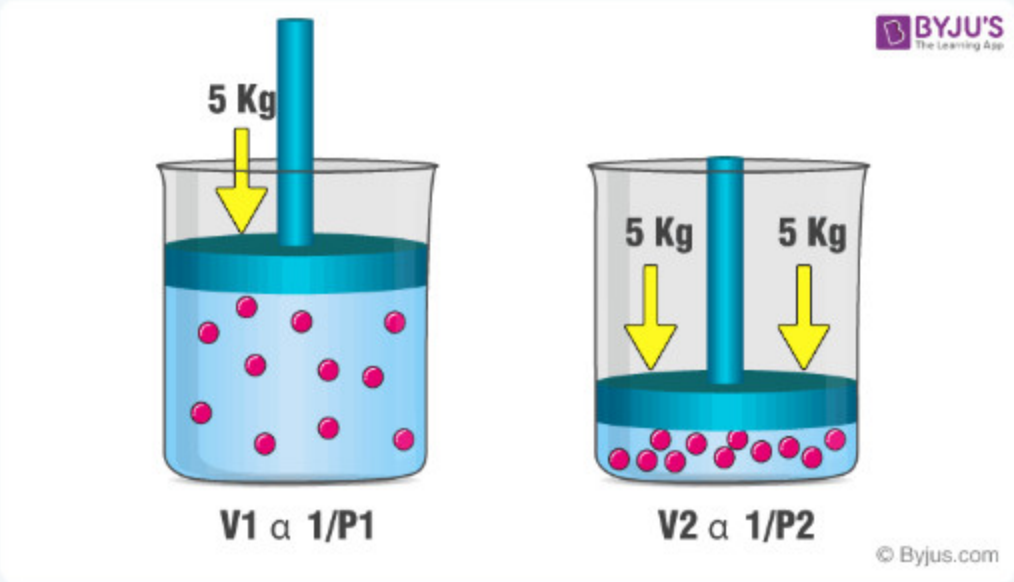
One ATA in Fresh Water and Sea Water

One ATA equivalents in water pressure

1 ata = 34 feet of fresh water (ffw)
1 ata = 33 feet of sea water (fsw)

Fresh water exerts:
14.7 psi ÷ 34 ft = .432 psi/ft

Salt water exerts:
14.7 psi ÷ 33 ft = .445 psi/ft



Gauge Pressure

Gauge pressure is used primarily for the diver's Information System. Gauge pressure does not take atmospheric pressure into account. The specific pressure being measured does not include atmospheric pressure. The depth gauge is calibrated to read zero at sea level and measures depth in feet of seawater.

The air pressure gauge will read zero when the cylinder is off and all air, other than ambient, is out of the high-pressure hose. Cylinder pressure is measured in pounds per square inch gauge, or psig.



Halcyon SPG

Absolute Pressure

The term absolute pressure describes the total pressure exerted on an object, including the diver. At the surface, you experience one atmosphere from the weight of the air (atmospheric pressure). As you descend, the additional weight of the water adds hydrostatic pressure. Absolute pressure is the sum of atmospheric and hydrostatic pressure, and is commonly expressed in bar. In seawater, hydrostatic pressure increases by one additional atmosphere for every 33 feet of depth.

Absolute Pressure (ATA) = Depth (fsw) / (33 fsw/ata) + 1

Example: at 132 feet in seawater, every 33 feet adds 1 ATA, so water pressure is 4 ATA. Add 1 ATA of air pressure at the surface: total absolute pressure is 5 ATA.

Equilibration and Acclimatization

Upon ascent to altitude, two things happen. The body “off-gases” excess nitrogen to come into equilibrium with the lower partial pressure of nitrogen in the atmosphere. It also begins a series of complicated adjustments to the lower partial pressure of oxygen.

The first process is called equilibration. The second is called acclimatization. Approximately twelve hours at altitude is required for equilibration. A longer period is required for full acclimatization.



Residual Nitrogen Before an Altitude Dive

If a diver begins a dive at altitude within 12 hours of arrival, the residual nitrogen left over from sea level must be taken into account. In effect, the initial dive at altitude can be considered a repetitive dive, with the first dive being the ascent from sea level.

A simple way to figure this is to increase your residual nitrogen group by one letter group for every 1,000 feet in elevation gain.

Example 1 | Idaho Falls to Yellowstone Lake

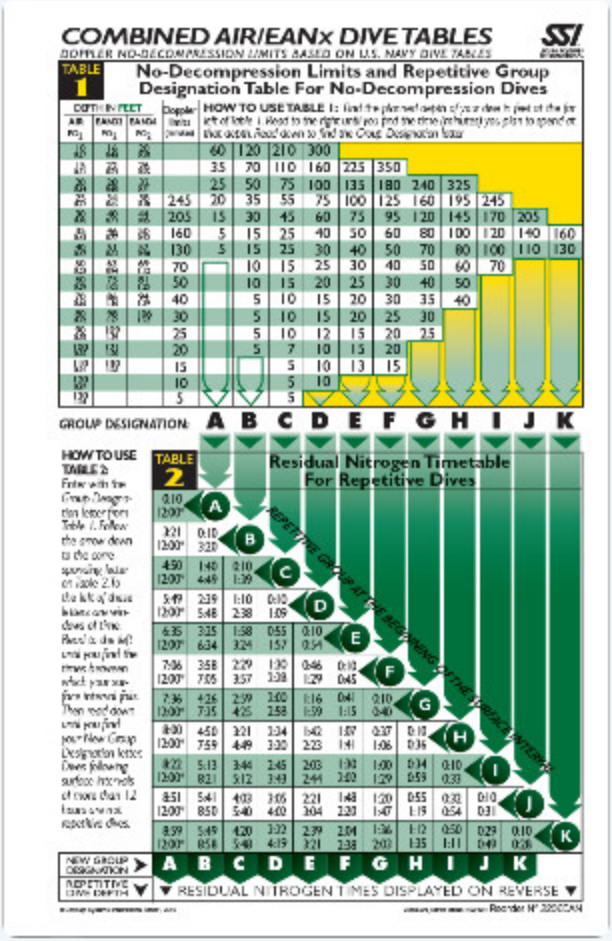
Jim drives from Idaho Falls (elevation 4,500') to Yellowstone Lake (elevation 7,500').

Jim gains 3,000' in elevation.

To compensate for this elevation increase, Jim will need to start his dive as a D group diver.

OR

Wait 5 hours 49 minutes to return to being an A group diver.



Winter Diving



Pressure | Review of Boyle's Law

- The effects of altitude on atmospheric pressure
- The role of atmospheric pressure in dive-table calculations

If temperature remains constant, the pressure and volume of any gas are inversely related.

Boyle's Law at Sea Level

At sea level, a flexible, gas-filled container is submerged to 33 fsw. At that depth it has a volume of 1 cubic foot. What will the volume be if it is brought directly to the surface?

A. 1 cubic foot

B. 2 cubic feet

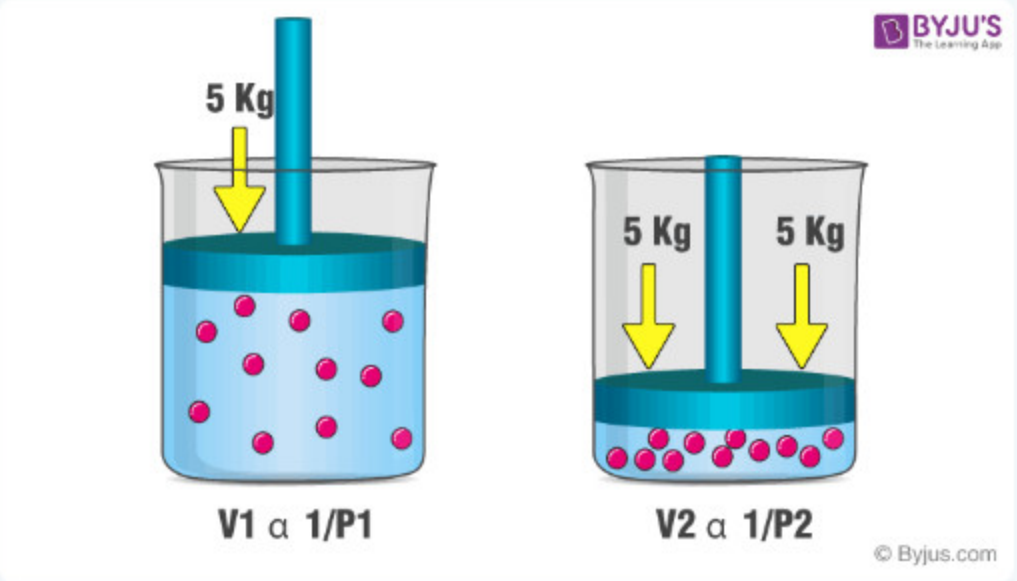
C. 2.7 cubic feet

D. 1.5 cubic feet

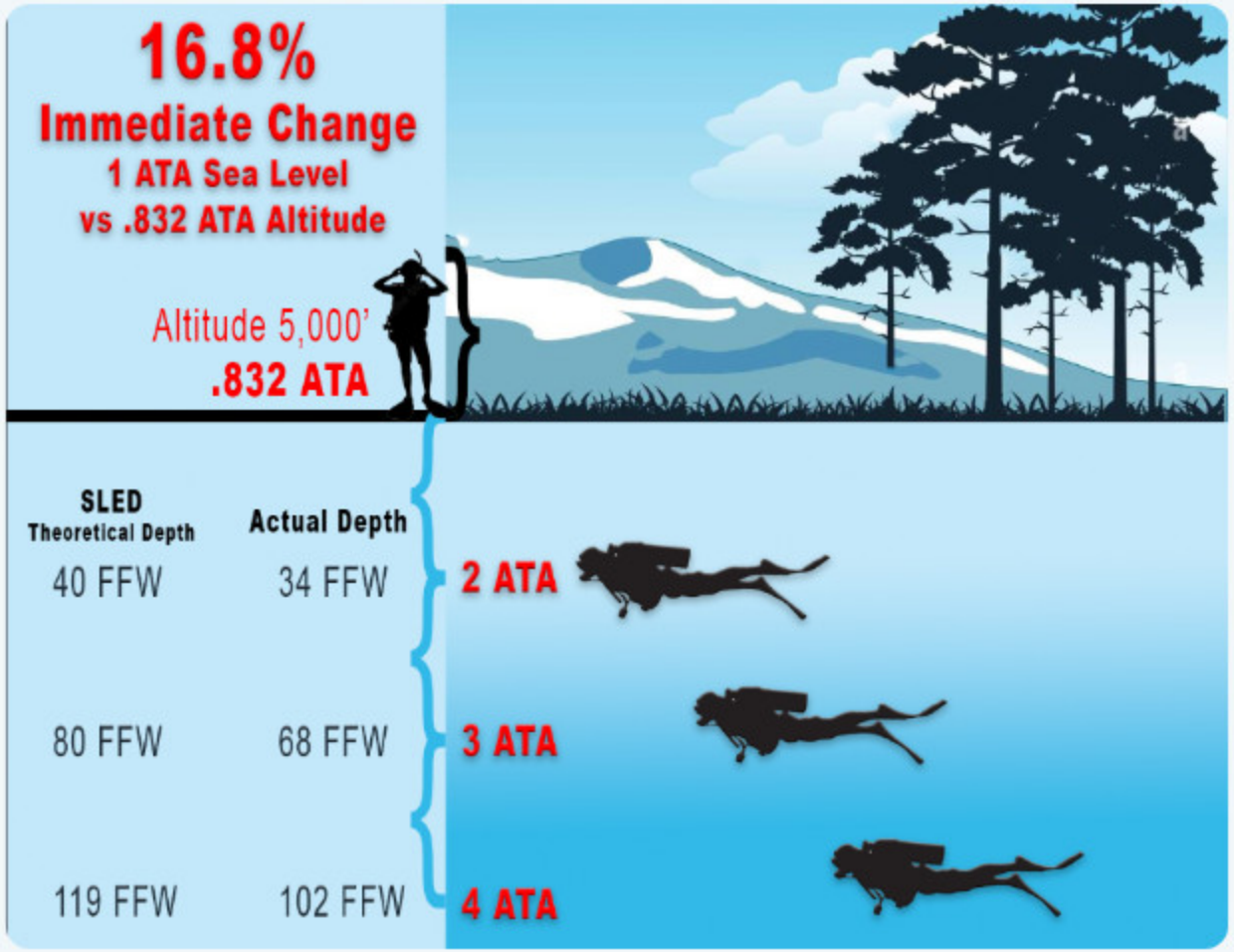
One Cubic Foot of Water at 5,000 Feet

1 cubic foot of water weighs 62.41 pounds at sea level.

How much does the same amount of water weigh at 5,000' of elevation?



What Is Sea Level Equivalent Depth?



Why Use a Sea Level Equivalent Depth?

- While the weight of the water is equal no matter where we are, the atmospheric pressure is different.

- If a diver set their safety gradient high to 85 or 15% safety margin and did not account for the altitude pressure difference when they surfaced at 5,000' or an ATA of .832, the diver's new gradient high would now be 101.8% of M-value or 1.8% over NDL and create a very high risk of DCS.



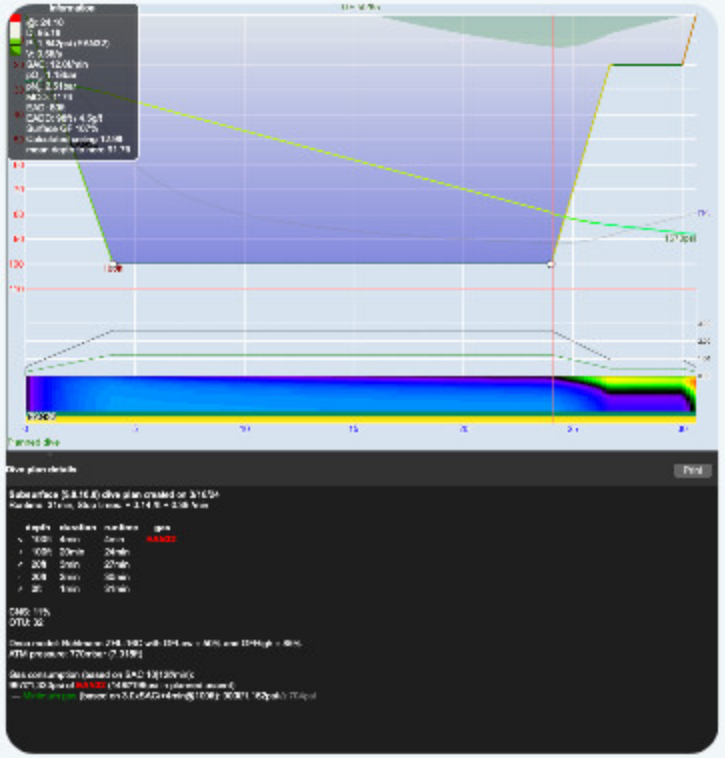


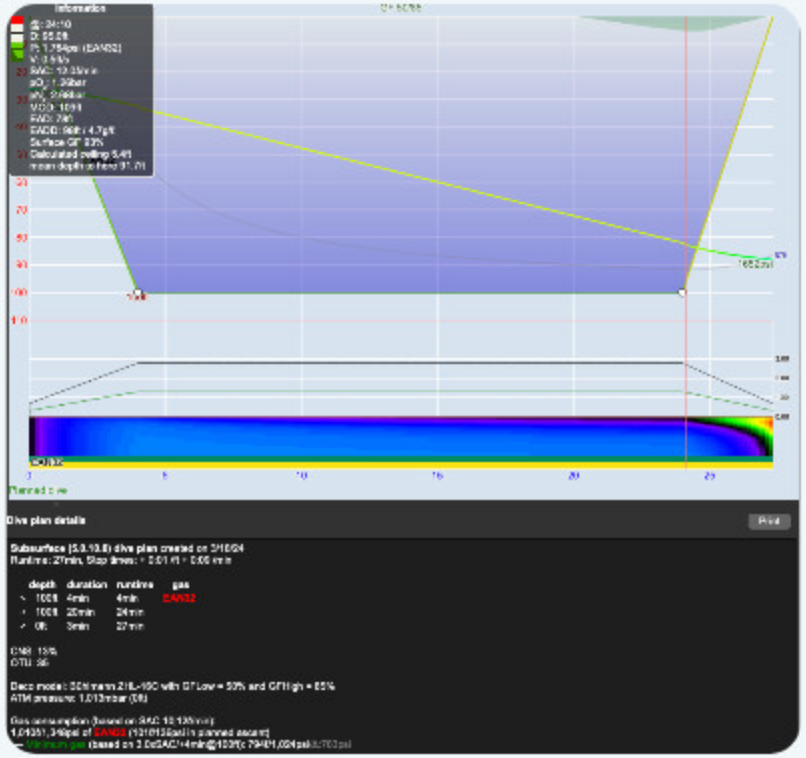
Dive Planning Samples

Dive plan: 100 feet maximum depth | 24 minutes total bottom time (including 4 minutes of descent) | 32 EAN gas | 50/85 Gradient Factor | Gas Density 5.15 g/L

(EAN 32 = 1.30764 g/L @ 1 ATA. 100 FFW (34' per ATA freshwater) = 3.9411 ATA.)

Figure 1: Sea Level - NO Deco Obligation
Figure 2: 7,000' Elevation - DECO 3 minute @ 20 feet ceiling





SLED | Theoretical Depth Calculations

SLED (Sea Level Equivalent Depth) = actual depth × (P1 ÷ P2)

Use the Sea Level Equivalent Depth Table with ATM or hectopascal pressure units. Most common dive tables rely on a minimum hydrostatic cap of 1.00 ATA at the surface.

Example: find the equivalent depth of 49 fsw at 4,000 feet above sea level.
1. ED = 49 fsw × (1 ÷ 0.864)
2. ED = 49 fsw × 1.157
3. ED = 57 feet
4. Take P1 and P2 from the Altitude Pressure Variations Table.

Safety-stop depth modifications should also be modified.

Sea Level Equivalent Depth Table

Actual Depth ffw	Altitude (feet) 1000	2000	3000	4000	5000	6000	7000	8000	9000	10,000
10	10	15	15	15	15	15	15	15	15	15
20	20	25	25	25	25	25	30	30	30	30
30	30	35	35	35	40	40	40	50	50	50
40	40	50	50	50	50	50	50	60	60	60
50	50	60	60	60	70	70	70	70	70	80
60	60	70	70	70	80	80	80	90	90	90
70	70	80	80	90	90	90	100	100	100	100
80	80	90	90	100	100	100	110	110	120	120
90	90	100	110	110	110	120	120	130	130	140
100	100	110	120	120	130	130	130	140	140	150
110	110	120	130	130	140	140	150	150	160	160

Table derived from formulae and information in the NOAA Diving Manual 4th Edition

Theoretical Difference | Example at 4,699 Feet

Theoretical difference between sea level and altitude:
1 - (ATA pressure at altitude ÷ ATA pressure at sea level)

Example
0.8353 ATM ÷ 0.9927 ATM = .8414
.8414 - 1 = .1586 difference from sea level
.1586 + 1 = 1.1586 factor to theoretical depth

Theoretical depth is 15.86% deeper than actual depth.

100' dive at 4,699' elevation = 116' theoretical depth, or Sea Level Equivalent Depth (SLED).

Altitude Pressure Variations Table

Atitlude (feet)	0	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	10000
Pressure (ATA)	1	0.964	0.95	0.93	0.91	0.896	0.88	0.864	0.85	0.832	0.82	0.801	0.79	0.772	0.76	0.743	0.73	0.715	0.7	0.69
Calculations determined at ideal conditions, with an air temperature of 60 F																				
Add .01 Pressure (ATA) for every +10 F																				
For maximum accuracy, calculate variation bassed up current atmophic pressure at the location to be dove.																				

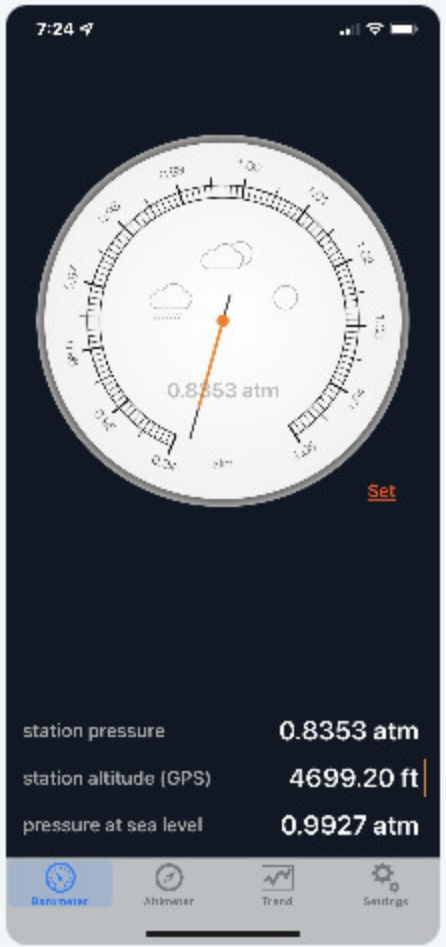
Quick Tools for Altitude Dive Planning

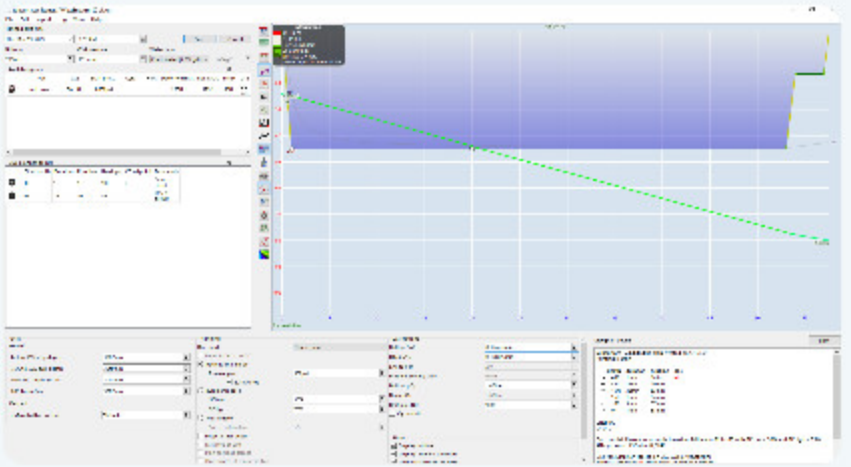
NOTE: Using the barometric math is always the most accurate. The following are quick solutions that will provide a reasonable solution.

•

http://www.divebuddy.com/mobile/calculator/altitude.aspx

- Add 3.5% per 1,000'
- Barometer AP for phone (Most accurate)
- Subsurface Dive Planner
- Sea Level Equivalent Depth Table





Sea Level Equivalent Depth Table

Actual Depth ffw	Altitude (feet) 1000	2000	3000	4000	5000	6000	7000	8000	9000	10,000
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20	20	25	25	25	25	25	30	30	30	30
30	30	35	35	35	40	40	40	50	50	50
40	40	50	50	50	50	50	50	60	60	60
50	50	60	60	60	70	70	70	70	70	80
60	60	70	70	70	80	80	80	90	90	90
70	70	80	80	90	90	90	100	100	100	100
80	80	90	90	100	100	100	110	110	120	120
90	90	100	110	110	110	120	120	130	130	140
100	100	110	120	120	130	130	130	140	140	150
110	110	120	130	130	140	140	150	150	160	160

Table derived from formulae and information in the NOAA Diving Manual 4th Edition

What About MOD Calculations?

- The weight and atmospheric absolute pressure does not change at altitude, only the sudden exposure to the reduced pressure upon surfacing.

- With the body's equilibration at altitude, this can create a hypoxic equilibrium. Divers have reported additional sensitivity to Gas Density, Hypoxia, and Narcosis.

- It is reasonable to also consider that the brain's reaction to higher PPO2 could be affected due to the imbalance of O2.

Adding additional safety margins at altitude for MOD, Gas Density considerations, and Narcosis is just smart diving!



Garmin Descent X50i with T2 transmitter

What About SAC Rate?

- There isn't any real evidence that SAC rate is affected.
- Acclimatization to the higher altitudes can place the body in a state of hypoxic equilibration.
- With the new balance of O2, it is reasonable to consider that SAC rate could be increased as well.

Adding additional safety margins at altitude for SAC is just smart diving!



Calibrating and Measuring EAN

Correctly measuring EAN at altitude is extremely important.

Ensure that the PPO2 of the gas you are breathing matches the PPO2 in the tank.

1. Calibrate your Nitrox analyzer on location to 21%.
2. Measure your tanks on location and mark tanks to the new PPO2.



Boyle's Law at 3,000 Feet

A flexible, gas-filled container is submerged to 34 FFW at an altitude of 3,000 ft. At that depth it has a volume of 1 cubic foot. What will the volume be when it reaches the surface?

A. 2 cubic feet

B. 1.3 cubic feet

C. 1.5 cubic feet

D. 2.21 cubic feet

Altitude Dive Planning | Discussion

- What is the most accurate way to determine SLED?
- How would this affect your ascent rate?
- How would this affect your safety stop?
- Would there be any additional consideration for traveling after altitude diving?

Atmospheric Pressure at 4,000 Feet

From the altitude pressure variation table, what is the atmospheric pressure at 4,000 feet?

A. 0.864 ata

B. 0.832 ata

C. 0.964 ata

D. Both 1 and 2

Sea Level Equivalent Depth

A diver plans a dive at 4,000 feet to 70 ffw. What is the diver's sea level equivalent depth (SLED)?

A. 50 ffw

B. 70 ffw

C. 80 ffw

D. 100 ffw

Dry Suit and Advanced Nitrox

Dry Suit Diving
The course covers dry suits, specialized equipment, their benefits, and dry suit emergencies.

Advanced Nitrox
An available technical diving course from Stuart Scuba.



Henry's Law: The Kool-Aid Law

Henry's Law states that: “At a constant temperature, the amount of a given gas dissolved in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.”

For this class, remember Henry's Law as the Kool-Aid Law.

The law essentially has two parts:
- As pressure increases, the solubility of gases in liquids increases.
- As temperature increases, the solubility of gases in liquids decreases.

In simple terms:
- Under more pressure, a greater quantity of gas can be absorbed by a liquid.
- The cooler the liquid, the more gas can be absorbed. As a liquid warms up, the gas escapes from it.



If we dump the Kool-Aid in the water without stirring, how well does it mix? Will it mix better if we stir it?

Safety Stops

- Safety stops must be recalculated to the new SLED for more efficient and correct off-gassing.

- Safety-stop lengths should be increased to account for the rapid decompression difference between below the surface and surfacing.



Safety Stops and Ascents

Due to these additional considerations, safety stops and ascents must be much more closely monitored for the safety of the diver.

Safety stops of three to five minutes at or near 15 feet are recommended for any dive made to a depth of 20 feet or deeper, unless an emergency or other safety-related reason dictates otherwise. Because most altitude dives are done at higher elevations and divers are more prone to cold and reduced blood flow to the extremities, the following procedures are strongly recommended:

- Ascent rates should be reduced by 5' per minute (or more) for every 4,000' of elevation to allow for the colder water.
- Safety stops should be adjusted to the correct theoretical depth based upon dive site.
- Safety-stop times should be increased by a factor of 10% (or more) for every 2,000' of elevation gain to allow for the larger atmospheric change at the surface.

Pro Tips

Typically, more cold-water dives end due to exposure to the cold and discomfort than due to dive length or non-decompression limits.

It is recommended that divers keep a continual mental and physical assessment of their comfort level and ensure they end the dive with enough time to allow for a slow ascent, sufficient safety stop and sufficient thermal comfort.

Ending your dive prior to strong discomfort and shivering will not only increase the satisfaction of your dive but increase your safety point as well.



Thermal and Equipment Considerations

- Discuss exposure protection before, during and after the dive.
- The effects of altitude on atmospheric pressure.
- The role of atmospheric pressure in dive-table calculations.

1. Include the benefits of dry suits.
2. Use shelters for pre-dive dressing and post-dive undressing.
3. Warm liquids.
4. Hydration in cold weather.



Cold, Nitrogen Loading and Surface Intervals

Discussion

- How would cold affect your nitrogen loading and off-gassing?
- How would reduced atmospheric pressure affect surface intervals?



Gas Density | Understanding and Applying Gas Density



What Is WOB (Work of Breathing)?

How does this relate to Gas Density?



What Is WOB?

WOB is an integral of pressure as a function of volume that is used to measure the effort required to breathe. A high WOB means it takes more effort (measured in energy, typically joules) to draw breath (a measure of volume, typically in liters).

High WOB results in increased CO_2 production, and that CO_2 increase can result in hypercapnia, narcosis, and loss of consciousness among other symptoms.

Gas Density

Gas density is a measure of mass per unit volume, measured in grams per liter (g/L). A high gas density means a given volume of gas weighs more and takes more effort to move, resulting in increased WOB.

Increased gas density also skews the pressure gradient between inspired and arterial CO2, resulting in further decreased CO2 off-gassing efficiency and a recurring system that results in further complications.

Gas	Density (g/L)
Hydrogen	0.09
Helium	0.179
Nitrogen	1.251
Oxygen	1.428
Air	1.293

Maximum Gas Density | 5.2 and 6.2 g/L

Maximum gas density of 5.2 g/L | Hard maximum of 6.2 g/L

Working with both open-circuit and rebreather divers, Anthony Mitchell found that gas density near the 6 g/L mark significantly increased the risk of dangerous CO2 retention during dives. Their test subjects failed more than half their attempted dives and experienced issues at more than three times the rate of divers using gas even 1 g/L less dense.

Their takeaway from this research was an ideal maximum gas density of 5.2 g/L (equivalent to air at 102 fsw/31 msw), and a hard maximum of 6.2 g/L (equivalent to air at 128 fsw/39 msw).

Gas Density | Examples at Depth

The use of EANx 32 (32% oxygen, 68% nitrogen) at 110 fsw/34 msw exceeds recommendations with a gas density of 5.66 g/L and more than 6.54 g/L at 132 fsw/40 msw.

Technical divers using trimix 18/35 (18% oxygen, 32% helium, balance nitrogen) will overshoot recommendations, reaching 6.93 g/L at 200 fsw/61 msw and a PO2 of just 1.26.

Trimix 10/70 (10% oxygen, 70% helium, balance nitrogen) reaches 6.73 g/L at 396 fsw/121 msw and 10.29 g/L at 495 fsw/151 msw.

Treating Gas Density Like DCS

The reality is that gas density is another in a series of dynamic risk factors that divers of all levels must contend with. Treating gas density like DCS by acknowledging and mitigating the hazards via personal fitness, decreased work at depth, and appropriate dive planning has worked in the past and will continue to work.

This research shows why we face the issue we do at depth, a possible understanding of corollary hazards like DCS and IPE, and how we might be able to use that data to keep ourselves safer.

Understanding the Risk

As divers continue to go deeper, an understanding of effort during a dive MUST be realized.

Deeper dives MUST contain lesser and lesser effort. There are many examples of how the load of gas density can cause undue stress.

58% of diver deaths are cardiac related.

The Statistics

Dives with less than 6 g/L
Less than 10% failure rate

Dives with MORE THAN 6 g/L
IMMEDIATE JUMP
More than 40% failure rate

Hypercapnia

Hypercapnia (hypercarbia) is when you have high levels of carbon dioxide in your blood. Carbon dioxide is a waste product that your body gets rid of when you exhale. If you can't get rid of it, it can build up in your blood.

Hypercapnia | Symptoms

- Lightheadedness
- Euphoria
- Slowed response
- A feeling of well-being
- Increasing judgmental errors; giddiness
- Deterioration of fine dexterity
- Fixation of ideas
- Time distortion
- Deterioration of multi-task reasoning
- Numbness
- Tingling
- Sleepiness
- Inability to remember parts of the dive
- Confusion (Brain Fog)
- Semi-consciousness
- Distorted memory of the dive
- Decreased conceptual reasoning
- Disorientation
- Paranoia
- Anxiety
- Shortness of breath
- Headaches

Hypercapnia and Narcosis | Symptoms

Hypercapnia

- Lightheadedness
- Euphoria
- Slowed response
- A feeling of well-being
- Increasing judgmental errors; giddiness
- Deterioration of fine dexterity
- Fixation of ideas
- Time distortion
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- Semi-consciousness
- Distorted memory of the dive
- Decreased conceptual reasoning
- Disorientation
- Paranoia
- Anxiety
- Shortness of breath
- Headaches

Narcosis

- Lightheadedness
- Euphoria
- Slowed response
- A feeling of well-being
- Increasing judgmental errors; giddiness
- Deterioration of fine dexterity
- Fixation of ideas
- Time distortion
- Deterioration of multi-task reasoning
- Numbness
- Tingling
- Sleepiness
- Inability to remember parts of the dive
- Confusion
- Semi-consciousness
- Distorted memory of the dive
- Decreased conceptual reasoning
- Disorientation
- Paranoia
- Anxiety
- Visual hallucinations
- Auditory hallucinations
- A feeling of relaxation

Become a Certified Dry Suit Diver

Dry suit diving opens up a world of opportunities, including diving remote Arctic destinations and exploring cold-water dive sites teeming with life. Dry suit diving also keeps you warm on multi-dive days when you do not want to spend your time getting in and out of a cold wetsuit.

The Dry Suit Diving specialty program teaches the knowledge and techniques needed to dive safely and comfortably in a dry suit. It covers specialized equipment such as dry suits and BCs, their benefits, and dry suit emergencies unique to this type of diving. Upon completion, you will earn the Dry Suit Diving specialty certification.



Pre-Dive Safety Checks | Equipment and Buddy Check

Each diver should conduct a functional check of all gear and equipment before a dive. Particular attention should be paid to regulators and inflator valves. If leakage or free flow is detected in these items, the dive should be postponed until the malfunction is corrected. If a regulator or inflator valve is found to be free flowing on the surface, it is a virtual certainty that it will free flow at depth.

Divers should also perform a pre-dive buddy check before each dive. It can be easy to forget to attach a suit inflator or strap, and a quick check can ensure a good start to the dive.

Divers should go over hand signals, the dive plan and hazards that might be present.

Remote-Site and Dry-Suit Preparation

If a diver is going to be at a site that is far away, it is recommended that they bring along a spare regulator in case one of their regulators malfunctions. They should also take extra thermal undergarments, cold-weather gear and dive gloves or liners in case of a suit leak.

All divers should be able to disconnect the dry-suit low-pressure hose from the dry-suit inflator valve with gloved or mitted hands. Otherwise, a dry-suit inflator free flow in the water could result in an uncontrolled ascent. Remember that your dive buddy is there to help as well. It is a good technique to practice this action at the end of a dive, during the safety stop. That is when the diver is close to the hole and hands are at their coldest.



Redundant Equipment | Discussion

How could redundant equipment help you in high-altitude diving?

- Before the dive
- During the dive



H-Valves, Y-Valves and Pony Bottles

Discuss benefits of H or Y valve configurations or Pony Bottles





Cold-Water Air Delivery Systems

Discuss benefits of air delivery systems designed for cold water.



Computer Settings at Altitude

Determine if your computer can be set to altitude manually or automatically.



Lake Diving

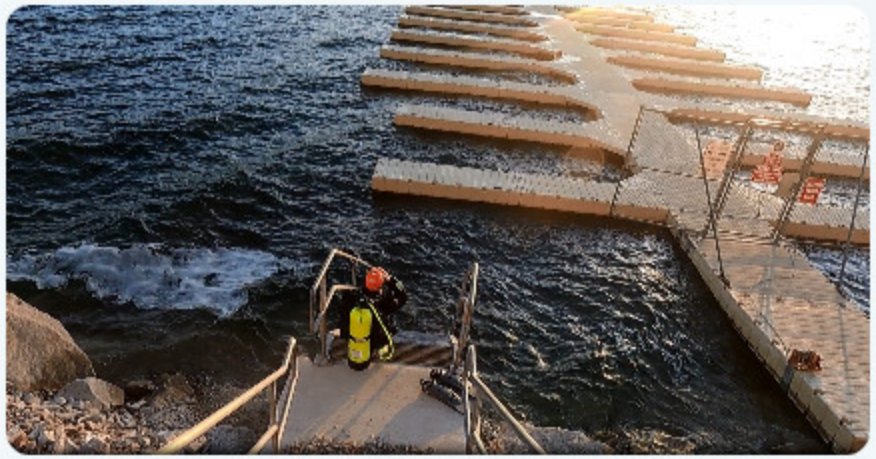
- Visibility considerations
- Surface swim
- Environmental conditions
- Water temperature
- Entanglement considerations

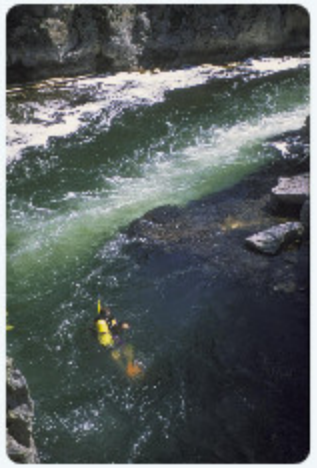




River Diving

- Visibility considerations
- Safe entry
- Environmental conditions
- Water temperature
- Entanglement considerations
- CURRENT





Emergency Procedures | Preparation

- Location to emergency services
- O2 Provider Kit
- AED
- Distance to Pressurization chamber



Emergency services



O_2 Provider Kit + AED



Pressurization chamber

Stop-Breathe-Think-Act

In any emergency situation, you need to regain control before you act. The best way to regain control quickly is to immediately stop, calm down, and take several deep breaths. This will relax you and help you make a rational decision, and also prevent an irrational decision that might be dangerous. Once under control, you can weigh the alternatives and choose the appropriate action.

This whole process should only take a few seconds because in an emergency, time is of the essence. An out-of-air situation is the most critical and demands immediate attention, but in most cases, “stop-breathe-think-act” is the best way to regain control and make an intelligent decision. For more detailed information on dealing with stress while diving, taking the Diver Stress and Rescue Course from your local dive shop is highly encouraged.

Dehydration at Altitude

Aridity (dehydration) is one of the biggest concerns.

In this environment, the onset of dehydration can be rapid and insidious. Divers should make every effort to stay hydrated and maintain proper fluid balance. Urine should be copious and clear. Diuretics like coffee, tea and alcohol should be avoided before a dive.

Dehydration occurs when more water and fluids leave the body than enter it. Even low levels of dehydration can cause headaches, lethargy and constipation. The human body is roughly 75 percent water. Without this water, it cannot survive.

Dehydration | Breathing and Symptoms

Dehydration can cause shortness of breath. When the airways become too dry, the risk of breathing problems increases. Water is used in the nasal passages, bronchial tubes and lungs to keep them moist.

Dehydration commonly causes fatigue. Even mild cases can cause tiredness and affect the body's ability to perform essential functions. Dehydration commonly occurs when a person is sick and has vomiting or diarrhea.

Symptoms
- Dry mouth and tongue
- Feeling very thirsty
- Dry mouth
- Urinating and sweating less than usual
- Dark-colored urine
- Dry skin
- Feeling tired
- Dizziness



Cold Water and Hypothermia

The first defense the body has when exposed to cold water is to enact mechanisms by which core temperature is maintained. Priority is given to protecting the vital organs:

- Brain
- Heart
- Liver
- Lungs

The first heat-conserving mechanism is determined by body build. The endomorphic individual is short and stocky and has the greatest resistance to heat loss. The ectomorphic individual is tall and thin and has the least resistance to cold.

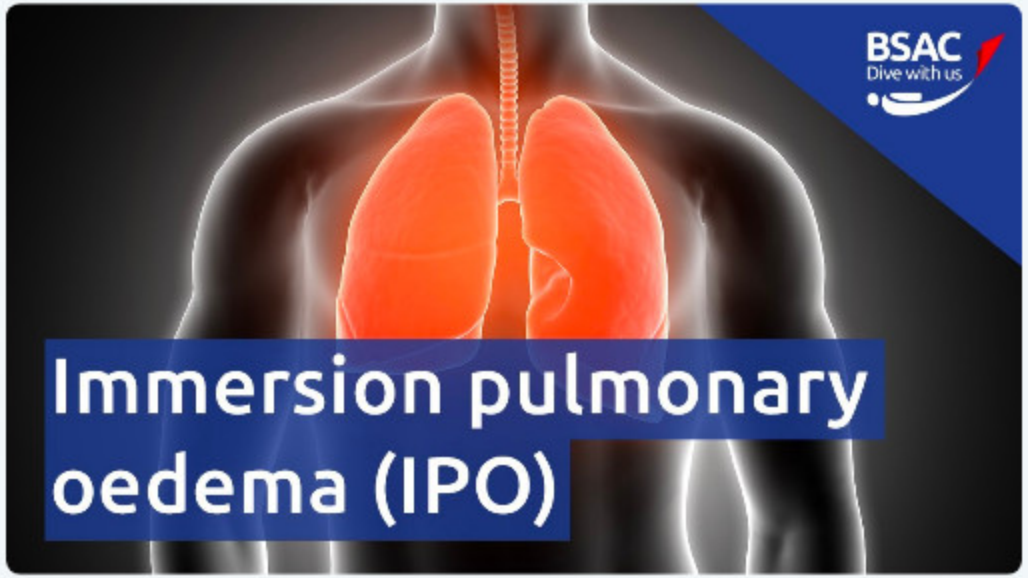
- Cold water can affect body and mental functions.
- It can prevent clear thinking and physical movement.
- It requires additional energy to stay warm.
- Hypothermia occurs when core temperature drops below 37 degrees C.
- Symptoms: blue skin, shivering, loss of coordination.



Causes of IPO

When we are immersed in water, hydrostatic pressure compresses the leg veins. Blood that normally pools in the legs is pushed centrally into the chest. Increased central blood volume raises pressure in the alveolar capillaries and may cause fluid to leak into the lungs, causing difficulty breathing and, if not corrected, death.

High blood pressure carries an increased risk of pulmonary oedema, which is why it is one of the screening questions on a diving medical form. Very strenuous exercise can also trigger IPO. This has been reported in military divers under extreme training and could arise during a rescue or while fighting a current.



IPO | Avoidance

- Hypertension: High blood pressure can contribute to risk. Divers with high blood pressure should seek specialist advice from a Medical referee.

- Hydration: Divers should NOT drink excessive fluids prior to a dive.

- Exercise: Extreme levels of exercise can contribute to IPO even in very fit individuals. Where possible, minimize the need for extreme exercise.

IPO | Recognition

Consultation with an expert is continuing to assess whether IPO is likely in incidents where the description implies it may have occurred. As information and evidence develop, divers should be aware of factors that could indicate IPO:

- Breathing difficulties when not exercising particularly strenuously, including rapid, uneven or heavy breathing, or coughing uncontrollably.
- Confusion or swimming in the wrong or random directions.
- Inability to carry out normal functions while appearing to concentrate on breathing.
- Belief that a regulator is not working properly.
- Indication of “out of gas” when regulators work correctly and gas supplies are adequate.
- Divers refusing or rejecting an alternate source when “out of gas.”
- Difficulty breathing at the surface.

IPO | Treatment

Advice from the medical experts at this time is that if you experience breathing difficulties underwater you should terminate the dive and ascend safely and exit the water. If you recognize any of the above factors in a buddy then assist them from the water as quickly as it is safe to do so. Once out of the water the casualty should:

- Sit upright if conscious.
- Be given oxygen.
- Keep warm.
- Do NOT give fluids.
- Seek medical advice.

Other Physiological Considerations for Altitude Diving

- Hydration
- Hypoxia and altitude
- Altitude diving and thermal stress
- Driving after diving

After-Dive Travel for Altitude Diving

After diving, it is important to know what group designation you are in based on the Combined Air/EANx Dive tables.

BEFORE leaving the site, it is important to know if you will be increasing in altitude and by how much.

Any increase in altitude of more than 999' MUST be taken into consideration, and a surface interval prior to this MUST be applied, just like waiting to fly.

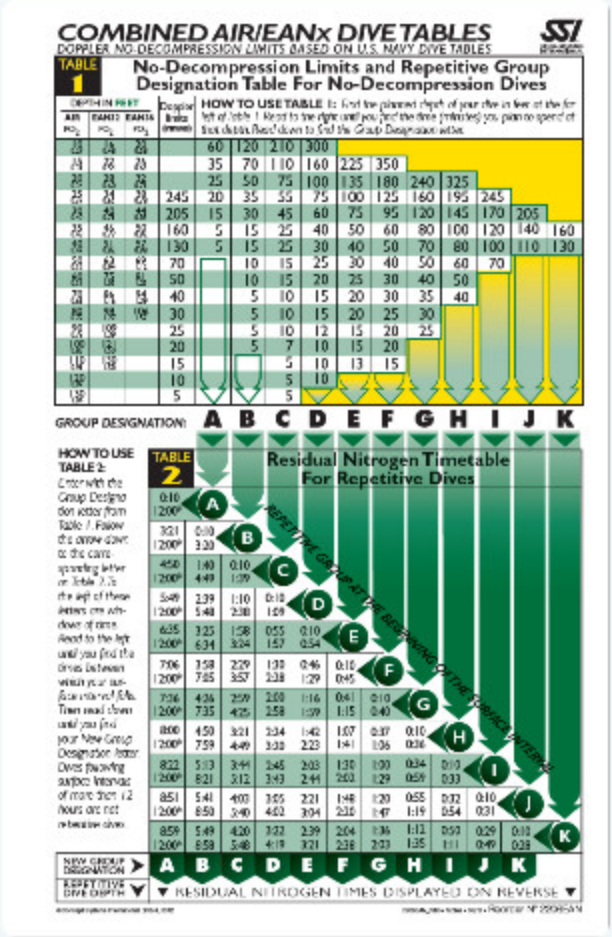
Determining Proper No-Travel Time

1. Determine what the maximum altitude change will be for your travel after your dive.

2. Each letter group is equal to 2 hours and 1,000'.

3. Prior to travel, the diver should be in Group A.

Example: Traveling to an elevation of 3,000' = 6 hours.



Diving at Altitude | Summary

Students have learned:

- How pressure shifts at altitude impact the diver.
- How to use theoretical depths as a compensation for decreased surface pressures.
- About other physiological considerations for altitude dives.

Specialty Programs | Continuing Education Ratings

Specialty Diver

2 Specialty Programs + 12 Logged Dives

Advanced Open Water Diver

4 Specialty Programs + 24 Logged Dives

Master Diver

4 Specialty Programs + Diver Stress & Rescue + 50 Logged Dives

FINAL EXAM

Knowledge Check

1. What is the minimum altitude that constitutes an altitude dive?

A. 2,000 feet

B. 1,000 feet

C. 3,000 feet

D. None of the above

Knowledge Check

2. What is the maximum recommended altitude for altitude diving?

A. 7,000 feet

B. 9,000 feet

C. There is no recommended maximum altitude

D. 10,000 feet

Knowledge Check

3. There are several contributing factors for decompression illness. Which one is the greatest concern for altitude divers?

A. Nitrox use

B. Alcohol consumption

C. Proper rest

D. Dehydration

Knowledge Check

4. You can identify all high-altitude dive sites by the presence of mountainous terrain.

A. True

B. False

Knowledge Check

5. At sea level, a flexible, gas-filled container is submerged to 33 ffw. At that depth it has a volume of 1 cubic foot. What will the volume of the container be if it is brought directly to the surface?

A. 1 cubic foot

B. 2 cubic feet

C. 2.7 cubic feet

D. 1.5 cubic feet

Knowledge Check

6. The container from question 5 is brought to the surface, but at an altitude of 3,000 ft. What will the volume be when it reaches the surface?

A. 2 cubic feet

B. 1.3 cubic feet

C. 1.5 cubic feet

D. 2.21 cubic feet

Knowledge Check

7. From the altitude pressure variation table, what is the atmospheric pressure at 4,000 feet?

A. 0.864 ata

B. 0.832 ata

C. 0.964 ata

D. Both 1 and 2

Knowledge Check

8. Most common dive tables rely on a minimum hydrostatic cap of _____ at the surface.

A. 0.93 ata

B. 1.0 ata

C. 1.013 ata

D. 0.977 ata

Knowledge Check

9. A diver plans a dive at 4,000 feet to 70 ffw. What is the diver's sea level equivalent depth (SLED)?

A. 50 ffw

B. 70 ffw

C. 80 ffw

D. 100 ffw

Knowledge Check

10. What advantage does a valve with a separate outlet provide for an altitude diver?

A. A redundant system in case of freeze-ups in cold water

B. None

C. The extra hoses look cool and techy

D. The H-valve helps to warm the air to prevent hypothermia

Knowledge Check

11. What is the preferred method of preventing hypothermia when altitude diving?

A. Use of a 7mm wetsuit with hooded over-vest

B. Use of a dry suit

C. Hot water bottles in a wetsuit

D. Never dive in water colder than 80° F

Knowledge Check

12. Safety-stop depths should be adjusted as you ascend in altitude.

A. False

B. True

Knowledge Check

13. A number of water skills are vital to managing risk on every dive. Which of the following skills is most critical to altitude diving specifically?

A. Ascent rate control

B. Gas sharing

C. Avoiding buddy separation

D. Compass navigation

Knowledge Check

14. A diver completes a dive to a SLED of 60 ffw for 45 minutes. What is the minimum surface interval time before ascending 4,000 feet in altitude to become an A group diver?

A. 6 hours

B. 8 hours

C. 10 hours

D. 12 hours

Knowledge Check

15. A diver completes travel from a location that is 5,000 feet above their home location for a dive. What letter group for residual nitrogen would the diver need to start with to account for the elevation difference?

A. B Group

B. D Group

C. G Group

D. F Group

Knowledge Check

16. A diver completes travel from a location that is 3,000 feet above their home location for a dive. How long would they need to wait prior to diving to become an A group diver?

A. 4:50

B. 2:39

C. 5:49

D. 4:26

Knowledge Check

17. A diver who is diving at altitude can make repetitive dives in the same day?

A. True

B. False

CONGRATULATIONS!

Residual Nitrogen and Safety Stops

Residual Nitrogen

Prior to altitude dive
A simple way to figure this is to increase your residual nitrogen group by one letter group for every 1,000 feet in elevation gain.

OR

2 Hours for every 1,000' you will ascend.

Residual nitrogen after an altitude dive
A simple way to figure this is to increase your residual nitrogen group by one letter group for every 1,000 feet in elevation gain.

OR

2 Hours for every 1,000' you will ascend.

Safety Stops

- Ascent rates should be reduced by 5' per minute (or more) for every 4,000' of elevation.

- Safety stops should be adjusted to the correct theoretical depth based upon dive site.

- Safety-stop times should be increased by a factor of 20% (or more) for every 4,000' of elevation gain.

Sea Level Equivalent Depth | Class Notes

Theoretical difference between sea level and altitude = 1 - (ATA Pressure at Altitude ÷ ATA Pressure at Sea Level)

Example
0.8353 ATM
0.9927 ATM

= .8414 - 1 = .1586 Difference from sea level

.1586 + 1 = 1.1586% Factor to theoretical depth

Theoretical depth is 15.86% Deeper than ACTUAL DEPTH

100' dive at 4,699' Elevation = 116' Theoretical Depth or Sea Level Equivalent Depth SLED

Quick Tools for Altitude Dive Planning

NOTE: Using the barometric math is always the most accurate. The following are quick solutions that will provide a reasonable solution.

- http://www.divebuddy.com/mobile/calculator/altitude.aspx
- Add 3.5% per 1,000'
- Barometer AP for phone (Most accurate)
- Subsurface Dive Planner
- Sea Level Equivalent Depth Table

To Determine the Proper No-Travel Time

1. Determine what the maximum altitude change will be for your travel after your dive.

2. Each letter group is equal to about 2 hours and 1,000'.

3. Prior to travel, diver should be in Group A.

IE Letter group G increase in elevation by 3,000' = 6 hours.

