

HAWAU-G-92-001 C2

Bubble Trouble

LOAN COPY ONLY

Diving Disease, Prevention
and Emergency Responses

CIRCULATING COPY
Sea Grant Depositor



Hawaii Sea Grant

INTRODUCTION

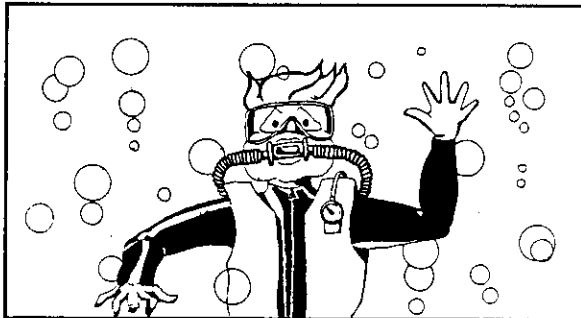
The warm, clear waters of the Hawaiian Islands offer excellent diving for residents and visitors from around the world. For your safety, this brochure describes basic dive physiology, decompression sickness, the signs and symptoms of "bubble disease," and some first-aid procedures in case of a diving emergency.

BASIC DIVING PHYSIOLOGY

The human body normally contains air in the lungs, middle ear and sinus cavity.

During a dive, air spaces in the body can be squeezed by the surrounding pressure if air is not allowed into the space to equalize the pressure. If these pressures cannot be relieved because of a cold or sinus problem, the diver may experience discomfort, pain, or even injury. This condition is referred to as a **squeeze**.

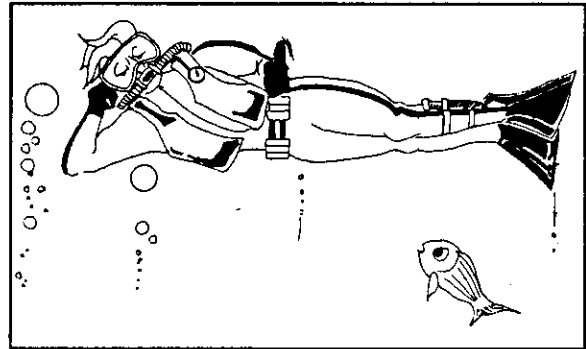
When ascending after breathing compressed air, air bubbles can form in other parts of the body, sometimes causing serious health problems.



PHYSIOLOGICAL PROBLEMS ASSOCIATED WITH DIVING

There are two types of decompression sickness, or bubble disease: (1) **Bends** — air bubbles forming within blood or tissues; (2) **Air embolism** — air bubbles being forced into the blood. These conditions can co-exist and make it difficult for doctors to distinguish which of the diseases is affecting a diver.

☒ **Bubble Formation in Tissues and Blood ("Bends").** Colorless, odorless and normally harmless, nitrogen makes up 4/5 of the air we



breathe. When nitrogen is compressed at depth, it is more concentrated.

This greater concentration in the lungs causes the blood to deliver more nitrogen to the body tissues at depth than at the surface. During a normal, slow ascent (if certain limits have not been exceeded), the nitrogen in the body tissues simply outgasses itself through the lungs.

Time and depth affect how much nitrogen is absorbed by the body. The longer or deeper the dive, the more nitrogen is absorbed. Dive tables are a result of years of careful research, designed to serve as a safety guide.

However, be warned that these are only guidelines and do not guarantee protection from the bends. Therefore, always dive well within the limits, by reducing the maximum bottom time by five minutes or by using the time for the next deeper depth listed on the table (or better yet, both). A good rule is never to go to the maximum limit on any table, no matter how it was designed.

☒ **Embolism.** Air in the lungs of divers expands as they ascend. If divers don't exhale properly, air will force itself out, bursting the pulmonary air sacs in their lungs. Then, air has three places to go: (1) between the lung and the chest wall, causing a collapsed lung, medically known as a *pneumothorax*. (2) along the airways and into the tissues of the chest and neck. This is usually harmless and is called a *subcutaneous emphysema* or *mediastinal emphysema*. (3) into the small blood vessels surrounding the lung sacs, then directly to the brain by way of the bloodstream. The bubbles travel as far as they can in the cerebral vessels, ultimately blocking the circulation that carries oxygen and nutrients to the brain tissue. This causes the stroke-like syndrome known as *arterial gas embolism (AGE)*.

Divers must always ascend at a slow, controlled rate of less than 60 feet per minute so that they have enough time to properly vent their lungs.

SYMPTOMS OF DIVE-RELATED DISEASES

☒ **Extreme Fatigue.** Although normal diving can tire a person, divers should be aware of extreme fatigue. This is one of the most common symptoms of the "bends."

☒ **Painful Joints and Limbs.** Pain in joints and limbs is the most common symptom associated with the "bends," and probably led to its name. People sometimes get less severe cases of the bends, which are often labeled "mild bends." Ignoring these "milder" pains can lead to bone rot later in life.

☒ **Dizziness and Deafness.** Bubbles in the inner ear can contribute to severe loss of balance or hearing.

☒ **Numbness and Tingling.** Bubbles can form in the spinal cord and nerves, disrupting their normal function. This can cause numbness, pain, tingling and loss of balance.

☒ **Weakness or Paralysis.** Disruption of nerves that serve muscles occurs as well, leading to symptoms ranging from barely detectable weakness to total paralysis.

☒ **Mental or Behavioral Changes.** Because bubbles can travel to, or form in, the brain, the ability to think or behave normally can be affected. Therefore, it is a good idea for divers to watch one another closely after a dive. Symptoms can range from a slight loss of concentration to drowsiness and coma.

☒ **Unconsciousness and Seizures.** Loss of consciousness is not uncommon, and seizures happen occasionally, as well.

CARE AND TREATMENT OF DIVE ACCIDENT VICTIMS

Cardio-Pulmonary Resuscitation (CPR). If a person's heart stops, Cardio-Pulmonary Resuscitation (CPR) must be administered immediately. CPR involves chest compressions to maintain blood flow and artificial respiration to maintain breathing. CPR should only be administered by those who have received proper training. For this reason, divers and non-divers should learn CPR as part of first-aid education.

☒ **Positioning.** It is recommended that injured divers **not** be placed in the traditional "left-side low, head-down" position but simply in a comfortable position that allows resuscitation.

If shock and/or unconsciousness develops, lay the victim down with the feet elevated. If the victim vomits, turn him/her to the side.

☒ **Pure Oxygen.** If the victim has a pulse and is breathing, the single most important thing to do is to administer oxygen.

A victim who is not breathing should be given oxygen with a resuscitation kit that contains devices that allow increased oxygen delivery, even during the use of artificial respiration.

A breathing victim should take oxygen from a demand-valve regulator system and tight-fitting mask. A clear plastic mask with steady flow of oxygen is inadequate and should be used only when an oxygen-clean regulator system is not available.

☒ **Fluids**

- If victims are conscious and alert, allow them to drink non-alcoholic beverages, juices or sports drinks.

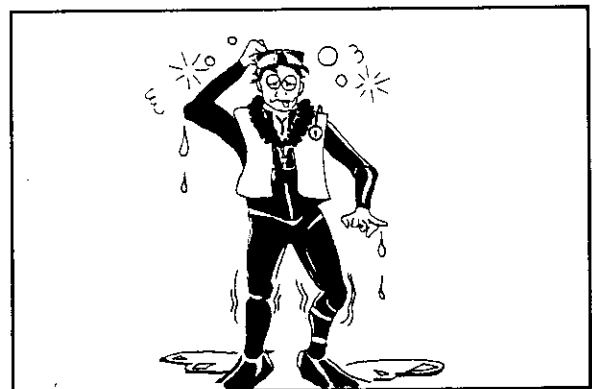
- Unconscious victims should receive intravenous fluids as soon as they are under the care of qualified personnel.

☒ **Miscellaneous**

- Record all events for later review by doctors and other authorities.

- Have the victim's diving partner give physicians any details about the dive that may be important in deciding proper treatment.

- Do not give the victim any medications.



HAWAII EMERGENCY MEDICAL SERVICES

☒ Transportation of victim

- Use the quickest, safest way possible.
- Avoid ascending to any altitude greater than 500 feet.
- Allow the coordinating agency to decide where and how to transport the victim.

☒ Coordinating agencies

- United States Coast Guard
 - On land: 1-800-331-6176
 - At sea: Marine Radio Channel 16
- Emergency Services: 911 (except Big Island: 961-6022)
- Hyperbaric Treatment Center:
 - Honolulu: 523-9155; Kauai: 338-9444

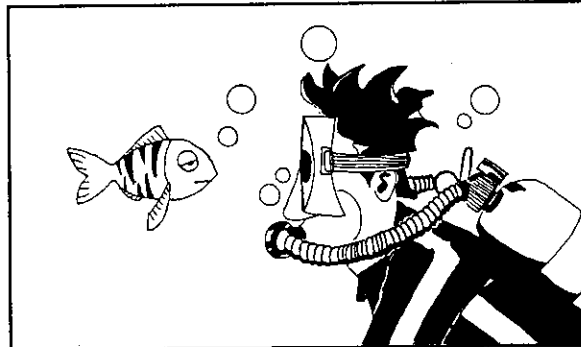
DIVE ACCIDENT PREVENTION

Persons with any of the following conditions should consult an experienced dive physician before diving.

- asthma
- chest surgery
- seizures, fainting or blackouts
- back injury with neurological changes
- history of collapsed lung
- pregnancy
- prior serious decompression sickness
- migraine headaches
- any mental disorders requiring drug use
- any neurological disease (e.g., multiple sclerosis, etc.)
- angina or heart attack
- heart surgery or pacemaker
- high blood pressure
- other miscellaneous heart disease
- wheezing in cold air or with exercise
- unrepaired hernias
- any eye or ear surgery
- any chronic ear or sinus problem
- any blood disorders (e.g., hemophilia, sickle cell anemia)
- insulin-dependent diabetes

There are many reasons these conditions can be dangerous while diving. For example, they may lead to lung over-expansion or loss of consciousness in the water, as well as conditions which can predispose the diver to both medical and psychological stress.

This list is not comprehensive but can serve as a guide. For any questions, please call any of the medical officers at HTC.



Safe Diving Practices. The following are some safe diving tips that may reduce the possibility of an accident. But even safe divers can have accidents, so be prepared, obtain proper safety equipment, and get advanced rescue training.

- Be in good physical condition
- Get proper training
- Use reliable equipment
- Never dive alone
- Know the diving area
- Use a boat, float, or both
- Plan your dive
 - Dive deep to shallow
 - Never dive to the limits of any table
- Be ready for emergencies
 - Get Rescue, CPR and first-aid training
 - Carry a basic first-aid kit
 - Know emergency numbers and the location of the closest hyperbaric chamber
- Never hold your breath
- Watch your ascent rate
- Conduct a 3 to 5-minute safety stop at 15 feet on every dive
- Get medical attention if any abnormality develops during or after a dive.

FLYING AFTER DIVING

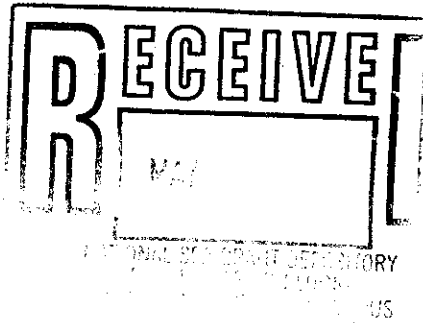
The following recommendations for recreational sport divers are adapted from those published by the Undersea and Hyperbaric Medical Society's "Flying After Diving" Workshop (1989).

☒ Flying to the mainland or abroad:

- 12-hour surface interval for:
 - No-stop diving only
 - Only two hours total dive time in 48 hours preceding flight
- 24-hour surface interval for no-stop diving or

- multi-day, unlimited repetitive diving
- 48-hour surface interval for any staged decompression diving
- ☑ **Flying inter-island**
- 6 to 12 hour surface interval for no-stop diving
- 24-to 48-hour surface interval for any staged decompression diving

The University of Hawaii is more conservative with its own divers, requiring all UH authorized scientific divers to wait at least 24 hours before any flight.



It has been said that the only sure way to prevent the bends is to either never go down or never come up. To the motivated sport diver, neither of these is an attractive or realistic choice. The only defenses a diver has are common sense and conservative diving.

This publication was prepared through the cooperation of the University of Hawaii Sea Grant Extension Service, the state of Hawaii Department of Business, Economic Development and Tourism, and the state Hyperbaric Treatment Center (HTC). This work was supported in part by the Ocean Resources Branch, State of Hawaii Department of Business, Economic Development & Tourism, ORB Contribution No. 90. For additional copies send a self addressed stamped envelope to UH Sea Grant Extension Service, 1000 Pope Rd., Rm. 226, Honolulu, HI 96822, USA.

Sea Grant Extension Brochure
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