Scientific Diving

- Definition
- History
- Training
- Modes of Diving
- Procedures

Scientific diving (according to OSHA)

Is --

For the researcher exploring his or her subject in the subaquatic realm, scuba is merely a tool. Scientific divers must be trained to use this tool to a level of proficiency that allows them to focus on the research task. For this reason, most scientific institutions and universities require extensive training and specialized experience before authorizing their scientists and research support staff to conduct underwater research using scuba.

Is Not --

Scientific diving does not include performing any tasks usually associated with commercial diving, such as placing or removing heavy objects underwater; inspection of pipelines and similar objects; construction; demolition; cutting or welding; or the use of explosives.

Differs from Recreational Diving --

Scientific diving differs from recreational diving diving in many ways. Scientific diving is diving performed solely for research purposes, or in support of research activities. The advancement of science is the single goal. For many recreational divers, the thrill of swimming under water, breathing on scuba and enjoying the panoramic view of life beneath the sea is in itself the end goal of learning to dive.

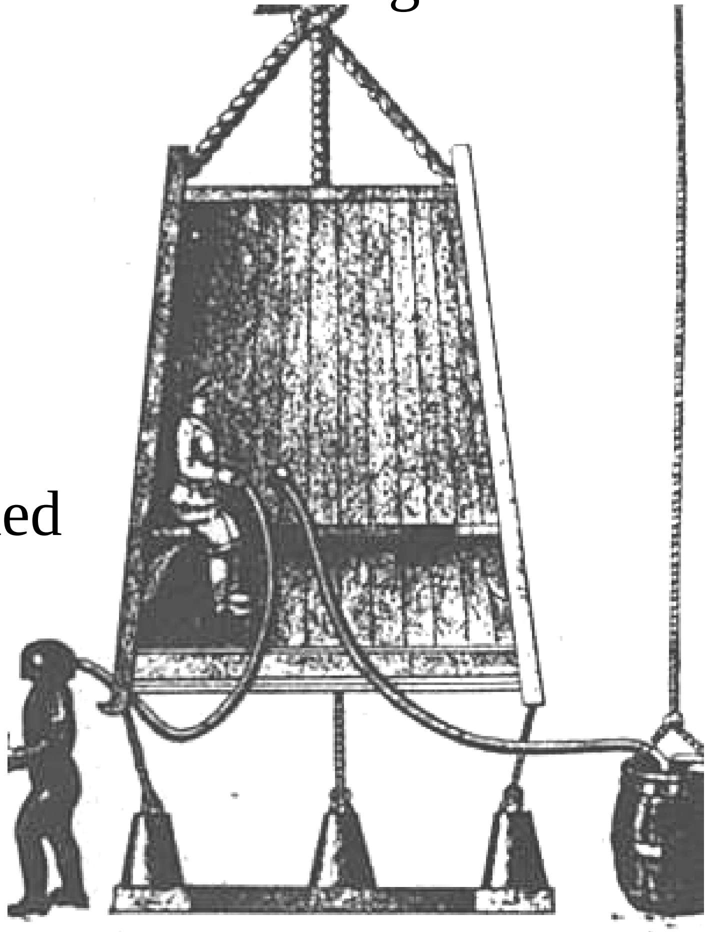
History of scientific diving

- 332 BC - Alexander the Great
  - breath-hold or bell-type diving
  - simple collections and observations

History of scientific diving

1691 the British astronomer Sir Edmund Halley

- built and patented a forerunner of the modern diving bell.
  - bell was made of wood coated with lead
  - approximately 60 cubic feet volume
  - glass at the top to allow light to enter
  - weighted barrels of air replenished the bell's atmosphere



History of scientific diving

1827 - Pouilliot

- piston-controlled pneumatic regulator

History of scientific diving

1837 - Augustus Siebe,

- seals a diving helmet 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

History of scientific diving

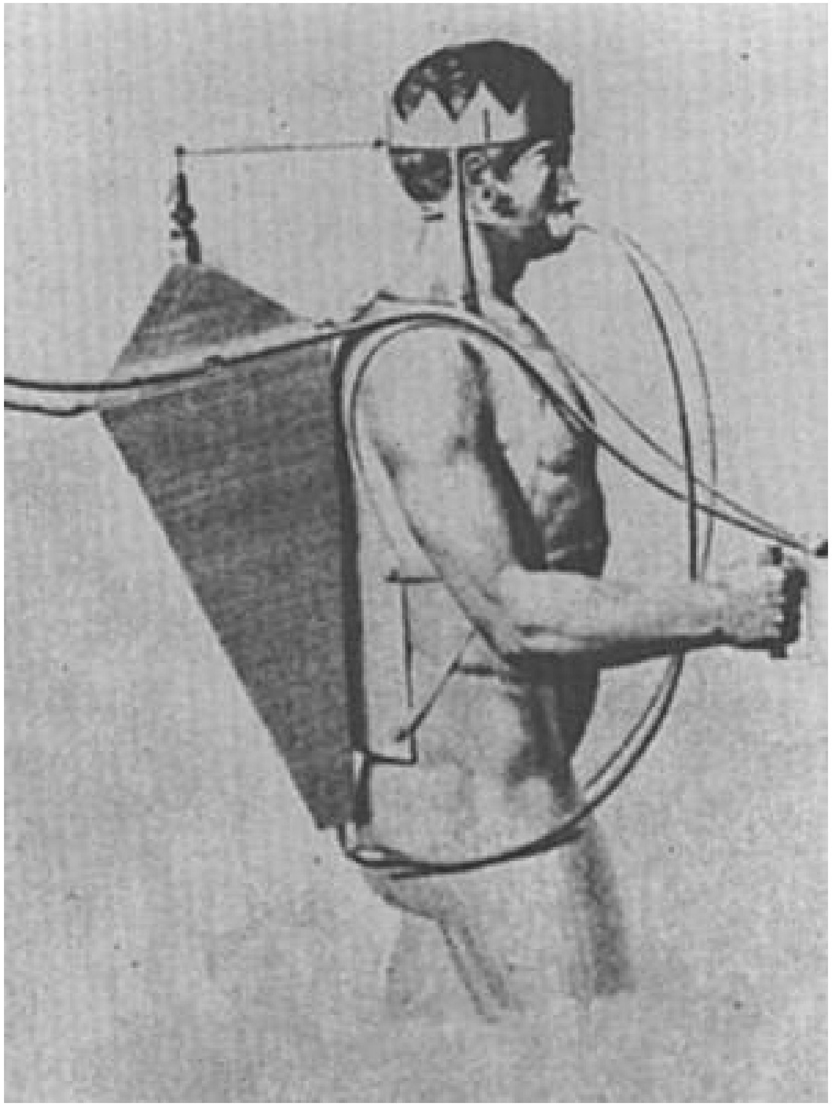
- 1844 - Henri Milne Edwards
  - commercial diving suit to make u/w observations (25 ft.)

History of scientific diving

1865 - Benoit Rouquayrol and Auguste Denayrouse,

- patent an apparatus for underwater breathing
- consisted of a horizontal steel tank of compressed air connected through a valve arrangement to a mouth-piece
- device delivers air only when the diver inhales, via a membrane that is sensitive to outside water pressure
- 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

History of scientific diving



History of scientific diving

1893 - Dahl

- first to quantitatively census a benthic community

- 1930 - Florida Geological Survey
    - used hard-hat diving equipment to collect fossil skeletons
- 1934 - Kitching
    - used diving helmet for kelp bed observations

History of scientific diving

1949 - modern scientific diving born in U.S.

- Conrad Limbaugh first used SCUBA at SIO

➢ this allowed researchers to work directly in the u/w environment

➢ rather than collecting data indirectly, scientists were now able to conduct experiments in situ

History of scientific diving

- 1951 - University of California conducted first formal scuba diving training program.
- 1953 - UC authorized the use of scuba diving in support of science.
- Early 1960s - George Bond (USN) developed saturation diving techniques.
- 1970s - Canadian universities formed scientific diving programs.

Formation of the American Academy of Underwater Sciences

- Late 1970s - challenge to scientific diving was made to OSHA by a labor union that contended that commercial divers could not compete for work with scientific divers due to their (commercial diving) extensive standards.

- Scientific diving community had to prove that its standards were not sub-par (via years of statistics highlighting safety records, training mechanisms, diving volume, etc.).

- 1977- AAUS (1983- CAUS) was created to provide the framework for the establishment of new scientific diving programs that would meet the exemption from commercial diving standards.

- 1982 - scientific diving was granted an exemption to commercial diving standards.

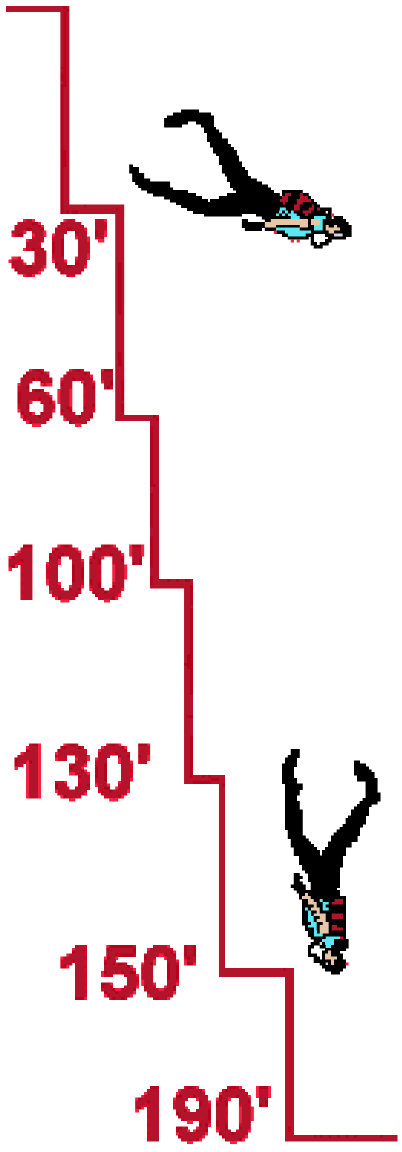
Scientific Diving Units

- Federal government
    - NOAA, NSF, Smithsonian Institution
    - DOI, MMS, USGS
    - USFS, NPS (Submerged Cultural Resources Unit)
    - FBI, Secret Service
    - Military
- State & local government
    - County DNR
    - Aquariums
    - Parks & Wildlife
    - DOT
    - Sheriff search and recovery units
- Universities (68 - most meet AAUS standards)
- Private
    - Independent research institutes
    - Consulting firms

Scientific Diving Training

Scientific divers must be trained to the point where the diving part of the project is almost automatic.

- Certification from a nationally recognized diving agency
- Pass a physical exam (yearly or bi-yearly)
- Theoretical aspects (~ 50 hours)
    - collecting techniques, biota identification
    - photography, use of scientific equipment
    - small boat operations, specialized diving techniques
    - tagging techniques, chemical use
- Practical training (~50 hours)
    - swimming proficiency, emergency oxygen administration
    - CPR, first aid for diving accidents
    - dive rescue techniques, practical dive management



Initially, a diver is authorized to dive to 30' (10m) depth

After 12 supervised dives between 31' and 60’, diver is authorized to dive to 60'.

After 4 supervised dives between 61' and 100’, diver is authorized to dive to 100'.

After 4 supervised dives between 100' and 130’, diver is authorized to 130’.

Divers may be certified to 150' and 190‘ by logging 4 supervised dives near each depth and completing a successful check-out dive with DSO (Smithsonian Institution).

Research Diver (Recreational)	Scientific Diver (AAUS)
Practical training only	OSHA defined
Training varies with agency	AAUS training standards
Variable # of training dives	100 hours of training
No medical exam	AAUS medical required
Lifetime certification	Must maintain “active” status
Independent instruction	Scientific diving program oversight
	Emergency training required

Modes of diving:

- Open circuit scuba
  - Compressed air, nitrox, trimix
- Rebreathers
- Saturation diving (employing both OCS and rebreathers)
- Surface supplied
- Lock-out diving from submersibles
- Specialty suits

Limitations associated with diving:

- Thermal stress
- Depth and time limitations
- Surface conditions
- Diver fitness
- Relatively labor and equipment intensive

Open circuit scuba is by far the most prevalent mode of scientific diving

Compressed air

Benefits (4):

- widely available
- relatively light weight and portable
- relatively easy training
- cost effective
  - equipment, manpower and vessel support requirements

Disadvantages (2):

- limited bottom time at depths >100 FSW
- increased chances of decompression sickness (bends) and nitrogen narcosis (at depth)

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Open circuit scuba - Breathing gases other than air can be used to improve safety, increase bottom times and decrease surface intervals.

- **Nitrox** (aka, enriched air, enriched air nitrox)
  - mixture of lower nitrogen and higher oxygen partial pressures than found in air
    - common mixes: EAN 32, EAN 36
  - strategy: reduce nitrogen partial pressure (nitrogen is the source of decompression and narcosis problems) by replacing it with oxygen (much of which is used metabolically)
  - disadvantages (4): depth limitations, costs, dedicated equipment requirements, potential oxygen toxicity

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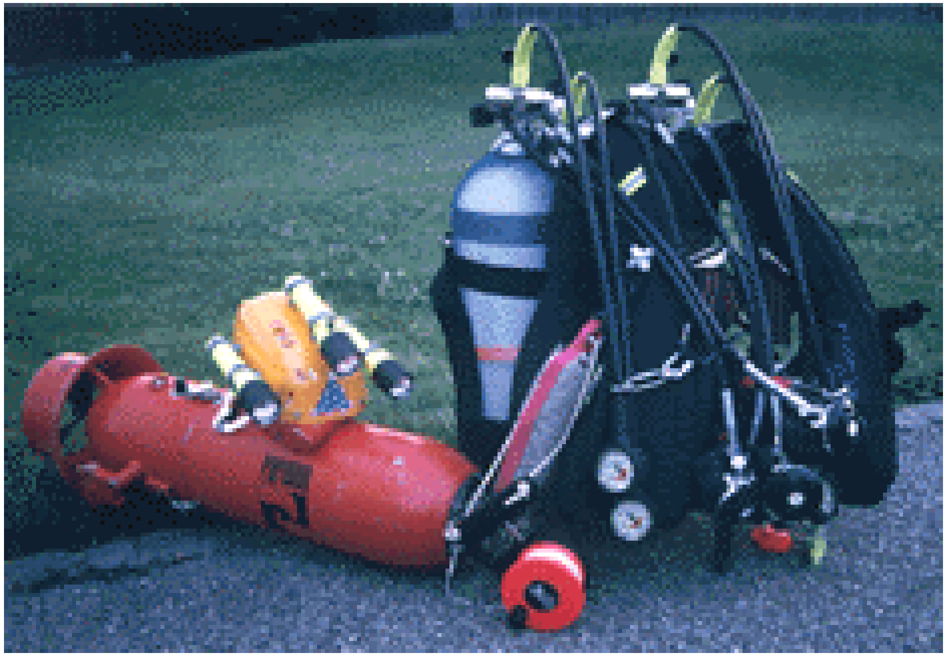
Open circuit scuba

- **Trimix:** mixture of two inert gases and oxygen (std bottom mix - 18% oxygen, 50% helium, 32% nitrogen)
    - allows for extended maximum depth and time capabilities
    - all gas concentrations are predetermined according to depth and time requirements
    - disadvantages (5): extensive equipment requirements (primary and redundant), limited availability, extensive training requirements, specific dive tables and computer-generated profiles, relatively small margin of error



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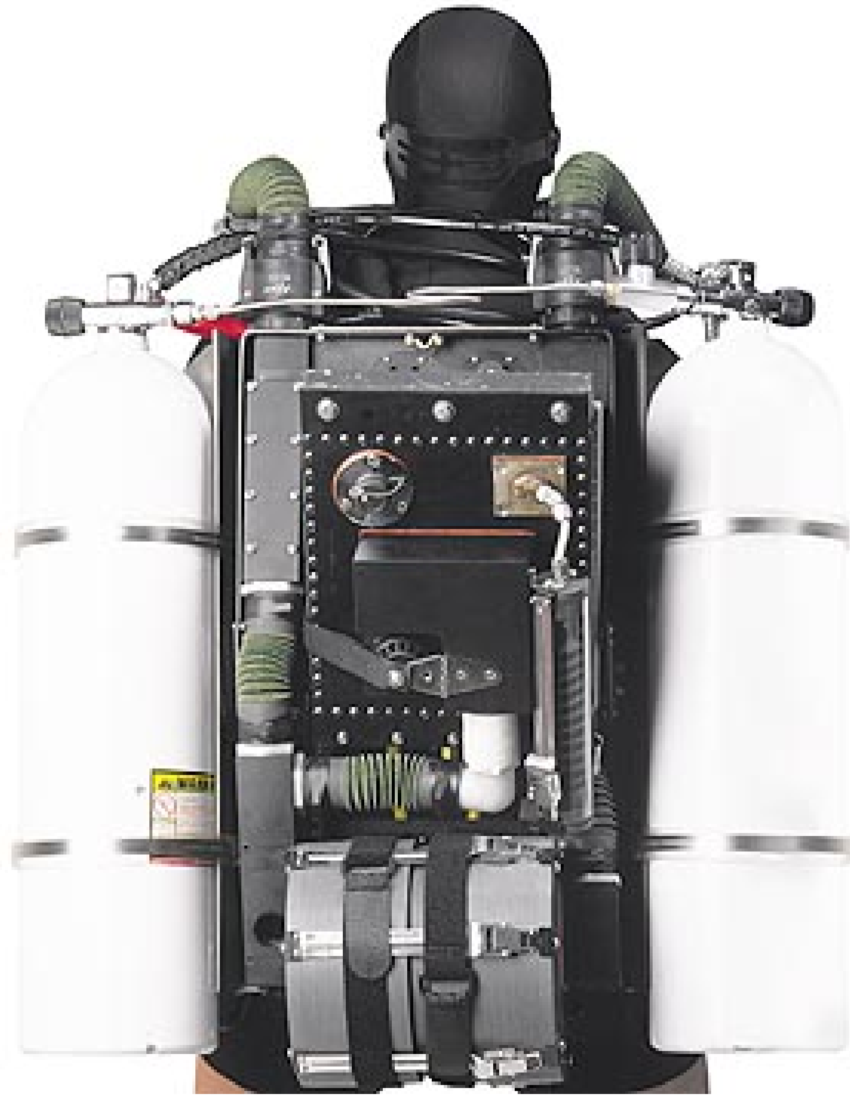
Rebreathers are "closed" circuit breathing apparatus that recycle a diver's breathing gases.

- Fully redundant systems recirculate exhaled air after it has been scrubbed of carbon dioxide and had oxygen injected (12 hour gas supply)
- Semi-closed systems emit a few small bubbles upon exhalation and can be augmented with nitrox (two hour gas supply)
- benefits(3): extensive gas supply, non-intrusive, valuable in areas where filling scuba cylinders can be a problem
- disadvantages (5): extensive training, high maintenance, contamination potential, limited availability, costly



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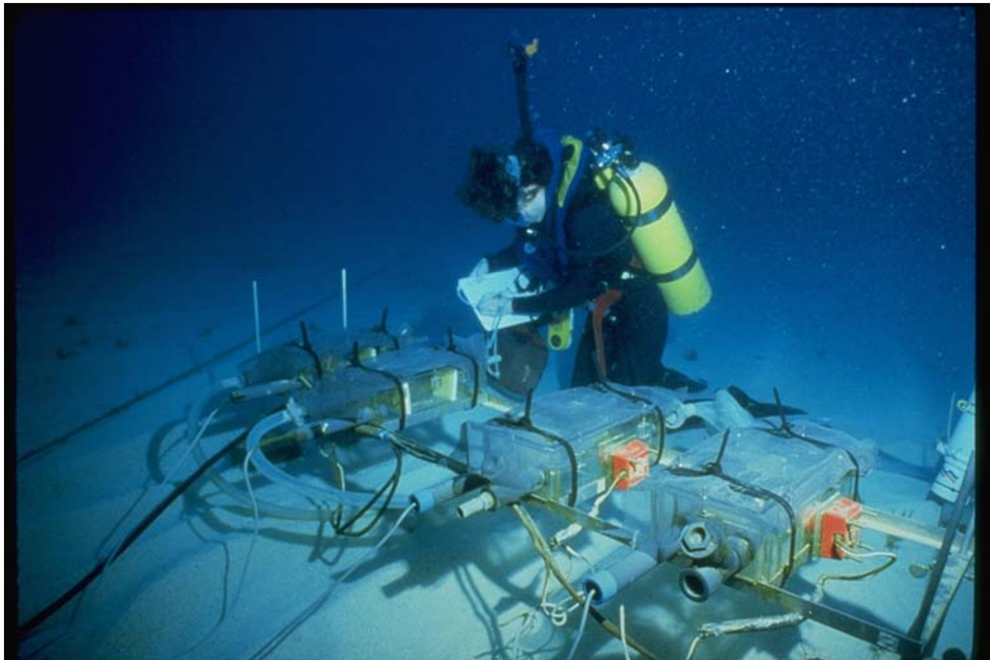
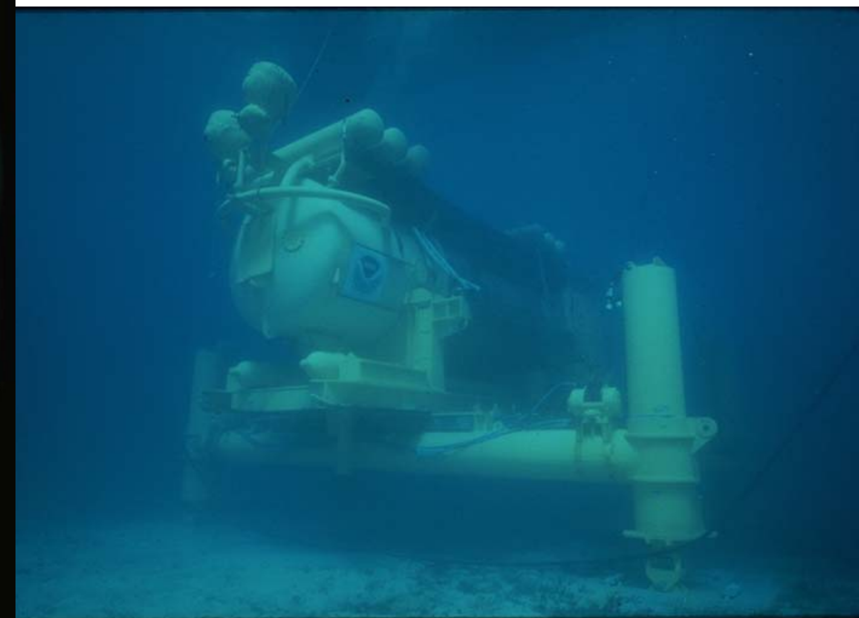
Saturation diving is conducted from an underwater habitat placed on the seafloor and pressurized near ambient pressure surrounding the habitat.

- since a diver's tissues become saturated with nitrogen, dives from the habitat (excursions) can last 6-9 hours
- missions can run from 5-30 days long
- benefits (4): time, scientists gain an overall underwater perspective of their subject, ability to set up elaborate sampling designs, decreased risk to decompression illness
- disadvantage (6): limited study sites, thermal stress, living in confined spaces, inability to surface if necessary, extensive planning necessary, advanced training, cost





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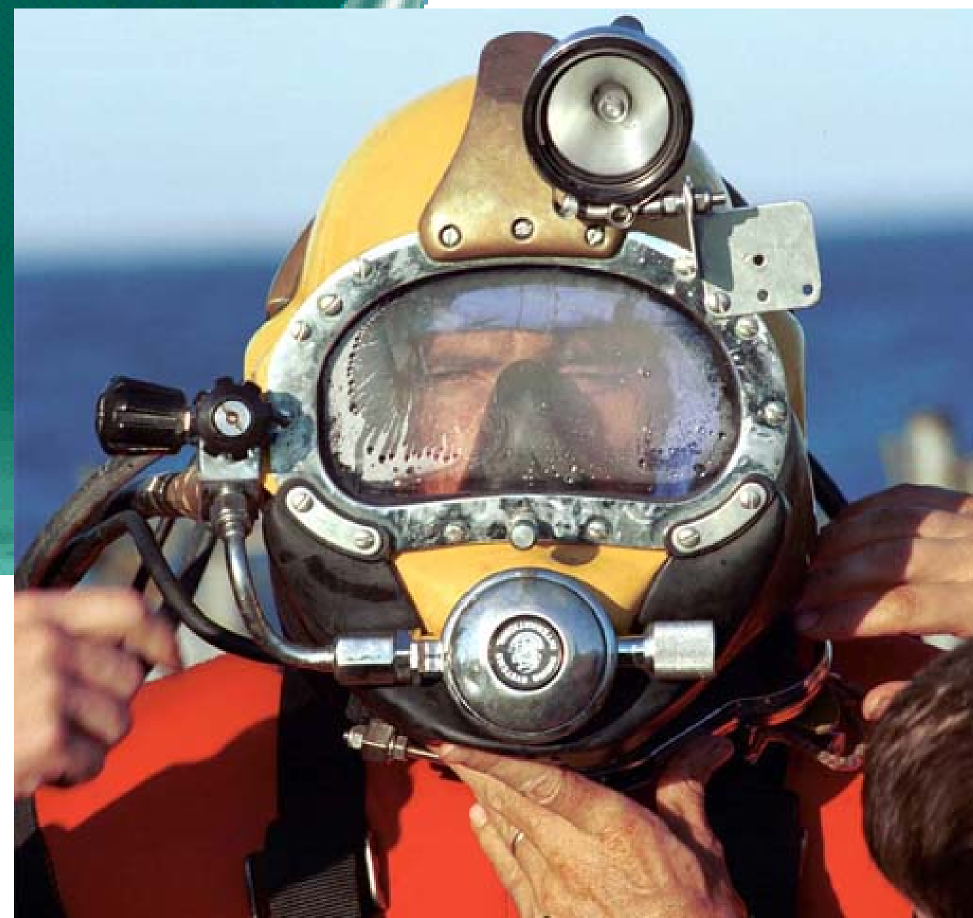
Surface supplied diving: mode where the diver's Breathing gas and hard wire communications are supplied by the surface

- advantages (3): potentially unlimited gas supply, surface personnel controlling diver's depth and decompression (freeing them to concentrate on science), communication with surface for data collection
- disadvantages (5): heavy/bulky equipment, costly, manpower intensive, high maintenance, limited u/w mobility



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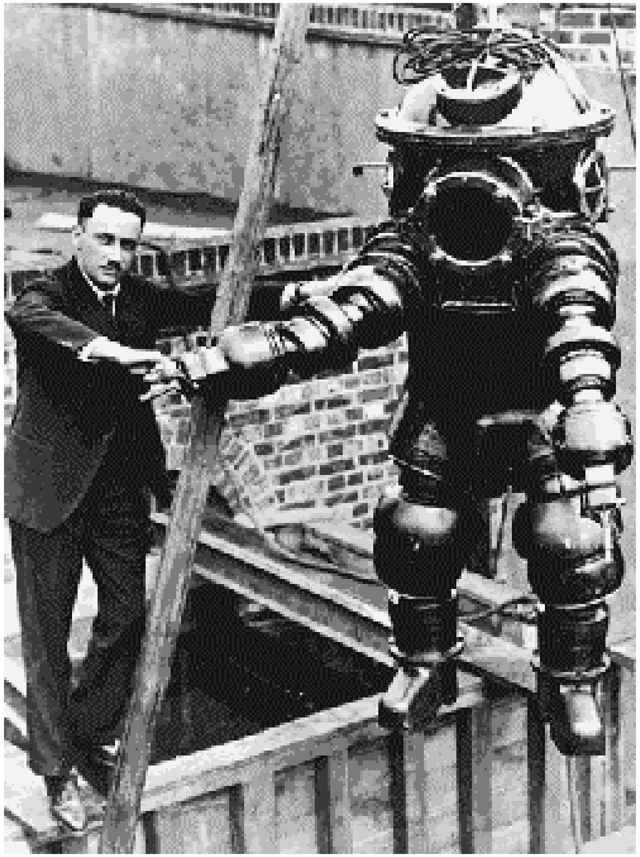
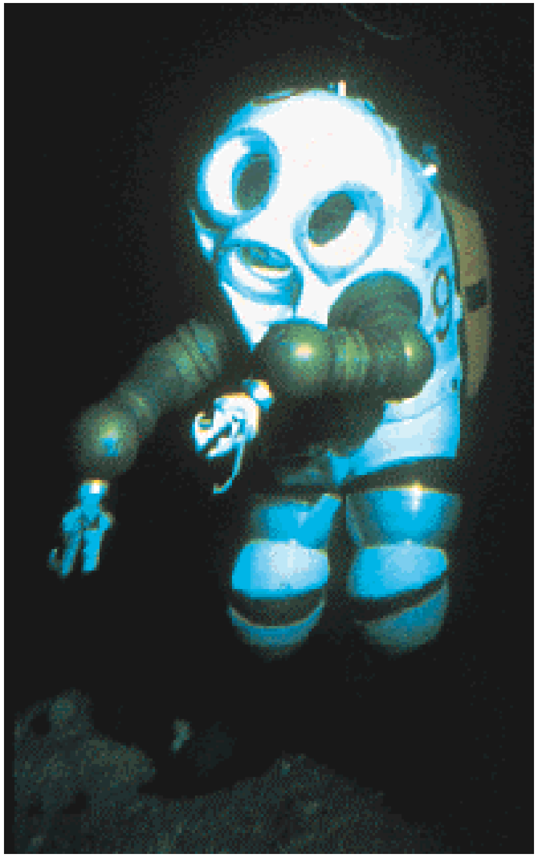
Lock out diving: diver is transported to the dive site inside a submersible and exits the sub by means of an umbilical (which supplies breathing gases) or via scuba

- advantages (1): sampling organisms that cannot be obtained using the sub or ROV manipulators
- disadvantages: costs, safety and training usually prohibit this mode of sampling.

Specialty Suits

- **Jim Suits**:first developed in the 1930s to salvage ship wrecks off France. Later gave way to more advanced suits that followed the original prototype. Currently used around the world to depths >600m (2000 FSW)





Procedures and Protocols

General

- Locating, marking, and mapping sites
- Data collection

Specific

- Geological measurements
- Physical oceanography
- Chemistry
- Benthic distribution and abundance studies
- Bacteria and infauna
- Fish assessments

Procedures

- **Locating, marking, and mapping** study sites are critical, especially in areas of low water visibility
  - From the surface...
    - Compass bearings and triangulation
    - GPS
    - Depth sounders
    - Sidescan sonar
    - Buoys

Procedures

- **Locating, marking, and mapping** (cont.)
  - Underwater...

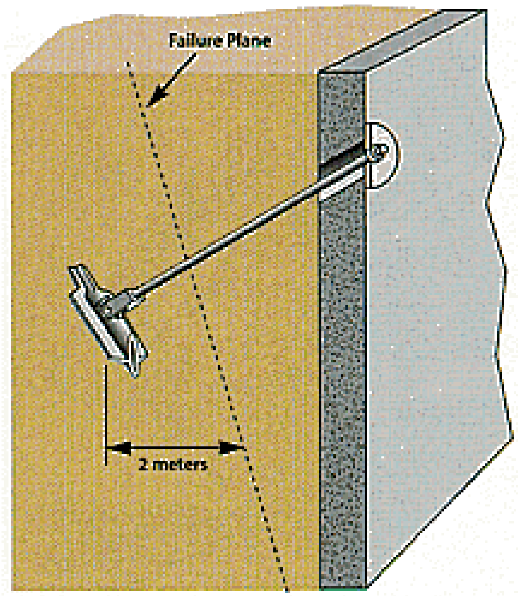
    Rocky areas:
    - railroad spikes, masonry nails and sharpened rebar can be driven into substrate with sledgehammer
    - pneumatic and hydraulic drills and masonary bits
    - cement and epoxy

Procedures

- **Locating, marking, and mapping** (cont.)
  - Underwater...

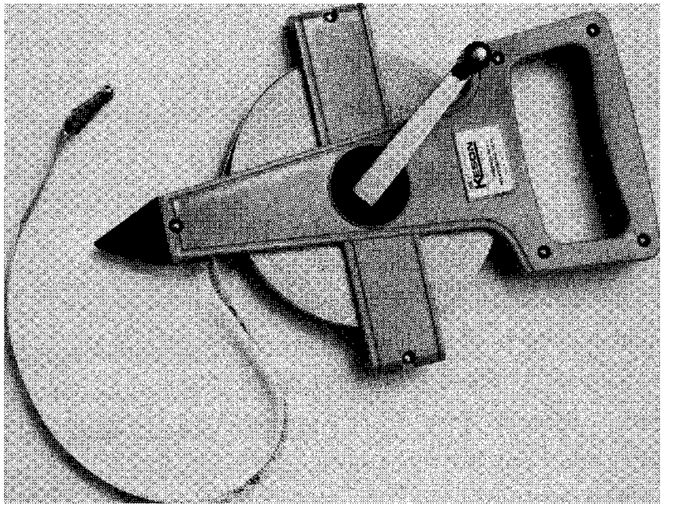
    Softbottom areas:

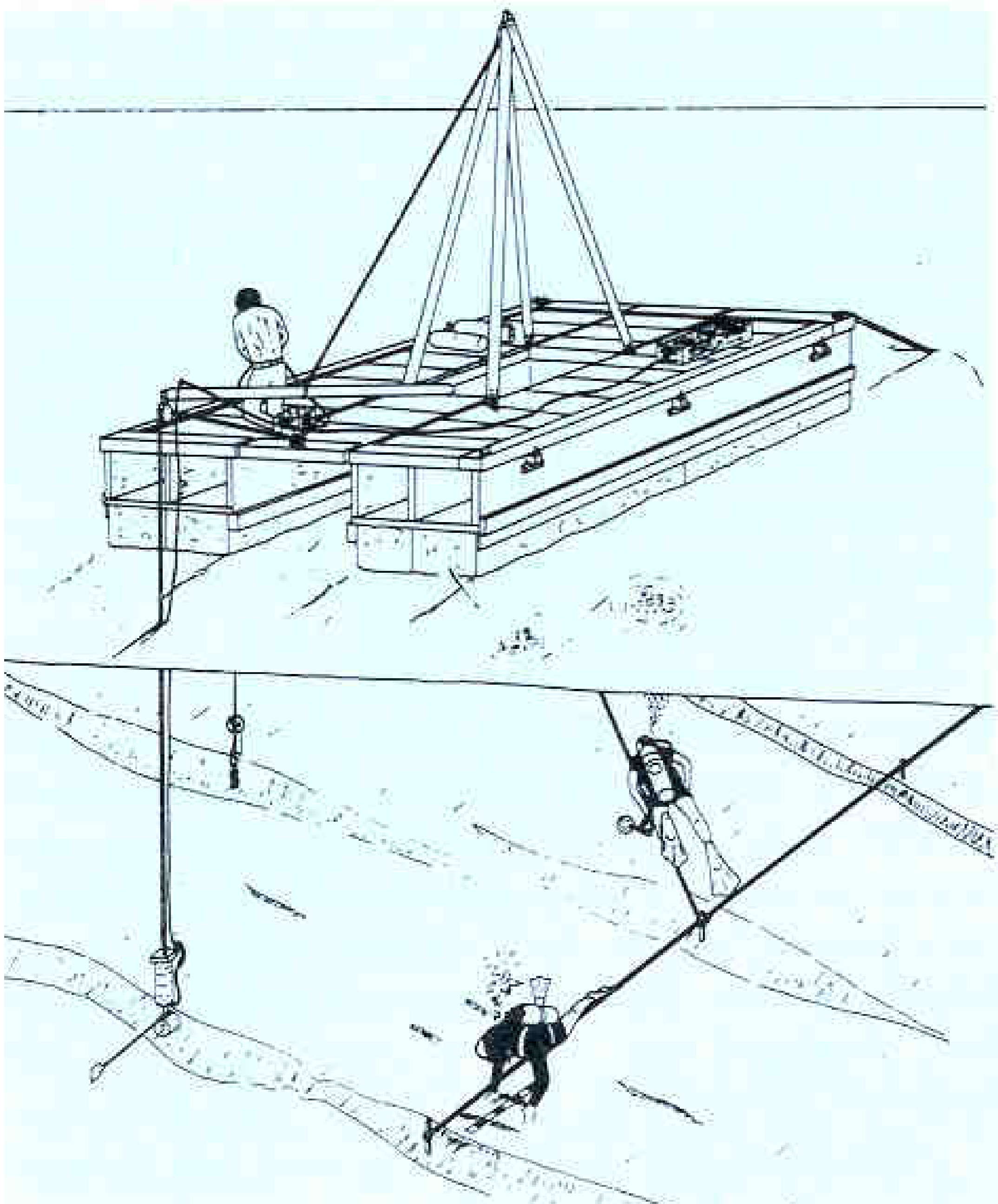
    - flanged anchors and mobile home tie-downs
      - increase visibility: attach electric cable ties, colored flagging tape, cow ear tags, PVC
      - pingers used in conjunction with handheld locator



Procedures

- **Locating, marking, and mapping** (cont.)
  - Underwater mapping
    - simple & most common - transect tape, compass, depth gauge, slate, and inclinometer
    - advanced - u/w electronic sonar and navigation systems





Procedures

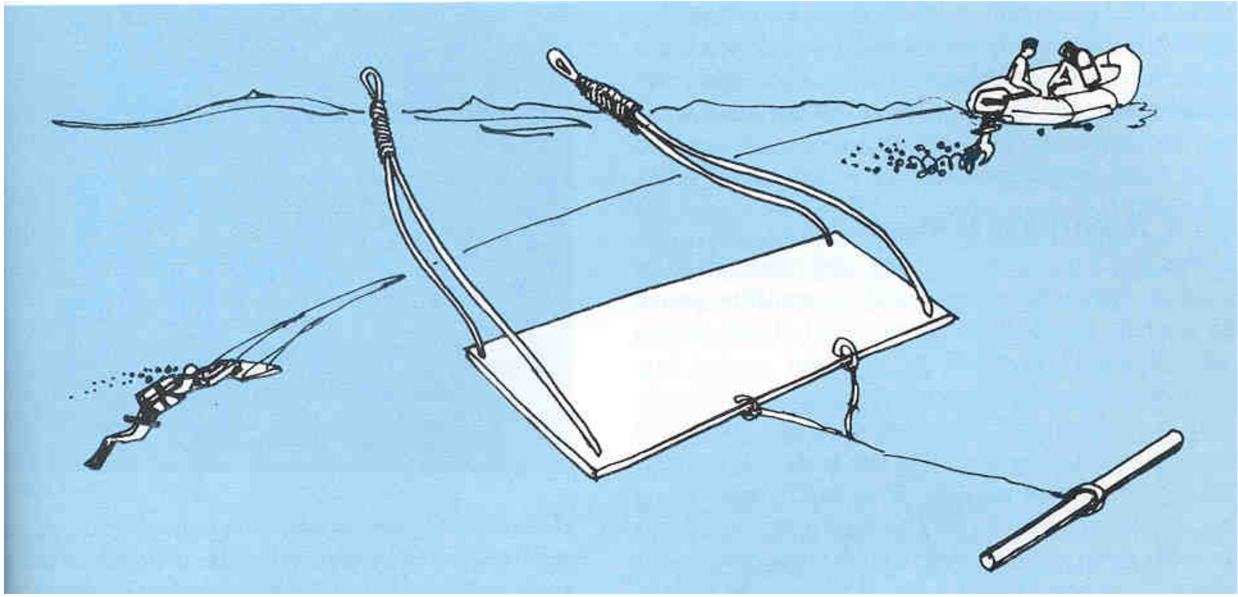
- **Data collection**
  - handheld slates
  - PVC pipe wrist cuffs
  - u/w communications and tape recorders

Procedures

- **Data collection** (cont.)
  - Photography and videography

Procedures

- **Data collection** (cont.)
    - diver propulsion vehicles
    - towed sleds



Procedures and Protocols

- **Geological measurements and collections**
  - crude rock collections via hammer, chisel, and crowbar
  - penetrometer (calibrated spring-loaded pole that is shot into the sediment to determine consolidation)
  - hand-held box and tube cores
  - Ekman grabs
  - hydraulic core sampler
  - inclinometer and meter stick (measure sand ripples)
  - air lift and suction sampler

Procedures and Protocols

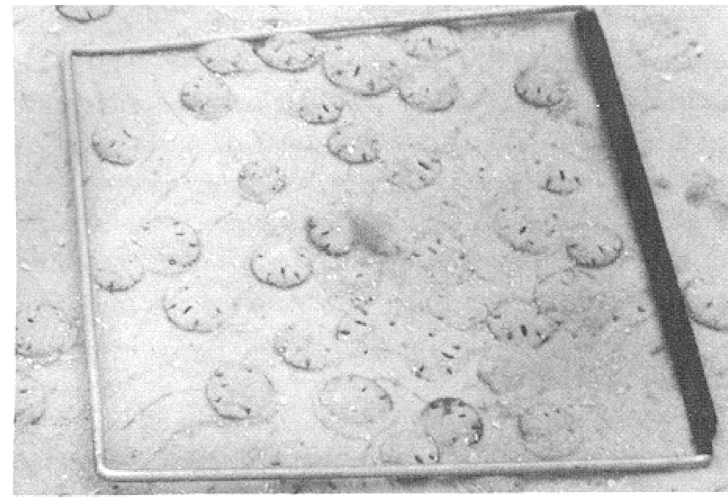
- **Physical oceanography**
  - current meters
  - CTD (conductivity, temperature, depth)
  - water sample bottles
  - thermometers and thermographs
  - dye tracers and videocameras (internal waves)
  - Li-Cor PAR sensors (photosynthetically active radiation)
  - PAM (Pulse-Amplitude-Modulation) fluorometers (measures chlorophyll a - photosynthetic pigment)
  - clod cards (blocks of plaster of paris are weighed, affixed to a frame, deployed for extended time periods. Blocks are then collected, dried, and weighed to give a relative measure of water motion by weight differences)

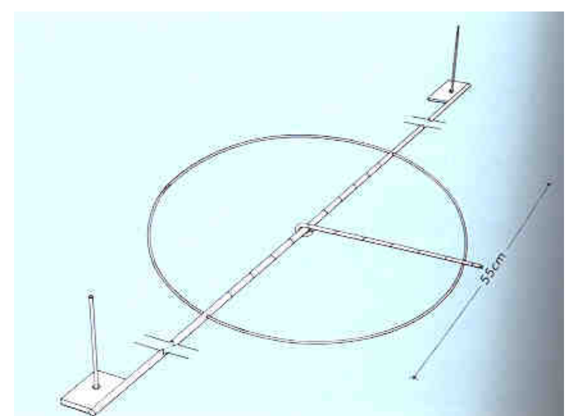
Procedures and Protocols

- **Chemistry**
  - polyethylene bottles for water samples
  - nutrient fluxes (inserting fertilizers in porous containers for slow release and measuring effects on surrounding plants and corals)
  - Chemetrix indicator ampules (dissolved oxygen)
  - oxygen microelectrodes (dissolved oxygen)

Procedures and Protocols

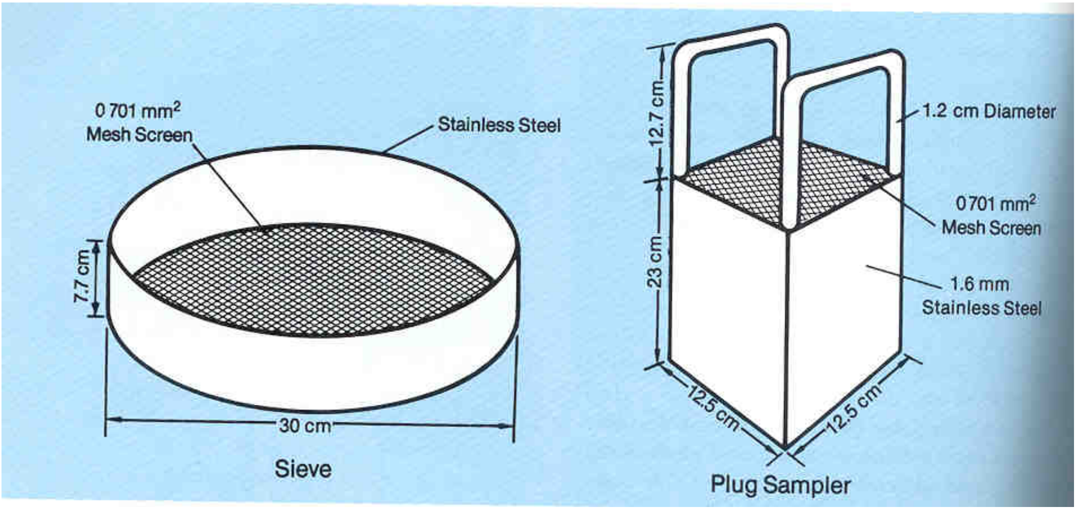
- **Benthic distribution and abundance studies**
  - simple transects using tapes and slates
  - quadrats (photoquadrats)
  - repetitive video transects (using computer program that identifies and maps attached organisms)
  - circle templates (benthic population density)
  - random point counts along transect
  - lead lines or chains (substrate rugosity using the ratio of measured chain length to linear distance)





Procedures and Protocols

- **Bacteria and infauna**
  - bacteria samples collected from corals using syringes
  - bacteria samples collected from fish and invertebrates by swabbing the animal and inoculating an agar slant contained in a inverted sample tube
  - infaunal organisms commonly collected and quantified by core samples



Procedures and Protocols

- **Fish assessments**
  - non-destructive census techniques
    - timed counts (total number of species and individuals per time interval; random)
    - transects (visual and video)
    - timed point counts (remain stationary for set period of time recording all species/individuals within a predetermined radius)
  - poisons and anesthetizing agents (rotenone & quinaldine)
  - electrofishing
  - slurp guns and spear guns
  - nets and traps