Antarctica
Scientific Diving Manual

National Science Foundation

Office of Polar Programs

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1. Introduction

1947: first dive by Americans in Antarctic waters, LCDR Thompson and Chief Dixon, as part of Operation Highjump, using Jack Brown masks and Desco oxygen rebreathers.

1951: first Antarctic open-circuit scuba dive.

1947-1967: research diving operations under USN Support Force, Antarctica.

1967: NSF-SIO agreement for polar research diving

1987: USAP Guidelines for conduct of research diving, based on AAUS standards.

1990: double-hose regulators phased out in favor of single-hose regulators.

1992: AAUS Polar Diving Workshop (Lang/Stewart)

2001: NSF-Smithsonian agreement for polar research diving.

2. Scientific Diving Authorization

1. Dive plan
2. Diver certification (min. qualifications)
   - 1-year diving certification
   - 50 open water dives
   - 15 dry suits dives
   - 10 dives in past 6 months
3. Pre-dive orientation and check-out

3. Antarctic Dive Sites

- McMurdo Station
  - Ross Island
  - New Harbor
  - Marble Point
- Palmer Station
  - Anvers Island
- Research Vessels
  - Antarctic Peninsula

4. Antarctic Diving Environment

Ice formation

- Ice crystallization at air-sea interface where temperature is greatest. Heat conduction from water to air (50C colder) promotes ice formation.
- Congelation ice formed under calm conditions is composed of needles, small disks, and dendritic stars, that forms a smooth sheet over the sea.

Ice Formation

- Frazil ice is formed under wind or wave conditions. These crystals clump together to form pancake ice, which can create complex, many-layered floes of pack ice.
- The ice sheet (congelation or frazil) becoming a solid surface joined to the shoreline is fast ice.
- Fast ice grows from beneath, through addition of supercooled platelet ice crystals that float upward and accumulate in a porous, loose layer at the bottom of the surface ice sheet (cm- to m-thickness).

Ice Formation

- An over-buoyant diver buried in a thick platelet layer may become disoriented and have trouble extricating themselves.
- Abundant platelet ice, dislodged by divers may float up and plug a dive hole.
- Anchor ice forms at <15m, attaches to rocks, debris, and invertebrates, which float up and are incorporated into the ice sheet.

Underwater Visibility

- Season (solar radiation impact on plankton blooms; glacier melt) and location dependent
- McMurdo: August-September 300m; mid-November 100-200m; mid-December 1m; West McMurdo 30m.
- Palmer: August-December 30m
- Brackish water lenses

Hypothermia symptoms

- Cold hands or feet
- Shivering
- Increased air consumption
- Fatigue or reduced strength
- Confusion
- Inability to think clearly or perform simple tasks or loss of memory
- Cessation of shivering while still cold

Aridity

- Antarctica is one of the driest deserts in the world
- Dehydration can be rapid and insidious
- Hydration and proper fluid balance
- Clear and copious urine
- Avoid diuretics before a dive

Fast Ice

- Calm, surge-free diving environment
- Stable platform (2-m thick), free of surface wave action
- Under-ice topography: homogenous fast ice, cracks and leads, snow cover and multi-year ice darkness, platelet ice rough and uneven, heterogenous pressure ridges
- Brine channels or ice stalactites: supercooled brine solution (increased density) freezes surrounding seawater

Access Through Fast Ice

- Natural cracks and leads
- Mobile drill (1.3-m hole < 5-m thick)
- Hole melter with hot glycol (1m)
- Chain saw (<60-cm thick)
- Saw and breaker bar (<25-cm thick)
- Explosives (>5-m thick) danger
- Safety hole
- Hole size and shape

Fast-Ice Dive Hole Maintenance

- Heated shelters
- Hole covers (foam between plywood)
- Ice removal with breaker bar
- Brash ice (congelation, frazil, anchor and platelet ice) can fill hole

Fast-Ice Diving Hazards

- Low light (sun angle, snow cover, ice thickness, blooms)
- Diver disorientation: high visibility (objects seem closer than they are).
- Loss of dive hole: darkness or covered with shelter, maintain positive visual contact with down line
- Emergency ascents issue
- Active holes must be marked with down line (former holes may look like safety hole from below)

Thin Ice

- Thin ice < 15-cm thick
- Entry hole near shore, swim to site
- Two independent regulators and a pony bottle recommended.
- “Thirds rule” of gas management.
- Tether line may be required
- One safety hole

Pack Ice

- Easy access to surface (caution with near shore shallow water access)
- Entry from shore or inflatable
- Hazards:
  - inherently unstable ice; wind may blow pack ice off- or onshore
  - wave action oscillates ice up and down
  - marine life, top predators
  - dim light

Other Environments

- Open water
- Blue water
- Ice edge
- Remote site preparedness
- Contaminated water (*E. coli* or hydrogen sulfide)

Dangerous Marine Life

- Southern Elephant (*Mirounga leonina*) and Antarctic Fur Seal (*Arctocephalus gazelli*) breeding season
- Crabeater Seal (*Lobodon carcinophagus*) dentition
- Leopard Seal (*Hydrurga leptonyx*) apply shark protection techniques
- Weddell Seal (*Leptonychotes weddelli*) air holes
- Killer Whale (*Orcinus orca*)

5. Dive Operations and Procedures

- Down line: required for all untethered dives with limited surface access; depth 50% greater than proposed working depth; nylon construction; 5-10kg weight; 2 strobes, checkered flags; reserve cylinders with regulator and pressure gauge.

Dive Operations and Procedures

- Hole marking: snow removal; radiating benthic lines
- Safety holes: one or more required
- Pre-dive safety checks: regulators and inflator valves
- Buoyancy regulation: regulate with dry suit, not BC; never use as lift bags
- Dive computers and tables

Dive Operations and Procedures

- Air management: based on cave diving rule-of-thirds
- Safety stops: 3-5mins at 10-30ft
- Tender: one per dive required
- Tethers: securely attached at surface; individual; t-shaped; L-shaped; blue-water; line-pull signals; entanglement

Dive Operations and Procedures

- Surface-supplied diving for the following dives: contaminated water; rapid deployments; physically demanding; communication requirement; penetration; shallow, long excursion; low visibility; long-duration cold exposure; single diver requires standby. Superlite17 helmets, Heliox 18 bandmasks

Dive Operations and Procedures

- Surface cold exposure: divers and tenders; loss of hut to fire; outboard failure; emergency rations
- Environmental protection: specimen collection; benthos disturbance; water layer mixing; explosives; fuel spills; Antarctic Treaty; Antarctic Conservation Act; marine mammals.

6. Dive Equipment

- Regulators: 2 fully independent systems; pre- and postdive care (warm and dry); free-flow failure causes
- Inflators: frequent short bursts to prevent rapid air expansion, adiabatic cooling, condensation and freezing
- BC: compatible with dry suit; care
- Weights: harnesses; dual buckle belts; overweighting; DUI weight system

Dive Equipment

- Gauges/DC: LCD issues; batteries
- Dry suits: type; automatic exhaust valves; polypropylene under layer, fleece, thinsulate; dry gloves or mitts; hoods; face protection
- O-rings
- Compressors
- Preventive maintenance

7. Dive Emergencies

- Loss of dive hole
- Loss of tether: vertical position with one hand on the ice; in low visibility; in current; in shallow water;
- Entrapment in under-ice platelet layer
- Dive hut fire

8. Accident Management

- Dive team response – immediate
- Emergency transport
- Recompression chamber/medical treatment
- Long-term oxygen therapy
- Fluid resuscitation
- Dive accident policy: delayed DCS; probabilistic event; no penalty
- Dive logs and documentation