Contents

1. Introduction to scientific diving
2. USAP scientific diving authorization
3. Overview of Antarctic dive sites
4. The Antarctic diving environment
5. Dive operations and procedures
6. Dive equipment
7. Diving emergencies
8. Accident management
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.


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 (50°C 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