Antarctic Dive Guide

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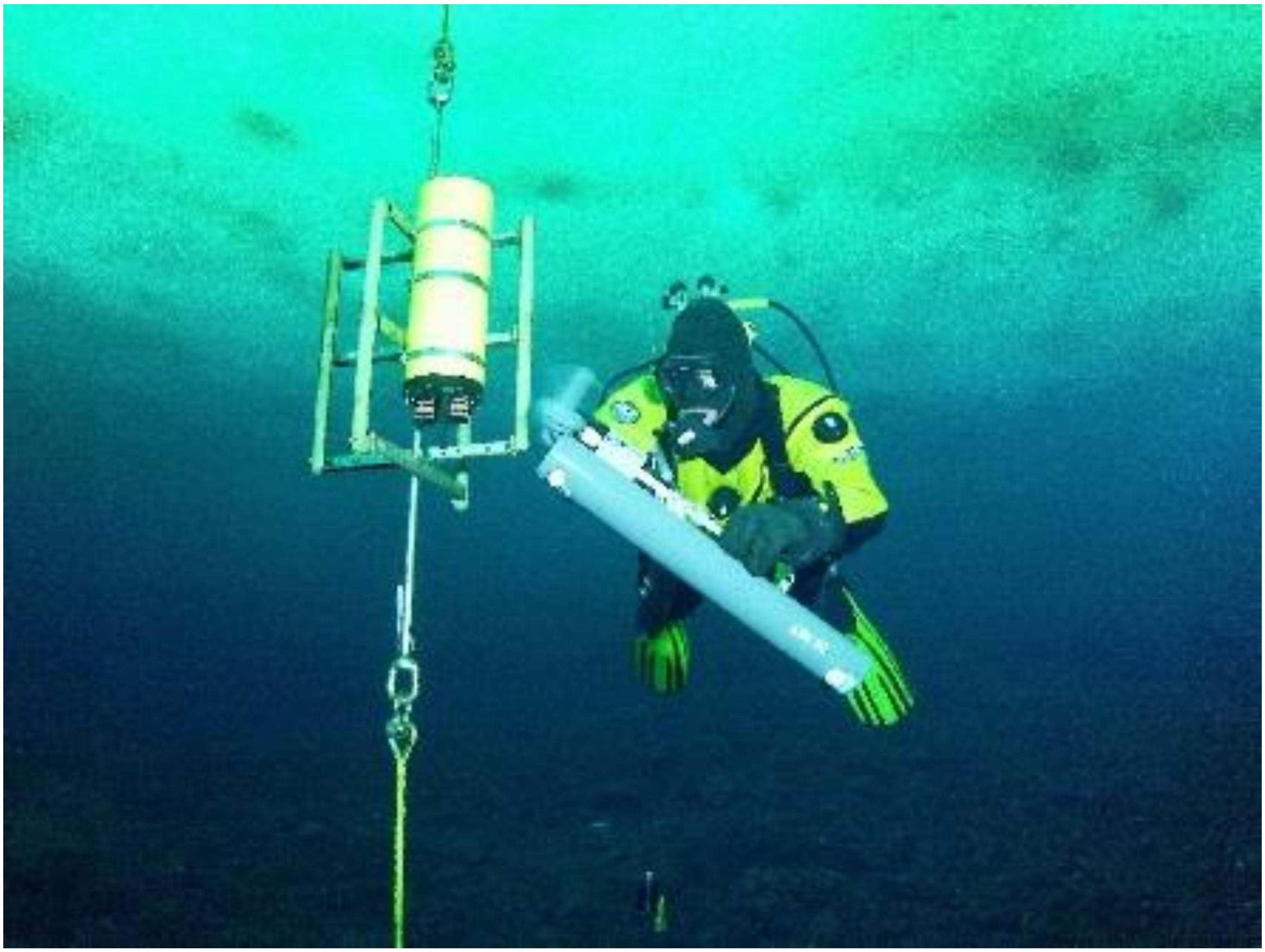
Version 1



July 2017

Version History

Version #	Date	Section (if applicable)	Author/Editor	Change Details
1	July 2017	All	Steve Rupp Dean Hancock	This document is derived from a former NSF document, ***Antarctic Scientific Diving Manual*** (NSF 99-22).

The document library holds the most recent versions of all documents.

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Signature *Print Name* *Date*
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Table of Contents

List of Figures

List of Tables

Forward

This guide seeks to provide the Antarctic diving researcher with information and expertise formerly available only by word-of-mouth. Although some relevant procedural requirements have been included, this guide is not intended to be a regulatory document. Guidelines governing National Science Foundation, Office of Polar Programs (NSF/OPP) funded research diving activities in the Antarctic are found in the United States Antarctic Program (USAP) Standards for the Conduct of Scientific Diving.

This document provides up-to-date information on dive sites, dangerous marine life, and dive safety and accident management. We have also included additional information on the Antarctic environment, as well as diving procedures/equipment. However, this is an evolving document, and we recognize that some of the information may still be incomplete. We therefore continue to invite comments from individuals actively involved in Antarctic research diving. These comments will be added to subsequent revisions, along with new technical and medical information as it becomes available. Our goal is to keep this guide as complete and up-to-date as possible.

Most of the procedures and protocols described in this document have been gleaned from decades of work by many Antarctic research, support, and commercial divers. A special thanks to Jim Mastro, Jeff Bozanic, and Rob Robbins for their excellent work on this guide's predecessor document: ***Antarctic Scientific Diving Manual*** (NSF-99-22). We also owe a debt to many of the pioneering scientists. For their valuable advice and comments. More specifically, we want to acknowledge the contributions of James R. Stewart, Dr. George Simmons, Dr. Paul Dayton, Dr. John Pearse, Dr. Gerry Kooyman, Dr. Langdon Quetin, Dr. Neal Pollock, Dr. Richard Moe, Dr. Glen Egstrom, Dr. Chuck Amsler, Dr. Dale Andersen, Michael Lang, and John Heine. And finally, thanks to Dean Hancock for his technical assistance and patience during the writing of this version.

Rob Robbins
Supervisor, Dive Services
1996-Present

Steven Rupp
Supervisor, Dive Services
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1. Introduction to Antarctic Scientific Diving

Scientific Diving activities can be found at two of the three year-round stations operated as part of the United States Antarctic Program (USAP). Both Palmer and McMurdo Stations support diving, as do the program's research vessels: the R/V *Nataniel B. Palmer* and R/V *Laurence M. Gould*.

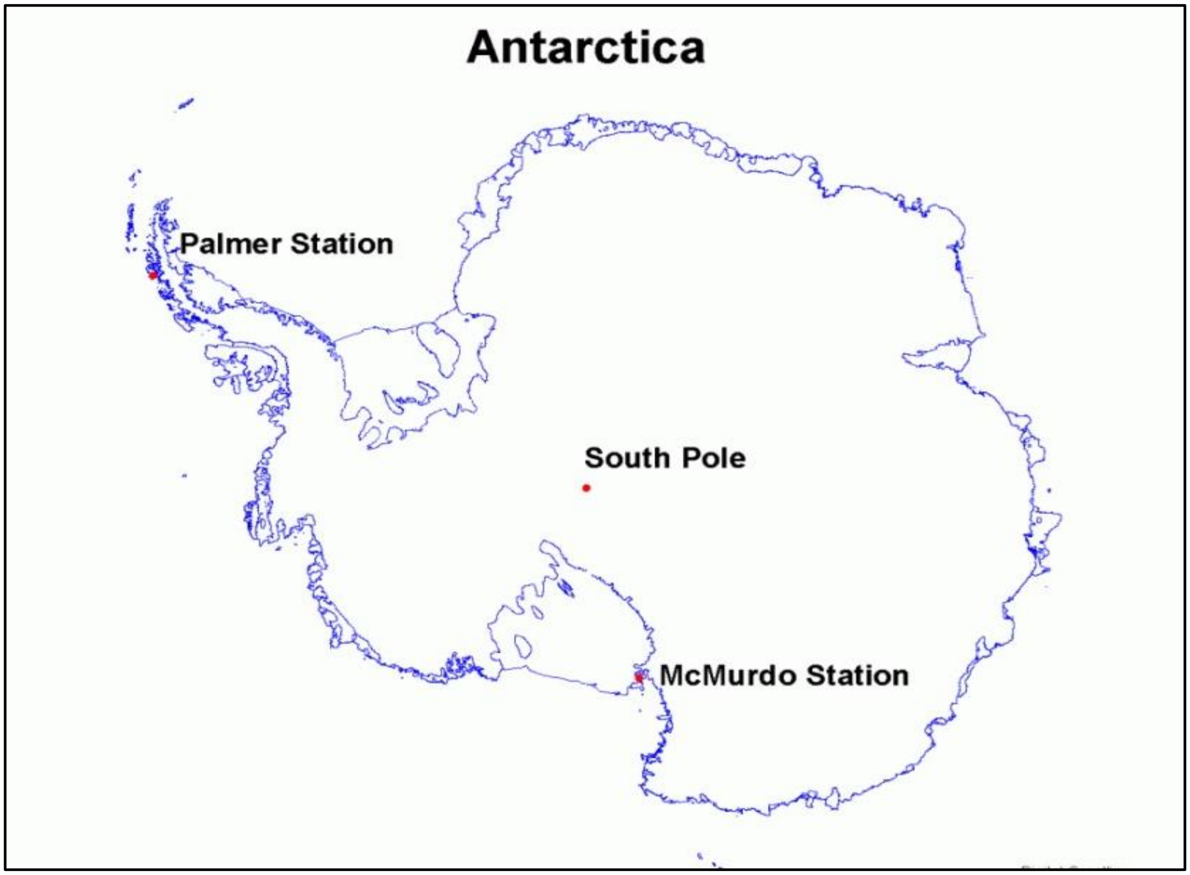

Figure 1: USAP's three year-round bases.

The first "open water" and "under ice" dive in Antarctic's icy water's was made by Willy Heinrich. He was no scientist though; this carpenter, mechanic, and inventor took the plunge on April 16, 1902 in an effort to complete ship repairs. It should be added that he did so in during the darkness of an Antarctic winter.

The first Americans to dive in Antarctic waters were probably Lieutenant Commander Tommy Thompson and a Chief Petty Officer Dixon. It was just after New Year's Day in 1947, and Operation Highjump was well under way. That was the United States' first major post-war Antarctic venture. They used "JackBrown" masks and Desco® oxygen rebreathers. The first Antarctic open-circuit SCUBA dive likely occurred in 1951.

Scientific diving in Antarctica commenced in 1961, when Verne E. Peckham began collecting marine organisms to photograph in his lab, and making contributions to benthic ecology. Like Heinrich, Peckham during winter's darkness; looking for creatures to take back to his lab. He dove by himself – in part for fun, and in part in his role as laboratory manager. Some of his 35 dives lasted up to one hour, and went to a depth of 160 feet.

Photo by James Stewart

Figure 2: Early use of wet suits, twin cylinders, and double-hose regulators.

Early SCUBA divers braved McMurdo Sound's 28.6ºF water with wet suits and double-hose regulators. Equipment advances since then have led to the use of variable volume dry suits, buoyancy compensators, dry gloves, and dive computers. Single-hose regulators took longer to gain acceptance due to problems with freezing. This meant that double-hose regulators were used almost exclusively in the McMurdo area until 1990. Since then, single-hose regulators have been identified which also resist freezing failure, and these are now in use.

From 1947 to 1967, research diving operations fell under the control of the U.S. Naval Support Force, Antarctica (NSFA). Divers adhered to established U.S. Navy diving regulations. In 1967, the National Science Foundation/ Division of Polar Programs asked James R. Stewart, Diving Safety Officer at the Scripps Institution of Oceanography, to establish guidelines for the conduct of research diving in Polar Regions. He set diving safety standards, trained and evaluated prospective divers, and standardized procedures. In 1987, these standards and procedures were codified as the Guidelines for the Conduct of Research Diving (now titled Standards for the Conduct of Scientific Diving), based on the guidelines published by the American Academy of Underwater Sciences (AAUS).

Both the AAUS and the United States Antarctic Program (USAP) guidelines are modeled after procedures and protocols developed during 50 years of safe research diving at the Scripps Institution of Oceanography (SIO). The USAP guidelines, like the SIO and AAUS guidelines that preceded them, are designed to make diving operations as safe as possible. Nonetheless, USAP researchers should understand that polar diving poses increased personal risks to the diver. Antarctic conditions are more rigorous and demanding of both divers and their equipment than most other diving environments. Each participant in USAP diving operations must fully understand and assume responsibility for the inherent risks.

Figure 3: Mobile drill on the sea ice in a storm.

As the photograph above illustrates, sudden whiteout conditions may force a cancellation of dive operations.

Table 1: Standard Units used in this guide

Standards units used in this manual	
Measurement	Units
Temperature	degrees Fahrenheit (ºF)
Pressure	pounds per square inch (psi)
Volume	standard cubic feet (cf)
Distance & Thickness	standard (inches, feet, yards, miles)
Diving depths	feet of seawater (fsw), since most dive computers, dive tables, and institutional diving authorization depth limits used by the scientific community in the United States are based on this unit of measure.

2. United States Antarctic Program Scientific Diving Certification

2.1. Project Dive Plan Approval

Once a research project requiring diving operations has been funded, the project's Principal Investigator (PI) will be contacted by the support contractor for more specific information on project dive plans and dive team member qualifications. The PI or the PI's designee will submit a project dive plan via the Polar Ice website to the support contractor's Supervisor of Dive Services (SDS), the United States Antarctic Program Diving Safety Officer (USAP DSO), and the NSF/OPP in Arlington, VA. Each of these parties will review the plan via Polar Ice. The plan must include the number of divers, their information/qualifications, proposed number of dives, proposed depths and times, location of proposed dives, proposed diving goals, and equipment/support required from the dive locker. Dive plans must be submitted with sufficient time for the plans to be adequately evaluated, and well in advance of proposed deployment to the Antarctic.

The USAP DSO will review all Project Dive Plans. Based on safety and feasibility criteria, the USAP DSO will forward his/her recommendations for approval or disapproval to the NSF/OPP Health and Safety Officer. The NSF/OPP Health and Safety Officer has the final authority to approve all scientific diving activities. He/she may request further information in order to make a determination. Disapproved plans may be revised and resubmitted.

2.2. Diver Certification

Individuals approved to dive in the Antarctic under NSF/OPP auspices must submit a record of certification to the contractor via the diver information section on the Polar Ice website. This record must include a section for the diver's home institution's Diving Safety Officer (if one exists) to add his/her comments and authorization to Dive. The record must also include AAUS depth certification and other pertinent information. This would include certification level, number of dives, dry suit experience, etc. The record must be submitted with sufficient time prior to deployment to be adequately evaluated.

If the diver's home institution does not have a DSO, then they must provide proof of experience equivalent to the AAUS depth certification required for the planned Antarctic diving location. (AAUS 60-foot minimum for Palmer Station and 100 foot minimum for McMurdo Station).

The Supervisor of Dive Services (SDS) will forward comments to the USAP DSO and to the NSF/OPP in Arlington, VA.

An explanation of the AAUS depth certification is presented below:

Certification to 30 Foot Depth - Initial permit level, approved upon the successful completion of training and least eleven ocean or open water dives in a variety of dive sites and diving conditions, for a cumulative bottom time of six hours.

Certification to 60 Foot Depth - A diver holding a 30-foot certificate may be certified to a depth of 60 feet after successfully completing, under supervision, 12 logged training dives to depths between 31 and 60 feet, for a minimum total time of four hours.

***Certification to 100 Foot Depth* -** A diver holding a 60-foot certificate may be certified to a depth of 100 feet after successfully completing, four dives to depths between 61 and 100 feet.

Certification to 130 Foot Depth - A diver holding a 100-foot certificate may be certified to a depth of 130 feet after successfully completing, four dives to depths between 100 and 130 feet.

***Certification to 150 Foot Depth* -** A diver holding a 130-foot certificate may be certified to a depth of 150 feet after successfully completing, four dives to depths between 130 and 150 feet.

***Certification to 190 Foot Depth* -** A diver holding a 150-foot certificate may be certified to a depth of 190 feet after successfully completing, four dives to depths between 150 and 190 feet.

Diving on air is not permitted beyond a depth of 190 feet.

The USAP DSO will use the following criteria to evaluate individual divers:

- AAUS depth certification (Required – 100 ft. for McMurdo and 60 ft. for Palmer)
- Length of time certified (Required one year minimum)
- Number of open water dives (Required 50 minimum)
- Date of last Dive
- Number of dry suit dives (Required 15 minimum)
- Number of dry suit dives in the last 12 month (Required minimum of ten dives)
- Date of last dry suit dive
- Dives to certification depth in the last six months (Required, one minimum)
- In addition to the above experience, all USAP divers must be current in First Aid/CPR/DAN O_2 training.

It must be added that the most important criterion is the diver's exhibited comfort level in the water, and with the equipment. The USAP DSO may request further information, or require that the proposed individual undergo more training before consideration. The USAP DSO will then recommend approval or disapproval of the proposed individual for Antarctic diving

A brief explanation of the "Diving" tab in Polar Ice:

Polar Ice is the online tool that the PI uses to enter Support Information Packet (SIP) information and requirements for their upcoming project year. This includes a "Diving" tab, where the PI or designated person enters the projects diving plan, equipment requests, diver information/certifications, and other diving related info. The "Diving" tab includes the following categories of information to be entered:

- **Diving Home**: This is the place to start if the project has divers, or needs ASC diver support. It's also where remote field support, or contaminated water zone support/equipment request can be made.

- **Cart**: Go here to enter equipment request for the various stations/general dive areas.
- **Dive Team**: Dive team members are entered here.
- **Diver Information Forms**: This is where you enter the pertinent diver information and certifications for the diving participants from the Dive team page.
- **Dive Plan**: The place to identify desired diving sites, number of dives planned, and what support is needed at each site as well as a place to enter a detailed diving plan for the season.
- **Dive Equipment**: A recap of the requested diving equipment and a section to request additional equipment not on the list.
- **Remote Site Dive Tanks**: Go here to request dive tanks for a remote area.
- **Contaminated Zone Dive Plan**: This is where you identify plans to dive in areas deemed contaminated. Such sites require specialized diving equipment and training (i.e., surface supplied diving with full-face masks or helmets).

The link to the Polar Ice website:

https://polarice.usap.gov/login/index.cfm

2.3. Pre-Dive Orientation

The support contractor SDS will conduct a pre-dive orientation briefing for each McMurdo research dive team. Subjects discussed include dive locker equipment, procedures, safety, and emergency procedures. This will include a review of the emergency oxygen kits issued to each group. At Palmer Station and on the research vessels, this briefing will be conducted by the Palmer Station Laboratory Supervisor and the vessel Marine Projects Coordinator, respectively.

All McMurdo divers will participate in one or more orientation or “shakedown” dives with the contractor SDS before beginning research diving activities. The number of shakedown dives required by an individual will be determined by the SDS. Skills to master include, but are not limited to: gearing up, setting up at the dive site, enter/exit procedures, buoyancy practice near the dive hole, and a general swim around the dive site including proper dry suit trim practice. An end of dive swap to the backup regulator (at the safety stop) will also be checked. This can prove difficult late in a dive, when the diver’s lips and hands are numb.

If the dive team is going to use surface supplied diving equipment – in either the dry valleys or the contaminated water zones around McMurdo Station – then additional orientation/training dives will be conducted with that equipment.

Lastly, divers should become proficient with the gear and techniques they will be using in their research before deploying to the Antarctic.

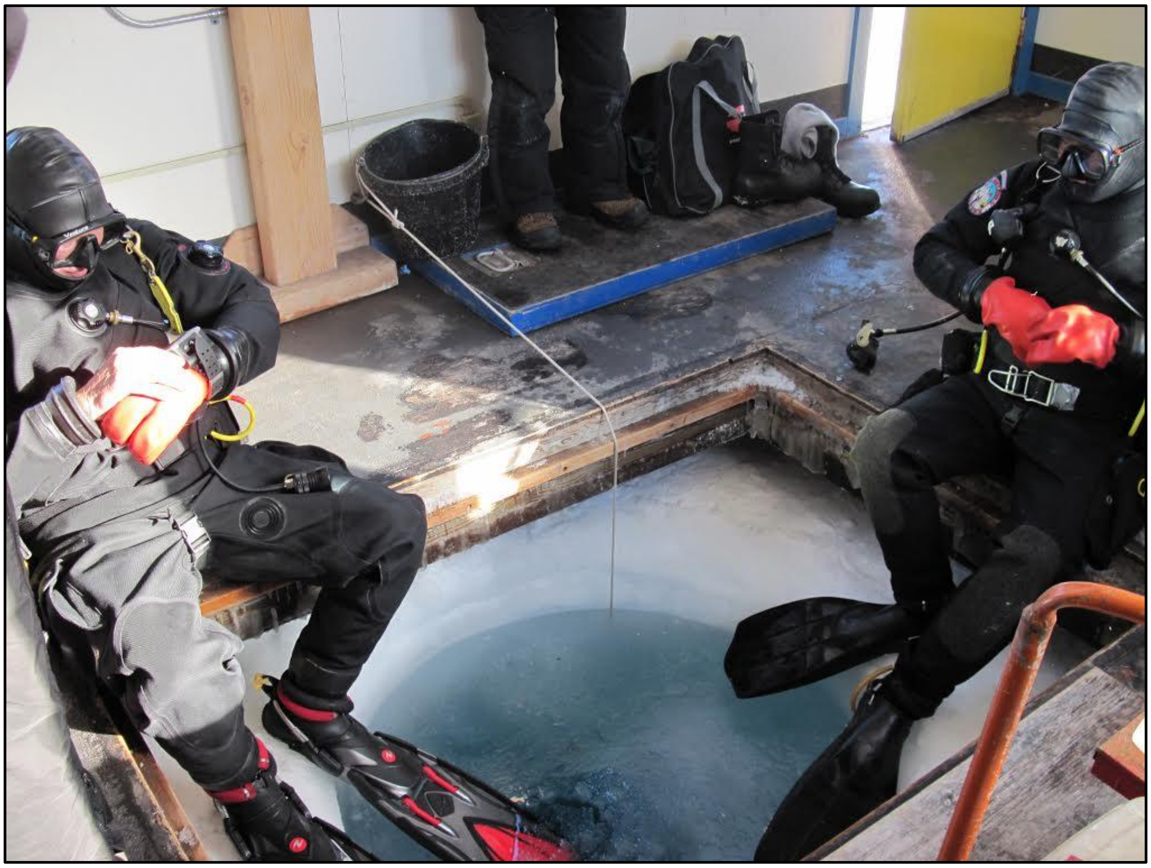
Photo by Rob Robbins

Figure 4: Divers preparing for an orientation dive.

3. Overview of Antarctic Dive Sites

Most U.S. research diving in the Antarctic has taken place around Ross Island, near McMurdo Station, in the New Harbor, Marble Point, Granite Harbor, and Dry Valley lake regions of the continent, around Anvers Island near Palmer Station, and from research vessels in the waters of the Antarctic Peninsula. Some bathymetric information is available for these sites.

3.1. McMurdo Diving:

As stated above, much of the USAP diving activity is based around McMurdo Station. This includes locations that are within driving distance of the station, as well as others that require helicopter transportation. The latter that may require an overnight stay. Most of the diving is in salt water, but there is also limited diving in the dry valley lakes. In some cases, these lakes contain fresh water, but others have hyper-saline water that requires specialized diving gear and techniques. The following maps depict the Hut Point Peninsula region of Ross Island with common dive sites, and a depth chart for a limited area near McMurdo Station.

3.1.1. McMurdo Dive Sites: Maps

The following pages provide an overview of the McMurdo region geography:

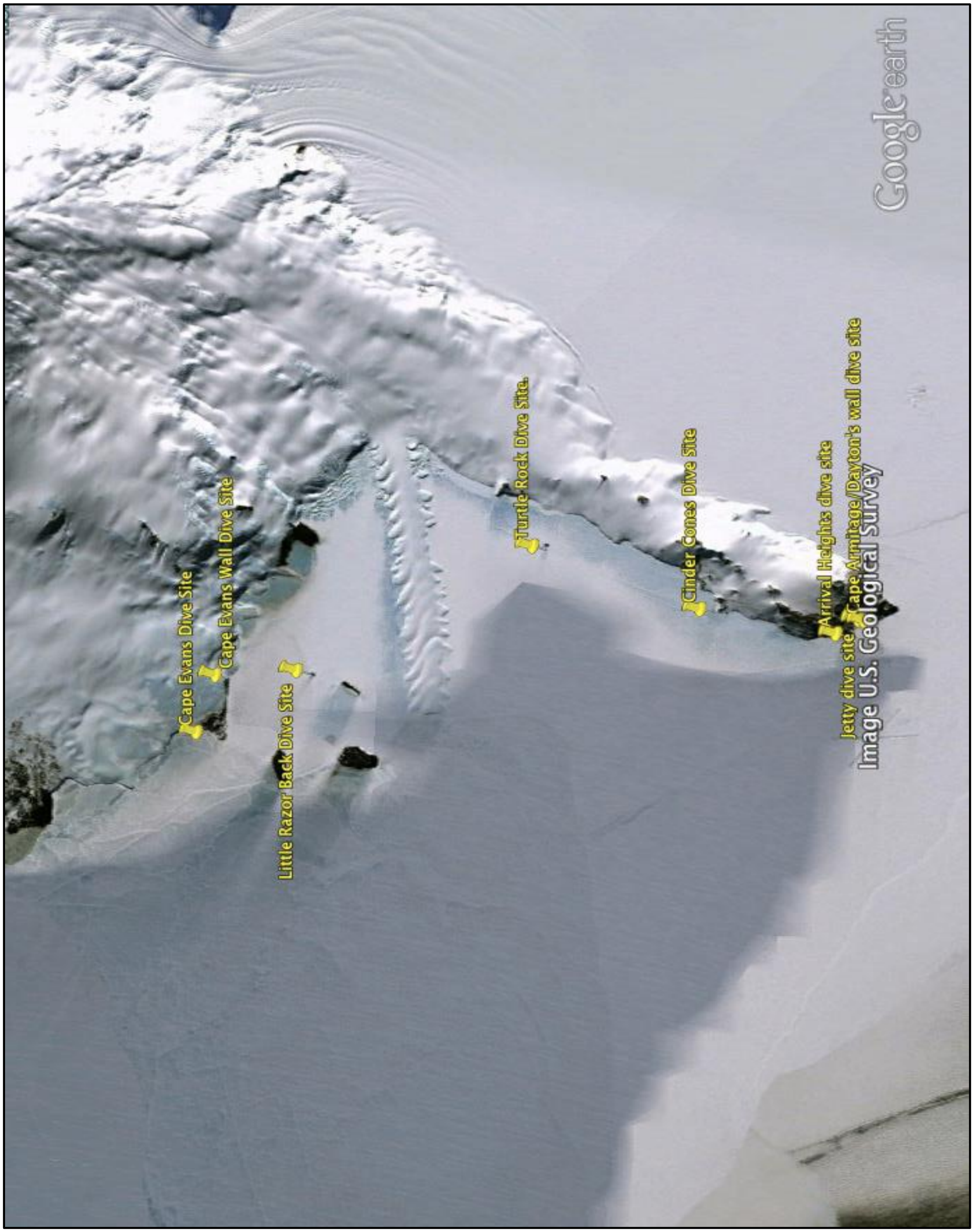

Figure 5: McMurdo Vicinity Dive Sites

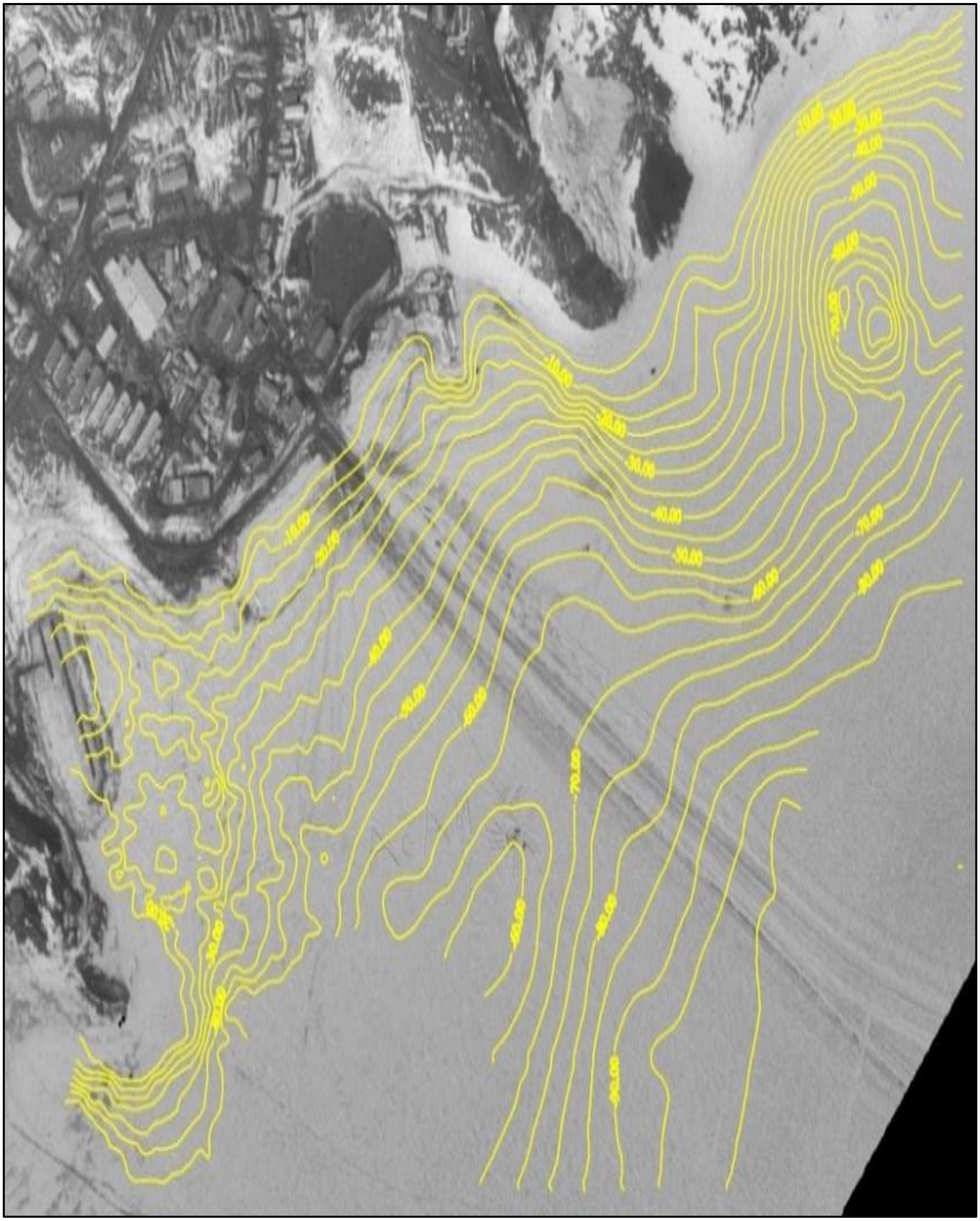

Figure 6: McMurdo Region Bathymetry Chart

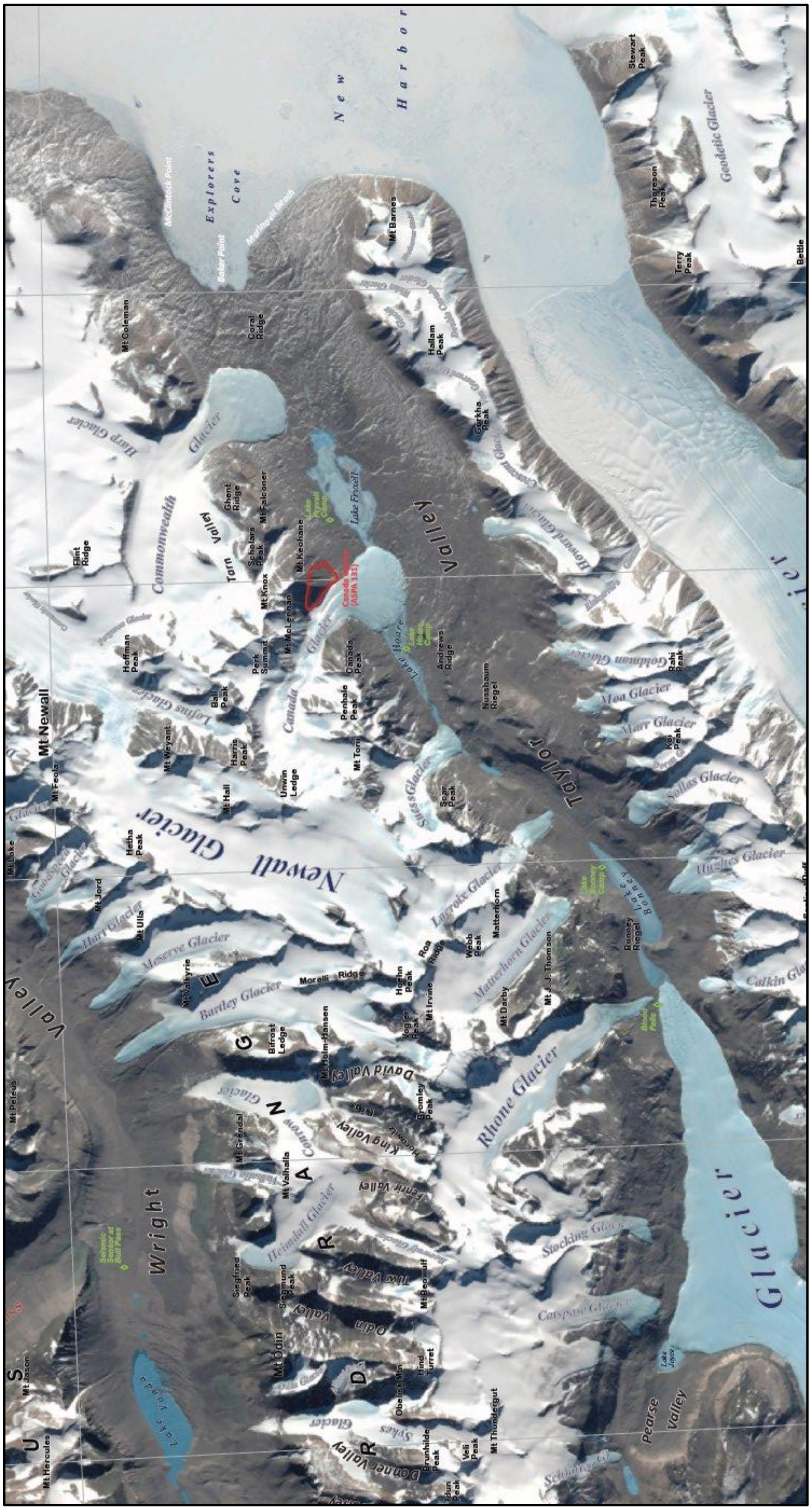

Figure 7: Dry Valley Lake region and New Harbor

3.1.2. McMurdo Dive Sites: Descriptions

The most commonly used dive sites around McMurdo are described below, along with some information about the site conditions/layout. This is by no means an exhaustive list, but these are the best-known sites, and usually have diving activity every season.

- **McMurdo Intake Jetty:** This is the closest dive site to McMurdo Station, and is within walking distance of the dive locker. During the diving season, there is always a hut placed at this site, and this is where most “shakedown” dives are performed. The site provides a good introduction to Antarctic diving by virtue of its ease of access, and its 50 to 75 ft. depth below the hole (depending on hut placement). The intake jetty rocks gradually drop down to a mud bottom and it’s easy to navigate and get oriented. It has little current and a good variety of marine life. Dragon fish and their eggs are common, and there are a number of large barrel sponges a short swim away at about 110 ft. deep. Good ambient light is also common at this spot.

- **Cape Armitage/Dayton’s Wall:** This site is very close to the jetty site but a bit closer to Scott Base. It’s usually deeper at the access hole (70 to 90 ft.), and a dive hut is commonly found there. It is known for its wall like cliff that starts about 90 ft. deep and drops down to beyond USAP diving limits. Common marine life here are nudibranchs, isopods, and sponges including the carnivorous sponge Asbestopluma. Brachiopods are occasionally seen there as well. A noticeable current may be encountered, especially in the shallows near shore. The bottom is mostly rocky.

- **Arrival Heights:** This site is just around the corner from Hut Point and is known for an abundance of barrel sponges and occasionally macroalgae. A hut can usually be found there during the season, and it’s a short drive from Station. Depths around the hole vary from 40 to 90 ft. depending on hut location, and can exceed 130 ft. nearby. There can be a current at this site as well. Bottom conditions are loose rock and gravel but some deeper spots have a muddy base.

- **Cinder Cones:** This site is further north along shore from the Arrival Heights area. Cracks and/or sea ice conditions can make the site inaccessible for drilling some years, meaning that no hut will be placed. Common marine life there include heart urchins (*Abatus*). Depending on the route, it’s about a half hour to an hour travel time. Depth at the dive hole can be from 30 to 80 ft. deep, but can reach 130 ft. Bottom conditions are sandy/loose rock.

- **Turtle Rock:** Even further north along the shore and is a very small island that is known for its Weddell Seal activity. There is a dive hut at this location when possible. But again, cracks and sea ice conditions prevent the placement during some years. It is usually about a 1-1 ½ hour drive to get to this hut, depending on the safe route. Depth at the dive hole can be from 60 to 150 feet, depending on the hut's precise placement. Bottom conditions include loose volcanic rock, pebbles, and sand. The depth drops off fairly quickly beyond scientific diving limits. There are several open cracks and seal holes near the island, especially in shallow waters. There is less sea life in the middle diving range than other sites, due to the loose volcanic material sliding down the steep angled bottom; but it's a good place to find seals, sea spiders, *laternula*, and the occasional octopus. Crinoids are also common at greater depths.

- **Little Razorback:** This site is similar to Turtle Rock, though it has a rockier bottom and less volcanic gravel and sand sloughing down its hills. Diving operations are not conducted here every season, but when a hut is placed it's usually closer to the island than at other sites. The depth at the dive hole ranges from 20 to 60 feet deep. Depths quickly go beyond scientific diving limits. It is about 1-1 ½ hour trip to drive there. Sea life at the site includes urchins, *laturnula*, seals, sea stars, etc.
- **Cape Evans Wall:** This site is located on the south side of Cape Evans, and is a very steep rock wall that is right next to a glacier wall as well. A dive hut is usually placed within swimming distance to the glacier wall. It's about a 1 ½ hour drive from McMurdo, as determined by the safe route. Depth at the dive hole is 80 to140 feet, with the wall close by. Bottom conditions consist of large rocks and hard rock or ice bottom. This site has been somewhat protected from large iceberg scouring, and has several species growing on the rocks. There is sometimes less ambient light here due to snow covering the ice, and the fact that the cliff wall casts a shadow on the surface above.
- **Cape Evans:** This site is located on the north side of Cape Evans and close to Scott's Hut. It has a rocky, more gradually deepening bottom and is known for having a lot of sea urchins and algae growing on the bottom. There is sometimes a dive hut placed at this site. Depth at the dive hole can be 50 to 110 feet. It is about 1 ¾ hour drive from McMurdo, depending on the safest route.
- **Granite Harbor:** This site is further north up the coast, and is accessible by helicopter. Diving is often done through cracks that form annually in the area. Depths at the dive holes can be anywhere from 15 to over 100 feet.
- **New Harbor:** A helicopter flight is required to get to New Harbor. It's on the continent, west of McMurdo Station. A few buildings stand there, and are utilized when science groups will be on site for extended periods. There is no access for the sea ice drill to travel there, so dive holes must be created through melting. It's known for its sandy bottom and relatively shallow depths (less than 100 ft.), with no significant current.
- **Dry Valleys:** These sites require a helicopter flight. A few of the lakes in the dry valleys have seen scientific diving operations. These include Lake Bonney, Lake Hoare, Lake Fryxell, Lake Joyce, and Lake Vanda. These

lakes require hole melting if diving operations are to be conducted. They are mostly fresh water, at least near the surface. Some, like Lake Bonney, have a distinct chemocline at about 70 feet, and the density of the water changes dramatically. Surface supply diving equipment is used at these lakes to minimize the number of divers in the water, and reduce disturbing bottom materials, and mixing of the water layers. Each lake has its own dedicated diving umbilical to prevent cross contamination with the other lakes.

3.2. Palmer Station Diving:

Although most USAP diving activity occurs in the region around McMurdo, Palmer Station also has its share. Most of the diving at Palmer uses local dive spots that can be reached by small boat, though some require that diving operations be based on one of the program's research vessels. Nearly all of the diving occurs in the waters near the islands within the boating limit around Palmer Station. Divers may dive anywhere within the boating limit, although dive teams should always confer with station management, and make the effort to remain updated regarded any changes or restrictions.

Note: Palmer Station is currently procuring longer range Rigid Hull Inflatable Boats (RHIBs). This will result in extended boating limits. They will surpass those currently in effect by several miles. As of this edition, (2017), only one RHIB has been delivered to Palmer Station, and the plan is to have two in service within the next few years. As new information becomes available, it will be incorporated into subsequent editions of this manual.

The following maps and photo depict the Palmer boating area, with common dive sites. A depth chart and aerial view of the region are also included.

Note: Operations in the Extended Boating Area (as defined in the Palmer Zodiac Regulations) are primarily for transit or multi-boat operations, as emergency response times are longer and the capacity for response is limited until such time as other equipment (e.g., RHIBs) is available. Therefore, regular water-based survey work should be planned within the standard boating area. Working in the Extended Boating area may be accommodated on a case-by-case basis. It will require the approval of Palmer Management, and the identification of a second boat working in the area. Prior to departing the station a safety meeting must be held to discuss responsibilities, activities, operational area, and a "check-in schedule."

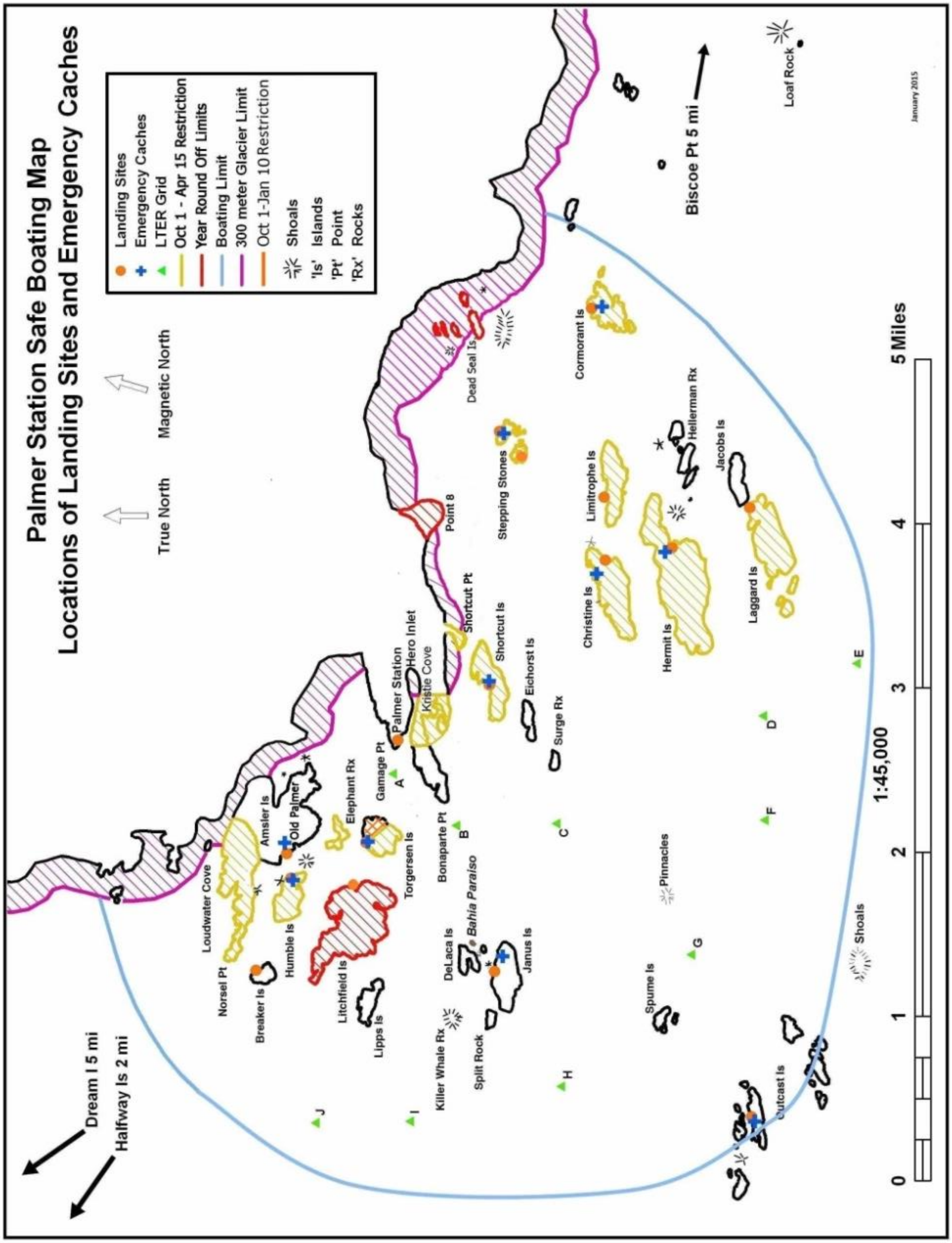

Figure 8: Map: Palmer Station and Vicinity (Not drawn to scale)

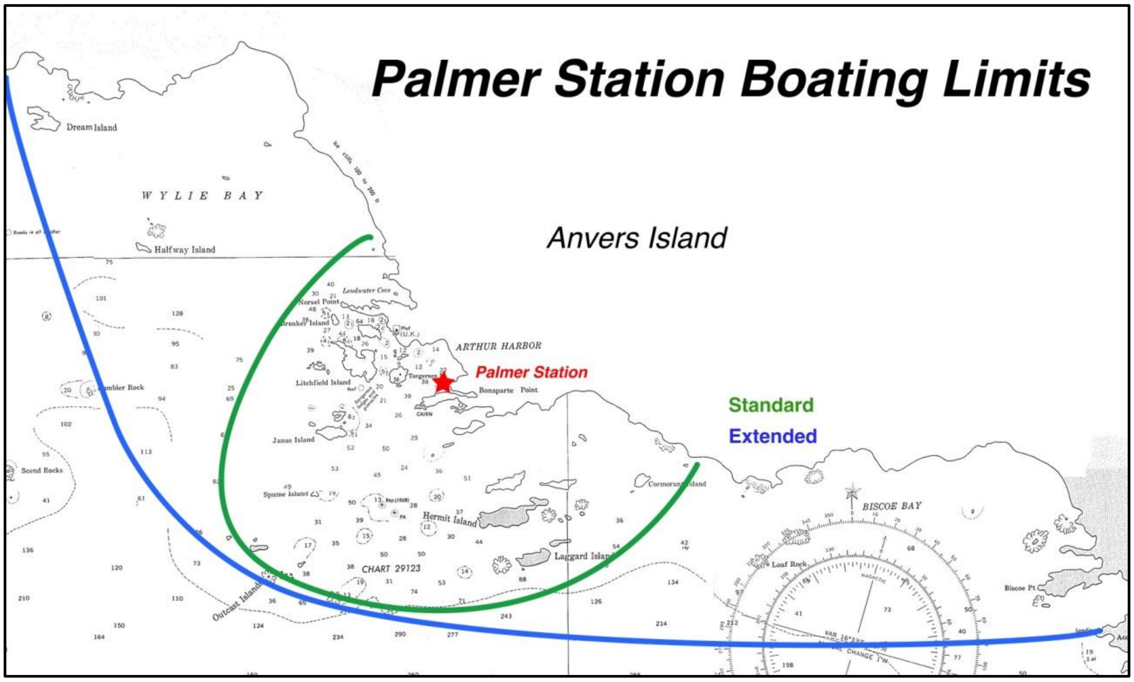

Figure 9: Map: Palmer Station Boating Limits

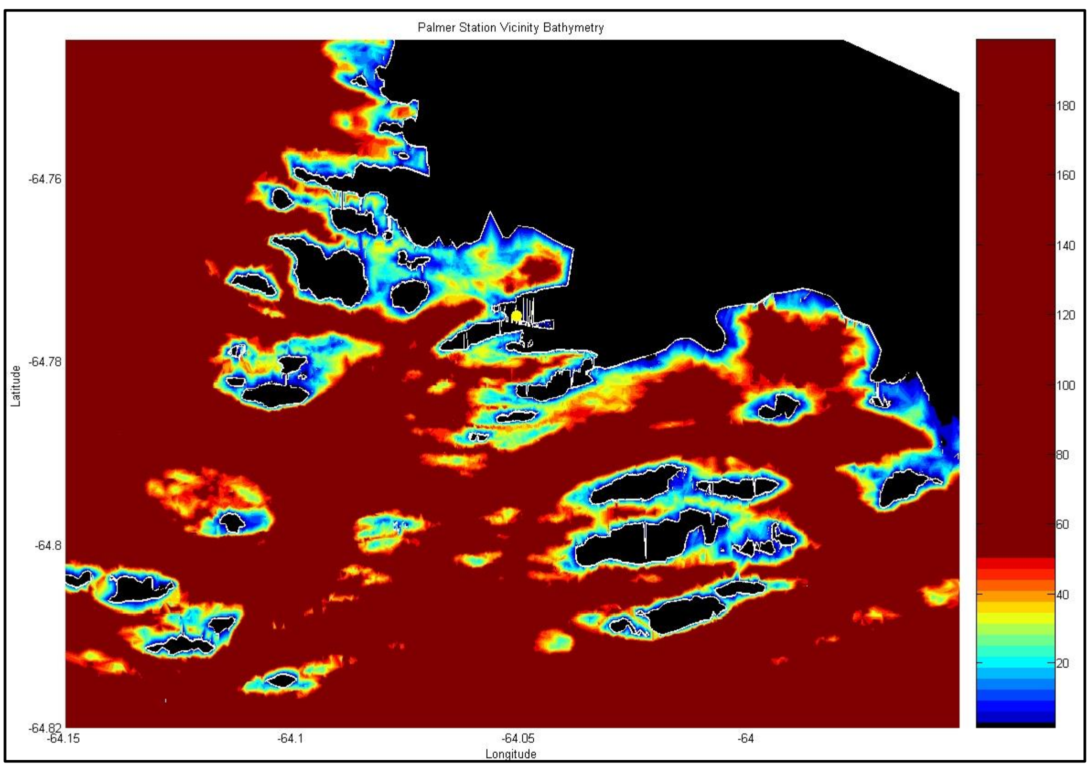

Figure 10: Map: Palmer Station Bathymetry

Figure 11: Aerial view of Palmer Station and LM Gould.

Below is a list of the dive sites around Palmer Station, and some information about the site conditions. Information on these sites is less than we would like, and additional information on their features continues to be collected. As with McMurdo, these are not the only places that have seen diving operations, but they are the best-known sites. These are the spots where diving activities have been commonly conducted during recent seasons.

- **Alan's Wall**
- **Amsler Island**
- **Arthur Harbor:** (East side) Sediment slope with rock outcroppings; similar to Gamage Point but more diffuse. Visibility is usually mediocre at best, but the site is often accessible on those some days when you can't get to others. S 64° 46.299 min., W 64° 02.778 min.
- **Bonaparte Point:** North side near tip, just east of weather station; can start to east on wall dominated by macroalgae, particularly *Desmarestia anceps*, but with sponges and other sessile invertebrates becoming more numerous with increasing depth to 120 to130 ft. Divers commonly angle to the east on ascent, and do their safety stop in the protected cove that has the weather station at its mouth: S 64° 46.622 min., W 64° 03.986 min. South-East wall is a little further offshore than most, but this is a relatively protected site so you can go there when many other sites too rough: S 64° 46.754 min., W 64° 02.657 min.
- **Breaker Island**

- **Bahia Pariso:** This shipwreck lies roughly east-west, with stern to east and what's left of the deck on the north (i.e., it lies on its starboard side, although it's almost completely rolled over now). It's most scenic on the north/deck side. Drop in at the stern; the props are still impressive. Then head to the bottom. At the stern, it's roughly 70 ft. deep, and then swim towards bow. Most dives are on the deck (north) side of the wreck where overhangs and remnants of the superstructure create habitat for a wide variety of macroalgae and sessile invertebrates. The hull (south) side also supports a variety of sessile invertebrates. Although changing over the years, many of the invertebrates are more weedy species that are not as common at other common diving locations. The remnants of the helo deck at the stern shades the bottom, and allows collection of some macroalgal species that are normally found in deeper water. S 64° 46.699 min., W 64° 05.776 min.
- **Christie Cove**
- **Cormorant Island:** Nice wall. Exposed to south or southwest swell, so you need relatively calm water. Off rock at southwest side; approach from south. Leopard seals relatively common here during some seasons. S 64° 47.767 min., W 63° 58.252 min.
- **DeLaca Island**
- **Dream Island**
- **Eichorst Island**: Northwest end. Not a steep wall, but great spot for *Cystosphaera* (deep growing, floating, large brown alga) – also good for invertebrates. S 64° 47.121min., W64° 03.049 min.
- **Elephant Rocks**
- **Gammage point:** This is the point right in front of Palmer Station. The topography of the point extends from shore underwater. Drop in right off the tip of the point and swim along north side of the underwater point down to the wall. This is rock mixed with soft sediment, and has a community that's different from the other sites listed here (other than East Arthur Harbor), so this is worth a visit.
- **Halfway Island**
- **Hellerman Rocks**
- **Hermit Island:** Nice wall. Exposed to south or southwest swell, so you need relatively calm water. South side: S 64° 48.139 min., W 64° 01.438 min. (alternative: East at S 64° 48.166 min., W 64° 01.149 min.).
- **Hero Inlet** (and in front of Palmer Station and pier): Rocky bottom right in front of pier with everything from cobble to four-foot diameter rock with silt underneath. Approximately 24 to 26 feet deep right in front of pier where it levels off a bit with a slow decent to about 45 feet. Further out there is a steeper slope that angles down to about 80 feet where one finds a silty bottom. Rocky with various surge on either side of the pier

depending on the sea state. Heading up into Hero inlet it gradually gets shallower and is rocky on the sides with some silty bottom in the middle. Limpets, invertebrates, various small fish, coralline algae.

- **Humble Island**
- **Jacobs Island**
- **Janus Island:** Nice wall. Exposed to south or southwest swell, so you need relatively calm water southeast side. It has a broad wall with a wide variety of macroalgae and sessile invertebrates. The algae dominate to about 100 ft. with invertebrates becoming dominant below. The wall continues much deeper than the normal 130 ft. dive limit: S 64° 47.080 min., W 64° 05.997 min.
- **Joubin Islands**
- **Killer Whale Rocks:** One of the best walls, but calm water is required to dive. Approach from straight (true) east to left of center of the exposed rock, then drop in away from rock and swim a compass course while descending. Swim back away from rock during safety stop, usually towards southeast – depending on what the wind was doing when you went in: S 64° 46.763 min., W 64° 09.706 min.
- **Kristie Cove**
- **Laggard Island:** Nice wall. Exposed to south or southwest swell, so you need relatively calm water. Southwest side (little more scenic than second site): S 64° 48.574 min., W 64° 00.986 min. Second site: Southeast side: just west of isthmus at S 64° 48.497 min., W 64° 00.515 min.
- **Lipps Island:** Wall on north side with some protection from south swell: S 64° 46.251 min., W64° 06.318 min.
- **Litchfield Island:** Northwest side wall. Some protection from south swell: S 64° 45.972 min., W 64° 05.964 min.
- **Loudwater Cove**
- **Lovers Lane**
- **Norsal Point:** Nice wall. Exposed to south or southwest swell, so you need relatively calm water. Near tip on south side. Look for large vertical crack in rock face – a little better protected than a lot of other sites. The site is a steep slope dominated by the large brown alga *Desmarestia anceps* but with an understory of smaller algae and some sessile invertebrates. At approximately 100 ft. there is a vertical wall dominated by sponges and other sessile invertebrates ranging down to about 120 ft. where the slope lessens. Divers commonly ascend at an angle to the east, and do their safety stop in the afore-mentioned and somewhat protected cove: S 64° 45.638 min., W 64° 05.874 min.
- **North-West Shortcut:** Something of a “stair-step” wall: S64° 46.953 min., W 64° 03.039 min.

- **Old Palmer**
- **Outcast Islands**
- **Shortcut Island**
- **Split Rock**
- **Spume Island:** One of the best walls, but calm water is needed to dive. Southeast corner of rock off the south side of main island. Approach from due south. The wall is not very wide but fairly tall. A wide variety of sponges, soft corals, and other sessile invertebrates extend to depths beyond the normal 130 ft. dive limit. Probably the most visually spectacular Palmer dive site: S 64° 47,935 min., W64° 06.793 min.
- **Stepping Stones:** Off the southwest end of the southwest island. Go in almost at far west end of island and swim east. It's not as deep as other sites, and not a complete wall but there is a concave overhang at mid depth that supports a lot of inverts. No need to go much deeper than 100 ft. so a good second dive spot: S 64° 47.830 min., W 63° 59.830 min.
- **Surge Rock**
- **Torgersen Island**

4. The Antarctic Diving Environment

4.1. Ice Formation

Ice crystallization begins at the air-sea interface, where the temperature differential is greatest. Because the air may be as much as 70°F colder than the water, heat conduction to the air from the water promotes the formation of ice. Under calm conditions, this "congelation" ice is composed of needles, small disks, and dendritic stars. If calm conditions persist, this ice will form a smooth sheet over the sea.

When the freezing sea is subjected to wind and wave action, "frazil" ice crystals clump together into "pancake ice," which consists of roughly circular, porous slabs with upturned edges. These slabs may be 1.5 feet to several feet in diameter. (See **Figure 12**) If the water between them freezes, the "pancakes" may solidify and join together. Otherwise, pancake ice continually interacts with wind, waves, and other ice to create complex, many-layered floes of "pack" ice.

Over time, the ice sheet – whether congelation or frazil in origin – will become a solid surface that's joined to the shoreline. This is called "fast ice." Fast ice forms a nearly unbroken cover across McMurdo Sound during the winter, spring, and summer months, from the Ross Ice Shelf to Cape Byrd on Ross Island, and from Ross Island to the continent at Granite Harbor.

Figure 12: Pancake Ice

Once the ice sheet is established, it continues to grow from beneath. Low-density seawater beneath ice shelves and floating glaciers undergoes adiabatic super cooling. “Platelet” ice crystals form in this super cooled water and float upward, accumulating in an initially loose and porous layer at the bottom of the surface ice sheet. This platelet layer continually solidifies by freezing, thus increasing the thickness of the ice sheet. The unfrozen platelet layer can be just an inch thick, or several feet.

The platelet layer is interesting for several reasons, many relating to biology. It can serve as a substrate for the growth of microbial communities dominated by microalgae, and it as a home for other organisms that feed on the microalgae and each other (e.g., amphipods and ice fish).

This ice is also of concern to divers. An over-buoyant diver buried in a thick platelet layer may become disoriented, and find it difficult to extricate himself or herself. **If enough platelet ice is dislodged by divers, it may float upward and plug a dive hole. This is significant because the dive hole is the only egress point for the divers. The water and hole should be monitored, and ice removed by the surface tenders as it accumulates.**

Ice may also crystallize on the benthos. This “anchor ice” generally forms at depths of 50 feet or less but can be as deep as 70 to 80 feet. It attaches to rocks and debris, and even to live invertebrates. If enough ice forms on these objects, they will float up and may be incorporated into the ice sheet.

4.2. Underwater Visibility

Visibility varies dramatically depending on dive location and time of year. In the McMurdo region, visibility may be up to 900 feet in August and September. Increased solar radiation during the austral summer gives rise to an annual plankton bloom that reduces visibility. In mid-November, the visibility may still be 300 to 600 ft. By early December, the visibility drops quickly, reaching a nadir on about December 15 of as little as 5 feet. Visibility on the west side of McMurdo Sound may remain 100 feet or more well after the visibility on the east side has dropped to near zero. Divers have reported 200 feet of visibility at New Harbor in late December.

Photo by Steve Rupp

Figure 13: Benthic community at 130 feet near McMurdo Station.

Regarding the photo above: The light area marks where the snow has been blown off the sea ice. The far edge is approximately 300 feet away.

In the Palmer region, visibility from August through early December can be as much as 100 feet. As the summer phytoplankton bloom develops, visibility will drop to between five and ten feet. Glacier melt will also reduce visibility. At this time of year, water clarity often improves below ten to 15-foot depth, though the turbid surface waters obviously decrease light penetration to deeper depths. This typifies diving conditions until sometime in March, when visibility usually improves. Throughout the austral summer, wind and temperature will influence visibility by virtue of their impact on glacial melt. Near the station, winds from the east tend to increase visibility by blowing more turbid waters offshore, and causing upwelling of clearer, deeper water. Visibility in the open waters of the Antarctic Peninsula may vary from 900 feet to less than ten feet, depending on location, time of season, and phytoplankton and zooplankton density.

The visibility values and seasonal limits presented here are approximate and may vary from year to year depending on climate, weather, sea state, and other conditions. As glacial or sea ice melts, the resulting water may form a brackish water lens over the seawater in some areas. Visibility within these lenses is markedly reduced, even when the visibility in the water below is still good. As a result, divers should be mindful of the fact that they may lose sight of a surface access hole, even when they are near it.

4.3. Cold

Divers in the Antarctic should never lose sight of the limitations placed on dive operations by the environment. Cold ambient temperature is, of course, the overriding factor. The water temperature is a fairly steady 28.6° F. around McMurdo, and varies from 28.6° F to 33° F in the Palmer region, depending on the time of year. This may seem a small difference, but it makes the use of attached dry gloves or mitts almost mandatory at McMurdo, while wet mitts are a viable alternative at Palmer. Hands seem to be the part of the body most susceptible to cold, because thermal protection of the hands must be compromised to allow dexterity. Dives should be terminated before a diver's hands become too cold to effectively operate the dive gear or grasp a down line. This loss of dexterity can occur quickly (five to ten minutes) if hands are inadequately protected. Chemical hand warmers inside dry gloves can be effective in delaying the onset of discomfort and loss of dexterity, though they are dependent on oxygen for the chemical reaction to continue. Once oxygen inside the small glove space is depleted, the chemical reaction causing heat slows. Historically, the average lengths of Antarctic dives have been around 30 to 40 minutes with cold hands being the limiting factor.

Note that grasping a camera, net, or other experimental apparatus will increase the rate at which a hand becomes cold. Switching the object from hand to hand or attaching it to the down line may allow hands to re-warm.

The cold environment can also cause chilling of the diver, which may result in a reduced cognitive ability due to hypothermia. The symptoms of hypothermia should be understood by all members of a dive team, and all members must remain vigilant where these symptoms are concerned.

4.3.1. Symptoms of Hypothermia:

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

Note: While it is unlikely that increased air consumption would be the symptom first noticed on the surface, it may be very noticeable underwater.

Heat loss can occur as a result of inadequate insulation, exposed areas (such as the head, under an inadequate hood), and through the breathing of cold air. The air in a SCUBA tank will match the ambient temperature initially, and chill as it expands through the regulator. Air consumption may increase as the diver cools, resulting in even more cooling as breathing increases. Significant chilling may also occur during safety stops, as the diver will be stationary.

Cold-water diving requires greater insulation. Its bulk decreases general mobility, and may lead to buoyancy problems. Increased gear also gives rise to additional drag. Swimming effort is impacted, and added gearing and de-gearing efforts may also increase fatigue.

A few diving equipment manufacturers offer electrically heated undergarments that have been tried in the Antarctic, with varying degrees of success. These include vests, under suits, gloves, and booties. Most of them are powered by an external battery source, and a controller that requires a “penetrator” through the dry suit to run the wiring.

4.4. Aridity

Antarctica is one of the driest places in the world. 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.

4.5. Fast Ice

At McMurdo Station, diving conditions are typified by a solid fast-ice cover for most of the austral diving season. Fast ice also occurs briefly at Palmer Station, and it may be present during diving operations conducted from USAP research vessels.

There are both benefits and hazards associated with fast-ice diving. A solid fast-ice cover helps provide a calm, surge-free diving environment, as well as a stable working platform free of surface wave action. Researchers should never forget that fast-ice strength will vary depending on time of year and the ambient temperature. An ice thickness that will support a dive operation in October may be insufficient for a similar activity in December.

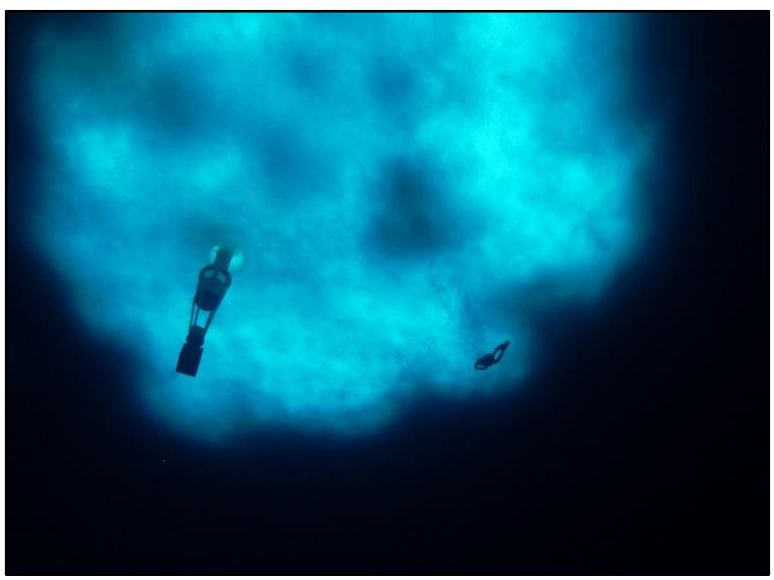

Photo by Steve Rupp

Figure 14: Diver near the observation tube under fast ice at the intake jetty.

The under-ice topography will vary dramatically, depending on dive site, time of year, microalgae activity, ocean current, age of ice, and other oceanographic, biological, and climatic factors. When viewed from below, a fast-ice sheet may appear relatively homogenous – a hard, flat surface forming a lid over the ocean, as shown in **Figure 14**. In places, the ice sheet is punctuated by cracks and open leads, which appear as bright lines in an otherwise dark roof (**Figure 15**). Areas of thick snow cover will appear significantly darker than snow-free regions (see Figure 15).

Photo by Rob Robbins

Figure 15: Cracks in sea ice as seen from below.

Photo by Jim Mastro

Figure 16: Crack in the sea ice as seen from the surface

If platelet ice is present, the underside of the ice will appear rough and uneven. Areas of multi-year ice will be darker because of increased ice thickness. Where pressure ridges and tidal cracks are present, the under-ice topography is more heterogeneous. Here, large and small chunks of broken ice may jut down into the water column in profusion, creating an environment reminiscent of cave diving.

Photo by Jim Mastro

Figure 17: Broken chunks of ice under a pressure ridge

An interesting under-fast-ice feature is the “brine channel” or “Brinicle.” As seawater cools and freezes, salt is excluded. This salt forms a super cooled brine solution which sinks because of its increased density. As it sinks, it freezes the seawater around it, resulting in a thin, hollow tube of ice stretching down from the underside of the ice sheet. These brine channels may be several yards in length and may appear singly or in clusters. They most often occur near cracks or breaks in the ice sheet.

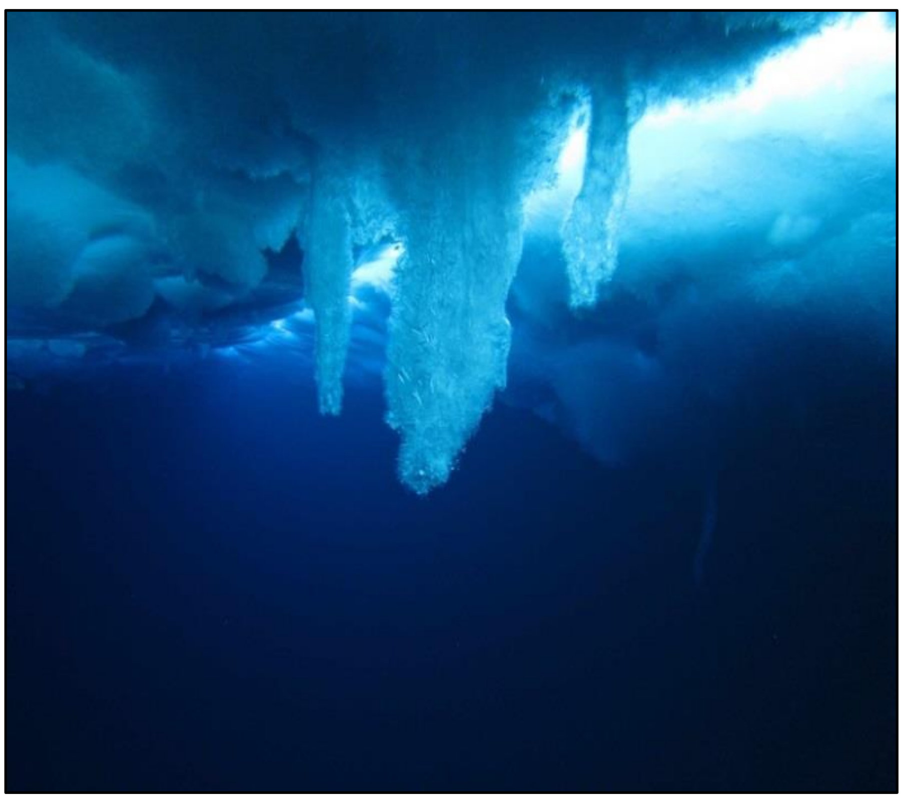

Photo by Rob Robbins

Figure 18: Under ice “Brinicles” near Turtle Rock.

4.5.1. Access through Fast Ice

At McMurdo, the annual fast ice may be over six feet thick. Multi-year fast ice may exceed 12 feet in thickness. Dry Valley lake ice may be over 20 feet thick. At Palmer Station, fast ice, when it is present, generally does not exceed one foot in thickness.

There are several ways of gaining access to the water beneath fast ice:

4.5.1.1. Natural Cracks and Leads:

Tidal action, currents, and other forces produce open cracks and leads which divers may use to enter the water. Accessible tidal cracks may be found between the fast ice and the shore, or between fast ice and a floating glacier. Divers working from USAP ice-breakers and research vessels often use the leads cut by the vessel for their access to the water. Areas of open water known as *polynyas* have also been used. It is always wise to be vigilant regarding weather changes, tides, and currents when diving through natural cracks and leads. Changes in any of these factors could affect the size of the crack and/or close it up completely with little warning.

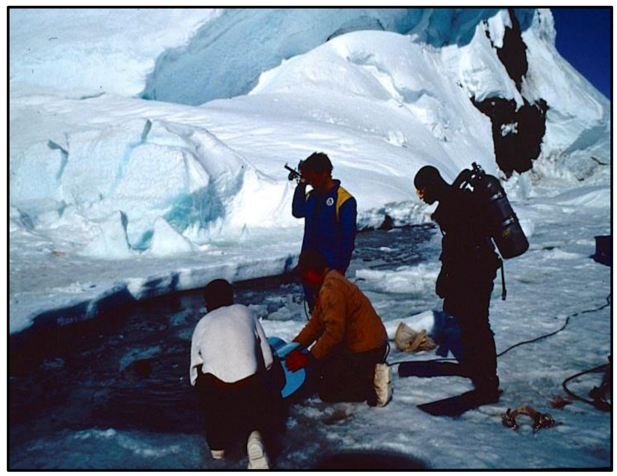

Photo by Jim Mastro

Figure 19: Diving at a tidal crack near Hutton Cliffs.

4.5.1.2. Mobile Drill:

A hydraulically operated mobile drill (see Figure 20) is usually available at McMurdo to cut four-foot diameter holes in ice that is 20 feet or less in thickness. Dive groups sometimes request that one or more safety holes are drilled near the primary dive hole if the diving activity is going to be in a location far from the main hole. The mobile drill is limited to the McMurdo Station vicinity, extending as far north as Cape Royds (ice conditions permitting). It is not available for use at New Harbor or the Dry Valley lakes.

Photo by Rob Robbins

Figure 20: Mobile drill on fast ice at Cape Evans Wall

4.5.1.3. Hole Melters:

Hole melters consist of coiled copper tubing filled with hot circulating glycol or alcohol. They are used to open holes if the mobile drill cannot get to a dive site around McMurdo, New Harbor, and in the thick ice cap that covers the freshwater Dry Valley lakes. Melters provide a dive hole that's clean and variable in size, but they are slow. Actual melting time – depending on ice thickness, air temperature, and efficiency of heat source – may be anywhere from several hours to several days. An oft used technique is to start by drilling a "jiffy hole," and then insert the melting "wand." Extra holes can be drilled while melting to expedite the process of creating the wider hole. Melters have also been used to keep existing dive holes open, and large enough to use for diving. This is important given that a dive hole will shrink if given the chance.

Photos by Steve Rupp

Figure 21: Hole melting in the Dry Valleys.

4.5.1.4. Chain Saws:

Chain saws can be used to cut an access hole through ice that is 1/2 to two feet thick. Cutting a hole through ice thicker than two feet is possible, but not recommended. Wielding a chain saw is dangerous at any time, and the risk is increased when the researcher is forced to lean over a deep hole. Standing in the hole as it is being cut also exposes one to high concentrations of exhaust fumes.

When a chain saw is being used, the ice should be cut away in pieces small enough to be handled easily and safely, and they should be removed as they are cut free. Access holes may be cut into square or triangular shapes, and large enough to accommodate two divers in the water simultaneously. Some divers maintain that entry and exit are easier from triangular holes.

At Palmer Station, divers have used Jiffy drills to make holes in ice 1/2 to one foot thick, and then used saws between the holes to create a large dive hole. Attaching ice anchors to the chunks of ice allows them to be easily removed once they've been sawed free.

4.5.1.5. Saws and Breaker Bars:

For ice 1/2 to one foot thick, ice saws and breaker bars (a six-foot length of steel pipe or solid bar with a sharpened tip) may be used to cut and break away the ice to form a hole, or to expand the width of an existing crack or seal entry-exit hole. No dive operation should be conducted on ice thinner than 1/2 foot.

4.5.1.6. Explosives:

If dive holes are required in ice thicker than 15 feet, or in ice out of range of the mobile drill, explosives may be necessary. However, the use of explosives is generally discouraged for environmental reasons, and rarely used. In cases where explosives are the only choice, researchers should plan on several hours of clearing ice from the hole before a dive can be made. Furthermore, transport requirements for explosives are stringent and require significant advance planning and permitting. See **Section 6.2.2. Hazardous Cargo Requirements** for more information. Explosives are not used at the Dry Valley lakes.

Note: *In some cases, the distance from the working surface to the water may be substantial. Freeboard from a dive hut floor to the water may be five feet or more. Exit from the water in these instances is simplified by having a crevasse or metal ladder at the dive hole. These ladders are provided by the dive locker.*

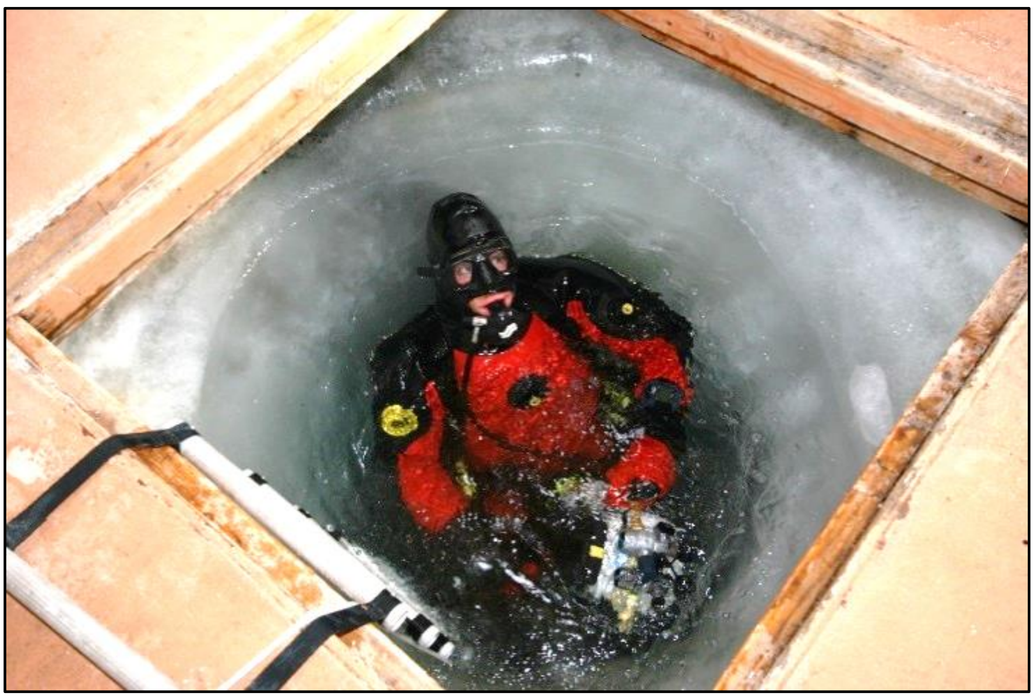

Photo by Jack Baldelli

Figure 22: Diver using ladder to exit dive hole.

4.5.2. Fast-Ice Dive-Hole Maintenance

When air temperatures are extremely cold, dive holes freeze in quickly, but several techniques can be used to keep them open. These techniques mainly apply to the McMurdo vicinity, where most fast-ice hole diving takes place.

4.5.2.1. Heated Shelters

Positioning a heated hut or other portable shelter (see **Figure 29**) over a dive hole will delay the freezing process. All of the huts now have solar/battery electric power, and a fan with a plastic tube that is hung above the hole, and positioned so that warm air from the hut blows down onto the water in the dive hole. Portable shelters also provide divers and tenders with comfort, as well as permitting diving in adverse weather conditions.

Photo by Steve Rupp

Figure 23: Dive hole blower fan and tube

Wind blowing under a dive hut can increase the rate at which the dive hole freezes, and blow up into the hut. This will reduce the efficiency of the hut heating system and blowing tube. After the hut is positioned, a request should be made that the bulldozer operator push snow up to the edges of the hut, or have the dive group at the site shovel snow around it to block the wind.

Photo by Rob Robbins

Figure 24: Portable heated dive hut and PistinBully

Note: Once the hut is positioned, a large wooden block or snow and slush can be used to construct a step. The step will freeze overnight, permitting easier and safer access to the hut when carrying heavy SCUBA gear.

4.5.2.2. Ice Removal

Even with the interventions described above, ice will continue to form on the surface and around the sides of the dive hole during the coldest months. If the hut loses heat or the hole is outside, even when covered, it will quickly freeze over. A week of neglect during spring and early summer may render a hole unusable, even if the hole has been covered. When the hole becomes too small to use or freezes over to a point where it cannot be opened up again with a chipper bar and dip nets, the hole will need to be re-drilled, or a new hole made. Another option would be to use a hole melter to get the hole back to the size needed to support diving operations.

Congelation ice, frazil ice, floating anchor ice, and platelet ice dislodged by divers can quickly fill a dive hole. This combination is often called “brash ice,” and it can form and go away at various times of the diving season. **It must be monitored, and if necessary, cleared by tenders. This will be necessary both before the dive, and while divers are in the water. If platelet ice is allowed to accumulate in a dive hole while divers are in the water, it may be difficult or impossible for returning divers to reach the surface.** Caution should be used when the platelet layer around the dive hole is thicker than 3 feet. If it’s much thicker than that, it will become a decision point as to whether to dive the hole or not.

Figure 25: Using a dip net and chipper bar to remove ice from a dive hole.

4.5.3. Fast-Ice Diving Hazards

4.5.3.1. Low Light

Lighting is often dim under a solid ice cover, particularly early in the austral spring when the sun is low on the horizon. Snow cover and ice will also attenuate light transmission, meaning that the thickness of snow and ice layers will have an impact on what lies below. Microalgae blooms and increased zooplankton during the austral summer will also reduce available light. Low light conditions may make it difficult for divers to locate buddies, down lines, and underwater landmarks.

4.5.3.2. Diver Disorientation

High visibility early in the austral summer season may make under-ice or benthic objects seem closer than they are. This illusion may entice divers to travel farther from the access hole than is prudent. The extreme clarity of the water can also make it difficult to keep track of buoyancy changes and accent/descent rates due to lack of visual references in the water column.

4.5.3.3. Loss of Dive Hole

The greatest hazard associated with fast-ice diving is potential loss of the access hole or lead. Access holes, leads, and cracks in the ice are often highly visible from below due to daylight streaming through them; however, conditions of darkness or covering them with portable shelters may make the holes difficult to see. Therefore, a well-marked down line is required for fast-ice dives and are supplied by the dive locker. These down lines are weighted at one end and marked with checkered flags and colored loops to connect strobes and gear to, including a small emergency pony bottle/regulator. Divers should always strive to maintain situational awareness, and keep positive visual contact with the down line during the dive. They should not become so distracted by their work that they fail to take frequent note of their position in relation to the access hole or lead.

Problems requiring an emergency ascent are more serious, since a vertical ascent is impossible except when a diver is directly under the access hole or lead. If the diver has lost visual contact with the dive hole, the problem becomes extremely serious.

4.5.3.4. Low Visibility

When visibility becomes lower late in the season, it will become necessary for divers to use a tethering system.

4.5.3.5. Current

Tethers can also be used in a situation where there is current, although it's not very common at most McMurdo dive sites. A good way to check for current before a dive is to look at the down line once it is deployed. It should be easy to get an idea from the attached flags as to how strong the current is. If the current is deemed to be too strong for safe diving, the dive should be postponed until slack tide. If the current is slight and the planned dive commences, it is a good practice to start a dive swimming against the current so the return swim to the dive hole is downstream. The tides are not typically very extreme around Ross Island, so this is not often an issue. Below is a link to current Ross Island tide information:

http://tides.mobilegeographics.com/locations/5412.html

Note: Former dive holes which have frozen over may still look like safety holes from below. To eliminate confusion in a frequently drilled area, all active holes should be marked with a down line.

4.6. Thin Ice

In cases where the ice is too thin to support a diving operation (less than six inches), divers will have to open a hole near the shore and swim to their work site. This condition should be treated procedurally as a solid-ceiling dive, since the divers may have to struggle to break through the ice in an emergency. If possible, an extra hole should be located or opened near shore and the divers should stay in visual contact with the main and spare hole at all times. A downline and extra strobes can also be laid out along the bottom as a reference point. Each diver should also carry a spare air source (pony bottle with regulator). Divers in this environment should follow the "Thirds Rule" (i.e., divers should plan dives to use 1/3 of their air for the excursion, 1/3 for the return trip, and keep 1/3 of their air as a reserve). In this situation, a tether is another viable option - and required if visibility is low.

Photo by Jim Mastro

Figure 26: Tethered diver surfacing through thin ice

4.7. Pack Ice

Pack-ice diving offers benefits and challenges quite different from those of fast-ice diving. The broken ice cover of the pack environment usually eliminates the need to cut access holes for diving. Easy and ubiquitous access to the surface generally makes a down line unnecessary, though one may be used to mark the exact entry point for convenience. The pack-ice environment tends to be much more heterogeneous than that of fast ice. Ice may be present in all stages of development, and the floes themselves may vary in size, age, structure, and integrity. Pack-ice divers will find themselves under an ever-shifting and dynamic surface. As in most open-water diving, weather, wave action, and currents must be considered.

In cases where the pack ice is forced against the shore and is solid but unstable, divers will have to open an access hole near shore in shallow water. This dive should be treated procedurally as a fast ice dive, since additional access to the surface may not exist (see **Section 4.5.**). Divers must also take into account tidal fluctuations which may alter the size of their dive holes or vary the depth under the holes. (see **Section 4.7.2.**).

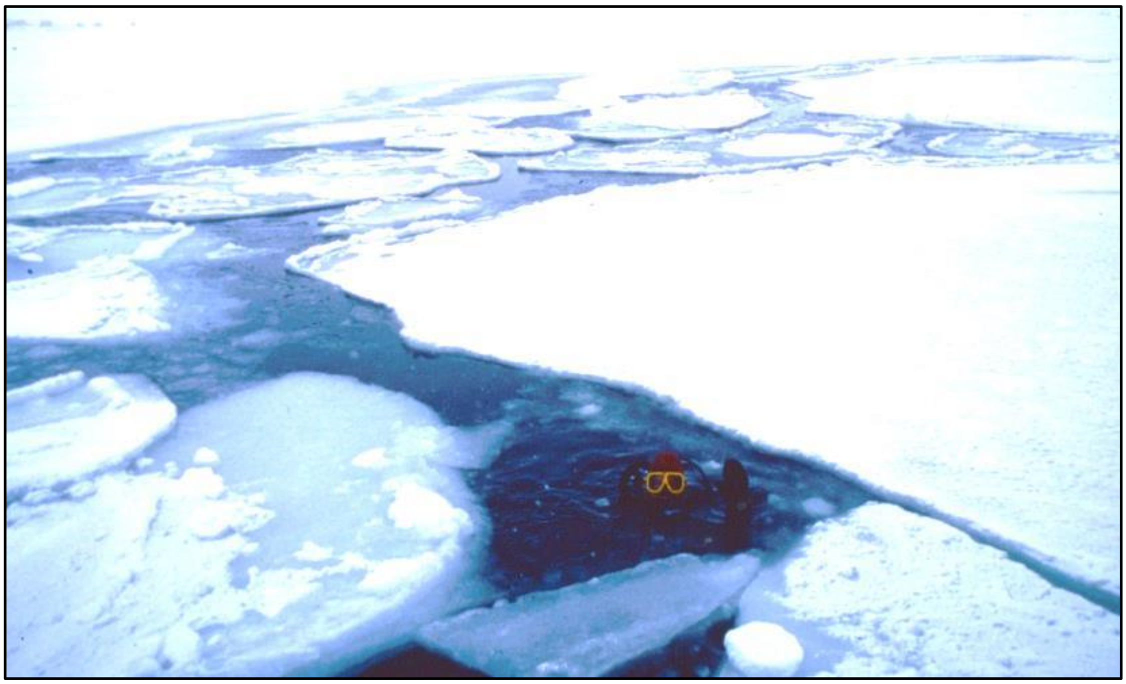

Photo by Jim Mastro

Figure 27: Diver surfacing in pack ice

4.7.1. Access through Pack Ice

Entering the water through pack ice from shore is especially common at Palmer Station. Inflatable boats launched from shore or a research vessel, or from large ice floes or a fast ice edge are also common methods. Depending on the density, stability, and thickness of the ice, transit time to and from a dive site via inflatable boat may be time-consuming. This factor should be considered in the dive plan. In early spring, broken ice around Palmer Station may make Zodiac operations, and therefore diving, nearly impossible.

Figure 28: Diver descending through pancake and brash ice.

4.7.2. Pack-Ice Diving Hazards

4.7.2.1. Ice stability

Pack ice is inherently unstable. Pack ice conditions can change rapidly, due largely to surface winds. An offshore wind may blow pack ice away from the shoreline and loosen the pack. An onshore wind may push large amounts of pack ice against shorelines or fast-ice edges, obstructing what may have been clear waters when divers entered the water. This means that the access area may become covered or blocked. Similarly, increased wind pressure on pack ice may make Zodiac travel more difficult or impossible. Pack ice conditions must be continually monitored by both divers and tenders, looking for any changes that affect dive safety. The entry area must be kept clear. Also, down lines and tethers can be disturbed by a shifting pack ice. Dive tenders must be vigilant to keep these lines free of moving ice.

Figure 29: Underside of pack ice, with contours reminiscent of cave diving.

In the photo above, the diver is using a modified aquarium net to collect juvenile krill (*Euphausia Superba*), which use the ice as a source of food and refuge.

4.7.2.2. Wave action

Surface swells, even if only light to moderate, may cause pack ice to move up and down several feet. In shallow water it is possible for a diver to be crushed between rising and falling pack ice and the benthos. At Palmer Station, surges from the calving glacier in Arthur Harbor may create a similar hazard. Divers should avoid diving under pack ice if the clearance between the ice and the benthos is ten fsw or less.

4.7.2.3. Marine Life

Leopard seals, killer whales, and other marine predators are often found in the pack ice environment and may pose a hazard. (See **Sections 4.10. Ice Edge** and **4.13. Marine Life**.)

4.7.2.4. Dim Light

Light may be dim under a heavy pack ice cover. Ice thickness, snow cover, phytoplankton bloom, increased zooplankton, glacial flour, and melt water will all contribute to light attenuation and low visibility.

4.8. Open Water

Open water may develop in the McMurdo Sound region when the fast ice breaks up in late December or early January. In the Palmer region, any existing fast ice usually breaks up by the end of October. Pack ice may be present for another month or two, and intermittently after that, but open water frequently defines the diving environment after early December. It should be noted that these are approximate dates. Climatic conditions can and will cause variation in annual ice conditions.

Divers operating in open water and from small boats should fly a “diver down” or “Alpha” flag when other boat traffic in the area is likely. When diving from small boats, particularly inflatables such as Zodiacs, it is very hard if not impossible for a fully-geared diver to climb back into the boat. It’s often necessary to remove the tank and weight harness before getting into the boat. A dive tender on the boat usually pulls the tank and weights on board. Lines extending into the water should be hung over the boat gunwales with carabineer clips at their ends to minimize the chances of losing gear while the divers are getting back into the boat. Dive weight harnesses should have D-rings attached (preferably near the shoulders), and tank backpacks with buoyancy compensator devices should have lines with clips or loops attached. It’s a good practice to partially inflate the BC/tank/harness so it will float if it comes unclipped or dropped. When returning to the boat, divers can clip the tank to one rope before removing it. Likewise, the D-ring of the weight harness can be clipped onto a rope before removing it. In addition to minimizing the chance of gear loss, these lines and clips enable divers to get out of their gear and climb into the boat, and then retrieve the gear without the aid of a boat tender. This may occur if an emergency forces tenders to concentrate their attention on a diver in distress.

Particularly when diving in open water where leopard seals may appear (see **Section 4.13.**) or where weather changes can quickly make surface operations unsafe and require a return to the station or ship the boat is operating from, it is necessary to have a mechanism for boat tenders to recall the divers. In shallow waters, revving the boat engine or banging on a tank that is placed into the water with a hammer can be effective signals. However, on deeper dives, the sounds from tank-banging or revving a 4-stroke outboard motor may not be loud enough to get a diver's attention. In such situations, a commercial diver recall horn is recommended. Palmer station has one in its dive locker. Regardless of the method, it is recommended that two different signals be established. One (e.g., constant sounding of the horn, motor revving, or tank banging) should be used to signal that leopard seals have been sighted, while a second (e.g., breaking the sounding pattern up with brief pauses every few seconds) should be used to signal other situations that require divers to exit the water as quickly as safe diving practices allows.

4.9. Blue Water

When diving in blue water, California Sea Grant College Program (CSGCP) blue water guidelines generally apply. Divers should be tethered, and wear buoyancy compensators. It may also be useful to deploy a down line if conditions warrant. Divers operating below pack ice in blue water should be aware that perceived current often increases with increasing depth. Wind action causes the pack to move, which in turn moves the water directly below. This effect decreases with depth, such that divers in still water at 30 fsw will have the illusion of movement as the pack ice above them drifts.

4.10. Ice Edge

Ice-edge diving is usually conducted in blue water, so a tether system is also required. It tends to be shallow (less than 20 fsw). The underside of the ice sheet provides a depth reference lacking in ice-free blue water dives. Ice-edge divers should watch for dangerous marine organisms. In particular, leopard seals may pose a hazard to ice-edge divers. Leopard seals have been known to lunge out of the water to attack people at the ice edge. They may also lurk under the ice, waiting for a penguin – or a diver – to enter the water. If penguins in the area demonstrate a reluctance to enter the water, it may be an indication that a leopard seal is nearby. If, on the other hand, penguins are swimming calmly next to the ice edge, it's unlikely that a leopard seal is present. Killer whales may also pose a hazard at the ice edge. (See **Section 4.13. Marine Life.**) Another factor to monitor is the current at the ice edge. If it's moving in the direction towards under the ice, and the divers and/or tenders are not paying attention, the diver or his/her umbilical could get swept under the ice further than is comfortable. Groups planning to work on the sea ice edge will need special training from the Field Safety and Training Dept. (FS&T) in addition to their regular sea ice training.

Photo by Rob Robbins

Figure 30: Ice edge diving operation near McMurdo.

4.11. Remote Sites

Remote-site diving operations carry increased risks and responsibilities. Medical care and logistical assistance may be several days away. Dive groups planning on remote operations must have sufficient dive gear, backup gear, medical supplies, and oxygen.

4.12. Contaminated Water and Specialized Diving areas

4.12.1. Contaminated Water

The following is a partial list of diving areas in Antarctica that may be regarded as contaminated water environments:

- The region between the southern tip of Hut Point and a point approximately 600 feet from the shoreline on the annual sea ice transition road. This region includes the sewage outfall and all of Winter Quarters Bay. In general, this area is considered contaminated because of the elevated levels of *E. coli* bacteria. *E. coli* levels have been measured up to 100,000/100 ml, but are lower now due to the installation of a water treatment plant. There are also other industrial contaminants, trash, and debris in and around Winter Quarters Bay. Most dates to the era when trash was dumped there, and runoff from town was high in contaminants that would concentrate there. In general, the seabed in these areas should be avoided, and not disturbed by divers.
- The region near the Palmer Station sewage outfall. This area runs from the seaward side of the pier to Gamage Point.
- The hydrogen-sulfide layer in Lake Vanda.

These environments require special consideration and should be discussed with the USAP DSO and contractor SDS for the latest information before planning dive operations near these areas. It requires specialized equipment and procedures and training for diver protection. Diving with standard SCUBA will leave a diver exposed to the water, so its use is prohibited in these areas. Surface-supplied/contaminated-water diving equipment is available for the McMurdo area. The equipment ranges from Heliox-18b band masks, for use with any vulcanized rubber dry suit, to Superlite-17b helmets that mate to special Viking® suits. (See **Section 5.11: Surface-Supplied Diving**.) Equipment requirements will depend on the type and level of contamination. Steve Barsky's book, ***Diving in High-Risk Environments***, provides more information on contaminated water diving.

https://www.amazon.com/Diving-High-Risk-Environments-Steven-Barsky/dp/0967430518

4.12.2. Specialized Diving Areas

Diving in the Dry Valley lakes also requires the use of surface supplied diving equipment, though not due to contaminated water (other than Lake Vanda, see above). The concern with these lakes is the need to minimize the disturbance of the water by divers, their actions, and their bubbles. These lakes are pristine environments, and every effort is made to minimize the impact left by divers.

Furthermore, the unique nature of each of these lake makes it essential that cross-contamination not occur. With surface supply and an umbilical, a single diver can be in the water instead of two as well as there being a certain amount of buoyancy control from the surface. Some of the lakes also have chemoclines that result in different densities at different levels, making proper weighting a challenge. Specific equipment has been assigned to each lake so as to prevent any cross contamination.

Photo by Steve Rupp

Figure 31: Dry Valley Lake dive station at Lake Bonney

4.13. Marine Life

Few Antarctic animal species are considered dangerous to the diver, though a few large mammalian predators pose a risk. Common sense should prevail in any interactions with these species.

4.13.1. Southern Elephant and Antarctic Fur Seals

The southern elephant seals (*Mirounga leonina*) and Antarctic fur seals (*Arctocephalus gazelli*) may become aggressive, particularly during the late spring or early summer breeding season.

Figure 32: Southern Elephant Seal (*Mirounga leonina*).

According to some researchers, elephant seals, while aggressive toward people on the surface, are generally non-threatening in the water. Antarctic fur seals, on the other hand, are very aggressive during the breeding season, around October-November, in and out of the water. Diving in areas with fur seals during that time should be avoided. Fur seals, especially juvenile males, are occasionally aggressive to divers at other times of the year, but this is uncommon.

Figure 33: Antarctic Fur Seal (*Arctocephalus gazelli*)

4.13.2. Crabeater Seals

Crabeater seals (*Lobodon carcinophagus*) have demonstrated curiosity toward divers, but have not shown behavior in the water that could be construed as aggressive. It should be noted, however, that even playfulness or curiosity on the part of a seal or group of seals may constitute a hazard. Crabeater seals have shown aggression to humans on the surface.

Photo by Steve Rupp

Figure 34: Antarctic Crabeater Seal.

4.13.3. Leopard Seals

Leopard seals (*Hydrurga leptonyx*) have been known to attack humans on the surface, have threatened divers in the water, and in one case attacked and killed a diver snorkeling in shallow water near Rothera Station. Dives should not be conducted when leopard seals are nearby. When diving from a small boat, the shoreline for several hundred meters on each side of the site should be reconnoitered before the divers get into their gear. Boat tenders should be attentive for the appearance of seals while the divers are getting into their gear. If at any time a leopard seal is spotted, the dive should be aborted. After the divers are in the water, the tenders should remain alert for the appearance of seals and signal the divers if leopard seals are seen (see **Section 4.10**.). The dive should be terminated immediately. If a leopard seal approaches divers in the water, the divers should apply shark protection techniques. If the divers are in midwater, they should face the seal, hold any available tools out in front of them as a barrier, and swim slowly toward the dive boat or toward shore. Divers on the bottom should stay close to the bottom if possible and head toward shore, always keeping eyes on the seal. Movements should be slow and deliberate. At no time should divers swim quickly away or give the appearance of flight. Such behavior mimics prey behavior familiar to the seal and may entice the animal to attack.

Photo by Steve Rupp

Figure 35: Leopard seal (*Hydrurga leptonyx*)

If a leopard seal approaches too closely and appears to be inclined to attack, the divers may wish to feign aggressiveness – charging at the seal as it charges them. These actions can be accompanied by loud exhalations of air and exaggerated arm waving. This protean behavior is unlike anything the seal expects from potential prey, and may confuse it or encourage it to retreat. But divers should also consider the possibility that aggressive behavior on the part of a leopard seal is the result of territoriality rather than hunger. Consequently, aggressiveness on the part of divers should be considered as a self-defense of last resort, and only if an attack appears imminent and escape is impossible. At all times during a leopard seal encounter, divers should stay close together and act in concert.

If a diver is bitten, prompt and careful attention must be paid to the wound. Beyond the obvious need to stop bleeding and minimize tissue damage, seal bites can be extremely infectious and should be thoroughly cleaned as soon as possible. Prophylactic antibiotic treatment may be required.

Encounters with all of the aforementioned animals are usually restricted to areas of open water, ice edges, or pack ice. Most encounters have occurred near Palmer Station or in other areas of the Antarctic Peninsula. Divers and other researchers working at the ice edge or other areas where leopard seals may be present should maintain constant vigilance.

4.13.4. Weddell Seals

Divers in the fast ice around McMurdo may encounter Weddell seals (*Leptonychotes weddelli*) in the water. Occasionally, a Weddell seal returning from a dive will surface to breathe in a dive hole. Generally, the seal will vacate the hole once it has taken a few breaths and replenished its oxygen stores, especially if divers are approaching from below and preparing to surface. Divers should approach such a seal with caution though, since an oxygen-hungry seal may aggressively protect its air supply.

Photo by Rob Robbins

Figure 36: A young Weddell seal (*Leptonychotes weddelli*) using a dive hole.

Typically, Weddell seals are not noted for aggressive behavior toward humans, except during their breeding season. Divers generally needn't be concerned about their presence at other times of the year. Like all pinnipeds, though, they may bite if provoked. During the breeding season (October through mid-November), a male Weddell seal may stake a territorial claim to a dive hole and prevent divers from surfacing. In these cases, the seal will have to be enticed out of the hole. Often, divers can simply wait out the seal at their safety stop a bit longer. If this doesn't work, letting exhalation bubbles come up under the seal is usually the simplest and safest method. Weddell seals protecting their surface access will often invert into a head-down, tail-up posture to watch for rivals. If exhalation bubbles don't work, a diver absolutely has to come up from the dive, he/she can lightly touch the seal's tail fin and then quickly back away to give the seal room to leave. From the surface, a gentle prodding by the surface tender of the seal's flippers will usually convince the seal that it's time to leave.

Divers entering or exiting the water are vulnerable to aggressive male Weddells, who tend to bite each other in the flipper and genital regions. At least one diver has had his fin bitten in this way. It's best to avoid areas of high seal activity during the breeding season, particularly if surface access is limited. Adult and sub adult male Weddells may show aggressive behavior toward divers in the water, even when the dive hole is not the seal's objective. This can be particularly true of peripheral males in non-breeding areas. (During the 95-96 season, divers were threatened by aggressive males at Tent Island and Cape Armitage.) Aggressive behaviors include posturing, "thumping" (a low frequency staccato vocalization), and charging. As with leopard seals, divers should keep their eyes on an aggressive seal and make their way back to the dive hole, without giving the appearance of flight. In those rare cases when a Weddell seal has become too bold, arm waving and counter charging have caused it to retreat. However, these techniques should again be considered a last resort.

Photo by Steve Rupp

Figure 37: Weddell seal (*Leptonychotes weddelli*) showing threat posture.

4.13.5. Killer Whales

No incidents of killer whale (*Orcinus orca*) attacks on divers have been recorded in the Antarctic. However, it's prudent for divers to avoid going in the water if killer whales are nearby, and to exit if the whales appear during a dive. Surface tenders and divers on the surface should be aware that their under-ice silhouette may resemble that of a large penguin. Standing too near the ice edge or in a broken area when killer whales are present is not advisable.

Figure 38: Killer Whale spy-hopping.

Note: Here is a link to a detailed online underwater field guide that is very helpful in identifying the various flora/fauna found in the Antarctic:

http://peterbrueggeman.com/nsf/fguide/index.html

5. Dive Operations and Procedures

5.1. Down Line

A down line is required on all un-tethered dives conducted from fast ice, or any other stable overhead environment with limited surface access. The purpose of the down line is to clearly mark the access hole from below. The McMurdo dive locker has a supply of ready-made downlines. They are usually left in the dive huts that are frequently used during the season, along with a ladder, diver recovery device, O_2 kit, and air circulating fan.

Note: A dive team must have an O_2 kit on site at all times during diving operations. If the team gets to a dive site and the O_2 kit is not in the hut or was forgotten, they must come back to station and acquire one before beginning diving operations.

It is very important that the down line be securely attached at the surface in such a way that it cannot accidentally come loose.

A down line consists of a rope – usually nylon – of sufficient length to reach either the bottom under the dive hole, or a length 50 percent greater than the proposed working depth. The down line should be of sufficient diameter to allow its easy grasping by gloved or mitted hands. Nylon is used mainly because it retains its flexibility in the cold, it is strong, and it is readily available at McMurdo Station where most fast-ice diving takes place. It should be weighted at the bottom with five to fifteen pounds. In addition to stabilizing the line, this weight serves as a safety device for divers experiencing buoyancy problems on ascent. Also, the down line should be anchored with the weight suspended just off the bottom to reduce damage to the benthos. The line should be clearly marked by highly visible flags placed at regular intervals along its length. Black and white checkered flags work best. As an added visibility measure, especially in dark diving conditions, two to three underwater strobes may be attached to a down line. One strobe should be attached to the line just under the ice at the safety stop level (approximately 15 feet deep), one at the mid-level of the line, and another near the bottom or at the working depth. A butterfly or some other sort of loop knot is handy to have at various intervals on the line to be able to clip off equipment and other items before or during the dive.

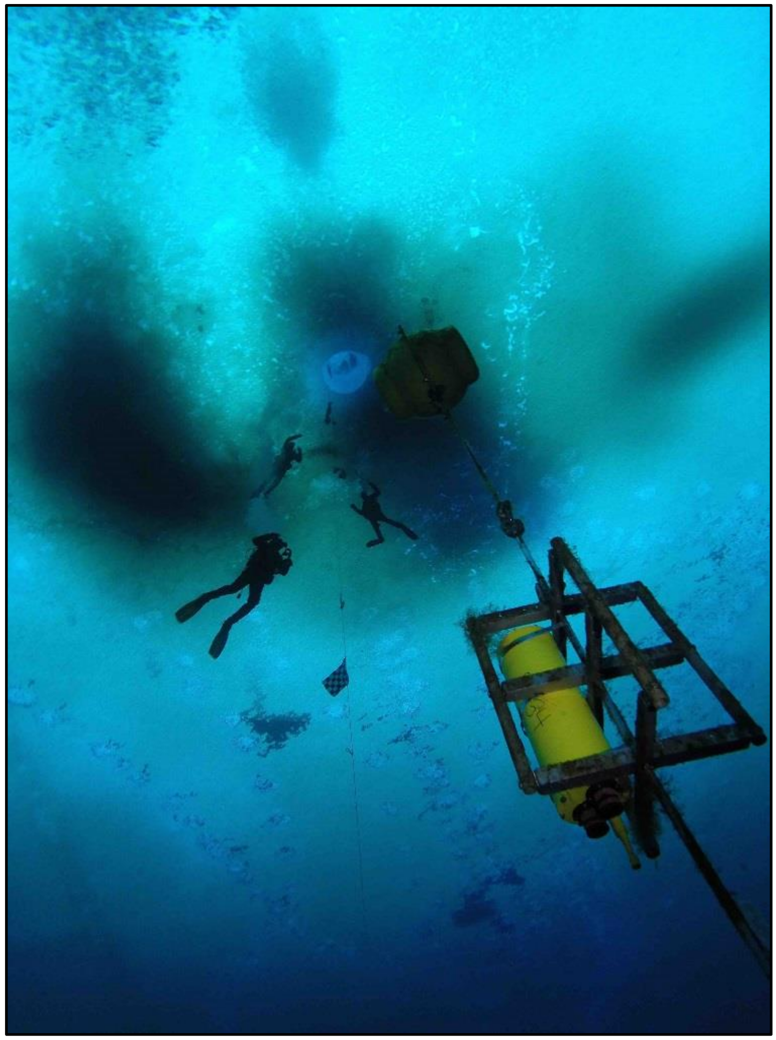

Photo by Steve Rupp

Figure 39: Divers ascending a down line at Cape Evans.

A 13.7-cubic-foot or larger reserve cylinder with regulator and submersible pressure gauge should be attached to the down line at the 15-foot safety stop. This keeps the regulator out of the mud, and makes the air supply more readily available to a diver in an emergency ascent or at the safety stop if he/she is low on air at that point. The cylinder is attached securely with a clip to a loop in the down line – a system that also allows the cylinder's ready removal by a diver.

A down line is not required on tethered dives, though one may be used at the divers' discretion. They should be mindful of the fact that there is a possibility of entanglement with the divers existing tether. A down line is sometimes required for attaching heavy loads for later retrieval. To avoid entanglement, tethered divers using a down line should plan to work in a single direction from the hole, with the down line placed on the opposite side.

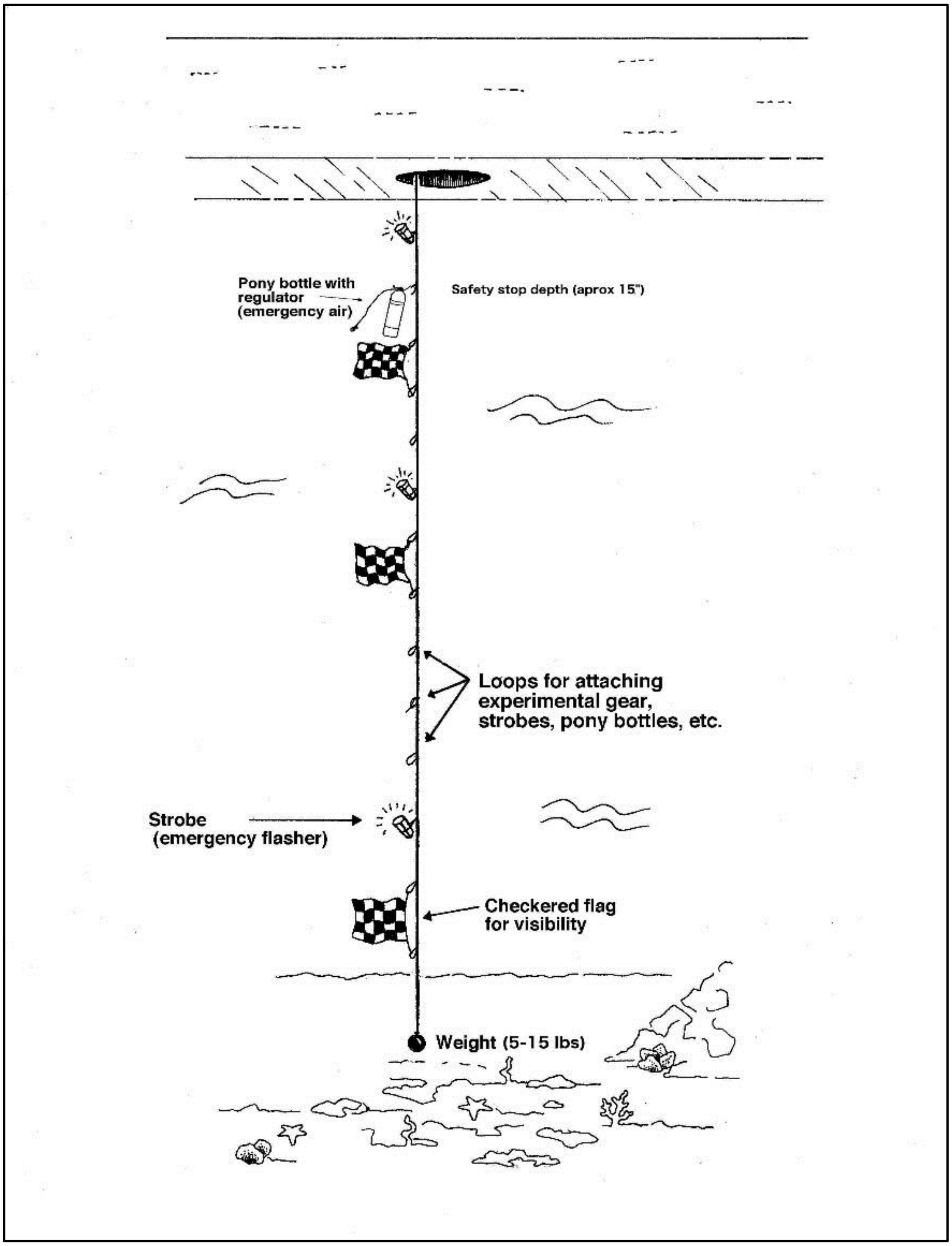

Figure 40: Down line with attached gear

As the graphic above illustrates, a down line should have a number of attached items. Included are strobes, loops for attaching experimental gear and other items, checkered flags, a pony bottle with a regulator, and a weight.

5.2. Other Hole-Marking Techniques

To further protect themselves against loss of the dive hole, research divers have employed one or both of the following methods:

5.2.1. Snow Removal

Where snow cover exists on the fast ice, a bulldozer (or shovel) can be used to scrape the snow off in a series of straight lines radiating outward from the dive hole. These lines are quite visible from underwater.

5.2.2. Benthic Lines

Marked lines may be laid out on the benthos, radiating outward like the spokes of a wheel from a spot directly beneath the dive hole. These lines should be marked so that the direction to the dive hole is clearly discernible. Divers anticipating the need to work a site late into the season when visibility is likely to be poor should lay these lines out early when visibility is still good. The lines should be about 100 feet long. The existence of benthic lines also ameliorates the danger associated with loss of a tether in low visibility. (see **Section10.2**) Another option is to run a "cave reel" line along the bottom from directly below the main hole to the working dive site. This will give the divers a direct path along the bottom to get back to the entry/exit hole.

5.3. Extra Dive Holes

If the work being conducted at the dive site is a long distance away from the main dive hole/hut, an additional dive hole that's closer to the work site may be necessary. The main function of this hole is to allow easy surface access in case of emergency. They also allow continued dive operations and surface access in cases where a Weddell Seal appropriates the primary dive hole. (See ***Section 4.5.3.3. Loss of Dive Hole*** for additional safety hole information.) If an extra hole is drilled/melted, it's not typically covered by a hut like the main hole, and will require much more maintenance by dive teams to keep it from being frozen over and rendered unusable. It only takes an inch or two of ice covering the hole to make it virtually impossible for a diver below to break through. From underwater, such a hole will look like a perfectly usable escape route, and in an emergency situation could confuse the diver at the moment that a critical decision must be made. If there's an extra hole at a dive site, it should be checked out on the surface before diving commences. If necessary, the extra hole should be opened up again by the team before diving commences. All useable holes should be marked with a downline so divers know at a glance that it will be a viable escape route.

5.4. Pre-Dive Safety Checks

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. Likewise, divers should perform a pre-dive buddy check with their fellow divers 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 what hand signals they may use (emergency or otherwise), a quick review of the dive plan, and whatever hazards might be present during the upcoming dive.

It is recommended that if a dive team is going to be at a site that is far away from McMurdo or Palmer, they bring along a spare regulator in case one of the diver's regulators malfunctions. They should also take extra thermal undergarments, Extreme Cold Weather gear, and dive gloves/liners in case of a suit leak situation.

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's a good technique to practice this action at the end of a dive, during the safety stop. That's when the diver is close to the hole and hands are at their coldest.

5.5. Buoyancy Regulation

Because air must be put into a dry suit to prevent "suit squeeze," it's most efficient to regulate buoyancy at depth with the dry suit. Participants in the *1991 AAUS Polar Diving Workshop* concluded that there may be occasions when the dry suit diver is more at risk with a BC than without one. Also, in the *2001 Smithsonian At the Poles Workshop* it was mentioned that BC use is not currently required for dives under a fast ice ceiling (most McMurdo area diving) where a down line is deployed, and the dive is not a blue water dive due to the lack of need for surface floatation. Diving under fast ice means having a "hard ceiling," and trying to manage two different air pockets with the possibility of an uncontrolled accent increases the danger. At Palmer Station, BC's are used due to the fact that almost all diving there is open water and there is a direct route to the surface. When climbing into an inflatable boat, a diver will almost always remove their tank/BC and hand it up to the tenders or clip it off to a line before climbing on to the boat and putting air in the BC at the surface will prevent it from sinking if it gets dropped or unclipped. Air in a dry suit also serves as thermal insulation. Weighting should be sufficient to enable the diver to achieve neutral buoyancy with a comfortable amount of air in the suit.

Dry suits and BC's should never be used as lift bags. When heavy items must be moved underwater, separate lift bags designed specifically for that purpose should be used, and the diver should be well trained on how to use them.

5.6. Computers and Dive Tables

It is now mandatory that all USAP divers use the dive computers that are issued by the McMurdo and Palmer dive lockers. Currently they are *Mares Nemo Wide* models. Follow this link to Mares to find out more info about this model:

http://www.mares.com/products/computers/wrist-dive-computer/nemo-wide/5623/?region=us

Divers are allowed to use their own computer as well, but they must still dive with the USAP issued model and stay within the no decompression limits stated by the USAP computers. Additionally, divers must maintain a provided dive log spreadsheet, and turn it in to the SDS at the end of their diving season.

With the advancement in dive computers over the last several years, the use of dive tables has become a rarity. Official NSF/OPP policy states that any dive tables used in Antarctica must be "at least as safe as the U.S. Navy dive tables." The more conservative University of Michigan Sea Grant "HUGI" tables and Canadian Defense and Civil Institute of Environmental Medicine (DCIEM) tables have come to be recognized as alternatives to the Navy tables, and they are currently recommended for use in the Antarctic.

On any given day repetitive dives should be made to progressively shallower depths. Divers at both stations must stay within the no decompression limit for all dives and be able to ascend directly to the surface at all times. Several factors in Antarctic diving increase the risk of decompression sickness, including the cold and the effort required to deal with heavy gear. Dive teams should also keep in mind that they are in a fairly remote environment and even though there are medical facilities at all the stations, it is a lot more limited than most parts of the world. McMurdo Station does have a staffed recompression chamber but Palmer station currently does not and getting transport to an available facility could take several days or longer. Because of these factors, it is recommended that divers use redundant safety factors and use very conservative dive plans.

5.7. Air Management

Based on cave diving protocols, it is recommended that divers operating beneath fast ice or other overhead obstructions (anything that prevents direct access to the surface) maintain at least twice the volume of air necessary to return to the dive hole or access point. This amount of air is in addition to a recommended reserve minimum of 20 cubic feet. This reserve gas may be used to conduct safety stops during the ascent as deemed appropriate. The standard cylinder issued at McMurdo and Palmer is a steel 95 cubic foot LP cylinder (they are filled to 2400 psi). There are a few steel 115 and 71 cubic foot cylinders available at Palmer station. The following table lists equivalent units of pressure (pounds per square inch gauge [psig]) for 20 cubic feet in the cylinders that are available.

Cylinder Type and Capacity Minimum Pressure (PSIG)

Single Steel - 71.2 (65) 700psi

Single Steel - 95.1 (86) 550psi

Single Steel - 115 (100) 480psi

* Manufacturers rate steel cylinder volume inclusive of a 10% overfill. However, once a cylinder has been hydro tested, this overfill is no longer allowable, effectively reducing available volume. This post-hydro reduced volumes for steel cylinders is indicated in the values in parentheses above.

5.8. Safety Stops

Safety stops of three to five minutes at or near 15 feet are recommended for any dive made to a depth of 50 fsw or deeper, unless an emergency or other safety-related reason dictates otherwise. Missing this stop is not considered omitted decompression.

5.9. Tending

Tenders help divers into their gear and into the water, hand the divers collection and photographic gear, handle tether lines, receive samples and specimens, and help divers out of their gear and out of the water when the dive is completed. In case of accident, tenders are on hand to pull an incapacitated diver from the hole and help begin emergency procedures. To increase safety and efficiency, it is recommended that dive teams arrange for one tender per diver, especially when tether diving. **A minimum of one tender per dive is required.**

Tenders are usually either members of the research team, or volunteers drawn from the science or support communities of the research base or vessel. The procedure to get a volunteer at McMurdo is to contact the McMurdo Chalet administrator – preferably the day before the planned diving – who will then contact the various work centers to find an available tender or tenders. Because dive tending is considered a morale trip for the tender, going through the Chalet is the best way to ensure that the volunteer opportunity gets shared fairly. They are an important part of the dive effort, and their assistance is very helpful to the dive teams.

Dive tenders are usually notified via email from the chalet and instructed what to bring (full ECW gear, lunch, sunscreen, etc.) and where to meet the dive team. This is usually at the McMurdo dive locker near the helicopter field below the Crary lab. (Building #144)

Once at the dive locker, the dive tender (s) will be given an overview of the days planned activities and some instructions as to what they will need to do. They are the first responders in case of accident, and will be instructed as to what needs to be done in case of an accident, including a quick overview of the DAN O_2 kits and radio procedures. It is preferable but not mandatory for the dive tender to have some amount of first aid/CPR training. It is even better if the tender has familiarity with SCUBA diving, radio use and vehicle/boat operation. Likewise, dive tenders should be physically able to lift heavy dive gear (often more than 40 pounds) and endure working out in the cold.

Cartoon by Matthew Davidson

Figure 41: Cartoon: New dive tender

In accordance with AAUS guidelines, all divers must be current in CPR, First Aid, and Oxygen administration. In the event of an accident or injury to a diver, one of the other members of the dive team can direct the tenders on how they can assist on-site. If a dive requires more than one volunteer tender, at least one of these tenders should be trained.

Likewise, at Palmer Station or the vessels, the dive tenders are pooled from the station/vessel population and instructed by the dive team there on the upcoming diving activities. Most diving at and around Palmer is from boats, and the tenders must have completed the Boating 1 or 2 course to participate. Because the volunteer pool is much smaller at Palmer, the dive team will conduct an impromptu dive tender training for interested volunteers.

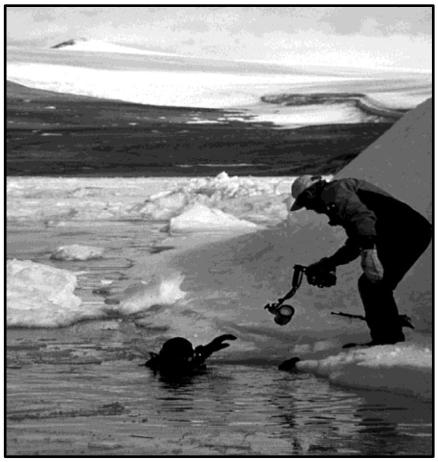

Photo by Lisa Mastro

Figure 42: A tender hands a camera to a diver

5.10. Tethering Systems

Dives conducted under fast ice where there is a current, in reduced visibility, in blue water, or where the water is too shallow to maintain visual contact with the dive hole, will require a tether according to NSF/OPP guidelines. Any type of tethering system holds the potential for entanglement. Divers should employ tethers with care and, ideally, should practice using the anticipated system in a more benign environment before deploying to the Antarctic.

Note: The tether must be securely attached at the surface in such a way that it cannot accidentally come loose and be lost into the water.

Several types of tethering systems have been used in the Antarctic at one time or another. Each tethering system has its advantages and disadvantages.

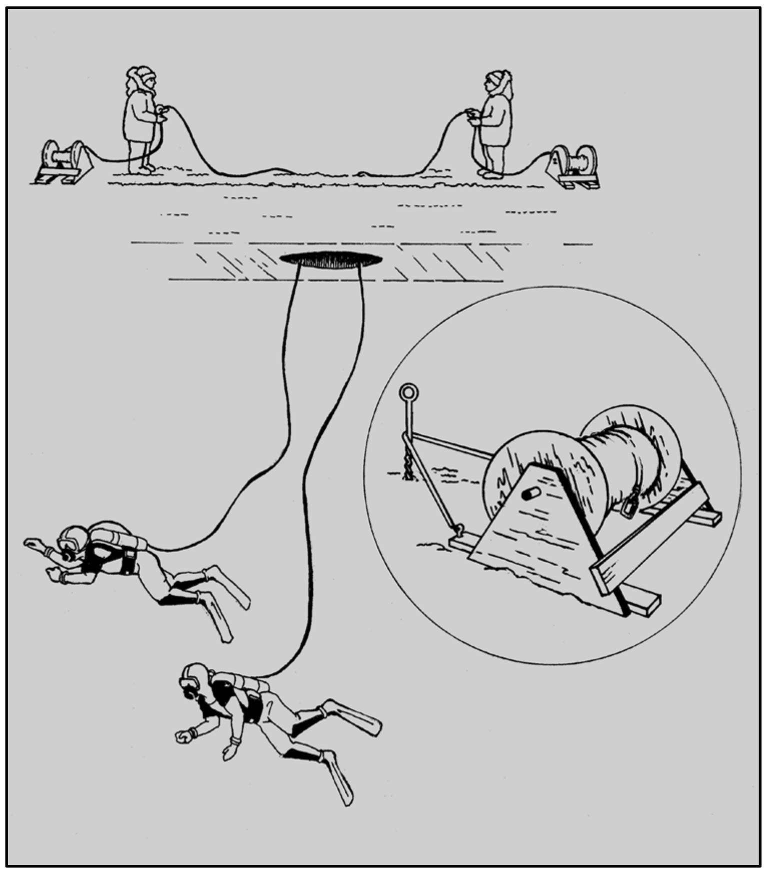

Figure 43: Each diver is tethered individually

Some dive groups conducting benthic or water column research in McMurdo have tethered each diver individually, as shown in **Figure 43**. Tethering each diver individually increases the danger of entanglement, but allows for more efficient work.

Others have used an L-shaped system where the tether line is attached to one diver who in turn is attached by a second line (or an extension of the original line) directly to the other diver. This configuration is depicted in **Figure 44**.

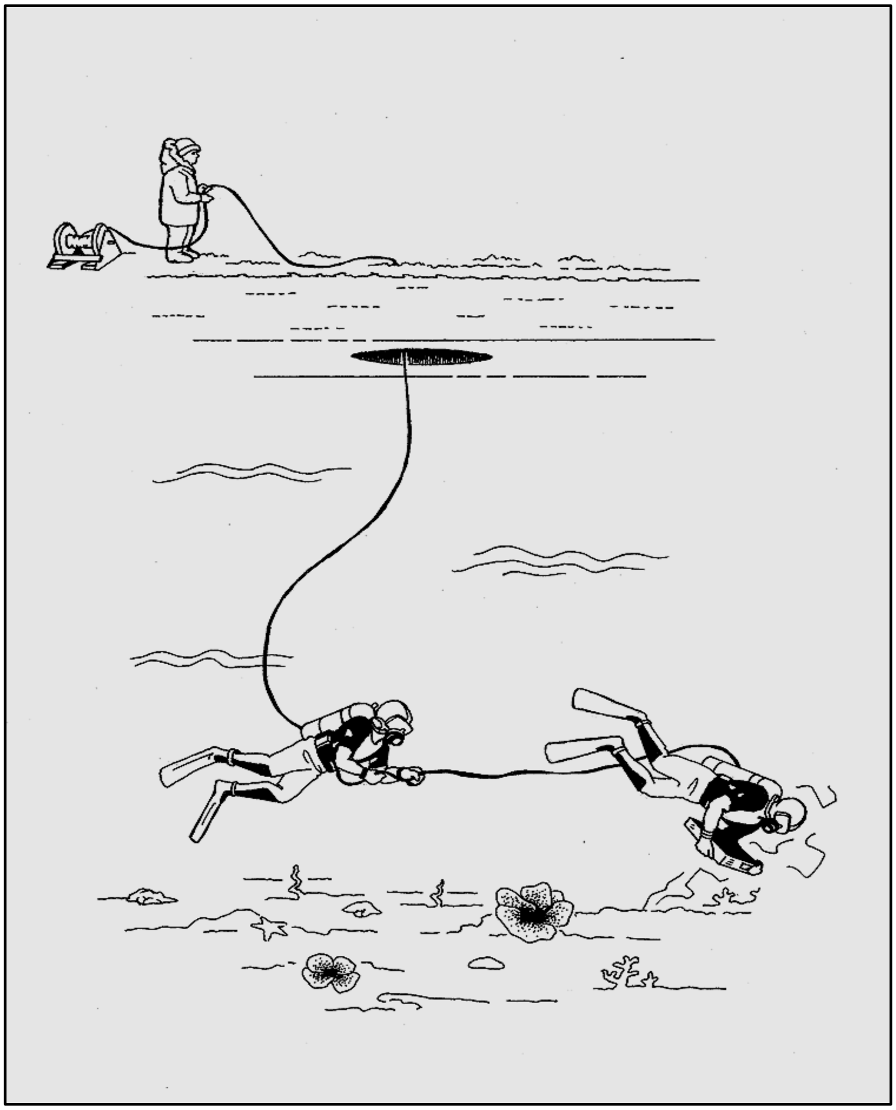

Figure 44: L-shaped tether system (tether and buddy line)

The length of this diver-to-diver line is limited by the need for a safe working distance between divers, and by the desire to keep volume of line and potential entanglement to a minimum. Some dive groups have recommended five to ten meters as an appropriate diver-to-diver line.

The L-shaped system (tether and buddy line) is modeled after the system described in the Blue Water Diving Guidelines, where one diver serves as a safety diver – controlling the tether line and preventing entanglement – while the other "working" diver performs the required task. It is also the safety diver's responsibility to maintain a positive communication link to the surface. With this system, line pull signals are easily transmitted between the safety diver and the surface tender, as well as between divers. The disadvantage with the L-shaped tether is that only one diver is fully available for work at depth.

Another variant is a T-shaped system. In this system, each diver's tether meets at a common point, which then leads to the surface, as shown below in **Figure 45**. A major disadvantage to this tethering system prevents clear line signal communication with the surface tender and therefore should not be used. It is noted here for illustrative purposes only.

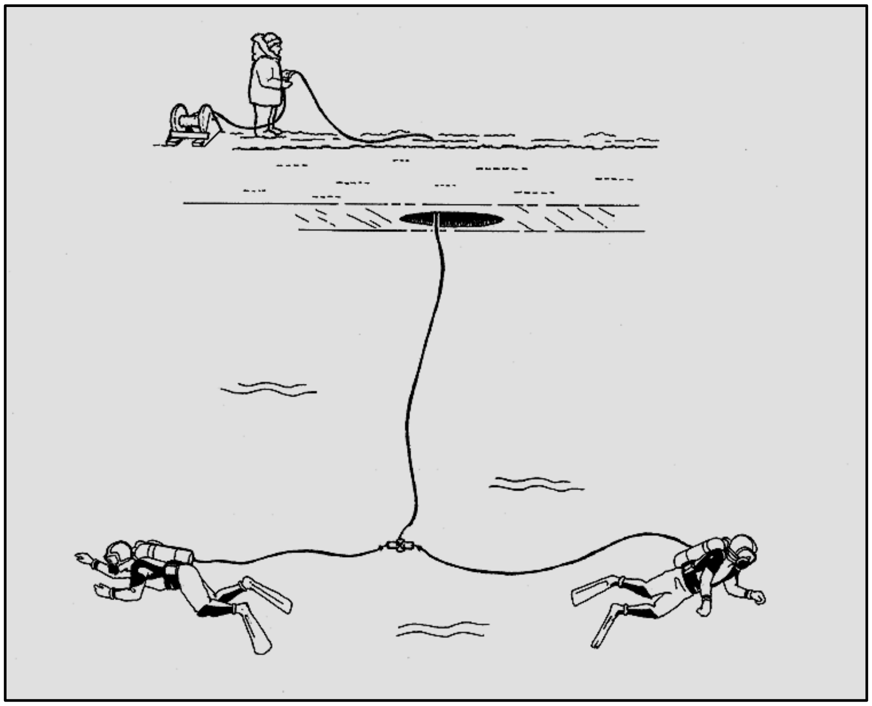

Figure 45: T-shaped tether system.

Dive groups operating in blue water from a USAP research vessel have used tethering systems based on those described in the CSGCP Blue Water Diving Guidelines. The U.S. Navy Diving Manual and The Cold Water Diver's Handbook offer additional information on tethering.

The surface tender must maintain enough positive tension on the tether line to immediately recognize line-pull signals from the safety diver, without impeding the activity or motion of the divers. It's good practice for the tender to periodically pull up any slack in the line and gently "fish" for the diver to make sure there is not too much slack in the water. The following basic signals, taken from the U.S. Navy Diving Manual, are considered to be an industry standard:

Tender to Diver

1 pull = Are you OK?

2 pulls = Go down or change direction.

3 pulls = Prepare to come up.

4 pulls = Come up.

Diver to Tender

1 pull = I'm OK.

2 pulls = Give me slack.

3 pulls = Take up slack.

4 pulls = Haul me up.

Rapid and continuous pulls = Pull me up immediately.

Line-pull signals should be practiced in advance of dive operations. It should be noted that single pulls may be mistaken for inadvertent tugs on the line by a moving diver. Tethered divers should pay close attention to each other and constantly monitor each other's position and status. Divers should never assume that a tether relieves them of normal buddy-diving responsibilities. Tethered divers working in a current should always swim and conduct work up-current unless returning to the dive hole.

5.11. Surface-Supplied Diving

Surface-supplied diving equipment is available at McMurdo Station. As mentioned in **Section 4.12**., its use is required for diving in contaminated water areas such as Winter Quarters Bay and the Sewage outfall, but it has also proved useful in other situations. These include the following:

- Rapid deployments, when dives must be conducted from multiple holes in a short period of time. A SCUBA diver must carry all his/her life support equipment on his/her back. Preparing two SCUBA divers for a rapid series of dives is thus more complicated and time-consuming than preparing a single surface-supply diver who, once suited, need only remove and replace the bandmask between dives. For the same reason, surface-supply diving is much more practical and efficient when the rapid dive series includes travel between multiple locations.
- Physically demanding dives, when high aerobic activity is required SCUBA regulators can only deliver a limited volume of air to the diver, thereby limiting the diver's work capacity. With a surface-supply bandmask, larger and longer quantities of air can be delivered. Work capacity is limited only by the individual diver's level of fitness.
- Dives that require communication with the surface. In addition to the hose that delivers air to the surface-supply diver, an attached cable provides a positive two-way communication link to surface tenders. This system is safer and more reliable than tethered communication systems with SCUBA.
- Penetration dives (i.e., dives into enclosures such as pipelines or ship wrecks) Dives into enclosures such as pipelines or ship wrecks generally require an unbroken line from the diver to the surface, and positive communications – both of which are provided by surface supply.
- Shallow, long excursion dives when a diver must move far from the access hole, especially in shallow water where the hole cannot be seen, it is generally safer to conduct the dive with equipment that provides a larger amount of air, communications, and a physical tether to the surface.
- Late-season dives, when visibility is reduced and a tether is required. A tether is required for any low visibility dive under ice. In many cases, the larger amount of

air and communications of surface supply may enhance the safety or increase the efficiency of these dives.

- Long-duration dives, when cold exposure is a real concern. The thermal protection of a surface-supply bandmask is greater than that provided by dry-suit hoods alone, as worn by SCUBA divers. This may be important when the diver must be exposed to cold for long periods of time.
- Any dive that is best done by a single diver. Solo dives are allowed in the Antarctic only if the diver is tethered and has surface communications with a suited standby diver. Surface-supplied diving provides these things, as well as the unlimited air and other advantages noted above. In the dry valley lakes, this technique is used to reduce the footprint of having multiple divers in the water to disturb the benthos and/or water column.
- Blue water dives where there is no bottom within diving depths. Having the diver on surface supply with an umbilical to the surface would allow the topside support team to limit the maximum depth of the diver in the event of over weighting or buoyancy failure.
- Use of lift bags. In addition to the air and communication line on a surface supplied diver's umbilical, there is a third component called a *pneumo line*. It's an open ended smaller air hose that is connected to a depth gauge on the surface that topside personnel can control to measure the diver's depth from the surface. This can also be turned on and used by the diver to fill up lift bags.

Equipment available includes: Superlite 17 helmets, Heliox 18 band masks, Superlite yoked Viking dry suits, a 35 cubic foot per minute (cfm) low pressure (LP) compressor, an 8-20cfm LP compressor, a high pressure (HP) gas manifold storage bank, floating umbilicals in lengths up to 350 feet, (each Dry Valley lake has a specific umbilical assigned to it to prevent cross contamination of the other lakes or salt water), one and two diver communication systems, dive control manifold boxes, surface supply harness/bail out systems, and weight belts.

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Photo by Andrew Klein

Figure 46: A diver prepares for a surface-supplied dive

This equipment is available to any qualified dive group, but requires extra training/orientation from the support contractor Dive Services SDS. Often, the support contractor Dive Services provides the surface supplied divers and personnel to perform the required diving since they are very familiar with the equipment and procedures. Although surface-supplied diving is generally done with a single diver in the water, a suited standby diver is required for all solo dives.

5.12. Surface Cold Exposure

Dive teams should be aware that the weather can change quickly in the Antarctic. When venturing into the field, all divers and tenders must have sufficient Extreme Cold Weather (ECW) clothing for protection in any circumstance.

In McMurdo, possible circumstances may include dry-suit failure/flooding, loss of vehicle power, storm conditions that delay return to station, or loss of fish hut due to fire. At Palmer, dry-suit failure, wet/stormy conditions while boating, and boat motor failure may strand dive teams away from the station. Tenders on dives conducted outside must also be prepared for the cooling effects of inactivity while waiting for the divers to surface. In addition, some food and water and possibly a thermos with hot liquids should be a part of every dive team's basic equipment. Besides serving as emergency rations, water is important for diver rehydration after the dive. For more information on survival procedures, see the ***USAP Field Manual***.

Figure 47: Dive tenders suited up in cold weather gear

5.13. Environmental Protection

All researchers in the Antarctic should avoid degrading the integrity of the environment in which they work. There are several common-sense ways to accomplish this:

- Do not over-collect. Because knowledge on Antarctic faunal growth rates is limited, divers should assume that recovery and recruitment rates are slow, particularly for rare or uncommon organisms. Over-collection could severely deplete an organism and alter the ecology of a research site.

- Do not unduly disturb the benthos. Whenever possible, divers should maintain neutral buoyancy when working on the bottom to avoid kicking and stirring up the sediment. When negative buoyancy must be used, divers should take care where they place their knees, hands, and feet. If diving in contaminated areas around McMurdo, divers should take particular care to avoid stirring up the contaminated sediment.
- Minimize mixing of water layers, such as haloclines. Water layering occurs in many Dry Valley lakes, such as Lake Bonney and Lake Vanda in the Wright Valley.
- Exercise extreme care with oil, gasoline, and other chemicals used with machinery or in research. Prevent spillage as much as possible, but if it happens, try to get an exact location and follow the proper procedures to report it and get it cleaned up. Any spill, regardless of size, is reportable. Part of the field training includes specific procedures on how to accomplish this.
- Around McMurdo, the Dry Valleys, and Palmer Stations, there are several Antarctic Specially Protected Areas (ASPA's). They require special permitting and permission to enter and conduct science. Dive groups should contact their support contract planner/implementer to obtain the proper permits before the field season starts.
- At Palmer Station, dive operations which promote further oil or fuel release from the shipwrecked Bahia Paraiso should be avoided.

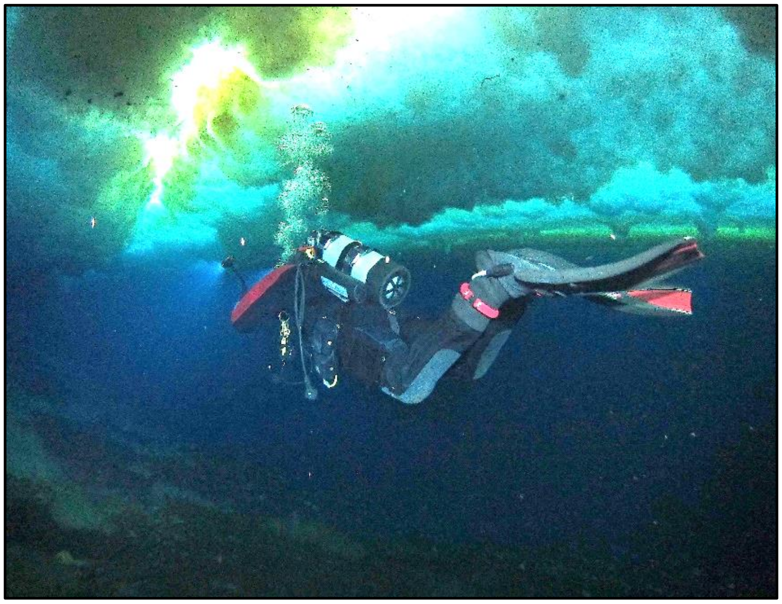


Photo by Rob Robbins

Figure 48: A neutrally buoyant diver hovers below the ice ceiling

In the McMurdo region, divers may sometimes need to use Weddell Seal holes or open leads in breeding areas for access to the water. Seals in these areas should be respected and given as wide a berth as possible. Increased attention to Antarctic Treaty protocols on environmental protection and implementation of the Antarctic Conservation Act have made human-seal interactions a more sensitive issue. Because seals will avail themselves of anthropogenic holes in the ice, dive operations will always disturb natural behavior to a certain degree. However, if it appears a dive operation will unduly disrupt natural behavior (i.e., by causing seals on the surface to become agitated, to move, or to leave the area), the dive should be aborted or its location changed. Furthermore, dive groups should avoid Weddell Seal breeding areas during the breeding season, unless they have a compelling reason to dive there, or unless they have a permit to do so. In either case, the limitation listed above should be respected.

Photo by Steve Rupp

Figure 49: Weddell seal and diver sizing each other up at the dive hole.

5.14. Initial Orientation and Checkout Dives

Upon arrival at McMurdo, science teams have a lot of training and orientation to complete. This usually consumes several days. When the team is going to be diving, there is also a diving orientation that is held at the Dive Locker (building #144) before they can commence diving operations. The SDS will show the groups around the dive locker and go over diving operations and procedures related to Antarctic diving. Below is an outline of dive orientation subjects:

5.14.1. Orientation for McMurdo Dive Groups

5.14.1.1. Dive locker

- General walk around.
- Where and how to store gear in the dive locker to keep things organized.

5.14.1.2. Gear

- Weight belts (yellow handles), backpacks, bags, ankle weights, strobes, pony setup, lights, etc.
- Familiarization with regulators and 2-regulator system, first stage bleed valve, slider and overpressure valves. Rinsing between dives.

- Setting up a gear configuration
- All divers must wear our computer, but can use their own as well. Familiarize with new computers. Note that divers need control their accent rate. Coming up too fast will lock them out of diving for 24 hours!
- Marking of your gear, including regulator colors. Tape available
- Only take tanks with tape on the valve (they are full ones). Tanks are 2400 psi not 3000. Try to re-use tape by sticking it on rack. We like to get the tanks back with around 500 psi in them. If you do happen to empty the tank completely, let us know so we can take a look inside it before re-filling.
- Tank handling, loading, traveling, etc. Talk about opening both valves at the same time to prevent accidentally having one on and one off.
- After dive equipment rinse and store (1 hook for gear, suit and underwear area, regulator hanging with mouthpiece down, glove driers, etc.).

5.14.1.3. Dive procedures

- Down line/strobes/pony/O_2/ladder setup for dive holes
- Getting in and out of the hole safely
- Importance of buoyancy control and dry suits/clear water as well as situational awareness, currents, knowing where the hole is at all times. Remember that, in most cases, the hole is the only way out.
- Safety stop at 15 ft. and 3 minutes. Used to be right about at ice ceiling level.
- Occasional seal encounters at the hole.

5.14.1.4. Familiarization/Check out dive

- Allows divers to become comfortable with diving in McMurdo environment and get gear sorted.
- Explanation of jetty site
- Buoyancy practice – Descend to bottom strobe and then ascend to top strobe on downline and hovering.
- Swim around to get comfortable, try not to mess up seabed.
- Regulator change at safety stop (end of dive cold lips makes it harder)
- Attempt re-connecting suit inflator. (Good to try but good for dive buddy to help as well)

5.14.1.5. Emergencies

- Procedures for contacting Mac Ops in case of dive emergency vs. non-dive emergency
- Distance to town and methods for getting diver back.

- Must have an O_2 kits on hand when diving. **Can't dive without one.** When to use.

5.14.1.6. Miscellaneous

- Filling out the dive log and importance of doing so accurately. It's better to keep up with it.
- You need approval for each and every dive over 130'
- Helicopter flights after diving.
- Quick overview of O_2 kit.
- Tenders overview. (yellow weight belt handles, gear moving, emergencies, etc.)
- Everyone sets up their backpacks, weight belts and puts their gear together for checkout dive.

Photo by Steve Rupp

Figure 50: Dive team going through an early season orientation.

Once the divers on the dive team go through one or more check out dives with the SDS, they can start their science diving operations. The Support contractor SDS and staff are there to help. Please come to them with any questions, or to assist with diving needs.

6. Transportation

6.1. Modes of Transport: McMurdo Station and Vicinity

6.1.1. Fixed-Wing Aircraft

LC-130 Hercules and Twin Otter aircraft have been used to transport divers and their gear to remote field sites for extended stays. These aircraft are seldom used for short duration dive trips. When fixed-wing aircraft are used, special consideration should be given to the limitations on flying after diving. A sufficient surface interval should be scheduled. Generally, 24 hours after diving is enough time for divers to be able to safely fly. (See the Undersea Hyperbaric and Medical Society (UHMS) recommendations on flying after diving in **Section 12.2**.)

6.1.2. Helicopters

Helicopters used in the McMurdo area are privately contracted A-Stars and Bell 212s. Royal New Zealand Air Force UH-1Bs and U.S. Coast Guard HH-65A's may also be available on occasion.

Helicopters are frequently used for single-day dive trips, as well as placement of long-term field camps involving divers and equipment. When transporting divers that have been diving in the last 24 hours, the helicopter pilots should be instructed not to exceed 500 feet of actual (radar) altitude if the flight path permits. **It's the responsibility of the divers to ensure that the pilots are aware of their post-dive status.** A minimum one-hour surface interval is required before flying in a helicopter.

Figure 51: A-Star Helicopter approaching McMurdo Station.

Figure 52: A-Bell 212 Helicopter supporting operations at Lake Bonney

6.1.3. Tracked Vehicles

There are five models of tracked vehicles currently in use by the USAP: Ski-Doo®, Haaglund®, PistinBully®, Tucker, and MatTrack trucks. Of these, PistinBully's are the most commonly used for diving operations. With heated, enclosed cabs and passenger compartments, they are useful for changing in and out of dry suits during inclement weather when a dive hut is not at the dive site. They also have comparatively long track length which gives them the ability to cross larger sea ice cracks than other vehicles. Tracked vehicles are generally used for diving within a 16-mile radius of McMurdo Station, though operations farther afield have taken place.

Photo by Steve Rupp

Figure 53: PistinBully and "Apple/Tomato" portable shelter.

6.1.4. Trucks:

Pickup trucks without the MatTrack conversion are sometimes used to transport divers and diving equipment to dive sites immediately adjacent to McMurdo Station. These dives are generally conducted from the shore. Depending on snow cover, trucks are sometimes taken onto the sea ice directly in front of McMurdo for dive support purposes, but are limited by the sea ice terrain conditions as well as their small tire footprint. The latter limits what can be crossed safely by these vehicles.

6.1.5. Snowmobiles:

Snowmobiles have also been used by divers for transportation to and from dive sites. Use is most frequent at remote camps in the McMurdo region, where other tracked vehicles are not available. The advantage of using a snowmobile lies in their speed. Disadvantages includes exposure of diver and equipment to cold, and limited cargo carrying capacity. Attaching sleds to the back of the snowmobile can increase cargo capacity, but sleds tend to be unstable. They have been known to tip over in rough snow or ice.

6.1.6. All-Terrain Vehicles (ATVs):

All-terrain vehicles are used more often than snowmobiles at some field camps for the transport of divers and dive gear. In cases where divers must move from land to the sea ice and back, the ATV is often more efficient and more appropriate than a snowmobile.

6.1.7. Icebreakers and Other Research Vessels:

Though icebreakers and research vessels are infrequently used to support dive operations in the McMurdo area, such support is a possibility. Research vessels may support other modes of transport, such as inflatable boats and helicopters.

6.2. Equipment Transport Requirements: McMurdo Vicinity

6.2.1. Equipment Protection

Transport of dive gear should be undertaken with care. Intense cold may cause some equipment items to become more brittle, and rough handling may cause breakage. The nature of the ice surface and of the vehicles used to traverse it mandates that equipment be properly secured for travel. During transport, cylinders, regulators, cameras and other fragile equipment require the most attention. Cylinder valves can be jarred open or damaged during rough transit. Slow air leaks from a damaged valve may not be audible over the sound of the vehicle engine. In the past, divers have arrived at a dive site after a long, rough journey only to find their tanks empty. On all dive excursions, regardless of transport method, cylinders should be properly secured and their valves protected against impact. Very cold temperatures may cause contraction in valve O-rings and Teflon seats, resulting in slow leakage. Cylinders transported on the open back of a vehicle or at ambient temperature should be checked on a regular basis to ensure that the valves are fully closed. Divers will often set up their tank/harness/regulators at the dive locker and load/secure them in the passenger area of the PistinBully in that configuration. This can prevent the tanks from draining out during transport if a valve gets loosened up. Care must be taken however to pack the units so the regulators and hoses don't get damaged during transit.

6.2.2. Hazardous Cargo Requirements

Compressed gas cylinders are considered hazardous cargo. Certain regulations govern and restrict their transport aboard all USAP aircraft. All cylinders including SCUBA, pony bottles, and O_2 kits must be taken to the Science Cargo department and certified at least 48 hours in advance of a planned dive trip or transport to a remote site. Specially designed crates are provided by the McMurdo dive locker for the transport of all SCUBA cylinders, and their use is required. The O_2 kits are already packed in Pelican Box cases and can be brought up as is.

6.3. Modes of Transport: Palmer Station and USAP Vessels

6.3.1. Sleds

During late winter and early spring, the area in front of and around Palmer Station is sometimes covered with fast ice. Divers wishing to dive in this area must load their gear aboard "banana" sleds and haul it by foot over the ice to the dive site. To date, no snowmobiles or any other vehicles have been allowed on fast ice near Palmer Station. Some areas of the fast ice, particularly near the shore, may be thin and weak. It is therefore recommended that all personnel who cross onto the ice to conduct or support a dive be dressed in dry suits or survival suits in anticipation of immersion.

6.3.2. Inflatable Boats

The vast majority of dives performed in the vicinity of Palmer Station are conducted from inflatable boats. These small craft are maintained and sometimes operated by a Marine Tech/Boating Coordinator. Research divers and station personnel can participate in the station's Boating 1 class to be a passenger on the boats and Boating 2 to be authorized to operate them. Small boats are allowed access to all areas within a two nautical mile perimeter of the station (see **Figure 8** in **Chapter 3**). Boating operations are limited by wind/weather conditions and daylight, which is covered in the Boating 1 class.

6.3.3. Icebreakers and Other Research Vessels

Dives conducted outside Palmer's two-mile small boating perimeter are supported by USAP research vessels. These vessels also support research diving performed in the open waters of the Antarctic Peninsula. Most diving is conducted from inflatable boats launched from the research vessel. These boats are operated by qualified members of the ship's crew. Occasionally, divers will disembark the vessel and conduct dives from the surrounding ice. As noted in **Chapter 3**, Palmer Station is currently in the process of procuring longer range Rigid Hull Inflatable Boats (RHIBs) with plans to be able to extend the current boating limits. As of this edition, (2017) the plan is to have them in service in the next couple of years and this could vastly expand the Palmer safe boating limit.

Photo by Chuck Amsler

Figure 54: Divers in Zodiac at Palmer (LM Gould in the background)

6.4. Equipment Transport Requirements: Palmer Station and USAP Research Vessels

6.4.1. Protection of Equipment

The need to protect equipment during transport is as important at Palmer and aboard USAP research vessels as it is at McMurdo. However, requirements are simplified by the limited modes of transport available. Cylinders and equipment should be secured to prevent shifting during boat movement, and valves and regulators should be protected from impacts. Additionally, regulators should be kept as dry as possible before the dive. Particular care should be made to keep snow/rain off regulator second stages before the dives. During transport, accumulated rain or melted snow can slosh around the deck of the boat, so care should also be taken to keep regulators off the deck. Although regulator free flow problems are less common at Palmer than McMurdo (due to the warmer climate and water), it's still a possibility, and keeping any kind of fresh water away from the regulators will go a long way towards preventing regulator problems.

6.4.2. Hazardous Cargo Requirements

SCUBA cylinders do not need to be certified before transport on USAP vessels.

7. Communications

Positive communication between dive groups and the local base of operations – whether McMurdo Station, Palmer Station, or a USAP research vessel – is important. Several types of radios and telephones are used in the Antarctic, depending on location and communication requirements. As part of a science group's field training, they will be trained on the use of the appropriate types of communication that is relevant for their field season. For a more detailed explanation of communications and equipment, refer to the ***USAP Field Manual***.

https://www.usap.gov/travelAndDeployment/contentHandler.cfm?id=540#Chapter1

7.1. Communication Requirements for Diving Operations

All science groups are required to inform the appropriate operational center before leaving the station for a research site, before each change of location while in the field, and immediately upon returning to the station. These operational centers currently are as follows:

McMurdo Station:

Winfly - Fire House / Call sign: Fire House

Main Body - Field Operations Communication Center (FOCC) / Call sign: MAC OPS

Palmer Station:

Comms Center

Research Vessel:

Bridge

At Palmer Station and on the vessels, dive groups are also required to confirm a positive communication link with their base of operations before diving begins. If communication cannot be established, the dive operation should not proceed. In the McMurdo area where a dive group is being rendered close support by helicopter or fixed-wing aircraft, direct communication with the FOCC is not required.

7.2. Communications: McMurdo Station and Vicinity

Dive groups operating in the local McMurdo Station area will be issued VHF FM line-of-sight transmitter/receivers, either hand-held and/or as part of their vehicle equipment. Dive parties farther afield may be issued High-Frequency Single-Side-Band (HF SSB) radios. In most cases, Satellite phone systems and Emergency Position Indicating Radio Beacon (EPIRB) will be provided to field parties in addition to their radio. Several dive groups in the past have made it a policy to have two independent, operating radios and spare batteries on hand during dive operations. This redundancy enhances safety.

Checking out of McMurdo:

When going out on the sea ice for diving operations, you must check out with either Mac Ops or the fire house (depending on the time of year) via radio with the following information:

- PistinBully or snow machine number
- Group or Science event number
- Driver name
- Number of people in party
- Destination
- In town Point of Contact info who knows your plan for the day
- Time of return

Checking back in to McMurdo:

When you return to McMurdo, you must check back in on or before your time of return that you previously reported. ***This is very important because Mac Ops or the Fire House will initiate the EOC (Emergency Operations Center) and start coordinating potential rescue operations as early as 5 minutes after your scheduled check in time if they have not heard back from your party***. Make sure you keep track of the time during your day and call back into Mac Ops or the Fire House if you need to extend your party's time for the trip.

7.3. Communications: Palmer Station and Vicinity

Divers operating in the Palmer Station vicinity will carry a minimum of two water-protected, hand-held radios and spare batteries with them on dive excursions. As in McMurdo, these radios are VHF FM line-of-sight devices.

7.4. Communications: USAP Research Vessels

Communication equipment, protocols, and procedures for the USAP Research Vessels are similar to those for Palmer Station. Dive groups operating from research vessels – whether in inflatable boats or by foot on the ice – should at all times carry two functioning water-protected, hand-held radios.

7.5. Communications: Remote Sites

Dive groups at remote camps will be issued HF SSB radios, Satellite phones and EPIRBs. Camp personnel are requested to check in each morning as part of their normal field-camp activities. Permission to proceed with diving operations at times when communication cannot be established should be received from the USAP DSO prior to field deployment.

8. Dive Equipment

Particular care should be taken in the selection and maintenance of diving equipment for use in the Antarctic. Antarctic waters are among the coldest a research diver can expect to experience (28.6°F in McMurdo Sound). In these temperatures, not all diving equipment can be expected to operate properly, and malfunctions may be more frequent. Diving under total ice cover also imposes safety considerations, which are reflected in the choice of gear. Years of testing and use by researchers and other Antarctic divers have demonstrated the reliability of some equipment items and the inappropriateness of others. (See **Chapter 8: Dive Equipment**.) In addition, specific care and maintenance regimens have been developed to ensure the safe, reliable operation of the equipment.

8.1. Regulators

At McMurdo, divers are required to use two fully independent USAP issued Sherwood Maximus SRB 7600 first and second stage regulators attached to their air supply whenever they are diving under a ceiling. A cylinder "Y" valve is the most common tank valve used at McMurdo that can be attached to both regulators. These regulators are the only model currently approved for use in the Antarctic by the USAP DSO, the Scientific Diving Control Board (SDSB), and the contractor Supervisor of Diving Services (SDS). At Palmer little diving is under a ceiling, and a single first stage with two-second stages is allowable.

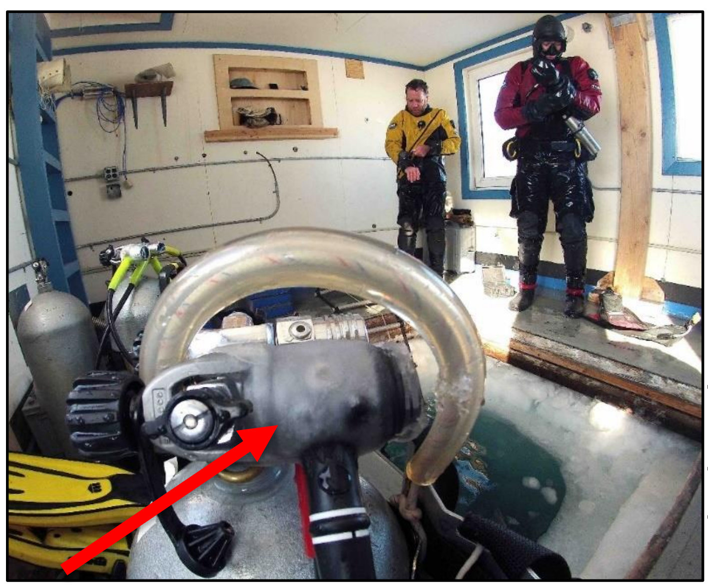


Photo by Brenda Konar

Figure 55: Ice on regulator first stage from adiabatic super cooling.

Proper use and proper pre-dive and post-dive care can substantially improve the reliability of the regulators used. Regulators should be kept dry and as warm as possible before a dive. Divers should not breathe through the regulator before submersion, except to quickly ensure that the regulator is functioning. Moisture from a diver's exhaled breath will promote free flowing. This is particularly important if the dive is being conducted outside in very cold temperatures. During a dive, a regulator that is being used for breathing should never be used to fill a lift bag. (small "Pony Bottles" are available for this purpose.) Large volumes of air exhausted rapidly through a regulator will almost certainly result in a free-flow failure. The primary regulators are affixed with a second stage "slider" cut off valve and first stage overpressure relief valves so that the diver can stop the primary regulator from free flowing after switching to the backup.

Note: *Once a diver has to switch to his/her backup regulator for any reason, they no longer have a redundant system and must terminate their dive immediately. At the end the diver's initial check out dive, they will have to demonstrate they can switch to their backup source and switch off the primary regulator with the slider valve.*

Inflator hoses and HP gauges should always be attached to the back-up regulator, in case the air supply to the primary must be turned off to stem a free flow. The backup regulator second stage should be attached to the cylinder harness or buoyancy compensator such that it is readily accessible and easily detached. Quick release second stage clips are supplied by the McMurdo dive locker for this purpose. If the second stage is allowed to hang loosely from the cylinder and drag on the bottom, it can become contaminated with mud and sediment and may not function properly if required.

At the end of the diving day, regulators should be rinsed and allowed to dry. During the rinsing, care should be taken to exclude water from the first stage interior regulator mechanism. The diver should either rinse the regulator while it is still on the cylinder and pressurized or ensure that the regulator cap is seated tightly, and that the hoses and plugs on the first stage are secure. On the second stage, make sure the purge is not accidentally depressed during the rinse. The primary cause of regulator free-flow failure in the McMurdo area is water within the mechanism that freezes once the regulator is used. Fresh water in the regulator may freeze simply with submersion of the regulator in seawater or upon exposure to extremely cold surface air temperatures. If multiple dives are planned, it may be better to postpone a freshwater rinse of the regulator until all dives are completed for the day.

8.2. Inflators

Inflator valves are also subject to free-flow failure, again because of water in the mechanism. Dry suit and buoyancy compensator (BC) inflators should be kept completely dry. Inflator hose connections should be blown free of water and snow before attachment to the valve. When inflating a dry suit or a BC, the diver is advised to use frequent short bursts of air. Inflator buttons should not usually be depressed for longer than one or two seconds at a time. Otherwise, rapid air expansion, adiabatic cooling, and subsequent condensation and freezing may cause a free flow.

8.3. Buoyancy Compensators (BCs)

Buoyancy compensators, when used in water without a ceiling, should allow unimpeded access to dry suit inflator and exhaust valves. As much water as possible should be removed from the BC bladder after diving and rinsing. Freshwater in the bladder may freeze upon submersion of the BC in ambient seawater. BC use in the McMurdo area is not currently required by NSF/OPP guidelines when the dive is conducted under a fast-ice ceiling. A BC should never be used to compensate for excess hand-carried weight. A good practice is to keep the BC empty and use the dry suit for buoyancy adjustment. That way a diver only has to manage one air space, and the BC is still functional for a backup.

8.4. Cylinders

Steel cylinders are almost used exclusively as the diver's main supply. They are preferred to aluminum cylinders for durability in cold temperatures. The standard issued USAP cylinder is a LP (2400psi) 95 cubic foot model. When certain circumstances require the need for a secondary bail out gas supply, and for a backup supply on the downline at the safety stop depth, there are a certain number of smaller aluminum "bail out" bottles available for use from 13 to 40 cubic feet.

8.5. Weight Belts

Divers are advised to wear sufficient weight to allow them to maintain neutral buoyancy with a comfortable amount of air in the dry suit, but over-weighting should be avoided. The dive lockers at McMurdo and Palmer have a supply of DUI® brand weight belt harnesses with ditch able weights available for dive groups if they don’t bring their own. When using **surface** supply equipment, commercial diving belts which are designed to not be ditch able to prevent accidental release are used due to the fact that the diver can be hauled up to the surface with the umbilical. At Palmer, divers sometimes use weight integrated BCs as well.

Figure 56: Dry-suit-clad diver wearing a DUI® weight system

8.6. Gauges, Timing Devices, and Computers

All USAP divers must use the dive computers that are issued by the McMurdo and Palmer dive lockers. Currently they are *Mares Nemo Wide* models. Follow this link to Mares to find out more info about this model:

http://www.mares.com/products/computers/wrist-dive-computer/nemo-wide/5623/?region=us

The USAP SDS keeps these units up to date with their current firmware and supplies batteries as well. They have a fairly large screen, a light, and have user changeable batteries. It uses Mares-Wienke RGBM (Reduced Gradient Bubbles Model) Algorithm.

Divers are allowed to use their own preferred computer as well but they still must dive with the USAP issued ones as well and stay within the no decompression limits of them. Due to the very cold conditions in Antarctic waters, battery life can be greatly reduced with many models. It's a good idea to bring along spare batteries for the specific model being used since there are so many different battery types, and the odds of there being any spares on station are low. Some computers now also have pressure transducers that connect to the regulator first stage and display cylinder pressure on the display. For redundancy though, the USAP issued regulators also have mechanical HP gauges connected to the backup regulator.

Gauges and computers should always be thoroughly rinsed in clean freshwater after each dive. Low humidity seems to encourage salt buildup and encrustation. Some divers soak their computers for several hours occasionally to remove built-up salt. Otherwise, salt may accumulate in seams and force computer casing components apart.

8.7. Dry Suits and Insulation

Many dry suits have functioned adequately in the Antarctic (DUI®, Nokia®, Poseidon®, Viking®). Choice of dry suit depends on the diver's preference and on the options available with each suit. Vulcanized rubber suits must be used when diving in contaminated water because of decontamination requirements.

Note: Over inflation of the dry suit should never be used as a means to compensate for excess hand-carried weight or to move heavy objects underwater.

Photo by Charles Amsler

Figure 57: Two styles of dry suit (DUI tri-laminate and Viking vulcanized rubber*).*

The choice of dry suit underwear is perhaps more important than the choice of a dry suit, because it is the underwear that generally provides most of the thermal protection. Many divers wear a base layer of heavy duty polypropylene or fleece (Patagonia Expedition Weight Capilene® for instance) with one or more outer layers of thick Polar Fleece® or Thinsulate.® There are many brands of cold weather diving specific undergarments, some one piece, some two piece. It’s really a matter of the individual diver’s personal preference and cold tolerance. The disadvantages of very thick underwear include the potential of getting overheated before the dive, and having to wear added weight to compensate for the increased bulk.

There are a handful of companies (DUI®, Golem®, Santi®) that are producing electrically heated undergarments/booties/glove liners that have been tried out with varying degrees of success in the Antarctic. Most of the units involve the use of an external battery and wire penetrator into the suit to power the heat source. This adds a layer of complexity to the process of suiting up for a dive and potential for suit or electrical failures, but some divers have found that it is worth the extra effort. These systems are also generally expensive.

Hands seem to be the main factor that determines the length of a dive in Antarctica. Once dexterity is lost in the diver’s hands, the dive should be ended quickly. Divers always want to have some dexterity at the end of a dive to be able to use their suit inflator or change to their backup regulator. Several types of gloves or mitts are available as accessories to the dry suit. Divers preferring dry hands have several options. SI Tech®, DUI®, Kubi®, Viking® and others make various types of dry gloves and mitts. Most are designed to attach to the dry suit with a detachable ring system. DUI® also has a Zip-Glove® that can be switched between a cuff or an attached 5 fingered glove. These are essentially just a waterproof shell, and require an inner insulating glove or two for the thermal part of the system. Divers who use these gloves/mitts usually place a small piece of tubing or cord under the inner wrist seal, if used, to allow for warm air equalization into the glove at depth. Pile glove liners and sometimes a thin base layer seem to work most effectively for this purpose. Some divers have used common heavy latex/rubber gloves that also seal over the Viking ring system. The 5 finger glove systems allow for substantially increased dexterity over mitts or 3 fingered “lobster” gloves while still offering thermal protection. The three-fingered variety seem to be the warmest system although divers sacrifice a certain amount of dexterity as a tradeoff.

Dry hands usually stay warmer. The biggest disadvantage of most dry-glove systems is the high loss of thermal protection if the gloves or mitts flood. Fortunately, this is an uncommon occurrence if the diver/tender is diligent while connecting the gloves to the dry suit. As with regulators, it’s a good idea to have an extra set of gloves and liners along as backup in case of a glove hole or breach of the ring seal.

Some divers, especially at Palmer Station, use neoprene three-finger mitts designed to get wet inside. Divers who use wet mitts often pre-fill them with hot water just before entering the water.

Note: Hand comfort is individual and varies considerably among divers. A glove system that works for one diver may be entirely inadequate for another. The best systems use layers, but it is important to note that lack of constriction is much more important than increased layering. A constricted hand is a guaranteed cold hand.

8.8. O-rings

Severe cold may compromise O-ring seals. All O-rings exposed to the environment should be cleaned and lubricated frequently.

8.9. Compressors

Proper compressor care and operation are necessary to ensure a reliable supply of clean air. When diving at McMurdo Station or Palmer Station, the contractor's Dive Services staff will fill bottles and maintain the compressors. Compressors should be kept warm or should be adequately warmed before starting if possible. Cold starting attempts will drain batteries and may unduly strain compressor components. If a compressor has to be started cold, it should have adequate time to warm up before engaging in cylinder filling. Compressor hours should be noted on the hour meter that is connected to the unit and compared to its next scheduled maintenance due. This information is usually attached to the compressor on a paper tag. Air filters and crankcase/compressor oil are scheduled to be changed on a regular basis by the Mechanical Equipment Center (MEC). The cleansing capacity of portable compressor filters is usually limited, so air intake hoses should be positioned upwind and well away from compressor engine exhaust. When the compressor is in operation, manual condensate drains should be purged frequently (i.e., every eight minutes or so) to prevent moisture contamination of the filter.

Note: When charging cylinders, it is critically important to always purge the cylinder valve of moisture before attaching the fill whip. Also, the person filling the tanks must stay and attend to the filling to ensure that they can quickly shut down the compressor if anything goes wrong with the filling operation.

The MEC will provide training on the use of compressors for dive teams working in remote areas.

8.10. Dive Gear Preventative Maintenance

All diving gear, including cylinder valves, should be rinsed in fresh water at the end of every diving day (except as otherwise noted) to reduce salt buildup and corrosion.

8.11. USAP Dive Gear Availability

As stated previously, there are a few dive gear items that all USAP divers are required to use. This includes regulators, dive computers, DAN O_2 kits, and tanks. The availability of gear provided by the USAP varies according to location. At Palmer Station, dive teams need to bring a lot more of their own gear and spares due to the fact that there is not usually an on-site SDS. The section below lists gear available to researchers at each respective station at the time of this publication. In general, if the gear is not listed here, researchers will need to supply it themselves. All NSF/OPP-supplied equipment that researchers wish to use should be listed in detail in the Support Information Package (SIP) in the Diving tab on Polar Ice. https://polarice.usap.gov/login/index.cfm , which is submitted to the support contractor during the pre-season planning phase. Some of the equipment listed on the following page is available only on a limited basis or as emergency replacement for lost or malfunctioning researcher supplied equipment.

Distribution of this backup equipment is at the discretion of the SDS or authorized contractor representative. These items are marked with an asterisk (*).

McMurdo Station:

Regulators- Sherwood Maximus SRB-7600 – (required)

Dive computers – Mares Nemo Wide – (required)

SCUBA cylinders – (required)

DAN O_2 kits – (required)

Backpacks

DUI® weight belts and soft weights

Mechanical pressure gauges

Air compressors - (portable, supplied by the MEC)

Dive lights

Collections bags

Surface-supplied dive equipment (use must be coordinated with SDS)

De-fog

Down lines

Strobes

Crevasse ladders

*Fins

*Ankle weights

*Masks

*Suits and gloves

*Thermal underwear

*Tools and suit repair materials

Palmer Station:

Regulators- Sherwood Maximus SRB-7600 – (required)

Dive computers – Mares Nemo Wide – (required)

SCUBA cylinders – (required)

DAN O2 kits – (required)

Air compressors (in dive locker)

Air compressor (portable)

Backpacks

Weight belts and weights

DUI® weight belts and soft weights

USAP Research Vessels:

Air compressor

SCUBA cylinders and backpacks

Weight belts and standard weights (limited)

*Depending on logistics, some gear for research vessel diving ops will be loaned out from one of the USAP dive lockers either at Palmer or McMurdo.

9. Safety Equipment

9.1. Safety Equipment: McMurdo Station and Vicinity

McMurdo Station is equipped with a modern 54-inch, double lock recompression chamber operated by a trained crew. The chamber building adjoins the McMurdo Medical Clinic, and medical treatment for pressure-related injuries is administered by trained medical personnel.

Photo by Steve Rupp

Figure 58: Recompression Chamber at McMurdo Station

All dive teams – whether they are working immediately adjacent to McMurdo or farther afield – are supplied with emergency oxygen first-aid kits and are required to have it at the dive site during all diving operations. Standard first-aid kits are also available. Dive groups operating out of mobile fish huts are supplied with emergency diver-extraction kits (consisting of a hand-operated winch with a specially designed strap) for pulling an unconscious or incapacitated diver out of the dive hole.

9.2. Safety Equipment: Palmer Station

The nearest functional recompression chambers to Palmer Station are located at the British Antarctic Survey's Rothera Station, King George Island, and in Punta Arenas, Chile. These chambers are listed in the ***Palmer Station Dive Accident Management Plan*** (STPS-PLN-0002). At the beginning of any diving season, station management will contact the various chamber facilities to determine which ones are functioning and staffed for that time of year. In the case of a diving emergency, transportation will be arranged to move the victim to a chamber. This transportation may involve USAP research vessels, civilian passenger cruise liners, military vessels (U.S. and foreign), and U.S. or foreign aircraft. However, because transportation resources around the Peninsula are limited and may not be readily available, there is a strong likelihood of extended delay (several hours, in a best-case scenario, to four or more days) before arrival at the chamber. Emergency oxygen kits are available at Palmer Station for use by dive groups within the two-mile small-boat limit. A supply of medical oxygen is also on hand at the station, along with an oxygen concentrator system which permits long-term surface oxygen delivery. Divers operating from small boats are provided survival bags which contain some first-aid supplies. Additional first-aid equipment and supplies are available from station medical staff.

9.3. Safety Equipment: USAP Research Vessels

The R/V Laurence M. Gould and the R/V Nathaniel B. Palmer have emergency oxygen first-aid kits for divers similar to the ones in use at Palmer Station. A supply of medical oxygen in large cylinders is also available on both vessels, along with a mask and regulator system to permit long-term surface oxygen delivery. In case of a dive accident, the victim would be transported by the vessel to the nearest treatment facility or to an airfield if air transport is available. Similar to Palmer Station, there is a likelihood of extended delay before arrival at a chamber

10. Dive Emergencies

Several possible emergency situations specific to the Antarctic, and particularly to the fast-ice environment at McMurdo, are listed in this chapter – along with methods for dealing with them. The best method for dealing with SCUBA emergencies, of course, is to prevent them. Divers should halt operations any time they become unduly stressed due to cold, fatigue, nervousness, or any other reason. Similarly, diving should be terminated if equipment difficulties occur, such as free-flowing regulators, tether-system entanglements, leaking dry suits, or buoyancy problems. Emergency situations and accidents rarely stem from a single major cause; they generally result from the accumulation of two or more minor problems. It is best to terminate a dive before problems multiply. In any emergency situation, it is important to not panic. Maintaining the ability to think clearly is the best preparation for the unexpected. In addition, most dive emergencies are best handled with the assistance of the dive buddy, reiterating the importance of maintaining contact between buddies while in the water.

10.1. Loss of Dive Hole

Following established procedures (as described in this manual) and maintaining a safe proximity to the surface access point makes losing the dive hole an extremely unlikely occurrence. Situational awareness during the dive and always being in visual contact with the dive hole is of paramount importance. If however, during the course of a fast-ice dive, a diver loses contact with the dive hole and cannot locate a safety hole, the first action should be to locate the buddy. The buddy may be able to point the way. If both divers have lost the hole, they may be able to retrace their path. A suspended silt layer in the water column will indicate where divers have kicked along the bottom. Scanning the water column for the down line and strobes should be done slowly and deliberately, because the strobe light flash rate is reduced in the cold water. If the hole cannot be found, an alternate access to the surface may have to be located. Often there will be open cracks at the point where fast ice touches a shoreline. In their search for the dive hole or for an alternate access, lost divers will have to constantly balance a desirable lower air consumption rate in shallow water with the need for the wider field-of-view available from deeper water.

10.2. Loss of Tether

Because tethers are used in low visibility diving operations, loss of the tether is one of the most serious Antarctic dive emergencies, especially if the dive is under fast ice. If the dive is not under fast ice and if the tether line cannot be reconnected, the diver should terminate the dive and surface. For fast-ice dives, tether loss for each situation requiring a tether will be discussed separately. Exercising reasonable care (especially by paying careful attention to how the tether is attached to the diver) makes a loss of tether emergency unlikely.

10.2.1. Loss of Tether in Low Visibility

If one diver comes off the tether line, this diver should make an attempt to locate the line or the buddy in the immediate area. If neither can be located, the diver should ascend to the underside of the ice and assume a vertical posture, extending one or both arms over the head. (See **Figure 59**) This presents the largest possible target. The tethered buddy will run a circular search pattern by swimming 30 to 60 feet farther away from the hole than the divers were working and sweeping in a clockwise or counterclockwise direction just under the ice. The tether line should catch the untethered diver. The lost diver should keep one hand on the ice and should watch the water below his or her feet. A rescue line passing just under the ice or a few feet below the diver will be caught or seen.

Figure 59: Off-tether diver position

The figure above depicts a diver who is off tether. He/she should take a vertical position with one hand on the ice above, and look down trying to find the search diver or the tether line.

If both divers become disconnected from the surface tether, they should immediately establish contact. If they are still connected by a safety line, they should initiate a circular search pattern for the surface tether. In this pattern, one diver remains stationary while the other swims to the limit of the available line and does a sweep. If the tether cannot be found, the divers should ascend to the underside of the ice and initiate a similar search pattern for the dive hole. Multiple patterns may be run, provided the ability to return to the initial position is maintained. Staying shallow will conserve air supplies. If neither the hole nor the tether can be found, and if another dive team is known to be available, the divers should follow the procedure outlined in the previous paragraph.

On the surface, if the tender notices that the divers have become disconnected from the tether, they should immediately inform the base of operations that divers have been lost. If the tether is still attached to the surface, **the tender should not pull up the loose line.** The divers might still be able to locate it if it is still down and not far away from them. Under some conditions it may be possible to deploy a search-and-rescue dive team. They should also look around the dive site for any potential cracks or other nearby spots that the divers might have been able to surface to. The danger associated with the loss of a tether in low visibility is mitigated if the divers have previously deployed a series of benthic lines (see **Section 5.2.2.**).

10.2.2. Loss of Tether in Current

If one diver becomes disconnected from the tether in a current under fast ice and the tether cannot be reconnected, the dive should be terminated. The diver should attempt to make physical contact with the buddy's tether. If the divers are in the water column and have been working up current as they should, it may only be necessary to drift back to the down line. If the divers are down current, it may be necessary to crawl along the bottom to the down line or crawl upside down along the ice ceiling. It is always advisable to deploy a down line on tethered fast-ice dives made in a current. Diving in conditions of low visibility and rapid current is not advisable. Also, a good way to determine if the current is running too strong is to lower the down line into the dive hole and observe what it is doing. If the current is strong enough to move the down line out of site, it is probably too strong to safely dive.

10.2.3. Loss of Tether in Shallow Water

When one or both divers lose the tether in shallow water where the access hole is not readily visible, they should first establish contact with each other. If the tether line cannot be found or reattached, the divers should attempt to retrace their path to the hole. Barring this, an alternate access may have to be located. No dive should be made in such a situation without clearly marking the access hole. There are several ways to do this:

- Deploy a well-marked down line with strobes.
- Establish recognizable "landmarks" under the hole at the outset of the dive. These landmarks may be specific ice formations.

- Leave a strobe light, a flag, or some other obvious and highly visible object on the substrate just below the hole and possibly a second one towards the intended work site.
- Shovel surface snow off the ice in a radiating spoke pattern which points the way to the dive hole. Such ice-free areas are generally very visible from below.

As mentioned above, if the surface tender realizes the divers have become disconnected from the tether, he/she should immediately deploy a brightly marked down line (if one is not already in the water), **not** pull up the tether line, and then notify the operations center.

Photo by Jim Mastro

Figure 60: Tethered diver entering the water

10.3. Diver Trapped in Under-Ice Platelet Layer

The under-ice platelet layer can be several meters thick in places. It is possible for an over-buoyant diver to become trapped within this layer to the extent that he or she is unable to see, and becomes disoriented. The best and most obvious solution is to dump air from the dry suit to achieve negative buoyancy. If this is not possible for some reason and if the platelet layer is not too thick, the diver may stand upside down on the hard under surface of the ice so that the head is out of the platelet ice. The over-buoyant diver can then orient to the position of the dive hole and buddy. Another major concern is platelet ice becoming dislodged and floating up into the dive hole. Diver’s bubbles and fining near the hole can cause the platelet ice to quickly fill up the dive hole and “pack in” to a point where the divers will have extreme difficulty getting back out. In a situation where there is a lot of platelet ice on the ceiling around the hole, divers should attempt to not linger too close to the immediate area around the hole so their bubbles/actions dislodge as little of the ice as possible. The same is true during the safety stop.

On the surface, dive tenders should keep a good watch of the accumulating ice in the hole and remove it with dip nets/shovels as necessary throughout the dive.

10.4. Dive Hut Fire

Fire is one of the greatest hazards to any scientific operation in the Antarctic. The low humidity ultimately renders any wooden structure susceptible to combustion, and once a fire has started it spreads quickly. Dive teams must always exercise the utmost care when using heat or open flame in a dive hut. Hut heaters should never be left on at a high level, particularly when the hut is unattended. All dive-team members should be familiar with fire prevention methods and fire extinguisher operation. There should be a fire extinguisher in each hut and a small one in the PistinBully. If not, inform the dive locker personnel and they will arrange to have one installed.

10.5. Dangerous Marine Life

Dangerous marine life encounters are covered in more detail in **Chapter 4, Section 4.13.** The main types of dangerous marine types are Leopard, Fur, and sometimes Weddell seals, and Killer whales. In almost all cases, if dangerous marine life is encountered before diving, then diving operations should be postponed until the threat has passed. If they are encountered during a dive, the divers should stay together and exit the water as calmly and quickly as possible.

If a diver gets bit by one of the above-mentioned animals, they should first get clear of the immediate danger and get out of the water. Once all divers are out and clear of danger, prompt and careful attention must be paid to the wound. Beyond the obvious need to stop bleeding and minimize tissue damage, seal bites can be extremely infectious and should be thoroughly cleaned as soon as possible. Prophylactic antibiotic treatment may be required.

10.6. Vessel and Small Boating Situations

Diving around medium and large size vessels can be hazardous due to the fact that they have props, thrusters, and intakes that could injure a diver if they are activated during diving operations. The preferred method of diving in this situation is to use surface supplied diving equipment and trained personnel. This provides communication to the diver as well as the diver being connected via the dive umbilical to the surface. If diving under or around a larger vessel, coordination and communication with the ship's captain and crew is essential. A "before dive plan" and proper lock-out/tag-out procedures need to be implemented on any pumps or motors onboard to ensure that they don't accidentally get turned on during diving operations. During the dive, the dive team should be in constant communication with the crew via radio. Divers and dive teams should also keep in mind that they are very hard to see when diving in this situation.

When diving from a small boat (inflatables/RHIB's, etc.) be aware that they have similar hazards. When divers are entering and exiting the water, the boat motor should be turned off if possible and at the very least, put in neutral while divers are in the water near the boat. Divers should surface away from the boat and make sure they are seen first and then approach the boat to the front or side and always treat the situation as if the prop is turning. Sometimes conditions warrant a "live boating" situation where the wind or current is pushing the boat enough to where the operator has to run the motor in order to keep near the dive site. This should be avoided if possible and the boat operator should always be at the controls so he/she can shut the motor down immediately if the divers drift too close to the back of the boat. Good communication and constant visual contact is very important in this situation. Other hazards are getting in and out of the boat. It is virtually impossible for a diver to climb on to an inflatable boat with all of their gear on, even with help from a dive tender on the boat. Normal procedure is for the diver to take off their tank/BC unit and hand them up to the tenders and then do the same with their weight belt. Another technique is to have some lines hanging off of the boat for the divers to clip their gear on to. This can be much faster for multiple divers who might need to get out of the water quickly due to a leopard seal or other marine life encounter. The RHIB's that are planned to be used in the near future will have a dive ladder installed on them that should allow a diver to climb out of the water with all of their gear on. As with most boat decks, especially in cold climates, there are always slip and trip hazards while moving around topside. A diver trying to move around with all of their gear on in choppy seas is very unstable and could easily get injured in a fall.

If a group of divers, or a boating team, happens to lose visual contact with each other during rough seas or bad weather, the first thing they should do is stay together and try to listen for the sound of the missing boat plus try to make themselves visible by waving or splashing. If there is land or an ice edge nearby, the group should start swimming towards it. Many of the islands around Palmer station have emergency caches on them. Divers should have an emergency whistle on their BC and having a Surface Marker Buoy (SMB) is advisable. If the boating crew loses site of the divers they should try to scan the horizon and look for the surfaced divers. It may be that the divers just haven't surfaced yet and it can be very hard to spot diver's bubbles in rough water. The station or vessel should be contacted immediately if the boat team is sure that they have lost the divers. The sooner they are notified, the sooner they can launch a search and rescue team.

11. Dive Accident Management and Procedures

An Emergency Dive Accident Management plan (EDAM) is in place for every location where diving occurs under NSF/OPP auspices. The EDAM outlines procedures to follow for pressure-related diving emergencies. Procedures will differ depending on location, and sometimes depending on austral season. These plans are updated as necessary to keep current with changes in personnel and operational status. Each person diving under NSF/OPP auspices should be familiar with the dive accident procedures relevant to his or her work location.

Each EDAM consists of three parts: Dive-team response, transport, and medical diagnosis and treatment, which may include hyperbaric oxygen therapy in a recompression chamber.

11.1. Dive-Team Response

Each individual member of a dive team is responsible for knowing the dive-accident procedures appropriate for his or her dive location. Should a dive accident occur, dive team members must do the following:

- Remove the accident victim from the water.
- Determine the status of the victim (i.e., respiration, heartbeat, state of consciousness, and other symptoms).
- Provide the victim with oxygen first aid.

- Perform CPR or other necessary life-sustaining activity.
- Communicate the situation to the base of operations, along with the intent to transport the victim or the need for a Medevac.
- Transport the victim back to the base of operations or stabilize the victim while waiting for a Medevac to arrive.
- Provide the victim with fluids (if possible).

11.2. Emergency Transport

In the McMurdo vicinity, transport to the on-site chamber will depend on the location of the accident and vehicle availability. Dive groups operating near McMurdo Station will in most instances transport an accident victim directly to the medical clinic for evaluation by a doctor, who will consult with Divers Alert Network (DAN). If it is deemed a pressure related dive injury, the patient will be brought to the chamber which is adjacent to the medical clinic. Once they have been informed that a dive accident has occurred, personnel at the McMurdo air operations command center may direct a nearby helicopter to the accident site for a more rapid evacuation.

For accidents that occur more than a few miles from McMurdo Station, a Medevac helicopter will likely be activated to evacuate the victim. However, the possibility exists that no helicopters will be available, and the dive group may be forced to provide transport to the chamber.

Accident victims at relatively distant sites in the McMurdo region, such as New Harbor or Marble Point, will have to await the arrival of a Medevac aircraft. For even more remote sites, any available transportation will be arranged. This may mean LC-130 transports, Twin Otters, helicopters, ships, or any combination of these. Dive teams working in these areas should arrange to have extra quantities of O_2 on site in case of delayed transport to McMurdo.

Because of weather conditions and other contingencies, dive-accident victims at remote sites may face a prolonged delay in transport to the McMurdo Chamber. Depending on circumstances and location, a diver may be directed to the Italian recompression chamber at Terra Nova Bay for treatment.

At Palmer Station, dive-accident victims must be transported by the dive team back to the station either by inflatable boat or by banana sled over fast ice. Transport must then be arranged from Palmer Station to the nearest functional recompression chamber by whatever means are available. This may include USAP research vessels, foreign military or civilian vessels, private vessels (cruise liners), civilian aircraft, military aircraft, ground transport, or any combination of the above.

Victims of dive accidents resulting from USAP research vessel diving operations will be transported by the vessel to the nearest recompression chamber or to a location where more rapid transport may be obtained.

11.3. Recompression Chamber/Medical Treatment

Dive accident victims in the McMurdo vicinity will be treated initially at the McMurdo medical clinic and the McMurdo recompression chamber (as mentioned in chapter 9) if prescribed by the attending physician after consulting DAN. (Except, as noted before, where a diver at a remote site may be directed to the Italian chamber at Terra Nova Bay.) No further treatment may be necessary. If treatment beyond the scope of the McMurdo clinic is required, the patient will be transported via aircraft to a New Zealand medical facility.

For an accident victim at Palmer Station, all available medical treatment will be provided pending transport to the nearest recompression chamber. The patient should be maintained on a 100% oxygen ventilation schedule as long as possible. (See **Section 11.4.**). The victim should also be provided with fluids to maintain proper hydration. Urine should be clear. Diuretics like coffee, tea, and alcohol should be avoided. (See **Section 11.5.**).

Dive-accident victims on the R/V Laurence M. Gould and the R/V Nathaniel B. Palmer will be treated according to the Palmer Station protocol described above.

11.4. Long-Term Oxygen Therapy

For short transport times (a few minutes or hours), dive accident victims should be administered oxygen at the highest partial pressure deliverable (100%) without interruption, until recompression. For longer transport times (many hours or days), Dr. Richard Moon, Medical Director at the Diver's Alert Network, Duke University Medical Center, has suggested the following protocols regarding long-term oxygen therapy and fluid resuscitation:

The patient should be provided initially with 100% oxygen, via tight fitting mask and demand valve. If oxygen administration results in a complete relief of symptoms, the administration should be continued for at least two hours longer. If symptoms persist, the victim should receive 100% oxygen for six hours, followed by continued administration with loose fitting mask or non-rebreather mask (for an inspired concentration of about 50%) until recompression. This may require wearing an oxygen mask for days, with only the necessary breaks for food, drink, and elimination.

If the patient shows evidence of pulmonary pathology (aspiration of water or vomitus, or pneumothorax), oxygen administration beyond the six hours at 100% should be guided by pulse oximetry, keeping the arterial oxygen saturation greater than 95%. An accurate record should be kept on the length of time the patient is on O_2 to avoid Pulmonary oxygen toxicity from long exposure times.

11.5. Fluid Resuscitation

The patient should also be kept well hydrated. Oral fluids may serve adequately for this purpose; however, high-glucose (sodas and undiluted juice) and diuretic (coffee, tea, alcohol) beverages are not ideal. The osmolality of most sugar-containing drinks is usually too high, and both alcohol and caffeine-containing beverages may promote excessive fluid excretion by the kidneys. For oral fluid administration, standard infant oral resuscitation formulas (e.g., Pedialyte-Abbott Laboratories) or Gatorade are commercially available beverages that have appropriate osmolality, electrolyte, and glucose concentrations. A suitable solution can be improvised by mixing one part apple or orange juice with two parts water and adding one-half teaspoon salt to one liter (35 fluid ounces) of the mixture. Fluid should not be withheld just because an ideal fluid is not available. However, some patients may be unable to take oral fluids because of nausea, vomiting, or impaired consciousness. Also, taking oral fluids requires interrupting oxygen administration, which, if the patient is hypoxic, may be inadvisable. In these situations, the patient should be hydrated intravenously using isotonic fluids without added glucose, such as normal saline, Ringer's solution, or Normosol-R (Abbott Laboratories). With either oral or intravenous fluids, one liter or more can usually be administered in the first hour, with subsequent fluid intake maintained at the level required to produce normal blood pressure and a urine output of 1-2 ml per kg of body weight per hour. As with any guideline, this one may be modified at physician discretion, depending upon specific circumstances and requirements.

11.6. USAP Dive-Accident Policy

All pressure-related diving injuries should be treated as emergencies, given the potential for permanent disability. These injuries should be reported to the appropriate local medical authorities immediately. The reality of Decompression Sickness (DCS), however, is that most cases are mild and show a delayed manifestation (often several hours). All cases of DCS so far treated at the McMurdo chamber have resulted from ambulatory patients admitting themselves to the dispensary for evaluation.

NSF/OPP recognizes that DCS can strike a diver even when safety regulations and decompression schedules are followed to the letter. Therefore, there is no penalty, either to the diver or to the diving project, for seeking medical and/or recompression chamber treatment. Instances where DCS results from exceeding dive computer limits or procedures are evaluated on a case-by-case basis.

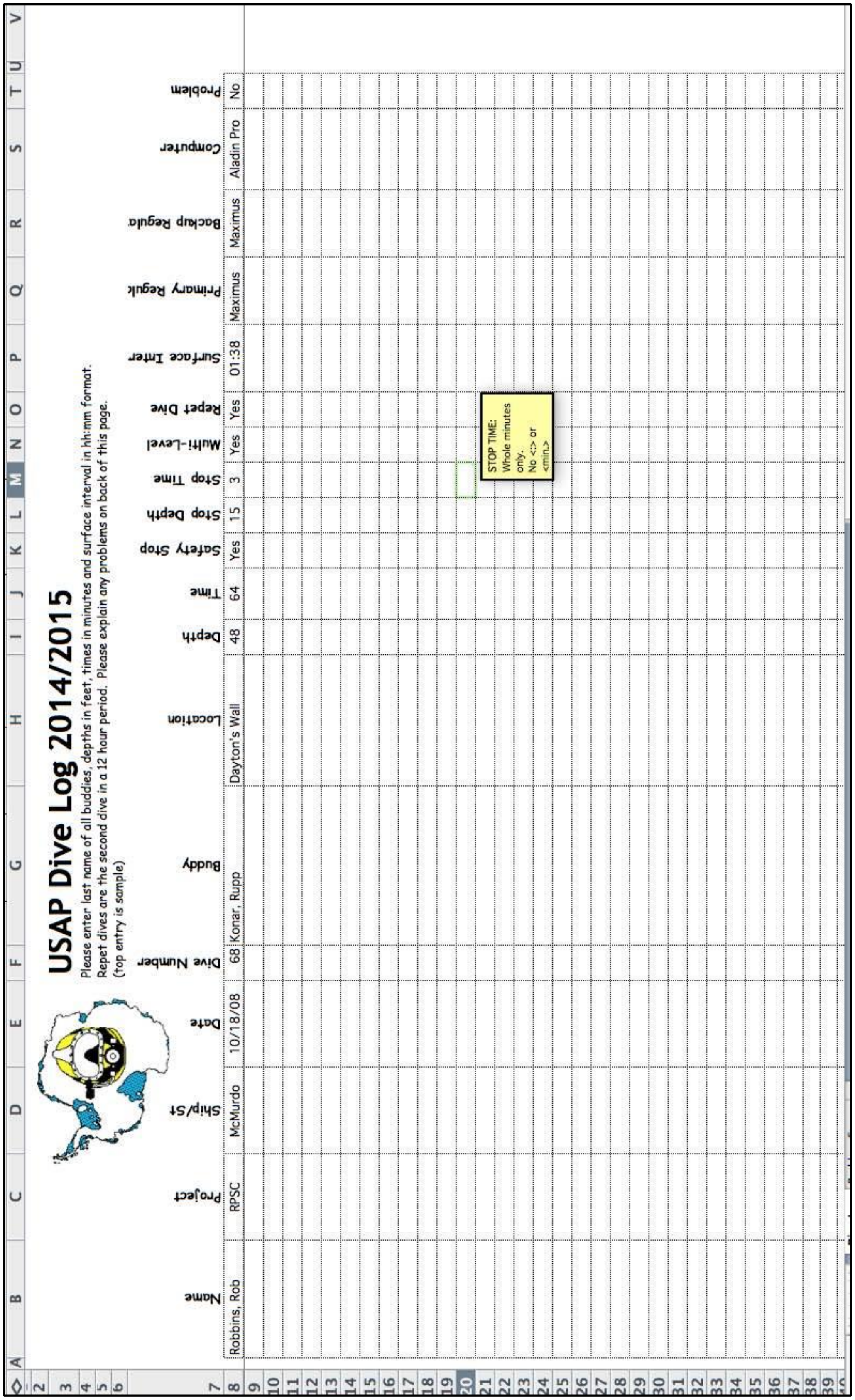
12. Post-Dive Procedures

12.1. Dive Logs

All divers operating under the NSF/OPP auspices must maintain a dive log. An Excel spreadsheet version is supplied by the SDS and should be kept updated on a regular basis. These logs should be submitted to the SDS or other appropriate contractor at the end of the diving project or season. Dive logs will include a minimum of the following information for each dive:

- Name
- Project
- Ship/Station
- Date
- Dive Number
- Buddy
- Location
- Max Depth
- Dive Time
- Safety Stop y/n
- Stop Depth
- Stop Time
- Multi-level y/n
- Repetitive dive y/n
- Surface interval
- Primary and backup regulator
- Backup regulator
- Computer type
- Problem y/n

An example of a USAP dive log spreadsheet is found on the following page.



USAP Dive Log 2014/2015

Please enter last name of all buddies, depths in feet, times in minutes and surface interval in hh:mm format.
Repet dives are the second dive in a 12 hour period. Please explain any problems on back of this page.
(top entry is sample)

Name	Project	Ship/St	Date	Dive Number	Buddy	Location	Depth	Time	Safety Stop	Stop Depth	Stop Time	Multi-Level	Repet Dive	Surface Inter	Primary Regul	Backup Regula	Computer	Problem
Robbins, Rob	RPSC	McMurdo	10/18/08	68	Konar, Rupp	Dayton's Wall	48	64	Yes	15	3	Yes	Yes	01:38	Maximus	Maximus	Aladin Pro	No

STOP TIME:
Whole minutes only.
No <> or <min.>

Figure 61: Example USAP dive log spreadsheet

12.2. Flying After Diving

Current Undersea and Hyperbaric Medical Society (UHMS) guidelines recommend a minimum 12-hour surface interval before flying. Previous UHMS guidelines were more conservative, recommending a minimum 12-hour surface interval after less than two hours total accumulated dive time in the last 48 hours, 24 hours after multi-day, unlimited repetitive dives, and 24 - 48 hours after decompression dives. Divers in McMurdo generally allow for 24 hours minimum surface time after the last dive before flying to greater than 500-feet altitude. When helicopters are used to transport divers post-dive, standard procedures mandate that the pilots do not exceed 500 feet of altitude if possible with the terrain. It’s up to the dive team to inform the pilot that they have been diving. In addition, divers are required to plan for a minimum one-hour surface interval before flying in a helicopter.

13. Appendices

Appendix A: Recommended Literature

Other publications that contain information applicable to Antarctic diving operations are listed in this appendix. Researchers preparing to dive in the Antarctic are encouraged to refer to these documents for additional information.

- ***Cold Water Diving: A Guide to Ice Diving, 2nd Edition*** – 2015 by John N. Heine

https://www.amazon.com/Cold-Water-Diving-Guide-Ice/dp/1930536879/ref=sr_1_3?s=books&ie=UTF8&qid=1497540150&sr=1-3&keywords=ice+diving

or

https://www.bestpub.com/books/scientific-diving/product/442-cold-water-diving-2nd-edition/category_pathway-42.html

- ***The Antarctic Dive Guide: Fully Revised and Updated Third Edition*** by Lisa Eareckson Kelley

https://www.amazon.com/Antarctic-Dive-Guide-University-WILDGuides/dp/0691163448/ref=tmm_pap_swatch_0?_encoding=UTF8&qid=1497540620&sr=1-2

- ***NOAA Diving Manual***, 5th Edition

https://www.bestpub.com/books/noaa-diving-manual.html

- ***Scientific Diving Techniques,*** 2nd Edition by John N. Heine

https://www.bestpub.com/books/product/cid-132.html

or

https://www.amazon.com/Scientific-Diving-Techniques-Practical-Research/dp/1930536682/ref=asap_bc?ie=UTF8

- ***American Academy of Underwater Sciences Standards for Scientific Diving***

https://www.aaus.org/diving_standards

- ***United States Antarctic Program Field Manual***

https://www.usap.gov/USAPgov/travelAndDeployment/documents/USAP-Continental-Field-Manual.pdf

- ***Diving in High-Risk Environments, Third Edition*** by Steven M. Barsky

https://www.amazon.com/Diving-High-Risk-Environments-Steven-Barsky/dp/0967430518/ref=sr_1_1?ie=UTF8&qid=1497550177&sr=8-1&keywords=diving+in+high+risk+environments

- ***Scientific Blue-Water Diving*** – 2005 by Steven H.D. Haddock & John Heine

https://www.amazon.com/Scientific-Blue-Water-Diving-Steven-Haddock/dp/1888691131/ref=sr_1_3?ie=UTF8&qid=1497552328&sr=8-3&keywords=Scientific+blue+water+diving

- ***Dry Suit Diving*** – 2006 by Steven Barsky

https://www.amazon.com/Dry-Suit-Diving-Steven-Barsky/dp/0967430569/ref=sr_1_2?s=books&ie=UTF8&qid=1497550351&sr=1-2&keywords=dry+suit+diving

- ***Final Report of the Workshop on Scientific Shipboard Diving Safety***. Graduate School of Oceanography Technical Report 90-4, University of Rhode Island, Narragansett, RI. p. 86

https://www.unols.org/sites/default/files/Shipboard%20Dive%20Safety%20Report.pdf

- ***Cold Water Diving for Science*** – 2001 by Stephen Jewett

https://www.amazon.com/Water-Diving-Science-Stephen-Jewett/dp/1566120691/ref=sr_1_1?ie=UTF8&qid=1497554115&sr=8-1&keywords=cold+water+diving+for+science

- ***Small Boat Diving: A Guide to Buying, Outfitting, and Using Small Boats for Diving*** 1995 by Steven M. Barsky

https://www.amazon.com/gp/product/0941332438?ref%5F=sr%5F1%5F7&s=books&qid=1497553427&sr=1-7&pldnSite=1

- ***Standards for the Conduct of Scientific Diving***, Office of Polar Programs, National Science Foundation

https://www.usap.gov/proposalInformation/documents/DivingStandards_OPP.pdf

- ***USAP Field Manual***

https://www.usap.gov/travelAndDeployment/contentHandler.cfm?id=540#Chapter1

- ***McMurdo Station Dive Accident Management Plan***

(STPS-PLN-0001)

— Available upon request or at USAP.gov.

- ***Palmer Station & USAP Vessel Dive Accident Management Plan***

(STPS-PLN-0002)

— Available upon request or at USAP.gov.

Appendix B: Benthic Community References

The following references may serve as a starting point for obtaining benthic community and benthic organism information:

Underwater Field Guide to Ross Island & McMurdo Sound, Antarctica

http://peterbrueggeman.com/nsf/fguide/index.html

Brey, T., Pearse, J., Basch, L., McClintock, J., & Slattery, M. 1995. "Growth and Production of Sterechinus neumayeri (Echinoidea: Echinodermata) in McMurdo Sound, Antarctica." Marine Biology 124: 279-292.

Dayton, P.K., G.A. Robiliard and R.T. Paine. 1970. "Benthic Faunal Zonation as a Result of Anchor Ice at McMurdo Station, Antarctica." Antarctic Ecology. Vol. 1: 244-258. Academic Press, London.

Dayton, P.K., G.A. Robiliard, R.T. Paine, and L.B. Dayton. 1974. "Biological Accommodation in the Benthic Community at McMurdo Sound, Antarctica." Ecol. Monogr. 44: 105-128.

Dayton, P.K. and J.S. Oliver. 1977. "Antarctic Soft Bottom Benthos in Oligotrophic and Eutrophic Environments." Science 197: 55-58.

DeLaca, T.E. and J.H. Lipps. 1976. "Shallow Water Marine Associations, Antarctic Peninsula." Antarctic J.US. 9: 12-20.

McClintock, J.B. 1994. "The Trophic Biology of Antarctic Echinoderms." Mar. Ecol. Prog. Ser. 111: 191-202.

Antarctic Scientific Diving Manual (2nd edition) 128 McClintock, J.B., J.S. Pearse, and I. Bosch. 1988.

"Population Structure and Energetics of the Common Antarctic Sea Star Odontaster validus." Mar. Biol. 99: 235-246.

Miller, K.A. and J.S. Pearse. 1991. "Ecological Studies of Seaweeds in McMurdo Sound, Antarctica." Amer. Zool. 31: 35-48.

Appendix C: Antarctic Organisms

The following references may serve as a starting point for obtaining benthic community and benthic organism information:

Underwater Field Guide to Ross Island & McMurdo Sound, Antarctica

http://peterbrueggeman.com/nsf/fguide/index.html

Annelida

(Class Polychaeta)

Tubeworm (feather duster) ----------*Potamilla antarctica*

Spiky polychaete (150 mm) ---------*Flabelligera sp.*

Scale worm ----------------------------*Harmothoe sp.*

Burrowing, tentacle feeding worm --*Terebellidae* (Family)

Arthropoda

(Classes Crustacea, Pycnogonida)

Giant isopod (100 mm) --------------*Glyptonotus antarcticus*

Burrowing isopod ---------------------*Austrosignum grande*

Burrowing amphipod -----------------*Heterophoxus videns*

Burrowing amphipod -----------------*Monoculodes scabriculosus*

Amphipod (red, ice algae eating) ---*Paramoera walkeri*

Amphipod (deep water) (30 mm) ---*Orchomene plebs*

Amphipod (lives on jellyfish) -------*Hyperiella dilatata*

Cumacan arthropod -------------------*Eudorella splendida*

Tanaid arthropod ----------------------*Nototanais dimorphus*

Large pycnogonid (200 mm) --------*Colossendeis robusta*

Pycnogonid ----------------------------*Colossendeis megalonyx*

Pycnogonid ----------------------------*Thavmastopygnon striata*

Pycnogonid
(large, New Harbor) ---------------*Colossendeis australis*

Pycnogonid
(red, hairy, New Harbor) -----------*Nymphon australe*

Pycnogonid
(skinny, ten legs) --------------------*Pentanymphon antarcticum*

Antarctic Scientific Diving Manual (2nd edition) 130

Brachiopoda

Brachiopod (30 mm) -----------------*Liothyrella uva*

Bryozoa

Senestrate, Lacy Bryozoan ----------*Terepora frigida*

Solid, Wavy, Erect Bryozoan --------*Hippadenella carsonae*

Bryozoan -------------------------------*Caberea darwinii*

Chordata

(Subphylum Urochordata)

(Classes Pisces, Mammalia, Aves)

Weddell seal ---------------------------*Leptonychotes weddelli*

Fish (white spot on crown) ----------*Trematomus bernachii*

Fish (no white spot) ------------------*Trematomus hansoni*

Fish -------------------------------------*Trematomus nicolai*

Fish -------------------------------------*Trematomus newnesi*

Fish (white spots on brown skin) ---*Trematomus pennellii*
Tunicate --------------------------------*Cnemidocarpa verrucosa*
Tunicate (small, knobby) ------------ *?*
Tunicate (orange, colonial) ---------- *?*

Cnidaria

(Classes Hydrozoa, Scyphozoa, Anthozoa)
Large jellyfish (30-100 cm) ---------*Desmonema glaciale*
Small jellyfish (20 mm) --------------*Solmundella bitentaculata*
Red jellyfish (rare) (150 mm) -------*Atoila wyvillei*
Helmet jellyfish -----------------------*Periphylla periphylla*
Bell jellyfish (fringed tentacles) ----*Arctapodema sp.*
Common jellyfish (lacy) -------------*Diplulmaris antarctica*
Hydroid (solitary, white) -------------*Lampra microrhiza*
Hydroid (solitary, purple) ------------*Lampra parvula*
Hydroid (colonial, tiny polyps) -----*Halecium sp.*
Anemone
(orange base, thin tentacles) -----*Urticinopsis antarctica*
Anemone
(orange base, thick tentacles) ----*Isotealia antarctica*
Anemone (tall, brown stalk) ---------*Hormathia lacunifera*
Anemone (tall, white stalk) ----------*Artemidactis victrix*
Small anemone (10 mm) -------------*Edwardsia meridionalis*
Soft coral (orange) --------------------*Alcyonium paessleri*
Soft coral (white) ---------------------*Clavularia frankliniana*
Soft coral (pink, tall, New Harbor) -*Gersemia antarctica*

Ctenophora

Large ctenophore (100 mm) ---------*Beroe cucumis*
Small ctenophore (20 mm) ----------*Callianaria cristata*

Echinodermata

(Classes Asteroidea, Echinoidea,
Holothuroidea, Ophiuroidea, Crinoidea)
Crinoid ---------------------------------*Anthometra adriani*
Crinoid (New Harbor) ----------------*Promachocrinus kerguelensis*
Red sea star (70 mm) -----------------*Odontaster validus*
Large yellow sea star (250 mm) ----*Acodonaster conspicuus*
Sea star (orange) (70 mm) -----------*Odontaster meridionalis*
Large red/rust sea star ----------------*Perknaster fuscus*
Sea star (giant orange) ---------------*Macroptychaster accresscens*
Sea star (white, knobby arms) -------*Diplasterias brucei*
Sea star (New Harbor) ---------------*Bathybiaster loripes*
Sea star (New Harbor) ---------------*Psilaster charcoti*
Sea star (New Harbor) ---------------*Porania antarctica*
Sea star ---------------------------------*Notasterias armata*
Sea urchin (80 mm) -------------------*Sterechinus neumayeri*
Heart urchin (New Harbor) ----------*Abatus nimrodi*
Heart urchin ---------------------------*Abatus shackletoni*
Pencil urchin (New Harbor) ---------*Ctenocidaris perrieri*
Brittle star ------------------------------*Ophionotus victoriae*

Large orange brittle star
(New Harbor) -----------------------*Ophiosparta gigas*
Sea Cucumber (perching) ------------*Cucumaria femeri*
Sea Cucumber ("spiked") ------------ *?*

Mollusca

Antarctic Scientific Diving Manual (2nd edition) 132
(Classes Bivalvia, Gastropoda, Cephalopoda, Pteropoda)
Gastropod
(with shell, triton-like) ------------*Trophon longstaffi*
Gastropod
(with shell, white, spiral) ----------*Neobuccinum eatoni*
Gastropod
(yellow, internal shell) -------------*Marseniopsis mollis*
Clam (small, epifaunal) --------------*Limatula hodgsoni*
Clam (large, burrowing) -------------*Laternula elliptica*
Pteropod (sea butterfly) --------------*Clione antarctica*
Pteropod (shelled) --------------------*Limacina helicina*
Scallop ---------------------------------*Adamussian colbeckii*
Nudibranch (lacy back) --------------*Tritoniella belli*
Nudibranch (serrata on back) -------*Notoeolidia gigas*
Nudibranch (similar to *N. gigas*) --- *?*
Opistobranch --------------------------*Austrodoris kerguelensis*

Nematoda

No information

Nemertinea

Nemertean worm (1 meter) ----------*Parborlasia corrugatus*

Porifera

Vascular sponge -----------------------*Artemisina apollinis*
Fan sponge -----------------------------*Calyx arcuarius*
Spiky sponge (multiple morphs) ----*Cinachyra antarctica*
Orange dendritic sponge -------------*Clathria nidificata*
Yellow cactus sponge ----------------*Dendrilla antarctica*
Kitchen sponge ------------------------*Ectyodoryx nobilis*
Mushroom sponge --------------------*Ectyodoryx ramilobosa*
Staghorn sponge ----------------------*Gellius tenella*
Brain sponge ---------------------------*Guitarra sigmatifera*
Finger sponge (white pipes) ---------*Haliclona dancoi*
Thimble sponge ----------------------*Hemigellius bidens*
Lacy sponge --------------------------*Hemigellius fimbriatus*
Bushy sponge -------------------------*Homaxinella balfourensis*
Knob sponge ---------------------------*Inflatella belli*
Tube sponge ---------------------------*Isodictya antarctica*
Polychaete sponge --------------------*Isodictya erinacea*
Stringy sponge ------------------------*Isodictya setifera*
Yellow rope sponge -------------------*Isodictya spinigera*
Wafer sponge -------------------------*Kirkpatrickia coulmani*
Red sponge ----------------------------*Kirkpatrickia variolosa*
Globe sponge (green, two morphs) -*Latrunculia apicalis*

Rubber sponge ------------------------*Leucetta leptoraphis*
Sponge ---------------------------------*Leucetta sp.*
Pink finger sponge (New Harbor) --*Microxina charcoti*
Pink staghorn sponge -----------------*Microxina benedeni*
Slimy sponge --------------------------*Mycale acerata*
Pink stalagmite sponge ---------------*Myxodoryx hanitschi*
Pencil sponge --------------------------*Pachychalina pedunculata*
Brown saguaro sponge ---------------*Phorbas areolatus*
Cone sponge ---------------------------*Polymastia invaginata*
Vase sponge (white, knobby sides) -*Rossella nuda*
Root sponge ---------------------------*Rossella racovitzae*
Volcano sponge (smooth sides) -----*Scolymastra joubini*
Knobby (tubular) sponge ------------*Sphaerotylus antarcticus*
Sea peach sponge --------------------*Suberites caminatus*
Yellow ball sponge -------------------*Suberites sp.*
Sponge ---------------------------------*Tedania charcoti*
Basketball sponge ---------------------*Tetilla leptoderma*
Sponge ---------------------------------*Xestospongia sp.*
Vase sponge (brown, folded sides) - *?*

Protozoa

No information

Macroalgae

Seaweed (McMurdo Sound) --------*Iridaea cordata*
Seaweed (McMurdo Sound) --------*Phyllophora antarctica*

14. Glossary

American Academy of Underwater Sciences (AAUS)

An association of research diving scientists, diving technicians, and diving safety officers which is generally responsible for setting community diving standards for scientific diving. Divers who will be diving in the USAP diving program have a 100 feet or equivalent AAUS diving certification for McMurdo or a 60 feet or equivalent AAUS diving certification for Palmer.

Anchor Ice

Ice crystals that form on objects or animals on the benthos, usually at depths of 20 meters or less.

Austral Seasons

Seasons as they occur in the Southern Hemisphere.

Bail out

It is a smaller cylinder of gas and can be another term for a pony bottle as well as a backup air supply for the diver. It can be on the down line or attached to the diver. During surface supply diving operations, it is on the divers back attached to the diving harness and connected to the dive hat.

Blue Water Dive

A dive in mid-water where the bottom is effectively too deep to allow the dive team a reference and/or working horizon.

Brash Ice

Ice debris that collects in a dive hole, usually consisting of congelation ice, platelet ice, and broken ice chunks.

Ceiling or Hard Ceiling

Any dive area that has an overhead environment and does not have a direct exit for the diver.

Congelation Ice

Ice in the process of formation and crystallization on the surface of the water.

Contaminated Water

Water containing high levels of coliform bacteria, human or animal waste, or toxic chemicals.

DAN Oxygen kit

This is a Pelican box that contains emergency medical Oxygen bottles and regulators in case of a pressure related dive accident. It is required to have a DAN kit on site during any diving operations.

Dive Computer

An electronic device for tracking depth and time and computing inert gas uptake and off-gassing.

Dive Hole

The entry/exit hole that the divers enter and exit during a dive. Often times this can be the only way back to the surface.

Dive Hut

Portable, heated wooden structure for use on the fast ice, which may have holes in the floor for direct access to the ocean.

Dive Log

A record of an individual’s dives throughout the diving season. The SDS will provide each diver with a dive log spreadsheet that they are required to fill out and keep updated during the diving season.

Dive Site

The physical location of a dive.

Dive Team

Divers and support individuals who participate in or control the participation in a dive.

Diving Mode

The type of diving in use, for example, snorkel, SCUBA, tethered SCUBA, or surface-supplied air.

Diving Safety Officer (DSO)

The individual responsible for the safe conduct of a scientific diving program. The individual who advises the NSF/OPP Health and Safety Office on all issues related to Antarctic diving. The PARD recommends the approval or disapproval of all applicants wishing to dive under USAP auspices.

Down Line

A well-marked, weighted line used to mark the location of a dive hole in fast ice or solid pack ice. Flashing strobes and a bail out bottle/regulator are attached to this line as well.

Dry Suit

An exposure suit that has airtight seals at the neck and wrists, allows the introduction and exhaust of compressed air through valves, and keeps the diver dry during the dive.

Decompression Illness (DCI)

A pressure-related or induced trauma, such as Arterial Gas Embolism (AGE) or Decompression Sickness (DCS).

EDAM

Emergency Dive Accident Management plan. This is a document that outlines the procedures that should be followed during a pressure related diving emergency.

Fast Ice

Ice that abuts the shoreline and forms a solid ceiling over the ocean.

Field Safety Training department (FS&T)

The department at McMurdo station who provides all of the field safety, sea ice, and survival training as well as providing Search and Rescue operations.

Frazil Ice

Ice crystals formed in conditions of wind and wave action.

Hazardous Cargo

Cargo which by DOT or DOD definition may be hazardous to humans during transport.

Hyperbaric

A condition defined by pressure greater than one atmosphere at sea level.

Hyperbaric Chamber

A chamber used to subject people to elevated atmospheric pressures. Used primarily in the treatment of Decompression Illness (DCI). Also called a recompression chamber.

Ice Edge

The point at which the fast ice and the open water meet. This is usually a dynamic area as far as ice movement and marine life interaction.

Lead

An open area between slabs of ice in an otherwise solid sheet, usually large enough to be navigable by vessels or small craft.

MAC OPS

McMurdo Operations. The field operations communication center at McMurdo station.

McMurdo and Vicinity

The region that encompasses McMurdo Station, the Ross Island shoreline, McMurdo Sound from Cape Byrd to Granite Harbor and south to the Ross Ice Shelf.

Mobile Drill

Large diesel powered drill system that is towed behind a Challenger tracked plow on the sea ice that is used to drill dive holes around McMurdo Sound in the areas that it can be towed to. The standard diameter hole is approximately 4 feet in diameter (48 inches) It is also known as a Reed drill.

Multi-level Dive

Dive conducted wherein a diver effects a greater than ten-foot seawater change in depth more than once, descent and ascent not included.

National Science Foundation/Office of Polar Programs (NSF/OPP)

The governing body for the entire Antarctic research program.

Open Water

Either salt or fresh water that does not have any ice or other obstructions floating on it that allows for direct access to the surface

Pack Ice

Sea ice cover composed of various sized and disconnected pieces. Pack ice can be further categorized into three types: 1) solid pack, in which separate floes have closed up due to wind and sea conditions and which therefore exhibit almost no leads or holes for access to the ocean; 2) close pack, in which the floes form a nearly solid cover on the surface of the ocean but in which there are open areas allowing access to the water; or 3) loose pack, in which flows are widely scattered and have large areas of open water among them.

Pancake Ice

When congelation ice crystals begin to clump together into “pancake ice”. It consists of roughly circular, porous slabs with upturned edges. These slabs may be 1.5 feet to several feet in diameter

PistinBully

A tracked vehicle powered by a diesel engine. A PistinBully can accommodate one to eight passengers, depending on model, and it may be used to transport people and equipment over ice and snow inaccessible to wheeled vehicles.

Platelet Ice

Also known as Brash Ice. Crystals of ice formed in the water column that float up and collect on the underside of the ice sheet. These are of particular concern to divers around the McMurdo area as it can be easily dislodged by diver activity and/or bubbles and build up in the dive hole, potentially occluding the dive hole which can be the divers’ only exit.

Polar Ice

The website where the science teams submit and update their SIP (Support Information Packet) for review. This includes a project dive plan. The website is https://polarice.usap.gov/login/index.cfm

Polynya

An area of open water in sea ice.

Pony Bottle

A small, usually 13.7 cubic foot air bottle that is normally connected to a SCUBA regulator and is used on the down line at the safety stop level as an emergency backup supply.

Pre dive Orientation

When arriving at McMurdo or Palmer stations, dive groups will get a pre dive orientation of the dive locker and diving procedures/equipment orientation either by the SDS at McMurdo or the PI at Palmer station.

Principal Investigator (PI)

The scientist in charge of a science project, usually the senior scientist.

Project Dive Plan

The section of the SIP that addresses the science teams diving plans and dive team member qualifications for the SDS/DSO/OPP to review.

Rigid Hull Inflatable (RHIB) boat

A hybrid of a hard hulled and inflatable “zodiac” style smaller boat that Palmer Station has just started to utilize. They have a longer range than standard inflatable boats and have the added benefit of more speed as well as a certain amount of shelter on board.

Remote Site

A research site at a significant distance from the nearest base of polar operations, such that immediate support, transport, and resupply is not possible.

Safety Diver

The diver who is tasked with monitoring the tether, preventing entanglement, watching for dangerous marine life, and assuring the safety of the working divers.

SCUBA with Umbilical

A mode of diving in which the diver is using a self-contained breathing apparatus with full face mask and is connected to the surface by an umbilical which allows voice communication between surface tenders and the diver.

Scientific Diving Control Board (SDSB)

The group of individuals who provide guidance and make recommendations in matters concerning a scientific diving program.

Standby Diver

A diver at the dive location capable of rendering assistance to a diver in the water within five minutes. (Usually in a surface supply diving situation where there is only one diver in the water connected to an umbilical)

Supervisor of Dive Services (SDS)

The support contractors person or persons who run the dive locker, coordinate dive services, maintain USAP diving equipment, and support the scientific diving teams in Antarctica.

Support Information Package (SIP)

A package of information and forms sent by the NSF/OPP support contractor to each funded science project. In the SIP, scientists specify their support requirements for the upcoming austral season via the online Polar Ice web site.

Surface-Supplied Diving

A diving mode in which the diver in the water is supplied from the surface with compressed gas for breathing, either from a high pressure air bank or from a low pressure compressor with volume tank.

Tether

A line attached to a diver or divers to prevent their becoming lost underwater or under ice due to poor visibility or current.

Tethered SCUBA

A mode of diving in which divers using standard SCUBA gear without surface communications are tethered to the surface with a line for safety.

Thirds Rule

When using this rule during diving, divers should reserve a minimum of 2/3 of their air for exiting.

Tracked Vehicle

A vehicle with tracks instead of wheels, used for traversing ice- and snow-covered terrain. Usually a PistinBully or Snow machine.

Umbilical

The composite hose bundle between the surface and a diver which, in the case of a surface-supplied air dive, supplies the diver with breathing gas and communications, and which, in the case of a SCUBA with umbilical dive, provides for two-way voice communication between surface and diver. The umbilical also includes a safety line between the diver and the surface.

Under Ice Diving

Any salt or fresh water diving that has ice on the surface that does not provide the diver with a direct path to the surface.

USAP

United States Antarctic Program: The Antarctic division of the National Science Foundation’s Office of Polar Programs (NSF/OPP) Term