Underwater Field Guide to Ross Island & McMurdo Sound, Antarctica: Scuba Diving

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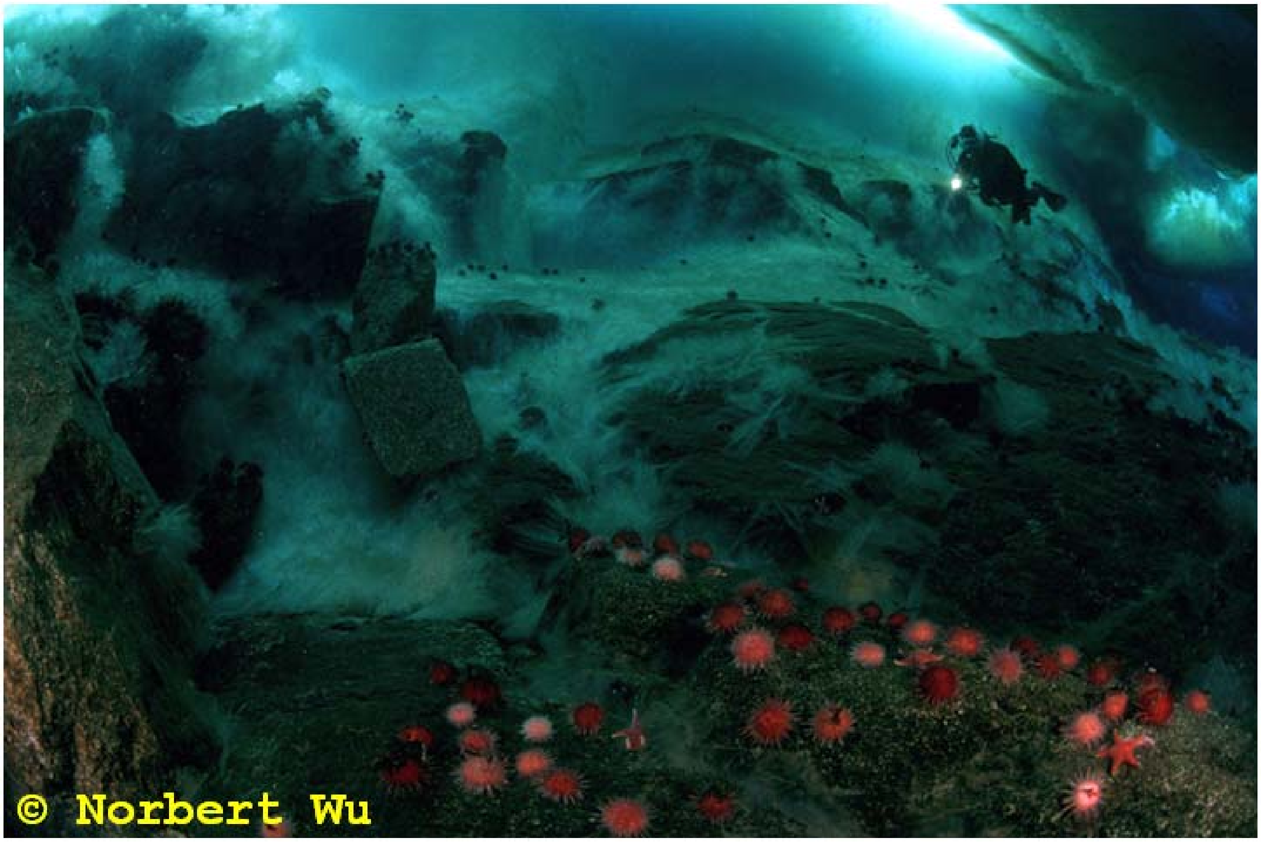


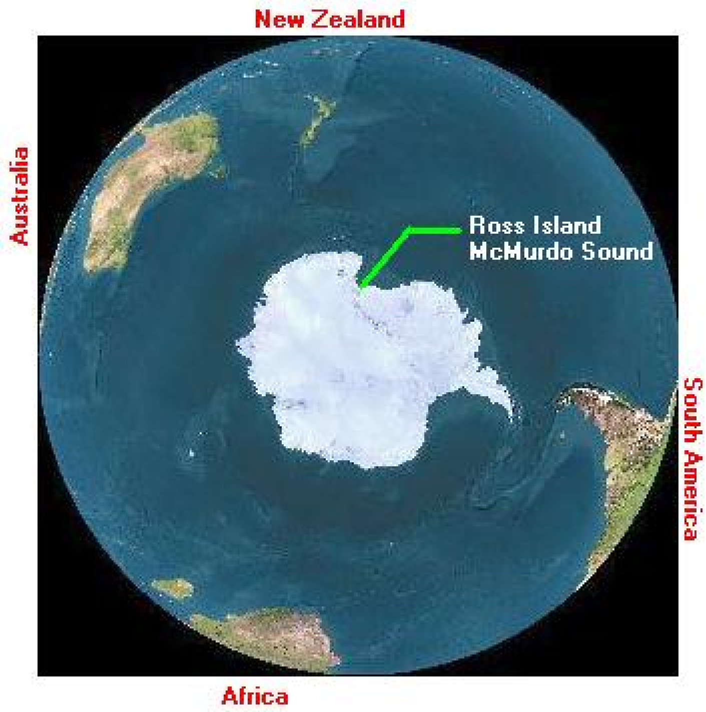
The National Science Foundation's Office of Polar Programs sponsored Norbert Wu on an Artist's and Writer's Grant, involving scuba diving and underwater photography. This Guide is a direct result of that sponsorship and Norbert Wu's efforts.

What is it like scuba diving under the ice in Antarctica ? Cold and dark ... and an epic experience !

Antarctica ..... the coldest, windiest, highest, and driest continent ..... but what is it like to a scuba diver underwater? An underwater photography team went to document it photographically in 1997, 1999, and 2000, conducting over 150 dives. Led by Norbert Wu, an underwater photographer/cinematographer, a team effort was needed to support Norbert's underwater photography in the difficult working environment of Antarctica. Topside before leaving for a dive site, team members prepped the underwater cameras, pulled together and loaded up the dive gear, survival clothing and gear into a Spryte tracked vehicles or snowmobiles towing Nansen sledges. At the dive site, team members unloaded gear and prepared dive gear and cameras for use. Up to seven underwater cameras were taken underwater at one time, so all team members had to hand camera gear in and out of the water and carry additional cameras. In addition, team members would pose as models for shots. Topside after a dive, team members would load up gear into the vehicles. After returning to the base or camp, tasks included reloading the cameras with film, general camera maintenance, unloading and washing off the dive gear. All this activity made for a long day. The total time to support three dives of underwater photography typically was ten to twelve hours. In the first few weeks of a season, however, Norb was dealing with camera and setup problems, and he was typically up at 5AM and finished by midnight.

Norbert Wu's underwater photography team did its diving in the Antarctic spring season (largely October and November) before Antarctic summer. In McMurdo Sound, where all the diving took place, visibility is far better in spring before plankton blooms reduce it during late summer. Underwater visibility looked in the hundreds of feet. Rob Robbins, the Scientific Diving Coordinator at McMurdo Station, estimates average underwater visibility in spring at 300 - 600 feet (91 - 183 meters) [1]. Antarctic waters are amongst the world's clearest because phytoplankton biomass is low and because there is little particulate and dissolved material of terrestrial origin [1]. Jim Mastro, a former Scientific Diving Coordinator, measured one aspect of underwater visibility in McMurdo Sound by scraping off snow from the sea ice at measured intervals. He could see light marks up to 800 feet (244 meters) [2]; however this differs from seeing reflected light from a distant object because it blasts light down through the sea ice ceiling like spotlights. As a diver looks off into the distance underwater, visibility seems to be reduced by the dim light coming through the sea ice ceiling, rather than the more usual reduction of visibility experienced by divers due to particles in seawater.

Where in Antarctica ?

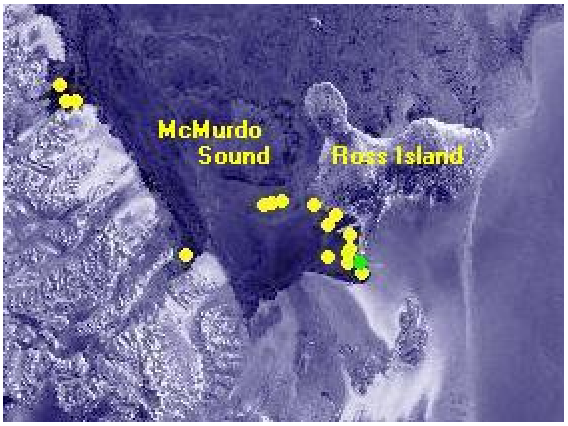


McMurdo Station on Ross Island in McMurdo Sound was the base of operations for Norbert Wu and his team.

McMurdo Sound (longitude 165º00´E; latitude 77º30´S) is a bay about 35 miles (56 kilometers) long and wide, lying at the junction of the Ross Sea and Ross Ice Shelf between Ross Island and Victoria Land on the Antarctic mainland. McMurdo Sound is located about 2,415 miles (3,864 kilometers) south of Christchurch, New Zealand and 850 miles (1,360 kilometers) north of the south pole.

McMurdo Sound was discovered by Captain James Clark Ross in February 1841 and named for Lt. Archibald McMurdo of the *Terror*. McMurdo Sound and Ross Island were the entry way for the early Antarctic explorations of Scott and Shackleton.

McMurdo Station is located at the south end of Ross Island and is the principal US research station in Antarctica. Ross Island lies on the east side of McMurdo Sound and extends 43 miles (69 kilometers) from Cape Bird (north) to Cape Armitage (south) and a similar distance from Cape Royds (west) to Cape Crozier (east). Ross Island is entirely volcanic with Mount Erebus at 3,795 meters (12,450 feet) near its center. Mount Erebus is the most active volcano in Antarctica and the southernmost active volcano on earth, emitting steam from a lava lake in its crater. North from Mt. Erebus along a fracture zone lies the smaller and extinct Mt Bird at 1,765 meters (5,790 feet), and along an eastern fracture zone lies Mount Terror at 3,230 meters (10,597 feet) and Cape Crozier with a chain of parasitic cones between them. Along the southwest rift zone of Ross Island are a chain of small basalt cones terminating at the trachyte dome of Observation Hill next to McMurdo Station and Scott Base. Captain James Clark Ross thought that Ross Island formed part of the mainland of Victoria Land. Scott's British National Antarctic Expedition (1901-4) determined that Ross Island was an island and named it for its discoverer.



The yellow dots mark locations where Norbert's team conducted dive operations in the vicinity of McMurdo Station (green dot).

Dive sites were located along the Ross Island coastline, two islands offshore Ross Island (Little Razorback, Turtle Rock), at the sea ice edge of McMurdo Sound, and on the Antarctic mainland Victoria Land) at Granite Harbor (Couloir Cliffs, Discovery Bluff, Kar Plateau) and New Harbor (Explorer's Cove).

Here's another look at McMurdo Sound from a NASA Galileo satellite picture (taken Dec 8, 1990).

You can see McMurdo Sound just above the middle of this picture, with the Ross Ice Shelf to the right.

Diving Operations at McMurdo Station

Diving at McMurdo Station follows the United States Antarctic Program's *Guidelines for the Conduct of Scientific Diving* and is supervised by an on-site Scientific Diving Coordinator (Rob Robbins, seen here in the McMurdo Station Diving Locker). Dive rules are no-decompression diving with a 130 foot depth limit (40 meters).

Divers are untethered when diving in springtime when underwater visibility is hundreds of feet. Safety is emphasized and though McMurdo Station has a hyperbaric chamber to treat diving accidents, the objective is not to use it.

Diving gear is kept in the Diving Locker building at McMurdo Station. Dive teams meet there to prepare and pack their diving equipment before a field diving excursion. The Scientific Diving Coordinator maintains the customized scuba diving regulators seen here hanging from a wall rack. Oxygen kits for emergency use in the field by dive teams are underneath. The batteries of underwater lights are recharging on the cabinet top at the left. The diver changing area is in the background.

Rob Robbins was the Scientific Diving Coordinator at McMurdo Station, assisting our team's work. Our team's third season at McMurdo (2000/2001) was Rob's 22nd season. Rob has an abundance of ice diving experience, and it was important to listen to everything he says (and actually follow his advice). Scuba divers can be rather independently minded, which is not such a good thing when diving under the ice in such cold water. A new and unfamiliar set of rules are presented to the scuba diver in such a diving environment, so experienced advice from the Scientific Diving Coordinator is critical.

Rob does a checkout dive with you, your first time in the water, and then monitors a team's activities after that, occasionally accompanying a team into the field. He also maintains and fixes all the Station's dive gear, and has some equipment to loan should your personal gear malfunction. Rob has good qualities for the job, particularly patience, taking the time to answer basic questions, and explain things clearly. His good humor was appreciated, as the Diving Locker is small, and everyone and their gear is crammed in there together.

After a diving excursion, scuba diving gear is rinsed and stored in individual lockers in the Diving Locker's diver changing area. Drysuit undergarments are hung up to air out (at right). Scuba tanks are refilled by the Scientific Diving Coordinator from the Diving Locker's air compressor. Small "pony" air tanks used by the dive teams on the droplines hanging down from dive holes are stored on the upper shelves. The Scientific Diving Coordinator is invaluable for advice and impromptu repairs for problems that the dive teams may be having with their gear.

Getting Under the Ice and Into the Water

How do you get under an ice layer two meters thick (six feet) to go scuba diving?

Use a big drill !

A work crew drives out in tracked vehicles to a prospective dive site near McMurdo Station. The crew uses a large auger mounted on the back of a tracked vehicle to bore holes through the ice.

These holes will be used by scuba divers from McMurdo Station to get under the ice.

Two holes are drilled; a secondary safety hole is drilled a short distance away from the primary dive hole. Seawater comes up the auger when it has drilled all the way through the six foot thick sea ice ceiling.

The work crew sleds a dive hut out to the dive site and parks it directly over the primary dive hole they just drilled. As shown here, snow is piled around the hut's base to seal out the strong Antarctic wind; otherwise snow will blow into the hut through the hole in the hut's floor. Warmed inside by a heater, the scuba diver is protected from the elements while suiting up and getting in and out of the water.

Here's the **primary dive hole** under the dive hut. The water is near the top of a dive hole and the diver drops down six feet through that hole of ice until coming out under the sea ice ceiling. Obviously the diver cannot be claustrophobic ! There is a layer of platelet ice beneath the sea ice consisting of small ice crystals and large platelets; these are dislodged by divers' bubbles and float into the hole as seen here. A long-handled dipnet is used to keep the dive hole open and free of this ice.

A weighted drop line (seen here at the left of the diver) hangs straight down from the primary dive hole and has the following attached: black and white checkered flags, two to three strobes, and a pony bottle (extra emergency air) with regulator. The drop line can be used to descend to and ascend from the bottom immediately under the dive hole if there is a strong underwater current. The drop line is also a useful point of reference for the diver's safety stops to prevent decompression illness. The diver sees the flags close by and can see those strobes from far, far away. As the submerged diver looks up, the primary dive hole is rather dark since there is a hut over it (though still lighter in shade than the sea ice ceiling).

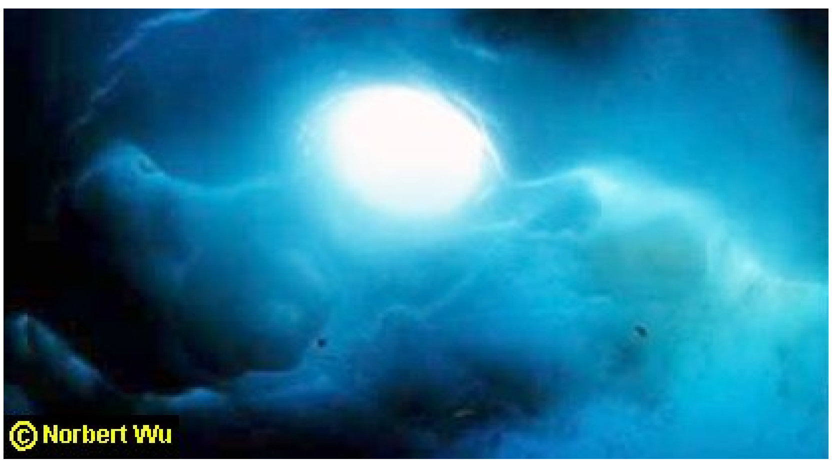
The **secondary dive hole** is a safety hole out in the open a short distance away from the dive hut. It is used in case the primary hole is blocked by a Weddell seal. Topside, the safety hole is marked with a flag pole (so the divers can find it after a blizzard) and is covered with a foam plug when not in use (to prevent freeze-over).

When a submerged diver looks up at the sea ice ceiling, the secondary hole has bright light streaming down on a sunny day, because it is out in the open and not under the dive hut. This bright light shining down the hole makes it easy for the diver to spot the dive hut and hole location from far away. It is easy to dive safely under the ice by remaining in the vicinity of these dive holes. There was usually only a very slow current so a diver didn't have to worry about getting swept away from the dive hole. There was no underwater surge complicating diver activities. Due to the ice ceiling, there were no waves affecting dive operations at the surface. In addition, we didn't have to pay attention to tides. Antarctic tidal movement is unique in the world's oceans because there are no significant land masses to impede the East/West (counterclockwise) sweep of the tides around the Antarctic continent [1]. Antarctic tidal movement is principally a progressive wave, and the tide is diurnal (one high water and one low water each tidal day, a lunar day of 24 hours and 50 minutes) [3].

f it is very cold, particularly in a strong wind as shown here, an ice crust slowly forms over the outside secondary dive hole. This crust has to be removed so that submerged divers can exit through this outside hole in an emergency. The ice crust is broken up with a pole or chipper bar (in the diver's hands) and then pieces are fished out with a dipnet (behind the diver).

Diving under the ice from a dive hut is comparative luxury compared to diving out in the open. At locations far away from McMurdo Station, a hut may be unavailable (like Discovery Bluff at Granite Harbor as shown here). Divers then enter the water through holes in sea ice cracks, either seal-made or man-made. This hole was seal-made and was shared with Weddell seals. Weddell seals enlarge holes in sea ice cracks for their use and keep them open throughout the year. If seal-made holes are unavailable, divers may open up a hole along a crack, using hand tools or chainsaws.

When diving close to McMurdo Station, a hole can be drilled in the ice (as shown above), or a Weddell seal hole can be used (as shown here at Turtle Rock). There may be a bit of wiggling involved to fit through restrictions in a Weddell seal hole. Here a diver has finished a dive and has handed out his air tank. Next he will lift out his weight harness, and then hoist himself out of the hole.



Here's a diver's eye view looking up at a Weddell sea hole used by our team to dive. The Weddell seals keep these holes open year round with their teeth, pivoting around in the hole, gnawing at the ice. That's why this seal hole looks so round. If divers are polite and ask first, the Weddell seals will let divers use these holes. Divers don't linger in these seal holes for very long, because the seals need them to breathe while in the water, and to get in and out of the water. One member of our dive team was poked about his rear end as he floated in a seal hole. Another member of our dive team waited underwater to exit, while two Weddell seals fought it out over temporary turf rights to the hole.

Here's another diver's eye view looking up at a Weddell sea hole used to dive on a grounded iceberg offshore Cape Barne (no dive hut). You are looking up at the underside of a crumpled pressure ridge of sea ice alongside that grounded iceberg. You can see the drop line hanging down from the hole and used by the divers for a point of reference and tie-off for emergency air supply. When there is a current, the drop line is used for handholds while descending to the seafloor and ascending to the surface, in order to avoid drifting away with the current.

Gearing Up

How cold is the McMurdo Sound water for the diver ? .... -1.86 degrees Celsius / 28.65 degrees Fahrenheit !!

Salt water freezes at a lower temperature than freshwater. Seawater's freezing point decreases about 0.5 degrees Fahrenheit for each five parts per thousand increase in salinity. At 35 ppt sea water will begin to freeze at 28.6 degrees Fahrenheit. McMurdo Sound seawater has a nearly constant mean annual temperature of -1.86 degrees Celsius (28.65 degrees Fahrenheit) and temperature doesn't vary much with depth or season -- 0.2 degrees Celsius (0.36 degrees Fahrenheit). Typical dives lasted an hour with some shallow-depth dives stretching to ninety minutes underwater. Cold hands can be a limiting factor for many divers scuba diving under the Antarctic ice. Everyone's internal thermostat dictates their own comfort level with remaining underwater; some people put out more body warmth and can last longer than others. Divers may not be cold right away, but given time and even the best diving gear, the cold seawater will triumph.

What does a diver wear to stay warm in such cold water ? .... a drysuit

Here a diver wearing a DUI drysuit is standing over the dive hole inside a dive hut putting on a neoprene hood.

For warmth, the diver wears a drysuit with several layers of undergarments. Unlike the more familiar wetsuit, the diver stays dry within a drysuit. No water can enter inside the drysuit due to seals at the wrists and neck; there are no seals at the diver's ankles since the drysuit has attached booties. A special watersealing zipper enables the diver to enter and exit the drysuit. At the back of the diver's head is this drysuit's attached latex hood which will be pulled over this neoprene hood in order to seal out water (the diver's hair stays dry underwater).

On the diver's chest is a drysuit inflation valve. The diver lets air into the drysuit from a scuba tank hose through this valve in order to counterbalance external water pressure and maintain neutral buoyancy. The diver's left upper arm has a drysuit exhaust valve for releasing air when ascending or descending in order to maintain proper buoyancy.

Following is a description of the dive gear we used. This is what worked for us. There is a wide variety of dive gear and opinions, so many different gear configurations will work. We saw a lot of variety in other dive teams, so there are multiple approaches to diving in Antarctica. We sought advice from a variety of people, brought down some extra gear to experiment in the field, and arrived at what worked best for us. Your mileage will vary.

Warm Wind Drysuit Undergarment

It's what you wear inside the drysuit that keeps you warm; the drysuit only keeps you dry. The first clothing layer was regular or expedition weight polypro long underwear.

Over that, the team wore a Warm Wind Thermal Liner Polartec® series 200 jumpsuit as a second layer.

The team wore DUI 400G Thinsulate® (400 gm/m2) Type B nylon shell booties (shown here). Some wore only these booties; some wore polypro or US Antarctic Program issue socks in combination with these booties.

DUI Drysuit Undergarment

A third and final layer was a DUI 400G Shell Type B Thinsulate® 400 gm/m2 Thermal Garment.

The DUI 400G Shell Type B Thinsulate® 400 gm/m2 Thermal Garment worked really well as the top layer for general wear before, between, and after dives. Its wind-resistent shell kept out wind and its insulation combined with underlayers was warm as several layers of US Antarctic Program clothing.

DUI drysuits

The team used every model of DUI drysuit ranging from the TLS trilaminate models to the CF compressed neoprene models. They all worked admirably with no leaking. Drysuits were pressure tested and repaired as needed by DUI before Antarctic use.

Trilaminate drysuits are advantageous for diving out in the open when it is extremely cold and windy. Trilaminate drysuits don't retain surface moisture as do compressed neoprene drysuits. Surface moisture on a compressed neoprene drysuit will freeze and stiffen the drysuit which makes it very cumbersone to maneuver in a drysuit topside. In addition, trilaminate drysuits tend to be lighter than compressed neoprene drysuits which helps in keeping overall equipment weight down for weight-limited helicoptering to remote field sites.

The drysuit inflator valves on the drysuit air inflator line are specially modified at McMurdo to put a larger knurled brass collar on the valve end so that clumsy, cold fingers can easily pull that valve on and off.

When first dropping into the 28 degree F water, there is no cold shock since there is almost no skin in direct contact with water. You can see here that only the diver's lips will be exposed to water! Shortly after beginning a dive, the diver's lips go numb a bit from the cold but since lips are well vascularized, it isn't a problem.

Hoods & Gloves

Divers varied in hood setup, with some having attached latex or neoprene hoods on their DUI drysuits. The attached hoods reduce water circulation around the diver's head, and were pulled over a neoprene underhood.

As underhoods,all divers use Henderson ice caps (at left, aka ice hoods) that have a strip of neoprene running across the upper lip. These are thin 3 millimeter full face hoods that reduce the skin area that will be in contact with the water.

The team used dry gloves that were inexpensive concrete mixing gloves; these were tough and very supple, making it easy to stretch them down and over the dry glove cuff rings mounted on the drysuits. We also used Viking five-finger rubber dry gloves, which are less supple and more expensive than the concrete mixing gloves. Take two pairs of dry gloves in case you get a puncture.

Under the dry gloves, the team used various combinations of fleece gloves or winter mountaineering glove liners. Take several gloves/liners and see what works best in the field. For example, a thin polypropylene glove can usually be worn inside a mountaineering glove/liner for extra warmth if needed. One team member used Marmot mountaineering glove liners. One team member used the inner pile liners from Black Diamond mountaineering gloves. One team member used Outdoor Research Expedition/Professional Modular Glove Standard Liners (these liners have extra thick insulation on the back of the hand and thumb/fingers, with curved fingers/boxed construction to minimize insulation compression and finger constriction.).

In order to let the air equalize between the dry glove and the dry suit, a short length of cotton rope or Tygon® tubing was inserted under each drysuit wrist seal in order to break the seal a bit and let air exchange between the dry glove and the drysuit sleeve. Knot the rope at the ends to keep it from slipping all the way through the wrist seal.

The comfort level of the DUI drysuits, hoods, and undergarments was so considerable that team members (here Norbert Wu) could lounge in dive holes out in the open with subzero wind chill while waiting for gear setup or other divers.

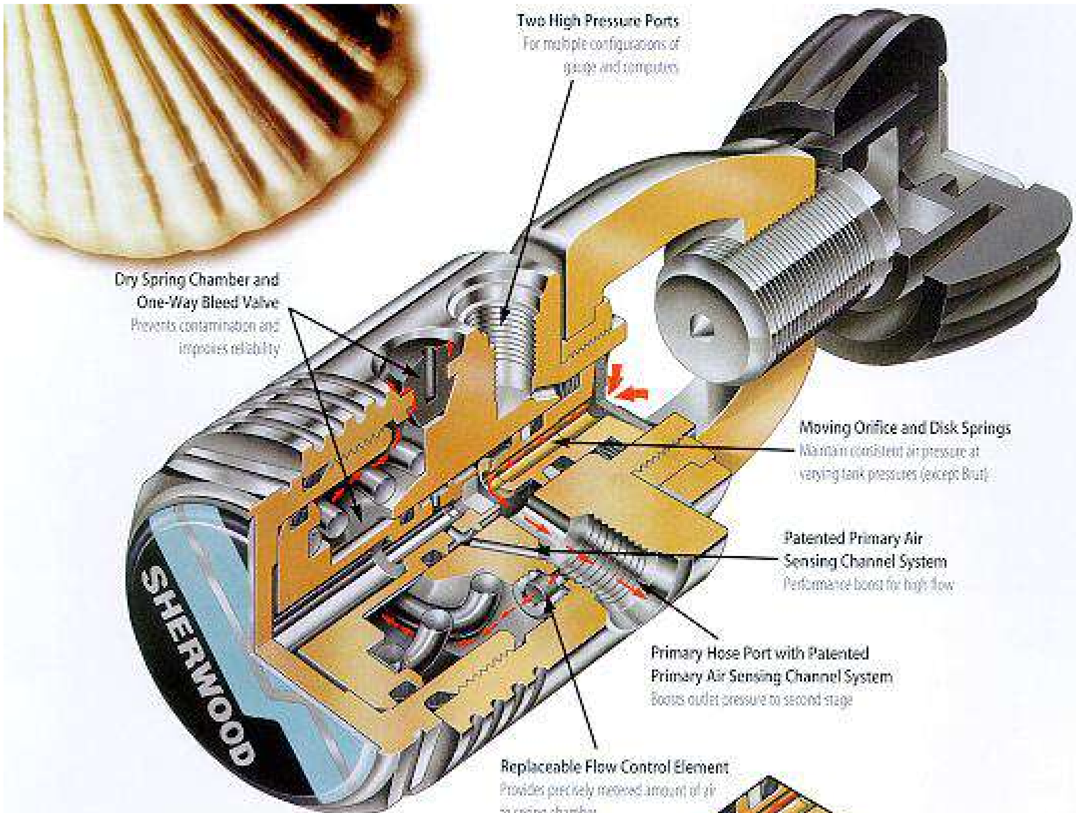
two modified Sherwood Maximus regulators

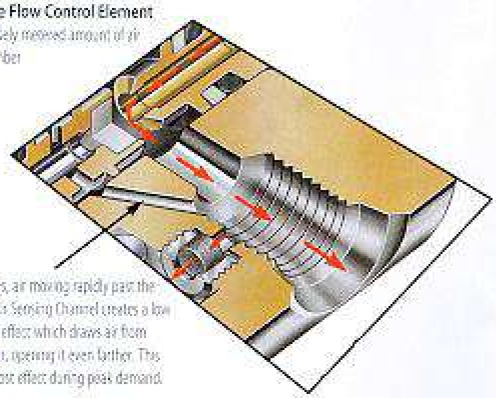
McMurdo Station modified its Sherwood Maximus regulators to avoid freezing and freeflow in the icy waters around McMurdo Sound (-1.86 degrees Celsius / 28.65 degrees Fahrenheit). A scuba diving air regulator has two pieces: the **first stage** (attached to the tank) and the **second stage** (in the diver's mouth and attached to the first stage by a pressure hose).

Divers used two Sherwood Maximus regulators and they were attached to the air tank through a Y valve. One regulator has a single second stage attached and is the primary breathing supply; the other regulator functions as the backup air source and has the air pressure/depth console and drysuit inflator hose attached. A dive computer is very useful to track dives. The Sherwood Maximus regulators were selected after extensive testing.

first stage: The Sherwood Maximus 1st stage used for breathing becomes almost totally ice-encased during a dive (see picture above). The pressurized air moving and expanding through the first stage cools down the 1st stage and ice forms around it as a result. In one study, the air leaving the 1st stage of a regulator on its way to the 2nd stage in the diver's mouth dropped to -10 degrees F [4]. So it's no wonder that the 1st stage regulator comes out of the water looking like an ice cube, with ice almost a half inch thick around it !

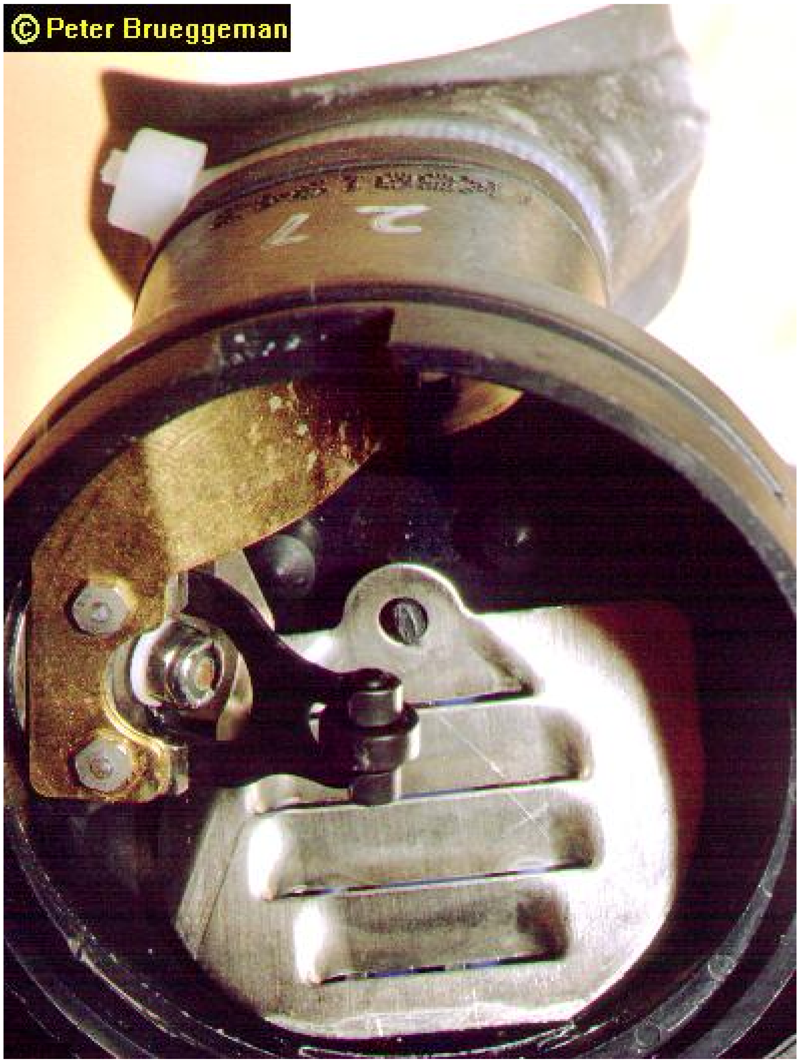
The Sherwood Maximus 1st stage doesn't allow seawater inside its pressure-compensating mechanism (see catalog illustration below) which thus prevents problematic icing up of the regulator. The regulator senses the external water pressure (which a 1st stage regulator must do in order to deliver air appropriately) by an air bleed valve, a port that constantly trickles out tiny air bubbles which the regulator uses to sense ambient water pressure.





First Stage (5000 series)

The enhanced performance 5000 series first stages feature Sherwood's Air Sensing Channel System. This patented design causes outlet pressure at the primary hose port to rise instead of fall during extremely high flow rates delivering ultra high performance in a compact package. Sherwood's tried and true Dry Air Bleed System helps keep the interior of the regulator clean and free of contaminants, while the unique Moving Orifice balances the outlet pressure against changes in tank pressure.



second stage: the McMurdo- modified Sherwood Maximus 2nd stage has two interior metal pieces which act as heat sinks and transfer heat from the diver's exhaled breath to the air inlet orifice which is susceptible to freeze up. Heating of the inlet orifice is needed because air flowing through the restricted orifice in the 2nd stage inlet valve cools down. Any moisture present will freeze, thereby freezing the inlet air valve, leading to a freeflow of air streaming into the diver's mouth, which can abort the dive. One metal strip inside the 2nd stage (copper-colored strip) leads into the mouthpiece, transferring exhalation-breath heat to the inlet valve; it is found in off-the-shelf Sherwood Maximus regulators. A second large metal plate (silver-colored stainless steel louvered plate, with edge strip running up to the inlet valve) was fabricated at McMurdo and fits over the exhalation ports, to further utilize exhalation-breath heat. This setup solved McMurdo's regulator freezeup problems. Divers open up the 2nd stage before leaving McMurdo Station each morning and use pressurized air to blow out any residual water from previous gear rinsing. Any water left inside the 2nd stage can freeze up and lead to a freeflow. If camping out in the field with no easy way to rinse, the gear is left untouched to minimize problems.

ScubaPro 95 cubic foot steel tank

McMurdo supplied ScubaPro 95 cubic foot steel tanks with a Y valve to use with two Sherwood Maximus regulators; the tank is mounted on a hardshell backpack. Generally no buoyancy compensating vest was used since the diver's drysuit can be used for buoyancy compensation (here Dale is using his Dive Rite BC).

The backup Sherwood Maximus regulator hangs from a loop of surgical tubing tied to the right shoulder strap of the tank backpack.

At Explorer's Cove, New Harbor, twin 72 cubic foot steel tanks were used instead of the 95 cubic foot tanks.

DUI Weight and Trim System weight harnesses

McMurdo Station supplied DUI Weight and Trim System weight harnesses to the team along with lead weights and ankle weights. The harness holds the extra weight needed to be neutrally buoyant underwater. The yellow tube handles on the harness are a quick-release system to drop the weights quickly in an emergency. These DUI Weight and Trim System weight harnesses were easy to don and adjust. Divers could easily slip out of them while floating at the surface of the ice hole and then hand them up to someone out of the water.

Divers can use ankle weights (as shown here) to distribute weight better on the body and to keep one's feet weighted down in order to prevent air expansion in the feet in an uncontrolled ascent.

Photography & Cinematography

About **underwater still photography using film cameras** (this was the pre-digital days) in Antarctica, Norbert Wu said "I used Nikon N90s (called F90X out of the US) and F4s bodies in Subal and Aquatica aluminum housings. ... The cold wreaked havoc on my underwater cameras. (For the first trip), I brought a dozen camera bodies, seven underwater housings, and a dozen underwater flash units. By the end of my (first) stay, only three housings and strobes were working properly, and I had shot 400 rolls of film. ...Because of ice and snow cover, Antarctic waters are very dark, necessitating long shutter speeds when photographing..." For some shots, Norbert used a "....Nikon 16mm fisheye lens, two Ikelite Substrobe 200 underwater flash units, Kodachrome 200, 1/30 sec., f/2.8. I used a fast film and a slow shutter speed in order to show the ambient light level under the ice -- to show the colors of the sea ice ceiling ..." Some "... photographs normally required exposures of 4 to 8 seconds to bring out ambient light." "... I used lithium AA batteries in all the cameras. They worked great. The temperature of the water is not that cold, so lithium or nicad batteries should work fine. I used Ikelite Substrobe 200s with their nicad battery packs and they worked great. ... For film, I used everything from Fujichrome Velvia, Provia, Ektachrome E100S and E100SW, Kodachrome 64 and 200. " In frozen conditions, always dry cameras after rinsing them with fresh water, before taking them into cold salt water. "At temperatures like we had in Antarctica, fresh water immediately freezes when you do that. So any water that might have seeped into a crack will immediately freeze, and you won't realize it until you are down there shooting."

Norbert Wu did his **underwater cinematography** using HDTV technology for Thirteen/WNET New York's Nature series, US television's premier natural history venue. "Under Antarctic Ice" is scheduled for broadcast on PBS stations in Fall 2001. Norbert said "It represents, to my knowledge, the first time that HDTV technology has been used in Antarctica, which is the coldest, windiest, harshest, driest, and most remote continent in the world. It's a tribute to HDTV technology that my team had few problems with our equipment there, topside or underwater."

Norbert used two Sony HDW-700A (1080i) high-definition camcorders (HDCAM) for topside and underwater shooting. For the topside and aerial shooting, he used two different Canon high-definition lenses: one HJ18x7.8B and one HJ9x5.5B HD-IF. For the underwater shooting, he used two Fujinon HA 10x5.2BERD lenses. "Underwater, the Fujinon lenses [the HA 10x5.2BERD model] gave us great range, so much so that we never used any filters, mainly shooting wide open." The HDCAMs were encased in aluminum underwater housings developed by Vincent Pace, president of Pace Technologies, who worked closely with Fujinon to create the underwater camera housings. Norbert said "Both the Canon and the Fujinon lenses worked fine. Even in the extreme cold, the Canon lenses didn't freeze up. We beat them up, and they kept on going -- real workhorses."

About HDTV, Norbert said "Natural history filmmakers like myself are particularly excited about HDTV technology because of the numerous advantages over film it gives. For the first time, a small three or four-person crew can create images that rival 35mm film. It's a tremendously exciting and enabling technology. My biggest problem as an underwater filmmaker has always been the size of the film loads. A typical 400-foot load of 16mm film generally lasts for only 12 minutes of shooting, which means that I often have to cut my dives short to reload film. Especially in demanding diving conditions like Antarctica, every trip to the surface means precious shooting time wasted. In comparison, I was able to shoot 40 minutes per dive with the Sony HDCAMs." "We didn't have to worry about film-changing issues, and we could stay underwater longer, which was important since we only had limited windows of time when we had decent light down there. We could just pop a 40-minute cassette in and be done. We didn't have to lug tons of film stock all over the polar region. Those things make a big difference."

"Other advantages of shooting video versus film underwater are numerous. I have not often used zoom lenses underwater, since the cardinal rule of underwater photography is to get close with a wide, prime lens. The Fujinon lenses, however, offered the ability to zoom in on subjects with no discernible loss of sharpness or contrast. They offered great depth of field and a fast lens to deal with the low light conditions under the ice.

This was another benefit of using the HDCAMs -- their low light gathering capabilities. We pushed the cameras to their limit, using gains of 6 to 12 db during shooting in order to bring out ambient light under the ice. As a comparison, we would have had to use film rated at ISO 1600 to 6400 otherwise. The HDCAMs picked up this very dark environment well. For underwater lighting, I used portable SunRay High Intensity Discharge (HID) lights from Light and Motion Industries. I also had 1300 watt PAR 36 surface supply lights which I normally use for my film shoots in brighter locations such as California waters and the tropics. ... In Antarctica, we had less need for such powerful lights since the ambient lighting was so low. This was another benefit of the HDCAMs -- we were pushing them to their limit, using gains of 6 to 12 db during shooting in order to bring out ambient light under the ice." "The camera really works well in low-light situations, but the lights were needed because that deep underwater, everything becomes blue, no matter what camera you use. Therefore, we mainly needed them for the purpose of bringing the colors out, and there are spectacular colors under that ice." "And we really pushed the camera-we even overrode its white balance settings in order to get the maximum light out of the situation, and we really pushed the gain to get images like extreme high-speed film. Had we shot on film, I doubt we could have gotten the same kind of color saturation as what we did with HD." "As a comparison, my still photographs normally required exposures of 4 to 8 seconds to bring out ambient light. The HDCAMs picked up this very dark environment well."

"We did have a few problems with the gear, none of them substantial. In extremely cold conditions, the HDCAMs exhibited flicker problems. The extreme depth of field and sharpness of the HD lenses also led to problems, because any speck of dust or snow shows up with major effect on the image. We had penguins jumping up in front of us splashing water on the lens, and even the tiniest particles would appear in the picture. With film, dust particles on the lenses are far less of a problem." In frozen conditions, always dry cameras after rinsing them with fresh water, before taking them into cold salt water. "At temperatures like we had in Antarctica, fresh water immediately freezes when you do that. So any water that might have seeped into a crack will immediately freeze, and you won't realize it until you are down there shooting."

"A few other essential items in our gear bags were the gear bags and cases themselves, supplied by LowePro and Pelican Products; Anton/Bauer batteries and chargers; Really Right Stuff's mounting plates and clamps, which we used to hold all kinds of gear underwater and topside; and an Extron CVC 200, a HD or component to RGB converter that we used to output the signal from the HDCAM to computer monitors and video projectors." About Lowepro bags, Norbert said "Lowepro gear proved useful for our constant packing and unpacking, in all phases of our Antarctic field operations -- via snowmobiles, sledges, helicopters, & tracked vehicles." The HDCAMs were powered by Anton/Bauer HyTRON 100 and Digital ProPac batteries. Norbert said "I could not have accomplished what I did in Antarctica without Anton/Bauer equipment. The HyTRON 100 and Digital ProPac batteries allowed us to work for hours in the harshest climate in the world. The batteries were often charged in remote camps using small generators to run the PowerChargers. After the production I used the chargers' power feature to run the HDCAMs as we made dubs. The batteries and chargers performed flawlessly." About Really Right Stuff's quick-release plates and clamps, Norbert said "We used their precision, anodized aluminum clamps and plates to hold our cameras and lights both underwater and topside in Antarctica. They performed flawlessly in this harsh environment, never freezing up or rusting."

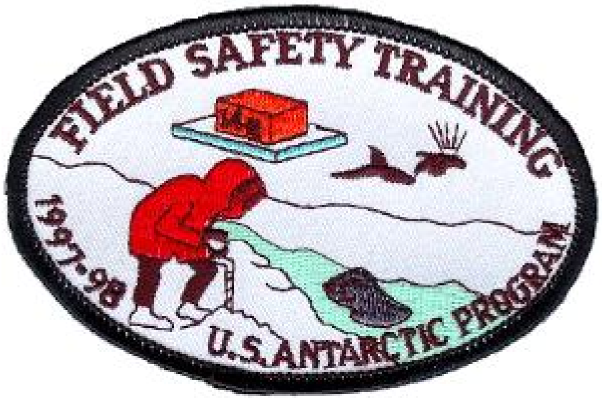
What's It Like to Work on a Diving Project There?

Wear the **E**xtreme **C**old **W**eather clothing when going out into the field and take it all along !

Here are several people outfitted in some of their ECW gear on the Hercules transport flight from New Zealand to McMurdo Station, Antarctica. The ECW clothing becomes a constant companion during one's time with the US Antarctic Program.

Antarctic continental temperatures are usually below freezing throughout the year. Coastal regions have 40-100 centimeters of snowfall per year. Katabatic winds are a characteristic feature. Antarctica has an average elevation over 2000 meters and cold dense air from the high continental plateau spills down slope to the coast under gravity's influence. When channeled through valleys, katabatic winds can reach gale force at the coastline, sometimes exceeding fifty meters per second.

The US Antarctic Program prepares the participant for survival in this environment by outfitting each participant with **E**xtreme **C**old **W**eather clothing before departure from New Zealand. This ECW outfit has everything needed for topside clothing in Antarctica, comprising everything from long underwear to a cold weather parka, and emphasizing layering for warmth. The team brought some additional clothing for personal preferences and for diving undergarments



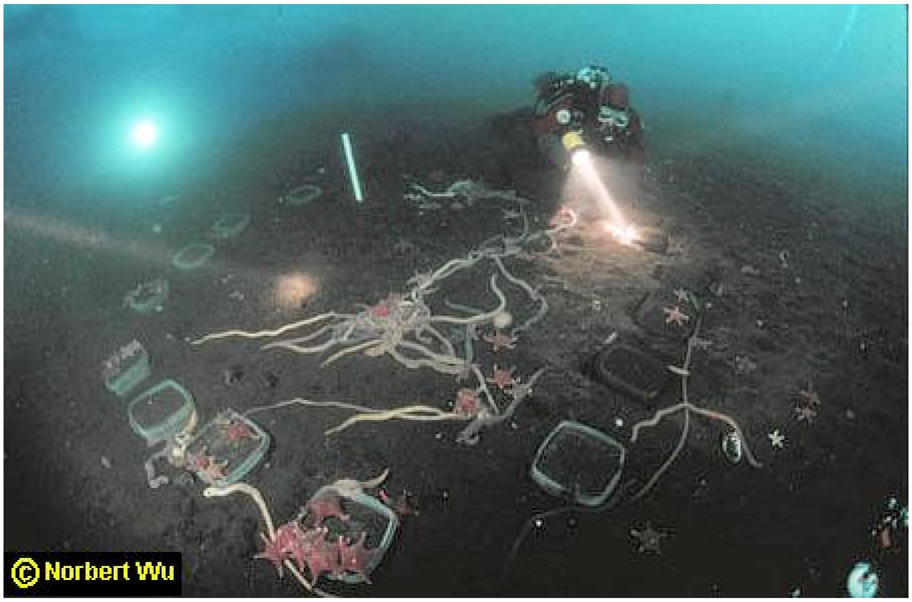
Anyone leaving McMurdo Station to go out into the field has to participate in several trainings as safety preparation. For the team, this included Field Safety Training (more below), snowmobile training (driving and emergency field troubleshooting and repair), vehicle driving (Spryte tracked vehicles, radio procedure), sea ice training (ice safety, sea ice crack awareness, tent pitching on ice), and helicopter load training (safety around helicopters, emergency procedures, load distribution).

Field Safety Training prepares the US Antarctic Program participant for going out into the field in Antarctica. The essentials of snow camping are taught including cutting snow blocks for wind-shelter, snow cave making, tent pitching and anchoring, staying warm and fed, etc. Weather knowledge is discussed as well as crisis mangement and search party techniques in blizzard whiteouts. Usage of field radios and MSR stoves is practiced. The tent on the right is a Scott tent which is capable of standing up in gale force winds. It is the most comfortable since its occupants can stand and have a lot of floor space. The other tents that are sheltering from the wind in a snow block wall are four-season winter mountaineering tents with more limited floor space and ceiling height. Subzero synthetic-fill sleeping bags are used with two layers of sleepmats underneath. Water bottles are kept inside the sleeping bag at night so that there will be unfrozen water to quench thirst.

Field teams check out their field camping gear and get their food supplies from McMurdo Station's Berg Field Center. Considerable time is spent in advance planning and staging field camping equipment and food. The Berg Field Center (shown here) consists of two 2-story warehouses that are fully stocked for camping, travelling, and mountaineering in Antarctica. Field gear might include ice axes, winter mountaineering tents, ice screws for tent pegs (when setting up tents on sea ice), sleeping bags, fleece sleeping bag liners, ensolite and ThermaRest pads, MSR Whisperlight stoves, water jugs, emergency dehydrated food, canned food, perishable food, shovels, toilet tank, ice saws to saw snow into blocks to build wind sheltering walls for the tents, ice drill used to drill anchors in the sea ice for tent guidelines and check for ice thickness etc, sledge hammer, on and on and on. There are a lot of details and many questions arise. BFC staff proved to be consistently patient with an inexperienced field team.

Load up a Spryte tracked vehicle with diving gear, ECW clothing bags, and survival camping gear. Diving in the vicinity of McMurdo Station involves driving to the dive site. Drive the Spryte along the frozen ocean to a dive site along the shoreline of Ross Island or its offshore islands. The deluxe setup would be to have a heated dive hut available at the dive site, as shown here for a dive site at a grounded iceberg south of Cape Evans. That's Mount Erebus in the background and a helicopter hovering over the iceberg.

Less deluxe would be diving out in the open. Here's a shot from a sea ice crack opened up a bit with chipping bars to allow divers to enter and exit the water. Though sunny outside, the biting wind combined with the cold air temperature requires divers to bundle up for warmth when out in the open between dives, or simply stay suited up in the drysuit between dives. At least one of the divers has to remain topside while other divers are underwater in order to assist divers in and out of the water. As the last step in gearing up, the diver's dry gloves are pulled over the drysuit's wrist seals and assistance is helpful. When the dive is over, the diver strips off the tank/regulators and the weight harness in the water and hands them up, then climbing up and out of the dive hole.



Scientific diving is hard work and not a vacation dive experience. The divers working on research projects centered at McMurdo Station have specific objectives and tasks underwater. There is usually little time for sightseeing dives because a large body of work has to be completed within a relatively short period of time. Here some divers are surveying a site of a long-term experiment.

Antarctic storms can blow up quickly, pinning field teams down until the blizzard relents. Blowing snow greatly affects the ground visibility. Three weather conditions are defined by the US Antarctic Program. Condition Three is normal, clear weather and ground visibility is greater than 1/4 mile. Travel by open vehicle like snowmobiles is allowed. Condition Two has ground visibility less than 1/4 mile usually due to high winds. Travel is allowed only by covered vehicle like the tracked Sprytes. Condition One has ground visibility less than a few hundred feet or almost none. Travel is not allowed and can be impossible. If a Condition One storm blows in while a field team is out in the field, the team usually cannot see far enough ahead to drive the Spryte tracked vehicle safely back to McMurdo Station along the flagged sea ice road. The storm must be waited out either in the vehicle or, as seen here, in a dive hut. Waiting can take hours or days and field teams are supplied with emergency food, sleeping bags, water, and field stoves.

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3: Sailing Directions (Planning Guide & Enroute) Antarctica. Publication 200. National Imagery and Mapping Agency, Bethesda, Maryland. 1997. page 77; **4:** Undercurrent 17(5):3, 2002