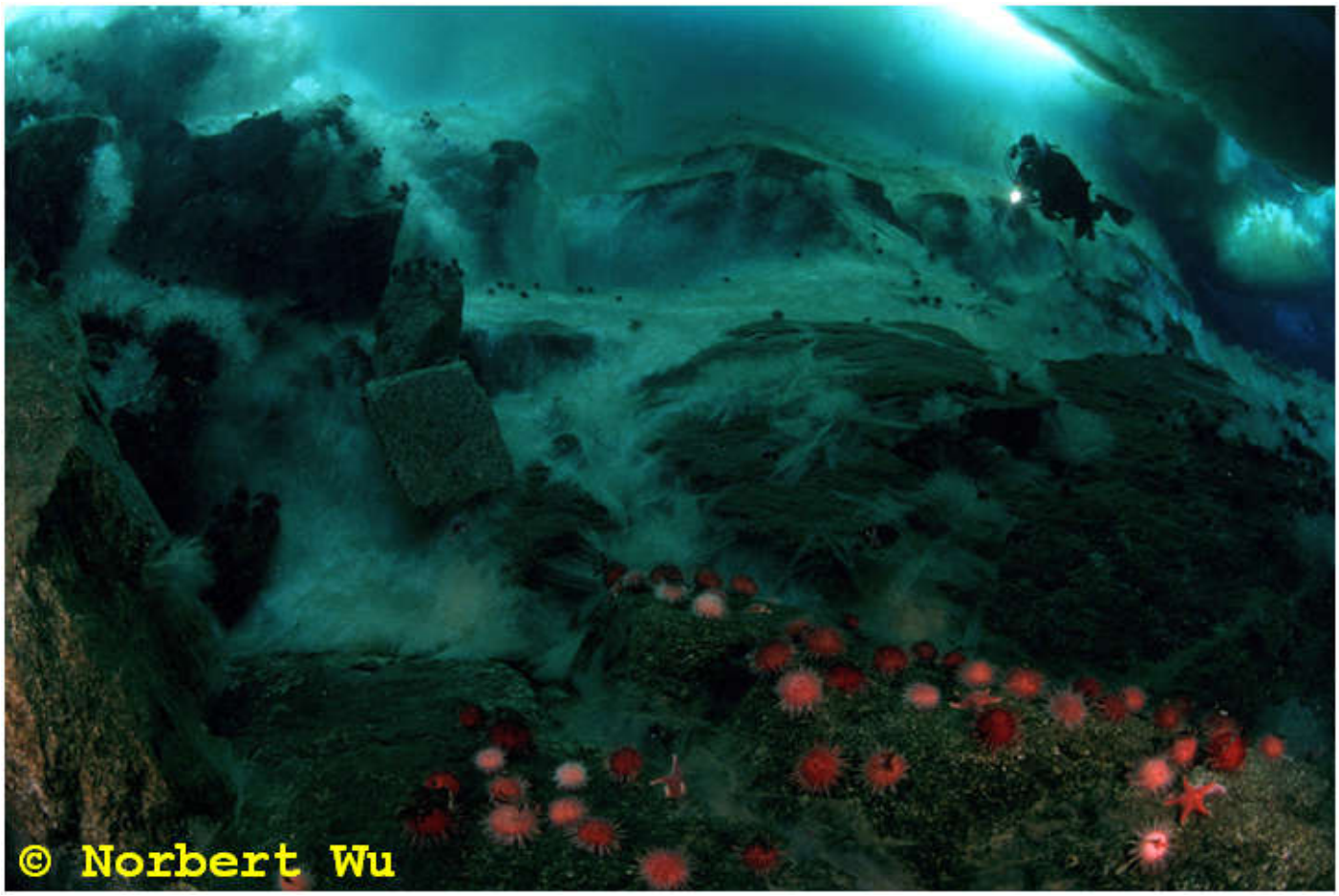
Diving Under Antarctic Ice

scuba diving at Ross Island & McMurdo Sound, Antarctica

Peter Brueggeman



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.

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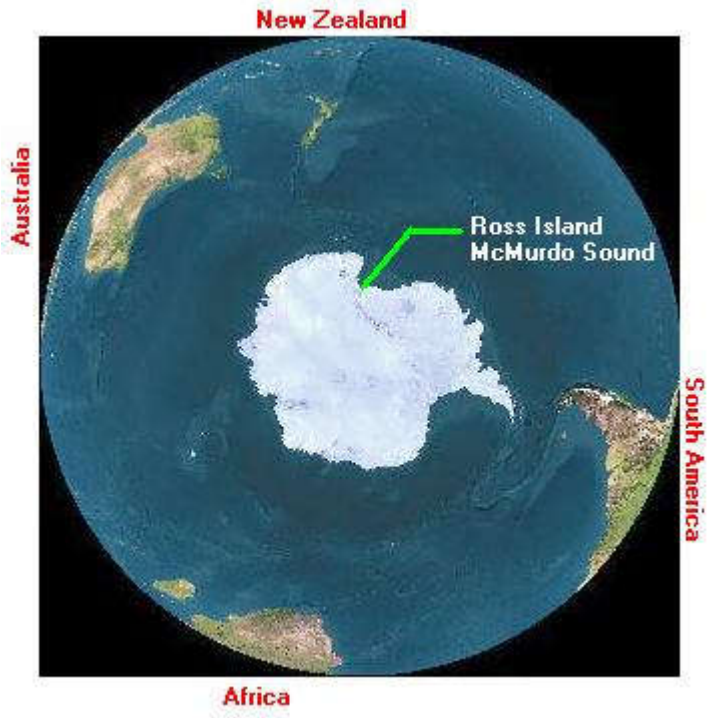
What is it like scuba diving under the ice in Antarctica ? Cold and dark ... and an epic experience !

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 ?

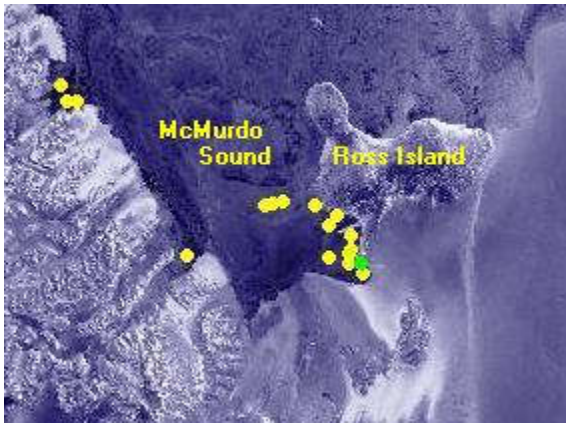


McMurdo Station on Ross Island in McMurdo Sound was the base of operations for Norbert Wu and his team.

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.

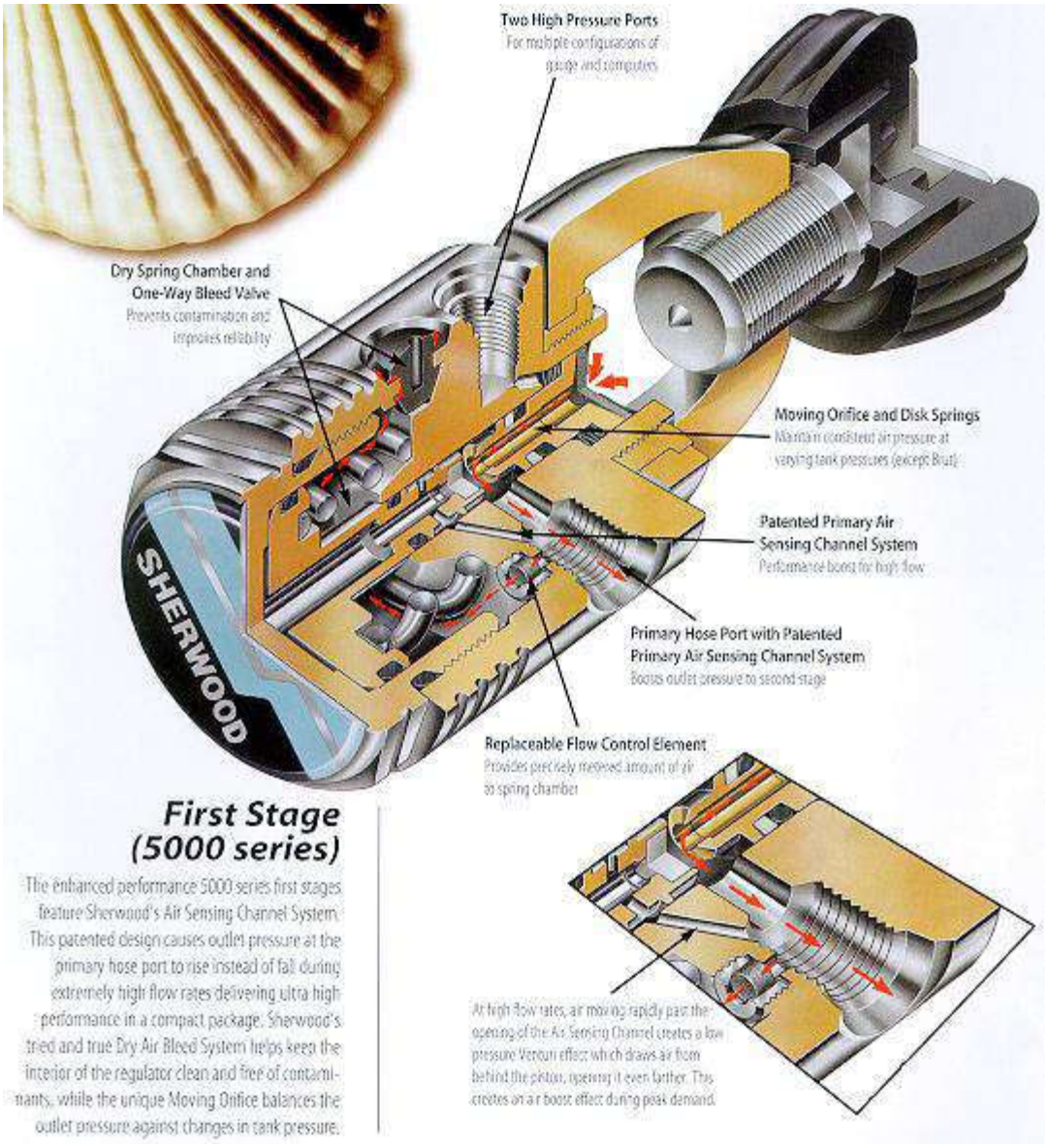
two modified Sherwood Maximus regulators

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).

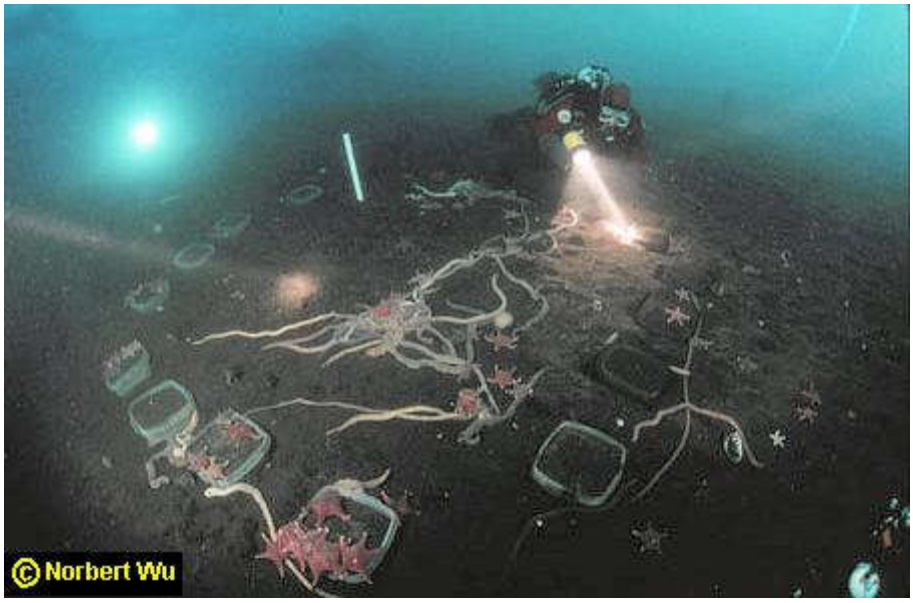
Field Safety Training prepares the US Antarctic Program participant for going out into the field in Antarctica. The essentials of snow camping are taught including cutting snow blocks for wind-shelter, snow cave making, tent pitching and anchoring, staying warm and fed, etc. Weather knowledge is discussed 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.

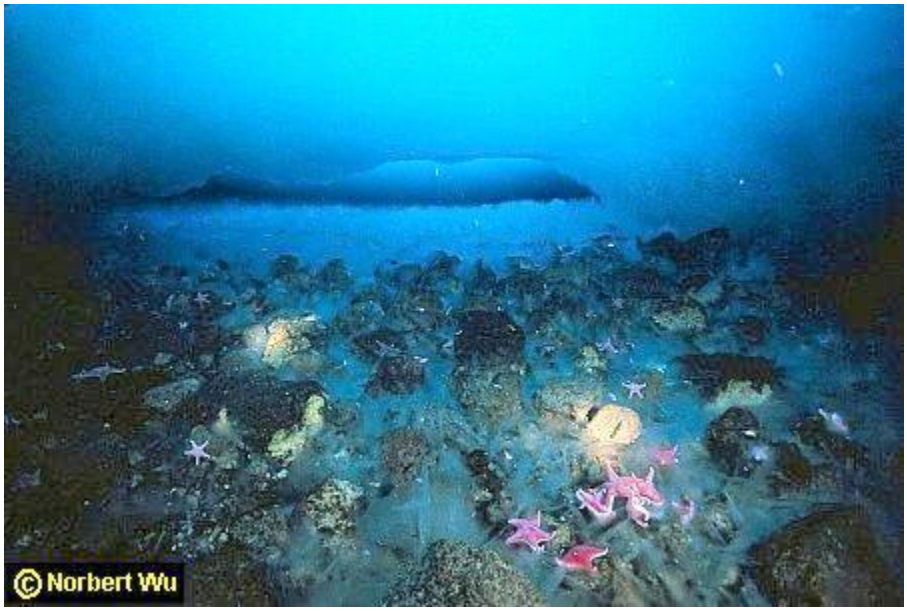
Less deluxe would be diving out in the open. Here's a shot from a sea ice crack opened up a bit with chipping bars to allow divers to enter and exit the water. Though sunny outside, the biting wind combined with the cold air temperature requires divers to bundle up for warmth when out in the open between 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.

References: 1: Rob Robbins, personal communication, 1999; **2:** Jim Mastro, personal communication, 1999
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



ANCHOR ICE ....

clear jagged plate-like ice carpeting the seafloor in crystalline sheets and fastened to submerged objects like rocks, gravel, and animals. Anchor ice forms on the seafloor at depths shallower than 33 meters, and most significantly at depths shallower than 15 meters. Under the sea ice, anchor ice plays a key role in the shallow benthic ecosystem as a natural physical disturbance.

In deeper water seawater cools below the surface freezing point. When the seawater is upwelled to shallower water and pressure is reduced, it drops below the in situ freezing point and anchor ice freezes out. However this does not fully explain such a well-defined lower limit of ice formation, and the shoaling and freezing of supercooled deep water originating below the ice shelf may be at work. When anchor ice grows large enough to become buoyant and break free, chunks of it float slowly up and join the platelet ice on the undersurface of the sea ice ceiling.

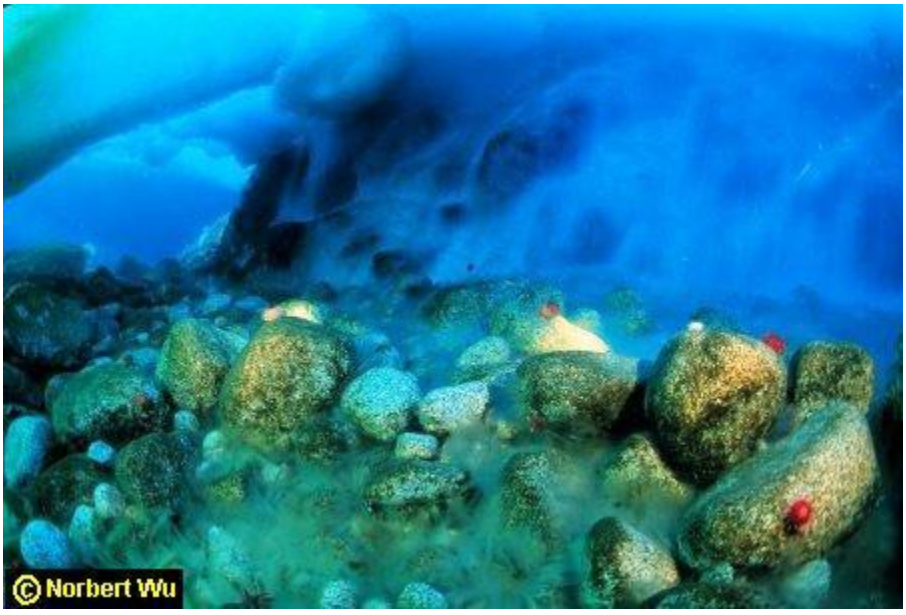
Anchor ice forms wherever conditions are suitable and that may be on or around a slow-moving or sessile organism. Anchor ice can entrap sea urchins, seastars, worms, isopods, sea spiders, sponges, and other animals as well as algae, rocks, and sediment. Animals may remain alive surrounded by an ice prison, or become frozen and killed. When an anchor ice mass becomes bouyant, it lifts off the bottom carrying its entrapped organisms up to the sea ice ceiling. Some become a food source for animals and bacteria under the sea ice ceiling. Some get frozen into the sea ice ceiling or may rain back down to the bottom some distance from where they floated up. Anchor ice also serves as a refuge from predators with its numerous small cracks, crevices, and caves.

References 1: Polar Biology 8:377-391, 1988; **2:** Science 163(3864):273-274, 1969; **3:** Science 167(3915):171-172, 1970; **4:** Deep Sea Research 21(3):169-174, 1974

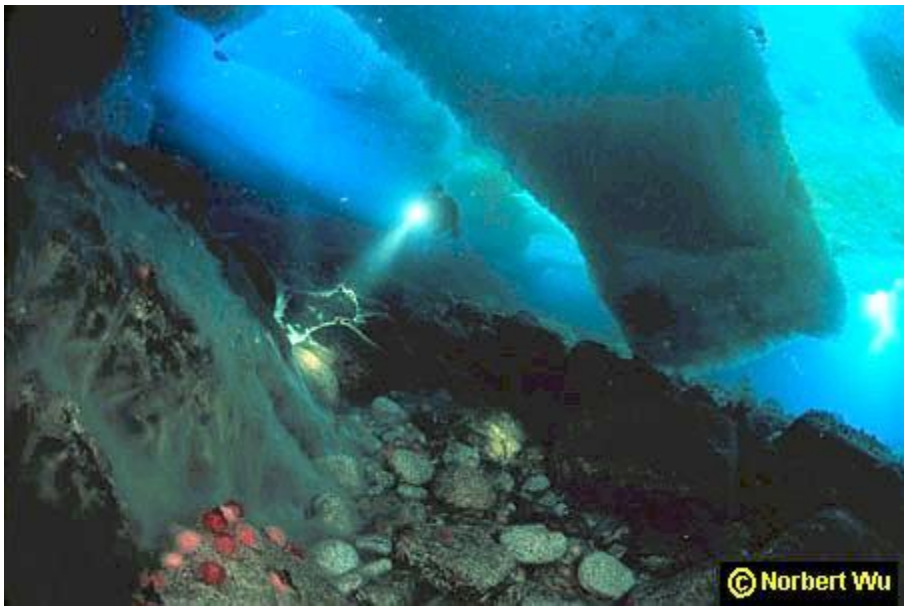
COULOIR CLIFFS at Granite Harbor…

are granite cliffs, three miles long and from thirty to sixty meters high, at the east side of Avalanche Bay in Granite Harbor, Victoria Land (lattitude 77°01'S; longitude:162°48'E). That's a diver field camp pitched on the frozen ocean near that base of Couloir Cliffs.

Couloir Cliffs were named by the Granite Harbor Geological Party, led by the geologist Griffith Taylor, of Robert Scott's British Antarctic Expedition (1910-13), because these cliffs have numerous chimneys and couloirs (a mountainside gorge). In summer 1911-1912, Taylor led a four-man field party on a survey of Victoria Land and finished their Granite Harbor work in the second week of January 1912.

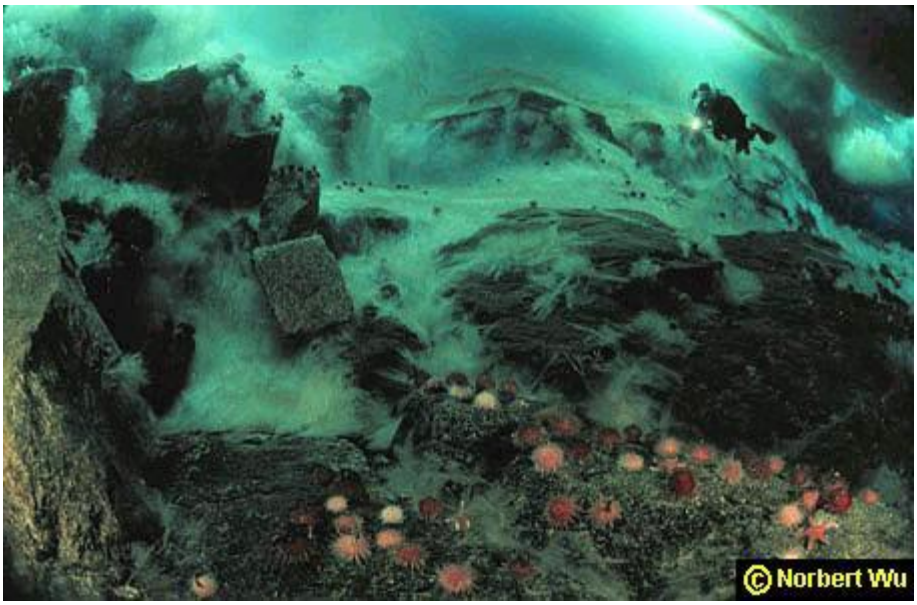


Steep rock walls underwater at Couloir Cliffs are coated with ice giving the appearance of an underwater ice waterfall. The bottom is fifteen feet deep next to the icefall in this picture and covered with rocks and boulders and anchor ice.



The exposed rock topside soaks up warmth from the sun, melting the covering snow. This underwater ice cliff may be formed from this meltwater migrating through permeable rock and freezing when it encounters cold seawater, or it may be formed from a very cold underwater rock mass freezing seawater.

A huge ice mound hung down from the sea ice ceiling and touched bottom. The underside of the sea ice ceiling is not always flat; it can be mounded and there can be scattered stalactites.



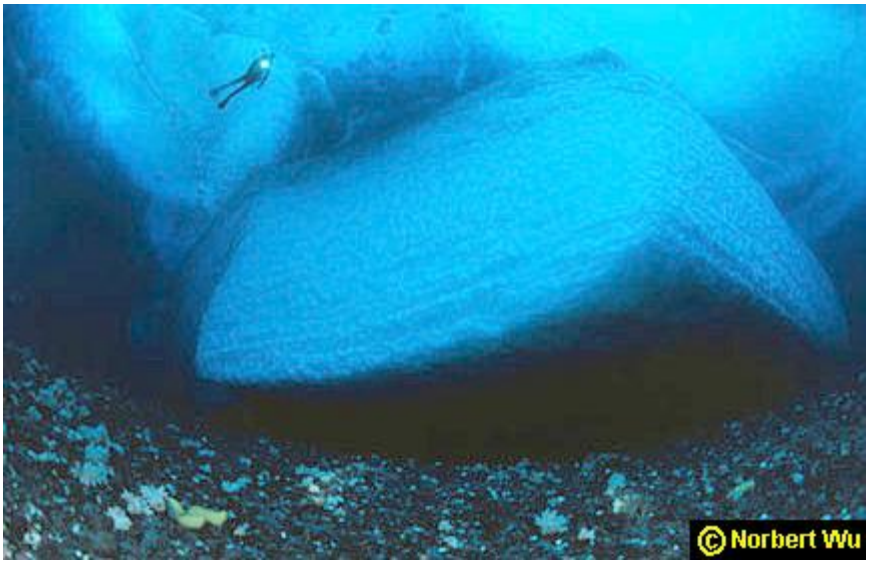
The sea urchin *Sterechinus neumayeri* is a ubiquitous scavenger in shallow water here at the Couloir Cliffs icefalls. The urchins are in right foreground of this photo. Animals trapped in the frozen icefall are a food source. Nearby there was a long nemertean worm frozen in place on the icefall suggesting that it had been crawling along when meltwater streamed down over it and froze it in place. It was a frozen meal awaiting the arrival of the urchins.

The *Sterechinus neumayeri* urchins look for food on the bottom and up on the icefall itself. The brown color of the icefall is due to diatoms which the urchins scrape off and eat.

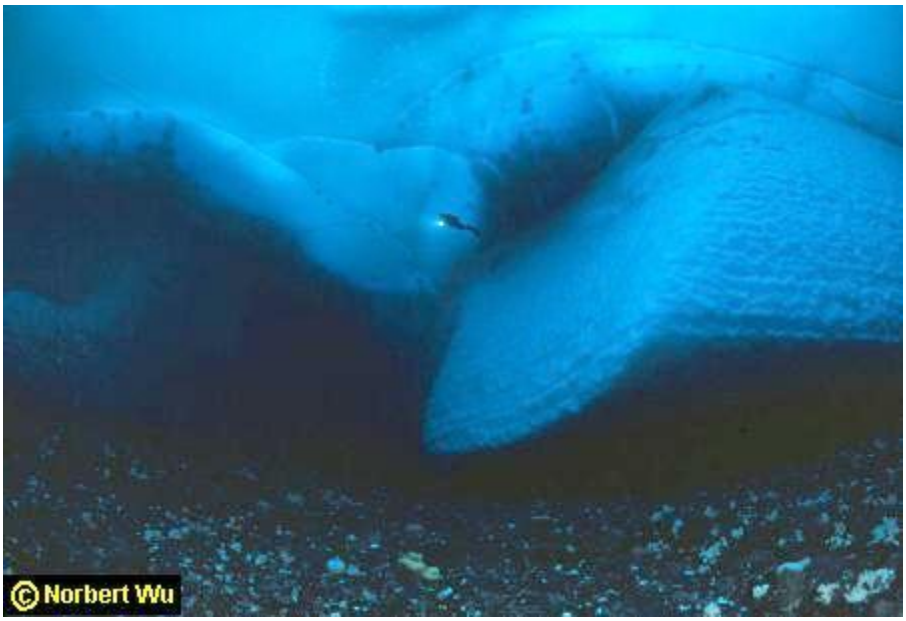
GROUNDED ICEBERGS…..

Icebergs are large masses of floating ice calved from the fronts of glaciers or from permanent ice shelves. Pushed along by wind and mostly by the prevailing current, icebergs become grounded in shallow coastal water by plowing into the seafloor, just like a ship running aground.

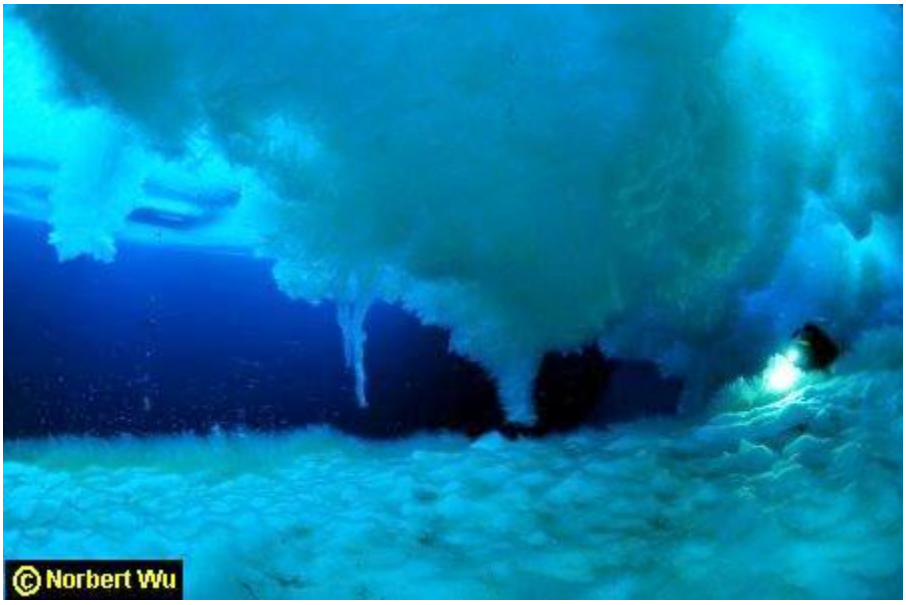
When the ocean freezes over in winter, the grounded iceberg is locked in by the surrounding sea ice. This grounded iceberg was just south of Cape Evans on Ross Island. It is about two hundred feet long with about forty feet of iceberg showing above the sea ice.



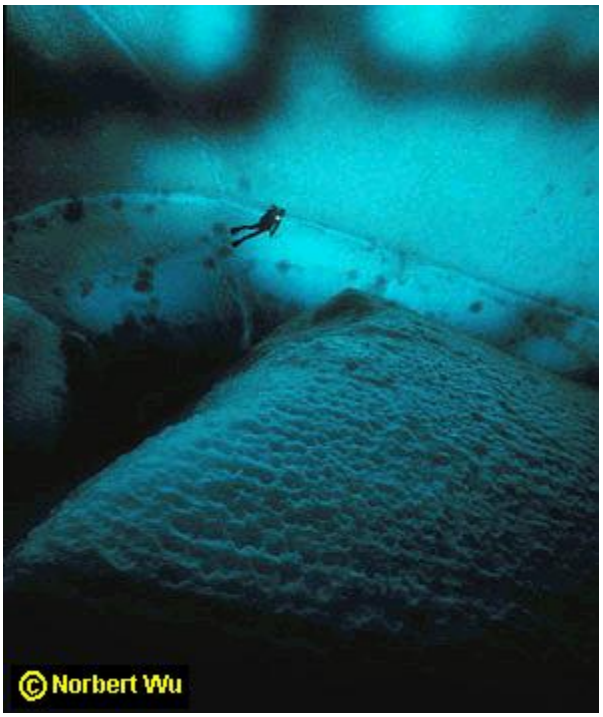
The keel of the grounded iceberg causes gouges, scouring and plow marks on the sea floor. This natural physical disturbance of the seafloor, along with seafloor disturbance caused by anchor ice and drift ice, contributes to making shallow water undesirable for sessile (attached) organisms.



The iceberg is a solid wall of ice all the way to the bottom, 90 feet deep at the dive hole. This iceberg cut a large trench into the bottom when it drifted towards shore and ran aground; it is about 120 feet deep near the trench. How deep can icebergs scour the bottom? Tabular icebergs (flat-topped bergs that break away from ice shelves) can have a draft down to 330 meters depth; non-tabular icebergs (bergs from glaciers) and tilted tabular icebergs are the majority of Antarctic icebergs and can increase their draft 50% by rolling, so their draft may go down to 500 meters depth [1].



Icebergs may possess underwater spurs and ledges which extend a considerable distance from the visible topside portion of the iceberg. Here a diver explores the shallower reaches of the Cape Evans grounded iceberg which has a shelf of ice that sticks out at about the twenty foot level. The shelf is covered in ice algae and loaded with bright red amphipods grazing for food. These amphipods in turn attract fish that feed upon them.



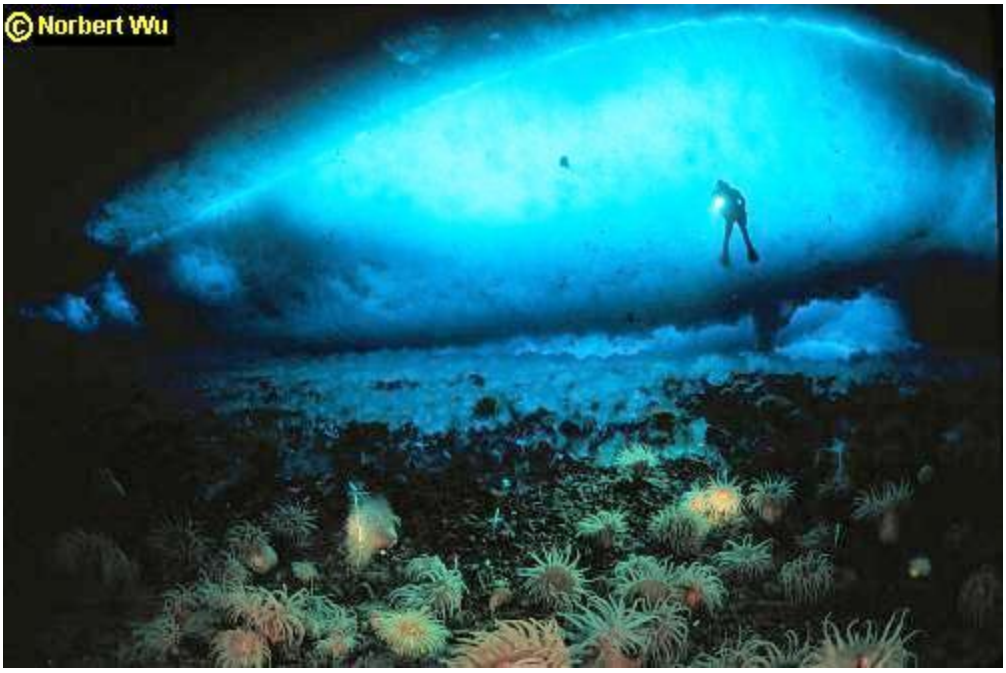
Diving under the ice on a grounded iceberg is a visually stunning experience !

References: **1:** Antarctic Journal of the United States 30(5):130-131, 1987

SEAFLOOR ZONATION….

Zone 1: Natural physical disturbances of the seafloor in shallow water under fifteen meters in depth make it undesireable for sessile (attached) organisms. Ice is the dominating influence, not predation. The formation of anchor ice on the seafloor can smother and kill sessile and motile organisms. As the anchor ice becomes buoyant enough to float free, it can lift entrapped organisms off the bottom and imprison them in the sea ice ceiling. In addition, the seafloor is scoured by drift ice (and icebergs) pushed in by winds and currents. This shallow zone appears devoid of invertebrate life with only motile organisms found. There is an absence of competition for food and space and little predation; the animals present are predominately detritus feeders. Common occupants are seastars and sea urchins and other motile organisms like fish, sea spiders, and nemertean worms may be found.

Weddell seal feces and the occasional seal pup carcass (as shown here) provide a rich food resource in shallow water under fifteen meters in depth (Zone 1). Seastars and urchins swarm in to feed and long nemertean worms join in as well.



Zone 2: In water from fifteen meters depth down to thirty-three meters depth, much less anchor ice forms and the seafloor is below the scouring effect of drift ice. The reduced impact of anchor ice affords anemones an opportunity to attach to the seafloor. The invertebrate fauna has numerous sessile (attached) organisms and is predominated by cnidiarians: anemones, soft coral, hydroids, hydrozoans, etc. Also found are ascidians (tunicates), fish, seastars, sea urchins, nemertean worms, and sea spiders. This picture shows the demarcation between Zones One and Two: anchor ice above and anemones below.

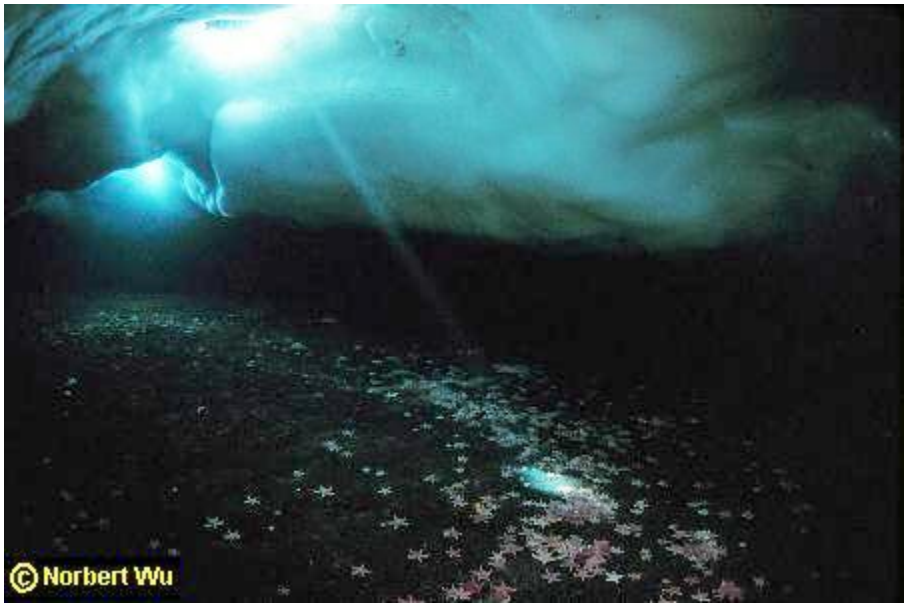
Zone 3: Where anchor ice ceases to form in water below thirty-three meters depth, the seafloor community changes dramatically. Sponges dominate this zone below thirty-three meters and there is a rich and diverse community of invertebrates. This zone is physically stable being below the depth of anchor ice formation. This stability encourages the development of a complex, diverse community regulated primarily by predation (rather than physical factors as in Zones 1 and 2). The seafloor is covered with a mat of sponge spicules laid down by many generations of sponges. Seastars are the most conspicuous motile animal in this zone and some of them are sponge predators.

References: 1: Ecological Monographs 44(1):105-128, 1974; **2:** Antarctic Ecology, Volume 1. MW Holdgate, ed. NY: Academic Press, 1970. pp244-258; **3:** Science 163(3864):273-274, 1969

SEA ICE MICROBIAL COMMUNITY….

The fish *Trematomus borchgrevinki* perches on a grounded iceberg just south of Cape Evans on Ross Island. The surface of the ice is covered with a sea ice microbial community comprised of diatoms and other microalgae, bacteria and protozoans. The brown coloration is due to photosynthetic pigments in the microalgae. Crustaceans and molluscan pteropods graze on the microalgae and fish prey on the crustaceans. Antarctica in the area of McMurdo Sound is continuously dark for four months in the winter and continually light for four months in the summer; these are separated by two-month transition periods in which the light increases or decreases by twenty minutes per day [1]. To the human eye, lighting can be dim under the sea ice. The sea ice reduces light as does its overlying snow cover and the organisms living on its underside. At noon during McMurdo Sound summer, the sea ice undersurface receives less than 1% of the sun's irradiance [2]. This isn't much light to use for photosynthesis yet the sea ice microalgae have adapted. Called cryophiles for their ice lifestyle, the sea ice microalgae live in low light intensity and make a significant contribution to primary productivity under the ice [2].

References: 1: Science 238:1285-1288, 1987; **2:** Polar Biology 2:171-177, 1983



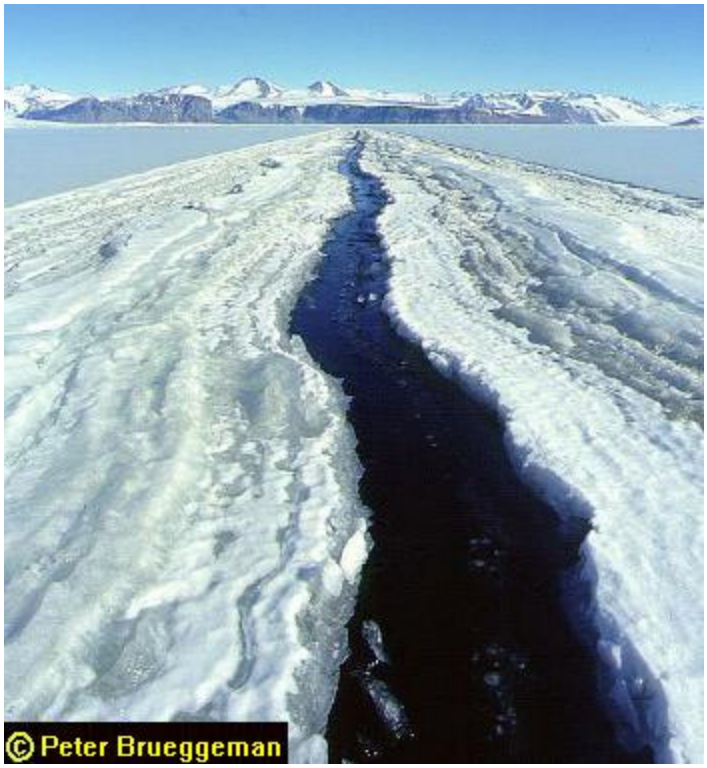
SUNBEAMS UNDER THE ICE….

Sunbeams are seen by the diver under sea ice cracks on a sunny day. The word "sunbeam" is commonly used for rays of light formed by the shadows of scattered clouds in the atmosphere. When sunbeams form from the sun shining through a gap in the clouds, they are bright; bright sunlight streaming through sea ice cracks is analogous. Other names for sunbeams are "crepuscular rays", "Buddha's fingers", "ropes of Maui", "sun drawing water", and "backstays of the Sun." The contrasting light scattering by seawater inside and outside the sunbeam makes the sunbeam visible to the diver. Depending on the sea ice crack, the sunbeam may strikingly illuminate the seafloor with a spot beam, a long band of light, or both in combination.

Sunbeams are usually one or more shafts of light appearing to diverge from the sun. Sunbeams are parallel and the viewer's perspective makes them appear to diverge due to the small distance of the viewer to the sunbeams compared with his distance from the sun.

Sunbeams have been depicted in Western art since medieval times where they were sometimes shown emerging from a gap in the clouds created by the hand of God. When Western painting increasingly depicted cloud cover after 1500, sunbeams have been painted realistically and were no longer shown simply as thin lines.

References: 1: Journal of the Optical Society of America A, Optics and Image Science 4(3):609-611, 1987; **2:** Applied Optics 30(24):3514-3522, 1991



SEA ICE CRACKS….

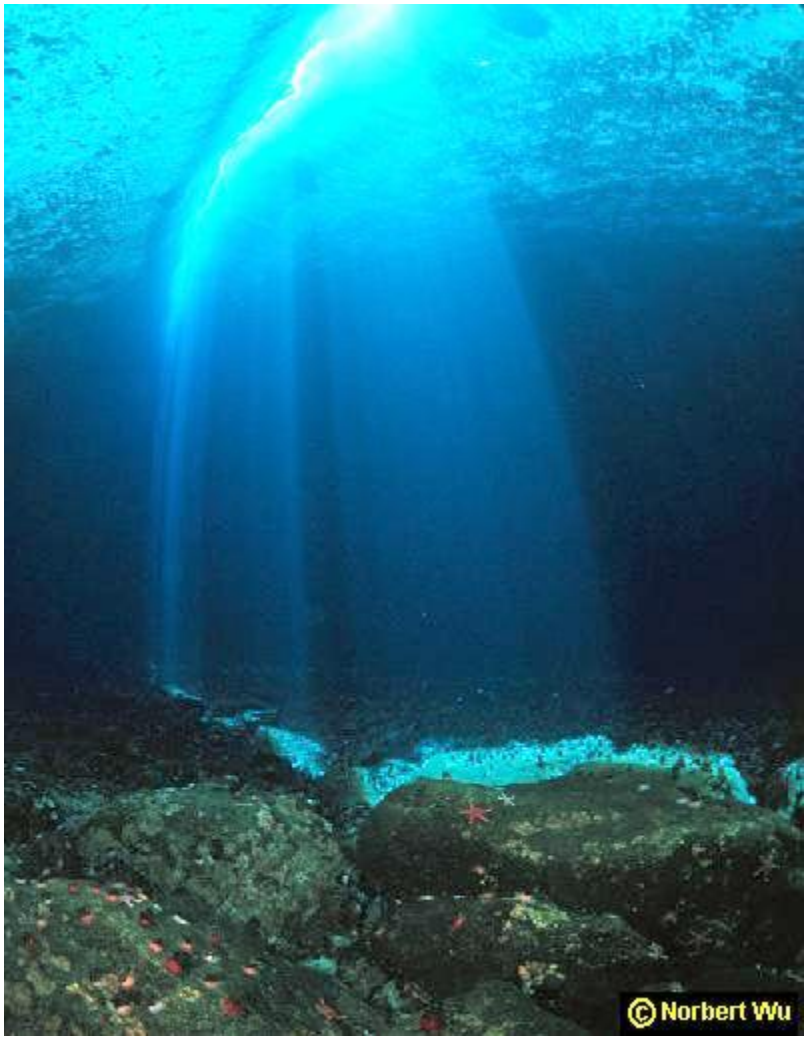
Sea ice cracks are either blatantly obvious or spotted as roughly straight raised features on the sea ice. A sea ice crack can be jammed closed or still open with snow drifted over obscuring its presence visually. This sea ice crack was at Couloir Cliffs at Granite Harbor and its open stretch was about a half meter across. The sea ice surrounding a crack becomes reduced in thickness approaching the center of the crack and field teams have to be vigilant when approaching a sea ice crack. Ice drills are used to determine the thickness of the sea ice surrounding a crack if a crack is questionable for supporting the passage of tracked vehicles.

Sea ice cracks form due to forces working on the sea ice sheet. Ice sheets move in response to current and wind and they rise and fall with tidal rhythms. Deposition of snow by wind builds up pressure on the sea ice surface. Waves move into shallow water, increase in height and cause stress in the overlying ice sheet. Where the ice sheet comes in contact with an island or shoreline, sea ice cracks and pressure ridges will be evident. When a fast moving ice sheet comes into contact with a slow moving or stationary ice sheet, a pileup of ice blocks of angular shapes may form.

Sea ice sheets fold, fault and crumple; they compress and stretch. Sea ice cracks are an inevitable result. Here is a tidal pressure ridge at the Cape Evans shoreline with the Royal Society Range in the background across McMurdo Sound. Tidal sea ice cracks are observed near sea ice bound to a shoreline; tidal action lifts the sea ice sheet above or below the level at which it is bound to the shoreline. Pressure ridges or blocks may jut up from these shoreline cracks. Sea ice cracks tend to form parallel to shore at a distance dependent on the sea ice thickness; they open, refreeze and reopen and are of variable width.

The Weddell seal depends on sea ice cracks in stable contiguous sea ice for breathing and for entry/exit. The Weddell seal keeps a hole open year round with its teeth; its strong teeth project forward and are used to ream ice. Here a Weddell sea mother and pup sun themselves next to a sea ice crack; the sea ice blocks in the background were thrown up by forces on the sea ice sheet.

Weddell seal mothers and pups float in shallow water under a sea ice crack near where the mother gave birth to the pup. The seals' entry/exit/breathing holes in the sea ice crack are visible as bright lights above them. When young, pups do not swim very far away from the hole in which they enter and exit the water.



Sea ice cracks break up the deep blue visual continuity of the sea ice ceiling for the diver. On sunny days, sunbeams may stream down through open sea ice cracks and illuminate the seafloor with a band of light. Sea ice cracks that are jammed closed are seen by the diver as a light fine line running along the sea ice ceiling.

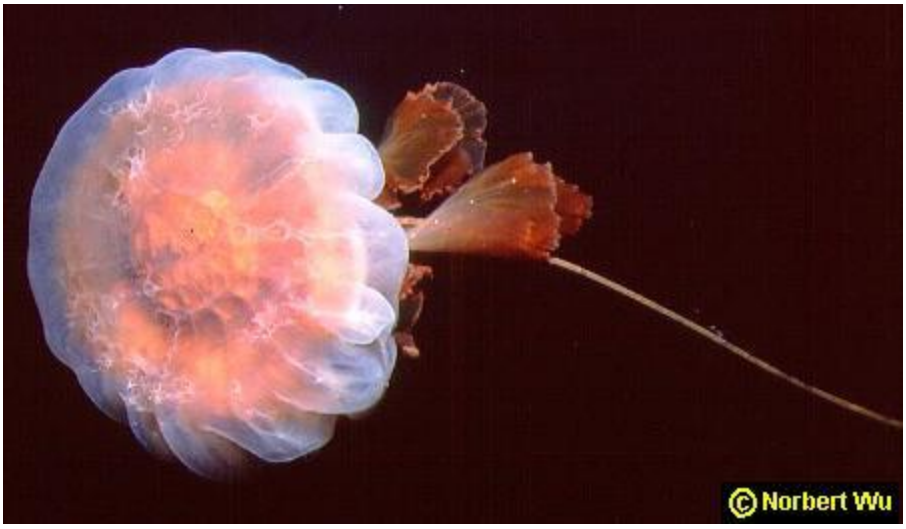
References: 1: Ice Shelves of Antarctica. NI Barkov. Washington DC: Office of Polar Programs, National Science Foundation, 1985; **2:** Ice and Snow: Properties, Processes, and Applications. Proceedings of a Conference held at the Massachusetts Institute of Technology, February 12-16, 1962. WD Kingery, ed. Cambridge, Massachusetts : MIT Press, 1963. pp.322-334

FAST ICE EDGE…

McMurdo Sound is covered by sea ice for 10-11 months of the year. Fast ice is sea ice which forms and fastens to the coastline; the boundary between fast ice and open ocean is the fast ice edge. The fast ice edge is dynamic; sea ice cracks form and enlarge while ice floes (large relatively flat pieces of sea ice) break off. Drifting ice crunches up against the fast ice edge piling up angular ice blocks. Emperor and Adelie penguins can be seen in small groups taking rest breaks between group fishing excursions. Predators are on the prowl for penguin prey. In this photo, killer whales *Orcinus orca* cruise in a pack along the McMurdo Sound fast ice edge looking for penguin prey. Leopard seals *Hydrurga leptonyx* also hunt along the fast ice edge. In mid-November when this photo was taken, the fast ice edge joined Ross Island at Cape Royds; Mt Erebus is in the background.

The diver looks up at a sharp vee in the fast ice edge and sees swimming Emperor penguins. Emperor penguins swim in groups to increase their safety from predators. Emperor penguins eat fish, squid, and euphausid and amphipod crustaceans which they dive and pursue to capture at speeds up to 3.4 meters per second.

References: 1: The Penguins, Spheniscidae. TD Williams. Oxford : Oxford University Press, 1995. pp.152-160



GELATINOUS ZOOPLANKTON…

Weddell seals cruise by underwater but gelatinous zooplankton -- medusae (jellyfish), siphonophores, salps, ctenophores (comb jellies), and some molluscs -- are the most prominent midwater organisms seen by divers under the ice near McMurdo Station. Gelatinous zooplankton refers to a general grouping of animals that are well adapted to life in open water and that lack rigid skeletal structures [6]. Gelatinous zooplankton can be quite small and so transparent that a diver's underwater light is needed to see and highlight their bodies; others can be longer than a diver. Gelatinous zooplankton are more numerous near the ice edge or in open water than under the McMurdo Sound sea ice but there are plenty to see while diving [1] Large gelatinous carnivores, like ctenophores and the medusa *Desmonema glaciale* shown here, are a predominant and sometimes the main component of the macroplankton and nekton community in the Southern Ocean surrounding Antarctica [3,4]. Gelatinous carnivores are important components of the food web because they are a control mechanism for its structure [6].

Here, the diver shoots underwater video of the medusa *Desmonema glaciale*, drifting along with the prevailing current. *Desmonema glaciale* occurs near the surface in Antarctic continental shelf waters and its bell can be over one meter in diameter [5].

The larger medusae are active swimmers and more properly classified in the nekton than the plankton.

The sea butterfly *Clione antarctica* is a free-swimming shell-less pteropod mollusc up to 4.2 centimeters long [7]. *Clione antarctica* is commonly found in McMurdo Sound near the undersurface of the sea ice and is sparse in water deeper than twenty meters [7].

Clione antarctica preys on a planktonic shelled pteropod mollusc *Limacina helicina* [7]. *Clione antarctica* is also part of a unique relationship with the hyperiid amphipod *Hyperiella dilatata*; this amphipod holds onto *Clione antarctica*, using it to chemically defend itself from predators [10].

The ctenophore or comb jelly *Beroe cucumis* completely engulfs prey as large as itself; larger prey are bitten into pieces with bundles of fused cilia lining the inner lips [8].

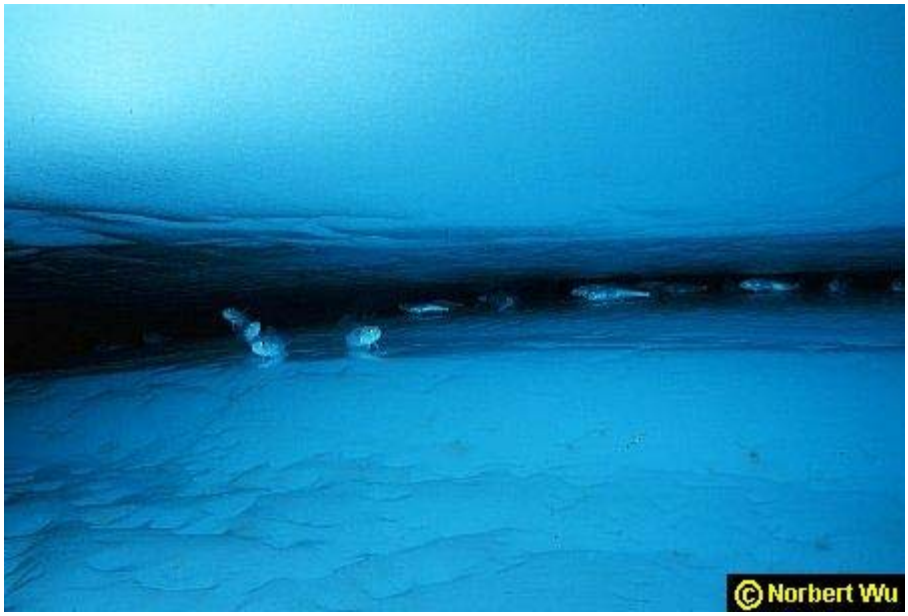
In the open ocean, there is no place to hide from predators so gelatinous zooplankon appear to use their transparency to hide in a transparent environment [6].

Some gelatinous zooplankon are carnivores while others are particle feeders or herbivores, like this shelled pteropod mollusc *Limacina helicina* which filter feeds on phytoplankon [6,9].

Medusae brush the bottom in shallow water and are captured by the tentacles of anemones like *Urticinopsis antarcticus* or, as shown here, *Isotealia antarctica*, devouring the medusa *Periphylla periphylla* [2]. The struggle continues for quite awhile; the medusa pulses its bell as it tries to swim away while the anemone slowly pulls the medusa into its mouth.

Oftentimes, two adjacent anemones pull in different directions while devouring the same medusa -- a slow-motion tug of war. It may be that the initial capture and struggle with one anemone leads to the medusa bumping into an neighboring anemone and getting captured by that neighboring anemone as well.

References 1: Antarctic Journal of the United States 23(5):135-136, 1988; **2:** Antarctic Ecology, Volume 1. MW Holdgate, ed. NY: Academic Press, 1970. pp. 244-258; **3:** Marine Ecology Progress Series 141(1-3):139-147, 1996; **4:** Annales de l'Institut Oceanographique 73(2):139-158, 1997; **5:** Pelagic Scyphomedusae (Scyphozoa: Coronatae and Semaeostomeae) of the Southern Ocean. RJ Larson. Washington, DC: American Geophysical Union, 1986; **6:** Annales de l'Institut Oceanographique 73(2):123-124, 1997; **7:** American Malacological Bulletin 8(1):67-75, 1990; **8:** Guide to the Ctenophores of the Southern Ocean and Adjacent Waters. D O'Sullivan. ANARE Research Notes No.36. Kingston, Tasmania : Australian National Antarctic Research Expeditions, 1986; **9:** Polar Biology 8(1):41-48, 1987; **10:** Nature 346:462-464, 1990



How do these fish keep from freezing?.....F**ISH ANTIFREEZE**

Trematomus borchgrevinki lives in upper six meters of water swimming beneath the sea ice undersurface and entering it to feed and take refuge. In McMurdo Sound, the 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). Ice grows in the uppermost thirty meters of McMurdo Sound during spring and early summer when water temperature is below the seawater freezing point [1]. Ice formation decreases with increasing depth due to the effect of pressure on the freezing point. Shallow water fish have evolved to live in close association with ice. *Trematomus borchgrevinki* (& all notothenid fish in McMurdo Sound) are protected by glycopeptide and peptide antifreeze compounds which lower the freezing point of their body fluids below the freezing point of seawater [2,5]. These compounds are synthesized in the liver, secreted into the blood, and distributed to body fluids where they prevent freezing by adsorbing to, and inhibiting the growth of ice crystals [3,5]. These fish actually have ice present on their external tissues (integument, gills, and intestinal tract) while their internal tissues (except the spleen) are ice-free [1]. The presence of ice in the spleen suggests that the spleen removes ice crystals from the fishes' circulation [1].

These antifreeze compounds are being commercially marketed for product development by A/F Protein; their web site mentions several potential applications, including cell protection during cold storage (animal and human eggs, blood platelets) and improved quality of frozen foods [4].

References: 1: Freezing Avoidance and the Presence of Ice in Shallow Water Antarctic Fishes. R Tien. PH.D. dissertation. University of Illinois at Urbana-Champaign, 1995; **2:** Science 172:1152-1155, 1971; **3:** Antarctic Communities: Species, Structure and Survival. B Battaglia, J Valencia and DWH Walton, eds. Cambridge: Cambridge University Press, 1997. pp.202-208; **4:** www.afprotein.com; **5:** Water and Life : Comparative Analysis of Water Relationships at the Organismic, Cellular, and Molecular Levels. GN Somero, CB Osmond, CL Bolis, eds. New York : Springer-Verlag, 1992. pp. 301-315

Gigantism…… Why do some Antarctic marine invertebrates seem to be unusually large compared to related species elsewhere?

Shown here is a crustacean, the giant Antarctic isopod *Glyptonotus antarcticus*. Only those Antarctic benthic invertebrates whose growth is not hampered by calcium deficiency seem to reach a large size [1]. Those using little calcium are arenaceous foraminifera, crustaceans, and tubicolous polychaete worms; those not using calcium are hydroids, nudibranchs, ascidians, and many polychaete worms [1].

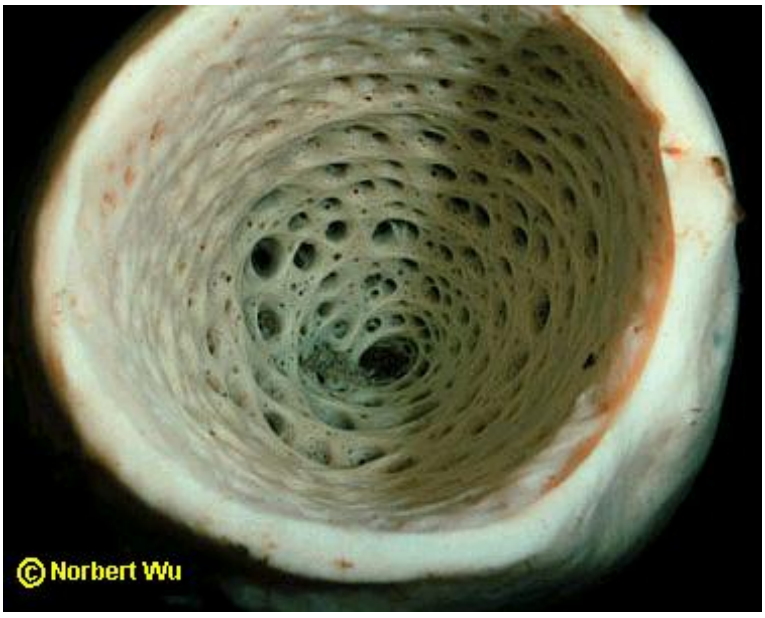
Why is calcium an issue? It is difficult to precipitate calcium carbonate at low temperatures and as a result, Antarctic calcareous (calcium-using) invertebrates like molluscs, echinoderms, and bryozoans are usually very fragile [1]. Extracting calcium carbonate for shell building and maintenance requires more energy than in warmer waters [8]. Antarctic invertebrate animal groups that are physically small include calcareous foraminifera, prosobranch gastropods (have calcareous shells), bivalves (have calcareous shells), scaphopods, and brachiopods (have calcareous shells) [1]. When an organism in very cold water isn't hampered by a need for calcium, gigantism can be a consequence of a slow rate of development and growth [1]. Biochemical processes relating to growth are influenced by temperature; slower growth occurs in colder water and sexual maturity is somewhat delayed, with a resulting larger adult body size [1,7].

Here is a pile-up of the proboscis worm *Parborlasia corrugatus*, which grows up to two meters in length; it is chemically defended by an acidic mucus (pH 3.5) which potential predators avoid [2,4].

When an organism in very cold water isn't hampered by a need for calcium, gigantism can be a consequence of low predation pressure --- when predation and competition for food within one's own species are low, organisms grow to a larger size, and to an older age [1,7,8].

This siliceous hexactinellid sponge *Scolymastra joubini* can be up to two meters high and 1.4 meters in diameter [5].

When an organism in very cold water isn't hampered by a need for calcium, gigantism can be a consequence of a high abundance of available silica --- siliceous organisms like radiolarians, hexactinellid sponges, and diatoms can reach large sizes because the availability of silica is not a limiting factor in Antarctic waters [1].

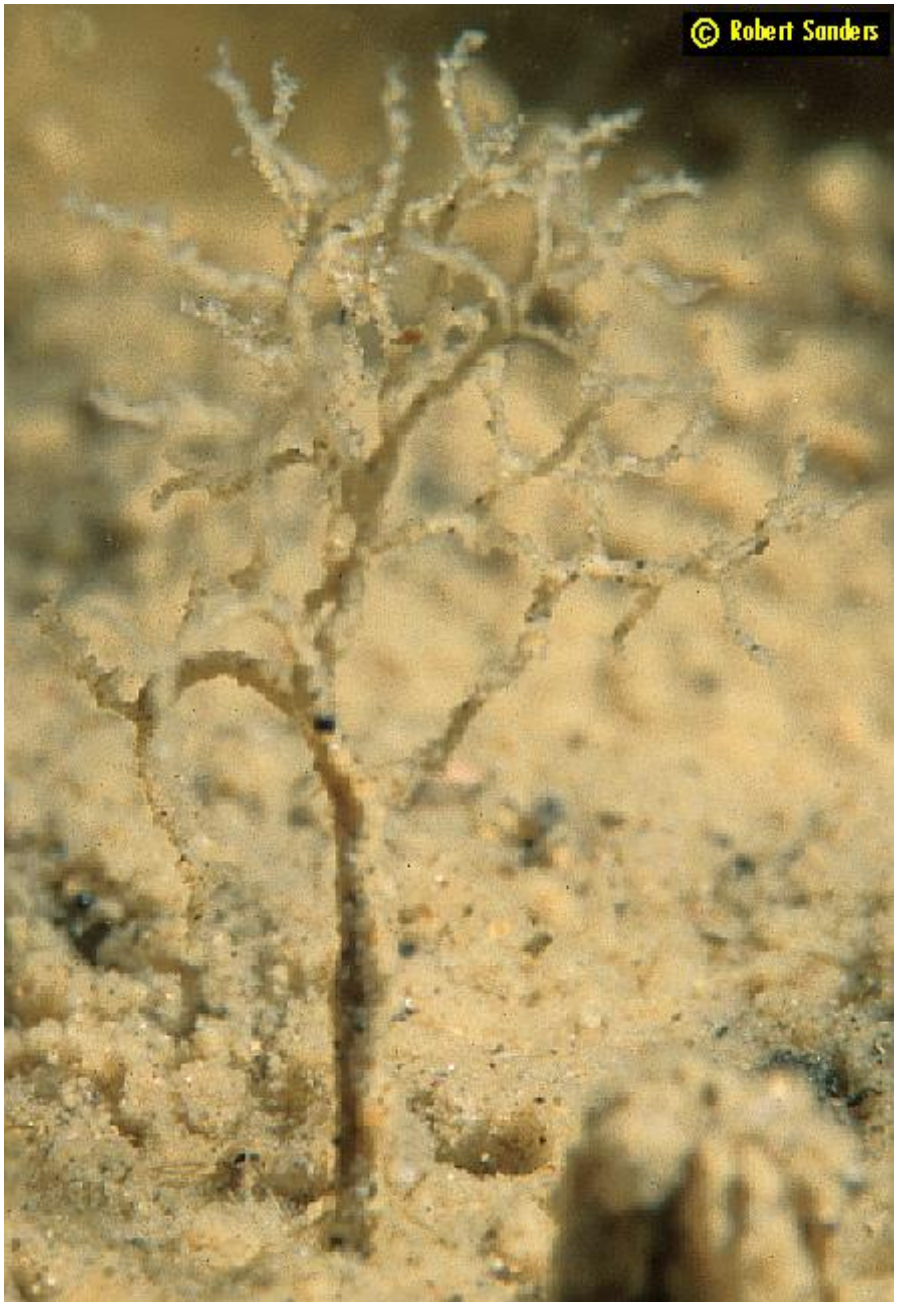


Here is the inside of the volcano sponge *Scolymastra joubini* (which, as mentioned above, can be up to two meters high and 1.4 meters in diameter) [5].

As shown here, a cold-water animal can increase its body size by constructing a silica lattice skeleton occupying a large volume; this huge lattice skeleton could not be constructed with calcium carbonate in cold water due to the calcium precipitation problem [3].

Here is the sea spider or pycnogonid *Colossendeis australis*. This sea spider shows how an animal can increase its body size with little building effort simply by elongating its appendages; it occupies a large amount of space with very little body mass [3].

This serolid isopod illustrates how body size can be increased by flattening to occupy more two-dimensional space; flattening helps an organism minimize sinking into a fine-grained soft bottom on which it may live [3].



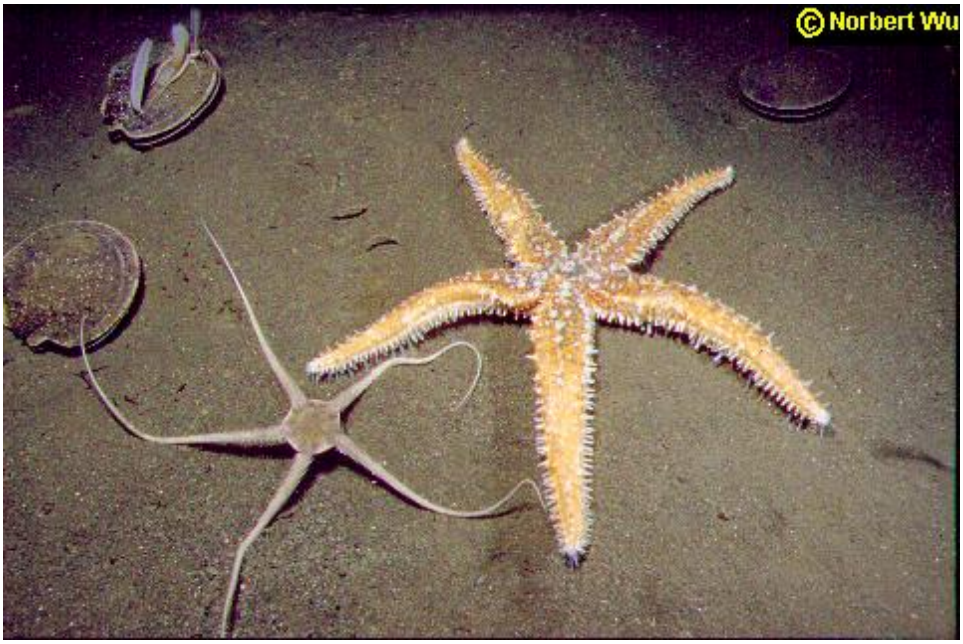
This giant arborescent agglutinated foraminiferan *Notodendrodes antarctikos* stands up to 3.8 centimeters high -- remarkably large for a unicellular organism [6].

Relatively large body size can be gained by using prefabricated building blocks, as in the sediment grains glued together by this foraminiferan *Notodendrodes antarctikos* [3].

References 1: Adaptations within Antarctic Ecosystems, Proceedings of the Third SCAR Symposium on Antarctic Biology. GA Llano, ed. Washington DC : Smithsonian Institution, 1977. pp. 135-157; **2:** Biology of the Antarctic Seas XIV, Antarctic Research Series 39(4):289-316, 1983; **3:** The Environment of the Deep Sea, Rubey Volume II. WG Ernst & JG Morin, eds. Englewood Cliffs, NJ : Prentice-Hall, 1982. pp. 324-356; **4:** Journal of Experimental Marine biology and Ecology 153(1):15-25, 1991; **5:** Ecological Monographs 44(1):105-128, 1974; **6:** Zoological Journal of the Linnean Society 69(3):205-224, 1980; **7:** Adaptations within Antarctic Ecosystems : Proceedings of the Third SCAR Symposium on Antarctic Biology. GA Llano, ed. Washington : Smithsonian Institution ; Houston, Tex. : distributed by Gulf Pub. Co., 1977. pp. 327- 334; **8:** The Biology of the Southern Ocean. GA Knox. New York : Cambridge University Press, 1994. pp.193-220

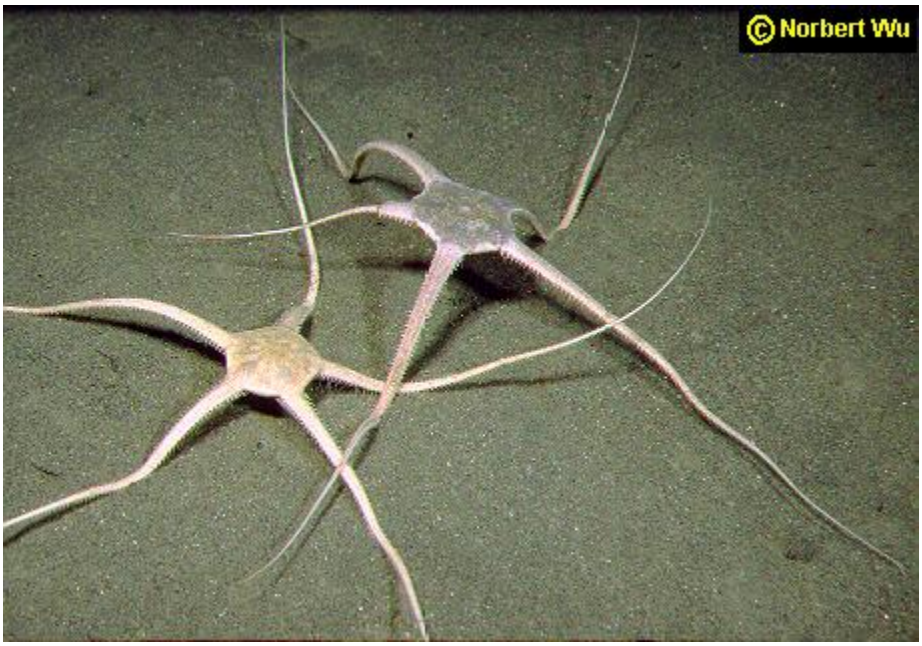
Explorer's Cove is at the northwest head of New Harbor, on the western side of McMurdo Sound (Ross Island with McMurdo Station is on the eastern side of McMurdo Sound). Explorer's Cove was named by the US Advisory Committee on Antarctic Names in recognition of the large number of explorers that have worked in area. New Harbor was discovered by Scott's British National Antarctic Expedition (1901-1904) and was named because this new harbor was found while the *Discovery* was seeking a southernmost anchorage along the coast of Victoria Land.

Here at Explorer's Cove, the crinoid *Promachocrinus kerguelensis* is perched on a large volcano sponge *Anoxycalyx (Scolymastra) joubini*, surrounded by a muddy sandy bottom. The criniod is perched up high to better position itself for filter feeding where it can take advantage of near-bottom currents. The crinoid's arms are edged with feathery pinnules containing sensory tube feet and reproductive organs; the arms are used to trap drifting plankton and they have grooves down which food particles are carried by hair-like cilia to the upward-facing mouth. On the left of the sponge is the Antarctic scallop *Adamussium colbecki* and on the right is the brittle star *Ophionotus victoriae*.

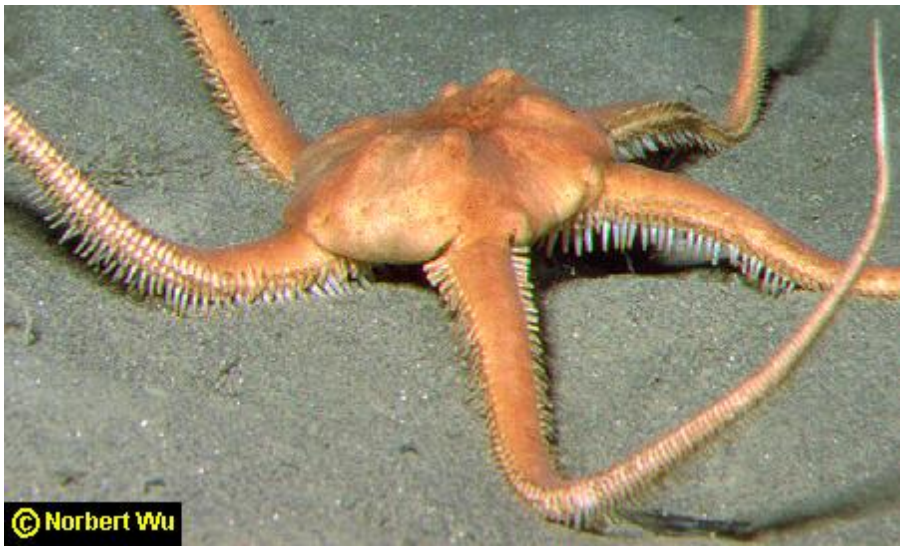


Here is a typical bottom scene at Explorer's Cove: Antarctic scallops *Adamussium colbecki* (on the left and upper right); the brittle star *Ophionotus victoriae* (in the middle); the seastar *Notasterias armata* (on the right). The western side of McMurdo Sound which includes New Harbor differs ecologically from the eastern McMurdo Sound along Ross Island [1]. The large shallow-water filter feeders seen along Ross Island are relatively rare at New Harbor and along western McMurdo Sound; there are fewer benthic species and benthic animal densities are an order of magnitude less compared to the eastern McMurdo Sound [1]. Bathed by a northerly current from under the permanent Ross Ice Shelf and more completely covered throughout the year by sea ice, New Harbor is a food-scarce environment (oligotrophic) and doesn't experience the plankton blooms as does eastern McMurdo Sound [1].

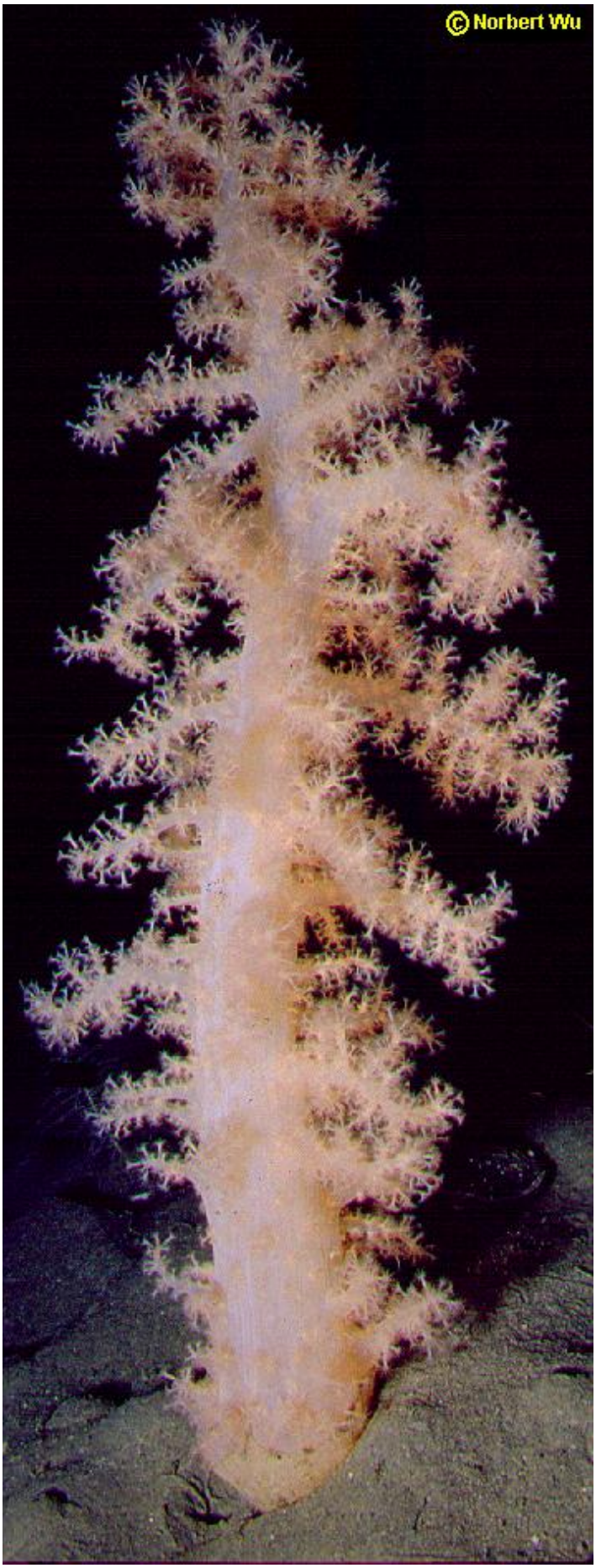
Here at Explorer's Cove is a pencil urchin *Ctenocidaris perrieri* surrounded by Antarctic scallops *Adamussium colbecki*. New Harbor has been described as similar to a deep sea environment, with a soft bottom with occasional biological structures like sponges and foraminiferans, fecal pellets, and depressions left by animals [1]. The Antarctic scallop *Adamussium colbecki* is the dominant species in shallow water and frequently found in shallow depressions it makes in the seafloor; this digging resuspends bottom detritus for filter feeding by *A. colbecki* [2,3]. As seen on the left here, juvenile *A. colbecki* are usually attached to larger individuals [2]. This survival enhancement for the juvenile *A. colbecki* gives them a better position for filter feeding in the water column where they can take advantage of water flow generated by adults as well as near- bottom currents [3]. The bush sponge *Homaxinella balfourensis* is seen attached to the spines of the pencil urchin. There is little hard substrate in Explorer's Cove so pencil urchin spines and scallop shells are what is available; the sponge's resulting elevated position as well as the urchin's movement undoubtedly facilitates its filter feeding.



Other similarities between New Harbor at 30-45 meters depth and the deep seafloor from 180 to 1800 meters depth (bathyal) are water temperature, constancy of physical environment, low terrestrial sedimentations, and the brittle star *Ophionotus victoriae*, which is similar to a particular deep sea brittle star in population density and distribution, size, and morphology [1]. *Ophionotus victoriae* uses its two leading arms in a typical brittle star rowing fashion as it moves on the seafloor searching for food [6].



The predatory brittle star *Ophiosparte gigas* moves quickly and efficiently on the muddy sand bottom of Explorer's Cove using its paddle-like arm spines and stilt-like tube feet [5]. *Ophiosparte gigas* preys on the brittle star *Ophionotus victoriae* above, which responds to *O. gigas* contact by quickly fleeing [6,7,8]. If successful in capture, *Ophiosparte gigas* holds the disc of *Ophionotus victoriae* under its own and clips off arms to ingest [7].



The nephtheid soft coral *Gersemia antarctica* is occasionally seen by the diver at Explorer's Cove.

Soft corals have internal skeletons consisting of calcium-containing needle-like spicules and are colonial, composed of numerous cylindrical polyps with mouths surrounded by eight tentacles. The tentacles are armed with harpoon-like stinging structures, called nematocysts, that paralyze prey.

G. antarctica colonies can inflate to over two meters in height [4]. .

In addition to an upright feeding posture, *Gersemia antarctica* can bend its entire colony down so that the polyps reach the bottom to feed there [4].

The food that *G. antarctica* seeks on the bottom includes benthic diatoms, foraminiferans, and particulate organic matter [4].

This grazing behavior has likely evolved to supplement plankton capture from the water and is useful in Antarctica where plankton in the water column is seasonal [4].

Here is a partially buried brittle star *Ophionotus victoriae* in front of *Gersemia antarctica* stretched out on the bottom.

A *G. antarctica* colony can move along the bottom like an inch worm, to reach undisturbed sediments for grazing [4].

G. antarctica colonies have been observed moving over fourteen meters in one year's time [4].

When a moving *G. antarctica* colony encounters sediment previously grazed by *G. antarctica*, it contracts from it [4].

References 1: Science 197:55-58, 1977 ; **2:** Marine Biology 78(2):171-178, 1984; **3:** Ecology of the Circumpolar Antarctic Scallop, Adamussium colbecki (Smith, 1902). Paul Arthur Berkman. Ph. D. Dissertation, University of Rhode Island, 1988; **4:** Marine Ecology Progress Series 149(1-3):299-304, 1997; **5:** The Fauna of the Ross Sea, Part 1, Ophiuroidea. HB Fell. New Zealand Department of Scientific and Industrial Research Bulletin 142, New Zealand Oceanographic Institute Memoir 18, 1961; **6:** Adaptations within Antarctic Ecosystems : Proceedings of the Third SCAR Symposium on Antarctic Biology. George A. Llano, ed. Washington : Smithsonian Institution ; Houston, Tex. : distributed by Gulf Pub. Co., 1977. pp.293-326; **7:** Polar Biology 16(5):309-320, 1996; **8:** Norbert Wu, personal communication, 1999

SYMBIOSIS… is a living arrangement between two different species, called symbionts, wherein the species benefit, harm, or have no effect on each other. There are several types of symbiotic relationships, including mutualism, commensalism, and parasitism.

Mutualism is an association between two different species which benefits each species.

Sterechinus neumayeri urchins attach algae to themselves as a detachable shield to shed when a potential predator (including anemones, seastars) grabs onto the attached algae [1,2]. The algae manufactures unpalatable defensive chemicals to avoid getting eaten by the urchin [1,2]. The urchins pick up loose algae drifting on the seafloor and move fertile drift algae throughout sunlit waters, thereby keeping the fertile algae in the reproductive area with other attached and drift algae [1]. The urchins also extend the vertical and horizontal range of the algae and facilitate recolonization after ice scouring of the bottom or when conditions allow growth of attached plants at greater depths [1].

Commensalism is a relationship between two species in which one species obtains food, shelter, support, locomotion, or another benefit from the other, without harming or benefiting it.

The free-swimming Antarctic scallop *Adamussium colbecki* may have the bush sponge *Homaxinella balfourensis* attached [3,4]. The usual position of the sponge on the scallops is near the shell's peripheral margin, suggesting that the sponge is seeking the water flow over the scallop shell in order to facilitate its own filter feeding [3].

Another commensal relationship

The crinoid *Promachocrinus kerguelensis* can be seen perched on large volcano sponges *Anoxycalyx (Scolymastra) joubini*, using the sponge for support to feed higher up in the water column, where they feed off particles and organisms drifting in the current [9].

Parasitism is a relationship between two species in which one benefits at the expense of the other, without killing it.

Parasitic copepods like this one on the Antarctic cod *Dissostichus mawsoni* are free-swimming as juveniles [5,6]. Females find a host, attach, and are stationary for life, diverting their energy to reproduction; males move or swim around to find females to reproduce [5,6]. This female parasitic copepod is burrowed into the skin, sucking blood and fluids or grinding away at flesh [5,7]. The female stores the male's sperm and fertilizes its eggs as it expels them into chitinous sausage-like ovisacs [7,8]. The ovisacs gradually lengthen as eggs are expelled [8].

References: 1: Marine Ecology Progress Series 183:105-114, 1999; **2:** Journal of Phycology 34(1):53-59, 1998; **3:** Ecology of the Circumpolar Antarctic Scallop, Adamussium colbecki (Smith, 1902). Paul Arthur Berkman. Ph. D. Dissertation, University of Rhode Island, 1988; **4:** Tethys Supplement 4:9-24, 1972; **5:** Copepod Parasites of Marine Fishes. NK Pillai. Calcutta : Zoological Survey of India, 1985; **6:** Parasitic Copepoda of British Fishes. Z Kabata. London : Ray Society, 1979; **7:** Parasitic Copepodes on the Fishes of the USSR = Paraziticheskie Veslonogie Ryb SSSR. AP Markewitch. New Delhi : Published for the Smithsonian Institution and the National Science Foundation by the Indian National Scientific Documentation Centre ; Springfield, VA : available from the National Technical Information Service, 1976; **8:** British Parasitic Copepoda. T Scott & A Scott. London : Ray Society, 1913; **9:** Antarctic Science 10(4):398-405, 1998

ICE STALACTITES…

Looking up slope, the diver swims under a six foot thick sea ice ceiling in shallow water under twenty feet in depth. The seafloor is carpeted with clusters of newly formed anchor ice. The sea ice ceiling is mounded and has ice stalactites hanging down. Sea ice stalactites are hollow, tapering structures up to several feet long. As ice forms from seawater, the salts do not become part of the ice lattice and remain as a dense and cold brine solution. This dense chilled brine drains downward from tiny brine channels and pools in the sea ice and enters the near-freezing seawater below the sea ice (the seawater is not as cold as the brine however). Ice forms around the draining cold brine streamers, thus forming a hollow ice stalactite. Sometimes this brine streamer can be seen draining downward from the tip of the stalactite; it has a different density than seawater which makes it visible.

Once the ice tube is formed, heat is horizontally transferred between the brine and seawater through the ice wall of the stalactite. However salt cannot be laterally transferred. After a tube forms, the relatively warm brine is in contact with the inner ice wall and the brine is above its equilibrium temperature. To reestablish its phase equilibrium, the brine must be both cooled and diluted which is accomplished by melting the inner tube wall with the heat of melting coming from ice forming on the outer wall. Thus the lengthening sea ice stalactite grows on the outside while ablating on the inside.

References: 1: Polar Biology 8:377-391, 1988; **2:** Science 163(3864):273-274, 1969; **3:** Science 167(3915):171-172, 1970; **4:** Geophysics of Sea Ice. Norbert Untersteiner, ed. New York : Plenum Press, 1986. pp.110-111

The **Weddell seal** *Leptonychotes weddellii* can be over three meters (ten feet) in length and 400 - 450 kilograms (880 - 990 pounds) in weight. Its population is estimated at 800,000 individuals. Weddell seals are commonly found at 8 - 12 years of age with individuals 18 and 22 years old noted in the literature.

Half or more of the Weddell seal diet is fish with the rest being squid, octopus, krill, mysids, isopods, amphipods, and decapods [3,4].

The Weddell seal commonly occurs on fast ice and nearshore pack ice along the Antarctic coast and in small populations in some subantarctic islands. The McMurdo diver will see them around sea ice cracks along islands, coastlines, and grounded icebergs. Weddell seals move around the sea ice, are not gregarious, and are spaced apart when seen hauled out on the sea ice. Due to the Weddell seal's preference for fast sea ice, the impact of predators such as leopard seals upon the Weddell seal population is minimal.

Here's a Weddell seal swimming up through a hole to haul out onto the ice.

The Weddell seal dives beneath stable contiguous sea ice and it keeps breathing and entry/exit holes open year round with its teeth. Its strong teeth project forward and are used to ream ice. These teeth are so critical to survival that they influence adult survival; when the teeth wear out, Weddell seals may lose their ability to maintain breathing holes and die at an earlier age than other seals.

Weddell seals can store a large amount of oxygen in their bodies mostly in their blood and muscles [5]. This enables them to stay underwater for a usual dive to 300-400 meters (980-1,310 feet) for fifteen minutes [5]. Weddell seals have been observed staying underwater for 82 minutes and diving down to 700 meters [5]. Weddell seals glide a lot in deep dives rather than swim continuously [2]. The lungs of the Weddell seal collapse from water pressure during a dive, thus decreasing the seal's buoyancy on descent [2]. The Weddell seals' limited oxygen storage is thus conserved by taking advantage of this physical change during a deep dive and reducing the amount of swimming during deep dives looking for fish [2]. After several dives, they can be observed coughing up a foamy white lung surfactant [6]. Their underwater swimming speed is estimated at 4-7 knots (4.5-8 mph or 7.4-13 kph) [5].

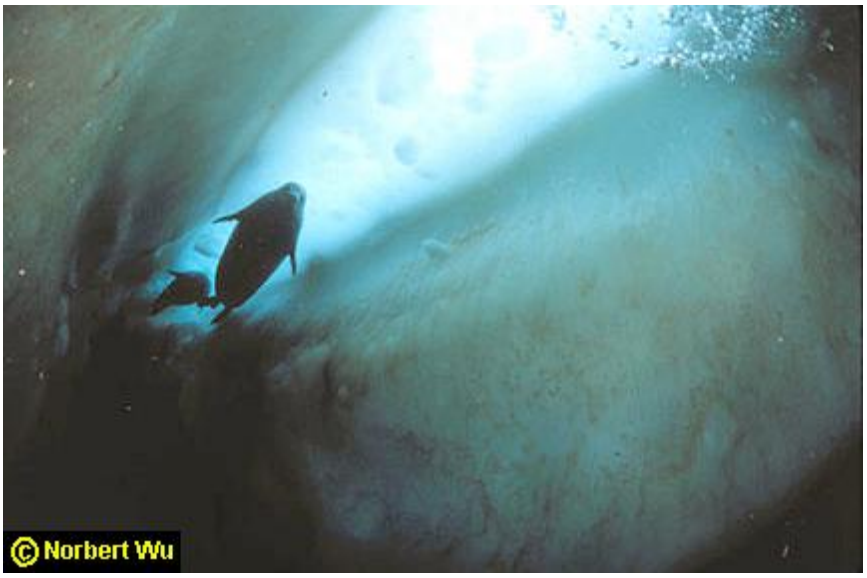
Weddell seals are restless when breathing at a hole when other seals are nearby. They peer down and if a hole fits only one seal, the seal will either dive as another seal comes up or reverse and face down to prevent the intruding seal from surfacing. Weddell seals adopt a head-down fighting posture with eyes looking forward, foreflippers extended and sometimes their jaw open. If a hole is large enough for two seals and the breathing seal refuses to leave, the arriving seal may surface with a fight usually ensuing. It has been suggested that a Weddell seal does not defend an area to the complete exclusion of other seals but to the discouragement of other seals. An intruding seal may be physiologically forced to take a breath which would override territorial aggression.

Breeding and pupping occur in the summer months. Breeding Weddell sea bulls set up under-ice territories of twenty meters diameter and tend to remain in the water where breeding takes place. Female Weddell seals move freely through the territories of the bulls. Subordinate males have their activity restricted by the dominant bull when moving through a territory. Females claim less well defined territories, individually or jointly with other females.

The mother gives birth to her newborn on the sea ice and stays with it for the first twelve days; after that, the mother will spend 30-40% of her time in the water while the pup remains on the sea ice. The pup is born at 29 kilograms and gains 10-15 kilograms per week.

Here a Weddell sea mother and pup float in shallow water under a sea ice crack; their entry/exit/breathing holes are visible as bright lights above them. By seven weeks of age, the pups can remain submerged for five minutes and dive down to 92 meters. The moulting of the pup's fur is complete in thirty days. The pup nurses for 45 days and, when weaned, the pup weighs 113 kilograms. Weddell seals have high juvenile survival due to a lack of predation in fast sea ice.

The Weddell seal vocalizes underwater and the diver is very aware of their presence even when they cannot be seen. Their calls make an eerie symphony for the diver. Weddell seals produce a wide range of calls: lengthy buzzes descending from a higher pitch to a lower pitch called "trills", whistles, and chirps. Certain vocalizations are associated with aggressive displays and have been characterized as a trill, a rapid chi-chi-chi, an eeeyo, and a chirrup. A teeth clacking sound was observed as seals passed one another entering and leaving breathing holes. A trill is used by mature males to establish and mark their underwater territory; it is associated with tense situations. When a trill isn't heeded, a fight may ensue.



Here's a mother and her pup. Weddell seals are highly vocal during the peak of breeding season at the Hutton Cliffs colony; researchers recorded almost twenty underwater calls per minute [1]. In mid-December when mating is almost over, the pups are being weaned, and adults dispersing, the underwater calls of Weddell seals at Hutton Cliffs decreased to two per minute [1]. Why? Their predators, leopard seals and killer whales, showed up at the fast ice edge about twenty kilometers away [1]. Weddell seals are no longer so isolated from their predators by distance from the fast ice edge since the edge shifts south as summer progresses [1]. Killer whales prowl the fast ice edge for prey and leopard seals can swim long distances under ice seeking out Weddell seals and their breathing holes [1]. Leopard seals and killer whales vocalize underwater and Weddell seals hear them [1]. Sounds are important for Weddell seals to communicate with their species but they also need to avoid detection by predators [1]. Absence of sound from Weddell seals is an anti-predation strategy when the risk of predation by leopard seals and killer whales is increased [1].

Reviews: Handbook of Marine Mammals, Volume 2, Seals. SH Ridgway & RJ Harrison, eds. London: Academic Press, 1981, pp.275-296; Antarctic Research Series 70:287-301, 1996; **Sounds & Behavior:** Antarctic Journal of the United States 2:105-106, 1967; Biology of the Antarctic Seas III, Antarctic Research Series 11:227-261, 1967; **1:** Antarctic Journal of the United States 30(5):232-234, 1987; **2:** Science 288(5463):133-136, April 7 2000 **3:** Adaptations within Antarctic Ecosystems, Proceedings of the Third SCAR Symposium on Antarctic Biology. GA Llano, ed. Washington, DC: Smithsonian Institution, 1977. pp.749- 768; **4:** Journal of Mammalogy 46(1):37-43, 1965; **5:** American Scientist 85: 530-539, 1997; **6:** Peter Brueggeman, personal communication, 1997

Cape Crozier forms the eastern extremity of Ross Island and was discovered in 1841 by a British expedition under Captain James Clark Ross and named for Commander Francis R. M. Crozier, captain of the *Terror*, one of the two ships of Ross' expedition.

The jagged edge of the vast Ross Ice Shelf is seen rising up above and beyond the relatively flat fast ice that lies in between Cape Crozier and the Ross Ice Shelf. This fast ice can break up each year by late summer but the Ross Ice Shelf is permanent and thick.

Adelie penguins surround the Cape Crozier message post erected on 22 January 1902 by Scott's National Antarctic Expedition of 1901-04. The edge of the permanent Ross Ice Shelf can be seen in the distance.

The emperor and Adelie penguin colonies at Cape Crozier are the subject of long-term studies of population dynamics and social behavior. The Adelie penguin colonies are located on the bare ground of Cape Crozier. The emperor penguin colony is located along the base of the jagged cliffs of the Ross Ice Shelf in the distance and was the first discovered breeding colony of emperor penguins.

Here's the emperor penguin colony on fast ice at the base of the permanent Ross Ice Shelf at Cape Crozier.

The Cape Crozier breeding colony of emperor penguins is the farthest south of the emperor penguin breeding sites. The most important physical characteristics of emperor penguin colonies are stable fast ice, nearby open water, access to fresh snow, and shelter from the wind [1].

Here's a closer view of the emperor penguins on the fast ice at the base of the permanent Ross Ice Shelf. The chicks are the shorter downey gray penguins. During Scott's second Antarctic expedition starting in late June 1911, Wilson, Bowers, and Cherry-Garrard undertook the famous "worst journey in the world" to travel seventy miles from Cape Evans to visit this breeding colony during polar darkness. They were beset by bitter cold and winds throughout their thirty-six day trip and were successful in collecting several emperor penguin eggs for embryological studies.

An emperor penguin chick begs a parent for a feeding of regurgitated food.

The small Cape Crozier emperor penguin colony has varied in the number of fledgling chicks over the years, from total losses some years due to blizzards and other hardship to a recorded high of 1,325 [1,3].

References: **1:** Antarctic Science 5(2):143-148, 1993; **2:** Antarctic Ecosystems: Ecological Change and Conservation. GL Kooyman, JL Mullins, KR Kerry, G Hempel, eds. Berlin: Springer-Verlag, 1990. pp. 169-176 ; **3:** Nature 203(4947):849-851, 1964

ICE LEADS…

McMurdo Sound is covered by sea ice for 10-11 months of the year. Fast ice is sea ice which forms and fastens to the coastline; the boundary between fast ice and open ocean is the fast ice edge. The fast ice edge is dynamic; sea ice cracks form and enlarge while ice floes (large relatively flat pieces of sea ice) break off and float away, joining the pack ice further offshore. The long cracks that form in the fast ice are called leads.

Mt. Erebus on Ross Island is in the background, with Mount Bird and Cape Bird on the left of Mt. Erebus.

A hunting pod of killer whales *Orcinus orca* travels down an opening lead or crack of ice.

Killer whales will travel up these sea ice cracks a considerable distance from the open ocean, hunting penguins and diving deep under the ice to hunt Antarctic cod.

A mother and calf are seen in an opening lead of ice.

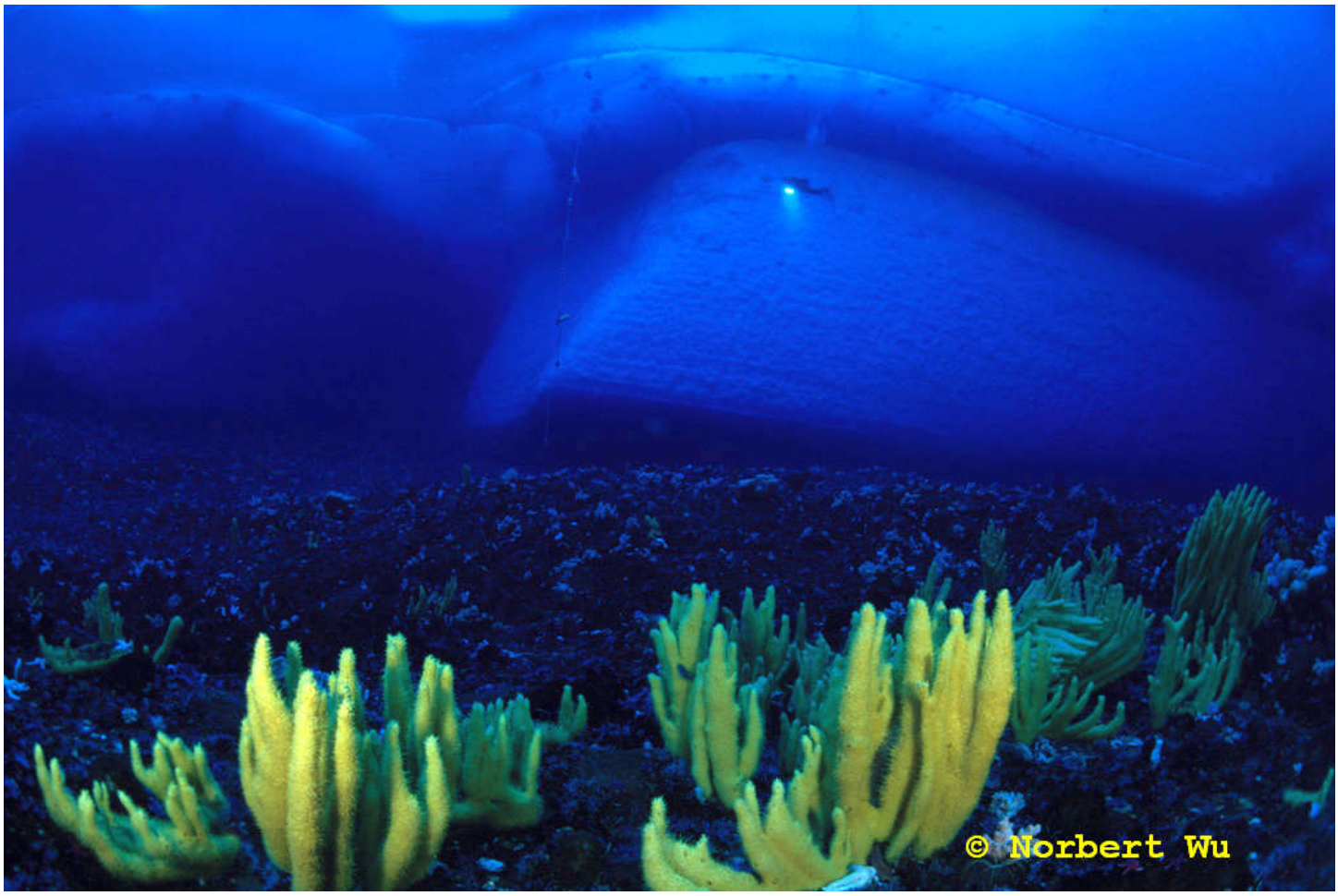
By mid-summer in McMurdo Sound, the plankton bloom reduces underwater visibility dramatically. Killer whale calves nurse for twelve months and may remain with the mother for as long as ten years [1].

A pod of killer whales reaches the end of an opening lead in the ice of McMurdo Sound and rests, spyhopping to take a look around.

References: 1: FAO Species Identification Sheets for Fishery Purposes : Southern Ocean (Fishing Areas 48, 58 and 88) (CCAMLR Convention Area). W Fischer & JC Hureau, eds. Rome : Food and Agriculture Organization of the United Nations, 1985

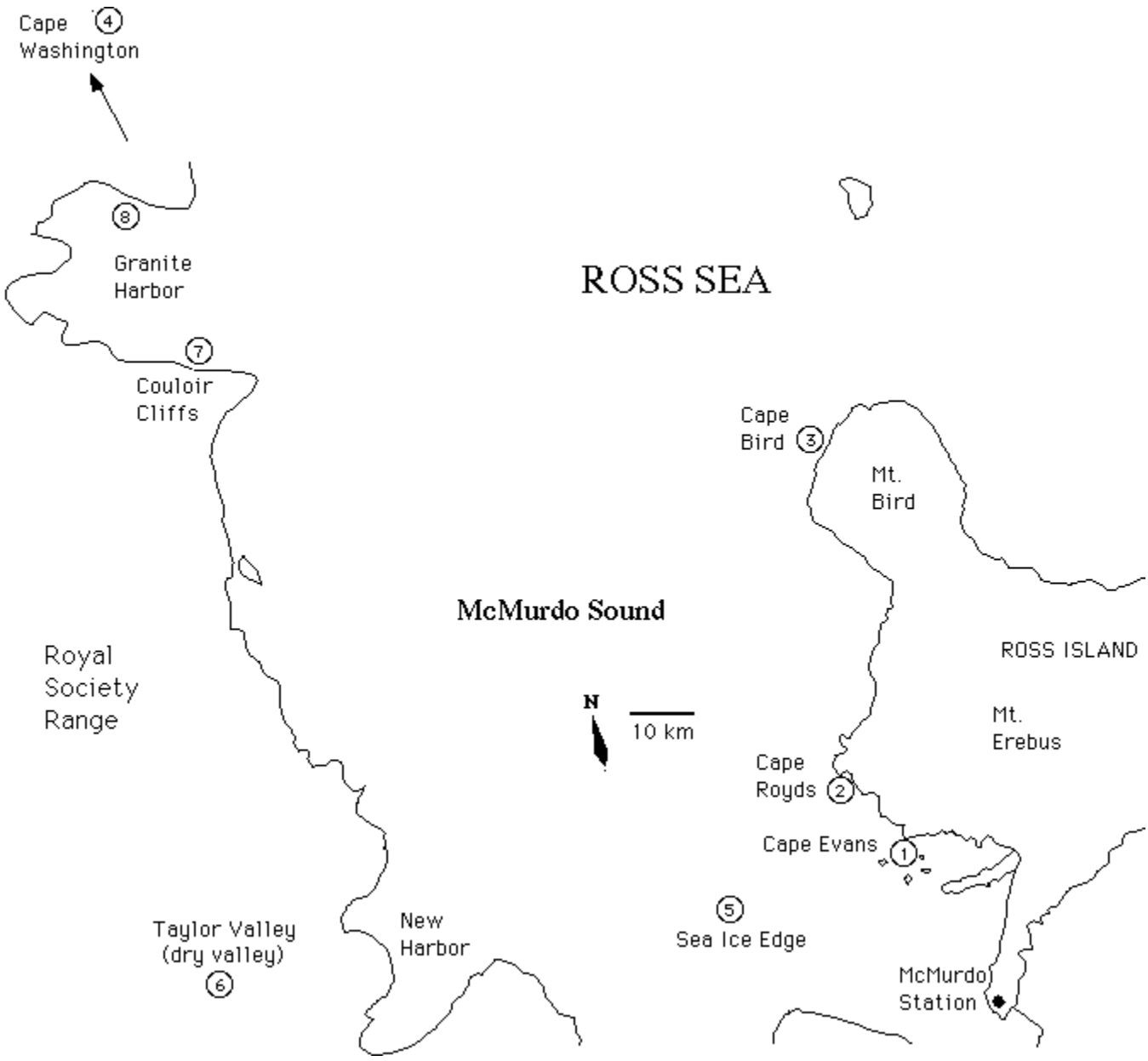
Antarctic Journals of M. Dale Stokes and Peter Brueggeman

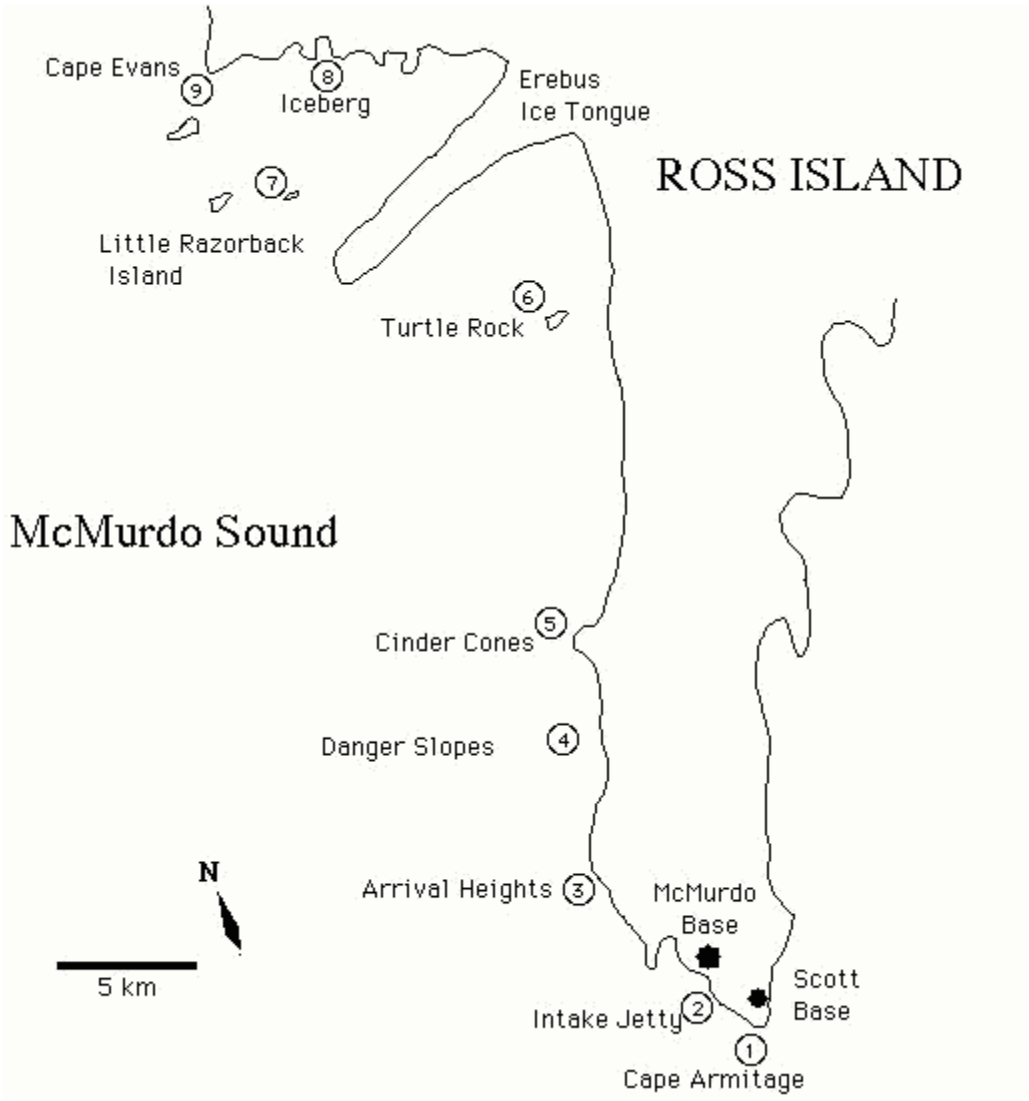
Text: M. Dale Stokes & Peter Brueggeman
Photographs: Norbert Wu



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. These Diver Journals were written during that endeavor.

Maps showing McMurdo Sound, Ross Island, and Antarctic mainland, and locations mentioned in these journals




Cape Evans
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Iceberg
Erebus
Ice Tongue
ROSS ISLAND
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Little Razorback
Island
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Turtle Rock
McMurdo Sound
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Cinder Cones
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Danger Slopes
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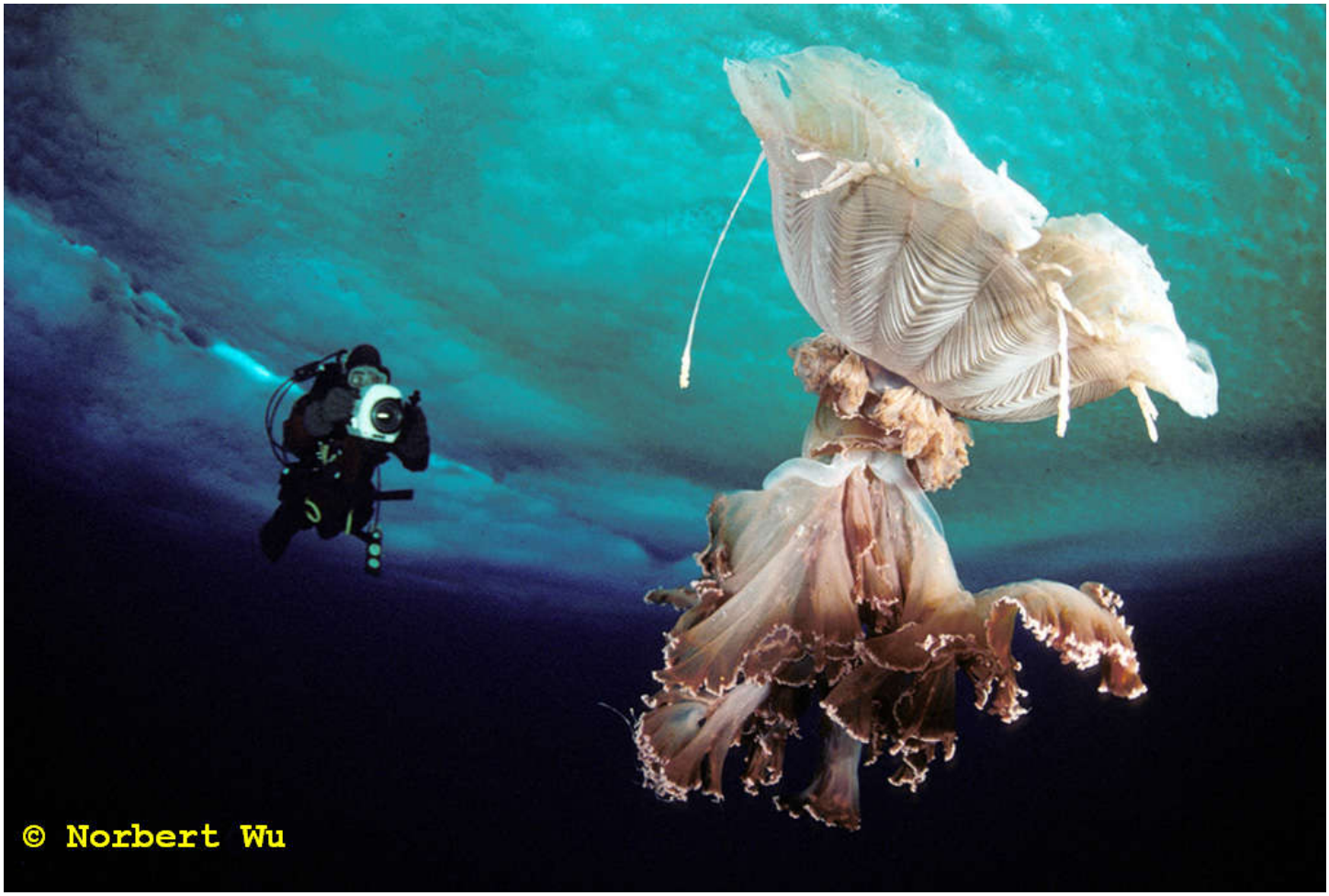
Arrival Heights
3
McMurdo
Base
Scott
Base
5 km
Intake Jetty
2
1
Cape Armitage

ANTARCTIC JOURNALS OF M. DALE STOKES

Dr. M. Dale Stokes is a marine ecologist with a PhD in Biological Oceanography from Scripps Institution of Oceanography at the University of California San Diego. In 1997, 1999, and 2000, he visited Antarctica as part of a team led by **Norbert Wu**, a professional underwater photographer/cinematographer, on a **National Science Foundation** sponsored underwater photography expedition. The team was based at McMurdo Station on Ross Island in the Ross Sea and Dale did numerous scuba dives at various locations in McMurdo Sound. As a previous visitor to Antarctica in a research capacity, Dale was an indispensable member of Norbert Wu's team, with extensive diving experience in both cold-water and tropical environments. He is an accomplished underwater photographer and made a strong contribution to the photographic aspects of this project. This photo shows Dale diving under the frozen sea ice of McMurdo Sound.



Antarctica 2000, Report #1
Oct 5. 1900hrs. McMurdo Base
Temp: -15 deg C, Wind: 5 knts clear sky

Hello everyone..... again!

It seems that at the end of each trip down here to the ice, I claim that it will probably be my last. And yet, here I am once again.

Just so that you know some of the details of what we are doing down here in McMurdo this year.... We are finishing up the production of a documentary film project for PBS Nature (that should air in the fall of 2001) on life under the Antarctic Ice. The project is being directed by Norbert Wu, a well known and astounding underwater photographer. The group this year also includes Christian McDonald as an assistant diver and cameraman. Christian (a.k.a. 'Hoss') is very experienced on the ice, with several seasons at McMurdo and he works primarily as a marine technician on the National Science Foundations' icebreakers in polar seas. His nickname stems from his burly size (all the better to lug heavy equipment in and out of our dive holes) and happy demeanor. This season Doug Quin, a sound engineer, has joined us to make professional recordings of assorted sounds to go along with the film. This is his second trip to McMurdo. We haven't come up with an nickname for him yet, but I am sure we will soon enough. I am back to resume my role as diver, back-up cameraman and 'scientific liaison' for the project. I will also be able to make sediment (sponge spiculite) collections, for sharing with a group of Canadian geologists, during my dives. This is my 4th trip to McMurdo and 6th to the polar regions. Unfortunately, our good friend Peter Brueggeman will not be joining us this year.

The Trip Down.

We started this year’s journey in ominous fashion. Our flights were canceled at LAX due to mechanical problems and we were forced to spend the night. Perhaps it was foreshadowing the usual weather delays in the flights from New Zealand to Antarctica, or maybe it was just practice. Nevertheless, we spent a night in a hotel all of 200 miles from San Diego and flew on to Auckland the next day (with the usual tedious 14 hour flight). I have learned my lesson from previous trips, so I had up-graded to the cushy comfort of Business Class, so I managed to get some rest and the flight progressed quickly. Unfortunately all the connecting flights were also messed up, so we had to race through the Auckland airport with over 20 large crates of equipment to catch a connection to Wellington and then on to Christchurch, where we arrived in the middle of the night.

We arrived on the weekend and couldn't make it to the Antarctic programs' Clothing Distribution Center (CDC)for our polar survival clothing outfitting until Monday morning (with the flight scheduled for the following Tues. morning), so we spent a relaxed day travelling around the countryside and eating far too much food. Christchurch is a marvelous city. Compact and very clean. Happy. Everyone walks outside, wanders the town square and downtown shops. There is a busy arts complex in the downtown area next to an enormous botanical garden, and outdoor murals and other artworks that nobody spray paints or vandalizes. It sends out a really hopeful signal -- cities don't have to spiral into messy squalor. They can stay tidy, friendly and safe. I spent some time in Smiths Bookshop. An old 3 story used bookstore and magnet for bibliophiles. Inside there are enormous floor to ceiling bookshelves and teetering old ladders to negotiate them, stacks, nay, mounds of books heaped on tables, piles of maps and old prints and papers, cabinets with books overflowing out of drawers and great faded pictures of the queen on the wall. Great stuff!

The next day, our clothing distribution went without a hitch and we quickly organized our crates of equipment for shipping. That left time for a little more sightseeing and another fine meal before leaving early the next morning.

We woke at 4am the next morning, piled into a shuttle bus and drove bleary eyed to the CDC for our departure. You have to wear all your extreme weather survival gear on the plane, just in case there is a crash (although the odds would be that you would land in the ocean, where a heavy down parka isn't going to do much good anyway). So, you change into a pile of heavy clothes (and start to immediately sweat to death) and march into the 'lounge' area where you are weighed and sit to wait to board the plane.

Despite the earlier bad flight karma from LAX, there were no problems with either the plane or the weather reports so we quickly had a flight briefing and got underway. This year we flew down on an Air Force C-141 jet transport which was much faster (about 5 hours) than our previous C-130 flights. Alas, although it was a much faster trip, it still wasn't a comfortable one. There was over 100 of us crammed into the cargo bay like nylon-wrapped sheep. There are no real seats. You sit wedged side by side in 4 long rows on nylon net webbing. The people opposite to you are so close you have to alternate the placement of your knees and legs and take turns stretching. 6 people at a time were allowed to stand up and stretch in the little area at the rear of the aircraft between a large cargo pallet and the little curtain around the 'pee barrel'. Yippee! But, it was only 5 hours.....

By 1pm we were back down in McMurdo and there were many familiar faces to great us. Some had wintered over from last season, and I must admit, after spending 12 months continuously on the ice down here, were starting to look a little wild-eyed (they will be leaving over the next few days). Others had arrived about 6 weeks previous, during Winfly and were already settled in to their working routine. Most of the science staff were arriving with us (the first flight of the season) or will be arriving over the coming month.

My time since arriving has been occupied with preparations for our work on the sea ice. So far we have spent the last 2 days with a science party briefing, training sessions for snowmobile, Spryte tractor and truck use - A session on waste management (how to store and handle your garbage for end-of-the-season recycling) - Meetings with the radio communications group - A dive safety briefing - A meeting at the field food supply storage area. Sorting through our field gear and other unpacking. And last, but not least, helicopter safety training and field survival school. Because members of our group are all fairly experienced on the ice, we didn't have to take part in the 2 day survival school ("Happy Camper School") and instead we had a day-long 'push' course to reorient ourselves with the equipment that we took with a group of helicopter pilots. The highlight was listening to the head of Petroleum Helicopters Inc.(the contract group who runs the helicopters on the ice), who was down to check on his team at the start of the season. He was a rather melodramatic fellow and he stood up, cleared his throat and said, "the tips of the main and tail rotor turn at over 400 mph. Ya get too close, and they'll kill ya. That will just ruin your whole day.." The pilots all rolled their eyes and we all looked at each other thinking, "who the heck is this guy?"

Antarctica 2000, Report #2
Oct 8. 1830hrs. McMurdo Base
Temp: -15 deg , Wind: 5 knts cloudy sky

Our weather has been particularly strange today. It started clear, blustery and very cold. Then it warmed slightly, clouded over and we had poor visibility with blowing snow. Then the gusty winds died and the snow stopped falling, and it really felt like the next day should be Christmas. Perhaps this was because I just came from Southern California.

The day before yesterday we finished the last of our preparations and we made our first dive. In part, it was an orientation dive to once again get used to all the bulky gear and clothing as well as operations around the dive hole. However, for me it was a very important event. It was my first dive back under the ice since last seasons' accident. After what seemed like a never ending series of medical tests back in San Diego, being poked and prodded by umpteen doctors and far too many hours spent sitting in clinic waiting rooms, I was deemed fit to dive again. I resumed diving back at Scripps in March, but working under the albeit chilly waters of California is not quite the same as diving under 2 meters of ice here.

I wish I could say that my return was a profound, enlightening experience, and full of psychological reflection, but it wasn't. Instead I felt a great sense of relief-- relief to be finally back in the sea and out from under the careful, yet prying thumbs of the diving medical community. And relief from the almost claustrophobic, heavy, and constricting dive gear at the surface. It takes a few dives to get used to the bulky suits with tight seals and double layered hoods that make it impossible to move your neck. The heavy gloves that make your fingers seem useless, heavy weight belts, harnesses and tanks. It is awkward having to depend on others to help suit you up when you are used to being self-sufficient. However, when you finally get into the water and sink down through the shaft-like entrance hole and you drop out into the open water, everything changes. Your gear feels as light as a feather and less constricting, and in the crystal clear water you seem to fly, rather than swim, across the seascape.

I had forgotten how shockingly cold the water is. 28 deg. F or -2 deg C. The only part of your body exposed to the water is a little strip around your lips and it burns like fire when you get in the water and then goes completely numb. Our suits do a good job keeping us warm, but the cold is always there. You can feel it when the air shifts around in your suit and the water pressure starts to crush the insulation onto different part of your anatomy. After half an hour your hands and feet start to ache if you don't have something to occupy your mind. We were just testing our gear by swimming around over a mostly featureless bottom near the seawater intake jetty for the base, so all I could think about was how bloody cold it was, what are we having for dinner tonight, and wouldn't a big steaming cup of hot chocolate go down nicely right about now. After 35 minutes we deemed the test a success and beat a hasty retreat to the surface.

Yesterday, after a long morning of preparations (food and equipment for our dive hut) and fiddling with cameras, we made the 40 minute Spryte journey (our faithful snow tractor) to Turtle Rock. The dive itself was nothing special. This season, the spectacular pressure ridges and ice tunnels around the shallows are not present. Instead, when the ice set in around the island, it froze into a near continuous wall right to the shoreline. As a consequence of this, there are not too many cracks and openings for the Weddell seals to use as breathing holes. Last season there were dozens of seals around Turtle Rock. This year we counted only 2.

The water was incredibly clear and blue. In contrast to yesterdays dive which was very dark due to a thick layer of snow lying on the ice, at Turtle Rock, the ice had been swept clear of snow by high winds and beneath the water was a brilliant azure blue. There was very little plankton at all in the water, and it was very hard to judge distances. You could see jellyfish off in the distance, but only when swimming towards them did you realize just how far away they were. The most spectacular sights were some extremely long (over 8 m long) brine tubes that reached from the sea ice ceiling right to the dark volcanic pebble bottom. The supercooled brine had even poured out the bottoms of the brine tubes (that look like stalactites) and formed frozen rivers along the bottom beneath them. There were two seals along with us and we played hide and seek with them amongst the brine tubes and some shallow ice-crystal rimmed tunnels. Great fun! A 55 minute dive was over quickly.

I had forgotten the tedium of Spryte travel as well. These machines are noisy, lumbering beasts. They belch exhaust, have almost no suspension and the windows quickly get packed with snow when you travel, obliterating any outside view. The ice 'roads' are still fresh and rough with sastrugi (hard wind-packed ridges of snow) so you have to hang on tight and keep all of the gear from bouncing around the cabin. How on earth did we manage to nap in these things last year? Oh well, at least our Spryte hasn't burst into flame yet, or thrown its tracks, but we know it is only a matter of time.

Today was a repeat of yesterday. Back to Turtle Rock for another dive. The island gets its name because from a distance it looks like the back of an enormous black turtle protruding from the ice. I brought a close-up camera rig with me today because I was hoping to take some photographs of the jellyfish and the tiny parasitic amphipods that dot the outside of their bells. Of course, where yesterday I saw dozens, today I only saw one lone jellyfish (which always seems to be the case when you have a camera in hand). I could see the remains of the others, they had crashed into the island slope and were being consumed by anemones and starfish and others

were caught up in the platelet ice below the ice ceiling. It's a tough life being a jellyfish at the mercy of the currents.

Now it's time for a quick dinner and my turn at doing a load of laundry.

Antarctica 2000, Report #3
Oct 10. 1900hrs. McMurdo Base
Temp: - 15 deg C, Wind: 10 knts sky partly cloudy

I used to think that helping another photographer was potentially the most boring thing possible -- Now I know that that isn't the case. It is much more tedious helping a sound engineer (sorry Doug). This afternoon, Doug Quin and I flew by helicopter out to the ice edge to try and make sound recordings of penguins and whatever else we could find at the edge of the ice sheet. The edge of the sea ice is about 15 km closer this season, but still about a 30 minute flight away from McMurdo. And, when we arrived, there was no 'hard' ice edge at the moment. There was several km of soft ice and slush (far too unstable to walk on, much less land a helicopter on) between the sea ice shelf and the open water.

We skimmed along the ice 'edge' for a while, looking for penguins with no luck. Turning back we landed next to a small open pool of water at the edge of the soft ice because I thought we could at least make some background sound recordings of the open sea and any seals and whales with our hydrophones. We weren't on the ground 5 minutes when 20 Emperors jumped out of the little pool and waddled over to check us out. I have mentioned previously how the penguins seem to worship helicopters. It really is funny. They all gather around, look us up and down, then walk all around the aircraft, look at the tail rotor for a while, make squawking noises, check out the cockpit, more standing around, check out the storage cage... This is great, but the boring part is that Doug has to do his sound recordings of all this, and we are not allowed to move since the crunching sounds of snow and ice and rustling clothes are all easily transmitted to the microphones. So, we had to try to sit on the ice motionless for 20 minutes at a time, in the cold and a howling wind, then while he was swapping batteries and resetting his phones, we could jump around and try to warm up a bit. The penguins were great, but I was really happy when he was finished.

Antarctica 2000, Report #3
Oct 11 . 1750hrs. McMurdo Base
Temp: - 10deg C, Wind: 0 knts sky clear

Just like anywhere else, you can have good days and you can have bad days. The whole day wasn't bad, just the afternoon dive. Christian, Rob Robbins (the diving officer here) and I went for a quick dive at the intake jetty in front of the base. Rob and I were going to take pictures of the many invertebrates found on the jetty boulders and Christian was along for a little sight-seeing.

The dive was ominous from the start. The hut we were using for shelter was also being used by Dr. Art DeVries' group for setting traps and fishing from (they study ice-resistant glycoproteins in fishes) and smelled incredibly bad from a combination of rotten bait and fish guts all stewing in an enclosed space with the heater running full blast. Whew! So, we had to leave the door open to make the air breathable, which cooled the hut down again. They had also been testing an enormous 10kW submersible heater to help prevent the holes from freezing closed. It seemed to have worked well -- the normally 1.5 m diameter hole had doubled in size along one side and the top half of the hole had ballooned open like a huge crater. Looking down through the hole in the hut floor it was like looking into a swimming pool. I think if they had run it for much longer the hut would have been floating. Ooops.

While suiting up I realized that I had left my 'glove tubes' back at the dive locker. Although they are not critical, they let you equalize the pressure between your drysuit body and the separate dry gloves. I decided to go on without them. About 2 minutes into the dive, right after I had found the perfect jellyfish subject, my camera flashes conked out. I fiddled with the settings and switches to no avail and had to return my camera rig to the tenders in the hut. I found out later that a strobe cord connector failed (perhaps because a tiny bit of freshwater remained in an O-ring groove after rinsing that then froze in contact with the seawater) and flooded one strobe and shorted out the cable, creating what will be a very expensive, useless paperweight for the rest of my trip. I returned to my buddies on the bottom and now that I was deeper, the hydrostatic pressure crushed my gloves vise-like around my hands. There was no way I could equalize the pressure. It was painful, at first, but I could hardly flex my fingers and most of the insulation in the glove liners was lost. As a consequence, my hands got very cold very quickly. It turned out that all of us were getting chilled on this dive for one reason or another, and we cut it short at 30 minutes. At the surface my hands felt like they were on fire as they heated up, and all of us huddled around the fish-stinky stove to try to warm up.

During the dive I did manage to observe a wonderful Antarctic chaetognath in mid water. This was a voracious zooplankton predator, about 3 cm (about an inch) long, almost completely transparent and long and thin like a sliver of glass (a common name is 'Arrow Worm' -- although they are not worms at all). They have delicate fins along their body and the head end terminates in a spike-filled jaw. It was almost invisible unless you head your head at just the right angle. I am curious to know what it is feeding upon, since there is almost no plankton in the water at the moment -- perhaps it is fasting until the plankton bloom later in the summer.

Antarctica 2000, Report #3
Oct 11 . 1935hrs. McMurdo Base
Temp: -10 deg C, Wind: 5 knts sky clear

This morning it was incredibly cold, and unfortunately we had to spend most of it outside trying to break a dive hut free from the ice in front of the base and ready it for towing to a site at Little Razorback Island. Not only was it about -25 deg, it was also very windy, with strong gusts and blowing snow; just the type of morning you would rather be lying in bed.

We also experienced some of the thickest "ice fog" that I have ever seen down here. This is created when slightly warmer, moist air is rapidly cooled over the ice sheets and, much like fog in temperate climates, the moisture condenses. However, here the water droplets form microscopic ice crystals. It cut the visibility to just few hundred meters but in the sky we were treated to some spectacular "icebows" around the sun. Like a water rainbow there were two complete bows at about 22 deg and 44 deg (if I remember the physics correctly) out from the sun that are associated with refraction off of the two primary ice crystal orientations. Nifty.

After getting the hut free we hitched it to the back of a large Cat tractor and drill rig, which then followed our trusty Spryte for the 1.5 hour trek towards Little Razorback.

Fortunately the ice fog lifted once we passed the Erebus Ice Tongue (an extension of a large ice cap glacier on Mt Erebus that protrudes far out into the sea ice) and we were able to find the Island without too much trouble. Then came all the preparations associated with setting up a new dive hut. The drill rig made a primary dive hole and a secondary safety hole (in case the primary hole is blocked, i.e. by a seal, or if say, the hut is on fire -- it has happened), the hut is towed over the primary hole, snow piled around its sides to protect it from the wind, and the ice is plowed free of snow to allow more light to penetrate into the water. Inside the hut the fuel to the heater is reconnected, the heater lit, the floor panels over the dive hole removed, and a table and cooking stove is set up. Tah, dah -- ready to go. All this took several hours. Then we started the laborious task of flagging our route back to the main ice road so that we are able to find our way back when the weather turns sour. We drilled a zillion holes in the ice about 50 m apart and popped a bamboo pole with a flag on top into them to mark the

way. It took a long time, and we were cold and tired, but the end result was rather festive looking -- a line of bright green flags marching across the snow and ice. We made it back just in time to catch dinner at the galley.

Antarctica 2000, Report #4
Oct 12. 2100hrs. McMurdo Base
Temp: - 24 deg C, Wind: 12 knts clear

I suppose there is a reason all Sprytes are equipped with a fire extinguisher. Our trusty Spryte #242 was doing so well. We had even just turned in Spryte #243 to the heavy shop to have its oil system checked, but 242 was running like a dream. Alas, it burst into flame this morning.

Doug and I were driving up to the BFC (Berg field center) to pick up a load of supplies from our storage cage when we noticed an unusual smell. It wasn't the usual odor of burning electrical insulation, it had an almost pleasant, woody smell. We stopped the Spryte to investigate. When we got out and looked under the tracks we could see orange flames enveloping what appeared to be the transmission and the braking system and it was alarmingly close to the large fuel tank. Doug doused it with the fire extinguisher and I dashed into "F -Stop", the field survival training building, to use the telephone to call the mechanics. It was actually rather humorous, flaming Sprytes are apparently common enough to not elicit any big reactions. The head of the SAR team looked up as I came in and said,

"Hey Dale, what's up?".

"Our Spryte's on fire."

"Oh, Ok, the phone is over there...."

We certainly have a love - hate relationship with the Sprytes. They do function well for traveling across the snow and ice, they can carry a good load of dive gear, and in a testosterone sort of way, their dual-tracked, tank-like qualities make them rather fun to drive. For the first half hour that is. They are incredibly slow, and noisy, and generally cranky beasts. They break down constantly, overheat, and their treads fall off. And, they can burst into flame.

The polar program is now looking for replacement vehicles and it will be interesting to see what they come up with. In the meantime, we were given Spryte #093 to use. A real gem. It is 10 years older, is even slower and has a box-like cabin with tiny slot windows. It looks like an orange brick on caterpillar tracks. We call it a "Spryte Classic" model and its official nickname is "Percy."

Antarctica 2000, Report #4
Oct 17. 1820hrs. McMurdo Base
Temp: - 30 deg C, Wind: 2 knts clear sky

A fair amount has been happening since my last notes. Doug and I had another attempt at collecting footage and sound recordings of penguins at the ice edge a few days ago. We flew out to check things out but I ended up aborting the landing. Strong winds from the north has kept a layer of thin pancake ice and small floes packed up against the hard ice shelf so there was no open water we could work around. If we had landed the helicopter on thick ice we would have been at least 1-2 km from the open water and a few hundred meters from a wide open moat that paralleled the ice edge but would have been unsafe to approach due to the thin ice. So, rather than risk falling in, we returned to McMurdo.

The odd northerly winds have made for interesting weather here. The conditions have been quite wonderful actually. The sky has been crystal clear, and the wind speeds have been low. It has been quite cold (-30), but not unbearably so. In fact, we are hoping for a small storm to come along to clear the thin ice away from the ice edge and for Norb to get some footage of seals and penguins coping with stormy conditions for his documentary.

The cold temperatures and crystal clear air has also meant that we have seen some great Fata Morgana mirages while driving out to our dive sites. These illusions are formed when light rays from distant surface features are refracted in the air by a temperature inversion close to the ice. To your eye it looks like pillars and columns of ice rising from the snow, or distant ice cliffs and icebergs.

We have been spending a lot of our time diving at Little Razorback Island, which has to be one of my favorite sites on this side of McMurdo Sound. The island is the steep-sided remnants of an ancient volcanic crater that looks like a jet black fin of rock sticking up from the sea ice. On each end of the island there are huge pressure ridge systems where the ice has been forced up against the island and look almost like breaking waves. The pressure ridges have left behind many smaller cracks and openings that dozens of Weddell Seals use for breathing holes and for hauling out into the air. It is almost pupping season and we could see a half dozen or so pregnant females lounging about on the ice.

Underwater, the sides of the island quickly fall away into hundreds of meters of water with steep slopes and rocky outcroppings and ledges. Below about 20 meters, these outcrops are covered with an incredibly diverse marine invertebrate community. Soft corals, anemones, starfish, sponges, worms and gorgonians all in a rainbow of pastel hues. If the water wasn't -2 degrees C you would think it was a coral reef.

At one end of the island there is a shallow shelf with about 1 meter of water between the bottom and the ceiling of the sea ice. By squeezing through this slot along the bottom we could come into a series of long, thin rooms that coincide with the pressure ridges above. Some of the tunnels are about 10 meters across and 4 meters tall and lit by the sun from above through thin sections of ice in the upthrust ridges, or through the holes the seals have chewed open to breathe. One tunnel in particular seems to glow a vivid blue. Blue ice, blue from light filtering in through snow above, blue-tinted anchor ice on the bottom and purple starfish scattered all about. It is quite hard to describe -- sort of like swimming around in a fussy person's toilet bowl. All the while we share the tunnels with the seals and are haunted by their trilling calls. They're impressively big, 400 kg or more, yet they dance down the tunnels and can swim without barely moving a muscle. Often they will just sit down on the bottom, and stare at you for a while.

We spent some time going in and out of some cracks at the end of the island away from the warmth of our hut. It was interesting, but not really worth the extra effort and exposure to the elements. By the time we returned to the warmth of the hut, our suits and equipment were caked with snow and ice. I was actually afraid to bend the regulator hoses and parts of my suit since it looked like they might crack open in the cold.

On our last dive at the island I made a long swim with Christian all the way through one of the main tunnels to where it opened up on the far side of the island. It was pitch black, and the tunnel here dipped to the bottom about 20 meters deep. Exiting this, we turned to the side and swam into a vast cathedral-like room. Our lights could pick out the dark bottom below, and above the ceiling was a huge dome tinged blue and white. On this trip, this will probably be one of my most vivid memories.

The shadow of the dome of pleasure
Floated midway on the waves;
Where was heard the mingled measure,
From the fountain and the caves,
It was a miracle of rare device,
A sunny pleasure-dome with caves of ice!

Coleridge, of course, for I can think of no better words. This would be my sunny pleasure dome of blue sea ice, haunted not by demon lovers but by the ghostly visions of gliding seals.

Antarctica 2000, Report #4
Oct 18. 2040hrs. McMurdo Base
Temp: - 38 deg C, Wind: 10 knts partly cloudy

Christian and I left early this morning on snowmobiles to secure our hut at Turtle Rock and ready it for towing to the ice wall at Cape Evans. The drill rig and tractor would meet us along the way so we could help with the tow hook ups and check the ice around the new dive site. It was incredibly cold with a strong biting wind. We hoped that by travelling by the snowmobiles that we would get it all over with quickly rather than enduring another 3 hours of Spryte travel over rough terrain. So, we bundled up as best we could (I had 5 layers of clothes on) and set off.

Alas, bad mechanical karma followed us. One snowmobile gave us trouble with a faulty electrical connection on the way out (requiring some bare-handed work with a wrench set and Swiss Army knife to correct whenever it had to be started) and on the way back, the one I was driving suddenly quit. Perhaps because of the low temperatures, the fan belt pulled apart and flew into the engine, seizing it solid. After not too long, Christian noticed that I was no longer behind him and he turned back for me. Then we rode double back to McMurdo. Unfortunately, our job was only half done and now, without our snowmobiles we had to pile into a Spryte anyway, and make the long drive to Cape Evans.

We spent the rest of the afternoon drilling holes, checking cracks and setting up the hut at the base of a glacier wall that plunges into the Sound. It is a stunning location, flanked by volcanic rock on one side and electric blue, stripped ice on the other. But it was also extra chilly as it is tucked up against the cliffs and remains in the shade almost all day long. By the end of the work our eyelashes, hoods, beards and collars were all rimmed with ice. It should be worth it because this was the site of some of last year's most impressive albeit spooky diving. Tomorrow we will be back to check it out.

Antarctica 2000, Report #5
Oct. 23. 2015 hrs. McMurdo Base
Temp: -34 deg , Wind: 15 knts

These last few days it has remained bitterly cold with temperatures in the evening 35 below zero on the ice and a wind chill around -80 deg.. It has been the sort of cold where your first breaths when you step outside cause your nostrils to stick together and your lungs to hurt. But then, it is a harsh continent after all (or so the saying goes around here). The steam from buildings and vehicles seems to hang in the air and the ice and snow squeaks and snaps underfoot. We did have a brief period of high winds and blowing snow, but fortunately that quickly died mid-afternoon. Now it is quite still with just occasional gusts.

The day before yesterday we had to cancel an initial attempt at filming around the summit of Mt. Erebus (the local active volcano). It was about -40 deg, without including the wind-chill (it was -119 last night with the wind- chill), and not the sort of weather in which you want to be flying around in a helicopter with the doors off for filming. Norbert did manage to make the flight yesterday while the rest of us were off diving. He managed to get some spectacular footage of the summit caldera but returned with some frostbite on his cheeks from being exposed to the winds.

The record low temperatures (for this time of year) have also delayed the first flights to the South Pole station. They can't land the planes when it is below -50 deg (they have problems restarting the engines) so the scientists and support staff have been stuck in McMurdo waiting to leave on the next leg of their journey. The National

Science Foundation has over 300 flights planned for South Pole station and other field camps this season and they are off to a slow start due to the weather.

The cold temperatures didn't stop us from doing our dives at the glacier icewall. We made the long, bouncing Spryte trip 3 times to our little hut nestled in the shade of the Cape Evans glacier. Fortunately the heater worked well in the hut, since it seemed to be twice as cold out whenever you were not in the sun. One day after the first dive, we had to go back outside to unload more equipment from our vehicle. I was still wearing my drysuit which was wet from the dive but with only the legs in place (the arms and neck hanging from my waist). In the intense cold, my suit froze almost completely solid. I could hardly bend my legs, and the torso and arms were frozen stiff, with the arms outstretched like a scarecrow. Before I could get it on again, I had to thaw it over the stove.

The dives have been worth it. Almost other-worldly. Here we could swim far above a bright white-ice bottom, over to the side of the glacier where it plunged away into the deep. Swimming alongside it was almost disorienting because there was no easy way to tell where the water stopped and the surface of the ice began. The glacier wall was so smooth and clear you sometimes couldn't tell where it was until you bumped into it. Off in the other direction from the hut, we could dive along a shear wall of black volcanic rock. It was peppered in places with huge anemones, sponges and zillions of starfish and sea spiders. One table-shaped rock in particular was spectacularly covered in a small forest of light-pink coloured soft-coral 'trees' that stood over a meter tall and looked like they had been teleported there from a tropical reef in the Indo Pacific.

Alas, our Spryte troubles have not ended. Returning into McMurdo, at the end of a long day, the left track fell off. Well, tore in half actually. Quite impressive. Fortunately, the repairs to our trusty Spryte #242 have been completed and it has returned Phoenix-like from its previous fire.

Today we returned to Little Razorback Island to make another dive and check on the seals. Some of the females have started to pup and we were curious to see if their behaviour underwater had changed. We didn't see any mothers and pups, but there was one lone, very large, male that had some real 'attitude'. While we were not using the dive hut, it decided to stake out our dive hole as its personal breathing hole and territory. When we put our safety line, lights and extra tank in the water, it swam over and bit off one of the flags we have marking the line and continued to yank on the rope. Underwater, it cruised by us a few times, but when we swam back to the hole, it started dive-bombing us, blowing bubbles, barking and mouth-gaping. Fortunately it is was all 'huff and puff' and we could exit the hole without getting more than our fins nipped. But, having a 1000 lb seal zoom up to you, mouth agape, is a little disconcerting.

It was also a fairly short dive, 30-min dive for me. I rather spastically forgot to pack my ice hood, a special neoprene face hood that we wear under our regular dive hoods to protect our faces. They leave only a little slot around your mouth exposed to the water. Without it, the cold water was pretty intense on my face and head, particularly when I first jumped in. After that, well, nothing hurts when you are numb.... But, after half an hour it felt like someone was jabbing a pick through the back of my skull and I surfaced with the most amazing "ice-cream headache" you can imagine. Tomorrow we will go back, and I will definitely remember all my gear.

Antarctica 2000, Report #6
Oct. 26. 1800 hrs. McMurdo Base
Temp: 0 deg C, Wind: 35 knts

This is the night of our "Bag Drag," marking the end of this trip. After a day of vigorous packing, we will schlep our mountain of gear up to a storage building where everything, ourselves included, will be carefully weighed for the flight back to Christchurch. In theory, we will fly out tomorrow, but right now it doesn't look like the chances of leaving will be good. We had been hoping for some stormy weather weeks ago to do a little filming, instead, after weeks of clear skies and cold weather, we are now getting hammered by a blizzard. If it

clears up by midnight, they might be able to clear the airstrip in time for a plane to land. But, the current weather reports are not very optimistic. Oh well.

Yesterday we managed to get back to Little Razorback Island for a last series of dives. We wrapped up the filming with closeups and scenes of a swarm of blood-red amphipods consuming the remains of a fish carcass. Then the four of us (Norbert, Christian, Rob and myself) made a last long swim down the ice tunnels to the far end of the 'Blue Room'. It was once again spectacular, and a fitting way to end the season. Because the sea ice environment is a very dynamic one there were subtle differences in the surroundings since our last dive there. We dove at a higher tide so there was a bit more clearance above our heads in the narrow slot around the island that separated the deep slope from the tunnels of the pressure ridges. And, in the far Blue Room itself, a long thin pool of air was present that shimmered like quicksilver in our lights. Using this air pocket were 4 Weddell seals that hung below the domed roof like blimps, taking slow, casual sips of air and staring down at us swimming around below them. At the very bottom of a pressure ridge that formed one of the room's walls, a small crack had opened up in a manner very similar to what I had seen in the Granite Harbor ice ridges several years ago. I managed to squeeze up vertically through this crack and emerged within the interior of the pressure ridge. It can only be described as swimming into the inside of a white crystal geode. The room was oblong, about 10 meters long and perhaps 4 meters wide at most and every single inch was covered in delicate ice crystals. There was no algae living in the ice yet, so the entire room was a brilliant white and seemed blindingly bright compared to the dark tunnels below. By shining my light around I could make the walls all sparkle from the reflections off the millions of crystals. It was absolutely stunning, but, a little claustrophobic because there was only one narrow entrance to this chamber. I joined my friends and we slowly made our way back to our dive hole and the warmth of the hut.

Apparently you haven't truly experienced the Antarctic sea until you have met it in all your nakedness. One on one, so to speak. Also known as the Polar Plunge. The idea is to strip to your birthday suit and then to jump quickly down into the dive hole before you change your mind. It is the sort of thing you do that seems to make sense at the end of a season, yet to a warm and sane observer elsewhere, must be completely ludicrous. There is no sauna or hot tub involved, just a brief unbalanced struggle out of many layers of clothes, a quick tiptoe across the cold and wet hut floor and then bare flesh versus -2 deg water. Sort of a quick naked leap into a giant slurpee. I could remember the pain of diving without the added protection of my ice hood on my face, but I tried to push all that to the back of my mind. Then, operating only from the 'lizard part' of my brain I jumped in. When I first hit the water and submerged it didn't seem like too big a deal. Then, a microsecond later, there seemed to be an almost searing flash of pain over my entire body. A wonderful, pure adrenaline, "fight or flight" response then took over and I quickly thrashed my way back up to the surface and scrabbled up the side of the ice hole into the hut. My skin was entirely numb so I didn't notice the dozens of cuts on my arms, feet and hands from the ice crystals. Back in the hut, it was then a race to see how quickly I could get all my clothes back on while huddled close against the stove and without setting them on fire in the process. Despite its lunacy, it was actually quite satisfying once it was all over. I certainly won't be forgetting the experience any time soon.

It seems that whenever I end one of these journal series, I am very thankful for the experience and seem fairly confident that I won't be back. I believed that back in 1995 after my first journey here, and here I am finishing a 4th trip. There is no more filming planned for next season, so, for the next little while at least, this will be my last trip to McMurdo. I do hope to return and head my own oceanographic project in the future, but I cannot say when. Our documentary efforts these last 2 seasons should be shown on a PBS Nature Special, "Under Antarctic Ice" in the fall of 2001. Norb has done a spectacular job so far and I am certain the final film will be stunning.

What's next for me? I don't have any research cruises scheduled for the next little so I will be spending most of my time in San Diego working on a series of data sets collected during our recent experiments. I hope to be back up in the high Arctic with the "NASA boys" for a short period next summer. Who knows, maybe I will land another science trip in the near future -- I just hope it will be somewhere in the tropics for a change.

Trip report # 1
Date: Oct 14, 1999
Weather: Condition 3; temp -18 deg C, wind 0 knots

Whoever coined the term, getting there is half the fun, had obviously never tried to make it to Antarctica at the beginning of a summer field season. The flight from LAX was extremely exhausting. We were cramped in coach class, surrounded by coughing people, most of whom were ASA and NSF personnel en route to the McMurdo Station, like ourselves. It was hard not to feel like a hypochondriac and paranoid. I definitely didn't want to catch the flu again this season (the infamous McMurdo crud) and the sniffling and sneezing put us all on edge. It was similar to being in a kindergarten class, surrounded by little viral vectors, except in this case, all the kids had just been traveling in exotic parts of the world during their time away from the ice. Of the person next to you didn't have the cold, perhaps they were harboring Ebola virus. After 16 hours of flight and 2 days of travel, from L.A. to Auckland, NZ and then to Christchurch, we were able to finally get some sleep.

Our team this season is similar to last. It is headed by a friend of mine, Norbert Wu, a well known underwater photographer who is here this season to continue working on a National Science Foundation project to photograph and document the marine life under the Antarctic shelf. Additionally, this year he will be shooting an underwater documentary film for PBS Nature on life under the ice. My role will be similar to last time; I'll act as a scientific liaison for Norbert's project, help with the U/W still photography, and do some additional sampling of glass sponge spicule mats for myself. Also along is Christian McDonald, as a support diver (a veteran of previous Antarctic dive projects), and D.J. Roller as secondary underwater cinematographer (DJ has worked on numerous underwater film projects, for CNN, freelance work and for Bob Ballard's Jason Project). An additional team member, Peter Brueggeman, the intrepid Scripps Institution librarian, will be arriving in a few weeks when DJ leaves (Peter was present on our previous trip as well).

On our first full day in Christchurch, we spent the morning at the International Antarctic Centers clothing distribution center (CDC) to be fitted and receive the field clothing for this season. Most important was the ECW gear (extreme cold weather gear); a heavy down parka, fleece jumpsuits, bunny boots, underwear, thermal pants, gloves, mitts, hats, goggles etc., that we would wear on the plane as well as carry with us as survival gear whenever we work out on the ice. We were scheduled to fly out the very next day. Alas, we didn't fly out the next day, or the next, or the next 6 days in fact. A series of storms in McMurdo prevented any flights from landing at the ice runway. Also, they prevented any flights from leaving McMurdo in an attempt to make an emergency landing at the South pole station to retrieve the physician stationed there who had contracted breast cancer while over-wintering (you may have heard about it in the news -- they have been waiting for the temperature at the pole to climb above -50 deg, so they can attempt a landing). Despite the aborted flights, we still had to get up very early every morning, arrive at the Antarctic center at 4 AM, get dressed, then sit around waiting to hear about the weather and status of the flights. When we were lucky the flight would be canceled before we made it to the airport, and we could stay in bed. After the aborted flights we would wander around the town in a groggy daze, eating endless souvlaki sandwiches for late lunches and stocking up on Thai food at dinner (there would be nothing so exotic down on the ice, so we decided to enjoy it while we could). Since we had to stay around Christchurch in case of any change in flight status, we were unable to do much sight seeing around New Zealand while delayed.

We finally made it to the ice the day before yesterday. We packed onto the C141 Air Force jet cargo transport like sardines. There were over 100 of us now waiting to fly so we were all jammed in with the cargo. It was once again very uncomfortable, but fortunately, in the jet, we only had a 5.5 hour flight, compared to the 8 hour flights we had previously in the LC130 Hercules. It really is a terrible flight. You sit shoulder to shoulder and with knees touching others seated in the webbing jump seats facing you. There is absolutely no place to stand, except for on top of your nylon seat (which does provide a bit of a stretch, but makes it difficult to read while wobbling back and forth trying to keep from falling onto your fellow passengers). Going to the bathroom (a funnel behind a tarp near the rear of the plane) required climbing over the tops of everyone like sheep. It was

incredibly noisy even with earplugs on and the heating pipes were a bit wonky. It was freezing cold near the front of the cargo area, and we recorded 87 degrees back where we were sitting; which started a frantic struggle to remove layers of clothes before we were cooked. But, we made it all in one piece and landed on a bright, crisp, windless evening. The next day we spent doing a sea-ice travel and survival refresher course and started unpacking our 30 cases of equipment. Today, we have continued to get settled, finished quick classes on radio coms, Spryte tractors and snowmobiles. We are almost all set to get out diving. We will be traveling in the field tomorrow to check out possible dive hole locations and test the ice for the drill rig. Monday we hope to make our first dives.

Antarctic Trip Report #2
Date: Oct 18, 1999
Weather: Condition 3; temp -22 deg C, wind 22 knots

We have been very busy these last few days. We have finished all of our training (finishing up with snowmobile field repair and then a quick meeting with the field radio communications group to sort out what frequencies we will be using in the field this season). Today we even managed to make our first dives to test gear and re-familiarize ourselves with diving protocols.

Our first full day in the field was the day before yesterday. Christian and I traveled in our Spryte (a strange looking tracked vehicle used for traveling, albeit slowly, on snow and ice. You might have seen similar vehicles around ski slopes) out on the ice about 1 hour north of the base to Little Razorback Island. We are fortunate this year to have been given 2 'newish' Sprytes to use -- the infamous Spryte #666 (the anti-Spryte) from our last season, is not in the lineup for this year. It is still around though, I saw it yesterday buried in a snowdrift behind the diesel mechanics shop.

We had traveled to the island in order to scout the route in to the island from the main ice roadway. We had to make sure there were no large cracks in the ice or other hazards that might prevent the drill truck from making it to where we wanted to put in a dive hole and hut. Once we reached the island, we made a few exploratory test drills by hand Kovacks drill to measure the ice thickness where we wanted our hole (it was about 2 meters thick) and check the depth of the water under the ice (about 33 meters). We didn't find any cracks too large for the drill rig to cross, and the large pressure ridge system was similar in appearance to what we had seen previously. We did see a few pregnant Weddell seals around; they should be having their pups over the next couple of weeks.

After checking out the area we started the long, laborious process of 'flagging' the route across the ice. This would make it possible for us to find the main ice road when visibility drops during stormy conditions. We would drive the Spryte a little ways, toss out a pile of long bamboo poles with bright red flags tied onto the top, and then walk along with our hand drill and take turns drilling a few feet into the ice, inserting the poles and then packing snow and ice around the pole to hold it tight. We placed flags every 40 paces and it took us the entire afternoon to mark our route out to the main road. We made it back to the base in the early evening, just before the galley closed, tired but satisfied with a long day's work. Tomorrow the drill rig will follow our flags and drill our dive holes.

Yesterday we returned to the same area, this time on snowmobiles and with a pile of camera equipment. D.J. wanted to film the snowmobiles scooting across the barren ice, with just the Royal Geographic Range of mountains in the background, as well as film the snow blowing across the ice in long sinuous snakes. It was only a partial success - we hadn't brought along a special "polar bear" bag to insulate the camera, and after a while the batteries started causing problems, and the blowing snow was threatening to jam the controls. It wasn't too bad a day, but the wind was very gusty. The remainder of the day was spent preparing our equipment for upcoming dives, and getting supplies for our dive huts (it is nice to have them stocked with soups and snacks for between dives, and each hut has to have shovels, ice scoops, picks, first aid kits etc.). In the evening we

attended a lecture by Dr. Sam Bowser. His team (the only other large dive group at McMurdo this season), will be stationed across the sound at Explorer's Cove, New Harbor, and will be collecting and studying benthic Foraminifera. Foraminifera are one-celled organisms that are very common in deep sea sediments (and also in the New Harbor area). We will be spending a few days using their dive holes later in the season, so I'll babble more about benthic forams then.

This morning we went for our first dive of the season. We loaded up the Spryte with all our equipment and chugged the short distance to the Arrival Heights dive hut, about 1 km from the base. This was our 'check-out' dive with Rob Robbins, the station's diving safety officer. We went over a few diving and emergency procedures and then got wet, or at least as wet as you can get wearing a dry suit. You feel incredibly clumsy on the surface and a little stressed, particularly on the first couple of dives. You are not very mobile in your suit and insulating undergarments. I just had a new neck seal and hood replaced on my suit, so that felt extra tight and constricting. It takes a separate dive tender to help you into your gear and fix the dry gloves onto your hands. Then finally, you can fall into the small hole (about 1.5m in diameter), sink through the ice tunnel and pop out under the sea ice with hundreds of meters of visibility in all directions. At last all the heavy equipment feels weightless and you can move without feeling constricted. And you remember just how cold this water is; -1.8 degrees! My body was pretty warm during the short period of the dive (about 30 minutes), but I had forgotten about those first few moments of pain when the water hits the bare skin around your mouth and regulator.

The underwater scenery at this location wasn't too spectacular, just a steep gravel slope, peppered with large orange sea anemones, but the water was brightly lit (most of the snow had blown off the ice in this area, so the sun could shine through) and there were lots of jellyfish hovering in the mid-water. I will be going back tomorrow to take photographs of the jellys as they occasionally collide with the gravel slope, become damaged, and then are slowly devoured by the anemones. Nature, red in tooth and claw.....

Antarctic Trip Report #3
Date: Oct 24, 1999
Weather: Condition 3; temp -27 deg C, wind 30 knts

Life and material goods are transient (or, 'the Razorback follies')

We have just finished a series of dives at Little Razorback Island, situated about an hour by Spryte north of the base. And despite this location being one of my favorite sites from our previous season here, the diving this time began with a rather inauspicious start. The first time I cinched my dive backpack to my tank, the buckles shattered in the cold prompting some quick field repair, and after entering the water, my trusty dive computer conked out (sorry Bruce -- I found out later that a bit of moisture entered the main battery compartment threads when I switched batteries. When I got in the cold water, it froze, expanded and broke the watertight seal, flooding the compartment and causing the batteries to leak and corrode the contacts). Once all the equipment problems were sorted away, I ended up making 8 dives at this location, and they were all wonderful. Tomorrow we will be moving our dive hut and drilling new holes in an area south of Cape Evans, where a glacier icefall from Mt. Erebus crosses a rocky cliff and plunges into the sound.

The past few days since I last wrote have been crisp and bright, with hardly a cloud in the sky. The horizon looks razor sharp and the sky bright blue. We are starting to see mirages when we travel on the sea ice to our dive sites. Fata morgana -- a famous polar mirage, appears as a series of ice cliffs off in the distance and is formed when a temperature inversion occurs in the air just above the ice. Light rays are bent upwards from a distance, reflecting a distorted image of the snow and ice into the sky where it meets the ground. Polar explorers have been tricked into thinking that these false images are actually cliffs of islands or glaciers in the distance. With a couple hours of commute across the sea ice, the mirages are an interesting diversion. It is amazing how spoiled you can get when every day being faced with magnificent scenery. Erebus, the resident active volcano

juts into the sky out our right vehicle window, ringed in spectacular ice fields. Out the left, across the sound, is the Royal Society Range of mountains and the mouths of the Dry Valleys. And on the way to Little Razorback, we pass the jet black mound of Tent Island, and the black rocky spines that make up Inaccessible and Big Razorback islands.

I wasn't the only one who has experienced a few mechanical difficulties. The day before yesterday we drove out to our dive hut in 2 separate teams. When Norbert and I arrived, we found one of our team, Christian, sitting at the surface with soaking wet drysuit undergarments. His watertight zipper wasn't closed correctly, and his suit flooded with icy water just as he sank beneath the ice ceiling. His particular suit is designed such that the zipper travels diagonally across his chest from shoulder to hip -- it flooded through the hip end, and the first part that got soaked was his groin -- as he said later, "I decided I had to get out of there real fast...". D.J.. surfaced a few minutes later with a face covered in blood; X-rays back at the base would reveal an acute case of sinusitis, with one facial sinus completely blocked and full of blood-- he will have to remain topside for a few days to heal.

Then it was our turn. I entered first and while waiting on the bottom under the hole, I looked up and saw Norbert dropping rapidly while struggling with something at his chest and trying to keep hold of his camera. I swam over to help and he motioned at his drysuit inflater, it wasn't working properly -- not at all in fact. As he sank, the increasing pressure crushed all the air out of his suit, making him heavier still. I fiddled with the valve and hoses trying to free it (it was hard for him to move with his suit crushed down like that) but we kept slipping down the gravel drop-off, trying to juggle hoses, lights and a 100lb movie camera. In the end, I took the camera from him and he was able to swim over to the safety line and pull himself up it to the tenders above. They found the inflater hose frozen solid, so they swapped it out for a new one, and he was quickly back under the water again and we continued on our dive without further incident.

Despite these few difficulties, we are all feeling comfortable in the water again and are routinely making dives over an hour in duration. It takes a few dives to get yourself used to the heavy gear and awkward suits, as well as used to the idea of working under the ice and being a long swim from the dive and safety holes. To be honest, there is no way to really feel 'comfortable' after an hour in the water -- you are quite cold. I emerged from our second dive this afternoon, 71 minutes long, with numb hands that quickly felt red hot and incredibly painful when I got to the surface and warmed them over our dive hut stove. We were quite chilled since we had been spending our time on the shallow shelf surrounding the island, and to control our buoyancy in the shallow water we had to dump most of the insulating air from our suits. Norbert said he felt like his lips were going to fall off....

The underwater scenery in this location is among the most amazing on this side of the sound. Down deep, there are craggy drop-offs and deep gullies, coated in starfish, hydroids and sponges. These steep slopes are a reflection of the island topside-- all steep slopes and rocky cliffs. Razorback is the perfect name. However, in stark contrast, in the shallow water at the east end of the island, there is a broad flat shelf, with water at most 7 meters deep and about the size of a football field. Up above, there are huge pressure ridges, where the sea ice has been smashed against the side of the island, up into the air and then deep into the water below. In most places, the ice formed a low ceiling, about 1 meter, or less, high. Just enough that we would squeeze through, tanks rubbing on the ceiling and bellies scraping along the bottom. All along this narrow slot, there were still thousands of starfish, urchins, isopods, amphipods, and juvenile fishes.

In a few areas, the ice moved upwards again, under the highest pressure ridges, and formed long parallel tunnels and rooms that we could comfortably swim through, and that we were sharing with 2 Weddell seals, that would cruise past like curious, eyed and finned zeppelins. We named the major tunnels, 'A', 'B' and 'C' to aid our pre-dive planning and help navigation. The 'C' tunnel was the shortest, it ended in a small low room, lined with ice crystals, with a circular tunnel that looped along one wall with a seal breathing hole in the roof. The 'B' tunnel was much longer, also ending in a small room, that had bright blue walls and a triangular tunnel off to the side that lead to the 'A' tunnel.

The 'A' tunnel could also be reached through a larger mouth-like opening. It was much longer than your lights could penetrate and it was about 8 meters wide and maybe 6 meters tall. Swimming through it, was like swimming along at twilight, with just a hint of light penetrating the roof. It went all the way across the shallow shelf and opened up on the drop-off at the other side of the island. There, the ice arched far up overhead again, like a huge domed ceiling, and there was a single, 5 meter long brine tube hanging down which D.J. had nicknamed 'the fang' (brine tubes look just like a stalactite, and form from super-cooled brine that freezes the surrounding sea water as it seeps down from cracks in the ice above).

I had been engrossed in examining the anchor ice on these past few dives. Because the sea water is right at the freezing point, it often spontaneously crystallizes along the bottom in shallower water, forming saucer sized, wafer-like crystals. There are often big beds of it, thousands of crystal platelets stretching along the bottom for hundreds of meters.

Many of the sea urchins here are covered in a cap of red algae fragments that they hold in place with their tube feet (wearing them as camouflage perhaps, and as a mobile buffet table -- they can then graze on their own algal covering). This algae is quite often the starting point for anchor ice crystal formation. The anchor ice is buoyant and if enough builds up on the algae, and the urchin loses its grip of the substrate with its tube feet, it is slowly lifted off the bottom and then rises up to the ceiling of sea ice where it is frozen in place amongst the platelet ice. In some areas above large beds of anchor ice you can find clumps of the bottom, stones and mud and hapless victims; urchins, starfish and other invertebrates all slowly getting entombed under the ice ceiling when torn free. The marine life here is really in a very delicate balance.

Antarctic Trip Report #4
Date: Oct 30, 1999
Weather: Condition 3; temp -18 deg C, wind 5 knots

Since my last report our small team was split into 2 groups for a few days. Christian and D.J. spent 2 nights at Cape Crozier, shooting topside film footage of the Emperor penguin colony there and to scout it out for more work later in the season if necessary (underwater). Meanwhile, Norbert and I made a series of dives at our latest dive hut location.

Several days ago, two large caterpillar tractors, one towing a drilling rig behind it, the other towing the huge dive hole drilling bit, followed us out towards Cape Evans. Along the way, the convoy stopped by Little Razorback Island, and our dive hut was hooked up to a tractor as well (the huts are built off the ground on sled-like runners to facilitate towing across the ice). We then dragged all this equipment towards the Southern side of the Cape, right next to a small rocky cliff and adjacent to a huge glacier wall that was spilling into the sea. The huge drill rig managed to chew 3 dive holes (1 main hole for the hut and 2 safety holes, all about 4 feet in diameter in ice 7 feet thick) in short order. The hut was then towed into place and snow packed around its base to keep the wind from blowing through the hut. We were all finished putting in the hut in less than 2 hours. Then we went for a dive.

This location turned out to be one of the most amazing we have encountered on this side of the sound. The rocky cliff continued underwater, slightly decreasing in slope, but still very steep and dipping way out of sight. The huge, blocky, rocks were dark brown and black coloured, volcanic, and rather sinister in appearance. What made the slope spectacular was the incredible profusion of invertebrates living on the rocks, some in bright colours that contrasted spectacularly with the dark rock walls. There were lots of large starfish, anemones and, most amazingly, large numbers of 1 meter tall deep water soft corals. These were in muted colours, pink, white and purple --that looked almost identical to the soft corals more commonly encountered on tropical South Pacific reefs. Down here, they had only previously been seen over on the other side of the sound in New Harbor (which sports a benthic fauna more characteristic of the deep sea).

In the shallows above the wall, the sea ice dipped down in a couple of jutting ridges, all peppered with chandeliers of platelet ice. In between the ice crystals we could see thousands of juvenile borch fishes, all flashing between the crystals and hovering around the ice in small schools; again giving the location a tropical feel.

Swimming much farther from the dive hole, and far away from the last safety hole (unfortunately) we could swim along the face of the glacier that had finally ground its way down Mt. Erebus into the sea. It is hard to adequately describe the sensations swimming next to this towering wall of ice. It was as smooth and flat as a pool table, and if you swam directly towards it, it was difficult to tell where the milky surface of the ice began and the water ended, until you crashed your hands into it. Swimming along the wall, it progressed outwards into deeper and deeper water and eventually fell away in a vertical wall, beyond the reach of our lights, way, way, way, beyond diving depths. At the shallower end of the wall, at about 100 feet, the bottom was also composed of white glacial ice. From above it looked like white rivers, running through a dark land composed of black sand, and small blocks of glacial till. Here we were seeing the terminal moraine of a glacier being deposited, but in this case, underwater. Looking down on divers swimming above the rivers of ice, made it look like they were floating above the surface of some alien, glaciated planet.

Unfortunately diving around the glacier wall was a bit hazardous. It was a very long swim from the closest safety hole (and even farther still to the primary dive hut hole), prompting us to be extra careful in watching our air supplies. Additionally, the icy walls and bottom were incredibly slippery. Anything placed onto the bottom wanted to quickly slide away into the deep, whether a camera or a slightly over-weighted diver. We actually had a few close calls, with frozen suit inflators, and frozen regulators, but careful planning before the dives, with double tanks for extra air, extra tanks hanging at the safety hole and close buddy attention made potentially lethal situations merely inconvenient.

We have also just experienced our first stormy day this season. Last time we were here, the weather was the worst on record; 5 large blizzards and Condition 1 weather on base. This season has been relatively benign so far (touch wood). Crisp and cold and slightly breezy perhaps, but nothing that has stopped our working. However, 2 mornings ago we woke up to winds gusting over 50 knots, -25 degree temperatures (much colder with wind chill), and limited visibility on the sea ice. After things calmed a little bit, we loaded up our gear in our Spryte and went diving anyway. In case the weather deteriorated further, we only traveled the short 10 minute distance to Cape Armitage and dove out of a hut there. It was pretty strange; we quickly dragged our gear through the storm into the warm hut and got suited up while looking out the hut windows into the swirling snow. Once in the water you had no idea it was so awful up above the ice. It was very dark down below due to all the snow cover and cloudy skies, but under our lights, the colourful benthic community stood out vibrantly. As quickly as the storm had appeared, it then disappeared. By early evening the sun was shining brightly.

Life at the base is very surreal. McMurdo base is a busy place because it is the hub for all scientific work on this half of the continent as well as at the South Pole station. It supports the New Zealand, Italian, American and occasionally the Russian bases -- you often hear a half dozen different tongues being spoken in the galley. It has all the squalor and charm of an old mining town. Most of the equipment and supplies are left out in the open (tied down of course), and all the electricity, plumbing, sewers etc. are all laid above ground within insulated conduits that crisscross all over the base. The buildings are a rag-tag bunch of old military barracks, steel huts and more modern buildings (like the new Crary laboratory). And all are built on dark volcanic cinders that quickly gets tracked into the snow making everything look incredibly grimy. You never know what you will see. Just last night I walked out of the main building #155 (which houses a small 'ships store', the galley, some dorm rooms, radio rooms, some computer facilities, and some administrative type offices) and looked down into a series of large metal dumpsters. The one marked "Construction debris", was filled to overflowing with dozens of old, upright vacuum cleaners. They looked like relics from the 1950's, all shiny steel and bright red hoses. The recycling program here is extensive. Over 90% of the material waste of any sort is recycled and returned to the States at the end of the season. We have to sort our trash into 14 different categories. But vacuums? How could they have all died at once?

Tomorrow we are going to travel out to "Weddell World", the sea ice camp of Dr. Randy Davis and colleagues. They are studying the diving behavior of Weddell seals by strapping instrument packages onto the seals' backs. We hope to get some pictures of the seals as they start their dives. Then we will be scouting out our next dive location. We will be moving our hut to a large iceberg frozen into the sea ice just off the base of the Barne Glacier. We will have to check the area for any cracks and test the thickness of the ice to be sure the tractor and drill rig can work safely where we would like our dive holes. It will be a long day, but without having to dive, it won't be nearly as exhausting.

Antarctic Trip Report #5
Date: Nov 3, 1999
Weather: Condition 3

[Editor's Note: In the following text, Dale writes about getting decompression sickness from diving. After extensive medical followup when Dale returned home, Dale's doctor diagnosed Dale's symptoms as being caused by a pinched nerve in his back, a result of all the heavy lifting of equipment on this diving/photography project. Dale's doctor feels that Dale's previous "decompression sickness" episodes were also due to a pinched back nerve; heavy lifting was involved on those research trips as well.]

Bad Dreams (a.k.a. "it's go time")

This is going to be a difficult report to write, but let me start by putting peoples minds at ease; everyone is ok.

Almost a week ago, the day after my last dives at the glacier ice wall, I awoke in the night with symptoms of decompression sickness ('DCS' or 'the bends'). Partial paralysis in my legs, left arm, hand, that then spread into the left side of my face. My left shoulder started to feel like it was being crushed in a hot vice and pain in my thoracic vertebrae spread to shooting pains through the rest of my back. Not good. Even though the last dives I made were relatively routine, bubbles of the inert gas, nitrogen, had come out of solution in my body and collected at points in my spinal column and shoulder joint causing pain, and ultimately tissue and nerve damage. Lying down was particularly bad, as inflamed tissues in my spine were crushed by gravity into the surrounding bone and pinched spinal nerves. I was fortunate that the research base has an excellent hyperbaric treatment facility. The recompression chamber has been used for a few diving incidents in the past as well as to treat pilots who make high altitude flights around the pole. The doctor (a military flight surgeon) is knowledgeable and, the diving officer, Rob Robbins is very experienced in chamber operations. Within the hour I was being prepared for treatment and the medics here were in constant contact with hyperbaric medicine specialists back in the States.

Thus started many days of treatment in the chamber. (For the diving wonks out there, 5 modified Table 6 treatments, followed by 3 modified Table 5's) Initial compression back to an equivalent depth of 60' provided almost immediate relief of most symptoms, but these would slowly return (to a lesser degree each time) as I was slowly brought back up to atmospheric pressure, and rested between the treatments. The treatments would last as long as 6 hours, during which myself and a medic would sit or lie in the cramped metal chamber (with 3 view ports which gave us, the occupants, a wonderful view of the ceiling of the hospital, but allow the doctors outside to look in), and which would become alternately warm or cold depending on the pressure change. I breathed pure oxygen through a mask strapped on my face but was allowed a 5 minute 'air break' every half hour. The mask breathed with considerable resistance, which was annoying at first, but after 4 or 5 hours it would have become exhausting, and a mental struggle to keep from tearing it off my face feeling suffocated. The treatments sometimes ended in the middle of the night, and I would crawl out of the chamber and be helped straight into bed in the infirmary to try to sleep. It was very exhausting, and I needed 12 hour breaks to let my lungs recover from the effort of breathing pure oxygen at high pressure -- which becomes poisonous after long exposures and tends to burn your lung tissue. At the end of it all I felt like I had been run over by a fire truck. My face was pretty bruised and chaffed from the breathing mask, my chest was killing me, and my ears tender from all the

efforts at constant clearing. I was a pretty sorry sight, with the look and feel of an extra from the movie "Das Boot". But it worked....Now I just have to 'recover from the treatment.' I have the medical and emergency staff here to thank profusely. They worked almost round the clock for many days to help me recover. Who knows what would have happened if there wasn't a chamber available. I would have had to have been flown to New Zealand, which would have exasperated the symptoms, and continued bad weather this week has delayed flights down here by a week.

Unfortunately this isn't the first time I have had to 'get squeezed' in a recompression chamber. Previous diving work in Florida on a colleagues' reef project over the last few years has led to members of the team needing recompression for DCS, myself included. Diving carries inherent risks. Every dive is a decompression dive and the tables and computers that we use to calculate our allowable dive times at different depths are statistical in nature. There is always a slight chance of a problem, and because as scientific divers we tend to be doing heavy work, under more stressful conditions than recreational divers, the risks are slightly higher than normal. It is an occupational hazard we have had to accept, but we make efforts to dive as conservatively as possible. Several years ago, after thousands of dives, the statistics caught up with me, and despite following the rules, I was hit. The damage done at this initial time was then the seed for further trouble later on. Despite a full recovery, the nervous tissue was damaged and hence more susceptible to further injury. Now, with this incident, the doctors and myself are wondering whether further diving might lead to more permanent paralysis. At the very least, I will not be allowed to dive for 3 months, and then it is questionable whether they will let me ever dive again, at least professionally. A depth restriction of 30 feet, where the risk of DCS is minimal, might be recommended, which would be ok for a lot of my current work in California, where diving is primarily in the near shore and very shallow. However, no final decisions have been made.

Imagine being told that you can no longer do the activity that is one of the most important to you in the entire world, something that has been a large part of your life since you were a young child. That is what I am coping with losing right now. I do feel rather selfish for being depressed about losing what some may consider to be a frivolous and potentially hazardous pastime -- which compounds the guilty feelings from having to leave a job unfinished. What makes it particularly bad is that, after a complete recovery, there is apparently nothing wrong -- you feel fine, but you can't go back into the water. I have now spent days (and previously months) recuperating, while my buddies were out working on the reef, or in this case, returned to diving under the ice. I have in the past and will this time, continue to help out topside, but will burn with envy since I can't return to diving this season. We will soon be traveling to Granite Harbor, where we last time found some of the most spectacular diving on the planet. I will have to live vicariously through my dive buddies, retain a positive attitude while walking on the top of the ice knowing that just below they are seeing incredible things and content myself with sharing the pictures and stories that they bring back.

What is next? There was some talk of my having to return stateside for more testing and possible MRI of my spine; but my hyperbaric treatment has gone well, so we don't think that will be happening. My current plan is to stay here through our planned season. I will be able to help topside with the diving and for support at our camps farther in the field. I can also begin to do some of the topside filming both outside and in the laboratory (close-ups of marine organisms). I will also be able to get back in the water at the ice edge (where we will be mostly snorkeling to film penguins) and perhaps around the cape as well, once I have recovered my strength. So, I shall be staying very busy -- I will just have to focus my attention on some of the topside scenery for a change.

Antarctic Trip Report #6
Date: Nov 10, 1999
Weather: Condition 3; temp -10 deg C, wind 30 knots

I would like to start by thanking everyone for all the kind messages I have received over the last few days; I have been slightly overwhelmed and I am sorry if I haven't responded to them all personally. I am feeling much

better now and have been able to get back out into the field with the rest of the team. It is nice getting outside again, however, I am still a little depressed about heading out and not being able to dive.

A few days ago another real zinger of a storm came through keeping everyone indoors and on the base. The wind speeds topped 90 km/h and there was lots of blowing snow. Interestingly enough, the temperature felt fairly warm (if you didn't have any exposed skin), and it might have even been amusing because you could almost lean all your body weight into the howling blast. Unfortunately, visibility was only 10 meters or so, and almost zero out on the ice.

I talked with a friend who was out at the "Penguin Ranch" (a remote field camp about 1 hour by Spryte out onto the ice) during the storm and he had some great stories about having to get up and shovel snow every hour to keep things cleared. Most importantly, they had to keep the snow from filling up their "penguin corral", a large fenced pen where they keep about a dozen Emperor Penguins to monitor them as they do their dives. If too much snow accumulates within the corral, the penguins can just walk over the top of the fence and escape. So, they spent their time frantically digging a moat around the inside of the fence, while getting blasted by the storm, and the penguins apparently looked on with stoic calm. These birds spend the winters down here, incubating their eggs, during storms much more severe than these, and with the temperature dropping to below -100. They were yawning, and stretching, preening their feathers, and no doubt laughing at the scientists as they ran around in a shovel-wielding frenzy.

As I have mentioned before, the storms here are very different from the ones I was familiar with in Northern Ontario. There, there was considerable warning before the weather turned sour. Here, in addition to the storms being of much greater ferocity, they can also appear with startling swiftness. Within an hour, the weather can turn from relatively nice, to a raging blizzard. And then, a few hours later, just as rapidly disappear. This isn't just due to the limited long-range weather forecasting ability at the base. You can actually look south along the sea ice towards Minna Bluff (many km distant) through what is known as 'Herbie alley' and see the storms come barreling along. I am not exactly sure how they have become affectionately known as 'Herbies'. When you lose sight of the bluffs, you often have less than an hour before the storm hits the McMurdo area.

Since I haven't been able to dive, I have been placating myself with helping to drill dive holes and moving huts around to new locations. I have had to delegate some of the heavier tasks to the G.A.'s (general assistants) who often come with us out into field to help tend, or, in this case, help dig through snow drifts. I have also been busy with the logistics of getting organized for our field camp at Granite Harbor next week. There are hundreds of little niggling details that go into setting a camp in the field, and a zillion more when there is diving to worry about as well. We have to arrange with the helicopter crews the flights of our cargo, gasoline to be staged, getting our snowmobiles into sling loads and moving all our equipment to the Helo pad. All our hazardous materials have to be 'Dash-2'd', cleared for flight, which means moving all our tanks, oxygen kits, fuels and batteries up to science cargo and then back down to the helo's. All our equipment has to be individually tagged and weighed and listed on flight manifests....Hmmmm, I still have to help arrange the food -- 5 people for a week, adds up to a lot of 'noodles 'n sauce', cup-o-soups, and dehydrated meals. I'll keep everyone posted..

Antarctic Trip Report #7
Date: Nov 20, 1999
Weather: Condition 2; temp -15 deg C, wind 35 knts, gusting to 55

Bent but not broken

We have just returned from our week's stay at Granite Harbor/Cape Roberts. We had spectacular weather most of the time; it was clear, sunny and warm (relatively) almost the entire stay. The bay is located about 150 km north of McMurdo, just north of the dry valleys on the continent proper. Returning this afternoon, we left bright

sunlight at Cape Roberts and flew into degenerating weather, with high winds, clouds and blowing snow. "Mac Town" (another local name for the base), looked uncommonly dreary after our trip.

Granite Harbor was the location for some of our most spectacular dives during our previous season. This time, because we had no camp at the Harbor proper, we staged ourselves out of Cape Roberts, about 5 km south of the Couloir Cliffs (one of our favorite sites). At Cape Roberts was a large encampment to support the international drilling project and we were able to depot the fuel for our snowmobiles there, set up our tents nearby, and use some of their facilities (power for charging batteries, freshwater for showers, and we were able to take dinner with the drill team between their shift changes). In return for their hospitality, we gave them our extra fuel and flew in extra supplies, including 80 meals.

The population at the base hovered around 40 people, with two separate drill teams of about 15 persons that worked round the clock, traveling 10 km out over the sea ice to their drilling platform. There, the scientists (geologists and micropaleontologists) and the drillers were collecting rock and sediment cores from out in the sound primarily to study the past climatic and geologic history of this region of Antarctica. They had already drilled to over 850 m, and were well on the way to their goal of 1000 m by the end of this season at which point they will have run out of drill string. Drilling in water over 150 m deep is quite a technological achievement. To imagine the scale of things, picture a piece of dental floss hanging from the ceiling of your room, and then guiding it through a tiny hole in the floor below. The drill team guides a long drill 'string' through the sea ice, down through the water, and into a tiny guidance cone on the sea floor where it starts boring its way through the sediments beneath. They are hoping to continue drilling at a new site in the future, that promises an even older historical record, but to reach the seafloor they will have to pass through over 350 meters of water. Actually, as amazing as it all sounds, marine geologists have been doing this for quite some time, and they manage to also do the drilling from a ship in the middle of the ocean, rather than the stable sea ice.

Most of our first day was spent setting up our tents and anchoring them into the ice in case of any high winds. After a few hours of drilling holes, tying things down and unpacking crates of cameras and dive equipment we set off by snowmobile to search for possible dive locations. Since we didn't have a drill-equipped tractor on this side of the sound, we had to look for thin spots in the ice, around large pressure cracks and around seal holes that we could enlarge to provide access to the water. All around the Cape were large icebergs that had broken off the surrounding glaciers and ice caps, some had grounded in the shallows, while others were locked into the ice farther out to sea. Our first goal was to find an entry point near enough to one of the bergs to allow diving.

The icebergs were quite spectacular, I don't think I have ever seen so many different shades of blue and green all in one small area. The one that we thought had the most promise had touched bottom then become frozen into the ice at the beginning of last winter. At some point it had then become unstable, and part of it had tipped upwards, ripping through the surface ice, pushing it into a jumble of bright blue fractured blocks, and then splintered into several house-size fragments. There was a seal at the base of it so it had obviously come from a hole nearby. When we did find the hole, it was only just big enough for a seal to squirm through, and opened onto a shallow ice shelf less than a meter deep, that would not allow a diver to pass through to reach deeper water. However, while poking around the seal hole, we found a thin section of slushy ice in a sloping side gully that looked promising, and we started work on our other dive hole option....

What could be more frightening than standing on a slippery ice ledge, above a slushy pool of sea water, in the lee of a recently collapsed iceberg and wielding a screaming chainsaw with a blade more than a meter long to try to cut blocks of 2 meter thick sea ice to make a hole big enough for divers to enter? I couldn't think of anything, so, I graciously let Christian manage the chainsaw and I helped drag the cut blocks out of the water. Rob Robbins, Christian and I worked for about 3 hours and managed to open a small hole, and make an enormous mound of ice chunks beside it. Unfortunately, when we got Christian into the water to check it out, (in his dive gear of course) we were once again defeated. There was a tiny passageway that allowed our test line to reach open water and then the sea bottom some 28 meters below, but any motion in the water would dislodge

large ice blocks and fragments from beneath that would float up and block the hole. A diver could possibly enter, but the chances were too great that the ice would shift and he would not be able to exit again.

We searched for possible locations around all the icebergs in the bay with little success, even cruising along the length of a massive tabular berg more than 1km long. We abandoned our search after a long day and returned to our camp. In my case, to a tent almost completely stuffed with gear and warm clothing; pile jackets, down sleeping bag, 2 sleeping pads, ECW gear, stacks of dry socks, heaps of long underwear and down clothes. It was a very comfy, brightly coloured, pile-lined nest and home for a week.

The next day we made a high-speed run across the ice to Couloir Cliffs, the site of our previous camp, and we had the good fortune to find a large crack in the sea ice almost in the identical spot as before. Some quick work with the chainsaw, some shoveling and hole clearing with nets and we had a hole big enough for divers to fit through. We had similar success at Discovery Bluff, located on the other side of the bay. We found a hole that seals had enlarged (big enough for 2 divers), and most importantly, it was situated next to the bluff in shallow water (many of the seal holes were over water 100's of meters deep).

The area around Discovery Bluff was a great place to get a real sense of the power of the ocean and of the sea ice. With your back to the bluff, a 2 meter thick slab of sea ice, stretched off into the distance as far as you could see while ringed in by the rocky cliffs and bluffs of the bay, and by the icefalls of the McKay and Wilson Piedmont glaciers. As enormous as this slab of ice was, millions and millions of tonnes of ice, you could still hear it groan and scrape when large ocean swells from across the southern ocean collided with the ice sheet and sent ripples through the ice sheet into the bay. The ice also lifted and fell, over a meter each day with the tide and this constant motion created the long cracks parallel to the shoreline that both the seals and us, were able to use.

Much of our time was spent traversing across the sea ice between our camp at the Cape and the dive holes by snowmobile and towing a large sled heaped with dive gear. With all the equipment, we ended up spending many hours of the day driving (wrestling might be a better term) the snowmobiles across the ice at a snail's pace for fear of tipping our loads on the bumpy sections. Between the bone-jarring sections of sastrugi (small, hard, drifts of snow) there were long open sections on smooth polished ice like a skating rink. These were often the size of football fields, and rather hazardous since they would lull you into attaining high speeds and just a little jostling of the handlebars could then cause a crashing sideways skid (a similar accident injured two people the last time we were here).

The need for intense concentration was made more difficult with the surrounding scenery. Who can concentrate on driving when faced with such views! We would pass huge icefalls and towering glaciers and weave between icebergs. Crossing Avalanche Bay, we could see huge rivers of ice spilling from the high mountain sides and swirling around protruding rock cliffs like an enormous river rapid, a thousand feet high and frozen in place.

The weather we had during almost the entire trip was amazing. There often wasn't a cloud in the sky, and the sun was so intense that our number one concern became sunburn. With 24 hours of continuous daylight, a high albedo environment with reflection off the snow, sea ice and surrounding glaciers and not to forget the ozone hole above our heads, we took great care not to get fried. I spent most of my time with my face cocooned up like a mummy, until it felt too suffocating, at which point I switched over to a thick Kiwi sun block cream. It went on our faces like white tar, and I would find out that it was next to impossible to remove. Soap and water seemed to have little effect (perhaps paint thinner or acetone applied with some steel wool would have worked) -- after a week, it felt like it had to be carved off with a putty knife. But, it worked, and we returned not too badly burned up.

The diving at our Granite Harbor sites this year has also exemplified how difficult it is to specifically plan things around Mother Nature. We arrived this season with a specific agenda based on our experiences two years previous, and from the observations of other scientists in other years. It turned out that 1997 was a special year.

There were not as many cracks this year (although the ones that were present were in the same location as before), however, a relatively calm winter didn't produce storms violent enough to really fracture and move the sea ice sheets. Not only were there fewer places to gain access to the water, the large and spectacular pressure ridges were not present this season. Also, this year it appears as though the plankton bloom is arriving early in the Sound and visibility is already starting to drop, particularly in the north, closer to the open sea. If we had waited longer in the season for the cracks to widen for easier diving, the visibility would have not been very conducive for filming. So, it appears as though there is only a narrow window for optimal diving conditions in the Granite Harbor area, and in 1997 we were fortunate enough to be there at exactly the right time.

When I closed my journal entry from Granite Harbor in 1997 I reflected that after the dives there I considered my life underwater complete, and that I would be content to not dive again. I now suppose those were musings based on then eternal optimism. When I was topside this past week and helping my colleagues to enter the water, I really ached to be able to join them. At the large crack at Couloir Cliffs, I entered water with my snorkeling gear and could peer down through sun beams at my buddies disappearing over the drop off to the deep benthic community below. The crack was fairly interesting, with cathedral arched sides already thick with a golden-coloured diatom and microbial film and swimming along the channel I could just see the frozen subsurface freshwater icefalls at the base of the cliffs. It was interesting for a while, and it was nice to get in the water again, but not quite the same as my previous experience.

Antarctic Trip Report #8
Date: Nov 25, 1999
Weather: Condition 3 ; temp 2 C degrees above freezing!, wind 0 knts

Sprytes from hell

Yes, it is above freezing this afternoon! A real change, and now McMurdo base resembles its other nickname "McMudhole". The base is constructed on dark volcanic cinders, so it doesn't take much to melt off the surface snow on the roads and turn everything into a muddy mess. After the temperature drops again tonight, everything will be locked up in ice...

Just the other afternoon, Norbert and I headed out to the Penguin Ranch located about 1.5 hours NW of McMurdo in the middle of the sea ice. We had just been commenting on the good luck we had been having with our two, less-than-trusty, Sprytes this season (the 2-tracked vehicles we drive around out on the snow and ice), and we shouldn't have spoken. This turned out to be the start of a series of Spryte follies, akin to problems last time we were here.

We hopped into our wonderful Spryte #242, with a mountain of camera equipment and tried to head out of the base. As soon as we made it over the sea ice transition, and out onto the ice, we were assaulted by a horrible thumping noise. Some of the grouser bars (long metal cleats on the tracks) had broken loose from one track and were trying to tear a hole through the chassis, hence the noise. The rest of our group was diving at the hut at Cape Armitage (right near the base), so we traded Sprytes with them to continue. Alas, on our other Spryte, #241, the left brake had started to fail (you use the brakes to steer), so we could really turn only to the right, a manageable albeit awkward problem. Worse still, the inside window fans were broken, so the windshield constantly fogged up under the blowing snow. Driving became a 2 person operation -- I handled the controls, while Norb constantly wiped a viewing hole with a towel so we could see. The wind picked up, and out by the Mt. Erebus ice tongue there was lots of blowing snow which made it difficult to navigate. On top of this, we generated our own little traveling white out, because of the wind direction, all the snow we were kicking up as we drove, was blown in front of us and around the vehicle. At times there was almost zero visibility and we had to slow to a crawl to let the snow settle, wipe a new peep hole and then drive to the next marker flag (on one occasion I found the next flag by driving over it. Oops).

We finally did make it to the penguin ranch, where Dr. Paul Ponganis (also from Scripps) and a few SIO post-docs are studying the diving physiology of these remarkable birds. At their camp, they have about a dozen Emperor Penguins and a single dive hole that is located about 20 km from the ice edge. The birds can't possibly swim away, so they have to enter and exit this one hole, making it easy for the researchers to study them as they go about their foraging dives. Topside, they are rounded up and marched across scales buried in the snow for daily weight measurements, they have blood samples drawn, and some of them carry miniature instrumented backpacks with them as they dive. It is a pretty slick set up. One of the penguins, carrying a miniature video camera on its back, video-taped itself catching "borchs", an icefish that lives just under the brash layer of platelet ice. They were also rather humorous to watch (as all penguins are); they stood around in small groups inside their corral, rather like at a dinner party. Now and then casting glances at the scientists, no doubt wondering what on earth they were going to have to do next.

I climbed down into the observation tube situated beside the birds' diving hole. It opened into a small, 1 person, viewing chamber about 5m down and I had a complete 360 degree view beneath the ice (the next best thing to diving) and into the inky black of water a thousand meters deep . Here you could really see what is truly special about penguins. Topside they waddle like clowns, in the water they fly like the most graceful of rockets. They dive for as long as 10 minutes, and to more than 100 meters in depth. I could watch them glide out of sight below and then shoot up from the depths leaving bubble trails and blast out of the hole like little tuxedoed missiles.

The next day, the Spryte with the track problem went into the shop, and we were given a replacement (not #666, the antispryte of last season, but, #756 -- which turned out to be Beelzebub, or some other demon incarnate). I waited for a G.A. to arrive and then we left in #756 and roared out of the base at about 5 km/h. (A G.A. is a general assistant, someone who is assigned by the science office to help when an extra pair of hands is needed, i.e. particularly for something mindless, repetitive, and/or backbreaking, but what the heck, it gets them off the base so nobody complains)

The Spryte was painfully slow!-even slower than a regular Spryte (which really makes you wonder what bozo named them in the first place). It made lots of noise. The engine bucked and screamed in fact, but hardly moved. We had to meet the drill rig to move a dive hut from the Cape Evans glacier wall back to Little Razorback Island and then drill some new dive holes. It quickly became obvious we were not going to make it in time to meet them. We roared along! About 0.5 km from the island, and 45 minutes past our meeting time, we could see the hut already being moved into position (the drill team started the move without us), and with a sudden lurch, the Spryte rolled to a stop, engine still roaring. Then the glycol coolant burbled out of the heating coil at the front of the driving compartment, puddled at my feet around the pedals and ran down into the engine proper, where it quickly turned into smoke and steam. I switched off the engine and we swung open the doors to clear the cabin of smoke and then called Mac Ops (the radio communications center) to inform them of our good fortune. We got in contact with the drill team, and we decided to finish moving the hut and drilling holes, and then worry about our demon-possessed vehicle.

When we were finished, Tom, the head of the drill team and a very good mechanic, crawled under our Spryte and discovered that the linkage between the throttle and foot pedal had broken, hence the rolling stop. It seemed that bouncing over rough snow and ice had finally torn a joint apart. He quickly jerry-rigged a fix with a pair of vice-grips. The glycol leak was a bit more tricky. Nothing short of a full mechanical exorcism would work. So, we were forced to limp back to the base at less than half our original snail's pace to keep from overheating the engine and with all the doors and windows open to clear the fumes (the compartment filling up with blowing snow wasn't too big a deal). So, 2.5 hours later, we made it back to McMurdo and back to the heavy shop. "Thanks for the loan of the Spryte. We busted it."

The next day we were off to start filming at a large grounded iceberg off the Barne Glacier located north of Cape Evans and about 2 hrs from the base. The iceberg was a huge, towering piece, split down one side into 2 azure blue and white halves. We thought it should have been hanging in open water, at least hundreds of meters

deep, but it turned out that it had run aground against the side of a submarine pinnacle that reached within 30 m of the surface. So, it was stuck in place and had ploughed its way into the pinnacle sediment. At its base was a spotty field of soft corals and sponges and the pinnacle sides sloped away into the depths. A stunning place to photograph.

To reach Cape Barne meant that it was time to procure a new Spryte for the day. Another loaner from the Heavy Shop. This time it was #758, a "pick-up" Spryte with seats for 4, and an open back platform for equipment. We loaded up all the bulky equipment on the back and followed the rest of the group traveling in the other Spryte. There were 3 of us in #758; myself, Kevin Hoefling and Terri McGerran (both are graduate students working on the antifreeze glycoprotiens in Antarctic fishes. Kevin was going to make a dive to look for any ripe females or any fish eggs). Everything was fine for the first few minutes, the infernal machine was even moving at a good clip, for a Spryte that is (about 12 km/h). And then when we made our first turn to head north along the sea ice our bad luck continued. It seemed that the exhaust manifold was no longer connected to the engine, it had corroded and broken away I suppose (don't they check these things at the shop?). The exhaust fumes billowed up into the main cabin as soon as the wind was at our backs. Since Beelzebub, yesterday's loaner, was still being fixed, this was our only vehicle to make the trip, so we decided to cope with it. At first we drove along with all the doors wide open, even the ceiling escape hatch, and wearing all our cold weather gear. But, soon even that was intolerable. Our eyes were watering and Terri was getting a splitting headache. So, for most of the 90 minute journey Kevin drove with his head poking out of the escape hatch (he could just reach the steering handles with his finger tips), Terri stood behind him on the driver’s seat, and I sat clinging to the top of the roof. With our heads outside, at least we could breathe and it looked somewhat like we were on a jaunty African safari. It is a good thing that Sprytes don't go very fast, or the wind-chill would have been unbearable. Imagine driving around sitting on the roof of your car in the middle of winter -- the view is great, but it gets a little chilly.

Today we returned to the Barne Glacier with a new vehicle, Spryte #755. In a way I am unhappy to report that it performed admirably. There were no problems at all, which made for a less stressful day, but is certainly less fun to write about.

Antarctic Trip Report #9
Date: Nov 28, 1999
Weather: Condition 3 ; temp -5 deg C, wind 5 knts

Back to the sea

Just the other afternoon I spent a few hours hiking up to the top of Observation Hill, a steep pile of cinders and rock about 275 m tall directly behind McMurdo Base. In a backpack I was carrying about 25 kg of batteries, tapes, a tripod, and a $100,000 high-definition video camera to film the view from the top. The dollar value of the camera in the pack made it a nerve-wracking, as well as exhausting ordeal. I felt like I was overheating on the way up due to the exertion, but I had no space left to stash my parka so I had to wear it. I knew I would need it at the top, because I would be standing around in the high wind, so I did my best to keep from getting too sweaty. And, I climbed up very slowly for fear of slipping on the ice and loose rock with the camera. At the top is an excellent view of both the New Zealand research station "Scott Base", a small cluster of bright green buildings on the south side of the peninsula, and the sprawling McMurdo base on the opposite side. A recent dusting of snow made both bases look rather picturesque, rather than like grubby mining towns with most of their supplies piled up outside.

Also at the top is "Scott's Cross", a massive 4 m tall wooden cross that is a monument to Robert Falcon Scott and his team. They accomplished so much under unbelievable conditions just after the turn of the century, with no Goretex, no synthetic pile underwear, down-filled jackets, fancy boots and by pulling all their gear by hand. They also perished on their return from the pole, and this cross was constructed at the top of Observation Hill

by the remaining members of their expedition who had stayed behind. In fact, all around McMurdo base (which was built at "Hut Point", a location central to many of the journeys during the Heroic age of Antarctic exploration) are a series of monuments to various people who have been killed, one way or another, in this area over the years. The most recent were two people from McMurdo who fell down a crevasse after straying from the flagged route just outside the base a couple of years ago.

We have been busy making use of the recent clear, calm weather to continue to film and dive around the Cape Barne iceberg. There is no hut directly over the dive hole there, just a "Polar Haven" fabric tent which does block the wind while changing, but then you still have to waddle up a snow drift and then slither through a seal hole to get into the sea. It is a much more pleasurable experience when the sun is beaming down and the wind isn't howling.

This afternoon I jumped into my drysuit, grabbed my mask, and then ducked down through the hole to get a glimpse of the surroundings and to help put into context the stunning footage that Norbert has been shooting around the iceberg. The hole opened onto a narrow shelf, squashed from the sides by the iceberg and a jutting ridge of yellow- gold ice starting to drip with algae. The cracks continued like bright lightning bolts off into the distance. Below the shelf the ice veered away onto the sloping shelf of the iceberg proper. Here the ice was dimpled like a giant golfball; each individual cup starting to collect algae. Here and there on the ice I could see juvenile fishes darting around, between the cups and under hidden cracks and ledges. The iceberg sloped away on all sides obscuring my view of the deeper water, except when I craned my neck and I could just make out the dark blue water beyond.

As far as I could see my view was dominated by ice. The immense scale of the iceberg below water is highlighted in the camera footage. It is a huge towering mass above the soft corals and benthos, and dwarfs the tiny divers swimming alongside. At one end it was possible to swim the camera underneath the berg and shoot directly upwards. From here the ice loomed overhead and looked eerily like the bow of an enormous ghostly ship. The ice ceiling beyond was a crazy mixture of blues and greens and gold spots and splashes. Tiny dots of light looked just like stars in the night sky, and the ceiling reminiscent of the Milky Way.

Working around the icebergs has a certain special charm that is tempered with a healthy dose of wary reality. Just last year, a group of filmmakers from TV New Zealand were filming an iceberg on the Antarctic peninsula. They were documenting the disturbance to the benthic community as the iceberg gouged its way across the bottom. Their divers were underneath the iceberg when it became unstable and suddenly overturned. On the surface the tending boat, which was anchored to the side of the 'berg, was dragged up on top and had to be cut free by its occupant and then left to drop back into the water. What happened below was truly the stuff of nightmares. The iceberg rotated directly above the divers, who were filming alongside a large boulder directly underneath, and, as it flipped the iceberg swung just a few feet above them before grinding into the bottom. It was pure luck that the shape of the iceberg was such that a more concave section passed above the divers instead of crushing them beneath a million tonnes of ice. We heard this story at the Antarctic Center in Christchurch, from the fellow who was tending the boat, and has always been in the back of our minds whenever we have worked around the icebergs.

The following day started out cold and blustery, but it cleared up and the winds died in the mid-afternoon and it turned into another stunningly beautiful day. We had been dropped by helicopter to film along the ice edge, and the brilliant sunshine couldn't have been better. We landed close to a group of about a half dozen Emperor penguins. Within an hour we had attracted a few dozen Emperors and a bunch of Adelies, all curious to examine this huge noisy red bird that dropped from the sky. They would slowly walk over and examine us as we organized our gear along the ice edge -- they would cluck and squawk a bit, crane their necks to look over our shoulders as we sat on the ice, and then mill about in small groups, just kind of "hanging out with the divers."

We were going to snorkel around in the open water and we tried to quickly strip out of our foul weather gear into our drysuits. It was still extremely windy and cold, so it wasn't a very fun process. When I spit into my mask to defog it, the spit froze into a disgusting lump during the few seconds it took for me to stoop to the ice edge and try to rinse it in the water. In the end I sort of had to chip it all out. Ugh. A minke whale swam past, some penguins dove in from the edge, and then we slid into the water.

There have been a few experiences down here that will stay vivid in my memory hopefully forever. The submarine icefalls and cavernous rooms of golden ice at Granite Harbor, and swimming along tunnels with Weddell seals and above a bottom peppered with soft corals and sponges around the Razorback Islands are still intense visions. And now this day at the ice edge. The sky and water looked like they had been lifted from a Caribbean postcard. Blue! Intensely vivid blue water. The entire spectrum of blues, from silver and azure to the darkest navy when looking far under the ice edge. And all around us, "god beams" of light, (or crepuscular rays) danced about and cast shadows of our bodies into the deep. The water surface rippled with the wind and made crazy reflections of the sky and objects floating on the surface. It was great to be back in the water and to be able to swim around. It was much warmer in the water (-2 deg) than it was topside, and I wasn't just ducking down a hole for a quick peek, or squirming along narrow tidal cracks. I was back zipping about, helping film, and happy as a clam.

Then there were the penguins. Once we were in the water for a while, more of the penguins entered the water (I guess we no longer looked like a threat), and many more joined the group from out in the open sea. They bobbed along at the surface in little packs and rocketed beneath us like schools of fish. They flapped their wings and did barrel rolls, and dove out of sight beneath the ice leaving contrails of bubbles. Then they would approach the sharp edge of the ice sheet (only about 1.5 meters thick here) and blast from the water to land topside, sometimes turning around immediately to go back in, maybe just for fun. It is a terrible misconception to think that penguins don't fly -- they do, they fly through the water like the most graceful beings you could possibly imagine. I have seen nothing else in the water that comes close. We were in the water for quite a long while and I was spellbound the entire time. The penguins would come and go. One second they were there, and then they would be gone for a while. Just when you thought they had all left, dozens would appear and bob along beside you. And just looking at the ice edge stretching out of sight, and gazing into the blue water thousands of meters deep was a treat. We saw huge jellyfish, with tentacles stretching 20 meters behind it, tiny ctenophores and siphonophores, but alas, we never saw the Minke whale again.

I climbed out of the water to help Peter suit up and to film Norb from the surface and my drysuit started to freeze solid in the wind. After 30 minutes and everyone was topside it was like hard cardboard and a real struggle to remove. It was a cold, frantic dash to change back into our ECW gear and parkas. Then, almost as soon as we were dressed, the wind stopped. Almost instantly it felt warmer and we spent the rest of the day lazing about in the sun with the penguins filming them as they worshipped the helicopter, stately walked around, preened their feathers, and then all lay down to doze. The flight back treated us to glorious views of the Erebus icefalls and glaciers. Off in the distance we could see Cape Bird shrouded in clouds, where we spent a week last time we were here. From above we could see the zigzag geometry of the cracks in the sea ice, and small groups of seals hauled out where cracks had widened. We even saw our friends in a slow moving Spryte creeping down the ice road, returning from a day of diving at Cape Evans.

Yesterday afternoon was a quiet day around the base with people recovering from over eating and the festivities of Thanksgiving the night before. Christian and I drove our Spryte out to Little Razorback Island to pick up a large gel-cell battery that required recharging and to make some more hydrophone recordings of the Weddell Seals living there. It was easy to forget we were traveling across a frozen ocean. The air was perfectly still, and the sun felt warm, even without heavy clothes on. Topside it was silent except for the crunch of our boots on the snow and the occasional snort or groan from the seals sunning themselves. Underwater my hydrophone revealed a raucous symphony of sounds. Emulating the seals, we sat around listening through headphones to the trills, slide-whistles, thumping barks and hoots that the seals make as they define their territories, and interact beneath the ice. They are quite haunting sounds, some loud, and some soft. Our hydrophone is very sensitive and we

could hear the faint sing-song notes of seals far away in the background as well as the blasting hoots of seals much closer to the island. After listening for a while, we walked around the perimeter of the island, weaving a path through the pressure ridges and snapping photos of the mothers and pups lying on the ice. Most of the pups had lost their downy looking fur, but were still suckling. It was quite a perfect afternoon on the ice for everyone.

Tomorrow we leave for Cape Crozier where we will be camping in the field alongside an enormous penguin rookery. I'll write when we return.

Antarctic Trip Report #10
Date: Dec 6, 1999
Weather: Condition 3 ; temp 0 deg C, wind 5 knts

Waiting....and a change of plans

December 2nd

Antarctica is known as the coldest, driest, highest and windiest continent on the planet, it can also be the most frustrating. We have been waiting for 4 days for the weather to cooperate in order to fly to our field camp at Cape Crozier. Unfortunately we have been continually delayed due to heavy snowfall, high winds or low clouds (or all three). Actually it hasn't been so much the ferocity of the weather, but its direction.

The Cape lies almost directly to the east across Ross Island, and while conditions at McMurdo have at times been rather clement, the bad weather and cloud cover has been streaming in from that direction, sometimes making it all the way to the base, but more often the front just stopping at the center of the island. We would be able to load up and take off, but there would be no way to navigate and land near Cape Crozier. As a frightening example of what can happen under such conditions, the New Zealand helicopter left Cape Roberts 2 days ago, and on the journey back to McMurdo, it ran into the low cloud and heavy snowfall blowing in from the east. They flew north towards the ice edge, followed it for visual reference across the Sound and then located the flagged road route on the ice near Cape Royds and tried to follow that back to base while flying low. Unfortunately they were then blinded in a white out and crashed into the ice. Luckily nobody was injured, but the helicopter suffered heavy damage and had to be towed by tractor back to the base. I am sure somebody will be looking into why they pushed ahead with the flight under such bad conditions instead of turning back to Cape Roberts.

While all this was happening, we would dutifully load up about 500 kg of gear in the morning, stage it at the helo hanger and then wait through the delays and then, finally, the canceled flights. Afterwards we would make frantic preparations to dive locally, or, sometimes, if it was already mid-afternoon, we would cancel the day's plans and head to the library to relax, or to our rooms to catch up on sleep.

The visibility in the water is continuing to decline. Diatoms and microbes have thickly colonized the bottom of the sea ice and a fine, brown sludge rains down on the divers at the merest brush of their exhaled bubbles. Down on the bottom, this algal rain feeds the benthos but is also easily stirred up by the kicking of fins. Just looking down the dive hole the water is starting to look green rather than crystal clear. Soon the visibility will be less than 30 meters, then quickly less than 10 meters and then down to about 1 meter at the peak of the plankton bloom. It will stay like pea soup for weeks, and then slightly improve by the end of the summer (Feb.). It doesn't recover its spectacular clarity until after the winter, when 6 months of darkness will have killed many of the algal cells and the prevailing currents have advected the water far under the Ross Ice Shelf.

December 6th

Our plans have been changed. Instead of traveling immediately out to Cape Crozier, we are now heading to New Harbor (across the sound at the head of the Taylor Valley) this evening. This was to be our next stop, however, time is running short and we have to take advantage of the clear weather to the West rather than just waiting in McMurdo for good weather that might not materialize.

This was my second journey to New Harbor, I was there in '95 with Brian Stewart, an ecologist friend from New Zealand. We placed a larvae settlement experiment through the ice and then had some spare time to do some hiking along the shore of Explorers Cove and into the valley. I could swear it hasn't changed a bit. This time we stayed at the camp of Dr. Sam Bowser, a biologist from the New York Department of Health who is studying the foraminifera that are easily collected from the cove sediments. These single-celled animals construct tiny houses (a few mm across) around themselves by fusing sand grains together with a special glue. It is hoped that if the glue can be isolated it would have important medical uses. They are also studying the ecology of these organisms which are more common to deep sea sediments beyond the reach of Scuba.

They and their colleagues have discovered that the forams produce long extensions of cytoplasm (pseudopods) that extend in a web-like net outwards from their sand-grain houses. Anything that lands in this net is slowly entangled, dismembered and then digested by the pseudopods. Neat-o! Very grim, at least to plankton and tiny animals on the bottom. They collect the forams with a diver-operated suction dredge on the bottom that is connected by a pipe to their dive tent above. On the surface the sea-water / sand slurry is sieved on metal screens and the forams collected for culture in plastic tubs. Their team has been doing a dive or two a day for over a month and most of their work is now finished. It was interesting to note that their internal circadian clocks have been free-running, and were slightly out of synch with our own. Morning for them, was about our noon, so it was easy to stagger our team's dives with theirs to keep the hut from getting too crowded.

The diving in Explorer's Cove is not what I would call very exciting, so I didn't feel too badly sitting on the surface (although it would have been nice to poke my head down there at least once). The ice in this area was about 4 meters thick, and to put in a dive hole required blasting a big hole, fishing out the broken ice chunks, letting it freeze over again, and then cutting by handsaw a more manageable hole about 2 meters square. A large, heated tent was then constructed on top of the hole. Underneath, the hole looked like a mine shaft, with craggy sides and then a sharp, rectangular opening into the tent. The water was about 30 meters deep above an almost flat sand plain and because very little light could penetrate the thick ice above, it was almost as black as night. On the sand (in addition to the foraminifera) were lots of scallops, a few urchins, a couple of crinoids, at least 2 species of brittle stars, and the occasional soft coral 'tree' (the same as we saw at the ice wall on the other side of the sound). All in all, very barren, and looked like some pictures of the deep-sea floor.

The camp proper was situated on a gravel and sand beach about 300 meters away from the dive tent. It consisted of two war-era Jamesway tents (olive drab tents, shaped like oil-drums cut length wise, about 8 meters long and with springy plywood floors) joined side by side. One half was the working and cooking area, while the other was the sleeping quarters. Hanging from the ceiling in the center of the sleeping area was a pink, plastic flamingo wearing a pair of purple woman's underwear. What that was all about, I am not exactly sure, but it certainly did add to the atmosphere of the place... Beside the tents was a small wooden, "lab module" building with tables for microscopes and storage space for chemicals etc., and behind that a small shack that housed the generator. It sounds spartan, but was actually rather luxurious compared to some of the places we have set up field camps. They even had a radio-telephone link back to McMurdo and a microwave oven.

When we arrived, I was the last one in, and all the canvas cots were taken. We had already set up a separate mountain tent for Norbert to stay in (outside and far away from the camp -- he is an infamously loud snorer) so I opted to sleep outside as well. I managed to secure a tent fly to the side of a couple of cardboard storage boxes and then folded the material over and around my sleeping bag like a giant burrito to try to block the wind. I managed to stay warm enough, however the wind was relentless. When it really started to howl, I would wake up being slapped silly by the fly, and with the sand blasting along the sides of my little yellow nest. In the

mornings, everything was coated in grit. On the last night, there was space in the Jamesway and I managed a blissful, sand free, sleep.

Traveling the distance between the camp and the dive tent was always an adventure. The transition zone here was split by large tidal fractures, and because of recent warm weather, the surface was starting to melt as well. Sea water would gush up through cracks with the tide, and run in rivers along the ice and sandy shore. The melting surface ice formed large (and sometimes deep) pools that had thin ice coverings on top that wouldn't support body weight. In fact, Sam's team had a snowmobile plunge through one up to its handle grips the day before. The ice was also very dirty, completely covered in places by wind blown dust and sand from the valley. Between the sandy sections, melt-water pools and rivers, were sections of smoothly polished blue ice that routinely caused skull-cracking "Three Stooges" type falls with both feet suddenly zipping out and flying overhead. Hysterically funny, but only for the first 7 or 8 times it happened. So, the traverse to the dive tent consisted of splashing along the muddy beach onto the edge of the ice. Then a period of cursing and swearing while trying to tip-toe through the mine field of melt pools and channels while crashing through and getting soaked. And finally the slippery dance with arms windmilling to keep from landing on your butt. We did that two, sometimes three times a day.

I managed to get out for a couple of long hikes in the Taylor Valley during the afternoons while the divers were resting. On the first, I made the 16 km round trip walk from our camp to the shore of Lake Fryxell, one of the famous Dry Valley Lakes. The Dry Valleys are so named because they have very little snow in them, only the occasional wind-blown drift. It is incredibly dry, with next to no precipitation year round and they are blasted by Katabatic winds from the high-polar plateau. These gravity-induced winds roar down from the high-Antarctic ice cap and reach speeds over 150 km/h through the valleys -- often blowing non-stop for days on end. So, the valley floor is rock, dust, sand and gravel.

In a few places, enough melt-water from surrounding valley glaciers (which hang along the mountainous sides of the valleys) has trickled down over the centuries to form fairly large (and moderately deep) lakes. These have curious water chemistries beneath their thick ice covers, and are populated only by a few species of bacteria and algae. One lake in fact, is so hypersaline at its bottom that it acts like a large solar battery. Sunlight easily penetrates the clear ice floating on top and has managed to heat the water below. The heat is trapped in the brine, and the bottom of the lake stays an almost constant 19-20 deg. C!

The terrain was a very deceptive one to hike in -- enough to make you weep. It was difficult to judge distances, and sense the relief. There was always another invisible hill or gully beyond the one I had just climbed. The ground was also tough to walk on. The substrate was often very unconsolidated, so you would slog your way through dust and fine sand beneath gravel about ankle deep. But what a view! Rolling rock hills and steep mountains sides rimmed the valley and there were 4 hanging glaciers along the way (The Wales, Crescent, Canada and Commonwealth glaciers). I walked to the center face of the Commonwealth glacier which was a solid wall of ice, maybe 30 meters tall and stretching a kilometer or so in either direction. To the east I could see Mt. Erebus and Mt. Bird, over 75 km away in a vivid blue sky. The sun was so bright I found myself squinting behind my dark glasses. Along the ground were hundreds of millions of ventifacts (rocks that had been sand-blasted and polished by the wind into smooth, streamlined shapes -- some graceful, others into weird gargoyles, often standing 2 meters tall).

Another long hike took me along the northern shore of New Harbor. It was very windy and with my parka hood cinched tightly I had unconsciously adopted a rather narrow view of my surroundings. I had to stop in order to look up and gaze around at the marvelous scenery, and then go back to watching my footsteps along the shore. Again, Erebus was bright in the distance, but this time my gaze was across jumbled spires of sea ice and a few icebergs locked in center of the bay. Unfortunately despite the tremendous view of either the sea ice and distant Ross Island, or the mountains along the sides of the valley, it was always the same view due to the large distances involved. I would walk for hours across moraine hills and gullies, or strike out across gravel pavements and the distant picture was always the same. Spectacular yes, but I feared I was getting tired of New

Harbor. The gravel and sand was almost the same in all directions....a region perhaps best enjoyed by quickly skimming over huge areas by helicopter. I was getting jaded, and bored, and tired of helping the divers without being able to dive myself. I said it was almost the same in all directions...

I did happen across more than just ventifacts and wind-blown gravel slopes. I found the remnants of an old geological experiment from 1960; with steel posts and anchors fixed into the ground around a series of stone hexagons of frost-patterned ground in the run-off delta of the Commonwealth glacier. They were in incredibly good shape for having been there for almost 40 years. I also came across an old food cache from a New Zealand expedition in the mid to late 1950's. Some of the food (candies, meat bars (?), canned goods) was probably still edible. Most remarkable were the mummies. I saw the remains of about a dozen seal mummies while hiking in the valley. I had heard about them from others, and seen other seal remains around McMurdo, but these were something else. Some were close to shore, while others were farther inland. I found a pair of Crabeater seals about 5 km inland from the coast. They were horrible, yet still fascinating to look at; like gruesome driftwood. Their skins were cedar stained, their eyes eroded away and their teeth showing in a grimace. Some even had their whiskers still intact and bones protruded beneath shrunken flipper skin like x-ray images.

In addition to the well preserved remains, there were often more scattered bone piles, again somewhere remarkably far from the sea. Nobody is really sure why the seals head inland at times. Researchers have seen them slowly worming their way over rocks and sand away from the coast. Perhaps they get confused, and just start heading off in the wrong direction, following some distant mirage or spying some distant glacier, thinking it will lead them to open water or a new set of breathing holes.

We flew back to McMurdo this afternoon, in a helicopter stuffed to the top with so much gear we couldn't look out the windows. We were all pretty tired and in need of showers, laundry and rest. I can't imagine what it was like for those first explorers here. They spent at least a year at a time, often through the winter for an early start the next spring. With all the modern conveniences available to us, we are getting tired after only a couple of months. Oh well.

Antarctic Trip Report #11
Date: Dec 12, 1999
Weather: Condition 3 ; temp -12 deg C, wind 21 knts

Preparations to leave.

Our team has finished all the diving for this season and we have been doing some last topside filming in the laboratory and close by McMurdo. In the lab we have been doing a last series of time-lapse camera sequences in the aquarium facility inside a large 1000 gallon tub. Most of the benthic invertebrate 'drama' in the polar seas happens very slowly. The attack by starfish on a dead sponge, or jellyfish takes days and days. By shooting time-lapse we compress the time and can see the advancing 'red menace' of Odontaster starfish swarming over their victim like the ruthless carnivores that they truly are. The pycnogonids (sea spiders) usually walk in painfully slow steps, but this way we can see them march around and poke into anemones searching for food. Likewise we filmed the giant linguini-like nemertine worms streaming across the bottom like serpents and hand-sized isopods walking across the bottom, attacking a long-spined polychaete worm and sucking the insides out leaving behind an empty husk.

We also spent two days working at Cape Royds, a 2-hour Spryte ride north of McMurdo. This was the location of Shackelton's Hut that he built in 1907 during the Nimrod expedition, a wonderfully preserved monument of that era of exploration. Inside it is still full of food stores, clothes, papers and equipment all perfectly preserved (although with quite a funky smell).

Outside was an Adelie penguin rookery of about 6000 pairs managing to create quite a din (and another even funkier smell -- whew!) while incubating their eggs. The little Adelies have to walk about 10 km to reach the rookery from the ice edge (the pairs take turns incubating and feeding at sea) and once back at the nest seem to spend most of the time squabbling with their neighbors over the choicest stones for nest building and then hissing and growling like angry cats when the circling Skuas try to attack and steal their eggs.

Skuas are large, seagull-like birds that nest around the periphery of the penguin rookery and eat just about anything they can grab. Penguin eggs and chicks are their primary food sources at this time of year. They are larger than the penguins, but the penguins sort of gang up on them when they dive into the nesting area. It was an incredible scene with the Adelie rookery on a light brown soil composed of old feathers, dust, bird excrement, and dead penguins, surround by contrasting black volcanic rocks and the white snow and ice.

One evening, after a long day out at Cape Royds, I walked through the upper level hallway of the Crary lab building. Most of the lab lights were out and the building was mostly deserted. I could hear a violin playing -- it sounded like Mozart. The music got louder and louder as I walked down the hall until I stopped in front of a lab door nearly at the end. I turned to look through the door window, expecting the hustle-bustle of a late-night experiment in progress and with a stereo playing loudly in the background. Instead I could see a figure playing the violin while gazing beyond their outside windows. They appeared only in silhouette against the bright image of McMurdo Sound and the Royal Society Mountains in the distance. I couldn't tell who it was, and I didn't want to disturb their peaceful practice so I listened quietly for a minute or so, and then wandered off to my room and to sleep. It was the perfect coda to a tiring day. You just never know what to expect around here.

The day before yesterday we helo'd out for a days filming at Cape Bird. At least I hoped it was only going to be for a day. Last season I wound up stuck there for a few days in bad weather, waiting to get out and then fly to New Zealand. So, once again, like some bad movie cliche, I was winding up my Antarctic season at Cape Bird. Fortunately, the weather was fantastic -- warm and sunny the entire day. We had no problems on our flights back and forth to the Cape and we even managed to do some fun flying over the surface of the Barne Glacier to get aerial shots of the gaping crevasses, and the icebergs beyond.

We returned to Cape Bird to film at another Adelie penguin rookery, this one much larger than at Cape Royds. Here there were over 60,000 nesting pairs of birds making a ruckus and 'doing what penguins do'. We were specifically filming them as they traveled across a thin strip of sea ice between their nesting sights and the open ocean. On this thin strip they would all pile up in little curious, squabbling groups waiting to see who would be the first ones to enter the water. Cruising the edge down below were Leopard Seals, rather ferocious beasts waiting to make a meal out of the penguins. The penguins would gather around the edge, peering over, looking for any Leopard Seals and sort of pushing and shoving. If they saw other penguins in the water, returning from feeding at sea, they would sense that it was safe and all quickly flop, tumble and less-than-gracefully dive into the sea. If they didn't see other penguins in the water, they would finally push and shove enough that one hapless bird would fall over the edge. Then, the remaining birds would gather around and peer over the edge to see what happened. If the 'test bird' made it, the others would quickly jump in. Quite funny to watch, although deadly serious for the Adelies. They are most vulnerable to attack when getting into or out of the water, and you could tell they were pretty anxious.

Around McMurdo, science teams have been wrapping up a lot of the work on the sea ice as it slowly becomes more unstable. For these groups, the season is ending with the warmer weather, for other science groups, those who are working inland on the higher, colder plateau, the season is just beginning. (There might be a few problems with some of the field work this season, because just this afternoon the NSF Twin Otter airplane crashed out in the field while flying back from an AGOR site. The plane was blasted by a violent wind gust on take off that caused it to twist and catch a wing on the snow. The wing was torn off, but fortunately nobody was hurt.) The dive and fish huts are being packed up and moved off the ice and camps being broken down. The transition zone between the land and the ice is very broken and now has a fairly wide water filled moat. Tractors are constantly pushing snow and dirt into these cracks to keep it passable for vehicles, but soon they will stop

doing even that and movement on the sea ice will be restricted to travel on snowmobile, then on foot, then not at all as the sea ice breaks up (sometimes completely) at the end of the summer season.

We too are getting ready to leave and have been very busy packing bags, cleaning gear and returning field equipment. We have had a great season, despite a few ups and downs. The footage that we have collected so far is quite spectacular, unfortunately it will be a couple of years before it reaches its audience. As well it is unfortunate that, due to the timing of my diving accident, I was unable to do much sampling for my own work, but I do not regret remaining for the rest of the season. I was able to busy myself helping with the topside filming, and I was still able to get out to see some amazing sights.

Leaving McMurdo might prove to be as difficult as our trip down. Already there are problems. Three days ago, a C-130 (Hercules) enroute to the South Pole Station aborted take off at last minute and wound up sliding off the end of runway into soft snow. They did some slight damage to an engine I believe, so they are down a plane until it is repaired. Also, the base now depends on a new runway on the permanent ice shelf in order to land ski-equipped aircraft as the sea ice runway has degraded in the warmer weather. Because there is now a push for some scientists to leave the base, and due to the limited number of flights available (many of the flights are dedicated to field camp support), there is now a backlog of people waiting to fly to Christchurch. The last flight to make it out was 2 days ago, and they had to bump personnel in order to put more cargo on the plane (the broken Kiwis helicopter parts for example), so now those people are also waiting. Even though we are scheduled to fly out tomorrow morning, there is a good chance that we will be delayed. C'est la vie.

I have already mentioned that on top of Observation Hill is a memorial cross for Captain Scott and his men who died on their return from the South Pole. Inscribed below their names are some of the last words from Tennyson's Ulysses; "to strive, to seek, to find, and not to yield." I can think of no better words to honor those men who came here almost a century ago. They were explorers and they were scientists and they pioneered the way for all of us who have since followed. Compared to the incredible challenges that they faced, our modern travels are relatively tame and we can hardly claim to fill their footsteps. I feel very fortunate to have been able to see and work in those places that the early explorers visited and sometimes lost their lives. And it has been a special privilege to dive and explore under the very ice that those first men struggled to cross not knowing what fantastic sights lay just beneath them.

Antarctica Report, October 4, 1997

McMurdo Station

Current Weather: Condition 2, visibility less than 1/4 mile, -26 deg C, 30 knt winds, gusting to 45.. Chilly!

Back in wonderful McMurdo. The trip to New Zealand went without incident, but unfortunately our flight out of Christchurch to McMurdo was delayed by a day due to mechanical problems. Last time I did this we flew over in a LC-130 (Hercules) in a very uncomfortable 8 hour flight. This time we few in a LC-141 (Starlifter) jet transport in a very uncomfortable 5 hour flight. This was the first main flight in for the 'summer' season and it was packed with cargo and almost 100 people. There were no comfy seats, no in-flight movie and next to no leg room. We sat jammed side to side and back to back in webbing jump seats wearing earplugs due to the interior noise. Not much to do. We took turns stretching our legs and most people either tried to fall asleep or read a book.

We arrived without a problem and unfortunately I promptly became very ill. There is viral flu here known as the 'McMurdo Crud' which, as I found out, can be pretty nasty. A high fever, vomiting, diarrhea, sore throat and sinus inflammation kept me pretty much confined to my room until today. I was even in the infirmary yesterday being hydrated intravenously. Antarctica is an extremely dry environment and your body dehydrates very

quickly, so, flu symptoms become very serious. Intravenous fluid addition is the only way to put fluid back in the body when your intestinal tract is all messed up. Not much fun. However, I am feeling much better today.

We have a fair amount of training to go through before we head out alone on the ice and start our diving program. This coming Monday will be spent in Sea Ice training (learning to navigate on the ice etc.) and Tuesday will be spent learning to use our assigned radios, GPS units, tracked vehicles (called Sprytes) and waste management. We hope to be doing our first dives starting on Wednesday.

Antarctica Report, Oct. 9, 1997

current weather: Condition 3. clear, -30 deg. C, 35 knt winds, gusting to 40 knt. Cold!

I am almost over the flu. It has taken almost a week. However, most of our group has been sick as well. As a consequence, not much diving has been going on (none in fact). The flu has been running rampant at the base -- lots of people are under the weather. This happens from time to time; not too surprising when you think about the circumstances..... it is cold and stressful and lots of people are sharing close quarters with one another. It is easy for the germs to get around. So far, the flu has apparently been viral, which you just have to let run its course.

Some information about weather etc. that Steve's class has asked.

Time: Time here at McMurdo (and elsewhere on the US bases) is running on New Zealand time. (4 hours behind California, but one full day ahead since we are on the other side of the international dateline. I'll try to make posts with a 24hr clock so things don't get confusing, however I will leave it up to you to convert things to whatever time local time scheme.

Weather Condition. A 3 condition weather plan is used here and temperature doesn't usually factor into it.

- Condition 3 = 'normal' clear conditions. Visibility on the ground greater than 1/4 mile. You are allowed to travel by foot or in an open vehicle (i.e. snowmobile).
- Condition 2 = visibility on the ground less than 1/4 mile. Usually accompanied by high winds. Travel is allowed only by covered vehicle, i.e. in snow cat . On clear days, Condition 3 may become Condition 2 if there is excessive wind chill
- Condition 1= visibility less than a few hundred feet (to almost none at all). Travel is not allowed (and often impossible).

Visibility is affected most by blowing snow and varies from location to location.

What have we been doing besides trying to get well? We have managed to take a bunch of various training courses to allow field operation down here. These have included field safety (digging snow caves, setting up tents and radios in storms etc.), classes in radio and GPS use, waste management classes, vehicle use and a dive orientation.

We'll be taking additional classes in helicopter loading etc. when we start operations farther in the field.

We did manage to spend most of the day yesterday out in the field. We went to a location just a few km north of the McMurdo Base known as the cinder cones. These are a series of extinct volcanic cinder cones located on Ross Island where we will be doing some of our diving. We went out with a drill rig in the morning to drill the 4 foot diameter dive holes in through 2-3 meters of ice. We drilled 7 holes, covered them with large insulated wooden covers (to keep them from freezing solid too quickly) and then used a tractor to tow a large dive hut from McMurdo for placement above the main hole. These huts can hold about 6 people and have a hole in the

floor above the dive hole and are equipped with several big heaters. Most dive operations are done from within the hut so they can continue regardless of the weather conditions outside. Then we spent several hours 'flagging' our route on the ice with bamboo poles and flags so the travel route across the ice can be followed even when visibility drops. We are starting to get anxious to get into the water!

The base is slowly starting to get busy. There are science groups arriving from all over now. There is a large party working at Cape Roberts. A large drill rig has been erected to drill through the ice, through several hundred meters of water, then for hundreds of meters into the sea floor. The team is composed of scientists primarily from 4 nations (USA, Germany, New Zealand, Italy), with the New Zealand group organizing most of the effort. There is about 30 scientists all together in their group. They will collect all their samples at the drill rig and then do the processing in the Crary Lab here at McMurdo (lots of geology and micropaleontology).

The support staff here is busy trying to gear up for the season. And there are crews out in the field setting up the radio communications repeater stations for field camps, preparing helicopter fuel caches and the like. South Pole Station won't be operating until late in the month.

A bit of excitement. A group of scientists were out at Cape Royds when a storm settled in the day before yesterday. They had to brace the helicopter down with over 1000 lbs of hand carried boulders (there were 75 knt winds) and then seek shelter in a little emergency hut built out on the cape. Unfortunately a winter storm had completely destroyed it -- the doors were gone and the shelter was full of snow. They managed to get their survival bags and spent the night inside Shackleton's hut. A famous landmark that the polar explorer used on one of his many Antarctic journeys. They made it back the next day.

I don't have too much more to report. If our sinuses have cleared up enough, tomorrow we might try to head out for a dive.

Antarctica Report, Oct 11, 1997, 19:50 hrs

Weather, Condition 2, -20 deg C, 45 knt winds
Getting very stormy! lots of blowing snow.

Despite our teams' (and other dive groups) illness, we had to go for a dive yesterday. The Scientific Diving Coordinator must be present when you make your first dives so he can be sure that you know what you are doing (dive groups will have practiced techniques and equipment before coming down) and to give some last minute instruction on various aspects of Antarctic diving. Unfortunately the Scientific Diving Coordinator here (a great guy, Rob Robbins) was also starting to come down with the flu, so he wanted to get everyone checked out before he wound up in bed. We dove.

The location was the Intake Jetty, located right in front of McMurdo Station. We had dove out of a dive/fish hut about 5 minutes from the dive lockers (a small heated building near the shore). The hole was in 80 feet of water. To be honest, I would have been more excited if I hadn't be dreading having to dive with a congested head (it plays havoc with trying to clear your ears etc.). Suiting up takes about 20 minutes, with all the multiple layers of undergarments, dry suit and then dive equipment. A surface tender who doesn't dive helps you suit up since it gets impossible to move around with all the heavy gear and thick gloves etc.. Once you get in the water you sink feet first down a vertical tunnel in the ice, 4 feet in diameter -- the ice here was about 6-8 feet thick. Then you hit the incredibly blue, open water beneath. Very stunning....

Light comes in through the ice, and is brighter under the larger cracks. And yes, the water is very clear; although the Intake Jetty (where the main sea water intake pipes are for the laboratory facility) isn't the best I hear. It was only so-so, which in this case was about 400-500 feet. Other locations we will be diving have visibility in the 600 foot range. It really feels like you are hovering in air, and it is very difficult to estimate distances at first. What looks like it is just beneath you can be in well over 100 feet of water. If you sit on the

bottom under the dive hut, it looks like the dive hole is just a few feet away -- instead it is 80 feet above you. We dove for 30 minutes testing our equipment. Yes, I got cold, but not until the last few minutes of the dive. Now the bad part...diving with a congested head. I had managed to equalize my ears and sinuses on the way down, but on the return to the surface they blocked and I had a terrible reverse squeeze. Ouch. It feels like someone is driving a spike into your head. Oh well, it eased up after a few hours topside.

Today, I wisely decided not to dive to give my head a day to recover and instead worked as a dive tender for the other divers.

One of Steve's students asked what the difference was in diving here as compared to where I normally dive, i.e. in California:

The actual diving isn't that different once you get in the water. Some of the gear we are using is specially modified to work in very cold water (-1.8 deg. C). The regulators have special adapters to keep them from freezing closed. We use 2 completely separate regulator systems for total redundancy. A large steel 95 cu inch (volume) tank. We are using special weight harnesses since we are using a minimum of 40 lbs of weight each. Under our drysuits we are wearing capiline long underwear, a Polartec® jumpsuit, and a thick Thinsulate® jumpsuit. The drysuits have attached hoods for extra warmth and we are wearing a "full face" hood or "gorilla mask" under that has only a thin slot for your regulator to fit in. Gloves have warm liners and flexible rubber outer shells that seal against special flanges built into the wrists of our suits. I'll be diving with an additional small tank full of argon on my later dives. This will be used to inflate my suit with denser (=warmer) argon rather than air. A few extra techniques are used while diving. You try not to breathe through your regulator until totally submerged to prevent icing up, when injecting air into your drysuit you do it in only tiny burst to prevent the input valve from freezing open.. After diving we have to be very careful rinsing all the gear to prevent any fresh water from collecting anywhere that might freeze on the next dive.

Tomorrow our plan is to go diving at a place called Cape Evans, about 90 minutes drive by Spryte (the 2 tracked vehicles we are using to drive on the ice) north of McMurdo base on the sea ice. It is the location of Captain Scott's last hut -- where he left from on his fateful trip to the pole. However this will only happen if the weather calms down. In the time it has taken me to type this, the weather has turned to Condition 1. The winds are well over 50 knts and I can only see about 20 feet out of the library window. The windows are shaking and you can hear the wind shrieking between the buildings. Hopefully it won't last long.....

Antarctica Report, Oct. 15, 1997, 16:30 hrs

Weather: Condition 3. -10 deg C, 10 knt winds quite nice but overcast

Well, the storm absolutely raged for 2 straight days. The winds was blowing 60 + knts for over 8 hrs straight at one point. Very spectacular. The clean-up afterwards was equally spectacular. There were (and still is) huge snow drifts all over the place. The road below the dive locker was erased by huge drifts and they just got it dug out today. Our Spryte tracked vehicles were buried in the snow and the cabins full of snow (which seems to be able to blow in any tiny crack or hole).

We did have a few hour lull in the weather so we managed to zoom out and do a couple of dives in a nearby dive hut. Very nice (although I am still having some lingering effects from my recent flu -- a little trouble clearing my ears.). A large Weddell seal was hanging around during the dive and even managed to pop its head up our dive hole in-between dives. Even after being submerged for 40 minutes I didn't feel too cold; at least on the first dive...the second dive felt like ice! I guess you lose a lot of calories in between dives, even in a heated dive hut. The visibility still seems amazing. After swimming around a rocky outcrop, one section of the bay opens up into a bowl shape and you can see for hundreds of feet in all directions, lit with a very spooky blue light that makes it in through the occasional crack (in this case the large cracks that form parallel to the

shoreline because the tide (about 1 meter max.) flexes the sea ice up and down and forms cracks along the shore). Very nifty.

Then the storm returned for about 12 hours. There isn't much to do outside when the weather conditions deteriorate, however indoor work, lab work etc. continues as usual. For those groups that rely on outdoor travel stormy conditions mean a chance to catch up on sleep, relax a bit and get caught up with other jobs.

Yesterday we took the 2 hour Spryte journey to Cape Evans (we had been stormed out previously). I was actually surprised that travel on the sea ice was so easy and there were so few drifts -- most of the snow just blew away from the flagged 'road'. At the Cape Evans hut, we found out where some of the blowing snow wound up -- piled up against the dive hut. It took 30 min. to dig our way through drifts to the door, and a further half hour to dig out some of the snow that had somehow filled the hut (there was a huge snow bank in the center of the hut covering most of the dive hole). After that the safety hole had to be located under the drifting snow and then uncovered and chipped free of ice to allow emergency surfacing (more digging!). Then, finally, our dive team went into the water. I declined to dive in order to let my ear recover and instead worked as a tender for the other divers. Working as a tender entails lots of lifting tanks, weightbelts etc. and then helping the divers dress since they have difficulty maneuvering with all the bulky garments and gear. Once the divers enter the hole (one at a time) the tender hands in all the equipment (cameras etc.) that is needed for the dive. While the divers are under the ice the tender keeps the dive hole free of floating ice, and looks menacing to any seals that might take residence in the hole and prevent the divers from surfacing. When the divers have returned to the hole, the tenders recover the equipment and then help the divers remove all their gear in the water (very cold on the hands!) since they can't come out of the hole with their gear in place... I spent most of my time in the Cape Evans hut trying to keep the stove lit inside the hut to keep it warm and made pots of hot soup for between-dive feasts. The diving itself was disappointing because, due to the large amount of drifting snow, hardly any light was able to penetrate beneath the ice -- it was in essence night diving. We were unable to visit Scott's Hut on this trip to Cape Evans since the wind was still pretty high and the snow was still blowing around. Making the 15 minute hike across the cape wouldn't have been wise (better safe than sorry). We shall return.

After the diving was done we drove the Spryte to the Mt. Erebus ice tongue. This is a branch of a large glacier on Mt. Erebus that extends far out into the sea ice. We had wanted to check out some of the ice caves but the entrance had been drifted in by the storm. We lacked the motivation for more digging, so we'll have to wait for another group to reopen the entrance for exploration. We made it back to McMurdo for a mad dash to the galley before dinner was over...we had spent 11 hours out on the ice.

Today we did a few dives at Arrival Heights, located approximately 1 km north of McMurdo. It is nestled up against the shore, near Danger Slopes so named because one of Scott's party slid in his smooth sole seal-skin boots and was unable to stop himself before hurtling over a cliff into the sea (the ice had blown out late in the season). Fortunately it wasn't too drifted in with snow. Again, I stayed out of the water to tend and heal my ear and 'showed the ropes' to another would-be-tender who plans to help us in the future. I'll be diving there tomorrow so I will be able to give a better idea of what the bottom terrain is like.

Antarctica Report, Oct 17, 1997. 2000 hrs

Weather -- condition 3. -15 deg C, wind 10 knts, overcast.

Well there is good news from down on the ice... a lot of us, myself included are starting to feel a lot better. In fact I consider myself about 95% healed -- diving today caused no problems. The bad news is that a new flu bug is starting to float around apparently, and new batch of people are getting hit... I am hoping that I have enough antibodies left from the last one to escape the new illness.

Today we did some spectacular diving underneath a grounded iceberg. Stunning. The iceberg apparently broke free of the Ross Ice shelf late last season and was pushed towards the shore and stuck fast on the bottom before

the sea ice formed up again. It is now located about 0.5 km south of Cape Evans (where we were a few days ago). The iceberg itself is fairly small (but still huge) -- "only" about 40 feet is showing above the ice level and it is about 200 feet long and 100 feet high. Underwater it is much larger of course (most of an icebergs mass is below sea level). The dive hole is located right beside it and looking through the hole at the correct angle, you can just make it out under the water. Once you are diving, the berg forms a solid wall of ice all the way to the bottom (about 90 feet deep below the hole), and slopes deeper down away from the hole. You can just make out the large trench the berg cut into the bottom when it drifted towards shore -- it looks about 120 feet deep near the trench, probably much deeper (something to be checked on a later dive). The berg is also cut by a large tunnel that disappears back around a corner as a vertical slot. Tomorrow I shall be going back with high powered lights to check to see how far the tunnel under the berg goes.

There is a shelf of ice that sticks out at about the 20 foot level that is covered in ice algae and loaded with bright red amphipods that are grazing for food. These amphipods in turn have attracted a large number of ice fish that are feeding upon them. We managed to find one icefish that was protecting an egg mass within a hole in the iceberg and a large crack that shimmered with a large school of the icefish. Very impressive. The bottom around the iceberg is a fine mud that is easily disturbed, but covered in clumps of bright yellow sponges and white starfish. It is hard to describe how the entire scene looks when you are diving around it. You can see for hundreds of feet in all directions, until it gets too dark. The iceberg is channeling a lot of light within itself by internal reflection and refraction so it glows a ghostly blue colour under the water -- like a big fluorescent wall, and looking up, you can see the bright patches where the there is less snow on the ice, and dark patches under deeper drifts. Most amazing is looking out and seeing dozens of large jelly fish that look like they are just hanging in the air. Some of them are large, 1 m long, and the water is so clear they look like tiny toys when far away. All I can say is 'Wow'.

We did two dives and it took most of the day since it was a long slow trip in our Spryte (which we have nicknamed 'Pokey'). We left at 0800 this morning and just made it back in time for last meal at 1900 hrs. Tomorrow we plan on returning. With us will be a NASA scientist who will help as a dive tender and who will also be doing some ozone measurements with some special machinery. It should be an interesting day.

Antarctica Report, Oct. 19, 1997, 1400 hrs.

Weather: Condition 3, -10 deg C, wind 10 knts (overcast but pleasant...all things considering)

Yesterday we made 2 exciting dives at the iceberg location. And, once again the dives were stunning. I managed to take some time to explore the long tunnel that extends through the iceberg...it was a long spooky swim, but the tunnel opened up on the other side of the berg (between 2 fragments of the berg). The snow had been blown off the ice at the far end of the tunnel so a shaft of blue light penetrated the light, and looking out, the water is the same colour of blue that you see in fussy people's toilets.... Most interesting, at the far end of the tunnel, there were some large brine channels, some 2 - 3 meters long, hanging from the bottom of the sea ice. These look very similar to cave stalactites and form from super cold brine that seeps from within the surface sea ice, finds its way down little cracks and channels and emerges all in one spot. It is much colder than the sea water so the sea water freezes in a tube around the outflowing brine and continues to build up forming a hollow icicle or 'brinecicle'. Nifty. I wanted to explore more, but it was a long swim, and the far side of the tunnel is a long distance from our dive and safety holes. Not the type of place you want to have any problems. We found another exciting place on the main berg -- there is a large shelf at about 20 -30 feet in depth that is coated in algae and is making a home for lots of baby fish, amphipods and other creatures...following this shelf back into the iceberg we came to a short tunnel that extended back and then parallel to the iceberg exterior. The entire tunnel is coated in huge ice crystals and is like swimming inside a giant snowball. The photographer in our group was busy taking pictures and every time his flash went off, the entire tunnel would sparkle with light.

One of our dive tenders was Dr. Steve Schearer. He is a NASA volcanologist who is based at the Goddard Space Flight Center in Greenbelt, Maryland. He had brought along his portable ozone and UV measuring equipment and made a series of measurements between dives. Even though he is trained as a geologist he uses satellites to monitor the emission of gases from various volcanoes around the world. And since Mt. Erebus is located right behind McMurdo Station and it is an active volcano, he can 'ground truth' the satellite measurements with those he can make on his own on the ground. He also spent some time collecting special rock samples along the shore near the dive hut.

We had taken a different Spryte to our dive location (our Spryte, #666 'the antiSpryte' was in the shop) that was much faster than old Pokey so we managed to get there in a record 95 minutes.

Some topside exploration late in the day indicate that the large iceberg has actually fragmented into 3 pieces on the opposite side to the dive hut, so we have many other pieces to explore underwater there. Unfortunately, the light outside was very flat and it was difficult to see fine structures in the snow and ice, so it became dangerous walking around the sea ice -- we couldn't see the subtle (and not so subtle) changes in snow texture that can indicate cracks in the ice. We returned to our hut before exploring the entire area around the iceberg.

Today (Oct. 19), Spryte #666 lived up to its name. We were set to dive at Little Razorback island this morning at 0800 -- we lost our tachometer on the way to the fuel pump (a harbinger of things to come), and then lost oil pressure once we crossed the transition from the land to the sea ice. Rather that risk a break down far from the base, we drove a short distance to the intake jetty hut and did a dive there. We planned a deep dive to 120 feet, down to a bed of sponge spicules that I am interested in. After surveying that area, we returned to a large rockfall near the jetty shore at a depth of 60 feet, hunted for 'dragon fish' to photograph and slowly worked our way up to the shallow anchor ice to provide a little decompression (needed after the deep dive as a safety stop).

I swam over to the observation tube (a large steel pipe sunk through the ice for people to climb down to a small window covered chamber at about 20 foot depth; it allows those who can't dive a chance to see what is going on under the sea ice). The windows had become encrusted with platelet ice and I smashed those loose to allow those entering the chamber a chance to see -- I was greeted by a happy face waving a video camera on the inside.... A glance to the north showed an enormous swarm of pteropods and small jellyfish coming towards us. Pteropods are similar to small swimming snails -- the largest about 4 cm in length -- they look almost like little transparent angels with their flapping, wing-like muscles and mantle. The swarm also contained thousands of thumb sized jellyfish and ctenophores (comb jellies). By the time we were ready to exit the dive hole we had been in the water for almost 1 hour -- much longer than normal and ice crystals had started growing on our fins and dive equipment. I came out of the water looking and feeling like "the human popsicle".

Spryte 666 wasn't through with us yet -- about 30 meters from its parking spot at the base dive locker, it threw its left track off leaving us stranded. Sigh. We had to hand carry all the equipment across the snow to the dive locker. Oh well.

Tomorrow 666 goes back to the shop and we will try once again (with a different one) to get to Little Razorback Island.

Antarctica Report, Oct 21, 1997 -- 1915 hrs

Weather: Condition 2 (on the sea ice), Condition 1 in McMurdo base temperature, -25 deg C, overcast, wind 30 knts, blowing snow

It is very amazing how quickly the weather changes here. Today, as you can see from the header, was rather blustery and cold. Yesterday was entirely different. It was only -15 C (fairly warm), there wasn't a breath of wind and not a cloud in the sky. You could see for miles and miles in every direction.

We drove (in a faster Spryte this time #242 "peppy") out to the iceberg again for what would probably be some of our last dives there. The iceberg is actually grounded near shore at the base of what look like some formidable icefalls on the glaciers surrounding Mount Erebus -- it just took a clear day to really see them. In fact it was so clear there weren't even any clouds around the summit of Erebus and we could see the steam rising out of the summit caldera very clearly. We did 2 very long dives on the iceberg. The first for 55 minutes and the second for 71 minutes... The phrase for the day became, "71 minutes is too long." Yes -- we were quite cold by the time we were finished the dives and we were thankful that our tenders kept us filled with hot soup after surfacing.

Norbert Wu managed to finish up all the photography he wanted to do in this area and I spent some time taking a few final photographs of him working with all his equipment underwater. He had brought his 16mm underwater movie camera along as well (nicknamed "the widow-maker" because the housing alone is 1 m long and weighs over 75 lbs) and he took some footage around the iceberg as well. Once all the filming was over, we swam off towards the other end of the iceberg where we still hadn't been. A large shelf continued at 30 foot depth, covered in algae similar to the area we had already been diving but without the spectacular ice caves towards the interior. At the far end of the berg, the shelf was about as wide as a tennis court. I continued swimming past the end of the berg towards the 3rd fragment that we had identified on our earlier topside exploration. After a few minutes a ghostly white bulk appeared in view, still hundreds of feet away. Unfortunately snow cover was very thick in this area and very little light was penetrating the ice sheet so the water was extremely dark; and deep. The berg disappeared far past the limit of my lights into depths well over 200 feet. By this point we were a long way from our entrance and safety holes, so, spooked by the whole situation we returned to our dive hole, light, and the warm interior of the dive hut.

One of our tenders was again the volcanologist Steve from NASA who wanted to collect a few more rock samples and get out of the lab for some fresh air. The other tender was one of the firemen from McMurdo base, Reno. It was his day off and he wanted to come help so he would get the chance to get away from McMurdo for a while. During our long second dive, a helicopter landed outside the dive hut and unloaded a group of Reno's friends who work on the search and rescue team (who make sure the scientists working in the field down here don't kill themselves). We surfaced to find the hut full of tenders, the rescue team and the helicopter pilots all sitting around telling stories in the sauna like heat of our hut. An impromptu party of sorts then developed....

On our drive back to McMurdo we stopped in at Little Razorback Island to make sure the heater in the hut was working and make sure there was food and water for our next day’s dives there. Steve was also able to make a few rock samples from the shores of the island (part of an eroded volcanic plug).

Every now and then a whole series of tiny events, seemingly unrelated, all come together to produce a very unique and special moment. Our short stop at Little Razorback Island yesterday became just that, a very special experience that made all the hardships and difficulties so far, the cold weather, the hard work, equipment problems and being away from home and loved ones, seem worthwhile. As we were walking around the pressure ridges of ice, thrust up around the sides of the island, we turned a corner and there on a slab of snow, surrounded by spires of blue ice and with the blue sky and Mt. Erebus in the background was a mother Weddell seal and her pup. She had just given birth a few minutes before since the afterbirth and small pools of blood on the ice had not yet frozen. The mother and pub lay side by side in the sun, content and peaceful. We stood on a ridge of ice completely speechless -- there was nothing we could say. We all glowed for a while and returned to the Spryte. Steve turned to me and said, "this is why I had to come to Antarctica." I couldn't have agreed more. Steve had left his wife and 10 month old baby to come here to spend a few weeks making ozone measurements and collect a few rock samples. He flies back to Washington tomorrow.

Today we just returned from two dives at Little Razorback. The weather was cold and blowing strong. The mother seal and her pup were still lying close to where we had seen them last. However, now they were covered in blown snow and bits of ice. They still looked content and happy though.

The diving was interesting. The terrain beneath the hole was very steep and rocky. You were afraid to put anything on the bottom for fear of it sliding away forever. The deeper walls are sprinkled with anemones and hundreds of thousands of purple sea stars. There were lots of nemertine worms, pycnogonids (sea spiders), large 10 cm long isopods and lots of sea urchins. Most interesting was the shallow rocky shelf surrounding the island. In water about 9 feet deep the sea ice hangs like a low convoluted roof. In some areas the brine tubes and clusters of platelet ice hand down from the ice ceiling. The bottom is covered in isolated clumps of anchor ice and sprinkled with small cobbles and sea stars. It was possible to swim in along this shelf with it extending as far as you could see into the distance. In areas (beneath the topside pressure ridges), large cracks extend up through the sea ice forming high ceilinged rooms with almost enough room to stand upright. In the tops of some of these domes were the breathing holes that the seals keep open by chewing with their teeth. The entire scene really emphasized how truly special these animals are. Throughout the year, even in the long, dark winter night, these seals dive beneath the ice, through the low tunnels we had just careful picked our way through, and keep their breathing holes chewed open or else they will suffocate. We didn't see any seals beneath the water on these dives today. We could hear them faintly in the background occasionally. I brought along a special hydrophone and after the dives we lowered it through the ice hole and we could hear a whole symphony of seals far off in the distance. Very cool.

Antarctica Report Oct 23, 1997, 1750 hrs.
Weather, Condition 1 -- wind 60+ knts, -47 deg C.

We are officially confined to the indoors. In my case, I am confined to the lab facility (along with a bunch of other scientists). This is the second day of this storm and it is amazing that the weather deteriorated so fast. A few days ago it was bright and sunny. Then yesterday the main front moved into our area, Condition 2 on base, but condition 1 on the sea ice, so we were unable to go diving. This morning the storm intensified even more and after lunch today, it became condition 1 on base with no travel allowed. We will probably not be able to make it to the galley for dinner (but there is lots of emergency food around just in case) and if continues for much longer the search and rescue team will begin to string safety ropes between the buildings to allow some limited movement around the base.

It is hard to describe the intensity of these storms. The buildings are shaking under the wind and it sounds like a locomotive is constantly passing overhead. Visibility is only a few tens of meters out the window and only a few feet when you are out in it. I was knocked over by the wind en route to lunch this afternoon.... It didn't seem too cold outside because we are so bundled up, however it is very difficult to move around when visibility is so restricted by blowing snow. The forecast is for the storm to continue into tomorrow -- we are hoping it will let up enough for us to make a dive later tomorrow if the weather cooperates.

Some questions from Steve Bartram's class in San Diego...

oh -- our latitude and longitude here is: 77 deg 50.769min S, 166deg 39.891min E.

All the times I am posting are in New Zealand time -- Zulu time is actually the same but 12 hours displaced.

Period 1 Question: Is the ice at different positions made differently? How is the berg "grounded" as compared to the floating part?

There are different types of ice here.... The sea ice is made from the freezing of sea water so it does contain small pockets of salt water (brine) that makes it taste salty if you put some in your mouth. The icebergs are freshwater ice that break (calve) off the many glaciers that come off the surrounding mountains and reach into the sea. There is also the ice of the Ross Ice Shelf and Antarctic Ice cap -- huge glaciers that cover thousands of square miles.. The glacier ice is made primarily of compressed and compacted snow that over the years is packed into solid ice... There is so much ice and snow (thousands of feet thick) in the glaciers and ice caps that

the weight makes the edges of the icecap slowly ooze outwards towards the sea. On mountains, gravity also helps the glaciers flow downslope like a giant river.

The iceberg became grounded because wind blowing on it pushed it through the sea into shallow enough water for it to get stuck on the bottom. An iceberg is very heavy, so once it starts moving it is very difficult to stop. As the berg was pushed to shore, it dug a deep trench into the soft bottom before it came to a stop.

Period 1 Question: Is it difficult to estimate distances? How do you compensate for vision problems. What was the cause of the steam from Erebus?

Yes it is difficult to estimate distances at first. The only way to get around this is through experience on the ice and a knowledge of the surrounding geography. Vision problems...when it is sunny on the ice, it is very easy to burn your eyes and go snow blind. We wear goggles and special sunglasses when traveling out on the ice.

The steam on Mt. Erebus is coming from the active volcanic vent at the summit of the mountain. Mt. Erebus actually has an active lava lake in its summit crater but it is hardly seen due to all the steam. The high temperature gases warm the air around the summit of Erebus which makes what little moisture in the air condense into fog which adds to the 'steam' from the vent.

What is your normal oxygen consumption in a standard tank. What are your reserves and emergency procedures in case of closure of the icehole?

We can usually dive for approximately 60 minutes on our tanks, but since it is related to our diving depth, we can stay down much longer if we are working in the shallows. The normal limiting factor is staying warm. We try to keep a good reserve of air in our tanks even at the end of the dive in case there is a problem with the dive hut hole. The most common problem is for a seal to take up residence in the hole and try to defend it (they can become territorial during the breeding season). To avoid a bite, we would then surface through a safety hole that is kept open nearby (but not inside the hut -- brrrrrrr.). We spend a lot of time before diving chipping and clearing ice from the holes to prevent them from freezing over while diving.

How can someone get to be part of the crew. (dive tenders)

We normally have no shortage of people willing to tend for us. There are lots of service people around who can help on their days off. They take a short instructional course from the diving safety officer and we give them additional instruction when they come with us for the first time. Many are already divers or paramedics so they don't need too much help, except learning a few special ice diving tricks. They like to come since it gets them away from the base for a while.

What is the type of helo used, capacity for both cargo and passenger. Special equipment (de-ice - blade warmers, etc) Where are the pilots recruited from, are they volunteers or paid.

I'll ask a helo pilot about these ones...

Antarctica Report, Oct 30, 1997, 2130 hrs
Weather Conditions: Condition 3, -15 deg C, wind 10 knts

Sorry I have not posted for a little while.... Things have been very hectic since the storm.

Since my last message-- the storm got progressively worse and absolutely pounded the base for 3 straight days. Needless to say, no diving. In fact, not much of anything since we were confined to those few buildings connected by lifelines. The maximum wind speeds were over 91 knots, hurricane force. The storm was one of

the worst they have had in the last 5 years and the worst 'summer' storm in recent history. In retrospect it was very exciting and gave me a real feel for all that Antarctica is. It also gave me an even heightened respect for the earlier Antarctic explorers who didn't have internal plumbing, Goretex® and heated tractors... I have never experience weather of such intensity for such a long period of time; not ever at sea, in the mountains or in Northern Ontario. The wind blasted and howled between the buildings, the power cables shrieked and I was blown to the ground twice on one trip to the galley.

The not so exciting part came after the storm -- cleaning up and digging out. There were enormous snow drifts in places and it took a long time for the tractors to clear them out. It took 2 days to plow and repair the ice runway for planes to land. Our less-than-faithful Spryte was filled right to the very top with snow. Amazing. It took 2 hours to shovel out the interior and the rest of the morning to slowly poke the snow out of the engine compartment (which was also filled solid). The other Sprytes were in similar shape. Several of the dive/fish huts were so drifted with snow (one also had the interior filled to the top) that the weight of all the snow pushed the huts below sea level by flexing the ice beneath. The huts then promptly filled with 6 inches of water (which all had to be chipped out and the huts then moved). People worked round the clock and after a few days the base was back to normal, although now staffed by exhausted people.

The Cape Roberts drilling program (to retrieve sediment cores beneath the sea ice) took a beating and the drill rig and adjacent buildings had to be abandoned mid storm (it was quite as intense there, so the workers and scientists there were evacuated to the other side of the Sound). The high winds and huge seas near the ice edge started to break up the sea ice and they were afraid of having the entire complex drift to sea. Then huge swells started causing the sea ice beneath the drill rig to move up and down up to 35 cm... The rig has been moved closer to the coast onto safer ice and they are now looking for an alternative site to work the rest of the season.

When we finally managed to get back on our diving schedule (despite several set-backs with cantankerous Sprytes) we returned for a last day of diving at the Iceberg before the hut was moved (which we did today). The safety hole was starting to shrink to the point of uselessness and the ice around the hut was starting to sag...The hut is now moved to Turtle rock, and hopefully we will dive there tomorrow.

Traveling back and forth from the far dive sites we have been encountering small groups of Emperor Penguins for 3 days in a row. Very amazing animals. The slowly march across the ice and seem to home in on anything they consider to be out of the ordinary....like humans. We would see them a few hundred meters away and get out of the Spryte, and within 15 minutes or so they would have all walked or "tobogganed" over and be standing all around us as if to say, "What the heck are these red coated things?" They are absolutely fearless and very inquisitive.

We then put our efforts into diving for a few days at Little Razorback Island. The site of the seal pupping. The mother and pup we had seen there previously are still there and now they have been joined by another half dozen pairs. We have been doing a lot of diving along the shallow shelf under the low ice ceiling. Truly stunning. We have been working farther and farther back through a series of tunnels and small rooms and have found some beautiful sights (tunnels and rooms bright blue and covered with ice crystals) and some pretty cool animals (pure white octopus). We often have to 'share' the tunnels with the seals (that seem the size of automobiles underwater) that have made breathing holes in some places in the roofs. We get out of the seals way -- although they seem inquisitive not aggressive. We were at first a little apprehensive at working (photographing, carrying equipment), so far down these tunnels, away from the dive hole, but once we assured ourselves that we could get our heads out the same holes the seals use if there was a problem, it wasn't quite as creepy. We dove there again today, this time with a large movie camera. We have been staying down a long, long, long time on these shallow dives. We came up today quite cold after a 95 minute second dive.

We also had another small weather adventure the day before yesterday at Little Razorback. When we came up from the second dive a blizzard had socked us in. Condition 1. Extreme winds, cold and visibility was about 10 meters. There was no way we could see the flags to get on the road out. We radioed back to base outlining our

situation and found out that other groups were stranded all over the place by the sudden storm. We fortunately had the shelter of the dive hut, lots of hot soup and cookies so it wasn't too bad. Until the hut heater ran out of fuel..... The Sprytes are equipped with survival bags full of tents, emergency rations, a small stove, and sleeping bags. We dragged these into the hut and made ourselves comfortable for 6 hours until the weather cleared.

Yesterday we took snowmobiles out to the ice edge under the guidance of a sea ice expert. It was a 90 minute ride out past Cape Royds. The ice edge was blown in with pack ice, so we couldn't see any open water, but we did see lots of Adelie Penguins and a few more Emperors. We then checked out a possible location for our ice edge camp (where we will be working from in a couple of weeks) in "Back Door Bay" near Shackleton's Hut (very cool) and a large Adelie Penguin rookery (also really nifty -- but also noisy and pretty smelly; 3000 nesting pairs of penguins!).

Tomorrow we will do a few more dives, hopefully at Turtle rock....

Antarctica Report, Nov. 3, 1997, 1910 hrs

Weather: Condition 3, clear skies, -10 deg C, wind 10 knts.

Today we had a rest day. Not much of a rest actually -- we spent most of our time running around preparing equipment and schedules for some upcoming work farther afield. So no diving. I did spend a few hours late in the afternoon helping to relocate a new dive hole and hut at Cape Armitage. There was an enormous amount of snow on the ice which had again pushed the ice surface below sea level. When the hole was drilled, sea water gushed out and flooded the area. It turned out to be impossible to bulldoze enough of the snow away for the area to drain. So, instead, the area was piled with more snow and the hut positioned high above the dive hole. Now that the hut was dry, the interior hut hole was unfortunately about 4 feet above the ice hole to dive through. To allow diving, we constructed a small interior platform just below the hut opening to allow divers to climb in and out.

We have been diving the last few days at Turtle Rock. An area populated by a large seal colony. Underwater most of the ice was very dark (the ice is about 2.5 m thick there, covered with drifting snow), but in certain areas large cracks are visible that have been formed by pressure ridges. The seals have enlarged a series of breathing holes along the ridge and cruise back and forth along the crack systems and disappear into the darkness under the shallow shelves close to the island shore. Very cool. The large number of seals in the area means that there is a large amount of 'seal poop' under the cracks as well (it looks like they have been eating mustard!). This seal poop feeds a rich benthic community and the sediment below the cracks swarms with starfish, worms, and clams all eating what falls down from above.

One of the most remarkable sights occurred on our last dive yesterday -- hundreds of large, say basketball sized, jellyfish went floating by. Amongst them was a single enormous jelly of a different species. Its bell was approximately 1 m across, and its oral feeding arms 1.5 m long, and its stinging tentacles looked like they could extend at least 10 m. Huge! It slowly pulsed its bell along, at times almost turning inside out and looking remarkably like a tulip. Tomorrow we are planning to go back.

One member of our team, Dr. Leighton Taylor is now returning to the USA. Actually, he tried to leave today, but the C141 that landed this morning had somewhat of a crash landing on the runway. Large chunks of snow came off the runway as it touched down, they bent some of the landing gear, tore off landing gear doors and packed the gear bays with snow. The last I heard they were attempting to get the plane back into the air so it could attempt a gear down flight back to New Zealand, without cargo or passengers aboard. The next flight will be in 2 days so Leighton is stranded. Also, 2 C-130 flights left for the South Pole station today and had to turn back due to bad weather conditions over the pole... With all the people now stuck at McMurdo, housing is becoming a bit tight. No new scientists or staff will be flying in for a while until they can move people out to the Pole and other field stations.

The latest member of our team, Peter Brueggeman, from Scripps, has now completed his survival training etc. and after his check-out dive tomorrow, will be ready to start diving with us in the field. Hopefully we will all get out to Turtle Rock tomorrow.

Questions:

Early on, Steve Bartram and class had asked about helicopters...

After a chat with 'Beeze', a remarkable helo pilot who has flown down here for a number of years (first as a Navy Pilot, now with Petroleum Helicopters the contractor doing the helicopter work now that the Navy helicopters have left). Here is the scuttlebutt

They are flying Bell 212's (weight 11200 lbs) with a payload of approx. 2500 lbs, or max. 12 passengers. And Aerospecial AS350-B2's with a max. payload of 1500 lbs. The Kiwis are still flying a few Bell 205's.

They don't do too many special things to keep the helicopters flying here. They have few problems with icing since the air is so cold and dry, so they don't have to de-ice the rotors and blades. They do use a lighter weight oil in the engines and transmissions for the cold weather.

During storms they tie the helo's down to whatever they can, and fix the blades in place with lines and support poles to keep them from vibrating apart.

Some of the pilots are like Beeze, Navy pilots who flew for years down here and then moved into the private sector when the helo operations were contracted out. The other contract pilots picked from those candidates that have minimum number of hours flying in the mountains, and have enormous total flight times. Many are pilots who work the Alaskan oil fields and other areas during the summer months. They are top notch pilots. Questions from Bruce et al.

Power failures and their danger (i.e.. then you lose heat). Yes, power failures would be a big big problem. However, I have never experienced or heard of one happening here at McMurdo. Keeping the generating plant running is the number one priority for the base. They have lots of redundant systems and a bunch of engineers running it around the clock.

Redundant diving systems. We dive with two complete regulators; first and second stages each on their own valve (a slingshot valve). All suit inflators, gauges etc. are placed on the back up regulator. In the event of a primary regulator failure, we can move to the secondary, switch off the primary at the valve and still have the gauges working. The dive is then canceled. Yes, pulling off the facemask is not possible. So, you try not to knock it loose....

Antarctica Report Nov. 5, 1997. 2010 hrs

Weather: Condition 1-2 in town, Condition 1 on the sea ice.
temp -15d deg C, wind gusts +45 knts. another storm has hammered us.

Once again, what started out as a beautiful day yesterday turned to storm by late in the afternoon. This will be the 4th significant storm since we have arrived. Today we were unable to dive or travel onto the sea ice. So far it hasn't turned to Condition 1 in town, so we are still able to move around the base. The temperature has remained fairly warm, but, high winds and blowing snow has reduced visibility making travel anywhere but in town next to impossible.

We were still incredibly busy today without the dives. We took a snowmobile mechanics course in the morning (to learn how to troubleshoot and repair snowmobiles in the field) and a helicopter safety and cargo loading course just after lunch. After all that we spent most of our time building cargo manifests and weighing each individual item of gear that will have to be helo'd across the Sound to our upcoming camps at Granite Harbor and New Harbor and then to the Kiwis Camp at Cape Bird. Lots of work still to do -- we have to plan all our meals and pack up the food and water for helo sling loads (dangling cargo beneath the helicopters).

The dive we did yesterday morning was incredible. We drove out to Turtle Rock (also known as Sparkle Rock, because the rocks that make it up are loaded with olivine crystals that catch the light) early in the morning and planned to make one quick dive. Instead we spent 90 minutes underwater. I was trying a new Argon rig on this dive (for dry suit inflation and extra warmth) that turned out to be more of a hassle than it was worth. There was all sorts of extra gear to schlep around for a nominal difference in warmth (at least in the sort of diving we were doing). I will probably be going back to what we are calling "the toe heater sandwich" for extra warmth. -- We stick dry chemical heat packs (normally used for warming fingers and toes) on both sides of our feet before putting on our suits and I am contemplating just sticking them all over my entire body (just kidding). It is quite amazing what a little additional heat down on the feet can do to make a long dive more comfortable.

While we were photographing under a large crack that runs towards shore over the shallow island shelf a mother seal entered the water with her pup and started to teach it how to swim. Amazing. We managed to get quite close and the mother and pup didn't mind our presence at all. At times the pup would dive down, quite spastically actually, and swim right up to its reflection in the dome port of the video camera I was using. The mother would then just cruise by and inch the pup back towards the breathing hole. There was a solitary seal cruising the area that seemed much more aggressive and whenever it came close both the mother and the intruder would posture and make all sorts of noises and then the mother would chase the intruder away. I am guessing that the intruder was a juvenile male seal and the mother didn't want any trouble with her pup on its first swim. It was incredible to watch the pup being introduced to its new environment; it looked so eager and unskilled and tiny, and its mother so graceful and huge.

The newest member of our team, Peter, made his check out dive with us and unfortunately had to contend with what can be a very serious problem. He had both his drysuit wrist/glove seals flood (due to incorrectly installed cuffs) and the small tubes we place in the seal to equalize pressure allowed his suit to flood to his elbows. Despite being soaked he managed to stay in the water for 14 minutes. Back at the surface his hands were very cold and stiff, not to mention painful.

As we were leaving Turtle Rock the weather started to change. It became windy and snow was falling. Visibility progressively worsened en route to McMurdo.

After dinner we managed to sneak in another dive at a nearby location (Cape Armitage) in what looked like to be a break in the weather. The hut had been scheduled to move that evening and we wanted to get in a dive before it left. (this is the same hut that we had to install the additional platform in). The dive itself went very well. Peter had a great dive and his reinstalled glove seals worked perfectly. It was an interesting location although not as exciting as some of the other areas. There was so much snow on the ice above it was similar to a night dive. There were just 2 shafts of light penetrating the ice, one from the hut hole and one from the safety hole. All else was black. Directly under the hole was a shallow valley at a depth of about 60 feet, sloping gradually deeper. The bottom was mainly sponge spicule mat, sprinkled with brachiopods, sponges and the occasional small rock outcropping. I used this dive to take a core sample of the sponge spicule mat to send to some researchers in Canada (the core was a partial success -- but that is another story). The most amazing thing I can remember from the dive was looking up the slope from my sampling site (at about 120 feet) and seeing Peter and Norbert, back-lit by their powerful dive lights as they swam along the bottom far up the slope taking photographs. As they passed under the safety hole there was enough light to illuminate their bubbles as they floated towards the surface. Very nifty. It is amazing diving in such clear water.

Once the dive was over we hastily packed the Spryte and I drove us back to the base in progressively worsening weather. What should have been a 5 minute ride to the transition took almost 20 as our tender had to help me find the flags that marked the path back to the base. We had to squint our way from flag to flag. Once we were off the sea ice it wasn't nearly as bad since there wasn't as much blowing snow. The weather continued to degrade all night and into today.

Hopefully the weather will improve and we will make it back to Turtle Rock tomorrow.

Antarctic Report Nov. 9, 1997, 1900 hrs
Weather: Condition 2, -10 deg C, 40 knt winds. Condition 1 on sea ice.

Another blustery day to say the least. It was very bad again this morning so we were unable to travel onto the sea ice. To make the most of our time we continued preparations for our future field work. It is amazing how long it takes to organize and pack all the food and equipment necessary for work far away from base. In addition to preparing the air compressor and diving gear there are all the 'little' things that are needed and which take most of the time to organize. Packing meals, water (60 gallons), fuel (both diesel and gasoline), camping supplies, a 'polypack' (for use as a field toilet), personal items, radios, generators, solar panels, etc. etc. and then weighing and tagging each item takes a long time.

I have lost count of the number of storms we have had this season. Apparently this is now the worst they have had on record. The forecast is for decreasing winds tomorrow, so we will try to get out (back to Turtle Rock to film the seals again) again. It didn't hit condition 1 on base today, but the sea ice was getting blasted (often with what is called a 'ground blizzard' = a blast of driven snow that is only about 12 feet thick that hugs the ground and is forced by very high wind speeds. Impossible to navigate in.). A group of scientists with a camp out on the sea ice radioed in last night with wind speeds greater than 85 knots that was threatening to destroy their main jamesway tent (a large, half-domed shape military tent).

We did head out yesterday but were lucky not to be caught by the changing weather. We made a quick dive in the morning at Arrival Heights. I spent my time photographing the pelagic animals (mainly tiny jellies, salps and pteropods) that had drifted into the area in a very large front. There were millions of them and by diving below and then looking up towards lighter spots under the ice, I could just see their faint outlines and swim closer to take pictures. I quickly finished a roll of film and surfaced to change the film in my camera. Descending again my regulator second stage started to freeze up (probably due to my surfacing, partially warming the regulator in the warm dive hut and then descending again into the freezing water). The regulator alternately free-flowed and then leaked (well, flooded actually) water but it never stopped functioning and I managed to breathe it for the rest of the dive until the final ascent when I had to switch to my back-up regulator. I hope the pictures turn out.

After the dive, we loaded up what felt like a zillion pounds of camera equipment and headed out to Cape Royds again with the Sea Ice Wizard, 'Buck' and some of his SAR friends: us to take pictures of penguins and hopefully make it to the ice edge; Buck et al. to check on ice conditions farther afield and get away from the base for a bit of a break. The drive in our wonderful Spryte (now loaded with an additional 20 gallons of fuel) took over 2.5 hours, but it was worth every second. The afternoon was sunny, the wind not too strong and the scenery along the coast stunning. When we got to the Cape the wind had picked up slightly but it certainly wasn't threatening. We took photographs of the Adelie Penguin rookery and then of the groups of penguins (both Emperors and Adelie's) walking between the rookery and the ice edge about 1 km distant. The Adelie penguins are hilarious. They really are like little cartoon characters; always hurrying and scurrying about with great purpose and commotion. They appear to be reincarnated New Yorker's if you believe in that sort of thing. The Emperor penguins appear just like their name. Emperial. Majestic. They are slow and methodical and move with a sense of purpose.

After a brief snack our plan was to cross over a spit of land to reach the sea ice edge beyond -- a hike of about 30 minutes. However, the wind had really started to gust by this point and the distant Mt. Discovery started to disappear into threatening cloud, and the closer Mt. Erebus was half-capped in spectacular lenticular clouds and blowing snow. It was time to go. Unfortunately one of our less than trusty Sprytes was overheating on the way out so we had to creep back slowly to prevent losing it entirely. We crept back to base at 0230 this morning just as wall of blowing snow rolled down the sound towards the base. Less than 30 minutes after we had unpacked the base was again being hammered by a storm (which has continued off and on all day today).

Another dive group wasn't so lucky. Returning from Cape Evans after a late-night dive they were still a few kilometers from McMurdo when the storm hit. They managed to get back at 0500 this morning in spectacular fashion. They would inch their first vehicle along the flag road in the direction of the next flag until their other vehicle was just starting to lose sight of it. Then, some lucky person (a marine biologist from F.I.T.) would venture from the Spryte with a rope tied around his waist and then sweep around for the next flag. Then, the rear vehicle would be contacted and drive up behind the forward vehicle which would then follow the rope to the flag... Then the long, slow and cold process would repeat. At times they were able to climb up the top of the Spryte and look above the ground blizzard for landmarks to make sure they were going the correct direction.

As all this was going on, I was already fast asleep in my room on base.....

Antarctica Report, Nov. 12, 1997, 2000 hrs

current weather: Condition 3. temp -5 deg C, winds 5 knts
just beautiful outside.

Well, we have been having an incredibly busy few days. Some of the bad weather has cleared up (but there is rumors of another storm on its way) and the last 2 days have been glorious. Clear skies, warm temperatures, and low winds. We are hoping that it continues...

2 days ago we returned for another few dives at Turtle rock to film the seals. Everything worked very well. We even brought a generator along to power some very intense underwater movie lights to experiment with. They worked very well, although 'tending' the generator for an hour at a time, while sitting in the wind and blowing snow wasn't all that much fun. It did give us a good chance to just sit still and admire the seals (moms and pups) that are all over the sea ice surrounding the island.

Yesterday was an interesting day as well. We started out with grand plans, but were once again foiled by an evil Spryte. We planned to first photograph a group of scientists working at their field camp far out on the sea ice. Then we were going to head towards Little Razorback Island to drop off some water and do a quick dive, then we were going to stop at a series of ice caves in the Erebus Ice Tongue on the way back to the base. Alas, it wasn't to be. We made it as far as the ice camp (run by Dr. Randy Davis who is leading a collection of studies on seals) and then Spryte 510 (once again just back from the repair shop) lost all oil pressure and then stopped. We managed to get a ride back to base with the seal scientists at the end of the day, but then didn't have time to complete the rest of our plans.

The research being done by Dr. Davis and his group is just fascinating. They have a very elaborate encampment of several portable buildings (Jamesway tents, polar havens, and the 'Solar Barn' -- covered with solar panels), a large generator and a lab tent that houses loads of computers and scientific gear and most importantly, a seal hole and seal. They moved a Weddell seal to the center of the sea ice shelf and drilled a solitary hole so that the seal must dive and return to the same spot. When it surfaces it breathes into a plastic dome over the hole and they are able to collect and study its respired gases. They can also take blood samples and perform other physiological tests. The really cool part of the project is that they have fitted the seal with a small electronic backpack that measures its diving depth, swimming speed and direction and has a miniature video camera attached. After a dive they can download the data, reconstruct the seals diving pathway and can see what it was

doing via "Seal Cam". One of the things they hope to see with the camera is how and what the seals feed upon (i.e. what type of fish) - -something they have only speculated on previously.

Today we flew by helicopter to the ice edge and fortunately the helo operated much better than the Sprytes we have been using. We left early this morning, packed a mountain of dive and photographic equipment and flew towards the far side of the sound to see if we could find some whales and large groups of penguins. The weather was warm, clear and very sunny -- it would have been perfect if it hadn't been for the wind. It was blowing a steady 35 knots which made some of the work near the ice edge fairly hazardous. The wind was blowing directly out to sea and was threatening to break up and pull away the ice edge. To prevent disaster (i.e. us and helicopter floating away on a tiny ice floe) we landed a good distance away from the edge and then walked all the gear to the edge to check it out. There were large groups of Emperor and Adelie penguins sitting around in small groups, inquisitive as always (they would wander over to check us out -- some even wandered all the way to the helicopter, no doubt to check out how on earth such a thing could fly). The penguins were not entering the water because the edge was being patrolled by a group of about 20 Orcas. It was incredible how close to the edge they would come; you could almost reach out and stroke their dorsal fins when they came right in. Unfortunately, due to the direction and strength of the wind it was unsafe to spend much time right on the ice edge, waves were washing over and turning the surface into a slippery, slushy mess. More importantly, the waves were eroding the bottom of the ice edge and making it undercut. When we finally left and returned to the helo, waves had flooded a large section of the sea ice and was starting to push it further underwater. Flying over, huge sections were being broken off and were drifting out to sea.

We then flew towards Cape Royds, a place we had visited by ground vehicle just a few days ago. The winds were still high, but because there wasn't as much open water for the wind to blow across, the waves were not yet very large and dangerous. There was no slush or water on the ice and we had solid footing right to the very edge. There were quite a few penguins around where we landed, but not whales unfortunately. Norbert, the nature photographer, went into the water and mainly snorkeled along the edge waiting to catch images of the penguins entering and exiting the water. (they exit the water like slippery little ballistic missiles -- the Adelies land on their feet, the Emperors land on their bellies). We spent our time frantically pointing to where we thought the next penguins would appear to try to guide him to the next shot. We also rigged a drift line and float for him in case he ran into problems then we could drag him back to the ice. It worked very well and he hopefully managed to get some great pictures. Tomorrow we will try again.

We made it back to McMurdo just in time to catch dinner, after 9 hours out on the sea ice. Dinner? Roast pork chops, vegetables, scalloped potatoes and brownies for dessert. Captain Scott certainly never had it so good!

Antarctica Report, Nov. 15, 1997, 1530 hrs

Weather: Condition 2, -10 deg C, 40 knt gusts

Yet another storm is rolling through, although this one doesn't seem very severe. We are hoping things continue to clear up over the next few hours so that we can head out for some dives this afternoon and evening. After another morning of running around preparing for our trip to Granite Harbor (we are scheduled to helo out Nov. 17) we are ready to get into the water again.

Yesterday we returned to Little Razor Back Island for some more filming. It was stunning as usual. What was most interesting was how much the shallow shelf ice had changed since the last time we were there. In fact, it seemed as if it was a completely different dive location and we had to get reoriented to the ice tunnels and escape holes all over again. The ice ceiling had compressed downwards and in most places was only about 1 meter high, just enough to squeeze through wearing all your gear. We were able to share the slightly more spacious tunnels with the seals to travel farther along the shelf.

One of the most interesting things we watched on the dive was an enormous female pulling herself out of the water through her breathing hole. To move such a massive body (many weigh more than 600 kg) up out of the buoyant water was an incredible feat of strength. By beating her hind flippers she was able to thrust her way up and out through the overhead snow and ice and doing so she churned a large hole in the underlying sediment.

There are many solitary pups around now, having just been weaned by their mothers. They are still spending most of their time on top of the ice though -- I have yet to see a solitary pup in the water. After leaving their pups, the mothers go into estrus again and will soon be receptive to the roving males. In the meantime they warily watch the males from their breathing holes and the males seem to spend most of their time, "cruising".

Later in the evening I returned to the Seal Camp I mentioned earlier (where they are studying the diving seal). The group there had asked if I could make a dive and clean off the windows of the underwater observation tube they use to watch the seal. The "ob tube" is a long cylinder about 10 meters in length that terminates in a small window filled chamber that allows one person to climb down a long ladder and look out under the ice. It is sort of a submarine in reverse. After it has been in the water for a while, platelet ice starts to grow on it and obscure the viewing windows....

Since I have been here I have made some of the most spectacular (i.e. the iceberg dives) and now the spookiest dive I have ever made in my life. I entered the water through the hole in the floor of the large science tent they use to study the seal (the seal had been moved back to its point of capture) and the water beneath the hole was over 600 meters deep. Since it was a "blue water" dive, I was able to do it alone because I was connected by a tethered line to my tender on the surface. Descending through the hole, the entire experience quickly became very surreal. The solid ice was at least 2 meters thick and then beneath that there was another 3-4 meters of platelet ice that had grown on the bottom of the sea ice. By the time I emerged into the open water I was almost 20 feet deep.

The water was incredibly dark. Pitch black below since the bottom was over 1000 feet away and dark above due to the thick ice and overcast evening. Very spooky and very quiet. I didn't see another living thing on the entire dive (larger than algae that is). I swam over to the observation tube, about 10 meters from the dive hole and tried to find the windows. Unfortunately, platelet ice, often more than 1 meter thick in places had covered the entire structure and to find the windows I had to pull, push and smash nearly all of it away. Fortunately it was very brittle and easy to pull apart. One of the camp scientists had entered the tube to try to take some pictures of the process, but was unable to see more than an occasional hand appearing out of the swirling ice, pushed up against a window. When I had completed the job I sank to the base of the observation tube and settled on the large ballast weight there and just looked down into the dark and then out into nothing. Wow. It makes you feel incredibly small, insignificant and very isolated. I followed my safety line back to the hole.

It was a study in contrasts. I surfaced from the very lonely and dark water, up though the long ice tunnel and into a warmly-heated Jamesway tent, filled with bright lights, flashing equipment, computer screens, science equipment, and some smiling faces to help me shed my gear.

The weather has cleared -- we're going to go for a quick dive....

Antarctica Report, Nov. 16, 1997, 1930 hrs

Weather, Condition 3. temp -10 Deg C, winds 30 knts.

The weather had improved enough yesterday afternoon to let us make a quick dive at a nearby site. We loaded up the not-so-trustworthy Spryte and roared off for "Dayton's wall" at Cape Armitage, not 10 minutes from the dive locker. We had completely suited up and prepared our gear before leaving so we were able to dash out of the Spryte, yank the cover off the dive hole and jump in without getting too cold (we were out in the open -- no dive hut). The site is named for Dr. Paul Dayton who did extensive ecological work there for many years (and

incidentally was my advisor at Scripps) and is a small but spectacular steep slope covered in all sorts of good stuff. A very lush benthic invertebrate community covered much of the bottom and we were disappointed to have to leave after a short dive (we were fairly deep, 120 feet, which limited our bottom time).

Today we spent the morning doing the final loading for the trip tomorrow and in the afternoon we drove ourselves and a few of our dive tenders (we weren't diving today however) up the coast to Cape Evans to see Scotts' Hut. A long drive but worth it. We spent a few hours photographing inside this most famous of Antarctic huts (Scotts main hut, where he left for his ill-fated journey to the pole). Low light and howling wind made it an authentic experience all round. The inside is remarkably preserved and like stepping into a time capsule. Quite remarkable what those men endured.

I had neglected to mention a trip we made one night out to the edge of the Erebus Ice tongue (a large section of glacier that protrudes far into the Sound) and into some ice caves there. The caves were a series of small chambers and tunnels that followed some large crevasses into the glacier. Snow had filled in the tops of the cracks so we could walk around underneath. It was the closest thing to diving I have experienced topside, akin to walking around inside a giant snowball. The ceilings of the larger chambers were completely covered with ice crystals and icicles. And the light that penetrated the roof and some of the clear walls was a stunning light blue. We had previously flown by helicopter over the top of this section of glacier; sweeping and soaring around the cliffs and cracks like in a giant amusement park ride and it was just as spectacular walking around inside it.

Tomorrow we fly off to our camp at Granite Harbor where we will be diving through ice cracks and off of ski doos. Sounds chilly but exciting. We will be gone for the week and I will try to send a report as soon as I return.

Antarctica Report, Nov. 22, 1997. 1100 hrs

Weather: Condition 3, temp, -5 deg C, wind 5 knts
not a cloud in sight...beautiful

We returned late last night from our weeks stay in a field camp at Granite Harbor.

Spectacular. Awe-inspiring.

This morning we did a bit of running around to reorganize for our upcoming week-long trip to Cape Bird (to work out of the Kiwis camp there). We will helo out Monday morning and return on Friday. It is difficult to exactly schedule plans since the helicopter flights change all the time as different field parties run into difficulties or require resupply etc. Regardless, we will spend some more time tomorrow morning staging our equipment for packing. This afternoon we hope to get away for some diving locally.

Granite Harbor.

The opportunity to make a trip like the one we just returned from is just one of the many reasons why this time Antarctica has been so special. Granite Harbor turned out to be a very impressive place, both topside and underwater. The weather was glorious almost the entire time -- just a few overcast hours (fortunately at night) and we had high winds only infrequently.

It was located about a 40 minute helo flight away, on the other side of the Sound on the continent proper. The "harbor" itself is an enormous bay surrounded by tall granite cliffs and by 3 separate glaciers that feed into the sea. The Mackay Glacier was the largest and most prominent. It had enormous icefalls and a glacier tongue that extended out into the bay. When you gazed out across the sea ice you could see glaciers, large mountains and cliffs far in the distance, and icebergs scattered around.

Our camp consisted of one Jamesway tent (for storing dive gear, cooking and filling tanks), a small Scott tent (pyramidal and photogenic yellow -- used as our outhouse), and a small cluster of mountaineering tents for sleeping. It was situated about 50 meters from the base of a granite cliff out on the sea ice, right alongside a convenient crack that we enlarged for some "close" diving. There were lots of seals hauled out everywhere there were larger cracks. These seals proved to be much more vocal topside than the groups we were acquainted with closer to McMurdo. You could always here them "honking" and groaning away.

The best diving required traveling by snowmobile to several different locations that also had cracks big enough for us to enter. It was fun zipping around on the skidoos, at least on the way out. The return trips were considerably less fun since we were typically wearing our wet dive gear and it got a little chilly! The sea ice had been blown free of snow and provided a skate-able hockey rink at least 100 square miles in size. Pretty nifty, but since we hadn't brought skates it made walking (and skidooing) around rather tenuous. (a few days previous a skidoo had skidded out of control on the ice, throwing the passengers -- both had concussions and one also dislocated her shoulder).

The cracks we were diving through also proved to cause problems. They gave us access to the water for diving, but they also made travel across the surface to distant sites rather serpentine. We had to search around to find safe places to move the snowmobiles and gear sled across them -- sometimes having to travel far off the quickest route. While we were there the cracks moved and opened noticeably. They were formed around pressure ridges of colliding ice masses and around the headlands and shores. We tended to the dive the cracks near shore since they were over shallower water and frequented by the seals.

A typical day included: getting up around 0700, eating some oatmeal, loading the gear sled with dive and camera gear, heading out for a dive, returning for a hot soup lunch, filling tanks, heading out again, returning for a fast "boil it up" noodle dinner, filling tanks and heading out again... Needless to say, most of the dive gear and garments never really dried out -- things were getting rather damp and smelly by the time we returned (no showers out there).

The underwater scenery was very different than on the other side of the Sound. Here we saw large granite boulders (some huge) and steep drops and cliffs rather than the more gently sloping cinder, mud or pebble bottoms. At one location we were almost right next to shore, yet the water under the dive crack was still 100 feet deep. There were many very large, white "volcano" sponges (some over 1 meter in diameter), lots of urchins, scallops, sea spiders and soft corals. Quite beautiful. In the shallow water starfish and urchins were in profusion, all feeding on the abundant seal poop.

To me the most impressive sights on the dives were the larger "big picture" vistas. At one dive (eloquently named, "Hole # 2") the surface crack was situated so that when the light was higher in the sky it would beam directly through the opening and because the water was so clear it would create a bright crack-shaped outline on the bottom. The edges often tinged by "rainbows" as the sharp ice edge worked as a perfect diffraction slit. In the midwater, the light formed a sinuous curtain of crepuscular rays (or "god beams") so bright that if you swam through them you left a diver shaped shadow on the bottom. Wow. Right up against the vertical shore line we found frozen waterfalls under the water. Melt water trickling down from the cliffs above had entered the sea and frozen along the rocks. They looked exactly like the long time- exposure pictures you see of waterfalls and river rapids on land. Here they were frozen in place, yet still appeared fluid.

One dive in particular is still burned into my mind (please allow me to wax rhapsodic for a while). After dinner one evening I traveled across the bay to dive the poetically named crack "200 meters south of Hole #3", (or "the dike" named for the black vein of rock in the cliffs above) with a few scientist friends in the camp with us (they are collecting sponges for natural products chemistry -- there were 7 of us at the camp). We hadn't dove this particular crack before so we didn't know what to expect. Our group had finished work for the day, so I was able to take the entire dive to go exploring.

I swam beneath a long pressure ridge and crack system that formed the icy roof above a shelf of large pink-granite boulders. Along one side of the shelf, the bottom dropped away, vertically in places into deep blue water. The other side of the shelf was a wall of ice and granite, with intermittent frozen icefalls, and shimmering curtains of platelet and anchor ice. Ice algae has started to bloom on the lower surface of the sea ice, so that light shining through is tinted a golden colour and looking up is like gazing into a glass of ginger ale. There were lots of seals around and now and then I could watch them glide past and the entire dive was accompanied by their singing and whistling.

In places where the cracks widened, shafts of light stabbed down to the bottom and I swam along these back and forth around and beneath the pressure ridges that jutted down to the shelf. Some of the ridges protruded 30 feet beneath the surrounding ice. After swimming wide-eyed for about 25 minutes along the ridge system, I dropped beneath a large ice ridge and slipped between some granite boulders on the shelf. On the other side the shelf opened into a large bowl and the ice arched upwards far over head into a colossal ceiling, split with gold and blue cracks. Around the outer edge of the ice roof, huge, 20 foot brine tubes hung down like teeth and on the other side a jumble of ice blocks and bright white ice coated the walls like cake frosting. I don't really have the words to adequately describe it...

The scenery had sprung directly from Coleridge's mind:

It was a miracle of rare device,
a sunny pleasure-dome with caves of ice!

When I could tear myself away from that spectacular vision I swam back towards our dive hole, hugging the inner wall. In the areas where topside the huge, rolling pressure ridges were pushed downwards, it was sometimes possible to enter cracks in their bottoms and swim into their interior. The sea ice was now turned inside out. The old ice surface now became the floor of an ice chamber, some 10 feet tall and 30 feet long with a new ice ceiling frozen in place above. You could then swim inside this layering of sea ice, with all the walls yellow and gold with algae and bright with light. Entering one of the larger chambers I encountered a seal hovering inside. We stared at each other for about 3 minutes before it slowly slipped down a hole on the opposite side. Some of the chambers were swarming with amphipods and my swimming and bubbling away made blizzards of tiny creatures. Truly incredible. I really wanted to swim around in the shallows for hours, but shaking with cold, it was time to head back.

When I emerged from the dive crack I saw the excited faces of the other divers -- they too had experienced something special. And when queried about what I thought, I replied, "I saw God on that dive." I currently don't believe in an omnipotent creator, however, after an experience like that dive, I really wish I had someone to thank. If that was to have been my last dive in Antarctica, or the rest of my life for that matter, I would consider my life underwater complete. In retrospect what is even more exciting is that I am sure there will be other dives just as spectacular and moving, if not in Antarctica, then elsewhere. I hope.

We have all come to Antarctica for different reasons. There are scientists here for research. There are people here to support the scientists and photographers and writers to record their visions. I think I came so that I could, among many things, have that one special dive.

Antarctica Report, Dec. 1. 1997, 2100 hrs

Weather, Condition 3 (finally), -5 deg C. wind 5 knts (a beautiful evening)

If all things run smoothly, at 0700 tomorrow I will be sitting on board a C-130 Hercules flying back to New Zealand. The end of an exciting adventure.

I was lucky to get back to McMurdo today, in time to make "Bag drag" (taking cargo to the terminal for my flight out). I was stuck an additional 3 days at Cape Bird due to bad weather. Poor visibility from heavy fog over the land restricted all helo flights in the region and even prevented the airplanes from landing and leaving the ice runway. It was so bad, that our first attempt at landing at Cape Bird (the most northern point on Ross Island) was aborted half-way up the coast as the helo flew into impenetrable clouds. They have to be able to see the ground to navigate so they couldn't risk continuing. We waited until later in the day and managed to make it.

We did our flying to Cape Bird with the New Zealand "kiwis" pilots in their Huey. They run a much more casual operation than the PHI group out of McMurdo. We jammed all our gear (over 1200 lbs) into the Huey, squeezed ourselves in and the last kiwis crewman crawled up the load as well as us and squeezed between the cargo and the ceiling while safety belting himself under the roof. "No worries, Mates, " was all he said.

The Cape Bird station was a lone Kiwi hut, perched on the side of a cinder hill, just underneath a part of the Cape Bird Ice Cap. Stunning scenery. Down below on the beach and stretching out of sight was an enormous Adelie penguin rookery with over 60,000 birds. You would not believe the noise 60,000 penguins can make. And the smell.... Zowie. Standing downwind from that many screaming birds is a complete sensory experience. We spent a lot of our time wandering around between the birds, taking pictures of their various behaviours and having a good laugh at their antics.

What we were really hoping to get footage of were the leopard seals that cruise along in the ocean in front of the rookery. The penguins are making constant trips between their nests and the ocean to feed, and are the leopard seals' primary prey. As the penguins enter and exit the water, they are most vulnerable and the seals lurk just under the edge of the ice, waiting for a penguin to fall in, or miss a landing on exciting. The penguins can easily out-maneuver the seals in open water. Before jumping in, the penguins all pile up on the shore at a suitable entry point and then just sort of sit around, making noise, looking down at the water, pushing and shoving -- just to see who will be the first to enter, and possibly get eaten if there is a leopard seal nearby. If one falls in and swims away safely, or if some penguins swim up from feeding down below, then the entire group quickly dives into the water. Watching up and down the coast you could see dozens of groups of penguins waiting to get into the water.

The leopard seal is a very frightening predator. -- the scariest thing I have seen in the ocean (much more frightening than any shark since you can obviously see that they are very intelligent). They are big, over 3 meters long and they look almost reptilian with a long head and gaping mouth. They spent most of their time silently swimming just under the ice edge out of sight from above, sneaking up on their prey. When they do snatch a penguin, they grab it by the head and shake it vigorously out of the water until the outer skin and feathers pulls away. The researchers at the Cape Bird hut watched a leopard seal attack a Weddell Seal and almost manage to do the same thing to it -- whipping a thousand pounds of seal back and forth above the water to turn it inside out. Yikes.

On our first attempt to get close to the leopard seals, Peter and I tied a freshly dead penguin to a length of cord and tossed it just off the ice. Peter pulled it about 5 meters along the edge when a leopard seal popped up out of the water, not at the penguin, but at me. It hadn't fallen for the "dead penguin trick" and instead decided to check out the bigger and perhaps tastier morsels on shore... We didn't stand so close to the ice edge after that.

In the end we decided against getting into the water with them. A combination of poor visibility (just a few meters at most due to all the melt water run off and penguin poop), low light (it was overcast, snowy and foggy most of the time) and an uninteresting bottom fauna made it not worth risking injury for some mediocre pictures of the seals. We did manage to get lots of topside footage of the penguins and seals however.

The bad weather ended up trapping me at Cape Bird for an additional 3 days and I was beginning to get anxious that I would miss my flights home. Now I know the frustrations that friends had felt when their flights were delayed earlier in the season. No matter how wonderful and exciting a place can be, you can easily get

depressed and begin to see it negatively if you really want to be elsewhere. I did. The snow and fog stretched on, delaying flights and ruining my chances at a last few dives in McMurdo over this past weekend. More importantly I was beginning to fear I would miss my return flights to Christchurch where I would be meeting my girlfriend who I have been missing desperately the entire time I have been gone.

Yesterday, when we knew I was stuck once again, I took a long hike with one of the penguin researchers to the "south rookery" about 3 hours south of the main camp. It was a large colony of about 30,000 birds perched atop a steep slope below the Shell Glacier above the iceberg dotted Wolfschlag bay. The sun came out occasionally and the scenery was magnificent and I did manage to cheer up a bit. There was nothing I could do about the missed flights so I was foolish to look at things in a black mood. We made it back to the camp in the evening, ate a big meal and I went to sleep after talking to helo ops on the radio who reassured me that they would try to get a helo out the next day and that the weather looked like it was improving. They were right. We made it back -- and tomorrow I should be on my way to Christchurch.

Before heading to Cape Bird I did manage a last couple of dives at Cape Armitage. The visibility was still continuing to drop (probably only about 200 feet now) and hovering beneath the ice ceiling caused large clumps of ice algae to come raining down. My last images of the dive was of the bottom of the sea ice, sprinkled with brine tube stalactites stretching off out of sight into the darkness, and the bright blue dive hole above. Swimming up the hole was swirling through crackling and clinking platelet ice into the light and down beneath my fins was dark black water. The diving has been incredible and I will miss it.

Antarctica Report: Dec. 22, 1997. Epilogue

Weather: Condition 3. temp +15 deg C, wind 10 knts
(a nice sunny day in Monterey)

Hello Everyone.

I thought I might just make one last post.....

I returned to California safely 1 day ago and now I have had a little bit of time to digest some of my recent experiences.

Miracle of miracles, my plane (a C-130 Hercules) actually left on time -- there were no delays. I had a frantic last day of packing after returning from Cape Bird and then early the next morning, 20 other researchers and myself squeezed into the cargo-stuffed plane for an uncomfortable 8 hour flight back to New Zealand. We landed mid-afternoon on a hot, muggy summer day fully dressed in all our down survival gear (which must be worn on the plane). We made it back to the NSF Antarctic center staging area just before we had completely melted into little puddles of sweat. Ugh.

The next morning I flew from Christchurch (on the south island) to Auckland (on the north island) to meet up with Vera for a couple of weeks of R&R. We had a marvelous time traveling and camping about both islands. To make a long story short we managed to pack in hiking, climbing, caving, whitewater rafting and sight-seeing all into less than 3 weeks (we certainly wanted more time). Then it was time to return back to the real world -- or at least the real world according to academia in Calif.

Readjustments? It certainly was a bit of a shock traveling from McMurdo back to life in America, however, I think there might have been more of a shock if I hadn't had the "decompression period" back in New Zealand. Some of the little things that seemed strange were:

Driving. Cars are much faster than cruising around in the infamous Sprytes with their top speed of 11 mph. They are also less prone to bursting into flame, throwing tracks, filling with snow and you don't have to scream

to the other passengers to be heard over the engine noise. Traffic was a bit of a change also -- the "rules of the road" are a little more relaxed when you have an entire icesheet to drive on.

Eating. Hmmm, no galley to cue up in for meals. However, now you have to do your own dishes, and if going out to a restaurant (or the gas station for that matter) you actually have to pay! But the choices in the supermarket! you can eat anything you want....

Noise. Except when in the hustle and bustle of a city the wilderness of New Zealand seemed pretty quiet at first.. There always seemed to be some sort of noise (most of the time) on the ice. The howl of the wind, a roaring helicopter or Spryte engine, cracking and booming ice, heating fans in buildings etc.. Under the ice there was the constant bubbling of our dive gear and the singing of the seals and whales. When it was quiet in Antarctica it was incredibly quiet, like in few other places I have been (with the exception of a few caves).

Rain. For a few days it poured in New Zealand...No rain in Antarctica, just snow and because the air is so dry you hardly ever felt damp. After a few days of downpour on the west coast of the south island Vera and I got pretty soggy.

People. Lots of them. In McMurdo you tended to interact with a small group of people most of the time. The others you at least recognized their faces after seeing them at meal time etc. Back in the real world there are lots and lots of different people, all the time, and most you will never see again.

Thinking back about our time on the ice some things still cling vividly on my mind. The diving of course. I can still see clearly the ice tunnels at Little Razorback Island and the stunning views under the golden ice at Granite Harbor. Thinking back, I have no way of remembering the sensations of temperature -- the numb hands and feet we would experience on the long dives. I just remember that we would get cold, but the actual feeling is no longer there (maybe that is a good thing). With such amazing visibility early in the season I had my best impressions of the vastness of the ocean. Nowhere else have I dove did you get the same feeling. Elsewhere you are restricted in your view to a hazy scene a few hundred feet around, or limited by the beam of your dive light. Under the Antarctic ice, when it was free from snow and the sun shone through you could see for hundreds and hundreds of feet in all directions and see animals poised in the water like we can see birds and clouds in the sky. The ocean will always seem to me to be much bigger now.

The ice, I think, was most spectacular. The benthic marine life and the life topside was wonderful, but the ice really seemed alive as well. Both topside and below the ice took on so many forms and it changed through the season. It moved, sometimes quickly, and made noise as it crashed together in sheets, or cracked with changing temperature.

I can still hear the songs and barks made by the Weddell seals and I will remember them giving birth in the howling wind of the blizzards we experienced. And the smell of thousands of penguins at the rookeries.

And the people of course. Some of whom have become close friends due to the peculiar circumstances that enfold such expeditions. When faced with such an extreme and often harsh and dangerous environment, that is also full of such wonders people can bond together quite closely through their shared experiences and the requirements of intense cooperation. I will miss them all and I hope that in writing my reports I have been able to let others experience some of the same feelings. cheers, *Dale*

ANTARCTIC JOURNALS OF PETER BRUEGGEMAN

In 1997 and 1999, Peter Brueggeman assisted with a **National Science Foundation** sponsored underwater photography expedition led by **Norbert Wu**, a professional underwater photographer/cinematographer. The team was based at McMurdo Station on Ross Island in the Ross Sea and Peter did forty-nine scuba dives at various locations around McMurdo Sound. Peter Brueggeman was the Director of the Scripps Institution of Oceanography Library at the time of this project, and authored the Underwater Field Guide to McMurdo Sound, associated with this project. This photo shows Peter scuba diving at Cape Armitage under the ice.

November 11, 1999. Cape Armitage

Antarctica is the highest, driest, windiest, and coldest continent --- it can also be the most irritating. Due to weather and mechanical delays, I cooled my heels for seven days in Christchurch, New Zealand waiting for a flight to Antarctica. Though this may sound like a vacation, it isn't much of one in practice. One has to show up each day at the Antarctic Center terminal in order to don cold-weather gear, check-in, and catch a flight. The show-up times varied; sometimes 2:45am, sometimes 5:45am, even 8:45am. It all depends on the weather forecast the previous evening. You arrive, don the cold-weather clothes, check-in baggage, and then WAIT. Weather is checked and flights are put on two-hour, four-hour, even six-hour weather delay. There can be successive weather delays -- wait two hours, wait another two hours, and then they give up on the weather for the day. We even got on the plane one day, taxied around, and then there was a mechanical problem aborting the flight. You catch a shuttle back to town at 11am - 1pm or so. That blows off doing out-of-town vacation-type tours which all start first thing in the morning. However on two of the seven days, the flight was called off in the wee hours of the morning before I left for the airport and I was able to sightsee in the Christchurch area as well on a free day before my first scheduled departure day. I went whale-watching in Kaikoura to see sperm whales (also saw the little blue penguin, dusky dolphins, NZ fur seals, wandering albatross), went to see picturesque Akaroa (an historic French settlement on the Banks Peninsula), and went on a trip to Alexander Pass in the Southern Alps (including jetboating on a stretch of wild river and some back-country dirt road travel). Afternoons in Christchurch were spent reading or going to movies or walking around to kill time. Since my vacation leave clock was ticking, losing those seven days hurt.

On my eighth scheduled departure day, we boarded a C141 transport plane and departed for Antarctica. I squeezed in with 110 passengers, all in webbing seating running in two rows down the plane, with cargo in the back. You sit right next to others and have to intertwine your legs with the person facing you since there isn't much legroom.

Five hours later, we landed at McMurdo Station and the air temperature was a balmy 25 degrees F -- and it was sunny. The next day, I attended my required orientations: the waste management/recycling briefing; the truck/Spryte tracked snow vehicle briefing; and, the Snowcraft/Sea Ice/Helicopter Safety refresher briefing. Since I have been here before, I did a four-hour refresher on the last one rather than losing three days on them as do newcomers. The next day (yesterday), I did my required checkout scuba dive under the ice off Cape Armitage with the Scientific Diving Coordinator here. It was an outside dive, meaning we entered a dive hole out in the open that is bored in the six feet thick sea ice. The air temp was 20 deg F, the wind was blowing snow at 15-20 mph, wind chill was -5 to -20 deg F - things were frosty. I suited up, entered the water which is 28 deg F (at the freezing point of seawater), and immediately felt the seawater contact the only part of my body that was exposed: my lips surrounding my regulator mouthpiece. I had forgotten about that first frozen blast on the lips and today my lips are chapped like I have been kissing a freezer door.

The dive was great under the ice and I went down to 90 feet depth and looked around with a handlight. Since I have been working on a web-based field guide to the underwater animals here, it was thrilling for me to see the animals now and know something about what I am seeing. On my previous trip, the creatures passing before my eyes were nameless and a fantastical, colorful blur, hard to pick out individual things in the passing parade. Now I know their names and it was like seeing old friends: hey, there's (scientific name); hey, there's (scientific name); etc. It all made much more sense what I was seeing and I poked along with the light, taking my time and inspecting the bottom life closely. The overall scene was familiar. I was diving on a black volcanic gravel slope with cliff drops of 10- 15 feet down in my 90 foot depth range. The sea ice ceiling up above looked like a relatively flat cloudy dark sky in shades of deep blue. Looking out horizontally, the water dimmed out to black. Looking up slope to shallower water, I could see broad fields of crystalline plates of anchor ice formed on the bottom. I was back and it felt good.

Finished the dive, made some minor gear adjustments, and reviewed some film footage shot by Norbert Wu, on whose National Science Foundation sponsored Artists and Writers project I am assisting. Norbert is shooting a high- definition film for PBS Nature here and I am gear carrying and helping out as before. The film footage I have seen is spectacular and I look forward to seeing it on in final form on television in Fall 2001.

This afternoon we are scheduled to go film Weddell seals at Turtle Rock, an offshore islet, frozen into the sea ice. Of course, I don't do the filming nor do I wish to attempt it. I am handling dive gear, doing still photography of the film work for promotional purposes, and other things. There are two $134K high definition video cameras in use each with underwater housings; it is all very high-tech looking and quite a different enterprise than the previous still photography shoots on which I have accompanied Norbert. In the days ahead, we will be camping at various locations in the McMurdo Sound/Ross Island area. If weather holds and things work out, we will be visiting Cape Roberts in order to dive/film at Granite Harbor (these are locations on the Antarctic mainland coastline - McMurdo Station is on Ross Island); New Harbor on the mainland coastline at the entrance to the Dry Valleys; and Cape Crozier on the NE corner of Ross Island - the location of the mid-winter journey by A. Cherry-Garrad and others to get Emperor penguins eggs as chronicled in the book "The Worst Journey in the World." I am hoping for a better experience!

November 12, 1999. Turtle Rock

Yesterday afternoon, we drove out to Turtle Rock, a small low rounded islet a short distance north along the Ross Island coast from McMurdo Station. Piling our gear into two Sprytes (two-track snow vehicles), we arrived and set up Norbert and Christian to go diving in a sea ice crack near the island in order to film Weddell seals underwater. I provided topside support and shot still photographs for Norbert of the general diving action plus shots of sponsored equipment in use. While they were underwater, I walked around and did some sightseeing. The air temp was in the low 20s and the wind was blowing at 15-20mph with gusts faster than that. Weddell seal mother and baby pairs were laying about in the open near sea ice cracks. The babies were snuggled close to their mothers, usually sleeping. I watched a baby and its mother nuzzle each other and the baby Weddell seal made its characteristic howling/moaning call. I watched a baby nurse on mother's milk as well. Though it was windy and cold, the seals were so well insulated that they were laying about like it was a sunny day at the beach. The air was clear and I could see the long stretch of the Antarctic mainland coastline with the Royal Society Mountain range and its glaciers stretching away at least 80 miles or more.

The next day (today) we went to Turtle Rock again. This time I went diving with Norbert. I suited up at the vehicles and then did a long walk to a sea ice crack to get into my dive gear and get in the water. McMurdo staff workers go along to help us on their day off; they haul the dive and camera gear around for us so that really helps. Again the air temp as in the low 20s but the wind was much less. My drysuit undergarments kept me sufficiently warm out in the open before I suited up; the drysuit only keeps me dry and its undergarments keep me warm in the 28 degree F water. My undergarments are in three layers: expedition weight long underwear; a WarmWind polypropylene jumpsuit, and a thick DUI thinsulate jumpsuit with a nylon windshell. They actually are too warm to wear about in 20 degree F weather and I have to open up the zippers a bit to cool off; it isn't good to start a cold water dive sweaty which then speeds up the chilling process. The sea ice crack was a jagged crack about five feet long and about 2 1/2 feet wide at two points. You sit at the edge, get helped into your dive gear, and then ease yourself into the sea ice crack, with the seawater about 2 1/2 feet down from the surface of the sea ice. You twist and turn a bit and scrape around to get yourself and the scuba tank on your back into the water properly at the crack's widest point. Then you stick your regulator in your mouth and start descending further down the crack until the crack ends and you are under the sea ice ceiling. It is very close quarters; you push down with your hands on the walls of the sea ice crack in order to go down and you twist and turn a bit to squeeze through. If you are claustrophobic, then this isn't the dive for you.

So I started down, took an inhalation, and my regulator let in air mixed with a large volume of icy slushy seawater. I blew it out, took another breath that was again a large volume of icy slush with air. Took a few more

and decided I wasn't going to get a proper air supply and didn't want to spend my dive trying to breath and spitting out seawater ice slush with every breath. I surfaced, pulled my regulator out of my mouth, and a team member (DJ) reached down into the sea ice crack, pulled open my regulator assembly, and cleared out an ice bit stuck in the regulator diaphragm (which was creating the leakage). I put the regulator back in my mouth and reached up for my hand-carried items. I was tasked to bring down an Antarctic cod fish head to place on the bottom in order to film invertebrates climbing and feeding on it. I had not seen it previously and was simply told I was to take down a fish head and place it on the bottom. I looked up from the surface of the seawater as I was wedged in this sea ice crack and a monstrous fish head about 2 1/2 feet long and 18 inches in diameter was handed down on top of me. I laughed internally as this huge fish head blocked out the sky and became my special friend (let's call him George), wallowing on top of me as I grappled to find a gill slit in order to grasp George with a free hand. I did so and then reached up for my other hand-carry item: an octopus in a mesh bag that I was to let loose with Weddell seals nearby in order to film their curiosity. Another special friend along for the ride.

I descended vertically down the sea ice crack and then it opened out -- I was under the six foot thick sea ice ceiling with the bottom at 12 foot depth. We were on a shallow bench nearshore Turtle Rock and the bottom was covered with black volcanic gravel. Ice was forming on the bottom in crystalline plates (called anchor ice) and was spread out in broad crystalline fields here and there. The sea ice ceiling was covered with these crystalline plates as well; it was wavy and mounded and hitting bottom here and there. The overall effect was diving in an underwater ice cave with a very low ceiling. Some areas I went through gave me a few inches clearance below and above me. Some brine stalactites were seen here and there; supercooled brine drips down from the sea ice ceiling and freezes the surrounding seawater into a hollow tube of clear ice extending to the bottom. In some places, larger clumps of anchor ice had broken free of the bottom and were slowly floating up to be incorporated into the sea ice ceiling. Gravel could be seen embedded in the crystalline sea ice ceiling that had been entrained in anchor ice floating up. Here and there, one could see bright areas of sunlight shining on the shallow bottom; these were under sea ice cracks and holes used by the Weddell seals to get in and out of the water. Weddell seals could be seen cruising slowly and gracefully here and there and I could hear their underwater vocalizations.

The gravel seafloor was largely barren since it gets swept clean by the ice forming on the bottom. The only animals were mobile ones since stationary animals would be engulfed by anchor ice. There were small seastars in profusion; some long bicycle-inner-tube-like nemertean worms about four to five feet long; giant isopods looking like armored bugs as big as my hand; sea spiders; small sea urchins; a few large seastars; a spiny worm; ---- and lots of Weddell seal poop, which was supporting most of this ecosystem. The animals were piled up eating the seal poop. Enough of that. I placed George down and bid him farewell. I swam over to Norbert and let the octopus out of the bag near some Weddell seals; they couldn't have cared less. After awhile I herded the octopus back into the mesh bag and then started picking up small seastars and putting them into the mesh bag. They are now in a large aquarium tank at McMurdo where Norbert will time-elapse film them attacking and eating the large seastars on which they prey. I was then on my own and explored this icy underwater palace. Weddell seals passed me occasionally or I swam through their breathing hole territory. A large male seal passed by, making an assertive or territorial sound, that sounded like a very deep doonk, doonk, doonk --- I felt like I was being sonar pinged and I could feel the deep loud sound throughout my body. The seal didn't come after me and the next time I saw him, I imitated his sound and he turned his head and stared at me -- probably laughing at this pathetic assertion of Weddell seal masculinity. I terminated the dive after sixty minutes underwater and I did not suffer from the extreme cold hand syndrome as I did two years previously. I have found better gloves and though I wouldn't say my hands were warm, they definitely were not getting stiff and cold and screaming at me.

I looked closely at George before I ascended up the narrow sea ice crack. George was covered with reddish amphipods dining happily, one seastar had already starting climbing aboard to chow down, and several small fish were nipping at pieces of George. The feast was beginning. The octopus and I ascended, I twisted and turned a bit to get my head out of the water, handed up the octopus bag, then wiggled here and there while I

unfastened my scuba tank harness and my weight harness and handed them up. I then hoisted myself up and out of the sea ice crack in a most ungraceful manner and felt a happy glow from experiencing a wonderful dive under the ice with the Weddell seals.

November 15, 1999. Cape Armitage & Turtle Rock

Here's an update of today and the previous two days. Two days ago in the morning, Dale and I went with Kevin and Terri of Art Devries research group to help them pull in Antarctic cod, *Dissostichus mawsoni*. They catch them with a baited line of ten hooks set to a depth of 1,568 feet from a hut set up over a hole bored in the sea ice about two or three miles offshore McMurdo Station alongside the sea ice road to the airplane runway. The Antarctic cod is a deepwater fish and can be huge; they used a steel cable fish line and huge hooks with 6-8 inch long fish as bait. They winched up the line and pulled six Antarctic cod off the ten hooks; the largest was 5.6 feet long and 118 pounds. This is the same species of fish as the fish head (George) that I took underwater at Turtle Rock previously. I helped Kevin haul the big one up from the sea ice hole; we reached down with our bare hands and grabbed it up under its jaws in front of its gills. It was truly an awesome fish with pretty big teeth and a huge mouth; it struggled, I struggled, we struggled and we hauled it up and flopped it on a weighing/measuring tray, after which we lifted it into a fish transport coffin with aerated seawater. Other fish were also hauled up, weighed, measured and put into fish transport coffins; the smallest about 35 pounds. They selected the fish to take back for research on their antifreeze proteins and physiology and released the largest one and some others.

That afternoon I did a dive on the sloping wall at Cape Armitage to a depth of 130 feet for 36 minutes duration. There was a very stiff wind blowing snow almost horizontally and air temp was low; we suited up in a tent-like hut and then stepped outside to walk a few steps to the dive hole and get in the water. I was tasked to stay in Norbert's general area underwater and spot anything interesting happening and wave him over to film this. We were diving a study site named Dayton's Wall after Paul Dayton of SIO who did a lot of the defining benthic ecological work here. There was a submerged buoy anchored downslope that marked some of his study area. I enjoyed seeing the large volcano sponges and myriad other sponges, vertical wall sections of 10-15 feet height, the colorful soft corals, and lots of invertebrates. Weddell seals could be heard vocalizing in the distance underwater but I only saw one. I didn't see anything interesting in animal behavior to wave at Norbert for filming. Invertebrates move very, very slowly in Antarctica and much of what a diver sees looks great in still photos and would simply look like static scenery in a film. Films need action so Dale has now setup an aquarium tank with a natural volcanic gravel bottom in order for Norbert to do time elapsed filming; Norbert started with seastars gang-attacking a larger seastar. A lot happens underwater in Antarctica but it is on seastar time and not human time.

The next two days (Nov 14-15) we did dives at Turtle Rock with the Weddell seals. On each day I did a single dive of 63 minutes duration with most of my time spent in the shallow water exploring the seafloor life, ice caverns, and Weddell seal breathing and haulout holes as I described previously. With now three hours time spent underwater over three dives at Turtle Rock, I have it burned into my memory circuits fairly well and it is an unforgettable diving experience. My now-heavier weight belt was perfect and my diving was carefree. One has to be weighted with a lot of weight to counteract the thick undergarments and to allow air inside the drysuit for insulation in the undergarments. I tend to be buoyant and my weight belt is 48 pounds (others are at 40 plus pounds) and I use ankle weights for an additional 4 pounds. In combination with a steel 95 cubic foot scuba tank, I am heavily encumbered out of water and especially as I crouch down to get into a dive hole. Underwater I am weightless. My under-gloves are doing a good job keeping my hands from getting too cold and my limiting factor underwater seems now to be air consumption or having to take a leak. It would be interesting to see how long I can take this immersion in 28 degree water; I'm not warm throughout but I'm not freezing cold either --- more an uncomfortable state in between that I know will pass. Actually the worst situation is my lips, just like everyone else getting started diving here. After exposure to cold, dry winds and exposure to 28 degree seawater,

one's lips freak out, crack all over, and start sloughing shreds and sheets of skin. I hope it ends soon because my lips really sting from the seawater when I start a dive until the freezing water takes over as an anesthetic.

There was a Weddell seal pup carcass on the bottom nearshore; it was covered with amphipods and seastars devouring it. There were numerous amphipods on the bottom surrounding the carcass that had evidently engorged themselves and were killing time digesting. I stirred them and they didn't react. George, the fish head, had been carried fifty yards closer to shore by a seal, and was being eaten by a giant Antarctic isopod, amphipods, and seastars. Weddell seals cruised by here and there in the ice tunnels, low-ceiling passageways, and rooms. A baby Weddell seal with its mother following approached me underwater in a ice room. The baby seal swam slowly right up to the top of my face mask as I held still so as not to spook it. It nosed around on my neoprene-hooded forehead and I realized that it was playing with its nose in the air bubbles that stream up from the regulator in my mouth. The baby seal continuing nosing at my forehead and my bubbles as it probably enjoyed the sensation on its whiskers. I looked down and over and saw its nine foot long mother watching me VERY closely from about seven feet away. The mother's vigilance made me decide not to engage in any reciprocal behavior with the seal pup. After the pup nosed around awhile, it swam fluidly away and mother followed.

I moved throughout the area, keeping a careful eye out at all times for the route back to the ice crack from which we entered the water (which I described previously). Weddell seal underwater vocalizations can be heard occasionally throughout the dives. Turtle Rock is a tricky area with lots of under-ice passages and ice rooms and it is easy to get lost wandering around. Nearshore the sea ice is jumbled into pressure ridges reaching down to the bottom in large rounded boulder-like forms, constructing rooms, some with beams of light shining down like spotlights from holes in the ice above. Ice tunnels connect the rooms and parallel tunnels have low-ceiling caverns which you can pass through to move from one tunnel to another. Clearance can be tight in some spots; one time, I measured about 18 inches from my chest to the seafloor when I floated my back up right against the ceiling. Other areas it was like caving, where you move through a crack between ice boulders to move from one ice room to the next. The advantage is that you float through weightless and don't have to crawl and get dirty.

Tomorrow Norbert and I fly by helicopter to Cape Roberts on the Antarctic mainland, which will be our base of operations to snowmobile to dive sites around the Granite Harbor area, including Couloir Cliffs. We will be sleeping outside on the sea ice in tents but using the bathroom and kitchen facilities of the Cape Roberts drilling encampment. We are joining up with Christian and Dale, the other members of Norbert's film team, who left the day before to set up our tents and start scouting dive sites and ice cracks in the Granite Harbor area. This field trip is scheduled for up to ten days so I will be out of contact for awhile!

November 20, 1999. Granite Harbor

I spent the last four nights/five days at Granite Harbor. Norbert's photography objectives were accomplished relatively quickly given the lack of open sea ice cracks there; he didn't need as much time as anticipated. Since it is logistically involved for NSF to set us up in our own field camp, we share the field camps of other scientific parties when we go off-base for overnighters. For Granite Harbor, we stayed at the Cape Roberts seafloor drilling project/encampment which supports forty people at a location on the sea ice at the south end of Granite Harbor. Granite Harbor is a very large bay on the Antarctic coastline about eighty miles from McMurdo Station on Ross Island. Granite Harbor is distinguished in its middle by the large Mackay Glacier spilling down a broad valley and into the frozen ocean, extending out into the water in an glacier ice tongue. The Mackay Glacier is a river of ice flowing downhill towards the coast from the Antarctic interior. Cape Roberts is a collection of mostly interconnected insulated cargo containers holding kitchen, shower room, laundry, electrical generator, desalinator, bunk rooms, science lab, and dining space. There was no sleeping room for us so we pitched tents outside but ate in their meal shifts and used their showers. The cooking was great so that was nice after a long, cold day.

The frozen sea ice around the Cape Roberts encampment is embedded with large icebergs that drifted in, ran aground, and then froze in place by the seasonal sea ice. It is a spectacular setting with large blue-ice icebergs, many with flat-tops, which indicate that they have broken off from permanent ice shelves like the Ross Ice Shelf many miles away. Some frozen-in ice bergs were irregularly shaped on top which indicates that they had calved off from seaside glaciers or were tipped-over icebergs. Looking back towards Ross Island eighty miles away, we could see its towering Mount Erebus, the world's southern-most active volcano.

Every morning we loaded up scuba diving gear and scuba tanks on Nansen sledges that we attached behind SkiDoo snowmobiles. The five of us (including Rob Robbins, the Scientific Diving Coordinator at McMurdo) would go on three SkiDoos and drive about 4-5 miles on the frozen sea ice along the coastline towards the middle area of Granite Harbor -- the objectives being two stretches of seaside rocky cliff called Couloir Cliffs and Discovery Bluff. The coastline along which we snowmobiled was mostly glacier cliffs and also some snow covered rocky cliffs and points. Weather was typically 20 degrees F plus or minus with winds making for a colder wind chill. The drive along the sea ice crossed patches of sea ice blown free of snow which is like driving on slick blue ice. Other sea ice sections had snow cover, either evenly distributed or accumulated in small hard ridged drifts (sastrugi). The snowy sastrugi patches were sometimes sparsely distributed on the blue sea ice, making snowy white arabesque patterns on the blue sea ice. The sastrugi also made for slower, bouncy snowmobiling.

As I mentioned, several of the team had arrived the previous day and had chain sawed open a dive hole at Couloir Cliffs. There were almost no open sea ice cracks for diving entry along this stretch of Granite Harbor coastline which was why a chainsaw hole was necessary for entry to Couloir Cliffs underwater. The visibility underwater on all my dives has been great by any standard. The dive coordinator here at McMurdo estimates that the average underwater visibility is 300 to 600 feet; another expert measured a maximum at 800-1000 feet. I did several dives at Couloir Cliffs, a long rocky cliff along the coast. The underside of the six foot thick sea ice was covered with brownish algae and diatom growth, almost like a mat. The sea ice cracks were jammed shut and tented up into vaulted ceilings lit brightly with the sunlight shining down through the thinner crack ice. One dive to 109 feet involved repeated swim-overs of large volcano and other rosselid sponges as Norbert filmed me. The seafloor was cobbled and boulder strewn on a steep slope covered with colorful sponges.

On this dive late at "night", the sun angle was low and it was very dark underwater, like a night dive. The air temperature topside was in the upper teens and the breeze blowing made the wind chill -5 to -15 degrees F. It was very cold changing from topside clothing into the dive gear. To make it easier, I wear my drysuit undergarments all the time so I need only put on extra insulating footwear, don my drysuit, and then put on head and hand gear along with the rest of my dive gear. HOWEVER, this process exposes one's bare head -- and particularly hands -- for some period of time and that is where it can get brutal when the cold Antarctic wind is blowing. My drysuit undergarments consist of expedition weight long underwear, a WarmWind polypropylene jumpsuit, and a DUI 400G thinsulate jumpsuit with nylon wind shell; all of them combined are warmer than standard issue US Antarctic Program Extreme Cold Weather Clothing. I wore them snowmobiling and while standing around outside tending the dives of other members of the team.

Back to that cold "night" dive -- my dive gear from my previous dive remained wet and I had left it inside my dive bag which stayed out in the open at the dive site. When I pull out my neoprene dive hoods, they were frozen stiff from the seawater left on them so I worked them onto my bare head as my head warmth loosened them up. Putting on the drysuit is easy because it is a trilaminate material which doesn't retain surface water -- and thus doesn't freeze up and stiffen -- except for the feet boots which were frozen and stiff and had to be worked carefully onto my feet. One uses bare hands to finish donning, buckling, and hooking up dive gear because it can be wet work and dexterity is needed. Move fast, slip your hands into your drysuit insulating gloves, and then the cold wind doesn't matter. After the dive, it was so cold that the seawater on my drysuit froze into a frosty crystal sheen as I exited the water, then my outer hood and drygloves froze into a crystal sheen as well. With the wind blowing, it was disconcerting taking my gloves and hoods off and exposing my

head and hands after a long dive in such cold water. I moved quickly and got into my regular topside hand and head wear.

One dive at Couloir Cliffs lasted 74 minutes -- my record time underwater. As I swam underwater towards the shallow shoreline under the ice, a *Trematomus bernachii* fish that was eight inches long rose up and faced off in front of my dive mask. Charmed by this unusual encounter, I held my ground as it approached the top of my dive mask and inspected me closely. I was recalling my recent face-to-face encounter with the curious Weddell seal pup as this fish darted in and took a bite of my upper lip with its thin covering of neoprene ice hood. This was the final Antarctic insult for my chapped, cracked, and shredded lips; I shrieked in pain and waved the fish off. My lips are the only part of my body exposed to the water and I guess a whitish lip under a thin neoprene ice hood looks like a wound to nip at on a Weddell seal or something. It really hurt since the fish had serrated jaws but it didn't get a chunk out of me since the neoprene ice hood deflected its bite. The cold water dulled the pain and I moved on.

I saw a jellyfish with tentacles about twelve feet long and with hitchhiking amphipods on its clear gelatinous bell. The bottom in shallow was strewn with boulders of all sizes and was covered copiously with crystalline jagged anchor ice. I swam along the underwater base of the steep cliffs, covered with frozen meltwater which had run down from the topside portion of the rocky cliffs. The meltwater formed a smooth wall of frozen crystalline ice along the underwater rocky cliff, with crystalline anchor ice carpeting the wall in some areas and with other wall areas left barren. Sea urchins and some seastars crawled up on this ice wall, grazing on algae. Some moved too slowly and ice had overgrown them; they were embedded under ice and would be a nice meal for an urchin or seastar later when the ice thawed. The sea ice ceiling had numerous hollow brine ice stalactites handing down. I entered one tiny cove along the cliff shoreline that was a stalactite room filled with numerous stalactites hanging down from the ceiling with many almost touching the shallow (9-10 foot) bottom. I swam among them to the back of the room, which was lit a brilliant deep blue by the sunlight filtering down through the sea ice along the shoreline. The floor of the stalactite room was carpeted by crystalline anchor ice -- it was quite spectacular. There were two tiny coves that were blue rooms with crystalline floors, deep blue back walls, and deep blue ceilings; it was like swimming into a 60s black light room (but no psychedelic posters). There was a frozen-up ice crack along the shoreline that let in streams of brighter light in some sections along this frozen stretch of cliff shoreline. A large Weddell seal cruised by on a long traverse under the ice; it looked quite surprised to see me underwater and I was very surprised to see it since there were no seals in the immediate area and no holes other than our chain sawed hole. The boulder- strewn shoreline allowed for a succession of rooms along some stretches of the shore; one could pass through bouldered tunnels between adjoining icy rooms. Norb did swim-over filming of me poking around when we crossed paths a few times on this dive. One time he gauged his swim-over too closely and ran the bottom of the movie camera housing into my head! We repositioned ourselves for another take.

One evening, Dale and I took a snowmobile drive around the grounded icebergs surrounding Cape Roberts. We drove through flat valleys surrounded by flat-topped, towering blue iceberg mesas. Icebergs were blocked or sculpted, had fallen blocks sloughed off, had blue frozen meltwater pools at their base, had stratified snowcaps showing years of minuscule snowfall in layers like sedimentary rock, or were cleft with large cracks that were deep blue inside. One spectacular iceberg had a long horizontal crack at ground level with a sky-blue background with overhanging tall icicles at the edge and a blue frozen meltwater pool at its base. The late night low angle sunlight accentuated the blue ice color of these grounded icebergs.

Another day, we scouted for a Weddell seal entry/exit hole along sea ice cracks at Discovery Bluff in order to have a place to enter the water for diving. At Discovery Bluff, there were mother and baby Weddell seals laying out along a sea ice crack with a few holes and also some male seals. Discovery Bluff is a steep rocky huge hump of a hill and underwater it is the same -- large rocks and boulders on a steep slope as one moves away from shore. My dive at Discovery Bluff was on a nice, sunny calm day with air temperature in the upper twenties -- shirt sleeve weather. There was a nice sea ice crack in a tented-up pressure ridge along the shoreline with a large seal hole for us to enter the water. Seals would pop up their heads occasionally and take several

breaths right next to us as we set up dive gear and finishing suiting ourselves up for diving. They didn't seem to mind our presence at or use of their hole. Underwater, the sea ice crack displays its tented-up topside appearance by having a somewhat vaulted ceiling along the crack, with the light shining through the thinner ice of the crack next to the six foot thick, regular and largely flat, and much darker blue sea ice ceiling. Right under the seal hole where the sunlight beamed down on the very shallow bottom, leafy algae was growing. There has been much sunny weather this season and the underside of the sea ice was pretty brown from algal and diatom growth this early in the season. Just inshore of the sea ice crack, there was a blue ice wall along the shore and one could follow along to a very shallow and small cove, entering a blue-walled crystalline ice room with crystalline anchor carpeting the floor and crystalline platelet ice covering the ceiling. The deep blue coloration one sees from light filtering down through the sea ice is remarkable and serene. I spotted a small jellyfish floating nearby in this glittering deep blue room and inspected it closely; it was covered on its clear gelatinous bell with hitchhiking amphipods -- small crustaceans getting a free ride for a chance at running across more food to catch. I then went down the boulder-strewn slope to 119 foot depth and passed white lacy nudibranch sea slugs; lacy white bryozoans; long sea whips; large clumps of soft coral in profusion in shades of pink and orange; numerous seastars in reds, yellows and white; reddish sea urchins; and, yellowish sea spiders, including one larger than the span of my hand. Down deep, there were big white volcano sponges and yellow cactus sponges.

November 23, 1999. Cape Armitage & Little Razorback Island

Yesterday I did a collecting dive off Cape Armitage at 90 feet for half an hour. I described this area previously. It is a relatively steep slope covered with the variety of Antarctic benthic life (sponges, sea spiders, soft coral, anemones, worms). The sea ice overhead looks very blue-dark and cloudy, like a stormy sky. It is very dark underwater and the color on the animals only shows up with a light -- otherwise everything looks blue-gray in color. A large Weddell seal swam slowly by way up overhead as I poked around on the slope. Christian was tasked to collect helmet jellyfish and I was to collect some anemones. I selected various *Isotealia* anemones that were attached to small rocks semi-buried in the muck on the slope; this muck is very soft being the accumulation of sponge spicules and other matter into a mat over a foot thick. I also found a helmet jelly on the bottom as did Christian who found two; they come in on the currents from the open ocean and bump into the bottom along the coastline here. We brought them back up in buckets for transport to a setup tank in the lab aquarium for time-lapse filming.

Today I did a dive for a half hour at Little Razorback Island to scout out Weddell seal filming for Norbert while he went diving at another site. A dive hut had been dragged out and placed over a hole bored through the six foot thick ice ceiling. The hut is heated so this is a much more comfortable and civilized way to dive, without exposure to the wind and cold while suiting up or unsuiting. The Little Razorback Island site is much like Turtle Rock (previously described) but it has a less extensive shallow bench underwater (ten feet deep), and less underwater ice pressure ridge tunnels and caverns. The bottom is covered with patches of glittery jagged plate-like anchor ice. I moved in close to the island's shore which is ringed with ice pressure ridges with seals laying about on top of the ice. The seals use holes and cracks in these shoreline ice pressure ridges to get in and out of the water. Right next to shore, my depth was only three feet as I moved along a shoreline pressure ridge tunnel system that corresponded to the seal haulout holes. I approached a large Weddell seal in a shallow ice cavern who was breathing in a hole on top. He came underwater and towards me, doing the male territorial sound, a deep chooonk-choonk-choonk (hard to describe). I watched him move off and continued on.

I spotted a dead fish covered with seastars and amphipods -- quite a feast for them compared to the usual seal feces, also widely prevalent as I swam around. I moved back offshore through a narrow ceiling section which was one of the few ways out. When I lifted my body and scuba tank up against the ice ceiling, my bottom clearance was the length of my forearm from elbow to wrist. Split that length in two and that is how much clearance I have on top and on bottom as I move under the sea ice ceiling towards shore and away from shore -- in the areas where I can do so and where the ice ceiling is not almost touching the bottom. After exiting the

island's shallow shoreline bench, the bottom drops off incredibly steeply down a talus-like slope into inky depths. In this short distance away from shore, the sea ice ceiling is undisturbed by pressure ridges and appears as a flat blue-colored ceiling. I swam a long way around the island; I then turned back when I felt my air volume indicated that I had better head back for my way out. Throughout this swim along the edge of the bench, I would see possibly that same male seal; I think he was cruising about through the area and I wouldn't be surprised if he was keeping tabs on me. It took me quite awhile to swim back but I managed my dive correctly and had ample air left. I poked around a bit more and surfaced in the dive hut's hole. After the dive, a baby Weddell Seal surfaced to take breaths in our dive hole inside the dive hut. He looked at us curiously between breaths as did we at him!

November 24, 1999. Cape Barne

A long day today -- we drove in a convoy of two Sprytes an hour and a half up the Ross Island coastline along the frozen sea ice to Cape Barne in order to dive on a grounded iceberg. I drove one of the Sprytes myself so, rather than napping, I saw the McMurdo Sound/Ross Island scenery at a pace of about twelve miles an hour. It was a sunny clear day and I could see across the frozen ice of McMurdo Sound to the Trans-Antarctic Mountain range along the Antarctic coastline about fifty miles and more distant. As we drove along a marked route on the frozen sea ice that roughly paralleled the Ross Island coastline, we passed by Turtle Rock, the Erebus Glacier Tongue (a blue ice glacier that extends far out into the ocean like a peninsula -- but now frozen in by sea ice of course due to the season), a group of small islands including Little Razorback, Cape Evans with Scott's ill-fated Antarctic expedition hut visible, Barne Glacier (vertically cleft blue ice glacier cliffs along the frozen shore), and then approached a iceberg that had floated in, grounded itself on a pinnacle, and become frozen in by the annual sea ice.

Topside, the iceberg was composed of several sizes of blocks, with the smaller blocks having calved off the largest block. The iceberg was surrounded at its base by a crumpled sea ice pressure ridge with a few Weddell seals and a crabeater seal laying out nearby. We used one of their holes to enter and exit the water and they paid us no heed. I did two dives totaling a bit over an hour underwater. As I descended, I wiggled down around some ice boulders immediately under the hole and then it opened out into the passageway under the crumpled sea ice pressure ridge alongside the iceberg. Dropping down a bit further, I was under the sea ice and on the wall of the iceberg itself as it dropped down toward deeper water below. The iceberg wall itself was whitish- blue and covered with big dimples like a golf ball. Small silver fish were flitting about on it. There was a fairly strong current coming in from the direction of the open ocean miles away; I hung onto the downline as I descended so I wouldn't be swept away and have to kick my way back hard to the hole.

The iceberg wall sloped down at a sixty degree angle and then steepened to a vertical drop down to the bottom at 85 feet or so. The bottom was actually the top of an undersea pinnacle on which the iceberg had grounded itself. The pinnacle was covered with a lush lawn of large orange-pinkish soft coral, looking like chubby bushes. The iceberg stretched as far as I could see in both directions and was actually undercut on its very bottom; it looked like a huge blue ice ship or submarine run aground. I swam towards the up-current edge of the pinnacle; I looked down a steep slope into blue-blackness and then I looked to the right and under the iceberg; the pinnacle also sloped down steeply there into blue-blackness. Neither was an inviting direction in which to venture so I turned back towards the middle of the pinnacle. In the passing current, clear gelatinous comb jellies (including lots of Beroe) were streaming by and I also saw a very large jellyfish with long, long tentacles go by. The strength of the current made every diver cautious and respectful. Though I dive in ocean currents as strong as this off Point Loma, I don't have the option to swim back on the surface to the boat here in Antarctica. When that one dive hole is the only way out and the current is running, one stays pretty close to the downline to avoid having to swim hard back to it and using up lots of air in the process.

The pinnacle top not covered by the grounded iceberg was relatively small in area. After ranging around a bit, I spent considerable time just sitting back on the bottom, weighted down and just looking around and up. Down

deep where I was lounging on the bottom, the iceberg looked just like a huge blue ice ship grounded on a underwater peak. It was an impressive scene and I could see each direction at least two hundred feet. Away from the iceberg, the underside of the sea ice ceiling was flat and covered with dark brown algae. In places the algal mat had holes; sunlight came through these holes so the sea ice ceiling looked like a dark brown nighttime sky with twinkling stars of light. Since it was sunny outside, sunlight streamed down from the seal hole at a 45 degree angle and shone like a spotlight on the iceberg wall. The sea ice crack around the base of the iceberg also let in sunlight on its irregular path around the iceberg. The play of light underwater here is truly remarkable; it streams down through cracks and holes and provides strong contrast to the general bluish dark twilight underwater.

November 25, 1999. Cape Barne

Today we returned to the grounded iceberg off Cape Barne that I described yesterday. It presents such an incredible underwater scene that Norbert is filming it in every possible way, including the usage of high-intensity underwater lights powered by a surface generator and connected by a long underwater cable. I slipped down the seal hole for a fun half-hour dive between Norbert's filming dives. I won't describe the grounded iceberg again (see yesterday) and I will stick to what was different for me this time down for a half-hour dive. First off, I entered the water at slack tide or something; the current was almost nothing so I felt comfortable roaming far away from the hole --- and so I did. I went up current to the very front edge of the iceberg which was a long, long swim from the hole and way, way out of sight. I swam forward at about the 20-25 foot depth level along the upper flank of the berg.

The golfball-like indentations on the iceberg flanks are occupied by small silver fish either individually or in pairs. The indentations are actually quite elaborately sculpted by the micro-eddies that must swirl from the passing water. What looks like a simple concave indentation from far away has, on closer inspection, little back caves or carved ledges in almost every indentation. The silver fish occupy these little caves or ledges, oftentimes curled up in them due to lack of space. Little bits of algae and detritus are caught in these tiny caves and ledges so it looks like the fish have a nest. It seemed that this was an ideal habitat to hang out and then dart out to eat something interesting passing by in the current of water sweeping along the iceberg. I looked hard but didn't see any eggs with the fish so they may not be nesting.

I continued on up the grounded iceberg wall and then the top part of the wall stretched back and flattened out to my right. A large male Weddell seal approached me head-on and did the characteristic underwater territorial sound - a deep choonk, chooonk, choonk sound. I held my ground and did not advance towards him; he swam to the back of this flattened berg top under the sea ice which was like a large room with a seal hole at its top. I had obviously entered HIS space in the vicinity of HIS hole and he was letting me know. After I determined that he was just going to watch me and not come after me, I continued swimming on to the front end of the iceberg. The pinnacle top sixty feet below me dropped away beneath the front of the iceberg and I couldn't see a bottom. The iceberg was run aground on a pinnacle tip pressed against its middle it seemed and I was on the forward portion cantilevered out over some deep water. I finally came to the front of the iceberg and turned a corner; the iceberg was flat-fronted and very broad. I had come far enough and safety dictated that I turn back with my remaining air. On the way back, I saw that Weddell seal some more, swimming around in the open water off the iceberg and zooming along the iceberg wall. . He was about nine feet long and a huge blimp of a seal --- very well insulated and a master of this environment. Not me. Stuffed into a drysuit with voluminous undergarments and wearing a mega-weight belt, double neoprene hoods sandwiching a latex hood, and loads of dive gear, I am a noisy, bubbling, encumbered beast that probably invokes more pity from these seals than concern as I enter their territorial space. I dropped down to the pinnacle top and renewed my memories of this grand scene of the iceberg run aground. It was time to ascend.

As I neared the hole in which to exit the water, that Weddell seal was there in the tunneled chamber under the sea ice pressure ridge at the hole. Since he was there first and it is not good practice to jockey for an air hole

with a huge air-breathing mammal with teeth, I held back and waited. A second Weddell seal approached the area under the hole at a depth of 15 feet. The first Weddell seal turned towards that seal, swam quickly to it, bared its teeth, and attacked -- a duel for the hole was on. Both seals were showing teeth and biting each other, tumbling and swirling around each other, like an underwater catfight mixed with synchronized swimming. The seals are so fluid in the water that even their fights look graceful. They ignored me as I watched from fifteen feet away and held my ground. I wasn't going to contest that hole since I was watching what might happen to me if I made a move towards the hole to exit. The seals tussled for 15 - 20 seconds and then one seal turned and swam off with the other chasing it off for about twenty feet. The victorious seal then turned and went to the hole and took several long slow breaths as I watched and waited for my turn at the hole. I had enough air and was prepared to wait a long, long time after what I had just witnessed. The seal then submerged and swam off, leaving me to make a very hasty exit up that hole and out of the water, should that seal return and see my rear end and flippers hanging down from the hole. I look more seal-like from that perspective.

November 26, 1999. Sea Ice Edge of McMurdo Sound

McMurdo Station doesn't celebrate Thanksgiving until Saturday (today's Friday) but it does take off a two day weekend for holidays instead of the usual one day weekend (a six day work week here). That doesn't stop us though and we can dive locally while McMurdo is shut down for the holiday weekend. Today we helicoptered out to the sea ice edge of McMurdo Sound in order to film penguins swimming and diving in the water. McMurdo Sound is the body of water between Ross Island (on whose southern tip sits McMurdo Station) and the Antarctic mainland. McMurdo Sound itself is a small section of the much larger Ross Sea, an embayment on the Antarctic continent that is larger than France in area. Ross Sea has a permanent ice shelf and extending from that seasonally is annual fast ice. So we helicoptered out to the edge of that annual fast ice (by February the annual ice will have broken out all the way back to McMurdo Station). Right now the ice edge of McMurdo Sound extends from the northern part of Ross Island under Mount Bird across McMurdo Sound to the Antarctic mainland somewhere way north of Cape Roberts/Granite Harbor, where we camped. When we were standing on the sea ice edge today, we could see way, way up the Antarctic coastline beyond Granite Harbor, which was about seventy miles away from where we stood. I would guess I was seeing coastline one hundred miles away - it was that clear and sunny a day.

The helicopter pilot and Norbert scouted locations along the sea ice edge suitable for Norbert's film objectives. Looking down, I could see the larger Emperor penguins and the smaller Adelie penguins. It was windy when the helicopter landed us at the ice edge so we stayed bundled up. After we landed and started unloading gear, some Emperor penguins walked or tobogganed over to the helicopter for a closer look at us. Emperor penguins make a characteristic honking greeting even to non-penguins like us so we felt welcomed. Emperor penguins are the largest penguin, about three feet tall, and are very stately and calm - truly magnificent birds. They are curious and followed us as we hauled our gear from the helicopter to the sea ice edge. More Emperor penguins arrived as minutes ticked by; they were coming from near and far to observe our activities. There is nothing out here but flat sea ice and ocean for miles in every direction, so I imagined that we constituted considerable amusement on a slow day. The smaller Adelie penguins also came over to hang out with the Emperor penguins and us. At the largest, our encampment numbered three humans, twenty plus Emperor penguins, and about fifteen Adelie penguins.

As we hauled our first load of gear to the sea ice edge, a minke whale surfaced as it passed slowly by our area. Minke whales are plankton feeders and that was the only whale, minke or killer, we were to see today. Norbert got into his drysuit and I helped him into his dive gear and into the water so that he could film underwater. Dale and I brought our drysuits, masks, fins, gloves, etc. so that we could snorkel and see the penguins swimming underwater. Dale went first and then I.

Since the wind was blowing so stiffly, it was very cold exposing hands and head to that wind while donning my drysuit and gear. My drysuit's CF compressed neoprene booties were frozen and difficult to slip over my feet;

the rest of my drysuit is a different material which doesn't retain moisture (trilaminate) and therefore much easier to don in frigid conditions. The funniest thing was seeing Dale wiggle out of his drysuit after he had been out of the water for some time; his suit is entirely made of the same CF compressed neoprene material as my drysuit booties and Dale was encased in a frozen stiffened drysuit and had a devil of a time getting the thing off.

At the sea ice edge, I went through the motions of putting on my fins, mask, etc. Divers typically spit on their mask's faceplate to put a viscous layer on it that keeps the faceplate from fogging up during the dive. As usual, I did so and my spit froze quickly inside my mask - it was that chilly out there. I slipped into the water and floating out along a drift line to take a look.

The sea ice at this location was about four feet thick and totally flat on the underside as well as the surface on which we had landed. The sea ice edge itself runs in straight sections or is irregular, even jagged. It all depends on how cracks develop in it, which then develop into ice floes, breaking off and floating away. We had landed near an active working crack at a zig-zag in the edge and the sea ice on the ocean side of that crack was moving up and down about six inches with respect to the sea ice on the inland side of that crack. You could straddle the crack and feel the outer sea ice move up and down.

Emperor penguins and Adelie penguins were swimming both on the surface and underwater as I snorkeled. I watched Adelie penguins swimming fast and porpoising through the water as they swam at the surface. Penguins were darting around in straight lines and irregular paths underwater, dropping down out of my sight into the very deep water below me. I would see them fade out as they dropped down and would also see others coming up fade back into view. The underwater visibility was in hundreds of feet and I could also see very large jellyfish floating slowly with the current. Some penguins appeared to be swimming with no particular purpose and just enjoying a swim with the group. Other penguins made beeline dives down deep to catch fish, krill, or other food. They also seemed to be heading back under the sea ice a lot, possibly to catch fish under the sea ice rather than in the open ocean --- it's hard to say when you are just floating at the surface and watching. The penguins jetted around gracefully underwater and when they put on high speed, their feathers would flatten down and a stream of small bubbles would be released from their feathers, forming contrails behind the penguins. Penguins were jetting around me in all directions, right and left, up and down, front and behind, and some were laying down zig-zag bubble contrails streaming out behind them. The sun was shining brightly and as I looked directly down under me at penguins, sunbeams rayed out and presented a breathtaking scene of clear blue water, with penguins darting around in sparkling sunrays.

After my snorkel session, I really froze in that wind while I got out of my drysuit. Norbert did some topside penguin filming as we hung around for about two hours watching the penguins watch us. They hung around us the whole time, occasionally going for a swim, and then returning to the company of the other penguins and ourselves, for continued sunning and preening of themselves. Penguins are good company - gregarious, curious, respectful -- and I felt a bit sad leaving them as we called it a day and helicoptered away.

November 30, 1999. Cape Barne & Cape Armitage

We have been waiting on weather and a helicopter backlog to clear for the last two days in order to go to the Adelie penguin rookery at Cape Crozier. Over the last four days, I did three dives at the grounded iceberg at Cape Barne (previously described) and three dives at Cape Armitage (also previously described). Dives were great fun for me, though nothing extremely newsworthy to report -- unless you are really interested in Antarctic marine invertebrates like me.

One interesting invertebrate: I viewed an extensive bed of *Abatus* heart urchins, golden brown in color, with the urchins all buried in the sediment with barely anything showing. What makes them especially interesting is that the top of the urchin shell has five deep grooves that the urchin uses to brood embryos and its young urchins. The embryos and young urchins are down in the grooves and covered over by a rim of protective spines along

the upper margin of the grooves. I strained hard trying to see little urchins in those small grooves but it would take a dissecting microscope to really peruse them (and not a floating diver underwater).

Another interesting invertebrate: On one dive I collected giant Antarctic isopods for filming. These are related to the sow or pill bug and look like them in general plan but with longer legs, spines all over, and about as big as your hand. These isopods look like something from a 50s science fiction movie. Several of the collected isopods were carrying lots of juveniles on their underside in a translucent pouch. We didn't realize this until one isopod released its young when we transferred it to a holding tank in the lab aquarium. On time lapse filming, one of these isopods grabbed a large spiny polychaete worm and sucked out its insides.

On one dive, I was diving very shallow up near the shoreline at Cape Armitage. A huge sheet of anchor ice (newly formed ice on the bottom) had started slowly rising off the bottom as I passed slowly over it and bumped into me from below. I jumped because one doesn't expect to get bumped during the solitary sort of diving here and the thought of nipping male Weddell seals is never far out of mind. Not only small clumps of anchor ice rise off the bottom to float up and join the sea ice ceiling but also big interconnected sheets of anchor ice as well. I have seen some sheets rising up that are five or six feet across. Whenever sufficient ice forms to buoy up the embedded gravel and organisms and then breaks free, it rises up. The sea ice ceiling has lots of gravel in its icy understructure and a few embedded organisms as well.

December 6, 1999. Little Razorback Island & Explorer's Cove/New Harbor

I returned this afternoon to McMurdo from Explorer's Cove at New Harbor on the Antarctic mainland, where we spent three nights. After waiting four days for the weather to clear at Cape Crozier, Norbert gave up and switched our field camp destination to New Harbor.

Since my last report and before our departure for New Harbor, I did two dives at Little Razorback Island. One dive was particularly deep, down to 130 feet, and I spent considerable time just looking around. I described Little Razorback Island previously -- a relatively short shallow bench along its shoreline with a steep tumbling talus slope starting at twenty feet depth or so. Weddell seals cruise under the sea ice along the bench; you are on your own when you dive deeper here. Going down, the talus slope is folded into canyons and is interrupted by rocky outcrops covered by predominantly yellow, tan, and white sponges of various species. Short trees of pinkish soft coral are abundant. Lots of interesting marine invertebrates to see as well as fish here and there. Down deep below one hundred feet, it is very dark with everything in deep shades of gray and black. The sea ice ceiling and the water depth conspire to shut out most of the light filtering down. Down deep, there are rocky cliff sections covered with invertebrate life. I saw big white volcano sponges looming out of the dark; I swam down to one of the larger ones and it was five feet tall on its downhill side and rounded enough for me to stick my head into (though I didn't). I swam a few canyons over looking around and headed back up to find the dive hole.

We helicoptered to Explorer's Cove at New Harbor, the seaside entrance to Taylor Valley, one of the Dry Valleys. The Dry Valleys are sandy and gravelly and have little snow in them; the glaciers from the Antarctic interior highland cannot pass through their encircling mountain ranges and thus what little snow falls in the Dry Valleys melts away or is ablated. The helicopter dropped us and our gear off at the encampment of Dr. Sam Bowser, who studies foraminifers here at New Harbor. The encampment is located just up the beach at Explorer's Cover and is two Jamesway huts interconnected at one end, a science lab hut, and a generator hut. There was a gas stove, microwave oven, sink, tables, cots, etc. The refrigerator is a steel box outside with some snow piled around it. We were quite comfortable and Dr. Bowser and crew were very good company.

The diving here was from a heated Jamesway hut about fifty yards offshore on the frozen sea ice. The sea ice ceiling is extremely thick here -- twelve feet or more -- so a dive hole is blasted through the ice and then the Jamesway hut is dragged and set up over the hole. Inside, a heater runs all the time drying out your dive gear

and keeping the holes from freezing over. A compressor is available inside to fill scuba tanks with air. Since the bottom is flat and fairly deep, the scuba tanks we used were double 72 cubic foot (cf) tanks for a combined air volume of 140 cf (the usual tank size in the US is 80 cf and I use 95 cf in San Diego). There was even a step down into the dive hole -- a very comfortable setup for Antarctic diving.

Over the course of the next three days, I did six dives, all around 90 to 100 feet depth, for an aggregate time underwater of four hours and thirteen minutes. The bottom was flat and sandy under the dive hut and sloped up steeply far away as one neared the shore. The sea ice ceiling is twelve feet thick with snow and ice cover so it is very dark underwater. The ceiling itself is mostly flat on the underside and in the dim filtered light, it appears mottled in colors of black and deep, dark blue. Looking horizontally, the water looks deep blue-gray - - very dim indeed and it gave me a gloomy feeling compared to the more brightly lit diving I had been doing under thinner sea ice with sea ice cracks with sunlight streaming down. As you swam away from the dive hole at depth, you did not swim far until you could not see the dive hole or the hang line itself in the dim light. The only visual cue to find your way back to the hole is flashing strobe lights attached to the hang line. There were usually three or four of them flashing away; one would burn out its batteries occasionally so you want redundancy in using several. As you swam a good distance away from the hole, the flashing strobes would become smaller points of light until you saw them from far away as pinpricks of flashing light as you scanned the horizon to establish your bearings. Throughout your dive, you glance around to pinpoint the location of those strobes in order to avoid getting too far away and lost.

The bottom was littered with scallops and brittle stars -- zillions of them. The brittle stars were a gray species or a very large orange-red species with body discs as large as the palm of my hand. Some of the brittle stars held their body discs above the sand by holding their arms in an S shape. Others held their arms up above the sand in S-shaped curves. Some laid flat on the sand. Some of the gray brittle stars were moving vigorously forward with a stroking motion of their forward arms. The scallops were almost as big as my hand, reddish-brown in color and were free-swimming; if disturbed, they would open and close their scallop shells and jet up off the sandy bottom. Some scallops had younger, smaller scallops attached to them. Other scallops had stalked sponges and tunicates attached to them. There were a few fish scattered around but clearly the numerical advantage was the scallops and brittle stars.

Big jellyfish with bells about three feet across and with long, long dangling tentacles floated through this dim underwater world. The jellyfish were far above the ninety foot bottom but with such long tentacles, some of the longest tentacles could reach down near the bottom. One jellyfish about forty feet above the bottom had caught a bottom fish with one of its tentacles. I watched as the eight inch long fish struggled, jerked, and swam vigorously in a head-down position trying to break free of the tentacle dangling from the space ship far above us. The fish finally broke free after I watched it struggle for two minutes.

Here and there were a few vase-like rossellid sponges, which had found a few stray rocks to which they could attach on this vast sand plain. Many of these sponges would have feathery white crinoids attached to their upper areas, with the crinoids having their feathery arms spread out for filter-feeding. I also saw a few crinoids directly on the sand bottom. This species of crinoid likes to perch on things for a better position for filter feeding but there are not a lot of perches available on this sandy plain. Crinoids are also capable of slow movement so they could have been on the move, looking for a place to perch. The sandy plain also had yellow cactus sponges and rumpled-looking ball sponges with spiky tufts sticking out from their bodies for protection. Wherever a stray rock was located on the sand plain, one could see several invertebrate species attached to it --- attachment space was at a premium.

Here and there in the deeper areas, one could see a single-stalked coral-pinkish-red soft coral with short branches covered with polyps. These soft coral are seen erect (2.5 to 3 feet tall) or bent over in a U-shape, with their top branches touching and imperceptibly sweeping the sandy bottom for food. Filter feeding isn't sufficient and these soft coral also graze on the bottom for food. You could decipher their motion by the traces they left on the sand rather than by seeing it with your eyes -- most marine invertebrates here move very, very slowly. I also

found a few of these soft coral totally flattened along the bottom. I have read that they move slowly like inchworms to new locations but I would need time-lapse eyes to verify if I was seeing that. I spent dives scouting out the locations of these few soft coral. I made a rough map and then preceded Norbert into the water, guiding him to these soft coral with a flashing strobe light. It is very easy to get disoriented on a dark, sandy plain and our underwater time was limited at these depths, so my scouting role saved him time in finding these soft coral for filming and still photography.

There were a few seastars I would see on the course of a dive. Occasionally I would see one hunched up and over a scallop, opening up its shell and consuming it. I also saw a fat whitish sea cucumber with pointy projections all over its body, with a faint reddish-brown banding around its mid-section. There were large pencil urchins around, with sponges growing on some of their pencil-like spines. There were also dark yellow tinged brown urchins scattered around -- another species of *Abatus* urchin which broods its embryos and young in spine-protected grooves on the top of its test (shell). There were a few of those long nemertean worms previously mentioned -- not many but they were exceptionally long. I saw one stretched out on the bottom nine feet long, about three fingers wide, with a flattened off-white body (also colored purplish- brown, brown, etc). These worms lay out in the open without fear of predation because they have an acidic (pH 3 !) mucus on their body which keeps them from being eaten.

December 11, 1999. Cape Royds & Cape Bird

Three of the previous four days have been visits to Adelie penguin rookeries for filming. On two successive days, I snowmobiled from McMurdo to Cape Royds to a small penguin rookery there. At about thirty miles an hour, it is a lot of fun to drive a snowmobile (SkiDoo Alpine 2) along the frozen sea ice offshore Ross Island and heading north to Cape Royds. The air is nippy at speed but bundled up, it is an invigorating ride. Cape Royds is where Ernest Shackleton's hut is located and I had an opportunity to look inside at the period furnishings. It is smaller than Scott's hut at Cape Evans and has an impressive iron stove inside. It is also built near an Adelie penguin rookery so they had game and eggs in season.

The penguins are nearing the end of the egg incubation period; the male and female take turns sitting on two eggs on a pebble nest. Skua birds were heavily attacking the Royds rookery on one visit. We watched them pester the penguins to raise up off their nest and then dart in and grab an egg. A skua would fly off with an egg in its beak and then usually share it with its mate. One study estimated that nine percent of eggs were lost to skuas at a specific rookery. Skuas are very patient waiting for an egg-stealing opportunity; they sit very close to nesting penguins, watching for an opening. The penguins usually stand up and stretch and nudge their egg around a bit every once in a long while. In addition, they stretch up and peck at skuas hovering low overhead which presents another opening. The penguins raise quite a commotion when a skua is in the midst of their nests and on the prowl.

The skuas themselves nest on the ground just outside the penguin nesting area, screeching when you walk to close to a nesting skua. If the mate is nearby, it will dive bomb you and swoop down very near the top of your head, trying to run you off. I always feel like stomping all over skua eggs and helping out the penguins but that would interfere with the natural order.

We helicoptered one day to the north end of Ross Island to the Cape Bird Adelie penguin rookery. We situated ourselves along the shoreline for filming penguins jumping into the water and hopping out. The penguins obliged as we watched lots of them do so. One group was incredible. They were reluctant to go in and were on a steep and short ice cliff above the water; when they did go in, it was like watching Nature's bloopers. One penguin fell head first down the ice, bumped off a ledge, spun around, and went in tail first. Another penguin got pushed off the cliff by an anxious penguin behind it, performing an ungainly water entry -- a sideways flop. Several others toppled into the water with not a single graceful swan dive among them. The weather has been sunny with a light wind so it has been enjoyable spending seven hour sessions at these penguin rookeries.

On another day, I did a final scuba dive at Cape Armitage -- it was fun to take a last look around. Last night, I hiked up Observation Hill next to McMurdo with Dale and Dave. Observation Hill rises steeply above McMurdo Station to a height of 750 feet, with a fine view in all directions. Looking north, you can see Mount Erebus, the high point of Ross Island on which I stand, with its steaming volcanic peak. Observation Hill has the original memorial cross dedicated to those who lost their life returning from the South Pole on Scott's Antarctic expedition; it is made of heavy Australian jarrah wood timbers that the expedition members dragged up this very steep hill. It was sunny and calm on top of Observation Hill. You could see Scott's hut on the point next to McMurdo Station, built by Scott's first Antarctic expedition and used in his second expedition as a waystation.. From Observation hill, looking south, you could see the southerly direction taken to the pole by the exploring Antarctic expeditions of Scott and Shackleton. It was impressive to see the scale of the distance and relative emptiness faced by these explorers. Far off, I could see the crinkled transition between the fast annual ice and the permanent Ross Ice Shelf -- their first dangerous passage as they headed south. Even farther away, I could see Minna Bluff, on the shoreline of the Ross Ice Shelf, marking their route to the South Pole. Not for me -- I came to scuba dive !

Far below, we could see the activity surrounding the moving of McMurdo air operations from the annual ice runway to the permanent ice shelf runway location farther in on the Ross Sea. They shift runway operations from the fast annual ice close to McMurdo Station to the permanent ice shelf much farther away from McMurdo; they have to do that well before the fast annual ice starts weakening in the weeks before it breaks up. We are slated to take off from the permanent ice shelf runway (Williams Field) for the 7.5 hour flight back to New Zealand. Though scheduled to leave on a specific day, one may get delayed a day or so in departure as passengers and cargo get weighed and reconsidered (or if the weather turns for the worse). IT'S BEEN FUN !

October 29, 1977. McMurdo Station

I arrived at McMurdo Station yesterday and can't do much of anything until I complete my field trainings allowing me to go out in the field away from McMurdo.

I just got done seeing the other three off on snowmobiles to travel to the sea ice edge. Norb is going to use his pole camera setup which is used to stick a still camera into the water using a video camera focused on the still camera's viewfinder. This allows for underwater photography without diving. I spent 1 1/2 hours digging out a snowmobile sled where a storm had drifted snow over it. So the exercise will do me good.

I can't go along for awhile. I have to take a waste management briefing tomorrow, go on an overnight survival camping outing on Friday and Saturday in order to get briefed on the basics, take a sea ice training session, and then a diving checkout. So I am helping out with gear meanwhile (loading, etc.) and Norb has left me some to-dos.

It is very pretty to look out across the frozen sea and see the mainland mountain ranges, glaciers, etc. There is a fair amount of dirt showing on closer look but it still looks all snow covered. The sun is up 24 hours; sunset isn't until February.

October 30, 1997. McMurdo Station

Errands to run, etc. Went to machine shop to get an external battery mount fabricated for Nob's underwater video camera. Some other stuff. Went to a Waste Management orientation: they recycle 70 per cent of their material; the best US city is Seattle at 20 percent or so. Very ecologically conscious here at McMurdo. Learned

how to E6 process slide film last night by hand and did two rolls in order to double check Norbert's exposure setting.

Tomorrow I go to Snowcraft School (called "Happy Camper School") where I learn how to survive in the field in case sudden weather comes up forcing us to stay where we are rather than return to McMurdo. It's a two day training including camping out overnight. Should be good preparation since we will be camping out in the weeks ahead.

On Monday there is a sea ice training workshop where I learn how to judge the lay of the sea ice and avoid danger. On Tuesday I get my first dive -- a checkout dive. After that I am up to speed and learn how to drive the two-track Sprytes (snow cats); I've been riding in one already and cannot wait to get behind the dual sticks (no steering wheel since it is a two track vehicle). It was sad to see them jet off on snowmobiles yesterday and not go along. I can't wait to zip out across the frozen ocean on those puppies.

I know I am making this sound like a playground but there is a lot of work ahead. I am helping out already and there is a fair amount of gear loading and unloading: dive gear, survival equipment and food, survival clothing, tools for opening or keeping open ice holes, etc.

Today is a "warm" day meaning it isn't too far below zero. If this weather holds for my overnighter, I will have it relatively easy. One class got caught out in severe conditions and had to stay in the hut rather than camp out.

Some of my fellow US Antarctic Program travelers I met at my bed and breakfast hotel in Christchurch NZ are still around. They are slated to go to the South Pole station and work construction there. South Pole has had bad weather and has not been able to fly in the summer people. So there are a few familiar faces about and I am meeting some others.

November 1, 1997. Ross Ice Shelf

I'm not diving yet but I finally went off base to start my training before I can join Norbert Wu in the field. I got back late this afternoon from an overnight campout in the open on the Ross Ice Shelf east of Scott Base (the NZ station) out beyond the end of the Hut Peninsula.

The Field Safety instructors drove a group of us trainees out in Hagglunds tracked vehicles onto the Ross Ice Shelf which is the permanent ice shelf on the Ross Sea. It was a spectacular setting because looking north I could see the peaks of Ross Island. Mount Erebus is the highest and to its east was Mount Terror: both were totally snow covered with glaciers flowing down their slopes into the Ross Ice Shelf. Mount Erebus is the southernmost active volcano and it has steam clouding from its summit. Looking east I saw a flat horizon of the Ross Ice Shelf; it's over 500 miles to the eastern shore of the Ross Sea. Looking south, I can see two large high islands in the Ross Sea (White and Black Islands) and the continental mainland beyond with its high Transantarctic Range; Mount Discovery is over 10K feet.

They taught us how to use the emergency equipment one takes along on forays away from McMurdo: three kinds of tents, radios, stoves. We cut snow blocks and built wind barrier castle walls within which we pitched the two mountaineering tents. I went for a two hour walk after dinner and turned in at 10pm. The air temperature was five degrees below zero Fahrenheit with a slight breeze making it somewhat chillier. We had all our survival clothing along. You had to stick bare fingers out occasionally for some tasks but you didn't leave them out long. The glacier glasses came in very handy particularly today since there was bright sunshine. Being on a flat ice shelf with tall snow covered peaks nearby meant that it was bright out there.

I slept well and warm in a two man mountaineering tent. I opted out of sleeping in the two-man snow mound cave we all built; I left that for the younger, more adventuresome fellows. Actually when it was time to claim a

sleeping spot, it was pretty obvious from running chatter from the hours before that the snow cave was less desirable than the tents. No one moved to claim a sleeping spot; I read the situation perfectly, strode over to the gear pile, grabbed my two bags of clothing and sleeping gear, walked over to the two man tent and threw them in without saying a word. I'm capable of making an executive decision without shared decision making when it's five below zero out in the open with a bunch of strangers in Antarctica! It was a fun camping trip and it was nice to get back to McMurdo and hit the hot shower.

Tomorrow I am accompanying my diving friends into the field though I cannot dive yet; I'll help out with gear. Monday I spend in sea ice school and then Tuesday is my checkout dive with the Scientific Diving Coordinator.

November 2, 1997. Turtle Rock

Today I accompanied my friends Norbert and Dale in a Spryte snowcat maybe ten miles north along the west shore of Ross Island to Turtle Rock. We drove quite a distance offshore along the frozen ocean and the shoreline/mountain scenery was magnificent. It was fairly clear and we could see Mt Erebus and its steaming as well as the mountain ranges of the mainland.

Turtle Rock is a large rocky island and where the ice shelf butts up against it is cracking apart. Therefore you couldn't walk around much for fear of falling in a hidden crack with snow drifted over it. However the Weddell seals use the cracks to haul out of the water and jump in. We went to a dive shack there which is an insulated container building with a square hole in the floor with a round hole bored into the ice shelf. We could dimly see the bottom fifty feet down. Even saw a jellyfish drift by. I cannot go diving yet so I went along to help out with gear, etc. The Weddell seals were laying about in the below zero Fahrenheit air temp with 30 knot breeze. There was snow drifting and blowing along the surface. Pretty chilly. Some seals were mothers and had baby seals laying alongside them in the lee so that the baby was sheltered a bit from the wind. It was visually ironic seeing them lay there soaking up the sun's rays while it was cold and blowing. Snow was blowing onto them, coating them and drifting against them. It looked like summer at the beach though. There were maybe forty seals spread around a large area and some birds (skuas) about. It was interesting to see how a dive is managed and I can hardly wait to jump in myself.

Tomorrow I have sea ice training and then the day after tomorrow I have my checkout dive with the Scientific Diving Coordinator.

November 3, 1997. Cape Evans & Barne Glacier

Today I went out for sea ice training in a group with one of the field safety instructors that lead the overnighter. We departed in a Hagglunds snow cat plus trailer that held eleven people plus gear. We learned some basics about pitching tents on hard sea ice using ice screws or anchors made with augurs. We learned about the different types of cracks in sea ice and how to spot them to avoid stepping onto thin ice and falling in (or driving onto a crack and falling in). Sea ice has to be at least thirty inches thick to support a vehicle; it is weaker than freshwater ice which has to be only four inches thick. A crack of thin ice or open water cannot be wider than one third of the SnowCat tread. Nice things to know as you can imagine. You can spot cracks as roughly straight raised features on the sea ice. The crack can be jammed closed or still open with snow drifted over obscuring its presence visually. The Weddell seals exploit these cracks to find breathing and haul-out holes. They are far inland from open ocean and thus far away from predatory orca killer whales. Pretty smart. They keep holes open by gnawing at them if necessary. We saw small groups hauled out here and there. Some were very incongruous; you would be several miles offshore on the frozen sea ice and there would be a few seals hauled out sunning themselves. Visually you cannot see how they got there unless you walk up close and see their hole. I watched a seal or two come up for air in a hole for awhile; they would take several deep breaths and then dive away.

Driving out from McMurdo, we could see a mirage called fata morgana when we looked across at the distant shore of the Antarctic mainland across McMurdo Sound. The landforms right above the sea ice were stretched vertically in appearance as if there was a cliff running along the distant shoreline opposite us. Objects like the top of an island reappeared as an inverted shape over that same island. It was crystal clear looking south toward Minna Bluff, the critical direction in which to look for approaching weather. Looking north, the clouds were darkened a bit on their bottom end far away; this is called water sky and is a reflection of the blue color of the ocean on clouds overhead. This cloud phenomenon indicates where open ocean lies.

We drove north along the west shore of Ross Island on the frozen sea ice for about 18 miles. We stopped at Cape Evans and went inside Scott's historic hut that he built in 1911 or 1912 for his trek to the South Pole. He reached the South Pole one month after Amundsen and perished on the way back only a few miles from one of his food caches. The hut had all original stuff as they left it but spruced up a bit by the Antarctic Heritage Foundation. There was ample food supplies of that era, a chemistry/science lab in one corner, a kitchen in one corner, a photo darkroom, horse stables along one wall but entered outside the inner door, stored slabs of seal blubber they used for fuel (and yes, it was a tad stinky having laid there frozen for 85 years), etc. It was like a step back into time, everything under one roof for warmth. Stuff was scattered around outside just as left. We studied tidal sea ice cracks and pressure ridges on the snow covered frozen seashore just downhill from Scott's hut.

Driving further north, we went to Barne Glacier, a glacier from Mt Erebus flowing into the ocean. The front of the glacier was almost 100 feet high with a spectacular blue ice color. Weddell seals lay here and there at the foot of this deeply eroded blue ice wall. Sea ice cracks with the holes they use to haul in and out were scattered about. There was a mother and baby seal and the other were adults (unless I missed seeing a baby tucked in close next to its mother).

Looking north the clouds about fifteen miles away were darker in color. This indicates the presence of open ocean; the clouds reflect the darker color of the ocean and indicate the edge of the ice shelf. The day was fairly clear with spectacular viewing of Mt Erebus and its wisps of steam from volcanic vents. The wind picked up, misty clouds were drawing closer so we left. All in all, a spectacular day for a coastal drive with the highway being the frozen ocean.

Tomorrow I do my first dive, a checkout dive with the Scientific Diving Coordinator. Finally I go under the ice and enter another world.

November 4, 1997. Turtle Rock & Cape Armitage

Today I went diving...finally after one week here. We drove north along the west coast of Ross Island to Turtle Rock which I described previously. Even more Weddell seals were laying about. I struggled to get into even more dive gear than usual and made it into the water. The water was 28 degrees Fahrenheit, below freezing. Felt very comfortable with no shock on impact. You drop down from the dive hut through about six feet of ice through a round hold bored through it. Down elevator. Then the view opens up and WOW ! It is dark since the light is filtered through the sea ice and reduced by snow cover on the sea ice. The sea ice from underneath is mounded with a crystalline look due to recently crystallized ice floating up from the bottom. The ice forms on the bottom on things like sponges etc., as clear ice plates, break loose and float up. The bottom was carpeted with this anchor ice in groupings all over like crystalline bouquets. Small fish shelter within it. The sea ice is shades of dark blue looking up at it and the cracks used by the Weddell seals to breathe and haul in and out let in bright light in beams illuminating areas of sea floor. It was very shallow about 24 feet. The bottom was black lava rock with no plant life/algae growing on it since there isn't enough photons to go around. Animal life included sponges, lots of red sea stars, urchins, sea spiders, etc.

Oh, oh after five minutes both of my dry gloves started leaking in water slowly and steadily. Since the water is 28 degrees, I am headed for a problem. I decided to tough it out as long as I could since there was nothing to be done. I continued looking about and turned back when my hands didn't flex so well anymore due to cold; they had been screaming at me for six minutes maybe, and it was time to listen. Chilling slowly in San Diego diving for years is good training; I lasted fourteen minutes on that dive which has amazed several people here including the diving officer. I stripped off my gear when I got out of the dive hole, stuck my very cold and screaming hands in wool socks and started breathing on them. They came back to life after five minutes. The dry glove sealing rings were incorrectly installed and I fixed that back at the dive locker with the supervision of the diving officer. So it was a great dive but too short.

The second dive today was in the evening at Cape Armitage. A blizzard was blowing up but we could still travel. We wore our drysuits since the drive was short to the dive site. It kept me warm out in the blizzard. The dive was of 24 minutes duration with a max depth of 54 feet. It was very dark with the sea ice very dark blue looking up. I could see far off into inky darkness everywhere; my dive light seemed to go on a long way (underwater visibility can be 500 feet here). The bottom was black lava (Ross Island is volcanic). I saw white aeolid and dorid nudibranchs, small blenny-like fish, sponges, large white anemones, an anemone eating a jellyfish, jellyfish floating about, long purplish-orange nemertean worms looking like weird flattened intestines on the bottom. The nemertean worms were often piled up together doing something unmentionable I'm sure. It was a dive with some macro photography possibilities but not spectacular like Turtle Rock with scenery and Weddell seals.

November 5, 1997. McMurdo Station Blizzard

It's noontime and we have to stay on base at McMurdo due to blizzard conditions. Air temperature is 16 deg Fahrenheit above zero but the 35 mph winds put the wind chill to minus 25 deg Fahrenheit below zero and visibility is limited for driving due to whiting out from blowing powder snow.

Norbert is meeting with people about upcoming multiday trips to remote sites for photography and diving. We take food, sleeping gear, scuba gear, scuba tanks and air compressor, et., and fly off in helicopters and set up a diving camp or move into a single Jamesway hut at a remote location. It sounds like there are possibilities to visit Granite Harbor on the Antarctic mainland and also visit a NZ (Kiwi) hut at Cape Bird on Ross Island. It sure sounds fun -- sort of an extreme version of the self-contained Baja diving and camping trips I have taken with Bob Bayer and friends.

I went to a two hour snowmobile training class this morning about snowmobile operation with most of the time spent on troubleshooting problems in the field and repair. When you zoom off on snowmobiles, you take a lot of repair parts along so you aren't stuck out somewhere. I have helicopter training this afternoon.

November 6, 1997. McMurdo Station Blizzard

The blizzard blew all night and all day. Air temp is 15 deg Fahrenheit above zero, wind speed is still 25-30 mph and wind chill is 25 deg Fahrenheit below zero. It feels kind of warm if you don't turn into the wind. The powder snow blowing about is drifting up everywhere and we will have to dig out Spryte snow cats when the storm lets up so we can drive off and go diving,

Norb wants to go to Cape Royds on the northwestern edge of Ross Island many miles away. At Cape Royds there is a penguin rookery and the sea ice edge. Norb wants to get shots of penguins diving into the ocean and swimming about. He has a pole mounted underwater video camera so he can watch and see and then remotely trigger the shutter release on an underwater still camera. He is also talking about snorkeling for shots and maybe

using a small 30 cubic foot pony tank to get shots. So this should prove to be my first look at penguins on Saturday.

Since we couldn't dive today due to the blizzard, Dale and I spent the whole day on trip planning. The station here has two story warehouses where you can sign out for winter mountaineering gear and camping gear and food. It is like a fully stocked outdoor store for Antarctica. Since Norb plans three multiday field camps, there is a lot of food and details. Everything has to be inventoried and weighed so that the helicopter pilot can load the helicopter appropriately. Ice axes, winter mountaineering tents, ice screws for tent pegs (since we have to set up tents on sea ice), sleeping bags (long one for Peter please), fleece sleeping bag liners, Ensolite pad, Thermarest pad, MSR Whisperlight stoves, water jugs, emergency dehydrated food, shovels, toilet tank, pee bottles if you have to pee at night so you don't have to get out of your sleeping bag (hey, it's cold here; you'd do it too if it was you, believe me, you don't want to get out of that warm sleeping bag until you absolutely have to), ice saws to saw snow into blocks to build wind sheltering walls for the tents, scuba diving gear, scuba diving tanks, air compressor for filling scuba tanks, full load of cold weather clothing issued to each of us in New Zealand, 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. Everything inventoried and weighed. Food shopping took some time since this is camping by committee. Each of us has personal food preferences and dislikes. A common dislike is pea soup.

The weather station here says the blizzard will let off tonight or early tomorrow (but they said that yesterday). At least I got my first two dives in and we do need some days to arrange the logistics for our field camps. So our time is being well spent.

November 7, 1997. Turtle Rock

We went diving today to Turtle Rock, the location of my first Antarctic dive. Turtle Rock is a large rock offshore of Ross Island (McMurdo is on the south end of Ross Island). Sea ice cracks and forms pressure ridges around islands so Weddell seals hang about since they have access to the water. On the drive north along the frozen ocean to Turtle Rock (it really is convenient driving along the ocean to get to places along the coastline), we spotted two Adelie penguins moving in close formation south toward McMurdo. Since we were about 18 miles south of the ice edge where penguins live, it was rather surprising to see two penguins on such a dedicated journey far away from where they usually live. This may well have been survival of the fittest in action; however they move along pretty fast so they could get back if they turn around at some point. They were walking and tobogganing. To toboggan, a penguin lays on its stomach and paddles its short wings along just like it is swimming. They move pretty quick this way. It looked very incongruous to see them in the middle of nowhere with miles of unbroken sea ice around. They walked and tobogganed right through the middle of the sea ice training center: one hut and an outhouse. I got a shot or two of a penguin standing right in front of the outhouse like it was waiting to go inside. Then they went right through the middle of a small group of people totally unconcerned at the presence of humans. I heard at dinner time that those two penguins trucked right through the sea ice runway with its huge cargo jets, cargo trucks, and people running around. That would have been a good shot.

At Turtle Rock, I did a 42 minute dive to a max depth of 119 feet. At 115 feet there was a fairly large crinoid, a feathery echinoderm related to sea stars, attached to a sponge. This was a rare sighting since crinoids are deeper water organisms in Antarctica though they are seen across McMurdo Sound at New Harbor on the Antarctic mainland (which is known for having deep water species in shallower depths). The Turtle Rock terrain was pretty flat down to 25 feet and then a relatively steep slope down to whatever; I only went to 119 feet and was happy to turn around and head for shallower water due to a measure of nitrogen narcosis. The sloping bottom was covered with sponges of various colors, polychaete worms with long thin spines, brachiopods, buried geoduck-type clams showing only their siphon pairs (exquisite green coloration against the black volcanic gravel), sea spiders (pycnogonids), urchins, small red sea stars, an occasional huge white sea star, and some blenny-type fish. On the flat shallower part, I was close under the six foot or thicker sea ice. One can look up

and see the different color streak of a sea ice crack and see occasional holes of light which are the holes maintained by the Weddell seals to breathe and haul in/out. I watched a seal swim up to a hole, hang out and breathe for quite awhile. The sea ice is fairly flat over the deeper water; over the shallower water, the sea ice is highly irregular underneath. The seafloor in shallow water is covered with the clear crystalline anchor ice plates about the size of teacup saucers but all jumbled around. The ocean is starting to freeze and starts forming anchor ice on something on the bottom. As the anchor ice plates grow and increase in areal extent, they become buoyant enough to break free of whatever they are anchored on and they float up to the sea ice. So the sea ice is highly mounded underneath with fat stalactites poking down. The sea ice undersurface is crystalline too so there is a crystal cathedral effect on the sea floor and sea ice ceiling as one wanders through passages and chambers. Some stalactites are actually supercooled brine tunnels extending down to the sea floor and it looks like a rough pipe of ice sticking down from the sea ice ceiling to the sea floor. I watched the seals for awhile and poked around. My hands started feeling cold at forty minutes mostly because I need to remember to shift warm air from the body of my drysuit through the little air tubes I have inserted under my drysuit sleeve seals to let air get into my dry gloves. I must remember to do that next time. I drove the Spryte snowcat back to McMurdo which was fun.

What I am describing in these dives is pretty much what I see the scientific diving groups do except they gather animal specimens or do other work in addition to looking around. We have shared dive huts and ice holes with them. The support workers here at McMurdo have a slang name for the scientists: beakers or beaks. Even if you are a scientist who doesn't use beakers, you would be generically called a beaker.

November 8, 1997. Arrival Heights & Cape Royds

We had a long and fun day. In the morning we went to do a scuba dive at Arrival Heights which is just north of McMurdo. The dive hole is located over 110 feet of water so when I dropped down through the 6 foot ice hole shaft, it was like dropping down into a huge immense room with the bottom far below. As I descended the bottom always appeared visually close yet it wasn't. The underwater visibility is so clear that it is deceiving. When I reached 60 feet and descending on the hanging drop line, it looked like the bottom was 20 feet away. Nope. Down and down I went. When I hit bottom I adjusted the buoyancy of my drysuit again and took a visual survey of where I was. My task was to follow Norbert down deeper carrying a second camera that he would take from me. There was allegedly a photogenic sight down deeper that he wanted to see and photograph. At 125 feet I paused to adjust to the nitrogen narcosis and catch my breath from the swim down slope. I continued on and stopped up slope from Norbert. I looked around and up. The sea ice ceiling was fairly flat and had a brownish tinge to its usual blue tonalities. Some algae can function in the lower light level and the brown color was due to that. I could see a fairly straight sea ice crack that was whiter in color. A large single Weddell seal was cruising about the area mostly staying along that sea ice crack. I could see him/her silhouetted. Weddell seals are very vocal underwater and provide an eerie running soundtrack throughout the dive. Their sound can be a chirping or a long eerie tone starting at a high frequency and sliding gradually down to a low frequency. It's wonderful to hear though eerie and a discomforting soundtrack when you are trying to keep your mental act together during a deeper dive. I handed the camera off to Norbert and took off swimming back up slope to shallower water to avoid a decompression obligation and bring back some clarity by reducing my nitrogen level. Since I didn't have an underwater light and was swimming along on a mission, I couldn't stop to look at details. Looking at the bottom, the substrate was black volcanic gravel and due to low light anything white colored popped out to the eye dramatically. It was like swimming through a black light room with white sponges of various shapes arrayed out below me. I saw three very large vase sponges and lots of smaller white branched and encrusting sponges. I saw much more as I ascended the drop line and spent many minutes doing a safety stop at 20 feet. Brownish jelly fish of various sizes were floating through the water under the sea ice. One was six feet long down to the tip of its tentacles. I could see numerous juvenile Trematomus fish just under the sea ice; I think they feed on crustacean swimming/crawling about under the sea ice. The Weddell seal was still in the area singing its songs. I surfaced after a total dive time of 28 minutes; I couldn't stay down much longer because almost all of my air was depleted. Diving at deeper depths really runs through the air quickly.

After lunch Dale and I gathered gear, jerry cans of gas, and a Spryte snowcat. We were all going to Cape Royds which is 20 miles north of McMurdo. We were going to drive with a larger Hagglunds snowcat with trailer in a convoy with another group of people. Off we went but why go to Cape Royds? It is the southernmost breeding rookery of Adelie penguins and also the sea ice edge had extended to there (open ocean) at this time of year. Norbert wanted to get penguin rookery shots and also do some photography above and below water at the sea ice edge. The drive north along the sea ice took two and a half hours and the scenery was spectacular. We had full views of the western coastline of Ross Island, distant views across the flat sea ice of the Ross Sea to the Royal Society Mountains on the Antarctic mainland sixty miles away (massive, tall range of mountains with glaciers flowing down into the Ross Sea, part of the Trans Antarctic Mountain range), Mt Erebus on Ross Island, Mt Erebus' glaciers sloping down to the sea iced ocean, ice cliffs at the sea edge of glaciers, icebergs that drifted onto the shore and have gone aground becoming surrounded by sea ice, the offshore rocks and islands of Ross Island, Weddell seals laying out on the ice shelf in the open in the middle of nowhere, etc. At one point I spotted a single Adelie penguin tobogganing along north towards Cape Royds. Dr Dale Stokes, the marine ecologist in our group, insisted that it was a trash bag and I insisted that it was a penguin. It was some distance away but I was correct. We are now teasing Dale about the rarely seen Trashbag Penguin, a new species. The penguin was heading to Cape Royds in the same general direction as our Spryte snowcat; when we stopped, the penguin noticed and walked over to take a look at us. He/She was some distance way so we watched as the penguin approached and stood directly in front of our Spryte snowcat about five feet away. I am certain the penguin was trying to figure out what type of penguin we were in our bright red-orange two-tracked Spryte. After the penguin satisfied its curiosity with a long look, it took off towards the shoreline.

We drove north past Barne Glacier (my previous northernmost travel) and went to Backdoor Bay which is on the back side of Cape Royds. We gathered our gear and walked up a snowy hill with black volcanic rocks sticking out. Topping the ridge and looking west, we could see on our left the hut that Shackleton built and used during the 1909 British Antarctic Expedition and further west past a flat area, the low hilly rocky penguin rookery. The rookery was covered with 3600 mated pairs of Adelie penguins, all chattering away, squabbling, pecking in the dirt for pebbles, a lot of commotion. There were maybe six Emperor penguins scattered about in the rookery; I imagine they would gradually come to the conclusion that they were attending the wrong party. There were a few skuas flying about probably trying to scavenge dead animals or something worse; I couldn't see any chicks through the long lens of my camera (no one is allowed to walk through the rookery). It did look like many penguins were sitting on eggs but you couldn't see the eggs of course. The wind was blowing constantly and a refreshing smell of penguin poop was in the air --- INVIGORATING! We could walk on the outskirts of the rookery and be quite close to the penguins at the northern edge. There were some dead penguins and penguin parts lying about and lots of penguin poop. Beyond the penguin rookery hills, there was the sea ice below covering the Ross Sea and to the right (north) the sea ice ended with open water about a mile away. It was great to see open ocean. We could see penguins standing at the sea ice edge and a few traveling back and forth to the rookery. It appeared though that the vast majority of penguins preferred to hang out at the rookery. We stayed around a long time viewing, smelling, and taking photos and then decided to have something to eat before hiking to the sea ice edge.

I took a closer look at Shackleton's hut on the way back. For the life of me, I have a hard time visualizing the delight of early Antarctic exploration when I see one of these huts. Seems like a great place for a bunch of sweaty smelly guys to hang out in a small clubhouse atmosphere and bitch about their marriages all winter -- not for me. We didn't have a key to go inside but outside everything was as left. There were food stores in crates stacked outside, crates were falling open and tin cans inside were rusting. One was open and had beans inside. One side of the hut was a horse stable that is now broken down and without its roof. Shackleton used ponies for hauling supplies to depots along the sea ice. At the vehicles, Buck Tilley, the sea ice surveyor, decided the approaching weather dictated that we head back rather than hike out further and get caught out in a blizzard on the drive back. We headed back to McMurdo and arrived there at 1:15 am (a long day).

November 9, 1997, McMurdo Station Blizzard

The blizzard blew in after we went to sleep last night and we are grounded on station.

Dale and I spent the morning gathering more supplies for our upcoming helicoptered field camping trip and shifted those that can go out ahead of us on flights of opportunity to the helicopter operations hanger. All the helicopters were tucked inside the hanger with their blades removed to weather out the blizzard. The blizzard is doing the usual: air temp is warm at 18 deg Fahrenheit but winds of 30+ mph bring the wind chill down to minus 25 deg F or lower. Visibility is restricted from blowing snow so we couldn't drive off to go diving.

We spent more time on trip-related preparation this afternoon and I had a rare afternoon nap to catch up on lack of sleep from the day before.

November 10, 1997. Turtle Rock

Today was a long one; we got back from the field at 7pm. We went to Turtle Rock again because Norbert wanted to shoot 16mm movie film of the Weddell seals underwater using surface-supplied underwater movie lights. We set up a generator at the edge of a sea ice crack and hooked up his 250 feet of underwater cabling and lights which I personally brought to Antarctica as part of my luggage (actually it was most of my luggage). Norb went down first with his movie camera in its underwater housing; it is pretty heavy to hoist in and out of the water (he calls it the "widowmaker" but it is neutral in water). He swam over from the drop line to the 12-15 foot deep shelf area right under the sea ice cracks where the Weddell seals breathe. The drop line from the dive hut's ice hole hangs down over 55 feet of depth; you go down and head over without dropping to the bottom. I finished gearing up and dropped into the water. I could see him far over there on the shelf and I swam over and picked up the video lights. My task was to stay next to or right above him casting light either on the foreground or up onto a seal. It took some doing because the seals were not too curious about very bright lights and tended to shy off. We did get some great footage of seals nosing up to the ice crack holes and breathing several breaths and then dropping down to swim slowly away. We also got some footage of what it is like to swim under sea ice in shallow water. The bottom was twelve feet deep and the sea ice takes up the top six feet. That leaves six feet of clearance for us plus or minus depending on the mounded nature of the glittery sea ice ceiling. The sea ice is sparkly crystalline in appearance due to the anchor ice plates that form on the bottom and break free floating up to the ceiling. The water is colder than freezing but needs something to nucleate on in order to start forming ice. So a poor sponge or a polychaete worm or something ends up being the starting point for ice formation. An ice plate (anchor ice) forms and grows out and additional plates form at tilted angles to the first plate. You see rosettes of ice plates formed on things and sometimes slow moving animals are trapped to death. When the anchor plate mass is buoyant enough, it floats up to the ceiling of the sea ice. It may break up a bit releasing whatever started the nucleation. In this way some animals like sponges are dispersed by a physical process. Carrying the movie lights between film sequences afforded me the best underwater lights for seeing the bottom creatures one could ever hope for. I saw sea spiders, long spined polychaete worms the size of two-thirds of a hot dog, a chiton, lots and lots and lots of urchins, brittle sea stars, various species of sea stars, small fish, geoduck-type clam siphons in the black volcanic gravel, sponges, etc. The dominant animal was the sea urchin which differs from the usual. The sponge dominates the underwater landscape in Antarctica and one sees predators on them such as sea stars and nudibranchs. Urchins are detritus feeders and usually not so abundant as at Turtle Rock. Why? As Dr Dale Stokes, the marine ecologist on our dive team, says, it's the fecosystem. The seals poop; I won't characterize the size or color but there is a lot of it. It is a feeding frenzy on the bottom as the invertebrates thrive with this constant food supply. Around the Weddell seal ice holes, urchins are very happy and busy feeding on seal poop detritus; I also saw swarms of amphipods, polychaete worms, and sea stars feeding on seal poop. Once this facet of this ecosystem becomes apparent, it was fascinating to swim around looking at the signs of this rich ecosystem. Norbert got the footage needed and I ended my dive after 67 minutes with a max depth of 38 feet. Yes, 67 minutes is quite awhile in 28 degree water even with my drysuit et al. I had to flex my hands regularly to generate some muscle warmth to slow down the chilling of my hands. My torso felt the chill around it but due to extensive diving at depth in San Diego and chilling myself there regularly with

friends Bob Bayer and George Spalding, that wasn't so bad. My feet were fine; it seems my hands will be my limiting factor.

The second dive was a fun dive with no work objective. I headed down to 124 feet max and turned a right angle staying at that depth looking for various animals particularly soft coral (which is found deeper). I found them in shades of pink and looking just like pictures of soft coral in the South Pacific. I saw two dorid and one aeolid nudibranch. One of the dorid nudibranchs I saw in profusion on a large boulder. A marine natural products scientist working here who studies defensive chemistry of nudibranchs among other things was unfamiliar with this particular nudibranch as I described it to him this evening. I described its appearance and location to him and he will go diving and retrieve them, grind them up and study their defensive chemistry for possible drugs from the sea. My extensive nudibranch hunting with George Spalding in Scripps Canyon and with Bob Bayer off Point Loma paid off since I was able to describe the nudibranch in sufficient detail and with technical terms. This dive lasted 28 minutes. At 120 feet, I knelt and looked slowly all around and up. I could clearly see the sea ice ceiling stretching out above me toward shallower water up the slope. Down the slope behind me was darkness and deeper water. The sea ice ceiling over deeper water was bluish with a brown caste due to algae. There were softer whitish sea ice cracks running along the ceiling. Light was streaming down from our safety hole which is out in the open and softer light was streaming down from the hole inside our dive hut. Seal breathing holes were also letting light stream down. A seal or two was swimming about far away and up slope from me with their eerie and interesting sounds filling my ears. The slope up was black volcanic gravel dotted with lighter colors of sponges, nemertean worms, urchins, shells, etc. There were a few jellyfish scattered about higher up above me; they were brownish in color. The highly mounded sea ice ceiling on the shallow shelf up slope from me was sparkling with a whitish-blue caste. It was pretty outstanding! The two dives were great and as I drove the Spryte snowcat back to McMurdo for one and a half hours, I was pretty happy from the experience.

November 11, 1997. McMurdo Sound

This morning we shagged gear around for our upcoming helicopter flight to the sea ice edge to photograph/film penguins (and other animals if we are lucky). It seems to take an increasing amount of logistical preparation for any work away from McMurdo; however Norbert hopes it will be worth the effort in photographic payoff. We started out in the Spryte snowcat in late morning and drove way out on the sea ice about 6 miles away from Ross Island to photograph the work of some seal researchers. It was a clear sunny day; air temperature was just below freezing and the sunshine was melting snow. It was great to walk around McMurdo in shirts and pants with no long underwear or extra clothing; 30 degree weather feels like a heat wave here. However to travel out into the field we have to wear a few layers of our "extreme cold weather" (called ECW) clothing since we have to take the complete set of ECW clothing along in our ECW bag whenever we leave McMurdo. You never know what might delay your return, e.g. bad weather, Spryte breakdown, etc. It was great to be out on the frozen white sea ice plain and looking at both shores on either side of use. We could see the full array of islands sticking up here and there. the snow cover drifted over the sea ice looks just like windblown sand which is another aeolian process. There are ripples, striations, and other features etched out with the snow.

I drove us out to a field camp where three scientists plus some research and technical support personnel were encamped. They had a complex of three buildings out in the middle of nowhere on the sea ice. They had weathered winds of up to 85 mph during the recent storms and were no longer sleeping in one of their buildings since it was literally shaking apart so loudly in high winds that they couldn't sleep (they said that building was good up to 60 mph winds). In one of the Jamesway (quonset-like) huts, they had a hole in the sea ice and a Weddell seal using it for breathing. Since they were way out in the middle of the sea ice, the seal was a prisoner of theirs for research since it couldn't swim away to sea ice cracks/holes that were miles away. The seals stick to areas where they can have breathing holes generated from ice cracks; this tends to be near land, capes/points, or islands since the ice sheet is under movement stress near land, capes and islands. So the Weddell seal had to use their breathing hole in the hut. They had a head-mounted video camera and various physiological monitoring

instruments mounted on the seal's back along with depth and time instruments. Batteries lasted for six hours and they would have to swap out instrument/battery unit on the seal's back. The seal did not seem bothered by these units on its back and head. There was a fleet of data logging computers running in the hut and they could place a cover over the hole to measure how much oxygen the seal took in and how much carbon dioxide it breathed out. I sat down and watched the seal do several dives and rests between dives. It didn't mind my presence and seemed somewhat curious at times and other times ignored me. The water under the hole went down 1800 feet deep. The seal was an adult weighing over 1000 pounds and maybe 7 feet long. It was wider around than a 55 gallon oil drum by far. A Weddell seal is an impressive animal with a very stout blubbery body to withstand the cold Antarctic conditions. Before it went down for a dive, it would exhale and its body reduced in diameter. They probably need to do this to get down since air-filled lungs would make them very buoyant. It probably also helps them avoid decompression illness and other problems with deep diving. It would be gone for quite awhile like 15-25 minutes. Previously recorded head-mounted videos using infrared light showed it cruising down and about; you really couldn't see much other than the top of its head until it came back up. Then you would see the sea ice ceiling and see the ice hole and the room we were in as the seal surfaced. It wasn't really hunting for food yet having only been doing this for 36 hours; the people there said you would see a fish occasionally. When it surfaced, it would take very deep breaths. Sometimes an exhalation was in my area and Weddell seal breath didn't smell very bad at all.

What was really interesting was that after a few dives, it started hacking something up and then white foamy liquid streamed out of its mouth. The scientists said that this was lung surfactant and that deep diving Weddell seals do this naturally. One scientist said it was similar to what a human would do when out running hard in very cold weather. Interesting, I'll have to read up on this. It looked pretty disgusting actually but the fact that it was lung surfactant made it pretty interesting. If it was seal snot, I wouldn't be so intently interested; I have my limits on observing nature. Norbert Wu has his limits too. When he was shooting with his long telephoto lens camera at the edge of the penguin rookery a few days ago, he had his sunglasses off and the wind blowing straight from the rookery into his face. He came down with an eye infection in the exposed-to-the-wind eye and no infection in the eye looking through the camera viewfinder. Remember I mentioned the strong smell of penguin poop? Well, we are all certain he got some penguin poop flecks in his eye and it got infected. So much for the wild, pristine beauty of Antarctica!

We got back in the Spryte and I drove off. I noticed that there was no oil pressure at the same time I heard the engine making some unusual rattling/knocking sounds. I shut it down. We checked the oil -- no oil. Looked around in the Spryte -- no oil and no funnel/hose to put some into the filler hole. We radioed back to the seal scientists and they had only a pint of motor oil -- not enough. Two of them were leaving for McMurdo in twenty minutes and they offered to give us a ride back. We were lucky since we would not have to wait for someone to come out from McMurdo to pick us up. We left the Spryte out there for the heavy equipment shop to deal with (found out later the Spryte had a cracked block which was why the oil disappeared). After all the survival training and the imperative to take our ECW clothing and camping equipment/food whenever we left McMurdo, it seemed incongruous to realize that there was no survival planning for the vehicles used in the field. No spare oil, no tools, no spare gas, no oil funnel/hose, no critical spare parts like distributor cap and rotor or fuel filter. I have accompanied my friend Bob Bayer on two major Baja scuba diving / camping trips and our vehicles are much better prepared for surprises. Here in Antarctica we are not so well prepared. We have radios to call for help so it isn't so bad and we radio when we leave McMurdo and when we return. So they know who's out there and when someone is astray.

November 12, 1997. McMurdo Sound ice edge

Today we flew by Astar helicopter to the sea ice edge where the open ocean edges against the ice shelf. Currently the sea ice edge extends roughly from Cape Royds on Ross Island across the McMurdo Sound part of the Ross Sea to Marble Point on the continental mainland. As we flew across the sea ice, I could see the irregular jigsaw of sea ice cracks all jammed-shut on the annual sea ice shelf. Along the cracks I could see the

haul-out and breathing holes used by Weddell seals. There were one to four seals typically around a hole; you could see the hole due to the glistening ice sheen around it from the seawater that drips off the seals as they haul out and then freezes. At the sea ice edge, we could see scattered small groups of penguins, both the large Emperor penguin and the smaller Adelie penguin. The Emperor penguins were not afraid of the helicopter but the Adelies scrambled for the water

. We touched down in a promising area with penguins and pods of orca killer whales cruising offshore for penguin lunch. The orcas were as close as thirty feet from the sea ice edge so I got a very good look at them; they were in groups of 4-10 and cruising up and down along the sea ice edge. We were about ten miles from the Antarctic mainland and the vistas were magnificent: snow covered peaks and mountain ranges, glaciers, vast expanses of ocean and sea ice, some ice floes floating away from the sea ice, etc. We moved our gear towards the ice edge and Norbert took various photos. The ocean was choppy making water entry for Norbert problematic and the penguins were not having anything to do with diving into the water due to the orcas patrolling offshore. After a long time, we moved out gear back to the helicopter. A group of 29 Emperor penguins marched up in single and double file honking away as they do and checking out the helicopter. They are curious about people and especially curious about a helicopter. We took photos and observed them up close as they clustered around us and the helicopter. I watched pairs slowly drop their heads down in unison and then raise them back up again. As we lifted off in the helicopter, they were unperturbed by this thundering beast leaving them.

We flew to an area of ice edge with calmer ocean water and no orcas. We moved out gear to the ice edge and a group of eleven Emperor penguins promptly left their location and marched over to visit us. They parked themselves right next to us and watched our equipment preparations avidly. Norbert entered the water with camera and finned back and forth trying to shoot photos of penguins underwater. He got a few but knows better what to do next time. We saw both Adelie and Emperor penguins. The Emperor penguins are very stately birds and very curious. The Adelie penguins are less curious and more skittish and shy away. It was fun having them around for company in the sub-zero wind chill; it was sunny and the air temperature was warm but the wind out in the open was knifing. We saw a white petrel or tern zipping along on a jagged flight path along the ice edge.

We flew back to McMurdo after eight hours in the field. I have now exhausted my must-see checklist: orcas, Emperor penguins, and Adelie penguins. Tomorrow we will be entertaining more penguin visitors at our worksite at the sea ice edge.

November 13, 1997. McMurdo Sound ice edge & Erebus Glacier tongue

Today we made another helicopter flight out to the sea ice edge of the Ross Sea between Ross Island and the Antarctic continental mainland. We left McMurdo and first flew over the islands offshore Ross Island. The pilot was great but it wouldn't have been fun for someone who gets carsick easily. It was like a Star Wars ride where you sit in front of a screen and everything tilts, swoops, etc. We circled low in tight turns around Inaccessible Island and then lifted quickly up and over its black volcanic ridge. We flew straight towards the 100 foot high ice wall of Barne Glacier and then lifted up quickly so we wouldn't hit it and then into a steeply banked turn. Lots of G-forces, swooping around, tight steep turns, etc. I was in roller coaster heaven.

We cruised along low along the sea ice edge heading towards the mainland and then turned and flew back along the edge towards Ross Island. Again I could see some orca killer whales cruising just off the sea ice looking for penguin brunch but I didn't see as many as yesterday. We could see the penguins in small groupings at the sea ice edge. The Adelie penguins looked like small children running scared for the water when we flew over. The Emperor penguins looked like grownups who weren't going to move just because some damn helicopter was flying overhead. The penguins really did look like people down there running around on two feet.

We set down at a likely spot. I was off to the sea ice edge carrying the first load of gear. A delegation of 21 emperor penguins got up and walked over to greet me. They honked upon arrival and I set my gear down and honked back, flapping my arms with my elbows held to my side to simulate a penguin. They weren't buying it; they moved up real close to see what kind of damn idiot penguin this was and then moved on after a short time. We staged our gear near the edge and then Norbert got into the water to film swimming penguins with the underwater movie camera (the widowmaker since it is a bear to hoist in and out of water, in and out of helicopter, in and out of Spryte, lift, carry, lift, carry, I'm humping a lot of gear down here). Lots of Adelie penguins and the larger Emperor penguins were in the water so we hung around in the subzero wind chill for six hours. Very brisk out there in the open.

A few Emperor penguins popped out of the water right in front of me, quickly registered surprise at me being there, and then hustled right back into the water. I watched penguins diving in and popping out the whole time we were there. Though it happens episodically; they seem to do everything in relative unison. The Adelie penguins are smaller and lighter so they get more air when they pop out. The heavier Emperor penguins just kind of pop out without much height and sometimes they don't make it. They were all swimming around and Norbert shot movie film and still photos. I also watched closely how the penguins scooter along on their stomachs. They push themselves along very quickly with their feet and use their short wings for occasional corrections. To stand back up, they use their beak in conjunction with their feet. We had our lunch in the helicopter and the Emperors all marched over to look at us. They did a promenade around the helicopter honking away while we were inside out of the infernally cold wind eating lunch. Eventually they went back to the ice edge. We finished up the afternoon work and took off in the helicopter while some Emperor penguins stood by our take-off site and watched the helicopter lift off. I think Emperor penguins worship helicopters. Actually there is so little variance out there visually that I would march over for a look too if I were an Emperor penguin.

We then headed over to Ross Island and the helicopter hugged the shoreline of the island as we flew back to McMurdo We had a great flight back like an amusement park ride with G-force turns, quick elevator ups, tilting and swooping, etc. We saw the glacier edges where they flow down off 13000 foot high Mt Erebus and end up as fractured cliff edges at the frozen ocean; we saw them well since they were RIGHT in front of us. We swooped in close and up and over rocky coastal promontories of volcanic rock. There were blue frozen meltwater pools on some headlands, islands had sea ice cracking and pressure ridges, lots of glaciers ending abruptly in ice cliffs where the glacier met the frozen ocean. Pretty spectacular scenery.

I never bothered much with jackets or sweaters in my native Southern Californian lifestyle. It has been interesting trying out a full range of winter mountaineering clothing issued to me for use; you really can stand outside in subzero weather with a strong wind with the right clothes. I can't say I recommend the runny nose that comes with it though.

At night (though sun is fully out of course), we drove a Spryte snowcat out to the Erebus Ice Tongue glacier and went inside its deeply eroded ice crevasse caves down at sea level. This is a popular excursion for McMurdo residents. We parked where the flagged road ended and walked over to the low cliffs of the glacier at the edge of the sea ice. There was a tunnel going inside that we crawled through. Once inside we were in interlinked glacier crevasses with snow bridged roofs. The sights were spectacular and the sun was fully out giving pleasing white and bluish tones to the light filtering through the snow roofs of the glacier crevasses. You could go from one crevasse chamber to another by following narrow slots or close tunnels stepping up and down and crawling about. The ceilings were spectacular in several of the larger chambers. They were like Gothic rose windows made of ice with icicles hanging down like stalactites and the icicles were covered with feathery dendritic ice crystals. Upper walls and ceilings all looked feathery, branching and delicate with lots of stalactites. Very spectacular. We took photos for quite awhile and then crawled out into the nighttime sun and arrived back at McMurdo very late.

November 14, 1997 Little Razorback Island

Went scuba diving today at Little Razorback Island and did two dives (124 feet max for 42 min and 97 feet max for 38 min). Little Razorback is an island offshore of Ross Island just south of Cape Evans. It is a knife-like volcanic ridge island and nearby is a larger island just like it. There are tidal sea ice cracks around Little Razorback Island that the Weddell seals lay around and use for access to the water. There were several mother-baby pairs about; the babies were large and there was a weaned baby laying around too. The hole in the dive hut dropped down into 55 feet of crystal clear water. Light was good because the snow had been removed from the surface of the sea ice for some distance around the dive hut for someone's experiment I guess.

My mission was to take one of Norbert's cameras down and place it on the ten foot deep shallows for Norbert to pick up later. I was then to follow him down to 120ish feet to pick up and carry one of the two cameras he was taking himself in order to lighten his load. The bottom topography was stunning. There was a ten foot deep very wide shelf that extended toward the shore of the island until the sea ice laid on top of it and you could swim no more. At the ten foot deep end you had 4 feet of clearance between the bottom gravel and the sea ice ceiling. At the break of this wide shelf, the bottom dropped steeply with some vertical cliffs and the slope dropped down to God knows what depth. I dropped off the camera on the shelf and went down.

There was a profusion of urchins with attached algae in shallower depths and as I went down there was too much to look at. There were gigantic orange sea stars and large white sea stars. There were featherduster worms with white plumage on top of tall stalks maybe eight inches tall. There were lots of littler sea stars, pinkish soft corals, sponges of various colors, orangish sea spiders, white lacy dorid nudibranchs, lacy bryozoans very similar in appearance to those I see off Point Loma, very long nemertean worms looking like deflated bicycle inner tubes in colors like purplish or orangish, and lots more than I can remember.

I met up with Norbert and took the second camera and followed. He snapped shots and we swam over to a cliff section at the base of which were three immense vase sponges clustered together with the largest being four feet tall. We then went up to the shallow shelf so that Norbert could photograph seals at their breathing holes. There were indeed a few seals scooting about. We went slowly in through the low overhead taking care to keep ourselves just off the bottom yet not grinding the top of our scuba tank into the sea ice ceiling. Occasionally you do grind at the soft sea ice ceiling a bit since clearance was close -- maybe ten inches above and ten inches below. It helped to be expert at adjusting your buoyancy so you wouldn't plaster yourself against the ceiling or weight yourself against the bottom. I did well and scooted along mostly by grabbing hold of rocks and pulling myself along.

We approached a tidal sea ice crack near the shoreline of the island. The sea ice tented up towards the crack which let in light. It was like you entered a room suddenly after passing through a long horizontal tunnel. There was a seal floating up at the top of the crack taking some breaths. We had seen a few seals scooting about through the horizontal tunnel area which was very broad; the seals were obviously in transit from the sea ice crack to deeper water to feed. We continued on and went through some close clearance areas that opened out into other tented rooms with openings to the surface. When my air was running low, I left Norbert and exited the narrow shelf area; don't want to run out of air in there! In more open water (yet always under a sea ice ceiling of course), I watched two Weddell seals sport about, twisting and turning around each other. Then I got out to warm up.

On my second dive, my task was to carry the underwater movie lights down slope so that Norbert could film the bottom scenery. The lights were excellent for looking at the bottom life as I made my way down. I held them up for lighting as Norbert filmed various sights. Then we were done filming and I was excused to return the lights to the dive hole and then burn off the rest of my air sightseeing in this wonderful place. I saw lots more of the same as mentioned above including a ctenophore (a jelly-like animal) and a pteropod (a winged swimming mollusc). There was a lot to look at but I only saw one seal on this dive; I guess it was afternoon siesta time.

November 15, 1997. Cape Armitage

We went for an early evening dive to an open dive hole (no dive hut) located just south of McMurdo and known informally as Dayton's Wall (after Paul Dayton of SIO). This was my first time diving in the open sans hut and I will be doing this for five days starting tomorrow. It is very different than suiting up in the warm comfort of a dive hut. There's you, a dive hole in the sea ice in the open wind, and some momentarily exposed skin areas screaming to get out of the wind and the cold. I learned that I need to more carefully manage my transition from clothing to dive gear particularly for my head and hands; you don't want to start out a dive here with slightly chilled hands.

The wind was blowing as usual so it was very nippy -- the usual zero-ish wind chill. My task was to take topside pictures of Norbert and Dale getting ready to dive and getting into the hole and then I was to follow along with one of Norbert's cameras and join up with him for camera handoffs as needed. Since I entered the water later than them, I didn't see the wall since they had moved off by the time I joined up. Doesn't matter much - it was still an interesting 29 minutes at max depth of 80 feet. The hole in the ice was over 60 feet of water and I dropped down from sunlight to relative darkness. I waited for my eyes to adjust to the dim light under the sea ice and while I was waiting I was worried I wouldn't be able to see much. If you wait a while you really can adjust to the low light and see fairly well.

I finally spotted Norbert down slope and joined up, handing cameras back and forth as needed as he moved about. The area that I saw was basically a fairly steep slope starting down from a shelf at 15 feet. The bottom is the usual black volcanic gravel. I saw lots of big yellowish anemones, whitish finger-like sponges, lots of other sponges in various colors, pinkish soft corals, a dragonfish which has a very pointed snout, some nudibranchs, and lots of the usual Antarctic benthic life I have reported previously like featherduster worms, nemertean worms (nothing eats these fellows I think; they just lay about in profusion out in the open), etc. There were a few jellyfish moving about up in the water column. I went over to look at a big piece of anchor ice that had formed a large enough aggregation of crystalline ice plates to become buoyant enough to lift off the bottom like a crystalline airship. It was still borderline buoyant and not floating up much at all; it hovered well of the bottom with a few gravel rocks trapped within the anchor ice plates. The sea ice ceiling was a lovely dark blue color with a brownish tint from algae in some areas.

What was really a spectacular sight was seeing Norbert stopped at the 20 foot depth (making a safety stop before exiting) right under the ice hole when I was quite some distance away. He was spot lit from the daylight coming down through the ice hole and around him it was pitch black clear sea water with a dark blue sea ice ceiling. A great visual effect like he was suspended in space.

November 16, 1997. Cape Evans

This morning we packed up the bulk of our gear for our upcoming field camping trip to Couloir Cliffs in the Granite Harbor area and took it to the helicopter operations center.

This afternoon we went to Cape Evans to see Scott's hut which I had previously visited sans Norbert. Norbert wanted to get pictures inside Scott's hut so off we went. This hut was taken south on the ship Terra Nova by Captain RF Scott RN for the British Antarctic Expedition of 1910-1913. It is the largest historic building in Antarctica. When Scott's party departed from Cape Evans after Scott's fatal trek to the South Pole, they left a large quantity of provisions, equipment and clothing behind. These came to be vitally important to the ten men of Shackleton's Ross Sea party marooned there in 1915 when their ship Aurora was blown out to sea. Two of Aurora's anchors remain embedded on the beach next to Scott's hut.

In addition to what I described previously, they had tins of ox tongue, lunch tongue, chutney, curry powder, rhubarb, digestive biscuits, etc. I saw Heinz ketchup bottles that looked pretty much like we see now. There were tins of Colman's mustard that look the same as now. There is a bench were the marine biologist worked, a small table used by the meteorologist, a chemistry lab, medicinals on a shelf including thyroid extracts, boxes of eggs (penguins?), round metal containers labeled Dutch cheese (I presumed these were Gouda chess balls encased in tin balls), etc. The upper ranked men had their own mess table and slept on one side of the room. The lower ranked men slept on the other side with the kitchen and the door to the outer shed surrounding two sides of the hut. The outer shed had a rusted dissembled bicycle, the afore-mentioned seal blubber slabs, wooden skis, picks, shovels, the horse stables with each horse's name painted opposite each stall, etc. It is like taking a step back into time going into the hut and the most interesting things are the foodstuffs (my vote for most revolting is that stack of blubber slabs -- it certainly lends an "atmosphere" to the outer shed).

Tomorrow morning we helicopter off with our gear in a sling load under the helicopter and fly to Couloir Cliffs south of Granite Harbor on the Antarctic mainland. I will be camping for four nights and you won't hear from me for awhile obviously. This should prove to be an interesting experience.

November 17, 1997. Granite Harbor

This day commenced a four night camping trip to the Granite Harbor area of the Antarctic mainland northwest of McMurdo Station on Ross Island. After a Labor Day backpacking trip in the high country of Yosemite with Kathy, my friend Calvin, and two others turned into a twelve day snow camping and survival experience, I vowed never again to do snow camping or turn vacations into adventures. So I broke my snow camping vow in Antarctica; at least I did it in grand fashion.

We helicoptered with our gear to the Granite Harbor area on the Antarctic mainland about eighty miles NW of McMurdo Island. We crossed over the northwestern part of the Ross Ice shelf, the largest ice shelf in the world and about the size of France. From the air we saw icebergs that had floated into shore and run aground and then had become entrapped by the annual sea ice. Some of the grounded icebergs were surrounded by sea ice cracks and had numerous Weddell seals and pups around them. Many of the larger sea ice cracks we saw from the air had Weddell seals strung out along them at irregular intervals. At the sea ice edge, it was breaking up here and there into ice floes. We landed at Couloir Cliffs on the southern part of the bay encompassing Granite Harbor on the north, Mackay Glacier in the middle and Couloir Cliffs in the south. The Mackay Glacier is a broad glacier running down to the ocean from the Antarctic highlands. Mackay Glacier is surrounded by high coastal cliffs of granite sometimes topped with volcanic rock and by coastal peaks of 1000-2000 feet height. We joined up with another diving oriented research group and shared a common campsite and facilities next to a long sea ice crack. There was a Jamesway (small quonset-like) hut for cooking, eating, storing dive gear, and filling scuba tanks with a compressor. The outhouse was a Scott tent and I'll say no more about that. We slept in two man tents nearby that we anchored down to the sea ice with ice screws. We were about thirty yards offshore from Couloir Cliffs and it was like camping on a big ice cube. We used snowmobiles to transport ourselves and dive gear; one snowmobile had a wooden sled with Teflon runners. Dive holes were widened out with hand tools from sea ice cracks.

My first dive was near camp and was 74 feet for 29 min. I was tasked to be a model for wide angle photography of a diver swimming below a sea ice crack lit up by the light streaming down through the crack. I am not a great scuba diving model. I don't fin kick aesthetically so I have to correct that while posing and I am slow on the uptake at understanding Norbert's underwater hand signals. The sea floor sloped down steeply from shore and several jellyfish went by. I watched a Weddell seal breathing at the sea ice crack. The overall scenery underwater was magnificent because it was well-lit; there was no snow on the sea ice so a lot of light was coming down. The sea ice ceiling tents up at the sea ice crack and looks like a brightly lit jagged line running along the sea ice ceiling as far as one can see (which is very far). A shaft of sunlight dropped down to the

bottom from the dive hole. I tended on another dive and watched topside as skuas picked at a seal pup carcass and fought tug-of-war over scraps.

November 18, 1997. Granite Harbor

I did a dive along Couloir Cliffs for 130 feet 29 minutes. I was tasked to carry an extra camera and hand it back and forth as needed for macro photography. The bottom life was much better deeper than shallower. I saw: whip-like soft coral with short white sea cucumbers perched on the whip ends; sea spiders (Antarctica has the largest sea spiders in the world; they can be as large in span as a Frisbee); brittle stars; sea urchins with algae that they stick on top like top hats (for chemical defense I hear); various sea stars in purple, red, white colors; gray free-swimming scallops; white dorid nudibranchs with frilly edges; lacy bryozoan clumps; small fish of two kinds; ctenophores (comb jellies) like Beroe; lots of sponges in various colors; some big volcano sponges down deep; pink and white soft coral. The sea ice ceiling had hollow brine tube stalactites hanging down. Underwater visibility was great and there was a jagged sea ice crack running along the sea ice ceiling.

A second dive was at Discovery Bluff, a rocky promontory immediately south of Mackay Glacier. There were many Weddell seals along the tidal cracks at the base of this point and many, many pups bellowing for their mothers. I heard a thunderous avalanche come down some distance away; it was on a steep slope inland from the appropriately named Avalanche Bay ! This second dive was 120 feet for 46 minutes. It was a granite bouldered bottom dropping steeply with a shallow shelf at twenty feet running toward shore. There were big white volcano sponges, urchins, white aeolid and dorid nudibranchs, sea spiders, sea cucumbers, sponges, and seals cruising the area continually and up at the cracks. From below, I watched a seal mother and pup laying about at a crack. A large male seal cruised right up to Norbert making barking noises underwater; this was almost certainly an aggressive display and something we watch out for. Weddell seals when aggressive will bite between another seal's hind flippers, a sensitive area on a seal. On a human diver, aggressive Weddell seals have been known to bite between the flippers too --- the diver's crotch. As you might imagine, this factoid does cross the mind when around male Weddell seals underwater. When we went to bed, it was snowing lightly.

November 19, 1997. Granite Harbor

We returned to the second Couloir Cliff dive site, deciding that it was the best. I did a 42 foot dive for 39 hellish minutes being a model for Norbert's wide-angle photography, swimming back-and-forth, back-and-forth in the light streaming down from a sea ice crack. You don't get to see much other than the larger view but I did see ctenophores (comb jellies) and purple and red pteropods (winged free-swimming molluscs). Topside, I watched how a skua would fly low and follow a sea ice crack, scouting for whatever it might find to eat along the crack. There was a seal pup and mother at a sea ice crack. The pup was calling for its mother who was underwater at the time. The mother would stick her head out and call back. The pup inched over to the crack and touched noses with mom and slide into the water gracelessly right on top of mom.

Later I did another dive at this second Couloir Cliff dive site for 30 minutes at 113 feet. The sea ice crack runs to shore into tidal cracks and pushed-up pressure-ridge ice blocks. Underwater the scenery is amazing. The ceiling is a tented-up pressure ridge ceiling of sea ice blocks covered with a crystalline ice surface. The bottom is only fifteen feet deep and covered with crystalline anchor ice clumps. The bottom ran straight into a vertical shoreline rock wall covered with frozen water that had streamed down as meltwater from the snow-covered granite rock cliffs above. This underwater shoreline rock wall looked like a crystalline underwater waterfall with deep blue ice coloration over the rocks. The water had melted above, trickled down and then frozen as it flowed down under the sea ice. This frozen water coats the fifteen foot vertical or near vertical drop. The whole place for some distance along the shore looked like a crystalline cathedral with some crystalline brine tube stalactites thrown in for added effect. It was magical swimming slowly along and watching the play of light across these structures as the light came down from the tidal cracks above. In one spot along the frozen wall, I

saw a long nemertean worm frozen in place; it had obviously been crawling along when a fresh batch of meltwater streamed down over it and froze it in place.

Down deeper, the benthic life was more interesting with urchins, brittle stars, sea spiders, nudibranchs, soft coral, anemones, large white volcano sponges, a huge brown knobby-surfaced volcano sponge, and various sea stars.

November 20, 1997. Granite Harbor

We snowmobiled across the bay to the other side; you have to go forward in a zig-zag manner to maneuver around larger sea ice cracks. I tended this dive at the base of high granite cliffs topped with volcanic rock layer. Though one misses a dive while tending one's fellow dives by helping them gear up, pass cameras, assist in getting out of the water, etc, you do get a grand opportunity to sit in silence while they are underwater and enjoy the magnificent scenery. This truly felt like the middle of nowhere. You get where you think you are in the middle of nowhere in the western US and you see jet contrails overhead; here no contrails, no nothing, just you and some bellowing seal pups.

Later we went back to the better Couloir Cliffs dive site where I did a 62 minute dive for 54 feet max depth. Norbert wanted me to stay perfectly still in place against the frozen ice wall for a multisecond tripod exposure. I move up and down slightly with normal breathing so Norbert swam over and hit my drysuit air inflator button thereby filling my suit so full with air that I was buoyantly plastered almost immobile against the sea ice ceiling. He had a mirthful look in his face as he did this. Now I was the perfectly still model he needed and he did several shots; I stuck my arms and lower legs down a bit so it wouldn't look like I was unnaturally flattened against the ceiling. It gets very cold staying perfectly still for multisecond shot after shot; my fingers got pretty numb. After Norbert got the shots he needed I was released to cruise around on my own and sight-see. There were six to seven foot long brine tube stalactites hanging down along the chambered shoreline with anchor iced bottom, ice wall, and sea ice ceiling as previously described. A seal cruised through the area and I saw ctenophores (comb jellies) and the usual bottom critters.

November 21, 1997. Granite Harbor

I decided to pay heed to my slight head cold of the day before and take a day off diving to get better. I tended while Norbert and Dale did more diving at the better Couloir Cliffs dive site. Dale had a whole dive of swimming back and forth, back and forth, back and forth in the light shining down from the sea ice crack. It was a bright sunny day and perfect for the wide angle shot of a diver illuminated underwater from God's beams streaming down from a sea ice crack.

I felt like this was a perfect day to sit out if one had to get over a slight cold. The air temperature was right at freezing and with the sunlight, the sea ice cracks in the area were thawing and opening up a bit. There were seals laying about and totally enjoying their sunbaths.

We returned by helicopter to McMurdo.

November 22, 1997. Cape Armitage

Today we did some running around in preparation for an upcoming field camping trip to Cape Bird starting in two days.

In the afternoon, we did a dive at the Dayton's Wall area of Cape Armitage just south of McMurdo. I did a 130 foot dive for 29 minutes. I saw a crinoid perched on the edge of a three foot high white volcano sponge. I saw: sea spiders; two big yellow anemones doing tug-of-war eating of a big conical jelly fish; another anemone eating a big jellyfish; yellow banana-like sponges in clumps with long spines; white banana sponges in clumps; brittle stars; a jelly fish over six feet long way up in the water; several jellyfish and many small ctenophores. A Weddell seal was audibly nearby but unseen and it added its eerie soundtrack to my dive.

November 23, 1997. Little Razorback Island

Today we drove out along the ice shelf to Little Razorback Island for a dive. Some sea ice cracks were opening up en route on the main flagged road marked out offshore on the ice shelf used by every field party to traverse along the western shore of Ross Island. The continued sunshine is really loosening the ice up; one crack we crossed was about 1 1/2 feet wide and it went straight down. A bit spooky to drive across these. At the Island, I did a 130 foot dive for 39 minutes. I described the Little Razorback Island dive site before and got a better look at it deeper in this return visit. The steep rocky hillside underwater has gullies, rock outcroppings, and vertical wall sections. This makes for splendid invertebrate habitat and this dive site is my favorite for invertebrate sightseeing of the places I have been diving. There are large white volcano sponges down deep and they appear like ghostly apparitions as one looks down the dark steep slope or into gullies. I saw a white dorid nudibranch perched up on a foot long feather duster worm tube just below the feather duster feeding apparatus. There were plenty of the usual: sea spiders, sponges, nudibranchs, hydroids, soft coral, a fish perched on a yellow sponge, white sponges in big clumps that looked like moose antlers. The wall sections were especially colorful since the organisms stood out so clearly. When it was time to leave the depths, I looked at the siphonophores floating about at twenty foot depth below the sea ice. They looked like a Vienna sausage with a long tail; the tail had fine strands sticking out from it. When the siphonophores sensed my nearby presence, they retracted the tail strands, shortened up their tail section, and started jetting water to move away. I could cruise up to one and it would be fully arrayed and motionless, just fishing away; after a few seconds, some water current from me or something would alert it and it would start the flight reaction. There were also ctenophores in the water column and small medusa (jellyfish). These transparent jelly animals are one of my favorite things to see while diving and these Antarctic waters are full of them. They can be very hard to see until you catch the light just right on them and realize there is an animal there.

Tomorrow morning we shift our field camping gear and food to the helicopter operations area and fly off in the afternoon to Cape Bird, the northwestern point of Ross Island. There is an Adelie penguin rookery there and supposedly leopard seals cruising for penguin brunch. The sea ice does not extend so far north on Ross Island so we will see rocky coastline and open ocean. Norbert wants to get in the water and photograph the leopard seals and penguins swimming about. Our dive operation is scaled back in consideration of our impact on the small New Zealand field camp we will be visiting. Only Norbert will be diving. Actually he will be snorkeling around a lot to find subjects to film and then using the scuba tank on his back for short excursions underwater to film. Dale will be bringing his dive gear for snorkeling in order to be a safety person in the water if needed. I will be hauling gear, handing cameras back and forth to Norbert, setting up Norbert's scuba rigs, etc. This will be a six night field camp so you won't hear from me for awhile. Since the air temperature at McMurdo here has been staying around freezing, the sunshine has been melting snow around McMurdo in a hurry. McMurdo looks mostly like volcanic gavel and mud holes now; some call it McMudhole when it is like this. Its more common nickname is MacTown.

November 24, 1997. Cape Armitage

Weather came in and our afternoon helicopter flight to Cape Bird was canceled (all flights were canceled). The air temperature got colder and light, big fluffy snowflakes started falling. McMurdo is now white again though only a thin coating.

Dale and I decided to go for a dive at Cape Armitage nearby in the late afternoon (I win either way: camping trip or local dive). I did a 106 foot dive for 29 minutes and it was great: no camera gear, no camera cases to load, just sight-seeing. I saw the usual critters and headed into an area with rock outcroppings and big fields of white bushy hydroids. It looked just like that: a field of white bushes underwater. I saw a big anemone choking down a large jellyfish. One animal I saw in abundance were large dark brown stalked tunicates (ascidians) as big as footballs. I went up shallow where the sea ice ceiling ran into the seashore and headed towards a large thin hollow brine tube stalactite I saw. It was over six feet long and reached down to the seafloor (which was just under seven feet below the sea ice ceiling. Where the brine tube touched the seafloor the supercooled brine branched and flowed downhill in two iced-over small streams on the seafloor.

On the way back up and over to the ice hole, I noted a large number of juvenile fish hanging about just below the sea ice ceiling where they feed and find refuge. In the water column there were several jellyfish floating about; one had bright white spots on its clear bell. I also saw small medusa and several of those tailed siphonophores. It was a fun dive. We will see what the weather allows us for tomorrow.

November 25, 1997. Cape Bird

Did a six night stay at Cape Bird on the northern end of Ross Island (McMurdo is at the south end of Ross Island about 45 miles away). Cape Bird has a New Zealand research hut and is the location of a large Adelie penguin rookery. We helicoptered in the morning but turned back due to low clouds; a second evening flight was successful. The sea ice shelf ends currently at Cape Royds (about midway up Ross Island) and there were ice floes and old icebergs along the Ross Island shoreline towards Cape Bird. After we landed, I was surprised to see the inside of the Cape Bird hut and realize that my expectation of field camping was radically wrong. This large hut was a short but steep hike up a hillside from the iced-up beach, had a great view of the coastline, and was very comfortable -- two bedrooms with bunk beds, a large dining/cooking/lounging room, a hut heater, a dry lab room, food pantry, and a storage room. Even had an outhouse with a killer view of the penguinated coastline. Absolutely palatial considering we were once again out in the middle of nowhere. The Cape Bird hut is located at the northern penguin rookery comprising 60,000 penguins. Sixty thousand Adelie penguins -- the cacophony, the overwhelming smell, the countless numbers of penguins everywhere -- made for a total immersion experience for six nights. I previously described visiting the Adelie penguin rookery at Cape Royds which has 1,500 penguins; it paled in comparison to seeing sixty thousand Adelie penguins.

First off, let's get the smell out of the way -- yes, it smelled constantly and strongly of penguin poop with its fragrant and complex bouquet. Diaper experience is adequate preparation.

In the rookery area, the Adelie penguins build nests on ridges or raised areas of ground. They construct their nests of small rocks. The ground around the nests and in the open areas immediately around the raised nesting areas is solid penguin poop, penguin feathers, and dead penguins or penguin parts. Generation after generation of penguins have lived here. The ground is built up of many layers of penguin poop, feathers, and penguins but mostly penguin poop. There are dead penguins, adults and chicks, everywhere in various stages of decomposition. They are freeze-dried and so the carcasses can be quite old. Some carcasses are embedded in the ground and slightly raised out with their bones showing like fossils.

Adelie penguins are cute and engaging. After several days of observation, I realized that Adelie penguins are tough birds and they can kick butt anytime, anywhere. They fight other Adelie penguins and predatory skuas by striking with their beaks or bashing with their flippers. A flipper bash makes a very loud thud when landed on another penguin; the two penguin researchers in residence with whom we stayed said it could break your finger. When we arrived, the Adelie penguins were laying on their bellies incubating one or two eggs (usually two). The male and female Adelie penguin take turns incubating while the other feeds. The Adelie penguin has a brood pouch at the bottom of their belly in which the eggs (and later, the chicks) tuck in. There is a constant stream of penguins leaving and entering the penguin rookery on their way to or from the ocean. The eggs

incubate for a month and the very first chicks were expected a week after we left. In addition to laying around incubating eggs, the Adelie penguins would stand up, stretch and shift their egg around a bit. A male standing next to his nest mate would do ecstatic calls which are loud shrieking calls proclaiming the nest territory. There was a lot of ecstatic calling going on as well as mated pairs proclaiming their bond or something; the rookery was a noisy place. The Adelie penguin partner not incubating and not feeding would spend time getting more rocks either from the area surrounding the rookery subgroup or from another penguin's nest. There is a lot of rock stealing going on. Adelie penguins get away with rock stealing when it is behind the nesting penguin's back and MAJOR squabbles erupt when rock thievery is noticed by the nesting penguin. Rocks are the major currency of the penguin rookery and a lot of Adelie penguin time is spent in gathering rocks. Major squabbles break out between non-incubating penguins on occasion and mad chases ensue with one penguin chasing another throughout the rookery and almost every penguin along the way throws in a peck or two. It looked like running the penguin gauntlet.

I spent a lot of time sitting around on the edge of various rookery subgroups watching the action. Mating was largely finished by the time we visited and I saw penguins mating a few times only. One rookery subgroup had a light brown colored Adelie penguin, a rare color variation called a leucistic penguin (not an albino). The penguin researchers said that they had spotted another in the rookery elsewhere. It snowed one day and the dusting snowfall and colder temperature seemed to quiet down the penguin rookery. A few Emperor penguins wandered into the shoreline area on one day but this was definitely Adelie penguin country. We saw snow petrels flying along the shore a lot on our last day; they must have been fishing. We even saw one Weddell seal on one day, hauled out on an ice floe.

The area of Cape Bird with the northern penguin rookery had volcanic rock cliffs and steep slopes topped by the Bird Icecap. Meltwater from the Icecap trickled down in small streams on warmer days. There was an ice waterfall along the cliff at one spot with long icicles making up the waterfall. The shoreline ended on the north where the Bird Icecap was a 100 foot blue ice cliff next to the ocean; from the top of this blue ice cliff, huge long icicles hung down. The beach along the shore was edged by old stacks of pack ice pushed up into pressure ridges. The volcanic beach dirt was blown and tracked all over this rugged iced shoreline making it look like a miniature Alps for penguins. The penguins tracked all over it and were quite agile climbers.

Down at water's edge, there are penguins standing around in groups waiting for the right moment to jump in, penguins walking in long lines looking for the right spot to jump in, penguins jumping out of the ocean and standing about, and penguins swimming and porpoising in the water. Penguins are very particular about where and when they will go in the water. I watched long lines of penguins march way, way down the shoreline looking for the "right" spot while passing up many such spots already in use by other penguins. Penguins are followers and do everything in groups so it takes something special for them to choose a spot to jump in and the time to jump in. In both cases, seeing a lot of other penguins doing the action in question will help make up a penguin's mind.

I spent considerable time sitting still at a point regularly used by penguins to jump in the water. If you sit still, the Adelie penguins don't mind that you are there; fifty to eight penguins would crowd around in front of me waiting to jump in. So what does it take for them to jump in? They watch the water and when a large group of penguins comes swimming into their immediate area, the Adelie penguins start getting very vocal. They start jostling, jockeying for position, squabbles break out, beaks peck back and forth, some flipper bashing back and forth, lots more loud discussion, more jostling, more pecking, and finally the braver ones will jump in followed by an immediate chain reaction of everyone rushing to jump in the pool all at the same time, no waiting, every person for themselves. Of course this isn't good enough for some timid ones who hesitate a bit and then decide the time isn't just right for them and stay back.

It was a blast to watch this right behind the penguins; they were close enough to touch (but I didn't reach out since Nature is not a petting zoo). If I could anthropomorphize them and then translate into words my

impression of a penguin group's verbal and bodily behavior while they mill around before diving into the water, it would go like this:

HEY, HERE COMES SOME PENGUINS -- Looks like a lot of them -- Do you think we should go in? -- NO, LET'S WAIT FOR MORE PENGUINS -- Hey, I think that's enough penguins; let's go in -- I'M NOT GOING IN -- Stop pushing (peck) -- I DIDN'T PUSH; HE DID (peck back and peck at another penguin) -- I didn't push; don't peck me (flipper bashing) -- Hey, I'm going to move over here away from you rowdies -- HEY, YOU STEPPED ON MY FEET (peck, peck) -- You pushed me too (peck) -- Hey, stop pecking me (peck, peck, peck) -- Hey, that's a lot of penguins in the water -- No, it isn't and I think there's a leopard seal lurking and ready to eat us -- I'M JUMPING IN -- DON'T JUMP IN YET -- I'm going (splash) -- I'M GOING IN (splash) -- DON'T JUMP IN -- I'm going (splash) -- I'm going (splash) -- I'm going (splash) -- I'm not going and I think you're stupid to go -- Me, too; let them get eaten!

You get the idea. Incredibly loud discussion and commotion -- jumping in happens when it seems to reach a fever pitch. Looks a bit silly but it isn't; it is serious business. After all, these Adelie penguins have to worry about getting caught and eaten by leopard seals and orca killer whales patrolling the shorelines. A penguin by itself is at greater risk than a penguin in a group with many eyes watching for predators and many voices to sound the alarm. If there are lots of penguins already in the water in front of you, then it is likely to be safe to go in. If you jump in as a group, you are safer than if you jump in alone. Watching the penguins go through their behaviors of marching up and down the shoreline en masse and then waiting for incredibly long periods of time to jump in starts to make sense if you are the chicken of the sea.

The penguins like to swim along porpoising; I imagine they can see where they are headed with regard to sea ice and also confuse any following predators. When the Adelie penguins are ready to come ashore, you can see them porpoising until they are about sixty feet offshore. Then they swim underwater building up speed and pop out vertically at the shoreline. Since there is sea ice blocked up several feet high along the shoreline, they have to jump up fairly high to get out of the water. You can see whole groups at a time doing this. Some misjudge and fall back in.

One day, Norbert and I took turns taking photos from a spot at water's edge where we were screened from the ocean by an ice block. It was right at a low spot where the penguins liked to jump out. I sat there and watched Adelie penguins jumping out in mid air just a few feet in front of me. They launch themselves out of the water with a lot of velocity and height and usually land gracefully. When they touched down on the ice, several were quite surprised to see me there and ambled off quickly.

We saw leopard seals daily but not regularly; they did not appear to be present in this area in large number. Our first sighting occurred after I selected a relatively fresh penguin carcass to use as a leopard seal decoy. Dale and I tied it on the end of a long line in order to throw out in the water and hope that it's splashing would attract leopard seals for photography. I named the penguin carcass George after a good friend. George stayed with us for several days. We even engaged a few penguins with George dangling on his noose like a macabre marionette. Dale tossed George in and I held the end of George's line. Immediately a large leopard seal stuck his head out of the water right next to Dale and not George. It eyeballed Dale and showed no interest in George. Dale was immediately rattled and jumped back from the edge of the water. It was obvious that George the decoy would fool no one. On other occasions, we saw a leopard seal usually by chance cruising along the coastline in an area where we happened to be sitting taking photos. The leopard seal would usually eyeball us (large delectable morsels that we were) and move along about his business. I saw a leopard seal spyhop and raise straight up out of the water at water's edge to look at some penguins standing along the shore a few feet back from the edge. The seal didn't go for them and the penguins took off. Dale and I both saw a leopard seal chasing penguins in the water, porpoising along behind penguins porpoising higher than ever and penguins moving faster than ever.

One day, a pack of orca killer whales cruised along the edge of the pack ice that was just offshore; there were about thirty of them strung out. I didn't see them attack any Adelie penguins though it was evident they were looking for brunch opportunity cruising so close to the ice edge. A few spyhopped for a topside look but they mostly just cruised by. The pack ice that was just offshore started moving very fast towards the shoreline due to some winds or current very far away. The big ice plates broke up into smaller blocks and raised up into new pressure ridges. There was a loud constant crunching sound during this movement period which lasted under an hour. It was like watching plate tectonics in action. There were jumbled chunks, plates and peaks being formed -- a brand new version of the existing shoreline we had been hiking about on. It was now obvious how the old jumbled ice along the shoreline had been formed. The orca killer whales were just down the coast and the channel in which they had been traveling along our shoreline closed up due to this movement of the pack ice. I could see through the long lens of my camera that the killer whales moved into a small area left open and started spyhopping frequently. They were evidently trying to see a way to swim out and I could see them open up some narrow passageways with their bulk. After milling about for awhile spyhopping and trying some passageways leading nowhere, the killer whales dived down and I didn't see them surface; they must have swam away underwater for quite a way.

Skuas were constantly about; they are the bad boys of the Antarctic and the most southern-ranging bird on the planet (skuas have been seen far inland near the South Pole). Skua pairs have hunting and nesting territories staked out in the penguin rookery and fight to retain them. Skuas eat krill, fish, penguin eggs, penguin chicks, and penguin carcasses. I was able to watch penguin egg hunting by skuas on a few occasions; it is difficult to be in the right area at the right time. Skuas are very patient and they would sit patiently just a foot or two away from the outskirts of a penguin rookery subgroup waiting for an opportunity. I saw a skua dart in and cause a single penguin parent's egg to break on the ground and also cause a penguin pair's egg to roll out of the nest. An incredible ruckus of noise broke out among angry penguins and a screeching skua. An egg out of the nest is usually doomed and is not recognized as "mine" by the penguins. The penguin pair chased after the skua and were fighting mad at it but did not move the egg back to their nest though they had ample time. The skua waited a bit, flew in and snatched the egg in its beak while the penguins fought back to no avail. The skua is at some risk from getting its bones broken by a penguin flipper or getting its eyes pecked. The skua flied off a very short distance, stretched its wings and screeched in triumph standing over the egg; then it pecked open the egg. Certain places in the penguin rookery were favored egg eating places and had numerous broken eggs on the ground. Skuas fly really low over a penguin rookery and the penguins will strike out if the skua is low enough. A cocky penguin ambling along will go out of its way to attack a skua standing idly about. The skuas seemed to have a lot of respect for the danger of attack by an Adelie penguin and stay out of their way. The skuas nest right around the penguin rookery and many times I walked unwittingly through their nesting areas. You knew when you did so because they would fly straight at you right above your head trying to get you to leave. If they didn't do that, they would stand around and screech at you so loudly you would want to leave. I saw a few skua eggs laid on the ground; I felt like stomping on them on the penguins' behalf but refrained from doing so.

Tomorrow, Dale leaves and Norbert and I are scheduled to fly by de Havilland Twin Otter ski plane to the Emperor penguin rookery at Cape Washington on the Antarctic mainland. This is too far for helicoptering so we go by airplane. If there are any helicopter fans, we have been using the Bell 212 for trips to Granite Harbor and Cape Bird and the Astar for trips to the sea ice edge. The 212 carries a lot more gear.

December 2, 1997. Cape Washington

Got back late at night from a de Havilland Twin Otter ski plane flight to Cape Washington on the Antarctic mainland far, far away from McMurdo Station. Cape Washington is the site of a major Emperor penguin rookery with 20,000 chicks in annual attendance. The ski plane followed the Antarctic coastline and views of the mountains and glaciers were exceptional due to the clear sunny weather. We flew over two glacier ice tongues; these are immense seaward extensions of a land glacier sticking way, way out into the ocean. The Nordenskjold Ice Tongue is a seaward extension of the Mawson Glacier. The really big one we flew over was

the Drygalski Ice Tongue of David Glacier; it ranges from 9-15 miles wide and is about thirty miles long. Many times we were flying not too far above the water and at some points, the pilot flew the plane right alongside glacial ice cliffs at water's edge. We landed on the fast sea ice at Cape Washington and could see Mount Melbourne towering over us further inland. Mount Melbourne (8,966 feet) is the only volcano on the Antarctic mainland. Other Antarctic volcanos (like Mount Erebus on Ross Island) are on Antarctic islands.

We jumped down from the ski plane and could see thousands of Emperor penguins spread out along the base of the cape and stretching way out onto the ice shelf around us. They were older Emperor penguin chicks in down plumage whose parents were at sea gathering food. The Emperor penguin lays its egg, incubates, and hatches it in the Antarctic winter and we were seeing fairly grown chicks now in the early Antarctic summer. The Emperor penguin does its rearing on sea ice and not on land. The Emperor penguin chicks were large enough to be left alone and vastly outnumbered the adult Emperor penguins present. There were some skuas around but they didn't bother the chicks. The skuas were flying in and landing where there was an adult Emperor penguin feeding a chick; the skuas were hoping to get some spilled regurgitated food. Norbert went straight to the rookery area to photograph while tasking Rob Robbins (the scientific diving coordinator who was accompanying us in order to assist) and I to survey the shoreline for underwater photographic opportunities. The shoreline was a thirty minute hike away through soft snow up to one's shins and occasionally thighs. I plunged in pretty deep sometimes.

At the sea ice shoreline, adult Emperor penguins were present in small numbers standing out of water and in packs cruising along the shoreline. We watched them porpoise along when swimming fast. Occasionally they would swim more slowly and stick their heads up to survey the shoreline. The Emperor penguins would dive down and not come up within the usual time period; then they would suddenly pop up out of the water onto the sea ice edge to come ashore. They came out of the water more horizontally than the Adelie penguin and not quite as high -- about chest high on me. How do I know it is chest high? Because two groups spotted Rob and I on the shoreline with 2-3 other Emperor penguins and decided that we constituted a large enough group of penguins and substitute penguins to come ashore. Expecting absolutely nothing, I was standing at the sea ice edge wondering where the penguins had gone when suddenly I saw a large shape with white marks hurtling straight towards me from about six feet underwater. I yelled out in surprise and ducked for cover and a sixty to ninety pound four foot tall Emperor penguin landed right next to me where I had been standing. It just missed me. Two more Emperor penguins suddenly erupted out of the water nearly hitting Rob and myself (again). The Emperor penguins landed around us and then casually got up and walked off; they thought nothing of it. This happened again about twenty minutes later with about five Emperor penguins; it is hard to count them when they are whistling through the air around you. There would have been two direct hits in this second batch and the latter of the two would have taken out both Rob and I if we didn't side step. The thought of being hit right in the chest by one of these large fellows was a sobering thought though we were having a great time seeing them launch out of water right smack dab in front of us. We hung around and assessed the underwater photography opportunities further and decided that there wasn't enough Emperor penguin action compared to Norbert's previous underwater photography at the sea ice edge to justify sledging the extensive and heavy gear over. There were a few Adelie penguins about, obviously immature ones since they weren't at a rookery. There were lots of white Antarctic snow petrels flying along the sea ice edge back and forth; these are beautiful birds with black beaks and eyes and a robust snowy white body and wings. We also saw lots of Wilson's storm petrels, a small black bird with white streaks on its wings.

Rob and I hiked back to the plane, picked up some topside photo gear and sledged it over to Norbert at the Emperor penguin rookery. The rookery was full of Emperor penguin chicks as previously described and the relatively few adult Emperor penguins present were either laying about (presumably with a chick nearby) or standing next to a chick that was pestering for a regurgitated feeding. I watched as Emperor penguin chicks pestered for a feeding and received it from their parent's beak. Lots of penguin chicks were just standing about without parent and many of them were calling. Their sound was quite melodious and the sound of an Emperor penguin rookery filled with chicks is much more pleasant than the sound of an Adelie penguin rookery filled with nesting adults. No substantial fighting or squabbling was going on among the Emperor penguins that I

could see. I saw some chicks trade off minor pecks jockeying for a feeding, probably between the chick that should get the feeding and a hungry interloper chick. Overall the rookery scene was fairly peaceful on this sunny mild day.

Norbert decided to get photos of porpoising Emperor penguins so we hiked over to the sea ice edge. While standing around waiting for an Emperor penguin group to cruise by, Rob was casually kicking a bump on the sea ice on which he was standing near the edge. A big chunk of the sea ice on which he was standing suddenly broke off and tumbled into the water as a result of his action; Rob had to dive back onto the unbroken sea ice to avoid going into the water. This was pretty funny and laughs were shared all around. Norbert unconsciously did the same thing himself about thirty minutes later as an even larger piece of sea ice on which he was standing broke off and dropped into the water. Norbert had to dive backwards sprawled out to avoid falling in the water. Wise one that I am, I did not similarly tempt fate.

We hiked back to the ski plane and flew to the Italian Antarctic base at Terra Nova Bay; Cape Washington is at the far end of this bay. En route, we flew over the unused German Gondwana Antarctic base and then landed at Terra Nova base. We had a nice Italian dinner there (great pasta) and walked around looking at their base. We picked up an American scientist and his absolute gravimeter equipment at Terra Nova and then flew back to McMurdo.

December 3, 1997. Arrival Heights

Today Norbert and I did two dives at Arrival Heights in a new location; they move the dive huts occasionally. Having been out of the water for some time, it felt very good to get back in and get some nitrogen bubbling around my system. The first dive was at 106 feet max for 38 minutes and the second dive was at 86 feet max for 43 minutes. My hands seem happiest with a forty minute dive if I am assisting and/or modeling for Norbert. My activity level is lower following a photographer around and my hands suffer from the cold long before I start to feel really cold on my torso. My feet and head don't get cold at all though my only exposed skin -- my lips -- get properly numb as they get instantly cold. However lips are heavily vascularized and seem to withstand this freezing water well except for a constant slight case of chapped lips. The drop line hanging down from the dive hut hole hit bottom at sixty feet in the midst of a volcanic gravel and rock slope running from the shoreline close by down to deeper water below. Up shallow there was a lot of crystalline anchor ice clumped together as large plates; I could see many animals trapped within the ice. I saw one anchor ice clump that had grown sufficiently and broken free to achieve buoyancy and was on its way up to the sea ice ceiling to add to the ice plates there. The benthic (bottom) community was dominated by large and small anemones (beautiful big yellow ones and small white ones with intensely white tentacles) and also sponges of various colors including stalked sponges and volcano sponges. I saw sea spiders, long-spined polychaete worms, loads of bicycle inner tube looking nemertean worms, white aeolid (similar body style to Tritonia festiva) and white dorid (similar body style to Hermissenda crassicornis) nudibranchs, a large anemone still battling for capture of a still alive and pulsing jellyfish, various sea stars, large red urchins, geoduck-type clam siphons in the gravel, large brown stalked tunicates, white-topped stalked featherduster worms, soft coral, and lots of small white sea cucumbers with their feathery feeding arms fully extended.

I could hear the eerie calling of a Weddell seal or two throughout both dives though I never saw one. There was a large sea ice crack nearby and the light coming through it broke up the dark blue and brown tones of the sea ice ceiling. Two volcano sponges had fish inside their bowl looking quite picturesque perched there. There was a big pile-up of sea stars and a few nemertean worms eating an upside down large white sea star; smaller sea stars of one species attack the larger sea stars of another species here. The sea ice ceiling had the usual vibrant community action going on along it; there were numerous juvenile fish, crustaceans, and pteropods (winged free-swimming molluscs).

On the first dive, I was tasked to follow Norbert around with a second camera and pass cameras back and forth as needed. On the second dive, I was to be a model, a task at which I'm not the best to put it mildly. The sea ice ceiling looked like puffy dark clouds when one looked up and Norbert wanted to take wide angle long exposure photos of the sea ice ceiling and slope with me posed against the ceiling. Since I am incapable of staying absolutely still for a four minute exposure by an underwater camera on a tripod, I over-inflated my drysuit and pinned myself up against the sea ice ceiling. I put the beam of a hand-held underwater light on the previously arranged spot on the seafloor and then stayed absolutely still for five minute stretches with rearrangements of position in between as directed by Norbert. It gets darn cold particularly in the hands staying stock still for fifteen minutes and having one's face right next to the sea ice ceiling is a reminder how cold it really can be. I was happy to be released for a sight-seeing dive on my own for the rest of my underwater time; I flexed my fingers constantly trying to get some warmth going in them. They still feel stiff as I type this.

December 4, 1997. Danger Slopes

Today we did a single dive at Danger Slopes, a short distance north from McMurdo on Ross Island and just beyond Arrival Heights. The bottom fauna was similar to what I described yesterday but more sparse. This dive was 87 feet max for 39 minutes and marks my 21st and last dive here in Antarctica. It's been enough because it's starting to look very familiar and I'm growing tired of constantly flexing my fingers during a dive to generate muscle heat. It will be nice to return to diving in San Diego and not look like a grasping idiot throughout a scuba dive. The Danger Slopes dive site was remarkable physically. There was a gradual slope up to the shore and it stopped a forty foot depth where a large ice wall from the glacier above met the ocean. The ice wall cantilevered up at a 45 degree angle from the seafloor, went up forty feet and met a tidal sea ice crack which streamed in sunlight. The blue ice wall and the sunlight streaming in were beautiful; we cruised along this wall for quite awhile enjoying the view.

Tomorrow our luggage has to be humped to the air cargo building, I have to check back in our field camping gear and field HF and VF radios, and then we fly out the day after tomorrow (weather permitting). I have had my fill and am looking forward to coming home.

December 5, 1997. Dry Valleys

Weather opened up and a helicopter was available. We rushed to drop our luggage off early in preparation for the flight from McMurdo to Christchurch, New Zealand tomorrow. You drop off baggage a day ahead of departure for loading in the hold of the cargo transport planes. There are about eight passengers on our flight. Tomorrow morning we report at 6:10 am for our flight. The slower planes are now in use; I have a seven hour flight back to New Zealand instead of the 5 1/2 hour flight I had coming down.

Norbert had an Astar helicopter at his disposal for photography so off we went to the Dry Valleys on the Antarctic mainland across the McMurdo Sound part of the Ross Sea from McMurdo on Ross Island. Our pilot was my favorite who likes to swoop around and bank in tight turns for a bit of a thrill ride. It isn't so good for photography but it sure is fun. First we helicoptered to the sea ice edge and looked for leopard seals, killer whales, etc. We spotted an area with killer whales and minke whales and set down for some photos from the sea ice edge. The orca killer whales were just a few feet away from us as they cruised along next to the sea ice edge. A minke whale went by and dived down under the sea ice edge to feed on plankton under the sea ice. It came back out in several minutes and went diving down under the sea ice again.

We then helicoptered to the Explorer's Cove area of New Harbor on the mainland and flew onto land there up the Taylor Valley, a dry valley. The Dry Valleys have almost no snowfall and the mountains around them are high enough to keep out major glaciers coming down from the Antarctic highlands in the interior. Whatever snow does fall in a dry valley (and there were patches and traces) is melted quickly by solar heat soaked up by

the exposed ground. The Taylor Valley looked to me similar to the other dry valleys we were to see: craggy mountains rimming a valley with bare dirt slopes, infrequent running streamlets, and seasonally frozen ponds (saw one unfrozen pond, Don Juan Pond, which we were told never freezes). We landed at Lake Hoare for a closer look; it was currently frozen and was sited next to a big glacier that pierced into Taylor Valley. We looked around the research station there and took off up valley.

We left Taylor Valley in the Lake Bonney area and flew over the mountains to the Wright Valley, another dry valley. We dropped down into Wright Valley at Lake Vanda which had a running streamlet flowing into it and a craggy cliff on one side. It was a gorgeous sight. We flew around a bit for photos and then landed at Bull Pass which exits Wright Valley. We were left there for an hour while the helicopter went to refuel. Bull Pass is dry itself and noted for its ventifacts - wind-eroded rocks. Many granite rocks were wildly eroded with biomorphic shapes; the sculptor Henry Moore would have felt at home. We walked around examining wind erosion on various types of rocks and walked back to the landing site when we heard the helicopter approach (it zoomed by about thirty feet overhead; I love that pilot).

From Bull Pass, we flew to Victoria Valley, another dry valley to a view of Victoria Upper Glacier. The Victoria Upper Glacier was spectacularly edged in a gracefully curved glacial ice cliff and meltwater ran off down slope to frozen blue ice ponds. We flew back to Wright Valley and up to the Wright Upper Glacier and a misty cloud-enshrouded view of the Airdevronsix Icefalls where a glacier drops down in an icefall into the Wright Upper Glacier (I think; hard to tell exactly with the clouds in the upper reaches).

Flying down from the Victoria Upper Glacier, we exited through the Labyrinth section of Wright Valley. The Labyrinth is a winding narrow-sided craggy canyon and it was an incredible thrill to fly down it with tightly banked turns. A flight down the Labyrinth was featured in the IMAX Antarctica film. Our pilot said that he led the film crew helicopter through the Labyrinth to show them the way. We exited the Labyrinth to continue flying down Wright Valley to the ocean.

Along the way we landed twice to shoot photos of mummified seals that had erroneously traveled up into the Wright Valley instead of turning back to the ocean. Since it is so cold and dry where their bodies lie, they are well-preserved and rather ghastly looking. I read in a book that they are crabeater seals; they didn't look massive enough to be Weddell seals and I cannot imagine that a Weddell seal would hump so far inland (since they prefer fast sea ice and ice crack holes).

We exited the Wright Valley where a glacier pierced it and flew to Marble Point to refuel. Marble Point is a refueling depot on the Antarctic mainland across the McMurdo Sound from McMurdo on Ross Island.

We flew back along the sea ice edge again and I spotted a few killer whales. We landed when the pilot spotted a leopard seal lounging in the sun at the water's edge on the sea ice. After we landed, it humped into the water and we stood some distance back from the sea ice edge watching. It was cruising back and forth and would stick its head up and look at us occasionally. It was a large leopard seal (they can be nine feet long) and its head looked huge in comparison to the Weddell seals I have been seeing. No one wanted to tempt fate and stand right next to the sea ice edge looking for it. The spot where the leopard seal had been laying had feathers all around, undoubtedly a penguin lunch. Leopard seals capture and eat penguins standing right next to the sea ice edge. After awhile, the leopard seal hauled itself onto the sea ice for a short while. Some Emperor penguins nearby were totally unconcerned. I think they know where they are in danger since I rarely see an Emperor penguin standing right next to the sea ice edge; they stand about six feet back. The Emperor penguins even started walking in the general direction of the leopard seal; they wouldn't be in danger on the ice since the penguins can move much faster than a seal on ice. After awhile, the leopard seal went back in the ocean. It was time for us to fly back to McMurdo.

1999 DIVE LOG				
Dive #	**Date**	**Location**	**Max Depth (ft)**	**Time (min)**
1	11/10/99	Cape Armitage	92	19
2	11/12/99	Turtle Rock	18	60
3	11/13/99	Cape Armitage	130	36
4	11/14/99	Turtle Rock	28	63
5	11/15/99	Turtle Rock	24	63
6	11/17/99	Couloir Cliffs / Granite Harbor	107	32
7	11/18/99	Discovery Bluff / Granite Harbor	119	34
8	11/19/99	Couloir Cliffs / Granite Harbor	65	74
9	11/22/99	Cape Armitage	90	32
10	11/23/99	Little Razorback Island	24	32
11	11/24/99	Cape Barne	88	29
12	11/24/99	Cape Barne	86	35
13	11/25/99	Cape Barne	72	29
14	11/27/99	Cape Barne	119	37
15	11/28/99	Cape Barne	125	27
16	11/28/99	Cape Barne	72	30
17	11/29/99	Cape Armitage	60	48
18	11/30/99	Cape Armitage	70	49
19	11/30/99	Cape Armitage	79	46
20	12/1/99	Little Razorback Island	58	57
21	12/1/99	Little Razorback Island	130	25
22	12/3/99	Explorer's Cove / New Harbor	90	44
23	12/4/99	Explorer's Cove / New Harbor	88	41
24	12/4/99	Explorer's Cove / New Harbor	99	42
25	12/5/99	Explorer's Cove / New Harbor	99	39
26	12/5/99	Explorer's Cove / New Harbor	93	44
27	12/5/99	Explorer's Cove / New Harbor	88	43
28	12/9/99	Cape Armitage	48	41

1997 DIVE LOG				
Dive #	**Date**	**Location**	**Max Depth (ft)**	**Time (min)**
1	11/4/97	Turtle Rock	24	14
2	11/4/97	Cape Armitage	54	24
3	11/7/97	Turtle Rock	119	42
4	11/8/97	Arrival Heights	130	28
5	11/10/97	Turtle Rock	124	28
6	11/10/97	Turtle Rock	38	67
7	11/14/97	Little Razorback Island	126	42
8	11/14/97	Little Razorback Island	97	38
9	11/15/97	Cape Armitage	80	29
10	11/17/97	Couloir Cliffs / Granite Harbor	74	29
11	11/18/97	Couloir Cliffs / Granite Harbor	130	29
12	11/18/97	Discovery Bluff / Granite Harbor	120	46
13	11/19/97	Couloir Cliffs / Granite Harbor	42	39
14	11/19/97	Couloir Cliffs / Granite Harbor	113	30
15	11/20/97	Couloir Cliffs / Granite Harbor	54	62
16	11/22/97	Cape Armitage	130	29
17	11/23/97	Little Razorback Island	130	39
18	11/24/97	Cape Armitage	106	29
19	12/3/97	Arrival Heights	106	38
20	12/3/97	Arrival Heights	86	43
21	12/4/97	Danger Slopes	87	39

Diving Under Antarctic Ice
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Thanks to the National Science Foundation Office of Polar Programs for their support of Norbert Wu's underwater photography expeditions to Antarctica.

www.nsf.gov

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Diving Unlimited International (DUI) for their support and advice on diving gear for the expedition. **All** of the team members used DUI suits and undergarments for diving under the ice in water temperatures below freshwater freezing. Their knowledgeable staff has been exceedingly helpful and their support is appreciated.

www.dui-online.com

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www.ikelite.com

Lowepro for supplying camera bags, packs, cases, & Photographer's Gloves. Lowepro gear proved useful for our constant packing and unpacking, in all phases of our Antarctic field operations -- via snowmobiles, sledges, helicopters, & tracked vehicles.

www.lowepro.com

Really Right Stuff for providing their wonderful quick-release plates and clamps for our still photography and video equipment. 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, and therefore earn our highest recommendation.

www.reallyrightstuff.com

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www.sherwoodscuba.com

Film Sponsors

Thanks to the following sponsors who donated significant services or goods to support the high-definition video film for PBS Nature, entitled "Under Antarctic Ice." They offer the highest quality products and service and get our highest recommendation for the quality of their products and service.

Anton Bauer for supplying their excellent rechargeable batteries and recharger which we used with high-definition video cameras. These proved indispensable in Antarctic field work due to their long run time, cold resistance, and ease of use.

www.antonbauer.com

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www.extron.com

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www.uwimaging.com/

Lowepro for supplying camera bags, packs, cases, & Photographer's Gloves. Lowepro gear proved useful for our constant packing and unpacking, in all phases of our Antarctic field operations -- via snowmobiles, sledges, helicopters, & tracked vehicles.

www.lowepro.com

Pace Technologies for supplying their underwater camera housings for the Sony HDW-700A high-definition camcorders.

www.pacetech.com

Pelican Products for supplying their totally indestructible cases in which we packed high-definition video camera gear for travel and field use.

www.pelican.com

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www.aandi.com

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www.divediscovery.com

Marmot for providing outdoor gear & undergarments to a team member

www.marmot.com

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www.seaandsea.com

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