

ELYSIUM

Shackleton's Antarctic Visual Epic

EXPEDITION REPORT

An Ocean Geographic Project
Explorer Club Flag 108 expedition
10 February - 2 March 2010



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1. The Project

Inspired by the heroic spirit of Sir E. Shackleton, on 10 February 2010 an extraordinary team of explorers convened to photographically document a part of Antarctica the world's last pristine wilderness. The production will serve as a gift for future generations with an imaging epic that guarantees to inspire, invigorate and challenge for preservation of planet earth. The photographic production from Elysium Epic shall provide insights to the impact of global warming on Earth's last remote place. The 57-member team of explorers from 18 countries, convened by Australian project director Michael AW of the Ocean Geographic Society, were meticulously selected and comprise of the world's most celebrated artists, photographers, film makers, musicians and scientists. "Elysium Epic is about extraordinary explorers using advanced imaging technologies to document the last wilderness on our planet."

2. Mission

The mission plan of the 19 day expedition is to scout, record, and analyse the land of ice and snow and to produce a film, a book and a visual library of the impact of climate change on the southern polar region.



3. Objectives

As the route of the expedition approximately follows the track of Ernest Shackleton and his crew after they lost the *Endurance* – from the Weddell Sea and across the treacherous Drake Passage to South Georgia, one of the primary photographic objectives of *Elysium* is to document the sights and sounds of the region that Shackleton’s explorers would have seen in the present time.

With the expertise and professionalism of some of the world’s most celebrated image makers, the production of the film and book aims to encapsulate the splendour of the fauna, the terrain of the southern Polar region in a manner that no one has ever done before.

By using the state of the art imaging technology and survey techniques to conduct research of microscopic organisms such as krill and copepods which are a vital barometer of climate change science.

To produce a photographic index – Shackleton’s Antarctic Visual Epic (SAVE) image archive shall be derived from images captured from the *Elysium* expedition, to serve as a reference index of the Antarctica Peninsula and South Georgia. A curator shall be appointed to manage the archive and curate new images of the region from 2010. This archive will be made available for educational and scientific reference of the Antarctic Peninsula and South Georgia for climate change study.

To successfully make a landing on Elephant Island. Elephant Island, though enchanting and mystical, is a notoriously difficult landfall to approach due to its ice-covered mountainous terrain, dense fogs, icebergs and a lack of safe anchorage. Throughout history just a handful of people have successfully landed on Elephant Island. Our aim was to attempt a landing with the full complement of expedition members.



4. The Team

Michael AW: Project & Expedition Director

Expedition Leader: Goran Ehlme

Chief Medical Officer: Dr Saw Huat Seong

Diving Medical Officer: Dr Craig Cook

Science Team Leaders

Dr Cabell Davis: Woods Hole Oceanographic Institute, Boston. Chief scientist of expedition

Dr Steve Nicol: senior scientist from the Australian Antarctic Division is an expert on all aspects of the biology and ecology of krill, Antarctic fisheries, and the dynamics of Southern Ocean ecosystems will serve as the deputy chief scientist of expedition.

Principal Members

David Doubilet & Jennifer Hayes: photographer in residence, National Geographic

Emory Kristof: Titanic and deep-sea vent discoverer - National Geographic Photographer in residence;

Michael AW: Director, Ocean Geographic and 3 time winner of the BBC Wildlife photographer of the Year competition

Amos Nachoum: underwater photographer - big marine animal specialist

Leandro Blanco: eight-time World Underwater Pictures festival Winner

Ernest Brooks II: the master of black and white imagery, acclaimed as the Ansell Adams of the Sea

Jenny Ross: ILCP photographer and Nature's Best Wildlife Winner

Jonathan Shackleton: cousin to Ernest Shackleton is to serve as historian

Wyland: internationally renown fine art artist:

Stuart Ireland: award winning documentary producer

Team Leaders

David Borus: Carl Brandes : Craig Cook : Cabell Davis

Edward Dixon: Robert Fallon: Emory Kristof : Steve Jones

Steve Nicol: Karen Richardson : Scott Portelli : Davide Vezzaro

Supporting Team Members

Jorgen Rasmussen, Alhay Avila, Gwen Noda, Emily Chan, Brian Daly

Christine Chan, Kliment Kolosov, Jicky Vogel, Toni Williamson, Susan Eaton

Sally Allen, Gillian Clark, James Clark, Andreas Jaschek, Stephen Henshall

Paul Jessett, Wendy McIlroy, Elizabeth Quat, Fabienne Korchia

Jamie Watts, Virginia Fage, Eric Bettens, Ricky Wong ,

Evelyn Cook, Jenny Johannsen, Aimee Johannsen, Bartosz Strozynski

Ulrich Kosmer, Henry Yip, Martin Vavrek

Diving and Expedition Support: Marlynda Elstgeest

Director of Diving: Peter Szka





5. The Achievements

Successfully procured two terabytes of useful images and over 200 hours of high definition footage – above, over and underwater. Acquired useful images to dispel the myth that leopard seals are dangerous.

Successfully landed at Point Wild, Elephant Island with the entire expedition team on 20 February 2010

Successfully executed eight Video Plankton Recorder launches and sampling collections from West Antarctic Peninsula to South Georgia.

Successfully completed the 3277 nautical miles expedition from Ushuaia to the Antarctic Peninsula, crossing to South Georgia

Identified twelve sites for the climate change photographic database; images of these sites will be curated into the index.

6. Expedition Log

10 Feb; Advanced Party – arrival Ushuaia; expedition staff meeting

11 Feb: Science, medical, film and key staff meeting, logistic – equipment preparation

12 Feb: Arrival remaining team members, boarding at 15:30 pm, push off at 18:00

13 Feb - Entered the Drake Passage just after midnight with a surprisingly placid condition; sightings included Southern and Northern Royal and Wandering Albatross - the three largest seabird species on earth. Cape Petrels and Giant Petrels were seen soaring the southern skies around the expedition ship. Expedition director assistant, Gwen Noda conducted brief for the image makers on the image collection and assessment criteria for the Elysium project. Jonathan Shackleton, expedition historian recounts the early explorations of Antarctica - the first sightings in 1820 and the first landing in 1821.

14 Feb – Valentine’s Day & Chinese New Year Day crossing of the Drake; another placid day on the passage with sea temperature dipping to 2°C as the vessel cross the 60° S latitude - the Antarctic Convergence; entering Antarctic waters, in a region where subantarctic waters meet with the colder and denser waters. This is the biological limit of the Antarctic ecosystem and the edge of the distribution of krill the main food supply for the Antarctic birds and marine mammals. Project director defined photographic workflow and etiquette for the expedition and Goran expedition leader elaborates on equipment handling, routines and techniques for polar photography. Expedition principal scientists Cabell Davis and Steve Nicol gave an overview of ice, krill and plankton. First iceberg sighting was 17:05. Wildlife sightings of the day included minke whales and dolphins.





15 Feb - Melchior Island ($64^{\circ} 19' S$ $062^{\circ} 57' W$), & Danco Island ($64^{\circ} 44' S$ $062^{\circ} 37' W$), – as anticipated, we arrived at the Melchior Islands in Dallman Bay, on the west coast of the Antarctic Peninsula, around 07:00 hrs about 9 hours ahead of schedule. Humpback whales were sighted as we enter the area albeit an overcast day framed by the ice-capped Anvers and Brabant Islands. In the middle of the bay are the Melchior Islands a group of small ice capped rocky islands. Underwater team members conducted familiarisation dive determining weighting and dealing with the inevitable leaky glove while the other expedition member investigated the bay environ comprise of icebergs, bergie bits (tiny bergs) and growlers (smaller pieces of floating ice). Plethora lives are mostly singular Fur and Weddel seals, Leopard seals and small group of Crabeater seals. There were also small gaggles of Chinstrap penguins on ice floes. Bird life included were skuas, blue-eyed shags and arctic terns. The afternoon we crossed the Gerlache Straight to Danco Island in the southern part of the Errere Channel to survey a sizeable colony of Gentoo penguins. On route to Danco Island, Humpback whales, a dozen or so crabeater and leopard seals were sighted. Danco Island is a one-mile long island which lies a few hundred metres off the west coast of Graham Land - the Antarctic Peninsula. A team of underwater photographers ventured for the first underwater survey to find sea stars, brittle stars, sea urchins and nudibranchs while some members swam with leopard seals and Adelie penguins.

*Feb 15 is Ernest Shackleton's Birthday; born 1874 at Kilkea House, County Kildare, Ireland.



16 Feb - Lemaire Channel ($65^{\circ} 02' S$ $063^{\circ} 55' W$), Pléneau Bay ($65^{\circ} 06' S$ $064^{\circ} 04' W$). and Petermann Island ($65^{\circ} 10' S$ $064^{\circ} 10' W$). An early morning crossing the Lemaire Channel to Pléneau Bay; the 10km long channel is 1.3km across at its widest 600m across at the narrowest runs northeast to southwest separates Booth Island from the Antarctic Peninsula. Towering cliffs and ridges with icy peaks and ice falls rise on both side of the channel. At Pléneau Bay, the topside shooters documented the congregation of icebergs of varied size and form. Lone and small group of Crabeater and leopard seals sporadically were found resting on smaller ice floes. Here a few fortunate underwater photographer were able to interact with a couple of boisterous leopard seals underwater. The weather closed in as we continue survey on zodiac to find masses of krill were observed leaping from the water, getting out of the way of the zodiacs. The first Adélie penguins of the trip were spotted resting on a rock island. Petermann Island is the southernmost observation point on this section of the expedition is also home to the northern colony of Adélie penguins and the most southerly colony of Gentoo penguins as well as blue-eyed shags. When snow melts, grass and moss can also be found on the northern section of the island. Rain today; expedition principal scientist and senior scientist of the Australian Antarctic Division commented that in 25 years of surveying Antarctica, this is the first time he experienced rain.





17 Feb - Cuverville Island ($64^{\circ} 41' S$ $062^{\circ} 38' W$) & Paradise Harbour ($64^{\circ} 53' S$ $062^{\circ} 52' W$)

Morning landing on Cuverville Island to survey another Gentoo penguin colony; albeit report of decreasing numbers, recent counts confirmed that there are about 5000 mating pairs, the largest Gentoo colony in the region. Sighting also confirmed for Giant petrels, kelp gulls, Antarctic terns, sheathbills, brown skuas, and south polar skuas. Another interesting feature of the island is the presence of two plants, a moss and a grass, crucial indicators of warming weather. On a cold snowy windy afternoon, the expedition vessel sailed into Paradise Harbour; while the topside headed for Almirante Brown, currently and unmanned Argentine research station other team members survey the brash ice coverage, glaciers and a few did a wall dive to document a foliage of sea stars, nudibranch and sponges.





18 Feb - Astrolabe Island (63° 17' S 058° 40' W) After a 12 hour sail, on a cold sunny blue sky morning, the expedition vessel arrived at Astrolabe Island. Local denizens on the island are small colonies of Chinstrap and indication that we are now heading north of the continent. This is the day of leopard seals; three were located near an iceberg. The underwater team managed some close encounters with these seemingly ferocious animals of the southern ocean. At 16:50 hrs the expedition vessel arrived at Gourdin Island (63° 12' S 057° 18' W) near the entrance to the Antarctic Sound. Low pressure fog restricts visibility to about 30m. Underwater exploration was abandoned but the team made a short landing to find the island occupied by Gentoo, Adelie and Chinstrap penguins.

19 Feb - The expedition vessel attempted to sail through the Antarctic Sound to survey sea ice coverage around Paulet Island but was forced to turn back at Rosen Island due to sighting of dense sea ice coverage at about 0500 hrs. Morning was spent documenting tabular icebergs, migrants from the Weddell Sea, most likely the result of calving of the Larsen Ice Shelf. Landing was made again to Gourdin Island and the underwater team documented behavior of the Antarctic fur seals both above and below water. Out of ordinary behavior of a fur seal catching and killing an Adelie penguin was recorded. Plankton collection is underway; the VPR (video plankton recorder). Plankton holographic camera and plankton net are all ready to sample and record data from the Weddell Sea to South Georgia.



20 Feb: Elephant Island – landed at Point Wild ($61^{\circ} 06' S$ $054^{\circ} 52' W$) 0915hrs. Clear crispy blue sky morning, a rarity at Elephant Island heralded a successful expedition landing – a first for the all the seven Explorer Club members and expedition leaders. On the island are colonies of Chinstraps and Adelie penguins and several fur seals. Jonathan Shackleton, who has ventured to this area on several occasions and has had many of his landing attempts aborted, says that this is the best landing by far that he has had yet! We enter into the next phase of the expedition – a 60 hour sail to South Georgia. During this segment the focus is on plankton science – attempt to launch the VPR and plankton nets ten times





21 Feb: On route to South Georgia – plan to stop at South Orkney Islands aborted due to increasing wind and rough weather. The VPR and plankton net was again launch to find bucket full of salps with only a few larval krills.

22 Feb : Continued crossing of the Scotia Sea – weather calming allows the film team to start studio work. Two more plankton / VRP launch and documented larval krill of varied species including copepods, tomopterid worm and a Ctenophore jelly.

23 Feb: Arrived and landed at Grytviken (54° 17' S 036° 30' W) South Georgia; Aborted landing at Gold Harbour due to large swell but instead sail direct to Cumberland Bay. Jenny Johanssen became ill, diagnosed with kidney stone which also required medical attention at the medical facility at Grytviken. Fur seals, elephant seals, King penguins, Skus were documented along the bay. Entire expedition team gathered for a memorial at Ernest Shackleton's grave, toasting with Jamesons Irish whiskey.





24 Feb: Snowy morning and landing at Fortuna Bay ((54° 08' S 036° 47' W); Easy landing on a pebbly beach to find King Penguins, elephant and fur seals; a 500m walk to find a huge colony of King Penguins beneath a mountain range. Among the endemic animals are Reindeer, the only surviving animals from whaling era. A dive was made and documented nudibranch, crustaceans and playful fur seals. Jonathan Shackleton led a team of explorer member through the last segment of Shackleton's crossing in 1915. Afternoon landing at Jason Harbour (54° 13' S 036° 36' W); this crescent beach is to find a group of moulting King Penguins, fur and elephant seals resting on tussock grass.





25 Feb: Overcast morning landing at Salisbury Plain (54° 03' S 037° 19' W) The plain is home to the second largest colony of King Penguins – average of 200,000 mating pairs. While the penguins are dominant, young fur seal pups are found in huge number along the foreshore. Second morning stop is at Prion Island (54° 02' S 037° 17' W) to document the nesting Wandering Albatross. Final dive for the expedition was at Prince Olav Harbour (54° 04' S 037° 10' W). Huge swell restricted underwater exploration but a group persisted to capture images of fur seals in the swell.





26 Feb: First day crossing the Southern Sea. While there are substantial swells, the seas were calm. We passed Shag Rocks late morning, and everyone was up on deck to enjoy waves breaking dramatically on the rocks. One wave also broke over the bow of the Professor Molchanov, soaking those lined up along its edge, observed from above and captured in a photo (just prior to impact) by Ernie Brooks. The bird life included shags and both Wandering and Black-Browed Albatross. During the plankton sampling session when the ship slowed and the “gismo” and net were lowered, it didn’t take long to be surrounded by albatross, apparently conditioned by fishing boats to expect a free snack. There were a few humpback whales and dolphins to be seen in the distance, and we came extremely close to two Southern Right Whales—close enough that we were worried that we might hit one. As we are back in transit phase, lectures are back on the program. Jamie talked about whales and Michael Aw gave a beautiful presentation of “The Story Behind the Pictures”.





27 Feb to 1 March: Dr. Saw Huat Seong, chief medical officer dispensed Scopalamine patches to 13 people, 22 patches in all (one person needed 5), and 12 people have asked for seasickness pills. This, of course, does not include those who brought their own medication. We were not affected by the Chilean earthquake and tsunami, but we are heading into a low-pressure system. Winds picked up and soon are into Force 11 – that is hurricane force; at one stage we hit 45 knot winds and 12 meter swell. Due to the storm, we are behind schedule, and expect to arrive in Ushuaia sometime late 2 March afternoon, causing a large number of team members to miss flights out of Ushuaia.



7. Elysium Underwater Shoot Summary

There are 32 divers and snorkelers on the expedition guided by veteran ice divers Goran Ehlme and Peter Szyszka. Most of the team members are photographers or videographers who joined the expedition to make images that capture the Antarctic seascape and what it feels like to swim under the ice, through a kelp forest or face to mask with penguins, leopard and fur seals. The water temperature averages -1 degree C so the gear list is long and specialized: dry suits, multiple layers of underwear, the on going dilemma of dry versus wet gloves, and twin regulators on separate air feeds in case of ice induced free flow. We assembled into four dive teams that operated out of a specialized pod anchored on the aft deck. We kicked off with a checkout dive at Melchior Island where fine tune adjustments were made and everyone slowly got used to operating small knobs on underwater housings with giant gloves. Working the cameras in ice water with gloves is quite like using your cell phone with boxing gloves in a bathtub filled with ice cubes. We pushed into peninsula waters prepared for morning and afternoon shoot with just enough time in between to eat, dry out, swap batteries and memory cards and warm up before the next zodiac departure. At Danko Island we scouted leopard seals resting on small floes and rolled off the boat moving like human icebreakers through thick brash ice trying to protect the big glass domes on the cameras. In the "Iceberg Graveyard" at Pleaneau Bay divers descended down the sides of stable icebergs that resembled giant glass sculptures with slick and sinuous curves. We made our way to Cuverville Island below a small gentoo penguin colony where a few divers descended deep to find the kelp fields that lie beyond the ice scoured bottom while others submerged themselves at the shoreline waiting for penguins to leap into the water in front of their lens. In the wind driven waters of Paradise Harbour divers slid down steep vertical walls draped in burgundy colored kelp that hid orange anemones, starfish, nudibranchs, skittering amphipods and sea spiders

Our last scheduled dive in peninsula waters was Astrolabe Island on the exposed side of Bransfield Strait where squadrons of leopard seals shifted their focus from penguins to chase from camera to camera mouthing the domes in mock aggression, and peering curiously into masks. Turned back from Paulet Island we returned to Gourdin Island to scout for the holy grail of images: leopard seal predation on penguin chicks. No leopard seals in sight we rolled in with rowdy fur seals and a quirky game of underwater tag. Gear was stowed for the final push to South Georgia. Visually speaking, South Georgia Island is more about topside wildlife than about diving. Nutrients from penguin and seal colonies run off the island creating pea soup visibility – actually there is probably better visibility in a bowl of pea soup than waters near the Salisbury Plain king penguin colony. Desperate for one dive on South Georgia we made our way to Prinz Olaf Harbour, a small kelp filled bay loaded with fur seals. A big swell pushed and pulled us across the bottom like rag dolls and we quickly gave up the idea of making a single image. One by one, divers surrendered to body surf the big waves with a tumultuous crowd of fur seals. It was hard to tell human from seal, or who was having more fun crashing into the other in the powerful waves.





8. Executive Summary

The Antarctic Peninsula is one of the most rapidly warming parts of the planet and this is evident from many scientific studies that have documented the changes in terrestrial and marine life, the reductions in sea ice, the collapse of ice sheets and shelves and the increases in the air and water temperatures. During the Elysium Project we were able to witness many of these changes and observe, first hand, how this spectacular part of Antarctica is being affected by the past and present activities of humankind.

Warming is evident in the moistness of the air in this area of the world's driest continent. Rain is now not uncommon and whilst this may encourage plant life, it is probably detrimental to the health of many of the breeding birds which get damp and cold. This moistness also results in more snow falling and this too can affect the breeding habits of nesting birds when it falls during their incubation period, burying their eggs in cold snow. At Peterman Island, we saw penguins soaked by the rain, and this is a location where the more northern gentoo penguins are increasing in numbers at the expense of the Adélies which are more suited to colder conditions.

The snow algae appear to be thriving in the moist conditions staining the drifts and banks of snow green and red. These unicellular plants benefit from an unusual cycle that involves transfer of nutrients from their cousins in the ocean by an indirect route. Algae (phytoplankton) are the grass of the sea and form the basis of the food web. Krill graze on these plants and the summer production in the ocean supports a vast population of these swarming crustaceans. Penguins, in particular, feed voraciously on krill in the summer months and return to feed their chicks on land. The waste generated by these vast colonies is rich in nutrients from the sea and fertilizes the surrounding soil, rock and snow benefiting the algae that grow in this normally barren environment. At South Georgia, where the conditions have always been more temperate and moist than those at the Peninsula, there is a greater variety of endemic land plants, including herbs, grasses, mosses, lichens and algae.

Everywhere we went we saw penguins: gentoos, Adélies, chinstraps and Kings. In Shackleton's day, penguins would have been abundant too and they provided one of the staples of their diet during their ordeals. In some areas of the subantarctic, king penguins were killed for their oil in the early years of the 20th century. Interestingly, one of the first conservation victories in the Antarctic region was the prohibition of harvesting of king penguins on Macquarie Island in the 1920s, some 50 years before serious conservation measures were adopted for other species. Scientific studies have indicated that there have been shifts in the distribution of penguin colonies through the Peninsula region. The ice-loving Adelie penguins appear to be losing their grip on the more northern areas and may be consolidating in the south. Gentoo penguins, on the other hand, seem to be moving further south as the sea ice declines, taking over areas where Adélies previously bred. Both species feed on krill but gentoos may be more adaptable and can also feed well on fish. We have seen evidence of these changes, with visits to the most southern breeding colony of gentoos at Peterman Island which was booming. This year the penguins appear to be feeding well, with mostly fat chicks and plenty of evidence of abundant krill in the pink-stained guano. Krill, however, are known to suffer from population cycles and can be highly abundant in one year and virtually absent in others.

The most obvious seals around the Antarctic Peninsula have been the crabeater and the leopard, though Weddell and fur seals were also seen. Crabeater seals are the most abundant seal on earth and are likely to be present in the millions around Antarctica. They feed almost exclusively on krill and the ice floes on which they rest are frequently stained red with their krill-rich faeces. Because they are so widespread, they occur in the pack ice zone right around the Antarctic continent, it is difficult to estimate whether their population is growing or shrinking. Most recent studies suggest that there are perhaps fewer crabeater seals than had been previously thought (50 million) but that the population does not seem to be experiencing a significant boom or crash. Leopard seals are one of the top predators in the system and should be a good indicator of the health of the whole ecosystem. Leopard seals are versatile feeders and probably feed mainly on krill, merely augmenting their diet with young penguins during the breeding season. We had no difficulty in finding leopard seals and most appeared to be fat and healthy, though they appeared more common in the Peninsula region, than in South Georgia.

Our landing at Elephant Island was notable for the presence of fur seals at Wild Point. When Shackleton and his men arrived there, there would have been none; these islands were stripped of their fur seal populations in the 18th and 19th centuries and are only now beginning to recover. The epicentre of their recovery is South Georgia and here the beaches were jumping with the boisterous pups and the more surly adults. Last year, apparently, there was little krill in the waters around South Georgia, resulting from an intrusion of warmer water from the north and many predators at South Georgia failed to breed successfully. This year, researchers told us, the krill came back in November and the evidence was there in the large number of healthy seal pups.

It was encouraging to encounter whales in our travels. The great whales are now protected but are recovering from the massive exploitation of last century. The humpbacks appear to be making the most rapid comeback but fin whales are definitely more abundant in recent years. Unfortunately, the largest of the whales, the blue, is still in low numbers and its recovery is still uncertain.

The sea ice in the Peninsula region has been shrinking over the last 20 years. This means that there is less sea ice in winter, and the winter sea ice season is shorter; most of the region is free of sea ice in summer. We observed little sea ice although this might be expected at this time of year. Our intended visit to Paulet Island had to be curtailed because of pack ice at the mouth of the Weddell Sea – this is not unusual, the clockwise circulation in the Weddell Sea tends to bring pack ice and icebergs northwards along the eastern Antarctic Peninsula, as Shackleton found to his peril.

The glaciers draining the ice caps of the islands and the mountains of the peninsula are shrinking too. This has resulted in the formation of more icebergs and a greater run off of freshwater. We were able to hear the thunderous calving of icebergs and the rumble of avalanches which were witness to this process. It is thought that the greater freshwater runoff as a result of melting glaciers and ice sheets has affected the plant communities that grow in the waters of the western Antarctic Peninsula. This shift at the base of the food chain may well affect the herbivorous animals that depend on the phytoplankton and this in turn may affect the larger animals near the top of the food chain.



On several occasions we saw krill flitting around amongst the bergs near the Peninsula. Krill are the dominant herbivores of the Southern Ocean and feed the teeming masses of seabirds and seal, and the recovering populations of great whales. It was originally thought that once the great whales were almost eliminated, the krill population would boom, freed from a predation pressure estimated to be around 150 million tonnes a year. This increase was never observed, nor did the other krill eating predators seem to increase massively which suggests that the Southern Ocean ecosystem is not as simple as was first thought. There have been reports of huge declines in the krill population in the South Atlantic over the last 3 decades but there has been little evidence of a similar decline in the animals that feed on krill – most of the seals, penguins and whales. This suggests that the decline, if it has happened, may be not quite as dramatic as was first suggested, or that the changes observed are a result of changing distribution or behaviour.

We started seeing salps in the waters around Astrolabe Island and continued to see them in the water all the way to beyond Elephant Island. Salps are gelatinous herbivores that occurs generally more northern waters. Finding salps means that there is not much phytoplankton in the water and they seem to be moving south as the oceans warm. It was noticeable that where we found salps the divers reported good visibility, and that where there was poor visibility, hence more food in the water, there were no salps. Our scientific sampling also revealed an abundance of smaller herbivorous marine crustaceans, copepods, which are also a major consumer of phytoplankton and which are consumed by fish and krill. The balance in the herbivorous elements of the food chain determine the types of larger animals that can be supported by the ecosystem, and there are suggestions that the system is changing from one that supports krill and its predators to one that may result in more fish and possibly squid.

South Georgia was a highlight of the expedition because of the abundance of wildlife – and the reminders of the wildlife that once flourished in these waters. The abandoned whaling stations at Grytviken, Stromness and Prince Olav Bay testify to the industrial scale of the slaughter of the largest populations of the most massive animals that have ever inhabited the planet – the fin and blue whales. At South Georgia we also encountered introduced species and such introductions will become more common with climate change as the Antarctic becomes a more hospitable place to live for plants and animals. Most conspicuously, reindeer roam the hillsides but probably more damaging are the rodents that have infested the inhabited and wilderness areas since sealers first arrived. Plants too have arrived accidentally and dandelions and other weeds were seen emerging between the native grasses and mosses.

Man-made structures were evident in several places ranging from abandoned whaling stations to scientific research stations although in most cases there was little evidence of habitation or science. Significantly, the habitation at King George Point in South Georgia is now largely devoted to servicing the needs of fisheries management rather than basic science, a reflection of the growing importance of the fisheries for krill and fish. Although early attempts to catch fish were made from the whaling stations, the harvesting of fish and krill only began once the whale stocks were exhausted. Shackleton was unlikely to have been offered fresh fish when he eventually reached Stromness.



Arriving at Stromness the exhausted explorers would have noted the wheeling flocks of seabirds: gulls, petrels and skuas. These birds fed on the offal from the whaling operations and their numbers apparently skyrocketed. Indeed, there were concerns raised over the fate of these birds once whaling stopped. Nowadays the birds are actually more in peril from harvesting operations and albatrosses and petrels have been dying in their tens of thousands on the hooks of longliners. Although the problem of seabird bycatch has largely been solved in Antarctic waters, these wide ranging birds are still being caught in vast numbers in more northern waters. Some populations of albatrosses and petrels are thus in a sharp decline. When we stopped for scientific work near Shag Rocks, the boat was surrounded by albatrosses and petrels, obviously educated to view stationary vessels as a potential source of food.

In his boat trip Shackleton would have been overjoyed to see evidence of a ship. Even twenty years ago a ship in this area might see no others for months on end; this has changed recently. We saw numerous ships as we sailed through the islands and channels off the Antarctic Peninsula and at one point there were four in view. These vessels range from large cruise ships to small yachts and although there must have been fishing and research vessels in the area, we saw none. Increased vessel traffic brings with it the risks of pollution, but it also provides an opportunity to educate passengers about the threats and challenges faced by the Antarctic region.

Change was all around us on the Elysium Expedition; some of it good, some unfortunate and some of uncertain effect. Ecosystems are naturally subject to change and ecosystems in extreme environments such as the Antarctic often fluctuate greatly as a result of natural cycles. Single visits to a region can mislead and all observations need to be put in the context of the cyclical changes that are known to affect the region. For example, the 2008/09 summer at South Georgia was known to be unusual with warmer waters and so little krill that the fishery was forced to relocate to the South Orkneys. Such perturbations are known to naturally occur every decade or so, but there are suggestions that the periodicity of such events may alter as the waters warm. In comparison, the 2009/10 season appears to have been more typical of the average conditions providing evidence that the ecosystem can recover rapidly. The animals of the region are often long-lived and their populations are evolved to cope with the occasional breeding season failure. There are concerns that if poor breeding seasons become more prevalent then populations of the marine-dependent species may go into decline. Some of the changes that are occurring in the Antarctic region are manageable – the harvest of fish and krill is subject to quotas and these can be altered in response to the changes in the ecosystem. The recovery of whales is also dependent on the moratorium on commercial whaling and the prospects of the great whales reaching anything like their former numbers is only likely if the moratorium is maintained. Some changes, however, are caused by events outside the Antarctic and are far more difficult to address. How the Antarctic ecosystems will cope with the effects of a warming, more acid ocean is subject to much scientific research, but the solution to these problems will come from the political world rather than from the realm of science. During the Elysium expedition we saw a wilderness that is still magnificent; it has been radically altered since Shackleton's time and it faces the prospect of still more dramatic change. Hopefully our mission to document the changes – good and bad – that we have observed will help to raise awareness so that the Antarctic region can continue to be a source of awe and wonder for future generations.





*The science on this expedition is focused on the plankton of the West Antarctic Peninsula (WAP) and how it is being impacted by climate change. The term plankton refers to the organisms in the ocean and freshwater which are carried about by water currents. Nearly all species living in the ocean are plankton for at least part of their lives, including the eggs and larvae of all the familiar forms like crabs, fish, starfish, krill, etc. Krill in particular are the dominant food source in the Southern Ocean, and the WAP is thought to be a primary source area for krill, but the connection between the WAP and downstream areas has not been verified. In addition, it is thought that the jelly animals called salps are becoming more abundant in the Southern Ocean due to global warming and are displacing the krill, changing the ecosystem. We collected krill and salps in the WAP and South Georgia and froze them in liquid nitrogen for later DNA analysis, which will tell us whether the populations in these two areas are connected. We also used optical imaging systems (the Video Plankton Recorder and a holographic plankton camera) to measure fragile plankton and marine snow, organic particles that may be food for krill. We were able to collect samples, optical data, and environmental data at six stations and will analyze these data upon our return to shore to determine how the krill, salps, fragile plankton, and marine snow are related to each other and to the environmental variables. The experience of working with the diverse talents on board, including artists, photographers, and cinematographers for this outreach effort has been particularly valuable and will help shed light on the beauty and fragile nature of the Antarctic ecosystem and how it is being impacted by climate change.



9. Elysium Science - Sampling Plankton and Marine Snow

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Abstract

The productive shelf of the Western Antarctic Peninsula (WAP) is thought to be a major source of krill (*Euphausia superba*) in the Southern Ocean, with their populations carried downstream into the Scotia Sea by the Antarctic Circumpolar Current (ACC). This downstream region, the so-called Atlantic sector, contains the bulk of the krill population in the Southern Ocean and is being impacted by climate change. The observed warming in this region has coincided with a reduced krill population and a concomitant expansion of salp (*Salpa thompsoni*) populations. Extensive studies have been done examining the physical/biological processes controlling krill and plankton populations within the WAP itself (e.g., SO GLOBEC, and SO LTER), but less is known of the fate of these populations once they leave this area. A recent modeling study suggests that krill populations originating in the WAP could potentially provide source populations for South Georgia and downstream areas along the Antarctic shelf, but that the amount of food available to sustain the krill during this transit is insufficient for survival, unless marine snow is also available as a food source. Prior studies have not measured marine snow abundance in this region, and more generally little is known about the abundance of fragile plankton in the Scotia Sea, as prior collection methods have involved use of destructive net or bottle sampling.

As part of the Elysium expedition, we sampled plankton and marine snow on both sides of the Scotia Sea near Elephant Island and South Georgia. We used 1 m ring net (150 μ m mesh) together with a Video Plankton Recorder at six stations to sample krill, salps, and other plankton and marine snow. These samplers were deployed together with a CTD/fluorometer on the same casts to measure abundance and biomass of plankton in relation to marine snow and hydrography. A portion of the net samples were frozen in liquid nitrogen and sent to the Census of Marine Zooplankton for DNA barcoding of the plankton and for genetic composition of the salp and krill populations to determine the degree of genetic similarity of populations across the Scotia Sea. The VPR images also serve as photo-documentation of the planktonic environment.



Introduction

The productive shelf of the Western Antarctic Peninsula (WAP) is thought to be a major source of krill (*Euphausia superba*) in the Southern Ocean, with their populations carried downstream into the Scotia Sea by the Antarctic Circumpolar Current (ACC) (Fig. 1, Tynan et al. 1998). This downstream region, the so-called Atlantic sector, contains the bulk of the krill population in the Southern Ocean and is most impacted by climate change (Fig. 2). The observed warming in this region has coincided with a reduced krill population and a concomitant increase of salp populations. Extensive studies have been done examining the physical/biological processes controlling krill and plankton populations within the peninsula region itself (e.g., SO LTER and SO GLOBEC; Smith et al., 1995; Hoffman et al., 2004), but little is known of the fate of these populations once they leave this area. A recent modeling study (Fach et al., 2006) suggests that krill populations originating in the WAP could potentially provide source populations for South Georgia (and downstream areas along the Antarctic shelf), but that the amount of food available to sustain the krill during this transit is insufficient for survival, unless marine snow is also available as a food source. Prior studies have not measured marine snow abundance in this region, and more generally little is known about the abundance of fragile plankton in this region, as prior collection methods have involved use of destructive net or bottle sampling. Although microsatellite DNA markers are being developed for *E. superba* from the WAP, the genetic similarity with downstream populations is not known. Similarly, little is known of the genetic composition of *Salpa thompsoni* in this region.

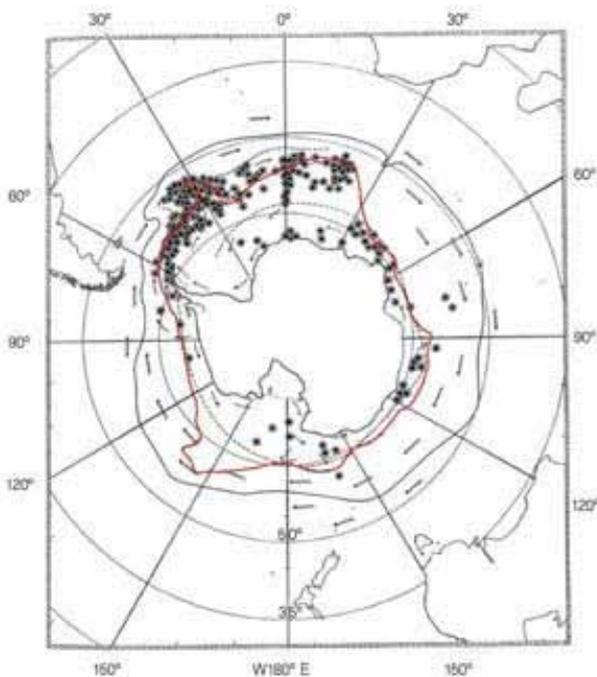


Figure 1. Krill distributions downstream of the West Antarctic Peninsula (circles = principal concentrations of krill) (from Tynan et al., Nature, 1998).

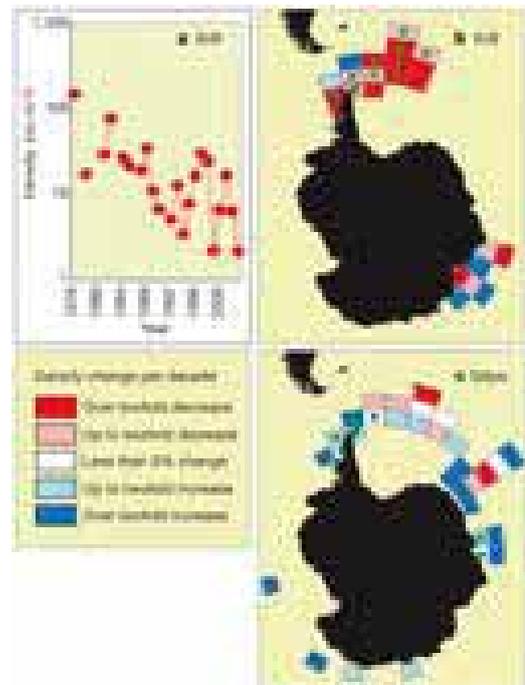


Figure 2. Regions of krill declines and salp increases in the Southern Ocean from 1976-2003. (from Atkinson et al., Nature, 2003).

Methods

We sampled fragile plankton and marine snow on both sides of the Scotia Sea using non-destructive optical imaging (Digital Autonomous Video Plankton Recorder, DAVPR). We also made a test deployment using a digital holographic imaging (DHI) camera. This optical sampling was done together with traditional net sampling of krill, salps, and other robust plankton. The DAVPR is an underwater video microscope that images plankton and particles in the size range of 100 μ m – 1 cm. It is a self-contained, battery powered system that is attached to a stainless steel frame (Fig. 3). The DAVPR system includes a color video camera with magnifying optics, a xenon strobe (8" ring-illuminator), a Seabird SBE-49 FastCat CTD, and a Wet Labs fluorometer and turbidity sensor (ECO FLNTU). The DAVPR with its frame weighs 125 lbs (56 kg) in air (95 lbs in water, 43 kg) and has dimensions (LxWxH) of 52"x31"x15" (1.3x0.77x0.38 meters). Data are stored on a removable hard drive which is detached upon retrieval and the data uploaded to a computer for processing. The VPR has been described extensively elsewhere (Davis et al, 1992a,b, 1996, 2004, 2005; Hu and Davis, 2006; Davis and McGillicuddy, 2006).

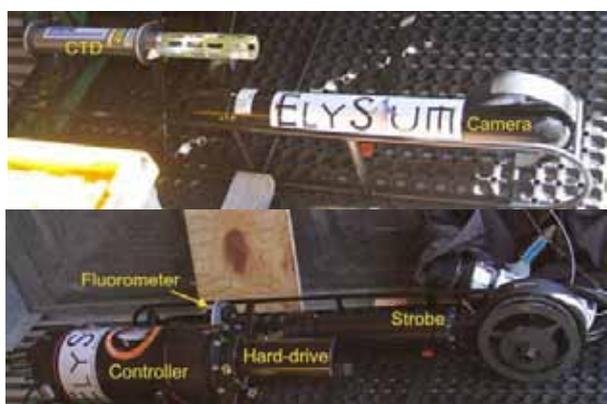


Figure 3. Color Digital Autonomous Video Plankton Recorder (DAVPR). System consists of a strobed ringilluminator, a digital color camera with magnifying optics, a CTD, fluorometer-turbidometer, a control unit for power distribution and data acquisition/storage, and a removable USB hard drive.

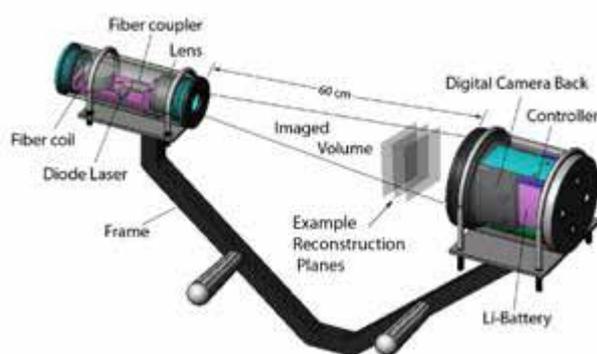


Figure 4. Digital holographic camera consists of a digital camera back, controller, fiber coupled diode laser, and a mounting frame. The holocamera images plankton particles in the size range of 0.1-36 mm in a digital sample volume of 300ml.



The holocamera consists of a 60 mW 658 nm fiber-coupled diode laser and a digital camera back (Fig. 4, Loomis et al. 2007) and weighs ~15 lbs (6.8 kg). The DHI camera as configured took a hologram every 3 seconds during each deployment. The holocamera samples a volume of 300ml per hologram, and high resolution images of plankton within this volume are extracted. The VPR images and holograms were downloaded to a computer on the ship, and rapid analysis software and hardware was used to process the video and holograms and extract images of plankton at sea (Davis et al., 2004; Li et al., 2007). We currently are manually sorting a subset of the images to develop a training set of images and will use our existing image identification software (Hu and Davis, 2006) to automatically classify the remaining images.

Plankton net tows were made using a 0.5m diameter ring net (150"m mesh) in hauls to depths of 148-216m, depending on the station. The DAVPR, net, and holocamera were deployed together during a test cast and at the first station. It was realized during these first deployments, that the hologram images were contaminated by the DAVPR strobe light, so the holocamera was not used at subsequent stations. For each deployment, we attached a cargo lifting strap to the aft end of the DAVPR frame and shackled it to the end of 300m of 3/8" nylon (Yalex) rope. We then launched the DAVPR using the capstan and crane. The Yalex line was fed from its source in a plastic fish tote on the deck, around the capstan (3 wraps), through a fixed cargo block at deck level, and through a second cargo block on the end of the crane boom, then to the attachment point on the DAVPR. During launch, the articulating crane boom was "knuckled down" to minimize the amount of line between the DAVPR and the tip of the crane boom. The DAVPR then was lifted up and over the side, steadying it with a tag line. The crane, capstan, and deployment operations were located on the starboard side of the fantail. Once the DAVPR was in the water, Yalex line was paid out until the attachment loop (braided into the main line) for the plankton net reached chest level. Prior to launch, the flowmeter revolutions reading was recorded. The plankton net bridle then was hooked into Yalex loop and the crane boom was moved outboard 5m away from the ship. The time (GMT) and position (lat, lon) were recorded at the time the DAVPR entered the water using a handheld GPS. The DAVPR and net then were lowered using the capstan until 240 meters of Yalex had been paid out. The ship's crew had measured and painted marks every 10m on the line, and we counted 24 marks when paying out the line. During each cast, the ship was de-clutched and drifted with the wind pushing on the starboard side. It took a total of ~27-28 minutes per tow to pay out and retrieve the 240m of Yalex, lowering and raising the DAVPR/net, so the rate out and in was ~17.5 meters/minute. The maximum tow depth achieved depended on the drift of the ship and the drag on the Yalex line, but ranged from 148-216m. Upon retrieval, the plankton net was detached from the Yalex loop and the DAVPR then was brought on board, rinsed with fresh water, and secured. The time (GMT) and position were recorded at the end of the tow together with the plankton net flowmeter revolutions. The USB hard drive was removed from the DAVPR and taken into the ship for uploading to a computer. The plankton in the net was rinsed into a plastic bucket. The plankton bucket then was carried to the ship's bar/lounge where a sample processing area was set up, including a sink and microscope/sorting table. Specimens of krill and salps were removed from the catch and placed individually in 5ml plastic cryogenic vials and transferred to a liquid nitrogen Dewar tank. At some stations, large copepods (*Rhincalanus*) and hyperiid amphipods were also removed and frozen. Some individuals in the catch were photographed in an ad hoc manner by various photographers on board using SLR cameras and macro-lenses. An attempt was made to take photomicrograph using a Nikon coolpix camera mounted on a Wild stereoscope, but the quality of the images due to the ships motion was too poor to be useful. After removal of specimens for freezing, the remainder of the catch was concentrated using a sieve and placed into plastic sample jars and preserved in 5% buffered formalin for subsequent analysis at WHOI.

Results

Sampling was conducted at 6 main stations plus an initial test site (Fig 5, Table 1). The initial site (Station #0) was located near Gourdin Island and was used for testing the deployment/retrieval of the gear and to make sure the equipment was in proper working order. The original plan was to sample 10 stations equally spaced between Elephant Island and South Georgia but high winds prevented us from sampling across most of the central Scotia Sea. We were able to sample 2 stations on each side of the Scotia Sea and two on the west side of South Georgia toward Shag Rocks. Station 1 was occupied in the afternoon (1330 local time) of February 20 (following our morning landing on Elephant Island). Station 2, located 155 km northeast of station 1 (Fig. 5), was occupied in the evening of February 20 (2130 local time [February 21, 0030 GMT]). Stations 3 and 4 were sampled on February 22 and were located near South Georgia (Station 3 was 916 km from Station 2). Stations 5 and 6 were sampled after leaving South Georgia and steaming past Shag Rocks. Station 5 was 27 km west of Shag Rocks, and Station 6 was 153 km west of Station 5.

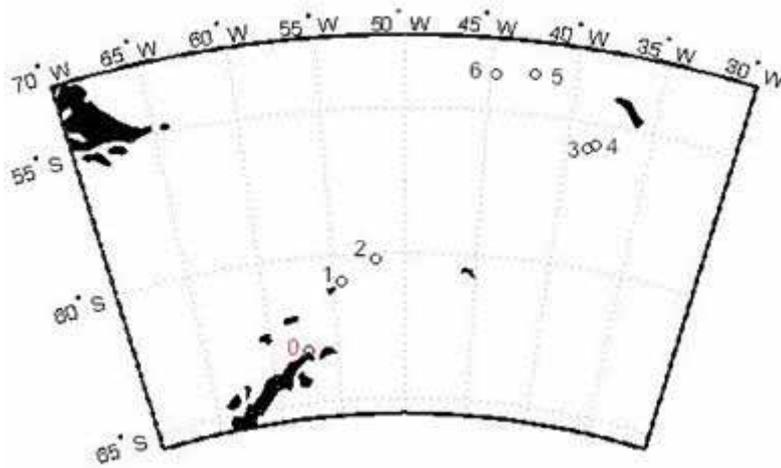


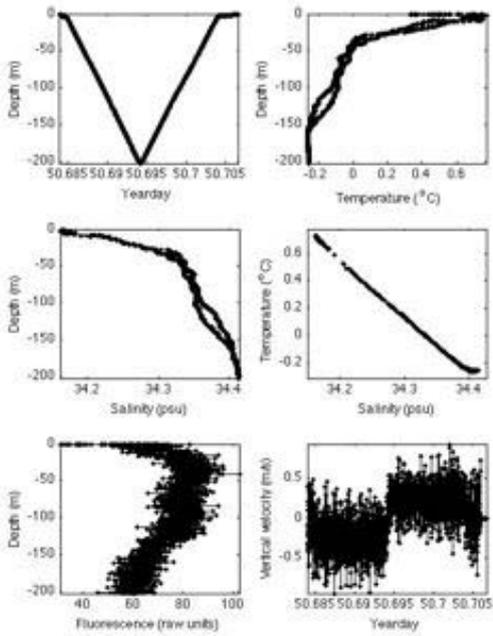
Figure 5. Positions of stations (open circles) sampled using the DAVPR and 0.5m ring-net. Station numbers (0-6) are also shown. Station 0 was used for equipment testing station.

Table 1. Station locations and sampling times.

Sta	Date (GMT)		Start Position		Time (GMT)		End Position							
	YYYY	MM	DD	Deg	Min	Deg	Min	Start	Bottom	End	Deg	Min	Deg	Min
0	2010	02	19	-63	11.640	-57	17.084	17:53:17	17:58:07	18:07:04	-63	11.640	-57	17.084
1	2010	02	20	-60	56.208	-54	25.122	16:24:50	16:39:19	16:53:34	-60	55.883	-54	24.861
2	2010	02	21	-60	12.829	-51	59.364	0:35:27	0:49:19	1:08:28	-60	12.155	-51	59.034
3	2010	02	22	-55	53.177	-38	44.055	21:13:55	21:28:44	21:46:48	-55	52.861	-38	43.738
4	2010	02	22	-55	43.857	-38	18.861	23:22:29	23:47:25	0:05:22	-55	43.434	-38	18.758
5	2010	02	26	-53	35.191	-42	25.814	15:04:00	15:18:26	15:36:11	-53	35.394	-42	25.737
6	2010	02	26	-53	43.944	-44	43.618	23:19:52	23:34:39	23:52:00	-53	44.022	-44	43.518

The environmental variables revealed a stratified water column at all stations (Figs. 6-8). At station 1, a shallow thermocline and halocline were observed, with water warmer than 0.0oC above 40 m and temperature decreasing to -0.2oC between 40-150m. Temperature remained at -0.2oC at 150-200m depth. A subsurface fluorescence maximum occurred at 40m. At station 2 the upper 50m was well-mixed (1.45oC), with temperature decreasing to 0.2 oC at 90-130m and decreasing further to 0.0 oC at 140m. Station 2 fluorescence was high throughout the upper mixed layer and decreased gradually down to 100m.

Station 1



Station 2

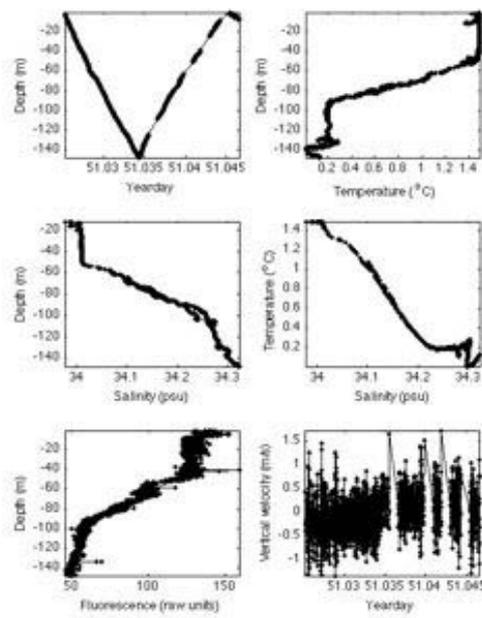
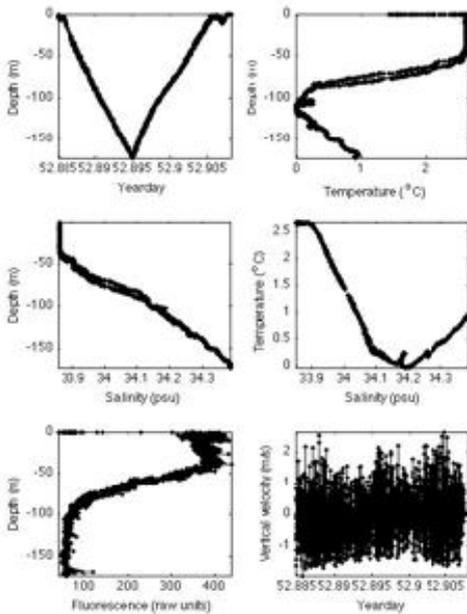


Figure 6. Environmental variables measured by the DAVPR at Stations 1 and 2 near Elephant Island. Panels for each station show tow profile, temperature, salinity and fluorescence vs depth, T-S plot, and vertical velocity of the tow.

Station 3



Station 4

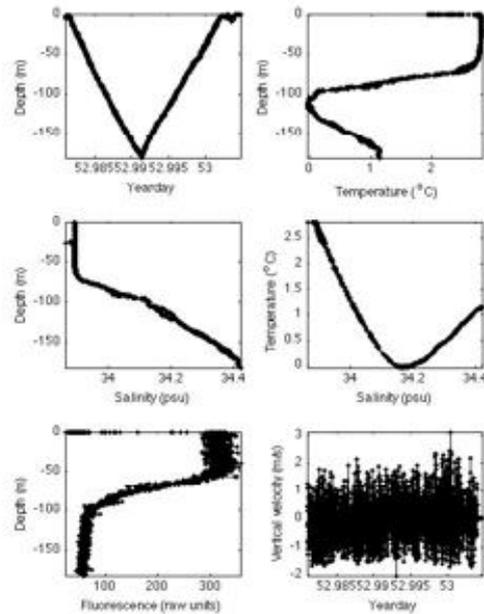


Figure 7. Environmental variables measured by the DAVPR at Stations 3 and 4 near South Georgia. Panels for each station show tow profile, temperature, salinity and fluorescence vs depth, T-S plot, and vertical velocity of the tow.

Station 5

Station 6

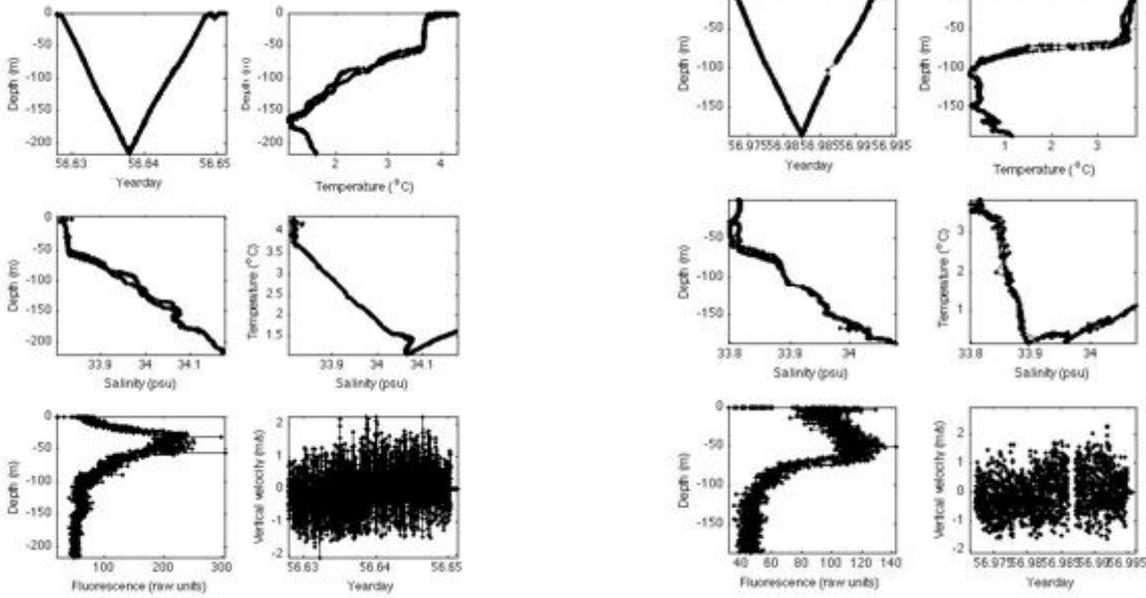


Figure 8. Environmental variables measured by the DAVPR at Stations 5 and 6 west of Shag Rocks. Panels for each station show tow profile, temperature, salinity and fluorescence vs depth, T-S plot, and vertical velocity of the tow.

Stations 3 and 4 were also stratified with temperatures near 3.0oC in the upper 50-60m, decreasing to 0.0oC at 100m and increasing again to 1.0oC by 180m. Salinity was constant at 33.85 in the upper 50-70m and there was very high fluorescence in the upper mixed layer at both stations. Stations 5 and 6, west of the Shag Rocks, had temperatures or 3-4 oC in the upper mixed layer (50-70m). Salinities were 33.8 in the upper mixed layer and increased above 34 psu below 200m. A strong fluorescence maximum was found at both stations at 50m. Plankton tows at stations 1 and 2 were dominated by salps and the fluorescence was much lower at these stations. A few krill were found at station 2. Both salps and krill were frozen for subsequent DNA analysis. Marine snow was observed at both stations. Stations 3 and 4 were extremely rich in large phytoplankton and marine snow. A few salps and krill were observed at these stations, but not *E. superba* or *S. thompsonii*. Stations 5 and 6 near Shag Rocks was also rich in plankton with large numbers of large copepods (*Calanus* and *Rhincalanus*) Example images from the 6 VPR tows are shown in Figures 9-14.

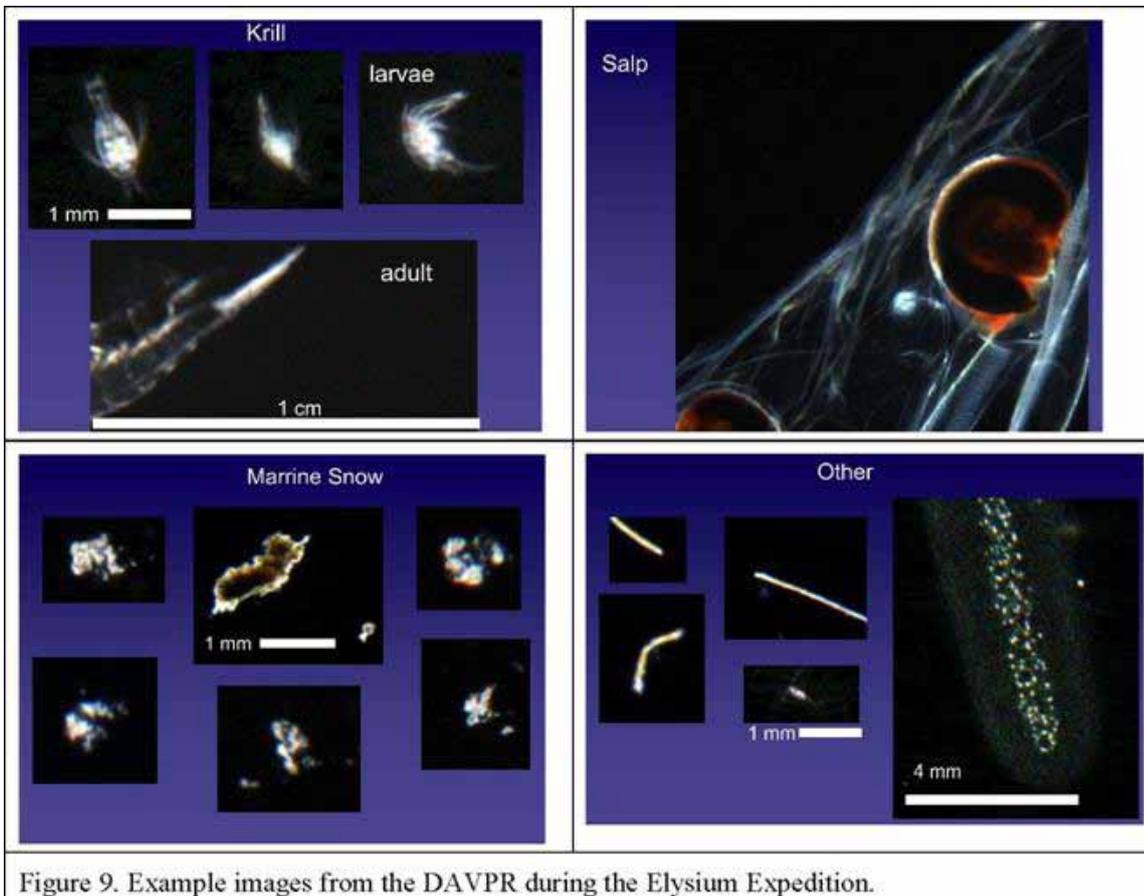


Figure 9. Example images from the DAVPR during the Elysium Expedition.

In summary, the cruise was successful scientifically in that we had an excellent science team who worked selflessly and achieved the main objectives, namely to collect krill and salps for DNA analysis and quantification of marine snow particles using optical imaging methods. The DAVPR worked well on every cast and the plankton tows yielded a rich assortment of organisms for subsequent laboratory analysis. Once fully processed the data from this sampling will provide estimates of abundance and biomass of krill and other plankton in relation to marine snow and hydrography. A portion of the net samples were sent to the Census of Marine Zooplankton for DNA barcoding and for genetic composition of the *E. superba* population in the WAP and South Georgia regions (using microsatellite DNA markers).

The science outreach activity on this cruise was excellent. The interfacing of scientists with photographers, cinematographers, artists, writers, and musicians was unparalleled. The forthcoming book and film will present our observations on the effects of global climate change on this fragile ecosystem. Our observations of high krill abundance in the WAP, is in keeping with the disturbing trend noted by Atkinson et al. 2004 that a climate-warming-related increase in salps is displacing krill in the Atlantic sector of the Southern Ocean. This sector represents the heart of the *E. superba* population in Antarctica. Our subsequent DNA and plankton enumerations will help shed new light on this problem and will provide new data that will lead to further more intensive investigations of this problem.

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