Project Description

The Heard Island Expedition

Discovering Life and Links in the Extremes

Version 6.3
8 Oct. 2015

Robert W. Schmieder, Ph.D.
Organizer/Expedition Leader

Cordell Expeditions
4295 Walnut Blvd.
Walnut Creek, CA 94596
(925) 934-3735
schmieder@cordell.org
www.cordell.org

THIS DOCUMENT

This document is a summary description of The Heard Island Project: Discovering Life and Links in the Extremes. The Project is centered on a scientific expedition to Heard Island, Territory of Australia, in the Southern Ocean, during Mar./Apr., 2016. The website for this project is www.heardisland.org.

Heard Island is a large (20x30 km, 368 km^2), subAntarctic island lying at 53°S, 73°E, nearly 1000 nautical miles from Antarctica and more than 2000 nautical miles from Africa and from Australia. It has a 2745-m active volcano, about a dozen fast-moving (and retreating) glaciers, (seasonally) large populations of seals, penguins, and seabirds, and extensive areas of mosses and grasses. While about 200 species of plants and animals are known from the island, estimates indicate that several hundred more species, mostly in the size range 0.1-10 mm, remain to be discovered. These missing species are a major part of the island's biodiversity; they are critical to our understanding of the extreme ecosystem.

One goal of the expedition is to discover and document the missing species in order to extend the known biodiversity of this extremely isolated, extremely severe ecosystem. A compelling reason for the expedition emerges from two facts:

- Heard Island has no recognized human-introduced species; and
- Heard Island is extremely sensitive to the changing global climate.

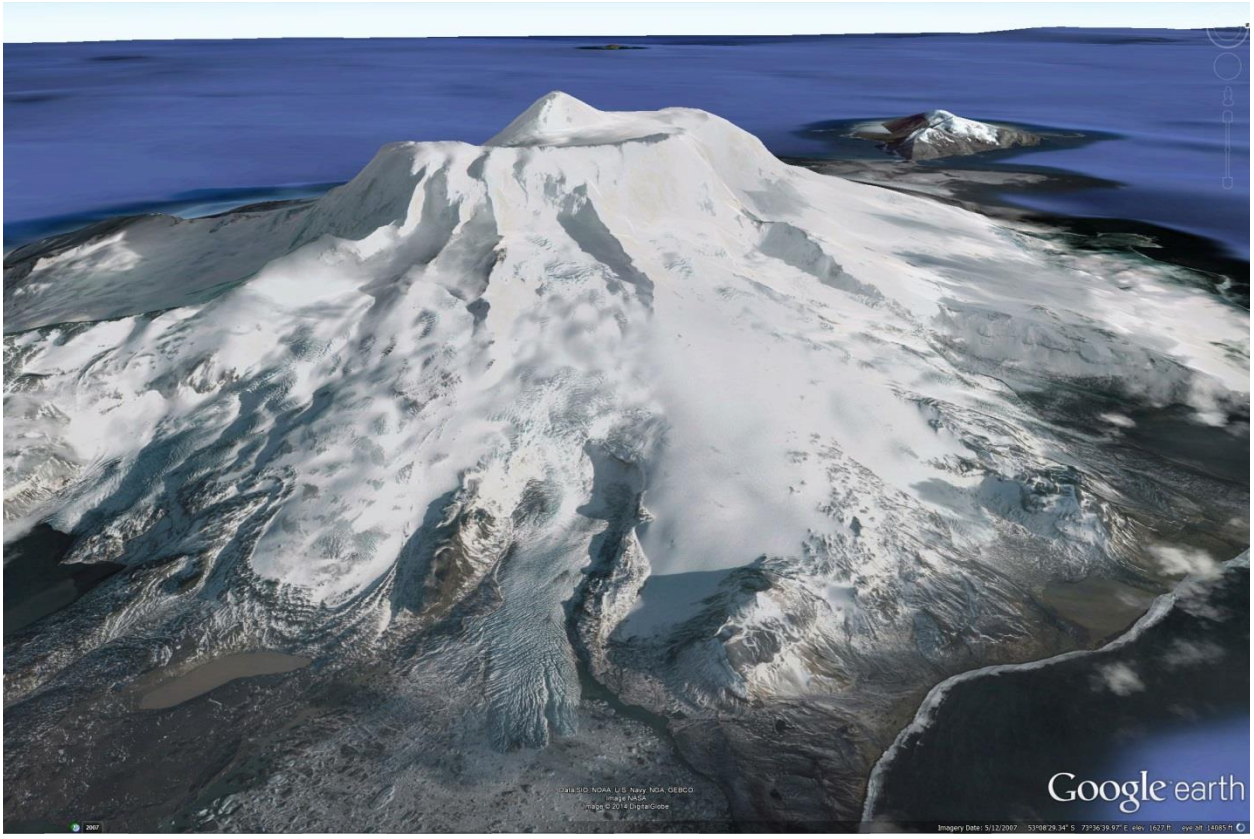
This fortuitous (and probably unique) combination offers a remarkable opportunity to separate the effects of natural climate change from anthropogenic effects: extension of the species list will enable more quantitative tests of the effects of global climate on polar regions. Thus, the first motivation for the expedition is to enhance our ability to predict and manage the future of the Earth's biosphere.

A second goal also derives from the extreme isolation of Heard Island: development, deployment, and testing of new communications technology for use in extreme, and extremely isolated, environments. One of the most effective means for obtaining communications data is amateur radio. Worldwide, about 3 million radio amateurs have licenses, and many of them have the ability to send and receive signals from very distant locations. What makes this interesting is that propagation of radio signals are only partially predictable from models; more data is needed to test and improve such models. Happily, radio amateurs are enthusiastic about making radio contacts with such remote locations, and consider it a sport; probably 50,000 stations will make a serious effort to contact Heard Island, once there is an active radio there. The two goals comprise the theme of the expedition: *Discovering Life and Links in the Extremes*.

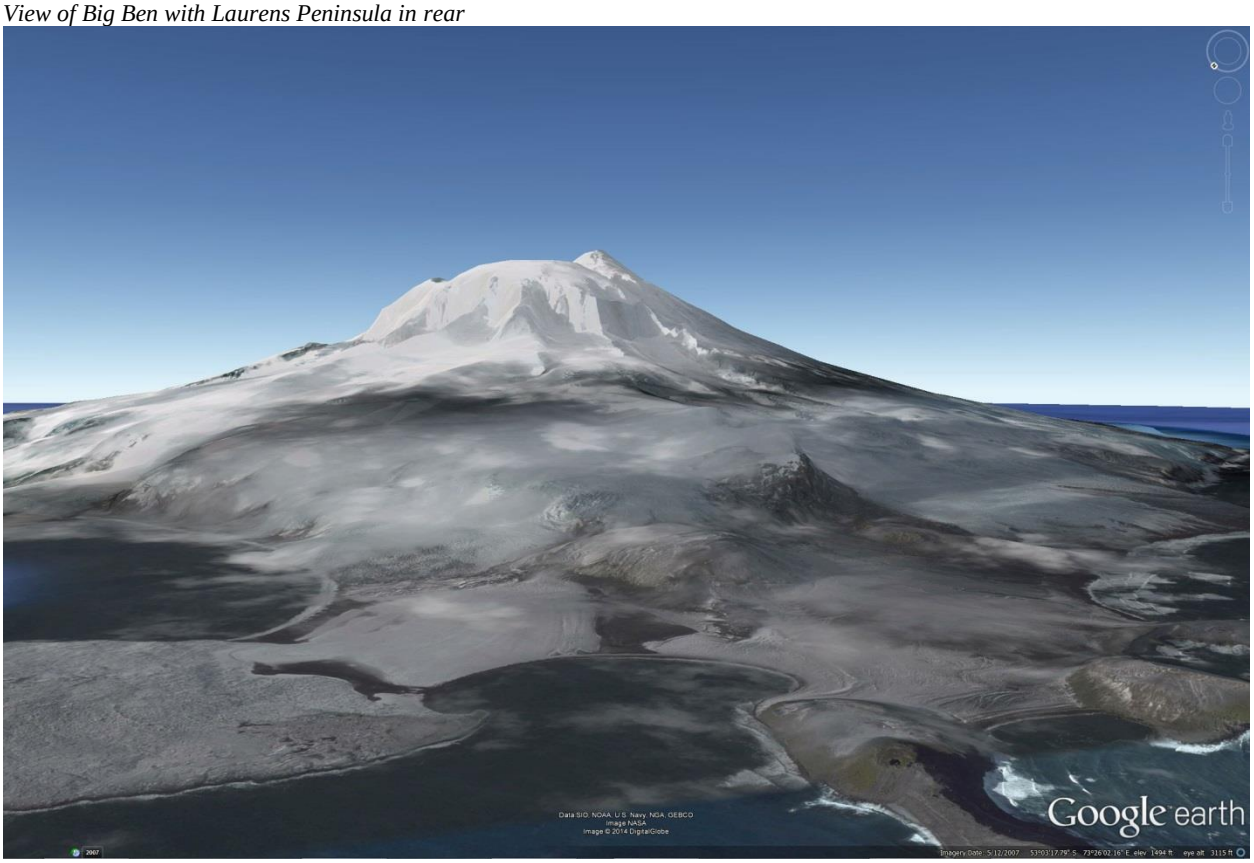
The project is being organized by Cordell Expeditions (CE), a private nonprofit scientific research organization located in Walnut Creek, California. Details about the organization are available at www.cordell.org. The 2016 Heard Island Project follows the successful 1997 expedition to Heard Island organized and carried out by Cordell Expeditions. Some aspects of the present project are similar to that project, in particular the extent of planning and preparation, the emphasis on safety and security of the island and its resources, and the extent of documentation. Details about the 1997 expedition are available in the book *VKØIR Heard Island*, which can be downloaded from the Project website.

Heard Island is managed by the Australian Antarctic Division (AAD), Kingston, Tasmania, under the Heard Island and Macdonald Islands (HIMI) Marine Reserve Management Plan of 2005 (revised to 2014). Cordell Expeditions is coordinating with the AAD and other appropriate agencies to ensure that the proposed activities conform to the requirements for visits to, and research at, Heard Island. For further information, please contact the Expedition Organizer/Leader.

CONTENTS



View of Big Ben with Laurens Peninsula in rear



Big Ben with Atlas Cove in the foreground

Images: Google Earth

A CONSPECTUS OF THE PROJECT

Life and Links in the extremes…

It has become common knowledge that we still don't know about all the plants and animals that live on the Earth: out of an estimated 10 million species, we know about only a quarter of them. Worse, the biosphere is so complicated that we don't have any accurate models for what happens when the global climate changes, or how an invasive alien species can disrupt an otherwise stable ecosystem, or what we should do to protect key organisms such as agricultural crops upon which our world economy and our very existence depend. This situation is a prime driver of our wider interest in life in the universe, exemplified by the rapidly developing fields of exobiology and astrobiology.

One fact has become abundantly clear in recent decades: life exists in the worst of places: in the dark abyssal depths, in boiling hot springs, in toxic chemical vents, in the absence of carbon-based nutrients and photosynthesis, in acids, in rocks, in vacuum, and maybe in the soil on Mars. In our quest for the limits of life on Earth, we are diligently searching for those special places where conditions are extreme: the sea floor, volcanos, glaciers, the Arctic and Antarctic, on islands, and in laboratories.

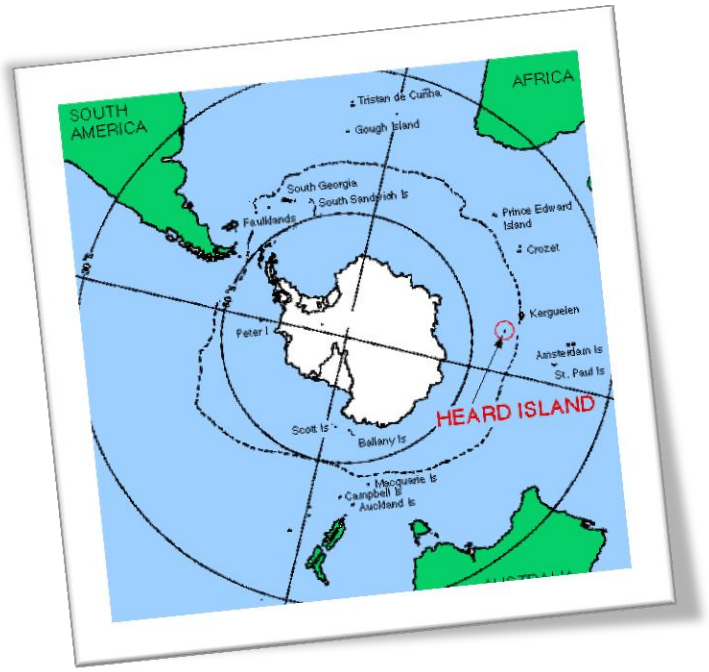
An encounter with Heard Island is an almost inevitable step in this quest. The island is located deep in the Southern Ocean, some 2200 nautical miles from the nearest continent and far from most other islands. It is 20 miles across, with a 9000-ft. high active volcano in the middle, covered with glaciers. Fumeroles vent hot toxic fumes from the high slopes, and some of the glaciers fall straight off the cliffs into the ocean. Violent winds whip up, down, and around the mountain, and across the relatively small treeless plains. It is a land of extremes: extremely windy, extremely hot and extremely cold, extremely dry and extremely wet, and extremely isolated. It is a good place to look for organisms capable of living in such extreme conditions: *Life in the Extremes*. But there is a second major reason to consider Heard Island: communications. At the high southern latitude of the subAntarctic islands, even satellite communications are marginal, and require special equipment and procedures. Propagation of radio waves to the island is only partially understood; the effects of the volcano are only now beginning to be modeled, but there is no experimental data to check the modeling. Thus, the second goal is to develop and deploy advanced radio communications technology, and gather data on its effectiveness: *Links in the Extremes*.

The Heard Island Project responds to this extreme opportunity: the plan is to put a team of scientists, technologists, and explorers on the island to search for unknown species of plants and animals, and carryout the advanced communications. The team will collect samples from the soil, from the wind, in the putrid downwash from penguin colonies and elephant seal excreta, in the carcasses and skeletons of dead seals and birds, in the ooze under lagoons, in glacial meltwater, and many other places. The communications effort will focus on quantitative measurements of radio signals, and accumulating as many radio contacts as possible in order to develop a large database from which meaningful statistical analyses can be made. Thus, the theme of the expedition: *Discovering Life and Links in the Extremes*.

All these activities (and more) will be carried out during the 3-week stay at Heard Island, scheduled for Mar./Apr 2016. Many of these activities will be seen on prominent internet sites and in social networking, in real-time. People worldwide will be able to interact directly with the expedition team, sending and receiving information, comments, and suggestions. The central theme of the Heard Island Project is to increase our understanding of the effects of *extreme conditions in extreme isolation*. The expedition seeks to make a significant contribution to our understanding of life and communications in the extremes, to understanding of the effects of climate change on biodiversity. That aspect of the project is fundamental to our understanding of the limits of life, and therefore our own future on Earth.

The romance of Heard Island

Heard Island could well have been conceived by Jules Verne. It's so remote that only a few hundred people have actually seen it. Fewer still have set foot there. Yet it is a storybook island. To get there, you have to sail across some of the wildest and most dangerous seas on Earth, across the Roaring Forties and into the Furious Fifties. Seas up to 50-ft. high may be part of the experience; it's not for the faint-hearted. The best bet is allocate two months for the journey. If you can you should take a helicopter; landing on Heard Island through the surf is challenging. Take a camera, and backup plans.



The island is 20 miles tip-to-tip, about half the size of Liechtenstein, with a titanic live volcano smack in the middle, smothered in glaciers that slip down it flanks at the dizzying pace of 0.00002 miles per hour. If you drop your watch in a crevasse near the top, the glacier would drop it in the ocean hundreds of years later. The weather is even worse than you can imagine. It's a mixture of Seattle, Chicago, London, and the South Pole. On an average day in the middle of summer, the sun shines perhaps 2 hours per day. It's so windy the flies don't have wings. With conditions as they are on Heard Island, it's a wonder *anything* lives there. But live there they do. You'll find the world's largest colony of King penguins, and heaps and piles of elephant seals. And a beautiful bird called (what else?) the Heard Island Cormorant, coming back from near extinction. For amateur radio operators, Heard Island is *the* most attractive target because…*almost always, there is nobody there!* For them, rarity equals desirability.

In a newly familiar irony, the features that make Heard Island so unattractive for tourists make it irresistible to scientists and explorers. But except for the 1947-53 and 2003 Australian scientific expeditions, there have been precious few visits and even fewer attempts to carry out comprehensive scientific studies. The mountain, aptly called Big Ben, has been summited only three times, and never traversed. Smoke and vapors can be seen issuing from vents on its flanks, but no one has ever seen them up close. Winds whip around the mountains, shedding giant vortices, modifying weather patterns for hundreds of miles. We are familiar with the worldwide explosion of oceanic plastic debris that is so devastating to wildlife, but we have practically no documentation of such threats in Antarctic islands. If that weren't enough, there are rare opportunities to witness the Centaurid meteors and the Aurora Australis.

About 300 species of plants and animals are known to live on Heard Island. But it's virtually certain that there are hundreds more, probably many of them in the organic outfall from tens of thousands of penguins, seabirds, and seals. The "little creatures" are a critical part of the composition of the ecosystem, its *biodiversity*. At present, we are unable to explain this diversity, due to major gaps in the inventory of organisms in the 0.1-10 mm size range. That's one of the reasons why we have to go there, to find out *what* lives there, *how* they live, and *why* they live there at all.

Motivations for an expedition to Heard Island

Why should we field an expedition to Heard Island? Why not another location that is easier to reach?

The simple answer is that *Heard Island is unique*. It is extremely sensitive to changes in the global climate and therefore it is a sensitive indicator of such changes. This suggests that monitoring the biodiversity on Heard Island could not only indicate the changing conditions on the island, but also give early warnings of global biological shifts. We will explain and support this assertion.

More than a decade ago, Walther, et al.,[1] described the global shift of populations. Quite generally, populations are moving poleward, both toward the Arctic and the Antarctic.[2] This movement is driven by both rising global temperatures and by human transport. On sub-Antarctic islands, it is estimated that more than 50% of the higher-plant diversity[3] and a considerable portion of the insect and mite faunas[4] are due to human introduction, but it is not obvious how to separate this portion from that due to natural causes.

This fact is arresting: Unlike the other sub-Antarctic islands, the biodiversity on Heard Island is entirely determined by natural causes, including the effects of global warming *but excluding human transport*. Normally, the complexities of interacting populations, especially those in competition, make it nearly impossible to separate the natural and anthropogenic effects on populations.[5] But Heard Island presents us with an extraordinary opportunity to separate these two major causes of global migration. Thus, simply monitoring the biodiversity at Heard Island may provide a powerful tool to help unravel some of the complexities of global climate change.[6]

The Australian Antarctic Division (AAD), which manages Heard Island, provides this statement:[7]

> The research undertaken on Heard Island … [involves] compelling science that cannot be undertaken elsewhere and takes advantage of Heard Island's location, its relatively undisturbed condition and its unique, unusual and dynamic natural features.

To emphasize the point: Heard Island provides a unique opportunity to separate the effects of natural climate changes from human-caused changed. It is a large island with multiple extreme environments, including a sporadically active volcano, glaciers, tundra, and barren sedimentary plains, and large populations of megafauna, but *no known human-introduced species*. This combination presents a unique opportunity to learn about the limits of life in the extremes: extreme conditions, extreme isolation, and suggests in turn that its biodiversity can serve as an indicator of the effects of global climate change. The task is conceptually simple: get to Heard Island and search for plants and animals until we can't find any new ones. Once we believe the species list is essentially complete, we could go about understanding it, and its dependence on the world climate.

---

[1] G-R. Walther, E. Post, P. Convey, A. Menzel, C. Parmesan, T. J. C. Beebee, J-M. Fromentin, O. Hoegh-Goldberg, and F. Bairlein. Ecological responses to recent climate change, *Nature* **416**, 28 March 2002, pp. 389-395.
[2] Bergstrom, D. M. & Chown, S. L. Life at the front: history, ecology and change on southern ocean islands. *Trends Ecol. Evol*. **14**, 472-476 (1999).
[3] Smith, R. I. L. Introduced plants in Antarctica: potential impacts and conservation issues. *Biol. Conserv*. **76**, 135±146 (1996).
[4] Pugh, P. J. A. Non-indigenous Acari of Antarctica and the sub-Antarctic islands. *Zool. J. Linn. Soc.* **110**, 207±217 (1994).
[5] T. W. Shoener, J. B. Losos, and D. A. Spiller, Island Biogeography: An Introduced Species Transforms Survival Patterns, *Science* **310**, 16 Dec. 2005, pp. 1807-1809.
[6] Easterling, D. R. et al. Climate extremes: observations, modeling, and impacts. *Science* **289**, 2068±2074 (2000).
[7] http://www.antarctica.gov.au/media/news/2009/rare-visit-to-remote-southern-ocean-territory-finds-changes

Heard Island as a World Heritage site

The United Nations Educational Scientific and Cultural Organization (UNESCO) maintains and develops a list of World Heritage sites, defined according to a list of criteria. Heard and McDonald Islands (HIMI) was added to the list in 1997, according to the following criteria:[8]

> (viii) *An outstanding example representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.*
>
> (ix) *An outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.*

The UNESCO website also contains the following statements about the importance of scientific study of Heard Island: [9]

> The distinctive conservation value of Heard and McDonald – one of the world's rare pristine island ecosystems – lies in the complete absence of alien plants and animals, as well as human impact.
>
> It is the only subAntarctic island group to contain no known species introduced directly by man, which makes it invaluable for having, within one site, an intact set of interrelated ecosystems; terrestrial, freshwater, coastal and marine, in which the ongoing evolution of plants and animals occur in a natural state.
>
> These intact ecosystems provide opportunities for ecological research investigating population dynamics and interactions of plant and animal species, as well as monitoring the health and stability of the larger southern oceans ecosystem. Areas of newly deglaciated land as well as areas isolated from each other by glaciers provide unparalleled opportunities for the study of the dispersal and establishment of plants and animals.
>
> As the only volcanically active subAntarctic islands, they 'open a window into the earth', thus providing the opportunity to observe ongoing geomorphic processes and glacial dynamics.
>
> Heard Island's relatively shallow and fast-flowing glaciers respond quickly to climate change, faster than any glaciers elsewhere, making them particularly important in monitoring climate change. They have fluctuated dramatically in recent decades and have retreated significantly.
>
> The driving westerly winds above the Southern Ocean in these latitudes create unique weather patterns when they come up against the enormous bulk of Big Ben, including spectacular cloud formations around the summit and unbelievably rapid changes in winds, cloud cover and precipitation.

These reasons should be convincing evidence that Heard Island is a unique site presenting an extraordinary opportunity for studying biodiversity as a tool for understanding global climate change. This opportunity provides our motivation for the Expedition, and in following sections of this document we will elaborate our plan to respond to this opportunity.

[8] http://whc.unesco.org/en/criteria/
[9] http://whc.unesco.org/en/list/577

The AAD policy on research at Heard Island

In 2005 The Australian Antarctic Division (AAD) published the Heard Island and McDonald Island Marine Reserve Management Plan. Part 3 of that document contains the following statements concerning scientific research in the Reserve:[10] Additional statements from the 2005 document are shown in Table 2.

Scientific Values

The subAntarctic zone in general is a region of immense importance to a full understanding of how the Antarctic system exerts its effects on the rest of the planet. It is a region where the nutrient–rich Antarctic waters meet the nutrient–impoverished sub–Tropical waters and where there is significant transport of nutrients carried by the Antarctic Circumpolar Current (ACC). It is one of the regions where, both in the sea and on land, the consequences of atmospheric warming can be clearly seen. The Reserve constitutes a uniquely appropriate location for conducting of scientific research into global warming, environmental change and its consequences, due to a combination of the islands' position south of the Antarctic Polar Frontal Zone (APFZ), the presence of permanent ice caps and retreating glaciers, the simple vascular flora, and vegetation communities free from confounding influences of introduced herbivores. The terrestrial fauna of the islands is a sensitive indicator of marine change and is of significance with respect to Australia's sustainable management of the HIMI fishery.

The key drivers for scientific work in the Reserve can be broadly classified as:

Management: Science assists the achievement of management objectives for the Reserve, including meeting requirements under legislation and national and international agreements.

Location: The Reserve is located in an isolated and unique geographical location of the subAntarctic, south of the APFZ and in the flow of the ACC.

Content: The Reserve contains unusual, unique and highly dynamic features, physical and biological systems and natural processes.

Condition: The Reserve shows very little evidence of anthropogenic influence and consequently displays features, physical and biological systems and natural processes in a relatively undisturbed condition. Of these drivers, the latter three promote the conduct of scientific research in the HIMI region that cannot adequately be undertaken elsewhere. Examples of the key scientific values of the region, arising from these drivers, are given in **Table 2**.

In 2014, the AAD published a revised Management Plan 2014-2024. On 13 May 2014 the Director of the Australian Antarctic Division implemented a prohibition on entry to the Territory of Heard Island and McDonald Islands, with certain exceptions. The policy provides that "Visits … may be undertaken if authorized." The present project assumes that such authorization will be sought and obtained.

[10] Australian Antarctic Division, www.aad.gov.au

Table 2. Key scientific values for research in the HIMI region

Key Scientific Value
The natural, undisturbed communities of the HIMI region are excellent indicators of environmental change and impacts of environmental change.
Heard Island provides a unique opportunity to measure the rate of glacial retreat, as an indicator of climate change.
The islands are still forming, giving a unique opportunity to gain an understanding of island and plateau formation.
Heard Island provides opportunities to obtain records of past climate from a temperate latitude.
The islands are an appropriate site for studying the development of marine plateaux.
Big Ben provides unique opportunities for studying deep–earth magmatic processes.
As an ecosystem so far largely unaffected by human impact, Heard Island is a unique site for measuring physical processes and addressing fundamental biological problems, testing ecological theory and assessing and modelling the dynamics of environmental change and associated biological responses.
The HIMI region is one where effects of climate change on the marine environment can be clearly seen.
The islands provide a significant site for understanding how, and from where, colonization of recently exposed land occurs in areas undisturbed by human activities. Low species numbers provide an opportunity to investigate their interactions with relatively reduced complexity.
Heard Island is a critical site for recording biotas along an Antarctic terrestrial transect, This provides a means to identify and monitor the effects of climate change in the region.
Possibilities for direct examination and understanding of the early geological history and geological evolution of this region of the Southern Ocean.
The Reserve provides a scientific reference area for the study of ecosystem function within the HIMI region.
Heard Island is one of few stable platforms in the Southern Ocean for the establishment of observatories (geophysics, meteorology).

Biodiversity of Heard Island

The megafauna (penguins, seabirds, seals) at Heard Island are well-known. A description of the diversity is provided by the monograph of Green and Woehler,[11] and a concise summary is conveniently available on Wikipedia.[12]

Regarding the invertebrate fauna, the Wikipedia article states:

> Heard Island supports a relatively low number of terrestrial invertebrate species compared to other Southern Ocean islands …. Endemism is also generally low and the invertebrate fauna is exceptionally pristine. … The arthropods are comparatively well-known with 54 species of mite and tick, one spider and eight springtails recorded. … Despite a few recent surveys, *the non-arthropod invertebrate fauna of Heard Island remain poorly known* [emphasis the author's].
>
> There is a pronounced seasonality to the insect fauna, with maximum in summer. … Distinct differences in relative abundances of species between habitats has also been shown, including a negative relationship between altitude and body size for Heard Island weevils. … The freshwater fauna includes 1 species of Protista, 1 species of gastrotrich, 2 species of tardigrade, at least 4 species of nematode, 26 species of rotifer, 6 species of annelid and 14 species of arthropod. The marine invertebrate fauna is similar in composition and local distribution to other subAntarctic islands, *although relatively little is known about the Heard Island communities*.
>
> Despite Heard Island's isolation, species richness is considered to be moderate, rather than depauperate, although the number of endemic species reported is low.

Regarding the flora, the Wikipedia article states:

> In this cold climate plant life is mainly limited to grasses and mosses. Low plant diversity reflects the islands' isolation, small size, severe climate, the short, cool growing season and substantial permanent ice cover. The main environmental determinants of vegetation are wind exposure, water availability, parent soil composition, salt spray exposure, nutrient availability, disturbance by trampling (from seabirds and seals) and, possibly, altitude. At Heard Island, exposure to salt spray and the presence of breeding and moulting seabirds and seals are particularly strong influences on vegetation composition and structure in coastal areas. … Volcanic activity has altered the distribution and abundance of the vegetation. … Bryophytes (mosses and liverworts) contribute substantially to the overall biodiversity of Heard Island, with 43 mosses and 19 liverworts being recorded. … At least 100 species of terrestrial algae are known and at least 17 other species of seaweed are known. …
>
> One of the most rapidly changing physical settings in the subAntarctic has been produced on Heard Island by a combination of rapid glacial recession and climate warming. The consequent increase in habitat available for plant colonization, plus the coalescing of previously discrete ice-free areas, has led to marked changes in the vegetation of Heard Island in the last 20 years or so. … It is likely that further changes will occur, and possibly at an accelerated rate.

[11] Green, K. & Woehler, E. J. (eds). 2006. *Heard Island, Southern Ocean Sentinel*. Surrey Beatty & Sons, Chipping Norton, Australia, including the article S. L. Chown, P. Greenslade, and D. J. Marshall, Terrestrial invertebrates of Heard Island.

[12] http://en.wikipedia.org/wiki/Heard_Island_and_McDonald_Islands

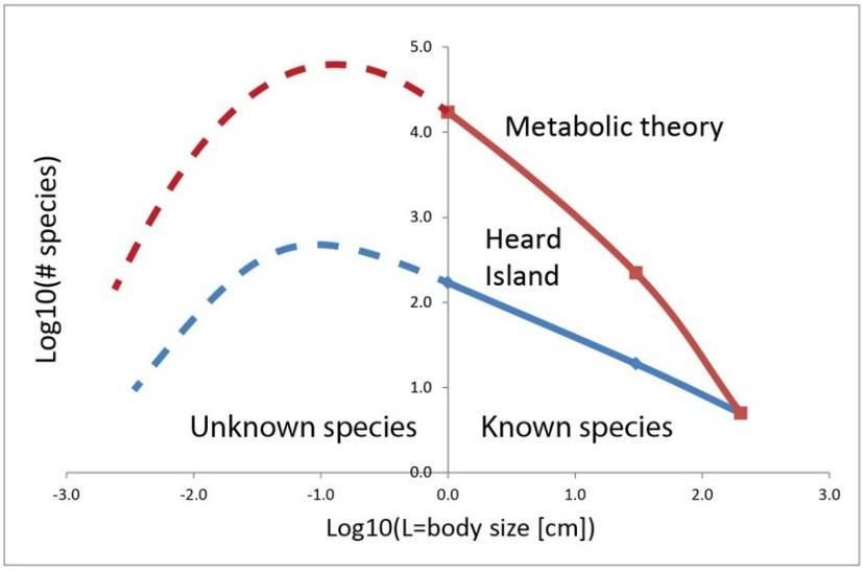
It is clear from the above descriptions that it is the little creatures, the insects and other semi-microscopic and microscopic forms, that are not yet fully described. Yet it is specifically these organisms that comprise the dominant populations and perhaps the greatest diversity, and therefore should get our most serious attention. This therefore constitutes our prime motivation for the Expedition.

The records indicate that perhaps 200 small (L<1 cm) species are known at Heard Island. How many species might we expect remain to be discovered? To estimate this, we examine models of the number of species as a function of body size (or mass). The metabolic theory of ecology (MTE), proposed many years ago by Hutchinson and MacArthur[13] and Robert May,[14] and developed extensively since by many others,[15] predicts that the number of species scales inversely as their length-squared. That is, $N=C/L^2$. Considerable observational data shows that this relation is valid in many cases.

We can use this relation to make a prediction for Heard Island fauna as follows: From the records listed in Green and Woehler, the number of species and a very rough categorization of their sizes is:

Group	Size [cm]	# species
Mammals	300	5
Birds	30	19
Invertebrates	1	170

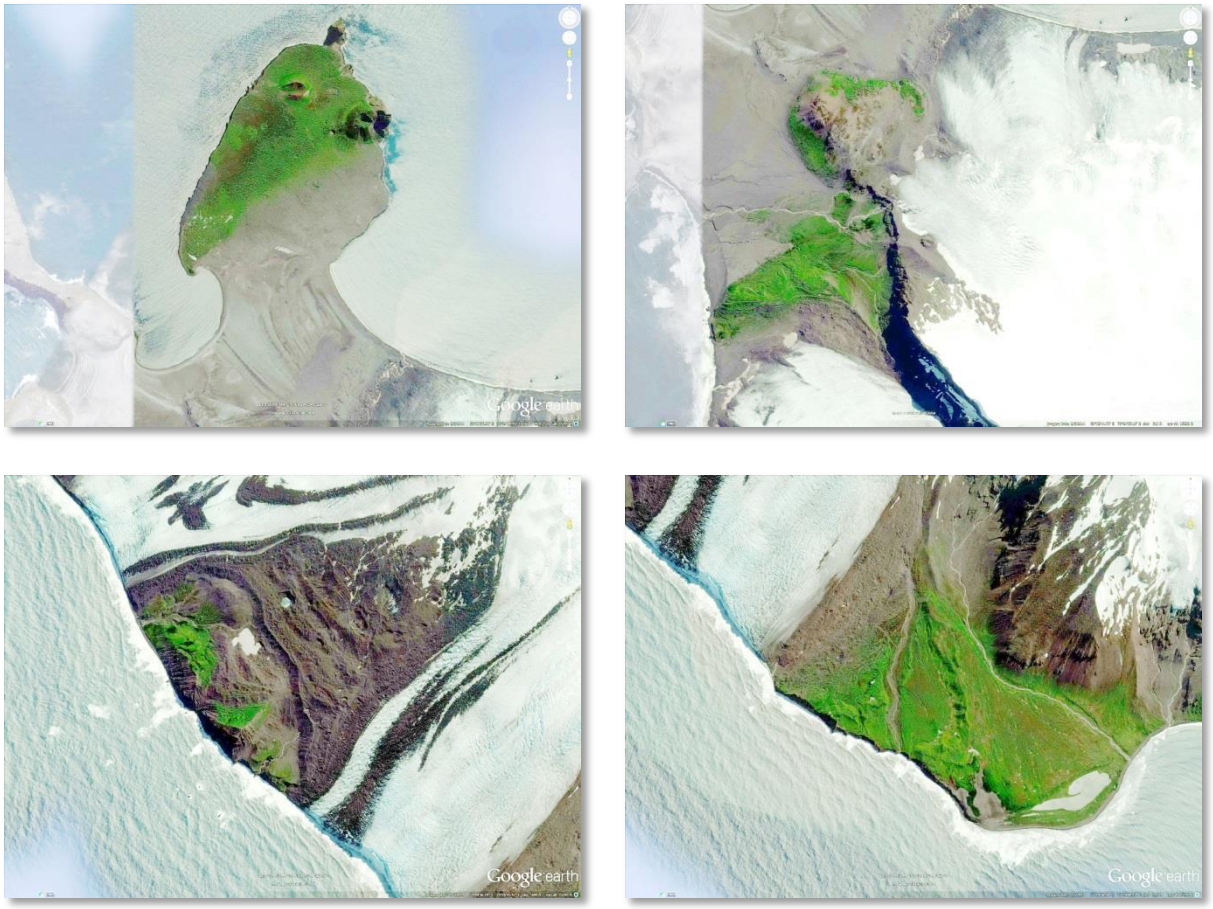
Now according to the MTE, we scale the number of mammals by $1/L^2$ to get the predicted number of birds (=500) and invertebrates (=17100). Clearly these numbers of species are far higher than observed on Heard Island, confirmation of the description of the island as *reduced* ("moderate" or "low") *diversity*. In the following graph we plot (solid lines) the number of species versus size (from the table above), together with the scaled MTE predictions. The area under the Heard Island curve to the right of zero (L=1 cm) contains about 200 species (the curve was constructed to be this way, to match the observations).



[13] Hutchinson, G E & MacArthur, R H (1959) A theoretical ecological model of size distributions among species of animals. *American Naturalist* **93**(869):117-125.
[14] May, R. *Diversity of insect faunas*. Blackwell Scientific Publications: London. 1978.
[15] Brown, J. H., Gillooly, J. F., Allen, A. P., Savage, V. M., & G. B. West (2004). Toward a metabolic theory of ecology. *Ecology* **85** (7): 1771–89.

In fact, the metabolic model scaling ($1/L^2$) is correct only asymptotically to large size, i.e., for the right-hand-size of the species-size distribution in the figure. Observed distributions always reach a peak at a modal size, falling off toward larger and smaller sizes. We are clearly at a loss to know precisely how the distribution at Heard Island falls off, or even where the modal size is. This is, of course, the reason we need to go there: to determine the actual curve!

However, we can make a rough estimate of the total number of macrofauna species on Heard Island as follows: First, because at L=1 cm, the curve appears to be still rising toward smaller sizes, we can assume that it will continue to rise for L<1 cm, until it starts to turn over it approaches the modal size. Second, we will arbitrarily assume that the modal size is approximately L=0.1 cm (=1 mm). With these assumptions, we can draw hypothesized extensions of the distributions smaller than L=1 cm (the dashed lines in the plot above). From the plot, it appears that the area under the left-hand-side of the Heard Island curve (L<1 cm) is perhaps 50% larger than the corresponding area on the right-hand-size (L>1 cm). If we limit our search to the range L=0.1-10 mm, we include the algae and protozoa, but exclude fungi, bacteria, and viruses. To this could be added an unknown number of floral species. We thus conclude that there are probably between 200 and 300 undiscovered species at Heard Island in the size range L=0.1-10 mm. Note that two taxa, known at Heard Island, namely foraminifera (L=0.3 mm) and tardigrada (L=0.5 mm), are well within this range. It will not be surprising to find additional new species in these two taxa, and perhaps additional undocumented taxa.



Places on Heard Island we might find unknown species

It is sensible ask the question: "What is the relationship between the climate on Heard Island and the diversity (=species richness) there?" There is, of course, considerable literature concerning this question. For instance, Chambers,[16] in a review mostly concerning Australia, stated:

> Recently there has been a resurgence of interest in the use of natural systems as indicators of climate change, with evidence mounting that the anomalously high temperatures seen in the twentieth century have already been associated with changes in many physical and biological systems around the globe, …

Among additional examples, she cites observations for Heard Island and the Australian sub-Antarctic:

Component	Natural system change	Reference
Glaciers, snow cover/melt	Glacial retreat; approx. 35 km^2 of new terrain exposed between 1947 and 2000	Bergstrom, 2003[17]
Mammals	Population increase in fur seals *Arctocephalous gazella*	Budd (2000)[18]
Birds	Population increases in black-browed albatross *Diomedea melanophris* and king penguin *Aptenodytes patagonicus*	Chambers et al. (2005)[19]
Invertebrates	[No information]	
Vegetation	Changes in plant communities, e.g., native creeping herb outcompeting and overgrowing the dominant plant species, a cushion plant	Bergstrom, 2003

The environmental change on Heard Island is described by Thost and Allison:[20]

> There is now considerable evidence that the climate on Heard Island is changing, resulting in significant glacier retreat, formation of lagoons and freshwater lakes, and colonization of newly exposed land by plants and animals. … These changes are a reflection of large-scale changes that have been identified elsewhere in the Southern Ocean.

Chambers goes on the say that, because there have been very few studies of climate effects,

> … for many of the categories, particularly for invertebrates, amphibians, and reptiles, it is clear that we have very little idea of how changes in climate are affecting these species and systems on local, regional, or national scales.

From these and many other sources, it is clear that: (1) the climate change experienced on Heard Island is driven by global change; (2) the change is large; (3) the effects of the change on the ecosystem are major; and (4) the diversity is inadequately documented and poorly understood. This set of connections, together with the alien-free ecosystem of Heard Island, provide a strong incentive for the expedition, to complete the record of the island's biodiversity and link it with global climate change.

[16] Chambers, L. E. Associations between climate changes and natural systems in Australia. *Amer. Meteorological Society*, Feb. 2006, pp. 201-206.
[17] Bergstrom, D., 2003: Impact of climate change on terrestrial Antarctic and subantarctic biodiversity. *Climate Change Impacts on Biodiversity in Australia: Outcomes of a Workshop Sponsored by the Biological Diversity Advisory Committee, 1–2 October 2002*, M. Howden et al., Eds., Dept. of the Environ. and Heritage, 55–57.
[18] Budd, G. M., 2000: Changes in Heard Island glaciers, King Penguins and Fur Seals since 1947. *Papers of the Proc. Roy. Soc. Tasmania*, **133** (2), 47–60.
[19] Chambers, L.E., L. Hughes, and M. A. Weston, 2005: Climate change and its impact on Australia's avifauna. *Emu*, **105,** 1–20.
[20] Thost, D. and Allison, I. 2006. The climate of Heard Island. In Green and Woehler (next footnote).

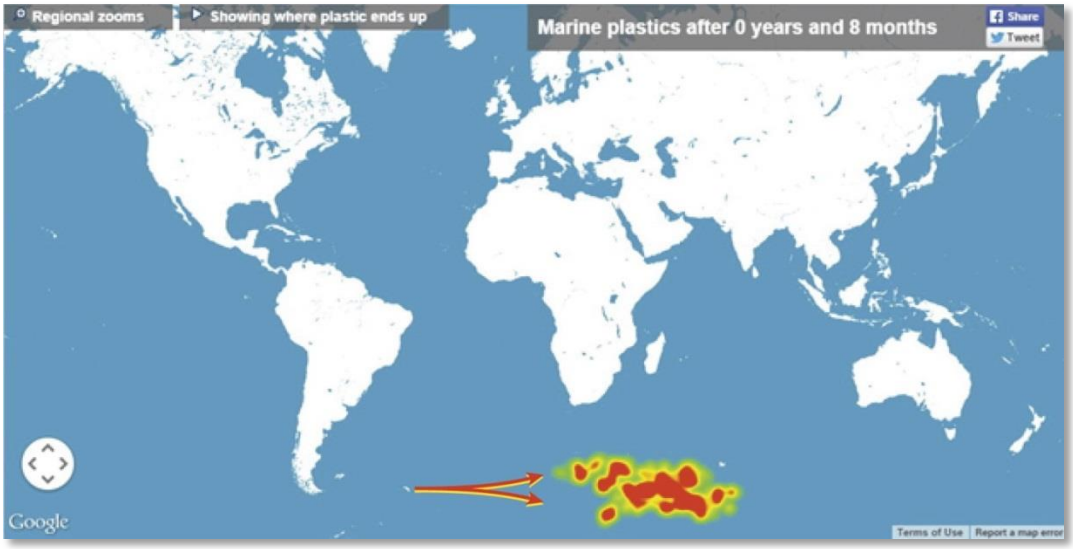
The connection to South Georgia and South Sandwich Islands

Floating debris provides potential rafting for organisms over great oceanic distances. While some of these rafts are clearly anthropogenic, other just as clearly are of completely natural origin. Whether plastic rafts and natural materials resulting from terrestrial outfall (e.g., construction projects) should be considered anthropogenic or natural dispersion may be a matter of semantic convenience; what is important is the flux of biological materials to Heard Island. Because wind-driven rafting of floating debris is a worldwide concern, we are interested in its importance to Heard Island, regardless of the exact nature of the debris.

Prof. Eric van Sipple (Imperial College, London) has developed a simulation of dispersion of plastic (or any similar) debris from any point in the ocean. The simulation (www.adrift.org.au) enables the user to select any point on the world map to inject floating debris. The simulation then computes the drift of the material forward in time, up to 10 years.

We have used this tool to investigate potential sources of debris to Heard Island. We find that the circumpolar current effectively shields the Southern Ocean from debris originating from north of the Antarctic Convergence. Essentially the current deflects the debris, and the only polar flux is due to the relatively slow transverse mixing, or more probably, exceptional weather/current events. There is one exception: the islands of South Georgia and South Sandwich lie at about the same latitude as Heard Island, and to the west. This puts them on a direct wind-path connection to the latter. This may be significant for Heard Island because South Georgia was recently recognized[21] as having very high biodiversity: almost 2000 marine species, the highest of any location in the Southern Ocean.

The following image is a screen-capture image from the adrift simulation. The duck symbol represents the point at which the simulation injected the plastic debris. After 8 months the debris is spread out over a 1000-nm swatch just arriving at Heard Island. After another 4 months, the swatch is some 2000-nm long, heading directly for Heard Island. After another 2 months this swatch has passed Heard Island, and it begins to spread out. The simulation can follow the debris for up to 10 years, but the greatest impact is about 1 year after release from South Georgia and South Sandwich islands.



[21] http://www.livescience.com/30464-southern-ocean-island-south-georgia-biodiversity.html

Goals, purposes, and motivations of the Expedition

In the simplest terms, the "*Discovering Life in the Extremes*" part of the Expedition goal is to determine the species-size distribution curve for L<1 cm, as described above. With that, various models of the *mechanisms* of the diversity could be examined. These models might involve speciation, dispersal ability, extinction, competition, and energetic constraints. Another way to view this is that we want to develop an understanding of the energy flow to, around, and from the island, particularly relating to the volcano Big Ben, and its effects on the biological community, since energy flow is the unifying theme for all aspects of environmental dynamics. Our first main goal for this part of the Expedition, therefore, is: *The elaboration of the biodiversity of Heard Island*. Part of our motivation is to provide data and information to the Australian Antarctic Division (AAD) and other agencies for continued monitoring and management of the Heard Island Territory. Still another motivation is to enhance worldwide awareness of remote wilderness sites and their importance to global climate change and biological diversity.

The second goal is to develop and deploy state-of-the-art real-time communications to enable interactive collaborations, reach large numbers of people interested in ecosystems, biodiversity, wilderness, and many other special interests, ensure safety and effectiveness of the operations, and field-test models of the effects of terrain on radio signals.. Among the tools we will use is amateur radio and a satellite connection (Inmarsat) for passing data in real-time. This activity will generate literally tens of thousands of contacts worldwide, enabling quantitative comparison with model predictions, thereby enabling adjustment of the models used for other areas of the world.

We have obtained financial support and in-kind equipment sponsors from the following sources, among others:

- ✓ Participants
- ✓ Communications equipment corporations
- ✓ Communications satellite corporations
- ✓ Specialized equipment companies
- ✓ Suppliers of food, fuel, materials, supplies, etc.
- ✓ Amateur radio foundations, clubs, and individuals

An application for a permit to operate radio has been approved, authorizing use of the callsign VKØEK. A copy of the license is appended to this document. We will use Inmarsat satellites to connect the Expedition with the internet, allowing real-time two-way communications. We will have a high-speed link (Inmarsat Ka-band), enabling us to upload live images and video.

In the rest of this document, we elaborate various aspects of the Expedition, under the major sections:

ENVIRONMENTAL SCIENCE
COMMUNICATIONS SCIENCE
OPERATIONS
PROJECT MANAGEMENT
SUMMARY
PERSONNEL
SUPPLEMENTARY
BIBLIOGRAPHY
CONTACT INFORMATION.

ENVIRONMENTAL SCIENCE

The strategy

The central biological science goal is to extend the species-size distribution plot. This suggests that the primary strategy should be to search as many different micro-environments as possible. These include, among others:

- ✓ *Terra*
  - Soil
  - Beach sand
  - Recently deglaciated areas
  - Lagoon deposits
- ✓ *Faunal*
  - Excreta
  - Carcasses
  - Skeletons
- ✓ *Flora*
  - Moss
  - Grass
- ✓ *Water*
  - Glacial runoff
  - Lagoon water
  - Shallow subtidal marine
  - Offshore marine
- ✓ *Ice*
  - Glacial ice
  - *Glacial terminus*
- ✓ *Atmosphere*
  - *Near-ground wind*
  - *Altitude wind*

We will search for organisms primarily smaller than L=1 cm, examples of which include:

foraminifera	insects	lichens	meiofauna
mites	parasites	pollen	saprophytes
spiders	spores	tardigrades	ticks

Elaboration of diversity, not the mere accumulation of census data, is the goal. We will be less concerned with counting populations than with identifying unknown or undocumented organisms. Thus, the equipment, personnel, and schedules will be determined to maximize breadth, rather than depth. Of necessity, a considerable portion of the resources will be tasked with indirect support, such as hiking, communications, facilities, supplies, and services. About one-third of the team will be engaged in the field science; some of these persons also will be engaged with the various communications efforts.

The desire to examine as many habitats as possible will inevitably group several activities together, principally determined by the environment. The personnel who will carry out the searches may therefore have to be multi-tasking. Here we briefly describe the major environments and some of the associated tasks.

The campsite(s). The main campsite will be located just to the east of the ANARE site in Atlas Cove, close to the location used for the 1997 expedition. The facilities will comprise various shelters, generators, water and food supplies, galley and sleeping tents, sanitation and safety facilities, communications equipment, and antennas. Considerable investigation will be done around the site, since it has proximity to the Nullarbor and the biologically rich Azorella peninsula.

The Nullarbor. This large flat flooding sandy plain is the rookery for King penguins, and should be a good place to collect residues and outwash that could contain small parasites and commensals. The number of animals there during the visit should be significantly reduced from its summer peaks.

The beach. Meiofauna, including foraminifera, will be found in the sediments of the Nullarbor and the beach. In particular, small commensals with seaweeds, invertebrates, and plastic debris are likely.

Glacial ice. Ice at the termini of the glaciers may be hundreds of years old, hence of potential value for discovering relictual foraminifera, spores, and other microscopic organisms.

Glacial runoff. Extensive suction filtering of runoff should yield organic objects, perhaps similar to the glacial ice.

The shallow subtidal. Invertebrates and algae are known from the subtidal around Heard Island, but the limited collections suggest that many species remain to be documented.

Lagoons. Of greatest interest will be the oldest lagoons. Grab samplers and dredges will be used to obtain samples of the sediments. A corer is available that can be used if conditions permit. The nearshore shallow water likely harbors phototropes.

The wallows. One of the most productive habitats is the wallows at the edges of the Azorella Peninsula. We expect to find many organisms in the excreta of the dense populations of birds and mammals there.

The ephemeral creek. Near the ANARE station (ruins) an ephemeral creek runs, carrying with it materials from the plants and animals flopped in the wallows. The creek should be a good source of micro-organisms.

The ocean. Taking advantage of the ship as a platform of opportunity during the voyage to, and from, Heard Island, , we plan to carry out a search for the new type of killer whale documented over the past decade. This will involve observers staying onboard the vessel, and the vessel making periodic forays away from Heard Island.

In order to maximize the likelihood of finding unknown organisms, we will occupy Spit Bay for perhaps a week. There is also incentive to investigate Long Beach, on the southern shore, but the opportunity for this will depend on the conditions and operations during the Expedition.

Here is a list of some specific projects that have been proposed for the Expedition. Some of these projects are in the planning and/or preparation stages; others are still only proposals. Some of these projects (e.g., cryptofauna) are directly involved with searching for unknown life, while others (e.g., glacial runoff, airborne biota) are supportive of that goal.

In the sections below, we provide very brief descriptions of some of these projects, as well as additional information about the expedition (in particular the Operations).

- ✓ Aerial imaging and sensing
- ✓ Airborne particulates
- ✓ Amateur radio communications
- ✓ Archives and monograph
- ✓ Environmental debris
- ✓ Geology of the Laurens Peninsula
- ✓ Glacial ice
- ✓ Invertebrate traps
- ✓ Killer whale observations
- ✓ Lagoonal sediment
- ✓ Macrobiology
- ✓ Megabiology
- ✓ Meteorology
- ✓ Microbiology
- ✓ Real-time internet communications
- ✓ Recently deglaciated habitats
- ✓ Remote macrophotography and video
- ✓ Cryptobiology (tardigrade) experiments
- ✓ Vortex winds
- ✓ Water-borne particulates
- ✓ Website and webcast.

This list is representative, rather than comprehensive. For some of these projects, brief descriptions are available, while for others, the project is in preparation/evaluation stages. We are well aware that the conditions and resources may not allow us to carry out all the studies we wish, hence the projects will be done opportunistically. Please see the comments in the SUMMARIES section.

Macrobiology

At Heard Island, two groups of macrofauna are well-known: tardigrades and foraminifera.

Tardigrades.

The moist mossy environment at Heard Island supports large numbers of tardigrades. In 1997 we collected tardigrades at Heard Island with Prof. Harold Heatwole of North Carolina State University, who subsequently described them.[22] In 2005 Prof. William Miller, et al, described a new species of tardigrade from Heard Island.[23] Profs. Heatwole and Miller will collaborate with us during the expedition to identify and describe the tardigrades collected on the Expedition.

We pose the following question of fundamental interest: Has the isolation of Heard Island caused the local tardigrades to have lost (or gained) some ability to enter cryptobiosis? We propose to store collections of tardigrades for some years in selected cryptobiosis,[24] and examine the collections at intervals, making attempts to revive them. The results could show whether the conditions at Heard Island are producing speciation. Additional remarks are provided below concerning experiments that we propose to study cryptobiosis.

Foraminifera

Modern foraminifera are primarily marine, although some can survive in brackish conditions. Fossil foraminiferal assemblages are useful for biostratigraphy, paleoclimatology, and paleoceanography. Living foraminiferal assemblages are used as bioindicators in coastal environments.[25]

We will make collections of sediments at Heard Island to search for foraminifera. This project will be done in collaboration with Dr. Mary McGann (U.S. Geological Survey), who has collaborated with Cordell Expeditions for more than 20 years.

These are but two of the many organisms that we expect to see at Heard Island. As indicated above, we expect that perhaps 300 faunal species are as yet unrecorded. In addition to the two taxa listed above, we will be looking for nematodes, planarians, mites, copepods, cladocerans, and other small taxa.

---

[22] Miller, W. R., S. K. Claxon and H. F. Heatwole (1999). Tardigrades of the Australian Antarctic Territories: Males in the genus *Echinsicus* (Tardigrada: Heterotardigrada). *Zoologischer Anzeiger* **238**: 303-309.

[23] Miller, W. R., S. J. McInnes, and D. M. Bergstrom (2005).Tardigrades of the Australian Antarctic: *Hypsibius heardensis* (Eutardigrada: Hypsibiidae: *dujardini* group) a new species from sub-Antarctic Heard Island, *Zootaxa* **1022**: 57-64.

[24] Anhydrobiosis (dessication), anoxybiosis (lack of oxygen), chemobiosis (toxins), cryobiosis (cold), and osmobiosis (solute concentration).

[25] http://en.wikipedia.org/wiki/Foraminifera

Microbiology

The literature on microbial life on subAntarctic islands is not extensive. As guides, there are various reviews of Antarctic microbiology,[26] [27] [28] and there are some studies of microbes on subAntarctic islands.[29] [30] [31] [32] [33] [34] [35] These citations are merely representative, and most do not refer to Heard Island directly, but are relevant to all subAntarctic islands.

While the emphasis on searching for new species at Heard Island will concentrate on the size range 0.1-10 mm, we are also very interested in the microbiology of Heard Island, ca., 1-100 μm. The extrapolation of species richness to sizes smaller than 0.1 mm as presented above, is very uncertain, hence we do not wish to adopt an estimate of the diversity in this size range. Instead, we will simply plan to collect samples from interesting environments and process them to reveal the micro-organisms present on the island at the time of collection.

One of the potentially most interesting sites on Heard Island is the vent on the west shoulder of the Big Ben massif. The vent was observed at a distance by the author in 1997, but to date no detailed documentation of it, or any other possible vents on Big Ben, has been made. If the vent has provided long-term local warmth and possibly chemical feedstock, it is not unreasonable to expect that it might support a local community. Considering the much greater ability of prokaryotes (archaea and bacteria) to survive in extreme environments than eukaryotes (protozoa, fungi, algae), we might expect to find the former, if not the latter. Unfortunately, in the absence of the opportunity to climb Big Ben, we probably will not be able to sample this fascinating micro-environment.

We plan to establish a modest science lab at our camp on Heard Island, equipped with working table and chairs, storage, instrumentation (microscopes, pH meters, centrifuge, etc.), sieves, chemicals for fixing and preserving specimens, containers such as vials and zip-lock bags, photographic equipment, labels, and a computer. The specimens will be fixed or kept refrigerated until they can be delivered to various specialists for analysis.

---

[26] R. V. Miller and L. G. Whyte, *Polar Microbiology: Life in a Deep Freeze*, Amer. Soc. for Microbiology, 2012.
[27] E. I. Friedman, *Antarctic Microbiology*, Wiley-Liss, 1993.
[28] W. F. Vincent, *Microbial Ecosystems of Antarctica*, Cambridge University Press, 2004.
[29] D.C. Grobler, D.F. Toerien, V.R. Smith, Bacterial activity in soils of a sub-antarctic island, *Soil Biology and Biochemistry*, Volume 19, Issue 5, 1987, pp. 485–490.
[30] V. R. Smith, M. G. Steyn, Soil microbial counts in relation to site characteristics at a subantarctic Island, *Microbial Ecology*, December 1982, Volume 8, Issue 3, pp. 253-266.
[31] Valdon R. Smith, Effects of Abiotic Factors on Acetylene Reduction by Cyanobacteria Epiphytic on Moss at a Subantarctic Island, *Appl. Environ. Microbiol*., September 1984 vol. 48, pp. 3594-3600.
[32] Andrea Lubbe, Valdon R. Smith, Field Soil Respiration Rate on a Sub-Antarctic Island: Its Relation to Site Characteristics and Response to Added C, N and P, *Open Journal of Soil Science*, Vol. 2 No.2, June 2012, pp. 187-195.
[33] Björn Herrmann, Rubaiyat Rahman, Sven Bergström, Jonas Bonnedahl, and Björn Olsen, *Chlamydophila abortus* in a Brown Skua (*Catharacta antarctica lonnbergi*) from a Subantarctic Island, *Appl Environ Microbiol*. Aug 2000, **66**(8): 3654–3656.
[34] Pratima Gupta, Preeti Chaturvedi, Suman Pradhan, Daniel Delille, and Sisinthy Shivaji, *Marinomonas polaris* sp. nov., a psychrohalotolerant strain isolated from coastal sea water off the subantarctic Kerguelen islands, *Intl J Systematic and Evolutionary Microbiology*.
[35] Peter Convey, Terrestrial ecosystem responses to climate changes in the Antarctic, in *"Fingerprints" of Climate Change*, 2001, pp. 17-42.

Environmental debris

Plastic debris

The 1991 observations of Slip and Burton[36] called attention to threats from foreign debris. The 2004 paper of Auman, et al.[37] quotes Slip and Burton, and states:

> At Heard Island two *Pachyptila desolata* [Antarctic prions] were found to have ingested plastic fragments. As these seabirds are surface seizers, it was not surprising to the authors that they had ingested plastics.

This article also gives an indication that the problem is extensive [text slightly edited]:

> Density of marine debris was 13 items/km at Heard Island. Plastics were the main type of material sampled; fishing-related debris was 40% of the total. … Direct impacts on the marine biota have also been reported.

The AAD has also expressed concern about plastic debris at Heard Island:

> We encounter these pieces [of plastic] in seal feces and in stomach samples from birds. A priority for future research is to determine whether plastics in the Southern Ocean are at levels that are causing harmful impacts on the wildlife[38].

According to the 2011 paper by Ivar do Sul, et al.,[39] compared to other Antarctic islands (S. Orkneys, S. Georgia, Marion, etc.), plastic debris at Heard Island is poorly documented. While the number of plastic debris items at Heard Island was small in the period 1986-89, the increase in the subsequent 25 years could be very great. In the Southern Ocean, plastic debris increased 100 times during the early 1990s.[40] If Heard Island has experienced a comparable increase, the density could be as high as 10,000 items/km, or ten items per meter. Indeed, a recent article by Erikson, et al.,[41] documents the daily accumulation rates of marine debris on sub-Antarctic beaches. These authors state the rate at Macquarie Island is an order of magnitude higher than predictions based on 5-year records. If the increase at Heard Island is similar, such high levels of debris could well have a significant impact on the resident fauna.

---

[36] Slip, D. J. &. Burton, H. R. (1991). Accumulation of Fishing Debris, Plastic Litter, and Other Artifacts, on Heard and Macquarie Islands in the Southern Ocean, *Environmental Conservation* **18**: 249-254.

[37] H. J. Auman, E. J. Woehler, M. J. Riddle, and H. Burton, First Evidence of ingestion of plastic debris by seabirds at sub-Antarctic Heard Island, *Marine Ornithology* **32**: 105-106 (2004).

[38] http://www.antarctica.gov.au/science/australian-antarctic-science-strategy-200405-201011/impact-of-human-activities-in-antarctica/past-research/marine-debris

[39] Ivar do Sul, J. A. David K. A. Barnes, Monica F. Costa, Peter Convey, Erli S. Costa and Lúcia Campos, Plastics in The Antarctic Environment: Are we looking only at the tip of the iceberg? *Oecologia Australis* **15**(1): 150-170, Março 2011, doi:10.4257/oeco.2011.1501.11.

[40] Copello, S., and Quintara, F., Marine Debris Ingestion by Southern Giant Petrels and its Potential Relationships with Fisheries in the Southern Ocean, *Marine Debris Bulletin* **46** (2003): 1513-1515.

[41] Cecilia Eriksson, Harry Burton, Stuart Fitch, Martin Schulz, and John van den Hoff, Daily accumulation rates of marine debris on sub-Antarctic island beaches, *Marine Pollution Bulletin*, **66**(1–2), 15 January 2013, :199–208.

Bone debris

While not comprising polluting debris *per se*, skeletal remains of birds and mammals are extremely common on Heard Island. If these animals had ingested significant plastic or other debris that may have contributed to their death, such evidence would be intermingled with the skeletons (this was not recorded in 1997). We propose to photo-document bone debris that is accessible from the campsites (Atlas Cove and/or Spit Bay). We do not propose to collect or disturb such remains unless specifically permitted.

Other debris

Over many years of intermittent occupation, it is likely that metallic debris (tools, machine parts, etc.) lie buried in the sediments and beach areas, and it would be of interest to investigate this and document the observations.

Subsurface metal objects can be detected easily with a simple metal detector. Unless specifically authorized, we would not investigate any of the high-occupancy areas at the Atlas Cove site (the ANARE buildings and environs). Rather, we would concentrate on areas removed appropriate distances, such as the beaches and Nullarbor at Atlas Cove. One area of particular interest might be the landing beach of the 1947 ANARE team. Considering the difficulty they had using the boats for landing, it is likely that some tools, parts, or equipment was lost in the surf.[42]

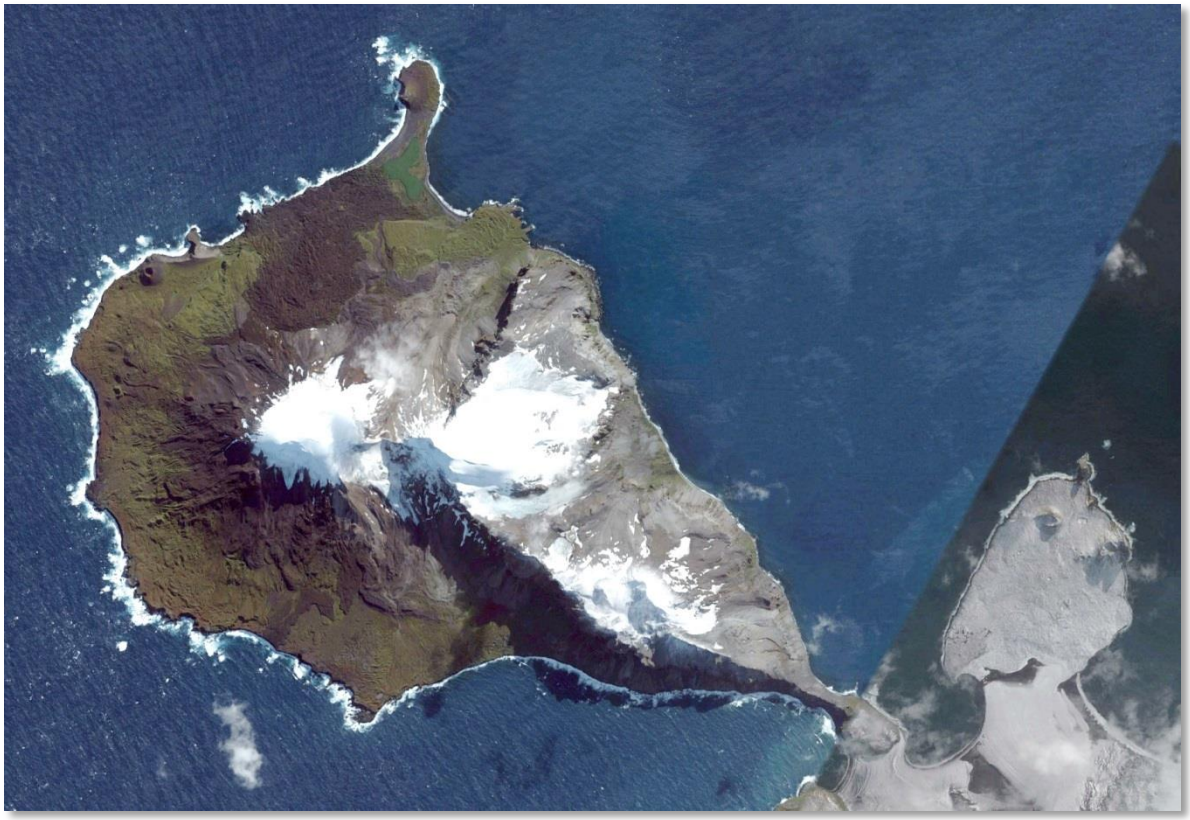
All artifacts discovered in this process would be documented. Within appropriate guidelines, some discovered objects could be conserved and forwarded to the AAD, while others would be documented and reburied. We would follow the instructions of the AAD in this activity.

[42] Arthur Scholes, *Fourteen Men*, E.P. Dutton & Co., New York, 1951.

The Laurens Peninsula

[Prepared by Jodi Fox[43]]

Jodi Fox has submitted a proposal for geologic mapping and sampling, with primary emphasis on the Laurens and Azorella Peninsulas. The indented remarks were provided by Ms. Fox in her full proposal; they have been abridged here.



Source: Google Earth

Introduction

The geological history of Heard Island is inadequately understood; there is no existing complete geological map (Stephenson, 2005; Truswell et al., 2005). Clearly, a thorough understanding of the geology of Heard Island is essential, as it provides the context for all flora, fauna, and marine studies on and around the island. With this motivation, we propose to study the geology of Heard Island, with emphasis on the Laurens and Azorella Peninsulas.

Purpose of Proposed Field Work

The field work will be focused on addressing the following questions:

- What are the nature and timing of previous volcanic eruptions on Laurens Peninsula? Of particular interest is the relationship between the parasitic cones located around the coast of the peninsula and the relatively fresh lava flows from Mt Dixon.
- What types of interactions between glaciers and volcanoes have occurred, and what influence have these had on the distribution of the volcanic rocks and the

[43] University of Tasmania, Hobart

geomorphology of Laurens Peninsula?
- Is there any evidence on Heard Island of felsic eruptions? To date only basaltic and trachytic volcanic rocks have been identified by researchers.

Proposed Field Work

- Observation and documentation of the products within the parasitic cones on the Laurens Peninsula, which are likely related to an explosive eruption style.
- Geological mapping of Laurens Peninsula with particular focus on recent volcanic rocks.
- Geological sampling of volcanic rocks, including lavas and explosive eruption products, for further geochemical and quantitative analysis (possibly whole rock, isotope and SEM imaging).
- Mapping and sampling of a primary bimodal pumice deposit at Oil Barrel Point.
- Collection of pumice from Elephant Spit believed to be from the 1992 eruption of nearby McDonald Islands.

Field Work Logistics

It is proposed that a two-person team, consisting of the author [Ms. Fox] and one other person, use Atlas Cove as a base to conduct field work on Laurens Peninsula.

Outcomes

This work will expand the scientific knowledge of the geology of Heard Island. Deliverables include a geological map of Laurens Peninsula (potentially expansion to a larger area), and better understanding of the eruptive history of Mt. Dixon.

References

Stephenson, J., Barling, J., Wheller, G. And Clarke, I. 2005, The geology and volcanic geomorphology of Heard Island, in Green K. and Wochler, E. 2005, *Heard Island: Southern Ocean Sentinel*, Surrey Beatty & Sons, Chipping Norton.

Truswell, E.M., Quilty, P.G., McMinn, A., Macphail, M.K. and Wheller, G.E., 2005, Late Miocene vegetation and palaeoenvironments of the Drygalski Formation, Heard Island, Indian Ocean: evidence from palynology, *Antarctic Science*, 17(3), 427-442.

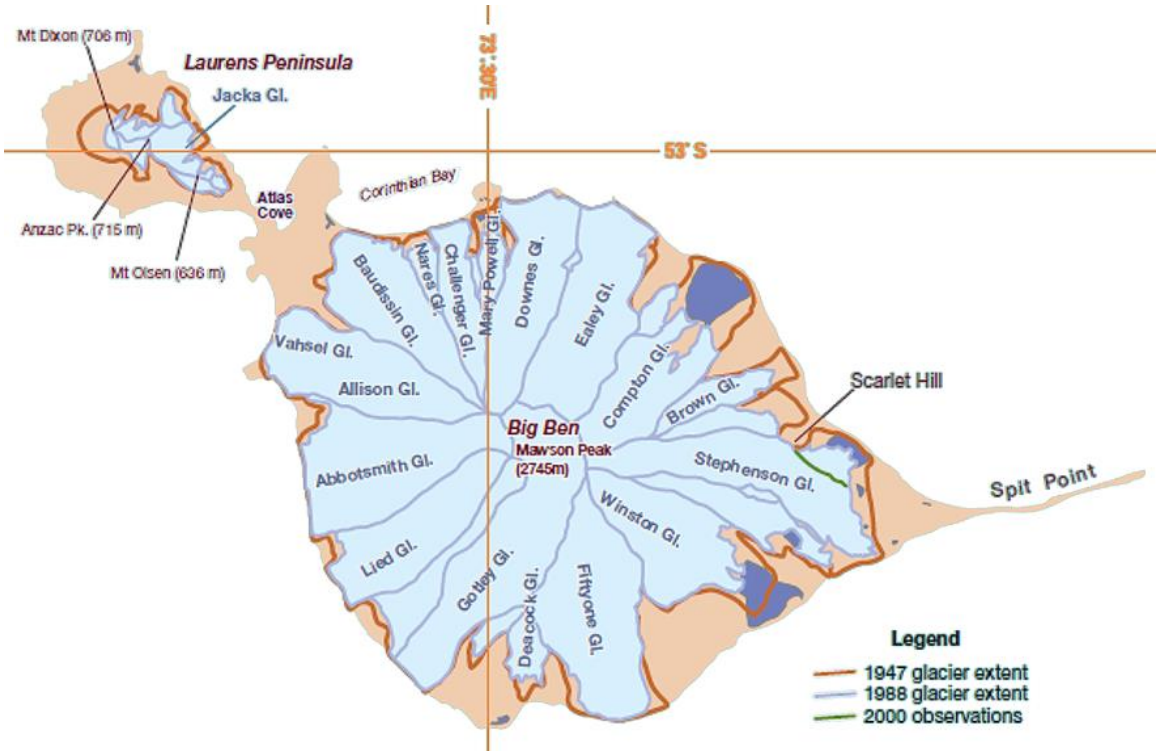
Quilty, P.G. 2012, Heard Island and the McDonald Islands – Unresolved Geological Issues, unpublished essay.

As with other -related projects, this is project is opportunistic, taking advantage of the exploration of the Laurens Peninsulas for unknown life to record the geological description. However, because Heard Island is so isolated, understanding the geology is quite relevant to understanding the present biodiversity. The coupling of the biological investigations and the geological ones seems to this author sensible, if not mandatory.

The excellent paper of Truswell, et al., [op. cit.] is very instructive. These authors examined samples of the Drygalski formation, the "prominent, cliff-forming unit visible around the island, which in turn forms the foundation of the modern volcano." In the rocks, they found foraminifera, radiolarians, diatoms, sponge spicules, and abundant palynomorphs, mostly spores and pollen. These gave evidence of two main ecological associations, a low grassy association and a taller, fern or tree-fern assemblage.

In this context, the proposed investigation of Jodi Fox takes on special significance. It extends the goal of the Expedition from elaborating the contemporary diversity to embracing past ecosystems to the Miocene. While maintaining predominant focus on the present and the future diversity and its dependence on climate change, the geologic past is also a potentially important part of this investigation.

The glaciers



Much of glacier research related to climate change is focused on the big picture of the large mountain ranges and impact to water supplies or polar ice shelves and possible impact on ocean levels. But the study of smaller glaciers, and especially more isolated mountains, provides a more immediate assessment of impact of climate change, because they may in fact disappear first. Heard Island provides an ideal laboratory to study these changes, and to make measurements to determine whether the observed changes are due to localized natural causes or global factors. It is important to measure the extent, and advance or retreat over time, of the Heard Island glaciers through satellite imaging of ice and snow coverage area, as well as the health of the glaciers through the determination of their thickness and mass. To that end, we will pursue the following projects:

> Photographic Imaging of the glaciers with the specific aim of photographing glaciers from the same vantage point, angle, and distance of prior glacier photographs. These can be used for computer-based analysis of the advance, retreat, thickness and mass of the glaciers.

Glacial ice is extremely valuable as a source of information about paleoclimate.[44] A very visible program is that carried out by Prof. Paul Mayewski of the University of Maine and his colleagues. Referring to the program of analyzing glacial ice cores, his seminal book *The Ice Chronicles* says:

> Locked within these ice cores are secrets about Earth's past–its geology, its climate, and its ecosystems… These amazing frozen records document 100,000 years of climate history, revealing the dramatic influence that humans have had on the chemistry of the atmosphere and climate change...[45]

[44] http://www.gisp2.sr.unh.edu/MoreInfo/Ice_Cores_Past.html

[45] P. Mayewski and F. White, *The Ice Chronicles: The Quest to Understand Global Climate Change*, University Press of New Hampshire, 2001. Quote from a flyleaf review by Cliff Davidson, and from the back cover.

Considering the direct connection of the ice cores with climate, obtaining ice cores will be a high-value effort. Based on it recent very rapid change in a warming environment, Stephenson Glacier, shown in the following Google Earth image, is a very interesting subject. The glacier is reachable from Spit Bay using the small landing boat. However, final selection of the site(s) will remain an option.

Stephenson glacier, which terminates near the Spit Bay. This image is now outdated, since the lower part of the glacier has completely melted to form the Stephenson-Doppler Lake. Please compare the photographs in the next sections.

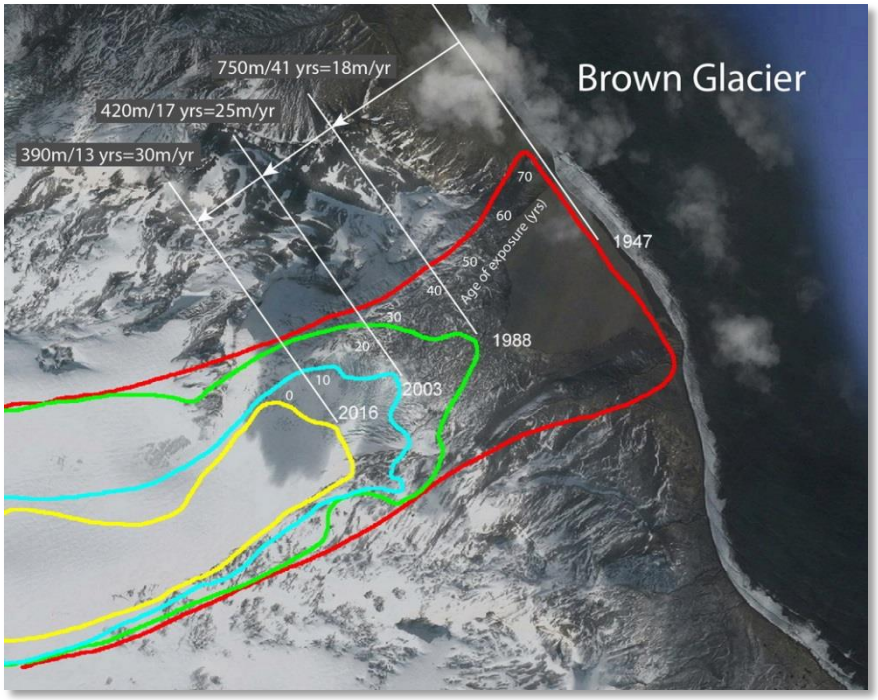
We will also collect glacial ice from the termini of other glaciers we can reach. We plan to conduct preliminary chemical analysis of the water in the ice, to test for elements that might be associated with volcanic eruptions.

Source: Google Earth

Recently deglaciated habitats

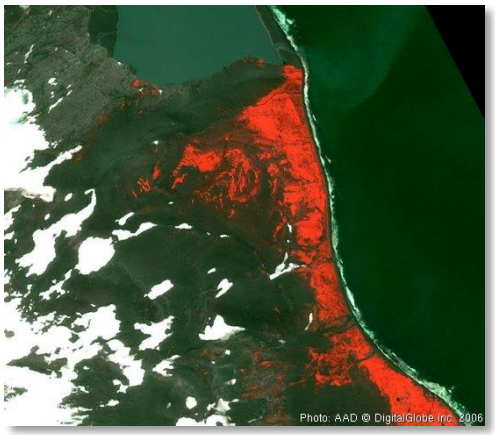
The extensive retreat of glaciers on Heard Island is well-documented.[46] We will make special efforts to examine recently exposed areas for colonizing macrofauna and macroflora. In this regard, the recent work of Catherine La Farge of the University of Alberta is of particular interest.[47]

Among other glaciers on Heard Island, Brown Glacier stands out as retreating rapidly and consistently. The following diagram[48] shows its retreat since 1947, at an average rate of about 20-30 m/yr. The area exposed is about 160,000 m^2.



Source: Google Earth and the AAD

The advance of vegetation onto this recently (last 70 years) deglaciated areas is seen in the false-color image at right (vegetation is red).[49] Clearly, the vegetation, well-established on the lowland coastal strip, is just beginning to appear in the deglaciated areas. This satellite image cannot resolve individual plants, but the appearance of observable stands is strong evidence that plants are establishing themselves on the bare areas.



We plan to search this area, and also the much larger area (600,000 m^2) exposed by the retreat of the Compton Glacier, lying just above the freshwater melt lake in these images.

[46] G. M. Budd, Changes in Heard Island glaciers, King penguins, and fur seals since 1947, *Papers and Proceedings of the Royal Society of Tasmania*, **133**(2), 2000, pp. 47-60.
[47] Catherine La Farge, Krista H. Williams, John H. England. Regeneration of Little Ice Age bryophytes emerging from a polar glacier with implications of totipotency in extreme environments. *Proceedings of the National Academy of Sciences*, 2013; DOI: 10.1073/pnas.1304199110.
[48] Source: Australian Antarctic Division
[49] Source: Australian Antarctic Division

Lagoons and tarns

Heard Island has several lagoons of significant size, some communicating with the ocean and some stranded. The glacial movement produces copious amounts of till and glacial flour, and the meltwater transports this material downslope, some into the lagoons. It is therefore of interest to sample the lagoonal sediment, and it would be of great interest to obtain a depth profile, if samples could be obtained from relatively quiescent locations.

The satellite image of the region around Spit Bay shows that Stephenson-Doppler (S-D) Lake has two openings that are navigable using the landing boat that we will have on the expedition. Hence this lagoon, and Compton Lagoon (which also has a large opening) will be accessible to us, although Winston Lagoon (lower left below) is closed. In collaboration with the University of Minnesota, we have developed a facility for obtaining sediment cores in the field, and analyzing them in the laboratory. This effort would be carried out at the same time as the radio operation at Spit Bay (about a 1-week interval).

In the satellite image, the relatively small (1 km) unnamed tarn, (center left) is isolated from the ocean. This is a particularly attractive target for examination. It appears to be fully loaded with sediment, which spills out as a major plume into S-D Lake. Details are presented in the next section.

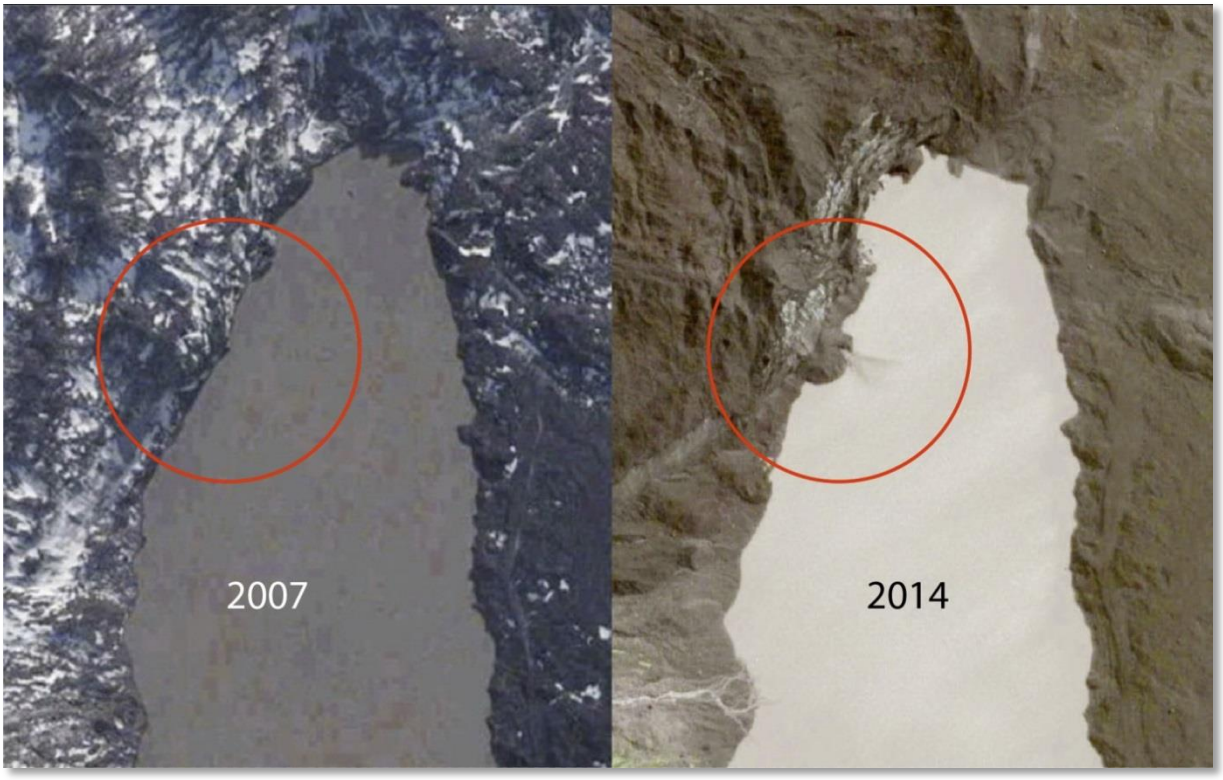
Source: Google Earth Imaging 2014

Subsurface streams

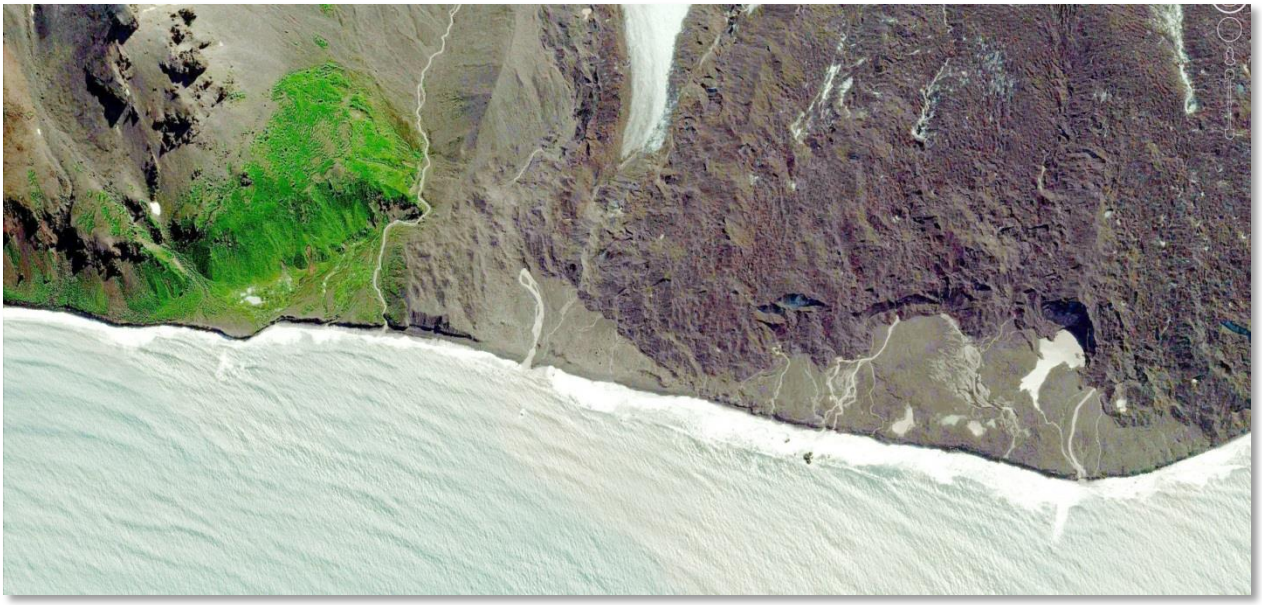
From a detailed examination of the satellite images available on Google Earth, we have found some evidence for two, and possibly many, streams emanating from subsurface channels, perhaps lava tubes but more probably fissures opened by glacial hydrostatic pressure. The following two images show the outflow from the tarn shown on the previous page. We plan to visit this area.

The drain from the unnamed tarn. (Left) From above, north up. The stream is about 15 m wide and about 500 m long. The violent splashing into the Stephenson Lagoon is emphasized in this (slightly) false-color image. (Right) Perspective looking to the southwest. In more detailed images of this feature, the drain appears to emanate from a channel not visible in the images.

Another example of a likely subsurface stream is seen in the images of the northern edge of the tarn. Apparently sometime between 2007 and 2014 a major block or landfall (about 50 m across) protruded into the lagoon. Detailed examination of the imagery indicates a large (ca. 3-5 m) a large plume issuing up to 30 m into the lagoon from the an apparent opening in this feature. We will examine it as well.



The following pictures show evidence for other major streams issuing directly from vents in the cliffs. The area pictured is Lavett Bluff, slightly to the east of Long Beach, on the southern side of the island.



Enlarged images of these streams (below) indicate that these streams emanate from the bases of ridges, which might be large lava tubes, or irregular vents. The opening of the middle stream below is about 8 ft. wide and 10 ft. high.

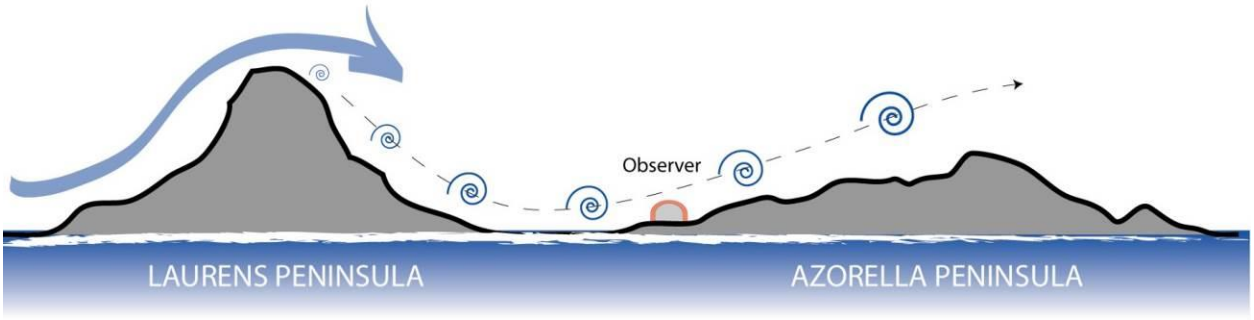
A reasonable hypothesis is that these tubes and vents were blocked by ice until significant warming began in the last few decades. With the melting of the ice, these vents open, providing low-impedance paths for the draining of glacial melt. This drainage will accelerate erosion in the vents, further enlarging them, and will drain water from the glacier termini, further exposing them to higher wind erosion. These processes will contribute to the nonlinear (precipitous!) erosional loss of glacial mass, already recognized in the massive retreat of the Stephenson Glacier.

During the expedition we plan to conduct an aerial photographic examination of these sites, using a drone launched and controlled from the vessel, as shown in the chart above for Lambeth Bluff, just west of the Winston Lagoon next to Spit Bay. A similar examination will be done for the Lavett Bluff.

Winds and weather

The violent and persistent winds on Heard Island are a major influence on the local biota. This fact was recognized by the 1947-48 ANARE expedition: The high mountains, especially Big Ben, both cause and modify wind patterns at lower elevations. One of the characteristic wind patterns is vortices.

Vortices are usually produced when flowing fluid encounters a barrier with edges. The latitude of Heard Island (53°S) places it directly in the strong circumpolar winds, hence we would expect to see vortices at scale lengths roughly comparable to geomorphic dimensions. We plan to attempt observations of two kinds of vortex winds on Heard Island: small-scale, horizontal-axis vortices ("rollers"), and large-scale, vertical-axis vortices ("von Karman").



Roller vortices↑

In 1997, the author experienced the remarkable phenomenon of shedding of roller vortices by the Laurens Peninsula. The vortices had a characteristic noisy propagating front as they approached and passed through the campsite, with a period of approximately 4 minutes. Apparently, wind blowing over the peninsula created the rollers that raced down the lee side of the mountain, across the bay, and up the slope where our shelters were situated. The figure above shows this mechanism. We plan to deploy standard meteorological instruments to record this phenomenon, and we will attempt to correlate the biota in the region with wind patterns.

von Kármán vortex street ➔

The other structure produced by Heard Island is the *von Kármán vortex street*, patterns regularly seen in satellite images.[50] The vK vortex street was detected on the ground at Heard Island by Beggs, et al.[51] in 2000/2001, who noted differences in winds between Spit Bay and Atlas Cove.

With weather stations at both Atlas Cove and Spit Bay, we would be sensitive to meso-beta scale phenomena such as the vK vortex street. The signature of the von Kármán structure will be alternating out-of-phase wind velocities. The data will be correlated with satellite imaging taken at the same time.

[50] http://en.wikipedia.org/wiki/K%C3%A1rm%C3%A1n_vortex_street

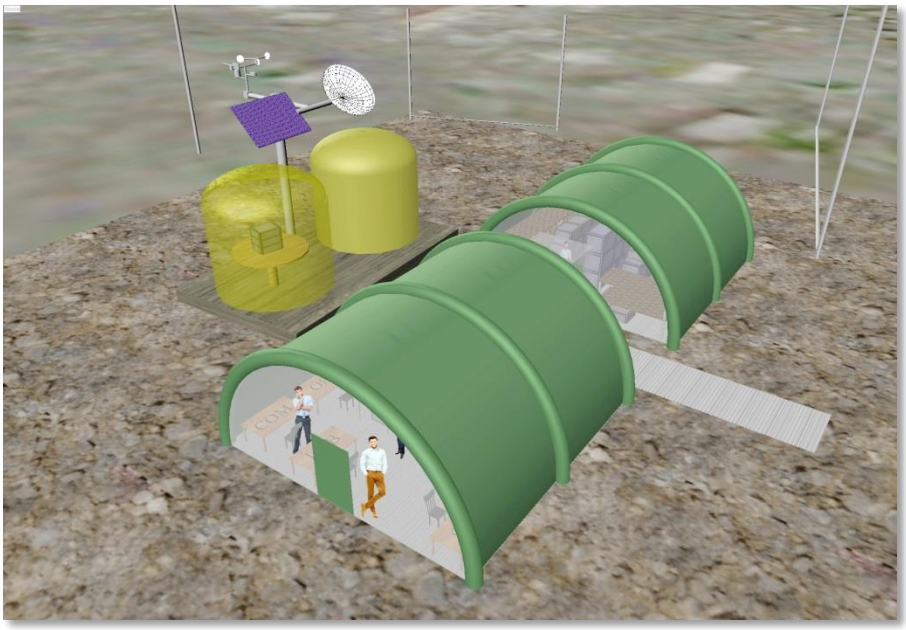
[51] Beggs, P. J., Selkirk, P. M., and Kingdom, D. L., Identification of Von Karman Vortices in the Surface Winds of Heard Island, in: *Boundary Layer Meteorology*, **113**(2):287-297 (2004).

Long-term environmental monitoring

There is considerable interest in long-term environmental monitoring of Heard Island. Besides continuous weather monitoring, the opportunity and motivation are there to provide geophysical data, images of the Atlas Cove vicinity including the megafauna, monitoring of eruptions and venting of the volcano, monitoring of the condition of the ANARE site ruins and the AAD refuge shelters, and real-time studies of radio wave propagation, including the signals from communications satellites.

We propose to partner with an organization that can provide a platform that can be installed as a permanent fixture adjacent to the AAD refuge shelters at Atlas Cove. These shelters are mounted on one of the platforms that were originally part of the ANARE facility, but are outside the restricted area. We anticipate working closely with the AAD on the goals, implementation, and operation of this system.

The conceptual diagram (below left) shows the proposed facility. The block diagram (below right) shows a typical system, this one developed by Info-Electronics Systems, Inc.[52] The outside equipment, including the weather instruments, solar panel, and satellite dish, would be mounted on the pole (or tower), which would be bolted to the platform. Inside one of the shelters would be the electronics and a battery to be kept charged by the solar panel. The electronics would provide for long-term high-volume storage of data, so that even in the event of failure of telemetering the data could be retrieved during a future visit. Placing the electronics inside the refuge ensures its safety from the weather, animals, and thermal cycling.



In operation, the controller would accumulate data from the various sensors and inputs, including images from video cameras, and store them for timed or triggered telemetering. In addition, we would provide for the ability to upload instructions for the controller, such as repositioning the camera, changing the interval between image captures, recalibration to aging, and storage management. We believe this system could operate unattended for 5 years or more.

[52] http://www.info-electronics.com

COMMUNICATIONS SCIENCE

Communications will be both an integral and essential part of the Expedition, enabling safety, efficiency, alternative planning, remote collaboration, and real-time information to the internet for distribution to various websites and social media. It turns out to be advantageous to use amateur radio operators for most of the communications team, and amateur radio equipment for many (but not all) of the communications functions. Here we describe these operations according to the various functions.

Amateur radio communications

Heard Island presents perhaps the ultimate in difficulty for amateur radio operation. Its remoteness, the harsh climate, and the absence of permanent facilities are reasons for the very infrequent amateur radio activity, and therefore for its great demand for contacts in the amateur radio community. The most recent radio operation from Heard Island was in 1997 (shown below), organized and led by the author.[53]

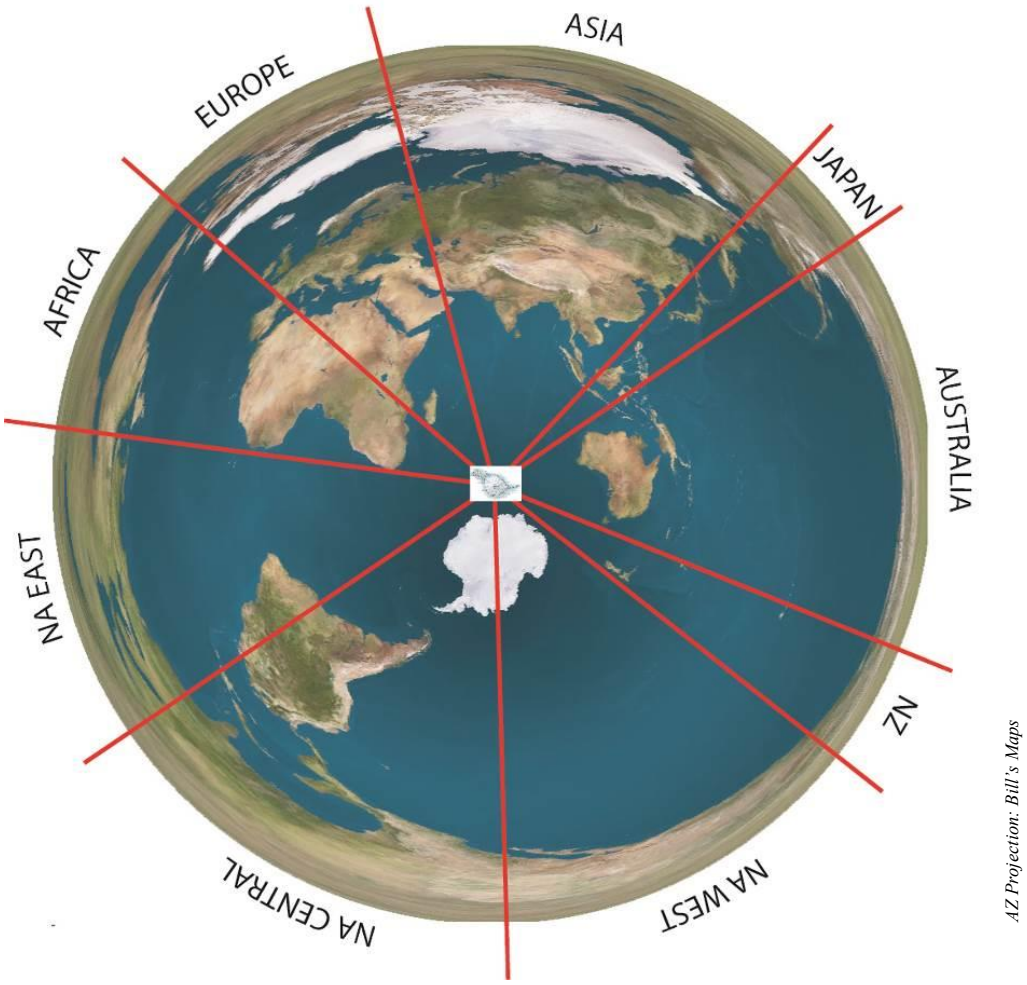
Photo: R. W. Schmieder

Overview of the 1997 VKØIR DXpedition site at Atlas Cove

[53] R. W. Schmieder, *VKØIR Heard Island*, Cordell Expeditions, 1997.

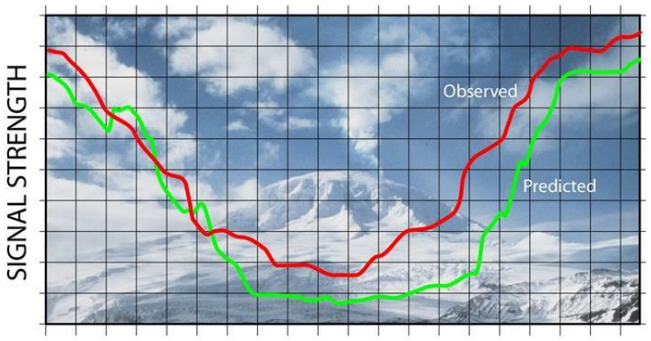
For the current expedition, we will use the callsign VKØEK. We expect worldwide demand for as many as 150,000 contacts, with as many as 50,000 different stations. In order to satisfy this demand, we will operate four to six stations for a period of nearly three weeks, with a team of 12 radio operators. We are developing a "fast deploy" strategy so that we can be on the air in one day, and break down in one day maximize the time on the air. This will be a "full service" operation (all-bands, all modes), using at least four stations running continuously. We plan to dedicate one station to making only "All-time-new-ones" (ATNOs), giving radio operators their first contact ever with Heard Island. We will also make special efforts to log contacts with all license class operators, who have more limited band privileges.

Part of the challenge of successful radio contacts is aiming the signals in the correct direction. The diagram below shows an Equidistant-Azimuthal projection map[54] centered on Heard Island. This projection distorts the world around Heard Island in such a way that the directions from the island to anywhere in the world are true. As the Earth rotates (i.e., the map rotates clockwise), the best propagation rotates with the sun, enabling the best signals between the successive regions (Asia, then Europe, then Africa, then North America East, etc.). We will direct our antennas to the optimum direction for each region, given the time of day.



[54] http://roziturnbull.com/bill/Maps/maps.htm

An even greater challenge for radio operations from Heard Island is the presence of the volcano Big Ben. The 9000-ft. mountain lies directly in the path of signals to major parts of North America, effectively blocking the signals, as shown in the simulation diagram below.



Because of the blocking effect of the mountain, the West Coast of the U.S. cannot be contacted from Atlas Cove (but can be from Spit Bay), while the East Coast cannot be contacted from Spit Bay (but can be from Atlas Cove). Some locations (e.g., Japan) can be contacted from both locations.

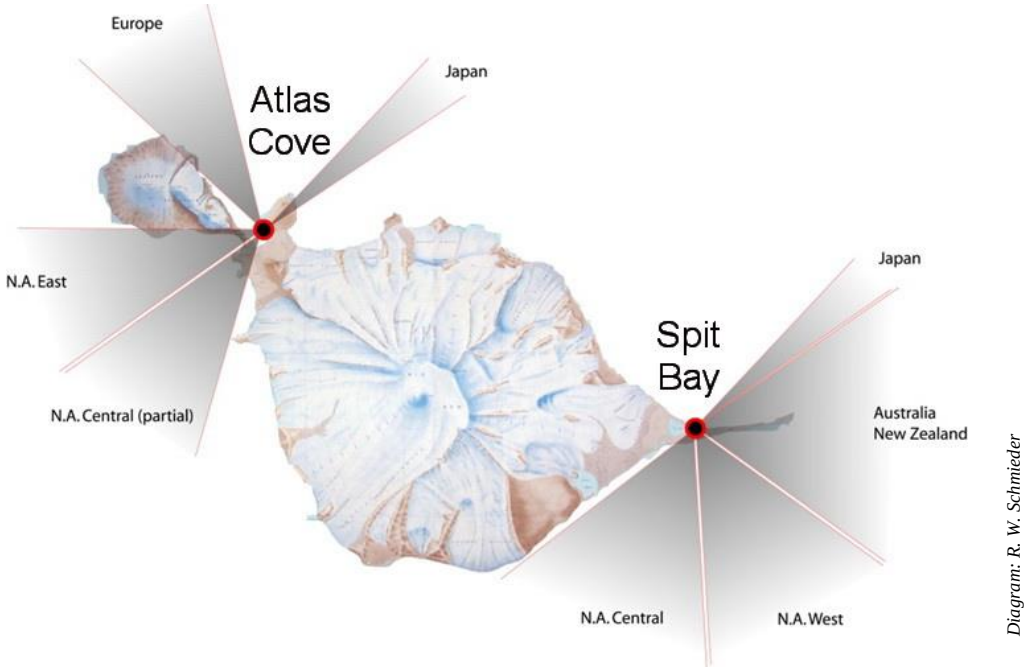


Diagram: R. W. Schmieder

This circumstance is strong incentive to occupy both Atlas Cove and Spit Bay, and we plan to conduct radio operations at both sites. In order to optimize our antennas, we are conducting extensive modeling of the propagation, including the effects of the terrain, particularly Big Ben. Dean Straw, N6BV, has developed innovative software called High Frequency Terrain Assessment (HFTA)[55] that takes into account the local terrain on radio wave propagation. The model predicts the blocking effect of Big Ben as shown in the diagram at the top of this page.

[55] http://www.arrl.org/files/file/Product%20Notes/Antenna%20Book/hfta.pdf

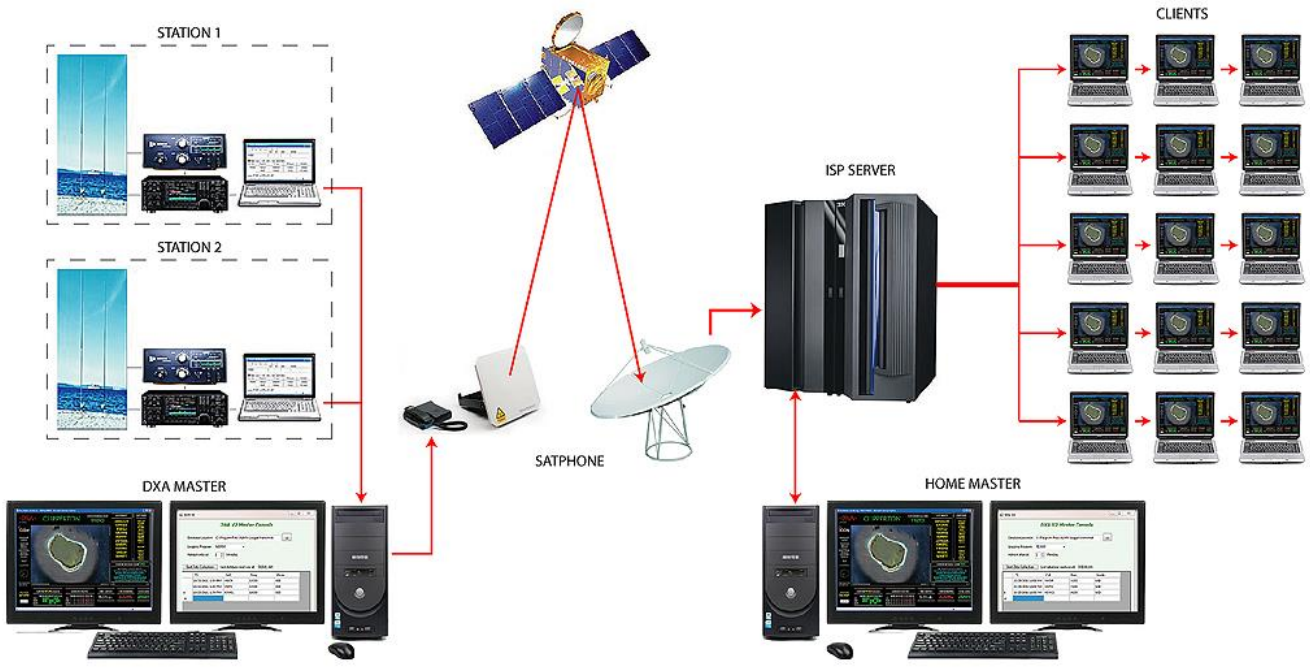
Real-time internet communications

Real-time internet connection and communications are extremely important for this expedition. Some uses of real-time are:

- ✓ Advertising content with live update
- ✓ Audio from wind (e.g., vortex winds)
- ✓ Images from kite-borne camera
- ✓ Images of bird overflights during the day
- ✓ Live feeds for sponsors
- ✓ Monitor of weather instruments, including cloud cam
- ✓ Offshore medical consultation and support of rescue effort
- ✓ Public interaction with the onsite team
- ✓ Video of cloud cover
- ✓ Web display of personnel locations and activities

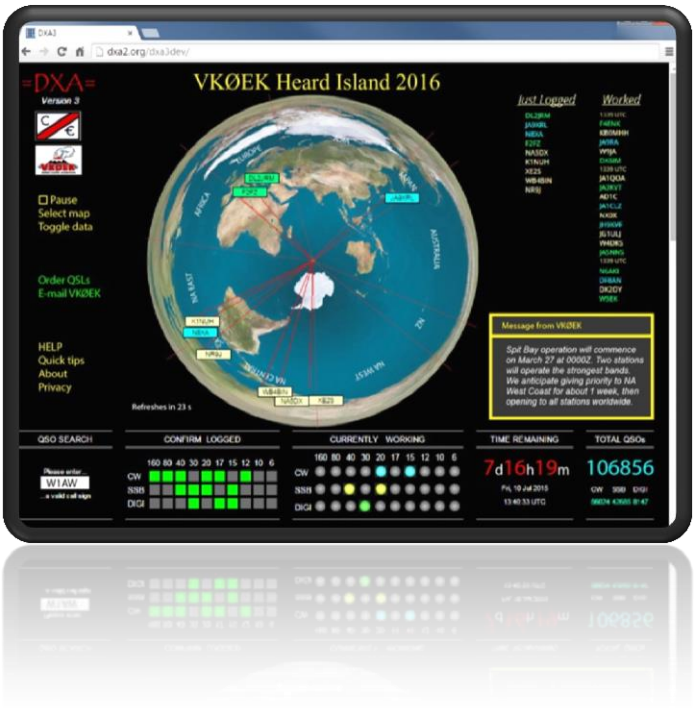
Clearly, there is both a great need and great opportunity for implementing real-time communications. With this capability, we plan to implement a variety of live web pages showing the status and activities on the island.

For the Heard Island Expedition, we will deploy a system we developed and used very successfully on several previous expeditions, called DXA,[56] shown in the figure below. The networked computers on the island feed data to a satellite terminal, which sends it to a host with access to the internet.



[56] http://www.dxa2.org and http://www.cordell.org/DXA

DXA makes use of a satellite link, typically a BGAN transceiver, to send and receive data between the remote site (Heard Island) and the host. On the island, data sent from the island is packetized with headers; at the host, the data is parsed and distributed to various applications such as databases and web pages. Any client anywhere in the world with a normal browser can see the web pages, which automatically update (typically once per minute) as new data is received.



The screen shot at right shows the main screen of DXA as used on the 2005 Kure Atoll expedition and the 2013 Clipperton expedition.[57] During both expeditions, the DXA website received around 40 *million* hits. The response from the amateur radio community viewing DXA was overwhelmingly positive.[58]

For the Heard Island expedition, we will implement additional services within DXA. Thus, we envision uploading not only radio logs, but also data obtained from weather instruments, the real-time locations of personnel, status reports, images, and live audio and video clips, essentially all the services listed above. Additionally, DXA has the ability for live chat, which will be very valuable in adapting the activities on the island.

Outreach, publicity, and archives

Outreach is a manifest policy of the Australian Antarctic Science Strategic Plan 2011-12 to 2020-21,[59] namely:

- …public outreach will be built into all projects… (*Plan*, p. 65)
- …advances in communication technologies…for distributed, networked collaboration (*Plan*, p. 71).

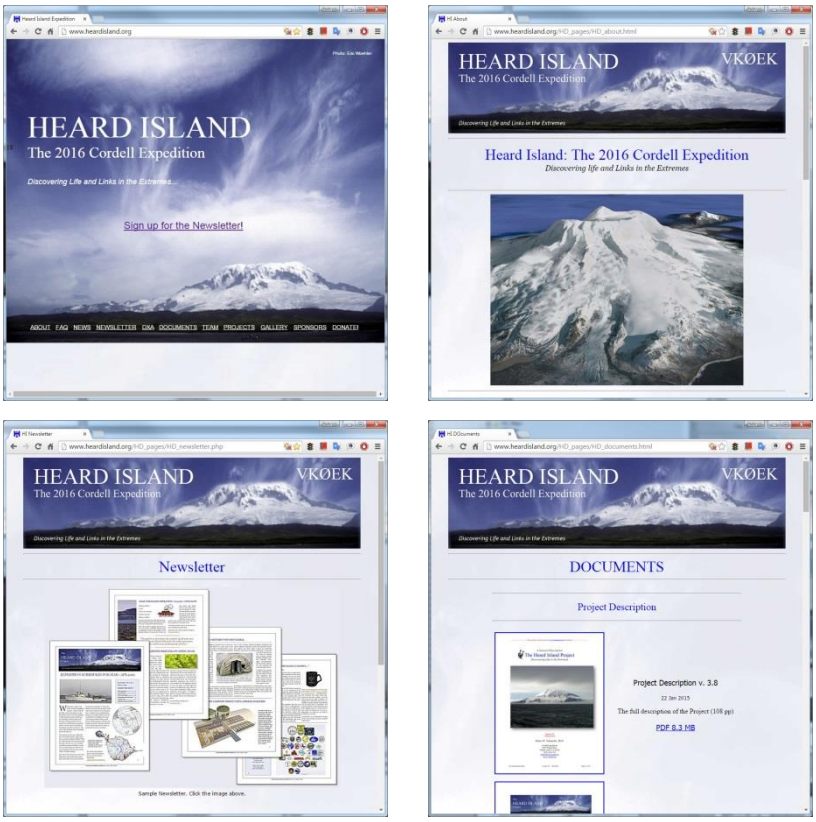
A key idea in this activity will be to make use of social networking to extend the outreach. This we have included several types of outreach in the Heard Island Project, including websites, blogs, facebook, twitter, etc.

We have established several connections to educational institutions, including universities in Australia and the U.S. If we are able to field the high-speed satellite connection described above, we will schedule various live interviews and broadcasts with these, and possibly other, institutions.

[57] http://www.cordell.org/CI
[58] R. W. Schmieder, *DXA. The Online Real-time Radio Log Server*, Cordell Expeditions, 2013.
[59] http://www.antarctica.gov.au/science/australian-antarctic-science-strategic-plan-201112-202021

Websites

Cordell Expeditions established a website http://www.heardisland.org (below, left) for the project. This domain heardisland.org is actually a pointer to the website www.cordell.org/HD, which will be the central site for the Project, with information, documents, links, and real-time interactive content for the expedition. The website provides the Internet focus for this project, from which various social media can be accessed.



Archives and monograph

We consider it central to the project to capture and preserve as many records as possible. For that purpose, one member of the team, Joan Boothe, will have the task of archiving records and collecting resources such as historical manuscripts. Joan is a member of the Explorers Club. She has published a definitive history of the Antarctic Peninsula.[60]

All data resulting from the Expedition, including radio logs, photographs and video, field notes and maps, and all other similar material, will be kept in an Archive of the Expedition, with Cordell Expeditions as custodian. All materials will be available to all members of the Project, as well as others with a legitimate need. The material will contribute to a monograph to be published describing the operations and scientific results of the Expedition. The archives will eventually be accessioned into an appropriate repository of record, probably the Australian Antarctic Division in Kingston, Tasmania.

[60] J. Boothe, *The Storied Ice: Exploration, Discovery, and Adventure in the Antarctic Peninsula* Region (Regent Press, 2011).

OPERATIONS

Most of the facilities and equipment for the expedition will be assembled, tested, and packed in California and Virginia. An offsite support team will acquire the equipment such as tents, generators, heating and sanitary facilities, radios, computers, and antennas and go through a comprehensive test protocol. Together with supplies, this material will be packed in a container which will be shipped from Norfolk, VA to Cape Town, South Africa.

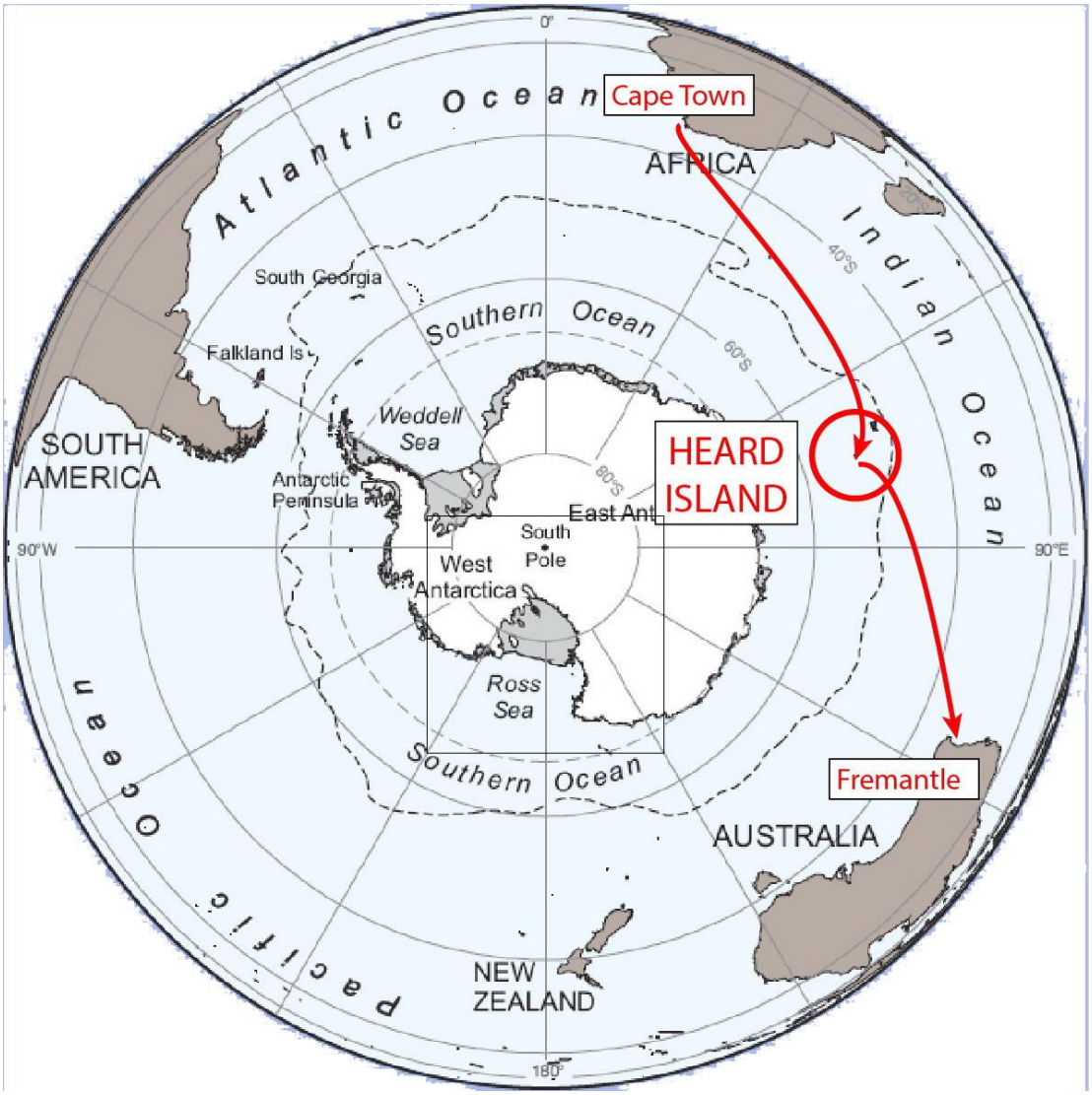
The voyage

The Expedition will use the vessel Braveheart, owned and operated by Nigel Jolly. The vessel is an ice-strengthened polar research and supply vessel, extensively used for oceanographic touring, research, and amateur radio expeditions. The ship Braveheart accommodates 14 passengers and a crew of five.

The specifications of the Braveheart are:

Length:	39 metres
Construction:	All steel
Engine:	NIIGATA 1200 hp
Generators:	2 x Niigata 125 kVA
RIB Boats:	5.2m with 90 hp outboard 4.8m with jet unit for coral reefs and ice
Accommodation:	12 passengers in 2 berth cabins, air-conditioned
Crew:	Normally 5
Helicopter deck	√
Fuel capacity:	94000 lts
Range:	33days steaming 24hrs per day
Water capacity:	6000 lts
Water maker:	4500 lts per day
Ship air conditioned and heated	√
Last slipping for survey:	Jan 2007. Under New Zealand Safe Ship Management.
Survey company:	Survey Nelson.

The voyage from Fremantle to Heard Island will take about 10 days to cover the distance of 4092 km, or 2209 nm. Departure will be in early March 2016. The voyage will be across the "Roaring Forties" and into the "Furious Fifties," references to the usual high winds and sea state in these latitudes. Thus, the voyages are expected to be physically challenging, but not particularly unsafe.

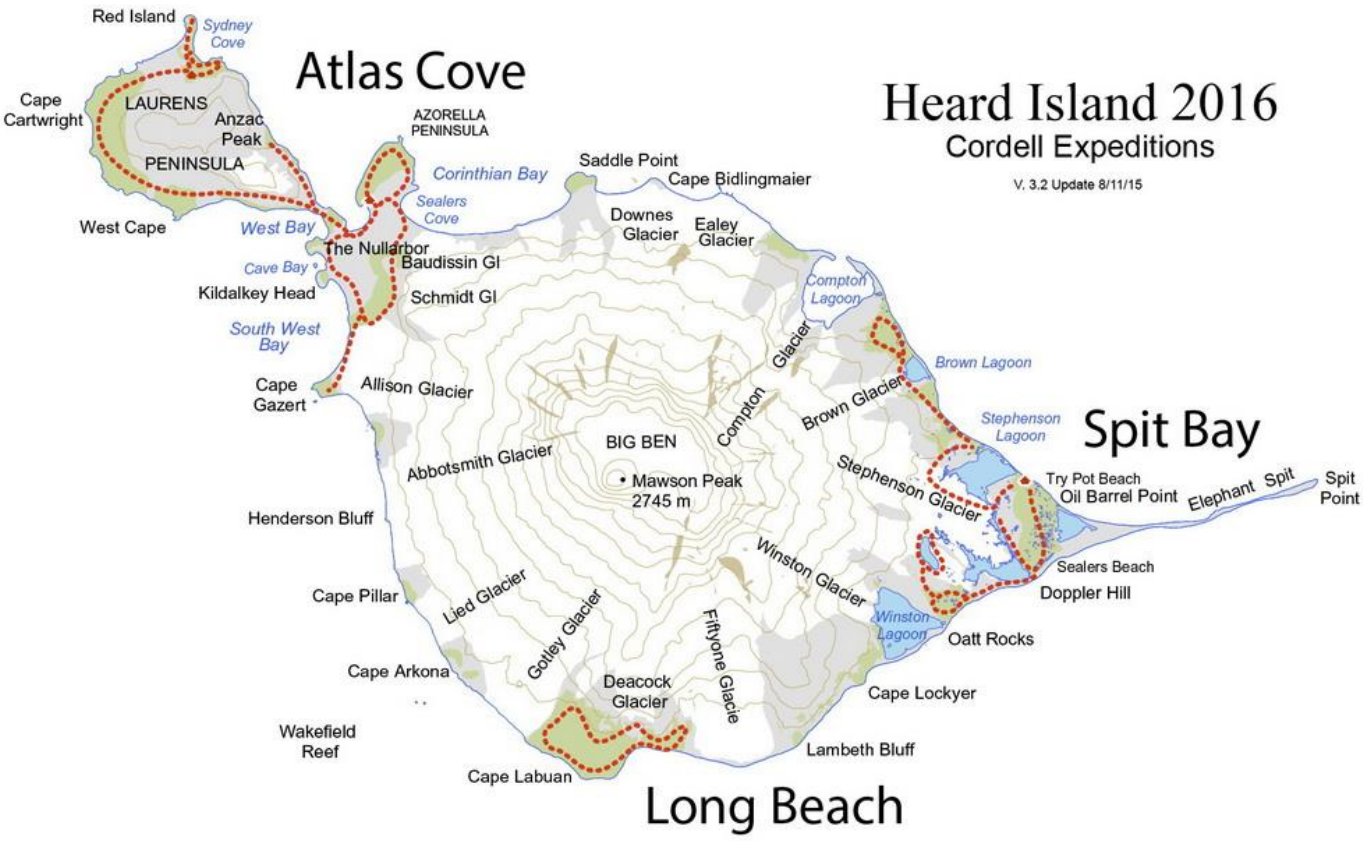


The vessel will remain onsite at Heard Island for a nominal 21 days, with an optional extension. During this time it will be available for transferring a small team and minimal equipment to Spit Bay, and possibly to Long Beach. The vessel will be in continuous contact with the camps, and with service son Kerguelen, the French island 250n to the north.

The voyage to Fremantle will also be about 10 days, making a total for the Expedition of 46 days. Upon arrival at Fremantle, some equipment will be disposed and the balance will be shipped back to California for return to its sources.

Areas to be visited

The following diagram shows the areas that the team proposes to visit on Heard Island. These areas are within the designated Visitor Access Zones as defined by the AAD, or are accessible from those Zones by walking. The areas are chosen to provide for accomplishing the two mission goals, namely to search for unknown species and to conduct an amateur radio operation. Each of these areas is described in some detail in the following pages. Please note that the Stephenson Lagoon is very much larger than indicated in this map. As shown in the satellite image on p. 33, we will have boat access to much of the area marked on this map in the vicinity of Stephenson Glacier.



The initial landing will be done at Atlas Cove, where the main campsite will be established. We are well-aware of the need to stay clear of the ANARE site (ruins), and this will pose no problem for our logistics. From the main camp, we will visit adjacent areas for the various scientific projects, but the radio operation will be done exclusively from the main camp.

Assuming conditions permit, sometime during the 3-week stay at Atlas Cove we will move a small team (probably 4 persons) to Spit Bay. There they will establish a station to make contacts preferentially with the west coast of North America. During that time we will carry out scientific studies of beach debris, biota in deglaciated areas, and lagoon sediments. We plan to spend about 1 week at Spit Bay.

If possible, we will make a short visit to the Long Beach Visitor Use Area. No radio operation will be done from there; it will be sampling related to the biodiversity research.

Atlas Cove

The Atlas Cove Visitor Access Zone will be the location of the main camp. As in 1997, we will establish the campsite to the east of the ANARE Heritage Zone, near the boundary between the Nullarbor and the Azorella Peninsula lava flow. From the campsite, we will be able to explore areas adjacent to the Nullarbor, including the Laurens Peninsula. The latter is of extreme interest, since it undoubtedly harbors many unknown species in its hummocky and mossy habitat, as well as the western (windward) coastline where additional marine species might be found.

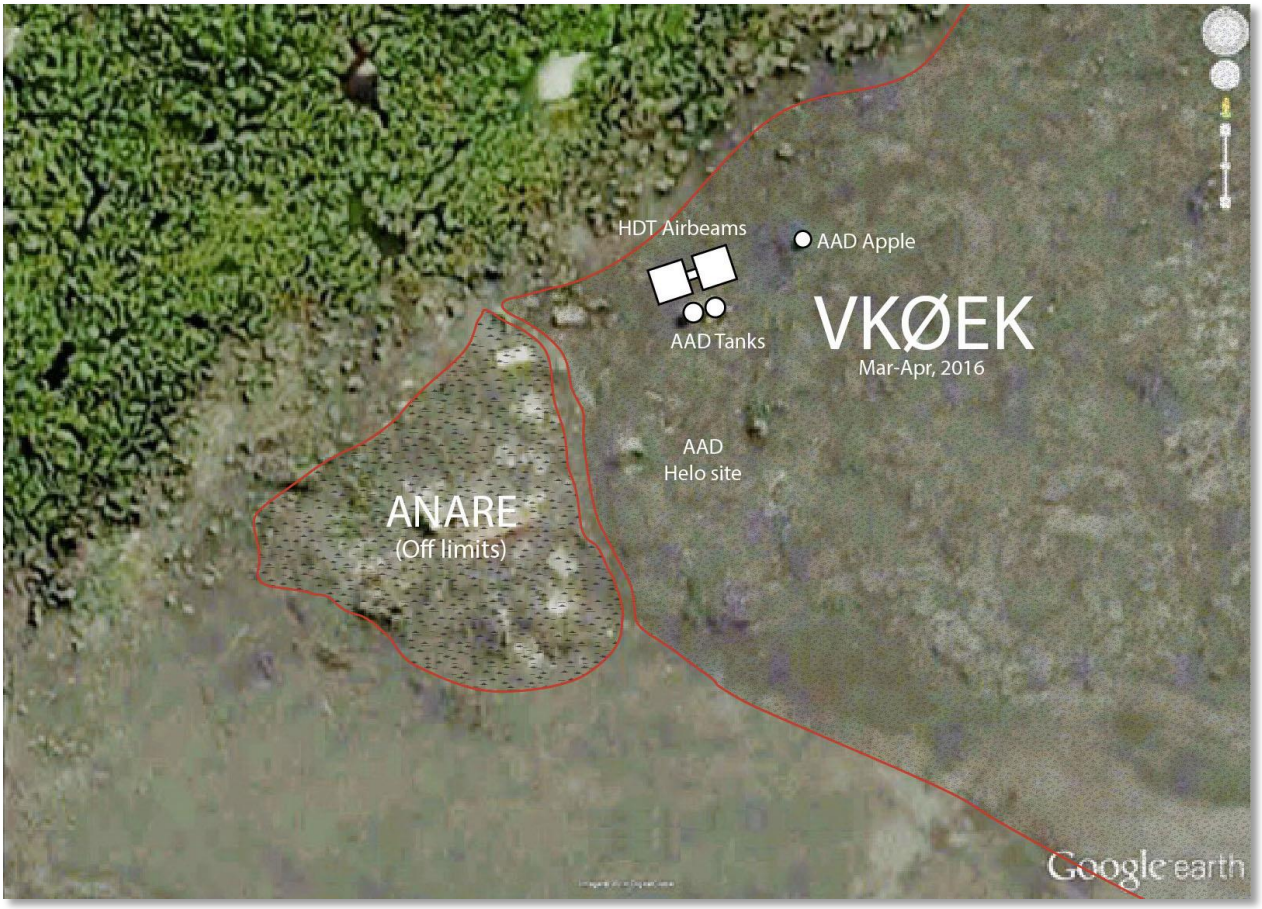
Approximate anticipated location of the main campsite at Atlas Cove.

From the 1997 Cordell Expedition to HI, we are very familiar with the area at Atlas Cove. [61] The following satellite image shows the area, including the ruins of the 1947 ANARE camp, and three refuge shelters that were placed in this vicinity in 2005.

For the current Expedition we are also very interested in the area around Spit Bay. There are several reasons for accessing both general use areas. A major motivation is to enable collection of biological and geological specimens at the two locations. For example, we want to document the sediment and resident microfauna in the lagoons on the east side, accessible from Spit Bay, but not Atlas Cove. Another reason is to establish radio communication to the West Coast of the U.S. From Atlas Cove this area is almost completely blocked by the volcano, whereas from Spit Bay it is open.

There is also some chance that we will want to land in the area on the southern coast known as Long Beach. The reason for this is that the southern exposure may support populations not extant on the northern coast. A spectacular example of this is the recent observation of previously unknown populations of the Heard Island cormorant, raising the number from 200 to more than 1000 breeding pairs.

[61] R. W. Schmieder, *VKØIR Heard Island*, 1997, pp. 57 et seq.



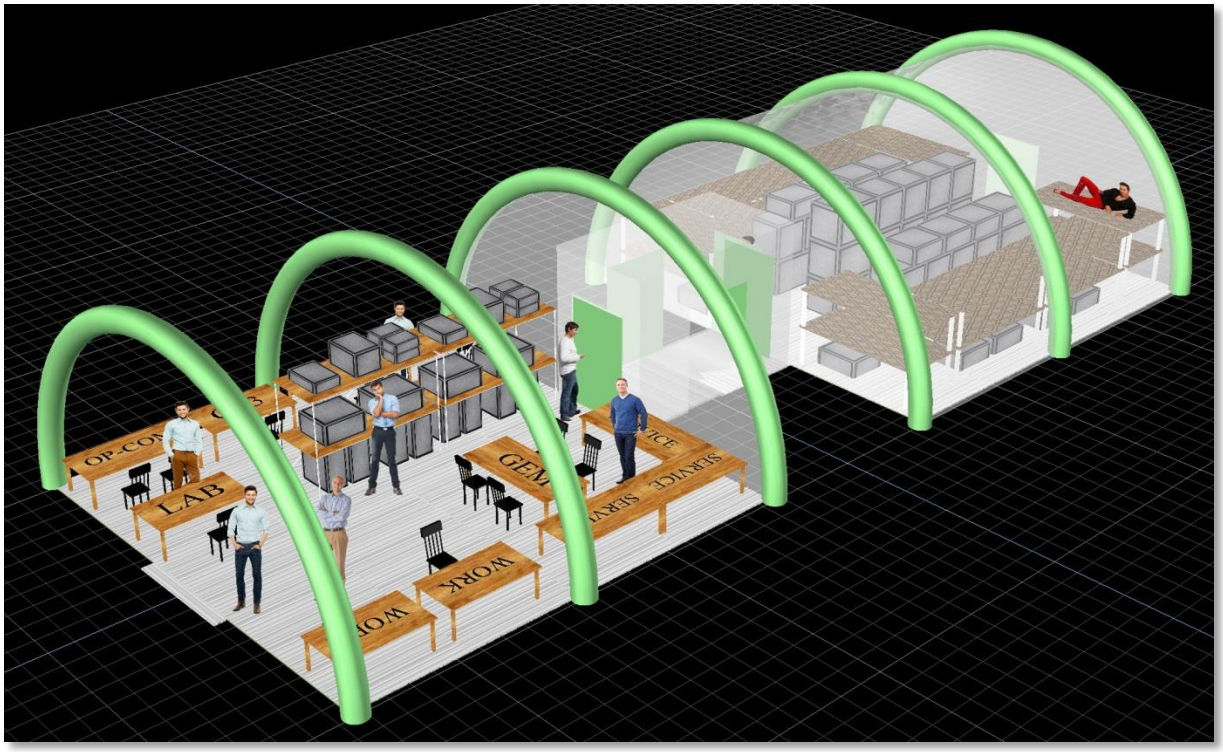
Source: Google Earth, AAD, R. W. Schmieder

General layout of the main campsite at Atlas Cove in the vicinity of the 1947 ANARE station (ruins)

The main shelters at Atlas Cove will be the "AirBeam" shelters made by HDT Global[62]. A drawing of one of these tents is shown below. This shelter is 20 ft. x 21 ft. These tents are supplied by HDT for military organizations worldwide. They are extremely strong and reliable. They have zipper doors and an internal plastic accordion-fold floor. It has the very desirable features of inflating very rapidly (15 minutes) with a compressor and being rated for very high wind loads.

The drawings on the next two pages show our plan to link two of these shelters with a hallway. Access to the outside is provided by doors on each AirBeam, and through one door in the hallway. One shelter will be used as a work area, with tables for radios, lab, food service, computers, and storage, while the other will be a dormitory, for sleeping and storage.

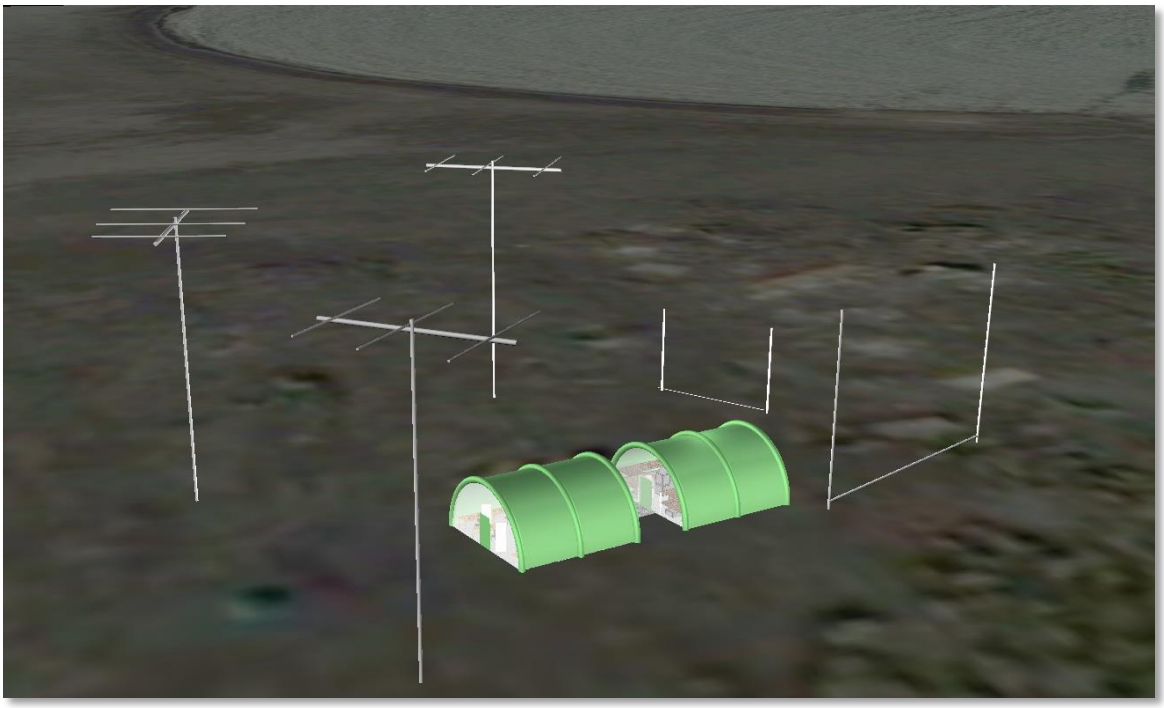
[62] www.hdtglobal.com



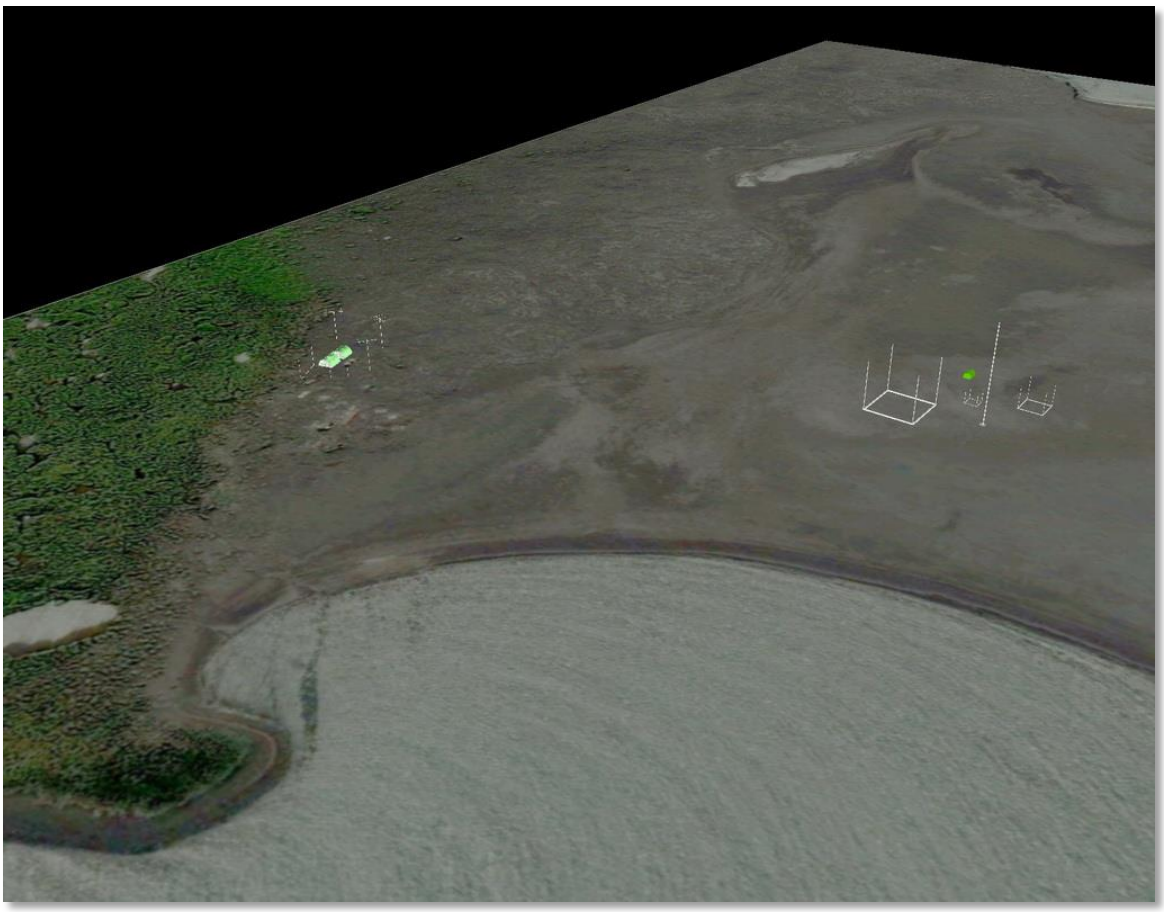
Virtual reality (VRML) renderings of the planned main shelters for Atlas Cove

The drawings on the next page show a conceptual layout for the campsite at Atlas Cove, including an array of radio antennas. The exact configuration of the antennas is not yet determined, but generally will be arrayed around the tents, connected by coax cables.

Under consideration is a second radio operating site on the Nullarbor, about ¼ mile from the ANARE ruins. The reason for the second site is to separate the antennas sufficiently to prevent interstation interference, and to enable the use of vertical 4-square antenna arrays for optimum radio signal propagation. This configuration was used on the previous expedition VKØIR 1997; they were positioned at the edge of the Nullarbor, since all the shelters were near the ANARE site. The drawing at right (below) illustrates this possible second radio station location. The Nullarbor floods during high winds, but it rises gently so the facilities would be located in a non-flooding area. It is emphasized that no final decision has been made as of this writing on where, and indeed whether, to establish this site.



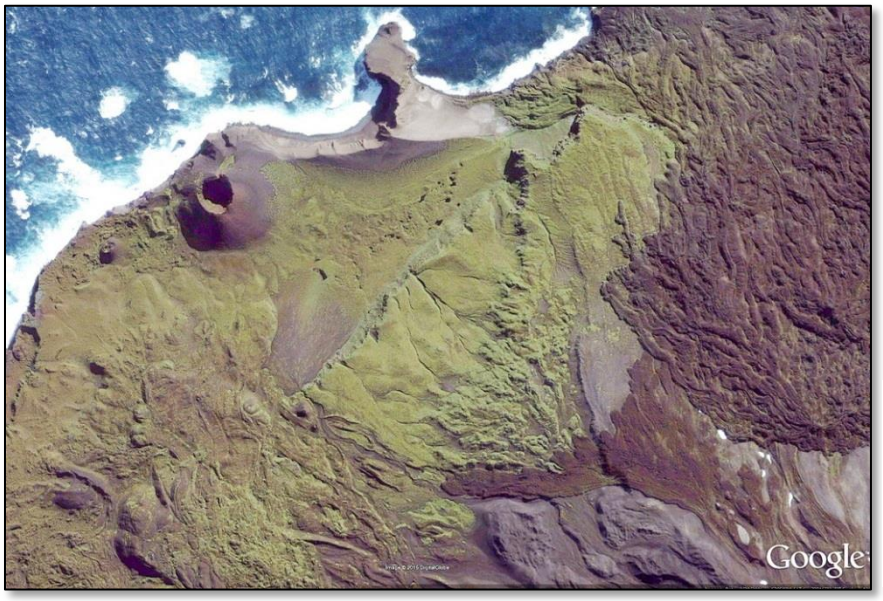
Conceptual arrangement of the main campsite at Atlas Cove. The ruins of the ANARE station are in the background.



Conceptual arrangement of a second station, located on the Nullarbor.

Laurens Peninsula

Some details of the need to examine the geology of the Laurens Peninsula are provided in the statement by Jodi Fox (above). Because the peninsula also probably harbors numerous unknown species, examination of the peninsula there is very high priority. Among the areas of greatest interest is the northwest corner, seen below. This area includes a variety of microhabitats, so it is a good candidate for searching for unknown organisms. Near this area is the apple shelter located at Red Island. If permitted, we may make use of this shelter for several days of exploration in this area.



Source: Google

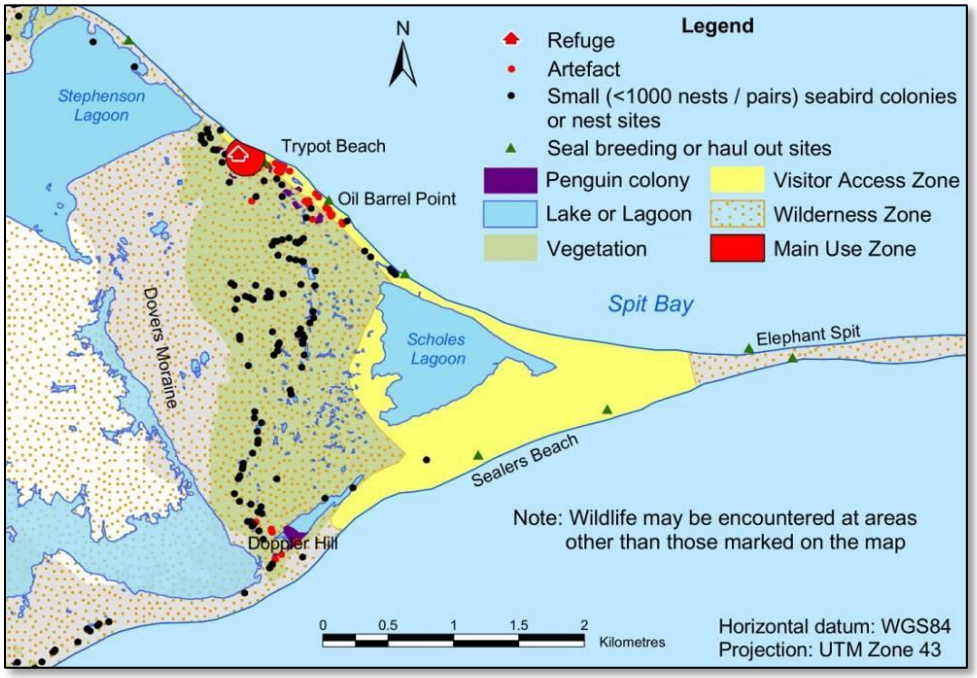
(Above) The area on the NW corner

(Below) Shelter on the N end [AAD]

Source: AAD

Spit Bay

The map below shows the visitor use area at Spit Bay. The vessel will bring a small team (perhaps 4 persons) for the landing. We would prefer to use the existing refuge shelters (shown below) to minimize logistics and environmental impact). It is anticipated that we would be at Spit Bay for about 1 week, conducting limited radio operations and exploratory searches in adjacent areas.



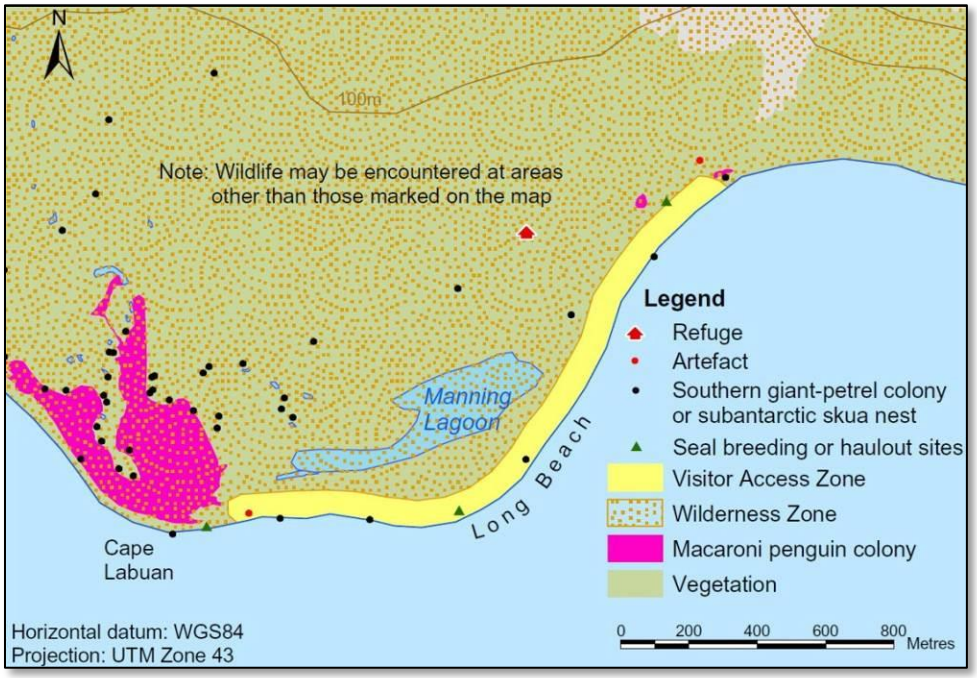
Source: AAD

(Above) The visitor use area at Spit Bay (Below) The Spit Bay encampment 2003

Source: AAD Woehler

Long Beach

The map below shows the visitor use area at Long Beach, on the extreme southern side of Heard Island If conditions and time permit, we wish to land on Long Beach, to search for debris on the beach and biota in the nearby area. We do not anticipate conducting any radio operation from this location, and probably would not stay overnight.



Source: AAD

(Above) The visitor use area at Long Beach *(Below)Remains of sealers hut*

Source: Estelle Lazer

Special equipment

Water-borne particulates

Heard Island produces copious water in glacial runoff, lagoons, and surf. All of these sources will contain entrained and suspended particulates, some of which may be cryptobiota, while others may be mineral fragments indicative of their origin or processing. We plan to collect water-borne particulates with a simple low-cost multi-stage filtering system, shown generically below. The pump/filters will be housed in a portable container, powered by the portable generator. A large variety of filters will be shipped and selected according to the local conditions. If the burden of rock flour is too large, it may simply be dumped after the last stage of filtering. Filters containing particulates will be preserved for shipboard and offsite examination and identification of the particles.

Airborne particulates

Airborne particulates (e.g., aerosols) are potentially important to the glaciers on Heard Island: glaciers in the Andes are melting significantly faster than expected. This was (incorrectly) attributed to airborne aerosol particles that deposit on the glaciers and in turn increase their capacity to absorb energy and solar radiation.[63] We plan to sample airborne particulates using standard air filtration. Three standard systems could be used (shown below): (1) a wet-dry vacuum, with appropriate internal filters;[64] (2) the standard Anderson cascade impactor;[65] and (3) the Next Generation Impactor (NGI).[66]

[63] http://www.dailymail.co.uk/sciencetech/article-2151066/Another-warming-myth-busted-Climate-change-ISNT-blame-melting-glacier-Bolivia--aerosols-are.html
[64] http://www.shopvac.com/wet-dry-vacs/vac-details.aspx?vacId=298&vacSKU=586-61-10
[65] http://www.bgiusa.com/agc/cpci.htm
[66] http://www.genengnews.com/gen-articles/engineering-regenerative-medicine-s-future/3794/?page=2

Remote videography

A very valuable capability will be a WiFi-connected high-resolution digital camera. This system will enable us to obtain remote video of selected sites. We fielded this system on the Clipperton 2013 expedition.[67] On Heard Island, we plan to use a macro lens to focus on small habitats that could harbor unknown macrofauna.

Invertebrate traps

Another useful tool for collecting cryptofauna will be traps, both baited and UV-lighted. Because of their advantages (cheap, small, static, effective), we will field several types of traps. Some traps can be examined periodically, but most traps will be left for the duration of the stay and collected upon departure. Traps deployed on the ground will be protected from birds.

Aerial imaging and sensing

In the past few years, a new tool has become commercially available for aerial imaging and exploration: the multi-rotor helicopter ("multirotors"). A variety of these Unmanned Aerial Vehicles (UAV) craft are available[68] (e.g., below/left). Because so many areas on Heard Island are practically inaccessible, this capability would be of very high value. The remotely-operated aircraft could be used to obtain images of terrain that are inaccessible, such as the cliffs and crevasses of glaciers. It would be valuable for safety, and for public outreach through the satellite link. In addition, it could carry sensors the make measurements of atmospheric conditions and geophysical data.

Another platform with great potential is a kite. There is a large community (e.g., American Kitefliers Association[69]) involved in Kite Aerial Photography (KAP)[70], and members of Cordell Expeditions have extensive experience with KAP. A typical camera rig is shown in the photo above/right.[71] While this is a rather sophisticated mount, we expect that it will be necessary to adapt a rig specifically for the Heard Island environment, due to the expected high winds, precipitation, and low temperatures.

[67] Ed Cox, Use of High Speed multimedia on the Clipperton Island Expedition. Working document, Nov. 26, 2012.
[68] http://multicopter.org/wiki/Multicopter_Table
[69] http://www.aka.kite.org/, http://kite.org/
[70] http://en.wikipedia.org/wiki/Kite_aerial_photography
[71] http://www.draganfly.com/uav-helicopter/draganflyer-x6/features/flir-camera.php

PROJECT MANAGEMENT

Protecting Heard Island

Among the greatest concerns of the AAD, Cordell Expeditions, and ecologists in general, is the issue of introduced alien species. The AAD website contains the following statement:[72]

> Heard Island is the largest sub-Antarctic island with no known human-introduced plants. Invasive introduced species (those which spread rapidly and displace existing vegetation) can have considerable consequences for the diversity of plants and invertebrates. … The Management Plan and associated Environmental Code of Conduct for the HIMI Marine Reserve include strict quarantine measures to prevent the introduction and spread of alien species and disease to HIMI.

We understand well the foundation and implications of these statements, and we have recent experience with appropriate protocols. The Environment Advisor, Operations Branch, AAD, provides the following description of the mitigation strategies and actions for the 2003-2004 expedition:[73]

> A range of environmental mitigation strategies and actions were employed to protect Heard Island's environment during the 2003-04 expedition. In particular, a detailed environmental assessment was prepared prior to the expedition, pursuant to the Heard Island Wilderness Reserve Management Plan. The assessment identified a number of possible impacts:
>
> - Introduction of alien species to the island;
> - Disruption to wildlife populations;
> - Trampling of vegetation and disturbance to soil;
> - Pollution from chemicals and wastes;
> - Effect of human activity on cultural heritage; and
> - Loss of wilderness and aesthetic values from the establishment of camps.

Specific actions to mitigate these environmental impacts included:

- Strict quarantine measures such as the purchase of new equipment, non-supply of fresh fruit and vegetables, and rigorous cleaning and inspection regimes on all cargo;
- Presence of restricted areas and controls on vehicle movements, field camp locations and wildlife approach distances;
- Deployment of unusual animal mortality response kits in the event of a disease outbreak;
- Deployment of field fuel spill kits to prevent and clean up fuel spills;
- Reduced packaging on all cargo to minimize waste prior to departure;
- Removal of solid waste from current and previous expeditions, and proper disposal of liquid waste;
- Preparation of an environmental code of conduct, a comprehensive environmental training program for all participants; and
- An environmental reporting regime while on the island and upon return.

We appreciate and will abide by any measures to be taken to avoid alien introductions, and we expect to follow all relevant protocols.

---

[72] http://www.heardisland.aq/nature/ plants/introduced-species-plants
[73] http://www.antarctica.gov.au/__data/assets/pdf_file/0011/20360/0920protecting20heard20island27s20environment.pdf

ACM risk to personnel at the ANARE site

We plan to erect our temporary shelters and working campsite to the east of the ANARE ruins, essentially in the same place that we occupied during the1997 expedition.[74] Although we are fully aware of the prohibition against entering this Heritage Zone, the site presents some hazard to personnel in its vicinity. In addition to the possibility of flying debris and ground contamination, we have been informed[75] that asbestos-containing material (ACM) is present within the Heritage Zone and in parts of the Atlas Cove Main Use Zone that borders the Heritage Zone. Risks associated with PCM include asbestosis, mesothelioma, lung cancer, and pleural plaques. We are aware of the threat through various information websites, such as https://www.asbestossafety.gov.au/asbestos-information.

In order to mitigate the threat to our personnel from the ACM, we will implement the following actions:

1. The Expedition leader will provide a safety briefing (which includes information on asbestos awareness) to all persons on the expedition;

2. A ground inspection for possible ACM will be undertaken prior to the establishment of any encampment in the Atlas Cove Main Use Zone. An encampment in the Atlas Cove Main Use Zone may only be established at a site where ACM would pose an acceptably low level of risk.

3. Establishment of a flag-delineated buffer zone around the Heritage Zone.

4. Incidents of exposure to ACM will be reported to the AAD.

We are grateful to the AAD for providing this information.

[74] R. W. Schmieder, *VKØIR Heard Island*, Cordell Expeditions, 1997.
[75] James Fleming, private communication, email 23 Sept. 2015.

Protocols

Legalities

All activities undertaken by the Project will be in strict conformance with all legal requirements from all recognized authorities. There will be zero tolerance for any illegal activity, regardless of the person, context, or circumstance.

Safety

Cordell Expeditions considers safety of the personnel and protection of the resources at Heard Island to be paramount, taking precedence over any other planned activities. The author of this proposal and permit applicant, Dr. Robert Schmieder, considers it his personal responsibility to maintain zero tolerance of any potential safety violations, and he will guarantee the appropriate behavior of every member of the CE team.

Power

Power will be obtained from a set of gasoline-driven generators, similar to those used in 1997. Fuel will be stored in drums in a secure area, dispersed to protect against accident, and brought to the generators by jerry can to prevent spread from an accidental fire. Spill-prevention and remediation will be provided. The electrical service will be assembled from industry-standard electrical components with appropriate insulation and grounding.

Waste and sanitation

We do not expect to generate any toxic waste; waste will be from food preparation, wash water, packaging, and human sanitation. Handling of wastes will be in conformance to the Management Plan and instructions provided by the AAD. IN particular, we are planning to include in our facilities an incinerating toilet that will completely eliminate human wastes from the campsite. The toilet is vented to the outside, but emits no ash or smoke.

The AAD refuge shelters

Water tank and apple shelters have been permanently installed at Atlas Cove, Spit Bay, Long Beach, and Reds Island (Laurens Peninsula). We will plan our visits and carry sufficient supplies to be able to operate without using these shelters, except under emergency conditions. Should it be necessary to use these, we will respect the shelters and their anticipated future use. We will not use consumables (if there are any) except in the event of a true emergency. If any consumables are used, they will be replaced from the stores on the vessel. The AAD will be informed of any occupation and/or use of these shelters.

Teardown and cleanup

At the end of the operation, all of the facilities will be dismantled and packed for departure, with the possible exception of a permitted automatic weather reporting station to be installed at Atlas Cove. It has been the policy of Cordell Expeditions for 35 years to leave a completely clean site, and it is the personal responsibility of the Expedition Leader to ensure that there is zero residual from the occupation.

Formalities

Permits

All operations on the Expedition will be carried out under permits issued by the Australian Antarctic Division (AAD). It is the policy of Cordell Expeditions to fully conform to and abide by all laws, rules, and stipulations by all agencies with authority over Heard Island. For instance, we are aware of the need to minimize the danger to birds due to radio antennas. We expect to receive instructions from the AAD associated with the permit issues such as these, and we will abide by such instructions.

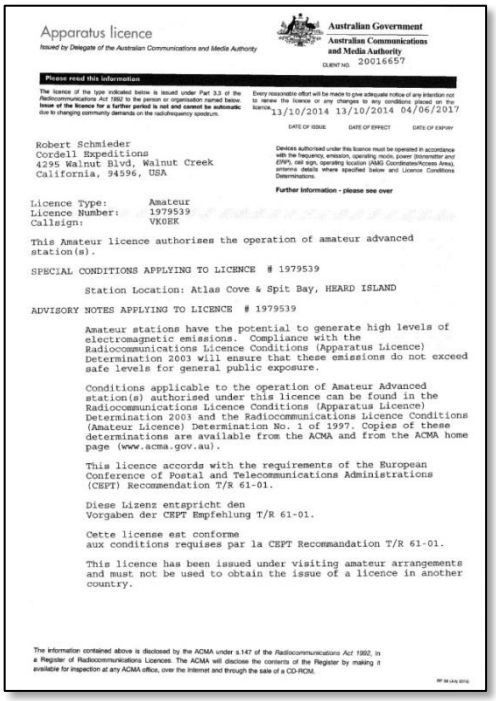
Separate from the permit to visit Heard Island, we will seek permits to collect and conserve live specimens. We are aware that most countries, including Australia, have restrictions on exporting and importing live specimens, and we will seek to satisfy all these requirements. At present we do now have a complete list of collaborators who want such specimens, so we cannot list them here. We do note, however, that Heard Island is part of Australia, so we hope that the restrictions on bringing specimens to laboratories in Sydney, Melbourne, Tasmania, and similar centers, will not prevent the scientific work.

Amateur Radio Licence

The Australian Communications and Media Authority has issued licence # 1979539 for the operation of an amateur radio station on Heard Island, at Atlas Cove and Spit Bay, using the callsign **VKØEK**. A copy of the licence is shown below (left):

Public Liability Insurance (PLI)

We have secured a policy of Public Liability in the amount NZ$20 million. A copy of the summary of this policy is shown below (right). This policy was accepted by the AAD as being both the required amount and provisions and from an authorized company providing such a policy.



Apparatus licence

Issued by Delegate of the Australian Communications and Media Authority

Australian Government
Australian Communications and Media Authority

CLIENT NO. 20016657

Please read this information

The licence of the type indicated below is issued under Part 3.3 of the Radiocommunications Act 1992 to the person or organisation named below. Issue of the licence for a further period is not and cannot be automatic due to changing community demands on the radiofrequency spectrum.

Every reasonable effort will be made to give adequate notice of any intention not to renew the licence or any changes to any conditions placed on the licence.

13/10/2014 13/10/2014 04/06/2017
DATE OF ISSUE DATE OF EFFECT DATE OF EXPIRY

Robert Schmieder
Cordell Expeditions
4295 Walnut Blvd, Walnut Creek
California, 94596, USA

Devices authorised under this licence must be operated in accordance with the frequency, emission, operating mode, power (transmitter and EIRP), call sign, operating location (AMO Coordinates/Access Area), antenna details where specified below and Licence Conditions Determinations.

Further information - please see over

Licence Type: Amateur
Licence Number: 1979539
Callsign: VK0EK

This Amateur licence authorises the operation of amateur advanced station(s).

SPECIAL CONDITIONS APPLYING TO LICENCE # 1979539

Station Location: Atlas Cove & Spit Bay, HEARD ISLAND

ADVISORY NOTES APPLYING TO LICENCE # 1979539

Amateur stations have the potential to generate high levels of electromagnetic emissions. Compliance with the Radiocommunications Licence Conditions (Apparatus Licence) Determination 2003 will ensure that these emissions do not exceed safe levels for general public exposure.

Conditions applicable to the operation of Amateur Advanced station(s) authorised under this licence can be found in the Radiocommunications Licence Conditions (Apparatus Licence) Determination 2003 and the Radiocommunications Licence Conditions (Amateur Licence) Determination No. 1 of 1997. Copies of these determinations are available from the ACMA and from the ACMA home page (www.acma.gov.au).

This licence accords with the requirements of the European Conference of Postal and Telecommunications Administrations (CEPT) Recommendation T/R 61-01.

Diese Lizenz entspricht den Vorgaben der CEPT Empfehlung T/R 61-01.

Cette license est conforme aux conditions requises par la CEPT Recommandation T/R 61-01.

This licence has been issued under visiting amateur arrangements and must not be used to obtain the issue of a licence in another country.

The information contained above is disclosed by the ACMA under s.147 of the Radiocommunications Act 1992, in a Register of Radiocommunications Licences. The ACMA will disclose the contents of the Register by making it available for inspection at any ACMA office, over the Internet and through the sale of a CD-ROM.

uig united insurance group
AFS Licence No: 327131 ABN: 31 131 564 522

smart business insurance

Smart Business Insurance
Authorised Representative of United Insurance Group

Schedule of Cover Our Reference: 15090727

Insured: Cordell Expeditions

Interested Parties: nil advised

Business: Principally research voyage to the Australian Territory of Heard Island between 1/3/2016 to 30/4/2016

Interest Insured:

All sums which You shall become legally liable to pay for compensation in respect of Personal Injury or Damage to Property, which happens during the Period of Insurance, and is caused by an Occurrence in connection with the Business.

Territorial Limits: Worldwide excluding United States of America or Canada, their territories or protectorates.

Limits of Liability:

Public Liability - Any one Occurrence AUD $ 20,000,000
Products Liability - In the Aggregate AUD $ 20,000,000
(any one Period of Insurance)

Property in Your physical or legal control AUD $100,000

Excess:

AUD $1500 Each and Every Occurrence and inclusive of Costs

Personal Injury to Contracted
Employees or Workers Excess: AUD $25,000 Each and Every Occurrence and inclusive of Costs

Policy Wording: SMLLIAB0313
(please refer to www.hostsure.com.au for a copy)

Optional Benefits:

plus Endorsements and Optional Benefits described in this Schedule

Optional Benefit - Workcover Defence Costs Not insured
Optional Benefit - Criminal Defence Costs Not insured

Insurers: Primary AUD $5,000,000, Certain Underwriters at Lloyds (100%)
Excess up to the Limit of Liability stated above, Certain Underwriters at Lloyds (70%) and W.R. Berkley Insurance (Europe),Limited (30%)

Premium is Minimum and Deposit. If this Insurance is cancelled, no refund will be given.

It is hereby agreed and declared that this Policy excludes Personal Injury or Property Damage in respect to any Marine Liability

15090727

SUMMARIES

A brief summary of the project

This document is a brief description of the Heard Island Project, which is centered on the 2016 Expedition to Heard Island. The theme of the Project is "Discovering Life and Links in the Extremes," which includes the search for exotic, alien, and undocumented biota and fielding a sophisticated system for real-time communications. One motivation for the Project is to enhance our understanding of the consequences of global climate change and the potential for mitigating its unwanted effects, while another motivation is to contribute to the development of advanced communications on remote sites.

To these purposes, the Expedition will field a team of 14 persons plus a vessel crew of 5 on Heard Island for a nominal 21 days.

A specific goal is of the expedition is to extend the species-size distribution in the range 0.1-10 mm. The underlying motivation for this effort is to enable more reliable comparison with ecological models, particularly models incorporating global climate change. Additional interest is in the geophysical and meteorological factors that affect the environment and the biota. Cordell Expeditions has a variety of collaborators in various specialties who will contribute to studying the specimens and data and interpreting the observations.

The second goal is to develop, deploy, and use advanced communications from the extremely remote location of a major subAntarctic island. Principally this will be done using amateur radio, logging contacts with more than 100,000 stations worldwide. Part of this research will enable better understanding of radio-wave propagation around natural barriers such as the 9000-ft. volcano Big Ben. Another effort is the development of a system for reliable real-time data exchange from remote sites, as well as deployment of automatic instruments for telemetering weather data, images, and potentially real-time video.

The vessel (Braveheart) will stand by for the entire duration of the stay at Heard Island. This capability will enable deployment of small teams to carry out specific examination of selected sites, such as Spite Bay and Long Beach. It will also enable detailed photo-documentation of areas of the island essential for mapping but inaccessible to the team.

It is expected that tangible results from the Expedition could include:

- ✓ Discovery of numerous undescribed species
- ✓ New measurements of glacier morphology and dynamics
- ✓ High-resolution documentary photographs and video footage
- ✓ Data for modeling of radio wave propagation, mesoscale wind dynamics, etc.
- ✓ Development of new real-time remote communications capabilities
- ✓ Direct involvement with students as educational collaborators
- ✓ Technical papers in scientific journals and presentations at conferences
- ✓ Articles in general interest magazines and newspapers
- ✓ Personal appearances and lectures by the members of the group

In summary, the Expedition to Heard Island offers the opportunity to combine a program of biodiversity research with the capabilities of real-time communications to make a significant contribution to the preservation and rational management of the HIMI Marine Reserve, and to provide interest and education to the public.

Classification of the activities and their priorities

The following table lists the various projects that have been proposed for the 2016 Cordell Expedition to Heard Island. While this is a long list, it is important to understand the strategy and management plan for the visit, described in the next section. Specifically, we emphasize that this list represents a relatively small number of *required* activities, and a relatively large number of *optional* activities.

CATEGORY	DISCIPLINE	ACTIVITY	LOCATION
Communications science	Radio operations from fixed shelters		
	Amateur radio	Contacting amateur radio stations worldwide	Atlas Cove and Spit Bay
	Real-time communications	Data upload using real-time Inmarsat BGAN satellite (DXA). Live audio, video using Inmarsat Ka mode.	Atlas Cove
Photodocumentation	Photographic documentation of features likely to provide information about climate change		
	Photovolcanology	Big Ben, possible venting	Any vantage point with Big Ben visible
	Photogeology	Geological structures visible	From the vessel during circumnavigation of the island
	Photobiology	Megafauna populations	Elevated vantage points at distance from colonies
		Plant communities	Elevated vantage points at distance, plus close-up photographs of selecterd plants in non-restricted zones
	Photoglaciology	Glacier morphology, runoff streams, slumping, termini, calving. Emphasis on termini of retreated glaciers.	Any vantage point providing view, including aerial platform (quadcopter). Particular interest in subsurfce streams, plumes, particularly Lavett Bluff
	Photolimnology	Inlet and outlet flows into tarns, lakes. Lagoon shorelines.	Stephenson-Doppler Lake and tarn
Environmental science	Limited collections of samples and specimens to extend the known biodiversity and ecology		
	Biology	Macrobiota and micro-biota, meiofauna, plant propagules, relictual biota	Micro-environments, deglaciated areas, lagoon and beach sediments, carcasses, organic debris, insect traps, shallow soil cores, deglaciated areas
	Geology	Rocks	Selected outcroppings, particularly Laurens Peninsula, various Drygalski formation outcroppings
	Sedimentology	Particulates	Cores at lagoon shorelines, glacial runoff, air filtration
	Meteorology	Real-time during stay, automatic remote operation after departure	Main camps at Atlas Cove and Spit Bay. AWS to be installed adjacent to the AAD tank shelters at Atlas Cove.
	Ecology	Documentation of organic debris, including bones, spoor, accumulations of plant matter	Nullarbor, deglaciated areas, under covers (e.g., rocks)
	Environmental science	Documentation and collection of inorganic debris, particularly plastic and glass	Beaches
Maritime	Operations undertaken on the high seas during the outbound and inbound voyages		
	Marine biology	Observation of Type D kiiller whale	Within 40-55°S annulus on vessel track
		Collection of plankton and floating debris	Entire vessel track, multiple times per day
	Oceanography	Deploy drift bouys from NOAA, WHOI	Entire track, once per day
	Amateur radio /MM	Amateur radio /MM operations	Entire track, when desired
	Public meadia	Voice, video interviews aboard ship using satcom	Entire track, when desired

Limitations and strategies for managing them

Even a cursory glance at the present document immediately raises a sensible question: How can 14 men accomplish all the activities described herein in the space of a 3-week visit? The candid answer is: We can't. The Expedition is, in fact, deliberately designed with a large number of options, so that we can work opportunistically. Almost all of the radio operations are done from the fixed shelters at Atlas Cove, and to a minor extent a short-duration visit to Spit Bay. Most of the scientific work is observational and photographic, with a relatively small amount of sampling and specimen collection. There are essentially no extensive systematic surveys, population inventories, or detailed mensuration. While this plan may disappoint scientists who are eager for extensive quantitative information and data, we have to accept the reality that this project is a privately funded expedition with two purposes: radio operations and opportunistic science. As such, it simply cannot compete with a fully-funded large-scale expedition of the kind carried out by the AAD with governmental resources. For example, the most recent AAD science visits to Heard Island, around 2000-2003, cost upwards of $3 million, support that is not only far beyond that accessible to this group, but also, due to the change in Australian politics and the economy, currently inaccessible to the AAD itself.

The consolation for this disappointment is that the HIMI Management Plan does provide the opportunity for private expeditions, with the provision for permitting appropriate activities outside the Main Use Area. It is this opportunity that enables the present project, and we hope the result will be a significant body of new information of value to both scientific community and to the management of the HIMI Marine Reserve. The scientific emphasis in this project is on observation of gross features that could be associated with climate change, and the serendipitous discovery of undocumented species that can extend the known biodiversity. Considering the relatively low cost (almost zero cost to Australia!), any reasonable amount of such information seems likely to be significant. This statement seems particularly compelling because the changes seen in satellite images over the last decade, during which there has been no sensible ground-based examination or photo-documentation, show very clearly the extensive and significant changes that have resulted from atmospheric warming, volcanic eruption, and ecosystem alteration. Particular examples are the creation of the very large Stephenson-Doppler Lake by the retreat of the Stephenson Glacier, the complete filling of the caldera on Mawson Peak, the recent (2007) creation of subsurface streams and plumes, and the major increase in the population of the Heard Island cormorant. It seems axiomatic that we need to have reasonably systematic photo-documentation of the current geological and glacial structures, and at least minimal sampling of macro- and micro-biota if we are to bridge the decade-long gaps between major expeditions.

Thus, the management plan for the 2016 Cordell Expedition is to ensure that the required activities (life support, the radio operations, communications to and for sponsors and media, etc.) are carried out, and to provide for the various scientific investigations as the conditions, time, energy, and interest allow. How many projects and how much new information will result cannot be predicted, but we have the strong conviction that the results of the expedition will be worthy of the effort.

Acknowledgments

We wish especially to acknowledge many people who have helped to formulate and form this expedition, but for various reasons are not listed on the page of team members. Some of these people helped in the initial concepts, while others were involved in the ongoing development of the project. Numerous people were on the roster to go to Heard Island but were unable to do so when we were forced to shift to a smaller vessel. Regardless of specific involvement or contribution, the author and the project extend our sincere thanks to all these people, and many more, for their most valuable contributions.

Barry Fletcher ZS1FJ
Ben Weiland
Camilo Rada
Chris Hannagan ZL2DX
Chris Janssen DL1MGB
Christopher Wells PhD
Christian Eichenauer
Damien Gildea
Donald Greenbaum N1DG
Donald Walsh PhD
Ed Cox KE3D
Paul Klemes MD
Eleanor Forbes
Eric Woehler PhD
Gary Hinson ZL2IFB
Glen Pacey
Grahame Budd PhD
Inga Gilchrist
Jacky Calvo ZL3CW
Jeff Blumenfeld
Jeff Bozanic PhD
Joan Boothe
Jodi Fox
John Weigel
Ken Ehrhart
Kim Hoon
Kip Edwards W6SZN
Kirsti Smith VK9NL
Lee Jennings ZL2AL (SK)
Louis-Philippe Loncke
Martin Budd
Martin Rietze
Martti Laine
Max Delgado
Mike Mraz
Paul Mayewski PhD
Peter Casier
Pista Gaspar HA5AO
Robert Pitman PhD
Rohan Clarke PhD
Rusty Epps W6OAT
Stan Strzyzewski SQ8X
Steve Smith PhD
Viola Krebs
Wes Lamboley W3WL
Willy Ruesch HB9AHL
Wolfgang Meschede MD

Financial contributors and partners are posted on our website:

http://www.heardisland.org/HD_pages/HD_sponsors.html

Major sponsors include:

- Cordell Expeditions
- Diablo DX-ers
- Northern California DX Foundation
- German DX Foundation
- Swiss DX Foundation
- HDT Global
- Inmarsat
- International DX Association
- Lone Star DX Association
- Heard Island Angel
- Northern California DX Club
- Kan Mizogouchi
- Steve Hammer

PERSONNEL

(As of 1 Oct. 2015)

Organizer, Expedition Leader
Dr. Robert W. Schmieder (USA)

THE ONSITE TEAM

Mr. Adam Brown K2ARB (USA)
Mr. Fred Belton (USA)
Mr. Hans-Peter Blattler HB9BXE (Switzerland)
Mr. Alan Cheshire VK6CQ (Australia)
Mr. Jim Colletto N6TQ (USA)
Mr. Dave Farnsworth WJ2O (USA)
Mr. Vadym Ivliev UT6UD (Ukraine)
Mr. Kenneth Karr USN (ret) (USA)
Dr. David Lloyd K3EL (USA)
Mr. Gavin Marshall (Australia)
Dr. Bill Mitchell AAØEE (USA)
Dr. Carlos Nascimento NP4IW (USA)
Dr. Robert Schmieder KK6EK (USA)
Dr. Arliss Thompson W7XU (USA)

TECHNICAL DEVELOPMENT

Co-organizer
Mr. Rich Holoch KY6R (USA)

California Team
Jack Burris K6JEB
Mike Coffey KJ4Z
Edwardo Gonzales-Fuentes
Peter Hoffman W6DEI
Elliot Medrich N6PF
Jim Nicastro KI6SDF
Mathison Ott KJ6DZB
Aaron Williamson

South Africa Team
Malcolm DeBeer ZS6MAL
Paul Johnson ZS1S
Pierre Trompf ZS1HF

Australia Team
Andrew Albinson VK6IA
Keith Bainbridge VK6RK
Richard Beck VK6BEC
Wes Beck VK6WX
Stuart Bedford VK6LSB
Wayne Johnson VK6EH
Zeljko Krestelica VK6VY
Peter McMahon VK3HEX

HONORS

The Fourteen Men (Australia)
Jim Smith and Kirsti Smith (New Zealand)
Jean-Michel Cousteau (USA)
Prof. Joseph Taylor (USA)

ADVISORS AND COLLABORATORS

Advisors
Dr. Anders Jepsen (USA)
Zorro Miyazawa JA1AJT (Japan)
Dr. Alan Nichols (USA)
Donald Schliesser K6RV (USA)
Dr. Donald Walsh (USA)

Scientific, Technical Collaborators
Dr. Robert Anderson (USA)
Ms. Joan Boothe (USA)
Mr. Peter Bourget W6OP (USA)
Dr. Grahame Budd (Australia)
Mr. Ed Cox KE3D (USA)
Prof. Harold Heatwole (USA)
Mr. William Hein AA7XT (USA)
Dr. Rocco Mancinelli (USA)
Dr. Mary McGann (USA)
Mr. John Miller K6MM (USA)
Prof. William Miller (USA)
Mr. Tom Schiller K6BT (USA)
Prof. Erik van Sibble (Australia)
Mr. Dean Straw K6BV (USA)
Dr. Eric Woehler (Australia)

Honors

The Heard Island DXpedition is dedicated to

The Fourteen Men

who built and occupied the ANARE Station, Heard Island, 1947-48

[Left to right] *A. R. "Doc" Gilchrist, Medical Officer; Robert (Bob) Dovers, Surveyor; A. Norm Jones, Cook; Alan Campbell-Drury, Radio Operator, Photographer; A. Jim Lambeth, Geologist; A. T. "Shorty" Carroll, Observer; Arthur W. Scholes, Radio Operator; Keith W. York, Radio-sonde Operator; Aubry V. Gotley, Meteorologist; Jo E. Jelbart, Physicist; Johnny Abbottsmith, Engineer; Fred J. Jacka, Physicist; L. E. "Lem" Marcy, Senior Radio Operator; G. S. "Swampy" Compton, Assistant Surveyor-Geologist.* [Source: Arthur Scholes, *Fourteen Men*, E. P. Dutton, 1952]

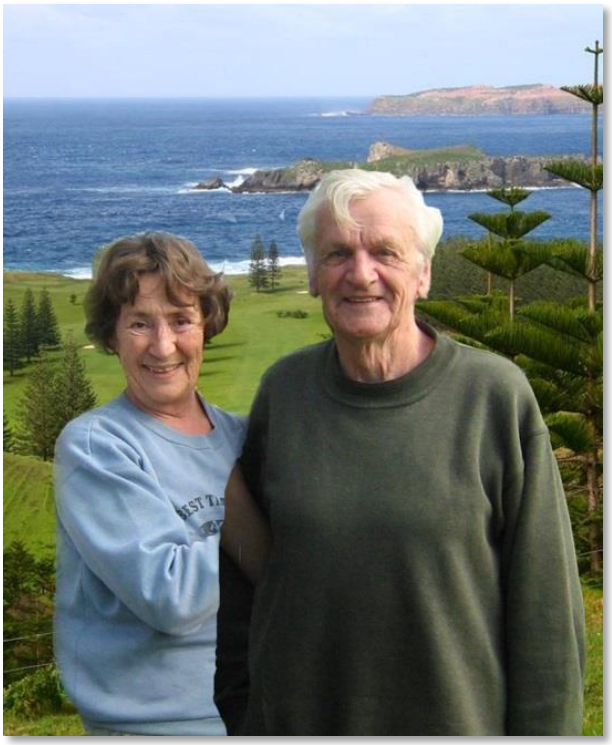
The party from the Australian National Antarctic Research Expedition (ANARE) arrived at Heard Island in December 1947. The 14 men spent 15 months at Atlas Cove, and constructed an entire small city, complete with a small power station, food store, mess, workshops, shower, toilet, electrical and plumbing stores, medical annex, biology lab, science lab, hen coop, dog run, and a large tractor. These men carried out meteorological, geophysical, upper atmosphere, and biological research, a program that continued for 7 years until the base was abandoned. Since 1969, ANARE has visited Heard Island every few years and there have been several privately funded expeditions.

The book *Fourteen Men*, written by Donald Scholes, provides a vivid description of the 1947 ANARE expedition, and the prospects for visitors to Heard Island: "On the whole, the island was a depressing place. There was little beauty in the gaunt grey rocks, the barren flat and grim precipitous coastline. But despite that, there was something of almost indefinable loveliness about it. In the morning sunrise, the great mountain was a heap of sparking diamonds, reflecting flashing tints. When the sky behind the dome was the pale clear blue of the Antarctic, the mountain was awesome. When a full moon glinted round the ice slopes the dome shone like silver. At sunset, when the shadows flitted in long lines across the glaciers, the mountain top was a dome of gold."

The Heard Island DXpedition is dedicated to

Jim Smith, VK9NS (SK) and Kirsti Jenkins-Smith, VK9NL

Norfolk Island



James Bruce Smith (Jim Smith to everyone who knew him or knew of him) joined the RAF in 1946 and trained in radio communications. In 1948 he was sent to Singapore and then on to Car Nicobar in the Indian Ocean with the RAF Signals Detachment. It was here that he became interested in Amateur Radio and operated the call CAR from there. On return to Singapore he held the call VS1BQ and his interest in the hobby became ingrained. Not only in making contacts around the world, but also the technical side of it. Thus he became one of the pioneers in the technology of SSB during his time in Germany where served 1952-1957, holding the call DL2TH.

On his return to England he worked as a civilian radio instructor at RAF, Locking. Still spending time on his hobby, his English call was G3HSR. The early 60's saw him working in Saudi Arabia where he was a project manager at Dharan International Airport. In 1968 Jim went back to Singapore where he was employed in writing a 10 part electronics course for the Singapore Armed Forces Technical Defence. By 1975 Jim gained a position with the Civil Aviation Authority in Papua New Guinea where he worked several years as a radio inspector. He was also engaged in Amateur Radio, using the call P29JS. He taught many a would-be amateur radio enthusiast and was President of the PNG amateur Radio Society. During his time in PNG, Jim undertook a couple of DXpeditions to other islands. In 1980, he visited Norfolk Island and operated as VK9NS. Later in the year, he made a permanent move to Norfolk Island where he met and married Kirsti, VK9NL, a former ship's radio officer from Norway who had settled on Norfolk Island in 1963.

Of the many DXpeditions Jim undertook in the following years, the major one was the DXpedition to Heard Island in 1983, operating VKØJS with Kirsti operating VKØNL. Kirsti wrote the riveting book *Heard Island Odyssey*, an account of the Heard Island DXpedition and the harrowing experience of getting back from Heard Island on a ship that should never had left port. Jim started up the very successful amateur radio DX club HIDXA which became the mainstay of every DXpedition that followed. Jim and Kirsti both operated from Howland Island in 1988 and from Willis Island in 1992 with Jim making several other DXpeditions to various Islands in the Pacific and Indian Oceans. At home Jim also ran a popular DX net, attracting check-ins from all over the world. In 1989 Kirsti travelled to Svalbard and so with Heard Island in 1983, she can truly say that she has operated from both the far south and the far north! Later she also wrote QRV, A DXer's Life for Me, a collection of essays written over several years during the 1980's and 1990's, and includes stories about Howland Island, Murmansk, Svalbard, Sarawak, Japan and Willis Island.

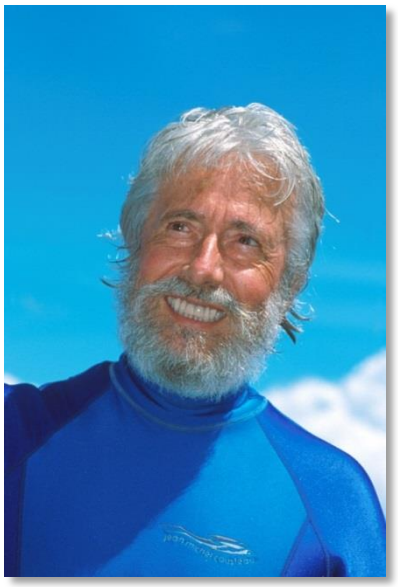
Jim was elected to the CQ Magazine's Hall of Fame in 1986. Apart from his many DXpeditions, he also worked tirelessly to have amateur radio introduced legally in both Bhutan and Bangladesh, helping both governments with writing the necessary legislation.

Jim wrote his book *The Old Timer: 60 years in Amateur Radio 1947-2007*, published in 2008, only months before his death in February 2009.

Honorary Expedition Leader

Jean-Michel Cousteau

Ocean Futures



Explorer. Environmentalist. Educator. Film Producer. For more than four decades, Jean-Michel Cousteau has dedicated himself and his vast experience to communicate to people of all nations and generations his love and concern for our water planet.

Since first being "thrown overboard" by his father at the age of seven with newly invented SCUBA gear on his back, Jean-Michel has been exploring the ocean realm. The son of ocean explorer Jacques Cousteau, Jean-Michel has investigated the world's oceans aboard Calypso and Alcyone for much of his life. Honoring his heritage, Jean-Michel founded Ocean Futures Society in 1999 to carry on this pioneering work.

He has produced over 80 films, received the Emmy, the Peabody Award, the 7 d'Or, and the Cable Ace Award. In 1989, he became a syndicated columnist for the Los Angeles Times where his articles appeared in over sixty newspapers worldwide. Reaching millions of people globally through Ocean Futures Society, Jean-Michel continues to produce environmentally oriented adventure programs and television specials, public service announcements, multi-media programs for schools, web-based marine content, books, articles for magazines, newspaper columns, and public lectures.

As Chairman of the Board and President of Ocean Futures Society, Jean-Michel travels the world, meeting with leaders and policymakers at the grassroots level and at the highest echelons of government and business. He is dedicated to educating young people, documenting stories of change and hope, and lending his reputation and support to energize alliances for positive change.

Jean-Michel also has a long history of innovative design in the field of architecture and the ocean. Acting on a childhood dream to build cities under the sea, he pursued a degree in architecture from the Paris School of Architecture and remains a member of the Ordre National des Architectes. Artificial floating islands, schools, and an advanced marine studies center in Marseilles, France, are among his projects. In 1969, he led the transformation of a 100,000 square foot section of the Queen Mary into the Living Sea Museum in Long Beach, California.

In recognition of his many and diverse contributions to learning, Pepperdine University awarded Jean-Michel an Honorary Doctor's Degree in Humane Letters in 1976. He has received DEMA's 1994 Reaching Out Award and the 1995 NOGI Award from the Academy of Underwater Arts and Sciences. In 1996, Jean-Michel was awarded the SeaKeepers Award from Showboats International, and the John M. Olguin Marine Environment Award from the Cabrillo Marine Aquarium. In 2003, he was inducted into the International Scuba Diving Hall of Fame and became a Trustee of the British Virgin Islands National Parks as well as being the first recipient of the Ocean Hero Award from Oceana. He has also received the Poseidon/Lifetime Achievement Award from Reef Check and been elected to the Global Green Board of Directors. In 2008, he received the Lifetime Achievement Award from Jules Verne Adventures and the National Marine Sanctuaries Foundation Lifetime Achievement Award.

For information, please contact:

Ocean Futures Society
325 Chapala St.
Santa Barbara, CA 93101
805-899-8899

Source:

http://www.oceanfutures.org/about/jean-michel-cousteau

Honorary Communications Leader

Joseph Taylor, B.A., M.S., Ph.D.

Princeton University, Nobel Prize Physics

Joseph Hooton Taylor, Jr. (born March 29, 1941) is an American astrophysicist and winner of the 1993 Nobel Prize in Physics.

Taylor was educated at Haverford College (B.A. Physics 1963) and Harvard University (Ph.D. Astronomy 1968). After a brief research position at Harvard, he went to the University of Massachusetts, eventually becoming Professor of Astronomy and Associate Director of the Five College Radio Astronomy Observatory. Taylor's thesis work was on lunar occultation measurements. He is a Professor Emeritus at Princeton University.

At the National Radio Astronomy Observatory's in Green Bank, West Virginia, Taylor participated in the discovery of the first pulsars discovered outside of Cambridge. Since then, he has worked on all aspects of pulsar astrophysics. In 1974, Taylor and his student Russell Alan Hulse discovered the first pulsar in a binary system during a survey for pulsars at the Arecibo Observatory in Puerto Rico. Working with his colleague Joel Weisberg, Taylor used observations of this pulsar to demonstrate the existence of gravitational radiation in the amount and with the properties first predicted by Albert Einstein. He and Hulse shared the Nobel Prize for the discovery of this object. There are now scores of binary pulsars known, and numerous independent measurements have confirmed Taylor's results.

In addition to the Nobel Prize, Taylor has been recognized with many other awards, including the first Heineman Prize of the American Astronomical Society, the Henry Draper Medal of the National Academy of Sciences, the Tomalla Foundation Prize, the Magellanic Premium, the Carty Award for the Advancement of Science, the Einstein Prize, the Wolf Prize in Physics, and the Schwartzchild Medal. He was among the first group of MacArthur Fellows. He has served on many boards, committees, and panels, co-chairing the Decadal Panel that produced the report Astronomy and Astrophysics in the New Millennium that established the United States' national priorities in astronomy and astrophysics for the period 2000-2010.

Joe Taylor is also known by his amateur radio callsign K1JT. He developed several innovative programs that enable weak signal detection, including WSJT (“Weak Signal [Communication] by K1JT”), which is optimized for meteor scatter, ionospheric scatter, and EME (moonbounce) at VHF/UHF, as well as HF skywave propagation, and WSPR (“Weak Signal Propagation Reporter”), which is designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands. Users with internet access can watch results in real time. The program can decode fraction-of-a-second signals reflected from ionized meteor trails and steady signals 10 dB below the audible threshold.

Sources:

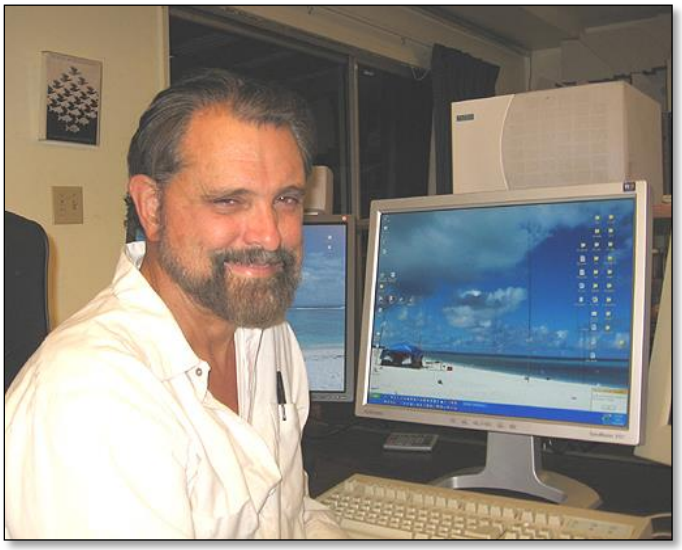
http://www.mlahanas.de/Physics/Bios/JosephHootonTaylor.html
http://physics.princeton.edu/pulsar/K1JT/index.html

Organizers

Organizer, Expedition Leader

Robert W. Schmieder, A.B., B.S., M.A., Ph.D.

Physicist, Explorer



Bob is the founder and Expedition Leader of Cordell Expeditions. The group is responsible for the creation of the Cordell Bank National Marine Sanctuary and for numerous research expeditions to remote oceanic sites. Professionally he is a research physicist, with about 100 publications and several patents. He is the founder of NanoLogic, Inc. He is a Fellow of the Explorers Club and former Chairman of its Northern California Chapter. He is the owner and operator of a research vessel, the *Cordell Explorer*. His specialty has been developing new technology for scientific expeditions.

Professional:

A.B. (Physics) Occidental College, 1963
B.S. (Physics) California Institute of Technology, 1963
M.A. (Physics) Columbia University, 1965
Ph.D. (Physics) Columbia University, 1969
Research Staff, Lawrence Berkeley National Laboratory, 1969-74
Research Staff, Sandia National Laboratories, 1974-97
Founder, Director, Cordell Expeditions, 1978-present
Founder, CEO, NanoLogic, 1997-present

Honors:

Schmieder Bank (a rocky bank in the eastern Pacific)
Codium schmiederi (an alga)
Erylus schmiederi (a sponge)
Megalomphalus schmiederi (a gastropod)
Pharia pyramidata schmiederi (a starfish)
Amateur Radio Hall of Fame, elected 2011
Chiltern DX Club Certificate of Merit, 1997
Environmental Enrichment Award, International Underwater Foundation, 1995
Expedition of the Year (Peter I 1994, Easter Island 1995, Heard Island 1997)
Fellow, Explorers Club, 1986-present
Honorary Life member, Central Arizona DX Association, 1997

Selected expeditions:
Cordell Bank 1977-95
Pt. Sur, Schmieder Bank 1987-88, 91
Farallon Islands 1989
Rocas Alijos 1990, 1993
Peter I (Antarctica) 1994
Easter Island 1995
Heard Island 1997
San Felix Island 2002
Kure Atoll (2005
Clipperton Island 2013
Heard Island 2016

Selected expedition books:
Schmieder, R. W. 2013. *DXA: The real-time online radio log server*
Schmieder, R. W. 2010. *Great Adventures.*
Schmieder, R. W. 2002. *XRØX San Felix Island*
Schmieder, R. W. 1997. *VKØIR Heard Island Expedition*
Schmieder, R. W. 1995. *Rocas Alijos: Scientific Results from the Cordell Expeditions*
Schmieder, R. W. 1995. *DX-Aku: Messages from the 1995 Easter Island DXpedition*
Schmieder, R. W. 1994. *3YØPI Peter I Island 1994 DXpedition*
Schmieder, R. W. 1991. *Ecology of an Underwater Island*
Schmieder, R. W. 1978. *Edward Cordell and the Discovery of Cordell Bank*

Selected expedition reports and publications:
Schmieder, R. W. 2013. TX5K Clipperton Island, F*unkAmateur*.
Schmieder, R. W. 2006. Real-time Online Information from DXpeditions, *DX Magazine.*
Schmieder, R. W. 2006. K7C – The 2005 Kure Atoll DXAdventure, *QST Magazine.*
Schmieder, R. W. 1997. The 1997 VKØIR Heard Island Expedition, *QST Magazine.*
Schmieder, R. W. 1996. One down, 326 to go! *QST Magazine.*
Schmieder, R. W. 1994. A Minimalist's DXpedition, *DX Magazine.*
Schmieder, R. W. 1994. 3YØPI The Peter I Island 1994 DXpedition, *QST Magazine.*
Schmieder, R. W. 1993. The Farallon Islands IOTA NA-178, *DX Magazine.*
Schmieder, R. W. 1989. Cordell Bank Marine Sanctuary: Exploitation or full protection? *Bodega Bay Signal*, Mar. 1, 1989.
Schmieder, R. W. 1988. The 1988 Expeditions to Pt. Sur. Summary of Results, CE Publication CE-89-04 (1989).
Schmieder, R. W. 1988. Cordell Bank: An oceanic marvel. *Defenders* **63**(3):24-29.
Schmieder, R. W. 1987. A Fishing Disaster at Cordell Bank? *Cormorant* (Oceanic Society) Feb/Mar, 1987.
Schmieder, R. W. and W. Kruse 1987. Terraces, tilting, and topography of Cordell Bank, California. *California Geology* **40**(11):258-264.
Schmieder, R. W. 1986. Preliminary Report: 1985 Cordell Bank Expeditions. Report prepared for NOAA/SPD.
Schmieder, R. W. 1985. The Expeditions to Cordell Bank. *Proc. Joint International Scientific Diving Symposium, Amer. Acad. Underwater Sciences*, Scripps Inst. Ocean., La Jolla, CA. 31 Oct.-2 Nov. 1985. pp. 248-255.
Schmieder, R. W. 1985. Preliminary Report: 1984 Cordell Bank Expedition. Report prepared for NOAA/SPD.
Schmieder, R. W. 1985. List of species observed at Cordell Bank, California. Report prepared for NOAA/SPD.
Schmieder, R. W. 1985. Cordell Bank Expeditions 1978-79. *Nat. Geog. Soc. Res. Repts*. **20**:603-611.
Schmieder, R. W. 1984. Preliminary Report: 1983 Cordell Bank Expedition. Report prepared for NOAA/SPD.
Schmieder, R. W. 1984. Cordell Bank: marine sanctuary candidate rises from obscurity. *Oceans Magazine* **17**:22-25.
Schmieder, R. W. 1983. Final Report: 1980 Cordell Bank Expeditions. CE Publ.
Schmieder, R. W. 1982. Shape irregularity in *Pedicularia californica*, *Veliger* **24**(3):272.
Schmieder, R. W. 1982. A preliminary summary of knowledge of Cordell Bank, California. Rept. for NOAA/SPD.
Schmieder, R. W. 1981. Preliminary Report: 1980 Cordell Bank Expedition. CE Publ.
Schmieder, R. W. 1980. Preliminary Report: 1979 Cordell Bank Expedition. CE Publ.
Schmieder, R. W. 1980. Intermediate forms and range extension of *Pedicularia californica* and *Pedicularia ovuliformis*, Veliger, **22**(4):382-384.
Schmieder, R. W. 1980. Final Report: 1979 Cordell Bank Expedition. CE Publ.

Schmieder, R. W. 1980. A Lighthouse (Pt. Reyes) 'Way Down There? *Pt. Reyes Historian*, Summer, pp. 508-509.
Schmieder, R. W. 1979. Final Report: 1978 Cordell Bank Expedition. CE Publ.
Schmieder, R. W. 1978. Preliminary Report: 1978 Cordell Bank Expedition. CE Publ.

Websites:
http://www.cordell.org (Cordell Expeditions 1985+)
http://www.heardisland.org (Heard Island 2016)
http://www.cordell.org/CI (Clipperton Island 2013)
http://www.cordell.org/DXA (DXA 2005+)
http://www.cordell.org/HI (Heard Island 1997)
http://www.cordell.org/EI (Easter Island 1994)

Contact information:

4295 Walnut Blvd.
Walnut Creek, CA 94596 USA
Tel. and Fax: (925) 934-3735
robert@schmieder.com
schmieder@cordell.org

Rich Holoch, KY6R

Co-Organizer (Offsite)

Education:
Lock Haven University of Pennsylvania

Current position:
Director, Technical Support, Splice Machine

Summary:
Director of Technical Support in the Big Data space, helping build, mentor and manage a team of Technical Support experts. Principal Data Architect, specializing in Hadoop/HDFS/HBase, Impala, Splice Machine, SQL RDBMS, Evolutionary Database Design and Big Data based data architecture including Domain Data Modeling. Hands on / Pragmatic Data Governance through Data Bus and Data Integration architecture. Specialties: Distributed Data Warehousing, Parallel and Distributed ETL and ELTLT using clustered partitions (sharding), High Performance, SQL RDBMS Data Warehouse and Hadoop technologies (HDFS, Hbase and Hive). 3NF and 2NF OLTP, Kimball Star Schema and Inmon database design. Analytical data processing and report development. Splice Machine, Oracle, Teradata, MySQL, PostgreSQL, DB2, Hadoop-HDFS-Hbase, Cassandra, NEO4J, PL/SQL, SQL, Pentaho PDI, Business Objects, Perl, PHP, Shell, Pig, ERwin, ER Studio, ModelRight, Flyway, Liquibase, Apache Derby, Spark, Flume, Tableau, Zendesk

Amateur radio:
I was first licensed in 1973 at age 13 (WA2QHN). Have earned 8BDXCC and Honor Roll (2013). Almost at the DXCC Challenge 2000 level. Active in various radio clubs, as a pilot and website developer for various expeditions.

A major activity is developing high-efficiency antennas. Earned DXCC Honor Roll 2013.

Onsite team

Adam Brown, N2ARB

KC4/K2ARB - VP8DKF COMMS, Patriot Hills 2006-07 K2ARB/MM Radio Officer, US Merchant Marine, 4X/K2ARB. During December 2008 and January 2009 I returned to Antarctica to work as the communications speciallist at the Patriot Hills Base Camp in the Ellsworth Mountains, Antarctica (80°S / 81°W). From December 16 through approximately December 27, I operated as CE8/K2ARB from Punta Arenas, Chile. During the remainder of December and all of January, I was QRV from Patriot Hills on 40 and 20 meter CW, SSB, and P_SK31 as KC4/K2ARB and VP8DKF. I also set up a station with a 20 meter IARU beacon and operated on 40 and 20 as CE9/K2ARB from the nearby Antonio Hunneus Base (Chile). If you would like to read more about my experiences in Antarctica, please read my article on page 52 in the January 2009 issue of QST or feel free visit to visit my blog at www.k2arb.blogspot.com.

Alan Armstrong Cheshire, VK6CQ

Perth, Western Australia
Home Callsign VK6CQ
Antarctic Callsigns: VP8PJ & VKØLD
Commericial Merchant Marine Radio & Electronics Officer Licence
BSc Radio Physics & Telecommunications Engineering, Grad Dip IT
MIEEE, MIET, MinstPhysics
Ex British Antarctic Survey
VP8PJ 1976 -1980
Ex Australian National Antarctic Research Expeditions
VKØLD, VKØMM 1999 – 2001
Ex Antarctic Logistics & Expeditions
VP8PJ, 9VØA & CE9/VKØLD at Patriot Hills summer camp 2003 – 2012
Other callsigns over the years: A4XYF G4EEL P29AC VK8AC VS5AC V85AC 9V1DX
I presently work as a telecommunications engineer in the oil and gas industry.

David Lloyd PhD K3EL

Dave's introduction to shortwave radio was in the 1970s, listening to the Voice of America, Radio Moscow and the BBC. He obtained his first amateur radio license in the UK while at school, as G4HJT. He then took a break from radio for many years - at college he devoted his energy to another passion, caving (spelunking), as a team member, co-organizer or leader of expeditions to discover and explore some of the world's deepest caves. Professional life then took over - Dave has worked as an analytical scientist in both academia and industry. He has published over 60 research papers, edited two books on separations science, and has been editor of two international scientific journals. He holds a BSc in Physics and PhD in Chemistry from the University of York, UK.

Active in amateur radio again as K3EL since the mid-2000s, Dave now enjoys CW ragchewing, occasional contesting, SOTA (chasing and activating), chasing DX, and when possible, being DX. He was a member of the ZL9HR DXpedition to Campbell Island in 2012. He organized TX5RV, a mini-DXpedition to Raivavae, Austral Islands, in 2013, and was a member of the VK9MT Mellish Reef DXpedition in 2014. Dave is a life member of the ARRL, a member of the Frankford Radio Club, A-1 Ops, the Chiltern DX Club, NCDXF and INDEXA.

Dave Farnsworth WJ2O

Dave has been a licensed ham since 1970 has enjoyed a passion for DXing and CW Contesting. An experienced DXpeditioner he has traveled to and operated from over 40 different DXCC entities. They include being a member of the last group of hams on Navassa (KP1) in 1993 and joining KK6EK on Easter Island (XR0Y) in 1995 as well as Clipperton (TX5K) in 2013.

His operations include: 3DA0 (twice), 6W, 6Y5, 8P, C6A (twice), CE, CE0A, EI, ES, F, FJ, FM, FO8, FS, GI, GJ, GU, J3, J6, KH6, KP1, KP2, KP4, LU, LY, OX, P4, PJ2, PJ4, PZ, SP, TF, V2, V31, VE (Zones 1 & 2), VP2E (twice), VP5 (6 times), VP9, YL, ZF, ZP and ZS. He maintains details of each trip at http://www.wj2o.com.

Since the age of 22, Dave has been a small business entrepreneur building a number of different enterprises. He currently operates a software and database development firm. He and his wife raised two daughters and enjoy four grandchildren.

Carlos Nascimento NP4IW

Carlos was born in Santiago, Chile, and is now 66 years old and. He is a biochemist, holding a Ph.D. in Biochemistry from Baylor College of Medicine (Houston, Texas). He has over 58 scientific publications and five US patents.

Carlos left Chile over 30 years ago. He lived for three years in San Juan, Puerto Rico, where he was licensed with his present Extra Class (NP4IW). In addition, he holds a "Superior" class in Chile (XQ3AQI).

He was one of the organizers (with KK6EK) of the 1995 Easter Island/Salas y Gómez expedition XRØY/Z. He personally led the expedition to Salas y Gómez (XRØZ) resulting in a new IOTA (SA-083). He was one of the organizers (with KK6EK and ON6TT) of the 1997 Heard Island (VKØIR) expedition. He was the prime organizer and expedition leader for the 2002 San Félix expedition (XRØX). He was a member of the Peter I Island expedition (3YØX) in 2006. He continues participating in several radio contests, particularly from the South of Chile as part of the Temuco Radio Club, Chile (XR6T).

Kenneth Karr NG2H

Ken has was first licensed in 1955 and credits amateur radio for launching his interests in science, engineering and oceanography. He was awarded BChE & MEng (Chemical) from the University of Louisville and later MNucE & MS (Oceanography) from the University of Washington. Ken entered the Navy through the NROTC program, and served in the Nuclear Submarine Service commanding two nuclear fast attack submarines and then serving as the senior member of the Navy's Atlantic Fleet Operational Reactor Safeguards Examining team responsible for evaluating the safety of nuclear ships, tenders, and shore facilities. He was presented the "Legion of Merit" (three awards) and other honors during his 25 year Naval career.

Ken retired from the Navy and joined the Institute of Nuclear Power Operations (INPO) as a team manager and senior representative. INPO is an industry excellence-in-safety organization formed after the accident at Three Mile Island to oversee and evaluate nuclear safety at commercial nuclear generating stations. He then served as Vice President of the Advanced Reactor Corporation (developing new electric generation reactor designs), President of KRK Inc., and as an expert with the International Atomic Energy Agency (IAEA).

After many busy but rewarding years Ken is now devoting more time on the air and pursuing interests in scientific activities that align with his education and experience supporting meaningful initiatives. He is a member of his area Amateur Radio Emergency Services (ARES) organization, enjoys teaching leadership and facilitating professional teams in business and non-profit organizations to attain challenging performance objectives. Ken is also a long time member of Rotary International (motto "Service Above Self") and is President-Elect of the Rotary Club of Charlottesville, Virginia.

Bill Mitchell PhD AEØEE

Bill was first licensed in 2012 as AG6RB while in graduate school at the University of California, Berkeley. After finishing his PhD in 2014, he relocated to Minnesota and acquired his current callsign, AEØEE. Bill was part of a mini-expedition to North Dakota in August, 2014 to activate W1AW/Ø. He is most often found on CW, but also enjoys digital modes and SSB.

When not on the radio, Bill enjoys doing and teaching science. He holds a BA in chemistry from Carleton College, and a PhD in Chemistry from UC Berkeley. While his primary focus is physical and analytical chemistry, his research has been broad, spanning organometallic synthesis, kinetics, polymers, 2-photon photochemistry, atmospheric chemistry and physics, geochemistry, and geology. His dissertation focused on high-precision uranium-lead dating.

Vadym Ivliev UT6UD

49 years old, Kiev, Ukraine

RF Engineer (1987), running own distribution company from 1994 till now.

First license – 1979. Other calls : EZ5JAI, H44UD, A35UD, S21XV, FO/UT6UD.

Interests: Low-band contesting and DXing.

Hans-Peter Blattler HB9BXE

Hans-Peter HB9BXE is 65 years old and married to Maya. They have a daughter, Gabrila and son, Philipp. Hans-Peter is a development engineer and works for a company that manufactures electronic components. In fact, most of his amateur radio equipment is homebrew.

Licensed in 1978, he enjoys DXing and Contesting mostly on CW. He is a lifetime member in the Swiss DX Foundation (SDXF), member of USKA, HTC, and he is on DXCC Honor Roll.

Hans-Peter operated as HBØBXE, VK4BXE, 5H1BP/AFØ32, XV4B was a member of the 1998 3B7RF, P29VPB/OC-069 (1998) and 3YØX (2006) Expedition, as well as the team leader for the 3B6RF (2001) and the 3W6C (2010) Expedition.

Fred Belton KM4MXD

Fred Belton is a retired university mathematics instructor and former electrical engineer. He has traveled in more than 100 countries and territories and done extensive trekking in many of them. He has made two 3-year "world exploration" trips. He is particularly interested in volcanoes, has climbed around 50 active volcanoes worldwide, and has spent much time exploring volcanic terrain. In 1997 he became focused on Ol Doinyo Lengai in Tanzania, the only volcano that erupts natrocarbonatite lava. In 1999 he assisted a German film team with a television documentary there. From 2000 until the commencement of explosive activity in 2007 Fred organized and led Ol Doinyo Lengai expeditions for scientists, photographers and film teams. Expedition members spent a week at the crater while it was erupting. In conjunction with the expeditions, Fred collected lava samples and worked with a geology graduate student on data collection and research to investigate the possibility of tidal influences on magmatic activity. In 2004 he was QRV from top of Kilimanjaro, Uhuru Peak, 5895 m above sea level. Probably this is the first successful DXpedition from Africa's highest mountain. Fred was originally licensed as WB4YRM.

Selected trekking experience over the past 25 years:
Iceland: Hornstrandir Peninsula 23 day exploration/unsupported trek- Aðalvík to Norðurfjörður.
Iceland: Interior Highland Plateau (across Ódáðahraun south to north) 14 day unsupported trek
Iceland: Exploration of Laki fissure area out to Vatnajökull and Skaftá River.
Faroe Islands: coastal exploration.
Corsica: GR-20.
Italian Dolomites: Numerous via ferrata routes.
Tasmania: South Coast Track.
New Zealand: East Matukituki Traverse.
Scotland: 73 "Munros" climbed.
Romania: Făgăraș and Piatra Craiului ridge traverses.
Venezuela: Mt. Roraima.
Indonesia: Gunung Tambora.
Monticellite from Natrocarbonatite, Oldoinyo Lengai, Tanzania, *Mineralogical Magazine*, **68**. (5), 787 – 799.

Arliss Thompson W7XU

Arliss is a semi-retired emergency room doctor. He has undergraduate degrees in mathematics and biological sciences, and an MD in internal medicine. He has been a serious alpine ski racer, a sheepherder, and work carrying out marine mammal watches and collecting specimens of fish that had not previously been documented in the Bering Sea. He was employed by ITT Antarctic Services as the communications coordinator (chief radio operator and repair technician) at the Amundsen-Scott South Pole station (90 degrees south). In ham radio he enjoys operating CW, SSB and RTTY. He has been on DXpeditions to: FY, 8R, CE0Y, 9G, CY9, J3, VP2V, FJ, TZ, C5 and VP8 (Falklands), KC4, KL7, KH6, VY1 and a number of Canadian provinces. He participated in the WØSD multi-op ARRL RTTY Roundup effort, with a number of top 3 placings. He has held some meteor scatter distance records on 222 and 432 and has also worked all lower 48 states on 2m without EME. He bicycled from Oregon to Washington, DC, then up into Newfoundland and back to Vermont in 1980, as well as New Zealand, Australia and SE Asia enroute home following his year in Antarctica.

Gavin Marshall

Born in Nelson New Zealand I re-ignited my interest in the outdoors approx. 15 years ago trekking in the Tararua Ranges north of Wellington, New Zealand. And from that simple beginning I've been pursuing outdoor adventure opportunities when and wherever I can.

Several years as a volunteer in the Wellington Search and Rescue organisation, a period as the National SAR Treasurer and also time training a wilderness search dog ensured I maximised my time in the outdoors.

In January 2009 I moved to Sydney with my wife and son where I renewed my involvement with the local Search and Rescue organisation. I'm currently a member of the NSW Bush Walkers Rescue Squad and Vertical Rescue team.

In 2011 two close friends and I attempted an independent climb of Mt McKinley in Alaska. After a week of holding out in camp 3 for weather on the summit to clear we were forced to descend. I'm not someone to take defeat easily and that descent became the trigger for me to set a personal goal of climbing the 7 summits. To date I've reached the summit of Mt Kosciusko, Australia (2,228m); Mt Kilimanjaro, Africa (6,895m); Mt Aconcagua, South America (6,982m); and Mt Elbrus, Europe (5,642m). In May 2014 I made a return to Mt McKinley. Once again I was knocked back by the weather. I reached high camp at 17,200 feet before once again being forced to descend.

2014 has been a busy year for me, 10 months off work to travel and continue chasing my 7 summits goal along with a period of volunteer work in Kampala, Uganda. I'm now back in Sydney, using my skills as an Accountant and Project Manager to install ERP business solutions. As fate would have it I have secured a role on a project based in Port Moresby – Papua New Guinea. I'm sure there's an adventure to be had somewhere in the mountains of PNG!

I hold amateur radio licence VK2BAX.

Jim Colletto N6TQ

Jim is 52 years young and married to Katy. They have a daughter Hurricane Mia (12) and a son Tropical Storm Jake (8).

After high school, Jim spent a stint in the U.S. Coast Guard and then graduated with an Bachelor of Science in Ocean Engineering from Florida Tech. Jim also holds an MBA in International Business from Georgetown University.

Jim was first licensed in 1976 (7th grade) as WB6ZHZ and then acquired the call N6TQ in 2011. Jim enjoys DXing, Lowbands and 160m contesting. Jim recently made DXCC Honor Roll and believes the Heard Island trip strongly aligns with his passion for adventure, having spent six weeks trekking in the Himalaya (1998), two weeks trekking in the jungles of Laos (1999), four weeks tracking the white-desert rhinos of Namibia (2000), summiting Kilimanjaro (2002) and, most recently, operating from the remote Tuli Preserve in eastern Bostwana (A25TQ - Sept 2014).

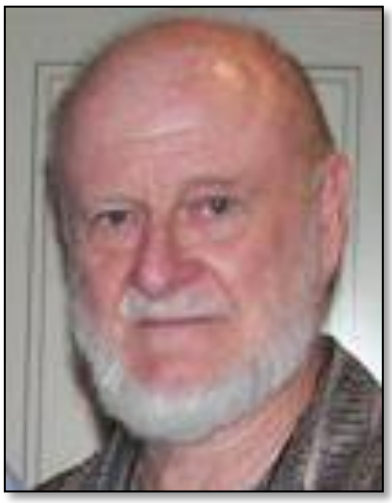
Jim is currently between jobs, giving him the once in a lifetime opportunity to participate in the Heard Island expedition, after spending his first career as a pipeline engineer and his second at Cisco Systems, Inc., most recently helping transform the company's product support organization.

Advisors and collaborators

Advisor (Biology)

Harold Heatwole, B.A., M.S., Ph.D., Ph.D., D.Sc.

North Carolina State University



Education/Training:
B. A. (Botany), 1955, Goshen College, Goshen Indiana
M. S. (Zoology), 1958, University of Michigan, Ann Arbor
Ph.D. (Zoology), 1960, University of Michigan, Ann Arbor
Ph.D. (Botany), 1987, University of Queensland, St. Lucia, Qld.
D. Sc. 1981, University of New England, Armidale, NSW

Positions and Employment:
University of Michigan, Ann Arbor, Michigan, Instructor, 1959-60
University of Puerto Rico, Rio Piedras, P. R.; Professor, 1960-66
University of New England, Armidale, NSW, Australia; Senior Lecturer, l966-71, Assoc. Prof., 1972-1991
NC State University, Raleigh, NC; Head of Zoology Dept. 1991- 1996; Professor, 1991-present
Standing Committee on Island Ecosystems, Pacific Science Association, 1970-72
President Australian Coral Reef Society, 1982, 1983
President Australian Society of Herpetologists, 1977-78
Council Member: Association for Tropical Biology, 1967-68, 1989-90; Great Barrier Reef Committee, 1971-82; Australian Coral Reef Society, 1983-86, 1990; Ecological Society of Australia, 1985-87

Editorial Experience:
Editorial Board, *Journal of Herpetology*, 1967-69
Editorial Board, *Australian Journal of Herpetology*, 1981-1983
Editorial Board, *Biotropica*, 1993-1996
Editorial Board, *Journal of Arid Environments*, 1995-present
Editorial Board, *Systematics and Biodiversity*, 2002-present
Series Editor for series *Ecology in Australia* (8 volumes)
Editor of *Australian Journal of Ecology*, 1985-87
Fauna Editorial Committee, Australian Dept. of the Arts, Sport, the Environment, Tourism, and Territories, 1988-92
Series Editor for *Amphibian Biology*, 6 volumes (3 more in preparation)
Editor of *Integrative and Comparative Biology*, 2006-

Administrative Experience:
Director of El Yunque Biological Research Station, University of Puerto Rico, 1962-66
Heron Island Research Station Board, 1979-80; Deputy Chairman, 1980
Heron Island Research Station Advisory Board, 1981-83
Lizard Island Research Station Committee of Trustees, 1980-83
Consortium of Island Research Stations, 1980-83
Acting Head, Dept. of Zoology, University of New England, 1981-1983
Head, Dept. of Zoology, NC State University, 1991-1996
Organization of Tropical Studies, Board of Directors, 1993-1996
La Selva Research Station Board of Directors, 1993-1996

Contact:
Department of Zoology
Campus Box 7617
North Carolina State University
Raleigh, NC 27695-7617

Telephone (919) 515-3122
E-mail address:
harold_heatwole@ncsu.edu

Joan Boothe, B.A., M.B.A.

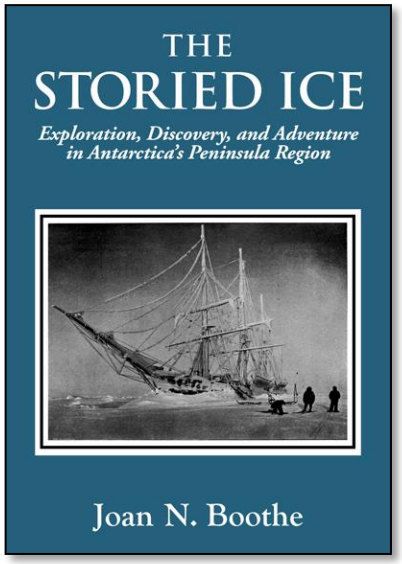
Historian and author

Joan Boothe is an Antarctic explorer and author. She graduated from Wellesley College, where she was elected to Phi Beta Kappa, with an honors degree in economics. Later education included doctoral work in economics as a National Science Foundation fellow at Columbia University; an M.B.A. in finance from the University of California.

Antarctic travel:

Joan made her first trip to Antarctica in 1995, after many years of study. She has returned to the Antarctic regions ten times since, including a 67-day circumnavigation of the entire Antarctic continent aboard an icebreaker. On many of these trips, she has been the lecturer on Antarctic history. In 2010, she taught a course on Antarctica's Heroic Age for Stanford University's Continuing Studies program. Her Antarctic book collection is one of the most comprehensive such private collections in the United States, numbering more than 1800 volumes.

"I have traveled more in the last 16 years to Antarctica than to anywhere else, so in a sense, Antarctica is my favorite place. But that's a very large place, and there are certain locales that speak to me more than others. Since my intellectual focus is on history, the places important to the human story of Antarctica tend to be the ones that stay with me the most. But the landscape has also captured me, so my absolutely favorite places are those with both fascinating stories and wonderful surroundings. Deception Island—an amazing small doughnut-shaped island in the South Shetlands that is an active volcano—most quickly comes to mind as a favorite place. Here there is a marvelous marriage of magnificent scenery, geology, and a deep history that stretches from the beginnings of Antarctic exploration up through today. Ruins of the abandoned whaling station and a British base, victims of the 1967–70 eruptions, are among the first things one sees after sailing through the narrow cleft in the island walls into the drowned crater that fills the island center. I feel ghosts around me as I walk about there—sealers from the 1820s; the first dedicated scientific expedition to Antarctica; whalers; the earliest Antarctic aviators; Argentine, British, and Chilean scientific bases. On a sunny day, the hillsides, where they are not covered by glaciers, display a wonderful color palette of black and red lava. Steam rises from black sand beaches where one may also see the occasional penguin or fur seal. On the outside wall of the island, facing the sea, there is a huge chinstrap penguin rookery. This is a very special island, with a unique human and geological story, and it is indeed one of my favorite places in the world."



Book:

J. Boothe, *The Storied Ice: Exploration, Discovery, and Adventure in the Antarctic Peninsula Region* (Regent Press, 2011).

Contact:

joannboothe@joannboothe.com.

Jodi Fox, B. Sc.

Geologist

Experience:

Geological and geophysical data collection (mapping, logging, sampling, gravity and magnetics) and interpretation/modeling/processing skills). Strong computer skills including effective management of geological data. Advanced nursing clinical assessment and intervention skills applicable to remote environments.

Academic history:

- 2013 PhD Candidate, Univ. of Tasmania. Supervisors: Prof. Jocelyn McPhie and Dr. Rebecca Carey
- 2007 Bachelor of Science Honours (Geophysics), University of Tasmania, First Class
- 2006 Bachelor of Science (Geology), University of Tasmania
- 2006-07 Recipient AusIMM EEF/Newmont Scholarship
- 2006 Recipient Zinifex Scholarship
- 1992-94 Bachelor of Nursing (Undergraduate), University of Tasmania
- Mar 2012 – Present Contract Exploration Geologist, Gnomic

Exploration Services:

- Mar 2011 – Feb 2012 Exploration Geologist, MGT Mining Limited
- Jan 2010 – Feb 2011 Exploration Geologist, MMG –Lawn Hill District
- Jan 2008 - Jan 2010 Graduate Mine Geologist, MMG - Century Mine
- Nov 2006 - Feb 2007 Student Geologist, St Barbara Ltd
- Dec 2005 - Feb 2006 Student Geologist, Zinifex LImited
- Dec 1994 - Jan 2008 Registered Nurse

Professional development and achievement:

- Level 2, Workplace First Aid, September 2012 St John's Ambulance
- 34th International Geological Congress – Brisbane, Australia, August 2012
- Volcanic Products, Processes & Successions Short Course, November 2011 Ray Cas, Monash University
- IUGG – Earth on the Edge Conference, July 2011 Geological Society of Australia
- Exploration Is In Our Hands Conference, August 2010 Australian Society of Exploration Geophysicists
- Geochemistry Workshop, June 2010 IO Global
- Applied Field First Aid and 4WD Winch Recovery Techniques, April 2010 Driver Awareness & Safety Australia
- Clastic Hosted Pb-Zn-Ag Deposits, February 2010 Dr David Leach
- Geophysics for Exploration Geologists, October 2009 Flagstaff GeoConsultants Pty Ltd
- Apply Risk Management Processes, Conduct Safety & Health Investigations, Communicate Information, 2008 TAFE Queensland
- Geological Society of Australia, Member 2008-Present
- Australian Society of Exploration Geophysicists, Associate member 2010-Present
- Recipient AusIMM EEF/Newmont Academic Scholarship, 2006 – 2007
- Recipient Zinifex Professional Scholarship, 2006

Contact information:

School of Earth Sciences and ARC Centre of Excellence in Ore Deposits
University of Tasmania, Private Bag 79, Hobart, TAS, 7001
E-mail: mailto:Jodi.Fox@utas.edu.au
Email: jmfox@utas.edu.au
Mobile: 0408 177 774

Advisor (Biology)

Mary McGann, B.A., B.A., M.A., Ph.D.

U. S. Geological Survey

Contact:
USGS Pacific Coastal & Marine Science Center
345 Middlefield Road MS 999
Menlo Park, CA 94025
(650) 329-4979
(650) 329-5441 (FAX)

Mary McGann is a staff member at the U.S. Geological Survey, Menlo Park, CA. In addition to her research, she is involved in public information and educational activities involving the Survey and the Monterey Bay Research Institute.

Education:

B.A. in exercise physiology, University of California, Berkeley
B.A. and M.A. in paleontology University of California, Berkeley.
Ph.D. in integrative biology, University of California, Berkeley.

Representative publications:

Chin, J. L.; Woodrow, D. L.; McGann, M.; Wong, F. L.; Fregoso, T.; Jaffe, B. E. Estuarine sedimentation, sediment character, and foraminiferal distribution in central San Francisco Bay, California; 2010; OFR; 2010-1130.

Anima, R. J.; Chin, J. L.; Finlayson, D. P.; McGann, M. L.; Wong, F. L. Interferometric Sidescan Bathymetry, Sediment and Foraminiferal Analyses; a New Look at Tomales Bay, California; 2008; OFR; 2008-1237.

Ross, Stephanie L.; Lee, Homa J.; Parsons, Tom E.; Beyer, Larry A.; Boore, David M.; Conrad, James E.; Edwards, Brian D.; Fisher, Michael A.; Frankel, Arthur D.; Geist, Eric L.; Hudnut, Kenneth W.; Hough, Susan E.; Kayen, Robert E.; Lorenson, Thomas D.; Luco, Nicolas; McCrory, Patricia A.; McGann, Mary L.; Nathenson, Manuel; Nolan, Michael; Petersen, Mark D.; Ponti, Daniel J.; Powell, Charles L.; Ryan, Holly F.; Tinsley, John C.; Wills, Chris J.; Wong, Florence L.; Xu, Jingping, Comments on Potential Geologic and Seismic Hazards Affecting Proposed Liquefied Natural Gas Site in Santa Monica Bay, California; 2008; OFR; 2008-1344.

Normark, W. R. and M. L. McGann, Late quaternary deposition in the inner basins of the California continental borderland - Part A. Santa Monica Basin; 2004; SIR; 2004-5183.

M. L. McGann, Foraminifera of Rocas Alijos, in: *Rocas Alijos. Scientific Results from the Cordell Expeditions*, R. W. Schmieder, Ed., Kluwer Academic Publishers (1996).

Sliter, W. V. and M. L. McGann, Age and correlation of the Calera Limestone in the Permanente Terrane of Northern California; 1992; OFR; 92-306.

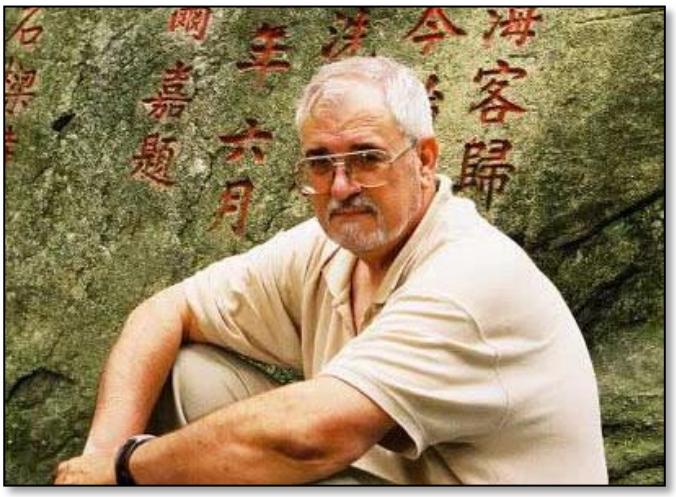
McGann, M. L. and C. Brunner, A Paleoenvironmental analysis of latest Quaternary levee deposits of Monterey Fan, Central California Continental margin: foraminifers and pollen, Core S3-15G; 1990; OFR; 90-692.

McGann, M. L. Quantitative microfossil (foraminfers and pollen) and sedimentologic data on core S3-15G from Monterey Fan, Central California continental margin; 1988; OFR; 88-693.

Advisor (Biology)

William Miller, B.A., M.A., Ph.D.

Baker University



Director of Research, Assistant Professor
Department of Biology
Baker University
Baldwin City, KS 66006
Phone: 785-594-8379
Fax: 785-594-8360
E-mail: William.Miller@BakerU.edu

Research Associate
Academy of Natural Sciences
Biodiversity Group
1900 Franklin Parkway
Philadelphia, PA 19103

Education:
Ph.D., Zoology, University of New England, Armidale, NSW, Australia, 1996
M.A., Zoology, University of Montana, Missoula, Montana, 1975
B.A., Zoology, University of Montana, Missoula, Montana, 1967

Professional/Academic appointments:
2010-Present Director of Research, Department of Biology, Baker University, Baldwin City, KS
2005-Present Faculty, Department of Biology, Baker University, Baldwin City, KS
1999-Present Research Associate, Biodiversity Division -Academy of Natural Sciences, Philadelphia

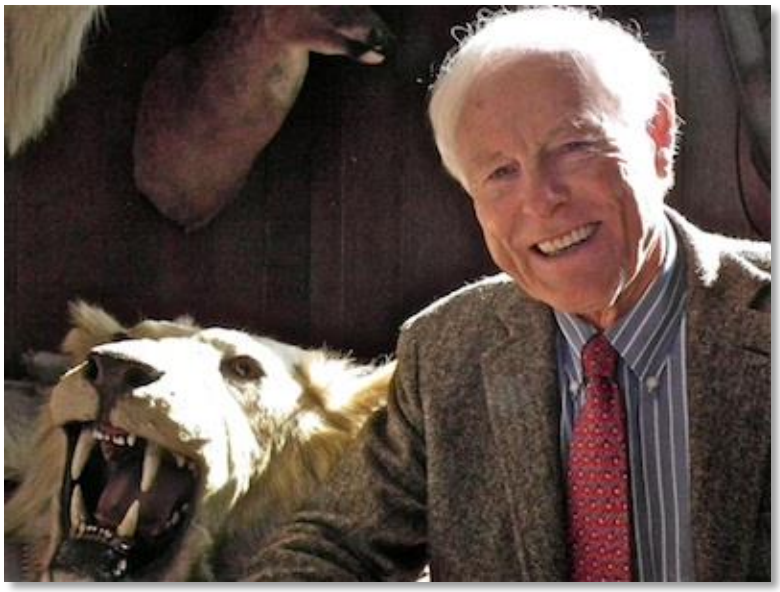
Synergistic activities:
Co-Editor, Transactions of the Kansas Academy of Science, 2012-2017
2007-2011 PI NSF Research Grant, $600,000, RUI: Tardigrades of the LTER sites: A Framework for the Distribution and Phylogeny of North American Tardigrada.
2004-2009 PI NSF Research Grant, $480,000, RUI: Tardigrades of China, $480,000, RUI: A Survey of Moss Dwelling Tardigrades of China.
Master's students supervised: 28

Representative publications [62 total, 54 about tardigrades, 4 in press]:
Miller, W.R. 2011. Tardigrades. *American Scientist*, **99**:384-391.
Miller, W.R. 1997. Tardigrades: Bears of the Moss. *The Kansas School Naturalist*, **43**: 1-16.
Miller, W.R., Miller, J.D. & Heatwole, H.F. 1996. Tardigrades of the Australian Antarctic Territories: the Windmill Islands, *East Antarctica Zoological Journal of the Linnean Society*, **116**: 175-184.
Miller, W.R. & Kristensen, R. M. 1999. Tardigrades of the Australian Antarctic: A new species of the Marine Genus Echiniscoides from Macquarie Island, Sub-Antarctica. *Zoologischer Anzeiger*, **238**: 289-294.
Miller, W.R. McInnes, S.J., & Bergstrom, D.M. 2005. Tardigrades of the Australian Antarctic: *Hypsibius headensis* (Eutardigrada: Hypsibiidae: dujardini group) a new species from sub-Antarctic Heard Island, *Zootaxa* **1022**: 57-64. [See reprint of first page in this document]
Miller, W.R. &. Mehlen, R.H. 2007. Tardigrades of North America: re-description of *Echiniscus tamus* Mehlen, 1969 (Tardigrada: Heterotardigrada: Echiniscoidae: Echiniscidae). *Proceedings of the Biological Society of Washington*. Vol. **120**(2):185-187.

Advisor (Expeditions)

Alan H. Nichols, B.S., LL.B, J.D., D.S. (Hon)

Past-President, The Explorers Club (emeritus)



Alan H. Nichols is the President of The Explorers Club. He is an explorer, by nature a problem solver, and a captivating public speaker.

Alan is the founder and CEO of The Nichols Professional Law Corporation in San Francisco, specializing in finance, water law, nonprofit corporations, and special assessment bonds. When his law firm merged, he continued part-time practice in nonprofit corporations and special assessments. As President of San Francisco Unified School District and City College, Alan was interim head while a national search for Superintendent of Schools was completed. He also led the California College of Medicine, and served on the boards of several private schools. He has served our Board to facilitate our issues. He chaired several political campaigns in California, including a run for the U.S. Congress and managing a statewide gubernatorial effort. He was also San Francisco County Chair for his party. He chaired successful campaigns for Stanford earthquake libraries restoration, school drives, California College building projects, political campaigns, and the Ewald Foundation (education) and Sacred Mountain Foundation. He served as liaison officer in the Korean War to ameliorate differences between American and Korean forces. He served many years as American Bar Association arbitrator.

He has carried the Club flag on seven expeditions. He has thirty publications including books (To Climb a Sacred Mountain, Journey, A Bicycle Odyssey Through Central Asia, San Quentin Inside the Walls), and five articles in the Explorers Journal. He has made innumerable presentations and lectures. He has done scores of other expeditions relating especially to sacred mountains, spiritual site layering, altitude and stress lipid research, comparative religions, cycling extremes, indigenous survivors of totalitarian oppression...on mountains and mountain ranges all over the world. He was the first Person to bicycle the entire Silk Web (10,300 miles), to bicycle from Ueumchi, Xingjiag to Lhasa, Tibet, and the first westerner to circumambulate Mt. Kailas in Tibet and climb the sacred mountains of China when those areas were opened to foreigners.

Alan has been a member of The Explorers Club since 1984. He has served as Northern California Chapter Chair, Vice Chair, Membership, Programs. He initiated and expanded special activities including Sirdars, field trips, membership contest, award programs and special events (Story Night, Academy of Science Gala), Hawaii outreach program, sponsor relations, and others. He has prepared special reports and plans for The Explorers Club and the Board relating to Exploration Products, Chapter Support, Nominations Revisions, Board Collegiality Recommendations, and Ethics Accusations Resolution. He was Ombudsman and has served on the Legal, Management, and Nomination Committees. He was the finalist in an early Explorers Club Photo Contest.

Alan resides in Belvedere, California (San Francisco Bay Area), with his wife Becky.

Advisor (Communications)

Yasuo "Zorro" Miyazawa

CEO, Foundation for Global Children

Zorro is the founder and CEO of the Foundation for Global Children*. The objective of the foundation is: "to explore problems in child education and care, both in Japan and overseas, create a vision of an ideal future, provide solutions to the problems and work to nurture and assist the development and wellbeing of children, in order to develop in children the ideal of living and working together in harmony and to support the development and wellbeing of children, both in Japan and overseas."

Overseas activities of the FGC:

Bhutan:

- Exchange program with RTC (Royal Thimphu College, the first private university in Bhutan)
- Established Ashi Kesang - Miazawa Seisa Scholarship
- Invited high school age students to Japanese high schools
- Joint research with Royal Society for Protection of Nature (RSPN)
- Joint researches, faculty member exchange programs, and participation in Phobjikha Project-
- Joint research on Asian Himalayan Studies
- Invited Mr. Dago Tshering (former Ambassador Bhutan to India)
- Joint research with Mr. Masayuki Itonaga,
- Special Adviser, University of Alaska Fairbanks
- Soccer coach/trainer support and exchange programs

Bangladesh:

- Support Agrasara Orphan Destitute Home
- Support for improvement of the facilities
- Provide education and training to nurture future teachers
- Establish a sewing factory and provide technical training to children
- Establish international NGO, Seisa-Bangades

Myanmar: Nurture IT technicians and trainers

- Provide training for IT technicians and trainers-
- Support for improvement of medical and educational environment
- Provide water purification equipment
- Introduction of soap to improve hygienic environment
- Provide education and training for doctors, nurses, and public health workers

Other related projects in medical and educational fields:

- Joint project with Union of Myanmar Federation of Chambers of Commerce and Industry (UMFCCI)
- Joint projects with UMsFCCI for improvement of medical and educational environment

Amateur radio activities:

Yasuo Miyazawa has the amateur radio callsign JH1AJT, and is one of the most famous and accomplished hams in Japan. Over the years, he has been to many DX spots throughout Asia, Africa and the Pacific Ocean including 7O1A, XW30/XW30A, A51/JH1AJT, XU1A, XW8KPL, E31A, S21YZ, among others. Together with Dr. Glenn Johnson (W0GJ), Zorro was an Honorary/Founding Member of the Bhutan Amateur Radio Club, for which he was issued the special lifetime callsign A51A. He was the honorary DXpedition Leader for the 2013 Clipperton Island Expedition TX5K.

*http://www.fgc.or.jp/english/about/management.html

SUPPLEMENTARY

Recent volcanic activity of Big Ben

2013	According to NASA Earth Observatory (EO) an image acquired on 7 April 2013 from the Advanced Land Imager (ALI) on NASA's EO-1 satellite showed that Mawson's Peak crater on Heard Island had filled and a lava flow had traveled down the SW flank. The lava flow was visible in an image acquired on 20 April 2013 and had slightly widened just below the summit. Further eruptions were reported in Oct. 2013.
2012	Satellite images showed hotspots at Heard Island volcano on 21 and 24 September, 10th, 19, 28 Oct, 6 Nov, and 11 Dec 2012. A Heritage Expeditions cruise, which departed Fremantle, Australia, reached Heard Island in the south Indian Ocean on 21 Nov 2012. A photo posted on the expedition's twitter page showed the volcano under clear skies. There was no visible plume from the summit. NASA's Earth Observatory reported that a satellite image acquired on 13 October showed a possible dark area in the summit crater of Mawson Peak and hot surfaces within the crater, indicating the presence of lava in or just beneath the crater.
2008	Hotspots at Big Ben in February and March 2008.
2007	Big Ben was active throughout most of 2007. Two hotspots separated by 300 m were detected on 29th February 2007, and possibly indicated separate active vents at the volcano.
2006	Eruptive activity at Big Ben throughout most of 2006. There was evidence that a lava lake was present in the summit crater, however this was not be confirmed by satellite images.
2003-04	Hotspots were detected on 9 June 2003, and continued frequently until 14 June 2004.
2001	Observations from Atlas Cove, 15 km NW of the summit, showed plumes up to 1 km high over Big Ben. The eruptions appeared to originate from two vents, one at Mawson Peak, and the other at a newly discovered vent 300-400 m further down the south flank.
2000	Eruptions at Big Ben on 24 May; 3, 5, and 6 June; 25 Sep; 29 Oct; 5, 15, 19, and 24 Nov; 16, 17, 26, and 30 Dec 2000.
1997	Fumerole on W flank about ca. 500m from summit observed by R. W. Schmieder during Cordell Expedition January, 1997
1993	A new lava flow was observed at Mawson Peak in mid January 1993. Lava flowed in two lobes from 2600 m altitude to below 1400 m altitude, on the SW flank of the volcano. Lava followed the same path taken by the 1985-87 lava flow.
1992	On 29 May 1992, an orange glow observed above the volcano. Pulsating cycles of incandescence occurred between 2130 and 2200 hr.
1986-87	A helicopter landing was made at the summit of Mawson Peak by Australian National Antarctic Research Expeditions (ANARE) on 21 Dec 1986. Incandescent lava was visible inside the 40-50 m wide, 50-70 m deep crater. The crater appears to have been formed by the 1985-87 eruption because it was not seen by climbing expeditions which reached the summit of Mawson Peak in 1965 and 1983.

Source: http://www.volcanolive.com/heardisland.html

Ascents of Big Ben

Early attempts

Eric von Drygalski appears to have been the first to attempt to climb the mountain, which he had named Kaiser Wilheim Peak. John Béchervaise, ANARE station leader, made an attempt in 1953, albeit unsuccessfully due to attrocious weather. Grahame Budd, station leader in 1954 succeeding Béchervaise, and Warwick Deacock made an unsuccessful attempt in 1963. The pair started from Atlas Cove, skirted around the eastern and southern coasts, traversing glaciers en-route, and started their ascent from Long Beach. They climbed the eastern limits of the glacier now known as Deacock Glacier, passed through Budd Pass, continued in a north-easterly direction along the eastern limits of the Gotley Glacier. They reached the plateau of Big Ben at c2,000 m, but were unable to continue to the summit.

The first ascent

During the summer of 1964-5, a small private group, bearing the title South Indian Ocean Expedition to Heard Island, succeeded. The expedition was led by Warwick Deacock and included Grahame Budd, John Crick, Colin Putt and Philip Temple. The climbing party made their ascent along a ridge then headed westward towards Budd Pass, through which they reached the Gotley Glacier. The ascent continued in a north-easterly direction along the eastern limits of the Gotley Glacier. When they reached the plateau of Big Ben they turned west to climb Mawson Peak from the east. They were fortunate to get a break in the weather, which enabled them to make a dash for the summit, up a 45° slope obstructed by crevasses and ice cliffs. They found that Mawson Peak had a furrow-like crater only 76 m long, 23 m wide and 7 m deep, emitting sulphurous fumes. The expedition returned to Sydney on 14 March 1965.

The second ascent

The second successful ascent was made by another Australian party on 9-10 February 1983. After being landed at Skua Bay on the eastern side of Big Ben by the ketch, Anaconda II, William Blunt, Jonathan Chester, Pauline English, Martin Hendy, and Ross Vining reached the summit via Long Ridge. Although route finding was problematical, technical difficulties for the climb were low. Aside from climbing, the group conducted glaciological and biological investigations.

The third ascent

The third successful ascent of Mawson Peak was by Australians, Robb Clifton, Tim Curtis, Stuart Davies and Matthew Rogerson. They were landed at Atlas Cove on 1 January 2000. After being thwarted by the island's notoriously violent weather on their first attempt, they reached the summit on 10 January 2000 via a new route from the west. The party experienced poor climbing conditions and encountered many crevasses. They also noticed sulphur and steam escaping from a vent close to the summit.

Source: http://www.summitpost.org/phpBB3/kiwi-summits-world-s-most-remote-island-t61480.html.

Glacial retreat

Recent glacier retreat on Heard Island

BY

G. M. BUDD[1] and P. J. STEPHENSON[2]

ABSTRACT

A survey of glaciers on Heard Island in 1963 showed that general major retreat had recently occurred. Re-survey in 1965 suggested possible readvance in two glaciers.

Photographic and other records from expeditions visiting the island in 1974, 1902 and 1929, and from the ANARE occupation of 1947–1955, show no apparent changes until 1947 but general minor recession by 1955.

Meteorological records show a rise in air temperature since 1948, which seems to be the major cause of the retreat. Possible movement of the Antarctic Convergence cannot be demonstrated and volcanic activity is discounted as a general influence.

Introduction

Heard Island (Fig. 1) is a mountainous island south of the Antarctic Convergence. It is 27 miles long, 12 miles wide, and 9000 feet high. The

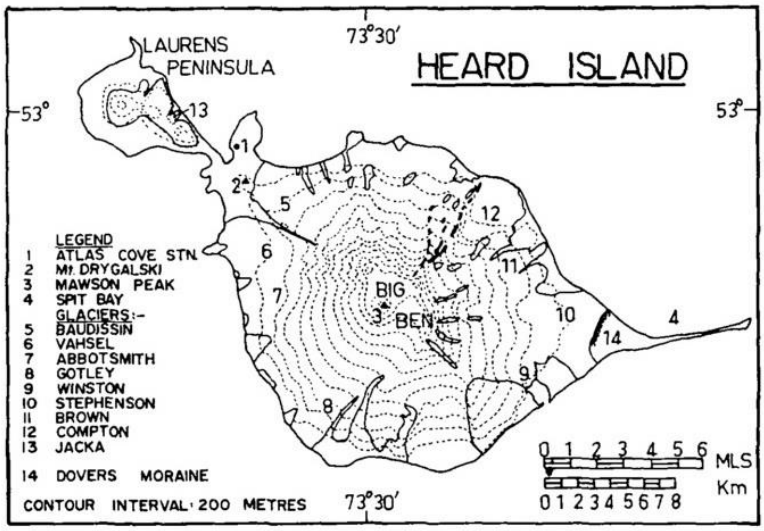


FIG. 1. Topographical features, Heard Island.

[1]School of Public Health and Tropical Medicine, University of Sydney, Australia

[2]Geology Department, University College of Townsville, Australia

Source: Budd, G.M. and P.J. Stephenson, 1970. Recent glacier retreat on Heard Island. *International Association for Scientific Hydrology* **86**: 449–458.

Von Karman vortex street

IDENTIFICATION OF VON KARMAN VORTICES IN THE SURFACE WINDS OF HEARD ISLAND

Research Note

PAUL J. BEGGS[1,*], PATRICIA M. SELKIRK[2] and DENNA L. KINGDOM[1]
Departments of [1]Physical Geography and [2]Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia

(Received in final form 12 September 2003)

Abstract. Heard Island (73°30′ E, 53°05′ S) is an isolated island in the sub-Antarctic located in a region of strong westerly winds. The dominant topographic feature is a large glaciated volcano, which peaks at 2,745 m in altitude. Only limited meteorological information exists for the island, with incomplete records from a station at Atlas Cove covering the period 1948 to 1954, and from a station at The Spit from 1992 onwards. We present the results of wind observations that were conducted on Dovers Moraine at the eastern end of Heard Island over the 2000/2001 summer, with the aim of characterising local winds at this location on the island. Wind was measured using a Woelfle type mechanical wind recorder. Wind speed was comparable, and on occasions stronger, at this location compared to simultaneous records at the western end of the island. Winds were predominantly from the south-south-west, or north-north-west to north. A number of periods of relatively low wind speed coincided with repeated wind direction patterns, which we associate with the surface signature of von Karman vortices. Results from this study suggest there are significant topographically-generated differences in wind characteristics between the eastern and western ends of the island.

Keywords: Heard Island, Sub-Antarctic, Surface, Topography, von Karman vortices, Wind.

1. Introduction

Sub-Antarctic Heard Island (73°30′ E, 53°05′ S) is approximately 4,850 km south-east of southern Africa, 4,350 km south-west of Western Australia, and 1,650 km north of the Antarctic continent (Figure 1). The dominant topographic feature is a large glaciated volcano, Big Ben, which peaks at 2,745 m in altitude. The island is 42 km long and 20 km wide, is oriented on a north-west to east-south-east axis, and covers an area of 385 km^2.

Heard Island's latitude places it in what are known as the 'Furious Fifties'. The predominant wind direction is from the westerly quarter. Only limited meteorological information exists for the island. An Australian National Antarctic Research Expedition (ANARE) station at the western end of the island (Atlas Cove) provided routine meteorological observations between February 1948 and December 1954 (Site No.: 300005, WMO No.: 95997). The Australian Bureau of Meteorology has a weather station at Spit Bay (The Spit) at the eastern end of the island (Site No.:

* E-mail: paul.beggs@mq.edu.au

Boundary-Layer Meteorology **113:** 287–297, 2004.

Macrobiota

Zootaxa 1022: 57–64 (2005)
www.mapress.com/zootaxa/

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

1022

Tardigrades of the Australian Antarctic: *Hypsibius heardensis* (Eutardigrada: Hypsibiidae: *dujardini* group) a new species from sub-Antarctic Heard Island

WILLIAM R. MILLER[1], SANDRA J. MCINNES[2], & DANA M. BERGSTROM[3]

[1] *Dept. of Biology, Baker University, Baldwin City, Kansas 66006 U.S.A., email: William.Miller@BakerU.edu*
[2] *British Antarctic Survey, Natural Environment Research Council, Madingley Road, Cambridge CB3 0ET, United Kingdom, email: sjmc@bas.ac.uk*
[3] *Australian Antarctic Division, 203 Channel Highway, Kingston Tasmania 7050, Australia, email: Dana.Bergstrom@aad.gov.au*

Abstract

A new species, *Hypsibius heardensis* **sp. nov.** (Tardigrada: Eutardigrada: Hypsibiidae) is described from samples collected during the Australian National Antarctic Research Expeditions (ANARE) 1986-87 expedition to Heard Island, in the southern Indian Ocean. The new species belongs to the *dujardini* group and differs from similar species of *Hypsibius* by the absence of eyes, large apophyses, near equal macroplacoids, lack of a microplacoid, the presence of a small septulum, and cuticular bars near the base of all claws.

Key words: Tardigrada, *Hypsibius heardensis* sp. nov., Heard Island, Antarctica

Introduction

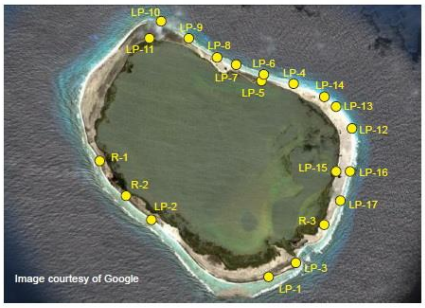
Heard Island (53º 06' S, 73º 30' E) (Figs 1A, B), is located in the southern Indian Ocean to the south of the Polar Frontal Zone, only 1650 km north of Antarctica, and about midway between Australia (4350 km to the east), and South Africa (4850 km to the west) (Clark *et al*. 1983). The island is mainly volcanic, built on pelagic limestone of Miocene age (Barling 1990; Clarke *et al.* 1983), and approximately 40 km long by 20 km wide (an area of 367 km^2), with one main peak, Big Ben, rising to 2745 m (Allison & Keage 1986). Though extensively ice covered, between 1985 and 2000/01 there has been a substantial reduction in ice extent, which has reduced from over 80% to approximately 69% of total surface area (Ruddell, per. comm.).

Accepted by C. Beasley: 28 May 2005; published: 25 Jul. 2005

Dr. Mary McGann has collaborated with Cordell Expeditions for more than 20 years. Most recently she has identified forams and proximate organisms from sediment collected during the author's 2013 expedition to Clipperton Island. The following informal note, prior to publication, is an initial summary of her findings. There appears to be no record of shallow marine or brackish forams at Heard Island, so we expect to make this kind of discovery there.

Foraminifera of Clipperton Island

Mary McGann, Louis-Philippe Loncke,
and Robert W. Schmieder



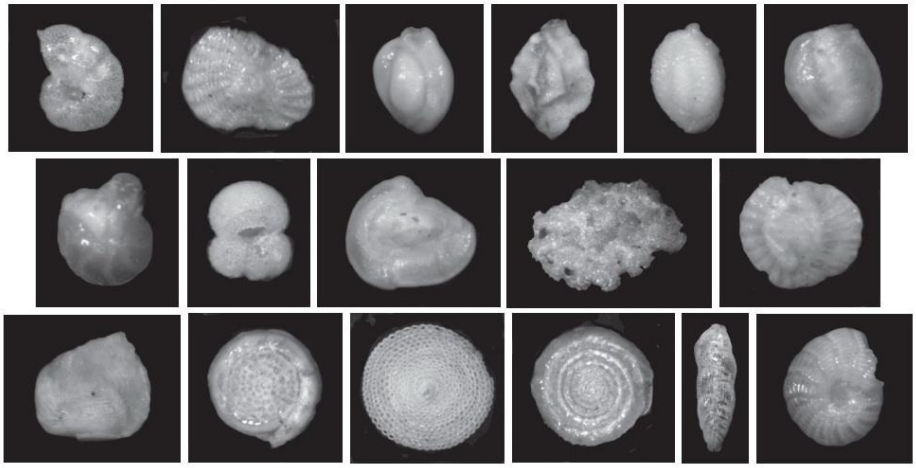
Clipperton Island is of great interest to biologist because it is so remote, situated 1290 km from the west American mainland, and because abyssal depths lie between it, the other four islands of the tropical eastern Pacific, and the mainland. The island's isolation has prompted inquiries into the presence of mixed biogeographic faunas (tropical eastern Pacific [Panamic Province] and Indo-Pacific) represented, how they disperse to this location, and what role both inter-island and local endemism plays.

The island is the only atoll of the tropical eastern Pacific and is characterized by extensive coral cover. Diverse island habitats typical of most tropical islands, such as muddy, silty, and sandy bottoms, rocky shorelines, and extensive plant life situated near the water such as, among others, mangroves and algal mats, are lacking here. As a result, biodiversity is far lower than most tropical islands.

Because of its unique environmental conditions, one goal of the 2013 Cordell Expedition (TX5K) to Clipperton Island was to document the distribution of an element of the island's biota: microscopic (sand-sized) single-celled animals known as foraminifera which produce a fossilizable shell and are ubiquitous in brackish to marine waters. The expedition successfully collected sediment samples from 17 locations in the surf zone around the perimeter of the island as well as three from the margin of the inner brackish-water lagoon. This is the first known detailed investigation of these organisms in the vicinity of the island.

As expected, preliminary results suggest that the foraminiferal diversity is extremely low on Clipperton Island compared to other islands in the Pacific. Whereas hundreds of species are typically encountered, only 21 species, representing 11 genera, were recovered: *Sorites, Quinqueloculina, Spirillina, Peneroplis, Pseudohauerina, Elphidium, Massilina, Cibicides, Planorbulina, Rectobolivina*, and *Globigerinoides*. The impoverished fauna may be due to several factors on Clipperton Island, including a lack of variable habitats, reduction of food sources, and a pounding surf that pulverizes biotic and sedimentologic debris that is deposited in the surf zone and along the beach. Faunal representatives of both the tropical eastern Pacific and Indo-Pacific were found, but no endemic fauna have yet to be recognized.

In addition to the foraminifera, remains of other biologic groups were recovered. Among the surf and beach samples, these include bivalve mollusks, bryozoans, crab claws, sea urchin spines, gastropods and their opercula, ostracods, and worm tubes. In the inner lagoon, the remains of fish (bones and teeth), bivalve mollusks, gastropods, ostracods, a winged insect, a tiny finger bone (mammal?), seeds of aquatic plants (*Scirpus*), and charophyte gyrogonites (calcium carbonate algal reproductive structures) were encountered.



Source: Dr. Mary McGann, U.S. Geological Survey, private communication, 2013.

Plastic debris

FIRST EVIDENCE OF INGESTION OF PLASTIC DEBRIS BY SEABIRDS AT SUB-ANTARCTIC HEARD ISLAND

H.J. AUMAN[1], E.J. WOEHLER, M.J. RIDDLE & H. BURTON

[1]*Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7005, Australia (hauman@utas.edu.au)*
Current address: University of Tasmania, Dept. of Zoology, Hobart, TAS 7001, Australia

Received 3 March 2003, accepted 4 July 2003

The presence of ingested anthropogenic marine debris in seabirds is of growing concern, especially in areas of the earth remote from point sources. It is increasing despite control measures, and impacts to wildlife are poorly understood (Ryan 1993). We report here the first evidence of ingestion of plastic debris by seabirds at sub-Antarctic Heard Island (53°S, 73°E) in the southern Indian Ocean during the Australian National Antarctic Research Expeditions (ANARE) visit in 2000/01.

Seabird carcasses were collected between October 2000 and January 2001 around Atlas Cove, an unglaciated region on the northwestern coast of Heard Island. To assess accurately any impactions, lacerations or ulcerations in the digestive systems attributed to ingestion of plastic debris, birds were collected for necropsy only if found intact and not decomposed (Auman *et al.* 1998). Totals of 10 South Georgian Diving Petrels *Pelecanoides georgicus,* four Subantarctic Skuas *Catharacta antarctica,* one Southern Giant Petrel *Macronectes giganteus,* two Antarctic Prions *Pachyptila desolata* and one unidentified diving petrel *Pelecanoides* sp. were collected.

Of the 18 carcasses dissected, we found only two birds, both Antarctic Prions, with plastic particles inside their digestive systems. One prion had a single orange-pink plastic particle (8.1 × 5.4 × 0.4 mm, 9.8 mg) in the proventriculus, which also contained two squid beaks and the remains of unidentified crustaceans. The bird was of indeterminate sex with an early-stage brood patch and no visceral or subcutaneous adipose tissue. A second adult male Antarctic Prion contained one light blue plastic particle in the gizzard (6.0 × 4.4 × 0.6 mm, 9.0 mg). The diameter of this particle was larger than the pyloric sphincter against which it was lodged. This may have created an obstruction to food; however, the bird had an empty proventriculus and high amounts of visceral and subcutaneous adipose tissue.

Because Antarctic Prions are surface seizers it is not surprising that we found plastic debris in this species and not in the others that employ different feeding methods (Marchant & Higgins 1990). Ryan (1987) found that 36% of 77 Antarctic Prions found dead on South African beaches contained plastics, whereas 73% of 11 birds collected at sea of South Africa contained plastics. Mean number of particles was 2.7 (maximum: 22) and mean mass was 50.2 mg (maximum: 615 mg) for 88 birds.

The quantities found in the two Antarctic Prions at Heard Island are not likely to cause physiologic stresses seen in other birds, such as starvation (Dickerman & Goelet 1987), suppressed appetite and reduced growth (Ryan 1988a), lower fledging masses (Sievert & Sileo 1993), decreased fat deposition (Conners & Smith 1982), increased PCB and other organochlorine assimilation (Ryan *et al.* 1988) or satiation and obstruction in the gut (Auman *et al.* 1998).

To assess potential indirect sources of marine debris ingestion, regurgitated Subantarctic Skua casts (pellets) were collected from several roosting localities around Atlas Cove. Of 396 casts dissected, two (0.5%) contained small plastic particles (16.7 × 3.8 × 1.0 mm, 178.83 mg; 5.7 × 4.1 × 2.7 mm, 104.38 mg). One piece of plastic material was found next to an old scattered cast and not collected, but we believe that it was once part of that cast. Ryan & Fraser (1987) reported a much higher incidence (22%) of casts

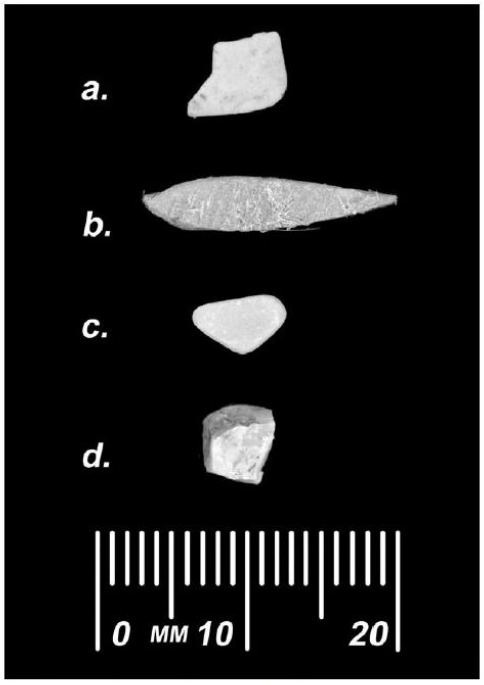


Fig. 1. Plastic debris ingested by seabirds at Heard Island, 2001/01.

containing plastic debris in Subantarctic Skuas at Inaccessible Island, South Atlantic. Because skuas have the ability to eliminate indigestible remains such as feathers, bones and eggshells, ingestion of small amounts of plastic debris is not likely to pose a problem to individuals of this species.

Although the incidence of anthropogenic materials in the digestive systems and casts of seabirds at the Heard Island World Heritage Site appears to be at a low level when compared with other less remote localities (Ryan 1987; but note that breeding birds may carry lower plastic loads than non-breeding birds, Ryan 1988b), their presence remains troubling. The persistence of marine debris at localities far removed from point sources should not be underestimated, and the long-term impacts merit an increased level of attention on an international scale.

ACKNOWLEDGEMENTS

HJA thanks S. Fitch for his assistance in carcass collection and the Australian Antarctic Division for the opportunity to work on Heard Island.

REFERENCES

AUMAN, H.J., LUDWIG, J.P., GIESY, J.P. & COLBORN, T. 1998. Plastic ingestion by Laysan Albatross chicks on Sand Island, Midway Atoll in 1994 and 1995. In: Robertson, G. & Gales, R. (Eds). Albatross biology and conservation. Surrey Beatty: Chipping Norton. pp. 239–244.

CONNORS, P.G. & SMITH, K.G. 1982. Oceanic plastic particle pollution: suspected effect on fat deposition in Red Phalaropes. *Marine Pollution Bulletin* 13: 18–20.

DICKERMAN, R.W. & GOELET, R.G. 1987. Northern Gannet starvation after swallowing Styrofoam. *Marine Pollution Bulletin* 18: 293.

MARCHANT, S. & HIGGINS, P.J. (Compilers). 1990. Handbook of Australian, New Zealand and Antarctic birds. Vol. 1. Ratites to ducks. Melbourne: Oxford University Press.

RYAN, P.G. 1987. The incidence and characteristics of plastic particles ingested by seabirds. *Marine Environmental Research* 23: 175–206.

RYAN, P.G. 1988a. Effects of ingested plastic on seabird feeding: evidence from chickens. *Marine Pollution Bulletin* 19: 174–176.

RYAN, P.G. 1988b. Intraspecific variation in plastic ingestion by seabirds and the flux of plastic through seabird populations. *Condor* 90: 446–452.

RYAN, P.G. 1993. Marine litter keeps increasing. *Nature* 361: 23.

RYAN, P.G., CONNELL, A.D. & GARDNER, B.D. 1988. Plastic ingestion and PCBs in seabirds: is there a relationship? *Marine Pollution Bulletin* 19: 217–219.

RYAN, P.G. & FRASER, M.W. 1988. The use of Great Skua pellets as indicators of plastic pollution in seabirds. *Emu* 88: 16–19.

SIEVERT, P.R. & SILEO, L. 1993. The effects of ingested plastic on growth and survival of albatross chicks. In: Vermeer, K., Briggs, K.T., Morgan, K.H. & Siegel–Causey, D. (Eds). The status, ecology and conservation of marine birds of the North Pacific. Ottawa: Canadian Wildlife Service Special Publication. pp. 212–217.

Source: Auman, H.J.; Woehler, E.J.; Riddle, M.J. & Burton, H., 2004. First evidence of ingestion of plastic debris by seabirds at Sub-Antarctic Heard Island, *Marine ornithology* **32**: 105-106.

Bibliography

General

Budd, G., May-June 2013. Untamed Southern Isle. *Australian Geographic*), pp. 87-98.

Green, K. & Woehler, E. J. (eds), 2006. *Heard Island, Southern Ocean Sentinel*. Surrey Beatty & Sons, Chipping Norton, Australia.

Scholes, A., 1952. *Fourteen Men*. E. P. Dutton, New York.

Australian Antarctic Division (AAD)

AAD: http://www.antarctica.gov.au.

About us: http://www.antarctica.gov.au/about-us/publications

Environment Policy and Management: http://www.antarctica.gov.au/environment/environment-policy-and-management

Environmental Law and Guidelines: http://www.antarctica.gov.au/environment/environmental-law-and-guidelines

Expeditioner Handbook. Australia's Antarctic Program. (June, 2012): http://www.antarctica.gov.au/living-and-working/predeparture/forms-expeditioners-must-sign/expeditioner-handbook

Heard Island and McDonald Islands Marine Reserve Management Plan: http://www.heardisland.aq.

Protecting and Managing Special Areas: http://www.antarctica.gov.au/environment/protecting-and-managing-special-areas

Publications: http://www.antarctica.gov.au/about-us/publications

Birds

Woehler, E. J., 2006. Status and conservation of the seabirds of Heard Island and the McDonald Islands. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 128-165.

Climate and Meteorology

Beggs, P. J., Selkirk, P. M., and Kingdom, D. L., 2004. Identification of Von Karman vortices in the surface winds of Heard Island, in: *Boundary Layer Meteorology*, Volume **113**(2): 287-297.

Thost, D., and Allison, I., 2006. The climate of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 52-68.

Debris

Auman, H.J.; Woehler, E.J.; Riddle, M.J. & Burton, H., 2004. First evidence of ingestion of plastic debris by seabirds at Sub-Antarctic Heard Island, *Marine ornithology* **32**: 105-106.

Ivar do Sul, J. A. David K. A. Barnes, Monica F. Costa, Peter Convey, Erli S. Costa and Lúcia Campos, 2011. Plastics in The Antarctic Environment: Are we looking only at the tip of the iceberg? *Oecologia Australis* **15**(1): 150-170.

Slip, D. J. &. Burton, H. R., 1991. Accumulation of fishing debris, plastic litter, and other artifacts, on Heard and Macquarie Islands in the Southern Ocean, *Environmental Conservation* **18**:249-254.

Ecosystems

Davies, K. F., Melbourne, B. A., McClenahan, and Tuff, T., 2011. Statistical models for monitoring and predicting effects of climate change and invasion on the free-living insects and a spider from sub-Antarctic Heard Island. *Polar Biology* **34**(1):119-125.

Geology and volcanology

Fitch, S., Lock, A., Klok, C.J., Kiernan, K., McConnell, A., 2001. Heard (Indian Ocean). Increased fumarolic activity in February and March 2001; possible lava flow. *Bulletin of the Global Volcanism Network* **26**(2):3-4.

Ivanac, J.F., 1948. Geological Investigations on Heard Island. *BMR Record* 1948/38.

Kiernan, K., 2000. Heard. Discovery of a distinct vent below Mawson Peak; brown fumes in November 2000 *Bulletin of the Global Volcanism Network* **25**(11):3-4.

Kiernan, K., Fitch, S., McConnell, A., 2001. Big Ben: the fire beneath the ice Haywood, E (ed.) *Australian Antarctic Magazine* **2**:31-32.

Kiernan, K., McConnell, A., 1998. Geomorphology of Heard Island. R. Bourman, (ed.) 8th Goolwa, SA 15-20

November.
Kiernan, K., McConnell, A., 1998. Management of the Heard Island lava tube caves. Selkirk, P. (ed.) *ANARE Research Notes* **101**. 27.
Kiernan, K., McConnell, A., 1998. Reconnaissance of the geomorphology of Heard Island and McDonald Island. Selkirk, P (ed.) *ANARE Research Notes* **101**:27.
Kiernan, K., McConnell, A., 1999. Geomorphology of the sub-Antarctic Australian territory of Heard Island-McDonald Island. *Australian Geographer* **30** (2):159-195.
Kiernan, K., McConnell, A., Yates, T., 1998. Tube-fed Pahoehoe lava-flow features of Azorella Peninsula, Heard Island, southern Indian Ocean. *Polar Record* **34**(190):225-236.
Lambeth, A.J., 1952. A geological account of Heard Island. *Journal and Proceedings of the Royal Society of New South Wales* **85**:14-19.
Quilty, P.G. and Wheller, G., 2000. Heard Island and the McDonald Islands: A window into the Kerguelen Plateau (Heard Island Papers). *Pap. Proc. R. Soc. Tasm*. **133** (2):1–12.
Stephenson, J., Barling, J., Wheller, G., and Clarke, I., 2006. The geology and geomorphology of Heard Island. In: Green, K. & Woehler, E. J. (eds), *Heard Island, Southern Ocean Sentinel*, pp. 10-27.
Stephenson, P.J. (1964) Some geological observations on Heard Island. Adie, R.J. (ed.) *Antarctic Geology* 14-24.
Williams, R., Duhamel, G., 1986. Volcanic activity on Heard Island. *Polar Record* **23**(142):88-90.

Glaciers

Allison, I. A. and Peter L. Keage, 1986. Recent changes in the glaciers of Heard Island. *Polar Record* **23** (144):255–272.
Budd, G.M. and P.J. Stephenson, 1970. Recent glacier retreat on Heard Island. *International Association for Scientific Hydrology* **86**:449–458.
Budd, G.M., 2000. Changes in Heard Island glaciers, king penguins and fur seals since 1947 (Heard Island Papers). *Proc. R. Soc. Tasm.***133** (2):47–60.
Thost, D. E. and Martin Truffer, February 2008. Glacier Recession on Heard Island, Southern Indian Ocean. *Arctic, Antarctic, and Alpine Research* **40** (1):199–214.
Taylor, A., 2006. An inventory of present glaciers of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 28-51.

Invertebrates

Chown, S. L., Greenslade, P., and Marshall, D. J., 2006. Terrestrial invertebrates of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 91-104.
Dartnell, H., 2006. The freshwater fauna of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 105-113.
Miller, W. R., S. K. Claxon and H. F. Heatwole, 1999. Tardigrades of the Australian Antarctic Territories: Males in the genus *Echinsicus* (Tardigrada: Heterotardigrada). *Zoologischer Anzeiger* **238**: 303-309.
Miller, W. R., S. J. McInnes, and D. M. Bergstrom, 2005.Tardigrades of the Australian Antarctic: *Hypsibius heardensis* (Eutardigrada: Hypsibiidae: *dujardini* group) a new species from sub-Antarctic Heard Island, *Zootaxa* **1022**: 57-64.

Marine mammals and fishes

Green, K., 2006. The marine mammals of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 166-183.
Williams, R., 2006. The nearshore fishes. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 114-127.

Mountaineering

Bowden, T., 2011. Heard Island – The climbing of Big Ben. *Aurora* **30**(3):6-12.
Budd, G. M., 1964. Heard Island expedition, 1963. *Polar Record* **12**:193-95.
Budd, G. M., 2007. Australian exploration of Heard Island, 1947-1971. *Polar Record* **43**(225):97-123.

Plants

Scott, J., and Bergstrom, D., 2006. Vegetation of Heard Island. In: Green, K. & Woehler, E. J. (eds) *Heard Island, Southern Ocean Sentinel*, pp. 69-90.

CORDELL EXPEDITIONS

Cordell Expeditions (CE) is a nonprofit scientific educational association, formed in 1977 by Dr. Robert W. Schmieder. Its main activities are to carry out expeditions to remote oceanic sites to acquire scientific information that can contribute to rational management and protection of such sites. In addition, the group owns and operates a research vessel, the Cordell Explorers, and maintains an ongoing schedule of educational cruises for students and other groups interested in oceanography and marine biology.

Cordell Expeditions organized and carried out the following expeditions:

Cordell Bank (California) 1977-1986 Marine research.

First underwater exploration and description of Cordell bank, California. Over a 10-year period many diving expeditions were made, resulting in the first species list, new information about the topography and geology of the Bank, and the nomination to the U. S. National Oceanic and Atmospheric Administration for designation of the Cordell Bank National Marine Sanctuary (done in 1989 by Act of Congress). Extensive collaboration with major institutions including U. S. National Museum of Natural History, Los Angeles Museum of Natural History, etc. More than 200 contributors to the project. All the archival specimens, photographs, logs and other data were accessioned by the California Academy of Sciences. Numerous new species, range extensions, first observations.

Monograph: *Ecology of an Underwater Island.*

Schmieder Bank (California) 1987-1989 Marine research.

First underwater exploration and description of the bank offshore from Pt. Sur, eventually resulting in the designation of *Schmieder Bank* and the inclusion of the area within the Monterey Bay National Marine Sanctuary.

Farallon Islands (California) 1989 Marine research.

First underwater exploration of the North Farallon Islands, resulting in major collections of algae and the discovery of a subsurface tunnel completely penetrating one of the islands. First collections of algae from the Southeast Farallon Island. First diving exploration of Middle Farallon Island.

Rocas Alijos (Baja California) 1990, 1993 Marine research.

Two expeditions involving 40 persons to the large oceanic volcano lying 200 miles offshore from Baja California. First comprehensive underwater exploration, first ascent of the emerged rocks, first radio contacts from the site, first measurements of currents, water temperatures, etc.

Monograph: *Rocas Alijos: Scientific Results of the Cordell Expeditions*, Kluwer Academic Publishers.

Guadalupe Island (Baja California) 1990 Radio operations and marine research.

Excursion on return from the Rocas Alijos expedition. First radio contacts from the island and collection of marine invertebrates for the California Academy of Sciences.

Roqueta Island (Mexico) 1992 Radio operations

First radio contacts from the island.

Castle Rock (California) 1992 Radio operations

First radio contacts from the island.

Ventura Rocks (California) 1993 Radio operations

First radio operation from the rocks.

Farallon Islands (California) 1993 Terrestrial invertebrates and radio operations

Investigation of avian mortality due to a dermestid-vectored botulism outbreak.

Peter I Island (Antarctic) 1994 Radio operations (3YØPI) and environmental studies

Radio operations from the #1 most-wanted remote site in the World and collections of samples of rocks and lichens for U. C. Berkeley.

Book: *3YØPI: Peter I Island Antarctica.*

Easter Island/Salas y Gómez (Chile) 1995 Marine research and radio operations

Exploration of the last remaining unexplored subtidal areas of Easter Island, collection of marine specimens, extensive radio communications technology innovations (including first expedition website, online logs, etc.).

Book: *DX-AKU: Messages from the Easter Island Expeditions.*

Heard Island (Antarctic) 1997 Radio operations

Radio operations from the #1 most-wanted remote site in the World.

Book: *VKØIR: Heard Island.*

San Felix Island (Chile) 2002 Radio operations and environmental sampling.

First amateur radio communications from the island. Collection of marine invertebrates for the L. A. Museum of Natural History. Re-discovery of the large plant *Thamnoseris* (formerly thought to be extinct) and subsequent molecular analysis of nuclear ribosomal DXA sequences, resolving its disputed phylogenetic classification.

Book *XR0X: San Felix Island, Chile*.

Kure Atoll (Hawaii) 2005 Radio operations and environmental science.

Amateur radio operations, development and first use of DXA, the satellite-linked online log server that enables near real-time updates from the expedition site (cf., www.cordell.org/DXA. Investigation of means for controlling the invasive pest ant *Pheidole megacephala*.

Clipperton Island (Pacific) 2013 Radio operations) and environmental science.

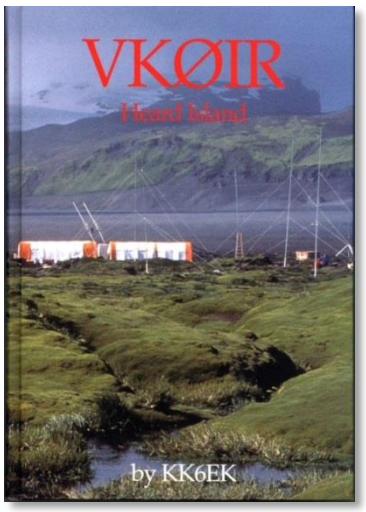
Amateur radio operations, including DXA version 2, real-time video, and other advanced communications modes. Search for *Pheidole*, collection of algal specimens for U. C. Berkeley.

Book: *DXA. The real-time online radio log server*.

Cordell Expeditions maintains collaborative relations with many organizations and institutions, including: University of California, Berkeley; Los Angeles Museum of Natural History; U. S. National Museum of Natural History, Washington, D.C.; California Academy of Sciences; City of Berkeley; Mt. Diablo College; St. Mary's College; Texas A&M University; Humboldt State University; Ocean Futures (J-M Cousteau); San Diego Museum of Natural History; and many others.

Cordell Expeditions has received numerous awards. Over 30 years the group has produced more than 1000 new species, new depth and range extensions, and first observations on site, numerous journal publications and seven books. A full bibliography is available on the website.

In the context of this Project, it should be noted that Cordell Expeditions carried out the expedition to Heard Island in 1997, principally for the purposes of amateur radio operation, with the author as the principal organizer and Expedition Leader. That expedition is described in the Participant's Handbook (copy in the library of the AAD and available from the author), the book, *VKØIR: Heard Island*, and on the website www.heardisland.org.



An excerpt from the book might be of interest here: It describes an interaction between the author and a pod of elephant seals near the camp. The encounter was entirely mental, an imagined exchange of greetings, queries, and observations between the author and one seal in particular, named Elleo as the conversation proceeded. The dialog went on for more than an hour, and when it was over, the following occurred:

> *In the gathering gloom, I returned to our village, melancholic and pensive. I longed to stay with the seals, to talk with the others, to learn more of the world at the end of the world. Looking across the water, and back at the hummocks, listening to the cries of the penguins and skuas, watching the splashing of the fur seals and petrels, feeling the chill air on my face and fingers, watching the dark shadows envelop the mountain and chase the volcanic plain into blackness ... I paused at the edge of the village to imprint the experience, looking back in the direction from which I had just come. I thought of the old seal named Elleo, and the others, and that for them this was not the edge of the world, but the center. I knew at that moment that I had just gotten what I really came here for...*

CONTACT INFORMATION

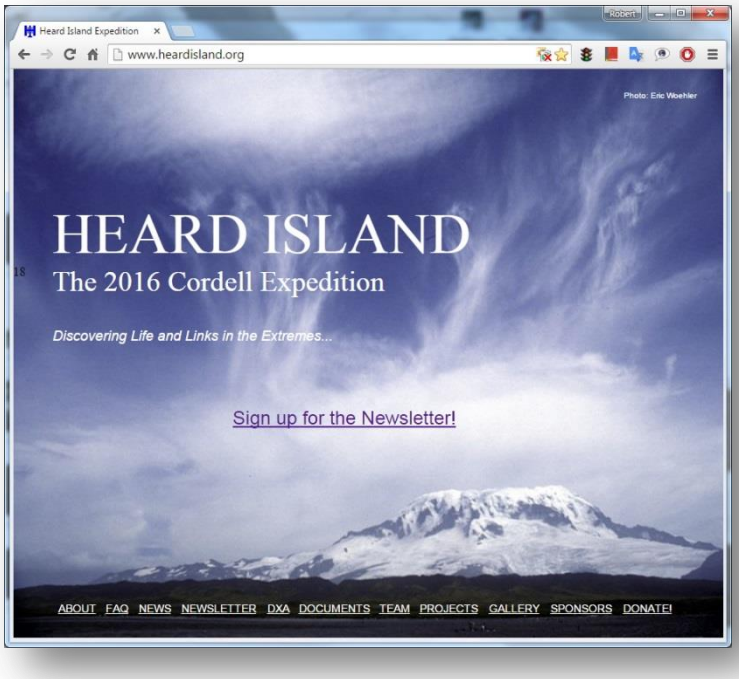
Organizer/Expedition Leader:
Dr. Robert W Schmieder

Mailing address:
Cordell Expeditions
4295 Walnut Blvd.
Walnut Creek, CA 94596

Phone:
(925) 934-3735

e-mail:
schmieder@cordell.org

Website:
http://www.cordell.org



Website for the Heard Island Project:

http://www.heardisland.org