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A study of the health and physiological adaptation of an expedition in Antarctica with special reference to occupational factors

Anthony F. Dick

ANTARCTIC DIVISION
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CONTENTS

APPENDIXES

PLATES

FIGURES

TABLES

A STUDY OF THE HEALTH AND PHYSIOLOGICAL ADAPTATION OF AN EXPEDITION IN ANTARCTICA, WITH SPECIAL REFERENCE TO OCCUPATIONAL FACTORS

by

Anthony F. Dick
Commonwealth Department of Health
Furzer Street
Phillip, Act, Australia

ABSTRACT

Aspects of man's adaptation and reaction to working in an isolated, cold environment are examined.

The number of wintering personnel at Australian stations has increased markedly in the last five years. Building construction, maintenance and related activities have become a major part of station work programs and have introduced new hazards to the work environment.

The health of the Davis 1982 expedition was generally good, with 6.2 cases per wintering expeditioner. Forty-five per cent of cases were the result of accidents. Subject and occupational influences on morbidity are discussed.

The results of monthly measurements of nine physiological parameters are reported and compared with the findings from two previous Australian expeditions. The fitness of the expedition, calculated using a submaximal work technique, increased as a linear function over the year, including the winter period.

Measurements of temperature changes in divers showed that current practices result in only small falls in body temperature and are unlikely to lead to hypothermia.

1. INTRODUCTION

1.1 PREAMBLE

This study is a result of the author's appointment as medical officer with the 1982 Australian National Antarctic Research Expedition (ANARE) to Davis, Australian Antarctic Territory, and is based on a treatise submitted to the University of Sydney in 1985 for the degree of Master of Public Health. The degree was conferred in 1986.

The author's term as medical officer coincided with the period during which nearly all of the twenty-six wintering expeditioners were at the station. The exceptions to this were three late arrivals and three early departures. Two expeditioners arrived on 20 February 1982 and the third, who elected not to take part in the physiological experiments, on 2 April 1982. The three early departures occurred on 7 December 1982.

In addition, twenty-five expeditioners in the 1981-82 summer period and nineteen in the 1982-83 summer period were on the station engaged in scientific, technical, trade and support work. These summer personnel did not take part in any of the applied physiological experiments nor are they included in the medical log of primary health care for the purposes of this study.

The study is therefore confined to the 1982 wintering party from 11 January 1982 to 16 January 1983.

1.2 AIMS

The aims of this study were:

(a) to examine aspects of living and working for a year in Antarctica, with particular relationship to the health and physiological status of participating personnel;
(b) to comment on differences between living and working in Antarctica and Australia; and
(c) to allow comparison with previous Antarctic expeditions to determine changes over time.

Five component investigations were undertaken to achieve these aims.

1.3 THE INVESTIGATIONS

1.3.1 Occupational study

In recent years, building construction projects have occurred on an unprecedented scale on Australian Antarctic stations, including Davis. The result has been a change in the occupational status and roles of expedition members, as well as the creation of new hazards. An examination of the occupational composition and work programs of the 1982 expedition to Davis was undertaken and a comparison with the ANARE expedition to Davis nineteen years previously was made.

That Antarctic expeditions face hazards associated with the environment is universally known. However, changes in the occupational roles and in work tasks in current expeditions have introduced new hazards. An examination of these hazards is reported.

1.3.2 Health of the expedition

Primary medical care and its documentation are the main functions of the medical officer. This morbidity study was undertaken to determine what illnesses and injuries occurred, the role of occupational and individual factors, and as a comparison with previously published studies.

1.3.3 Monthly physiological measurements

Measurements of body weight, skinfold thickness, arm circumference, basal pulse rate, blood pressure and oral temperature were performed on a monthly basis, and the findings reported. As these parameters have been measured on previous expeditions, a comparison between this study and others is made.

1.3.4 Physical fitness study

The purpose of this study was to determine the changes in physical fitness over a twelve month period in Antarctica, and to observe any effects due to the long Antarctic winter when prolonged outside activities were restricted.

Measurements of physical fitness were made monthly, using a cycle ergometer and an indirect determination of maximum oxygen uptake as an indicator of physical fitness.

1.3.5 Thermal loss in Antarctic divers

A year-round diving program for biological research purposes was carried out at Davis during 1982. This was the first such program conducted on an Australian expedition. As the thermal protection used was relatively unsophisticated, thermal assessment was performed on divers to determine in-water heat losses. This served as a monitor of the divers' status as well as providing information for the development of future diving programs and equipment.

2. ENVIRONMENTAL FACTORS

2.1 DAVIS AND THE VESTFOLD HILLS

Davis (68°35'S, 77°58'E), is situated in the Vestfold Hills, Princess Elizabeth Land (Figure 1). The nearest occupied stations are Mawson, 610 km to the west, and Mirny, a Russian station 670 km to the east.

2.1.1 Geography, geology and biology

The Vestfold Hills (Figure 2 and Plate 1) are situated on the eastern side of Prydz Bay, between 68°22'S and 68°40'S. The area, of about 400 km^2, is an ice-free 'oasis', triangular in shape, bounded by the sea to the north-west, the Sørsdal Glacier 12 km to the south and ice-covered slopes merging with the continental ice-cap ('plateau') to the east.

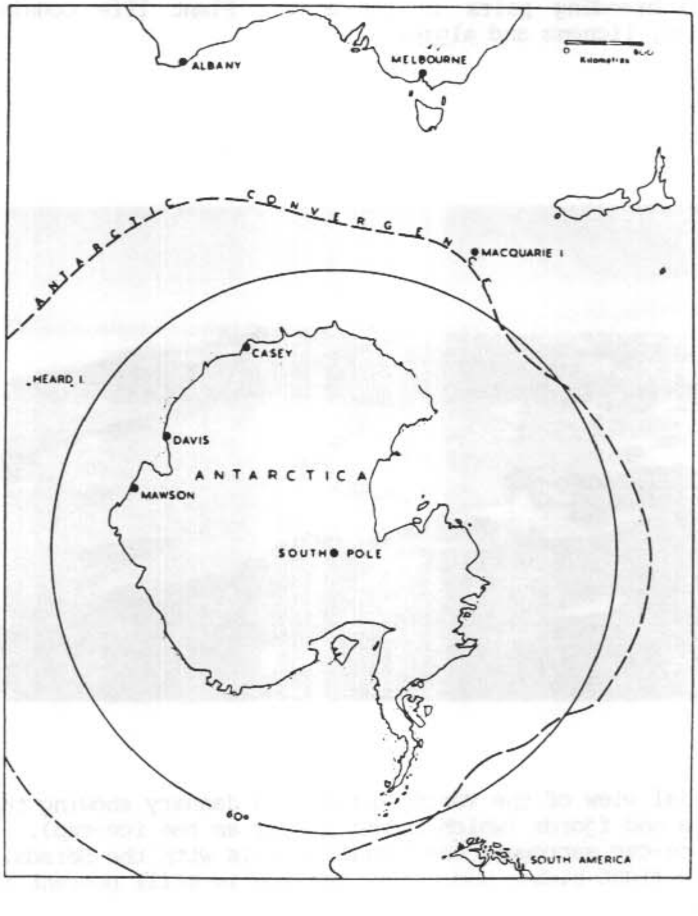

Figure 1. Antarctica and the Southern Ocean.

Law (1959) and McLeod (1963a) described the physical features. The Hills are of moderate relief, with a maximum height of 158 m. Valleys are narrow and filled with glacial rubble ranging from large boulders to fine silt. Lakes abound, from small pools to large expanses of water several kilometres long. Freshwater lakes are more common towards the ice-cap. Saline lakes are more common towards the coast, having been extensions of the sea previously. McLeod (1963b) and Burton and Campbell (1981) described the saline lakes, which vary from slight to extreme salinity. Surface water temperature of the lakes ranges from +6°C to -26°C, depending on season and salinity.

In general the terrain is much more rugged, with sharper relief and higher altitude towards the continental ice-cap. Four long inlets or fjords extend inland, the longest is 20 km in length and reaches the base of the ice-cap.

The geology of the area has been depicted by Crohn (1959) and McLeod (1963a) and a detailed account of the biology of the Vestfold Hills has been published by Johnstone et al. (1973). The area is visited by four species of seals and many species of birds, including the Adélie penguin which has about 130 000 breeding pairs in the area. Plant life consists of small patches of moss, lichens and algae.

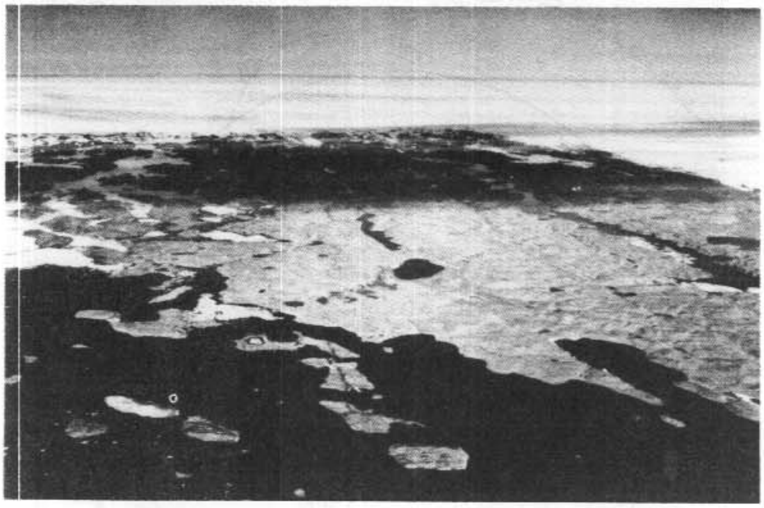

Plate 1. Aerial view of the Vestfold Hills in January showing the offshore islands, lakes and fjords (which indent as far as the ice-cap). The continental ice-cap surrounds the Vestfold Hills with the Sørsdal Glacier in the right background. Fast sea-ice is still present in Long Fjord (left).

(Antarctic Division photograph by P.G. Law)

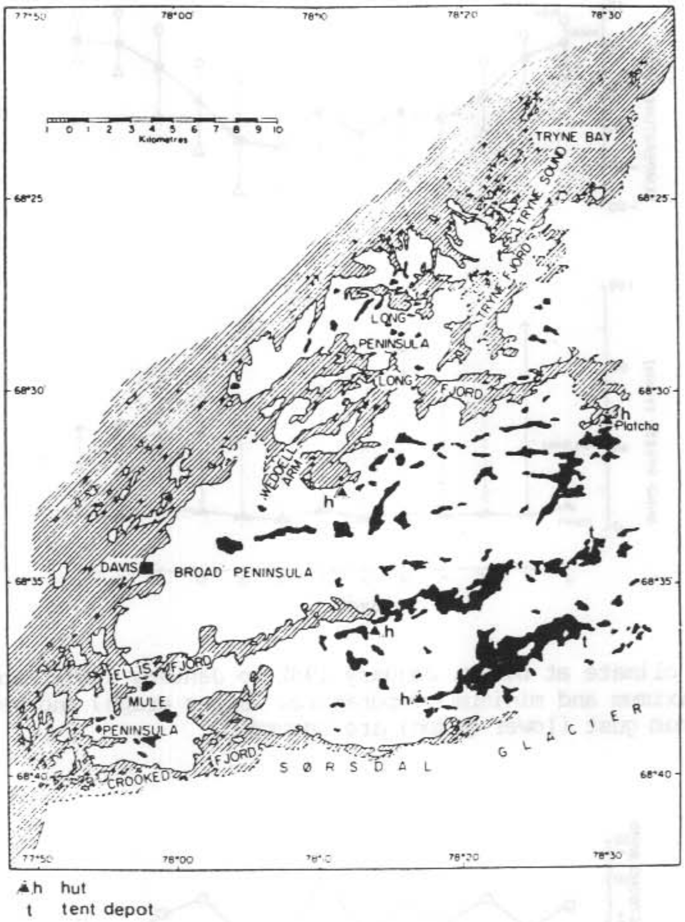

Figure 2. Map of the Vestfold Hills.

2.1.2 Climate

While the climate at Davis bears a general relationship to that of coastal Antarctica, it is significantly modified by local conditions. Katabatic winds, a prominent feature in most coastal areas, exhibit a regular pattern on the inland boundary of the Vestfold Hills adjacent to the ice-cap where a satellite station was manned from May 1961 to January 1982 (Lied 1963). However, they are dissipated by the 20 km of ice-free hills and are generally not evident at the station. Davis has a low average annual wind velocity (about 20 km/h) compared with other areas such as Mawson (average annual wind velocity of nearly 40 km/h) (Betts 1981). However, blizzards frequently bring gale-force winds. Streten (1968, 1969) described the wind patterns of the Vestfold Hills area.

The monthly climatic details for Davis during the period 1 January 1982 to 31 January 1983 are summarised in Figures 3 and 4 and Appendix I. The data

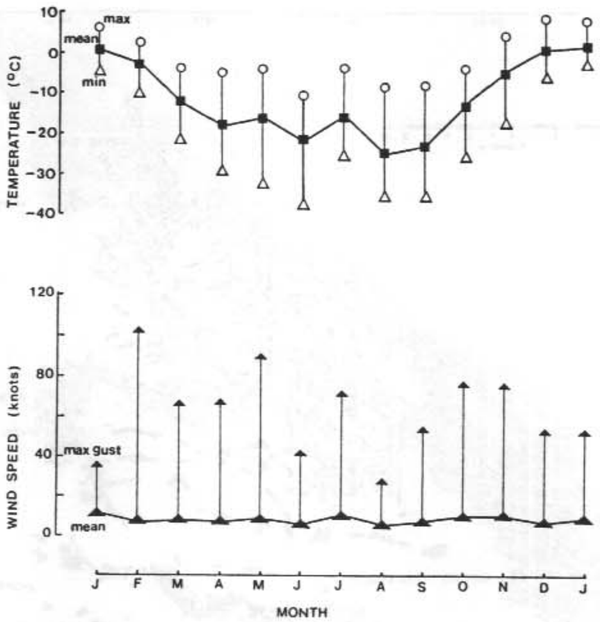

Figure 3. The climate at Davis, January 1982 to January 1983. For each month, mean, maximum and minimum temperatures (upper graph) and mean wind speed and maximum gust (lower graph) are recorded.

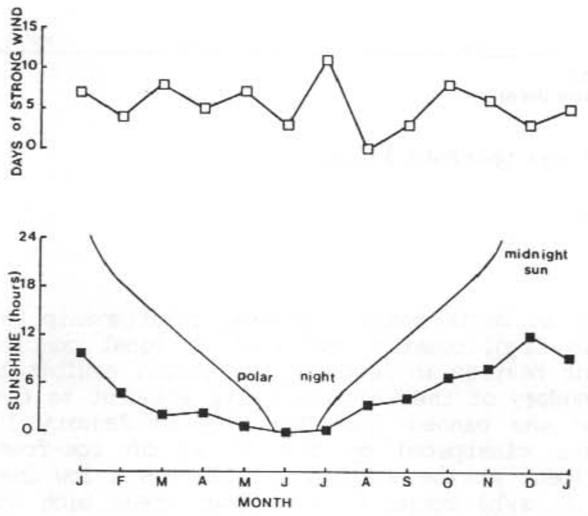

Figure 4. The climate at Davis, January 1982 to January 1983, showing for each month, the number of days of winds greater than 22 knots (upper graph). Sunshine means were taken from continuous recordings of sunshine as compared with maximum duration.

were collected by expedition members from the Australian Bureau of Meteorology.

The 1982 annual mean temperature was -12.5°C with a maximum of +8.2°C in December and a minimum of -38.1°C in June. The annual mean windspeed was 15.8 km/h (8.5 knots) with sixty-six days of strong winds (greater than 22 knots) and thirty-four days of gale winds (greater than 34 knots). The maximum gust was 189 km/h (102 knots) in February. Precipitation as snow was recorded on 148 days.

Figure 4 shows the mean monthly sunshine for 1982, together with the theoretical maximum in the absence of cloud. Mean annual hours of sunshine were 4.5, with a range of 0 (June) to 12 (December).

Mellor (1960) and McLeod (1967) published reports on the annual sea-ice regime in the Davis area. In 1982, formation of sea-ice commenced on 2 March. During winter, breakouts to the foot of the Sørsdal Glacier occurred on at least two occasions following blizzards. From late November, progressive breakouts towards the Davis coast took place but fast-ice remained in Davis harbour until 8 January 1983. Fast-ice remained in the fjords throughout the 1982 expedition year.

Figure 10, Section 8, shows the monthly sea-ice thickness and water temperature (range -2.0°C to -0.7°C) at a site 1.5 km from the shore.

Indoor thermal environment

The majority of the station buildings were heated when in use to suit personal comfort, the main exception being the various stores. Heating the powerhouse during construction was a particular problem. The internal fit-out was carried out during winter months. Electric heaters and a kerosene burning fan heater were used. However, due to the very large internal volume of the building and the fact the kerosene heater could only be used intermittently due to a potential build-up of carbon monoxide, the ambient room temperature was generally below 10°C.

Exposure climate

The design and geographic layout of the station (Section 2.2), the work programs (Section 4.2), and the amount of time spent in the field (Section 4.2.4) ensured expeditioners spent long periods of time outside heated buildings and were subjected to considerable cold exposure. As there was no regular pattern to each man's cold exposure, it was considered not feasible to document the degree of exposure of the group. Due to the nature of their work some subjects, e.g. biologists and construction workers, were more regularly exposed than others. Participation in field activities subjected expeditioners to cold exposure in larger 'blocks' of time. Time spent in the field over the year varied considerably between subjects.

The author spent a total of forty-six nights in the field. Day trips of three to six hours were made on a further sixty-five days.

It is concluded that the expedition to Davis in 1982 was no less cold exposed than other ANARE groups.

2.2 DAVIS STATION

The station is built on frozen morraine deposits close to the seashore. There is currently an extensive rebuilding program, both for the replacement of ageing existing facilities and the creation of new. The design features of Australian Antarctic buildings have been outlined by Gosbell and Holmes (1982). The minimisation of fire risk and control of fire spread is an important consideration. Buildings are therefore erected as separate entities with often considerable distances between them. In winter the old building line including the sleeping quarters, becomes buried in a huge snow drift. New buildings completed in 1982 were the living quarters, kitchen, dining area, recreation area, library, theatrette, trades workshops, water services building and tarn pumping building. During 1982 a new powerhouse was the major construction task and was commissioned in January 1983.

2.3 STATION FACILITIES

Each expeditioner had his own small room. Electricity (240 volts) was generated twenty-four hours a day. There was an extensive range of scientific and meteorological equipment and the trade workshops were well equipped. Plant ranged from large bulldozers and cranes to compressors and generators. Mechanised transport consisted of two trucks and three four-wheel drive vehicles for use within the station precincts. Six motorised toboggans (skidoos) were used for over-snow and over ice transport.

Radio communications with Australia were maintained on a daily basis, except for occasional periods of radio blackout due to ionospheric disturbance. A twice daily radio telephone service for private calls was available. Regular radio contact with field parties was also maintained.

A wide range of foods with a variety and nutritional balance similar to that available in Australia was provided and a twelve month reserve of food held in case of failure of resupply and relief in adverse seasons.

Water was obtained by melting snow, supplemented for three months in summer by pumping from a nearby tarn. At that time the practice was for kitchen and general solid waste to be dumped in a depression 0.5 km from the station and periodically burnt. Liquid waste drained directly onto the ground adjacent to the sea while faecal matter was incinerated in gas fired toilets.

Medical facilities were provided to treat any potential medical or surgical condition, with the exception of chemotherapy and radiotherapy of neoplastic disorders. Australian medical services in Antarctica have been discussed by Lugg (1982).

Recreational activities are essential in breaking the monotony of station life and improving morale. A large variety of indoor activities were provided, including games, television videotapes, 16 mm films and a library. Photography, including film processing and printing, was universally popular. A number of outdoor activities were also popular, particularly walking. A small gymnasium was improvised. Social functions including parties, dinners, a concert and novelty events were held.

2.4 FIELD HUTS AND EQUIPMENT

There were four huts and three tent depots at various locations throughout the Vestfold Hills (Figure 2). These facilities were mainly used for overnight stays and were equipped with kerosene stoves, cooking utensils and food stocks. A wide range of tents, sledges, snow and ice equipment and rescue gear was kept on the station.

The commonest mode of travel was on foot. For part of the 1981-82 summer, helicopters were available for some field trips. From April to October motorised toboggans (skidoos) were used for many trips. Approximately 11 000 km were travelled by the six skidoos. Two manhaul trips involving three men each were made of eleven and five days duration.

In summer in the absence of sea-ice, two fibreglass boats, a rubber inflatable dinghy and Army amphibious craft (Larcs) were also used.

3. PERSONNEL

3.1 SELECTION

The recruitment of potential expeditioners is an elaborate process commencing nine to twelve months prior to departure for Antarctica. The selection process is based upon formal written application in response to national newspaper advertisements, references, personal interview, medical assessment and psychological adaptability testing. Occupational suitability is of prime importance. Many positions may be highly specialised but also require general skills and the ability to solve problems in isolation. Personal qualities and character, with the ability to fit in with a small isolated group are further important aspects.

Medical standards for expeditions have been discussed by Lugg (1982) and Bachelard (1982). Assessment for ANARE consists of detailed history, physical examination, chest X-ray, electrocardiography, haematological examination, blood group and serology for sexually transmitted disease, and hepatitis B. Expeditioners are required to supply a certificate of dental health prior to departure for Antarctica.

Psychological suitability screening tests are conducted by the Australian Army Psychological Research Unit. This is a difficult area of selection (Lugg and Gormly 1982). Similar problems have been noted by the French in their Antarctic selection procedures due in part to inability to determine the probable dynamics of the group in isolation (Rivolier 1982).

3.2 PHYSICAL CHARACTERISTICS

The group consisted of twenty-six males. Twenty-four of the subjects were Australian citizens (one of whom was of Melanesian extraction) and two were foreign nationals (Chinese and Russian). Three of the Australians and the Russian had previously wintered in Antarctica.

The physical characteristics of subjects are listed in Appendix II.

The mean age at mid-year (30 June 1982) was 30.5 years with a range of 23 to 42 years and a standard deviation of 5.9 years. Height ranged from 170 cm to 196 cm with a mean of 179.4 cm and a standard deviation of 5.9 cm. The mean weight was 78.33 kg with a range of 65.6 kg to 106.75 kg and a standard deviation of 8.48 kg.

3.3 TRAINING

All except the foreign expeditioners received a period of three to four months pre-departure training consisting of a basic component involving safety, fire and accident prevention, search and rescue techniques, field and station procedures and a week of practical training in the field (Tasmanian highlands).

Individuals also undertook specialised training in specific tasks associated with, or in addition to their primary occupational position e.g. leadership, management, fire officer's duties, refrigeration, crane operation, power generation, diving, diving medicine, dentistry, explosives, photography, breadmaking and pastry cooking.

3.4 CLOTHING

Man's ability to survive in Antarctica is dependent on efficient clothing. The features of polar clothing have been described by Law (1965). It needs to be warm and windproof but also to have provision for ventilation and ease of removal to prevent overheating and sweating when working.

Clothing utilised by Australian expeditions has been described by Linton-Smith (1968). Table 1 lists the clothing issue. Expeditioners were expected to provide their own casual and underclothing. Casual light clothing was worn indoors. Such clothing was often worn commuting between buildings and for brief tasks outside.

While thermal comfort was generally satisfactory, all personnel experienced periods of considerable cold discomfort, particularly in the field and in adverse weather conditions. Heat discomfort was also experienced. Budd et al. (1969), in a survey of 101 men working outdoors in the Antarctic and subantarctic, found heat discomfort of the trunk equally as common as cold discomfort.

3.5 TRANSPORTATION

Transportation to and from Antarctica was by ice-strengthened ships. The sea voyages were of two to three weeks duration, depending on the itinerary and pack-ice conditions. The nature of the ship voyages meant a period of forced inactivity which on arrival at the station contrasted with long and strenuous work unloading cargo.

FULL 'WINTER' ASSEMBLY	ADDITIONAL ITEMS*
Parka, windproof (yellow ventile)	Caribou boots and liners
Trousers, windproof (yellow ventile)	Workman's boots
Sweater, rollneck	Overalls
Cap, balaclava	Working mitts, leather
Cap, sheepskin	'Housewife' repair kit
Shirt woollen	Kit bags
Singlet, long sleeve, cellular	
Trousers, woollen	
Underpants, long leg, cellular	
Socks, woollen, Australian Army	
Socks woollen, Norwegian long	
Boots, mukluks and inner soles	
Liners, mukluk, woollen	
Gloves, woollen	
Mitts, woollen	
Sledging mittens	
Sun goggles	

*Expeditioners supply their own 'non-specialised' items, the use of which is common to any region.

Table 1. ANARE clothing issue, Davis 1982.

Occupational category	No. of expeditioners
Construction tradesmen	7
Maintenance tradesmen	5
Scientific personnel	5
Meteorological personnel	3
Radio staff	3
Others (Officer-in-Charge, cook, medical officer)	3
Total	26

Table 2. Simplified occupational classification of wintering expeditioners at Davis in 1982.

Year	Mawson	Davis	Wilkes/Casey	Total
1963	26	9	23	58
-				
1977	26	14	23	63
1978	26	14	24	64
1979	30	15	24	69
1980	31	21	25	77
1981	32	25	28	85
1982	33	26	34	93

Table 3. Number of wintering expeditioners at continental ANARE stations for 1963 and 1977-82.

4. OCCUPATIONAL FACTORS

4.1 OCCUPATIONS

Occupational classification of the expeditioners at Davis in 1982 using the International Standard Classification of Occupations (International Labour Office 1968) is given in Appendix III. A simplified descriptive classification is given in Table 2.

Expeditioners had other official duties (e.g. the author was Second-in-Charge (shared), messing officer (shared), field equipment and huts officer and sea-ice observer) and spent considerable time assisting others. Thus most of the non-tradesmen were actively involved in assisting the tradesmen in their work while everyone helped with scientific and/or meteorological projects, which often entailed field trips.

General station duties including cleaning of communal areas, kitchen hand, relief cook, waste disposal and clearing of drift snow from building accesses were also shared.

Appendix IV tabulates the number of 'wintering' expeditioners at all ANARE stations in the period 1948-82. Table 3 shows the continental stations for 1963 and 1977-82 only.

Lugg (1977) published details of the occupational composition of the nine expeditioners wintering at Davis in 1963. There were no officially appointed tradesmen. The Officer-in-Charge was responsible for power generation and maintenance, aided primarily by the cook. Four of the nine were weather observers.

The total number of wintering expeditioners in 1963 at the three continental stations was fifty-eight. Fourteen years later, in 1977, the total was sixty-three, an increase of only five. In the five subsequent years there was a significant annual increase, with ninety-three persons wintering in 1982 (an increase of 148% on the 1977 total). The increase at Davis is the largest (fourteen in 1977 and twenty-six in 1982). This build-up of personnel coincides with the commencement of the station reconstruction program in 1978. The increase is in the trade occupations.

4.2 WORK PROGRAMS

A summary of the major work tasks for the 1982 expedition to Davis, based on the report of the Officer-in-Charge (Beinssen 1983), follows:

4.2.1 Construction

A new powerhouse was constructed and commissioned (Plate 2). Site services (Plate 3) supplying electricity, water (potable, fire-fighting and heating) and communication cables were completed to all new buildings.

Six kilometres of roadworks (including two bridges) were undertaken and a rockfill wharf was built.

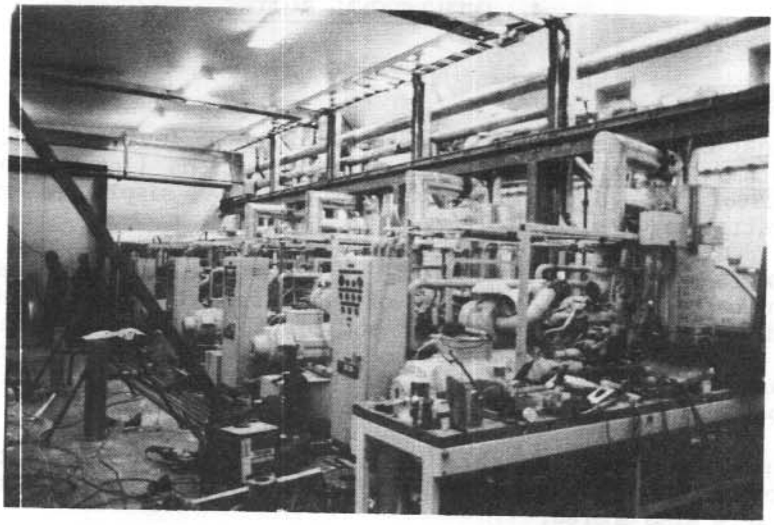

Plate 2. Inside the powerhouse (under construction) showing the four generator sets. The control room is out of the picture to the left. (Photograph by A.F. Dick)

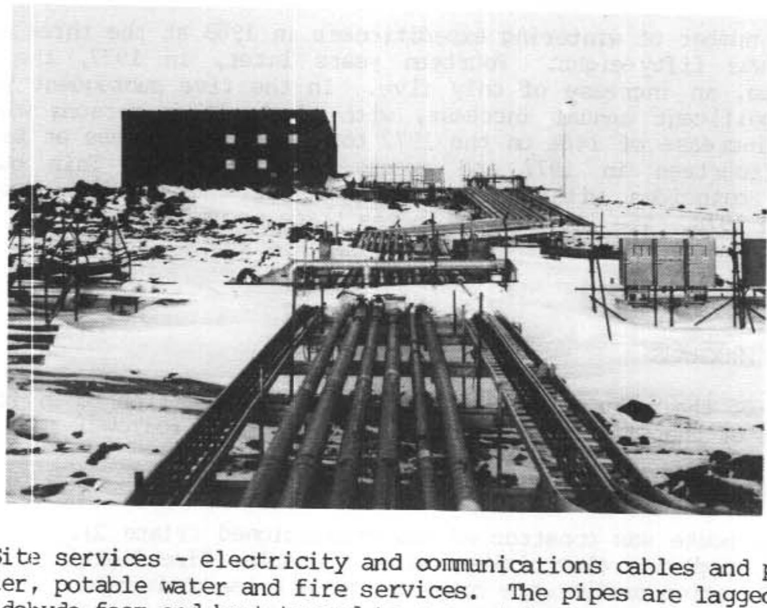

Plate 3. Site services - electricity and communications cables and pipes for heating water, potable water and fire services. The pipes are lagged with urea formaldehyde foam and heat-traced to prevent freezing, and are off-set to prevent breakage due to cold contraction. To the right is an electrical ring-main unit. (Antarctic Division photograph by P. Sullivan)

4.2.2 Maintenance

Maintenance work included the placement and fitting out of sleeping, ablution and laboratory units; reconstruction of the balloon shed and hydrogen production unit and the refurbishing of several other buildings. Two new radio masts were erected.

4.2.3 Scientific

Two physicists studied upper atmospheric phenomena. The three biologists were mainly concerned with marine studies using a variety of sampling techniques including diving. Meteorological work consisted of routine weather observations during the year, a study of the local climate during winter and manning field weather stations. Other scientific programs included regular sea-ice recordings, measurement of ground mattrix pegs, medical investigations and seal tagging.

4.2.4 Station administration

Service based work tasks included radio operations, cooking, administration, medical care, unloading, transportation and storage of goods, cleaning and waste disposal.

4.2.5 Field activities

Activities necessitating field trips were: scientific programs, the construction of a new field hut, maintenance of existing huts, hut and depot resupply, a search for a proclamation cairn and recreation.

A total of 968 man-nights were spent in the field, averaging 37.2 nights for each man. The trips took place throughout the year but were less frequent during June and July.

Trips involving part of the day only were frequently made and no permanent record was kept of these. Except during the mid-winter period, between two and eight men would spend part of the day off the station.

4.3 THE HAZARDS OF WORKING IN ANTARCTICA

4.3.1 Introduction

The climatic hazard of Antarctica is universally recognised. However, in terms of morbidity on modern Antarctic stations, it is secondary in importance to the hazards associated with specific occupations and activities. This section examines in general terms the hazards of working at Davis in 1982.

4.3.2 Antarctic physical environment and field activities

While low temperatures are a significant hazard, wind is a major compounding factor as convection is the most important single route of heat loss under cold conditions (National Institute for Occupational Safety and Health 1973). The cooling effect of wind coupled with temperature is given by the 'wind-chill factor' (Siple and Passel 1945) in terms of an equivalent still air temperature. Cold and wet is another dangerous combination resulting in rapid heat loss. This can occur as a result of immersion in the sea, fjords or lakes or from sweat produced by overheating due to heavy work in excessive clothing.

Trips into the field represent the most significant continuous exposure to the hazards of the physical environment. In 1982 two expeditioners became lost while travelling to a hut on foot and spent a night in the open with temperatures below -30°C with only a sleeping and bivvy bag each. The result was exhaustion and one case of local cold injury to the hand. Despite the extreme hazard of cold, it directly accounts for only a small portion of the cases in Antarctica. On Australian stations in the period 1947-72 it caused about 2% of cases, with an incidence of 81.3 per thousand population (Lugg 1977). Two deaths have resulted from exposure on ANARE.

In addition to the direct effects of cold, such as generalised hypothermia and local cold injury, indirect effects are also important. These include frozen and slippery surfaces; cold hands causing a loss of manual dexterity, strength and tactile sensitivity (Hayduk 1980); and clumsiness as a result of heavy clothing, particularly hand protection (mitts and gloves).

Other hazards exist in the field, particularly in huts and tents with the use of fuel-burning apparatus for cooking, lighting and heating. Fire can result in loss of shelter. Carbon monoxide poisoning has been reported on many expeditions (Byrd 1938, Goldsmith 1959, Pugh 1959, Taylor 1960 and Lugg 1977). High levels of carbon monoxide were detected (using spot detectors manufactured by Medical Safe-T, Inc, Torrington, Connecticut) in huts when adequate ventilation was not maintained. One case of mild carbon monoxide poisoning was recorded. Decreasing oxygen levels were also noted in the huts, as evidenced by reduced flame and light in apparatus. It can be assumed that the decreasing oxygen level closely correlated with increasingly toxic levels of carbon monoxide and carbon dioxide.

Immersion is a hazard, particularly in the period December through to April, when field activities are at their peak and open water or unstable ice are present and boating activities are often undertaken. The very low freezing point of the hypersaline lakes makes these hazardous at all times of the year. Hypothermia, both in the water and subsequently out of the water awaiting rescue, is a major consequence of immersion. It is well recognised that most cold water drownings are, in fact, deaths from hypothermia. Three 'drownings' have occurred on ANARE.

4.3.3 Fire

Fire is potentially a most dangerous hazard, not only for the acute risk of burns but also for the loss of shelter and provisions in an adverse environment without the immediate possibility of relief. Eight lives were lost in one fire at Mirny in 1960. On Australian stations, fires have resulted in the loss of two powerhouses and two scientific buildings while smaller fires have caused much minor damage (Antarctic Division 1980).

At Davis in 1982 two serious gas explosions occurred (Plates 4 and 5). In addition there were minor fires when exposed polystyrene foam was ignited by welding sparks and when fuel on an outboard motor being tested ignited (Adolph 1983).

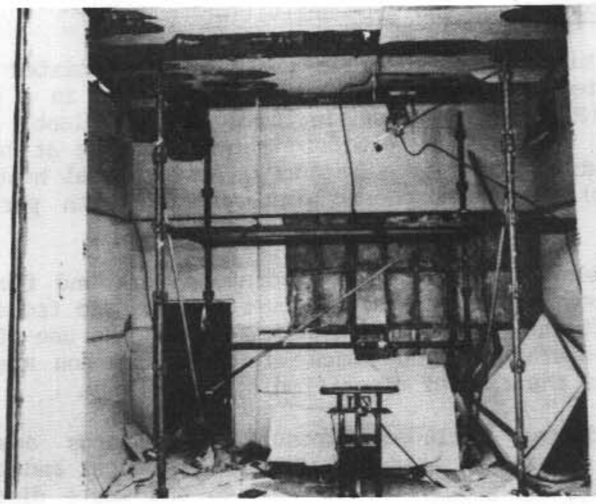

Plate 4. Balloon shed including centrally located gas filling pedestal following hydrogen explosion. The building was being refurbished at the time; hence the presence of the scaffolding which caused rupture of the balloon and explosion triggered by static electricity. One man was burnt. (Antarctic Division photograph by J. Adolph)

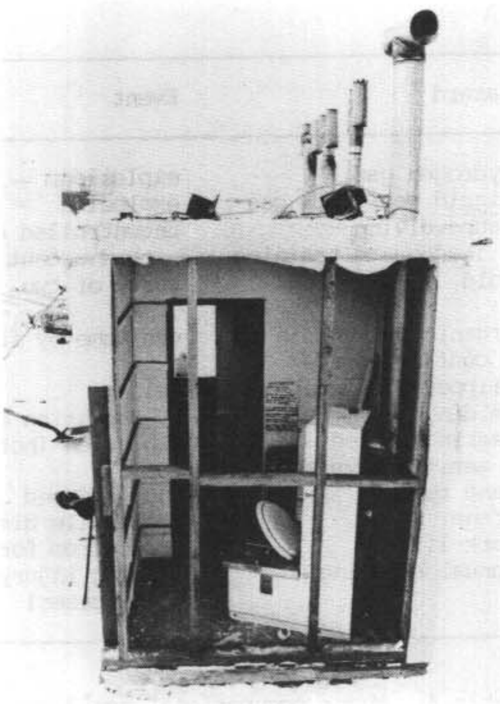

Plate 5. The latrine after LPG explosion. The maintenance electrician was undertaking repairs at the time and suffered burns. (Antarctic Division photograph by J. Adolph)

4.3.4 Hazards of occupations and work activities

The diverse activities of personnel in the trades associated with building construction, maintenance and mechanical work resulted in a wide range of hazard exposures (Plate 6). These included use of plant, equipment and rotary/hand tools; the risk of electric shock; working at height; use of explosive, inflammable and toxic substances; noise; local heat; ultraviolet radiation (welding); and atmospheric contaminants, both particulates and gases/vapours.

Scientific personnel were engaged in laboratory work and field activities including diving, boating and travelling over sea-ice and frozen lakes. For meteorological staff the most significant hazard was the use of hydrogen gas (Plate 4). Radio-operators spent much of their time on morse and telex duties which carries the risk of repetition strain injury.

General station duties included exposure to hazards associated with unloading of ships (Plate 7); transportation of personnel and goods on land, sea and air; storing of goods; cooking duties and waste disposal. It is notable that the maximum period of unloading activity occurs at the start of the expedition year when personnel are least fit (Section 7). In addition the expeditioners have no special skills in this type of work.

4.3.5 Major occupational accidents at Davis, 1982

Table 4 lists the major occupational accidents. Some were potentially very serious but, mainly due to chance, the injuries suffered were not severe.

Hazard	Event	Result
Hydrogen gas	explosion	burns
Liquid petroleum gas	explosion	burns
Scuba diving - inadequate training	uncontrolled descent, then ascent	bilateral aural barotrauma
Cold	party of two lost in field	impending hypothermia, local cold injury
Organic solvent in confined space	overcome by fumes	near collapse
Slippery surface	fall	dislocation of finger
Welding	UV radiation exposure	burns
Heating sealed aerated beverage	explosion (bottles)	lacerations
Hand tool	tool slipped	lacerations
Crane	fall while dismounting	torn ankle ligaments
Fork-lift	crush from forks	contusion, foot
Manual handling	lifting injury (x3 cases)	lumbar back strain (x3)

Table 4. Major occupational accidents, Davis 1982.

Plate 6. The plumbers' workshop including tools, a metal press, guillotine and oxy-acetylene welding gear. (Antarctic Division photograph by P. Sullivan)

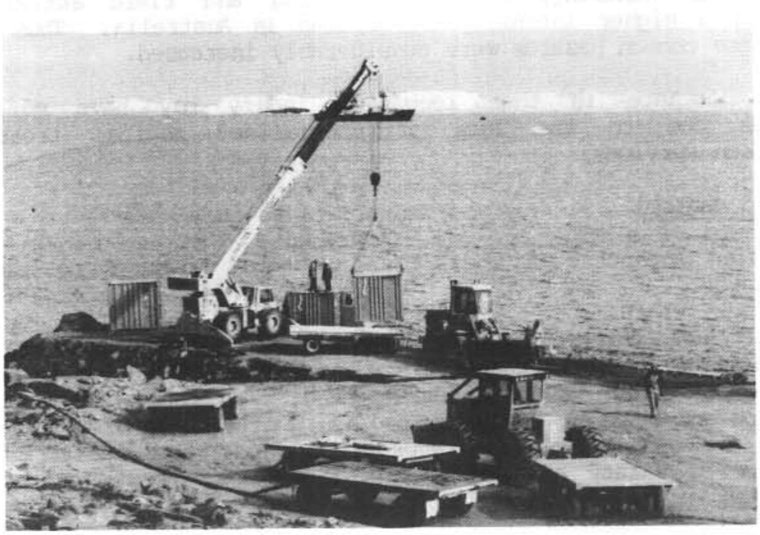

Plate 7. Unloading. Cranes, heavy vehicles and trailers are used to transfer containerised cargo on-shore. The floating hose (upper left) is pumping fuel ashore. Freeing the hose from drifting pack-ice was a particular hazard in the summer of 1982, requiring personnel to work from small boats, LARCS (right of ship) and on ice floes. (Antarctic Division photograph by R. Reeves)

Of the fifteen cases reported in the Table, three were directly attributable to the Antarctic environment; two expeditioners became lost in the field and one expeditioner fell after slipping on an icy surface. Eleven were associated primarily with an occupational task, the environment having no apparent influence. However, in more than half of these cases, the tasks were being performed by expeditioners not fully experienced in the work or the hazards associated with it. This remains a problem on Antarctic stations where a great variety of tasks have to be performed by a relatively small group, and where persons are working in tasks outside their area of expertise. This is further discussed in Section 4.3.7.

4.3.6 Comparison with Australia

No hazard is unique to Antarctica. Cold, while obvious in Antarctica, is also present to a lesser degree in temperate climates and the risk of cold injury needs to be recognised, particularly in outdoor activities. The lessons of Antarctica need to be applied in such situations (Lugg and Gormly 1982).

Fire can occur anywhere but there is an increased risk in Antarctica due to the dry atmosphere and the difficulty of extinguishing fires with limited supplies of water in an adverse climate.

The hazards of the specific occupations at Davis in 1982 were generally similar to those in Australia. However, compounding factors increased the risk. The factors included tasks being performed by inexperienced and unfit persons, and clumsiness due to cold and/or clothing (particularly mitts and gloves). Goods handling, cooking, cleaning and field activities were performed at a higher intensity level than in Australia. Thus the risks posed by these common hazards were considerably increased.

Also of importance is that resultant injury may have more serious consequences due to the lack of specialised medical treatment and rehabilitation services.

4.3.7 Hazard control

The Australian Antarctic Division has instituted measures to minimise the risk of hazards:

(a) Antarctic environmental hazard: written policies and procedures (ANARE Field Manual); pre-departure training; personal protection (clothing);
(b) fire: engineering design (separation of buildings); fire prevention, detection and fighting programs; provision of reserve of supplies, and
(c) hazards of occupations and work activities: pre-departure training; provision of safety and personal protective equipment (safety goggles, ear muffs, welding aprons).

The list of major occupational accidents at Davis in 1982 emphasises the importance of expanding pre-departure training, including instruction for all occupational groups in tasks associated with general duties and shared work. Training in occupational safety and accident prevention needs to be expanded. One member of the expedition should be officially appointed safety officer and receive pre-departure training in this discipline, especially the identification and control of hazards.

5. HEALTH OF THE EXPEDITION

5.1 INTRODUCTION

This study of health and morbidity in the 1982 Davis group is based on records obtained during medical consultations. Not included in the records are:

(a) self-treated minor ailments; simple analgesics, dressing and first aid materials were available at a number of work-sites and at the field huts and depots for use by expeditioners without reference to the medical officer;
(b) counselling sessions not involving psychopathology classifiable using the World Health Classification discussed below; many of these were casual or social encounters; and
(c) follow-up consultations consisting solely of an oral inquiry on resolution of illness without physical examination.

5.2 METHODS

All of the twenty-six wintering expeditioners took part in the study. The subject identification A-Z is specific to this study to maintain anonymity. As discussed in Section 3.1, subjects had been medically examined prior to appointment and had passed psychological aptitude tests.

Consultations were conducted in the station medical facility and details of clinical findings were recorded in a log maintained for this purpose. Cases occurring when the medical officer was in the field were assessed on his return.

Diseases and injuries were classified using the Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death (Ninth Revision) World Health Organisation 1977. Consultations consisting of a review of a condition were considered separately.

The results are expressed as percentages of total cases to allow comparison with other studies and because of the small number of expeditioners involved. In the study of occupational and subject variables (5.3.8 and 5.3.9) expedition incidence rates (cases per man for the expedition year) have been calculated to allow subgroup comparisons and as a pilot for future studies.

5.3 RESULTS AND DISCUSSION

5.3.1 General

A total of 161 cases were recorded with a further thirty-five consultations consisting of reviews of cases. Classification of cases and their occurrence are recorded in Appendix V. Table 5 summarises the data, showing the percentage of the total in each category. No cases were recorded in Categories II, III, IV, VII, XI, XIV and XV. Also shown in the Table are the percentages for the Davis 1963 expedition and ANARE 1947-72.

The average rate of 6.2 cases per man is slightly less than the ANARE 1947-72 average (seven cases per winter expeditioner). However, Lugg's

Category		Percentage of total cases		
		Davis 1982 (this study)	Davis 1963	ANARE 1947-72 (Lugg 1977)
I	Infectious, Parasitic Diseases	14.4		2.4
II	Neoplasms	–	–	0.5
III	Diseases, Endocr/Nutr/Metabol/Immun	–	–	0.6
IV	Diseases, Blood/Blood-forming Organs	–	–	0.1
V	Mental Disorders	5.0	1.0	1.8
VI	Diseases, Nervous Syst/Sense Organs	3.5	–	4.9
VII	Diseases, Circulatory System	–	4.0	1.7
VIII	Diseases, Respiratory System	3.5	6.0	5.4
IX	Diseases, Digestive Syst - Dental	13.0	12.0	8.8
	- Others	2.5	4.0	3.0
X	Diseases, Genitourinary System	0.5	–	0.6
XII	Diseases, Skin/Subcutaneous Tissue	7.0	8.0	9.8
XIII	Diseases, Musculoskel/Connect Tissue	2.5	4.0	3.9
XVI	Symptoms/Signs/Ill-defined	2.5	23.0	18.9
XVII	Injury/Poisoning	45.5	28.0	37.7
Total Cases		161.0	141.0	7248.0
No. persons (W=winterers, S=summerers)		26W	9W	1094S 1088W

Notes:
1. Classification is the Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, Ninth Revision, 1977, WHO.
2. Lugg's percentage figures are adjusted to conform with the Ninth Revision.
3. No cases were recorded in Categories XI, XIV and XV.

Table 5. Comparison of morbidity statistics for Davis 1982, Davis 1963 and ANARE 1947-72.

series included cases occurring in summer personnel while the denominator was the number of winter personnel only.

Comparison with other Antarctic morbidity studies is inexact, due primarily to lack of specificity in previously published works. This deficit includes classification of illnesses and injuries, total number of cases occurring, numbers of personnel involved and the inclusion of short term summer personnel and wintering persons in the same data set. As a result, most publications are largely descriptive (Goldsmith 1959, Tyler 1968, Lloyd 1973, Doury and Pattin 1973) or express illnesses and injury categories as a percentage of total cases (Hedblom 1961, Matusov 1971 and 1977, Lugg 1973 and 1977, Lugg and Gormly 1982). In some series dental cases are excluded from the medical survey total (Hedblom 1961, Lloyd 1973).

Classification of illnesses and injuries has been confusing in the past and a uniform classification needs to be adopted to make meaningful comparisons. The International Statistical Classification of Diseases, Injuries and Causes of Death is one such classification, and was used by Lugg (1973, 1977). Lugg used the Seventh Revision. His results have been adjusted to allow comparison with the Ninth Revision used in this study. He provides sufficient information so that any error in reclassification would be small (the expressed percentages would be within ± 1). Another suitable classification is that of the World Organisation of National Colleges and Academies of General Practice (WONCA) (1979).

Annual incidence rates for morbidity are lacking in previous studies. The combination of summer and winter personnel, together with their variable turnover leads to complexity in calculating annual rates. The small numbers making up the expeditions is another reason advanced (Lugg 1977, p. 135). However, when data from several years and/or stations are combined, the resulting numbers may warrant the calculation of incidence rates as a more meaningful measure of morbidity than percentage of total cases. For example, Lloyd (1973) examined data from 850 wintering personnel over 10 years at seven British bases; Norman (1982) looked at the records of 575 men at Halley Bay over 25 years and Lugg's review (1973, 1977) involved 1402 wintering positions and 1094 summer and short term personnel at ANARE stations during 1947-72.

5.3.2 Injury and poisoning (Category XVII)

This category accounted for 45.3% of the total cases. Results from other studies also show this to be the most common category. The findings from this study and other published results are summarised in Table 6. The result at Davis in 1982 is similar to the findings of other Australian studies.

Study	Injuries/Poisonings (% of total cases)
Davis, 1982 (this study)	45
Davis, 1963 (Lugg 1977)	38
ANARE 1947-72 (Lugg 1973, 1977)	38
ANARE 1978-79 to 1979-80 (Lugg and Gormly 1982)	56
US Navy 1955-60 (Hedblom 1961)	29
British Antarctic Survey 1961-70 (Lloyd 1973)	>50
Soviet expeditions 1955-66 (Matusov 1971)	25
Soviet expeditions 1964-73 (Matusov 1977)	21

Table 6. Comparison of the occurrence of injuries and poisonings in eight studies.

The occurrence of injuries directly attributable to cold has been reported as very low and mainly of a minor nature (Goldsmith 1959, Tyler 1968, Doury and Pattin 1973). On ANARE in the period 1947-72, cold injury made up only about 2% of the total cases (Lugg 1977) while the result for the cycle 1978-79 to 1979-80 was 2.5% (Lugg and Gormly 1982). The result is this study of 2% (three cases of minor frostbite) is therefore consistent with previous findings. Minor degrees of frostnip are generally regarded as 'normal' by Antarctic personnel and are not included in the morbidity statistics by most authors.

In the group at Davis in 1982, sprains accounted for 22% of cases in this category, wounds 14%, contusions and crush injuries 21%, burns 12% and poisonings 5%.

Burns (nine cases) made up 5.6% of total cases in this study. The more serious cases resulted from two gas explosions (hydrogen and liquid petroleum gas) and ultraviolet radiation from welding. Minor burns were sustained while cooking.

Two cases of nitroglycerine poisoning resulted from the handling of sticks of explosives and a further poisoning resulted from working in a confined space (water tank) with a silicone 'filler' containing a chlorinated hydrocarbon solvent. One case of mild carbon monoxide poisoning occurred in a field hut where kerosene burning equipment was used. Carbon monoxide poisoning must be regarded as a significant hazard on Antarctic expeditions and a large number of studies report cases (Byrd 1929, Goldsmith 1959, Pugh 1959, Taylor 1960, Doury and Pattin 1973, Lloyd 1973, Lugg 1977).

5.3.3 Infectious and parasitic diseases

This category represented 14.3% of the total cases in 1982, with 57% of these being skin and nail infections. A further 30% were streptococcal throat infections in two subjects who appeared to be carriers of the condition.

The presumed causative organisms of the infections were: warts viruses 35%, streptococci 30%, herpes simplex 13%, dermatophytes 13% and chlamydia (or other agent responsible for non-specific urethritis) 9%.

The figure of 14.3% is higher than the long term ANARE 1947-72 Category I (adjusted) result of 2.4% and the Davis 1963 group result of 0%. The higher occurrence is due to the chance selection of personnel with infections pre-existing prior to coming to Antarctica.

Infections of the respiratory system, sensory organs, digestive and genito-urinary systems and some skin and subcutaneous infections are classified based on the anatomical organ system and accounted for 4.5% of total cases (dental conditions excluded).

Comparison with other national reports is inexact due to lack of specific statistics. Tyler (1968), reporting on United States personnel (primarily summerers), noted that upper respiratory tract infections were the most common complaint. The French (Doury and Pattin 1973) found infectious disease to be rare. Matusov (1977), commenting on Soviet experience from 1964-73, reported that pneumonia accounted for 9.9% of cases; however, large numbers of Soviet personnel spend winter at high altitude, a significant predisposing factor.

5.3.4 Dentistry

The high occurrence of dental problems (13% of total cases) is consistent with other Australian studies. Fletcher (1983), p. 285, noted 'dental problems at Australian Antarctic stations frequently constitute a large proportion of the medical work'. Lugg's survey (1973) of ANARE from 1947-72 found that dentistry represented 8.8% of all cases. Fletcher (1983) postulated that a uniform pre-embarkation dental examination should be undertaken as the current standards seem very variable. The British Antarctic Survey findings support this proposition. In the period 1956-80 at their base at Halley Bay, 224 dental fillings and twenty-three extractions were performed on a total of 575 men. Since 1980, the British Antarctic Survey has demanded very high pre-embarkation standards and a dentist visits the stations in summer. This has resulted in a marked decrease in dental problems (Norman 1982).

Other factors postulated as contributors to dental caries in Antarctica include alterations in oral flora due to cold (Adams and Stanmeyer 1960) and poor oral hygiene and diet (Beynon 1969, Fletcher 1983).

5.3.5 Other medical conditions

Skin conditions (Category XII), consisting of various forms of dermatitis, benign growths and some infections, accounted for 6.8% of cases, compared with the adjusted figure for ANARE 1947-72 of 9.8% (Lugg 1977).

Category XVI (Symptoms, Signs and Ill-defined Conditions) made up only 2.5% of cases. The ANARE 1947-72 result is 18.9% and the Davis 1963 figure is 23% (Lugg 1977). The lower result in this study is due to the non-reporting of many minor symptoms (some self-treatment facilities being available) and the classification of some conditions into specific categories in the Ninth Revision of the Classification.

The percentages in the remaining medical categories were small and similar to the long term ANARE findings.

5.3.6 Mental disorders (Category V)

The percentage of 4.9 in this study is higher than the ANARE 1947-72 result of 1.8%. This is due to differences in classification in the Ninth Revision and four cases of mild reactions to stress and bereavement.

Although gross psychiatric disturbance has been recorded on a number of expeditions, e.g. three suicides on French expeditions - Doury and Pattin (1973), several authors noted that the incidence of serious mental illness on Antarctic stations is very low (Hedblom 1961, Gunderson 1968, Lugg 1982).

5.3.7 Seasonal variation

The number of cases recorded in each category for each month is shown in Appendix VI. Due to the small number of cases, interpretation of the results can only be in the form of general comments.

January 1982 consisted of twenty-two days of observation and January 1983 of fifteen days of observation. The number of cases in all categories combined was greatest in June (nineteen cases) and least in March, April and December.

For Category XVII (Injury and Poisoning), initial high numbers in January and February reflected the high level of activity and the relative inexperience of workers. The numbers were lower in the following six months, probably due to increased experience and some lessening of activities during the colder months although indoor work programs continued. The highest recordings were in September and October when extensive outdoor work resumed after the winter restrictions. This observation was also noted by Lugg (1977).

Infections occurred throughout the year. The role of the mid-winter environment in the five cases in June (three herpetic infections, an acute paronychia and a streptococcal throat infection) is uncertain.

Half of the dental cases occurred in the winter period May to August. Fletcher (1983) suggested that more time spent indoors increases the rate of dental caries.

The numbers in other categories are too small to allow any conclusions to be drawn. Further large scale studies are needed to determine the role of environment factors on the occurrence of disease and injury.

5.3.8 Occupational factors

The classification of the primary occupations of the Davis subjects has been described in Section 4.1 and Appendix III. A comparison between the expedition incidence rates in specified occupational groupings for three morbidity classes is summarised in Table 7. The purpose of the comparison is to determine whether there was a relationship between primary occupation and morbidity. Interpretation of the results needs to consider that the expeditioners had a wide range of other duties and often spent time working in occupational classifications other than their primary designation.

The occupational groups were chosen to combine common occupational factors. All the manual tradesmen spent lengthy periods working outdoors and were exposed to building construction and mechanical hazards. A further grouping combined biologists, whose program involved extensive outside work on a regular basis, with tradesmen. The final group consisted of radio-operators, Officer-in-Charge, medical officer and chef whose primary tasks were service based and indoors.

The morbidity classes were 'Injuries/Poisonings', 'Other Cases' and 'All Cases'. Manual tradesmen had the highest incidence rates in all three morbidity classes, while the combination of biologists and tradesmen produced lesser values, indicating the three biologists effectively lowered the rates in this grouping. The rates in service based personnel were much lower.

The Student's t-test was used to determine whether there was a statistically significant difference in the rates in each morbidity class between the chosen occupational grouping and the remaining personnel on the station. The incidence rates in the service based grouping in the Injuries/Poisonings and All Cases classes were significantly lower ($0.10>p>0.05$). There was no significant difference at the 10% level for all other rates.

The numbers of subjects in these samples are small; further large scale studies are needed to determine the role of occupation in morbidity statistics.

Occupational grouping	Number in group	Incidence (cases/man/expedition year) Injuries/ poisonings	Other cases	All cases
Manual tradesmen	12	3.2	4.1	7.3
Biologists and tradesmen	15	3.0	3.7	6.7
Service-based personnel	5	1.8*	2.6	4.4*
All personnel	26	2.8	3.4	6.2

*significance 0.10>p>0.05.

Table 7. Occupational grouping and morbidity incidence, Davis 1982.

Age group	Number in group	Incidence (cases/man/expedition year) Injuries/ poisonings	Other cases	All cases
<27 years	9	3.0	3.2	6.2
27-34 years	8	2.8	3.5	6.3
>34 years	9	2.7	3.4	6.1
All ages	26	2.8	3.4	6.2

Table 8. Subject age group and morbidity incidence, Davis 1982.

Previous Antarctic experience	Number in group	Incidence (cases/man/expedition year) Injuries/ poisonings	Other cases	All cases
Yes	4	3.3	3.7	7.0
No	22	2.7	3.3	6.0

Table 9. Previous Antarctic experience and morbidity incidence, Davis 1982.

5.3.9 Subject variation

The occurrence of cases in individuals is shown in Appendix VII.

'Subject age' and 'previous Antarctic experience' were examined as these were considered to have a possible effect on ill-health and accidents. Morbidity was divided into Injuries/Poisonings, Other Cases and All Cases.

The effect of age was studied by two methods. The first was by linear regression analysis of age and morbidity class; however, no statistically significant correlation was found. Secondly, the subjects were divided into similar sized sub-groups of <27 years, 27 to 34 years and >34 years and incident rates calculated for each. The results are summarised in Table 8.

For Injuries/Poisonings there was a slight decline in incidence with increasing age group, while Other Cases were least in the youngest age group. These differences were not significant at the 10% level.

Four of the expeditioners had previous Antarctic experience; three wintered on one previous occasion and the fourth on two occasions. Table 9 shows the morbidity experience of this sub-group and that of the remaining expeditioners. The rates in the three morbidity classes were slightly higher in the sub-group with previous Antarctic experience. However, the number in this sub-group does not allow meaningful comparison and large scale studies are needed.

5.3.10 Comparison with morbidity in Australia

The personnel on an Antarctic expedition are carefully selected and no statistics are available from a comparable sample in Australia. The following comments are therefore of a general nature.

The average rate of 6.2 cases per man in the Davis 1982 group would appear higher than that expected in an equivalent sample in Australia. Several explanations are postulated:

(a) the ready availability of a medical officer
(b) the reporting of minor conditions
(c) the inclusion of dental cases in the morbidity statistics (0.9 cases per man) and
(d) a higher rate of accidents as a result of increased risk from hazards.

The estimation of the significance of (d) requires comparison with a matched sample in Australia. Large scale studies are required to determine the increased risks from hazards in Antarctica.

6. MONTHLY PHYSIOLOGICAL MEASUREMENTS

6.1 INTRODUCTION

Body weight, skinfold thickness at two sites, basal heart rate, blood pressure and oral temperature have been measured on ANARE expeditioners for more than twenty years to investigate changes which may represent adaptation to living and working in Antarctica, and seasonal variations. The results have been analysed for two 1963 expeditions - Wilkes (66°15'S,110°31'E) (Hicks 1966) and Davis (Lugg 1977).

6.2 METHODS

Of the twenty-six expeditioners, one foreign national did not arrive on the station until April and elected not to take part in the study. The medical officer performed the measurements and was not included. The remaining twenty-four participated. All but one of the subjects were Australian residents prior to appointment. One subject was Chinese, another was of Melanesian extraction, the remainder were Caucasian. Their physical characteristics are described in Section 3.2 and Appendix II, Subject Numbers 10 and 26 being the two not participating in this study. The mean age of the participating group was 30.1 years at 30 June 1982. Three of the group had previously wintered in Antarctica.

The measurements were performed as near as possible to the twenty-sixth and twenty-seventh day of each month. Due to work programs, especially field activities, some flexibility was necessary; all measurements were made within three days of the 'target' days.

As measurements included basal readings, the subjects reported to the surgery immediately on rising. The indoor climate of the surgery was comfortable for examination (temperature approximately 16°C) and the subjects rested for at least ten minutes before basal readings were taken. The three meteorological staff were so irregular in their working and sleeping hours that basal readings could rarely be obtained and therefore they were excluded from the investigation of basal physiological variables.

Body weight readings were made on a beam balance which was serviced and checked in Australia and brought to the station in December 1981. It was accurate to 10 g.

Skinfold thickness measurements were performed at two sites using Harpenden skinfold calipers and standard techniques, taking the average of three readings (Burkinshaw et al. 1973). The two sites were:

(a) triceps - located on the dorsum of the left upper arm, midway between the olecranon and acromial process, with the skinfold running parallel to the long axis of the upper arm, and
(b) subscapular - 10 mm below the lower edge of the left scapula with the subject standing relaxed and the skinfold parallel to the natural cleavage.

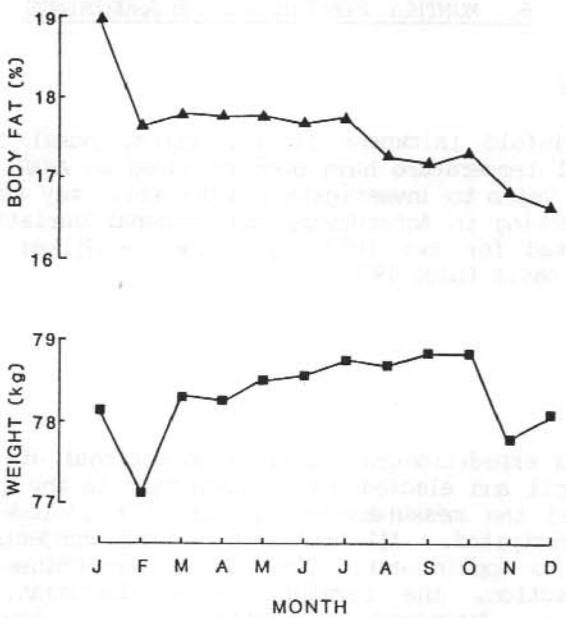

Figure 5. Mean monthly body fat and weight.

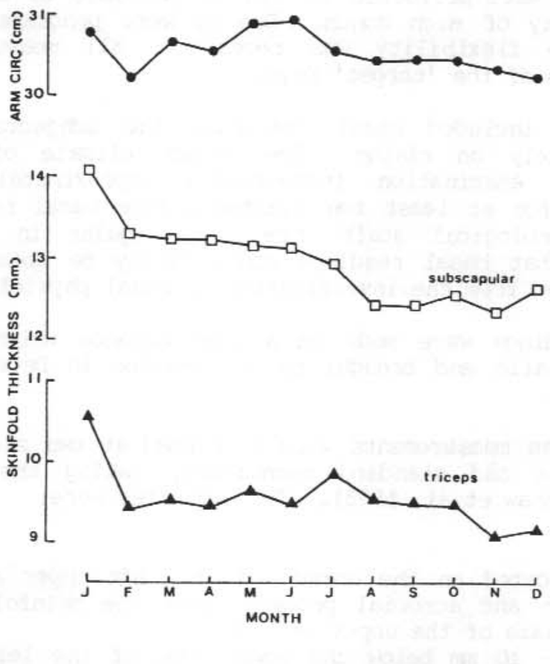

Figure 6. Mean monthly arm circumference and skinfold thickness (triceps and subscapular sites).

Arm circumference was taken using a fibre-glass tape on the relaxed left upper arm, midway between the olecranon and acromial process, and recorded to the nearest 5 mm.

Body fat was derived in two steps:

(a) Body density was calculated using the equations of Durnin and Womersley (1974), viz:

If age is 20-29 years then
density = 1.1525 - 0.0687 x log (skinfolds triceps + subscapular)

If age is 30-39 years then
density = 1.1165 - 0.0484 x log (skinfolds triceps + subscapular)

If age is 40-49 years then
density = 1.1519 - 0.0771 x log (skinfolds triceps + subscapular)

(b) Body fat was calculated from density using the equation of Siri (1956):

$$\% \text{ fat} = \frac{4.95}{\text{density}} - 4.5 \times 100$$

Basal temperature was measured sublingually with standardised clinical thermometers. The recorded temperature was taken when successive readings were the same, taken at an interval of at least one minute.

Basal heart rate was counted for a full minute at the wrist, with the patient seated.

Basal blood pressure was estimated using a mercury sphygmomanometer on the left upper arm, the subject being seated. The reading was recorded to the nearest 5 mm of mercury. Diastolic pressure was taken as the point when cessation of sound occurred.

Analysis of results was performed on the Commonwealth Department of Health IBM 3083/J16 computer, utilising the 'Statistical Package for Social Sciences (SPSSx)' program. The methods were:

(a) analysis of covariance for each physiological variable taken in turn with time (month), allowing for differences between subjects, and
(b) analysis of covariance between pairs of physiological variables, allowing for differences between subjects and from month to month.

Weight, skinfold thickness, arm circumference and percentage body fat results were analysed. Where the analysis included a basal variable, the results of the three meteorological staff were excluded.

There were potentially 288 sets of observations (twenty-four subjects for twelve monthly readings). Nine sets were missing due to late arrival on station, early departure, sickness and absence in the field. Four of the sets were missing from January and December each and one from November.

6.3 RESULTS AND DISCUSSION

The mean monthly values for the nine physiological variables are tabulated in Appendix VIII and graphically represented in Figures 5, 6, 7 and 8. The mean annual values are tabulated in Appendix IX.

6.3.1 Body weight

The mean monthly values of body weight are shown in Figure 5. The mean value decreased by 1.02 kg in February (probably reflecting the loss of excess weight gained during ship travel to Antarctica), showed a slight steady increase until October and fell in November with the December mean having a value 0.02 kg less than the initial January reading.

Body weight has been the most studied physiological variable on Antarctic expeditions. Conflicting results of weight changes have been reported. Increases in weight over a year have been reported by Lewis et al. (1960), Wilson (1960), Milan and Rodahl (1961), Edholm and Goldsmith (1966) and Easty (1967). Little change or a net loss have been recorded by Massey (1956), Goldsmith (1959), Orr (1965), Lugg (1977) and Acheson et al. (1980).

Theories relating to adaptation to the polar environment have been suggested by authors on early expeditions. In more recent times, these theories have been replaced by explanations in terms of energy balance to account for weight changes.

Edholm and Goldsmith (1966), p. 117, concluded 'food intake is not directly influenced by low environmental temperatures'. Orr (1965), p. 87, stated that 'detailed studies of nutritional balance have shown that seasonal fluctuations in body weight are more closely associated with changes in activity than directly with changes in temperature'. Campbell (1981) combined the results of seven published studies to determine the correlation coefficient of energy intake and body weight to be 0.697 ($p<0.001$).

Several authors (Massey 1956, Lugg 1977, Acheson et al. 1980) have suggested variations in weight correspond to levels of activity. In those expeditions where weight changes were minimal or a net loss was recorded, high levels of physical activity were maintained (Goldsmith 1959, Orr 1965, Lugg 1977).

As previously noted, the group at Davis in 1982 remained physically active throughout the year. This is reflected in the small weight changes during the series, and the increase in physical fitness (Section 7). The slight rise from March to October probably represents increased energy intake, while the fall at the end of the year corresponds to an effort by many to lose weight by dietary restriction.

The changes in weight over the year were statistically significant ($p<0.05$).

6.3.2 Skinfold thickness (Figure 6)

The mean skinfold thickness at both sites decreased markedly during the first month. The subscapular readings showed a slow steady decline for the next six months and fluctuated slightly for the remaining period. The triceps readings fluctuated during the year, reaching a peak for the July value. There was an overall decrease over the twelve monthly period at both sites - a 1.37 mm decrease at the subscapular site and 1.31 mm at the triceps site. The changes in skinfold thicknesses were statistically significant (subscapular site $p<0.001$, triceps site $p<0.005$).

Measurements of skinfold thickness on Antarctic expeditions have produced differing results. Massey (1956) and Lewis et al. (1960) noted increases in winter and falls in summer. Hicks (1966) and Lugg (1977) recorded initial rises; in Hick's series decreases were recorded later in the year, while in Lugg's report readings were steady for most of the year with slight rises in the last two months. Orr (1965) noted an initial fall for the first three months and during sledging trips, and rises on return to base. Goldsmith (1959) found no increase occurred in winter. Easty (1967) recorded an increase throughout the year. There is no firm evidence of cold adaptation resulting in increased subcutaneous fat as measured by skinfold thickness. The explanation of Orr (1965), p. 87, that changes are associated with variations in physical activity, would seem most likely.

6.3.3 Body fat

Total body fat correlates with skinfold thickness and can be calculated from such measurements (Durnin and Rahaman 1967). It is a more meaningful physiological variable than skinfold thickness.

The results of the Davis group (Figure 5) showed a marked decline in percentage body fat in the first month, with a slower but steady decline for the remainder of the year. The change was highly significant ($p<0.001$). Acheson et al. (1980) reported little change in body fat over a year in twelve British Antarctic Survey personnel but noted marked individual variation.

Most previous studies in Antarctica have examined skinfold thickness rather than body fat (discussed in 6.3.2).

6.3.4 Correlation between body weight and skinfold thickness/body fat

After allowing for differences between months and subjects, correlation of weight with skinfold thickness (both sites) and weight with body fat, were highly significant ($p<0.001$). This agrees with most previous polar studies, where changes in skinfold thickness have tended to parallel those in body weight (Acheson et al. 1980). These findings suggest that changing body fat is a major contributor to body weight variations in Antarctic expeditions.

Not all reports demonstrate this correlation (Orr 1965, Easty 1967). In Orr's study, a decrease in skinfold thickness occurred in the first three months with little change in body weight, leading Orr to postulate the change was due to development of muscle bulk associated with physical activity.

6.3.5 Arm circumference

Mean monthly readings of arm circumference (Figure 6) showed an initial fall in February, generally rising to a peak in June and thereafter declining. The change-over time was significant ($p<0.05$). However, as the readings were taken to the nearest 5 mm and the range of monthly means was small (302 mm to 309 mm), these changes need to be interpreted with caution.

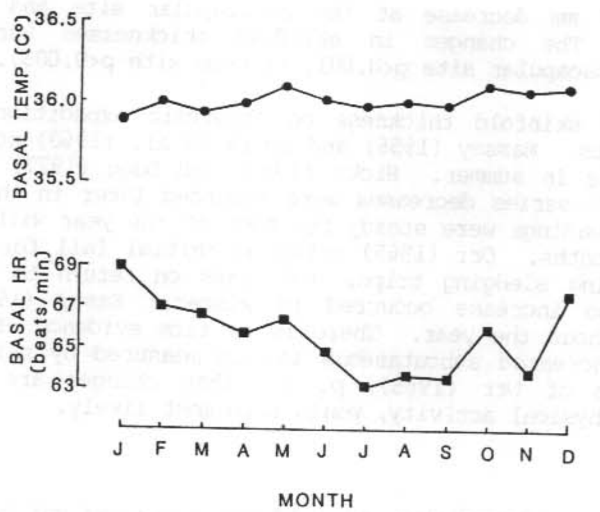

Figure 7. Mean monthly values for basal temperature (oral) and heart rate.

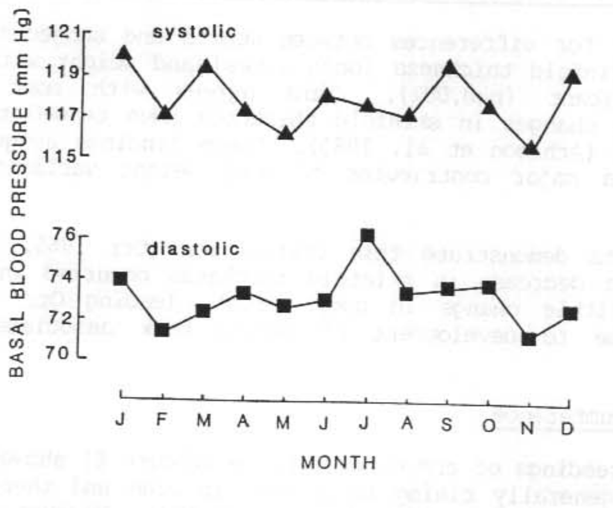

Figure 8. Mean monthly values for basal blood pressure (systolic and diastolic).

6.3.6 Basal temperature

The mean basal oral temperature was 36.0°C with the mean monthly reading varying 0.3°C. Figure 7 illustrates the monthly mean values. The changes in basal temperature were significant ($p<0.05$).

These findings are consistent with the reports of Hicks (1966) and Lugg (1977), with no demonstrable seasonal influence on basal temperature evident.

6.3.7 Basal heart rate (Figure 7)

The mean monthly values for basal heart rate show a steady decline from January to July, except for a slight rise in May. July to September readings were similar, while rises were recorded in October and December and a fall in November. The changes over the series were significant ($p<0.05$).

The results are similar to those of Hicks (1966) and Lugg (1977). Lugg considered the fall in the initial six to eight months represented adaptation to the Antarctic environment, while the changes later in the year were due to emotional causes associated with field work and preparing for return to Australia. Hicks also suggested the rise late in the year to be emotionally induced.

6.3.8 Basal blood pressure

Figure 8 illustrates the mean monthly values for both systolic and diastolic basal blood pressure. Systolic pressure mean values showed no consistent pattern, while diastolic values, after an initial fall, increased during the year with a fall in November. Final readings for both systolic and diastolic pressures were slightly lower than the initial ones. The changes over the series were not significant.

These findings differ from those of previous Australian studies (Hicks 1966, Lugg 1977), but 'no constant pattern has been found for men wintering in Antarctica' (Lugg 1977, p. 53, quoting Ove Wilson).

6.3.9 Correlations between basal blood pressure and other variables

The relationship between systolic and diastolic pressure was significant ($p<0.001$). For systolic blood pressure, significant correlations were obtained with weight ($p<0.05$) and subscapular skinfold thickness ($p<0.05$); insignificant results (at the 5% level) were obtained with body fat and triceps skinfold thickness. For diastolic pressure, significance was obtained with weight, body fat and skinfold measurements at both sites ($p<0.05$ in all cases).

Lugg (1977) also found basal systolic and diastolic blood pressure were correlated. The significant correlation between both systolic and diastolic pressure with body weight in this study differs from the findings of Hicks (1966) and Lugg who, in addition, both found negative correlations between triceps skinfold thickness and basal systolic blood pressure. The significant correlation between subscapular skinfold thickness and both systolic and diastolic blood pressure is also in contrast to Lugg's findings.

These difference may be due to the small numbers of subjects in each study (Hicks - eighteen subjects for basal observations, Lugg - eight subjects, this study - twenty-three subjects).

7. PHYSICAL FITNESS STUDY

7.1 INTRODUCTION

Seasonal factors influence Antarctic station programs and during the winter outdoor activities are largely curtailed. It has been assumed a decline in physical fitness occurs during this restrictive period.

This study aimed to determine the fitness trend in the Davis group over an annual cycle. Predicted maximum oxygen uptake values were used as indicators of physical fitness. Further aims were to determine any seasonal effect on fitness, the advisability of pre-departure physical assessment and training, and the necessity of maintenance physical fitness training, especially during the winter period.

7.2 METHODS

7.2.1 Locality

The study was conducted from February 1982 to January 1983. The station itself offered a moderate degree of comfort; nevertheless most expeditioners were involved in outside work, and even the more sedentary occupations had duties involving a high degree of physical effort, often outside in unfavourable climatic conditions. The geographical lay-out of the station ensured that all personnel spent time outside walking between buildings throughout the year. Climatic conditions are summarised in Section 2.4 and Appendix I.

7.2.2 Subjects

Twenty-two expeditioners took part. The subject numbering is the same as that used in Section 3. Two men did not take part for personal reasons (Subjects 20 and 26, Appendix II), and two were eliminated from the study due to lack of attendance at testing (Subjects 5 and 17).

Subjects included an Officer-in-Charge, tradesmen, radio operators, scientists, meteorological observers, chef and medical officer. Each man's physical effort varied considerably from day to day and week to week. Some expeditioners trained regularly in a small gymnasium while others did so on a sporadic basis. Field trips were undertaken by all men but again there was no regular pattern to these activities. There were very limited field activities in the period May to August due to extreme cold and lack of daylight. The testing program had no influence on the men's usual physical work patterns.

While Antarctic service tends to attract the more adventurous, most expeditioners came from backgrounds with no special emphasis on physical activity. Physical fitness and aerobic work capacity were not formally assessed as part of selection procedures. The men were chosen primarily on their vocational suitability. Pre-appointment screening ensured all were in good health on commencement.

7.2.3 Equipment

An air-braked cycle ergometer (Repco, Australia) provided a measurable work-load (units: kilopond meter/minute). The same machine and meter were used throughout the experiment without modification or repairs being necessary. Heart rate was measured using a digital read-out meter (Life Pak 6) utilising three standard ECG chest leads.

7.2.4 Procedure

Testing was performed in the first week of each month using the procedure outlined by Astrand and Rodahl (1977). After adjusting the bicycle seat height for the subject's height, ECG electrodes were attached to the subject. The subject then cycled at a set work-load for six minutes. The heart rate was monitored continually until a constant heart rate was obtained. This reading was recorded together with the work-load. The work-load was a submaximal one and was individually tailored for each subject so that a heart rate of at least 130 beats per minute was obtained. This is considered to be an adequate load and varied in subjects between 900 and 1500 kilopond metre/minute. During the year, work-loads were adjusted in individuals to accommodate changes in fitness.

The subjects' age and body mass were recorded for each monthly measurement. Using the normogram of Astrand/Ryhming/Astrand (with variables of sex, age, body mass, work-load and heart rate), the maximum oxygen uptake in millilitres per minute per kilogram ($V_{02}max.kg^{-1}$) of each subject was predicted from each monthly reading.

7.3 RESULTS

The monthly readings for individuals were analysed by the standard analysis of variance. The twenty-two subjects were considered blocks and the twelve monthly readings were the level of the 'treatment' factor. Ten of the total 264 individual monthly readings were missing (due to the unavailability of the subject at the particular monthly reading) and these readings were estimated by the analysis.

Table 10 tabulates the mean predicted maximum oxygen uptake (mean $V_{02}max.kg^{-1}$) of the experimental group as a whole for each month, the twenty-two individual values being added and a mean value calculated.

Table 11 is a summary of the annual mean predicted maximum oxygen uptake for each subject and of the group as a whole. The lowest and highest individual readings are also recorded.

Appendix X summarises for each subject, the series mean values of parameters used in the calculation of predicted maximum oxygen uptake.

7.4 DISCUSSION

Various exercise tests have been used as a measure of maximum oxygen uptake. Maximal work effort tests on either a bicycle ergometer (Astrand 1952, Astrand et al. 1959, Binkhorst and van Leuween 1963) or treadmill (Taylor 1944, Taylor et al. 1955, Mitchell et al. 1958) allow direct measurement of oxygen uptake. Less physically demanding submaximal work tests on a bicycle ergometer utilise a normogram to predict the maximum oxygen uptake indirectly (Astrand and Ryhming 1954, Astrand 1960).

Several comparisons of maximum oxygen uptake values from direct and indirect tests have been published (Astrand and Saltin 1961, Wyndham et al. 1959, Newton 1963). The most statistically significant comparison is that of Glassford et al. (1965) who found the Astrand/Ryhming/Astrand normogram produced a good estimate of maximum oxygen uptake values when compared with direct measurement. The test program used in this study utilised this normogram.

Apart from its reliability as an estimate of maximum oxygen uptake, the submaximal work test offers the further advantage of avoiding the excessive physical demands of a maximal work test. This is especially important when serial testing is performed over a long period. While the subjects on an Antarctic station are in a sense 'captive', subject-acceptable non-invasive, non-traumatic experimental protocols are necessary to maintain subject co-operation and motivation. In the past in the Antarctic, some medically-related experiments of an unpleasant nature have suffered from lack of subject acceptance.

The monthly mean maximum oxygen uptake is expressed graphically against time in Figure 9 and, on statistical analysis, interpretation of the relationship

Month	Mean max O_2 uptake (mL/min/kg)	
February	43.02	(SD = 8.41)
March	44.66	(7.83)
April	46.98	(7.78)
May	47.85	(7.62)
June	47.44	(8.09)
July	47.64	(8.34)
August	47.07	(9.12)
September	49.93	(9.44)
October	50.09	(8.75)
November	50.92	(7.43)
December	49.95	(9.37)
January	51.01	(7.87)

Statistical analysis:

Variance ratio: 13.2
Degrees of freedom: 11 and 221 ($p<0.001$)
Residual variance: 10.27 (not due to high positive correlation between successive measurements which were virtually uncorrelated).

Table 10. Mean maximum oxygen uptake for each month for the experimental group.

as a linear regression function was highly significant. The regression equation for this relationship is:

$$V_{O2}max.kg^{-1} = 43.96 + 0.631 \text{ (time)}$$

where time is the month number from one to twelve starting with February 1982. The correlation co-efficient for this regression line is 0.918 ($p<0.001$).

The maximum oxygen uptake increased with time in a linear fashion and expeditioners became more fit with time.

The linear increase in V_{O2}max. indicates the fitness of the group was well below the practical maximum even in the latter stages of the study, as one

Subject	Age (years) (on 30 June 1986)	Max. O_2 uptake (mL/min/kg)
1	30	51.12
2	38	34.79
3	28	41.54
4	39	44.13
6	24	53.21
7	25	40.08
8	29	54.04
9	26	58.95
10	35	41.96
11	35	62.86
12	27	53.42
13	27	46.93
14	27	45.87
15	38	47.54
16	26	49.17
18	26	47.00
19	25	59.58
21	24	54.04
22	26	53.67
23	42	39.97
24	23	40.12
25	29	46.42

Mean age: 29.5 years (Standard Deviation: 5.6 years)
Grand mean (max. O_2 uptake: 48.07 mL/min/kg (Standard Deviation: 7.99 mL/min/kg)
Lowest individual monthly reading: 28 mL/min/kg (Subject 20 in February 1982)
Highest individual monthly reading: 69 mL/min/kg (Subject 10 in September and October 1982)

Table 11. Subject annual mean maximum oxygen uptake values.

would expect a departure from a linear relationship and a flattening of the graph as the maximum value was approached.

The increase in $V_{O2}max.$ over the study period was 18.6%. It is postulated initial fitness was poor due to sedentary habits prior to and during transportation to Antarctica, and that the active Antarctic lifestyle provided a marked training effect. This increase in fitness occurred throughout the year. The readings in June, July and August suggest a slight plateau effect in these winter months but statistically this proved not to be significant.

As there was very little variation in the mean monthly weight values of the group during the year (Appendix V) the increase in $V_{O2}max.$ was not due to changes in weight.

As basal heart rate is another possible indicator of physical fitness, analysis of covariance was performed on these two variables. Allowing for differences between individual subjects and months, the correlation (negative) was found not to be significant, the p value (p=0.112) being just outside the 10% significant level.

Although largely confined indoors during the winter period, most expeditioners were involved in some physical work either as part of their vocation and/or for recreation. The geographic layout of the station demanded walking between work, sleeping and recreational areas, also ensuring some continual physical exercise. These findings indicate that the winter period was not associated with a fall in physical fitness level.

The factors which contributed to winter fitness are likely to continue for some time. The rebuilding program on the continental stations will continue for a number of years and the stations will therefore have a high percentage of tradesmen engaged in manual work requiring a reasonable level of physical effort throughout the year. Scientific programs usually involve some field work during winter and many non-scientific expeditioners are involved with assisting. All expeditioners participate in general station duties. Recreational facilities such as gymnasium equipment are continually being improved.

These findings are similar to those obtained at Halley Bay (Levack 1980) where a linear increase throughout the year was also demonstrated. This included the winter period when work-loads were known to be less.

There were considerable differences in readings between individuals (Table 11). These differences are not surprising in a group selected for occupational reasons and not for physical fitness. In addition, age, general physique, motivation, social habits (e.g. smoking and alcohol consumption), and probably other factors undoubtedly influenced the readings obtained.

The highest mean result was a maximum oxygen uptake of 62.86 mL/min/kg. The subject was 35 years old and trained extensively throughout the year including regular long distance running. The lowest mean value of 30.97 mL/min/kg was obtained with a 42 year old who smoked and drank heavily and engaged in little physical exercise.

People with particularly low levels of fitness are at greater risk in a hostile environment. Fortunately, in the 1982 Davis group, the least fit recognised their physical limitations and avoided situations requiring fitness and endurance beyond their means. Since, however, unforeseen stressful situations are not uncommon in Antarctica, the health risk of unfitness (especially in individuals who do not recognise their limitations) should not be condoned. It is arguable that fitness assessment and/or training be incorporated in the pre-departure training prior to embarking for Antarctica. A further fitness problem is the sea voyage of one to three weeks between Australia and Antarctica when little if any real physical work is done. A suitable on-board exercise program would be needed to maintain fitness during transit.

Physical training on arrival in Antarctica is a further option but would interfere with work programs. These procedures would benefit all expeditioners, as this study suggests all have least fitness early in their Antarctic stay when work-load associated with cargo unloading and building construction is highest.

While Antarctic station comfort and facilities continually improve, the Antarctic environment will remain as the most hostile on earth. Antarctic history has shown that fitness and endurance are essential in man's chances of survival in this inhospitable continent. A high level of physical fitness needs to be attained on arrival in Antarctica and maintained throughout the duration of the stay.

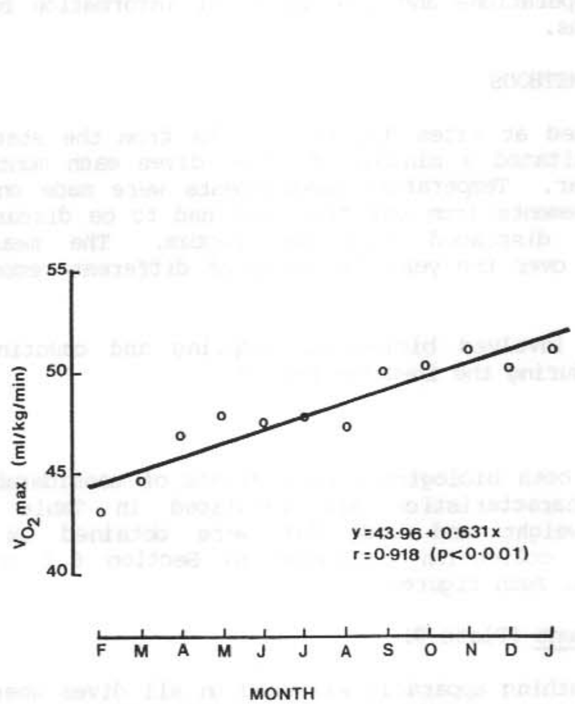

Figure 9. Correlation between time and maximum oxygen uptake.

8. THERMAL LOSS IN AUSTRALIAN ANTARCTIC DIVERS

8.1 INTRODUCTION

Diving programs were first undertaken in the Antarctic in the late 1950s by the United States Navy (Fane 1959) and in an American biology program (Neushul 1961). Summer diving was conducted by the Russians at Mirny and Molodezhnaya stations in 1965-66 (Gruzov et al. 1968) and the Japanese at Syowa station in 1968 (Fukui 1968). In 1963 a year-round scuba diving program was carried out at McMurdo Sound (Peckham 1964). The British Antarctic Survey has been conducting year-round diving at Signy Island in the South Orkney Islands for a number of years (Light 1980, Light et al. 1980, Bridgman 1984).

Before 1982, Australian diving operations on the Antarctic continent were limited to the summer. In the summers of 1971-72 and 1972-73 a team of three dived at Mawson. In 1981 an occasional dive was performed in both summer and winter at Mawson. During 1982 a year-round diving program was conducted by personnel at Davis.

The problem of thermal loss, potentially leading to hypothermia, is a major hazard in cold water diving, and the purpose of this study was to determine temperature changes of divers in polar waters as measured by rectal temperatures. This would indicate body heat loss in typical Australian Antarctic diving operations and give important information for the planning of future operations.

8.2 SUBJECTS AND METHODS

Diving was conducted at sites 0.5 km to 4 km from the station (Plate 8). The program necessitated a minimum of three dives each month at each site over the whole year. Temperature measurements were made on nine dives of each diver; measurements from one dive each had to be discarded due to the thermoprobe being displaced from the rectum. The measurements were performed randomly over the year for dives of different recorded depths and durations.

The divers' work involved biological sampling and counting, maintaining physical activity during the in-water period.

8.2.1 Subjects

The two subjects, both biologists, were divers of considerable experience. Their physical characteristics are tabulated in Table 12. Skinfold thickness, body weight and body fat were obtained as part of the physiological data collection described in Section 6.2 and the results tabulated are annual mean figures.

8.2.2 Diving equipment (Plate 9)

Surface supply breathing apparatus was used on all dives where measurements were taken. Breathing regulators were Sherwood Magnum Blizzard - a design specially suited to cold water diving. Partial face masks, fins, buoyancy compensators and weight belts were similar to those used for diving in temperate climates.

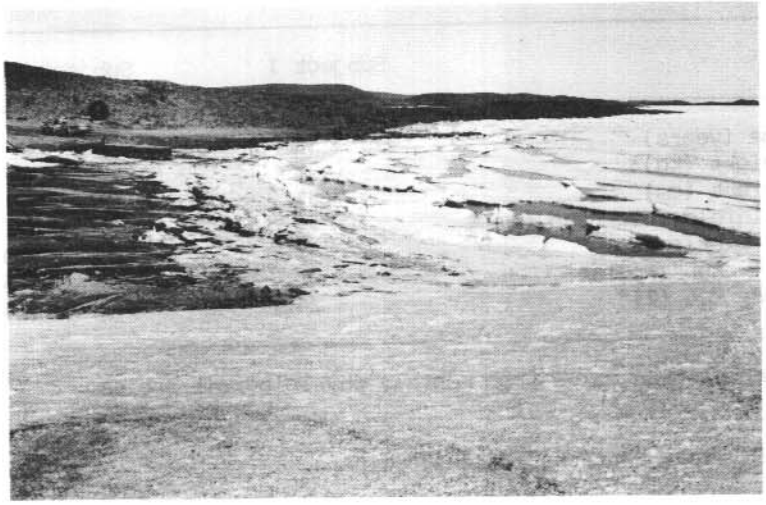

Plate 8. Diving site on the sea-ice off Davis. (Antarctic Division photograph by J. Adolph)

Plate 9. Ice diving. The seated diver illustrates the thermal protection and surface supply breathing apparatus ('Hookah') used in this study. The in-water diver is wearing a dry suit and using scuba. (Antarctic Division photograph by J. Adolph)

	Subject I	Subject II
Age (years)	38	25
Weight (kg)*	105	83
Height (cm)	186	179
Skinfold thickness (mm)*		
- triceps	9.7	6.0
- subscapular	21.7	14.6
Body fat (%)*	24.1	14.4

*Annual mean value from monthly physiological series.

Table 12. Physical characteristics of divers.

8.2.3 Water temperatures

There was not a great variation in the sea-water temperature during the year or at the depths used by the divers. Figure 10 shows the monthly sea ice thickness, and water temperatures at the surface and at 10 m depth at a site 1.5 km from the shore. When sea-ice was present, the surface water temperature was measured in access holes made in the ice.

8.2.4 Thermal protection

Divers wore tailor-made wet suits of 9 mm neoprene. The fit was not always perfect due to changes in body weight during the year. The suits came in two parts: trousers, which also covered the back, abdomen and lower chest; and jacket incorporating hood. Boots were 9 mm neoprene, and mitts were 6 mm neoprene with separate pockets for thumb and index finger.

8.2.5 Temperature measurements

A telethermometer and temperature probes (Yellow Springs Model 46, Series 400 probes) were used. The probes were inserted into the rectum by the divers when dressing in wet suits at the station. Temperature readings were taken on each diver immediately before entry into the water and immediately after exit.

8.3 RESULTS

Tables 13 and 14 summarise the details of each monitored dive.

Subject I, in most dives, performed a task immediately under the sea-ice for about ten minutes; the remainder of his time was spent sampling on the sea floor (Plate 10). Subject II was involved only in sea floor sampling. An exception to these routines were the longest dives when both divers spent an extended interval immediately under the sea-ice. The proportion of the dives spent on each phase is noted at the foot of the Tables.

Maximum depth (m)	Total dive time (min)	Rectal temperature		
		Before dive (°C)	After dive (°C)	Difference (°C)
19	20	38.0	37.8	-0.2
23	25	37.2	37.1	-0.1
13	30	38.6	37.8	-0.8
13	20	37.5	38.2	+0.7
23	30	38.2	37.5	-0.7
11*	90	37.4	36.8	-0.4
19	40	37.2	36.8	-0.6
13	30	37.7	37.3	-0.4

*11 m for 60 min and 2 m for 30 min.

Table 13. Details of each dive of Subject I.

Maximum depth (m)	Total dive time (min)	Rectal temperature		
		Before dive (°C)	After dive (°C)	Difference (°C)
19	20	38.0	38.2	+0.2
23	25	38.1	37.9	-0.2
13	15	38.2	38.4	+0.2
13	10	37.4	37.8	+0.4
23	10	37.4	37.8	+0.4
11*	60	37.6	37.4	-0.2
19	20	37.5	37.4	-0.1
13	30	37.5	37.2	-0.3

*11 m for 45 min and 2 m for 15 min.

Table 14. Details of each dive of Subject II.

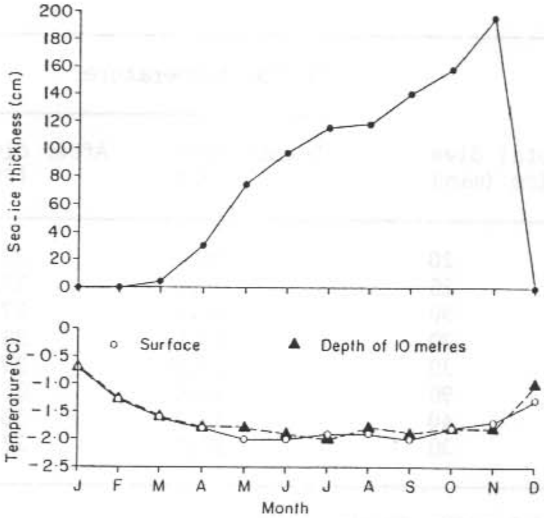

Figure 10. Monthly sea-ice thickness and water temperatures on surface and at 10 m depth at a diving site 1.5 km from shore.

Plate 10. Ice diving beside an iceberg at a depth of 40 m. (Antarctic Division photograph by R. Perrin)

8.4 DISCUSSION

Man is a poor judge of his thermal state and recognition of loss of body heat is difficult for the individual; thus the diver's recognition of early hypothermia is a real problem (Webb 1978) and a diver's own assessment of comfort is not always related to change in temperature. On many occasions divers fail to appreciate that quite marked cooling may have occurred (White et al. 1980). Undetected hypothermia has been postulated as a possible cause of unexplained diving incidents, including fatalities, in cold water diving in the North Sea (Keatinge et al. 1980). It is not known 'what the differences are between the man who responds to and complains of cold, and another man who cools and is unaware he is cooling' (Diving Medical Advisory Council 1981, p. 12).

A further problem is that repeated exposure to cold may contribute to hypothermia (Hayward and Keatinge 1979). It has been shown that repeated immersion in cold water (15°C) greatly reduces metabolic and respiratory responses to cold water immersion (Keating and Evans 1961). Thus it is of particular importance to determine the actual core temperature changes in such hazardous operations as a polar diving program.

Subject I showed a temperature drop in all but one dive. The maximum drop was 0.8°C. The mean drop over the eight dives was only 0.3°C. The depth and time in the water did not quite correlate with temperature drop; greater heat loss would be expected at greater depths due to wet suit compression resulting in decreased insulation. The maximum drop occurred at only 13 m depth for a thirty minute dive time. This dive was in mid-winter when ambient air temperature was below -25°C and peripheral cooling of the diver before the dive may have led to a greater drop in core temperature.

Subject II surprisingly showed as many rises in temperature as falls. The mean temperature difference over the eight dives was +0.05°C. His time in the water was, in general, less than Subject I and although his work task was slightly different it required a similar degree of physical effort. Furthermore, Subject II had less body fat (annual mean body fat: Subject I - 24.1%, Subject II - 14.4%) yet was more resistant to temperature falls.

The rises in rectal temperature occurred on dives of shorter duration and it is postulated heat generation from physical exertion exceeded dissipation retarded by peripheral vasoconstriction (due to cold extremities) and insulation (body fat and wet suits) during the short dive duration.

Subjective discomfort from feeling cold was not a significant problem during the sixteen dives of this study. Light et al. (1980) found that subjective comfort correlated significantly with rectal temperature ($r = 0.31$, p 0.05) while noting sufficient exceptions to suggest that use of this subjective assessment could be hazardous in prolonged and deep dives.

Localised cooling of the fingers, particularly the thumb and index finger did cause discomfort. This was largely countered by flooding the diving mitts with hot water immediately prior to entering the water. Chemically heated diving mitts as described by Burton and Chan (1983) were used in other dives during the program but not in the dives constituting this study. They may increase performance effectiveness.

It has been found that significant impairment of diving performance occurs in cold water (Stang and Wiener 1970) and performance progressively deteriorates with continued exposure (Bowen 1968). In the short-term peripheral cooling causes impairment of performance while long-term exposure affects performance due to deep body cooling (Vaughan 1975).

The results of this study indicate that for the type of diving operations carried out by ANARE, small, not generally significant, drops in rectal temperature may occur during the dive. As rectal temperature shows reasonable correlation with core temperature, the small temperature drop would indicate that hypothermia is not likely to be a problem.

Programs with longer and deeper diving profiles, or the use of thin divers with low subcutaneous fat deposits, might result in increased heat loss. Such programs would require temperature monitoring and perhaps supplementary heating using the exothermic reaction of particulate mixtures of iron and magnesium with sea-water in small sachets under the diving suit as reported by Chan and Burton (1981a, 1981b). Burton suggested that relatively low levels of heat generation, e.g. less than 50% of that required for thermal balance, may result in a significant increase in dive duration and of perceived comfort (Burton 1983).

Repetitive dives present a further problem. Light (1980) showed increased rates of cooling may occur during a second dive if the diver fails to rewarm between the dives. Heat loss out of the water before and after the dive, particularly during transportation to and from the dive site, was not investigated during this study, nor was the possibility of 'after-drop' of temperature during recovery studied.

Cold water diving in the Northern Hemisphere has reached a high level of sophistication. This has been a result of intensive diving programs in the development of natural resources, at considerable cost financially and in terms of human mortality and morbidity. Antarctic diving is currently in its infancy; it is research orientated, on a small scale, and usually has marked financial limitations. Additional problems of extreme geographic isolation, the presence of fast sea-ice and mobile pack-ice, and the lack of specialised medical back-up services add to the risk.

With growing interest in the potential resources of Antarctica, future diving programs will no doubt demand the provision of equipment, techniques and facilities used in professional cold water diving, and the diving practices on ANARE will need to expand.

9. CONCLUSIONS

9.1 OCCUPATIONAL STUDY

9.1.1 Personnel

The personnel numbers and composition of Australian expeditions to Antarctica have changed, particularly since 1977 when a substantial rebuilding program commenced. This has resulted in a much higher proportion of tradesmen on the stations. At Davis, the number of wintering persons increased 86% in the five years to 1982. Tradesmen formed 46% of the wintering group at Davis in 1982.

9.1.2 Hazards

The Antarctic environment will always remain the most obvious and specific hazard on expeditions but directly accounts for only about 2% of medical cases. Fire is another hazard of special consideration. However, the hazards representing the greatest risk to health are those associated with occupations and work activities such as the manual trades, scientific work including weather observations, and general station duties including cooking, cleaning and the unloading and storing of goods. These hazards accounted for nearly all accidents.

9.2 HEALTH OF THE EXPEDITION

The rate of 6.2 cases per wintering expeditioner is similar to the long term ANARE 1947-72 results. Forty-five per cent of cases were accidents, 14% infections and 13% dental cases. Seasonal factors appeared to influence the occurrence of accidents, higher numbers occurring early in the expedition year and on the resumption of extensive outdoor activities after winter restrictions. Small sample numbers made examination of occupational and subject variables difficult; however, men whose primary occupation was based indoors had a lower rate of accidents (compared with the remaining expeditioners) which was statistically significant at the 10% level. Large scale studies are needed to determine the effects of seasonal, occupational and subject variables on morbidity statistics.

9.3 MONTHLY PHYSIOLOGICAL MEASUREMENTS

Body fat and skinfold measurements decreased during the year, probably due to continuous physical activity by the group. There was no apparent seasonal effect. Body weight changes appeared to depend solely on energy balance factors, with falls very early in the year (a period of high activity after the restrictive sea voyage) and late in the year due to intensive work programs and purposeful dieting by many expeditioners. Basal heart rate fell for most of the year, the likely cause being the increasing physical fitness of the group. The rise in rate late in the year may reflect emotional factors associated with the approaching return to Australia. Basal blood pressure (systolic and diastolic) readings showed no consistent pattern. Basal temperature varied little during the year, with no apparent seasonal effect.

9.4 PHYSICAL FITNESS STUDY

No previous reports of physical fitness trends on Australian stations have been published and it has been assumed that a fall in the level of fitness occurs during the winter months. This study showed a linear increase in the physical fitness of the group throughout the year, using maximum oxygen uptake ($V_{O2}max.kg^{-1}$) as an indicator of physical fitness. The linear function was represented by the equation:

$$V_{O2}max.kg^{-1}(mL/min) = 43.96 + 0.631\ (time)$$

where time is the month number. It is postulated that the increase is due to current work programs, stations design and voluntary training in a small gymnasium. Physical fitness is poor early in the tour of duty yet work-loads are high.

9.5 THERMAL LOSS IN ANTARCTIC DIVERS

The first year-round Australian Antarctic diving program was carried out at Davis in 1982. An assessment of thermal loss in two divers was performed using the equipment currently utilised on ANARE scientific programs. Small temperature losses only occurred during the recorded dives and it is concluded that current practices are unlikely to result in hypothermia.

9.6 GENERAL

Despite the increase in expeditioner numbers, the intensive rebuilding program and the higher proportion of manual tradesmen at Davis in 1982, the morbidity pattern of this group was similar to the ANARE 1947-72 figures. The hazards of living and working in Antarctica are similar to those in Australia but represent a higher risk, especially the environmental hazards. This increased risk would appear to account for an increase in accident rates. However, there is insufficient data in an equivalent Australian population and further studies are needed to determine differences in morbidity patterns as a result of increased risk from hazards. Improved occupational hazard recognition and training in the wide range of occupational tasks is recommended.

Certain activities carry an especially high risk. Field work represents the most significant exposure to the Antarctic physical environment and adherence to prescribed policies and procedures, pre-departure training and physical fitness will help minimise the risk. The results of the study on divers indicate the risk of hypothermia is minimal with diving programs and practices similar to the ones at Davis in 1982. The demonstrated effectiveness of wet-suits as insulators in water recommends their general use in boating activities, and on occasions when the availability of rescue and rewarming facilities following accidental immersion is not immediate.

It is postulated that changes in physiological variables are related to changes in lifestyle rather than the direct effect of the Antarctic environment. Variations in weight, skinfold thickness and body fat depend on diet and energy expenditure (net energy balance), with no evidence of an Antarctic adaptation factor. A marked training effect from the active lifestyle (compared with the period preceding the expedition) resulted in an increase in physical fitness. Pre-departure and in transit training is needed to improve fitness in the early stages of the expedition.

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Appendix I. Monthly climatic summary for Davis, January 1982 - January 1983.

	Mean daily temp °C	Highest temp °C	Lowest temp °C	Mean daily sunshine (hours)	No. days strong winds (>22 knots)	Mean wind speed (knots)
January 1982	+0.3	+6.0	-5.0	9.6	7	11.3
February 1982	-2.5	+2.7	-10.3	4.7	4	7.0
March 1982	-12.2	-3.8	-22.2	2.1	8	8.4
April 1982	-18.1	-4.8	-29.4	2.4	5	7.5
May 1982	-15.9	-3.8	-33.4	0.7	7	8.4
June 1982	-22.2	-10.5	-38.1	Nil	3	6.0
July 1982	-15.3	-3.9	-25.8	0.4	11	10.5
August 1982	-24.9	-8.5	-35.9	3.4	Nil	5.7
September 1982	-23.1	-7.8	-36.2	4.1	3	7.3
October 1982	-12.9	-4.0	-26.2	6.8	8	10.1
November 1982	-4.8	+4.0	-17.8	7.9	6	9.8
December 1982	+1.0	+8.2	-6.4	12.0	3	7.2
January 1983	+1.8	+7.8	-2.9	9.3	5	9.3

Source: Senior Meteorological Observer, Davis.

Appendix II. The physical characteristics of the Davis subjects.

Subject	Age (yrs) (on 30.6.82)	Height (cm)	Mean for monthly series: Weight (kg)	Body fat (%)
1	30	172	80.09	24.9
2	38	186	105.03	24.1
3	28	176	70.20	13.0
4	39	170	67.43	21.3
5	35	185	88.14	21.6
6	24	184	71.94	15.1
7	25	185	88.35	12.9
8	29	172	72.63	22.6
9	26	178	77.58	10.3
10	35	188	85.04	(Not available)
11	35	179	75.44	18.0
12	27	176	69.49	12.7
13	27	177	77.82	14.6
14	27	175	80.11	14.6
15	38	176	83.65	19.0
16	26	182	83.46	17.9
17	32	180	69.91	21.6
18	26	186	80.81	19.1
19	25	180	78.87	13.4
20	42	172	70.05	22.9
21	24	179	82.48	14.4
22	26	175	78.96	15.9
23	42	196	85.12	20.8
24	23	179	73.79	16.2
25	29	175	68.47	13.5
26	35	180	(Not available)	(Not available)

Appendix III. Occupational classification* of 1982 Davis expeditioners on appointment.

ILO Code	Description
0-12	Physicist
0-12	Physicist
0-14	Senior Meteorology Observer
0-14	Meteorology Observer
0-14	Meteorology Technical Officer
0-51	Biologist
0-51	Biologist
0-51	Biologist
0-61	Medical Practitioner
2-19	Officer-in-Charge
3-80	Senior Radio Operator
3-80	Radio Operator
5-31	Cook
8-49	Senior Diesel Mechanic
8-49	Diesel Mechanic
8-52	Radio Technical Officer
8-55	Electrican
8-55	Electrican
8-55	Electrican
8-71	Plumber
8-71	Plumber
9-54	Foreman, building
9-54	Carpenter
9-54	Carpenter
9-54	Carpenter
9-74	Plant Operator

*International Labour Office. (1968). International Standard Classification of Occupations (Second Edition). ILO, Geneva.

Year	Heard Island	Macquarie Island	Mawson	Davis	Wilkes	Repstat	Casey	Amery Ice Shelf	Total
1948	14		13						27
1949	11		11						22
1950	14		16						30
1951	14	17							31
1952	14	14							28
1953	13	14							27
1954	9	13	10						32
1955		14	15						29
1956		15	20						35
1957		15	24	5					44
1958		16	29	4					49
1959		16	23	8	18				65
1960		15	33	8	18				74
1961		13	25	9	24				71
1962		15	24	9	23				71
1963		16	26	9	23				74
1964		17	26	10	24				77
1965		19	27		24				70
1966		19	26		27				72
1967		18	27		25				70
1968		20	23		26	4		4	77
1969		19	28	10			29		86
1970		18	22	10			24		74
1971		15	24	12			26		77
1972		15	26	12			26		79
1973		17	25	14			29		85
1974		19	26	14			26		85
1975		20	27	14			26		87
1976		19	29	14			23		85
1977		20	26	14			23		83
1978		20	26	14			24		84
1979		17	30	15			24		86
1980		18	31	21			25		95
1981		18	32	25			28		103
1982		19	33	26			34		112
Total	89	580	743	277	232	4	367	4	2296

Source: Antarctic Division (1982). Australia's Antarctic Stations (Pamphlet No. 8) Antarctic Division, Kingston, Tasmania.

Appendix IV. Number of persons 'wintering' at ANARE stations 1948-82.

Appendix V. Classification and occurrence of illnesses, diseases and injuries at Davis, 1982.*

I **Infectious and Parasitic Diseases** (23 cases)

034.0 (7 cases)	Strep throat inf	099.4 (2)	Non-specific urethritis
054.1 (1)	Genital herpes simplex	110.1 (1)	Fungal onychia
054.2 (1)	Herpes simplex - lip	110.4 (1)	Tinea pedis
054.4 (1)	Herpes simplex - eye-lid	110.5 (1)	Tinea corpora
078.1 (8)	Viral warts		

II **Neoplasms** (0 cases)

III **Endocrine, Nutritional and Metabolic Diseases** (0 cases)

IV **Disease of the Blood and Blood-forming Organs** (0 cases)

V **Mental Disorders** (8 cases)

300.0 (1)	Anxiety	307.8 (2)	Tension headache
300.1 (1)	Hysteria	308.0 (1)	Acute stress reaction
300.4 (1)	Depression	309 (2)	Adjustment reaction

VI **Diseases of the Nervous System and Sense Organs** (6 cases)

372.0 (4)	Conjunctivitis (cement)	381.0 (1)	Non-suppurative otitis media
380.1 (1)	Acute otitis externa		

VII **Diseases of the Circulatory System** (0 cases)

VIII **Diseases of the Respiratory System** (6 cases)

461.8 (1)	Acute pansinusitis	477.9 (1)	Allergic rhinitis
466 (1)	Acute bronchitis	493.0 (1)	Asthma
472.0 (2)	Chronic rhinitis		

IX **Diseases of the Digestive System** (25 cases)

521.0 (9)	Dental caries	523.2 (4)	Gingival recession
521.8 (1)	Sensitive dentine	525.3 (1)	Retained dental root
522.0 (2)	Acute pulpitis	528.4 (2)	Oral cyst
523.0 (2)	Acute gingivitis	535.0 (2)	Acute gastritis
523.1 (2)	Chronic gingivitis		

X **Diseases of the Genito-urinary System** (1 case)

597.8 (1) Urethritis

XI **Complications of Pregnancy, Childbirth and the Puerperium** (0 cases)

XII **Diseases of the Skin and Subcutaneous Tissue** (11 cases)

681.0 (2)	Cellulitis, finger	692.0 (1)	Contact dermatitis

681.2 (1) Ingrowing toenail
684 (1) Impetigo
690 (1) Seborrhoeic dermatitis
692.8 (2) Allergic dermatitis
702 (1) Cutaneous horn
706.2 (2) Sebaceous cyst

XIII Diseases of the Musculoskeletal System and Connective Tissue (4 cases)

716.1 (1) Traumatic arthropathy (knee)
719.4 (1) Joint pain (hand)
726.1 (2) Rotator cuff syndrome (shoulder)

XIV Congenital Anomalies (0 cases)

XV Certain Conditions from Perinatal Period (0 cases)

XVI Symptoms, Signs and Ill-defined Conditions (4 cases)

780.5 (3) Insomnia
782.0 (1) Paraesthesia

XVII Injury and Poisoning (73 cases)

834.0 (1) Dislocation of finger
842.1 (1) Sprain - hand
844.8 (3) Sprain - knee
845.0 (2) Sprain - ankle
845.1 (2) Sprain - foot
846.1 (1) Strain - sacro-iliac
847.2 (7) Strain - lumbar
873.0 (1) Open wound - scalp
873.6 (3) Chipped teeth
875.0 (1) Open wound - chest
881.0 (1) Open wound - forearm
882.0 (1) Open wound - hand
883.0 (1) Open wound - finger
914.0 (1) Superficial injury hand (uncomplicated)
914.7 (1) Superficial injury hand (infected)
915.0 (3) Superficial injury finger (uncomplicated)
917.2 (1) Superficial injury heel
920 (2) Contusion scalp
923.0 (1) Contusion shoulder
923.1 (1) Contusion elbow
923.3 (1) Contusion finger
924.0 (1) Contusion hip
924.1 (1) Contusion knee
924.3 (3) Contusion toe
927.2 (1) Contusion hand
928.2 (1) Crush injury foot
928.3 (3) Crush injury toe
930.0 (2) Foreign body cornea
930.1 (5) Foreign body conjunctival sack
935.0 (1) Foreign body mouth
941.1 (1) Burn face (erythema)
943.1 (1) Burn upper limb (erythema)
943.2 (1) Burn upper limb with blistering
944.1 (3) Burn wrist (erythema)
944.2 (1) Burn wrist (with blistering)
946.1 (2) Burns multiple sites (erythema)
982.3 (1) Poisoning, chlorinated hydrocarbon
986 (1) Poisoning, carbon monoxide
989.0 (2) Poisoning (dermal) nitroglycerine
991.1 (3) Frostbite hands
993.0 (3) Barotrauma, otitic

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*Classification using the Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, Ninth Revision, 1977, WHO.

Appendix VI. The monthly occurrence of cases at Davis in 1982 in morbidity categories.

Category	Month													
	J*	F	M	A	M	J	J	A	S	O	N	D	J+	Total
I Infectious, Parasitic Diseases	1	3		1	3	5		3	2		1	4		23
V Mental Disorders		1	1						2	2	1	1		8
VI Diseases, Nervous Syst Sense Organs	1				2		1	1				1		6
VIII Diseases, Respiratory System	1				2	2					1			6
IX Diseases, Digestive System	3	2	2		3	2	3	3		5	2			25
X Diseases, Genito-urinary System											1			1
XII Disease, Skin/ Subcut Tissue			1		2	3	1			1	2	1		11
XIII Disease, Musculoskel Connective Tissue		1	1									1	1	4
XVI Symptoms/Signs/ Ill-defined Conditions		1		2		1								4
XVII Injuries/Poisonings	7	7	3	6	4	6	6	6	10	8	5	2	3	73
TOTAL CASES	13	15	9	9	16	19	11	13	14	16	13	9	4	161
REVIEW CONSULTATIONS	5	5	4	1	6	3	-	1	4	1	2	2	1	35
TOTAL CONSULTATIONS	18	20	13	10	22	22	11	14	18	17	15	11	5	196

Notes:

1. All but three cases (all of which were in October) in Category IX were dental conditions.
2. No cases were recorded in Categories II, III, IV, VII, XI, XIV, XV.
3. *January 1982 records started 11 January; +January 1983 records ended 16 January.

Appendix VII. The occurrence of cases in each subject in morbidity categories, Davis, 1982.

CATEGORY	SUBJECT IDENTIFICATION																										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	TOTAL
I Infectious/Parasitic D		2	1	3		1	1	3		4			1		1					1		4	1				23
V Mental D			1	1	2		2		1								1										8
VI Nervous Syst/Sense Organ D			4											1						1							6
VIII Respiratory Syst D	1	1			1										1				1						1		6
IX Digestive Syst D	5	2			2	1	1	1					1	2	2	1	3	1	1	1					1		25
X Genitourinary Syst D							1																				1
XII Skin/Subcut Tissue D			1	1	1			1			1	1				2		1						1	1		11
XIII Musculoskel/Connect Tissue D	1	1				1															1						4
XVI Symptoms/Signs/ Ill-defined	1				2							1															4
XVII Injuries/Poisonings	3	5	4	5	2	6	4	2	6	2	6	4	3	3	2	2	1	1	3	2	3		2	2			73
TOTAL (NEW CASES)	11	11	11	10	10	9	9	7	7	6	7	6	5	6	6	5	5	3	5	5	4	4	3	3	3	0	161
REVIEW CONSULTATIONS	7	6	2	3	1	2	1	2	1	2		1	2			1	1	3									35
TOTAL CONSULTATIONS	18	17	13	13	11	11	10	9	8	8	7	7	7	6	6	6	6	6	5	5	4	4	3	3	3	0	196

Appendix VIII. Monthly mean values of the nine physiological parameters measured at Davis, 1982.

Time month	Weight kg	Skinfold (triceps) mm	Skinfold (sub-scapular) mm	Arm circum-ference cm	Body fat %	*Basal temperature °C	*Basal heartrate beats/min	*Basal BP (systolic) mm Hg	*Basal BP (diastolic) mm Hg
January	78.13	10.53	14.06	30.8	19.0	35.87	68.9	120.0	73.9
February	77.10	9.42	13.31	30.2	17.6	36.00	66.9	117.1	71.4
March	78.31	9.52	13.25	30.7	17.7	35.94	66.6	119.5	72.4
April	78.24	9.44	13.24	30.6	17.7	35.99	65.7	117.4	73.3
May	78.49	9.65	13.18	30.9	17.8	36.10	66.3	116.2	72.6
June	78.57	9.48	13.16	30.9	17.7	36.03	64.7	118.3	73.1
July	78.76	9.86	12.94	30.7	17.7	35.97	63.1	117.6	75.2
August	78.68	9.54	12.43	30.5	17.3	36.01	63.7	116.9	73.3
September	78.84	9.50	12.42	30.5	17.2	35.97	63.4	119.8	73.6
October	78.82	9.51	12.59	30.5	17.3	36.12	66.1	117.6	73.8
November	77.78	9.10	12.36	30.4	16.8	36.09	63.8	115.5	71.3
December	78.11	9.22	12.69	30.3	16.6	36.11	67.5	119.1	72.7

*Basal values exclude the three meteorological personnel.

Appendix IX. Annual mean values of the nine physiological parameters measured at Davis, 1982.

	Mean	Standard deviation	Range
Weight, kg	78.33	8.48	65.6 - 106.75
Skinfold (triceps), mm	9.56	2.76	5.2 - 17.6
Sinfold (subscapular), mm	12.96	3.39	8.6 - 26.0
Arm circumference, cm	30.6	2.2	25.5 - 38.0
Body fat, %	17.5	4.2	9.6 - 26.3
Basal temperature*, °C	36.0	0.4	35.0 - 37.4
Basal heart rate*, beats/min	65.5	8.8	36.0 - 84.0
Basal BP (systolic)*, mm Hg	117.9	8.7	100.0 - 140.0
Basal BP (diastolic)*, mm Hg	73.1	6.9	55.0 - 90.0

*Basal values exclude the three meteorological personnel.

Appendix X. Summary of annual mean values of parameters in physical fitness study in individual subjects, Davis, 1982.

Subj No	Age(yr) on 30.6.82	Weight kg		Work-load Kilopond.m/min		Pulse beats/min		Pred max oxygen uptake mL/min/kg		
		mean	(SD)	mean	(range)	mean	(SD)	mean	(SD)	(range)
1	30	80.09	(1.18)	1100	(900-1200)	139.7	(6.2)	53.38	(7.47)	(43.0-55.0)
2	38	105.03	(1.08)	1100	(900-1200)	140.6	(8.7)	34.79	(3.79)	(28.5-41.0)
3	28	70.62	(1.42)	900	(900)	153.2	(7.1)	41.54	(3.57)	(36.0-46.5)
4	39	67.43	(1.40)	900	(900)	140.3	(5.4)	43.60	(3.49)	(37.0-48.5)
6	24	71.94	(1.36)	900	(900)	135.2	(3.1)	53.21	(2.51)	(49.0-58.5)
7	25	88.35	(1.17)	950	(900-1200)	144.9	(9.6)	40.08	(3.99)	(36.0-46.0)
8	29	72.63	(3.82)	1000	(900-1200)	137.4	(7.3)	54.04	(5.09)	(46.5-63.0)
9	26	77.58	(1.76)	1227	(1200-1500)	143.3	(7.8)	59.41	(4.75)	(54.0-67.5)
10	35	85.04	(1.19)	1075	(900-1200)	142.7	(10.5)	41.96	(4.04)	(36.0-47.5)
11	35	75.44	(1.23)	1336	(1200-1500)	138.4	(8.9)	62.05	(3.88)	(58.0-69.0)
12	7	69.49	(0.85)	950	(900-1200)	139.9	(11.6)	53.42	(4.18)	(46.5-61.0)
13	27	77.82	(1.16)	1090	(900-1200)	153.6	(15.5)	46.09	(3.73)	(39.5-51.0)
14	27	80.11	(0.71)	900	(900)	135.8	(4.0)	45.88	(2.51)	(41.0-50.5)
15	38	83.65	(1.82)	1200	(1200)	140.8	(6.6)	47.54	(4.53)	(41.5-52.5)
16	26	83.46	(3.40)	1000	(900-1200)	137.3	(6.8)	49.17	(3.73)	(42.0-54.0)
18	26	80.81	(2.12)	900	(900)	134.5	(4.9)	47.00	(2.98)	(42.0-51.0)
19	25	78.87	(1.61)	1175	(900-1200)	139.0	(7.0)	59.58	(4.90)	(52.5-68.0)
21	24	82.48	(1.91)	1145	(900-1200)	140.9	(8.2)	54.50	(4.89)	(48.5-61.0)
22	26	78.96	(1.60)	1200	(1200)	148.4	(5.8)	53.67	(3.55)	(49.0-59.5)
23	41	85.12	(1.11)	933	(900-1200)	154.7	(7.4)	30.11	(1.69)	(28.0-33.5)
24	23	73.79	(1.20)	900	(900)	154.8	(9.3)	40.59	(3.93)	(33.5-48.5)
25	29	68.47	(0.80)	900	(900)	145.9	(10.1)	46.42	(5.20)	(39.5-56.5)

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