

Conservation Management at Southern Ocean Islands: towards the Development of Best-Practice Guidelines

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Abstract: Islands in the Southern Ocean are susceptible to several land-based threats, including invasion by human-introduced biota, disturbance of wildlife or sites, and various forms of pollution. In this biogeographical region there are 13 sub-Antarctic or cool temperate island groups without permanent inhabitants, which fall under the sovereignty of five countries and are subject to a variety of management practices aimed at addressing these threats. A review of these practices was undertaken, in order to highlight opportunities for developing consistent best-practice guidelines for management of these islands. Each of the island groups is of conservation importance and this is reflected by their protection status under national legislation and international agreements. All except the French-owned islands and Nightingale Island in the Tristan da Cunha group have formal management plans. Tourism is allowed at all island groups except the Prince Edward Islands and three of the five New Zealand groups, but the potential environmental impacts are mitigated by various restrictions, including the limitation of visitor access to certain zones and in some cases, to certain islands in a group. At all island groups, the importance of preventing introductions of alien (non-native) biota is recognized and at seven groups, successful eradication of alien species have been undertaken. However, the comprehensiveness of quarantine measures to prevent introductions varies considerably, a quarantine officer to oversee quarantine procedures prior to disembarkation is required at only a few islands, the cultivation of fresh fruit and vegetables is still allowed on some islands, and expedition vessels remain a potential source of marine introductions at most islands. At all islands, measures are in place to prevent or minimise human disturbance of wildlife, but these vary considerably. Similarly, there are differences in the extent of island infrastructures, although all management authorities address the issue of waste disposal and several have invested considerable time and effort in the removal of accumulated waste or obsolete structures. Limited use has been made of fuel-free power on the islands. The establishment of an international forum of managers and researchers would facilitate the exchange of information regarding best practices at these islands.

Zusammenfassung: Inseln im südlichen Ozean sind gegen verschiedene Gefahren an Land empfindlich, insbesondere gegen die Ausbreitung von durch den Menschen eingeführten Organismen, die Störung der Tierwelt und verschiedene Formen der Umweltverschmutzung. In dieser biogeographischen Region gibt es 13 subantarktische oder kühl-gemäßigte Inselgruppen ohne ständige Bewohner, die unter die Hoheit von fünf Ländern fallen. Sie sind gegen diese Gefahren einer Vielzahl von Managementpraktiken unterworfen. Der vorliegende Artikel gibt eine Übersicht über diese Praktiken, um so Möglichkeiten für bessere Management-Richtlinien für diese Inseln aufzuzeigen. Jede der Inselgruppen hat eine besondere Bedeutung für den Schutz, der durch den Schutzstatus im Rahmen der nationalen Gesetzgebung und internationaler Vereinbarungen widerspiegelt wird. Alle Inseln, ausgenommen der von Frankreich beanspruchten und von Nightingale Island in der Tristan da Cunha-Gruppe haben formelle Management-Pläne. Tourismus ist auf allen Inselgruppen – ausgenommen der Prinz Edward Islands und drei der fünf Neuseeland-Inselgruppen – erlaubt; die potentiellen Umwelteinflüsse

werden aber durch verschiedene Beschränkungen abgeschwächt, einschließlich der Begrenzung des Besucherzugangs zu bestimmten Zonen und in einigen Fällen, zu bestimmten Inseln einer Gruppe. Auf allen Inselgruppen wird die Vermeidung einer Einführung fremder Organismen erkannt; auf sieben Gruppen wurde eine erfolgreiche Ausrottung der vormalig eingeführten Arten erfolgreich vorgenommen. Der Umfang von Quarantänemaßnahmen zur Verhinderung einer Einfuhr fremder Organismen variiert beträchtlich: Ein Quarantäneoffizier zur Beaufsichtigung von Quarantänemaßnahmen vor der Ausschiffung ist nur auf einigen Inseln notwendig. Das Anpflanzen von Obst und Gemüse ist noch auf einigen Inseln erlaubt. Expeditionsschiffe bleiben weiter eine mögliche Quelle zur Einfuhr von Organismen auf den meisten Inseln. Auf allen Inseln gibt es Maßnahmen zur Verhinderung oder Minimierung der Störung der Tierwelt durch menschliche Aktivitäten, jedoch variieren diese beträchtlich. Unterschiede bestehen auch im Ausmaß der Insel-Infrastruktur; obgleich alle Managementbehörden den Punkt der Abfallbeseitigung ansprechen, investieren einige beträchtliche Zeit und Aufwand in die Beseitigung von angesammeltem Müll oder überholten baulichen Strukturen. Begrenzt werden auch alternative, kraftstofffreie Energiequellen auf den Inseln genutzt. Die Einrichtung eines internationalen Forums der Manager und Forscher würde den Informationsaustausch bezüglich der besten Praxis an diesen Inseln fördern.

INTRODUCTION

Clustered around the Antarctic Polar Frontal Zone are several islands and island groups that form part of the Sub-Antarctic Biogeographical Region (Fig. 1). Although relatively species-poor, these isolated land masses in the Southern Ocean provide breeding and moulting grounds for vast numbers of seabirds and seals, support a high proportion of endemic taxa and are amongst the few representatives of mid-to-high-latitude terrestrial ecosystems in the southern hemisphere (CHOWN et al. 2001). Their conservation value is thus nationally and in some cases internationally recognized (Tab. 1). The islands are dynamic systems and are subject to considerable natural pressures such as glacial and volcanic action. They have been relatively unaffected by humans and their biotic components remain relatively intact (references in CHOWN et al. 1998). Nevertheless, they are susceptible to a number of threats related to human activities. Whereas none of the islands considered in this review has a resident human population, representatives of almost all of the groups are regularly visited by research expeditions and some islands in most groups are also visited by tourists. The greatest threat to the islands associated with these visits is invasion by alien biota, exacerbated by climate change. Other significant land-based threats are disturbance of wildlife or sites of value, and various forms of pollution.

Although they form a biogeographical unit, the sub-Antarctic islands of the Southern Ocean are subject to the sovereignty of a number of countries and a variety of management approaches. In order to assist with the development of best-practice guidelines, we compare various management procedures,

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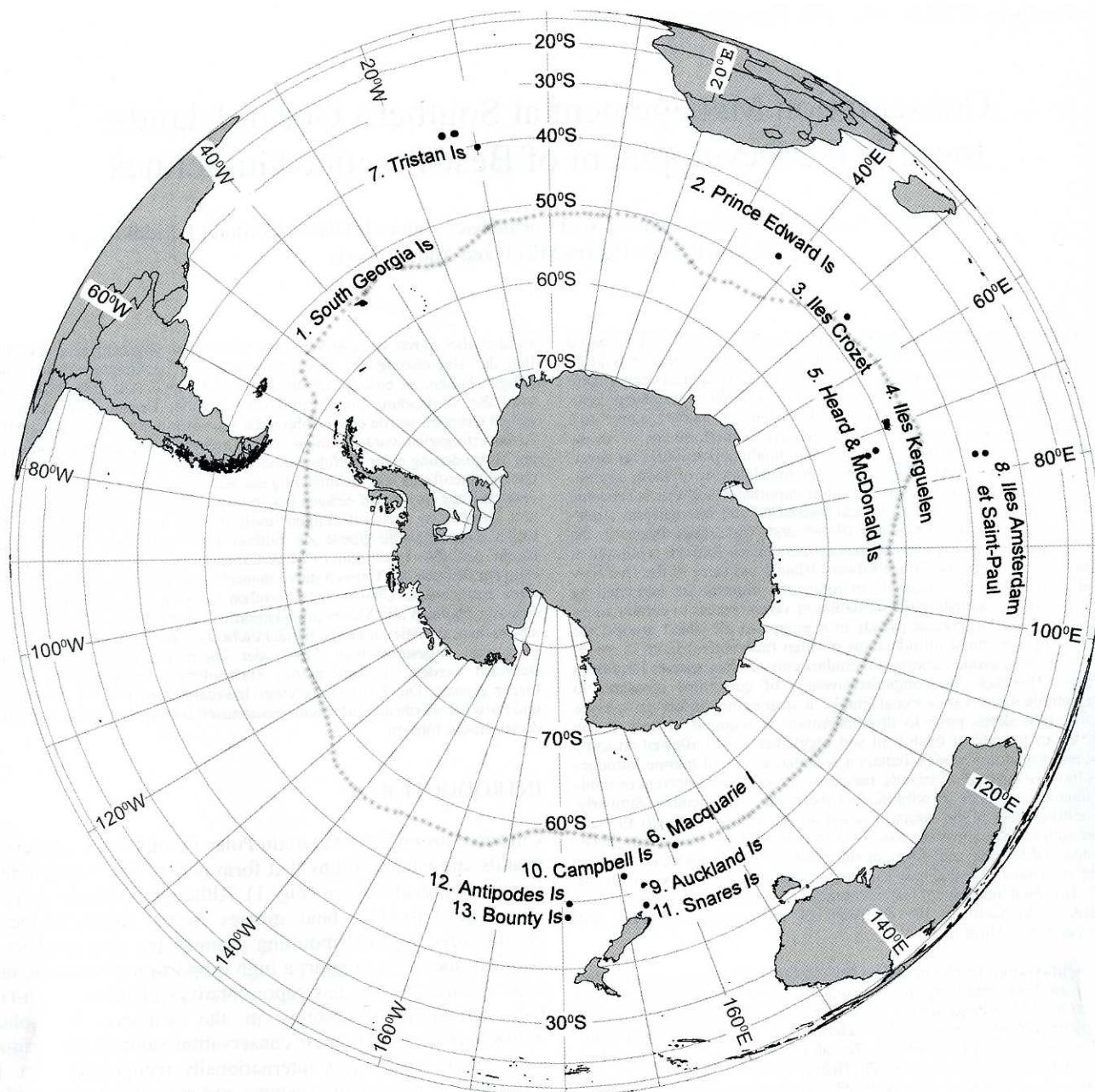


Fig. 1: The position of thirteen island groups without resident human populations in the Southern Ocean.

Abb. 1: Lage der dreizehn Inselgruppen im südlichen Ozean ohne ständige menschliche Bewohner.

which address each of the main threats to the terrestrial environment, identified above. We include in our comparison sub-Antarctic as well as several other more northerly Southern Ocean islands groups, all of which have no permanent human residents (Fig. 1, Tab. 1). Although the latter islands support woody vegetation and have thus been categorised as cool temperate rather than sub-Antarctic, they have many taxa and also some management practices in common with the sub-Antarctic islands. We exclude from our comparison islands in the maritime Antarctic, such as Bouvet oya, the South Sandwich and the South Orkney Islands, as these form part of a different biogeographical zone and have marked biotic differences. We also exclude those Southern Ocean islands with permanent human inhabitants (the main island of Tristan da Cunha and the Falklands / Malvinas) because of the broader

range of conservation issues which they face.

Conservation status and protection by international conventions

The thirteen island groups fall under the sovereignty of five countries (Tab. 1). South Georgia (together with the South Sandwich Islands, SGSSI) and the three Tristan islands considered here (together with Tristan da Cunha) are overseas territories of the United Kingdom, with management plans commissioned by the governments of SGSSI (McINTOSH & WALTON 2000, PASTEUR & WALTON 2006) and Tristan da Cunha (COOPER & RYAN 1993, RYAN & GLASS 2001), respectively. Although Australia has sovereignty at Heard and McDo-

| | | South Georgia | Prince Edwards | Crozet | Kerguelen | Heard & McDonald | Macquarie | Tristan Islands (Gough, Inaccessible, Nightingale) | Amsterdam and Saint-Paul | New Zealand islands (5 groups) |
|----------------------|--|---|--|--|--|--|---|--|---|--|
| Bio-geograph region | | Sub-Antarctic | Sub-Antarctic | Sub-Antarctic | Sub-Antarctic | Sub-Antarctic | Sub-Antarctic | Cool temperate | Cool temperate | Cool temperate |
| Sovereignty | | U. Kingdom (SGSSI) | South Africa | France | France | Australia | Australia (Tasmania) | United Kingdom (Tristan da Cunha) | France | New Zealand |
| International status | | Protected Area status IUCN World Heritage Site Biosphere Reserve Ramsar site ¹ | Ia nomination under review no no no, I | equivalent to Category II no no no | equivalent to Category II no no no | Ia yes no no, P | Ia yes yes no, I | Gough and Inaccessible, Ia Gough and Inaccessible no no, P | equivalent to Category II no no no | Ia yes all groups no no |
| National status | | Protected Area | Special Nature Reserve | NNR | NNR | Commonwealth Reserve | Nature Reserve | Gough and Inaccessible: NNR | NNR | NNR |
| Other status | | listed CHOWN et al. 2001 | yes PE only | not considered in analysis | no | yes both | yes | yes all three | no | yes all |
| Marine protection | | 12 NM no-fishing zone 200 NM restr. fishing Marine Protected Area (under investigation, 12 NM from coastline) | yes yes proposed | yes yes falls in Antarctic Ocean Sanctuary for cetaceans; NNR has a marine component | yes yes falls in Antarctic Ocean Sanctuary for cetaceans; NNR has a marine component | yes yes inner and outer marine zones part of reserve; falls within Indian Ocean Sanctuary for whales | no, but 3 NM zone yes yes | no (one concession holder) yes (by license) | no yes no | Auckland Island yes ² , other four groups no yes Marine Reserve around Auckland Island; 200 NM cetacean sanctuary |
| Management Plan | | previous current | 2000 ³ 2006 ⁴ | 1996 ⁴ draft 2006 ⁹ | none to be drafted | 1996 ⁵ 2005 ¹⁰ | 1991 ⁶ 2006 ¹¹ | none Gough 1994 ¹² (under revision), Inaccessible 2001 ¹³ Nightingale to be drafted | none to be drafted | 1982-1987 ⁷ 1998-2008 ¹⁴ |
| Advisory committee | | no | yes (Prince Edward Isls. Management Committee) | yes (Comité de l'Environnement) | yes (Comité de l'Environnement) | no | no | Gough only | yes (Comité de l'Environnement Polaire) | yes (Southlands Conservation Board) |

Tab. 1: Conservation and management status of Southern Ocean islands without resident human populations, grouped according to management plans or strategies. 'Ramsar site, I = intending to designate or in the process of designating, P = designation proposed. NNR = National Nature Reserve. Sources: ¹GRIFFITH 2002, ²McINTOSH & WALTON 2000, ³PEIMPWG 1996, ⁴AAD 1995, ⁵PEIMPWG 1996, ⁶PEIMPWG 1996, ⁷PEIMPWG 1996, ⁸PEIMPWG 1996, ⁹PEIMPWG 1996, ¹⁰PEIMPWG 1996, ¹¹PEIMPWG 1996, ¹²PEIMPWG 1996, ¹³PEIMPWG 1996, ¹⁴PEIMPWG 1996, ¹⁵PEIMPWG 1996, ¹⁶PEIMPWG 1996, ¹⁷PEIMPWG 1996, ¹⁸PEIMPWG 1996, ¹⁹PEIMPWG 1996, ²⁰PEIMPWG 1996, ²¹PEIMPWG 1996, ²²PEIMPWG 1996, ²³PEIMPWG 1996, ²⁴PEIMPWG 1996, ²⁵PEIMPWG 1996, ²⁶PEIMPWG 1996, ²⁷PEIMPWG 1996, ²⁸PEIMPWG 1996, ²⁹PEIMPWG 1996, ³⁰PEIMPWG 1996, ³¹PEIMPWG 1996, ³²PEIMPWG 1996, ³³PEIMPWG 1996, ³⁴PEIMPWG 1996, ³⁵PEIMPWG 1996, ³⁶PEIMPWG 1996, ³⁷PEIMPWG 1996, ³⁸PEIMPWG 1996, ³⁹PEIMPWG 1996, ⁴⁰PEIMPWG 1996, ⁴¹PEIMPWG 1996, ⁴²PEIMPWG 1996, ⁴³PEIMPWG 1996, ⁴⁴PEIMPWG 1996, ⁴⁵PEIMPWG 1996, ⁴⁶PEIMPWG 1996, ⁴⁷PEIMPWG 1996, ⁴⁸PEIMPWG 1996, ⁴⁹PEIMPWG 1996, ⁵⁰PEIMPWG 1996, ⁵¹PEIMPWG 1996, ⁵²PEIMPWG 1996, ⁵³PEIMPWG 1996, ⁵⁴PEIMPWG 1996, ⁵⁵PEIMPWG 1996, ⁵⁶PEIMPWG 1996, ⁵⁷PEIMPWG 1996, ⁵⁸PEIMPWG 1996, ⁵⁹PEIMPWG 1996, ⁶⁰PEIMPWG 1996, ⁶¹PEIMPWG 1996, ⁶²PEIMPWG 1996, 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nald Islands and at Macquarie Island, the former reserve is an external territory managed by the Australian Antarctic Division (AAD 2005) and the latter is part of the state of Tasmania, managed by the Tasmanian Parks and Wildlife Service (PARKS AND WILDLIFE SERVICE 2006).

Of the thirteen island groups, nine have the highest World Conservation Union (IUCN) rating (1a) (CHAPE et al. 2003), eight include islands which are World Heritage sites (UNEP-WCMC 2006), but only Macquarie Island is a UNESCO Biosphere Reserve (PARKS AND WILDLIFE SERVICE 2006). At present, none of the groups include islands which are listed as Ramsar sites according to the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, although applications have been made or proposed for five groups – UKOTCF 2005, SOUTH AFRICA 2006, McIVOR 2006, UKOTCF 2006) and South Africa will soon be listed (D. Peck pers. comm. 2006). Nine groups include some of the 18 islands listed by Chown et al. 2001 (needed to ensure the conservation of ≥90 % of indigenous species in the sub-Antarctic, while supporting a minimum number of alien species) (Tab. 1). All the islands have some degree of national protection, with the French islands declared part of a National Nature Reserve in 2006 (FRANCE 2006).

At most island groups, fishing is prohibited or strictly controlled in the 12-nautical mile (NM) zone, although at the Tristan Islands of Gough (COOPER & RYAN 1993), Nightingale (COOPER et al. in press) and Inaccessible (RYAN & GLASS 2001), as well as at Amsterdam and Saint-Paul Islands (T. Micol pers. comm. 2006), a single rock lobster fishery operates in this zone while at Macquarie Island, fishing is not permitted within 3 NM from land (PARKS AND WILDLIFE SERVICE 2006) (Tab. 1). At all islands, controlled fisheries operate within the Exclusive Economic Zone (EEZ). There are whale sanctuaries around the Australian islands (following the Environment Protection and Biodiversity Conservation Act of 1999), the New Zealand islands (DEPARTMENT OF CONSERVATION 1998) and the French islands (according to the Environmental Code of 1995). A 4980 km² area around the Auckland Islands (in the New Zealand group) is a marine reserve (NEW ZEALAND 2003) and marine protection options around the Campbell, Bounty and Antipodes islands are being investi-

gated (DEPARTEMENT OF CONSERVATION 2006). Heard and McDonald Islands are contained within a 65000 km² marine reserve (AAD 2005) and the Macquarie Island Marine Park, located adjacent to Macquarie Island (PARKS AND WILDLIFE SERVICE 2006), covers an area of 162,000 km². South Africa intends declaring a large Marine Protected Area within the EEZ around the Prince Edward Islands (LOMBARD et al. in press).

All except one of the involved countries are signatories of seven international agreements and conventions, which are relevant to addressing conservation threats at Southern Ocean islands (Tab. 2). The exception is France, which has agreed to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) but is not a signatory to this convention. For the United Kingdom, all agreements and conventions have been extended to the overseas territories of SGSSI and Tristan da Cunha (Tab. 2). There are formal management plans for all except the French islands, and all except South Georgia and the Australian islands have established committees of experts to advise on conservation and management issues (Tab. 1). The government of SGSSI intends to establish a panel of advisors (GSGSSI 2004), and the revised management plan for Macquarie Island recommends the establishment of a World Heritage Area Consultative Committee (PARKS AND WILDLIFE SERVICE 2006).

Utilisation of the terrestrial environment

All island groups except Heard and McDonald and the five New Zealand island groups are regularly visited – at least once a year – by scientific expeditions and have research and / or meteorological bases occupied year-round (the base on Campbell Island was closed to year-round occupation in 1995) (COOPER & RYAN 1993, DEPARTMENT OF CONSERVATION 1998, McINTOSH & WALTON 2000, RYAN & GLASS 2001, AAD 2005, ANONYMOUS 2006, CHOWN et al. 2006, PARKS AND WILDLIFE SERVICE 2006). The annual number of semi-permanent occupants ranges from zero to over 100 (Tab. 3, CHOWN et al. 1998).

Tourism is not allowed at four of the thirteen island groups:

| Convention | | |
|-------------------------|--|--------------------|
| Short title | Full title | Website address |
| ACAP | Agreement on the Conservation of Albatrosses and Petrels | www.acap.aq |
| CBD / Rio Convention | Convention on Biological Diversity | www.biodiv.org |
| CCAMLR | Convention on the Conservation of Antarctic Marine Living Resources | www.ccamlr.org |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora | www.cites.org |
| CMS / Bonn Convention | Convention on the Conservation of Migratory Species of Wild Animals | www.cms.int |
| Ramsar | Convention on Wetlands of International Importance Especially as Waterfowl Habitat | www.ramsar.org |
| World Heritage Convent. | Convention Concerning the Protection of the World Cultural and Natural Heritage | www.whc.unesco.org |

Tab. 2: Selected international agreements and conventions with special relevance to conservation threats at Southern Ocean islands without resident human occupants, signed or ratified by five involved countries and, for the United Kingdom, extended to Overseas Territories.

Tab. 2: Ausgewählte internationale Vereinbarungen und Konventionen mit besonderer Bedeutung für den Schutz der unbesiedelten Inseln im Südozean, unterzeichnet oder ratifiziert durch fünf einbezogene Länder und für Übersee-Territorien Großbritanniens.

| Island group | Islands | Area (km ²) | Visitor extent | | | | Mineral exploitation ² | Activities | | |
|--------------------------|---------------|-------------------------|-------------------------|------------------------------------|-----------------------|-----------------------------|-----------------------------------|----------------------------------|---|-------------|
| | | | Occupation ¹ | Annual occupants (max. year-round) | Visits by permit only | Tourism (numbers) | | Exploitation of indigenous fauna | Introduced mammals, deliberately maintained | Cultivation |
| S. Georgia | | 3755 | P | 111 (35) | yes | yes, (c. 4000) | N | past only | no | no |
| Prince Edwards | Marion | 290 | P | 51 (14) | yes | no | N | past only | no | no |
| | Prince Edward | 44 | N | 0 | yes | no | N | past only | no | no |
| Crozet | Cochons | 70 | N | 0 | yes | no | N | past only | no | no |
| | Apotres | 3 | N | 0 | yes | no | N | past only | no | no |
| | Pingouin | 3 | N | 0 | yes | no | N | past only | no | no |
| | Est | 130 | N | 0 | yes | no | N | past only | no | no |
| | Possession | 150 | P | 49 (27) | yes | yes (c. 60) | NP | past only | no | yes |
| Kerguelen | Grande Terre | 7200 | P | 123 (68) | yes | yes (c. 60) | NP | past only | yes | yes |
| Heard and McDonald | Heard | 368 | N | 0 | yes | yes (<100) | NP | past only | no | no |
| | McDonald | 3 | N | 0 | yes | no | NP | never | no | no |
| Macquarie | | 128 | P | 57 (25) | yes | yes (750) | NP | past only | no | yes |
| Tristan | Gough | 57 | P | 38 (8) | yes | no | N | past only | no | no |
| | Inaccessible | 12 | I | 0 | yes | yes (<200) | N | past only | no | no |
| | Nightingale | 4 | I | 0 | | yes (<300) | N | current | no | no |
| Amsterdam and Saint-Paul | Amsterdam | 55 | P | 38 (25) | yes | yes (c. 60) | NP | past only | yes | yes |
| | Saint-Paul | 8 | N | 0 | yes | yes (c. 60) | NP | past only | no | no |
| Auckland | | 626 | I | 0 | yes | yes, up to 600 ³ | N | past only | no | no |
| Campbell | | 113 | I | 0 | yes | yes, up to 600 ³ | N | past only | no | no |
| Snares | | 3 | I | 0 | yes | no | N | past only | no | no |
| Antipodes | | 21 | I | 0 | yes | no | N | past only | no | no |
| Bounty | | 1 | N | 0 | yes | no | N | past only | no | no |

Tab. 3: Extent of visitation and human activities at Southern Ocean islands without resident human occupants. Island areas and number of annual occupants adapted from CHOWN et al. 1998. ¹Occupation P = permanent base, I = intermittently occupied field station, N = no permanent structure. ²Mineral exploitation N = none currently taking place, NP = not permitted, NP* = Not permitted in a National Nature Reserve, status due to apply in 2006. ³150 at small sites, 600 at large sites.

Tab. 3: Besuchsumfang und menschliche Tätigkeiten auf unbesiedelten Inseln im Südozean. Inselflächen und jährliche Zahl der Besucher nach CHOWN et al. 1998. ¹Besucher P = permanent besetzte Station, I = periodisch besetzte Feldstation, N = kein permanentes Bauwerk ²Abbau von Rohstoffen N = findet zur Zeit nicht statt, NP = nicht erlaubt, NP* = nicht erlaubt in einem nationalen Naturschutzgebiet, Status bezogen auf 2006. ³150 an kleinen Stellen, 600 an großen Stellen.

Prince Edwards (HEYDENRYCH & JACKSON 2000, CHOWN et al. 2006) and Antipodes, Bounty and Snares Islands (DEPARTMENT OF CONSERVATION 1998) (Tab. 3). At the other island groups, tourist access is restricted to certain islands and in most cases, to certain sites on those islands (COOPER & RYAN 1993, DEPARTMENT OF CONSERVATION 1998, MCINTOSH & WALTON 2000, RYAN & GLASS 2001, AAD 2005, CHOWN et al. 2006, PARKS AND WILDLIFE SERVICE 2006, PASTEUR & WALTON 2006) (Tab. 4). South Georgia, the second largest island group after Kerguelen, receives the highest number of tourists annually (Tab. 3). The number of visitors per season is only restricted at Macquarie, Auckland and Campbell Islands (Tab. 4). Other restrictions include limits on vessel capacity, the daily number of visiting vessels, number of visitors ashore at one time, visitor group size, time spent ashore, number of landing sites, and overnight visits (Tab. 4). Heard Island receives less than 100 visitors per season and due to its remote location, it is considered unlikely that this figure will increase during the seven-year life of the current management plan (AAD 2005). The French islands also currently receive a relatively small number of visitors (53-58 per year), as opportunities are largely restricted to the four annual supply voyages (only two foreign tourist ships visited these islands in the last four years – T. Micol pers. comm. 2006). Tourism at the other island

groups is increasing. At South Georgia, for example, the number of visitors doubled between 1995 and 2005; in the 2005/06 season, the island group received 49 cruise ship visits and 26 yacht visits, and 5427 passengers (GSGSSI 2006). Walking tours are the most common form of tourism, but there is an increasing demand for a greater range of activities. At Kerguelen, for example, there has been increasing pressure for a variety of recreational activities such as hunting and fishing (T. Micol pers. comm. 2006).

Tour operators who are members of the International Association of Antarctic Tour Operators (IAATO) are not only subject to the national legislation and local administrative measures in place at the 13 island groups, but must also adhere to IAATO bylaws and regulations. These apply not only in the Antarctic but wherever landings are made. This implies a strict application of the Antarctic Treaty's Environmental Protocol measures and associated guidelines. Measures to reduce visitor impact include a limit on ship capacity (maximum of 500 passengers), a limit on the number of visitors allowed ashore at one time (maximum of 100 passengers plus expedition staff), and restrictions on landing sites and the time spent ashore for vessels carrying large numbers of passengers (IAATO 1992a). However, local administrative measures do

| | Limit on no. of visitors in season | No. of pass. per ship | No. of vessels per day | No. of visitors ashore at one time | Visitor group size | Time ashore | Landing sites | Accessible onshore areas | Over-night visits | Camping | Adventure sports |
|---------------------------------------|------------------------------------|-------------------------|-------------------------|------------------------------------|--------------------------------|---------------------|-----------------------------------|-------------------------------------|------------------------------|-----------------|------------------|
| South Georgia ^{1,2} | no limit | limit, except Grytviken | limit, 1-3 site-depend. | limit, 65-300, site-depend. | limited at one site, 20 guided | limited at one site | limited | limited, specially protected areas | allowed in some areas | allowed | permit required |
| Possession (Iles Crozet) ³ | no limit | no limit | no limit | no limit | no limit, recom. 12-15 guided | limited | limited to the base | limited, 2 visitor access sites | not possible | not allowed | not allowed |
| Kerguelen ³ | no limit | no limit | no limit | no limit | no limit, recom. 12-15 guided | limited | limited, 5-6 visitor access sites | limited, 5-6 visitor access sites | allowed in 3-4 huts | not allowed | not allowed |
| Heard ⁴ | no limit | no limit | no limit | limits of 30 or 60, site-depend. | limited, 15 with guide | limited | limited to visitor access zones | limited, 3 visitor access zones | permit required | permit required | permit required |
| Macquarie ^{5,6} | limited, 750 per season | max. 200 | limit, one | limit, 60-100, site-depend. | limited, 15 guided | limited | limited, 2 only | limited, 2 sites | not allowed | not allowed | not allowed |
| Inaccessible ⁷ | no limit | no limit | limit, one | limit, 100 per day | limited 8 guided | not specified | limited, 2 only | limited, "natural zone" | not allowed | not allowed | not allowed |
| Nightingale ⁸ | no limit | no limit | limit, one | limit, 100 per day | limited, 8 guided | not specified | limited, 2 only | limited, 2 sites | not allowed | not allowed | not allowed |
| Amsterdam ³ | no limit | no limit | no limit | no limit | no limit | limited | limited to the base | limited, only around base | allowed in one hut near base | not allowed | not allowed |
| Saint-Paul ³ | no limit | no limit | no limit | no limit | recom. 12-15 guided | limited | limited to one place | limited, only near landing site | not allowed | not allowed | not allowed |
| Auckland ⁹ | limited, 150-600 site-depend. | no limit | limit, one | limit 50 / 150 site-depend. | limited, 20 guided | limited | limited to permit condition | limited, certain sites on 3 islands | not allowed | not allowed | not allowed |
| Campbell ⁹ | limited 150-600 site-depend. | no limit | limit, one | limit 50 / 150 site-depend. | limited, 20 guided | limited | limited to permit condition | limited, certain sites on 3 islands | not allowed | not allowed | not allowed |

Tab. 4 Restrictions in place to reduce visitor impact at islands in the Southern Ocean at which tourism takes place but there are no resident human occupants. Sources: ¹PONCET 2003, ²PASTEUR & WALTON 2006, ³ANONYMOUS 2004, 2005, 2006, ⁴AAD 2005, ⁵PARKS AND WILDLIFE SERVICE 2005, ⁶PARKS AND WILDLIFE SERVICE 2006, ⁷RYAN & GLASS 2001, ⁸J.P. GLASS, pers. comm. 2006. ⁹DEPARTMENT OF CONSERVATION 1998. Where no published information was available, the personal knowledge of authors of this paper was used to complete the table.

Tab. 4: Beschränkungen auf unbesiedelten Inseln im Südozean, aber mit Tourismus, um Besucherauswirkungen zu reduzieren. Quellen: ¹PONCET 2003, ²PASTEUR & WALTON 2006, ³ANONYMOUS 2004, 2005, 2006, ⁴AAD 2005, ⁵PARKS AND WILDLIFE SERVICE 2005, ⁶PARKS AND WILDLIFE SERVICE 2006, ⁷RYAN & GLASS 2001, ⁸J.P. GLASS, pers. comm. 2006. ⁹DEPARTMENT OF CONSERVATION 1998. Wenn keine publizierten Informationen vorhanden waren, wurde das persönliche Wissen der Autoren zur Vervollständigung der Tabelle verwendet.

not require vessels to apply IAATO regulations at any of the islands, which receive tourists.

All the island groups included in this comparison have experienced some degree of exploitation of indigenous fauna (mainly seals) in the past. Nightingale Island is unique in being the only island at which this form of exploitation still occurs – seabirds, eggs and guano are collected (St. HELENA GOVERNMENT 2006). Deliberately maintained populations of introduced mammals are only present at Kerguelen (Corsican Mouflon *Ovis ammon musimon* and sheep *O. aries*) and Amsterdam Island (cattle *Bos taurus*) (Tab. 3). No extraction of mineral resources is taking place at any of the island groups. This is only expressly disallowed in management plans for Macquarie Island (PARKS AND WILDLIFE SERVICE 2006) and Heard and McDonald Islands (AAD 2005), and at the French

islands (FRANCE 2006). Cultivation of fresh produce is only practiced at Macquarie Island (hydroponics) (PARKS & WILDLIFE SERVICE 2006) and the French islands (fruit orchards, vegetable gardens, greenhouses – ANONYMOUS 2006) (Tab. 3).

Expedition-related threats and management practices

Alien introductions

Invasive alien species have a major impact globally, including in the sub-Antarctic. Impacts are both direct and indirect, and include substantial local loss of biodiversity and changes to ecosystem processes (FRENOT et al. 2004). Sub-Antarctic islands have relatively low biodiversity, and invasive species are easily able to take advantage of unoccupied niches (BERG-

STROM & CHOWN 1999). In the past, the islands' isolation and severe climatic conditions provided a measure of protection against invasive species (CHOWN et al. 1998). However, the ameliorating climate in the Southern Ocean is likely to increase the risk of alien species' establishment (BERGSTROM & CHOWN 1999), and temperate islands are even more susceptible than are cooler ones (CHOWN et al. 1998). Furthermore, the number of species introduced to Southern Ocean islands also depends on surface area and the number of human visitors (CHOWN et al. 1998). A clear acceleration in the rate of plant species introductions has been demonstrated with the establishment of research stations on several French Southern Ocean islands (FRENOT et al. 2001) and at Gough Island, the rate of introduction of pterygote insect species since the establishment of the research station was estimated to be one successful establishment every three to four landings (GASTON et al. 2003). Remote wilderness locations in the southern hemisphere are attracting increasing visitor interest (e.g., NAVEEN et al. 2001).

Heard and McDonald Islands have the lowest number of recorded alien species (no vertebrates, one species of vascular plant and three species of terrestrial invertebrates – AAD 2005, CHOWN et al. 1998). Kerguelen has the most introduced species of mammals (seven), the Auckland and Campbell island groups have the most introduced bird species (ten each), Amsterdam has the highest recorded number of introduced insect species (18) and Possession Island of the Crozet group has the most species of introduced vascular plants (101) (CHOWN et al. 1998). All the countries maintaining sovereignty at the Southern Ocean islands considered here acknowledge the severity of the threat posed by alien species (COOPER & RYAN 1993, DEPARTMENT OF CONSERVATION 1998, MCINTOSH & WALTON 2000, RYAN & GLASS 2001, AAD 2005, ANONYMOUS 2006, CHOWN et al. 2006, PARKS AND WILDLIFE SERVICE 2006, PASTEUR & WALTON 2006) and all have or are currently investigating alien eradication and / or control programmes (Tab. 5). Most efforts have focused on alien mammals, but increasingly attention is turning to other taxa, such as plants and invertebrates (Tab. 5). For example, a plan for the management of alien vascular plants on the Prince Edward Islands has been drawn up (GREMMEN 2004). However, feral and domestic livestock are still retained on some islands and several groups allow cultivation of fresh produce, although these practices are usually restricted to demarcated areas or certain islands in a group (Tab. 3).

Cargo, food supplies, expeditioners' gear and clothing (including footwear, which can harbour microbial pathogens – CURRY et al. 2005) can all act as vectors for the introduction of alien organisms (WHINAM et al. 2005). Fresh fruit and vegetables may harbour microbes – this may have been the source of the fungal pathogen *Botryotinia fuckeliana* which now infects stands of the Kerguelen cabbage *Pringlea antiscorbutica* on Marion Island (KLOPPERS & SMITH 1998). Poultry and poultry products can carry avian viruses such as that causing Newcastle's Disease, which can affect the indigenous birds breeding on the islands. The risk of human-mediated disease transmission to wildlife in remote areas is illustrated by the fact that on the Antarctic Continent, antibodies of poultry viruses were only found in penguin colonies close to scientific bases (GARDNER et al. 1997). Avian Cholera has been proposed as the cause of mortalities of Indian Yellow-nosed Albatrosses *Thalasseeus*

carteri and Amsterdam Albatrosses *Diomedea amsterdamensis* on Amsterdam Island (WEIMERSKIRCH 2004) and Macaroni Penguins *Eudyptes chrysolophus* on Marion Island (CRAWFORD et al. 2005). Although strict quarantine measures apply to the importation of poultry products at the latter island, domestic fowl are kept at Amsterdam and the postulated disease outbreak there could have been the result of contamination by poultry and poultry products. Supply vessels (through hull or ballast water, LEWIS et al. 2003) and the transport used for ship-to-shore transfers (WHINAM et al. 2005) are also potential sources of contamination.

Effective quarantine procedures are essential to minimise the risk of accidental introductions. The strictness of these varies considerably between the island groups (Tab. 6 and references therein). At all islands, some form of zoning exists which may limit the human-assisted spread of alien species. All management plans require checks of cargo, food and expeditioners' gear and clothing, and the cleaning of footwear prior to disembarkation. At the French islands, for which there are no formal management plans, the cleaning of footwear is recommended but voluntary (T. Micol pers. comm. 2006). A complete ban on all fresh produce is only in effect at the Prince Edward Islands and Gough Island (from September 2006) but there are various restrictions on poultry and poultry products at all other islands. However, at some islands under French management, live poultry is allowed on station, although fertilised eggs are forbidden. All management plans require visiting vessels to be in possession of de-ratting exemption, and this is also a requirement for the French supply vessel, the "Marion Dufresne". At all islands where onshore mooring is possible, it is prohibited, except South Georgia. No management plans require that the hulls of supply vessels be anti-fouled, although anti-fouling is a consideration in the issuing of permits to visit the Australian islands and is a requirement for the "Marion Dufresne". Regulations pertaining to the discharge of ballast vary from no regulations to no discharge within 200 NM. At some islands, the prior cleaning of supply vessel hulls is required. For all islands where this applies, except the French islands, management recommendations specifically mention measures to prevent the transfer of alien species between nearby islands. At the French islands, such measures are voluntary. Only Australia (AAD 2006) and New Zealand (BAKER 1999) have developed response plans to deal with outbreaks of disease in animal colonies resulting in unusually high mortalities, although this is also required by the draft Prince Edward Islands Environmental Management Plan (CHOWN et al. 2006).

In addition to these quarantine measures, IAATO tour operators also follow IAATO recommended guidelines for boot and clothing decontamination. In some instances these are stricter than local regulations, e.g., the IAATO guidelines require the cleaning of boots both prior to the first disembarkation as well as in between landing sites during a voyage (IAATO 2005).

Despite the tightening of quarantine procedures at many island groups, recent establishments of alien biota have occurred (e.g., Hairy Bittercress *Cardamine hirsuta* discovered at South Georgia in 2002, PASTEUR & WALTON 2006, Procumbent Pearlwort *Sagina procumbens* discovered on Gough Island in 1998, GREMMEN et al. 2001, and the isopod *Porcellio scaber* first recorded at Marion Island in 2001, SLABBER & CHOWN 2002).

| | Alien eradication | | | Research priority | | Management objective | Required by legislation |
|---|--|---|--|-------------------|----------------|----------------------|--|
| | Past | Present | Future | alien species | climate change | | |
| South Georgia | Norway Rats on Grass Island ¹ | Hairy Bittercress ² , Norway Rats at certain sites ¹ | Norway Rats on main island (pilot study completed), 1 of 2 herds of Reindeer ² | yes | yes | yes | no |
| Prince Edwards | cats, Brown Trout (both Marion Island) ³ | Red Top, isopod (both Marion Island) ³ | mice on Marion Island (feasibility study commissioned), several species of vascular plants ³ | yes | yes | yes | yes, National Environment Management Biodiversity Act 2004 |
| Crozet | none | none (except control of rats at one seabird colony) | Consideration of Ship Rats on Possession, cats on Cochons, rabbits on Est | yes | yes | yes | no |
| Kerguelen | rabbits (3 islands), cats (1 island) ⁴ | Ship Rats and mice on some islands ⁵ | mice and rabbits on some islands | yes | yes | yes | no |
| Heard & McDonald | none | none | consideration of control / eradication of Annual Meadow Grass on Heard ⁶ | yes | yes | yes | no |
| Macquarie | cats, Wekas ⁷ | rabbits, Ship Rats ⁷ | rabbits, Ship Rats, mice and possibly some plant spec. ⁷ | yes | yes | yes | no |
| Gough | Asthma Weed, Guano Bush ⁸ | Procumbent Pearlwort ⁸ | mice (feasibility study undertaken) ⁹ | yes | no | yes | no |
| Inaccessible | none | New Zealand Flax ¹⁰ | flax control or eradication | yes | no | yes | no |
| Nightingale | none | New Zealand Flax ¹⁰ | flax control or eradication | yes | no | | no |
| Amsterdam and Saint-Paul | cattle (controlled, not eradicated) at Amsterdam, ¹¹ Ship Rats and rabbits at Saint-Paul ¹² | Poison Hemlock at Amsterdam since 2001 ¹³ | consideration of mice and cats at Amsterdam | yes | no | yes | no |
| New Zealand islands (comprises five groups) | cattle, rabbits and mice at Enderby and Rose Islands ¹⁴ , goats at Auckland Island ¹⁵ , cattle, sheep and Norway Rats at Campbell Island ¹⁶ | various alien plants, trials for removal of pigs and cats at main Auckland Island ¹⁵ | all alien species, especially pigs, cats at Main Auckland, mice at Antipodes, and certain alien plants ¹⁵ | yes | yes | yes | yes Reserves Act 1977 |

Tab. 5: Eradication of alien species of fauna (non-feral livestock not included) and flora at selected Southern Ocean island groups without resident human occupants. Scientific names: Annual Meadow Grass *Poa annua*, Asthma Weed *Conyza floribunda*, Cat (Domestic) *Felis catus*, Cattle (Domestic) *Bos taurus*, Goat (Domestic) *Capra hircus*, Guano Bush *Senecio burchelli*, Hairy Bittercress *Cardamine hirsuta*, isopod *Porcellio scaber*, Mouse (House) *Mus musculus*, Poison Hemlock *Conium maculatum*, Procumbent Pearlwort *Sagina procumbens*, New Zealand Flax *Phormium tenax*, Pig (Domestic) *Sus scrofa*, Rabbit (European) *Oryctolagus cuniculus*, Rats (Norway) *Rattus norvegicus*, Rats (Ship) *R. rattus*, Red Top *Agrostis gigantea*, Reindeer *Rangifer tarandus*, Sheep (Domestic) *Ovis aries*, Weka *Gallirallus australis*. Sources: ¹PONCET et al. 2003. ²PASTEUR & WALTON 2006. ³DE VILLIERS & COOPER in press. ⁴LORVELEC & PASCAL 2005. ⁵ANONYMOUS 2006. ⁶E. McIvor, pers. comm. 2006. ⁷PARKS & WILDLIFE SERVICE 2006. ⁸COOPER & RYAN 1993. ⁹ANGEL & COOPER in press. ¹⁰RYAN et al. 2004. ¹¹MICOL & JOUVENTIN 1995. ¹²MICOL & JOUVENTIN 2002. ¹³ANONYMOUS 2006. ¹⁴TORR 2002. ¹⁵DEPARTMENT OF CONSERVATION 1998. ¹⁶SEDDON & MALONEY 2003.

Tab. 5: Ausrottung von eingeführten Tieren (nicht-verwilderte Tiere nicht eingeschlossen) und Pflanzenarten auf ausgewählten unbesiedelten Inseln im Süd-ozean. Wissenschaftliche Namen: einjähriges Rispengras *Poa annua*, weißes Berufskraut *Conyza floribunda*, Hauskatze *Felis catus*, Hausrind *Bos taurus*, Hausziege *Capra hircus*, schmalblättriges Greiskraut *Senecio burchelli*, behaartes Schaumkraut *Cardamine hirsuta*, Mauerassel *Porcellio scaber*, Hausmaus *Mus musculus*, gefleckter Schierling *Conium maculatum*, niederliegendes Mastkraut *Sagina procumbens*, Neuseeländer Flachs *Phormium tenax*, Hausschwein *Sus scrofa*, Wildkaninchen *Oryctolagus cuniculus*, Wanderratte *Rattus norvegicus*, Hausratte *R. rattus*, weißes Straußgras *Agrostis gigantea*, Ren *Rangifer tarandus*, Hausschaf *Ovis aries*, Weka *Gallirallus australis*. Quellen: ¹PONCET et al. 2003. ²PASTEUR & WALTON 2006. ³DE VILLIERS & COOPER in press. ⁴LORVELEC & PASCAL 2005. ⁵ANONYMOUS 2006. ⁶E. McIvor, pers. comm. 2006. ⁷PARKS & WILDLIFE SERVICE 2006. ⁸COOPER & RYAN 1993. ⁹ANGEL & COOPER in press. ¹⁰RYAN et al. 2004. ¹¹MICOL & JOUVENTIN 1995. ¹²MICOL & JOUVENTIN 2002. ¹³ANONYMOUS 2006. ¹⁴TORR 2002. ¹⁵DEPARTMENT OF CONSERVATION 1998. ¹⁶SEDDON & MALONEY 2003.

Quarantine procedures must be exhaustive and diligently implemented in order to be effective. Even if cargo is checked at pre-sailing storage facilities, infestation can occur during transfer to the supply vessel (DE VILLIERS 2004). Despite clothing checks, small seeds can nestle in the seams of bags and packs or adhere to Velcro fastenings and escape detection (COOPER et al. 2003, WHINAM et al. 2005, COOPER et al. 2006). Although footwear may be scrubbed, the efficacy of the disinfectant used is not always known (CURRY et al. 2005). Lack of enforcement of contracts with suppliers can also result in infestation of food supplies (COOPER & DE VILLIERS 2003, WHINAM et al. 2005). Only at the Prince Edward Islands,

Gough Island and the New Zealand islands is someone appointed to be in charge of quarantine issues on board and ashore (Tab. 6). Lastly, independent checks of all expeditioners' gear would be prohibitively resource-intensive and the onus for this is ultimately on each individual. Education is thus a key issue and is addressed in all management plans (COOPER & RYAN 1993, DEPARTMENT OF CONSERVATION 1998, MCINTOSH & WALTON 2000, RYAN & GLASS 2001, AAD 2005, CHOWN et al. 2006, PARKS AND WILDLIFE SERVICE 2006, PASTEUR & WALTON 2006).

| A | | South Georgia ^{1, 2} | Prince Edwards ^{3, 4, 5, 6} | Crozets ^{7, 8} | Kerguelen ^{7, 8} | Heard & McDonald ⁹ | Macquarie ^{10, 11} |
|-------------|--|--|---|--|--|--|---|
| Pre-sailing | stores, inspect | yes on BAS vessels | yes | no | no | yes | yes |
| | food, inspect | yes on BAS vessels only | yes | no | no | yes | yes |
| | fresh produce allowed | | no | yes, untreated | yes, untreated | yes for extended visits, if treated | yes, ozone treated |
| | poultry products allowed | eggs (untreated) deboned meat allowed on station but not in field | no eggs allowed, deboned meat allowed on station but not in field | no restrictions | no restrictions | none allowed | eggs (untreated) allowed on station but not in field |
| Sailing | vessel, de-ratting exemption | yes | yes | supply vessel only | supply vessel only | yes | yes |
| | vessel, ballast discharge | no regulations, under consideration | not within 3 NM | supply vessel only, not with in 200 NM | supply vessel only, not with in 200 NM | not in inner marine zone | not within 12 NM |
| | vessel, hull treatments | no regulations | hull to be cleaned | supply vessel only, hulls antifouled and cleaned | supply vessel only, hulls antifouled and cleaned | hull to be cleaned, anti-fouling considered in permits | hulls to be cleaned, anti-fouling considered in permits |
| | inter-island transfer procedures | yes, for Bird Island only | yes | no | no | yes | NA |
| | quarantine officer on board | no | yes, Conservator Officer | no | no | optional, considered in issuing of permits | no |
| | gear inspections | only compuls. for BAS trips | compulsory | voluntary | voluntary | compulsory | compulsory |
| | boot-washing | only compulsory for cruise ships | compulsory | compulsory on supply vessel only, becoming compulsory for others | compulsory on supply vessel only, becoming compulsory for others | compulsory | compulsory |
| On island | quarantine officer on station | no | yes, Conservation Officer | no | yes, Conservation Officer 8 months/year | no station present; expedition leader takes responsibility | yes |
| | onshore mooring | allowed | not allowed (min. distance 200 m offshore) | not possible | not possible | not allowed | not allowed (min. distance 200 m offshore) |
| | transport (dinghies, helicopters, etc) | cleaned, inspected | cleaned, inspected | no procedures | no procedures | cleaned, inspected | cleaned, inspected |
| | island zonation | pecially protected areas, 2 classes, all rat-free areas proposed Sensitive Areas | 4 management zones | 5 protected (research) and 3 restricted access islands/zones | 8 protected (research), 3 restricted access islands /zones | 7 management zones (5 terrestrial, 2 marine) | 3 management zones, Special Management Areas, and Tourist Areas |
| | livestock maintained | no | no | no | sheep, mouflon | no | no |
| | cultivation practiced | no | no | yes, greenhouse | yes, 2 greenhouses | no | hydroponics |
| | pest traps on station | yes | yes | no | no | | yes |
| | disease contingency plan | no | actions outlined in management plan, contingency plan required | no | no | | yes |

Table 6 continued next page

Table 6 continued

| B | | Gough ¹² | Inaccessible ¹³ | Nightingale ¹⁴ | Amsterdam and Saint-Paul ^{7, 8} | New Zealand islands (five groups) ^{15, 16} |
|-------------|---------------------------------------|---|--|--|--|---|
| Pre-sailing | stores, inspect | yes | yes | no | no | yes |
| | food, inspect | yes | yes | yes | no | yes |
| | fresh produce allowed | not allowed, except potatoes | | yes (restricted to Tristinians) | no restrictions | allowed, must be free of soil |
| | poultry products allowed | eggs irradiated, de-boned poultry allowed on station only | none allowed | yes (restricted to Tristinians) | no restrictions (live poultry on station) | only allowed if sourced from New Zealand |
| Sailing | vessel de-ratting exemption | yes | yes | yes | supply vessel only | yes |
| | vessel, ballast discharge | no regulations | no regulations | no regulations | supply vessel only, not within 200 NM | no regulations |
| | vessel, hull treatments | not specified | not specified | not specified | supply vessel only, hulls anti-fouled, cleaned | hull check, but no anti-fouling requirement |
| | inter-island transfer procedures | yes | yes | yes | yes | yes |
| | quarantine officer on board | yes (Environmental Officer) | yes (Conservation Officer) | yes (Conservation Officer) | no | yes, larger vessels (Conservation Officer) |
| | gear inspections | compulsory | compulsory | compulsory | voluntary | compulsory |
| | boot-washing | compulsory | compulsory | compulsory | compuls. on supply vessel only, becom. compuls. for others | compulsory |
| On island | quarantine officer on station | yes (Conservation Officer) | no | no | yes (Conservation Officer 4 mo/year on Amsterdam) | yes |
| | onshore mooring | not possible | not permitted (min. distance 200 m offshore) | not permitted (min. distance 200 m offshore) | not possible | not permitted |
| | transport (dinghies, helicopter, etc) | cleaned, inspected | cleaned, inspected | cleaned, inspected | no procedures | cleaned, inspected |
| | island zonation | four management zones | four management zones | two access zones | three protected (research) and one restricted access islands/zones | tourism at three (refuge) islands only. Large and small sites defined at tourist (refuge) islands. All other islands zoned as "min. impact" |
| | livestock maintained | no | no | no | poultry, cattle | no |
| | cultivation practiced | no | no | no | yes, greenhouse and gardens, vegetable, fruits | no |
| | pest traps on station | suggest. in management plan | no | no | no | yes |
| | disease contingency plan | no | no | no | no | yes, for New Zealand Sea Lion |

Tab. 6: Quarantine measures for the prevention of the introduction of alien organisms at Southern Ocean islands without resident human occupants. BAS = British Antarctic Survey, A = Sub-Antarctic islands, B = cool temperate islands. Blank cells indicate no information available. Sources: ¹MCINTOSH & WALTON 2000. ²PASTEUR & WALTON 2006. ³COOPER et al. 2003. ⁴CHOWN et al. 2006. ⁵COOPER et al. 2006. ⁶DE VILLIERS & COOPER in press. ⁷ANONYMOUS 2005. ⁸ANONYMOUS 2006. ⁹AAD 2005. ¹⁰PARKS AND WILDLIFE SERVICE 2006. ¹¹AAD 2006. ¹²COOPER & RYAN 1993. ¹³RYAN & GLASS 2001. ¹⁴J.P. Glass pers. comm. 2006. ¹⁵DEPARTMENT OF CONSERVATION 1988. ¹⁶AGNEW & ROBERTS 2004. ¹⁷BAKER 1999. Where no published information was available, the personal knowledge of authors of this paper was used to complete this table.

Tab. 6: Quarantänemaßnahmen zum Schutz gegen die Einfuhr fremder Organismen auf die Inseln im Südozean ohne menschliche Bewohner. BAS = British Antarctic Survey, A = Subantarktische Inseln, B = kühl-gemäßigte Inseln. Unbelegte Zellen zeigen, dass keine Informationen vorliegen. Quellen: ¹MCINTOSH & WALTON 2000. ²PASTEUR & WALTON 2006. ³COOPER et al. 2003. ⁴CHOWN et al. 2006. ⁵COOPER et al. 2006. ⁶DE VILLIERS & COOPER in press. ⁷ANONYMOUS 2005. ⁸ANONYMOUS 2006. ⁹AAD 2005. ¹⁰PARKS AND WILDLIFE SERVICE 2006. ¹¹AAD 2006. ¹²COOPER & RYAN 1993. ¹³RYAN & GLASS 2001. ¹⁴J.P. Glass pers. comm. 2006. ¹⁵DEPARTMENT OF CONSERVATION 1988. ¹⁶AGNEW & ROBERTS 2004. ¹⁷BAKER 1999. Wenn keine publizierten Informationen vorhanden waren, wurde das persönliche Wissen der Autoren zur Vervollständigung der Tabelle verwendet.

Disturbance of wildlife

Human disturbance can have negative impacts on breeding seabirds and seals. This can range from short-term behavioural and physiological responses (BORN et al. 1999, HOLMES et al. 2005, DE VILLIERS et al. 2005, 2006) to reduced breeding success (WOEHLER et al. 1994, McCLUNG et al. 2004). Most studies of disturbance concentrate on the responses of wildlife to approaches by humans on foot, but birds and seals may also be affected by aircraft operations (COOPER et al. 1994, ROUNSEVELL & BINNS 1991, HARRIS 2005) and scientific research (GÖTMARK 1992). Responses to human disturbance may be influenced by a range of factors, including the distance to which wildlife are approached (HOLMES et al. 2005, DE

VILLIERS et al. 2005), visitor group size (HOLMES 2006), stage of breeding (VÍÑUELA et al. 1995) and habituation effects (WALKER et al. 2006).

At all islands where tourism takes place (except the French islands, where group sizes are typically 20 or less – ANONYMOUS 2004, 2005, 2006) limits are imposed on visitor group size (Tab. 4 and references therein). At almost all islands, guidelines exist as to the appropriate minimum approach distances for breeding wildlife (Tab. 7 and references therein). At some islands, one distance is specified for all wildlife, e.g., for tourists at Macquarie Island and the New Zealand sub-Antarctic islands, the minimum approach distance is 5 m to all breeding seabirds and seals (PARKS AND WILDLIFE SERVICE

| | Code of conduct, all visitors | Min. approach distances | Ethics approval research | Aircraft | Small boats | Motorized vehicles |
|---|--|-------------------------------|--------------------------------|--|--|---|
| South Georgia ^{1, 2} | yes, guidelines for visitors | at one site only | yes | regulations regarding distance offshore, altitude, landing distances from seal and penguin colonies | no regulations | restricted to a certain area |
| Prince Edwards ³ | yes, visitors' guide | yes | yes | recommended flight paths, distance off- shore, altitude, landing distances from seabird colonies, restricted landing sites | no regulations | none operating |
| Crozet ^{4, 5} | yes, instructions for passengers | yes | yes | recommended flight paths, distance offshore, altitude, landing distances from seabirds and seal colonies | no regulations | restricted to base and to access to the landing site |
| Kerguelen ^{4, 5} | yes, instructions for passengers | yes | yes | recommended flight paths, distance offshore, altitude, landing distances from seabird and seal colonies | no regulations | restricted to base and nearby sites; tracks to huts |
| Heard and McDonald ⁶ | yes, environmental code of conduct for visitors | yes | yes | regulations regarding flight paths, altitude, landing sites and cetacean separation distances | regulations for the approach of cetaceans | restricted to certain areas |
| Macquarie ^{7, 8} | yes, guidelines for tourist opera- tions and visits | yes | yes | regulations regarding flight paths, landing sites, distance offshore, altitude, cetacean separation distances | regulations for the approach of cetaceans | restricted to a certain area |
| Gough ⁹ | yes, in management plan | no | yes | regulations for altitude, distance offshore, and landing distances from seal and penguin colonies | regulations for the approach of cetaceans | none operating |
| Inaccessible ¹⁰ | yes, guidelines for day visitors | yes | yes | regulations for timing of flights, altitude and distance offshore | no regulations | none operating |
| Nightingale ¹¹ | yes, guidelines for day visitors | yes | yes | regulations for timing of flights, altitude and distance offshore | no regulations | none operating |
| Amsterdam and Saint-Paul ^{4, 5} | yes, instructions for passengers | yes | yes | recommended flight paths, distance offshore, altitude, landing distances from seabird and seal colonies | no regulations | Amsterdam: restricted to base and tracks for cattle management Saint-Paul: none operating |
| New Zealand islands (five groups) ¹² | yes, minimum impact code | yes | yes | recommended altitudes | regulations for approach of cetaceans | none operating |

Tab. 7: Regulations pertaining to the disturbance of wildlife by aircraft, small boats, motorized vehicles and people on foot, at Southern Ocean islands without resident human occupants. Sources: ¹SOUTH GEORGIA WILDLIFE AND LOW FLYING AVOIDANCE MAP, 1: 100 000. BRITISH ANTARCTIC SURVEY, CAMBRIDGE. ²PONCET & CROSBIE 2006. ³CHOWN et al. 2006. ⁴ANONYMOUS 2005. ⁵ANONYMOUS 2006. ⁶AAD 2005. ⁷PARKS AND WILDLIFE SERVICE 2005. ⁸PARKS AND WILDLIFE SERVICE 2006. ⁹COOPER & RYAN 1993. ¹⁰RYAN & GLASS 2001. ¹¹J.P. Glass pers. comm. 2006. ¹²DEPARTMENT OF CONSERVATION 1988. Where no published information was available, the personal knowledge of authors of this paper was used to complete this table.

Tab 7: Regelungen betreffend der Störung der Tierwelt durch Flugzeuge, kleine Boote, motorisierte Fahrzeuge und Fußgänger auf unbesiedelten Inseln im Südozean. Quellen: ¹SOUTH GEORGIA WILDLIFE AND LOW FLYING AVOIDANCE MAP, 1: 100 000. BRITISH ANTARCTIC SURVEY, CAMBRIDGE. ²PONCET & CROSBIE 2006. ³CHOWN et al. 2006. ⁴ANONYMOUS 2005. ⁵ANONYMOUS 2006. ⁶AAD 2005. ⁷PARKS AND WILDLIFE SERVICE 2005. ⁸PARKS AND WILDLIFE SERVICE 2006. ⁹COOPER & RYAN 1993. ¹⁰RYAN & GLASS 2001. ¹¹J.P. Glass pers. comm. 2006. ¹²DEPARTMENT OF CONSERVATION 1988. Wenn keine publizierten Informationen vorhanden waren, wurde das persönliche Wissen der Autoren dieses Papiers zur Vervollständigung der Tabelle verwendet.

2006, DEPARTMENT OF CONSERVATION 2004). At other islands, guidelines are species-specific (e.g., French islands, T. Micol pers. comm. 2006) or particularly strict at certain stages of breeding, e.g., 25 m for displaying Wandering Albatrosses *Diomedea exulans* at South Georgia (GSGSSI 2005), and restricted access to Amsterdam Albatrosses during the stages of egg laying and hatching (DECANTE et al. 1987). Guidelines may also differ for different classes of expeditioners. For example at Macquarie Island, tourists only have access to the limited suite of wildlife species found at the designated visitor sites and the minimum approach distance to all of these species is 5 m. Expeditioners participating in the Australian Antarctic programme may need to approach a wider suite of species during the course of their research, support or management work but species-specific guidelines exist, such as 25 m for all albatross species and 50 m for Southern Giant Petrel colonies (N. Carmichael pers. comm. 2006). At all islands there is a code of conduct, which aims to minimize disturbance of any sort, and ethics approval is required for scientific research (Tab. 7).

There is also considerable variation in guidelines for aircraft operations, and these include suggested flight paths and corridors, limits on the number of landing sites, and regulations on wildlife colony over-flight heights and landing distances (Tab. 7 and references therein). Regulations relating to the approach of marine mammals at sea by small boats are only specified for the Australian islands (AAD 2005, PARKS AND WILDLIFE SERVICE 2006), the New Zealand islands (DEPARTMENT OF CONSERVATION 1998), and at Gough Island (COOPER & RYAN 1993) and Inaccessible Island (RYAN & GLASS 2001). Similarly, there are policies relating to the approach of wildlife on station by motorised vehicles in the new Macquarie Island Management Plan (PARKS AND WILDLIFE SERVICE 2006).

The marine wildlife watching guidelines of IAATO also apply to member tour operators. Methods of approaching wildlife at sea or on land are described, and minimum approach distances by aircraft, vessel or pedestrians are listed for cetaceans, seals and seabirds (IAATO 1992b).

Disturbance of significant sites, including habitat modification

At all island groups, historical sites exist which reflect the various countries' cultural heritages. These generally pre-date the establishment of scientific / meteorological bases, and include shipwrecks and other remnants of sealing operations and voyages of discovery. Sites of heritage value have been identified at all island groups and measures for their protection are in place (COOPER & RYAN 1993, DEPARTMENT OF CONSERVATION 1998, MCINTOSH & WALTON 2000, RYAN & GLASS 2001, AAD 2005, CHOWN et al. 2006, PARKS AND WILDLIFE SERVICE 2006, PASTEUR & WALTON 2006, T. Micol pers. comm. 2006). The disturbance of sensitive geological features is thoroughly addressed in the Macquarie Island Management Plan (PARKS AND WILDLIFE SERVICE 2006) and lava tunnels are given special protection at Heard and McDonald Islands (AAD 2005) and the Prince Edward Islands (CHOWN et al. 2006).

Fires can result in habitat destruction and modification, partic-

ularly at the cool temperate islands, which are more vegetated and have lower annual rainfalls than do the sub-Antarctic islands (e.g., an accidental fire at Amsterdam Island in 1974, DECANTE et al. 1987). In general, the lighting of fires is restricted to the burning of waste at or near island bases although at some islands, camp fires are permitted (Tab. 4).

Although trampling by people in sub-Antarctic environments can be highly visible, little is known about its ecological effects. An assessment of the impacts of human trampling on Marion Island revealed that different habitats respond in different ways, depending on soil characteristics and the structure of the original vegetation. Generally, however, trampling negatively affected species richness and plant cover and tracks were associated with an increase in the number and cover of introduced species (GREMMEN et al. 2003). On Macquarie Island, human trampling was shown to favour vascular plants, including exotics (SCOTT & KIRKPATRICK 1994). The management of human trampling and its potential effects varies considerably between island groups but only at Macquarie Island is there a formal track management strategy (DIXON 2001), although the Gough Island Management Plan outlines various measures to reduce the impact of human trampling (COOPER & RYAN 1993) and a track monitoring programme has been initiated on New Zealand's Campbell and Auckland Island groups (A. Roberts pers. comm. 2006.). On station, walkways may be employed to prevent damage to vegetation (PEIMPWG 1996) and may also serve to reduce disturbance to wildlife, by enforcing minimum approach distances (e.g., "catwalks" around the Marion Island base). Boardwalks for tourists to wildlife viewing points on Macquarie and Campbell Islands serve both purposes (PARKS AND WILDLIFE SERVICE 2006, DEPARTMENT OF CONSERVATION 1998), and 1.4 km of boardwalk provide access to seabird study sites on Amsterdam Island while protecting sensitive peat bog (ANONYMOUS 2004).

Introduced herbivorous mammals can significantly alter habitats on Southern Ocean islands. Before their successful removal, European Rabbits *Oryctolagus cuniculus* on Enderby and Rose Islands (Auckland Island group) restricted the distribution of various palatable plants and reduced nesting habitat for some seabird species. Collapsed rabbit burrows resulted in the deaths of New Zealand Sea Lion *Phocarctos hookeri* pups (TORR 2002). Rabbits on Macquarie Island have dramatically reduced the tussock vegetation around the coastal slopes, resulting in major habitat loss for burrow-nesting seabirds, increased erosion (COPSON & WHINAM 1998) and an inflated Sub-Antarctic Skua *Catharacta antarctica* population (JONES & SKIRA 1979, N. Carmichael pers. comm. 2006). Cattle on Amsterdam Island threatened the Amsterdam Albatross and the tree *Phylica nitida*, and trampling by cattle facilitated establishment of the thistle *Cirsium vulgare* (MICOL & JOUVENTIN 1995). Almost all islands which have been negatively affected by introduced herbivores have or are currently engaged in the control or eradication of the species responsible (Tab. 5 and references therein). An example of successful control is that of Amsterdam Island, where the culling of cattle and the control of their movements by the use of exclusion fences has benefited the breeding population of the Amsterdam Albatross, led to a regression of thistle in certain areas and, in combination with the active planting of seedlings, has resulted in signs of recovery of the threatened *Phylica* population (MICOL & JOUVENTIN 1995, ANONYMOUS 2006). However, the effective

management of introduced species, aimed at the restoration of communities and processes to pre-introduction levels, requires an integrated approach which takes cognisance of the responses of both target and non-target species (COPSON & WHINAM 2001, LORVELEC & PASCAL 2005).

Pollution of the marine inshore and terrestrial environments

Obsolete infrastructures are often the legacy of past expeditions, and may contain harmful materials. Litter is not only unsightly but may be harmful to wildlife, through entanglements or ingestion (RYAN 1987, NEL & NEL 1999, HOFMEYR et

al. 2002). For the Southern Ocean islands considered here, the degree of infrastructure is greatest on the larger islands (Tab. 8). Most islands require environmental impact assessments for future major developments, and have engaged in or earmarked as important the cleaning up of impacted sites (Tab. 8). For example, at South Georgia in the 2003/2004 austral summer, 600 tons of oil and approximately 3000 m³ of asbestos were removed from the Grytviken whaling station site, of many other hazardous materials were dealt with in small quantities and a large number of unsafe structures were demolished (PASTEUR & WALTON 2006, G.M. Liddle pers. comm. 2006). At the French islands, the cleaning up of bases and the removal of accumulated waste recently received attention, and

| | Base / Station | Field structures | Roads | Air-craft strip | Wharf or harbour | EIA required for major developments | Site cleanups |
|---|---|--|---|-----------------|---|---|--|
| South Georgia ¹ | yes, King Edward Point settlement, Grytviken and 2 research bases | eight huts, six abandoned whaling stations, gun emplacements, crashed aircraft | yes | no | four disused and two used port facilities | yes | yes, past, present & future. Disused huts removed, cleanups of whaling stations and disused scientific equipment |
| Prince Edwards ² | yes, Marion Island only | eight used huts and one container on Marion Island, none on Prince Edward Island | no | no | no | yes | yes, "country cleanups" of old hut sites, abandoned equipment and building site rubble |
| Crozet ³ | yes, Possession Island only | 3 regularly used scientific huts | yes from the wharf to the base | no | yes for small boats | yes | yes, past & present (mainly waste stocks) |
| Kerguelen ³ | yes, Grande Terre Island only | 20 regularly used huts, 18 huts used rarely, one abandoned whaling station, one abandoned salmon station | yes, on the base and nearby | no | yes for small boats | yes | yes, past, present and future (abandoned huts and waste stocks) |
| Heard & McDonald ⁴ | no | several temporary huts | no | no | no | yes | yes, ongoing |
| Macquarie ⁵ | yes | two disused and five used huts | yes, on station only | no | no | yes | yes, cleanups of hut sites |
| Gough ⁶ | yes | none | no | no | no | yes | yes |
| Inaccessible ⁷ | yes | none | no | no | no | no (approval of Tristan Govt. required) | recommended |
| Nightingale ⁸ | no | small shacks owned by Tristanians | no | no | no | no (approval of Tristan Govt. required) | yes |
| Amsterdam | yes | five huts regularly used (two for sci. purposes) | yes, from wharf to base | no | yes for small boats | yes | yes, past, present and future waste stocks |
| Saint-Paul ³ | no | one hut used once every two years | | no | no | yes | NA |
| New Zealand islands (5 groups) ⁹ | no | huts on some isls. of all groups except the Bounties | yes Campbell Isl. only (no longer used) | no | wharf at main Campbell Isl. | yes | Campbell base not expected to be demolished |

Tab. 8: Infrastructure on selected Southern Ocean islands with no resident human occupants. EIA = Environmental Impact Assessment. Blank cells indicate no information available. Sources: ¹McINTOSH & WALTON 2000, ²CHOWN et al. 2006, ³T. Micol pers. comm. 2006, ⁴AAD 2005, ⁵PARKS AND WILDLIFE SERVICE 2006, ⁶COOPER & RYAN 1993, ⁷RYAN & GLASS 2001, ⁸J.P. Glass pers. comm. 2006, ⁹DEPARTMENT OF CONSERVATION 1998. Where no published information was available, the personal knowledge of authors of this paper was used to complete this table.

Tab. 8: Infrastruktur auf ausgewählten unbesiedelten Inseln im Südozean. EIA = Umweltverträglichkeitsprüfung. Unbelegte Zellen zeigen, dass keine Informationen vorhanden sind. Quellen: ¹McINTOSH & WALTON 2000, ²CHOWN et al. 2006, ³T. Micol pers. comm. 2006, ⁴AAD 2005, ⁵PARKS AND WILDLIFE SERVICE 2006, ⁶COOPER & RYAN 1993, ⁷RYAN & GLASS 2001, ⁸J.P. Glass pers. comm. 2006, ⁹DEPARTMENT OF CONSERVATION 1998. Wenn keine publizierten Informationen vorhanden waren, wurde das persönliche Wissen der Autoren zur Vervollständigung der Tabelle verwendet.

| | South Georgia ¹ | Prince Edwards ² | Crozet ³ | Kerguelen ³ | Heard & McDonald ⁴ | Macquarie ⁵ | Gough ⁶ | Inaccess-ible ⁷ | Nightin-gale ⁸ | Amsterdam and Saint-Paul ³ | New Zealand Islands (5 groups) ⁹ |
|-------|--|---|-------------------------------------|--|---|---|-----------------------------|------------------------------------|------------------------------------|---------------------------------------|---|
| Waste | vessel galley or sewage waste disposal | not within 12 NM, except small vessels | not within 4 NM (supply vessel) | not within 4 NM (supply vessel) | not within 12 NM | not within 3 NM | not within 12 NM | not within 3 NM | not within 3 NM | not within 4 NM (supply vessel) | not within 12 NM of Auckland Islands |
| | ballast discharge | unregulated | not within 200 NM (supply vessel) | not within 200 NM (supply vessel) | not within 12 NM | not in marine park, preferably not in EEZ | unregulated | unregulated | unregulated | not within 200 NM (supply vessel) | no restrictions |
| | sewage, on station | sea, macerated | sea, untreated; under review | septic tanks | NA | sea, macerated (under rev.) | sea, untreated (under rev.) | sea, untreated | NA | septic tanks | NA (base no longer occupied fulltime) |
| | sewage, in field | shallow holes | shallow holes | shallow holes | removed to ship, or into sea untreated, or buried | sea | buried | sea or buried | buried | shallow holes | shallow holes, or soakage fields |
| | reduction at source | yes | yes | no | yes | yes | yes | yes | yes | no | yes |
| | separation scheme | yes | yes | yes | all removed | yes | yes | yes | yes | yes | NA, base no longer occupied fulltime |
| | non-biodegradable waste removed | yes | yes, except inert which is buried | yes, except inert which is buried | yes | yes | yes | yes | yes, under review | yes, except inert which is buried | yes |
| | biodegradable waste | sea, only macerated at one site | incinerated in a closed incinerator | bio-composter, compost used for greenhouse | removed or incinerated | sea, macerated | sea, macerated | sea, unmacerated or burnt | sea, unmacerated or burnt | given to poultry | removed |
| | cleaning products, biodegradable | no | yes | no | yes | not specified | yes | no | no | no | not specified |
| Waste | burning permitted | closed incineration frequent at one site but not BAS stations | yes, incineration on station | yes, on station in closed incinerator | yes, in a secure container | yes, on station only, incinerator | yes, on station only | yes, controlled open fires allowed | yes, controlled open fires allowed | yes, on station in closed incinerator | yes, on station only, closed incinerator |
| | hazardous waste regulations | yes | yes | no | yes | yes | yes | yes | yes, under review | no | yes |

Table 8 continued next page

Table 9 continued

| | South Georgia ¹ | Prince Edwards ² | Crozet ³ | Kerguelen ³ | Heard & McDonald ⁴ | Macquarie ⁵ | Gough ⁶ | Inaccessible ⁷ | Nightingale ⁸ | Amsterdam and Saint-Paul ³ | New Zealand islands (five groups) ⁹ |
|--------------|---------------------------------------|--|---|---|--|-----------------------------------|--------------------------------|---------------------------|--------------------------------|---------------------------------------|--|
| Fuel | ship to shore fuel transfer procedure | yes | yes | yes | yes | yes | yes | NA | NA | yes | NA (no fuel stored ashore) |
| | spillage report | yes | report procedures to be designed | yes, procedures to be designed | yes (report required whether spillage or not) | yes | yes | NA | NA | yes, procedures to be designed | covered by Maritime New Zealand, Tier 3 response |
| | contingency plan | yes | to be developed | no | no | yes | no | no | no | no | covered by Maritime New Zealand, Tier 3 response |
| Power supply | station | fuel oil. consider hydroelectric scheme under construction | diesel generator | diesel generator, also wind generator 8 % | NA | diesel generator | diesel generator | NA | NA | diesel generator | diesel generator at Campbell Island (minor use) |
| | field huts | petrol generators | petrol generator | petrol generator, also solar and wind generator 5 % | petrol, solar and wind generators | petrol, solar and wind generators | NA | NA | NA | diesel generator | petrol, solar and wind generators |
| Other | nightlights, minimized | yes, ship and shore | yes, stricter during petrels' breeding season | yes | yes, ship and shore; mast and guy wires marked | yes, ship and shore | yes, ship and shore | yes, ship and shore | yes, ship and shore | no | yes, ship and shore |
| | noise, regulations | aircraft guidelines | none | none | aircraft and vessel guidelines | aircraft and vessel guidelines | aircraft and vessel guidelines | aircraft guidelines | aircraft guidelines under rev. | none | aircraft and vessel guidelines |
| | antifouling, toxic | not allowed | no regulation | supply vessel TBT-free | no regulation | no regulation | no regulation | no regulation | no regulation | supply vessel TBT-free | no regulation |

Tab. 9: Regulations and procedures relating to various forms of pollution of the inshore marine and terrestrial environments at Southern Ocean islands without resident human occupants. Sources: 'McINTOSH & WALTON 2000, 'CHOWN et al. 2006, 'ANONYMOUS 2006, 'AAD 2005, 'PARKS AND WILDLIFE SERVICE 2006, 'COOPER & RYAN 1993, 'RYAN & GLASS 2001, 'J.P. Glass pers. comm. 2006, 'DEPARTMENT OF CONSERVATION 1998. Where no published information was available, the personal knowledge of authors of this paper was used to complete this table.

Tab. 9: Verordnungen und Verfahren in Bezug auf verschiedene Formen der Verunreinigung der Meeresküsten und terrestrischen Regionen auf ausgewählten unbesiedelten Inseln im Südozean. Quellen: 'McINTOSH & WALTON 2000, 'CHOWN et al. 2006, 'ANONYMOUS 2006, 'AAD 2005, 'PARKS AND WILDLIFE SERVICE 2006, 'COOPER & RYAN 1993, 'RYAN & GLASS 2001, 'J.P. Glass pers. comm. 2006, 'DEPARTMENT OF CONSERVATION 1998. Wenn keine publizierten Informationen vorhanden waren, wurde das persönliche Wissen der Autoren verwendet, um die Tabelle zu vervollständigen.

by 2005 about 90 tons of scrap metal had been removed from the islands. The dismantling of obsolete infrastructure continues, especially at Crozet, and at Kerguelen an area has been created for re-usable or recyclable waste (ANONYMOUS 2006). At the Prince Edward Islands, approximately 20 tons of rubble and other waste have been removed in the last five years as part of an ongoing programme of “country cleanups” (J. Cooper pers. comm. 2006). Site cleanups have also been undertaken at Heard Island (GREEN 2006).

Associated with human visits to the islands is the risk of pollution, and the greater the number of visits and / or visitors, the greater this risk. Pollution may result from the inappropriate disposal of waste products generated on board vessels and at sites on land. On Marion Island, for example, a recorded increase in the levels of certain chemicals in the eggs of scavenging species was postulated to have as its source plastics incinerated at the base (GARDNER et al. 1985). At the island groups included in this comparison, detailed procedures are in place to prevent pollution (Tab. 9, references therein).

Generally, regulations prohibit the disposal of human or galley wastes from vessels within at least 3 NM of the coast, and ballast water may also not be discharged near islands. Regulations regarding the discharge of ballast from vessels protect the islands from the introduction of alien marine invertebrates and also serve to reduce the risk of pollution to the islands’ inshore waters and coastlines. The use of non-toxic antifouling by ships is recommended for South Georgia (PASTEUR & WALTON 2006) and required for the supply vessel to the French islands (HEDRICH 2005) (Tab. 9). At most islands, untreated human wastes and grey water are disposed of into the sea (Tab. 9). In the only such study at a sub-Antarctic island, DELILLE & GLEIZON (2003) found that there was a persistent although localized faecal pollution plume around the sewage outfall of the scientific station on Kerguelen Island, indicating the risk of human-assisted introductions of micro-organisms in the Southern Ocean. Measures to reduce such risks have been investigated at a station on the Antarctic Peninsula (HUGHES & BLENKHARN 2003, HUGHES 2004). Faecal micro-organisms can remain viable for 30-40 years in the Antarctic terrestrial environment (HUGHES & NOBBS 2004). Disposal of human waste at field stations on some Southern Ocean islands in shallow holes in the ground may produce detectable environmental pollution over time.

At most islands, attempts are made to limit the amount of waste by reduction at source, i.e., prior to shipping. Waste separation is practiced, with non-biodegradable waste removed and biodegradable waste, disposed of in the sea (sometimes first macerated), burnt or re-cycled as compost (Tab. 9). At some islands, other burnable wastes are incinerated on station. Special regulations are usually in place for the storage and disposal of hazardous wastes. The use of biodegradable cleaning products is only required at a few islands (Tab. 9).

Oil pollution is a risk associated with the operation of vessels or other forms of transport. This was illustrated by the case of the Australian Antarctic Division supply vessel, the “Nella Dan”, which ran aground on Macquarie Island in 1987 and caused contamination of the sea with approximately 270000 litres of oil (SCOTT 1994). A year later, greatly reduced densities of marine invertebrates were recorded in the lower inter-

tidal and subtidal zones where the ship ran aground (POPLE et al. 1990). Cleanups can be expensive and labour intensive. Ship-to-shore fuel transfer procedures are outlined in some management plans, but few islands have the capacity to deal with a major oil spill. At the Australian, New Zealand and French islands, some use is made of fuel-free power sources (Tab. 9).

Light pollution can be associated with human activities at sea and on land. Several species of birds, notably burrowing petrels, are affected by light pollution. These birds are most active at night and may become disorientated and fly into infrastructures, resulting in injury or death. In the Southern Ocean, bird strikes on vessels occasionally involve hundreds of birds, e.g., nearly 900 birds collided with a vessel’s superstructure in South Georgia’s maritime zone, and 215 of these died (BLACK 2005). On Marion Island, 76 birds (mostly Salvin’s Prions *Pachyptila salvini*) were stunned after flying into buildings on a misty night (M. Wheeler pers. comm. 2004). At most islands, lighting at night is minimised on vessels and onshore to avoid such incidents (Tab. 9). At Macquarie and Heard Islands, some mast and guy wires are flagged and on Macquarie Island, wire aerials at field huts have been replaced with whip antennae, to help avoid bird strikes (E. McIvor, N. Carmichael pers. comm. 2006). Redundant masts and guys have been removed at Marion and Gough Islands (J. Cooper pers. comm. 2006) and on the French islands, most antenna masts were removed in 2004 and 2005. Noise pollution can interfere with marine mammals (e.g., RICHARDSON et al. 1995, KASTAK & SCHUSTERMAN 1998, O’SHEA & TANABE 1999) and may cause disturbance at breeding colonies of seabirds (HARRIS 2005). Whereas all islands regulate aircraft activity and thereby aircraft noise which may affect wildlife on land, only some have regulations in place regarding the approach of marine mammals at sea by vessels (Tab. 7).

CONCLUSIONS

Management procedures at all the island groups included in this review address the conservation threats of accidental or deliberate introductions of alien biota, the disturbance of wildlife and sensitive sites, and pollution. However, different islands are utilised by humans in different ways, to different extents and for different purposes, and there is considerable variation between island groups in the degree of protection against the aforementioned threats. Although tourism affords the general public an opportunity to experience and enjoy the islands, increasing numbers of visitors bring about increased risk of negative human impacts. The limitation of tourism and other human activities to certain islands in groups or to particular areas on islands reduces such risk.

The primary threat to the terrestrial environments of the islands included in this study is that of alien species introductions. Commendable efforts have been made at almost all affected islands to eradicate introduced alien biota and restore affected ecosystems. These have mainly targeted mammals, but increasing attention is now being paid to other taxa. Although alien eradication is important, the prevention of introductions should be a first priority. Quarantine procedures for some island groups (but not others) are extremely stringent

and detailed. A level of formality in this regard is likely to improve the effectiveness of procedures. There is a large body of research which has addressed the issue of human disturbance of wildlife in the sub-Antarctic and Antarctic, and a careful review of this might allow for a more streamlined approach to mitigating guidelines. Careful waste management procedures are in place at all island groups, with an emphasis on the reduction of waste at source.

This review has shown that there is a certain level of conformity between management practices in place at islands within the Southern Ocean. Nevertheless, with increasing levels of both knowledge and conservation concerns, there will continually be room for improvement in the procedures adopted by different management authorities. Improvements in the conservation status of Southern Ocean islands and their biota could be supported by the exchange of information between these authorities. This has taken place in the past, for example by way of international workshops (WALTON 1986, DINGWALL 1995) and reviews undertaken by international organizations (BONNER & LEWIS SMITH 1985, CLARK & DINGWALL 1985). However, descriptions of actual management practices often remain concealed in domestic "grey literature", and are thus not always easily available to the broader international community.

There is thus scope for a more structured arrangement to foster the development of best-practice guidelines for Southern Ocean islands. It is not the intention of this review to recommend a specific mechanism, but we suggest that those responsible for the conservation management of their southern islands consider both the value of creating a communication forum and also consider which existing international body might best offer a home for such a forum. Potential bodies include the Scientific Committee on Antarctic Research, SCAR (which considers sub-Antarctic islands), the World Conservation Union (whose Antarctic Advisory Committee specifically includes the Southern Ocean within its remit), the Council of Managers of National Antarctic Programs (COMNAP) and the Committee for Environmental Protection of the Antarctic Treaty Consultative Meetings (CEP, ATCM). However, these two last bodies concentrate their efforts within the Antarctic Treaty area, and do not regularly consider matters dealing with Southern Ocean islands north of 60 °S. The need for and format of a communication forum regarding management practices was recently considered at the 2006 International Forum on the sub-Antarctic, held in Hobart, Australia (www.scarcomnap2006.org).

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