PCAS 18 (2015/2016)

Supervised Project Report

(ANTA604)

Assessing Cumulative Impacts in the Antarctic under the Environmental Protocol - A Missed Opportunity?

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Word count: 9,000 (excluding the abstract, tables, references, appendices)

Abstract:

The Protocol on Environmental Protection to the Antarctic Treaty 1991 establishes provisions for protecting the Antarctic continent and its dependent and associated ecosystems. Under the Protocol all proposed activities are subject to Environmental Impact Assessment (EIA) prior to project approval. Consideration of cumulative (past, present and future) impacts is mandated under the Protocol for projects assessed at the higher levels of Initial and Comprehensive Environmental Evaluation only. The Antarctic Treaty System is challenged with developing a strategic approach for ensuring cumulative impacts are addressed at all levels of environmental assessment. Consideration of cumulative impacts in Environmental Impact Assessment has been minimal to date, attributed largely to inconsistent practices, inadequate exchange of information, the absence of structured assessment methodologies or just uncertainty amongst proponents and regulatory authorities regarding what to address. Nineteen Comprehensive Environmental Evaluations were reviewed and results generally indicated minimal consideration of cumulative impacts over and above a definition of the term in the environmental evaluation. This paper reviews the current regulatory provisions for assessing cumulative impacts in the Antarctic and discusses Environmental Impact Assessment, environmental monitoring, the protected area system and exchange of information as management tools to improve the assessment process. A framework is also proposed for usage in scoping cumulative impacts as part of a systematic approach to Environmental Impact Assessment for national and non-governmental operators.

Introduction

> *'Human activity has seriously damaged or changed the natural environment in many parts of the world and will compromise the Antarctic region unless measures are taken to identify and avoid or minimise possible harmful activities' (Abbott and Benninghoff 1990: 394).*

The Antarctic continent is typically perceived as the last great wilderness reserve, which has not yet been irreversibly transformed by large scale human development. Of the many reasons to protect Antarctica, the value of the continent for the conduct of globally significant research is fundamental and a requirement of the Antarctic Treaty. However, the scale of human presence in the Antarctic has affected the local environment and altered its 'pristine' natural condition (Keage 1985; Chown et al 2012; Shaw et al 2014). Over the last fifty years the development of scientific research programs, logistical support and tourism operations have impacted local terrestrial and marine coastal ecosystems through fuel combustion (for transportation and energy production), accidental oil spills, waste incineration and sewage (Bargalia 2008) and threats to biodiversity (Shaw et al 2014). Today, significant environmental footprints are evident across the Antarctic and peri-Antarctic (Tin el al 2009; Chown et al 2012) at locations including the Fildes Peninsula (Braun et al 2012), the Dry Valleys (Ayres et al 2008) and deactivated station and camp sites such as Cape Hallett still remain (Gilmore 2001). As elsewhere in the world, the scientific gains from activities in the Antarctic have not been achieved without some concomitant loss in environmental quality (Benninghoff and Bonner 1992).

It is a generally accepted view that human activity in the Antarctic, predominantly attributed to national government operations and the tourism industry, is growing rapidly (Kriwoken and Rootes 2000; Tin et al 2014; ASOC 2015). The Council of Managers of National Antarctic Programs (COMNAP) list eighty-two permanent research facilities in Antarctica and nineteen remote field camps (COMNAP 2016) supported by over 4000 annual national operator staff (Hughes et al 2013). However, the actual scale of logistical support and temporary infrastructure is likely to be much higher, as not all facilities are reported to the Antarctic Treaty Secretariat.

Growth, expansion and diversification also characterise Antarctic tourism (Roura et al 2011). The International Association of Antarctica Tour Operators (IAATO) report visitor projections of 40,029 for the 2015/16 season, inclusive of 28,304 landings (IAATO 2016). Cumulative environmental impacts are of particular concern around the Antarctic Peninsula, where high levels of repeated concentrated visitor

activity is common at historic sites and wildlife colonies (de Poorter and Dalziell 1996; Hofman and Jatko 2000; Hughes et al 2013). The continuing increase in visitation by ship and air, has also raised concerns regarding the impacts of activities on regional values (Enzenbacher 1992; Tin et al 2009; Roura and Hemmings 2011).

Under the Protocol on Environmental Protection to the Antarctic Treaty 1991 all activities proposed by national and non-governmental operators are subject to an assessment of potential environmental impacts. To date, the incorporation of cumulative impact considerations into the current environmental assessment process has been inadequate (Roura and Hemmings 2011; Australia 2014; ASOC 2015). This inadequacy can be partly attributed to the conduct of project-specific Environmental Impact Assessments (EIA), confusion over terminology and the absence of structured methodologies and guidance within the Antarctic Treaty System (ATS). Surely if the greatest value of Antarctic science is in the study of the natural, unperturbed environment then cumulative impacts must be taken into account in the assessment of human activities, to provide a true indication of the level of impact?

This paper examines the provisions for assessing cumulative impacts in the Antarctic with the aim of identifying management practices for improving the assessment process under the current regulatory framework. A general review of Comprehensive Environmental Evaluations (CEEs) for consideration of cumulative impacts is undertaken. A systematic framework is also proposed to assist proponents and regulating authorities in identifying and managing cumulative impacts as part of the already established EIA process.

Cumulative Impact – Not an Unfamiliar Concept

An extensive array of concepts have emerged to describe cumulative impacts and by defining the terminology analysts have highlighted the key elements to be considered in environmental assessments. Impacts in ecosystems accumulate in different ways, and recognition of how they accumulate is central to developing a scientific approach to evaluating cumulative impacts (Baskerville 1986; Clark 1986; Shaw et al 2014). There is general consensus (Clark 1986; Sonntag 1987; Bedford and Preston 1988; IUCN 1996; Burris and Canter 1997) that cumulative environmental change can be characterised by three key attributes – time, space and activity. This is based on the recognition that a site, a given location or a region is affected by numerous activities and that each of these activities has both short- and long-term impacts on that area and elsewhere in the environment. Individual impacts may also interact with one another in a manner so as to

produce effects that are greater in nature, bigger in magnitude, more long-lasting or more widespread than are the individual impacts (Dixon and Montx 1995).

Coinciding with the increasing human presence in Antarctica is the need for comprehensive consideration and management of cumulative impacts, or past, present and reasonably foreseeable activities, occurring over time and space (Smit and Spaling 1995; de Poorter and Dalziell 1996; Kriwoken and Rootes 2000; Roura and Hemmings 2011; Woehler et al 2014). In addition to providing an accurate prediction of the direct and indirect consequences of an action on an environmental parameter, cumulative impact assessment requires placing a proposed action and its impacts in the context of other or existing or expected actions and environmental conditions (Cowart 1986; Cooper 2004). Assessing cumulative impacts also provides an early warning of the effects humans activities are having on the environment (Contant and Wiggins 1989). Anthropogenic activities in the Antarctic generate impacts and the increase in environmental degradation supports the proposition that the focus can no longer be on single human activities or impacts. For example, the individual impacts arising from the operation of an Antarctic station may be negligible; however, when the impacts both accumulate and exceed a threshold of damage, or they are antagonistic or synergistic, these impacts could become considerable (Court et al 1994).

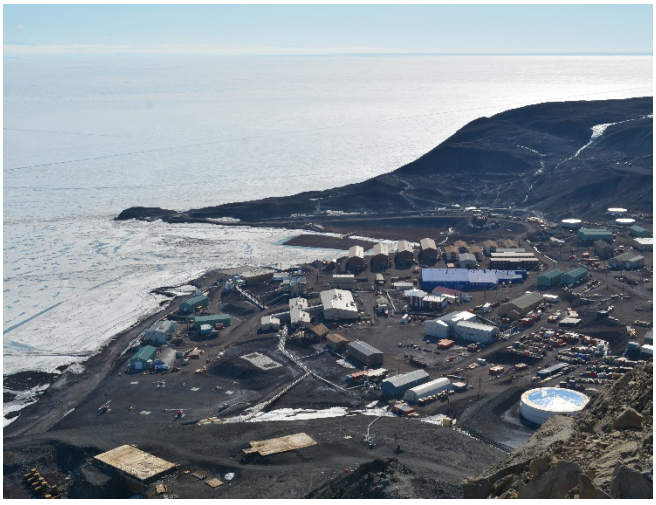

Figure 1. McMurdo Sound, Ross Island (Harding 2016)

The cumulative effect of human presence and associated shipping, air transport, scientific and recreational activities is particularly evident at McMurdo Station in the Ross Sea (figure 1), a facility managed by the United States Antarctic Program (USAP). Human activities attributed to prior waste disposal practices in the area have contaminated and disturbed adjacent marine benthic habitats with anthropogenic pollutants including petroleum hydrocarbons, chlorinated hydrocarbons and metals (Lenihan 1992; Kennicutt et al 1995, Negri et al 1996; Morehead et al 2008). Cumulative impacts over decades have also impacted the local marine fauna resulting in low species abundance of fish (Leninhan and Oliver 1995; Conlan et al 2004). Similar impacts have been identified at an old garbage tip site at Casey Station, East Antarctica (Stark et al 2003) as a result of decades of Australian waste disposal practices. Ongoing monitoring of such areas of known disturbance is necessary to quantify,

mitigate and minimise the cumulative effects of anthropogenic impacts and to inform management decisions regarding limits of acceptable change in environmental variables.

The Antarctic Regulatory Framework for Assessing Cumulative Impacts

The Antarctic Treaty System

The nations conducting research in the Antarctic agreed to create a Treaty which could perpetuate the unprecedented international scientific cooperation manifested in the International Geophysical Year (IGY) 1957-58 (Suter 1991). The four principles upon which the Antarctic Treaty System (ATS) is based are demilitarisation, international scientific cooperation, sovereignty and environmental protection (Pineschi 1996). Although the ultimate reason for human presence in the Antarctic is of a political nature, its sustained rationale lies in the continent's unique scientific interest (Manzoni 1992). While the Treaty provides the framework, the Antarctic Treaty Consultative Parties (ATCPs) implement its agreements via national laws. Differences in interpretation result in disparate methods of enforcement and compliance by the various nations involved in Antarctic research (Kriwoken and Rootes 2000).

The Protocol on Environmental Protection to the Antarctic Treaty 1991

It took the ATCPs less than two years to reach an agreement on the Protocol on Environmental Protection to the Antarctic Treaty 1991 (the Madrid Protocol) which designates the Antarctic continent as a 'natural reserve, devoted to peace and science'. The Protocol establishes environmental principles, procedures and obligations for the protection of the Antarctic environment and its dependent and associated ecosystems. The Protocol was established after the recognition that the Antarctic Treaty was unable to fully protect the Antarctic environment (Jezek at al 1995) and it is considered a marked improvement in environmental protection of the Antarctic:

> *'The Protocol is a giant step towards a comprehensive approach to environmental protection in Antarctica. Prior to the agreement, environmental measures were crafted on an ad-hoc basis, to cope with individual environmental problems as they arose. The result was a patchy set of rules that were difficult to revise and quickly became outdated' (ASOC 1991: 1).*

The introduction of the Protocol resulted in a legally binding regime mandating the comprehensive protection of the Antarctic environment. All visitors to the Antarctic including research scientists and support personnel of National Antarctic Programs and non-governmental organisations including tourism operators, have an obligation under the Protocol to manage environmental impacts. Consideration of intrinsic wilderness, aesthetic, historic, environmental and scientific values became a key requirement prior to the conduct of activities in the Antarctic Treaty. With such unprecedented international cooperation a higher standard of environmental protection had been afforded to Antarctica than is required in other parts of the world (Ensminger and Webb 1999).

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a systematic approach to considering potential impacts of an activity prior to the decision being taken on whether or not a proposal should be given approval to proceed (Jay et al 2006). An advantage of EIA is its capability to provide information for preventive environmental protection (Gilpin 1995). Importantly, the EIA process also facilitates development of proposed measures to address and mitigate potential impacts (Finnish Ministry of the Environment 1997).

The Protocol seeks to protect Antarctica from human impacts and to maintain its value for scientific research by regulating environmental impacts associated with human activities in the Antarctic (ASOC 1991). The principles articulated are fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area. As an integral and legally-binding element of the Protocol, the principles are expected to guide and shape environmental planning and decision-making for all activities in Antarctica and act as safety net to include potentially harmful activities that are not covered explicitly by the annexes to the Protocol. The determination of whether an activity can or should proceed is dependent on application of Article 3, which requires that:

> *'the protection of the Antarctic environment be a fundamental consideration in the planning and conduct of all activities in Antarctica and that they are planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgements about, their possible impacts on the Antarctic environment'.*

Article 8 of the Protocol requires the Parties to conduct EIA for their Antarctic activities, and provides for three levels of assessment according to the potential impacts of each activity. The first of five Annexes to the

Protocol, Annex I Environmental Impact Assessment, is the key instrument for managing human impacts in the Antarctic (de Poorter and Dalziell 1996). A three-tiered assessment process is articulated in Annex I and each level coincides with the predicted impact of the proposed activities and a determination based on the 'minor or transitory' nature of the proposed impacts:

(i) Preliminary Stage: the proposed activity is determined to have less than a minor or transitory impact;

(ii) Initial Environmental Evaluation (IEE): the proposed activity is determined to have a minor or transitory impact; and

(iii) Comprehensive Environmental Evaluation (CEE): the proposed activity is determined to have a more than minor or transitory impact.

Challenges continue to surround the interpretation and application of 'minor or transitory' as the Protocol leaves the term undefined and therefore somewhat ambiguous. The assessment process is also further complicated in that decisions on whether and how activities should proceed are undertaken at the national level and with national interests in mind (Bastmeijer and Roura 2007). Hemmings and Kriwoken (2010) note that not one EIA appears to have led to substantial modification of any activity as proposed by the proponent nor has a decision not to proceed with an activity ever occurred.

> *'The number of CEEs is small, but no CEE has resulted in a decision not to proceed with the activity and no non-state operator has yet produced a CEE; some IEEs are extremely slight, some simply atrocious' (Hemmings and Roura 2008).*

The effective use of the EIA process is central to the minimisation of impacts arising from human activities. However, the effectiveness of the environmental assessment in identifying and mitigating impacts is rarely verified, which risks the EIA process as being a purely administrative exercise (Tin et al 2009).

Consideration of Cumulative Impacts in Environmental Impact Assessments

Article 3 of the Protocol requires that the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty Area, are taken into account when planning activities and preparing EIAs. However, the term cumulative impact also remains undefined in the Protocol.

Annex I of the Protocol requires 'consideration' of cumulative impacts for EIAs submitted at the Initial and Comprehensive Evaluation levels only, not the Preliminary stage as follows:

Annex 1 Article 2 IEE:	'consideration of alternatives to the proposed activity and any impacts that the activity may have, including consideration of cumulative impacts in the light of existing and known planned activities'.
Annex 1 Article 3 CEE:	'consideration of cumulative impacts of the proposed activity in the light of existing activities and other known planned activities'.

The level of analysis that 'consideration' dictates is also not defined in the Protocol and legally binding standards have not been adopted.

In 1996, five years after the adoption of the Protocol, the International Union for the Conservation of Nature (IUCN) co-hosted a workshop with the Scientific Committee on Antarctic Research (SCAR) on minimising and managing Antarctic cumulative environmental impacts. Workshop discussions focused on how cumulative impacts could be integrated in current EIA procedures and used in a practical way by national and non-governmental operators, the Antarctic scientific community and the ATS in general (IUCN 1996). The ATCPs acknowledged the importance of using and adapting existing knowledge and experience from non-Antarctic regions although specific examples were not discussed in detail.

> *'We're not here to reinvent the wheel, but to put chains on it so it works on the ice' (Martin Riddle, Australian Antarctic Program Delegate, IUCN 1996).*

Annex I to the Protocol (Articles 2 and 3) only explicitly refers to taking into account existing and other known planned activities when assessing the impacts of any proposed activity. A key outcome of the workshop was the recommendation that consideration of cumulative impacts should include all relevant past, present and reasonably foreseeable activities (Recommendation 1, IUCN 1996). Parties also agreed that wherever obligations regarding environmental impact are identified, it should be taken that this includes cumulative impacts (Recommendation 2, IUCN 1996). Cumulative impacts were classified as a subset of impacts and as such to be considered even at the lowest level (preliminary) of environmental assessment, which goes above and beyond the requirements of the Protocol.

The Parties agreed on the following definition of cumulative impact, which has not been amended over the last twenty years:

'A cumulative impact is the impact of combined past, present and reasonably foreseeable activities. These activities may occur over time and space' (IUCN 1996).

A Review of Comprehensive Environmental Evaluations

An examination of literature, Information and Working Papers submitted to the Committee for Environmental Protection (CEP) revealed that no review of IEEs or CEEs has been undertaken to determine to what extent cumulative impacts have been assessed as part of the EIA process, if at all. The Antarctic Treaty Secretariat maintains the EIA database, making submitted IEEs and CEEs publically available; however, some ATCPs such as France choose not to submit draft or final CEEs to the Secretariat for inclusion on the database. The Antarctic and Southern Ocean Coalition (ASOC) has referred to undertaking a broad-brush evaluation based on examination of many IEEs and CEEs over the years and concluded that in many EIAs the assessment of cumulative impacts, when it exists, is rather cursory (ASOC 2015). Each Treaty Party is responsible for the activities of its own nationals and National Antarctic Programs and for ensuring that the minimum standards of the Protocol are adhered to. Some Parties implement higher environmental standards than normally required in their own country to ensure compliance with the Protocol; whilst others are less stringent (Connor 2008; Convey et al 2012) and this is reflected in the environmental evaluations and management practices.

Discussion

Of the 41 CEEs listed by the Antarctic Treaty Secretariat (2016) only 31 documents are currently publicly available for review, which includes both draft and final versions. CEEs for activities likely to have a more than minor or transitory impact have included construction, operation and maintenance of facilities, water sampling of a subglacial lake and stratigraphic drilling. The CEEs reviewed have been prepared by 14 of the 29 ATCPs to date with no CEE yet undertaken by a non-governmental operator. This review used an adapted questionnaire developed by Cooper and Canter (1997) for the purpose of determining how cumulative impacts are identified and assessed in environmental evaluations. At the time of writing, a review of the 1200 IEEs registered on the EIA database was beyond the scope of this paper.

In February 2016 a review of 19 final CEEs completed from 1991 – 2015 (appendix 1) was undertaken to identify references to cumulative impacts (tables 1 and 2). Overall results revealed minimal consideration of cumulative impacts in the majority of the CEEs over and above a definition of the term, despite 'consideration' being a requirement of the Protocol. Fourteen of the CEEs included a definition of cumulative

impact with 11 of the ATCPs using the accepted IUCN definition, although not all definitions referred to temporal and spatial boundaries (table 1). Table 2 indicates fifteen CEEs had a separate subsection listed to discuss cumulative impacts; however, the level of detail was extremely varied ranging from a reasonably comprehensive analysis by New Zealand (2006) and India (2010) to simply mentioning the term cumulative with little contextual discussion. Methods for assessing cumulative impacts were not discussed in any CEEs. Even when cumulative impacts were reported the overall cumulative impact assessment process was not detailed. The regulatory authority is then presented with limited knowledge regarding the quality and reliability of the reported cumulative effects. Furthermore details of cumulative impacts were only described qualitatively not quantitatively in the CEEs. The United Kingdom, Belgium and New Zealand were the only ATCPs to use an impact assessment matrix to review potential impacts and activities. The consistent lack of discussion of past, present and future activities and impacts, assessment methodologies and monitoring data in the 19 CEEs also provides evidence that the Parties require guidance on best practice for managing the assessment of cumulative impacts.

The results from this brief review support academic opinion that coverage of cumulative impacts in EIA documentation is often superficial at best (Roura and Hemmings 2011). A general review of IEEs and CEEs also undertaken in 1996 noted that if the potential for cumulative effects is stated in the evaluation it is little more than 'there is the possibility of cumulative impacts occurring' (Harding unpublished 1996). Although consideration of cumulative impacts has improved in CEEs it is still not a comprehensive analysis of past, present and future impacts in the context of all project activities. It has been proposed that including cumulative impacts in the assessment process increases the likelihood of identifying significant impacts (McCauld and Saulsbury 1996), which could result in project delays or non-approval. This may account, in part, for the lack of comprehensive discussion of cumulative impacts in the CEEs. As the precautionary principle is not strictly implemented and sanctions or penalties are not applied to project proponents that do not consider cumulative impacts, then it is possible past and present activities will be ignored if it is likely a significant impact finding may occur.

The general lack of detailed discussion of cumulative impacts in the CEEs is further evidence that despite general agreement that past, present and future actions contribute to CIs, there is no general agreement as to how these actions should be considered in impact assessments. At times the inclusion of a reference to cumulative impact appears to be administrative rather than for environmental protection or management purposes.

Table 1. Cumulative Impact Definitions in Comprehensive Environmental Evaluations (CEE; ATS 2016)

National Antarctic Program	Year	Cumulative Impact Definition
Belarus	2015	CI is defined as the resulting superposition of impact from certain activities in concern on the impacts from the activities that is already in process at the same area.
China	2013, 2008	CI is the combined impact of past, present & possible future activities.*
United Kingdom	2011, 2006	A CI is the combined impact of past, present & future activities.* These impacts can be cumulative over time & space.
India	2010	CI means growing by successive addition over time by addition of pollutants or by source of pollutants or additional routes of impact. This term may also be used to describe an individual's integrated exposure to pollutants while engaged in daily activities & moving through successive environment (Pratt 2000).
Korea	2010	CI refers to the combined impacts of past, present & future activities.* The direct & indirect impacts should be evaluated & the temporal & spatial ranges of individual impacts must be taken into consideration to estimate cumulative impact.
New Zealand	2006, 2002	A CI is the combined impact of past, present & reasonably foreseeable activities.* These activities may occur over time & space & can be additive or interactive/synergistic (eg decrease of limpet population due to the combined effect of oil discharges by base & ship operations). CIs can often be one of the hardest impact categories to adequately identify in the EIA process. When attempting to identify CIs it is important to consider both spatial & temporal aspects & to identify other activities, which have occurred & could occur at the same site or within the same area (COMNAP 1999).
Belgium	2006	Effects, impact or consequences that may come from similar or varied sources, but that are additive, antagonistic or synergistic in their effect, impact or consequence. For example, disturbance to nesting skuas caused by existing scientific use & by a proposed use.
United States	2004, 2003	A CI is the combined impact of past, present & reasonably foreseeable activities in the future.*
Norway	2004	A CI is the combined impact of past, present & reasonably foreseeable activities. These activities may occur over time & space & can be additive or interactive/synergistic.*
Germany	2005, 2000	Cumulative impacts may arise over time (recurrent impacts) as well as through the effects of different human activities at one particular location.

* denotes exact 1996 IUCN definition of cumulative impact

Table 2. Summary of Cumulative Impacts in Antarctic Comprehensive Environmental Evaluations 1991 – 2015 (adapted from Cooper and Canter 1997)

	Belarus 2015 Operational	**China 2013 Operational**	**China 2008 Operational**	**United Kingdom 2011 Science**	**United Kingdom 2006 Operational**	**India 2010 Operational**	**India 2006 Operational**	**Korea 2010 Operational**	**Russian Federation 2010 (Science)**	**New Zealand 2006 (Science)**
Is there a definition of CI detailed? Is it the IUCN definition?	Yes No	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes No	No	Yes Yes	No	Yes Yes
Is there clear reference to temporal & spatial considerations in the definition?	No	No	No	Yes	Yes	Yes	No	Yes	No	Yes
Is CI addressed in a separate section?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Is CI addressed separately for each environmental variable?	No	No	No	No	No	No	No	No	No	Yes
Is there a summary of the CIA methodology?	No	No	Yes	No	No	No	No	No	No	No
Is CI listed in the 'Table of Contents' or 'Executive Summary'?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Is CI addressed anywhere else in the report?	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Are specific CIA guidelines or methodologies described?	No	No	No	No		Yes	No	No	No	No
Are spatial boundaries defined for CI?	No	No	No	No	No	No	No	No	No	No
Are temporal boundaries defined for CI?	No	No	No	No	No	No	No	No	No	No
Does the discussion of CI address other past, present & foreseeable future projects in the defined boundary area?	No	No	No	Yes	No	Yes	No	Yes	No	Yes
Is CI quantitatively or qualitatively described?	No	No	Yes	No	Yes	Yes	No	No	No	No
Are prior CIA studies used to assess CI of the proposed project or action?	No	No	No	No	No	No	No	No	No	No

Table 2 continued. Summary of Cumulative Impacts in Antarctic Comprehensive Environmental Evaluations 1991 – 2015 (adapted from Cooper and Canter 1997)

	Belgium 2006 (Operational)	**United States 2004 Operational**	**United States 2003 Science**	**United States 1991 National Antarctic Program**	**Czech Republic 2003 Operational**	**Ukraine 2006 Operational**	**Norway 2004 Operational**	**Germany 2005 Operational**	**Germany 2000 Science**
Is there a definition of CI detailed? Is it the IUCN definition?	Yes No	Yes Yes	Yes Yes	No	No	No	Yes Yes	Yes No	Yes No
Is there clear reference to temporal & spatial considerations in the definition?	No	No	No	No	No	No	Yes	Yes	No
Is CI addressed in a separate section?	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
Is CI addressed separately for each environmental variable?	No	No	No	No	No	No	No	No	No
Is there a summary of CIA?	No	No	No	No	No	No	No	No	No
Is CI listed in the 'Table of Contents' or 'Executive Summary'?	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Is CI addressed anywhere else in the report?	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Are specific CIA guidelines or methodologies described?	Yes	No	No	No	No	No	No	No	No
Are spatial boundaries defined for CI?	No	No	No	No	No	No	No	No	No
Are temporal boundaries defined?	No	No	No	No	No	No	No	No	No
Does the discussion of CI address other past, present & foreseeable future projects in the defined boundary area?	No	No	No	No	No	No	No	No	No
Is CI quantitatively (Q1) or qualitatively (Q2) described?	Q2	Q2	Q2	No	No	Q2	Q2	Q2	Q2
Are prior CIA studies used to assess CI of the proposed project or action?	No	No	No	No	No	No	No	No	No

Environmental Impact Assessment Guidelines – A Missed Opportunity for Assessing Cumulative Impacts

In 1998 at the first CEP meeting it was agreed that proponents and regulatory authorities would benefit from guidance in undertaking EIAs (Australia 2014). In 1999 an Intercessional Working Group (ICG) was established and draft Guidelines for Environmental Impact Assessment in Antarctica were endorsed by the CEP. With an increasing acknowledgement by the Parties of the potential environmental impact of multiple activities, guideline reviews have occurred with the most recent commencing in 2014 at CEP XVII. At this meeting Parties agreed to discuss modifying the current guidelines to create a new section, or subsection, dedicated to guidance on the assessment of cumulative impacts.

Discussion of cumulative impacts is incorporated into the current Guidelines for EIA in Antarctica (Antarctic Treaty Secretariat 2016) but terminology is not expanded upon and other than an assessment matrix other methodologies are not proposed. There are seventeen references to cumulative impacts in the twenty-four page guidelines and despite two definitions most references are piecemeal in nature and lost amongst discussion of actions, parameters, predictions, direct, indirect and retrospective actions. The only example of a potential cumulative impact is 'a decrease of a limpet population due to the combined effect of oil discharges by base and ship operations'.

Although the guidelines note the importance of considering spatial and temporal boundaries, it is also recognised that cumulative impacts can often be one of the hardest impact categories to adequately identify in the EIA process. As the difficulty associated with assessing cumulative is acknowledged then surely the amended guidelines justify more than a predicted small 'subsection' focusing most likely on theoretical definitions and not practical application of CIA. ASOC also note that progress amongst the ATCPs in addressing cumulative impacts appears to be more conceptual than practical to date (ASOC 2015). However, consistent implementation and continual improvement of existing environmental management tools are paramount in improving consideration of impacts (Convey et al 2012). This does pose the question of how in a continent where non-governmental and governmental operators run largely independent operations and where each government considers itself sovereign within its own area of operation, can all Antarctic activities be effectively managed to avoid or mitigate environmental impacts (Tin et al 2014; Bennett et al 2015)? Although not mandatory, the EIA Guidelines are the logical starting point to expand upon requirements for assessing cumulative impacts.

Strengthening Antarctic Practices to Assess Cumulative Impacts

With regards to the Antarctic environment, cumulative impacts have been discussed from a range of perspectives in the academic literature and papers submitted to the CEP. Common themes have tended to focus on minimisation and management (De Poorter and Dalziell 1997; Bastmeijer and Roura 2004), tourism (IAATO 2001, 2003; Hofman and Jatko 2002; Tin et al 2009), assessment methodologies (New Zealand 2006), Strategic Environmental Assessment (SEA) (ASOC 2001, 2002; Roura and Hemmings 2011), data collection and exchange of information (France 2008; United Kingdom 2010). Twenty-four years after the adoption of the Protocol consensus has still not been reached on best practice for managing cumulative impacts (ASOC 2015).

Since the 1996 IUCN workshop that established the definition of cumulative impacts, thirteen Working and Information Papers have been submitted to the CEP/ATCM addressing various issues associated with assessing cumulative impacts (Antarctic Treaty Secretariat 2016). Party discussions have focussed on disparate aspects of the assessment process including limitations in data collection and availability, assessment methodologies and fundamental flaws in the EIA process (ASOC 2015). Establishing long-term environmental monitoring programs, SEA, improving exchange of information and protected area management are not new concepts to Treaty Parties, but have not yet been unequivocally used to manage cumulative impacts.

Project-Specific vs Strategic Environmental Assessments

The existing Antarctic project-specific assessment process does not necessitate comprehensive consideration of cumulative impacts during planning, regulation and decision-making (Roura and Hemmings 2011). The individual project-based approach to assessing impacts means that the combined effects of two or more developments are often overlooked (Cocklin et al 1992). Such a process of predicting and minimising the consequences of a single action does not adequately consider the cumulative nature of some effects, the nonlinear responses of some natural systems nor the linkages between a single action and other related activities (Vlaschos 1985; Roots 1986). Therefore, effects resulting from the cumulative nature of actions are largely ignored or underestimated in most impact assessments of individual projects (Contant and Wiggins 1991; Cooper 2004). Consideration of cumulative impacts at the preliminary stage of assessment is not a requirement of the Protocol.

To overcome the difficulties of project-specific EIAs, SEA or regional assessment, has been proposed as a systematic approach by which cumulative impacts can be addressed (Dixon and Montz 1995; McCauld and Saulsbury 1996; Roura and Hemmings 2011). Despite the increasing application of strategic approaches to environmental assessment on a global scale, there has been relatively little attention given to SEA in the Antarctic. SEA enables early consideration of potential environmental effects during planning and policy development. A strategic approach to undertaking assessments of cumulative impacts would require replacing the national-based or project-based EIAs and moving towards strategic joint assessments covering large geographical areas for scientific, logistical and tourism operations (de Poorter and Dalziell 1997; IAATO 2000; Roura and Hemmings 2014).

By expanding the scale and scope of the impact assessment process to a regional approach, SEA can evaluate the consequences of multiple activities and impact sources on a larger set of environmental components. SEA presents opportunities to improve regulatory decision-making, better plan practices for future activities, facilitate the flow of data between proponents and regulators and assess and mitigate cumulative effects by creating a holistic view of how multiple activities and impacts interact. However, although SEA could ensure a more comprehensive assessment process it is not a legal requirement under the Protocol. The challenge with SEA is determining what the process should deliver, what role it should play in the Antarctic Treaty System and how the process translates to improved decision-making and streamlined environmental assessments.

Environmental Monitoring Programs

Environmental monitoring is an appropriate tool for assessing and verifying predictions that are made in the process of identifying cumulative impacts on the environment (IUCN 1996). Continuous and effective monitoring is a means of verifying the effects of activities in Antarctica and detecting any unforeseen effect on the environment (Triggs 1990; Walton and Shears 1993). Current EIA practices have faltered in an area that could be its very strength; in that usually no follow-up monitoring is done to test the provisions of impact predictions (Glasson et al 1994; ASOC 2015). A follow-up procedure for monitoring environmental impact predictions is the single action that could most improve EIA (Buckley 1989) and project management (Glasson et al 1994). In as much as EIA is designed to avoid or limit the potentially hazardous effects of human activities, environmental monitoring can detect changes in environmental parameters that can serve as an early warning of adverse effects to the environment (Manzoni 1992; SCAR and COMNAP 1996).

As scientific interest in the Antarctic has developed, various ATCPs have initiated long-term monitoring programs on a voluntary basis collecting long time series of data to identify and understand the structure, dynamics, trends and perturbations of systems to expand ecological theory (Abbott & Benninghoff 1990; United States 2003). Although the majority of monitoring programs have been instigated for scientific research or to meet the minimum requirements under the Protocol, the results can aid in determining the effects of human activities on different environmental parameters, thereby providing the baseline information upon which to develop a monitoring program and assess cumulative impacts. Implementing a SEA approach is also advantageous when designing environmental monitoring programs. To address cumulative impacts on a regional basis is challenging, requiring a move away from focussing on individual activities and point sources to a more regional perspective. To ensure the proper consideration of past development activities, environmental monitoring can identify and track development actions by type, by location and over time and across regions (Contant and Wiggins 1991).

At CEP VI/ATCM XXVI (United States 2003) an ICG was established to develop a coordinated approach to monitoring cumulative impacts. Forty-one research programs were categorised under environmental, geographical, biological, or atmospheric science and focussed on anthropogenic impacts of station operations, sewage, heavy metal and hydrocarbon contamination and disturbance to avifauna. Importantly, the ICG also proposed coordinating Party efforts through development of a comprehensive database, which would combine data currently held by Parties and other operators.

Despite hosting an international workshop on possible cumulative impacts of ship-based tourism in 2000, IAATO somewhat boldly stated that tourism was not responsible for any significant environmental impact on any of the sites or the Antarctic ecosystem at ATCM XXVI in 2003 (IAATO 2003). A perhaps more precautionary approach was adopted by the ATCPs at ATCM XXX (2007) when it was recommended that 'the Parties discourage any tourism activities which may substantially contribute to the long-term degradation of the Antarctic environment and its dependent and associated ecosystems'. The reasoning behind this resolution was the desire to limit the potential impacts of tourist activities, including cumulative impacts upon the Antarctic environment (France 2007). The ATCPs have since acknowledged the need to also focus on sites that tourists visit regularly and that identifying appropriate indicator species would assist in determining which organisms were most vulnerable or most subject to impacts from human presence (United States 2003; Shaw et al 2014). France duly noted that without adequately tested methodologies, assessment tools and monitoring data, comprehensive assessment of cumulative impacts is difficult to implement (France 2008).

Obtaining monitoring data for analysis of cumulative impacts is often the most challenging aspect of any assessment process at any level (United Kingdom 2010). At ATCM XXX in 2010, the United Kingdom proposed a method to determine the distribution and concentration of national operator activities whereby the positions and dates of ground-based field activities were taken from records held in plant and geological specimen collection and survey databases. This is an example of how highly impacted or vulnerable locations may be identified more easily and protected based on physical parameters or biological diversity and levels of human visitation (Hughes et al 2013).

The importance of establishing programs to monitor anthropogenic impacts has been recognised by the ATCPs and non-governmental operators but there appears to have been little progress made towards achieving the synthesis and analysis of data that was agreed as a necessity by the Parties. Through further establishment of monitoring programs and development of comprehensive site inventories regulatory authorities can better understand and identify regions at greatest risk from human impacts, which could facilitate implementation of management strategies. For example, regions could be identified that are at high risk of non-native species introductions and biosecurity measures could be implemented (United Kingdom 2010). As a further example, irreversible cumulative impacts on soil microbes attributed to pedestrian traffic and trampling in the Dry Valleys (Ayres et al 2008), could potentially have been minimised if monitoring programs had been initiated when site visits initially commenced.

Exchange of Information and Database Management

The IUCN Workshop recognised that effective procedures for information management are crucial to managing the impacts of any Antarctic activity (IUCN 1996). IAATO (2002) and ASOC (2015) also reflect the common opinion that the availability of data for assessing cumulative impacts is one of the most challenging aspects of management. A further complication is that the different national legal systems have, by necessity, resulted in a variety of interpretations of the Protocol and written accounts of impacts of past activities in Antarctica are unavailable. This lack of information makes impact prediction a very uncertain task and means that the effectiveness of mitigation measures and monitoring is often unknown (Walton and Shears 1993). ASOC (2015) recently proposed that to progress the assessment of cumulative impacts, data from the Antarctic Treaty Secretariat EIA database could be analysed to identify what activities have been carried out in a particular area previously and what the assessment of the impact of those activities has been. However, ASOC did not suggest who would be responsible for the database and information analysis

nor acknowledge that the database only stores IEES and CEEs and not the insurmountable number of projects approved at the preliminary level.

Through IAATO long-term visitation data on tourist landings and activities in Antarctica (IAATO 2003) have been collected in Post Visit Site Reports since 1989 and are held in a centralised database (IAATO 2016). Despite this collation of twenty-seven years of site data, what outcomes for minimising and managing cumulative impacts have been achieved? Tour operators continue to provide site visitation information in post-visit reports but research scientists and national program support personnel are not being tracked unless via permit or EIA reporting and this is reliant on timely submission of post-activity reports. Annex III, Article 8 (3) of the Protocol includes the requirement for all ATCPs to prepare an inventory of the locations of past scientific and logistic activities in the Antarctic. Some data is available for review through the Antarctic Treaty Information Exchange process or COMNAP; however, information detailing the exact locations of national operators' past activities is not readily available (United Kingdom 2010). The Electronic Information Exchange System (EIES) is limited in the data encapsulated as only details of major field activities are provided. Information is often insufficient to identify specific locations of field activities, a full record of all Parties' activities is not provided and activities not subject to IEE or CEE may not be included on the inventory (United Kingdom 2010).

Exchange of information, submission of post-activity (permit, protected area and EIA) reports and availability of long-term monitoring data should ensure a consistent collective approach to managing cumulative impacts, but this is exceptionally difficult without a centralised database (IUCN 1996; Roura and Hemmings 2014; ASOC 2015). The development of a common meta-database accessible by all governmental and non-governmental operators and potentially managed through the CEP is required. A thorough assessment of cumulative impacts can only be made by the regulating authority if an accurate description of all activities, including past, future and those expected during the course of the season at that site are provided. This relies heavily on comprehensive and detailed advance notification and completion of domestic EIA and permit requirements where appropriate. Complicating exchange of information is that advance notification and post-activity reports are not always submitted to National Antarctic Programs, management plans are bypassed and site guidelines and codes of conduct are not enforceable (Haase et al 2009) which results in even less control over activity conduct and availability of information for evaluation.

Protected Area Management

With the enforcement of Annex V Area Protection and Management to the Protocol in 2002 a system for designating Antarctic Specially Managed Areas (ASMA) and Antarctic Specially Protected Areas (ASPA) was established. ASPAs are designated to 'protect outstanding values or ongoing planned scientific research' (Article 4). ASMAs are designated to 'assist in the planning and coordination of activities, avoid possible conflicts, improve coordination between Parties or minimise environmental impacts' (Article 4). Fifty-two years after the Agreed Measures were adopted there are 7 ASMAs and 72 ASPAs designated throughout the Antarctic and peri-Antarctic (Antarctic Treaty Secretariat 2016). An outcome of the 1996 IUCN workshop on cumulative impacts was the recommendation to use ASMAs and ASPAs as a tool for the management of cumulative impacts (Dalziell and de Poorter 1996); however, this has received minimal follow-up through the CEP/ATCM as evidenced by the lack of Information Papers and Working Papers submitted on this issue. The CEP has adopted guidelines for preparing management plans for ASPAs only and the inspection checklist, applicable to ASPAs and ASMAs, omits any reference to cumulative impacts (Antarctic Treaty Secretariat 2016).

In December 2015 a simple word search of the seven ASMA and seventy-two ASPA Management Plans identified all references to 'cumulative impact' (Antarctic Treaty Secretariat 2015; Harding unpublished 2015). Results indicated that only seven ASPA Management Plans referred to cumulative impacts. Furthermore, cumulative impacts are only briefly mentioned in relation to managing visitor numbers at the historic sites (e.g. ASPA 158, Hut Point, Ross Island) and with regards to the scientific value of geological, geomorphological and biological sampling (e.g. ASPA 148, Mount Flora, Hope Bay, Antarctic Peninsula). No guidance is provided on how cumulative impacts could be identified, assessed or managed in the context of past, present and future activities. Of the seven ASMA Management Plans only four briefly refer to minimising, monitoring, addressing and investigating cumulative impacts but again no guidance on the assessment process is provided. Designation as a protected area is not sufficient to manage cumulative impacts unless there is effective cooperation and communication between Parties and non-governmental visitors (Roura and Hemmings 2011; Chown et al 2012; Bennett et al 2015).

Protected areas, by virtue of their natural qualities, are likely to attract scientific and tourist interest, thereby leading to an increased risk of cumulative impacts occurring as evidence at highly impacted sites on the Fildes Peninsula (Braun et al 2012). Cumulative impact assessment, as a management tool, can facilitate future designation of protected areas (United Kingdom 2010), whereby sites subjected to frequent visitation may require additional management. Once identified, such sites could be systematically managed under the protected area system through site-specific management plans, mandatory establishment of monitoring

programs, comprehensive post visit reporting and permitting authorisation for entry. EIA is a key instrument for managing human impacts in designated protected areas (de Poorter and Dalziell 1997). Although the current protected area management system provides an existing framework in conjunction with the EIA process for managing cumulative impacts, it has not yet been explicitly used for this purposed by the ATCPs. Perhaps improved application of the precautionary approach, as used in Arctic environmental management, could be considered, which would result in a timeframe of 5-10 years being placed on protected areas to assess the level of cumulative impact occurring at selected sites (IUCN 1996). Designation of inviolate areas for the conservation of habitat at locations far from human activity has also been proposed to minimise impacts and provide monitoring data (Valencia 2000; ASOC 2015). The scientific understanding of how biological diversity varies across Antarctica is fundamental in meeting the Protocol's requirement to protect representative examples of major terrestrial ecosystems and in shaping a network of protected areas and the management of cumulative impacts (Hughes et al 2013).

Global Management of Cumulative Impacts

On an international scale, assessment of cumulative impacts had previously been given limited attention in EIA and resultant environmental impact statements with a focus on specific individual projects and direct impacts on the environment (Cooper and Canter 1997). However, spatial and temporal boundaries and consideration of all activities in the project area (past, present and reasonably foreseeable) are becoming more important in EIA practices (Cooper 2004; ASOC 2015). At the IUCN workshop it was recommended that the Antarctic community can learn from experience in assessing cumulative impacts from other areas of the world to enable selection of the best and most appropriate environmental management practices (IUCN 1996). However, progress towards identifying and applying such practices in the Antarctic has been minimal to date.

Although a comprehensive review of international guidelines is beyond the scope of this paper, it is acknowledged that procedures for assessing cumulative impacts have been developed across a variety of industries, particularly mining and hydroelectric developments in both polar and temperate regions. Such guidelines can be adapted for application to Antarctic operations. For example, the Cumulative Effects Assessment Practitioners Guide for the Canadian Environmental Assessment Agency (Hegmann et al 1999) and Bennett et al (2015) recognise the characteristics of the polar region that increase vulnerability to anthropogenic change, including low temperatures that can delay recovery from disturbance, lack of functional redundancy in ecosystems, and potential long-term attractiveness for resource exploitation.

Similarly, the EIA Guidelines developed by the Finnish Ministry of the Environment (1997) acknowledge that the lack of baseline information on environmental variables (eg soil microbes, avifauna population and distribution) may lengthen the EIA process compared with EIAs in temperate regions. Like the Arctic, environmental variables, land-use planning, values, geopolitics, climate and functioning of the ecosystems influence scientific investigations and the practicalities of undertaking environmental assessments in the Antarctic. Furthermore, management practices developed for temperate regions such as the United Kingdom and Australia can also have practical application to assessing cumulative impacts in the Antarctic.

Proposed Framework for Assessing Cumulative Impacts in Antarctica

As National Antarctic Program and non-governmental operators are currently without guidelines to assist with identifying and assessing potential cumulative impacts a basic general framework is proposed. The aim of this approach is to facilitate consideration of cumulative impacts in the planning and conduct of all activities in the Antarctic Treaty area, not only those that may result in a minor or transitory, or greater, impact. The framework suggested is based on a brief review of guidelines developed by regulatory agencies in the United Kingdom, Canada and Australia. Such an approach aims to provide a consistent and convenient way to develop a summary of the findings of the cumulative impacts considered during the EIA process.

Cumulative Impact Assessment

1.0 Introduction – What is a Cumulative Impact?

A cumulative impact can be:

- the combined impact of past, present, and reasonably foreseeable activities over time and space
- the result from the aggregation and interaction of impacts on an ecological receptor
- either positive or negative and can vary in intensity as well as spatial and temporal extent
- an interaction that may trigger or be associated with other impacts
- a linear or exponential aggregation that may reach a 'tipping point' after which major changes in environmental (and other ie historical, social) values can occur

Examples of cumulative impacts:

Atmospheric:	Local contamination of the environment from emissions associated with vehicular and air transport and station operations;
Marine:	Waste water discharge and resultant marine contamination may impact species diversity and abundance of nearshore marine benthic organisms;
Landscape:	Repeated anchoring of boats and disembarking of passengers at landing sites may result in ground disturbance and increase the rate of beach erosion;
Fauna:	Ongoing disturbance associated with repeated visitation to bird colonies during peak season may affect breeding success;
Flora:	The repetitive or transient occurrence of a single activity repeated periodically such as compaction of soil and vegetation due to pedestrian trampling may result in increased vulnerability to invasion by non-native species;
Historic sites	Any human disturbance may expedite degradation of artefacts already impacted by decades of weathering;
Resource Use:	Continual removal of soil and rock for use in station construction may result in permanent impacts to substrate, permafrost and soil microbes; and
Research:	Sampling fauna or flora over extended periods of time may impact upon ecosystem resilience.

2.0 When is an Assessment of Cumulative Impact Required?

In simple terms, along with direct and indirect impacts, cumulative impacts should be considered in the planning and conduct of all activities and addressed in project proposals.

Article 3 of the Protocol on Environmental Protection to the Antarctic Treaty 1991 requires that the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty area, are taken into account when planning activities and preparing EIAs.

Annex I to the Protocol, Environmental Impact Assessment requires consideration of cumulative impacts at the levels of Initial and Comprehensive Environmental Evaluation. However, although not legally mandated under the Protocol, cumulative impacts should also be considered at the Preliminary Assessment stage to ensure a systematic and strategic analysis of all individual activities and impacts is undertaken.

3.0 Step by Step Guide to Assessing Cumulative Impacts

Figure 1. A basic stepped approach for assessing cumulative impacts

Step 1: Determine the Scope of the Activity

Scoping, or the 'how and where', is the process of identifying the priority issues to be addressed in the context of the proposed activity including assessment objectives and indicators for cumulative effects. Factors to consider include:

- Define the activity, project area and acceptable risk to environmental values. Scoping serves to establish spatial and temporal boundaries for the assessment of the proposed activity;
- Ecosystem resistance, assimilative capacity and resilience should also be addressed in relation to spatial and temporal scales;
- Consider and define the intensity, magnitude, repetitiveness and duration of each activity;
- Identify all ecological assets and values and sensitive ecological receptors;
- Identify past, present and reasonably foreseeable plans for activities for the area. Consider the number of national operators in the area or tourist landings at particular sites of interest; and
- Undertake a risk assessment, which should address any unexpected activity that may trigger cumulative impacts such as a change in facility size, logistical support arrangements or seasonal timing for operational conduct.

Step 2: Ecosystem Review and Analysis

Ecosystem review involves identifying the environmental (and other) values within the established temporal and spatial boundaries. The review should:

- Analyse the effects of the activities proposed on ecological receptors. For example, assessment of cause and effect pathways can be determined based on environmental stressor-response models; and
- Conduct an assessment of all environmental baseline conditions for the receiving environment including determining how conditions have changed over time and setting thresholds or acceptable limits of change (carrying capacity).

During step 2 the activity and impact assessment methodology (table 1) can be selected, noting that there are a variety of methods or analytic tools available to assess cumulative impacts. No single technique is proposed but rather a combination of surveys, matrixes, matrices, diagrams and Geographic Information Systems are suggested to incorporate activities and potential impacts with environmental information (table 1). The methodology used to evaluate cumulative impacts should be described in the environmental evaluation.

The availability of data is fundamental to completing a comprehensive ecosystem review and analysis. The accuracy of any methodology used for assessing cumulative impacts depends wholly upon the quality and quantity of data available. Proponents should detail the data available to assist in the assessment process (ie site inventories, post-activity reports, monitoring, site visitation reports). Parties operating within the same geographic area of the intended project should also be contacted to determine past, present and future activity levels.

Step 3. Impact Prediction

Activities identified during the project scoping stage are analysed and expected direct and indirect impacts are assessed that might contribute to a cumulative impact. Impact prediction should also:

- Identify all potential impacts and effects that may potentially occur as a result of the proposed activity and predict the magnitude, probability of occurrence and the extent of the impact;
- Describe all potential interactions between the activity and the receiving environment in the context of all identified stressors. In the context of past, present and reasonably foreseeable activities are these cumulative? Is there a temporal or spatial overlap?;
- Identify the likely pathways or processes of accumulation for the assessed impacts of the proposed activity; and
- Determine the magnitude and significance of potential cumulative impacts recognising that effects may be changes resulting from an individual or multiple separate projects.

Table 1. Methods for assessing cumulative impacts (adapted from Smit & Spaling 1995; Hegmann et al 1999; Walker & Johnston 1999; SDD 2013)

Method	Description	Advantages	Disadvantages
Specialist opinion	· can identify & assess indirect, CI & impact interactions · expert panels/ICGs can be formed to facilitate exchange of information on project impacts	· a wider range of impacts can be considered as an integral part of the assessment process	· specialists may be removed from the regulating authority / proponent · qualitative not quantitative · specialist opinion has the potential to provide conflicting recommendations
Questionnaires	· a tool for gathering information about past, present & future activities which may influence project impacts	· flexible, yet can be focused to obtain site specific information · can expedite early consideration of potential impacts	· can be too subjective · reliant on responses, which may be poor or incomplete
Checklists	· provides a systematic means of identifying activities & likely impacts	· 'standard' checklists for similar projects can be developed	· can result in oversight of effects if not noted on checklist · links between cause & effect are not specified
Interactive Matrices	· a more complex form of checklist · can be qualitative & evaluate impact significance · can be formatted to consider CIs of multiple actions on a parameter	· can be an excellent visual summary of activities & impacts · can be easily adapted to identify & evaluate indirect & CI interactions · can facilitate ranking of impacts to assist in significance evaluation	· can be complex for large-scale projects with multiple sites & operators
Inspections	· conducting onsite inspections or reviewing previous reports can provide historical data & overviews of past impacts & mitigation measures adopted	· can provide succinct written background to past & present activities & impacts · photo-monitoring & other monitoring programs are often addressed in inspection reports	· usefulness of report depends on what was inspected at that point in time
Audit Reports	· internal or external audits can be undertaken to identify aspects & impacts related to the project	· can provide details of corrective actions or mitigation measures undertaken to minimise impacts arising from previous & current projects	· time consuming if information is not readily accessible
Spatial Analysis	· Geographic Information Systems (GIS) & map overlays	· flexible & easy to adapt & update · can consider multiple projects & map past, present & future activities & impacts · enables clear visual presentation	· GIS can be time-consuming and costly if proponents or regulatory bodies are unfamiliar with programs · does not facilitate quantification of impact significance · cause & effect relationships are difficult to determine

Method	Description	Advantages	Disadvantages
Carrying Capacity & Threshold Analysis	· uses knowledge of existing environmental thresholds	· identifies accumulation of impacts against predetermined thresholds · can adapt to consider environmental trends	· requires current data on environmental thresholds & limits for a resource or parameter
Ecological Modelling	· analytical tool for quantifying cause & effect relationships by simulating environmental conditions · can be applied to all environmental parameters if data sets exist	· enables cumulative effect quantification · explicit time & spatial boundaries are determined · cause & effect relationships are specified	· time consuming & requires significant financial funding & commitment · some models are difficult to adapt · successful modelling depends on availability of data

Step 4. Evaluation of Impact Significance

There are many factors to consider when evaluating the potential significance of the impacts of proposed activities regardless of the assessment methodology used in step 3. These include, but are not limited to:

Severity: Project-specific impacts may be negligible when assessed individually; however, when the impacts accumulate or exceed a threshold of environmental damage or impacts are antagonistic, synergistic. The severity of an impact is dependent on the nature of the impact.

Location: Particular area are subjected to the activities of frequent multi-operators, or to intense and repeated activities from one individual operator (IUCN 1996). Site accessibility is also important as sites that provide easy access will be more susceptible to cumulative impacts. Give example

Baseline Condition: The baseline condition of all environmental variables likely to be impacted must be established to accurately determine the potential effects of the proposed project before impact prediction commences. The existing environment should not be considered as the definitive baselines for EIA as it makes the effects of past and present activities part of the baseline rather than factors contributing to cumulative impacts. If past and present factors are not considered then proponents my incorrectly conclude that the proposed action would not contribute to significant impacts.

Uncertainties in Data: Absence of information or errors in interpretation can affect interpretation of data and determination of significance level. All uncertainties should be duly noted in the EIA. Limits of acceptable change are often uncertain or not identified.

Temporal Boundaries: All EIAs should consider that cumulative impacts may extend beyond the duration of the project. In the Antarctic, chemical, physical and ecological processes are often slower than in temperate regions, which is likely to effect the timespan of the proposed project.

Spatial Boundaries: All activities that have the potential to affect environmental variables should be considered. Due to the natural conditions in the Antarctic, the area of potential impact may extend to outside the immediate area affected by the project.

Incremental Condition: The potential level of impact beyond the threshold (level of sustainability) of the environmental variable should be addressed. Although individual activities in one area may have minimal impact, the ecological response may be delayed until a threshold or carrying capacity has been reached. Once reached the impacts become rapidly obvious.

Unavoidable Impacts: All unavoidable impacts for which no mitigation is possible should be identified and described in detail.

Direct/Indirect Impacts: Any changes in environmental components resulting from interactions between the environment and other impacts should be reviewed.

Causal Factors: Identify potential causal factors that can potentially result in cumulative impacts and determine if mitigation measures can be developed and implemented to minimise these impacts.

Step 5. Identify Mitigation Measures and Environmental Monitoring Programs

Measures should be adopted where appropriate to prevent or reduce potentially significant adverse effects on the environment resulting from the proposed activity. Furthermore:

- Proposed activities can be modified to minimise potential impacts and alternatives suggested to avoid, minimise or mitigate potentially significant cumulative effects;
- Environmental monitoring programs should be established based on defined objectives with measurable key indicators at an early stage to avoid any unforeseen adverse effects. Monitoring also serves as an early warning and enables appropriate remedial action to be implemented or mitigation measures to be revised, terminated or redeveloped; and
- It is of paramount importance that monitoring reports are prepared at regular intervals to document the program, key environmental trends and response actions. These reports should be made readily available to other governmental and non-governmental operators for review.

Step 6. Regulatory Authority Decision / Approval

After submission of the EIA the regulatory authority associated with the National Antarctic Program will advise whether the project can proceed or not, in the form of an environmental authorisation or permit. Conditions may be attached to the approval in addition to reporting requirements or further information may be requested if inadequate consideration of cumulative impacts is noted.

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Conclusion

This review has demonstrated that assessment of cumulative impacts is a cross-cutting issue that influences a range of environmental management practices within the Antarctic Treaty System. Despite the assessment of cumulative impacts being a requirement under the Protocol for higher level environmental evaluations, a review of CEEs provided evidence that understanding, identification and assessment is inconsistent, more administrative than practical and somewhat superficial in application. A strategic and systematic approach to assessing activities and impacts is required as part of the EIA process in conjunction with other management practices outlined such as long-term monitoring programs and use of the protected area system. Exchange of information is also fundamental in enabling Treaty Parties and non-governmental operators to implement best practice and fulfil the environmental obligations for assessing the cumulative impacts of all proposed activities. Appropriate assessment of cumulative impacts will potentially provide the long-term qualitative and quantitative data required to assist in the protection of the Antarctic environment and its dependent and associated ecosystems. The proposed framework provides a consistent beginning for systematically addressing cumulative impacts in the absence of approved guidelines under the Antarctic Treaty System.

Appendix 1

Comprehensive Environmental Evaluations (CEE) 1991 – 2015 (Antarctic Treaty Secretariat 2016)

Year	Party	Title	Activity	CEE Available
2015	Belarus	Construction and Operation of Belarusian Antarctic Research Station at Mount Vechernyaya, Enderby Land. Final Comprehensive Environmental Evaluation	Construction, operation and maintenance of facilities	Yes
2013	Belarus	Construction and operation of Belarusian Antarctic Research Station at Mount Vechernyaya, Enderby Land. Draft of the Comprehensive Environmental Evaluation	Construction, operation and maintenance of facilities	Yes
2013	China	Proposed Construction and Operation of a New Chinese Research Station, Victoria Land, Antarctica. Draft Comprehensive Environmental Evaluation	Construction/Operation of new facilities	Yes
2011	United Kingdom	Proposed Exploration of Subglacial Lake Ellsworth. Final Comprehensive Environmental Evaluation.	Direct measurement and sampling of Lake Ellsworth.	Yes
2010	India	Final Comprehensive Environmental Evaluation of New Indian Research Base at Larsemann Hills, Antarctica	Construction of Antarctic facility	Yes
2010	Korea (ROK)	Comprehensive environmental evaluation; Construction and operation of the Jang Bogo Antarctic Research Station, Terra Nova Bay, Antarctica	Activity aims to establish a plan that will minimize the impact of the construction and operation of a new Korean research station on the Antarctic	Yes
2010	Russian Federation	Water Sampling of the Subglacial Lake Vostok. Final Comprehensive Environmental Evaluation	Water Sampling of the Subglacial Lake	Yes
2010	United Kingdom	Proposed Exploration of Subglacial Lake Ellsworth. Draft Comprehensive Environmental Evaluation.	Direct measurement and sampling of Lake Ellsworth.	Yes
2008	China	Final Comprehensive Environmental Evaluation of Proposed Construction and Operation of the new Chinese Dome A Station	Construction of Kunlun Station at Dome A	Yes
2007	China	Proposed Construction and Operation of the new Chinese Station at Dome A. Draft CEE	Construction of a station	Yes
2006	Belgium	Proposed Construction and Operation of the new Chinese Station at Dome A. Final CEE	Construction of a new Station in Dome A, Antarctica	Yes
2006	India	Final CEE: Construction and Operation of a new Belgian Research Station, Dronning Maud Land, Antarctica	Construction of a new facility	Yes
2006	New Zealand	A Draft Comprehensive Environmental Evaluation (CEE) of New Indian Research Base at Larsemann Hills, East Antarctica	Science: climatology	Yes
2006	Ukraine	Draft CEE. Technological binding of a tank with capacity V=200.	Construction of new fuel tank	Yes
2006	United Kingdom	Proposed Construction and Operation of Halley VI Research Station, and Demolition and Removal of Halley V Research Station, Brunt Ice Shelf, Antarctica	Construction / Operation of Facilities	Yes
2005	Belgium	Construction and operation of the new Belgian Research Station in Dronning Maud Land, Antarctica. Draft Comprehensive Environmental Evaluation (CEE).	Construction of new Belgian Research Station	Yes
2005	Germany	Final CEE. Construction of the Neumayer III Station, Operation of the Neumayer III Station, Dismantling of the Existing Neumayer II Station	Station Construction	Yes
2004	Germany	Rebuild and Operation of the Wintering Station Neumayer III	Operational: construction	Yes

		and Retrogradation of the Present Neumayer Station II		
2004	Norway	FINAL Comprehensive Environmental Evaluation (CEE) for the upgrading of the Norwegian summer station Troll	Station upgrade	Yes
2004	United Kingdom	Proposed construction and operation of Halley VI Research Station. Draft CEE	Operational: construction	Yes
2004	United States	CEE for Development and Implementation of Surface Traverse Capabilities	Operational: Infrastructure	Yes
2004	United States	Draft CEE for Project IceCube	Science: Astronomy	Yes
2003	Czech Republic	Czech Scientific Station in Antarctic: Construction and Operation	Station construction and operation	Yes
2003	Norway	The Concept of Upgrading the Norwegian Summer Station Troll in Dronning Maud Land, Antarctica, to Permanent Station.	Station upgrade	Yes
2003	United States	Development and Implementation of Surface Traverse Capabilities in Antarctica	Operational	Yes
2003	United States	Project Ice Cube	Construction of a neutrino telescope	Yes
2002	New Zealand	Draft CEE for ANDRILL: The McMurdo Sound Portfolio	Science: Climatology	Yes
2002	Russian Federation	Water sampling of the subglacial Lake Vostok	Science: climatology	Yes
2000	Germany	Final CEE for European Project on Ice Coring in Antarctica (EPICA) - Dronning Maud Land	Ice drilling	Yes
1999	Germany	Draft CEE for European Project on Ice Coring in Antarctica (EPICA) - Dronning Maud Land	Ice drilling	No
1994	France	Concordia Project - Drilling activity at Dome C, Antarctica - Final Comprehensive Environmental Evaluation	Ice drilling	No
1994	France	Concordia Project. Construction and operation of a scientific base at Dome C, Antarctica - Final Comprehensive Environmental Evaluation	Construction, operation and maintenance of facilities	No
1994	New Zealand	Final Comprehensive Environmental Evaluation Antarctic stratigraphic drilling east of Cape Roberts in South West Ross Sea, Antarctica	Rock drilling	No
1993	South Africa	Draft Comprehensive Environmental Evaluation (CEE) of the proposed new SANAE IV facility at Vesleskarvet, Queen Maud Land, Antarctica	Construction, operation and maintenance of facilities	No
1992	France	Study of the environmental impact of the construction and operation of a scientific base at Dome C - Concorde base	Construction, operation and maintenance of facilities	No
1992	New Zealand	Draft Comprehensive Environmental Evaluation - Antarctic stratigraphic drilling east of Cape Roberts in Southwest Ross Sea, Antarctica	Rock drilling	No
1991	United States	Final supplemental Environmental Impact Statement for the U.S. Antarctic Program	National Antarctic Programme	Yes
1990	United States	Draft Supplemental Environmental Impact Statement for the United States Antarctic Programme	National Antarctic Programme	No
1989	United Kingdom	Proposed construction of a crushed rock airstrip at Rothera Point, Adelaide Island, Antarctica - Final Comprehensive Environmental Evaluation	Construction of air facilities	No
1988	United Kingdom	Comprehensive Environmental Evaluation - Proposed construction of a hard airstrip at Rothera Point, Adelaide Island, Antarctica	Construction of air facilities	No

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