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Proposal for a new SCAR Scientific Research Programme



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<p>1. Name of the Proposed SRP:</p> <p style="text-align: center;">Antarctic Thresholds - Ecosystem Resilience and Adaptation (AnT-ERA)</p>
<p>2. Name(s) of the lead proponent(s) (including affiliations and contact information):</p> <p>Julian Gutt, Alfred Wegener Institute, Germany, representing the entire PPG</p>
<p>3. Sponsoring SSG(s): Life Sciences</p>
<p>4. Estimated SCAR funding required over the total programme lifetime (in US\$):</p> <p>\$ xxxxx (\$ 9000/year)</p>
<p>5. Abstract</p> <p>Stresses on Antarctic ecosystems result from global climate change, including extreme climatic events, and from other human impacts. Consequently, Antarctic ecosystems are changing, some at a rapid pace while others are relatively stable. A cascade of responses from molecular through organismic to the community level are expected as a result of these stresses during the ongoing era of climate change.</p> <p>The differences in biological complexity between the polar regions and the rest of the planet suggest that stresses on polar ecosystem function may have fundamentally different outcomes from those at lower latitudes. Polar ecosystem processes are therefore key to informing wider ecological debate about the nature of stability and potential changes across the biosphere.</p> <p>The main goal of AnT-ERA is to define and facilitate the science required to examine changes in biological processes, from the molecular to the ecosystem level, in Antarctic marine, freshwater and terrestrial ecosystems. Tolerance limits as well as thresholds, resistance and resilience to environmental change are to be determined.</p> <p>Three key questions have been identified.</p> <ul style="list-style-type: none"> (1) <i>How are Antarctic organisms adapted to current and future environmental conditions and what are the genetic underpinnings to their life history, organism plasticity and physiology?</i> (2) <i>How does environmental change affect population performance and species interactions; e.g., how do species traits impact community stability, key ecosystem processes, and the identities of ecological winners and losers?</i> (3) <i>What are the likely consequences of a changing environment for key ecosystem functions and services?</i> <p>AnT-ERA will combine cutting edge bottom-up and top-down approaches <i>in situ</i>, in the laboratory (e.g. via 'omics') and <i>in silico</i> (e.g. modelling and database mining).</p>

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5 Introduction - scientific objectives and statement of task

6 The overarching objective of AnT-ERA is to define and facilitate the science required to
7 determine the vulnerability and resilience to change and stress of Antarctic biological
8 systems and, as a consequence, assess the likelihood of crossing biological thresholds: i.e.,
9 determine how close we are to the ecological cliff.

10 The latest report of the Intergovernmental Panel on Climate Change (IPCC, 2007)
11 concluded that “*Warming of the climate system is unequivocal...*” Current and projected
12 climate changes are unprecedented in magnitude and rate and pose major threats to
13 ecosystem functioning, services, and integrity. Areas along the Antarctic Peninsula are
14 warming faster than anywhere on Earth (except the Arctic) while in other Antarctic areas
15 temperatures are relatively unchanged, in part due to the ozone hole (Shindell & Schmidt
16 2004, Turner et al 2009). The many species living in warmed and unchanged areas provide
17 an opportunity to evaluate the resilience of all levels of biological organisation in all major
18 Antarctic environments, terrestrial, freshwater, and marine pelagic and benthic. Such
19 “natural experimental conditions” exist in very few places on Earth, and nowhere else at high
20 latitudes. Because we live in an era of rapid environmental change in polar ecosystems, it is
21 pressing that such studies be made within the next 10 years to inform climate-change policy,
22 or else a unique opportunity may be lost.

23 AnT-ERA will focus on current biological **processes** that may reflect a cascade of responses
24 to environmental forcing - from molecular and physiological to those at the organismic and
25 ecosystem levels. AnT-ERA will be classified into three overlapping general themes:

26 (1) Assessment of when, where, and with what impact climate change affects
27 **molecular and physiological performance**, and which performances will allow
28 coping with change or be forced across critical thresholds.

29 (2) Identification of interactions between drivers and **population processes**
30 (resulting, for example, from species traits) for a predictive understanding of
31 population resilience under future environmental conditions.

32 (3) Examination of **ecosystem functions** that are potentially sensitive to climate-
33 forced changes, and critical to the maintenance of biogeochemical cycles and
34 **ecosystem services**, including carbon storage, maintenance of biocomplexity,
35 nutrient regeneration, and biomass production.

36 This focus will complement that of the proposed “State of the Antarctic Ecosystem” (AntEco)
37 programme, which addresses the origins and evolution of current large-scale biological
38 patterns. AnT-ERA will contribute significantly to the realization of SCAR’s strategic plan,
39 especially encouraging excellence in research, which addresses topics of regional and global
40 importance as well as emerging frontiers in Antarctic science. AnT-ERA will also support
41 dissemination of important scientific knowledge to experts and all levels of society.
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43 **Ecological threshold** is a situation at which changes in external conditions cause rapid,
44 non-linear change in ecosystems and their health. When an ecosystem flips from one state
45 to another the term **tipping point** can also be used.

46 **Resilience** is the ability of an ecosystem to return to a previous state from which it has been
47 disturbed (see Folke et al 2004). It can also be considered as “self-repairing capacity”
48 (Walker et al 2004). **Disturbance** is defined as a discrete event that disrupts ecosystems,
49 communities or populations and changes resources, substrate availability, or the physical
50 environment (after Pickett & White 1985).

51 Modern biomolecular studies (“omics”) analyse *inter alia* at which rates genetic information is
52 translated to metabolically relevant components, e.g. proteins and enzymes. Such turn-over
53 rates allow conclusions on the **adaptation** of organisms to their environment and predictions
54 on the response of **physiological (life) processes** to stress.
55

56 **Background - foundational knowledge**

57 Environmental change occurs across broad temporal and spatial scales. Recent climate
58 change is slow compared to the daily changes, but is much faster than previous long-term
59 changes such as glacial cycles. For example, the Antarctic Peninsula is warming faster than
60 anywhere else on Earth: ocean temperatures have increased by approximately 2°C, and sea
61 ice extent and persistence have declined markedly since the 1950s (Meredith & King 2005,
62 Stammerjohn et al 2008). Currently, organisms across the planet experience a range of
63 environmental change from daily or tidal to seasonal and multi-year (e.g. El-Niño) to long-
64 term (e.g. glacial cycles). Terrestrial Antarctic species regularly experience periodic
65 temperature change that marine species have not experienced in millions of years. Antarctic
66 species generally have specific adaptations to extreme environments that suggest their
67 responses to climate change may differ from species elsewhere. All Antarctic ecosystems
68 (marine, terrestrial, freshwater, subglacial lakes and cryconites) are potentially affected by
69 environmental, especially climate, changes (Clarke et al 2007, Vincent & Laybourne-Parry
70 2008, Turner et al 2009, Brandt & Gutt 2011). However, the possible responses of
71 organisms to environmental change vary markedly across process scales, from gene to
72 ecosystem, and spatial scales from nanometre to regional (Peck 2011 in press).

73 Theme 1: Physiological limits, biomolecular processes, and thresholds: Organismal
74 responses to environmental change vary markedly across process and temporal scales,
75 from cellular/molecular to organism levels. Evolutionary theory predicts that environments
76 that have been stable for thousands of years will produce species with low genetic variation
77 around an optimal phenotype (stabilizing selection, Charlesworth et al, 1982). As a result,
78 many Antarctic species have a diminished capacity to respond to abrupt environmental
79 change because they have lost alleles, genes and/or metabolic pathways that are required
80 to tolerate a wider range of environmental stress, e.g., icefish that have lost the ability to
81 produce haemoglobin (Verde et al 2008). Some fish and terrestrial invertebrates spend
82 metabolic energy to synthesize antifreeze compounds (DeVries 1988), and a low capacity to
83 cope with warming is known for a number of marine species (Pörtner et al 2007, Peck et al
84 2009). Local species extinction is a predictable consequence of the loss of genetic
85 resources required for an organism to respond to environmental change (Burger & Lynch
86 1995). Understanding the physiological limits, the genetic underpinnings of these, and
87 environmental response thresholds of species that play a central role in current ecosystem
88 processes (e.g. krill, nematodes, macro- and microalgae, etc.) is needed to inform predictive
89 ecological models under scenarios of future climate change.

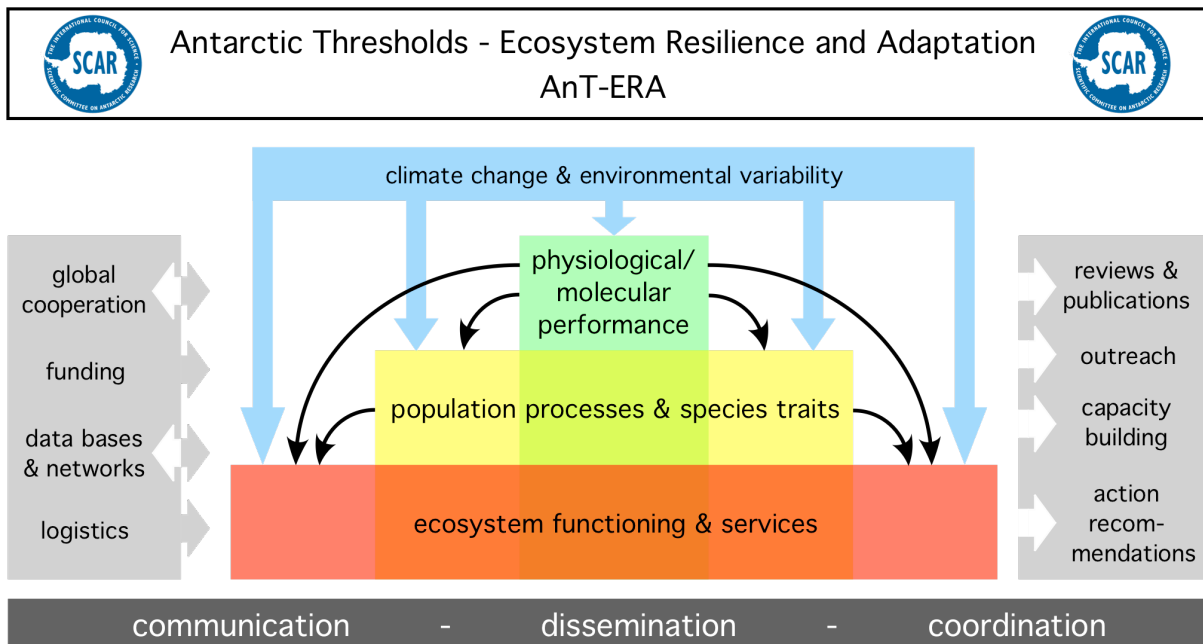
90 Theme 2: Population processes. Biotic and abiotic drivers can determine population
91 performance such as species distributions and competitiveness. These drivers work through
92 different species traits and processes, for example, growth, feeding, reproduction, migration,
93 and recruitment. Understanding interactions between drivers and population processes is
94 essential for modelling future population resilience to future temperature rise and ocean
95 acidification (Cummings et al 2011, Kawaguchi et al 2011). Indirect effects mediated through
96 the food web add further levels of complexity. Impacts on population processes in lower
97 trophic levels can be amplified through food webs, e.g. from krill, salps, and copepods, up to
98 apex predators (Atkinson et al 2004, Barrett et al 2008, Montes-Hugo et al 2009, Trivelpiece
99 et al 2011). Top-down effects are also likely; for example, cooling in the Dry Valleys has led
100 to a rapid decline of the key carbon cycling invertebrate, a soil nematode. The
101 unprecedented changes in flora and fauna may include both the entry or range expansion of
102 invasive species, e.g., king crabs (Thatje & Fuentes 2003, Bergstrom et al 2006, Tin et al
103 2009, Smith et al 2011) as well as the loss of species from the Antarctic ecosystems
104 (Jenouvrier et al 2009, Jacob et al 2011).

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106 Theme 3: Ecosystem functioning and services. Antarctic ecosystems play a key role in
 107 climate regulation and provide globally significant ecosystem services. Environmental
 108 changes may alter the production and transfer of energy and materials through marine and
 109 terrestrial food webs, as well as the sequestration of carbon in the deep ocean. For example,
 110 ecosystem processes in most parts of the Southern Ocean are closely linked to sea-ice
 111 dynamics, and sea-ice cover is predicted to decline by 25% in the next century (Arrigo &
 112 Thomas 2004). While primary production is typically high at the sea-ice edge (Arrigo et al
 113 2008), the responses of primary production to changes in sea-ice extent and duration are
 114 poorly constrained (Montes-Hugo et al 2009). Alterations in phytoplankton community
 115 structure are expected to have cascading effects on secondary production and export of
 116 organic carbon to the ocean's interior. In addition, recent observations of krill aggregations
 117 and humpback whale foraging in WAP fjords (Nowacek et al 2011) may be related to sea-ice
 118 loss on the open shelf. In the large off-shore pelagic system, a recovery from whaling of
 119 humpback whale stocks of ~10% per year contrasts with an enormous decrease in food
 120 resources, the krill stock, especially in the Atlantic sector of the Southern Ocean (Atkinson et
 121 al 2004, Ainley et al 2010). As another example of potentially climate sensitive ecosystem
 122 services, the sea-bed system receives phytodetritus from the sea-ice zone, and acts as a
 123 carbon sink, foodbank, and regenerator of nutrients, supporting rich assemblages of
 124 suspension and deposit feeders (Smith & DeMaster 2008, Gutt et al 2010). Finally, in
 125 terrestrial ecosystems, nematodes play a disproportionate role in soil carbon cycling;
 126 population declines due to climate change result in a decrease in this ecosystem process
 127 (Barrett et al 2008). Biological complexity in all Antarctic systems may enhance resilience in
 128 ecosystem functions and services (McCann 2000). Gradual, climate-related changes may
 129 initially have little apparent effect on the state of Antarctic ecosystems but alter the "stability
 130 domain," increasing the likelihood of shifts to alternate ecosystem states (Scheffer et al
 131 2001).

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135 Scheme of AnT-ERA's structure. Scientific themes in the centre in colour, strategic and
 136 management issues in grey boxes.

137 **Scientific approach and rationale**

138 Antarctic organisms include marine species that experience stable temperature regimes
139 (e.g. Peck et al 2009), whereas some terrestrial species survive regimes with possibly the
140 largest annual temperature amplitudes on Earth (Hengherr et al 2009). In addition, some
141 Antarctic ecosystems are undergoing very rapid climate change, whereas others appear to
142 be changing very slowly. It is important that we use such environmental differences to
143 assess resilience to changes in temperature, seasonality, and resource supply. As a
144 consequence, AnT-ERA will focus on selected key sites, where detailed studies will
145 elucidate ecosystem response to the full range of environmental variation. These studies will
146 cover three levels of biological organisation, ranging from molecular/organismic through
147 population to ecosystem levels.

148 Theme 1: Physiological limits, biomolecular processes and thresholds. Within this theme
149 geneticists, physiologists and systems biologists will investigate which genetic information is
150 involved in mitigating environmental insults and, thus, is directly responsible for a species'
151 resilience and its capacity to respond to change. The extraordinarily successful work on
152 known molecular adaptations to the Antarctic environment, such as development of anti-
153 freeze proteins, loss of red blood pigments and cells, and activity of heat-shock proteins
154 (Clark & Peck 2009), must be continued. The rapid development of new technologies
155 promises to provide further insights into the evolutionary responses and thus thresholds of
156 Antarctic organisms. In addition, next generation molecular tools can be wielded to identify
157 new molecular processes that enable organisms to cope with changing environmental
158 conditions or limit their organismic plasticity. One approach to reach these aims is the direct
159 comparison of populations living within areas of fastest environmental change with
160 populations of the same species in areas of little or no change. Other relevant studies will
161 involve comparing organisms with broad tolerance to environmental extremes (e.g.
162 terrestrial species) with those having restricted capacities to resist change (e.g. marine
163 ectotherms).

164 The above recommendations require comparative studies of genetic characteristics, their
165 expression and physiological flexibility in organisms across wide spatio-temporal scales
166 (including seasonal and climatic oscillations). This calls for coordinated activities between
167 stations and field campaigns in all major environments. Likewise, coordinated field and
168 station-based campaigns measuring relevant characteristics will be needed for terrestrial,
169 freshwater and marine benthic groups. These analyses are essential for individual-based
170 models (life-history models) and it is important that they be geo-referenced so that they can
171 inform spatial and temporal ecosystem models.

172 Theme 2: Population processes. An intended outcome of this theme is a predictive
173 understanding of synoptic effects of external drivers on population performance and
174 processes, such as population growth or decline, expansion or contraction of population
175 ranges. These studies will inform future population scenarios as an input for the ecosystem
176 functioning approach (Theme 3). To gain the necessary mechanistic understanding of
177 population processes and of their relationships to external drivers, observational (population
178 dynamics in space and time) and experimental (lab, microcosm, field) approaches are
179 required. For example, it is not yet clear to what extent population changes in penguins are
180 caused either by changes in krill biomass associated with ocean warming (Montes-Hugo
181 2009), or by increased snow accumulation that prevents successful reproduction (Ducklow
182 et al 2007). The two scenarios may produce different population projections in relation to
183 future changes in climate.

184 The value of long-term observation of populations is well recognised in this context, but
185 these are relatively well established only for a limited number of species, e.g., some seabird
186 and seal colonies (Trivelpiece et al 2011), terrestrial invertebrates (Simmons et al 2009), and
187 stream diatoms (Esposito et al 2006). While population changes may correlate with

188 environmental variables (e.g. Forcada et al 2006), these correlations do not necessarily
189 indicate causal relationships. Behavioural changes can buffer environmental impacts on
190 population processes (e.g. Mori & Boyd 2004), and may be used as sensitive indicators of
191 environment fluctuations (Costa et al 2010). Microevolutionary adaptation to the polar
192 environment may add spatial variability to population response to environmental change.
193 Even within Antarctic regions, populations of the same species can respond differently to
194 change, due to isolation of gene pools (e.g., Guidetti et al 2006, Convey et al 2011).

195 Speculation exists about radical damage due to invasion of durophagous predators, e.g.
196 stone crabs, on the continental shelf, an impact which has not occurred in the past millions
197 of years (Aronson et al 2007, Smith et al 2011). In contrast, some species may experience
198 “explosive” growth such as deep-sea holothurians (Gutt et al 2011) under favourable food
199 conditions, and *Homaxinella* sponges on recently the disturbed seabeds (Dayton, 1978).
200 Complete population performance of macro- and microalgae depends significantly on the
201 radiation regime. As a consequence, studies of their response to increased sedimentation
202 rates and turbidity are of high relevance to understand ecosystem changes (Wiencke &
203 Clayton 2009).

204 Theme 3: Ecosystem functioning and services. In some Antarctic and Sub-Antarctic regions,
205 ongoing rapid climate change will continue to alter ecosystem functions. As a consequence,
206 rapid scientific, multidisciplinary actions are urgently demanded to define baselines to track
207 ecosystem responses to such changes. There is also high demand from policy makers for
208 knowledge on climate-change impacts to sustainably manage Antarctic ecosystems
209 exposed to anthropogenic stress (e.g., overfishing, tourism, pollution, and glacial retreat).
210 Creative hypotheses concerning key ecosystem functions such as primary production,
211 secondary production of foundation species (e.g., krill), organic matter mineralization,
212 nutrient regeneration, calcification, and carbon export to midwater and bottom sediments
213 should be tested and corresponding ecosystem research activities coordinated. Another
214 important suite of hypotheses deals with the importance of latitudinal shifts versus entire
215 reorganization of Antarctic ecosystem functions and services in case of continuing
216 environmental change. The results can contribute considerably to clarification and
217 quantification of the role of the Antarctic, including the Southern Ocean, as a biological
218 carbon sink at present and in the future.

219 Theme 3 will be pursued by (A) identification of priority study areas, such as the Antarctic
220 Peninsula, where climate is warming rapidly, warm deep water is moving up onto the shelf,
221 and ice shelves and glaciers are retreating. Other targeted areas will include ecosystem
222 boundaries such as polar fronts, where major changes are expected in the future. In
223 addition, reference areas with relatively stable end-member conditions, e.g., the Eastern
224 Weddell Sea, McMurdo Dry Valleys, and the shelf of East Antarctica will be studied to
225 generate comparative information and to detect Antarctic-wide changes. (B) Synchronous
226 analyses of linkages across subsystems will also be conducted, e.g., of phytoplankton
227 blooms in the water column and their fallout and fate at the seafloor, and the effects of
228 glacial melt and ice-shelf collapse on marine and terrestrial ecosystems. (C) Finally, findings
229 from organismal physiology (theme 1) and population processes (theme 2) will be integrated
230 into the ecosystem-level syntheses.

231 AnT-ERA's ecosystem approach will include identification of key functional and indicator
232 species (e.g., seabirds, mammals, invertebrates) associated with ecosystem processes. To
233 make the observations representative of larger parts of the Antarctic ecosystems, detailed
234 investigations over long periods at fixed sites and covering broad spatial scales (e.g.
235 Continuous Plankton Recorder programme, Hosie et al 2003) will be implemented. These
236 new insights will be fed into state-of-the-art models of ecosystem function to more accurately
237 predict ecosystem resilience and tipping points over a range of future environmental
238 scenarios.

239 Synergies with other SCAR initiatives. SCAR has a key role in achieving AnT-ERA's goals.
240 Most important is that AnT-ERA's focus will complement that of the proposed "State of the
241 Antarctic Ecosystem" (AntEco) programme, which addresses the origins and evolution of
242 current large-scale biological patterns. Another important link will be developed with the new
243 "Antarctic Climate in the 21st Century" (AntClim21) programme of SCAR, since
244 environmental changes are a main driver of biological processes. Joint cruises and field
245 programmes will be organised through the "Council of Managers of National Antarctic
246 Programs" (COMNAP). It is essential to disseminate results and facilitate the fastest
247 progress through the SCAR Biology Symposia and Open Science Conferences. Such
248 networking and cross-linkage opportunities are powerful drivers for progress including
249 standardisation of scientific protocols to create added value for all parties involved. SCAR
250 has an essential role in the management of data and assisting with access to international
251 data portals through its Standing Committee on Antarctic Data Management (SC-ADM).
252 Data management will be supported e.g. by SCAR's biological data network ANTABif
253 (formerly SCAR-MarBIN), see "Data management plan". Interactions with scientists from
254 non-biological, but ecologically relevant, disciplines will be greatly facilitated by SCAR
255 support through its SSGs, and Expert and Action Groups, such as the SCAR Birds and
256 Mammals Expert Group. AnT-ERA will provide new results for regular updates to the
257 "Antarctic Climate Change and the Environment" (ACCE) report and through ACCE also to
258 IPCC. As a result, AnT-ERA will also directly contribute to SCAR's "Standing Committee on
259 the Antarctic Treaty System" (SC-ATS), allowing clear scientific information to be provided to
260 the "Committee for Environmental Protection" (CEP) and the Antarctic Treaty system as a
261 whole.

262 Research in Antarctica would continue even without SCAR support, but the development of
263 major paradigms like ecological resiliencies and tipping points would likely take decades
264 longer, and it may then be too late for inclusion in significant policy and conservation efforts.

265 **Experimental section and methodologies**

266 Theme 1: Physiological limits, biomolecular processes and thresholds. Understanding the
267 genetic and physiological processes that constrain how individual organisms mitigate stress
268 provides insight into understanding and predicting changes in the distribution, abundance
269 and functional diversity of ecological communities (informing Themes 2 and 3, below). For
270 example, gene expression and proteomic studies have already revealed the stress proteins
271 and metabolic pathways involved in heat-stress responses and UV-protectants exhibited by
272 some Antarctic terrestrial and marine species (Clark & Peck 2009, Rozema 2002, Peck et al
273 2006). Although these studies have been important in identifying the main molecular targets
274 linked to physiological adaptations to environmental stress, emerging technologies for
275 exploring whole transcriptomes and metagenomic responses to stress will strengthen our
276 ability to identify the ecological amplitude of eukaryotic species and microbial soil
277 communities. Progress in this area will require the use of current and next-generation
278 genomic methods. In addition, we need to combine transcriptomic and proteomic
279 approaches to understand how organisms may translate a changing environment into a
280 molecular response and how this response contributes to organism fitness. Such knowledge
281 forms the baseline for predicting how species and communities might respond to
282 environmental change.

283 Theme 2: Population processes. Observational and experimental studies are required to
284 predict the response of populations to environmental change. (i) Observation of key
285 population processes (e.g. feeding, reproduction, dispersal) across natural environmental
286 gradients in space and time will illuminate population performance under current and past
287 conditions (e.g. Wall et al 2011). Interspecific comparisons will show which specific traits are
288 important in determining resilience and which species are more or less sensitive to change
289 (Forcada et al 2006). (ii) Manipulation and comparative experiments at different scales (lab,

290 mesocosm, field) will be useful tools to determine population resilience capacity as well as
291 the significance of inter- and intraspecific interactions (e.g. competition). Both observations
292 and experiments will contribute to the development of scenarios and models of future
293 Antarctic life. There are several examples of how data on populations of a single species
294 can be used to determine their response to change. One example involves use of the diving
295 behaviour of elephant seals as a proxy for their local feeding conditions (Biuw et al 2007).
296 Through analysis of numerous existing (past) and future diving profiles in different areas, a
297 relatively complete image of temporal changes and regional differences can be provided. As
298 a consequence of ecological limits, the resilience and thresholds of populations can be
299 determined for this species, and maybe in the future for other endotherms.

300 Theme 3: Ecosystem functioning and services. In order to assess the consequences of
301 environmental change, we must first improve our knowledge of the current functioning of the
302 various ecological sub-systems. The relevant ecological processes that determine
303 thresholds and resilience of Antarctic ecosystems will be evaluated through interdisciplinary
304 surveys and studies. In terms of field methods, more *in situ* tools, which measure biological
305 processes automatically or with a higher spatial resolution than to date, must be developed.
306 Field measurements will be amplified by *in situ* experiments. A very efficient approach in this
307 context is to use (extreme) natural events as large field experiments. Examples are unusual
308 early melting of sea-ice affecting krill recruitment, massive sinking of phytoplankton to the
309 sea-bed after storms, disintegration of ice shelves changing the marine ecosystem structure,
310 disturbance and succession of benthos following iceberg scouring, warming across
311 terrestrial landscapes altering biogeochemistry of soil habitats, and increased snowfall
312 affecting survival of penguin chicks and eggs. The ecosystem approach will also benefit from
313 laboratory experiments conducted under Themes 1 & 2. The use of a variety of cutting-edge
314 technologies, from transcriptomics to remote sensing, will provide the basis for integrative
315 ecosystem modelling. Approaches, which correlate current and future environmental
316 conditions with biological features, should be refined by including extreme events, by using
317 finer spatial scales, and by implementing known physiological performance/limits. They
318 should be further developed into dynamic models, which are spatially explicit and include
319 physical forcing and population processes (e.g. dispersal, growth, mortality and
320 reproduction) and interactions. These can simulate a broad range of environmental and
321 biological characteristics and thus allow determination of specific combinations of
322 parameters at which the ecosystems reach thresholds or tipping points. The incorporation of
323 findings from molecular ecology (Theme 1) is a challenge for the future and demands new
324 modelling concepts to be developed (see Gutt et al in press).

325 **Management and reporting (including a Scientific Steering Committee)**

326 Management tasks directly follow from the AnT-ERA general objectives, which are to focus,
327 stimulate, and coordinate research activities dealing with thresholds and resilience of
328 Antarctic life and disseminate corresponding knowledge. There are two objectives. The first
329 is to provide a knowledge platform compiling basic information about any initiatives
330 worldwide dealing with our major goals in order to accelerate the exchange of concepts,
331 data, and experience. The second is to make AnT-ERA the centre of an informal network of
332 specialists and projects, by attracting the attention of the scientific community and offering
333 advice to new projects. This will facilitate an added value for both single initiatives and
334 collaboration within the overall AnT-ERA approach.

335 All three themes and all three types of ecosystems, marine, terrestrial and freshwater will be
336 represented in the steering committee. Each member will contribute to the decisions, e.g. on
337 workshops, review articles, development of concepts and general or specific
338 recommendations in this fast moving field of science. Each member of the steering
339 committee will represent part of the wider community of scientists according to the AnT-ERA
340 themes.

341 Dissemination of scientific results will be supported by the administration of AnT-ERA, by
342 maximising the flow of attractive scientific information to a wider public. A newsletter, a list of
343 projects, and key publications will be compiled and published electronically.

344 The steering committee will act as source of information and recommendations to decision
345 makers; such initiatives will depend on contributions from the entire community.

346 Reporting of scientific activities and high-impact publications is part of a continuous outreach
347 component of AnT-ERA. Such output will be summarised and briefly reviewed every two
348 years and presented to the cross-SSR meetings associated to the OSC. In addition, these
349 results will provide a basis for further discussion within the meetings of the LSSG and during
350 workshops of the SCAR Biology Symposium.

351 **Milestones, outcomes, and results**

352 AnT-ERA is designed as a broad scientific programme supporting excellent research and
353 disseminating corresponding novel information to the scientific community, decision makers,
354 and the wider public. The essential primary “tools” are publications in journals and papers
355 presented at scientific workshops, symposia and congresses. Deliverables will include:

- 356 (i) Primary publications in peer-reviewed journals,
- 357 (ii) Reviews and syntheses identifying current state of knowledge and important
358 future research directions,
- 359 (iii) Optimized flows of data and information made available through data-bases,
360 web--services and networks as well as advice to decision makers,
- 361 (iv) Presentations at influential Antarctic-specific symposia, especially SCAR OSC
362 and Biology Symposia, including AnT-ERA specific sessions,
- 363 (v) Presentation of results to the broader scientific community to inform global scale
364 syntheses and future research directions,
- 365 (vi) Leading of, and participating in, major workshops, which support both the
366 development of long-term observation networks (weather, ocean, lakes and
367 streams or terrestrial) and an integration of ecological information into
368 interdisciplinary models.

369 The quality and thus the measurable success of AnT-ERA's scientific output, especially
370 written publications, depends on the usual scientific evaluation of research results, their
371 uniqueness, novelty, and their broader disciplinary and cross-disciplinary context and
372 scientific awareness. An important final outcome of AnT-ERA could be a summary of
373 Antarctic ecosystem vulnerabilities to change and potential impacts on ecosystem
374 functioning, based on a much improved understanding of ecosystem processes. However,
375 such efforts demand external funds.

376 The following events mark potential milestones in communication within the AnT-ERA
377 community and will provide a platform for exchange with a broader scientific world:

- 378 2013 Kick-off AnT-ERA workshop at the XI Biology Symposium, Barcelona
- 379 2014 Mini AnT-ERA workshop at the XXXIII SCAR and Open Science Conference
- 380 2015 AnT-ERA Workshop: capacity building to train the next generation of specialists for
381 biological process studies
- 382 2016 AnT-ERA Syntheses-workshop at the XXXIV SCAR and Open Science Conference
- 383 2017 Meeting to plan the future of AnT'ERA
- 384

385 **Data management plan**

386 Large amounts of complex data, including genetic but also non-biological environmental
387 data and biological/functional process information, will be produced. Data management will
388 follow existing national and international conventions and use established infrastructure,
389 e.g., ANTABIF, Polar Information Commons, and GenBank. Such data systems not only
390 provide a modern way to accommodate and manage data and to make them widely
391 available, but also allow them to be successfully exploited, especially if adequate portals are
392 available (Parsons et al 2011). AnT-ERA will act as a meta-information node by dynamically
393 pointing to the relevant data.

394 **Capacity building, education and training plan**

395 “Education and Outreach” activities will be a major component of this programme to ensure
396 the issues facing Antarctic ecosystems and our latest research findings are highlighted in the
397 public domain and perception. Talks to schools, universities and the general public, popular
398 articles (in magazines and newspapers) and additions to school curricula will also be major
399 foci. A specially constructed website (including blogs and videos) will provide a variety of
400 general and detailed information but will mainly concentrate on scientific results of broad and
401 general relevance/interest. Similarly, through direct communication with policy makers and
402 end-user groups, and production of ‘white papers’, AnT-ERA scientists will contribute to the
403 development of policy at national and international levels (e.g. global emission control
404 strategies, biosecurity, tourism, strategic and ecosystem based management of Antarctic
405 marine resources).

406 This programme will foster the development of the next generation of Antarctic scientists by
407 ensuring the presence of APECS members in the steering committee of AnT-ERA. It will
408 also build capacity within the Antarctic community by increasing the accessibility of data
409 describing Antarctic ecosystem processes and encouraging collaboration to increase the
410 use of new tools, methods and technologies.

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490 **Supporting information**

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492 **I. Short biosketch and homepage URL for proposed Chief Officer(s) and lead**
493 **investigator(s)**

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495 Chief officer: NN ([http.....](http://...))
496 Theme 1: L. Peck, C. Verde, B. Adams
497 Theme 2: D. Wall, A. Takahashi, V. Cummings
498 Theme 3: C. Smith, E. Isla, I. Schloss
499 Liaison officer to PS SSG: T. Bracegridle; Liaison officer to IASC: NN
500 Liaison officer to ICED: E. Murphy (preliminarily); APECs representative: NN

501 **II. Justification for SCAR sponsorship (why does SCAR support add value?)**

502 Identifying resilience and tipping points in Antarctic ecosystems is a complex challenge.
503 Thus research within AnT-ERA needs a common focus, well-organised coordination and
504 strong cross-disciplinary linkages with other initiatives. This can be best provided by a large
505 interdisciplinary and international organisation such as SCAR primarily at the scientific but
506 also at the logistic level. Isolated research activities should be assembled and given the
507 opportunity to exchange experience for which SCAR meetings provide an excellent platform.
508 In addition, through SCAR SSG-LS AnT-ERA can attract the attention of new programmes.
509 AnT-ERA will also adopt the legacy of finished initiatives such as GLOBEC, JGOFS, EASIZ
510 and EBA. Providing the opportunity to jointly use large facilities AnT-ERA will not compete
511 with stand-alone features or core skills of smaller projects. In contrast, the coordination work
512 of AnT-ERA will increase the quality of their scientific work by creating synergistic effects.

513 **III. International involvement and partnerships**

514 Besides close links to other SCAR initiatives AnT-ERA will contribute with long-term data
515 sets to „Southern Ocean Observing System“ (SOOS) and parallel systems in non-marine
516 environments. AnT-ERA will also contribute to strengthen interactions between SCAR and
517 the “Commission for the Conservations of Antarctic Marine Living Resources” (CCAMLR),
518 the “International Arctic Science Committee” (IASC), and the “Integrating Climate and
519 Ecosystem Dynamics” (ICED) programme. Action recommendations to ATS/CEP and
520 initiatives such as IPCC have been mentioned in the main part of this document.
521 Dissemination of results to stakeholders and society depend on Outreach and Education.
522 This is especially so in the inclusion and engagement of young people through the
523 “Association of Polar Early Career Scientists” (APECS) and fellowship programmes.

524 **IV. Budget justification (other potential sources of funds)**

525 National Antarctic programmes will primarily fund the research to be combined under the
526 umbrella of AnT-ERA. The corresponding coordination and dissemination work, however,
527 does not fall into the responsibility of single research initiatives and, thus, requires financial
528 support from SCAR. This refers especially to distribution of various kinds of information
529 especially through electronic media and the organisation of periodic workshops.

530 **V. Other information (acknowledgements)**

531 This proposal has been written by T. Bracegridle, V. Cummings, J. Gutt, E. Isla, L. Peck, I.
532 Schloss, C. Smith, A. Takahashi, C. Verde, D. Wall, T. Brey, B. Meyer, D. Abele, B. Adams,
533 participants of a workshops held in May 2010 in Castiglioncello, Italy and October 2011 in
534 Delmenhorst, Germany. A draft had been collegially and unofficially been evaluated by
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