Protection of the Three Poles

Falk Huettmann
Editor

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Springer

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Cover Illustration:

Front Cover:
Upper: A large new walrus colony in 2007 at Cape Kozhevnikov; Chukotka, Russia (photo by Andrei Boltunov).
Center: Tourists from the *Marina Svetlaeva*, Aurora Expeditions, on an ice floe near Coulman Island, off Antarctica, January 2009 (photo by R.E. Barwick).
Lower right; from top, clockwise: A sadhu (holy man) from Pashupati Temple, Nepal (photo by Nakul Chettri). Himalayan rhubarb (*Rheum nobile*), North Sikkim, India (photo by Nakul Chettri). Antarctic toothfish (*Dissostichus mawsoni*) (photo by David Ainley).
Bottom, front and back cover: A map created by MARXAN showing a strategic conservation scenario for Antarctica by Falk Huettmann.

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Upper left: One of many sacred mountain sites in the Hindu Kush–Himalayas" (photo by Nakul Chettri).
Upper right: Polar bear roaming at a walrus colony at Cape Kozhevnikov; Chukotka, Russia (photo by Valeria Sebeova).

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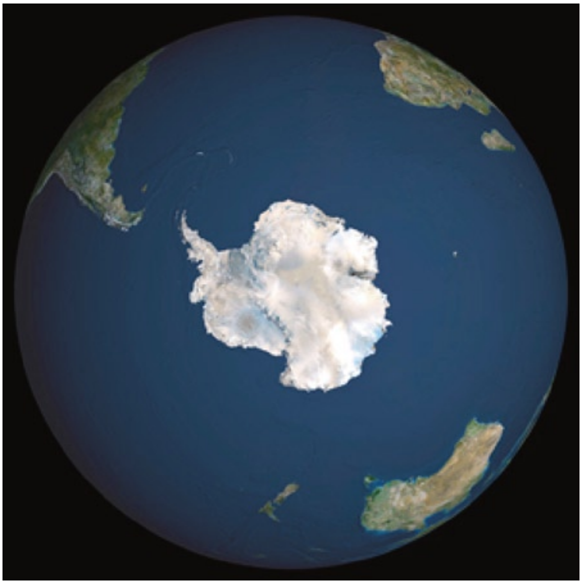
I dedicate this book to all people and their future generations. May they use science for the greater benefit of mankind.

Foreword

Epitaph for the Poles?

An Epitaph for the Poles, North and South, might one day read:

> How they graced Planet Earth, anchoring magnetic fields. They were wedded to Auroras, Borealis, and Australis. With their wildly extreme environs, the poles were evolutionary crucibles for spectacular life forms. They inspired the greatest of adventurers, then punished them severely for their trespasses. Yet they were good for many who never knew them. Along with the atmosphere and the rainforests, they moderated the Peoples' climate for 2 million years. Then a dangerous game of growth was played and the polar team lost: Wall Street Bulls, \$75 trillion GDP – Polar Bears, 0.



Note that the game is far along already; global GDP is currently about $62 trillion. So when they decided to write *Protection of the Three Poles*, what were the authors thinking? Most folks have already given up on polar protection. Polar bears are leading a long, sad procession of species off the poles, into the darkness of extinction. The list of polar contaminants increases with each new study. Nations and oil companies are staking their claims on the oceanic oilfields, newly accessible amidst the melting ice. Perhaps the best summary of polar problems is "*etcetera, etcetera*."

You might then wonder, why even include a question mark in "*Epitaph for the Poles*?" Why not just pronounce them dead and crack open a beer?

Because of the people who wrote *Protection of the Three Poles*, starting with the editor, Falk Huettmann. Huettmann, who also authored and co-authored several chapters, is among a new generation of ecologists who grasp the big picture, not only ecologically but economically and politically. In particular, they recognize that economic growth is destroying Earth's great ecosystems, even entire biomes.

In addition to their scientific specialties, surely all these authors know that the causes of biodiversity loss are a Who's Who of the global economy. They know that fossil-fueled economic growth is tantamount to climate change. They know that talk of economic growth based on alternative fuels is low octane and 99% fumes. They know that international diplomacy on capping emissions is stalled on grounds of economic growth. They know quite a bit, and their knowledge is steeped in sound science.

I hesitated to write a foreword to this scientifically rigorous book, as my admiration for science is ebbing. Incredibly expensive ecological studies have done incredibly little to stem the tide of environmental degradation. Too few researchers have taken their ecological expertise – their knowledge of the economy of nature – and applied it to the machinations of the human economy, or even to educating the public and policy makers on the tradeoffs they face between economic growth and environmental protection. Some ecologists have even sold out on the economy of nature and bought into the oxymoronic rhetoric of "sustainable growth."

Huettmann is an exception, and so is *Protection of the Three Poles*. This book begins and ends by clarifying the fact that all the science in the world won't save the poles – that includes the "Third Pole" (Himalayas/Tibetan Plateau) – unless human populations and their per capita consumption stabilize. This understanding makes it easy for the reader to connect most of the chapters in *Protection* with the perils of economic growth.

In other words, this is a book in which the reader will seldom be far from recognizing the root problem. This makes it a book worth forewording. It also makes it a book worth circulating.

My sincere hope is that readers will follow the lead of Huettmann and company and do more than study the problem to death. That only leads to epitaphs and eulogies. The challenge to polar protection (and atmospheric, oceanic, tropical, etc. protection) is far less technical than economic. But economic policy reform isn't for the faint of heart. Economic growth is a real political bear.

And that's the bear we'd like to see ambling off the ends of the poles.

Aurora Borealis mourns the melting of the North Pole

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Preface

Globalization has hit the "three poles" (the Arctic, Antarctica, and the Hindu Kush–Himalayas) in a dramatic fashion. These three poles make up a powerful but forgotten unity. Together they hold the majority of the world's ice and snow, and that makes them an essential part of the global climate engine and watersheds for billions of people. It is not only man-made climate change per se that melts them down, but also development, the one-sided promotion of economic growth, global tourism as part of an industrialized lifestyle, urbanization, electrification, westernization, militarization, and various other impacts that are not even recognized yet, let alone managed. Ignorance of biodiversity, destruction of the atmosphere, poor legal management concepts, political inefficiency, a so-called objective science that ultimately allows for environmental destruction, inappropriate governmental procedures and approaches, and lack of legal enforcement all have done their part one by one and cumulatively. Although globally proven to be disastrous in many ways, earlier ideas of sustainable development – "business as usual" – are still widely promoted, and many management and administrative bodies lack truly valid sustainability concepts even to maintain the status quo. Global ecological linkages, for example, with the tropics or the oceans, are rarely made or studied. Required institutional and national boundary changes are far from being discussed. Rather, major issues and intense controversies are on the increase in all three polar regions: oil and gas development (e.g., Bristol Bay in Alaska, the Mackenzie River in Canada, the Stockman gas field off Norway and Russia), tar sands in northern Canada, mining (e.g., the nickel smelter in Norilsk, Russia; zinc mines in Alaska), plankton harvest and fisheries [by the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) in the Antarctic; or in the Norwegian–Russian Barents Sea], shipping, land disputes (Tibet, various native claims, tourist sites), and (commercial) reindeer herding and hunting of polar bears, marine mammals, and waterbirds. By now, an epitaph for the three poles is truly in order. Even the immediate and total protection of the poles can hardly stop the melting sea ice, draining glaciers, invasive species, diseases, contamination, cultural changes, and the human tragedy that started unfolding many decades ago and continues widely unnoticed by the public at large. New laws, and all the goodwill by just a few, have yet to stop this process and the extinctions; the endangered species list just keeps getting longer, or it gets massaged with cheap talk and deception by corporate think tanks and their helpers in NGOs, in governments, and even in academia, misleading the public once more. Always, the environment pays the price. So, what can protection schemes really bring to the table?

This book is about the vast wilderness, the icy deserts, the landscapes and seascapes, the frontier land and its components, as well as about best professional practices. It is the first of its kind to present a consistent review of *the three poles*. It elaborates on the status and the pros and cons of polar protection schemes, and on what, if anything, can still be achieved when 10% or 50% protection levels are pursued, when Marine Protected Areas (MPAs) are added and when an updated management scheme is put in place, superseding the traditional ad hoc procedures that lack a thorough scientific base and global considerations. The recent International Polar Year (IPY) shows the global role of "modern science," what it could and could not achieve in 2007–2008, and it provides us with a polar baseline and achievement metric. The urgency of the task does not allow for any delays whatsoever. It is clear from the chapters of this book that already our children will pay a huge price one way or another for the plundering of the past, the present, and what is yet to come: The human population is expected to reach more than 8 billion soon, and things will get very tight with "peak oil," "peak fisheries," "peak ice," "peak water," and "peak agriculture," as well as when countries such as China, India, Brazil, and many African nations try to grow further by adopting lifestyles that ignore their own evolved culture. Ultimately, this book confronts us with the polar symptoms of a globally ruthless (Western) culture that neglected to promote the ideas of carrying capacity, sustainability, and even ethics, human well-being, world peace, happiness, and a balanced life. As this publication and its contributors show, there is no way back anymore as we evolve into a global (polar) village of an industrial kind. Hopefully, the change for a truly global sustainability will occur, if at all, using the best possible solutions and smoothest transitions possible. That is what this book and its contributors are about.

All proceeds of this publication go to the 'Protection of the Three Global Poles Fellowship'.

A Prefatory Note from the Editor

The following experience is not an isolated event but is quite common among people who work on issues of polar, international, and environmental conservation and protection. Most practitioners I know have similar stories to tell.

I had just come back from a long and exhaustive wilderness expedition on Sakhalin Island, which is in the Sea of Okhotsk, off the east coast of Russia. Arriving at London's Heathrow Airport around 10 P.M., I now had 16 h of flying behind me. The next day, Sunday morning, I had to be in Oxford for an invited conference and speaking engagement on "The Changing Earth." Being between trips and having traveled for so long, I had fallen asleep for an hour in the waiting hall of the airport, when two police officers showed up and interrogated me for 20 min about what I was doing there, hanging about in the airport and in expedition clothes. Seeing that all my papers were in perfect order, they began to recognize they had harassed the wrong guy. Finally, I was taken aside and asked, in private (!), what my personal opinions were about "climate change." I explained that as I live in Alaska, in the Arctic, and work worldwide on biodiversity issues, I see and experience climate change first hand. Climate change is for real, affecting the poles and mankind in big ways. But without even the blink of an eye, the interrogation began anew for another 30 min; I was taken into custody and treated like an enemy of the state. Eventually, a higher-ranking officer checked my university website on his iPod and recognized the mistake of the entire ordeal and set me "free." Escorted out of the airport, I was put into a police car and was asked to "not come back."

What is described here is nothing unusual for people who work in climate science research and on international issues of relevance for mankind. So many examples exist of such "professional abuse" that one apparently must withstand it for the sake of making progress in science, for mankind, the Earth, and its protection. Similar stories dealing with trivial research and with specimen permits are endless (just ask your colleagues).

And what has happened to our public spaces? In my view, no citizen, and certainly no one with valid documents and objectives (or when invited as a scientist to a conference dealing with the global good), should be treated in this manner. People contributing to better science and a better world should be welcomed and fully supported, certainly by all governmental representatives and agencies, instead of being harassed, intimidated, taken into a kind of custody for some personal beliefs and attitudes held by a few poorly informed and misbehaving government representatives. We find similar issues these days with airport security officers and TSA in the United States, whereas a better environmental and foreign policy would represent global improvement and effort better spent.

I have never received an apology from the UK police officers, but the conference paper in Oxford made it last year into a chapter of a now internationally celebrated book. With that, one would wish such literature would become required basic reading for our police and government agencies. And really, why not?

May 2011 Falk Huettmann, PhD

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Part I
Introduction

Chapter 1
Introduction: Why Three Poles and Why Protect Them?

Falk Huettmann

1.1 (Polar) Science: What for?

I recently asked an editor of one of the larger international ornithological journal, one that also deals with arctic species and is owned by a wealthy international publishing house (this scientist also works as a senior professor at an established governmentally funded Western research institution with a science tradition of more than 100 years), the following question:

Why are you actually doing science?

I never got a reply. That question to the editorial office was either found irrelevant, disturbing, too big to ask, perhaps out of context, or even impolite and offensive even. This attitude seems to be a typical reaction from many self-approved experts. They do not question their actions, their existence, or how they got there. They just hide behind the great blanket of "science," the publication machinery, their education and institutions, tradition, and their financial constructs and contracts. They merely stay silent on critical questions, ignoring any ethics queries, and do not provide a public reply to such an essential question about the meaning of life and science. Yet, science was not meant to be kept in the dark, hiding from scrutiny (e.g., Anderson et al. 2003; Braun 2005), nor should it be (Primack 1998; Bandura 2007; National Academies of Science et al. 2009). In the example I just provided, the ethics have been entirely replaced with "being busy," patronizing contributors, "having to make money," and serving giant constructs of mind, business, and government. However, this mindset is neither useful for science nor is it progress in conservation, society, or sustainability worldwide. The so-called period of enlightenment, started by J. Cook, and with a strong Western and scientific spin, has brought about the destruction of wilderness and endemic species,

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of native societies, and of sustainable lifestyles that have worked for millennia (Diamond 1999; Huettmann 2011). And we all pay the price.

It is widely known (Taber and Payne 2003; Paehlke 2004) that science which is set apart from the public, with hidden and secret goals (often trying to run exploitative schemes), does not provide "objective science." The consequences from such procedures are obvious, and such science should not be allowed and supported. In contrast, science that is public, and leads toward strict protection and sustainability efforts, sets the stage for more suitable scientific progress and for a society that can last long term. Science is to be used for the benefit of the people. The International Council for Science (ICSU; http://www.icsu.org) states that clearly, and so do many others (e.g., National Academies of Science et al. 2009; Johnsen et al. 2010 for the Arctic and its biodiversity).

There come crucial questions: "how to sustain a large human population on a finite globe" and when should much of the landscape simply be locked up for protection? It is very clear already that we can no longer continue with "business as usual" (Radermacher 2004; Hansen and Hoffman 2011), that entire Arctic ecosystems are already affected by climate change (Selas et al. 2010 for Norway), and that our resources are running short, leading us into serious resource conflicts. Protection of the Earth's ecological processes will at least (a) help us to leave the rushing train of enormous resource consumption and (b) provide unspoiled land and resources for future generations. Readers who have seen the differences and land pressures around protected zones versus surrounding areas in India, Nepal, Africa, Costa Rica, or the Arctic Refuge, for example, will easily agree. All the protected areas will even come with cheap and easy maintenance, not degradation, of ecological services. It is simply an investment in the future (Shtilmark 2003), and any society builds on that.

Such an outlook of free ecological services is actually very appealing in times when most other relevant predictions show species declines, habitat loss, global financial budget crisis, and a decay of any relevant ecological and social integrity (Sodhi et al. 2008; Young and Steffen 2009; Bradshaw et al. 2010; Mace et al. 2010). Such a grim view of the future is not simply a doomsday scenario, but reality (Radermacher 2004; Hansen and Hoffman 2011). The times in which we can afford just to be conservative, instead of realistic and precise, are past, as many of the constantly "underpredicting" sea ice models for the Arctic are showing us (Wang and Overland 2009; Polyakov et al. 2010). The Kyoto protocols were based on "old" science and widely missed the mark, and now we are in the 8°C forecast for the Arctic (see Meltofte et al. 2008 for effects)! Or to put in IPCC (Intergovernmental Panel on Climate Change) slang: A1B scenarios are not the baseline anymore; we are moving into B2 scenarios as the state of the art. We must face the fact that our resources are finite (Daly and Farley 2003; Czech et al. 2003). We must protect what we have, as well as associated ecosystem services. We must do this in ways that are low cost and low impact. These services must be optimized and strategically managed for mankind. And this is where science can help (Cushman and Huettmann 2010). Is not that worthwhile to try? As is shown in this book, the status of the world, and of the polar regions, does not allow for a delay, and every area now protected counts.

The accepted model of a science-based management, where only governmental research experts, managers, and nongovernmental organizations (NGOs) are in charge of safeguarding the earth, is widely disconnected from the people these entities serve (Chapin et al. 2009). However, they currently define what science is, what the agenda is, what it investigates and what it does not, and what is to be ignored. They determine how long it takes "until we know enough" and when to take action and when not (see Braun 2005 as a classic example). This concept was shown to have serious flaws even before the impacts of climate change were seen. So far, science alone, and science practiced without any ethical considerations, has simply failed its chance for sustaining future generations (Ludwig 2001; Taber and Payne 2003; Bandura 2007; Chapin et al. 2009). By now, it is clear that neither the governments nor the NGOs are acting proactively. They just run wildly behind, argue after the fact, and do not do enough, often using concepts from decades ago, if any (Klein and Magomedrova 2003; Paehlke 2004). Why would there be such a crisis otherwise? A classic example can be seen in the history of climate change, how it came about, who pushed for it, and who did not, and when. To this very day, the NGO BirdLife International, the Arctic member states of the Convention of Arctic Flora and Fauna (CAFF), and the International Union for Conservation of Nature (IUCN), all list Sabine's gull (*Xema sabini*; a seabird directly affiliated with Arctic sea ice) as being of LEAST CONCERN, and their argumentation goes something like this: a very low conservation priority label is justified because we still have so many of them and these birds are widely dispersed. It is just beyond belief: What did such decision makers learn from the meaningless extinction of the passenger pigeon and of all the other species (Paehlke 2004)?

Nobel Prize winner (Economy) Joseph Stiglitz (2008) showed convincingly that such policies simply favor industrial businesses and that they represent a business advantage, a subsidy, to keep producing with the lowest possible operating costs that are coming from incomplete bookkeeping (thus, they are artificially low and ignore the true costs to society and the world). This conviction is allowing human activity to destroy the polar regions and beyond. People living in the polar regions know that the true cleanup costs are not well penciled in (Ross 2001, 2006; Ott 2005), or worse yet, they are frequently waived to attract (international) business (Stiglitz 2008). Alaska's Arctic alone offers many examples of this sort, and Norwegian's pulp and paper mills in Canada and salmon farming in the Southern Hemisphere know this by heart.

If we were to adhere to the concept of

> For biodiversity research, the strategy must be to first identify a set of indices to assess changes in biodiversity and then to make the connections between those changes and potential stressors (Vongraven et al. 2009, cited in Gradinger et al. 2010)

it would take us at least another 250 years to fully understand biodiversity, let alone understood its even more complex ecological intricacies and subpopulation dynamics, which are all crucial for ecological processes. Should we really wait until then and continue with "business as usual"? Can we just ignore all the problems? And even then, what would be the best form of science management and governance?

Such simplistic mechanistic views, where things ought to be explained one by one, ideally with linear parsimonious statistics, are unfortunately still very popular (see Worm et al. 2010). Whereas the IUCN had already switched to the Precautionary Principle years ago.

Schweder (2001) already criticized this approach, more than a decade ago, using examples from (polar) whaling. In addition to governmental and NGO efforts, the small and basically inefficient roles that professional societies usually play for polar protection are shown in the Textbox and Table 1.2.

New paradigms had already formed years ago (see Cushman and Huettmann 2010 for discussion). So why is the old way still promoted? The main drivers of this attitude are the stakeholders who benefit from it (Czech et al. 2003; Paehlke 2004).

Traces of this wrong science model, which we can no longer afford, are easily seen in the landscapes and seascapes of this world: it is in their species, their nutrient cycles, the atmosphere, and in what is left for future generations. The biodiversity crisis makes it very clear that we need more simple protection efforts instead, and very well thought out schemes, before all is gone forever. Many agencies and institutions with global impact (see Table 1.1 for details), such as the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS),

Textbox The Role of Professional Societies: Virtually Ignoring Polar Issues?

Professional societies are trying to be part of the scientific and conservation management landscape. Various sizes, types, and qualities exist. They are usually made up of many individual members and traditionally consist of representatives from the public, the scientific community, the government (federal and state/provincial), NGOs, and contractors. There are many (traditional) reasons for the existence of those societies, and they usually might function as a knowledge pool, as a discussion forum, and for holding conferences and producing scientific journals. However, these professional societies often lack funds, are not affiliated with the universities, and tend to represent specific narrow and ideological "cultures." At least in North America, many administrative functions in such professional societies are directly run by governmental representatives, for example, the facilitation of LISTSERVS and editorial and administrative roles. Often, such societies receive endowment funds or donations, which can make them rather powerful and influential in regard to lobbying, political positions in the discipline, and beyond. A recent characteristic of many professional societies is that they want to stay nonpolitical, objective, and open for as many members they can reach. Thus, they do not take a stand on environmental issues such as carrying capacity. This intention has further led to the clearly political position to avoid controversy, that they avoid open access data sharing enforcements, climate change as a subject, or that climate change is man made. Memberships are not to be lost. A selection of professional societies, with their details and efforts regarding modern and efficient polar protection, are provided in Table 1.2. This compilation shows a wide lack of specific modern polar protection efforts and awareness in regard to subjects with which these professional societies are concerned, such as migratory species or ecology.

Table 1.1 Selection of agencies and institutions with a polar mandate and a global impact

Abbreviation	Full name	Location	Mandate (approximate wording)	Justification of global impact
USGS	U.S. Geological Service	USA	Research of Earth-Science data	Global connectivity, largest (polar) government in the world
USFWS	U.S. Fish and Wildlife Service	USA	To conserve, protect, and enhance fish and wildlife, and their habitats for the continuing benefit of the American people	Management and listing of endangered and migratory species
NOAA	National Oceanic and Atmospheric Administration	USA	Federal Agency for the Oceans and Atmosphere	Global atmosphere and oceans
NMFS	National Marine Fisheries Service	USA	Management of fisheries	Migratory and international stocks
UNEP	U.N. Environmental Program	Nairobi, Global	Coordinates United Nations environmental activities, assisting developing countries in implementing environmentally sound policies and practices	Global approach
IUCN	International Union for the Conservation of Nature	Gland, Global	To influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable	Endangered species listings
FAO	Food and Agriculture Organization	Rome, Global	Sustainable food production	Dealing with world agriculture and fisheries
CAFF	Convention on the Arctic Flora and Fauna	Akkureyri, Iceland	Arctic biodiversity	Global connections
AC	Arctic Council	Tromsoe, Norway	Arctic management	Global connections and impacts
SCAR	Scientific Committee on Antarctic Research	Cambridge, UK	Charged with the initiation, promotion and coordination of scientific research in Antarctica. SCAR also provides international, independent scientific advice to the Antarctic Treaty system and other bodies	Global connections and impacts

(continued)

Table 1.1 (continued)

Abbreviation	Full name	Location	Mandate (approximate wording)	Justification of global impact
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources	Antarctic	The Convention establishes a Commission to manage the marine living resources of the area for which it is responsible	Global connections
ICIMOD	International Center for Integrated Mountain Development	Hindu Kush-Himalaya	To enable and facilitate the equitable and sustainable well-being of the people of the Hindu Kush–Himalaya by supporting sustainable mountain development through active regional cooperation	Global connections
IPCC	Intergovernmental Panel for Climate Change	Global	Climate assessment and data	Global climate
The Bank	The World Bank	Washington, DC, USA	To fight poverty with passion and professionalism for lasting results and to help people help themselves and their environment by providing resources, sharing knowledge, building capacity and forging partnerships in the public and private sectors	Global
WTO	World Trade Organization	Global	Provision of a forum for negotiating agreements aimed at reducing obstacles to international trade and ensuring a level playing field for all, thus contributing to economic growth and development. The WTO also provides a legal and institutional framework for the implementation and monitoring of these agreements, as well as for settling disputes arising from their interpretation and application	Global connections and impact

Table 1.2 A selection of professional societies and their activity ranking regarding modern polar protection and management

Name	Specialty and focus area	Polar link	Activities in favor of efficient polar protection	Public sharing of Raw data	Promotion of metadata
Pacific Seabird Group (PSG)	Seabirds	Arctic seabird colonies and migratory polar species (Arctic and Antarctic)	Little	Very low	None
American Union for Ornithology (AOU)	Birds	Arctic migratory species	Very little	Very low	Little
The Wildlife Society (TWS)	Wildlife	Some Arctic and Antarctic wildlife	High (position statements on Arctic drilling, economic growth, polar bear hunting, etc.)	Very low	Very little
British Trust for Ornithology (BTO)	Birds	Arctic migratory species and wintering grounds	Very little	None	None
German Ecological Society	Ecology	Global ecology	Minimum	None	None
German Society for Informatics (GI)	Informatics (industrial and ecological)	Global economy and ecology	None	Very little	Very little
BirdLife International	(Sea) Birds	Antarctic seabirds	Little	Very low	None
International Association of Landscape Ecologists (World IALE)	Landscapes	Landscapes of snow, ice, and mountains	Minimum	Little	None

and state and provincial governments of the Western world (Taber and Payne 2003; Paehlke 2004), as well as those with a usual international mandate such as the United Nations Environmental Programme (UNEP), International Union for the Conservation of Nature (IUCN), and Food and Agriculture Organization (FAO), and The World Bank, Asian and European Development Banks and NGOs, cannot stop the global crisis we are now facing. Yet they carry the global responsibility, or always state they are in charge and take the lead, whereas the individual citizen and our assumed democracy are already widely removed from meaningful and sustainable involvement and decision making (Paehlke 2004).

The Arctic Council and CAFF in the Arctic, along with SCAR (Scientific Committee on Antarctic Research) and CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) in Antarctica, and many of the governments in the Himalaya regions, either are driven by outside funding, lack citizen input, or do nothing to halt the root cause of climate change. Nor do they even adapt well (Hansen and Hoffman 2011). Sometimes, they do entirely the wrong thing, or they cannot do, or do not do, enough. So then what are all their budgets (which are easily many billion dollars) truly buying us? It represents an institutional failure, because their institutional cultures simply do not allow for the achievement of relevant and concerted sustainability goals. And the global outlook does not appear any more promising, with more than 9 billion people expected on this planet by 2060, with failed Kyoto protocol goals, and (Western) budgets shrinking or shifting to other priorities. The effort to contend with endangered species alone, and entire vanishing ecosystems, will be enormous in terms of administration, financing, and recovery. Governments and their employees who still promote “business as usual,” therefore, should be a thing of the past (Hansen and Hoffman 2011). One way or another, protection of nature must be a priority; this must enter job evaluation criteria and all relevant public goals. Publishing narrow research papers in highly commercial impact journals, and based on a broken peer-review system (Riisgard et al. 2001; Wagner 2006; Hauser and Fehr 2007), holding one international science management conference after another that blur and distort the message, while no link to an effective management scheme is made, where not even the underlying raw data can be shown and documented (Huettmann 2005), must become obsolete. And how could it have ever come to this?

So-called sustainable development, and sustainable growth for the Arctic (see Klein and Magomedrova 2003 for some Arctic-wide impacts) must be stopped, at least in its current industrial and commercial form, before it further destroys the global environment (Easterly 2006). The fact that the current effort toward wise and sustainable uses fails us is already the sad truth for nations that legally must use this process and teach it as science-based. Many development and aid organizations still promote this now-dangerous concept, for example, Norway (Chaudhary et al. 2007), and The World Bank in Russia’s Arctic (Wilson Rowe 2009). However, the majority of nations do not even have a significant science budget, or relevant institutions with acknowledged capacity and throughput (see Huettmann 2011 for a Triple Digital Divide). Even in publications of global relevance such as *Life in the World’s Oceans: Diversity, Distribution, and Abundance*, edited by McIntyre (2010), and its chapters such as those by Worm et al. (2010), no relevant management model is presented, and certainly not for the poles. Such work lacks any "teeth"; a *laissez faire* culture of convenience still rules. Everybody then tries to promote their own views, whether taxonomic, environmental, synthetic, or simply motivated by industrial goals, while at the same time the reality of the earth shows us serious limits that we are not addressing.

1.2 Science-Based Management?

If you ever see a "manager," please talk to him/her and ask whether, and how, they take (our) science seriously. For myself, however, and while doing sustainability science in many countries of this world, I have never met the responsible managers in charge nor seen them in action. Nor have they ever contacted us. Although we have met many administrators, it is not so clear where the managers in charge really work. How do they get their information, is it first hand, and how much time do they spend reading the scientific literature and journals? Do they understand the underlying statistics, how do they interact with the public and the entities they are supposed to serve, and how do they implement all these things to solve assigned problems and make issues really work "on the ground"? What is really managed, by whom, and for what (Ludwig 2001)? Who understands and assesses the impacts of those decisions, and before problems occur? Needless to say that we experience that much of our own science is widely ignored, marginalized, and that this has been going on for years (see Spash (2009) for similar experiences in ecological economics). During my entire professional life we have pushed for better conservation and climate change policies, but almost nothing has yet been implemented. And even implementing the most basic and important features of a biodiversity management easily takes more than 20 years until they are realized (Klein and Magomedrova 2003; Cushman and Huettmann 2010). And usually by that time, many other issues have become even more relevant.

Classic examples can be found with Arctic waterbirds in Siberia, where massive declines were already known and reported by scientists during the 1970s and subsequently (Rogacheva 1992). But what was done by managers to really stop or reverse the trend, and when? Other classic examples are documented in the Intensive Management Law (1992; Ross 2001, 2006) and with predator control in (Arctic) Alaska. This practice is based on science from the 1980s, and stands for more than a decade in wide conflict with the Committee on Management of Wolf and Bear Populations in Alaska, National Research Council (1997), and other scientific information. Entire universities and departments in Alaska become meaningless because of this situation and due to political interference. Klein and Magomedrova (2003) even state in their Arctic review that animals such as ptarmigan and ermine are hunted in the Arctic virtually without regulations. Climate change makes that problem as visible as many other hunting issues, contamination, and the wider notion of an urgently needed coordinated sustainable Arctic land and ocean plan (Klein and Magomedrova 2003, which still does not really even exist, Huettmann and Hazlett 2010). Again, using an Alaskan example, in 2001 the Minerals Management Service (MMS 2001) estimated that between 2004 and 2034 several large crude oil spills (more than 20,000 gallons) would occur in some of the existing northern Alaska oilfields.

But what has been the action, or the balances and checks, so far? Instead, many new drill sites and explorations just went ahead, and many more are already planned (Bingham 2010).

Regarding "poor management," this fact can easily be seen in that most resource managers have no time budget written in their job description to actually "spend time reading, thinking, and debating the latest scientific literature and journals." Yet, it is a fundamental requirement that their jobs be science-based. There is not even a good and accepted education and career path for such managers. Should they be trained in economics, in ecology, in social science, or even in religion, and have a MBA, a PhD, or no degree at all (but be connected to the ground)? This lack of a clear path comes as quite the surprise when considering the relevance and urgency of science-based management action needed to solve the critical problems facing the world and polar regions today.

Arguably, adaptive management and its derivatives, are the key procedures to achieve sustainability (Walters 1986; Chapin et al. 2009; Belgrano and Fowler 2011). Such management should be based on modern tools such as the Internet and data sharing (Huettmann 2010), but currently it is not (see Carlson 2010 for the global lack of empirical data availability). It also becomes quickly clear that most students, for example, in business and law and even in biology, do not know what adaptive management really is, how to implement it, and why it even matters. The young generation must be the drivers (Starzomski et al. 2004), but are they? Key publications such as CAFF (2001) or McIntyre (2010) and their various chapters do not even refer to such concepts. Further, we do not have a legal system that truly allows for fast, fair, low-cost, and uncomplicated policy changes, as is required for an adaptive management framework to perform (Braun 2005). Nor do we have (polar) lawyers and judges who truly understand ecology or act accordingly. Carlson (2010) and Huettmann et al. (2011) drew us a pretty gruesome picture of the data situation for the poles. Despite many calls (Sarkar 2007), many polar data were collected, but these are not shared and thus are not publicly available. But if the data are not shared, science cannot perform well, nor can management. As can already be seen in the wide absence of metadata (Bluhm et al. 2010; Carlson 2010; Huettmann et al. 2011), not many science teachers promote repeatability, transparency, critical thinking, and challenging ideas. But this is the essence of what science is all about. It can only be achieved by following fundamental data policies of open access to raw data and its derivatives and tools (Huettmann 2011; Huettmann et al. 2011 for Arctic seabirds). However, and even worse, the majority of global, national, regional, and local decision makers and resource managers neither understand this basic concept nor promote it. Most give it lip service, at best. It still requires a major change.

One will not hear much from the media about adaptive management, sustainable management, open access of raw data, objective peer review, or why these things matter. The commercial and corporate owners of the media have other interests. From them, we hear "do not rock the boat" and "keep shopping" (Paehlke 2004). Their strategic interests might lie in the promotion of the latest NASCAR car race or in the marketing of Harry Potter books and Justin Bieber; Brittney Spear CDs easily make for a global promotion event. These things get celebrated as being of global relevance, but they really are not. The free markets are currently without a relevant sustainability framework, and the market's man-made beliefs are here fully at work (wrongly, however; see Easterly 2006; Paehlke 2004). Markets are merely man-made institutions (Stiglitz 2006): they require a good and sustainable bound in which to act (Daly and Farley 2003). Otherwise, they just do not deliver what we really need: happiness, balance, decision making for future generations, and sustainability for the poles and worldwide (Spash 2009). Mankind depends on this.

Mace et al. (2010) has already left us with a devastating global review, and so did the Millennium Ecosystem Assessment (http://www.millenniumassessment.org/), and many others before them (Wackernagel et al. 2002). From that, it easily follows that natural resource management does not currently deliver well, one way or another. And so, before it is all too late, the protection of our resources is THE urgency, a must. Protection levels beyond 50% at least must be the goal (a demanded increase of protection levels as boldly stated by UNEP; Johnsen et al. 2010). Currently, we are only trying to reach 10% ecosystem protection worldwide (an IUCN goal). Yet, we are far from achieving even that, or within the next 15 years. We do not even achieve these minimal goals when employing some very creative bookkeeping, for example, the inclusion of areas that have virtually no relevant protection status such as Ramsar sites, land easements, and World Heritage Parks. Just looking at the violations in National Parks (one of the strictest reserve system we have) and for the polar regions shows that resource extraction is commonly found within these areas and that tourism and other activities have devastating impacts (Gailus 2010 for a Canadian bear example; Pant and Samant 2008 for the endangered Himalayan yew in Nepal, which even became extinct within the sanctuary). The icon of the third pole, Mt. Everest, and its surrounding area had already become a National Park in 1976 and was designated as a UNESCO World Heritage Site (Bhuju et al. 2007). Problems with these concepts are clearly shown by Jha and Khanal (2010). Probably surprising to many, the North American style of protection, the National Park system, and its administrative and funding scheme (e.g., via tourism), simply seem not to be the best possible option we have when applied worldwide (Shtilmark 2003 for Russian concepts). Most National Parks, for instance, have no good yearly performance metrics, such as ISO (International Organization for Standardization) or similar criteria. Even the protection of the oceans is still in its infancy: the oceans carry a protection level of less than 1%, and the similar is true for the Arctic and Antarctic waters and for the (fresh)water bodies of the Himalayas. Cold region water protection (freshwater or saltwater, liquid or frozen) must become a priority. And it can only be done when protecting the atmospheric temperature and related processes. Their destruction is truly a crime, not just an environmental marginalization.

1.3 Three Poles: Why We Need a Coherent View Now

Based on scientific evidence, the Western world has acknowledged that the earth is round. It took a long time and intense disputes for this simple truth to become accepted in central Europe, by its experts and in society. Religious views had to be overcome and revised once more, despite the fact that other “primitive” cultures knew about the sun’s circulation and the shape of the earth much earlier. To this very day our mathematicians and geographers still wrestle with the fact that the earth is actually somewhat oval, and that the terrain is irregularly rugged, to the degree that no single mathematical algorithm can really describe it well. (In this context, the history of plate tectonic theory – a concept promoted by the polar researcher Alfred Wegener by 1920s and denied for many decades in Germany and in the United States and Russia until the 1960s – begs to be told here for comparison with the acceptance of man-made climate change, but for the sake of space it is not further pursued. The reader is encouraged to follow up with http://en.wikipedia.org/wiki/Alfred_Wegener.) When simply accepting the coarse concept that the earth is more or less round and that most of the “Western world” lives somewhere in the upper half of the Northern Hemisphere, it becomes clear that there is a top, and a bottom. And with that, the notion of the poles was born, and that they had to be symmetrical (which they are really not). The poles are not just top and bottom features, but huge, complex, and globally connected ecosystems.

Regardless, for most people, the North Pole came into being when the Western kingdoms sent their explorers “around” the world and when reports were received of ice oceans, frozen land, and their wildlife and people (the relevance of the global climate and atmosphere was not yet part of the story).

Although the North Pole was closer to central Europe, the South Pole was explored with a delay, and came into real existence for central Europe and the world only when the race for resources and prestige started between several countries, including Norway, UK, and the United States. This “race for the South Pole” was more of a race for its natural resources, approved by royal families, governments, and their funders (hoping for a big profit at the end). The history of whaling alone makes that already clear (Huettmann 2011 for patterns and references).

The third pole, as it is called here, and usually referred to as the Hindu Kush–Himalaya (International Center for Mountain Development 1996; Zurick et al. 2000), was also known in the West for more than 400 years, although somewhat in disguise. The idea of three poles does not make for a nice symmetrical story. The third pole is even located in a subtropical setting near the equator, but it features the highest altitudes in the world (International Center for Mountain Development 1996; Messner 2007). Eventually, it probably was the International Polar Year 2007–2008 (www.ipy.org) that has to be given credit for promoting the “Three Poles” all at once to a global audience. This certainly did it for me.

The Hindu Kush–Himalaya region is often called our third pole because it is covered with so much ice, snow, and glaciers (Zurick et al. 2000; Armstrong 2010 for a review and global context). It creates its own weather, too. The glaciers and snow packs of that region are simply incredible, without equal anywhere (Ohmori 1999 for images).These are the “water towers of Asia,” affecting billions of people (International Center for Integrated Mountain Development et al. 2007; Zurick et al. 2000; Banerjee et al. 2011), including the subsequent water tables elsewhere (Gopal et al. 2010), and even the oceans and coastlines (Hansen and Hoffman 2011). Again, it took much time to really value and comprehend these facts in the Western society and its (global) institutions. Only during the last 120 years perhaps, and with the advancement of the British Empire into India, did this region come “closer” to Europe. Although the highest mountain of the third pole carries an English name, Mt. Everest, implying Western dominance, the local people and their religions of course knew about it much earlier (locally referred to as Mt. Chomolungma or Sagarmatha; Zurick et al. 2000; Jha and Khanal 2010). The Europeans were actually not able to conquer this region well, nor were they able to extract much of its wealth quickly, and thus they left it more or less alone.

To this very day the English Army recruits the Gurkhas from Nepal (the same is true for the Indian, Singapore, Brunei, and U.S. armies); it makes for a global symbol of skill and sophistication, but also of aggression and conflict. The fact that conflict zones of global relevance, such as Pakistan, Afghanistan, and Tibet, are located in this region, further speaks to the complexity, the global role, and the impact of the third pole. The global forces China and India are also directly involved in the Hindu Kush–Himalaya region. As do the other two poles, the third pole involves huge, global economies and human wealth. Adding the third pole to our (Western) worldview naturally changes the center of the global perspective and universe, from Europe and North America right into Asia, and makes it less symmetrical and less convenient to manage. One inconvenient truth is how the nation of Bhutan has achieved more natural area protection (in percent land mass) than the United States, Norway, and UK combined. Yet, much more can still be learned from the three poles overall, and specifically from the third pole.

Just from the human perspective alone, the third pole brings additional complexity to the table. It also brings us known polar features such as religions, natural worldviews, social governance, the fate and rights of minorities, and people who have lived and evolved in their environment beyond centuries, and who now get pushed out of it, and for reasons beyond their comprehension or control such as global economy, atmospheric pollution, and a rising world temperature. The Himalaya region is already warming, with 0.5°C per decade, and this effect increases with altitude (see Photos 1.1–1.3[1] for a documentation).

Thus, “climate justice” is a very serious concern for all the poles and the world. A good example for the third poles is represented in the increase of glacier lake outburst floods (GLOFS), which threaten many villages of the third pole (Jha and Khanal 2010; International Center for Integrated Mountain Development 2010d; Ives et al. 2010). The local people did nothing wrong relative to atmospheric warming, but they must pay the price.

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[1] Photo credit: These photos are taken by Fritz Berger from Berne, Switzerland. Fritz worked in Greece and Pakistan for larger parts of his career and has first-hand experience on changes in mountain regions. He is specialized in People and “Fotomonitoring” – that is, pictures taken from the same spot in a certain interval showing the changes of landscapes caused by human activities, climate, or natural forces. The photos of 2010 are taken with the logistic support of ICIMOD. Fritz has published a number of books with photographs from Switzerland and Greece. He regularly organizes exhibitions of his work and together with Transhumana (more details are found at www.transhumana.ch).

Photo 1.1 Close-up of the north face of Annapurna II (7,973 m). During the monsoons the glaciers of the Himalaya melt to supply water for irrigation, consumption, and energy to Nepal and North India. This photo, taken in 1978, can be considered history about snow and ice coverage

Ecologically, the third pole is globally connected (this includes invasive species, as well as atmospheric contamination: International Center for Integrated Mountain Development 2010e for the Atmospheric Asian Big Brown Cloud ABC). The initial biodiversity of the third pole is rather high (International Center for Integrated Mountain Development et al. 2007; International Center for Integrated Mountain Development 2010b), and it includes many endemic species. More than 350 new species have been discovered in the Eastern Himalayas alone, and between 1998 and 2008; this makes for approximately 35 new species per year during the past decade (WWF 2010). As is true for the other poles, the area is still widely unexplored and unmapped (Gopal et al. 2010 for wetlands). This situation makes it a target of bioexploration (again, the Norwegians, besides other Western nations and with the help of Deutsche Volkswagen Stiftung, have already started this work in their very own interest; Chaudhary et al. 2007). The third pole plays a relevant role in the world's agriculture and in the Convention on Biodiversity (International Center for Integrated Mountain Development 2010a,b,c; Mace et al. 2010).

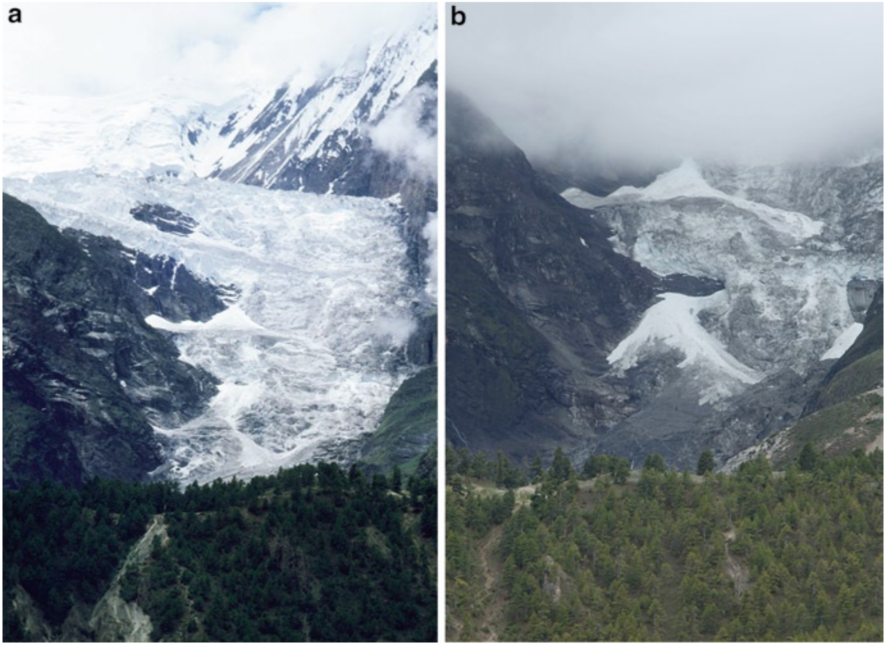

Photo 1.2 Manang Glacier. This glacier, with the name Gangapurna, lies opposite the village of Manang. Because of climate change, the Gangapurna Glacier has melted extensively, as can been seen when comparing the photos taken in 1978 (**a**) and 2010 (**b**)

From a global climate perspective alone, this region simply must be included in any serious discussion about the poles and global climate change (Armstrong 2010; International Center for Integrated Mountain Development 2009, 2010c; Macchi and ICIMOD 2010; Shrestha and Devkota 2010). And as found for the other poles, the third pole suffers from wrong global economic concepts. Jha and Khanal (2010) state for the Everest region that “The habitat of wildlife must be protected from excessive pressure, further exploitation and ill-judged commercial development.” C. Bonington (in Ohmori 1999) states explicitly the pressures from global tourism (see also Jha and Khanal 2010).

Last, all poles are characterized by large and charismatic animals: walrus, polar bear, Siberian tiger, muskoxen, whales, elephant seals, penguins, albatross, snow leopard, red panda, bears, yak, thar, blue sheep, and golden and imperial eagles, to name just a few. Many of those species are in serious conservation trouble, and some species related to polar and subpolar regions are already extinct, such as the great auk, Steller’s sea cow, and Labrador duck. Others are dramatically reduced in their populations, health, and ranges (e.g., many Antarctic whales, Arctic fox, red panda, snow leopard, tigers, and Kittlitz’s murrelets). It is therefore mandatory, and best professional practice, to provide joint and cumulative (ecological) views of all the poles. Ice cannot be preserved at one pole alone. If it melts, it does so globally. It is simply the temperature niche that makes for the poles and their characteristics.

Photo 1.3 Rolwaling mountains. The 6,257-m-high Chekigo peak is located above the village of Beding. It is one of the most distinctive mountains in Rolwaling Himal. The difference between the years 1974 (**a**) and 2010 (**b**) is noticeable. These melting glaciers are some of the consequences connected with the warmer climate in recent years

But mankind, industrialization, and its "modern institutions" still have great difficulty grasping these concepts (Young 2002; Hansen and Hoffman 2011). The Western worldview, its institutions and funding, likes to break things into small convenient pieces and to put them into administrative boxes. But ecology knows no boxes. If we still insist on administrative boxes, as in our education and management system, the environment starts to suffer. Western experts still prefer to look at things in detail, one by one, ignoring interactions or cumulative impacts (see Oppel et al. 2009 for a science discussion in ecology). However, other religions, notably the Hindu, Buddhist, and indigenous views, tend to treat the Earth as one vehicle and thus provide much more holistic concepts (Krupnik and Jolly 2002). These perspectives are dearly needed if we want to contend with the poles, the snow, ice, climate, and environmental niche in any relevant form and fashion, and if we want to keep them for future generations. The poles are more than just our climate engines: they are part of our lifeline, and not to be dominated.

1.4 Crisis at the Poles, and Elsewhere

The three poles is where polar bears, penguins, and snow leopard meet their fate: melting ice from a warming atmosphere, and all caused by humans and their actions and subsequent inactions. We are already truly overcommitting the globe (Wackernagel et al. 2002), and certainly the poles (Loring and Gerlach 2010 for the Yukon river watershed; Yablokov 1996 for the Russian Arctic; Jenouvriera et al. 2009 for an Antarctic penguin population, Zurick et al. 2000 for steep human population increases in the Himalayas). Only a few leaders really want to admit this and solve the dilemma we are currently in: using the natural resources from more than three worlds, when we only have a single world to live from (Living Planet Report 2010; http://www.footprintnetwork.org/en/index.php/GFN/page/2010_living_planet_report/). The race to Mars as a global solution (a major effort in which the Arctic nations of Russia and the United States, as well as China, have engaged for over a decade now) must be judged as truly lunatic. Neither Mars, nor the moon, has yet provided us with any food and shall probably not do so any time in the near future. The dominating space dreams of NASA already came to an end many years ago. After the Landsat7 debacle during the Bush years, we are still waiting for a public and high-resolution remote sensor allowing us to assess the state of the Earth and the poles as freely achieved by the Landsat missions in the 1980s for the entire world.

For decades, many science bodies just promoted constantly the development of new tools, so we could tackle the problems of mankind or live better. We did develop some new tools, such as Velcro and heat-resistant ceramics, but we did not really apply them in any meaningful or sustainable manner (Diamond 2005). The end result now, as we are moving into our polar regions, is that we are living in “technological deserts” (Klein and Magomedrova 2003). This scene fits tragically with the known track record of James Cook’s enlightenment efforts. The end stage has now been reached, finally: We extended our human niche and are established on all three poles ….

On a global note then, what have we done about the Arctic and its existing governance scheme? Has the Arctic Council and its related institutions, including the Convention of Arctic Flora and Fauna (CAFF), UNEP, IUCN, and industry, addressed these issues in any meaningful governance policy other than to set industry-friendly parameters of resource exploitation? (e.g., CAFF 2010; Johnsen et al. 2010; Polyakov et al. 2010 for a melting polar ice cap). In the year 2011, does the Arctic Council still ponder the existence of man-made climate change versus natural cycles: why humans did cause it at all, whether polar animals could potentially survive climate change, whether industry contributes to species and habitat loss, and how do we include or exclude from the poles more than 200 countries and their citizens? Is science still the driver for an Arctic management, or are the related universities and science institutions (e.g., University of the Arctic, University of Alaska, Svalbard University, Polar Institute in Tromsoe) mainly driven by oil, gas, mining, and national security interests and their politics? Are the military and industry fully in charge (Czech et al. 2003), or is there an overruling, democratic, and fair governance structure of the faculty, students, indigenous people, and all citizens in place for such institutions? From experience, ICIMOD will be the first to report that a "Council of the Poles" [with potential members such as the International Arctic Science Committee (IASC) and SCAR] that would exclude countries from Africa, as well as Brazil, India, China, the Arctic, and Himalayan indigenous people must be doing something seriously wrong (but see Bingham 2010 for stating that the Arctic seafloor is simply to be divided among the five Arctic nations). The government of Malaysia, for instance, has a longer and distinguished history in critiquing the resource scheme of the few wealthy countries behind the polar policies such as the Antarctic Treaty. Polar institutions, and the same ones who approved of commercial whaling, fish, and plankton harvest in international waters, only make these unbalanced management situations worse, and spark the conflict further. The grab for resources is that obvious.

Although the 7 Arctic countries and 11 Himalaya countries have no one single and consistent protection scheme or plan (CAFF 2001, 2010; Huettmann and Hazlett 2010; Johnsen et al. 2010 for protected areas in the Arctic; Bhuju et al. 2007; International Center for Integrated Mountain Development et al. 2007 for protected areas in the Hindu Kush-Himalaya; Sarkar et al. 2007 for the Indian context), the Antarctic region does have it, at least for its terrestrial section. The Madrid Protocol of the Antarctic Treaty System achieves this goal (ATS; http://en.wikipedia.org/wiki/Antarctic_Treaty_System). This treaty has been in existence since 1961, with 47 signatory nations, and has halted many negative impacts so far. It is a complex legal scheme that is evolving, and one that is probably confusing for the public. But, at least it had the effect that the South Pole is perceived as a virtually protected zone and as a consequence has not been exploited much, for example, in regard to mining and other extractive activities. However, the surrounding waters of Antarctica tell us a very different story. Their waters have been exploited by decades of whaling and sealing. An intense fish harvest occurs off the icy coasts of the southern continent, and more harvest of plankton, the foundation of life in the seas, is on its way. The now widely critiqued CCAMLR model of an ecosystem management rules widely, in the best of all cases.

The idea of halting mining and similar exploitation for Antarctica might also come with the commercial and strategic self-interest of many countries. For instance, geologists tell us that the continental makeup of Antarctica might not differ much from that of Australia and similar countries. In other words, by keeping Antarctica off limit for mining, it easily boosts a demand of existing mines in the surrounding regions. Knowing that Australia (and Africa), and subsequently Antarctica, has uranium mines to offer might then easily turn into a global security question.

So, what we called "modern progress" really just deals with keeping a broken system going for a little while longer. So far, we are just trying to cure the symptoms (Worm et al. 2010, for an example), but not facing the root causes (Rosales 2008; Hansen and Hoffman 2011). The root cause is allowing an aggressive and inappropriate business model, one that tries to grow and develop resource extraction on a finite land mass and seafloor, an ecosystem that is already widely overcommitted (Gaffney 1994; Spash 2009). This model serves very few. Trivial financing schemes, packed in pseudoscience and sophisticated words presented by "smooth operators" located at high-impact institutions, come to the forefront more than ever. Why did not the Ivy League schools stop the destruction we all witnessed? Where did all the knowledge and skill go to reach sustainable lifestyles and schemes for the poles and the world? Did not so-called primitive people live in many of the polar regions and elsewhere for thousands of years without leaving a global footprint, and why and how did they get so widely derailed?

The idea that the major NGOs would come to save us, as well as the world's environment, have become equally dubious by now (see CAFF 2010 for the state of the Arctic, for instance). NGOs are supposed to be "non-profit," but the World Wildlife Fund (WWF U.S.) has a yearly budget of easily millions of dollars. Their very wealthy counterpart, Greenpeace, is now heavily floated by wealthy German contributions. Their business model of financial sustainability rivals Exxon Mobil and could easily be mistaken as a love for money. NGOs are part of the industrial world and use all its tools. Sadly, big NGOs cannot operate any other way; it is inherent in the very structure of their existence and to obtain their income. We have been standing here for years, in a stupor of inaction, on the deck of a major shipwreck, waiting for the final wave to finish us off. Most environmental NGOs lack poverty reduction skills, and the required awareness and effort and assigned budget for doing so. NGOs do not have ISO compliance, or accepted performance metrics (other than being able to raise funds and keep going). So long as big NGOs such as WWF certify the harvest of plankton and virgin fish stocks as "sustainable and fit for global consumption," something cannot be right. What does it really mean to be "not for profit" and environmentally certified? What about the constantly increasing operational costs, and why do governments still allow the tax-exempt status of such NGOs? Why are we still donating, or using NGO donations, even to settle environmental legal disputes? Major NGOs such as WWF have already gotten very bad press on both poles when they made decisions that supported commercial interests and stakeholders and did NOT maximize environmental interests. The certification discussion of the Marine Stewardship Council on krill and toothfish made that clearer than ever. The fact that polar bears were listed on the Endangered Species List, but in reality were downgraded because of a legal change and loophole in the Endangered Species Act (ESA) is hardly reported by WWF, not a success story and makes for a cynical reality. The role of global NGO monopolies such as BirdLife International (also acting on all three poles) must be seen as equally problematic, and so is the role of Wetlands International, acting in Europe and Asia (but notably absent in North America and China). Why do they all avoid sharing of raw data, online and with metadata? And where are their claimed scientific data and contributions to sustainability science?

We live on a planet with finite space and a limited set of resources. It is simply impossible to maximize both environmental and financial interests of NGOs, and further have government and industry "buy in," and then happily protect the earth on top of it. All recent and historic trends illustrate that clearly (CAFF 2010; Johnsen et al. 2010). It is a pipe dream. The money spent by many NGOs is basically the revenue created by the destruction of critical habitat and anthropogenically used up ecosystem services in the first place.

Energy (and money) is not created within a vacuum (Daly and Farley 2003; Czech et al. 2003). Instead, energy is solely based on natural resources and has limits (Spash 2009). The laws of thermodynamics already have told us just that. These laws are taught to each high school student, but then are again ignored on major policy and science levels run by people with a Ph.D. and MBAs who promote growing the gross domestic product (GDP) "unlimited," who try to ignore ecological carrying capacity and the consequences, and who run endless fundraising and marketing campaigns (Paehlke 2004). One way or another, this is widely done on the costs of the environment and its natural resources.

NGOs and their endless funding quest within a global resource-consuming system is a schema that destroys wilderness and species. Do we have ethically certified NGOs? And should we make that a legal requirement? The current crop of high-powered NGOs and their hired academics do not promote the complete truth, the scientific process (transparency, debate, discussion, critical thinking), and their findings sufficiently. NGOs, often run by MBAs and Economists with an emphasis on public relations (PR) and business models, have almost no other income than that from fundraising. Therefore, many big NGOs resort to keeping the fires burning at all costs and to raising funds. They often insist that they have a right to take donations from anyone, including their corporate nemesis, by highlighting the basic right to earn money and "to own." It is important to understand that they fully live, participate in, and support the aggressive capitalistic and industrial process fueled by the Western world. Perhaps they really should not have those rights? For NGOs to be really useful and effective, they simply need a different structure and business model. And why is that change not demanded by them? Considering that we live in a world where most people live on less than $3 a day, and environmental NGOs do virtually nothing to improve this situation, then perhaps they do not have the right to continue this circular argument of existence? One way or another, and with a financial and ecological crisis worldwide, the classic NGO model is outdated, does not achieve, and needs to be improved. Unlikely; this change is promoted by the big NGOs themselves but should be done by the public, the scientific community, and the government first of all.

But such situations and problems are exactly the effect when major fundraisers are involved and taking over, green-washing "bad money" from oil and gas explorations, banking investments, and others for NGOs who do not have to expose their funding contributors. Many of the unnamed philanthropy funding institutions do very similar washing of "environmentally bad money" into "clean funds" but for a "good cause." However, the money meant to fix the problem is actually the root cause that created the problem in the first place. A Western culture is truly exposed and now shows its bare bones.

Further, we know that the role that international corporations play at the poles, and elsewhere, needs also a major scrutiny and revision. The well-entrenched procedure where "undisclosed funding sources" can float major conservation activities obviously needs to step toward a clear exposure of goals and strategies, as well as an ethical review and emphasis (Spash 2009). For studies concerned with animals and humans, such elaborate procedures do exist, for example, the Institutional Animal Care and Use Committee (IACUC www.iacuc.org; http://en.wikipedia.org/wiki/Institutional_Animal_Care_and_Use_Committee). Why not use such structures for NGOs, too?

But who reviews ethical procedures in the poles, internationally, and by corporations, and their contractors and NGOs? When it comes to these corporations, the identified major players must be named for their roles and impacts, and by their relevance for cultural and "climate" reasons: Who are the oil and gas companies staking claims in the Arctic, who owns them, and what research are they paying universities to do? These same questions, and more, hold true for fishing companies, for mining companies, and certainly for computer, food, and pharmaceutical companies. UNESCO (2009) has already promoted ethical procedures for the poles.

The fourth player in this game are the international media and publishing houses. This revelation might come as a surprise to many people, but many things that are said and promoted about the poles, in scientific journals and elsewhere, are truly managed, and controlled, by them. With most people never traveling to the poles, the TV becomes the real bottleneck reporting the polar truth.

The last thing we need, however, are more regulations and laws that do not work and a legal model of "quick-fixes" that presents bizarre cornucopia and a mosaic of failed policies (Johnsen et al. 2010; Huettmann et al. 2011 for seabirds). Nowhere does this schema becomes so clear than at the poles, in the tropics, in the marine wilderness, or in centers where humans are densely crowded. Laws without funding and enforcements cannot work; virtually all lawyers know it, yet they do nothing against it, while species increasingly close the distance to their own extinction. It is here where Western society and its culture has failed us so badly again; the United States and its elite law schools are in the lead here. We were fed the idea that more rules, more regulations, and more laws would provide us with a secure and stable fix, making things better (= "makes sense"). But this concept clearly failed in regard to climate change, human welfare, and in most environmental and wilderness applications, as well as in governments and financially (apart from the free and convenient lifestyle we are supposed to have). It even violates some human rights, for example, freedom of expression. Considering the huge numbers of poor people on this world and those who do not even enjoy the most basic human rights, it simply failed globally (Paehlke 2004). Even going through the institutions and becoming a "good lawyer" does not help anymore. The end of an era has been reached.

After the last world war, many of the issues and problems we have discussed here have been resettled, and organizations such as the UN have been set up to address them, such as issues of human rights, including access rights to water, food, education, and healthy ecosystems and their services. Just look at the IUCN and the role of NGOs such as WWF, and how multiple systems of federated governance seek to assure an anxious multijurisdictional population that they will work together for the better goals of mankind. The UN concept goes back to the League of Nations, but which failed so miserably that it might have led to the second World War (at least some people say so). Environmentally speaking, we seem to have a similar inefficient democracy, eating away at our natural resources, whereby the most vulnerable species and habitats are paying the price. Along this logic, democracies that entertain two capitals [e.g., the European Union (EU) in Strasbourg and Brussels], that have no workable government, that have overblown representative bodies, or which lack achieving legal policies, cannot be good environmental role models. The link between good democracy and environmental resources and efficiency has been known for centuries and is well documented (Taber and Payne 2003; Paehlke 2004; Diamond 2005).

1.5 In Times of Globalization: Progress Versus Failure, and a Renewal with Dramatic or Peaceful Consequences?

These days, it is no longer necessary to speak about the fatal role of globalization and the economic growth policies promoted by the world's major industrial nations, their leaders and politicians (Paehlke 2004; Diamond 2005; Stiglitz 2008). G20, G8, and G2 are good examples for that. There is an inherent conflict between the blind promotion of economic growth versus biodiversity (Daly and Farley 2003; Czech et al. 2003; Rosales 2008). It is very clear that the "Chicago School of Economics" has failed us nationally, regionally, and globally. Their leading economic theories widely cater to North American ideology (Gaffney 1994), are based on a loose agglomeration of theories and assumptions, include the infinite theoretical manipulations of numeric calculations, and are not really based on real modern science or data from the physical world and its realities, interactions, and limitations (Colander 2000). How can we have a good turnover and any reasonable outcome from such bad advisors, but who sit in "high-quality" schools and institutions that benefit from corporate-directed research and funding (Paehlke 2004; Perkins 2004; Stiglitz 2008)? Will they all "turn green" now? And if not, what comes next, what decisions are made, and what are the overall costs? Reducing the GDP toward a sustainable, steady state is probably not going to be cheap anymore.

Are the poles special? Of course they are. Do they need a special treatment? Of course they do. They are fragile, specialized ecosystems. So, blindly applying the economic growth scheme, enforced through institutions, does not work there either (Rosales 2008; Young and Steffen 2009). However, it is not so clear what the exact, underlying governance model should be, whether everybody agrees, which governance model really achieves the desired outcomes, and which model serves us best in the long term with ongoing climate change, human pressures, and lack of natural resources. There is no way back, but perhaps the indigenous way is the path to go? It must come as a surprise to many that these questions for the poles are not answered in the policy-making bodies of the western world, despite decades of science, and billions of research funds provided by and to citizens, nations, NGOs, and industry. We are still at infant steps here, and with no sustainable prescription to save us!

For instance, ecosystem management (e.g., in Antarctic) or resiliency has been promoted in recent years in North America, Sweden, and other places as a more relevant concept to provide sustainability and fairness (Chapin et al. 2009). This idea might be a good thing, but so far it has widely failed to deliver. Also, it is not such a new concept overall (Braun 2005), and sometimes it even achieved the opposite (http://depts.washington.edu/meam/MEAM6.html#Pauly), resulting in just a blur of more extreme resource exploitation, where locals overuse the resources. Our biological resources, for example, Steller's sea cow, polar bears, albatross, and snow leopard, are certainly NOT resilient, and the "tyranny of the locals" (wherein local committees drive resources to extinction) comes into full play instead; see for equal or worse problems with ecosystem-based management (Belgrano and Fowler 2011).

Finally, and in times of a total globalization: Is the concept of nation-states still relevant, is it still useful and efficient for managing the poles, or for any natural resources and wilderness? Has it become clear to all that this structure, policy framework, and funding scheme (primarily based on national taxes and national resources) has not worked, and there is no good outlook indicating that it will work at any time in the near future, and on a sustainable basis? Many nations are already empty of resources.

The status of the Exclusive Economic Zones (EEZs) in Arctic nations such as Iceland, Faroe Islands, Norway, Russia, Canada, and Alaska all show evidence of overfishing (CAFF 2001; Wilson Rowe 2009). Antarctica has reached a similar state, and so have many lakes and rivers in the Himalaya region. What is needed here is an immediate review, revision, and improvement of the governance structure and all its members. The Federated Systems might initially appear to work well, but the current structure and overall framework are widely unsustainable. In its present state, we will all just walk down the "spiral of destruction." Such thoughts and calls for change are rarely heard within the UN (Stiglitz 2008; UNESCO 2009) and its Arctic member nations (Bingham 2010) with their benefiting contributors, contractors, NGOs, and media-machines.

One has to admit that our state-of-the-art policies (which are not pleasant ones when it comes to an honest review) also greatly contribute to the failure of our diplomatic system. The (repeatedly failed) Climate Change agreements, for instance, were widely prepared and negotiated by the diplomatic corps and embassies. Many international resource conflicts are negotiated by similar institutions and "professionals" (see Wilson Rowe 2009 for examples). Most fishery conflicts and related border and overfishing disputes are directly dealt with by diplomats, for example, in the Bering and Barents Sea waters and Antarctica. And at the third pole, water and their natural resources are nothing but battlefields for diplomats. However, the call for a new world order, a new deal, an institutional design, has already been made by many (Hansen and Hoffman 2011), including from the EU itself (Radermacher 2004). The Hindu Kush–Himalaya membership nations such as India and China have been making that call for years. Most notably here is probably the call for a global justice system, including the call for a global currency (Stiglitz 2008) and for a world court (Radermacher 2004). So far, most of these types of law cases are settled with "class action" law suits in the U.S. courts (e.g., the Bhopal accident was settled that way with the Dow Chemical Company), but these do not deal well with international and environmental problems, and certainly not with polar problems. Where is the good ecological diplomacy there, and one that resolves conflicts on sustainable grounds and which truly makes everybody happy? Despite years of discussion, the ideas of "protecting temperature," "frozen water," "clean atmosphere," or "specific carbon levels" have widely failed, and I know of no legal system yet that gives these features value truly and efficiently (whereas some South American nations started to include rights for the abiotic environment). Climate and the atmosphere simply must receive legal protection. It is here where the Western world could show innovative leadership.

For the poles, the notion of national restructuring and "new borders" is anything but new (Byers 2009). For instance, for a long time it has been public knowledge that the Saami nation people have tried for many decades to claim their own, autonomous nation (http://en.wikipedia.org/wiki/Sami_people). Together with many other native nations, they maintain that their land has simply been stolen (see also Gallagher 2001 for Alaska). Wilson Rowe (2009) presents in detail the International Labour Organisation (ILO) human rights discussions for Russia's indigenous people in the Arctic. Similar cases are presented by Gray (2005) for Chukotka and by Gallagher (2001) for Alaska and its oil resources. The battle against poverty in the Arctic is in reality a War for Wealth, run by the Western society. It is a multibillion dollar dispute about land and resources. It is for that reason that the Arctic Council has representatives of the Aleut International Association (AIA), Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Council (ICC), Raipon, and The Saami Council as its permanent participants (but not yet as independent entities).

The North Pole and its shelf sea are now "open for business" and up for grabs by many countries (see Bingham 2010 for a discussion of the Russian claim). China, India, Japan, and South Korea are very interested in participating (Kuhrt 2007; Byers 2009; Wilson Rowe 2009): The largest embassies in Iceland are now from China and India! The same can be said for Svalbard (although legally owned by Norway, it is somewhat still claimed by many countries, e.g., as expressed in research stations). In the South Pole, relevant resource claims have clearly been investigated and staked out (the exact borders of Antarctica are not as well known and internationally agreed upon, however). The third pole, the Himalayas, has experienced changes in its borders, and some of these disputes have been violent. Yet, despite these hard and somewhat accepted boundaries, the zones of influence are widely changing there, almost on a yearly basis. The recent addition of Ukraine, South Korea, India, Japan, and China to the "polar" family is a good example of how such influences change. The initial American increase, and now fluctuating decline after the Bush years, provides other examples for the dynamics of the "Polar Game" and how fast it changes.

By now we know that global security, policing, and military considerations are a constant part of the "Polar Game" (Byers 2009; UNESCO 2009; Bingham 2010; Wilson Rowe 2009) and affect all relevant aspects of the environment and ecological services. However, what is even more difficult to deal with is the "Global Game."

This truly is a world exercise, and many of the stakeholders and institutions are not prepared for the relevance and magnitude; ethics have hardly evolved yet. Aggressive tension, warfare, is to be avoided. Countries that try to play big in a global theater, such as Norway, Iceland, Holland, Japan, and Germany, can probably be crushed in the blink of an eye by only one of the global forces from Asia or North America. So, to avoid conflict-causing imbalances, global and complex deals are made by all players involved in natural resources. Classic examples involving natural resources and military considerations include, for instance, forestry, fisheries, rare and strategic metals and NATO (Wilson Rowe 2009), the Security Council, and UNEP, as well as wider terrorism considerations and Asian security actions (see Kuhrt 2007 for the U.S. presence in Uzbekistan, and for Chinese weapon deals). Tibet already makes an excellent example. Experts know that melting glacier (= water) issues in the Hindu Kush–Himalayas affect the warfare in Afghanistan and provoke tensions in virtually all surrounding countries of Nepal.

These are the real inconvenient polar truths that exist on the ground today. These are transnational issues. They go largely unreported by the mainstream press, and as a result are largely unnoticed by the general public. However, they are noticed by experts in the field, and they are the issues that our children and their children will experience first hand and more intensely just a few years from now. It does not matter much whether this is in 10 years, or in 40 years, but strong changes will happen unless we get a handle on resource consumption and shortage. The changes in food prices, tightly linked to oil prices (Esmaeili and Shokoohi 2011; Daly and Farley 2003 for ecological economics) and to the amount of biofuel grown on otherwise limited precious soil, illustrate the sensitivity of the forces that determine hunger, famine, and social–political stability (Taber and Payne 2003). It is now incumbent on us to determine the life of future generations, and our own life, for better or worse. A purpose of "Science" is to categorically seek answers from the unknown. The morality of science, its justification and need for public funding, is "For the benefit of the people," and in this purpose, it involves setting up protected areas for free ecological services in the best possible manner, with scientific and transparent tools. Let us maintain and preserve what is left, and in the best possible condition. Thus, we must move vigorously toward Sustainability Science, one way or another.

So, in conclusion, from this detailed excursion of thought across our three poles, we need a global view that includes and maintains the entire cryosphere. We need a science that has "sustainability" written on its main agenda. We need good institutions that make it happen. We need a global analysis and a focus using best available data and analysis. These resources come mainly from the Internet, but also from people working on the ground. We need landscape protection levels of greater than 50% and achieving atmospheric temperature maintenance if we want a minimal maintenance of the status quo or better.

This book, the first of its kind, and all the contributions in each of the chapters, are trying to set the stage for such a necessary discussion and efforts crucial to the global well-being of the living and of the nonliving world, because many of the existing efforts and institutions continue to fail us. Thus, we seem to have no other chance than to make it happen from the bottom up and to do it ourselves.

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Part II
Polar Overview

Chapter 2
IPY 2007–2008: Where Threads of the Double Helix and Sputnik Intertwine

David J. Carlson

2.1 Introduction to Polar Years

Near the end of an era of heroic (and, occasionally, foolhardy) individual exploits often motivated by visions of national commercial advantage, the Austrian naval lieutenant Karl Weyprecht, himself an Arctic explorer, recognized the need for an alternative approach to polar research. He called for simultaneous and coordinated observations conducted through collaboration rather than competition and through international cooperation; his motivations included a genuine sense that understanding the vast Arctic required much more than a sequence of random and uncoordinated explorations (Sullivan 1961). Weyprecht's timely vision stimulated the first International Polar Year (IPY) in 1882 and 1883 – from the start, polar researchers have organized their "years" based on the logistics of polar travel with little regard to 12-month calendars – which also represented one of the first instances of international cooperation and coordination in modern science.

Fifty years later, in 1932 and 1933, international science organizations declared a second Polar Year, motivated by advancing global (radio) technology, by growing scientific understanding and improved observational capabilities, but also by enduring curiosity about polar regions and by Weyprecht's vision of the need for and benefit of international scientific cooperation on polar research. The visions of the second Polar Year could not overcome the reality of global economic depression, but substantial international cooperation occurred, producing substantial data. When ideas of a third Polar Year arose, targeting 1957 and 1958, compelling global issues in geophysics, astrophysics, and oceanography (not to mention an acute need for international cooperation) almost immediately expanded the polar model into an

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International Geophysical Year (that lasted 18 months). For geophysical and geopolitical reasons the IGY stimulated an enormous effort in Antarctica, resulting in strengthened polar cooperation, then and since, and initial efforts at polar protection, two of the many remarkable legacies of IGY.

Recognizing the passage of 50 years since IGY, several groups developed plans for celebratory and research activities for 2007 and 2008, including the electronic Geophysical Year (eGY), the International Heliophysical Year (IHY), the International Year of Planet Earth (IYPE), and the International Polar Year 2007–2008 (planned for 24 months). For this IPY, a sense of urgency overwhelmed ideas of commemoration as more than 1,000 groups around the world proposed collaborative activities in response to the call for "an intensive burst of internationally coordinated, interdisciplinary, scientific research and observations focused on the Earth's polar regions" (ICSU 2004). In that phrase, one finds Weyprecht's vision of international cooperation coupled with urgency and refocused on the polar regions.

For several reasons, the first two Polar Years and the IGY focused almost exclusively on geophysical sciences. Many of the systems then under study, such as the outer atmosphere or the interior of ice sheets or global plate tectonics, had no biology. Although biology and ecology had global reach and impact, and had produced breakthrough technologies (the announcement of the double helix structure of DNA in 1953 preceded the launch of Sputnik in 1957), geophysical scientists, particularly meteorologists, had longer experience in organizing international cooperation and with producing and sharing global data sets. Also, the polar logistics in those eras retained close connections to military resources and objectives. The military considered polar biology, if they considered it at all, as an annoyance at best: polar bears apparently destroyed a row of lights along one of the snow runways in use by a drifting Arctic research camp during IGY (Sullivan 1961).

Although some have remarked at the inclusion of social sciences in this IPY (the first IPY also included social sciences), the unprecedented inclusion of a rich and vibrant array of biological sciences seems to have attracted no particular notice and required no particular advocacy. Most national polar research programs, now anchored in research agencies and councils although still partially dependent on military or quasi-military logistic support, include biological sciences as large and essential parts of their programs; those components would naturally have joined this IPY. Motivating documents such as the Arctic Climate Impacts Assessment (2005) called for prominent attention to Arctic ecosystems, while existing treaty obligations, such as the Antarctic Treaty Convention on the Conservation of Antarctic Living Marine Resources (CCAMLR, http://www.ccamlr.org/), ensured attention to ecosystems of the Southern Oceans. And we must acknowledge the role of the public, whose interest in *isbjørn* and *pingouins* played a significant role in political and financial support for IPY. Perhaps most important, many of the science questions of this IPY, notably the roles of polar regions as predominant sources and sinks in the global carbon cycle, the impacts of polar changes on local ecosystems and global biodiversity, and the current and future well-being of Arctic residents and communities, require input from biological sciences (including ecology, zoology, genetics, physiology, and toxicology) operating as full partners to every other area of IPY science.

In other words, to address the most urgent issues in polar science, Polar Years of this era must include essentially all areas of science. Sciences that evolved from the double helix and from Sputnik now collaborate to address planetary urgencies.

The attention to polar ecosystems and to the role of those ecosystems in human well-being as a prominent part of this IPY raises necessary and welcome issues of conservation and protection. For the first time, products and results of an IPY hold potential relevance to current and future regional and global conventions and protocols on contaminants (persistent organic pollutants or mercury, for example), on biodiversity and endangered species, and on managed marine and terrestrial natural resources. One notes the absence, with the singular exception of stratospheric ozone, of any modes of protection for geophysical components of the polar regions. This absence is notable, because the change (decrease) of ice sheets or permafrost or sea ice will have substantial, and arguably determinative, local and global impacts on ecosystems and human systems, not only in the Arctic and Antarctic but also in alpine glacier systems around the world, particularly in the so-called third polar region of the Plateau of Tibet in the heart of Asia. Unfortunately, protection for snow and ice rests within the uncertain future of international climate agreements. The attention to ecosystems and the involvement of the biological community raise vital and challenging issues on how participants of this IPY share and use data, on the timeliness and social and political impacts of results and products, on the fundamental motivations for research, and on how we report and evaluate the impact of this IPY. Issues of conservation and protection stimulate these particular data issues, but the issues reverberate throughout this IPY.

The hundreds of researchers' ideas and plans, formalized as 1,200 expressions of interest, merged into international, interdisciplinary, and endorsed IPY Projects. The endorsement process required that each Project, among other characteristics, "contributed to international collaboration and coordination" and "provided open and timely access to data and encouraged the long-term management of IPY data and information" (ICSU 2004). Weyprecht would have recognized the first requirement. He, and we, should remark at the second requirement. Does not open and timely access to data and wise long-term management of those data constitute the essential and universally recognized life fluid of polar (and modern) science?

2.2 IPY Data

Eventually, IPY Projects, with substantial success, received funding through national selection processes. In many cases the successful Projects competed for preexisting funds available for polar research or for research generally, but in not a few countries the occasion and prominence of IPY stimulated additional incremental polar research funding. The disparate funding processes and practices in various countries make accounting difficult, but we can estimate that this IPY, in its 24 (nearer to 30) months of operations, expended US $1.2 billion on gathering data. (This total does not include IPY-stimulated expenditures on major polar infrastructure – new icebreakers, new Antarctic bases, a new ice-focused satellite – which will produce and support future polar data.) The research funds allowed the partners of the various IPY Projects to implement their plans, gain access to the ocean, ice, or frozen lands, and to gather data. What does 1 billion dollars of data “look” like?

In volume, the IPY data set certainly amounts to many petabytes. (For an amusing definition, search on petabyte and follow the links to Gizmodo.) The billion dollars of new IPY data do not include a large volume (at least terabytes, perhaps even petabytes) of preexisting data, the data streams that come from (or in the case of archived data, came from) existing observation systems and programs. IGY and the previous Polar Years had none of these data sources: satellite data and images, ice-tethered instruments, ocean profiling floats and drifters, and decadal times series of population and species distributions, conditions, and abundances. These existing and ongoing data do not provide sufficient or adequate coverage of polar regions and polar processes, but if we know how to find and use them they provide an important background asset. As but one example, one can hardly overstate the importance to this IPY of the 30-year archive of satellite passive microwave imagery of sea ice. For most investigators of this IPY, a full research data set must include continued and enhanced access to existing and historical products.

The billion dollars for IPY does include every possible form and format of data: images wide, narrow, and panoramic, profiles upward and downward, hourly to millennial time series, isotope ratios and fractions, energy and material fluxes, species identities and distributions, interviews in common and rare languages, disease types and rates, genealogies and genetic sequences, samples and artifacts, and singular events and gradual processes. These data exist, inevitably, in the jargon and units and collections and reference systems of various specialties, from anthropology to astronomy, genomics to glaciology, and ecology to economics. This awesome variety and amazing breadth of data represent IPY’s initial success! Most IPY Projects, themselves formed of multiple groups and teams and work packages, achieved most of their objectives: they obtained most of the data they hoped to obtain. We should understand, therefore, a well-deserved sense of achievement. After hard effort, against funding, scheduling, logistic, and environmental challenges, deployments succeeded, instruments worked, and data became real and tangible and secured.

From the aspect of polar ecology, the IPY data sets seem almost impossibly rich. IPY produced new data on char, spiders, wasps, rangifers, bears, seals, whales, penguins, copepods, ciliates, murres and geese, and more. On mosses, lichens, fungi, grasses, shrubs and trees, and still more. On individuals, populations, and ecosystems. IPY researchers produced data in terms of habitat – terrestrial, marine, and freshwater – for organisms often intimately associated with snow and ice. The IPY data sets show organisms as indicators, vectors, sources, sinks, migrants, or invaders, functioning at the life-limiting extremes of cold, dark, and desiccation. Described by their formal names, familiar names, behaviors, or genetic sequences, IPY data constitute a remarkable contribution to a census of polar (and global) organisms and to delineation of ecosystem dynamics and energy flows. The Census of Antarctic Marine Life (CAML, http://www.caml.aq/index.html) and the Circumpolar Biodiversity Monitoring Programme (CBMP, http://cbmp.arcticportal.org/) in the north both offer hints of these vast IPY data sets. However, although both programs gained resources and built new capacities during IPY, neither program has the mandate or resources to serve as a comprehensive access site for IPY biology and ecology datasets.

Following the Sputnik thread, the space-borne effort of this IPY generated hundreds of multifrequency radar scenes of ice sheet surface velocities, captured through acquisition strategies specifically modified for IPY by at least three different national space programs; these particular data sets over Antarctica provide ten or more scenes per month over regions that have not had a single high-resolution image since 1997. Enhanced space agency cooperation during IPY also provided optically derived digital elevation models of extraordinary resolution of the perimeter regions of ice caps and ice sheets, repeat fine-resolution mapping of the entire Southern Ocean sea ice cover, and unprecedented coverage of circumpolar permafrost and of freshwater (lake and river) freeze-up and break-up from high-resolution visible and thermal infrared (IR) imagery. Researchers also explored and improved technologies for deriving wind and atmospheric chemistry products for polar regions from operational satellites. The Global Inter-agency IPY Polar Snapshot Year Project (GIIPSY, http://bprc.osu.edu/rsl/GIIPSY/index.htm) guided this effort and has compiled documents from national space agencies describing many of these data sets. Again, however, neither GIIPSY nor any of the space agencies has the mandate or the resources to serve as a comprehensive inventory or access site for the remarkable array of IPY satellite products.

From this successful data-gathering effort, with this burst of new data in hand, how do we now achieve the larger and more difficult goals of free and easy data access and sharing, of complex analysis and integration, and of rapid conversion of new knowledge into predictive skill? How do researchers following the double helix threads (of biology and ecology) discover and access the products of the Sputnik thread, and vice versa? How do we quickly respond to the public who funded and followed IPY, and how do we ensure that IPY data have maximum influence on and benefit to post-IPY plans for future polar observations and monitoring, and for the urgent processes of polar conservation and protection?

2.3 The Challenges of Integration, Prediction, and Impact

The breadth, volume, and immediacy of IPY data shine new light on existing data challenges. We can say, most clearly, that no single existing data system and no plausible combination of existing disciplinary or national or world data systems and services does now or will soon provide a one-stop encompassing inventory of the type and availability of all the IPY data, much less access to any fraction of the IPY data itself. This statement, discouraging despite the remarkable efforts and accomplishments of many people and many data centers for IPY, does not represent new or surprising or even unexpected information. It represents a documented preexisting condition, brought into sharper focus because of the impending appearance of an IPY-generated multidisciplinary multinational burst of polar data. The IPY Data Management subcommittee, the sources of the substantial efforts and accomplishments mentioned above, have described and itemized, in urgent terms, the challenges of sharing and publication, interoperability, and preservation of IPY data (SPD 2010). Rather than retracing those steps, I propose an alternate approach focused on hypothetical but plausible data users.

Despite the urgency inherent in many original proposals, and despite the widespread acceptance of IPY data access and sharing policies, most IPY research will not automatically lead to the rapid development of useful predictive skill and most IPY data will not become immediately accessible or relevant to issues of conservation and protection. I link prediction and protection because I see related processes and outcomes, similar urgencies, and identical barriers to progress. As a thought process to help understand the potential impact of IPY data on both prediction and protection, I imagine three user groups, each group including researchers, operators, and decision makers. I then assess the IPY data impact for each group. I use this approach to identify the potential for, or obstacles to, rapid development of polar prediction and protection systems and skills; in other words, to the full success and impact of IPY.

2.3.1 Marine Operations

Focused on transportation in the Arctic and on tourism in the Antarctic, this marine operations group could include commercial shipping and resource extraction companies (e.g., hydrocarbon or fishery), insurance and regulatory bodies, port authorities, tour operators, and national policy- and decision makers. IPY's potential impact on this group would occur through improved predictive skills for ice, ocean, and marine weather, embodied in daily, monthly, seasonal, and decennial forecasts, and on new or strengthened proposals for protection (largely chemical) of the marine environment. These prediction systems and protection proposals, under the treaty conventions and obligations in Antarctica and perhaps starting from a national basis and focus in the Arctic, could and should make use of new IPY information on sea ice formation, evolution, and drift; ocean currents; high-impact weather (including waves, storms, thaws, and surges); sea level; changes in hydrology and terrestrial water resources; aerosols, cloud systems, and visibility; and seasonal to decennial trends for winds, currents, and sea ice.

2.3.2 Carbon Impact Community

This carbon impact group could include climate modelers, climate negotiators and regulators, national and international assessment groups, and a growing carbon-literate public. This group could and should use new IPY information on northern terrestrial carbon sources and sinks; northern and southern oceanic carbon sinks and sources; and changes in hydrology and snow cover and their influence on vegetation and fire. Predicting the timing and quantity of methane emissions from terrestrial and submarine permafrost and the carbon impact of future changes in Southern Ocean ecosystems would emerge as issues of immediate urgency.

2.3.3 Natural Resource Managers

The natural resources group could represent present and future consumers and managers of polar marine and terrestrial ecosystem resources, health specialists, sociologists and community activists, economists, and local, regional and national governments. These users could and should make use of new IPY information on marine and terrestrial ecosystems; community adaptability and survivability; polar biodiversity; health impacts of regional (aerosols) or global pollutants [mercury, persistent organic pollutants (POPs)] deposited in polar regions; condition, timing, and predictability of snow cover, lake and river ice, and sea ice; structural changes in permafrost; and options and mechanisms for local management and governance. They would address management of current and future fisheries, establishment of marine and terrestrial reserves, and the well-being of polar communities.

These three user groups need robust predictive skill for key polar questions about ice, carbon, and ecosystems; reliance on “climatologies” or extrapolation of recent trends clearly will not provide sufficient guidance. They need comprehensive and synthesized data sets from the Sputnik and the double helix threads, and the merger of new IPY information with longer-term records, to identify protection priorities and delineate protection regions and strategies. IPY’s strength as an international program derives from its bottom-up and inclusive nature; in no other way would we have encouraged such broad scientific and political engagement. Now, however, from the point of view of these user groups, that breadth represents a deception. These groups can identify relevant labels and keywords from the broad list of topics covered by IPY Projects, and therefore anticipate prompt and integrated products for their needs, without understanding the data access limitations and challenges inherent in that very breadth.

2.4 Barriers to Sharing and Exploring IPY Data

I ask the reader to envision, from a polar point of view, the animated sequence of annual Arctic sea ice extent. From March to October sea ice recedes from the immediate coasts, it retreats over large central areas in the east or the west (or both), and, in most years, it exits along the Canadian archipelago and out through the Greenland Sea. At the same time, if you please, envision the northward retreat of snow, the melting of lake ice and river ice, and the progressive greening of vegetation, all reversed and propagating southward in the autumn. Now add to your vision the aerial arrival and departure of hundreds of thousands of birds and the meandering migrations of caribou from winter ranges to summer grounds and back. Many of us show individual components of this vast circum-Arctic freeze and thaw, advance and retreat: sea ice of the previous 12 months, 10-year composites of monthly caribou positions, springtime changes in satellite-determined greenness or leaf area. Often we say in retrospect "Why don't we put all those components together, to really promote a view of how the Arctic functions as a system?" Indeed, why not, for the Arctic or for a similar and equally rich view of the annual surges and retreats of the ice, ocean, and ecosystems around Antarctica? The public, already fascinated by ice or caribou images, would react very favorably to these views of the polar regions as integrated breathing systems. And what better format on which to overlay both the perambulations of individual animals (bears or elephant seals or foxes or penguins) and longer-term indicators: the poleward propagation of invasives and competitors, the disappearance of multiyear sea ice and redistribution of annual sea ice, the degradation of permafrost, the relocation and change of productivity zones? We have at hand unique sets of polar data converted (or convertible) into compelling imagery, hard-won assets of in situ monitoring and of new high-resolution remote sensing, and yet we cannot share the data among ourselves, much less produce integrated and accessible presentations. More seriously, we cannot make the data available in layers and formats so that some other viewer, whether scientist or interested member of the public, can explore and manipulate the displays to make their own discoveries. The integrated view(s) of the polar regions that I imagine here would go a long way to meet the information needs of our three user groups and would stimulate all users to explore specific applications and processes within a larger context.

I recognize substantial technical impediments to such free and open and useful access, related to formats, permissions, reference systems, bandwidth, and so on. For this discussion I categorize those obstacles as issues of interoperability. I do not minimize them, but I consider them solvable (e.g., SPD 2010). Beyond these technical challenges, I submit that our data access limitations actually derive from behavior issues, of individuals, groups, and organizations.

2.4.1 Barrier 1: Not Accustomed to Sharing

Neglecting for the moment the various national implementations and interpretations of data "ownership," copyright, and intellectual property, most scientists, even those who, as participants in IPY, accepted a free and open data-sharing policy, do not consider data sharing as an immediate or compelling priority. They developed the ideas, they wrote the successful proposals, and they, as polar researchers, endured substantial difficulty just to procure the data. They need first to do quality control, to protect their graduate students, to produce a quick paper, and to write the next proposal. Later, they may register their data, and might, if they have access and experience, archive the data with a data service. Institutions and organizations, even those with advanced data policies, have neither the time nor motivation to insist on or enforce better and more prompt data behavior. For IPY data, indeed for all data in the rapidly evolving field of polar science, this individual and institutional reluctance allows the persistence of a collective and inhibitive data inertia. Our three user groups need to voice loud and immediate displeasure with this situation. Their needs do not allow for such resistance and delays, and they should, with justification, expect better from IPY.

2.4.2 Barrier 2: Absence of Incentive and Rewards

Substantial creative technical professional and collaborative work goes into gathering and displaying the circum-Arctic data sets alluded to at the start of this section and into the assembly, quality control, and dissemination of almost every high-level data product, from the circum-Arctic distributions of seabirds to maps of glacier outflow velocities around the periphery of Antarctica. Who gets credit for those efforts, and in what form? When a scientist devotes months to such products, at a level of effort equivalent to the effort involved for a publication or a proposal, how does that person gain equivalent recognition? The urgency of IPY, and particularly the urgency to quickly and skillfully merge complicated data sets into useful products for prediction and protection, force these incentive and reward issues again to the forefront, but these issues have a long and persistent history in our scientific culture. One solution, also not new, involves increased attention to publication of the complex data sets themselves, as a way to record and reward creative intellectual contributions. At least one new data journal, the *Earth Systems Science Data Journal*, appeared specifically in response to IPY, but its long-term survival seems uncertain. The user groups described here could encourage these recognition and reward processes by themselves acknowledging and crediting data sources; perhaps they would evaluate, rate, and, indeed, purchase sea ice or seabird or sea-level applications for their mobile devices.

2.4.3 Barrier 3: Absence of Prediction and Protection Frameworks

A challenging and urgent gap exists between the many observations and studies of polar systems undertaken during IPY and the development of useful predictive skill for integrated geophysical and biological and (Arctic) social systems. This gap has several causes. The ingrained tendency of science to focus on research publications represents a primary cause. A lack of suitable and capable predictive models for polar systems also contributes to the gap. Even when good component models exist, the complexity of integrated geophysical, ecological, and social linkages has generally deterred attempts at integrated modeling. Development of integrated protection strategies runs aground on the same issues of individual publication tendencies and daunting complexity: the need to incorporate local, regional, and global concerns while focusing on indicator species, managed fisheries, or circumpolar ecosystems. As in the case of data sharing, the real barriers to prediction and protection derive from underlying social issues. Even though most of the IPY Projects described explicit model deficiencies and an urgent need to predict or protect as motivation for their work, many IPY researchers do not see their individual work as leading to, contributing to, or even relevant to, prediction or protection, at least not without additional time, without intermediary steps (such as assessments), and without the actions of third parties.

2.4.4 Barrier 4: Not Interacting with Customers

Users of polar information, from the three groups described here but also from diverse groups that will undoubtedly emerge, should and will develop the needs, timescales, and mechanisms for prediction and protection products. For the most part, science today still assumes that user benefit will emerge automatically, subsequent to the research process, but that in inception, in initial idea development and planning, individual ideas remain primary and preeminent. Occasionally, if a particular review process requires proposers to justify broader impact, the authors will find an education or commercialization partner, but almost always as an afterthought. When Lubchenco (1998) charged science to address the most urgent needs of society, to communicate knowledge and understanding widely, and to exercise good judgment, wisdom, and humility, I believe she challenged us to listen more closely to user needs at the earliest and most formative stages of planning.

2.5 Some Reasons for Optimism: Examples from IPY

One can easily identify positive accomplishments and trends across the range of IPY activities. I focus here on integrating activities with potential utility to our three user groups, namely, steps toward predictive skill and protection strategies for ice, carbon, and ecosystems.

With the Polar Information Commons (PIC, http://www.polarcommons.org/), IPY hopes to create a fast and easy-to-use open data resource accessible through normal search and browse tools. The PIC mirrors the "real" commons of the Antarctic (defined in the Antarctic Treaty) and responds to the common interests of humanity in the Arctic by serving as an open repository for scientific data and information about the polar regions and as a community-based infrastructure that fosters innovation and stimulates participation.

In the PIC vision, investigators expose their data to the world and share them, without restriction, through open search and broadcast protocols on the Internet. All PIC data carry a digital badge that denotes cooperation and expectations among providers and users based on open access norms and best practices. Providers and users have the ability to discover, share, and exchange data and information without necessarily registering or depositing data in formal repositories or catalogs and without arranging passwords and permission for access on one or multiple systems.

Widespread use of PIC labels and protocols will stimulate rapid data sharing and access through standard tools and based on community norms, while establishing and facilitating background processes for long-term preservation and stewardship of critical data through collaboration among data centers. The PIC framework evolves from protocols developed by the Science Commons, in which the establishment of "scientific norms" encourages appropriate attribution, appropriate use, and sensible quality control. Compliance with these norms occurs through peer pressure and through growing recognition of the long-term benefits of collaboration and participation within the community. These benefits include increased integration and use of PIC data by a broader range of users than would otherwise occur and greater assurance of long-term preservation and stewardship of contributed data. Ultimately PIC involves collaboration among scientists who collect data, archives that preserve data, and a broad community who use, repurpose, and share polar data. The three groups defined here represent the forefront of that broad user community.

During IPY, international groups (20 in 2008, 15 in 2009) have contributed monthly sea ice extent estimates leading up to the September Arctic sea ice extent minimum, sharing, freely and openly, their estimates as well as their techniques and reasoning. This collaboration, organized and compiled by the SEARCH program (http://www.arcus.org/search/seaiceoutlook/index.php), publicizes the skills of the groups and demonstrates the clear benefit of rapid sharing of information and ideas. It also will rapidly advance the understanding and prediction skill for Arctic sea ice! Listening closely to one user group, Alaskan walrus hunters, several of the prediction teams have further refined their efforts to include products with improved resolution, relevant timing, and enhanced local impact and feedback. One can anticipate the wide utility of efforts such as this as essential components of regional or species protection efforts.

In the Southern Ocean, observationalists and modelers (the distinction becomes less and less relevant) have cooperated to use the SOSE (Southern Ocean State Estimate, http://www.mit.edu/~mmazloff/SOSE.html) model to plan, guide, and analyze an ocean tracer experiment. Using the SOSE assimilation framework to synthesize a wide range of IPY Southern Ocean observations seems quite feasible; analysis of such a state estimate will represent a hopeful step toward understanding and predicting the biology, chemistry, and dynamics of the Southern Ocean. The strengths of this effort lie in its openness and ability (and willingness) to assimilate a broad range of data from multiple national sources. Our carbon and ecosystem user groups should take the development and implementation of such tools as an innovative and positive step forward; they should also advocate additional progress and wider participation.

One can also find reasons for optimism in many smaller and informal efforts, evident in several recent publications. Ohse et al. (2009) applied a geographic information system (GIS) modeling approach, using freely available data and software, to predict present-day distributions of white spruce (*Picea glauca*) in Alaska. Based on their goal of accurate spatial predictions, the specific model, its data sources and tools, and its open access approach will undoubtedly stimulate research on the importance of biological factors and environmental variables, many of which vary on climate timescales. The work and its approach set an admirable example and pattern for understanding, in a quantitative but also transparent and accessible manner, land use and climate impacts on species distributions for the purpose of improved decision making.

Strugnell et al. (2008) considered an analogous problem although on a very different timescale, namely, understanding how paleoclimatic forcing has generated and maintained large-scale patterns of biodiversity in the deep sea as a critical step forward in evolutionary research and in predicting the impacts of global climate change. They used innovative phylogenetic approaches to determine relationships and divergence times for a lineage of deep-sea octopuses and incorporated paleoclimate and plate tectonic evidence to show that development of the global thermohaline circulation served as an evolutionary opportunity and driver enabling the Southern Ocean to become a center of origin for deep-sea fauna. Their ability to determine the processes, routes, and timings provides an important view into dispersion and evolution processes that undoubtedly continue under the present climate system; from their work we better understand complex and integrated geophysical-ecological systems susceptible to future changes.

Setting aside the troublesome question of how our user groups would even know about these useful but disparate publications (PIC? IPY Publications Database?), we can identify positive and relevant features. Both publications apply advanced ecological and biological techniques in the context of state-of-the-art remotely sensed and reconstructed geographic and paleoclimate data sets: here threads of Sputnik and the double helix (and continental drift) truly intertwine. Both research group rely on publicly available tools and take the intentional steps of sharing their own products and tools. Both groups conduct and discuss their results in a prediction framework with climate change as one of the drivers. Although our user groups may never need the detail of these studies, they should feel positive about directions and practices.

These examples of international cooperation and of data sharing, the examples of IPY sea ice and ocean mixing "prediction" exercises, and the integrated studies of biology in climate and paleoclimate contexts represent the tips of a few icebergs. Many groups develop independent descriptions and models of regional ice–ocean–atmosphere coupling, permafrost degradation, vegetation propagation, snow accumulation, disease invasion, fishery adaptation, and human migration, to list only a few IPY activities. This abundance, this great variety of exploration and study, will lead to an improved and broadened knowledge of polar systems. However, without an explicit prediction framework that continues to stimulate and support these efforts, that successfully draws them together, and that links them to operational observation and prediction services and to widespread and actively discussed conservation and protection plans, this advanced and amazing IPY research and cooperation will not, or at least will not quickly, lead to integrated predictive skill or protection impact. In other words, without immediate, intense, and enduring interaction with the public, our ultimate users, we will not achieve the full IPY success.

2.6 Developing Prediction and Protection Frameworks

I could entitle this section "meeting customer needs." And we should admit that understanding, much less anticipating, the varied, fickle, and evolving needs of polar customers represents an endless and frustrating task, one which science often, with justification, has avoided. Here, however, I make the argument that adopting a more explicit prediction and protection approach, including the required albeit difficult consultation with a wide group of interested users, can help both the providers (scientists) and users better define their needs and plans.

Many scientists avoid, as a matter of training and principle, any hint of prediction and any sense of protection. In this prevalent view, our limited and preliminary understanding of systems currently under study (and particularly of biological systems) precludes any possibility of predictive skill, and in any case the scientific process itself requires a cautious certainty of unpredictability. As for protection, those decisions belong to politics: we as scientists complete our responsibilities by providing accurate data. I disagree with the prediction and the protection points of view, and I believe that science must emerge from these protective but isolating shells; again see Lubchenco 1998. Although we should regard prediction as a formidable challenge, one rife with difficulties, we should not regard prediction as impossible. We should instead see it, just as the weather community has for 50 years, as a necessary and useful process to increase and improve our understanding while and by increasing and improving our interactions with users. We should understand both predictions and protections as mechanisms that increase collaboration, data sharing, and information exchange, within science and between science and users. Producing polar predictions and developing an integrated polar protection strategy will entail risk (and require changes in thinking and funding), but will also encourage and push us to think operationally, to assess the timeliness and quality of present and sustained observations, to develop and use polar data assimilation schemes, and to understand and meet user needs with timely products.

IPY at this point needs an explicit and vigorous prediction focus on snow and ice (for weather, climate, sea-level, and transportation applications), carbon (for emission and ecosystem applications), and ecosystems (for future fisheries, forestry, biodiversity conservation, and human and ecosystem health). IPY likewise needs an explicit and encompassing focus on protection, a framework and energy that integrates species, ecosystem, and regional possibilities and concerns. Mutual dependencies will immediately emerge. Prediction of carbon sources and sinks will require prediction of climate and ecosystem functions, which in turn will require predictions of sea and land ice. Protection plans will depend on growing capabilities in prediction. Our three user groups will recognize substantial overlaps in both their needs and their products.

The use of probabilities, familiar to users of North American forecasts but still unfamiliar (exotic, to use a recent BBC description) to European citizens, avoids a too-simple dichotomy of prediction performance or research outcome as only right or wrong. Instead, probabilities add flexibility and information content to customer interaction, putting the science behind the predictions into a similar realm of complexity, uncertainty, and risk as virtually all other forms of information, including economic or health, that engage the citizens who follow our work and try to assimilate our products. By making probabilistic forecasts, the provider offers information in the context of estimation, evaluation, iteration (ensembles of data gathering or analysis or modeling), verification (if possible), and uncertainty, a more humble but also more informative product; the sea ice estimates described above represent probability information in a clear and useful format. Users recognize the efforts, explorations, and creativity of the science process and understand more of the validity and uncertainty of predictions. Overall, the provider and the user agree that all predictions require improvement, both by the provider to refine the product and by the user to refine needs and expectations. Each prediction, failed or successful, and its subsequent evaluation and verification, thus becomes a recognized and ongoing part of the scientific process and, equally important, a valuable ongoing communication between science and society.

Advancing from prediction to protection becomes, if not politically easier, at least more plausible, open, and organized. Individual protection decisions, always involving costs and benefits to multiple parties, can, ironically, place more reliance on prediction probabilities than on vague or competing projections. Integrated protection planning, of how much at what level and where, and beginning when, becomes an important user of, and definer of, the prediction products.

2.7 What if We Succeed (in Polar Regions)?

With many others, I regard the trends, magnitudes, probabilities, and impacts of climate change very seriously. Also in common with others, I doubt that we humans have developed the wisdom to recognize or can gather the will to react to these urgencies before we inflict irreparable harm to some of our neighbors and to some fellow species on this planet. Unfortunately, I expect changes and damages to happen most quickly in polar regions.

From that pessimistic starting point, I then take very seriously, and with equal urgency, the question of what could we achieve for the (three) polar regions if IPY really succeeded? Beyond the initial success of collecting data, what if we shared IPY and future polar data openly, freely, and widely through PIC? What if data responsibilities become recognized and rewarded and data preparation and exchange activities become expected and respected? What if we developed and distributed a broad array of polar prediction products as widely and openly as we do now for Arctic sea ice extent? What will happen as more and more research teams utilize predictive frameworks, merge and explore varied data sets, and adopt open access strategies? In all these questions, I seek to identify and stimulate a positive set of actions and options in process and in play for a time not too far in the future when a clear mandate will emerge for enhanced protection and conservation of polar ecosystems.

The full success of IPY, from a polar conservation and protection viewpoint, would include the following:

- A broad polar community of scientists and citizens using and exploring accessible IPY data sets to stimulate and support a unique and vigorous dialogue on protection proposals and options, moving rapidly and collectively from the what and why to the how, when, and where.
- The development, independent of the resolution of Arctic territorial claims, among a global community of scientists, advocates, citizens, parliamentarians, and decision makers, of a common heritage approach to the three polar regions, extending Antarctic policies and protections to Arctic and alpine glacial regions as appropriate, and strengthening the intent, implementation, and compliance of effective environmental and biodiversity protections in all polar regions.
- Coordination, among this energized polar community, of our various messages, products, report cards, strategic outlooks, and assessments, for common purpose and maximum impact, and development of attractive new polar products for public use on modern communication platforms.
- A recognition among the global environmental and biodiversity communities of the impact, applicability, and effectiveness of the polar community's policies, practices, and products to the issues and challenges faced by fragile and vulnerable parts of the planet.

The reader may wonder at this point whether the author has gone daft. In place of firm conclusions and tangible actions, I have offered an idealized, naïve, even Utopian wish list. What possible utility does such a list have for individuals or institutions? First, let me say in my defense that no one accepts the tasks of an IPO International Programme Office for a large project without an unusual measure of idealism. But let me also claim, as I have throughout this chapter, that technical barriers do not prevent us from achieving the goals on my list. Technical challenges, certainly, but in reality we face intention and motivation and behavior barriers. We have, I believe, scientific and public hunger for action and solutions to benefit polar regions. We know the advances in data sharing, in open access, and in engaging with users that will allow us to move forward, and we know, acutely, the consequences of restrictive access and of ignoring user needs. With continued energy, collaboration, innovation, and common purpose, à la Weyprecht, we can and should use the challenges and urgencies arising from IPY to weave skillful predictions and strong protections from the threads of the double helix and Sputnik.

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Part III
The Antarctic

Chapter 3
Unnatural Selection of Antarctic Toothfish in the Ross Sea, Antarctica

David G. Ainley, Cassandra M. Brooks, Joseph T. Eastman, and Melanie Massaro

3.1 Fishing Further and Deeper

Historically, fishermen targeted fish in shallow, nearshore waters relatively close to port (Pauly et al. 2005). As these species became depleted, to meet growing demands, fishermen were forced to move offshore and into deeper waters (Hutchings and Reynolds 2004; Koslow et al. 2000; Morato et al. 2006; Hilborn et al. 2003; Pauly et al. 2002, 2005). Steady advances in fishing technology facilitated the exploitation of previously inaccessible fish stocks (Hutchings and Reynolds 2004; Koslow et al. 2000; Morato et al. 2006; Hilborn et al. 2003; Pauly et al. 2002, 2005), and by the mid-1980s fishermen began longline fishing in the northern Southern Ocean for the deep-living Patagonian toothfish *Dissostichus eleginoides* (Knecht 2006). Despite international efforts to regulate this fishery, extensive illegal, unregulated, and unreported (IUU) fishing compromised management and caused severe population declines, leading to localized depletions and stock closures within 10 years (Agnew et al. 2002). In search for other profitable toothfish stocks, fishermen soon moved into the southernmost marine regions of the Antarctic, to the freezing waters of the Ross Sea, this time in pursuit of the Antarctic toothfish, *Dissostichus mawsoni*. Reflecting market forces, both toothfish species are sold in industrialized countries under the market name "Chilean sea bass" and cost $25 or more a pound, a price that few can afford.

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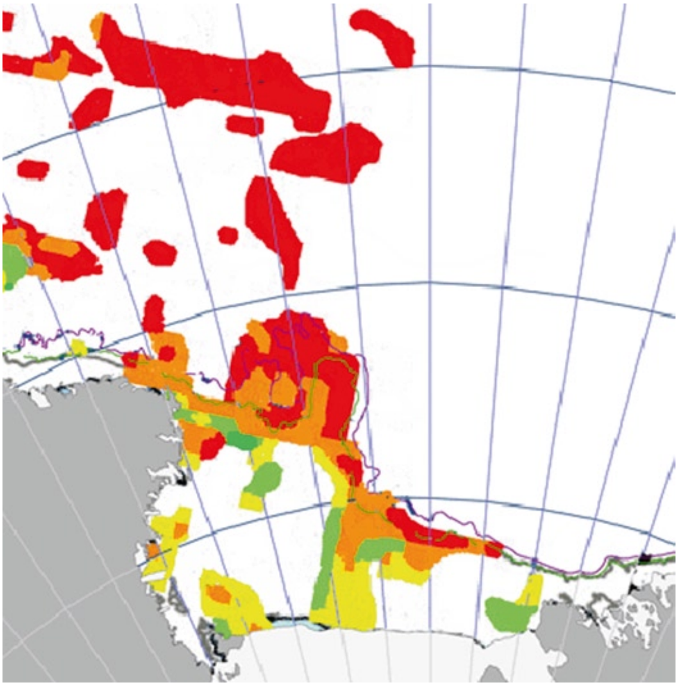

Fig. 3.1 The distribution, on average, of Antarctic toothfish, by size class (total length, TL), as taken in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Area 88.1 fishery: *green*, 40–80 cm; *yellow*, 80–100 cm; *orange*, 100–120 cm; *red*, >120 cm. (Redrawn from Hanchet et al. 2008). Area 88.2, for which even fewer data are available, is in the eastern half of this mapped area

Industrial-scale exploitations of large deep-sea predatory fish, such as the adult toothfish, have repeatedly been shown to be unsustainable (Baum et al. 2003; Myers and Worm 2003; Cheung et al. 2007). The typical life history characteristics of these fish, as reviewed here in detail for Antarctic toothfish, result in slow stock recovery times and render populations particularly vulnerable to overfishing (Koslow et al. 2000; Clark 2001; Haedrich et al. 2001; Devine et al. 2006; Morato et al. 2006). Industrial-scale fishing allows ships to take large quantities of these fish within a season. For example, one ship can catch as much as 40 t of these fish in a single haul and 300 t on a typical voyage (Knecht 2006). Thus, it is not surprising that Patagonian toothfish populations, similar to other deep-sea, *k*-selected fish stocks (Cheung et al. 2007), became rapidly depleted, with the industry then turning to Antarctic toothfish.

To date the main fishing grounds for Antarctic toothfish have been in FAO Area 88, the Ross Sea region (Fig. 3.1).

The Antarctic toothfish fishery in the Ross Sea region (FAO Area 88; see Fig. 3.1) is still considered "exploratory" by CCAMLR (The Commission for the Conservation of Antarctic Marine Living Resources) because insufficient data are available for management. This provision places CCAMLR managers in a unique position to apply precautionary practices before full, or "assessed," exploitation is allowed. Too often, as recognized by CCAMLR, fisheries have crashed when full-scale harvesting proceeded before understanding the life history traits and ecological needs of the fish species. A classic example is the orange roughy *Hoplostethus atlanticus*: this deep sea-mount fishery was managed assuming a 20- to 30-year longevity, but later age validation studies showed that orange roughy live more than 100 years and have an extremely slow growth rate (Smith et al. 1995; Andrews et al. 2009). By the time this essential information was available, fishermen had exploited this resource beyond levels of long-term sustainability and the fishery collapsed. Similarly, in the Northern Hemisphere, deep-living benthic rockfishes (*Sebastes* spp.) off the west coast of North America were fished in excess before accurate life history information was obtained. After populations crashed, age validation studies revealed that longevity and age at maturity, upon which management was based, had been drastically underestimated (see summary in Ainley and Blight 2009). As reviewed here, very little is known about the life history of the Antarctic toothfish. If responsible and precautionary management is implemented now, we can avoid adding this species to the growing list of overexploited deep-sea fishes.

3.1.1 Antarctic Toothfish: The Shark of the Antarctic

The fish fauna south of the Antarctic Polar Front (APF) is dominated mainly by an impressive radiation of perch-like species within several families, most notably the Nototheniidae. Among these is the Antarctic toothfish, also known as Antarctic cod, which is by far the largest and most trophically dominant fish in the Southern Ocean. Adults grow to 2.0 m in length and 140 kg in mass, whereas most other Antarctic fishes rarely become larger than 60 cm (a few, e.g., the marbled rockcod *Notothenia rossii*, reach 90 cm). Sharks, the typical top predators in most ocean ecosystems, are sparse in the Southern Ocean, occurring only at the northern periphery (close to the APF in the waters around Kerguelen and South Georgia Islands). The Antarctic toothfish's life history, size, and ecological role have led ichthyologists to refer to it, when adult, as "the greatest universal predator" of the region (Andriashev 1962, p. 150), the "largest midwater fish predator in the Southern Ocean … filling the ecological role of sharks in other oceans" (DeVries and Eastman 1998, p. 5), and "the most important piscine predator in the water column of the Southern Ocean" (Eastman 1993, p. 77).

As is typical of other top predators, the Antarctic toothfish is *k*-selected (as defined by MacArthur and Wilson 1967), being long lived (almost to 50 years), slow growing (2.3 cm and 1 kg per year, except in early years), late to mature (50% of females by 17 years, at about 100–120 cm total length), and likely of low fecundity (DeVries and Eastman 1998; Eastman and DeVries 2000; Horn 2002; Parker and Grimes 2009; Brooks et al. 2010). The fecundity of Antarctic toothfish has proved difficult to assess because no eggs, larvae, or small juveniles (young of the year, YOY) have been found in the Ross Sea or anywhere else. In fact, no toothfish smaller than 50 cm has ever been caught in the Ross Sea region (Hanchet et al. 2010). However, from what is known, Antarctic toothfish do not appear to be prolific spawners, in part because they do not spawn annually (Yukhov 1971; DeVries and Eastman 1998; Eastman and DeVries 2000; Brooks 2008; Parker and Grimes 2009). In contrast, the Atlantic cod *Gadus morhua*, another demersal, *k*-selected species, is among the most prolific fish species, with single females (100 cm long) annually producing 4–8 million eggs each measuring 1.2–1.7 mm in diameter (Collette and Klein-MacPhee 2002). For *D. mawsoni*, it is yet not known how many eggs a large female can produce, but it is estimated that they lay 2- to 4.5-mm-sized eggs (Hanchet et al. 2008), suggesting Antarctic toothfish invest more in their egg production than other ecologically similar fish.

Antarctic toothfish reside at depths from the surface to >2,200 m deep (Fuiman et al. 2002; Hanchet et al. 2003), with subadult toothfish residing over the shallower inner Ross Sea Shelf and most larger fish moving to waters overlying the deeper continental slope and the seamounts and ridges in the north of Area 88 (north of 70° S; Prutko 2004; Brooks and Ashford 2008; Hanchet et al. 2008; see Fig. 3.1). This ontogenetic shift in habitat coincides with the adults (fish >115–130 cm) achieving neutral buoyancy, one of only five nototheniid species to do so, which allows them to occupy the entire water column.

Over the Ross Sea continental shelf, large subadult and adult toothfish prey heavily on Antarctic silverfish (*Pleuragramma antarcticum*), a species with life history traits similar to those of clupeids (loosely swarming baitfish; DeWitt and Hopkins 1977; Fuiman et al. 2002). Sampling of stomachs from adult and subadult toothfish caught in McMurdo Sound, on the southern Ross Sea Shelf, showed that silverfish were the primary prey item by both occurrence (71.2%) and dry weight (89.2%; Eastman 1985a). However, adult toothfish that occupy benthic waters of the continental slope forage principally upon macrourids and icefish (Fenaughty et al. 2003; La Mesa et al. 2004), as well as other species (Arana and Vega 1999; Prutko 2004). Occasionally, they feed on Adélie penguins (*Pygoscelis adéliae*), and, so far as is known, only rarely on subadult toothfish (Fenaughty et al. 2003; Prutko 2004; Petrov and Tatarnikov 2010). This seeming lack of widespread cannibalism in Antarctic toothfish is very unusual for these types of fish, in which adults usually prey on eggs, larvae, and small fish to an extent very much density dependent (e.g., it is rampant in Atlantic cod; Longhurst 2010). Although no sampling of Antarctic toothfish has ever been conducted in pack ice-covered seas of the winter, when the species is thought to spawn (Hanchet et al. 2008), the apparent lack of density-dependent cannibalism would increase the uncertainty of fishery models aimed toward managing toothfish “surplus production” (Longhurst 2010). Instead, the toothfish diet is more similar to that of large sharks, changing ontogenetically: adult toothfish feed on large prey items, whereas subadult toothfish (20–100 cm) eat smaller prey, such as prawns (*Nauticaris* sp.; Fenaughty et al. 2003), and the smallest toothfish (<20 cm) likely prey on zooplankton (however, very few fish <20 cm have ever been collected; see Foster and Montgomery 1993).

Recent evidence suggests that fish in Area 88 make a remarkable spawning migration, traveling thousands of kilometers from the continental shelf or slope of the Ross Sea to spawn along the Pacific Antarctic Ridge system in winter (Prutko 2004; Brooks and Ashford 2008; Hanchet et al. 2008), moving perhaps as fast as 6 km per day (Petrov and Tatarnikov 2010), before returning to the Ross Sea in summer. Much remains unknown of this migration, including whether it is an annual event for a given individual (Parker and Grimes 2010). Antarctic toothfish captured by sperm whales (*Physeter macrocephalus*) and by fishermen among the seamounts and ridge system north of the Ross Sea have often been extremely emaciated, which is consistent with being in a postspawning mode (Yukhov 1970, 1971; Prutko 2004; Fenaughty et al. 2008), further evidence of this spawning migration.

Although being the dominant piscine predator in the Ross Sea, Antarctic toothfish, including adults and large subadults (>100 cm), can be important prey of Weddell seals (*Leptonychotes weddelli*) and Ross Sea killer whales (*Orcinus orca*), especially in waters overlying the shelf (Ainley and Siniff 2009; Ainley et al. 2009). The seals may take as many as 0.8–1.3 large toothfish each per day. In shelfbreak and deeper waters, toothfish, including adults, are also consumed by sperm whales (Yukhov 1971) and elephant seals (*Mirounga leonina*) (Reid and Nevitt 1998; Goldsworthy et al. 2001), especially so around the seamounts in the northern part of Area 88 and typically during the ice-free months (see Fig. 3.1). Both sperm whale and elephant seal populations are severely reduced in the Pacific sector as a result of past exploitation and depression of prey (by fishing), respectively (reviewed in Ainley and Blight 2009), and although the sperm whale population is slowly recovering (Branch and Butterworth 2001), their numbers are still low relative to historical populations. Weddell seal and Ross Sea killer whale populations currently remain at or near levels attained through past millennia (Ainley et al. 2009; Ainley 2010).

3.1.2 The Most Remote Fishery

The Area 88 toothfish fishery is the most remote fishery on the planet, taking place between 150° E (longitude of Victoria Land) and 105° W (Marie Byrd Land) and south of 60° S (see Fig. 3.1). This fishing zone extends as much as 3,250 km south of Bluff or Dunedin, New Zealand, the closest ports of departure for many fishing vessels. The fishery officially began in 1997 (1996–1997 austral summer) when CCAMLR permitted one New Zealand vessel to explore the feasibility of catching toothfish, traveling as far south as the Ross Ice Shelf (78° S; Waterhouse 2001). Subsequently, the number of vessels and participating countries swiftly increased, up to the current annual average of 15 (in 2010: Argentina 1, New Zealand 4, Republic of Korea 4, Russia 2, Spain 1, United Kingdom 2, Uruguay 1; Fig. 3.2). Each year, the fishery commences roughly in December, when the seasonal ice is sufficiently broken to allow fishing vessels into waters overlying the Ross Sea slope. Vessels fish using longlines, and in recent years have started targeting the Ross Sea slope at depths between 800 and 1,700 m (Figs. 3.3 and 3.4). Competing boats fish

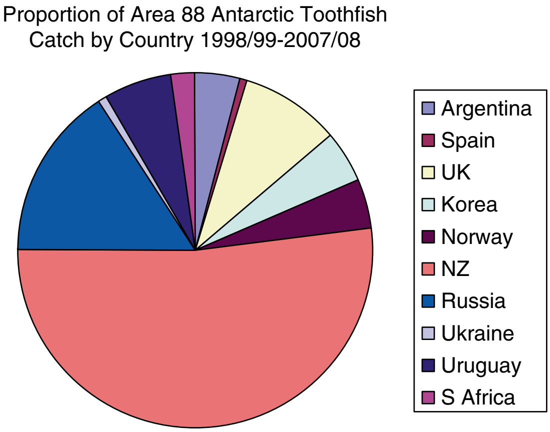

Fig. 3.2 The take of Antarctic toothfish by country in Area 88, 1998–2007

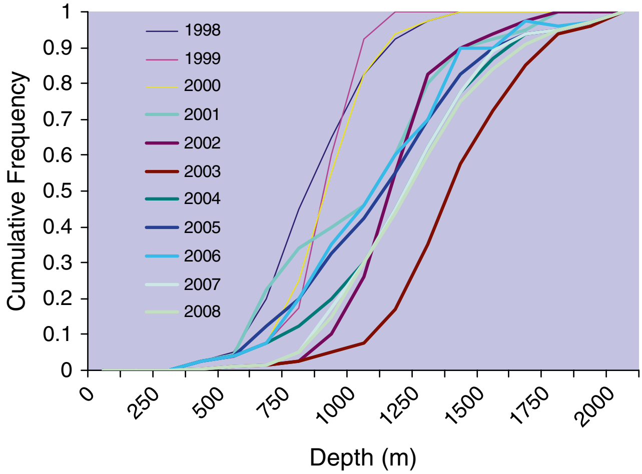

Fig. 3.3 The deepening of fishing effort, 1998–2008, in Area 88.1. After a few years of fishing at a wide range of depths, and then 1 year at very deep depths (2003), the fleet has concentrated sets between 1,000 and 1,250 m mainly over the Ross Sea continental slope in SSRUs (small scale research units) 88.1H and 88.1I (see Fig. 3.1). [Figure redrawn from Stevenson et al. (2008), their Fig. 3.2]

until the Total Allowable Catch for Area 88 is reached (TAC, in tons; most recently, ~3,500 t per year), or until the autumn growth of sea ice impedes the fishery. Some vessels (particularly those from relatively nearby New Zealand) are able to return to this region, and especially the seamounts in the north, for a second time at the end of the season after having dropped off their initial catch in port (Hanchet et al. 2007). Fishing vessels can no longer access the deep troughs of the westernmost shelf, in part owing to CCAMLR's prohibition of fishing along the Victoria Land coast (CCAMLR Conservation Measure 41-09), apparently to protect small fish. Despite these environmental and policy restrictions, fishing vessels have easily reached the annual TAC limit since 2005 (Fig. 3.5).

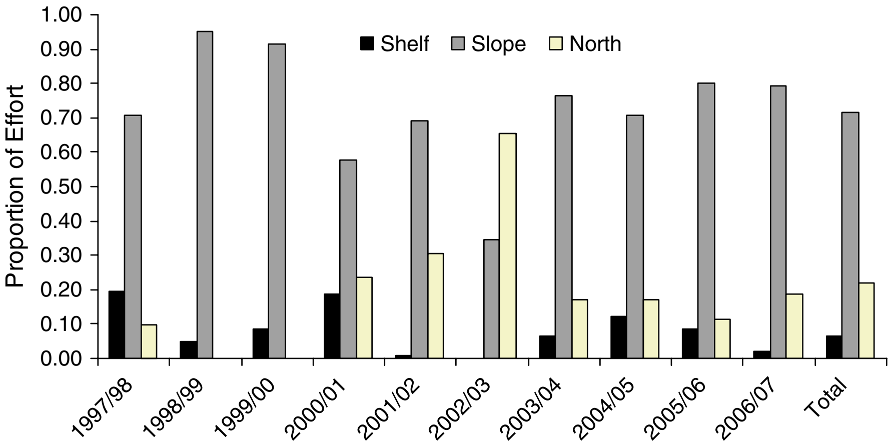

Fig. 3.4 Change in proportion of fishing effort over the Ross Sea continental shelf, its slope, and the seamounts to the north within Area 88.1, 1997–2007. When no real change in total landings (kg) was realized, the shelf waters became unimportant to the fishery after 2000 and the northern seamount waters after 2002. (Data from CCAMLR 2008)

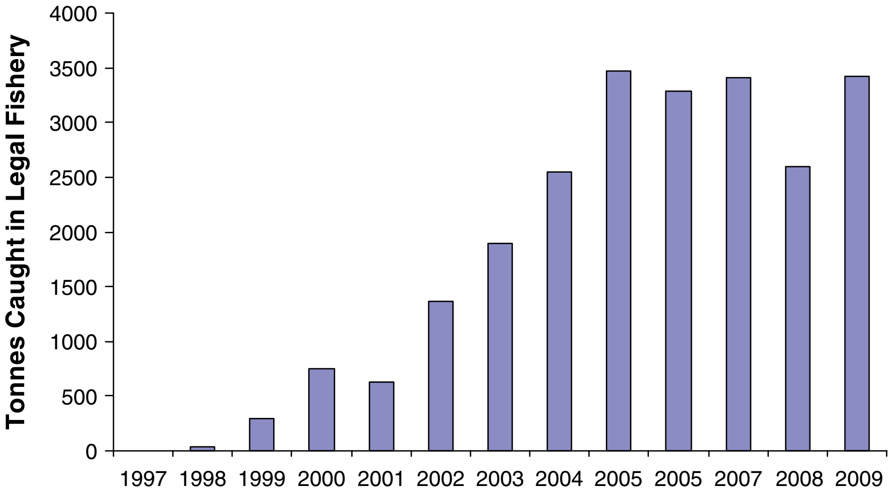

Fig. 3.5 History of the legal catch of Antarctic toothfish in Area 88. Only since 2005 has the fishery reached the allowable catch as determined by CCAMLR. (Data from CCAMLR 2009)

Illegal, unregulated, and unreported (IUU) vessels also target Antarctic toothfish in Area 88 (Barker 2008; MercoPress 2009). Although the history and level of extraction are not known, IUU catch in the Southern Ocean has been estimated by some, at least initially, to be three times that of the permitted catch as reported by CCAMLR (Clarke and Harris 2003; Hutchinson 2004; see also Agnew et al. 2009). Moreover, recent evidence suggests IUU fishermen are using deepwater gillnets in the Ross Sea region (TRAFFIC 2009). These nets are banned by CCAMLR and pose a significant environmental threat because of even higher by-catch levels than longlines and the risk of "ghost fishing," which refers to nets that have been left or lost in the ocean that continue fishing for years. The amount of toothfish caught in IUU gillnets remains unknown but is likely substantial (Österblom et al. 2010). For example, one net recently found by Australian officials spanned 130 km and had 29 t of Antarctic toothfish ensnared (TRAFFIC 2009), more than eight times the annual TAC for the area (outside of Area 88) where the net was retrieved.

3.2 Precautionary Management, Wise Use, or Blind Exploitation?

In this age of ecosystem-based fishery management (EBFM), designed to achieve rational or "wise use" (Leopold 1949), precautionary strategies are critical to ensure normal ecosystem functioning in the absence of adequate data (Constable et al. 2000; Croxall and Nicol 2004). In true EBFM, according to Pikitch et al. (2004, p. 346), "the overall objective … is to sustain healthy marine ecosystems and the fisheries they support. In particular, EBFM should (i) avoid degradation of ecosystems, as measured by indicators of environmental quality and system status; (ii) minimize the risk of irreversible change to natural assemblages of species and ecosystem processes; (iii) obtain and maintain long-term socioeconomic benefits without compromising the ecosystem; and (iv) generate knowledge of ecosystem processes sufficient to understand the likely consequences of human actions." EBFM is an approach to ensure that an appreciable portion of the fish population remains in the ecosystem, whereas many modern fishery models assume that there are "surplus" fish within an ecosystem which are there to take without any effects on the ecosystem (Longhurst 2010).

Heeding lessons learned from other collapsed deep-sea fisheries from around the world (Pauly et al. 2005; Cheung et al. 2007), "precautionary management" has become the watchword of CCAMLR (Constable et al. 2000). The CCAMLR charter clearly states precautionary rules to allow only conservative or low extraction levels to prevent damaging food web relationships and to ensure that stock levels can recover within 20–30 years if necessary (see treaty on CCAMLR website). Employing what is claimed to be a precautionary management strategy is admirable, particularly in a region where critical data for use in fishery models are often meager or missing (see above) owing to logistical difficulties of obtaining such data (reviewed in White 2010). However, despite the history of overexploitation of other toothfish fisheries, the lack of much data about toothfish natural history, and against its own precautionary rules, CCAMLR is aiming for the Ross Sea toothfish spawning stock to be reduced by 50% in the next 20 years. This extraction plan is applied by CCAMLR to all fish that are considered mainly as predatory species within an ecosystem; prey species, for example, krill, are allowed to be fished just to 75% pre-exploitation biomass (Constable et al. 2000; Pinkerton et al. 2007). As already noted, toothfish are important prey to several large mammal species.

Effectively, this management aims for maximum sustainable yield (MSY), a harvesting strategy that has been used for decades to manage other fisheries elsewhere (FAO 1998) and which has led to the declining harvest rates and populations of fish stocks worldwide (Longhurst 2010). Currently, there is no combined, formal research effort by CCAMLR to obtain ecosystem data of the Ross Sea and how this fishery affects the ecosystem, other than what can be acquired opportunistically by collecting data from commercially caught fish and by-catch. Nor is there dedicated research to understand the role of toothfish within its ecosystem or any attempt to verify what might be precautionary fishing in the Ross Sea. In reality, CCAMLR pays little attention to the Pikitch et al. (2004) EBFM points i, ii, and iv. Thus, the management of this fishery appears to be a single-species plan rather than EBFM.

Under the hypothetical MSY strategy, models predict that recruitment, growth, and rate of turnover of young fish increase from the removal of supposedly competing large fish from the population. Removal of the latter presumably frees up prey for the remaining younger, smaller fish and, in turn, increases growth rate and survival of those fish; this is the supposed "surplus production" that a fishery theoretically should be able to exploit without harming the ecosystem (see various chapters in Steele 1977; FAO 1998; Longhurst 2010). Under such a strategy, the only aspect that is predicted to change for the target species and the ecosystem is the density-dependent intraspecific competitive relationships (Steele 1977), which likely does not apply to toothfish, as reviewed here. The increased food availability, in part dependent on a species tendency toward cannibalism, is also predicted to affect other species within the food web positively if it is a competitor (competitive release) or predator of the target species (increased availability of alternate prey that the target species no longer consumes: Steele 1977; Longhurst 2010). Yet these models predicting target species and ecosystem responses to extraction under a MSY strategy do not account for many aspects of toothfish biology, including ontogenetic changes in their distribution, nor the differences in the sizes of prey taken by them (see Longhurst 2010). Finally, these models do not apply very well to long-lived species in general (Cheung et al. 2007). As we have shown earlier, there is considerable evidence that the vertical and horizontal distribution of Antarctic toothfish and their diet varies with age. If young and old fish do not share the same distribution and occupy different ecological niches, how can young fish experience a competitive release when the older fish are removed, other than by genotypic alteration? Moreover, taking out the larger, strictly "predatory" members of the stock, leaving just the smaller adults and subadults to the predators (including humans as predators), effectively alters the functionality of this fish within the ecosystem from being top predators to becoming only "prey." Applying the MSY strategy to the Antarctic toothfish fishery raises doubts about whether this management strategy of reducing 50% of the spawning biomass is truly precautionary.

A historical case demonstrating our point involves the overexploitation to near collapse of *N. rossii*, which was the pioneer of commercially exploited fish in the Antarctic (>500,000 t taken in the first two fishing seasons, 1970–1971, around South Georgia alone; Koch 1992). This fishery began before the formation of

Fig. 3.6 Large, adult toothfish were once caught regularly under the ice of McMurdo Sound, the southernmost portion of the Ross Sea, and, presumably, the species occurs near the surface under other areas of heavy sea ice as well. Almost all McMurdo Sound fish were caught, tagged, and released, but no longer is it possible to catch such fish as those pictured (DeVries et al. 2008). The occurrence of large fish under the southern Ross Sea ice thus does not fit with the pattern of fish caught in the longline fishery, which now catches only small fish, on average, in the southern shelf waters (cf. Fig. 3.1)

CCAMLR; however, soon after CCAMLR was established, it immediately closed several areas to any finfishing (e.g., Antarctic Peninsula and South Shetland Islands, CCAMLR subarea 48.1, and South Orkney Islands, subarea 48.2; see Conservation Measures on CCAMLR website) to protect *N. rossii* stocks and other fish species. Now, even three decades post collapse, with no fishing allowed, the populations of *N. rossii* and also some by-catch species (e.g., *Gobionotothen gibberifrons*) have not recovered (Barrera-Oro et al. 2000; Barrera-Oro and Marschoff 2007; Marschoff et al. ms). This is just one of many examples of a fishery not recovering despite cessation of harvesting, particularly for deep-dwelling, long-lived species (Longhurst 2010). These cases point out that the 20–30 year recovery rule of CCAMLR will likely prove problematic for the Antarctic toothfish, especially if the pre-fished biomass was reduced by IUU fishing before any scientific assessment began.

Ichthyologists have been unable to catch large toothfish at the southern periphery of its range in McMurdo Sound since about 2001, something that was easily accomplished during the previous 35 years (DeVries et al. 2008) (Fig. 3.6). This detection of a reduced presence of large fish at the southern periphery of its range just 6 years after CCAMLR authorized a permitted, exploratory fishery has raised concern among Ross Sea scientists and has raised questions about how close the fishery is to the point that it cannot recover in 20–30 years, as dictated by the CCAMLR treaty. In addition, the presence of fish-eating killer whales, also known to consume large toothfish, has declined in that area (Ainley et al. 2009), while populations of predators that prey on small fish (including silverfish), such as Adélie penguins, have recently increased explosively (Lyver et al., unpublished data). This observation suggests that the zoogeographic range of at least large toothfish is contracting northward, to overlie just the Ross Sea shelfbreak region (see Fig. 3.1), as judged from fishery catch data (Hanchet et al. 2008).

3.3 Evolutionarily Enlightened Management

For EBFM to be truly precautionary and effective, it is important to employ "evolutionary enlightened" management (Ashley et al. 2003), which incorporates not only ecological but also evolutionary concepts into management decisions. We outline here reasons why management, as practiced by CCAMLR to date, may not be as precautionary as is hoped. We believe that evolutionary consequences, especially for long-lived, ontogenetically complex species, should be considered, along with ecological consequences, to make informed decisions and adjust extraction strategies for better management and wise use of the ecosystem.

To date numerous studies have shown that fishing can greatly accelerate evolution and thus cause considerable and irreversible life history changes in the target species within only a few generations (Haugen and Vøllestad 2001; Conover and Munch 2002; Olsen et al. 2004, 2005; Edeline et al. 2009; Greenberg 2010). Some of the most profound examples of contemporary evolution caused by fishing occurred when the largest, oldest, and most fecund individuals were removed (see reviews in Browman 2000; Law 2000; Conover 2000, 2007; Ashley et al. 2003). Longline gear, using large hooks, targets large and presumably old Antarctic toothfish that occur in deep, ice-free waters (see Fig. 3.2), while avoiding young fish (<4 years of age). Big fish, which are generally the fittest, are also the most aggressive foragers (Birkeland and Dayton 2005, and references therein) and thus the first to be caught (as shown in Hanchet et al. 2007, their Fig. 9). By targeting the largest fish for profit, the fishery effectively removes the best survivors (under natural conditions) and the most fecund members from the population. Such fishing reduces the average age and size of fish in the population, leading to an overall age truncation or juvenescence of the Antarctic toothfish stock (Brooks 2008; Longhurst 2010) (Fig. 3.7).

Furthermore, continuous removal of the oldest fish from the population, and alteration of the age distribution (juvenescence), risks "longevity overfishing," a form of overfishing that results from managing a long-lived species for biomass but not longevity (Beamish et al. 2006). CCAMLR's current management goal of reducing spawning toothfish biomass by 50% provides a typical example of a species being managed for these goals. Such management of long-lived species for biomass

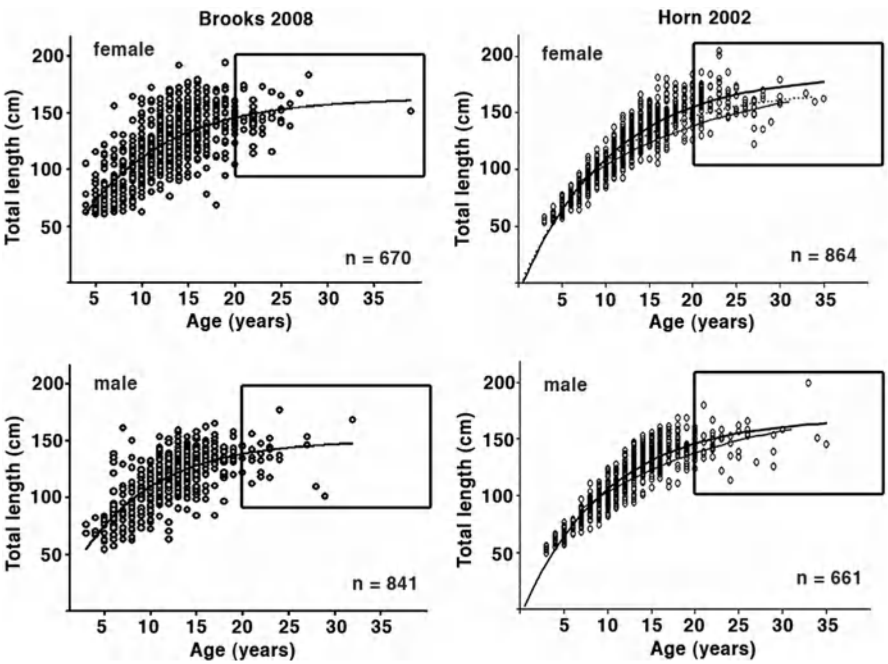

Fig. 3.7 Comparison of age structure, based on analysis of otoliths, in the complete 2003–2004 CCAMLR sample (Brooks 2008) with that from 1995 to 1999 (Horn 2002). Note truncation of age distribution with the passage of time

assumes that young fish have the same ecological function and productivity as older fish, an assumption that often is not supported by the literature (Beamish et al. 2006; Shust and Kozlov 2006). It also assumes that fecundity does not change with age (Longhurst 2010). Hence, by not including the population's age distribution and accounting for differences in productivity between age groups, the current management of the Antarctic toothfish is not truly precautionary, with the potential consequences reviewed below.

3.3.1 Evolutionary Consequences from Longevity Overfishing

Removing the largest and oldest individuals from the toothfish population in the Ross Sea region poses significant threats to the stock beyond ecological consequences. Age- and size-selective fishing may cause strong selection for slower growth and reproduction at a smaller size. Indeed, such selection has been shown to result in detectable changes in harvested species genotypes within months to years to decades, depending on the species generation time (Marteinsdottir and Steinarsson 1998; Thompson 1998; Browman 2000; Zimmer 2003; Hutchings 2005; Brander

2007; Allendorf and Hard 2009). For example, decreases in weight, length, and age at maturation have been observed in many commercially fished species (Law 2000; Conover 2000; Ashley et al. 2003; Conover et al. 2005), including heavily exploited stocks of deep-sea fish such as orange roughy (Smith et al. 1991; Kuparinen and Merilä 2007; Jørgensen et al. 2007) and Patagonian toothfish (Shust and Kozlov 2006). Paradoxically, age- and size-selective harvest reduces the prevalence of desired phenotypes (Conover 2007; Allendorf and Hard 2009), whereas in aquaculture and agriculture, breeders actively select for more productive phenotypes. Such unintended and "unnatural" selection (Allendorf and Hard 2009) through longevity overfishing not only causes smaller size distributions and earlier maturation but also leads to an exponential decline in the number of offspring produced and surviving until maturation (Berkeley et al. 2004a, b; Bobko and Berkeley 2004; Birkeland and Dayton 2005). Older fish are generally more experienced and successful spawners that also spawn for longer in a season. Therefore, selective harvesting of the most fecund individuals results in a reduction of the number and quality of larvae produced and a shortening of the reproductive season. In addition, this may in part reduce the larval survival window, a decrease in the average survival chance of larvae produced in response to intrinsic and seasonal environmental factors (Berkeley et al. 2004a, b; Bobko and Berkeley 2004; Birkeland and Dayton 2005).

For Antarctic toothfish, selection for slower growth and reproduction at a smaller size may have serious ecological repercussions, because only large, adult toothfish in good condition (>100–120 cm in size) are neutrally buoyant and can reside in surface waters without exerting muscular energy to hold position (addressed in more detail below) (Eastman and DeVries 1981, 1982; Near et al. 2003). Although Antarctic toothfish eggs have never been collected, recent models suggest that Antarctic toothfish eggs are released (or at least hatch) in surface waters where microplanktonic prey are abundant (Hanchet et al. 2008). Alternatively, spawning at depths of 1,500–2,000 m (where the longliners encounter adult fish in the nonspawning season) would force eggs or recently hatched larvae to undertake a long and precarious vertical ascent to reach surface waters where planktonic prey reside, assuming they could hatch at these depths. Hence, if fishery-induced selection causes Antarctic toothfish to spawn at a younger age when they are not large and buoyant enough to reach the surface waters without added energy expenditure, larval survival is likely to be greatly diminished, having grave implication for population sustainability (Munch et al. 2005; Greenberg 2010).

In extreme cases, harvest-induced unnatural selection can lead to irreversible loss of genetic heterogeneity (Birkeland and Dayton 2005; Allendorf and Hard 2009). For example, a recent study on Atlantic cod has shown that different genotypes of the species prefer different depth habitats, whereby "AA fish" prefer shallow water, "BB fish" are deep-water adapted, and "AB fish" are somewhat intermediate in their habitat choice (Árnason et al. 2009). As fishermen are targeting shallow waters, this fishery induces selection against the shallow-water-adapted fish, causing the AA genotype to rapidly disappear from the population (Árnason et al. 2009). In addition to the detrimental effects of the fishery-induced age truncation, this loss of the shallow-water-adapted genotype will likely contribute to the complete collapse of this fishery (Árnason et al. 2009).

Finally, the loss of genetic heterogeneity can seriously compromise the resilence of a species and its ability to respond to climate and other environmental changes. Studies have shown that juvenescent populations have unstable, nonlinear population dynamics that can result in extreme and unpredictable fluctuations (Hsieh et al. 2006; Anderson et al. 2008). Fish stocks that have a long-tailed age distribution can buffer environmental stochasticity to thus achieve stability, but with truncated age structure they become increasingly unstable because of changing demographic parameters (Anderson et al. 2008). Thus, these intrinsic consequences of fishery-induced juvenescence increase the likelihood of extirpation, without including the direct implications of harvesting (Anderson et al. 2008). The population sizes of Antarctic fishes have been shown to change considerably and suddenly; for example, *Champsocephalus gunnari* populations in the Scotia Sea region have marked fluctuations in numbers (Koch 1992).

Significant environmental changes, including alteration of ocean temperature, salinity, and sea ice cover, have been detected in the Ross Sea during the past few decades (Jacobs et al. 2002; Parkinson 2002; Jacobs 2006). As such, Antarctic toothfish are put at risk not only by increasing fishing pressure but also by the species decreasing ability to adapt to drastic environmental changes, as caused by reductions in genetic diversity through fishery-induced juvenescence.

3.3.2 Ecological Consequences of Longevity Overfishing

Longevity overfishing of large predatory fish species has occurred in marine ecosystems throughout the world (Pauly et al. 1998; Baum et al. 2003; Myers and Worm 2003; Worm et al. 2005). Overwhelming evidence suggests that this form of overfishing has profound effects on community structure and diversity within the affected ecosystems consequent to the losses of “ecological services” of affected species. For example, stable isotope signatures in scales of the haddock (*Melanogrammus aeglefinus*) from Georges Bank (off Newfoundland), collected between 1929 and 1987, showed significant declines in $\delta^{15}N$, with the two most considerable declines occurring immediately after fishing efforts had increased dramatically (Wainwright et al. 1993). These authors surmised that the indicated change in haddock diet is related to the declining trophic structure and complexity of the ecosystems as the abundance of haddock and other large predator(s) decreased.

Another example of ecosystem collapse resulting from longevity overfishing was triggered by the removal of large sharks from waters off the east coast of North America. This change caused a trophic cascade when the shark’s former prey species, the cownose ray *Rhinoptera bonasus*, exploded in numbers. Soon after, bay scallops (*Argopecten irradians*), the ray’s primary prey species during migration, virtually disappeared (Myers et al. 2007). In yet another case, the removal of large Atlantic cod and other predatory fish from the Northwest Atlantic resulted in a dramatic increase of benthic macroinvertebrates, predominantly the northern snow crab (*Chionoecetes opilio*) and northern shrimp (*Pandalus borealis*), which had been their prey (Myers and Worm 2003; Frank et al. 2005). This invertebrate explosion also affected other aspects of the ecosystem, such as the chemical composition of the waters as nutrient balances changed, as perhaps more detritus was being consumed. However, examples of trophic structure changes caused by longevity overfishing are not restricted to subpolar and temperate marine ecosystems. The removal of predatory fishes from reef ecosystems in Fiji and other tropical marine ecosystems facilitated an explosion of the crown-of-thorns starfish *Acanthaster planci*, which in turn decimated the coral organisms on which the starfish feed, and ultimately led to irreversible damage to the reefs themselves (Dulvy et al. 2004; Mumby et al. 2006, 2007; reviewed, also, in Longhurst 2010). These examples demonstrating trophic cascades caused by the overfishing of large piscine predators (see additional examples in Stevens et al. 2000; Baum and Worm 2009) begs the question: Will longevity overfishing of Antarctic toothfish have similar effects on the Ross Sea ecosystem?

The removal of toothfish, as one of the main predators of fish in the Ross Sea, risks several possible trophic cascades. These risks are presently speculation; however, they will likely be heightened by the ecosystem's simplified food web. One aspect of this simplified food web is that the Southern Ocean lacks the small, densely schooling fish species, such as herring, anchovies, or sardines, which in other ecosystems feed on phytoplankton. Instead, shorter-lived, swarming invertebrates, such as euphausiids, graze the phytoplankton in the Ross Sea. Euphausiids, in particular, *Euphausia crystallorophias*, are very important prey for many other predators in the Ross sea food web (Eastman 1993; Ainley et al. 2003; La Mesa et al. 2004). The loosely schooling Antarctic silverfish is one of the main predators of this euphausiid (reviewed in Ainley et al. 2006), and when euphausiids are seasonally depleted, this decreased availability leads to cannibalism in silverfish (Eastman 1985b). Because toothfish are the main predator of silverfish over the Ross Sea shelf, removing large toothfish should result in elevated abundance of silverfish, which would in turn reduce the abundance and density of euphausiids earlier in the season than occurs now. An earlier depletion of euphausiids could well have implications for other euphausiid predators, such as penguins, whose diet early in the summer is composed primarily of euphausiids (Ainley et al. 2003). For example, in recent years Adélie penguin populations in the Ross Sea have begun to increase dramatically (Lyver et al., unpublished data).

In the Ross Sea ecosystem, the majority of fish species, principally notothenioids, are benthic, preying on invertebrates (Eastman 1993; La Mesa et al. 2004). The best examples are the plunderfishes, *Pogonophryne* (Artedidraconidae). Including 19 species, they are the most speciose notothenioid genus (Eakin et al. 2009), and are well represented in the Ross Sea at depths ranging from 300 to 2,500 m. Occasionally they are taken as by-catch by toothfish longliners and can be an intermittent prey species of toothfish (Arana and Vega 1999; Prutko 2004). Given that these are cold-water fish, they grow slowly and reach maturity at an older age (Eastman 1993). They are also extremely sedentary and territorial (Olaso et al. 2000; Lombarte et al. 2003). These characteristics impart even greater sensitivity to perturbation than that imparted by slow growth and maturation, because population turnover and productivity following extraction would be very slow.

In shallower waters, species of *Trematomus*, also nototheniids, are ecologically important, and one species in particular, *Trematomus bernacchii*, is the principal predator of the Antarctic scallop *Adamussium colbecki* (Vacchi et al. 2000). As notothenioids have weakly ossified jaws and their teeth are small and weakly attached (Eastman 1993), *T. bernacchii* preys extensively on the soft scallop larvae, which in turn explains spatial variation in scallop abundance (Chiantore et al. 2000, 2001). Where scallops are dense they play an important role by filtering and cleaning a significant amount of the particulate content of the water column (Chiantore et al. 1998). Given that *T. bernacchii* has not been identified specifically as a prey of Antarctic toothfish, although unidentified *Trematomus* have (Prutko 2004; La Mesa et al. 2004), the example mentioned earlier involving sharks and scallops may foreshadow possible similar outcomes in the Ross Sea if large predatory toothfish are removed.

Overwhelming evidence from overfishing in other marine ecosystems suggests that ecosystem function is at risk when large predatory fish are removed. Thus, its quite plausible that longevity overfishing of Antarctic toothfish could cause profound changes to the Ross Sea ecosystem.

3.4 Management Solution for Antarctic Toothfish

To move away from longevity overfishing of the Antarctic toothfish in the Ross Sea and toward "wise use," managers must employ precautionary measures in the Total Allowable Catch. According to Allendorf and Hard (2009; p. 9988), "Fisheries and wildlife managers have yet to adopt management strategies that guard against rapid evolutionary response to exploitation. Managers have focused on demographic parameters that affect population abundance and growth rates because their primary goal is sustainable yield in the short-term. However, recognition is growing [as we have detailed above] that evolution under exploitation can reduce population growth and viability and ultimately might reduce yield" (Hutchings 2000; Law 2000; Milner et al. 2006).

In other fisheries that target long-lived fish (e.g., sturgeon, *Acipenser transmontanus*), successful management has been achieved by employing "slotted size limits," which utilizes gear that removes only middle-aged fish and avoids the youngest and oldest (Oregon Fish and Wildlife 2010). Such selectivity by gear type is not possible with longlines (except by change in hook size?) and it is likely not possible given the competition among vessels to fill their holds before the TAC is reached. But because toothfish seem to utilize different habitats during various stages of their life history, it would be possible to achieve "slotted size limits" through spatial management. While this would be complicated by their purported spawning migrations, various parts of the Ross Sea shelf, slope, and associated ridges and seamounts could be closed, perhaps via a Marine Protected Area to ensure the largest individuals are spared.

To ensure that the Ross Sea remains a functioning ecosystem, it is imperative that old, large toothfish are allowed to exist in relatively high abundance. To protect toothfish and this ecosystem for the long term, it is necessary to include major portions of the Ross Sea shelf and slope, as well as some of the seamounts to the north, in a network of marine protected areas (MPAs). Low-level fishing could then be allowed at the edges of these MPSs while keeping the majority of the toothfish population, with a natural age distribution, intact. Many examples of how such MPAs have succeeded in the management of fish stocks are available (Sumaila et al. 2000; Lubchenco et al. 2003), along with examples that failed owing to poor or unenforced management (Longhurst 2010). Currently, longline fishing throughout the entire Antarctic toothfish range extracts the oldest, largest, and likely most fecund fish (see above; Brooks 2008; Brooks and Ashford 2008) (Fig. 3.7). As we argued in this chapter, we believe that these old age classes of Antarctic toothfish need to be restored within this population to avoid irreversible evolutionary and ecological consequences, heightened in an age and area of rapid and profound climate change (Jacobs 2006; Trathan and Agnew 2010).

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Chapter 4
Protection of Wilderness and Aesthetic Values in Antarctica

Rupert Summerson

4.1 Introduction

The Madrid Protocol offers unparalleled opportunities to develop environmental protection measures for Antarctica that were undreamt of 2 years before it was signed in 1991. Two years earlier the Antarctic Treaty Consultative Parties, the group of nations that had acceded to the Antarctic Treaty to jointly manage Antarctica, had seemed to be on the point of an agreement to regulate mining, which was tantamount in the eyes of many to allowing mining to take place. Suddenly, the prevailing view collapsed, to be replaced instead with an agreement on comprehensive environmental protection. Now, 13 years after the Treaty was ratified, a review of perhaps its most difficult element, the protection of wilderness and aesthetic values, reveals that although progress has been slow, the will to bring in protection of these values has not been lost.

The signing of the Protocol on Environmental Protection to the Antarctic Treaty in Madrid in October 1991 brought to a close a turbulent period in Antarctic history. Ten years earlier the Antarctic Treaty Consultative Parties began to develop a convention to regulate mining in Antarctica, should it eventuate, which included measures for protecting the Antarctic environment. This process came to an end in 1988 with the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) being opened for signature. In 1989, Australia and France did the unthinkable for Antarctic Treaty nations and, instead of adopting the traditional consensus view, declared that they would not sign CRAMRA, favoring instead the development of a different convention providing comprehensive environmental protection. A flurry of diplomatic activity took place over the following 2 years as the

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new convention was shaped, until its signature in Madrid. A number of accounts document the debates during this era, for example, Cook (1990), Herr et al. (1990), Suter (1991), and Mosley (2009).

The conservation measures introduced by the Madrid Protocol reinforce and expand those introduced by the Agreed Measures for the Conservation of Antarctic Fauna and Flora in 1964 (ATS 2010). These measures introduced protection of the wilderness and aesthetic values, which, interestingly, had been included in the text of CRAMRA. But why had they been included in CRAMRA and what did the authors of CRAMRA and the Madrid Protocol intend? Are wilderness values different from aesthetic values, are they different aspects of the same thing, or did the authors intend this phrase to be a proxy for values that are difficult to articulate, perhaps something like spiritual values? No definitions are provided in the Madrid Protocol, nor is there any guide as to how these values might be protected.

It is, however, possible to trace some of the thinking behind the development of measures to protect the Antarctic environment, and which provides some guidance on what the authors of the Madrid Protocol, CRAMRA, and earlier measures and documents might have intended.

A further question would ask if the inclusion of protection of wilderness and aesthetic values was a product of the development of the Madrid Protocol and the politics of the era or was it something that had been in the minds of policy makers for some time? The answer to this question may reveal current attitudes to these values in the minds of Antarctic policy makers. If, for example, these values had been thrown into the policy mixing pot during the turbulent period following the abandonment of CRAMRA, perhaps as a sop to the environmental movement, it would be understandable that policy makers might have difficulty implementing protection of these values. If, on the other hand, the inclusion of protection for these values was the product of mature consideration over a long period, the delay in implementation is less understandable. While researching the history of interest in protecting these values, it soon became clear that the relationship between the Scientific Committee on Antarctic Research (SCAR) and the Antarctic Treaty Consultative Parties was a critical element. It might seem paradoxical that SCAR should promote cultural values, but in the 1970s and 1980s SCAR represented not just science but also the face of practical field expertise in Antarctica that was lacking in the official delegations that tended to comprise diplomats and bureaucrats. Field experience brings a respect for, and appreciation of, the natural environment in Antarctica that was rarely a consideration among official delegations.

4.2 Origins of Protection of Wilderness and Aesthetic Values in the Madrid Protocol

In this section I review, in reverse, the history of the discussion about wilderness and aesthetic values of Antarctica, although not necessarily using that exact phrase. The history, of course, culminates in the inclusion of protection of these values in the Madrid Protocol, the text of which, relating to wilderness and aesthetic values is included below. Protection of wilderness and aesthetic values is mandated in two parts of the Protocol:

ARTICLE 3

ENVIRONMENTAL PRINCIPLES

1. The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.
2. To this end:
   (a) activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems;
   (b) activities in the Antarctic Treaty area shall be planned and conducted so as to avoid:
   …..
   (vi) degradation of, or substantial risk to, areas of biological, scientific, historic, aesthetic or wilderness significance.

Second, in Annex V, the Madrid Protocol introduces the requirement to establish a system of protected areas, which includes protection of wilderness and aesthetic values:

Article 3 (Appendix V)

Antarctic Specially Protected Areas

1. Any area, including any marine area, may be designated as an Antarctic Specially Protected Area to protect outstanding environmental, scientific, historic, aesthetic or wilderness values, any combination of those values, or ongoing or planned scientific research.
2. Parties shall seek to identify, within a systematic environmental-geographical framework, and to include in the series of Antarctic Specially Protected Areas:
   …
   (g) areas of outstanding aesthetic and wilderness value;

4.2.1 Convention on the Regulation of Antarctic Mineral Resource Activities

Once Australia and France had indicated their refusal to sign CRAMRA and other countries started to follow suit, it became a matter of urgency to prepare a new convention on comprehensive environmental protection. It is therefore not surprising that many of the provisions on environmental protection in CRAMRA were incorporated into the text of the Madrid Protocol. The protection of aesthetic or wilderness values was mentioned three times in the final draft of CRAMRA.

First, in the Preamble:
The States Parties to this Convention, hereinafter referred to as the Parties:
<u>Recalling</u> the provisions of the Antarctic Treaty;
….
<u>Noting</u> the unique ecological, scientific and wilderness value of Antarctica;

…HAVE AGREED as follows:

Second, in Article 2:
Objectives and General Principles
…
3. In relation to Antarctic mineral resource activities, should they occur, the Parties acknowledge the special responsibility of the Antarctic Treaty Consultative Parties for the protection of the environment and the need to:
   …
   (d) respect Antarctica's scientific value and aesthetic and wilderness qualities;

Third, in Article 4
Principles concerning judgments on Antarctic mineral resource activities
2. No Antarctic mineral resource activity shall take place until it is judged, based upon assessment of its possible impacts on the Antarctic environment and on dependent and on associated ecosystems, that the activity in question would not cause:
   …
   (e) degradation of, or substantial risk to, areas of special biological, scientific, historic, aesthetic or wilderness significance.

4.2.2 Origins of CRAMRA

The discussion about Antarctic mineral resources started at ATCM VII (Wellington, 1972) with Recommendation 6 concluding:

ANTARCTIC RESOURCES - EFFECTS OF MINERAL EXPLORATION

The Representatives,
…
Recommend to their Governments that the subject "Antarctic Resources - Effects of Mineral Exploration" be carefully studied and included on the Agenda of the Eighth Consultative Meeting (ATS 2010).

The development of the regime for mineral exploitation that eventually became CRAMRA was initiated 9 years later at ATCM XI (Buenos Aires, 1981) with Recommendation XI-I:

ANTARCTIC MINERAL RESOURCES

The Representatives,
Recalling the provisions of the Antarctic Treaty, which established a regime for international cooperation in Antarctica, with the objective of ensuring that Antarctica should continue forever to be used exclusively for peaceful purposes and should not become the scene or object of international discord;
…
Recommend to their Governments that:

1. They take note of the progress made toward the timely adoption of a regime for Antarctic mineral resources at the Eleventh Consultative Meeting and related meetings and the importance of this progress.
2. A regime on Antarctic mineral resources should be concluded as a matter of urgency. … (ATS 2010).

There then followed 12 meetings of the Special Antarctic Consultative Meeting IV (SATCM-IV), at the last of which, in May–June 1988 in Wellington, the final draft of the CRAMRA was opened for signature. The final draft includes the three references to wilderness and/or aesthetic values, as already outlined. Unfortunately, none of the minutes or reports from the meetings of SATCM-IV, apart from the final report of session 12, have been made available through the Antarctic Treaty Secretariat, so it is not yet possible to identify with certainty when and in what circumstances protection of wilderness and aesthetic values was included in the text of CRAMRA.

4.2.3 The Role of the Scientific Committee on Antarctic Research

It seems likely, however, that the inclusion of protection of wilderness and aesthetic values arose in response to a report prepared by SCAR in response to Recommendation XIII-5 from ATCM XIII (Brussels, 1985), that reads (in part):

> MAN'S IMPACT ON THE ANTARCTIC ENVIRONMENT: ADDITIONAL PROTECTIVE ARRANGEMENTS
>
> The Representatives,
>
> …
>
> Recommend to their Governments that through their National Committees they invite the Scientific Committee on Antarctic Research (SCAR) to offer scientific advice:
>
> 1. on the system of protected areas in the Antarctic, including Sites of Special Scientific Interest and Specially Protected Areas and the question of a possible additional category of area under a different form of protection … (ATS 2010)

The report, *The Protected Area System in the Antarctic*, was prepared by the SCAR *ad hoc* Group on Additional Protective Measures and tabled at ATCM XIV (Rio de Janeiro, 1987). The terms of reference for the group included:

> II To consider how the concept of management of areas might be applied in the Antarctic Treaty as a means of:
>
> …
>
> ii) regulating the environmental impact of coastal and inland stations and field camps and their associated activities,
>
> iii) protecting areas of non-biological significance and/or outstanding scenic value,
>
> …

It is not known who set the terms of reference but it must be presumed that it was SCAR, based on the ATCM recommendation above.

Among the SCAR recommendations was a proposal to create a new category of protected area, in addition to Specially Protected Areas and Sites of Special Scientific Interest, already established. The new category, Antarctic Protected Area (APA), could include areas designated as containing one or more features, including the following:

> areas or features of particular significance by virtue of their scenic beauty, inspirational quality, potential for recreational pursuits, or their status as wilderness (SCAR *ad hoc* Group on Additional Protective Measures 1987).

Appendix 3 of this report proposes objectives of conservation in the Antarctica as identified by the ad hoc Group on Additional Protective Measures; at that stage these were not yet approved by SCAR. The objectives for conservation were derived, at least in part, from the World Conservation Strategy (WCS) that was developed by a group of international agencies including the IUCN, UNEP, UNESCO, and FAO (IUCN 1980). The following are relevant extracts:

1. Background

   …

   1.3 WCS is concerned with resource conservation; it is a strategy to allow the material processes of life on this planet to continue. Other, aesthetic, factors are also important to humankind, however. With a human population increasingly concentrated in urban centres, a trend which seems likely to continue, 'wilderness' is seen to have intrinsic value. Scenic resources (which may overlap with wilderness) are also valued for their aesthetic appeal. …

   1.4 The Antarctic shares with other parts of the world the general needs expressed in the WCS. …

   1.5 Antarctica comprises the last remaining extensive wilderness on Earth and, while not entirely pristine, is the area by far least affected by human activity. As such, it provides unparalleled opportunities for scientific research on systems and processes, the understanding of which may be vital to our future well-being. …

   1.6 The scenic values of the Antarctic are especially high …

2. Objectives

   …

   2.6 cultural values, such as scenic beauty, inspirational quality and wilderness status can be maintained;

   …

Appendix 5 of the SCAR report *The Protected Area System in the Antarctic* is titled Deficiencies of Existing Arrangements. Listed among the deficiencies are these:

2.3 There is no provision for protecting areas of recreational, cultural, aesthetic, scenic or wilderness value. Sites are chosen for almost entirely scientific reasons, as in the protection of research activities at SSSIs, and to preserve areas of unique natural ecological systems (SPAs).

No recommendations were made at ATCM XIV, and the issue was deferred until ATCM XV (Paris, 1989), as some delegations wanted more time to think about it and more information was anticipated from SCAR on a separate matter.

At ATCM XV (Paris, 1989), this report was discussed further as Agenda Item 10(c) (iv) (p. 29). It was noted that during ATCM XIV Australia, the United States and other Treaty Parties "called attention to the desirability of identifying and protecting areas of outstanding geological, recreational, scenic and wilderness value in Antarctica. There were differing views as to whether protection could be provided to such areas under existing provisions of the Agreed Measures. The United States therefore proposed establishing a new category of protected area, to provide a clear means for protecting such areas."

"The United States submitted a working paper on the subject. The Meeting agreed that provision should be made for geomorphological, aesthetic, scenic, and wilderness value as well as areas of outstanding ecological, scientific, and historic value in Antarctica. Recommendation XV-10, providing for designation of Specially Reserved Areas, was adopted." Recommendation XV-10 reads, in part:

Recommend to their Governments that:

1. They undertake a continuing review of the geographical features and uses of Antarctica and, as appropriate propose designating areas of outstanding geological, glaciological, geomorphological, aesthetic, scenic, or wilderness value as Specially Reserved Areas (SRAs).

…

3. In due course, they include in the series of Specially Reserved Areas representative examples of the major geological, glaciological, and geomorphological, features of Antarctica, and representative examples of areas of outstanding aesthetic, scenic, and wilderness value.

This recommendation is longer current, having been superseded by Annex V of the Madrid Protocol [Decision 1, 2007: ATCM XXX (New Delhi, 2007)].

The SCAR report *The Protected Area System in the Antarctic* was not developed in isolation, however. At ATCM XII (Canberra, 1983) a recommendation was made to request SCAR to provide advice on the types of activities that may have an impact on the Antarctic environment. Recommendation XII-3 reads:

MAN'S IMPACT ON THE ANTARCTIC ENVIRONMENT

The Representatives, …

Recommend to their Governments that:

…

3. through their National Committees, they invite the Scientific Committee on Antarctic Research (SCAR) to offer:

(i) scientific advice regarding the definition of categories of research and logistic activity in Antarctica which might reasonably be expected to have a significant impact on the environment. (ATS 2010)

The result of this was a report titled *Man's Impact on the Antarctic Environment: a procedure for evaluating impacts from scientific and logistic activities* (Benninghoff and Bonner 1985). This report was published by SCAR as a glossy pamphlet and was widely distributed. Both wilderness and aesthetic value are discussed throughout the report. The following are some extracts:

The Antarctic is the epitome of wilderness, yet it has contributed much to human welfare through the scientific discoveries made there. Continued use of the Antarctic, especially if increased, could erode or destroy some of the natural qualities of this unspoilt wilderness unless special care is taken to avoid or reduce the effects of new activities. (p. 3).

Wherever Man's activities impinge on natural systems, the wilderness included, a management plan and regimen are necessary to keep degradations of the natural condition to a minimum. For wilderness ecosystems, scientific knowledge and continuing investigation are essential to guide national and international policies and activities. (p. 18).

In practice, some impact assessments deal with environmental problems although they clearly do not involve living organisms other than Man (e.g., … degradation of the aesthetic values of landscapes). (p. 19).

Degradation or defacing of natural features and landscapes, thereby decreasing their aesthetic values, as by painting rocks or permitting 'urban sprawl' of stations, or by the storage and/or disposal of wastes. (p. 20).

Although the aesthetic and tourist (recreational) value of the Antarctic continent's vast wilderness should not be overlooked, the continent's prime value is as a unique source of information that it continues to provide in areas of geophysics, geology and biology useful to all of mankind. (p. 21).

Another impact, which lies outside the biologically-centred definition used in this report, concerns man-made features, which although biologically neutral, are aesthetically intrusive. The proliferation of such features should be subject to review. (p. 45).

… The terrestrial Antarctic is a very different matter as, unlike the marine system, it has not been subject to resource exploitation. It is the world's greatest wilderness and the ultimate in cold environments that are both natural and accessible. (p. 50) (Benninghoff and Bonner 1985).

The SCAR report *Man's Impact on the Antarctic Environment* was pre-dated by another report by the SCAR Working Group on Biology Conservation Subcommittee: *A Visitor's Introduction to Antarctica and Its Environment* (Bonner et al. 1986). This report seems to have been initiated in 1976, although its origins may date back to 1970 and Recommendation ATCM VI-4 (Tokyo, 1970), which related to what was to become a continuing theme during the 1970s and 1980s: "Man's Impact on the Antarctic Environment." In January 1977, the SCAR Working Group on Biology approved a proposal by the subcommittee on conservation to prepare an information brochure for support personnel and tourists. The text of the brochure was transmitted to national Antarctic programs for printing in each country. The page numbers in the extracts below are taken from the Australian version (Bonner et al. 1986). The following extracts demonstrate that the authors of this brochure recognized that both wilderness and aesthetic value were to be found in Antarctica.

> Introduction
> Antarctica, the last continent to be explored and exploited - the continent about which still least is known - has many unusual, interesting and beautiful features. (p. 1).
>
> Conservation in the Antarctic
> The need for conservation is probably be better understood today than ever before. The pressure of increasing human populations on the environment has produced a general awareness of the value of unspoilt nature or wilderness. The last remaining extensive wilderness is the Antarctic.
>
> The continent used to be protected by its remoteness and inaccessibility but now, technological advances have enabled increasing numbers of visitors to penetrate it. Some come as members of scientific expeditions, some as tourists wishing to visit an area unique both in its scenery and wildlife. Most, if not all, will value their stay in the Antarctic for the way in which it brought them in contact with nature at its simplest and most imposing.
>
> But life in the Antarctic has to contend with some of the world's harshest environments, and is pressed to its limits without the added stress that can be imposed by Man. If those who seek the wilderness are not to destroy what they search for, some controls based on an understanding of the system and a respect for its components are essential.
>
> The Antarctic is not totally unspoiled and pristine, though it is more nearly so than any other equivalent area of the world's surface. Man's influence is most apparent at the scattered scientific stations and sites of intensive research. The construction and operation of stations, with the associated problems of waste disposal, energy generation, transport and resupply, present an obvious threat to the nature and the aesthetic value of the environment. (p. 30).
>
> … (Bonner et al. 1986)

These statements are as valid today as when they were written 30 years ago. At least one of the authors had already formed views that were sympathetic to wilderness and aesthetic values some time before this report was published. In 1974 Benninghoff wrote that:

> Stepping still farther from my own speciality, I would hazard the opinion that we are ready to raise esthetic [sic] qualities of landscapes into our valuation lists. Polar landscapes in their natural states seldom fail to impress their beholder; therefore they might have intrinsic esthetic value. This value might be expected to increase as the wilderness areas of lower latitudes undergo the continuing attrition and damage that shows no sign of slackening (Benninghoff 1974).

It is only fair to state that he went on to express the view that signs of limited human habitation in wilderness areas increase their aesthetic value; a view that is not now universally shared.

Finally, the words of Robert Carrick, an Australian biologist who played an important part in drafting the Agreed Measures for the Conservation of Antarctic Fauna and Flora (1964), seem to have resonated with a number of people (Dr. K. Kerry, personal communication). Carrick wrote:

> Animate nature has an important scientific, cultural and aesthetic, as well as economic function in the life of man, and it is worth his while to avoid depletion of its variety, or over exploitation of its capital stocks" (Carrick 1964).

The articulation of the value of the aesthetic, as well as the scientific and the economic, must have been as inspirational as it was novel.

It seems highly likely that these reports, written by highly respected Antarctic scientists, and published by SCAR during the development of the minerals convention and widely distributed, would have been very influential. SCAR itself has developed a number of Principles of Protection of the Antarctic Environment, which are still current (SCAR 2010). They are reproduced in full below.

> The primary objective in protecting the Antarctic is to avoid or minimize disturbance by human activity. The principles recommended by SCAR to achieve this comprise:
>
> - the conservation of the diversity and integrity of natural phenomena and systems, both in the context of the Antarctic and Planet Earth;
> - preservation of the genetic diversity of indigenous biota by ensuring that adequate representative populations of animals and plants are maintained in situ;
> - prevention of the introduction and establishment of non-indigenous species to the greatest extent possible;
> - conservation of unique natural features, localities or complexes of features and sites of historical importance, which should remain undisturbed;
> - protection of cultural values, such as scenic beauty and inspirational quality, wilderness status and recreational potential.

There is, therefore, a clear path from *A Visitor's Introduction to Antarctica and its Environment* (Bonner et al. 1986) to *Man's Impact on the Antarctic Environment: a procedure for evaluating impacts from scientific and logistic activities* (Benninghoff and Bonner 1985) to *The Protected Area System in the Antarctic* (SCAR *ad hoc* Group on Additional Protective Measures 1987) and then to CRAMRA and finally the Madrid Protocol.

Given that protection of wilderness and aesthetic values has been discussed since at least 1980, that protection of these values was written into the text of CRAMRA, which was developed over the period from 1981 to 1988, and that it was thought sufficiently important to be included in the text of the Madrid Protocol which was signed in 1991 and came into force in 1998, it is surprising that Antarctic Treaty Consultative Parties are having difficulty with its implementation in 2010, some 30 years later. Can it be because these values are now thought to be less valuable since they were in 1980? In a world with an ever-expanding human population and a concomitant shrinking natural environment, this does not seem likely.

In this period the Antarctic tourism industry developed from 2 companies (Reich 1980) to the more than 100 companies that are members of the International Association of Antarctica Tour Operators (http://apps.iaato.org/iaato/directory/). Antarctica's reputation as "one of the last untouched wilderness areas on earth" and "the dramatic scenery" (Lamers 2009) are two of the main draw cards for tourists. It seems then that ATCPs have recognized that these values are important enough to warrant protection but have subsequently been unable to find the right mechanism for implementation.

Responsibility for implementation of the Madrid Protocol was devolved to the Committee for Environmental Protection (CEP), which was established under the terms of the Madrid Protocol and, after transitional arrangements, met for the first time in 1998 (Sanchez and McIvor 2007). The CEP has also struggled with implementation of protection for wilderness and aesthetic values. Although protection of wilderness and aesthetic values has been discussed at a number of meetings of the Committee for Environmental Protection, it has been the lack of agreed definitions in the text of the Madrid Protocol and the absence of a common understanding of wilderness, as well as higher-priority issues such as management of protected areas and non-native species, that has resulted in little progress in implementing protection of these values (H. Keys, personal communication).

4.3 Wilderness Values

The Madrid Protocol calls for the protection of the wilderness values of Antarctica. It is logical to deduce, therefore, that the authors of the Protocol considered that some portion of Antarctica comprises a condition described as "wilderness," that the condition must be in some way threatened, and therefore is worthy of protection by international treaty.

Wilderness is a word whose meaning has changed dramatically over the course of the past 200 years. The origin of the word is uncertain but perhaps derived from three words: "wild," "deor," and "-ness." Nash (1975) suggests that the root of the word "wild" is in "will," that is, self-willed or uncontrollable. Vest (1985) claims that the suffix "-ness" is derived from the Old Norse word "ness," which means a cape or promontory and, by extension, a prominent piece of land. The suffix "-ness" is widely used in English to build a noun from an adjective, thereby establishing a state or condition; other examples include greatness, from the adjective great, boldness, and slowness. Thus, the original meaning of "wilderness" is the state or condition of a place where wild deer or animals live (OED 1989). The opposite condition is presumably, therefore, where domesticated animals live: on the land occupied by humans.

The Oxford English Dictionary (OED 1989) gives the following definitions for wilderness:

1. Wild or uncultivated land. Distinguishable from desert, in that the latter denotes an uninhabitable and uncultivatable region, and implies entire lack of vegetation.
2. A wild or uncultivated region or tract of land, uninhabited, or inhabited only by wild animals.

3. A waste or desolate region of any kind, e.g., of open sea, of air.
4. Something figured as a region of a wild or desolate character, or in which one wanders or loses one's way; in religious use applied to the present world or life as contrasted with heaven or the future life.
5. A piece of ground in a large garden or park, planted with trees, and laid out in an ornamental or fantastic style, often in the form of a maze or labyrinth.

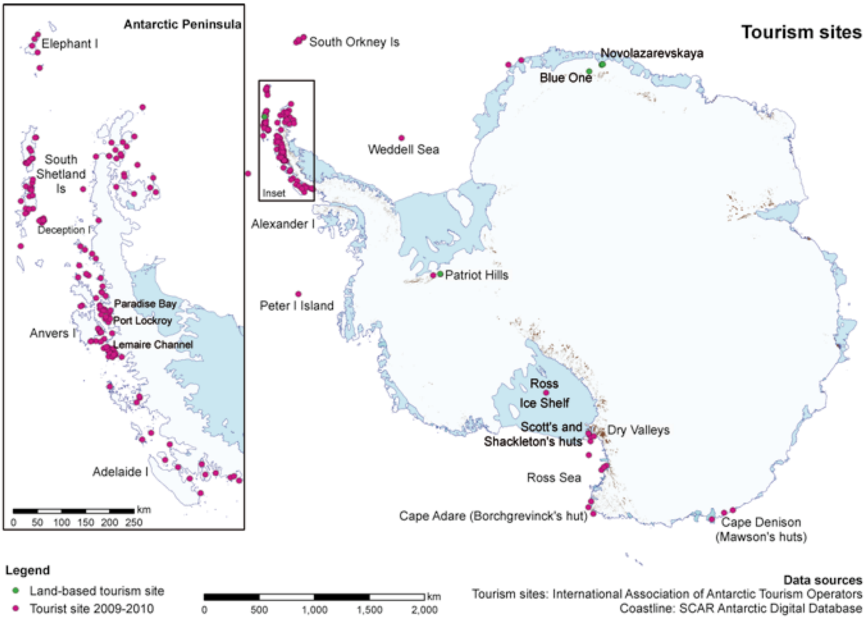
Ignoring definition 5, which was an eighteenth- and nineteenth-century gardening fashion (Thomas 1984), we can see that a workable definition of wilderness might be something like "an undeveloped and uncultivated tract of land, untouched by human activities."

4.3.1 Wilderness in Continental Antarctica

Antarctica is a continent that has never been permanently settled by humans. It was not until 1820 that the first humans saw Antarctica and not until the following year that anyone set foot on the Antarctic continent (Headland 1989). The first building to be erected on the continent was not until 1899 (Headland 1989), and the station with the longest continuous occupation on the mainland, Mawson Station (Australia), was established in 1954. There has been relatively little cultivation or harvesting of terrestrial resources, although seals were extensively exploited in the nineteenth century, especially on the sub-Antarctic islands and to a lesser extent on the Antarctic continent (Martin 1996). Whales were also extensively exploited in Antarctic waters, especially in the twentieth century.

From 1946 onward, with a few exceptions such as the Norwegian-British-Swedish Expedition (Giaever 1954), national Antarctic programs (NAPs) dominated activity in Antarctica. Science and exploration were the initial primary motivators, with the former taking precedence, especially during and after the International Geophysical Year (1957–1958). The primacy of science was enshrined in the Antarctic Treaty, which was signed in 1959 and came into effect in 1961 (Fogg 1992), and that became the driving force for operations in Antarctica. Tourists first visited the continent in 1958 (Reich 1980), and after about 1990–1991 tourist numbers exceeded the numbers of national Antarctic program staff (Enzenbacher 1992). Most tourism activity is concentrated on a relatively small number of perennially popular sites. Roughly two-thirds of all visits in the 2009–2010 austral summer were at 21 sites, all of which were at the northern end of the Antarctic Peninsula (Fig. 4.1a).

National Antarctic program operations, by contrast, are spread across the whole of Antarctica (Fig. 4.1b). With the exception of a handful of tourism summer camps, all permanent or semipermanent infrastructure was established by and is operated by NAPs. The Council of Managers of National Antarctic Programs (COMNAP) website (www.comnap.aq) currently (as of 23 March 2009) lists 111 facilities, including year-round and seasonally open stations, refuges, depots, and camps. Although this list includes all the major stations and facilities, there is a considerable amount of other infrastructure. It is a requirement under the Antarctic



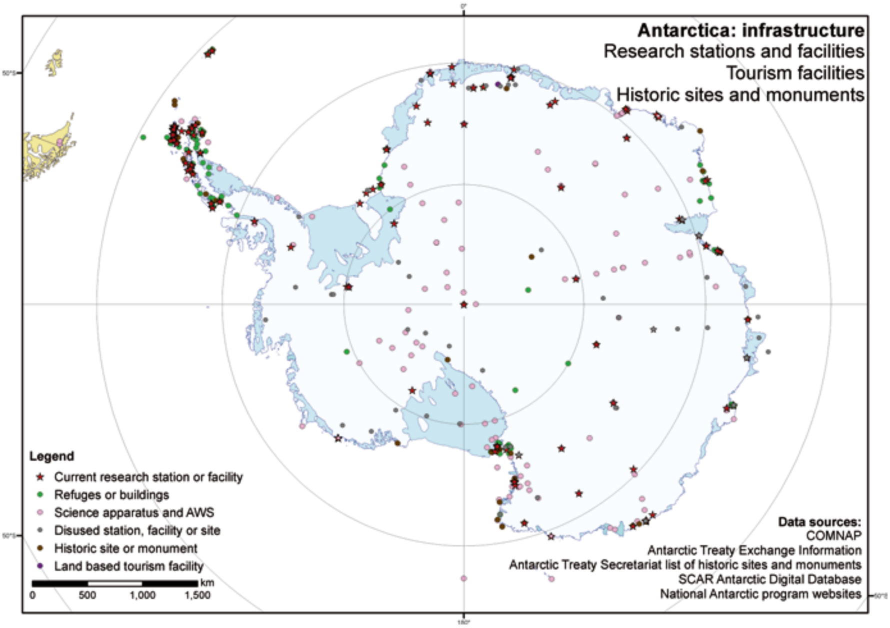


Fig. 4.1 All tourism landing sites during the 2009–2010 austral summer (*top*). Infrastructure established by national Antarctic programs, including historic sites and monuments. Land-based tourism sites are also included (*bottom*)

Treaty (Article VII) for contracting parties to exchange information about their activities. This information is now maintained by the Antarctic Treaty Secretariat (ATS) (www.ats.aq), although many NAPs now provide summary information to the ATS and maintain detailed information on their own websites. From this information a list of more than 620 items of infrastructure was compiled, including abandoned stations, automatic weather stations, scientific equipment, and sites and monuments.

Given that the word "wilderness" can be defined as the absence of human activity and given the large surface area of Antarctica, the relatively short history of human occupation, the lack of indigenous inhabitants, and the small and transient population, it seems reasonable and logical to propose that wilderness in Antarctica can be simply defined as all those areas where there is no evidence of human activity. Two distinctions should be noted: the first is between transient activity and infrastructure. It is infrastructure rather than transient activity that degrades wilderness, especially where the evidence of a scientific field party having passed by is obliterated by the next blizzard. The second distinction is between evidence of local human activity, that is, activity in Antarctica, and global human activity. Even though Antarctica is linked to the rest of the world by atmospheric and oceanographic processes (Lochte 2009), Antarctica is a discrete and unique entity. Apart from the immediate surroundings of Antarctic stations, for an individual human on foot the Antarctic environment is little different to that encountered by sealers in the early nineteenth century. As Tom Griffiths says:

> When humans visit Antarctica, they are both extremely vulnerable to nature and curiously outside it. On a windless day, they can hear the sound of their own blood coursing through their arteries. They can easily become stranded in their own little ebbing pool of life. (Griffiths 2007)

So, although Antarctica may be physically linked to global processes, perceptually, except for those parts degraded by human activity in Antarctica, it is the same wilderness as that encountered by the earliest explorers of the continent and is therefore still wilderness.

4.3.2 Wilderness and Aesthetic Values in the Sea Ice Zone

The Antarctic Treaty applies to the area south of 60° S (ATS 2010), but the continent itself lies well to the south of that line of latitude. Between the Antarctic continent and the 60° S parallel, and sometimes north of it, lies the sea ice zone. The sea ice zone is a dynamic and transient, although substantial phenomenon, forming and mostly dispersing over the space of a year. It reaches a maximum extent in about September when the area that is covered by sea ice more than doubles the area of Antarctic ice (Morris et al. 1998). The minimum extent occurs in March in most years. When it is fully formed, it can be more than 2 m thick and strong enough to land large aircraft on (Morris and Jeffries 1992).

There is little human activity in the sea ice zone, especially early in the season, because ice breaking is expensive on fuel. Apart from the passage of a few early research and re-supply vessels to Antarctic stations and a rare tourist ship, most traffic takes place after most of the sea ice has dispersed. For travelers passing through it, however, it is a wonderland of icebergs, of animal and bird life, which, together with the adventure of breaking through the ice and the noise and drama that accompanies it, is a notable and memorable feature of a sea voyage to Antarctica.

4.4 Aesthetic Values

Three questions need to be asked at the outset: What does "aesthetic values" mean? What are aesthetic values in the Antarctic context? And what did the authors of the Madrid Protocol have in mind when proposing protection of these values? These questions then lead to the question: how can the aesthetic values of Antarctica be best protected?

The word "aesthetic" was coined for the modern world in 1735 by Alexander Gottlieb Baumgarten (1714–1762) as "the science of how things are to be cognized by means of the senses" (Guyer 1998). Baumgarten derived the word from the Greek *αϋσθησις* (*aisthanomai*), which means able to be sensed or perceived, as opposed to be conceived, imagined, or thought. He later broadened this definition to include "the theory of the liberal arts, the logic of the lower faculty of cognition, the art of thinking beautifully and the art of the analogue of reason" (Guyer 1998). Baumgarten's theory defined beauty as perfection, a definition that has not entirely been abandoned. The word aesthetic, however, has gone through a series of mutations in interpretation and meaning, shedding association with truth and goodness and, in the late twentieth century, even with beauty (Morgan 2006). Its meaning transcended the study and appreciation of art in the eighteenth century when Immanuel Kant and later others included the natural environment in its field of study. Kant himself used aesthetic to describe the way we experience something rather than a means of describing whether the object viewed is pleasurable.

> Hence a judgment of taste is not a cognitive judgment and so is not a logical judgment but an aesthetic one, by which we mean a judgment whose determining basis cannot be other than subjective. (Kant 1987 [1776])

The word aesthetic took a long time to achieve acceptance, especially in the English-speaking world, and in the process generated a considerable amount of confusion about what it meant and to what it referred. Its definition, never very clear in the first place, has been muddied by indecision on whether it is a study of art or beauty. It is still not clear in the twenty-first century whether aesthetic is a synonym for beauty, a theory of beauty, a theory of art, or a philosophy of art, and whether it refers solely to the study of works of art. Jerome Stolnitz, for example, wrote:

> … anything like a definition I might offer would be either arbitrary or else so general that it would be worthless. … Like all philosophy, aesthetics is a process, not an end product, an inquiry, not an almanac (Stolnitz 1965).

None of this is very helpful in formulating a definition for aesthetic values in Antarctica that would help policy makers implement protection. The history of the development of the idea of protecting wilderness and aesthetic values, as just described, makes it clear that what the authors of the Madrid Protocol and earlier instruments had in mind was the protection of not only the scenic beauty of Antarctica. Bonner et al. (1986) refer to "many unusual, interesting and beautiful features" as well as "aesthetic value." Benninghoff and Bonner (1985) refer exclusively to "aesthetic value" but SCAR (1987) refers to both "aesthetic" and "scenic" value. Current usage, when describing affective responses to landscape, is for aesthetic preference, "preference" being considered a better measure than an arbitrary absolute value (Kaplan and Kaplan 1995). Although scenic beauty is often part of an aesthetic response, other forms of affect such as the sublime are also important, especially in Antarctica. The sublime is a slippery concept that has been the subject of much analysis since it was introduced into English philosophy in the eighteenth century by Edmund Burke (Knight 1903). There have been many attempts to define the sublime [Burke 1998 (1759); Kant 1987 (1776); Bradley 1950]. In brief, and abridging many of the arguments, the sublime is a feeling of awe in the face of an overwhelming power. There is no doubt that there are many beautiful landscapes in Antarctica, but I would contend that Antarctica is predominantly sublime. There is, however, no single word apart from aesthetic that conveys the range of affective response that incorporates both beauty and the sublime. Aesthetic is commonly used as an adjective, so aesthetic value has to do service as the appropriate compound noun.

4.5 Intrinsic Value

The Madrid Protocol calls for the "protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic values of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research…" (Article 3, Environment Principles). This phrase, if it is to be understood correctly, needs careful interpretation. At first glance, it would seem that the authors of the Madrid Protocol had, perhaps, reversed value systems as the Antarctic environment and dependent and associated ecosystems seem to be intrinsic values, whereas "wilderness and aesthetic values" and "value as an area for the conduct of scientific research" would seem to be instrumental values. There is only one mention of intrinsic value in the Protocol so there is no further description, qualification, or hint as to what the Protocol authors had in mind. There is no mention of intrinsic value in the text of the abandoned Convention on the Regulation of Antarctic Mineral Resources Activities (CRAMRA). In the absence of any more information on which to make an assessment of the Protocol's authors' intentions, it is therefore necessary to make an interpretation from the little evidence available.

The concept of environmental values originated in the 1960s with the publication of seminal papers such as "The historical roots of our ecologic crisis" by

Lynn White (White 1967) and "The tragedy of the commons" by Garrett Hardin (Hardin 1968). The field of environmental philosophy emerged in the early 1970s and with it the concept of an environmental ethic. Intrinsic value is a philosophical concept grounded firmly in ethics and as such has been subject to considerable recent debate. As John O'Neill put it: "To hold an environmental ethic is to hold that nonhuman beings and states of affairs in the natural world have intrinsic value" (O'Neill 1992). Intrinsic values, in brief, are those things that are valued for their own sake whereas instrumental values are things which are valued for the benefits they bestow on others. Instrumental values are usually easier to identify because they are things of value to humans and include objects such as trees for the timber they produce and rivers for the water they supply or hydroelectricity they generate. One of the key issues with intrinsic values that have exercised and divided philosophers is whether only humans can recognize intrinsic value, the so-called Humean thesis of projectivism (Lee 1996). That argument need not concern us here. The Madrid Protocol calls for the protection of the intrinsic values of Antarctica. The values we are concerned with are human values.

At the risk of "cherry picking," a definition that suits the intentions of the Madrid Protocol, I have chosen two authors to illustrate the complexities involved in defining intrinsic value: Paul Taylor and John O'Neill. Taylor proposes that to have "an attitude of respect for nature is to regard the wild plants and animals of the Earth's natural ecosystems as possessing inherent worth." Inherent worth, according to his definition, is that which possesses such worth regardless of any instrumental or inherent value it may have and without any reference to the good of other beings. Intrinsic value, by contrast, is when "humans or other conscious beings place positive value on an event or condition in their lives which they directly experience to be enjoyable in and of itself." "… Intrinsic value is likewise placed on goals that conscious beings seek to bring about as ends in themselves and also on interests they pursue as intrinsically worthwhile." Inherent value is the "value we place on an object or a place … that we believe should be preserved, not because of its usefulness or its commercial value but simply because it has beauty, or historical importance, or cultural significance." "Living things themselves can be judged to have inherent value" (Taylor 1986).

O'Neill identifies three meanings for intrinsic value:

1. As a synonym for noninstrumental value.
2. The value an object has solely in virtue of its intrinsic properties.
3. As a synonym for objective value, i.e., the value that an object possess independently of the valuations of others. (O'Neill 1992).

There is therefore some common ground between the two authors. Taylor's definition of inherent worth is close to O'Neill's first definition for intrinsic value. These two authors are just the tip of the iceberg as regard enquiries into the meaning of intrinsic value. Lee (1996) distinguishes between two senses of intrinsic value: of something being of value "for itself" and something being of value "in itself" the latter, she reserves for humans only, and the former for both human and nonhuman biotic nature.

Thompson (1995) argues the case that the former sense is perfectly compatible with aesthetic values. A number of authors, for example, Morito (Morito 2003), even question whether intrinsic value is a useful concept in environmental philosophy or whether it should be abandoned altogether. McShane (2007) makes a case for retaining intrinsic value as a useful way of relating to the natural environment on the basis that although instrumental values may be a useful and appropriate way to value some aspects of the natural environment, they cannot or should not be the only way to relate to it. She gives the examples of love, respect, and awe as attitudes that would not fit within a framework of instrumental value. Awe and respect are certainly two appropriate attitudes to bring to Antarctica.

Plumwood (1991) offers a sensible and practical definition when she says “in my own work the meaning intended in claiming that an item is intrinsically valuable is that its value cannot be explained by or reduced to instrumental considerations.” This is clearly the same as O’Neill’s first definition and could equate to any of Taylor’s definitions. If this definition could serve as the definition for intrinsic value in Antarctica, wilderness and aesthetic values could be considered as values that cannot be “explained by or reduced to instrumental considerations”; in other words, wilderness values and aesthetic values are those characteristics of Antarctica that we value for themselves and not for any gain we might receive from them.

There is some suspicion that wilderness is valued for the recreational benefit that it has, or may have for the wealthy elites who can afford to travel to remote wilderness areas and who therefore benefit from the solitude, away from the crowds, that wilderness provides (Cronon 1995). This view arises because of the wording of the U.S. Wilderness Act (1964), which defines wilderness as having, among other values:

> (2) [has] outstanding opportunities for solitude or a primitive and unconfined type of recreation
>
> (US Wilderness Act 1964).

Although this view has not yet been expressed about the Antarctic wilderness, tourists must certainly be wealthy to be able to experience it.

In terms of offering protection to wilderness values rather than wilderness and to aesthetic values rather than scenic beauty or scenic grandeur, it is important to recollect that the Madrid Protocol was drawn up over a period of 2 years in great haste and in a time of great uncertainty. It was not possible to accommodate all the different shades of meaning encompassed in a particular word or to define the exact meaning intended by a particular word. Blurred meanings are easier for everyone to accept than precise meanings that might offend a sensitivity or frustrate an ambition. That said, the use of value does imply a greater level of consideration of wilderness and landscape aesthetics; it is not just wilderness itself that should be protected, but that which we value about wilderness. This distinction forces consideration of what it is about wilderness, etc., that we value and therefore what human activities may destroy or degrade them. For example, a key characteristic of the natural environment of Antarctica is silence, and this could therefore be considered as a value of wilderness. One of the features of human activity is noise. I have argued that all Antarctica is wilderness except for those areas degraded by human activity. The calculation of the noise footprint created by the activity is a relatively simple exercise (Piercy and Daigle 1991). The area within the noise footprint, because it is no longer silent and therefore no longer characteristic of the natural Antarctic environment, is therefore no longer wilderness. A similar approach could be taken with the visibility of human infrastructure (see following).

4.6 The Human Footprint

The three Australian Antarctic stations, Mawson, Davis, and Casey, are a similar size, in terms of both station layout and population. The station layout at Casey is complicated, however, by the history of successive stations in that area (see below). The peak population at Davis and Casey is about 70, and at Mawson it is 60. Each station has a cluster of field huts nearby and is a base for scientific operations, some of which may be more than 100 km from the station. It is not certain how typical these stations are of Antarctic stations in general. I have visited nine Antarctic stations (ten if an abandoned UK station that is now an active Chilean station is included), and my estimation is that the Australian stations are larger and have more satellite infrastructure, such as field huts, than most Antarctic stations, with the obvious exception of McMurdo. If the station has satellite field huts, as is the case at all the Australian stations, or other infrastructure such as a fixed-wing aircraft landing strip, such as at Rothera (UK), Mario Zucchelli (Italy), and Casey, these features will extend the visibility footprint beyond that of the station itself. This definition leads to the conclusion that there are three levels of human influence around the larger stations: the station area itself (see below for how that may be defined), the visibility footprint of the station itself, and the visibility footprint of the satellite infrastructure, some of which may not be used during the winter months. True wilderness begins at the outer limit of the visibility footprint of satellite infrastructure.

4.6.1 The Physical Footprint of the Station

The term footprint has been used in the environmental literature as a metaphor for the spatial extent and intensity of human use of the natural environment. “Footprint” can be applied to physical presence (GERG 2003), the spread of emissions (Walton and Shears 1994; GERG 2003), and, more broadly, the totality of human “load” on the environment (Wackernagel and Rees 1996). Although the concept of footprint has been widely discussed in Antarctic governance forums, such as the CEP (CEP 2010), there is as yet no agreement on how the physical footprint should be defined. Julia Jabour notes that there have been attempts to measure the area occupied by stations by different NAPs, but without a common system of measurement, the results were not consistent (Jabour 2009). GERG (2003) used aerial photography to measure the area of physical disturbance at McMurdo Station, but this technique may not be feasible for all NAPs. It is therefore proposed that the physical footprint of a station be defined as the area that is occupied by the buildings, structures, roads, and other infrastructure associated with the operation of the station and is physically interconnected by human artefacts, such as by road or track, cable or pipe. This definition distinguishes station infrastructure from satellite infrastructure such as field huts that may be reached along a marked route but where the route itself has not been modified by human action. Casey, for example, is quite spread out, with the new station being set back roughly 1 km from the coast (Fig. 4.2). This arrangement means that there are almost two station areas; the new station area and the area occupied by the old station, near the wharf, which was demolished in the 1980s. There are still various forms of infrastructure in the area around the wharf, such as the fuel tanks, and the two areas are linked by a formed road. Mawson, on the other hand, by virtue of the amount of bare rock available to build on, is relatively compact, and Davis has remained on the same site with a relatively small expansion over the years it has been occupied.

The demarcation of the station area – the physical footprint of the station – may be by one of the following methods:

1. A minimum bounding rectangle or ellipse around the outer limit of infrastructure that is physically interconnected.
2. The perimeter of all the structures of the station formed into a polygon.
3. An existing boundary: each Australian station has "station limits" within which solo travel is permitted but beyond which requires permission from the Station Leader.

It should be noted that mapped infrastructure is unlikely to include all evidence of human occupation of an area; there will inevitably be debris, posts, markers, abandoned equipment, and other "stuff" that has not been mapped.

As can be seen in Fig. 4.2, the station limits at Casey do not encompass all infrastructure, so the station limits would not make a useful boundary. The "recreational limits" at Casey would not be suitable as they extend far beyond the area where infrastructure has been established but do not, for obvious reasons, extend into ASPA 135 where there is a set of radio masts. Of the three other methods – minimum bounding rectangle, minimum bounding ellipse, and polygon – the polygon, which is hand drawn, involves the greatest element of judgement on where to draw the line, such as how to generalize the line as it rounds features, whether to link outlying features, etc. As a consequence, the polygon is most subject to variability in interpretation and would therefore be less preferable than the least bounding methods.

The least bounding ellipse also requires an element of judgment, such as the degree of circularity, whereas the dimensions of the least bounding rectangle are determined solely by the extent of the infrastructure on the ground. For this reason, the least bounding rectangle is recommended as the best representation of a station's footprint.

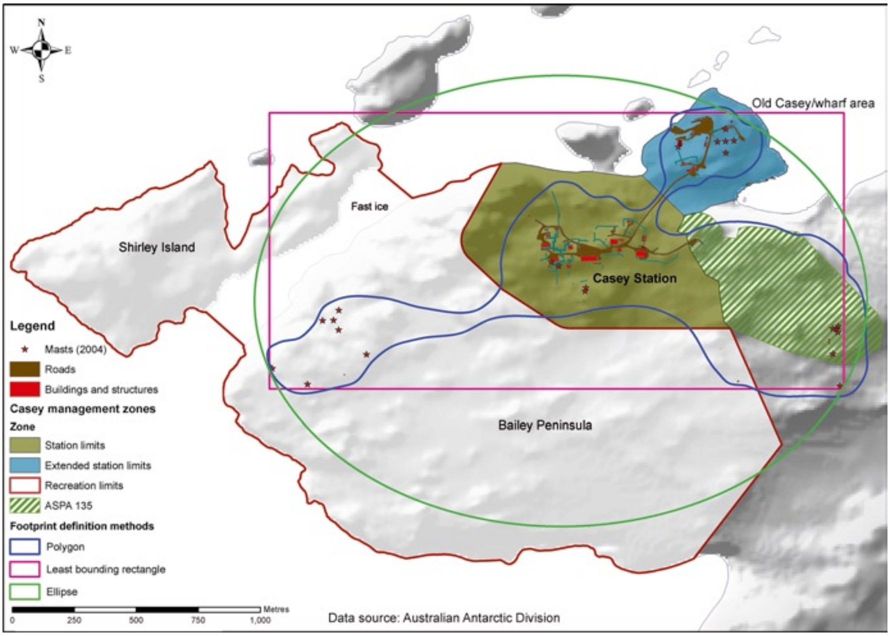


Fig. 4.2 Five options defining the footprint of a station: minimum bounding ellipse, minimum bounding rectangle, polygon, station limits, and recreational limits

4.6.2 Visibility Footprint of the Station

Every research station has an area surrounding it where the influence of the station can be sensed, including the area from which the station can be seen and activities within it heard. Station activities create a level of noise that can be heard from some distance, such as the reversing alarms on vehicles and the sound of diesel generators. With the exception of exhaust emissions from generators and vehicles, most biochemical emissions from stations are in the form of sewage and other liquid wastes ("grey water"). As 75% of all stations and permanent facilities are situated on the coast, these liquids are released into the sea, after varying levels of treatment. In the context of mapping areas of nonwilderness in Antarctica, nonapparent forms of footprint such as emissions of chemical compounds from diesel generators are not included because they cannot be detected by human sense organs. The term visibility footprint is proposed for the area from which infrastructure within the station footprint is visible. This term maintains a semantic link with the physical footprint of the station itself and describes the concept accurately. It is a relatively straightforward matter to map the visibility of station infrastructure using the heights of key infrastructure, a digital elevation model (DEM), and geographical information system software (Fig. 4.3).

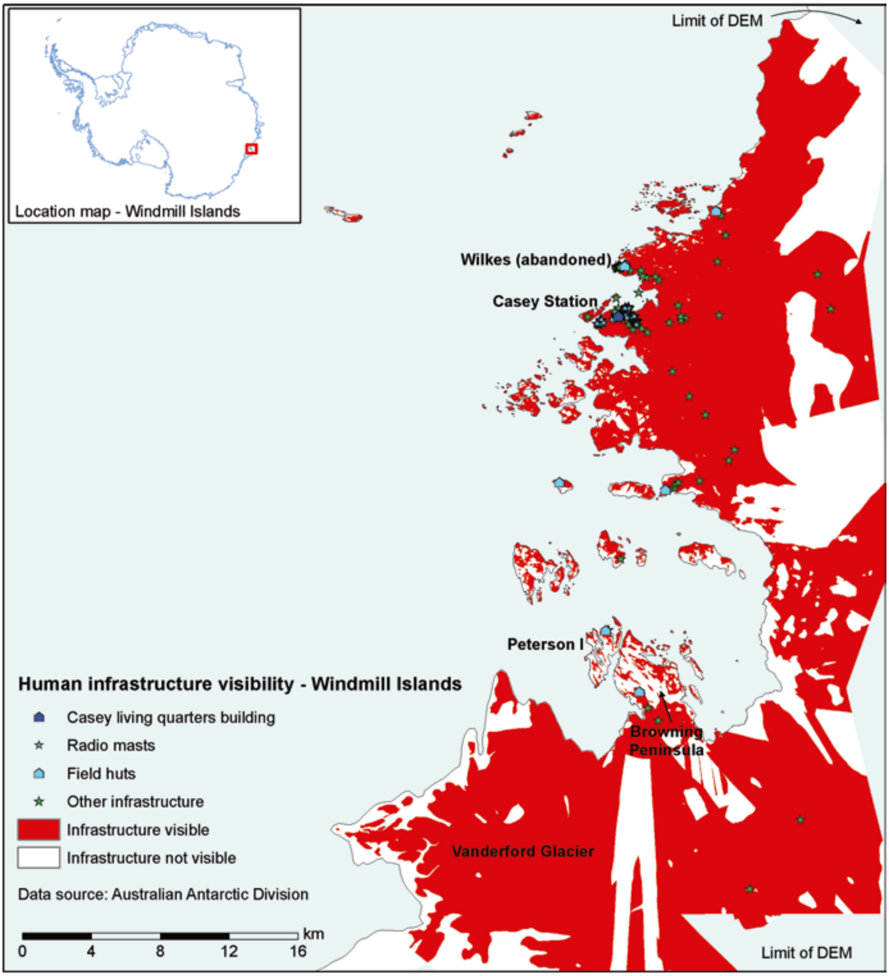


Fig. 4.3 Visibility of infrastructure in the Windmill Islands. Infrastructure includes Casey Station, Wilkes (abandoned), and satellite infrastructure, excluding the marked routes eastward to Law Dome and Wilkins Runway

4.6.3 Visibility Footprint of Satellite Infrastructure

In the area surrounding Casey Station, for instance, there are six field huts, although the exact location and number can vary according to operational necessity. Two kilometers northeast of Casey Station is the abandoned Wilkes Station. Wilkes was built by the U.S. Navy in 1957 during "Operation Deepfreeze," the U.S. logistical support program for their participation in the International Geophysical Year (Dufek 1960), and was occupied by them until 1959 when it was handed over to Australia

(Clark and Wishart 1993). It was, however, sited in a hollow, with the result that snow and ice built up round the buildings and meltwater began to rise up through the floorboards (Clark and Wishart 1993). Construction began on a replacement station ("REPSTAT") in 1965, which was completed in 1969 and named Casey (Clark and Wishart 1993). Wilkes was then abandoned and has remained problematic ever since, including causing a number of environmental problems such as diesel leaking into Newcomb Bay from old drums (Snape et al. 1998). There are a number of buildings still standing, including a hut that is used by personnel from Casey as a field hut, a distinctive radio theodolite dome, and some radio masts. As a consequence, Wilkes has its own visibility footprint.

There are marked routes from Casey to each of the field huts, to an aircraft ski-way 10 km due east of the station and to Wilkins Airfield 62 km to the southeast. There is also a marked route to a glaciological drilling site and other glaciological research infrastructure at Law Dome 115 km to the southeast and at 1,250 m altitude. Wilkins Airfield has been constructed for use by jet aircraft flying direct to and from Australia, whereas the ski-way is designed for use by ski-equipped aircraft flying within Antarctica. There are designated approach and departure routes to and from Wilkins Airfield, all of which create a footprint around the airfield. The station, the old station at Wilkes, the field huts, the airfields and flight paths, marked routes, and infrastructure at Law Dome all combine to create a large and complex area of human activity with the station at its core.

As with mapping the visibility footprint of the station, the visibility footprint of the satellite infrastructure can also be mapped using visibility modeling techniques in a geographical information system (GIS). There are, however, a number of issues to be considered:

1. Satellite infrastructure tends to be smaller, and where field huts are fitted with radio antennae, these tend to be in the form of a "whip" antenna on a much shorter mast than those in use at the stations. It is important, therefore, to have accurate data on hut dimensions and/or radio masts.
2. Many oversnow routes are marked at regular intervals and/or at waypoints, the size and type of marker should be taken into account and included in the visibility modeling.
3. The visibility of airfield runways will depend on how they are marked.
4. Airfield approach and departure routes do not have a permanent impact on wilderness.

There may be large areas within the visibility footprints that have wilderness-like characteristics. A depression or hollow in the topography may mean that structures are out of sight; with one's back turned to the infrastructure, the landscape may appear to be like wilderness and at the outer fringes of the visibility footprint whatever structures are visible will seem distant and insignificant. The boundary between the visibility footprint and wilderness is therefore indistinct and is best described as a "fuzzy" boundary (Zadeh 1965).

4.6.4 Noise Footprint

Noise from human activities has a direct impact on wilderness values, especially in Antarctica where silence is a key characteristic of the natural environment. That is not to say that there are no natural sources of sounds: penguin colonies are noisy places during the breeding season, seals and their pups are often heard calling to each other, and there is the much fainter sound of ice movement along the shoreline. The main sources of human noise are from vehicles, diesel generators, and helicopters. There are many types of vehicle in use in Antarctica, from “quads” (four-wheeled motorbikes), “utes,” and Hagglunds oversnow vehicles, to heavy vehicles such as bulldozers. It is not practical to attempt to model the noise propagation from all these types of vehicles in all situations. It is however feasible to model the footprint from one or two indicator noise sources such as the diesel generators that are a feature of most stations and reversing alarms, which seem to be prevalent on all heavy vehicles. The advantage of choosing two sources of noise such as generators and reversing alarms is that they cover both high- and low-frequency noise spectrums (Piercy and Daigle 1991).

4.6.5 Beyond the Visibility Footprints

If it is accepted that all of Antarctica is wilderness except for those areas under human influence, then beyond the visibility and noise footprints lies the Antarctic wilderness. That is not to say that humans will not, nor should not, explore those areas, nor that transient human presence means that area is no longer wilderness. It is the construction of infrastructure that degrades wilderness, not transient human activity.

4.6.6 An Important Caveat

It is important to reiterate that the focus of this section is the presence or absence of a condition described as wilderness, which I have defined as those areas from which it is not possible to perceive any human influence in the environment. The loss of wilderness does not necessarily imply loss of other features of the Antarctic environment. The visibility of human structures, for example, especially at the limit of their visibility, may have little or no impact on flora or fauna. Loss of wilderness does, however, signify human presence and it is human activity, especially the construction and operation of infrastructure, that is often associated with an impact on the environment.

4.7 Empirical Approach to Wilderness and Aesthetic Values in Antarctica

In attempting to answer questions about how wilderness and aesthetic values can be defined and the impact of human activities on these values measured, a large-scale public participation survey on the Internet was devised. Surveys are a well-established means of eliciting public preference for different landscapes (Daniel and Boster 1976; Kaplan and Kaplan 1995; Arriaza et al. 2004), and the use of the Internet has become an accepted medium for conducting landscape visual assessment surveys (Wherrett 1999, 2000; Roth 2006).

The survey comprised three sets of 30 images of Antarctic landscapes. As respondents logged on to the survey they were randomly allocated to a set. Half of all the images included some form of human activity at different levels of intensity and proximity. Sixteen of these images were digitally manipulated to remove activity or infrastructure. The counterpart image, which appears to be a natural scene, was included in another set of images so that no respondent saw both the original and the manipulated image. All the images were classified as belonging to one of six environmental regions using a reclassification of the Environmental Domains of Antarctica dataset (Morgan et al. 2007). The environmental regions are as follows:

- Coastal ice free
- Mountainous ice free
- Antarctic Peninsula ice fields
- Coastal–continental margin
- Ice shelves and floating glaciers
- Central Antarctic ice sheet

After logging on to the survey, respondents were briefed on the aim of the survey and were given some background information on the Madrid Protocol and instructions in how to complete the survey. They were asked to provide brief demographic data before proceeding to a page that showed all the 30 images they were being asked to evaluate. They were then presented with each image separately and asked to respond to three questions (Fig. 4.4):

1. Perceptions of wilderness
   Question: "Does this scene represent wilderness to you?"
   Response: Yes/No
2. Perceptions of aesthetic quality
   Question: "Please select your preference rating on a scale of 1 (low) to 7 (high)"
   Response: 1–7
3. Semantic descriptors
   Question: "How well does each of the following words describe this scene?"
   Response: Not at all, Not well, Neutral, Well, Very well


Click on image for full size.

Perceptions of wilderness
Does this scene represent wilderness to you? ○ Yes ○ No

Perceptions of aesthetic quality
Please select your preference rating on a scale of 1(low) to 7(high)
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7

Descriptive words
How well does each of the following words describe this scene?

	Not at all	Not well	Neutral	Well	Very well
Perfect	○	○	○	○	○
Grim	○	○	○	○	○
Beautiful	○	○	○	○	○
Austere	○	○	○	○	○

Please press here to preview the full set of images. PREVIEW

Fig. 4.4 A typical assessment page from the survey

The aim of the survey was to answer a number of research questions, including the following:

- What is wilderness in the Antarctic context, and therefore what area or areas can be designated as wilderness?
- What are aesthetic values in the Antarctic context?
- How can human impacts on wilderness values be defined and measured?
- How can human impacts on aesthetic values be defined and measured?

These questions can be reformulated to mean what is it that we value in the Antarctic wilderness and in the beauty of its landscapes.

Fig. 4.5 (*left*) The image with the highest average aesthetic preference rating (6.64). (Photograph courtesy of Zenobia Evans, NSF/USAP Antarctic photo library) (*right*). The image with the lowest average aesthetic preference rating (2.23). (Photograph by Rupert Summerson)

There are versions of the survey in three languages: English, French, and Japanese. To date, 330 people from 22 countries have responded to the survey. As some respondents did not complete the whole survey, there are 8,315 aesthetic preference assessments of the images and 33,260 semantic assessments.

Preliminary analyses of aspects of the survey have provided some tentative results: most infrastructure and the larger forms of transient activity, for example a tractor train, have a statistically significant negative impact on perceptions of both wilderness and aesthetic value (Summerson and Bishop, in review). It is notable that the images scoring the highest aesthetic preference ratings were those of mountainous regions (Fig. 4.5a) with no evidence of human presence and the lowest scoring images were those of the environs of Antarctic stations (Fig. 4.5b).

It is also notable, even if it is self-evident, that the images with the highest aesthetic preference ratings also had the lowest standard deviations, which indicates that most people were in agreement about which were the most aesthetically pleasing scenes. The images with the lowest aesthetic preference ratings also had relatively low standard deviations (Fig. 4.6), which suggests similar agreement about the least pleasing scenes.

There is a close relationship between aesthetic preference rating and wilderness rating. Respondents to the survey were asked to decide whether each scene was wilderness. An assessment of "wilderness" was coded as 1 and "not wilderness" was coded as 2. Figure 4.7 shows the average aesthetic preference and average wilderness ratings plotted together (but on different scales). Most of the images with the lowest wilderness scores, that is, the most like wilderness, are also the images with the highest aesthetic preference scores, although there are some images with low wilderness scores and relatively low aesthetic preference scores. Such images tend to be of "bleak" rather than "grand" scenes. See for example Fig. 4.8; the wilderness and aesthetic scores for this image are circled in Fig. 4.7.

Preliminary analyses of the semantic assessments component of the survey (Summerson and Bishop, in press) found that words associated with the sublime, for example, "breathtaking," "awesome," and "grand," were assessed as being more suitable adjectives for most images than words associated with the beautiful such as "delightful," "lovely," and "pretty," although "beautiful" itself was often rated as a

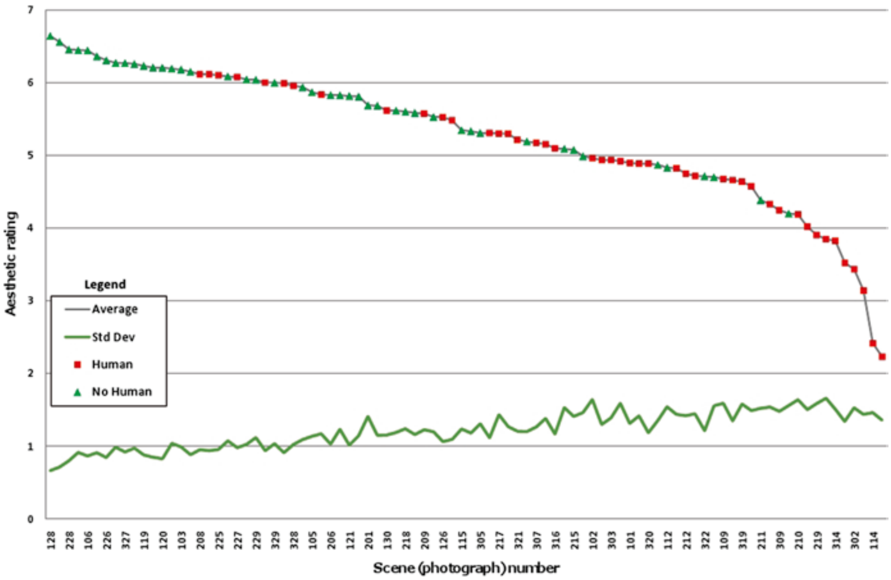


Fig. 4.6 Average aesthetic preference ratings and standard deviations for all 90 images in the survey. Images without human presence are shown as *green triangles*; images with some form of human presence are shown as *red squares*. There is no differentiation in the type of human presence, i.e., transient or infrastructure. Aesthetic preference is on an ordinal scale of 1–7

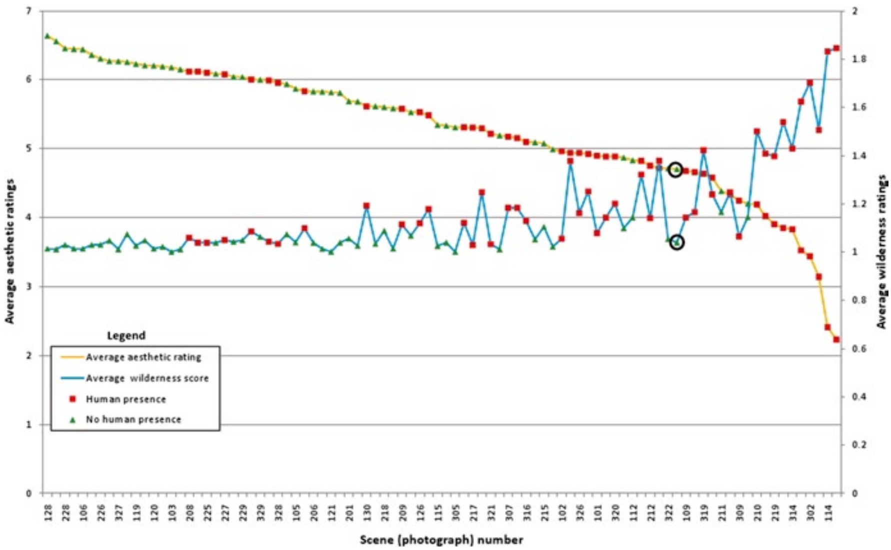


Fig. 4.7 Average wilderness (*right-hand axis*) and aesthetic preference scores (*left-hand axis*) for all the images in the survey. The wilderness and aesthetic scores for the scene in Fig. 4.8 are *circled*

Fig. 4.8 Image with a low wilderness score, i.e., more like wilderness, and a low aesthetic preference score, perhaps the epitome of “bleak.” The scene is of Marine Plain in the Vestofld Hills. (Photograph by Ewan McGregor)

suitable adjective. There are a number of implications arising from this finding: the first is that it confirms that aesthetic value includes not just scenic beauty but the vast scale of Antarctica, the awesome, the breathtaking, and the grand. Desolate, barren and bleak landscapes also have their place as landscapes with aesthetic value.

The sublime is a difficult concept to understand and theorize (Sircello 1993; Forsey 2007). As Dabney Townsend says, “The sublime … is at once one of the most important and one of the most elusive of aesthetic concepts” (Townsend 2006). It is often written off as “the Romantic sublime” (Cronon 1995) and therefore belonging to an earlier era, and yet, as this survey clearly shows, adjectives associated with the sublime are very much part of the current Antarctic lexicon. Further analyses of these results and other elements of the survey, for example, demographic factors in wilderness and aesthetic responses, are in progress.

4.8 Implementation of Protection for Wilderness and Aesthetic Values

Protection of wilderness and the aesthetic values of Antarctica was mandated by the Madrid Protocol that came into force in 1998. One of the sticking points impeding progress of implementation of protection of these values has been securing agreement on acceptable definitions of terms such as "wilderness." There is, however, plenty of experience with wilderness in many of the countries that are signatories to the Antarctic Treaty (Kormos 2008; Bastmeijer 2008). Therefore, a definition of wilderness that is suitable for Antarctica does seem to be readily achievable, especially as there are few of the issues that complicate it in the settled continents. If it can be agreed that, for example, all Antarctica can be designated as wilderness except for those areas where there is evidence of human activity (Summerson and Riddle 2000), then areas of human activity can be mapped, for example, by visibility mapping of infrastructure as in Fig. 4.3 and classified accordingly. That procedure would not necessarily result in the whole of the Antarctic wilderness becoming inviolate. It is proposed that a structure similar to an animal research ethics committee be established. In such committees, which are standard features of most research institutions, the effects of experimentation on animals are carefully weighed against the benefits that would accrue to science from the proposed research. A similar approach could be taken with proposals for sites where there has been no prior human activity. As with animal ethics committees, the benefits to science would be balanced against the disturbance to or degradation of the Antarctic wilderness. This would be a simpler and more logical approach than designating discrete areas as wilderness as Annex V (Area Protection and Management) to the Madrid Protocol seems to propose in Article 3:

> 1. Parties shall seek to identify, within a systematic environmental-geographical framework, and to include in the series of Antarctic Specially Protected Areas:
>
> …
>
> (g) areas of outstanding aesthetic and wilderness value; (ATS 2010).

It does not seem to make sense to designate an area as wilderness against the backdrop of the vast area of Antarctica that already is de facto wilderness, especially as wilderness areas must, by definition [e.g., U.S. Wilderness Act 1964 (www.wilderness.net)], comprise large areas. The protection of discrete areas to protect their aesthetic values is, however, valid. The results from the survey indicate that mountainous regions, for example, are particularly highly valued.

ATCM Recommendation XV-17 (Paris, 1989) recommends against excessive concentration of stations and logistic support facilities, noting that "excessive concentration of such installations may have a negative effect on scientific activities and on the environment" (ATS 2010). The effect on wilderness values is generally one of creeping erosion as a new station in a locality already occupied is often established at a distance from the others. The continuing proliferation of new stations must itself be questioned, especially those in coastal ice-free areas where there is already substantial clustering. In the Larsemann Hills, Princess Elizabeth Land, for example, which is an ice-free area of 40 km^2, five nations have established research stations. As Poland et al. (2003) note, coastal ice-free areas comprise 0.05% of the total land area of Antarctica and are breeding sites for most of Antarctica's iconic birds and mammals. Concerns about the degradation of wilderness relate not just to landscapes but the fauna and flora for which the wilderness represents habitat. Loss of habitat through the deliberate takeover of breeding grounds is unthinkable today, but impacts on wildlife in the vicinity of Antarctic stations such as through disturbance, disease, collision, and ingestion of litter, debris, and pollutants (Riddle 2009) represent a more insidious threat. A return to expedition-style science and the use of automated recording devices for long-term measurements would go a long way to reducing the human footprint.

The survey just reported demonstrates that people value undisturbed landscapes, and this is another reason to minimize unnecessary infrastructure. The survey also demonstrates the strong relationship between undisturbed landscapes and high aesthetic value. The approach briefly outlined for the Antarctic wilderness would also protect much of the aesthetic value of Antarctica. Although the lack of human impact in the sea ice zone and the rich aesthetic values experienced while traversing it make it a logical candidate for inclusion in any system of protected area, the generally low level of threat, the very large areas involved, and the difficulties in defining one or more discrete locations for protection of such a transient phenomenon would make nomination challenging. The Madrid Protocol itself provides substantial protection, so long as it is recognized that its provisions apply to the sea ice zone south of 60° S just as much as they do to terrestrial Antarctica.

4.9 Conclusion

In 1906 Rudmose Brown, a member of the Scottish Antarctic National Expedition (1902–1904), wrote:

> There is, I feel sure, no region in the world more grand in its scenery than the Antarctic, and no place more transcendent in its beauty. It is a vast wonderland laid out on a vast scale, in which littleness has no place; but its very vastness, no less than its beauty, while it quickens the traveller's daily wonder and deepens his reverence, forces him to feel that it is a world he can never conquer, a world in which the forces of nature are too tremendous to overcome, and must resignedly be bowed before in the hope that they will suffer him to come and pass again unscathed (Brown et al. 1906).

Many, I think, would agree that there is still no region in the world with grander scenery and that is more transcendental in its beauty, and the scale is still vast. Perhaps the sensation of vastness is even greater today in our overcrowded world. The importance of Antarctica as a continent for science is also even greater today as its role in the global climate is recognized. Antarctica's integrity as the last remaining continental-scale wilderness is an inheritance to treasure and a responsibility to protect.

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Part IV
The Hindu Kush–Himalayas

Chapter 5
Real World Protection for the "Third Pole" and Its People

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5.1 Introduction

The high mountain area [>2,000 m above sea level (asl)] of the Tibetan Plateau and its adjoining mountain ranges is one of the most complex, yet important, landmasses on this planet, affecting millions of people. The region, with an estimated total ice cover of 114,800 km^2, has dominant mountain ranges such as the Himalayas, where most of the glaciers can be found (33,050 km^2), and adjacent mountain ranges (with corresponding ice areas): the Karakoram (16,600 km^2), Tien Shan (15,417 km^2), Kunlun Shan (12,260 km^2), and Pamir (12,260 km^2) Mountains (Dyurgerov and Meier 2005). The Tibetan Plateau alone contains 36,800 glaciers, with a total glacial area of 49,873 km^2 and a total glacial volume of 4,561 km^3 (Yao et al. 2007): this is the greatest mass of cryospheric components found outside the two polar regions (UNEP 2007). Because of this perpetuated coverage of cryospheric components, and as it is the source of freshwater for billions of people, the region is well known as the "Water Tower" of Asia (Barnett et al. 2005), and it is also referred to as the "Third Pole" (Qiu 2008). As a geographic stretch, the Third Pole extends from the Karakorum, Hindu-Kush, and Pamir Plateau in the west to the Hengduan Mountains in the east, and from the Tian Shan Mountains and Qilian Mountains in the north to the Himalayan Mountains in the south, with the Tibetan Plateau in the middle (Fig. 5.1). The defined region covers a vast geographic area extending from 24.22° N to 45.75° N latitude and from 62.46° E to 106.40° E longitude, covering an area of 5,080,369 km^2.

The Third Pole is unique in many ways. First, in contrast to the other two polar regions, which are sparsely populated, the Third Pole is home to a substantial proportion of the global human population, with their rich cultures, traditions, and

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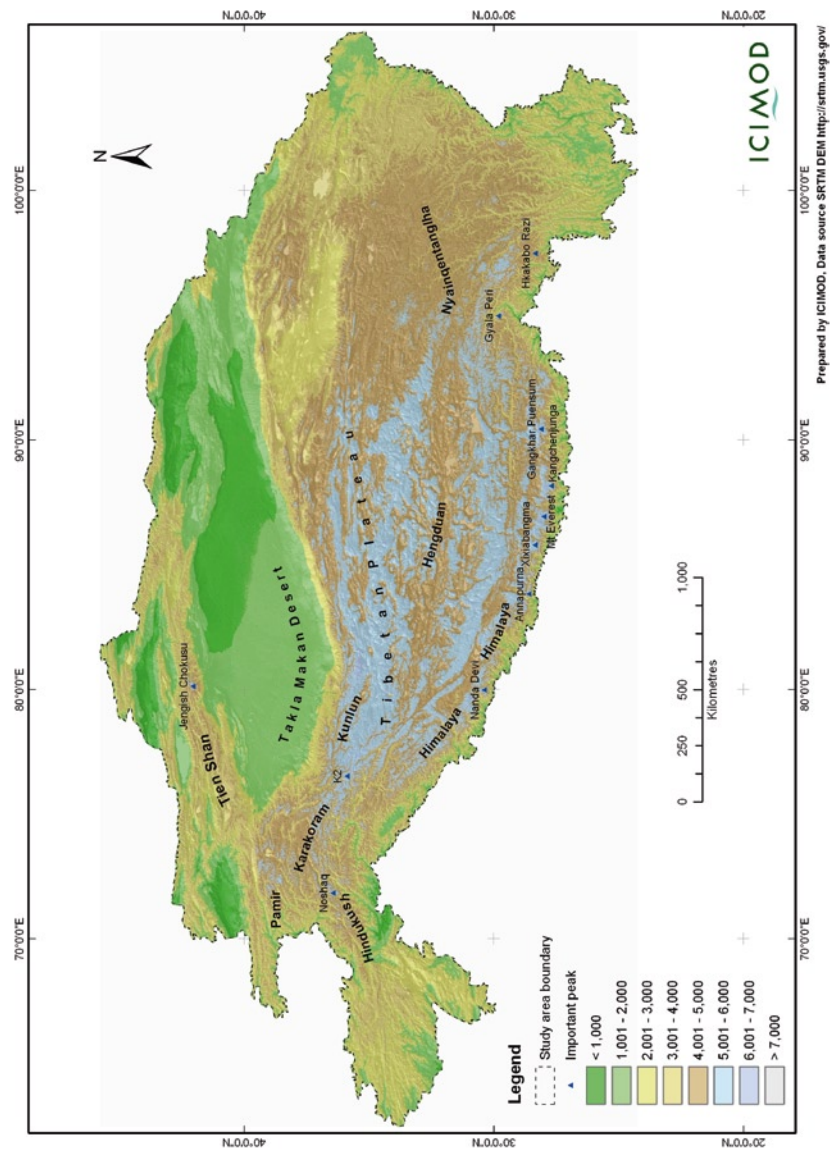

Fig. 5.1 Third Pole region showing altitudinal zones and major mountains

livelihood practices (WWF and Terralingua 2000). Second, with its vast geographic mass and variety of altitudinal gradients, there are significant differences in climate from east to west and from north to south, leading to the formation of many microclimatic zones within the different altitudinal ranges (Mei'e et al. 1985; Shamshad 1988). Microclimatic variations, especially in the Himalayas, can be observed even within a 100-m altitudinal range (Carpenter 2005). The majority of the northwestern region of the Third Pole is dry, and the wettest part of the region is in the southeast.

Third, these variations in geographic features and climate have made the Third Pole equally important in terms of biodiversity, with diverse ecosystems rich in flora and fauna (Schaller 1998; Lopez-Pujol et al. 2006) and with a high proportion of endemism (Mittermeier et al. 2004). The region is the habitat for some of the most charismatic species, including the snow leopard (*Uncia uncia*), Tibetan brown bear (*Ursus arctos pruinosus*), giant panda (*Ailuropoda melanoleuca*), and red panda (*Ailurus fulgens*), as well as numerous ungulates (Cai et al. 1990; Miller and Jackson 1994; Harris and Loggers 2004; Mishra et al. 2004; Zhou et al. 2004; Sheehy et al. 2006; Fox et al. 2008; Namgail et al. 2008; Schaller and Kang 2008; Worthy and Foggin 2008). Last, despite containing the highest as well as the largest freshwater resources outside the two classic Polar Regions, the region has not received due attention. Even the recent Fourth International Polar Year (IPY) and the Framework it developed initially followed the tradition of IPYs, bringing together international collaborators to study North and South Polar Regions – ignoring the role and significance of the Third Pole (International Council for Science 2004).

The communities living in these fragile and biologically rich ecosystems are the poorest of the poor and are marginalized from mainstream development. Their dependency on resources is higher than that of their counterparts living in the lowlands and elsewhere. About 75% of people in the region live in rural areas, with 80% of them dependent on land-based activities for their subsistence living. The mountain lands are characterized by poor soil fertility, inaccessibility, fragility, and heterogeneity in their use (CGIAR 1999). The mountainous specifics, such as inaccessibility, fragility, marginality, physical and economic vulnerability, and lack of opportunities, are leading to serious degradation in the Third Pole (Ives and Messerli 1989; Jodha 1992).

In recent decades, there has been growing concern about the deteriorating conditions in this unique region, which is the source of millions of people's livelihoods as well as the habitats for thousands of species (Sheehy et al. 2006; Xu et al. 2009). The drivers of such deteriorating conditions are multiple, but the most pressing challenges arise from the phenomenon of global environmental and climate change. This chapter analyzes the importance of the Third Pole in terms of global climate circulation systems, water resources, and biodiversity, and examines the challenges faced by the local people as a result of the changing environment in terms of their subsistence livelihoods. Regional experiences are also presented in relationship to addressing such challenges through protection and similar measures.

5.2 Specific Significance of the Third Pole

5.2.1 Goods and Services

The Third Pole is an inherent component of the culture, landscape, and environment of this high mountain area of Asia. The cryospheric components of the Third Pole represent a unique source of freshwater for agricultural, industrial, and domestic use, and are an important economic aspect of tourism and hydroelectric power production, yet they can also constitute a serious natural hazard (Eriksson et al. 2009; Xu et al. 2009). The snow-capped mountains and glaciers provide some of the clearest evidence of climate change and are essential variables within global climate-related monitoring programs (GCOS 2004). The Third Pole supports ten major river basins: the Indus, Ganges, Amu Darya, Brahmaputra (Yarlungtsanpo), Irrawaddy, Salween (Nu), Mekong (Lancang), Tarim, Yangtse (Jinsha), and Yellow River (Huanghe) basins (Table 5.1). Glacial melt makes an important contribution to river flow, varying from the lowest rate of 1.3% for the Yellow River to the highest rates of 40.2% for the Tarim and 44.8% for the Indus River Basin. It has been estimated that about 30% of the water resources in the Eastern Himalayas are directly derived from melting of snow and ice; this proportion increases to about 50% in the central and Western Himalayas and becomes as high as 80% in the Karakoram (Xu et al. 2009).

The Third Pole is also important for high-altitude wetlands, a source of freshwater resources, and plays an important role in water storage and regulating water regimes (Trisal and Kumar 2008). The Third Pole maintains water quality, regulates water flow (floods and droughts), and supports biodiversity. These regions also play an important role in mitigating the impacts of climate change by acting as carbon sinks. The peatlands on the Tibetan Plateau are one of the most important stores of carbon in the mountain region, storing 1,500–4,000 $t\,ha^{-1}$ (Trisal and Kumar 2008).

During summer, the Third Pole further provides an anomalous midtropospheric heat source for southwestern Asia and, thus, plays a prominent role in the Asian monsoon system (Yanai et al. 1992). Seasonal blocking episodes with associated anomalies in temperature and precipitation are also closely linked to the presence of mountains, which act as orographic barriers to the flow of moisture-bearing winds and control precipitation in neighboring regions (Manabe and Terpstra 1974; Kutzbach et al. 1993). For example, the Himalayas play an important role as a trigger mechanism for cyclogenesis through their perturbation of large-scale atmospheric flow patterns; they also act as a barrier to atmospheric circulation for both the summer monsoon and the winter westerlies. The summer monsoon dominates the climate of the region, but is longest in the Eastern Himalayas, lasting 5 months (June–October) in Assam, 4 months (June–September) in the Central Himalayas, and 2 months (July–August) in the Western Himalayas (Chalise and Khanal 2001). However, the Himalayas display a great variability in hydrometeorological conditions: the Western Himalayas and

Table 5.1 The ten major river basins in the Himalayan region

River basin	Basin area (km^2)	Countries	Population (×1,000)	Population density (/km^2)
Amu Darya	534,739	Afghanistan, Tajikistan, Turkmenistan, Uzbekistan	20,855	39
Brahmaputra	651,335	China, India, Bhutan, Bangladesh	118,543	182
Ganges	1,016,124	India, Nepal, China, Bangladesh	407,466	401
Indus	1,081,718	China, India, Pakistan	178,483	165
Irrawaddy	413,710	Myanmar	32,683	79
Mekong	805,604	China, Myanmar, Laos, Thailand, Cambodia, Vietnam	57,198	71
Salween	271,914	China, Myanmar, Thailand	5,982	22
Tarim	1,152,448	Kyrgyzstan, China	8,067	7
Yangtze	1,722,193	China	368,549	214
Yellow	944,970	China	147,415	156
Total	8,594,755		1,345,241	

Source: Adapted from Eriksson et al. (2009)

north-facing slopes are generally arid and dry, whereas the Eastern Himalayas and south-facing slopes are generally humid and wet.

Similarly, the Tibetan Plateau has a continental climate that is influenced by the southeastern monsoon in summer and western air circulation patterns and high Mongol-Siberian air pressures in winter (Huang 1987). As the steppe slopes to the southeast, moisture from the southwest monsoons flows up gorges from the east and south. Summer precipitation decreases in a gradient from east to west and from south to north. The east of the Tibetan Plateau is humid, the south is semi-arid, and the far west is arid. The central steppe is subfrigid in a broad band from Gansu and Qinghai Provinces west through Tibet Autonomous Region and it is humid in the east and semiarid in the west. The northern portion of the steppe is frigid and arid (Schaller 1998).

A recent international expert workshop sponsored by the United Nations Environment Programme (UNEP) held in Delhi debated the controversy raised by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, as well as various emerging issues in climate change, the state of tropospheric temperature, pollution, and melting glaciers, and their potential impact on the monsoon and high-altitude vegetation in the Himalayas-Tibetan Plateau (UNEP 2009). The workshop participants were of the opinion that the IPCC conclusion that the Himalayan glaciers could melt by 2035 may have to be revised because understanding of the phenomena has matured since data collection and synthesis for the Fourth Assessment Report. The participants, however, wanted to emphasize that this does not, in any way, reduce the need for mitigation of, and adaptation to, climate change initiated by the international community.

Table 5.2 Distribution of endemic species in the four Biodiversity Hotspots located in the Third Pole

Hotspot	Mammals	Birds	Amphibians	Reptiles
Himalayan	24	128	75	128
Indo-Burma	165	312	216	333
Mountains of Southwest China	10	13	14	20
Mountains of Central Asia	6	0	4	1

Source: Mittermeier et al. (2004)

5.2.2 Biodiversity

The Third Pole, with its varied landscapes and soil formation, and variety of vegetation types and climatic conditions, is well known for its unique flora and fauna (Mittermeier et al. 2004). Numerous critical ecoregions of global importance can be found in this region (Olson and Dinerstein 2002). Thus, the Third Pole has been highlighted in many global conservation prioritization strategies (see Brooks et al. 2006). Endowed with a high level of endemism, richly diverse gene pools and species, and ecosystems of global importance, the region hosts parts of four Global Biodiversity Hotspots: the Himalayan, Indo-Burma, mountains of Southwest China, and mountains of Central Asia (Mittermeier et al. 2004). These "hotspots" are the cornerstone of conservation for the many endemic species that are confined to these areas (Table 5.2).

In terms of species diversity, the region is equally rich in flora and fauna (Miller and Jackson 1994; Lopez-Pujol et al. 2006; Tang et al. 2008). The Third Pole in general, and the Himalayas and the mountains of Southwest China in particular, are endowed with high diversity at all levels (CEPF 2002, 2005, 2007). Similarly, the Tibetan Plateau has a high concentration of threatened species of global significance (Schaller 1998; Tang et al. 2008). In other words, the Third Pole supports a diverse array of fauna and the greatest part of its area, which is under grassland, contains a unique assemblage of large mammals. The region is home to all four big cats of Asia: the snow leopard (*U uncia*), tiger (*Panthera tigris*), common leopard (*Panthera pardus*), and clouded leopard (*Neofelis nebulosa*). Ungulates, a number of which are endemic, such as the Tibetan wild ass (*Equus kiang*), wild yak (*Bos grunniens*), Chiru (*Pantholops hodgsoni*), and Tibetan gazelle (*Procapra picticaudata*), are of special significance (Harris and Miller 1995; Schaller and Kang 2008). Some of these species are habitat specific and found only in some parts of the Third Pole (Table 5.3). [Please note that all the scientific and common names used in this chapter have been standardized according to ITIS (2010), and their status has been referred to the International Union for the Conservation of Nature (IUCN) Redlist data (IUCN 2010)].

The Third Pole is also important for many long-route migratory birds. Raptor migration between the Paleoarctic and the Indian subcontinent occurs mainly along two corridors: the Indus River in Pakistan and the Tsangpo-Brahmaputra River in Tibet and Eastern India (Ali and Ripley 1983). Wetland-specialized birds, such as the black-necked crane (*Grus nigricollis*), barheaded goose (*Anser indicus*),

Table 5.3 Some conservationally significant large mammals and their distribution in the Third Pole

Integrated Taxonomic Information System (ITIS) common name (subspecies–IUCN)	ITIS scientific name	ITIS taxonomic serial number (TSN)	Reported distribution	IUCN category (IUCN 2010)
Alpine musk deer	*Moschus chrysogaster*	625039	Along the Himalayas	Endangered
Himalayan musk deer	*Moschus chrysogaster* ssp. *leucogaster*	625039	Along the Himalayas	Endangered
Alpine musk deer	*Moschus chrysogaster* ssp. *sifanicus*	625039	Endemic to western China	Endangered
Black musk deer	*Moschus fuscus*	625040	Southeastern Xizang and Tibet, western Yunnan, northern Burma	Endangered
Chinese forest musk deer	*Moschus berezovskii*	625038	Most of the alpine regions	Endangered
Elk	*Cervus elaphus*	180695	Northern edge	Least concern
Elk (MacNeil's deer)	*Cervus elaphus* spp. *macneilli*	180695	Eastern edge	–
Elk (Tibet red deer)	*Cervus elaphus* spp. *wallichi*	180695	South Tibet	–
Kashmir stag	*Cervus elaphus hanglu*	202406	South and north edge	Least concern
Thorold's deer	*Cervus albirostris*	625045	Eastern steppe	Vulnerable
Siberian musk deer	*Moschus moschiferus*	625041	Northern edge	Vulnerable
Western roe deer	*Capreolus capreolus*	625063	Eastern steppe	–
Argali	*Ovis ammon*	625153	Across the Third Pole	
Argali (Marco Polo sheep)	*Ovis ammon* spp. *polii*	625153	Northwestern edge	Near threatened
Argali (Tibetan argali)	*Ovis ammon* spp. *hodgsoni*	625153	Central and eastern high mountains	Near threatened
Urial	*Ovis orientalis*	202414	Southeast and the Himalayas	Vulnerable
Bharal	*Pseudois nayaur*	625156	Central and eastern high mountains	Least concern
Dwarf bharal	*Pseudois schaeferi*	625157	Batang County of Sichaun Province	Endangered
Przewalski's gazelle	*Procapra przewalskii*	625116	Qinghai Lake	Endangered
Goitered gazelle	*Gazella subgutturosa*	625101	Northern edge	Vulnerable

Table 5.3 (continued)

Integrated Taxonomic Information System (ITIS) common name (subspecies–IUCN)	ITIS scientific name	ITIS taxonomic serial number (TSN)	Reported distribution	IUCN category (IUCN 2010)
Tibetan gazelle	*Procapra picticaudata*	625115	Ladakh	Near threatened
Chiru	*Pantholops hodgsonii*	625113	Northern edge	–
Brown bear	*Ursus arctos*	180543	Northwestern and the Himalayas	Least concern
Asiatic wild dog	*Cuon alpinus*	183831	Himalayas	Endangered
Gray wolf	*Canis lupus*	180596	Across the Third Pole	Least concern
Eurasian lynx	*Lynx lynx*	180584	Wakhan	Least concern
Red fox	*Vulpes vulpes*	180604	Across the Third Pole	Least concern
Siberian ibex	*Capra sibirica*	625142	Northwestern edge	Least concern
Snow leopard	*Uncia uncia*	183811	Across the Third Pole	Endangered
Steppe cat	*Felis manul*	183791	Himalayas	–
Takin	*Budorcas taxicolor*	625135	Ganzi Tibetan Autonomous Prefecture	Vulnerable
Tibetan fox	*Vulpes ferrilata*	621862	Tibetan Plateau including Nepal and India	Least concern
Tibetan wild ass	*Equus kiang*	624994	Southern edge and Himalayas	Least concern
Wild yak	*Bos grunniens*	183840	Across the Third Pole	Vulnerable

Sources: Cai et al. (1990), Miller and Jackson (1994), Harris and Loggers (2004), Mishra et al. (2004), Zhou et al. (2004), Sheehy et al. (2006), Fox et al. (2008), Namgail et al. (2008), Schaller and Kang (2008), Worthy and Foggin (2008) and ruddy shelduck (*Tadorna ferruginea*), use the various mountain passes and wetlands for feeding, roosting, or as temporary habitats during migration (Inskipp et al. 1996).

5.2.3 Culture and Lifestyle

The Third Pole is characterized by highly complex socioecological systems, with rich cultural diversity linked to equally rich biological diversity. Based on the agroclimatic zones and farming practices, the Third Pole can be broadly categorized into five major systems: (1) specialized pastoralism (purely livestock based, high-altitude transhumant subsistence livelihoods); (2) mixed mountain agro-pastoralism (livestock, agriculture, and agroforestry livelihoods based in the mid-hills); (3) cereal-based hill farming systems (agriculture-based livelihoods in the low- and mid-hill areas); (4) shifting cultivation (livelihoods based on rotational agroforestry with slash-and-burn practices); and (5) specialized commercial systems (livelihoods based on monoculture and other commercial crops). In each of these specialized systems there is a variation in crops and cropping patterns that supports a wide range of agro-biodiversity, which is the source of food, nutrients, and economic prosperity for the region (Sharma and Kerkhoff 2004).

Among these farming systems, specialized pastoralism is one of the oldest and the most predominant systems in the Third Pole. The people living in the higher and trans-Himalayan region of the Third Pole, one of the harshest ecological zones, have been practicing this system for the past 4,000 years, providing vital nutrients to the people of this zone (Barfield 1993). This practice is widely found in the Central Asian Mountains and trans-Himalayan regions of Pakistan, China, Nepal, Bhutan, and India. Some of the well-known pastoral communities found in the Third Pole are the *Bakrawals*, *Gujjars*, *Gaddis*, *Kanets*, *Bhotias*, *Kaulis*, and *Kinnauras* of the north Indian Himalayas; *Bhotias* and *Sherpas* of the Khumbu valley of Nepal; the *Kirats* of eastern Nepal; *Lachungpas* and *Lachenpas* of Sikkim; *Changpas* of Ladakh; *Brokpas* of Bhutan; *Tibetans* of China; and the *Shimshal* of Pakistan. These peoples' age-old dependence on the high pastures and livestock products is embedded in their culture and practices and governed by traditional knowledge and natural resources governance mechanisms. Pastoral production practices are similar across the different regions of the Tibetan Plateau and elsewhere, although livestock composition and the size of herds can be quite different (Miller 1999). Nomads throughout the region raise the same kinds of animals: yaks, yak-cattle hybrids, sheep, goats, and horses. Animal husbandry plays an important role in local and regional economies, wherever it is practiced, especially because livestock production is the only agricultural activity possible in many areas. Nomads also have strong economic links with agricultural communities outside the nomadic pastoral grazing areas.

These specialized pastoralist ecosystems perform numerous functions that have significant ecological and livelihood values for mountain societies (Wilkes 2008).

There is no other system more suitable than the indigenous management systems practiced by these communities, which have evolved over long periods of time and offer approaches to land use that are suitable to the varying climatic and biophysical conditions and ethnic diversity that characterize the Third Pole. The high altitude (above the tree line) imposes natural restrictions through available water and ambient temperature, making pasturelands mostly suitable for domestic and wild animal grazing and browsing but hardly suitable for crop cultivation or other types of commercial land use. Over time, these communities have developed an adaptive way of life and production best suited for using rangeland resources called “mobile livestock grazing,” a system of moving livestock from one place to another in search of grass and water. Wang et al. (2002) estimate that the Plateau’s grasslands store some 25% of China’s soil carbon. It is worth mentioning here that the transhumant and semi-transhumant pastoralists and the communities living in the mid-hills across the Third Pole also engage in pasture and forest management along with the maintenance of crop diversity for food. Thus, they are, and should be openly acknowledged as, the real custodians of their surrounding ecosystems.

5.3 Protection, Conservation, and Development Challenges

5.3.1 Management and Conservation Challenges

The Third Pole, although containing an abundance of water resources, biodiversity, and cultures, and the source of many important goods and services, is facing multiple challenges as a result of human activity and natural phenomena. It has been observed that the majority, if not all, of the highland areas of the Third Pole are facing climatic variability. There are differences in temperature and precipitation in each of the microclimatic zones (Shamshad 1988; Mei’e et al. 1985; Chalise

Table 5.4 Comparison of glacier changes over the Tibetan Plateau

Reported study area	Study period	Overall change in glacier area (%)
Su-Lo Mountain Glacier	1966–1999	−7.0
East Pamirs (northwestern Tibetan Plateau)	1962/1966–1999	−7.9
Xinqingfeng (northwestern Tibetan Plateau)	1973–2000	−1.7
Geladandong (central Tibetan Plateau)	1969–2002	−4.8
Karakoram (northwestern Tibetan Plateau)	1969–1999	−4.1
Pumqu (central Himalayas)	1970–2001	−9.0
Naimona’nyi (western Himalayas)	1976–2003	−8.8
Daxue Mountain (northeastern Tibetan Plateau)	1956–1990	−4.8
A’nyêmaqên Mountain (northeastern Tibetan Plateau)	1966–2000	−17.0
West Kunlun (northwestern Tibetan Plateau)	1970–2001	−0.4

Source: Wang et al. (2008)

and Khanal 2001; Duan et al. 2004; Zurick et al. 2006; Tan et al. 2008; Yao et al. 2008). Although the Himalayan region, including the Tibetan Plateau, has sparse and inadequate representation of climate stations, the available studies show consistent trends in overall warming for the past 100 years (Shrestha et al. 1999; Liu and Chen 2000; Yao et al. 2007; Xu et al. 2009). This warming trend implies that the highland areas are susceptible to global climate change and are reported to have warmed more, and perhaps sooner, than the rest of the globe. Liu and Chen (2000) argue that the Tibetan Plateau is a harbinger of climate change because of its early and accelerated warming. Based on various local and regional analyses, it is predicted that temperatures in the Third Pole will rise in the future. For example, Rupa et al. (2006) predicted that temperatures on the Indian subcontinent will rise between 3.5 and 5.5°C by 2100, and temperatures on the Tibetan Plateau are expected to increase by 2.5°C by 2050 and 5°C by 2100 (Shi 2001). For sensitive mountain areas, these are large changes.

The precipitation trend in the Third Pole is varied and inconsistent (Shrestha et al. 2000; Xu et al. 2009). Ice core studies on the Tibetan Plateau indicate that both wet and dry periods have occurred since 960 AD (Tan et al. 2008) and 1600 AD (Yao et al. 2008). In more recent centuries, the records show a weakening of the monsoon in the eighteenth century, then a strengthening of the monsoon between the nineteenth century and the early twentieth century, followed again by a weakening of the monsoon from the early 1920s to the present (Duan et al. 2004). During the past few decades, interseasonal, interannual, and spatial variability in rainfall trends have been observed right across Asia. Such varied trends in relationship to increases in temperature and precipitation regimes might have serious implications for biodiversity and the goods and services derived from it. Observational evidence indicates that the impacts related to climate warming are well underway on the Tibetan Plateau, with indications of vegetation degradation (Arthur et al. 2007), the cumulative negative mass balance of glaciers (Yao et al. 2007), thickening of the active layer, and increases in permafrost temperature (Zhao et al. 2004). There are signs of glacial retreat in most of the major glaciers of the region (Table 5.4). The rate of retreat for the Gangotri Glacier during the past three decades has been more than three times the rate during the preceding 200 years (Srivastava 2003). Most glaciers studied in Nepal are also undergoing rapid deglaciation (Seko et al. 1998; Kadota et al. 2000; Fujita et al. 2001). In the last half-century, 82.2% of the glaciers in western China have retreated (Liu et al. 2006). On the Tibetan Plateau, the glacial area has decreased by 4.5% during the past 20 years and by 7% over the past 40 years (CNCCC 2007).

Continued deglaciation is expected to have profound impacts on the hydrological regimes of the ten river basins originating in the Third Pole. It is suggested that river discharge is likely to increase for some time as a result of accelerated melting, but as glacier water storage capacity is reduced the flow is likely to decline (Eriksson et al. 2009). Based on current knowledge, the rivers most likely to experience the greatest loss in water availability in response to melting glaciers are the Indus, Tarim, Yangtze, Brahmaputra, and Amu Darya (Xu et al. 2009). Such deglaciation and water problems are very much linked to the resources and people living in the area.

The vast rangelands of the Third Pole are already facing degradation, mainly caused by human activities such as overgrazing (Miller 1999; Sheehy et al. 2006), the expansion of grazing to new areas and to the natural habitats of wildlife (Mishra et al. 2004; Namgail et al. 2008), and overstocking of unproductive livestock (Arthur et al. 2007), as well as other natural and ecological processes (Wilkes 2008). In addition, there are many incidents of poaching and hunting, and there is a flourishing illegal trade in wildlife and their products.

The region is home to some 200 million people, the majority living in rural areas. Their dependence on biodiversity goods and services is immense. The average vegetative production of the Chiang Tang Plateau is around 360 kg ha^{-1}, and that means every 2 ha of rangeland produces food sufficient for only 1 sheep unit (ICIMOD 2008). Adult livestock on the high-altitude pastures lose about 20–40% of their body weight each winter, and every year some animals do not survive the cold season. During the past 50 years, management of these rangelands has undergone major shifts from feudalism to collectivism to the privatization of livestock with individual grazing rights in China (Sheehy et al. 2006). Globalization has brought additional pressures. These changes in policy and practices are bringing new challenges in terms of social and ecological health and the resilience capacity of rangelands, people, and the biodiversity of the region (Banks et al. 2003; Zhaoli et al. 2005; Foggin 2008; Fox et al. 2008).

5.3.2 Management, Protection, and Conservation Interventions

The conservation of biodiversity and management of resources have been a top priority for the countries sharing the Third Pole. The region has many of the world's highest mountain protected areas, such as Sagarmatha National Park and Kangchenjunga Conservation Area in Nepal, and some of the largest conservation areas, such as Qiantang Nature Reserve in China. Our analysis, based on International Union for the Conservation of Nature (IUCN), United Nations Environment Programme (UNEP), and World Centre for Monitoring and Conservation (WCMC) data (IUCN et al. 2010) on protected area coverage (above 2,000 m asl) within the Third Pole, revealed that, until 2009, the countries sharing the Third Pole had established 304 protected areas within the boundary of the region, covering more than 1.03 million km^2, representing about 20% of the region's terrestrial area. China accounts for the largest area of protected area coverage within the Third Pole, with almost 18% of the total coverage. Similarly, there are 233 Important Bird Areas (IBAs) within the Third Pole, covering 11.5% (587,132 km^2) of the total area (Birdlife International 2007); however, many of these IBAs overlap with existing protected areas.

Looking at the conservation history of the Third Pole, there has been a gradual shift from conservation focused on flagship species to integrated conservation approaches addressing the human dimension through protected areas, buffer zones, community-based conservation areas, and landscapes and nature reserves (Chettri and Shakya 2008). This change was evident from the analysis, which

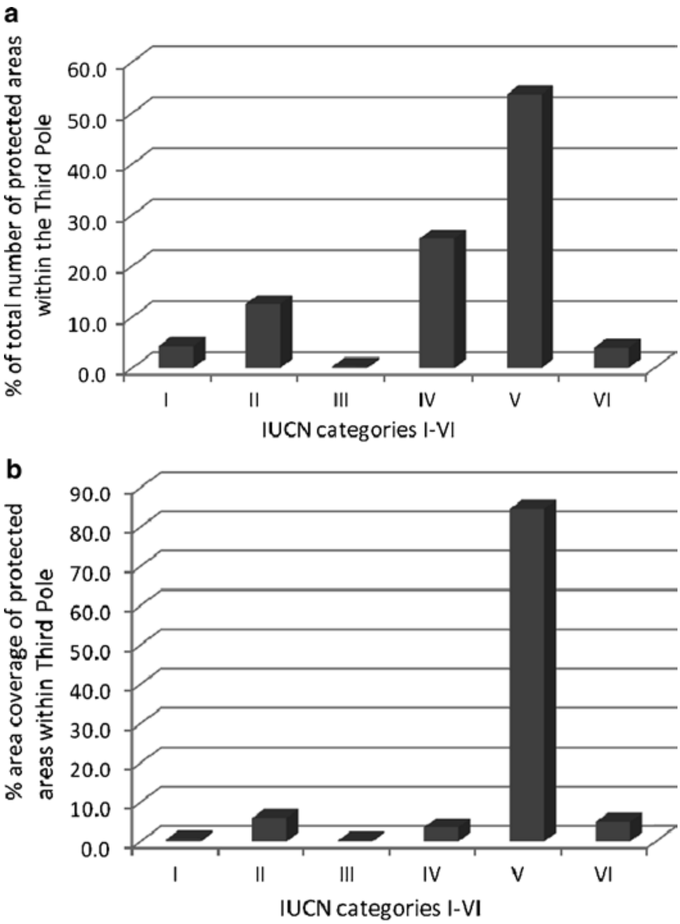

Fig. 5.2 (**a**) Proportion of the total number of protected areas under different International Union for the Conservation of Nature (IUCN) management categories within the Third Pole. (**b**) Proportion of the total area coverage of protected areas under different IUCN management categories within the Third Pole

revealed that 54% of the total number of protected areas and 84% of the total area coverage within the Third Pole are in Category V, followed by Category VI (4% in number and 5% in coverage) (Fig. 5.2a, b); these are basically "protected landscapes for conservation and recreation" and "managed resource protected areas," respectively. These protected areas are less strictly managed, and human activities are generally allowed. Of the 304 protected areas in the Third Pole, only 0.6% is managed as Category I, "strict nature reserve" or "wilderness area," in which no human intervention is permitted except for scientific monitoring: two nature reserves in China (Mo Tuo Nature Reserve and Shen Zha Nature Reserve) and one in Bhutan (Toorsa Strict Nature Reserve).

In terms of livelihood, pastoralists and those living at the “frontline” have developed their own coping mechanisms to adapt to the climate variability, but they are basically vulnerable and perhaps suffer more than any other people from natural disasters. The impacts of changing climate and increased climatic uncertainty in recent decades have been accompanied by globalization and tremendous population growth, making pastoralists more vulnerable than ever before. The anthropogenic pressure and climatic variations are likely to affect rangeland productivity, its ecosystem functions, and nutrient dynamics (Klein et al. 2005). Such changes have direct implications for the herding societies living in the Third Pole (Wilkes 2008).

5.4 ICIMOD’s Experiences in Addressing Such Challenges

The International Centre for Integrated Mountain Development (ICIMOD) is an intergovernmental regional organization that has been serving the Hindu Kush–Himalayas as a knowledge, learning, and enabling center for the past 25 years. It is a center where information and knowledge are developed and exchanged, and where innovation, technology transfer, and effective communication are used to empower partners in its regional member countries. In recent years, ICIMOD has been advocating for biodiversity conservation and sustainable development through its “mountain perspective framework,” which is characterized by understanding mountain specificities, such as fragility, inaccessibility, marginality, diversity, specific niche opportunities, and human adaptation practices, and the imperatives of these mountain conditions. ICIMOD has also been active in facilitating regional cooperation using the “ecosystem approach” considering transboundary landscapes and taking into account crosscutting issues related to policy, governance, and equity and gender, while at the same time mainstreaming information and knowledge management principles (see Sherpa et al. 2003; GoN/MoFSC 2006; Chettri et al. 2007). In recent years, the ecosystem approach to biodiversity conservation has been the basis for the selection of four trans-Himalayan transects and seven transboundary landscapes (see Chettri et al. 2009; Messerli 2009) (Fig. 5.3). Major principles in these approaches include the adoption of a transboundary regional approach; the development of a regional knowledge base, regional baselines, and policy enabling frameworks for knowledge and information sharing; capacity building; and national ownership of monitoring and research efforts (Sharma et al. 2007). The essence of these initiatives is to bring Hindu Kush–Himalayan countries together and facilitate effective conservation and protection of critical transboundary complexes across the region. In these initiatives, there has been a strong focus on community development at the local level, followed by cooperation at the regional level to meet global commitments such as that to the ecosystem approach of the Convention for Biological Diversity.

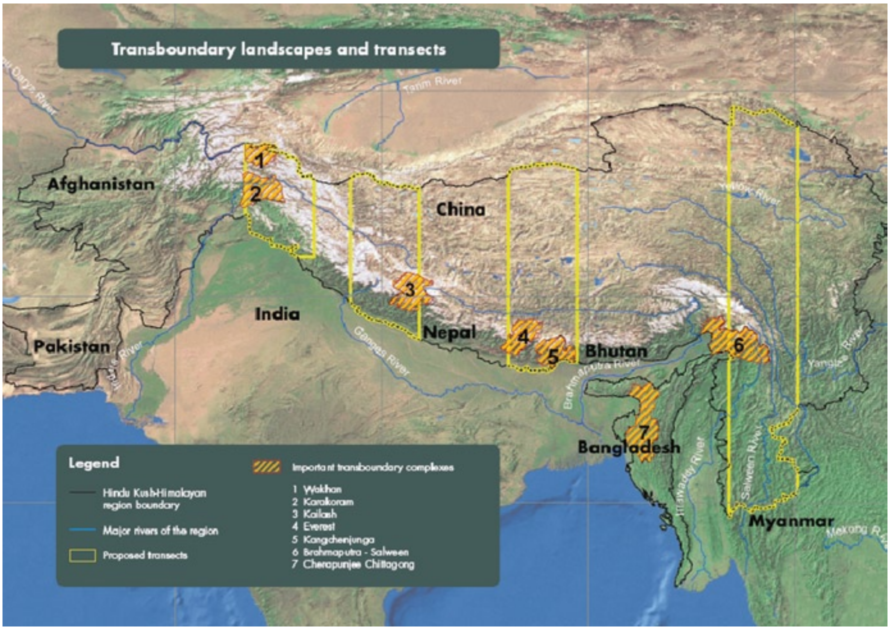

Fig. 5.3 Map showing seven transboundary landscapes and four transects in the Hindu–Kush Himalayas [International Centre for Integrated Mountain Development (ICIMOD) working area]

Similarly, ICIMOD, in partnership with Wetlands International (WI), the World Wide Fund for Nature (WWF), International Union for the Conservation of Nature (IUCN), and other local nongovernmental organizations (NGOs), is supporting governments in the region to establish the Himalayan Wetlands Initiative within the framework of regional cooperation under the Ramsar Convention. The initiative addresses wetland issues from global to regional and local levels toward achieving the goals of conservation, protection, and the wise use of wetlands as a contribution to sustainable development. This cooperation has led to the development of a regional strategy for the conservation of wetlands and is the driving force behind the development of the capacity-building framework, tools for wetlands, and the wetland information system. Over the past four decades, four countries in the Third Pole, namely, China, India, Pakistan, and Nepal, brought 29 sites covering about 11,000 km^2 in area within the Ramsar network. In addition, ICIMOD is also contributing to many of the seven focal areas and their associate indicators specified in the Convention on Biological Diversity by facilitating research on ecoregions and protected area coverage; promoting co-management in rangelands and participatory forest resources management; adopting integrated watershed management; promoting landscapes and connectivity in fragmented areas; and understanding ecosystem health and human well-being relationships, among other concerns (Chettri 2009).

5.5 Discussion and the Path Forward

The Third Pole, with its diversity of ecosystems, is facing multiple challenges. The cryospheric components are under threat with an increasing temperature trend, and the rangelands and forests are in different stages of degradation. The productivity of the grasslands and farmlands is decreasing, and people are facing acute shortages of food and other essential goods and services. These shortages will exert pressure elsewhere, for example, in the cities into which people must move. Biodiversity and ecological processes in the region have also been affected through modern developmental activities. Until recently, scholarly and official documents all agreed that overgrazing was the primary cause of rangeland degradation. In recent years, however, the impact of climate change on rangelands has become widely acknowledged, although separating the effects of climate change and anthropogenic factors remains difficult (Wilkes 2008). Observed impacts of climate change have been reported in relationship to rangeland productivity, plant community composition, and the distribution of plant communities, as well as on grassland soils and whole rangeland ecosystems. In addition, the new road networks constructed in the high mountain areas and on the Tibetan Plateau are increasing accessibility to natural rangelands, forests, and wilderness areas, which may lead to additional landscape conversion, which seems inevitable (Lu et al. 2009). Invasive species and fragmentation are additional impacts.

Most of the large rivers originating in the Third Pole cut across several countries. Geographically and hydrologically they are connected and interlinked. Thus, the development of water resources in the Third Pole requires transboundary cooperation. In the past, water resource management has been considered from a national and bilateral perspective, which has hindered the optimum development of transboundary water resources in an integrated manner. Climate change has posed additional stress and challenges on water resources development and management with increased scarcity of water in the dry season and enhanced hazards in the monsoon through increased temperature and snow and ice melting. As suggested by the experts in Delhi (UNEP 2009), there is a paucity of good research, and regional countries should come forward and address the challenges posed by climate change through sound research and cooperation among the countries in the region.

Similarly, the policy change that promoted the sedentarization of nomads in China has been counterproductive, with immediate habitat loss and increased fragmentation of the alpine grasslands (Lu et al. 2009); it has also had some significant impacts on local people and their environment. First, resources are inequitably allocated to many rangelands because of their highly variable topography, productivity, and availability of water resources. Second, access to social and economic services has been made more difficult for some, while social conflicts have increased. Third, the privatization of rangelands and sedentarization of nomads needs matching infrastructure, which is still missing in many places. Meanwhile, the privatization of rangelands has led to increased labor input in some places, and added to the workload of women and children (Zhaoli et al. 2005).

However, our understanding of the ecological processes and complexities is far from complete. Sparse climatological monitoring is a major obstacle to understanding the ongoing climatic changes and variability in the region. Most stations are either in the valley bottom or located in urban centers, and there is no adequate representation of the geographic area or consideration of altitude in current research. As a result, climatological monitoring stations have inherent biases and cannot represent background conditions. Scanty data are also a major hurdle in the validation of climate model performance and detailed impact studies. Regional studies require the assimilation of data from various national networks. Data sharing is still at a premature stage between most hydrometeorological services of the countries in the region. Regional standards in the observatories and coordination in the observation network design can facilitate better climate change monitoring. Similarly, only 20% of the region's terrestrial area is under formal protection. Many critical ecoregions and habitats are still outside the existing protected area network. Although the majority of these protected areas are established in high-altitude zones, their biodiversity and the impact of climate change on biodiversity and related services are poorly documented and researched. Thus, there is still a paucity of robust research in representative areas of this complex geographic region.

To address data gaps, we recommend more widespread and long-term tracking of glacial ice volumes, monitoring of alpine flora and fauna, landscape and transboundary approaches to biodiversity conservation, and more open data exchange and cooperation among all countries in the Third Pole region. In addition, international collaboration and investment for good research and understanding of the complexities of the region are urgently needed. To fully appreciate the multiscale and multidimensional ecological effects, it is critical to establish long-term monitoring programs with permanent field sites and to conduct initial field surveys to establish credible reference conditions for future research. To address this need, ICIMOD is promoting transboundary landscape management within the context of the "ecosystem approach" adopted by the Convention on Biological Diversity during Conference of Parties 7 (COP 7), highlighting the significance of regional cooperation in critical ecosystems. This approach includes both natural and managed components of biodiversity, including agro-biodiversity, wildlife and wildlife habitats, and the cultural diversity that maintains these biological resources within landscapes. Rangeland being the key land use type in the Third Pole, ICIMOD is promoting the multiple use and co-management concept in the region. Biodiversity conservation is a top priority on national agendas for these countries. So far, seven critical transboundary landscape complexes with globally significant biodiversity have been identified by ICIMOD across the Hindu Kush–Himalayan region for which a Regional Cooperation Framework is in place or being developed. ICIMOD has also proposed four trans-Himalayan transects to engage regional, national, and local partners, and the global research community, in long-term environmental and ecological research and monitoring by providing both geographic sampling and a supportive policy framework, building upon existing and proposed national and regional efforts (Chettri et al. 2009; Messerli 2009).

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Chapter 6
Mining the Himalayan Uplands Plant Database for a Conservation Baseline Using the Public GMBA Webportal*

Dirk Nemitz, Falk Huettmann, Eva M. Spehn, and W. Bernhard Dickoré

6.1 Introduction

For a long period of history, the world's highest mountains were as out of reach of human activities and interference as were the Polar Regions. The mountains' remoteness, rugged terrain, and harsh climate restricted commercial and economically profitable land use options.

Thus, human population densities remained generally low. However, mountain watersheds constitute the "water-towers" for mankind (Viviroli et al. 2007) and provide numerous other vital functions to the lowlands, both economically and ecologically. Mountain areas carry many rare or endemic plant and animal species, and some areas can still be regarded as nature reserves in close to pristine conditions. The conservation of these habitats and their species is of prime concern for global sustainability, and for mankind.

*This text exploits the field and database efforts of W. B. Dickoré, who collected, compiled, and curated the HUP data over more than 25 years.

GMBA = Global Mountain Biodiversity Assessment: the webportal is located at www.mountainbiodiversity.org).

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Increasing population pressure and technological progress have recently led to economic exploitation, development, and transformation, sometimes drastic, of many mountain areas, even those considered remote, even as another global threat is forming.

Regional climate change models and predictions are showing that the high mountain ranges will be affected by disproportionally large temperature increases (Böhm et al. 2001). Therefore, mountain habitats and their species are expected to be especially vulnerable to both processes: increasing disturbance caused by direct human interference and the impacts of global climate change.

A science-based sustainability management can be used to handle these problems. However, to successfully mitigate the impacts of developmental threats and global change issues on biodiversity, and to maintain ecological security, at least three important steps are necessary: (1) to acquire knowledge of species distributions and habitat requirements; (2) to monitor changes in population size, area and quality and (3) to proactively model ecological correlations between suitability of habitat and species occurrence, and to infer trends for ecosystem functions on the basis of predicted land use alteration and climate change.

It is intuitively clear that every modeling and prediction exercise for practical applications will gain from increased quality of the underlying data basis. However, perfect data are rare, and many mountain regions remain scarcely sampled. So far, there is hardly any substitute for original, specimen-level biodiversity data based on historic backgrounds, on ample sampling and documentation, and on authoritative taxonomies. Biodiversity data from heterogeneous sources and of varying quality are being collated and made universally accessible by huge online data collections, obviously with promising application prospects. Here we show how heterogeneous biodiversity data can be useful to support today's management and conservation decisions.

This chapter focuses mainly on the first point stated above, that is, collecting, collating, and making available biodiversity baseline data, here pertaining to the largest and highest mountain system on earth, the Himalayas and the Tibetan Plateau. The respective data set is an original, extensive, and well-documented collection of occurrence data by the corresponding author (WBD), entitled "The Himalayan Uplands Plant Database: Vascular Plants of the Hindukush, Pamirs, Karakorum Mountains, Himalayas and the Tibetan Plateau," hereafter simply referred to as the "HUP database." It should be noted that an adjacent, and partly overlapping, similar and logically complementary regional database exists with the Biodiversity of the Hengduan Mountains project (Biodiversity of the Hengduan Mountains Project 2010).

To mine HUP for content and description, an overview of the HUP database history and metadata is given here. Current status, format, and apparent gaps are described, and taxonomic constraints are outlined. We conclude with an outlook to documentation and conservation issues, and for potentials of the HUP dataset within larger complementary or interpretative frameworks, such as the Global

Biodiversity Information Facility (GBIF), and a recently set up webportal www.mountainbiodiversity.org of the Global Mountain Biodiversity Assessment (Global Mountain Biodiversity 2010).

6.2 HUP Database Background

A database designed to include and review vascular plant specimen records and observations from the Himalayas and the Tibetan Plateau, which has been developed and maintained by WBD since the year 1986, presently holds more than 200,000 original and interpreted specimen-level entries. These records refer to approximately 12,500 different identifications including accepted species, "pseudotaxa" in review, and unidentified or otherwise critical material. Species- and specimen-related information was organized as a relational database. The structure is simple and straightforward, but maintains three different data levels to accommodate, respectively, accepted taxonomic names with classification, taxonomic synonyms, and individual specimen records, linked via an accepted taxonomic name string. This structure generally allows constant additions and review through all levels, while referential integrity can be maintained on an "intuitive" and easy to manage basis. As it is typical for such datasets, the local database is undergoing permanent changes, corrections, improvements, and adaptations on an individual record basis as well as for larger-scale standardization and normalization procedures.

Data collection was primarily based on preserved herbarium specimens, which were gathered during several joint expeditions to China, India, Pakistan, Nepal, and Tajikistan by WBD and others; that were provided by various collaborators, for example, on a specimen and/or data for determination basis; or which have been reviewed in various public herbaria. These herbaria include the Berlin Botanic Garden and Museum (B), Natural History Museum London (BM), the Royal Botanic Gardens Edinburgh (E), University of Göttingen (GOET), University of Graz (GZU), the Royal Botanic Gardens, Kew (K), Kunming Institute of Botany, Chinese Academy of Sciences (KUN), Botanische Staatssammlung Munich (M), University of Munich (MSB), Pakistan Agricultural Research Council, Rawalpindi (RAW), Museum of Natural History, Vienna (W), University of Vienna (WU), and University of Zurich (Z).

Additional data, including observation and photographic records, were successively added and interpreted from various other sources including collaborative vegetation studies and literature reviews. Published specimen records from various sources (Fraser-Jenkins 1997; Grierson 1964; Grubov 1991; Huss 1978; Omer et al. 2001; Pampanini 1930; Schmid 1932; Stewart 1972) were imported and interpreted on a review basis. Original records were, to some part, published elsewhere, for example, in regional frameworks (partly published in Dickoré 1991, 1995, 2001b; Dickoré and Nüsser 2000; Eberhardt et al. 2006; Klimeš and

Dickoré 2005; Nüsser and Dickoré 2002; Wündisch et al. 2003). In turn, the database served as a resource and documentation pool to a number of taxonomic treatments and related works (Blöch et al. 2010; Dickoré 2001a; Dickoré and Hilger, in press; Dickoré and Kasperek 2010; Dickoré and Kriechbaum 2006; Pimenov et al. 2000; Staudt and Dickoré 2001).

6.3 HUP Database Status and Gaps

The HUP database comprises a fully identified, reviewed, and representative dataset of 164,360 occurrence records of vascular plants from the Himalayas, the Tibetan Plateau, and adjoining areas, pertaining to 5,562 accepted species (29.6 records per species on average). It was derived as a snapshot from the already described working database, basically, by extracting identified specimens and internally defined, accepted species. Furthermore, unreliable, poorly documented, redundant, and conflicting records were stripped, on both species and specimen levels, and to a major part under individual record control. Unless otherwise stated, specifications of the HUP database in the following refer to this public dataset, queried and formatted for the Global Biodiversity Information Facility (GBIF). Metadata are documented at the NBII website for a global search at http://mercury.ornl.gov/clearinghouse/ (National Biological Information Infrastructure 2010).

The geographic coverage of the HUP database extends from 24° N to 40° N and 60° E to 105° E, thus including substantial parts of Central Asia and temperate and subtropical South Asia, and including parts of the territories of Afghanistan, Bhutan, China, India, Nepal, Myanmar, Pakistan, Tajikistan, and adjacent national states (Fig. 6.1).

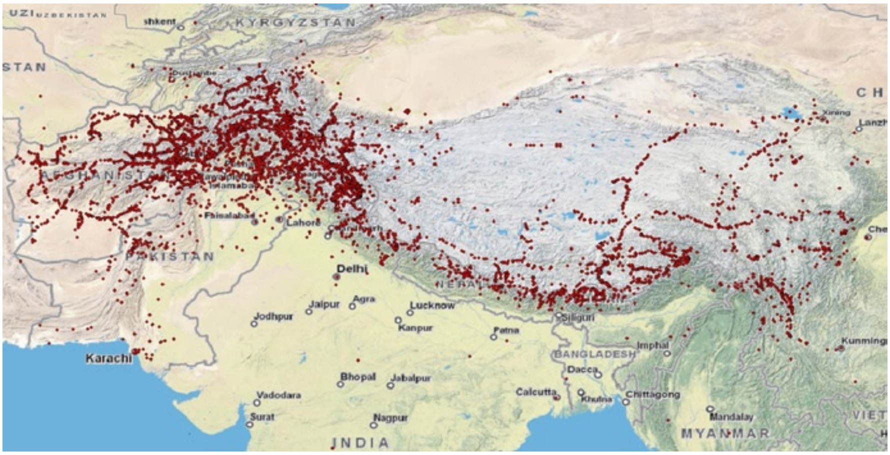

Fig. 6.1 Map of the Himalayan Uplands Plant Database (HUP) study area with georeferenced specimen records

An obvious geographic or sampling bias is accounted for by a suite of partly interrelated reasons. The western part of the HUP area including the Hindukush, Pamirs (in part), Karakorum Mountains, Western Himalayas including Kashmir, and Western Tibet was conclusively sampled. This selectivity relates to an initial focus on the flora of the Karakorum (Dickoré 1995), but also results from partial inclusion of a large data set from Afghanistan (collections of D. Podlech et al., Munich), and relates to a generally better availability of original data, specimens, and literature from this broad area. Data from the Central and Eastern Himalayas, and the Tibetan Plateau, including its eastern and southeastern declivities into Qinghai, Sichuan, and Yunnan (Hengduan Shan), were successively added. However, these were available on a more casual basis, either through "newly acquired" collections or by herbarium material revisions of selected plant groups. Although some regions, such as the wider surroundings of Lhasa in southeast Tibet, seem still quite well represented, there is an obvious bias toward the vicinity of roads across much of the eastern part of the Tibetan Plateau, but also for Afghanistan. For the Chinese territory, development and access has dramatically improved only in recent years. For some regions, such as parts of Nepal and Tibet, an apparent lack of data also relates to incomplete georeferencing.

Data from a major part of the Tibetan Plateau (central and northwest, Changtang) are few and patchy for several reasons. This area, almost exclusively situated at altitudes above 5,000 m, with mean annual temperatures below 0°C and precipitation often below 100 mm, has an obviously extremely sparse flora (e.g., Miehe et al. 2002). While historic adventurers, only since the end of the 19th Century, have occasionally managed to traverse the Tibetan Plateau along a few routes, very little collecting was done, and concrete localities were only rarely recorded. To date, regular access is hampered by extensive permafrost swamps not suitable for vehicles, as well as a lack of fodder for pack animals, and the very low biodiversity of a substantial area also seems to be less attractive to botanists. Apparently few in all, collections from the Changtang Plateau seem to be either located in rather "unexpected" repositories or, probably, in Chinese herbaria, where only a small part of collections in the Kunming herbarium was reviewed.

The largest fraction of the 164,360 HUP database records, 86,153 entries (52.4%), comprise preserved specimens, for the most part consistently identified or taxonomically verified by WBD. About 60,336 specimens (36.7%) were from physically "new" collections, originally processed and curated within the working database. Raw and observational data were to some part imported, but the majority of records are not represented in other data repositories. In contrast to the foregoing first fraction, 78,207 entries (47.6%) refer to specimens or records not seen by WBD. These records originated from various sources, for the major part published. Although not having been physically verified, these records were internally interpreted and have passed a number of routine quality checks with regard to probability and taxonomic and nomenclatural consistency. To date, 5,155 entries (3.1% of the total) are, for various reasons, flagged as probably valid but taxonomically uncertain.

Higher taxonomy is maintained in the HUP database primarily for internal sorting purposes, such as for five higher taxonomic groups: Pteridophyta

Table 6.1 Number of records and species for best-represented families

Number of records	Taxonomic family	Species number	Mean number of records per species
29,941	Compositae (Asteraceae)	752	39.8
16,637	Gramineae (Gramineae)	435	38.2
11,027	Cruciferae (Brassicaceae)	235	46.9
8,620	Leguminosae (Fabaceae)	293	29.4
7,845	Caryophyllaceae	190	41.2
7,824	Cyperaceae	164	47.7
6,512	Boraginaceae	114	57.1
6,267	Rosaceae	184	34.1
5,185	Labiatae (Lamiaceae)	183	28.3
4,452	Polygonaceae	101	44.1
4,373	Scrophulariaceae (s. l.)	212	20.6
4,325	Ranunculaceae	184	23.5
3,257	Umbelliferae (Apiaceae)	213	15.3

(1,805), Gymnospermae (1,325), Gnetatae (563), Dicotyledoneae (131,240), and Monocotyledoneae (29,427 records); and for families. Higher as well as conceptual taxonomies are obviously difficult to accommodate in a specimen-based and regional database (rather than with either parochial or worldwide synthetic concepts). Family names and assignments are presently maintained on a relatively conservative basis. Currently, the HUP database records refer to 208 recognized taxonomic families; data for the largest families are given in Table 6.1. The general figures including a species-based Compositae (sunflower family)/Gramineae (grasses) ratio of 1.73 (1.80 for specimens) seem characteristic for the overall dominant, relatively arid, and high-altitude setting of the general area. Geographic sampling and identification bias, as well as family-specific biological properties, may account for various deviations in ratios of specimens per species.

Species-level taxonomy is, for the most part, internally managed in the working version of the HUP database. Infraspecific ranks on accepted name level were restricted to a few, provisionally accepted, subspecies. Taxon-related information includes accepted name and synonym status, taxonomic authors, reference to publication, previous identifications, and various other internal or functional properties. This information is continuously updated and used for review purposes, and should, furthermore, be instrumental for improving links to worldwide taxonomic frameworks. Formal taxonomy in the HUP database restricts to accepted taxonomic name strings, but, to logically constrain to valid names, maintains also taxonomic authors (basionym and combining).

A wide range of Floras, monographs, taxonomic treatments, original publications, and databases has been consulted to identify and verify specimens and to develop, at least internally, consistent taxonomies. Flora and checklists relating to the general area are mostly synthetic, that is, not, or only occasionally, citing individual reference specimens, mostly artificially or nationally bound, and several are unfinished. Important, mostly monumental works consulted to determine specimens and to adjust taxonomic concepts within the HUP database include “An Annotated

Checklist of Flowering Plants of Nepal" (Hara et al. 1978–1982; Press et al. 2000), "Flora Iranica" (Rechinger 1963–2010), "Flora of Bhutan" (Grierson and Long 1983–2002), "Flora of British India" (Hooker 1875–1897), "Flora of China" (Wu et al. 1994–), "Flora of India" (Hajra et al. 1996–), "Flora of Pakistan" (Ali et al. 1970–), "Flora Reipublicae Popularis Sinicae" (Wu et al. 1959–2004), "Flora Tajikistana" (Ovczinnikov 1957–1991), "Flora Xizangica" (Wu 1980–1986), and "Plantae Asiae Centralis" (Grubov 1963–2007).

Taxonomic specialists who substantially contributed to determination and verification of HUP specimens include I. Al-Shehbaz (Cruciferae), D. Albach (Scrophulariaceae s.l.), D.F. Chamberlain (*Rhododendron*), R. Cranfill (Pteridophyta), A. Farjon (Gymnospermae), C. Fraser-Jenkins (Pteridophyta), H. Freitag (Chenopodiaceae, Ephedraceae), N. Friesen (*Allium*), R.J. Gornall (*Saxifraga*), I.C. Hedge (Labiatae), M. Lidén (*Corydalis*), J.Q. Liu (*Ligularia*), L. Liu (Gramineae), D.F. Mowle and B. Burrow (*Androsace*), H.J. Noltie (Cyperaceae, Juncaceae), N. Pearce (Orchidaceae), M. Pimenov (Umbelliferae), D. Podlech (*Astragalus*), A.J. Richards (*Primula*), H. Schneider (Pteridophyta), H. Scholz (*Bromus*, *Festuca*), A. Skvortsov (*Salix*), A.R. Smith (Pteridophyta), J. Soják (Rosaceae, *Potentilla*), and T. Yamazaki (*Pedicularis*). In addition, J.P. Gruber, H. Hartmann, L. Klimeš, M. Kriechbaum, K. Lewejohann, G. Miehe, S. Miehe, A. Millinger, K. Reiter, U. Wündisch, and others have identified parts of the collections. As may be inferred from the diverse taxonomic background, the wide range of collections and records concerned, and the need of developing consistent species–specimens relationships, determinations were often conflicting and, subsequently, variously interpreted, reviewed, or adapted. Identification histories, furthermore, were often unknown for herbarium specimens and are also not fully documented in part of the new collections. A total number of 39,936 original determinations are referred to WBD.

Figure 6.2 demonstrates the distribution of specimens per species ratios in the HUP database, peaking at the 8–20 specimens per species class. While 669 species were recorded only once, 445 species occurred twice. The most frequent species was *Poa attenuata* Trin. (1,159 records), next to 18 species each recorded more than 400 times: *Artemisia brevifolia* DC., *Artemisia santolinifolia* Krasch., *Aster flaccidus* Bunge, *Crepis flexuosa* (DC.) Benth. & Hook.f., *Cuscuta planiflora* Ten., *Draba altaica* (C.A. Mey.) Bunge, *Kobresia royleana* (Nees) Boeck., *K. schoenoides* (C.A. Mey.) Steud., *Krascheninnikovia pungens* (Pazij) Podlech, *Leontopodium leontopodinum* (DC.) Hand.-Mazz., *L. ochroleucum* Beauv., *Nepeta discolor* Benth., *Oxytropis microphylla* (Pall.) DC., *O. tatarica* Cambess., *Poa sterilis* M. Bieb., *Potentilla bifurca* subsp. *orientalis* (Juz.) Soják, *Potentilla pamirica* Th. Wolf, and *Scorzonera virgata* DC. All frequencies, however, must be considered as being of limited significance. Incidentally, *Poa attenuata* (the closely related *Poa sterilis* occurs at relatively lower altitudes) forms a "collective" species, which according to various and widely diverging sources is divided up into numerous, allegedly apomictic (asexually reproducing) and possibly distinct microspecies. As treated here, a "collective species," *Poa attenuata* (s. l.), may indeed comprise the most common and universally distributed high-altitude plants in the mountains of Central

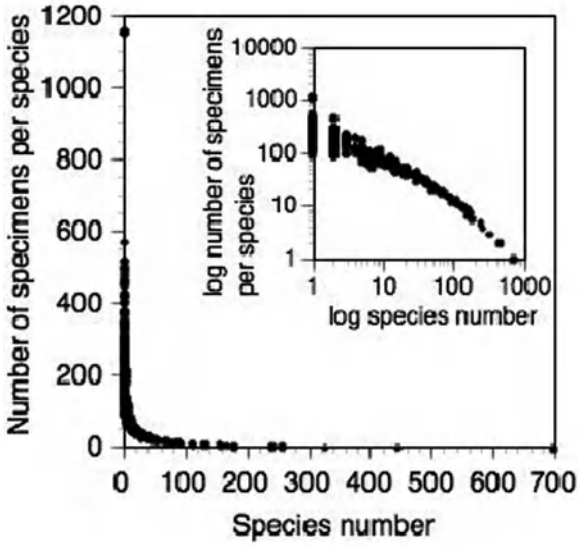

Fig. 6.2 Specimen number classes versus number of species

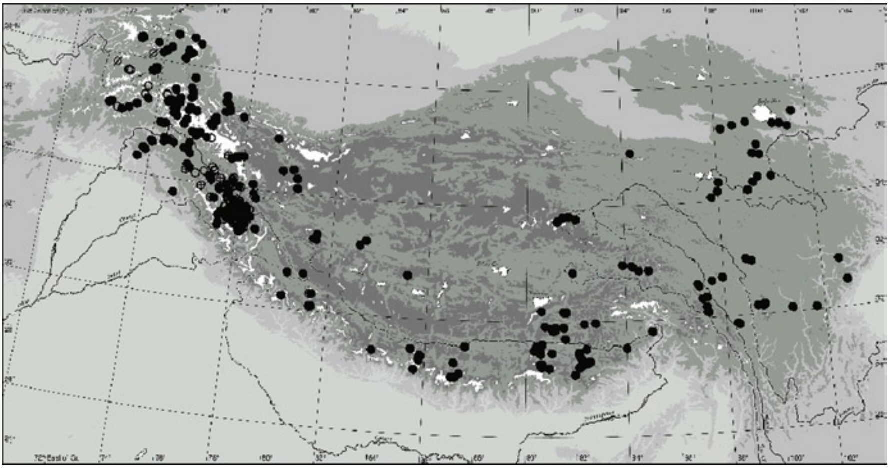

Fig. 6.3 Distribution of *Poa attenuata* (Gramineae), the most frequently recorded species in the HUP database. (Basemap courtesy of C. Enderle and G. Miehe)

Asia (Fig. 6.3). *Artemisia santolinifolia*, *Aster flaccidus*, *Draba altaica*, *Kobresia royleana*, *K. schoenoides*, *Oxytropis microphylla*, *O. tatarica*, and *Potentilla bifurca* subsp. *orientalis* are likewise widespread and common across most of the Tibetan Plateau and adjacent high mountain ranges. The other top-ranking species, however, rather concentrate in the Karakorum Mountains and adjacent arid western Central Asia. These species are obviously overrepresented as a consequence of detailed studies in this general area (Fig. 6.4).

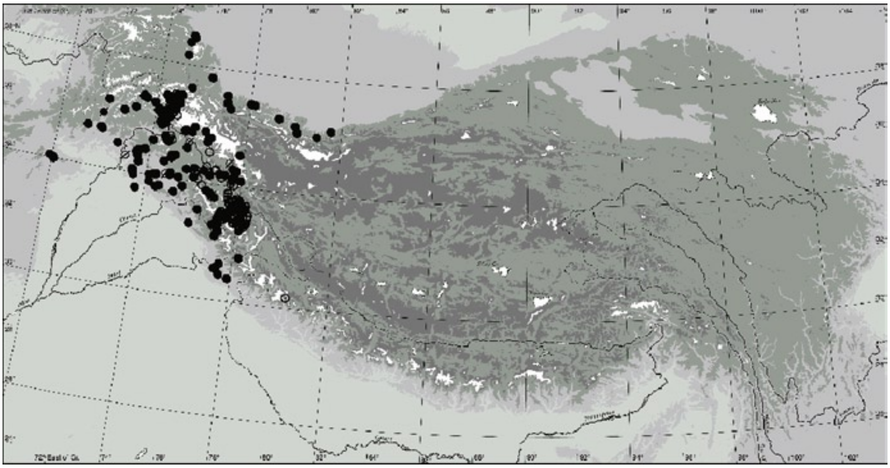

Fig. 6.4 Distribution of *Leontopodium leontopodinum* (Compositae)

Specimen-level information of the HUP database includes spatial, temporal, and referential data, such as for altitudinal, ecological, collecting event, and curational information. The majority of HUP records come from six countries (Table 6.2). Except for 808 records (0.5%) flagged as cultivated, only wild occurrences are concerned. The HUP database has a clear geographic bias (see Fig. 6.1), which is also indicated by record number:species number ratios. Although we can assume that the species representation for Pakistan (at least for the mountains) is nearly complete, the total species numbers for the other countries are rather underestimates. For example, we sampled only about half the number of records for China and arrived at the same species number as Pakistan, so China might well have twice the number of species. Species numbers for the other countries obviously underlie similar constraints, and they do not represent or include the putatively species-rich lower elevations. In several regions or countries, such as Bhutan, Myanmar, Nepal, and Tajikistan, species numbers are based on relatively small sample sizes.

As we studied one of the geographically, culturally, and politically most diverse regions on earth, spatial information to the HUP database is often critical. Many historic records and herbarium specimens come with imprecise or ambiguous locality information such as “Kashmir,” “Tibet,” or “Eastern Himalayas.” Historically, geographic coordinates were rarely reported, and if they were, then mostly in the “degrees, minutes North, East” format, and without considering geographic datum or error ranges. In contrast, reliable coordinates were available, or were generated, from maps, gazetteers, or by Global Positioning System (GPS) readings, for most of the newly acquired specimens. Accordingly, 75,688 records (46.1%) carried “original” coordinates. On that basis we generated geographic hierarchies (political country, province, and “naturally” defined regions, subregions) to narrow down the spatial error ranges for the remaining records. Subsequently, we tried to trace coordinates for these, based on verbatim locality names or itineraries and collecting dates.

Table 6.2 Number of Himalayan Uplands Plant Database (HUP) records by country

Number of records	Country	Species numbers
55,991	Pakistan	2,964
44,210	India	2,663
28,044	China	2,965
23,678	Afghanistan	1,857
6,816	Nepal	1,099
3,370	Tajikistan	612
1,205	Others/unknown	595

Table 6.3 Classified estimated uncertainty radius of HUP occurrence coordinates

Number of records	Estimated uncertainty (km)
75,713	1–5
56,034	5–10
4,387	10–100
12,282	>100

In fact, this did not generally work out on an automated basis, that is, by direct linking to spatial databases. We encountered a huge variation in locality names, which sometimes denoted mere campgrounds or uninhabited places. Many other ambiguities and peculiarities turned up, often individual record- or collection related, with regard to orthography, variants, inherent homonyms, and synonyms. In result, georeferencing was to be accomplished on a largely individual place name and record basis, by WBD and team using numerous maps, gazetteers, and spatial databases, and also through consulting collectors' itineraries (e.g., Schlagintweit-Sakünlünski 1876; Thomson 1852). Reasonable coordinates were finally identified for a total of 148,416 records (90.3%). An attempt at resolving remaining geographic issues with BioGeomancer (Guralnick et al. 2006, www.biogeomancer.org) was unsuccessful because of insufficient data for the regions in question. Error ranges were inferred for all georeferenced records (Table 6.3), where the greater than 100 km error radius class generally refers to a residue of very roughly located, mainly historical specimens, and to (literature) records that previously had been interpreted on higher geographic levels.

About 74% of the HUP data come with altitudinal information (Fig. 6.5). Although 100,078 occurrences carry "exact" original elevation data, an additional 21,009 records just give altitudinal ranges. Almost 90% of all values are in meters, about 10% in feet (however, this is to some part caused by previous "non-verbatim" conversions, including dubious or potentially erroneous). Altitudinal error ranges of about 300 m, roughly 1,000 ft., must be considered quite "best practice" for many historic records, which, at best, were often derived from measuring the temperature when water starts boiling, which depends on the elevation of the water. Larger ranges are commonly indicated. However, it cannot be generally identified whether a collector or observer intended to indicate an explicit observational range of "this

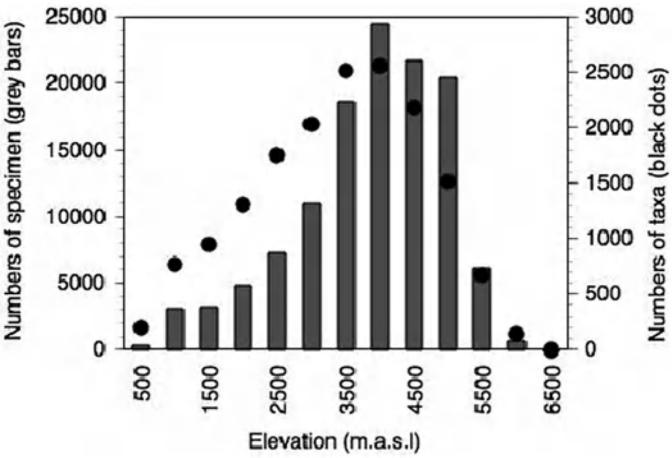

Fig. 6.5 Occurrence and species frequencies by altitude (*m.a.s.l.*)

species in that area," or just a point or error range within, or whether he referred to grouped data from any other source. Accordingly, single record altitudinal ranges exceeding 500 m (sometimes several thousand meters) were flagged as inappropriate. An error range of about 50 m seems frequent even for modern GPS readings.

Four species only (six records) were reported from altitudes of 6,000 m and above: *Arenaria bryophylla* Fernald, *Draba oreades* Schrenk, *Pegaeophyton scapiflorum* (Hook.f. & Thomson) C. Marquand & Airy Shaw, and *Saussurea gnaphalodes* (Royle) Sch.Bip. A few more were reported in the literature, but such extremes are obviously scattered and difficult to verify. Fieldwork at very high elevations, for example, on the relatively dry Tibetan side of the Mt. Everest massif, would likely improve that record.

Further ecological information in the HUP database comes as, verbatim or translated, qualitative descriptions of the habitat as reported on herbarium labels. Roughly 53,000 records carry this kind of non- or scarcely normalized ecological information, consisting of terms such as "*Artemisia-Stipa* steppe," "moist riverside meadows," or "undisturbed *Abies* forest 10° N-facing upper slope, with dead *Betula* individuals." This is obviously all we have, and it can successfully be used to qualify ecological properties of individual species. However, consistent classification and quantitative analysis or modeling of specimen-related verbatim ecological information is hampered by the heterogeneity of information.

Regarding data providers and "observational authority," the HUP database contains records of more than 2,000 collectors and observers, who had either directly or indirectly contributed, or which were derived from herbarium label information. Exact figures are difficult to generate as a result of various collectives and some historic uncertainties. Observation data, so far as considered reliable and included, were mostly confined to relatively small areas, and are often largely redundant to documented specimens, at least on the higher geographic scales. Observations are excluded from the list of the most prolific collectors, who each provided between

Table 6.4 The most prolific collectors of the HUP database

Collector/collective	Number of specimens
G. & S.Miehe	11,802
W.B. Dickoré	9,970
E. Eberhardt	8,292
U. Wündisch	3,123
M. Nüsser	2,873
G. Miehe & U.Wündisch	2,811
U. Schickhoff	2,481
G. & S. Miehe & U. Wündisch	2,175
M. Kriechbaum & W. Holzner	2,032
T. Thomson	2,002
R.R. Stewart	1,952
H. Hartmann	1,538
Bosshard, Klötzli, & Schaffner	1,362
L. Klimes	1,338
Miehe, Huang, Otsu, & Tunsu	1,122
Stainton, Sykes, & Williams	993

about 1,000 to more than 10,000 specimens (Table 6.4). The focus or geographic width for most collections and observations was highly specific, and for the major part centered in the western half of the area. Specimen and record identifications, whether derived from new collections or documented herbarium sources, provided as raw data by other contributors or taken from the literature, were verified or interpreted by WBD. Along with internal normalization procedures across other fields, this accounts for a certain amount of deviation from original record forms. WBD was in charge of curating the extensive collections of G. Miehe et al. for more than a decade and had identified the majority of these. It is interesting to note that some very prolific historic botanists have entered the top collectors' list, one in the nineteenth century, T. Thomson, and two early twentieth century collectors/collectives, R.R. Stewart and Stainton, Sykes, and Williams. These and other important historic collections were databased from public herbaria on an individual specimen basis. Evidently, only minor fractions of these could be processed.

At the same time, the HUP database covers a large timespan. The collecting date is reported for more than 100,000 entries (61%). Except for a few dubious records, the earliest specimen records date to the year 1821 (N. Wallich), while almost 70% of dated records refer to the period from 1980 to 2000, with the newest entries being from 2008.

6.4 HUP Database Availability

To make the HUP database available to anyone interested, we were using a number of existing and rapidly developing data-sharing infrastructures. Subsequent to the aforementioned described filtering and normalization, the information from all 50

HUP database columns was transformed into the Darwin Core 2 format by DN. Darwin Core (Biodiversity Information Standard 2009) is a data standard that has been developed by the Taxonomic Data Working Group (TDWG) for the purpose of sharing data by means of common and unambiguous formats that can be uploaded to shared federated databases.

Next, the data were uploaded to a publicly accessible database. We opted for the Global Biodiversity Information Facility (GBIF, www.gbif.org), because, to our understanding, this is the largest and most transparent international repository. In addition, the Global Mountain Biodiversity Assessment (GMBA), has in collaboration with GBIF, launched the Mountain Biodiversity Portal (MBP, www.mountainbiodiversity.org). The MBP refers to GBIF data, and therefore HUP data will be accessible via this portal as well. The GMBA web portal allows selecting mountain areas, using a coherent convention to define mountain area, based on ruggedness of the terrain (Körner et al. 2011). It allows us to query, filter, and download GBIF data specific for mountain areas, with a horizontal (region) and vertical (elevation, climate) dimension and includes many options, e.g., to analyze and visualize occurrence data by altitude or by bioclimatic "thermal belts" (based on an algorithm for a global treeline defined by temperature only, Körner et al. 2011). The "Mountain Biodiversity Portal" (GMBA 2010) aims at becoming a standard tool for the mountain biologists and ecologists community. More features are to be developed, and based on user feedback, making for a front-end tool for advanced query, exploration and access of mountain-related biodiversity information.

With a wealth of biodiversity data accumulating, good-quality metadata are considered essential (Huettmann 2010). For the HUP database, a first version XML-metadata information was already created according to the U.S. Federal Geographic Data Committee's (FGDC) "Biological Data Profile of the Content Standard for Digital Geospatial Metadata STD-001.1-1999" (Federal Geographic Data Committee 2010). The XML-file was uploaded by F.H. on the EWHALE lab server, University of Alaska, for the freely searchable National Biological Information Infrastructure (NBII) metadata clearinghouse http://mercury.ornl.gov/clearinghouse/ (National Biological Information Infrastructure 2010), and for global use. Thus, the HUP data are made accessible worldwide either by searching for metadata in the NBII clearinghouse database, searching for original biological data at GBIF, or searching for mountain-specific information at the GMBA mountain biodiversity portal.

6.5 Taxonomy and Conservation Baselines

In some contrast to the Polar Regions, land-surface biodiversity in the Himalayas and Tibet is huge and also unique, and "taxonomic impediment" (see Textbox) is especially valid for this region of the world. Cross-checking the HUP taxonomy with ITIS (Integrated Taxonomic Information System) was largely unsuccessful. Only 997 (17.9%) of the total 5,562 HUP-accepted species matched existing ITIS Taxonomic Serial Numbers (TSNs). ITIS is a U.S. governmental project with a

Textbox The Taxonomic Impediment

A lack of adequate taxonomic resources was addressed by Hoagland (1995) in a White Paper and acknowledged by governments party to the Convention on Biodiversity (CBD). As the Global Taxonomic Initiative (GTI 2010) puts it, the "taxonomic impediment" denotes inadequate taxonomic information and infrastructure, coupled with declining taxonomic expertise that hinders our ability to make informed decisions about conservation, sustainable use, and sharing of the benefits derived from genetic resources. In other words, effective conservation and management of biodiversity depends in large part on our understanding of taxonomy.

Presently, molecular and "cyber" systematics flourish and develop rapidly, while DNA-based phylogenies have certainly improved or revolutionized our understanding of evolutionary relationships. This development has distracted resources from traditional "alpha" taxonomy, which, in turn, is now often regarded as old-fashioned, slow, controversial, or plainly unscientific. In consequence, taxonomists are often left with few resources, but with the task of further developing and testing numerous, falsifiable hypotheses, that is, as to what specimens belong to which species, or they are blamed for inadequate or incoherent species definitions [in brief, according to Darwin (1859), species do obviously exist, but they are neither stable nor perfect]. Logical confusion, commonly in form of (near-)equating taxonomy and cladonomy or phylonomy (Brummitt 1997, 2006), has led to further problems. These range from more numerous than ever taxonomic name changes to the "reinvention of the wheel" such as the "PhyloCode" might be perceived (Nixon et al. 2003). Where obviously better representing evolutionary relationships, DNA sequence-induced taxonomic adaptations are certainly positive. However, name changes were apparently indiscriminately proposed and sometimes aggressively promoted, often on basis of individual molecular markers and poor representations, on both the species and specimen levels. Even well-documented molecular phylogenies, for example, that of Jordon-Thaden et al. (2010) for the large mountain genus *Draba* (Brassicaceae), seem to rather pose questions as to whether single, often conflicting nuclear (internal transcriber spacer, ITS) and plastid (trnL–F) marker phylogenies should lead to taxonomic consequences at all. However, instability of taxonomic names in the "web of life," also for historic and various other reasons, is inherent, whereas relative stability of identifiers such as needed for biodiversity databases can obviously be built only on accepted taxon names and on relatively complex nomenclatural regulatories (International Code of Botanical Nomenclature (ICBN) 2006).

Carvalho et al. (2007) comment on contemporary reductionist approaches to systematics, the bottom line being that arguments against "traditional" taxonomy are illusionary even for proponents of automated identification

(continued)

Textbox (continued)

processes (DNA barcoding) and "cybertaxonomy." Mayo et al. (2008) state that a crisis facing the conservation of biodiversity is reflected in a parallel crisis in alpha taxonomy. Although there is an acute need from government and nongovernment organizations for large-scale and relatively stable species inventories, molecular information becomes increasingly important but is also likely to result in greater taxonomic debate and controversy. Scotland et al. (2003) provide another set of arguments underpinning the overwhelming importance of taxonomy for biodiversity research and conservation issues. Whether all this evidence will substantially improve the current status of the maligned alpha taxonomists remains in question.

global mission to make standardized taxonomic information available to all federal agencies as well as other partners. It maintains a large taxonomic database open to the public and offering up-to-date tools for batch verification of large datasets. ITIS currently does not seem to include an exhaustive and consistent name set to the vascular flora of Central Asia. Major floras and taxonomic treatments consulted for taxonomic verification of HUP records were widely incongruent, although vascular plant taxonomies consistent across all groups and the huge area are obviously absent.

Notable efforts are underway to synthesize taxonomic concepts worldwide, such as the World Checklists of Selected Plant Families (WCSP 2010), GrassBase (Clayton et al. 2006), or The Plant List (2010). However, these are still often based on merged regional checklists, rather than on modern (taxonomic) revisions that are deficient for many, especially the larger, plant genera. Accordingly, simple conclusive figures, such as the total number of seed plants on earth, diverge by substantial margins (Govaerts 2001, 2003; Scotland and Worthley 2003; Thorne 2002). On the basis of a reasonably large sample of species names published up to the year 2000, Govaerts (2001) calculated a world total of 422,127 seed plants (58.4% synonymy rate), whereas Scotland and Worthley (2003) came up with only 223,300 species (78% synonymy rate). The latter figure is obviously based on a small and biased sample, but our random figures for genera that could reasonably be revised within the HUP database framework are rather suggestive of similarly high synonymy rates, about 80%.

Species "new to science" are constantly being described from all over the world, including the Himalayas and Tibet. Although inherent synonymy rates obviously vary greatly among different taxonomic groups, there is no logical, automated, or permanent procedure that could identify or constrain synonyms. On a rather intuitive basis, it seems that taxonomic synonymy for the HUP area tends to be rather underestimated. Species numbers were often rather lower than expected, and, the other way around, biodiversity might prove an even more precious resource than might be anticipated from meta-data lists. This constraint might be the result of a prevalence of large, wide-ranging (Eurasian or Holarctic) genera in the flora of the Himalayas and Tibet, which are often poorly revised, and with putatively inherent high synonymy rates. In contrast to common belief, and underlining the importance of physical documentation and taxonomic revisions, the identification of "new species" is more commonly based on revision of documented herbarium material, than on direct evidence from the field (Bebber et al. 2010).

Our knowledge of the Tibetan and Himalayan flora will certainly benefit from more field studies, but working up an enormous backlog of documented collections in the herbaria of the world would be as important. Both would certainly result in more concise taxonomies, but probably not in a dramatic increase of species numbers. With regard to individual identifications and shares of endemic or threatened species, Ungricht (2004) argues that the extent of overlap between countries and floristic regions is frequently not detailed, which easily leads to unrealistic figures of species richness. According to the continental setting and huge geographic extent of "Temperate Asia," the HUP area formally extending into "Tropical Asia," and with a number of mostly nationally bound and often highly diverging floras pertaining, this problem is huge and acute.

"Red Data" lists for endemic, and nationally or internationally threatened, species in the flora of the Himalayas are either nonexistent or full of taxonomic artifacts (Chaudhri and Qureshi 1991; Qureshi and Chaudhri 1987). The HUP database could, apparently, contribute to more realistic identifications and inventories. However, this would also require extensive further, individual species- and specimen-based studies, and linking of other databases, ideally with a largely complementary dataset, for example, from the Hengduan Shan "biodiversity hotspot" area (Biodiversity of the Hengduan Mountains Project 2010). The working version of the HUP database maintains an internal estimation of specimen-based representativeness for all species, which will need to be further specified and exploited. Meaningful distributions result for many species, as for common species with almost linear patterns along the Himalayas and the Hengduan Shan (Fig. 6.6), or for rare and endemic species (Fig. 6.7).

6.6 Conclusions

While promoting the HUP database as a treasure of knowledge about the biodiversity of the Himalayas and Tibet, a suite of backlogs, caveats, and apparent instability, whether internally or in larger interpretative frameworks, needs to be considered. Numerous examples can be found for datasets hidden and forgotten in some taxonomists' drawers, and even the best dataset in the world is virtually useless if not available (Costello 2009; Guralnick and Hill 2009). It is, therefore, mandatory to share these datasets with the public and scientists worldwide, and in standardized formats that facilitate their global use and for the benefit of mankind (Arzberger et al. 2004; Canhos et al. 2004). Ultimately, this transparency will not only put valuable data to a better use, but would also increase the chance of errors being spotted and reported; it is an active-only review system. Conservation issues, for example, with regard to threatened mountain habitats, will certainly benefit from sharing and "creative use" of biodiversity databases (Körner et al. 2007). A new culture needs to develop and

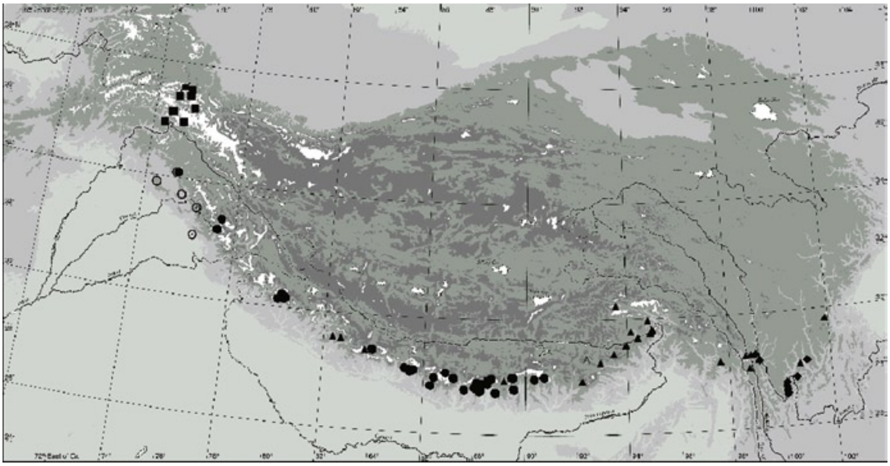

Fig. 6.6 Distributions of four interrelated species of *Saussurea* (Compositae): *filled circles*, *S. gossypiphora* D. Don (West and Central Himalayas; *open symbols*, doubtfully localized; *filled squares*, a probably new species close to *S. gossypiphora* (Karakorum); *filled triangles*, *S. laniceps* Hand.-Mazz. (Central and East Himalaya, Hengduan Shan); *filled diamonds*, *S. leucoma* Diels (Hengduan Shan)

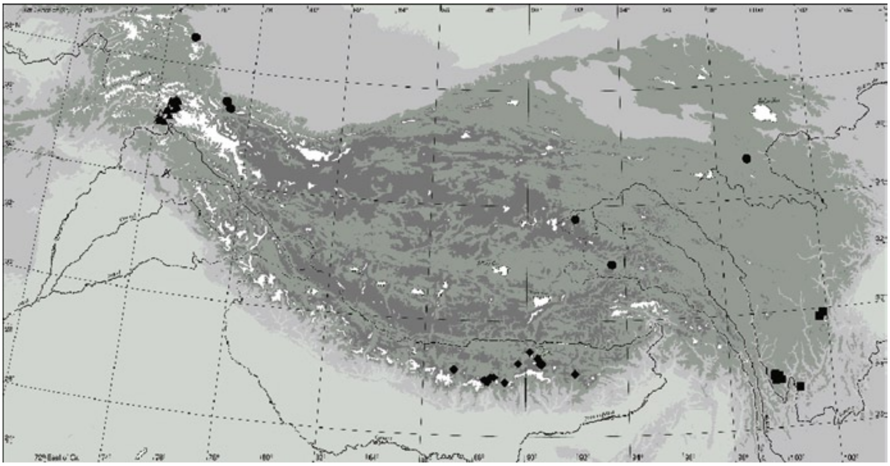

Fig. 6.7 Distributions of four "random" rare and endemic species: *filled circles*, *Carex tangulashanensis* Y.C. Yang (Cyperaceae; scattered West Kunlun Shan, Central Tibet, Qinghai; also known from Central Tian Shan); *filled squares*, *Leontopodium franchetii* Beauverd (Compositae; Hengduan Shan); *filled diamonds*, *Leontopodium haastioides* Hand.-Mazz. (Tibetan Himalaya); *filled triangles*, *Rhodiola saxifragoides* (Fröd.) H. Ohba (Crassulaceae; Hunza Karakorum; originally described from "Kashmir")

mature for sharing, exploiting, and improving primary biodiversity data, and for taxonomic work in progress (Cushman and Huettmann 2010; Drew et al. 2010).

Taxonomy, both on the scales of developing consistent cross-border registries and for the subsistence of individual taxonomists to identify specimens and to tackle some of the remaining problems, comprises one of the most obvious bottlenecks to our understanding of biodiversity. Meaningful conservation measures are to follow quickly (Cushman and Huettmann 2010; Drew et al. 2010). Substantial steps into these directions are concerted taxonomic assessments, for example, for the vascular plants of China, Nepal, and Pakistan by means of "eFloras" (Brach and Song 2006; eFloras 2010). However, the caveat is that much of this is still not strictly specimen based, but rather builds upon nationally bound checklists and synthetic treatments of very different qualities. Trans-national floras are not ranking high on the scientific agenda (see Funk 1993, with some obviously, already outdated perceptions), whereas these should ideally link national endeavors, regional treatments, and modern taxonomic revisions, with the latter obviously often being biased toward well-delimited, "overseeable," and rather smaller taxonomic entities. We can here only briefly mention the problems of "conceptual taxonomies," which the vegetation scientists community has also recognized and offered potential cures (Jansen and Dengler 2010). However, it seems that in the absence of consistent backbone taxonomies (perhaps, still pertaining to much outside Europe, North America), problems as to maintain specimen-species referential integrity in large databases, even on a local basis, safe at shared and interpretative levels, go far beyond that. Accordingly, physical documentation (collecting, preserving, and curating of good and representative herbarium specimens or other vouchers) and quality control must be stressed as often neglected, but still necessary, preconditions to vegetation- and ecology-related studies as well.

For historic, political, and practical reasons, much of the HUP database sampling followed largely opportunistic instead of systematic patterns. Positively, we consider the HUP database the least biased estimate, geographically and taxonomically, for the flora of a major part of the world's largest and highest mountain system. Its geographic strength lies in the western half of this region (Pamirs, Hindukush, Western Himalayas, Karakorum, and Western Tibet). This vast arid high mountain area is relatively poor in species and includes some of the most distinct (likely endemic) "cold spots" of biodiversity, apart from large deserts and the Polar Regions (Dickoré and Miehe 2002). However, western "High Asia" also constitutes a meeting ground of very different climatic regimes and is of great ecological and geological diversity (Nüsser and Dickoré 2002). Accordingly, its mountain flora is locally highly differentiated and is also relatively rich in endemics. The HUP database is thus about to contribute substantially to regional and other, specifically to be defined, inventories in that general area. Perhaps it can make for a global heritage in a digital online format, and for all to use, share, and enjoy?

Absolute species numbers remain guesswork. Dobremez et al. (1967–2009) enumerate 12,500 taxa of flowering plants for the Himalayas alone, which may be realistic if including all the highly diverse valleys and lower-altitude areas adjoining and extending into the Tropics. In contrast, the 5,500+ HUP database-accepted species result from rigorous scrutinity of much higher figures for names that would have resulted from a simple merging of published regional inventories. Considering a strong bias toward the higher altitudes, we may regard the HUP database as extremely well suited and representative, at least for the segment of plant life above 4,000 m elevation in the Himalayas and Tibet.

Making biodiversity data universally available in large record-based online repositories, such as GBIF, obviously opens promising prospects for a wide range of applications, but also poses some future problems. To some part, the collation of data from heterogeneous sources and of varying quality will accompany "loss of authority" and potentially inadequate higher-level interpretations or synonymies. However, information about species occurrence, locality, and point in time can be fed as raw data into data analysis to answer a number of new and relevant scientific as well as natural resource management and conservation questions (Elith et al. 2006; Huettmann et al., unpublished, for species predictions). Experiments with new nonlinear modeling approaches for such data show promising results even with "messy" and heterogeneous data (Craig and Huettmann 2009; Cushman and Huettmann 2010); synergies should be used. Again, taxonomic problems will probably appear, especially so for the still scarcely sampled or controversially treated regions and taxa. These problems can obviously only be handled with rigorous quality controls, not just for formal aspects and data integrity, but rather also on individual record and resource bases. The huge "Encyclopedia of Life" project (EoL 2011) may prove appropriate for collating and improving taxon-level information.

Returning to the issue of how we can manage regional and worldwide developments that likely result in substantial and accelerating threats to biodiversity, with species actually believed to go extinct before having come to scientific knowledge, some paradigm changes seem necessary. Pro-active management, before more harm occurs, and under what the IUCN has called the "precautionary principle" (IUCN 2007), is certainly desirable (Cushman and Huettmann 2010). We can obviously only try to conserve what we know, and taxonomy still provides the universal key to all properties of organisms including their potential uses and threats. There is no substitute for original, specimen-level biodiversity data based on ample sampling, documentation, authoritative taxonomies, and historical backgrounds, but it is intuitively clear that modeling and predictions for practical applications will also gain from increased quality of the underlying data basis. Perfect data, however, are rare, and many mountain regions remain scarcely sampled, even for allegedly well-known groups such as vascular plants.

The history of modern biodiversity exploration is brief, in the Himalayas occupying a mere 200 years, while dramatic ecological change and disturbance including massive deforestation, land degradation, melting glaciers, and increasing severity of natural hazards are very apparent and are happening almost everywhere. Historic data are thus precious, and not only because of the "priority principle" in biological taxonomy. Being often incomplete or ambiguous in terms of current scientific standards, they need to be examined on the broadest possible scale. Geographic bias could be overcome by targeted sampling, whereas remote-sensing, GPS, spatial databases, and geographic information system (GIS) software now offer a wide range of utilities to improve biogeographic documentation standards. In turn, these should also be improved and more consistently adhered to, for example, with regard to "verbatim" ecological information, parameters generated on the spot, and physical documentation. On the basis of consistent taxonomies, ecological niche models (see reviews in Cushman and Huettmann 2010 and Drew et al. 2010) could be developed and expanded to the identification of conservation priorities, for individual taxa and regions, and also for improving predictions and to adjust management goals. Elevation is among the most obvious and important factors (Körner and Paulsen 2010), but other mountain-specific, although even more scale-dependent, ecological parameters including slope, exposure, and ruggedness should be investigated. On the larger geographic and time scales, our understanding of phylogeographic questions as to continuity versus isolation, or speciation and persistence patterns, would certainly benefit from these studies, and so would the conservation management of the region.

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Part V
The Arctic

Chapter 7
Community-Based Surveys and Management of Walruses and Polar Bears in the Area of Cape Kozhevnikov (Chukotka, Russia)

Andrei Boltunov, Viktor Nikiforov, and Varvara Semenova

7.1 Introduction

The idea of involving local people in observations of wildlife is not unique. This approach seems especially reasonable in such areas as Chukotka, the most northeastern region of Russia. Historically, small native settlements appeared on the most productive parts of the coast that provided the highest chance for hunting marine mammals. In the twentieth century many such native settlements became extinct, although some changed into villages consisting mostly of native people (usually Chukchi). Today, there are ten such villages on the Arctic coast of Chukotka, numbering from 100 to 1,000 residents each. One of these villages is Ryrkaipiy, a comparatively large settlement (about 700 people) located on the western part of the Arctic coast of the Chukotski autonomous area of the Russian Federation (Fig. 7.1). Recent climate changes have brought new important components to the life of the village. Since 2007, herds of Pacific walruses have used, for about 2 months in autumn, a cape near the village as a resting site. It is interesting that the word Ryrkaipiy contains "ryrka," which means "walrus" in the Chukchi language. This toponymy allows us to speculate that in the past this place was also used as a walrus haulout, or perhaps people used it as a walrus hunting point.

The review of hydrometeorological processes in the Arctic Ocean in 2007 (Frolov 2008), prepared by the Arctic and Antarctic Research Institute (AARI, St. Petersburg, Russia), gives the following brief characteristics of changes observed in ice conditions

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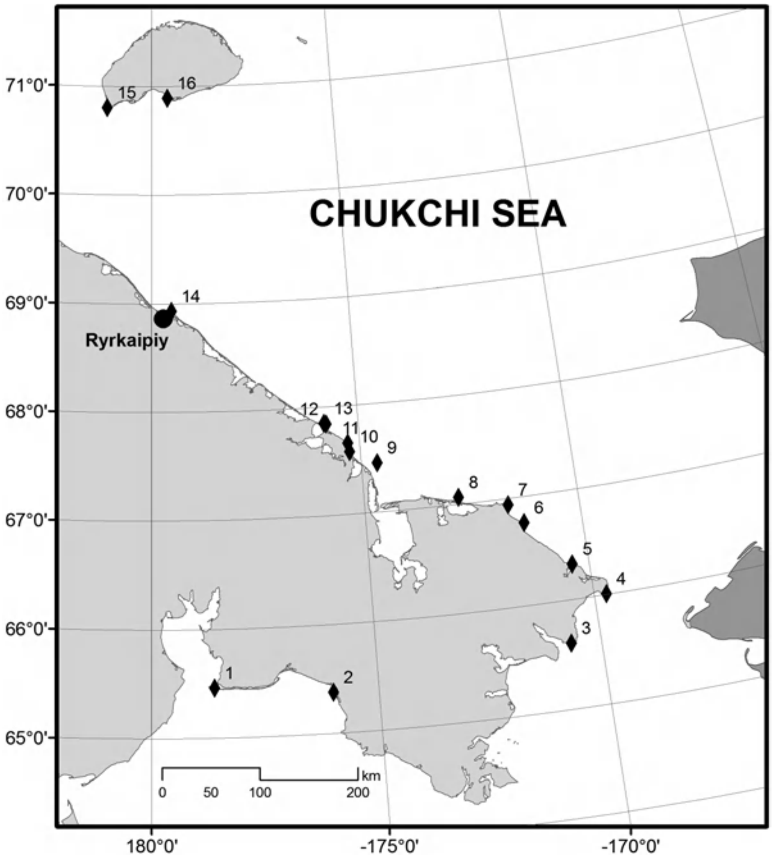

Fig. 7.1 Coastal haulouts of Pacific walruses in Russia in 2007–2009. *1*, Meechkyn Spit; *2*, Rudera Spit; *3*, Cape Nunyamo; *4*, Cape Peek (Dezhneva); *5*, Cape Unikyn (Inchoun); *6*, Cape Inkigur; *7*, Cape Serdtse-Kamen; *8*, Idlidlya Island; *9*, Kolyuchin Island; *10*, Cape Keleneut; *11*, Cape Onmyn; *12*, Karkapko Island; *13*, Cape Vankarem; *14*, Cape Kozhevnikov; *15*, Cape Blossom (Wrangel Island); *16*, Somnitelnaya Spit (Wrangel Island)

in the Arctic. In the period from the late 1950s until the late 1980s, ice conditions in the region fluctuated against a background of high ice cover; this basis then changed to a low ice cover in the 1990s, caused by warming temperatures recorded since the mid-1980s. Fluctuations of overall ice cover in the Russian Arctic seas in 1950–2007 were characterized by a well-marked overall negative linear trend. The average total amount of ice in the Arctic Ocean during the summer period has decreased by 20–30%. In September 2007, an abnormal decrease of ice cover was observed: the total area covered by sea ice was only 3.8 million km^2, compared to the previous normal area of 6.1 million km^2.

Such dramatic and abrupt changes in sea ice cover, one of the most important drivers of all ongoing processes in Arctic Ocean ecosystems, caused considerable change in the life of marine mammals: some species (i.e., whales, small cetaceans,

Fig. 7.2 Peak number of walruses on Cape Kozhevnikov, Chukotka (Russian Far East) in 2007. (Photograph courtesy of V. Khaustov)

eared seals) acquired an advantage for expanding their ranges while others (polar bear, walrus, ringed seal) are losing primary habitat. The life of Pacific walruses is tightly bound to sea ice. They spend the winter and give birth in the Bering Strait (Fay et al. 1984). In spring, they follow the retreating ice that moves northward (to the Chukchi Sea). By the end of summer, walruses start the autumn migration back to the wintering grounds in the Bering Strait. Until the mid-1990s, the walruses fed in a vast and comparatively shallow area of the Chukchi Sea during summer, using the scattered sea ice as resting platforms. They did not form coastal haulouts west of Kolyuchin Island (Sokolov and Krylov 2001) (see Fig. 7.1). However, because of recent climate changes, the shallow areas of the sea are now virtually ice free in summer, and the ice edge has retreated to deep water. Walruses following the rapidly retreating sea ice now end up in areas where they cannot feed normally because the water depth exceeds their diving abilities. In this situation, the only solution for walruses is to rest on shore, forming coastal haulouts (Boltunov and Nikiforov 2008; Kavry et al. 2008). As a result of the progressive decrease of summer ice in the Chukchi Sea since the mid-1990s, walruses now regularly form coastal haulouts on the capes of Kelienevyt, Onmyn, and Vankarem and on tiny Karkapko Isle, located just next to Cape Vankarem. In 2007, a new coastal haulout of walruses appeared on Cape Kozhevnikov (Kavry et al. 2008) (Fig. 7.2). A relevant protection status of the haulout was arranged by WWF Russia as a part of the "Polar Bear Patrol" project. In 2008 and 2009, the Marine Mammal Council, WWF Russia, and the All-Russian Research Institute for Nature Protection initiated a special project

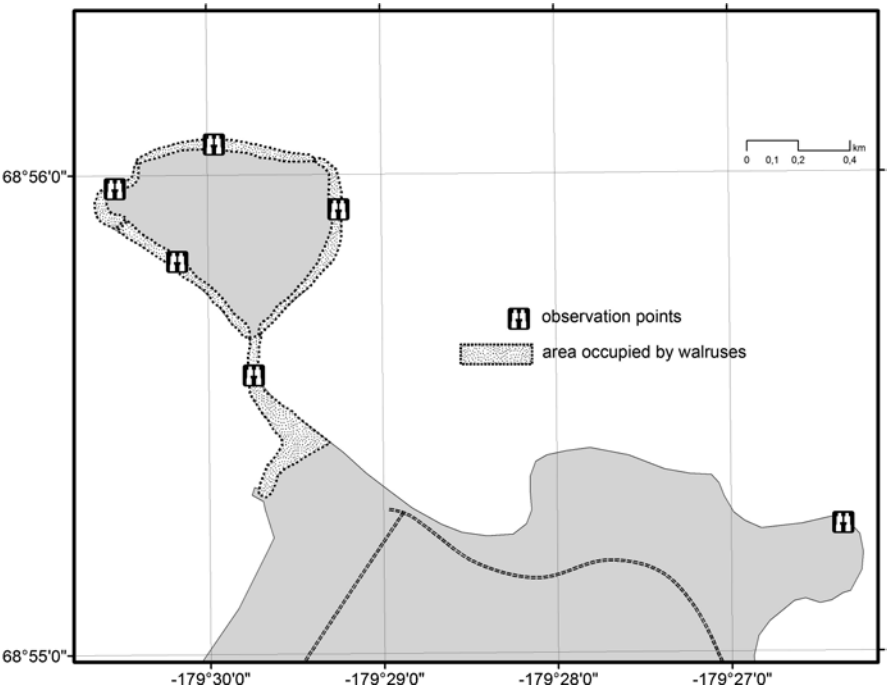

Fig. 7.3 Map of Cape Kozhevnikov, Chukotka (Russian Far East) showing observation points

on the monitoring and protection of walruses at this cape. The local branch of the Russian Association of Indigenous Peoples of the North, Siberia, and Far East took active part in this project. Authorities of the village of Ryrkaipiy, Iultinsky and Shmidtovskiy districts, and the Chukotski autonomous area provided comprehensive support for this activity.

The major aim of the project was to collect information that would provide a sound basis for the proper protection of Cape Kozhevnikov, an extremely important resting site for Pacific walruses (Fig. 7.3). In 2007, when walruses formed the haulout on the Cape for the first time, observations were performed by local people, using no special observation protocol. Most of the effort was aimed at protecting the animals and preventing more disturbance. In 2008 and 2009 observations covered the entire period when walruses appeared in the area (Table 7.1).

The main approach consisted of the following items:

- Management of the haulout site
- Education of the local people
- Collection of information about the haulout, such as:
  - Dynamics of walrus presence on the coast and in the nearest water area
  - Sex and age composition of walruses appearing in the area
  - Estimation of the number of walruses that died on the Cape and determination of mortality factors

Table 7.1 Observation effort and periods of walrus presence on Cape Kozhevnikov, Chukotka (Russian Far East), in 2007–2009

Year	Period of observations	Number of observation days	Period of walruses presence on the coast	Estimated maximum number of walruses
2007	Aug. 10–Oct. 30	Not estimated	Aug. 28–Oct. 30	About 50,000
2008	Aug. 28–Oct. 21	51	Sept. 22–Oct. 21	About 25,000
2009	Aug. 25–Oct. 22	48	Aug. 30–Oct. 22	About 45,000

7.2 Managing the Walrus Haulout and Education of the Local People

Analysis of the processes ongoing in the Pacific walrus population under recent ice conditions and the traditional knowledge of local hunters allowed us to propose that walruses could form a coastal haulout on Cape Kozhevnikov. However, this is possible only if the disturbance from village of Ryrkaipiy were reduced as much as possible. In 2007 we found residents of the village willing to secure and maintain a "quiet regime" on the Cape. The main task was to stop stray dogs from heading to the Cape and to ask people not to enter the area. In July special meetings were organized in the village to explain to people the importance of the project. On the day when first walruses hauled out on the cape (August 28, 2007), a special decree (#70 of 28.08.2007) was issued by the district authority. The decree announced that the Cape is a "quiet zone" during the period while walruses stay there. Similar decrees were issued in 2008 and 2009. When the number of walruses on the cape exceeded several thousands, they started to occupy steep slopes. It became obvious that any disturbance could provoke panic, which leads to high mortality of trampled animals. In general, people of the villages of Ryrkaipiy welcomed the appearance of the new large coastal haulout of walruses; they understood the restrictions imposed around the Cape. Local police supported the initiative and regularly patrolled the area of the Cape. However, some accidents happened in 2007. On September 6 several military aircraft passed over the Cape. Although the airplanes flew at a high altitude (about 8,000 m), the noise of their engines alone caused a big panic among the walruses. The head of the district authority applied to the authorities responsible for the flights and explained the situation. This information was taken into account, and such accidents never happened again during 2007–2009. The second big panic on the haulout in 2007 was induced by a simple tractor. On October 7 it approached the pier to prepare it for discharging cargo from a smaller cargo vessel. At that moment, the pier was surrounded by thousands of walruses and the tractor's appearance alone pushed all of them into the water. The work was stopped immediately, and the vessel was discharged using smaller boats. The district authority imperatively requested the enterprise that operates the pier to coordinate its activity with a team guarding the haulout. On October 10 the authority of the Shmidtovskiy district officially applied to WWF Russia asking help in establishing a nature protected area (Nature Monument) on the Cape to conserve one of the biggest haulouts of walruses in the world! On December 13, 2010 Nature Monument "Mys Kozhevnikova" was established.

In 2008 and 2009 the management of the haulout was improved, based on the experiences of 2007. In 2007, many walruses died during panics when rushing across the littered shore. Remains of ruined buildings and rusty metal constructions, and driftwood and so forth, not only interfered with the animals while they were hauling out but also served as an additional mortality factor for young walruses during panics. Thus, the local people decided to clean the shore before the walruses' arrival. Participants of the project, together with 15 local volunteers, performed for the first time in the Russian Arctic a cleanup of the shore just for walruses on August 30, 2008. Next day, schoolchildren from a local boarding school furthered the cleaning effort. Action groups with support of the local administration also applied to a regional civil aerial enterprise, asking that use of the local airstrip be stopped while the walruses are on the Cape. Airplanes landing on the strip, or taking off from it, inevitably fly right over the Cape. Following this request, one flight was postponed in 2008 and two in 2009.

Many people (residents of the village and guests) were interested to see walruses from a closer distance and take pictures. Guardians of the Cape formed small groups of such individuals and guided them carefully to specifically selected viewpoints. Participants of the projects regularly met with schoolchildren and gave them lectures about walruses.

Despite the fact that maximum measures were taken to protect the haulout, the dense crowding of the walruses led to mortality of the animals. Every year after walruses left the Cape, local action groups named "guardians of the walruses" removed most of the accessible carcasses from the shore and moved them into the tundra about 10 km away, which was done not only for sanitary reasons but because the numerous walrus remains act as a strong attractant for polar bears. In the period when the haulout is active, most polar bears are found in the ocean on pack ice. However, some part of the polar bear population remains, staying on shore for the summer. Some of these polar bears searching for food then visit the Cape (Fig. 7.4). Later in November–December, and when walruses are mostly gone, polar bears start coming in from the edge of the approaching pack ice (Boltunov and Nikiforov 2010). Their number on the Cape may exceed ten animals. Such a neighborhood with polar bears makes for quite a tense event, because the cape is less than 1 km away from the village of Ryrkaipiy. Occasionally, adult polar bear males push subadults away from the Cape that then head right to the village. Removing walrus carcasses from the Cape and placing them on the tundra away from the most probable path of incoming bears mitigates this situation.

7.3 Data Collected About the Walrus Haulout Site

Although the appearance of such a large number of walruses on the Cape in 2007 was somewhat anticipated, it still makes for a stunning event. No special observation protocol was initially prepared, and just basic observations were collected

Fig. 7.4 Polar bear eating walrus calf carcass at Cape Kozhevnikov, Chukotka (Russian Far East), in September 2009. (Photograph courtesy of V. Semenova)

by local residents. Fortunately, some of them took almost daily pictures of the haulout. In 2008 and 2009, observations were performed daily if allowed by weather (see Table 7.1).

In the course of the observations, the haulout was frequently photographed to register the distribution of walruses on the shore. State, approximate age, and sex composition of animals were assessed. Later, the photographs were used to estimate the number of walruses on the cape. We also registered the behavior of walruses on land and in the water area around the Cape, as well as the direction of movement of walruses approaching or leaving the cape area. Walruses occasionally left the Cape for different reasons: moving to feed, leaving the Cape for further migration, or simply responding to panics. In such cases we used the opportunity to examine the Cape by paying special attention to dead animals. When finding a carcass we registered its position and determined the age class and sex of the dead animal and the probable cause of death. In 2007, 577 carcasses were found on the Cape and on the adjacent coastline, 412 of which were calves of the year. In 2008, 149 carcasses were found, with 128 calves of the year among them; in 2009, 175 carcasses included 128 calves. The distribution and composition of dead walruses on the Cape reflected to a large degree the distribution and composition of walruses on the haulout with regard to intensive panics and the characteristics of the shoreline. In 2008 most of the carcasses (78%) were found at the southwestern side of the Cape, which is

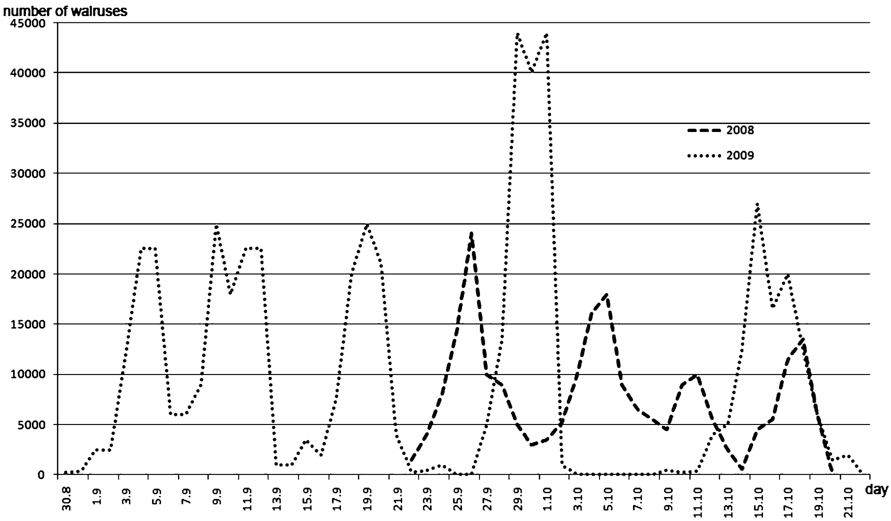

Fig. 7.5 Number of polar bears on Cape Kozhevnikov, Chukotka (Russian Far East), during 2008 and 2009

characterized by a multitude of large boulders; 101 juvenile calves were found there that had been crushed and died after a big panic on September 27. In 2009 the distribution of found carcasses was rather similar, which may be explained by the absence of massive panics.

It is generally difficult to estimate precisely the number of walruses on the Cape and in the surrounding waters. However, we used the following approach: From several observation points (see Fig. 7.2) we took high-resolution digital images of the haulout. Later on, we chose model plots in the images where all walruses were counted, and the actual density of walruses was estimated. The density was used to assess the number of walruses on the parts of the Cape, which were represented by certain model plots (Fig. 7.5). Clearly, this approach is suited for obtaining a basic index (minimum estimates) but not for precise estimates.

Satellite telemetry has shown that walruses not only rest on the Arctic coastal haulouts during migration but also perform short-distance round trips for feeding (Kochnev et al. 2008). Our observations agree with these results. Animals approached the Cape in loose herds numbering from hundreds to several thousand walruses. They aggregated near the Cape and then started to haul out on shore. As a rule, considerable but unknown numbers of the walruses stayed in waters near the Cape. The proportion of walruses in the water to those resting on land depended mainly on weather conditions. If the sea was calm, most animals preferred to rest in the water. The number of walruses and their composition in the area of the Cape never remained stable during a single season (see Fig. 7.5). We found it depended on the following factors:

- The coming and going of migrating walruses is characterized by a change in the sex and age composition of the walruses in the area of the Cape. Some of the

newly arriving walruses that had been many days in the water swimming from the ice edge to the Cape had a characteristic whitish color of the skin. Also, the behavior of new walruses on land was more skittish and nervous when compared to animals that already spent some days on the haulout.
- Panics were provoked by both natural and human-related reasons. Usually, walruses returned shortly after such panics, but in some cases, they left the area and continued their migration southeastward.
- During feeding trips (i.e., Sept. 13, 2009), walruses leave the area for several days for feeding and return in the same age and sex composition.

7.4 Conclusion

The newly reported coastal haulout of Pacific walruses on Cape Kozhevnikov presents the most western haulout and one of the largest in the world. This haulout has appeared as a response to the dramatic reduction of sea ice in this sector of the Arctic. Walruses on land are very sensitive to disturbances. Only comprehensive conservation and management measures undertaken by the local community, with environmental nonprofit funds and researchers, have allowed walruses to have a rest site in the immediate vicinity of the coastal village of Ryrkaipiy. Taking into account the turnover of animals during the season, one can propose that the overall number of walruses passing through the Cape exceeds 100,000, more than a half of the estimated population size for Pacific walruses (Speckman et al. 2011). In the past, the Cape was also used by female polar bears for maternity denning. Immediately recognizing the high importance of this Cape for walruses and polar bears, WWF Russia, the All-Russian Research Institute for Nature Protection, and the Marine Mammal Council prepared all necessary documentation for establishing a regionally protected area (nature monument), “Cape Kozhevnikov,” that has been established on December 13, 2010. This establishment provides a very important step when taking into consideration the plans for economic development of the region.

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Chapter 8
Toward the New Role of Marine and Coastal Protected Areas in the Arctic: The Russian Case

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8.1 Introduction

In the climate system of our planet, the Arctic is one of the most sensitive areas. Cyclic and other oscillations in the Arctic climate and sea ice cover are well documented (Alekseev 2004; Frolov et al. 2009; Macias Fauria et al. 2010). In past decades, the strong natural variation has interfered with anthropogenic forcing of the greenhouse effect. Although its contribution still stimulates hot discussion, much evidence of rapid climate change in the polar regions has already been seen at the end of the twentieth century and into the beginning of the twenty-first century (Anisimov et al. 2007; Rahmstorf and Schellnhuber 2006). Decrease in the

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extent of perennial sea ice, increases of air and water surface temperatures, and accelerated abrasion of permafrost coasts all lead to changes in the marine and coastal ecosystems of the Arctic. The causes and long-term tendencies of these climatic changes are largely unclear, which creates considerable uncertainty in climatic forecasts for the Arctic and Subarctic (ACIA 2005; Anisimov et al. 2007; Sommerkorn and Hassol 2009; Bollmann et al. 2010). At the same time, the Arctic is entering a new phase of economic development. The proponents of industrial expansion to the Arctic hope that decrease of the summer sea ice coverage and generally milder climate conditions will facilitate offshore oil and gas development. New industrial offshore and coastal projects will likely increase the footprint on ecosystem "hotspots" (Spiridonov 2006). However, the impact may be mitigated using instruments of marine spatial planning (Ehler and Douvere 2009). One of the instruments incorporated in the spatial planning is the development of marine protected natural areas.

An important task that natural protected areas fulfill is to create places where nature would be allowed to provide for itself, where species, populations, and entire ecosystems could thrive free of negative influences, using their own inherent mechanisms to adjust to changing conditions, perhaps even with some aid and protection provided by humans.

If appropriately designed, marine and coastal protected areas (MCPAs) can effectively mitigate particular threats at the regional and local scale (Mokievsky 2009). Furthermore, protected areas balance various kinds of space and resource use (Reimers and Shtilmark 1978). Another purpose of zapovedniks (a specific Russian legal term meaning strictly protected nature reserves), national parks, and other protected nature areas is to alert us to changes taking place in nature. In the USSR and Russia, zapovedniks traditionally also served as research stations where records of natural events, so-called Chronicles of Nature, have been kept: these chronicled data are essential for understanding the long-term processes in natural ecosystems. Although these datasets have a number of shortcomings and processing the time span of the records is often difficult, they are valuable (Reimers and Shtilmark 1978). Also, these records have become increasingly important for understanding the biodiversity consequences of climate change (Kokorin et al. 2001).

The Russian Federation has historically established a set of coastal and marine protected areas in the Arctic, although only a few of them have been designed with a focus on marine biotopes and ecosystem conservation. The purpose of the present chapter is to review the globally unique polar network of marine and coastal protected natural areas in Russia, to evaluate their role and potential for biodiversity conservation and monitoring in the changing Arctic, and to discuss the priorities of development.

8.2 Abbreviations, Terms, and Concepts Used in This Chapter

AARI Arctic and Antarctic Research Institute

CAFF Working group for Conservation of Arctic Flora and Fauna of the Arctic Council

EEZ	Exclusive economic zone
Flaw polynya	A term used by the AARI specialists to designate offshore polnyas, which may be stationary (more than 75% of occurrences), stable (50–74%), or episodic (frequency of occurrence less than 50%)
GEF	Global Environmental Fund
IUCN	World Conservation Union
MCPA	Marine and coastal (specially) protected area
METT	Management effectiveness tracking tool scorecard
MMBI	Murmansk Marine Biological Institute
MNR	Ministry of Natural Resources and Ecology of the Russian Federation
NGO	Non-governmental organization
SPA	Specially protected area
UNDP	United Nations Development Program
VMS	Vessel monitoring systems
WWF	The conservation organization also known as World Wildlife Fund

8.3 Data Sources and Methods of Analysis

The data on the federal and regional MCPAs in the Russian Arctic used in the present review were derived from the survey by Zabelina et al. (2006), corrected and complemented with the information provided by the MNR and the regional administrations. For geospatial information on the location of protected areas, we used the database that was jointly developed by several Russian NGOs (Anonymous 2002–2010).

A management effectiveness assessment of the Arctic SPAs with emphasis on their marine and coastal parts was conducted as part of a preparatory work to the UNDP/GEF project “Strengthening of Marine and Coastal Protected Areas in Russia.” The METT methodology (Stolton et al. 2007) was used. In completing the scorecards, experts focused upon the design, boundaries, protection system, research, and cooperation specifically related to the marine and coastal parts of the SPAs. These scorecards were also used in the evaluation of threats to biodiversity within MCPAs.

The potential for the extension of the MCPA system was evaluated in several steps of the gap analysis conducted by WWF Russia (Krever et al. 2009). By doing this we focused first on the identification of representative areas that may host marine ecosystems and which are characteristic for particular regions selected according to certain regionalization schemes (Ivanov 2011; Spiridonov 2011). Second, so-called biodiversity hotspots based on key marine and coastal biotope systems and biological entities were identified (Table 8.1). Their coverage by MCPAs was assessed throughout the Arctic.

Table 8.1 Valued biodiversity features associated with particular biotopes in the maritime Arctic

	Essential biodiversity feature											
Biotopes	1	2	3	4	5	6	7	8	9	10	11	12
Wadden shores	+	–	–	–	–	–	–	–	–	–	+	+
Maritime marsh massifs	+	–	+	–	–	–	–	–	+	+	+	+
Tombolo and spits	–	–	–	–	+	+	–	–	+	–	+	+
Coastal cliffs and rocky shores	–	–	–	–	–	–	–	–	+	–	–	+
River mouth areas	+	+	+	+	NA	–	+	–	+	+	+	+
Highly productive shallows and bays	+	+	+	+	+	–	–	+	+	+	+	+
Relict lakes	–	–	–	–	–	–	–	–	–	–	NA	+
Flaw polynyas	NA	+	+	+	–	+	+	+	–	–	+	+
Marginal ice zone	+	+	+	+	–	–	+	+	–	–	+	+
Stable sea ice	–	–	–	–	–	+	–	–	–	+	–	–
Oceanographic fronts	+	+	+	+	–	–	–	+	–	–	+	+
Upwelling zones	+	+	+	+	–	–	–	–	–	–	+	+
Seamounts and banks	+	+	+	+	–	–	NA	–	–	–	–	+

Features: 1, aggregations, colonies of benthic animals; 2, patches of high biomass of benthic organisms; 3, breeding and spawning grounds of vertebrates; 4, feeding grounds of aquatic organisms; 5, haulouts of marine mammals; 6, whelping areas of marine mammals; 7, wintering aggregations of aquatic organisms and seabirds; 8, wintering places of seabirds and waterfowl; 9, breeding aggregations of marine and aquatic birds (colonies); 10, molting aggregations of seabirds and marine mammals; 11, migration routes and stopovers; 12, habitats of rare and endangered/specially protected species

Sign + indicates that these biological phenomena are associated with a particular biotope or landscape

The concept of this table was developed by the authors and the other participants of the Petrozavodsk workshop on planning MCPAs in the Russia organized by WWF Russia in 2007 (see Acknowledgments)

8.4 Marine and Coastal Specially Protected Areas in the Russian Arctic

According to Russian legislation, the internal marine waters, the territorial sea, the EEZ, and the continental shelf are under federal jurisdiction. Therefore, legally, marine protected areas can be established only at a higher administrative level and must have a federal status. Their creation and functioning is regulated by the Federal Law “On specially protected natural areas” (#33 FZ of 14 March 1995).

The patchy network of federal SPAs in the Arctic coastal zone was shaped by the history of their development (Table 8.2; Fig. 8.1). Long-term planning and analysis of the challenges of preserving biological diversity played no significant role in their formation. Five of the strictly protected nature reserves or *zapovedniks* encompass marine compartments [Kandalakshskiy, Nenetskiy, The Great Arctic Reserve, Taymyrskiy Biosphere Zapovednik, and Wrangel Island (Ostrov Wrangelya)], whereas two zapovedniks have only maritime buffer zones (Gydanskiy and Ust’-Lenskiy). Another federal reserve with a marine area, the Koryakskiy

Table 8.2 Federal marine and coastal protected areas in the Russian Federation

Name of reserve	International status	Sea	Coverage of integral marine ecosystems (see text)	Terrestrial coastal habitat (ha)	Marine habitat (ha)	Total area (ha)	Marine buffer zone (ha)	Year of establishment
Zapovedniks (IUCN category I)								
Kandalakshskiy	RW	Barents, White	Porya Guba, semi-isolated inlets	20,947	49,583	70,530	0	1932
Koryakskiy	RW	Bering	NA	244,156	83,000	327,156	0	1995
Nenetskiy	–	Barents	–	131,500	181,900	313,400	242,800	1997
Gydanskiy	–	Kara	–	878,174	0	878,174	60,000	1996
Great Arctic (Bolshoi Arkticheskiy)	–	Kara, Laptev	Insular waters of eastern Kara Sea archipelagos	3,188,288	980,934	4,169,222	0	1993
Taymyrskiy	BR	Laptev	–	1,744,910	37,018	1,781,928	0	1979 (1994)[a]
Ust'-Lenskiy (Lena-Delta)	RW	Laptev	–	1,432,000	0	1,433,000	1,050,000[b]	1985
Wrangel Island	WH	Chukchi	Insular waters	795,650	1,430,000	2,225,650	3,240,000	1976
National parks (IUCN category II)								
<<Russian Arctic>>	–	Barents	Coastal waters	632,090	793,910	1,426,000	0	2009
Zakazniks (IUCN category IV–V)								
Franz Josef Land	–	Barents	Insular waters and polynyas area	1,600,000	2,600,000	4,200,000	0	1994
Nenetskiy	–	Barents	–	188,500	120,000	308,500	0	1985
Nizhne-Obskiy	RW	Kara	–	128,000	0	128,000	0	1985

(continued)

Table 8.2 (continued)

Name of reserve	International status	Sea	Coverage of integral marine ecosystems (see text)	Terrestrial coastal habitat (ha)	Marine habitat (ha)	Total area (ha)	Marine buffer zone (ha)	Year of establishment
Severozemelskiy	–	Kara, Laptev	–	367,771	53,930	421,701	0	1996
Nature monuments (IUCN category III)								
Mogilnoe Lake	–	Barents	Isolated meromictic lake	0	17	17	0	1985

International status: *RW* Ramsar wetland; *BR* UNESCO Biosphere Reserve; *WH* World Heritage site
[a]Year of extension to the coast of East of Taymyr and acquisition of a maritime buffer zone
[b]Including marine zone in the outer Lena Delta and New Siberian Islands
Source: Data from Zabelina et al. (2006) (corrected and complemented)

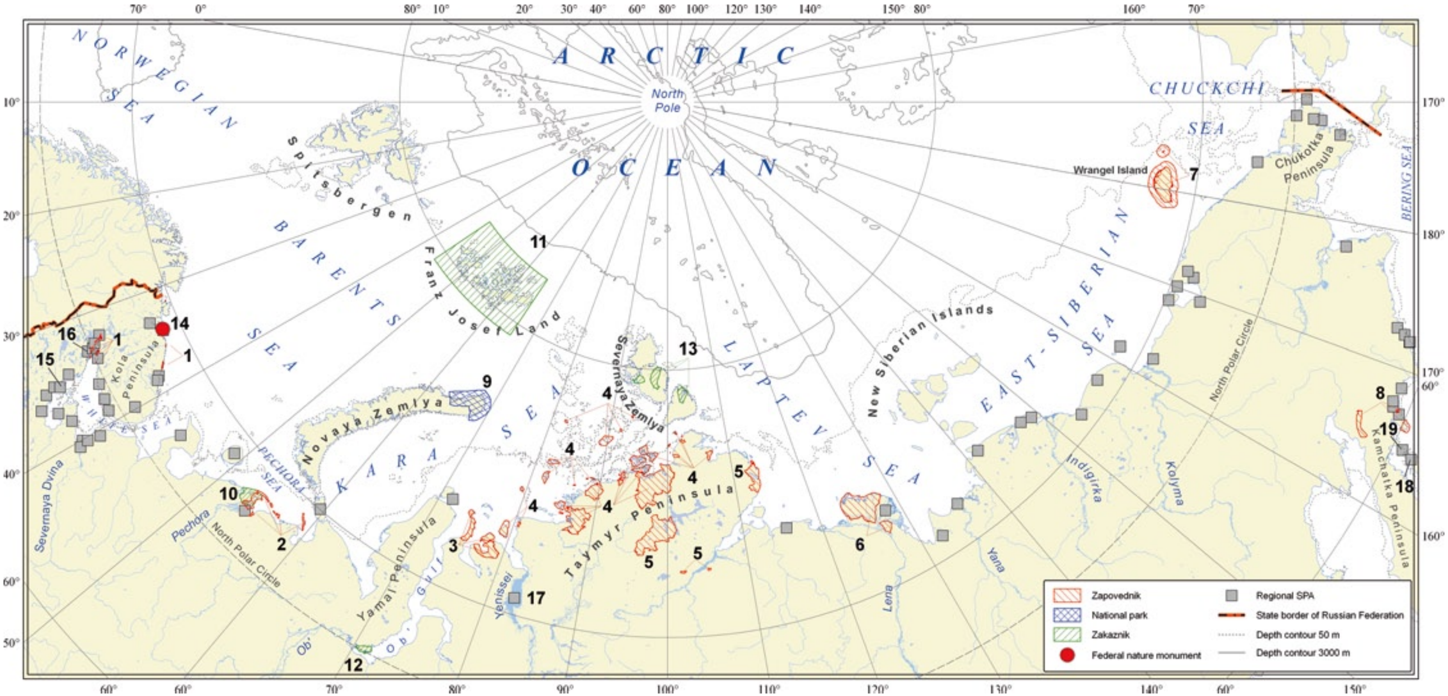

Fig. 8.1 Map of marine and coastal specially protected area (SPA) in the Russian Arctic. Zapovedniks (strictly protected nature reserves): *1*, Kandalakshskiy; *2*, Nenetskiy; *3*, Gydanskiy, *4*, Great Arctic; *5*, Taymyrskiy; *6*, Ust'-Lenskiy; *7*, Wrangel Island; *8*, Koryakskiy. National parks: *9*, Russian Arctic. Zakazniks: *10*, Nenetskiy; *11*, Franz Josef Land; *12*, Nizhne-Obskiy; *13*, Severozemelskiy. Nature monument: *14*, Mogilnoe Lake. Ramsar or other international conventions sites having a status of regional SPA: *15*, Kuzova Islands; *16*, Poliarnyi Krug; *17*, Brekhovskie Islands; *18*, Karaginskiy Island; *19*, Verkhoturov Island (see Tables 8.2 and 8.3)

zapovednik, is located in the northern Bering Sea, which is also assigned to the Arctic. The Komandorskiy Biosphere zapovednik, located in the southwestern Bering Sea and possessing an extensive marine area (about 30,000 km^2), is not considered here as an Arctic reserve because it has considerable specificity (although some relevant examples related to this reserve are mentioned in sections 8.9 and 8.10). Recently a new national park, "Russian Arctic," has been established in the northernmost Novaya Zemlya Archipelago with a marine zone expanding to the entire territorial waters, that is, within 12 nm from the coastline. Aside from these, there are four federal state reserves (or *zakazniks*, a Russian national category corresponding to the IUCN category IV or V) including Franz Josef Land Archipelago (with an extensive marine area), Nenetskiy, Nizhne-Obskiy, and Severozemelskiy, and the federal nature monument Mogilnoe Lake (a meromictic lake of marine origin with marine biota). The summed area of all offshore compartments (including marine buffer zones) located within federal protected areas in the Arctic Ocean (excluding the Bering Sea) totals 95,583 km^2, which constitutes approximately 2% of the areas of the Russian Arctic seas (internal marine waters, territorial sea, and the EEZ).

Regional specially protected nature areas can legally only be established on land. In reality, some regional protected areas (which are recognized internationally), although located onshore, can protect marine environment as well (Table 8.3). The federal MCPA are also complemented by other "specially designated or managed" areas that fit the IUCN criteria of particular types of marine protected areas. These are first of all the areas called marine mammal protection zones, which surround important marine mammals rookeries and haulout sites on the coast of Chukotka and in the northwestern Bering Sea (in addition to the Arctic waters, they have mostly been established in the coastal zone of Kuril Islands). In the Soviet time they corresponded to IUCN category IV or V and were legally supervised by the Ministry of Fishery Industry of USSR Order #349 (1986). Now, this regulation is superseded by the new Fishing Rules for the Russian Far East and adjacent parts of the Arctic Ocean adopted according to the Federal Law on Fishery and Protection of Aquatic Bio-Resources (#166 FZ of 20 December 2004). These rules confirm the no-fishing status of the areas around important marine mammal protection zones; however, they do not specify objectives of management and do not regulate the nonfishing impacts as the Order of 1986 had been doing earlier. In fact, there are numerous indications that the special regime of haulout protection that was established according to this Order is neither honored nor much complied with by the local population and visitors, nor is it much enforced (Kochnev 2010), although there is some positive development (see Chap. 7, this volume, on walruses). The total area of the marine mammal protection zones in Northeastern Russia amounts to 20,968 km^2,or about 4% of the total area of Chukchi Sea, the Bering Strait, and the Gulf of Anadyr under Russia's jurisdiction. In addition to this fishery closure, some areas have been historically introduced according to the basin fishing rules: these include important zones that are closed for bottom trawling in the Barents and the Bering Seas, while most of the estuaries of the great Siberian rivers (e.g., Ob' and Yenissei where important stocks of semi-anadromous fishes spend the winter) are closed for commercial fishery.

Table 8.3 Regional nature protected areas that have an international status important for protection of adjacent marine waters

Name of reserve	Region	International status	Sea	Terrestrial coastal habitat (ha)	Marine habitat (ha)	Total area (ha)	Year of establishment
Kuzova Islands	Republic of Karelia	RW	White	993	2,667	3,660	1991
Poliarnyi Krug[a]	Republic of Karelia	RW[b]	White	24,916	3,384	28,300	1990
Brekhovskie islands	Krasnoyarskiy Krai	RW	Kara	288,193	291	288,484	1999
Karaginskiy Island	Kamchatskiy Krai	RW	Bering	–	–	200,000[c]	1971
Verkhoturov Island	Kamchatskiy Krai	Site of the Russia/US and Russia/Japan Conventions on Migratory Birds	Bering	–	–	800[d]	1976

RW Ramsar wetland
[a]The reserve is unofficially managed by the N.A. Pertsov White Sea Biological Station of the Moscow University
[b]Area adjacent to Kandalkshsky Zapovednik
[c]Including 2-mile marine zone around the island
[d]Including 1-mile zone around the island
Source: Data from Zabelina et al. (2006)

8.5 Essential Marine and Coastal Biodiversity Features, Important Biotopes, and Monitoring Sites in Russia's Arctic MCPAs

The MCPA cover a variety of marine and coastal habitats, but their importance in context of general aims of marine environment and biodiversity protection differs significantly. In this section, we briefly describe essential biodiversity features of the existing MCPAs, also mentioning a spatial scale of some marine biotopes covered by these reserves as it is highly relevant for fulfilling the tasks of protected areas in the marine environment (Mokievsky 2009). The importance and potential of the MCPAs as sites and stations for monitoring of changes in the Arctic biodiversity are also mentioned. This potential depends in particular on the datasets that have been already obtained in the course of long-time research in the reserve's area.

8.5.1 White and Barents Seas

The Kandalakshskiy Zapovednik covers the archipelago systems in the western White Sea (Kandalaksha Bay) and in the southern coastal Barents Sea (Karpovich 1984). Important marine and coastal biotopes under protection include segments of the East-Atlantic Flyway (Scott and Rose 1996; Krasnov et al. 2006a,b), breeding, molting, and wintering grounds of seaducks, first of all the common eider (*Somateria mollissima*) and the endangered Steller's eider (*Polysticta stelleri*) of the Atlantic population (Krasnov et al. 2004b, 2006a), semi-isolated, stratified inlets (such as the Babye More Inlet) in the White Sea, insular seabird colonies along the north coast of the Kola Peninsula (with surrounding so-called ornithogenic communities; see Breslina 1987) (Fig. 8.2), and seal habitats (including those of the gray seal *Halichoerus gripus* on the easternmost boundary of the species range) (Kondakov 1999).

However, only a few marine areas were truly integral marine ecosystems, consisting of more than just their deliberately cut coastal portions that are protected. The Porya Guba, a shallow bay with specific oceanographic regime within the western White Sea, lies entirely within the Kandalakshskiy zapovednik's border and represents, because of its size (135.6 km^2) the system at the main level of the functioning of coastal ecosystems where elementary units of the mosaic (local communities) are arranged in a regular or stochastic manner (Mokievsky 2009). The fine-scale georeferenced survey of the Porya Guba, which was conducted in 1978 by the MMBI expedition and led by N.E. Denisov, was a unique and very promising case study for monitoring purposes that has never yet been revisited. Also, unfortunately, only some results of this survey have been published to date (Ozolinsh 1987).

For many years, the Kandalakshskiy zapovednik has been hosting summer field studies in marine ecology, which are performed by motivated school and university students from St. Petersburg, Moscow, Murmansk, and Petrozavodsk and school students from the neighboring town of Kandalaksha. Three permanent marine

Fig. 8.2 Seabird colony on Kharlov Island, Seven Islands Archipelago, Barents Sea. In the center is a Northern gannet (*Sula bassana*), a species that has expanded its nesting range to the Barents Sea in the 1980s. (Photograph courtesy of Yury Krasnov)

biological stations (NA Pertsov White Sea Biological Station of the Moscow University, OA Skaralato White Sea Biological Station of the Zoological Institute of the Russian Academy of Sciences, and the Marine Biological Station of St. Petersburg University: for their history and importance see Khlebovich 2007; Krasnova 2008) are located close to its border in Kandalaksha Bay. Therefore, marine species diversity in the waters of Kandalaksha Bay within the reserve area is probably better documented than in any other marine area of comparable size in Russia (Grishankov et al. 2000; Tchesunov et al. 2008), although there are still major gaps (Tchesunov 2008). Currently the NA Pertsov White Sea Biological Station has launched the online version of the Tchesunov et al. (2008) catalog (http://biota.wsbs-msu.ru/wiki/index.php/); this online resource can be continuously updated, so assessment of the biota of the important part of the Kandalakshskiy Zapovednik and the adjacent areas now involves a number of specialists associated with the NA Pertsov Station and the Kandalakshskiy zapovednik.

This zapovednik also has the longest time series of observations on colonial seabirds in the Barents Sea, which was launched by L.O. Belopolski (1957), as well as the seaducks in the White Sea. The observations on seabird colony dynamics indicated major change in the Barents Sea ecosystem following the decline of the capelin (*Mallotus mallotus*) stock in the 1980s (Krasnov et al. 1995). Later, the general situation in the country and the lack of consistent strategy within the administration of protected areas in Russia led to diminishing research capacity of the zapovednik, an interruption of these observation series (Krasnov and Barret 2000) and breaking integration of the colonial seabird observation program by academic science.

The Nenetskiy Zapovednik includes marine areas adjacent to continental part of the reserve in the Pechora Bay area and those surrounding the Dolgiy Island in the Pechora Sea. Among important marine and coastal biotopes one should mention the feeding areas of coregonid whitefishes in the almost freshwater Korovinskaya Inlet in the outer Pechora Delta, the largest known haulouts of the Pechora population of Atlantic walrus (*Odobenus rosmarus rosmarus*) on Dolgiy Island (Boltunov et al. 2010), and major breeding, molting, and staging grounds of waterfowl and waders (Krasnov et al. 2006a). Biotopes that are characteristic for the region are laidas and marshes of the Russkiy Zavorot Peninsula and Dolgiy Island and sandy tidal and shallow subtidal flats of the Pechora Sea. The spatial scale of marine areas under protection is small, and they do not encompass integral marine ecosystems and the variety of shallow-water benthic communities observed in the southeastern part of the Barents Sea (Denisenko et al. 2003; Kucheruk et al. 2003). However, the marine boundaries of the zapovednik cover such important benthic biotopes as densely populated subtidal blue mussel (*Mytilus edulis*) beds, which provide food to numerous seaducks (Gavrilo and Strøm 2005; Sukhotin et al. 2008). Tens of thousands of king eiders (*Somateria spectabilis*) (Fig. 8.3) from West and Central Siberian breeding grounds gather here for the molt and to refuel at sea before migration to their wintering grounds; black (*Melanitta nigra*) and velvet (*M. fusca*) scoters stop here as well during their summer and autumn migration, and flocks of other seaducks, including the long-tailed duck (*Clangula hyemalis*) and Steller's eider, mostly make use of the inshore waters of Dolgiy Island during the postbreeding season (Isaksen et al. 2000; Krasnov et al. 2002, 2004b).

The Franz Josef Land zakaznik (established in 1994) (Fig. 8.4) protects a set of unique and characteristic components of the High Arctic biodiversity, including the most northern kelps, seabird colonies of High Arctic type, habitats of a number of rare and endangered Arctic species including the ivory gull (*Pagophila eburnea*), Atlantic walrus, polar bear (*Ursus maritimus*), bowhead whales (*Balaena mysticetus*) of endangered Spitsbergen stock, and narwhales (*Monodon monoceros*) (Gavrilo et al. 2007; Tsyganova et al. 2009a). Extensive marine areas included in the zakaznik offer a prospective for integral protection of the marine ecosystem. A system of recurrent polynyas adjacent to the Franz Josef Land and the system of leads in the sounds of this archipelago sustain local populations of ice-dependent marine

Fig. 8.3 King eiders (*Somateria spectabilis*) concentrating near the Dolgiy Island, Nenetskiy Zapovednik, southeastern Barents Sea. (Photograph courtesy of Yury Krasnov)

Fig. 8.4 Polar bear (*Ursus maritimus*) at the ice edge. Franz Josef Land Archipelago Zakaznik. (Photograph courtesy of Maria Gavrilo)

mammals all year round. There are wintering grounds of Atlantic walruses, bowhead whales, ringed seals (*Phoca hyspida*), bearded seals (*Erignathus barbatus*), and seal-predating polar bears (Belikov et al. 2002; Gavrilo 2010; Gavrilo and Ershov 2010; Gavrilo and Popov 2011a). Studies of the coastal marine biodiversity of the archipelago began in the 1970s (Golikov and Averintsev 1977). The marine areas of

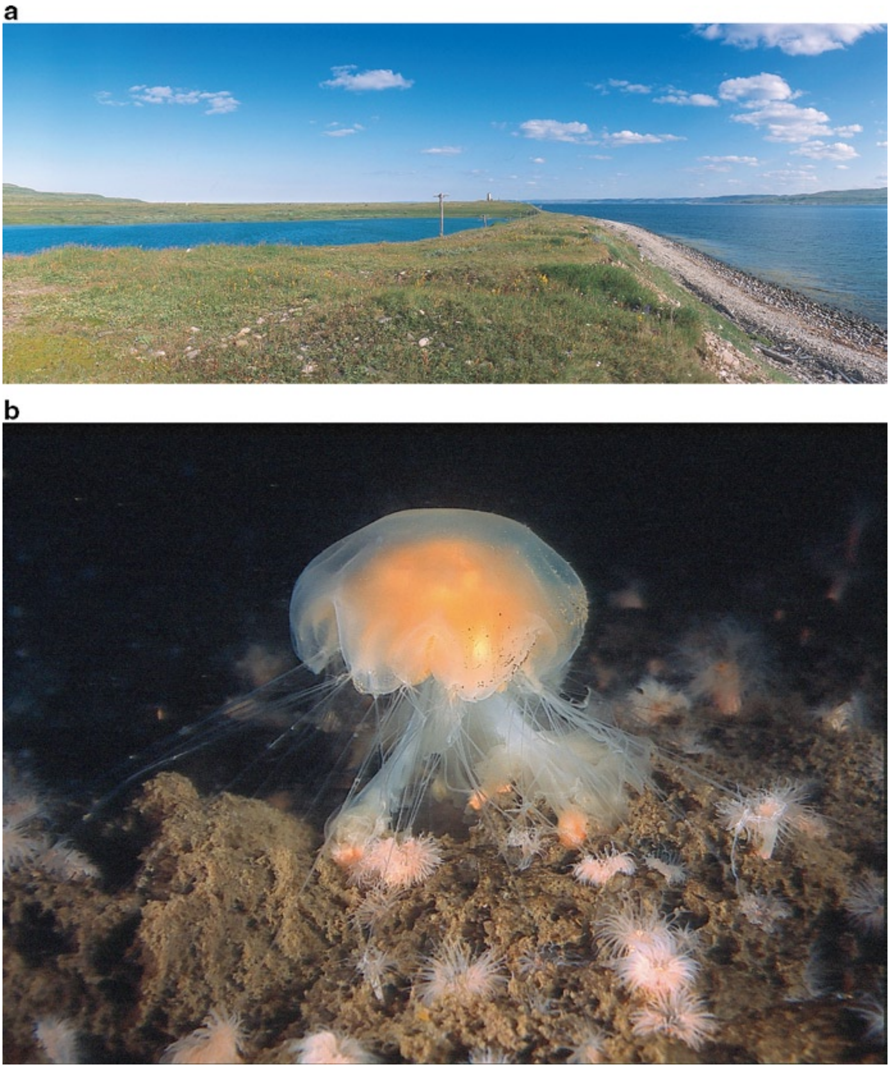

Fig. 8.5 (**a**) Meromictic Mogilnoe Lake, Kildin Island, Barents Sea, the federal nature monument. The meromictic lake (*left*) is separated from the sea by a natural dyke. (Photograph courtesy of Mikhail Fedyuk.) (**b**) Mogilnoe Lake: medusa *Cyanea capillata* caught by the predatory sea anemones *Metridium senile*. (Photograph courtesy of Mikhail Fedyuk)

the zakaznik are visited by occasional expeditions (e.g., Franz-Josef Land Archipelago 2004; The Russian Arctic 2008), but regular ecological surveys and integral ecological and biodiversity monitoring programs are lacking.

The meromictic Lake Mogilnoe on Kildin Island (protected as a nature monument) houses a unique assemblage of marine fauna isolated from the sea (Fig. 8.5), which in particular includes a form of cod described as a separate subspecies, *Gadus morhua mogilnensis* (Derjugin 1925). The lake is sporadically visited by scientific expeditions that document its biological diversity and the changes taking place since the first comprehensive account of the lake's biota by Derjugin (1925). These rare research visits remain the only way of recognizing human-induced threats to this unique natural phenomenon and raise alarm calls from inspections in the field (Strelkov et al. 2005).

8.5.2 Kara Sea

Nizhne-Obskiy Zakaznik is located on the floodplain of the inner Ob' Bay (Obskaya Guba), presenting a diversity of coastal biotopes: islands, lakes, channels, marshes, and meadows. This practically freshwater system (listed as an International Ramsar Site) is part of the vast Ob' estuary and an important node of the West Asian–African and Black Sea–Mediterranean Flyway (Golovatin 2006; Zabelina et al. 2006).

Gydanskiy Zapovednik does not have offshore areas (only a small buffer zone) but protects the coastal biotopes and ecosystems of Yavai, Mamont, and Oleniy Peninsulas and those of several islands and island groups (Shokalsky, Oleniy, Proklyatye, Pestsovye, Rovnyi). Important biotopes are the Arctic maritime tundras and laidas, which serve as nesting and staging areas for waterfowl (Sergienko 2011). None of the areas covers integral marine and coastal ecosystems, and the biology of the laidas and coastal waters of the Kara Sea in the zapovednik area is still insufficiently studied.

The Great Arctic Reserve (Zapovednik) includes seven archipelagoes in the northeastern Kara Sea. In this area, the fast ice persists for a long time, even in the current period of decreasing summer sea ice cover. Because of the harsh ice conditions, this area is still practically unstudied with regard to marine and coastal biodiversity. However, the protected coastal waters around the islands fit the scale criteria of integral shallow marine ecosystems: they deserve greater attention. If the tendency of decreasing summer sea ice cover continues, the waters around the islands in the northeastern Kara Sea, which even nowadays practically never become ice free, in contrast to the southwestern Kara Sea (Zubakin 2007), may serve as an important refugia for ice-associated biota (Gavrilo 2009). The Severozemelskiy Zakaznik has several clusters bordering both the Kara and the Laptev Seas. The offshore areas are very small and do not cover important marine biotopes, that is, the flaw polynyas west or east of the archipelago, which are integral part of the coastal ecosystem (Gavrilo et al. 2011). Small ice-bound islands of the northeastern Kara Sea (Fig. 8.6), including those protected within the Great Arctic Reserve and the Severozemelskiy Zakaznik, provide optimal breeding habitats for the ivory gull, the endemic species of the High Arctic red-listed by IUCN; here, the world's largest known colonies are located (Gavrilo et al. 2007).

Fig. 8.6 Endemic species of the High Arctic. Ivory gull (*Pagophila eburnea*) in the breeding colony on the Domashniy Island, Severnaya Zemlya archipelago, eastern Kara Sea. (Photograph courtesy of Maria Gavrilo)

8.5.3 Laptev Sea

Eastern clusters of the Severozemelskiy Zakaznik include coastal segments with important seabird colonies of the extreme High Arctic type, the species composition of which is dominated by dovkie (*Alle alle*) at their easternmost breeding range, but lacks thick-billed murres (*Uria lomvia*) because of the severe summer ice conditions. However, important adjacent marine habitats, including flaw polynyas and the marginal ice zone coincided with the shelfbreak, and which support seabird colonies and provide feeding grounds for postbreeding populations of both local seabirds and migrants from other breeding grounds [i.e., ivory gulls from all East Atlantic breeding populations stage here in the fall (Gilg et al. 2010)], are not protected.

The Arctic Branch of the Taymyrskiy Biosphere Zapovednik presents the coastal landscapes and biotopes of the East Taimyr: maritime tundra, marshes, dark-bellied brent geese (*Branta bernicla bernicla*) nesting and molting areas, and haulouts of the Laptev population of walrus, which is considered by some authors as a subspecies, *Odobenus rosmarus laptevi*, although this status has been recently disproved by molecular genetic studies (Lindqvist et al. 2008). However, the Laptev walrus is indeed a peculiar population, differing from the neighboring Pacific populations by the absence of long seasonal migrations and location of its wintering grounds in the Laptev–East-Siberian Seas polynya system (Gorbunov and Belikov 1990). Similar to that of many other coastal protected areas in the Arctic, the marine biodiversity of the area adjacent to the Taymyrskiy zapovednik is insufficiently studied.

Fig. 8.7 Landscape of the Lena Delta. In the center is a Ross gull (*Rhodostethia rosea*), a breeding endemic species of the Russian Arctic. Lena-Delta Reserve, Laptev Sea Basin. (Photograph courtesy of Viktor Nikiforov, WWF Russia)

The Ust'-Lenskiy Zapovednik (Lena-Delta Nature Reserve) encompasses part of the largest reserve in Eurasia and in the Arctic Lena delta system (Fig. 8.7). This nearly freshwater system is an important nesting and staging area for waterbirds and a feeding area for semi-anadromous fishes of the Lena watershed, including various whitefishes, Arctic charr (*Salvelinus alpinus*), and Lena sturgeon (*Acipenser baeri*). As for the birds, the great importance of the Lena Delta as a breeding ground for the globally threatened Steller's eider of the Pacific Flyway population and for the (Red Listed in Russia) dark-bellied brent goose (*Branta bernicla nigricans*) should be mentioned. Marine areas covered and adjacent to the reserve in the Lena Delta and surrounding marine waters have been subject to biological monitoring as early as the 1990s (Gukov 2001; Abramova and Tuschling 2005).

8.5.4 East Siberian and Chukchi Seas

The Wrangel Island Zapovednik boasts the world's largest population of Pacific walrus in summer, and in winter Wrangel and Herald Islands house the highest density of polar bear maternity dens. Shallow coastal waters, rich in benthos, are a major feeding ground for the eastern Pacific gray whale (*Eschrichtius robustus*) population (Bogoslovskaya et al. 1982; Belikov et al. 2002) and also for the

Fig. 8.8 Pacific walruses (*Odobenus rosmarus divergens*) off Vankarem Cape, Chukotka, Chukchi Sea (a marine mammal protection zone and a regional nature monument. (Photograph courtesy of Viktor Nikiforov, WWF Russia)

Bering-Chukchi-Beaufort population of bowhead whales (Bogoslovskaya et al. 1982). The reserve is the northernmost nesting ground for 100 migratory, mainly coastal, bird species, many of which are considered endangered. Marine areas included in the zapovednik and its buffer zone have a spatial scale (46,700 km^2) sufficient to protect integral marine–coastal ecosystems. An important feature of the coastal marine ecosystem are "flaw polynyas"; biological production in these areas apparently supports most of the important seabird colonies of the Chukchi Sea (Gavrilo and Popov 2011b). Furthermore, these polynyas serve as wintering habitat for a small part of the Pacific walrus (*Odobenus rosmarus divergens*) population that does not migrate to the Bering Sea (Stishov 2004). Seabirds and marine mammals of Wrangel Island show high sensitivity and clear responses to changing climatic and sea ice conditions (Stishov 2004). Nowadays, when observation on such responses has become critically important, regular monitoring of colonial seabirds is practically lacking in the zapovednik. Studies of the benthic communities of the insular waters began in 1989 (Golikov et al. 1991). Shallow areas of the Chukchi Sea adjacent to the reserve are characterized by unusually high benthic biomass, often more than 1,000 $g\,m^{-2}$ (Sirenko and Koltun 1992), which points to their exclusive role in maintaining populations of marine mammals that feed on bottom invertebrates, first of all walrus (Fig. 8.8) and gray whale.

Walrus haulouts in the marine mammal protection zones in Chukotka, in particular those in the Serdtse-Kamen' Cape area, are monitored by the regional fishery institute (Chukotka Branch of TINRO) (Kochnev 2010). Recently, indigenous people have been also involved in the monitoring and stewardship of these important habitats (see Chap. 7, this volume). The shelf areas northeast of the Serdtse-Kamen' Cape (partly within the marine mammal protection zone) host exceptionally rich biomass benthic communities, which are dominated by *Macoma calcarea* (the main walrus food); these communities have remained seemingly stable over the past 70 years (Sirenko and Gagaev 2007).

8.5.5 Bering Sea

The Goven Peninsula with its coastal waters in the Bering Sea is part of the Koryakskiy Zapovednik. Remarkable biotopes include seabird colonies with the characteristic Pacific composition of colonial species and one of the most southern haulouts of Pacific walrus (MNR 2008–2011). The abrasive shores and steep rocks of the Goven Peninsula are also characteristic biotopes for Pacific kelp, with sea urchins as the main grazers, and sessile seston feeders, such as ascidians (Kuznetsov 1964). Unfortunately, contemporary data on shallow-water biodiversity and ecosystems of the reserve are lacking.

8.6 Management Caveats

One could expect that the management of protected natural areas in the conditions of the High North poses significant problems, and this is indeed true. Many Arctic zapovedniks that include both terrestrial and marine areas have focused their management efforts on the most accessible terrestrial part and not on the marine areas, often not even having shipping facilities to study, monitor, and control the marine areas. The results of the management effectiveness assessment showed relatively low scores for the year 2008. Having said that, we need to emphasize that the METT methodology largely developed for terrestrial SPAs does not fully take into account the peculiarities of Russia's Arctic MCPAs. Some aspects of the assessment, in particular those considering active management of resources and involvement of local communities including indigenous people in the management process, are not applicable to the present case. Active management in polar marine ecosystems within a zapovednik has neither a conceptual nor legal background whereas the areas where Arctic MCPAs are located usually lack a permanent human population.

The assessment scores derived for particular reserves range between 29 and 50, with lowest values assigned usually to the MCPA with remote and hardly accessible islands. The lack of experienced research and managing staff is another functional shortcoming of the Arctic MCPAs. For comparison, it has to be noted that the zapovedniks that are located in other parts of Russia and are focusing on the protection of marine and brackish water ecosystems, the Far Eastern Marine Biosphere Zapovednik and the Astrakhanskiy Biosphere Zapovednik, have the highest scores, amounting to 63 and 62, respectively (maximum possible score, 100). Arctic federal zakazniks that factually lack both budget and staff were characterized by very low scores (13–29). There is thus much room to improve the effectiveness of existing MCPAs in the changing Arctic.

8.7 Threats and Future Challenges for the Protection of Arctic Marine Biodiversity and MCPAs

The low management effectiveness of Russia's MCSPAs is in some cases compensated by "natural" protection: many remote protected islands, such as the islands of the eastern Kara Sea, Severnaya Zemlya, and Wrangel Island lack any population and are removed from current economic pressures. Currently, the most serious natural threats for MCPAs and the associated biodiversity in Russia's Arctic coastal zone are habitat alterations associated with climate change. The principal anthropogenic threats include shipping (in the Barents, White, and western Kara Seas) (Bambulyak and Frantzen 2009), illegal hunting and fishing, remnants of previous military and economic activity (including wrecks and abandoned barrels with fuel), and marine debris. Using the adopted METT methodology and expert knowledge, these threats are currently scored as moderate in impact and in extent. However, detailed quantitative estimates for particular areas are lacking and are badly needed.

With developing industrial activities in the Arctic, the low to moderate threats of the current (up to 2010) offshore oil and gas development may turn into one of the high threats with significant risks (as we now, after the 2010 Gulf of Mexico catastrophe, know fairly well by heart) for large-scale accidents. In the Barents Sea, the Shtokman gas field, which is under development, is well known (Bambulyak and Frantzen 2009). Oil development at the Prirazlomnoe oil field already takes place very close to Dolgiy Island in the southeastern Barents Sea, which is a part of the Nenentskiy Zapovednik; the production platform is expected to be installed in 2012 at the latest. Oil and gas development on the Yamal Peninsula and in the Ob' Bay (Nikitin et al. 2006; Bambulyak and Frantzen 2009) is in proximity to the Gydanskiy Zapovednik, the Nizhne-Obskiy Zakaznik, and several other areas with high importance for maintaining biodiversity in the Kara Sea. In January 2011, BP and Rosneft made a deal agreeing to explore and develop three license blocks in the southern and the western Kara Sea; the licenses in question cover an area of approximately 125,000 km^2. The two corporations further succeeded in securing a favorable taxation regime for their joint enterprise (Barents Observer 2011; Bloomberg 2011). After several years of unsuccessful explorations in West Kamchatka and on the Magadan shelf of the Sea of Okhotsk, Rosshelf (the company jointly established by Gazprom and Rosneft for hydrocarbon development on Russia's shelf) now declares the importance of development of potential reserves in the Shelikhov Bay of the Sea of Okhotsk, the northern Chukchi Sea, and the De Long basins in the Chukchi Sea (RIA Novosti 2011).

This development may turn into a large-scale intrusion of the oil and gas industry into the Arctic seas. There is no guarantee that the lessons learned after the catastrophe on the BP platform in the Gulf of Mexico and several tanker accidents in the 2000s will prevent large-scale accidents and oil spills. The technical difficulties of responding to oil spills in the Arctic, especially in ice-filled waters, and the slow natural degradation of hydrocarbons leave no doubt that the consequences of the spill will be much more long lasting and severe than in tropical waters. The required preparedness gear alone is widely missing. Oil pollution will affect, first of all, the most essential biotope systems: marginal ice zones, flaw polynyas, river mouth systems, and laidas where organisms of various taxa and trophic levels are concentrated. If oil spills at sea (caused by a tanker or an oil rig accident) reach the laida shore, or oil accumulation from smaller leaks takes place there, the oil will remain in the laida zone for years and spread into the tundra along the network of laida canals.

Even under an accident-free scenario, the associated oil and gas development contains potential threats for marine biodiversity. Flaw polynyas will be more intensively used as natural shipping lanes, which will lead to increasing impacts of ship-based noise pollution and disturbance to marine mammals and seabirds that are also using the polynyas in various life activities (Gavrilo and Popov 2011a,b; Gavrilo et al. 2011). This disruption represents, in several respects, competition for habitat space and affects carrying capacity.

Coastal infrastructures located in close proximity to key habitats (laidas, estuaries, seabird cliffs, and pinniped haulouts) will adversely impact these biotopes and populations, as it involves the presence of large groups of people who may be ignorant or defiant of the rules humans should follow in a wildlife environment. Apart from illegal hunting or other types of poaching (e.g., egging), the very presence of large numbers of people and machinery alone will be a major disturbance factor for seabirds and mammals. There is an indication that construction activities carried out close to pinniped rookeries result in an increased number of pups abandoned by their mothers and lost to starvation (Matishov et al. 2005).

The consequences of infrastructure construction and indirect impact of the natural gas industry on anadromous and semi-anadromous fishes are already significant in the western Yamal Peninsula, where a truly large-scale gas development is still ahead. For example, in the lower stream of the Mordyyakhi River, arctic char vanished, while most whitefish species (Coregonidae) became rare, consequent to changing of the river regime and poaching (Bogdanov and Melnichenko 2009).

Tourism nowadays affects Russia's Arctic coastal zone in a patchy way. The main pressure (very rough estimate, around 100,000 visitors per year) is distributed among the Solovetskie Islands and the western White Sea (this is the authors' best guess). At the same time, cruise tourism is developing in the Franz Josef Land and in Chukotka, and no doubt the other Arctic archipelagoes are next in line. The principal problem associated with Arctic tourism is the absence of its environmental impact assessment, the lack of regulation, and ignoring of environmental and safety standards that can be potentially applied to Arctic tourism (in particular those developed for Antarctic tourism). Involvement of zapovedniks in the organization of tourism without development of a comprehensive control and management approach before the launch of operations raises a large degree of concern. The reasons for concern include, in particular, increased evidence of negative impact of uncontrolled whale watching on the estimates of newborn calf numbers in the gathering of beluga whales (*Delphinapterus leucas*) off the Solovetskie Islands (Krasnova et al. 2010).

Current trends of diminishing summer sea ice cover (and in some places also winter sea ice extent) (Macias Fauria et al. 2010), increasing air and surface water temperature and more frequent extreme weather events in the Arctic (Anisimov et al. 2007; Frolov et al. 2009), and intensified economic activities are expected to have a synergetic effect on biodiversity. In particular, extreme weather events increase the probability of accidents. Shifts in abrasion and accumulation processes in the coastal zone interfering with the mistaken practice of massive construction on the seashores may lead to the transformation, fragmentation, and loss of important coastal habitats, such as beaches, maritime marshes, spits, and other biologically important forms of seashore landscape. A relevant case study is provided by the history of beach loss in the Varandei settlement area where an oil terminal is located (Ogorodov 2005).

Finally, biological invasions also became, and will become more, an issue as a result of combined effects of anthropogenic and climatic factors. Currently, the number of established alien species in the Arctic seas is the lowest in the global view (Bollmann et al. 2010). In the Russian sector of the Arctic Ocean, these include only two species of algae, three species of crab (*Paralithodes camtschaticus*, *Chionocoetes opilio*, and *Eriocheir sinensis*), a caprellid, *Caprella mutica*, and pink salmon (*Oncorhynchus gorbuscha*) in the Barents and White Seas (Naumov and Berger 2004; Tsyganova et al. 2009b). In the future, tankers that transport hydrocarbons from the Arctic to the ports of the North Atlantic and North Pacific, and which bring back ballast water, may serve as vectors of invasion of various groups of organisms, including algae that cause harmful blooms and pathogenic microorganisms. Their establishment in the new areas will be likely facilitated by increased summer water temperature and a longer ice-free season.

A well thought out and well-designed network of MCPAs can effectively prevent eradication or transformation of local biotopes and communities and regulate harvesting of biological resources (Mokievsky 2009). Making MCPAs an effective regulator of the tourism impact (while using tourism as a source of supporting protected areas) is a difficult but perhaps achievable task. At the same time, marine reserves are not considered as barriers to pollution (including oil spills) and biological invasions (Mokievsky 2009). Although this is generally true, the presence of SPA or otherwise recognized unique biodiversity features in the areas of large-scale industrial project implementation can influence the practice of decision making even in contemporary Russia, either to move the project to a less vulnerable area or to modify it toward better environmental standards and compensation measures (Spiridonov 2006). For example, in December 2010 Rosneft cancelled plans to construct an oil refinery with a tanker terminal in the Vostok Bay in the Russian Far East where a regional coastal zakaznik and a biological station are located. One of the reasons (although not the ultimate one) for this decision was consistent advocacy for moving the refinery out of the valuable protected site to the Nakhodka harbor area that was organized by the general public, research institutions, and experts. As for the biological invasion problem, marine reserves, where regular monitoring of biological diversity is conducted, can play an important role in the timely detection of the invaders (Mokievsky 2009), and they do so for pollution detection (Chuprova and Chuprov 2004). Increasing human pressure on the Arctic calls for a strategy that would help to expand protected areas and develop MCPA capacity for meeting emerging challenges in a rapidly changing Arctic.

8.8 Gaps and Potential Extension of Marine and Coastal Protected Areas in the Russian Arctic

As it becomes clear from the foregoing review, there are few MCPAs in the Russian Arctic that cover the integral marine/coastal ecosystem and not only their coastal components. The WWF Russia proposal for new MPAs (Krever et al. 2009) broadly suggests offshore extensions of existing zapovedniks. It also proposes establishing zakazniks of appropriate size or a nature monument (for finer-scale phenomena, i.e., in the White Sea with its complicated coastline and diverse local conditions). Two new national parks were proposed: a national park at the New Siberian Islands and "Beringia" (including adjacent marine waters with important flaw polynyas). Such biotopes as salt marsh massifs and particular coast types providing habitats for seabird colonies and walrus haulouts may be in some cases protected by regional zakazniks or nature monuments. The reason for this is the jurisdiction: supratidal areas and most probably tidal coasts are considered to be under regional jurisdiction, and the procedure of establishing a new regional SPA has to be, in any case, technically easier than the creation of a new federal MCPA.

However, reality is different from what scientists and environmental NGOs recommend, and most of the proposed new MCPAs have not been taken to the agenda by the authorities. In 2010 MNR adopted a new national SPA planning scheme for the years 2011–2020. In accordance with this, for the maritime Arctic we can only expect the establishment of one new national park, "Beringia," on the Chukotka coast and possibly an extension of the marine buffer zones of some zapovedniks. The Beringia national park will include several coastal areas and the entire Kolyuchin Bay (see Golikov et al. 1998; Andreev 2004 for characterization of this area), which fits the criteria of an integral marine ecosystem and that houses important fish, pinniped, maritime plant, and waterfowl habitats.

The capacity to advocate for new MCPAs is inevitably limited in Russia. It is difficult to expect that their number can be significantly increased in the next decade. It calls first for looking for mechanisms of marine spatial protection complementary to classical federal MPAs (such as marine mammal protection zones, fishery refuge zones, and areas with specific regulation of shipping (Spiridonov et al. 2011) and balancing effort between advocating for creation new reserves and strengthening capacity of the existing MCPAs.

8.9 Strengthening Marine and Coastal Protected Areas Capacity and Developing New Tools for Monitoring and Surveillance

MCPAs cannot be in any sense effectively managed without sufficient funding, human resources, and technical support. The attitudes and mode of operation of the authorities change only slowly. Thus, serious and long-term advocacy efforts of scientists and NGOs are needed to promote a new approach to the protection of the Arctic seas. First, the specificity of the Arctic MCPAs must be recognized at the policy, planning, and organizational levels.

Second, working and living conditions for the staff should be essentially improved and, at the same time, staff selection criteria should be made stricter. Also, particular attention must be given to personnel professional training and career development.

To achieve this, scientists, and NGOs that collaborate with the zapovedniks and national parks, should develop an important message to society and the authorities and emphasize the role of the MCPA as a sentinel of changes in the Arctic marine environment and biodiversity. The MCPAs themselves should develop management plans and set specific targets for their development.

Historical series of observations on the components of marine ecosystems (mainly colonial seabirds) conducted for years and decades in the Arctic zapovedniks (e.g., at the Seven Islands Archipelago of the Kandalkshskiy Zapovednik or in the Wrangel Island Zapovednik) must be considered as a national marine heritage (Spiridonov et al. 2010), and the present discontinuation of this tradition (Krasnov and Barret 2000; Stishov 2004) should not be tolerated by society or the authorities by any means.

Although not in the best shape now, the Arctic marine zapovedniks are important platforms (along with permanent research stations) for monitoring processes and performing surveillance in the Arctic coastal zone. With few exceptions, MCPAs have a limited possibility to maintain their own marine vessels suitable for navigation in the Arctic conditions. The solution in this case should be commissioning or chartering a vessel to should perform research, monitoring, and surveillance work for several zapovedniks and national parks within a particular region during the summer season in a manner similar to the regular service provided to polar stations.

Even if an Arctic MCPA is able to operate a vessel or to charter helicopters, most of the remote marine and coastal areas still remain hardly accessible. This situation calls for a broader use of remote sensing methodology (McDermid et al. 2010) to monitor and control the coastal zone and offshore areas. Sea ice information is regularly updated online by the AARI (http://www.aari.ru/projects/ecimo/) and can be in principle provided to the MCPA in a format suitable for ecological monitoring and surveillance purposes. Of particular importance for monitoring ecosystem variability here are the data on sea ice formation and melting, development of fast ice, and flaw polynyas (Gavrilo and Popov 2011a; Gavrilo et al. 2011).

The modern free or low-cost satellite images (e.g., MODIS and others; McDermid et al. 2010) can be processed to obtain such important information for ecological monitoring as datasets on suspended matter in the water column, distribution of waters of riverine and marine origin, and location of oceanographic fronts. Furthermore, processing of satellite images supported by ground observation provides information on distribution and changes of coastal forms, laida biotopes, and salt marsh communities. Owing to some difficulties in obtaining comprehensive sets of satellite images for coastal studies in polar areas (ice and snow cover, clouds), compiling image libraries for monitoring purposes costs a certain amount of time and qualified manpower. However, this capacity can be gained as a result of developing research and monitoring partnerships.

The difficulties and limitations in conducting field surveys and censuses of seabirds and marine mammals using boats call for new instrumental methods covering extensive areas. Airborne methods have been developed and successfully applied to study distribution of seabirds and marine mammals at sea and on ice, although mostly outside MCPAs (Krasnov et al. 2002, 2004a,b; Melentyev and Chernook 2010). Adopted scales and logistic routines make it possible to cover the areas of several neighboring MCPAs along with adjacent waters in one survey. Taking into account the high relevance of such censuses of top predators in Arctic marine ecosystems to the aims of MCPAs, it would seem logical to fund such surveys from the budget of MNR, although readers acquainted with Russia's reality will certainly regard such an option as a fantastic one.

The surveillance of Arctic MCPAs can be also facilitated by using the modern instrumental methods. First, satellite-based VMS can provide data for tracking both cargo, industrial, and cruising vessels (to be informed about the number and tonnage of vessels passing the protected zone) and to control unauthorized landing. Development of permanent tracking tankers approaching and traversing the coasts of zapovedniks and national parks and other valuable areas presents a priority task that must be addressed before large-scale hydrocarbon development occurs in the Arctic (Bambulyak and Frantzen 2009).

In the areas where offshore fishery is developed, the VMS system operated by the Russian Federal Agency of Fishery is a valuable tool for preventing fishermen from entering protected waters. After several years of using the VMS data to control the shelf area, the Komadorskiy Biosphere zapovednik accustomed fishermen themselves to comply with the protection regime. Although most of the Arctic MCPAs are not presently affected by offshore fishing, this is actually the case for the Kandalkshskiy (southwestern Barents Sea) and the Koryakskiy (Bering Sea) zapovedniks and may become an issue for some others if fishing moves to higher latitudes as a result of climate change (Cheung et al. 2010).

Remote sensing proves to be a valuable tool in the detection of oil spills and other kinds of ship-based pollution. Several sources of information (e.g., RADARSAT, ENVISAT, and ERS-2 satellite images) can be used by MCPAs that are unfortunately located in the vicinity of hydrocarbon development or shipping lanes to monitor and control pollution. This approach, which is rapidly developing in the Baltic and the Black Seas (Kostianoy et al. 2006; Lavrova et al. 2010), needs to be adopted for the Arctic areas.

8.10 Developing Partnership and Cooperation

The challenges for the MCPA network in the Arctic are difficult to meet using the zapovedniks and national parks capacity. Traditional partnerships cover various kinds of cooperation between zapovedniks and scientific institutions/universities in Russia and abroad. However, in some cases these activities are determined by the priorities and financial possibilities of the partner scientific organizations and often are not integrated into programs that meet the aims of protected areas. On the other hand, zapovedniks themselves sometimes treat external research institutions as a source of money (preferably in cash) and not as partners that can help to increase local capacity. A solution can be probably found in developing a collaborative program of integral ecological monitoring with participation of a federal MCPA, partner organizations, and experts. Currently, a program of this type covering the terrestrial ecosystems of the Commander Islands, the ecosystems of the coastal zone, and the insular shelf and slope zone is under development for the Komandorskiy Biosphere Reserve (Anonymous 2010). All components of the program are divided into four categories: mandatory zapovednik observation (officially included in the Chronicle of Nature), mandatory measuring indicators of zapovednik management effectiveness, activities that have to be implemented within other national and international programs or networks, and facultative activities which need special opportunities and fundraising for implementation.

If such programs are developed for most of Russia's Arctic federal MCPAs, as a result of coordinated effort, links to international and national programs (including the Arctic Circumpolar Biodiversity Monitoring Program of CAFF) can be established, and opportunities for funding on a competitive basis can be provided to the zapovedniks and national parks.

Recently, some MCPAs suddenly become neighbors to the areas of hydrocarbon development (in the southeastern Barents and the Kara Seas) or oil terminals (in the White Sea). Complying with regulation, their operators contracted MCPAs (sometimes together with external research organizations) to conduct monitoring in areas presumably influenced within MCPAs, or adjacent to them. Although in most cases these relationships are formal, and have not yet presented themselves as interesting enough for promoting case studies, there is some potential to develop them into a real partnership.

Cooperation of the marine reserves with the tourism sector is developing in many regions of the world. In the Russian Arctic some touristic companies have informal agreements with the administration of particular zapovedniks and zakazniks. In exchange for the possibility of visiting protected areas they assist in transportation of the MCPA staff to remote islands. As issues of tourism are controversial in relationship to the Arctic MCPAs and in contemporary Russia, they require a special consideration. We are only going to state here that the focus should be given to the development of multilateral and transparent alliances between the MCPAs, touristic companies, science, and, possibly, NGOs; we intend to discuss this in detail elsewhere.

Although they do not receive necessary funding from the regional authorities, regional protected areas can only be managed sustainably on a participatory basis. Boltunov et al. (in Chap. 7 of this volume) describe a partnership between indigenous hunters of Chukotka, a conservation organization, and scientists established to monitor and protect walrus haulout sites; some of them are designated now as nature monuments (e.g., the Kozhevnikov Cape). Currently WWF Russia and the Marine Mammal Council are developing a similar partnership approach for the protection and monitoring of Vaigach Island (located at the boundary between the Barents and the Kara Seas), which has a status of regional reserve and hosts most of the Atlantic walrus haulouts in the southeastern Barents Sea (Boltunov et al. 2010; Nikiforov and Boltunov 2010). We expect that this experience will be further used in the development of participatory management of the future "Beringia" national park. We believe that establishing horizontal cooperation is the only way for protected natural areas to perform their important mission in the changing Arctic. Developing various kinds of partnership and collaboration of the Arctic MCPAs with external organizations now becomes imperative.

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Chapter 9
Status, Threat, and Protection of Arctic Waterbirds

Christoph Zöckler

9.1 Introduction

There are about 450 species of birds that breed or have bred in the Arctic region, as defined by the Conservation of Arctic Flora and Fauna of the Arctic Council (CAFF 2001). Of these, 279 (~60%) have a significant number of its population breeding within the Arctic (Scott 1998). The waterbirds comprise 174 Arctic breeding species of divers, grebes, seabirds, ducks and geese, cranes, waders, gulls, skuas, and terns. Seabirds are not included in this review, leaving 153 Arctic waterbirds for consideration. Forty-seven species breed entirely in the Arctic. Seventy-five percent of the total geese population, including 10 goose species and 22 species of waders, breed entirely in the Arctic region. In fact ,more than 80% of all 24 calidrid sandpipers breed in the Arctic.

Many of these species rely on the Arctic breeding conditions of open tundra wetlands with no or few trees, huge areas of wetlands, and 24 h daylight with vast availability of food and low predation rates. Because of the cold conditions the Arctic also appears to lack any relevant endoparasites, and hence these waterbirds seem to be not much affected by diseases. Furthermore, the vast wilderness and open areas with only scattered trees and bushes in the southern, subarctic areas of the forest tundra attract waterbirds and wildlife with little disturbance. It is part of their ecological niche.

Arctic waterbirds include divers, swans, geese and ducks (Anatidae), cranes, waders/shorebirds, skuas, gulls, and terns. Among these, the waders are the most numerous in species and individuals. Among the Arctic birds the population trend varies. Most of the global waterbird populations are declining (44% of the known trends) (Delany and Scott 2006). Geese and gulls are mostly increasing, shorebirds are largely declining, and in skuas and terns most trends are unknown. According to

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the IUCN Red List, 16 Arctic waterbirds are listed as globally threatened (BirdLife 2010), 3 of which are "critically" threatened, and the Eskimo curlew is most likely already extinct.

Habitat loss on the flyways, overharvesting, and climate change are the main impacting factors on waterbirds (Delany et al. 2010; Zöckler and Lysenko 2000). The reasons for these changes are multiple, and with migratory birds affecting the populations at all stages along the flyway, the causes of decline are complex and very difficult to determine. Similar changes in population trends across the circumpolar region for similar taxa indicate peculiar processes within the Arctic region (McRae et al. 2010), but declines in certain flyway populations compared to stable or increasing in others point to factors impacting the populations outside the Arctic along the migration route, as seen in the East Asian Flyway in particular (Syroechkovskiy 2006).

Because almost all waterbirds are also migratory, the impacts of habitat loss, hunting, and climate change along the flyway have a significant impact on the populations of many waterbirds. The range of the numerous threats here includes land use changes in the wintering grounds, changes in land cover and habitat loss, overharvesting, hunting and trapping, and pollution. These threats also include power lines and the more unexpected impacts, such as the plantation of mangroves in tropical mudflats and the development of offshore wind farms at a massive scale. Often, it is not easy to determine the main causes for the changes in population. So long as the populations are declining, cumulative impacts must be taken as serious. The protection of Arctic birds hence is largely determined by the level of protection along the migration route and from all its stressors. A so-called network of critical sites has been developed for the African Eurasian Waterbird Agreement region (AEWA) and for both major American flyway regions with a site network of several hundred sites. A similar network of flyway sites is under development for other flyways, such as the East Asian Australian Flyway (EAAF). Often, however, these sites bear little protection other than their nomination and do little to connect and safeguard declining waterbird populations (Huettmann and Gerasimov 2006 for the Russian Far East). There are also serious biological, ecological, and conceptual issues in the underlying concept of flyway sites per se, because not all birds follow these sites, some migrate more broadly, using multiple sites that are not fine tuned into the site network, thus facing a multitude of additional threats. Overriding many sites, climate change places further pressure on the network.

9.2 Status and Trends in Waterbirds

Table 9.1 provides an overview and summarizes the status and trends of Arctic waterbird populations, largely based on Delany and Scott (2006). Some of the Arctic proportion has been estimated based on the Arctic boundary (CAFF 2001) and the species distribution. This picture cannot always be as accurate as it appears in Table 9.1, but it does allow for an overall estimate of the size and trends of Arctic waterbirds by taxa.

Table 9.1 Trends in Arctic Waterbird population by family

Family (no. of species)	No of populations	Known population trends	Increase (%)	Stable (%)	Decline (%)	Total population size (×1,000 individuals)
Divers (5)	13	5	–	3	2 (40)	2,195
Grebes (2)	5	2	–	2	–	200
Swans (3)	13	9	6	1	3 (33)	513
Geese (12)	49	45	19	14	12 (22)	17,139
Ducks (26)	70	45	2	25	18 (40)	26,337
Eider ducks (4)	17	16	1	6	9 (55)	4,221
Cranes (2)	4	4	–	1	3 (75)	453
Waders[a] (71)	170	92	2	38	52 (56.5)	48,760
Gulls (20)	35	20	9	6	5 (20)	17,170
Terns (4)	7	4	–	2	2	5,680
Skuas[b] (4)	–	–	–	–	–	500
Total (153)	378	242	39 (16)	99 (40)	106 (44)	123,000

Sources: Based on Delany and Scott (2006) with additional sources for specific species, Griffin (2009), Mitchell (2009), Colhoun (2009), waders by Balachandran (2006), Sitters and Tomkovich (2010), Moores et al. (2008)

Arctic population delineated as defined by CAFF (2001)

[a]Includes rough estimates of Arctic proportion of semiboreal species, such as Common Snipe

[b]Skuas are not considered waterbirds in Delany and Scott (2006) but as predominantly Arctic tundra breeders included in this assessment

The Arctic is home to approximately 123 million waterbirds (see Table 9.1). This figure is largely based on data obtained by the Wetland International network; it is based on 50% of the populations with reasonable estimates available. For the remaining populations, crude estimates or educated guesses were applied. The estimates are still at the conservative range and could well be higher, by as much as 20%. It is not clear what proportion this estimate comprises of the global number of waterbirds. But clearly, apart from geese and most gulls, most waterbirds are declining, as are also divers and ducks. Although the majority of their populations are stable, an increasing number of duck populations are joining the declining category (Delany and Scott 2006). Arctic waders, with 46–49 million birds, are the most numerous group, and it is of concern to see the majority of populations declining, some at an alarming rate, such as those wintering in Africa and Asia (Delany et al. 2010).

Most waders, and in particular Arctic waders, are declining (Zöckler et al. 2003; Stroud et al. 2006; Delany et al. 2010). Their proportion of the Arctic populations in decline is, at more than 56.5%, among the highest rate of all Arctic waterbirds (Table 9.1). With a total estimated 48.7 million individuals, the waders act as prime indicators for the state of the Arctic and its migration routes. Because of their complex and not yet fully understood migration routes, it is not always easy to establish the cause for the decline. But there is strong evidence that these declines are largely driven directly or indirectly by human-induced threats.

The following examples, across the wide variety of waterbirds, illustrate the challenges for Arctic waterbird conservation and reflect the broad range of impacts along the entire flyway.

9.2.1 Red-Throated Diver (Gavia stellata)

The divers are truly an Arctic family, with all species dominantly distributed in the Arctic and subarctic region. Little is known about their overall trends. According to Delany and Scott (2006), 2 of 13 populations of five species are declining, whereas three species are stable. The white-billed diver (*Gavia adamsii*) has recently been uplisted to globally "Near threatened," indicating a decline related to subsistence overharvesting (BirdLife International 2010). Garthe and Hüppop (2004) noted the potential pressure on around 18,500 wintering divers, mostly red-throated divers, in the German Bay of the North Sea by offshore wind parks. With the prospect of expanding offshore wind parks in other areas, including main wintering areas in the Baltic Sea, these can be considered as major threats for the Atlantic populations. Marine Protected Areas are not yet established with the objectives of protecting wintering waterbirds or defining no-go areas for developers, leaving the population of red-throated and other divers vulnerable.

9.2.2 Brent Goose (Branta bernicla)

The dark-bellied Brent goose (*Branta bernicla bernicla*), breeding in the Russian Arctic, has displayed continuous declines since the mid-1990s. In contrast to most waterbird populations, however, Arctic geese are still increasing. There are differences between the species, but on the whole the Arctic goose population has almost doubled in population during the past 10 years (Zöckler 2008), and many populations continue to grow. Mostly, this growth in population is related to improved feeding conditions on the staging and wintering grounds in Europe and the Americas (Drent et al. 2006), often related to agricultural practices, but strong hunting regulations set in place in the 1970s in most parts of Europe and also in the Americas helped the recovery of many declining goose populations. The population dynamics of the Brent goose (Fig. 9.1) reflects this very well. However, the reasons for the recent decline remains unclear.

9.2.3 Bewick's Swan (Cygnus bewickii)

The northwest European Bewick's swan population is been in decline despite the generally stable or increasing trend of most Anatidae populations in this flyway area. The decline of more than 27% from over 29,000 in the mid-1990s to less than

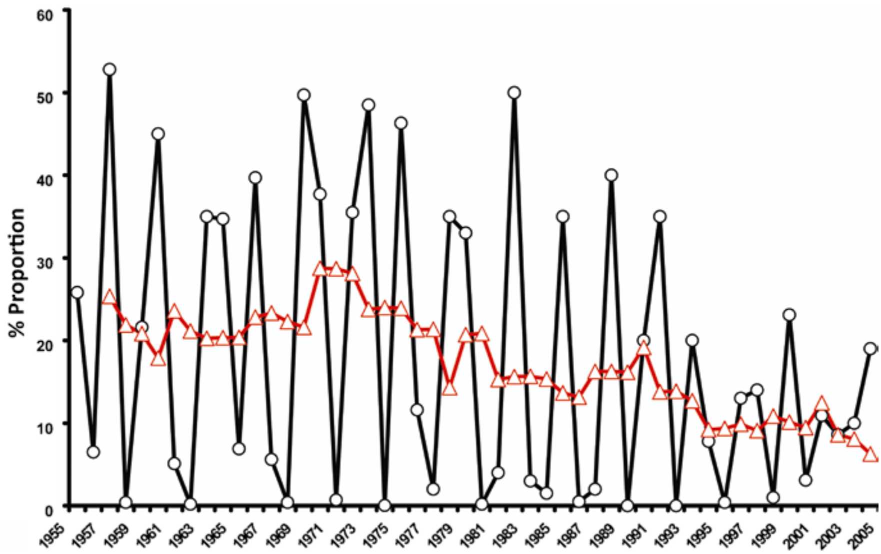

Fig. 9.1 Brent goose trends and breeding success over time

2000 in 2008 is considerable (Rees and Beekman 2010). The population follows a similar pattern as the aforementioned Brent goose, with a sharp fall in the mid-1990s and a continued gradual decline from then on. The reasons for the decline are discussed by Rees and Beekman (2010), but they remain inconclusive. The similar pattern as observed in the other High Arctic breeding waterbird species, such as the Brent goose, might be a reflection of more dramatic and systemic changes in the Arctic (see also Zöckler 2007). It would be nice to have more trend data from other High Arctic species available to confirm this speculation. Interestingly, trend data from High Arctic Canadian thick-billed murres (*Uria lomvia*) also show a similar sharp decline in the mid-1990s (Gaston 2010), which have been linked with abrupt sea ice changes, pointing to a more circumpolar pattern of changing regime conditions in the mid-1990s impacting waterbirds and seabirds alike.

9.2.4 Pintail Duck (Anas acuta)

Most Arctic duck populations are stable, but 18 of 45 populations with known trends (see Table 9.1) are declining and only 2 are recognized as increasing (Delany and Scott 2006). Many ducks are hunted within the Arctic region and along the flyway. Hunting regulations are in place for most populations, and many overharvested populations have recovered, as in the case of the wigeon (*Anas penelope*). Huge fluctuations have been observed in the mostly Arctic breeding pintail duck (*A. acuta)* population. The African wintering population dropped from previously high levels of more than 600,000 ducks to only 400,000 in the past 20 years;

this means a yearly loss of 10,000 individuals. Its population changes have been correlated with the droughts in the wintering area in the Sahel (Zwarts et al. 2009). Interestingly, among the Asian duck populations, it is again the pintail as the most northern breeding dabbling duck that is declining, whereas other ducks are stable or increasing (Li and Mundkur 2007), pointing to reasons within the Arctic as well, but the data for further analyses are not sufficient.

9.2.5 Eider Ducks (Somateria spp.)

Of the four eider duck species, three breed entirely in the Arctic, and the Common Eider does so predominantly. With a combined total Arctic population of well over four million birds, eider ducks play an important role in the Arctic also as a vital source for subsistence hunting communities. Across the Arctic region eiders are harvested for meat and eggs but also for their down. The latter provides an estimated annual revenue of more than $US4 million in Iceland (Petersen 2008). All these demands put pressure in addition to existing climate change on the populations, and most of the populations are declining. The reasons might not always be overharvesting, but the conservation of these populations, apart from the protection of its breeding and wintering sites, must take harvest quotas and measures of hunting regulations into account. Both king and Common Eider (*Somateria spectabilis* and *S. mollissima*) winter in significant numbers together with a total of 3.5–5.5 million seabirds in southwest Greenland. For Common Eider, a total of 500,000 birds, and for king eider, 300,000 birds, are estimated to winter in southwest Greenland, originating from north and west Greenland as well as from northwest Canada (Boertmann et al 2006). These ducks are also joined by about 100,000 long-tailed ducks (*Clangula hyemalis*), 5,000–10,000 harlequin ducks (*Histrionicus histrionicus*), and many more alcids. The hunting pressure is huge, as much as 10% of uptake of the wintering population. The areas are not protected but are designated formally as Important Bird Areas (IBAs).

9.2.6 Siberian and Whooping Cranes (Grus leucogeranus and Grus americana)

Only a few crane species are breeding in the Arctic, but two of the five Arctic species are already extremely rare and are considered globally as “critically endangered.” The American whooping crane has recovered from a very low population size of 15 in the 1940s to now more than 200 (Delany and Scott 2006), largely by protection of its prime breeding and wintering area. The Siberian crane lives in two distinct populations in the Russian Arctic. The protection of both populations requires, again, a true flyway approach. A network of critical sites along both flyways has been established through a Memorandum of Understanding (MoU) under the

Convention of Migratory Species (CMS) between the various countries involved. At present, at least the East Siberian population breeding in the Yano-Indigirko lowland tundra and wintering in Lake Poyang has been stabilized or even increased in numbers (Delany and Scott 2006), whereas the West Siberian population has reached a critical low and is likely to have gone extinct by 2002 (Harris 2009).

9.2.7 *Ruff (Philomachus pugnax)*

Among the waders, the majority of populations are declining, which includes even the common species, but for many populations (45%; see Table 9.1) no or little information is available. With an estimated 2.2–2.5 million breeding females (Zöckler 2002a) the ruff is still a common Arctic breeding bird across the Russian and Fennoscandian Arctic. Declines have been noted among the small populations of temperate breeding birds. It is unclear if these declines are also occurring among the Arctic population or absorbed by the large Arctic population in response to climate change (Zöckler 2002b). Fluctuations in the wintering population in the Sahel suggest that draught and other conditions in the wintering area are strongly affecting the populations (Zwarts et al. 2009). A more recent analysis (Rakhimberdiev et al. 2011) points to a West–East redistribution of the ruff on migration in Europe but also coinciding with a redistribution in the Arctic breeding grounds. Although this shows a high degree of flexibility to adjust to changing conditions, we do not yet understand if the ruff is declining overall.

9.2.8 *Curlew Sandpiper (Calidris ferruginea)*

Some populations, such as the East Asian population of the curlew sandpiper, have declined by more than 80% between 1980 and 2006 (Fig. 9.2) (Gosbell and Clemens 2006).

The decline is thought to be more likely a consequence of lower survival rates than of reduced breeding success (Rogers and Gosbell 2006), similar to the case of the spoon-billed sandpiper (Zöckler et al. 2010a), arising from influences at the stopover and wintering sites. In the case of the EAAF, this well might be the case as the region is not only experiencing the most serious habitat losses (Zöckler et al. 2008) but is also subjected to a massive scale threat by hunting and trapping (Zöckler et al. 2010b). The cumulative impacts should be considered, however, with many features not even known.

Curlew sandpipers in other flyways are also declining. The Indian population, monitored at Point Calimere in South India, plummeted from 150,000 birds in the 1980s to just 25,000 in 2003 (Balachandran 2006). In Langebaan Lagoon, South Africa long-term data analyses suggest a further decline to only 13,000 birds in 2003 from 23,000 in 1975, almost 50% in 30 years (Harebottle and Underhill 2006),

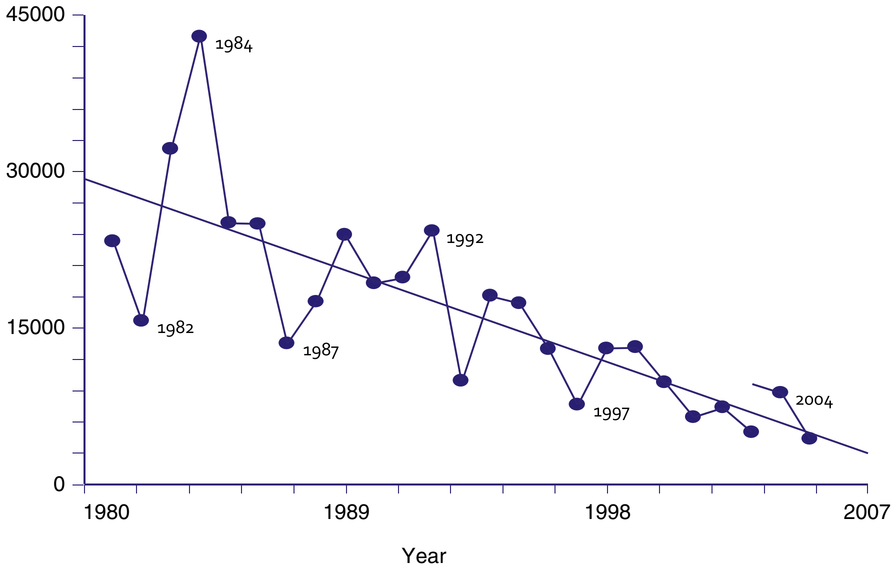

Fig. 9.2 Population decline of curlew sandpiper at seven sites in Australia, based on Rogers & Gosbell (2006)

corresponding with the decline in productivity measured in juvenile percentage also at Langebaan in South Africa. The West African population, according to Delany and Scott (2006), appears to be stable or even increasing and has been estimated at around a million individuals, but the population in Guinea in West Africa is difficult to monitor, and no trend could be obtained.

9.2.9 Spoon-Billed Sandpiper (Eurynorhynchus pygmeus)

Today, this charismatic shorebird is the most threatened Arctic waterbird with an estimated current population size of only 120–220 pairs (Zöckler et al. 2010a). Its decline is largely the result of hunting and trapping activities at the wintering sites between Bangladesh and Myanmar and along some staging sites (Zöckler et al. 2010b). In addition, habitat loss through reclamation and saltpan and shrimp farm development has further affected the fragile population (Moores et al. 2008; Zöckler et al 2008; Jing et al. 2011). Only 4% of the known breeding sites are protected through designated protected areas (Table 9.2). Along the flyway the situation is similar, with less than 20% protection of sites with regularly three individuals. The wintering areas are even less well protected. In fact, in the prime wintering area between Bangladesh and Myanmar, none of the known wintering sites is protected. Only marginal sites in India and in North Vietnam with irregular sightings are officially protected. However, real protection would, in addition to site designation,

Table 9.2 Calidrid sandpiper numbers, distributions, and protection by Arctic nation

	Breeding area ($km^2 \times 10^7$)	Percent (%) protected	Russia	Alaska	Canada	Greenland	Iceland	Norway	Sweden	Finland
Calidris: species and numbers			17	12	9	6	2	5	3	4
C. tenuirostris	1.050	0.2	100							
C. canutus	1.200	16.0	42	1.3	40	17				
C. alba	1.220	19.0	17	0.5	68	14		0.3		
C. pusilla	2.480	11.0	>0.01	15.0	85					
C. mauri	0.130	56.0	10	90.0						
C. ruficollis	0.460	1.6	100	>0.01						
C. minuta	0.980	7.1	99					0.9		0.03
C. temminckii	2.910	1.7	95					3.5	0.5	0.80
C. subminuta	2.330	?	98							
C. minutilla	4.260	10.0		33.0	67					
C. fuscicollis	1.290	6.5		2.0	98	>0.01				
C. bairdii	2.230	12.4	1	16.0	81	2				
C. melanotos	2.580	11.6	38	17.0	45					
C. acuminata	0.130	4.8	100							
C. ferruginea	0.950	8.7 (17.5)	100							
C. maritimus	0.930	13.0	14		45	24	4	12.0	0.2	0.10
C. ptilocnemis	0.120	31.0	19	81.0						
C. alpinus	2.610	12.0 (13.0)	53	10.0	29	4	2	2.0	<0.01	0.70
Eurynorhynchus pygmeus	0.074	4.2	100	>0.01						

also require a huge effort in site management, local community education, and raising awareness to mitigate the impact of hunting and trapping among the local communities in the wintering areas. Little information is available for the few protected areas along the flyway. Most importantly, this information refers not only to the well-studied spoon-billed sandpiper but applies to many other species migrating along this flyway, namely the curlew sandpiper, as already mentioned.

9.3 Protection

9.3.1 Site Protection

Designated protected areas are not a sufficient tool to safeguard migratory Arctic species. In fact, only a small fraction of Arctic waterbirds are protected in their Arctic breeding grounds. Zöckler (1998) summarized the degree of protection among the calidrid sandpipers, which breed almost entirely in the Arctic (see Table 9.2).

Some species have only acquired less than 2% protection of their entire breeding range. Although these data actually derive from the late 1990s, not many new protected areas have been established in the Arctic region, so little has changed.

While recognizing the gap in protection, a flyway approach to conservation has been developed and partly implemented to better protect Arctic migratory waterbirds (Boere and Stroud 2006). The establishment of such networks requires a good knowledge of the flyway and crucial stopover sites as well as good international cooperation, in addition to other matters. The flyway agreements under the CMS, such as the AEWA, are aiming to address these issues by coordinating the conservation activities between the members and partners. However, it is not clear whether this is sufficient and efficient to protect Arctic waterbirds sustainably, considering the increasing global pressures of further development and climate change.

9.3.2 Mitigation of Hunting and Trapping

Subsistence hunting and illegal hunting and egg collecting are widespread in the Arctic and create a significant pressure on Arctic waterbird populations (Merkel and Barry 2008). Many stopover and wintering sites of Arctic waterbirds are subject to heavy hunting pressure (Huettmann and Gerasimov 2006). The level and degree has not been fully anticipated and often is underestimated when analyzing the threats to Arctic waterbirds.

Iceland is taking annually on average about 350,000 seabirds, which equals 4–5% of the estimated 7.5 million breeding seabirds in Iceland, of which the most common is the Atlantic puffin (*Fratercula arctica*), followed by other alcids (Petersen 2008).

More than 3.5 million seabirds, mostly thick-billed murres (*U. lomvia*) and eiders, are wintering in southwest Greenland. Annually, 280,000–390,000 murres (*Uria* spp.) were harvested in the 1990s. The second most harvested bird is the eider, the Common Eider and king eider, both breeding mostly in northern Canada and wintering in the seas off southwest Greenland. The harvest of eider ducks varies between 24,000 and 90,000 per year (Boertmann et al 2006; Merkel and Christensen 2008). These numbers markedly dropped with the new hunting regulations in effect since 2002. In the same period, however, the number of by-catches from lumpsacker gillnets increased 20-fold for the king eider and 100-fold for the Common Eider (Merkel and Christensen 2008).

9.3.2.1 Examples in the Wintering Areas of Arctic Birds

The Bay of Martaban in Myanmar is estimated to hold 100,000–150,000 waterbirds, the majority of which are of Arctic origin. According to interview data an estimated 30,000 birds are caught annually (Zöckler et al. 2010b).

The numbers of waterbirds being caught in Indonesia are also staggering. In 1979, an estimated 1 million birds were caught in the Indramayu area of Java alone, but this had declined to about 300,000 in 1984–1985, 200,000 in 1987, and 150,000 in 1992. Bird hunting is also a major activity in Ujung Karawang Natural Preserve, Bekasi, West Java. Approximately 612,000 birds were hunted in the winter of 2008–2009, consisting of 63 species, of which 28 species are migratory from the Arctic (Purnama 2009), leaving open to speculation the estimated number of waterbirds hunted in total all over Indonesia and Southeast Asia.

Similar figures exist from other parts in the world. The ruff, a numerous wader in Africa, for example, is regularly subjected to hunting at the wintering areas in sub-Saharan Africa (Zwarts et al. 2009).

In Denmark, the annual hunting bag declined from 900,000 in the mid-1970s to 350,000 in the mid-1990s and has little changed since. The decline was partly caused by urbanization (decreasing outdoors activity) and in response to legal species protection in 1982 of divers, grebes, and some waders, followed in 1994 by the protection of the curlew (*Numenius arquata*), whimbrel (*Numenius phaeopus*), and some gulls (Bregnballe et al. 2006). The bags declined for the northern shoveller (*Anas clypeata*) and the Arctic breeding northern pintail, but not for others, indicating potential changes in the Arctic or other flyway areas.

9.4 Engaging the Public and Private Sector

By now, sustainable development has become a too often used phrase with little substance and is rarely a mechanism for conservation. It is now an unprotected "greenwash" term, even used for many activities that create environmental destruction. At present the level and rate of development globally still continues to destroy and impact critically important sites for Arctic waterbirds at an accelerating pace. Numerous examples from all continents pay witness to the continuation of the devastating destruction of the critical network of sites. The reclamation of the Saemangeum estuary (Moores et al. 2008; Birds Korea 2010), the destruction of South Chinese coastal wetlands (Barter 2003), the development of coastal shrimp farms in Bangladesh and India (Zöckler et al. 2008), deep-sea ports and industrial developments in Bangladesh and Myanmar, numerous touristic developments in Sri Lanka, Turkey, North Africa, and southern Europe, agricultural intensification in southern Spain, harbor projects in northern Germany, flood barrages in England, and Australian, Canadian and U.S. real estate development are endless examples of how the pressure for economic development has been prevailing over the conservation of critical sites for Arctic waterbirds (see also Huettmann and Czech 2006).

Still, today, despite many efforts of the global community to highlight the value of biodiversity, the ecological services and value of coastal and inland wetlands have been virtually unrecognized, or are not factored in, or in balance, and are not taken fully into consideration when developing economically attractive developments. These wetlands not only support millions of Arctic waterbirds, but at the same time serve a huge number of local peoples' livelihoods and often provide other services such as water purification, recreation, spawning grounds for fish stocks, etc.; the wetlands are even of (global) strategic relevance. All these factors have often been ignored and not fully considered when weighing the benefits and costs of developing these wetlands. Good examples for this situation can be found in California, for example, where approximately 90% of the wetlands have been essentially lost.

The protected areas network is vital and has saved biodiversity across the globe, but it largely failed to secure a critical site network of coastal and inland wetlands for migratory species, such as Arctic waterbirds. Not only governments and international institutions, but more and more the private sector, must take responsibility for the protection of biodiversity and securing the vital conservation of the critical site network of wetlands for the sake of Arctic waterbirds and the livelihoods of millions of local peoples.

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Chapter 10
Global Issues for, and Profiles of, Arctic Seabird Protection: Effects of Big Oil, New Shipping Lanes, Shifting Baselines, and Climate Change

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10.1 Introduction

Seabirds are an inherent part of the marine ecosystem (Schreiber and Burger 2002; Gaston 2004). They have been identified by numerous studies as indicators of the general health of the oceans (see Textbox; Cairns 1987; Furness and Camphuysen 1997; Piatt and Sydeman 2007; Parsons et al. 2008). For decades, many species of seabirds and their local populations have been decreasing (CAFF 2010 for the Arctic), and very few are increasing (Furness 1989; CAFF 2010 on seabird population changes). The extent to which seabird populations are decreasing is not well known, and an integrative assessment of all species has yet to be performed. The current decline of indicator species (e.g., seabirds) therefore raises the question: "What is the current state of the global oceans?" Human influence on the ocean has increased dramatically in the past 100 years (Norse and Crowder 2005; Chapin et al. 2010) and will continue to increase as human population and resource demands rise. However, our influence on the ocean can be partially mitigated through careful planning and environmentally and economically beneficial science-based strategies. To achieve the goal of lowering our impact on the oceans, broad-scale baseline studies, which do not exist in many cases, must be performed soon, as the issue is now time critical (see Textbox for constraints on availability of long-term data and need for such data virtually worldwide). Examples of such studies could include simple shipboard transects using sound survey techniques (e.g., distance sampling and compatible

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Textbox What Do Signals from Seabirds Tell Us About the Marine Environments?

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Signals from the Marine Environment

Now widely accepted as useful indicators of their marine environments, seabird populations around the world from the Arctic to the Antarctic are providing insights into and signals from marine ecosystems and their intrinsic processes (e.g., Furness and Camphuysen 1997; Ainley et al. 2005; Piatt et al. 2007a; Spear and Ainley 2008; Raymond et al. 2010). Perhaps most importantly, seabirds are providing novel information on recent changes in the biological and physical parameters of the world's oceans that might otherwise be undetected from other data sets over the same time periods (Montevecchi and Myers 1996; Barrett and Krasnov 1996; Veit et al. 1997; Iverson et al. 2007; Springer et al. 2007; Ainley et al. 2010). Many seabirds are top-level predators, and their population dynamics integrate the variabilities in their prey species and in their physical environments over a wide range of temporal and spatial scales.

Depending on the questions asked, the data collected, and the analyses undertaken, seabirds can provide signals on the marine environment over time periods from as brief as a day (e.g., foraging trip duration or the meal size fed to a chick), to weeks or months (e.g., chick mass gain to fledging), to seasonal (arrival mass at onset of breeding or breeding success), or years to decades (population trends) (Harding et al. 2007; Piatt et al. 2007b; Woehler et al. 2001; Woehler et al. 2003). Similarly, seabirds provide signals over spatial scales from local (colony extent) to regional (extent of foraging trips; Ainley et al. 2004) to ocean basin (postbreeding dispersion; Nicholls et al. 1997). Given their high visibility and wide-ranging oceanic habits, seabirds are perhaps unique in being able to readily provide signals from these spatial and temporal hierarchies concurrently.

Previous and current foci on seabirds' roles in the marine environment have been their relationship with physical and biological oceanographic features and processes, including the means by which seabirds detect their prey (e.g., Hunt and Schneider 1987; Bost et al. 2009; Ribic et al. 2011 and references therein), and their ability to provide real-time information on rates of recruitment in commercial fish species (Barrett and Krasnov 1996; Furness and Tasker 2000; Furness 2002, 2003). More recently, the focus has been drawn to questions addressing seabirds as indicators or proxies of environment (Springer et al. 2007; Ainley et al. 2010). A large body of knowledge

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now supports the premise of seabirds as indicators of marine environments around the globe (e.g., see Piatt et al. 2007a and following articles). However, two constraints reduce the predictive power and capacity of these long-term data sets: (1) the temporal extent of the data, and (2) the extensively perturbed contemporary marine environments in which the data have been collected.

Temporal Constraints

Seabird researchers, and those who interpret and utilize these data, seldom acknowledge or consider that these data and their interpretations lack constraints arising from the intrinsic temporal scale(s) of the data. There are many seabird data sets that span multiple decades, in some cases more than half a century [e.g., the emperor penguin (*Aptenodytes forsteri*) population at Pointé Géologie, Antarctica: Jenouvrier et al. 2005; Adelie penguin (*Pygoscelis adeliae*) in southern Ross Sea, Antarctica: Ainley 2002a; black-legged kittiwakes (*Rissa tridactyla*) in Scotland: Coulson and Thomas 1985], and there are many other seabird data sets that exceed a decade (e.g., Woehler et al. 2001). Data sets spanning such periods are obligatory for two reasons. The first is the high life expectancies of individuals of many seabird species, which exceed 40 years or more, and the second is the scales at which the physical and biological oceanographic processes are manifested in marine environments (Stommel 1963; Haury et al. 1978).

Based on the life expectancies of individual seabirds, the available data sets (including the longest) describe and reflect the dynamics of the variable(s) for only a few generations of the species under investigation at best. This is not a criticism: the scientists who have compiled these data have done so with minimal or even no institutional support, as the collection of any long-term data is widely seen as "monitoring" by governments and administrators, readily dismissing these efforts as having no perceived "scientific" value. It is perhaps only very recently that this attitude toward the value of collecting these long-term biological data sets has softened, as the demand for such data sets increases rapidly. This demand for long-term data, which greatly exceeds their very limited availability, has established the validity and utility of long-term seabird data sets as signals from the marine environment. The US Palmer-Long Term Ecological Research (LTER) program on the Antarctic Peninsula, Antarctica New Zealand/Landcare Research's Adélie penguin studies on Ross Island, Antarctica, the Phillip Island Nature Reserve's little penguin study in southeastern Australia, and the Farallon Island seabird program in California by the Point Reyes Bird Observatory Conservation Science are notable and exemplary exceptions.

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Perturbed Environments

Humans have been modifying their environments – terrestrial and marine – for centuries, if not longer; these modifications have adversely affected seabird populations around the globe. Seabirds and their eggs have been used as food and marine mammals have been hunted for their fur and flesh. Modern fisheries have plundered the biomasses of most commercial species beyond likely recovery (Pauly et al. 1998; Worm et al. 2009; Hutchings et al. 2010), and a broad spectrum of species ranging in size from microbes to vertebrates have been introduced deliberately or inadvertently to many sites around the world. There are countless instances of significant and irrevocable habitat modifications to marine ecosystems around the globe, as revealed by recent analyses (Halpern et al. 2007, 2008b; Worm et al. 2009; Zeller et al. 2011).

The spatial and temporal extents and biological consequences of these modifications have been lost in the pervasiveness of "sliding baselines," preventing all but the most general assessment that they are adverse and typically irreversible. The most adverse modifications comprise species extinctions such as the great auk (*P. impennis*) and the near-extinctions of various marine mammals, such as Stellar's sea lions (*Eumatopias jubatus*), sea otters (*Enhydra lutris*), fur seals (*Callorhinus ursinus* and *Arctocephalus* spp.), and blue whales (*Balaenoptera musculus*), and commercial fish species such as the North Atlantic cod (*Gadus morhua*). Many of these species, and others hunted to near extinction, are typically the top predators in their environments, and provide a top-down regulatory mechanism in shaping marine (and in some cases, terrestrial) community structures and functions.

These wide-ranging and extensive modifications have perturbed the marine environments in a complex suite of changes of varying degrees and thus unknown responses, altering the species compositions of communities, energy and nutrient fluxes, and carrying capacity, and reducing the resilience and recovery capacity of ecosystems (Halpern et al. 2008a; Baum and Worm 2009; Zeller et al. 2011). In concert, these historical and contemporary cumulative impacts present most contemporary researchers with a heavily modified environment that is missing any baseline data for comparison.

With this near-complete absence of baseline data that describe the marine environments from around the world before the modifying actions were affected – the Ross Sea shelf excepted (Ainley 2002b, 2007) – the removal of these predators has altered the balance between top-down and bottom-up regulation of ecosystem structures and functions (Baum and Worm 2009). In the absence of the appropriate baselines, and the relatively short time frames of extant datasets, we may reasonably hypothesize that the removal of top-order predators, including seabirds, has altered the trophodynamics and energy and

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nutrient fluxes of the oceans in a variety of ways that we cannot presently measure or describe (Ainley and Blight 2008; Baum and Worm 2009), and that the effects on marine ecosystem structure and function are not clear cut. It is highly likely the plasticity in seabird behavior and in their life histories that has allowed their survival in these highly modified marine environments.

The Challenges to Understanding the Signals

The seabird data sets provide signals from the modified and perturbed marine ecosystems in which they were obtained. The challenge now is to determine if and how these data can be used to provide information or insights into how these ecosystems may have functioned before they were modified andhow relevant they are with respect to the few minimally modified marine ecosystems that remain (Halpern et al. 2008b). Such insights or analyses are particularly pertinent if there is a need or intention to make predictions based on our current understanding.

But can we expect that future responses will be similar to those observed in the past? In a simple system, we may hypothesize that such systems either have been less perturbed or may be more resilient, and that we may have some confidence in extrapolating or predicting from the available data. In reality, however, the world's oceans are not simple; the perturbations to date have been extensive and undoubtedly have had cascading effects on portions of the ecosystem not directly related (Baum and Worm 2009).

Thus, the challenges that emerge are (1) how to place the analyses and interpretations of the existing long-term data sets into a meaningful context with respect to the contemporary, modified ecosystems and also to the few unmodified ecosystems, and then (2) to determine whether we have confidence in making extrapolations or predictions based on the existing data sets. These questions cannot be answered here at this moment, but they need to be posed, considered, and incorporated into future analyses, modeling, and interpretations, and particularly so in predictions based on models.

For much of the world's oceans, we are denied preperturbation baseline data for contemporary comparisons. A few areas of the world's oceans are minimally modified, including the Ross Sea off the Antarctic coast (Ainley 2002b, 2007; Halpern et al. 2008b). Clearly, this and other unperturbed areas must remain intact and not modified to provide valuable and unique research opportunities for both pure and applied investigations and applications. The preservation of these remaining minimally modified ecosystems will provide substantial opportunities to distinguish and disentangle the signals from the contemporary environment that may permit us to identify the consequences of past modifications to marine ecosystems elsewhere.

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We can be confident that the pressures on marine ecosystems will increase in their intensity, frequency, and spatial extents into the future. In addition, novel pressures will emerge, such as ocean acidification (Kerr 2010), and there will likely be an increase in the frequency and severity of extreme events. Climate change will act synergistically with existing pressures and modifiers to the marine environments, potentially realizing additive or multiplicative responses from the existing, already perturbed environments (Halpern et al. 2008a; Hoegh-Guldberg and Bruno 2010). These changes will produce ecosystems that are more perturbed than they are at present. Current cumulative impacts will incorporate additional modifications and perturbations, further altering ecosystem health and functions, and further constraining the research opportunities and predictions of researchers. Clearly, there will be a much greater concomitant need to assess the condition of the health of marine environments around the globe, and seabirds are the obvious choice for assessing these conditions, despite the limitations identified here.

There is no doubt that seabirds can provide useful signals from the marine environment, and to some extent, from their terrestrial habitats (i.e., those data from colony studies). But researchers and managers must be cognizant of the very clear limitations to the utility of the existing data, that is, the short time span of most data series (relative to the life expectancies of the individuals under investigation) that were often obtained from a heavily modified marine environment that has been perturbed from its original state, with no baseline data available for comparisons. The very limited availability of long-term seabird data sets from a minimal number of study sites within the geographic range of the species exacerbates the dilemma. These limitations must be explicitly acknowledged before they are incorporated into our analyses and syntheses of the global marine environments. Consideration of limitations will enhance the role of long-term data sets in future conservation and management efforts and should encourage the adoption and implementation of proactive strategies, rather than the reactive response approach currently favored.

Predictions of future conditions must be couched in terms of the constraints facing researchers. It is critical and fundamental to acknowledge the limitations discussed here, and also to expand the pool of long-term data sets, which will maximize the utility of the available data. The precious few long-term data sets should be supported by suitable resources committed to ensure their continuance. Complementary efforts should be encouraged to flesh out spatial, temporal, and species gaps.

Predictions made based on current data may be accurate, but this may not mean that we understand the system(s) under consideration. It is more likely that the systems are so perturbed that few possible outcomes or future states can be envisioned, a situation where there are few alternatives to a single

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outcome. Alternatively, the cumulative impacts arising from multiple modifications and perturbations are more likely to result in unexpected and unpredicted outcomes from interactions (Halpern et al. 2008b; Baum and Worm 2009), further reinforcing the value and significance of the few remaining minimally modified marine ecosystems.

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protocols) and distribution modeling with an emphasis on future predictions (for proactive management). These studies should be linked with many other efficient research options, for example, demography, stress physiology, movement analysis, and the existing data from colonial studies which characterize seabird research in the Arctic. Determining the current state of the global oceans is difficult, but it is clear there is a crisis, and indicator species such as seabirds can give us a good idea of how our actions impact the environment, both directly and indirectly, and both currently and into the future.

Historically, there are many native cultures in the Arctic that have used seabirds for subsistence (Loeng et al. 2005). In many ways, the knowledge of these native cultures acts as a baseline for the past conditions of various seabird populations. It is often these people who witness first hand any impact on local seabird communities (Krupnik and Jolly 2002) and who have been involved in the local management of seabird communities for many generations (i.e., via harvest). Most modern citizens do not have the same understanding of seabird management as indigenous peoples, and it is important for us to cultivate their knowledge (Chapin et al. 2010), to look at how populations have changed over time and how they foresee the management of seabirds in the future.

In modern times, specifically from the 1950s onward, we are faced with resource management schemes that are inherently based on “modernity” such as Western-style technology, industrialization, excessive use of carbon products, poorly performing legal policy mechanisms, and the (promoted) growth of population, consumption, and the global economy (Huettmann and Czech 2006). These schemes conflict with, and often overthrow, traditional “management efforts” that have been effective for thousands of years.

In this chapter we examine Arctic seabirds as a case example of these issues. We touch on the historic use and management of seabirds in the Arctic, and how oil exploration, climate change, and the opening of high-latitude shipping lanes may change the polar seascape. Although we cannot offer a thorough examination of every issue underlying seabird conservation in the Arctic, we can provide a profile, a trend, and an outlook about where we believe polar seabird research and seabird protection are generally heading. For a more complete picture, a brief section on global seabird indicator issues is also included (kindly provided as a Textbox by E. Woehler). We conclude the chapter by discussing what we see as a better way to strive for a healthy Arctic ecosystem, and how we can affect future generations to ensure a stable and more sustainable management plan for the Arctic.

10.2 A Brief History of Arctic Seabird Management

Seabirds are thought to have existed in the Arctic since the early Holocene (~9,400 years) (Yuan et al. 2009), indicating that they have been a part of indigenous cultures since humans began moving into the Far North, and just before the end of the last Ice Age. The importance of seabirds in Arctic native cultures has been expressed for the past several thousand years as they have been used primarily as a source of food. This practice has not been isolated to the Canadian Arctic, but is a circumpolar, if not global, feature with native cultures using seabirds in Russia, Norway, Finland, Scotland, Ireland, Iceland, Greenland, and Alaska (Denlinger and Wohl 2001; Baldwin 1994; Evans 1957). Until the advent of the millinery trade, human effects on seabird populations were, mostly the result of harvest for food. The millinery trade (combined with active harvesting by sailors for food) may have been the very reason species such as the great auk (*Pinguinus impennis*) disappeared in the mid-nineteenth century (Schreiber and Burger 2002). The Migratory Bird Treaty Act (MBTA) of 1918 prevented the harvest of birds for the millinery trade, but originally was only in place between the United States and Britain (for Canada). Before this, the only legally binding management scheme for (Arctic) seabirds was the First Bird Protection Act (FBPA) of 1869, which gave Scottish men special license to take northern gannets (*Morus bassanus*) (Barclay-Smith 1959). Neither the MBTA nor FBPA contained aspects that focused on the protection of pelagic birds or dealt with management issues in other countries. The harvest for seabirds has continued since that time for subsistence and commercial use, although the line between the two is relatively obscure. It is noteworthy that the MBTA is frequently cited as a conservation achievement; however, these laws, nearly 100 years old, are not performing adequately, and will not perform well into the future. For example, the Arctic murre species (*Uria* spp) that it includes have been in decline for decades (CAFF 2010), specifically because of increased pressures from fisheries, development, and climate change. The United Nations Environmental Programme (UNEP) has now recognized these limitations globally and for the Arctic (Johnsen et al. 2010). In lieu of the recognition of these downfalls, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has therefore been promoting scientific efforts into examining the relationship between economic growth (e.g., population growth, resource demand) and sustainability (UNESCO 2009).

For Arctic countries, seabirds have always been managed within their respective jurisdictions; this applies to terrestrial (e.g., nesting sites) and marine (e.g., coastal and pelagic waters) systems and the EEZs (Exclusive Economic Zones) (e.g., the MBTA applies in North America only). EEZs have been extended (likely due to fisheries pressures) over the years; however, that does not necessarily mean that seabirds receive more protection. In Canada, for instance, the EEZ is 2,755,564 km^2 with approximately 70 Canadian Coast Guard vessels to enforce protection, translating to each vessel having to protect nearly 40,000 km^2 of ocean, which is not feasible financially or technically. This situation is similar or becomes even more so when moving northward because of lack of relevant infrastructure and increased maintenance requirements. There is currently no evidence to suggest that the protection of EEZs and associated seabirds has been achieved, or is financially viable. It is critical that the people, professions, institutions and national legal mechanisms who are in charge of Arctic seabirds take a progressive approach to management and move away from current strategies (CAFF 2010). For other parts of the Arctic, Johnsen et al. (2010) claim the following: "Russia, despite having signed a number of international and bilateral agreements, has no adequate legal framework in place for the management and protection of marine ecosystems and its associated species within the Arctic regions."

To better handle the international aspects of seabird management, the CAFF (Conservation of Arctic Flora and Fauna) Circumpolar Seabird Group developed tools such as the International Murre Conservation Strategy and Action Plan (CAFF 1996) and the Circumpolar Eider Conservation Strategy and Action Plan (CAFF 1997). Both strategies, however, are basically single-species plans and generally ignore the wider community, ecosystem, landscape and seascape concepts (see Belgrano and Fowler 2011 and Cushman and Huettmann 2010 for suggested Ecosystem-based Management). They are simply a set of recommendations to some key countries in the Arctic on how to conserve these species and do not pertain to the protection of other seabirds (e.g., the ivory gull, *Pagophila eburnea*, covered independently by another plan; Gilchrist et al. 2008). The latest trends as reported by CAFF (2010) currently show no sustainable performance, despite the recommendations of their strategy plans. These plans do not report any financial budget that would prioritize conservation and sustainability while contending with the interests of stakeholders in the industrialization of the Arctic, and an objective analysis of effectiveness has yet to be performed. The continuing effort of seabird management in the Arctic is performed through formalized discussions within the Circumpolar Seabird Group (CBird). Despite this effort, a treaty that actively protects Arctic seabird species on the ground has yet to be written, adopted, and implemented. As is seen in the subsequent sections of this chapter, seabirds – and specifically sensitive endangered species – can require so much space that their effective protection could literally shut down the Arctic for any legal type of (oil) development and shipping. This spatial conflict could be better managed using scientific strategies (e.g., Huettmann and Hazlett 2010; Cushman and Huettmann 2010), wherein seabirds and industry are balanced realistically to prioritize conservation while still coping with the requirements and needs of stakeholders.

10.3 Open Access to Seabird Data

It is widely accepted that all science (particularly that which is publicly funded) should be transparent and repeatable. The notion of free data access, and documentation, performed primarily over the Internet, caters to this need. The concept is widely manifested in the Freedom of Information Act (FOIA), such as in the United States and Canada, and has been deliberated on since the 1980s (Fienberg et al. 1985). Sharing data is essential when research is discussed, disputes are to be settled, or when data are needed in a public forum (e.g., seabird densities and populations for endangered species designations, or oil spill assessments and settlements). Virtually all aspects discussed in this chapter here are affected by open access to seabird data. Although some open access initiatives have been moving forward with success (Bluhm et al. 2010), such have yet to be achieved with seabird data. Details of these concepts for seabirds are now becoming more widely discussed (Hatch 2010; Huettmann 2011) and are starting to form a standard and best professional practice (see Ohse et al. 2009 and Huettmann et al. 2011 for examples). Because of the existing digital divides in the Arctic (Huettmann 2007, 2011), and based on experience with seabird telemetry data in Norway, Iceland, and other countries (see OBIS-Seamap http://seamap.env.duke.edu/ for seabird data availability in these regions; Carlson 2010 for widespread lack of compliance with the International Polar Year IPY data policies), it could potentially take another generation until full scientific transparency is achieved. Many seabird data (which are often supported by public funds, or which deal with publicly owned natural resources such as the oceans and seabirds) are not accessible for reasons of private and industrial funding agreements. This limitation dissuades transparent science and reproducibility, as well as disowns the public and represents a privatization of a public good. Therefore, it removes certain objectivity that could help in developing sustainable management systems for the Arctic. The recent "seabirds.net" initiative could help on this front, for instance, by developing easily accessible free databases that include Arctic seabirds and offer "rewards" to contributors through "data citations," giving credit to those individuals who have spent many hours collecting at sea (or colony) data.

10.4 Attraction of Birds to Human Infrastructure, Platforms, and Vessels

With the increased occurrence of large oil platforms and cargo ships in the Arctic Ocean comes an increase in the amount of artificial light to which seabirds are subjected. Some seabirds have been shown to be attracted to lights from ships and other human-made structures, causing collisions that in some cases destroy the individual bird (Wiese et al. 2001). The effect of light on Arctic seabirds is generally unknown, and the presence of lights from oil platforms may have detrimental effects on certain Arctic species that remain there year round (e.g., some gull and guillemot species). Flares from oil and gas platforms are particularly a problem, as birds attracted to these lights tend to be incinerated while passing through (Weir 1976). Flaring is, for example, a legal procedure for Russia that is practiced in the Arctic and the Sea of Okhotsk (Huettmann 2008 and personal communication).

Flaring on the Arctic tundra (e.g., Deadhorse, Alaska) may also be a problem to the many birds (including gulls, jaegers and shorebirds) which breed there, as well as pelagic birds which may be attracted to flaring along the coastline.

Large amounts of infrastructure (e.g., land bases) will be required for the construction of offshore oil platforms. Some seabirds nest in those areas and will be affected. The common raven (*Corvus corax*) has been shown to preferentially nest on human structures (Backensto 2010), and an increase in infrastructure in the Arctic would potentially result in an increase in raven densities. Ravens can be predatory, feeding on a variety of animals, including birds (Gaston and Elliot 1997). The effect of ravens on Arctic seabirds in general is relatively unknown, but it is quite clear they are predators (Gaston 2004). Offshore oil platforms may give ravens access to large seabird colonies that were previously unavailable to them, which could have a huge impact on seabird populations that are not accustomed to predators as intelligent as ravens.

Glaucous gulls (*Larus hyperborealis*) are an Arctic breeding gull that also may be subsidized by humans through garbage disposal. There is good evidence to show that reproductive success is increased in gulls that use garbage as a food source (Weiser and Powell 2010). The increase of Arctic infrastructure inevitably means an increase in garbage from human presence. Offshore oil platforms and newly constructed land-based infrastructure (towns and villages) that do not properly dispose of waste will act as attractants to gulls and may increase their reproductive output. This effect is also shown in herring gulls (*Larus argentatus*) (Spaans 1971; Hunt 1972; Pons and Migot 1995). Glaucous gulls are known predators of a variety of birds (Gilchrist 1999). Human subsidization of glaucous gulls could therefore mean a decrease in sensitive bird populations (including shorebirds and other Arctic breeders on which they prey) and a consequent reduction of endemic biodiversity.

The opening of the Northwest Passage to large ships will mean a drastic increase in vessels that travel past seabird colonies in the Canadian Arctic and Bering Strait (including tourist and Coast Guard ships). The lights emitted from these vessels will likely attract birds from these colonies and potentially alter the birds' behaviors at sea. There are currently no modern, statistically-sound scientific studies to show the direct effects of ships on seabirds in the Arctic (Gavrilo 1998a, b) effects of ships on seabirds in the Arctic, and therefore we are left to only speculate on how populations will be affected. Figure 10.1 shows a map of shipping routes in the Arctic as per the Arctic Marine Shipping Assessment (see CAFF 2010, p. 47, for a more detailed map). When we examine Appendix (taken from Huettmann et al. 2011) in combination with Fig. 10.1, we see that the distribution of virtually every species overlaps shipping routes. In other words, almost no species will remain unaffected by the intrusion of increased ship numbers into the Arctic. Figure 10.2 was calculated by taking "presence only" data of the thick-billed murre (*Uria lomvia*) and calculating the distance to the nearest shipping route. Here it is shown that of these approximately 11,500 point locations, approximately 9,000 occur within 50 km of a shipping route. That is to say, on average, thick-billed murre are no farther than 50 km from a known shipping route whereas the thick-billed murre can easily make one-way foraging trips alone of up to 168 km (Benvenuti et al. 1998; Huettmann and Diamond 2001 for subarctic species that cover more than 500 km). Shipping routes are therefore likely to interfere with foraging murres.

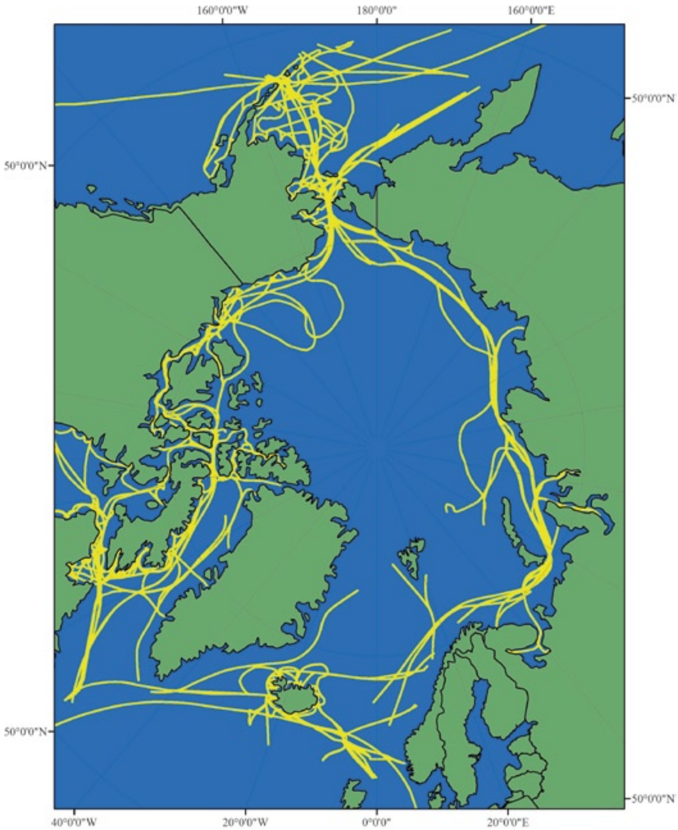

Fig. 10.1 Shipping routes in the Arctic as per the Arctic Marine Shipping Assessment

10.5 Pollution from Vessel Traffic

The increase of ships traveling through the Arctic will undoubtedly lead to an increase in marine pollutants, coming in addition to the already described contaminants, such as persistent organic pollutants (POPs) in seabirds and their habitats (Johnsen et al. 2010). Vessels that are expected to use the Northwest Passage pose, at the very minimum, a threat of losing cargo overboard (Cobb et al. 2009; see Table 8.1). This cargo could include anything from large vehicles to small packaging plastics to harmful chemicals (PCBs, mercury, etc.). The ingestion of plastics by seabirds has been well documented (e.g. Cadee 2002; Robards et al. 1995; though many other examples exist), and it is understood that this has strong deleterious effects on seabirds (Ryan 1987). Only recently has the ingestion of plastics been discovered in Canadian Arctic seabirds (Provencher et al. 2010), and this effect is likely to increase with the number of ships traveling into the Canadian Arctic. Current management deals with the issue of plastics on a population level, generally

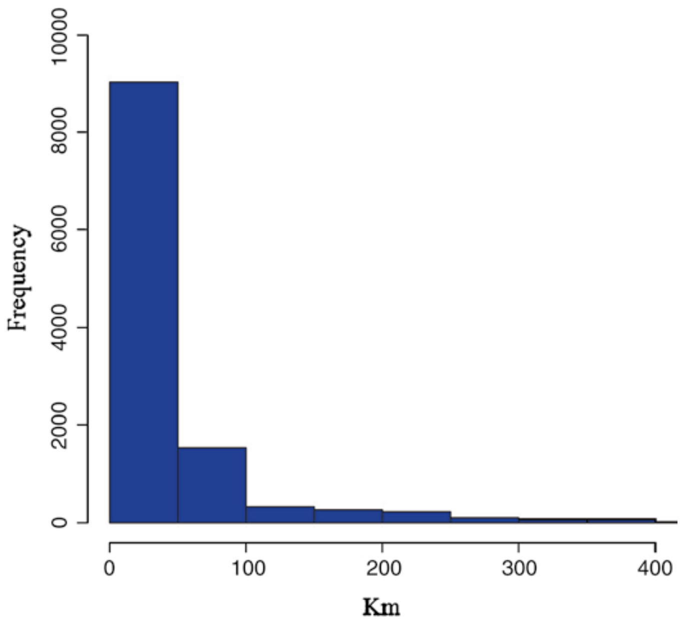

Fig. 10.2 Histogram of distances (frequency of known occurrences) for thick-billed murre (*Uria lomvia*) presences to shipping routes in the circumpolar Arctic

ignoring individual suffering of birds, when focus should be placed on a zero bird death scenario (particularly any deaths caused by human influence). These pollutants also have effects on human health, particularly in the indigenous peoples who use seabirds and areas around seabird colonies for food. Because seabirds are a top predator, they act as a vector for the transport of marine contaminants through trophic amplification. Seabird guano containing high levels of contaminants is released into the ocean, affecting the concentration of these pollutants in fish and other organisms that the indigenous people use for sustenance. There is a subsequent amplification of these already high contaminants in humans, which has forced many native communities away from traditional food sources (Blais et al. 2005), with rather bad effects.

Many ships discharge waste products and oil on a regular basis (Wiese et al. 2004), and there is always a risk of collision, particularly in the Northwest Passage, which has not been navigated enough to have mapped all potential risks, nor is there sufficient infrastructure in place to assist in the case of a collision. Regular ship discharges are regulated by the International Maritime Organization (IMO), and include grey water, black water, garbage, oil, and oily sludge. In Norway, it was estimated that approximately 2 tons of oil from ships is released in total per year, while estimates of oily sludge were up to 40,000 metric tons per year (Cobb et al. 2009). This area is not used as heavily for cargo, and oil exploration, as the Northwest Passage will be. Thus, the amount of oil being discharged into the Canadian Arctic will likely be tremendous. If not already so, the image of a pristine Arctic would truly be dead by then. We are therefore not clear on how agencies will fulfill their missions to stay within the legal and best environmental frameworks. The effects of oil on seabirds, particularly diving seabirds that nest in the high Arctic (e.g., thick-billed murre) are well known (Wiese 2003; Wiese and Robertson 2004; Wiese et al. 2004). The Northwest Passage consists of a series of channels between the High Arctic islands, and in many ways it is a “closed” system wherein the discharge of oil can have immediate consequences on populations of seabirds. It is likely that unless discharge from ships is completely eliminated (although we currently see no efforts that would achieve this goal, e.g., on the side of ship construction, policing, and goodwill by the industry or government budgets), particularly in these closed channels, seabird populations in the Canadian Arctic will suffer deleterious effects. It is not known how the rest of the Arctic will handle the problem of ship discharge, but it is clear that without mitigation, effects could be disastrous.

10.6 Oil Spills in the Arctic

The detrimental effects of oil on seabirds are already well established (Piatt and Anderson 1996; Piatt and Ford 1996; Wiese 2003; Wiese and Robertson 2004) and require no further discussion in this chapter. In almost all cases, studies examining these effects and the effects on other species have occurred just after the tragedies (e.g., *Exxon Valdez*, *Selendang Ayu*, *Deepwater Horizon*); many books have been written on the subject of oil spill impacts and recovery (e.g., Owen et al. 1995; Burger 1997; Ott 2005). Currently, statistically valid pre-spill baseline studies for the Arctic are lacking. Many high-latitude areas are very remote, with coast guard stations at a distance of 500 km or more in some cases. Even the most basic oil spill preparedness gear is not maintained along the Arctic coastlines, nor does it exist in sufficient quantity (Ott 2005). This lack makes it virtually impossible for (a) adequate response in the case of an oil spill, and (b) the creation of a baseline study on pre-spill distribution and populations of all species. Regardless of these problems, baseline studies must be performed through modeling exercises and aerial surveys to prepare for an inevitable spilling of oil and other substances into the Arctic Ocean. A more extreme (yet effective) approach would be to stop any development until baseline studies have been performed, adequate response infrastructure is in place, and efforts by oil and gas companies have been shown to stop, and not promote, climate change and environmental destruction. The “burden of proof” must be on the producer’s site. We see little effort on addressing these issues, and most seabird biologists, conservationists, or ecological economists are not included in these discussions where seabirds act as a primary indicator of marine health.

The Arctic is a very delicate ecosystem, and the effects of an oil spill are unknown in detail, although obviously detrimental. One of the biggest unknowns is how an oil spill will affect or be affected by sea ice, and how long oil will persist in the Arctic basin. It has been observed that sea ice bacterial communities can shift in the presence of crude oil, and may even degrade certain hydrocarbons, but further research is required to understand these processes and whether it is even a realistic technique on which to rely (Gerdes et al. 2005).

The Arctic basin acts in some ways as a closed system, with ocean currents that circulate the Arctic, and very few currents that transport water in or out, therefore leading to turnover times of the order of 11 years (Östlund and Hut 1984). Based on knowledge of current systems in the Arctic, an oil spill that occurs anywhere offshore will likely affect the entire basin. Gavrilo et al. (1998b) estimate that 92 species of seasonal birds of the Russian High Arctic are vulnerable to the effects of oil spills, including several species of seabirds. Seabirds are likely to suffer large-scale population loss because of direct oiling and the loss of primary food sources. Arctic cod (*Boreogadus saida*), for instance, are a primary source of food for many seabirds in the Arctic, and some species such as the thick-billed murre can eat up to 34 kg of this fish during the chick rearing period (22–24 days) (Brekke and Gabrielsen 1994). Arctic cod feed off planktonic organisms that live below sea ice (Gradinger and Bluhm 2004). Oil that would be spilled into the ocean would not float just at the surface of the water, but also under the sea ice, inevitably killing the arctic cod that must feed there. The loss of an important food source to seabirds could be devastating to entire colonies around the entire Arctic region. Connections to seals, polar bears, and whales are also clear and consequently they would be equally devastating.

Currently, as the *Deepwater Horizon* incident has highlighted, we are no further ahead at combating the effects of oil spills than what we were in the 1980s. Thirty years of environmental progress for seabirds in the Arctic could be virtually "wasted" if these issues are not addressed in full; the lack of explicit (pelagic) circumpolar seabird protection projects in the International Polar Year (IPY; probably the biggest research effort for the Arctic ever) makes this clear. Without a way of effectively stopping and cleaning oil spills, seabirds will suffer, and we will be no further toward good environmental practices or sustainable management schemes than we were decades ago.

10.7 Climate Change

Climate change is well known to be a global problem, and the Arctic has been shown to be an important player in global climate control (Gabric et al. 2005; McGuire et al. 2006). It is well documented that polar sea ice is melting, and that the Arctic climate, in general, has been warming (Alley et al. 2003; Zhang 2005; Brigham 2010). Increased freshwater input from melting glaciers, sea ice, river discharge, and permafrost and the exact consequences of that are not well understood, neither individually or cumulatively (Manabe and Stouffer 1995; Peterson et al. 2002). Sea ice also acts as an important habitat feature for many seabirds that rely on the organisms which feed underneath it (Bradstreet and Cross 1982; Fraser and Ainley 1986). A widely ice-free Arctic in the summer, predicted by some to occur by 2040, would therefore lead to important changes in ecosystems that include seabirds. Arctic seabirds that have evolved around the presence of seasonal and permanent sea ice could begin to die out in response to the lack of habitat, or potentially attempt to adapt to new feeding strategies or habitats to survive by means of the plasticity of seabird behavior (Kato et al. 1996; Garthe et al. 2003; Lewis et al. 2004; Congdon et al. 2005; Paiva et al. 2010). Seawater temperature is known to be an important feature for seabirds because of its effect on fish stocks, for instance (Decker et al. 1995). Climate change and melting sea ice will bring about shifts in seawater temperature because of the change in the physical thermodynamics of the Arctic (i.e., more open water for absorbance of heat; Gradinger 1995). These changes will certainly affect the trophic food web, which will have far-reaching impacts on seabird populations.

Dimethylsulfide (DMS) is another important molecule that may play a role in cloud formation, and subsequently global climate, and which acts as an attractant to seabirds (Nevitt 2003; Bonadonna et al. 2006; Cunningham et al. 2008). Concentrations of DMS at the sea ice edge can be up to three times higher than in open ocean waters (Trevena and Jones 2006). Under an assumption that seabirds in the Arctic use this important molecule as a signal to locate foraging areas, there remains the good possibility that in an iceless Arctic during summer, some species of seabirds may have difficulty locating prey items. In either case, with DMS indicating true biological mechanisms, (e.g., grazing on phytoplankton by zooplankton), changes in DMS concentrations caused by lack of sea ice will certainly indicate substantial changes in the Arctic trophic structure. This field still requires more research but would be worthwhile as it provides an important link between biology, climate, and oceans.

A northward shift in populations of horned puffins (*Fratercula corniculata*) in response to a warming Arctic may be detrimental for birds such as black guillemots (*Cepphus grylle*). Puffins are known to increase burrow competition for black guillemots, which may have effects on black guillemot reproductive output (Divoky 1982, and personal communication). This northward trend of species is not limited to puffins (Krasnov and Barrett 1997 for subtropic-temperate zone northern gannets now breeding in the Arctic White Sea) and may in fact bring predators and disease farther north that were unable to move in the previously lower temperatures.

10.8 Who Manages Arctic Seabirds?

In times of globalization, a governance system that considers migratory seabirds in the Arctic for conservation prioritization does not yet exist. How can we stop the already dramatic declines of the kittlitz's murrelet (*Brachyramphus brevirostris*), and the ivory gull (*Pagophila eburnean*) in a quickly changing ecosystem? The current political state of the entire Arctic is in question, with a variety of countries laying claim to certain important areas for oil and gas development. It has become a game of resource development, where politics and economy are the major players (Brigham 2010). In this situation, seabirds are a secondary thought, at best.

Table 10.1 Members of the Steering Committee of the Norwegian SEAPOP program (http://www.seapop. no/en/about/index.html; which states "… *A milestone for the mapping and monitoring of seabirds in Norway*…"), dealing with publicly owned seabirds, their trends, populations, and status in national and adjacent international Arctic waters, but being widely dominated by expertise beyond classic seabird research biology, e.g., oil and gas, fisheries, and various administrators

– Norwegian Petroleum Directorate
– Norwegian Oil Industry Association
– Institute of Marine Research
– Norwegian Maritime Directorate
– Norwegian Coastal Administration
– Norwegian Directorate of Northern Management

The *Exxon Valdez* oil spill experience shows us that seabirds can be depicted as a (public) threat to industry and development (Ott 2005). Most seabirds that breed in the Arctic are not citizens of a single country, but are international and global citizens, and must be treated as such (see Appendix). Most Arctic seabirds winter in southern (tropical or Antarctic) waters (Huettmann et al. 2011). With migration routes and breeding colonies that can span multiple countries and multiple ocean basins, the current system of each country looking out for, and protecting, its own colonies will not be sufficiently effective to combat impacts of increased human development. Currently, most global distribution maps of seabirds are limited to colony locations published in various books or journals (e.g., Gaston and Jones 1998), lack a digital access (Huettmann 2007), and only few pelagic modeling efforts have been undertaken (e.g., Raymond and Woehler 2003; Huettmann et al. 2001).

As the topic of seabird management is becoming increasingly important, there still exists no textbook (university-level courses or accreditations) or written guidelines that could lead biologists toward sustainable seabird populations. Money from governmental management schemes could easily be shunted to academia for specific interest courses or even workshops.

Many governments rely on soft money or have directly shared seabird projects with industries (e.g., Norway, Russia, Canada, and Alaska). The Canadian Wildlife Service (CWS), for instance, employs former oil industry representatives, and the Norwegian SEAPOP program (http://www.seapop. no/en/about/index.html) shows strong industrial and commercial influence in its steering board (Table 10.1). This type of management scheme, which is partially (or totally) driven by industry and development is biased, and skewed toward the goals of oil and gas exploration, fisheries, shipping, and economic growth, ignoring the ecological needs of many species (not only seabirds). This can be given the illusion of effective management by NGOs who are willing to cater to the desires and greed of these interested parties. In economic terms, the ongoing lack of official impact assessments for many subarctic (and other) fisheries that involve Arctic seabirds (Dietrich et al. 2009 for Alaskan waters) represents a subsidy for a quick and ruthless resource extraction industry, particularly when combined with receding ice and access to Arctic waters (Stiglitz 2008). It is important that humans move away from this and into a balanced, science (not industry)-driven management system.

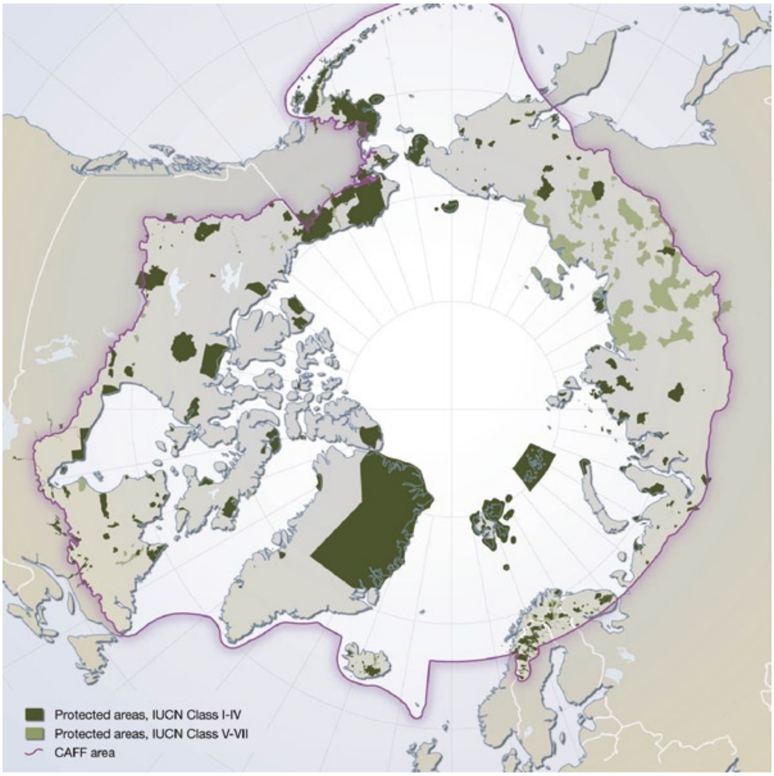

Fig. 10.3 Protected areas as defined by the International Union for Conservation of Nature (IUCN) class in the Arctic from Arctic Biodiversity Trends 2010: selected indicators of change. *Source*: CAFF International Secretariat, Akureyri, Iceland. May 2010. Barry, T.X. and McLennan, D., Indicator #21. Changes in protected areas, p. 97. Data downloaded from http://www.arcticdata.is

Currently, Arctic seabirds are overseen by the Circumpolar Seabird Group (CBird), a branch of CAFF, which is a branch of the Arctic Council. CBird (http://caff.arcticportal.org/expert-groups/seabird-group-cbird) is composed of members from across the Arctic community and is dedicated to the promotion and facilitation of communication between scientists in the Arctic to conserve seabird communities.

Although the formation of an international organization has been completed, there is still a lack of an effective management scheme in the Arctic (i.e., CBird cannot set quotas, delineate marine protected areas, or ask for an Adaptive Management scheme). Recommendations passed down by this organization can be examined by various government agencies for consideration, but these reviews can take more time than is available for sensitive Arctic species. Figure 10.3 depicts the current status of protected areas in the Arctic. This delineation is done ad hoc or by political compromise, and not according to scientific evidence and modern method (Huettmann and Hazlett 2010). As of now, there are few marine areas in the Arctic that are truly protected, leaving seabirds vulnerable at sea away from their colonies.

Although there are terrestrial areas that are protected, comprising mostly colonies, we still see decreases in Arctic seabird populations (CAFF 2010; Johnsen et al. 2010; see Merkel 2004 for some waterbirds as well). Arctic seabirds are still hunted for pleasure and commercial reasons: for example, up to 5% of the entire Icelandic seabird population is hunted annually (Petersen 2008 in Merkel and Barry 2008). The hunting pressure and associated disturbance from these activities is not known but can be believed to be “high.” This begs us to question whether the regulations and protected areas currently delineated are actually working effectively?

We recommend here that CBird reviews its actions, assesses its performance objectively (via transparent metrics), and moves to a proactive and precautionary management using adaptive management (e.g., Chapin et al. 2010). This effort would place a stronger focus on active management techniques in setting quotas and dealing with management violations and delineating important protected areas that will be required in the future. With limited space in the Arctic, combined with industrial pressure, it will be a difficult task for CBird to achieve this goal, but we recommend the task regardless. Current efforts by CBird to maintain a database of seabird populations and trends must be refined, statistically evaluated, and explored further as only several species have truly been addressed, such as the red knot (*Calidris canutus*), common eider (*Somateria mollissima*), black-legged kittiwake (*Rissa tridactyla*), thick-billed murre and ivory gull (see Gavrilo et al. 1998a for summaries of the latter 4 species). At least 25 other Arctic seabird species and their habitats are awaiting appropriate assessment (see Huettmann et al. 2011), and we highly recommend this be achieved soon unless we truly believe that seabirds are a marginalized economic cost or environmental write-off.

10.9 Conclusions

Seabirds are currently living in an oceanic crisis. The management scheme so far achieves very little. Baselines have dramatically shifted for seabirds globally and in the Arctic. Seabirds are (and will continue to be) indicators of many oceanographic and environmental features and their institutional achievements, although researchers must remain cognizant of the limitations of this (see Textbox). Major resources are located in the Arctic (nickel, oil and gas, fisheries, etc.) and are awaiting their imminent exploitation. Together with the continual warming trend in the Arctic, and combined with the introduction of even more oil and gas platforms, and increased shipping, tourism, and vessel-based fisheries, dramatic trends are shown (Brigham 2010; CAFF 2010) that spell a very precarious future for seabirds in the Arctic (Johnsen et al. 2010). The current profile of seabird management in the Polar North is characterized by the lack of (pelagic) data. That lack must be alleviated before we allow, if at all, industry and politics to dominate management regimes and diminish our ability to achieve sustainability. Without action, it is likely that we will lose many of these precious species, at least their meta-populations and genes, within the next 100 years, leaving behind a legacy of destruction and exploitation. We therefore recommend, at minimum, the following actions. (1) The establishment of baseline databases of species distributions in the Arctic through multidisciplinary modeling exercises using the best available science. It is critical that these be taken seriously and not ignored (e.g., Huettmann 2007) for the sake of conservation. (2) An increase in sea ice–oil interactions research to better prepare for the eventuality of an oil spill. (3) Strong sanctions and enforcement against vessels that pollute Arctic waters. (4) A strong management regime through an organization such as CBird (and others), which will have the ability to set quotas, preparedness, and delineate marine protected areas effectively. (5) More emphasis on how to mitigate seabird populations and predict shifts in trends with an increasingly variable climate. (6) The formation of an International Biodiversity Protection Treaty enforced by all Arctic nations to ensure a clean, diverse, and sustainable Arctic for the future.

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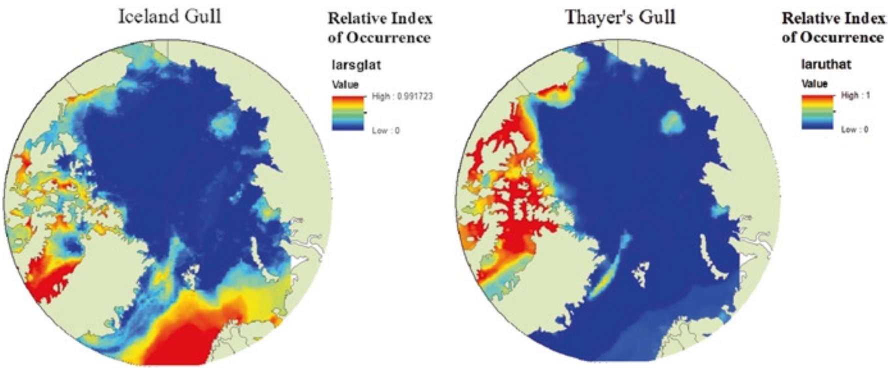

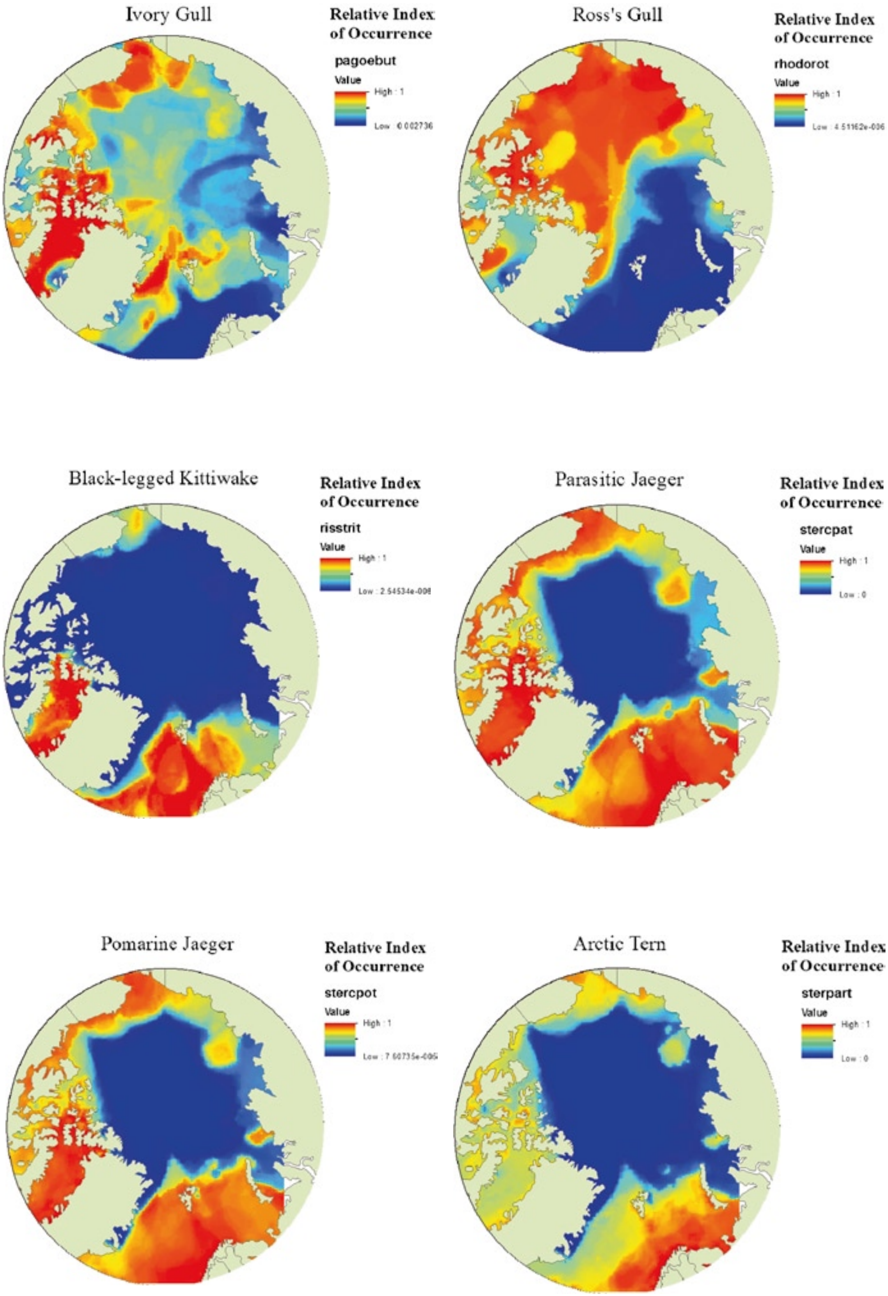
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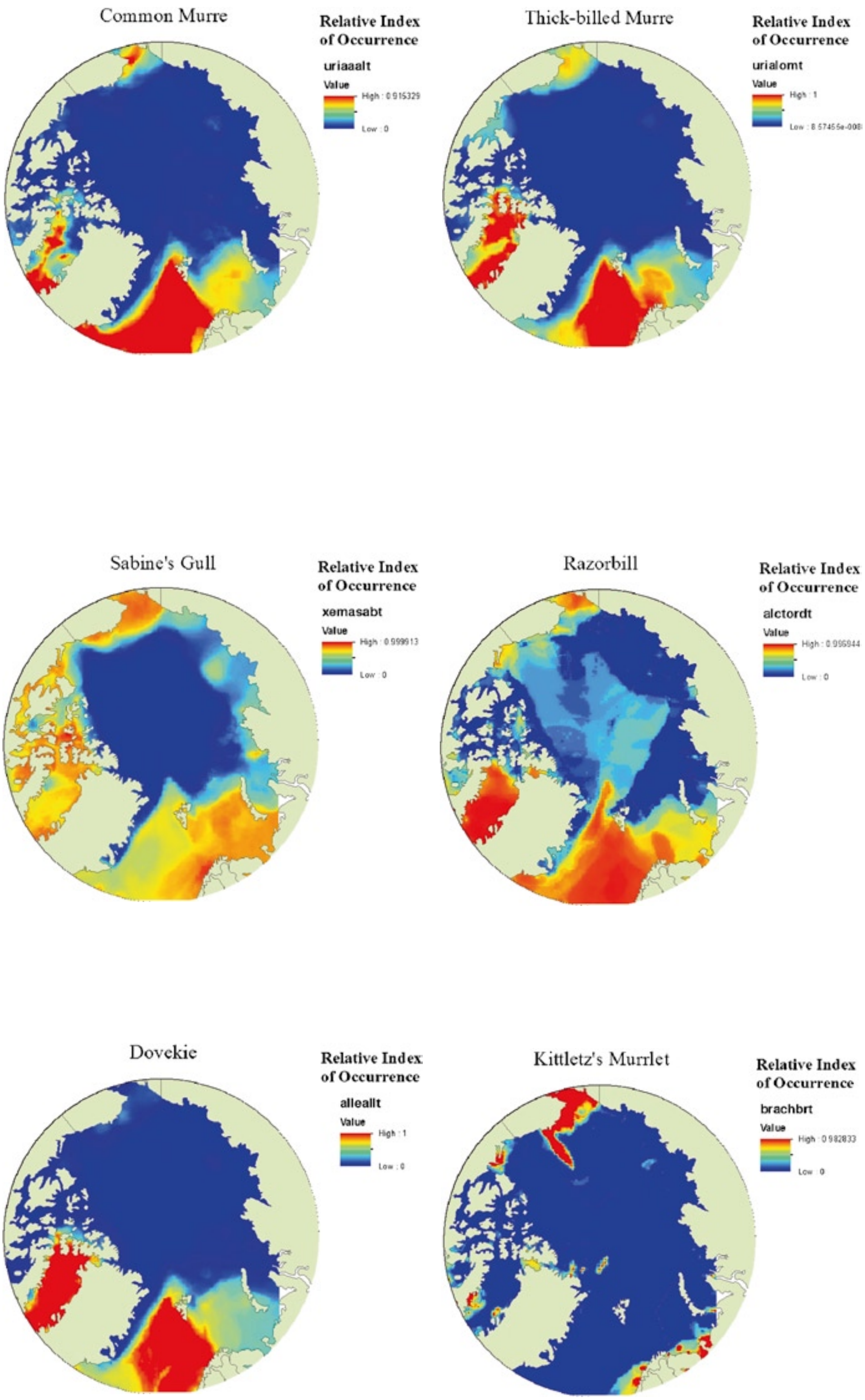
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Thick-billed Murre
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Low : 8.57455e-008
Sabine's Gull
Relative Index of Occurrence
xemasabt
Value
High : 0.999913
Low : 0
Razorbill
Relative Index of Occurrence
alctordt
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High : 0.996944
Low : 0
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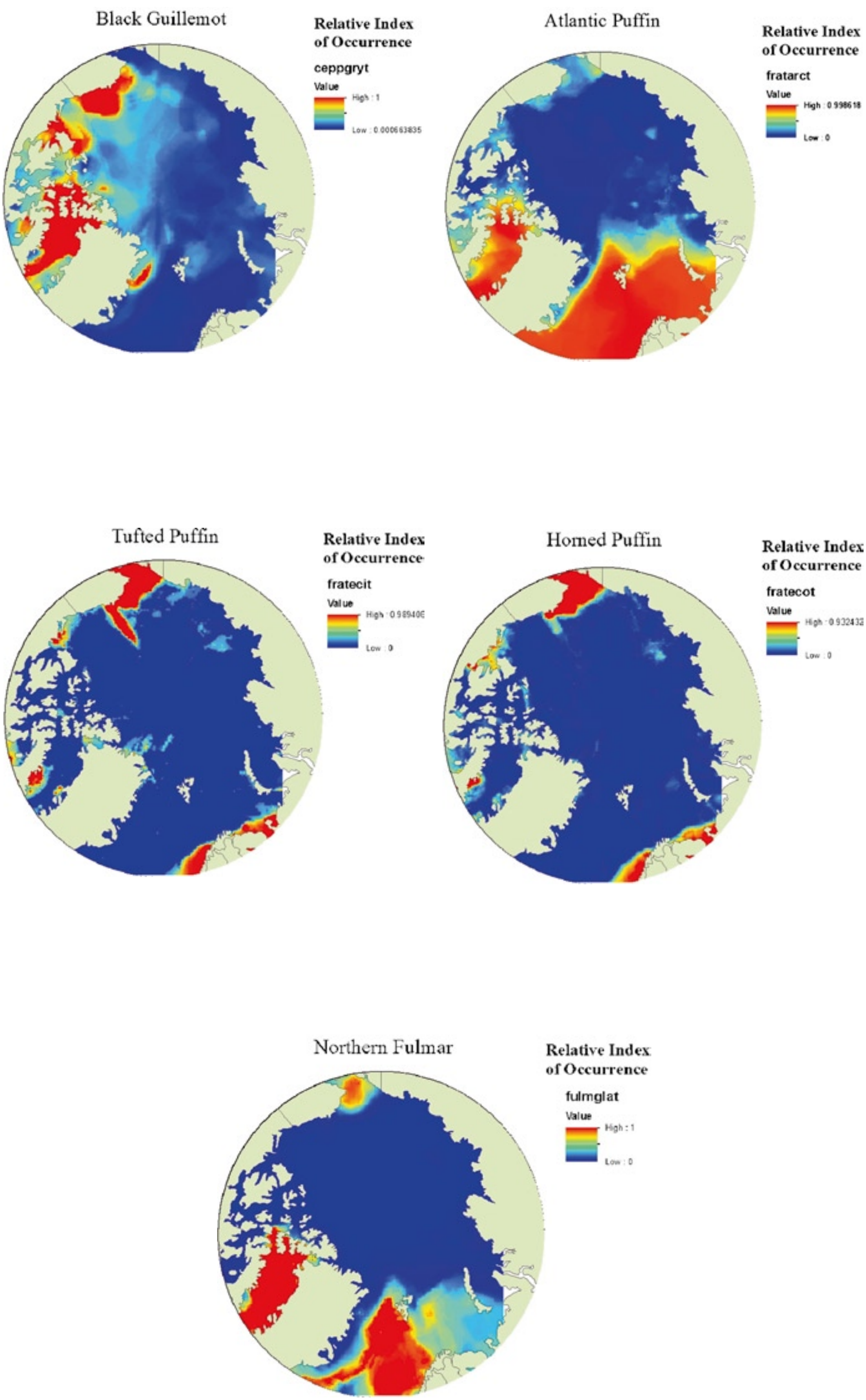
Black Guillemot
Relative Index of Occurrence
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Low : 0.000663835
Atlantic Puffin
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High : 0.998618
Low : 0
Tufted Puffin
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Low : 0
Horned Puffin
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Value
Low : 0
Northern Fulmar
Relative Index of Occurrence
fulmglat
Value
High : 1
Low : 0

Appendix

Modeled distributions of 19 Arctic seabirds (taken from the public data source in Huettmann et al. 2011)

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Chapter 11
Polar Diseases and Parasites: A Conservation Paradigm Shift

Susan J. Kutz

11.1 Introduction

11.1.1 Arctic Ecosystems

In considering the conservation of the Arctic, we typically picture a landscape dominated by vast expanses of ice and snow, extremes in weather, sparse vegetation, and tundra ponds. Animals that come to mind are the majestic polar bears (*Ursus maritimus*, TSN 180542*)* and the challenges of receding sea ice, the grand migrations of caribou (*Rangifer tarandus*, TSN 180701*)* with their complement of predators and scavengers, the prehistoric muskox (*Ovibos moschatus*, TSN 180708), the fabled "unicorn" (narwhal, *Monodon monoceros*, TSN 180485), and of course, the swarms and swarms of mosquitoes and other biting insects.

We can also picture the aboriginal peoples in this landscape. These are peoples who for generations have survived and made a living off the land and ocean in this harsh Arctic environment. Lifestyles have changed, but many aboriginal people maintain their roots in these traditions, perhaps hunting by snowmobile and rifle while also attending school and/or holding down wage jobs. This human presence is longstanding and an integral component of Arctic ecosystems (Fig. 11.1).

As we consider this spectacular ecosystem, its unforgiving climate and extreme seasonality, the flush of vegetation and brilliant carpet of flowers in the early summer, and the unique adaptations of the flora and fauna to life under these conditions, we realize that this represents only a fraction of Arctic biodiversity.

Living in or on each of the plant and animal species that we have named within this system, there is a bountiful biodiversity of parasites. In fact, every vertebrate

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Fig. 11.1 Hunter butchering caribou

species that we can list in the Arctic is essentially a banquet of parasite biodiversity. These parasites include a diverse array of microparasites (viruses, bacteria, and protozoa) and macroparasites (helminths and arthropods). Surprisingly, for many of these parasites we still have no name or, worse yet, remain completely unaware of their existence. Small, often microscopic, and difficult to identify, these components of northern communities have been critical drivers in the evolution of Arctic biodiversity and continue to play an integral role in the structure, function, and health of Arctic ecosystems (Hoberg et al. 2008; Kutz et al. 2009a).

11.1.2 Parasites and Conservation of Polar Regions

Parasites are perhaps best known for their negative impacts on individual hosts. In this context, they are typically considered somewhat repulsive and evil components of the biosphere, deserving only elimination. In fact, a major responsibility of human and animal health professionals and their institutions (and funding) has been to eradicate "the offending" parasites from their patients. However, parasites do serve a multitude of important roles in ecosystem health, and perhaps deserve more respect and recognition for the valuable services that they provide.

Conservation biology is concerned with (1) the factors that influence the maintenance, loss, and restoration of biodiversity and (2) the science of sustaining evolutionary processes which promote genetic, population, species, and ecosystem diversity (van Dyke 2008). Parasites are key components in conservation biology, both as components of biodiversity in their own right as well as having important short- and long-term interactions influencing the conservation of other organisms. They play important historical and ongoing roles in ecosystem health (Thomas and Guegan 2005; Poulin 2006; Huffman 2009). In this chapter I focus on parasites of one charismatic arctic species, the muskox, to illustrate how parasites interact with various components of the ecosystem and why they are relevant to conservation of polar regions.

11.2 The Muskox Case Study: Ecological Interactions Mediated Through Parasites

11.2.1 Parasite Biodiversity

There are two subspecies of muskoxen around the Arctic, *O. moschatus moschatus*, found across the mainland Northwest Territories and Nunavut, Canada, and *Ovibos moschatus wardi*, or the "white-faced muskox," found naturally in Greenland and the Arctic islands of Canada, with introduced populations in Alaska, the United States, Yukon and Quebec, Canada, Norway, Sweden, Greenland and the Taimyr, Russia (Lent 1999). At first glance this appears to be rather low biodiversity, but if we look more closely we see that these two subspecies harbor a diverse array of macro- and microparasites (Table 11.1, Fig. 11.2). Although documentation of bacterial and viral diversity is difficult, the natural helminth and protozoan parasite diversity of muskoxen is fairly well defined across most of their native range.

11.2.2 Parasite Diversity Informs Us About the Health of Muskoxen: Direct Effects of Parasites

It is generally accepted that, at high infection intensities, parasites can negatively impact the condition, survival, and reproduction of their hosts. In domestic animals there is also ample experimental evidence that even at low infection intensities parasites can reduce weight gain and growth (Elsheikha 2011). For free-ranging wildlife, determining impacts of parasitism is much more difficult because manipulation of the system is challenging and teasing out the effects of parasitism compared to other environmental conditions is often complicated. Nevertheless, landmark studies on the cecal nematode of red grouse demonstrated that this parasite influences the survival and productivity of grouse and can drive population cycles (Dobson 1992). Similarly, long-term studies on a feral population of Soay sheep (*Ovis aries*) demonstrated reduced survival associated with gastrointestinal nematodes as well as increased susceptibility to severe weather events (Gulland 1992a, b).

Table 11.1 Known helminth, protozoan, and arthropod diversity in natural, free-living muskox populations (does not include captive, translocated, or introduced populations)

No.	Parasite type	Genus	Species	Organ/tissue	Other hosts	Transmission pathway
1	Nematode	*Ostertagia*	*gruehneri*	Abomasum	Caribou, Dall's sheep	Environment
2	Nematode	*Teladorsagia*	*boreoarcticus*	Abomasum	Caribou, Dall's sheep	Environment
3	Nematode	*Marshallagia*	sp.	Abomasum	Caribou, Dall's sheep	Environment
4	Nematode	*Nematodirus*	spp. (2 at least)	Small intestine	Caribou, Dall's sheep, moose	Environment
5	Nematode	*Nematodirella*	spp. (2 at least)	Small intestine	Caribou, Dall's sheep, moose	Environment
6	Nematode	*Trichuris*	sp.	Cecum	Dall's sheep, caribou	Environment
7	Nematode	*Umingmakstrongylus*	*pallikuukensis*	Lung	None	Gastropods
8	Nematode	*Protostrongylus*	*stilesi*	Lung	Dall's sheep	Gastropods
9	Nematode	*Varestrongylus*	sp.	Lung	Caribou	Gastropods
10	Nematode	*Dictyocaulus*	*eckerti*	Lung	Caribou, moose	Environment
11	Cestode	*Taenia*	*hydatigena*	Liver/omentum	Caribou, Dall's sheep, moose	Carnivores
12	Cestode	*Taenia*	*krabbei*	Muscle	Caribou, Dall's sheep, moose	Carnivores
13	Cestode	*Moniezia*	sp.	Small intestine	Caribou, Dall's sheep	Mites
14	Cestode	*Echinococcus*	*granulosus*	Lung	Caribou	Carnivores
15	Protozoa	*Eimeria*	spp. (minimum 6)	Small intestine	None	Environment
16	Protozoa	*Giardia*	*duodenalis*	Intestine	People, sea and terrestrial mammals	Environment
17	Protozoa	*Cryptosporidium*	sp.	Intestine	Caribou, people	Environment
18	Protozoa	*Sarcocystis*	spp.	Muscle	Caribou, moose, Dall's sheep	Carnivores

19	Protozoa	*Besnoitia*	*tarandi*	Fascia	Caribou	Carnivores and/or insects?
20	Protozoa	*Trypanosoma*	sp.	Blood	Caribou, Dall's sheep	Insects (?)
21	Protozoa	*Toxoplasma*	*gondii*	Muscle	Caribou, Dall's sheep, sea mammals, birds	Felids, transplacental
22	Protozoa	*Neospora*	*caninum*	Nervous system	Caribou	Carnivores
23	Arthropods	*Hypoderma*	*tarandi*	Skin	Caribou	Environment

A minimum of 21 genera and 28 species of parasite infect muskoxen; note that many of these parasites (a) can infect other sympatric ungulate hosts ("Other hosts"), and/or (b) require an intermediate host (e.g., gastropods) or predator–prey interactions for transmission ("Transmission pathway"); ?, Kutz and Schuck, unpublished data

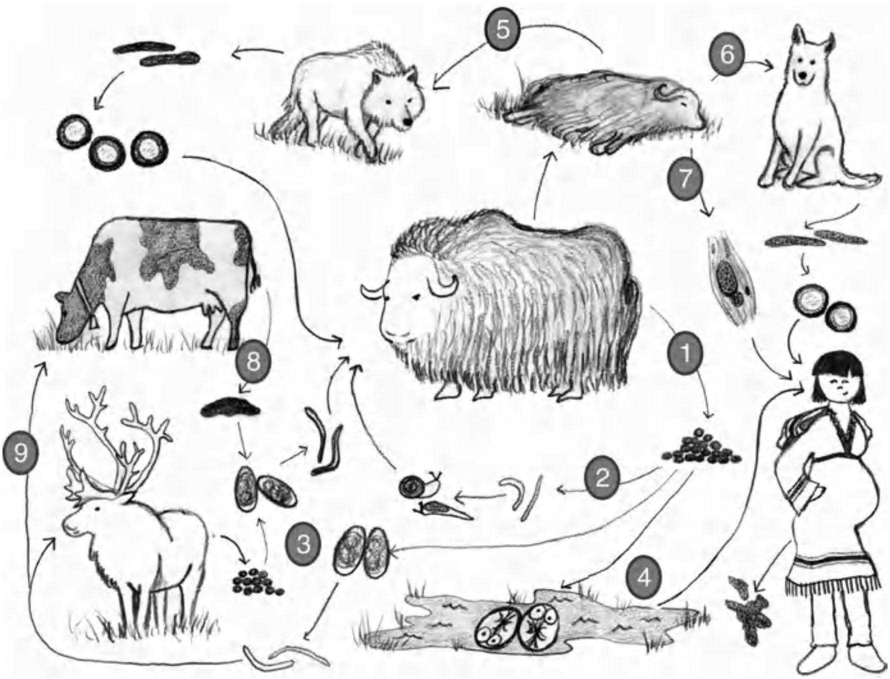

Fig. 11.2 There are numerous parasite-mediated interactions and interlinkages in the Arctic ecosystem. This figure illustrates just a few of these interactions. (*1*) Several parasites are shed in the feces of muskoxen and are transmitted to the next host through the environment. (*2*) Larvae from *U. pallikuukensis*, the muskox lungworm, and related parasite species (e.g., *Protostrongylus stilesi)*, must invade gastropod intermediate hosts for further development before they can again infect a muskox. Presence of the host-specific parasite *U. pallikuukensis* indicates that the muskox–gastropod relationship has been intact over thousands of years. (*3*) Caribou and muskoxen share many of the same directly transmitted gastrointestinal nematodes and may have negative impacts on each other through this interaction (parasite-mediated competition). (*4*) *Giardia* is shed in muskox feces and may be able to infect a variety of different mammalian host species, including people. It causes gastrointestinal upset and weight loss. (*5–7*) Through a predator–prey cycle, parasites cycle in the food chain. (*5*, *6*) Foxes, wolves, and dogs feeding on muskox carcasses may ingest tapeworm cysts or sarcocysts, which mature in their gastrointestinal tracts and are shed in the environment as eggs (tapeworm) or sporocysts (*Sarcocystis*). Muskoxen are then infected by ingesting these environmental stages. (*6*) One tapeworm of zoonotic importance is *Echinococcus granulosus*, which forms hydatid cysts in the lungs of the muskox. When eaten by the wolf or dog, the cysts mature to tapeworms in the carnivore intestinal tract and produce eggs. Muskoxen, and people, can be infected by ingesting the eggs in the environment. The impacts of *E. granulosus* on the carnivore hosts are small; however, these parasites may cause significant disease in the muskoxen and people. Note that without the carnivores these parasites would not exist. (*7*) *Toxoplasma* is also transmitted through a predator–prey life cycle. People are infected by eating cysts in undercooked or raw meat. Exposure for the first time during pregnancy may cause abortion or birth defects. (*8*) Introduction of domestic animals, particularly livestock, may lead to spillover of their parasites into muskoxen. Several pathogenic gastrointestinal nematodes of cattle (for example, *Haemonchus)* may cause disease in muskoxen. (*9*) Similarly, parasites of muskoxen may be able to establish in introduced domestic species. (Figure drawn by Jayninn Yue and digitally adapted by Jesse Invik)

Fully understanding the role of parasitism in muskoxen is difficult, however, because of their remote locations and the inability to manipulate the systems. The vast majority of the literature about parasites in muskoxen is limited to case studies in a small number of captive and wild animals, and thus population-level impacts are not well understood. Nevertheless, there are several examples of parasites causing reduced survival or productivity of muskoxen.

Dictyocaulus is a large parasitic nematode that lives in the airways of the lungs of most ungulate species. Adult worms produce eggs in the airways of the lungs. Eggs (or hatched larvae) are moved up the trachea and are then swallowed and passed in the feces as larvated eggs or first-stage larvae. In the environment, the larvae develop to the third (infective) stage (best in moist and warm conditions) and then are eaten by the muskoxen. Once ingested, larvae migrate to the lungs and eventually mature. *Dictyocaulus eckerti* is typically found in young animals, and yearling muskoxen seem to be particularly susceptible to infection. On Banks Island, Northwest Territories (NWT), the prevalence of *D. eckerti* increased in animals sampled between 1983 and 1987. This increase coincided with an increase in muskox population size. In June 1987, heavy lungworm burdens were observed in ten yearlings that were found dead and in an additional five emaciated yearlings. The authors concluded that this parasite was responsible for the poor condition and mortalities and was having a negative impact on this age class (Gunn and Mclean 1991).

Mortality events are probably the most obvious way that the impacts of parasites on hosts are detected. However, mortalities are generally the exception and not the rule. Most parasites have much more subtle, but equally important effects, often influencing body condition, behavior, susceptibility to predation, or reproduction.

One example of subtle impacts on reproduction is the protozoan parasite *Toxoplasma gondii*. This parasite can cause abortion and fetal defects in humans and most grazing ungulates. The typical life cycle includes sexual reproduction of *Toxoplasma* in the small intestine of felids, producing oocysts that are shed in the feces. Grazing animals may be infected by ingestion of oocysts from cat feces, but the parasite may also be transmitted directly from dam to fetus across the placenta. Disease typically occurs when females are exposed for the first time during pregnancy and the parasite then infects the fetus (Dubey 2009).

Toxoplasma gondii is present in approximately 30% of muskoxen on the NWT/western Nunavut mainland (Kutz et al. 2000). The life cycle on the tundra is not known, but transmission from lynx is one possibility (although lynx are extremely rare in this region), as is transmission from muskox mother to offspring in utero. This parasite may reduce the reproductive capacity of muskoxen. For example, transplacental transmission of *T. gondii* in a captive muskox resulted in abortion (Crawford and Dubey 2000). Such an impact on reproduction would be very important in natural settings, resulting in poor calving rates or weak calves. Aborted fetuses are unlikely to be detected on the tundra, and mortality of weak calves may be attributed to "predation." Thus, although the parasite might have significant effects on population dynamics, it is likely to remain "invisible" unless more extensive and intensive investigations are initiated.

Many other parasites could have subtle effects on individuals with broader population-level implications. For example, the gastrointestinal nematode, *Teladorsagia boreoarcticus*, is common at high infection intensities in muskoxen on Banks Island, NWT. Related nematodes in domestic sheep and reindeer can reduce body condition and pregnancy rates and drive population cycles (Albon et al. 2002). It is thought that this is likely the case for *T. boreoarcticus* as well. However, further research is required to evaluate the effects of this parasite (Kutz et al. 2004).

11.2.3 Parasites Inform Us About Sympatric Species

Documenting parasite biodiversity can provide important insights into the presence of sympatric species, as well as interactions among these species. For example, detection of the gastropod-transmitted sheep lungworm, *Protostrongylus stilesi*, in muskoxen in the Yukon, Canada, demonstrated that introduced muskoxen were using the same habitat as the native Dall's sheep (*Ovis dalli dalli*, TSN 180710) and consuming infected gastropods (Hoberg et al. 2002). Larval production of *P. stilesi* from muskoxen is extremely low, and it is unlikely that muskoxen maintain the parasite in the absence of Dall's sheep.

The *Taenia* spp. and *Echinococcus granulosus* tapeworms and *Sarcocystis* spp. protozoa provide additional examples. Species from all three of these parasite genera use muskoxen as intermediate hosts, forming cysts in the muscle, liver, and/or lungs of muskoxen. Carnivores are required as definitive hosts without which the life cycles cannot be completed. The presence of these parasites in muskoxen, therefore, indicates that the appropriate definitive hosts are also present in the ecosystem. Importantly, abundance of these definitive hosts may then influence the health of muskoxen through the shared parasites. For example, anecdotal reports from hunters in the Canadian Arctic have indicated a positive association between arctic fox abundance and *Taenia* cysts in muskox meat.

A significant challenge in interpreting parasite findings in muskoxen is that, for many parasites, they have not been identified to species (e.g., *Sarcocystis*) and the specific muskox-definitive host cycles are often unknown (i.e., which carnivore species are definitive hosts for which parasites). The recent identification of different definitive host species for two species of *Sarcocystis* in Fennoscandia (Dahlgren 2010) is an important advance in our understanding of these interactions.

Parasites can also provide us with a history of interspecific interactions. For example, the muskox lungworm *Umingmakstrongylus pallikuukensis* requires gastropod intermediate hosts for transmission (Kutz et al. 2001). This parasite is the only species within this genus and is specific to muskoxen; it cannot develop to maturity in any other mammal. The fact that it survived a significant bottleneck of its muskox host and has persisted in the relictual population of muskoxen in the western Canadian Arctic indicates that this gastropod–muskox system has remained intact since the Pleistocene or earlier. If this relationship had not been intact, the parasite would have gone extinct because transmission could not be completed in the absence of gastropods.

In addition to providing information about presence, absence, and interaction with sympatric species, parasites may also reveal new competitive interactions, as was illustrated by work on a nematode parasite shared by pheasants and partridges in Britain (Tompkins and Hudson 2000). In a series of studies, these authors demonstrated that pheasants maintain a parasite that has low impacts on the pheasants but high impacts on the partridges. Thus, through their parasites, the pheasants may be able to exclude partridges from some habitats. Although this phenomenon has not yet been detected in the Arctic, this probably reflects a lack of investigation rather than a true absence. Anecdotal evidence suggests that, all else being equal, the gastrointestinal parasite communities of caribou and muskoxen shift depending on the dominant ungulate species in the system (Kutz et al. 2004). Finer-scale interactions between host species through their parasites remain to be elucidated but can offer many new insights.

11.2.4 Human Health

Animals can be a source of infectious disease for people. In the Arctic, where wildlife remain an important part of the diet and economy for aboriginal communities, this is particularly important (Meakin and Tiina 2009). People depend on a safe and secure source of "country"/subsistence food (e.g., wild game harvested for food), yet parasites may alter the quality and safety of these foods. For example, *T. gondii* is a common parasite in caribou and muskoxen that can also infect people through ingestion of undercooked meat or contaminated water supplies. Major consequences of infection for women who are exposed to *T. gondii* for the first time while pregnant include fetal defects and abortions (Dubey 2009). Awareness of the parasite and appropriate precautions may prevent the infection. Similarly, *E. granulosus*, a common lung and liver parasite of muskoxen, can also cause disease in people. Although not contracted directly from the muskoxen, if the parasitic cysts are eaten by dogs the parasite can mature in the dogs' intestines and the eggs subsequently produced in dog feces are infective for people (Rausch 2003).

Muskoxen in some parts of their range also are host to the parasite *Giardia duodenalis*, more commonly known as the cause of "beaver fever." A potentially zoonotic strain of *Giardia* (Assemblage A) has been found in muskoxen on Banks Island, NWT (Kutz et al. 2008). Although the original source of *Giardia* for muskoxen remains unknown (perhaps spillover from people), it seems now to be maintained in the muskox population. *Giardia* is a water-borne organism and thus muskoxen, or more specifically, muskox feces, might serve as a major source of contamination of water bodies for people and other animals.

From these few case studies in a single host species, it becomes quickly apparent that understanding parasite diversity in Arctic wildlife provides insight into risks related to food and environment for people who depend on the animals and the environment for food and income.

11.2.5 Ecosystem Health

It is argued that a healthy ecosystem is one that contains a diverse assemblage of parasites (Hudson and Lafferty 2006), reflecting an intact, diverse system that supports the various transmission pathways for the parasites. Documentation of the parasite fauna from muskoxen provides us information on the “normal” parasite fauna. In this case, all the parasites already listed here, with the exception perhaps of *Toxoplasma* and *Giardia*, are considered part of the endemic and normal parasite fauna of muskoxen. This host species went through a major population bottleneck in the early 1900s, and currently the only host-specific parasites that are known in this species are *U. pallikuukensis* and probably *Eimeria* species: any other muskox-specific parasite species may have gone extinct during the bottleneck. Nevertheless, the current fauna provides a documented baseline of what parasites are present now and, therefore, a starting point to measure the impacts of ongoing and future environmental perturbations.

11.3 Changing Polar Environments and Host–Parasite Interactions

The parasite biodiversity in Arctic ecosystems today reflects past environments, host assemblages, colonization events, and ecological perturbations, including climate change. Historical biogeography studies provide insights into the current faunal structure and how they may have been shaped by episodic climate change (Hoberg 2005), thus providing a framework for understanding the effects of current and future environmental perturbations.

Arctic host–parasite interactions today continue to be dynamic processes, responding to various environmental changes, including extreme events as well as cumulative trends. Parasites that have free-living stages in the environment or within ectothermic intermediate hosts or vectors are likely to be affected by even slight changes in their ecological niche such as temperature, precipitation, and season length (Hoberg et al. 2008). Severe weather events can lead to emergence of disease, as has already been described for both nematode and bacterial pathogens. In muskoxen, outbreaks of pneumonia in Norway occurred during a summer with excessive heat and humidity. A high mortality rate in muskoxen was attributed to the combination of these environmental conditions together with additional stress imposed by increased human activity in the area (Ytrehus et al. 2008). Severe weather events in winter, such as melting and raining followed by freezing temperatures, can cause nutritional stress on ungulates that are unable to access forage because of thick ice layers on top of the snow. In Soay sheep, gastrointestinal parasitism exacerbated weather-related nutritional stress, and animals with higher parasite infection intensities were more likely to die. The synergistic effects of severe weather events and pathogens are likely a significant factor limiting conservation of wildlife in the Arctic, where animals are often living “on the edge.”

A key example of a disease outbreak associated with extreme weather events is that caused by *Setaria tundra* in reindeer. *Setaria* is a mosquito-transmitted nematode that as an adult migrates and reproduces in the peritoneal cavity of reindeer. In Fennoscandia, this parasite appears to emerge as a disease-causing agent following two abnormally warm summers (Laaksonen et al. 2010). Thus, exceptionally warm weather in two consecutive years, not just a single season extreme event, is required for this parasite to cause significant disease.

Climate warming trends can have a more gradual impact on pathogens, as has been demonstrated with the muskox lungworm *U. pallikuukensis*. Observations in the Arctic, together with model-derived predictions for larval development rates in gastropod intermediate hosts, suggest that, beginning in the early 1990s, this parasite shifted from a 2-year to a 1-year transmission cycle because of warmer summers (Kutz et al. 2005). There is also anecdotal evidence that it might be expanding its geographic range. Such nonlinear shifts in transmission cycles and range expansion are expected to continue under current warming regimes, and although effects are unknown, it is unlikely to allow for a status quo.

Invasions of new parasites and new host species can radically alter existing host–parasite interactions. Under warming conditions in the Arctic, new host species and vectors are likely to invade and bring with them at least some of their parasite fauna. How this will influence the existing parasite communities remains unknown, however, because the Arctic has a relatively low biodiversity and, therefore, it is likely to be particularly sensitive to invasions (Elton 1958). One example from the Yukon demonstrates how the introduction of a new host species into a subarctic environment can alter the abundance of existing parasites. Elk (*Cervus elaphus*, TSN 180695) were introduced to the Yukon on multiple occasions during the 1900s with the intent of eventually providing another source of game for the residents. These elk established and are currently host to high-intensity infestations of winter tick (*Dermacentor albipictus).* Behavioral characteristics of the elk, including herd behavior, habitat selection, and spatial patterns of land use (in particular, returning to the same area every spring and fall), may be responsible for the amplification of the winter tick in this ecosystem (Kutz et al. 2009b). Importantly, the elk may now serve as a significant reservoir of winter tick for other cervid species (caribou and moose) and, therefore, have negative consequences for the native fauna of this region.

With increased habitability and improved access to nonrenewable resources, land use is changing across the Arctic. Importantly, the development of a livestock industry will lead to the introduction of domestic animals and their parasites, as well as an expanded wildlife–domestic animal interface, facilitating parasite transmission among wild and domestic species. Arctic terrestrial wildlife are typically naive and highly susceptible to most of the common pathogens of domestic livestock and, therefore, may be significantly impacted. Altered habitats will also influence abundance and distribution of important intermediate host species. For example, snail density and infection of snails with trematode parasites is higher along roadways in Alaska compared to undisturbed habitats (Urban 2006). Gastropods are important intermediate hosts for parasites of many Arctic vertebrates, and shifts in gastropod abundance and distribution may influence parasite transmission patterns.

Host–parasite interactions are dynamic and sensitive to a variety of drivers from climate, landscape use, sympatric species, animal behavior, and other sources. Climate change, perhaps the major driver, is anticipated to have a number of negative impacts on host communities. In particular, increased abundance of endemic parasites, habitat disturbances that favor parasite development and transmission, as well as the introduction of new parasites and invasions of new hosts, may have negative consequences on the overall health of endemic wildlife species. Documenting these impacts, and a broader understanding of parasitism in these systems, is essential for the efficient conservation of polar regions.

11.4 Tools and Policies to Monitor, Predict, and Mitigate Impacts

Clearly, knowledge of parasite biodiversity and host–parasite interactions provides critical insight for the conservation of polar ecosystems. Nevertheless, a comprehensive understanding of pathogen biodiversity is lacking. To address this there have been several recent initiatives to better define the pathogen biodiversity in Arctic terrestrial systems, including the Beringian Coevolution Project (http://www.msb.unm.edu/mammals/Cook/CurrentProjects/0051.html), the CircumArctic Rangifer Monitoring and Assessment Network (http://www.carmanetwork.com), Norwegian Health Surveillance Program for Cervids, and the program for Surveillance of Reindeer and Other Deer Species in Finland (Hoberg et al. 2008; Tryland et al. 2011).

A second and complementary methodology for documenting and monitoring pathogen biodiversity includes engaging with local communities to monitor animal health, which has been done through a wildlife health monitoring program (Brook et al. 2009) and ongoing hunter training through the International Polar Year (IPY). Essential for these programs to be successful are clear and efficient protocols, as well as new tools for disease surveillance. One such tool is the collection of blood on filter paper for disease sampling (Curry et al. 2011). Filter paper blood collection allows members of the public to easily and safely collect and store blood samples from animals that they harvest for subsistence purposes. Implementation of this type of hunter-based sampling vastly expands the network of individuals involved in wildlife health monitoring and allows for much broader wildlife disease surveillance in both space and time. Other tools include development of standardized protocols, training videos, and resources (http://www.carmanetwork.com).

There is also a substantial need for archival collections of parasites and development of data resources that are backed by definitively identified specimens and genetic material (from genotypes to populations). Such archival collections and databases provide the baselines against which potential patterns of change can be assessed. Without such physical archives we cannot go back to reexamine or apply new techniques to historic specimens and archived DNA to assess change. Thus, these archival specimen collections become the self-correcting records of biodiversity (Hoberg 2002).

In addition to biodiversity documentation and monitoring there is a need to predict shifts in parasite communities and impacts. Examples of predictive models include those for the protostrongylids [*U. pallikuukensis* (Kutz et al. 2005), *Parelaphostrongylus odocoilei* (Jenkins et al. 2006), and *S. tundra* (Kutz et al. 2005; Laaksonen et al. 2010)]. Such models serve to provide insight into potential future parasite distribution and parasite-associated disease outbreaks. There remains, however, a great paucity of knowledge with respect to the impacts of these parasites on individual animals and, more importantly, on ecosystem health.

Finally, knowledge about the biodiversity of Arctic parasites, their impact, and the risks associated with invasive hosts and parasites must be communicated to the decision makers for appropriate risk assessments and policies to be developed and implemented in a timely manner. Without the translation of science to policy we are unable to effectively move forward in conservation and wildlife management efforts.

11.5 Conclusion

Parasites are numerically dominant and ecologically essential, yet often neglected, components of Arctic ecosystems. They influence the health and dynamics of host populations, are important components of food webs, and provide insight into ecosystem health, invasive species, and environmental perturbations. Under a regime of unprecedented climate change, accentuated at the poles, the impacts of parasitism are unlikely to decline. There remains much to be discovered with respect to the biodiversity and function of parasites in polar ecosystems under current and future conditions, and further exploration of these systems is warranted. A solid foundational inventory and knowledge of parasite biodiversity, together with an understanding of current and historical host–parasite interactions, will provide important tools for the holistic protection and conservation of polar ecosystems.

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Part VI
Synthesis

Chapter 12
Yet Another, But This Time Realistic, Polar Synthesis, Meta-Analysis, and Outlook: Protecting Ice, Snow, People, Species, Habitats, and Global Temperatures for Good?

Falk Huettmann

12.1 Reflections on Things That Are Gone, Already Forgotten, or Will Be Gone Any Time Soon

A celebrated keynote speaker who researches subarctic watershed management and climate change issues referred, in his invited keynote speech at the esteemed Society of Conservation Biology (SCB) conference, held in July 2010 in Alberta, Canada, to politicians as "spineless bastards." A big "awhh" went through the international audience.

How did it come to such disrespect, lack of trust, and openly stated disagreement? Is our public and federated governance system, the social contract, broken for good?

Before we address these important questions, let us first try to get at it from another angle and focus briefly on the day-to-day conservation practitioner. If the reader allows, let me start by providing a wider context, a short reasoning and excursion about why many of the contributors of this book and beyond do what they do, and what drives this book and numerous scientific efforts.

12.1.1 About Wild Landscapes, Wild Men, and Sustainable Societies

Working in big and wild landscapes leaves a strong impression on people. It tends to affect one's values, one's vision and outlook on life, and can easily leave a lasting (good) psychological impression. The human condition is tightly linked to

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environmental conditions. M. Lewis of the so-successful Lewis and Clark expedition killed himself eventually, as did several Russian Arctic investigators (e.g., Boris Pawlow; Nowak 2005). The polar explorer Frijdhoff Nansen turned to philanthropy and supported the human cause in Arctic regions. Alexander von Humboldt became outspoken on issues of human rights (despite the fact that he is a "real" Prussian), and as a direct consequence of his expeditions and experience worldwide. The infamous ornithologist Prof. Hans Christian Johansen, working in Siberia for decades, always insisted on sleeping under the open sky during his tundra fieldwork, even in winter (Nowak 2005). World record climber Reinhold Messner, active for decades in the polar region of the Hindu Kush–Himalayas (Messner 2007), became an outspoken green politician on mountain wilderness issues. And Jane Goodall, who worked for more than 25 years in wilderness regions, turned into a lifelong campaigner for wild landscapes and connectedness with nature and now supports a global steady-state economy (SSE www.steadystate.org). After thousands of hours in the field with bears, Jeff Gailus wrote the notable Grizzly Bear Manifesto (Gailus 2010), pointing out serious Canadian management governmental failures and for national parks. Charles Darwin changed our world views with his 4-year world trip on the *Beagle* and subsequent publishing (after 15 years of analysis work) of the infamous tome on evolutionary theory (http://darwin-online.org.uk/contents. html). Jacques Cousteau, having spent a large portion of his life on and in the world's oceans, became a major governmental critic (e.g., at the Rio Convention; Strong 2001) after seeing what worldwide governments can and cannot produce on environmental issues.

The list goes on and on, and is a convincing argument that people and their visions, the meaning of life, are shaped by intimate interactions with wilderness landscapes and related experiences. Here we focus on the polar regions of the world. It will become clear that most of the authors of this book are among those who "saw the wild," "ate the rock," "lived among bears, tigers, penguins, albatross, caribou, and muskoxen," and "swam with the walrus and whales." They might lose funding and jobs (all of us know this experience, a form of academic punishment for speaking and publishing unwanted truth, a common sacrifice for trying to change things to the better; see O'Neill 2007; Nowak 2005), but their ideals and visions cannot be killed. This book makes that case. If one of us is pushed down, another will take his/her place. The truth always remains valid, reasoning does not die, and quality always wins. The voice of the wilderness, of polar regions and the wild, will remain. It is because this is the true voice of nature; it comes from the Earth itself.

Myself, I was drawn to nature from birth. My childhood was spent running around local farms, meadows, and woods in the nowhere land just off the Iron Curtain, a place dominated by farming and forestry. I feel blessed for my early immersion in nature and a research career that has brought me to many wide and rich landscapes worldwide, and to study and assess them. I am a citizen of the world; that is my home. Like many others, I recognize the responsibilities and ethics that come with it. Thus, city life is not a real option for me. The list of my own works and travels for fieldwork is not unusual among people who are deeply linked to, and involved with, nature and global sustainability (compare for instance with

Fig. 12.1 Mountains of the third pole: A slim atmospheric cloud layer sits on top of 4,000 m of devastated landscapes (subsistence farming, overgrazed rangelands, and a fully used-up valley in the background). The mountain range shown is the Annapurna region, about 8,000 m high. (Photograph by the author, March 2011)

travels by the naturalist Thomas Belt in the 1800s): Arctic Alaska, the Yukon River, the Russian Far East, coastal Sea of Okhotsk, Amur River, China, Hawaii, Australia, and Tasmania, Sepik River, and the Bismarck Range in Papua New Guinea, the Caribbean, Costa Rican dry forests and rainforests, Venezuela, Nicaragua's cloud forest, Lake Ometepe, Ivory Coast, Ghana, South Africa, Nepal, Rocky Mountains, British Columbia's old-growth forest, the Bay of Fundy, Northwest Atlantic, Iceland, Norway, Nepal, and virtual Antarctica; the list goes on. One must feel blessed, and it is important to implement such experiences (see Fig. 12.1 for how many "wild" landscapes look) back into real life and global management. Such a life experience and attitude is not a new phenomenon as such, starting with travelers and explorers and naturalists such as Marco Polo, James Cooke, George Wallace, and continuing with Fred Kurt (Kurt 1981), Jared Diamond (1999), Tim Flannery (Flannery 1994), Michael Palin (Pao and Palin 2005), or David Attenborough.

The world these days simply comes closer to us all, and almost at the fingertip and by mouse click. That is reality. Technology makes this possible and it forces a new culture upon us, once again. The global village is our reality and only solution. It is in front of us, and we all live it (just think of bananas flown in daily straight from Costa Rica, or mangos from India). It is important to understand that in these times home can be "everywhere," so long as one is connected with the world, with the soil, with the atmosphere, and with its flora and fauna. This is true ecology. It does not matter so much where you sleep, but more that you are connected to the land and air, and that you ensure that it does not get spoiled for generations to come.

If you cannot handle and use nature now, leave it pristine and for generations later. This is Aldo Leopold's message in the pure sense: deep ecology (A. Naess; http://en.wikipedia.org/wiki/Arne_N%C3%A6ss). But that lesson was not considered when the Europeans entered North America, when the Spanish and Portuguese tried to make the best use of South and Central America (Brockett 1998), when the French, Germans, Portuguese, English, etc. established themselves in Africa (Hochschild 1998, for Belgium Congo), and Australia (Lines 1991; Flannery 1994), when the Dutch set up their Asian colonies, when the Danish started their control of Greenland, and when the forest, mining, and oil and gas industries promoted their agendas that are widely destructive to landscapes, flora and fauna, and the atmosphere, and (surprisingly) harmful to the economy (global, national, regional, and local) as well. It was referred to as "Crimes Against Nature," deserving global lawsuits for justice, compensation, and correction.

Not only did hunting pressures increase with industrialization and development schemes (Klein and Magomedova 2003; Ross 2001, 2006), but new and vicious diseases entered the landscape and its people (Diamond 1999). The occurrence of deadly malaria strains (Packard 2007 for Arctic Russia), or global influenza pandemics, and the antibiotic resistance problem are good examples.

Most participants were lost quickly in such a scheme, and often beyond recovery (Diamond 1999; Prugh et al. 2010). Despite the wealth that was created, poverty remained widely (Easterly 2006; Stiglitz 2006), the gap between some rich and most poor widened, and diseases turned upon us. Invasive species (Thomas et al. 2008), already as high as 30% of the flora in some areas of Russia and Alaska – or on Macquary Island (Raymond et al. 2010) – created eradication costs in the range of many millions of dollars, supporting that argument clearly. Similar examples include killer whales moving north, putting pressure on beluga whales and narwhales, and red foxes invading Arctic fox habitats (Klein and Magomedova 2003).

12.1.2 Devastated Landscapes Produce Desperate People?

By now, carbon dioxide must be perceived as one of the most deadly gases for mankind. It is highly toxic for all of us, but it still remains virtually unlisted by relevant conventions and treaties. The law widely failed, so far. The few CO_2 treaties that exist are not signed or not implemented well by relevant producers and consumers, for example, the United States, EU, China, Russia, Venezuela, India, or even the Organization of Petroleum Exporting Countries (OPEC). The processes responsible for CO_2 production continue at full steam (Czech 2000; Stiglitz 2006) and are in fact promoted more strongly than ever (see Yergin (1991) for global overview). Other gases, such as methane, released when permafrost thaws or produced by cattle, are hardly addressed or mitigated at all. Just in Russia's North alone there are more than 100,000 sources of air-polluting gases. Flaring is still legal and widespread (Klein and Magomedova 2003; AMAP 2006 for Arctic Haze; AMAP 2010; Johnsen et al. 2010 for persistent organic pollutants, POPs). However, any landscapes that produce, or support, global devastation cannot be our goal, or a sign of good leadership and sustainable compliance.

If a (global) society is dying, the Arctic and high-latitude people are among the first to be affected. And that is exactly what we see already: the polar regions are indicators. Landscape- and seascape-scale devastation exists, and it seems to continue to be promoted further. This devastation is facilitated by "men" with a tie and a suit (nowadays mostly made in China). What they can achieve, and what not, is seen in the case of CEO Tony Hayward and the BP oil spill (Heinberg 2003; Ott 2005 for a general review and critique). Effects of such a policy can be seen for the Arctic coastline and where oil spill preparation is poorly done, if at all. Most fish off northern Alaska are related to the Mackenzie River, for example, for spawning, but this is where the oil–gas impacts are large.

Such a management culture ignoring ecological realities often comes in a variety of sorts, shapes, and flavors, but all have a top-down business concept supported by governments, one that is widely unsustainable, and one which sooner or later creates misery for others. The global poverty gap increases. Business comes first, nature last (Paehlke 2004). Managers of this sort, and who ignore ecological carrying capacity and global well-being, conveniently hide behind subsidized terms and abbreviations such as CEOs, Advisors, Mentors, Board Members, Shareholders, Foreign Aid, and World Bank loans (www.worldbank.org), Debt Swaps, WTO (World Trade Organization; www.wto.org), GATT (General Agreement on Tariffs and Trade; http:// en.wikipedia.org/wiki/General_Agreement_on_Tariffs_and_Trade), OAS (Organization of American States; www.oas.org), TEEB (The Economics of Ecosystems and Biodiversity; www.teeb.org), and global Copyright Agreements such as TRIPS (http://en.wikipedia.org/wiki/Agreement_on_Trade-Related_Aspects_of_Intellectual_Property_Rights). Initially, these things might not appear to be widely destructive, but they actually provide for a double and triple whammy with a devastating after kick for land- and seascapes and the atmosphere worldwide; destroying nature is turned into entire job employment schemes on a national scale. Such policy lockups give people "something to do" and have become a global culture (while nature and its atmosphere have to foot the bill). Entire families cannot get out of these concepts until either they, or the entire system, break: this harms generations to come. So why should we embark on this scheme any further (Czech 2000; Netherlands Environmental Assessment Agency 2010 for an outlook)?

People who explored the last Third Pole have already been called "Conquerors of the Useless." As a matter of fact, the indigenous populations were never concerned much with the poles. The poles were holy to them, or at least unreachable, and the geographic locations were of no direct interest. Mt. Kailas, the holy mountain for Hindus and Buddhists in the Hindu Kush–Himalayas, thus remains unconquered to this very day. However, the Western world is obsessed with the poles and with their pursuit. Hundreds of people have died in the conquest of the Third Pole (Messner 2007). The inherent terror found in the poles and their mountains quickly becomes obvious.

The (prestigious and usually economically motivated) race to the poles not only creates death and misery to those who try to conquer it but also leaves a wider despair for the atmosphere, the global climate, and all who rely on it. In recent decades, the holiness of the poles, of the inaccessible, has been entirely lost (Messner 2007). It is time we treat the poles as part of the royal family of nature; the real dignitaries to obey (Tables 12.1 and 12.2).

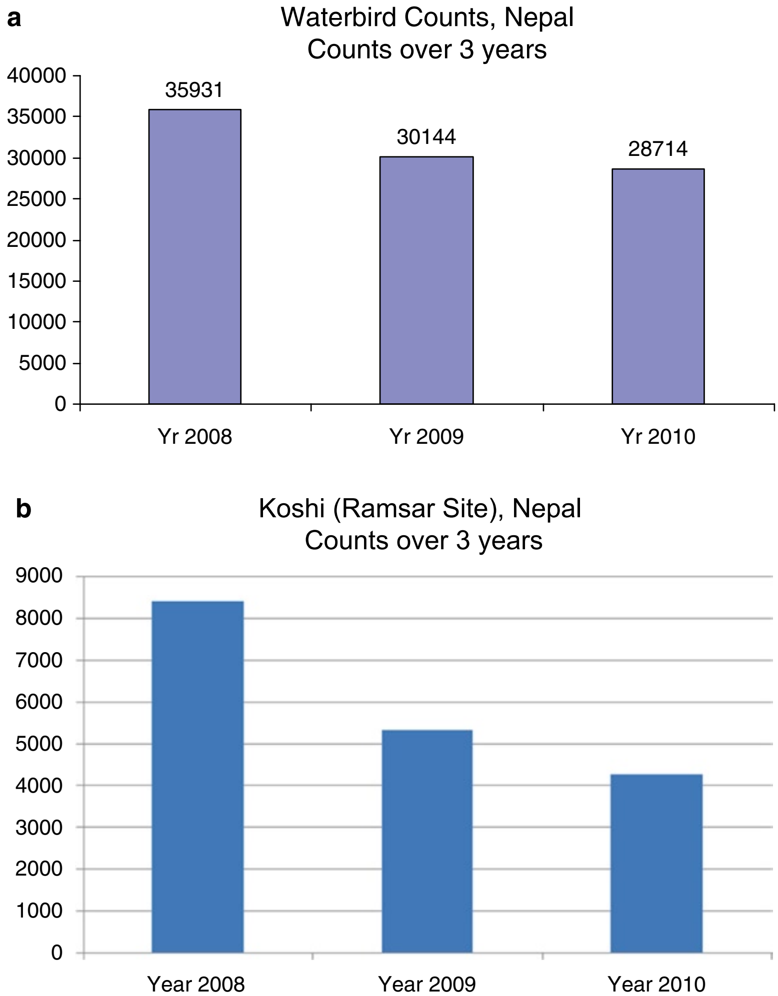

Fig. 12.2 (**a**) Asian Waterbird Census results for wetlands of Nepal for the years 2008, 2009, and 2010 show a general decline. (Data courtesy of H. Bara 2010. Results of Mid-Winter Waterbird Count 2010). (**b**) Asian Waterbird Census results for the Koshi Ramsar site for the years 2008, 2009, and 2010 show a decline of almost 50% within just 3 years. (Data courtesy of H. Bara 2010. Results of Mid-Winter Waterbird Count 2010)

12.2 Synthesis of the Three Poles

Global warming is accelerating (ACIA 2005; http://www.acia.uaf.edu/pages/scientific.html): it is affecting all poles (e.g., Yalowitz et al. 2009; Tse-Ring et al. 2010), and beyond the endemic biodiversity and habitat crisis it represents a human tragedy (UNESCO 2009). Never before have we known so much about nature and the atmosphere, yet we continue to make poor decisions worldwide. Never before have so many people worked toward conservation, for NGOs, and in science, but achieved so little and in such insufficient ways. Conservation has turned into a feel-good mass-employment scheme but that achieves virtually the opposite. While the difference between rich and poor widens, we still have no tools to tell us when to stop our destructive doings. Atmosphere and landscapes are very sensitive items (see Fig. 12.1 for an example). When will "objective science," applied for conservation and sustainability, be consistently used for making real-world decisions in favor of global sustainability? The track record of our actions is atrocious (Berkes 2010; Berkes et al. 2010 for a short overview). Why do the people on the ground remain widely inactive, just celebrating a broken culture of materialism, consumption, and subsequent destruction on virtually all fronts (Czech 2000)? Many science budgets have skyrocketed, as have those of journal publications and online. Scientific journal publishing houses make big profits, and some more than ever because of the advent of the Internet and commercial open access (which promotes instant access to PDFs for clients, but instead should be used for free, global dissemination of the underlying high-quality research and for the public good and global citizens, including libraries). Never before was the interface between science and management so often discussed and by so many people (Chapin et al. 2009; Larigauderie and Mooney 2010) but so rarely applied and with such insufficient achievements. Have we become simply a shallow discussion club, knowing full well that the state-of-the-art is in decline (Netherlands Environmental Assessment Agency 2010)? Can the race to the bottom still be avoided? The massive undercurrents of a "nice and friendly" world celebrated by public leaders are showing everywhere. A look at the poles leaves us with no doubt (Polyakov et al. 2010; Dixit and Ramackandaran 2010; see http://en.wikipedia.org/wiki/Wilkins_Sound for the ice collapse of Wilkins Sound). So why did most of the effort simply bear no relevant fruit? Why are the sciences and the related management and legal procedures (Johnsen et al. 2010) so inefficient, and can we afford such inefficiency any longer? Any textbook states that conservation is time critical.

If climate change hits us longer and harder, the administrative issues regarding the large number of endangered species alone will become huge and add to the fiscal sink already experienced. The Stern report (http://en.wikipedia.org/wiki/Stern_Review) convincingly showed just that (see Beazley and Boardman 2001 for administration of endangered species in Canada). We are widely overcommitting our own governance systems, and many goals we want to reach can no longer be reached.

People are already fleeing the rural polar regions (Wilson Rowe 2009; Hoermann and Kollmair 2009 for Hindu Kush–Himalayas), but industrial resource needs and tourism push back and offer urbanized lifestyles for high latitudes and altitudes that were never before populated by "cheap labor," for example, from Mexico, Philippines, or even Nepal (the staff composition at polar industry, research and visitor stations makes for such an argument). The structure of the polar industry is rather clear: oil, gas, coal, mining, fishing, and tourism are the big players; agriculture is widely discussed. All these receive strategic subsidy from many governments, that is, waiving of cleanup and delayed impact costs. Many of such polar industries rely heavily on immigrant workers (Wilson Rowe 2009, for an example), and it is entirely unclear why foreign embassies allow that to happen. How would the ambassadors shape immigration laws, how would the poles look like without cheap labor, and what do ambassadors do to change it? Should not the ambassadors be concerned about their own people and taxpayers, about their own nation, their host nation, the international fabric, about sustainability, and that minimum human rights and labor regulations are met (it must come as a surprise that many ambassadors are directly involved in setting up the Rio Convention and Kyoto meetings, and that they do many of the prenegotiations)? Such labor violations and the nations involved are well known and documented. But if all are turning a blind eye on this, why at least do the unions and United Nations not react? By now, entire economies run on these schemes (generally approved by unions and even green parties), whereas the humanitarian suffering, and the environmental impact, must not be further ignored.

12.2.1 A Meta-Analysis from This Book and Its Contributions

This book and its chapters is the first of its kind, providing us with a unique polar perspective and putting the protection of nature as the main focus. In many publications about the global environment a specific polar focus and expertise is missing (e.g., Netherlands Environmental Assessment Agency 2010, where even ocean acidification is not mentioned). The only similar book that covers "Polar Biology" (Thomas et al. 2008; and now published in its second edition) just deals with two poles, not the three poles. Its other shortcoming lies in the ignorance of dealing with economy, climate change, and conservation efforts. This book falls entirely short on the protection and conservation issue (the conservation section is only three pages long and mainly covers political claims and treaties, but with almost nothing on the conservation and climate change management side). It just does not offer solutions and does not achieve on these issues well, promoting a so-called objective science and business as usual. In addition to a lack of an on the ground empirical Arctic seabird expertise, various other biases and views can be found. Thomas et al. (2008) is descriptive, not predictive, in its science, and an overly mechanistic view is promoted.

Because the 12 chapters of this book here for the first time discuss three poles (instead of just one, or two), a polar meta-analysis of the environmental protection chapters and their findings, which has never before been done, is in place. Table 12.1 shows the following characteristics.

From Table 12.1 and the chapters of this book (see Table 12.2), there is little doubt that when all taken together, the book authors and experts on the subject indicate major problems in the way we approach the poles. Keep in mind that these 12 chapters obviously do not cover all polar aspects. The fact that we have three poles, and that all show similar symptoms albeit widely spaced apart, evolving virtually independently of each other, makes that point strongly. How can that be when our governments herald us otherwise? For example, Canada claims to be the global leader in biodiversity and species recovery (in Gailus 2010), or the United States

Table 12.1 Conservation issue development over time and as covered by each book chapter

Book chapter (author)	Topic	Historical status	Current status	Future outlook
2 (Carlson)	Polar wilderness	Relatively untouched	Threatened	Likely problematic
3 (Ainley et al.)	Toothfish stock	Relatively untouched	Poor	Problematic
4 (Summerson)	Antarctic wilderness	Relatively untouched	More affected than ever	Increasingly problematic
5 (Chettri et al.)	Natural resources and wilderness	Relatively stable	Affected and threatened	Increasingly problematic if problems are not resolved
6 (Nemitz et al.)	Plants	Relatively stable	Affected	Increasingly problematic, e.g., climate change
7 (Boltunov)	Walrus	Relatively natural state	Affected	Poor outlook
8 (Spiridonov et al.)	Russian Wilderness	Relatively untouched	Critical	Serious conflicts implied
9 (Zöckler)	Arctic waterbirds	Relatively natural state	Critical	Poor outlook
10 (Humphries and Huettmann)	Arctic seabirds	Relatively natural state	Strongly affected	Poor outlook
11 (Kutz)	Parasites	Relatively natural state	New parasites increasingly occur	More problems can be assumed

"under the management of fish and wildlife professionals, …, has become the world's premier network of wildlife habitats" (http://pubs.usgs.gov/of/2005/1428/vandegraft/index.html). Does that stem the tide of destruction? Is that what we see on the ground? The invited keynote speaker for the SCB conference in Edmonton, Alberta in 2010 (mentioned at the beginning of this chapter) expressed the situation clearly. By now, hubris, deep apologies, and an admittance of their lack of sustainability concepts and leadership to all who believed in them would behoove the leaders of Western culture well. Plans mentioned by the government to set up Marine Protected Areas (MPA) by 2020 (a time when most of the summer sea ice is predicted to be gone; Schiermeier 2007; Wang and Overland 2009) show the problem well. The contract between generations is clearly broken. But how can it be fixed?

12.2.2 An Annotated Summary of the Book Chapters and Within a Wider Polar and Global Context

Polar wildlife and habitat are clearly in crisis, and the IUCN approach has hardly addressed the problem. In addition to toothfish in Antarctica or snow leopards in

Table 12.2 Environmental problems covered in the chapters of this book

Book chapter (author)	Main reason given for environmental problem	Interpretation by author (F. Huettmann)
2 IPY (Carlson)	Institutional and cultural obstacles	Missing will for, and awareness of, global environmental progress
3 Antarctic toothfish (Ainley et al.)	Mathematical models that do not match biology; no evaluation that corrects wrong-doing	Economic gains from current models; lack of care and rigor
4 Antarctic ethics (Summerson)	Missing implementation and definition of ethical views that are legally manifested	Missing awareness, lack of legal enforcement
6 Himalaya plants (Nemitz et al.)	Lack of resources	Fear of protection schemes interfering with "business as usual"
	Lack of a complete biological assessment, missing awareness on digital data delivery	Missing awareness and priorities
7 Walrus (Boltunov et al.)	Changes in the (marine) environment	Management oversight re: large-scale circumpolar changes
8 Russian National Parks (Spiridonov et al.)	Lack of institutional support	Fear of protection schemes interfering with "business as usual"
10 Arctic seabirds (Humphries and Huettmann)	Man-made development	Fear of seabird schemes interfering with "business as usual"
9 Arctic waterbirds (Zöckler)	Development and climate change	Fear of environmental schemes interfering with "business as usual"
11 Arctic parasites (Kutz)	Climate change	Lacking knowledge

Lantang's National Park of Nepal, the circumpolar Arctic cod and Dolly Varden populations in Yukon are going down already, and so are those of many shorebirds. Large declines of Arctic fox are reported, despite a so-called 65 years of management and protection. The poor fate of some penguins has also been well described (Jenouvriera et al. 2008). Massive migratory Himalayan waterbird declines in wetlands has already been shown in Fig 12.2 by H. Bara. The Himalayan mountain tahr, red panda, black bear, and imperial eagle are additional candidates with a similar outlook. These are all strong indicators of ongoing changes and declines, while invasive species are on the rise. Many walrus (see Boltunov, Chap. 7, this volume) and polar bear populations and caribou herds are following suit. Nowadays, many caribou distributions stop suspiciously on the northern boreal forest cut-zones (Environment Canada 2008 and Johnsen et al. 2010 for overview maps). And reindeer herders in Russia and Norway wonder now whether they should breed and graze horses and cows instead, as the shrubs and grass come creeping in (see also UNESCO 2009). Rangelands in the polar regions are a big issue for most parts of the Arctic (Thomas et al. 2008) and even more so in the Hindu Kush–Himalaya (Harris 2007). Diseases add to the already-mentioned problems (Kutz et al. 2004; Knowles and Diggle 2009) but are still hardly studied (it is worthwhile to mention that avian influenza research in Antarctica goes back to the 1970s, but it was not much pursued and was subsequently ignored). Although polar nations such as Nepal are on a good alert regarding many diseases – for instance, *Trichinella* has been observed in the Arctic since the 1980s, affecting animals and humans alike – not much is done to avoid its spread. New Arctic diseases such as brucellosis (in polar bears) and phocine distemper (in seals) have been documented, and Arctic species such as narwhales and belugas have no good resistance: 80,000 narwhales and 150,000 belugas could be affected and would simply "die off" if infected. Further, the decline of most Arctic waterbirds has been discussed in this book by Zöckler (Chap. 9, this volume), while the worrisome status of pelagic seabirds is covered by Humphries and the author (Chap. 10, this volume). Species that have no, or a low, conservation status, might well be underestimated regarding how serious the situation

Textbox 1 How Protected Are Protected Areas and Managed Species Really? Faulty Conservation Ideas Rule, if at All

The notion of areas that are "too remote to be used" or "locked away," or which carry a "taboo," have existed virtually since the dawn of man (Taber and Payne 2003). Hawaii's Waikiki beach (now famous in the global tourism business) was not generally accessible for the commons because it was a restricted royal beach. Many migratory Arctic bird species pass by or winter there and thus basically enjoyed decent protection for millennia. The history of most Russian Arctic Protected Areas shows "protection through remote inaccessibility" (well described by Shtilmark 2003; and in part, by Nowak 2005). This concept certainly applied to the three poles. And therefore, many of these areas remained widely untouched until recent decades.

But now this situation has changed dramatically. Ecological economics describes that the human ecological niche expanded in new spaces, using technology but reaching earth's carrying capacity, or even going beyond it (e.g., Czech 2000). There are almost no places in the world anymore that remain "pristine" or unaffected by man (the Ecosystem Millennium Assessment makes that clearer than ever). Nowadays, this includes space (e.g., for telephone satellites) as well as the atmosphere.

Many institutions claim that 14% of the global land area is protected (Netherlands Environmental Assessment Agency 2010). And thus, they even state that the 10% protection goal set by IUCN would be met for most of the major 14 biomes. But in this view they entirely lack the (Polar) oceans and just merge many loose categories into the protection category. Toropova et al. (2010) reports already that although the total ocean area protected has risen by

(continued)

Textbox 1 (continued)

more than 150% since 2003, Marine Protected Area (MPA) coverage is very uneven and does not adequately represent all ecoregions and habitats important for conservation. MPAs are often just designed to increase fish harvest and consumption.

To make the best of a decaying situation, where protected areas increasingly fail to deliver what they were created for (Berkes et al. 2010; Klein and Magomedova 2003 for zinc mining in a national park of Greenland), landscape and national park connectivity projects are set up. YtoY (Yellowstone to Yukon; http://www.y2y.net/) is an example for one of those projects (but it is not connected to the Arctic Ocean or Alaska, or in the south all the way down to Chile's Fireland; but see Murphy et al. 2010 for a connection to the Yukon Delta). Surprisingly, connectivity projects and plans do not yet exist for the Circumpolar Arctic or involving the three poles (or the atmosphere for that matter). But in Nepal, the Terai Arc connection was already proposed (WWF 2004). In addition, Sacred Landscapes make for a large scheme in the Hindu Kush–Himalayas and have been proposed for protection (Government of Nepal (2010); see also Berkes et al. 2010 for a general review that involves religion to obtain protection measures). The significance of the region, its holiness, becomes easily clear when considering that Kathmandu alone has seven world heritage sites recognized by UNESCO, and more are found in the wider region.

From a narrow tourist perspective, the "Himalaya trail" might also make for an interesting land management scheme with some form of protection included (Boustead 2009). A more complete and wider corridor view for the Hindu Kush–Himalaya region has already been presented by Sarkar et al. (2007) and Worboys et al. (2010). Such network and optimization concepts are not well worked out for the Arctic and Antarctic yet (but see Huettmann and Hazlett 2010, and Huettmann unpublished; Fig. 12.3 for an overall polar protection optimization).

The dominant Western society still favors national parks as protection measures and to safeguard nature. But the national park concept comes with various problems, such as mass tourism, insufficient protection percentages, poor management, and inefficiencies (Berkes et al. 2010). Already the National Park Services in Canada and the United States themselves are hardly addressing these issues (National Park Service 2010; Gailus 2010).

There are many alternatives to the national park (which is a relatively new concept, widely untested over time). The UNESCO biosphere reserves "Man and Biosphere" could make for a powerful option (UNESCO 2009), but the concept is poorly implemented and has various problems. So far, it has hardly halted any land spoilage at all. More relevant options are still found in Russia, where the Zapovedniks (protected areas), Zapovednosts (complete land withdrawal from any economic use), Zakazniks (hunting reserves), Etalons (model landscape examples, free from human influence), and several other concepts already show the wide variety of protection options that can exist (Shtilmark 2003).

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Textbox 1 (continued)

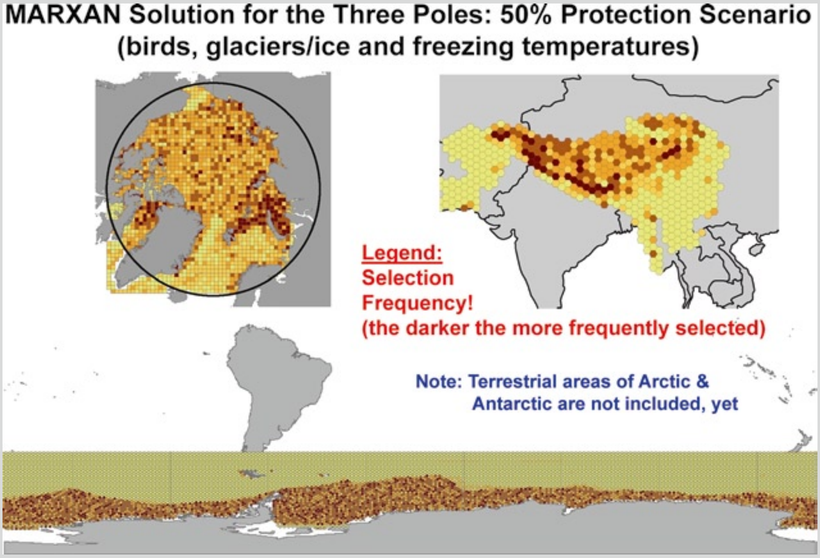

Fig. 12.3 A first global Strategic Conservation Planning Scenario optimized with MARXAN software (freely available online) for all three poles, trying to achieve a static 50% bird (seabird colonies and endemic pheasants), freezing temperature, and ice/glacier protection scenario (Huettmann, unpublished data). Results show selection frequency (in *dark*) and emphasize locations in high altitude (Hindu Kush–Himalaya), with sea ice (Antarctica and Arctic) and the Arctic Archipelago. (Note that terrestrial ice in Antarctica and the Arctic is not yet included)

Aside from a true protection status, one should also keep in mind the many animals that are under management and yet are in decline, for example, grouse in Norway (Selas et al. 2010), or Arctic fox.

For many regions of the third pole, "conservation areas," rather than strict national parks, are established, to avoid locking up the entire region from human use (Jha and Khanal 2010 for the Everest region in Nepal). However, regarding protection achievement, this is a dubious practice because it invites uncontrolled exploitation and does not maintain virgin landscapes (see Berkes et al. 2010 for such concepts with a mixed track record globally). Even worse, hydroenergy schemes were set up in Nepal with the help of WWF and UNEP, and with the idea to save forests (but at the known cost of the river systems). In stark contradiction to their own policy, WWF (2009b) states for the gharial (an endangered river crocodile in Nepal) that the "Construction of dams and barrages, sand mining, stone quarrying and river pollution in recent times have contributed to extensive loss of the gharial's river habitat." The polar impacts of dams are widely known and described (Netherlands Environmental

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Textbox 1 (continued)

Assessment Agency 2010). For Russia's Arctic, Klein and Magomedova (2003) stated that hydroelectric stations together with gravel and sand extraction already result in the degradation of as much as 93% of fish populations. Aquafarming, as done in the Hindu Kush–Himalayas for trout, and partly in subpolar Norway and Chile for salmon, adds to such problems.

Protected areas have been described as being legally and conceptually simple. But one way or another, most protected areas have a border problem: Either their borders are widely disputed, or get ignored and invaded, or in many cases the exact border of the protected area is not known or even was never defined! As another example, BirdLife International's Important Bird Areas (IBA) have no delineated polygons (i.e., they are just point locations), and the same was true for a long time for most Ramsar sites. The IUCN recommendation to have a (large) adjacent buffer zone is often poorly implemented (just think of such concepts for Arctic nations such as Iceland or Faroe Islands; and even countries like Germany violate these requirements in many of their national parks).

Arguably, Greenland has one of the largest national parks in the world, and Canada added new protective sites in Arctic regions. Many high-altitude regions in Nepal also carry a protection status. The terrestrial side of the Antarctic is also widely protected. We are good at protecting rock and some marginal ice locations, but we forgot to value and to protect the actual biodiversity assets, and relevant ecological processes, or enough of these to lead to global climate maintenance. By now we are running out of time and of space "to keep cool regions cool."

Further, fixed protected areas cannot easily react to a rapidly changing canvas, caused by climate change or changes in the surrounding but highly connected watershed and atmosphere. A classic example is the Key deer habitat in Florida, soon expected to be gone because of sea-level rise resulting from melting glaciers (Hansen and Hofman 2011). Similar impacts on habitats for endangered sea turtles cannot even be fathomed as yet.

When thinking about "Protected Areas" such as national parks, IBAs, RAMSAR Sites, and Wildlife Refuges, the reader is advised to carefully consider how easily the "protection level" of such areas gets undermined. The devil is in the details, as they say, and various opportunities exist to circumvent the blanket of protection. Alone from the administrative side, for instance, Magness (2010) found that the majority of refuge managers in charge in the United States do not even believe in climate change. And many refuges are specifically set up for hunting, and thus feed wildlife to facilitate their harvest. Introduction of species, such as trout, make for a base requirement in almost all the North American national parks. Of particular further note are the grandfather laws, which can widely be found in almost all protected areas. Trapping and hunting in national parks is also common, for example, by the indigenous population. And in some cases, even forestry is allowed. In Alaska, the federal national park status is overruled by state legislation, in fact reducing the protection status and allowing for snowmobiling, etc.

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Textbox 1 (continued)

An interesting question emerges: With good knowledge about the global environmental crisis we are in, and with the urgent need to protect large watersheds and ecological services, what does not qualify for a protected area today and how is a nondesignation truly justified? This question is specifically relevant for the poles, and can easily be asked for many Ramsar sites, and for the many non-Ramsar sites of relevance for Arctic shorebirds (Antonov and Huettmann 2008 for an example).

The call for polar World Heritage Sites was made (e.g., Huettmann 2008 for Sea of Okhotsk), but apparently it went unheard. Instead, we must protect as much as possible, and have protected areas to adjust to change (this includes legal and administrative aspects). The Netherlands Environmental Assessment Agency (2010), for instance, is using 50% protection levels for its scenario runs.

In times of climate change and huge human population increases, what in the three poles is no longer worth protection and a World Heritage Site status? I propose to give ICE and TEMPERATURE, and all related processes, an immediate World Heritage, Biosphere, and protection status. Not doing this can only expose our bias further and favors a short-term commercial takeover, destroying our assets and those of future generations.

already is. A simple reason for such a poor assessment can be the costs involved in obtaining a valid and sensitive status metric from field data, as well as administrative burdens to move these items forward. But it simply shows that polar nature does not fit well into our administrative ideas of the West; it is much bigger than that and rules the system overall. Even protected and conservation areas are showing clear signs of decline and decay (Sah 1997 for a Ramsar site in Nepal; Textbox 1, Fig. 12.1).

Simply put, we are basically facing a polar meltdown one way or another in less than 50 years (Schiermeier 2007), and that entails large global repercussions. Globalization makes it all the more connected. By now, everybody is in someone's backyard somewhere. The Asian Brown Cloud (ABC) and the black carbon discussion make for a good example (ICIMOD 2010a), and so does the nuclear pollution from Sellafield (UK) and Cap de la Hague (France) found in the Arctic (Thomas et al. 2008), and the accumulation of POPs found in breast milk (Thomas et al. 2008). Use of coal by China and India, as for instance supplied by Alaska and Russia (via the Trans-Siberian Railway), further show the global problems. Pointing fingers at others does not help anymore, and beyond the United States and China not signing relevant CO_2 agreements such as Kyoto (see ICIMOD 2010b for Malé declaration).

In the current polar ecosystem assessments of the 12 chapters of this book, one should not forget the species that are already gone, or those whose populations are heavily reduced, for example, Steller's sea cow, the great auk, and the heavily reduced eider species in the north. At the South Pole, fur and elephant seals (CCAMLR 2001), sooty shearwaters, and many penguins have taken a large hit (Trivelpiece et al. 2011). Many reduced populations are hardly known to most people: for example, by-catch in the Russian Arctic (Artukhin et al. 2010), or that rockhopper penguin populations crashed by 90% during the past 60 years and the remaining birds are now threatened by oil spills (Platt 2011). During a similar time window, a quarter of the Adélie penguins have gone from the western Antarctic Peninsula. Generally speaking, the Antarctic waters saw large-scale exploitation and rapid depletion of fish stocks followed by a switch to other stocks or species (CCAMLR 2001). Industrialized Antarctic fishing started in the 1960s (Thomas et al. 2008). But just in this short period alone, while BirdLife International and others happily promoted reduced bycatch and a clean fishery, trawling gear has already destroyed many seafloors (CCAMLR 2001), otherwise pristine for thousands, if not millions, of years and harboring a fascinating biodiversity (Brandt et al. 2007). A so-called unintentional overfishing has already occurred in the waters off South Georgia and South Orkney Islands (CCAMLR 2001). The natural dominance of animals, from large whales to small whales, was turned upside down in the southern waters. The International Whaling Commission (IWC) "… has failed to live up to expectations" (Thomas et al. 2008). Thus, large trophic cascades resulted and can be seen even today. Shifting baselines can be found on most poles (see Ainley et al., Chap. 3, this volume, for the Antarctic). Because whales are migratory, this affects areas outside the poles.

Clearly, ecological services (which are known to indicate how meta-populations fare and interact) are largely in decline, and their outlook is poor (Jenouvriera et al. 2008 for IPPC scenarios and king penguins; Partap and Partap 2001 and Ahmad et al. 2003 for pollination).

As shown by most authors, relevant institutional culture changes (Young 2002) are needed if we want to achieve an Earth Stewardship (Power and Chapin 2010 for the Ecological Society of America, ESA). But these changes tend to happen very slowly, that is, in 20 to 40 years, if at all (Berkes 2010; Cushman and Huettmann 2010; Hansen and Hoffman 2011; Rustamov and Rustamov 2007 for Central Asia). A classic example is the Marine Minerals Management Service (MMS, now called Bureau of Ocean Energy Management, Regulation, and Enforcement, or BOEMRE http://www.boemre.gov/). For decades this institution was known for its odd, non-transparent, and opaque procedures. For instance, it did not provide a required yearly report for some years. (This omission should qualify as a federal violation, but such violations are nothing unusual; many federally supported fisheries in the U.S. lack legally required thorough impact studies, and the Antarctic parties, for instance, could not agree on a "State of the Antarctic Environment" report either.) The name change came in 2010 just with the Deep Water Horizon oil spill in the Gulf of Mexico. It makes for a policy improvement by shock therapy. But did their administrative policies, funding setup, and internal culture truly change? Are they now more transparent and sustainable? This is unlikely as long as they keep promoting that carbon gets released into the atmosphere and the seafloor and terrestrial habitats get used up. Similar changes after the fact are described by Thomas et al.

(2008): "In Antarctica a pilot sealing expedition in 1964 from Norway rang alarm bells and led to the development of the Convention for the Conservation of Antarctic Seals, ratified in 1972." Such procedures are very inefficient, costly, and not proactive by any means.

To further support this argument on delayed actions and for not being proactive, as early as the 1970s the United States Congress, in Section 2 of the Endangered Species Act

> …finds and declares that various species of fish, wildlife, and plants in the United States have been rendered extinct as a consequence of economic growth and development… (see also National Research Council 1995).

But 40 years later, we still continue "business as usual," and industrial promotion remains at the core for creating endangered species (Czech 2000; see, for instance, Prugh et al. 2010 for Canada). What has really changed? Further, the CBD Biodiversity Targets for 2010 read:

> … to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth (www.cbd.int/2010-target).

It was stated earlier that we fully missed these Biodiversity Targets for 2010 (Mace et al. 2010; http://www.crisisoflife.net/). And most people might not know that within the current state and global framework we simply cannot ever meet these targets. It is impossible to do, on physical and mathematical grounds. We are out of space and resources, and beyond recovery, and already we need three worlds (e.g., Wackernagel et al. 2002). And so, as has often been done before, unless we just lighten up our goals and make them more "liberal" and friendly toward ongoing and coming destruction, we cannot satisfy our own policies anymore, as set by the UN. The atmosphere will not turn healthy in the next 50 years, invasive species will not disappear, oceans will not recover well, the human population and demand will not reduce or stabilize, lost DNA will not come back, nor do we have enough space and animal and plant populations to recover. There is no resilience in such situations (Chapin et al. 2009). This is a very serious global problem. Serious because the social targets, also set by the UN, have not been met during the past 20 years (Easterly 2006); targets simply keep getting moved for convenience far into the future. Further, we have a global financial crisis, banking on its own debt, with major ups and downs (Stiglitz 2006), and a massive atmospheric crisis is at hand (ACIA 2005), one that is widely not governed and with the traditional institutions making it worse, not better. We have global conflicts (e.g., Irak, Afghanistan, Libya), which occur even in economic free trade zones (e.g., the civil war-like situation in Mexico and the southern U.S. in the NAFTA free trade zone). What went wrong in the great times of "science," management, and liberal trade and commercialization, and while we have so many "professional" expert disciplines, Nobel prize winners, stakeholders, and big budgets? Why are all these not achieving?

It is pretty clear that the biosphere is not efficiently governed (Paehlke 2004; Chapin et al. 2009; Berkes 2010; Mace et al. 2010; Swartz et al. 2010). The current approach and vision for the North Pole, based only on the interests of the seven Arctic nations (UNESCO 2009; Bingham 2010; Wilson Rowe 2009) is not working. Similarly, the Hindu Kush–Himalaya region has no democratically elected legal oversight body, nor does a consistent policy or legal body exist. The Arctic Council, and SCAR (Scientific Committee on Antarctic Research) along with CCMLAR (CCAMLR 2001), generally fail on the conservation, fisheries, and climate change issues. It is not even widely acknowledged as a problem. They mislead their investors and the global public. Climate change continues and no truly sustainable exploitation schemes exist or have been promoted thus far. Initially, and preexploitation, CCAMLR (2001) looked rather strong on the ecosystem management approach to Antarctica, and the multispecies and precautionary principle. CCAMLR (2001) states that it promotes a holistic approach to the management of marine living resources in the Southern Ocean, but they seem to have forgotten climate change in this equation, and to do anything to halt it (compare also with National Research Council 2003 for Alaska's North Slope). Did CCAMLR fail to deliver on its promise? Gutt et al. (2010) stated already that Antarctic waters are increasingly threatened by the new longline fishing and by the impact of climate change. And Ainley et al. (Chap. 3, this volume) provide a classic example for CCAMLR's flagship management species, toothfish.

Thomas et al. (2008) state that CCAMLR came too late "…allowing the Soviet Union badly damage some key fish stocks …." The authors also state that "…Pirate fishing of toothfish is almost certainly being undertaken in part with connivance from some of the CCMLAR countries." All of this stands in a stark disagreement to what CCAMLR (2001) states and wants to achieve. It makes for an interesting side comment that most of the countries fishing in the Antarctic are bound to the Jakarta Mandate on Marine and Coastal Biological Diversity (part of CBD), as well as numerous other legal policies (Boardman 2005). A recent proposal to copy the CCMLAR concept for Arctic waters and fisheries can only be judged with serious doubts and when judged by the track record. So far, neither the Arctic nor the Antarctic management institutions acted proactively or called for a stop of carbon pollution and resource extraction industries (but see ICIMOD 2010a for the Hindu Kush–Himalaya; UNESCO 2009).

Most polar entities, institutions, and governments have virtually not stopped climate change, and some argue whether it still exists, even removing it from their research agendas and publications (J. Gutt, personal communication, as an example for Alfred Wegener Institute and SCAR publications). Agenda cleaning, often done indirectly through specific and strategic budget cuts, is widely known to all experts. But it must stand in stark contrast to statements that "SCAR …provides independent scientific advice on topical problems" (Thomas et al. 2008, p. 329). Widely entrenched procedures include ignoring or passing aside political hot topics, and employing old-fashioned science concepts, exclusionary decision-making concepts based on elongated meetings and procedures where politics overrule science; eloquence and funding becomes the driver at will. This approach simply does not work for nature, for the atmosphere, or for curtailing climate change. It is not democratic neither. But perhaps this style and such meetings look good in public and with the media?

Textbox 2 Seabirds and Big Oil in the Alaskan and Canadian Arctic (Beaufort Sea): Governance and Authorship Structure of the Book *The Birds of the Beaufort Sea* by Johnson and Herter (1989)

The tight connections between the governments of North America and the oil industry are well described (Yergin 1991; Heinberg 2003; Ott 2005). This can hardly be shown better than with the bird book titled *The Birds of the Beaufort Sea*, a resource for environmental impact studies and other environmental decision making. This book is published by BP (Alaska). For ordering a copy of the book, in lieu of the publishers, the book cover states that one simply can contact BP's environmental consultant LGL Limited based in British Columbia, Canada. The Foreword of this oil company publication is written by an employee of the Canadian Wildlife Service (CWS) from Alberta. Noteworthy are the acknowledgments, which expose the Iron Triangle and its structure, for the group who created the information and this book. (Note that seabirds are highly visible in oil spills and get used as environmental flagship species and for environmental impact assessments.) As shown in the Acknowledgments of Johnson and Herter (1989), in addition to CWS (Western and Northern regions), the Yukon Territorial Government, the Department of Renewable Resources, and the Department of Fisheries and Oceans (DFO) are also involved. On the U.S. side, the Department of the Interior, Fish and Wildlife Service in Fairbanks and Anchorage, as well as the Bureau of Land Management (BLM), Alaska Department of Fish and Game, acting managers of the Arctic National Wildlife Refuge, and Research Directors are intimately engaged with this work. Other contributors are ESSO Resources Canada Limited, members of the University of Alaska, and the University of Alaska Museum, Alaska Biological Research (ABR) contractors, and the British Columbia Hydro Authority.

This book and its content shows well who really creates such an "objective" science, and what for. The list of collaborators includes 15 individuals still acting in leading positions in government and professional societies and being responsible for funding and political decisions regarding seabirds. Therefore, a significant change in policy, procedure, protocols, and culture toward implementing sustainable and balanced science, based on the latest statistical methods, and dealing in an appropriate way with seabirds, climate change, carbon emissions, protection of nature, alternative and progressive sustainability solutions, and adaptive management (Chapin et al. 2009), cannot be expected from such a system. It is worth noting that this situation refers to Alaska as well as Canada.

With such a continent-wide arrangement and industrial setup for Arctic resources, it is very difficult to comprehend how an objective and balanced science can be accomplished. What are the ethical requirements, balances, and checks? Who has to provide the burden of proof, and how can the current arrangement not favor industry (see Huettmann et al. 2011 for an assessment)? This book, published by BP itself, but not provided with a typical high-quality

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Textbox 2 (continued)

science outlet such as Springer, Elsevier, Cambridge, Oxford, or Harvard Press, and which subsequently did not go through the typical scientific peer-review process, simply cannot be expected to provide sound information on birds or their habitats or the Arctic (Ott 2005 described such issues and setups for oil spill cases well). But because most bird researchers lack the money and even permits to study in the Beaufort Sea, this book presents a local standard, and one without an alternative. It presents an information monopoly almost to this very day. This cannot be objective science, nor a forum where seabirds and their habitats have an appropriate voice, and it does not really make for credible scientific and balanced information that protects the Arctic, nature, or the atmosphere. The cost we all pay.

The idea that this book would mainly represent at least naturalist information is harmful in two ways. First, it would then just represent a scientifically less rigorous seabird inventory source for crucial decision making (e.g., done without statistically valid surveys and conclusions), and second, it pushes the great and diverse (and otherwise unbiased) group of naturalists right into the arms of government and industry (a tendency that sometimes can be observed already elsewhere), which diminishes alternative first-hand information sources "from the ground."

Table 12.3 Example of circumpolar resource exploitation projects

Exploration scheme	Location	Global rank	Reference
Norilsk Mining complex	Russia	World leading source of nickel, palladium, and one of the largest copper producers	Bingham (2010)
Red Dog Mine	Northwestern Alaska	Largest zinc mine in the world	Bingham (2010); Thomas et al. (2008); Klein and Magomedova (2003)
Baffin Bay	Eastern Canada	Best undeveloped iron ore deposits in the world	Bingham (2010)
Citronen Fjord	Northern Greenland	Zinc mining	Klein and Magomedova (2003)
Disko Bay	West Greenland	Offshore drilling of major relevance for Greenland	Bingham (2010)
Snohvit gas field	Barents Sea, North Norway	Liquefied natural gas resource for Europe and North America	Bingham (2010)
Shtokman gas field	Norway/Russia sea floor	One of the world's largest natural gas deposits	Bingham (2010)

(continued)

Table 12.3 (continued)

Exploration scheme	Location	Global rank	Reference
Barents Sea fisheries	Norwegian–Russian waters	World-class fisheries	Bingham (2010), Wilson Rowe (2009)
Bering Sea fisheries	Alaska–Russian waters	World-class fisheries	Bingham (2010)
Bristol Bay	Subarctic Western Alaska	World-class salmon fisheries, offshore oil, Pebble Mine, tourism	http://en.wikipedia.org/wiki/Bristol_Bay
Yamal	Western Siberia	Largest Russian gas reserves	Klein and Magomedova (2003)
Ore	Sweden	Large iron mines	Thomas et al. (2008)

Note: Many subarctic regions such as Northwest Territories (for diamonds), Bristol Bay (for salmon, mining, and offshore oil), Sea of Okhotsk (fisheries and Sakhalin Island), Labrador (for iron ore and uranium), and Hudson Bay (shipping, ports) are not presented in this discussion but play an equally relevant role for the Arctic region and its ecosystems overall. Mining claims for Antarctica are currently on hold, but have been discussed since the 1970s (see Summerson, Chap. 4, this volume).

Using the polar regions as a consolidation prize for countries that are not part of the Security Council, or for other compensation deals, for example, linked with global trade and military deals elsewhere, fails because nature pays the bill, and most citizens of the world are excluded and harmed. A similar problem applies to all polar regions of this world, or natural resources for that matter; it is about a sustainable and fair access to those resources and a good life in the global village (Klein and Magomedova 2003). Here we still lack an appropriate governance system (Chapin et al. 2009), but we need one urgently.

The influence of the international corporate industry in the poles – namely the oil, gas, mining, fishing, bioexploration, and shipping industries – cannot be denied. Many blunt examples exist, and they have been widely published (Prugh et al. 2010). Here I use seabirds as just one example (Textbox 2; Table 12.3).

Setups and arrangements as shown in Textbox 2 and Humphries and Huettmann (Chap. 10, this volume) just cement an oil culture and an industrial takeover of the poles and its governance, while nature, the atmosphere, and mankind pay the price. That is, a government where carbon-related industries are the major players, and where oil and gas become the main drivers for virtually all relevant decision making (Wilson Rowe 2009), and where such industries can easily walk into governmental offices (whereas citizens cannot) and set agendas (Heinberg 2003). It is sad to see that this even receives a royal approval or tolerance, e.g. in Norway, UK, Denmark, Monaco, and Holland. Currently, many Arctic government goals tend to coincide with the goals of the oil and gas and mining industry, or at least they are very closely related (Yergin 1991). Considering that it is linked to global security, this is neither objective nor unbiased science, nor a good use of taxpayer assets for sustainability. How can science and a good climate flourish in such a setup, if at all?

It is clear that most of the powerful Western governments and their ministries and departments, including IUCN and UNESCO (UNESCO 2009; A recent proposal to copy the CCMLAR concept for Arctic waters and fi sheries Sherman and Adams 2010) still promote the idea that "we can have it all," neat and tidy; protected landscapes, resources, high schooling levels, personal happiness, public health, a long life, a clean atmosphere, and an infinitely growing economy. We would remain wealthy, and others can get wealthy, too. Broken ecosystems could simply be rebuilt; just pay for it. It makes for a nice story, and uninformed voters fall for it. Who would not? But of course, it is a pipedream. The leaders of such regimes make claims that fly in the face of reality, that are not supported by the numbers or the science (progressive, challenging, leading, innovative, alternative, or otherwise). Something has to give; many losers exist already, more are to come. A great example of how Arctic nations deal with environmental issues can be seen with seabirds (Petersen et al. 2008), specifically with the ivory gull, where legal international protection implies complete coverage and protection, but which has not been achieved in practice and with a change in climate (Huettmann et al. 2011; Johnsen et al. 2010 for a review of such legal problems). Focusing just on the animal, instead of the habitat and atmosphere (or sea ice and temperature), does not work. The sea ice habitat issue makes that clearer than ever (Wang and Overland 2009; Tynan et al. 2010). Retreating into such purely species-based concepts misleads the public and leads us to double standards. It violates all known base rules of ecology and physics, too, as taught in our high schools.

A quick review of polar nations shows many of these flaws and that we have ignored these aspects for much too long:

– Arctic Russia was already described as turning into a technological desert (Klein and Magomedova 2003). Yablokov (1996) has spoken for more than a decade about "the catastrophe" in the Russian Arctic. The Russian nation clearly benefits from its geopolitical position, and from its ability to cater to Scandinavian, European, and Asian markets (Kuhrt 2007, Wilson Rowe 2009). Its wilderness is one of the last untouched areas, but a wide disregard of environmental, atmospheric, and human issues exists throughout most of its region (Huettmann 2008; see Wilson Rowe 2009 and Johnsen et al. 2010 for ILO 169). The biggest industrial footprint in the world, the Russian Trans-Siberian Railway, shows up in any global space image. Together with its connections it makes for an industrial supply artery to the Arctic and Asian poles. A business model that benefits from war and conflict in Irak (boosting Russian oil prizes), and which lives from carbon pollution cannot be sustainable and can hardly serve the globe well.
– Norway, another big player in the three poles game, has about 4.8 million inhabitants (half the size of London; the majority of them living in the southern capital region of Oslo), and provides the world with offshore oil and gas, much from Arctic regions. In addition, Norway can afford to produce nitrogen and plastic products and entertain agriculture, whaling, krill harvest, and salmon industries. But the oil resources are relatively small and Norway will run out of cheap oil resources in less than 40 years (Heinberg 2003 for peak oil; other nations in the

North Sea went through that experience already). By now it is clear that Norway has virtually failed to build an alternative stable industry structure other than oil, or any sustainable source of income. Sadly, Norway's society has already turned explosive. Judged by history, adjacent Russia might not be a friendly neighbor when Norway runs out of oil (Wilson Rowe 2009) and when it is becoming powerless quickly. Much Russian collaboration and immigration, including disputes, have occurred in Norway already, specifically in the Arctic regions (Wilson Rowe 2009). Norway is frequently criticized for its whaling and krill harvest practices. And with the breakdown of the Cold War structures, where the NATO supported Norway as an ally presenting a "bollwerk" against the East, Norway might be soon out of luck even to maintain its status quo. Norway, still holding fast to the plankton harvest in the Antarctic, whaling, and aquaculture, such as through expertise transfer in Chile, and with its large ongoing bioexploitation efforts in Nepal, does not instill us with much environmental trust. This Norwegian model simply does not work, one way or another. The heralded Norwegian notion of Brundtland's Sustainable Development (e.g., Macdonald 1991; still promoted by UNESCO (2009), the UN, and NGOs to this very day (Sherman and Adams 2010), just left a global destruction of wilderness behind, further adding to the climate change problem. The least one can say is that sustainable development reduces wilderness and ecological services and adds to atmospheric destruction. It can only been seen as a tragedy that Norway and its Norwegian Agency for Development Cooperation (NORAD) still try to export its concept and unsustainable models to other poles (Antarctic and Nepal), and worldwide (pulp and paper forestry in Canada; agriculture in Africa; aquafarming now in Central America), all of which usually are even blessed by the royal family.

– Nations such as Sweden and Finland have no Arctic ocean coastlines, but they have several terrestrial and Baltic assets with Arctic characteristics. Both nations maintain Arctic and polar research, but the largest fraction of their populations live in warmer, southern regions. Finland acts as a narrow conduit between Russia and the West, heavily supported by the EU, while Sweden, also EU supported, can play its Arctic card through other venues such as economic power brought by its car industry. Noteworthy are Sweden's strong engagement in nuclear energy for the European Union. Both nations have traditional strongholds in the United Nations and hold powerful positions there to make their Arctic views heard, or to balance them with other items.
– Iceland, located outside of the Arctic Circle, is a role model in geothermal energy use. However, in 2008 Iceland was virtually bankrupt, and it still has not paid back its moral debt to many international lenders such as the UK and Holland. If it would do so, Iceland would presumably barely be able to function (apart from the fact that Iceland does not maintain its own military and thus has to follow the will of larger powers such as the U.S.; see Laxness 1982). Alone the tax volume from the approximately 320,000 Icelanders (mostly living in the urbanized Reykjavik region) is hardly enough to allow for meaningful Arctic activities, and other income must be sought to keep going, e.g. by becoming a giant polar shipping hub, and aluminum production though foreign bauxite and Chinese

investment. Iceland features a landscape widely overused for centuries. It should be mentioned that several Icelandic fish stocks are overfished, rangelands are notoriously overgrazed, use of (imported) oil is on the rise, and the only High Arctic seabird (dovekie) is in dramatic decline (probably a disappeared breeder by now; Hilmarsson 2010), and that about 7% (!) of the Icelandic puffin population is harvested (see also Zöckler, Chap. 9, this volume). The Icelandic business model and culture do not really look sustainable, nor can it truly compete in so-called open and huge markets (it simply gets swamped unless protected from the outside at will). Iceland and Greenland (see below) are classic examples where the neoclassic economic model cannot work well or assure sustainability.

– Greenland, legally on home rule but in reality supported by Denmark and predominately by the EU and the United States, is far from a truly independent modern model state. Its approximately 56,000 people widely rely on oil, gas, mining, and subsistence, and it is this reliance that is the major driver for its natural resources: the sea mammals, seabirds, and fish (UNESCO 2009). At least indirectly, this reliance on resources supports invasive species, environmental despair, and the melting of glaciers (Armstrong and ICIMOD 2010) and eventually the decline of sea ice (Wang and Overland 2009; Weeks 2010; Thomas and Dieckmann 2010). The declines in waterbird harvests have been well documented in the scientific literature for years (see also Zöckler, Chap. 9, this volume). Thus, Greenland does not have a sustainable business model either, one that fits well in the otherwise promoted open market scheme. Instead, such efforts will achieve the opposite, and as many indicators show.
– In Canada, the biggest export of its oil sand energy now goes to the United States. Many Canadian mining companies are managed, or have headquarters, in the United States (e.g., in Colorado or Texas). The international finance schemes that most Canadian resources underlie often favor Japanese and Chinese investment interests. Pipelines and ports in British Columbia and forest land management in Northern Alberta reflect that rather clearly. On the east coast, the federal government signed an "accord" with the provinces that waives all relevant environmental impact studies in favor of offshore oil development (most of this oil and gas is delivered directly to the U.S.; other countries are to demand it). These ocean areas are directly used by Arctic seabirds (Huettmann and Diamond 2001), and associated problems are well known. Hydroplants in Labrador and Northern Quebec also deliver large amounts of their electricity directly to U.S. cities. Despite being an Arctic nation, most of the approximately 34 million Canadians live just south, within 200 km of the U.S. border. Canada is among the worst per capita energy consumers in the world. Canada and its Arctic has turned into an international resource chamber for other nations, one where Canada simply gives away its wealth to the outside like African colonies did. This has been the business model of Canada (a dominion) for more than a century (see Taber and Payne (2003) for history of cod, white pine, beaver, and furbearers overharvesting).
– Last, Alaska is a major player in the Arctic and in the polar game. It only hosts about 700,000 inhabitants (e.g., a tiny fraction of the population of Los Angeles)

Table 12.4 Selection of consortiums with relevance for one of the largest polar stakeholders, the United States

Title	Abbreviation	Focus topic	Location
Arctic Research Consortium of the U.S.	ARCUS	Coordinating and suggesting Arctic research and for NSF	Arctic Alaska
Minerals Management Service	MMS (until 2010)	Administer oil and gas leases	Alaska
North Pacific Research Board	NPRB	Ocean management	Alaskan oceans
North American Pika Consortium	NA	Research and management of pika	Rocky Mountains; http://science.nature.nps.gov/im/units/ucbn/monitor/pika/pika_group/index.cfm
North Pacific Universities Marine Mammal Research Consortium	NA	Marine mammals of the North Pacific	NA
Native Corporations	Many (>15) exist	Management of Native lands and assets	Mostly Anchorage

and more than 85% live in cities (Anchorage, Fairbanks, and Juneau). But based on its massive fiscal, military, oil, and science power, usually directly supported by Washington, D.C. (Ross 2001, 2006), Alaskan representatives tend to flood most meetings and policies. The United States holds several Arctic and Antarctic stations, deals through USAID with glaciers in Nepal (Armstrong and ICIMOD 2010), and holds strategic control of the water supply for Afghanistan, India, China, etc. Much of the global sea ice research is dominated by the United States (Weeks 2010; Thomas and Dieckmann 2010). Alaska still runs a rather neoclassic business model mostly based on "consortiums" (Table 12.4). It is supported through (federal and international) outside money, investment decisions, political overruling, destruction of wilderness, and widely unsustainable financing schemas (Ott 2005; O'Neill 2007; Ross 2001, 2006). Washington D.C. is internationally well known for its huge lobby pressures on politics and often paid by 'undisclosed money'. Many experts have called the United States the failing giant, and some equal it with the Roman Empire. In either case, the Alaskan U.S. model and lifestyle is widely unsustainable (Stiglitz 2006; Paehlke 2004), and until now, it has offered us virtually nothing to stop climate change on the international policy arena (a topic going on in Alaska in full swing for more than 20 years: ACIA 2005; Ayers et al. 2010): rather the opposite. Because the United States includes the largest science and NGO budgets on climate change, it is adding to a rather dubious, nonfunctional, even unethical, situation regarding Earth stewardship (Power and Chapin 2010). Alone the roles of NOAA, NMFS, and WWF-US must be put in serious question.

– There are now other powerful players in the Arctic and in the poles (Yalowitz et al. 2009), for example, Japan, China, India (Winters and Yusuf 2007 for their roles), Korea, Ukraine, Malaysia, and even Poland and Switzerland. What do they promote to halt the polar juggernaut, other than national self-interest? And are governments really into altruism? The majority of these polar countries simply stand for ruthless economic growth regimes (see, for instance, what UNESCO promotes: UNESCO 2009), but even then, and with a sole emphasis on economy, they still run serious economic deficits (even China has an inflation now); these countries all need resources and an inflow of wealth from elsewhere, and no good alternatives are provided. Together with "peak fish" (where we will run out of most cheap resources soon; Netherlands Environmental Assessment Agency 2010), the poles make for an obvious and last target to get wealthy quickly and fill sustainability and fiscal gaps. Globalization offers even bigger opportunities for doing so, via co-funded projects in a sphere that is poorly regulated for sustainability (Stiglitz 2006), if at all.

Sovereignty in the polar region should not mean "one nation for itself," but include others. Neither the animals, nor the atmosphere, global temperature, or ocean and air currents, recognize borders. Although the state has sovereignty of resources (oil, gas, forest, fish, etc., are owned by the people; e.g., the Alaskan constitution states that clearly, so it does in Greenland and Russia), it still affects the global atmosphere and is now widely driven by international corporations (Paehlke 2004; Stiglitz 2006). How that great problem is to be resolved is not clear to anybody, yet.

Despite the huge onslaught on polar resources, a PR flyer from the Audubon Society stated: "There is no proven technology for cleaning up oil in the icy, stormy conditions of the Arctic Ocean and the ability to mount a large-scale clean-up effort simply does not exist–the closest Coast Guard station is almost 1,000 miles away!"

We only have one world, and our resources are limited (Daly and Farley 2003; Wackernagel et al. 2002). Continuing with ruthless growth schemes will only add conflicts and split and fragment "the canvas" (Nadeau 2003). If economic growth does not achieve the wanted goals (e.g., clean atmosphere, world temperature maintenance, ecological services, social and economic goals; reviewed by Czech 2000; Daly and Farley 2003; Rosales 2008), why stick with it any further? One would expect wealthy and prominent governments to do the mathematics of space, climate, resources, and human population and consumption correctly, and then provide global sustainability leadership for the future. Instead, we have a global crisis at hand, dominated by international corporations.

Most (polar) governments embraced the idea of soft money and fund raising, linking with NGOs and other contractors. Thus, governments put their work on the "free market," but one which is dominated and steered by large funders such as the corporate industry. Instead, taxpayer-funded governments and its institutions should be in the driver seat and lead sustainably (Berkes 2010 for decentralization trends). This free market is a concept that only can work under a good framework (as agreed upon by all its original promoters; Daly and Farley 2003). But it is now constrained by access to oil, affluence, cheap labor, initial wealth gleaned through earlier exploitation schemes (e.g., from the tropics; Easterly 2006), nontransparent and unfair global treaties (e.g., TRIPS), and driven by the owners of "big money" and their supporters (Czech 2000). Unless supported or subsidized, many Arctic countries and their citizens have no chance to participate in fair and equal means; for example, Iceland, Greenland, Finland, Faroe Islands, Nepal, Bhutan, Sikkim, Chukotka, and most indigenous populations. It comes as no surprise that people who know and work the polar landscapes and seascapes for thousands of years without a relevant impact (Thomas et al. 2008) are not well represented in such a global scheme that is widely driven by huge markets, several stakeholders, and the Iron Triangle (Berkes et al. 2010; Rosales 2008). They are pushed aside. This scheme just means flashy, unsustainable city cultures and their administrators and funders, and a whole horde of indirect supporters, and a new culture unproven for sustainability. Even well-meant initiatives like the Global Marshall Plan (Radermacher 2004) and the Club of Rome (promoted in large by a highly educated EU city culture but ignoring many indigenous and resource issues, for instance) suffer from this situation. Global sustainability is only possible when including the polar regions, their rural people, and wild, natural resources and the related skills and knowledge.

The playing field has changed since 1949 when many of the original institutions were set up. The track record exposes that WWF, IUCN, and UNEP are not working toward a sustainable vision at all; for more than 50 years they have not achieved it, nor protection of the global temperature and atmosphere, which are essential.

WWF declares itself as "…the world's leading conservation organization…". And the WWF mission goes "To stop the degradation of the planet's natural environment and to build a future which humans live in harmony with nature." (www.wwfnepal.org). But how is that achieved when economic growth is allowed to continue and CO_2 production is virtually unstopped?

Big NGOs are in for the money. Their budgets have grown huge, but their time is running out with a global environmental and financial crisis. NGOs just do what their funders ask them to do, and thus they basically work without any ethics, but on a global scale. They can easily turn into a "hired gun," and several have. Wealthy NGOs and their subcontractors will never set a science or management agenda that does not make them money or that sets them up for bankruptcy. And even if they want to act differently, they cannot because of their structure and setup. Therefore, big NGOs must not become, or be perceived as, spokespersons for the global environment. Perhaps they can help or contribute, but they must never dominate or be in the driver's seat.

A major disagreement exists between such city-dominated cultures and rural people. This rift is increasing and puts people with a deep landscape knowledge at the margin, into museums, into coffee-table books, and makes them extinct (it usually starts with key people taking early retirement out of frustration and then disappearing from the workforce). It is clear that there is hardly a way around ecological carrying capacity, globalization, and technology. And rural areas are part of the equation. The actual form of globalization, its governance, must be openly discussed, and requires it be driven by people and sustainability, not by pseudo-soft operators acting for international corporations, exploiting the notion of "tyranny of the locals" using all tools available. These operator entities, think tanks, directly linked with governments and neoclassic economists, were used after the fall of the Iron Curtain to further the Western ideology. They quickly used the legal vacuum in the global space for their own opportunities, ignoring thousands of years of environmental and human ethics and knowingly destroying most resources we had left for us and our children: wilderness, fisheries, forests, atmosphere, water, the cryosphere, and even the "banking landscape" and people's wallets and value systems, as well as entire homes.

12.3 What Not to Do for the Poles

The Ecosystem Millennium Assessment (http://www.maweb.org/en/index.aspx) was completed in 2005 and is very clear in its message: The world has been widely modified, ecological services are important but threatened, and we are running out of wild space and untouched resources as a result of human impacts (see also Sicroff 2007 for Hindu Kush–Himalayas; Swartz et al. 2010 for oceans). Unfortunately, by ignoring this message as a guiding principle in discussions about climate change and the human footprint, and letting the discussion take bizarre socioeconomic paths, many mistakes were made, many faulty concepts accepted, that now must be remedied. The management of the polar regions must appear as a tragic comedy of errors, and where the leading agencies now jump on the public bandwagon after the fact, but failed to act and deliver early on in regard to climate change. The International Council for the Exploration of the Sea (ICES, www.ices.dk) makes for a great example (Holliday et al. 2009; ICES 2009), where climate change is handled and reviewed in the most conservative possible way, and completely leaves out ICES's own contributions to climate change such as destruction of functional oceans and ecological services by their approved overfishing.

The widely celebrated so-called scientific concept of these institutions, that we would have to know things first through science before we can act (as stated by Vongraven et al. 2009; cited in Gradinger et al. 2010; see also Macdonald 1991; McIntyre et al. 2010) needs to be immediately replaced with a proactive sustainability science (Cushman and Huettmann 2010; Drew et al. 2011 for methods; Murphy et al. 2010 for an example). Ethics and moral questions apply here too (Bandura 2007). If applied, almost all findings from such work and analysis call for an immediate protection (e.g., Pandolfi et al. 2003). Efforts that ignore these concepts can no longer be defended. The precautionary principle should rule when scientific information is lacking (National Research Council 1995). But as an example, the federal decision not to list the red knot, an Arctic shorebird, on the U.S. Endangered Species Act (ESA; National Research Council 1995; Baker et al. 2004), must ignore the real world situation. These birds are not only threatened in the Arctic, but also at the Delaware Bay resting site, and in their subtropical wintering grounds that are plagued with human disturbance, sea-level rise, etc. (Morrison et al. 2004). But the mismanagement of the red knot is not unique. If one considers the perils of disease and habitat degradation faced by all species that fly between poles, such as the ruddy turnstone or the Arctic tern, all these species and their entire habitats must be listed as well (Krauss et al. 2010). The delayed decision of the U.S. Interior Department to not list polar bears as endangered because threats to the species are "only" of future concern represents the ultimate mistake when knowing that these species are already truly suffering. To some Arctic villagers, polar bear populations might appear to be on the rise, but this impression often comes from an increase of "problem bears" entering villages for food; it is just another result of distributional changes caused by loss of sea ice (Tynan et al. 2010). Some natives claim that the use of helicopters and telemetry would have a similar effect, turning bears "domestic." Does the "Agreement on the Conservation of Polar Bears" really help (http://en.wikipedia.org/wiki/International_Agreement_on_the_Conservation_of_Polar_Bears)? Beyond the United States, BirdLife International's downlisting of the Kittlitz's murrelet (a subarctic seabird species associated with tidewater glaciers that has declined by about 80%; Kuletz et al. 2003), and as a result of constant pressure from the Alaska government is equally careless. Many more examples for wildlife species can be provided.

A really poor example for such thinking, and carried out by governmental institutions, is provided through ocean fertilization (with the purpose to mitigate global warming by stimulating plankton growth through large-scale iron depositions in the ocean). The Intergovernmental Oceanographic Commission (IOC) of the UN Educational, Scientific and Cultural Organization (UNESCO) even worked on this issue longer and released a "Scientific Summary for Policymakers on Ocean Fertilization" (http://unesdoc. unesco.org/images/0019/001906/190674e.pdf).

Another example of poor, and virtually uncontrolled, management of polar regions can easily be found in the tourism industry. Thomas et al. (2008) stated already clearly that "…now virtually all of the Arctic is open to tourists." Antarctic tourism started in the 1960s, and nowadays commercial planes can fly in, for example, from Australia. Construction of hotels on the Antarctic continent has been discussed.

The Arctic as well as the Hindu Kush–Himalaya have no consistent, coordinated, and legally binding tourism management, but tourist numbers are increasing. In Antarctica, tourism is regulated by Association of Antarctic Tour Operators (IAATO; www.iaato.org), but this also has virtually no binding status or any relevant enforcement mechanisms. In times of limiting carbon footprints and invasive species, the promotion of polar tourism must appear counterproductive.

The promotion of economic growth, a pet topic for most governments but not part of any constitution, makes for another example of poor leadership and governance (Czech 2000). It is clear by now from the scientific literature and (ecological) economy textbooks (e.g., Daly and Farley 2003; Paehlke 2004) that economic growth must not be the goal for any nation, and certainly not for the three polar regions. The nation of Bhutan made that clear with their infamous quest for happiness and as a national performance measure. But further, promoting and subsidizing the consumption of products that stimulate economic growth should equally be avoided because it also supports a devastating economy (see Li and Li 2011 and literature within).

All these examples highlight a broken leadership, one in favor of decisions that in essence result in what Stiglitz (2006) refers as subsidies on behalf of industry, in favor of polluting the atmosphere. Instead of the engineering views that still rule, it is time we add ecological views, list entire ecosystems and all their components as endangered (Netherlands Environmental Assessment Agency 2010), and fully adjust our administrations and institutions to this concept. The government is not in the lead anymore (Berkes 2010 for decentralization). That concept has many implications because tax money is not worth much when the government rules but fails environmentally; it does not buy us sustainable leadership on a local, regional, national, and international level. The status of a governmental employee, or head of a ministry, dramatically declines also.

One simply must not overestimate what can realistically be expected from governments and their staff. They are widely limited in dealing with the real world environmental problems of 2011. Usually, they lack statistical training and even a good computing infrastructure. Almost by definition, they will run behind, trying to catch up, and just fix things as much as they can afterward (Taber and Payne 2003). What the governments realistically can do and achieve, and what not, and why, is already constrained by the "human" factor. Public employees are bound by workplace constraints, federal legalities, federal and state agreements, limited computing infrastructure, and by an 8-h workday to handle all the problems and issues the poles, and the globe, are facing. It is nearly an impossible task to resolve, especially when always acting after the fact and with such a heritage and institutional culture. Such a governance structure cannot achieve sustainable excellence. It is a good debate to have and question to ask: How much money is needed to deal with all environmental issues appropriately? And what governance system is required for doing so? In the United States, projects get declared as Superfund Sites, environmental write-offs, when the environmental issue is seemingly unfixable and too expensive to clean up. Similar procedures are found in Russia. And Ivituut (1987) and Marmorilik (1973) in Thomas et al. (2008) report that many mines in polar regions are already exploited.

Thomas et al. (2008) reports huge impacts from mining at the two poles, including "…abandonment of the sites when uneconomic." "…but political decisions on sovereignty of self-sufficiency have at times encouraged wholly uneconomic and damaging activities, for example, in Svalbard where Norway and Russia have been mining coal for many decades."

Many such situations exist in the polar regions already: those in Alaska are often related either to BP or to the military (details shown at http://www.epa.gov/superfund/sites/). How is this related to the benefit of mankind, and why should these players be allowed to act further? The failing role of the EPA (currently driven, in part, by former Monsanto employees) should be noted. The U.S. government also has no Ministry for Cultural Affairs (as most other nations have), a situation that does not speak in large favor of a localized polar sustainability culture and awareness.

But despite all such shortcomings, governments and their views and employees are still found on all relevant regulatory positions: from being editors,

Textbox 3 The Good Battle for Releasing Scientific (Environmental) Data: Digital Details, Metadata, Digital Divides, Transparency, and Achievements

Data make for scientific findings, for high-quality science-based management (Huettmann 2007c), and for environmental impact studies. Withholding data is a means to erase entire facts and decision subjects from the global agenda and for betterment. The same can be said when inaccessible data formats are used, and when data descriptions (e.g., metadata) are lacking. Access to high-quality data is the key for good and sustainable decision making, for transparency, and for a functional democracy and for a fair world. Such tasks are not to be taken lightly. Data are essential for polar protection. Thomas et al. (2008) provide an Antarctic fisheries example stating that "…the Soviet Union deliberately provided false data…", making it impossible to set scientifically sensible quotas.

The best available polar species inventory overview is given by Bluhm et al. (2010; Arctic), De Broyer et al. (in press) and Gutt et al. (2010; Antarctic), and Shrestha and Joshi (1996) and Bhija Shakya et al. (2007) for Nepal. And most of these data are available online, at our fingertips (at least as a PDF, but for the most part as real data; see Tables 12.5 and 12.6 for sources).

The International Polar Years (IPYs) have been huge international research initiatives creating a wealth of data (Carlson 2011). There have been four of these initiatives, providing "enlightenment" to the polar regions (it is noteworthy that sustainability was never explicitly mentioned or studied in the IPYs, or made as the overarching headline). For the most part, IPY priorities are set and efforts are directed by the "affluent white culture." It resulted in the creation of knowledge with many data collected. Such knowledge eventually caters to a culture of national and economic goals but ignores the needs of a healthy atmosphere.

Virtually all IPYs have the common characteristic that their data are widely lost; that is, their legacy (Carlson 2011). The recent IPY 2007–2008, where data sharing was a major priority, had a data policy compliance of less than 35%. Even the biggest science agency supporters in IPY such as ICSU, NSF, the EU, British Antarctica Service (BAS), Russia, and Norwegian Research institutes in Svalbard and Tromsoe either did not fully enforce a complete data-sharing policy or ignored high-quality metadata altogether. The poor performance records of polar research cruises regarding data sharing and metadata should be emphasized here (many of them also act without any reviewed and tested scientific research design).

But the poles are generally not poor in data at all (data collection efforts were ongoing for centuries), and many calls for data-sharing policies exist (e.g., Sarkar 2007; Spehn and Koerner 2009; ICIMOD 2010c). However, consistent, clean, and meaningful datasets publicly available free of charge and in a good format and with high-quality metadata are still widely missing on the

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Textbox 3 (continued)

local, relevant scale. A link with data for areas relevant to the polar regions but located outside the poles, for example, in the tropics, is urgently lacking. The ultimate link with peer-reviewed publication is discussed but virtually not yet achieved.

Additionally, a digital divide can be found for the poles in many ways (data access, skill, expertise, workflows, across nations). Arctic countries such as the U.S. (e.g., Alaska) easily lose approximately 40% of the initial data collected, and a high percentage is never published in the peer-reviewed literature, rendering them essentially inaccessible to the global audience. Research vessels can be notorious data skinks. Russia and its unique, rigorous, and huge data pool suffer less from data loss but makes for another example of inefficient data and information dissemination to the global community: these extremely precious long-term data are often hidden in Cyrillic letters and with Slavic nondigital administrative cultures that are not readily accessible to the world and are thus unavailable to contribute to best global decision making (often, not even the Russian government itself has those data handy). Most other countries suffer from similar problems, such as France, Malaysia, or South America. An international digital data culture and administration needs to develop, which can take decades to form. Because the poles are an international research item, a public good by itself, the huge but relevant data sets widely scattered throughout the world still must be recompiled for a coherent picture.

In addition to IPY, the Southern Hemisphere has had for more than 50 years the Antarctic Treaty System (ATS; see Summerson, Chap. 4, this volume; Boardman 2005) in place, which specifically states that ALL SCIENTIFIC INFORMATION IS TO BE SHARED. However, even rich nations acting in polar regions such as Japan, Norway, Iceland, Denmark, and the United States, for example, for many of its seabird and sea mammal data have still not accomplished that goal, and neither for their metadata. Language barriers make it worse and are used to make information not easily findable and readable. However, many smaller countries did achieve this well (see Belgium, and for plankton and benthos). The SCAR-Marbin website, for instance, shows a wide lack of U.S. data submissions, but it also shows that the United States is among the biggest data downloader and data user of datasets that were created and hosted by others. There is currently no data and metadata police, and ironically, the more charismatic the study and its species, the worse it tends to get. The TOPP program, certified by open access programs such as IPY, COM, and NSF, still provides for a great example of not sharing raw data or metadata in time. IPCC suffers dramatically from lack of easy access to the raw data and to virtually any high-quality metadata. Convenience, stubbornness, a wrong science model, and self-interest rule instead. With the

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exception of a few motivated individuals, the calls for OPEN ACCESS of raw data, metadata, and tools were fully ignored (Carlson 2011) and by many academies of sciences, funding agencies, and industries. Certainly most large NGOs did not provide or even contribute such data. [A good example is found in Greenwood 2007 for the British Trust of Ornithology (BTO) where relevant 100-year data sets on bird banding, amateur science, etc., were not made freely available through open access. Many such data are important for polar species.]

Templates, initiatives, and rules exist, however, to promote data access (see Tables 12.5 and 12.6). It is not only best professional practice but also common sense and "scientific," whereas not sharing data, along with its associated metadata, simply is NOT. It must come as a surprise that many polar protected areas do not even release their data paid for by taxpayers (e.g., see gyrfalcon data in Denali Park: Booms et al. 2009; and Everest data: Jha and Khamal 2010). Of specific concern is that high-impact journals, those frequently used as a performance assessment for science jobs, do not require or promote open access of the underlying data and metadata of the studies they publish (Chavan et al. 2011 for metadata). In these circles, open access is mostly understood as a commercial tool to promote PDFs and impact citations, but it widely ignores the public data-sharing and science transparency requirement. This attitude makes for a very disappointing example of scientific integrity, one that illustrates a commercial influence in the sciences, for a lack of funding-imposed time or data sharing. In most cases when data are not shared, commercial/industrial funding is involved (see Textbox 1 for an example). Being open, transparent, and considerate to all global citizens is simply not a known industrial feature or culture; rather, the opposite. But this is not good corporate citizenship at all. Many big NGOs, and easily with their million dollar budgets, have adopted such attitudes also. Birdlife International and its Ocean Wanderers project make for a great example, and so for most polar bear and marine mammal telemetry data, whereas the Society of Conservation Biology (SCB) clearly demands exposing a complete disclosure of conflict of interests. Not doing so is a reflection of our current world, and its value system widely manufactured by corporations and ancient science concepts, for example, initially set up by royal family structures and still promoted by various royal academies of sciences and their outlets, supporters, and beneficiaries. But eventually, the earth, its resources, and the poles, pay the price. Now is the time for making improvements. IPY set a good role model for change. Shifting toward open access of raw data and tools, and using high-quality metadata, represents progress in science, a step away from an opaque science-based management and toward transparent government, democracy, and sustainability.

Table 12.5 Selection of data sources for the Three Poles

Subject	Data Institution	URL	Public, freely available	ISO metadata
Antarctica biodiversity (land and marine)	SCAR-Marbin	www.scarmarbin.be/	Yes	Yes
Arctic biodiversity (marine)	ArcOD	www.arcodiv.org	Yes	Yes
Global biodiversity	GBIF	www.gbif.org	Yes	Yes
Marine top predators	TOPP	www.topp.org	No	No
Telemetry and tagging data	Movebank	www.movebank.org	Partly	Partly
The Global Procellariiform Tracking Database	Birdlife International	www.seabirdtracking.org/	No	No
Polar Data GCMD	IPY and NASA	gcmd.nasa.gov	Yes	Yes
Mountain Biodiversity Data	GMBA	www.mountainbiodiversity.org/	Yes	Yes
Hindu Kush–Himalaya conservation-related data	ICIMOD HKH Conservation Portal	www.icimod.org/ hkhconservationportal/	Yes	Partly
MANIS (mammals)	MANIS	manisnet.org	Yes	Partly
Influenza (avian, human, etc.)	IRD	fludb.org	Yes	No
Fisheries data	ICES, PICES	ices.dk, pices.int	Little	Partly
North Pole region data	Arctic Portal	www.arcticportal.org	Little	Partly
Wetland data for the Himalayas	Greater Himalayan Wetlands Information System	ghwis.icimod.org:8081/ wetlandsnew2/	Little	No
Mountain data for the Hindu Kush–Himalayas	Mountain GeoPortal	geoportal.icimod.org	Yes	Partly
Nepal biodiversity data	Biodiversity Portal of Nepal	biodiversityofnepal. icimod.org	Yes	Partly
Publications for the Hindu Kush–Himalayas	Himalayan Document Centre (HIMALDOC)	himaldoc.icimod.org	Yes	Partly

Table 12.6 Missing data sets and immediate sharing of raw data on a local scale: An Arctic Alaska Example

Name	Institution	URL (add www)	Name of the data subject that is not fully shared freely and with public open access	Metadata expertise on staff + infrastructure
USGS	USGS, Anchorage	alaska.usgs.gov/	Polar bear and marine mammal data	Yes
MMS EISs	MMS, Anchorage	boemre.gov	EIS data	Partly
Barrow Contractors	Various oil companies, local, state, and federal governments	e.g. ABR (abr.com), LGL (lgl.com), ABO (alaskabird.org)	Various biodiversity research and EIS data	Partly
AK COOP	USGS housed at UAF	akcfwru.uaf.edu/	Biodiversity research project data	No
UA Museum	Housed at UAF	uaf.edu/museum/	Majority of bird data	No
USFWS	USFWS, Anchorage	alaska.fws.gov/	Telemetry data AK, wildlife data, metadata	Partly
Board of Game	Anchorage	adfg.alaska.gov/ index.cfm?adfg=gameboard.main	Wildlife management data, e.g., wolf, browsing surveys	No
State Veterinary	Anchorage	dec.state.ak.us/eh/vet/	Georeferenced disease occurrence	No
Toolik Lake	NSF via UAF	toolik.alaska.edu/	Bird density data	Yes
IGERT/RAP	NSF via UAF	uaf.edu/rap/	Research data	No
BLM	Fairbanks	blm.gov.ak	Wildlife data	Yes

Table 12.7 List of 20 laws and treaties related to (Arctic) wildlife and its management in the United States

Name	Year of initiation	State, federal, or international	Background and goal	Selected item of conservation relevance	Major shortcoming	Arctic relevance
Pittman-Robertson Act (Federal Aid to Wildlife Restoration Act)	1937	State and federal (Dept. of Interior)	Hunter fee-based collaboration between state and federal agencies	Game species	Many waterbirds are declining; modern issues such as bird movements, DNA, climate change, habitat loss, adaptive management, globalization, and digital data management are not appropriately addressed	Arctic waterbirds
Dingell-Johnson Act (Fish Restoration and Management Act)	1950	State and federal (Dept. of Interior)	Tax-based cooperation between states and the federal government. Requires states to have a comprehensive fish and wildlife management plan	Fish and wildlife management plans	Many fish stocks are declining; modern issues such as fish movements, invasive species, nitrate input, hydro dams, DNA, climate change, adaptive management, globalization, increased consumption, and digital data management are not appropriately addressed	Arctic fish species

Migratory Bird Treaties	1916 (U.S. and Great Britain; for Canada) 1936 (extended with Mexico) 1972 with Russia and Japan	Federal	Prohibit the export and taking of birds (and small mammals in Mexico)		Many migratory birds are declining; modern issues like bird movements, DNA, habitat loss, climate change, adaptive manage-ment, globalization, and digital data management are not appropriately addressed	Migratory birds in the Arctic
Migratory Bird Conservation Act	1929	Federal and some states	Allows federal enforcement in collaboration with the states. Initiated a hunting stamp tax, established a wildlife refuge system, set up a Migratory Bird Commission. Started land acquisition and gifts	Deals with passerines and habitats	Many migratory birds are declining; modern issues like bird movements, DNA, habitat loss, climate change, adaptive manage-ment, globalization, and digital data management are not appropriately addressed	Arctic migratory birds
Lacey Act	1900	Federal and State	Enforcement of Migratory Bird Treaty	Illegal game, poaching	Lack of enforcement. Outdated in structure, principle, and relevant modern concepts and visions	Arctic migratory birds

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Table 12.7 (continued)

Name	Year of initiation	State, federal, or international	Background and goal	Selected item of conservation relevance	Major shortcoming	Arctic relevance
Fish and Wildlife Coordination Act	1956	Federal	Initiated the U.S. Fish and Wildlife Service	Representation at international meetings. Fish, shellfish, and wildlife as renewable resources of commercial interest and requiring proper management and with federal assistance. Prohibits airborne hunting	Failure to stop climate change from the U.S. side; loss of habitat and species	Management and stopping of climate change
Fish and Wildlife Conservation Act (Forsythe-Chaffee Act)	1980		Federal and state cooperation. Initiation of Conservation Plans to be developed by the state, which includes monitoring. Focus on nongame species	Conservation Plans as major tools to address previous shortcomings	Many states either lack a Conservation Plan, or do not have sufficient ones. Plans have insufficient legal support and wider structure	Alaska Conservation Plan does not deal well with Arctic, climate change, and modern conservation issues

National Forest Management Act	1976	Federal	Replaced organic act from 1897, and corrected "old-growth forest and dead wood" harvest terminology	Deals with 10-year road closures, air quality, and esthetics	Might deal with local issues, but ignores global demands and realities, putting pressure elsewhere. Insufficient for setting up digital infrastructures	No direct relationship
Federal Land Policy and Management Act	1976	Federal	Organic Act for Bureau of Land Management (BLM) and Dept. of the Interior	Basis to manage public land on a sustainable yield and multiple-use basis Supersedes the Taylor Grazing Act 1934	Impossible to achieve all goals specified. Inapproriate digital and GIS infrastructure; inappropriate dealings with climate change, land hunger, invasive species, and nitrification	Climate change management
Multiple-Use Sustained Act	1960	Federal	National forest administration. Provides for outdoor recreation, range, timber, watershed, and wildlife and fish purposes (in that order)	Provision of wilderness	Outdated concept and philosophy of land and its availability and distribution. Future and climate change issues virtually not addressed	No direct relationship
Wilderness Act	1964		Provides for the establishment of a National Wilderness Preservation System	Treatment of wilderness	Outdated and insufficient concept of (pristine) wilderness. Invasive species, climate change, and globalization not addressed	Arctic wilderness (maintenance and creation)

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Table 12.7 (continued)

Name	Year of initiation	State, federal, or international	Background and goal	Selected item of conservation relevance	Major shortcoming	Arctic relevance
Wild and Scenic Rivers Act	1968	NA	Provision of preservation of some rivers with outstandingly remarkable scenic, recreational, geological, fish and wildlife, historic, cultural, or other similar values in free-flowing condition		Most rivers in North America are damned (not free flowing). Law has not halted damning or protected Arctic and salmon rivers, for instance	Arctic river designation
Bald Eagle Protection Act	1972 (initiated 1940)		Prohibits taking (except for scientific, depredation, exhibition, and religious purposes). Update act from 1940	Revises the act from 1940. Puts Bald Eagle and Golden Eagle in national attention	Single species management approach. Does not deal well with habituation. Does not treat population explosion as inappropriate (assumes the more birds the better). Fines are too low	Golden Eagle protection, e.g., climate change, habitat loss

Endangered Species Conservation Act of Fish and Wildlife	1969	Federal, and cooperation with states by consultation	Provides for conservation, restoration, propagation, and protection of selected species of fish and wildlife, including migratory birds, that are threatened with extinction	Global leadership on the treatment of endangered species; listed species get funded	Ecological key features such as plants and plankton are excluded, so are ecological processes Driven (politically) by funding appropriations. Based on the inappropriate species and DNA concepts (not habitats and spatial modeling)	Delivering the Polar Bear to the Marine Mammals Act, and thus lowering de facto its protection status
Protection of Wild Horses and Burros Act	1971		Management of unclaimed and unbranded horses on public land in an ecological balance		Favoring of grazing and agriculture, and general biodiversity and wilderness loss	No direct relationship
Marine Mammal Protection Act	1972	Federal and states	Moratorium of taking and importing of marine mammals and products (some exemptions). States can only adopt laws in agreement with Dept. of the Interior	Regulating marine mammal hunting, trade	Inappropriate handling of ocean acidification, climate change, habitat loss, and species concept	Entirely insufficient protection during climate change and Arctic shipping, oil, and gas. Arctic habitat, e.g., sea ice, not protected. Development

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Table 12.7 (continued)

Name	Year of initiation	State, federal, or international	Background and goal	Selected item of conservation relevance	Major shortcoming	Arctic relevance
Land and Water Conservation Fund Act	1965	Federal, State	Provides matching funds to plan, acquire, and develop land and water areas plus facilities for recreational purposes, based on congressional appropriation	Requires outdoor recreation plan	Building recreational facilities is an outdated concept as such	No direct relationship
National Environmental Policy Act	1969		Declare nationally a policy that will encourage productive and enjoyable harmony between man and his environment; prevent or eliminate damage to environment, enrich understanding of ecological systems and natural resources, establish a Council on Environmental Quality. Establishing the Environmental Protection Agency	Establish EPA, Cabinet Committee that includes the Vice-President, set up Councils. Make Environmental Impact Statements a requirement	Climate change not stopped nor managed well in the U.S. Environmental impact studies virtually do not stop development	EPA is virtually not present in Alaska. Climate change has not been stopped or managed

ANILCA				Alaskan overruling of federal legislation, e.g., in national parks	Snowmobile use, hunting and climate change mitigation issues
Magnusson-Stevens Act	Federal	Provide management of fish stocks in national jurisdiction (EEZ)	Setup of Fisheries Councils to manage regional fisheries in the U.S.	Commercialization of fish stock and the decision-making process and its underlying science	Existing overharvest of various fish stocks. Future plans for (not stopping of) Arctic fisheries

to listserv moderators, as university-based scientists and teachers, graduate student supervisors, reviewers and funding facilitators, reviewing animal care ethics permits, and as board members in NGOs and elsewhere. Linked with industrial interests, it makes for a powerful control institution, creating environmental biases, inefficiencies, and lack of progress. Modern governments and their direct relationships with industry have harmed the environment and the globe's temperature. A change toward global well-being is needed, and quickly.

The often used method of removing, mobbing, and intimidation to quiet experts and alternative voices for political reasons, and to get agendas to one side's favor, is not only harmful, it is unethical (for examples, see O'Neill 2007 for the classic "The Firecracker Boys in Alaska" story).

Acclaimed projects that for decades do nothing but describe illusive species, maintain odd data, or pursue purely intellectual questions (e.g., what is the most parsimonious statistical inference or phylogenetic tree), or worse, lose data, or which are not in compliance with international standards (Textbox 3), miss the point, the urgency, management relevance, and impact. Carlson (2011) has already provided an example with the World Data Centers; many more exist (Brandt et al. 2007). If this goes on globally, absorbing funds in the neighborhood of 30 million per year or more for such projects, society and its environment will degrade. How can they not?

Biodiversity research and demography projects, such as those enthusiastically carried out in the Arctic on shorebirds or seabirds, suffer from such attitudes. They often require a 7-year investment before any relevant results and trends can be published. The actual implementation phase then often takes another decade. Overall, this easily makes for 20 years without action, despite fully paid research and management. By then, the underlying research data that are often needed for additional or follow-up scientific testing are usually no longer available (Box 4). Data loss is very common (as easily be seen by the inappropriately small budget items assigned for data management and delivery to the public + performance assessment).

Much of the dominating science and research seems to be content with eloquent mediocrity instead of focusing on producing precious data, making them publically available in an instant (on mouse click), using them to improve research and management efficiency, or as agents of change, improving species and habitat conservation (Anderson et al. 2003), or toward polar and global sustainability (a goal worthwhile to pursue, but which gets greatly discouraged by labeling it as "politics not to be dealt with," etc.). Instead, the business-like emphasis is always just put on reputation ("conservative, no risk taking and no trying") and PR ("must look good in public"). Emphasis on such superficialities does not lead to topical or environmental quality. Has it ever (Spash 2009)? Climate change and similar global problems are on the rise and cannot wait for a global resolution, be they formal or otherwise. Inaction is a political statement, and it will hit us all very hard, affecting even future generations.

In our current framework, conservation is either ignored, shows slow progress, or attracts contractors and "not-for-profit" NGOs that are primarily in it for the money. This attitude just sets up a competitive run for funds, one that is not healthy for the environment or the people. The biggest budget rules and determines the direction. It is a century-old Western society game and setup (well described in Perkins 2004). Currently, it is the overall economic framework that determines what can and what cannot be done. Even economists admit that so far the ecosystems always lose (Ring et al. 2010; see also Macdonald 1991). It is a one-sided approach to biodiversity, ineffective for a “good global temperature” and for mankind. IUCN, the leading conservation institution, acts as a fund-raising NGO as well as a government entity (Thomson 1992); this must set up a financially subordinate system where governmentally supported big industry (and some NGOs) always win, but to the detriment of nature (Paehlke 2004; Taber and Payne 2003). The IUCN must either be independent or lose its governmental and tax-free status (Thomson 1992). The poles deserve nothing but the best management.

When considering biodiversity, the poles are often ignored (Netherlands Environmental Assessment Agency 2010) or dismissed as less important biologically because they carry a lower species richness than the tropics, a view both ignorant and misleading (Gradinger et al. 2010). Despite well-known impacts of ocean acidification (AMAP 2006), some Norwegian researchers boldly suggest we may see an increase in marine biodiversity richness with climate change, and then imply its advantages. But this statement entirely falls flat on the holistic view that these current changes are not natural, are often caused by invasive species (including diseases), and result in the loss of endemic species and habitats (= reduced ecosystem integrity). Who wants palm trees and bananas growing in the boreal forest, and if this is imposed by societies from the outside? Species that are hybrids, or which are new to a given location, create large problems in addition to ecological issues, ethical and legal problems. The Pizzly Bear (also called Poly Bear or Grolar Bear; its taxonomy has not yet been established yet because it is so new and thus this species is not listed in any legal management text) makes for a case in point. Basically, our carbon industry has helped create new species, and we lack any culture, policy, or ethics to handle this. With the sea ice melting (Wang and Overland 2009; Tynan et al. 2010), the physical barriers that kept species from interbreeding are disappearing. Once these genetic barriers are subsequently gone, hybridization is impossible to reverse. Hybridization is already seen between harp seals and hooded seals, among narwhales and belugas, and probably between right whales and bowhead whales. Polar species as we know them today may be lost forever, certainly on the local scale. Does anybody care?

Larigauderie and Mooney (2010) and Mace et al. (2010) promote a more science based approach for such problems. But thus far, such type of science has been implemented as an agenda that favors industry goals. The IUCN concept of “species” listing supports just that (when a species gets in the way of economics, it simply gets lumped or split into independent subspecies based on DNA data, minimizing the impact and as required to continue with the development plans). Instead, we need habitat and atmosphere legislation that avoids such peculiarities to avert global destruction.

On the topic of scientific approaches, mathematical models are often used to assign a maximum sustainable yield (MSY) for commercially important species to animal populations. Theoretically, MSY determines the largest number of individuals that can be harvested from a species' stock over an indefinite period of time. But what is MSY really and how is it assessed? And should theoretical, model-based data really be used to manage stocks? CCMLAR and exploitation-happy modelers are gratefully pecking away unchecked in what they perceive as maximum sustainable yield. But instead, MSY is widely not recommended, even by experts (e.g., how are MSY and carrying capacity really assessed?). The public must review such work for validity and for being proactive and precautionary according to IUCN principles; it must all be an open-access and open-source process instead. The overall impacts caused by such models as MSY or the Rickert curve are considerable. Examples for failed models are provided by Ainley et al. (Chap. 3, this volume; Pauly 2010) and can be seen in Eastern Canada and the Davis Strait and elsewhere (Johnsen et al. 2010 for arctic cod; Parada et al. 2010 for Alaska's subarctic crab fishery in the Bering Sea).

Equally misunderstood is the discipline of economy, and that is specifically true for the polar resources. To this day we have no polar economy theory, and globalization does not achieve this on many fronts. Banking on ecological economics would serve us well, however (e.g., Daly and Farley 2003; Speth 2008). Its principles demonstrate convincingly that approaches from neoclassic economy are dangerous on most accounts. It also shows that TEEB (The Economics of Ecosystems and Biodiversity, www.teebweb.org; Ring et al. 2010) offers us just a narrow and misleading set of inefficient options. We can endlessly assess ecological values and ponder about trade-offs, yet never reach a meaningful goal, such as to stop environmental destruction in a holistic manner, while the underlying causes such as promotion of economic growth continue uncriticized. Nature must not be monetarized; this leads to wrong concepts and thinking. Entities that take on and promote such concepts are simply ill informed and pursue faulty policies, such as the German Helmholtz Gesellschaft, DIVERSITAS, Society of Conservation Biology, and UNEP. If science is used only to further the corporate agenda, to run business as usual for so long as possible (Rosales 2008), then such scientists and their advice will have failed us again. This is what has happened with climate change, biodiversity, and for the poles. There is a long history of governments misleading people with science, for example, in the use of nuclear energy, the chemical industry, and in the economic realm (see Gaffney 1994; Nadeau 2003; Perkins 2004; Ott 2005; Spash 2009 for an example). "Business as usual" will result in more losses of biodiversity and wilderness (Netherlands Environmental Assessment Agency 2010). We still lack a mechanism to shape and use science for the sustainable benefit of mankind. Clearly, the carbon industry's role would be different today if it had been vetted by sustainability-minded science and driven by ecological economy and such institutions.

Clearly, the international corporations cannot go on their ways. Tax breaks for international corporations (as were offered to BP in the United States during their 2010 oil spill year) represent perverse subsidies, a business advantage, and is not in favor of a free market, nor of the environment or the poles. Most national tax systems confirm fragmented instead of holistic environmental procedures, whereas globally we all face the same problems. Thus, we need the same approaches and frameworks for a sustainable solution.

The politics of environmental problems is messy and currently it is only getting worse. Money that is meant to fix environmental problems comes from industries that created the problem in the first place. Philanthropic groups and politicians are able to set up structures to link money schemes with humanitarian or environmental causes. It cannot achieve, but digs us in deeper. Money that is used for conservation often comes from exploitative actions. Funding entire research programs with money from the Beaufort Sea, and from Bering Sea oil development, is equally problematic and will just lead to academic greenwashing. Linking fuel consumption with environmental taxation is such a case and will not lead to relevant progress. Biofuel will not stop the causes of climate change either. Spending money from mines and oil on cleaning the Arctic or the poles sets us up for similar conflicts, as when used for humanitarian causes. Such political entanglement must be resolved. Instead of charity and philanthropy, it is better to stop the destructing source and restructure for the better. Public, scientific, and environmental funding obtained from the oil sands in Alberta, or from pulp and paper mills in the boreal forests (Berkes et al. 2010), make for such a case.

Arctic and polar border conflicts are widely regarded as "low relevance" by Yalowitz et al. (2009) and Bingham (2010). But these authors are too benign in their assessment (UNESCO 2009; Thomas et al. 2008 and Wilson Rowe 2009 discuss many such conflicts, and Arctic Canada recently split its territories away from a strict federal influence). Even the military itself sees the upcoming conflicts (Titley 2010). The case of Svalbard demonstrates that point clearly (e.g., the strong dispute between Russia and Norway; Thomas et al. 2008; and more than 40 signatories of the Svalbard Treaty maintain their claims, including Egypt, India, Monaco, Japan, and Australia; http://en.wikipedia.org/wiki/Svalbard_Treaty).

Indigenous populations – representing nations within a nation – occupy approximately 30% of the Earth; this percentage covers more land than is protected in National Parks (Berkes et al. 2010). An overview of indigenous populations and their lands for the circumpolar region is given by Johnsen et al. 2010. The indigenous views are vital, for example, in Alaska where native corporations make for a major political driver (Table 12.3; see Ayers et al. 2010 for indigenous views). The infamous Red Dog Mine (see Table 12.3) is owned by natives (Thomas et al. 2008). Demands by the indigenous people have resulted in the splitting of land ownership, and changes in land management and administrative borders, even putting pressures on Arctic university setups, funding, and curricula. Human health and human rights issues are large for the poles (AMAP 2009; Pao and Palin 2005 for Tibet), and some have already referred to what is happening in some regions as ongoing genocide. The discussion about ILO 169 is a major issue for Russia (Wilson Rowe 2009) and beyond (Johnsen et al. 2010). The ILO convention #169 is meant to assure recognition to, consulting with, and empowering the rights of indigenous people. How to accomplish this on a limited landmass and with resources that are already assigned and/or overused remains widely unresolved and likely is not ever to be resolved. Adding to the different points of view about "land" on the local level, at the third pole in the Hindu Kush–Himalayas, Utrakand, India, declared itself as a "Herbal State" with a strong focus on the development of medical and aromatic plants, run by the native population (ICIMOD 2010d).

Textbox 4 Ecology: Teachers versus Advocacy?

Scientists who work on conservation, in ecology, or on climate change have for long time been accused of taking (political) sides. Many (polar) examples exist wherein they were removed from their positions (O'Neil 2007) or harassed otherwise (Nowak 2005). Advocacy (for climate change and sustainability) has been portrayed as not being objective, not being serious, not being professional, and not being ethical. But many of the earlier accusations were actually made against scientists who were paid by industry (this was at a time when the governments still employed most scientists and when industry did not provide for their soft money). Although the addition of conservation biology, ecology, or climate change as research disciplines, taught at universities and with serious textbooks, has changed this situation, there is still no real Arctic, nor even a Polar Conservation Program or degree (while there are certified Arctic Engineering and Architecture programs, let us say). An Arctic University exists, however, and so does America's Arctic University, but polar protection issues are hardly promoted there.

People who promote such type of "objective science," and where almost any conservation issue becomes a political if not even forbidden item, have entirely forgotten that ecologists and conservation scientists do teach about carrying capacity (it is within their professional purview to do so; Huettmann 2007a). This fact makes for the core of the discussion about advocacy: yes, we HAVE a carrying capacity; yes, getting closer to the carrying capacity should be avoided and will make life very miserable for all (an ecological law); and yes, we consume resources as if we have three worlds available. And so, yes again, scientists MUST advocate in public, as well as in the classroom, that there are limits of nature and resources that we all live under. Nobody can escape the ecological carrying capacity: it is not a political issue but a fact of life (and death). We cannot just turn our universities into "resource extraction institutions." Ideally, these institutions should study how to live life best, for infinity and by what means. Scientists have these efforts actually written right into their job description (public outreach to promote scientific findings and knowledge, to avoid nonscientific decision making, and to improve human well-being). They are paid by public tax money for doing so. Every biochemist essentially works along these principles when developing medical treatments or studying diseases.

The traditional job description for most scientists goes: Public Service, Teaching, and Science. This description inherently includes sharing of scientific findings and the promotion of scientific knowledge, for example, ecology and conservation science; both are essential in the times of climate change.

This goal builds on the basics of science, which are (1) transparency, (2) repeatability, and (3) challenging existing ideas and critical thinking. Although these make for the foundations of Western principles and of our modern

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Textbox 4 (continued)

science-based society, they are actually common sense approaches, and were widely celebrated in earlier high civilizations such as in Arabia, ancient Egypt, and China. One could argue that ANY group of human beings can be convinced by these three basic principles.

Assuming that society is led by reason, and thus by science, ethics need to be a driver for our science actions one way or another. But many animal care procedures still ignore habitat, atmospheric, sustainability, and data-sharing considerations (see www.iacuc.org for Institutional Animal Care Use Committee IACUC). If not changed, we easily end up with a science argument that is not in favor of mankind. However, it is also clear that generational and cultural changes have to occur, and that an overly hierarchical, power- and money-hungry, old-aged, and nationally biased approach is harmful and is not achieving well. Despite decades of federated governmental systems and with the UN at its lead, it is surprising that most institutions, experts, and decision makers still have no answer, nor a vision on how to achieve and improve such things, and with what structure, culture, and funding. Considering the state of the world and its outlook, it must further come as a big surprise that the goal of science is not moving more explicitly toward the direction of "sustainability research." In the following, I shall outline basic components and directions of such a science and effort.

Now, what makes for bad science, and real industrial advocacy? If kickback from industry occurs one way or another for conservation decisions, such makes for bad science also. Similar cases can be reported from all over the poles. As the story of this book unfolds, the outrageousness of such situations will be become evident to everybody. Such situations must not go on, and not under the umbrella of "objective" science. Instead of accusing scientists for promoting or pointing out best sustainable methods, one must instead change the inherent promotion of industrial goals and agendas in most of the Western institutions. The culture of resource extraction must be changed toward global sustainability of the poles and beyond.

Textbox 5 Examples of Birds with Deformed Beaks in Alaska: Hype, Precautionary Science, or Nothing to Worry About?

In the year 1991, the first sightings of birds with malformed beaks were reported. Most reports came from the Anchorage and Fairbanks areas where serious environmental contamination exists (http://www.epa.gov/superfund/sites/). The EPA is not that active in Alaska, and Anchorage, for instance, acted for years under a peculiar sewage treatment exception (Mundy 2005).

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In 2000, at least 475 bird individuals were affected, and beak deformities have been observed in 18 species, for example, in chickadees. Many hypotheses have been suggested why these events occur but none have been confirmed. And no such observations have been reported from other areas of the Arctic, and only a few other locations are known for North America overall. Caged birds are known to show beak deformities when fed at feeders, with soft food, or in captivity. This could hint at a true urbanization, but still man-made, effect caused by "overfeeding." Urbanization is already recognized as a huge issue in polar regions, changing their wilderness ambience (Huettmann et al. 2011 for seabirds; A. Baltensperger unpublished for Ravens).

Another real possibility is perhaps that the beak deformations are caused by pollutants, for example, PCBs, POPs, dioxins, insecticides such as DDT, military waste (e.g., phosphate, missile fuel, radioactive material perhaps), and their synergies ("toxic tort"); most of these pollutants are known to be harmful to people as well. But why is there so little interest in getting to the bottom of this cause and find out the underlying mechanisms (a scheme that otherwise gets promoted by scientists involved). If not for the birds' sake, then why is it not pursued for our own sake? In addition to the relatively inactive EPA, much ongoing pollution is found in Alaska beyond Superfund Sites; see Ott 2005 for examples). Might this problem represent a risk to our children? Does it explain certain cancers? Can it be linked to other illnesses in the region? Is it perhaps a reason why native rural populations generally live at least 5 years less than the national average? Although this could not be a more obvious example of "the canary in the coal mine," yet a decade later governmental scientists still have no answer for us about what the deformed beaks mean. And without relevant budget allocations a resolution is likely not on the horizon anytime soon. Contrast the current situation with what one would expect under the Precautionary Principle where policy makers can make discretionary decisions in cases such as this, when there is risk of harm and when scientific evidence is lacking, and where adequate funding is made available to solve this puzzle for birds, as well as for people and the Arctic.

Textbox 6 The Proactive Monitoring Disaster for the Arctic: When the Lack of Science, Rigor, Budget, and Management Link Is Exploited by Politics

Monitoring of the three poles is probably done better than for many other regions, but it still is widely inefficient. While Bhutan, Nepal, Tibet and India present many biodiversity datasets in GBIF (Global Biodiversity Information Facility) (www.gbif.org; usually the benchmark for publicly available data), other parts of the Hindu Kush–Himalaya are less well covered (See Nemitz et al. Chap. 6 this volume). The Antarctic still shows wide data gaps and so does

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the Arctic, widely lacking publicly available information ready at our fingertips. The wide lack of publicly available monitoring data in GBIF for Arctic research stations such as Zackenberg (Melofte 2008), Toolik Lake, Abisco, several Russian sites, Svalbard, and missing raw data sharing in research programs such as TOPP have been openly discussed for years. But most data are still lacking in the public realm. Although the International Whaling Commission (www.iwfoffice.org) runs now statistically designed monitoring and inventory schemes for Antarctica, and while many year-long monitoring data for the Hind Kush–Himalaya region exist (see Table 12.5 for overview), the Circumpolar Biodiversity Monitoring Program (CBMP http://cbmp.arcticportal.org/ is notorious for just being based on opportunistic, widely incompatible methods across the Arctic, not even showing relevant metadata or having a statistical review. Other than some flashy technology products without much meaningful content, not much has happened over the past 100 years when it comes to sustainable Arctic monitoring and a subsequent stewardship. A statistical and model-based performance review (widely recommended as a best practice in most textbooks; e.g., Braun 2005) has still not occurred across the poles (Nichols and Williams 2006), and is far from being well funded, staffed, implemented, and enforced. Virtually all biodiversity surveys in Alaska are, for instance, still done opportunistically and without any relevant research design at all; that approach even gets defended and continued (Irons in Petersen et al. 2008).

Almost none of these monitoring schemes was in place before climate change occurred as a public discussion item but rather got initiated after the fact. Noteworthy is that this monitoring attitude directly includes IUCN, USA, Canada, and Norway, and that other players and better concepts were widely ignored and pushed aside.

Birds have widely been used worldwide as monitoring sentinels. However, authoritative efforts such as those of Petersen et al. (2008) just show a rather one-sided focus on breeding birds, thus bringing it down from over 64 species to just 6 species breeding in the Circumpolar North. The majority of birds still await any quantitative assessment (see Zöeckler, Chap. 9, this volume; Thomas et al. 2008; but see Huettmann et al. 2011).

The lack of publicly available (bird) monitoring raw data in any digital format has already been known for years (Irons in Petersen et al. 2008; Huettmann et al. 2011; see Box 4).

Any monitoring scheme can only be efficient if it feeds directly into a management process (Huettmann 2007b). But how this is done and achieved, and when the management schemes are not even known or agreed upon, is unclear. The least one can say is that such type of monitoring is not appropriate for polar regions that will undergo meltdown in less than 50 years (Schiermeier 2007). We are not even counting the deckchairs on the *Titanic*, but simply provide an obituary (see Epitaph and Foreword by B. Czech, this volume). This can hardly be a valid goal for handing over the globe for future generations.

Further, the notion of nation states and their tax systems simply requires updating in times of globalization where boundaries are blurred, public tax income is heavily fought for, and where some international corporations have bigger budgets than many polar nations themselves. In times of globalization such policies affect us all, and beyond borders. Our own needs are well in line with migratory species, which are found at all three poles. Aside from the ecological perspective (see Berkes et al. 2010 for porcupine caribou in the Canadian/Alaskan Arctic; see Zöckler, Chap. 9, this volume, for birds), this must be addressed to move toward much better border arrangements, or rearrangements.

Finally, we live in a man-made world that is based on education and man-made reasoning. Ecologists, conservation biologists, geographers, and atmospheric scientists are teachers; they hold precious expertise. They teach lessons from their disciplines. Calling them advocates, or biased, is not only wrong, but harmful and utterly outdated (Textboxes 4 and 5).

Note that none of them has yet stopped climate change (Textbox 6).

12.4 What the Poles Want and How to Make It Happen: Mother Earth Rights

The International Council of Science (ICSU www.icsu.edu), the National Science Foundation (NSF www.nsf.org) of the United States, and the Society of Conservation Biology (SCB www.consbio.org), as well as many other influential and relevant science-related organizations, are very clear in what science efforts are to be used for: *Science is to be used for the long-term benefit of the people, their future and their habitats*. And thus, polluting the atmosphere must not be our goal. This statement makes common sense and is best practice. But if it still is not pursued, one wonders what the argumentation, justification, and the meaning of life, is otherwise? And so, the U.S. Fish and Wildlife Service (National Wildlife Refuges), acting in all polar regions, has, for instance, the following mission statement:

> …to "administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."

One of the key terms in this mission statement probably is "…for the benefit of present and future generations of Americans"! This makes for a major ethical paradigm, including consideration of long-term benefits and assessments. And the North American National Park System claims similar goals (National Research Council 1995):

> The National Park Service preserves unimpaired the natural and cultural resources and intrinsic values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation, and outdoor recreation throughout this country and the world. National Park Service (2010)

Textbox 7 The Science and Politics of "Who Did It"? Forensics of Environmental Degradation, and the Destruction of the World as We Know It

Modern human society lives within a so-called sophisticated rule set, assigning fault and guilt for societal wrongdoing by use of legal procedures. Massive administrative programs are maintained nationwide to assure cars are registered and parked correctly, that citizens maintain law and order, and that taxes are paid. Violations result in fines and even prison terms. But when it comes to environmental destruction, even that of the worst kind such as the production of CO_2, the liability question is widely ignored. Laws are supposed to take care of such, but as can be seen with the steep rises in economic growth, climate change, and human population increase, no fault has been assigned nor the process halted. Why is that? It is not only that our governance fails, and the lawmakers, but also the science bodies, and most academies of sciences are rather weak in identifying the real culprit. Many scientists either still argue about whether animals do decline, whether climate change does exist, that there are uncertainties, or, even better, that there are some losers but also winners (implying the overall impacts are just benign or better). For instance, Thomas et al. (2008) state regarding Antarctic climate change that "… conclusions are difficult to draw," although the authors state a few lines later "…there can be no doubt that the Antarctic Peninsula region is one of the regions of the world that is warming the fastest…," and the Larsen B Ice Shelf collapse is also discussed. The text is simply not clear in its overall message and confusing to read. Again, Thomas et al. (2008) is an endorsed IPY book and even an outreach project.

An objective science culture talking about all real-world issues, or approaching the issues carefully with latest scientific methods and philosophies the issues with scientific methods, or challenging these with data, is virtually not happening. It is not encouraged and thus not expressed by most scientists. They hide behind an old game of 'not knowing in detail, and delay'. This avoidance makes for a nonscientific approach, which is otherwise based on challenging the existing constructs of mind and procedure, and testing whether they hold up (sensu K. Popper). Clearly, in times of climate change and missed targets of biodiversity and social and economic goals, business as usual fails (Hansen and Hofman 2011; Netherlands Environmental Assessment Agency 2010).

Such a style of science is found widely and even is called a good thing and an appropriate professional style, whereas it is not. This attitude must appear to be surprising because scientists often claim they would address the core issue, and in a parsimonious fashion, deal with the core mechanism. But when it comes to climate change and conservation, the general trend often is ignored, and instead many scientists can make a living in arguing about ivory-tower

(continued)

Textbox 7 (continued)

details that detract from the big picture. And what is not science, or what cannot be made or argued in scientific terms?
How should scientists in public offices spend their time, what should they work on, and how is that determined, and by whom?

These are very old questions, and they require constant redefinitions and adjustments, and structures that allow for a public and efficient debate. In times of globalization, we have shifted toward an economic paradigm and value system, but one which appears to fail widely in times of climate change and all the frequently missed global targets. So where to go from here, and who is correcting this system back to something normal and better?

But how can all of that be achieved under the current scheme? And how do the science institutions fare and contribute? What tools exist to make it happen? And how is the performance assessed, and based on what metrics and global standards? These mission statements require immediate updating as they do not well consider digitization, globalization, or large human populations (see Netherlands Environmental Assessment Agency 2010 for future scenarios). We need to learn from the south, and where sustainability worked well for millennia. We still need a public debate and assessment on how best to achieve these goals.

We obviously need environmental monitoring (see Textbox 7). The Convention on Biological Diversity (CBD) has not served us that well, but probably remains the only really powerful and realistic tool (Netherlands Environmental Assessment Agency 2010). Changes in our business must come through the Rio framework.

Science represents reason, and it is an investment in future generations. But judged by the status of the world, how are our sciences doing and being applied, when it comes to the current state of the Earth, its people, and the future outlook? Is our science correct (see Textbox 7), proactive, or simply misled, and how can we set it on the path toward urgently needed sustainability and human well-being?

We need global science reform, and it can be done through the poles. The three poles need a better sustainable science model for the sake of global well-being. Questions are centered around this: Science what for, and how?

For the marine regions in the Arctic, Yalowitz et al. (2009) and many others urge the signing of the United Nations Convention on the Law of the Sea (UNCLOS) (UNESCO 2009). This act will settle many disputes and allow for better planning, and determine how resources are accessed, used, and protected. It will lead to progress in sustainability science, such as through Marine Protected Areas (MPAs). As a matter of fact, UNCLOS should be centered, and build upon, an ocean protection system.

Although Yalowitz et al. (2009) and Bingham (2010) claim that the Arctic does not lend itself to a new and better treaty system (such as that done in Antarctica; see Summerson, Chap. 4, this volume; Boardman 2005 for overview), we must have dramatically improved laws and legal concepts, which inherently include protected areas and a thorough link with science. Presumably, this must happen globally and include climate and generational justice (Rosales 2008, http://www.gene rationen-gerechtigkeit.de/). The current MPA initiative has not achieved this (less than 3% of the world's ocean are considered as protected), and it is unlikely that it will achieve much within the next 20 years (a time when at least half the Arctic summer sea ice is expected to be gone (Wang and Overland 2009), along with many related fish stocks; Netherlands Environmental Assessment Agency 2010). Instead of just holding an elaborate joint meeting of Arctic Council and Antarctic Treaty partners (Yalowitz et al. 2009; http://arctic-council.org/meeting/ 1195042723.6), an exclusive polar clique (Thomas et al. 2008), we need wider and proactive views that include all three poles, and beyond. We need a new global contract for the poles and beyond (Radermacher 2004).

With that, we need a (global) tax and public funding reform (public science is clearly affected by funding and funding directions). For instance, the U.S. Fish Wildlife Service, and as a major player for polar research, is still funded in part through hunting permits (instead of the regular tax pool). It just cannot perform on outdated business models, or by using soft money and industrial support to compensate. Likely, we need to change nation state funding and move bigger (free-trade zones clearly point that way). Also needed is an overruling Ministry of Climate Change. (It is truly surprising that such an entity does not widely exist yet. Should not every nation have such a ministry acting in concert with global entities?) To this day, we still have no good concept for representative government and a democracy for the three poles, the cryopshere overall, or for the atmosphere and global citizens for that matter.

Equally critical, we need land ownership questions settled, including water and mining rights. This must happen across all scales: local, regional, national, and global. But this idea moves us into a new sphere of planning, administration, and cost-and-benefit assessment.

Yalowitz et al. (2009) have already asked for environmental contingency and disaster planning. Klein and Magomedova (2003) demanded circumpolar land and resource plans. Strategic conservation planning for the poles, and specifically for the atmosphere, should be done (e.g., comprehensive, adequate, unique, representative), but it is virtually lacking for most areas (but see Huettmann and Hazlett 2010 for the Circumpolar Arctic, and Huettmann, unpublished, for the entire polar region). Although ecological service maintenance should be the goal for any protection scheme (Tallis et al. 2010), it is very likely that not all goals can be achieved at this point. Thus, we must not be shy of new concepts. For instance, some public voices suggested already running the entire UK as a single National Park (and if so, why not the entire commonwealth?). And the Netherlands Environmental Assessment Agency (2010) runs scenarios that cater to 50% protection levels.

And what about a simple "no-extinction" and "no population loss" law for the Poles and elsewhere? What is so difficult about it? Initial Russian environmental laws followed these concepts for their endangered species (which have since been changed favoring industrial activities). The issue for such an evolution here is culture, media, convenience, infrastructure, and sustainable leadership (or lack thereof), finally allowing us to lose species, habitats, and the integrity of nature, of the atmosphere, and of life. Several ways exist to overcome these problems. The emerging culture of have-nots, squatters (a group consisting of billions of people), is surely in favor of a change (e.g., Easterly 2006). A system where only a tiny fraction of people harvest all the wealth has never worked for long. We can look to the fall of Russian communism, ongoing depowering of royal families and dictators, and the global raise of parliaments (people governments). So, there is some hope that we can move into a functional democracy for the poles.

In the meantime, everybody should work toward, and be prepared for, relevant changes, those that are hopefully based not on violence but on fairness and equity. Change for the better (Chapin et al. 2009). Major global changes have occurred already over the past decade, such as the spread of Americanization on one hand, and moves toward reducing the ozone hole on the other (Macdonald 1991). The abandonment of slavery and child labor, use of seatbelts, end of tobacco smoking, and abandoning apartheid have been achieved, but many more changes must be expected if we and our children want to survive. It is on us to make things pleasant for all and to spread wealth more fairly and equally. It is worthwhile to point out that many earlier cultures celebrated exactly these public values and concepts, and in a sustainable form for thousands of years and thousands of people (e.g., the potlatches of the Northwest Pacific tribes; whaling and sharing of such resources among circumpolar tribes). In the Hindu Kush–Himalaya region, Hindu and Buddhist religions dominate, which promote being in balance with nature (e.g., the consumption of meat is widely reduced; see Netherlands Environmental Assessment Agency 2010 for impacts of meat consumption on climate change).

Obviously, changes can only occur if they are taught to others, and our educational institutions must take them on, the quicker the better. When looking at the biggest polar universities, however, this might not provide such a positive message. Similar to the African continent, most polar universities have no strong academic standing; they are not even ranked among the 100 top universities. That can be explained, in part, by the fact that the demand and market for such training is not mainstream (why not?), but it must be addressed and improved toward high-quality education and sustainability for polar regions affecting the world's atmosphere. One of the universities in the Arctic with one of the largest budgets and highest student throughput, the University of Alaska, has been led for years with the direct involvement of former military generals as presidents. The governance and related funding structure of the University of the Arctic is not that transparent either. It comes as no surprise that Thomas et al. (2008) entirely ignore such topics in their "objective" science concept for the polar regions. If we are running, and teaching, polar universities as pure resource extraction institutions, our current problems will just be reinforced and remain with us for generations to come. A change is needed in the polar regions and beyond (Huettmann 2007a,c).

For those who believe in legal changes and in any type of climate justice (Rosales 2008), it is worth noting that changes usually come from outside. That is because the existing legal landscape and its actors (lawyers, judges, and their prestigious law schools) are not likely to provide for much betterment of the endangered species, of the three poles and the atmosphere. Based on their track record, the legal community will just make our financial bondage stronger, which result in more budget pressures and environmental destruction. The establishment of a Global Court of Justice might be beneficial on a large scale, allowing for a move away from U.S.-centric class action lawsuits that traditionally undervalue global views and perspectives in favor of large Western-style corporations and specific cultures (Radermacher 2004, Stiglitz 2006). An example is provided by the Alaskan islanders of Kivalina suing Exxon Mobil (UNESCO 2009) etc., for compensation regarding their forced move caused by floods caused by sea-level rise (http://en.wikipedia.org/wiki/Kivalina_v._ExxonMobil_Corporation); another example is found in the next American generation suing their rights for a healthy environment. Many environmental changes are just due to lawsuits, such as the listing of polar bears and with the help of big NGOs. But neither the earlier League of Nations, nor the U.N. or U.S. class action lawsuits, have displayed truly efficient democratic procedures. The deaths of many people and polar destruction have resulted. Perhaps the fate of the atmosphere is the true legacy of UN and its bodies such as UNEP, IUCN, and WWF?

Regarding climate change, and thus regarding a fast protection of the poles: if just the United States and China alone could come to a sustainable bilateral agreement, almost half the problem would be resolved. Adding India and perhaps Russia and Brazil or the International Monetary Fund IMF dominated for no justifiable reason by the EU would handle most of the issue even more. So why is that fast, quick, and efficient solution not pursued and promoted?

Other good solutions for the poles are found elsewhere in such countries as Bolivia and Ecuador (Alberto Acosta); they have spearheaded Mother Earth Rights (www.motherearthrights. com). These are in line with many native views, and are now on the agenda of the UN and for the next Conference of the Parties (COP). They offer hope for a truly global view, and for its citizens. Alberto Alcosta from Ecuador, for instance, found it much smarter to keep the oil in the soil, instead of extracting it with methods destructive to its native land and blasting the product into the atmosphere, contributing to climate change. The oil industry remains one of the most dirty businesses that mankind ever has engaged in.

So what actually can the individual citizen do? The answers are relatively easy. Herman Daly has already summarized them in his three principles for sustainable resource use: (1) limit the use of all resources to rates that ultimately result in levels of waste which can be absorbed by the ecosystem, (2) exploit renewable resources at rates that do not exceed the ability of the ecosystem to regenerate the resources, and (3) deplete nonrenewable resources at rates that, as far as possible, do not exceed the rate of development of renewable substitutes.

To be more specific, here is an initial and short list for individuals who want to take action, which has not yet been implemented and that shows where the obstacles are and what is still to be overcome:

- Just say no to habitat loss
- Read and implement lessons from Aldo Leopold. Consider books and concepts from Felix Sthilmark, Jared Diamond, Jon Muir, O'Neill et al. (2010), Herman Daly, Vandana Shiva, etc.

- Challenge NGOs, institutions, and politicians when they promote, or are silent on, economic growth and its negative impacts
- Build a nation and its GDP on sustainable agriculture and sound concepts (but not on debt trading and boom-and-bust cycles)
- Change the global economy to focus on the "well-being of the people worldwide"
- Implement a science-based adaptive management scheme
- Remain critical and blow the whistle on sustainability issues, each and every time
- Limit resource use and waste production
- Stabilize population
- Achieve fair distribution of income and wealth
- Change the way we measure progress
- Improve global relationships
- Shift the behavior away from consumerism
- Engage politicians and media

12.5 With Reason Toward Sustainability Research and Management: A Safe Science Investment for the Benefit of Mankind, the Poles, and the Earth Overall

By now, the status of the three poles is clear. Even actions that help to assure long-term gains mean initial losses globally (Netherlands Environmental Assessment Agency 2010). Based on an intense global analysis, the same authors state that more economic growth promotion for the future is certain, that energy use will increase, and that more trade liberalization scenarios are widely discussed. With that, the connection between global food production and consumption, and even forestry, forest policy, wood supply and the poles, becomes clear.

The public trust doctrine is widely broken. But what should be done, and what not, is generally known also (Rosales 2008; Daly and Farley 2003). International and national science, big NGO and management structures, are currently among the worst setups for the poles and for the well-being of the globe. But it is on us to make it better: a global vision must be formed and pursued (O'Neill et al. 2010; Klein and Magomedova 2003 for promoting a World Community). The idea that science-based management and human reasoning will lead to the best possible decisions is widely known. It is promoted by the National Academies of Science and their institutions (e.g., National Research Council 2003 for Alaska), and goes back beyond Aldo Leopold, John Muir, and others. It might well be based on the period of enlightenment and beyond, starting with the ancient Greece, Egypt, Mayans, China and similar high civilizations.

However, it should not be forgotten that most of those structures included “big government,” and that virtually all of them failed eventually (Diamond 1999; Taber and Payne 2003)! We must do better. So then, why not build change and transition into a good global science, management, and administrative structure? Change must come as the global population increases, as human consumption is kept high, and ever higher, and all of this can hopefully happen on good terms and without warfare. Avoidance of warfare and any human suffering has always been the prime goal.

The call for institutional design is a reality (Young 2002; O’Neil et al. 2010), and was widely achieved after World War II, then with the subsequent rise of neoclassic economy, namely with the World Bank and its supporting arms (Rich 1994; Perkins 2004 for overview).

Good components of a new, truly sustainable polar science and reasoning have been discussed by UNESCO (2009) and others. But they should, at the very least, consist of the following items (modified from Spash 2009; O’Neill et al. 2010):

- Focus on global perspectives, e.g., cumulative and as a synthesis
- Need for balancing power
- Awareness of the need to frequently change methods, institutions, and laws
- Need to work at all scales
- Need for public empowerment and engagement
- Recognize the importance of human and nonhuman components
- Include and study Earth Rights
- Work toward climate ethics, polar ethics, global ethics, and moral obligations
- Move toward a democratic governance system
- Provide transparency on all accounts
- Add ethics to the sciences and their publications
- Implement polar and atmospheric health as a legal requirement
- Value pluralism and diversity
- Truly support an interdisciplinary science management
- Reject overly mechanistic and reductionist approaches
- Challenge simple linear statistics, and use nonlinear predictive methods for comparison and for a science-based management
- Reject sole mathematical formalism and its claimed rigor
- Accept that uncertainties are part of daily business but should not stop achieving sustainability progress
- Focus on reliable proactive decision making
- Implement sustainability in the curricular worldwide
- Mandatory institutional reviews, and restructuring as needed

At the very least, this is worth a try, and in the light of the global crisis and the overwhelming pressures to come upon us, upon the poles, and upon the new generation. It looks like we are headed for a great ride indeed.

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[1] Note: The literature on the Three Poles is huge: here a representative but not necessarily complete selection is provided and cited.

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Epilogue

Everest was no longer merely a mountain, but a commodity

Jon Krakauer, cited in Messner (2007)

Here is a point in time where our institutions are wrong. Our economics is not fit for purpose. The outcomes of this economic system are perverse…

O'Neil et al. (2010)

Oil is the blood of nature

U'wa people

…However, we are opposed to offshore oil and gas activity, as we do not believe it can be done safely. …

E.S. Itta
(Mayor of the North Slope Borough, Alaska
President of the Inuit Circumpolar Council ICC Alaska
Whaling Captain and a member of the Barrow Whaling
Captains Association) in UNESCO (2009)

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