9. Exploiting the Southern Ocean: Rational Use or Reversion to Tragedy of the Commons?

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The tragedy of the commons, first described by Garrett Hardin in 1968, arises in situations where multiple individuals, acting independently in their own self-interest, deplete shared limited or finite resources, even when it is evident to all that it isn't in anyone's long-term interest to do so. While some regions exist where communities have learned to conserve (e.g. Johannes, 1981; Menzies, 2006; Berkes, 2008), often throughout human history, particularly when dealing with large international spaces, Hardin's analysis has shown humans to be incurable of their self-interest mentality. First on land and then at sea, humans started with the "low-hanging fruit" or those biotic resources easiest to obtain and consume (Longhurst, 2010; Swartz et al., 2010). Humans were first documented consuming marine resources, in this case shellfish, along the shores of southern Africa 164,000 years ago (C. Marean *in* Koerth-Baker, 2009). The first evidence of fish extirpation, an estuarine-fresh water catfish, comes from a 90,000 year-old midden in coastal Congo. With catfish gone, these peoples readily moved on to exploit other species (Yellen et al., 1995). It is possible that some communities only started consuming marine resources once their land-based food sources were overexploited or diminished from climate change, as was the case in the above shellfish example. In the ocean, humans began with the nearshore, shallow-water species, which were easy to obtain and equally easy to deplete (Pauly et al., 2005). As industrial fishing evolved and technology advanced, and to keep up with an escalating human population hungry for fish, exploitation moved into ever deeper and more remote waters (Figure 1). Finally, humans reached the Southern Ocean, then into coastal Antarctica's Ross Sea, the most remote body of water on Earth (Hutchings and Reynolds, 2004; Morato et al., 2006; Pauly et al., 2005; Swartz et al., 2010).

Antarctica is a true global commons, being the only continent without a native human population. Yet humans have long been interested in Antarctica for its value to international science and as the last wilderness frontier for explorers for more than a century (Fogg, 1992). With this rich history, and shared concern that Antarctica could become the scene or object of international discord, 12 countries signed the Antarctic Treaty in 1959, formally recognizing Antarctica's great international value as a region that should be protected from self interest and devoted to peace and science. Among other things, the Treaty prohibits military operations, nuclear testing, and disposal of nuclear waste, provides for on-site inspection to ensure compliance with its provisions, and requires advance notice of the timing, composition

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and purpose of all expeditions to and in Antarctica. Throughout this article, we refer to “value” as meaning the importance or preciousness of something. In the case of Antarctica, these values include, but are not limited to, importance to science, intrinsic elements (environmental and wilderness space) and historic exploration - all of which are foundations of the Antarctic Treaty.

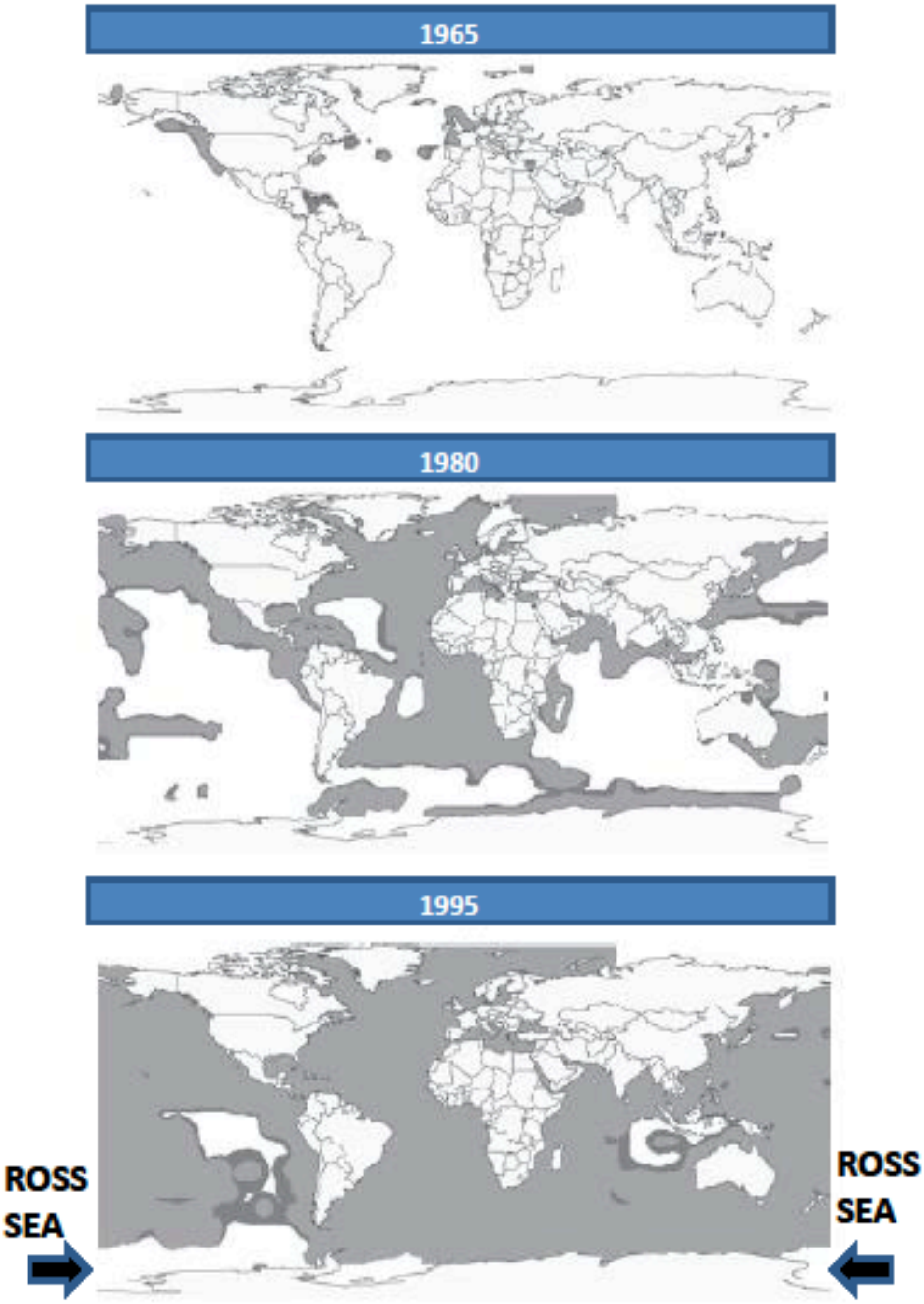

Figure 1: Year of maximum catch. Dark shading indicates major exploitation during the year shown (1965, 1980, 1995); light shading indicates that maximum catch has already been achieved; white color indicates no or as-of-yet minimal exploitation (Sea Around Us Project, 2005). As the map is centered on the 0° meridian, the Ross Sea, which is split by the 180° meridian, is separated artificially into two parts.

In further recognition of Antarctica's unique values, the Treaty Parties have since adopted a variety of measures to protect them, most notably the 1964 *Agreed Measures for the Conservation of Antarctic Fauna and Flora* and the *Madrid Protocol on Environmental Protection*, which was added in 1991. Among other things, the Protocol prohibits mineral exploration and development for at least 50 years, provides for the establishment of specially protected areas and specially managed areas to conserve the unique wilderness, aesthetic, scientific and other values of the area, and established the Committee on Environmental Protection (CEP) to advise the Treaty Parties of actions needed to meet its intent and provisions. These and related measures have to date saved the Antarctic continent from the "tragedy of the commons" suffered by the renewable resources and natural systems on the other six continents. The Treaty Parties, the CEP, NGOs (e.g., ASOC, 2009a, 2011), and the Antarctic scientific community continue to work to ensure that the human footprint on Antarctica remains relatively and absolutely small. As a consequence, the Antarctic continent is effectively a World Park, one of the most marvelous achievements of humanity, perhaps proving that we can indeed escape Hardin's tragedy when we wish to do so.

The Antarctic Treaty applies to the lands and ice shelves south of 60^{o} South Latitude, but not the high seas within that area. Nor did the Treaty have any language or specific measures that dealt with the exploitation of living resources. Overharvesting and declines in North Atlantic Harp Seal (*Pagophilus groenlandicus*) populations in the late 1950s and early 1960s (Mansfield, 1970) led in 1964 to a private Norwegian sealing expedition to determine if some of the market demand for Harp Seal skins could be met by harvesting pack ice seals in the Antarctic (Øritsland, 1970). Unregulated, market-driven hunting in the 1790s and early 1800s had already caused the near extinction of Antarctic Fur Seals (*Arctocephalus gazella*) and Southern Elephant Seals (*Mirounga leonina*). Fearing the same would happen to Antarctica's other seal species, the Scientific Committee on Antarctic Research (SCAR), an organization established in 1957 to promote science in the Antarctic, called the attention of the Antarctic Treaty Parties to the impending exploitation. To avoid continuing the "tragedy of the commons" (baleen whales had also been decimated by the 1960s), the Committee recommended that the Treaty Parties take steps to ensure the sustainability of any Antarctic seal hunting that might occur. The Parties established a free-standing regulatory agreement, the Convention for the Conservation of Antarctic Seals, which entered into force in 1978. Incredibly, this was the first international agreement providing for the regulation of commercial harvesting of a marine living resource before an industry developed. Part of the regulation enacted included the closing of a few areas entirely to any sealing to protect scientifically valuable breeding populations. For example, this agreement protected populations of Weddell Seals (*Leptonychotes weddellii*) in the Ross Sea, whose demography had been studied since the 1950s, but exploitation was initiated by New Zealand to feed sled dogs, just as explorers had done during the heroic expeditions of the past (Ainley, 2010)).

Having known full well that industrial activities in the Antarctic during the past had decimated elephant seals, fur seals, King Penguins (*Aptenodytes patagonica*), several whale species and several demersal fish (Kock, 1992; Constable, 2000; Croxall and Nicol, 2004), similar concerns regarding the development of a fishery for Antarctic Krill (*Euphausia superba*), an important forage species in the Antarctic marine ecosystem, led to further action by SCAR. The organization held a workshop in 1976 to identify and determine the research needed to resolve uncertainties concerning the biology and ecology of krill and related species in the Southern Ocean (BIOMASS, 1977). SCAR also called to the attention of the Antarctic Treaty Parties the need to regulate the fishery to ensure that it did not have significant adverse effects on the target krill stocks, on krill dependent species, or their ecosystems. In response, the Treaty Parties initiated negotiation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), which subsequently entered into force in 1982. The Convention applies to all marine organisms that are part of the ecosystem in the Southern Ocean from the Antarctic northward to the Antarctic Convergence or Polar Front. This area extends beyond the area covered in the Antarctic Treaty to the northern boundary of Antarctic seas (Polar Front or Antarctic Convergence). The Treaty Parties further established a regulatory commission and scientific advisory body – the Commission and the Scientific Committee for the Conservation of Antarctic Marine Living Resources, respectively – and specified their responsibilities for meeting the intent and provisions of the Convention. Substantive decisions of the Commission require the consensus of all members.

The intention of the Convention, with the realization that some treaty nations were fully intent to continue exploitation, was to ensure that any fishing that occurs in the Convention area does not cause depletion of the target stocks or have significant adverse effects on dependent and associated species or the ecosystems of which they all are component parts. The Convention states that:

“ARTICLE II

1. The objective of this Convention is the conservation of Antarctic marine living resources.

2. For the purposes of this Convention, the term ‘conservation’ includes rational use.”

The contrasting language of this Article, “conservation” juxtaposed with “rational use”, demonstrates the competing priorities of those parties that negotiated the Convention (Stokke, 1996). Perhaps due to these competing interests, CCAMLR’s execution and definition of rational use has evolved over the course of its existence, as we detail below.

Quite rationally, upon its coming into force, CCAMLR immediately closed regions where demersal fish stocks had become economically extinct owing to fishing before the Convention was conceived, particularly in the Scotia Sea, waters bordering the Antarctic Peninsula and over the Kerguelen Plateau. Many of these stocks, even today, have yet to recover (CCAMLR, 2010), suggesting that these cold-water-adapted species are incredibly vulnerable to overexploitation and further indicate how little we know about Antarctic marine systems and species. All of this brings into the discussion another important provision in the Convention, yet to be addressed in any meaningful way by its members:

"ARTICLE II

3(c). prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources."

CCAMLR has been quite successful in exercising "rational use" with respect to Antarctic krill, providing harvest rules that acknowledge the vital role krill play in the diets of many predators in the Southern Ocean (Constable et al., 2000; Constable, 2011).

For example, in 1985, within just a few years of coming into force, CCAMLR initiated its Ecosystem Monitoring Program (CEMP; Croxall and Nicol, 2004) with the goal of detecting any effects of the krill fishery on selected krill predators such as seabirds and seals. This program, which is based on input from CCAMLR's Scientific Committee, constitutes recognition that the fishery must be managed on scales that take into account the presence and needs of regional predator populations. Indeed, indicating continued diligence in the incorporation of "rational use" into its management, CCAMLR recently enacted a Conservation Measure (51-07; CCAMLR 2010) that shifts the krill take away from areas important to predators when the regional allowable take exceeds specified trigger levels (15-45% depending on the area). While further work is needed to verify these levels, this procedure is revolutionary as it truly attempts to employ "ecosystem-based fisheries management" in very specific terms. Recognizing the value of CEMP, as a means to monitor ocean resources, CCAMLR has expressed the importance of protecting CEMP sites (penguin and seal breeding localities) from any land-based impacts (Conservation Measure 91-01).In stark contrast, finfish have not been managed with the greater effects on the ecosystem in mind. The requirement to minimize the risk of ecosystem changes that are not reversible in "two to three decades" has largely been ignored by CCAMLR. Owing to the industry's and fishing nations' increased desperation to find new fish stocks (e.g. Swartz et al., 2010), and the huge profits to be made in doing so, CCAMLR's concept of "rational use" as applied to finfish has evolved simply to "use". Today CCAMLR's strategy for finfish, particularly the very lucrative toothfish (*Dissostichus spp.*) fisheries, closely resembles the traditional single species maximum sustainable yield (MSY) fisheries management that CCAMLR had tried to avoid as indicated by the language in its charter. In fact, the MSY strategy is expressly stated by Constable et al. (2000) in their review of CCAMLR management "harvest rules": reduction of spawning biomass of toothfish to 50% of pre-fished levels, with the assumption that this will increase yield and have no ecosystem effects. The arguments against single-species MSY, and examples of how and why it has failed, are too numerous to recount here (Longhurst, 2010).

In 1996, as an example of reverting to the concept of "use" under the CCAMLR harvest rules, New Zealand initiated a longline fishery for Antarctic Toothfish (*D. mawsoni)* in the Ross Sea, a species never before fished and in the last unaltered global commons (Ainley, 2002; 2004; 2010). A number of CCAMLR delegations opposed the unilateral action due to the lack of information on the distribution, abundance, productivity, and life history of the species. In mind was the fact that more often than not, fisheries have crashed when full-scale harvesting proceeded before understanding life history traits and ecological associations of the fish species, especially deep-sea, demersal species, which typically have life-history characteristics making them very sensitive to adult mortality (Cheung et al. 2007), e.g. Orange Roughy (*Hoplostethus atlanticus*) off southeast Australia (Smith et al., 1995) and rockfish (*Sebastes*) species of the California Current (Ainley & Blight, 2009, and references therein). Indeed, deep-sea fisheries around the globe have proved virtually impossible to monitor and manage successfully. As noted most recently by Norse et al. (2011: 307), "deep-sea fisheries more closely resemble mining operations that serially eliminate fishable populations and move on."

Subsequent development and expansion of the Ross Sea toothfish fishery was inevitable, due in part, to the unwritten rule-of-thumb: You can't understand the species without a fishery (expressed D. Miller using other words in Hutchison, 2004: 16). Rational use had thus become a politically expedient and misused concept. Owing to the expense of scientific research, thus far, virtually all data used to manage the fishery have been fishery dependent, with stock and allowable catch estimates based largely on elegant, mathematically balanced models with guesses used for many inputs. Indeed, some important parameters in stock models are averages taken from other, warmer water species, despite full knowledge that temperature is a major factor affecting movements, growth and reproductive patterns and other life history processes in fish (e.g. Myers et al., 1995; 1999). Even so, CCAMLR views the results of its stock models, with no means for independent verification, as "precautionary".

More than 15 years after its initiation, the Ross Sea toothfish fishery remains classified by CCAMLR as "exploratory" because of the paucity of data available about the species' life history and demographics that are needed for management at a level analogous to well-managed fisheries elsewhere. This approach to harvesting the species is a rationalization, rather than rational use, ignoring the species' sensitivity to fishing mortality and its central role as predator and prey (depending on life stage) in the ecosystem. Toothfish are a major fish predator, but are also the prey of Weddell Seals, Sperm and Killer Whales (Physeter macrocephalus, *Orcinus orca*), and Colossal Squid (Mesonychoteuthis hamiltoni; Pinkerton et al., 2010). Amazingly, despite CCAMLR's success with the krill fishery, no CEMP program exists to monitor any potential impacts on dependent and related species by this or any toothfish fishery within their responsibility. The fishery nevertheless has carried on despite the consensus within the marine ecological community outside of CCAMLR that we still don't know much about the Antarctic Toothfish and its ecosystem, and surely not enough to effectively or sustainably manage this fishery (Blight et al., 2010).

Having fully exploited and depleted most of the economically valuable fishery resources in other parts of the world's oceans, national and industrial fishing companies were now willing to travel thousands of kilometres, through ice-choked, stormy seas, to set longlines in this most remote stretch of the ocean. It became worth the cost of time, fuel, gear, vessels, and lives (i.e.

the sinking of a Korean vessel in 2010 and another catching fire in 2011, with loss of many lives, and the "rescuing" of several disabled vessels previously and since), because Antarctic Toothfish, sold as "Chilean sea bass", commands a very high market price. It is sold at ~NZ$70/kg (approximately USD$25/lb), affordable only by wealthy consumers, primarily in the United States and Europe. The "exploratory" fishery has expanded, currently to 15- 20 vessels from a dozen nations in an Olympic-style mode, taking >3000 tonnes annually of these long-lived, late to mature, deep-dwelling fish, which have limited capacity to reproduce.

Quite soberingly, the opening and expansion of the Ross Sea toothfish fishery, a little known action, facilitated the completion of humanity's sequential consumption of all the "low hanging fruit" it had encountered as it spread and dominated the globe (Pauly et al., 2005). Humans were now extracting an ecologically important species from one of the few remaining unexploited stretches of ocean remaining on Planet Earth (Figure 1). Until recently, the Ross Sea was considered the least anthropogenically affected stretch of ocean on the globe (Halpern et al., 2008), and perhaps in relative terms it still is. The Ross Sea, largely protected by remoteness (being thousands of kilometers to nearest port) but also an inhospitable environment, remained largely free from major industrial fishing or whaling until the initiation of the toothfish fishery in 1996. Of the whaling that did occur, first for blue whales (*Balaenoptera musculus*) in the 1920s and then Antarctic minke whales (*B. bonaerensis*) in the 1970s, the minke population has recovered and the blue whale shows initial signs of doing so (Ainley, 2010). The Ross Sea has experienced no wide-spread pollution, no plastic patches, no red tides, fish kills nor dead zones, no jellyfish invasions, and no apparent introductions of alien species, all of which plague or have plagued other oceans including the northern reaches of the Southern Ocean. As stated on several occasions (Ainley, 2002; 2004), due to its relatively pristine nature, the Ross Sea acts as a reference for other areas of the Southern Ocean.

"Rational use" is an interesting precept of conservation, first expressed in the 1940s by hunter and renowned conservationist, Aldo Leopold. The term implies that humans cannot continue to exploit renewable resources at will and expect them to last. It further cautions that we be more thoughtful and deliberate in conserving our natural assets and treasures. This concept has guided conservation efforts on land, including the establishment of nature reserves and national parks. To date roughly 12% of Earth's land is contained within protected areas, with more added annually (United Nations, 2010: 56). Few debate the value of these achievements. In addition to that 12% is the entire Antarctic continent (14 million km^2), which today essentially is a fully protected "World Park" because "rational use" was viewed at the broadest scale of human existence. What could be more rational than setting aside a large area of Earth, including the ocean portion, for the sake of peace, science and future generations?

The secret to successful "rational use," as known and practiced by land-use managers, lies not just in "precautionary management" but also in attention to the concept and issue of scale. Biological communities and ecosystems that include key, wide-ranging species require large areas --- some as expansive as millions of square kilometres --- to achieve effective protection. This is clearly recognized in the boundary definitions of some national parks and reserves, like the vast Kruger National Park in South Africa and the Arctic National Wildlife Refuge in Alaska.

These areas are some of the few places left in the world that support healthy populations of apex- and meso-predators, animals which though few in number, exercise their influence over vast areas of unbroken space to complete their life cycles (Wirsing & Ripple, 2011). Sound science has shown that the ocean's ecological processes and organisms also operate over multiple scales, many of them vast (Levin et al., 2009). Within that vein of knowledge, the Ross Sea toothfish, the ecological equivalent of sharks in warmer waters, purportedly moves thousands of kilometres between spawning and post-spawning-recovery areas (Hanchet et al., 2008). Such a pattern adds considerable and likely unsolvable problems to management and protection at small spatial scales.

Marine reserves of any size are exceedingly rare, owing to the tragedy of the commons that continues to rule the high seas as evidenced by the excessive illegal, unregulated, unreported (IUU) fishing that occurs widely, including the Southern Ocean (Hutchinson, 2004; Österblom et al., 2010). In contrast to Earth's land, less than 2% of the world ocean is in reserves (Toropova et al., 2010: 29). The Southern Ocean constitutes about 12% of the world ocean, yet less than 1% is formally protected in marine reserves, despite the disastrous history of Southern Ocean exploitation, the still depleted populations of cetaceans and some fish, and the inclusion of the following in the CCAMLR charter:

"ARTICLE IX

2. The conservation measures referred to in paragraph 1(f) above include the following:

(g) the designation of the opening and closing of areas, regions or sub-regions for purposes of scientific study or conservation, including special areas for protection and scientific study;"

While marine reserves clearly reside within CCAMLR's management toolbox, they have not yet been utilized.

Looking at Figure 1, keeping in mind the large geographic scale and knowing that so little of the ocean has been protected in reserves, we can easily and legitimately apply the lessons learned on land and rationally move forward in protecting the remaining intact ocean ecosystems we have left. A number of conservation organizations, including the International Union for Conservation of Nature, have proposed that certain ocean gems should be designated marine protected areas. One of these, the crown jewel, is the Ross Sea (Ainley et al., 2010; ASOC, 2009b; 2010), the last ocean on Earth where an intact, open ocean ecosystem still exists with all its flora and fauna still present. Including the waters beneath the Ross Ice Shelf, the Ross Sea is only 3.2% of the Southern Ocean, about 0.4% of the world ocean; a small area to set aside, with such profound implications for science, biodiversity and honoring the Antarctic Treaty.

We know so little about how ocean ecosystems work, and yet we appear to be on our way to irrevocably altering all of them, forgoing the Antarctic Treaty's devotion to science, before we have a chance to find out. We can continue our irrational exploitation to its dismal end, a process begun many thousands of years ago, or we can choose to forge a new path. In keeping with the bold, historic creation of the Antarctic Treaty, we can forgo the tragedy of the commons and make rational choices for the greater human good. We can use the enlightened reasoning of the 21st century to designate the Ross Sea a marine park and no-take reserve, taking its place alongside the other great parks and reserves of the world that we have rationally opted to create. There is value, isn't there, in having at least one major oceanic wilderness that teems with life on this planet for all time, devoted to peace and science?

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