MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

"Resource Conservation in Antarctica: Applying the Tragedy of the Anticommons to an area without clearly defined property-rights"

verfasst von/ submitted by

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angestrebter akademischer Grad/ in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien 2018/ Vienna, 2018

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	A066913
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Volkswirtschaftslehre
Betreut von / Supervisor:	Mag. Dr. Wolfgang Weigel, Ao.Univ.-Prof./Associate Professor i.R.

Abstract

The thesis examines the issue of resource conservation in Antarctica, an area without clearly defined property-rights. The continent and its surrounding seas offer a wide variety of resources, e.g. fish, krill, minerals, potable water or pristine wilderness. Although, Antarctica appears to be a typical Tragedy of the Commons, without clearly defined ownership but with an environment sensitive to exploitation, there is no resource overuse since the Antarctic Treaty System entered into force. In the thesis, it is argued that the ATS turns Antarctic natural resources, usually prone to overuse, from Commons into Anticommons by giving any member of the ATS exclusion instead of use rights. Any potential resource use can be vetoed by any Treaty party, thus, increasing the transaction costs of reaching an agreement and the costs of exploitation significantly. This results in the Tragedy of the Anticommons, an inefficient underuse of a good or resource due to prices above the efficient price level. The Tragedy of the Anticommons protects Antarctic resources from exploitation and circumnavigates the delicate question of ownership.

Abstrakt (In German)

Die Arbeit untersucht die Problematik des Ressourcenschutzes in der Antarktis, ein Gebiet welches keine klar definierten Besitzrechte aufweist. Die Resourcen des Kontinents und der umliegenden Meere sind vielfältig, unter anderem zählen Fisch, Krill, Mineralien, Trinkwasser aber auch die besondere und unberührte Natur dazu. Obwohl die Antarktis auf Grund der ungeklärten Besitzverhältnisse und einer sensiblen Umwelt ein typisches Allmendenproblem zu sein scheint, werden die natürlichen Ressourcen der Region seit in Kraft treten der Antarktisverträge (Antarctic Treaty System) nicht übernutzt oder ausgebeutet. In dieser Masterarbeit wird argumentiert dass das Antarctic Treaty System die Antarktis von einer Allmende (Commons) in eine Anti-Allmende (Anticommons) umwandelt. Dies geschieht dadurch, dass jedes Mitglied der Verträge weitreichende Veto-Rechte bekommt, mit denen die Nutzung jeglicher Ressourcen untersagt werden kann. Dies steht im Gegensatz zur Allmendenproblematik, bei der jedes Mitglied Nutzrechte besitzt, jedoch nicht die Möglichkeit hat andere von der Nutzung der Allmende abzuhalten. Die Möglichkeit eines jeden Vertragsmitgliedes die Nutzung einer Ressource zu unterbinden erhöht die Kosten eine Übereinstimmung bezüglich der Verwendung eines jeden Rohstoffs zu erreichen signifikant. Dies entspricht der Anti-Allmendenproblematik: auf Grund eines Preises oberhalb des effizienten Preislevels wird ein Gut nur ineffizient genutzt. Genau dieser Mechanismus und die daraus resultierende, ineffiziente Nutzung von Gütern, schützt die antarktischen Ressourcen vor Ausbeutung. Zusätzlich kann dieses Konzept auch ohne klar definierte Besitzrechte angewendet werden, was insbsonder für die Antarktis wichtig ist, da es keine absehbare Einigung bezüglich potentieller Ansprüche oder Besitzverhältnisse gibt.

Contents

I. List of Abbreviations

ASOC……Antarctic and Southern Ocean Coalition

AT.....Antarctic Treaty

ATCM……Antarctic Treaty Consultative Meetings

ATCP…….……Antarctic Treaty Consultative Parties

ATS……...…….Antarctic Treaty System

CCAMLR……Commission for the Convention of Antarctic Marine Living Resources

CCAS……..Convention for the Conservation of Antarctic Seals

CEP…….……Committee for Environmental Protection

CRAMRA…….….….Convention on the Regulation of Antarctic Mineral Resource Activities

IAATO….…….……..International Association of Antarctic Tour Operators

IGY…….International Geophysical Year

IUU……...……..Illegal, Unrestricted and Unreported Fishing

MPA……..……..Marine Protected Areas

PEP…….…….…….Environmental Protocol (Madrid Protocol)

SCAR……...……...Scientific Committee on Antarctic Research

II. List of Figures

1. Introduction

Antarctic is the southernmost continent and encloses the geographical and magnetic south pole. It is the only continent where there has never been war and it has no native human population. Additionally, it is the coldest, driest and windiest place on earth, challenging humans, flora and fauna. Although, the oceans are teeming with life and habitat or at least feeding grounds for numerous fish, mammals and birds, the landmass itself is habitat for only a few plants and animals. It is this hostile and unworldly environment that fascinates researchers, adventures and tourists alike. Since its discovery in 1820, the inflow of explorers into Antarctica is continuous and more recently tourists on the search for pristine nature and something new have discovered the area. Every bookshop with a reasonable section of travel literature has guide books about the southern continent on offer and nature photographers and film makers bring the fascination for the cold and white continent to the interested traveller.

However, Antarctica is not only of interests for tourists and adventurers seeking something new and unknown, also international politics and businesses keep the southernmost continent on the agenda. The most recent agreement is the *Ross Sea Region Marine Protected Area* that created the world´s largest marine protected area on earth (McGrath, 2016). On the 27th of October 2016, after five years of negotiation, the members of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) agreed to protect the unspoiled and nutritious area of the Ross Sea waters for the next 35 years (McGrath, 2016). CCAMLR together with other commissions, agreements, protocols and the Antarctic Treaty itself builds the Antarctic Treaty System (ATS), which regulates and governs Antarctica. What makes this Treaty so special and unique is the absence of clearly defined property rights relevant for the Antarctic continent and surrounding waters. Apart from the political relevance the unsettled property rights question is also of economic interest. If no one holds property rights, everyone could simply go there, use and exploit Antarctica. A typical Tragedy of the Commons situation. This is exactly what happened between the 1890s and the 1960s, when first sealers and later whalers hunted several species down to near extinction. Other Antarctic resources were not accessible or exploitable at this time and hence managed to escape the Tragedy of the Commons. However, with changing demands and improving technologies the question remains: why are (accessible) Antarctic resources not yet exploited? Even more, they are not only not exploited but the continent´s environment and ocean are protected. Although the ATS regulates the use of

Antarctica and its resources, it has no mechanisms to punish violations but relies on consensus and peaceful resolving of conflicts. From an economic point of view, this does not sound very promising for protecting the environment and foreclosing a Tragedy of the Commons situation for Antarctic resources. Nevertheless, the ATS seems to accomplish the mission of environmental protection. The ideas or mechanisms it uses are very different to those of classical cap and control mechanisms for environmental protection (like taxes or certificate trade) use. The main reason for this, is of course the absence of property rights, which are an essential assumption for any economic approach to protect the environment or to slip through the Tragedy of the Commons. Instead of creating property rights and therefore risking international conflicts, the ATS gives its members veto and therefore exclusion rights. Any kind of use is subject to discussion, but any agreement needs to be reached unanimously. This is a special form of defragmented property as usage can only start once everyone agreed to it. It does not only increase the transaction costs of reaching an agreement, but it leads to the tragedy of the Anticommons. The Tragedy of the Anticommons is the symmetrical problem of the Tragedy of the Commons. Instead of overuse, underuse is the result. In the case of environmental protection and resource exploitation this underuse is beneficial. The ATS manages to turn the "good" Antarctica, which is prone to become a Common and to suffer from the Tragedy of the Commons, into an Anticommon and to protect resources and environment alike by making them subject to the Tragedy of the Anticommons.

To better understand how Antarctica is protected from exploitation by using the concept of Anticommons, some key information about Antarctica will be given in the beginning. The next part, section 3, expands on the possibly exploitable resources. It is set forth, that not only living resources, like seals and whales, or resources like oil, gas and minerals are of interest but also the landmass itself as well as the amount of potable but still frozen water. Furthermore, the value of Antarctica, especially its wilderness and unique ecosystem, is of great interest for tourists and researchers alike. The fourth section elaborates on Antarctic resource conservation and explains why conventional economic models for environmental protection or at least against exploitation cannot work in the case of Antarctica, the main reason being the absence of property rights and missing governmental competencies. The fifth part starts with a recap of the Tragedy of the Commons as a base for a better understanding of the Tragedy of the Anticommons. Both concepts will be explained game theoretically and a concluding comparison shows similarities and differences. The section is concluded by showing how Anticommons can be utilised to minimise exploitation of resources and therefore to protect the environment. Section 6 expounds Antarctica as an Anticommon. First, ATS as well as the

cooperation under the ATS are explained in more detail. It is followed by presenting how the treaty System turns Antarctica from a Common into an Anticommon. As practical examples, the Convention for the Conservation of Antarctic Seals, the Commission for the Convention of Antarctic Marine Living Resources and the Convention on the Regulation of Antarctic Mineral Resource Activities as well as the Protocol on the Environmental protection will be discussed and illustrate how the different resources can be protected from exploitation by turning them from a Common into an Anticommon. Since those example, also show some shortcomings of the concept of Anticommons for environmental protection, a brief discussion of those will conclude the thesis.

2. Antarctica, an Overview

2.1. History

The name "Antarctica" stems from the Greek word *antarktikos* and can be translated with "opposite the Arctic or North". As early as 150 AD, the ancient Greeks, though they never lay eyes on the southernmost continent, suspected the existence of a landmass in the southern hemisphere to balance the north and prevent earth from tipping over (lonelyplanet, 2017). In 1773, Captain James Cook came close to be the first to discover the Antarctic continent but miserable weather, thick fog and an unfortunate route stopped him from sailing further south and denied him the privilege of finding a new continent (Day, 2013). The first human to set foot on Antarctica was the Russian explorer Fabian Gottlieb von Bellingshausen in 1820. The Englishman Edward Bransfield followed just three days afterwards. It marked the beginning of the "heroic era" of the great explorers and adventurers who were fascinated by this new, unknown and white continent in the very south (Ward, 2001a). The Norwegian Roald Amundsen and Robert Scott of the United Kingdom competed against each other to be the first to reach the South Pole in 1911/ 12. Amundsen won "The Race to the South Pole" on the 15th of December 1911. Scott arrived several weeks later and the whole team died on the way home due to exhaustion, cold and hunger. Antarctica and the surrounding waters did not only captivate the attention of adventurers as well as explorers but attracted sealers and later whalers. From 1780 on, British, French, American, and Australian seal hunters stayed on the Antarctic Peninsula and the surrounding islands. They left in 1892, but it was only after they had nearly extinct all their prey. In the early 20th century, mainly Norwegian, Chilean, Argentinian and British whaling stations were set up in the area. Falling demand, a declining population of whales and outdated technologies forced the industry to be closed in the mid-20th century

(Backovic, 2013). However, those whalers and sealers did not only hunt for prey, but claimed land, especially islands in the Antarctic region for their respective countries (Day, 2013). With the emergence of innovative technologies, foremost better planes, the United States of America, Norway, Australia, New Zealand and the Soviet Union (now Russia) began to map and name as much as possible of the continent (Day, 2013). Often those actions were overlapping but every country aimed at gaining a predominance in the perception of the public (Day, 2013). Antarctic post offices and stamps, country specific names for Antarctic landmarks as well as symbolic flag raising were the means to emphasise claims and to show the public that Antarctica belongs to for example Australia, New Zealand, the US and so on. Argentina and Chile chose a different but not less symbolic act to underline their respective claims. The first baby was born on 7th of January 1978 to a wife of an Argentinian official, who was flown in just days before the delivery (Day, 2013). Chilean and more Argentinian children followed (Day, 2013). Argentina, Australia, Britain, Chile, France New Zealand and Norway have official claims to parts of the Antarctic continent, with some of them overlapping. The United States and Russia (the former USSR) do neither make nor accept any claims. Although, property-rights and ownership are unsettled, the potential claimants and others continue to operate on the continent. The US started operation "highjump", a military training in extreme cold right after the Second World War and amidst the cold war (Hoversten, 2007). Also, the use of the frozen continent as a nuclear waste disposal was considered, but plans were abandoned in the 1970s (The Economist, 2012). From the 1st of June 1957 to the 31st of December 1958, the International Geophysical Year (IGY), an international scientific programme, took place and yielded some ground-braking findings (Collis, 2009). But it was not only the scientific results that were outstanding but the level of peaceful cooperation among different nations, especially since the United States and the Soviet Union worked together in the middle of the cold war (Collis, 2009). The IGY, and the goodwill and cooperation it created among the participants, including all (potential) claimants, was the base for the formation of the Antarctic Treaty (AT). The Treaty designates the continent and the surrounding waters to peace and research while freezing the question of ownership. It was signed in 1957 and entered into force in 1961. Today the Antarctic Treaty System (ATS) consists of the Treaty, several commissions, amendments and conventions. Currently 53 countries are participating.

2.2. Geography

In contrast to the Arctic, Antarctica is a landmass covered with ice and hence a continent. It is the fifth largest continent and its size is roughly that of Australia and Europe combined. Together with South America, Africa, Arabia, India Australia and New Guinea, Antarctica formed the supercontinent Gondwanaland. The individual parts drifted in different directions and climate zones when Gondwana broke apart. Thus, Antarctica, formerly rich in Flora and Fauna, cooled down and became an icy desert.

FIGURE 1: REPRESENTATION OF GONDWANA BREAKING UP (AUSTRALIAN ANTARCTIC DIVISION, 2002B)

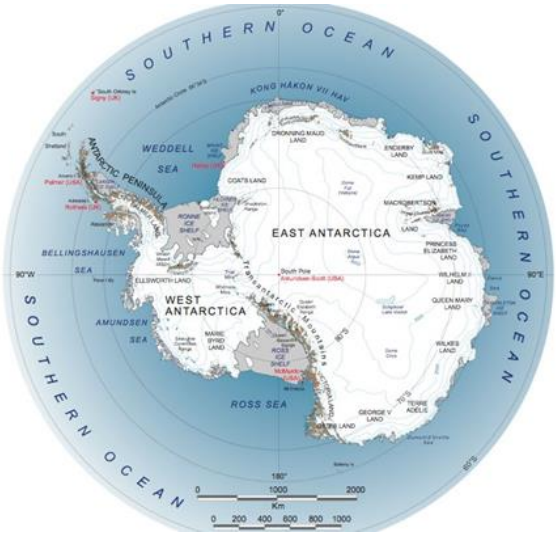

FIGURE 2: MAP OF ANTARCTICA (BRITISH ANTARCTIC SURVEY, 2018)

By now, most of the mainland lies within the Antarctic circle and is surrounded by the Southern Ocean. The landmass is covered with an ice shield that is up to 5 km thick and grows in winter to about six times as large as in summer. Only the coasts and some islands have ice free periods.

Both, the geographical and the magnetic south pole are on the continent. Antarctica is divided in East and West Antarctica and the Antarctic Peninsula (Hale, 2014). The Transantarctic mountains, with a highest elevation of 4892m separate the east from the west. Additionally, the ice sheets move from the respective fold flank to either the east or the west coast of the continent. West Antarctica, the smaller part together with the Antarctic Peninsula the Ross and the Ronne ice shelf, belongs to the ring of fire and is made of volcanic rocks. East Antarctica is composed of metamorphic rocks and covered with a thicker ice shield. Most of the surrounding island as well as archipelagos are of volcanic origin but covered with ice.

2.3. Climate and Weather

Antarctica is the coldest, driest and windiest place on earth (Australian Antarctic Division, 2003). The lowest temperature ever measured on earth is -89,2°C, and was recorded in East Antarctica in Vostock (Australian Antarctic Division, 2002a). Figure 3 gives the average monthly temperatures for several research stations in Antarctica. It shows that the coastal areas are much warmer with an average of 0°C in summer and down to -30°C in winter. Degrees above zero are possible in the warmer months. The seasons in Antarctica are divided into six months of summer (Mid-September to Mid-March) with daylight and six months of winter (Mid-March to Mid-September) without daylight. The inner part of the continent (Figure 3: Vostock Station), has an average temperature range from -70°C in winter to -30°C in summer. A further feature of Antarctica is that it experiences nearly no precipitation and if so as snow fall, thus it is per definition a desert (Australian Antarctic Division, 2002a). Fierce winds, together with warm-cold differences within the Southern Ocean create strong currents. The Antarctic Circumpolar Current is the world´s largest and merges waters from the Atlantic, Pacific and Indian ocean (Antarctic Climate& Ecosystem Cooperative Research Centre, 2015). Additionally, the Southern Ocean stores substantial amounts of heat and carbon dioxide (Antarctic Climate & Ecosystem Cooperative Research Centre, 2015). The winds together with currents and the storage function of the waters have a profound influence on worldwide oceans, climate and weather. The Antarctic ice sheet reflects incoming solar radiation, which affects the global climate as well. With less ice, more radiation is absorbed by the Earth´s surface and leads to more global warming. The area does not only influence the global climate and weather, it is also highly affected by a change in it (Antarctic and Southern Ocean Coalition, 2018c). Additionally, the southern continent and ocean influence the world weather and climate greatly. "Alterations in those systems will affect climate all over the planet (Antarctic and Southern Ocean Coalition, 2018c).

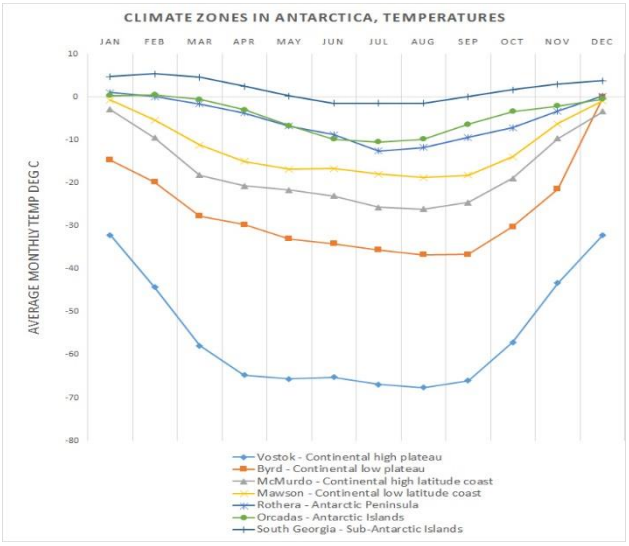

FIGURE 3: CLIMATE ZONES IN ANTARCTICA, TEMPERATURES (WARD, 2001C)

2.4. Flora and Fauna

The harsh environmental conditions with low temperatures, fierce winds and only little precipitation demand a great deal of adaption from plants and animals living on the Antarctic continent. There are only few plant species that grow in the warmer parts of the peninsula and the island. Climate change and the melting of ice however, will enlarge the potential habitat and create room for more and new species (Lee et al., 2017). Additionally, snow algae and mosses can be found on the main land. Lichens, some bacteria, fungi, a few mites and midges are the only native and permanent inhabitants that live only on and of the Antarctic continent.

The waters around Antarctica are home to various species ranging from planktons to fish and squids to large mammals like whales and seals. The smallest one is phytoplankton which is consumed by larger plankton, krill, fish, birds and mammals. It is the fundament for every other form of life in and around the seas. Whales are by far the largest inhabitants of the Antarctic waters and stay there either permanently or partly. Seals, especially fur, elephant, leopard and ross seals use the abundant food supply the Southern Ocean offers but live on shores or ice packs. The same holds true for penguins, they hunt in the ocean but breed in the icy Antarctic desert. Other birds of the region apart from penguins include seabirds, like petrels or albatross, as well as shore birds, like the blue-eyed cormorant and brown skua. Again, the ocean or shallow waters serve as hunting grounds, shores and rocks as breeding areas. Many of the Antarctic animals are only seasonal visitors and use the rich pantry during the Antarctic summer.

Humans came with the discovery of the seventh continent, but Antarctica has neither a native nor a permanent human population (World Population Statistics, 2016). During the summer months roughly 4000 people “live” in Antarctica but only a quarter of this number is present during winter. In general, the turnover is high, and most people stay there for 1-2 years only.

The short introduction to Antarctic history, climate and weather as well as flora and fauna points out that the continent and surrounding waters have their very own, challenging as well as fascinating characteristics. Furthermore, it gives a good idea and background knowledge about the possible resources the area holds.

3. Antarctica- exploitable resources

As most parts of Antarctica are covered by ice and hardly accessible, there is only little evidence of existing resources. But the former neighbouring continents Australia, Africa and South America as well as matching geography suggest that there exist oil, gas and mineral deposits. Other resources are land as such, potable water stored as ice and snow, edible animals, mainly fish and krill as well as a pristine nature valuable for tourism.

3.1. Oil and Gas

Thick ice, moving glaciers and harsh weather prohibited an elaborate search and extensive exploration of potential oil and gas fields. Geological research and findings in other continents suggest that there is a possibility for oil and gas deposits. However, estimates of potential fields and the potential amount of oil and gas differ greatly and there exists no reliable data or proofs for any oil or gas at all. Macdonald et al. (1987) doubt the existence of any extractable petroleum. John Kingston estimates in an open file report by the US Geological Survey (1992) that there is a potential for oil, however, it is neither a lot of petroleum nor everywhere to be found. Of course, more optimistic views exist, and the little information and speculation fuel the myth of an immense fortune under the ice.

One aspect everyone agrees on are the technical and environmental difficulties the extraction of oil or gas would face. The biggest problems are not the working in a cold environment but the drilling itself, the transport, the supply of men and material and the recovery in the event of oil spills. Drilling through a frozen but moving ground is a challenge for any material and technology. Furthermore, oil and gas, men and supplies need to be transported. The Antarctic environment requires special ships, gear and machinery, which adds to the costs of transport. Secondly, the weather, especially the Antarctic winter can seal the continent off. Long and expensive transportation together with the requirement for special equipment and workers that are willing to work in the cold, increase costs and difficulties. Therefore, the cost of extraction of either oil or gas in the Antarctic region is more expensive than in most other areas, making it less attractive to be exploited at all.

If all those challenges were cost-efficiently solvable and extractable oil and gas were in existence, then the recovery and responsibility of any spills or other accidents pose a further challenge. The oil spill of the *Exxon Valdez* in the Prince William Sound, Alaska in 1989, a region, though on the other side of the globe, that is very similar to Antarctica, was one of the biggest environmental disasters, killing thousands of animals, polluting kilometres of shores

and ruining a whole ecosystem and the adjunctive economy, like fishing and tourism (Ölkatastrophe: Das dunkle Erbe der "Exxon Valdez", 2014). The consequences can still be felt and seen today (Ölkatastrophe: Das dunkle Erbe der "Exxon Valdez", 2014).
A spill in Antarctica is likely to have even worse effects, as the emergence-action infrastructure is less developed. Furthermore, the currents around Antarctica would quickly spread the oil (Ölkatastrophe: Das dunkle Erbe der "Exxon Valdez", 2014).

3.2. Minerals

Mining for minerals and drilling for oil are very similar, both, in the existing knowledge with regards to the deposits of minerals, oil, gas and coal, but also with regards to the (technical) difficulties and economic efficiency of extracting. By now, no economically significant discoveries were made. The former neighbouring continents and mineral discoveries along the shores suggest the existence of some minerals, e.g., copper, iron, gold, silver or uranium. Also, coal was discovered, but it was of low quality (Ward, 2001e). However, mining is expensive and difficult, making it not feasible or economically meaningful. The problem of moving glaciers, a thick ice cover and the extreme weather conditions require special technologies and challenge humans and machines. The costs of mining, transportation and the supply of men and material would exceed the potential profit by far. A further point, that makes Antarctica less interesting for mining then other areas are climate and weather, but not in the already discussed way of challenging humans as well as machines. Antarctica is a desert with low precipitation and nearly no liquid flowing water. However, rivers and other flowing waters wash minerals out and transport them. Hence, there are usually areas with less minerals and areas with a higher concentration. Those with a higher concentration are the one suitable for exploitation. Since, this did not happen to Antarctic minerals, they are still spread out and the mining for them is economically not viable or meaningful (Ward, 2001e).

3.3. Land

The Antarctic mainland is not suited for any agricultural use. Also settling and living on the continent is hardly possible and “inhabitants” live and work there for just a few years. Most of the land is neither economically, nor scientifically used and apart from the research stations and adjunct houses and a little infrastructure, it is free of any occupation. McMurdo station is with 250 ha and roundabout 85 buildings the biggest permanent human settlement on the frozen continent that has a size of roughly 14.000.000 square kilometres.

But a continent unsuited for living and agriculture holds other possibilities. One is to test and use (nuclear) weapons or to train militaries far away from public opinion and the danger of damaging the own home country. In 1946, the US started operation "highjump" to train soldiers in combat in an icy environment (Hoversten, 2007). Furthermore, the suspension of nuclear (missile) testing in the pacific area, created a need for a new area where those bombs could be tested without disturbing the public or endangering any humans. Antarctica was an obvious choice (Suter, 1991). But not only the test of atomic or other weapons is an option. Also, storage and ultimate disposal of those materials as well as other kinds of waste were considered (The Economist, 2012). The pollution and dumping of any kinds of waste has reached even the most remote places in Antarctica and is mainly inflicted by scientists as well as the support staff (Tangley, 1988). Leaving left overs behind, most often quickly covered by snow, is cheaper than organising transport and waste disposal. However, waste recoveries are underway and abandoned stations and dump sites are cleaned (Stark/Snape/Riddle, 2006). Nowadays, precautions are taken to minimise human or waste impact on the Antarctic environment (Australian Antarctic Division, 2012a).

3.4. Potable Water

About 70% of the earth´s fresh water is stored in the ice caps and glaciers (Brain, 2000). With 90 % of the total permanent ice cap, Antarctica holds the biggest reservoir of fresh and potable water (Brain, 2000). Although it is the driest continent and has only little precipitation, ice, glaciers and snow store it for an extended period. This is a valuable resource, especially for the drier but inhabited parts of the planet. Many smaller and bigger icebergs break apart from the main ice shield during the warmer Antarctic summer. Those icebergs float in the ocean until they melt and mix with the salty water. Instead of letting them dissipate, icebergs could be caught and towed to countries in need of water. Also, explicit harvesting of parts still attached to the main ice sheet is thinkable. The idea is far from new and was considered as early as in the 19th century, but was never realised (Sample, 2017). Today, a firm in the United Arab Emirates has the ambitious plan to solve the water shortage of the country by harvesting icebergs and towing them to the emirates (Sample, 2017). Still, the plans are doomed to failure as most technical issues have no solution yet. Of course, moving icebergs in an intended direction is neither new nor impossible and done regularly to keep ship passages free. However, it makes a difference if the aim is to keep a water way free or to drag millions of tonnes of ice across oceans and against currents. Additionally, there are several environmental concerns. The

still very icy water from the melting ice berg could disarrange the composition in an ecosystem and harm the inhabitants by cooling down the water and by changing the degree of salinity.

3.5. Food and Fish

Antarctic waters are of greater interest for food supply than the continent itself. No bigger animals live permanently onshore. Birds breed on Antarctica and the respective eggs and animals are usually suitable for food. The explorers of Antarctica are known to have eaten penguins and their eggs (Coulson, 2012). However, Antarctic birds never reached any commercial food industry. Under the Madrid Protocol (EP), any disturbance of Antarctic wildlife is prohibited except for use in emergencies or if a permit to take animals was issued before (Widof, 2002).

The more interesting food supply is not on shore but underwater. Seals, whales, krill and fish inhabit the Southern Ocean in abundance and are a popular and commercialised food source. From 1780 until 1965, the hunt for seals and whales brought both species to the verge of extinction. Sealing is forbidden under the CASS and whaling is regulated by the international whaling convention. Permits to hunt the animals for scientific purposes are issued. Japan is accused by NGOs and other countries to use most of those permits not for scientific but for commercial whaling (McCurry, 2018). Several fish species faced the same fate as seals and whales. Under the ATS fishing is allowed but highly restricted and controlled by now. Only a few types of fish can be caught (Ward, 2001d). Additionally, special technics as well as nets must be used, and any catch must be reported (Ward, 2001d). However, illegal fishing is still a problem (Ward, 2001d).

The largest commercial fishery branch in Antarctica is the krill fishery. The small crab-like animal that is a vital part of the ecosystem and food chain and lives in abundance in the waters around Antarctica (Ward, 2001d). Additionally, it is highly nutritious and one of the last underused supplies of animal protein (Suter, 1991). Due to technical difficulties in the fishing and handling processes, exploitation was never an issue. However, recent developments in both techniques make larger catches possible (Nicol/Foster/Kawaguchi, 2011). The limits are not reached yet but a further commercialisation and technical improvements could test the convention on Antarctic marine living resources (CCAMLR) and its enforceability and effectiveness (Nicol/Foster/Kawaguchi, 2011).

3.6. Tourism or touristic value

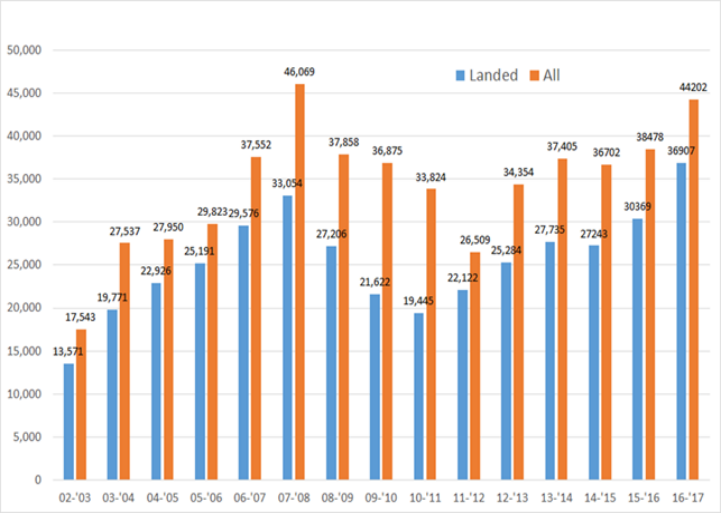

FIGURE 4: NUMBER OF ANTARCTIC TOURISTS (WARD, 2001B)

Tourism or value for tourists is probably one of the most accessible as well as usable resources Antarctica offers, and the numbers of visitors are on the rise (see Figure 4). The first official touristic activities started in the 1950s, but one can also see the early explorers and their race for fame as the beginning of adventure tourism. The extreme conditions of Antarctica and the challenges it poses on humans are one reason for visitors to come to the cold and icy continent. One example are the marathons and other long-distance running events in Antarctica organised since 2005 (Global Running Adventures, 2018). Also, diving or kayaking tours are offered, and some people dare to swim in the icy waters (Planet D, 2015). Apart from those events and tours, solo adventurers seeking new challenges find them in Antarctica that still offers many opportunities to accomplish something, no one did before. Although the southernmost continent attracts many thrill-seeking travellers, most tourists visit Antarctica because of its stunning and unparalleled nature. Cruises visit natural or historical sites, like the huts of the Antarctic explorers or whalers. With most tours on offer, the travellers live on board a cruise ship and take part in day tours to the mainland, islands or research stations. Before visiting Antarctica, a permit needs to be issued and tourists must follow the Antarctic conservation guidelines. However, numbers are not restricted, neither the ones of visitors nor of tour operators. The only limitation is the Antarctic weather, since it is only possible to navigate the waters and to land on the continent during the Antarctic summer.

In 1991, the International Association of Antarctic Tour Operators (IAATO) was founded and is an amalgamation of tour operators that work under strict guidelines (e.g. the size of ships, waste disposal or number of landings) to limit negative influence on the continent (Ward, 2001b). Nevertheless, membership in the IAATO is not compulsory and private landings are not forbidden or restricted.

An improvement in technologies, foremost ships, opens the possibilities to visit Antarctica without the need to relinquish any luxury or comfort, thus making it feasible as well as desirable for more and more people that search for new challenges, extraordinary nature as well as

pristine and untouched environments. Antarctic tourism is ambivalent. On the one hand the environmentally-sensitive, and usually financially affluent visitors promote the protection of the area and function as "ambassadors" (Snyder/ Stonehouse, 2007). On the other hand, exactly those Antarctic and conservation "ambassadors" have above average greenhouse gas emissions on their trips to the very South due to flying long haul or using luxury cruise ships (Eijgelar/ Thaper/ Peeters, 2010). Additionally, tourists are a potential threat to the breeding and feeding animals on and around the continent (Ward, 2001b). Although they do not hunt for the animals, the mere physical presence can disturb the local wildlife. Furthermore, the destruction of breeding sites and dumping waste are an issue. Since the waters around Antarctica are difficulty to navigate with strong currents, high waves and floating icebergs, ship accidents are an additional issue and can have disastrous consequences (Jainchill, 2009).

The increase in the number of visitors affects the "touristic value" negatively. The more visitors come to Antarctica the less untouched and pristine the continent becomes.

Another point is the direct trade-off between researchers and travellers. It became visible when the director of New Zealand Tourism urged to build new research sites close to areas with touristic potential and to consolidate New Zealand as a gateway to Antarctica (Day, 2013). Although researchers and travellers do not use the same funds or supporters, the former ones feel hampered as well as disturbed by tourists and most believe Antarctica should be purely designated to science (Ward, 2001b). The main point of commonality between scientists and tourists is the Antarctic infrastructure which is build, as well as maintained for researchers and not for travellers. Although, tours do not rely on this kind of infrastructure or the support of the local scientific community but host their guests on board, it is the only possibility that is left in an emergency and can be used for rescue missions.

Tourism or more precisely the value for tourism, especially pristine, untouched and extraordinary nature but also the unique challenges for adventurers is one of the most accessible and usable resources of Antarctica. Like mineral resources it can be subject to exploitation and for this resource it is technically more feasible than for any other resource. Furthermore, overuse may not be visible but manifests itself in disturbed animals, pollution as well as conflict with the scientific use of Antarctica.

3.7. Science and Bioprospecting

Antarctica is of enormous scientific interest for two reasons. One is the extraordinary environment, geographical position and its influence on the world climate, weather and living, the other is that the continent is hardly influenced or altered by humans. The International Geophysical Year (IGY) in 1957/58 fostered and established international scientific cooperation in Antarctica. Scientists from twelve countries (Argentina, Australia, Belgium, Chile, France, Great Britain, Japan, New Zealand, Norway, South Africa, USSR (now Russia) and the US) worked together in the Antarctic region to establish about 50 new research stations for comprehensive scientific activities (Suter, 1991). Outside Antarctica more than 55 additional countries participated with over 10000 researchers and technicians worldwide that worked together (Suter, 1991). The IGY was an enormous success, both scientifically and politically (Collis, 201). International cooperation among otherwise non-cooperating governments amidst the cold war generated significant findings in a wide range of research fields. The peaceful cooperation and goodwill during the IGY were the perfect setting for the first Antarctic Treaty conference in 1959 and the twelve countries, particularly interested in Antarctica, adopted the Treaty in the same year (Collis, 2010). A cornerstone of the ATS, following the spirit of the IGY, is peaceful and cooperative scientific research:

> *"Freedom of scientific investigation in Antarctica and cooperation toward that end … shall continue (Art. II).*
>
> *Scientific observations and results from Antarctica shall be exchanged and made freely available (Art. III)." (Antarctic Treaty,* 1959, 1961*)*

Science and research are not per se an exploitable resource, as findings must be shared and benefit everyone, without restricting other scientists. However, tourism can conflict with scientific use. Nevertheless, scientific results, especially those that can be used commercially or for patents can lead to exploitation. The Antarctic and Southern Ocean Coalition (ASOC) defines so called bioprospecting as "the use of native organisms from a natural habitat in commercial products ranging from pharmaceutical / medical technologies to cosmetics and personal care." (Antarctic and Southern Ocean Coalition, 2018b). Biological prospecting can be divided into two subgroups. One is the actual harvesting of native Antarctic organisms for commercial use, which is very similar to hunting, fishing or mining. The other one is the use of scientific knowledge created in cooperation or even freely available to fabricate economically profitable products. The latter one may not harm the Antarctic environment or exploit species,

but it undermines Art II and III of the Antarctic Treaty (Hughes/ Bridge, 2010). The moment in which researchers or enterprises can make substantive profits from bioprospecting, cooperation and the exchange of results will probably break down. On the other hand, using Antarctic organisms for commercial products is a typical use of a resource and can be compared to hunting. The ATS protects the living resources, however, a legal or contractual framework for bioprospecting is not developed yet (Hughes/ Bridges, 2010, and Antarctic and Southern Ocean Coalition, 2018b). Although, the topic is on the agenda of the ATS meetings, so far, no agreement could be reached, since questions of ownership as well as benefit sharing are always difficult, and a ready-made or well-tried solution does not exist. Without a special agreement in addition to the ATS which is only partially covering the extraction of organisms, bioprospecting and the successive harvesting is a common resource subject to overuse.

Science and bioprospecting are, like tourism, only an umbrella term for the diverse use of other Antarctic resources to their end, e.g., the untouched nature or spectacular views, which are valued by tourists but also destroyed by too many of them. In the case of science, one could say the more the better, since results need to be shared. The exploitable resource that arises here, are the commercially profitable findings, either knowledge that can be turned into money by patents or the harvesting of previously undiscovered organisms with an economic value.

3.8. Resource exploitation

Of course, not every resource is subject to exploitation but the section on the Antarctic resources shows that there are several obvious or less obvious ones that may be exploited. The more typical resources like minerals, oil and gas are not so much threatened to suffer overuse or to become a Tragedy of the Commons, as it is still very difficult to gain reliable knowledge about the actual amount and even more to extract it. On the other hand, resources like fish and other animals are comparably easy to exploit. Also, the use of Antarctica for tourism as well as bioprospecting becomes more and more feasible and may be subject to the Tragedy of the Commons. Especially without clearly defined property rights, theoretically everyone could extract any resource as exclusion is hardly possible, thus leading to a typical Common with overuse of the resource. Sealing and whaling before the 1960s are examples for this.

3.9. Antarctic resources as a Common: Sealing and Whaling before 1970

Sealing and whaling were two industries well underway in the time before the discovery of Antarctica. The former was hunted for their meat and fur, the latter for oil which was used in numerous ways and an everyday household supply. When the first explorers sailed in Antarctic waters they noticed the abundance of both species and brought the information back home as they were not only interested in finding new lands but also in finding new economic possibilities (Basberg, 2017). The first sealers arrived before the 19th century and started a sealing colony on South Georgia, an island between the tip of the Antarctic peninsula and the tip of the South American continent. However, the animals were soon extinct in this area and the hunters had to look for new areas in the Southern Ocean (Basberg, 2017). The same faith befell all other sealing areas and it took only a few years to overexploit the resource seal, especially fur seals, and make it economically inefficient to continue the hunt (Basberg, 2017). A typical Tragedy of the Commons situation where unregulated hunting by too many sealers affected the entire population negatively.

The same happened in the case of whaling. The hunt for those marine mammals started later than sealing and lasted until the early 1960s. Only once the former hunting grounds for whales were exploited or access to them was strongly restricted, Antarctica became of interest (Basberg, 2006). Additionally, innovative technologies allowed for a more efficient hunt and more catches (Basberg, 2006). Whaling followed the path of sealing and overexploited one area after the other. "Most often, the longevity of a catching ground was like an intermezzo: rapid expansion, over-exploitation and decline." (Basberg, 2006). In the beginning, large catches as well as profits attracted more and more hunters which led to more and more exploitation of the resource. The British and Norwegians were aware of the problem of an overuse and resource depletion and tried to regulate the catching (Hofman, 2016). But no international agreement could be enforced to help the whales or the whaling industry from suffering from the Tragedy of the Commons. A near extinction of many whale species and a decrease in demand for their oil let the industry finally collapse (Hofman, 2016).

Whales and seals were exploited due to three main reasons. The first was, that they belonged to no one and hence, everyone could go hunting for them, a typical Common good. The second reason was the economic profitability of catching and selling those animals. The whalers and sealers had positive expected profits and thus it was only rational to catch more and more. The third was that the technical possibilities allowed for cost-efficient and large-scale catches.

3.10. The role of technical specifics for resource exploitation

Other resources could avoid the faith of whales and seals since the technical possibilities were or are not given to make the use of the resource economically feasible. Whaling and sealing was an established industry and the conditions as well as requirements were not very different from the ones the hunters previously faced (Basberg, 2006). For most other resources the point of departure was very different, requiring the introduction of completely innovative technologies and ideas. Thus, they were protected from immediate overuse. Antarctica, its climate, weather and the whole environment challenge humans, machines and technologies. From nearly landing there with a wooden sailing ship in 1773, to motorized private yachts, planes and highly specialised polar engineering teams, the change in technology was immense and challenged Antarctica. The development of innovative technologies made Antarctic resources accessible one by one. Early exploiters used new ships and harpoons to hunt for whales and seals. Nowadays, new ways to harvest and process krill make an increased use of this kind of resource possible. In the beginning, even seasoned adventurers like Scott died in the harsh environmental conditions. Today, several thousand tourists manage to survive Antarctica every year with cold-proof cloths, heaters and other technologies that make the weather bearable. Planes and snowmobiles make it easier to get around and modern telecommunication allows everyone to stay in contact with others. A resource that could be accessed early were fish, seals and whales as the methods to hunt them in icy waters already existed and improved quickly. Mining and drilling on the other hand is still not feasible and may take some more time before efficient technologies for extraction and transport are developed. Thus, they are protected from exploitation and will not face the Tragedy of the Commons anytime soon. Other resources are at a point where technologies are developed enough that extraction is economically viable, thus making them prone to overuse. For example, tourism and bioprospecting, two aspects where exploitation is not clearly visible, are both of concern to researchers, environmentalists and policymakers. The towing of icebergs to transport potable water to regions in need is at the verge of becoming economically viable to exploit. The know-how is not sufficient enough yet, but only minor adaptions and progresses are necessary to make iceberg towing commercially profitable and hence threaten the resource with exploitation.

Most resources were protected from exploitation since the scientific know-how was not advanced enough to extract them, or at least to extract them in an economically profitable way. However, the example of sealing and whaling shows that Antarctic resources face the Tragedy of the Commons once it is technical possible to us them. Additionally, some other Antarctic resources became technically and economically exploitable in the last years, like tourism and bioprospecting and others, e.g., the towing of icebergs to gain and transport potable water, will be ready for use in the near foreseeable future.

4. Conservation and Resource Protection

4.1. Antarctica a Common

The example of the faith of whales and seals before the 1960s is clearly a Tragedy of the Commons. It seems that in the moment it is technically feasible to start using one of the Antarctic resources they become subject to overuse. Without clearly defined property-rights, use and exclusion rights, everyone can utilise them. Furthermore, the resources are rivalrous goods, so if one party uses a resource or parts of it anyone else lost the possibility to do so. An example to illustrate this is fishing; everyone with the technical abilities could go fishing, but every fish can only be caught by once and is benefitting only this single fisherman. Rivalry and non-excludability are what defines a Common good. Both is clearly fulfilled for Antarctic resources. "In the absence of effective governance institutions at the appropriate scale, natural resources and the environment are peril from the increasing human population, consumption and deployment of advanced technologies for resource use" (Dietz/Ostrom/Stern, 2003). Increasing human population is not a topic for Antarctica yet, but it may be some time in the future. Consumption on the other hand was an issue from 1780 onwards. Seals, whales and fish were always taken out of the oceans and even nowadays Japanese fishers hunt whales. Advanced technologies make the exploitation of several other resources like oil drilling or ice berg towing possible.

An additional point is that Antarctic resources are not or only slowly renewable which increases the aspect of rivalry between the individual users. That is obvious for minerals and fossil fuels, but also potable water is recovering only slowly since the area is one of the driest worldwide. Living resources (fish, krill, mammals, birds) have a certain threshold where the reproduction keeps the population at a stable level, however, the Tragedy of the Commons suggests that the use of the resource is higher than the ability to reproduce. Furthermore, Antarctica and the

Southern oceans are a resource that may be exploited by tourists or by the conversion of the land (e.g. military use or waste disposal) that is not revertible.
A further point is that every resource is part of a large and complex ecosystem, hence it is not sufficient to look at the resources one by one and to prevent overuse. Antarctica and the surrounding oceans are a fragile ecosystem in which the use of one resource may have far reaching effects. Thus, it is necessary to include any potential external effects and protect the Antarctic environment beyond the Tragedy of the Commons.

4.2. Conservation and Protection of Antarctica

Antarctica is a fragile ecosystem and not much is known about it. Conservation is not only important to safe this environment for future generations but also to gain additional time to learn more about the region and to gain a better understanding of (potential) externalities from using and exploiting it. Without a native or permanent population, the need to balance between environmental protection and human demands is low as well as in favour of conservation (Koivurova, 2005). A clash of interests and valuations is still inevitable since different stakeholders, e.g. national or international politicians, researchers as well as NGOs have an interest in Antarctica and prioritise different ideas and outcomes (Summerson, 2011). A general agreement among the various groups is foresight, mindfulness and conscious interaction with the most southern part of the world. Every national research programme run in the region needs to evaluate any potential impacts of scientists, the research or the support team on the Antarctic environment before it can be started (Hemmings/Roura, 2003). The ASOC motivates its conservation efforts and the need for protection as follows:

> *"As the world's last great unspoiled wilderness, Antarctica is the natural heritage of all humankind. We seek to ensure that Antarctic marine and terrestrial environments receive the highest protection possible so that Antarctica will continue to be pristine."* (Antarctic and Southern Ocean Coalition, 2018a)

The recognition of the importance of the Antarctic wilderness and environment are generally accepted among researchers and they recognise three core values of it in the Madrid Protocol 1991: scientific, aesthetic and wilderness (Shah, 2014). Due to no human indigenous population and a relatively late discovery combined with the harsh environmental conditions, Antarctica has a small human footprint and nearly no infrastructure, thus making it the largest unspoiled wilderness area (Summerson, 2011). Apart from aesthetic and natural values, the significance for science is immense, especially since the Antarctic area plays a key role for global climate,

weather and biodiversity and only little of it is understood so far. The same holds true for its unique geography and ecosystem. This one of a kind nature needs to be protected from exploitation at least until the consequences of any resource exploitation are known and understood and can be incorporated in the costs. An additional factor, that holds true for many ecosystems but applies specifically to the Antarctic region, is the slow recovery of it and the mitigation of done harm (Ward, 2001f). Furthermore, the continent´s specifics do not only make the seventh continent worthy of protection, they also require customised methods. The four main challenges for environmental protection mechanisms are: the *absence of clearly defined property rights* as well as little knowledge of *external effects*, since the know-how is still very limited, but vulnerability is high. Additionally, the need for flexibility to include *changes in technologies,* altering the costs and benefits from exploitation of a certain resource and *changes in the valuation of Antarctica,* affecting the general opinion towards the region, resource exploitation, needs and environmental protection.

4.3. Property Rights: Claims and legal status of Antarctica

The Antarctic legal and geopolitical territory is regulated under the Antarctic Treaty System, however, it is not defined or conceptualised in the same way as nation states are. The only two other spaces that are legally indeterminate are the high seas and outer space (Collis, 2009). The moment humans discovered the continent and were able to survive there, questions of ownership and claims appeared. Antarctica has neither a native nor a permanent population. Nevertheless, seven countries, Argentina, Australia, Britain, Chile, France, New Zealand and Norway, claim parts of the continent and adjacent waters. Russia and the United states do neither claim nor accept any claims but reserve the right to make some at any time in the future. Figure 5 shows the demands each country has and the research stations that exist in Antarctica. The Peninsula and the Weddell Sea are claimed by three countries at once, but the part between the Weddell and

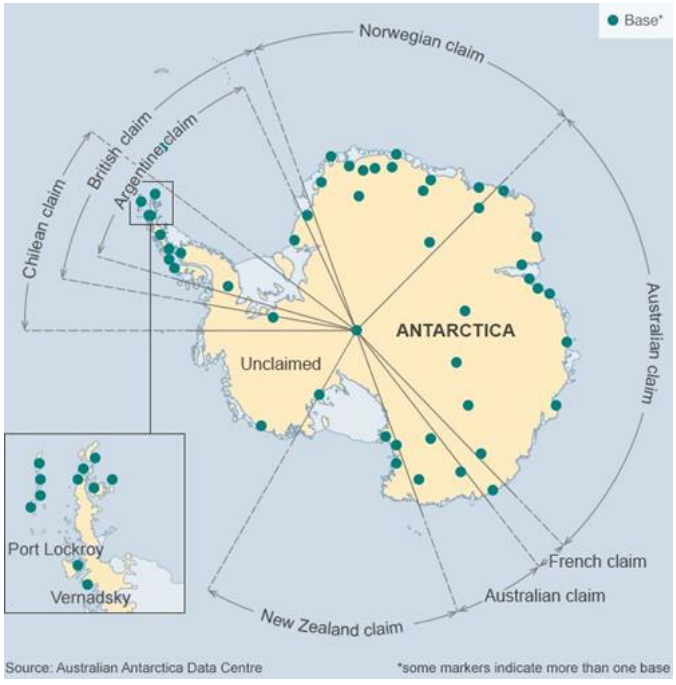

FIGURE 5: CLAIMS AND RESEARCH STATION (AUSTRALIAN ANTARCTIC DATA CENTRE)

the Ross Sea is mostly unclaimed. Australia demands the biggest share, followed by Norway. The reasons for the individual countries´ claims are diverse and range from geographical closeness (Australia, New Zealand, Chile and Argentina) to the claims made by explorers or whalers (Britain, Norway, France). Also, the approaches to support the claims vary. Chile as well as Argentina maintain settlements on Antarctic islands and both have citizens that were born in Antarctica. The first children born on Antarctic land are progeny of scientists or other persons working on the continent. The highly pregnant wives were flown-in, to have a Chilean or respectively an Argentinian citizen that was born in Antarctica and to underline the country´s claims with this (Day, 2013). The other claiming nations, especially the Soviet Union, Australia, Britain and the United States tried to emphasize their (potential) claims by mapping and naming any potentially important site or geographically distinct feature with their own names and historical references (Day, 2013). Thus, every claimant had its own name for the Antarctic peninsula and a compromise between the English-speaking parties but without the inclusion of Chilean and Argentinean interests, could only be reached in 1964 (Sullivan, 1964).

An additional way to remind everyone of the demands each nation has, is the building of research stations on geographically significant sites rather than choosing scientifically relevant locations (Day, 2013). The United States for example have a station at the geographic south pole. Russia on the other hand, built a station at the exact middle of Antarctica. Due to the movement of the glaciers, none of the buildings is at its original site anymore.

Although no claim was ever formally accepted by the international society, the five non-South American countries do recognise each other's demands.

However, a solution for the white continent was needed, especially as no one wanted to start a war over some icy and hostile continent with unknown benefits (Suter, 1991). Additionally, the (potential) claimants did not want the UN to intervene or as a worst-case scenario, to disentitle any claims (Day, 2013). International conflict is unlikely if lands or continents have little economic value and are highly inaccessible (Creek, 2001). A peaceful and cooperative solution was the best choice for the initial Treaty signatories, as the costs of not solving the issue were potentially high (loosing claims or even start a war), whereas the costs of cooperating were low (no obvious value of Antarctica that could not be shared, and any issues could be postponed).

The International Geophysical Year in 1957 was the foundation stone to devote Antarctica to peaceful, international cooperation and research. Even though some persuasion was necessary to reach an agreement that included all seven claimants as well as the five non-claimants that showed a special interest in the seventh continent, the Antarctic Treaty was the result of the

successful cooperation during the IGY. It was signed in 1959 and entered into force in 1961 once all participants had ratified it in their national governments.

The Antarctic Treaty does not resolve the issue of property rights or claims but freezes them. No one can accept, issue or reject any further claim. Existing ones are frozen and resolving the issue is postponed to an unknown time in the future. It addresses practical problems of jurisdiction or decisions concerning the continent, its surrounding waters and islands. The first one considers people living or researching in Antarctica and defines them as being subject to the laws and regulations of their respective home country and citizenship (Art VIII, *Antarctic Treaty*, 1959, 1961). Decisions are based on the concept of unanimity and consensus. The members have the right to control every other party and its activities. Furthermore, any issue can be brought up at Treaty meetings and be subject to discussion. Actions that have no reference in the Treaty, any amendments or changes of rules need to be reached via consensus and in unanimity. This gives every party only little room to use the continent but equips it with an extensive veto power.

The outside views on the property rights and claims in Antarctica vary, depending on the party. Visitors and tour operators visit the continent Antarctica and not the Australian or any other part. Usually they see it as one free land and not as an area with unsettled rights. The view of NGOs is similar. They interpret Antarctica as belonging to everyone (Suter, 1991). The environmental value and pristine nature is what they turn their attention on. Countries that are not part of the ATS, mostly developing countries, support the idea of a common continent and call for their fair share of rights and gains. They see the Antarctic Treaty as an exclusive club that makes it possible for the (developed and rich) member states to secure any profits for themselves (Day, 2013). The claimant states, however, still believe in the rightfulness of their claims and integrate them in their everyday politics, news and education system (Dodds, 2011). Every attempt to resolve the question of ownership and claims failed so far and it was not possible to find a (legal) solution that was acceptable for all involved parties.

Property rights and ownership are not defined for the Antarctic region and any claims or reserved rights to make them at any point in the future are frozen but not resolved by the Antarctic Treaty. This makes Antarctica, together with the high seas and outer space, to a legally unspecified space which is, with respect to legal and governmental circumstances, very different to nation states.

4.4. Little know-how about External Effects

External effects, positive or negative, are additional costs to third parties, benefits or losses that emerge from using or producing something but are not considered in the individual decision making. For example, the Tragedy of the Commons, where the use of the shared resource by an individual affects the profitability of the Common for all negatively. An illustrative example of external effects related to Antarctica is the melting of ice. The permanent ice melts faster due to global warming, less ice changes Antarctica as an ecosystem, affecting many species and organisms, but it also leads to an increase of sea levels, affecting many countries. There are many more examples of how something that is done somewhere far away from the pole has ramifications on Antarctica, but also vice versa, minor changes in the Antarctic environment can have stark effects on other systems. External effects are not only more pronounced in Antarctica, very often they are unknown or only little researched. The extreme conditions make it hard for scientists to conduct research and to gain knowledge about every detail. Though Antarctica is dedicated to science and numerous programmes as well as expeditions are run every year, some specifically oriented towards resilience[1], the exact working ways and dimensions of externalities are still not foreseeable. Very often it is not only the scope of the externality that is uncertain, but the actual external effect is not known at all. This lack of knowledge is one of the reasons why bioprospecting or an increased harvesting of krill is viewed sceptically (Hughes/ Bridges, 2010).

If it is not possible to settle the claims and the question of property rights, how can it be even thinkable to answer the question of who is responsible for any external effect (positive or negative)?

4.5. Technological changes

Technologies have a profound influence on living, working and travelling in Antarctica but also on resource extraction. Without the right know-how, neither is possible, and the continent would have stayed untouched by humans. However, technologies are advanced enough to affect Antarctica and to alter its appearance, accessibility and usability. Changing as well as developing technologies and new know-how has a profound influence on Antarctica and requires adapted governance and new institutions (Shackelton, 2008). While resources were not threatened to be used or overused, there was no necessity to define use rights, responsibilities

[1] For example, the Scientific Research Programmes “Antarctic Climate Change in the 21st Century - AntClim21” or “Antarctic Thresholds - Ecosystem Resilience and Adaptation - AnT-ERA” by the Scientific Committee on Antarctic Research.

or schemes for benefit sharing. Once a resource is accessible, those questions will bring up the need for negotiations. The Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) failed, amongst other reasons, due to unsolved questions of ownership and benefit sharing in the case of mineral extractions (Day, 2013) .The follow up agreement, the Protocol on the Environmental Protection (PEP) to the Antarctic Treaty, postponed the creation of institutions and solutions to deal with the issues by forbidding mining altogether (Redgwell, 1994). However, once the potential profits are sufficiently high, stakeholders will be willing to take the effort, hassle and expenditures to create new governance and institutions to be able to use the resources. This might be far in the future for mining and drilling, where costs are high, technology underdeveloped and profits more than uncertain. But tourism, bioprospecting and ice berg towing are not only feasible but promise potentially high gains.
New developments in technologies and know-how change the economic, scientific and touristic possibilities in Antarctica, thus altering the challenges to resources and the environment. Those constant changes need to be observed and incorporated in any conservation attempt, requiring adaptions in institutions and governance.

4.6. Changes in the preferred use and valuation of Antarctica

Attitudes towards certain issues like environmental protection or the use of minerals as well as the valuation of those are not only different with respect to various stakeholders but change over time. During the cold war time, the international hostile tensions between East and West were predominant, and Antarctica was only of little interest to the public (Suter, 1991). This changed drastically when the hole in the ozone layer above the south pole was detected by joint Antarctic research (Suter, 1991). Stakeholders utilise events related but also unrelated to Antarctica to influence and shift public opinion about the southern continent and how it should be governed, conserved or exploited, e.g. the sinking of the oil tanker *Exxon Valdez* in the Arctic. *Greenpeace*, the only non-governmental organisation that maintained a research station in Antarctica, used the sea accident to influence politicians and public opinion:

> "In 1989, the Exxon Valdez oil spill in Alaska undermined any oil company's argument that drilling in ecologically sensitive areas could be conducted in a safe, environmentally friendly manner. Greenpeace offices worldwide lobbied their governments to take a responsible position protecting the Antarctic…" (Greenpeace, 2001)

The interests and needs of future generations are unpredictable. On the one hand, there is climate change, calling for more scientific research and less negative interaction between

humans and nature, which is strengthening the argument for increased conservation as well as protection of Antarctica. On the other hand, the world population is growing, needing more space, energy, water and food, making Antarctica an attractive continent with regards to its resources. It is neither today´s generations task nor ability to decide what is best for future generations (Mahoney, 2001).

The past showed that interest for and the attitude towards Antarctica, especially the use and conservation of it can change and that certain events, e.g. the sinking of the *Exxon Valdez* or the discovery of the hole in the ozone layer, can lead to quick and unpredictable changes in the public opinion. Thus, it is impossible and hubristic to predict the needs and interests of the future human population. Any conservation mechanism or institution must be flexible to be adapted or adapt itself to a change in the environment. Here environment can be understood quite literally, for example a draught that makes potable water urgently needed but also a change in the Antarctic environment due to e.g. climate change. It also includes public opinions or the legal and political framework of the Southern continent. However, the requirement to react flexible on changing circumstances and demands is imposed on most conservation schemes, but what makes Antarctica truly unique from an institutional or economical point of view is the absence of property rights and the geopolitical vacuum.

4.7. Environmental protection methods

The following section will give a short recapitulation of the most common environmental protection methods from an economic point of view. Next to explaining the main idea as well as mode of operation of the protection method, prerequisites will be stated. Additionally, a short reference to why each protection method is not suitable to conserve Antarctic resources is made. Environmental protection or conservation does not necessarily mean no pollution or not using resources at all but taking potential negative externalities into account and including them into the costs. Thus, the use becomes more efficient (at least for producers and consumers) and potential damage is offset by higher prices. The Coase Theorem and the institutional approach to facilitate the friction-free implementation of bargaining does not include any conservation issues but is purely interested in internalising external costs. Most other mechanisms can be designed in numerous ways and with different parameters, allowing them to stimulate environmental protection above the market-based pareto-efficient level. Taxes for example can be that high that no one continues to pursue the taxed activity. This is usually neither the best solution for consumers, nor producers, nor the tax collecting institutions, but it guarantees the best possible method of conservation of this particular good - no use at all.

Environmental protection methods can be grouped in three categories*: Institutional approaches to internalise external costs,* thus facilitating the working of the Coase Theorem, *Command and Control* mechanisms *and economic incentives for market-based solutions*. Each has several sub-topics and instruments, allowing for various possibilities to facilitate environmental protection and resource conservation. Since the details of every mechanisms are slightly different with strengths and weaknesses, they can be more or less suitable for different situations. The variety of environmental issues is wide and requires different solutions making one approach preferable to another depending on the situation and circumstances (Sinclair, 1997). Antarctica has very distinct features, most notably no clearly-defined property rights, but also its seclusion and the challenges it poses to humans and technologies. Antarctic resources are diverse and with specific characteristics, as well. For most there is only little knowledge about the exact occurrence, their externalities and implications on each other and the worldwide ecosystem.

4.7.1. Institutional approaches to internalise externalities

The Coase Theorem broaches the issue of bargaining between individuals as the pareto optimal solution for the correction of externality problems, if several assumptions are satisfied. Those prerequisites are: Clearly defined property rights, the right to pollute or to have a pollution free environment, no transaction costs and full information. With those assumptions fulfilled, the involved parties can bargain and agree on a price for pollution or its abatement that reflects their respective preferences, costs and benefits. The institutional approach to internalise externalities tries to create and perpetuate the necessary assumptions as well as frame conditions, such that the actual externality problems can be solved by private bargaining. Examples are the specifications of liabilities, freely available information platforms or support for consumers to overcome transaction costs like lawsuits or costs of contracts.

Antarctic resources fulfil nearly none of the assumptions. For example, the unsettled claims: if it is not possible to settle the claims it will be hardly feasible to determine the property rights for pollution or abatement.

4.7.2. Command and Control Instruments

Command and Control instruments for environmental protection rely on regulations, e.g. permissions, prohibitions, quotas or (technical) standards. Governments or other supranational institutions like the European Union, define guidelines and regulations which are applied in a top-down approach. Command and Control works within legislation borders or with supranational institutions (Knight/Meffe, 1997). The prohibition of certain pesticides or the requirement to use specific engine technologies for cars are typical command and control instruments. The approach is widely used, as it is relatively easy to implement and does not require exact knowledge about external costs or perfect markets. However, it is this simplicity that makes command and control mechanisms inefficient, expensive and stifles innovation. With strict regulations concerning technologies, inputs and outputs, firms have a decreased incentive to develop new technologies and to invest in innovation. Inefficiency stems from the top- down character of the standards that do not or at least not fully consider economic parameters like costs, benefits and social costs. Implementing and controlling Command and Control mechanisms is costly and in contrast to taxes, does not generate any income. Although those critiques are justified, Command and Control instruments cannot be dismissed as poor approaches for environmental conservation. They can be most efficient in sense of environmental protection (Cole/Grossmann, 1999), since harmful substances, pollution exploitation or the use of detrimental technologies can be prohibited or at least minimised. Furthermore, economic incentives like taxes, or even more the Coase Theorem rely on perfect markets with full information and no transaction costs. This is highly unrealistic thus making Command and Control mechanisms the most efficient tools in an economic sense for some situations (Cole/Grossmann, 1999).

Command and Control mechanisms are widely used by the individual bodies under the ATS, as they do not require exact knowledge about externalities, costs and benefits. An example therefore are the catch limits for fish and krill or the requirement for special catching techniques. However, those instruments are used on the foundation of voluntary compliance. Antarctica has no supranational government or institution that has the power to command and control but is governed by the members of the Treaty. Decisions and agreements are based on comprehensive discussions and unanimity. Controlling or even punishing misconduct is neither possible nor intended by the ATS.

4.7.3. Economic incentives (market-based)

Environmental protection with incentive-based instruments creates a voluntary change in the behaviour of firms and individuals. Taxes and subsidies, compensation payments or payments for performance influence costs and benefits of certain actions which make them more, or less desirable. Emission trading allows firms to find the ideal amount of pollution or abatement of it by allocating a price to pollution and creating a market. The new costs for production or new prices for the consumers change the amount of supply and demand of a certain good. A tax on a product that harms the environment makes it more expensive and less of it will be demanded as well as supplied, which in turn is better for the environment. Of course, finding the right amount of taxation, subsidies or certificates requires full knowledge of external costs and smooth functioning markets.

The absence of such a market is not the main reason why economic incentives for environmental protection are unsuitable for Antarctic resource conservation though. Those incentives need, like the institutional approach to internalise externalities, clearly defined property-rights. Not only the ownership of the land and seas needs to be defined but also the right to use, pollute, trade and furthermore, to collect taxes or royalties must be settled and accepted by all involved parties. This is clearly not the case in Antarctica, where many countries are involved, some with overlapping claims, others with a strict non-acceptance of any possible claim or ownership. The Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) tried to regulate potential Antarctic mining and although it was negotiated and agreed upon by all involved parties, Australia and France withdrew their support and never signed it so far. Next to environmental concerns, the unsettled question of the distribution of potential royalties from mining and drilling led to the drawback of Australia (Blay/ Tsamenyi, 1990). Currently, it is not conceivable that the issue of rights or the distribution of potential gains by royalties and tax income can be solved. Even the question of claims seems to be far from any solution. So far, any suggestion of use that requires at least some kind of property-rights adjudication failed.

5. Towards a new mean of environmental protection: Antarctica as an Anticommon

The short recapitulation of the standard economic approaches to environmental protection and resource conservation showed that Antarctica is a very special case where none of the usual mechanisms work. This is mainly due to the unsettled property-rights which are the base of most economic ideas and institutions. Although Command and Control instruments are used in some parts of the ATS, they are not the superordinate working way, but the easiest implementation of protection without actual property-rights. However, the absence of a strong Antarctic government or an institution that has its powers makes the controlling as well as punishment unfeasible and noncredible. The members of the ATS comply voluntarily with the caps they imposed on themselves. The questions are why this cooperation among the members of the ATS exists and why as well as how exactly do they protect the continent from the Tragedy of the Commons. The example of early seal and whale hunting shows that Antarctic resources are prone to become commons once the technological and economically feasible possibilities for exploitation exist. Furthermore, the Tragedy of the Commons for the case of seal and whale exploitation could not be solved since the cooperation among the hunters failed (Hofman, 2017). To understand how Antarctica is protected under the ATS it is important to have a good knowledge about Commons and the Tragedy of the Commons since the mechanism behind the Antarctic environmental protection is not conservation per se but underuse which can be achieved through Anticommons or rather the Tragedy of the Anticommons.

5.1. Revisited: Common Goods and the Tragedy of the Commons

The Tragedy of the Commons is a well-known and researched phenomenon in economics. In his article "The Tragedy of the Commons" in *Science* in 1968, Garreth Hardin argues that maximising the own interests or benefits in a shared and free common brings ruin to all. He describes the logic behind this Tragedy with the help of a common pasture:

> "As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly (…) he asks: `What is the utility to me of adding one more animal to my herd? ´ (…) the rational herdsman concludes that the only sensible course for him to pursue is to add another animal (…). But this conclusion is reached by each rational herdsman sharing the common." (Hardin, 1968)

Contrary to the idea of the invisible hand, the rational and utility-maximising behaviour of the individual to use more and more of the Common is not the best outcome for all the users of the common taken together. The reason for this is that negative externalities are not internalised. The herdsman sees only the gains for himself by having animals. He does not consider the negative effects, like overgrazing or trampling the grass down, that animals have on the pasture itself (Hardin, 1968).

Typical Commons are not only shared grazing fields but most natural resources, parks and shared property. Common property does not imply that it is everybody´s but the concept can also be applied to groups of potential resource owners that cannot be excluded (Ciriacy-Wantrup/ Bishop, 1975).

Although, Hardin´s view to solve the Tragedy of the Commons was rather pessimistic (Dietz /Ostrom/Stern, 2003), several concepts and ideas to reach cooperation and to avoid the Tragedy were developed. One was to turn the common into private property, such that use as well as exclusion rights are given, and the individual utility maximisation is best for all. Buchanan and Yoon (2000) argue in the same direction but do not go as far as turning Commons into private property. They state that "Only with full centralization of decision authority within the ''mind'' that is coincident in range with that of potential resource use can full internalization of the potential externalities be guaranteed." (Buchanan/ Yoon, 2000). In *The New Palgrave Dictionary of Economics*, Elinore Ostrom (2010) finds that close-knit communities can be successful in governing and using commons efficiently. The ability to exclude outsiders as well as sharing values and interests are a key to protect shared resources (Dietz /Ostrom/Stern, 2003). Furthermore, Ostrom (2010) suggest four criteria that make it possible to overcome the Tragedy of the Commons. 1.) a low discount rate / long-term planning of the users 2.) homogenous interests of the users 3.) the cost of communication and sharing information is low and 4.) the costs of reaching and enforcing an agreement are low. The less the group of common property users fulfils the above criteria, the less likely it becomes that the Tragedy of the Commons can be avoided. An example for a well working international agreement to overcome a tragedy is the Montreal Protocol, which regulates the use of substances harming the ozone layer. The negative externalities were clearly visible and traceable, for which reason everyone agreed that it is necessary to do something against it (homogenous interests). Having an intact ozone layer is a long-term goal and avoiding the use of fluorochlorinated hydrocarbon CFC was relatively easy. On the other hand, there is the Kyoto protocol, which is a good example of an international agreement that did not help to overcome the Tragedy of the Commons (manmade climate change). Economic short-term goals of the decision makers, here states, are more important

than long-term climate goals. Additionally, there is no consensus about the why and the how of the climate change, leading to heterogenous backgrounds, beliefs and interests. Costs of reaching and enforcing the agreement were high, as well. Both examples show, that international treaties or agreements may work to solve environmental and international common problems, but their success depends strongly on the circumstances and characteristics of each individual problem as well as on each user and originator.

5.2. Anticommons and the Tragedy of the Anticommons

The Tragedy of the Anticommons is similar to the Tragedy of the Commons but instead of having an overuse of a shared resource, an Anticommon is underused. Heller (1998) defines an Anticommon as a shared and scarce resource for which "multiple owners are each endowed with the right to exclude others." The use and exclusion rights are not identical here. Everyone can exclude others from using a scarce resource. Hence, one party can exclude all others but for using it everyone's approval is required. Exclusion or permission of every member are complements to each other and it is not possible to substitute them by something else, in order to utilise the resource.

> "The tragedy of the anticommons is a result of the fact that common resources will remain idle even in the realm of positive marginal productivity. This is because the multiple holders of exclusion rights do not fully internalize the cost created by the enforcement of their right to exclude others." (Schulz/Parisis/Depoorter, 2002).

As with commons, the tragedy arises because the external effects are not considered by the individual decision makers. However, the decision of the individual is not how much to use (setting the quantity) but how much to charge others to do so (regulating the amount of usage). The exclusion, although optimal for the individual decision maker, has negative effects on the other members. The resource is not used optimally but too little, yielding a loss in total revenue and productivity (Parisi/Schulz/Depoorter, 2000). Additionally, the cross-price effect of complements makes it rational for all members with exclusion rights to increase the price of usage, leading to a further decrease in the quantity used and subsequently in a decrease of productivity as well as total revenue (Parisi/Schulz/Depoorter, 2000).

Anticommons can come in different variations and the Tragedy of the Anticommons has many real-world applications.

A good example to understand the efficiency loss due to cross-price elasticity of complementary goods and the increased price is a road divided in several toll sections. If those roads are

substitutes to each other (the driver can take either road A or road B) the price will be at the MC of the toll operators (Bertrand competition). But if the driver must take road A and road B (the roads are complements) than the toll of A and B will be both, above the MC and above the monopoly price as the toll operators maximise their individual revenues with respect to the behaviour of the other operator but without cooperation. This, individually rational behaviour leads to higher prices and hence to a lower usage. The example shows the price setting component in contrast to the quantity setting as it is done in the case of commons.

But not only the complementary setting of prices has anticommon characteristics. The concept as it is defined refers to fragmented ownership but can be extended to fragmented decision making (Heller, 2013).

Disintegrated property rights can either be different rights for separate owners for a shared resource or the dividing of it in several small pieces but such that the resource can only be used if some or all owners work together. An example for the latter one are big construction projects like motorways or airports, where usually land from more than one party needs to be bought to be able to build and run the respective venture. Due to "Enormous transaction costs of negotiating with all relevant parties, prospective developers most certainly would be discouraged from pursuing development project in the area." (Parisi/Schulz/Depoorter, 2000)

Fragmented decision making refers to the rights every member has to determine the use of a shared resource. Examples therefor are patent laws. Heller and Eisenberg (1998) find that the protection of patents, especially drug-related patents, leads to less innovations and fewer new pharmaceuticals because the use of the protected knowledge is too expensive and non-optimal for the companies. Another example is the requirement to obtain several permits before a resource can be used (Parisi/Schulz/Depoorter, 2000). Also, common ownership with veto rights is subject to the Tragedy of Anticommons (Schulz/Parisi/Depoorter, 2002). Vetoing and thereby increasing the total price of a common good can be individually rational but leads to underutilisation and in extreme cases to no utilisation at all. "In the limiting case, in which all persons in a large group are assigned rights of exclusion such that each proposed user must secure the permission of all persons, the resource may not be used at all, despite its potential value." (Buchanan/Yoon, 2000).

The common feature of all Commons and Anticommons problems is the discrepancy between individual rational behaviour and what is best for all users or excluders.

Cooperation of all exclusion right holders would lead to an optimal, monopolistic result but defection is individually rational. "If too many owners control a single resource, cooperation

breaks down, wealth disappears, and everybody loses." (Heller, 2013) This is true for both, Commons and Anticommons.

Defragmenting property such that usage and exclusion rights are equal (private property) is one possibility to overcome the Tragedy of the Anticommons. However, transaction costs and an unwillingness by the members to give up their property and exclusion rights make the transformation expensive and complicated (Parisi/Schulz/Depoorter, 2000). Instead of transforming the property rights it is also possible to find cooperative solutions, e.g. close -knit homogenous groups (Heller, 2013). Also, punishment mechanisms in the case of defecting from the cooperative solution may work.

A further approach is not to solve the Tragedy of the Anticommon. "The 'comedy of the anticommons' insight suggests that sometimes, for some resources, we should promote little or no use." (Heller, 2013). Underuse may not be economically optimal, but it can be a method for conservation and protection of natural resources. Especially, if the resource shall be conserved in the long-run and beyond the time of initial owners (Parisi/Schulz/Depoorter, 2000). Long-term conservation needs to consider changes in technologies and possibilities as well as the potential alterations of the interests or valuations of the conservers or the whole society (Mahoney, 2001). It is hubristic to assume that today´s ideas and presumptions about the why and the how to conserve are equal or even superior to those of future generations (Mahoney, 2001). Anticommons can internalise changing interests or valuations of potential users or excluders as they can be interpreted and represented by simple, linear price-quantity equations.

5.3. The maths behind the Commons and Anticommons

Mathematically or game theoretically the Tragedy of the Commons and the Tragedy of the Anticommons are Cournot (simultaneous) or Stackelberg (sequential) oligopolies with a Nash equilibrium that is rational for each individual decision maker but does not maximise the total revenue.

In Commons situations, the users set quantities and maximise their personal revenue. In Anticommons situations, the excluders set prices to maximise their individual profit. The cooperative solution is the monopoly outcome (having only one player) and it is the same for both Tragedies independent of price or quantity setting.

If the Tragedy is simultaneous or sequential depends on the design of the decision making of each user/excluder. Schulz, Parisi and Depoorter (2002) differentiate between horizontal and vertical Anticommons. In the latter case one permit must be acquired after the other. In the horizontal case, decision makers have the same rights and powers. A vertical choice rule is clearly sequential. In the event of horizontal decision making one can assume simultaneous oligopolies, although the decision to veto may not be made simultaneously. Cross veto-powers and the right to revise one´s own decision make the game simultaneous, although it appears to be sequential at first (Schulz/Parisi/Depoorter, 2002). Hence, it is the same as playing a simultaneous game.

The model that will be applied here follows Buchanan and Yoon (2000)[2]. It is a simple, linear price-quantity relation or as the authors state it: P is the value and Q usage. The assumption here is that both, P and Q are greater zero. Although, negative prices are a possibility, not participating is always the better choice compared to paying a negative price (costs). The same is true for quantity or usage.

$$P = a - b * Q, \text{ with a and b constant}$$

$$P, Q > 0$$

For Commons one has: $\sum Q_i = Q, i = 1, \dots, n$

For Anticommons one has: $\sum P_i = P, i = 1, \dots, n$

[2] For a detailed mathematical discussion of the model see Buchanan and Yoon (2000)

For reasons of simplicity and to highlight the structure as well as the logic behind the Tragedy of the Anticommons, perfect complements will be assumed, hence only one "good" will be used. However, the concept of anticommons is not limited to using perfect complements, prices and quantities. Schulz, Parisi and Depoorter (2002) use for example value and effort. Also, imperfectly complementary goods can be subject to being Anticommons. The easier one of the goods can be substituted by another, the less effective is the fragmentation and the less severe is the underuse. The case of perfect substitutes leads to a Betrand competition where the least expensive good gains the whole market. However, this is no longer an Anticommon situation and only mentioned for reasons of completeness and clarification.

5.3.1. Cooperative Solution for Commons and Anticommons

The cooperative solution for Commons as well as Anticommons is the Monopoly Price and Quantity which maximises the total revenue, Q*P. It is the same for both and independent of maximising for the quantity or for the price.

$$\max_{Q} Q * P = (a - b * Q) * Q$$

The first order conditions for the rent maximisation under cooperation for Commons are:[3]

$$a - 2bQ = 0$$

$$P, Q > 0$$

Solving the first order conditions for the stable monopoly solution yields an equilibrium price of $P^* = \frac{a}{2}$, which can be obtained by inserting Q^* in $P = a - b * Q$. The equilibrium total quantity is $Q^* = \frac{a}{2b}$. The total revenue in equilibrium is $P^* * Q^*$ and $TR^* = \frac{a^2}{4b}$. With equal sharing the revenue for each member i of either the Common or the Anticommon is: $TR_i^* = \frac{1}{n}\frac{a^2}{4b}$ for $i = 1 \ldots . n$. The share of revenue gets smaller with an increasing n as the total revenue is constant and depends only on a and b.

[3] For Anticommons the decision makers choose the Price P, instead the Quantity Q, to maximises the total revenue. However, the optimal result is the same (Duality).

5.3.2. Simultaneous Commons

The Tragedy of the Commons with simultaneous decision making refers to a Cournot Oligopoly, where the n equal users of the Common set the quantity of their use without knowing the quantity of the other´. But as everyone is a rational and egoistic profit maximiser, the strategies and reactions of everyone are known and incorporated in every user´s consideration and maximisation.

$$\max_{Q_i} Q_i * P = (a - b * Q) * Q_i$$

The first order conditions under individual profit maximisation with quantity setting are:

$$a - b * Q - b * Q_i = 0$$

$$P, Q > 0$$

As we have n players the FOC is n-times yielding the Reaction Function for each user i

$$Q_i = \frac{a - b * Q_{-i}}{n * b}$$

Solving the first order conditions and the respective reaction functions gives a stable and symmetric solution for all n users of the Commons with a quantity of $Q_i^* = \frac{a}{(n+1)*b}$ for each player i and a total quantity of $Q^* = \frac{na}{(n+1)*b}$. The equilibrium price is $P^* = \frac{a}{(n+1)}$ and becomes smaller with an increasing number of users n. As a consequence of non-cooperation, the individual profit $\pi_i^* = \frac{a^2}{(n+1)^2*b}$ and the total revenue of all n players together, $TR^* = \frac{n*a^2}{(n+1)^2*b}$, are decreasing in n as well.

5.3.3. Sequential Commons with two Players

The sequential solution for the Tragedy of the Commons is referred to as Stackelberg Oligopoly. One player moves after the other and can observe what happened so far. However, the first mover (Leader) can anticipate what the rational and profit-maximising Follower will do and adjusts his move accordingly. In the case of two players, the two maximisation problems are as follows:

Follower:

$$\max_{Q_2} Q_2 * P = (a - b * Q) * Q_2$$

In a two-player game maximises the last mover the profit with respect to the own quantity Q_2, and takes Q_1 into account as if it were a simultaneous game. Hence the first order conditions for player two in a two-player sequential oligopoly game are:

$$a - b * Q_1 - 2b * Q_2 = 0$$

$$Q_1, Q_2 > 0$$

Solving the first order conditions for Q_2 leads to the reaction function of the Follower:

$$Q_2 = \frac{a - b * Q_1}{2b}$$

The leader can anticipate what the follower will do or respectively how the reaction function of player two looks like, and maximises the individual profit accordingly:

Leader:

$$\max_{Q_1} Q_1 * P = \left(a - b * (\frac{a - b * Q_1}{2b} + Q_1)\right) * Q_1$$

The first order conditions are:

$$\frac{a}{2} - b * Q_1 = 0$$

$$Q_1, Q_2 > 0$$

Solving the first order conditions of player one and inserting the equilibrium quantity $Q_1^* = \frac{a}{2b}$ in the reaction function of player 2, the follower, gives the equilibrium quantity $Q_2^* = \frac{a}{4b}$. The total quantity produced in the stable Stackelberg-Nash equilibrium is $Q^* = \frac{3a}{4b}$ at a price $P^* = \frac{a}{4}$. The total revenue for the two players is $TR^* = \frac{3a^2}{16b}$, with $TR_1^* = \frac{a^2}{8b}$ for the leader and $TR_2^* = \frac{a^2}{16b}$ for the follower.

5.3.4. Simultaneous Anticommons

The Tragedy of the Anticommons is symmetrical to the Tragedy of the Commons. Instead of quantity setting by the users, one has price setting by the excluders. However, the goods are complements and not substitutes, hence it is not a Bertrand competition but still a Cournot competition. However, the maximisation problem is not solved for quantities but for prices in the simultaneous case.

$$\max_{P_i} P_i * Q = \left(\frac{a - P}{b}\right) * P_i$$

The first order conditions for n players maximising the individual profit with respect to the price P_i are:

$$\left(\frac{a - P}{b}\right) - \frac{1}{b} P_i = 0$$

$$P_1, P_2 > 0$$

As we have n identical players solving the maximisation problem and the FOC for P_i yields the reaction function for each user i:

$$P_i = \frac{a - P_{-i}}{n}$$

The equilibrium price for each excluder on the Anticommon is $P_i^* = \frac{a}{(n+1)}$ and the total price that must be paid is $P^* = n * \frac{a}{(n+1)}$. The individual price goes to zero with increasing n but the total price goes towards a, which is the maximum possible value with only positive Q. The supplied quantity in equilibrium is $Q^* = \frac{a}{(n+1)*b}$ and is shrinking with increasing n. The profit each player gains is $\pi_i^* = \frac{a^2}{(n+1)^2*b}$, the total revenue is $TR^* = \frac{n*a^2}{(n+1)^2*b}$. Both decrease in n.

5.3.5. Sequential Anticommons with two Players

Comparable to the solution of the sequential, two-player Tragedy of the Commons, is the Tragedy of the Anticommons a Stackelberg Oligopoly with price instead of quantity setting. Again, there is a leader, who anticipates what player two will do and a follower, who observes what player one did. The maximisation problem of the follower is the same as in the simultaneous game:

Follower:

$$\max_{P_2} P_2 * Q = \left(\frac{(a - P)}{b}\right) * P_2$$

The first order conditions for the two-player sequential game and the follower are:

$$a - P_1 - 2P_2 = 0$$

$$P_1, P_2 > 0$$

Hence, the reaction function of the follower is:

$$P_1 = \frac{(a - P_1)}{2}$$

The leader, or player one can anticipate the reaction function of the rational and egoistic profit maximising follower and integrates it in his own maximisation problem.

Leader:

$$\max_{P_1} P_1 * Q = \left(\frac{a - P_1 - \frac{(a - P_1)}{2}}{b}\right) * P_1$$

The derivative with respect to P_1 gives the following first order conditions for the leader:

$$\frac{a}{2b} - \frac{1}{b} * P_1 = 0$$

$$P_1, P_2 > 0$$

Solving the leader´s first order conditions for P_1 and inserting the equilibrium price $P_1^* = \frac{a}{2}$ in the follower´s reaction function gives $P_2^* = \frac{a}{4}$ and a total price $P^* = \frac{3a}{4}$. The equilibrium quantity in the two-player sequential Stackelberg game with price setting is $Q^* = \frac{a}{4b}$. The total revenue $TR^* = \frac{3a^2}{16b}$ is the sum of the individual profits $TR_1^* = \frac{a^2}{8b}$ and $TR_2^* = \frac{a^2}{16b}$.

5.4. A comparison of Commons and Anticommons

The Tragedies of the Commons and of the Anticommons work symmetrically and the total revenue or the loss of total revenue is the same in both cases if all parameters and the used price-quantity equation are the same.

In the case of Commons, the quantity or usage of a good is high, between $Q_M \; and \; Q_c$ in *Figure 6* and increases in the number of users n. Additionally, playing will increase the quantity compared to playing simultaneous. The price on the other hand is lower than the monopoly price (between P_m and 0 in the graph) and further decreases in the number of players n. Also, choosing sequentially instead of simultaneously diminishes the price or value. However, the sequential values of P, Q and the revenues converge with an increasing n or sequences played to the simultaneous outcomes.

The Tragedy of the Anticommons and the respective prices and quantities can be observed and retraced in *Figure 6* as well. Instead of a quantity above the monopoly price, the quantity or usage is between 0 and Q_M. The sequential game has a lower Q than the simultaneous game with the same number n. The price P, on the other hand, is between the monopoly price $P_M \; and \; H$. Laterally reversed to the Commons, P increases, and Q decreases in n for Anticommons.

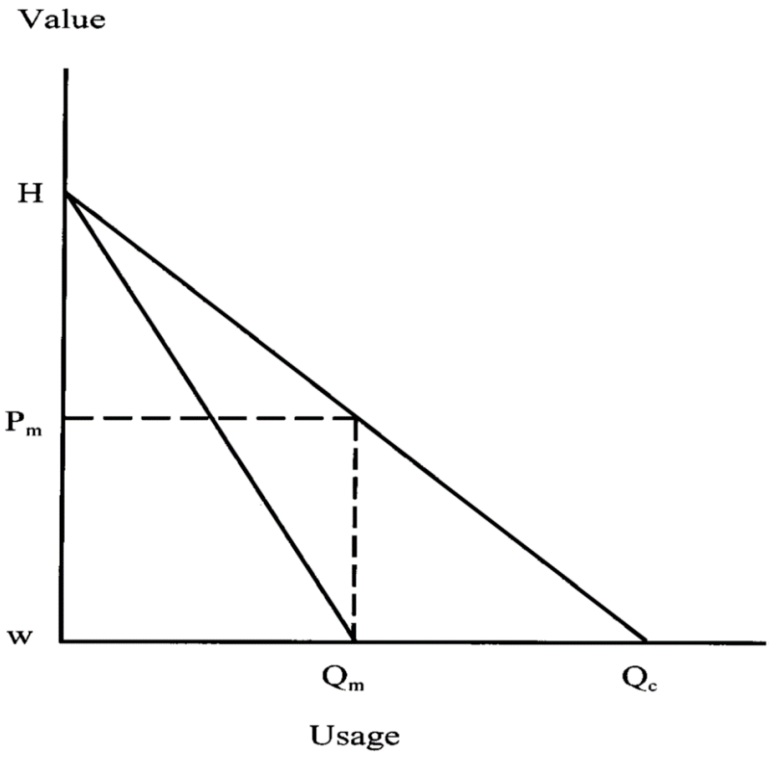

FIGURE 6: VALUE/USAGE GRAPH (BUCHANAN/ YOON, 2000)

The symmetry becomes clear when looking at the total revenues or the loss in total revenue compared to the cooperative monopoly solutions. The latter one is equal for Commons and Anticommons, as it is the maximisation of the same area under the same curve. The single user in a Common sets the monopoly quantity and realises the monopoly price. The single excluder in an Anticommon sets the monopoly price and realises the monopoly quantity. Hence, the total monopoly revenue is equal. The total revenue under individual maximisation is smaller than the monopoly revenue and further decreases with n in both cases. The symmetry goes much further than evoking the same reaction to an increase in n. In the case where the same function is used, and every player holds the same rights, either price or quantity setting, as it is given in the example in the text, the revenue loss of both tragedies is the same if all parameters, the structure of the game and n are equal (Parisi/Schulz/Depoorter, 2000). For example: The price that two players with price setting (Anticommons) choose simultaneously will be such that the according quantity will be the very same quantity as if two players with simultaneous quantity setting had played and vice versa. Thus, the total revenue $P * Q$ is equal in both cases. Figure 7 compares Anticommons and Commons with respect to the total price, total quantity and the revenue. If $n = 1$ in the simultaneous or sequential case, then it is equal to playing the monopoly game. Additionally, the outcomes of the sequential game will be equal to the simultaneous outcome if either the repetition or the players n are infinite.

Comparison	Anticommons	Commons
Total Price	$P_M < P_{sim} < P_{seq}$	$P_M > P_{sim} > P_{seq}$
Total Quantity	$Q_M > Q_{sim} > Q_{seq}$	$Q_M < Q_{sim} < Q_{seq}$
Revenue	$TR_M > TR_{sim} > TR_{seq}$	$TR_M > TR_{sim} > TR_{seq}$

FIGURE 7: COMPARISON OF COMMONS AND ANTICOMMONS (AUTHOR)

This symmetry stems from an equal misalignment that Commons and Anticommons have. The welfare loss is a result of not internalising the external effects of individual behaviour on the group outcome (Parisi/Schulz/Depoorter, 2000). Using a Common makes it less usable for all others. Not using an Anticommon makes it less profitable for the others to use it. Hence, the value or total revenue declines in both tragedies with the number of users or excluders because

more and more externalities are not internalised. With n going to infinity the total value dissipates completely (*see Figure 8*).

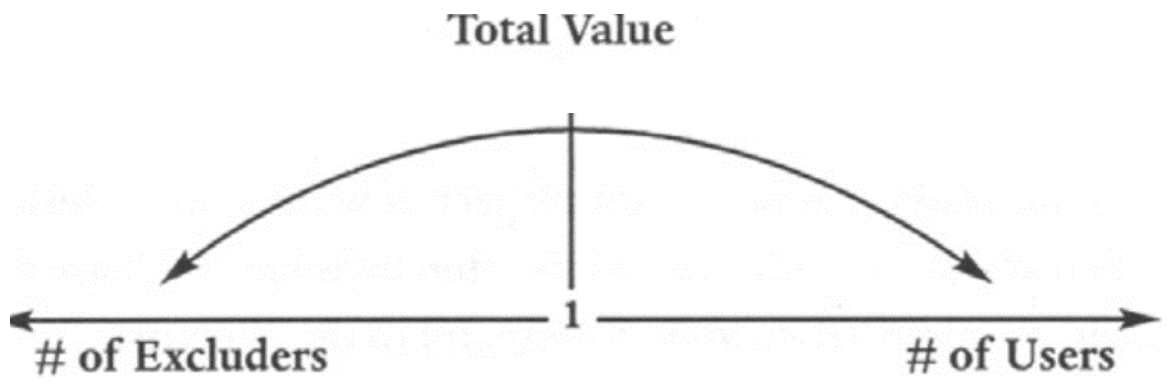

FIGURE 8: TOTAL VALUE DEPENDING ON THE NUMBER OF USERS OR EXCLUDERS (HELLER, 2013)

The symmetry of Commons and Anticommons is an important aid to understand the concept of Anticommons and logic behind them as the former ones are better researched and understood. However, in their study "From Tragedy to Disaster", Vanneste et al. (2006) conclude that the two concepts are not symmetrical. They show that the price setting in an anticommon is even more restrictive and that even more revenue is lost zhan the game theoretic solution and the outcome of the same game with quantity setting predict (Vanneste et al., 2006). This outcome is in line with loss aversion. Giving someone a permit or selling something one already owns leads, according to the concept of loss aversion, to the asking of higher prices.

5.5. Anticommons as mean for environmental protection

A common good exists when multiple owners have use but no exclusion rights. An anticommon good is the laterally reversed case, where multiple owners have the exclusion but not the usage rights. The latter one is subject to underuse, the former one prone to exploitation. From an economic point of view, both are not efficient. However, using a resource less than economically optimal can be beneficial for the environment. Especially if an area is prone to overuse, like Commons are. The usual economic approach to protect the environment and to use non-renewable resources in a socially optimal way, is to include external costs (the costs the use of the resource imposes on the whole society) in the calculation of prices and costs. Taxes, subsidies, royalties and so on can be added to the market price and shift the equilibrium to a more environmentally-friendly and optimal solution. The other economic approach is to determine who has the right to pollute or the right to a pollution-free environment. Assuming zero transaction costs and full information this will lead to a solution that incorporates external costs without any state intervention (Coase Theorem). However, the exact amount of external

costs is rarely known and perfect markets can hardly be assumed in any case. Command and Control mechanisms do not require the exact knowledge of the externalities, but they need strong institutions that have the right and power to command and even more important to control the compliance with the regulations. Antarctica´s environmental and geographical circumstances make it nearly impossible to figure out potential externalities from using one of its resources. The geopolitical situation as well as the unsolved question of claims and property-rights add to the difficulties to use common approaches for environmental protection.

Anticommons are not an instrument to avert environmental degradation or to promote a behaviour that includes external effects in the decision-making process. Anticommons are a type of good that has the characteristic to be prone to underuse. It is this Tragedy of the Anticommons, the non-efficient use of a good that can be used to protect resources. The main advantage is that neither knowledge of external costs, nor property-rights (however, exclusion rights are necessary), nor strong institutions are required to create and use an Anticommon. Additionally, a change in the preferred use or valuation of a good or area as well as a change in the circumstances can easily be incorporated as they affect the willingness to pay and accept. This is important for long-term protection of a resource or environment as our ideas of conservation may differ greatly from the wishes of future generations (Mahoney, 2001) For example, if the oil price increases and modern technologies for drilling in an icy environment were developed, then the oil firms´ willingness to pay to get drilling rights increases. On the other hand, if public opinion and political support depends on the well-being of Antarctic animals, then the price for harming them will increase.

Using the concept of Anticommons for resource conservation is done in the US. The property-rights for a piece of land with "natural beauty and value" were split between the owner and the state. The former full proprietor had a continuous right to live on the land but had to conserve parts of it as natural habitat. The owner was compensated for this restriction. (Mahoney, 2001). Separating the full property-rights in two distinct groups (ownership and the right to live on the land but no right to sell or alter the property) turned the former private good in an Anticommon. The result was the conservation of the parcel but also an inefficient underuse in terms of monetary values, since the owner had no right to use the country for anything else but living.

Applying the concept of Anticommons for environmental conservation or the protection of resources is nothing new and though it may lead to inefficient underuse and is not designed for efficient resource conservation, it is a further and promising concept to protect the environment from exploitation. Especially, since it does not require the exact knowledge of external costs, perfectly operating markets or strong and credible institutions.

The Tragedy of the Anticommons and its game- theoretic representation shows that underuse arises if more than one "owner" has the right to set a price for the use of the good. E.g. if a party A as well as a party B can each set a price, and both must be paid to be able to use the good. Also, transaction and bargaining costs to acquire a permit of each owner of a good create an Anticommons situation with price setting. Those are both examples for fragmented property rights. Another possibility to have an Anticommon is to give each involved party exclusion instead of use rights. It allows the owners or in this case the excluders to veto any kind of use or to set a certain price for not vetoing. This can be quite literally a monetary value, or it can be the costs a potential user faces to convince every party to allow the use of the good or resource. Heller (2013) notes that most international agreements with strong veto-powers, or turning the idea of prohibition around, with the requirement for unanimity are in fact Anticommons, since every member needs to agree. Unity and a joint support for a cause is usually accompanied by lengthy negotiations and high bargaining and transaction costs.

The added costs and the inefficient underuse of an anticommon resource lead to an unintentional conservation of it. Of cause this conservation is unlikely to be optimal, since the probability to be at exactly the point that would be best under the consideration of external and social costs is very small. Furthermore, a complete conservation, no use at all, is unlikely as well. Therefore, the number of price setters would need to be very large (the price very high) or the willingness to pay of the potential users would be required to be extremely low.

Although Anticommons are not an intentional instrument for resource conservation and environmental protection, the fact that the Tragedy of the Anticommons is subject to inefficient underuse compared to the efficient use by just one player, makes it an additional option for environmental protection. The conservation will most likely be non-optimal (compared to other instruments, designed for resource conservation) but the main advantage is that it can be used in cases with unknown externalities, weak institutions or not clearly defined property-rights.

6. Antarctica as an Anticommon

6.1. From Common to Anticommon

The example of the early whalers and sealers made clear that Antarctic resources were prone to become Commons and to suffer from the Tragedy of the Commons once it was possible to use them (technically and economically). So far, most resources were protected from exploitation by being inaccessible. This protection will not last forever and one after the other, Antarctic resources will be open for exploitation and potentially face the Tragedy of the Commons. The concept of Anticommons is an approach, though not intended for environmental protection in principal, that can be applied to conserve Antarctic resources or at least save them from the Tragedy of the Commons. Anticommons build on fragmented property-rights, which are on a par with giving all involved parties (more than one of course) veto or exclusion rights. Though they are not an intentional instrument for resource conservation and the Tragedy of the Anticommons is, in terms of total revenue, as inefficient as the Tragedy of the Commons, they have the advantage of requiring only little to work and thus to protect resources from overuse. This makes them an interesting approach for an area like the Antarctic, where property-rights are undefined, institutions inexistent or weak and external effects only little known. Furthermore, Anticommons allow for changing preferences and technologies, since they will be included in the willingness to pay and to accept.

The question now is how to turn a common good (Antarctica without any regulations, institutions and so on) into an anticommon good. Usually, it is only considered how to privatise a Common or how to align use and exclusion rights. However, this consideration is incomplete, since the case of full exclusion but no usage-rights is neglected (Heller/ Dagan, 2001).

Including Anticommons to the ridge of goods sorted by use and exclusion-rights adds a fifth type and antipode to Commons. Although they are on opposite sides with regards to property-rights, they have many common characteristics. The game-theoretical examination followed by the comparison of both types of goods shows the differences and similarities that exist. On one end there are Common goods with full use rights but no or only little exclusion rights (*see Figure 9*). The decision makers maximise their utility by choosing the quantity Q. For Anticommons, the utility is maximised with respect to P and the exclusion rights exceed the rights to use the good (*see Figure 9*). Thus, the main difference is that in one case we have price-setting for Anticommons (allowing other people to use the good but not using it itself) versus quantity-setting for Commons (using the good but not being able to exclude others).

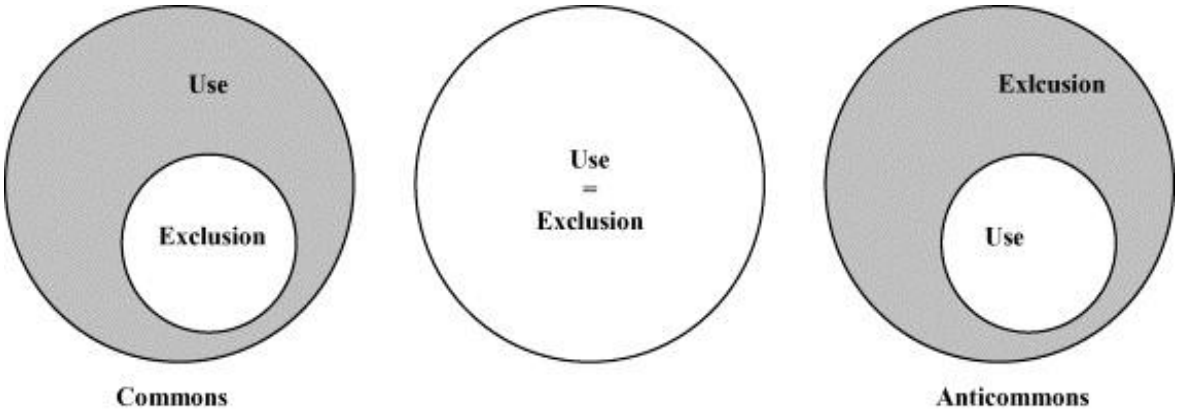

FIGURE 9: USE AND EXCLUSION RIGHTS FOR DIFFERENT TYPES OF GOODS (VANNESTA ET AL., 2006)

To turn a Common into an Anticommon and vice versa, the rights to use and to exclude need to be reversed. From Common to Anticommon can be compassed by fragmenting the property-rights of the good, either by literally dividing the good or by giving different parties different rights. Anticommons can be the aspired goal, as in the case described in Mahoney (2001), where the rights to lands with extraordinary beauty was split between the U.S. and the original owner. However, Anticommons can also be the unintentional outcome of the attempt to solve the Tragedy of the Commons and lead to an outcome as inefficient as the starting point (Ciriacy-Wantrup/ Bishop, 1975). E.g. the opening of grocery and other shops in the former Soviet Union was overly regulated and several permits were needed to use them like private property (Heller, 1998). This led to an underuse of the existing shops and sometimes to no use at all resulting in and suppliers starting to set up new stores just outside the overly regulated sales floors (Heller, 1998). Those examples suggest that it is not only possible to turn a Common into an Anticommon but that it may be easier than turning it into a private good. Speaking in terms of Figure 9, swapping use and exclusion rights is less complex than equalising them.

The premise in Antarctica was a typical Common with no property-rights at all. The seas were used by every seafaring nation and the continent, though the first to land was the Russian Bellingshausen, was claimed by more than one nation.

Dividing the Antarctic in small lots and hence fragmenting the property size is one possibility to turn it into an Anticommon, whereas the other one is to allocate (full) exclusion rights to all involved parties. For both approaches a strong "Antarctic institution" or full cooperation among all parties is necessary to decide in detail about either the dividing of land as well as sea or the allocation and design of exclusion rights. Creating a strong and supranational Antarctic institution or passing every decision-rights to the United Nations (UN) was opposed by the seven original claimants, the United States and the Soviet Union (Day, 2013). Creating an own, strong institution to govern Antarctica has its own challenges and none of the (potential)

claimants was and is willing to give up its (potential) claims. Furthermore, dividing the continent and the surrounding seas in small parcels faces several difficulties, most of which are far from finding any solution. The first is, that different Antarctic areas are of different use. The coast as well as the oceans for example, are accessible, many other parts of Antarctica are hard to reach and even harder to use for living, science or economically. The geographical and the magnetic South Pole are each of geopolitical as well as psychological meaning. On top of that come sites of historical importance to some countries, e.g. the huts of early fishermen, explorers and adventurers (Day, 2013). The second problem is, that, especially the peninsula is claimed by more than one country. Thus, allocating it to one will necessarily create resentments. Hence, a strong and powerful organisation seems out of reach as well as fragmenting the Antarctic region in small parcels is very difficult and probably not enforceable. This leaves only voluntary cooperation among the involved parties and the arrangement of exclusion over use rights to turn the common into an anticommon good.

The cooperation during the IGY was a good base to build on and to find a solution to protect Antarctica as well as every party´s interests in it. The Antarctic Treaty was designed to conserve Antarctica but not to resolve the claims (Dodds, 2010). It is an institution that gives no one use rights but everyone exclusion rights. The Treaty and subsequent agreements ban certain activities, e.g. nuclear waste disposal or military actions, and fosters cooperation and peaceful, unanimous decision making. As every convention must be reached via consensus, every member has a de facto veto right and can prevent the implementation as well as execution of any subject. Although the concept of the Anticommons is built on the notion of fragmented property or shared property with many excluders, giving every party a veto right yields the same outcome and circumnavigates the difficult topic of property rights and claims.

6.2. Antarctica Today: The Antarctic Treaty System

The Antarctic Treaty followed the successful execution of the IGY in 1957-58 and promotes peaceful cooperation while circumventing any potential conflicts. It was signed in Washington D.C. on the 1st of December 1959 by the 12 nations that conducted research during the IGY. All seven claimants as well as the five non-claimants ratified the Treaty. It entered into force on the 23rd of June in 1961. As of today, 17 further Consultative parties and 24 non-consultative parties joined the AT. The former have research facilities and a special interest in Antarctica. Both a criterion to participate in active decision making and voting. Non-consultative parties can make suggestions, provide advice and be part of discussions and meetings, however, they have no voting power. The Treaty itself has 14 articles, with the first four being the most important and the backbone of the Treaty.

> *"Antarctica shall be used for peaceful purposes only (Art.I)*
>
> *Freedom of scientific investigation in Antarctica and cooperation toward that end … shall continue (Art. II).*
>
> *Scientific observations and results from Antarctica shall be exchanged and made freely available (Art. III).*
>
> *No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica or create any rights of sovereignty in Antarctica. No new claim, or enlargement of an existing claim to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force. (Art. IV)"* (Antarctica Treaty, 1959, 1961)

Freedom, cooperation and peaceful use for scientific research are the values promoted as well as supported by the Treaty. Any claims

Treaty Members (53)

Original Members (12):

Claimants (7):
Argentina
Australia
Britain
Chile
France
New Zealand
Norway

Non-claimants (5):
Belgium
Japan
South Africa
United States
Russia (former Soviet Union)

Consultative Parties (17):
Brazil
Bulgaria
China
Czech Republic
Ecuador
Finland
Germany
India
Italy
Netherlands
Peru
Poland
South Korea
Spain
Sweden
Ukraine
Uruguay

Non-Consultative Parties (24):
Austria
Belarus
Canada
Colombia
Cuba
Denmark
Estonia
Greece
Guatemala
Hungary
Iceland
Kazakhstan
Malaysia
Monaco
Mongolia
North Korea
Pakistan
Papua New Guinea
Portugal
Romania
Slovakia
Switzerland
Turkey
Venezuela

and questions of sovereignty will not be considered while the Antarctic Treaty is in force. The remaining eight articles forbid any nuclear testing or waste disposal (Art. V), define the geographical area the Treaty refers to (Art. VI) and give all members the rights to observe and investigate what the other parties are doing in Antarctica (Art. VII). Article VIII regulates the jurisdiction of the researchers as well as staff and defines that any potential conflict must be resolved by peaceful means until the reaching of a unanimous agreement. Regular meetings of all Treaty signatories (Art. IX) as well as the promotion of it (Art. X) are defined and Article XI provides the procedure that shall be followed in the event of a conflict between one or more parties. "Those Contracting Parties shall consult among themselves with a view to having the dispute resolved by negotiations, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their choice" (Art. X, Antarctic Treaty, 1959, 1961). The remaining articles deal with the admittance of new members, the signing and ratifying, the modifications and amendments of the Antarctic Treaty and the versions of the agreement in Russian, French and Spanish.

The Antarctic Treaty, together with other agreements and arrangements regulating the relations between and behaviour of the Treaty members within Antarctica is called the Antarctic Treaty System (ATS). The most important documents of the ATS, apart from the Treaty, are the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) (1982), the Convention for the Conservation of Antarctic Seals (CCAS) (1972) and the Protocol on the Environmental Protection to the Antarctic Treaty (1991, 1998). There are regular meetings of the members, the Antarctic Treaty Consultative Meetings (ATCM) to consult on and discuss present issues and topics. They are hosted annually by one of the Treaty members. Furthermore, the Scientific Committee on Antarctic Research (SCAR), the Committee for Environmental Protection (CEP), the Antarctic and Southern Ocean Coalition (ASOC) and the International Association of Antarctica Tour Operators (IAATO) participate in the meetings and support them with expertise (Secretariat of the Antarctic Treaty, 2011).

In 2004, a permanent secretary located in Buenos Aires, Argentina, was established. Having a permanent body became necessary as the number of members grew and organisational tasks became more diverse (Scott, 2008). The duties of the secretary are general administration, organisation and the supply, circulation and archival storage of information (Scott, 2008).

The ATS is a decentralised, flexible and dynamic system, which gives all consultative members equal power. It relies on consensus and cooperation rather than on control and punishment. The system is enlarged whenever a new issue or topic arises. This keeps the ATS flexible and

adjustable to innovative technologies and new opinions. Thus, nothing is forbidden forever and even the purpose of peaceful cooperation could be reversed if the members wished to do so. Every area is subject to its own institutional body (Koivurova, 2005) and every resource is viewed as well as protected separately, making it possible to include all specifics and to adjust to changing technologies, interests or issues.

6.3. Cooperation under the Antarctic Treaty System

The ATS and its regulations are not binding, and punishment is neither included nor intended. However, the parties managed to sustain cooperation and to protect Antarctic resources. The treaties, protocols and amendments command environmental protection but they cannot control or prosecute. Cooperation and compliance is beneficial for the involved parties and they do so out of free will. The ATS regulates an area and a topic that is not a priority in many countries´ interests and most of them are neither willing to start a war over it, nor to resign their interests. The Treaty and the careful formulation of it are the cornerstone of the wide acceptance and inclusion of all parties. (Dodds, 2010). It is not the purpose of the ATS to solve the issues of the claims. Freezing and postponing the question of property-rights as well as claims enabled all parties to sign up to the ATS, while still preserving their individual and collective future options (Dodds, 2011). An additional point, equally important for the voluntary cooperation among the member states, is the fact that most Antarctic resources are of little economic value. Thus, the benefits of using them and the potential profits are rather small compared to a) the costs of extraction and b) the costs of non-compliance. Not cooperating, although not directly punishable by the ATS, can have different and costly consequences. The first one is extensive negotiations with the other treaty members, since this is the mandatory proceeding in cases of violations. Additionally, the other parties can pressure the free-rider out of the Treaty, e.g. by less research cooperation or on international or political levels, that are not related to Antarctica. The third costly consequence is public and political pressure. Non-governmental organisations, like Greenpeace or *Seashepherd* take care that the public knows about any Antarctic incidents. For example, *Greenpeace* made headlines when activists blocked the building of a French airstrip in Antarctica and the plans were eventually given up (Greenpeace, 2001). Australia and France refused to sign CRAMRA, an agreement which was prepared with their help, due to public pressure by environmentally concerned citizens (Blay/ Tsamenyi, 1990).

This shows, while there are no punishment mechanisms incorporated in any agreement or treaty under the ATS, non-cooperation is still costly and makes it less attractive to violate the Treaty System. Furthermore, the flexibility and openness of the ATS allows for potentially anything

whilst all Treaty members agree on it. The expected costs of breaching the contract and exploiting the resources must be lower than the expected benefits by doing so. Moreover, they must also be lower than the expected costs of reaching an agreement that allows for the exploitation under the ATS. Thus, the Treaty System will last so long as mutual agreements are less costly than violating the contract and Antarctic resource exploitation offers only little expected benefits.

6.4. From Common to Anticommon: The ATS in practice

Without any institution, Antarctica is a Common as the example of the early sealing and whaling shows. The reason why other resources were not exploited so far, is purely technical and not due to environmental concerns. It was just not possible to mine or drill on a continent completely covered in ice and subject to fierce winds as well as extremely cold temperatures. However, technical progress will eventually open any resource to exploitation. It was not necessary to protect the complete continent and surrounding waters at once, but many different issues came up one after the other. In the beginning, the prevention of conflict or any military actions were the most crucial points. This was followed by the protection of seals, once the interest in sealing arose again. The next topic was the regulation of all marine living resources. Mineral exploitation and a general environmental protection were the topic in the 80s and early 90s (Suter, 1991). Today´s challenges are the increasing number of tourists, the use of the potable water and the effects of climate change.

The gradual inclusion of new topics and emerging issues demonstrates the great flexibility in addition to the capability to respond to changing interests as well as valuations. A good example therefore is the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) which was intended to regulate mineral exploitation. It was agreed upon and signed. However, by the time of ratification the preferences of Australia and France had changed and the public concern for environmental degradation due to exploitation was increased. Subsequently, the CRAMRA was never fully ratified and the Environmental Protocol banned any mining activities at all.

A major contribution to the success of the ATS, the inclusion of that many members and the distribution of equal representative participation is the absence of any indigenous inhabitants that have special entitlements (Koivurova, 2005). Every involved, consultative party is granted a veto or exclusion but no use right, which is one option to obtain an Anticommon. This is, as noted earlier, the only practical option for Antarctica, since it is hardly possible to fragment the ownership in any other way. The Antarctic Treaty does neither weaken nor strengthen the

claims and it has no intention of solving the property-rights question. It is merely designed to manage Antarctica (Dodds, 2011). Once the stewardship of an Antarctic resource is dealt with in the ATS, all members must agree to any action that affects the said resource. Decisions to alter the regulations require unanimity (except in the CASS where a two thirds majority is sufficient).

Of course, not all members are equal. They all have distinctive characteristics, preferences and possibilities but all can veto or prevent any actions and decisions, which they do not support. There is not one superpower, but a group of nations equipped with the same rights and obligations (Scott, 2008). Without one strong leader there is also no watchdog or superior government, everyone must follow. Consensus and cooperation are the keys and any dissension must be resolved by peaceful means.

Discussing with every decisive member makes decision processes slow and costly, which adds to the price in the theoretical price-setting model used above. Slowing down the process does not only increase the transaction costs due to direct financial implication but also by requiring plenty of time that could be used otherwise and more productively.

Lengthy discussions and wide time frame to reach an agreement are not unusual. An example for this is the creation of the permanent secretary took from 1985 to 2004. Nearly ten years passed before a general recognition of the need for a permanent body was unanimous but even after that it took a further decade to agree on the details (Scott, 2008).

Although every decision takes a long-time which may be economically inefficient, and the consensus approach adds to the transaction costs, the ATS is still flexible as well as adjustable to recent technologies and a change in interests.

Modelling the Antarctic Treaty System in general can only be a mere sketch, as it is impossible to know countries´ exact preferences or to identify monetary values for bargaining and transaction costs. Especially, since not everything is measured in monetary units, e.g. existing networks, rights or a historical sense of belonging.

But allowing for some details and alignments to match the reality of the ATS, whilst staying as close as possible to the simple model used to show the mechanisms of an Anticommon, demonstrates that the ATS does in fact turn a common resource into an anticommon resource. In the simple model, every decision maker maximises his or her expected profit or utility by choosing a price P_i . The sold quantity Q depends on the total price P, that is the sum over all P_i. The individual decisions can be reached simultaneously or sequentially. So far, the utility or profit function and the number of players were of no concern.

For the ATS, there are two distinct groups of players; the actual decision makers, the 29 consultative parties, which are empowered to veto any suggestion made and the 24 non-consultative parties. The latter group has no veto rights but participates in the negotiations and can suggest topics. All Treaty members can put alterations to the Treaty forward, hence to propose the use of a resource but only the 29 consultative parties are authorised to vote and veto any proposed alteration which is equal to set the price for their non-vetoing. Price setting happens via transaction costs. Every member can block negotiations and decisions, require special clauses in the treaty or use any other monetary and non-monetary persuasions. The actual profit or utility of each country depends not only on the price but also on the outcome. Since any alteration of the treaty directly affects the decision-making party, it must consider what the impacts are for the country itself. For example, allowing for the drilling of oil does not only benefit the requestor but has some economic implications for any member of the ATS. Hence, the utility is a function of the gains by negotiating and opening the resource to use as well as the implication this has for the country i itself: $U_i = f(P_i * Q, Outcome)$. f is different for every party and reflects its preferences. The utility of a certain outcome can be positive or negative and depends on the interest of the respective party. P_i can be monetary or non-monetary. For the demand side it can be summarised as any transaction cost that comes up and must be rendered to reach an agreement.

The 29 players can play sequentially forever, which leads to the same solution as playing simultaneously.

$$\max_{P_i, Outcome} U_i = \left(\frac{a-P}{b}\right) * P_i + U_i(outcome), \text{ for } i = 1,2\ldots,29$$

Since the first part of the equation is identical with the example equation in section 5.3., the outcome and the interpretation of the outcome will be identical, too. Although, the players are not symmetrical and thus, will not have the same price that maximises their utility, the implications are the same. More players result in a higher total price and a lower total quantity supplied. This is a typical Anticommon and results in less use of the Antarctic resources than would be economically optimal.

Summarising, the ATS equips its members with partial or full veto rights and gives them thereby exclusion instead of usage rights. The need for unanimity, consent and peaceful cooperation makes decisions slow and adds to the transaction costs or put differently increases the price every excluder chooses, but it also leads to compliance with the agreed-on results. Furthermore, the ATS is a flexible system that can incorporate changes in technologies as well

as valuations/interests that are mirrored in the willingness to pay and to accept or in the utilities of the members. Thus, the Treaty System manages to turn the "Common Antarctica" into an "Anticommon Antarctica" for every considered resource.

6.5. Anticommons in practice: Examples

As noted before, the ATS consists of several treaties, protocols and amendments. The main document is the Antarctic Treaty itself, dedicating the continent and the surrounding seas to scientific cooperation while freezing any claims. The other parts of the ATS cover different, usually resource or environmentally related, issues. Upcoming or novel issues will either be included in an existing document or a new one will be drawn up and agreed upon. Hence, every resource that is technically and economically exploitable and thus endangered to become a Common can be transformed into an Anticommon by giving it its own part under the ATS.

6.5.1. Sealing under the ATS

After the population of the seals declined in such a way that it was economically not feasible anymore to hunt them, the industry died out in the Antarctic area. When some countries started hunting for seals again the by then existing ATCP prompted research on the seal population. Eventually, the results led to the CCAS agreement, which was the first under the ATS and regulated sealing and any potential sealing industry in the future (Hofman, 2016). The CCAS turned the former Common in an Anticommon, as every activity needs the approval of at least two thirds of the members. Hence, any sealing intentions or the development of a new industry face high transaction costs of bargaining and securing the support of two thirds of the parties increasing the price for sealing and making it less attractive. Therefore, the threshold of starting the business is much higher leading to an underuse of the resource, compared to the monopoly result or the use under being a Common.

6.5.2. Fishing and krill-fishing

The resources fish and krill were long protected by the remoteness of the Antarctic region. Weather, climate and distance made it economically inefficient to catch them. However, this changed in the early 1960s when some species of toothfish were heavily exploited and at the verge of extinction in some areas (Commission for the Conservation of Antarctic Marine Living Resources, 2013). This and the fear of an overfishing of krill, which was little researched by that time, led to negotiations in 1977 (Constable et al., 2000). The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) entered into force in 1980. The covered area consists of all waters adjunct to the Antarctic continent and "represents around 10 percent of the Earth's oceans and has a surface area of 35 716 100 km²." (Commission for the Conservation of Antarctic Marine Living Resources, 2018).

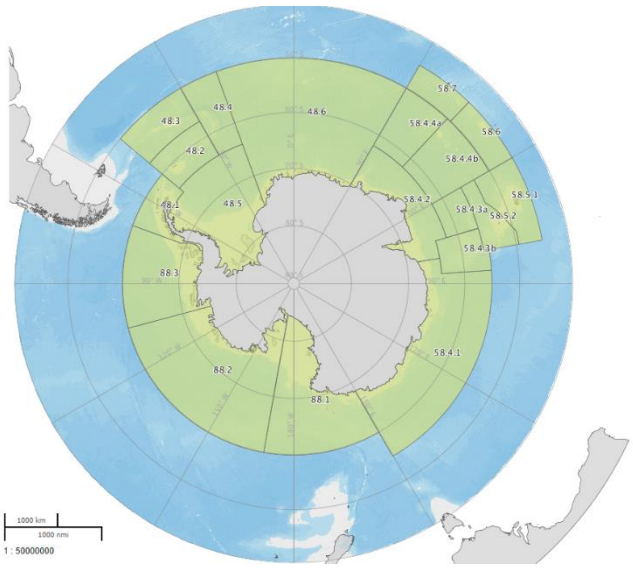

FIGURE 10: AREAS SUBJECT TO CCAMLR (COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES, 2018)

The CCAMLR is an integral part of the ATS, but members of the latter are not automatically members of the Convention. 25 countries with either an interest in fishing or a scientific interest are part of the CCAMLR and decisions are made by consensus (Constable, 2011). Additionally, a special scientific committee is part of the CCAMLR. Its main responsibility is to advise on the catch quotas and to conduct research to this end (Constable et al., 2000). The Convention on the Conservation of Antarctic Marine Living Resources applies to all marine living resources within the covered area except whales and seals which are subject to other international agreements (Commission for the Conservation of Antarctic Marine Living Resources, 2014). The approach is a precautionary one in the sense that nothing is allowed until it is regulated and incorporated in the CCAMLR such as, using new methods for catching or starting to fish for a new species (Constable et al., 2000). The core themes and the backbone of the CCAMLR are:

> "a) the prevention of decrease in harvested populations to levels below those which ensure stable recruitment;

b) the maintenance of ecological relationships between harvested, dependent and related populations;

c) the prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two to three decades." (Constable, 2011)

The Convention was created due to fear of overexploitation, extinction of certain species and irreversible ecosystem damage. It was never intended to prohibit fishing but to regulate it and the decisions are based on the best scientific knowledge available (Constable, 2011). The focus of the CCAMLR changed over time; from the recovery of overfished species to establishing a process that regulates fishing in general, to targeting unregulated and illegal fishing and currently developing an approach to krill fishing as well as protecting the ecosystem (Constable, 2011). By now, most of the members have a direct interest in fishing but less so in science (Constable, 2011). "States are unlikely to give up their right to fish in perpetuity, but may be willing to temporarily defer that right to ensure sustainability of the fishery into the future" (Constable, 2011). Being part of the CCAMLR equips the countries with the power to shape and influence the Convention towards their own interests. The constant surveillance of fish stocks as well as the development of new technologies to do so, diminish the uncertainties related to sustainable catching and allows for higher quotas and more profits (Constable, 2011). The precautionary approach is clearly in line with Anticommons. Every decision, quota or regulation is based on scientific knowledge and any economic activity needs the approval of every member of the CCAMLR. Every decision is reached by consensus, and different interests and preferences must be aligned. However, long negotiations increase the transaction costs and since the Convention consists of two distinct groups, scientific and fishing interest, agreeing can take some time and the outcome is of foremost importance to the parties. The one group is clearly in favour of more fishing, whilst the scientifically interested countries prefer increased conservation. The approval to adopt certain decision rules on catch limits took four years and needs to be revised regularly to incorporate recent developments (Constable et al., 2000). The time-lag creates an economically inefficient underuse of the marine resources but protects them from premature exploitation.

Nonetheless, the CCAMLR shows only the flaws and weaknesses the approach of using an Anticommon for environmental protection has. First, resource conservation is not its main purpose or goal, hence it can also work against it as the case of the negotiations to join other marine protected areas (MPA) shows. Those areas have strict environmental regulations and

fishing is even more restricted. Additionally, the parties have less influence and the regulation of MPAs is less often revised and adapted to the needs of the members. They are a long-term conservation approach and a command and control instrument. The members of the CCAMLR were unable to reach consensus about the question of joining the MPAs, though the external pressure to do so was immense and extraordinary meetings were levied (Brooks, 2013). This raised the question if the actual interest of the CCAMLR parties lies in economic use of the fish or protection (Brooks, 2013). Furthermore, some members of the CCAMLR were opposed to joining the MPAs since this would mean giving up power and to lose the possibility to agree on conservation, use or exclusion (Brooks, 2013). Giving up negotiation power and losing the flexibility of the CCAMLR to include upcoming technologies and preferences was of major concern to some of the members of the Convention. The outcome of the negotiations is also supporting the view that, once an Anticommon exists, it is hard to reverse it and to extract the exclusion rights from their owners.

A further weakness of using an Anticommon for environmental protection lies in the way in which an institution is created to apply the Anticommon. In this case it is an international contract with voluntary participation and consensus-based decisions. The members will comply so long as it is beneficial for them and less costly than being a non-member or simply infringing against it. The (economic) benefits of either not partaking in CCAMLR or breaching it are such that some countries conduct illegal, unregulated or unreported (IUU) fishing (Constable et al., 2000). Although to tackle IUU fishing was a main concern of the CCAMLR, it was not possible to solve the issue or to enforce compliance (Constable, 2011). Hence, it is not the Anticommon situation as such that may break down but the institution, in this case an international, consensus-based convention, that is doomed to fail once benefits of non-compliance exceed the costs of doing so.

Since the benefits of fishing may exceed the benefits of staying in the commission, the existence of CCAMLR is not guaranteed. Though measures against IUU fishing are taken, they are not binding. Apart from the compliance issue, CCAMLR works well as an Anticommon and since everything needs to be discussed, the contract is evolving and incorporating recent scientific as well as technical developments. All members are actively interested in the outcome, since this is a prerequisite for being one. Furthermore, they need to agree on any catch related limit or regulation before it is possible to start fishing. Although there are only 25 members, this takes time and increase the transaction costs.

6.5.3. Exploration of Oil, Gas and Minerals

When thinking of resources, oil, gas and minerals are at the very top. Although there are only a few scientifically proven deposits in Antarctica and the exploitation is economically and technically hardly possible, the mere existence fuels the imagination of companies, politicians, the public and environmental protectionists alike.

The exploitation of those resources was very unlikely and not of imminent interest during the time the Antarctic Treaty was negotiated, thus, prospecting and mining were not included in the AT (Blay/ Tsamenyi, 1990). In 1970, a query to discuss a mineral regime came up for the first time, however, the first talk to do so was in the early 1980s and it took six more years and ten meetings to agree on the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) (Blay/ Tsamenyi, 1990). CRAMRA was designed to regulate and facilitate mineral exploitation, comparable to the Commission for the Conservation of Antarctic Marine Living Resources. Although the Convention was reached via consensus and signed by all participants, France and Australia later rejected to ratify it, which is why it is still not in force yet. The dismissal of CRAMRA by those countries was due to two main reasons. First, the distribution of royalties from potential mineral exploitation that is not defined in the convention. The issue came up during the negotiations and although Australia and France signed the Convention on the Regulation of Antarctic Mineral Resource Activities, they favoured a distribution to only claimant states, which was not supported by the non-claimant parties (Blay/ Tsamenyi, 1990). The second and decisive point were environmental concerns. CRAMRA requires a thorough analysis of (potential) impacts on the environment (Art. IV) as well as sufficient funds and strategies to offset any damages (Art. VIII) (Convention on the Regulation of Antarctic Mineral Resource Activities, 1988, not ratified). Nevertheless, human interaction with Antarctica, especially mineral exploitation is always a threat to the pristine area. The pressure from various interest groups as well as the public, fuelled by a ship accident in Antarctica and the sinking of the Exxon Valdez in the Arctic region both in 1989, finally led to the rejection of CRAMRA by Australia (Redgwell, 1994).

After it became evident that the Convention on the Regulation of Antarctic Mineral Resource Activities would not be ratified any time soon, the Protocol on Environmental Protection (PEP) was negotiated and agreed on in 1991. It entered into force in 1998 but several annexes are still due to be ratified. To find an agreement two points required special attention: issues of sovereignty and environmental concerns especially with regards to mining. The first was solved by not raising it which is like the approach of the Antarctic Treaty towards the question of property-rights (Redgwell, 1994). After increased pressure by the public, NGOs and third world

countries that feared to miss their share of potential gains from exploiting Antarctica, all mineral activities except for scientific reasons were banned (Redgwell, 1994).

Every decision under the PEP or an alteration of it has to be made unanimously giving every party full veto-rights. To give advice and to carry out specific research the Committee for Environmental Protection (CEP) was founded and participates in the meetings, however, without an active voting right. Arising conflicts must be solved peacefully and by reaching consensus in any case. The only exemption to this procedure are changes with regards to mining or drilling. In those cases, an alternative solution to regulate mineral activities must be agreed upon before the arrangements of the PEP can be resolved (Redgwell, 1994).

In contrast to the CRAMRA, the protocol is subject to renegotiations every few years and after 50 years it will be re-examined and modified if needed (Redgwell, 1994). Furthermore, a "`walk-away´ provision was added (…), which permits a State to withdraw from the Protocol upon two years' notice if any modification or amendment has not entered into force within three years of being communicated to the parties." (Redgwell, 1994). The possibilities to exit the Protocol or to alter it make it more flexible but also less stringent.

CRAMRA and the PEP differ in many ways. The most striking discrepancy lies within the approaches to mining and mineral exploitation. As the name is already suggesting the Convention on the Regulation of Antarctic Mineral Resource Activities regulates and facilitates those activities. The PEP on the other hand banns them completely.

By defining strict regulations for any mineral activities, CRAMRA can be interpreted as a Command and Control mechanism. However, the negotiations, the final rejection due to changed (public) interests as well as the agreement on the PEP underline the Anticommons situation. Once the more pressing issues of sealing and fishing (both were technically and economically feasible) were sufficiently cared for in the Treaty System, the parties turned to the topics of oil, gas and mineral exploitation. After it was not possible to agree on an institution that allows but strictly regulates mining and prospecting, the parties finally signed and ratified a protocol that satisfies the current interests of the participants (sovereignty and environmental concerns) but offers a greater flexibility. Although any mining activity is prohibited under the PEP, alterations of this are possible but require the consensus of all parties. Hence, every signatory has a veto-right as well as the right to launch a query to change the PEP and allow for mineral exploitation. Additionally, the requirement to have an alternative solution to regulate mining, drilling or prospecting before the Protocol for the Environmental Protection can be altered with regards to this, adds to the transaction costs.

The PEP clearly has the core characteristics of an Anticommon. Exclusion rights are guaranteed by giving any involved party a veto-right. Although mineral exploitation is generally prohibited, changing it is always possible but costly. The price to allow for drilling or mining is composed of the costs to bring every signatory party to agree on a new regime for mineral exploitation and to alter the PEP. The high transaction costs, i.e. the high price to use the goods oil, gas and minerals, lead to the Tragedy of the Anticommons and an inefficient underuse which, however, is protecting the Antarctic environment.

Apart from the fact that minerals, oil and gas are well-known non-renewable resources and the PEP a good example of how those can be turned into an Anticommon, the failure of the CRAMRA is significant as well. It shows that it is of greatest importance to be able to react to changes in technologies or interests and valuations. The public pressure and environmental concern led to a rejection of the convention especially after the ship accident in the Antarctic and Arctic. Furthermore, the issue of unsolved claims and anything related to it, e.g. royalties, will impede instruments for resource conservation like Command and Control mechanisms.

7. Shortcomings of the ATS and of Anticommons as conservation mechanisms

7.1. No regulatory power an no punishment mechanisms

The previously discussed protocol and conventions and how they manage to turn a good that is prone to become a Common into an Anticommon, show that the concept of Anticommons can be applied to protect the environment. The ATS is turning the Tragedy of overuse into the Tragedy of underuse, thereby conserving Antarctic resources. However, the main caveat is that compliance with the ATS and any of its Protocols, Amendments or Appendices is voluntary. Although the regulations within the Treaty System are binding international law, there is no institution with the power to enforce compliance or to punish in the case of violations (Hughes, 2010). The Treaty itself has no such mechanisms, but requires peaceful resolving of conflicts (Art. X, Antarctic Treaty, 1959, 1961). Monitoring human impacts of Treaty members is the duty of the other members, however, this is costly in a monetary sense but also in the sense that the countries want to keep goodwill and smooth diplomatic relations with each other (Hughes, 2010). Supervising or accusing other countries is not beneficial to that end and starting a diplomatic crisis over minor offenses on a continent no one lives on is not a viable option. The ongoing whaling by Japan in the name of science underlines this problem. Whaling is only allowed for research purposes and Japan has an unusually high demand for those licenses and

it is commonly known that the catch is sold. Still, the only reaction, which was provoked after *Seashepherd* published pictures "showing the slaughtering of protected whales inside Australia's Antarctic whale sanctuary" (Slezak, 2017), was that "The Australian government is deeply disappointed that Japan has decided to return to the Southern Ocean this summer to undertake so-called 'scientific' whaling," (Frydenberg cited in Slezak, 2017). Due to those missing enforcement mechanisms and the reluctance of the other countries to actively punish, compliance cannot be guaranteed but is voluntary. The moment it becomes more beneficial for a member to seize its participation in the ATS or simply not to comply anymore, it will do so. This may happen for several reasons, i.e. an increase in prices for Antarctic resources or advanced technologies that allow to access and exploit those resources more cost-efficiently. Without voluntary compliance as well as cooperation, the institution, the Antarctic Treaty System, and with it the mechanisms that turn Commons into Anticommons will break down and allow for exploitation.

7.2. Anticommons are a type of good and not an institution for resource conservation

A further shortcoming of using Anticommons and the Tragedy of the Anticommons for the protection of Antarctic resources but also for resource conservation in general is that it is not designed to protect or conserve resources. Anticommons are a type of good which happens to suffer from underuse instead of optimal use and in contrast to the overuse of Commons. This can be applied to use natural resources under the efficient level and thereby protecting them. However, the actual use will most likely be non-optimal as well, even under the consideration of external costs to third parties. Furthermore, once an anticommon exists, it is difficult to turn it into private property, since many owners need to give up their property-rights (Vanneste et al., 2006). The unwillingness of the member parties of the ATS to hand over any rights to the United Nations or to create a common world park supports this. Already the creation of a Marine Protected Area with indefinite time-horizon was opposed by some CCAMLR countries as they refused to give up their rights to make decisions and to control.[4]

The main advantage Antarctica has and the main reason why it is possible to protect the Antarctic resources are the already high costs of accessing as well as exploiting. Turning the goods that are prone to become Commons due to the lack of clearly-defined property-rights, into an Anticommon by giving every member a veto-right, adds further to those costs. Thus,

[4] See section 6.5.2.

mining, drilling, sealing and so on become economically not viable. For fishing, the costs and benefits of the CCAMLR are such that compliance with the convention and sustainable harvest of fish and krill are beneficial. To guarantee this, catch limits, types of fish and allowed techniques are constantly reviewed and adapted.

However, resource protection through Anticommons will only last until potential buyers are willing to pay the higher prices for the access and use. This scenario has two possible outcomes; one option is that the Treaty is adjusted in such ways that it is still beneficial to participated, which means that it needs to allow for resource exploitation (like the CCAMLR). The other option is the complete break-down of the Treaty System, which also means turning the Anticommon back into a Common and returning to the situation before the Antarctic Treaty and the IGY.

8. Conclusion

Antarctica is one of the last pristine wildernesses. Still it offers resources, e.g. minerals, oil and gas but also fish, krill or other animals. Additionally, Antarctica is the largest storage of potable water. The most accessible resources though are its values for scientific research as well as for tourists. Since the claims and thus property-rights are not settled, the continent is theoretically open to everyone, also for every kind of use or exploitation. Hence, Anatarctica resources are a Common good and may suffer from the Tragedy of the Commons. The exploitation of seals and whales as well as some fish species before the regulation under the Antarctic Treaty System underlines this. Environmental protection through well-tried mechanisms, e.g. taxes or cap and control mechanisms cannot be guaranteed mainly due to undefined property-rights but also due to extreme uncertainties with respect to external effects. However, the fact is that Antarctic resources do not suffer from exploitation. The reason therefore is that most resources were turned into Anticommons. Although Anticommons are not a mechanism designed to guarantee environmental protection or resource conservation, the economically inefficient underuse which is the so-called Tragedy of the Anticommons ensures that resources are used less or not at all. The situations are laterally reversed to the Tragedy of the Commons. Both lead to a loss in total revenues, the former by overuse (the quantity is too high and the price too low), the latter one by underuse (the price is too high; thus, the quantity is too low). For Commons, the involved parties can use the good but not exclude any other party from using the good, too. For Anticommons, use rights are not required but exclusion or fragmented property- rights, allowing the parties to exclude others from the use or to ask a certain price for the use of the

good. Thus, the allocation of clearly-defined property-rights, where use and exclusion are guaranteed to the one and the same party are not necessary. Furthermore, use rights do not need to be defined at all, since it is only necessary to be able to exclude others from the (potential) use of the good. Additionally, externalities can be disregarded, which makes it a feasible method to protect Antarctic resources without touching the claims or requiring exact knowledge about externalities. Thus, the unsettled claims and undefined property-rights situation of Antarctica is irrelevant and does not influence the Anticommons situation. Only exclusion-rights need to be defined and this is done by the Antarctic Treaty System. Since 1961, the Antarctic Treaty and its adjoint Committees, Conventions and Protocols manage to protect Antarctic resources. A good starting point to find such a solution was the International Geophysical Year. The exemplary cooperation during the IGY was taken a base to negotiate and agree on the Antarctic Treaty. The Treaty dedicates the area to peaceful scientific cooperation and freezes any question of claims. Furthermore, agreements must be consensus based as well as unanimous giving any member effectively a veto-right to prevent any use or decision. The power to block any arrangement is an exclusion right, thus every member can set a price (through bargaining and transaction costs) for its approval to any suggestion. The price-setting characteristic for a good with fragmented property rights makes Antarctic resources regulated under the ATS subject to underuse, since every member sets a price above the efficient price-level. Although the underuse is economically not optimal, it is conserving the good, in this case resources. Of course, Anticommons are not a general solution to the exploitation of resources, since they are not designed for it but can merely applied to guarantee a certain underuse of a resource, which is neither economically nor ecologically optimal. However, their main advantage compared to other institutions or mechanisms for environmental protection, that might generate more efficient outcomes, is that they require less presumptions, foremost, clearly-defined property rights are not necessary. This makes the concept of Anticommons for environmental protection very interesting for upcoming problems like the regulation and protection of undefined spaces like the moon or outer space in general.

III. Bibliography

Antarctic and Southern Ocean Coalition (2018a), *Antarctic Environmental Protection*, Antarctic and Southern Ocean Coalition, 22.01.2018. https://www.asoc.org/advocacy/antarctic-environmental-protection

Antarctic and Southern Ocean Coalition (2018b), *Biological Prospecting*, Antarctic and Southern Ocean Coalition, 16.04.2018. https://www.asoc.org/advocacy/antarctic-environmental-protection/biological-prospecting

Antarctic and Southern Ocean Coalition (2018c), *Climate Change and the Antarctic*, Antarctic and Southern Ocean Coalition, 16.04.2018. https://www.asoc.org/advocacy/climate-change-and-the-antarctic

Antarctic and Southern Ocean Coalition (2018d), *The Antarctic Oil Myth*, Antarctic and Southern Ocean Coalition, 22.01.2018. https://www.asoc.org/component/content/article/9-blog/1184-the-antarctic-oil-myth

Antarctic Climate & Ecosystem Cooperative Research Centre (2015), *Ace Project R1.1: The Southern Ocean in a Changing Climate*, Antarctic Climate & Ecosystem Cooperative Research Centre, 16.04.2018. http://acecrc.org.au/project/southern-ocean-in-a-changing-climate/

Antarctic Treaty (1959, 1961), opened for signature 01.12.1959, entered into force 23.06.1961.

Australian Antarctic Division (2002a), *Antarctic environment*, Department of the Environment and Energy: Australian Antarctic Division, 18.03.2018. http://www.antarctica.gov.au/about-antarctica/environment

Australian Antarctic Division (2002b), *Antarctic prehistory*, Department of the Environment and Energy: Australian Antarctic Division, 18.03.2018. http://www.antarctica.gov.au/about-antarctica/environment/geology/antarctic-prehistory

Australian Antarctic Division (2012a), *Human impacts in Antarctica*, Department of the Environment and Energy: Australian Antarctic Division, 18.11.2017. http://www.antarctica.gov.au/environment/human-impacts-in-antarctica

Australian Antarctic Division (2012b), *Pollution and Waste*, Department of the Environment and Energy: Australian Antarctic Division, 18.11.2017. http://www.antarctica.gov.au/environment/pollution-and-waste

Backovic, L (2013), "Rust and Ruin: The Downfall of Antarctic Whaling", *Spiegel Online*, 08.10.2013. http://www.spiegel.de/international/zeitgeist/history-of-the-grytviken-whaling-station-near-antarctica-a-926711.html

Basberg, B (2006), "Perspectives on the Economic History of the Antarctic Region", *International Journal of Maritime History*, vol. 18 (2), pp. 285-304.

Basberg, B (2017), "Commercial and economic aspects of Antarctic exploration – from the earliest discoveries into the "Heroic Age"", *The Polar Journal*, vol. 7 (1), pp. 205-226.

Blay, S & Tsamenyi, BM (1990), "Australia and the Convention for the Regulation of Antarctic Mineral Resource Activities (CRAMRA)", *Polar Record*, vol. 26 (158), pp. 195-202.

Brain, M (2000), *If the polar ice caps melted, how much would the oceans rise?*, HowStuffWorks.com, 17.04.2018. https://science.howstuffworks.com/environmental/earth/geophysics/question473.htm

British Antarctic Survey (2015), *Discovering Antarctica: Antarctica´s Climate: Key Factors*, British Antarctic Survey: Natural Environment Research Council, 11.11.2017. https://discoveringantarctica.org.uk/oceans-atmosphere-landscape/atmosphere-weather-and-climate/key-factors-behind-antarcticas-climate/#

British Antarctic Survey (2018), "Antarctica Overview Map" British Antarctic Survey: Natural Environment Research Council, 11.04.2018. https://lima.usgs.gov/documents/LIMA_overview_map.pdf

Brooks, CM (2013), "Competing values on the Antarctic high seas: CCAMLR and the challenge of marine-protected areas", *The Polar Journal*, vol. 3 (2), pp. 277-300.

Buchanan, JM & Yoon, YJ (2000), "Symmetric Tragedies: Commons and Anticommons", *The Journal of Law and Economics*, vol. 43 (1), pp. 1-14.

Ciriacy-Wantrup, SV & Bishop, RC (1975), "`Common Property´ as a concept in natural resource policy", *Natural Resources Journal*, vol. 15, pp. 713-727.

Cole, DH & Grossmann, PZ (1999), "When Is Command-and-Control Efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection", *Wisconsin Law Review*, vol. 887, pp. 887-938.

Collis, C (2010), "Critical legal geographies of possession: Antarctica and the International Geophysical Year 1957- 1958", *GeoJournal*, vol. 57, pp. 387-395.

Commission for the Conservation of Antarctic Marine Living Resources (2013*), History of the Convention*, Commission for the Conservation of Antarctic Marine Living Resources, 05.04.2018. https://www.ccamlr.org/en/organisation/history-convention

Commission for the Conservation of Antarctic Marine Living Resources (2014*), CAMLR Convention*, Commission for the Conservation of Antarctic Marine Living Resources, 05.04.2018. https://www.ccamlr.org/en/organisation/camlr-convention

Commission for the Conservation of Antarctic Marine Living Resources (2018), *Convention area*, Commission for the Conservation of Antarctic Marine Living Resources, 05.04.2018. https://www.ccamlr.org/en/organisation/convention-area

Constable, AJ (2011), "Lessons from CCAMLR on the implementation of the ecosystem approach to managing fisheries", *Fish and Fisheries*, vol. 12, pp. 138-151.

Constable, AJ, de la Mare, WK, Agnew, DJ, Everson, I & Miller, D (2000), "Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)", *ICES Journal of Marine Science*, vol. 57, pp. 778–791.

Convention on the Regulation of Antarctic Mineral Resource Activities, (1988, not ratified), opened for signatures 02.06.1988, not in force.

Day, D (2013), *Antarctica: A Biography*, Oxford University Press, Oxford.

Dietz, T, Ostrom, E & Stern, PC (2003), "The Struggle to Govern the Commons", *Science*, vol. 302 (5652), pp. 1907-1912.

Dodds, KJ (2011), Sovereignty watch: claimant states, resources, and territory in contemporary Antarctica", *Polar Record*, vol. 47 (242), pp. 231–243.

Eijgelaar, E, Thaper, C & Peeters, P (2010). "Antarctic cruise tourism: the paradoxes of ambassadorship, "last chance tourism" and greenhouse gas emissions", *Journal of Sustainable Tourism*, vol. 18 (3), pp. 337–354.

Greenpeace (2001), *Creating the World Park Antarctica: Groundbreaking environmental protocol keeps the Antarctic pristine*, Greenpeace, 13.03.2018. http://www.greenpeace.org/usa/victories/creating-the-world-park-antarctica/

Global Running Adventures (2018), *Antarctic Ice Marathon and 100k*, Global Running Adventures, 16.04.2018. http://www.icemarathon.com/site/race-info/2.html

Hale, G (2014), "East and West: The Geography of Antarctica", *National Aeronautics and Space Administration: Operation IceBridge: NASA Blog*, blog post, 19.11.2014. https://blogs.nasa.gov/icebridge/2014/11/19/east-and-west-the-geography-of-antarctica/

Hardin, G (1968), "The Tragedy of the Commons", *Science*, vol. 162, pp. 1243-1248.

Heller, MA (1998), "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets", *Harvard Law Review*, vol. 111 (3), pp. 621-688.

Heller, MA (2013), "The Tragedy of the Anticommon: A Concise Introduction and Lexicon", *The Modern Law Review*, vol. 76 (1), pp. 6-25.

Heller, MA & Dagan, H (2001), "The Liberal Commons", *Yale Law Journal*, vol. 110 (4), pp 549-623.

Heller, MA & Eisenberg, RS (1998), "Can Patents Deter Innovation? The Anticommons in Biomedical Research", *Science*, vol. 280 (5364), pp. 698-701.

Hemmings, AD & Roura, R (2003), "A square peg in a round hole: fitting impact assessment under the Antarctic Environmental Protocol to Antarctic tourism*", Impact Assessment and Project Appraisal*, vol. 21 (1), pp. 13-24.

Hofman, RJ (2017), "Sealing, whaling and krill fishing in the Southern Ocean: past and possible future effects on catch regulations", *Polar Record*, vol. 53 (268), pp. 88–99.

Hoversten, P (2007), "Operation Highjump", *Air and Space Magazin*, 07.2007. https://www.airspacemag.com/history-of-flight/operation-highjump-18223476/

Hughes, KA & Bridges, PD (2010), "Potential impacts of Antarctic bioprospecting and associated commercial activities upon Antarctic science and scientists", *Ethics in Science and Environmental Politics*, vol. 10, pp.13-18.

Hughes, KA (2010), "How committed are we to monitoring human impacts in Antarctica?", *Environmental Research Letters*, vol. 5, pp. 1-3.

Jainchill, J (2009), "Ship accidents in Antarctica raise ecological and safety concerns", *Travel Weekly*, 28.04.2009. http://www.travelweekly.com/Cruise-Travel/Ship-accidents-in-Antarctica-raise-ecological-and-safety-concerns

Knight, RL & Meffe, GK (1997), "Ecosystem Management: Agency Liberation from Command and Control", *Wildlife Society Bulletin*, vol. 25 (3), pp. 676-678.

Koivurova, T (2005), "Environmental Protection in the Arctic and Antarctic: Can the Polar Regimes Learn From Each Other?", *International Journal of Legal Information*, vol.33 (2), pp. 203-218.

Larsen, E (2014), "How Do I Get to Antarctica?", *Outside Online Blog,* 20.11.2014. https://www.outsideonline.com/1927676/how-do-i-get-antarctica

LonelyPlanet (2018), *History*, lonelyplanet and beyond, 20.12.2017. https://www.lonelyplanet.com/antarctica/history#pageTitle

Lee JR, Raymond B, Bracegirdle TJ, Chadès I, Fuller RA, Shaw JD & Terauds A (2017), "Climate change drives expansion of Antarctic ice-free habitat", *Nature,* vol. 547, pp. 49–54.

Mahoney, JD (2001), "Perpetual Restrictions on Land and the Problem of the Future", *Public Law and Legal Theory Research Papers Working Paper No. 01-06.*

McCurry, J (2018), "Japan to replace whaling mother ship in sign hunts will go on", *The Guardian*, 23.01.2018. https://www.theguardian.com/environment/2018/jan/23/japan-to-replace-whaling-mother-ship-in-sign-hunts-will-go-on

McGrath, M (2016), "World's largest marine protected area declared in Antarctica", *BBC Science and Environment,* 28.10.2016. http://www.bbc.com/news/science-environment-37789594

National Aeronautics and Space Administration (2008), *What Is Antarctica?*, National Aeronautics and Space Administration: NASA knows, 22.11.2017. https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-antarctica-58.html

National Geographic (2018), *Antarctica*, National Geographic Society: Education, 10.11.2017. https://www.nationalgeographic.org/encyclopedia/antarctica/

Nicol, S, Foster, J & Kawaguchi, S (2011), "The fishery for Antarctic krill – recent developments", *Fish and Fisheries,* vol. 13, pp. 30-40.

"Ölkatastrophe: Das dunkle Erbe der "Exxon Valdez"" (2014), *Spiegel Online,* 21.03.2014. http://www.spiegel.de/wissenschaft/technik/exxonmobile-konsequenzen-oelpest-1989-der-exxon-valdez-a-960020.html

Oloffson, K (2009), "Antarctica", *Time,* 01.12.2009. http://content.time.com/time/world/article/0,8599,1943658,00.html

Parisi, F, Schulz, N & Depoorter, B (2000), "Duality in Property: Commons and Anticommons", *Würzburg Economic Papers no 21*.

Planet D (2015), "11 of the Best Things to do in Antarctica", The Planet D: Adventure is for Everyone: Blog 08.2015. https://theplanetd.com/the-best-things-to-do-in-antarctica/

Redgwell, C (1994), "Environmental Protection in Antarctica: The 1991 Protocol", *The International and Comparative Law Quarterly*, vol. 43 (3), pp.599-634.

Sample, I (2017), "Could towing icebergs to hot places solve the world's water shortages?", *The Guardian,* 05.05.2017. https://www.theguardian.com/environment/2017/may/05/could-towing-icebergs-to-hot-places-solve-the-worlds-water-shortage

Sandler, T (2010), "Overcoming Global and Regional Collective Action Impediments", *Global Policy*, vol. 1 (1), pp. 40-50.

Sandler, T (1998), "Global and Regional Public Goods: A Prognosis for Collective Action", *Fiscal Studies,* vol. 19 (3), pp. 221-247.

Schulz, N, Parisi, F & Depoorter, B (2002), "Fragmentation in Property: Towards a General Model", *Journal of Institutional and Theoretical Economics,* vol. 158, pp. 594–613.

Scott, K (2008), "Institutional Developments within the Antarctic Treaty System", *International & Comparative Law Quarterly,* vol. 52 (2), pp. 473-487.

Shackelford, SJ (2008), "The Tragedy of the Common Heritage of Mankind", *Stanford Environmental Law Journal,* vol. 27, pp. 101-157.

Shah, RM (2015), "Public Perceptions of Antarctic Values: Shaping future environmental protection policy", *Procedia - Social and Behavioral Sciences,* vol. 168, pp. 211–218.

Secretariat of the Antarctic Treaty (2011), *The Antarctic Treaty Consultative Meeting (ATCM),* Secretariat of the Antarctic Treaty, 23.04.2018. https://www.ats.aq/e/ats_meetings_atcm.htm

Sinclair, D (1997), "Self-Regulation Versus Command and Control? Beyond False Dichotomies", *Law and Policy*, vol. 19 (4), pp. 529-559.

Slezak, M (2017), "Japan criticised after whale slaughtered in Australian waters", *The Guardian,* 16.01.2017. https://www.theguardian.com/environment/2017/jan/16/frydenberg-criticises-japan-after-whale-slaughtered-in-australian-waters

Snyder, J. & Stonehouse, B. (2007), "The growing significance of polar tourism", in: Snyder, J. & Stonehouse, B. (editors), *Prospects for polar tourism,* Oxford: CABI International: 3–14.

Stark, JS, Snape, I & Riddle, MJ (2006), "Abandoned Antarctic waste disposal sites: Monitoring remediation outcomes and limitations at Casey Station*", Ecological Management and Restoration*, vol. 7 (1), pp. 21-31.

Sullivan, W (1964), "A New Name, Antarctic Peninsula, Goes on Map", *The New York Times,* 13.03.1964. https://www.nytimes.com/1964/03/13/a-new-name-antarctic-peninsula-goes-on-map.html

Summerson, R (2011), "Wilderness and Aesthetic Value of Antarctica", in DLiggett & AD. Hemmings (eds.), *Proceedings of the workshop Exploring Linkages between Environmental Management and Value Systems: The Case of Antarctica held at the University of Canterbury,* Christchurch, New Zealand, 05.12.2011, pp. 22-47.

Suter, K (1991), *Antarctica: Private Property or Public Heritage?,* Pluto Press Australia, Leichhardt.

Tangley, L (1988), "Who's Polluting Antarctica?", *BioScience*, vol. 9, pp. 590-594.

Taylor, A (2014), "The Exxon Valdez Oil Spill: 25 Years Ago Today", *The Atlantic*, 24.03.2014. https://www.theatlantic.com/photo/2014/03/the-exxon-valdez-oil-spill-25-years-ago-today/100703/

The Economist (2012), "Hot stuff", *The Economist: Technology Quarterly*, 02.06.2012. https://www.economist.com/node/21556100

USGS Water Science School (2016), "Ice, Snow, and Glaciers: The Water Cycle", *U.S. Department of the Interior: U.S. Geological Survey*, 22.11.2017. https://water.usgs.gov/edu/watercycleice.html

Vanneste, S, Van Hiel, A, Parisi, F. &Depoorter, B (2006), "From `Tragedy´ to `Disaster´: Welfare effects of Commons and Anticommons Dilemmas", *International Review of Law and Economics,* vol. 26 (1), pp. 104-122.

Ward, P (2001a), *Antarctic History -1897-1922: The Heroic Age of Exploration*, Cool Antarctica, 29.03.2018. https://www.coolantarctica.com/Antarctica%20fact%20file/History/The_heroic_age_of_Antarctic_exploration.php

Ward, P (2001b), *Antarctica Tourism - Human Impacts Threats to the Environment*, Cool Antarctica, 29.01.2018. https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_tourism.php

Ward, P (2001c), *Antarctica Weather and Climate*, Cool Antarctica, 29.03.2018. https://www.coolantarctica.com/Antarctica%20fact%20file/antarctica%20environment/climate_weather.php

Ward, P (2001d), *Human Impacts on Antarctica and Threats to the Environment - Fishing*, Cool Antarctica, 20.11.2017. https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_fishing.php

Ward, P (2001e), *Human Impacts on Antarctica and Threats to the Environment - Mining and Oil*, Cool Antarctica, 20.11.2017. https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_mining_oil.php

Ward, P (2001f), *Human Impacts on Antarctica and Threats to the Environment – Pollution*, Cool Antarctica, 29.01.2018. https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_pollution.php

Widof, HE (2002), "Animal Rights and the Antarctic Treaty System", *Human Ecology Review*, vol. 9 (2), pp 59-67.

World Population Statistics (2016), *Population of Antarctica 2016*, World Population Statistics, 16.04.2018. http://www.worldpopulationstatistics.com/population-of-antarctica/