UPPSALA
UNIVERSITET

Master thesis in Sustainable Development
Examensarbete i Hållbar utveckling

Ontology and Law: Bioprospecting in Antarctica

Rakesh Prasad

DEPARTMENT OF
EARTH SCIENCES
INSTITUTIONEN FÖR
GEOVETENSKAPER

Master thesis in Sustainable Development
Examensarbete i Hållbar utveckling

Ontology and Law: Bioprospecting in Antarctica

Rakesh Prasad

Supervisor: Susanna (Lize-Marié) Hansen van der Watt
Subject Reviewer: Thomas Dahlgren

Contents

Ontology and Law: Bioprospecting in Antarctica

RAKESH PRASAD

Prasad, R., 2022: Ontology and Law: Bioprospecting in Antarctica. *Master thesis in Sustainable Development at Uppsala University*, No. 2022/18, 103 pp, 30 ECTS/hp

Abstract:

Could it be that even though no international treaty or regulation regulates bioprospecting in Antarctica, some features of the techno-science of bioprospecting already lie embedded in the deep texts of the potentially most relevant treaties and regulations? If so, international law already to that extent comprehends the phenomenon, making for sustainable governance and thereby sustainable development. To find out, first an ontology of bioprospecting was synthesized, by an activity theory based conceptual system modeling (CSM). Treating bioprospecting as an activity of search for and research of naturally occurring biota, a set of Conceptual Graphs and associated Tables were drawn up as its ontology-synthesis. Features of this conceptualization were then searched for by an ontological-analysis of the deep texts of selected twenty-five legal instruments, through an ontological legal research (OLR). Search results did unearth several features dispersed and intriguingly embedded in several of the selected treaties and regulations, quite richly in some of the most recent ones. The cross-application of CSM followed by the hybridized OLR, is a methodological innovation and the generated empirical results of each are resources for further research. The language of international law is revealed as possessing a surprisingly better-than-expected techno-scientific literacy of bioprospecting.

Keywords: Sustainable Development, Conceptual Modeling, Ontological Legal Research, Knowledge Artifact, Activity Theory, Deep Text

Rakesh Prasad, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden

Ontology and Law: Bioprospecting in Antarctica

RAKESH PRASAD

Prasad, R., 2022: Ontology and Law: Bioprospecting in Antarctica. *Master thesis in Sustainable Development at Uppsala University*, No. 2022/18, 103 pp, 30 ECTS/hp

Summary:

Bioprospecting or biological-prospecting refers to the search for new lifeforms and their genetic materials in the natural environment, and to doing scientific research on them. This knowledge production activity is in-part motivated by and contributes eventually to the bioeconomy. The frozen continent of Antarctica including the Southern Ocean around it with its continental shelves and deep-sea bed contains a unique biodiversity of lifeforms adapted by an isolated evolution to its extreme geophysical and ecological habitats. Antarctica is like an ancient natural laboratory of evolution holding peculiar lifeforms. This attracts bioprospecting. International law is practically the only law in Antarctica but no treaty or regulation regulates bioprospecting in and from its natural environments. Sustainable development requires sustainable governance but the regulation of an emergent, techno-scientifically complex and large-scale phenomena, both spatially and temporally, like bioprospecting poses special challenges. International law is currently passive-permissive towards bioprospecting but if it is to regulate interventionally in the future, it must first develop a techno-scientific literacy, a conceptualization of the processes of bioprospecting. Could it be, however, that existing treaties and regulations already comprehend such a conceptualization in a latent, hidden-from-plain-sight sense? Might it be that some features of an ontology (non-overlapping, comprehensive conceptual categories and their interrelations) of bioprospecting already occur in the language itself, in the deep text that is, of existing treaties and regulations? If so, international law will be revealed as already primed to regulate bioprospecting more interventionally should there be a policy change. This will be good for sustainable development. To find out, first an ontological conceptualization of bioprospecting was synthesized by conceptual system modeling. The ambit of bioprospecting was treated as excluding patenting and commercialization, whether as motive or consequence. It was assumed that traditional knowledge is not implicated, an assumption that holds for Antarctica which does not have any indigenous population. The features of the ontology so synthesized were then searched for through an ontological legal research, in the deep text of selected twenty-five treaties and regulations. These legal instruments span six major treaty constellations – Antarctic treaty, convention on biodiversity, law of the sea, conservation of migratory species, protection of industrial property particularly patents, plant genetic resources for food and agriculture – and a stand-alone treaty on the regulation of whaling. They were selected for appearing to be the ones potentially most relevant. Their ontological-analysis examined the terminology and vocabulary of the selected legal texts for excavating the features being searched for. The search did find several features intriguingly embedded within and across various treaties and regulations in strikingly insightful framings and combinations, quite richly in some of the most recent ones. The conclusion is that the language of international law is revealed as already possessing a surprisingly better-than-expected level of techno-scientific literacy of bioprospecting. Some elements of the underlying ethos and values of bioprospecting were also unearthed and offer fascinating complementary insights.

Keywords: Sustainable Development, Conceptual Modeling, Ontological Legal Research, Knowledge Artifact, Activity Theory, Deep Text

Rakesh Prasad, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden

List I. Figures

List II. Appendices

Appendix A: Research materials (data) for conceptual system modeling (CSM): Four lists of incipient conceptual categories of an ontology of bioprospecting for knowledge production

Appendix B: Main table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Input Object Type, Sub-Activity, Output Object Type and Operator/Custodian)

Appendix C: Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Input Object)

Appendix D: Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Sub-Sub-Activity)

Appendix E: Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Output Object)

Appendix F: Full page versions of Figures 4-16 (Conceptual Graphs depicting the domain of bioprospecting for knowledge production and having an associated ontology)

Appendix G: Research Materials (data) for ontological legal research (OLR): Six constellations of treaties and regulations and a *sui generis* treaty that have been selected as potentially most relevant to the governance of bioprospecting in Antarctica

1. Introduction

Bioprospecting (the search for, and the techno-scientific research on, naturally occurring biota for knowledge production with consequences for the bioeconomy) as a phenomenon can be understood as an activity. It is both complex by being suffused with the latest technologies, and by having a vast spread on a global scale. It is particularly complex even if its purpose is limited to only knowledge production, and particularly vast spread even if its ambit is limited to a single region like Antarctica referring to the continent and the Southern Ocean around it, including its deep-sea bed. The governance of bioprospecting is especially challenging, and even more so the sustainable governance thereof. Sustainable development requires sustainable governance.

In this thesis, two concepts are central – governance and the activity governed. Some activities, especially those suffused with the latest technologies, can be particularly complex and their governance particularly challenging (Keating et al. 2014).

Framing the activity as a socio-technical system (STS), the social aspects being limited to the operating institutions, is an approach that could meet this challenge.

Conceptualizing an activity as a system is to synthesize an ontology of its domain: conceptual categories and their interrelations as building blocks of the system. The word 'ontology' comes from the Greek *ontos*, for 'being,' and '*logos*,' for 'word.' It refers to the subject of existence, i.e., the study of being as such (Gaševic et al. (2009, p.45). To know the domain of an activity through an ontology is like knowing a body through its skeleton, with the synthesis functioning as an X-Ray.

Activities on a global or regional scale can be particularly vast spread and their governance particularly challenging in an international context (Orsini et al. 2020; Meadowcroft 2007). International law making through treaties and regulations is an attempt to meet the challenge.

It would appear from the literature review conducted for this thesis that no attempt has been made to synthesize an ontology of bioprospecting, even by limiting the ambit of bioprospecting to knowledge production by excluding commercialization and other ends of the knowledge economy. Neither has any attempt been made to analyze existing international treaties and regulations potentially most relevant to bioprospecting with the aid of such an ontology, even limited to a specific region such as Antarctica.

This thesis aims to address these twin knowledge gaps. First, it presents a synthesized ontology of bioprospecting limited to knowledge production. Second, it presents an analysis conducted with the aid of this ontology, of international treaties and regulations potentially most relevant to bioprospecting in Antarctica. It is the features of the synthesized ontology that are searched for in the ontological-analysis.

The ontology-synthesis assumes that Traditional Knowledge (TK) is not implicated in bioprospecting for knowledge production. The ontological-analysis is of legal texts in the context of Antarctica where Traditional Knowledge (TK) is not implicated in bioprospecting for knowledge production. Antarctica's endemic biodiversity, particularly its psychrophiles and other extremophile lifeforms, attract bioprospecting interest (Convey et al. 2013).

The conceptual system modeling (CSM) synthesis of the ontology will be a future resource for the sustainable governance of bioprospecting for knowledge production in Antarctica as well as other places like for example the deep sea-bed planetwide, where Traditional Knowledge (TK) is not implicated. Additionally, the ontological legal research (OLR) analysis of the existing treaties and regulations potentially relevant to bioprospecting in Antarctica, will be a future resource for the sustainable governance of bioprospecting in Antarctica. Together, these two outcomes can be resources for the sustainable governance of bioprospecting and subsequently its sustainable development.

The ultimate objective in this thesis is to investigate an intriguing question: Could it be that even though none of the treaties and regulations regulate bioprospecting, they nevertheless already contain an embedded comprehension of the techno-science of bioprospecting? Might it be that in the language of their deep text, some of the conceptual features and interrelations (i.e. features of an ontology) of bioprospecting for knowledge production do lie, albeit hidden from plain sight? In other words, in relation to Antarctica, does the language of international law already have some comprehension of the phenomenon of bioprospecting for knowledge production, even though there is not even one treaty or regulation regulating it? If so, international law will be revealed to be already possessed of techno-scientific literacy and thus already primed for interventionally regulating bioprospecting should the current passive-permissive policy prescription change.

This thesis relates to the interaction of science and technology with international law (Dellapenna 1999). It attempts to provide a limited-context answer under some assumptions, to a broad set of questions underlying the sustainable governance of new sciences and novel technologies: Is contemporary international environmental law based on science (Avgerinopoulou 2019)? What is the state of techno-scientific literacy in international law concerning bioprospecting? How well or badly positioned is the emergent governance of the emergent techno-science of bioprospecting (Marchant 2013)?

1.1. Research Aim, Research Questions and Hypotheses

Research Aim:

To conceptualize bioprospecting as an activity for knowledge production and to locate the warrant for its comprehension, if any, in international law for the governance of bioprospecting in Antarctica.

Research Questions:

What does the ontology of bioprospecting as an activity for knowledge production look like and what are its features?

Do any of these features occur in the texts of public international law treaties and regulations potentially most relevant to the governance of bioprospecting in Antarctica even though none of them regulate bioprospecting?

Hypotheses:

It is possible to synthesize a sensible and insightful set of Conceptual Graphs as Knowledge Representation, a form of Conceptual System Model (CSM), with an associated ontology, for the domain of bioprospecting as an activity for knowledge production.

It is possible to find some features of the synthesized ontology by conducting an ontological-analysis through ontological legal research (OLR) lying scattered and embedded in the terminology and vocabulary, i.e. the deep text of some of the treaties and regulations selected for being potentially most relevant to the governance of the activity of bioprospecting in Antarctica, even though none of them regulate bioprospecting.

2. Background & Knowledge Gap

2.1. Sustainable Development & Sustainable Governance

Sustainable governance of life below water is subsumed under Sustainable Development Goal (SDG) 14. Sustainable governance of life on land is subsumed under SDG 15. The role of governance has been highlighted for achieving the SDGs (Monkelbaan 2019). Not just any governance, but knowledge-governance has been advanced as key to sustainable development (van Kerkhoff 2014). SDG 14.a refers to "increase in scientific knowledge", SDG 14.5 to "scientific information" and SDG 14.4 to "science-based management plans." Together they emphasize scientific principles for sustainable governance.

2.2. No consensus on definition of bioprospecting

There is no common understanding of what bioprospecting is nor any consensus on what a working definition might be. Several scholars have pointed towards instances where this lack of consensus have been a major obstacle in regulating bioprospecting internationally but also specifically in Antarctica (see for example Heinrich 2019, Leary 2020, Meduna 2015, Davis 2011). This absence of a shared understanding of what bioprospecting means, has been noted for nearly as long as the term first cropped up in the literature (Hemmings & Rogan-Finnemore 2008). In a submission to the Commission on Conservation of Marine Living Resources (CCAMLR), the International Union for Conservation of Nature (IUCN) described the problems this poses as follows:

> The term bioprospecting is not defined in any international convention or agreement. Indeed, there remains a range of views in the literature and in policy circles as to what bioprospecting involves. Definitions differ largely on how far 'bioprospecting' extends down the commercialization path and whether it includes the development process of the bio compound through to full scale commercialization and marketing. This makes it difficult to generalize any legal implications of 'bioprospecting' and even harder to draw implications of this activity on resource management" (IUCN CCAMLR-XXVII/BG/36 2008, p.2).

Hemmings and Rogan-Finnemore (2008) emphasized another key-point for this thesis, that this absence of a definition also makes it difficult to discern when science ends and commerce begins.

In the context of Antarctica, the Scientific Committee on Antarctic Research (SCAR), tasked with reporting on bioprospecting activities in Antarctica to the Antarctic Treaty Consultative Meeting (ATCM) under the Antarctic Treaty (AT), issued a questionnaire enquiring about bioprospecting activities conducted over the past decade (IP Information Paper: 12 2021). The language the questionnaire resorted to is revealing of the many semantic landmines even a scientific committee had to navigate in order to execute such a task. To start, the questionnaire had to employ a convoluted phrase as a stand-in for the term bioprospecting: "research that is considered bioprospecting or natural products research." Even the inherent subjectivity in the word "considered" was found insufficient and the expression "natural products research" was employed upfront in the questionnaire, almost as a substitute for the term bioprospecting (Information Paper: IP 12 2021, Q.1). A subsequent question had to further qualify this phrase by giving illustrative examples, such as "gene sequencing, collections of genetic material, biochemical analyses or extractions, isolation of microorganisms or taxonomic research" (Information Paper: IP 12 2021, Q.3). Yet another qualifier needed to be deployed: "that could contribute to, or later be used for", just before the main phrase – "bioprospecting or natural products research" (Information Paper: IP 12 2021, Q.3). In the fourth question, the semantic maneuvering was taken to an extreme when project names had to be listed to show how they are connected with the notion of bioprospecting, with an explanation that:

> The projects listed covered an array of scientific investigations including biological material collections, genetic and genomic analyses, biochemical analyses, physiological studies and ecological studies. Studies covered an array of organisms including viruses, bacteria, yeasts, micro- and macro-algae, protists and terrestrial invertebrates. Molecular ecology and genetic studies on higher organisms (sea birds, fish, pinnipeds and cetaceans) were also recorded. Many biological studies were focused on adaptations of Antarctic organisms and their potential responses to changing environmental conditions (Information Paper: IP 12 2021, 4.).

Hemmings and Rogan-Finnemore's observation, that "no one has been able to ascertain the precise nature and full extent of current Antarctic bioprospecting activities" (Hemmings & Rogan-Finnemore 2008, p. 531) is indeed still valid, more than a decade later.

2.3. The split binary in some definitions

No international treaty defines bioprospecting. The term is not featured in the Oxford English Dictionary and there seems to be no consensus definition. There is not even a particularly popular definition. Only a few countries like USA, New Zealand, Australia have enacted domestic legislation featuring definitions of bioprospecting (Meduna 2015, p.468) which also vary. There are two main approaches to defining the term - one focusing on the single purpose of knowledge production and the other on the dual-purpose - knowledge production with commercial intent. Examples of these follow below:

Nichols et al. (2002, p.85) defines bioprospecting as the "search for new or better bioproducts or technological processes from biological sources." This definition restricts itself to a single purpose with a single usage of the word 'for.' The single direct purpose characterizes definitions of bioprospecting as some kind of knowledge production.

Sometimes bioprospecting is defined as having a dual purpose - or rather an uncomfortable split binary. Refer for example, the definition: "It is a term that 'appears to cover…the range of activities associated with searching for, discovering, and researching unique biodiversity for potential commercial applications.'" (Hemmings & Rogan-Finnemore 2008, p.529) In this definition, the word "for" occurs twice: there is an immediate purpose (for - searching, discovering, researching) followed by a subsequent or ultimate purpose (for – potential commercial applications). The first immediate purpose is some form of knowledge production: to create one or more knowledge artifacts. The second, ultimate purpose is an intent related to commercialization. Screening the knowledge artifacts for a use or an industrial application, product development to serve that use or application, clinical or other use trials, seeking marketing approvals, marketing, promotion and sales, patenting and licensing – these are subsumed under commercialization. This kind of split binary purpose can also be found, for example, in Leary (2020, p.273), who observes that bioprospecting involves "…the collection of small samples of biological materials for screening in the search for commercially exploitable biologically active compounds or attributes such as genetic information…Owing to the close relationship between scientific research and bioprospecting it is often difficult to distinguish between the two." Leary (2020, p.273) goes on to explain that "this blurring of the distinction between scientific research and bioprospecting and its implications for regulation is a recurrent theme in nearly all international debates on bioprospecting." Some split binary type definitions are self-conscious and divide the definition into two or more sentences to feature not more than one of the two purposes in any one sentence. See, for example: "The term bioprospecting covers practices of systematic search through natural resources, with a view to pursuing further scientific development. In many cases, though not always, such developments also have a commercial aim" (Cloatre 2016, p.361).

Sometimes a split binary type definition even has straddling content in between the two purposive sentences or sentence-groups. For example, on one page occurs the first purpose: Tvedt quotes Farrell and Duncan

(2005) expressing that "'Bioprospecting' is generally understood to be the search for new (and valuable) biological material, biochemical or genetic material" (Tvedt 2011, p.46). Then, there is straddling content. Then, only on the next page, the first purpose is again cited along with the second purpose: "Bioprospecting encompasses activities with different ends, from strictly academic or taxonomic research to the highly commercial search for economically valuable traits for the biotechnological or pharmaceutical industry (Farrell and Duncan 2005, p.11 in Tvedt 2011, p.47). The first purpose is "strictly academic or taxonomic research." The second purpose is "highly commercial search for economically valuable traits for the biotechnological or pharmaceutical industry."

Borrowing the '*actus rea* (actual act) and *mens rea* (mental act)' doctrine from criminal law, the first immediate and direct purpose of knowledge production is like *actus rea* and the second, sequential and ultimate purpose, the intent, motive or ends is like *mens rea*. It is easier to put a finger on the first one: it admits direct proof by evidence. The second one, *mens rea*, is only inferential and can be fiendishly difficult to establish especially if multiple individuals as well as corporations and agencies intermediate in a long chain that takes decades to yield commercialization as the end result. It is almost impossible to establish in advance of the culmination or attainment of tangible ultimate commercial consequences of bioprospecting. What this means is that the split binary type definition may be useful for problematizing but inherently impractical methodologically for empirical analysis.

This impracticality has been noted previously. In its annual report to the General Assembly, the Secretary General of the United Nations wrote that – "the difference between scientific research and bioprospecting therefore seems to lie in the use of knowledge and results of activities, rather than in the practical nature of the activities themselves" (A/60/63/Add.1, para 202, 15 July 2005, quoted in IUCN CCAMLR-XXVII/BG/36 2008, pp. 3-4).

What the split binary definition type problematizes is a real-world phenomenon. However, incorporating the problem inside the definition itself renders the split binary type definition of bioprospecting impotent for objectivization type study and external sourcing of solutions. By including consequences and concerns therewith, the split binary type definition of bioprospecting is much too complex to synthesize an ontology for it when an ontology has not been synthesized yet even for the first type definition i.e. bioprospecting as just knowledge production.

One study notes the obscurity in the split binary definition type: "Both pure academic research and industrial research, the latter with a commercial or profits objective, are involved in bioprospecting, and the interface between the two is often obscure" (Herber 2006, p.139). Herber proceeds to adopt the alternative, the single purpose definition: "Bioprospecting involves the search for knowledge in the domain of diverse biological and genetic resources. The "knowledge that is acquired becomes part of the overall body of knowledge possessed by mankind" (Herber 2006, p.140).

In the context of Antarctica, the very underlying rationale for a certain aspect of problematization of bioprospecting does not hold - the absence of indigenous rights' holders. Given the absence of any indigenous people in Antarctica with sovereignty over Antarctica's biotic resources who can be compensated from the proceeds of commercialization of bioprospecting, bioprospecting may stand reduced only to its process (Davis 2011, p.200). In any case, no sub-stage of commercialization occurs in Antarctica itself. All of that happens elsewhere, in the home countries of those involved in activities downstream from the *in situ* bioprospecting happening in Antarctica (Meduna 2015, p. 468).

For bioprospecting in Antarctica thus, given the absence of the exploitation of indigenous knowledge, the first type of definition of bioprospecting which is limited to knowledge production, is simpler to use and better amenable to an ontology-synthesis.

2.4. Elements of the single purpose type definition

A pre-omics visualization of bioprospecting as a sequential four-step process (Phase I: Collection, Phase II: Isolation, Phase III: Screening, Phase IV: Development), in the context of Antarctica as an area outside national jurisdiction where Traditional Knowledge (TK) is not implicated, occurs in the literature just over a decade ago, in Davis (2011, Figure 1 on p.7).

This is a pre-omics visualization in as much as DNA sequencing is mentioned only under the 'Isolation' phase as being after the 'Collection' phase, and genetic sequences is mentioned only under the 'Screening' phase as being after both the 'Collection' and 'Isolation' phases. Now a decade later, post-omics, environmental genetic material can be sequenced and matched *in-situ* itself during sampling.

This visualization is stated to be drawn from the work of Jabour-Green & Nicol (2003, pp.85-87) and includes both purposes – knowledge production and commercialization. It is thus an example of a visualization based on a split binary type definition.

Biota which are natural bio-occurrences can be perceived in Davis (2011, Figure 1 on p.7) as raw material of an industrial pipeline process conceptualization of the activity of bioprospecting. The production output of the pipeline can be seen to be various type of knowledge artifacts. The 'Collection Phase' seems to corresponds to i*n situ* exploration and the 'Isolation Phase' to laboratory analysis, each a sub activity of bioprospecting. Explorer-scientists and analyzing laboratories can be seen to be some of the socio-institutional agencies or entities that operate these sub activity pipelines. Although Davis (2011, Figure 1 on p.7) does not highlight it, an operating agency (entity) would presumably have default custody of the knowledge artifact produced by the knowledge production sub pipeline that it operates.

About a decade ago, the omics revolution was already being taken note of in the literature. It was referred to in one study as the "rapidly evolving fields of 'omics' (genomics, proteomics, lipidomics, etc.), bioinformatics and synthetic biology" (Leary & Juniper 2013, p.785). Advances in omics technologies including proteomics and metabolomics are still being cited as recent and as having a transformative impact on the processes of bioprospecting of extremophiles (Information Paper: IP 12 2021). A visualization of the post-omics comprehension of the split binary type definition of bioprospecting, available in recent literature is **Figure 1**:

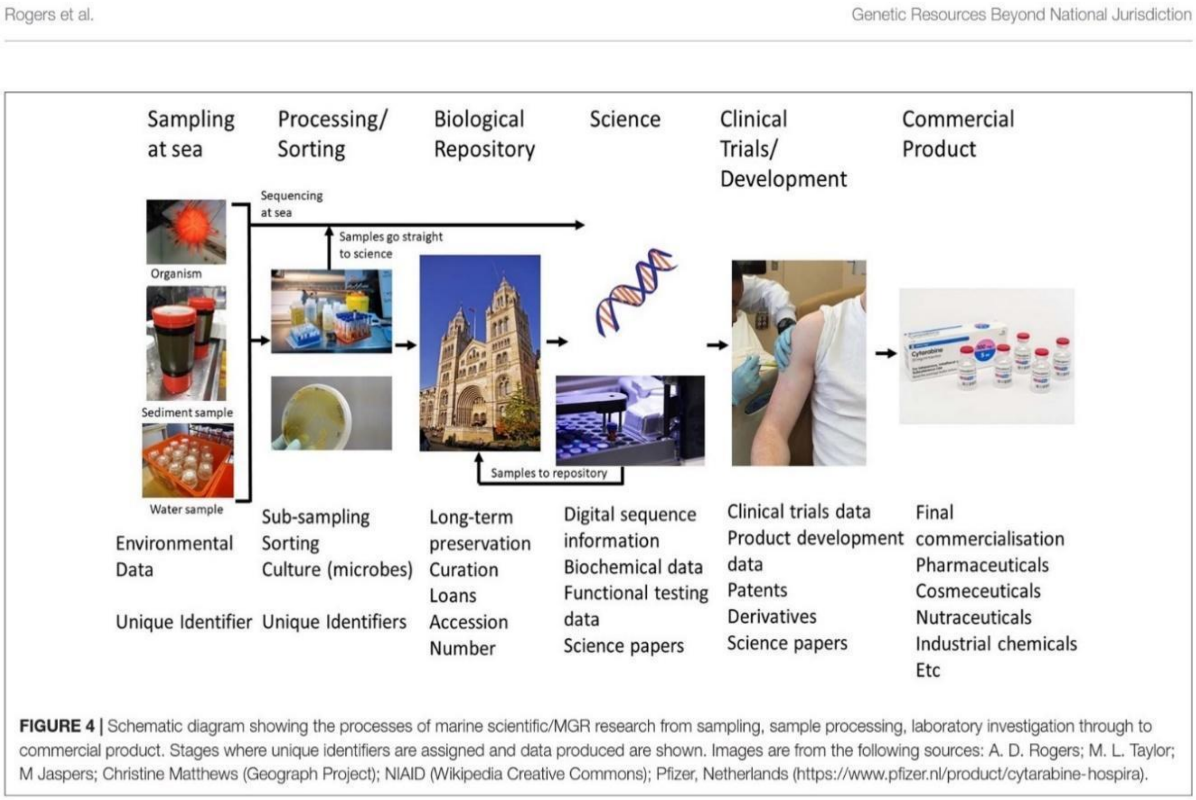


Figure 1: This figure by Rogers et al. is an example of a post-omics visualization of stages of the split binary type definition of bioprospecting including both purposes – knowledge production and commercialization, in which Traditional Knowledge (TK) is not implicated (Rogers et. al. 2021 p.11). Used with permission of Alex D. Rogers.

Compared to the split binary type definition, the single purpose of knowledge production restricts the definition of bioprospecting making it more self-contained. To prefer the single purpose definition over the split binary type definition is to exclude from consideration the subsequent commercialization related phases of screening, development, trials, regulatory approvals, marketing and sales. Whether or not to exclude patents as well? Patents are quintessential knowledge artifacts but they are not produced entirely only from bioprospecting and the prior art, the body of existing knowledge. Patents critically and necessarily embody the inventive step as well which is attributable to the inventor's fertile mind, an additional and independent component that is not protocol-driven or procedural in nature.

In a bioprospecting patent, so to speak, this inventive step or non-obviousness component always exists and it is inextricably combined with the information and results obtained from bioprospecting itself. Hence, patents are knowledge artifacts but they ought not to be considered as knowledge artifacts produced only by bioprospecting. On this view, the patenting phase should also be excluded from consideration in the single purpose definition of bioprospecting which is restricted to knowledge production.

One such post-omics visualization of the single purpose definition of the technologically suffused activity of bioprospecting limited to the knowledge production purpose, available in recent literature is **Figure 2**:

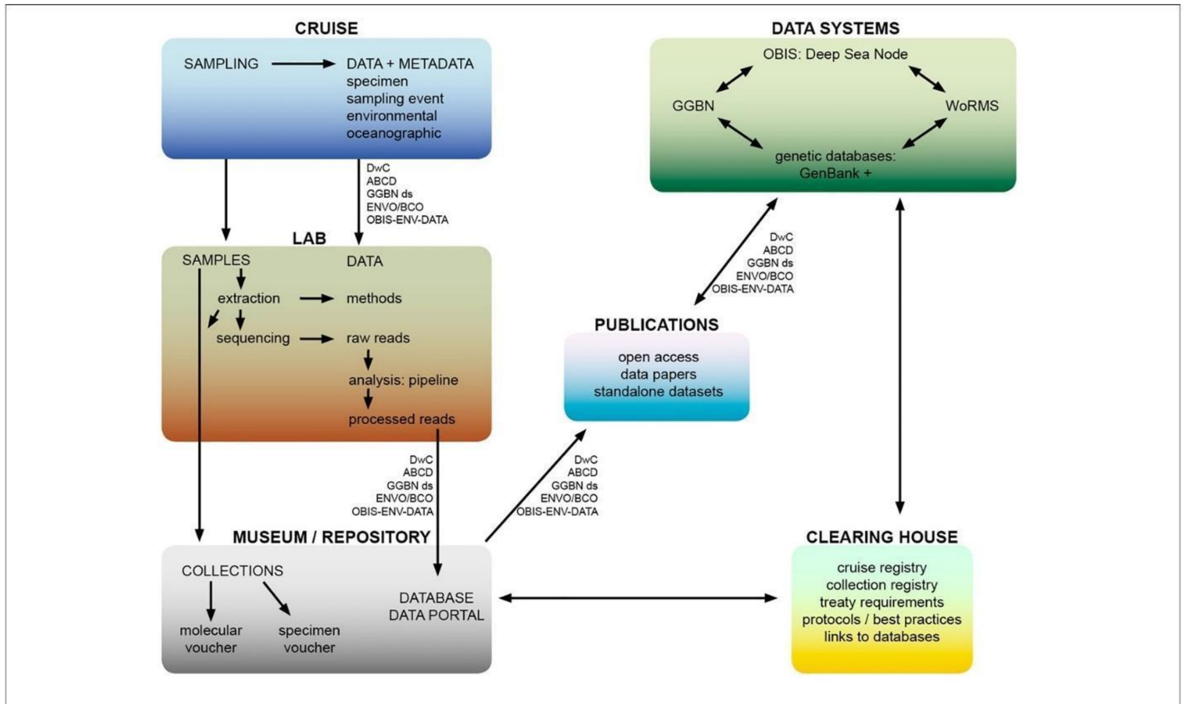


FIGURE 4 | Potential workflow from cruise to data publication of access to MGR from ABNJ, including the scope of a potential clearing-house mechanism. Data standards are also shown, acronyms are as follows – Dwc: Darwin Core, ABCD: Access to Biological Collection Data GGBN ds: Global Genome Biodiversity Network data standard, ENVO: Environment Ontology, BCO: Biological Collections Ontology, OBIS-ENV-DATA: OBIS extendedMeasurementorFact DarwinCore Extension. These data standards are also listed in **Table 1**.

Figure 2: This figure by Rabone et al. is an example of a post-omics visualization of stages of the single purpose type definition of bioprospecting featuring only the purpose of knowledge production, in which Traditional Knowledge (TK) is not implicated, but involving standards generated by networking initiatives (Rabone et al. 2019, p.16). Used with permission of Muriel Rabone.

Even though the single purpose type definition of bioprospecting is much restricted compared to the split binary type definition, the above visualization of the former shows that a lexical version of it would still be verbose and unwieldy. A lexical description of even the pre-omics comprehension in Jabour-Greene & Nicol (2003) spanned two pages (pp. 85-87) even though it was highly summarized. A post-omics lexical description of the above visualization or of any other visualization of even the single purpose definition of bioprospecting for that matter, would need several more pages. At increasingly extended page count, lexical description type definitions start losing their appeal. Visualizations come to be preferred.

From a visualization like the above, the elements constituting the definition can be discerned but require background knowledge to be made sense of. A brief outline of the elements follows with a minimally explanatory background to describe the phases of bioprospecting for the purpose of knowledge production, an activity utilizing current omics technologies.

The phases of *in situ* exploration and of laboratory analysis have already been noted. ROVs (Remotely Operated Vehicles) and submersibles have opened up the deep-sea bed to sampling and studying. More sensitive instruments and more delicate sensors and probes can be placed *in situ* and accessed from afar or retrieved later recording, relaying and collecting richer data over longer durations (Glover et al. 2009, pp. 3-4). Supplementing *in situ* exploration survey databases such as for example for the deep seabed - DeepData (https://www.isa.org.jm/deepdata), ocean observing/monitoring initiatives also collect samples, e.g. the Global Ocean Observing System (GOOS, https://goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=16761), the Deep Ocean Observing Strategy (DOOS, https://www.oceandecade.org/actions/deep-ocean-observing-strategy/), and the Marine Biodiversity Observation Network (Marine BON, https://marinebon.org/) (Collins et al. 2021, p.309).

In situ exploration involves photography, videography, extraction, extrication (sequestration), sampling and sorting. These activities take place further on the vessel and in laboratories even further away. Activities like sieving, washing, preservation, taxonomic identification, stable isotope analysis, genetic/genomic sequencing studies type activities are involved (Rogers et al. 2021, p.10). Labels, tags, identifiers and vouchers for samples and specimens are important. For a sampling event, these records critically accompanying biogeographical data pertaining to place, depth, temperature, salinity, turbidity, nutrient profile, dissolved gaseous content, topography, ecology, etc. (Rogers et al. 2021, p.10). Metagenomics and e-DNA analysis enable direct genomic analysis and genome matching of *in situ* Environmental Genetic Material (EGM) (Gura & Rogers 2020). Time-date and other metadata constitute good practice for future tracking and for traceability of flows of materials, data and information (Rogers et al. 2021, p.17). Monitoring *in situ* rapid phenotype shifts under predation and other ecological interactions draws attention to the emerging field of eco-bioprospecting. Natural products (NPs) are products of evolution by natural selection in the context of ecosystem dynamics (Beattie et al. 2011, p.342).

Museums and collections are types of bio-banks that physically hold materials obtained from bioprospecting. As repositories of specimens and samples whether preserved, cryopreserved, maintained or musealized, along with data and information especially vouchers logging the point and time of collection and provenance, these institutions are a diverse set. These *ex situ* biobanks exist as a variety of entities such as culture collections, germplasm collections, cell banks, stock centers, herbaria, zoos, museums, botanical gardens, brood stock collections, cryopreserved banks, university holdings, aquatic gene banks and sample repositories (Humphries 2018, p.50). Initiatives to network them include the World Federation of Culture Collections (WFCC, https://wfcc.info/), Global Genome Biodiversity Network (GGBN, https://www.ggbn.org/ggbn_portal/) and the International Society for Biological and Environmental Repositories (ISBER, https://www.isber.org/) (Collins et al. 2021, p.309).

Collections are rarely passive, acting only as repositories. Cataloguing, curation and managing access and loans require knowledge-expertise. Some collections offer exhibitions, displays and musealizing. Some engage in taxonomic and other research work. Networking initiatives of taxonomic facilities include the Consortium of European Taxonomic Facilities (CETAF, https://cetaf.org/).

In analyzing laboratories, spectroscopic and molecular assays may be possible. Direct genomic screening for bio activity using PCR blotting (Rogers et al. 2021, p.14) instead of traditional profiling of characterized metabolites is an option. Dereplication or elimination of previously identified bio molecules is often required before purification and isolation of the NP (Natural Product) or a derivative (Rogers et al. 2021, p.14). There exist databases of NPs, for example the National Cancer Institute's Natural Products Library (NCI-NP, https://dtp.cancer.gov/organization/npb/introduction.htm) including its prefractionated and fractionated sub libraries (Rogers et al. 2021, pp. 13-14). Natural products (NPs) produced by Antarctic organisms that mediate their ecological relationships remain a largely untapped source of potential human use and more studies are needed to better understand them (Avila 2016, pp. 772-73). This is because "chemodiversity recapitulates biodiversity" (Núñez-Pons & Avila 2015, p.1127). Examples of relevant NP Libraries are MarinLit (MarinLit, https://marinlit.rsc.org/) and a suite at the National Institute of Health – National Center for Complementary and Integrative Health (NIH-NCCIH, https://www.nccih.nih.gov/grants/natural-product-libraries).

Sequencing laboratories perform genomic analysis, a kind of computer based bioinformatic analysis of biological origin materials. DNA barcoding, for example, is a strategy to archive a distinctive specified region of a gene to serve as a reference database for taxonomic matching (Hebert et al. 2003; Glover et al. 2009, p.5) using protocols like high throughput amplicon sequencing (Hestetun et al. 2020, p.2). NGS (Next Generation Sequencing) on Illumina machines is another example of transformative advance of the omics revolution. It has opened up large scale low cost genome sequencing leading to a boom in genomic analysis (Hestetun et al. 2020, p.5). It is morphological studies based on physical *in situ* sampling that now lags behind molecular studies when both are required synergistically for sense to be made of the data (Hestetun et al. 2020; Page 2016) Many microorganisms remain unculturable but new omics technologies like single-molecule-real-time-sequencing (SMRT) hold a prospect for discovering biomolecules from them (Beattie et al. 2011).

Lab sequencing produces digitized data sets. Following the Census of Antarctic Marine Life (CAML, https://www.antarctica.gov.au/news/2009/australian-polar-research-at-close-of-ipy/census-of-antarctic-marine-life/), other prominent databases in which bioprospecting generated datasets especially in the context of Antarctica, can be found include the Barcode of Life Data System (BOLD, http:// www.boldsystems.org), the Register of Antarctic Marine Species (RAMS, http://www.marinespecies.org/rams) and the SCAR-Marine Biodiversity Information Network (SCAR-MarBIN, https://www. scarmarbin.be), integrated into the SCAR Antarctic Biodiversity Portal (https://www. biodiversity.aq), and the Biogeographic Atlas of the Southern Ocean (http://www.biodiversity.aq), Register of Antarctic Marine Species (RAMS, https://www.marinespecies.org/rams/), World Register of Marine Species (WoRMS, https://marinespecies.org/), Biodiversity Heritage Library (BHL, https://www.biodiversitylibrary.org/part/216956), Global Biodiversity Information Facility (GBIF, https://www.gbif.org/), Catalogue of Life (https://www.catalogueoflife.org/), Ocean Biodiversity Information System (OBIF, https://obis.org/), and others (Saucède et al. 2021).

Digital Sequence Information (DSI) on genetic resources itself most commonly ends up in an International Nucleotide Sequence Database Collaboration (INSDC, https://www.insdc.org/) database through any of its three participating databases – DNA Databank of Japan (DDBJ, https://www.ddbj.nig.ac.jp/index-e.html), the National Center for Biotechnology Information – Genbank (NCBI-Genbank, https://www.ncbi.nlm.nih.gov/genbank/) and the European Molecular Biology Laboratory – European Bioinformatics Institute (EMBL-EBI, https://www.ebi.ac.uk/) (Rogers et al. 2021, p.18; Humphries 2018, p.52).

The elements outlined above will be relied upon later in this thesis for synthesizing therefrom an ontology of bioprospecting for knowledge production.

2.5. An ontology of the single purpose type definition

The elements of the single purpose type definition of bioprospecting for knowledge production outlined above present the knowledge domain itself as overly complex and inherently complicated. It is to circumvent the challenge of understanding such domains of knowledge that ontology offers a solution. Ontology, the overarching theme of this entire thesis, is like a "'knowledge skeleton' "to which all other knowledge of the activity being studied can stick" (Gaševic et al. 2009, p.47). It provides a shorthand vocabulary, possibly just the abbreviations or symbols, for referring to the conceptual categories and their interrelations that constitute an understanding. Ontologies are different from human-oriented vocabularies like glossaries in a natural language like English not only by avoiding risk of semantic ambiguity and polysemy but also because of lack of taxonomy of conceptual categories and lack of revelation of hierarchies, sequences, networking and other aspects of interrelational topology.

An ontology of a domain is thus a description of what its "world is made of" by being based on "primitives" to describe the structure of a domain and a "calculus" to describe how it functions (Valente & Breuker 1994, p.113). A domain ontology builds a typology of conceptual categories and their interrelations, a "representation vocabulary" (Chandrasekaran et al. 1999). In this sense, "ontologies are just one step before languages" (Valente & Breuker 1994, p.114).

Ontologies can be used as tools to implement a "divide-and-conquer strategy" (Valente & Breuker 1994, p.115) to attack the complexity of the domain. It is usually desirable in the taxonomy of an ontology to cluster elements comprising the knowledge of a domain like an activity by their characteristics into interse mutually-exclusive or non-overlapping conceptual categories (Lee & Chen 2018). It is usually also desirable that these conceptual categories be collectively "exhaustive" meaning that together they include all possibilities.

An ontology embodies an analysis of the types of things or relations that do not necessarily exist in any particular place or time but can theoretically exist (Kilduff et al. 2011, p.299). This is why ontologies are useful "as a basis of the conceptualization process" (Thalheim 2010, p.3104). It is possible to build a conceptual model on the foundation of ontology (Burton-Jones & Weber 2014) as a system. Conceptual system modeling (CSM) automatically entails building and synthesizing an ontology.

2.6. The missing ontology: The first knowledge gap

From the literature review conducted for this thesis it would appear that there is no synthesized ontology conceptualizing bioprospecting as an activity only for knowledge production, even under the assumption that Traditional Knowledge (TK) is not implicated. The brief summarization previously of the elements of a post-omics definition of bioprospecting for knowledge production exhibits the inherent complexity of the domain. The domain itself is revealed thereby, especially to someone lacking background knowledge, as complicated and messy. At this level of complexity and detail, lexical definitions and descriptions are unwieldy and of limited utility.

A systemic understanding can delimit the domain with boundary-construction at multiple hierarchical levels to aid understanding. Conceptual categories can be useful to comprehend the structure and functioning of such a system and its subsystems, hierarchically as well as sequentially in a network. Preferably, these conceptual categories in any class at any level of hierarchy should be non-overlapping and mutually exhaustive in coverage (Lee & Chen 2018). Hierarchies and sequences in a network can encode interrelations between conceptual categories (Mäki 2009, p.30).

Ontology of a system refers to the taxonomy of such conceptual categories (elements) and the relational scheme of the system's elements and their interconnections (interrelations). Reducing a large mass of complex and messy factual details to the organized minima of an ontology for comprehension involves "control for noise" (Mäki 2009, p.30) by "idealizing assumptions, silent omissions, simplifications and approximations" (Knuuttila 2011, pp. 262-63, 270).

From the literature survey conducted for this thesis it would appear that there is no previously synthesized Conceptual Graph or Knowledge Representation or an ontology in any other form such as for example in an ontology modeling computer language like OntoUML, for the domain of bioprospecting, not even for only the single purpose type definition restricted to knowledge production. Existing visualizations in the literature on bioprospecting, even the post-omics ones, discovered from the literature review for this thesis, are only illustrative in character. None of them claim or purport to be an ontology in the sense of being taxonomically comprehensive. This is a knowledge gap that hinders the scientific empirical analysis of a kind relating to bioprospecting in a variety of contexts.

2.7. Discourses of bioprospecting and its governance

Even though this thesis does not employ any kind of discourse analysis as research method, a discursive contextualization of the research topic is furnished below.

Bioprospecting as knowledge production can be viewed as an industrial perspective (Borris 2016) or discourse intimately connected to a modernity discourse, where modernity is understood as "ordering things into categories, frequently differentiating parts of a whole from each other" (Davis 2011, p.25). Science as progress and knowledge production as quest are associated discourses. In this conception, there is an inherent contradiction between the poor state of knowledge of biodiversity and the aspiration to develop a sustainable bio-economy. Without knowledge of "what actually lives out there" (Glover et al. 2018), it cannot be sustainably managed as a bio-resource. The gap in our knowledge of biodiversity has been described as "abysmal" (Glover et al. 2009). And yet, resourcism as a treasure hunt and biomimicry with nature as tutor, abide as companion narratologies of the win-win knowledge production discourse (van der Hout & Drenthen 2017). Prominent discourses critiquing it are of neoliberal commodification of nature (Neimark 2012) and of biopiracy (Svarstad 2020; Benjaminsen & Svarstad 2021). Actor-network theory offers a methodological critique of the discourse of bioprospecting as being its own engine. This critique points to the role of conscious intent and of actors possessing or exercising it (Cloatre 2017). The operating institutions that control the processes of bioprospecting and have default custody of the produce of bioprospecting, ought to be factored into any conceptualization.

In relation to the governance of an activity, one that is complex, ill defined, whose impacts and questioned and contested and whose technologies are novel and emergent, the role of the law governing it poses special challenges. This role traverses a difficult terrain of contested values and of "chosen paths to conflicted modernities" (Cloatre 2016, p.385). Since this law is itself also emergent, its legal scholarship is hardly extricable. It is inherently not external to the object of its study. It is, instead, "generative of new identities, mobilization, imaginaries and claims as they unfold– each loaded with its own consequences, which may be either productive or reductive of new inclusions, rights and equalities" (Cloatre 2016, p.385). This is a sobering reflection in advance of the legal research proposed to be conducted in this thesis.

2.8. Discourses of Antarctic governance

Natural geographies have only a tentative correspondence with "legal geographies" (Braverman et al. 2014), jurisdictional boundaries and the boundaries of our endeavors as a specie. Multiple discourses of Antarctic governance contest the past to claim the future such as "decolonization" (Mancilla 2020) and regime "legitimacy" (Yermakova 2021). There also exists a discourse to combine the Antarctic with the

Arctic to create the imaginary of the “polar” (Dahl et al. 2019). Discourses as much embody as they reveal our collective aspirations.

Bioprospecting taps on the Antarctic environment as a resource and Antarctica is itself “a continent for environmental discourse” (van der Watt 2017, p.584). Not just defined but constituted by environmental law, Antarctica’s environment is a “privileged arena in Antarctica politics, a space where controlling and establishing the discourse becomes crucial to having an effective voice over what can and cannot be done in Antarctica” (van der Watt 2017, p.593). The public’s idealizing “dream” of Antarctica as a “continent of wilderness” is a discourse that may for example be at odds with a prominent discourse of Antarctica as a “continent for science” (Bastmeijer & Tin 2014). On the landmass of Antarctica, though, it is the less-wilderness sub-Antarctica region that may host more biodiversity (Leihy et al. 2020). It is biodiversity along with endemism, however, that motivates bioprospecting (Hemmings & Rogan-Finnemore 2008, p.529). Antarctica is also the subject of developing discourses for recreation and of cultural heritage (Frame et al. 2021). It is visualized variously as a vast “natural laboratory” (Dodds 1997), a “global knowledge commons” (Chaturvedi 2013), a continent for peace (van der Watt 2017, p.589) as well as the site of a “battle for the seventh continent” (Abdel-Motaal 2016). Indeed, even though it has no permanent or indigenous human population, it is a “continent for the humanities” (Roberts et al. 2016, p.2).

As stated earlier, this thesis does not press into service any kind of discourse analysis as a research method. Discourse analysis offers little hope of discovering any features of the ontology of bioprospecting for knowledge production in treaties and regulations that on the surface have nothing to do with bioprospecting. Searching in such legal texts unconcerned with bioprospecting, even for content having semantic equivalence to a glossary of the scientific terminology of bioprospecting is unlikely to find anything notable. The discourses presented above are only to contextualize the topic. For the intended ontological-analysis, this thesis will need to identify and employ a research method that will be able to comb the deep text of treaties and regulations for discovering and extracting the conceptual categories and interrelations, i.e. features, of an ontological conceptualization of bioprospecting for knowledge production. Before undertaking such an ontological-analysis however, such an ontology will itself first have to be synthesized by identifying and applying a suitable research method.

2.9. Legal framework of Antarctic governance

In this thesis, geographically, Antarctic is the continent of Antarctica and its surrounding Southern Ocean (including its continental shelves as well as its deep sea-bed) northwards up to the Antarctic Convergence which together with the atmospheric Antarctic Vortex somewhat geo-physically isolates the region. Jurisdictionally, however, different parts and aspects of this spatiality are included within the ambit of different public international law treaties and regulations.

With all national territorial claims frozen under the *sui generis* Antarctic Treaty System (ATS), no national sovereignty, no indigenous people, and in being a continent surrounded by ocean instead of an ocean surrounded by land, Antarctica is fundamentally different even from the Arctic as far as governance is concerned (van der Watt & Roberts 2018, p.140). Antarctica does not qualify under the Convention on Biodiversity (CBD) as a ‘country of origin’ having sovereignty over resources within its geography (Humphries 2018, p.55).

Concerning bioprospecting in Antarctica, governance challenges have been seen as pertaining to the sustainable management of marine genetic resources. These challenges have been summarized as fragmentation and privatization in international law (Barros-Platiau & Gonsalves 2019, p.9). The prevailing legal regime of a number of different treaty constellations in relation to the governance of Antarctica has been called a "patchwork" (Heinrich 2019, p.56) and a "confusing framework" of both gaps and overlaps (Cunningham-Hales, 2017, p.17).

International law for bioprospecting in the deep sea developed through "narrow, regime-specific *lex specialis*" treaties and risks "conflicts across treaty boundaries" (Krabbe 2021, p.512). These conflicts are symptomatic of regime fragmentation. This is not merely a loss of systemic coherence; it also risks loss of credibility and legitimacy (Krabbe 2021, pp.504-06). Regime overlaps have been highlighted specifically in Antarctica (Hemmings 2006) and the practical hierarchy of authorities in these regime complexes is often a matter of negotiation and appearances (Green 2022). It has been actively and repeatedly urged by prominent stakeholders to take cognizance of a regulatory gap in the governance of bioprospecting in Antarctica (Working Paper: WP 26 2009).

Contrary views have also been expressed: "It would be unreasonable to suggest that biological prospecting is currently a key concern in Antarctic marine environment, but it seems likely to become a more important issue in the years ahead" (Hemmings 2015, p.425). Passive-permissive governance of bioprospecting in Antarctica may be the right governance: "The status quo of non-regulation is never advanced as an explicitly positive outcome" (Davis 2011, p.167). The possibility that the absence of legal instruments governing bioprospecting is just as things should be is immediately marred subliminally if the circumstance is described as one without regulations, i.e. as unregulated. It is as if 'unregulated' simply cannot be 'governed', much less 'well governed.'

Acknowledging regime fragmentation and taking a "solutions based approach", it has been recommended that the Antarctic Treaty System (ATS) take into account the Biodiversity Beyond National Jurisdictions (BBNJ) Revised Draft (Heinrich 2020, p.59). This draft has been produced as the negotiating text of a proposed Independent Legally Binding Agreement (ILBI) under the United Convention on the Law of the Sea (UNCLOS) on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction **(**ABNJ) (Nickels 2020; Humphries et al. 2021).

Patent documents referencing Antarctica show a "rising albeit irregular trend" (Working Paper: WP 16 2021; Oldham & Kines 2020) but this cannot directly be taken as a trend for the patenting of Antarctic-origin bioprospecting (Working Paper: WP 16 2021; Oldham & Kines 2020). Addressing a criticism over delay owing to patenting of scientific information and results from bioprospecting in Antarctica, it has been argued that the prevailing system of time bound full disclosure requirement of patent publication already provides a full answer. The argument refutes the charge that patenting entails delay in dissemination which is a constraint on freedom of scientific access and exchange of information obtained from Antarctic bioprospecting (Connolly-Stone 2005, pp.94-97).

National science programs of a just a handful of countries, of only some of their universities and some select corporations hosted in these very few countries, are involved in Antarctic bioprospecting with strong commercial linkages (Oldham & Kines 2020). The mixed scientific-industrial character of bioprospecting and the mixed public-private profile of the institutions conducting bioprospecting have been presented sometimes as posing a moral hazard to the expectations of a pristine Antarctic science (Hemmings 2010). It has been suggested by the same study, however, that the situation can be addressed by allowing access to biodiversity for scientific and small-scale commercial activity but not for more fully industrial bioprospecting (Hemmings 2010, p.11). How does international law perceive the role of the for-profit private sector in bioprospecting in Antarctica for knowledge production? This thesis will be mindful of this question while conducting legal research of international law.

The domain of legal regulation of *in-silico* bioprospecting in Antarctica or in any other locale extends far beyond Antarctica or that other locale. The seeding of and the reliance upon gene banks and other digital databases and resources, an increasingly important feature of bioprospecting, transposes bioprospecting *in* *situ* of natural bio-occurrences out of that place and into cyberspace (Rabitz 2019). Under the auspices of the Convention on Biodiversity (CBD), traceability of Digital Sequence Information (DSI) on genetic resources to the physical location of access to those genetic resources by bioprospecting, is being actively examined (Houssen et al. 2020; Laird & Wynberg 2018). If the culmination of this examination process results in treaty (or regulation) making in international law, its reach may also be sought to be extended to bioprospecting in Antarctica.

In this backdrop of the possibility of extension of jurisdiction, under the United Nations Convention on the Law of the Sea – Biodiversity Beyond National Jurisdiction (UNCLOS-BBNJ) process to the marine biodiversity of Antarctica, and under the Convention on Biodiversity – Digital Sequence Information (CBD-DSI) examination process to genetic resources from Antarctica, there arises a possibility of conflict with the Antarctic Treaty System (ATS). In this regard, the 2017 Antarctic Treaty Consultative Meeting (ATCM) yet again reiterated that the ATS is the "competent framework" for managing bioprospecting in Antarctica (Heinrich 2019, p.40).

2.10. Potentially relevant international treaties and regulations

No treaty or regulation claims or purports to govern or regulate bioprospecting in Antarctica. Six major treaty constellations and a single *sui generis* treaty have been identified in this thesis as potentially most relevant for the governance of bioprospecting in Antarctica. This thesis proposes to search their texts to find features of a conceptualization of bioprospecting embedded in them, if any. Treaty constellations comprise a parent treaty as the nucleus and a familial set of one or more subsidiary and sister treaties and regulations. The six treaty constellations are - the Antarctic Treaty System (ATS), the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on Biodiversity (CBD), the Convention on Plant Genetic Resources for Food and Agriculture (PGRFA), the Convention on Protection of Industrial Property (Paris Convention 1883) particularly in relation to patents, and the Convention on the Conservation of Migratory Species (CMS). The *sui generis* treaty is the International Convention on Regulation of Whaling 1946 (ICRW) that, though deserving in some ways to be clubbed with the CMS constellation, happens to be prior and formally lies outside it. In this thesis, 'regulations' refers to legal instruments familial but subsidiary and subordinate to 'treaties' and referred to variously such as for example: Bye Laws, Codes, Protocols, Recommendations and Rules.

Not all treaties in the six specific constellations, nor all regulations, are of significant potential relevance to the governance of bioprospecting in Antarctica. Only the relevant ones have been selected. No regulation has been selected without also selecting its parent treaty. Not all regulations under a selected treaty have been selected though. The criterion for selection within a constellation is the same in each instance: at least potential relevance to the governance of bioprospecting in Antarctica.

Altogether twenty-five legal instruments have been selected in this thesis for ontological-analysis: fifteen treaties and ten regulations. Selected treaties and regulations are all currently in force, and collectively their adoptions span almost a century and a half, with the earliest, the Paris Convention, adopted in 1883. The basic idea of bioprospecting is quite old though its modern form, especially its post-omics avatar, is only decades old. This thesis will examine the selected treaties and regulations broadly in the chronological sequence of their adoption.

The subscribing countries and regional organizations are different for different treaties and regulations. The number of subscribers varies with treaty and regulation. There are sometimes hierarchies not only within a treaty constellation but also between them. These treaty constellations have not been negotiated, adopted and ratified with the goal of forming an integrated and unified system covering all possible regulatory concerns. International law, even potentially relevant to the governance of bioprospecting in Antarctica, is a patchwork quilt of such *lex specialis*.

2.11. Missing ontological legal research: The second knowledge gap

From the literature review conducted for this thesis, there seems to be a lack of legal research on texts of international law treaties and regulations searching for the features of an ontology of bioprospecting for knowledge production. This is so even of those international law treaties and regulations that are potentially most relevant to the governance of the activity of bioprospecting in Antarctica having no habitation of indigenous people with relevant Traditional Knowledge (TK). Since even the treaties and regulations potentially most relevant to the governance of bioprospecting in Antarctica do not claim or purport to regulate bioprospecting however named, defined or described, they cannot be expected to feature any directly relatable doctrinal content. A different approach can be to study the texts at a more granular scale than the scale of legal doctrines.

It is possible that some features of the synthesized ontology of bioprospecting for knowledge production lie scattered in the texts of some of these treaties and regulations. If so, it is only in the deep text that they may lie embedded. It is only in the terminology (definitions) and the vocabulary (undefined words and phrases used in the definitions or effectively as definitions) of the texts, in the very grain of the texts that is, that a search would have to be conducted to excavate them.

An ontological legal research (OLR) of the texts of these treaties and regulations can unearth such features. From the literature survey conducted for this thesis, it would appear that no such ontological analysis has been conducted in previous scholarship. Since there is no ready-to-use ontology of bioprospecting for knowledge production synthesized by any previous study, conducting such ontological legal research requires first to synthesize such an ontology. This double step requirement for such research may be a special reason why it has not been undertaken yet. This points to the second lacuna in the scholarship which this thesis will try fill.

Can any such features of the synthesized ontology of bioprospecting for knowledge production can be found on a search lying scattered and embedded in the texts of any of the selected treaties and regulations? The nature of the search results will speak to the intersections of techno-scientific comprehension and legal comprehension (Dellapenna 1999, Avgerinopoulou 2019). Significant finds will imply that the legal community is conscious at some level of the intricacies and complexities of the techno-scientific processes of bioprospecting. This will mean that the existing law is already primed to tackle regulatory challenges of bioprospecting under any changes to the regulatory-policy prescription. Weak finds will imply that these intricacies and complexities are known only to the scientific community and that the legal community is yet to gain cognizance of them. This will mean that much techno-scientific learning in the legal field will be a prerequisite for coping with the regulatory challenge of bioprospecting if and when a different regulatory-policy prescription is provided (Marchant 2013).

Sustainable governance of newly emergent and complex activities like bioprospecting for knowledge production requires the law to possess techno-scientific literacy. Techno-legal literacy and interdisciplinary expertise are needed to sustainably govern complex, emergent techno-scientific activities, at least collaboratively if not on an individual level Marchant 2013; Dellapenna 1999).

3. Theory & Method

In this thesis, choice of theory and method are motivated by the requirements and constraints of the ultimate objective which is to conduct an ontological-analysis of the deep text of selected treaties and regulations by way of a search for the features - conceptual categories and interrelations - of a conceptualization of bioprospecting for knowledge production. The ontology-synthesis and then the ontological-analysis on its basis, are each proposed to be conducted manually instead of algorithmically through a computer-implementation. This inherently imposes constraints on the level of complexity that can be handled at each of the two stages. Nevertheless, the level of complexity that is generated and handled must also be high enough to have a realistic hope of discovering a significant enough body of finds to afford useful insights. A balance thus is required to be struck on the level of complexity that would suit the research goals of this thesis.

The result of the ontology-synthesis must prove to be satisfactory aid to the consequent and subsequent ontological-analysis. It is critical that the typology of features of the synthesized ontology be such as can be expected in minimally adequate measure to be found in the search through the subsequent ontological-analysis. This means that not just the complexity but also the nature of the design of ontology-synthesis should align with an advance sense of what kind of search-finds can be hoped for. On a sense, hoped-for search-finds would be some of the techno-scientific processes that form components of bioprospecting as an activity, some of the natural bio-occurrences that bioprospecting accesses and maybe some of the knowledge artifacts that bioprospecting produces. It is much less likely to search-find specific entities that conduct any component activity, interactions between different such entities, ideas and theorizations, and direct engagements of entities either with natural bio-occurrences or with knowledge artifacts produced by bioprospecting. The prospects of finding elements of downstream management of the results of bioprospecting can be assessed in advance as even poorer.

Conceptual frames of the theoretical framework and associated methodology are mentioned below in italics at the head of each paragraph dealing with it one by one.

3.1. Ontology-Synthesis

3.1.1. Theory - Knowledge Artifacts and Activity Theory

Activity: The proposed ontology-synthesis conceptualizes bioprospecting for knowledge production as an activity with the aid of Activity Theory of "human–technology interaction" (Kaptelinin & Nardi 2018, p.4).

Production: Bioprospecting is treated as a technological activity for the ontology-synthesis. Technology can be defined as "a set of pieces of knowledge ultimately based on selected physical and chemical principles, know-how, methods, experiences of successes and failures, and also, of course, physical devices and equipment" (Dosi & Grazzi 2006, p.175). Knowledge itself can be defined through the "data-information-knowledge hierarchy" as "actionable information" where "information is data endowed with meaning" and "data are the codification of observable facts" (Salazar-Torres et al. 2018, p.856). A procedural view of technologies is taken in this thesis in terms of input–output relations (Dosi & Grazzi 2006, p.174). The concern is with '"what comes in and what goes out' of the 'production process'", a "perspective on the theory of production" (Dosi & Grazzi 2006, p.173).

Systems & Networks: As specified by Activity Theory, an activity will be treated as the "basic unit of analysis" (Kaptelinin & Nardi 2006, p.32) by the ontology-synthesis. It will be deconstructed to examine if it is composed of "a sequence of steps" (Kaptelinin & Nardi 2006, p.62). An activity's sub activities will also be conceptualized where helpful as a "hierarchical structure" (Kaptelinin & Nardi 2006, p.62).

Ontology-synthesis will focus on "operations" instead of on the more conscious and deliberative "actions" (Karanasios 2018, p.138). It is also proposed to examine the possibility of "two interacting activity systems connected by a shared object" and "networks of interacting activity systems" (Engeström 2001).

Socio-Technical System (STS): Ontology-synthesis will adopt a systems approach. A system is a set or collection, structurally, of elements or components having interrelations or interconnections amongst each other, functioning together as an integrated and organized complex whole towards a common purpose or goal. An "interdisciplinary" (Blunden 2009, p.1) system perspective will be taken by treating bioprospecting for knowledge production as a socio-technical system (STS). For this, Activity Theory will be applied as if bioprospecting for knowledge production is a "collective activity" in the form of "social action" by the human "community" (Engeström 2001). This will subsume both the 'social' and the 'material' in a single theoretical framework that rejects "analytical dualism" between social context and the use of technology by taking a "socio-technical perspective" (Karanasios 2018, p.135-36).

Ontology of a System Under Study (STS): Ontology of any system including an STS refers to the taxonomy and relational scheme of the system's elements and their interconnections. Ontology-synthesis will synthesize an ontology of a conceptualization of an STS of bioprospecting as an activity for knowledge production.

Activity vs. Objects (Input/Output) and Subject (The social institution operating the Activity, the Operator): It is the "primacy of activity" over not only the object, input or output, but even over the subject that sets Activity Theory apart from Interaction Theory (Kaptelinin & Nardi 2006, p.31). Instead of trying to know first the subject and the object and only then make an inference about an activity as their interaction (Kaptelinin & Nardi 2006, p.31), the order will be reversed in this thesis. Social institutions which can be agencies, corporations and universities amongst others will be treated as the subjects. The processes of bioprospecting will be treated as transforming an input object into an output object through a mediation by the subject as an instrument of "human intentionality" (Kaptelinin & Nardi 2006, p.10). Ontology-analysis will thus proceed in conformity with recognition of an inherent "asymmetry of people and things" (Kaptelinin & Nardi 2006, p.10) in that only people as subjects have the agency to effect transformation. This is why this thesis does not draw upon Actor-Network Theory.

Transformations into Artifacts: Resulting from the transformation of input objects, output products or artifacts are produced by activities. Artifacts "mediate our relationship with the world" (Kaptelinin & Nardi 2006, p.42). Artifacts produced by bioprospecting for knowledge production will be treated by ontology-synthesis as having a "dual nature"– not only distinct, taking in the physical or tangible as well as the intangible or intellectually-corporeal, but also "functional" (de Vries 2006, p.20, 29). To qualify as an artifact in the ontology-synthesis, it will also be required to be "an object that has been intentionally produced for a specific purpose", "the result of a disciplined human activity", having necessarily both "an author and a purpose" (Salazar-Torres et al. 2018, p.856). In contrast, the notion of a 'natural object' will be used in this thesis to indicate an object that has not been intentionally modified i.e. transformed by an activity (de Vries 2006, p.21).

Knowledge Artifacts: For the ontological-synthesis, an artifact can qualify as a knowledge artifact if it is "made of knowledge" (Salazar-Torres et al. 2018, p.856) or even "made up" of knowledge (Cabitza & Locoro 2014) or "represents" knowledge by being an "encoding" of knowledge" itself "created with specialized knowledge" (Salazar-Torres et al. 2018, p.857). It will require functionally to cater to "the transfer and utilization of knowledge" (Salazar-Torres et al. 2018, p.856). Knowledge artifacts will therefore be treated as "vehicles for knowledge sharing" (Salazar-Torres et al. 2018, p.857) that are themselves "objectified knowledge" "vehiculated" by "circulation of knowledge" (Cerroni 2015, p.432, 434). More practically, to conceptually identify them for the ontology-synthesis, knowledge artifacts will be understood to "convey and hold usable representation of knowledge" (Holsapple & Joshi 2001).

Knowledge Production: An activity producing knowledge artifacts will be treated in the ontology-synthesis to qualify as "knowledge production" (Gibbons et al. 2010; Hessels & van Lente 2008; Gurukkal 2019). The conduct of knowledge production activities will be considered to perform "knowledge transformations" (Newman 2004; Dosi & Grazzi 2009, p.177) which are the "foundations of knowledge flows" (Newman 2004) and can be subjected to "input-output" analysis (Drejer 1999). A particularization of knowledge production is "scientific knowledge production" (Knorr-Cetina 1999; Kilduff et al. 2011, p.311). Knowledge production will be understood in this thesis in a purposive sense but in a value-neutral manner. It will not be deemed beneficent generally or as aiding sustainable governance. The struggle over its values happens to have significant implications for sustainable development (Halvorsen 2017). This is because knowledge artifacts lie initially in the default private exclusive custody of the subject, the institutional operator which operates the knowledge-transformation activity pipeline. From such custody spring power and control that intersect variously with the sustainability of governance. The study of these consequences of default custody are, however, beyond the scope of this thesis. Other than to aid the proposed ontological-analysis of selected legal texts in this thesis, ontology-synthesis in this thesis does also hope to generate an academic resource to aid the future study of such consequences.

3.1.2. Method - Conceptual System Modeling (CSM)

System Under Study (SUS): Ontology-synthesis will treat bioprospecting for knowledge production as a system under study (SUS) or, to use another phrase as equivalent, a target system. Ontology-synthesis in this thesis is an exercise in studying to understand a real world phenomenon so as to arrive at a conceptualization of it. The emphasis in the ontology-synthesis will be on looking at the activity of bioprospecting for knowledge production as a "real-life use of technology as a part of unfolding human interaction with the world" (Kaptelinin & Nardi 2006, p.34).

Objectives of the Ontology-Synthesis: Visualizations of the processes of bioprospecting that exist in the scholarship are only illustrative. They do not claim to be nor are taxonomically comprehensive as an ontology. This thesis proposes to synthesize such an ontology. The ontology proposed to be synthesized will not be unique as the only possible ontology. Indeed, there are many ontologies that can be synthesized for any real world system - so as to serve different objectives. The method of ontology-synthesis needs to be suited to the objective the synthesized-ontology has to serve. The objective of ontology-synthesis here in this thesis is twofold. The first objective is to generate an ontology as a generic academic resource for future research on different aspects and dimensions of bioprospecting. The second and more immediate objective is to generate an ontology from which the features of the ontology can be obtained which can then aid the intended ontological-analysis of selected legal texts, in this thesis itself.

First Objective - Ontology as a Generic Academic Resource for the Future: The seeming lack in the literature of any conceptual understanding of bioprospecting as an activity for knowledge production has been identified previously as a knowledge gap from a literature review conducted for this thesis. New avenues of research on bioprospecting generally can be expected to open up if this knowledge gap is filled. The synthesized ontology can serve as a new basis to propel various kinds of future research on bioprospecting. It can have the potential to open up conversations about bioprospecting that speak to "the larger global concerns that the deployment of our technologies unquestionably affects" (Kaptelinin & Nardi 2006, p.13). To serve this objective, the ontology-synthesis method should span the domain of bioprospecting for knowledge production as widely as possible and as systematically as possible. To achieve this, it is proposed in this thesis that the synthesized ontology be itself constituted as a system. What this implies is that for the real-world phenomenon of bioprospecting being itself looked at as a system, its ontology be also synthesized itself as a system.

Second Objective - Ontology as a Resource of its Features for Utilization in this Thesis Itself: The seeming lack in the literature of any ontological-analysis of legal texts potentially relevant to the governance of bioprospecting in Antarctica has been identified as a knowledge gap previously from a literature review conducted for this thesis. The synthesized ontology will, in this thesis itself, aid such an ontological-analysis. For the ontological-analysis of a legal text to be a search for the features of the ontology in that legal text, the features of the ontology must become easily available from the ontology in a form that sustains the searching. To serve this objective, the ontology-synthesis method should yield the features of the domain of bioprospecting for knowledge production as discernibly as possible and in number and simplicity amenable to a manually conducted ontological-analysis as is intended in this thesis. To achieve this, it is proposed that the synthesized ontology be constituted using only a limited number of simple conceptual categories as its building blocks.

A Model: To achieve both objectives (supra), the proposed ontology-synthesis will craft a model of bioprospecting for knowledge production. Modeling anything in the real world, including an object or a population, under whatever theory, treats the real-world thing as a System Under Study (SUS) (Knuuttila 2011, p.264; Thalheim 2010, p. 3107). The crafted model's reliability, adequacy, explanatory power and its correspondence to reality will be the yardsticks for its quality and success (Knuuttila 2011, p.265). From the model a "set of statements" about the model will be taken as valid about the real world (Seidewitz 2003, p.27). The model will be a surrogate (Suárez 2004; Mäki 2009, p.34) by isolating key facts and dependencies from the "noise" (Mäki 2009, p.30). The ontology-synthesis in this thesis will create a model that will be inherently "inaccurate" and "distorted" (Callender & Cohen 2005, p.71; Knuuttila 2011, pp. 262-63) as a representation of reality, containing not only idealizations, assumptions and omissions but also simplifications, approximations and fictional elements. The model, a "portrait, map or mirror", a "simulacrum", and a "rendering of an 'original' in a different medium" is intended to be productive, offering "cognitive gains" as an "epistemic tool" Knuuttila 2011, pp.263).

Structure of a Model: The "inferential capacity" of the model for making statements about bioprospecting for knowledge production will turn on the model having an "internal structure" such that its parts and relations can be interpreted in terms of the target's parts and relations" (Knuuttila 2011, p.266). The representationalism of the model will derive from "isomorphism", the "structure-preserving mapping" between their respective structures (Knuuttila 2011, p.265).

Conceptual System Modeling (CSM): Conceptualization is an abstract, simplified view of reality A conceptualization is based on the concepts, objects, and other entities that are assumed to exist in the real world and the relationships that are perceived to exist between them (Gaševic et al. (2009, p.46). Conceptual system models incorporate conceptual categories of the knowledge of the domain being modeled as a system.

Knowledge Representation: Through conceptual system modeling (CSM), the activity of bioprospecting for knowledge production will be modeled in this thesis not only to indirectly draw inferences from the model but also conceptually so as to directly increase the knowledge of the activity, to directly enable and amplify "understanding and communication" (Verdonck et al. 2015, p.197). The resulting model will be a Knowledge Representation, a type of Conceptual System Model (CSM) (Valente & Breuker 1994, p.112).

Conceptual Graphs: A Conceptual Graph is a particular type of Knowledge Representation. It provides a "universal knowledge representation language that combines the expressive power of natural languages with the precision of symbolic logic" (Sowa 1992, p.75). The proposed ontology-synthesis will generate a set of Conceptual Graphs as a form of Knowledge Representation. These Conceptual Graphs will be pictorial but include some small written pieces of text including legends. The set of Conceptual Graphs that will be drawn will together depict and represent the domain of bioprospecting for knowledge production.

The theoretical framework above is reduced to a template for drawing the Conceptual Graphs in this thesis, in **Figure 3**.

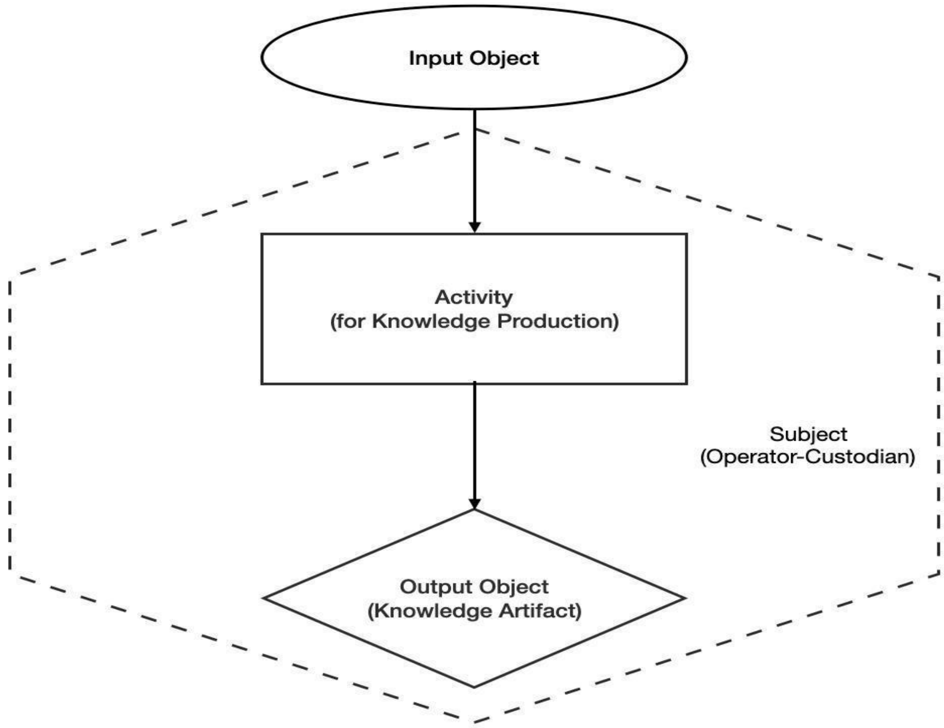


Figure 3: Template of system view for drawing the Conceptual Graphs as a form of Knowledge Representation, a Conceptual System Model (CSM), to be synthesized in this thesis to depict an ontology of the single purpose type definition of bioprospecting as an activity only for knowledge production, in which Traditional Knowledge (TK) is not implicated; a conceptualization based on Knowledge Artifacts and Activity Theory showing an Activity (for Knowledge Production) as part of a Socio (Institutional)-Technical System (STS), with Input Object, Output Object (Knowledge Artifact) and Institution-Subject (Operator of Activity cum Custodian of Knowledge Artifacts produced by Activity). Interrelational topology is shown by arrows and four types of emboxments. Inspired by and credit for theorization: (Kaptelinin & Nardi 2006).

Ontology of a Set of Conceptual Graphs: Conceptual Graphs bear a specification of how they see reality, whether or not made explicit as ontological commitments, "a language in which we say things about the world" (Valente & Breuker 1994, p.112). By acknowledging the existence of some things and being blind to that of others, any set of Conceptual Graphs of any domain like for example bioprospecting for knowledge production, will always have "ontological underpinnings" (Valente & Breuker 1994, p.113). A single Conceptual Graph, or a set of Conceptual Graphs as is actually proposed to be drawn in this thesis through ontological-synthesis, being a type of "Knowledge representation", will be seen to use an ontology as "an associated underlying data structure" (Gaševic et al. (2009, p.46). The eventual goal of each of the twin objectives of ontological-synthesis in this thesis is the "elicitation of a high-quality conceptual schema" (Thalheim 2010, p.3102) of the domain of bioprospecting as an activity for knowledge production. It is proposed to attain this goal by drawing up a set of Conceptual Graphs and tabulating its associated ontology.

Features of the Ontology of a set of Conceptual Graphs: Having inherently always an associated data structure, an ontology can be disaggregated into its data types or distinct features. If an ontology of a domain is like a skeleton of a body, the features of the ontology are like the bones and their joints. The bones correspond to the conceptual categories and the joints to their interrelations. Each feature can motivate a search for that feature in another domain such as for example a particular legal text.

It is with the aid of the above theoretical framework and methodological framework that the proposed ontology-synthesis of bioprospecting for knowledge production is proposed to be conducted in this thesis. Next, the theoretical and methodological framework of the ontology-analysis to be conducted in this thesis, of the texts of treaties and regulations selected as being potentially most relevant to the governance of bioprospecting in Antarctica, is described.

3.2. Ontological-Analysis

3.2.1. Theory - International Law and Deep Text

International Law: Article 38 (1) of the Statute of the International Court of Justice mandates the application of "international law." Like any branch of law, international law has its sources (Thirlway 2019; Bowman & Kritsiotis 2018; Besson 2010). The sources of international law are particularly problematic to identify and rely upon (Fitzmaurice 2017; Roberts & Sivakumaran 2018). In this thesis, a set of selected sources of international law are proposed to be subjected to an ontological-analysis.

Public International Law: Article 38, supra, seeks the application of international law in the form of, inter alia, "international conventions, whether general or particular, establishing rules recognized by the contesting states" (clause a). This ostensibly relates to the inter-nations aspect of international law or public international law. Public international law, comprising the legally binding rules and principles governing state (nation) interactions (Arroyo & Mbengue 2017, p.800) is classically distinguished from private international law. Private international law or transnational law or conflict of laws (de Boer 2010, p.184) concerns interactions between non-state (nation) actors i.e., private actors, of, from and subject to different national domestic jurisdictions (Arroyo & Mbengue 2017, p.801). Public and private international law have, however, been discussed as having "inescapable interactions" (Arroyo & Mbengue 2017, p.797) and even as "living apart together" (de Boer 2010, p.183). In this thesis, a set of selected sources of public international law are proposed to be subjected to an ontological-analysis.

Treaties and Regulations: Conventions are also referred to as treaties and are a source of positive or human-made international law (Hall 2017, p.184). Treaties are formally concluded, adopted and ratified agreements between nation states or their groupings. In this thesis, only those treaties will be selected that have already come into force and continue to be in force. As stated by Hall, "Treaties are the real workhorses of international law" having preeminent status as sources of international law (Hall 2017, p.183). A multilateral treaty may possess a "general character" as referred to in Article 38, supra, and be regarded as "legislative" (Hall 2017, p.184). Regulations are under a treaty in the sense of being subsidiary thereto. A regulation is either itself a subsequent treaty or framed by an authority empowered by the parent treaty to frame regulations.

Doctrinal Legal Research vs. Discourse Analysis vs. Content Analysis: Discourse analysis studies the language of texts but with an "externalist approach" (Pirker 2021, p.503). Text-Linguistics adopts a discourse-internal perspective by considering the "setting" (Pirker 2021, p.504). Content analysis "deconstructs text…rather than synthesize meaning from the text" as it seeks to quantify and identify patterns (Hutchinson & Duncan 2012, p.118). Doctrinal Legal Research plumbs a legal text for doctrines or rules that can be practically applied. It is by being treated as forming part of an integrated system of law, that doctrines are distilled. Doctrinal legal research deals mainly if not only with the ‘black letter’ of the law, referring to legislations being previously printed in law books printed in set type using a Gothic font with bold black color (Hutchinson & Duncan 2012, p.94). Doctrinal legal research has thus a “strongly internalist point of view” (Bodig 2010, p.494) that “systematizes” the elements of the law, treating law as an “autonomous discipline” (Smits 2017, p.210-11). Doing this kind of legal research, “the doctrinalist places himself inside the legal system” which would be considered unacademic in some other disciplines (Smits 2017, p.209-10). Another aspect of doctrinal legal research is that its specific genre of writing is itself the genre of research (Pahuja 2021, p.65). In this thesis, ontological-analysis has been preferred to be undertaken by a method that is a variant of doctrinal legal research, preferring it over alternatives like discourse analysis and content analysis. The reason for this is that this variant of doctrinal legal research, more particularly ontological legal research (OLR), is more suitable for searching in the selected legal texts for the features of the ontology that will be synthesized through ontology-synthesis. Neither deconstructing the legal texts nor examining their setting will be useful since none of them even claim or purport to regulate bioprospecting. For the same reason, wider discourses of bioprospecting are even less likely to occur in such legal texts.

Structure of the Language of International Law instead of the Doctrines of International Law: Seeing international law as a structure offers insights especially if attention is directed not only to the surface but also the “deep structure” (Sinclair 2021, p.217, 226). The surface structure is doctrinal, but the deep structure takes in “a way of being in and seeing the world” (Sinclair 2021, p.227). This deepening marks a shift towards international law’s ontology. (Sinclair 2021, p.217, 226, 230). In this thesis, ontological-analysis denotes this shift. Doctrinally, international law has a “fragmented and decentralized structure” holding a particular challenge for “structural analysis” (Kammerhofer 2021, p.96). The solution in this thesis is to focus instead on the structure of the language of the law. The analogy between law and language has been acknowledged and analyzed (Gibbons 1999). International law has been described as having a “grammar” (Koskenniemi 2007, p.563) on a “system” view (Collins 2021, p.16). In its workings, “international law is language” (Pirker 2021, p.521). This thesis will adopt a linguistic approach to examining the deep structure of the selected legal treaties and regulations.

Legal Text and Deep Text: Treaties and regulations have texts, a “manifestation of language” and are “a communicative language event in a context” (Beaugrande & Dressler 1981, p.63). Under the ‘surface text’ actually used to spell out doctrinal positions, lies a deeper text that is applied during cognitive processing of the text. (Beaugrande & Dressler 1981, p.63). Legal interpretation implicitly factors in these “elements from elsewhere” (Pirker 2021, p.508). Ontological-analysis in this thesis proposes to plumb the deep text of the selected legal texts and the ‘elements from elsewhere’ that will aid the ontological-analysis will be the features of the synthesized ontology of bioprospecting for knowledge production. Plumbing the deep text will entail searching for the said features in the terminology (definitions) and the vocabulary (words and phrases used to build definitions or otherwise used self-definitionally) of the selected legal texts.

Values Embedded in a Legal Text: Any law is law because of a “legal mindset” (Sinclair 2021, p.218). This legal mindset co-develops with the political economy, imbibing its ethos and values. For international law, capitalism which is “inherently legalistic” has been identified as one such ethos (Sinclair 2021, p.225). The global political economy has also been described as undergoing a process of juridification in which a commodified legal form provides a template” for regulation (Cutler 2005, p.528). A legal mindset of the values of capitalism and a trend of juridification, for example, may also lie embedded in the deep text of the deep structure of the language of the texts of the selected treaties and regulations. In this thesis, the proposed ontological-analysis may chance upon some such underlying ethos and values and if so, will also report on them in the search results.

3.2.2. Method - Ontological Legal Research (OLR)

Theoretical and Fundamental Legal Research vs. Doctrinal Legal Research: In contrast to interpretative and application-oriented doctrinal exposition through doctrinal legal research, theoretical research focuses on the conceptual bases of the law (Hutchinson & Duncan 2012, p.94). Fundamental research attempts to secure a deeper understanding of law as a social phenomenon (Hutchinson & Duncan 2012, p.102). Taking linguistics to be the scientific study of the structure and nature of languages or of a language, theoretical-fundamental research deals with linguistic concepts and categories – whether they are already available from within the legal system or whether they are imported from outside (Hutchinson & Duncan 2012, p.115). Doctrinal Legal Research can be ontologically-oriented towards theoretical-fundamental research by adopting a linguistic approach for conceptual analysis (Bodig 2010, p.483). For this, questions like 'what is the law' and 'what is the legal position' on a specific point sought to be answered by doctrinal legal research will need to be converted into the ontological question – "how does the law exist?" (Aarnio 2011, p.45). From an instrumentalist perspective, the task of such a variant of doctrinal legal research will not be to state the law or ascertain the legal position but to "lay the foundations" for doing so (Bodig 2010, p.484). It is this task that ontological-analysis in this thesis seeks to accomplish.

New Doctrinal Scholarship of Ontology: Methodologically stringent legal research of truly positive law (made by humans) can be considered a kind of New Doctrinal Scholarship in international law (Kammerhofer 2021, p.105). New Doctrinal Scholarship "must primarily analyze how its chosen legal order is structured, finding out how their component parts interrelate and interact" (Kammerhofer 2021, p.107). The focus of such a New Doctrinal Scholarship then will be ontological, on "how does the law exist?" (Aarnio 2011, p.45). This is intimately linked to the "theory of language" (Aarnio 2011, p.52) of law. This language of the law has a vocabulary and on its basis, a terminology. The vocabulary and the terminology are more suited for certain frames of comprehension and their expression, than for others. Law does not have access to any "neutral vocabulary" (Bodig 2010, p.512). Ontological-analysis in this thesis has the aspiration to discover if there is any comprehension of bioprospecting for knowledge production in treaties and regulations potentially relevant to the governance of bioprospecting in Antarctica, and if so to lay bare what that comprehension is. To fulfill this aspiration, New Doctrinal Scholarship can enable the conduct of ontological-analysis with the aid of the features of the ontology that will be synthesized, through an empirical analysis searching for those features in the terminology and vocabulary constituting the deep text of selected legal texts.

Ontological Legal Research (OLR) as a type of Theoretical and Fundamental Research, a variant of Doctrinal Legal Research and an example of New Doctrinal Scholarship of Ontology: An ontological turn in legal research can be discerned in the titles of several academic publications. These titles relate to, inter alia, the ontology of concepts and characteristics of arms control treaties and non-proliferation treaties (Poucet 2006), the ontology of law and technology (Tranter 2007), anthropocentric ontology of international environmental law for sustainable development (Kotzé & French 2018), sacred spaces and competing ontologies in mining law (Harm 2012), terminological and ontological-analysis of EU Directives (Ajani et al 2007), constructing a legal ontology from a EC legislative text (Despres & Szulman 2004) and critiquing the ontology of intellectual property law (Peukert 2021). By subjecting a legal text to ontological legal research (OLR), the legal text can be ontologically analyzed for any externally imported set of conceptual categories and interrelations. Ontology, to recall, means the "common and ideally unambiguous terminology for a domain" (de Oliveira Rodrigues et at 2019, p.12). In this thesis, ontological legal research (OLR) refers to a type of theoretical and fundamental research, a variant of doctrinal legal research and an example of New Doctrinal Scholarship of the ontology of law. In this thesis, ontological-analysis will implement such ontological legal research (OLR) as a research method since semantic equivalence of the techno-scientific terminology of bioprospecting offers little hope of finding matches in legal texts that ostensibly have nothing to do with bioprospecting.

Search in a Text for an External Ontology or for Features thereof: An ontology, or even its features, can be searched for in another domain such as for example a text through an ontological-analysis. Ontological legal research (OLR) is posited in this thesis as a method of ontological-analysis of legal texts (Kurcheeva et al. 2018). The external ontology is not always made explicit while conducting such ontological legal research (OLR) but making it explicit makes for greater intellectual rigor and academic transparency. If the external ontology has no connection with a selected text, little or nothing of the former can be expected to be found in the latter. Occasionally, some features of the ontology of an activity may , however, lie embedded even in a legal text not mainly or overtly or even at all concerned with that activity. Features of an ethos or culture or value system or historical legacy or social setting or economic paradigm underlying the external ontology may also be found embedded, sometimes quite deep, in a legal text that claims or purports to be concerned with altogether other matters. To discover them, the text will have to be excavated and unearthed, mined and sifted. Undertaking such ontological legal research (OLR) will be similar to an exploration mission and an archaeological dig. That is the challenge of the ontological-analysis in this thesis.

4. Research Strategy

Methodology (Alignment of Theory with Method): Interdisciplinary, Mixed Methods Research (MMR): This study employs two methods – conceptual system modeling (CSM) for ontology-synthesis followed by ontological legal research (OLR) for ontological-analysis - in a dependent sequence. For CSM synthesis, the unit of study is an activity, and the unit of synthesis is a sub activity. For OLR analysis, the unit of study is a treaty and the unit of is 'words and phrases.'

Research Design: This thesis implements a sequential two step research design. Firstly, through conceptual system modeling (CSM), to synthesize a set of Conceptual Graphs along with associated tables, as Knowledge Representation and ontology of the domain of the activity of bioprospecting for knowledge production. Secondly, through ontological legal research (OLR), to analytically search for the features of the synthesized ontology in the terminology and vocabulary, i.e. the deep text of treaties and regulations selected as potentially most relevant to the governance of the activity of bioprospecting in Antarctica, and to report on the findings.

4.1. Delimitations

This is not a doctrinal or problematizing or value-ascriptive or normative or prescriptive study. It does not make any judgement on the adequacy or quality of the regulation of bioprospecting. This thesis does not concern itself with any legal position, brief, statement argument or conflict. Nor does this thesis express any views about political economy.

4.2. Quality and Ethical Considerations

Quality Assurance (Integrity of Research Process & Validity of Results): In this thesis, an ontology is proposed to be synthesized to serve the specifics of the research design of this particular thesis. Alternative ontologies are possible both taxonomically and in terms of comprehensiveness, and they would yield different results and conclusions valid in their own frames of reference. Their insightfulness, however, can vary. The ontology-synthesis in this thesis can be assessed self-referentially for integrity and quality but not for relative insightfulness without alternative ontology-syntheses being also undertaken and then the results compared. In this thesis, the search results of the ontological-analysis have been written in a summarized fashion given thesis size constraints, without reproducing the entirety of the cited articles, sub articles, sections, sub sections, rules, regulations, clauses and sub clauses. This renders recourse necessary to the full texts of the cited provisions in the texts of the treaties and regulations for any quality check.

Ethical Considerations: Being focused exclusively on conceptual theorization followed by an ontological feature search, this research thesis avoids direct exposure to and entanglement with ethics. It is conscious, however, of the embeddedness of any research, indeed of any knowledge practice, and especially of legal research, in society. Under the circumstances, this thesis does the best it can to make explicit all the limits and the restrictions, the premises, subjections and conditionalities - of its findings, outcomes, conclusions and statements. A separate 'Delimitations' subsection, above, has also been included in furtherance.

5. Ontology-Synthesis and Ontological-Analysis

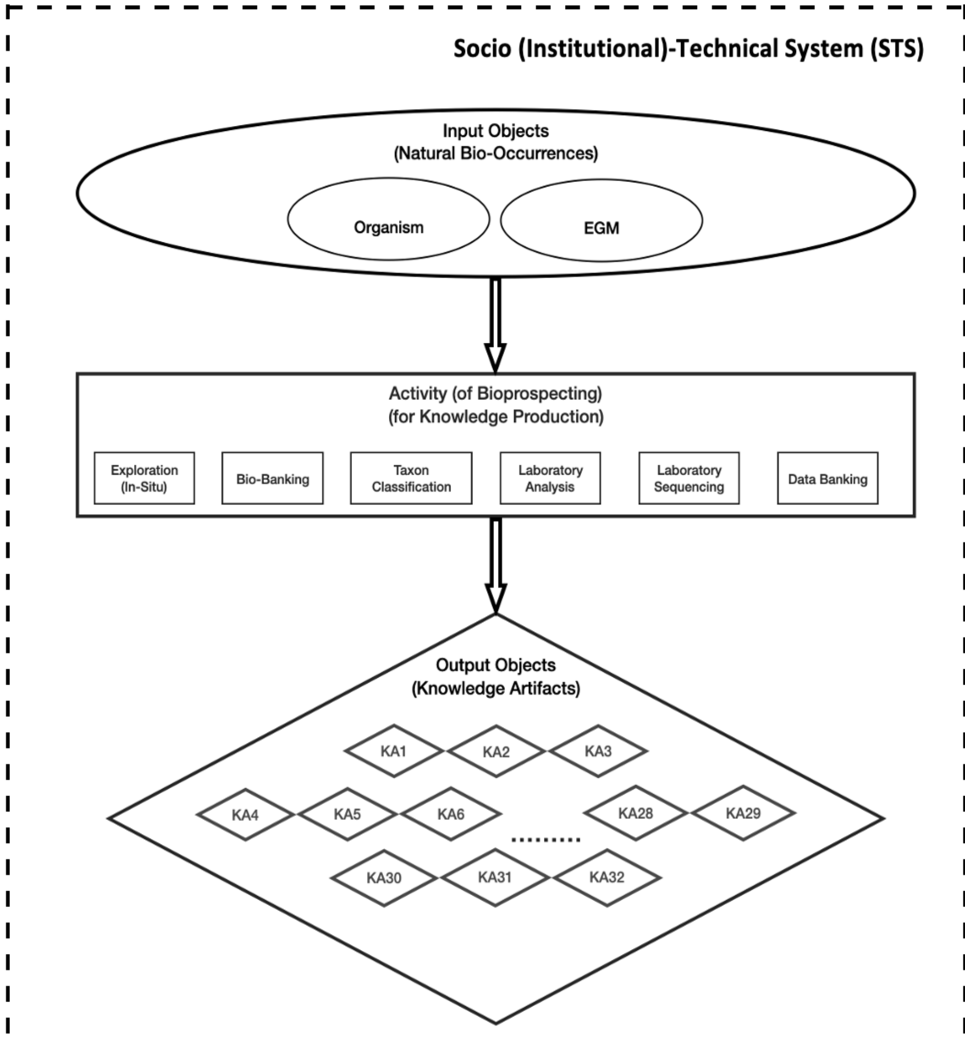
5.1. Ontology-Synthesis

5.1.1. Ontology-Synthesis: Materials - Lists of Incipient Conceptual Categories

The research materials (data) for the ontology-synthesis that follows can be presented as items belonging to four lists in Appendix A. available in the scientific literature on bioprospecting. The selection of these items inherently involves already the commencement of the ontology-synthesis. These research materials or data comprise lists - of items that are bioprospected, tools and entities that/who bioprospect, activities comprising bioprospecting and items produced by bioprospecting.

5.1.2. Ontology-Synthesis: Results – Conceptual Graphs and Tables

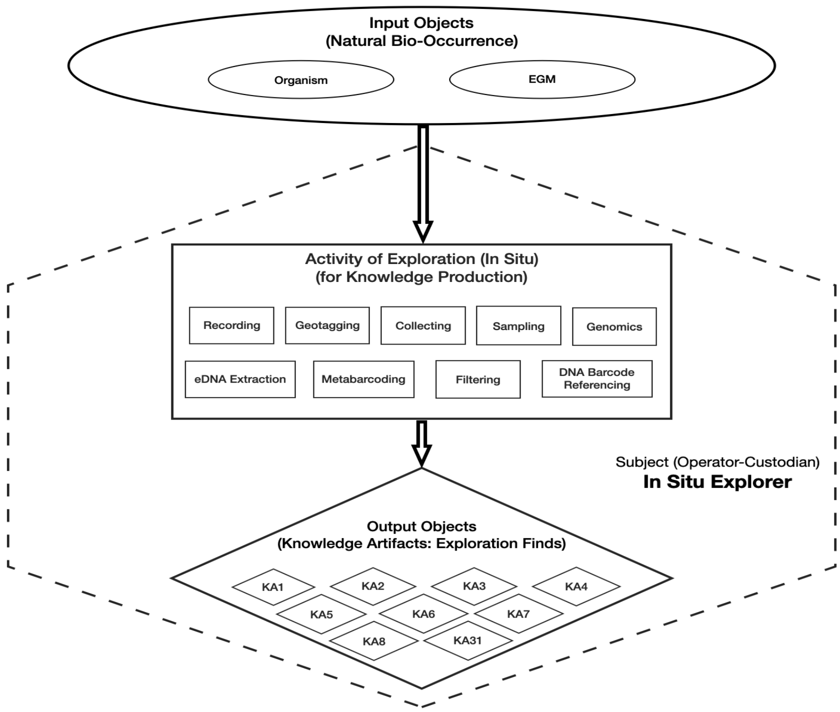
Results, below, are from the application of the research method of conceptual system modeling (CSM) to the research materials (supra). To tackle the complexity of the domain of bioprospecting for knowledge production, the conceptualization in this thesis adopts the divide and rule strategy for synthesizing an ontology. A systems approach is taken by synthesizing two higher levels, the mid-level and the top level, at which levels the complexity is more amenable to conceptualization than at the actual bottom level. At both higher levels, the systems are a hybrid - a Socio (Institutional) - Technical System (STS). There is one system at the top level comprising six subsystems at the mid-level. Ontology-synthesis is depicted in this thesis through a set of thirteen Conceptual Graphs (**Figures 4-16**), below, as a form of Knowledge Representation. The first Conceptual Graph, **Figure 4**, depicts a top-level system view of the activity of bioprospecting for knowledge production. The next pair of Conceptual Graphs, **Figures 5-6**, depict respectively a system view from the outside in, and the corresponding internal view, of the first of the six subsystems at the mid-level, namely ‘Exploration (In Situ)’. The five pairs of Conceptual Graphs that follow, **Figures 7-16**, are, respectively, for each the five remaining mid-level subsystems: Bio-Banking, Taxon Classification, Laboratory Analysis, Laboratory Sequencing and Data Banking. These five pairs of Conceptual Graphs are also depicted in the same way: a system view paired with its corresponding internal view. Each system view Conceptual Graph is drawn using the template in Figure 3. In each Conceptual Graph, the topology of interrelations between conceptual categories have been depicted through arrows and four types of emboxments. The synthesized ontology of bioprospecting for knowledge production is as associated with this set of thirteen Conceptual Graphs, and is a result of this thesis. The ontology is discernible from the Conceptual Graphs and is also presented separately in tabular form in Appendix B, C, D and E. Appendix B is the main table focusing attention on a set of the four interlocked conceptual categories of the ontology. Appendices C, D and E are each differently column-toggled versions of the main table so as to afford attention focused one by one on the three other conceptual categories of the ontology. In each table, the conceptual categories are available lexically as entries in the box-cells. Interrelations between conceptual categories are encoded in the interlocking of the box-cells in a row and in the entries in the box-cells. The techno-scientific processes of bioprospecting for knowledge production are comprehensively presented as thirty sub-sub activities producing thirty two Knowledge Artifacts. Full page versions of **Figures 4-16** are furnished in Appendix F.



KA=Knowledge Artifact; EGM=Environmental Genetic Material; eDNA=Environmental DNA; NP=Natural Product; DSI=Digital Sequence Information

KA1=Record; KA2=Geotag; KA3=Specimen; KA4=Tissue; KA5=Genome; KA6=Genome Match; KA7=eDNA; KA8=Meta Barcode Match; KA9=Preserved Item; KA10=Cryopreserved Item; KA11=Musealized Item; KA12=Captive Specimen; KA13=Bred Specimen; KA14=Cultured Specimen; KA15=NP Isolate; KA16=NP Characterization; KA17=NP Derivative Isolate; KA18=NP Derivative Characterization; KA19=Genetic Biological Material (GBM); KA20=Cryptome; KA21=Proteome; KA22=Metabolome; KA23=DNA Barcode; KA24=Meta Barcode; KA25=Metadata; KA26=Taxon List; KA27=NP Library; KA28=DSI; KA29=DNA Barcode Archive; KA30=Meta barcode Archive; KA31=EGM Substance; KA32=Taxon Entry

Figure 4: Conceptual Graph of top-level system view of the synthesized ontology of bioprospecting for knowledge production, based on the template in Figure 3.



KA=Knowledge Artifact; EGM=Environmental Genetic Material; eDNA=Environmental DNA

KA1=Record; KA2=Geotag; KA3=Specimen; KA4=Tissue; KA5=Genome; KA6=Genome Match; KA7=eDNA; KA8=Meta Barcode Match; KA31=EGM Substance

Figure 5: Conceptual Graph of mid-level system view of Exploration (In Situ) within the synthesized ontology of bioprospecting for knowledge production, based on the template in Figure 3.

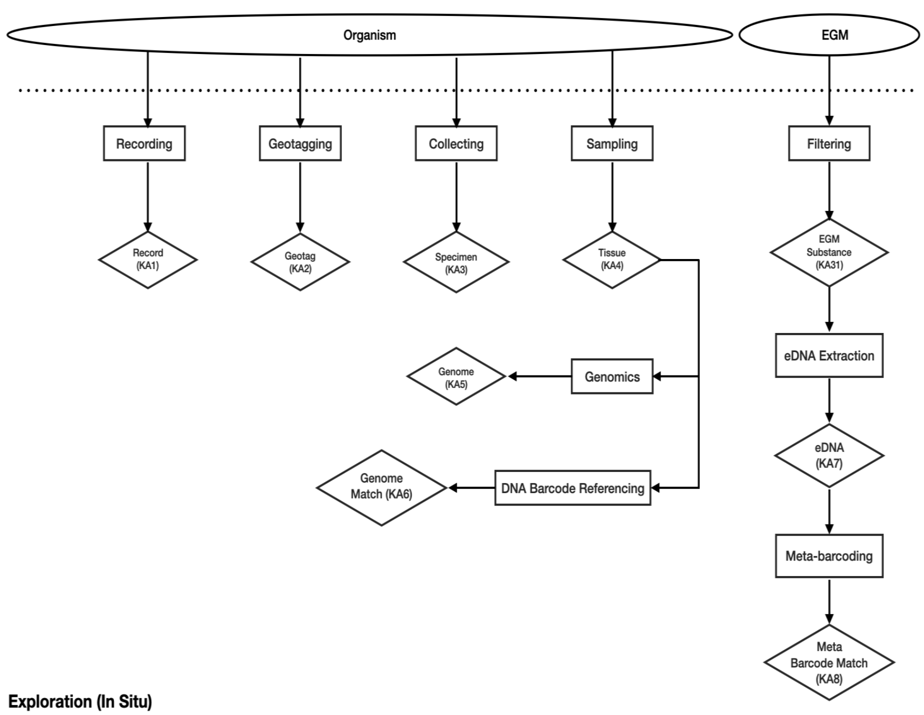
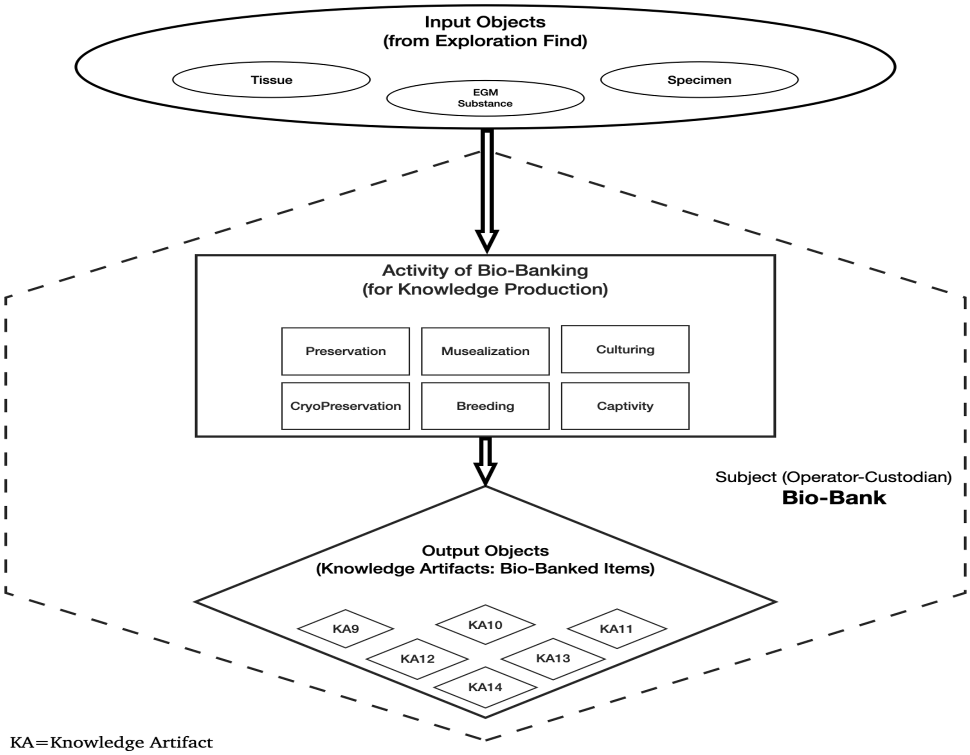


Figure 6: Conceptual Graph of mid-level internal view of Exploration (In Situ), corresponding to the system view in Figure 5.



KA=Knowledge Artifact

KA9=Preserved Item; KA10=CryoPreserved Item; KA11=Musealized Item; KA12=Captive Specimen; KA13=Bred Specimen; KA14=Cultured Specimen

Figure 7: Conceptual Graph of mid-level system view of Bio-Banking within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

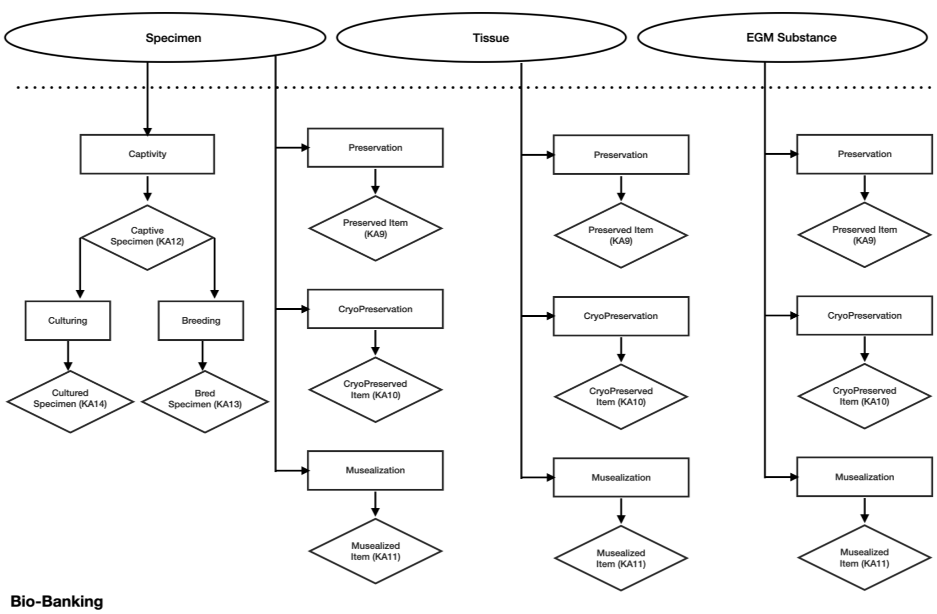


Figure 8: Conceptual Graph of mid-level internal view of Bio-Banking, corresponding to the system view in Figure 7.

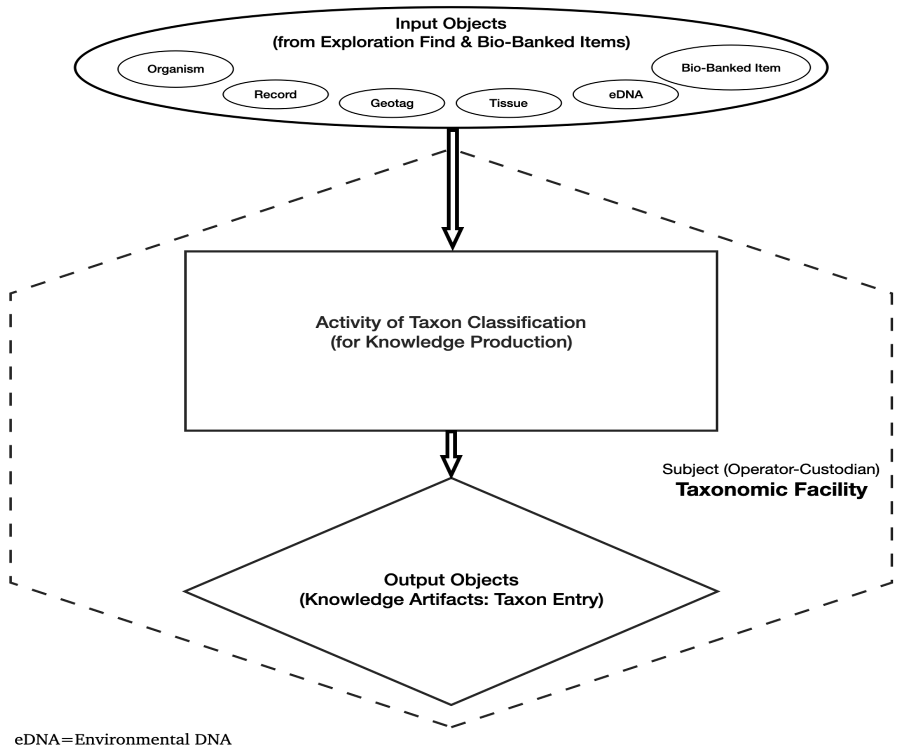


Figure 9: Conceptual Graph of mid-level system view of Taxon Classification within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

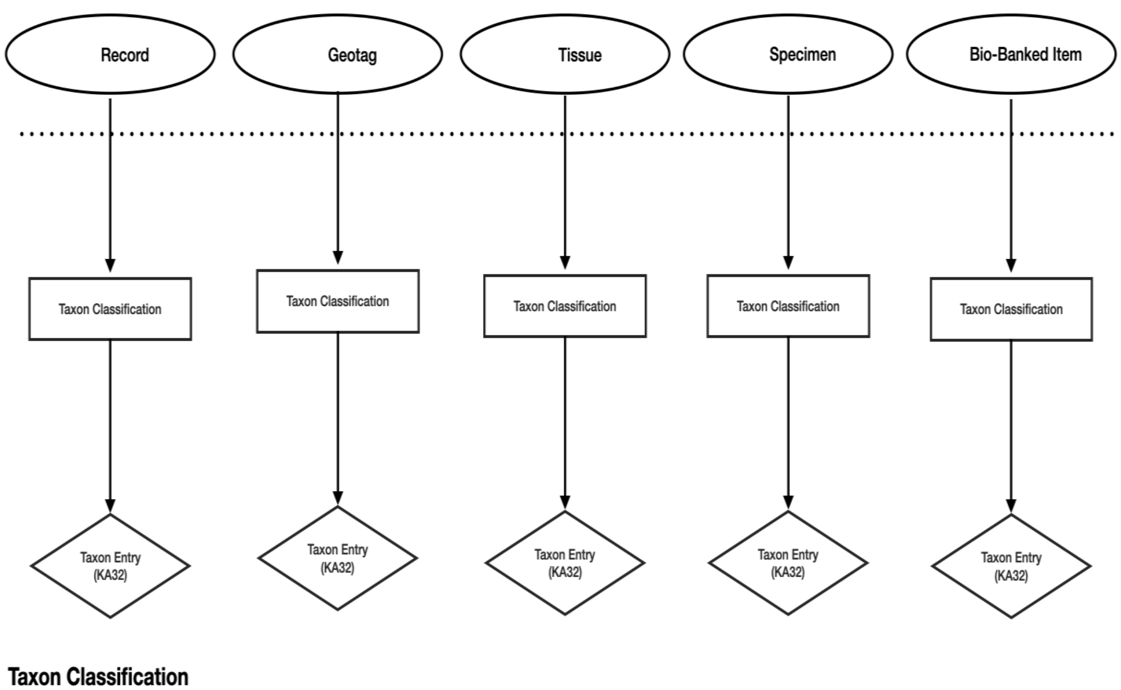
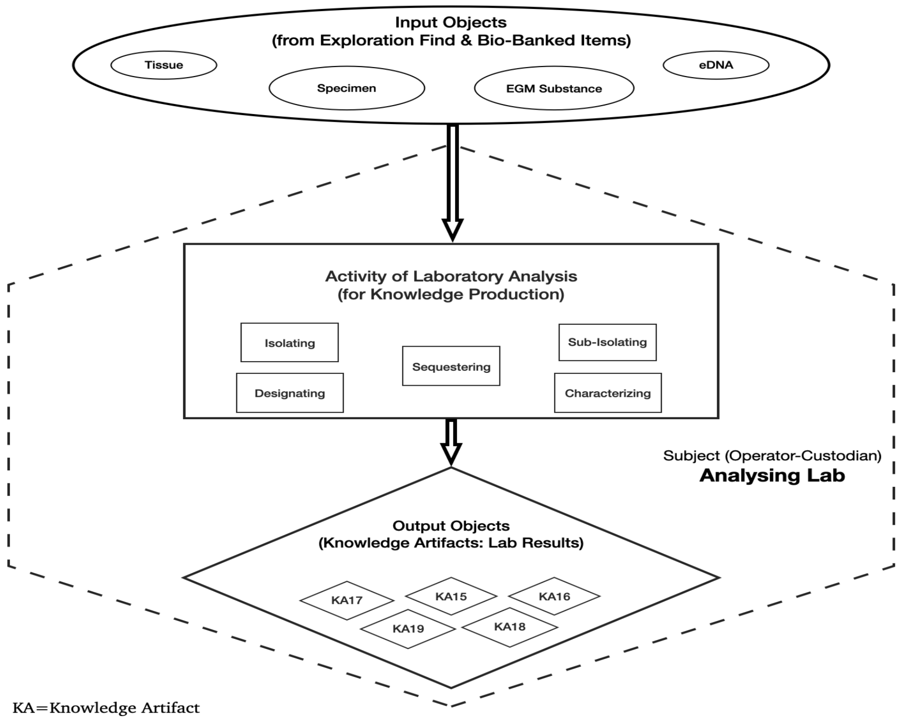


Figure 10: Conceptual Graph of mid-level internal view of Taxon Classification, corresponding to the system view in Figure 9.



KA=Knowledge Artifact

KA15=NP Isolate; KA16=NP Characterization; KA17=NP Derivative Isolate; KA18=NP Derivative Characterization; KA19=Genetic Biological Material (GBM)

Figure 11: Conceptual Graph of mid-level system view of Laboratory Analysis within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

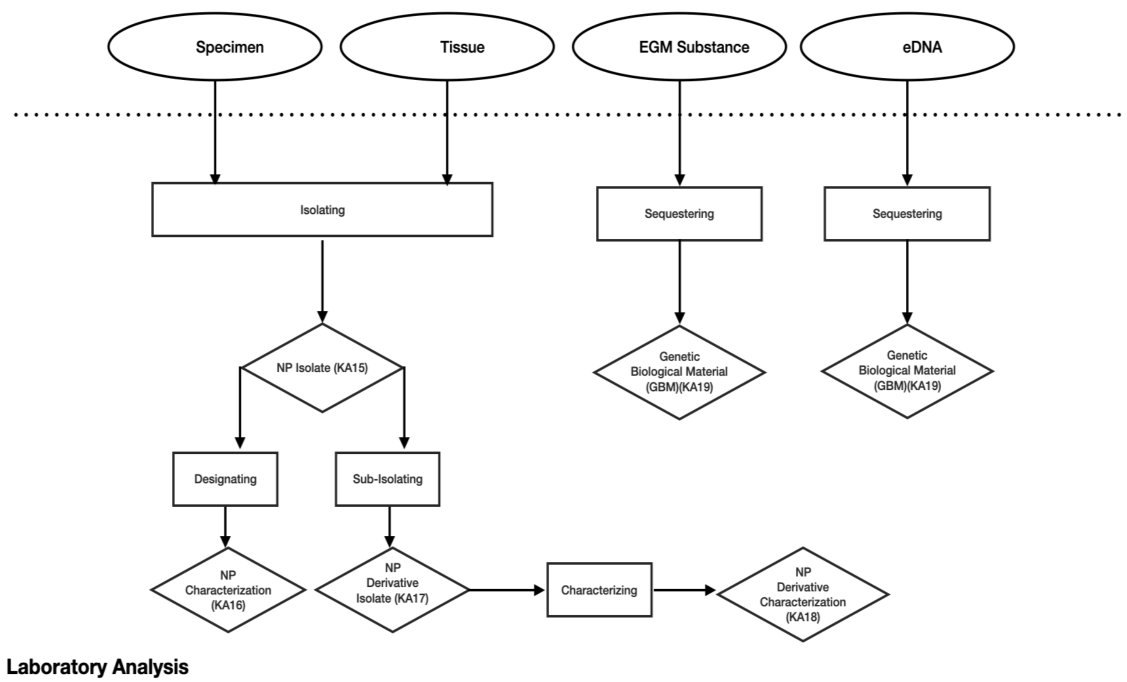
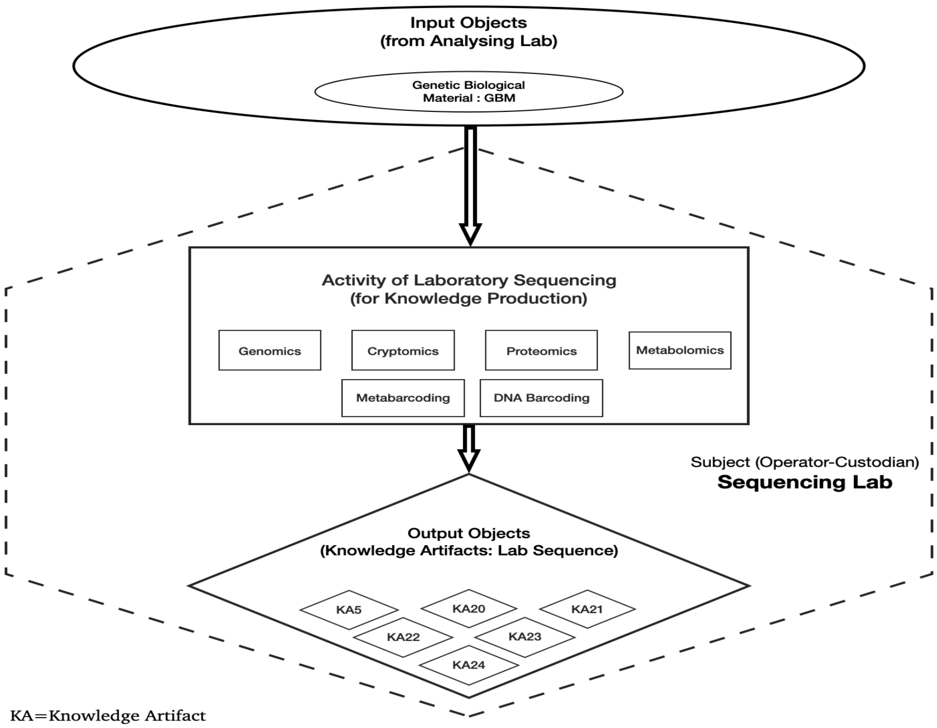


Figure 12: Conceptual Graph of mid-level internal view of Laboratory Analysis, corresponding to the system view in Figure 11.



KA=Knowledge Artifact

KA5=Genome; KA20=Cryptome; KA21=Proteome; KA22=Metabolome; KA23=DNA Barcode; KA24=Meta Barcode

Figure 13: Conceptual Graph of mid-level system view of Laboratory Sequencing within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

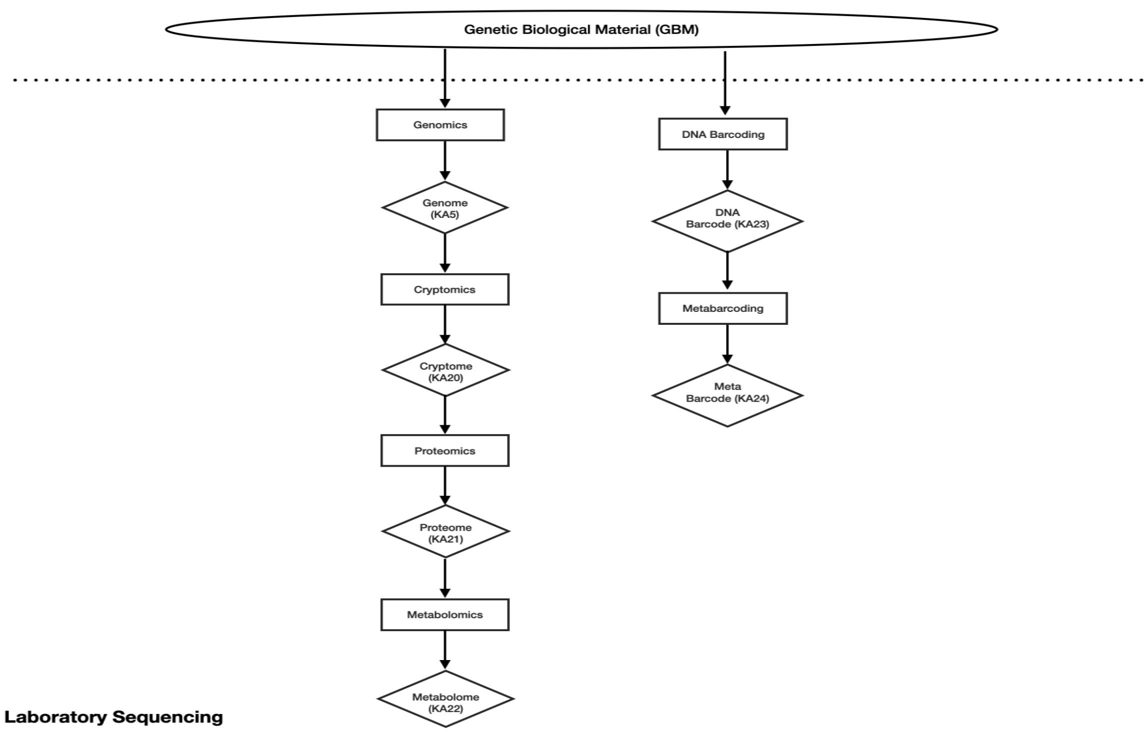
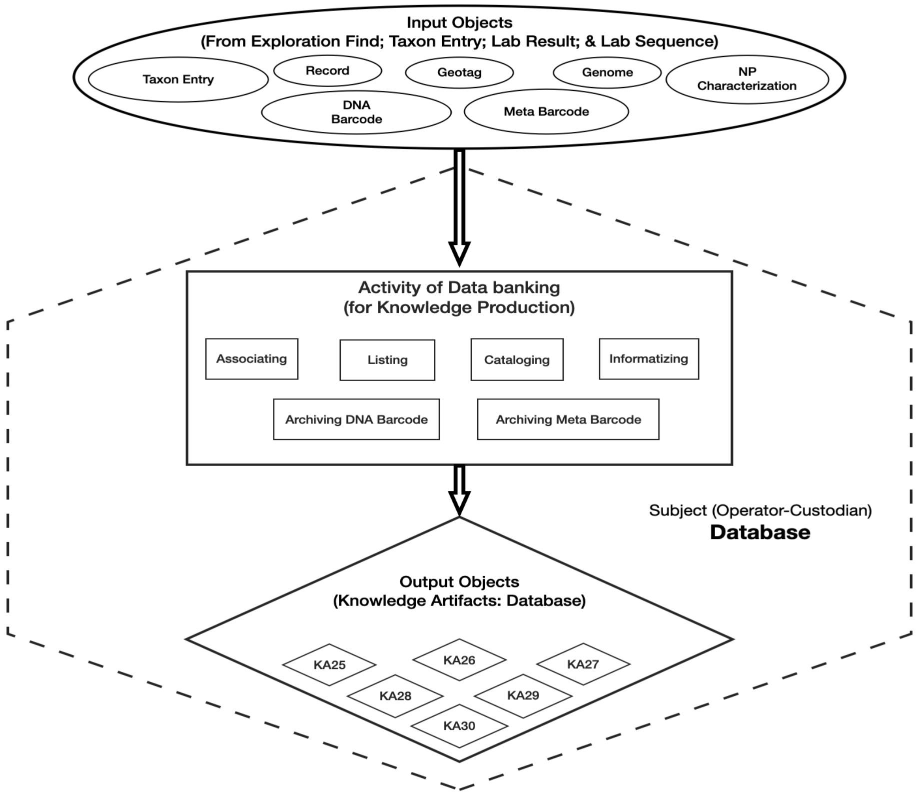


Figure 14: Conceptual Graph of mid-level internal view of Laboratory Sequencing, corresponding to the system view in Figure 13.



KA=Knowledge Artifact; NP=Natural Product; DSI=Digital Sequence Information

KA25=Metadata; KA26=Taxon List; KA27=NP Library; KA28=DSI; KA29=DNA Barcode Archive; KA30=Meta barcode Archive

Figure 15: Conceptual Graph of mid-level system view of Data Banking within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

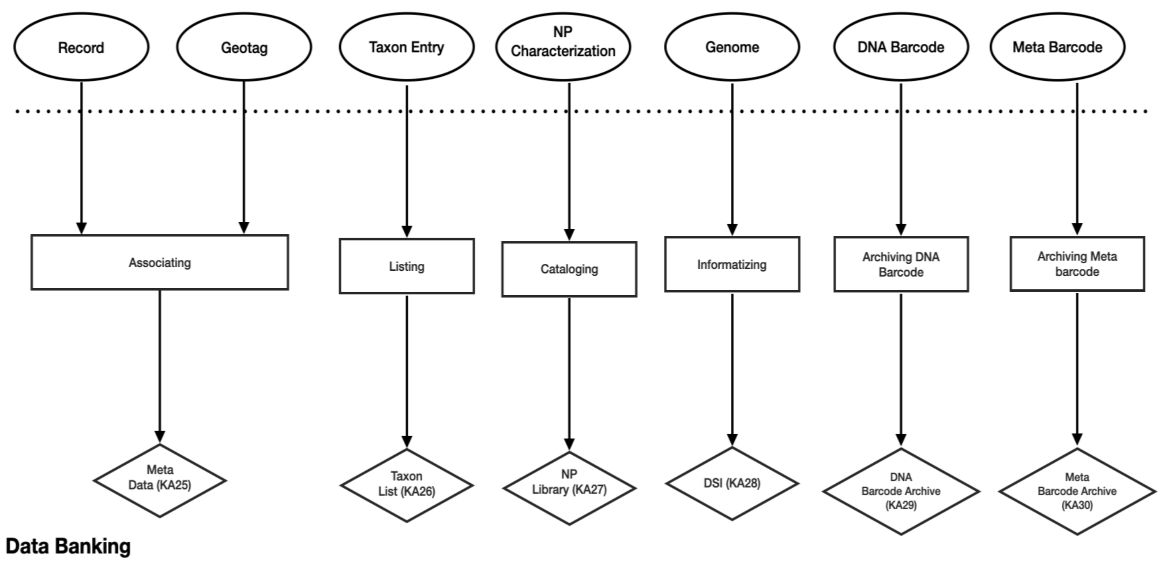


Figure 16: Conceptual Graph of mid-level internal view of Data Banking, corresponding to the system view in Figure 15.

5.1.3. Ontology-Synthesis: Discussion

Mutually exclusive and collectively exhaustive conceptual categories have been synthesized for the activities as well as the operating institutions, input objects and output objects. This has been achieved spanning thirty-two knowledge artifacts, six sub activities, three levels, two topological elements – arrows and emboxments, four emboxments and thirty sub-sub activities. Each of these numbers inherently admits of increase, to factor in greater complexity. The system boundary and interrelations between the conceptual categories has been synthesized at the top level and at the mid-level for each of the six sub systems.

Through integrating the conceptual categories of the activities with the conceptual categories of the input objects and of the output objects, a technological system has been synthesized. The technological system is not merely a structural one of a static domain but also a functional one of a dynamic domain. This too is modelled at the top-level and mid-level for each of the six sub systems. Integrating the operating institutions with the Technological Systems enabled the synthetization of a hybrid Socio (Institutional)-Technical System (STS). The STS is not just a structural one of a static domain but also a functional one of a dynamic domain. Further, such a STS has been synthesized not only at the top level but also at the mid-level for each of six sub systems. Unsurprisingly, there is no bottom level system view nor internal view. These views at that level are so complicated that a Conceptual Graph would be too messy. It is only by constructing a three-tier system model that an insightful and useful conceptualization has been arrived at.

The synthesized Conceptual Graphs reveal the features of the ontology. These features are also available in purely lexical form as entries in a set of tables in Appendix B, C, D and E. The tables are a different kind of representation of the same ontology. The Conceptual Graphs and the Tables are isomorphic in the sense that either is enough to generate the other. The features enable an ontological-analysis through ontological legal research (OLR) of the texts of selected treaties and regulations.

5.2. Ontological-Analysis

5.2.1. Ontological-Analysis: Materials – Selected Treaties and Regulations

The sources (data) used for the ontological-analysis that follows are treaties and regulations selected for being potentially most relevant to the governance of bioprospecting in Antarctica. Treaties and regulations falling across six major treaty constellations have been selected along with a *sui generis* treaty. All selected fifteen treaties and ten regulations are presented in Appendix G.

5.2.2. Ontological-Analysis: Results & Discussions – Features of the Ontology Found

Results, below, are from the application of the research method of ontological legal research (OLR) to the research materials (supra). An ontological-analysis of the selected treaties and regulations is presented below clustered into twenty sets that are analyzed cluster by cluster. The sequence is broadly in chronological order but not strictly: occasionally the clustering within a set is by familial relationship spanning a number of years fouling the otherwise chronological treatment but as will become evident, this is not of concern. For each set, results and discussions are presented below in a combined way than separately. Results are the search-finds in the research materials of the features of the synthesized-ontology. Comments on related aspects are presented along with as accompanying discussion.

 # 1/20: Paris Convention for the Protection of Industrial Property (Paris Convention 1883) https://wipolex.wipo.int/en/text/287556

The treaty text evidences a major step towards juridification of patents with implications for inventions springing from natural bio-occurrences accessed through bioprospecting.

"Patents" are not defined but under Article 1 (2) they are an object of "protection of industrial property." Various kinds of "industrial patents" are specified by Article 1 (4) to be included under the head of "patents." This is the framework in which patents are recognized internationally as a type of industrial property. The words "invention" and "inventor" occur repeatedly in the treaty text in relation to patents but without any definition and without any statement of the connection between them. Article 4 B. presents as possibilities the "publication" of an invention as also of the "exploitation" of an invention.

In as much as patents are inventions, natural products would be patentable only if they amount to inventions. Article 11 speaks of "patentable inventions" indicative of eligibility requirements for patentability of inventions. This treaty is silent about what these patentability requirements are.

Neither industry nor commerce are defined. The same goes for natural products and products themselves. Article 4quater speaks of "patented product", however, as also of "patented process." Process itself not defined either. Under the same provision, a product may be one that is "obtained" by means of a patented process. Article 5quater speaks of a product "manufactured" by a patented process. Manufacture seems thus allied to the notion of obtention.

Under Article 1 (3) industrial property is to be understood in the "broadest sense," applying not only to "industry" and to "commerce" proper but also to, inter alia, "natural products." In relation to natural products, processes may be patentable which result in obtention of the natural product, possibly but not necessarily through manufacture.

Article 4 C lays down the principle of "priority" from the filing of a provisional specification, a docking of novelty claim date without as-yet disclosure because publication is deferred for a prescribed period. This puts the onus on the patent applicant to bear the risk of delaying filing even a provisional specification, eventually to dock a fuller disclosure for a wider monopoly over the subject matter of the sought patent. It is for an intending patent applicant to weigh the possible benefit of delayed filing and the concomitant withholding of earliest disclosure against the possible risk of losing priority over the subject matter invention. This risk would be owing to someone else either publishing it or docking priority first. It is this inherent risk of forfeiting patent property rights because of delaying a filing that mitigates the attendant harm to public knowledge. Keeping the latter deprived temporarily of a potential accretion to its corpus, constitutes the disclosure bargain of a patent. This aspect, a feature of all domestic patent regimes, is an assumed feature of the treaty text in its provisions which deals extensively with priority.

The implication for bioprospecting as an activity for knowledge production is that delay in making public the information or/and results of bioprospecting either by publishing or by filing a patent specification, even a provisional one, carries an inherent risk in that someone else could, in the interim, publish a scientific article or file a patent specification. That will render infructuous and otiose the intended but delayed publication or filing. The inbuilt priority safeguard of the patent system embodied in the priority provisions constituting global novelty as a criterion for patenting puts the possibility of abuse of excessive delay in check. The risk of delaying excessively bears an irretrievable and fatal risk that is unavoidable and ineluctable. It is a central tenet of the patent system and operates in contexts other than bioprospecting as well. In the context of bioprospecting for knowledge production, it serves to hold the potential to penalize, without any advance warning, a bioprospector who delays a scientific publication or alternatively a patent filing.

The framework thus contains the most critical input and output objects of bioprospecting for knowledge production and their knowledge-transformative relationship. Natural products yielded by bioprospecting and bioprospecting activities that are processes for the isolation of natural products and their derivatives, and processes of their characterization, are each patentable if they amount to inventions.

The basic and the most critical features of the ontology of bioprospecting for knowledge production are thus manifest in the terminology and vocabulary of this treaty, but not very much more.

 # 2/20: The Antarctic Treaty (AT 1959) https://www.ats.aq/documents/ats/treaty_original.pdf

The word "activity" occurs twice in the treaty text. "Activity" prepositionally "in" Antarctica, is used in Article X as something someone can potentially "engage" in. In Article IX.2, the word "activity" occurs again but instead of occurring freely as a noun, here it occurs embedded in the noun phrase "scientific research activity," combining activity with research. "Scientific research", prepositionally again "in" Antarctica, in the "substantial" sense is defined implicitly with two illustrations – the "establishment of a scientific station" and "dispatch of a scientific expedition." Presumably, "activity" therefore illustratively includes, respectively, the "establishment" and the "dispatch." Inasmuch as bioprospecting is an activity and partakes the flavor of a scientific activity or scientific research activity, it is covered by the language of the treaty text.

There is an undefined "freedom" of scientific investigation in Antarctica. That scientific investigation which is foundational to bioprospecting for knowledge production, enjoys untrammeled freedom of traverse in Antarctica is unassailable. As to what exactly this freedom encompasses and what it does not, though, is a different matter.

With respect to a proscribed "activity in Antarctica", the "no one" referred to in Article X is seemingly wide enough to include public entities and commercial companies in addition to treaty member nations. Commercial companies having capacity to undertake and conduct scientific activities in the Antarctic Treaty Area means they can undertake and conduct bioprospecting to the extent bioprospecting qualifies as a scientific activity.

"Expeditions" prepositionally "to and within" Antarctica and "stations" prepositionally "in" Antarctica are each within the contemplation of Article VII.5 (a) and (b) respectively. The use of the prepositional "to and within" indicates expeditions are possibly from outside of Antarctica to there. Expeditions can be of "ships" or of "nationals" in Article VII.5 (a) implying nationals can arrive on an expedition even otherwise than on a ship. Also mentioned as *ejusdem generis* (of same kind) enumeration, in Article VII.5 (c), are "personnel" and "equipment" "introduced" prepositionally "into" Antarctica. The use of the preposition "into" here is different from the more frequently used preposition "in". The noun "personnel" occurs embedded in the noun phrase "scientific personnel" in the next Article, Article VIII. These "scientific personnel" are prepositionally "in" Antarctica where they have "functions" which they exercise. "Scientific personnel", "expeditions" and "stations" are each again mentioned in Article III.1 (b). "Scientific research" is mentioned also in Article I.2 indicative of the connection between science and research. Each of these aspects and angles of the undertaking and conduct of scientific activity and research fleshes out its range and scope. In as much as bioprospecting for knowledge production be a scientific research activity, the range and scope of bioprospecting are fleshed out. Reciprocally, the fleshing out helps conceive bioprospecting as a scientific research activity.

Notably, further, the noun phrase “living resources” also occurs, in Article IX.1 (f), prepositionally “in” Antarctica. Article IX.1 (a) speaks of “use” prepositionally “of” Antarctica. Presumably but only so, use of “living resources’ “in” Antarctica could amount to “use” “of” Antarctica. Whether use of living resources “from” Antarctica is contemplated as amounting to use “of” Antarctica is even more conjectural. There is an indirect support though for this reading in so far as the concern with “preservation and conservation” of “living resources” of Article IX.1 (f) presupposes “use” of those “living resources” that possibly jeopardizes or threatens. The terminology unequivocally points to an awareness of the biotic component in the environment that is viewed through the prism of a resource. It is this biotic component that is of interest to bioprospecting. Certainly, “interest” in Antarctica is acknowledged in Article III.2. Given the perception of living things as living resources, it should not surprise that there is interest in them. Any prospecting, bioprospecting included, is a sign and symptom of such interest.

In Article III.3 interest is both “scientific” and “technical” and the difference between the two, if any, is not spelt out. There is also a conflation of the scientific with the technical. In so far as the scientific is enmeshed with research, this conflation connects the technical with research. For bioprospecting then, there would be a technology associated with the research. This enables seeing bioprospecting as a technological activity.

For Antarctica, in addition to the prepositions “in”, “within”, “to” and “into” as noticed supra, the preposition “from” has also been used. Article III.1 (c) comprehends “scientific observations and results” “from” Antarctica. The noun phrase “scientific investigation” occurs twice in the Preamble and once each in Article II and Article III. On each occasion, it occurs prepositionally “in” Antarctica. The *sequitur* seems to be that whereas scientific investigation happens is ‘in’ a place, scientific observations and results are ‘from’ the place. For investigation, the site is local but there is an enlargement when it comes to observations and results for which the language is concerned with attribution, traceability and the derivatization. It is as if observations and results of scientific investigation are not of where the investigated living things are but, in a manner of speaking, where the microscope is. Contextualized to living things in the place, their investigation happens there but the observations and results of the investigation become ‘from’ there. The language itself involves an exportation of custody over the produce of science.

If it is only “scientific research” that yields “scientific observations” and only “scientific investigation” that yields “scientific results”, this dichotomy passes *sub silentio* in the framing of Article II and Article III.

The Preamble mentions “scientific knowledge.” Presumably, only “scientific observations and results” comprise “scientific knowledge.” That “scientific research activity” produces ‘scientific knowledge” is plausible but also left to inference. For bioprospecting as a scientific research activity thus, it is only inferential in the treaty text that it produces knowledge.

Viewing bioprospecting as an activity for knowledge production is not antithetical to the treaty text but neither it etched out by it. A juridical separation of the produce of science from nature from the site of nature is made by this treaty text. This separation is foundational to the entire edifice of bioprospecting for knowledge production. It is the key inter relational aspect of the ontology of bioprospecting for knowledge production.

 # 3/20: International Convention for the Regulation of Whaling (ICRW 1946) https://archive.iwc.int/pages/view.php?ref=3607&k=

“Studies” and “investigations” related to whales are undefined in Article IV.1 (a) but are to be encouraged, recommended and organized. Studies and investigations would be subsumed under the word “activities” as occurring in Article IV2. There is an implicit valorization of studies and investigations as activities even in a treaty whose principal objective ostensibly is the regulation of the activity of whaling. The convention marks the development of the idea of science-based regulation.

Study and investigation activities are directly that of member nations or through their public or private agencies, establishments and organizations. Nationally hosted private for-profit companies seem countable amongst private agencies, establishments and organizations of member-nations. In as much as the domestic regulatory regimes of member-nations charter or direct studies and investigations, these activities are through the concerned member-nation. The legitimacy of the private sector in study and investigation activities like that entailed in bioprospecting seems indisputable.

Article IV.2 speaks of "scientific and other pertinent information" relating to whales. It does not state what the "other" pertinent information encompasses is not stated. Since the provision refers not only to whales but also to whaling, it may be that the other pertinent information relates to whale stocks or catch and its statistics. Elsewhere, in Article VIII.3 there is a mention of only "scientific information" and this is with reference only to "whales." Article IV does mention whale stocks, making sharper the distinction between whales and whale stocks. Perhaps the distinction between scientific information and other pertinent information does overlap the distinction between whales and whale stocks. Perhaps an underlying incipient differentiation begins to emerge between scientific interest in whales as biological organisms and other kinds of interest in whale stocks and whaling. If so, it would constitute the foundations of a differentiation between scientific bioprospecting's interest in living organisms and commercial-industrial interest in communities and population stocks of living organisms.

"Killing" and "taking" of whales are each mentioned in Article VIII. "Taking" and "holding on to" are comprehended by Article II.3 and a ship doing so is a "whale catcher." "Scouting" for whales is also mentioned. Hypothetically, the language as used allows for a reading that scouting can also be for an individual of a hitherto unknown species or phenotype, for study and investigation, than only of a community of individuals as stock for hunting. This construction though could be more a matter of contemporary sensibilities than a hermeneutic one. That the catching, the taking, the holding on to or even the killing or mere scouting by itself are all types of sub activities of the activity of studies and investigations may be persuasive but it is not expressed in the language.

The language of this treaty has an inkling of but fails to set up a typology of sub activities that comprise bioprospecting for knowledge production. The concerned features of the ontology of bioprospecting for knowledge production have, at best, some promising but only indicative placeholders in this treaty. The features themselves, however, are missing in these placeholders. The ethos of viewing bioprospecting as an activity for knowledge production does find resonance in the scheme of this treaty.

 # 4/20: Convention for the Conservation of Antarctic Seals (CCAS 1972) https://www.ats.aq/documents/keydocs/vol_1/vol1_13_CCAS_CCAS_e.pdf

The word "activity" does not occur at all in this treaty text. It is only in the Final Report of the 1988 Meeting to Review the Operation of the CCAS, in its Para 17, that the word "activity" occurs in the sense of something that is "under" a permit. Article 4 envisages a permit to "kill" or "capture." That to kill or capture is an "activity", however, is not expressly stated. Killing or capturing of seals treats a seal as a living organism. Under Article 4.1 (c) killing or capturing can provide "specimens" for "museums, educational or cultural institutions." Specimens can possibly be of an organism, of biological nature and origin. The use of the word specimen also represents a seal as a living creature. It is as a lifeform that the treaty text purports to conserve seals. A 'forms of life' view of the biotic component of nature is the key to the drafting-mind of the treaty.

Under Article 4.1 (b) specimens can also be provided for "scientific research." Under Article 41. (c) specimens can be provided to museums. The use of the word "or" at the end of Article 4.1 (b) separating it from Article 4.1 (c) can indicate mutual exclusion. This seems to functionally distinguish museums from scientific research institutions. To musealize is, in this view, different from 'to do scientific research.' To musealize is perhaps intended here as to only collect, store and display for motivating scientific curiosity whereas to do scientific research is to indulge that scientific curiosity. A museum here thus has a passive connotation compared to a laboratory where scientific research is thought of as being actively conducted. This might be considered unusual in some places where museums of natural history have a long tradition of doing significant scientific research. For the present text, though, in the context of bioprospecting, museums are akin conceptually to the conceptual category of biobanks in the synthesized ontology, whereas the site for scientific research may be akin conceptually to a laboratory. Both are eligible for being perceived as custodians of knowledge artifacts, musealized in one, dissected and atomized in the other.

Whether these possibly separate purposes of killing and capturing to produce a specimen would be subsumed in the notion of the respective "activity", a term itself not used in the treaty text, is conjectural. A permit itself is specifically possible in the form of a "scientific research permit." Otherwise, a permit would seemingly be for "industry" as mentioned in Article 6 (b). Whether these seemingly distinct ultimate purposes of killing and capturing, scientific research versus industry, would also be subsumed in the notion of the respective "activity" is no less conjectural as far as the literal text is concerned.

"Programmes for scientific research" are specifically mentioned in Article 4 (a) as are "scientific programmes" in Article 6.1 (c) (iii). "Scientific research" is also mentioned by itself in Article 4.1 (b) as already noticed. The Preamble speaks of "biological and other research" as something to be encouraged seemingly widening the scope of "scientific research." The Preamble as well as Article 3.1 refer to "scientific study." If "scientific study" is used in the sense of being based upon and consequent to "scientific research", there is no clear warrant for it in a literal reading of the text. Even if it is not based upon and consequent, the study aspect as embodied within and part of the research aspect expands what could be understood as being scientific research. This general conclusion can be particularized to bioprospecting and pertains to bioprospecting for knowledge production.

In Article 3.1, clause (i) features a reference to biological "records" and clause (j) features a reference to "scientific information." The Preamble mentions information as being prepositionally "from" research. Article 5.4 (a) treats biological "data" as something that can be collected. For Article 3.2 scientific and technical "evidence" forms the basis for measures to be adopted. Biological and other "evidence" is also referred to in Article 5.4 (b) as the basis for reports to be rendered. Data and evidence are thus homologous as being the basis for measures and reports respectively. The word knowledge is mentioned in the Preamble as embedded in the noun phrase "scientific knowledge" about which it is stated that it is something to be improved. Perhaps this "knowledge" subsumes "information", "data" and "evidence", but this is not made clear. Nor is it made clear that it is "scientific study" of Article 3.1 that produces either information or data or evidence. The elements are all present but the treaty text does not quite plate them together as bioprospecting for knowledge production.

For scientific study, Article 3.1 indicates that it is prepositionally "of" seal "resources." Resourcism, a foundational value for bioprospecting, is embedded deep in the text of this treaty. The Preamble too contains a similar mention, of "living resource" and then to it as "this resource." Clause 7 (b) of the Annex also mentions "resources." A life form can perhaps be expected to be treated as a resource for industrial or economic exploitation in such a treaty text. Given the exploitation versus conservation type object of this treaty, it is less to be expected that the life form be treated as a resource for scientific study. This kind of resource-for-science ontology of the biotic components of nature encourages the theoretical isolation of an activity like bioprospecting limited to its knowledge production aspect by excising its industrial-commercial-economic production aspect from it.

It is not only scientific study, of course, for which seals are a resource. Article 3.1 mentions human "use" of seal "resources." This "human use" is used conjunctively with "scientific study" in said Article 3.1 which conjointly refers to them prepositionally as being "of" seal "resources." The Preamble itself mentions "commercial exploitation." Article 6.3 mentions "harvest" of a specie. Article 6.1 explicitly mentions "commercial" sealing. Clause.6 (b) of the Annex in fact actually mentions "industry" although that is the only such mention anywhere in this treaty. It is noteworthy that these references to the human and industrial use of seals are laid out in the treaty text as distinct and separate from scientific research use of seals.

There is nothing in this legal instrument that is inconsistent with the ontology of bioprospecting purely for knowledge production. Instead, values foundational to the bioeconomy as well as to bioprospecting for knowledge production are ingrained in its deep text. Several of the structural elements of the ontology of bioprospecting for knowledge production are to be found in this treaty text, albeit some only in nascent form.

 # 5/20: Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure https://wipolex.wipo.int/en/text/283781 ***, and the Regulations under the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure (Budapest Treaty & Regulations 1977)*** https://wipolex.wipo.int/en/text/283787

Biobanks that are culture-collections for "microorganisms" are described as "Depository Institutions" in Article 2 (vii). Under Article 7 and Article 8, nomination by the host nation within whose territory these biobanks are located qualifies such a biobank as an International Depository Authority (IDA) as defined in Article 2 (viii). Under Article 2 (vii) an IDA receives a "deposit" as defined in Article 2 (ii). Upon receipt, it accepts, stores and subsequently furnishes samples. Under Art.6.2 (v), it examines viability upon receipt, before acceptance. Rule 3.1 (b) (ii) specifies that an IDA has to possess "facilities" and "scientific standing." Rule 2.1 states clearly that an IDA can be a government agency or public institution but that it can also be a private entity instead.

"Microorganism" is left undefined leaving scope for an expansive comprehension that includes plasmids and tissue cultures. Rule 6.1 (b) requires that a "scientific description and/or proposed taxonomic designation" accompany a deposit. The nature of this requirement is such that deposits of unknown or hitherto unknown microorganisms obtained from bioprospecting is also covered.

Deposits are made in an IDA "for the purposes of patent procedure" under Article 1. A patent for an "invention" is understood as a type of patent under Article 2 (i). An invention itself is left defined. "Secrecy" is required to be maintained under Rule 9.2 subject to permitted furnishing of samples under Patent Office certification or notification under Rule 11. At the pre-publication stage of a patent specification by a Patent Office, furnishing can only be on a certification of exceptionalism by such a Patent Office under Rule 11. After "publication for the purposes of patent procedure" defined in Article 2 (iv), the certification required from a concerned Patent Office under Rule 11 is less stringent. After publication of a patent grant, mere general notification by a Patent Office of the accession number enables entitlement. The scheme of furnishing of samples by the IDA thus appears to correspond to the scheme of publication of a patent specification for patent disclosure.

In envisaging biobanks with considerable conceptual clarity, this regulation text embodies a major aspect of the ontology of bioprospecting for knowledge production. In recognizing microorganisms and as broadly as it does so, this regulation text strongly reflects microorganisms as one particular conceptual input-object category of the ontology of bioprospecting for knowledge production.

 # 6/20: Convention on the Conservation of Migratory Species of Wild Animals (CMS 1979) https://www.cms.int/sites/default/files/instrument/CMS-text.en_.PDF

The "taking" of a member of a species is defined in Article I.1 (i) as "conduct" that includes "capturing.' Such taking seems to correspond to the fundamental *in situ* conduct of bioprospecting.

Whether so taken or not, according to the Preamble, these species are "forms" which are "held" as "resources" by "each generation of man" as a "legacy." The inter-generationality speaks to notions of sustainable development. Man here would refer to homo sapiens. The phraseology seems to suggest that it is from one's in-possession or in-custody 'holdings' that one catches.

A specie has a structural character, being constituted by its "taxons" under Article I.1 (a). In the aggregative direction, under Article I.1 (c) a specie is a "component" of its "ecosystem." At the next level of aggregation, the earth itself comes in for systems theory treatment in the Preamble. It has a "natural system."

This "natural system" bears "good of mankind" as stated in the Preamble. Corresponding to such good of the human species, for other species, under Article IV.3 there can be "benefit of the species." There can also be taking that can operate under Article III.5 (d) to the "disadvantage of the species." Systems thinking is imbued here with an utilitarian instrumentalism.

Under Article 5 (a), the taking can be prepositionally "for" a "scientific purpose." The scientific purpose is alluded to in Article V.5 (d) as well as in Article VIII.5 (b) each of which speaks of "information" prepositionally "on" the migratory species and of "results of research." The tendentious nature of research leading to results is embedded in the latter phrase. Under Article II.3 (a) research is to be promoted and supported. There is also adjectival use of the word "scientific" such as in "scientific matters" in Article VIII.1 and in "scientific advice" in Article VIII.5 (a). The scientific is perceived as an entire realm.

Not all provisions unambiguously privilege science. The Preamble mentions the "scientific" and the "genetic" as only two amongst several named "points of view" such as the social, cultural, ecological, environmental, aesthetic etc. Article II.2 points to "scientific evidence" as "reliable evidence" but no other kinds of reliable evidence are mentioned. Together, there is a curious mix and ambivalence between the privileging of the scientific and of its deprivileging. The separation though of the scientific from other matters, is invariably treated as a given.

Interestingly, the separate mention in the Preamble of the "genetic" is carved out from the more general and the otherwise encompassing typology of the scientific. It is hard to tell if this separation stems from a view that favors genetics over other disciplines of science. If so, this may be attributable to a perception that genetics employs particularly novel technologies. The treaty language does not expound upon these conjectures. The mention of the word "genetic" is a solitary one, that also only in the Preamble of the text.

On the whole, this treaty denotes an ambivalent turn in the approach to viewing bioprospecting as being for knowledge production. Some terminology and vocabulary in this treaty text reveal significant features of the ontology of bioprospecting for knowledge production. Most significantly, systems thinking is explicitly endorsed in this text. Other terms however, notably compel a look at aspects other than knowledge production in the conception of bioprospecting. This runs counter to the theoretical isolation of the knowledge production aspect in the ontology of bioprospecting for knowledge production and the supposed wholesomeness of its extrication.

 # 7/20: Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR 1980)
https://www.ccamlr.org/en/system/files/e-pt1_3.pdf

"Activity" is mentioned in Article III, IV and X. In Article X "activity" is as undertaken by a national or a vessel. In Article XV.3 "activity" occurs embedded in the noun phrase "scientific activity". Scientific activity, as subsumed in bioprospecting and other endeavors, is thus clearly visible to the treaty-eye as a type of activity.

Article II.2 mentions "use" embedded in "rational use" while defining conservation which in the preceding Article II.1 is of "Antarctic marine living resources." The word "Antarctic" adjectivally pre-qualifies “marine living resources.” The enquiry whether Antarctic marine living resources are only marine living organisms living “in or found living in” the Antarctic or also includes those “from” the Antarctic is not embarked upon in the substantive provisions of the treaty text. If the Preamble is to aid interpretation of the treaty’s substantive provisions, the scope is limited to living organisms “found in” Antarctic waters, to Antarctic marine living “resources” in this sense.

The connection between activity and use remains *sotto voce* (below audible/perceptible levels) for the treaty text. With this caveat in mind, to the extent rational conservation of life forms is sensibly subsequent to and critically predicated on discovery and knowledge of those life forms, rational conservation rests on bioprospecting for knowledge production.

Article II.3 conjunctively mentions two types of activities – “harvesting” and “associated activities.” Contextually, each of these two types of activities appears to be in relation to “living resources” itself defined in Article I.2 as including all species of “living organisms.” The Preamble envisages “utilization” of these resources as a “source” of “protein.” Whether “protein” here refers only to food and nutrition consequent to “harvesting” or also possibly to peptides and other biochemical compounds that are called proteins consequent to the “associated activity” of “scientific activity” by isolating them from the living organisms, is an intriguing question. Perhaps the latter possibility was not in the treaty drafting mind, so to speak, but the language of the treaty text does now admit of it on a contemporary reading.

Article IX.1 (a) speaks of “research” as well as of “comprehensive studies.” “Scientific studies” are mentioned in the Preamble itself. Article XV.1 mentions “scientific research” and contemplates “collection” with respect to living resources, as also “information” in their respect. The Preamble mentions “scientific information.” These references flesh out the ambit of scientific endeavors of any kind, including bioprospecting.

Article XV.3 mentions the “work” of technical and scientific organizations, in parallel with the mention of “scientific activities.” One way to understand such “work” and such “activity” is in a non-overlapping manner. That it is nationally hosted public entities and maybe even nationally hosted commercial companies that conduct these “scientific activities”, is left here to inference. The Preamble seems to have only some nation states in mind as “states engaged in research.” Article XV.2 (f) shows an awareness of “programmes of research” as being international or national. Participation of nationally hosted public entities and commercial companies in these “programmes of research”, whether international or national, appears an open possibility but is not made explicit. Bioprospecting conducted as the work of a technical and scientific organization or as a programme of research, is not incompatible with bioprospecting as a scientific activity. That bioprospecting may be at the behest of only some states, only those states that are actually engaged in research, is also an acknowledged position.

“Knowledge” is directly mentioned in the Preamble itself, as something it is “essential to increase.” The motivation for this is not directly shared by the treaty text but can be partially gleaned from it by reading between the lines. “Scientific information” is implicitly comprised within “knowledge” because increasing the latter is stated to be essential to be able to base harvesting decisions on the former. It is stated in Article XV.1 that knowledge is “extended” by scientific research. Article II.3 (c) indicates that knowledge can be qualified meaningfully as “available knowledge” and that this has a “state”, presumably temporal, in the form of “state of available knowledge.” The treaty text accords prestige status to the cause of advancement of scientific knowledge and imbues knowledge with utilitarian attributes. In both respects, the treaty text can be understood to recognize and foster any knowledge production activity and bioprospecting in as much as it contributes to it.

With its strong privileging of science and scientific knowledge, this treaty text accords strongly with the ontology of bioprospecting for knowledge production. Few specific features of the ontology, however, are discernibly in the text.

 # 8/20: United Nations Convention on the Law of the Sea (UNCLOS 1982) https://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf ***, and the Agreement Relating to the Implementation of Part XI of the UNCLOS (Implementation Agreement 1994)*** https://www.un.org/depts/los/convention_agreements/texts/agreement_part_xi/agreement_part_xi.htm

Although prospecting is not defined for living resources, it is defined for mineral resources of the seabed and ocean floor, including the subsoil thereof, lying beyond any national jurisdiction. For such mineral resources, "prospecting" is defined in Annex III. Article 2.2 as including the "recovery" of a reasonable quantity of minerals "to be used for testing." The definition does not itself deal with the results of "testing". Nor does it deal with the transport post "recovery" or with its sequestration or storage, still less with its disclosure or access. In so far as "testing" bears an element of scientific research, the definition does not concern itself with future change of intent from the scientific to the commercial. The definition does not attempt to cover ultimate or eventual commerce of the results or of other consequentiality of either the "recovery" or of its "testing."

In Annex III. Article 2.22 it is only with respect to the mineral resources themselves, that non-appropriation is emphasized. Prospecting shall not, it is declared, confer on the prospector any rights with respect to the resources. Ostensibly, even the "recovered" mineral resources to be "used for testing" fall outside the purview of appropriation. There is no indication that this principle extends to biotic resources. There is nothing in this treaty text to indicate that the sampled, sequestered and extracted biotic specimens and biotic samples transported and exported beyond and outside the area and site of their catchment, capture and entrapment and ending up in museums and laboratories elsewhere do not stand appropriated. There is also no warrant in the treaty text for an extended application of this principle to knowledge artifacts "produced" by bioprospecting for knowledge production.

Article 243 contains a rare instance of elucidation of the combined phenomenological and the processual aspects of an undefined "scientific research". It speaks of "the efforts of scientists in studying the essence of phenomena and processes occurring in the marine environment and the interrelations between them." The "essence of a phenomenon" makes for an intriguing idea in the context of scientific research on biological components of natural environments. In as much as a biotic component is a phenomenon of natural bio-occurrence, might its essence be grasped as its 'functional units of heredity'? Such a grasp relates to the contemporary 'omics' turn in bioprospecting with its focus on genomics and on genetic expression through the steps sequentially of transcriptomics, proteomics and metabolomics.

Under Article 249.1 (c) "data and samples" are "derived" from scientific research projects. Under Article 249.1 (b), scientific research generates "preliminary reports" and then "final results and conclusions" after the completion of the research. "Assessments" of data, samples and results, are possible under Article 249.1 (d). Article 244.1 perceives "knowledge" as "resulting from" scientific research. Article 244.2 speaks of "scientific data and information" as "resulting from" scientific research. Objects such as original samples would be extracted and sequestered from the natural bio-occurrences of biotic components of nature. These can be viewed as the input objects of the bioprospecting pipeline activity. Objects such as data, information, preliminary reports, final reports, conclusions, and assessments accord well with the conceptualization of intermediate and final output products of the bioprospecting pipeline activity for knowledge production. The final products can be understood as knowledge artifacts produced by the bioprospecting pipeline. As intermediate products, they can be understood as products of a sub pipeline subsidiary-activity that become an input object for the next sub pipeline subsidiary-activity of bioprospecting for knowledge production. There is a high level of match with the ontological framework of bioprospecting for knowledge production.

An asymmetry of some research-capable member nations and others less so or not so research-capable appears to be reflected in the language of Article 249.2 and Article 277 (f). Under Article 249.2 a Coastal State is to bilaterally request for or may require a prior agreement for making "internationally" available the research results from scientific research conducted within its dominions. Under Article 277 (f) national centers are supposed to come up in developing coastal states and they are to discharge the "function" of "prompt dissemination" of research results. It notable that for the "areas beyond the limits of national jurisdiction" under Article 1.1 (1) there are no provisions in the treaty eliciting or compelling either prompt dissemination or the making publicly available of any research results. On the view that Antarctica is an area beyond national jurisdiction, this lack of any compulsion or obligation to disseminate results from bioprospecting for knowledge production, is notable in contrast with the provision in the Antarctic Treaty.

That technology is closely associated with scientific research and that scientific research is sensibly comprehended as being techno-scientific research, emerge from the conjoint reading of Part XIII dealing with marine scientific research and Part XIV dealing with marine technology. As per Article 244.2 "scientific research" presupposes a "capability." Article 240 (b) understands the conduct of scientific research to be with appropriate scientific "methods and means." Article 249.1 (g) and Article 258-262 expects scientific research "installations" and "equipment" in the marine environment for the conduct of marine scientific research. Marine "science" and marine "technology" are mentioned in the same breath in Article 266.1. Article 266.2 speaks jointly of marine "scientific and technological capacity." Article 277 (e) combines the scientific and the technological aspects as 'scientific and technological data and information." Article 268 (a) speaks of "technological knowledge" but Article 269 (c) combines "scientific and technological subjects."

Marine scientific research is envisaged in all geophysical domains constituted by the treaty. Across all domains and subject to respective regulatory regimes, there is a right under Article 239 to do marine scientific research and member nations are reciprocally obligated under Article 255 to promote and facilitate it. This can be subject to regulation as mentioned for example in Article 21.1 (g) and Article 40. For another geophysical context, under Article 87.1 it is "freedom of scientific research" that is emphasized. This constitutes, correspondingly, freedom of bioprospecting in that geophysical context. Freedom to bioprospect means, *inter alia*, freedom to bioprospect purely for knowledge production. An untrammeled freedom in the pursuit of knowledge is an integral part of the ontology of bioprospecting for knowledge production.

Under Article 123 (c) "exploration" of the "living resources" of the sea and "scientific research" are each to be coordinated. In this Article, "exploration" and "exploitation" are used co-extensively for "living resources" and "non-living resources." Under Article 56.1 (a) and (b) (ii) "exploring" "living resources" and "marine scientific research" are possible. "Living Resources" are expressly identified as a "natural resource", as are "non-living resources." "Exploiting" living resources is also a specifically mentioned possibility in Article 56.1 (a) and the references to "utilization" in the Title to Article 62, to "harvest" in Article 62.2, to "catch" in Article 69.3 and to "surplus of the living resources" in Article 70.1 seem to point to it. It is not made clear though that exploitation and exploration are mutually exclusive categories with scientific research being a matter solely concerned with exploration. For a different context, Article 77.2 speaks of 'exploration" of "natural resources," as also of their "exploitation." Under Article 77.4 "living organisms belonging to sedentary species" are a "natural resource" as are "mineral and other non-living resources." There is little warrant in this particular context for concluding that exploration pertains only to living resources and that exploitation pertains only to mineral and other non-living resources. The language does admit instead of exploration of mineral resources and exploitation in the sense of harvest catches of sedentary species. Regardless, exploration and exploitation even conjunctively understood of living and non-living resources, has no conflict with scientific research. The full ambit of this is available to bioprospecting in relation to living resources if but only if it can be cordoned off from the commercial, the industrial and the economic as pure scientific research.

Piracy is defined in the context of the High Seas in Art 101 which definition notably does not deal with any aspect of biopiracy. It deals only with piracy of ships, aircraft and passengers. Nor is there any other definition or other provision dealing with any element of biopiracy whether on the High Seas or in any other geophysical context of the domain of the treaty. The biopiracy critique of bioprospecting for knowledge production finds no support in this treaty text.

Interestingly, systems terminology lies scattered across the entire treaty text. Illustrative examples include not only "ecosystems" in Article 194.5 but also "system of baselines" in Article 10.6, "harbour system" in Article 11, "system of communications" in Article 19.2 (k) and "mining and processing systems" in Annex III. Article 17.2 (b) (ii). This can be treated as intrinsic validation in the treaty text for adopting a systems approach to its study.

The emphasis on technology in this treaty text is an endorsement of the technical aspect in the ontology of bioprospecting for knowledge production. There is also an implied endorsement of the systems approach, another feature of the ontology. The unreserved exceptionalism for scientific research echoes the ethos of the ontology. Resourcism values of the ontology pervade the treaty text, even with reference to living resources. Knowledge production's processual and phenomenological bases as constitute a feature of the ontology, are both expressly recognized in this treaty text.

 # 9/20: Protocol on Environmental Protection to the Antarctic Treaty (PEPAT 1991) https://www.ats.aq/e/protocol.html

Article 3 predicates the "conduct" of "scientific research" over "activities" making the two categories distinct instead of making the former a subcategory of the latter. The predication is as listed out in Article 3.2 (a) to (e). This predication is made absolute in Article 3.3 according to which the planning and conduct of activities shall accord priority to scientific research. As per Article 15.1 (a) scientific research programmes are "performed", as in fact are activities. Under Article 3.4 activities are undertaken pursuant to these scientific research programmes. Article 6.1 (a) envisages programmes of "scientific" and "technical" value. Although only in relation to mineral resources, Article 7 considers scientific research possibly at risk of being comprehended as an activity and so explicitly makes it an exception to the prohibition.

Under Article 3.2 (c) (iv) any activity has an operational aspect which is provided for by "technology" and "procedures." Article 3.2 (c) (v) in fact speaks of "operating procedures." The umbrella of programmes over scientific activities is a combination of the scientific and the technical. Even with bioprospecting as merely scientific research, its overarching programme is techno-scientific. Even when "performed" independently of any programme, bioprospecting inherently has an associated operative technology. The upshot is that technology is inseparable from bioprospecting as scientific research. Bioprospecting for knowledge production cannot be understood sensibly as only a scientific activity. It is sensibly understood only as a techno-scientific activity. The approach in the language is to hybridize the scientific with the technological, to fuse them together than treat them as distinct. This is a salient point emerging from the ontological-analysis of this particular text as an underlying ethos of the ontology of the activity of bioprospecting for knowledge production. This activity is comprehended in the language of this text as an inextricably combined techno-scientific activity.

Under Article 13.5 an activity can be undertaken not only directly by a member nation but also by its agencies, instrumentalities, persons natural as well as juridical, ships, aircraft and other "means of transport." A visitation or a spatial survey seems inherently indicated by the reference to the generic "means of transport" but the indication can also comprehend sequestration of specimens and biological materials from the area to the beyond and outside. Under Annex VI. Article 2 (c) the "carrying out" of an activity is "organized" by an "Operator" who or which can be a natural or juridical person and can be governmental but also possibly non-governmental. This underlines the legitimate scope for and benefits of private sector role in an activity like bioprospecting.

Research can be focused inwards but also oriented outwards, inductively or as applied research. As a particularizing instance of outwards oriented inductive or applied research, Article 3.1 and Article 3.3 both mention research essential to understanding the "global" environment. The Preamble too stresses this potentially larger geographically-implicational scope of research conducted in a delimited location. It also speaks of an intermediate hierarchical slot of enlargement of the geographical implication, that of the regional lying between the local and the global. The Preamble acknowledges the "unique" opportunities Antarctica offers for scientific monitoring of and research on processes of "global" as well as "regional" importance. The possibility that dependent and associated ecosystems of the environment of the geographically delimited Antarctic Treaty Area can lie outside the Antarctic Treaty Area is clearly indicated by Article 3.2 (e). Under Article 3.2 (c) (v) an ecosystem has components so the enlargement in the scope of geographically-implicational scope is accompanied simultaneously by a spatial granularization thereof. Consequently, bioprospecting for knowledge production is well comprehended as being both microscopic and telescopic in its approach. The telescoping inherently involves the cross application of the knowledge artifacts produced by bioprospecting to other fields. This highlights the artifactual nature of the produce of bioprospecting for knowledge production, speaking intimately to the ontology of bioprospecting for knowledge production.

With the use of the words "monitoring" and "processes", supra, the Preamble creates a further enlargement of the scope of scientific research. This is an enlargement over the processual in contradistinction to that over the phenomenological pertaining to occurrences. The word "monitoring" is also used in Article 12.1 (k) which speaks of the need for scientific research, including environmental monitoring. It would appear that monitoring could include the time-study of ecological interactions of organisms of a species, particularly of their ecologically-intermediated secondary metabolisms. This opens the doors to the emerging possibilities of eco-bioprospecting, a subfield of bioprospecting. The ontology of bioprospecting for knowledge production as has been synthesized does not delineate a distinct suite of knowledge artifacts of eco-bioprospecting. This protocol text therefore points to the need and scope for amplifying the ontology itself.

Attention to the processual and to its monitoring makes for a more than merely episodic understanding of bioprospecting. Bioprospecting, especially as knowledge production, is better understood in the durative sense.

Article 3.2 (c) (v) mentions "increased knowledge" implying knowledge as something that increases, presumably over time. That this increase is attributable to research and monitoring, however, is not made explicit.

The delimited "area" of Antarctica prepositionally "for" the conduct of scientific research has a "value" for that end as per Article 3.1, as also for some other ends and also intrinsically in and of itself. Article 3.2 (c) short-circuits the mention of the delimited "area" to directly describe Antarctica as a whole having a value for the conduct of scientific research. Value-ascription of an area for the purposes and ends only of science reflects a core ideology in this text that is congruent with the blueprint of the ontology of bioprospecting for knowledge production.

Article 3.2 (b) (vi) has in mind some areas specifically of "biological" significance as also of more general "scientific" significance. Eligibility for an area to be specially protected is indicated in certain situational contexts explained below. Annex V. Article 3.2 (c) indicates as an example of such a situational context, areas with "unusual assemblage of species." Another example that is mentioned in sub clause (e) as areas of particular interest to ongoing or planned scientific research. Since planning can be initiated at any future point of time during the treaty's subsistence, prospective planning is also covered. Areas of biological research interest, present or future, would on this view, be eligible for special protection. Here, bioprospecting interest seems reasonably eligible to be a stand-in for biological research interest. Under sub clause (d) the type locality or only known habitat of any species is mentioned as yet another example. These areas would be of interest for scientific research and monitoring of unknown and understudied ecological interactions even if the specie or the phenotype involved be an already discovered one. Such and other scientific interest in an area is a fit ground for the area being declared a specially protected area. It is not only environmental protection or ecosystem conservation *stricto sensu* that calls for an area to be specially protected; scientific research interest in an area, and more particularly biological or ecological research interest in the area, also qualifies in certain situational contexts. An area having an unusual assemblage of species, an area of particular interest to scientific research, and an area that is the type locality or only known habitat of any species, are examples of these situational contexts. Each of these three situational context areas that are exemplars for special protection appears to be of special interest to bioprospecting.

Value ascription to a place itself as a site of bioprospecting for knowledge production challenges the design of the synthesized ontology of bioprospecting for knowledge production. It does so by focusing on a place instead of on an activity or even on input/output object or on subject. Spatiality is a largely ignored aspect in the ontology. The ontology itself hardly creates any legal geography. Special areas for enhanced bioprospecting for knowledge production is an idea in this text that is not misaligned, though, with the ontology. Knowledge artifacts of eco-bioprospecting pointed to by this text are not currently a feature of the ontology but there can be a case for their inclusion. Not merely episodic but also the durative connotation of bioprospecting for knowledge production is brought up by this text. A different underlying design of knowledge artifacts is required in the synthesized ontology if it is to cover such connotation.

 # 10/20: Convention on Biodiversity (CBD 1992) https://www.cbd.int/doc/legal/cbd-en.pdf

The Preamble bemoans the "general lack of information and knowledge" regarding biodiversity. In contemplating "scientific advances" in Article 12 (c), a hope may be discernible, though, regarding knowledge, inter alia, of biodiversity. A definition of biodiversity is provided. It uses "organism", "complex" and "species" as building blocks of the definition without defining these three words themselves.

Annex I. Article 1 mentions ecosystems associated with key "evolutionary processes." Article 7 (a) refers to Annex I. for identifying "components of biodiversity." It would appear dogmatically thus that evolutionary processes generate components of biodiversity. The Preamble is conscious of the "importance of biodiversity for evolution" implying that evolution is generated by biodiversity. Together, the twin implication is that "evolution" generates and is generated by "biodiversity."

The link between evolution or evolutionary process and "functional units of heredity" is assumed, not explained in the treaty text. Under Article 2, "functional units of heredity' are "contained' in "genetic material." Under Article 2 "value", potential or actual, of genetic material qualifies it as "genetic resource." Under Article 1 genetic resources are capable of being "accessed" and they have potential for "utilization" yielding "benefits." Under Article 2 genetic resources are "possessed" in "in-situ conditions" from where they can be "collected." This enables in Art 2. a definition of a country of origin of a genetic resource under certain circumstances. By extension, any delimited location or area can also be defined as being a place of origin for a genetic resource under certain circumstances. This definition has traceability consequences for genetic resources "collected" from Antarctica through bioprospecting.

In a similar vein, Article 2 defines a country consciously "providing" or "supplying" a genetic resource in its custody, respectively either "collected" from an *in situ* source or "taken" from an *ex situ* source. *In situ* sources may be located in Antarctica but *ex situ* sources may well be located beyond and outside its borders. The scheme itself envisions the possibility of "collected" organism specimens and biological materials to be transported out to museums and biobanks or directly to laboratories in member-nations' domestic territories where they would respectively be "maintained" or "used for testing."

Under Article 2 "genetic resources" along with "organisms" and parts thereof and "biotic components of ecosystems" comprise "biological resources." Article 3 suggests a connection between 'activities" and the "exploitation" of resources. In Article 7 (b) "sampling" is subsumed within the scope of "activities" and generates "data." This renders bioprospecting as conceptually imagined to be an activity involving sampling and exploiting biological resources and generating the knowledge artifact that is data as an intermediate or end product.

Biotic components of ecosystems are not defined but "ecosystem" itself is. Under Article 2 it is a "dynamic" "complex" of plant, animal and micro-organism communities and their non-living environment interacting as a "functional unit." "Complex" itself is not defined. Analogous to the functional unit of heredity being a component of genetic resource for temporal evolution, an ecosystem appears to be a functional unit of the biophysical environment for spatial subsistence.

Using the definition of "ecosystem" and the three undefined terms "organism", "complex" and "species", "biological diversity" is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and ecosystems.

The indicative list in Annex I. for identifying components of biodiversity important for conservation and sustainable use cites "species" of "scientific importance." It is conjectural whether as yet undiscovered and therefore unknown species are covered by being inherently of scientific importance taxonomically. In one reading, treating them as not covered would practically guarantee failure to meet the conservation objective given the lament over the "general lack of information and knowledge" regarding biodiversity as expressed in the Preamble.

Annex I. also cites ecosystems and habitats of 'scientific importance." In Article 2 "habitat" means the place or type of site where an "organism" or population "naturally occurs." Natural occurrence is not described further but a habitat of natural occurrence seems closely allied to the term "natural habitats" featuring in the Article 2 definition of "in-situ conditions" and also to the term "natural surroundings" featuring in the Article 2 definition of "in-situ conservation." Again, it is conjectural whether a habitat likely to host the natural occurrence of an as yet undiscovered and therefore unknown organism is covered through being inherently of scientific importance. Treating it as not covered would also practically guarantee failure to meet the conservation objective given the lament over the "general lack of information and knowledge" regarding biodiversity as expressed in the Preamble.

Ecosystems and habitats containing large numbers of "endemic" species are also in the indicative list of Annex. I. Yet again, it is conjectural whether an ecosystem and habitat likely to host a large number of endemic but as yet undiscovered and therefore unknown species is covered. Treating it as not covered would practically guarantee failure to meet the conservation objective given the lament over the "general lack of information and knowledge" regarding biodiversity as expressed in the Preamble.

The expansive interpretations of the citations above in Annex I. are misconceived, however, if these citations are to be read *ejusdem generis* with the citation in Annex I. of only "described" genomes and genes. If as yet undiscovered and therefore unknown genomes and genes do not qualify for being identified as components of biodiversity of importance for conservation and sustainable use, on the same principle, "species" and habitats with "organisms" and ecosystems and habitats hosting "endemic species" that are as yet undiscovered and therefore unknown, would also not qualify.

Article 10 (e) records that involving the private sector in cooperation with governmental authorities is integral to developing methods for sustainable use. Methods for *ex situ* conservation, in particular, should therefore also be amenable to such non-governmental participation. Under Article 17 member-nations are to facilitate exchange of results of technical and scientific research and of other information from "all publicly available sources." If a private sector entity is in whole or in part the custodian of the *ex situ* conservation, it is possible that to cover its investment, the *ex situ* conservation will not be operated as a "publicly available source." In that case, the member-nation hosting the private sector entity and the *ex situ* conservation would not be obligated to facilitate exchange, especially completely open source and open access exchange. To the extent this interpretation is plausible, prompt dissemination and public availability of research results procured by or hosted in a private or privately sponsored *ex situ* conservation, would stand automatically restricted.

Genetic natural bio-occurrences are noticed in this treaty text. This makes for a direct match with several items in the taxonomy of the ontology of bioprospecting for knowledge production. The reference in the treaty text to the link between genetic biological material and evolution makes a connection between bioprospecting and biodiversity. Evolution operates on time scales much bigger than human intergenerationality but the interplay is not taken up in the treaty text. The conceptualization in the treaty text of undiscovered and unknown elements of biodiversity points directly to the drivers of bioprospecting for knowledge production. The reference to endemicity in the treaty text has special significance for bioprospecting for knowledge production in a unique bio habitat like Antarctica, especially its icy waters, its weighed-down continental shelves, its liminal areas, volcanic areas, subglacial lakes, dry valleys and nunataks. The typology in the treaty text of *in situ* and *ex situ* biotic resources corresponds to the ontology of bioprospecting for knowledge production. The typology of *in situ* bioprospecting activities in this text also has a good correspondence with the synthesized ontology.

 # 11/20: Convention for the Conservation of Southern Bluefin Tuna (CCSBT 1993)
https://www.ccsbt.org/sites/ccsbt.org/files/userfiles/file/docs_english/basic_documents/convention.pdf

"Biological samples" finds a direct mention in Article 5.3. Biological samples are up for "collection" in the language of this provision. By explicitly contemplating the collection of biological samples for scientific research, Article 5.3 envisages the core aspect of bioprospecting.

Article 5.3 also mentions "collection" of "data" and "other relevant information." Relevance is for "scientific research."

The word "activity" is used for fishing in Article 2.(b) but the definition of fishing is rendered broadly and subsumes not only catching and harvesting but also "taking." "Taking" is left defined but fishing itself is stated in an expanded definition to include any "operation" at sea in direct support of catching, harvesting and "taking." The words "activity" and "operation" accordingly can refer to bioprospecting as a sub activity and sub operation within the broad class of activities thought of as fishing.

The importance of "collecting" scientific information is emphasized in the Preamble. Under Article 5.2 "scientific information" is something that can be "provided." Article 12 describes "scientific information" as a kind of possible "best available information" but what other kind of information could also qualify finds no mention. Article 8.4 (a) valorizes "scientific evidence."

The Preamble also expressly acknowledges the "importance" of scientific research. "Scientific research" also finds particular mention in the provisions, not only in Article 5.3 supra but also in Article 8.4 (e) as something that can be "contributed to." Article 9.2 (b) wraps up the scheme of these provisions by referring to "research and studies" prepositionally "on" the concerned species.

Biological sampling is a feature of the ontology of bioprospecting for knowledge production and also occurs in the vocabulary of this treaty text. The prestige status accorded to scientific research is aligned with the underlying philosophy of the ontology.

 # 12/20: Agreement on Trade-Related Aspects of Intellectual Property Rights, Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, 1994 (TRIPS 1994)
https://www.wto.org/english/docs_e/legal_e/31bis_trips_01_e.htm

Under Article 29 "sufficiently clear and complete disclosure" of the invention is to be compulsory in a patent application and the "best mode" for carrying out the invention may be additionally required to be disclosed. With such disclosure embedded in their specifications, patents are exemplar as knowledge artifacts.

Information and results from bioprospecting can form part of invention-disclosure in a patent specification, perhaps a provisional specification, filed at a Patent Office to dock priority. For patentability, such information and results as embodied in the subject invention must be "novel" as on the priority date. This is enshrined in Article 27 which mandates that patents shall be available for any inventions "provided they are new." This implies two things necessarily. Firstly, the patent applicant must not have made the invention-incorporated information and results public already. Secondly, no one else should have done so either.

Information and results whether from bioprospecting or another source when released into the public domain form an accretion to the corpus of the prior art, the existing body of knowledge. Scientific publication is a possible mode of release. Disclosure in a patent specification filed at a Patent Office is another mode of release with a built-in further delay-period only after which the Patent Office actually releases the disclosure by publication. Working the invention in public or releasing it commercially are amongst other modes.

The two forms of release of particular relevance to the issues with bioprospecting in Antarctica – scientific publication and patent specification filing – can entail some delay on part of the person, whether as would-be author of the scientific article or as would-be patentee. This period of delay enables the person to improve and broaden the coverage of what is released, for credit in the case of a scientific publication, for patent exclusivity in the case of a patent. Against this advantage of improved and broadened coverage, however, there is an always inherently an unavoidable and ineluctable risk of losing all possibility of publication credit or patent exclusivity as may be. The scheme is one of delaying to get more but at risk of getting nothing. When to draw the line and no more tarry is for the person to decide as would-be scientific author or would-be patentee. Excluding patents from the ontology-synthesis is thus a clean affair. Delays in dissemination of the knowledge produced by bioprospecting is not a residue left behind from the exclusion.

As knowledge artifacts, patents from any source including bioprospecting, possess an additional feature. This feature is the "inventive step" which is also called "non-obviousness" in some national jurisdictions. Article 27 demands it as an essential and compulsory additional element for patentability of any invention, over and above the element of "novelty." Article 27 mandates that patents shall be available for any inventions "provided they involve an inventive step." The Footnote 5 to the text states that for the purposes of this Article, the term "inventive step" may be deemed to be synonymous with the term "non-obvious." This inventive step or non-obviousness requirement is distinct from the novelty requirement. The inventive step cannot be attributable to and traceable from entirely the very same elements of novelty of information and results from the particular instance of bioprospecting activity from which the subject invention has derived. The inventive step is attributable to the inventor's inventive mind. This means that the inventive step is to be an extra, not derivationally connected to the bioprospecting from which the patent emanates. As a knowledge artifact, a patent therefore, is never altogether purely from bioprospecting even as aided by the existing body of knowledge or the prior art. A patent always contains this contribution that comes from a source other than the bioprospecting for knowledge production and also other than the corpus of prior art. This understanding of Article 27 supports the synthesized ontology of bioprospecting purely for knowledge production not considering and including patents as a knowledge artifact "produced by" bioprospecting for knowledge production.

"Microbes" are not defined in this treaty text, nor are "microbiological processes" but as mandated by Article 27.3 (b) neither can be excluded from patentability by any member-nation. This means that for sub activities of bioprospecting that are a microbiological process such as that of culturing or of microbial genetic expression through genomics, proteomics or metabolomics, patents are mandatory. This also means that for microbes themselves, isolation patents and characterization patents, both process and product patents, are mandatory where an inventive step (obviousness) is involved. Patents are granted at least for microbes and microbiological processes of bioprospecting for knowledge production.

There can be no blanket compulsory license of a patent. It is only on a case to case basis considered "on its individual merits" that a member-nation can under Article 31 (a) override a patentee's monopoly. Like any other patent, a bioprospecting patent also cannot be overridden by any member-nation as an entire class of patents.

Article 7 declares the principle of intrinsic balancing in the intellectual property rights system between conferment of a patentee's exclusivity for a limited duration and the contribution from the attendant disclosure to knowledge accretion in the public domain. Patent monopoly and public disclosure classically co-constitute a bargain. Article 7 states that the protection and enforcement of intellectual property rights should contribute not only to the promotion of technological innovation but also to the transfer and "dissemination" of technology. Dissemination here seems to have the ring of "exchange" and "release" of information such as renders information "public information." This is deemed to be "to the mutual advantage" of "producers" and "users" of technological "knowledge." The delayed release of information and results of bioprospecting for knowledge production, and only as incorporated in an invention-disclosure, is built into the very bargain that is foundational to the patent system.

The treaty text validates the taxonomy of the ontology of bioprospecting for knowledge production as concerns microorganisms and microbiological processes. Not including patents in the ontology is consistent with the treaty text. Built-in publication and dissemination delays in the patent system, as in the scientific publication system with which this treaty itself is not concerned, do not infringe the soundness of the ontology's system integrity in isolating knowledge production from other aspects, issues and concerns with bioprospecting for knowledge production.

 # 13/20: Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1992 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (FSA 1995)
https://www.un.org/depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm

Article 7.2 (d) and Article 9.1 (a) explicitly mention that the "biological characteristics" of the stocks should be taken into account. Annex. I. Article 3.2 (b) mandates to "collect" "biological information". This biological information can pertain to "age, growth, recruitment, distribution and stock identity." These provisions pertain to species of "living marine resources" under Article 1.1 (b). Annex I. Article 1.1 states it as a general principle that not only target species but also non-target and associated or dependent species are included in coverage for such "data" collection. Article 6.2 (d) is to the same effect. "Analysis" and "analytical techniques" for such data are mentioned in Annex. I Article 1.1 and Annex. I Article 2 (f). The datafication of biodiscovery, a key feature of the ontology of bioprospecting for knowledge production, is endorsed by this treaty text. How to proceed with information that points to an as-yet unknown species is however not dealt with in the treaty provisions. The terminology and vocabulary of this treaty text do not yield more than this.

The possibility that scientific information can have lacunae is nonetheless recognized. Article 6.2 speaks of absence of "adequate" scientific information. Article 5 (b), Article 6.7 and Article 10 (f) speak of "best scientific evidence available" as if availability is an inherent constraint on quality. In a similar vein, Article 6.3 (a) speaks of "best scientific information available". This draws attention yet again to the gaps and inadequacies in the larger body of scientific knowledge from which scientific information or scientific evidence is to be accessed. Unsurprisingly, Article 5 (k) and Article 14.3 avow that "scientific research" is to be promoted and conducted. Article 10 (g) avows similarly that "scientific assessments" are to be promoted and conducted. It also avows that "results" are to be "disseminated" but do not compel it to be either immediate or a curtailment of conscious risk-taking for fuller scientific publication or broader patent specification filing.

The scientific is assumed to be capable of imbuing worth to matters like advice. Article 9.1 (d) and Article 10 (d) speak of "scientific advice." Annex. I Article 6 (b) invites "scientific observer programmes." Scientific bio-observation is, like scientific bio sampling, a core feature of the synthesized ontology of bioprospecting for knowledge production.

There is a reference to "appropriate technologies" in Article 5 (k) and to "scientific procedure" in Annex. I Article 1, both in the context of management of stocks. There is no direct allusion to the 'technological', though, in relation to any of the other core aspects of the ontology of bioprospecting for knowledge production such as the collection of biological characteristics or of biological information.

Other than endorsing datafication, an aspect also noted in some other treaty texts analyzed thus far, this particular treaty text does actually reveal a few other features of the ontology of bioprospecting for knowledge production. In the main, these pertain to organism life cycle and to population biology. These aspects are present in the ontology but only indirectly coded into it as 'records' and 'geotags'. Only an ontological legal research (OLR) type analysis could have detected the presence of these features of the ontology embedded so deep in this treaty text. The find vindicates the choice of method.

 # 14/20: Cartagena Protocol on Biosafety to the Convention on Biodiversity (CBD) (Cartagena Protocol 2000) https://www.cbd.int/doc/legal/cartagena-protocol-en.pdf ***, and the Nagoya - Kuala Lumpur Supplementary Protocol on Liability and Redress (Supplementary Protocol 2010)*** https://bch.cbd.int/protocol/text/

As noted earlier, the term "living organism" is left undefined but is used to define "biological diversity" in the CBD. This is the first text to define a "living organism": in Article 3 (g) a living organism is defined as "means any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids." The inclusion of sterile organisms which can be both naturally occurring and LMOs (Living Modified Organisms) in the definition of the set enables LMOs to be treated as a subset. Since against-target screening of metabolites for applied uses itself is treated as lying outside the system boundary of bioprospecting for knowledge production, such further downstream activities like LMO (Living Modified Organism) development, *a fortiori* (more strongly) lies well outside.

The definition of ‘living organism’ in this text does not count as a feature of the synthesized ontology of bioprospecting for knowledge production but is an important building block of the ontology. It is a still lower-deeper level ontological feature than of which the synthesized ontology takes formal cognizance.

 # 15/20: Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, International Seabed Authority (PN ISA Regulations 2000) https://isa.org.jm/files/files/documents/isba-19c-17_0.pdf ***[also Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area, International Seabed Authority (PS ISA Regulations 2010)*** https://isa.org.jm/files/files/documents/isba-16a-12rev1_0.pdf ***, and also Regulations on Prospecting and Exploration for Cobalt-Rich Ferromanganese crusts in the Area, International Seabed Authority (CC ISA Regulations 2013)*** https://isa.org.jm/files/files/documents/isba-18a-11_0.pdf ***]***

“Prospecting” is a defined term in these regulations, but in the context of abiotic resources for their extractive mining – of polymetallic nodules (or of polymetallic sulphides or of cobalt-crusts – refer the appropriate Regulations). This definition forms part of a scheme with definitions of “exploration” and of “exploitation,” also in the extractive mining context of these abiotic resources.

In Regulation 1.3 (a) [all references are to the 2010 Regulations unless stated otherwise] exploitation involves the “recovery’ of nodules which can be thought of as natural geophysical-occurrences (in contrast to natural bio-occurrences as is relevant to bioprospecting), for “commercial purposes”, and the “extraction” of minerals therefrom. Unlike such exploitation, however, the synthesized ontology of bioprospecting for knowledge production does not inherently either involve “recovery’ in this sense nor does it inherently entail a “commercial purpose”, nor is any consumable resource like a mineral inherently ‘extracted” therefrom.

In Regulation 1.3 (b) mineral exploration involves “searching” for “deposits” of the nodules and their “analysis.” Unlike such mineral exploration, however, the type of “searching” that is recognizable as a feature of the synthesized ontology of bioprospecting for knowledge production, does not inherently involve searching for any “deposits.” Nor is the “analysis” of the biological material, a feature of the ontology, akin to the analysis of “deposits.” Incidentally, the “searching” as part of mineral “exploration” is qualified in this definition, as being “with exclusive rights.” This exclusivity is a material point of distinction with the “searching” recognizable as a feature of the synthesized ontology.

In Regulation 1.3 (e) mineral prospecting involves the “search” for “deposits” of the nodules including “estimation” of the composition, sizes and distributions of these “deposits” and of their “economic values.” The search for abiotic mineral deposits is without any exclusive rights, as is the search for biotics. Unlike mineral prospecting, however, the “searching” for biotics which is recognizable as a kind of bioprospecting, does not inherently involve searching for any “deposits.” Nor is the “estimation” of biotics on par with that of the abiotic mineral ore. Estimation of “economic values” may not be basic science as commonly understood but it may still legitimately qualify as knowledge production in the synthesized ontology. Still, economic value of “deposits” is beyond the purview and scope of the synthesized ontology in as much as “deposits” themselves have no equivalence with any input object of the synthesized ontology.

Regulation 2.4 provides, in the context of the nodules, that a prospector may “recover” a “reasonable quantity” of “minerals”, being the quantity necessary for “testing” and not for “commercial” use. Natural bio-occurrences as a feature of the synthesized ontology, does involve “recovery” of “reasonable quantity” of biological material, being the quantity necessary for “testing” and not for “commercial use”, but biological material are unlike "minerals" in that the latter themselves are a consumable exhaustible resource.

"Biological communities" find mention in Annex II. Section 19 (b) in relation to an applied-for exploration area. It is an isolated mention. It is one of the "environmental parameters" about which "information" in the form of "data" needs to be submitted by an exploration applicant.

"Biological components" are better ensconced in the language of these Regulations. Reg.1.3 (c) expressly includes them in the definition of the marine environment. Neither "biological components" nor "biological communities" have been defined. The connection between biological components and biological communities is left open for inference.

"Biota" is also mention in the text but this mention is likewise without definition. Regulation 31.6 refers to "biota of the seabed." Its representativeness and stability is to be ensured in a mining-free 'preservation reference zone.' The objective is to assess "changes in the biodiversity" of the marine environment. The connection of "biota" to "biological communities' and "biological components" is similarly left open to inference. As noted, though, an 'assessment' connection has been made between biota and biodiversity-change.

Carrying out "studies in respect of environmental factors", with the definition of the marine environment including its biological components as noted, is itself within the definition of 'exploration" in Regulation 1.3 (b). A "programme of activities" is required to be submitted for it by an applicant for an exploration contract under Regulation 18 (a) read with Annex IV. Section 1.1 (b). Regulation 12.2 requires a "survey and evaluation" of the area.

Under Regulation 12.1, exploration is "work" and the explorer-contractor must be "technically capable." Regulation 12.10 and Annex II. Section 23 (a) emphasize "expertise, skills, technical qualifications and expertise." Annex. II. Section 23 (b) describes equipment and methods as a "characteristic" of technology of exploration. All these references are to the activity of mining exploration as a technological activity, not to bioprospecting as a technological activity but there is a parallelism with the synthesized ontology.

"Environmental baselines" are not defined but are key to the scheme for environmental monitoring in these Regulations. In Regulation 32.1 the verb "to gather" is used for environmental baseline "data" and the verb "to establish" is used for the environmental baselines themselves.

Regulation 18 (b) and Annex II. Section 24 (b) direct attention to "oceanographic and environmental" baseline studies and to the impact on biodiversity. The word "oceanographic" is not defined is not mentioned elsewhere. The extent of the overlap between "oceanographic" and "environmental" is unclear and so, accordingly, is whether "oceanographic" also, like "environmental" includes biological components.

The word "sample" occurs but without definition and it only directly so in an Annex. The references are all to the polymetallic nodules (or correspondingly to samples or cores of polymetallic sulphides or cobalt-crusts – refer concerned Regulations) as samples, not to samples of any biological material. These references do however, point to the possibility of analogous usage for biological samples in another context. Annex IV. Sections 10.2 (b) and 11.2 (e), for example, speaks of "recovery" of samples prepositionally "for" the "purpose of testing." Annex IV. Section 10.4, for example, speaks of "analysis" of a "representative portion" of such a sample. Annex. IV. Section 11.2 (f) for example, comprehends samples as "archived" for subsequent "availability." Each of these exemplar references is for polymetallic nodules or polymetallic sulphides or cobalt crusts in a mining context, but each aspect admits of cross-application to the bioprospecting context, Thus, the recovery, severance of representative portion, archiving, availability and analysis of biological samples - which are all features of the synthesized ontology of bioprospecting for knowledge production, find a parallel in the mining context of these regulations.

Under Regulation 31.2 "data" and "information" are to be submitted on both the implementation and the results of environmental monitoring. The definition of the marine environment has been noted earlier to include biological components. Annex IV. Section 10.2 (a) elaborates the "results" "obtained from" environmental monitoring programmes to include "observations", "measurements", "evaluations" and "analyses." These correspond well to the knowledge artifact output objects of the synthesized ontology of bioprospecting for knowledge production. "Knowledge" or "technology" are "improved" over time as per Regulation 42.2. At any point of time, there is a "best available" science and technology, as per Regulation 31.4. "Production" of knowledge is not explicitly referred to at all in Regulations but the conception is well aligned with the Regulations.

Under Regulations 7.1 and 36.2 "data" and "information" about the marine environment and generated from the environmental monitoring programs accompanying prospecting or exploration of nodule deposits, shall not be considered "confidential." Since the marine environment includes the biological components, the knowledge produced by the bioprospecting mandated by and accompanying prospecting and exploration of nodule deposits, is thus rendered public and open access. This is not in discord with the synthesized ontology. If anything, it has potential for enhanced knowledge production in the public domain from officially mandated and monitored bioprospecting as an accessory activity to mining.

This text is noteworthy for containing several parallels with the features of the synthesized ontology of bioprospecting for knowledge production without there being as many actual matches. Analysis of biological materials is a prominent exception though. Vocabulary like biota, biological component, biological community and sample occurring in the text is another prominent exception. These vocabulary items match with taxonomic categories in the synthesized ontology. The ethos of knowledge production as undisputed societal gain is a value embedded in the text, one that also holds up the edifice of the synthesized ontology of bioprospecting for knowledge production. Technology as critical aid in the knowledge production endeavor is another such ethos.

 # 16/20: Agreement on the Conservation of Albatrosses and Petrels (ACAP 2001)
https://www.acap.aq/agreement-text/206-agreement-on-the-conservation-of-albatrosses-and-petrels/file

"Taking" is defined in Article I.2 as a "conduct" that also includes "capturing." Article III.2 prohibits the taking even of eggs of the treaty birds. Article III.3 (b) however, exempts the taking for "scientific purposes" though only "on a selective basis and to a limited extent." The synthesized ontology of bioprospecting for knowledge production does not subsume any taking otherwise than subject to such imposed constraints. The treaty text thus admits of bioprospecting as a possible activity and a legitimate one in relation to knowledge production.

That "knowledge" of biology and ecology is "limited" is declared in the Preamble itself. This is, as stated in the Preamble, "notwithstanding past and ongoing" "scientific research." There is an unstated but obvious link between scientific research and knowledge production. That the reservoir of knowledge is less than full is adverted to in yet another provision. Article II.3 speaks of "scientific certainty" and the possibility of the lack of it fullness.

Article III.1 (d) states that research is to be initiated and supported. This is in accord with the acknowledgement in the Preamble that in light of the knowledge-deficit, it is necessary to develop research and monitoring.

Article V.(a) envisages the collection and analysis of data. Under Article VI.2 (e) information is collated. There are allusions to a good part of the entire range of activities featuring in the synthesized ontology of bioprospecting for knowledge production.

"Information" *simpliciter* is mentioned in Article V.(a) and Article V. (b) but Article V.(d) mentions "public information." The language itself comprehends that some information may be non-public or that sometimes it may be non-public. This distinction between information generally and public information more specifically speaks to the inherent possibility of delays in publication and dissemination of information such as would render it public. As discussed earlier, this delay could be because of lack of resources invested in bioprospecting or it could be because of conscious risk-taking entailed in submitting a fuller scientific publication or a broader patent specification filing. As noted earlier, neither reason for the delay prejudices the integrity or representationalism of the synthesized ontology of bioprospecting for knowledge production.

Article V.(f) speaks in the same breath of "knowledge", "techniques" and of "expertise" for being exchanged. Annex. 2 Clause 7.2 follows up but whereas it mentions "knowledge" and "techniques" appearing to be respectively against "research" and "management", it substitutes "skills" for "expertise" apparently against "monitoring." Presumably, these two words – "skills" and "expertise" have been used in the same sense. In as far as knowledge is segregated from techniques as well as from skills and expertise, the language is consistent with the adjectival use in the synthesized ontology of the word "technological" for the activity of bioprospecting. It is also consistent with the use of the phrase "knowledge production" as the result of the activity of bioprospecting.

This treaty text is remarkable in relation to the synthesized ontology of bioprospecting for knowledge production for expressing a sense of dissatisfaction with the current state of knowledge, which it describes as being in deficit, and further for expressly particularizing this knowledge deficit to be the field of biology and ecology. In thus acknowledging a problem with the vastness of the unknowns of biodiversity and its components, especially the part thereof that is potentially knowable already by investigative procedures currently available, this treaty text makes a compelling case for the kind of ontology that has been synthesized.

 # 17/20: International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA 2001)
https://www.fao.org/3/i0510e/i0510e.pdf

The Article 2 definition of "genetic material", akin to the Convention on Biodiversity (CBD) definition noticed earlier, utilizes the undefined term "functional units of heredity." The only difference is that the definition here restricts itself to material of plant origin and specifically includes reproductive and vegetative propagating material. Corresponding to the CBD definition of "genetic resources" as genetic resources of actual or potential value, the term defined here is "plant genetic resources for food and agriculture." Genetic material in the definition here is restricted to plant-origin and value is restricted in scope to value for food and agriculture. The Article 2 definition of *in situ* conservation here is *pari materia* with that in the CBD. Without defining habitat or natural habitat, these terms are used here to construct a definition in Article 2 of an "ex-situ collection." In the CBD, using the same undefined terms, it is "ex-situ conservation" that is defined, not "ex-situ collection." The definition here, of "ex-situ collection" describes what is collected as plant genetic resources for food and agriculture instead of as components of biological diversity being what is conserved. Here, what is collected is mentioned in the definition of "ex-situ collection" as "maintained", a word that is missing in the CBD definition of "ex-situ conservation." An adaptation of the definition here can serve to define an "ex-situ collection" for the purposes of the CBD. Such an adapted definition would emphasize the active maintenance activity of an *ex situ* collection, an extra over the passive element in *ex situ* conservation. This extra element can conceptually distinguish a biobank from a mere conservatory. In the synthesized ontology of bioprospecting for knowledge production, this distinction is reflected in the taxonomy of produced knowledge artifacts instead of in the taxonomy of subjects (operators of knowledge production activity pipelines who/which are also default custodians of the knowledge artifacts produced by concerned activity pipeline). In this ontology, a conservatory is only a subtype of biobank but a preserved item is distinct and different from a musealized item.

Endemic uniqueness attributable to evolutionary processes to which there is only a passing reference in the CBD Annex I. is subsumed in the subject matter of two specific definitions here in Article 2. These two definitions are respectively of "centre of origin' and of "centre of crop diversity." The language of each of these definitions offers useful insight into the possibilities of analogously comprehending adapted hypothetical definitions in the CBD context, respectively – "centre of origin of a specie" and of "centre of cluster diversity of a genus or family."

Both definitions denote a type of geographic area. The definition of "centre of origin" has a significant usage of the word "first." Centre of origin means a geographic area where a plant species – domesticated or wild – "first" developed its distinctive properties. Taking inspiration from this definition poses for consideration an analogous hypothetical definition for "centre of a specie" as "means a geographical area where a wild species first developed its distinctive properties." The "first" development seems to connote evolutionary origin. On this reading, centre of origin connotes centre of evolutionary origin and native endemism. These connotations are particularly significant for bioprospecting in Antarctica for endemic lifeforms not found outside the region.

The definition of "centre of crop diversity" has a significant usage of the term "in-situ conditions", a term that is itself defined not here but in the CBD. Centre of crop diversity means a geographic area containing a high level of genetic diversity for crop species in "in-situ conditions." Taking inspiration from this definition poses for consideration an analogous hypothetical definition for "centre of cluster diversity of a genus or family" as "means a geographical area containing a high level of genetic diversity for a cluster of species of a genus or family in *in situ* conditions." This is quite significant for cryptic species in Antarctica.

The lack of these two definitions in the CBD points to lack of focused attention in the CBD to geographic areas so comprehended, whether for exploration-based conservation or for exploration based sustainable use. This terminology of the treaty text being analyzed is ideationally useful for future treaty-making to improve the governance of bioprospecting, especially in Antarctica. This is a collateral contribution of the present analysis, and a pointer to possibilities for further research.

Biobanking related terminology and vocabulary in this treaty text are recognizable as features of the synthesized ontology of bioprospecting for knowledge production but under a different conceptual categorization than in the treaty text. Finding this kind of a match was possible only through an ontological legal research (OLR) analysis. Once again, the find vindicates the method.

 # 18/20: Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their Utilization to the Convention on Biodiversity (CBD) (Nagoya Protocol 2010)
https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf

Amongst the twenty-five legal instruments being ontologically analyzed, it is only in this text that the term 'bioprospecting" occurs. It occurs only once, in Article 22.5 clause (f): "Bioprospecting, associated research and taxonomic studies." Clause (f) is one of set of clauses that illustrate what may be included in capacity-building and capacity-development measures that member-nations may take by way of implementation. "Access" to biodiversity and the "sustainable use" of its components is mentioned in clause (h). If clauses (f) and (h) are read together, bioprospecting would entail access to biodiversity and use of its components.

This minimalist inferential description is the closest shave the entire set of treaties and regulations has with defining bioprospecting. Notably, "bioprospecting" occurs in the very same clause along with "associated research" and "taxonomic studies." The latter two terms point to the single purpose type definition of their companion term: "bioprospecting" for knowledge production. There is nothing pointing to the split binary type definition of bioprospecting involving commercialization.

The term "derivative" features without definition in the Convention on Biodiversity (CBD) definition of biotechnology. Here, in Article 2 (e) it is defined for the first time as being a "biochemical compound" that is "naturally occurring." The definition delinks the question of whether or not functional units of heredity are present in a derivative. The definition also expressly encompasses a derivative resulting from metabolism instead of only resulting directly from genetic expression. This definition meshes with the product of the bioprospecting activity in an analyzing laboratory of isolating and characterizing a metabolite, especially a secondary metabolite. Such a conceptual category of laboratory analysis as activity and of analyzing laboratory as its operator (subject), exist as features of the synthesized ontology of bioprospecting for knowledge production. Natural product (NP) and its isolates and derivatives are also conceptual categories of the ontology and they match with the terminology of derivatives and the vocabulary of biochemical compounds occurring in this text.

Conducting research and development on the genetic and/or biochemical composition of genetic resources is termed as "utilization of a genetic resource" in Article 2 (c). The CBD only mentions "use of components of biodiversity" while defining sustainable use. The terminology here is wider in scope.

The "source" of a genetic resource is referred to in 17.1 (a) (i). It is the only such reference in this text. There is no accompanying definition. In the CBD, such references to "sources' are made only as for genetic resources "collected from in-situ sources" or "taken from ex-situ sources" in the Article 2 definition of "country providing genetic resources." It would appear that the bare reference in Article 17.1 (a) (i) is in the same sense as in the CBD. There is no apparent inconsistency.

In the context of access to scientific information, there is a reference in Annex. Clause 2 (k) to "biological inventories" and to "taxonomic studies." Biobanks of the synthesized ontology of bioprospecting for knowledge production can subsume such vocabulary of biological inventories whose inventory presumably comprises items originating as items of natural bio-occurrence. Taxonomic Facilities, another conceptual category of the synthesized ontology would house in the form of knowledge artifacts, results of taxonomic studies as mentioned in the vocabulary of this text.

"Technical and scientific research and development" is spoken of in a single breath in Article 23. Not only is the scientific combined with the technical, the development aspect of knowledge production is also combined with the research aspect of knowledge production. In both respects, an integrated perception is evident. Article 17.1 (a) (iv) explicitly recognizes "stages" in utilization of genetic resources as also being stages in collection of relevant information. These stages are spelt out as, *inter alia*, "research, development, innovation, pre-commercialization or commercialization." The commercialization stage though is not segregated in the mention from the three prior-mentioned stages by treating the three prior-mentioned stages as knowledge-production stages.

There is a reference in Article 10 to utilization of genetic resources in "transboundary situations" and "for which it is not possible to grant or obtain prior informed consent." The latter phrase perhaps has some correspondence with the United Nations Convention on the Law of the Sea (UNCLOS) Article 1.1 (1) phrase "areas beyond the limits of national jurisdiction."

Several features of the synthesized ontology of bioprospecting for knowledge production are to be found in the vocabulary of this text, and some in its terminology. These span across conceptual categories of the synthesized ontology. Natural products, derivatives and isolates; bio-banks and analyzing laboratories; laboratory analysis - these are all directly relatable to features of the synthesized ontology.

 # 19/20: Recommendations for the guidance of contractors on the content, format and structure of annual reports, International Seabed Authority – Legal and Technical Commission. (AR ISA-LTC Recommendations 2015) https://isa.org.jm/files/files/documents/isba-21ltc-15_1.pdf

The biological aspect of the establishment of "environmental baselines" is described in detail concerning the exploration of polymetallic nodules in Annex. I. Section IV. Article 9 (g) mentions but without defining, "biological communities" and "biodiversity" studies as inclusive of "megafauna", "microfauna", "meiofauna", "microflora", "nodule fauna", "demersal scavengers" and "pelagic communities." Concerning the exploration of polymetallic sulphides, Annex. II. Section IV. Article 9 Clause (g), and concerning the exploration of cobalt crusts, Annex. III. Section IV. Article 9 (g) are each *pari materia* with the vocabulary above for polymetallic nodules but for the additional mention of "habitat diversity" and "bacterial mats."

Article 10 Clause (f) mentions "seabed communities", Clause (d) to "the abundance of individual species" for "biological communities" and Clause (h) to "species ranges and dispersal on the scale of ocean basins" indicating a community approach and then also a biogeographical approach.

Supplementing the above 'organism', 'community of organisms' and 'biogeographical' approaches, for polymetallic nodules, Clause (h) provides a higher scale and biochemical approach to bioprospecting. It mentions "ecosystem functioning" with measures of - "bioturbation", "stable isotopes" and "sediment oxygen consumption." For cobalt crusts, the corresponding Clause (h) has ecosystem functioning include "food webs", "stable isotopes", and "fatty acids." For polymetallic sulphides, the corresponding Clause (h) also includes "methane and hydrogen sulphide metabolism." For polymetallic nodules, Clause (f) draws attention to "dissolved and particulate Organic Carbon." For cobalt crusts, the corresponding Clause (f) also draws attention to the biomolecule "chlorophyll a."

In Annex. I. Section III., the language reflects a mostly technological character of exploration work. Article 4 speaks of the "results" of polymetallic nodules exploration work as including "mapping" and "sampling." It mentions "photography and video recording" as examples of methods and "corers", "grabs" and "dredges" as examples of equipment for this. The corresponding provision in Annex II. for polymetallic sulphides, and in Annex. III. for cobalt crusts, also mentions "submersibles", AUVs "autonomous underwater vehicles", ROVs "remotely operated vehicles." The methods and equipment for establishing environmental baselines are not separately specified whether for biological components of the marine environment or for any other components. It could be that the extant sophistication of technology is expected by these Recommendations to be deployed for such bioprospecting activity as well.

The knowledge production aspect of such bioprospecting is pointed to but not explicitly so. Annex. I. Section IV. Article 9 Clause (b) mentions "technical equipment" used "at depth" instead of *in situ*, "on board" instead of on-ship and "in the laboratory (including analysis software)" instead of *ex situ*. The express mention of "analysis software" can point, in the context of bioprospecting, to not only bio-imaging and other sub activities in an analyzing laboratory but also to bioinformatics and other sub activities in a sequencing laboratory. The latter are intimately connected to the omics processes of the synthesized ontology. Data banking as well as database referencing as through genomic bar codes and meta bar codes are comprehended within this possibility but these are not specifically mentioned. The closest reference is the mention in Clause (d) of "interpretation of the findings" as including "comparisons with published data from other studies." The bioprospecting required to accompany exploration is not confined to mere raw material, information or data collection but seems to extends to further studies of a consequential, referential, derivative and comparative nature. Such an extended comprehension of bioprospecting matches the full set of features of the synthesized ontology of bioprospecting for knowledge production.

The terminology and vocabulary of this text constitute to a match across almost the entire set of the taxonomy and the inter relation rules of the synthesized ontology of bioprospecting for knowledge production. The thoroughness of the matching, however, is not uniformly high. In parts, it is quite patchy.

 # 20/20: Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, International Seabed Authority – Legal and Technical Commission. (EIA ISA-LTC Recommendations 2019) https://isa.org.jm/files/files/documents/26ltc-6-rev1-en_0.pdf

Strikingly, genomics and other 'omics' sub activities of the synthesized ontology of bioprospecting for knowledge production find a very good match in the language of certain provisions of this text. Article III. 15 (d) (vii) speaks of "genetic" connectivity of key and representative species. Article VI. 32(f) includes in its list of technologies used in exploration, the "DNA screening of biological samples." Annex. I Section 31 adverts to "molecular assays." Annex. I. Section 32 (a) underscores the importance of "molecular studies" in conjunction with morphological taxonomic analysis and mentions "DNA extraction" as a technique. Clause (b) goes on to explicitly mention "DNA sequencing" drawing attention to a Technical Study issued by the International Seabed Authority (ISA) for its protocols. Clause (c) envisages "molecular analysis" at a later point of time for microeukaryotes (Foraminifera) provided the biological sample is preserved in an appropriate stabilizer of "nucleic acids such as RNA." Clause (d) recommends "cloning/sequencing" for diversity assessment of microbes. Clause (e) recommends "metagenomic or amplicon sequencing" for biodiversity monitoring through environmental DNA (eDNA). eDNA is explicitly defined in Annex. II.

Annex. I. Section 35 highlights "molecular" analysis as a complement for food-web linkages. Annex. I. Section 41 (e) seeks cryogenic freezing or preservation in an adequate "DNA preservation buffer" of microbes on board for subsequent "extraction of gene material" and "high throughput methods (e.g. Illumina sequencing)" for "sequencing of the molecular material." Targeted metagenomics (or metabarcoding)" focusing on taxonomic markers such as the "ribosomal RNA gene" is cited for distinguishing the signal of living species from that of ancient, dead material. "Metagenomics" and "metabarcoding" are each explicitly defined in Annex. II. Metabolites information is recommended for integration into the analysis of taxonomic and "function gene diversity."

Annex I. Section 47 speaks of "molecular methods" for modern taxonomy, with "Barcodes, or DNA sequences" suitable for identifying species. Annex. I. Section 48 shows cognizance of "bioinformatics", explicitly mentioning "metagenomic analyses" using "throughput sequencing (next generation sequencing)" for very small organisms like bacteria, archaea, micro- and meiofaunal protozoa and metazoa. "High-throughput sequencing" is explicitly defined in Annex. II. as are "metagenomics" and "next-generation sequencing."

A critical feature of the ontology of bioprospecting for knowledge production, the omics technologies and their in-suite compendium of items, is to be thus found quite well laid out in this text.

A large range of probes, sensors, tools and other devices are identified in this text, constituting nearly a full-suite description of the tools and technologies girding the synthesized ontology of bioprospecting for knowledge production. Article III.15 (d) (v) suggests "record" of "sightings" for mammals, large animals and bird aggregations. Article III.16 (d) recommends "remotely operated vehicle" or "submersible" else "rock dredge" and "rock drill" samples for meiofauna and microbial community structure and biomass associated with polymetallic sulphide deposits. Clause (e) advises "discrete sample boxes" for "precision sampling" for active hydrothermal vent systems. Article III.18 (a) advises "stratified sampling" and "replicate biological samples" to deal with the highly localized distribution of biological communities associated with cobalt crusts. Clause (c) suggests, inter alia, "towed photographic/video transects" and "benthic landers" for demersal fishes and other seafloor nekton. Article VI.32 (f) mentions "non-bottom contact gear (e.g. towed camera platforms)" as a particularly benign technology. Article VI.33 (f) mentions "epibenthic sled", "dredge" and "trawl" as examples of technologies that are not benign.

Correspondingly, a range of techno-scientific tests, diagnostics and evaluative processes and protocols are also mentioned. Annex. I. Section 30 endorses "stratified random sampling" to deal with variability. Annex. I. Section 31 advocates "insulated" sample containers to protect psychrophilic biological specimens and materials from degradation during recovery. Annex. I. Section 32 (d) advises "sterile devices" for microorganisms, bacteria, archaea, fungi, viruses and microeukaryotes. Annex. I. Section 33 specifies "colour photographic documentation" of organisms, together with clear labels. Annex. I. Section 39 suggests "multiple corers" for soft sediments and "box corer" for low faunal density.

Annex. I. Section 40 endorses "slurp sampling" and "grab samples" for larger organisms on hard substrata. Annex. I. Section 41 (a) suggests a "time-lapse camera" for activity level of surface fauna, and "baited traps" and "baited cameras" for motile less-abundant megafauna. Annex. I. Section 41 (b) suggests "megacorer" for bathyal sediment environments. Annex. I. Section 41 (e) advises "multiple corer" or "push corer" for microorganisms in sediment habitats. Annex. I. Section 41 (g) mentions "photographic surveys", "baited lander deployments" and ROV (remotely operated vehicle) "transects" for demersal fishes. "Baited traps" are recommended for surveying amphipod and necrophage communities. Annex. I. Section 42 lists "nets", "moored plankton pumps" and "sediment traps" for the pelagic community in the benthic boundary layer. For surface to 200 m depth, subclause (b) mentions the "Bongo net" and the for the near-bottom layer, the "Brenke sled." Subclause (c) mentions "optical tools" such as "underwater video profilers" and UAV/ROV (autonomous underwater vehicle/remotely operated vehicle) "transects" for gelatinous zooplankton. In most of these mentions as is evident, there is the scientific and the technological aspects of accessing the components of biodiversity are inseparably combined.

In the range of bioprospecting tools and devices that are featured and in the specificity of circumstances of their respective suitability, as well as the range of their applicatory use, these Recommendations are seen to be pioneering in their attention to detail and in their sophistication. These Regulations read almost like an accompanying reference manual for several relevant conceptual categories of the synthesized ontology of bioprospecting for knowledge production. The motivation is strongly scientific: to ensure repeatability of data collection and comparisons over space and time.

In this text, several entities, agencies and miscellaneous types of repositories have also been identified for conducting the variety of different sub activities of bioprospecting and for housing their myriad produce of knowledge artifacts. This makes for yet another area of a high degree match with the features of the synthesized ontology of bioprospecting for knowledge production.

Article III. 15 (d) (viii) refers to "archive of context/setting information for each sample." "Specimens" archiving is mentioned in Annex. I. Section 36 as part of "national or international collections." These collections would be subsumed under the head 'biobanks' as featured in the synthesized ontology. Article III. 19 points to "certified…laboratories." Article III. 22 requires biological and molecular samples to be "archived" in the appropriate ling-term "storage facility" after completion of studies. "Natural history museums", "core depositories" and "international labelled collections (microbiology)" are cited as examples of such a 'storage facility.' "Curated collections facility" is another mention in Annex. I. Section 47, as a kind of repository. It receives deposit of "voucher specimens and molecular samples, including DNA extracts." These would fit under the head of 'Biobanks' in the synthesized ontology.

Annex. I. Section 47 refers to “major laboratories and collections” that carry out “taxonomic studies.” These would correspond to the ‘taxonomic facilities’ in the synthesized ontology. Annex. I. Section 31 contemplates “fixation and preservation” of organisms, noting that formaldehyde/formalin is not appropriate for all taxa. It recommends “cold rooms” “on board” the ship or vessel especially if “molecular assays” are planned. Annex. I. Section 32 notes “freezing” or “preservation in molecular grade ethanol” for molecular studies. It advises that samples be first “sorted live” and “photographed.” Digital archiving is recommended in Annex. I. Section 33. “Sample derivatives (e.g. photographs, preserved material, gene sequences)” is used in contradistinction to “samples” in Annex. I. Section 34. Metadata seems to be referred to as “collection information (…date, time, method of sampling, latitude, longitude, depth and cruise identifier)” which should be linked up with the samples as well as the sample derivatives. Such associative data points are integral to taxonomic work.

Under Annex. I. Section 32 it is only at the “home institute” instead of “on board the exploration vessel” that PCR (polymerase chain reaction) analysis should be done so as to avoid contamination. “PCR” is explicitly defined in Annex. II. The word “institute” also occurs as part of “research institute” in Annex. I. DNA extraction and purification from preserved samples must also happen only in “land-based laboratories”, not “on board in the shipboard laboratory.” Section 57. Cryogenic “long term” archived storage of “voucher specimens” is contemplated by Annex. I. Section 32 (a). Clause (b) contemplates the holding in solution “for further processing” signaling to the sequenced and possibly deferred sub activities of bioprospecting. Identifying “new species” is emphasized through “cultivation procedures” in clause (e) pointing to breeding and culturing. In the synthesized ontology, this can happen in the ‘Analyzing Lab’ or in the ‘Sequencing Lab’, depending on whether the goal is isolation and characterization of biomolecules or the genomic sequencing and identification.

“Remotely sensed data”, for example chlorophyll a, is mentioned Annex. I. Section 42 (a) pointing to how extended the bioprospecting chain is. A combination of temporal “monitoring” as well as spatially separated “shipboard and laboratory experimentation” is thought necessary for ecotoxicological impacts in Annex. I. Section 45.

Notably, Annex. I. Section 47 mentions not only “international databanks” but actually an example - “GenBank” as well. There is no specific mention though of the International Nucleotide Sequence Database Consortium (INSDC) or of its other two members, EMBL (European Molecular Biology Laboratory) and the DDBJ (DNA Data Bank of Japan). Molecular sequences should be deposited in “GenBank or equivalent internationally recognized sequence databases.” DNA Barcode or genome based molecular taxonomic information combined with morphological taxonomic information are stated to be “added” to “international databanks.” Databanks and databases appear to have been used interchangeably here. They correspond to the ‘Database’ in the synthesized ontology.

It can be seen from the above how closely and extensively the language of this text reflects the conceptual categories especially of subjects (operators-custodians) and their interrelations, as encoded in the synthesized ontology of bioprospecting for knowledge production.

Knowledge adjectivized with the words ‘scientific’ and with ‘current’ occurs in Articles I.1.4 I.1.7 as “current scientific knowledge.” Article I.1.7 combines ‘scientific knowledge’ with ‘information’ as “scientific knowledge and information.” This too has a “current state.” Annex. I. Section 57 combines “knowledge and technology.” This has a “development” which in the context seems to refer to a co-development. Annex. I. Section 57 perceives “gaps in knowledge.” Annex. I. Section 47 describes taxonomic expertise as being “extremely limited.” In Article III.A.13 the “best available” technology and methodology for sampling is recommended to be adopted at any given point of time. An evolutionary trajectory of growth in knowledge seems implicit in the choice of the words - “current”, “state”, “progress”, “development” and “best available.” The phrase “knowledge production”, however, does not occur. Annex.

I. Section 57 speaks of "biological and scientific expertise." Article V. 29 speaks of "academic and other professional expertise." "Research Institutes" are referred to as having such expertise as well as "sampling equipment" for "sampling" in "remote areas." In Annex. I. Section 1.7 "experts" are referred to as prepositionally "from" the "scientific community." The reference is not to any experts but to "recognized" experts. There is no description though of the mechanisms of such recognition. A partnership is recommended between contractors and the "scientific community" in Annex. I. Section 59.

Article V. 29 offers support to the "coordination and dissemination" of the "results of research." Under Article IV. 26 biological and other data prospected on a cruise is to be made "freely available" for "scientific analysis" within four years of completion of cruise. Annex. I. Section 63 recalls the parent treaty as mandating to coordinate and disseminate the "results" of research "and analysis" "when available."

The inherent self-borne risk in delaying scientific publication or patent specification filing appears subsumed in a broad construction of the phrase "when available."

In this text, the omics dimension, the suite of tools and technologies and the comprehensive coverage of the typology of operators-custodians respectively embody corresponding features of the synthesized ontology of bioprospecting for knowledge production. They do this more comprehensively and thoroughly than is done by any other text that has been analyzed.

6. Conclusions

Each of the two hypotheses of this thesis stand affirmed filling each of the two identified knowledge gaps. It has been possible to synthesize sensible and insightful Conceptual Graphs as Knowledge Representation, a form of Conceptual System Model (CSM), with an associated ontology, for the domain of bioprospecting as an activity for knowledge production. It has also been possible to find some features of the synthesized ontology associated with the synthesized Conceptual Graphs through conducting ontological legal research (OLR) in the selected legal texts. They were searched for and found lying scattered and embedded in the terminology and vocabulary of the texts of several of the treaties and regulations selected for being potentially most relevant to the governance of the activity of bioprospecting in Antarctica.

The first research question of this thesis was: what does the ontology of bioprospecting as an activity for knowledge production look like and what are its features? The answer is that Conceptual Graphs of **Figures 4-16** depict what it looks like and its features are as contained lexically in the box-cells of the four tables in Appendix B, C, D and E. The second research question, if any of these features occur in the texts of public international law treaties and regulations potentially most relevant to the governance of bioprospecting in Antarctica even though none of them claim or purport to regulate bioprospecting, is also answered in the affirmative. These features are as presented in the set of results and discussions of the ontological-analysis (supra).

The aim of this thesis was to conceptualize bioprospecting as an activity for knowledge production and to locate the warrant for its comprehension, if any, in international law constituting the governance of the activity of bioprospecting in Antarctica. The ontological-synthesis of **Figures 4-16** and the associated Tables contained Appendix B, C, D and E conceptualize the single purpose type definition of bioprospecting for knowledge production under the assumption that Traditional Knowledge (TK) is not implicated. The results and discussions of the ontological-analysis located the warrant for the comprehension of this conceptualization in practically the only international law there is relevant to the governance of the activity of bioprospecting in Antarctica.

It is found that even though there is no treaty or regulation that claims or purports to regulate bioprospecting in Antarctica, the language of the deep text of the set of treaties and regulations most potentially relevant to its governance surprisingly already contains several of the features of its conceptualization embedded in it. The necessary techno-legal literacy and expertise already exists. It is as if the conceptualization has seeped into the deep text piecemeal over time and as if international law is already as a result cognizant at a subconscious level of the intricacies and complexities of the techno-scientific processes of bioprospecting for knowledge production. It is the deep text of the selected treaties and regulations that shows an embedded comprehension of a conceptualization of bioprospecting for knowledge production. Especially in the last decade or so, there has been a profusive growth of such a comprehension. Consequently, a remarkably nuanced apparatus already exists hitherto invisible to the scholarship, in the language of international law in relation to bioprospecting. The post-omics single purpose definition of bioprospecting solely for knowledge production is hardly a conceptual stranger to the legal vocabulary and terminology of international law notwithstanding that governance of bioprospecting is described as passive and permissive and even problematized as underregulated. International law, it turns out, is actually already primed and equipped with the necessary toolkit to implement a shift, if and when occasioned, from the current stance of a passive and permissive mode of governance of bioprospecting in Antarctica. In terms of techno-legal capability for sustainable governance towards sustainable development, international law is revealed for the first time in this thesis to be in an unexpectedly ready-mode to regulate bioprospecting with greater intervention if and when the regulatory policy-prescription changes.

The synthesized ontology has served the purpose of its synthesis through enabling the intended ontological-analysis of the selected treaties and regulations. The ontology synthesized here affords a conceptualization of bioprospecting for knowledge production. The conceptual categories and their interrelations, within the system and subsystem boundaries and also across the sub system boundaries, were depicted using Conceptual Graphs, which in turn are knowledge representations, a Conceptual System Model (CSM). As with any model no matter how insightful or useful, it is pertinent to remain cognizant that reality is considerably more complex.

The set of individual results and discussions of the ontological legal research (OLR) are an academic resource for further scholarship on Sustainable Governance and thereby for Sustainable Development. Further scholarship could explore, for example alignments with other ontologies, historical trends, and intersections with other fields of scholarship like institutional economics, political ecology, political economy, technological literacy, and sustainable values.

Some further interpretations can be elaborated upon here:

The results and discussions show for example the multiseeded genesis of different ontological features of bioprospecting for knowledge production in the earlier treaties. The ontological-analysis also shows an uneven trajectory of growth of a comprehension of bioprospecting for knowledge production. Features seeded in one treaty constellation sometimes get picked up in and grow further in another treaty constellation. An example of such a pair is the United Nations Convention on the Law of the Sea (UNCLOS) and the Convention on Biodiversity (CBD) notwithstanding the switch from the ethos of common heritage of mankind to national sovereignty over natural resources. Sometimes ontological features are only adumbrated in a parent treaty but really come into their own in a subsequent regulation. An example is the Convention on Biodiversity (CBD) and the Nagoya Protocol. There are sometimes unexpected bursts of phenomenal growth as for example in the International Seabed Authority (ISA) Exploration Recommendations in the United Nations Convention on the Law of the Sea (UNCLOS) treaty constellation. There is even an instance, in the Convention on Plant Genetic Resources for Food and Agriculture (PGRFA), of pioneering language ('center of origin' and 'center of crop diversity') that can foreshadow future doctrinal law making to regulate bioprospecting in Antarctica and elsewhere.

Although the treaty constellations are highly distinct, it is as if the ontological features of bioprospecting for knowledge production embedded in them form a single unified corpus from which the drafting of the language of each new treaty and regulation unreservedly borrows and steadily contributes to the growth of. There is unconstrained lending and borrowing of these ontological features as if in a shared epistemological framework cross cutting constellation boundaries.

Another fascinating facet is the embeddedness of values and paradigms of the thinking underlying the ontology. The unwavering acknowledgement of and emphasis on the role of the private sector is an example. The valorization of science is another. The occasional ambivalence in privileging the scientific over the social and the cultural is also notable. The tendency to privilege the genetic as separate from the scientific is also noteworthy. This owes perhaps, as noted earlier, to the novelty of gene-sequencing technologies within science. The trend of an inextricable blending of science and technology into a combined genre of the techno-scientific is also notable for blurring the traditional boundary between them. The growth of systems thinking and conservation values impresses especially in the Convention on Migratory Species (CMS) treaty constellation. It is also accompanied by a subliminal discrepancy between thinking of evolutionary timeframes and the shorter timeframes of human intergenerationality implicit in 'Sustainable Development' thinking.

Given the heterogeneity of the *lex specialis* treaties analyzed, the degree of consistency of their deep seated ontological features appears quite remarkable. When it comes to the mined ontological features, the corpus of treaties at any point of time is quite consistent and cohesive though the distribution of these features between treaties and regulations is very uneven. Almost the entire ontology, as synthesized, of bioprospecting as a techno-scientific activity producing knowledge is by now reflected in the language of international law, though doctrinally there is nothing. The seepage of such a comprehension in the language of international law has developed and grown over time with intriguing turns and accelerations even as the science and technology of the phenomenon itself has transformed over time. Their interplay raises intriguing questions that lie beyond the domain of this thesis but the academic resources generated by this thesis may pave the way for researching them in the future.

6.1. Contribution and Significance

The present thesis borrowed from a wide range of disciplines, ranging from biology and systems engineering to science and technology studies and law. It contributes to current scholarship on the topic of bioprospecting in instances where Traditional Knowledge (TK) is not implicated, in terms of theory, method and empirical results.

Theoretically, the thesis contributes with the synthesized Conceptual Graphs and their ontology. The Conceptual Graphs update previous flow charts and visualizations of bioprospecting to deepen them to a three-tier system conceptualization and also to usher them into the era of bioinformatic genetics, genomics and Digital Sequence Information (DSI).

Methodologically, this thesis contributes through a cross application of conceptual system modeling (CSM) to the sub fields of bioprospecting studies and Antarctic studies, in the larger field of law and governance studies. This thesis also contributes methodologically through its adoption and method-application of ontological legal research (OLR) as a hybridized legal research method to analyze the deep texts of treaties and regulations in the sub fields of bioprospecting studies and of Antarctic studies, and legal texts more generally in the larger field of law and governance studies.

Empirically, this thesis contributes to the topic with its report on the search for features of the synthesized ontology in the selected treaties and regulations.

6.2. Limitations

This thesis is limited to English language sources. This is of particular significance though only in the ontological-analysis part of this thesis. It is only the official English language versions of the texts of the treaties and regulations that have been ontologically analyzed. All these treaties and regulations have official versions in other languages and subjecting them to ontological-analysis has the potential to reveal comparative insights. For conducting their ontological-analysis, it not necessary, however, to undertake a new ontology-synthesis in the other language. Ontology is by definition independent of natural languages. Merely translating the short lexical terms in the Conceptual Graphs, also occurring as lexical entries in the box-cells of the associated Tables, will suffice.

This thesis has not synthesized a socio-techno-legal system, which restricts its greater generalizability and real-world applicability.

In the synthesized ontology, the disaggregation of conceptual categories within any parent conceptual category type, in each instance of it, is only to a certain degree. That degree is as would have suited the intended subsequent manually performed ontological-analysis. Further disaggregation of conceptual categories and of interrelations by splitting up or even by carving out additional tiers (levels) of typology, would have incorporated additional complexity but also imposed a too heavy burden on the manner of the intended ontological-analysis. For example, the number of knowledge artifacts conceptualized in this thesis is thirty-two. This number can be increased considerably to increase complexity and make the ontology-analysis more sophisticated. Incorporating such additional complexity in the ontology-synthesis was beyond the capacity of this research effort. Algorithmic implementation of ontological-analysis can also handle greater complexity but that was also beyond the research plan of this thesis.

Whereas the ontology incorporates activities, inputs, outputs and operating institutions, it does not incorporate networks of institutions. It also does not incorporate technological standards generated by networking initiatives. It was beyond the scope of this research effort to do so.

6.3. Suggestions for further research

Some suggestions for interdisciplinary enlargement of research scope have already been noted above. Other suggestions are:

Geographical, Aspectual Enlargements: The Conceptual Graphs could be modified and expanded for regions other than Antarctica by accommodating, if relevant, additional aspects like traditional knowledge and ethno-ecological knowledge.

Corpus Enlargements: The corpus of treaties and regulations can be modified or expanded to include other kinds of legal instruments and texts. Draft treaties and regulations such as the BBNJ Revised Draft and the Draft ISA Exploitation Code can, for example, be included. Another possible enlargement is possible by including other sources of international law such as tribunal decisions, background and preparatory materials of international conferences and of the drafting of treaties and regulations, law reviews and other forms of legal scholarship. Still further enlargement can take in domestic law of one or more national jurisdictions. This can include not only legal instruments but also court decisions.

Alternative Cross-Applications and Applications: The methodological cross application of conceptual system Modeling (CSM) can be similarly cross-applied to other subfields of law and governance studies. The adoption and method-application of ontological legal research (OLR) can also be applied to other fields of law and governance studies.

AI (Artificial Intelligence) Implementation: Modelling computer programming languages like for example UML, Protégé, RDF, OWL, OntoUML, can be used for synthesizing the ontology. Features of the synthesized ontology will thereby get encoded to computer-generate the Conceptual Graphs which have been drawn manually for this thesis. Such algorithmic ontology-synthesis can easily handle far greater levels of complexity than was manually possible in this thesis. This thesis only demonstrates the method and its possibilities. Scaling up is possible and will be rewarding by using a modeling language. Ontological-analysis is also possible by running a computer algorithm. That can also take on an Artificial Intelligence (AI) dimension and trawl much bigger textual data sets than was possible manually to do in this thesis. In this regard too, this thesis is only a demonstration of methodological possibilities.

7. Declarations & Acknowledgements

7.1. Declarations of Independence & Non-Conflict

The author declares that this research thesis is an independent and original, self-researched and self-authored work undertaken, discharged, completed and written by the author, and not previously submitted or published anywhere, whether in whole or in part. The author also declares the absence of any commercial, financial or other relationships, affiliations and motivations that could be construed as conflict of interest. It is specifically stated that no funding or other financial support has been received for this research thesis.

7.2. Acknowledgements

I am deeply grateful to Susanna (Lize-Marié) Hansen van der Watt, Division of History of Science, Technology and Environment, KTH Royal Institute of Technology, my Thesis Supervisor, for the invaluable supervision by way of encouragement, guidance, inputs and suggestions from the start to the finishing line of this thesis. I doubt if I had would have completed this thesis without her continuous and caring supervision. I am also deeply grateful to Thomas Dahlgren, Department of Marine Sciences, University of Gothenburg, my Thesis Subject-Reviewer, for the insightful reviews and constructive feedbacks. I am also grateful to Amanda Jonsson my thesis opponent. Demerits and other deficiencies of this thesis are entirely mine to shoulder. Appreciation for the continuous and well organized departmental support from Malgorzata Blicharska, Thesis Course Director, is hereby acknowledged as is the helpful workshop and the initial stage guidance provided by Cecilia Mark-Herbert, Thesis Course Teacher. I owe special thanks to Ashwani Balayan, Partner (Patents) at ALG India Law Offices LLP for sharing with me intricacies of the world of biotechnology and insights into the complexity of its patents. I also owe special thanks to Anneli Ekblom, Department of Environmental History at Uppsala University, for teaching me so very patiently how to do research. This research thesis would never even have been undertaken without the ever-enriching academic journey behind it.

Address for correspondence: rp.rakeshprasad@gmail.com

8. References

Aarnio, A. (2011). 'On the Ontology of Law' In: *Essays on the Doctrinal Study of Law.* Ch., pp. 45-52. Law and Philosophy Library, vol. 96. Dordrecht, NL: Springer Science & Business Media. https://doi.org/10.1007/978-94-007-1655-1_7

Abdel-Motaal, D. (2016). *Antarctica: the battle for the seventh continent.* Santa Barbara, CA, USA: Praeger, ABC-CLIO. Available from https://www.abc-clio.com/products/a5142c/

Ajani, G., Lesmo, L., Boella, G., Mazzei, A., & Rossi, P. (2007). 'Terminological and ontological analysis of European directives: multilinguism in law' In: *Proceedings of the 11th international conference on Artificial Intelligence and law*, pp. 43-48. https://doi.org/10.1145/1276318.1276327

Arroyo, D.P.F. & Mbengue, M.M. (2017). Public and private international law in international courts and tribunals: Evidence of an inescapable interaction. *The Columbia Journal of Transnational Law*, vol. 56, p. 797. Available at https://archive-ouverte.unige.ch/unige:137388/ATTACHMENT01 [2022-04-22].

Avgerinopoulou, D-T. (2019). 'Introduction: Is Contemporary International Environmental Law Based on Science?' In: *Science-Based Lawmaking*. pp.1-21. London, UK: Springer, Cham. https://doi.org/10.1007/978-3-030-21417-3_1

Avila, C. (2016). Ecological and pharmacological activities of Antarctic marine natural products. *Planta Medica*, vol. 82 (9/10), pp. 767-774. https://doi.org/10.1055/s-0042-105652

Barros-Platiau, A. F., & Gonsalves, L. R. (2019). Antarctica and ABNJ in the Anthropocene: Challenges to the sustainable management of marine genetic resources?. *Ambiente & Sociedade*, vol. 22. https://doi.org/10.1590/1809-4422asoc20180173vu2019l3td

Bastmeijer, K., & Tin, T. (2014). Antarctica–a wilderness continent for science: the 'public's dream' as a mission impossible?. *The Yearbook of Polar Law Online*, vol. 6 (1), pp. 559-597. https://doi.org/10.1163/1876-8814_020

Beattie, A.J., Hay, M., Magnusson, B., de Nys, R., Smeathers, J. & Vincent, J.F.V. (2011). Ecology and bioprospecting. *Austral ecology*, vol. 36, no. 3, pp. 341-356. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1442-9993.2010.02170.x

Benjaminsen, T. A., & Svarstad, H. (2021). 'Discourses and narratives on environment and development: The example of bioprospecting' In: T.A. Benjaminsen & H. Svarstad (eds) *Political Ecology, A Critical Engagement with Global Environmental Issues*. pp. 59-87. London, UK: Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-56036-2_3

Besson, S. (2010). 'Theorizing the sources of international law' In: S. Besson & J. Tasioulas (eds.) *The philosophy of international law*. Ch.7, pp. 163-185. Oxford, UK: Oxford University Press. Available at https://www.legalanthology.ch/t/besson_theorizing-the-sources-of-international-law_2010.pdf [2022-04-22]

Blunden, A. (2009). An interdisciplinary concept of activity. *Outlines. Critical Practice Studies*, vol. 11(1), pp. 1-26. https://doi.org/10.7146/ocps.v11i1.2119

Bodig, M. (2010). Legal theory and legal doctrinal scholarship. *The Canadian Journal of Law and Jurisprudence*, vol. 23 (2), pp. 483-514. https://doi.org/10.1017/S0841820900005014

Borris, R. P. (2016). 'Bioprospecting: An industrial perspective' In: R. Paterson & N. Lima (eds) *Bioprospecting. Topics in Biodiversity and Conservation*, Vol 16. pp. 1-14. London, UK: Springer, Cham. https://doi.org/10.1007/978-3-319-47935-4_1

Bowman, M. J., & Kritsiotis, D. (eds). (2018). *Conceptual and contextual perspectives on the modern law of treaties*. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781316179031

Braverman, I., Blomley, N., Delaney, D., & Kedar, A. (eds). (2014). *The expanding spaces of law: A timely legal geography*. Stanford, CA, USA: Stanford University Press. https://doi.org/10.11126/stanford/9780804787185.001.0001

Burton-Jones, A., & Weber, R. (2014). 'Building conceptual modeling on the foundation of ontology' In: H. Topi (ed) *Computing Handbook, Third Edition: Information Systems and Information Technology*. Boca Raton, FL, USA: CRC Press: https://doi.org/10.1201/b16768

Cabitza, F., & Locoro, A. (2014). 'Made with Knowledge. Disentangling the IT Knowledge Artifact by a Qualitative Literature Review' In: *IC3K 2014: Proceedings of the International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - Volume 3, October 2014.* pp. 64-75. http://dx.doi.org/10.5220/0005086100640075

Callender, G., & Cohen, J. (2005). There is no special problem about scientific representation. *Theoria. An International Journal for Theory, History and Foundations of Science*, vol. 21 (1), pp. 67–85. https://doi.org/10.1387/theoria.554

Cerroni, A. (2015). 'Knowledge Artifacts: When Society Objectifies Itself in Knowledge' In: *KMIS*. pp. 429-435. IC3K 2015: Proceedings of the International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management. https://doi.org/10.5220/0005661704290435

Chandrasekaran, B., Josephson, J. R., & Benjamins, V. R. (1999). What are ontologies, and why do we need them?. *IEEE Intelligent Systems and their applications*, vol. 14 (1), pp. 20-26. https://doi.org/10.1109/5254.747902

Chaturvedi, S. (2013). 'Antarctica as global Knowledge commons: geopolitics, science and trusteeship' In: R. Ramesh & S. Chattopadhyay (eds) *Scientific and Geopolitical Interests in Arctic and Antarctic*. pp. 11-31. Delhi, IN: Lights Research Foundation. Available from https://www.abebooks.com/first-edition/Scientific-Geopolitical-Interests-Arctic-Antarctic-edited/14683185877/bd [2022-04-22]

Cloatre, E. (2016). 'Biodiversity, knowledge and the making of rights: Reviewing the debates on bioprospecting and ownership' In: M. Bowman, P. Davies & E. Goodwin (eds) *Research handbook on biodiversity and law*. pp. 361-386. https://doi.org/10.4337/9781781004791.00023

Cloatre, E. (2017). 'Actor-network theory and the empirical critique of environmental law: Unpacking the bioprospecting debates' In: V. Brooks & A. Philippopoulos-Mihalopoulos (eds) *Research Methods in Environmental Law: A Handbook*. Ch. 4, pp. 80 – 104. Cheltenham, UK: Edward Elgar Publishing. Available at https://kar.kent.ac.uk/id/eprint/62094 [2022-04-22] https://doi.org/10.4337/9781784712570.00010

Collins, J. E., Rabone, M., Vanagt, T., Amon, D. J., Gobin, J., & Huys, I. (2021). Strengthening the global network for sharing of marine biological collections: Recommendations for a new agreement for biodiversity beyond national jurisdiction. *ICES Journal of Marine Science*, vol. 78 (1), pp. 305-314. https://doi.org/10.1093/icesjms/fsaa227

Collins, R. (2021). *'How to defend international legal method?'* In: R. Deplano & N. Tsagourias (eds) *Research Methods in International Law*. Ch.2, pp. 9-26. Cheltenham, UK: Edward Elgar Publishing. doi: https://doi.org/10.4337/9781788972369.00009

Connolly-Stone, K. (2005). 'Patents, Property Rights and Benefit Sharing. Antarctic Bioprospecting' In: A. D. Hemmings & M. Rogan-Finnemore (eds) *Antarctic bioprospecting*. pp. 69-97. Gateway Antarctica, University of Canterbury, Special Publication. Christchurch, NZ. Available at https://www.researchgate.net/profile/Alan-Hemmings/publication/261996054_Antarctic_Bioprospecting/links/0a85e5363316c9c3e1000000/Antarctic-Bioprospecting.pdf [2022--4-22]

Convey, P., Brandt, A., & Nicol, S. (2013). 'Life in a cold environment' In: D. Walton (ed) *Antarctica: global science from a frozen continent.* Ch. 6, pp. 161-210. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9780511782299.007

Cunningham-Hales, P. (2017). *Why is the Regulation of Bioprospecting in Antarctica Lacking and What Could the Future Hold*. PCAS 19 (2016/2017) Supervised Project Report, University of Canterbury. NZ. Available at http://ir.canterbury.ac.nz/handle/10092/14085 [2022-04-22]

Cutler, A.C. (2005). 'Gramsci, Law, and the Culture of Global Capitalism', *Critical Review of International Social and Political Philosophy*, vol. 8 (4), pp. 527–42. https://doi.org/10.1080/13698230500205227

Dahl, J., Roberts, P., & Van der Watt, L-M. (2019). Is there anything natural about the polar?. *Polar Record*, vol. 55 (5), pp. 326-329. https://doi.org/10.1017/S0032247419000652

Davis, J. M. (2011). *Reconsidering Antarctic Bioprospecting through Territorialities of Science, Property, and Governance*. Doctoral dissertation, The Ohio State University. Ohio, USA. http://rave.ohiolink.edu/etdc/view?acc_num=osu1299535648 Available at https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=osu1299535648&disposition=inline [2022-04-22]

De Beaugrande, R. A., & Dressler, W. U. (1981). *Introduction to text linguistics* (Vol. 1). London, UK: Longman Linguistics Library No.26. Available from https://www.routledge.com/Introduction-to-Text-Linguistics/Beaugrande-Dressler/p/book/9780582554856 [2022-04-22]

de Boer, T. M. (2010). Living apart together: The relationship between public and private international law. *Netherlands International Law Review*, vol. 57 (2), pp. 183-207. https://doi.org/10.1017/S0165070X10200049

de Oliveira Rodrigues, C.M., Freitas, de Barreiros Frederico, L.G., Azevedo, E. F. S. & de Almeida Filho, A. (2019). Legal ontologies over time: A systematic mapping study. *Expert Systems with Applications*, vol. 130, pp. 12-30. https://doi.org/10.1016/j.eswa.2019.04.009

de Vries, M. J. (2006). 'Technological Knowledge and Artifacts: An Analytical View' In: J.R. Dakers (ed) *Defining Technological Literacy Towards an Epistemological Framework*. pp. 17-30. New York, USA: Palgrave Macmillan https://doi.org/10.1057/9781403983053_3

Dellapenna, J. W. (1999). Law in a shrinking world: the interaction of science and technology with international law. *Ky. LJ*, vol. 88, p.809. Available at https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1550&context=klj [2022-04-22]

Despres, S., & Szulman, S. (2004). 'Construction of a legal ontology from a European community legislative text' In: T. Gordon (ed) *Legal Knowledge and Information Systems*. pp. 79-88. Jurix 2004: The Seventeenth Annual Conference. Amsterdam: IOS Press. Available at http://jurix.nl/pdf/j04-10.pdf [2022-04-22], https://hal.archives-ouvertes.fr/hal-00089075 [2022-04-22]

Dodds, K. J. (1997). *Geopolitics in Antarctica: Views from the Southern Oceanic Rim* . New York, USA: John Wiley & Sons. Available from https://www.wiley.com/en-ie/Geopolitics+of+Antarctica:+Views+from+the+Southern+Oceanic+Rim-p-9780471969921 [2022-04-22]

Dosi, G., & Grazzi, M. (2006). Technologies as problem-solving procedures and technologies as input–output relations: some perspectives on the theory of production. *Industrial and Corporate Change*, vol. 15 (1), pp. 173-202. https://doi.org/10.1093/icc/dtj010

Dosi, G., & Grazzi, M. (2009). On the nature of technologies: Knowledge, procedures, artifacts and production inputs. *Cambridge Journal of Economics*, vol. 34 (1), pp. 173-184. https://doi.org/10.1093/cje/bep041

Drejer, I. (1999). *Technological change and interindustrial linkages: Introducing knowledge flows in input-output studies.* Ph.D. Thesis, Aalborg University, DK. Available at https://vbn.aau.dk/ws/files/316451683/afhandling.pdf [2022-04-22]

Engeström, Y. (2001). Expansive learning at work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, vol. 14 (1), pp. 133-156. https://doi.org/10.1080/13639080123238

Fitzmaurice, G. G. (2017). 'Some problems regarding the formal sources of international law' In: M. Koskenniemi (ed) *Sources of international law.* Ch. 3, pp. 57-80. London, UK: Routledge. https://doi.org/10.4324/9781315087795-3

Frame, B., Liggett, D., Lindström, K., Roura, R. M., & van der Watt, L. M. (2021). Tourism and heritage in Antarctica: exploring cultural, natural and subliminal experiences. *Polar Geography*, vol. 45 (1), pp. 37-57. https://doi.org/10.1080/1088937X.2021.1918787

Gaševic, D., Djuric, D., & Devedžic, V. (2009). 'Ontologies' In: *Model driven engineering and ontology development*. 2. ed. Ch. 2, pp. 45-80. Belin, Heidelberg, DE: Springer. https://doi.org/10.1007/978-3-642-00282-3_2

Gibbons, J. (1999). Language and the law. *Annual Review of Applied Linguistics (Cambridge University Press)*, vol. 19, pp. 156-173. https://doi.org/10.1017/S0267190599190081

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, & Trow, M., (2010). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London, UK: SAGE Publications Ltd. https://dx.doi.org/10.4135/9781446221853

Glover, A. G., Sundberg, P., & Dahlgren, T. G. (2009). In Linnaeus' wake: 300 years of marine discovery. *Zoologica Scripta*, vol. 38 (s1), pp. 1-6. https://doi.org/10.1111/j.1463-6409.2009.00375.x

Glover, A. G., Wiklund, H., Chen, C., & Dahlgren, T. G. (2018). Point of view: managing a sustainable deep-sea 'blue economy' requires knowledge of what actually lives there. *Elife*, vol. 7, e41319. https://doi.org/10.7554/eLife.41319

Green, J.F. (2022). Hierarchy in Regime Complexes: Understanding Authority in Antarctic Governance, *International Studies Quarterly*, vol. 66 (1), sqab084. https://doi.org/10.1093/isq/sqab084

Gura, C., & Rogers, S. O. (2020). Metatranscriptomic and metagenomic analysis of biological diversity in subglacial lake Vostok (antarctica). *Biology (Basel, Switzerland)*, vol. 9 (3), 55. https://doi.org/10.3390/biology9030055

Gurukkal, R. (2019). *History and theory of knowledge production: An introductory outline*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/oso/9780199490363.001.0001

Halvorsen, T. (2017). 'The Sustainable Development Goals, knowledge production and the global struggle over values' In: T. Halvorsen, H. Ibsen, H.-C. Evans & S. Penderis (eds) *Knowledge for justice. Critical perspectives from Southern African-Nordic research partnerships*, Ch. 1, pp. 13-36. https://doi.org/10.5281/zenodo.1092695

Harm, B.M (2012). Mining sacred space : Law's enactment of competing ontologies in the American west. *Environment and Planning. A*, vol. 44 (6), pp. 1443-1458. https://doi.org/10.1068/a44579

Hebert, P. D., Cywinska, A., Ball, S. L., & DeWaard, J. R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, vol. 270 (1512), pp.313-321. https://doi.org/10.1098/rspb.2002.2218

Heinrich, K. (2020). Biological Prospecting in Antarctica–A Solution-Based Approach to Regulating the Collection and Use of Antarctic Marine Biodiversity by Taking the BBNJ Process into Account. *The Yearbook of Polar Law Online*, vol. 12 (1), pp. 41-60. https://doi.org/10.1163/22116427_012010005

Heinrich, K. (2019). *Biological prospecting in Antarctica: is there a need for intensive cooperation between the BBNJ and the ATCM over bioprospecting in ABNJ?* Doctoral dissertation, University of Akureyri, IS. Available at http://hdl.handle.net/1946/34005 [2022-4-22]

Hemmings, A. (2010). Does bioprospecting risk moral hazard for science in the Antarctic treaty system? *Ethics in Science and Environmental Politics ESEP*, vol. 10, pp. 5-12. https://doi.org/10.3354/esep00103

Hemmings, A. D. (2006). Regime overlap in the southern ocean : The case of southern blue fin tuna and CCSBT in the CCAMLR area. *The New Zealand Yearbook of International Law*, vol. 3, pp. 207-217. Available at http://www.nzlii.org/nz/journals/NZYbkIntLaw/2006/11.html [2022-04-22]

Hemmings, A. D. (2015). 'Commercial harvest in Antarctica: Exploitation of Antarctic marine living resources' In: D. Liggett, B. Storey, Y. Cook & V. Meduna (eds) *Exploring the last continent.* Ch.20, pp. 413-428. New York, USA: Springer International Publishing. https://doi.org/10.1007/978-3-319-18947-5_20

Hemmings, A. D., & Rogan-Finnemore, M. (2008). 'Access, Obligations, and Benefits: Regulating Bioprospecting in the Antarctic' In: M. I. Jeffery, J. Firestone & K. Bubna-Litic (eds) *Biodiversity, Conservation, Law and Livelihoods: Bridging the North-South Divide.* Ch. 28, pp. 529-552. New York, USA: Cambridge University Press Available at https://www.academia.edu/14949042/Access_Obligations_and_Benefits_Regulating_Bioprospecting_in_the_Antarctic [2022-4-22]

Herber, B. P. (2006). Bioprospecting in Antarctica: the search for a policy regime. *Polar Record*, vol. 42 (2), pp. 139-146. https://doi.org/10.1017/S0032247406005158

Hessels, L. K., & van Lente, H. (2008). Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy*, vol. 37, pp. 740–760. http://dx.doi.org/10.1016/j.respol.2008.01.008

Hestetun, J. T., Bye-Ingebrigtsen, E., Nilsson, R. H., Glover, A. G., Johansen, P. O., & Dahlgren, T. G. (2020). Significant taxon sampling gaps in DNA databases limit the operational use of marine macrofauna metabarcoding. *Marine Biodiversity*, vol. 50, 70, pp. 1-9. https://doi.org/10.1007/s12526-020-01093-5

Holsapple, C.W & Joshi, K.D. (2001). Organizational knowledge resources. *Decision Support Systems*, vol. 31 (1) pp. 39–54. https://doi.org/10.1016/S0167-9236(00)00118-4

Houssen, W., Sara, R. & Jaspars, M. (2020). *Digital Sequence Information on Genetic Resources: Concept, Scope & Current Use. CBD/DSI/AHTEG/2020/1/3 dated 29 January 2020.* Convention on Biological Diversity: Ad Hoc Technical Group on Digital Sequence Information on Genetic Resources. Available at https://www.cbd.int/doc/c/fef9/2f90/70f037ccc5da885dfb293e88/dsi-ahteg-2020-01-03-en.pdf [2022-04-22]

Humphries, F. (2018). 'Banking on a Patent Solution for Sharing Ex Situ Genetic Resources from Antarctic Waters' In: Lawson, C. & Adhikari, K. (eds) *Biodiversity, Genetic Resources and Intellectual Property: Developments in Access and Benefit Sharing*, Ch. 4, pp. 41-76. Oxfordshire, UK: Routledge. https://doi.org/10.4324/9781315098517

Humphries, F., Rabone, M., & Jaspars, M. (2021). Traceability Approaches for marine genetic resources under the proposed Ocean (BBNJ) Treaty. *Frontiers in Marine Science*, *8*, Article-number 661313. https://doi.org/10.3389/fmars.2021.661313

Hutchinson, T. & Duncan, N. (2012). Defining and describing what we do : Doctrinal legal research. *Deakin Law Review*, vol. 17 (1), pp. 83-119. https://doi.org/10.21153/dlr2012vol17no1art70

Information Paper: IP 12 (2021). *Information Paper (IP) 12: Antarctic Bioprospecting: SCAR Survey of Member Countries, 28/04/2021. Submitted to Antarctic Treaty Consultative Meeting (ATCM) XLIII - CEP XXIII Paris (2021) by: Scientific Committee on Antarctic Research (SCAR).* Available at https://scar.org/antarctic-treaty/actm-papers/atcm-xliii-and-cep-xxiii-2021-paris-france/5693-atcm43-ip012/file/ [2022-04-22]

IUCN CCAMLR-XXVII/BG/36 (2008). 2008.01.02. *Biological Prospecting in the Southern Ocean*. Submitted by International Union for Conservation of Nature (IUCN) for the consideration by Commission on Conservation of Antarctic Marine Living Resources (CCAMLR). Available by submitting request at https://www.ccamlr.org/en/ccamlr-xxvii/bg/36 [2022-04-22]

Jabour-Green, J., & Nicol, D. (2003). Bioprospecting in areas outside national jurisdiction: Antarctica and the Southern Ocean. *Melbourne Journal of International Law"*, vol. 4 (1), pp. 76-111. https://search.informit.org/doi/10.3316/informit.181795621589288

Kammerhofer, J. (2021). 'International legal positivist research methods' In: Deplano, R., & Tsagourias, N. (eds) *Research Methods in International Law*. Ch. 7, pp. 95-110. Cheltenham, UK: Edward Elgar Publishing. doi: https://doi.org/10.4337/9781788972369.00015

Kaptelinin, V., & Nardi, B. (2018). Activity theory as a framework for human-technology interaction research. *Mind, Culture and Activity*, vol. 25 (1), pp. 3-5. https://doi.org/10.1080/10749039.2017.1393089

Kaptelinin, V., & Nardi, B. A. (2006). *Acting with technology : Activity theory and interaction design*. Boston, MA, USA: MIT Press. Available from https://mitpress.mit.edu/books/acting-technology [2022-04-22] https://doi.org/10.5210/fm.v12i4.1772

Karanasios, S. (2018). Toward a unified view of technology and activity: The contribution of activity theory to information systems research. *Information Technology & People (West Linn, Or.)*, vol. 31 (1), pp. 134-155. https://doi.org/10.1108/ITP-04-2016-0074

Keating, C. B., Katina, P. F., & Bradley, J. M. (2014). Complex system governance: concept, challenges, and emerging research. *International Journal of Systems Engineering*, vol. 5(3), pp. 263-288. https://www.inderscienceonline.com/doi/full/10.1504/IJSSE.2014.065756

Kilduff, M., Mehra, A., & Dunn, M. B. (2011). From blue sky research to problem solving: A philosophy of science theory of new knowledge production. *The Academy of Management Review*, vol. 36 (2), pp. 297-317. https://doi.org/10.5465/AMR.2011.59330922

Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge.* Cambridge, MA, USA: Harvard University Press. https://doi.org/10.4159/9780674039681

Knuuttila, T. (2011). Modelling and representing: An artefactual approach to model-based representation. *Studies in History and Philosophy of Science Part A*, vol. 42 (2), pp. 262-271. https://doi.org/10.1016/j.shpsa.2010.11.034

Koskenniemi, M. (2007). 'Methodology of International Law' In: A. Peters & R. Wolfrum (eds) *Max Planck Encyclopedia of Public International Law.* Oxford, UK: Oxford University Press. Available from https://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1440 [2022-04-22]

Kotzé, L. J., & French, D. (2018). The anthropocentric ontology of international environmental law and the sustainable development goals: Towards an ecocentric rule of law in the Anthropocene. *Global Journal of Comparative Law*, vol. 7 (1), pp. 5-36. https://doi.org/10.1163/2211906X-00701002

Krabbe, N. (2021). *Bioprospecting and deep-sea genetic resources in a fragmenting international law*. PhD Dissertation, Handelshögskolan vid Göteborgs Universitet Juridiska Institutionen. Gothenburg, SE. Available at https://gupea.ub.gu.se/handle/2077/67465 [2022-04-22]

Kurcheeva, G., Rakhvalova, M., Rakhvalova, D., Bakaev, M. (2019). 'Mining and Indexing of Legal Natural Language Texts with Domain and Task Ontology' In: A. Chugunov, Y. Misnikov, E. Roshchin & D. Trutnev (eds) *Electronic Governance and Open Society: Challenges in Eurasia. EGOSE 2018. Communications in Computer and Information Science*, vol. 947. London, UK: Springer, Cham. https://doi.org/10.1007/978-3-030-13283-5_10

Laird, S., & Wynberg, R. (2018). *A fact-finding and scoping study on digital sequence information on genetic resources in the context of the Convention on Biological Diversity and the Nagoya Protocol. CBD/DSI/AHTEG/2018/1/3 dated 12 January 2018*. Convention on Biological Diversity: Ad Hoc Technical Expert Group (AHTEG) on Digital Sequence Information on Genetic Resources. Available at https://www.cbd.int/doc/c/e95a/4ddd/4baea2ec772be28edcd10358/dsi-ahteg-2018-01-03-en.pdf [2022-04-22]

Leary, D. (2020). 'Bioprospecting at the poles' In: K. N. Scott & D. L. Vanderzwaag (eds) *Research handbook on polar law*. Ch. 14, pp. 272-292. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781788119597.00021

Leary, D., & Juniper, S. K. (2013). 'Addressing the marine genetic resources issue: Is the debate heading in the wrong direction?' In: C. Schofield, S. Lee & M.-S. Kwon (eds) *The Limits of Maritime Jurisdiction.* Ch. 34, pp. 769-85. Leiden, NL: Brill. https://doi.org/10.1163/9789004262591_037

Lee, C. Y., & Chen, B. S. (2018). Mutually-exclusive-and-collectively-exhaustive feature selection scheme. *Applied Soft Computing*, vol. 68, pp. 961-971. https://doi.org/10.1016/j.asoc.2017.04.055

Leihy, R. I., Coetzee, B. W. T., Morgan, F., Raymond, B., Shaw, J. D., Terauds, A., Bastmeijer, K., & Chown, S. L. (2020). Antarctica's wilderness fails to capture the continent's biodiversity. *Nature (London)*, vol. 583 (7817), pp. 567-571. https://doi.org/10.1038/s41586-020-2506-3

Mäki, U. (2009). Missing the World. Models as Isolations and Credible Surrogate Systems. *Erkenntnis* (1975-), vol. 70 (1), pp. 29–43. Available at http://www.jstor.org/stable/40267406 [2022-04-22]

Mancilla, A. (2020). 'Decolonizing Antarctica' In: D. Bunikowski & A.D. Hemmings (eds) *Philosophies of Polar Law*. Ch. 3, pp. 49-61. New York: Routledge. https://doi.org/10.4324/9780429461149-3

Marchant, G. E. (2013). 'Chapter 13: Conclusion: emerging governance for emergent technologies' In: G.E. Marchant, K.W. Abbott & B. Allenby (eds) *Innovative Governance Models for Emerging Technologies*. pp. 254-258. Cheltenham, UK: Edward Elgar Publishing. Available at https://www.elgaronline.com/view/edcoll/9781782545637/97817825 [2022-04-22] https://doi.org/10.4337/9781782545644.00020

Meadowcroft, J. (2007). Who is in charge here? Governance for sustainable development in a complex world. *Journal of Environmental Policy & Planning*, vol. 9 (3-4), pp. 299-314. https://doi.org/10.1080/15239080701631544

Meduna, V. (2015). 'The search for extremophiles: Antarctic biological prospecting' In: D. Liggett, B. Storey, Y. Cook & V. Meduna (eds). *Exploring the last continent. An introduction to Antarctica.* Ch. 22, pp. pp. 463-476. New York, USA: Springer International Publishing. https://doi.org/10.1007/978-3-319-18947-5_22

Monkelbaan, J. (2019). *Governance for the sustainable development goals*. *Exploring an Integrative Framework of Theories, Tools, and Competencies*. Singapura: Springer. Available from https://link.springer.com/book/10.1007/978-981-13-0475-0 [2022-04-22]

Neimark, B. D. (2012). Industrializing nature, knowledge, and labor: The political economy of bioprospecting in Madagascar. *Geoforum*, vol. 43(5), pp. 980-990. https://doi.org/10.1016/j.geoforum.2012.05.003

Newman, B. (2004). 'Agents, artifacts, and transformations: The foundations of knowledge flows' In: C.W. Holsapple (ed) *Handbook on Knowledge Management 1. International Handbooks on Information Systems, vol 1*. Ch. 15, pp. 301-316. Berlin, Heidelberg, DE: Springer. https://doi.org/10.1007/978-3-540-24746-3_15

Nichols, D. S., Sanderson, K., Buia, A., Van De Kamp, J., Holloway, P., Bowman, J. P., Smith, M. W., Nichols, C. M., Nichols, P. D., & McMeekin, T. A. (2002). 'Bioprospecting and biotechnology in Antarctica' In: J. Jabour-Green & M. Haward (eds) *The Antarctic: past, present and future, Antarctic CRC research report*, vol. 28, pp. 85-103. Proceedings of a conference celebrating the 40th anniversary of the entry into force of the Antarctic Treaty on 23 June 1961 held at the University of Tasmania, Hobart, Australia on 22 June 2001. Available at https://eprints.utas.edu.au/2661/16/15_Nichols_et_al.pdf [2022-04-22]

Nickels, P.P. (2020). Revisiting Bioprospecting in the Southern Ocean in the Context of the BBNJ Negotiations. *Ocean Development & International Law*, vol. 51 (3), pp. 193-216. https://www.tandfonline.com/doi/pdf/10.1080/00908320.2020.1736773

Núñez-Pons, L., & Avila, C. (2015). Natural products mediating ecological interactions in Antarctic benthic communities: A mini-review of the known molecules. *Natural Product Reports*, vol. 32(7), pp. 1114-1130. https://doi.org/10.1039/C4NP00150H

Oldham, P., & Kindness, J. (2020). Biodiversity Research and Innovation in Antarctica and the Southern Ocean. *bioRxiv*, Available at https://www.biorxiv.org/content/biorxiv/early/2020/05/03/2020.05.03.074849.full.pdf [2022-04-22]. https://doi.org/10.1101/2020.05.03.074849

Orsini, A., Le Prestre, P., Haas, P.M., Brosig, M., Pattberg, P., Widerberg, O., Gomez-Mera, L., Morin, J.F., Harrison, N.E., Geyer, R. and Chandler, D. (2020). Complex systems and international governance. *International Studies Review*, vol. 22 (4), pp. 1008-1038. https://doi.org/10.1093/isr/viz005

Page, R. D. M. (2016). DNA barcoding and taxonomy: dark taxa and dark texts. *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 371, 20150334. https://doi.org/10.1098/rstb.2015.0334

Pahuja, S. (2021). 'Methodology: Writing about how we do research' In: R. Deplano & N. Tsagourias (eds) *Research Methods in International Law*. Ch.5, pp. 60-77. Cheltenham, UK: Edward Elgar Publishing. doi: https://doi.org/10.4337/9781788972369.00012

Peukert, A. (2021). *A Critique of the Ontology of Intellectual Property Law*. Vol. 57. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781108653329

Pirker, B., & Smolka, J. (2021). International law and linguistics: Pieces of an interdisciplinary puzzle. *Journal of International Dispute Settlement*, vol. 11(4), pp. 501-521. https://doi.org/10.1093/jnlids/idaa020

Poucet, A. (2006). Arms control and non-proliferation treaties: An ontology of concepts and characteristics. In: R. Avenhaus, N. Kyriakopoulos, M. Richard, G. Stein (eds) *Verifying Treaty Compliance - Limiting Weapons of Mass destruction and Monitoring Kyoto Protocol Provisions*. pp. 41-60. New York, USA: Springer Verlag. JRC36575 https://doi.org/10.1007/3-540-33854-3_3

Rabitz, F. (2019). Gene drives and the international biodiversity regime. *Review of European, Comparative & International Environmental Law, Special Issue: New Frontiers in Ocean Environmental Governance.* vol. 28(3), pp. 339-348. https://doi.org/10.1111/reel.12289

Rabone, M., Harden-Davies, H., Collins, J.E., Zajderman, S., Appeltans, W., Droege, G., Brandt, A., Pardo-Lopez, L., Dahlgren, T.G., Glover, A.G. & Horton, T. (2019). Access to Marine Genetic Resources (MGR): Raising awareness of best-practice through a new agreement for Biodiversity Beyond National Jurisdiction (BBNJ). *Frontiers in Marine Science*, vol. (6), p. 520. Available at https://www.frontiersin.org/articles/10.3389/fmars.2019.00520/full [2022-04-22]

Roberts, A. & Sivakumaran, S. (2018). 'The Theory and Reality of the Sources of International Law.' In: M. Evans (ed) *International Law*. 5. ed. Oxford, UK: Oxford University Press. https://doi.org/10.1093/he/9780198791836.003.0004

Roberts, P., Howkins, A., & van der Watt, L. (2016). 'Antarctica: A continent for the humanities' In: P. Roberts & van der Watt, L. (eds) *Antarctica and the humanities*. pp. 1-23. London, UK: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-54575-6_1

Rogers, A. D., Baco, A., Escobar-Briones, E., Gjerde, K., Gobin, J., Jaspars, M., Levin, L., Linse, K., Rabone, M., Ramirez-Llodra, E., Sellanes, J., Shank, T.M., Sink, K., Snelgrove, P.V.R., Taylor, M.L., Wagner, D. & Harden-Davies, H. (2021). Marine genetic resources in areas beyond national jurisdiction: Promoting marine scientific research and enabling equitable benefit sharing. *Frontiers in Marine Science*, vol. 8:667274. https://doi:10.3389/fmars.2021.667274

Salazar-Torres, G., Colombo, E., Da Silva, F. S. C., Noriega, C. A., & Bandini, S. (2008). Design issues for knowledge artifacts. *Knowledge-Based Systems, vol.* 21 (8), pp. 856-867. https://doi.org/10.1016/j.knosys.2008.03.058

Saucède, T., Eléaume, M., Jossart, Q., Moreau, C., Downey, R., Bax, N., Sands, C., Mercado, B., Gallut, C., & Vignes-Lebbe, R. (2021). Taxonomy 2.0: Computer-aided identification tools to assist Antarctic biologists in the field and in the laboratory. *Antarctic Science*, vol. 33 (1), pp. 39-51. https://doi.org/10.1017/S0954102020000462

Sinclair, A. (2021). Why we should see international law as a structure: Unpicking international law's ontology and agency. *International Relations*, vol. 35(2), pp. 216-235. https://doi.org/10.1177%2F0047117820916223

Smits, J. M. (2017). ‘What is legal doctrine?: On the aims and methods of legal-dogmatic research’ In: R. van Gestel, H.-W. Micklitz, & E. L. Rubin (eds) *Rethinking legal scholarship: A transatlantic dialogue*. Ch.5, pp. 207-228. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781316442906.006

Sowa, J. F. (1992). Conceptual graphs as a universal knowledge representation. *Computers & Mathematics with Applications*, vol. 23(2), pp. 75-93. https://doi.org/10.1016/0898-1221(92)90137-7

Suárez, M. (2004). An inferential conception of scientific representation. *Philosophy of Science (Symposia)*, vol. 71 (5), pp. 767–779. https://doi.org/10.1086/421415

Svarstad, H. (2020). ‘A global political ecology of bioprospecting’ In: S. Paulson, & L. L. Gezon (Eds.) *Political ecology across spaces, scales, and social groups.* Ch. 13, pp. 239-256. Rutgers, NJ, USA: Rutgers University Press. https://doi.org/10.36019/9780813542546-014

Thalheim, B. (2010). Towards a theory of conceptual modelling. *J. Univers. Comput. Sci.*, vol. 16 (20), pp. 3102-3137. Available at https://www.jucs.org/jucs_16_20/towards_a_theory_of/jucs_16_20_3102_3137_thalheim.pdf [2022-04-22]

Thirlway, H. (2019). *The sources of international law*. 2. ed. Oxford, UK: Oxford University Press. Available from https://opil.ouplaw.com/view/10.1093/law/9780198841814.001.0001/law-9780198841814 [2022-04-22]

Tranter, K. (2007). Nomology, ontology, and phenomenology of law and technology. *Minn. JL Sci. & Tech.*, vol. 8 (2), p. 449-474. Available at https://scholarship.law.umn.edu/cgi/viewcontent.cgi?article=1255&context=mjlst [2022-04-22]

Tvedt, M. W. (2011). Patent law and bioprospecting in antarctica. *Polar Record*, vol. 47 (1), pp. 46-55. https://doi.org/10.1017/S0032247410000045

Valente, A., & Breuker, J. (1994). ‘A functional ontology of law’ In: *Towards a global expert system in law*, pp. 112-136. Available at https://www.researchgate.net/publication/2514368_A_Functional_Ontology_of_Law [2022-04-22]

van der Hout, S. & Drenthen, M. (2017). Hunting for Nature’s treasures or learning from nature?: The narrative ambivalence of the ecotechnological turn. *Nature and Culture*, vol. 12 (2), pp. 162-180. https://doi.org/10.3167/nc.2017.120204

van der Watt, L-M. & Roberts, P. (2018). ‘Voicing Bipolar Futures: The Antarctic Treaty System and Arctic Governance in Historical Perspective’ In: Wormbs, N. (ed) *Competing Arctic Futures*: *Historical and Contemporary Perspectives*, Ch.7, pp. 139-164. London, UK: Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-91617-0_7

van der Watt, L-M. (2017). ‘Contemporary environmental politics and discourse analysis in antarctica’ In: K. Dodds, A.D. Hemmings & P. Roberts (eds) *Handbook on the politics of antarctica*. Ch. 37, pp. 584-598. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781784717681.00050

van Kerkhoff, L. (2014). Knowledge governance for sustainable development: a review. *Challenges in sustainability*, vol. 1 (2), pp. 82-93. Available at https://www.researchgate.net/publication/268804471_Knowledge_Governance_for_Sustainable_Development_A_Review [2022-04-22]

Verdonck, M., Gailly, F., de Cesare, S., & Poels, G. (2015). Ontology-driven conceptual modeling: A systematic literature mapping and review. *Applied Ontology*, vol. 10 (3-4), pp. 197-227. https://doi.org/10.3233/AO-150154

Working Paper: WP 16 (2021). *Working Paper (WP) 16: Antarctic Bioprospecting: SCAR Survey of Member Countries, 28/04/2021. Submitted to Antarctic Treaty Committee Meeting (ATCM) XLIII - CEP XXIII Paris (2021) by: Scientific Committee on Scientific Research (SCAR).* Available at https://www.scar.org/library/policy/antarctic-treaty/atcm-xliii-and-cep-xxiii-2021-paris-france/5704-atcm43-wp016/file/ [2022-04-22]

Working Paper: WP 26 (2009). *Working Paper (WP) 26: A Gap Analysis of the Antarctic Treaty System Regarding the Management of Biological Prospecting. Submitted to the Antarctic Treaty Committee Meeting (ATCM) XXXII - CEP XII Baltimore (2009) by: Netherlands, Belgium, Bulgaria, Finland, France, Germany, Spain, Sweden*. Available from https://www.ats.aq/devAS/Meetings/DocDatabase?lang=e [2022-04-22]

Yermakova, Y. (2021). Legitimacy of the Antarctic treaty system: Is it time for a reform?. *Polar Journal*, vol. 11(2), pp. 342-359. https://doi.org/10.1080/2154896X.2021.1977048

9. Appendices

Appendix A

Research materials (data) for conceptual system modeling (CSM):
Four lists of incipient conceptual categories
of an ontology of bioprospecting for knowledge production

1. *Items that are bioprospected*: eDNA, Environmental Genetic Material (EGM), Exploration Find, Geotag, Natural Bio-Occurrence, Organism (Specimen), Record (of Sighting/Observation/Monitoring), Tissue

2. *Tools and Entities that/who bioprospect*: Analyzing Laboratory, Bio-Bank, Camera, Catcher, Database, Device, Extractor, Probe, Scoop, Sensor, Sequencing Laboratory, Taxonomic Facility, Tool, Trap

3. *Activities comprising bioprospecting*: Archiving DNA Barcodes, Archiving Meta barcodes, Associating, Breeding, Captivity, Cataloging, Characterizing, Characterizing, Collecting, Cryo-Preservation, Cryptomics, Culturing, Data banking, Designating, DNA Barcode Referencing, DNA Barcoding, eDNA Extraction, Exploration (In Situ), Filtering, Genomics, Geotagging, Informatizing, Isolating, Laboratory Analysis, Laboratory Sequencing, Listing, Metabarcoding, Bio-Banking, Metabolomics, Musealization, Preservation, Proteomics, Recording, Sampling, Sequestering, Sub isolating, Taxon Classification

4. *Items produced by bioprospecting*: Bred Specimen, Captive Specimen, Cryo-Preserved Item, Cryptome, Cultured Specimen, DNA Barcode, DNA Barcode Archive, DNA Barcode Match, DSI (Digital Sequence information), eDNA (Environmental DNA), EGM Substance, Genetic Biological Material, Genome, Geotag, Meta barcode, Meta barcode Archive, Meta barcode Match, Metabolome, Metadata, Musealized Item, Natural Product (NP), Natural Product Isolate, NP Characterization

Appendix B

Main table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Input Object Type, Sub-Activity, Output Object Type and Operator/Custodian)

Input Object Type	Input Object	Sub-Activity	Sub-Sub Activity	Output Object Type	Output Object	Operator / Custodian
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Recording	Exploration Find	Record	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Geotagging	Exploration Find	Geotag	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Collecting	Exploration Find	Specimen	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Sampling	Exploration Find	Tissue	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	Genomics	Exploration Find	Genome	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	DNA Barcode Referencing	Exploration Find	Genome Match	In Situ Explorer
Natural Bio-Occurrence	EGM	Exploration (In Situ)	Filtering	Exploration Find	EGM Substance	In Situ Explorer
Natural Bio-Occurrence	EGM Substance	Exploration (In Situ)	eDNA Extraction	Exploration Find	eDNA	In Situ Explorer
Natural Bio-Occurrence	eDNA	Exploration (In Situ)	Meta-barcoding	Exploration Find	Meta Barcode Match	In Situ Explorer
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Preservation	Bio-Banked Item	Preserved Item	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Cryo-preservation	Bio-Banked Item	Cryo-preserved Item	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Musealization	Bio-Banked Item	Musealized Item	Bio-Bank
Specimen/Tissue/eDNA (from Exploration Find)	Specimen	Bio-Banking	Captivity	Bio-Banked Item	Captive Specimen	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Breeding	Bio-Banked Item	Bred Specimen	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Culturing	Bio-Banked Item	Cultured Specimen	Bio-Bank
Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Taxon Classification	Taxon Classification	Taxon Entry	Taxon Entry	Taxonomic Facility
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	Specimen/Tissue	Laboratory Analysis	Isolating	Lab Results	NP Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Designating	Lab Results	NP Characterization	Analyzing Lab

Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Sub-Isolating	Lab Results	NP Derivative Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Derivative Isolate	Laboratory Analysis	Characterizing	Lab Results	NP Derivative Characterization	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	EGM Substance/eDNA	Laboratory Analysis	Sequestering	Lab Results	Genetic Biological Material (GBM)	Analyzing Lab
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	Genomics	Lab Sequence	Genome	Sequencing Lab
GBM (from Analyzing Lab)	Genome	Laboratory Sequencing	Cryptomics	Lab Sequence	Cryptome	Sequencing Lab
GBM (from Analyzing Lab)	Cryptome	Laboratory Sequencing	Proteomics	Lab Sequence	Proteome	Sequencing Lab
GBM (from Analyzing Lab)	Proteome	Laboratory Sequencing	Metabolomics	Lab Sequence	Metabolome	Sequencing Lab
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	DNA Barcoding	Lab Sequence	DNA Barcode	Sequencing Lab
GBM (from Analyzing Lab)	DNA Barcode	Laboratory Sequencing	Meta-barcoding	Lab Sequence	Meta Barcode	Sequencing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Record/Geotag	Data banking	Associating	Database	Metadata	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Taxon Entry	Data banking	Listing	Database	Taxon List	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	NP Characterization	Data banking	Cataloging	Database	NP Library	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Genome	Data banking	Informatizing	Database	DSI	Database

Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	DNA Barcode	Data banking	Archiving DNA Barcode	Database	DNA Barcode Archive	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Meta barcode	Data banking	Archiving Meta barcode	Database	Meta barcode Archive	Database

Appendix C

Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Input Object)

Input Object Type	Input Object	Sub-Activity	Sub-Sub Activity	Output Object Type	Output Object	Operator / Custodian
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	Genomics	Exploration Find	Genome	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	DNA Barcode Referencing	Exploration Find	Genome Match	In Situ Explorer
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Taxon Entry	Data banking	Listing	Database	Taxon List	Database
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Preservation	Bio-Banked Item	Preserved Item	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Cryo-preservation	Bio-Banked Item	Cryo-preserved Item	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Musealization	Bio-Banked Item	Musealized Item	Bio-Bank
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	Specimen/Tissue	Laboratory Analysis	Isolating	Lab Results	NP Isolate	Analyzing Lab
Specimen/Tissue/eDNA (from Exploration Find)	Specimen	Bio-Banking	Captivity	Bio-Banked Item	Captive Specimen	Bio-Bank
Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Taxon Classification	Taxon Classification	Taxon Entry	Taxon Entry	Taxonomic Facility
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Record/Geotag	Data banking	Associating	Database	Metadata	Database
GBM (from Analyzing Lab)	Proteome	Laboratory Sequencing	Metabolomics	Lab Sequence	Metabolome	Sequencing Lab
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Recording	Exploration Find	Record	In Situ Explorer

Natural Bio-Occurrence	Organism	Exploration (In Situ)	Geotagging	Exploration Find	Geotag	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Collecting	Exploration Find	Specimen	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Sampling	Exploration Find	Tissue	In Situ Explorer
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Designating	Lab Results	NP Characterization	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Sub-Isolating	Lab Results	NP Derivative Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Derivative Isolate	Laboratory Analysis	Characterizing	Lab Results	NP Derivative Characterization	Analyzing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	NP Characterization	Data banking	Cataloging	Database	NP Library	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Meta barcode	Data banking	Archiving Meta barcode	Database	Meta barcode Archive	Database
GBM (from Analyzing Lab)	Genome	Laboratory Sequencing	Cryptomics	Lab Sequence	Cryptome	Sequencing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Genome	Data banking	Informatizing	Database	DSI	Database
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	Genomics	Lab Sequence	Genome	Sequencing Lab
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	DNA Barcoding	Lab Sequence	DNA Barcode	Sequencing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	EGM Substance/eDNA	Laboratory Analysis	Sequestering	Lab Results	Genetic Biological Material (GBM)	Analyzing Lab

Natural Bio-Occurrence	EGM Substance	Exploratio n (In Situ)	eDNA Extraction	Exploration Find	eDNA	In Situ Explorer
Natural Bio-Occurrence	EGM	Exploratio n (In Situ)	Filtering	Exploration Find	EGM Substance	In Situ Explorer
Natural Bio-Occurrence	eDNA	Exploratio n (In Situ)	Meta-barcoding	Exploration Find	Meta Barcode Match	In Situ Explorer
GBM (from Analyzing Lab)	DNA Barcode	Laboratory Sequencin g	Meta-barcoding	Lab Sequence	Meta Barcode	Sequencing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	DNA Barcode	Data banking	Archiving DNA Barcode	Database	DNA Barcode Archive	Database
GBM (from Analyzing Lab)	Cryptome	Laboratory Sequencin g	Proteomics	Lab Sequence	Proteome	Sequencing Lab
Specimen/Tissue/EG M Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Breeding	Bio-Banked Item	Bred Specimen	Bio-Bank
Specimen/Tissue/EG M Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Culturing	Bio-Banked Item	Cultured Specimen	Bio-Bank

Appendix D

Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Sub-Sub-Activity)

Input Object Type	Input Object	Sub-Activity	Sub-Sub Activity	Output Object Type	Output Object	Operator / Custodian
Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Taxon Classification	Taxon Classification	Taxon Entry	Taxon Entry	Taxonomic Facility
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Sub-Isolating	Lab Results	NP Derivative Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	EGM Substance/eDNA	Laboratory Analysis	Sequestering	Lab Results	Genetic Biological Material (GBM)	Analyzing Lab
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Sampling	Exploration Find	Tissue	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Recording	Exploration Find	Record	In Situ Explorer
GBM (from Analyzing Lab)	Cryptome	Laboratory Sequencing	Proteomics	Lab Sequence	Proteome	Sequencing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Preservation	Bio-Banked Item	Preserved Item	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Musealization	Bio-Banked Item	Musealized Item	Bio-Bank
GBM (from Analyzing Lab)	Proteome	Laboratory Sequencing	Metabolomics	Lab Sequence	Metabolome	Sequencing Lab
Natural Bio-Occurrence	eDNA	Exploration (In Situ)	Meta-barcoding	Exploration Find	Meta Barcode Match	In Situ Explorer
GBM (from Analyzing Lab)	DNA Barcode	Laboratory Sequencing	Meta-barcoding	Lab Sequence	Meta Barcode	Sequencing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Taxon Entry	Data banking	Listing	Database	Taxon List	Database
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	Specimen/Tissue	Laboratory Analysis	Isolating	Lab Results	NP Isolate	Analyzing Lab

Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Genome	Data banking	Informatizing	Database	DSI	Database
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Geotagging	Exploration Find	Geotag	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	Genomics	Exploration Find	Genome	In Situ Explorer
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	Genomics	Lab Sequence	Genome	Sequencing Lab
Natural Bio-Occurrence	EGM	Exploration (In Situ)	Filtering	Exploration Find	EGM Substance	In Situ Explorer
Natural Bio-Occurrence	EGM Substance	Exploration (In Situ)	eDNA Extraction	Exploration Find	eDNA	In Situ Explorer
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	DNA Barcoding	Lab Sequence	DNA Barcode	Sequencing Lab
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	DNA Barcode Referencing	Exploration Find	Genome Match	In Situ Explorer
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Designating	Lab Results	NP Characterization	Analyzing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Culturing	Bio-Banked Item	Cultured Specimen	Bio-Bank
GBM (from Analyzing Lab)	Genome	Laboratory Sequencing	Cryptomics	Lab Sequence	Cryptome	Sequencing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Cryo-preservation	Bio-Banked Item	Cryo-preserved Item	Bio-Bank
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Collecting	Exploration Find	Specimen	In Situ Explorer
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Derivative Isolate	Laboratory Analysis	Characterizing	Lab Results	NP Derivative Characterization	Analyzing Lab
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	NP Characterization	Data banking	Cataloging	Database	NP Library	Database
Specimen/Tissue/eDNA (from Exploration Find)	Specimen	Bio-Banking	Captivity	Bio-Banked Item	Captive Specimen	Bio-Bank

Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Breeding	Bio-Banked Item	Bred Specimen	Bio-Bank
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Record/Geotag	Data banking	Associating	Database	Metadata	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Meta barcode	Data banking	Archiving Meta barcode	Database	Meta barcode Archive	Database
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	DNA Barcode	Data banking	Archiving DNA Barcode	Database	DNA Barcode Archive	Database

Appendix E

Toggled table of the synthesized ontology of bioprospecting for knowledge production

(Sorting by Output Object)

Input Object Type	Input Object	Sub-Activity	Sub-Sub Activity	Output Object Type	Output Object	Operator / Custodian
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Sampling	Exploration Find	Tissue	In Situ Explorer
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Taxon Entry	Data banking	Listing	Database	Taxon List	Database
Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Record/Geotag/Specimen /Tissue (from Exploration Find); Bio-Banked Item	Taxon Classification	Taxon Classification	Taxon Entry	Taxon Entry	Taxonomic Facility
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Collecting	Exploration Find	Specimen	In Situ Explorer
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Recording	Exploration Find	Record	In Situ Explorer
GBM (from Analyzing Lab)	Cryptome	Laboratory Sequencing	Proteomics	Lab Sequence	Proteome	Sequencing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Preservation	Bio-Banked Item	Preserved Item	Bio-Bank
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	NP Characterization	Data banking	Cataloging	Database	NP Library	Database
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	Specimen/Tissue	Laboratory Analysis	Isolating	Lab Results	NP Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Sub-Isolating	Lab Results	NP Derivative Isolate	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Derivative Isolate	Laboratory Analysis	Characterizing	Lab Results	NP Derivative Characterization	Analyzing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	NP Isolate	Laboratory Analysis	Designating	Lab Results	NP Characterization	Analyzing Lab

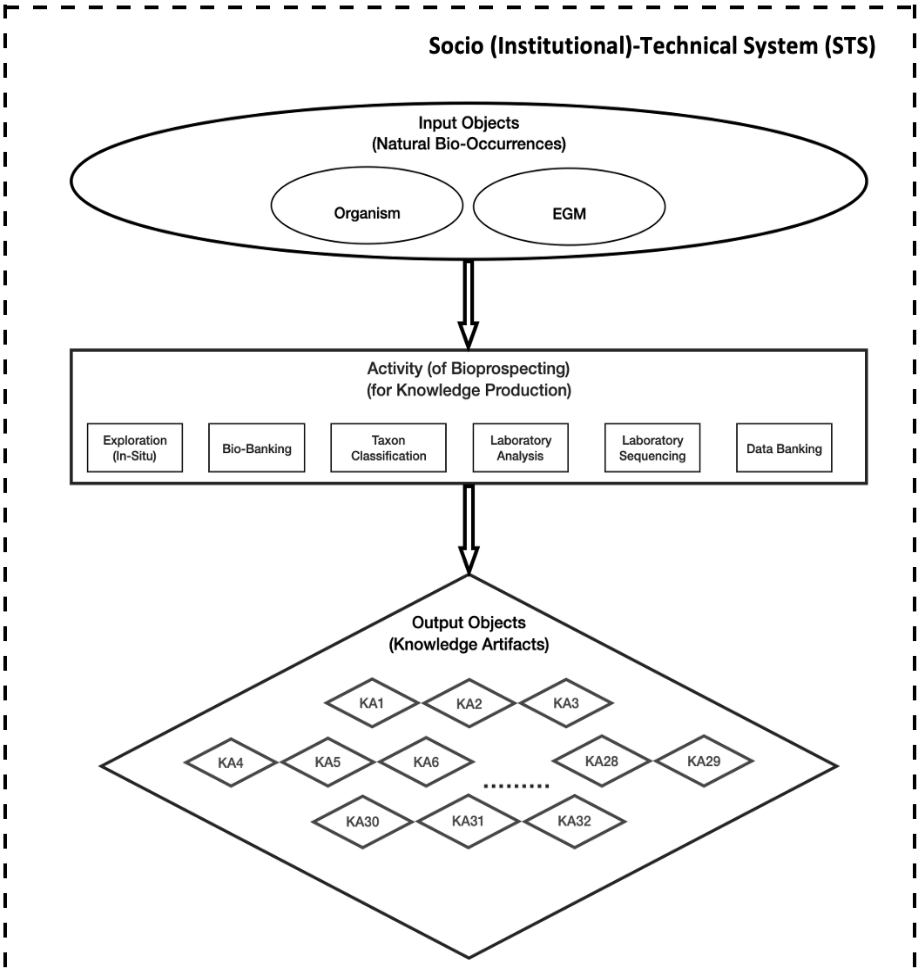
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Musealization	Bio-Banked Item	Musealized Item	Bio-Bank
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Record/Geotag	Data banking	Associating	Database	Metadata	Database
GBM (from Analyzing Lab)	Proteome	Laboratory Sequencing	Metabolomics	Lab Sequence	Metabolome	Sequencing Lab
Natural Bio-Occurrence	eDNA	Exploration (In Situ)	Meta-barcoding	Exploration Find	Meta Barcode Match	In Situ Explorer
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Meta barcode	Data banking	Archiving Meta barcode	Database	Meta barcode Archive	Database
GBM (from Analyzing Lab)	DNA Barcode	Laboratory Sequencing	Meta-barcoding	Lab Sequence	Meta Barcode	Sequencing Lab
Natural Bio-Occurrence	Organism	Exploration (In Situ)	Geotagging	Exploration Find	Geotag	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	DNA Barcode Referencing	Exploration Find	Genome Match	In Situ Explorer
Natural Bio-Occurrence	Tissue	Exploration (In Situ)	Genomics	Exploration Find	Genome	In Situ Explorer
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	Genomics	Lab Sequence	Genome	Sequencing Lab
Specimen/Tissue/EGM Substance/eDNA (from Exploration Find)	EGM Substance/eDNA	Laboratory Analysis	Sequestering	Lab Results	Genetic Biological Material (GBM)	Analyzing Lab
Natural Bio-Occurrence	EGM	Exploration (In Situ)	Filtering	Exploration Find	EGM Substance	In Situ Explorer
Natural Bio-Occurrence	EGM Substance	Exploration (In Situ)	eDNA Extraction	Exploration Find	eDNA	In Situ Explorer
Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	Genome	Data banking	Informatizing	Database	DSI	Database

Record/Geotag (from Exploration Find); Taxon Entry; NP Characterization (from Lab Result); Genome/DNA Barcode/Meta barcode (from Lab Sequence)	DNA Barcode	Data banking	Archiving DNA Barcode	Database	DNA Barcode Archive	Database
GBM (from Analyzing Lab)	GBM (from Analyzing Lab)	Laboratory Sequencing	DNA Barcoding	Lab Sequence	DNA Barcode	Sequencing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Culturing	Bio-Banked Item	Cultured Specimen	Bio-Bank
GBM (from Analyzing Lab)	Genome	Laboratory Sequencing	Cryptomics	Lab Sequence	Cryptome	Sequencing Lab
Specimen/Tissue/EGM Substance (from Exploration Find)	Specimen/Tissue/EGM Substance	Bio-Banking	Cryo-preservation	Bio-Banked Item	Cryo-preserved Item	Bio-Bank
Specimen/Tissue/eDNA (from Exploration Find)	Specimen	Bio-Banking	Captivity	Bio-Banked Item	Captive Specimen	Bio-Bank
Specimen/Tissue/EGM Substance (from Exploration Find)	Captive Specimen	Bio-Banking	Breeding	Bio-Banked Item	Bred Specimen	Bio-Bank

Appendix F

Figures 4-16

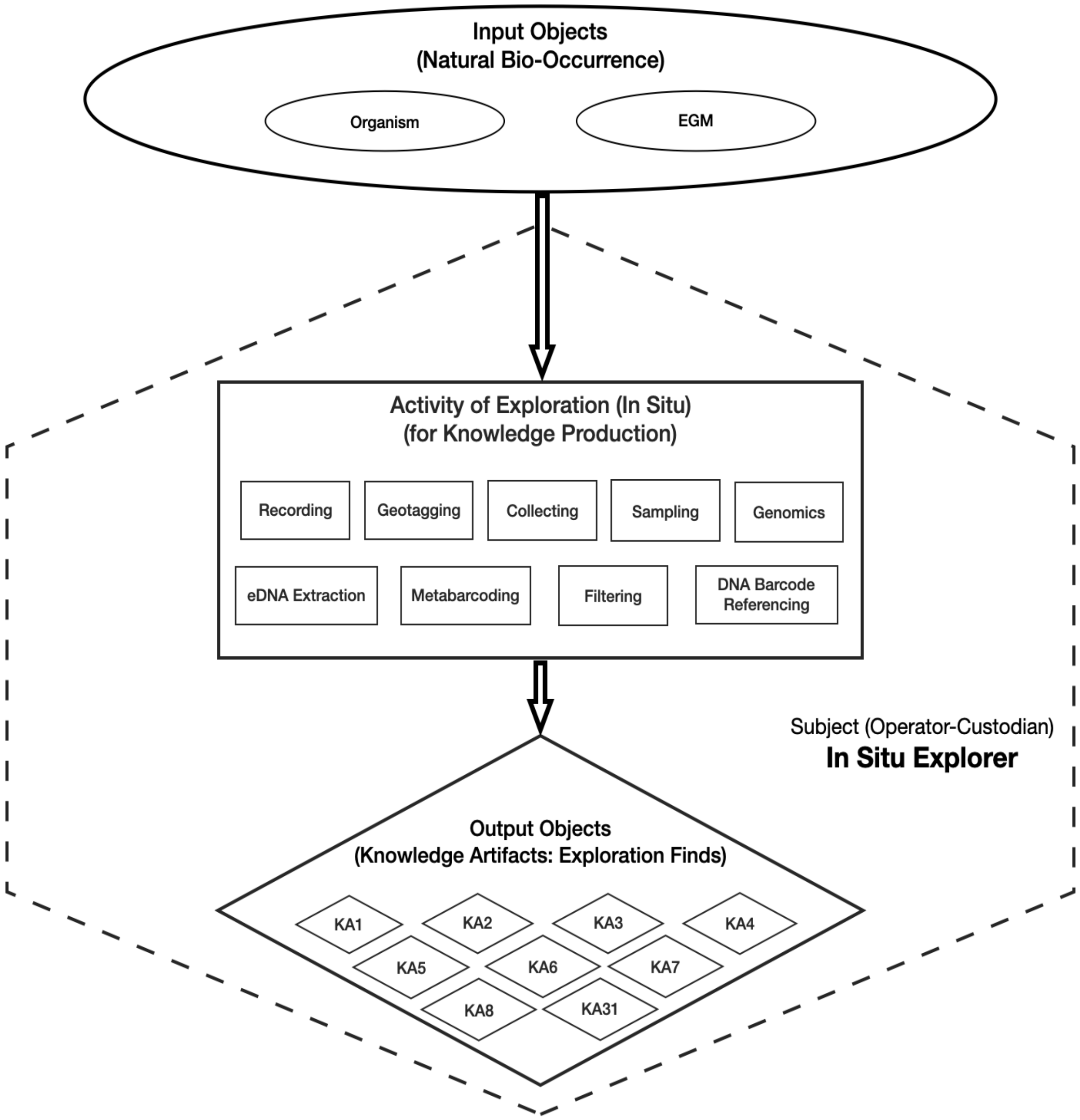
(Conceptual Graphs depicting the domain of bioprospecting for knowledge production and having an associated ontology)



KA=Knowledge Artifact; EGM=Environmental Genetic Material; eDNA=Environmental DNA; NP=Natural Product; DSI=Digital Sequence Information

KA1=Record; KA2=Geotag; KA3=Specimen; KA4=Tissue; KA5=Genome; KA6=Genome Match; KA7=eDNA; KA8=Meta Barcode Match; KA9=Preserved Item; KA10=Cryopreserved Item; KA11=Musealized Item; KA12=Captive Specimen; KA13=Bred Specimen; KA14=Cultured Specimen; KA15=NP Isolate; KA16=NP Characterization; KA17=NP Derivative Isolate; KA18=NP Derivative Characterization; KA19=Genetic Biological Material (GBM); KA20=Cryptome; KA21=Proteome; KA22=Metabolome; KA23=DNA Barcode; KA24=Meta Barcode; KA25=Metadata; KA26=Taxon List; KA27=NP Library; KA28=DSI; KA29=DNA Barcode Archive; KA30=Meta barcode Archive; KA31=EGM Substance; KA32=Taxon Entry

Figure 4: Conceptual Graph of top-level system view of the synthesized ontology of bioprospecting for knowledge production, based on the template in Figure 3.



KA=Knowledge Artifact; EGM=Environmental Genetic Material; eDNA=Environmental DNA

KA1=Record; KA2=Geotag; KA3=Specimen; KA4=Tissue; KA5=Genome; KA6=Genome Match; KA7=eDNA; KA8=Meta Barcode Match; KA31=EGM Substance

Figure 5: Conceptual Graph of mid-level system view of Exploration (In Situ)

within the synthesized ontology of bioprospecting for knowledge production, based on the template in Figure 3.

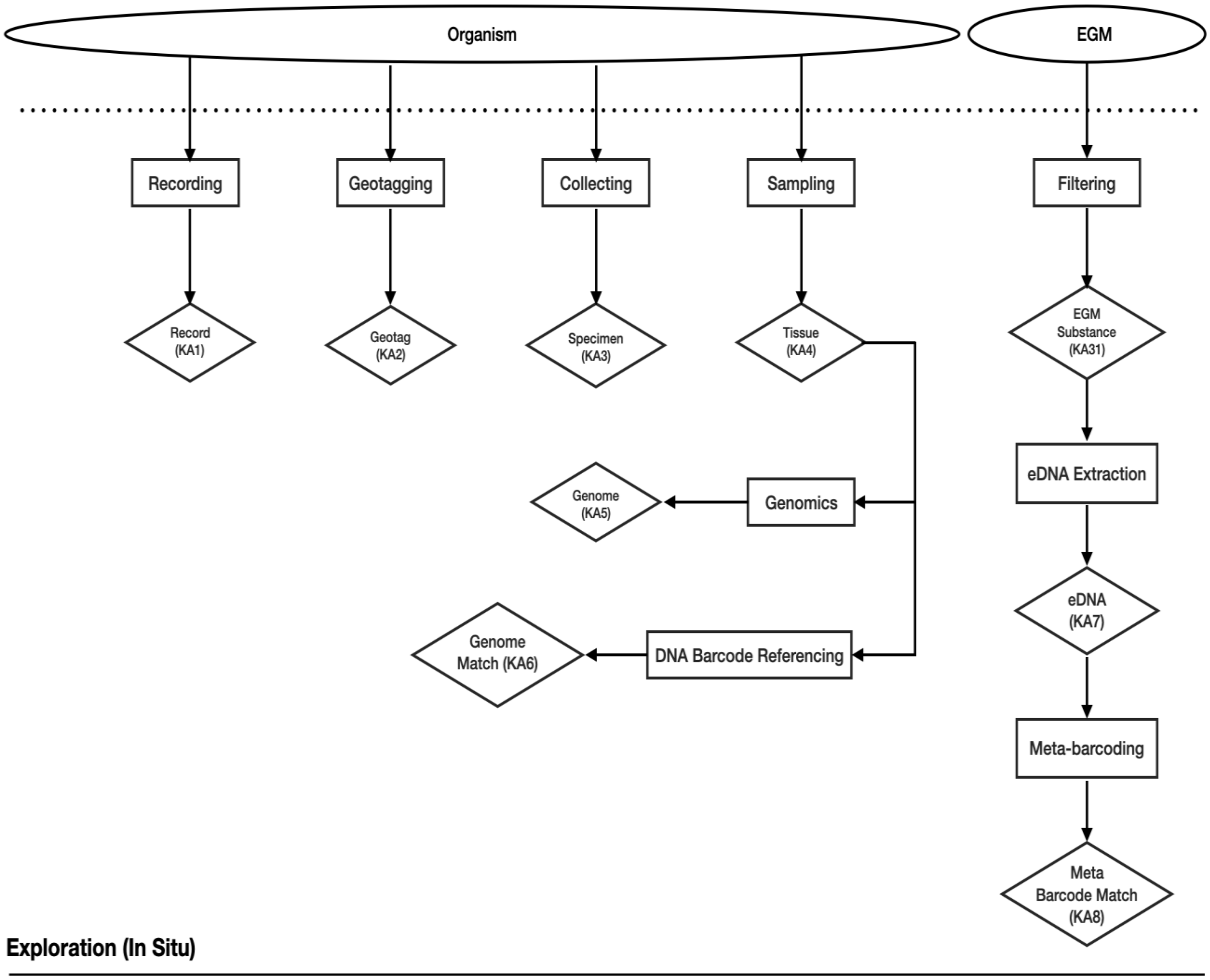
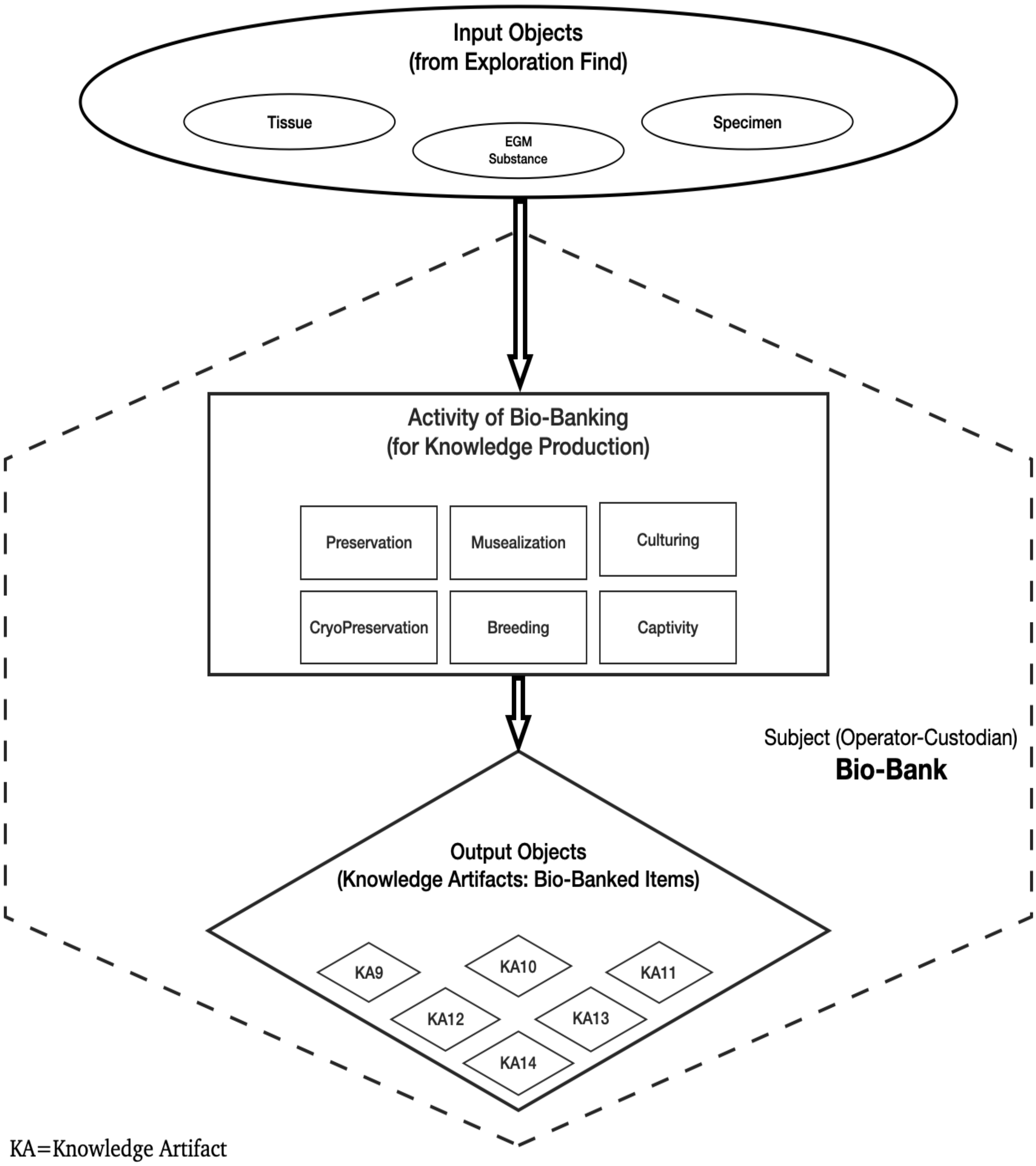


Figure 6: Conceptual Graph of mid-level internal view of Exploration (In Situ), corresponding to the system view in Figure 5.



KA=Knowledge Artifact

KA9=Preserved Item; KA10=CryoPreserved Item; KA11=Musealized Item; KA12=Captive Specimen; KA13=Bred Specimen; KA14=Cultured Specimen

Figure 7: Conceptual Graph of mid-level system view of Bio-Banking within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

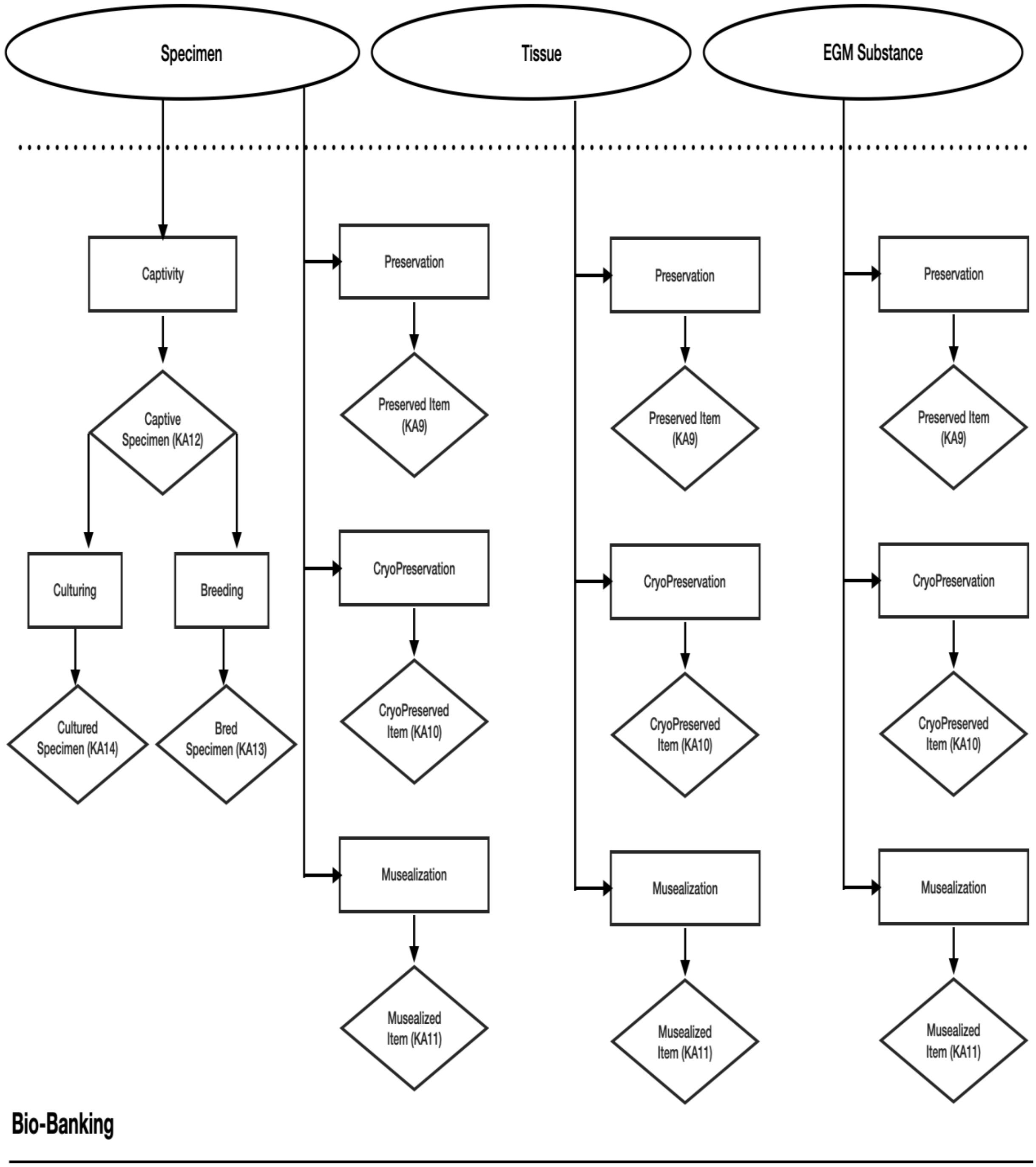
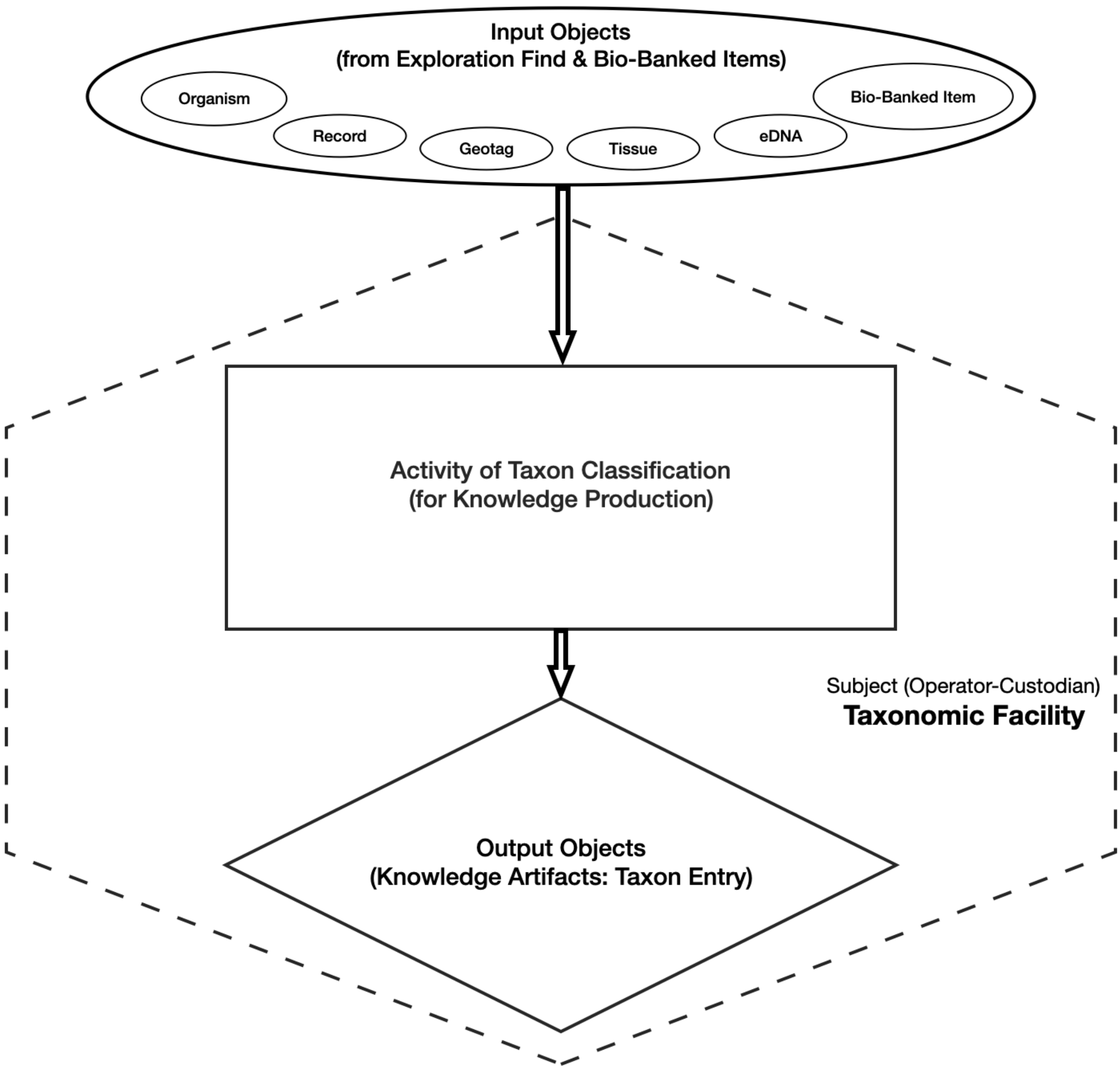


Figure 8: Conceptual Graph of mid-level internal view of Bio-Banking, corresponding to the system view in Figure 7.



eDNA=Environmental DNA

Figure 9: Conceptual Graph of mid-level system view of Taxon Classification within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

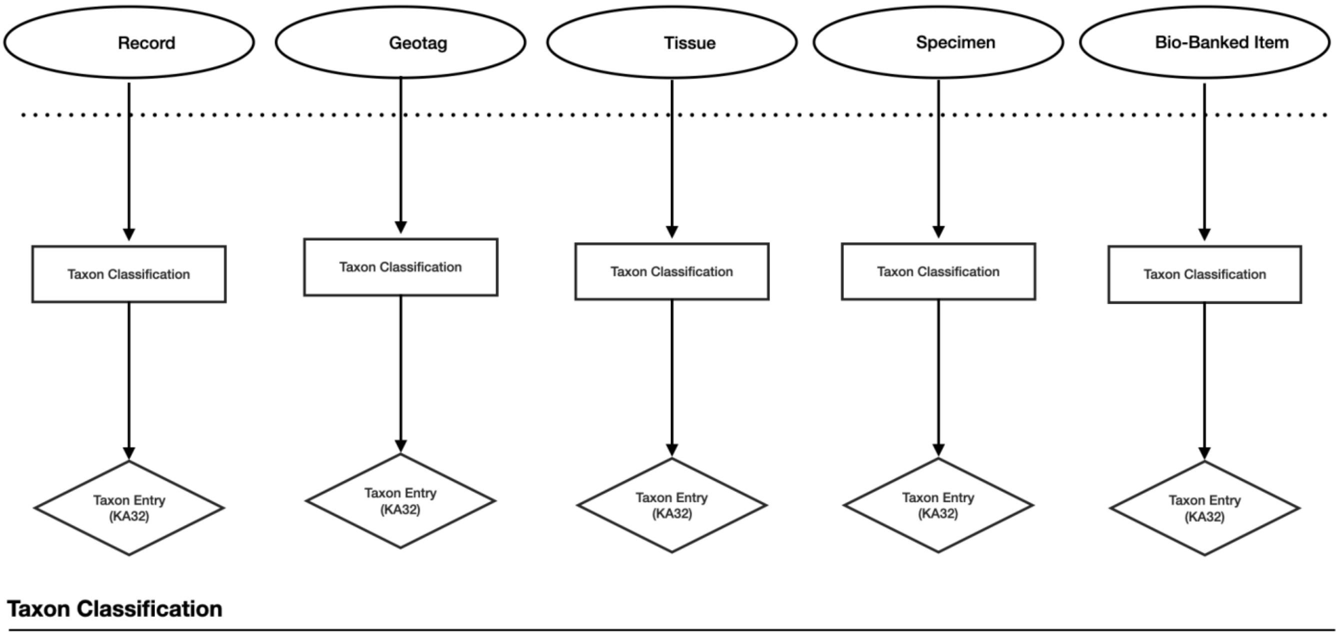
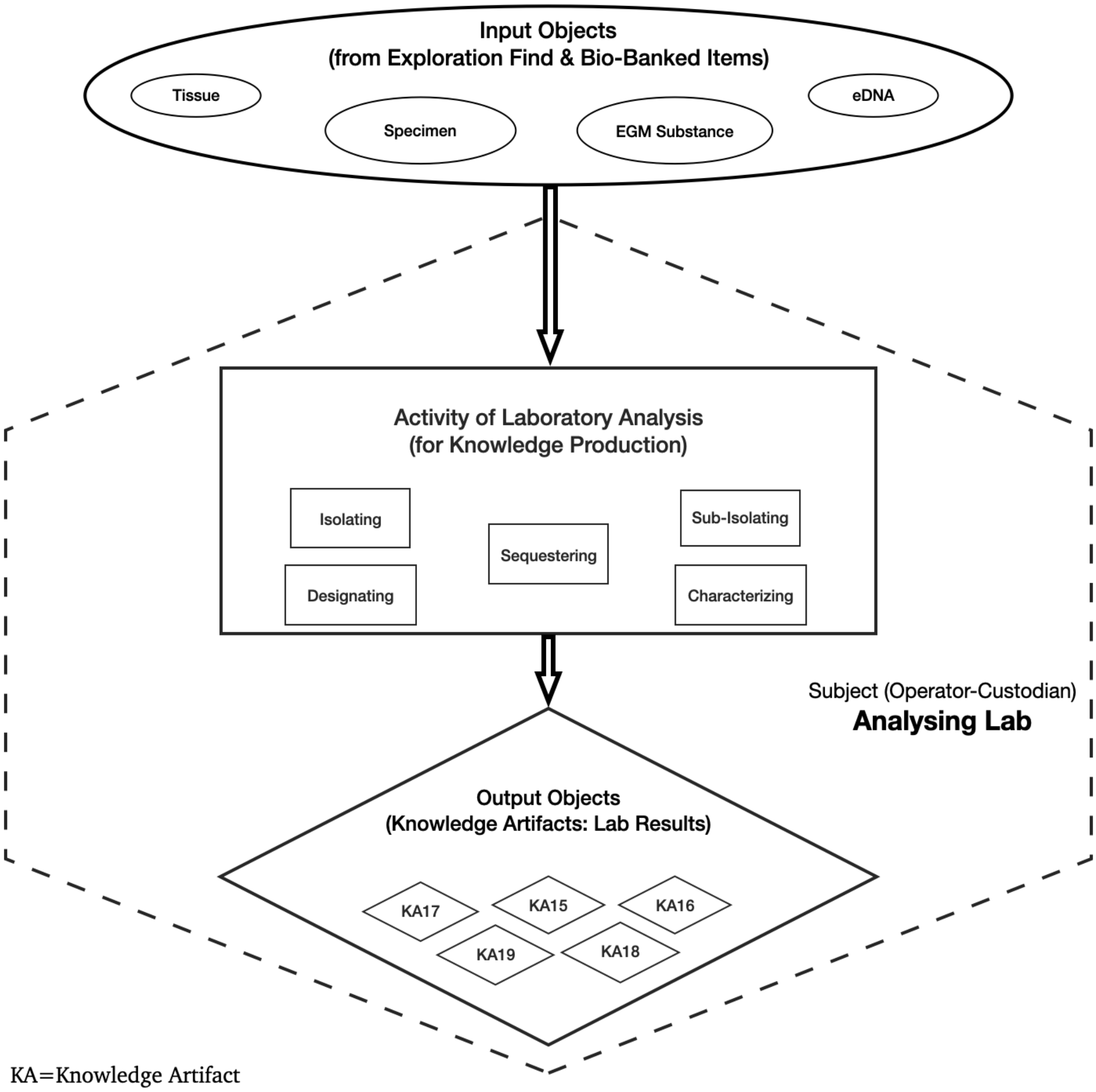


Figure 10: Conceptual Graph of mid-level internal view of Taxon Classification, corresponding to the system view in Figure 9.



KA=Knowledge Artifact

KA15=NP Isolate; KA16=NP Characterization; KA17=NP Derivative Isolate; KA18=NP Derivative Characterization; KA19=Genetic Biological Material (GBM)

Figure 11: Conceptual Graph of mid-level system view of Laboratory Analysis within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

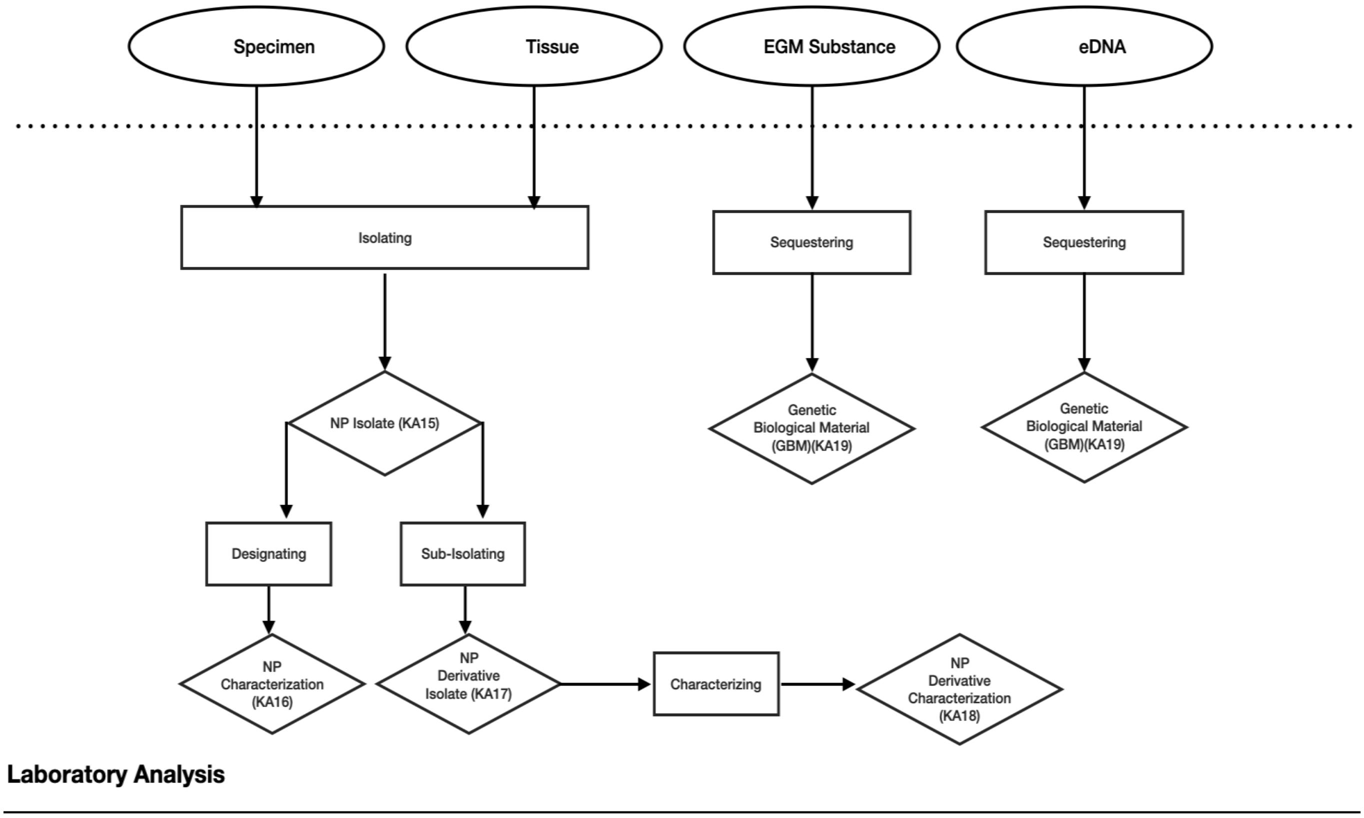
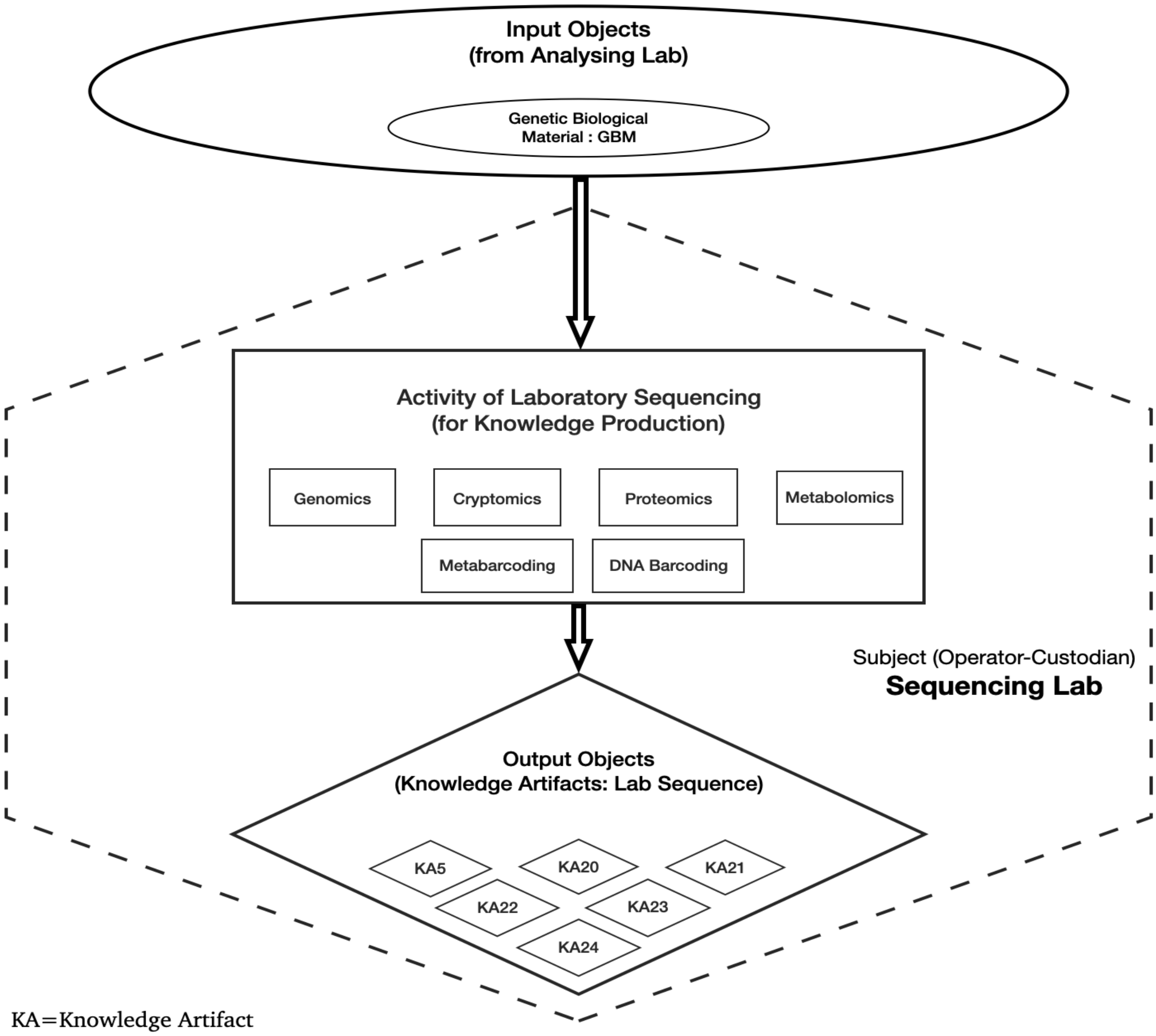


Figure 12: Conceptual Graph of mid-level internal view of Laboratory Analysis, corresponding to the system view in Figure 11.



KA=Knowledge Artifact

KA5=Genome; KA20=Cryptome; KA21=Proteome; KA22=Metabolome; KA23=DNA Barcode; KA24=Meta Barcode

Figure 13: Conceptual Graph of mid-level system view of Laboratory Sequencing within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

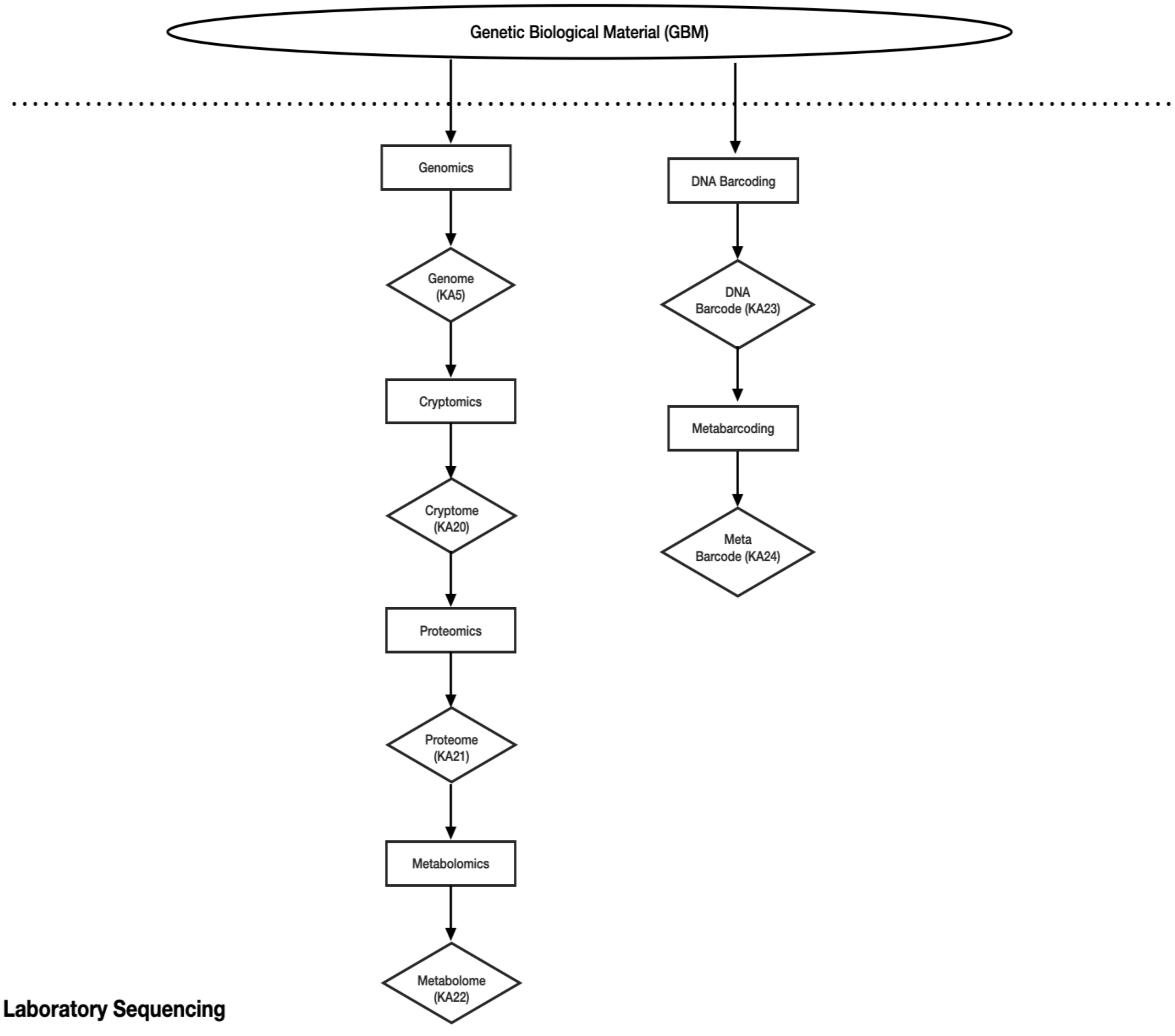
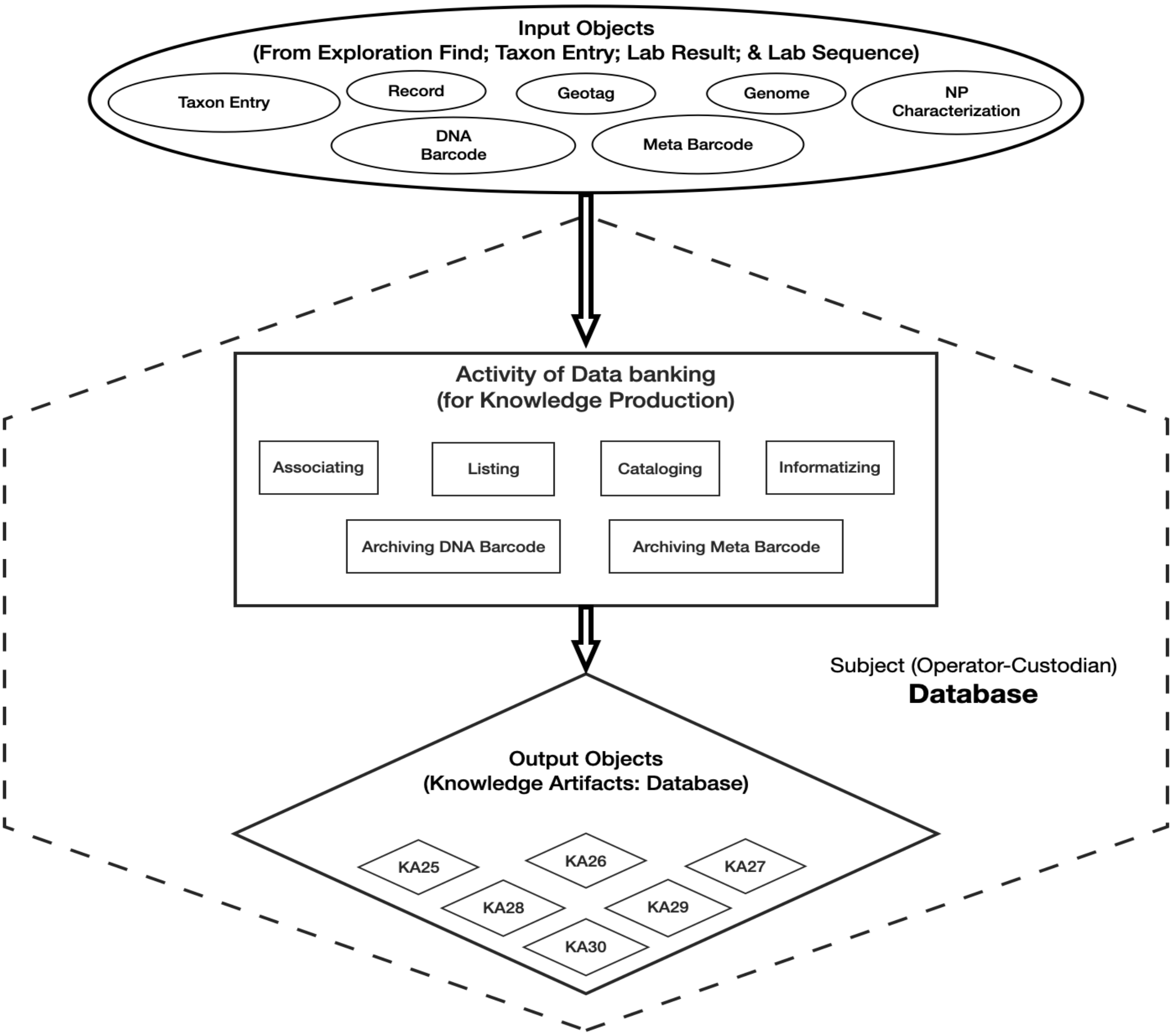


Figure 14: Conceptual Graph of mid-level internal view of Laboratory Sequencing, corresponding to the system view in Figure 13.



KA=Knowledge Artifact; NP=Natural Product; DSI=Digital Sequence Information

KA25=Metadata; KA26=Taxon List; KA27=NP Library; KA28=DSI; KA29=DNA Barcode Archive; KA30=Meta barcode Archive

Figure 15: Conceptual Graph of mid-level system view of Data Banking

within the synthesized ontology of bioprospecting for knowledge production, based on template in Figure 3.

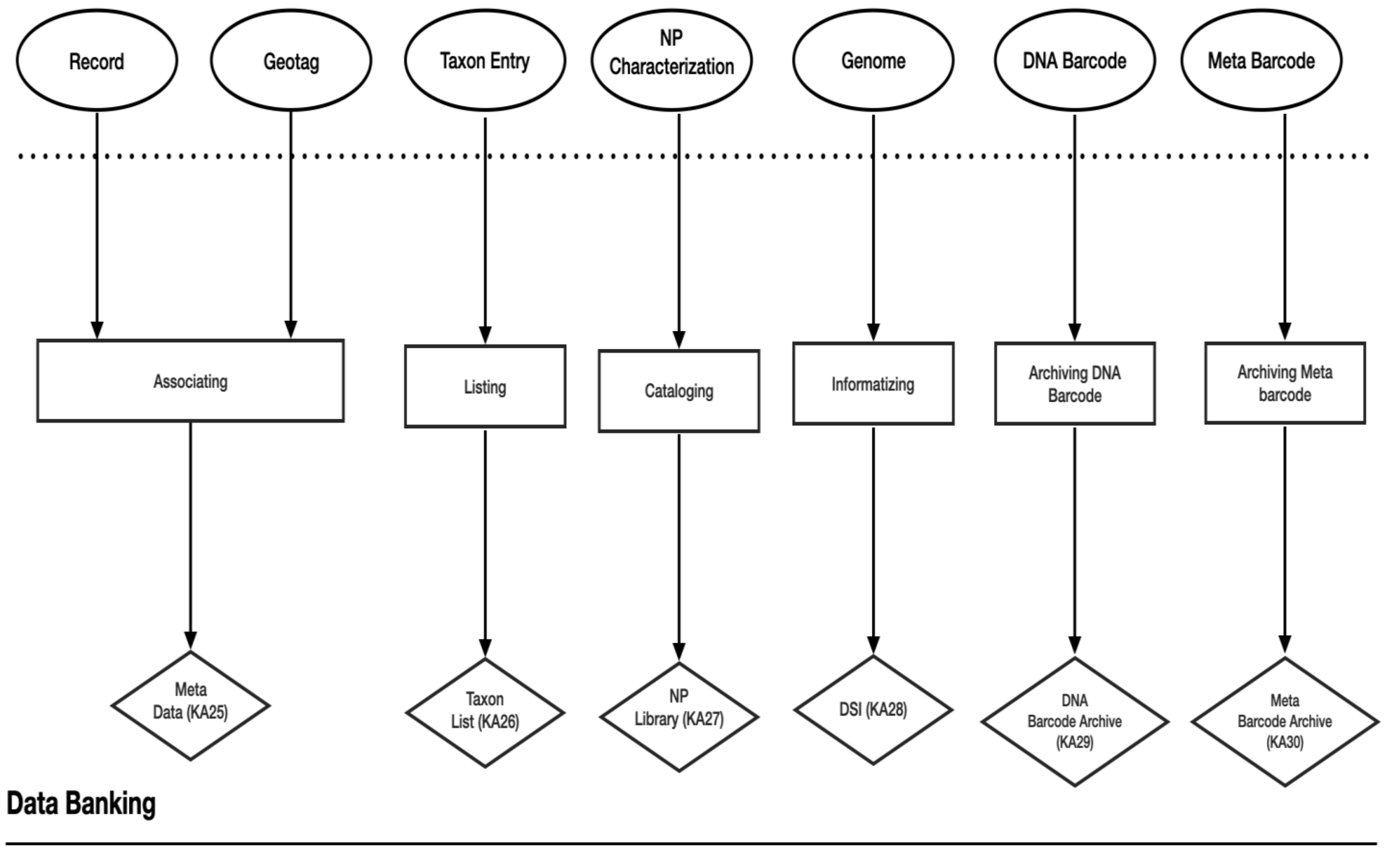


Figure 16: Conceptual Graph of mid-level internal view of Data Banking, corresponding to the system view in Figure 15.

Appendix G

Research Materials (data) for ontological legal research (OLR):

Six constellations of treaties and regulations and a *sui generis* treaty

that have been selected as potentially most relevant

to the governance of bioprospecting in Antarctica

Treaty Constellation # 1/6: Antarctic Treaty System (ATS)

AT (1959). The Antarctic Treaty. https://www.ats.aq/documents/ats/treaty_original.pdf

CCAS (1972). Convention for the Conservation of Antarctic Seals. https://www.ats.aq/documents/keydocs/vol_1/vol1_13_CCAS_CCAS_e.pdf

CCAMLR (1980). Convention on the Conservation of Antarctic Marine Living Resources. https://www.ccamlr.org/en/system/files/e-pt1_3.pdf

PEPAT (1991). Protocol on Environmental Protection to the Antarctic Treaty. https://www.ats.aq/e/protocol.html

Treaty Constellation # 2/6: United Nations Convention on the Law of the Sea (UNCLOS)

UNCLOS (1982). United Nations Convention on the Law of the Sea. https://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf

Implementation Agreement (1994). Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea. https://www.un.org/depts/los/convention_agreements/texts/agreement_part_xi/agreement_part_xi.htm

FSA (1995). Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1992 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. https://www.un.org/depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm

PN ISA Regulations (2000). Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area (International Seabed Authority). https://isa.org.jm/files/files/documents/isba-19c-17_0.pdf

PS ISA Regulations (2010). Regulations on prospecting and exploration for polymetallic sulphides in the Area (International Seabed Authority). https://isa.org.jm/files/files/documents/isba-16a-12rev1_0.pdf

CC ISA Regulations (2013). Regulations on prospecting and exploration for cobalt-rich ferromanganese crusts in the Area (International Seabed Authority). https://isa.org.jm/files/files/documents/isba-18a-11_0.pdf

AR ISA-LTC Recommendations (2015). Recommendations for the guidance of contractors on the content, format and structure of annual reports (International Seabed Authority – Legal and Technical Commission). https://isa.org.jm/files/files/documents/isba-21ltc-15_1.pdf

EIA ISA-LTC Recommendations (2019). Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area (International Seabed Authority – Legal and Technical Commission). https://isa.org.jm/files/files/documents/26ltc-6-rev1-en_0.pdf

Treaty Constellation # 3/6: Convention on Biodiversity (CBD)

CBD (1992). Convention on Biological Diversity. https://www.cbd.int/doc/legal/cbd-en.pdf

Cartagena Protocol (2000). Cartagena Protocol on Biosafety to the Convention on Biological Diversity. https://www.cbd.int/doc/legal/cartagena-protocol-en.pdf

Supplementary Protocol (2010). Nagoya - Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety. https://bch.cbd.int/protocol/text/

Nagoya Protocol (2010). Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf

Treaty Constellation # 4/6: Plant Genetic Resources for Food & Agriculture (PGRFA)

ITPGRFA (2001). International Treaty on Plant Genetic Resources for Food and Agriculture. https://www.fao.org/3/i0510e/i0510e.pdf

Treaty Constellation # 5/6: Paris Convention

Paris Convention (1883). Paris Convention for the Protection of Industrial Property. https://wipolex.wipo.int/en/text/287556

Budapest Treaty (1977). Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure. https://wipolex.wipo.int/en/text/283781

Budapest Regulations (1977). Regulations under the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure. https://wipolex.wipo.int/en/text/283787

TRIPS (1994). Agreement on Trade-Related Aspects of Intellectual Property Rights, Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, 1994.

https://www.wto.org/english/docs_e/legal_e/31bis_trips_01_e.htm

Treaty Constellation # 6/6: Conservation of Migratory Species (CMS)

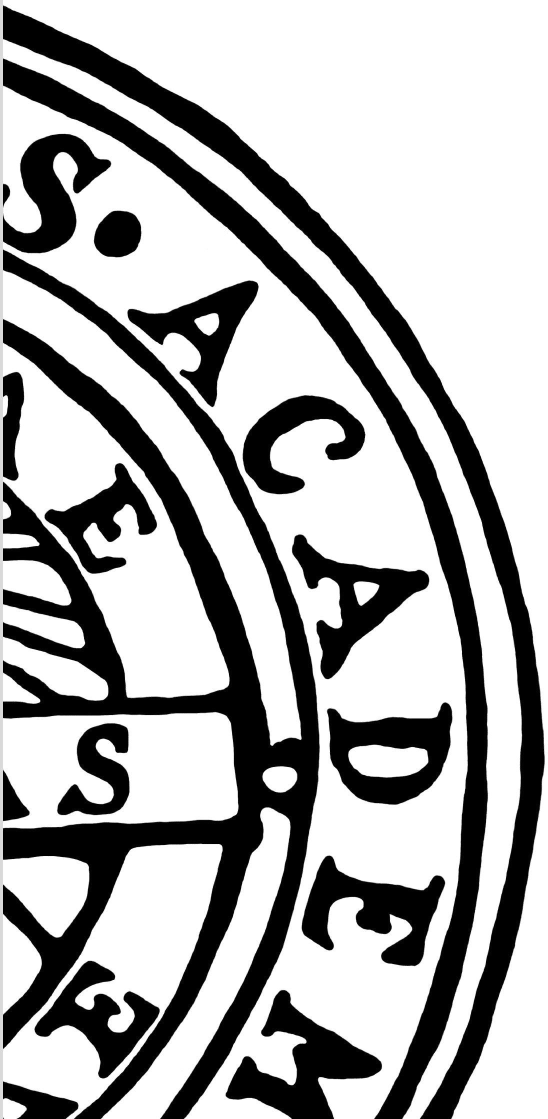
CMS (1979). Convention on the Conservation of Migratory Species of Wild Animals. https://www.cms.int/sites/default/files/instrument/CMS-text.en_.PDF

CCSBT (1993). Convention for the Conservation of Southern Bluefin Tuna. https://www.ccsbt.org/sites/ccsbt.org/files/userfiles/file/docs_english/basic_documents/convention.pdf

ACAP (2001). Agreement on the Conservation of Albatrosses and Petrels. https://www.acap.aq/agreement-text/206-agreement-on-the-conservation-of-albatrosses-and-petrels/file

Sui generis Treaty

ICRW (1946). International Convention for the Regulation of Whaling. https://archive.iwc.int/pages/view.php?ref=3607&k=


S. ACADEM