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Patentability and Governance of High Seas Genetic Resources: A Case Study of Antarctic Krill

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Abstract

The genetic potential of Antarctic krill and other marine genetic resources offers significant scope for innovation, with ongoing genome sequencing projects continually revealing new functional genes and potential pathways. However, the legal and ethical implications of patenting these innovations remain largely unexplored. While the recent UN Marine Biodiversity of Areas Beyond National Jurisdiction (BBNJ) Agreement introduces a benefit-sharing provision for genetically unmodified marine organisms, its application to existing patents on oceanic genetic resources is yet to be determined. This paper examines the current intellectual property rights pertaining to krill within the framework of this new international legal instrument governing high seas genetic resources. It argues that while the BBNJ Agreement may permit krill patenting, the common heritage of humanity principle necessitates a degree of self-restraint to mitigate concerns arising from their public domain resource character.

Keywords: patent eligibility, genetic resources, legal regulation, Antarctic krill

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Патентоспособность и управление генетическими ресурсами открытого моря: исследование на примере антарктического криля

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Аннотация

Генетический потенциал антарктического криля и других генетических ресурсов значителен. Многочисленные проекты секвенирования генома выявляют все больше функциональных генов и возможных путей для инноваций. Правовые и этические последствия патентования этих инноваций остаются в значительной степени неизученной областью. В недавно принятом Организацией Объединенных Наций Соглашении о биологическом разнообразии в открытом море (BBNJ), устанавливающем новые международные рамки для морского биоразнообразия, содержится положение о распределении выгод от использования генетически немодифицированных организмов в океане. Остается неясным, как это положение будет регулировать существующие патенты на генетические ресурсы океана. В данной статье рассматриваются существующие права интеллектуальной собственности на криль и инновации в контексте новейшей международной правовой базы для генетических ресурсов открытого моря. Утверждается, что новая правовая база может разрешить патентование инноваций на криль, но в силу характера ресурсов, находящихся в общественном достоянии, необходимо проявлять определенную осторожность, чтобы учесть интересы общего наследия человечества.

Ключевые слова: патентоспособность, генетические ресурсы, правовое регулирование, антарктический криль

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Introduction

The Antarctic krill (*Euphausia superba*), representing a pivotal species in the Southern Ocean fishery, is not only gaining recognition as a marine resource, but also as a potential source of a biological genetic bank (Chi et al., 2013). The recognition of the biological resource potential of Antarctic krill is due to significant progress achieved in the whole-genome sequencing and in gene mining over the last few years. It is possible nowadays to isolate and express various functional genes from krill. As a result of the recent progress in this field, a huge number of patents have been applied. This raises the very important issue as to whether genetic resources and biotechnological innovations based on the genetic resources of the Antarctic krill, considered as a resource of the Area in the absence of jurisdiction, can be patented. This issue has become part of the case law of the Antarctic Treaty System. However, the recently concluded Marine Biodiversity of Areas Beyond National Jurisdiction (BBNJ) agreement does not address how it will address patent protection issues as governed by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement and related Patents. Setting out to address this question on the basis of doctrinal research, the present paper will discuss several issues (Taghizadeh, 2025).

Values of Antarctic Krill in Biology

With an estimated biomass of between 650 million and 1 billion tons, Antarctic krill is among the most plentiful multicellular organisms on Earth. Due to advances in bioinformatics and biotechnology, krill are no longer considered solely in terms of conventional fisheries, but also as a potential source of novel genetic material. Due to the possibility of patenting technological uses of such material, it now becomes necessary to carefully consider the associated legal questions.

Biotechnological Innovations in Krill Genes

Bioinformatics research has identified genes that could lead to numerous advancements in the biotechnology sector. One of the most studied areas is the recombinant production of antifreeze proteins that impede the development of ice crystals. Such proteins can be used to keep food products fresh or for the cryopreservation of tissues. Research has shown that such genes can be used to produce recombinant proteins that are ice-active. In synthetic biology, interest in the heterologous synthesis of certain highly unsaturated fatty acids is growing. Research groups are attempting to overcome the problem of unsustainable harvesting of krill and other fish species by transferring the necessary krill gene sets to yeast and microalgae for the production of valuable Omega-3 fatty acids. New possibilities for gene discovery have been created by metagenomics. Antarctic krill species also serve as hosts to complex microbial communities, including those that are poorly cultivable. By directly sequencing the genetic codes of these communities, scientists are able to exploit previously uncharacterized areas.

Novel achievements in the development of bioactive krill peptides have been also reported. The release of bioactive peptides from krill protein using enzymatic hydrolysis was found to possess antioxidant, antihypertensive and hypoglycemic activities (Xin et al., 2024). Bioinformatics tools were employed in the research. Such as identifying potential cleavage sites for bioactive peptides using BIOPEP-UWM database, evaluating potential

activities of the peptides using Peptide Ranker tool and elucidating the potential mechanisms of action of the bioactive peptides using molecular docking study (Saetang, 2025).

Intellectual Property Requirements for Technological Development

The opportunities for high value krill biotech products will depend on how intellectual property (IP) is constituted in this sector. Indeed, in order to protect huge investments in primary research and the characterization of genes of interest for the development of biotech products, adequate IP protection mechanisms have to be implemented in order to allow the innovator to get an economic return on his investment. Since biotechnology inventions are often easy to copy, patents are necessary to prevent free riding and build portfolios in order to secure venture capital and public-private partnerships to take the product to the market. Meanwhile, patenting activities are widespread and strategies vary from one claimant to another. For instance, universities and research institutions are generally more involved in patenting the early stages of research and innovation processes, such as genome and gene function characterization. On the other hand, a number of companies – in particular, in the fishing industry – have explored the later stages of the value chain to develop new processes and products such as micro-encapsulation of krill oil and machines for mechanically separating krill from their shells.

Legal Status of High Sea Genetic Resources

The development of the Antarctic krill biotechnology industry is accompanied with high degree of uncertainty related to continuing ambiguity of the ownership of genetic resources of the high seas. Although the Antarctic Treaty System has now made it legal to bioprospect for profit resources found there, it was designed originally to ensure the Antarctic would be available for scientific exploration, free of conflict or contest, for the good of all. Although this principle was affirmed in the recent BBNJ Agreement in terms of benefit sharing, the issue of ownership of the high seas genetic resources was left intact, reflecting in microcosm the conflicting ideological positions in the North between the "open access" positions defended by the developed countries versus the "commons" approach advocated by the developing world (Feng, 2026). Antarctic krill exemplifies fragmentation in the current legal system, since the same species can be subject to completely different regulations according to whether it is being used to derive genetic information or whether it is krill biomass that is being harvested. However, when attempting to make sense of the intricate web of rules and regulations, the main question that arises with regard to patent law is of a more fundamental nature: If the genetic materials found of the high seas are res nullius, can they still be considered to be owned in the context of a patented invention that employs them?

Rules on Resource Utilization in Antarctic Treaty System

The relevant legislation for Antarctica includes international treaties that apply to Antarctica. The Antarctic Treaty 1959, which provides the basic framework in international law for actions in Antarctica, includes the promotion of scientific research and prohibits actions which are not for peaceful purposes (Section 1). It provides for unrestricted sci-

entific investigation in Antarctica, allowing freedom of investigation in all places save Areas under the jurisdiction of any other country, and stipulating that the results of such investigations shall be widely publicized. The Antarctic Treaty does not cover non-exploitation of the biological resources which may be found by the contracting parties. The Madrid Protocol 1991 (which incorporates Annex V) considers Antarctica as a natural reserve, to be used exclusively for peaceful purposes in the interests of science and for furtherance of international co-operation, as well as containing some specific environment protection measures. In particular, Annex V of the Protocol, while establishing provisions for Antarctic Specially Protected Areas, again fails to mention biological prospecting. The 1980 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) was the first in its regional scope to establish a governing regime for the southern Antarctic Marine Living Resources. In all Marine Protected Areas, Article II of the CCAMLR permits the taking of some of the marine resources, thereby ensuring a balance between marine conservation and the principle of "rational use" that justifies exploitation of the marine resources. CCAMLR has developed a krill harvesting strategy that allows for the establishment of limits, subareas, and monitoring the impact of the harvesting on the ecosystem. However, until now krill has largely been treated as a fishery, rather than a genetic resource. While biological and data considerations are important for the regime, observations indicate that the analysis has transcended biological considerations, confirming the need for an analytical framework that incorporates genetic/resource considerations.

Institutional Innovations and Enduring Issues of the BBNJ Agreement

The BBNJ Agreement endorsed by the United Nations General Assembly, which includes the United Nations Law of the Sea, is envisaged for the protection and sustainable use of biodiversity. Considering the preceding two-decades-long negotiation process, it is a pioneering achievement for international treaty negotiations that opens the issue of plastics and other wastes on the high seas. Since the BBNJ Agreement will be a key normative document in the international regulation of the high seas, it will be have important implications for international law. For many non-governmental organizations, it gives them a platform for protest due to opening the high seas for litigation. While this Agreement does not completely accommodate the concerns of developing nations that prioritize collective heritage, it equally fails to accommodate the concerns of developed nations that prioritize liberalism of the high seas, taking a middle position between the two. Thus, in terms of benefit distribution, the Agreement adopts a dual approach. In the case of monetized benefits, a percentage of such revenues are to be placed in a fund aimed at strengthening developing countries. Non-monetized benefits are equally captured in this Agreement.

Different Views Between Developed and Developing Countries

The conflict between the interests of developed vs. developing nations with regard to the regulation of marine genetic resources in jurisdictional grey areas forms the crux of contemporary debates. The viewpoint generally expressed by developed nations is that the principle of freedom of the high seas

should apply to resources that are located beyond national jurisdiction, implying that such resources should be freely exploitable. According to this logic, innovations connected with the exploitation of marine resources are considered patentable. The argument is advanced on the basis that, because the UN Convention on the Law of the Sea reflects the principle of freedom of the high seas, this should preclude any regulation of the corresponding genetic resource. Conversely, the developing nations represented by the Group of 77 more strongly advocate the principle of common heritage of mankind, typically arguing that the genetic resources of the high seas are a common heritage of mankind and should not be exclusively utilized for the profit of developed nations and their transnational corporations. This concern falls within the scope of current global inequities. Indeed, recent studies indicate that 90% of the world's patents for marine genetic resources belong to the top 10 developed countries, with three of them controlling almost 70% of the patents, in the same fashion as the patenting of human and plant genes (Arnaud-Haond et al., 2011).

According to this scenario, researchers are now considering the prospect of compromise. Some studies indicate that non-monetary benefit-sharing may have greater potential for resolving the conflict than approaches that focus on monetary benefit-sharing (Humphries et al., 2021). Provided that these approaches are designed properly, they could potentially resolve the commercial logic of patenting that countries of the North have with the interests of the South to participate more significantly in marine genetic research. In the long term, such compromise approaches may aid in the creation of a more inclusive and equitable system.

Conceptual Divide Between Fisheries and Genetic Resources

Antarctic krill are a special case that demonstrates the ambiguity in high seas genetic resource management. As a general rule, krill is regarded as a fisheries resource, which fall under the regulation of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). There are a number of harvesting activities regulations including an annual catch limit, a set number of quotas for specific regions, and impact assessments for the harvesting of all living marine resources. In the previous 2023–2024 fishing season, the total reported krill catch was 500,000 metric tons, which is very close to an interim catch limit of 620,000 tons. According to the interim limit set, the legal status becomes more ambiguous if krill is treated as a resource of genetic material. While the management of "harvesting" falls within the scope of CCAMLR's mandate, this organization lacks the institutional and jurisdictional resources to manage the fallout from any biotechnical modifications to the genetic code of krill or the intellectual property rights that may arise from such modifications. Meanwhile, the Antarctic Treaty System is also silent on the potential to regulate such prospecting.

Patent Eligibility of Antarctic Krill Biotechnology Inventions

Biotechnological patents involving Antarctic krill are likely to satisfy the three most traditional requirements of patentability, including novelty, inventive steps, and utility. The prior disclosures of the sequences of Antarctic krill and other biotechnological advancements do not wholly eliminate novelty. Since the inventive step can be demonstrated through additional validation, utility

can always be shown by a potential industrial use. While biotechnological advances involving Antarctic krill do demonstrate potential utility, a tension between the publicly accessible genetic materials circumscribed by the private grant and exclusivity of patents demonstrates a deeper issue of justice (Mao et al., 2024). The concomitance of the current patent regimes and the rapidly evolving theories of the oceans' genetic resources being labeled the "common heritage of mankind" is a question of patent justice. From the perspective of developing nations, in order to achieve such patent justice, it becomes necessary to think outside of the traditional confines of patent law to consider the incorporation of elements of a benefit-sharing system.

Basic Criteria for Patent Eligibility

The eligibility of patents has to do with how an invention complies with patentability criteria. Regarding international law, the most recent guidance on eligibility under the TRIPS Agreement, Article 27(1), outlines that patents must be available for an invention in any field of technology as long as it is not reiterative (i.e., is genuinely novel), demonstrates a creative contribution (inventive step), and is useful (capable of industrial application). Member states may choose to implement "inventive step" as "non-obviousness" and "industrial application" as "utility". It is noteworthy that the TRIPS Agreement does not include a definition for "invention". The omission of such a definition is significant due to the considerable amount of leeway it allows in terms of national legislation.

The Status of Prior Art Regarding Genetic Resources from the High Seas

When assessing novelty, it must also be taken into account whether the invention has been made public. As far as any invention based on Antarctic krill genes is concerned, it must be considered whether the gene sequences that are being deposited in the Gene Bank Database constitute prior art. Public disclosure of gene sequences does not constitute prior art because the sequences cannot be used by another person to make the invention. The Antarctic krill genome is known due to having recently been described in the scientific literature. However, functional genes were not made public before; moreover, even after the genome was published, the fact that the location of the genes has been made public does not prevent others from making claims to the functional genes that have not been made public.

The Leap from "Discovery" to "Invention"

The evaluation of inventive step is still the highest legal hurdle in determining whether genetic inventions are patentable or not. Indeed, the test for patentability of genetic inventions is quite straightforward: is the functional characterization of Antarctic krill gene expression an invention that can be protected by patent law? Thus, the transition of a discovery to the level of invention involves the need to pass the test for inventive steps. More generally, the transition from discovery to invention can be made in a number of ways. At first, Functional Validation of Gene Expression transfers abstract concepts – mostly having originated in computer-simulated studies – into reality-based information on gene expression. The second hurdle to be overcome is the need to demonstrate technological advances, which must include native sequences changes, expression systems optimization or genes combinations lead to the new traits absent in nature. In the third place, applica-

tions-oriented research and developments, which in some cases may actually involve the industrial application of gene expression (e.g., antifreeze protein in food processing), serve to relate what has been invented to its respective inventiveness. Indeed, the discovery of a gene (regardless of the genomic level of organization to which that gene belongs) should, for the time being, conjure only visions of what is new and interesting.

Possibilities and Limits of Industrial Application

The utility requirement differs from other requirements: although it creates fewer disputes, it maintains equivalent significance. In this situation, the requirements for the invention become apparent. The system must operate in industrial environments because it needs to deliver specific results through its manufacturing capabilities. There should be a defined purpose and practical application for inventions that rely on genetic material.

In order to fulfill utility requirements, an invention arising in the course of Antarctic krill research must demonstrate actual or expected application. The phrases "may be useful" and "has potential" do not meet requirements in this situation. The application of the invention must provide sufficient information to show skilled experts that it can achieve its designated functions. The available evidence establishes that krill genetic material can provide actual or expected applications. Antifreeze proteins function as effective agents for preserving food through their use. Enzymes exist which can initiate the synthesis of essential fatty acids that have economic value. Bioactive peptides possess therapeutic potential for disease treatment and blood pressure management. Krill biotechnology has attracted commercial interest from various business entities.

From Exclusive Patent Rights to Equitable Benefit-Sharing

The main challenge in the governance of genetic resources of the high seas has transformed from a consideration of the legitimacy of patenting to potential of striking a balance between private exclusive rights and the public good (Puig-Marcó, 2014). A new governance system is being developed in international settings which moves beyond proprietary systems to protect public interests according to prudent governance principles. The future will determine whether the patent system maintains its validity while evaluating how private and public goods obtain their value through financial and non-financial methods. Thus, while the patent system permits biotechnological inventions to receive protection in the Antarctic marine context, any benefits accruing as the result of such developments must also serve public interests (Xu et al., 2025).

Coordination Attempts Within the Existing Institutional Framework

The BBNJ Agreement entered into binding force on 14 December 2017. Thus, the present study focuses on the substantive effect of its binding rules and regulations having become applicable upon its entry into force. The current research on this topic mainly revolves around the relationship between the CBD and TRIPS Agreement. This research mainly centers on the complete disclosure method, which requires the disclosure of origin at the stage of patent examination. On the basis of their respective interests, India and Brazil proposed at the TRIPS Council of the WTO

in the 2000s that patent applicants have to disclose and provide proof that the genetic resources they utilized were obtained from countries of origin of genetic resources in accordance with national legislation, including a statement that they have obtained the necessary informed consents. Patent applications shall be rejected if applicants fail to prove that they obtained genetic resources in accordance with national laws and regulations of the country of origin of such genetic resources.

The study of compulsory licensing and fair use copyright has been established such principles as forming a potential solution to issues concerning the exploitation of genetic resources of the high seas. The TRIPS Agreement permits patented inventions to be used without patent owner permission under specific conditions. The system enables developing countries to obtain technology which utilizes genetic resources. The system of compulsory licensing exists to protect patent rights which become active after a patent is granted. The system does not solve the main issue which deals with the legitimate use and access of genetic resources. The system functions in a restricted manner because of its inherent structure.

The recent period has seen database protection together with digital sequence information protection as the main conflict point in ongoing discussions. The scientific community faced a conflict between its established practice of providing free access to gene sequence databases and the risk that digital sequence information databases could become protected or create mandatory benefit-sharing requirements. The BBNJ Agreement achieved legal clarity through its inclusion of digital sequence information.

Redesigning Benefit-Sharing Under the BBNJ Agreement

The BBNJ Agreement mainly focuses on the main part of the Agreement dealing with the rules for distribution of the benefits arising from the use of marine genetic resources. This part contains the most important institutional innovations. The benefits are distributed in the form of financial benefits when the economic use of the MGRs reaches a certain level and some of the benefits are channeled into a special fund. The aim of the fund is to be used for capacity building of developing countries and also for the conservation of MGRs of the high seas. This way the unequal distribution of benefits to developing countries arising from the genetic resources is avoided.

The BBNJ Agreement provides economic benefits and other benefits that are not economic in character. This means that developing countries can obtain many practical benefits from unused genetic resources in terms of study and achieved capacity development. Since the period for genetic resources to enter the market can be long, the potential returns on such efforts are highly speculative.

The BBNJ Agreement uses a fair method to solve problems related intellectual property rights. The BBNJ Agreement recognizes the existing IP system and the significance of patents as drivers for innovation. The benefit-sharing mechanisms will permit access to high seas genetic resources that will serve the common good of all people. The Agreement extends its coverage to digital sequence information which prevents developed countries from restricting its application to genetic resources only.

Establishing a Special Safeguard Mechanism for High Seas Genetic Resources

After discussion of the legal aspects of the new BBNJ Agreement, it is necessary to elaborate on the procedure of establishing new institutional mechanisms to attain the goal of the treaty through effective methods. It is considered that the main way to gain economic advantages of the high seas Gene-tic Resources Fund will be mentioned in this discussion. Article 52 of the treaty explicitly states that the fund will receive monetary contributions from the Parties so that the marine genetic resources are maintained. This trigger mechanism will provide a stable financial base for the operation of the fund, as it automatically comes into effect when the patent income exceeds a predetermined limit.

The system needs strong source registration procedures due to the vital role that they play in tracking and upholding the benefits sharing system. The adoption of the Treaty on Intellectual Property Genetic Resources and Related Traditional Knowledge on May 2024 at the World Intellectual Property Organization (WIPO) Diplomatic Conference marked a crucial achievement in this area. The treaty requires inventors to disclose information about the genetic resources used in their invention when their invention directly relies on those resources. The implementing regulations will address the issue of high seas genetic resources due to the current lack of a sovereign jurisdiction that is competent to designate a source for such resources.

The research process and its subsequent commercialization process require regulation through Material Transfer Agreements. MTAs enable research centers to establish benefit-sharing requirements which their Antarctic krill research results will bring about through future commercialization. The framework becomes more complex as a result of new technologies which include IP-NFTs. The smart contracts will create monetary donations to the specified fund when BBNJ approval IDs exist in the metadata of these NFTs and commercial milestones which have been predefined are reached.

The framework of open innovation functions as a regulatory system for controlling high seas genetic resource inventions. This framework helps to solve the conflicts that occur between exclusive rights and knowledge dissemination because it enables organizations to maintain their proprietary technologies. Non-patent methods that follow open innovation principles and open-source biotech methods can support knowledge sharing for specific high seas genetic resource inventions while solving equity problems that arise from private monopolization.

The Interface Between International and Domestic Law

The BBNJ Agreement achieves its high aspirations through its implementation by various countries through their respective domestic legal systems. China became a BBNJ Agreement signatory when it ratified the treaty and submitted its necessary documents to the United Nations on 15 December 2025, positioning China among the first countries to ratify the BBNJ Agreement. The process requires China to implement BBNJ Agreement benefit-sharing rules through domestic laws, which will allow their enforcement by Chinese judicial and administrative bodies. Different countries exhibit different methods of implementing the BBNJ Agreement through their national treaties. For example, Brazil and India possess

extensive experience in genetic resource regulation, which is used to develop their domestic laws for participating in the BBNJ Agreement process. The fourth amendment to Patent Law in China establishes a legal requirement for patent applicants to reveal genetic resources according to existing case law, which serves as an example of this situation. According to some experts, the development of China's marine law system should base its foundational structure on the country's BBNJ Agreement implementation.

The patent examination guidelines require special attention needed for their examination process. Following WIPO treaty ratification, patent offices must confirm the validity of disclosed source information and decide on penalties for cases of non-compliance. The traditional definition of national source, which currently requires prior informed consent to access high seas genetic resources, should be replaced by a new approach. In this connection, it is recommended that the BBNJ information exchange mechanism require patent applicants to submit their source registration codes as proof before their applications can proceed to examination.

In addition to the legal framework, companies operating in the Antarctic krill fishery might consider developing codes of conduct as a means to implement benefit-sharing principles in jurisdictions where compliance is left to interpretation. Such mechanisms deliver two advantages: not only do they establish an industry standard that promotes responsible development, but they also create real-world scenarios which will help establish future formal regulations.

Conclusion

The development of Antarctic krill from traditional fishery product into important genetic material has created new opportunities for biotechnological research. The situation has created a primary legal conflict, which requires resolution through applicable legislation. Although krill gene sequence inventions meet the official criteria for novelty, inventive step, and industrial applicability, the fundamental issue emerges about whether private patent rights can exist for genetic materials obtained in regions outside national control, which are the objects of disputes between the common heritage of mankind and the freedom of the high seas. The existing legal system permits no direct solution to this inquiry. The Antarctic Treaty Regime does not provide any applicable regulations for bioprospecting activities. While the BBNJ Agreement establishes benefit-sharing requirements, it does not determine whether the resources in question have legitimate status. The resolution of this conflict requires an examination of integrated benefit-sharing methods that maintain patent functions to ensure that genetic resource exploitation in international waters serve the needs of all humanity. The main obstacle exists between developing this principle into operational regulations which function across multiple national legal systems.

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