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Pampa Azul Initiative:
Post-normal Science for Coastal and Marine Stewardship

Iniciativa Pampa Azul:
ciencia post-normal para la gestión costera y marina

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Abstract

The future of humanity is closely linked to the ocean, whose importance is being accentuated by the growing demand for resources and by the decrease of land-based sources. Studying the Argentine Sea is key for developing conservation policies within the framework of sustainable development.

The Pampa Azul Initiative (IPA by its acronym in Spanish), which was launched in Argentina in 2014 by seven national ministries and then was called off in December 2023, was aimed at integrating scientific research, technological development, and innovation in coastal-marine areas. Its focus was on the sustainable stewardship of estuarine, coastal, and marine zones, applying the Post-Normal Science principles. A key example of IPA's work is the Marine Spatial Planning (MSP) process, the first of its kind in Argentina and in the Southern Cone. The MSP process described in this work demonstrates the complex challenges of managing marine resources, in a context where facts are uncertain, values are contested, stakes are high, and decisions must be taken urgently.

Pampa Azul was an innovative approach for scientific research and sovereign technological development, driven both by knowledge and responsibility towards the national social and environmental needs of the 21st century.

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Marine Spatial Planning, post-normal science, science-policy interface, Pampa Azul Initiative, argentine sea, Malvinas

Resumen

El futuro de la humanidad se encuentra íntimamente ligado al océano, cuya importancia se ve acentuada por la creciente demanda de recursos y la disminución de fuentes terrestres. El conocimiento del mar argentino es fundamental para desarrollar políticas de conservación en el marco del desarrollo sostenible.

La Iniciativa Pampa Azul (IPA), lanzada en la Argentina en 2014 por siete ministerios nacionales y suspendida en diciembre del 2023, tuvo como objetivo integrar la investigación científica, el desarrollo tecnológico y la innovación en áreas costero-marinas. Se enfocó en la gestión sostenible de zonas estuariales, costeras y marinas, aplicando principios de la ciencia post-normal. Un ejemplo clave de su trabajo es la Planificación Espacial Marina (PEM), primera de su tipo en Argentina y el Cono Sur. El proceso PEM, descrito en este trabajo, evidencia los desafíos complejos de la gestión de los recursos marinos en un contexto donde los hechos son inciertos, los valores están en disputa, hay mucho en juego y las decisiones deben tomarse con urgencia.

Pampa Azul representó un enfoque superador para la investigación científica y el desarrollo tecnológico soberano, impulsado tanto por el conocimiento como por la responsabilidad frente a las necesidades ambientales y sociales nacionales del siglo XXI.

Palabras clave

Planificación Espacial Marina, ciencia post-normal, interfaz ciencia-política, Iniciativa Pampa Azul, mar argentino, Malvinas

Introduction

Is the future of humanity rooted in the ocean? With the rising demand for resources and diminishing land-based sources, there is a growing anticipation of the ocean playing a pivotal role in human development. While staking claims on marine resources and space is not a novel concept, the present-day aspirations are unparalleled in terms of their extent, intensity, and diversity (Jouffray et al., 2020, 2021). Termed as the *blue acceleration*[1] it characterizes a competition among various and often conflicting interests for oceanic food, materials, and space (Jouffray et al., 2020). Understanding the implications of this new reality for the global ocean and determining how to navigate it sustainably and equitably pose an urgent challenge (Jouffray et al., 2021).

The burgeoning ability to industrialize the ocean presents a pressing challenge: unprecedented cumulative pressures on marine ecosystems from human activities and climate change (Halpern et al., 2019; Intergovernmental Panel on Climate Change [IPCC], 2022; McCauley et al., 2015). From ocean acidification and marine heatwaves to plastic pollution and disrupted ecological connectivity, these threats transcend political borders, demanding a united front for sustainable ocean governance (Merrie et al., 2014); and Argentina is not exempt from these problems (Ministerio de Ambiente y Desarrollo Sostenible de la Nación, 2021).

Argentina's coastline is vast, stretching a total of 16,050 km, this includes 4,725 km along its mainland and 11,325 km in the Antarctic territories and southern islands. The marine area under Argentina's jurisdiction covers a large extension of 6,683,000 km2. Notably, the Argentine Continental Shelf near the mainland and islands alone makes up a significant portion of this, at 3,744,000 km2, representing a remarkable 56% of the total marine space. The Exclusive Economic Zone of Argentina is home to commercial fisheries, hydrocarbon basins and mineral deposits of great economic relevance. Likewise, the Argentine Sea is an important potential source of marine energy (Weiss et al., 2018).

Argentine maritime spaces include ecosystems whose biological richness is comparable to that of the most important terrestrial ecosystems. However, the biodiversity of the Argentine Sea is being increasingly exposed to pollution generated by coastal urbanization, hydrocarbon industry, extractive and transportation activities, and the incidence of illegal, undeclared, unregulated or unsustainable fishing activities, among others (Macfadyen et al., 2019; Gil et al., 2019; Ministerio de Ambiente y Desarrollo Sostenible de la Nación, 2021). Likewise, climate change caused by human activities is promoting transformations that could be irreversible such as acidification, more intense marine heat waves and loss of oxygen, with an unknown impact on biodiversity.

Around 700 vertebrate species have been reported in Argentine marine areas, including at least 112 Chondrichthyes, 418 Osteichthyes, 82 seabirds, 55 marine mammals and four sea turtles. According to the International Union for Conservation of Nature (IUCN), a significant number of these species are threatened with extinction, including all sea turtles, a large number of seabird and marine mammal species, and a growing number of sharks and rays (Ministerio de Ambiente y Desarrollo Sostenible de la Nación, 2021). Among invertebrates, mollusks alone comprise ca. 900 species. Some 1,400 species that make up the zooplankton and more than a thousand species included in the phytoplankton have also been described. The microbiological heritage is relatively unexplored although its value as a potential indicator of contamination. Despite the biodiversity contained in these waters, the country still does not have a characterization and monitoring program of the genetic resources in deep waters and the seabed.

Both the estructural and functional characterization of marine ecosystems and the pluralistic valuation of their services or contributions to people, particularly on the productive marine fronts, constitute an essential condition for the sustainable practice of socio-economic activities. This is essential in a context of global climate

change that irreversibly affects both the biodiversity of species but also those human activities, and the diversity of healthy ways of inhabiting the planet manifested by minority groups or more informal sectors of the economy (e.g. artisanal fishing, and sustainable tourism ventures) (see Sala, 2022, for a discussion on this).

Although considerable scientific information is available on the species of greatest conservation interest (e.g., charismatic species and/or species with a higher risk of extinction), knowledge about the entire large marine ecosystem is still limited (Gil et al., 2019). Then, knowing the Argentine Sea is essential to establish policies for the conservation and management of natural and cultural heritage under the sustainable development paradigm (Sala et al., 2023). The Pampa Azul Initiative was created in 2014 in order to promote the systematic exploration and sustainable management of this heritage as a strategic national objective (Sala, 2018).

This essay seeks to examine the main characteristics of the Pampa Azul Initiative (PAI), implemented in Argentina from April 21, 2014, to December 10, 2023, highlighting its potential to create spaces or “agoras” suitable for the application of post-normal scientific practices (sensu Funtowicz and Ravetz, 1993). These practices promote pluralistic, participatory, and democratic approaches to the governance and management of Argentina’s coastal and marine spaces. To achieve this objective, the work begins by presenting initiatives comparable to PAI, developed in other countries of the Global South. It then outlines the differential epistemological features of PAI and its post -normal character. Subsequently, the example of the Marine Spatial Planning (MSP) process initiated in Argentina in 2022 –the first of its kind in the Southern Cone region– is used to illustrate the post-normal nature of PAI. The essay concludes with reflections on the importance of State policies such as PAI, where post-normal, inclusive, and pluralistic scientific processes were developed for the sustainable stewardship of the submerged national territory and its coast.

Pampa Azul Initiative: Science at the service of national sovereignty

The Pampa Azul Initiative[2] (PAI) began to be implemented in Argentina in August 2014, through an agreement between seven national ministries (i.e., science; environment; agriculture, livestock and fishing; tourism; chancellery; defense; and security). The main purpose of the PAI was to articulate the actions promoted by the different areas of the National State in everything related to scientific research, technological development and innovation at sea. After a strong paralysis between the end of 2017 and the end of 2019; in July 2020 it was relaunched, during the COVID19 pandemic, according to the guidelines of the new national public administration. Their meta-objectives for the relaunch were: 1) deepen scientific knowledge as a basis for the construction of public policies for the conservation and stewardship of our coastal and marine natural commons; 2) promote technological innovations applicable to the sustainable use of national natural commons and the development of industries linked to the Argentine Sea and its coasts; and 3) strengthen the maritime awareness of Argentine society and support the sovereignty of this country in the Southwestern Atlantic region with information and scientific presence (see Bilmes and Sala, 2022; Sala et al., 2023). After nearly four years of a virtuous process of strengthening (see Sala et al., 2023), with the arrival of President Javier Milei to the National Government in December 2023, the PAI, like most strategic state programs, was completely deactivated, underfunded, dismantled, and annulled in its entirety.

In its initial stage, the PAI delineated five Priority Geographic Areas (PGAs) to focus marine and coastal research: 1) Río de la Plata Estuary System, 2) San Jorge Gulf and North Patagonian Frontal System, 3) Blue Hole-Continental Slope, 4) Southern Atlantic, and 5) Subantarctic Islands [Figure 1]. The selection of these areas was explained by the spatial heterogeneity of the ocean, which made an exhaustive study of the Argentine Sea unfeasible and necessitated focusing on sectors of particular scientific, ecological, and political relevance. Although at first the PGAs covered considerably smaller

surfaces, the continuity of PAI as a State policy over a decade –with fluctuations until December 2023 (see above)– allowed a significant expansion of the research territories (see Sala et al., 2023) [Figure 1].

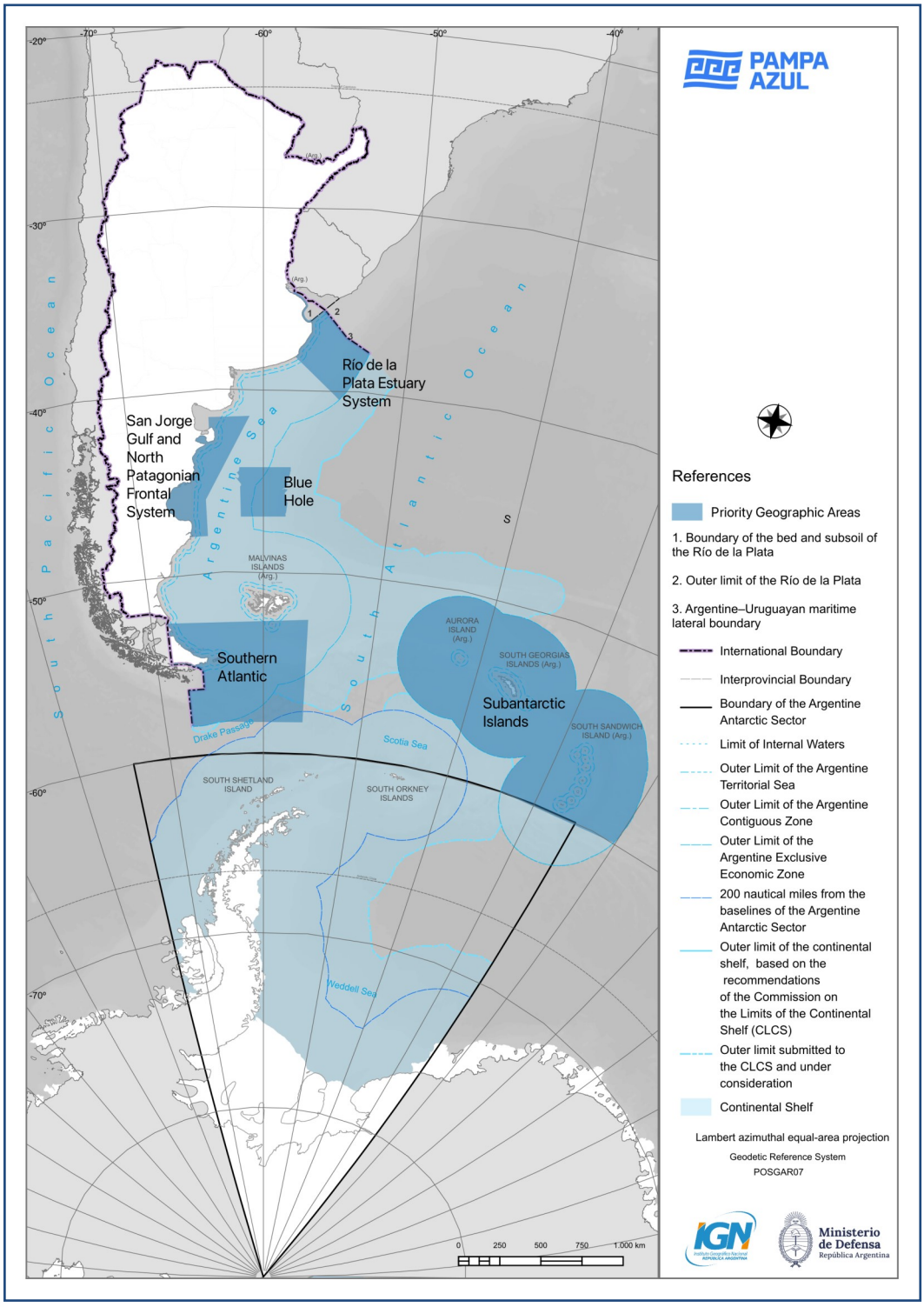

Figure 1. Delimitation of the new Priority Geographic Areas (PGAs) defined by the Pampa Azul Initiative as focal research regions. Source: own elaboration

The PGAs were distinguished by their high biological productivity, remarkable biodiversity, central role in the life cycles of commercially valuable and conservation-relevant species, as well as their contribution to climate regulation and, in certain cases, their geopolitical or federal significance. Each of them presented a unique identity, shaped by natural, economic, and political factors, and constituted complex social-ecological systems in which human and natural dimensions converged in an interconnected manner. Their analysis required transdisciplinary approaches capable of integrating scientific research with the examination of productive activities and ecosystem services.

Understanding the dynamics of the PGAs was essential to ensure the sustainability of ecosystems and human activities that took place within them. This entailed addressing key questions regarding biological production and its transfer through food webs, biodiversity patterns and their role in community resilience, the role of PGAs in the life cycles of species, the anthropogenic threats they faced, and their contribution to the carbon balance. All these aspects were intertwined with the potential impacts of global climate change.

Furthermore, several PGAs held outstanding geopolitical importance, among them the Subantarctic Islands, the Southern Atlantic, the Río de la Plata Estuary System, and the Blue Hole-Continental Slope. In the case of the San Jorge Gulf and the North Patagonian Frontal System, their value lay in articulating efforts between the national government and the provinces of Chubut and Santa Cruz, thereby promoting the federalization of research. Knowledge generation under an ecosystem-based approach, particularly regarding fisheries, made it possible to develop alternative scenarios for public policy design and provided the basis for assessing the impacts of activities such as fishing, hydrocarbon exploration and potential exploitation, mining, as well as processes associated with climate change.

In relation to the objectives of this work and from a geopolitical perspective, it was relevant to highlight the role of the Southern Atlantic and Subantarctic Islands PGAs [Figure 1]. The Southern Atlantic PGA

covered approximately 373,854 km² and was organized around three main nuclei: the Namuncurá-Burdwood Bank and Yaganes Marine Protected Areas (MPAs), and the Beagle Channel, which encompassed a significant portion of the territory under dispute with the United Kingdom of Great Britain and Northern Ireland (UK) [Figure 1]. Burdwood Bank, a submerged plateau east of Tierra del Fuego and south of the Malvinas Islands, was declared an MPA in 2013 (Law 26.875) and represented a site of high benthic diversity and endemism, with significant scientific interest due to its ecological processes and complex oceanographic dynamics. The Yaganes MPA, established in 2018 (Law 27.490), was characterized by its complex bathymetry –including canyons and seamounts– which fostered high productivity and biodiversity, functioning as a fundamental feeding and breeding ground for numerous species. The Beagle Channel, a strategic passage between the Atlantic and Pacific Oceans, combined glacial and tectonic geomorphological features within an estuarine environment of remarkable physical-chemical heterogeneity, with growing demand for ecosystem services by local and international actors (tourism, green hydrogen, fisheries, and aquaculture).

The research objectives of this PGA included: examining the role of the area in carbon reservoirs and fluxes; studying the connectivity between terrestrial, marine, and offshore carbon reservoirs; evaluating carbon transport to deep waters; comparing responses to climate change in Beagle, Yaganes, Burdwood, and the Drake Passage; characterizing benthic diversity and functionality in slopes and deep waters, considering their connections with the Blue Hole [Figure 1]; and providing information to apply the ecosystem approach to fisheries management.

In terms of research, the creation of the Namuncurá-Burdwood Bank MPA enabled the funding of 16 oceanographic campaigns in the region, with the participation of 19 institutions –three of them international– and a total of 144 researchers and technicians. These surveys provided fundamental data on biodiversity, oceanographic

processes, and ecological connectivity, consolidating a strategic scientific foundation for the management and conservation of this subantarctic space (see Sala et al., 2023).

The other geopolitically significant PGA corresponded to the Subantarctic Islands, which included the archipelagos of South Georgia and South Sandwich, integrated into the Scotia Arc, within an area of more than 1.2 million km² [Figure 1]. This once again represented a substantial portion of the national territory in dispute with the UK, along with the Malvinas/Falkland Islands (Ortega, 2024). This region exhibited high biological productivity, great fisheries wealth, and relevance for climate regulation, under the influence of the Antarctic Circumpolar Current and the sea ice field. Despite their proximity, there were marked environmental differences between the archipelagos: the South Sandwich Islands, volcanic and uninhabited, with active volcanism and strong seismicity; and South Georgia, mountainous and glaciated, where human activities related to tourism and fisheries were present. These islands constituted the northern limit of the distribution of Antarctic krill (*Euphausia superba*), a key species in Southern Ocean ecosystems, together with exploited resources such as Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*). In this context, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR, 1982) set the guidelines for conservation and sustainable exploitation, with Argentina playing an active role.

The objectives of the Subantarctic Islands PGA focused on assessing the impacts of climate change on species distribution, analyzing the conservation status of marine resources, and providing scientific evidence to CCAMLR to ensure the sustainability of fisheries. Following campaigns conducted in the 1970s and 1990s, in 2023 Pampa Azul coordinated a new campaign aboard the Fisheries and Oceanographic Research Vessel Víctor Angelescu of the National Institute of Fisheries

Research and Development (INIDEP, by its Spanish acronym). This survey was aimed at studying juvenile Patagonian toothfish, mackerel icefish, and the ecological dynamics of the area, including physical, chemical, biological, and pollution parameters (microplastics) (Sala et al., 2023).

In addition to the territorial deployment, the activities, interests and capabilities of the different organizations and agencies of the seven ministries were articulated in Pampa Azul, e.g., National Scientific and Technical Research Council (CONICET), INIDEP, Argentine Navy, Argentine Naval Prefecture, National Geographic Institute (IGN), Argentine Antarctic Institute (IAA), National Parks Administration, among others; along with other external, e.g., National Universities, Secretariat of Energy, Argentine Mining Geological Service (SEGEMAR), among others; and the subnational governments, i.e., provinces and municipalities of the Argentine Atlantic coast; the private sector, e.g., Applied Research Society of the State (INVAP), shipyards, fishing chambers, among others; and civil society organizations, e.g., Regional Assembly in Defense of the Coastal Environment - AREDAC (Bilmes and Sala, 2022; Sala et al., 2023). All of this constituted a true institutional innovation at the global level, especially in the Global South, in terms of the sustainable stewardship of nations' sovereign maritime territories, as we will see below.

Brief comparative analysis of Pampa Azul-like initiatives in the Global South

Based on a review of the scientific literature, this section aimed to identify initiatives comparable to Pampa Azul implemented by countries in the Global South, considering similarities in material and human resources as well as macroeconomic conditions shared by these nations. Although few publications explicitly identify and describe initiatives analogous to Pampa Azul (e.g., Garcia et al., 2014 and references therein), five comparable initiatives were identified in Brazil, China, Indonesia, the Philippines, and South Africa. The key features of these initiatives, along with their similarities and differences with the PAI, are summarized in Table 1. Notably, Brazil and China were selected for further analysis due to their significant alignment with the objectives and framework of the PAI.

Table 1. Summary of the comparative analysis between initiatives similar to Pampa Azul deployed throughout the Global South. Source: own elaboration

Country	Program name	Overview	Similarities with Pampa Azul	Differences with Pampa Azul	References
Brazil	National Policy on Marine Resources (PNRM)	Launched in 1989. Focuses on sustainable marine resource management, marine research, and technological development. Coordinated by the Interministerial Commission for Marine Resources (CIRM), under the oversight of the Navy.	Focus on marine research and sustainable development; Interministerial coordination; Strategic prioritization of marine resources.	Relies on sectoral policies without an overarching integrated national strategy; Coordinated by the Navy, emphasizing military oversight.	Roth, 2015

China	State Oceanic Administration (SOA)	From 2014 to 2018, the State Oceanic Administration (SOA) served as a centralized governance body overseeing China's vast maritime domain, including internal seas, territorial waters, and exclusive economic zones. Reporting directly to the State Council, the SOA reflected the strategic importance of China's maritime interests, encompassing responsibilities such as law drafting, marine spatial planning, resource management, environmental protection, and national security. It integrated diverse functions, including regulating island development, addressing marine pollution, and enforcing laws against crimes like smuggling and illegal immigration, ensuring cohesive management across the maritime jurisdiction. This centralized model enabled rapid decision-making and enforcement to address complex issues such as maritime disputes and environmental degradation. The SOA also prioritized strategic planning and inter-agency coordination, particularly through functional zoning and collaboration with local enforcement, supporting national goals for marine economic development and ecological sustainability. In 2018, its functions were absorbed into the Ministry of Natural Resources, ending the SOA's role as an independent institution.	Focus on marine research and environmental protection; Strategic prioritization of national maritime interests; Inter-agency coordination at a high administrative level.	Highly centralized and autonomous structure with direct reporting to the State Council; Strong emphasis on national security, maritime sovereignty, and enforcement, which contrasts with Pampa Azul's more conservation-driven approach.	Garcia et al., 2014; Halpern et al., 2015; Chang y Li, 2019

Indonesia	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF)	Regional initiative launched in 2009 with Indonesia playing a key role, but which includes the Philippines, Malaysia, Timor-Leste, Papua New Guinea and the Solomon Islands. Aims to conserve coral reefs and associated ecosystems, enhance food security, and promote biodiversity conservation through inter-ministerial and international cooperation.	Conservation of marine biodiversity; Emphasis on research and regional cooperation; Coordination among ministries and international stakeholders.	Focuses heavily on local community engagement and climate adaptation, areas less emphasized by Pampa Azul.	Garcia et al., 2014; Halpern et al., 2015
Philippines	Integrated Coastal Zone Management Program (ICZM)	Coordinated by the Department of Environment and Natural Resources (DENR). Focuses on sustainable coastal management, climate change mitigation, and the protection of biodiversity while engaging local communities. This led to the National Strategy for Coastal and Marine Zone Management, formalized in 2001, which laid the foundations for the integration of efforts in coastal planning.	Protection of coastal ecosystems; Integration of science and management; Multi-sector participation with emphasis on community engagement.	Focuses heavily on local community engagement and climate adaptation, areas less emphasized by Pampa Azul.	Garcia et al., 2014
South Africa	Operation Phakisa: Oceans Economy	Launched in 2014. Aims to accelerate the development of marine-related sectors like aquaculture, coastal tourism, and offshore mining while ensuring environmental sustainability. Led by the Department of Environment, Forestry, and Fisheries.	Promotion of sustainable marine economic sectors; Use of scientific research to inform policy; Coordination across ministries to streamline actions.	Stronger focus on economic growth and development of marine industries compared to Pampa Azul's balanced approach.	Garcia et al., 2014; Halpern et al., 2015; Vreÿ, 2019

Brazil and China exhibit distinct approaches to coastal and marine governance, shaped by their geographic, economic, and political contexts. While Brazil emphasizes sectoral policies coordinated through interministerial frameworks -as was the case for Pampa Azul- China operates with a centralized, highly autonomous administrative structure to manage its vast maritime domain (Garcia et al., 2014; Halpern et al., 2015; Roth, 2015; Chang and Li, 2019).

Brazil's maritime governance centers on the “Blue Amazon”, reflecting the strategic importance of its approximately 8,500 km coastline and resource-rich continental shelf. Although the country lacks a unified National Maritime Strategy as Pampa Azul, its “Política Nacional de Recursos do Mar” (PNRM) partially compensates by providing a framework for sustainable use and exploration of marine resources (Roth, 2015).

The PNRM, first publicized in 1989 alongside the “Plano de Levantamento da Plataforma Continental Brasileira” (LEPLAC), seeks to align national interests with sustainable resource use. It focuses on fostering human resource development, marine science, and technology, and coordinating interministerial actions through the Comissão Interministerial para os Recursos do Mar (CIRM). CIRM, established under the Navy's oversight, ensures the integration of diverse ministries, addressing gaps in comprehensive maritime strategy through its sectoral approach [Table 1]. The fundamental difference here with Pampa Azul is that, in the latter initiative, the overall coordination and supervision were under the responsibility of the Argentine Ministry of Science, Technology and Innovation (see Sala, 2018; Sala et al., 2023).

Brazil's governance structure reflects a decentralized yet cooperative model, leveraging the *Navy's supervisory* role to align scientific research, resource exploration, and environmental protection initiatives. However, the reliance on sectoral policies may lead to fragmented implementation and limited adaptability to emerging challenges, such as technological advancements and resource scarcity (Roth, 2015).

Between 2014 and 2018, China operated a centralized governance model through the "State Oceanic Administration" (SOA), an autonomous entity that reported directly to the State Council. The SOA's responsibilities included drafting laws, marine spatial planning, resource management, environmental protection, and law enforcement. Its autonomy underscored the strategic importance of China's oceanic interests, particularly in areas such as national security, economic development, and ecological sustainability (Chang and Li, 2019).

The SOA integrated a wide range of functions, such as regulating island development and addressing marine pollution, to ensure cohesive management across China's extensive maritime jurisdiction. It enforced laws against criminal activities like smuggling and illegal immigration while safeguarding marine safety and security. This centralized structure enabled rapid decision-making and enforcement, which were crucial for tackling complex issues such as maritime disputes and environmental degradation [Table 1].

During its operation, the SOA emphasized strategic planning and coordination, as reflected in its involvement in marine functional zoning and collaboration with local enforcement agencies. This approach facilitated efficient resource allocation and consistent policy implementation, supporting national objectives to enhance marine economic development and protect ecological integrity. In 2018, these functions were absorbed into the newly established Ministry of Natural Resources, marking the end of the SOA as an independent entity (Chang and Li, 2019).

China's centralized model, embodied by the SOA, emphasized the ocean's critical role in national development and security. The agency's former autonomy and integration of diverse functions had ensured cohesive, executive and effective management, but also limited local stakeholder engagement, which was considered a potential drawback in fostering inclusive governance (see Chang and Li, 2019).

Both nations illustrate the challenges and opportunities of managing vast maritime domains. While Brazil's governance model highlights the

importance of intersectorial cooperation –more similar to the Pampa Azul model–, China's centralized approach demonstrates the efficacy of cohesive strategic planning. Future research should explore how these models adapt to global challenges such as climate change, marine pollution, sustained biodiversity loss and the geopolitical implications of maritime resource competition (Garcia et al., 2014; Halpern et al., 2015; Chang and Li, 2019).

Overlapping science, policy, and society spheres

Like the international initiatives presented above, the PAI was an excellent example of a science-policy-society interface (e.g., IPCC and IPBES[3]; see Sala and Torchio, 2019) on a national scale, although with regional and international scope and interactions (Sala et al., 2023: 211 -220), acting as a *boundary organization* (Sala and Torchio, 2019). These are organizational systems (i.e., programs and institutional arrangements) that facilitate the interaction between producers and users of science and technology and stabilize the science-policy-society interface.

Therefore, Pampa Azul necessarily involved transdisciplinary methodologies: the co-construction of situated knowledge and the development of public policies from the interweaving of various scientific disciplines and other types of knowledge (e.g., scientific, technological, traditional, local, bureaucratic-institutional, among others). To do this, the PAI generated and used *boundary objects* (Sala and Torchio, 2019). An emblematic example of this was climate scenarios, which were distinguished from simple data by their use, facilitating stabilization between two social worlds: in this case climate modeling and climate policy. Other good examples of boundary objects used by the PAI were ecosystem services and/or nature's contributions to people (Sala and Torchio, 2019; Sala et al. 2023).

Pampa Azul, knowledge integration and post-normal science

But the most important thing here is that the PAI constituted an excellent multidimensional space, a plural, horizontal, equitable and democratic *agora*[4] for the knowledge integration through the development of post-normal science (PNS) practices. Post-normal science is both a conceptual framework and a practical approach for problematic situations where "facts are uncertain, values are in dispute, the stakes are high, and decisions are urgent" (Funtowicz and Ravetz, 1993, p. 744). In some way, it represents the need to face the end of the "Cartesian dream" that gave structure and functioning to normal science program throughout modernity (see Sala and Torchio, 2019, for a discussion on this). One of the main contributions of the PNS approach is that of an *extended peer community* (Funtowicz and Ravetz, 1993).

An extended peer community is a concept from the sociology of science that helps people make decisions, by mediating technical and lay interests, when traditional distinctions between facts and values are unclear. It was first introduced in the 1990s by Silvio Funtowicz and Jerome Ravetz. This produces knowledge that integrates technical and contextual matters, and is legitimated by all relevant stakeholders. Post -normal science proposes the extension of the peer community to co-produce *better quality knowledge* for decision-making on issues like climate change. Post-normal science emphasizes cultivating a plurality of knowledges in the face of complex, urgent challenges. The concept of an extended peer community is concerned with seeing what changes in the practice of science and in its institutions will be entailed by recognition of uncertainty, complexity, and quality within policy-relevant research (see Funtowicz and Ravetz, 1993, 2000).

In this framework, projects are no longer evaluated solely by scientific peers, but by a diverse community of stakeholders who evaluate the implications of any project for their daily lives. This implies a radical transformation of scientific endeavor, since organized communities will

be able to evaluate the process of co-construction of knowledge, giving a deeper social meaning to the scientific practice (see Funtowicz and Ravetz, 1993; Sala and Torchio, 2019).

Therefore, if we really want to intervene and have a positive impact on our coastal and marine social-ecological systems, i.e., on the ecosystems and the people that make them up, as is the case of Pampa Azul activities, it is necessary to move towards a public policy-ready science (Sala and Torchio, 2019). To achieve this, we must transcend the normal science program that has reached its zenith and embrace the reconceptualization of PNS (Funtowicz and Ravetz, 1993; Sala and Torchio, 2019).

Marine Spatial Planning as an example of a post-normal science approach

Through a concrete example, I will attempt to show how the PAI can –and should– be understood as a new agora for PNS. The example selected for this purpose is the first Marine Spatial Planning (MSP) process that Argentina developed under the framework of the PAI between August 2022 and December 2023, the final documents of which are about to be published (Sala et al., 2023, pp. 186-194; see below).

The Marine Spatial Planning is a public process of analyzing and mapping the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a *political process* (see Ehler and Douvere, 2009). Like any management and/or administration activity linked with the complexity and dynamics of marine environments, MSP processes necessarily involve PNS schemes. This is because there is *high uncertainty* (i.e., low availability of data and very expensive and/or difficult to obtain; e.g., every working day on an oceanographic and/or fishing research vessel costs between 10 and 120 thousand dollars,

depending on the type of vessel); *high risk* (e.g., given the physical characteristics of the marine environment, any decision made in a given place can affect very distant areas and populations); and *conflicting values* (e.g., sectoral interests that are often in conflict); as well as *important decisions at stake* (see below). It is necessary to mention that, in general, the same does not occur with the management and/or administration of terrestrial and/or inshore ecosystems, where obtaining reliable data is usually easer and less expensive, which reduces uncertainty when making decisions.

As Silvio Funtowicz (2021) argues:

> When systems uncertainties or decision stakes are small, we are in the realm of 'normal' science, where expertise is fully effective. When either systems' uncertainties or decision stakes rise then skill, judgement and sometimes even courage are required. This is the realm of professional consultancy. And when either or both systems uncertainties or decision stakes are high this is the realm of post-normal science (s.p.).

The main characteristics of the MSP process proposed by Ehler and Douvere (2009), and adopted by the exercise carried out from the PAI by the Argentine National Government in the period 2022-2023 (PAI-MSP; Sala et al., 2023: 186-194), are: 1) it is based on (socio) ecosystems, balancing ecological, economic and social objectives; 2) it is comprehensive, between sectors and agencies, and between levels of government (i.e., municipal, provincial and national); 3) is place-based; 4) is adaptive/iterative (i.e., capable of learning from experience); 5) it is strategic and anticipatory, with a long-term focus; 6) is participatory (i.e., stakeholders actively participate in the entire process). As we have seen, all these characteristics are shared by the PNS approach presented above (see Funtowicz and Ravetz, 1993, 2020; Sala and Torchio, 2019).

It is necessary to highlight here that the participation of the different stakeholders involved in the MSP process must be guaranteed at all

steps [Figure 2]. And this participation, I understand, has to be conceived from the PNS approach. Otherwise, the most common are consultative processes with the media or public hearings, which, although useful and necessary, do not involve the actors as a constitutive and permanent part of the process, losing the binding nature of their proposals. Therefore, a crucial task of the coordination of any process like this is to generate the conditions for the consolidation of a true and sustained extended peer community (Funtowicz and Ravetz, 1993; cf., Sala and Torchio, 2019).

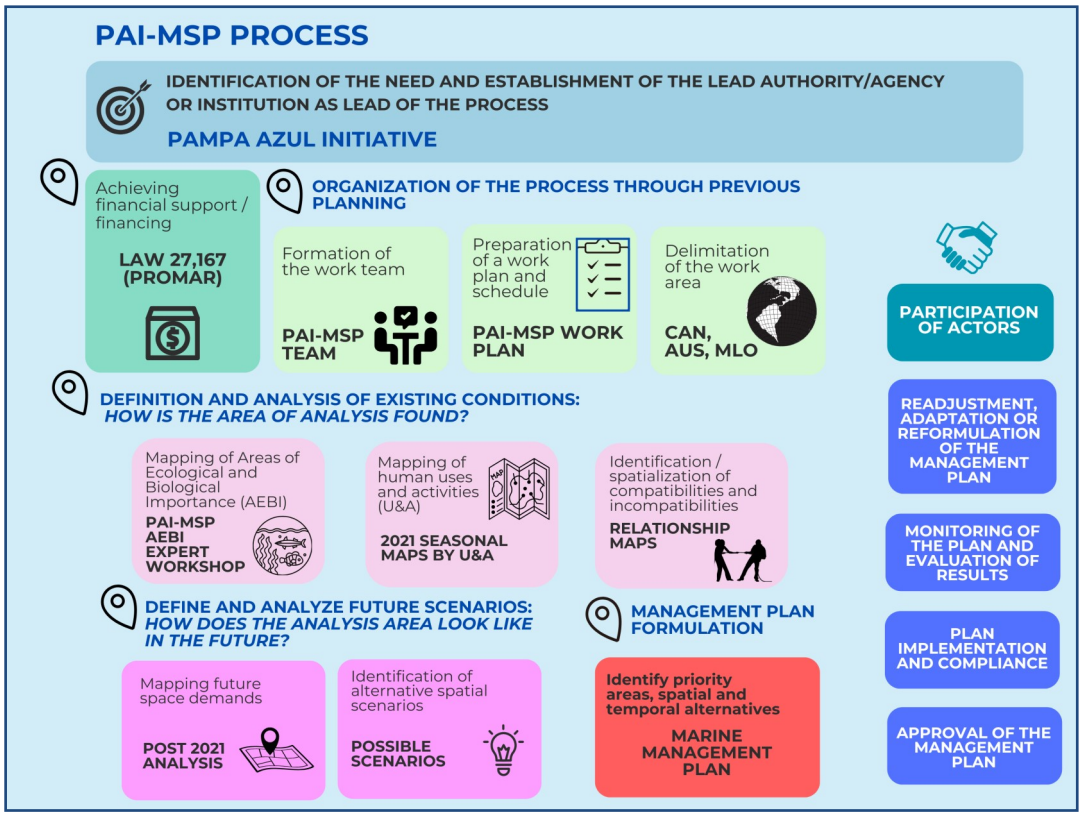

Figure 2. Diagram of the Pampa Azul Initiative (PAI) Marine Spatial Planning (MSP) process (PAI-MSP). Source: Adapted from Ehler and Douvere (2009)

The MSP-PAI process and the (possible) exploitation of offshore hydrocarbons

In August 2022, the formal presentation was made before the Interministerial Committee (IC), the Scientific Advisory Council (SAC), and the Technological Advisory Council (TAC) of Pampa Azul (i.e., its governing bodies), marking the start of the PAI-MSP process. From that moment onward, a "roadmap" was co-constructed, which included bilateral meetings with stakeholders, workshops with specialists and technicians, as well as plenary sessions with government agencies and other actors. To synthetically visualize the complexity of the process and its post-normal character, a brief summary is provided below [Figure 2].

Between August 2022 and December 2023, the Pampa Azul Initiative (PAI) promoted a Marine Spatial Planning (MSP) process of a multisectoral, ecosystem-based, and participatory nature. An ad hoc Working Group was established under the IC of the PAI, bringing together researchers, technicians, and officials from various governmental institutions. This coordinating group set as its objective the ordering and reconciliation of human uses and activities in the Argentine Sea, providing predictability for current and future exploitation, while simultaneously addressing the conservation of biodiversity and marine ecosystem services (Sala et al., 2023: 186-194). As a result of pre-planning, two pilot areas were selected for the PAI-MSP process: the Northern Argentina Basin (CAN) and the Austral/ Malvinas West Basin (AUS-MLO) [Figure 3], applying a standardized methodology internationally recommended (IOC-UNESCO). These areas were delimited by Resolution 65/2018 of the Ministry of Economy and the National Secretariat of Energy. This resolution responded to the call for Offshore Public International Tender No. 1 for the allocation of offshore hydrocarbon exploration permits. For the MSP process, in each basin a 70 km buffer zone was added to the boundary areas to include the surrounding environment [Figure 3]. These focal areas,

delimited by pre-existing regulations on offshore exploration blocks, served to initiate the planning process within a defined and prioritized scope.

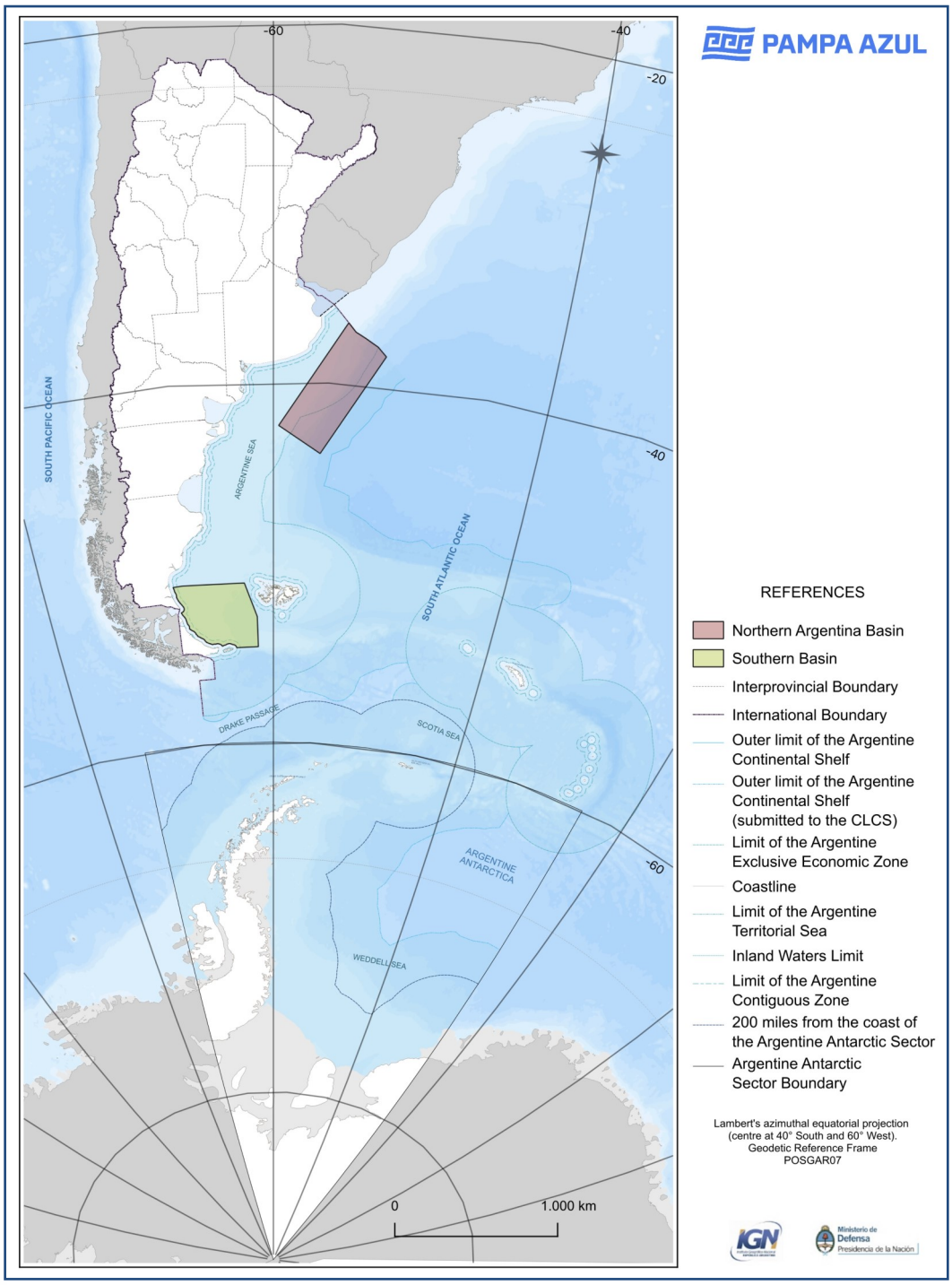

Figure 3. Location of the two pilot areas of the PAI-MSP process

Source: Adapted from Sala et al., (2023)

The PAI-MSP process followed a phased methodological approach [Figure 2], cyclical and adaptive in nature. In a *Preparation Phase*, the scope and initial objectives were defined, institutional support and resources were secured, and the process was organized through the creation of an inter-institutional technical team, the establishment of legal frameworks, and the definition of participation mechanisms. Then, in the *Planning Phase*, multidisciplinary information was collected and analyzed to produce a comprehensive diagnosis of ecological, socioeconomic, and existing use conditions in the pilot areas. On that basis, compatibilities, conflicts, and synergies among activities were identified, conservation and development objectives were established, and possible future scenarios were constructed. Finally, a preliminary spatial plan was designed, proposing marine spatial zoning and the definition of management guidelines (e.g., creation of protected areas, fishing zones, navigation routes). As for the *Implementation and Adaptation Phase* (still prospective), the process foresaw the execution of the plan through legal and operational instruments, accompanied by a monitoring and continuous evaluation system to provide feedback and adjust management measures based on new data or contextual changes. It is worth highlighting that throughout all stages, the validation of partial results and the incorporation of relevant actors were promoted, ensuring participatory instances to correct and deepen the analysis as necessary.

Various institutional actors actively participated in the PAI-MSP process, contributing technical knowledge and information. Through sectoral meetings, agencies such as the Undersecretariat of Fisheries and Aquaculture, the Ministry of Environment and Sustainable Development, the Secretariat of Energy, the Directorate of Maritime Interests of the Argentine Navy, the Argentine Coast Guard, the National Commission on the Outer Limit of the Continental Shelf (COPLA), and the Naval Hydrographic Service, among others, provided key data within their respective areas of competence. With each entity,

the data required for sectoral analysis were identified, and technical inputs corresponding to the baseline year 2021 were obtained [Figure 2]. These inputs included spatial and statistical information on different uses of the sea (commercial fishing, passenger and cargo maritime transport, submarine communication cables, hydrocarbon exploration and exploitation, defense, conservation, marine scientific research, among others), which were temporally standardized for a complete seasonal analysis.

The process thus generated thematic maps and baseline cartography –e.g., maps of naval traffic density and fishing effort– covering the historical period 2014-2020, with particular focus on 2021. The resulting cartography and diagnoses constituted fundamental intermediate products of the process, serving as inputs to delineate the spatial plan and representing the distribution of human activities and ecological values in the pilot areas. Likewise, the PAI-MSP process drew upon information from prior and contemporary marine scientific research; in line with the objectives of Pampa Azul, emphasis was placed on reinforcing the knowledge base through additional oceanographic research campaigns in the studied areas. In summary, the Marine Spatial Planning process of the Pampa Azul Initiative was characterized by a rigorous methodological sequence with broad inter-institutional participation, and by the production of technical inputs (maps, diagnostic reports, geospatial data, and scientific campaign results) that supported the adaptive spatial planning of the Argentine Sea. It must be recalled here that this entire process, as well as all other activities carried out by Pampa Azul, were completely suspended following the inauguration of President Javier Milei's National Government.

Now, I will try to explain why in the MSP process coordinated by the PAI, "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz and Ravetz, 1993, p. 744). As mentioned recently, Argentina has put out to tender two areas of its Continental Shelf

territory, one in the center of the country and another in the southern region [Figure 3], in order to advance in the exploration and future exploitation of offshore hydrocarbons (i.e., oil and natural gas). Given that in Argentina the exploitation of offshore hydrocarbons in deeper waters has not yet been developed (i.e., although for more than 20 years the 20 % of the natural gas used in the country has been produced through coastal platforms without history of environmental problems), this has unleashed a significant repertoire of adverse reactions from civil society (Verón et al., 2022). These reactions were - and are being- driven, mainly, by some big international conservation non-governmental organizations (NGOs)[5], in collaboration with their local counterparts, as well as other representatives of historical activities for the country's marine environment such as industrial fishing and tourism (Verón et al., 2022).

It is striking that there is no a similar reaction by these same NGOs against the exploration of offshore hydrocarbons with licenses awarded by the illegal and illegitimate government of the United Kingdom of Great Britain and Northern Ireland that controls the Malvinas Islands and its surrounding maritime territories based, only, on its military power (Bilmes and Sala, 2022), to companies such as the British Premier Oil, Tullow Oil, Rockhopper Exploration, or the Israeli Navitas Petroleum, among others. It is enough to do a quick search on the Internet to find that if you search, for example: "*Greenpeace + offshore + oil and gas + Argentina*" the result is a large number of press articles. However, if you repeat the search changing the categories to "*Greenpeace + offshore + oil and gas + Falkland Islands*", the result is null. Not a single "green-article". Not a single protest campaign.

This is particularly significant as the Sea Lion project is advancing rapidly. The Falkland Islands Government has completed its public consultation on a revised Environmental Impact Statement (EIS) regarding oil extraction from a field 136 miles north of the Malvinas Islands, which was announced on July 2, 2024[6]. Explaining the role of big international conservation NGOs is beyond the scope of this article;

but to understand the level of impact on the agenda setting as well as in conservation practices that they produce in Argentina, I recommend reading the discussion about this issue in Sala (2022). It is not the objective of this work to problematize the interests of the occupying power of the islands regarding the hydrocarbons beneath the bed of the Argentine Continental Shelf, but I recommend reading Livingstone (2022) and Bilmes (2025) in relation to this.

Although this "new" activity could imply socio-environmental risks and there is some uncertainty regarding extractive practices in deep waters (Brañas et al., 2023); the country, through initiatives such as Pampa Azul, would have the capacity and maturity of its national science, technology and innovation system to be able to carry out all the studies, baselines, controls and monitoring necessary to guarantee that both risks and uncertainty would be handled (Sala et al., 2023). And thus ensure the quality of knowledge through an extended peer community consolidated through ten years of history. Even more, the exploitation of these offshore resources would allow the country to achieve self-sufficiency (especially in natural gas reserves); and, with it, the generation of genuine foreign exchange, via exports. This will also allow for the growth of many SMEs and the emergence of new ones, and the generation of thousands of qualified jobs (Brañas et al., 2023).

Conservative estimates of the productive potential of the blocks in the Northern Argentina Basin (CAN) [Figure 3] suggest that the country could add hundreds of thousands of barrels of oil per day (Brañas et al., 2023). This would imply doubling –or even tripling– YPF's (Yacimientos Petrolíferos Fiscales, a mixed company whose main shareholder is the Argentine State) current production, which presently amounts to around 7 billion USD annually. Furthermore, YPF geologists forecast the existence of several additional deposits with similar characteristics, meaning that this initial volume could be multiplied several times.

At the same time, there is an urgency –or a limited window of opportunity– regarding the possibility of taking advantage of deep-water offshore hydrocarbons, since the companies with the most experience

in the subject –and YPF partners in this activity– such as Norway's Equinor, are changing their business models and are gradually withdrawing from this type of complex production (Feder, 2020). This means that Argentina, if it plans to take advantage of this type of resource, will do so in the short term and as part of its "National Energy Transition Plan to 2030", approved through Resolution 517/2023 of the National Secretariat of Energy, and published in the Official Gazette, that establishes natural gas as a transition energy source.

In a national context like the current one, of great macroeconomic restrictions resulting, among other things, from the enormous external debt carried out by the National Government administration of the period 2015-2019 (i.e., that of President Mauricio Macri, mainly with the International Monetary Fund; but also with private creditors, both investment funds such as BlackRock, Fidelity, Allianz, Ashmore Group and PIMCO, as well as banks such as HSBC, JP Morgan Chase, Citibank, Deutsche Bank, and Bank of America)[7], worsened at present by President Javier Milei's new external indebtedness; the possibility of taking advantage of the hydrocarbon resources located on the Argentine Continental Shelf seem to be an excellent alternative (see Brañas et al., 2023). To this end, the development of a MSP process, based on the PNS approach [Figure 2], is crucial to better manage the existing tensions between various human activities (e.g., fisheries, research, conservation, hydrocarbons exploitation, transportation, communications wiring, tourism, defense, among others) and of these with the environment; as well as to achieve a positive impact on public opinion (Verón et al., 2022).

Last but not least, climate change is a fact that worries and concerns us but both the common but differentiated responsibilities, and the small percentage of Argentina's contribution to the increase in greenhouse gases worldwide (i.e., 0.67 % relative contribution), encourage us to advance in this strategic endeavor. Then, as we see, what is at stake is transcendental, the uncertainty is high, there are multiple values in conflict, and the decisions to be made are urgent. This is, indeed, the realm of post-normal science (Funtowicz, 2021).

Final thoughts

Spanning from coastal areas to the ocean depths, the profound impact of the blue acceleration is evident, resulting in significant social and ecological outcomes (Jouffray et al., 2020, 2021). Preserving the sustainability of the ocean amid swift transformations necessitates collaborative and transdisciplinary post-normal science to steer the actions and motivations of governments, corporations, and civil society toward responsible ocean stewardship (Lubchenco et al., 2016; Jouffray et al., 2020).

The Pampa Azul Initiative, Argentina's ambitious undertaking to explore and steward its vast ocean territory, it stood for 10 years as a lighthouse of post-normal science. In these turbulent times, where complex challenges as the explored above demand solutions that transcend disciplinary boundaries, Pampa Azul embodied the very essence of this dynamic approach. Unlike traditional science, which often operates within well-defined parameters, post-normal science embraces uncertainty. It recognizes the intricate interplay between scientific knowledge, societal values, and political realities.

Pampa Azul exemplified this by bringing together, to the same agora, diverse stakeholders –scientists, policymakers, industry players, fishermen, park rangers, educators, and local communities, among others– to navigate the intricate tapestry of Argentina's marine environment (see Sala et al., 2023). The data collected were not only systematized and published periodically, but also informed political decisions for the safeguarding of vulnerable ecosystems (e.g., the creation of marine protected areas), the promotion of sustainable fishing practices (e.g., the establishment and management of closed areas, improvements in gear selectivity, enhancements in traceability and landing marking, among others), and enabled the advancement of MSP processes such as the one presented above (see Sala et al., 2023: 186–194 and this essay).

This collaborative spirit is not merely an ethically correct gesture. It is a necessity. The Argentine Sea harbors a treasure of great ecological wealth (Sala et al., 2023). However, it faces threats such as

overfishing, plastic pollution, and climate change; as well as the most important sovereignty conflict in the Global South (see Bilmes and Sala, 2022). Addressing these challenges requires not only scientific or technological expertise and capacity, but also a deep understanding of the social and economic forces that shape maritime activities and geopolitics (Jouffray et al., 2020, 2021).

Pampa Azul never shied away from this complexity. By integrating scientific research within a broader framework of social responsibility and environmental management, and by actively involving local communities, it empowered them to become guardians of their own coastal ecosystems (see, e.g., Sala et al., 2023: 111-113). It fostered innovation, seeking technological solutions that balanced economic development with ecological sustainability (see, e.g., Sala et al., 2023: 84-102). It succeeded in transcending the "ivory tower" image of science and fully immersed itself in the complex realities of the real world.

Finally, the next time you hear about the Pampa Azul Initiative, remember that it was not only about mapping the depths of the Argentine Sea or studying where the southern right whales feed. It was about charting a new course for scientific research, one that could navigate the turbulent waters of the 21st century with an unwavering commitment to both knowledge and the ethics of responsibility, national interest, and sovereignty. For this reason, and for all that has been mentioned here, we need Pampa Azul to exist again in Argentina.

Acknowledgments

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NOTES

1. "New phase in humanity's relationship with the ocean that exhibits a phenomenal rate of change over the last 30 years, with a sharp acceleration of ocean uses characterizing the onset of the 21st century" (Jouffray et al., 2021, p. 6).

2. To learn more about the Pampa Azul Initiative please see: https://www.pampazul.gob.ar/

3. Intergovernmental Panel on Climate Change and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

4. The concept of the agora emerged in Classical Greece (510–323 BC) as the center of social, political, and commercial life, where debates, elections, celebrations, commercial activities, theater, and sports were held. However, access was restricted to men and the wealthy classes. Pampa Azul redefined this idea as a plural, horizontal, and democratic agora, promoting gender equality, the federal distribution of resources, and the inclusion of all sectors, particularly the most disadvantaged.

5. See https://www.greenpeace.org/argentina/tag/marargentino/ and/or https://www.greenpeace.org/international/story/52326/greenpeace-argentina-saved-argentine-sea-oil-companies/

6. See https://www.express.co.uk/news/world/1937274/argentina-falkland-islands-oil-field-tensions and https://www.offshore-energy.biz/sea-lion-ready-to-roar-as-next-big-thing-once-falkland-islands-gives-the-all-clear/

7. See https://www.pagina12.com.ar/262148-oferta-de-canje-de-deuda-quienes-son-los-10-acreedores-mas-p