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Developing strategic environmental assessment in contexts of non-systematic practice: contributions for offshore energy transition

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ABSTRACT

Energy transition initiatives are expanding the frontiers of offshore wind generation. Impact assessment instruments, such as strategic environmental assessment (SEA), should consider the consequences of these developments. By reviewing the literature on SEA and a case in Brazil, we draw lessons for harnessing potential SEA contributions to support offshore wind development in jurisdictions where its practice is non-systematic, i.e. conducted in the absence of standard rules and guidance at the national level as well as being dispersed and highly variable, for example, in terms of motivations and approaches. This flexibility can be an opportunity to align energy transition purposes with the targets of other uses of marine space and conservation goals. On the other hand, if no formalized set of SEA rules is agreed upon by key stakeholders, SEA and its outcomes can be highly vulnerable to political influence. Our investigation reinforces the importance of public participation, assessment of alternatives, integration with regional initiatives, and a focus on cumulative impacts in SEA. Finally, SEA for future offshore wind developments should be formulated in time to influence project-level decisions with tiered recommendations that are fundamental for avoiding further conflicts and properly assessing and mitigating the impacts of the energy transition.

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Offshore wind; impact assessment; Brazil; tiering

1. Introduction

Climate scientists emphasize that without substantial reductions in greenhouse gas emissions in the coming years, the world's temperature will exceed the critical thresholds of 1.5°C and 2°C above pre-industrial levels (Intergovernmental Panel on Climate Change (IPCC) 2023). To meet the targets of the Paris Agreement, several nations are changing their energy matrix by implementing low-carbon energy systems, one of the most important actions to mitigate the climate crisis (van Bommel and Höffken 2023). Therefore, there is a growing pressure to provide a massive deployment of low-carbon energy as soon as possible (Slameršak et al. 2022). However, the call for immediate action fuels the debate about the extent to which impact assessment (IA) would be capable of guaranteeing environmental and social safeguards when accelerating decisions about the impacts of these new initiatives (González and Sobrini 2023). This is particularly relevant to vulnerable environments already impacted by cumulative human pressures, such as the oceans (Halpern et al. 2019).

Offshore wind energy is rising globally as a powerful alternative for exploring energy beyond the most common terrestrial sources (Esteban et al. 2011). In 2023,

the offshore wind energy power capacity increased by 24% compared to the previous year, representing the second-best year in history for new offshore wind installations (GWEC - Global Wind Energy Council 2024). The ocean can generate 40 times more renewable energy by 2050 and contribute to 20% of the greenhouse gas reduction needed to keep the world within 1.5°C (Stuchtey et al. 2020). Although the development of offshore projects currently costs more than onshore wind farms for equivalent capacity, the International Energy Agency foresees a 38% cost reduction by 2050, enabled by technological developments and increased economies of scale (GWEC - Global Wind Energy Council 2023). In 2023, the largest installed offshore wind energy capacity worldwide was located in the Asia-Pacific (41 GW), including China (around 38 GW), and Europe (around 34 GW), mostly in the United Kingdom, with 43% of the total (GWEC - Global Wind Energy Council 2024). Countries such as Brazil, India, the Philippines, and South Africa have demonstrated significant technical potential for deploying new offshore wind projects (ESMAP 2019). As offshore wind attracts investments and scales up energy production, national jurisdictions need to develop or improve legislation and environmental

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instruments to address the impacts of these activities on marine and coastal social-ecological systems.

Strategic Environmental Assessment (SEA) plays a fundamental role in supporting better strategic decisions and influencing policies, plans, and programs toward more sustainable futures (Partidário et al. 2023). SEA is, therefore, a planning instrument that can be applied to a given territory, integrating different existing and/or potential activities, or to a specific sector (for example, energy and mineral resources). The role of SEA in addressing the cumulative impacts of multiple offshore activities and integrating other marine plans and programs is well recognized (Kusters et al. 2024). The enhanced connections between other planning initiatives and public engagement at the strategic level are among the many benefits of SEA (Siqueira-Gay and Sánchez 2019). Strategic assessments undertaken in a tiered mode may explicitly transfer information from planning to the project level before initiating project-based environmental impact assessments (EIA) (González and Therivel 2022). Moreover, aiming to streamline EIAs to fulfill the demand for renewable energy, SEA may provide tiered recommendations with the potential to improve project appraisal efficiency. These tiered integrations (across planning levels and sectors) provided by SEA applications are fundamental in the context of developing new offshore activities (Willsteed et al. 2018). Thus, robust tools and SEA methods are often required to address the complexity of marine ecosystems and interactions, and trade-offs among impacts require a proper consideration of regional and cumulative impacts (Watson et al. 2024).

SEA can be applied in different contexts: (i) nationally regulated and required by law, or (ii) non-systematic practice. In this paper, the term ‘non-systematic practice’ is applied to contexts where SEA practice is characterized by the absence of standard rules and guidance at the national level (even though there may be some regulation for specific types of planning), with dispersed assessments featured by different frameworks, methods, and outcomes (Malvestio and Montaña 2019; Morgan and Taylor 2021). The absence of official procedures and technical guidance leads to different interpretations of SEA purposes and applied methods (Margato and Sánchez 2014), and usually, the potential to promote learning through the SEA practice is hindered (Malvestio and Montaña 2019). An example of non-systematic SEA practice is its application to support the oil and gas (O&G) development in Brazil, called Environmental Assessment of Sedimentary Area (EASA) (Vilardo and La Rovere 2018).

Notwithstanding, even in non-systematic/non-regulated contexts, benefits from SEA have been reported in the literature (Jha-Thakur and Rajvanshi 2021; Montaña et al. 2021). Hence, in this research, we aimed to investigate the main

lessons from previous SEA experiences for harnessing its potential contributions to offshore wind development in jurisdictions where its practice is non-systematic. This question unfolds into two research topics: investigation of SEA in a non-systematic context and investigation of SEA experiences in offshore energy planning, including offshore and onshore O&G activities in a case review. Previous experience from offshore O&G extraction and production can result in several learning opportunities for developing offshore wind energy. The evaluation of previous experiences can provide knowledge on procedures and criteria, including lessons for practitioners, regulators, academics, and affected communities (Morgan 2017; Sánchez and Mitchell 2017).

For this purpose, we conducted a literature review of SEA in the context of non-systematic practice and a review of SEA for offshore energy planning. We reviewed the case of the Environmental Assessment of Sedimentary Area (EASA) developed in Brazil to support oil and gas exploration and production projects and discussed possible contributions for new assessments related to offshore wind developments. Brazil presents an estimated potential of 700 GW for offshore wind development (EPE, 2020). In January 2025, a new law established the rules and conditions for leasing and the specifics for environmental protection. While leasing will be conducted by the National Electric Energy Agency, environmental assessment and licensing will be conducted by the federal environmental agency, the Brazilian Institute of Environment and Renewable Natural Resources – Ibama – that had received dozens of expressions of interest in the development of offshore wind projects.¹ In the following sections, we present our methods (Section 2), including a literature review (Sections 3 and 4), a case review (Section 5) and, finally, a synthesis of our main findings with recommendations for SEA of offshore wind projects in the context of non-systematic practice (Section 6).

2. Methods

This research seeks to analyze the following question: What are the main lessons from previous SEA experiences applied to offshore energy planning for furthering SEA in offshore wind planning in non-systematic contexts? As stated above, the study was developed in three steps: (i) a review of the literature on the current state of SEA in non-systematic contexts; (ii) a review of the literature about the current state of SEA for offshore energy planning, and (iii) a case review of SEA for O&G in a non-systematic context focusing on both, offshore and onshore sedimentary basins in Brazil. This threefold approach grounded the findings about lessons for SEA

Research question: ask what are the main lessons from the previous experience of SEA applied to energy planning for furthering SEA of offshore wind planning in non-systematic contexts?

Main components of research: investigation on SEA in a non-systematic context (research step 1) and previous experience on offshore energy planning and case review (research steps 2 and 3)

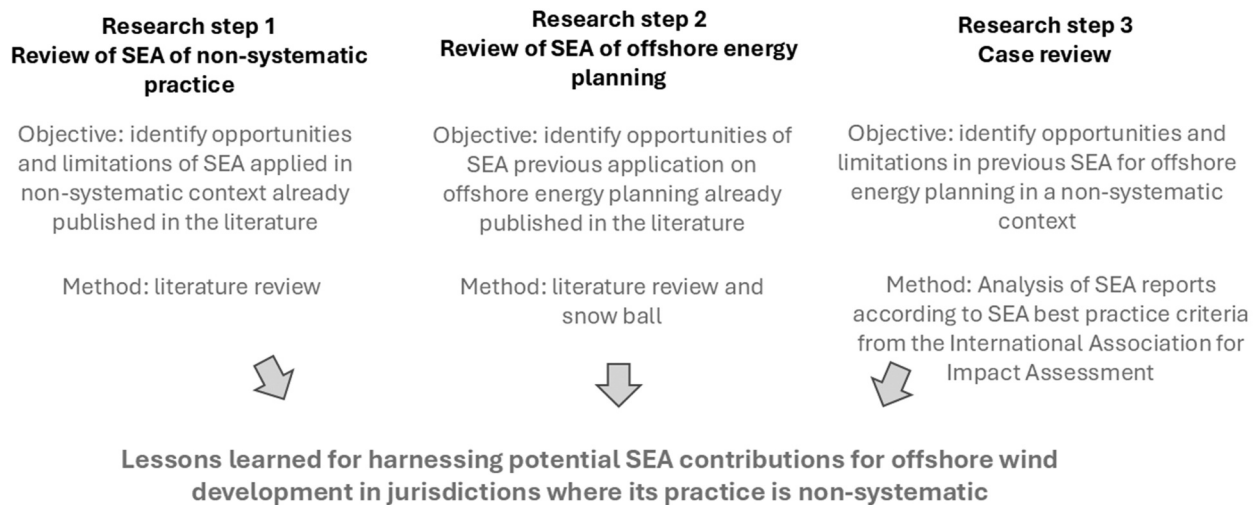


Figure 1. Research workflow with methods.

regulations related to offshore wind projects in the context of non-systematic practice (Figure 1).

2.1. Review of SEA in non-systematic contexts

This review aimed to characterize non-systematic SEA practice and assess the opportunities and limitations already described in the literature. The Scopus and Science Direct databases were searched for published research articles on SEA within a non-systematic context by using the combination of keywords ('strategic environmental assessment' and 'non-regulated'). Due to the limited number of results retrieved, the snowball sampling technique was also applied to identify additional relevant studies through citation tracking.

2.2. Review of SEA for offshore energy planning

We summarize an overview of published literature, including analysis of case studies and reviews, to contextualize previous experiences about relevant opportunities and limitations of SEA applied to offshore energy planning (e.g. oil and gas, tidal streaming, wave). This includes SEA for offshore wind development and, consequently, its integration with Marine Spatial Planning (MSP), considering its role in supporting the decision-making process related to the multiple uses of the marine and coastal spaces (UNESCO-IOC/European Commission 2021). The Scopus and Science Direct databases were searched for published research articles on SEA using a combination of the keywords 'strategic environmental assessment' and 'offshore energy'.

2.3. Case review

This review involves the analysis of official documents from the two EASA studies conducted in Brazil that are publicly available. Two of the coauthors were involved in the preparation of a technical report with an independent critical review of the EASA role in the IA process of new O&G projects and are familiar with the case study (Observatório do Clima 2021).

There are several ways to evaluate SEA reports and processes, including perception interviews and applying evaluation criteria, among other methods and tools (Arce-Ruiz et al. 2019; Therivel and González 2019). The International Association for Impact Assessment (IAIA) has been discussing the best practices and good quality of SEA practice since the early 2000 and proposed a set of performance criteria (IAIA - International Association for Impact Assessment 2002). In this study, we used these criteria to evaluate the published content and context of the application of the two published EASA reports. The performance criteria include whether SEA is integrated, sustainability-led, focused, accountable, participative, and iterative.

The review of the O&G case has limitations. Firstly, the analysis was not focused on the effectiveness of strategic SEA influence on policies, plans, and programs, but it was grounded on the general best practice criteria and mainly focused on the tiered decisions at the project level. The O&G sector has its specificities, such as the regulatory frameworks, stakeholders involved, and specific impacts, such as alteration of water quality due to

oil leakage. Our recommendations from the case review are limited to general aspects of offshore projects, such as the existence of similar EIA structures and challenges related to the management of coastal and marine environments for both types of projects in Brazil.

3. SEA in the context of non-systematic practices

SEA practice has been evolving worldwide, being applied both mandatorily and voluntarily (González and Therivel 2022; Gutierrez et al. 2023). Some jurisdictions do not have a national law or precise requirements for SEA developments, including screening criteria such as positive lists and designation of mandatory sectors, as is the case in the European Union (Fischer et al. 2009) and Canadian directives (Noble et al. 2019). Further, at subnational levels or through regulation and subordinate regulation, SEA is provided for specific sectors or regions within the legal framework (Gutierrez et al. 2023).

Several countries and jurisdictions do not have an institutionalized SEA practice. In Namibia, Olagunju and Gunn (2015) show that SEA initiated the rationale of strategic thinking in the context of developing multiple projects in the same region and was the main driver for assessing cumulative impacts, biodiversity conservation, and regional planning in the context of mineral extraction. In Asia, Victor and Agamuthu (2014) highlight the importance of legislative framework and stakeholder engagement in the design of SEA systems. The authors show that several countries 'imported' SEA regulations from the European directive without customizing and adapting the instrument for the local conditions, revealing the importance of SEA flexibility to achieve the main goals and effectiveness for assessing strategic actions. This flexibility, therefore, can be understood as one of the main potential benefits of SEA in non-systematic practice.

When analyzing Asian jurisdictions, Victor and Agamuthu (2014) emphasize the need for political will to implement SEA, especially in contexts of non-systematic practice. Moreover, one of the well-studied jurisdictions without a systematic SEA practice is Brazil, where studies have shown that SEA is an isolated instrument, currently vulnerable to the local institutional context and political will (Oliveira and Malvestio 2022). Therefore, the flexibility of SEA can be seen as a risk once it makes the instrument vulnerable to political influence, showing an important recommendation for SEA in non-systematic practice.

New Zealand also does not have a systematic practice, and SEA is not recognized in any legislation or administrative procedures (Morgan and Taylor 2021). The non-institutionalized practice leads to fragmented

cases, without common principles or frameworks, as observed in other countries with non-systematic SEA practice. Therefore, there are few opportunities for knowledge transfer and exchange of experiences among practitioners, government, and stakeholders, and no solid SEA community is observed in New Zealand (Morgan and Taylor 2021). Since there are no formal requirements or minimum aspects to be considered, different frameworks have been developed, and, in some cases, the methods applied are unclear and do not follow international good practices, posing risks to SEA effectiveness (Malvestio and Montaña 2019).

In some cases, SEA may be driven by multilateral financial institutions (Margato and Sánchez 2014). An analysis of a SEA application in South America to assess an initiative of massive infrastructure deployment reveals the important role played by SEA in evaluating the impacts of strategic initiatives when there is a lack of legal provisions (Madrid et al. 2011). Although multilateral agencies usually require appropriate methods, formal standards, and stakeholder engagement, this case study showed a lack of institutional and operational capacities and coordination among sectors. Madrid et al. (2011) emphasize the need for capacity building, i.e. institutional and financial resources, for implementing the proposed actions along with the involvement of related ministries and other sectoral stakeholders.

Therefore, the opportunities and limitations identified are mainly related to the trade-offs of SEA flexibility in non-systematic contexts. The SEA showed the capacity to adapt and provide intended outcomes when it is not mandatory. However, this flexibility can lead to risks that limit SEA's capacity to influence other planning-tiered decisions and be an opportunity for supporting only a political rather than a technical decision.

4. SEA for offshore energy planning

In this section, we provide a review of worldwide SEA practices for offshore energy planning, highlighting successful aspects and identifying key opportunities for improvement across different jurisdictions. These reviews reinforced four main opportunities and limitations to be considered from previous SEA for offshore energy planning: (i) lack of documentation and reports on public participation; (ii) limitation in the assessment of cumulative impacts; (iii) low integration with other regional initiatives; and (iv) uncertainties in the assessments.

Firstly, the SEA literature points out limitations in public engagement and cumulative impact assessment (CIA). In general, SEA is recognized as an instrument for mainstreaming environmental and social considerations in strategic actions, including

supporting decisions in the energy sector (Geißler et al. 2021). Regulated practice, however, does not necessarily equate to good practice or conformance with prescribed conditions, and its effectiveness differs between sectors and the types of plans and programs to which it is applied (European Commission 2019). Assessing the quality of SEA reports of Regional Energy Plans in Italy, in the context of regulated practice, Montis (2014) showed several pitfalls in analyzed documents, as the statement of objectives is usually incomplete, the evaluation of impacts is usually qualitative and superficial, and transboundary impacts are not considered.

Moreover, the direct, indirect, and cumulative impacts are rarely described and measured, and there is no clear information about public participation. González and Sobrini (2023) analyzed the simplified SEA process in Spain for renewable energy development and emphasized the limitations of these assessments in properly considering public participation and CIA. Fischer et al. (2020) discussed SEA's effectiveness in renewable energy planning in South Africa. They emphasized that SEA in this context may enhance resource-use efficiency and shorten the duration of the project-level assessment. By analyzing SEA reports for wind energy planning in the UK and Germany, Philip-Jones and Fischer (2015) showed that the influence of SEA in decision-making is limited, and it lacks effective tiering decisions from SEA to project-level EIA.

Secondly, the literature emphasizes opportunities for integrating SEA with other regional initiatives, including other regional and sectoral planning. In the context of offshore energy development in the Arctic, Noble et al. (2013) identified opportunities for SEA that go beyond the sector-specific concerns, such as the case of early engagement and improved baseline science and monitoring for addressing cumulative impacts. The authors discuss that SEA conducted by the O&G sector is usually restrictive, requiring an integrated and multi-sectoral SEA, and describe uncertainties declared by the government about the spatial scales of offshore SEA and by the industries related to timeframes.

In several countries, SEA is undertaken in support of strategic decisions in the marine environment, including O&G developments (Fidler and Noble 2012; Lamorgese et al. 2015; Bonnell 2020) and offshore wind farms (Lovells 2023). Lovells (2023) mentions that SEA is mandatory for new offshore projects in Denmark, as required by the EU SEA Directive 2001/42/EC for energy planning. In the UK, SEA for offshore energy exploitation activities has been conducted since the 2000s. From 2001 to 2018, 11 SEA studies were conducted, and three of them included offshore wind developments (BID – Banco Interamericano de Desenvolvimento, PPI – Programa de Parcerias de Investimento – Ministério da Economia 2020). These

SEAs were integrated, considering multiple offshore activities, such as O&G exploration, and wind and tidal energy generation. The latest offshore energy SEA was undertaken considering different sectors, such as offshore wind, to enable the future renewable leasing process (BEIS – Department for Business, Energy & Industrial Strategy 2022). A series of recommendations were made based on previous SEAs, which inform, in part, the research priorities under the SEA program. They are related to regulation and management, as well as understanding the baseline, effects, and monitoring (BEIS – Department for Business, Energy & Industrial Strategy 2017). In the UK, SEA is legislated under the EU Directive (Fidler and Noble 2012) and locally under the Environmental Assessment of Plans and Programmes Regulations 2004 (England), the Environmental Assessment of Plans and Programmes (Wales) Regulations 2004, the Environmental Assessment of Plans and Programmes Regulations (Northern Ireland) 2004, the Environmental Assessment (Scotland) Act 2005. There are cases of SEA applied to exploration rounds (Lamorgese et al. 2015) to identify areas for future licensing in the UK (Fidler and Noble 2012) and to provide recommendations about moratoriums in areas where knowledge of environmental conditions is considered insufficient, and follow-up must be publicly reported.

The strategy for implementing SEA varies according to jurisdiction (Fidler and Noble 2012), and previous experience from offshore O&G can support several lessons for developing offshore wind energy (Sánchez and Mitchell 2017). In Canada, SEA for the O&G sector operated under a non-legislated federal directive and served as a preliminary assessment before opening areas for exploration (Fidler and Noble 2012) and regional assessments have recently been developed for offshore wind development in Nova Scotia, Newfoundland, and Labrador.² These assessments provide information on potential effects (including cumulative effects) of offshore wind developments and mitigation and follow-up measures for these areas, besides informing future planning and licensing processes and project-specific federal impact assessments and decisions for offshore wind projects.

Moreover, in Norway, offshore projects are designed in an integrated regional planning model (Fidler and Noble 2012). In the United States, the Programmatic Environmental Impact Study (PEIS) can be applied to plans, programs, and policies that follow SEA purposes (Geißler 2013). The Bureau of Ocean Energy Management (BOEM), responsible for managing the development of offshore energy and mineral resources in the Outer Continental Shelf (OCS), undertakes PEIS for the O&G leasing program in the OCS considering 5 years, identifying alternatives, describing the affected environment, and analyzing

environmental impacts – including cumulative impacts – as well as defining mitigation measures.³ A PEIS was also developed to support the program's establishment for authorizing renewable energy and alternative use activities on the OCS, including wind farms, which examined the potential environmental effects of the program and identified policies and best management practices.⁴ Moreover, PEIS is also applied to analyze potential impacts from anticipated offshore wind energy activities considering commercial lease areas to i) identify, analyze, and adopt mitigation and monitoring; and ii) focus project-specific environmental analyses.⁵ Public participation is highly encouraged during the scoping phase and draft PEIS.

In a review of cases of O&G onshore and offshore, from Australia, Bolivia, Canada, Cyprus, Greenland, Mauritania, the United Kingdom, and Iceland, Lamorgese et al. (2015) reiterated the role of a structured instrument like SEA in providing a plural vision of the process, bringing, through public participation, different interests that may arise from the development of these activities. The benefits obtained through SEA are highlighted, especially the analysis of long-term cumulative impacts and recommendations for more integrated mitigation and monitoring measures. Doelle et al. (2013) described the case of O&G exploration in the Beaufort Sea (Canada), reinforcing some aspects of the decision-making process and emphasizing the engagement of relevant institutions in the SEA process to influence tiered and other related decisions, such as land use planning procedures.

Fidler and Noble (2012) analyzed the practice of SEA of the O&G sector in Canada, the United Kingdom, and Norway and emphasized the need for coordination among the various decision-making levels for the effective implementation of SEA to overcome the limitations of project assessments. The authors emphasized the limited role of SEA in assessing cumulative impacts that usually present a strategic nature and vague scope. The authors highlighted the need for multisectoral studies that encompass both onshore and offshore projects to systematically and regionally consider environmental and social impacts.

SEA is also broadly known for its potential to integrate other related policies, plans, and programs. In the context of offshore wind generation, MSP is considered an important instrument for planning multiple marine activities (UNESCO-IOC/European Commission 2021). Ehler (2021) indicated that about half of the countries with marine waters (75 out of 150) have initiated some form of MSP, and interest in MSP continues to grow. MSP and SEA share common goals of integrating environmental considerations into planning processes

and promoting sustainable development. While SEA has the potential to play a critical role in supporting MSP by providing a systematic approach to assess potential environmental impacts, explore alternatives, and support strategic decision-making (Calado et al. 2021; Kusters et al. 2024), MSP faces significant challenges. These include shortcomings in political and institutional frameworks, limited stakeholder engagement, insufficient integration of human and social dimensions, poor balancing of economic development with marine ecosystem conservation, and the need to adapt to global environmental change (Frazão Santos et al. 2021).

Kapoor et al. (2021) analyzed the SEA role in O&G in Nova Scotia. They emphasized the importance of integrating MSP and SEA to facilitate negotiations and conflicts among sectors interested in sharing marine space. In the case study analyzed by Kapoor et al. (2021), it is not clear how current O&G regulation can be aligned with the MSP to address coastal communities' relevant concerns, revealing a relevant aspect to be considered when developing other offshore projects, such as the case of offshore wind energy regulations. Another relevant aspect of MSP and SEA integration is mentioned by Poelzer et al. (2024), who emphasized that research conducted in specific areas to gather relevant information about the affected environment as part of the MSP and SEA process may benefit several tiered decisions of new offshore projects. This decreases the uncertainty of the SEA process, leading to an optimized sitting process with fewer risks for investors.

Finally, some cases highlight limitations due to the uncertainties in the SEA. Some challenges regarding the improvement of SEA international practice are presented, such as improving scoping (Lamorgese et al. 2015; BID – Banco Interamericano de Desenvolvimento, PPI – Programa de Parcerias de Investimento – Ministério da Economia 2020; Bonnell 2020) and developing guidelines and references of SEA best practices (Fidler and Noble 2012; Lamorgese et al. 2015). Uncertainties were declared by stakeholders involved in the case of Arctic projects, emphasizing issues related to spatial scales of offshore activities and methods applied along with uncertainties about the timeframes to develop SEA versus industry technological advances. Figure 2 synthesizes the main findings of this review and organizes the limitations and opportunities in the main lessons for SEA practice. In the following section, we reviewed two cases of strategic studies for the O&G sector in Brazil to evidence possible lessons for future regulations of offshore wind projects.

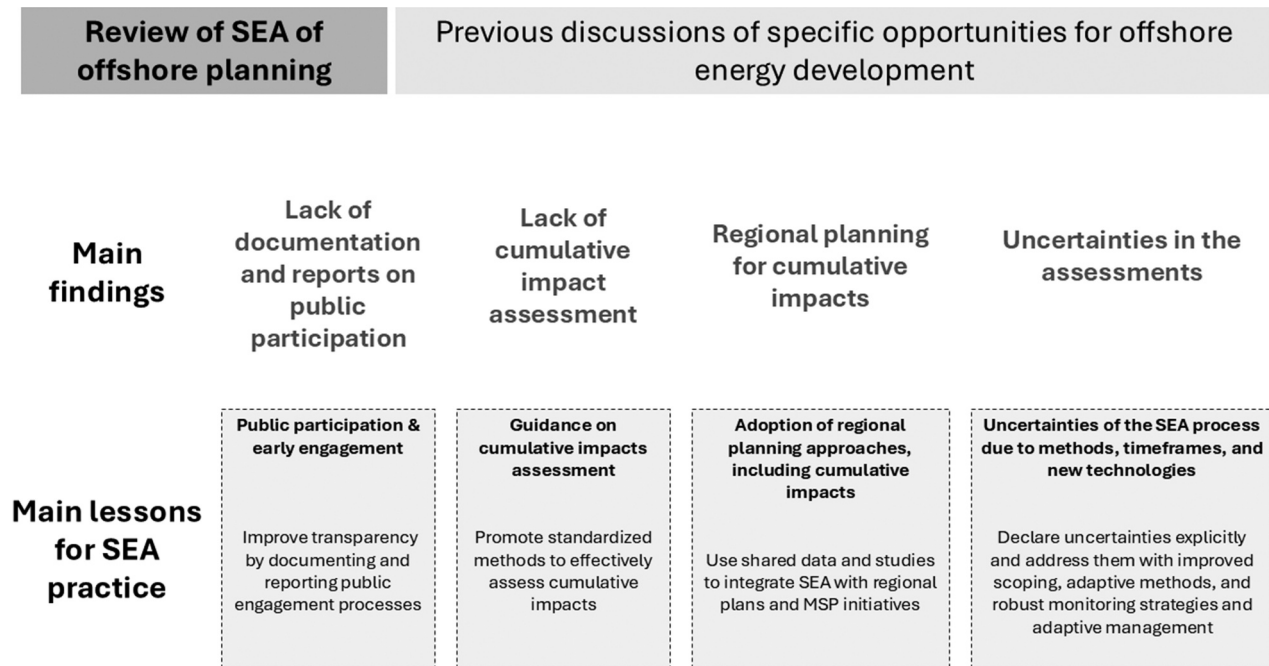


Figure 2. The main limitations and opportunities (lessons) identified in the SEA literature of offshore energy planning.

5. Case review: context of O&G initiatives in Brazil and the environmental assessment of sedimentary area

The assessments of O&G projects played an important role in developing knowledge and experience in assessing the impacts of offshore projects on marine environments in many countries, such as in Brazil (Vilardo and La Rovere 2018; Vilardo et al. 2020). Although the impact assessments for O&G projects have been meeting with several shortcomings, the Brazilian federal environmental agency and other agents have used innovative approaches, such as multi-project assessment and a platform for sharing monitoring information,⁶ seeking to improve the efficiency and efficacy of impact assessment-based decision-making (Vilardo and La Rovere 2018). The multi-project assessment was first used in 2009 to assess the impacts of O&G deep water development of pre-salt provinces (Vilardo and La Rovere 2018). Under this approach, several exploration and production wells and sea floor pipelines have their impacts assessed in one environmental impact study, and a common set of mitigation measures is defined. Afterward, each undertaking is granted a separate license with, if applicable, particular conditions. This approach also made room for assessing the cumulative impacts of O&G development with other past, present, and reasonably foreseeable offshore and onshore activities, especially along the coast. Another approach is applying a specific type of SEA, the abovementioned Environmental Assessment of Sedimentary Area (EASA). This tool was created by a ministerial ordinance in 2012 to

strategically inform new bidding rounds of areas for O&G exploration (Vilardo et al. 2020). So far, it has been used only for two areas, and the studies provided recommendations about areas suitable or unsuitable for receiving new projects.

Apart from EASA, there is no federal regulation for applying SEA for policies, plans, or programs in Brazil (Oliveira and Malvestio 2022), despite the considerable number of SEAs conducted since the 1990s (Montaño et al. 2021). However, due to some conflicts arising from offering leases in environmentally sensitive and biodiverse areas, and consequent litigation, the federal government weaved an arrangement between the Ministry of Mines and Energy and the Ministry of Environment, establishing a procedure for conducting strategic-level assessments before bidding. As defined by Interministerial Ordinance 198/2012, EASA is a 'multidisciplinary study with regional scope, aimed primarily at supporting the classification of areas for the granting of exploratory blocks for oil and natural gas, as well as producing regional environmental information to support the environmental licensing of specific projects.'

5.1. Contextualization of SEA-type application in Brazil

Only two EASA reports were publicly available until 2024: the *Solimões* terrestrial sedimentary basin and the *Sergipe-Alagoas* and *Jacuípe* maritime sedimentary basins. Although the *Solimões* is a terrestrial basin, both environmental assessments followed the same

Table 1. Reports content information.

Report	Number of pages	Date	Study area (km ²)	Baseline (Critical Decision Factors)	Areas classification
Sergipe-Alagoas Jacuípe	707	July/2020	85,982	Biodiversity and environmental aspects: Threatened and sensitive species Sensitive ecosystems Environmental quality Land use and social development: Land use and natural resources Regional infrastructure Economic development Sensitive economic activities Fisheries production Operational safety, technology, and risk management: Emergency response structure Logistics, services, and waste management	Suitable areas (69,811 km ² – 76%) Unsuitable areas (16,170 km ² – 24%)
Solimões	560	August/2020	309,538	Land use and social characteristics: Land use conflicts and social characteristics Indigenous peoples and traditional communities in vulnerable situations Living conditions Local economic development Tangible and intangible heritage Biodiversity and environmental aspects: Endemic, threatened, or overexploited species Water Deforestation Sensitive ecosystem Physical vulnerability	Leased areas (33,074 km ² – 10.7%) Suitable areas (86,047 km ² – 27.8%) Areas under moratorium (11,188 km ² – 3.6%) Unsuitable areas (179,229 km ² – 57.9%)

Adapted from Observatório do Clima (2021).

guidance; thus, their review is potentially useful for this research. These reports, prepared by different consultants, have a similar structure. Both present hydrodynamic transport and oil dispersion modeling, discussion of scenarios and development strategies, classification of areas regarding their suitability, and guidelines and recommendations for activity development (Table 1). The methodological approach of both studies was guided by Partidario (2012).

One of the most valuable recommendations provided by EASA reports is the classification of the area into four categories based on the potential impacts of O&G development:

- leased areas (areas already in use);
- suitable areas (areas considered to be adequate to receive new projects);
- unsuitable areas (areas featuring highly relevant environmental and social values to be conserved);
- areas under moratorium (areas where more investigation and studies need to be conducted to evaluate the suitability for new projects).

The classification of the suitability of areas is not applicable for activities such as transportation, port infrastructure, terminals, and support vessels. In the study of *Sergipe-Alagoas* and *Jacuípe*, the suitability classification was based on environmental indicators

related to (i) the occurrence of marine manatee, a species with high vulnerability; (ii) areas of mud bottoms, due to their importance in aggregating benthic organisms and consequent concentration of the seven-bearded shrimp; (iii) reef environments, as they are fragile, rare ecosystems with high diversity; (iv) marine no-take protected areas, as their management plans do not explicitly foresee mineral exploration, resulting in incompatibility with O&G activities; and (v) oil shoreline contact time of less than 20 h, based on oil dispersion modeling to enable possible containment of oil shoreline contact. In the Solimões basin, an evaluation of unsuitable areas was conducted based on the distribution of protected areas, indigenous lands, isolated indigenous peoples, and proximity to rivers, lakes, and floodplains of the region. For the definition of moratorium areas, the surroundings of traditionally occupied lands and areas with priority for the creation of protected areas were considered. Areas not classified in the previous categories were considered suitable.

The study of the *Sergipe-Alagoas* and *Jacuípe* sedimentary basins presents strategic objectives related to the production and development of the O&G industry, guided by the classification of the suitability of the areas. In this study, most of the areas are suitable for receiving new projects (Table 1). Moreover, the study contains 12 recommendations for environmental licensing. Of these 12 topics, 5 have broad application, i.e.

to various types of enterprises: 'Periodic impact assessment', 'Conducting pre-meetings with the technical team involved in the preparation of the environmental study before issuing Terms of Reference for the studies', 'Involvement of local actors in the licensing process', 'Broad availability of data associated with licensing processes', and 'Presentation of technological alternatives for drilling, production, and flow', this latter already included – in a generic manner – in the minimum content of an EIS according to the 1986 federal regulations (Sánchez and Duarte 2022). Other recommendations included 'Standardization of minimum environmental project methods' and joint action between companies in the implementation of environmental programs ('Development of regional socio-environmental projects'). There are recommendations for 'Conducting integrated environmental studies by region', 'Conducting regional characterization and monitoring campaigns', and 'Development of environmental diagnoses targeting local sensitivities'.

The study of the *Solimões* basin contains 39 recommendations, with 18 of general application, two related to seismic research, six applicable to exploratory drilling, eight related to the production phase, four related to transportation, and one applicable to the decommissioning phase. General recommendations are related to considerations of impacts on affected communities, possible interference with threatened and endemic species, and respective mitigating measures and monitoring actions. In the case of this terrestrial basin, the state environmental agency is responsible for the environmental licensing of exploration and production activities.

5.2. SEA analysis

The main benefits of EASA in the O&G sector are related to public participation at the strategic decision-making level. Anticipating public engagement and keeping it as a continuum during the entire IA process is already recognized as a good practice (IFC - International Finance Corporation 2012; Sinclair and Burdett 2024). The energy demand scenarios and respective impacts are fundamental for discussing the implications of the strategic objective. This proactive analysis can further benefit offshore developments like wind projects. The discussion of technological alternatives can also benefit further projects in the sedimentary basin, especially as presented in the *Solimões* EASA, the study of infrastructure to support the O&G production flow.

One of the main shortcomings of EASA is the lack of influence on the decision of new O&G projects (Table 2). The reasons are related to the delay in the effective implementation and utilization of the instrument, the time lag between conducting studies and holding bidding rounds, and the non-alignment

between sector planning based on exploration rounds, with blocks offered in different basins, and the application of the instrument in sedimentary basins. Therefore, in practice, we reported that the bidding rounds have consistently presented blocks with interferences with areas under study to be legally protected, areas near the coast, and other environmentally sensitive regions. In this context, it is important to note that the Interministerial Ordinance nº 198/2012 provides clear statements on the need to integrate EASA into decision-making processes relating to the granting of exploration blocks, contributing to the prior definition of the suitability of the sedimentary area for oil and natural gas exploration and production activities or ventures, besides proposing recommendations for licensing.

Moreover, the EASA reports do not present an integrated baseline of the ecosystem to be affected and the relevant social matters. This integrated analysis is fundamental for assessing the complexity of marine impacts, especially considering ecosystem services methods and tools (Watson et al. 2024). Besides that, no CIA was conducted to evaluate the synergistic and additive impacts that resulted from several O&G and other related projects in the sedimentary basins analyzed.

In the case of O&G planning, offering blocks without a systematic prior environmental assessment represents a risk to the bidding companies' business – greater difficulty for environmental licensing or project financing in sensitive areas. The absence of prior environmental assessments may influence the investment risk assessments made by companies and deter some from participating in auctions, reducing competitiveness (Observatório do Clima 2021).

5.3. SEA-related initiatives for O&G in Brazil

The context of the EASA application also emphasizes the importance of SEA integration with other offshore initiatives. Other SEA-related initiatives applied for O&G in Brazil are also notable, as the development of an environmental study with a regional scope, providing regional information that can support different environmental licensing processes of projects submitted for approval. In this way, Ibama may exempt the entrepreneur from generating information already available in those regional studies (as well as in EASAs) (Ministry of Environment Ordinance nº 422/2011). However, there is no legal provision on the circumstances in which it is requested, and it is currently defined according to specific situations by the federal environmental agency, especially in areas with environmental sensitivity. Examples include the Regional Environmental Study of the Foz do Amazonas Basin, a unified baseline that subsidized the environmental

Table 2. Analysis of environmental assessment of sedimentary area (EASA) studies according to strategic environment assessment (SEA) performance criteria (IAIA - International Association of Impact Assessment 2002).

IAIA SEA performance criteria		Solimões sedimentary basin	Sergipe-Alagoas/Jacuipe sedimentary basin
Is integrated	Ensures an appropriate environmental assessment of all strategic decisions relevant to the achievement of sustainable development	Include decisions related to the sequence of O&G activities (characterization from seismic research to decommissioning). Discussion of alternatives for transportation included.	Include decisions related to the sequence of O&G activities (characterization from the seismic research to decommissioning). However, there is no assessment of related actions such as transportation and port activities
	Addresses the interrelationships of biophysical, social, and economic aspects	No integrated assessment is presented.	No integrated assessment is presented
	Is tired of policies in relevant sectors and (transboundary) regions, and, where appropriate, to project EIA and decision making	Provide recommendations for O&G future EIAs. No information is provided for other related projects.	Provide recommendations for O&G future EIAs. No information is provided to other related projects.
Is sustainability-led	Facilitates the identification of development options and alternative proposals that are more sustainable	Scenarios considering the level of O&G extraction and development, including alternatives for extracting shale gas. Technological alternatives to the project outflow.	Scenarios and alternatives assessment considering the level of O&G extraction and development, but no information about technological alternatives is presented.
Is focused	Provides sufficient and usable information for development planning and decision making	Methods and database provided. Maps of area classification and recommendations are presented.	Methods and database provided. Maps of area classification and recommendations are presented.
	Concentrates on key issues of sustainable development	Presented aspects related to traditional communities and social impacts.	Presented sustainability indicators for the CDF (Table 1), including fisheries concerns.
	It is customized to the characteristics of the decision-making process	Provide recommendations for project appraisal, but did not influence the decision-making.	Provided recommendations for project appraisal, but did not influence the decision-making.
	It is cost- and time-effective	No influence on the decision-making of bidding rounds so far.	No influence on decision-making of bidding rounds so far.
Is accountable	It is the responsibility of the leading agencies for the strategic decision to be taken	The Commission provided a conclusive report, and the ministerial commission decides.	The Commission provided a conclusive report, and the ministerial commission decides.
	It is carried out with professionalism, rigor, fairness, impartiality, and balance	Study publicity available, report is clear, and methods are well described using the reference of Partidario (2012). The teams are multidisciplinary, with all members listed in the study.	Study publicity available, report is clear, and methods are well described using the reference of Partidario (2012). The teams are multidisciplinary, with all members listed in the study.
	It is subject to independent checks and verification	The technical commission provided a conclusive report, and the ministerial commission decides.	The technical commission provided a conclusive report, and the ministerial commission decides.
	Document and justify how sustainability issues were taken into account in decision-making	Study publicity available, report is clear, and methods are well described. The criteria for choosing CDF are not presented. The SEA recommendations involved the zoning options, general guidelines of strategic actions, and recommendations for the environmental licensing, considering actions for the main stakeholders involved.	Study publicity available, report is clear, and methods are well described. The criteria for choosing CDF are not presented. The SEA recommendations involved conservation and social aspects.
Is participative	Informs and involves the interested and affected public and government bodies throughout the decision-making process	The public consultation was conducted online and in person. Interviews and workshops were used to collect and present information about SEA development. However, no evidence about how to incorporate the comments and suggestions was documented.	The public consultation was conducted, but the document was not attached to the final report publicly available. The SEA report declares that the main SEA recommendation was grounded in the public consultation processes, but makes no mention of which recommendations were considered.
	Explicitly addresses their input and concerns in documentation and decision-making	Report on public consultation and interviews, but there is no explicit consideration of how the recommendations are considered in the assessment.	Report public participation during the study development, but there is no explicit consideration of how the recommendations are considered in the assessment.
	Has clear, easily understood information requirements and ensures sufficient access to all relevant information	In general, there are good figures, maps, and written material, but it presents problems with maps scale.	In general, good figures, maps, and written.
Is iterative	Ensures availability of the assessment results early enough to influence the decision-making process and inspire future planning	No influence on the decision-making of bidding rounds so far.	No influence on the decision-making of bidding rounds so far.
	Provides sufficient information on the actual impacts of implementing a strategic decision, to judge whether this decision should be amended, and to provide a basis for future decisions	Scenarios and alternatives assessment. Recommendation and classification of areas presented.	Scenarios and alternatives assessment. Recommendation and classification of areas presented.

Legend of evaluation findings

Positive aspects were found

Neutral aspects were found

Negative aspects were found

N/A

licensing of three drilling activities, by different companies. Besides, an Environmental Characterization Project (Baseline) of the Equatorial Brazilian Margin was also developed to complement the previous study with additional primary data (BID – Banco Interamericano de Desenvolvimento, PPI – Programa de Parcerias de Investimento – Ministério da Economia 2020). Despite the potential of these studies to inform project assessments, Ibama found great uncertainties related to the Individual Emergency Plan of drilling projects proposed for this area. Consequently, Ibama issued a negative opinion regarding the approval of these drilling projects. Similarly, the use of data and information from previous studies can be observed in other EIA systems related to the O&G sector, such as the United States, Australia, Mexico, and Norway (BID – Banco Interamericano de Desenvolvimento, PPI – Programa de Parcerias de Investimento – Ministério da Economia 2020).

Another initiative under the licensing process of offshore O&G is the development of regional monitoring programs, for the same area of concentration of projects, which can be shared or not between companies (Ministry of the Environment Ordinance n° 422/2011). Those regional monitoring programs represent an opportunity to share costs and responsibilities among proponents and to better relationships with communities (improved communication, increased trust). There is also the possibility of public–private partnerships and the participation of various research institutions for inputs of scientific knowledge and best practice consultation. The results indicate that regional monitoring programs can help with the creation of a shared database, establishment of indicators and acceptable limits on a regional scale; increased effectiveness of mitigation measures; greater transparency; facilitation of assessment of cumulative impact management (Kakinami et al. 2020). Finally, as mentioned before, multi-project assessment, including several projects, can also be conducted, enabling better context to address regional cumulative issues by expanding spatial and temporal boundaries, when compared to project-level assessments (Vilardo and La Rovere 2018).

6. Lessons about SEA potential contributions for offshore wind developments in the context of non-systematic practices

The literature review on SEA practices for offshore energy activities, the review of SEA features in a non-systematic context, and the analysis of O&G strategic assessments in Brazil showed several contributions of SEA conducted in a non-systematic context for offshore wind developments (Figure 3).

Our investigation showed that SEA can be adapted to local planning conditions when applied in non-systematic practice, introducing relevant sustainability aspects. However, such flexibility makes SEA vulnerable to the political context and, at times, too lenient to the point of being stripped of robust assessment methods and meaningful public participation. Therefore, the SEA in non-systematic contexts must present defined objectives, approaches, and desired outcomes grounded in well-established SEA guidance to inform potential approaches and methods to be applied (Partidario 2012). Malvestio and Montaña (2019) emphasized the need to define stakeholders' responsibilities to manage SEA's flexibility and, therefore, influence its effectiveness. Therefore, primary concern related to SEA in non-systematic contexts is to deal with its flexibility to adapt but explicitly determine the purpose and responsibilities of the strategic assessment.

We found that one of the main benefits of EASA is enabling public participation at a strategic level. The engagement of affected communities is fundamental for planning the energy transition and low-carbon initiatives (Carley and Konisky 2020; Levenda et al. 2021). Public engagement and documented consultation in the case of analyzed studies were among the main benefits of developing strategic assessment in the O&G sector. Meaningful public participation reduces project risks (Sánchez et al. 2024). Therefore, offshore wind energy planning should consider promoting public participation during all decision-making stages to decrease future risks and uncertainties for investors.

Moreover, the assessment of technological alternatives and area classification can inform and be informed by MSP. The latter presents several challenges in many countries and is still under development in Brazil. Therefore, SEA can help in mainstreaming sustainability-related objectives and, consequently, improve the considerations of social and environmental aspects in planning multiple marine activities. The reviewed EASA presented project design alternatives considering different O&G extraction and production levels. This assessment, along with zoning proposals, can support robust decisions about where and how to allocate projects to meet the expected demand in the Brazilian coastal areas.

Noble et al. (2013) reported uncertainties declared by the government about the spatial scales of offshore SEA and by the industries related to timeframes. Moreover, uncertainties of offshore assessments are also related to methodological aspects, such as the case of data collection for baseline and monitoring offshore initiatives that need to be improved (Wilding et al. 2017). The rapid technological developments in the offshore wind industry may not advance at the same pace as the SEA processes, potentially questioning alternative

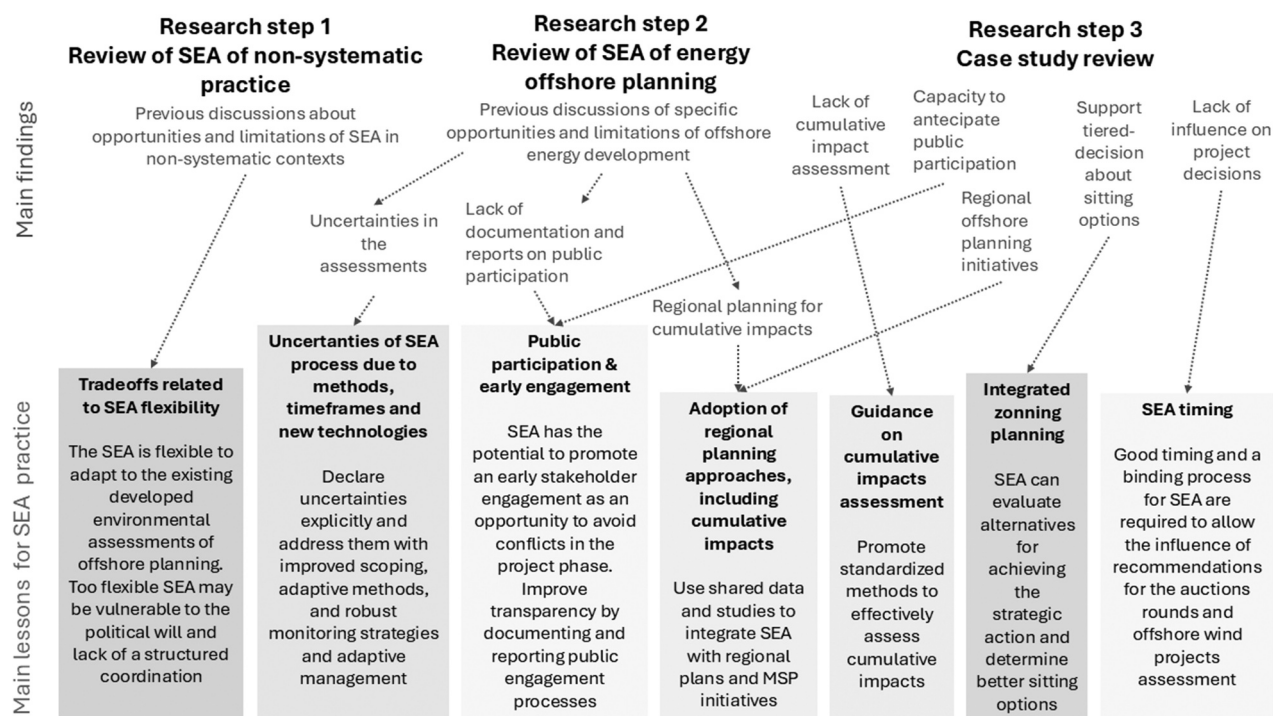


Figure 3. Synthesis of main lessons about strategic environmental assessment (SEA) contributions for offshore wind initiatives in a non-systematic context (MSP; marine spatial planning).

assessments and the relevance of the reports facing the new technologies (Willsteed et al. 2018).

Reviews of SEA applications for offshore energy and O&G planning show that, even in a formalized SEA context, such as the case of the UK and Germany, there is hardly explicit evidence of SEA influencing decisions and resulting in tiered decisions, similar to the cases analyzed in Brazil, in a non-systematic context. The EASA was conducted considering the sedimentary basin, but the auctions were offered in rounds of blocks scattered in several basins. This dealignment may influence the coordination between the tiered recommendations (Fidler and Noble 2012), and the same problem can happen for offshore wind energy if the same dealignment occurs between auction rounds and area assessments. Therefore, this timely influence should be strengthened in all SEA contexts, especially considering the opportunity to avoid conflicts and optimize the project-level assessment. Therefore, we emphasize the importance of timely and coordinated studies preparation, in the context of bidding decisions, to support decisions about opening new exploration frontiers and conducting project-EIA.

Another lesson derived from the shortcomings observed in the EASA experience is the consideration of cumulative impacts. No mention of cumulative impacts was found in the documents analyzed nor in the literature reports deficiencies in the CIA in some of the SEA cases analyzed. Moreover, no integrated analysis of impacts on marine ecosystems and communities was presented in the Brazilian experience

analyzed. Therefore, improvements to the current practice are required when developing guidance for offshore wind planning. These integrated approaches and consideration of cumulative impacts are mandatory given the complexity of marine impacts and trade-offs involved (Watson et al. 2024), as already shown from current offshore wind assessments practice (Willsteed et al. 2018). Here we emphasize the need for SEA guidance, especially considering the assessment and monitoring of the cumulative impacts of multiple marine activities.

Under these shortcomings and uncertainties, we highlight the potential contributions of SEA-related initiatives applied to the O&G sector that could be practiced for regional planning and development of wind energy. These initiatives include conducting baseline studies with regional scope, using data and information from previous studies, especially considering the long-term experience of the O&G sector in key areas for developing offshore wind energy, and conducting regional monitoring programs. We found that regional monitoring programs in Brazil are an opportunity to create a shared database, indicators, and thresholds that can support a better understanding of regional impacts and cumulative impact management (Kakinami et al. 2020). Replicating these initiatives can foster the assessment of cumulative impacts in the marine and coastal environment, supporting multidisciplinary thinking and action for assessing and managing cumulative environmental change (Willsteed et al. 2017). Therefore, SEA integration with

other regional initiatives is fundamental for supporting holistic and integrated cumulative impacts assessment.

7. Conclusions

The rapid energy transition calls for new regulations and strengthened SEA practice, especially those aimed at dealing with decisions for deploying new offshore projects. Several jurisdictions in the North Sea, a common region for European countries including parts of Norway, Sweden, Denmark, Germany, the Netherlands, and the UK, have evolved their practice of conducting SEA for offshore energy development. Some emerging markets, such as Brazil, present relevant experience in the offshore O&G sector. However, they are still developing their IA regulations for offshore wind projects and feature important SEA experience, albeit a non-systematic practice. Grounded on the findings of our literature review and limitations of O&G projects in a non-systematic context, we discussed potential contributions for developing offshore wind energy strategic assessments.

We found that SEA flexibility in methods and procedures can be an opportunity for aligning SEA purposes with the targets of other marine and offshore project planning instruments. Although this flexibility can help to adapt and integrate other initiatives, it can also pose a risk if key stakeholders do not agree on formalized rules, potentially leaving SEA and its outcomes vulnerable to political influence. As in the case of Brazil with the EASA, when there are no general rules for applying SEA, sectoral regulations and technical committees can be established for designing a tailor-made and fit-for-purpose strategic assessment. Effecting an important potential contribution of SEA – namely, addressing cumulative impacts – requires specific guidance when SEA is not non-mandatory or regulated. Good timing, bidding processes, and prioritization of SEA are required to allow the influence of recommendations on the auction rounds and offshore wind project impact assessments.

Following the model presented in the O&G sector in Brazil, it is possible to foresee a similar offshore wind sector instrument that can attend to SEA purposes. A SEA designed for specific applications can be developed through specific regulations, as in the case of EASA. It could support relevant decisions, especially for defining suitable areas for offshore wind energy development, selecting valuable environmental components of interest for CIA, and deploying regional monitoring measures. The development of regional baseline studies is also a crucial step for these activities, and it could support other regional planning and management processes, such as MSP. In future research, we recommend investigating the strategic role of SEA in a non-systematic context, with particular attention to its

potential to influence broader planning processes and improve project quality. As we move forward, the lessons learned from literature, EASA, and other frameworks will be instrumental in shaping the future of offshore wind energy worldwide.

Notes

1. Available at: https://www.gov.br/ibama/pt-br/assuntos/laf/consultas/arquivos/20250311_Eolicas_Offshore_Ibama_marco_25.pdf.
2. Available at <https://iaac-aeic.gc.ca/050/evaluations/proj/84343?culture=en-CA> and <https://iaac-aeic.gc.ca/050/evaluations/proj/83514?culture=en-CA>
3. Available at: <https://www.boem.gov/oil-gas-energy/national-program/national-ocs-oil-and-gas-leasing-program>.
4. Available at: <https://www.boem.gov/renewable-energy/regulatory-framework-and-guidelines>.
5. For example: <https://www.boem.gov/renewable-energy/regulatory-framework-and-guidelines>.
6. Mention to the 'Programa de Monitoramento de Praias' with the shared information here: <https://simba.petrobras.com.br/simba/web/>; 'Banco de Dados Ambientais': NETUNO (<https://libgeo.univali.br/bandar/pt-br>) 'Banco de Dados de Caracterização Ambiental: Banco de Dados de Caracterização Ambiental: Institucional (bdca.com.br)'

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