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Artificial intelligence in negotiating energy production and other interests in marine spatial planning—managing transparency and bias

Juei-Cheng Jao[1,†] and Jason C.T. Chuah[2,3,†,*]

[1]College of Ocean Law and Policy, National Taiwan Ocean University, Taiwan
[2]Faculty of Law, Universiti Malaya, Malaysia
[3]City Law School, City St Georges, University of London, United Kingdom

*Corresponding author. Faculty of Law, Universiti Malaya, Malaysia and City Law School, City St Georges, University of London, United Kingdom. The authors acknowledge with thanks the support provided by the National Science and Technology Council of Taiwan, NSTC Grant: 114-2410-H-019-003-MY3. E-mail: jason@um.edu.my or jason.chuah.1@city.ac.uk

†Equal co-authors.

ABSTRACT

The placement of offshore energy production units and structures (such as pipelines) will invariably come within the scope of any prevailing marine spatial planning (MSP) regime. There is increasing reliance on AI to ensure precision in placement. The data generated in many instances would be adopted by the authorities in implementing any applicable marine spatial plan. However, where there are many competing socio-economic and legal interests in the marine space, the use of AI by offshore energy corporates might well produce bias, whether intentional or not. This work maps out the risks of bias in this offshore energy and MSP context. It asks whether a liability system scheme like the EU AI Law could work. It concludes with thoughts on how, from a legal and regulatory perspective, spatial data sharing and AI used in an MSP context for offshore energy could be improved.

The production and transport of energy resources, whether renewables such as wind or non-renewables such as oil and gas, in the marine space will invariably come within the scope of any prevailing marine spatial planning regime. The placement of energy production units (such as oil platforms, wind turbines, ocean thermal energy conversion systems, etc) and transportation networks (such as pipelines) in the marine space has long been dependent almost entirely on where those energy resources are found geographically. Moreover, there is a long-standing quip in the industry, 'one rock, two geologists, and three opinions'. It is trite to say that uncertainties have always characterized the sector. Thus, even when energy production companies try to be responsible, luck might not always be on their side when placing drilling units or similar structures in the seabed. However, with the introduction and implementation of binding marine spatial planning (MSP)[1] rules requiring that these energy production units or devices are placed taking into account intersecting marine interests such as fisheries, shipping, tourism, military, underwater cabling, and the marine ecosystem, better precision is critical.

The geological and technical decisions provided by highly systematic algorithms trained on large data sets assist greatly not only in the exploration and placement stages but also in the operational[2] aspects of production. The use of predictive AI in seeking out not just optimal sites for drilling and facilitating extraction processes, which are sensitive to other uses of the same marine space, is fast becoming a norm.

This transformation, however, holds several key challenges for the industry and MSP regulators. This research is interested in one specific problem—the challenge of transparency in data collection, collation, and application. Key to the use of AI in ensuring an optimal share in the marine space in any marine spatial plan is the availability of data. From a marine spatial planning regulatory system perspective, planners or authorities will call for accountability from the users (such as the offshore energy producers) as to their commitment to the sectoral carve-outs provided for in the marine spatial plans. In sum, energy companies operating in MSP areas are often required to:

- Submit spatial data (eg platform coordinates, safety zones)
- Participate in stakeholder consultations
- Provide environmental monitoring results for planning updates.

However, for the commercial operators, as is also immediately obvious, alongside the cost implications there are concerns as to the loss or compromising of commercially and technically valuable data for the energy companies. Being too transparent with their data may not be to their commercial advantage. From an MSP perspective, there are concerns about the dependency on the so-called science of AI—AI software and applications could lead to disputes over bias (whether intentional or otherwise), accuracy, and integrity. This research focuses on the risk of bias, which has increasingly been brought out by scientific and technical research. Marine spatial planning is data-dependent.[3] Where the data generated, surveyed, interpreted, and evaluated is unreliable because of bias, the integrity of the state's MSP scheme is threatened. Broadly speaking, this is exacerbated by the fact that MSP is often under-resourced, with few regulators taking active steps to interrogate the data. Moreover, there is a real risk of unquestioning reliance on AI.[4]

This article examines first the provisions of MSP and the implications for the offshore energy production sector. It then identifies the risk of bias and maps the risk to the role of an MSP in balancing the competing interests in the marine space. The question as to whether a liability system scheme like the EU AI Law could work to limit the risk of bias will be examined, notably also against the backdrop of the voluntary general-purpose AI Code of Conduct introduced by the

[1] On a working description of MSP please see below at p. 3.

[2] Operational here refers to processes undertaken in the upstream sector of energy exploration, development and production, as well as the midstream sector of handing, storage and transportation, and the downstream sector of refining and processing raw energy products.

[3] This research is carried out under the auspices of the Taiwanese government and is part motivated by the increasing important role of AI technology in the Taiwan Marine Spatial Planning infrastructure. In Taiwan there are very technology intensive provisions relevant to MSP. They are (a) NODASS (the National Ocean Database and Sharing System operated by National Academy of Marine Research) aggregates oceanographic, meteorological, and human-use data (winds, waves, currents, AIS/vessel density, biodiversity) and links to other open data (wave/tide forecasts, Environmental Impact Assessment (EIA) repositories; (b) OCA's (Ocean Conservation Administration) conservation and environment data warehouses (marine life, debris, education, monitoring) and public-facing visualizations that provide the biodiversity basemap for MSP; (c) Taiwan's VTS and shipping information networks where in this regard, S-100-aligned hydrographic products are being developed for navigation safety integration around wind farms and busy approaches. The next step in the Taiwan MSP implementation trajectory is to publish a single, authoritative MSP geospatial portal: a 'one map' showing legally effective zones (conservation, energy, cables, military danger areas, ship routes/anchorages, aquaculture concessions, cultural heritage exclusion buffers), with metadata on the legal instrument and effective dates. Critically too there are plans to reduce data fragmentation. NODASS and OCA platforms are strong, but agencies curate data in separate portals; authoritative, up-to-date layers (legal boundaries, permits, monitoring) should be federated into a single 'live' MSP map. The role of AI in creating this integrated map cannot be understated. Official source from the Ocean Affairs Council: News and Releases-Taiwan Steps into OOC: Minister Kuan Bi-ling Reaffirms Commitment to Sustainability and a Smart Blue Future - Ocean Affairs Council.

[4] A. Klingbeil, C. Grützner and P. Schreck , 'Trust and Reliance on AI—An Experimental Study on the Extent and Costs of Overreliance on AI', (2024) 160 Computers in Human Behavior 108352. Also, S Blanco, 'Human Trust in AI: A Relationship Beyond Reliance' (2025) AI and Ethics 1–14.

EU.[5] These matters will be explored within an MSP context—a context where the local law on MSP may provide for certain dynamics such as the role of the MSP regulator or authority. It concludes with thoughts on how spatial data sharing and AI used in an MSP context for the transport of energy resources and the exploitation of offshore energy might lead to the (re)negotiation of marine governance. As a piece of normative work, suggestions for improving the MSP system as it interacts with the energy sector and AI would be made.

MARINE SPATIAL PLANNING AND ENERGY PRODUCTION

As is common with most literature on marine spatial planning, it is useful first to set out a working description of MSP. The United Nations Educational, Scientific and Cultural Organization (UNESCO) Intergovernmental Oceanographic Commission describes MSP in this way: 'Marine Spatial Planning (MSP) is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process.'[6] From this definition it is reasonably clear that MSP is not intended to be an end in itself but a practical means 'to create and establish a more rational use of marine space and the interactions among its uses, to balance demands for development with the need to protect the environment, and to deliver social and economic outcomes in an open and planned way'.[7]

Indeed, offshore energy is a relatively new kid on the block in comparison to fisheries and shipping, the traditional sectors making claims on the marine space. However, like all other sectors, technology is making significant strides in the exploration, development, and production of offshore energy, renewable or otherwise. In the offshore energy sector, and it is conceded that, in the interest of space, there have inevitably to be some generalizations made of the different AI solutions. An AI solution for drilling for oil is not going to be the same as one for seeking out geothermal deposits. However, from a legal and policy perspective, the implications for using AI in most energy-related operations (upstream, mid-stream, or downstream) could be evaluated against the backdrop of an MSP framework.

It is beyond the scope of this article to detail the different commercial AI products. It suffices to say that in an offshore oil and gas context, predictive AI is now routinely deployed to spearhead seismic data interpretation. AI, especially deep learning (eg CNNs[8]), automates the analysis of 2D/3D seismic datasets to identify subsurface structures like faults, folds, and traps. In particular, AI can detect potential hydrocarbon accumulations. The speed of interpretation time can be reduced significantly, from weeks to hours. Machine learning models can also analyse petrophysical logs (eg resistivity, porosity, gamma ray) efficiently to predict lithology, fluid types, and reservoir quality, and classify rock types and map pay zones.[9]

Another vital role for AI products is mapping and surveying the marine space. Hydrographic and geological surveys are routinely now undertaken by autonomous survey platforms with onboard AI. The services attended include seabed mapping, pipeline inspection, marine archaeology, UXO (unexploded ordnance) surveys, seafloor survey, subsea infrastructure inspection,

[5] There are three chapters to the Code—one on transparency, one on Copyright and one on safety and security. Text available at <https://digital-strategy.ec.europa.eu/en/policies/contents-code-gpai> The Code of Conduct was published on 10 July 2025 (accessed 12 January 2026).

[6] See Marine Spatial Planning | Intergovernmental Oceanographic Commission.

[7] ibid.

[8] Convolutional neural networks (CNNs) are a branch of AI, trained on a large volume of datasets can perform many functions key to the oil and gas sector. There is a large amount of scientific and technical literature on CNNs. See eg N Vahabi and DR Selviah, 'Convolutional Neural Networks to Classify Oil, Water and Gas Wells Fluid Using Acoustic Signals' *2019 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT)*, Ajman, United Arab Emirates, 2019, pp. 1–6; J Zang and J Wang, 'Expertise-informed Bayesian Convolutional Neural Network for Oil Production Forecasting Geoenergy Science and Engineering' (2024) 240, 213061; T Li, 'Research on Convolutional Neural Network in the Field of Oil and Gas Exploration' (2023) Open Access Library Journal 10 1–10; S Mohd Razak and B Jafarpour, 'Convolutional Neural Networks (CNN) for Feature-based Model Calibration under Uncertain Geologic Scenarios', (2020) 24 Computational Geosciences 1625–49.

[9] See eg D Joshi, and others, 'Prediction of Sonic Log and Correlation of Lithology by Comparing Geophysical Well Log Data Using Machine Learning Principles', (September 21, 2021). Available at SSRN: https://ssrn.com/abstract=3932293 (accessed 12 January 2026).

carbon storage site monitoring, pipeline tracking, etc.[10] There are also AI applications or software used to process hydrographic data, drawing on deep learning technologies. Hydrographic data of course is essential in the determination and understanding of the marine space based on uses and interests. It is thus also not unsurprising that AI is employed for environmental and habitat mapping. There is much scientific literature on the use of AI in mapping biodiversity and climate change patterns at sea.[11]

MANAGING RISK OF BIAS

The dependence on AI for an MSP-compliant energy sector, quite obviously, is here to stay. However, the use of AI for such purposes has led to researchers and other stakeholders proving that bias can and does occur. Clearly, there is much by means of scientific methodologies can do to reduce the risk of algorithmic bias in data collection, collation, processing, and interpretation.[12] This article, however, is not concerned with the scientific and technological redeeming measures but the appropriate regulatory (whether part of an MSP framework or simply more generally) responses.

Marine spatial planning needs to secure the buy-in of the many stakeholders in our oceans. With so many different interests in direct competition with each other for the same marine and maritime space, trust is vital. Where the data aspect of the decision-making process is tainted by algorithmic bias, that puts in jeopardy the soundness of the execution and implementation of MSP policies at *all* levels, whether national or regional. On top of that, many MSP systems do not have established and explicit procedures for challenging the MSP scheme other than broadly defined judicial review mechanisms. In the law relating to judicial review, in many jurisdictions, an allegation of data or automation bias will need to cross a very high threshold before a claim for judicial review would be entertained. For one thing, from a legalistic perspective, the presence of automation or algorithmic bias is not necessarily the same as bias in the decision outcomes. The former is the presence of bias in how data is collected, collated, and analysed. The latter refers to any bias in the decisions made, whether in reliance on data or not.

The legal principles on judicial review[13] might be relevant in three contexts, but in all situations, the automation or algorithmic bias must lead to biased outcomes. First, for example, where the assertion that the automated system had caused the exclusion of factors which the decision-maker should have taken into account by law or where the system had been used out of context to make a decision that the output is not intended or able to support. The scope of this principle, however, is narrow as is obvious;[14] it is difficult to prove that the overall decision was improper since those factors in question might well not be the only ones befitting of accommodation. Secondly, where the decision-maker blindly follows the automated data without exercising their own judicious discretion. In such a case, the data or algorithm prompt might be said to have fettered the decision-maker's discretion.[15] The third scenario is closely allied to the second—where the decision-maker had adopted the data and/or conclusions produced by the AI without inquiring into the relevant facts that might constitute a breach of the duty of inquiry.[16] However, it is also pellucid that these claims are difficult to satisfy.

Nevertheless, leaving aside claims for judicial review, which are often damaging to the notion of good governance and citizens' trust, MSP schemes would be far better for overall governance if

[10] There are numerous commercial providers in the market. It is not the intention of this article to cite any specific provider in the interest of balance.

[11] As an example, please see the resources cited by the EU funded research project titled 'Mission Atlantic' at Towards the Sustainable Development of the Atlantic Ocean | Mission Atlantic.

[12] See eg the literature in SMK Mühling, 'Utilizing Artificial Intelligence (AI) for the Identification and Management of Marine Protected Areas (MPAs): A Review', (2023) 11 Journal of Geoscience and Environment Protection 118–32.

[13] For the purposes here, UK administrative law will be used as a basic template for analysis. It is submitted that other comparable systems of administrative law will contain equivalent legal devices for challenging decisions made on the basis of defective automated data. See too T Kazim and J Tomlinson 'Automation Bias and the Principles of Judicial Review', (2023) 28 Judicial Review 9–16.

[14] See the UK case of *E v Secretary of State for the Home Department* [2004] EWCA Civ 49, [2004] QB 1044.

[15] *Lavender v Minister of Housing and Local Government* [1970] 1 WLR 1231.

[16] *Secretary of State for Education and Science v Tameside MBC* [1977] AC 1014.

they are founded on sound data collection and data interpretation. The point here is that judicial review and other remedies *ex post facto* are taken because the AI-reliant MSP project has failed. It is far better to look to prevention rather than cure.

That is where AI product laws would be useful. A product-oriented law on AI, such as that which the EU has introduced, might serve as a useful template on how best to manage the risks of bias in our context, but there are also important provisions to be made on the use of AI in an MSP context.

REGULATING BIAS AND THE EU AI LAW AND ITS RELATED GOVERNING PROTOCOLS

A quick word should be said about the EU AI law's approach. European Union Regulation 2024/1689[17] or EU AI Act, as it is better known, is significant not least because it is arguably the most comprehensive law specifically developed to address the risks associated with the use of AI technologies. That said, there is voluminous literature about the EU AI Act, which, as a pioneer in the global arena, would deservedly garner. It is not the object of this article thus to venture into the now well-trodden subject. Critically, the focus is on the broad regulatory approach and on proposing a possible adaptation for MSP purposes.

The values and interests espoused by EU law are consistent with those of creditable international organizations such as the Organization for Economic Cooperation and Development (OECD), amongst others. The EU AI Act is introduced explicitly to establish an environment to foster commercial competitiveness and innovation in 'human centric and trustworthy artificial intelligence (AI) while ensuring a high level of protection of health, safety, fundamental rights as enshrined in the Charter of Fundamental Rights of the European Union … , including democracy, the rule of law and environmental protection'.[18] The Act classifies AI products based on the risk they pose—their system risks are classified as unacceptable, high, limited, and minimal. These risk classifications will determine whether the products in question would be prohibited, subject to a pre-market conformity assessment, or subject to transparency rules, or free from regulation.

Pivoting back to bias, the EU AI Act cannot be said to predominantly provide for bias. Indeed, there is empirical research to show that the bias issue was not at the forefront of the European Parliament in the early stages of the passage of the Regulation.[19] The preamble to the Regulation makes it plain that bias is a risk which would count towards the gravity of the risk profile of any AI product in question.[20] As far as the text of the Regulation is concerned, Article 10 requires *high-risk AI systems* to be developed on the basis of training, validation, and testing data sets. What that means is that the data sets and algorithmic processes used should meet the standards set out by the Regulation. Article 10(2) explicitly states that training, validation, and testing data sets shall be subject to data governance and management practices appropriate for the intended purpose of the high-risk AI system. The AI Act classifies systems into four risk categories: unacceptable, high, limited, and minimal risk. Bias mitigation obligations primarily apply to high-risk AI systems, which include:

- AI is used in employment, education, law enforcement, migration, and access to essential services.[21]
- Systems that affect individual rights, like credit scoring, hiring, or recruiting algorithms.[22]

It is not entirely clear whether AI systems, which are used in spatial planning—namely, land use, offshore energy exploitation, and energy transport activities fall within the high-risk category.

17 COM(2021)0206–C9-0146/2021–2021/0106(COD)). <https://www.europarl.europa.eu/doceo/document/TA-9-2024-0138_EN.pdf> (accessed 12 January 2026).
18 Recital 1, Preamble to the Act.
19 A Chiappetta, 'Navigating the AI Frontier: European Parliamentary Insights on Bias and Regulation, Preceding the AI Act' (2023) 12 Internet Policy Review 1, at 11.
20 Recitals 32, 54, 61, 67, 70, 75, and 110 eg make mention of bias in the use of AI systems.
21 Annex III of the EU AI Act.
22 art 6(1) and (3).

Taking Taiwan as an example, spatial decisions that impact indigenous lands and marine resources must comply with Article 21, Indigenous Peoples Basic Law, and its implementing rules on consultation, and consent/participation. The rules explicitly list activities that trigger Indigenous consultation, and the MSP system must internalize these procedures, especially for coastal fisheries, nearshore aquaculture, and conservation areas near indigenous communities. The question as to AI when used to provide for shared use of the marine area between energy-related activities and indigenous and other community interests, also would be deemed as high risk. While certainly arguable, the EU AI Act's characterization of high risk in Annex III and Article 6 might not stretch that far.

As regards AI systems of a lower order of risk, the so-called limited risk systems, there are provisions on transparency.[23] The emphasis there is to enable users to do so intelligently, paying regard to the risks involved. Those risks include the risk of bias.

The finding here is that where there exists a law on AI products that provides for mechanisms to ensure that the suppliers properly prevent their products from causing harm goes some way to assist users, such as MSP agencies, to avoid bias. The just-published code of practice is also one of the solutions provided by the EU.[24]

MARINE SPACE GOVERNANCE AND USE OF AI

Alongside the supplier's duty to manage the risk of bias for their AI systems, at the policy level, the algorithmic risk in tools that are now so prevalent in MSP should also be evaluated by the users. Drawing from the most recent research findings[25] available, there are several aspects of engagement for the authorities involved in undertaking the MSP.

Data governance in the Marine context

- **Balance sectoral data**: Shipping and offshore energy often generate rich datasets (AIS, infrastructure surveys), but artisanal fisheries, small-scale aquaculture, and cultural uses are poorly mapped. Authorities, whether those responsible for MSP or the wider geo-economic space, should invest in community-led data collection, participatory mapping, and citizen science to fill gaps.[26]
- **Ground-truth ecological models**: AI models trained on satellite or sensor data may overrepresent visible habitats (like coral reefs) while underrepresenting less detectable ecosystems (deep sea, seagrass). Marine surveys and scientific validation are key.[27]
- **Cross-border harmonization**: In shared seas (eg Straits of Malacca, South China Sea, Taiwan Strait), bias arises when each state uses different standards. Regional data standards and shared repositories may reduce misalignment.[28]

[23] See generally Chapter IV of the EU AI Act.

[24] The General-Purpose AI Code of Practice | Shaping Europe's digital future; art 3(63) AI Act defines a 'general-purpose AI model' as 'an AI model, including where such an AI model is trained with a large amount of data using self-supervision at scale, that displays significant generality and is capable of competently performing a wide range of distinct tasks regardless of the way the model is placed on the market and that can be integrated into a variety of downstream systems or applications, except AI models that are used for research, development or prototyping activities before they are placed on the market'. See also Commission Guidelines on the scope of obligations for providers of general-purpose AI models under the AI Act (18 July 2025) C (2025) 5045 final.

[25] Sources to be provided below and are referenced against each discrete research output.

[26] D Sharp and others, 'A Participatory Approach for Empowering Community Engagement in Data Governance: The Monash Net Zero Precinct' (2022) 4 Data & Policy e5. doi:10.1017/dap.2021.33.

[27] L Figuerola-Ferrando and others, 'Marine Citizen Science and the Conservation of Mediterranean Corals: The Relevance of Training, Expert Validation, and Robust Sampling Protocols' (2024) 73 Environmental Management 646–56. <https://doi.org/10.1007/s00267-023-01913-x> (accessed 12 January 2026).

[28] See eg the work of the US National Maritime Intelligence-Integration Office (NMIO) at Maritime Information Sharing (MIS) – Regional Initiatives.

Transparency and explainability in MSP

- **Explainable[29] zoning maps**: If AI identifies a 'suitable site' for wind farms, the algorithm's key drivers (currents, seabed type, shipping density, etc.) should be shown clearly to decision-makers and stakeholders. That transparency not only helps build trust but also provides a better understanding and awareness of the science needed for a proper implementation of MSP.
- **Uncertainty visualization**: Instead of binary maps ('this area is good/bad'), show uncertainty ranges or confidence levels. This avoids false precision that could disadvantage marginalized users.[30] This is particularly important where the marine energy sectors are involved. It is sometimes easy for these industries to be painted as 'bad'. A sound MSP system should take into account the nuances of the different users and uses of the marine space without any broad-brush assumptions or generalizations.

Inclusive stakeholder engagement

- **Participatory validation of AI outputs**: Before adopting AI-generated plans, hold consultations with fishers, coastal communities, port authorities, and conservation groups to ground-truth findings.[31]
- **Accessible mapping platforms**: Dashboards and interactive maps in local languages, using icons or simple overlays, allow non-experts to see and question AI results.[32]
- **Recognition of traditional and indigenous knowledge**: Coastal communities often hold long-term ecological knowledge (eg spawning grounds) that AI models might miss. Integrating this can rebalance biases towards industrial data sources.[33] This inclusion might also be called for by law, as with the Taiwan legislation mentioned above.[34]

Algorithmic safeguards for MSP[35]

- **Bias stress tests**: Although already done by several quarters in the offshore energy tech sector, the law can recognize a failure of professional and operational standards if AI models are not run with and without certain datasets (eg large shipping data) to check whether results over-prioritize one sector.[36] This is important to the marine energy sector for obvious reasons.
- **Scenario diversity**: Given the diversity of interests and values in the MSP framework, multiple models or assumptions (climate projections, economic growth rates) should be adopted to avoid locking in a single worldview. This is where energy sector undertakings can play a

[29] There is a great deal of scientific data about achieving explainable AI(XAI); a notable output with a good range of sources is S Singh, AT Tien and S Momina (eds), 'A Comprehensive Study of AI (XAI) for Ocean Health Monitoring' *Artificial Intelligence and Edge Computing for Sustainable Ocean Health* (Springer Nature Switzerland 2024) 213–40. Importantly and from a lay perspective, XAI is AI which makes its decisions and behaviour transparent and interpretable, so humans can understand why it produced a particular output or recommendation.

[30] There is good evidence of this in the Australian marine spatial map developed by the Commonwealth Scientific and Industrial Research Organisation—see Seamap Australia – National Marine Benthic Habitat Map.

[31] This is very much dependent on the transparency of the process and data output of the AI systems used in the MSP work.

[32] See generally J Baeyaert, 'Harmonizing Creativity and Ethics in AI Systems' (2025) AI and Ethics 1–21; SJ Kennedy, 'Transforming Big Data into Knowledge: Experimental Techniques in Dynamic Visualization' (Doctoral dissertation, Massachusetts Institute of Technology, 2025).

[33] There is good evidence from African to Asian indigenous coastal communities as to local knowledge and wisdom being especially relevant to the purposes of MSP. See K Shilabukha, 'Indigenous Knowledge and Management Systems for Marine Resources among the Giriama of North Coastal' (Doctoral dissertation, University of Nairobi, 2015) in the case of Kenya, S Touwe, 'Local Wisdom Values of Maritime Community in Preserving Marine Resources in Indonesia,' (2020) 4 Journal of Maritime Studies and National Integration 84–94 and E Djunarsjah and AP Putra (2021, June). Marine Fisheries Zoning based on Adat Sasi Indigenous Local Wisdom: A Technical Overview. In *IOP Conference Series: Earth and Environmental Science* (Vol 805, No 1, p 012012) (IOP Publishing) in the case of Indonesia.

[34] See Indigenous Peoples Basic Law above.

[35] There is a huge amount of literature on this subject—a notable and recent commentary is L Grozdanovski and J De Cooman (eds), 'Individual Safeguards in the Era of AI: Fair Algorithms, Fair Regulation, Fair Procedures' in *Cambridge Forum on AI: Law and Governance* (Vol 1, p e18) (CUP 2025).

[36] S Flynn and others, 'Management of Spatial Data Integrity Including Stakeholder Feedback in Maritime Spatial Planning' (2023) 156 Marine Policy 105799.

significant role. The amount of geo-spatial data collected for commercial energy exploitation and transport could tidily help planners from making inappropriate assumptions for their model testing.

- **Human-in-the-loop zoning**: AI should inform, not dictate. It is probably trite to remind marine planners to interrogate model outputs before embedding them in legal zoning instruments.

Legal and institutional safeguards

- **Explicit role of AI in MSP law/policy**: In the legal framework for MSP, it is useful to clarify in the MSP legislative instrument or the offshore energy expropriation or facilitation licences and agreements whether AI outputs are advisory tools or binding evidence in zoning/licensing.[37] Naturally, these provisions could also be made appropriate to a more generalized AI product-focused legislation, such as the EU AI Act.
- **Regional oversight**: In shared seas, joint commissions or regional bodies can review AI methodologies to ensure one country's data bias does not disadvantage another[38]. This is especially helpful, though challenging to facilitate in contested waters.
- **Appeals mechanisms**: Fishers or coastal communities should be able to challenge AI-driven spatial allocations if they feel excluded or misrepresented. This is of course largely a matter for national law—in some jurisdictions like Taiwan, there is legislation (Indigenous Peoples Basic Law) which confers rights of consultation to indigenous peoples. Such laws, for example, could be extended to the right to challenge AI-driven spatial decisions.

Capacity and training in MSP agencies

- **Marine data literacy**: A properly resourced MSP scheme should also train officials to understand how ecological, geopolitical, and socio-economic data feed into AI models, and what 'bias' might mean in practice (eg privileging high-value tanker traffic, pipelines, or oil fields over artisanal fishing grounds). There is also a role *nevertheless* for the high-value sectors such as shipping and offshore energy to contribute to the literacy programme.
- **Cross-disciplinary teams**: Although perhaps not something for legal sanctioning or facilitation, industry standards could place AI engineers seeking to work in the energy sectors as a good practice standard to consult marine ecologists, environmental scientists, and legal experts to detect biases early.

Adaptive monitoring of AI decisions

- **Track social impacts**: Did AI-guided zoning reduce small-scale fishing opportunities? Were conservation gains equitably distributed? These are real questions of impact. Impact on the marine space evolves through time and circumstance. It is therefore crucial for MSP systems to ensure that adaptive management as a principle[39] is adopted not merely to aid the development of MSP policy but also specifically to track the impact of AI-led decisions.[40]

[37] The discussion as to whether AI policy is best provided in MSP law or policy is an extensive subject which falls outside the scope of this article.

[38] See for P Cihon, 'Standards for AI Governance: International Standards to Enable Global Coordination in AI Research & Development' (2019) 40 Future of Humanity Institute. University of Oxford 340–42 where there is emphasis on jointly developed standards for the monitoring of AI methodologies.

[39] See generally L Rist, BM Campbell and P Frost, 'Adaptive Management: Where are We Now?' (2013) 40 Environmental Conservation 5–18; CR Allen and AS Garmestani, 'Adaptive Management' in CR Allen and AS Garmestani (eds), *Adaptive Management of Social-Ecological Systems* (Springer Netherlands 2015).

[40] F Douvere and CN Ehler, 'The Importance of Monitoring and Evaluation in Adaptive Maritime Spatial Planning' (2011) 15 Journal of Coastal Conservation 305–11.

- **Feedback loops**: A major problem, usually with less highly resourced economies is the failure to keep models up to date as new data emerges (eg shifting fish stocks due to climate change). It is important to avoid locking MSP into outdated baselines.[41] This too is in line with the adaptive management principle,[42] which is critical to the optimal implementation of any MSP.
- **Periodic review cycles**: The adaptive management principle also calls for AI-driven plans to be embedded into adaptive MSP processes that are revised every 5–10 years, not static 'forever' allocations.

CONCLUDING THOUGHTS

Energy-related activities are incorporated into national and regional marine spatial plans as a matter of course. These plans face several challenges. One is accommodating a large amount of data. As has been stressed earlier, AI goes a long way to integrate data in an efficient and MSP-policy-relevant manner. However, many stakeholders do not have equal access to data and as such are unable to participate in decision-making in a meaningful manner. Indeed, the converse is also true. Local communities, indigenous people, and fishers may have been given erroneous data, which lead to their rejection of marine spatial plans that are actually beneficial. For example, the placement of certain offshore renewable energy sources might actually be beneficial for coastal communities. It is therefore crucial for the AI that is being used to manage this heavy load of information to be free (as best as practicable) from bias.

This article argues that one way of achieving that is to place a legal burden on providers of AI systems to those operators and agencies working in the MSP sphere to ensure that their systems are meeting the industry's best practices. A product-oriented AI law, like the EU AI Act, is certainly a feasible option. However, that is only part of the picture. It is also important for MSP norms and rules to place a responsibility on users of AI to engage with the functionalities of the AI systems in a manner that reduces the deleterious impact of AI bias.

41 SB Olsen, E Olsen and N Schaefer, 'Governance Baselines as a Basis for Adaptive Marine Spatial Planning' (2011) 15 Journal of Coastal Conservation 313–322.

42 See n 39.

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