Preference and Willingness-to-pay analysis for an eco-engineering technology for floating wind turbines

Antoine Dubois[1,2], Pierre-Alexandre Mahieu[3], Alison Bates[4], Jenifer Meredith[4], Franck Schoefs[2,5]

[1]Nantes Université, École Centrale Nantes, CNRS GeM, UMR 6183, Nantes, France
[2]Nantes Université, CNRS, IUML, FR CNRS 3473, F-44000, Nantes, France
[3]LEMNA, Nantes Université, Nantes, France
[4]Buck Lab, Department of Environmental Studies, Colby College, Waterville, Maine, USA
[5]Nantes Université, ISOMer, UR2160, 2 rue de la Houssinière, BP 92208, F-44000, Nantes, France

Correspondence to: Antoine Dubois (antoine3.dubois@gmail.com)

Abstract. Floating offshore wind turbines (FOWTs) raise concerns among coastal communities due to their potential impacts on marine biodiversity and fisheries. This issue is particularly striking in France, where the government is accelerating offshore wind deployment to meet decarbonisation targets while maintaining a relatively large fisheries sector. This study investigates public preferences and willingness-to-pay (WTP) for an innovative eco-engineering solution aiming at enhancing marine biodiversity, supporting artisanal fisheries and minimising seabed disturbance. A discrete choice experiment (DCE) was conducted among 306 residents across five French coastal territories (*i.e.* departments) to quantify trade-offs among four attributes including structure material, biodiversity gain, fishery impact and additional cost on the electricity bill. Results from a Conditional Logit Model reveal strong and consistent public support for eco-engineering features. Biodiversity enhancement, fishery revenue growth and the use of recycled steel for building eco-engineering structures were all positively valued by respondents, as reflected in their willingness-to-pay. The territorial variation was more limited than initially assumed, reflected in similar coefficients between departments, except for recycled steel which showed variation between two departments. This paper provides new evidence on how targeted eco-engineering measures can improve social acceptability by combining preference modelling with ecological design considerations. The results show how important it is to include public preferences in the early design of FOWT projects to improve both environmental performance and public acceptance.

1 Introduction.

Over the past decade, the French government has set an ambitious trajectory to cut its greenhouse gas emissions and move toward a low-carbon economy. The country has committed to reaching net-zero carbon emissions by 2050, a goal in line with the European Green Deal and its own Climate and Energy Framework (ADEME, 2024). To do so, France aims to produce 40% of its electricity from renewable sources by 2030, with offshore wind power emerging as a cornerstone of its future energy mix (Ministère de la Transition Écologique, 2024). The French government has set a new target for offshore wind deployment: 45 GW by 2050. This aim is an unprecedented leap given that only 1.5 GW had been commissioned by mid-2025. This suggests that over the next 25 years, about 96.7% (43.5 GW) remains to be installed (Figure 1 & Table A1).

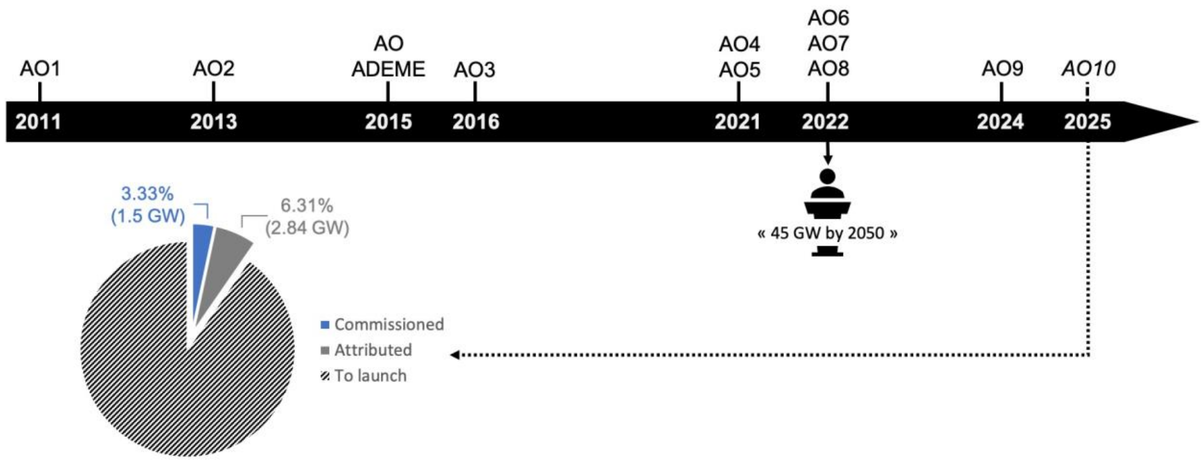

Figure 1. Chronological order of call for tenders for Offshore Wind projects launched in France, and proportion of national goals achieved and remaining.

Floating Offshore Wind Turbines (FOWTs) are emerging as a key technology and a promising solution for France to meet its ambitions on offshore wind energy, particularly in areas where deep waters (> 60 m depth) preclude the use of bottom-fixed turbines. FOWTs allow to build wind farms farther out to sea, which makes them less visible and gives them more space to produce renewable energy (Zountouridou et al., 2015). However, they also bring up specific environmental and social challenges, as well as the need for adaptation of harbors infrastructures (Crowle and Thies, 2022). The greater depth and distance of FOWTs does not always mitigate public worries. Instead, they might make people more preoccupied about the unknown effects on the environment, possible conflicts with fishing activities, and the cumulative stress on marine ecosystems (Chaumette, 2017; Dubois et al., 2025a; Jiang, 2021).

This technological shift and acceleration are reflected in the growing scale and ambition of national offshore wind tenders. Over 10 GW of capacity had entered formal procedures by the end of 2024 (Figure 1), and the upcoming "AO10" call for tenders will bring the total area of wind exploitation in French metropolitan waters over 3,000 km². Among these "AO10" projects are several large-scale floating wind farms, each involving between 1 and 2 GW capacities (Table A1). These projects mark a clear shift toward industrial-scale deployment, both in terms of capacity and spatial footprint. This dynamic is happening at the same time as an explicit objective to use the newest technologies to generate as much energy as possible. While the bottom-fixed Saint-Nazaire wind farm (awarded in 2012) used 6 MW turbines, more recent projects such as "*Bretagne Sud 1*", "*Golfe de Fos 1*" or "*Narbonnaise Sud-Hérault 1*" plan to deploy FOWTs of more than 20 MW per unit. However, there are still significant delays in implementation (Table A1): on average, it may take ten years from the time a project is awarded until construction begins. For instance, construction of the wind farm projects awarded in the tenders "AO4", "AO5" and "AO6", awarded respectively in 2023, 2024 and 2024 (Table A1), is not expected to begin until 2031–2032, but the concept of the turbine used is fixed when the tendered company is selected (i.e. around 5 years before the park is commissioned).

In this context, spatial planning and public acceptance are emerging as major challenges for the successful growth of offshore wind energy (Joalland and Mahieu, 2023). Many studies have demonstrated that public opposition to offshore wind farms can be driven by a wide range of factors. These include visual concerns (Ladenburg, 2010), place attachment (Brownlee et al., 2015), perceived fairness and justice during the process (Bacchiocchi et al., 2022; Firestone et al., 2012) or even trust in institutions (Druckman, 2015; Handmaker et al., 2021). Impacts on marine biodiversity is also frequently cited as a major concern (Bush and Hoagland, 2016; Galparsoro et al., 2022). Thus, developers are increasingly required to implement early-stage environmental monitoring, such as the evaluation of acoustic pollution, analysis of benthic disturbances and assessment of interactions with marine mammals (Degraer et al., 2021; Maxwell et al., 2022). Furthermore, these studies and monitoring are part of the process of verifying the proper integrity of structures throughout the farm's service life (Coolen et al., 2018; Coughlan et al., 2025; Dubois et al., 2025b).

Eco-engineering is increasingly being investigated as a viable method to balance technological development and ecological integrity. This idea refers to the design and inclusion of infrastructure that integrates ecological functions and improves ecosystem services (Pardo et al., 2023). In the case of offshore wind power, the technique may be applied by integrating habitat-enhancing structures directly into wind farm elements such as moorings, scour protection or substations to promote biodiversity and ecosystem functioning (O'Shaughnessy et al., 2020). New frameworks like Nature-Inclusive Design (NID) and marine Nature-Based Solutions (NbS) have made it even more crucial to integrate such approaches directly within the development process. This is especially relevant to respect the "avoid–reduce–compensate" hierarchy used in marine spatial planning (Hermans et al., 2020; Sutton-Grier et al., 2015). These strategies seek to mitigate ecological damage while simultaneously producing quantifiable co-benefits for marine ecosystems and local stakeholders. Eco-engineering involves the modification of structures through the use of artificial reefs, textured concrete modules or biologically active substrates, as well as the inherent design of structures to attract reef-associated species, stabilise sediments or create nursery habitats (Firth et al., 2014; Lengkeek et al., 2017). However, Bishop et al. (2017) indicated that the ecological efficiency of such measures is significantly influenced by spatial size, species-specific needs, and physical compatibility.

Eco-engineering is being recognized as a social as well as technical innovation, raising important questions about governance, legitimacy and the role of local communities in defining what constitutes acceptable and meaningful ecological compensation (Dennis et al., 2018; O'Shaughnessy et al., 2020; Varenne et al., 2023), especially in the context of ocean sprawl or Non-Indigenous Species facilitation (Gauff et al., 2023).

Studies indicate that such measures could improve social acceptance, in particular if they create induce snowball effect in the society (Klain et al., 2020; Strain et al., 2019). Additionally, a recent qualitative study (Dubois et al., 2025a) compared coastal community perceptions of marine renewable energies in France (Pays de la Loire) and in the United States of America (Maine) and highlights the complexity of public attitudes towards eco-engineering applied to floating offshore wind farms. Persistent concerns were expressed regarding environmental impacts (biodiversity, seascapes), economic consequences (fisheries, tourism) and technical issues (cost, maintenance), but an overall support for the energy transition was still shown. These findings underline the importance of transparent, participatory and science-based governance in harmonising climate goals with the social expectations of coastal communities characterised by diverse identities and conflicting uses.

The present study investigates public preferences for an innovative eco-engineering solution specifically designed for integration into floating offshore wind farms. The solution takes the form of a multifunctional artificial structure intended to simultaneously 1) increase local biodiversity, 2) support artisanal fishing and 3) reduce the ecological footprint of FOWTs by limiting seabed dragging caused by mooring lines. As a hybrid between ecological compensation and technical optimisation, this innovation tries to embody a model of spatial and functional cohabitation that could help mitigate stakeholder opposition and contribute to the long-term viability of floating wind deployment.

While existing studies have explored how environmental attributes influence public preferences for wind energy, few have examined the acceptability of integrated technological and ecological innovations into such technology. Moreover, no previous study has assessed such preferences in the specific context of France's floating offshore wind strategy. This study addresses that gap by implementing a Discrete Choice Experiment (DCE) targeting a representative sample of 306 coastal residents across five French departments with various cultural, economic and industrial relationships to the sea. The DCE includes four key attributes: 1) the material used for building the structures, 2) expected augmentation in marine biodiversity (specific richness), 3) anticipated economic effects on the local fisheries and 4) a cost attribute to estimate willingness to pay (WTP). This approach allows to quantify trade-offs in citizen preferences and explore variation in acceptability across regions and individual profiles.

More specifically, the primary objective of this study is to identify the preferences of citizens from five French departments regarding an integrated offshore eco-engineering solution and to test whether social acceptability varies across territories and individual attitudes. Thus, this territorial comparison is designed to test whether public preferences vary across coastal contexts. While the null hypothesis assumes no significant differences between departments, we expect that local factors (such as dependence on fisheries or exposure to existing offshore projects) may influence the acceptability of eco-engineering solutions. Identifying these variations can support more tailored and socially informed planning strategies. Another possible hypothesis to make is that offshore wind opponents will try to minimise environmental or social impacts by selecting projects that include mitigation measures.

The paper is organised as follows: Section 2 describes the tested concept of eco-engineering, the method used to analyse its societal acceptability and the territorial identities of the 5 selected departments. Section 3 presents the results of the willingness-to-pay for the application of the concept and the parameters influencing the choice of scenario. Section 4 discusses the results depending on the department studied and the effect of attitude toward offshore wind power on the application of an eco-engineering concept. Section 5 is dedicated to developers and industry stakeholders for future offshore wind power development and section 6 summarises the findings of the study. Thus, this study explicitly examines whether nature-inclusive design features influence both acceptance and willingness to pay for floating offshore wind projects.

2 Material & method.

2.1 The eco-engineering concept.

In our study, we focus on a concept designed specifically for application in floating offshore wind farms. After discussions in a previous study (Dubois et al., 2025a), we targeted the respondents' priorities and concerns to help in the design of this structure. In the end, the concept was a stack of steel pipes of various diameters (Fig. A2). Despite the paucity of information on this subject, some sources indicate an optimal volume for an artificial reef in OWF of the order of 320 m³ (Glarou et al., 2020; Langhamer, 2012). Thus, the theoretical volume of this concept is 400 m³ with a steel volume of 43.5 m³. Together with the increase in biodiversity and biomass, the structure fits into the framework of eco-engineering (Hermans et al., 2020; Pardo et al., 2023; Pioch et al., 2018) by limiting the seabed dragging by the mooring lines. This could be achieved by passing the mooring line through the centre of the structure, thus shifting the line upwards so that it does not touch the seabed. For the chain, such an arrangement reduces wear and tear, and for the environment, it considerably reduces chain slippage on the floor as the float moves. This type of structure would be used above each floating wind turbine anchor on a wind farm.

Overall, they would serve a triple purpose: 1) they would limit the footprint of a farm, 2) they would provide an opportunity for refuge and habitat creation, and 3) they would have an impact on society in terms of both societal acceptability and the economy (*e.g.* fishermen).

2.2 Survey design.

2.2.1 DCE method.

This study uses the Discrete Choice Experiment (DCE) method to identify individuals' preferences (Hoyos, 2010) and estimate their willingness-to-pay (WTP) for different characteristics of a good or service (Hanley et al., 1998). This approach is based on the theory of random utility (McFadden, 1974) and relies on the analysis of choices made between several alternatives defined by combinations of attributes. DCE was chosen for its ability to quantify trade-offs between attributes and to incorporate a payment vehicle enabling direct monetary estimation. Its implementation in digital format also facilitates large-scale dissemination and enables a large and geographically diverse sample. This method has several advantages: theoretical soundness, applicability to non-market goods, and the ability to model preference heterogeneity. However, it has certain limitations, including a potential cognitive burden for respondents, questionable rationality assumptions and sensitivity to formulation or fatigue biases. Despite these constraints, DCE remains a benchmark method for preference analysis and the economic evaluation of goods and services.

The experimental design was generated using Ngene software following a D-efficient design approach. The design efficiency was optimised for a conditional logit model using prior parameter values derived from expected signs and magnitudes of the attributes. In particular, negative priors were specified for the price attribute, while positive priors were assumed for environmental and economic benefits, in line with standard expectations in environmental valuation studies. The final design consisted of 16 choice sets, each including two policy alternatives and a *status quo* option. To reduce the cognitive burden on respondents, the choice sets were divided into two blocks so that each respondent completed 8 choice tasks. In the design generation process, an additional imbalance penalty was considered to avoid excessive level repetition across alternatives and to improve the statistical properties of the design. The final design ensured sufficient variation in attribute levels across choice tasks, allowing reliable estimation of the preference parameters. (detailed below in section 2.2.4 to section 2.2.5.4, illustrated in Table A2). The detailed tasks with attributes and their respective values are presented in Table A3.

Prior to the choice tasks, attributes and their associated levels were introduced sequentially to respondents, with explanations provided for each attribute to ensure comprehension. The *status quo* option corresponded to a conventional floating offshore wind development without eco-engineering measures. The exact wording presented to respondents for the *status quo* explanation was (translated from French): *"Option C means a conventional floating offshore wind development <u>WITHOUT</u> artificial reefs".* To encourage respondents to read the attribute descriptions, the "next" button appeared only after a short delay on the screen presenting the explanations. Finally, both the overall length of the questionnaire and the number of choice cards presented to each respondent were deliberately limited to reduce respondent fatigue. In addition, attribute descriptions were written in simple and non-technical language so that they could be easily understood by a general audience, thereby reducing the risk of attribute non-attendance.

2.2.2 Geographical sampling.

An online national survey was performed through a market company in April 2024. Five French territories (*i.e.* departments) were sampled, depending on their proximity to planned development of Floating Offshore Wind Farm. These departments were the following: Aude, Bouches-du-Rhône, Hérault, Morbihan and Pyrénées-Orientales. Four of these departments boarder the coast of the French Mediterranean sea (south of France) and one (Morbihan) is on the western coast of French Brittany and boardered by the Atlantic Ocean. The total number of respondents was 306 and sampling was carried out in such a way as to obtain proportions as representative as possible to the number of inhabitants in each department, with 20 respondents from Aude, 114 from Bouches-du-Rhône, 87 from Morbihan, 54 from Hérault and 31 from Pyrénées-Orientales. The sampling did not rely on formal quotas or post-stratification weights; however, recruitment through the survey company ensured a balanced distribution in terms of age and gender across departments. The resulting sample composition was verified to be consistent with INSEE departmental demographic data, providing reasonable confidence in the representativeness of the respondents.

We drew up the territorial identities of the sample departments (Table 1) in relation to the subject of study, taking into account demographic and blue economic statistics, including tourism (the touristic rate being the number of touristic beds divided by the number of residents in the department), fishing and industry, information on ecology (through protected areas) and fishing (share of maritime employment and tonnes of seafood landed). The percentages are expressed as function of the department level.

2.2.2.1 Aude: a discreet coastline between tourist appeal and economic fragility.

Literature and data obtained for the Aude department generally point to limited maritime employment in this territory, with 3.1% of employees working in the maritime sector (INSEE, 2017) and 1,600 tonnes of seafood products landed (FranceAgriMer, 2024) for a population of 376,000 persons (INSEE, 2025a). However, commercial tourism is highly structuring the economy of the department, with a high rate of second homes (25.3% of departmental homes) and a relatively high tourist function rate of 42.82% (Agence de Développement Touristique, 2024). Finally, the maritime domain is still little preserved, with around 6% of its surface area under any protection regime (Les sites Natura 2000 dans l'Aude, 2019).

2.2.2.2 Bouches-du-Rhône: a strategic, industrial-port coastline and less tourist.

The Bouches-du-Rhône department is one of the most urbanised and densely populated French coastal areas with more than 2 million residents (INSEE, 2025b), but with limited tourism according to the touristic rate of 18% and 4.8% of secondary homes (Observatoire en ligne Provence Tourisme, 2025). The area is also characterised by a strong maritime presence, but is rather focused on logistics and industry than fishing with around 3,833 tonnes landed per year (Ifremer, 2024b). It hosts the second most important commercial harbour in France (Marseille-FOS). On the other hand, there are some real natural gems, such as the "Côte Bleue" Marine Park and the Calanques National Park, which are considered true marine sanctuaries thanks to zones reserved from human impact (diving and fishing), bringing the surface area of protected marine areas (all statuses combined) to around 45,000 ha (Bottin, Garcia and Meinesz, 2020) and almost 10,000 ha fully preserved from anthropic activities.

2.2.2.3 Hérault: a dense, multifunctional coastline, between tourism and the blue economy.

Hérault is characterised by a dense population of more than 1.2 million residents (INSEE, 2025c) and a single harbour structuring the marine employment that is located at Sète, where the fishing landings are concentrated and cumulating around 7,146 tonnes of seafood annually (Ifremer, 2024c). The proportion of maritime employment in the departmental activity is around 4.4%. This department is highly attractive for tourism, especially the seaside tourism, and this activity represents a great part of the local economy, highlighted by the tourist function rate of 83% and the proportion of secondary residences of 17.8% (INSEE Flash Occitanie, 2022; Chiffres clés Tourisme et Loisirs Hérault édition 2024, 2025). Also, with 8,500 ha of marine protected areas, this department is in the process of reconciling tourism with the protection of its natural heritage (Bottin, Garcia and Meinesz, 2020).

2.2.2.4 Morbihan: a coastline balanced between maritime traditions and tourist appeal.

The Atlantic Ocean borders the Morbihan department, giving it a distinct history from the Mediterranean departments. This Breton department has one of the highest maritime employment rates in France, with more than 7% (Février and Le Guen, 2018), for a population above 760,000 residents (INSEE, 2025d). At the same time, the fishing industry in Morbihan is one of the main sectors in the local economy, with almost 22,000 tonnes of seafood products landed each year (Ifremer, 2024d). On top of this, the area is a major draw for tourists thanks to its culture and landscapes, with a high tourist function rate of 85% and 17.8% of secondary residences. Another attraction for tourism is the balance between maritime exploitation and preservation in the Gulf of Morbihan, with some 70,000 ha of protected marine areas (DREAL Bretagne, 2023).

2.2.2.5 Pyrénées-Orientales: a hyper-touristic coastline with a modest maritime profile.

Last but not least, the Pyrénées-Orientales department lies midway between mountain ranges and coastlines, making it an attractive location for tourism. The population is modest, with almost 490,000 residents. This demographic profile is reflected in the tourism offer, particularly in the tourist function rate of 132% (Capacité d’accueil Pyrénées Orientales Tourisme, 2025) and a high rate of 27.7% of second homes (INSEE, 2025e). Tourism is thus the mainstay of the local economy. On the other hand, maritime activity is more limited, with a low proportion of maritime employment (3.7%, INSEE, 2017) and more limited landings than other departments (1,501 tonnes/year Ifremer, 2024e). The documentation found estimates at around 11,000 ha for the surface of marine protected areas of any status (Bottin, Garcia & Meinesz, 2020; De Paoli et al., 2023).

Table 1. Identities of the sampled territories (departments) subject to floating offshore wind development.

Metrics	Aude	Bouches-du-Rhône	Hérault	Morbihan	Pyrénées-Orientales
Number of residents	376,028	2,056,943	1,201,883	768,687	487,307
Proportion of maritime employment	3.1%	4.4%	3.2%	7.4%	3.7%
Tons of seafood landed per year	1,624 tons	3,833 tons	7,146 tons	22,607 tons	1,501 tons
Tourist function rate (nb of tourist beds/residents)	42.82%	18%	83%	85%	132.52%
Proportion of secondary residences (departmental)	25.3%	4.8%	17.8%	17.8%	27.7%
Surface of marine protected areas (any status) in acres	34.5 acre	111k-123k acre	21k acre	173k acre	27k acre
Marine High-protection zone in acres	0 acre	23k acre	0 acre	32.5 acre	247 acre

2.2.3 Organisation of the survey.

The questionnaire started with socio-demographic questions: place of residence (zip code), education level, current employment status and income after taxes and per month (France). The choice experiment followed these questions. Before the series of choices, an introduction was included with the following information:

1. Electricity mix in France and governmental goals.
2. Explanation of a FOWT and what the situation is in their country.
3. Explanation of the reasons for going towards a FOWT development.
4. Goals about this technology development, comparison with nuclear power and number of households' electricity consumption.
5. Impacts of FOWT (environmental, economic).
6. Presentation of the eco-engineering concept with visualisations.
7. Explanation of how a DCE works and description of each attribute with their meanings.
8. Explanation of the status quo.

After the choice experiment, respondents were asked several follow-up questions about their (prior) attitude about offshore wind power (OWP), their relation with the ocean (any relatives working with/depending on the ocean and/or fishing), having heard or seen an OWF before this survey, and finally a New Ecological Paradigm test was performed through a Likert-scale questionnaire with 15 questions (Table A4; Anderson, 2012; Dunlap et al., 2000). These parameters were implemented into a correlation test after the econometric model. The zip code of residency allowed to calculate the average distance from the coast, the department of the city and the region of the city.

2.2.4 The *status quo* scenario.

The *status quo* scenario chosen reflects France's current trajectory in offshore wind power: rapid, intensive development of wind farms, with no particular requirements beyond the regulatory framework imposed. It corresponds to floating wind farm projects that could be described as “classic”, with no specific eco-engineering measures, apart from the environmental monitoring required before and after commissioning and throughout the farm’s service life until decommissioning. This scenario serves as a realistic reference point, consistent with national guidelines, and enables the measurement of preferences for alternatives that incorporate greater ecological ambitions.

2.2.5 The attributes and their levels.

The attributes were chosen on the basis of a preliminary study in which respondents expressed their fears and priorities with regard to the development of offshore wind power, whether bottom-fixed or floating (Dubois et al., 2025a). Moreover, literature was considered to scale the levels of chosen attributes (Börger et al., 2015; Dalton et al., 2020; Iwata et al., 2023; Kermagoret et al., 2016; Kim et al., 2019; Klain et al., 2020). The definition of levels for each attribute is based on a synthesis of the scientific literature, empirical data from fisheries, energy reports, and adjustments based on pre-testing of the questionnaire. The aim was to propose realistic, credible and comprehensible levels for respondents as well as ensuring sufficient variability to capture differentiated preferences.

2.2.5.1 Structure material.

The material used for the structure (recycled or new steel) is a central environmental indicator. With an emission reduction potential of 1.5 tonnes of CO_2 per tonne of steel (World Steel Association, 2021), recycled steel has a 20-25% lower carbon footprint than new steel (Fennell et al., 2022). France already produces around 40% of its steel from recycled materials (CNDP, 2024), making this attribute both credible, measurable, and culturally relevant. It also makes it possible to test citizens' sensitivity to aspects of circularity in energy infrastructures.

2.2.5.2 Impact on marine biodiversity.

The biodiversity attribute was defined on the basis of extensive literature on the effects of both offshore wind farms and artificial reefs. Submerged structures (foundations, cables, floats) promote colonisation by fixed species such as mussels, anemones, algae or soft corals (Andersson and Öhman, 2010; Coolen et al., 2018; Degraer et al., 2021; Dubois et al., 2025a), inducing a local increase of biodiversity. Rates of increase in biodiversity ranging from 10% to 200% have been reported depending on the context (Brock and Norris, 1989; Fabi and Fiorentini, 1994), although the range generally adopted in previous DCE varies between 10% and 60% (*e.g.* Klain et al., 2020). To remain within a zone of ecological plausibility and facilitate understanding for respondents, the following four levels were retained: +10%, +20%, +30% and +40% increase in marine biodiversity on average throughout the service life of the farm. This increase refers to the increase in species richness “S” (Anon, 2009). The experimental design was inspired by previous work carried out on artificial reefs where the addition of hard substrates has demonstrated strong potential for biological colonisation (Koeck et al., 2014; Komyakova et al., 2021). The structures studied were modelled with a volume of around 320 m³ (Glarou et al., 2020), the optimum size suggested in the literature to maximise ecological effects.

2.2.5.3 Impact on local fisheries revenue.

The impact of floating wind turbines on fishing activities was assessed by examining changes in the income of local fishermen, an indirect measure that was proved pertinent (Bates and Firestone, 2015; Firestone and Kempton, 2007). Based on studies of fishing yields around artificial reefs (CPUE - Catch Per Unit Effort), a link was established between an increase in biomass and biodiversity, combined with a potential increase in catches. A literature review (De Backer and Hostens, 2019; Ramos et al., 2006; Reubens et al., 2013) was used to translate CPUE gains into economic impacts. A 60% catch-to-revenue conversion was adopted on the basis of existing data (Pan, 2021). This rate was then reduced to take into account operational constraints (closed areas, affected ports, etc.). The estimated impact was refined by cross-referencing wind farm development zones with data from the main fishing ports in the French Gulf of Lion (Ifremer, 2024a). To include differentiated but plausible scenarios, and following the pre-test highlighting the absence of an “extreme” case, the levels retained were: +1%, +5%, +10% and +15% increase in fishing income in the zones concerned and on average throughout the service life of the wind farm.

2.2.5.4 Cost to households - electricity bill.

The last attribute was the payment vehicle for the willingness-to-pay and represents the monthly extra cost on the electricity bill induced by the integration of eco-engineering structures in wind farms. This cost was estimated by modelling the price of steel structures from computer-aided design (320 m³ total volume, 43.5 m³ steel) and its installation offshore. This amount was then integrated into electricity production costs via an economic simulator (Energy101, 2025). Standard parameters were considered for floating wind farms: a capacity of 1,050 megawatts, a capacity factor of 60%, a lifespan of 20 years and an interest rate of 6%. Three consumption profiles were simulated (1 person, 2 people and 4 people respectively in a studio, a small apartment or a house), with amounts ranging from +€0.40 to +€7.76 per month depending on the profile. In addition to these estimates, feedback from the pre-test suggested the inclusion of a higher cost level to capture economic trade-offs. Thus, five levels have been retained: +1 €, +2 €, +3 €, +5 € and +10 € per month, over a 20-year period and for a household. These values were in line with previous research (Kim et al., 2019; Krueger et al., 2011).

2.3 Econometric models.

2.3.1 Conditional logit model & Willingness-To-Pay (WTP) estimation.

The analysis conducted in this study relies on the Random Utility Theory maximisation approach (McFadden, 1974). When a respondent chooses a scenario for a FOWF development, the respondent is supposed to choose the option that maximises the satisfaction that is derived from the attributes and their levels. The utility function is as follows Eq. (1):

$$U_{nj} = \beta X_{nj} + \varepsilon_{nj} \quad (1)$$

where U_{nj} represents the utility that individual n derives from alternative j, X_{nj} is the vector of observed attributes associated with that alternative, β is the vector of preference parameters to be estimated, and ε_{nj} is the stochastic error term capturing unobserved influences on choice behaviour.

In the present study, the attribute vector includes the material used for eco-engineering structures (recycled or new steel), the variation in marine biodiversity (%), the change in local fisheries income (%), and the additional monthly electricity bill (€/month). Conditional logit models were estimated separately for each department in order to examine potential territorial differences in preferences. All attributes were specified as alternative-varying.

After estimating the Conditional Logit Model, Wald tests were performed to evaluate linear restrictions on the estimated coefficients (Greene, 2019; Woolridge, 2010; Train, 2009). They were applied to assess whether specific parameters were statistically equal across departments. The Wald test is computed from the estimated coefficients and their covariance matrix and follows an asymptotic chi-square distribution under the null hypothesis that the tested parameters are equal to zero. It allows to test whether groups of variables contribute significantly to the explanatory power of the model.

The marginal WTP, also called the implicit price, can be estimated for each of the non-cost attributes as follows, as explained by Hanley et al. (1998), where β_c is the coefficient of any of the attributes and β_y is the coefficient of the cost attribute (which corresponds to the marginal utility of income), Eq. (2):

$$WTP = -\frac{\beta_c}{\beta_y}$$

WTP estimates were therefore derived from the conditional logit specification with a linear cost coefficient. Confidence intervals were computed using the delta method based on the estimated variance-covariance matrix of the model parameters (Train, 2009). All models were estimated in R using the '*Apollo*' choice modelling package (Hess & Palma, 2019).

2.3.2 Zero-Inflated Negative Binomial regression model to explain the choices

A zero-inflated negative binomial (ZINB) regression model was used to analyse the determinants of respondents' tendency to choose the *status quo* option. The dependent variable ('*Number of status quo chosen*') represents the number of times each respondent selected the *status quo* across the eight choice scenarios performed by the respondent. Preliminary inspection of the distribution revealed a large proportion of zeros, indicating that many respondents never chose the *status quo* option. This overdispersion and excess of zeros (Cameron & Trivedi, 2013) makes traditional ordinary least squares (OLS) regression unsuitable, as it assumes normally distributed residuals and constant variance. Preliminary OLS models confirmed the lack of fit and heteroscedasticity.

The ZINB model decomposes the data-generating process into two parts (Hilbe, 2011, 2014; Yau et al., 2003): (i) a count model, which predicts the number of *status quo* choices for respondents capable of choosing it, modelled using a negative binomial distribution, and (ii) a zero-inflation model, which predicts the probability that a respondent never selects the *status quo*, modelled with a logistic regression. The count part included the following covariates: prior attitude toward floating offshore wind power, stated gender, age, level of education, professional status, monthly revenue, prior exposure to offshore wind power projects (having already seen or heard about offshore wind turbines), environmental attitudes (through the NEP mean score), relationship to the ocean (having a relative working with the ocean), fishing activity (having a relative that is a commercial fisher) and finally the distance to the coast in kilometres. To ensure interpretability of the ZINB coefficients and transparency for reproducibility, the variables included in the ZINB model (Table 2) were coded and scaled as follows:

Table 2. Coding of variables for the ZINB model

Variable name	Type of variable	Codification
Prior attitude toward offshore wind power	Continuous	From 1 (“very positive”) to 5 (“very negative”)
Age	Continuous	Age of the respondent
Gender	Binary	1 if female, 0 if male
Education level	Binary	1 if university degree or similar, 0 if no
Professional status	Binary	1 if in professional activity or student, 0 if unemployed, retired or other
Monthly income (in thousands of euros)	Continuous	Midpoint of the income bracket
NEP score	Continuous	Mean NP score
Distance from the shore	Continuous	Crow-fly distance (in km) from home to the shore

Model selection was informed by comparisons of Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) across alternative specifications, including Poisson, negative binomial, zero-inflated Poisson (ZIP) and ZINB models. The ZINB model was selected as the most appropriate due to its superior fit (lowest AIC and BIC in Table 3) and ability to accommodate both overdispersion and excess zeros (Greene, 1994; Hall, 2000).

Table 3. Akaike Information Criterion and Bayesian Information Criterion for optimal selection of model.

Model	AIC	BIC
Poisson	1378.600	1427.007
Zero-inflated Poisson	929.801	985.655
Zero-Inflated Negative Binomial	912.510	972.088
Negative Binomial	945.438	997.568

All analyses were conducted in R (version 4.3) using the *“pscl”* package (Jackman, 2024) for zero-inflated models. Standard errors and statistical significance were derived from the model summary output, and incidence rate ratios (IRRs) were calculated by exponentiating the coefficients from the count model to aid interpretation.

2.3.3 Mixed logit model

A panel mixed logit model was estimated as a robustness analysis following the conditional logit specification to account for repeated choice observations per respondent and to explore potential unobserved preference heterogeneity (Table A5 & A6). In contrast to the conditional logit model that assumes homogeneous preferences across individuals, the mixed logit model allows preference parameters to vary randomly across respondents (Hensher, Rose & Greene, 2005; Train, 2009).

Under this specification, the utility that respondent n derives from alternative j in choice situation t can be expressed as:

$$U_{njt} = \beta_n X_{njt} + \varepsilon_{njt}$$

where X_{njt} represents the vector of attributes associated with the alternative and β_n is a vector of individual-specific preference parameters. The term ε_{njt} represents the unobserved component of utility and is assumed to be independently and identically distributed according to a type I extreme value (Gumbel) distribution. These parameters are assumed to follow statistical distributions across the population.

In the present study, the coefficients associated with the non-cost attributes (recycled steel, biodiversity increase and local fisheries revenue growth) as well as the alternative-specific constant for the *status quo* option were specified as normally distributed random parameters. The cost coefficient was specified as lognormally distributed to ensure that the marginal utility of cost remains negative for all individuals.

The resulting utility specification can be written as:

$$U_{njt} = \beta_{recycled,n} Recycled_{njt} + \beta_{biodiv,n} Biodiversity_{njt} + \beta_{local,n} Local_{njt} + \beta_{cost,n} Cost_{njt} + ASC_{sq,n} + \varepsilon_{njt}$$

Additional interaction terms were included to explore behavioural and territorial heterogeneity. In particular, respondents' prior attitudes toward offshore wind power interacted with the *ASC* to capture systematic differences in the propensity to select the *status quo* alternative (Lancsar & Louviere, 2008; McFadden, 1974). The attitude score (Likert scale from 1 = very positive to 5 = very negative) was mean-centred. Interactions between the recycled steel attribute and the department of residence were also included to explore potential territorial differences in material preferences.

Parameters were estimated using simulated maximum likelihood with 2000 draws. The model was estimated using the '*Apollo*' package in R (Hess & Palma, 2019), which allows flexible specification of panel mixed logit models. The mixed logit model was estimated in preference space. Consequently, the coefficients represent marginal utilities rather than direct willingness-to-pay estimates. This specification is therefore used primarily to assess the robustness of the conditional logit results and to analyse the extent of preference heterogeneity across individuals.

3 Results of Willingness-to-pay for an eco-engineering concept.

3.1 Descriptive statistics.

The sample is characterised by a departmental profile contrast in comparison with the national average (Table 4). The Bouches-du-Rhône sample stands out with younger respondents, a high activity rate (75%), a high proportion of high education (41% at least bachelor's) and an average net income well above the national average (€3,100 vs. €2,336). Conversely, the Aude sample has an older population, lower levels of education (30%), a lower activity rate (50%) and the lowest average income (€2,000). Morbihan and Hérault samples present intermediate profiles with average incomes but an older population (especially in Morbihan) and relatively low graduation rates. Lastly, Pyrénées-Orientales has a high income but a more masculine structure and moderate activity levels.

Table 4. Socio-demographics data from the samples; [a]data from 2019; [b]data from 2017 (INSEE, 2020)

Variables	Aude	Bouches-du-Rhône	Hérault	Morbihan	Pyrénées-Orientales	France
Mean age	54.5 (+/- 14.12)	50.57 (+/- 12.38)	51.59 (+/- 13.81)	54.68 (+/- 12.20)	53.35 (+/- 14.97)	*NA*
Proportion female	0.45	0.5175	0.5517	0.5741	0.4194	0.517 [a]
Income (monthly, net, after taxes)	2000 € (+/- 877.35)	3100.88 € (+/- 1498.79)	2689.66 € (+/- 1318.45)	2875 € (+/- 1188)	2927.42 € (+/- 1453.72)	2335.83 € [b] (+/- 3791.66)
Education (at least bachelor or equivalent)	30.00%	41.23%	27.59%	22.22%	35.48%	23.6% [a]
In professional activity (employed or independent)	50%	75.44%	55.17%	57.41%	54.84%	65.5% [a]
Observations	20	114	87	54	31	*NA*

3.2 Conditional Logit Model: relative importance relative of attributes per territory (*i.e.* department).

Table 5. Coefficients from the Conditional Logit Model.

Attributes	**Aude**	**Bouches-du-Rhône**	**Hérault**	**Morbihan**	**Pyrénées-Orientales**
Recycled steel	0.652** (0.271)	0.589*** (0.129)	0.152 (0.138)	0.293* (0.177)	0.262 (0.256)
Increase of biodiversity	0.028** (0.009)	0.026*** (0.004)	0.024*** (0.004)	0.013** (0.006)	0.026*** (0.007)
Local fishing revenue growth	0.031* (0.018)	0.033*** (0.008)	0.037*** (0.01)	0.046*** (0.012)	0.035** (0.014)
Increase of renewable-based electricity bill per month	-0.165** (0.057)	-0.235*** (0.027)	-0.225*** (0.033)	-0.203*** (0.038)	-0.216*** (0.057)
Notes	** for p-value < 0.05; ** for p-value < 0.01; *** for p-value < 0.001. Robust standards errors are in brackets.*				

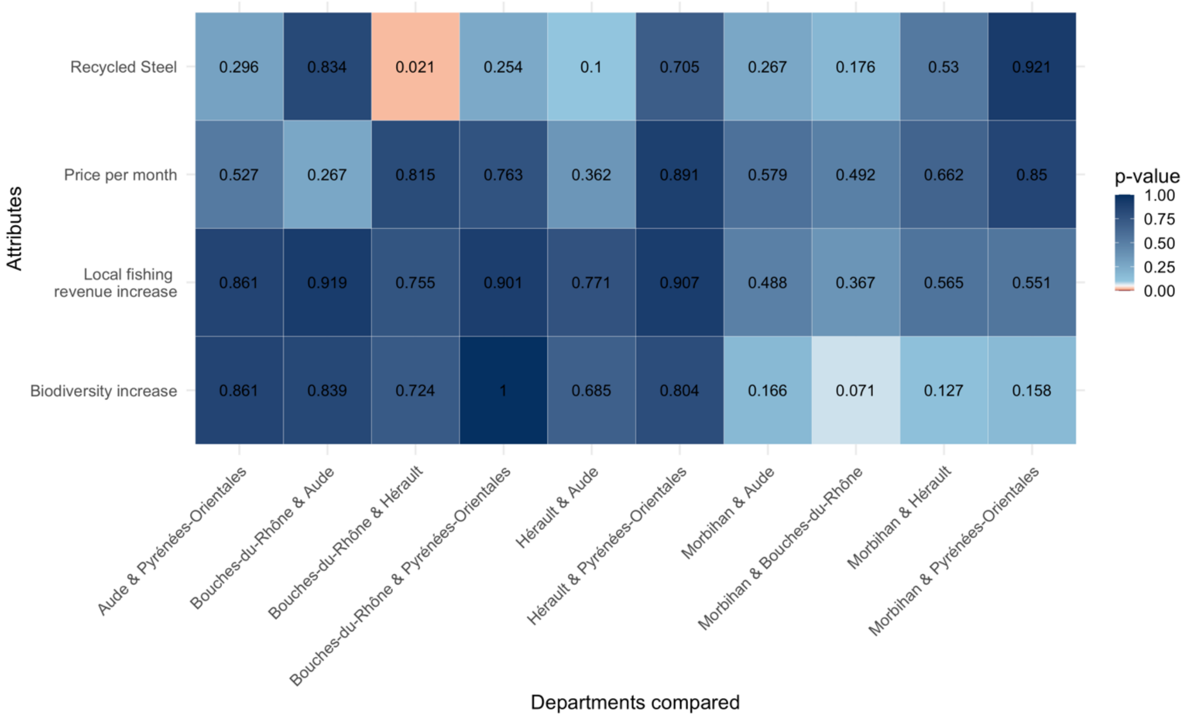

Figure 2. Conditional Logit Model coefficient comparison (Wald Test) between department in function of attribute.

The conditional logit model carried out on the data according to department shows significance for practically all the factors taken into account (Table 5). The 'Recycled steel' factor is significant for the departments of Hérault and Pyrénées-Orientales at the 5% level. The results thus indicate the sensitivity of respondents to the attributes and their levels. The payment attribute (electricity bill) is the only one to have negative coefficients, indicating a limitation on the increase in values for this attribute by respondents.

A Wald test was performed to analyse the presence or absence of differences in attributes between sampled departments (Figure 2). The null hypothesis (H_0) tested that the coefficients associated with a given attribute are equal across departments (H_0: $\beta_i,dep_1 = \beta_i,dep_2$). Rejection of this hypothesis therefore indicates that respondents from different territories valued an attribute differently. Only the 'Recycled Steel' attribute between the Bouches-du-Rhône and Hérault departments was significantly different. Despite the absence of statistical evidence (p-value > 0.05), the attribute 'Increased biodiversity' between the Morbihan and Bouches-du-Rhône departments is notable.

3.3 Estimated Willingness-To-Pay (WTP).

Table 6. Baseline marginal WTP estimates from the Conditional Logit Model with two scenarios as examples.

Attribute	**Bouches-du-Rhône**	**Hérault**	**Morbihan**	**Aude**	**Pyrénées-Orientales**
Use of recycled steel (over new steel)	2.51* [1.29 ; 3.72]	0.68 [-0.49 ;1.84]	1.44 [-0.31 ; 3.2]	3.94* [0.25 ; 7.63]	1.21 [-1.02 ; 3.44]
Biodiversity increase (+1 %)	0.11* [0.07 ; 0.15]	0.11* [0.07 ; 0.15]	0.06* [0.01 ; 0.12]	0.17* [0.0 ; 0.33]	0.12* [0.04 ; 0.2]
Local fishing revenue increase (+1 %)	0.14* [0.07 ; 0.21]	0.16* [0.08 ; 0.25]	0.22* [0.1 ; 0.35]	0.19 [-0.03 ; 0.41]	0.16* [0.03 ; 0.29]
Scenario A (Recycled steel, + 10% biodiversity, + 5% fisheries income)	4.31€/month	2.58€/month	3.14€/month	6.59€/month	3.21€/month
Scenario B (New steel, + 30% biodiversity, + 10% fisheries income)	4.7€/month	4.1€/month	1.7€/month	2.65€/month	2€/month

Notes: ** for p-value < 0.05; Values represent average household willingness-to-pay derived from marginal estimates of the conditional logit model. Biodiversity and fisheries impacts are expressed as percentage changes relative to current conditions. Confidence intervals (in brackets) were computed using the Delta method based on the estimated variance–covariance matrix.*

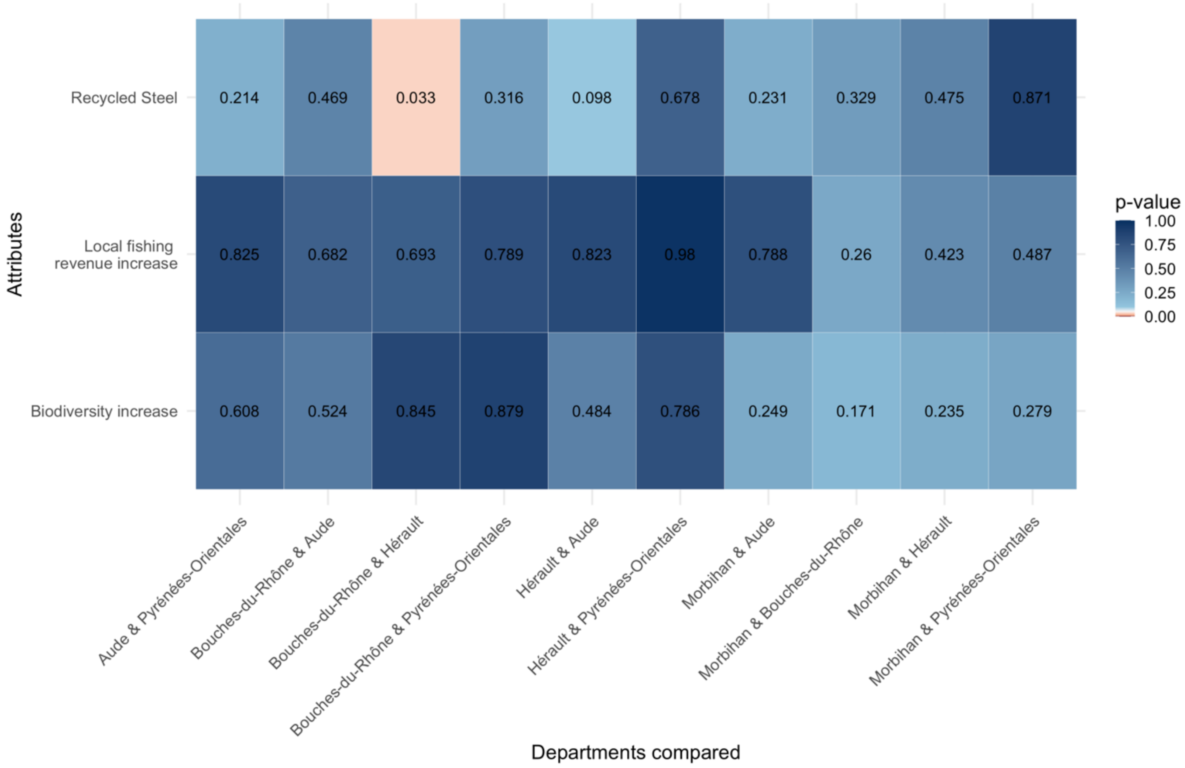

Figure 3. WTP (Wald Test) between each territory (department) in function of the attributes.

The estimation of WTP revealed a large majority of significant coefficients (Table 6). The coefficient for the attribute ‘Recycled steel’ is not significant for the departments of Hérault, Morbihan and Pyrénées-Orientales. The same case is found for the attribute ‘Growth in local fishing revenues’ for the Aude department.

A Wald test was performed to analyse whether or not there was a significant difference between departments for an attribute (Figure 3). The null hypothesis was that the estimated coefficients were equal across departments. This test revealed a single significant difference between the coefficients derived from the Conditional Logit Model for Recycled Steel between respondents from Bouches-du-Rhône and Hérault (p-value < 0.05). Similarly, the marginal WTPs were analysed with this Wald test, and the same result emerged: only the marginal WTP for recycled steel was significantly different between respondents from Bouches-du-Rhône and Hérault.

3.4 Attitude towards offshore wind power: a global point of view rather than territorial.

A Chi² test was performed to assess whether the respondents' departments of origin had an effect on their attitudes towards offshore wind power (Figure 4). The results of this analysis showed no significant difference between departments in attitudes (Chi² test, p-value > 0.05). In an attempt to discern a trend, an identical test was carried out, grouping 'Very Positive' with 'Positive' and 'Very Negative' with 'Negative': the results of this test were also unsuccessful in detecting differences (Chi² test, p-value > 0.05).

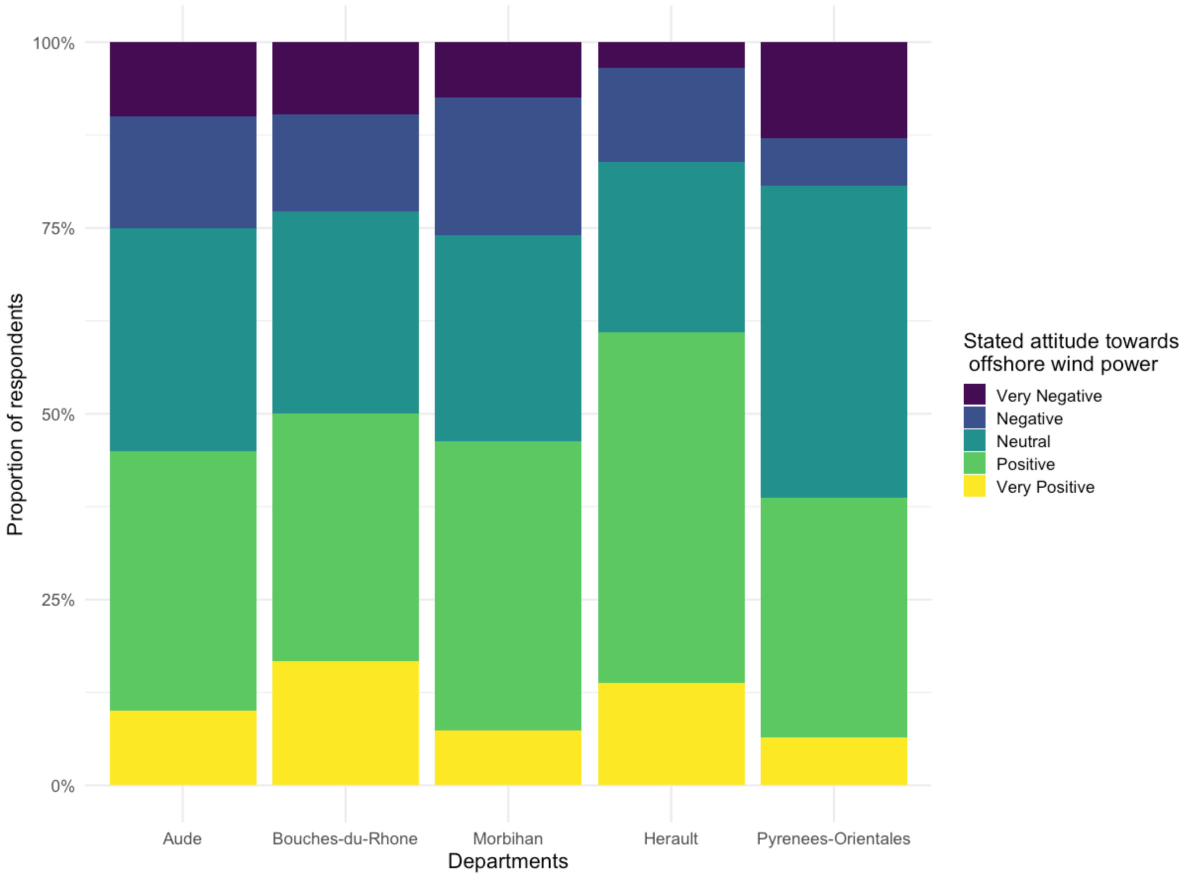

Figure 4. Proportion of each attitude toward offshore wind power depending on the territories (*i.e.* department).

3.5 Link between stated attitude towards offshore wind power and frequency of chosen *status quo*: Zero-Inflated Negative Binomial regression model.

To facilitate interpretation and visualisation, two categories of respondents were considered: those who chose the *status quo* more than four times out of eight (> 50%), and those who selected it four times or fewer (≤ 50%). This threshold was chosen to capture a meaningful distinction between consistent and occasional selection of the *status quo*. A chi-square test of independence revealed a significant association between stated attitudes and the number of *status quo* choices (χ^2=57.89, p < 0.001). Respondents with very negative attitudes chose the *status quo* significantly more often than expected. Neutral and very positive respondents did not significantly deviate from expected frequencies (Table 7).

Table 7. Number of status quo chosen in function of stated attitudes by respondents.

Stated Attitudes	**≤ 4 times on 8 *status quo* chosen**	**> 4 times on 8 *status quo* chosen**	**Total**
Very negative	9	15	**24**
Negative	30	11	**41**
Neutral	71	14	**85**
Positive	114	3	**117**
Very positive	33	6	**39**
Total	**257**	**49**	**306**

Table 8 presents the coefficients of the ZINB model and distinguishes them between the count component (number of *status quo* choices among respondents capable of selecting it) and the zero-inflation component (probability of always choosing zero). In the count model, the attitude toward offshore wind power was a significant predictor ($\beta = 0.217$, $p < 0.001$): it indicates that respondents with a more negative attitude toward offshore wind power were more likely to choose the *status quo*. The corresponding IRR of 1.243 (Table 8) suggests that for each unit increase in the scale of attitude toward offshore wind power (from very positive to very negative), the expected number of *status quo* choices increases by approximately 24%. Other covariates in the count model, including declared gender, age, education, professional status, prior knowledge/exposure to OWF, NEP mean score, ocean and professional fishing relationship and distance to the coast, were not statistically significant at the 0.05 level.

As the overdispersion parameter (θ) was significantly different from zero ($\log(\theta) = 1.302$, $p < 0.001$), it confirms the necessity of a negative binomial specification over another model. The ZINB model revealed that the attitude toward offshore wind power was also a significant predictor of the structural zeros ($\beta = -0.504$, $p < 0.001$). This negative coefficient indicates that respondents with a more positive attitude toward offshore wind power are more likely to belong to the group of individuals who never choose the *status quo* over the two other options where the eco-engineering concept was applied. In other words, the tendency to avoid each time the status quo, and the frequency of status quo choices when selected, are strongly associated with respondents' prior attitudes toward offshore wind power.

Table 8. ZINB model: count and zero-inflation coefficients (IRR for count part).

Component	Predictor	Estimate	Standard Error	Z value	p-value	IRR
Count	*Intercept*	*-0.047*	*0.863*	*-0.054*	*0.957*	*0.954*
Count	Prior attitude toward OWP	0.217	0.062	3.477	0.001***	1.243
Count	Gender (Female)	-0.216	0.17	-1.266	0.205	0.806
Count	Age	0.009	0.007	1.198	0.231	1.009
Count	Level of education (University degree)	0.206	0.168	1.227	0.22	1.229
Count	Professional status (In activity/student)	-0.149	0.187	-0.794	0.427	0.862
Count	Monthly household revenue	-0.004	0.058	-0.063	0.95	0.996
Count	Have already seen OWF	0.007	0.279	0.025	0.98	1.007
Count	Have already heard about OWF	-0.081	0.178	-0.457	0.648	0.922
Count	NEP mean score	0.106	0.18	0.588	0.556	1.111
Count	Relation to the Ocean	0.579	0.532	1.09	0.276	1.785
Count	Relation to professional fishing	-0.501	0.511	-0.981	0.327	0.606
Count	Distance to the coast	0.004	0.005	0.69	0.49	1.004
Count	Log(θ)	1.302	0.392	3.321	0.001***	3.676
Zero	*Intercept*	*1.779*	*0.366*	*4.855*	*0*	*NA*
Zero	*Attitude toward OWP*	*-0.504*	*0.121*	*-4.158*	*0*	*NA*

Table 9. Reasons of respondents that were exclusive chooser of Option C.

Reasons	Bouches-du-Rhône	Hérault	Morbihan	Aude	Pyrénées-Orientales	Total
The subject (artificial reef) does not interest me.	0	1	1	1	2	**5**
The subject (floating wind turbine) does not interest me.	2	3	1	0	0	**6**
My income is too low.	5	0	2	0	1	**8**
We already pay enough taxes in France.	13	4	6	0	2	**25**
This research is unfeasible.	4	1	0	1	0	**6**
Another reason	2	1	2	1	0	**6**
Sample	*15*	*6*	*8*	*2*	*3*	*34*
Total	**26**	**10**	**12**	**3**	**5**	**56**

Those who chose only the *status quo* mainly cited the argument that they were already paying too much tax in France (Table 9) to support the inclusion of eco-engineering in their electricity bills. Some people also added other arguments to the list provided (13 people chose two arguments, three people chose three arguments and one person chose four arguments).

3.6 Complementary analysis with a Mixed logit model

To account for repeated choice observations and explore potential unobserved preference heterogeneity, a panel mixed logit model was estimated as a robustness check of the baseline conditional logit results (Table A5). Territorial differences were explored by introducing interaction terms between the recycled steel attribute and the department of residence because the number of observations was insufficient to estimate separate models for each department. This attribute was selected as it was the only one showing a difference across departments in the conditional logit specification (see section 3.2).

Overall, the mixed logit specification confirms the direction and magnitude of the preference patterns identified in the conditional logit models that average preferences remain broadly similar across departments. The estimated mean coefficients confirm the main preference patterns identified in the conditional logit models. In particular, biodiversity enhancement, growth in local fisheries revenues and the use of recycled steel all exhibit positive average effects on utility, whereas the cost coefficient remains negative. These results indicate that respondents generally favour eco-engineering features associated with floating offshore wind projects while remaining sensitive to increases in electricity bills.

The interaction terms between recycled steel and departments remain relatively weak in the mixed logit specification. It implies a limited territorial variation in preference for this attribute. These findings are consistent with the conditional logit specification that indicated minor variation across departments.

Moreover, the interaction between respondents' prior attitudes toward offshore wind power and the *status quo* is positive and statistically significant (Table A5). It confirms the pattern found with the ZINB model that people holding stronger negative attitude toward offshore wind power are more likely to select the *status quo* option.

4 Discussion.

4.1 Do preferences vary depending on territories (*i.e.* departments)?

The results suggest a relatively homogeneous pattern of preferences across the departments sampled. Only one attribute (the use of recycled steel over new steel) demonstrated a statistically significant difference between territories in the conditional logit specification. Respondents from Bouches-du-Rhône reported a higher willingness-to-pay for the use of recycled steel (€2.51 per household per month) than those from Hérault (€0.68). On the contrary, preferences for biodiversity enhancement and growth in local fishing revenues appeared consistent across departments.

These results suggest that the territorial context plays a more limited role than initially expected in shaping preferences for eco-engineering characteristics. The overall pattern indicates a widely shared appreciation of the environmental and socio-economic benefits with the application of eco-engineering. However, differences in the perception of recycled materials may reflect local contextual factors such as exposure to industrial activities or discourse around circular economy practices. Nevertheless, the effect found for recycled steel remains moderate, as it was only found between two departments, and the mixed logit specification also supports this by showing no territorial variability for this attribute. This convergence of preferences contrasts with previous research that found significant contextual variance in the social acceptability of energy infrastructures (Lennon et al., 2019; Perlaviciute et al., 2018). Instead, the present results suggest that citizens may share relatively stable preferences regarding key project characteristics, and particularly for biodiversity enhancement and local economic benefits as artisanal fisheries.

From a policy perspective, the limited territorial variation observed in the results may represent an important opportunity for large-scale deployment strategies. If preferences for key eco-engineering attributes are consistent across coastal regions, developers and policymakers may be able to rely on relatively standardised design configurations rather than highly differentiated regional approaches. Such standardisation could facilitate economies of scale in the development of floating offshore wind projects incorporating eco-engineering features.

In this context, it becomes particularly relevant to consider combinations of attributes that could maximise public support. For example, a scenario combining the use of recycled steel with an increase of 10% of the biodiversity (within the observed range from the literature see section 2.2.5.2) and a growth of 5% of the revenues for local fisheries would lead to positive WTP in any departments, with an average of €3.9 per month

(Scenario A, Table 6). This bundle design demonstrates how societal support can lead to efficient and responsible deployment strategies.

Interestingly, these results are consistent with previous studies showing that preferences for environmental and socio-economic attributes can be remarkably robust across countries, despite significant differences in institutional settings, tax regimes or energy cultures (Firestone and Kempton, 2007; Iwata et al., 2023; Klain et al., 2020). This suggests that certain attributes, in particular marine biodiversity enhancement and local economic impact, can benefit from broad cross-border support if correctly stated and culturally significant in the development territory. It also leaves room for tailored approach to each region to take into account recent or specific contexts (Batel, 2020). Overall, this study reinforces the relevance of using eco-engineering that is both technically robust and symbolically credible (Pardo et al., 2023).

4.2 Does the attitude toward offshore wind power influence its acceptability?

The results indicate a clear link between respondents' attitudes toward offshore wind power and their propensity to select the *status quo* option. Individuals expressing strongest negative attitudes regarding offshore wind were significantly more likely to support the *status quo* alternative. In other words, those who were initially ardent opponent of offshore wind tended to reject configurations that had ecological and socio-economic improvements.

Interestingly, this finding contradicts our initial hypothesis, where we thought that opponents to offshore wind would try to reduce environmental or social impacts by choosing projects (options) with mitigation measures. Several explanations may account for this pattern. First, the *status quo* option may have been interpreted by some respondents as representing "no project at all", even with the clear explanation before the choice experiment and the indication within the choice cards. Thus, the *status quo* was chosen as a symbolic choice for those rejecting offshore wind development. Second, the consistency of *status quo* selections (Table 7) may reflect a form of systematic opposition sometimes described in the literature as "technology fatigue" or ideology-driven rejection (Anon, 2013; Cohen et al., 2014; Devine-Wright, 2009). Lastly, follow-up questions revealed that many of these respondents mentioned financial concerns, particularly regarding the already existing French taxation. Some explicitly stated that they "already pay too much" and could not support additional fees, even modest ones for eco-engineering regarding an average electricity bill, suggesting that financial resistance may be tightly bound to broader political or economic dissatisfaction. Our results also echo prior findings (Klain et al., 2020) showing that choices often reinforce existing attitudes rather than changing them. But it is not entirely pessimistic, since respondents who declared a "only" negative attitude (or a moderate one) chose scenarios with eco-engineering integrated. Despite the resistance to wind power sometimes encountered it paves the way for the broad development of this technology. In addition, qualitative comments collected during the survey suggest that financial factors may also play a role. Several respondents explicitly stated that they already felt heavily taxed and were reluctant to support additional electricity costs. This suggests that resistance to offshore wind projects may be rooted in broader political or economic dissatisfaction rather than a direct evaluation of the project attributes themselves.

These findings highlight that the acceptability of offshore wind projects cannot be explained solely by the ecological or economic characteristics of the projects. Individuals' responses to proposed project configurations appear to be strongly influenced by their attitudes toward technology.

5 Practical recommendations for policy makers, non-governmental organizations, developers and industry stakeholders.

The results of this study provide several practical insights for policymakers, developers and other stakeholders involved in offshore renewable energy deployment. Public opposition is frequently motivated not only by technical misconceptions, but also by symbolic, cultural or emotional dimensions as distrust of institutions and a perceived loss of democratic agency.

These findings suggest that simply upgrading project technical design may not always be enough to resolve public concerns. Communication efforts should therefore go beyond communicating ecological advantages or compensatory mechanisms, instead addressing underlying social representations and beliefs of fairness. At the same time, the findings show that many people with moderately negative opinions are willing to explore project alternatives that include significant ecological or socioeconomic improvements. This shows that early participation and open communication with local populations can help lessen resistance and encourage more positive talks about project design. More broadly, the relatively limited territorial differences observed in the study suggest that similar eco-engineering design principles could potentially be implemented across multiple coastal regions. This may facilitate the development of scalable solutions while still allowing for local adaptations where necessary.

Finally, tools like discrete choice experiments, particularly when combined with qualitative or deliberative approaches, can provide valuable insights into public expectations and help anticipate potential sources of opposition. Acceptability levers such as improving biodiversity, using recycled materials or addressing local economic repercussions should not be considered as 'incidental' additions, but rather as truly structural components of the project's legitimacy and viability. In a context where environmental legitimacy must be earned rather than presumed, aligning renewable infrastructure with social expectations and sustainable operation is not optional: it is an imperative.

6 Conclusion.

The aim of this study was to assess how social preferences for floating wind projects associated with eco-engineering may vary across territories and according to respondents' stated attitudes toward offshore wind. The survey was designed to capture opinions and preferences of non-specialists toward an emerging technology. The results highlight a relative consistency in preferences across the French coastline. Environmental and socio-economic attributes of eco-engineering were positively valued by respondents. Only limited territorial variations was observed, indicating broadly shared preferences across coastal areas. In this context, the use of recycled steel further increases the value of willingness to pay and supports the idea of responsible energy exploitation in every aspect. These findings suggest that similar eco-engineering design principles could potentially be implemented across different territories, facilitating scalable deployment strategies for floating offshore wind projects.

The results also show a strong association between stated attitudes towards offshore wind power and the choices made in the experimental scenarios. Ardent opponents of offshore wind power were significantly more likely to favour the *status quo* option, even when ecological or socio-economic improvements were incorporated into the proposed alternatives. In contrast, those with simply "Negative" views were more likely to engage with scenarios of applied eco-engineering. This nuance is essential, as it highlights that while a segment of the population may be unreachable through technical or communicative adjustments, another large portion remains open to projects designed with attention to their values and concerns (*i.e.* impact on marine and societal environments).

Some limitations of the study should be acknowledged. Uneven sample sizes across departments may have reduced the power of certain local comparisons. Moreover, the hypothetical nature of scenarios imply a degree of abstraction that may differ from behaviour in a real policy context. Attitudes were self-reported and may also reflect some social desirability bias. Future research could further explore how emotional factors, risk perception or place-based identity interact with preference heterogeneity identified through mixed logit modelling approaches.

Table A1. List of Offshore Wind Farms on French maritime territory and their status.

<table>
<tr><th>Name</th><th>Call of tender number (date of launch)</th><th>Year of Attribution</th><th>Attachment department (number)</th><th>Total capacity power</th><th colspan="2">Status (at July 2025)</th><th>Status updating year</th><th>Surface (km²)</th><th>Technology</th></tr>
<tr><td>Saint Nazaire</td><td>AO1 (2011)</td><td>2012</td><td>Loire-Atlantique (44)</td><td>480 MW</td><td>Operational</td><td>■■■■■</td><td>2022</td><td>78</td><td rowspan="12">Fixed</td></tr>
<tr><td>Saint Brieuc</td><td>AO1 (2011)</td><td>2012</td><td>Côtes-d’Armor (22)</td><td>496 MW</td><td>Operational</td><td>■■■■■</td><td>2023</td><td>75</td></tr>
<tr><td>Fécamp</td><td>AO1 (2011)</td><td>2012</td><td>Seine-Maritime (76)</td><td>500 MW</td><td>Operational</td><td>■■■■■</td><td>2023</td><td>60</td></tr>
<tr><td>Îles d’Yeu et Noirmoutier</td><td>AO2 (2013)</td><td>2014</td><td>Vendée (85)</td><td>488 MW</td><td>In construction</td><td>■■■■□</td><td>2025</td><td>83</td></tr>
<tr><td>Courseulles-sur-mer</td><td>AO1 (2011)</td><td>2012</td><td>Calvados (14)</td><td>450 MW</td><td>In construction</td><td>■■■■□</td><td>2025</td><td>50</td></tr>
<tr><td>Dieppe-Le Tréport</td><td>AO2 (2013)</td><td>2014</td><td>Seine-Maritime (76)</td><td>496 MW</td><td>In construction</td><td>■■■■□</td><td>2024</td><td>83</td></tr>
<tr><td>Dunkerque</td><td>AO3 (2016)</td><td>2019</td><td>Nord (59)</td><td>600 MW</td><td>Attributed</td><td>■■■□□</td><td>2019</td><td>50</td></tr>
<tr><td>Fécamp Grand Large</td><td>AO10 (2025)</td><td>-</td><td>Seine-Maritime (76)</td><td>2 x 2 GW</td><td>Public debate</td><td>■□□□□</td><td>2025</td><td>483</td></tr>
<tr><td>Oléron 1</td><td>AO7 (2022)</td><td>-</td><td>Charente-Maritime (17)</td><td>1 GW</td><td>Concurrence</td><td>■■□□□</td><td>2025</td><td>180</td></tr>
<tr><td>Oléron 2</td><td>AO9 (2024)</td><td>-</td><td>Charente-Maritime (17)</td><td>1 - 1.25 GW</td><td>Concurrence</td><td>■■□□□</td><td>2025</td><td>250</td></tr>
<tr><td>Centre Manche 1</td><td>AO4 (2021)</td><td>2023</td><td>Manche (50)</td><td>1 GW</td><td>Attributed</td><td>■■■□□</td><td>2025</td><td>183</td></tr>
<tr><td>Centre Manche 2</td><td>AO8 (2022)</td><td>-</td><td>Calvados (14)</td><td>1.5 GW</td><td>Concurrence</td><td>■■□□□</td><td>2025</td><td>270</td></tr>
<tr><td>Golfe du Lion Centre</td><td>AO10 (2025)</td><td>-</td><td>Hérault (34)</td><td>2 GW</td><td>Public debate</td><td>■□□□□</td><td>2024</td><td>400</td><td>Floating (commercial)</td></tr>
</table>

Golfe de Gascogne Sud	AO10 (2025)	-	Charente-Maritime (17)	1.2 GW	Public debate	■□□□□	2024	250	
Bretagne Nord-Ouest	AO10 (2025)	-	Finistère (29)	2 GW	Public debate	■□□□□	2024	350	
Golfe de Fos 1	AO6 (2022)	2024	Bouches-du-Rhône (13)	230 - 280 MW	Attributed	■■■□□	2024	52	
Golfe de Fos 2	AO9 (2024)	-	Bouches-du-Rhône (13)	450 - 550 MW	Concurrence	■■□□□	2025	103	
Narbonnaise Sud-Hérault 1	AO6 (2022)	2024	Aude (11)	230 - 280 MW	Attributed	■■■□□	2024	48	
Narbonnaise Sud-Hérault 2	AO9 (2024)	-	Aude (11)	450 - 550 MW	Concurrence	■■□□□	2025	96	
Bretagne Sud 1	AO5 (2021)	2024	Morbihan (56)	250 MW	Attributed	■■■□□	2024	45	
Bretagne Sud 2	AO9 (2024)	-	Morbihan (56)	400 - 550 MW	Concurrence	■■□□□	2025	225	
Provence Grand Large/Port-Saint-Louis-du-Rhône	AO ADEME (2015)	2016	Bouches-du-Rhône (13)	25.2 MW	Operational	■■■■■	2024	0.78	
Gruissan	AO ADEME (2015)	2016	Aude (11)	30 MW	In construction	■■■■□	2025	8.15	Floating (pilot)
Leucate-Le Barcarès	AO ADEME (2015)	2016	Pyrénées-Orientales	30 MW	In construction	■■■■□	2025	6.17	

Figure A1. Examples of visualisations of the concept shown to respondents during the Discrete Choice Experiment survey (credit illustration: Dubois A.).

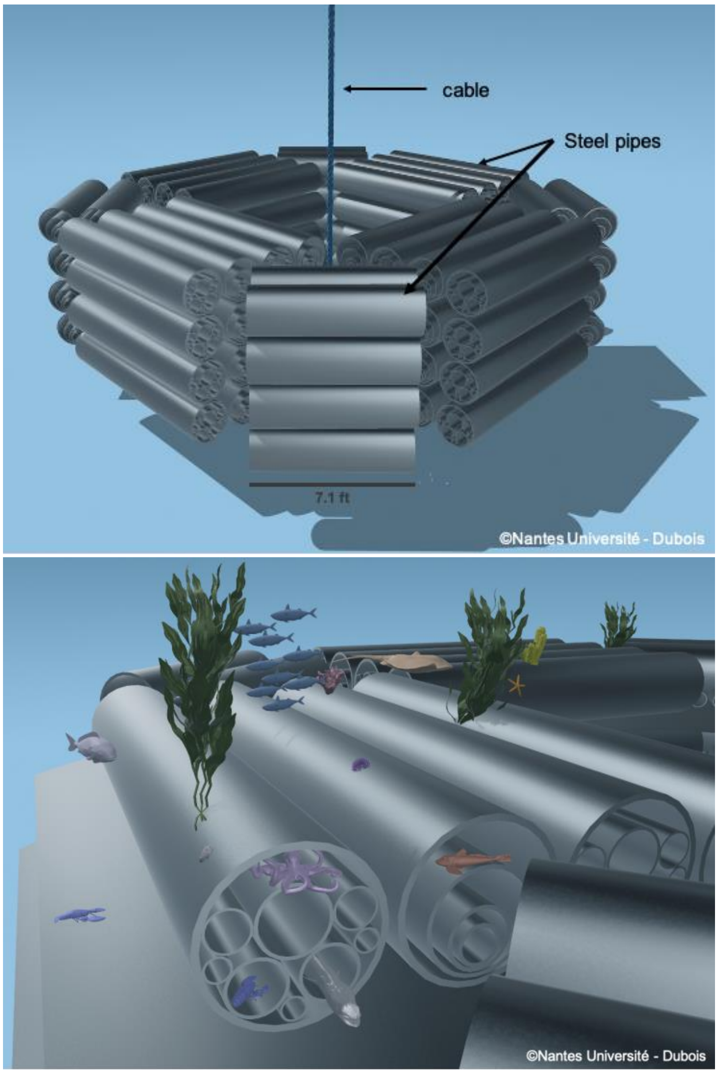

Table A2. Example of choice cards shown to participants during the Discrete Choice Experiment survey (translated from French).

	Option A	**Option B**	**Option C: farm without reefs**
Reef material	New Steel	Recycled Steel	No Reef
Increase of underwater species	+30%	+20%	No change
Growth of local fishermen revenue	+10%	+5%	No change
Rise of household electricity bill (per month on 20 years)	+$5	+$1	No change

Table A3. Attributes and their values for each block and tasks.

Block	Task	Material of artificial reef		Biodiversity increase (%)		Local fisheries growth (%)		Cost (€/month)	
		Option A	**Option B**	**Option A**	**Option B**	**Option A**	**Option B**	**Option A**	**Option B**
1	1	recycled	new	10	40	10	5	5	1
	2	new	recycled	20	30	1	15	3	3
	3	new	recycled	20	30	10	5	1	10
	4	new	recycled	30	20	15	1	3	2
	5	new	recycled	30	20	5	10	1	10
	6	recycled	new	20	30	15	1	10	1
	7	recycled	new	30	20	5	10	5	2
	8	recycled	new	40	10	1	15	3	3
2	1	new	recycled	20	30	15	1	1	5
	2	recycled	new	40	10	5	10	2	3
	3	recycled	new	10	40	10	5	2	5
	4	new	recycled	10	40	1	15	5	2
	5	recycled	new	40	10	10	5	1	10
	6	new	recycled	40	10	15	1	10	1
	7	recycled	new	10	40	5	10	2	5
	8	new	recycled	30	20	1	15	10	1
Note	*Each respondent was assigned to one of the two blocks and completed the eight tasks in random order.*								

Table A4. The 15 Likert-scale (Strongly disagree, disagree, neutral, agree, strongly agree) statements of the New-Ecological Paradigm questionnaire (Anderson & Dunlap, 2012).

1. We are approaching the limit of the number of people Earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will ensure that we do not make the Earth unlivable.
5. Humans are seriously abusing the environment.
6. The Earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.
10. The so-called “ecological crisis” facing humankind has been greatly exaggerated.
11. The Earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

Table A5. Mixed Logit model accounting for repeated choices and preference heterogeneity.

Variable	Means			Stand. dev.		
	coef.		s.e.	coef.		s.e.
Recycled steel	0.720	***	0.140	1.340	***	0.155
Biodiversity	0.042	***	0.005	0.045	***	0.005
Local fishing revenue	0.067	***	0.009	0.061	***	0.013
Cost (mean log)	−0.783	***	0.130	1.626	***	0.126
$ASC_{Status\ quo}$	−1.916	***	0.215	NA	NA	NA
$ASC_{Status\ quo}$ x Attitude toward OWF	0.914	***	0.239	NA	NA	NA
Recycled steel x Aude	0.364	*	0.205	NA	NA	NA
Recycled steel x Hérault	0.061		0.331	NA	NA	NA
Recycled steel x Morbihan	−0.324	*	0.195	NA	NA	NA
Recycled steel x Pyrénées-Orientales	−0.068		0.238	NA	NA	NA
Number of individuals	306					
Number of observations	2448					
BIC	3205.066					
LL at convergence	1547.912					
Adjusted R^2	0.419					
Number of draws	2000					

*Notes: s.e. robust; * p<0.1, ** p<0.05, *** p<0.01; Department of reference: Bouches-du-Rhône; Random parameters are assumed normally distributed except for the cost coefficient specified as lognormally distributed. The model includes interactions between respondents' attitudes toward offshore wind power and the status quo alternative, as well as territorial interactions with recycled steel preference. The specification accounts for repeated choice observations at the respondent level.*

Table A6. Willingness-to-pay derived from the mixed logit model.

Attribute	Mean	Share β > 0
Use of recycled steel (over new steel)	5.970 [3.12 ; 11.6]	70.6%
Biodiversity increase (+1%)	0.344 [0.204 ; 0.588]	82.8%
Local fishing revenue growth (+1%)	0.564 [0.339 ; 0.93]	86.0%
Random scenario A: Recycled steel, +10% biodiversity, +5% fisheries income	12.23€/month	*NA*
Random scenario B: New steel, +30% biodiversity, +10% fisheries income	15.96€/month	*NA*

Notes: €/household/month; biodiversity and income = per percentage point; share β > 0 = share of simulated preference draws implying a positive marginal utility. Confidence intervals for mixed logit WTP summaries were obtained using a parametric bootstrap: parameter vectors were drawn from the estimated (robust) variance–covariance matrix and individual-level WTP distributions derived from simulated preference parameters.

Authors contribution.

AD, PAM, AB and FS conceptualised the study. AD, PAM, AB and JM developed the methodology. AD and PAM performed formal analysis, investigation, visualisation. AD, PAM and FS prepared the original-draft. PAM, AB and FS provided supervision. All authors contributed to the draft review and editing.

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