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A REVIEW STUDY ON THE EFFECTS OF USING OFFSHORE WIND ENERGY ON ECOSYSTEM IN JAPAN

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ABSTRACT: Offshore wind energy is widely regarded as one of the most credible sources for increasing renewable energy production towards a resilient and decarbonized energy supply. However, current expectations for the expansion of energy production from offshore wind may lead to significant environmental impacts. Assessing ecological risks to marine ecosystems from electricity production from wind is both timely and vital. It will support the adoption of management measures that minimize impacts and the environmental sustainability of the offshore wind energy sector. In this study, the review of literature analyzed the external effects of wind turbines, which are often considered detrimental to the promotion of wind power generation. Understanding these externalities is essential to reaching a consensus with residents who live near the site of a planned wind turbine. Our research objective was to determine the relationship between wind turbines and people’s well-being in areas where they have been installed for a long time. They hypothesized that wind turbines would have a negative impact on people’s well-being. Also conducted a survey by postal mail in Chōshi City, Chiba Prefecture, Japan, to examine the external effects of wind turbines, adopting a subjective well-being index to measure respondents’ well-being. Regression analysis suggests that having a view of wind power turbines has a positive effect on the subjective well-being of residents. Moreover, the results indicate that such well-being increases with increasing distance from the turbines. Except for scenic elements and found that wind turbines are not always considered desirable by residents. Therefore, it is important to further clarify the external influence of wind turbines and other facilities in local communities.

Key words: Wind turbines, renewable energy, offshore wind energy, environment.

INTRODUCTION

Ocean energy and offshore wind energy (OWE), in particular, have been identified as potential renewable energy sources, with a view to decarbonizing and reducing greenhouse gas emissions (**International Energy Agency, 2019**) and contributing to achieving the United Nations Sustainable Development Goal (SDG) 7, Affordable and Clean Energy (**United Nations, 2016**). OWE provides local electricity production capacity and reduces the need for oil or gas maritime transportation, preventing the risk of spills (**Copping, 2016**). Moreover, the current context of increasing energy prices, supply-side constraints, and dependency on third countries for traditional energy sources are positioning OWE as a strategic renewable energy source to achieve resilience.

In the last decade, electricity production from wind energy has grown exponentially worldwide in the last decade, benefiting from technological advances (**Dean, 2020**), declining production costs, and strong subsidies from states and investors (**Global Wind Energy Council, 2020; Jansen, 2020**). In terms of the Levelized Cost of Energy, an almost 55% drop is anticipated from 2018 to 2030 (**IRENA, 2020**), and 37% to 49%

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declines in production costs by 2050 (**Wiser, 2021**), making the offshore wind sector increasingly competitive with fossil fuels (**IRENA, 2020**).

Offshore wind farms (OWFs) already accounted for 10% of new wind power installations around the world in 2019 (**Global Wind Energy Council, 2020**), and are expected to contribute more than 20% of the total installed capacity of offshore wind electricity production by 2025 (**Global Wind Energy Council, 2020**). To attain this growth rate, the global installed capacity of offshore wind projects needs to increase almost tenfold by 2030 (to 228 GW) and continue to rise to 1000 GW by 2050 (**IRENA, 2019**). To achieve such expectations, experts predict that by 2035, 11–25% of all new offshore projects globally will feature floating foundations (**Wiser, 2021**).

From the perspective of climate change and energy security, the rapid introduction of renewable energy is greatly expected. Countries around the world have been researching and introducing renewable energies that take advantage of local natural capital (**Seyedhashemi *et al*., 2021**). Despite the remarkable growth of photovoltaic energy via a feed-in-tariff (FIT) scheme, the installed capacity of renewable energy has not been fully utilized in Japan. Therefore, the introduction of other renewable energy sources, such as wind and geothermal power generation, has been greatly expected. In fact, in announcing that it will achieve carbon neutrality by 2050, the Japanese government proposed the expansion of onshore wind power and offshore wind power (**Japan Wind Power Association, 2021**). However, it has been suggested that the operation of wind power generation facilities may bring negative externalities to local communities. For example, Japan’s Ministry of the Environment **Wang *et al*. (2017)** reported typical damage and negative impacts that building or operating wind turbines has caused, including obstructed views, noise, low-frequency sounds, impacts on animals and plants, and shadow flicker, which represent negative externalities for residents, leading to conflicts regarding the construction of wind turbines.

Conflicts related to the construction of wind turbines are a disincentive for their expansion. In Japan, conflicts have occurred in approximately 40% of the cases of wind turbine construction (**Ministry of the Environment, 2021**). According to estimates by the Ministry of the Environment (**Azechi *et al*., 2014**), the potential for wind power energy in Japan is approximately 1.9 million MW. However, the amount of installed capacity as of 2020 was 443.9 MW (**Ministry of the Environment, 2021**), which shows that the use of wind power is lagging behind its potential. Of course, such conflicts also exist in other countries. In Europe, for example, wind power is more widely installed than in Japan (approximately 220,000 MW in 2020) (**Japan Wind Power Association, 2021**). However, in Europe, as in Japan, approximately 40% of projects have been postponed due to disputes (**Wind Europe, 2021**). In response to these conflicts, in 2008, the International Energy Agency Wind Technology Collaboration Programme (IEA Wind TCP) started a task force related to the social acceptability of wind power, which has been working toward more rapid introduction of wind power in Europe (European Wind Energy Association asbl/vzw, **EWEA, 2021**).

Given the current situation, it is critical to develop a framework to deal with the conflicts related to turbine construction and accelerate the introduction of wind turbines in Japan. One option is to share the benefits related to the construction and operation of wind turbines. Therefore, it is necessary to examine the possible negative externalities and review relevant studies that can be used for discussion with residents. To the best of our knowledge, such studies have not been conducted in Japan. Therefore, this study is the first attempt to examine whether and how wind generation results in negative externalities in Japan.

The purpose of this study is to clarify the extent of externalities in areas where wind turbines have been in operation for a long time. There are some areas in Japan where wind turbines have been operating for a long time after conflicts were resolved, but the externalities in these areas have not been clarified. They believe that clarifying these external externalities will be useful for building consensus when constructing wind turbines in the future. They hypothesize that even if conflicts did not occur, externalities exist and have some negative impact on people. The purpose of this study is to clarify this hypothesis.

While wind power mitigates the negative externalities of conventional electricity technologies, notably the emission of CO2 and other air pollutants, it also entails externalities (**IEA Annual Report, 2009**). There are many studies on the externalities of wind turbines, for example, visual pollution (**Zerrahn, 2017**), noise pollution (**Huber *et al*., 2017**), and impacts on wildlife (**Nunneri *et al*., 2018**). Several studies have investigated the negative impacts on landscape aesthetics (**Zerrahn, 2017**). While there have been several studies on the noise impact of wind turbines (**Huber *et al*., 2017**), many studies report that annoyance does not indicate evidence of causal health effects (**IEA Annual Report, 2009**). In addition, wind turbines may change the habitats of wildlife such as birds and bats, and many studies have examined whether and how wildlife is impacted (**Nunneri *et al*., 2018**). However, whether the general effect on wildlife is positive or negative is uncertain (**IEA Annual Report, 2009**).

On the other hand, wind turbines do not always lead to only negative externalities for residents. They can induce positive externalities by stimulating the tourism industry if they can create special landscapes. There are numerous studies about such effects on tourism, but with different results, so the evidence on local tourism effects remains mixed (**IEA Annual Report, 2009**). Some case studies establish negative impacts on local touristic appeal (**Jensen *et al*., 2014**), while others detect negligible effects or enhanced attractiveness (**Broekel and Alfken, 2015**).

Research Methods

There are typically two types of methods for conducting research on wind turbine externalities. First, there are research methods involving the use of questionnaire surveys, such as the contingent valuation method (CVM) and choice experiment (CE). These estimate respondents' willingness to pay (WTP) to prevent the construction of wind turbines or their willingness to accept (WTA) construction. Many CVM and CE studies have shown that neighboring residents perceive negative externalities from wind turbines (**Nordman and Mutinda, 2016**). On the other hand, some studies show that consumers are willing to pay for wind turbines to obtain green electricity (**Ma *et al*., 2015**). There is also an analytical method that combines the CVM and CE with the travel cost method (TCM), which predicts landscape value from tourist travel costs (**Sundt *et al*., 2015**). They used this method to show the negative impact of wind turbines. These methods have some problems. First, they may be affected by strong opposition from local residents to the construction of wind turbines. In such cases, the results will be greatly biased. In addition, the scenarios of the questionnaires used in these methods can greatly affect respondents' evaluations. In this regard, we need to be very careful when creating questionnaire scenarios.

A second analytical method involves the use of a hedonic approach (**Trice, 1958**). When people select housing, they make decisions by considering environmental factors, including noise levels and landscape. The hedonic method in this context is based on the premise that land prices include people's WTP for the environment. By using this method, we can assess how the externalities of wind turbines, such as noise and landscape effects, affect land prices (**Rosen, 1974**). **Jensen *et al.* (2014)** analyzed the impact of the presence of wind farms on land prices using Danish land price data. In their study, they analyzed the negative influence of wind turbines in terms of landscape and noise separately. Numerous other studies have also used the hedonic method, including those by **Sims and Dent (2007)** in the UK, **Heintzelman and Tuttle (2012)** in the USA, **Dröes and Koster (2016)** in the Netherlands, **Sunak and Madlener (2016)** in Germany, and **Gibbons (2015)** in England and Wales. However, in the Japanese context, using the hedonic method of analysis is difficult because there are only a few cases where wind power generation facilities have been introduced near housing, and there is a very small amount of data on housing transactions near wind power generation facilities. However, there are some cases where wind turbines are constructed very close to residences, because there are no regulations controlling the distance between them in Japan.

According to the "Wind Power Generation Facilities and Installations Report in Japan"

(**Chōshi City, 2021**), 35 wind power generation facilities were operating in Chōshi as of March 2017. Indeed, the eastern part of the city had a concentration of commercial facilities before the construction of wind turbines began. Figure 1 shows a map of the Chōshi area and the locations of wind turbines. We mapped the locations of wind turbines on Google Maps using address information from NEDO (The New Energy and Industrial Technology Development Organization, NEDO, 2018) and the basic residence register for Chōshi City. The home icons indicate the residential locations of our sample, the X icons indicate wind turbines that were not targeted, and balloon pins represent the targeted wind turbines. Although there are windmills in Asahi City and Kamisu City around Chōshi City, we focused on windmills in Chōshi and houses near them. We also excluded from our analysis those windmills that were already out of operation even if they were located near targeted houses. The average output of wind farm facilities is 1500 kW; however, some facilities have much a higher output, up to 2400 kW. Since the size of wind turbines in Chōshi does not vary much, in this study we considered their size to be almost constant.

RESULTS AND DISCUSSION

Results in Table 1 shows the descriptive statistics of the data that they used for estimation. Table 1 indicates that more than half of the respondents could hear noise, based on the regression results that does not affect their perceived level of well-being.

Contrary to expectations, their study finds that the existence of wind turbines does not negatively affect the well-being of residents, because there were few negative evaluations of noise and low-frequency sounds. Moreover, noises from sources other than wind turbines do not affect well-being, suggesting that such noises in Chōshi city may be considered to be at an acceptable level. There are two possible explanations.

First, it is conceivable that the noise level in Chōshi city is generally acceptable to the residents.

Second, although there are noises, including those from wind turbines in Chōshi, residents are already used to their environment, hence their well-being may remain unaffected. To clarify this point, it is necessary to analyze the data using a quantitative noise level measure.

They also find that a view of wind turbines is positively related to well-being. They suggest that positive evaluations of wind turbines, could contribute to the estimation results. Moreover, the respondents did not negatively evaluate other large facilities.

Based on these results, they think that wind turbines could operate without having a negative impact on people in areas with some pre-existing or low-frequency noise. However, they need to pay more attention to the noise of wind turbines and health hazards. On the other hand, the health hazards of noise tolerated by residents are uncertain. In the future, they will need to analyze the relationship between noise, health hazards, and subjective well-being in more detail.

Environmental impacts from wind energy production devices on marine ecosystems

Offshore energy production can have both positive and negative impacts on marine ecosystems **(Hall *et al*., 2020**).

Negative impacts are reported more frequently (up to 10% of the scientific findings) being especially linked to birds, marine mammals, and ecosystem structure. Positive effects are less reported (up to 1% of scientific findings), relating mostly to fish and macroinvertebrates (Fig. 2). The ecological risks derived from the negative impacts of wind energy devices can vary biogeographically, depending on the environmental characteristics and vulnerability of the affected area (e.g., presence of migrating bird species especially sensitive to wind turbines (**Iglesias *et al*., 2018**). The identification of potential significant impacts is, therefore, always case-specific. In particular, the real impact of an OWF on protected species and habitats will show high spatial variability; it must be carefully assessed with respect to local conservation objectives and the affected species/habitats (**Iglesias *et al*., 2018**). Furthermore, environmental impacts will also depend on the initial state and

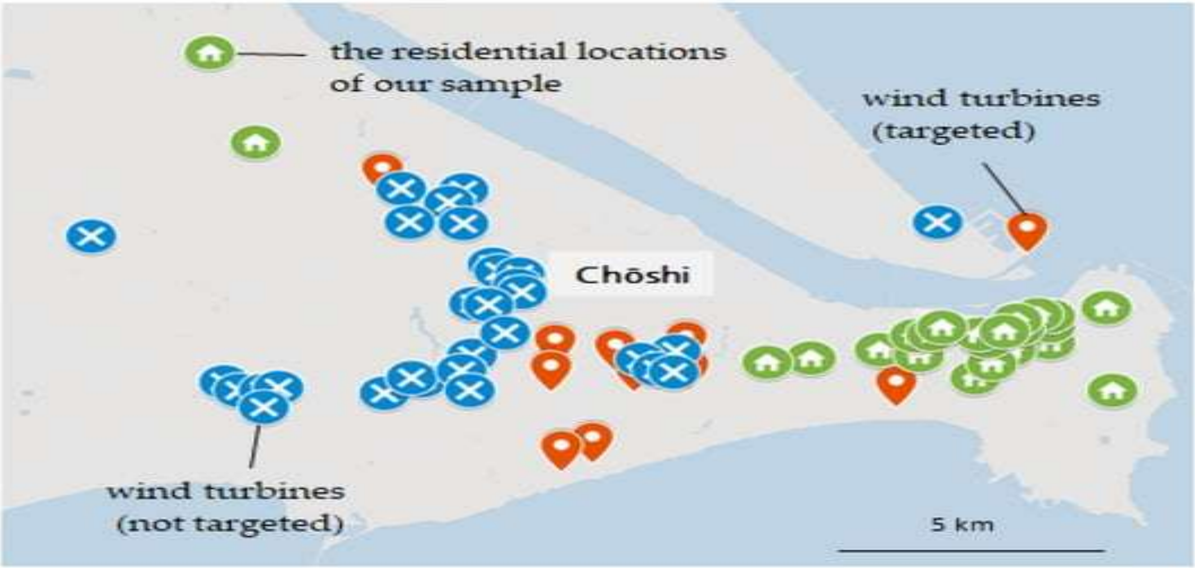

Fig. 1. Map of Chōshi area and locations of wind turbines

Table 1. Descriptive statistics (N = 201 observations)

Variable	Mean	Std. Dev.	Min	Max
Well-being	6.56	1.85	1	10
View	0.49	0.50	0	1
Distance (<500 m)	0.05	0.22	0	1
Distance (500–1000 m)	0.18	0.39	0	1
Distance (1000–1500 m)	0.32	0.47	0	1
Distance (1500–2000 m)	0.36	0.48	0	1
Distance (>2000 m)	0.08	0.28	0	1
Noise	0.58	0.49	0	1
Income (<2 million JPY)	0.16	0.37	0	1
Income (2–3 million JPY)	0.23	0.42	0	1
Income (3–4 million JPY)	0.10	0.31	0	1
Income (4–5 million JPY)	0.12	0.33	0	1
Income (5–7 million JPY)	0.19	0.40	0	1
Income (7–10 million JPY)	0.10	0.31	0	1
Income (10–15 million JPY)	0.05	0.22	0	1
Income (>15 million JPY)	0.03	0.17	0	1
Male	0.51	0.50	0	1
Employment	0.60	0.49	0	1
Ln Age	4.00	0.35	2.9	4.5
Ln Age Squared	16.12	2.70	8.4	20.1
Education (≧High school)	0.27	0.45	0	1
Marriage	0.63	0.48	0	1
Duration of Residence (<10 years)	0.11	0.31	0	1
Duration of Residence (10–20 years)	0.18	0.39	0	1
Duration of Residence (20–30 years)	0.24	0.43	0	1
Duration of Residence (>30 years)	0.46	0.50	0	1

Source: Kunugi *et al.* (2021)

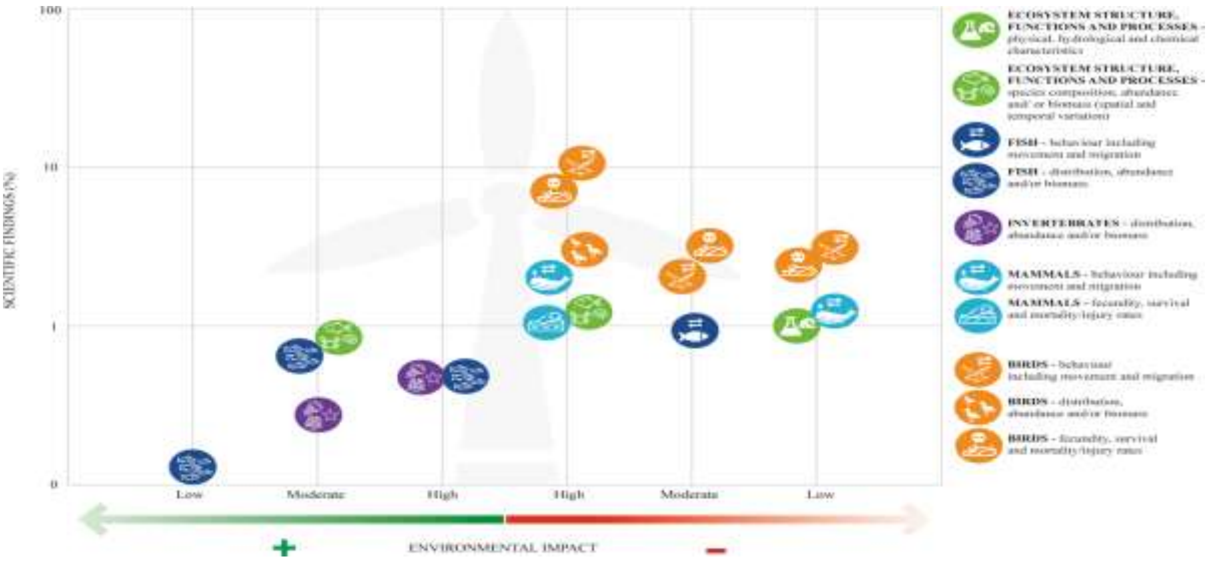

Fig. 2. Most frequently reported environmental impacts of wind energy devices on the most representative indicators of ecosystem elements, by type (positive/negative) and magnitude (high to low)

resilience of the area, which can change dramatically for some ecosystem elements (**Copping and Hemery, 2020**).

Indirect impacts, which tend not to be fully investigated, must also be considered. Increases in prey species (e.g., pressure tolerant) at OWFs will increase food availability to higher trophic levels (e.g., bird and mammal species), thereby increasing their populations (**Vanermen, 2020**). Impacts will thus vary among species within the same ecosystem element (e.g., different seabird species may be affected in different ways by turbines) (**Thaxter, 2017**). In some cases, impacts may be positive (e.g., seabirds have rest areas and more resources for food), while in others, species may suffer significant adverse effects impacting their behavior. Impacts may spread far from the OWF area (e.g., lower number of organisms of migratory populations at the final destination), as is the case for land-based wind farms (**Thaxter, 2017**). It is, therefore, fundamental to consider the spatial and temporal distribution of the most sensitive species when determining the risks associated to a given project. For the adoption of such an approach, better data is required on species distribution and abundance over annual cycles and on the migration routes of birds, fish, and marine mammals.

Despite the evident negative impacts of OWFs on ecosystem elements, potential positive impacts must also be highlighted. According to several authors, positive environmental impacts are linked to reserve and reef effects on the area of OWF deployment and mooring structures. These can function as artificial reefs and fish aggregation devices for small demersal fish, attracting more marine life than natural reefs. Evidence suggests that OWFs may enhance diversity in areas with homogeneous seabed. Also, the prohibition of bottom trawling near OWFs for safety reasons eliminates disturbance of fish, benthos, and benthic habitats, partially by providing protection from fishing. Findings suggest that negative impacts on fishing activities can be mitigated by spill-over effects due to increased catches (up to 7%, close to wind farms) and slight modifications in catch composition. Long-term monitoring and additional information on ecological processes influencing fish stock dynamics will further enable the demonstration of whether extra production at population level occurs.

Pressures on Ecosystem Elements and Their Indicators

Of the 867 findings identified, biological pressures correspond to the most-studied pressure category (63%) (Fig. 3a). From 16 pressure types, 10 pressures were assessed, the most frequent ones being those associated to biological disturbance (**Wilber *et al*., 2018**) and noise input (**Kastelein *et al*., 2017**) (62% and 18% of the findings, respectively; Fig. 3b). Most findings associated to ecosystem elements were reported for species (87%, especially birds), ecosystem structure, functions, and processes (11%), and habitats (3%) (Fig. 3c). The most studied indicators were behavior (**Vanermen, 2017**) (37%), fecundity, survival, and mortality/ injury rates (25%), and distribution, abundance and/or biomass (24%) (Fig. 3d).

Indicators that are most studies for analysing the effects of the pressures produced by wind turbines on ecosystem elements are identified in Table 2. Despite the relatively high number of species studied, there is a bias toward northern distribution species such as *Phocoena phocoena* (47 findings), *Phoca vitulina* (26 findings), *Uria aalge* (16 findings), or *Gadus morhua* (13 findings) (**Brandt, 2018**), and a lower number of findings to invertebrates. However, with the expected global expansion of OWFs projects to new areas, impacts on temperate, subtropical, and tropical species must be further investigated (**Lloret, 2022**). While disturbance of high taxonomical levels is important (i.e., mammals, seabirds, fish), physical loss and physical disturbance of benthic habitats needs to be investigated in detail, as large OWF developments and the high density of wind turbines may hinder the achievement of good environmental status for biodiversity or seafloor integrity.

Impact Type and Magnitude

Among the 867 findings extracted from the analysed publications, 72% reported negative impacts, while 13% were positive (Fig. 4a). Regarding impact magnitude (either positive or negative), 54% were reported as being high or moderate, while low or negligible impacts accounted for 32% (Fig. 4b). The distribution of impact type and magnitude on each ecosystem element is shown in Fig. 5, For instance, the impact type of 'biological disturbance' pressure (row 1) over ecosystem element 'birds' (column 5) is mostly reported as being negative (Fig. 5; red-coloured bars). There is also a high degree of scientific consensus. Conversely, impact magnitude is more evenly distributed among classes (Fig. 5; row 1, column 5, green-coloured bars) and, therefore, certainty is lower. Note that the number of analyses found in literature plays an important role in certainty interpretation (e.g., when only one paper describes the impact and magnitude of a pressure type on an ecosystem element, interpretation must be cautious).

The information is classified according to impact type (a) and magnitude of the impact (b). ESFP ecosystem structure, functions, and processes.

The intersection between a pressure type (rows) and an ecosystem element (column) shows the relative frequencies of each impact type (red), and magnitude (green). ESFP ecosystem structure, function, and processes, Neg negative, Pos positive, PN positive and negative, NS not significant, NK unknown, H high, M medium, L low, N negligible.

The relatively high degree of agreement regarding impact type (e.g., positive, negative) of wind devices on ecosystem elements is noteworthy. By contrast, certainty regarding impact magnitude is relatively low, especially for marine mammals and ecosystem structure, functions, and processes. This highlights the lack of empirical evidence needed to assess impact magnitude and, hence, the full ecological risks associated with OWFs.

For all ecosystem components together, high-moderate negative impacts accounted for 45% of the findings, 32% of which referred to effects on birds. Negative impacts are associated with changes in bird abundance due to collision mortality and displacement, changes in distribution patterns, and alteration of behavior to avoid OWFs (**Kelsey *et al*., 2018**). Species differed greatly in their sensitivity to pressures, with different responses depending on their ecology (i.e., flight altitude, season, sex). In turn, only 1% of the findings reported high-moderate positive impacts on birds (e.g., attraction behavior toward OWFs by gulls or cormorants) (**Lloret, 2022**).

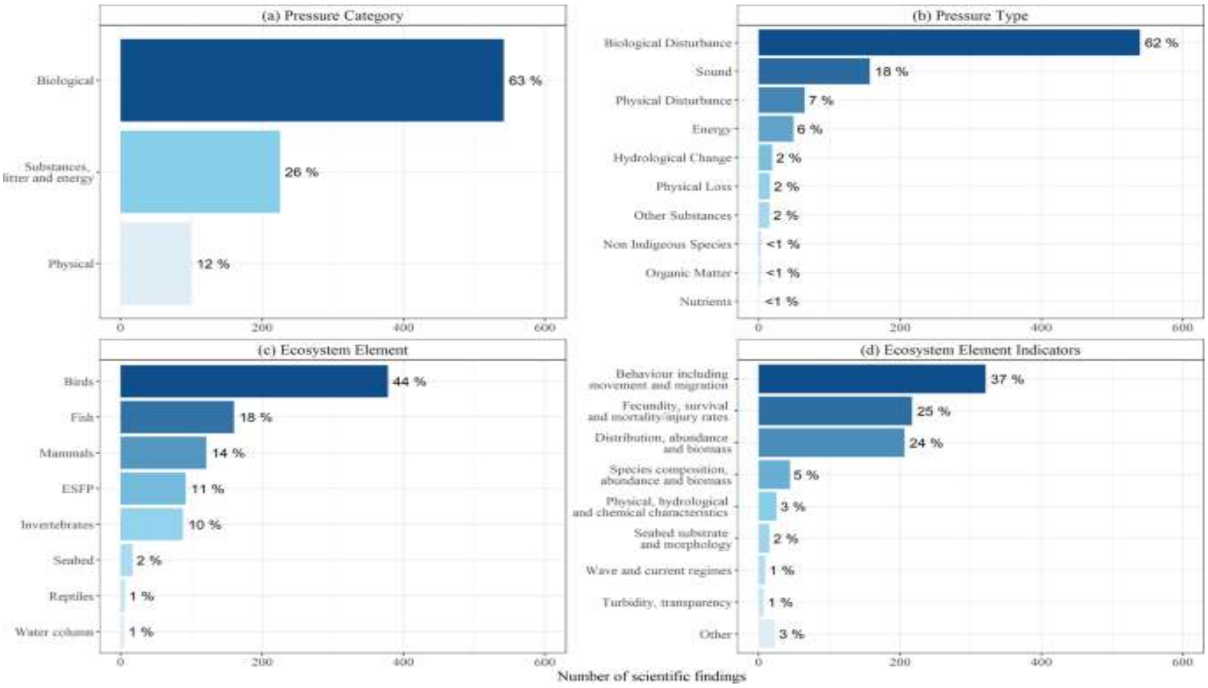

Fig. 3. Proportions of scientific findings of interactions between offshore wind energy devices and marine ecosystem extracted from the literature review

The information is classified according to studied pressure category (a) and type (b); and for ecosystem elements (c) and indicators assessed (d) in scientific research. ESFP ecosystem structure, functions, and processes.

Source: Galparsoro *et al.* (2022)

Table 2. Interactions between pressures from offshore wind devices and ecosystem elements, including species, habitats and ecosystem structure, functions and processes

Indicators for:	**Ecosystem elements**				
Species	**Birds**	**Fish**	**Mammals**	**Invertebrate**	**Reptiles**
Number of findings	378	160	121	88	6
Number of species	111	49	11	39	Not specified
Distribution, abundance and/or biomass	49 (13%)	73 (46%)	28 (23%)	56 (64%)	
Behavior (including movement and migration	175 (46%)	54 (34%)	77 (64%)	12 (14%)	3 (50%)
Fecundity, survival, and mortality/injury rates	154 (41%)	31 (19%)	15 (12%)	14 (16%)	3 (50%)
Species composition, abundance and/or biomass (spatial and temporal variation)		2 (1%)	1 (0.8%)	6 (7%)	
Population growth			<1%		
Habitats, ecosystem structure, functions and processes					
Number of findings					114
Species composition, abundance and/ or biomass					36 (32%)
Physical, hydrological and chemical characteristics					25 (22%)
Seabed substrate and morphology					15 (13%)
Wave and current regimes					9 (8%)
Turbidity and transparency					7 (6%)
Habitat distribution and extent					4 (4%)
Habitat for the species					4 (4%)
Other indicators					14 (12%)

Source: Galparsoro *et al.* (2022)

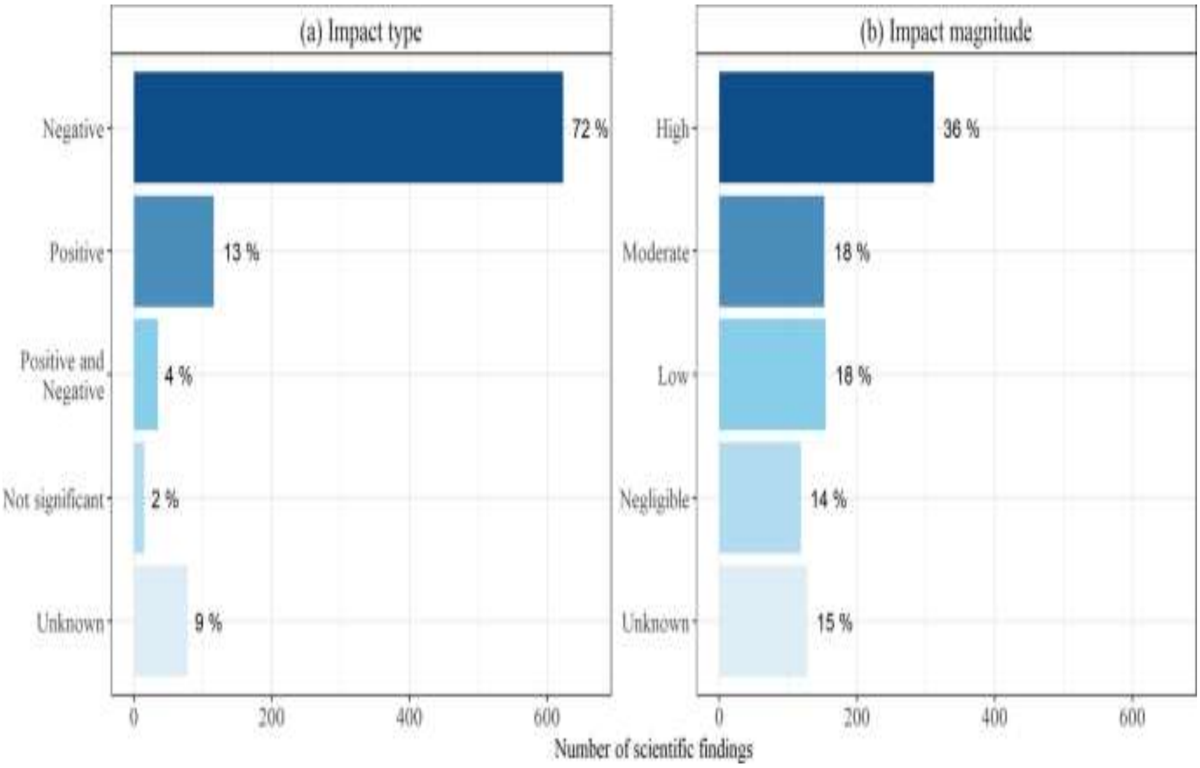

Fig. 4. Proportion of scientific findings about the impacts of wind energy devices on marine ecosystems

<u>**Source**</u>**: Galparsoro *et al*. (2022).**

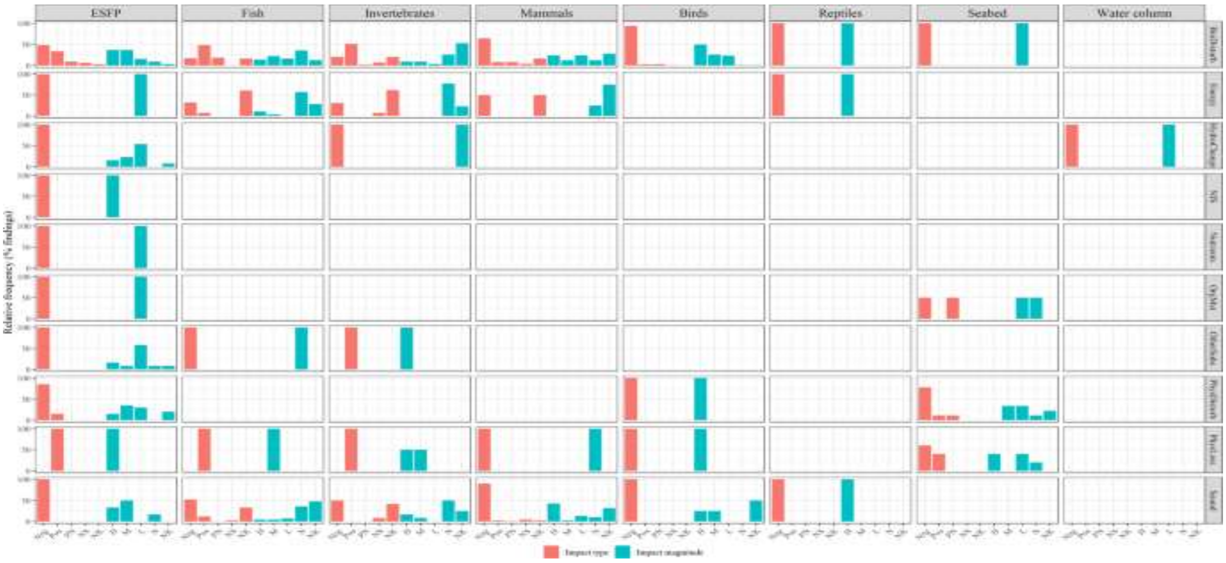

Fig. 5. Impact type and magnitude of wind energy devices for each pressure over each ecosystem element based on information extracted from the systematic literature review

<u>**Source**</u>**: Galparsoro *et al*. (2022)**

As for marine mammals, up to 7% of the findings referred to negative impacts, depending on the OWF development phase. Pile driving can have a significant impact on mammal's abundance and distribution (e.g., avoidance behavior with porpoises temporarily leaving the construction area). By contrast, 0.5% of the findings reported positive effects. It has been reported that the abundance of harbor porpoises increased after construction ended, with animals using the OWFs more frequently than reference areas. This is potentially related to food availability due to reduced fishing, artificial reef effects, and the absence of vessels.

In what regards fish, over 2% of the findings reported high-moderate negative impacts. The magnitude of such impacts depends on the affected species and its level of vulnerability/ sensitivity, with potentially more severe effects for elasmobranchs. The same percentage of findings reported high-moderate positive impacts related to shelter (against currents and predators) and food availability, stimulating aggregation behaviour (**Graham, 2019**). OWFs may act as fish aggregation devices, with spill-over effects. Fish species from rocky environments were more abundant close to OWFs than those from sedimentary environments.

Future Recommendations

First, we need to consider a more detailed classification of factors that can be negative externalities of wind turbines. In this study, we focused on landscape and noise as externalities; however, there are other possible problems such as flicker and shadows depending on the time of day. In addition, the shape and appearance of wind turbines could also be considered for analysis. To sum up, in order to examine people's acceptance of wind turbines, these types of externalities of wind turbines should be included in the estimation models.

Second, additional health hazards caused by the externalities of wind turbines can be investigated. For example, there are many studies on wind turbine noise and health hazards, but the relationship between acceptable levels of noise and health hazards is uncertain. We believe that an analysis of health hazards is important to improve the cost–benefit analysis of wind turbines.

Third, we could analyze possible changes in preferences over time. This would require an analysis using panel data such as the one used by **Krekel and Zerrahn (2017)**. With cross-sectional data, we cannot analyze effects that change over time. Therefore, we believe that it is very important to investigate how the negative externalities of wind turbines that decrease over time change over a longer period of time.

Fourth, an analysis of wind turbines as a tourism resource is desirable. In order to comprehensively consider sustainable local economic development, it is important to discuss wind turbines not only as a region-specific energy resource, but also as a tourism resource. In order to do so, we need to analyze wind turbines not in terms of negative externalities that destroy the existing natural landscape, but as entities that complement the landscape and make it more valuable.

Fifth, we are considering the use of cross terms. Initially, we analyzed the combined effect of distance to and view of wind turbines to conduct a more detailed analysis of the influence of landscape on well-being. By using the cross term between distance and view, we expected to test whether people who can see wind turbines from a certain distance and those who cannot have different levels of happiness. However, as mentioned in the research limitations, we were not able to do a detailed analysis due to the small sample size. For a future study, we could analyze the distance at which the view of wind turbines affects the level of well-being by using a larger sample.

Sixth, factors other than wind turbines near houses could be further investigated. From the questionnaire survey, we found that there are environmental factors that may affect people more than wind turbines. However, we were not able to use them for the ordered probit analysis in this study. We could analyze the effects of wind turbines more precisely by controlling the effects of other buildings and noise around houses.

Seventh, it is important to analyze attachment to the land and well-being. In the present study, our analysis showed that the number of years of residence increased the level of well-being. The length of residence may indicate attachment to the land. Residents who are attached to the land where wind turbines exist may have a higher level of well-being due to the view of the turbines. On the other hand, residents who are attached to the landscape before the construction of wind turbines may have a lower level of well-being due to the turbines. We need to conduct an analysis that takes into account the landscape of wind turbines, the level of well-being, and attachment to the region at the same time.

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دراسة مرجعية عن اثار استخدام طاقة الرياح البحرية على النظام البيئى فى اليابان

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بناءً على الدراسات السابقة، تعتبر طاقة الرياح البحرية على نطاق واسع واحدة من أكثر المصادر مصداقية لزيادة إنتاج الطاقة المتجددة نحو إمدادات طاقة مرنة وخالية من الكربون. ومع ذلك، فإن التوقعات الحالية للتوسع في إنتاج الطاقة من الرياح البحرية قد تؤدي إلى تأثيرات بيئية كبيرة. تقييم المخاطر البيئية على النظم البيئية البحرية من إنتاج الكهرباء من الرياح هو في الوقت المناسب وحيوي. وسيدعم اعتماد تدابير الإدارة التي تقلل من الآثار والاستدامة البيئية لقطاع طاقة الرياح البحرية. في هذه الدراسة، حللت مراجعة الدراسات السابقة التأثيرات الخارجية لتوربينات الرياح، والتي غالبًا ما تعتبر ضارة لتعزيز توليد طاقة الرياح. يعد فهم هذه العوامل الخارجية أمرًا ضروريًا للتوصل إلى إجماع مع السكان الذين يعيشون بالقرب من موقع توربينات الرياح المخطط لها. كان هدفنا البحثي هو تحديد العلاقة بين توربينات الرياح ورفاهية الناس في المناطق التي تم تركيبها فيها لفترة طويلة. لقد افترضوا أن توربينات الرياح سيكون لها تأثير سلبي على رفاهية الناس. أجرى أيضًا مسحًا بالبريد العادي في مدينة تشوشي بمحافظة تشيبا، اليابان، لفحص الآثار الخارجية لتوربينات الرياح ، واعتماد مؤشر رفاهية شخصي لقياس رفاهية المستجيبين. يشير تحليل الانحدار إلى أن الحصول على رؤية لتوربينات طاقة الرياح له تأثير إيجابي على الرفاهية الذاتية للسكان المحليين. علاوة على ذلك، تشير النتائج إلى أن هذه الرفاهية تزداد مع زيادة المسافة من التوربينات. باستثناء العناصر ذات المناظر الخلابة، ووجد أن توربينات الرياح لا تعتبر دائمًا مرغوبة من قبل السكان. لذلك، من المهم زيادة توضيح التأثير الخارجي لتوربينات الرياح والمرافق الأخرى في المجتمعات المحلية.

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