

A room with a blue view: The impact of Blue Economy activities on housing prices across Scottish regions

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ABSTRACT

This study examines the indirect impacts of sustainable transitions on coastal communities by analysing the relationship between the visibility of Blue Economy activity and house prices using four Scottish regions as a case example. The research employs hedonic price modelling and spatial econometrics to assess how the visibility of various Blue Economy activities, such as conservation, fossil fuel extraction, ports and aquaculture, has influenced residential property prices from 2012 to 2019. Utilising a unique database of property listings and geographic data, the analysis considers three distance bands to determine the extent to which ocean views containing different marine activities affect housing values. The findings reveal that oil and gas sites negatively impact housing prices across all distance bands and property price quartiles, consistent with existing literature on land-based oil and gas extraction. Conservation activities like Marine Protected Areas (MPAs) only affect prices positively at larger distances when spatial autocorrelation is accounted for, indicating a nuanced relationship between environmental conservation and property values. The study also highlights the complex interactions between aquaculture and housing prices, with positive effects noted at closer distances. Moreover, the analysis shows that port facilities positively influence housing prices, suggesting that accessibility to job opportunities and public services provided by ports is a valued amenity in rural, tourist-oriented regions. This study's methodological innovations contribute to a deeper understanding of the spatial effects of Blue Economy activities on housing prices, providing valuable insights for marine spatial planning and regional economic strategies in coastal areas across the world.

1. Introduction

The Blue Economy, and its twin concept, Blue Growth, was introduced by the European Union (EU) in 2012 as a means of promoting sustainable economic development in the marine and maritime sectors (Graziano et al., 2022). Blue Growth recognises that the oceans and seas have the potential to support sustainable economic growth and job creation in a wide range of industries such as fisheries, aquaculture, shipping, marine tourism, and offshore energy. The concept also acknowledges the importance of protecting and preserving marine ecosystems and biodiversity as a precondition for long-term economic

benefits.

Marine industries are a crucial component of the global economy. In 2021, the global fish trade was valued at approximately \$164 billion, with seafood products being one of the most traded commodities in the world (Sharma and Nikolik, 2022). Shipping is another critical marine industry, with over 90% of global trade being transported by sea (OECD, undated). According to the Food and Agriculture Organization (FAO), global aquaculture production has increased from 11.4 million tonnes in 1990 to 82.1 million tonnes in 2018 (FAO, 2020). Indeed, marine aquaculture accounts for approximately 25% of the total global aquaculture production (ibid). As of 2021, global marine energy capacity

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amounted to 524 MW (Fernández, 2022) and The International Renewable Energy Agency (IRENA) estimates that around 10 GW could be commercially deployed by 2030 (enough to power 8.34 million homes; IEA, 2018). These industries are all important components of Blue Growth and have significant economic and social value.

Yet Blue Growth also has impacts on the coastal communities in which the associated maritime industries operate, impacts which are complex and varied. There is some evidence to suggest that pollution caused by (for example) shipping and offshore oil and gas activities can damage the environment and affect the health of coastal communities (Andrews et al., 2021). Furthermore, it has been noted that the expansion of coastal infrastructure to support marine industry can lead to habitat loss, coastal erosion, and displacement of communities (Powell et al., 2019). However, there is much that we do not yet know. For example, what impacts might Blue Growth have on coastal tourism? While it may provide infrastructure and services that attract tourists, any negative impacts on the marine environment may harm tourism activities and destinations. Moreover, whilst marine industries might increase house prices in coastal communities by providing employment opportunities, attracting businesses, and creating amenities that make these areas more attractive to potential residents, offshore installations (aquaculture, wind turbines etc.) may impact the view and aesthetic of coastal communities, which can reduce the appeal of these areas for potential homebuyers.

Amenities (such as access to parks and waterfronts or shopping centres and cultural institutions) have long been believed to increase the value of property. Not a new area of research focus, a substantive body of work exists which explores the effects of amenity and disamenity on property prices. Indeed, several reviews and meta-analyses of existing studies have been undertaken (e.g. Sims et al., 2008; Schaeffer and Dissart, 2018; Chen et al., 2019).

It is argued that open spaces such as parks, urban forests and nature reserves can provide health and social benefits improving quality of life, mental and physical wellbeing, and social cohesion and that these open spaces are associated with higher house prices (e.g. Aliyu et al., 2016; Crompton and Nicholls, 2020; Turner and Seo, 2021). In particular, views of such green spaces can increase house prices (Jim and Chen, 2009), although views which include different land cover types (view richness) may reduce sale prices (Sander and Polasky, 2009). Proximity to green space has also been proposed to lead to a premium on property value (Song and Knaap, 2004; Gibbons et al., 2014; McCord et al., 2024). Similar findings have been uncovered for blue spaces, those visible water bodies or watercourses, such as rivers, lakes, canals and the sea (Peng et al., 2023; McCord et al., 2024).

Conversely, disamenities such as industrial sites can have a negative impact on house prices. Again, proximity is one factor which has been much explored, particularly in relation to hazardous or polluting industries (e.g. De Vor and De Groot, 2011; Grislain-Letremy and Katossky, 2014; Tsai, 2022) and it has been shown that the further a property is from an industrial site (up until a certain distance), the higher the house price (De Vor and De Groot, 2011). This has been shown, however, to vary within areas (Grislain-Letremy and Katossky, 2014), suggesting that local context and even personal perception may play a role. Interestingly, when such sites are redeveloped as industrial heritage, positive external effects on houses are present (Duijn et al., 2016). Even non-polluting or hazardous industrial development has been shown to affect house prices. For example, much work has focused on the impact of wind farms on house prices (e.g. Sims et al., 2008; Dröes and Koster, 2016; Skenteris et al., 2019). Recent research has started to consider the effects of conservation and development in marine and coastal spaces (e.g. Jim and Chen, 2009; Evans et al., 2017; Spanou et al., 2020; Dong and Lang, 2022), although there has been, to date, far less focus on these areas – particularly those that are less developed and more rural.

These complex and varied effects of conservation and development on coastal communities have implications for Marine Spatial Planning processes (MSP). MSP is a tool used to manage and regulate the use of

marine space. It is a process that aims to balance the competing demands of various marine activities (Ehler and Douvere, 2009). MSP is an essential tool for promoting sustainable Blue Growth, as it enables the identification and exploitation of opportunities in the marine sector while minimising negative impacts on marine and coastal environments. At present, MSP is most widely adopted in Europe, where it is mandatory under the EU's Marine Spatial Planning Directive. Many European countries have developed and implemented MSP frameworks, and several transboundary MSP initiatives have been launched, promoting cooperation among neighbouring countries. In other parts of the world, MSP is gaining traction, but progress has been slower. For example, in the United States, MSP is still in its early stages, with several regional initiatives underway, but there is not yet a national MSP framework; the African Union has launched a program to support MSP initiatives on the continent but progress has been slow; and in Asia, MSP is gaining momentum, with countries such as China, Japan, and South Korea developing MSP frameworks. It is imperative that, with substantial policy initiatives relating to both Blue Growth and MSP, there is the necessary evidence base to support marine industry initiatives whilst also managing and regulating the space in which they operate and the negative impacts they may cause.

We currently lack a comprehensive understanding of how Blue Growth affects coastal communities: one potential impact of Blue Growth relates to coastal housing stock and amenity. Coastal amenities such as view, proximity to beach, and recreational values, have traditionally been attractive assets to real estate investors and developers, but marine industry development may pose a threat to these values. Revealed preferences, in the form of coastal housing values, can be used as a proxy indicator to explore this potential impact. This data could be fed into an MSP process to mitigate such an effect. As such, the aim of this study is to investigate the indirect impacts of Blue Growth on coastal communities by providing insights into the relationship between marine activity visibility and housing prices - in order to contribute to the knowledge base in this area as well as any potential policy implications, particularly for MSP.

2. Material and methods

In our analysis, we combine a GIS approach with (spatial) econometrics for estimating the effects of Blue Economy activities on housing prices. The following section briefly introduces the study area and then explains each of the approaches.

2.1. Geographical scope

Scotland is one country with an explicit strategy for the Blue Economy. The Scottish Government's (2022) 'A Blue Economy Vision for Scotland' sets out the government's ambition to 2045 to ensure shared stewardship of the marine environment in a way that supports ecosystem health, improved livelihoods, economic prosperity, social inclusion and wellbeing. The publication makes clear why the Blue Economy is important to Scotland, citing the 18,734 km of coastline, the 75,500 jobs in the marine economy, a marine area that is seven times greater than the land area, and also the importance of marine sectors including seafood production and marine energy (Scottish Government, 2022). Moreover, coastal communities make up 41% of the total population of Scotland (The James Hutton Institute, 2022). For these reasons, we chose to use Scotland as a case study through which to assess the indirect impacts of blue growth on coastal communities, but it should be noted that many countries around the world have adopted/are adopting Blue Economy/Blue Growth strategies.

Within Scotland, we chose four sub-case study locations, each representing a Council Area: Argyll and Bute, Orkney, Shetland, and the Western Isles (Fig. 1). These are rural areas (where Blue Growth is most commonly focused) which are important for seafood production (commonly salmon [*Salmo salar*] and mussels [*Mytilus edulis*]), have

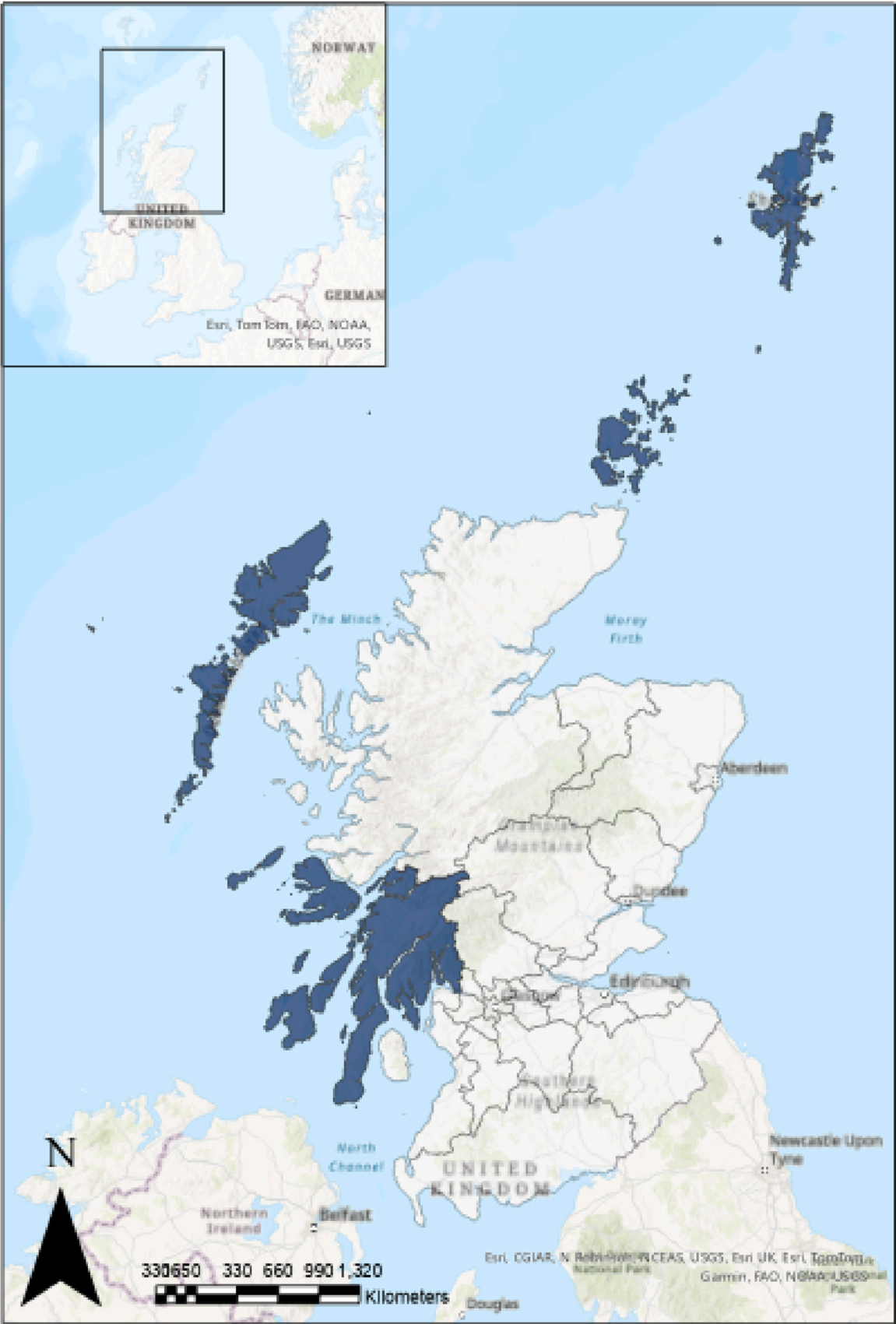


Fig. 1. Map showing case study locations (highlighted navy blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

been important for oil production (e.g. Flotta in Orkney and Sullem Voe in Shetland), and are areas which will see an increasing focus on offshore renewable energy production over the next decade (Graziano et al., 2017).

Argyll and Bute: The second largest of Scotland's administrative areas, Argyll and Bute is located on the mid-west coast of mainland Scotland. The population in 2023 was 87,810 over an area of 6907 km². The majority of the population are employed in service industries with a significant focus on tourism. Other business sectors include food and drink production (primarily aquaculture and distilleries), marine science, renewable energy, forestry and creative industries.

Orkney: An archipelago located 10 miles off the north coast of mainland Scotland, Orkney has approximately 70 islands, 20 of which are inhabited with a population of around 22,000 in 2023. The key sectors in Orkney include agriculture, fishing, aquaculture, tourism and renewable energy.

Shetland: An archipelago lying between Orkney, the Faroe Islands and Norway, Shetland is the northernmost region of the United Kingdom (170 km from the Scottish mainland). The population is only slightly larger than that of Orkney at 22,920 in 2023. Key economic sectors include fishing and aquaculture (considered the cornerstone of Shetland's economy), oil and gas operations and tourism.

Western Isles: Also known as the Outer Hebrides, this archipelago consists of 15 inhabited islands (and more than 50 uninhabited islands), comprising an area of 3056 km², off the west coast of Scotland. A population of approximately 27,000 are employed across sectors such as tourism, fishing and aquaculture, crofting and the production of Harris Tweed. The area also has a growing potential for renewable energy.

2.2. Data description

The unique database, comprised of a combination of two datasets (described below) used for the analysis is among our contribution to the debate regarding the indirect effects of the blue economy. The first dataset, provided by Zoopla¹ is of properties for sale and to rent in Scotland advertised between 2012 and 2019. The second dataset is for the portion of water encompassed in the viewshed of any property and its use. The latter database has been entirely created by the authors using geographical data matched with the information about the properties. Below is a detailed description of the process.

2.2.1. Real estate data

Data about houses, i.e., their listed sale prices, rent and structural characteristics, come from the advertisements that Zoopla managed during the chosen period. The database included detailed information about the type and characteristics of the properties, such as the number of bedrooms, bathrooms, and receptions, as well as their geographic location and price.

To ensure a clean and robust database, we pre-processed the data to address issues such as multi-purchases of the same property, property let rather than sold and geographical distribution of the data points. Starting from the multi-purchase of the properties, we realised that some properties have been advertised and sold more than once during 2012–2019. For those properties, we consider only the most recent entry because our model results are not dissimilar when we use previous sale prices, and the choice of the most recent entry increases the comparability of monetary values. With respect to the dichotomy of properties for rent versus properties for sale, our database had information about both, but not significant enough to allow a meaningful and robust analysis for both, i.e., rented properties represent only 8% of our sample and its numerosity didn't match the viability conditions for an unbiased regression analysis. Therefore, we decided to leave the properties for

rent to further research and focus solely on sales. This choice was supported by the different nature of the decision-making problem as the drivers for renting and buying a house are completely different. In this study we wanted to focus on the former, given its importance for the mortgage and financial sector.

After the excluding the properties for rent and cleaning the database we ended up with 5070 observations overall,² spread across four counties in Scotland: Argyll & Bute (4474 properties, i.e., 88% of the sample), Orkney (225, 4.44%), Shetland (13, 0.26%), and Western Isles (358, 7.06%). Further details about data distribution and variable names can be found in Appendix A.

The second set of data comprises information about the viewshed. We matched each property with the portion of waterfront in square kilometres that can be seen from it (see the following section for more details). With respect to the water use, originally, we had thirteen categories of different water uses that we grouped into the following five.

- i. Landscape: world heritage site.
- ii. Farming: area with aqua farming.
- iii. Oil and gas: area with oil or gas related infrastructures (e.g., platforms, buoys, surface free span, etc.)
- iv. Conservation: Ramsar sites, Sites of Special Scientific Interest, Special Protection Areas, Special areas of Conservation Marine Protected Areas, Wetlands of International Importance.
- v. Coastal use: area with harbours and coastal light.

Conservation of coastal cultural and natural ecosystem services in addition to oil and gas infrastructure play a fundamental role in both Scottish society and its economy. The health of cultural ecosystem services is deeply engrained in the fabric of several communities across the area of study (Bryce et al., 2016; Stanik et al., 2018), and it is vital for the tourist industry. Similarly, the provision of ecosystem services is pivotal for Blue Economy industries like aquaculture (Brooker et al., 2018) and tourism (Spanou et al., 2020). The oil and gas sector continues to play a pivotal role in the Scottish economy, contributing between 6% and 12% of the regional GDP (2020 Marcus and McGeoch) and about 10% of the government's budget (The Scottish Government, 2023), and a central one in regions such as Shetlands and Orkneys, where revenues and the devolutionary policies developed from the infrastructure associated with these industries have provided the basis for developing Blue Economy sectors (Graziano et al., 2017).

Our data are calculated for a radius of one, five and 15 km from the single property and the analysis is performed accordingly. Table 1 shows the summary statistics of the main variables used for the analysis, while Fig. 2 shows the distribution of the log-prices of properties.

2.2.2. Viewshed analysis

To determine the area (in square kilometres) of sea view for each property a viewshed analysis was performed for each of the properties in the dataset. A viewshed is a geographical area that is visible from a particular location (O'Higgins et al., 2018). Viewshed analysis uses the elevation value of each cell of a digital elevation model to determine visibility to or from another cell. Longitude and latitude for each of the properties in the Zoopla property dataset were obtained from Google maps using an automated R (language for statistical computing) Script. Elevation data from the EU-DEM (Digital Elevation Model) was obtained from the European Environment Agency.³ The data have a 1 arc second (approximately 30m) resolution. Further spatial datasets on the extent

¹ Zoopla Limited. Economic and Social Research Council. Zoopla Property Data, 2019 [data collection]. University of Glasgow - Urban Big Data Centre -

² Any difference in the number of observations reported in the tables of our empirical analysis is due to missing values for the variable property type (347 missing data points) and for the variable "View of marine conservation areas" beyond 15 Km (50 missing data points).

³ See <http://www.eea.europa.eu/data-and-maps/data/eu-dem> for the dataset and its metadata.

Table 1
Properties distribution by County.

Variable	Obs	Mean	Std. dev.	Min	Max
Price	5069	162,101.4	128,882.20	10,000	5,500,000
Bedrooms (#)	5070	2.903	1.236	0	12
Floor (#)	5070	0.242	0.629	0	4
Bathrooms (#)	5070	0.677	0.952	0	10
Receptions (#)	5070	0.497	0.815	0	6
View of World Heritage Site 1 km (sqkm)	5070	0.013	0.133	0.000	2.724
View of aquaculture sites 1 km (sqkm)	5070	0.001	0.005	0.000	0.085
View of oil and gas sites 1 km (sqkm)	5070	0.002	0.039	0.000	1.277
View of marine conservation areas 1 km (sqkm)	5070	1.288	0.587	0.061	6.796
View of harbours and other facilities 1 Km (sqkm)	5070	0.449	0.497	0.000	2.899
View of World Heritage Site 5 km (sqkm)	5070	0.153	1.464	0.000	26.314
View of aquaculture sites 5 km (sqkm)	5070	0.008	0.016	0.000	0.162
View of oil and gas sites 5 km (sqkm)	5070	0.011	0.212	0.000	5.107
View of marine conservation areas 5 km (sqkm)	5069	20.046	11.692	0.038	96.741
View of harbours and other facilities 5 Km (sqkm)	5070	9.566	8.653	0.000	34.103
View of World Heritage Site 15 km (sqkm)	5070	0.344	2.727	0.000	76.063
View of aquaculture sites 15 km (sqkm)	5070	0.012	0.022	0.000	0.275
View of oil and gas sites 15 km (sqkm)	5070	0.019	0.341	0.000	7.307
View of marine conservation areas 15 km (sqkm)	5020	38.080	36.553	0.000	493.166
View of harbours and other facilities 15 Km (sqkm)	5070	13.541	16.824	0.000	132.908

Source: Zoopla

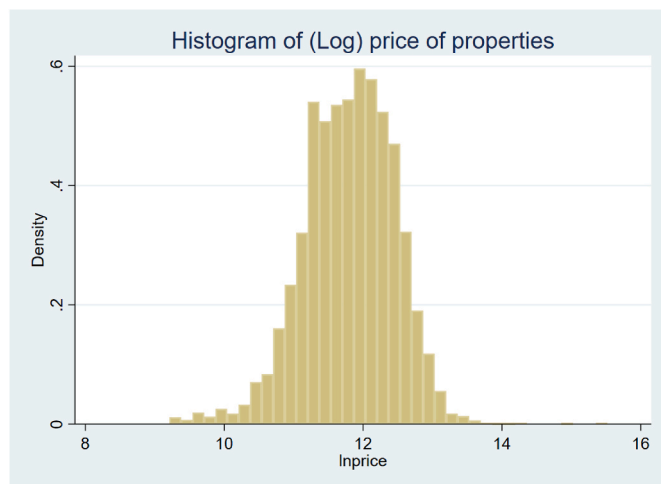


Fig. 2. – Distribution of the (Log)price of properties. Source: Authors' elaboration on data provided by Zoopla.

and location of world heritage sites, aquaculture operations, oil and gas infrastructure, marine conservation areas, and harbours were overlayed on the viewshed data to calculate the area covered by each of these classes of activity, in the viewshed of each property. For each property, the distance from the sea was also recorded. The tabulated results of the spatial analysis were combined with the sale characteristics for each property for the econometric analysis. This approach follows that used by O'Higgins et al. (2018), which allowed for viewshed areas to be paired with real estate transactions and Blue Economy target features (in their case, MSP areas). Subsequently, for each property, we then binned the number of observed features incrementally at 1, 5, and 15 km. The first distance records the highest level of proximity, the second (5 km), approximates the farthest distance a person could see without visual supports, while the third one (15 km) represent the farthest value in our viewshed analysis.

3. Theory and calculation

Our empirical strategy can be partitioned into two steps. First, we adopt a standard hedonic model (see, among the others, Ball, 1973; Grether and Mieszkowski, 1974) with the following specification:

$$Y_n = \beta_0 + \beta_n X_n + u_n \quad (\text{Eq 1})$$

Where Y_n represents the $n \times 1$ vector of observations for the log prices of properties, X_n is the $n \times k$ matrix of exogenous controls and u_n the $n \times 1$ vector of disturbance terms. The regressors are divided into three categories: (i) physical characteristics of the property,⁴ (ii) macroeconomic controls, and (iii) water uses, i.e., the amount of water sight devoted to each different use (see Appendix A for further details). The choice of the physical characteristics of the properties and of the water use has been driven by the data available, whereas the choice of the macroeconomic controls rely on the link between house price dynamics and the business cycle already proven by the standard academic literature (see, among the others, Ahnert and Kenny, 2004). Following the conventional framework for clustering (see, among the others, Cameron and Miller, 2015; MacKinnon et al., 2023; Abadie et al., 2023) and to account for the intra-county heterogeneity in socio-economic conditions, we clustered standard errors at a county level. The set of water-related variables represents one of our contributions to the literature: *it reports how much (in terms of square kilometres) water view is available to each real estate unit and is devoted to the different types of uses (see Section 2 for further details).* Standard errors are clustered at a county level.

To assess the effects throughout the overall market structure, we performed a quantile regression focusing on the upper and lower hand of the properties' price distribution, following the work of Osland and Thorsen, 2008,.

As a second step we performed a Moran's I test to check for spatial autocorrelation, an issue often found when analysing effects on housing prices (see e.g. Basu and Thibodeau, 1998; Zhang et al., 2021). The test performed on different distances yielded a Chi-squared value of 4.54, 3.60 and 4.30 respectively relative to a distance of 1, 5 and 15 km. It provided evidence for spatial autocorrelation in the error terms, therefore suggesting the need to account for the spatial dimension of the data to obtain an unbiased and efficient estimate. Building on the standard hedonic specification, we then estimated a Spatial Autoregressive model (see, for instance, Anselin, 1988; ,) with the following specification:

$$Y_n = \beta_n X_n + \lambda_n W_n Y_n + u_n \quad (\text{Eq 2})$$

$$= Z_n \delta_n + u_n$$

With $Z_n = [X_n, \lambda_n W_n]$, $\delta_n = [\beta_n, \lambda_n]'$ and

⁴ All the characteristics of the property available in the database have been included.

$$u_n = \rho_n M_n u_n + \varepsilon_n \quad (\text{Eq 3})$$

Here, as well as in the previous specification, Y_n is the $n \times 1$ vector of observations for the log prices of properties, X_n is the $n \times k$ matrix of exogenous controls and u_n is the $n \times 1$ vector of disturbances. In addition, W_n and M_n are $n \times n$ matrices of spatial weights based on inverse distance between observations, λ_n and ρ_n are unknown parameters and ε_n is the innovation term. In this way, we can account for spatial dependence where $\bar{Y} = W_n Y_n$ and $\bar{u} = M_n u_n$ are the spatial lags respectively of Y_n and u_n .

4. Results

We address the first step of our analysis estimating the hedonic model in Equation (1) with a standard OLS technique after testing for the classical assumptions and clustering standard errors at a county level.

Table 2 displays the results articulated into three columns according to the sea view distance available to any single property. Column one shows the result of regressing the log price of a property on its structural characteristics and the sea view (and its use) available in a radius of 1 km. Columns two and three report the results of a similar analysis where log prices of properties are regressed on their structural characteristics with the only difference that respectively, the radius considered for the sea view (and its use) is 5 km for column two and 15 km for column three.

As shown in Table 2, our model results conform to the hedonic price literature, as we find that the log price of residential properties in Scotland is positively affected by the number of bedrooms and receptions, and is negatively impacted by the number of floors – as walking stairs is perceived as an annoyance – and by the property type (i. e., Barns, bungalows and cottages, Houses, Country houses, Flats, and Hotels and commercial properties). The coefficient estimates for the number of bathrooms are positive, as expected, but not statistically significant.

When we zoom in on the marine coastal variables, the view of the waterfront plays a statistically significant role, especially when it is devoted to two specific activities: when the marine area hosts oil and gas infrastructures and in the presence of marine conservation areas. This result is particularly interesting, as it is consistent through all the model specifications, considering the three distances we analysed, though with differences. The first difference is in the weaker significance for longer distances. As expected, different uses of the waterfront in a radius of 15 km still play a role in driving the price of properties, but not with the same statistical relevance, nor with the same magnitude. This is particularly true for the use of oil and gas infrastructures. According to our analysis, marine protected areas exert a negative influence on log prices of properties in the short reach (i.e., 1 km), but this is reverted into a positive one when longer distance of 5 km is considered. Our interpretation of the result is that, as expected, the presence of a marine protected area in the view shed of a property affects positively the value of that property (the results we have at 5 km). When the protected areas are too near to the house, though, its positive influence on the landscape is taken over by the negative one due to the limitation of its usability by those living in the area. When considering an even longer distance of 15 km, the effect fades completely away becoming statistically insignificant.

A deeper look at the estimated coefficient shows a non-negligible magnitude of the effects related to the statistically significant coefficients. According to our empirical analysis (Table 2) a unit increase in the sea view of the use of water for oil and gas infrastructure implies an average decrease of the price of properties equal to roughly 65% in a 1 km radius, 18% in a radius of 5 km and 10% within 15 km. On the other hand, a unit increase in the marine conservation areas implies an average decrease in house prices equal to roughly 2% in a radius of 1 km. The effect is reversed in the medium range of 5 km, where for the same unit increase, the price of properties shows a weak gain below 1%. When

Table 2

Hedonic model assessing the effect of properties' characteristics on their log-prices. Among the properties characteristics we consider the waterfront available to each property and its specific use.

	Model 1 Km	Model 5 Km	Model 15 Km
Bedrooms (number)	0.2800*** (0.0157)	0.2783*** (0.0182)	0.2813*** (0.0149)
Floor (number)	−0.1090** (0.0133)	−0.0892** (0.0089)	−0.1048** (0.0149)
Bathrooms (number)	0.0167 (0.0077)	0.0266 (0.0104)	0.0126 (0.0092)
Receptions (number)	0.0533** (0.0081)	0.0530* (0.0091)	0.0561** (0.0079)
Property type	−0.1737** (0.0145)	−0.1736*** (0.0099)	−0.1660** (0.0155)
Real GDP	0.0000 (0.0000)	−0.0000 (0.0000)	0.0000 (0.0000)
Inflation	−0.0517* (0.0152)	−0.0383* (0.0116)	−0.0508* (0.0105)
Last year in the market	−0.0226* (0.0039)	−0.0213*** (0.0014)	−0.0229** (0.0022)
Absolute poverty index	−0.0000 (0.0000)	−0.0000 (0.0000)	−0.0000* (0.0000)
Total turnover of tour operators	0.0006*** (0.0000)	0.0005** (0.0001)	0.0005** (0.0000)
View of World Heritage Site 1 km (sqkm)	−0.0639 (0.0545)		
View of aquaculture sites 1 km (sqkm)	6.2645 (4.8154)		
View of oil and gas sites 1 km (sqkm)	−1.0592** (0.1603)		
View of marine conservation areas 1 km (sqkm)	−0.0257* (0.0050)		
View of harbours and other facilities 1 Km (sqkm)	0.0835 (0.0373)		
View of World Heritage Site 5 km (sqkm)		−0.0007 (0.0032)	
View of aquaculture sites 5 km (sqkm)		0.9998 (0.5569)	
View of oil and gas sites 5 km (sqkm)		−0.2007** (0.0167)	
View of marine conservation areas 5 km (sqkm)		0.0053* (0.0009)	
View of harbours and other facilities 5 Km (sqkm)		0.0030 (0.0040)	
View of World Heritage Site 15 km (sqkm)			0.0007 (0.0017)
View of aquaculture sites 15 km (sqkm)			−0.9781 (0.6829)
View of oil and gas sites 15 km (sqkm)			−0.1048** (0.0178)
View of marine conservation areas 15 km (sqkm)			0.0006 (0.0007)
View of harbours and other facilities 15 Km (sqkm)			0.0006 (0.0019)
Observations	4722	4721	4675
Adjusted R-squared	0.521	0.532	0.517

Note: result of an OLS estimation of the plain hedonic model linking the log-price of properties and their characteristics among which we list the area of water available in each property and its specific use. Standard Errors in parenthesis and significance levels set as follows: *p < 0.05, **p < 0.01, ***p < 0.001.

Source: Authors' elaboration on data provided by Zoopla

the radius of the observation reaches 15 km, there is no significant effect.

The strongest and most significant effect estimated must be reconducted to the presence of oil and gas infrastructure. To better understand it, we show below in Fig. 3 its marginal effect respectively at 1 Km (panel (a)), at 5 Km, (panel (b)) and at 15 Km (panel (c)):

As shown, the effect on the expected average price is negative for all the distances. To elaborate further on marginal effects, it is evident how not only has the short distance a stronger (negative) influence on property prices, but its estimate is also more precise according to the respective confidence intervals. Finally, Fig. 3 shows a different dynamic

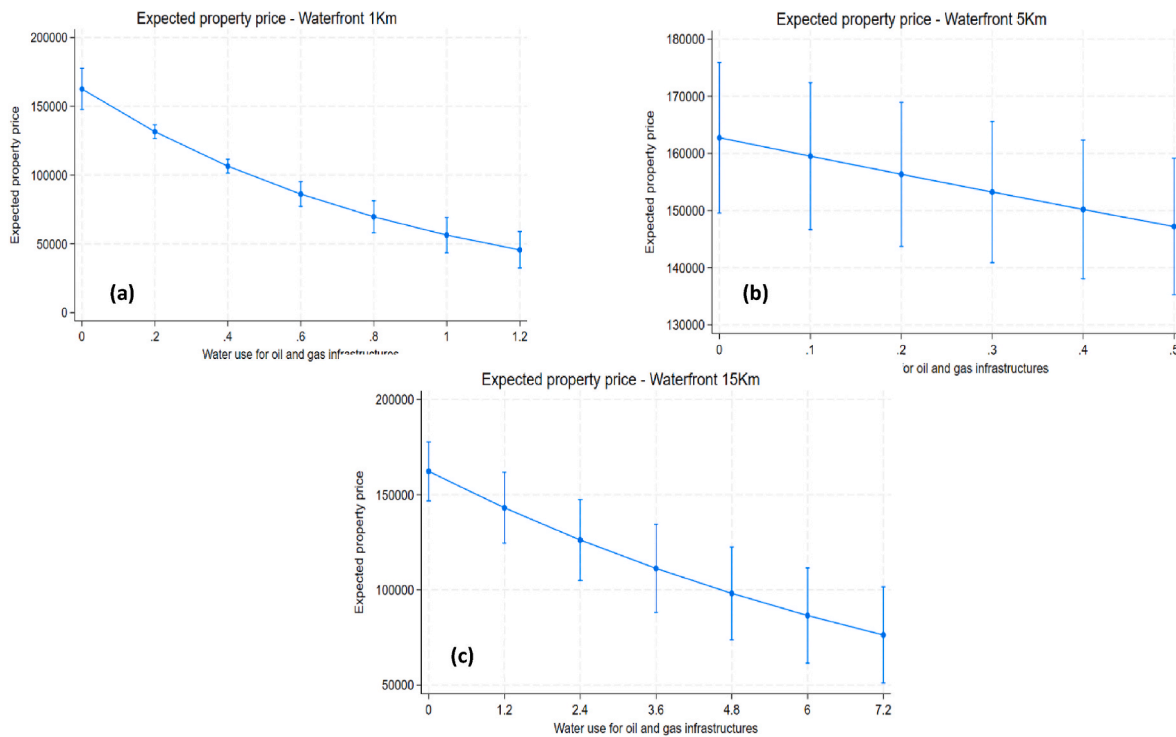


Fig. 3. – Distribution of the (Log)price of properties. Source: Authors' elaboration on data provided by Zoopla.

for the change in expected properties prices: the medium and long range are more linear and straightforward, whereas within 1 km the effect is nonlinear with a change in sign at around 1.20 square kilometres of oil and gas infrastructure in the viewshed at this distance.

It is common knowledge among practitioners and academic literature that different ends of real estate price distribution have different dynamics in their prices (see, for instance, [Farmer and Lipscomb, 2010](#)). Therefore, to get a better sense of the effect of water use on the whole market of properties, we perform the same analysis described above on the upper and lower quartile of the distribution of property prices. We estimated the following (Eq. (4))

$$Y_n = \beta_q X_n + e_n \quad (\text{Eq. 4})$$

where β_q is the vector of unknown parameters associated with the q th quantile.

The pairwise comparison looks extremely interesting and worth a comment. The picture shown by [Table 3](#) is more complex than the average effects from [Table 2](#). For the upper (75%) and lower (25%) end of the market the use of water is more important in determining the price of properties. For closer interactions (i.e., 1 km), the presence of aquaculture sites, a harbour and oil and gas infrastructures are all statistically significant drivers of the price dynamic. As expected, an increase in aquaculture and harbour uses implies an increase in the average price of houses which, conversely, drops when the presence of oil and gas infrastructure goes up. In general, the effects are weaker for the upper end of the market (upper quartile), and it is interesting to notice how oil and gas infrastructures are not even statistically significant drivers of the price. Conversely, for the upper end, the other characteristics of the properties not related to the use of water (e.g., number of bedrooms), exert a bigger influence on prices with respect to the lower quartile possibly stating a hierarchy of wants for the most expensive properties. [Table 3](#) shows the same trend for the medium range (i.e., 5 km) with two differences: marine conservation areas join the list of drivers for the house prices, though, with an extremely weak effect (roughly 0.3% for both the lower and upper end of the market which means, using quartile specific median house prices, an increase of respectively roughly £20

and £83 per additional square meter of the marine area in the viewshed). Moreover, the difference in the effect of each driver for the upper and lower quartile is smaller than that estimated for the short distance. As shown, the estimated values are in general close, but, interestingly, this is not the case for the presence of oil and infrastructure where still there is a not negligible difference between cheaper and more expensive properties. In our view, that result could be a clear signal about the user value of the two types of properties that can be identified in the direct enjoyment of the natural environment for the lower end and an indirect benefit from the overall experience for the upper end. As confirmation, for the long range (i.e., 15 km) the estimates show a general loss of significance, but the few that still persist are interesting to comment on. The negative influence of oil and gas infrastructure is significant for the lower end (i.e., an average decrease in prices equal to roughly £10,800 per additional square meter of oil and gas facilities in view), and it is not for the more expensive properties, again supporting our claim that direct enjoyment is more important for the former. Conversely, the presence of marine protected areas is statistically significant for the upper end and is not for the lower one and the same is true, *mutatis mutandis*, for the presence of harbour and aquaculture in the viewshed (see [Table 4](#)).

4.1. Hedonic model with a spatial autoregressive component

There is strong evidence in standard academic literature that house prices are affected by a strong autocorrelation (see, among the others, [Basu and Thibodeau, 1998](#)). Therefore, for the second step of our analysis, we estimate a hedonic model with a spatial autoregressive component as in Equation (2) and Equation (3).

Thanks to the spatial correction, now the picture gets more complex: some of the characteristics highlighted by the simple hedonic model persist, but others contribute to build up a more complete story for the house prices. As in the standard model, a unit increase in the view of oil and gas infrastructures is a statistically significant driver for a decrease in property prices at all the distances analysed. Considering spatial autocorrelation, though, the effect is smaller, i.e., a decrease in properties' price equal to roughly 43%, 12% and 8%, respectively for 1 km, 5

Table 3

Hedonic model assessing the effect of properties' characteristics on their log-prices, at the lowest and highest quartile of the price distribution for all the three distances considered.

	Model 1 Km (25p)	Model 1 Km (75p)	Model 5 Km (25p)	Model 5 Km (75p)	Model 15 Km (25p)	Model 15 Km (75p)
Bedrooms (number)	0.2846*** (0.0085)	0.3118*** (0.0065)	0.2823*** (0.0095)	0.3153*** (0.0070)	0.2813*** (0.0165)	0.3172*** (0.0063)
Floor (number)	−0.1106*** (0.0157)	−0.1212*** (0.0121)	−0.0810*** (0.0132)	−0.1094*** (0.0107)	−0.1121*** (0.0188)	−0.1229*** (0.0128)
Bathrooms (number)	0.0181 (0.0136)	0.0121 (0.0105)	0.0320 (0.0168)	0.0142 (0.0120)	0.0162 (0.0168)	0.0118 (0.0101)
Receptions (number)	0.0534*** (0.0151)	0.0607*** (0.0116)	0.0552* (0.0217)	0.0584*** (0.0096)	0.0662*** (0.0156)	0.0510*** (0.0101)
Property type	−0.1803*** (0.0092)	−0.1380*** (0.0071)	−0.1817*** (0.0090)	−0.1344*** (0.0065)	−0.1784*** (0.0109)	−0.1280*** (0.0054)
Real GDP	0.0000 (0.0000)	0.0000 (0.0000)	−0.0000 (0.0000)	0.0000 (0.0000)	−0.0000 (0.0000)	0.0000 (0.0000)
Inflation	−0.0271 (0.0373)	−0.0458 (0.0288)	−0.0105 (0.0441)	−0.0315 (0.0291)	−0.0431 (0.0333)	−0.0516* (0.0253)
Last year in the market	−0.0332 (0.0175)	−0.0289* (0.0135)	−0.0222 (0.0164)	−0.0186 (0.0167)	−0.0259* (0.0131)	−0.0209* (0.0106)
Absolute poverty index	−0.0000 (0.0000)	0.0000 (0.0000)	−0.0000* (0.0000)	0.0000 (0.0000)	−0.0000 (0.0000)	0.0000 (0.0000)
Total turnover of tour operators	0.0004 (0.0004)	0.0010** (0.0003)	0.0001 (0.0003)	0.0008* (0.0004)	0.0003 (0.0004)	0.0010*** (0.0003)
View of World Heritage Site 1 km (sqkm)	−0.0047 (0.0682)	−0.1160* (0.0527)				
View of aquaculture sites 1 km (sqkm)	6.9028*** (1.9510)	6.0984*** (1.5062)				
View of oil and gas sites 1 km (sqkm)	−1.5116*** (0.2405)	−0.1380 (0.1857)				
View of marine conservation areas 1 km (sqkm)	−0.0185 (0.0170)	−0.0077 (0.0131)				
View of harbours and other facilities 1 Km (sqkm)	0.1006*** (0.0207)	0.0613*** (0.0160)				
View of World Heritage Site 5 km (sqkm)			0.0020 (0.0038)	−0.0036 (0.0047)		
View of aquaculture sites 5 km (sqkm)			1.4429* (0.6036)	1.3503* (0.5785)		
View of oil and gas sites 5 km (sqkm)			−0.2929*** (0.0832)	−0.1826* (0.0740)		
View of marine conservation areas 5 km (sqkm)			0.0042*** (0.0006)	0.0043*** (0.0007)		
View of harbours and other facilities 5 Km (sqkm)			0.0080*** (0.0010)	0.0006 (0.0008)		
View of World Heritage Site 15 km (sqkm)					0.0030 (0.0025)	−0.0001 (0.0025)
View of aquaculture sites 15 km (sqkm)					−0.2003 (0.3875)	−0.9518* (0.3862)
View of oil and gas sites 15 km (sqkm)					−0.1741*** (0.0461)	−0.0546 (0.0388)
View of marine conservation areas 15 km (sqkm)					−0.0002 (0.0002)	0.0007*** (0.0002)
View of harbours and other facilities 15 Km (sqkm)					0.0022*** (0.0005)	−0.0008 (0.0005)
Observations	4722	4722	4721	4721	4675	4675

Note: result of an OLS estimation of the plain hedonic model linking the log-price of properties and their characteristics among which we list the area of water available in each property and its specific use. Standard Errors in parenthesis and significance levels set as follows: *p < 0.05, **p < 0.01, ***p < 0.001.

Source: Authors' elaboration on data provided by Zoopla

km, and 15 km. Similarly, the view of marine conservation areas drives up the price of properties in the medium, and this time also in the long range (5 km and 15 km), but not in the short range (1 km). Here, we register, instead, a strong significance, of the sight of harbours and other similar facilities implying roughly an 8% increase in properties price for each unit increase of this water use in the view shed.

In general, adjusting the standard model with spatial component allowed us to confirm the strong importance of oil and gas infrastructure driving up the price of properties and returns a more complex picture of the effects of different water uses. In this respect, we have been able to document also positive effects of specific activities linked to the blue economy that should be accounted for in the formulation of policies and planning and that will be discussed in the next section.

5. Discussion and conclusions

Economic activities associated with the Blue Economy span across multiple sectors. The objective of this study is to investigate and quantify how the span of Blue Economy activities affects housing prices across coastal, tourist-oriented, rural regions of Scotland. We employed hedonic price modelling to estimate how visibility of a several Blue Economy activities – spanning from conservation to fossil fuel extraction and transportation – affect residential housing prices in 2012–2019. We modelled this relationship by using three distance bands characterising the ocean view from the houses (at 1 km, 5 km, and 15 km). Furthermore, we expanded our investigation to ascertain whether these impacts were robust when accounting for spatial autocorrelation, and if and how they changed across property prices by using a quantile regression.

Table 4
Hedonic model with a spatial autoregressive component.

	Model 1 Km	Model 5 Km	Model 15 Km
Bedrooms (number)	0.2700*** (0.0079)	0.2690*** (0.0078)	0.2738*** (0.0080)
Floor (number)	-0.0953*** (0.0148)	-0.0815*** (0.0148)	-0.0985*** (0.0150)
Bathrooms (number)	0.0407** (0.0130)	0.0478*** (0.0132)	0.0407** (0.0136)
Receptions (number)	0.0387* (0.0156)	0.0431** (0.0154)	0.0460** (0.0159)
Property type	-0.1704*** (0.0089)	-0.1666*** (0.0088)	-0.1617*** (0.0088)
Real GDP	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)
Inflation	-0.0841* (0.0357)	-0.0779* (0.0351)	-0.0794* (0.0359)
Last year in the market	-0.0021 (0.0176)	0.0010 (0.0173)	-0.0068 (0.0177)
Absolute poverty index	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)
Total turnover of tour operators	0.0005 (0.0004)	0.0004 (0.0004)	0.0006 (0.0004)
View of World Heritage Site 1 km (sqkm)	-0.0653 (0.0589)		
View of aquaculture sites 1 km (sqkm)	4.1896* (1.7382)		
View of oil and gas sites 1 km (sqkm)	-0.4862* (0.2149)		
View of marine conservation areas 1 km (sqkm)	-0.0100 (0.0162)		
View of harbours and other facilities 1 Km (sqkm)	0.0928*** (0.0201)		
View of World Heritage Site 5 km (sqkm)		0.0008 (0.0048)	
View of aquaculture sites 5 km (sqkm)		0.8954 (0.5519)	
View of oil and gas sites 5 km (sqkm)		-0.1202* (0.0494)	
View of marine conservation areas 5 km (sqkm)		0.0062*** (0.0010)	
View of harbours and other facilities 5 Km (sqkm)		0.0036* (0.0015)	
View of World Heritage Site 15 km (sqkm)			0.0021 (0.0027)
View of aquaculture sites 15 km (sqkm)			-0.8846 (0.4724)
View of oil and gas sites 15 km (sqkm)			-0.0957** (0.0305)
View of marine conservation areas 15 km (sqkm)			0.0007* (0.0003)
View of harbours and other facilities 15 Km (sqkm)			0.0018** (0.0007)
Constant	20.3996 (32.4146)	13.9258 (31.9245)	28.8916 (32.6248)

Note: result of a two stage least square estimation of the plain hedonic model with spatial autocorrelation. Standard Errors in parenthesis and significance levels set as follows: *p < 0.05, **p < 0.01, ***p < 0.001.

Source: Authors' elaboration on data provided by Zoopla

Overall, we find that in the global results, across all distance bands and model specifications, oil and gas sites negatively affect housing prices. These results are consistent when focusing on the top and bottom price quartiles (i.e. highest/lowest 25%). This result is in line with existing literature assessing the effects of land-based oil and gas extraction (see e.g. Boxall et al., 2005; Bennett and Loomis, 2015). Additionally, and surprisingly, conservation-related activities such as Marine Protected Areas appear to affect prices only at larger distances from the ocean (>1 km) when correcting for spatial autoregression, with similar effects for both higher and lower priced houses. Importantly, this result expands our understanding from previous research within the same region conducted by Spanou et al. (2020) in two ways. Firstly, and thanks to the use of distance bands and viewshed, it offers us a better

understanding about the 'where' (i.e. at which distance) MPAs provide benefits to homeowners, signalling that the view of MPAs increase in importance only at further distance from them, explaining the mixed results the authors found in 2020, also correcting for spatial autocorrelation. Secondly, it highlights the importance of MPAs for both higher and lower priced dwellings, thus indicating a more generalised interest in visual proximity to MPAs. Finally, it offers the opportunity to generalise the results across a broader region, characterised by a more diverse use of the ocean and the coastline.

In line with these results and conversely from Spanou et al. (2020), this work also highlights the statistically weak, yet quantitatively strong and positive effects of aquaculture at close visual distance (within 1 km). This result is in line with those of Sudhakaran et al. (2021) and Evans et al. (2017), and, similarly to both these works, it highlights the likely complexity of aquaculture-housing prices interactions. In the quantile results, albeit positive at larger distances (up to 5 km), the results are mixed at the largest extent depending on the quartile.

A third relevant result is the positive effect that port facilities exercise on housing prices for the top and bottom quartiles. At first, this result may seem odd and driven by the location and characteristics of the harbour areas of these Scottish Council Areas. After all, most of these ports are small (i.e. classified as 'minor ports' by Marine Scotland), often serving tourist activities such as ferries and marinas, while only three ports in our study fall under the 'Major Port' category.⁵ However, literature from other parts of the world, and in very urbanised or mixed contexts found viewership and proximity to port and harbour areas to have positive effects on housing prices. For example, in the context of Hong Kong, a highly urbanised area, Jim and Chen (2009) found that view of the harbour commands 2.18%–2.97% higher prices for residential properties depending on the view of the harbour. If we combine our results with the broader concept of accessibility used by Franklin and Waddell (2002), then the widespread rurality of our study area, these remote small towns are also service centres, with low population densities, but higher accessibilities, thus acting as job and service centres. Within this framework, lower-priced dwellings can benefit from easier access to job opportunities and public transportation, while higher priced dwellings may be positively impacted by the harbour view proper, and easier access to entertainment services. In other words, proximity to harbours (and, therefore, towns) acts as an amenity within two sub-markets, an effect previously found in the literature (see e.g. Adair et al., 2000), possibly driven by different accessibility drivers, similarly to the findings of by Osland and Thorsen, 2008, albeit in our case the sign of the effects is the same for both sub-markets.

From a policy perspective, our results suggest that in rural, tourist and natural resource rich regions Blue Economy activities have (spatially) limited positive effects on housing prices, except for oil and gas operations. These impacts should be incorporated when marine spatial planning and regional economic plans are developed by local and national authorities, especially when confronted with local opposition in relation to new industries such as aquaculture and marine renewable energy. This information is key to using revealed preferences (i.e. the prices paid by home buyers) in conjunction with context-specific stated preferences, an approach previously suggested by Spanou et al. (2020), among others. The use of housing prices and hedonic modelling can thus become a link for funnelling information between water-focused planning and coastal (i.e. land-based) regional economic and social dynamics.

To conclude, in this work we introduced a few methodological novelties building on a strong overall research framework (hedonic pricing): the use of activity-specific viewshed calculated using dwelling-based viewshed for a large region, represents a step forward for understanding the overall impacts of Blue Economy activities on housing

⁵ See <https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=23> for the latest definitions.

prices, and, ultimately, on people's preferences. Thanks to increased computational power, future research should focus on larger, more diverse regions, possibly entire countries, across different seascapes so that the relationship between past and present water and coastal uses and regional geographies (e.g. accessibility, remoteness, etc.) can be better understood, and further generalised for informing marine spatial and regional economic planners.

CRediT authorship contribution statement

Marcello Graziano: Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Maurizio Fiaschetti:** Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization. **John W. Gross:** Methodology, Investigation, Data curation. **Karen A. Alexander:** Writing – original draft, Supervision, Conceptualization. **Alberto Longo:** Writing – original draft, Funding acquisition, Data curation, Conceptualization. **Tim O'Higgins:** Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Marcello Graziano reports financial support was provided by Central Michigan University. Alberto Longo reports financial support was provided by Invest Northern Ireland. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. – Data distribution and variable names

The empirical analysis of our paper makes use of three main categories of variables.

- a) Hedonic variables, i.e., related to the characteristics of the properties.
- b) Macroeconomic variables, i.e., related to the economic conditions of the area/property
- c) Water use, i.e., related to the use of the waterfront visible from the single property

Table A1 below lists the variables, their types and for the type of property, it shows the distribution through the sample and across the.

Table A1

Variable names, types and distribution

Variable Category	Variable Type	Variable Name	Number of properties	Frequency
Hedonic	Numerical	Number of Bedrooms	✓	✓
Hedonic	Numerical	Floor	✓	✓
Hedonic	Numerical	Number of Bathrooms	✓	✓
Hedonic	Numerical	Number of Receptions	✓	✓
Hedonic	Categorical	Type of the Property	✓	✓
		1. Barns, bungalows and cottages	1077	17.13%
		2. Houses	2880	45.82%
		3. Country houses	287	4.57%
		4. Flats	2034	32.36%
		5. Hotels and commercial properties	8	0.13%
		5.A - Hotel/guest house		
		5.B - Leisure/hospitality		
		5.C - Mobile/park home		
		5.D - Retail premises		
Macroeconomic	Numerical	Real GDP	✓	✓
Macroeconomic	Numerical	Inflation	✓	✓
Macroeconomic	Numerical	Last year in the market	✓	✓
Macroeconomic	Numerical	Total turnover of tour operators	✓	✓
Macroeconomic	Numerical	Absolute poverty index (Scotland)	✓	✓
Water Use	Numerical	View of World Heritage Sites	✓	✓
Water Use	Numerical	View of aquaculture sites	✓	✓
Water Use	Numerical	View of oil and gas sites	✓	✓
Water Use	Numerical	View of marine conservation areas	✓	✓
Water Use	Numerical	View of harbours and other facilities	✓	✓

Source: Authors' elaboration on data provided by Zoopla

Appendix B. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2025.103632>.

Data availability

Data will be made available on request.

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