

Evaluating the benefits of beach protection measures in the face of climate change: the case of Languedoc-Roussillon

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Abstract:

In the face of increasing beach vulnerability due to climate change, the objective of this article is to improve knowledge of the understanding, expectations, preferences and behaviour of beach users and non-users concerning beach functions and the types of management measure which can be implemented. As part of an French National Research Agency interdisciplinary project, contingent valuation surveys were carried out on 881 people (318 living in their main residence, 163 in their secondary residence, 301 tourists and 99 day trippers) representing all types of population affected by the maintenance and the protection of beaches within a pilot zone in Languedoc-Roussillon. A double-bounded dichotomous-choice contingent valuation method was used, based on a scenario which put the Intergovernmental Panel on Climate Change (IPCC) hypotheses into context at French Mediterranean level (developed by the project's geologists). Various questions common to all sub-populations elucidated beach use and practices, perceptions of risk and preferences concerning its management and *in fine* allowed the estimation of a model to evaluate the willingness to pay. The latter showed the relative significance of perception variables compared to economic characteristics. Over and above perception differences between sub-populations, the findings concerning the significance of these variables are crucial for the development of public policies for adaptation to climate change. Clearly, as regards beach protection and more generally the management of the coastline, the recommended policy of managed retreat requires an in-depth knowledge of the population's trade-off between their attachment to the beach and their risk perception.

Key words: climate change – sea level rise – erosion – economic valuation – beaches

JEL classification system: D6, Q51, Q54

1. Introduction

Beaches, whose paradisaic image is stressed by sociologists, generate significant seaside tourism with 40% of national overnight stays (Direction du Tourisme, 2005) which constitute the main source of value-added in coastal activities (44% according to DATAR, 2004). This attractiveness has led to a concentration of accommodation capacity for both tourists and permanent residents, whose preference for the coast is causing significant migration and increasing urbanization to the extent that, in France, a specific law and institution (the coastal conservatory) has been created in order to regulate this appeal. Currently, more than 60% of the world population lives less than 150km from the coast and it is estimated that this percentage will reach 75% in 2025 (DATAR, 2004).

However beaches, zones where sediments accumulate along low coastlines, are subjected to natural erosion and accretion dynamics which vary at different time-scales, from natural seasonal or medium-term occurrences to very long-term processes at geological scale depending on sea level variations. Over and above these natural events, beach dynamics are currently over-determined by human development (less sediments due to coastal river dams, manmade dune areas and backshores ...), which, by limiting the natural regulation of sediment flow, generates or worsens erosion and in some cases leads to the disappearance of beaches. Hence erosion, which affects 20% of European coasts (EUROSION, 2004) and 25% of French coasts (IFEN, 2006), is particularly marked in the Hérault department as one third of beaches are affected, with a total net loss of 230ha of beach between 1945 and 1996 in the Languedoc-Roussillon region (Frayssinet, 2002). The first erosion management policies consisted of building heavy defence works (sea walls, breakwaters) which proved to be capable of fixing the sand only at the expense of neighbouring zones, increasing rather than controlling erosion. The authorities have since tended to favour so-called soft methods of beach recharge, the limits of which relate to the cost and the availability of materials (Rey-Valette et al., 2008).

Given this already very worrying situation, the prospect of a rise in sea level resulting from climate change adds a very significant risk of worsening erosion which could undermine the long-term future of beaches and therefore the attractiveness of the coast. Adapting the hypotheses of the Intergovernmental Panel on Climate Change (IPCC) to the Languedoc-Roussillon case (Lecacheaux et al., 2010) gives a predicted sea level rise of 7 centimetres in 2030 and, depending on the hypotheses, of 35 centimetres, or perhaps even 1 metre, by 2100. Even if their frequency remained unchanged, storms would still have much more pronounced effects given the height of the water, comparable to current hundred-year reference points. In the face of these new medium- and long-term risks, it is possible to anticipate and implement adaptive policies (GIEC, 2001a, b). Future damage must be minimized so as to show a gross benefit defined by Agrawala and Frankhauser (2008) as the difference between the damage due to climate change with or without adaptation, from which is subtracted the cost of adaptive measures. The national adaptive strategy on climate change (ONERC, 2007) emphasizes first the willingness to anticipate, second so-called no-regret measures as they present other advantages, and third the due regard to equity conditions between territories, whilst also highlighting the limits of insurance systems and the need for information and awareness-raising. In the case of beaches and the coastline, the recommended policies relate to measures known as strategic retreat, which, through the rehabilitation of wet zones or dunes, would lead to the restoration of the natural recharge processes and to the progressive retreat of beaches rather than their disappearance (MEDDEM, 2010).

Implementing such measures requires better knowledge of the behaviour and representations of the population and of beach users. The MISEEVA¹ project provided an opportunity to study the functions and vulnerability of beaches and to consider the types of adaptive policies to climate change that could be both technically appropriate and socially acceptable. To that end, and among other things, surveys were carried out to understand the population's perceptions of the risk of, and of policies to combat, marine submersion and to evaluate their Willingness to Pay (WTP) for the implementation of protection measures other than strategic retreat.

The objective of this article is, therefore, to discuss the practices and perceptions of the different coastal populations (full-time residents, secondary residents, tourists and day trippers) and evaluate their WTP for beach protection. The novel features of our approach derive from the methodological difficulties encountered in understanding the long-term risk of climate change and from the

¹ "Marine Inundation exposure hazard and Social Economic and Environmental Vulnerability Assessment". The overall objective of the project is to study the social, economic and environmental vulnerability of the coastal zone to the risk of marine submersion within the framework of global change in 2030 and 2100.

combination of several surveys which aim to include all population types and to highlight possible differences in vision and commitment. We first outline the methodological protocol, and then present the main descriptive results concerning practices and perceptions and the valuation model of the WTP for beach protection. Finally, these results are discussed with respect to the need for further knowledge and the constraints to the implementation of public adaptive policies that this article seeks to elucidate.

2. Methodology

2.1. Description of the study area

The Languedoc-Roussillon coastline, South-East France, is one of the largest open bays in Europe. It is 231 kilometres long, over half of which (56%) consists of sandy beaches, equally divided between urban and natural beaches. The pilot study zone defined for the MISEEVA project consists of the coast near Montpellier, a 12.2 kilometre stretch between the Abbaye of Villeneuve-lès-Maguelonne in the West and the Grande Motte (not included) with very busy beaches in well-known modern resorts such as the Grande Motte and traditional ones such as Palavas-les-Flots. This site also attracts a large number of visitors from the Greater Montpellier area.

This zone was selected both because it is representative of the diversity of issues at stake (due to its proximity to Montpellier, the regional capital) and because physical data are available enabling risk modelling (Lidar bathymetry data). The selected local districts, i.e. Mauguio-Carnon (15,507 inhabitants in 2007), Pérols (8,515 inhabitants) and Palavas-les-Flots (6,048 inhabitants) are highly urbanized. They are representative of both seaside resorts and residential towns along the coast. The example of Mauguio and its adjacent resort of Carnon is a perfect illustration of the dual character of urbanization whilst Palavas is simultaneously a traditional resort, a residential town and an artisanal fishing port open to the sea and the lagoon. Carnon is typical of the new towns built in the 1970s during the Racine tourism development period of the Region and consists mainly of relatively tall buildings. Palavas, which is more at risk of submersion (MIAL-LR, 2003) is, on the contrary, made up of houses and often bungalows. The Pérols district, situated further back, is part of Greater Montpellier. It consists mainly of bungalows. As it is not on the seafront, the marine submersion risk is related mainly to its location on the edge of the Méjean and Or lagoons.

2.2. Climate change characteristics

A contingent valuation was undertaken to assess the value placed on beach preservation. We estimated the WTP of full-time residents, users and non-users, to fund traditional sand recharge operations and the building of hard structures such as sea walls or breakwaters. Such measures are familiar to the users and residents as the former have been regularly undertaken for around fifteen years and the latter for some fifty years. In 2009, a large-scale recharge operation (€8.7 million) was carried out on the beaches of the study site together with a significant communication effort by the Hérault department, the contracting authority.

We deliberately did not ask interviewees for opinions about the far-distant future such as the year 2100, when the impacts are going to be much more significant, or on a scenario of a metre rise in the sea level, which makes neophytes envisage a catastrophic event with engulfed beaches, whereas the progressive nature of the event leads to a partial surface loss depending on the slope of the beach, and above all, to a gradual retreat of these naturally dynamic environments. In fact, the long-term damage to beaches due to global warming will depend more on their capacity to retreat than on the height of the water that they face. Therefore, strategic retreat policies for front line roads and buildings will determine beach vulnerability. Basing scenarios on these processes, both because they happen in the very distant future and because they require a profound knowledge of the sedimentation process, has led to very significant biases.

Finally, in order to strengthen bid credibility, valuation questions were preceded by numerous questions on beach perceptions and practices, and by one question on the preferences of interviewees concerning submersion management policies (including strategic retreat) which was discriminatory for the implementation of the contingent valuation. Thus, WTP was only calculated for users who had selected classical coastline management policies, so that the budget, although substantial, remained of an order of magnitude that was relevant to the interviewees. Users who had selected laissez-faire policies, i.e. non-intervention policies, or strategic retreat, which requires a much more considerable budget and much more than simple beach maintenance, i.e. integrating the safety of people and goods at risk², were not asked the WTP question. They were considered as zero valuations.

2.3. Constructing the questionnaire

The base population consisted of all people potentially affected by the disappearance of beaches in the study zone. Contact was made through two sub-populations:

1. The residents of main and secondary properties³ of Palavas-les-Flots and Carnon-Mauguio;
2. Tourists and day trippers⁴ visiting the selected beaches.

This population structure allowed all beach users, regardless of their origin, as well as non-users living locally, to be taken into account. The proportion of non-users was relatively high for full-time residents (19.5% stated that they never go to the beach in the summer) whilst it was negligible for secondary residents (3.5%). This non-use only concerns the recreational function of the beach. Non-users may still be involved, for example through the aesthetic (sea view) or storm regulation functions. It should be noted that beach proximity was cited as the main choice criterion when deciding where to live by 19% of full-time residents compared with 26% of secondary residents.

Most of the questionnaire was common to the two groups in order to allow comparisons. Other than the economic valuation part, its objective was to collect information on uses (beach and lagoon activities, frequency of visits...), awareness of the risk of sea level rise (timing, expected impact, confidence in public authorities, experience...) as well as socio-economic data on the interviewees and their household. The sampling and data collection methods depended on the category of interviewee. Data from the most recent population censuses were used for residents (1999 and 2007). Within the three study towns, only French Institute for Statistics and Economic Studies (INSEE) sectors less than 2 kilometres from the coastline were used so that only the people potentially the most concerned by the risk of marine submersion were interviewed. This choice meant that the whole town of Palavas-les-Flots was selected but only 54% of dwellings in Mauguio-Carnon and 41% in Pérols. A quota method was then used based both on the proportion of properties in the sector compared to the total number of properties in the surveyed zone and on the distribution between main and secondary properties within each sector. The quota method was used for tourists and day trippers, so that interviews could be undertaken proportionally to the length of each beach, i.e. 33 surveys per km, regardless of the type of beach, given the fact that there is no significant difference in uses between urban and natural beaches (Rey-Valette et al., 2007). The breakdown between tourists (75%) and day trippers (25%) was defined according to estimates of tourist flows from the Public Works Department (CETE Méditerranée, 2002, cited by ACT Ouest and SCE Montpellier, 2006). Once on the ground, interviewees were then selected randomly whatever their sub-population.

² Whilst traditional policies actually target services rendered by beaches, in particular recreational services, retreat policies help to prevent damage not only to beaches but also to everything situated on the front line and this includes protecting people in the event of storms.

³ A main residence can be defined as "*the property usually occupied*" by the household whilst the secondary residence is "*used for week-ends, spare time or holidays*" (INSEE definitions). Occupants of the former are referred to in this article as "full-time residents" and the latter as "secondary residents".

⁴ Day trippers are "*day visitors*" whilst tourists "*spend at least one night in collective or private accommodation in the site they are visiting*" (European Commission definitions n°C(1998)-3950).

2.4. The valuation question

The approach used was the double-bounded dichotomous-choice contingent valuation method introduced by Hanemann (1985). The introductory question presented the scenario of a rise in the sea level such as described by the IPCC in 2007. Interviewees had to choose their preferred method to combat the rising sea level:

“Scientific models from the Intergovernmental Panel on Climate Change (2007) predict that within twenty years the sea level could have risen by seven centimetres in Languedoc-Roussillon. This would lead to increased coastal erosion and therefore a reduction in the size of beaches and even the disappearance of some of them. Several methods can be envisaged to prevent such an outcome. Which method would you favour?”

- Beach sand recharge
- Building underwater sand bars
- Building or strengthening breakwaters, dykes, sea walls, rip rap.
- Strategic retreat, abandoning front-line buildings
- Laissez-faire
- Other method (specify)
- Don't know”

As mentioned above, the first genuine valuation question was asked only of those who did not select “strategic retreat” or “laissez-faire”⁵. This question was based on the dichotomous choice principle introduced by Bishop and Heberlein (1979) and recommended by the National Oceanic and Atmospheric Administration panel (Arrow et al., 1993) as it offers a strong incentive to reveal preferences and avoids incongruous observations (Bateman et al., 2002). In order to increase credibility, the payment methods used differed slightly according to the sub-populations:

To residents (full-time and secondary): “Would you be prepared to pay an increase of € X on your local property tax (per year and for the next 20 years) for this measure to be implemented, provided that it is to maintain the beach?”

To day trippers: “Would you be prepared to pay an increase of € X on your local property tax (per year and for the next 20 years) for this measure to be implemented, knowing that this money would then be given to coastal towns for them to maintain the beach?”

To tourists: “Would you be prepared to pay an increase of € X on your holiday accommodation (per year and for however long you stay) for this measure to be implemented, knowing that this money would then be given to coastal towns for them to maintain the beach?”

The payments, however, were identical. Following Hanemann and Kanninen’s recommendations (1999), five bid levels ranging from €15 to €35 were suggested in order to avoid starting point biases (Flachaire and Hollard, 2006), and these amounts were rotated across the questionnaires. The values were selected on the basis of previous work (Roussel et al., 2009) and a literature review (Lamberti and Zanuttigh, 2005; Shivilani et al., 2003). These bids ranged from €15 to €35. Likewise, the choice of payment method was influenced by the results of previous work showing that a payment directly related to beach access was rejected (and indirect payments through parking charges raised strong objections). This valuation question was followed by a second one where the “take it or leave it” bid was greater than the first one when it was accepted and lower when it was refused (Hanemann and Kanninen, 1999).

⁵ Individuals who did not choose a measure (2 tourists, 1 day tripper, 7 secondary residents and 18 full-time residents) were excluded from the sample.

The questionnaire was tested on some twenty Languedoc coast residents in March 2009⁶. It was then implemented in several phases. Full-time and secondary residents were interviewed during the 2009 April holiday then during the first two weeks of July. Interviews were carried out at their homes so as to be able to see the risk that they faced. Each interview lasted between 20 and 30 minutes⁷. Tourists and day trippers were surveyed directly on the beach as users, during the last week of July and the first week of August of the same year in order to take into account profile differences between the two months. The questionnaire took between 15 and 20 minutes. All interviews were carried out face to face. This method, advocated by Arrow *et al.*, (1993), facilitates the collection of information, as the response rate is higher (Bennett and Blamey, 2001) and improves control over the way the interview is conducted. In all, 881 questionnaires were completed: 318 full-time residents, 163 secondary residents, 301 tourists and 99 day trippers.

3. Results

3.1. Descriptive statistics of the sample

3.1.1. Beach use

A χ^2 test shows that beach use in the summer is very strongly related to user type (significant at 1%). Hence, tourists are over-represented among those going to the beach “every day or nearly every day”, and the opposite is true for full-time residents (Table 1). A larger number of the latter “never” go, day trippers go “once to three times per month” or “per week”.

Table 1: Beach use in the summer (in %)

	Full-time residents	Secondary residents	Tourists	Day trippers
Every day or nearly every day	31.8	72.4	77.4	26.3
Once to three times per week	25.8	16.6	21.3	49.5
Once to three times per month	14.8	3.7	1.3	23.2
Less frequently	8.2	3.7	-	1.0
Never	19.5	3.7		
Total	100.0	100.0	100.0	100.0

Out of season, the beaches remain very attractive. Hence, about four out of ten tourists (37.8%) state that they go to the beach at least once a week when they are on holiday in the Department in the spring and autumn and 17% in the winter. Day trippers whose main residence is located near the coast (48.5%) go to the beach at the end of the summer season and 22% in the winter, which represents a fair percentage of the population. For their part, full-time residents (34.9%) and secondary residents (29.4%) state that they go to the beach once to three times a week in the spring and autumn. Respectively 24.8% and 13.5% of them go to the beach with the same frequency in the winter.

⁶ It should be noted that as tourists and day trippers were not around at that period, we re-tested the validity of the questionnaire on the beaches at the beginning of July.

⁷ The interview involving the residents was more thorough, in particular as regards their attachment to the coastal zone.

On average, tourists and day trippers stay on the beach for four and a quarter hours⁸ but duration and practices vary with profiles and the latter tend to come to the beach during the morning (73.7% against 56%, χ^2 test significant at 1 %) for a slightly shorter time (three and a quarter hours against four hours 37 minutes) (Table 2)⁹.

Table 2: Daily beach use by user type

	Period of use			Duration of use	
	Tourists	Day trippers		Tourists	Day trippers
Afternoon	46.4	22.2	2 hours and less	20.3	29.3
Morning	37.7	62.4	3 hours	25.9	47.5
Evening or night	8.5	10.3	4 and 5 hours	34.6	20.2
Daytime	7.4	5.1	6 hours and more	19.3	3.0
Total	100.0	100.0	Total	100.0	100.0

3.1.2. Beach users

The analysis of the three main beach activities shows that sunbathing and resting are the most common (Table 3). These results can be compared with observations from the literature. In Loire Atlantique, 89% of users go bathing, 28% play beach games, 10% build sand castles and a mere 4% fish (Mansotte, 2005). Surveys in the Nord Pas de Calais show that most users are families and pensioners living nearby with a so-called “pleasure seeker” profile centered on entertainment (bathing, walking, and picnics). “Utilitarians” who prefer fishing and “discoverers” who seek naturalistic interests are in the minority (Espace Naturel Régional, 1996; cited by Meur-Ferec, 2006). Similarly, the typology of beach users in Réunion highlights the number of “idlers” looking to relax (80%), of “sun-lovers” (59%) sunbathing (and sea bathing) whilst the “sociable group”, looking to meet people, represents only 10% of users (Mirault, 2007). Finally, Rulleau’s work in Gironde (2008) shows that bathing and nautical sports (cited over 90% of the time), as well as rest, relaxation and sunbathing (more than 70%), are very popular with both tourists and residents.

⁸ It should be noted that a national study undertaken by the Institute for Tourism Observation, Development and Technology (Dolle, 2000) showed that more than 70% of users spend at least 4 hours on the beach and, as a result, are involved in several activities. Likewise, observations made previously in the Department agree on the average time spent on the beach: between 3 and a half and 4 and a half hours for the Lido-Carnon - La Grande Motte (BRL, 2000, cited by ACT Ouest and SCE Montpellier (2006), 5 hours on the lido from Sète to Marseillan where tourists are in the majority and 3 hours 25 mins for the urban beach of Marseillan (CETE Méditerranée, 2002 cited by ACT Ouest and SCE Montpellier (2006). These studies confirm the differences in behaviour between tourists and day trippers, the latter tend to come to the beach in the morning and not stay as long.

⁹ Residents were not asked this question.

Table 3: Beach activities during the summer (in %, three possible answers)

	Full-time residents	Secondary residents	Tourists	Day trippers
Passive individual uses				
Sunbathing, tanning	33.4	45.8	70.8	59.2
Rest, reading	24.3	50.3	65.4	64.3
Active individual uses				
Bathing	54.1	69.7	87.9	87.8
Walking	39.5	36.1	12.8	20.4
Jogging	8.1	3.9	0.3	1.0
Dog walking	9.1	2.6	0.3	2.0
Fishing	10.5	9.7	4.0	-
Nature discovery	6.1	5.8	2.0	1.0
Collective uses				
Parties, meeting with friends	16.9	14.2	7.0	8.2
Family entertainment activities	16.6	16.8	23.5	26.5
Picnic	7.1	0.6	10.7	21.4
Nautical activities	13.5	10.3	5.0	3.1
Other	0.7	0.6	-	-
Sub-total				
Do not go to the beach	11.5	2.6	-	-

Note: activities in bold can be considered as the most representative in their category.

3.1.3. Risk perception

The perception of the risk of sea level rise is very strongly related to the user type (χ^2 test significant at 1% – Table 4): it is mainly tourists who think it is conceivable "in the next 10 years" in Languedoc-Roussillon. There is a strong similarity with the results of the survey undertaken in 2007 by Rey-Valette *et al.* (2007). Several of the questions from that survey were used again in our survey with similar answers from 77% of tourists and day trippers. It should be noted that only a few residents claim not to be worried.

Table 4: Estimation of the risk of a rise in sea level in Languedoc-Roussillon (in %)

	Full-time residents	Secondary residents	Tourists	Day trippers
Conceivable in the next ten years	44.0	37.4	73.4	77.8
Conceivable but in more than ten years	37.4	38.0	13.6	14.1
There will not be a significant rise so there is no need to worry	4.4	9.8	4.3	1.0
The predictions have not been proven.	9.1	11.0	5.3	3.0
Other	0.3	-	0.7	3.0
Don't know	3.5	1.8	2.7	1.0
I am not worried	1.3	1.8	-	-
Total	100.0	100.0	100.0	100.0

3.1.4. Risk management methods

The choice between management methods makes it possible to understand people's preferences and, in particular, their representation of the beach's aesthetics and functions¹⁰, of the significance of

¹⁰ Sea walls can, for example, depending on people, be seen as degrading the beauty of the site, as compartments or useful landmarks facilitating the surveillance of children, or as promontories facilitating recreational fishing ...

the natural dimension in site attractiveness, of their attachment to the seafront and also of their level of information about erosion. The preferred erosion management method depends very strongly on the population (χ^2 test significant at 1% – Table 5). Full-time and secondary residents are under-represented in the "strategic retreat" category which shows that they want to live as near the beach as possible, contrarily to day trippers who do not benefit from the aesthetic dimension. The latter are significantly fewer to choose so-called "hard" methods.

Table 5: Users' preferences concerning risk management methods (in %)

Methods	Full-time residents	Secondary residents	Tourists	Day trippers
Breakwaters, dykes, sea walls...	38.7	45.4	44.2	23.2
Underwater sand bars	22.6	25.2	22.3	20.2
Recharge	14.5	12.9	7.0	8.1
Strategic retreat	11.9	7.4	21.6	45.5
Laissez-faire	4.4	3.1	3.7	2.0
Other	2.2	1.8	0.7	0.0
Don't know/no reply	5.7	4.3	0.6	1.0
Total	100.0	100.0	100.0	100.0

3.2. Model estimation

The answers were then modelled in order to explore agents' WTP for beach protection measures, i.e. the value they give to maintaining beach size. This modelling relied on the following principle: in a dichotomous choice survey, the response of the interviewee does not directly give the value of their WTP but indicates whether or not it is higher than the price offered for the measure (Cameron, 1988). In other words, a qualitative binary variable can be observed (Hanemann and Kanninen, 1999) such as:

$$\begin{cases} Y_i = 1 \text{ si } WTP_i \geq B_i & (\text{accepts}) \\ Y_i = 0 \text{ si } WTP_i < B_i & (\text{refuses}) \end{cases}$$

The probability of accepting (or refusing) to pay is then equal to the probability that WTP_i is higher (lower) than B_i (Freeman, 2003). In other words, this approach implies that each individual compares their WTP with the proposed payment before answering (McConnell, 1990). We used here the formulation due to Cameron (1988) and Cameron and James (1987) which, like Hanemann's (1984), accords with welfare theory (McConnell, 1990) and the procedure suggested by Cameron (1991) to transform the estimated coefficients and calculate the asymptotic variance-covariance matrix of these estimators. It should be noted that when this technique is used, the model provides a direct estimate of the WTP and no longer the probability of accepting to pay for a particular policy.

The modelling results are presented in Table 6. Having excluded protest refusals (identified by a control question) and people who had not answered all the questions, the final database contained 792 observations.

Table 6: Results from the double-bounded dichotomous model

Variables	Coefficient	Standard deviation
Constant	10.383**	4.937
Personal characteristics		
Monthly household income	0.001*	0.001
Main or secondary residence (0-1)	19.136***	2.553
Palavas les Flots (0-1)	4.840*	2.478
Beach use		
Walking on the beach (0-1)	-6.454**	2.892
Risk perception		
Unproven predictions in Languedoc-Roussillon (0-1)	-8.741**	4.239
No impact from sea level rise in Languedoc-Roussillon (0-1)	-22.951***	7.668
Confidence in scientists (0-1)	8.329**	3.902
Protection strategy		
Protection of nature regardless of the cost (0-1)	5.607**	2.798
Protection of public works regardless of the cost (0-1)	6.403**	2.770
No protection of tourist activities as too costly (0-1)	-9.753***	3.667
No protection since damage unavoidable (0-1)	-13.126***	4.028
Preferences concerning erosion management methods		
Recharge(0-1)	14.057***	4.630
σ	28.559***	0.907
Number of observations	792	
Pseudo log likelihood	-2 735.514	
Wald $\chi^2(12)$	142.05***	

Note: some of the interviewees did not answer all the questions so they could not be integrated into the econometric model.

The link between Cameron and James' approach and Ordinary Least Squares (Cameron and James, 1987) and Generalized Least Square (Cameron, 1988) regressions facilitates the interpretation of estimators (Cameron and James, 1987). These correspond to the derivatives of the inverse demand function (Cameron, 1988) and thus represent the variation in WTP caused by infinitesimal changes in each explanatory variable (Hoehn, 1991), i.e. the partial derivative of the valuation function with respect to the scenarios (Santos, 1998). The bid does not appear directly in the Table 6, but the dispersion parameter σ corresponds to $(-1/\varphi)$ with φ as the distance coefficient.

4. Discussion

4.1. Factors determining WTP for traditional beach protection

We note first that incomes have the expected sign (Bateman et al., 2002). We also find that surveys in Palavas-les-Flots give a higher WTP. This result may be related to the conclusions of the studies on erosion and submersion management strategy in Languedoc-Roussillon which were carried out in 2003 and showed that this district faces one of the highest submersion risks (MIAL-LR, 2003). Walking is the only use which leads to a reduction in WTP, probably because although it suffers from the impact of beach erosion and the resulting landscape changes, this activity can be transferred elsewhere. Walking is mostly done by residents and is second to bathing in the active beach use category. Given the universal nature of the latter, walking can be considered to characterize the importance of active beach uses. Finally, the fact that full-time and secondary residents have a higher WTP than tourists and day trippers is doubtless due to the fact that they are more attached to their

properties, which might be related to some degree of geographic proximity¹¹ {Santos, 1998; Vidal, 2002} or to better knowledge and familiarity. The fact that the former are present all year round and therefore during the winter storms can affect risk perception.

The analysis of the variables that have a significant impact on WTP shows that these are more related to risk perception than to socio-economic characteristics. Hence, if an individual thinks that (1) predictions remain unproven and therefore that there is no real risk and (2) there will be no consequences in Languedoc-Roussillon, their WTP will be lower. On the other hand, this value will rise if people trust scientists' risk evaluation, a rather traditional result as shown by the Institute of Radioprotection and Nuclear Safety barometer (see for example Institut de Radioprotection et de Sécurité Nucléaire, 2010). In terms of collective management, an individual who wishes to protect the landscape and nature or public works (schools, hospitals...) against marine submersion, regardless of the cost, is prepared to pay significantly more than average, compared with those who think that the collective protection of tourist or economic activities would be too costly or that the protection of the cultural or historical heritage is futile as damage is unavoidable in the long term. These conclusions are important because they give public actors some indication both of the key role played by the protection of nature and public works in management policies and of the inevitability, as seen by beach users, of damage to tourist and heritage assets. Finally, it should be noted that individuals who favour the soft method of beach recharge are prepared to pay significantly more than the others. These methods are less intrusive and more efficient than bricks and mortar, despite the reassuring image of the latter. The presence of this variable in the WTP function suggests that these individuals are more sensitive to the environment and/or are better informed about the erosion process.

4.2. Contribution to the development of adaptive policies

According to Titus (1998), two main types of policy produce beach resilience: (1) the use of technology (hard or soft methods) to maintain the status quo despite the rise in sea level or (2) strategic retreat allowing the coastline to evolve naturally, an evolution to which it is necessary to adapt, as has happened, for example, with the policy of coastline realignment in the Humber estuary in the North-East of England (Turner et al., 2006). These retreat or realignment policies are considered to be the most relevant. The "hard" protective infrastructure is deliberately destroyed to allow the reimplantation of wet zones and to facilitate the natural functioning of the coastline. The wet zones created in this way ensure the protection of assets further inshore. They help prevent the loss of ecosystems squeezed between infrastructure and the progression of the sea level, i.e. the coastal squeeze. The policies may be in the form of regulations, urban planning with expropriation or rolling easements¹². Non-intervention ("laissez-faire") can also progressively lead to assets being abandoned, where these have lost their value because of recurrent damage. A cost-benefit study of the adaptation to erosion (Tecsult, 2008) comparing the types of measure undertaken showed that sand recharge and retreat were the most profitable, despite life-style losses (sea view) and the rebuilding costs (compensated by gains relating to landscapes and the safety of dwellings).

Despite their interest, the social acceptability of these policies poses a problem. Our surveys show that the proportion of interviewees favourable to strategic retreat is inversely related to people's attachment to beach proximity (Table 5). Almost half of day trippers, attracted by recreational uses,

¹¹ It should be noted that, contrary to what was expected, willingness to pay was not affected by the floor level (storey), or the fact of living on the seafront or next to the lagoon.

¹² "Rolling easement" consists of authorizing development in the coastal zone in the short term with no protection measures. Owners are warned that their property may eventually have to be abandoned to the sea. The retreat of the coastline goes hand-in-hand with the retreat of the Maritime Public Domain and assets become public property. The owner can then choose to leave and cover the destruction cost or to stay and pay a rent to the State, a rent that could rise to encourage departure and that will later fund the destruction operation (Titus, 1998).

are favourable to retreat policies. But this proportion falls drastically in the case of tourists who use the beaches closest to their holiday destination and even more in the case of residents, in particular, secondary ones, who are the most attached to the seafront. The same pattern is found, moreover, between full-time and secondary residents concerning their attachment to their dwelling (Meur-Férec, 2010).

If the beach were to disappear, day trippers would be prepared to travel (return journey) on average 39 kilometres (or 40 minutes) more in order to go to another site. In the case of the strategic retreat of businesses from the seafront, nearly half of beach users (48.8%) considered that this would be quite pleasant. This proportion rose in the case of day trippers, where more than three quarters (76.8%) felt the same way (χ^2 test significant at 1%). Yet, studies carried out in the United Kingdom (Myatt et al., 2003) show the importance of dialogue if administered realignment policies are to be accepted. This acceptance depends on land status (public or private) and the age of the buildings to be abandoned. Of course it also depends on the compensation offered and on the population's confidence in the management structure. Hence, the adaptation to climate change through retreat requires progressive policies with information and awareness-raising operations in order to change practices and representations. A change in direction is therefore necessary from the recreation-only vision of beaches to a more global understanding of their functions, in particular their role in storm and submersion regulation which justifies different management systems and requires changes in users' behaviour.

5. Conclusion

This work on the benefits of protection measures in a pilot zone could help evaluate the value attributed to the presence of the beach. However, the aggregation of WTP, which is always tricky, requires that data concerning beach usage are available. Yet, only fragmentary data are available for some sites (Rulleau et al., 2011). Moreover, so far as we are aware, there are relatively few reference studies. The valuation of coastal ecosystems in relation to the nature of biotopes carried out by Costanza et al. (1997) does not mention the case of beaches. A few studies show different WTP depending on the characteristics of the sites and the recreational activities undertaken there, the seasons, the types of tourism and user, the protection efforts undertaken, and in the particular case of Florida, the existence of turtle nesting areas. Overall, the value of beaches varies between €5 and €28 per visitor in the case of Italy (Polomé and Zanuttigh, 2005; Lamberti et al., 2005) and is around €20 for the beaches of southern Florida (Shivlani et al., 2003). Other avenues could be explored in order to understand the value of beaches, for instance the maintenance cost. This is evaluated by Vanroye and Auffret at €12 million per year in future years, given the fact that erosion is increasing and policies are changing, which represents a massive budget increase compared to previous spending (€117 million since 1948 (Vanroye and Auffret, 2010)). Alternatively, following King and Symes (2003) in California, one could consider the monetary flows generated by coastal tourism, i.e. €4.2 billion per year in the case of Languedoc-Roussillon. However, these are induced flows which on the one hand go well beyond the strict use value of beaches but on the other do not include non-market values, such as regulation services, in particular of storms and, in the medium term, of climate change.

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