

The effect of a estuary restoration project in recreational ecosystem services

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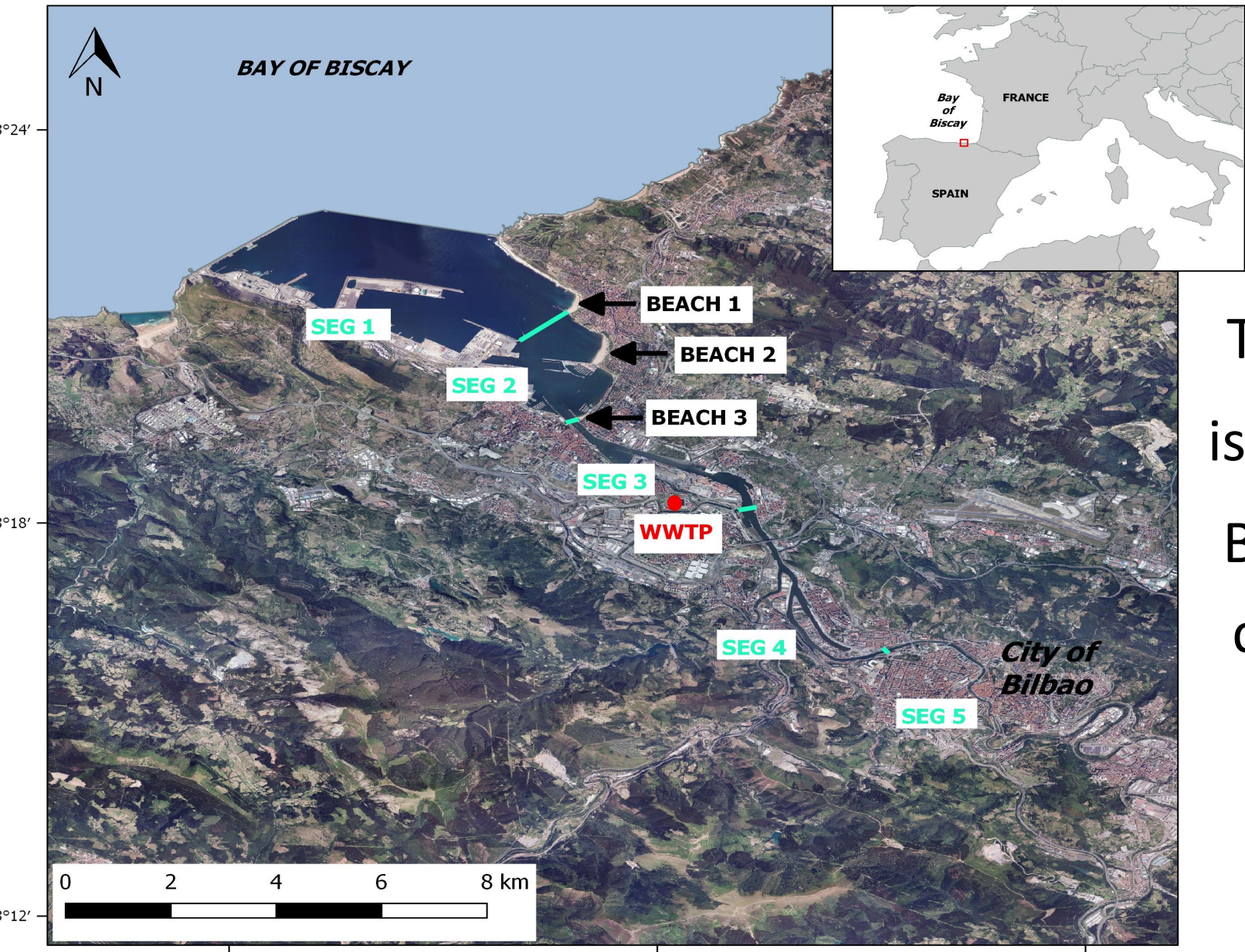
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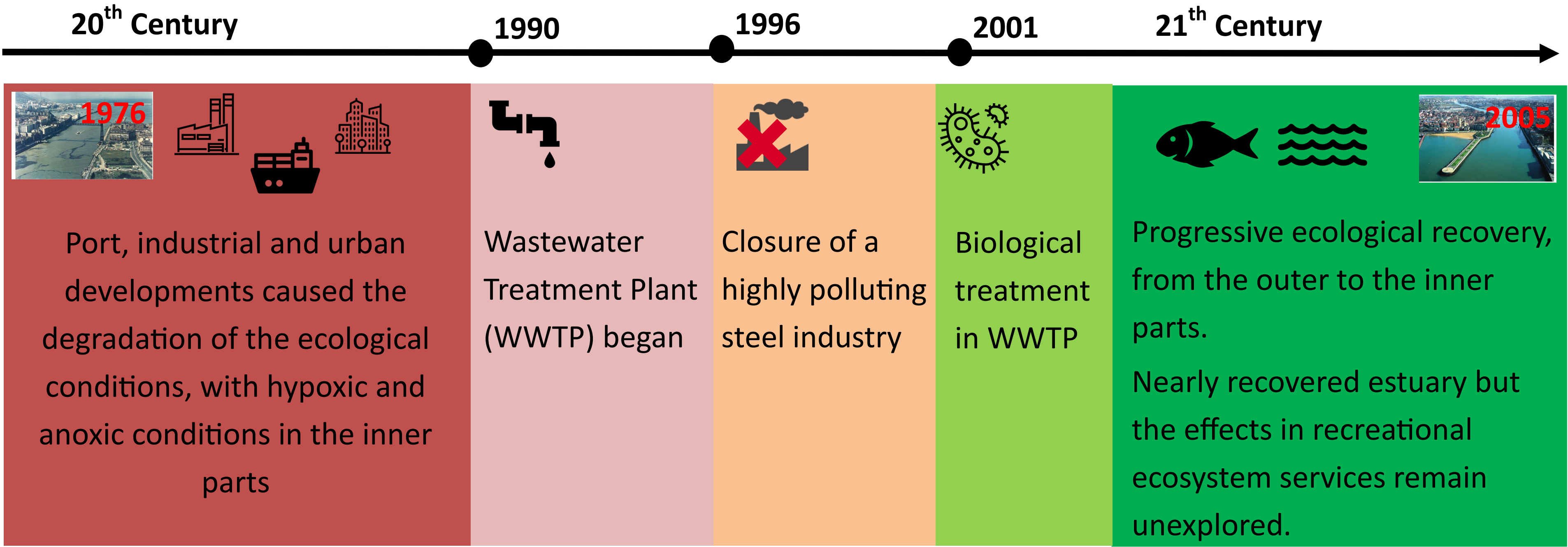


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INTRODUCTION



The **Nerbioi estuary** is located in the inner Bay of Biscay, on the coast of the Basque Country (Spain)



AIM

To clarify if the recovery of ecological conditions results in benefits for human wellbeing, focusing on: **recreational fishing** along the estuary and **bathing waters** in 3 beaches.

OBJECTIVES

- 1. To check the environmental changes potentially affecting the recreational activities.
- 2. To check users’ perceptions and behaviors in response to environmental changes.

MATERIALS AND METHODS

- 1. Analysis of temporal trends in environmental parameters:
 - Recreational fishing: water (O₂ and NH₄), fish (abundance, richness and size)
 - Bathing waters: microbial pollution and water transparency
- 2. Questionnaire survey for fishers and beach users:
 - Recreational fishing: 146 questionnaires
 - Bathing waters: 426 questionnaires

RESULTS

Recreational fishing

Environmental changes

Table 1. Simple linear regression for the temporal trends in environmental variables, split by segments. Key - Coeff: regression coefficient; SE: Standard Error. Significance levels: *p<0.05; **p<0.01; ***p<0.001.

		O ₂ surface (%)	NH ₄ surface (μmol l ⁻¹)	Fish abund. (Ind Ha ⁻¹)	Fish richness
SEG1	Coeff (SE)	0.40 (0.30)	-0.43 (0.13)	0.01 (0.01)	0.72 (0.81)
	R ²	0.08	0.38**	0.06	0.04
SEG2	Coeff (SE)	0.38 (0.05)	-0.11 (0.02)	0.00 (0.00)	1.84 (0.26)
	R ²	0.73***	0.54***	0.09	0.66***
SEG3	Coeff (SE)	0.57 (0.12)	-0.07 (0.04)	0.00 (0.00)	1.63 (0.36)
	R ²	0.66***	0.2	0	0.45***
SEG4	Coeff (SE)	0.33 (0.09)	-0.23 (0.12)	0.01 (0.00)	1.81 (0.23)
	R ²	0.51**	0.24	0.45***	0.75***
SEG5	Coeff (SE)	0.21 (0.09)	-0.11 (0.02)	0.01 (0.00)	0.84 (0.12)
	R ²	0.21*	0.55***	0.81***	0.71***

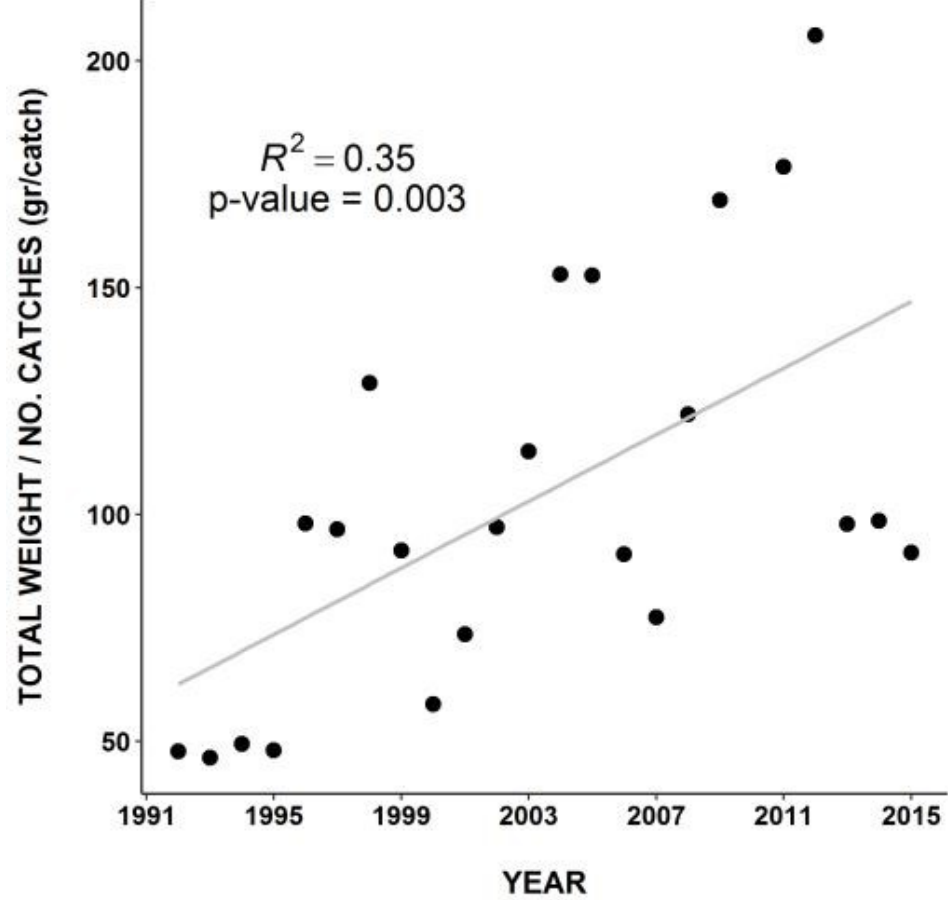


Fig. 1. Trend of catches weight (weight of the total catches/total number of catches) in the annual fishing competition.

Perceptions and behaviour

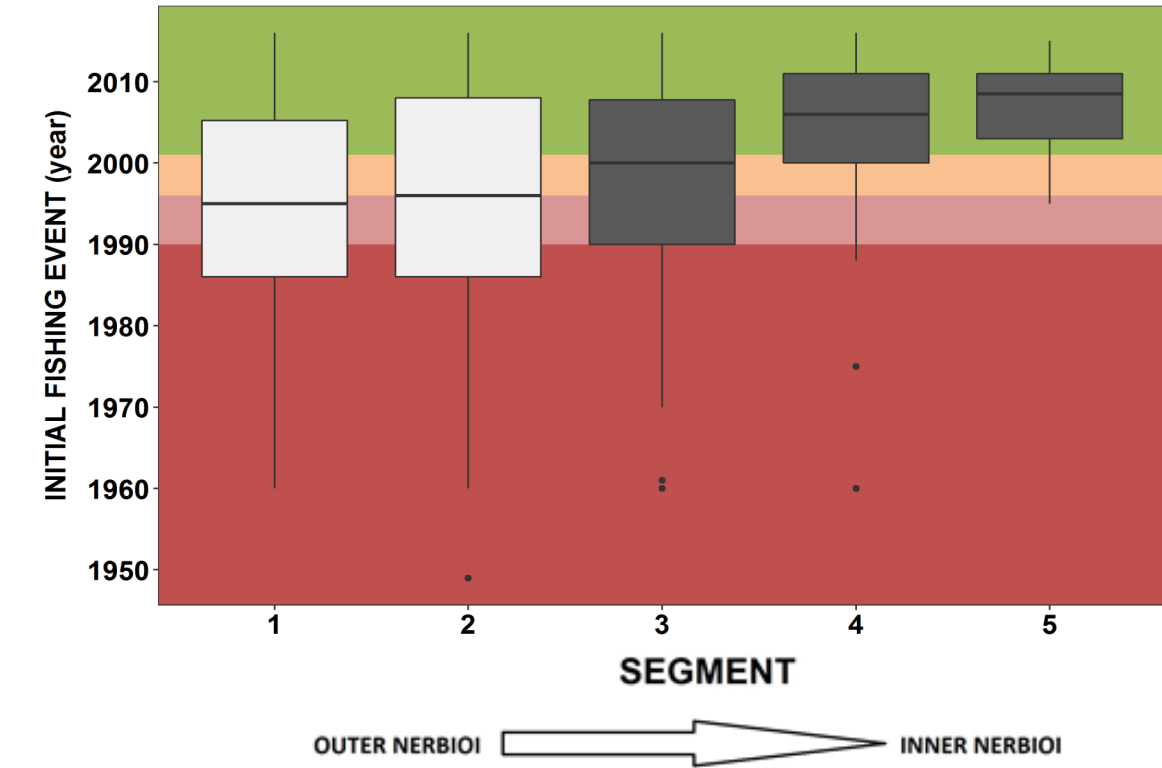


Fig. 2: Median (Q₁-Q₃) year of first fishing event at the 5 areas of Nerbioi. Background colours represent the restoration phases (from degraded: red, to near restored: green).

- Fishers perceived: improvement in water quality (80%), increase in number of fishers (79%), decrease of fish abundance (69%) and mainly no change in fish richness (36%) and fish size (45%).
- Longer fishing experience is: (i) positively correlated ($p<0.05$) with perception of water quality improvement and increase in number of fishers; and (ii) negatively correlated ($p<0.05$) with catch abundance and catch variety increase.

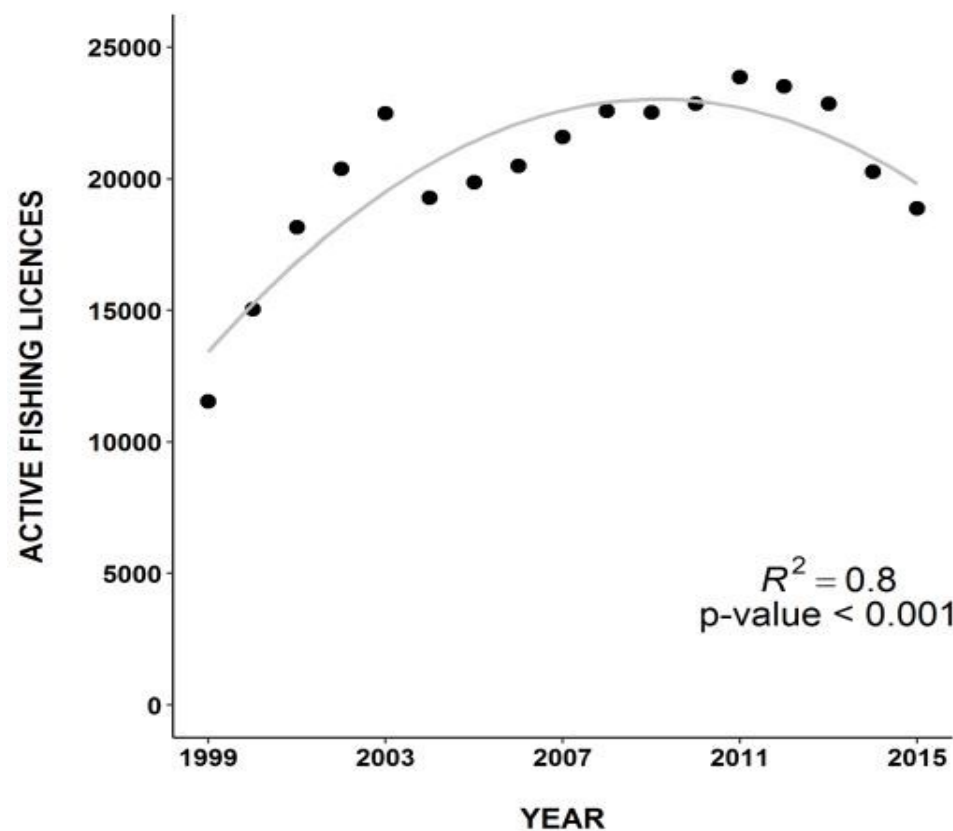


Fig. 3. Evolution of the number of active fishing licenses (on-shore and spearfishing) in the villages located along the estuary.

Bathing waters

Environmental changes

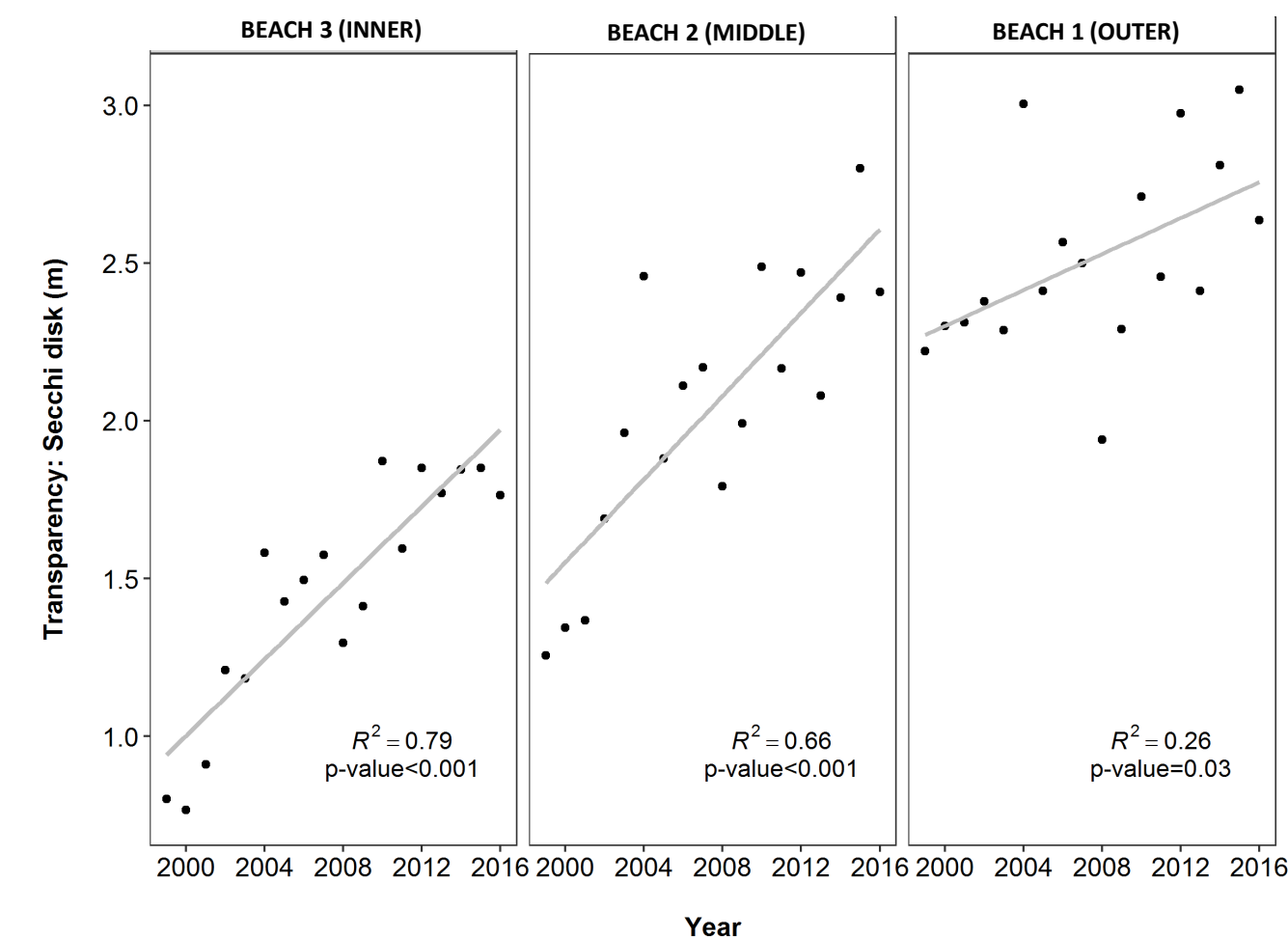


Fig. 4. Trends of the transparency, measured as depth of Secchi disk, in the surroundings of the three beaches. Grey lines indicate linear regressions.

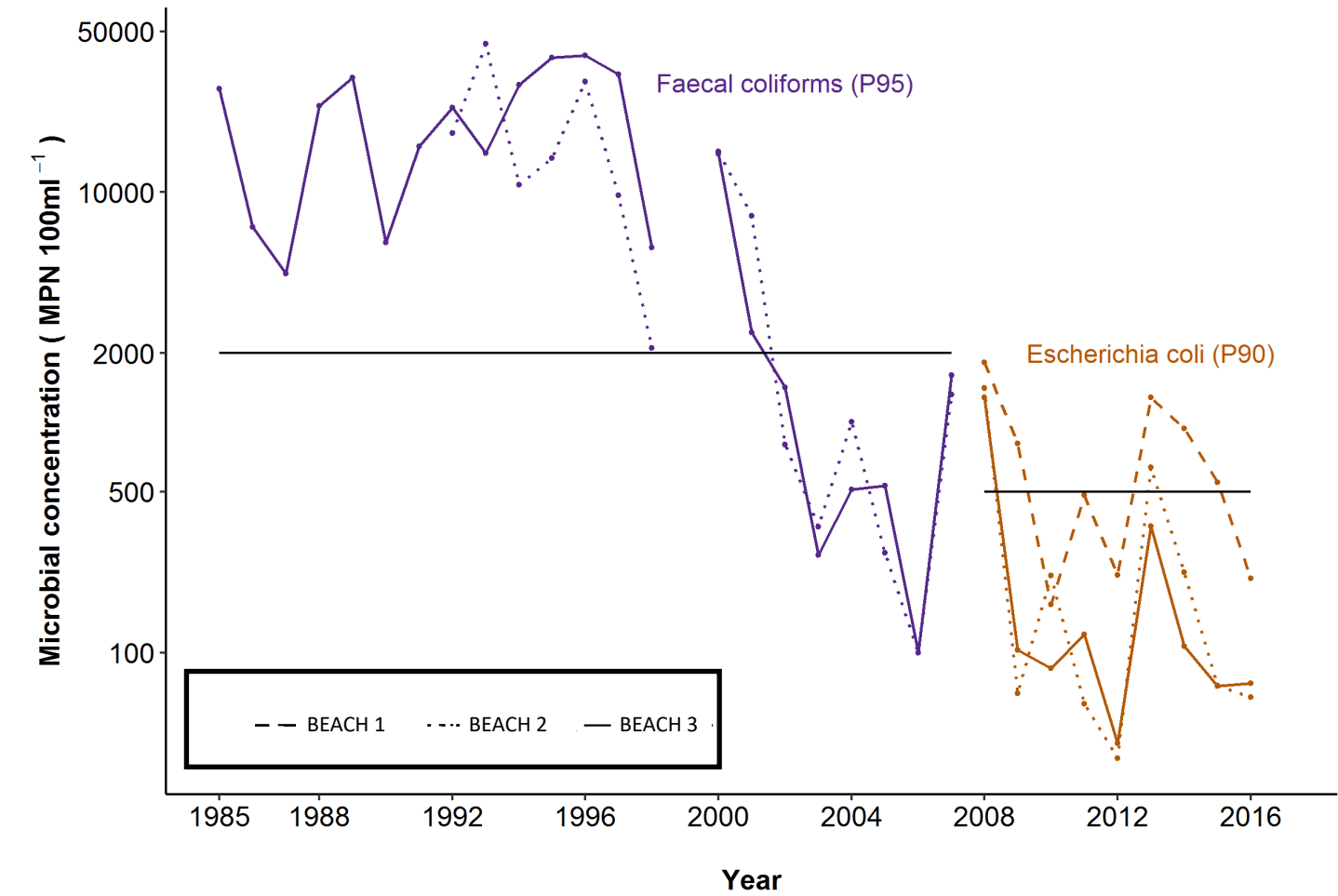


Fig. 5. Faecal coliform (95th percentile) and *Escherichia coli* (90th percentile) inter annual concentrations (MPN: More Probable Number) during the bathing season (May-September). Black lines indicate the imperative value (1985-2007) and the sufficient quality limit (2008-2016), as established in Directives 76/160/CEE and 2006/7/EC).

Perceptions and behaviour

- 92% of visitors are satisfied with their visit to these beaches
- From the inner to the outer beaches the trends are:
 - Percentage of users that practice aquatic activities increases
 - Perception of negative health impacts of bathing decreases
- Longer experience visiting the beaches is positively correlated ($p<0.05$) with a more accurate perception of the improvement on water conditions.

Table 2. Perception of change in bathing waters, split by the year when visitors started to visit Nerbioi beaches. *** means significant differences ($p<0.001$) after Chi squared test. Different lettering (A,B,C) indicate significant differences between visitors, depending on their level of experience of the beach (Chi square’s Post Hoc Test (fifer package in R) $p<0.05$).

	TOTAL	NEW VISITORS	EXPERIENCED VISITORS			Chi squared X ²
		2010-2015	2001-2009	1996-2000	≤ 1995	
BETTER	275 (74.7%)	40 (42.1%)	53 (70.7%)	35 (74.5%)	147 (90.7%)	71.256***
EQUAL	25 (6.8%)	8 (8.4%)	6 (8.0%)	0 (0.0%)	11 (6.8%)	
WORSE	68 (18.5%)	44 (46.3%)	11 (14.7%)	10 (21.3%)	3 (1.9%)	
	368	92	70	45	161	

CONCLUSIONS

Environmental conditions important for recreational fisheries and beach use have significantly improved as a result of restoration management activities

Improvement of environmental conditions have a positive effect on ecosystem services, reflected in changes in the behavior of recreationalists, and in their positive perception on water quality changes

Current recreational use pattern matches the ecological recovery pattern of the estuary: more intense use in the outer part (less polluted) and a less intense in the inner part (more polluted)

To follow a social-ecological approach that captures key environmental and social aspects allowed to provide a more complete comprehension of the dynamics of the restoration process

Investing in restoration of degraded coastal ecosystems can lead to positive outcomes for environmental conditions and also recreational opportunities that promote human physical and mental health

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