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The costs of environmental degradation in the Marine Strategy Framework Directive: A case study from France

Levrel H. (1), Jacob C. (1) , Bailly D. (2), Charles M. (3), Guyader O. (1), Mongruel R. (1), Aoubid S. (4), Bas A. (2), Cujus A. (4), Frésard M. (2), Girard S. (1), Hay J. (2), Laurans Y. (4), Paillet J. (3), Pérez J. (1).

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Abstract

The Marine Strategy Framework Directive requires an initial assessment of the current environmental status of national marine waters and the environmental impact and socio-economic analysis of human activities in these waters by 2012. One important requirement of the socio-economic analysis is the assessment of the costs of degradation of the marine environment. This paper addresses the assessment of the "costs of degradation of the marine environment" in France. Acknowledging the limits and difficulties of capturing the TEV of environmental benefits to assess these costs of degradation, the expert group of economists charged with assessing the costs of degradation of the marine environment in France decided to assess these costs from the environmental management costs, i.e. the real expenditures needed by a socio-economic system to maintain, or even enhance, the ecosystem services they benefit from, or to limit their decrease. The cost of environmental degradation in French waters was just over 2.054 billion Euros in 2010. We discuss our results with those of other Member States who have taken similar approaches in the context of the MFSD and with other similar works carried out at a global scale.

Introduction

The environmental component of the European integrated marine approach is represented by the Marine Strategy Framework Directive (2008/56/EC) (MSFD), which establishes a framework for community action in the area of marine environmental policy. The Directive provides a legislative framework for the ecosystem approach to the management of those human activities which impact the marine environment, and integrates the concepts of environmental protection and sustainable use. This involves several steps:

- the initial assessment of the current environmental status of national marine waters and the environmental impact and socio-economic analysis of human activities in these waters (by 15 July 2012)
- the definition of a Good Environmental State (GES) for national marine waters (by 15 July 2012)

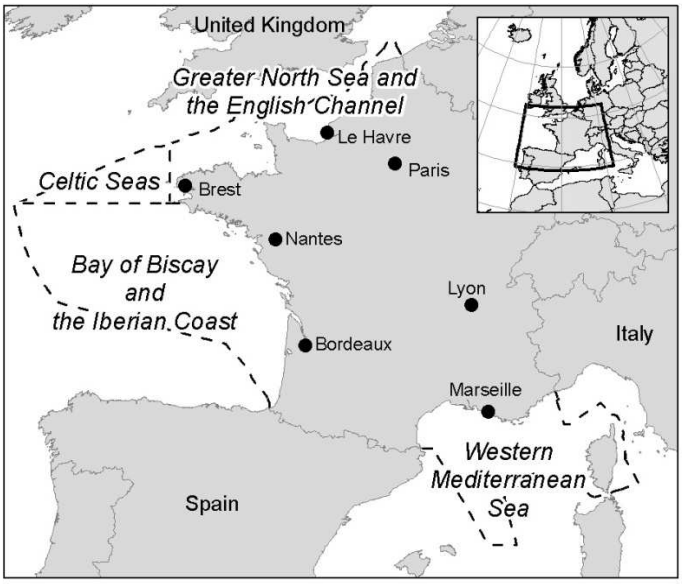
- the establishment of environmental targets and associated indicators for achieving a GES by 2020 (by 15 July 2012)
- the establishment of a monitoring programme for the ongoing assessment and regular update of targets (by 15 July 2014)
- the development of a programme of measures designed to achieve or maintain a GES by 2020 (by 2015)
- the review and preparation of the second cycle (2018–2021).

Member States are to make an initial assessment of their marine waters in each marine region or sub-region, taking account of existing data (where available). This will comprise:

- an analysis of the essential features and characteristics, and current environmental status, of those waters
- an analysis of the predominant pressures and impacts, including human activity, on the environmental status of those waters
- an economic and social analysis of the use of those waters and of the costs of degradation of the marine environment.

In France, the economic analysis of the cost of degradation has been assigned to an expert group of economists working in close relation with the ministry in charge of the environment and the agency in charge of marine protected areas. This analysis must be based on available data and carried out on a sub-regional scale. It will serve to define environmental goals, taking social and economic considerations into account. This in turn will feed into cost/benefit and cost/effectiveness analyses of measures to be defined by 2015 and will help identify disproportionate costs.
This paper addresses the assessment of the "costs of degradation of the marine environment" in France in four sub-regions: the Occidental Mediterranean Sea (OMS), the Channel-North Sea (CNS), the Bay of Biscay (BOB), and the Celtic Sea (CS) (Figure 1). Contributions for the Celtic Sea have sometimes been included in Channel-North Sea or not included if data were not available. The paper does not discuss French overseas territories.

Figure 1: Map of the four marine sub-regions



Method

According to the economic literature, there are two ways of assessing the costs of environmental degradation: as the costs associated with the loss of benefits resulting from the degradation of natural capital (Barbier et al., 2009; Environmental Protection Agency, 2009), and as the maintenance costs required to compensate for actual or potential degradation of natural capital (Bartelmus, 2009; United Nations et al., 2003).

When applied to the marine environment, the first assessment method is based on the Total Economic Value (TEV) of benefits forgone because of the depletion of ecosystem services delivered by marine biodiversity, while the second is based on the costs required to maintain the flow of ecosystem services delivered by marine biodiversity. For instance, in the case of an oil spill it is possible to assign two monetary values to environmental degradation – the loss of benefit caused by the injury, and the costs of restoration of marine biodiversity after the oil spill. There are many differences between these two approaches (Table 1).

Table 1: Differences between the two ways of assessing the costs of environmental degradation

	Cost of maintaining the flow of ecosystem services delivered by marine biodiversity	**Total economic value of benefits forgone because of the depletion of marine biodiversity**
Rationale	Expenditures for restoring or managing ecosystem services	Monetary value associated with loss of well-being resulting from the depletion of ecosystem services
Field of application	Law regarding environmental responsibility and environmental impact assessment	Financial analysis for project management
Cost assessment	Accounting costs	Economic costs
Target	Biodiversity primarily, and indirectly the well-being of the human population benefiting from it	Well-being of the population, including positive and negative externalities
Economic scale	Macro-economic (the socio-ecosystem)	Micro-economic (individual values)
Unit of equivalency	Biophysical units (habitat, species, ecosystem services)	Value units (utility, price, well-being)
Capital theory	Critical natural capital (Ekins, 2003)	Genuine saving (Atkinson and Pearce, 1993)
Large-scale assessment method	Costs transfer	Benefits transfer (Brouwer, 2000)
Level of sustainability	Strong to medium: the natural capital loss cannot be compensated for (replaced) by anything but natural capital. However, the level of compensation strongly depends on the indicator of biophysical equivalency used (habitat, species, etc.)	Weak to medium: the natural capital loss can be compensated for (replaced by) human or manufactured capital. However, it is possible to take into account some thresholds which limit the degree of substitutability

From the point of view of economic theory the first approach is more robust (Mäler, 2008). However, there are at least four major practical issues which have to be addressed when

considering monetary valuation of non-use values, indirect use values, and even simple non-market use values such as recreational activities (Barbier et al., 2009; Heal, 2000; Pearce, 2007; Wallace, 2008):

- the lack of data on interactions between biological entities, ecological functions, ecosystem services production, and changes in well-being (Costanza et al., 2007; Naeem et al., 2009; Carpenter et al., 2006, 2009)
- the high level of uncertainty regarding some of the values based on support services or cultural services (Ludwig, 2000; Toman, 1998)
- the controversies around the benefit-transfer method for extrapolating local values to a regional or national scale (Spash and Vatn, 2006; Braat and ten Brink, 2008; TEEB, 2010)
- the controversies around the stated preferences analysis for capturing non-use, indirect use, and non-market use values (Kahneman et al., 1990; Kahneman and Ritov, 1994; Horowitz and McConnell, 2002)
- ethical issues regarding the commensurability and monetisation of nature (Espeland and Stevens, 1998; Rutherford et al., 1998).

Moreover, the concept of environmental degradation is at least partly a social construct. For instance, the acceptable level of pollutants, the classification of a species as invasive, and environmental compensation are all defined on the basis of social, political, and legal norms. These norms reflect a number of negotiation processes and political trade-offs and are not the product of "environmental rationality" alone; nonetheless, they help to define what counts as a desirable environmental state and, indirectly, what constitutes "environmental degradation" with respect to them.

Recognising these limits, Pearce (2007) has proposed paying attention to the real costs borne by society to provision and maintain ecosystem services – that is, the costs of conservation policies. These can be divided into two categories, the opportunity costs of ecosystem conservation and the management costs of conserving biodiversity and provisioning ecosystem services. Bartelmus (2009) also suggests paying attention specifically to the degradation costs[1], which represent the maintenance costs of a given environmental state.

Acknowledging the limits and difficulties of capturing the TEV of environmental benefits, and considering the operationality of the Bartelmus and Pearce studies, the expert group of economists charged with assessing the cost of degradation of the marine environment in France decided to use what Bartelmus calls the maintenance costs and Pearce the management costs[2].

Concretely, maintenance costs can be understood as the real expenditures needed by a socio-economic system to maintain, or even enhance, the ecosystem services they benefit from, or to limit their decrease. This approach explicitly takes into account the collective choices that have been made about the formulation of the environmental problem, the norms and rules which exist to tackle this issue, and the effort (measured in terms of changes in use and/or restoration programmes) necessary to achieve them. Maintenance costs of course make sense

[1] "Maintenance cost is applied to environmental degradation. The SEEA reviews maintenance costing critically as the hypothetical cost of avoiding pollution or restoring the polluted environment (United Nations et al., 2003, ch.10D). Maintenance cost can be seen, however, as the weights for actual environmental impacts 'according to society's obligation and capacity for dealing with environmental concerns'" (Bartelmus, 2008, p.145); "Such costing is indeed more practical than the assessment of elusive damage effects from environmental impacts" (Bartelmus, 2009, p.1851).

[2] We use the term "maintenance cost" in this paper.

only if environmental standards exist by which to assess the level of natural capital that can be maintained through these investments.
This approach is well suited to the Marine Strategy Framework Directive (MSFD) context, since the main goal of the European Directive is to achieve a GES of the marine environment by 2020.

The initial level of costs of degradation concerned the observed costs for 2010, that is, the current flows of expenditure devoted to conservation of the environment. Unfortunately, the final list of indicators to be used to define the GES descriptors will not be ready before the end of 2012[3]. Consequently, even though the problems have been defined on the basis of the GES descriptors, it has not been possible to use the GES standards to calculate initial maintenance costs. In addition, since the GES standards are not supposed to be complied with before 2020, these standards are not suited to calculating maintenance costs in 2010. The team of French economists has thus adopted the current legal norms, specific to each degradation problem area, as the best substitute (Table 2).

Data

Cost assessment has been broken out in terms of "degradation problem areas". The list of degradation themes was derived from the MSFD list of GES descriptors, and also from the list of "pressures and impacts" in the initial assessment. The ecological standards used to carry out the analysis come from different existing legal frameworks, since the GES descriptors have not yet been quantitatively defined (Table 2).

Table 2: Problem areas, links with MSFD, and current legal standards used to assess maintenance costs

Problem areas	GES descriptors, pressures, and impacts in the MSFD	Current legal framework
Marine litter	descriptor 10 "marine litter"	OSPAR and Barcelona Conventions, Waste water treatment regulation, Water Framework Directive
Chemical compounds	descriptors 8 "contaminants and pollution, ecological effects" and 9 "contaminants in food"	REACH Directive, Waste water treatment regulation, Water Framework Directive, Bathing water regulation
Microbial pathogens	pressure-impact "introduction of microbial pathogens"	Waste water treatment regulation, Water Framework Directive, Bathing water regulation, Regulation on animal products for human consumption (Food law)
Oil spills and illegal discharges	descriptors 8 "contaminants and pollution, ecological effects" and 9 "contaminants in food"	MARPOL, FIPOL, OSPAR and Barcelona Conventions
Eutrophication	descriptor 5 "eutrophication"	Nitrate Directive
Non-native invasive species	descriptor 2 "non-native species"	Ramsar, CITES, Berne, Bonn, Biodiversity, Barcelona, OMI Conventions
Biological degradation of natural resources exploited (split into 2	descriptor 3 "status of species exploited"	European common fisheries policy

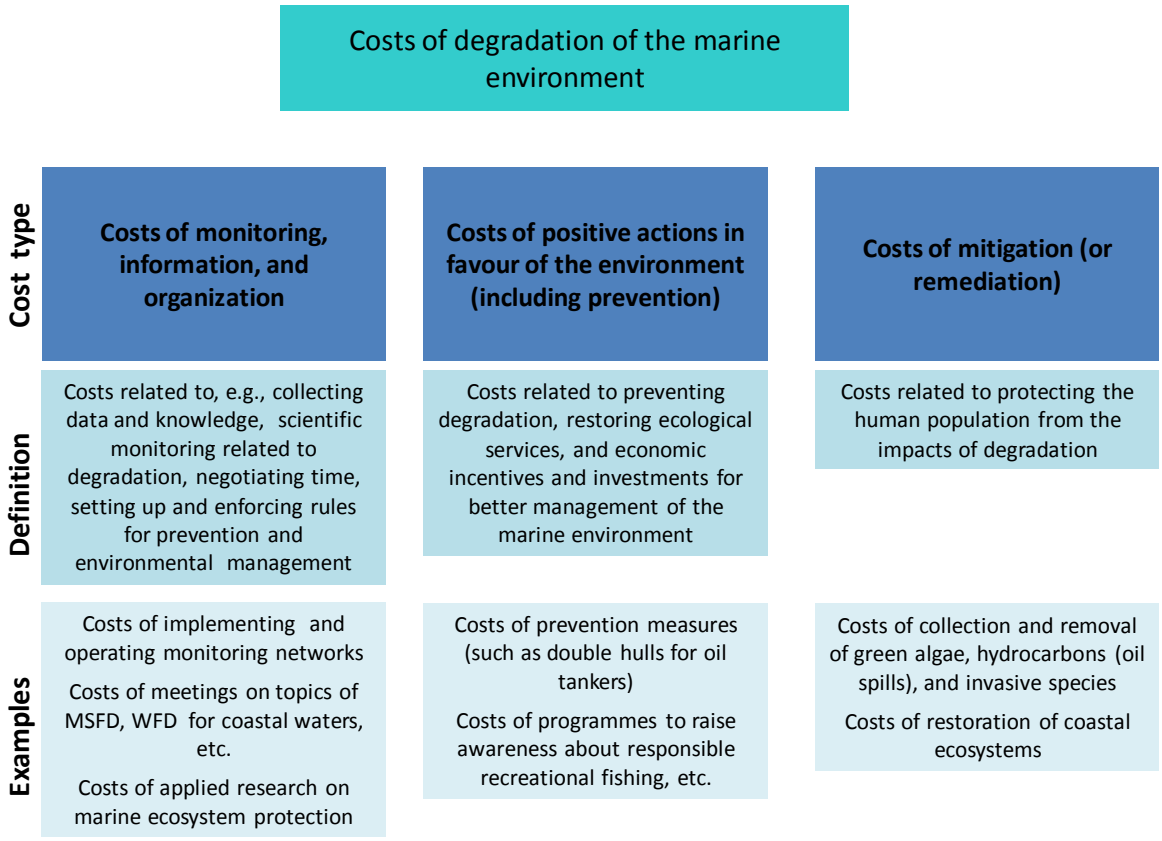
[3] The economic assessment had to be carried out at the same time as the ecological assessment. This was a problem, since it would have made more sense to develop the ecological standard connected with the GES before carrying out the economic analysis.

sub-problems, aquaculture and fisheries)		
Loss of biodiversity, trophic changes, loss of integrity of marine substrates	descriptors 6 and 1 regarding "biodiversity and integrity of the marine substrates" and descriptor 4 "webs"	Convention on biodiversity, European Strategy on Biodiversity, French Strategy on Biodiversity
Introduction of energy into the environment and changes in water regime	descriptors 11 "energy" and 7 "hydrography"	Environmental Impact Assessment Directive

The maintenance costs have been divided into three categories (figure 2):
- Costs of monitoring and information, aimed at improving information and coordination levels
- Costs of positive action for protection of the marine environment, meaning specific investments to prevent and avoid environmental degradation and improve biodiversity
- Mitigation costs, aimed at protecting the human population against the negative effects of environmental degradation, and including restoration costs and compensation costs.

All the costs listed in this assessment are focused on current flows of expenditure. This is one of the reasons why opportunity costs have not been taken into account in our valuation (Pearce, 2007).

Figure 2: The different types of cost of degradation of the marine environment



Information on the environmental costs was collected in 2011, with 2010 as the year of reference for our initial assessment. For each degradation problem, the same methodology was followed:

- Interviews with specialists in each problem area in order to complete the cost structure previously defined by expert referees
- A literature and report review, problem by problem
- Phone and email surveys to collect data from private and public organisations presumed to possess information on the costs listed in tables 1 and 2; more than 150 organisations were contacted during this phase.

The number of organisations to be contacted was quite varied and highly problem-specific (Tables 3 and 4).

Table 3: Organisations contacted

Problem area	Type of organisation contacted	Number of organisations contacted	Response rate
Marine litter	Ministry of the environment, research organisations, Navy, naval prefecture, regional centres of surveillance and rescue, environmental NGOs, maritime ports, environmental consultancy firms, shellfish and fisheries associations, turtle care centres	15	67%
Chemical compounds	Ministry of the environment, research organisations, Centre for marine and fluvial technical studies, maritime ports, French public body in charge of water management, environmental consultancy firm	25	85%
Microbial pathogens	Ministry of health, Sanitary Surveillance Institute, Ministry of the environment, Ministry of agriculture and fisheries, research organisations, NGO, French public body in charge of water management	7	100%
Oil spills and illegal discharges of oil	Ministry of the environment, research organisations, Navy, environmental NGOs, Centre for marine and fluvial technical studies, maritime ports, naval prefecture, local authorities, regional fisheries committees, professional organisation of the French companies of transport and maritime services, regional centres of surveillance and rescue, Naval Hydrographic and Oceanographic Service, International Oil Pollution Compensation Funds, regional tourism committee, environmental consultancy firms, national shellfish committees	25	65%
Eutrophication	Research organisations, French public body in charge of water management, national and regional administration, decentralised services of the agriculture Ministry, decentralised services of the health Ministry, shellfish committees, tourism organisations, maritime port, NGOs, organisations concerned with seaweed management	50	60%
Non-native invasive species	Ministry of the environment, regional and local authorities, research organisations, French public body in charge of water management, regional shellfish committees, diving clubs, marine protected areas, NGOs, French Marine Protected Areas Agency	25	45%
Biological degradation of natural resources exploited: aquaculture	Ministry of agriculture and fisheries, national and regional shellfish committees, shellfish technical centres, research organisations	15	100%
Biological degradation of natural resources exploited: fisheries	Ministry of agriculture and fisheries, research institute, national and regional fisheries committees, national NGOs	7	50%
Loss of biodiversity, trophic changes, loss of integrity of marine	Ministry of the environment, public organisations in charge of environment protection, marine protected areas, environmental consultancy firms, research	130	80%

substrates	institutes, Centre for marine and fluvial technical studies, operator of the French electricity transmission system, French committee of granulate producers, fisheries observers, national and local NGOs, environment observatories, maritime ports		
Introduction of energy	French electricity supplier, research organisations, regional administration, Naval Hydrographic and Oceanographic Service	5	80%

Table 4: Details of data collection for each problem area and each type of cost (incomplete data in grey):

Problem area	Information costs	Positive actions	Mitigation costs
Marine litter	Participation in international convention	Marine programmes of litter reduction of the Ministry of the environment	Collection of litter on beaches (incomplete data)
	Research programmes	Awareness-raising campaign	Collection of litter around nuclear power plants (incomplete data)
	Ministry of the environment (Marine programme)	Certification of litter management in ports (incomplete data)	Collection of litter on the water surface
	Information from Environmental NGOs about litter issues	Improvement of litter management on beaches	Collection of litter on the seabed
			Collection of litter in ports
Chemical compounds	Monitoring of pollution on the coast and in ports	Industrial sewage treatment[4]	None
	Monitoring of dragged sediments (incomplete data)	Collection and treatment of storm water	
	Implementation of REACH Directive	Management of sewage sludge	
	Water Framework Directive coordination for marine water	Action in the agricultural domain to reduce the use of phytosanitary products	
	Implementation of different programmes to reduce chemical compounds (incomplete data)		
	Monitoring of sewage sludge		
	Research programmes		
Microbial pathogens	Monitoring of pollution on the coast and in bathing waters	Domestic sewage water treatment (bacteria)[5]	Purification of shellfish located in a B classified zone
	Research on microbial pathogens	Collection and treatment of storm water	
		Measures linked to use of fertilizer in agriculture	
Oil spills and illegal discharges of oil	Research and data collection programmes (incomplete data)	Litter collection in ports (incomplete data)	Mitigation costs of oil spill impacts
	Functioning of monitoring	Marine pollution prevention	Valuation of voluntary

[4] Investment costs of industrial sewage plants over the whole of France (this corresponds to the zone of sensitivity to chemical contamination as identified by experts)

[5] Investment and functioning costs of sewage plants in a 5 km coastal strip (this corresponds to the zone of sensitivity to microbial contamination as identified by experts)

	and rescue centres (incomplete data)	system (POLMAR) (incomplete data)	work to mitigate oil spill impacts
		Functioning of a centre dedicated to prevention and reduction of marine pollution (CEDRE)	
Eutrophication	Coastal monitoring	Management of watersheds, water agencies (incomplete data)	Collection of green algae
	Research programmes	Information on the national programme on green algae (incomplete data)	Treatment of green algae
	Management of watersheds, water agencies (studies, monitoring)	Regional action programmes (incomplete data)	Construction of green algae treatment plants
	National programme on green algae	Measures to improve agricultural practices (incomplete data)	
	OSPAR implementation	Domestic sewage water treatment (phosphate and nitrate)	
Non-native invasive species	Scientific studies (incomplete data)	None	Reduction of population size (*Crepidula fornicata, Crassostrea gigas, Caulerpa taxifolia*)
	Impact assessment programmes (incomplete data)		
Biological degradation of natural resources exploited: fisheries	Coordination of fisheries management of the fisheries Ministry and decentralised administrations (incomplete data)	Management measures (decommissioning schemes, etc.)	Temporary cessation measures
	Functioning of professional organisations	Control of fisheries (incomplete data)	
	Recreational fishing NGO		
	Fisheries programmes of Environmental NGO		
	Scientific research and monitoring		
Biological degradation of natural resources exploited: aquaculture	Coordination of fisheries management of the Fisheries ministry and decentralised administration	Functioning of regional shellfish committees (except communication, shoreline management)	Cleaning and reorganisation of shoreline
	Functioning of professional organisations		Spat seeding
	Shellfish observatories (monitoring networks)		
	Research programmes (incomplete data)		
Loss of biodiversity, trophic changes, loss of integrity of marine substrates	Coordination of biodiversity conservation programmes of the Ministry of the environment and public structures	Preservation measures of public authorities (land buying, awareness campaigns, and Natura 2000 contracts)	Restoration and planning programmes of public structures
	Impact studies of granulate extraction and maritime port works (incomplete data)	International and national environmental NGO programmes	Restoration activity conducted in Marine Protected Areas
	Observations on "bycatch" (incomplete data)	Management of Marine Protected Areas	Snorkelling areas management
	Professional observatories		Attenuation and

	(incomplete data) Voluntary observatories Local NGOs programmes (incomplete data) Research programmes (incomplete data)		compensation measures linked to granulate extraction and maritime port works (incomplete data)
Introduction of energy	Research on impacts of acoustic devices, military sonar, shipbuilding (incomplete data)	Submarine pulse noise sources for seismic and sonar operators	None for acoustic perturbations
	Monitoring of thermal discards from electric plants Hydrologic parameter monitoring Hydrologic modifications monitoring linked to civil engineering on shore (incomplete data) Monitoring of Rhône alluvial inputs (incomplete data)	Installations providing for good thermal dispersion in sea water at power plant exits (incomplete data)	Shore protection programmes in the south of France

Unfortunately, data about the costs associated with some of the problem areas are not available on a large scale, or have turned out to be incomplete or of very poor quality. This is why the costs related to two of the problems, invasive species and marine litter, are not detailed in this paper. However, the lack of accurate data does not mean that the costs associated with these two problems are insignificant: a rough estimate is that the costs of beach litter collection might represent as much as tens of millions of euros per marine sub-region per year. When data for 2010 were not available or when using data from only one year did not make sense (due to high variability of the costs from one year to the next, such as in the case of oil spills), an inter-annual average was calculated.

Results

Results broken out by problem area

The total expenditure devoted to maintaining the current ecological status of marine waters for France was more than 2 billion euros a year in 2010 (Table 5). A significant proportion of these costs (1.232 billion euros) was related to positive action in the field of prevention against microbial pathogens, in the form of enforcement of water quality standards (99% of the cost was expended on wastewater treatment). These expenditures have as their primary purpose the protection of the health of human populations, and the benefits for the natural environment are indirect. The second highest was the chemical compounds category, with costs associated with prevention of chemical pollution amounting to nearly 350 million euros (80% of the cost was expended on industrial wastewater treatment). Here again, the goal is protection of human health, which explains the size of this expenditure. Next come the costs associated with loss of biodiversity and decrease of fish stocks, 148 and 133 million euros respectively. The high costs associated with fishing are due to the increasing erosion of fish stocks and the need for more sustainable management of these stocks (67% of costs). The costs linked to biodiversity loss are mainly related to monitoring and reporting (52% of costs), which indicate an increasing interest in these issues and a serious lack of scientific data. Finally there are three problems for which the costs of environmental degradation are much

lower: eutrophication (47.4 million euros), oil pollution (47.3 million euros), and degradation of exploited resources related to aquaculture (30 million euros). The costs of positive action for oil spills and illegal discharges come last, due to the fact that anticipating and preventing damage associated with accidental marine pollution is difficult, and also that political action to prevent such damage still seems inadequate.
It is important to note that expenditures related to water treatment also benefit other areas such as aquaculture, fisheries, and biodiversity.

Table 5: Monetary cost of environmental degradation of the marine environment in France, by problem areas and types of cost (in millions of euro)

		Loss of biodiversity	*% of cost type*	Chemical compounds	*% of cost type*	Microbial pathogens	*% of cost type*	Biological degradation of natural resources exploited: fisheries	*% of cost type*	Biological degradation of natural resources exploited: aquaculture	*% of cost type*	Eutrophication	*% of cost type*	Oil spills and illegal discharges of oil	*% of cost type*	Introduction of energy	*% of cost type*	Total	*% of cost type / total*
Costs of monitoring and information	**Organisation in charge of coordination**	8.914 €	*18%*	0.665 €	*1%*		*0%*	13.000 €	*26%*	7.300 €	*15%*		*0%*	19.334 €	*39%*		*0%*	**49.213 €**	*21%*
	Observation, monitoring, studies, expert analysis, impact assessment	23.071	*18%*	65.166 €	*51%*	5.828 €	*5%*	23.700 €	*18%*	5.216 €	*4%*	2.909 €	*2%*			2.600 €	*2%*	**128.489 €**	*55%*
	Research	45.525	*84%*	0.117 €	*0%*	2.302 €	*4%*		*0%*	3.455 €	*6%*	0.189 €	*0%*	1.801 €	*3%*	0.527 €	*1%*	**53.915 €**	*23%*
	TOTAL	**77.510 € (52%)**	*33%*	**65.948 € (19%)**	*28%*	**8.129 € (1%)**	*4%*	**36.700 € (27%)**	*16%*	**15.971 € (53%)**	*7%*	**3.098 € (7%)**	*1%*	**21.135 € (32%)**	*9%*	**3.127 € (6%)**	*1%*	**231.618 €**	*11%*
Costs of positive action for protection of the marine environment	**Measures for sustainable management (MPA, contracts, pollution treatment), control and enforcement**	**41.669 € (28%)**	*2%*	**281.770 € (81%)**	*16%*	**1,232.666 € (99%)**	*71%*	**90.200 € (67%)**	*5%*	**11.506 € (38%)**	*1%*	**35.507 € (75%)**	*2%*	**7.602 € (12%)**	*0%*	**38.600 € (73%)***	*2%*	**1,739.521 €**	*85%*
Mitigation costs	**Compensatory measures (legal obligation)**	11.181 €	*46%*			6.260 €	*26%*	6.800 €	*28%*		*0%*		*0%*					**24.242 €**	*29%*
	Restoration and compensation (voluntary)	18.131 €	*88%*				*0%*		*0%*	2.574 €	*12%*		*0%*					**20.705 €**	*25%*
	TOTAL	**29.312 € (20%)**	*35%*	**0 € (0%)**	*0%*	**6.260 € (1%)**	*8%*	**6.800 € (5%)**	*8%*	**2.574 € (9%)**	*3%*	**8.840 € (19%)**	*11%*	**18.571 € (28%)**	*22%*	**11.000 € (21%)**	*13%*	**83.358 €**	*4%*
TOTAL		**148.491 €**	*7%*	**347.718 €**	*17%*	**1,247.056 €**	*61%*	**133.700 €**	*7%*	**30.051 €**	*1%*	**47.445 €**	*2%*	**47.308 €**	*2%*	**52.727 €**	*3%*	**2,054.496 €**	

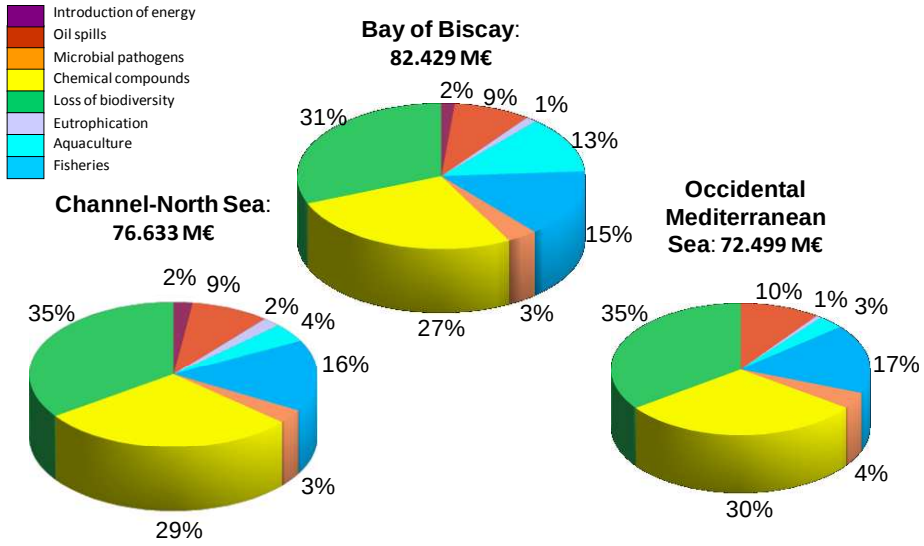
*with the costs averaged over 30 years (actual age of power plants)

Costs broken out by type and marine sub-region

The costs of positive action are by far the highest, at 1.7 billion euros (Table 5). This is mainly due to wastewater treatment for microbial pathogens and chemical compounds (accounting for 89% of these costs). Of the other five problem areas, three (biodiversity loss, oil spills and illegal discharges, and erosion of exploited resources for aquaculture) involve costs of monitoring and information which are higher than the costs of positive action for the environment. The mitigation costs are always the lowest, except for two problem areas (oil spills and illegal discharges, eutrophication) in which they come second; the costs associated with these two areas are related to clean-up of oil spills and green algae. We can also note that the erosion of biodiversity and oil pollution and illegal discharges are the two main contributors to the costs of mitigation.

The relative weight of the different types of cost is variable across the marine sub-regions. The distribution of the costs of monitoring and information is more or less the same in all the marine sub-regions (Figure 3), except for aquaculture, because this activity is mainly conducted in the Bay of Biscay where most of the shellfish farming businesses are located.

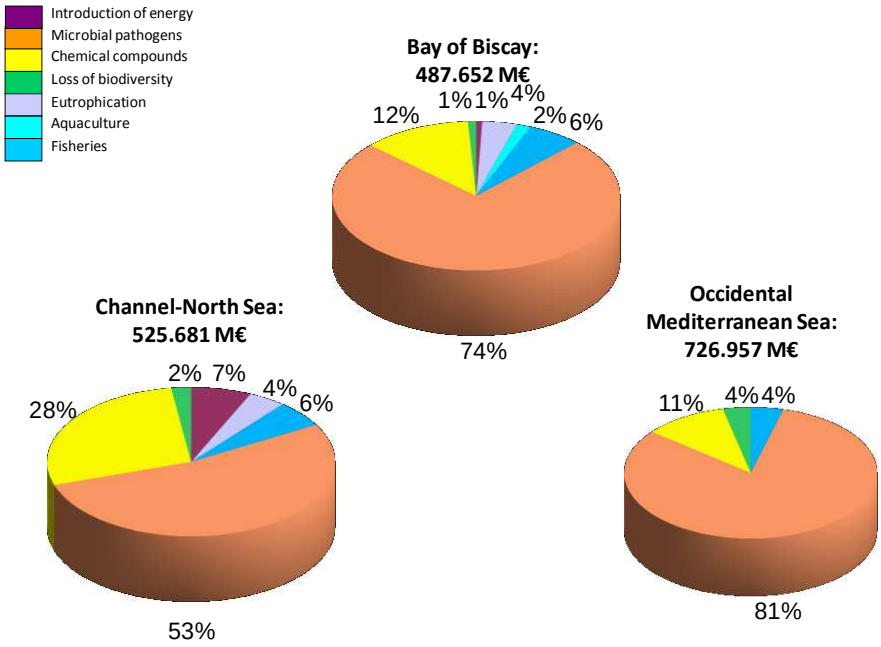
Figure 3: Distribution of monitoring and information costs for each marine sub-region



The distribution of the costs of positive action is highly variable (Figure 4), chiefly because the Occidental Mediterranean Sea benefits from a higher level of expenditure for positive action on the marine environment than the other two sub-regions. The high demographic density (sources of pollution and urbanisation), with 47% of the coastal population of France located in the Mediterranean sub-region, explains why costs associated with wastewater treatment for microbial pathogens and with land acquisition for biodiversity protection are higher. Moreover, the cultural-symbolic significance of the Mediterranean ecosystem and the level of pressure exerted on it create greater political interest in biodiversity protection in this region.

Among other differences, positive action to manage chemical compounds is significantly higher in the Channel-North Sea, where there is a long history of industrial activity. The cost of eutrophication is zero in the Occidental Mediterranean Sea because the principal cause of eutrophication in France is organic nitrates, mainly resulting from intensive livestock breeding located mostly in Brittany (2/3 of this in the Bay of Biscay sub-region and 1/3 in the Channel-North Sea sub-region); the only areas affected by eutrophication in the Mediterranean are lagoons, which are not taken into account in the MSDF. The greater cost of positive action for aquaculture in the Bay of Biscay is in line with the importance of this activity in the area.

Figure 4: Distribution of the costs of positive action for each marine sub-region



Mitigation costs are significantly lower than the two other types, and mainly affect the Channel-North Sea sub-region (47% of the total mitigation costs) (Figure 5). Three factors are relevant here. Compensation for biodiversity losses comes from harbour infrastructure development, granulate extraction, and compensation for environmental damage from recent oil spills in this area. It is necessary to collect and treat green algae on beaches where eutrophication is a source of green tides. Oil spills have also occurred in the Bay of Biscay.
While compensation costs for biodiversity loss are legally mandated (see Table 2) in the Channel-North Sea and in the Bay of Biscay, compensation in the Occidental Mediterranean Sea is related to voluntary efforts conducted in marine protected areas to restore degraded ecosystems.

If we take into account the costs related to marine litter collection on beaches, which are not based on reliable estimates but can be high (around €10 million in each marine sub-region), we see a new distribution of the costs, summarised in Figure 6.

Figure 5: Distribution of the costs of mitigation for each marine sub-region

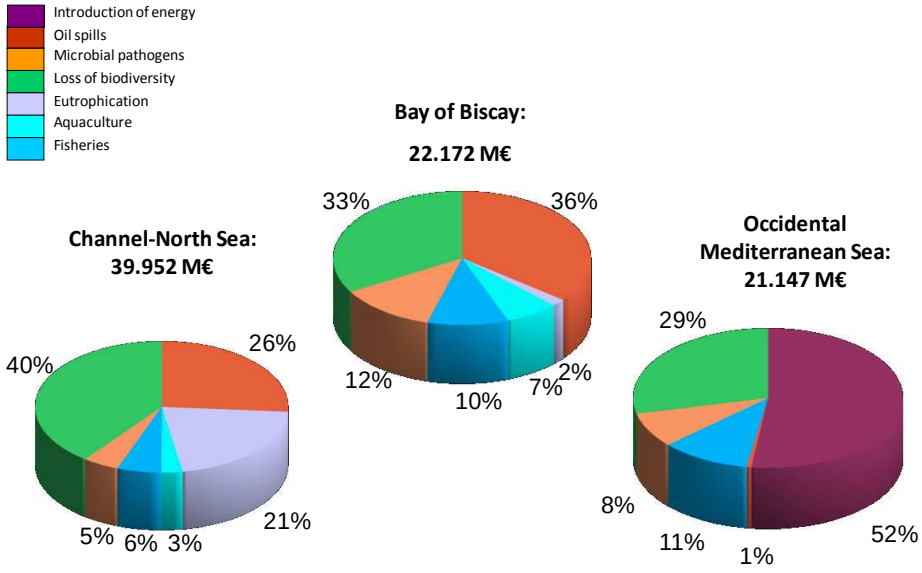
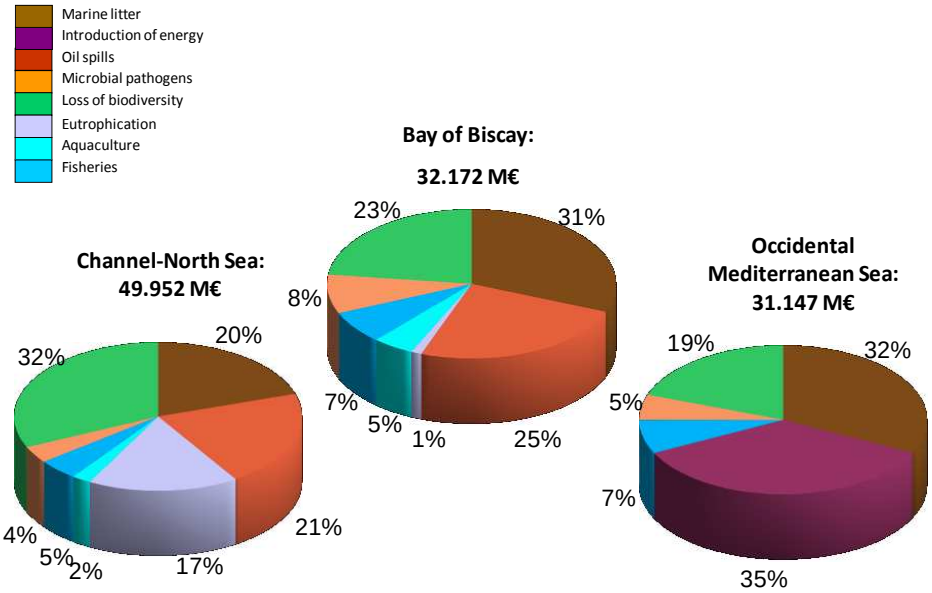


Figure 6: Distribution of the costs of mitigation for each marine sub-region (including the cost of marine litter collection on beaches)



Discussion

The cost of environmental degradation in French waters was just over 2.054 billion Euros in 2010 (not including costs related to marine litter and invasive species) (Table 5). Is this low or high? To find out, we can compare this result with other studies.

First, it is interesting to compare our results with those of other Member States who have taken similar approaches in the context of the MFSD, particularly the Netherlands and Spain. In the Netherlands, total expenditure devoted to the maintenance of desirable environmental conditions amounts to 1.58 billion euros a year, split into land-based costs (1.45 billion) and marine-based costs (0.132 billion) (Walker et al., 2011). Our estimated figures are fairly close to this, but the French coastline is seven times as long as that of the Netherlands. The difference between these results cannot be interpreted at this stage since the methods were not harmonised before the data were collected. In Spain, total expenditure for the maintenance of marine natural capital was around 1.53 billion euros in 2010, divided into seven problem areas (Ministerio de medio ambiente y medio rural y marino, 2011). Even if the problem areas are more or less similar, there are many differences in the way the Member States have broken out the expenditures to be taken into account to calculate the cost of degradation.
Despite the heterogeneous calculation methods, these results can be compared in some ways. For instance, the cost of water treatment in the river catchments represents the lion's share of expenditures in each case (73% in France, 90% in the Netherlands, 38% in Spain).

Pearce (2007) and Bartelmus (2009) have conducted assessments of maintenance costs on a global scale. Pearce focused on biodiversity conservation and Bartelmus on climate change mitigation, the two main global environmental change issues. Pearce drew on data on the costs arising in protected areas, debt-for-nature swaps, global environmental fund, and bilateral assistance; the study only analysed international expenditures devoted to biodiversity conservation and was based on various sources of information which have not been standardised. Bartelmus drew on reports of several organisations on the costs of avoiding pollution or restoring environments polluted by greenhouse gas and other air pollutants. The study excluded solid waste and water pollution, and was based on data from international reports published by the Intergovernmental Panel on Climate Change and the Commission of the European Community.

Bartelmus' analysis resulted in an estimate of $326 billion as the maintenance cost to mitigate climate change (2006). Pearce's analysis resulted in an estimate of $10 billion as the maintenance cost to conserve biodiversity (2004). In his paper Bartelmus compares his evaluation with that of Costanza et al. (1997), noting that maintenance costs are equal to 1% of the $33 trillion (1997) of TEV of the biosphere estimated by Costanza et al. In constant 2010 dollars, this ratio increases by 6.7% (Table 6). When we add the $10 billion estimated by Pearce for biodiversity conservation, the ratio does not change significantly. Even though Bartelmus and Pearce calculated maintenance costs in relation to environmental degradation on a global scale, unlike our study, it is interesting to compare their results with ours.

According to Costanza et al. (1997), a significant part of the $33 trillion worth of benefits delivered by the biosphere comes from marine and coastal ecosystem value: $8.381 billion from the oceans and $12.568 billion from coastal ecosystems. Martinez et al. (2007) provide a detailed evaluation for coastal areas in 2007. That paper notes that the TEV of the French coastal and marine ecosystem services (excluding overseas territories) amounted to $9.854 billion in 2007. If we compare these results to the maintenance costs that we estimated for

coastal and marine areas, 2.054 billion in constant 2010 euros, the ratio between our assessment and the total economic value of the French marine and coastal ecosystem services seems high. In constant 2010 dollars, the ratio is 18.42% (Table 6).

Table 6: Comparison of present GNP, TEV, and maintenance costs (in billions of constant 2010 dollars)

	Total economic value	Maintenance costs	% Maintenance costs / TEV
World	48,877.345 (Costanza et al., 1997)	3,254.597 (Bartelmus, 2009)	6.66 %
French marine coastal ecosystems (excluding overseas territories)	14.595 (Martinez et al., 2007)	2.688* (this study)	18.42 %

* Exchange rate 2010: 1,3084285 €/$

The claim that the costs of maintenance would be equal to 18.42% of the TEV of coastal ecosystem services is questionable, especially if we compare it with Bartelmus (6.66%). Several factors can be adduced to explain these differences:

- There are differences in the calculation methods.
- The scope of the data collection effort in the French case study is different from that of the Bartelmus and Pearce analyses: Pearce and Bartelmus omit many sources of data, especially on a national level.
- Costs of maintenance for marine and coastal ecosystems are significantly higher than for other types of ecosystems; it is clearly more costly to manage, monitor, and control conservation activity in marine and submarine areas.
- The level of regulation regarding environmental conditions in Europe is significantly higher than in other parts of the world; the norms in Europe, especially for marine and other bodies of water, are probably stricter than in the rest of the world (except other OECD countries) and require investment in water management policies.

All these comparisons (the Netherlands and Spain in the MSFD and the work of Pearce and Bartelmus on maintenance costs) highlight the lack of standardisation and homogenisation of costs assessment methods, in contrast to conventional monetary economic valuations which have been discussed for a long time and are more stabilised. However, the accounting approach we have adopted seems easy to standardise if common criteria are adopted for the expenditures to be taken into account.

In subsequent years, then, this initial statement ought to help in monitoring the additional environmental degradation costs resulting from the implementation of new legal norms (GES) associated with the MSFD. The programme of measures designed to reach the GES will indeed add new costs for public and private stakeholders. The core question is whether the efforts to reach the GES will be cost-effective. This would require assessing environmental degradation costs again in 2015 and 2020, to monitor increases in costs and the associated GES descriptors.

One limitation of this assessment is that these costs make sense only if they are balanced with the effectiveness of the conservation activity. For this reason, an additional indicator could be adopted to assess the level of effectiveness of environmental policies. This indicator would tell us whether the legal norm has been attained. If it has not, some impacts on society are still presumed to be observable: these may be called “residual impacts”. Non-monetary indicators can also be used, such as numbers of days when shellfish farming is prohibited due to bacterial pollution, time spent removing litter from fishing-nets, number of oil-coated birds, and so on.

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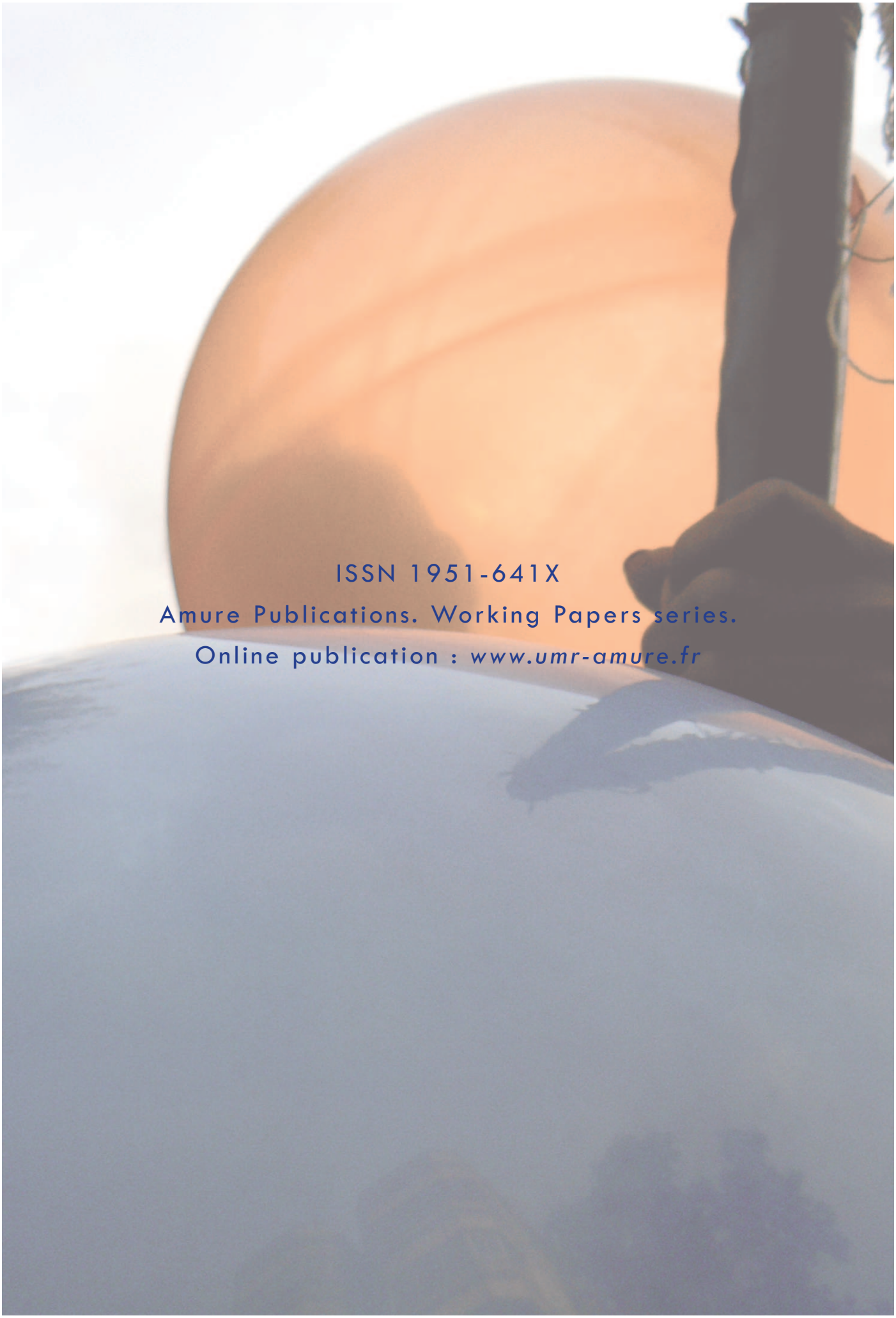

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