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The maintenance costs of marine natural capital: A case study from the initial assessment of the Marine Strategy Framework Directive in France

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Abstract:

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, and as the maintenance costs required to compensate for the actual or potential degradation of natural capital. The first of these methods is based on the Total Economic Value (TEV) of benefits forgone because of the depletion of ecosystem services delivered by marine biodiversity. The second method is based on the costs required to maintain a good state of marine biodiversity, one which makes it possible to deliver ecosystem services.

This paper gives an illustration of this second approach. It details how these maintenance costs have been calculated in the initial assessment of the Marine Strategy Framework Directive (MSFD) in France. It addresses nine problem areas – corresponding to nine sources of environmental degradation – from non-native invasive species to oil spills. It gives a total figure for these degradation costs (around 2 billion Euros). The results are compared with those of other Member States who have taken similar approaches in the context of the MSFD. One key conclusion is that it is not really possible to make meaningful comparisons at this stage, since the methods of data collection and the nature of the costs are very different. The need to develop such assessments in a standardised way is noted.

Highlights

► The MSFD requires an assessment of the degradation costs of the marine environment. ► In France, these costs have been assessed from the maintenance costs method. ► The cost of environmental degradation in French waters is 2.054 billion Euros. ► This result is balanced with those of other Member State.

Keywords: Maintenance cost ; Marine ecosystems ; Marine Strategy Framework Directive ; Economic analysis

1. Introduction

This paper discusses the assessment of the cost of environmental degradation, in the policy context of the Marine Strategy Framework Directive (MSFD). The MSFD represents the environmental component of the European integrated marine approach (2008/56/EC) and establishes a legislative framework for community action in the area of marine environmental policy. The ultimate aim is to design a programme of environmental measures to achieve a good environmental status (GES) by 2020. The MSFD is founded on an initial assessment of the current environmental status of national marine waters and a socio-economic analysis of human activities in these waters (carried out in 2012). The initial socio-economic assessment includes an analysis of the costs of degradation of the marine environment.

There are two ways of assessing the costs of environmental degradation [1]: as the costs associated with the loss of benefits resulting from the degradation of natural capital [2], [3], and as the maintenance costs required to compensate for the actual or potential degradation of natural capital [4], [5]. The first method for assessing the costs of environmental degradation is based on the Total Economic Value (TEV) of benefits forgone because of the depletion of ecosystem services delivered by marine biodiversity. The second method is based on the costs required to maintain a good state of marine biodiversity which makes it possible to deliver ecosystem services.

The expert group of economists charged with assessing the cost of degradation of the marine environment in France recognised the limits and difficulties of capturing the TEV of the environmental benefits discussed in the literature (see the Method section), and decided to use the maintenance costs method.

This paper presents the results of this assessment, and attempts to describe the challenges, strengths and limits of the maintenance cost assessment method.

The paper is organised as follows: the method and the data used to assess the costs of degradation in the French case study are described and discussed; next, the results of the assessment are detailed; finally, the results are discussed and compared with those of other Member States who have taken similar approaches in the context of the MFSD. In conclusion, the strengths, limits and prospects of these types of assessment are discussed.

2. Materials and method

2.1. Context

In France, the economic analysis of the costs of degradation has been assigned to an expert group of economists, specialists in marine economics who belong to the Centre for the Law and Economics of the Sea (UMR AMURE[1]), working closely with the Ministry of Ecology, Sustainable Development and Energy[2] and with the Marine Protected Area Agency.[3] To carry out the work two full-time agents were recruited, and three part-time external consultants were involved in the assessment process.[4] It was decided, in accordance with the MSFD, that this analysis had to be based on available data and carried out on a sub-regional scale. The analysis took four marine sub-regions into account: 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

[1] http://www.umr-amure.fr/index2.php
[2] http://www.developpement-durable.gouv.fr/
[3] http://www.aires-marines.com/
[4] The experts, consultants, and agents recruited for this task are listed as co-authors.

Sea, or not included if data were not available. This analysis did not take French Overseas Territories into account.

FIGURE 1

2.2. Economic assessment methods

As mentioned in the Introduction, there are two ways to assess the cost of environmental degradation: through the loss of benefits or through the cost of compensating for this degradation.

From the point of view of standard economic theory the first approach is more robust, since it is in accordance with the welfare optimisation analysis [6]. However, there are at least six 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 [2], [7], [8], [9]: the lack of data on interactions between biological entities, ecological functions, ecosystem services production, and changes in well-being [10], [11], [12], [13]; the high level of uncertainty regarding some of the values based on support services or cultural services [14], [15]; the controversies around the benefit-transfer method for extrapolating local values to a regional or national scale [16], [17], [1]; the controversies around the stated preferences analysis for capturing non-use, indirect use, and non-market use values [18], [19], [20]; ethical issues regarding the commensurability and monetisation of nature [21], [22]; and the limits of the TEV as a source of relevant information when the analysis is used in a policy framework in which certain strong sustainability goals are fixed [23], [24].

Recognising these limits, Pearce [8] has proposed paying attention to the real costs borne by society to provision and maintain ecosystem services – that is, the costs of conservation policies. Bartelmus [4] also suggests paying attention to the maintenance costs of a given environmental state.[5]

The maintenance cost assessment has, until now, mainly been used in specific environmental policies for the calculation of the environmental restoration costs associated with environmental damage following a pollution event [25], [26], [27]. In this context, the assessment is carried out to determine how much the polluters have to pay to restore what they have damaged and to reach a "no net loss" goal of ecosystem services, acting in accordance with a strong sustainability principle [26], [28]. Concretely, in the MSFD the maintenance costs can be understood as the real expenditures that a socio-economic system needs in order to maintain the level of natural capital required to deliver a certain level of ecosystem services.

This method does not take the economic welfare theory into account but draws on a basic accountability theory. Maintenance costs can therefore be disproportionate with respect to the measurable benefits resulting from the expenditures required to maintain the level of natural capital [3] (Table 1). This is clearly one of the main limits of this method; but it is also one of the strengths of the maintenance cost approach.

TABLE 1

[5] "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 ([5], 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"" ([4], p.145); "Such costing is indeed more practical than the assessment of elusive damage effects from environmental impacts" ([4], p.1851).

Thus, the maintenance costs assessment makes sense only within a policy framework in which some environmental standards have been adopted, reflecting the level of natural capital that a society agrees to maintain through a specific level of investment. This policy framework is a product of compromise over the formulation of the environmental problem, the norms and rules which are necessary to tackle this issue, and the effort (measured in terms of changes in use and/or restoration programmes) required to achieve them. The MSFD includes a clear environmental normative reference (the GES), reflecting a strong sustainability goal, which will be the product of a number of negotiation processes and political trade-offs.

In this context, it is inappropriate to provide a TEV resulting from individual aggregated preferences,[6] since that would be based on a different normative principle from the GES, namely the maximum of welfare. But it might seem meaningful to know the current maintenance costs devoted to marine environmental ecosystem management, considering the gap between the present situation and the GES goal. Indeed, to achieve the GES will require improving and complementing existing marine environmental management measures, which will generate additional costs. From this perspective, the maintenance cost approach will also provide the basis for a future cost-effectiveness analysis of the complex management system which will result from the Program of Measures recommended by the MSFD. It is for these reasons, in addition to those mentioned in the introduction, that the team of experts believed that this approach was the best to use for assessing the costs of environmental degradation.

The costs of environmental degradation discussed in this paper are the real expenditures devoted to conservation of the marine environment in 2010.[7] However, 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 thus adopted the current legal norms, specific to each degradation problem area, as the best substitute (Table 2).

The maintenance costs were then divided into three categories (Figure 2).

- Costs of monitoring and information: aimed at improving information and coordination levels relative to conservation of the marine environment
- Costs of preventing environmental degradation: costs of specific investment in preventing and avoiding environmental impact
- Costs of environmental restoration and remediation: costs of environmental restoration and remediation after destruction or an ecological accident.

FIGURE 2

2.3. Data

Data on the environmental costs was collected in 2011, with 2010 as the year of reference for our assessment.

[6] Assuming that it is impossible to set an aggregation rule that would make it possible to sum individual preferences within a TEV in a way that would be in accordance with the norms that society as a whole agrees to be essential, as noted long ago by Kenneth Arrow (1950), the maintenance cost assessment seems to be more suited to the MSFD in which some normative environmental goals have already been adopted.

[7] This was the last year of available data at the time the study was carried out.

Cost assessment has been broken out into nine "degradation problem areas": Marine litter; Chemical compounds; Microbial pathogens; Oil spills and illegal discharges; Eutrophication; Non-native invasive species; Biological degradation of natural resources exploited; Loss of biodiversity, trophic changes, loss of integrity of marine substrates; and Introduction of energy into the environment and changes in water regime. The list of degradation areas 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 (Table 2).

TABLE 2

For each of the nine degradation problem areas, the same methodology was followed:

- Interviews with specialists in the nine degradation problems from different public and private organisations, in order to complete the cost structure previously defined by the teams of expert economists
- 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 3 and 4; more than 150 organisations were contacted during this phase. The number of organisations to be contacted for each of the nine areas was varied and highly problem-specific. The organisations contacted are listed per category of environmental problem in Table 3 and per category of costs in Table 4.

TABLE 3

TABLE 4

The survey was conducted using the following questions:

- Is your organisation involved in one of the following types of activity: activities related to monitoring or information; measures for sustainable management, control, and enforcement; compensatory measures or restoration? (this question was modified depending on the remit of the organisation)
- Can you give some examples of activities? (this question was modified depending on the remit of the organisation)
- Can you give details of the budget allocated to each activity and the full-time staff equivalent devoted to each one?
- Do you have a financial statement which breaks out the different activities pursued?
- Does the budget allocated to each activity change from one year to the next?

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 problem areas, 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.

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.

3. Results

3.1. Results broken out by problem area

The total expenditure devoted to maintaining the current ecological status of marine waters for France was more than 2,054 million euros a year in 2010 (Table 5). A significant proportion of these costs (1,247 million euros) was related to preventing environmental degradation by microbial pathogens, and took 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. This is the reason why the costs are the highest. The perception of the risks associated with water pollution is greater when human health may be impacted than when only biodiversity is affected. The second highest was the chemical compounds category, with costs associated with prevention of chemical pollution amounting to 347 million euros (81% 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 substantial 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 preventing environmental degradation caused by 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.

TABLE 5

3.2. Costs broken out by type and marine sub-region

The costs of preventing environmental degradation 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 preventing environmental degradation. The costs of environmental restoration and remediation 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. Another point brought out by the analysis is that the erosion of biodiversity and oil pollution and illegal discharges are the two main contributors to the costs of environmental restoration and remediation.

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

The distribution of the costs of preventing environmental degradation is highly variable (Figure 4), chiefly because the Occidental Mediterranean Sea benefits from a higher level of expenditure for the prevention of marine environmental degradation 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, the cost of prevention related to managing 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 preventing environmental degradation relative to aquaculture in the Bay of Biscay is in line with the importance of aquaculture in the area.

FIGURE 4

The costs of environmental restoration and remediation are significantly lower than the two other types of cost, and mainly affect the Channel-North Sea sub-region (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.

Compensation costs for biodiversity loss are legally mandated (see Table 5). These costs are very substantial in the Channel-North Sea and in the Bay of Biscay, since there has been some project development (especially new harbours). In the Occidental Mediterranean Sea, the costs of restoration are mainly due to voluntary efforts conducted in marine protected areas to restore degraded ecosystems.

FIGURE 5

4. Discussion

The main question discussed in this paper, as noted in the Introduction, is the feasibility and robustness of the maintenance cost assessment method for evaluating environmental degradation costs. The literature on the maintenance costs of marine ecosystems seems limited to the costs of establishing and managing marine protected areas [29], [30], [31]. In the present study, we have attempted to produce an integrated assessment of maintenance costs for all the environmental components of French marine ecosystems. In order to take the interpretation of the results farther, they have to be compared with the assessments and studies carried out by other Member States; however, the limits of such a comparison also need to be recognised.

4.1. Comparisons with other national 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, especially 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 [32]. Our estimated figures are fairly close to this, but the French coastline is seven times as long as that of the Netherlands. In Spain, total expenditure for the maintenance of marine natural capital was around 1.53 billion euros in 2010, divided into seven problem areas [33]. Even if the problem areas are more or less similar to the French ones, 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. The differences between these results are difficult to interpret at this stage, since the methods were not harmonised before the data were collected.

However, 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). As noted above, this may be due to the fact that it is necessary to protect human health.

4.2. Comparisons of cost and effectiveness

This assessment should 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.

In subsequent years, our results ought to help in monitoring the additional environmental degradation costs that will result 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 key question is whether the efforts to reach the GES will be cost-effective. Answering this will require assessing environmental degradation costs again in 2015 and 2020, in order to monitor increases in costs and the associated GES descriptors.

One limitation of this assessment is that these costs are meaningful only if they are balanced against 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. Even if it has not, some impacts on society are still expected 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.

4.3. Limits of the maintenance cost method and recommendations

All these comparisons highlight the lack of standardisation and homogenisation of maintenance cost assessment methods, in contrast to conventional monetary economic valuations which have been discussed for a long time in the literature and are more clearly defined.

At this stage, there is no point in making any comparisons, given the lack of common methods for collecting data. In addition, it seems that the reported level of these costs is deeply influenced by the sampling efforts: the more actively you look for expenditures, the more the costs of maintenance are increased.

It is also important to note that this method is really time-consuming. The data collection took almost one year and required one full-time person plus one available expert for each of the "problem areas", in order to be sure that the costs about which information was collected are clearly related to the maintenance of the natural capital being assessed.

To improve the level of the quality of such assessments, it is crucial to develop some standards regarding

- A data collection framework or guidelines which would make it possible to: (1) define some categories of cost, as proposed in this paper; (2) target the organisations where collecting information on these costs is necessary; and (3) spell out how the interviews with the organisation representatives must be conducted, what sampling frame and extrapolation variables can be used if it is not possible to gather exhaustive data, and what types of cost are eligible (or not) for the assessment.
- An accounting system framework which would make it possible to: (1) link up with the national accountability system and companies" accountability systems; (2) organise the data collection; and (3) make comparisons using macro-economic and micro-economic indicators as well as ecological indicators from which effectiveness analysis could be carried out.

The only source of such standards are the United Nations systems of economic and environmental accounting [4]. It seems important to make the link between these accounting systems and this type of evaluation more explicit. It would also be useful to standardise the typology of management interventions (observation, prevention, and maintenance or restoration) that Member States will implement in their MSFD Programme of Measures in order to facilitate ex-ante and ex-post assessments of these Programmes, as well as comparisons across Member States.

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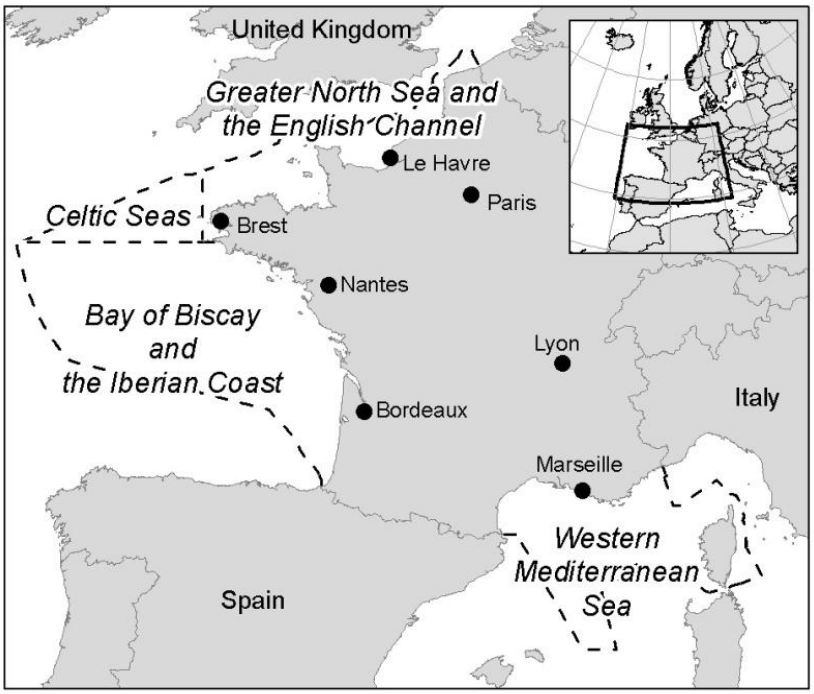
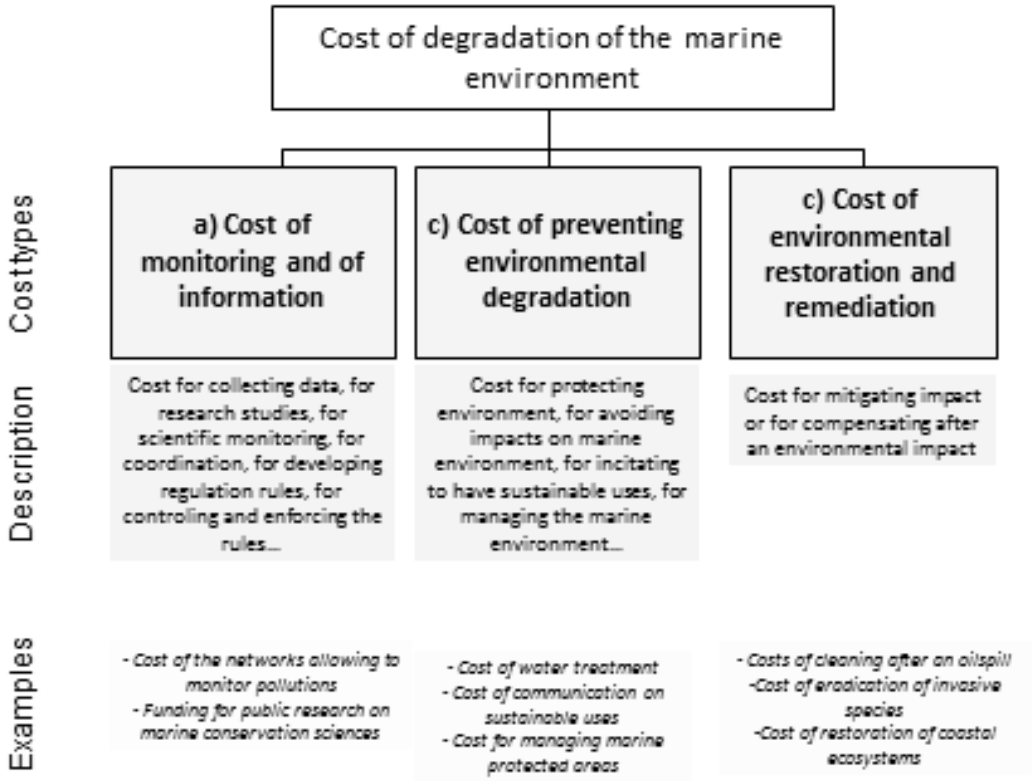
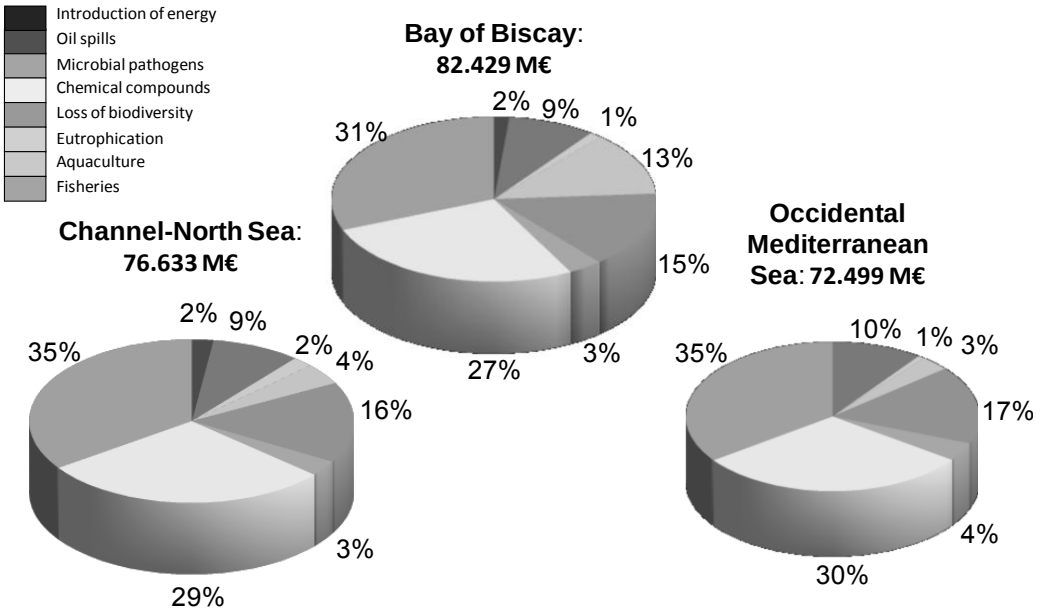
Figure


United Kingdom
Greater North Sea and the English Channel
Le Havre
Paris
Celtic Seas
Brest
Nantes
Bay of Biscay and the Iberian Coast
Lyon
Italy
Bordeaux
Marseille
Western Mediterranean Sea
Spain

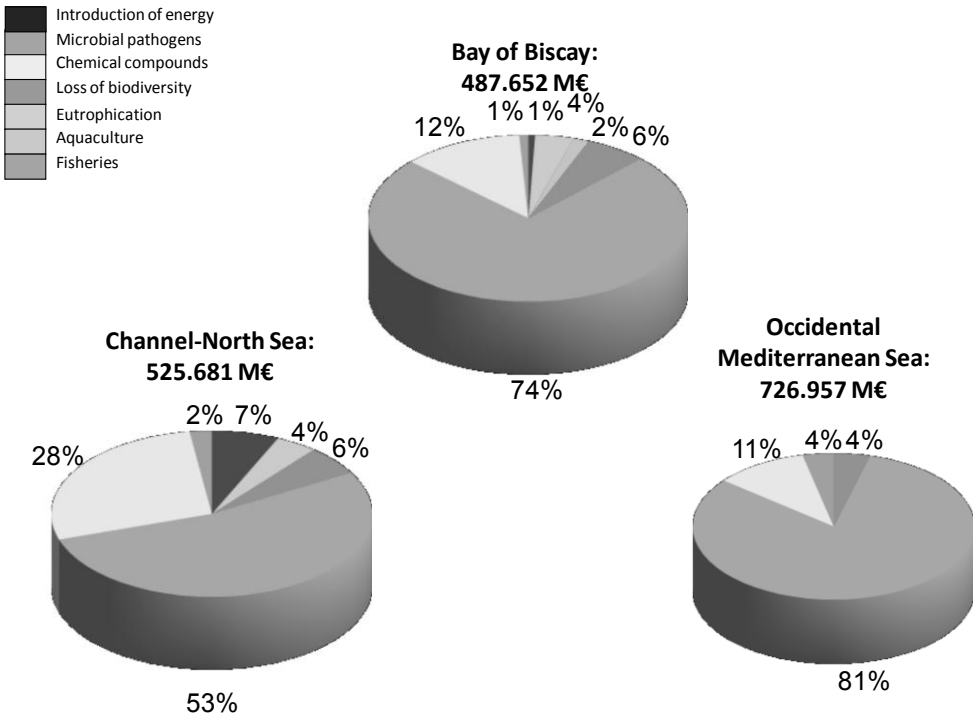
Figure


Cost of degradation of the marine environment
Costtypes
Description
Examples
a) Cost of monitoring and of information
c) Cost of preventing environmental degradation
c) Cost of environmental restoration and remediation
Cost for collecting data, for research studies, for scientific monitoring, for coordination, for developing regulation rules, for controling and enforcing the rules...
Cost for protecting environment, for avoiding impacts on marine environment, for incitating to have sustainable uses, for managing the marine environment...
Cost for mitigating impact or for compensating after an environmental impact
- Cost of the networks allowing to monitor pollutions
- Funding for public research on marine conservation sciences
- Cost of water treatment
- Cost of communication on sustainable uses
- Cost for managing marine protected areas
- Costs of cleaning after an oilspill
-Cost of eradication of invasive species
-Cost of restoration of coastal ecosystems

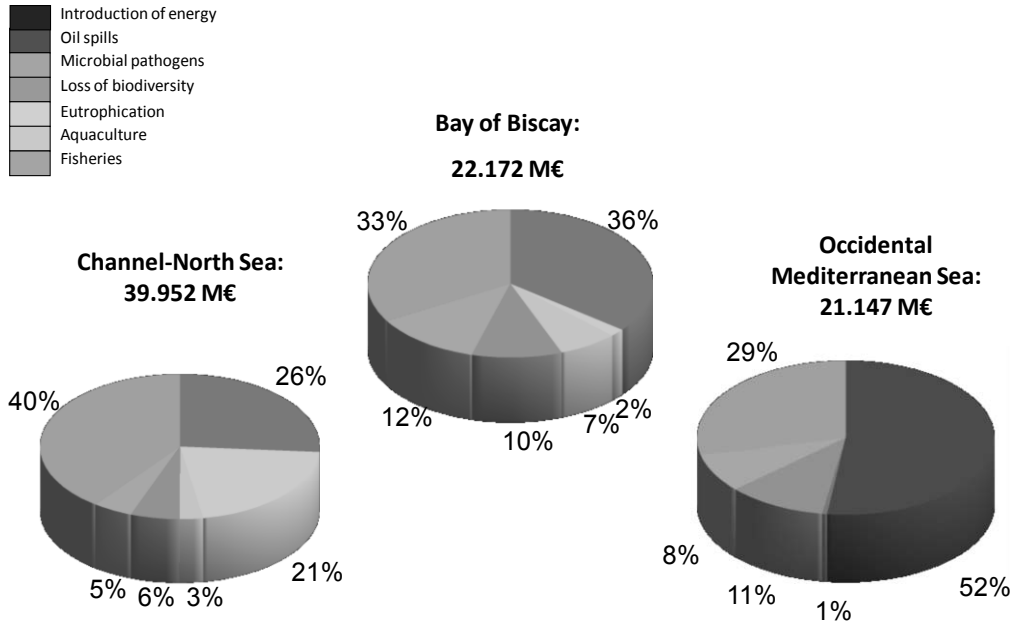
Figure


Introduction of energy
Oil spills
Microbial pathogens
Chemical compounds
Loss of biodiversity
Eutrophication
Aquaculture
Fisheries
Bay of Biscay:
82.429 M€
2%
9%
1%
13%
15%
3%
27%
31%
Channel-North Sea:
76.633 M€
2%
9%
2%
4%
16%
3%
29%
35%
Occidental Mediterranean Sea: 72.499 M€
10%
1%
3%
17%
4%
30%
35%

Figure


Introduction of energy
Microbial pathogens
Chemical compounds
Loss of biodiversity
Eutrophication
Aquaculture
Fisheries
Bay of Biscay:
487.652 M€
12%
1%
1%
4%
2%
6%
74%
Channel-North Sea:
525.681 M€
28%
2%
7%
4%
6%
53%
Occidental
Mediterranean Sea:
726.957 M€
11%
4%
4%
81%

Figure


Introduction of energy
Oil spills
Microbial pathogens
Loss of biodiversity
Eutrophication
Aquaculture
Fisheries
Channel-North Sea:
39.952 M€
40%
26%
21%
5%
6%
3%
Bay of Biscay:
22.172 M€
33%
36%
12%
10%
7%
2%
Occidental
Mediterranean Sea:
21.147 M€
29%
8%
11%
1%
52%

Table

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	Investment required for restoring or maintaining natural capital	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	Natural capital 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)
Main limit of the method	This method does not take economic welfare theory into account. Maintenance costs can be disproportionate relative to the benefit provided by the investment in natural capital (EPA, 2009).	Cost-benefit analysis does not say anything about ecological sustainability. The internalization of the externalities can lead to major loss of biodiversity and threaten social-ecological resilience (Bithas, 2011)
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

Table

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 included in the analysis	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 sub-problems, aquaculture and fisheries)	descriptor 3 “status of species exploited”	European common fisheries policy
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

Table

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 substrates	Ministry of the environment, public organisations in charge of environment protection, marine protected areas, environmental consultancy firms, research 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	130	80%
Introduction of energy	French electricity supplier, research organisations, regional administration, Naval Hydrographic and Oceanographic Service	5	80%

Table

Table 4: Detailed environmental measures whose costs have been estimated in this paper (in grey when the information is missing; when the data collected are incomplete, this is noted in parentheses)

Problem area	Costs of monitoring and information	Costs of preventing environmental degradation	Costs of environmental restoration and remediation
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[1]	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	
	Monitoring of sewage sludge		
	Research programmes		
Microbial pathogens	Monitoring of pollution on the coast and in bathing waters	Domestic sewage water treatment (bacteria)[2]	Purification of shellfish located in a B classified zone
	Research on microbial pathogens	Collection and treatment of storm water	
		Measures linked to use of fertiliser 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 and rescue centres (incomplete data)	Marine pollution prevention system (POLMAR) (incomplete data)	Valuation of voluntary 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	Treatment of green algae

[1] 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)

[2] 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)

		(incomplete data)	
	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 authorities
	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 (incomplete data)		Attenuation and compensation measures linked to granulate extraction and maritime port works (incomplete data)
	Voluntary observatories		
	Local NGOs programmes (incomplete data)		
	Research programmes (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	Installations providing for good	Shore protection

	discards from electric plants	thermal dispersion in sea water at power plant exits (incomplete data)	programmes in the south of France
	Hydrologic parameter monitoring		
	Hydrologic modification monitoring linked to civil engineering on shore (incomplete data)		
	Monitoring of Rhône alluvial inputs (incomplete data)		

Table

Table 5: Annual costs required to maintain current level of ecological status, detailed by problem areas and types of cost (in millions of Euros; "na" when the data is not available)

Problem areas / Cost types		Loss of biodiversity	%	Chemical compounds	%	Microbial pathogens	%	Decrease in fish stocks	%	Biological degradation of natural resources exploited: aquaculture	%	Eutrophication	%	Oil spills and illegal discharges of oil	%	Introduction of energy	%	Total	%
Costs of monitoring and information	Organisation in charge of coordination	8.914 €	*18%*	0.665 €	*1%*	na	-	13.000 €	*26%*	7.300 €	*15%*	na	-	19.334 €	*40%*	na	-	**49.213 €**	*100%*
	Observation, monitoring, studies, expert analysis, impact assessment	23.071	*18%*	65.166 €	*51%*	5.828 €	*5%*	23.700 €	*18%*	5.216 €	*5%*	2.909 €	*3%*	na	-	2.600 €	*2%*	**128.489 €**	*100%*
	Research	45.525	*84%*	0.117 €	*0%*	2.302 €	*5%*	na	-	3.455 €	*6%*	0.189 €	*0%*	1.801 €	*4%*	0.527 €	*1%*	**53.915 €**	*100%*
	SUB-TOTAL	**77.510 €**		**65.948 €**		**8.129 €**		**36.700 €**		**15.971 €**		**3.098 €**		**21.135 €**		**3.127 €**		**231.618 €**	
%		**52%**		**19%**		**1%**		**28%**		**53%**		**7%**		**45%**		**6%**		**11%**	
Costs of preventing environmental degradation	Measures for sustainable management (MPA, contracts, pollution treatment), control and enforcement **SUB-TOTAL**	**41.669 €**	*2%*	**281.770 €**	*16%*	**1,232.666 €**	*71%*	**90.200 €**	*6%*	**11.506 €**	*1%*	**35.507 €**	*2%*	**7.602 €**	*0%*	**38.600 €**	*2%*	**1,739.521 €**	*100%*
%		**28%**		**81%**		**98%**		**67%**		**38%**		**74%**		**16%**		**73%**		**85%**	
Costs of environmental restoration and remediation	Compensatory measures (legal obligation)	11.181 €	*46%*	0 €	*0%*	6.260 €	*26%*	6.800 €	*28%*	0 €	*0%*	**8.840 €**	*0%*	**18.571 €**		**11.000 €**		**24.242 €**	*100%*
	Restoration and compensation (voluntary)	18.131 €	*88%*	0 €	*0%*	0 €	*0%*	na	-	2.574 €	*12%*	0 €	*0%*	0 €	*0%*	0 €	*0%*	**20.705 €**	*100%*
	SUB-TOTAL	**29.312 €**		**0 €**		**6.260 €**		**6.800 €**		**2.574 €**		**8.840 €**		**18.571 €**		**11.000 €**		**83.358 €**	
%		**20%**		**0%**		**1%**		**5%**		**9%**		**19%**		**39%**		**21%**		**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 €**	*100%*
%		***100%***		***100%***		***100%***		***100%***		***100%***		***100%***		***100%***		***100%***			

Annex 1: The Marine Strategy Framework Directive

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.