

Final report

Information System on the Eutrophication of our CoAstal Seas (ISECA)

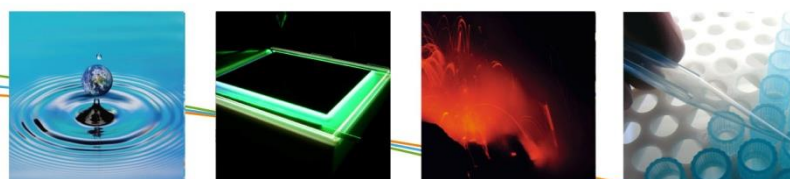
Deliverable DA1-4 : Socio-economic analysis .

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SUMMARY

The cross-border cooperation project ISECA (Information System on the Eutrophication of our Coastal Seas), which is supported by the INTERREGIVa 2Seas Program (www.interreg4a-2mers.eu), is a collaboration between Flemish, Dutch, French and British knowledge partners. The objective of the ISECA project is to improve the exchange of data and scientific insights related to the eutrophication of coastal waters in the English Channel and the Southern North Sea (Figure 1), aiming both at knowledge partners and the relevant authorities and general public. The project is coordinated by ADRINORD in France. The ISECA project is to demonstrate the added value of combining three complementary sources of information on eutrophication: earth observation, in-situ measurements and modelling.

This report covers the socio-economic analysis of eutrophication of coastal and marine waters. The aim is to estimate the socio-economic impacts from eutrophication and related algae blooms on tourism and recreation on the coasts. To this purpose, this work package has elaborated the following four research tasks, that stepwise build up information to estimate total damages of algae bloom for beach visitors in the 2seas area and economic benefits of eutrophication reduction policies.

First, A literature review on the socio-economic impacts, esp. the type of benefits associated with reduced eutrophication and benefits from reduced algae blooms for beach users. Previous studies have identified the impacts on tourism as the most important impact from eutrophication in the Belgian part of the North Sea (BCZ, Belgian Coastal zone). Earlier studies have identified that *Phaeocystis* algae blooms and foam deposits on the beaches is a frequent event in the Belgian part of the North sea and along the Belgian coast, especially in spring. Surveys have indicated that tourists and beach users are affected by algae bloom.

The review showed that there are very few economic valuation studies for the North Sea area (only France and Belgium), and only the one for Belgium is recent and uses more recent valuation techniques (choice experiment modelling). The best studies allow to make an estimation in terms of willingness to pay for the reduction of number of days with algae bloom. However, it also shows the complexities involved, as WTP is a non-linear function of length of algae blooms periods (number of days), the size of the foam, and the period of the year. Based on the choice experiment from Longo, 2006, we estimate the WTP to avoid a week of algae blooms on the beach varies from 8 to 26 €/household.year, depending on the level of foam on the beach (low to high). We prefer this range, based on Longo, 2006, above the estimations based on the meta-analysis from Ahtiainen, 2013, that result in a range for WTP between 6 and 59 €/household.year.

Second, it has been explored to which extent these results from literature can be coupled with results from environmental models to estimate benefits from eutrophication reduction policies. It requires environmental model to produce results that can be expressed in number of days with algae blooms. In a case study for the Belgian coast, it has been demonstrated that it is possible to estimate the risks for days of algae bloom per year, and the impact of policies on this indicator, provided a number of simplifications and assumptions are made. The Belgian case study also showed that it requires a lot of data and additional assumptions to estimate the number of people that are affected by the algae blooms. It was demonstrated that it is possible to estimate the economic benefit of eutrophication policies for beach visitors along the Belgian coast, but that the uncertainty boundaries are large. This detailed analysis suggests that benefits are much larger than estimated in earlier studies using more simplified data and assumptions. These benefits are small compared to the costs of the measures. However, as these benefits are only one part of the total

benefits, more information is needed to perform a complete cost-benefit analysis. These data only refer to the use values for beach visitors. The results of this analysis are reported in chapter 2.

Third, as there were no data on the economic value for the UK, an economic valuation study using a choice experiment was done for the UK, to explore to which extent people in the UK are willing to pay to prevent eutrophication. The scope of this UK study is wider, as – contrary to the approach mentioned above, this method gives information about both use and non-use values, for both beach visitors and non-beach visitors.

In the questionnaire of eutrophication in Solent water, UK, the case of pollution from sewage treatment and agricultural run-off that have impacts on human use of coastal waters and important habitat of several species of wildlife was investigated. Since there are several possible options for improving and preserving water quality, questions were asked from general public on their preference and perception on different options along with their associated willingness to pay. The first two attributes looked at two of the main anthropogenic causes of eutrophication. The first was upgrade of sewage treatment works (UPSTW) and it concerned the effects that incorrect or insufficient sewage treatment might have on the water quality. The second attribute involved reducing nutrient inputs to rivers and estuaries discharging to the Solent water (REDAGNUT), and it represents the number of farms which are compliant with the requirements of the Solent nitrate vulnerable zones (NVZ). The results are summarised in chapter 3 and the report is joint in annex.

Fourth, as there are so little data on WTP in the different countries of the 2seas areas, it is hard to judge to which extent preferences and WTP differ between these countries. To fill this gap, in the ISECA questionnaire, people in different countries in the 2seas areas were asked for their Willingness to pay to prevent eutrophication. This study indicated that people in different countries have a preference for and are willing to pay to prevent eutrophication. Within this project, the sample of respondents is too limited and not representative enough to estimate the size of the WTP with great certainty. Nevertheless, the data available allows to make a first estimation. These data were used further on to demonstrate the use of these data to estimate the total damage of algae blooms and benefits of emission reduction measures for beach visitors along the Belgian coast. These results are reported in chapter 4.

As there is still a lot of uncertainty and variation in the estimations of both number of days with algae bloom and the economic damages associated with these algae blooms, the data in this study need to be handled with care. There are rather a demonstration of possibilities and limits of the current state of understanding and data availability, but not a set of data that can be directly used for policy analysis or for benefit transfer to other regions.

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CHAPTER 1 FRAMING THE ECONOMIC ANALYSIS

Leo De Nocker, Jean-Luc De Kok (Vito)

1.1. INTRODUCTION

This study estimates the socio-economic impacts from eutrophication and related algae blooms on tourism and recreation on the Belgian coasts, with a focus on the benefits of emission reductions. Previous studies have identified the impacts on tourism as the most important impact from eutrophication in the Belgian part of the North Sea (BCZ, Belgian Coastal zone) (Rousseau et al, 2004; Longo et al, 2006; EEA 2010, Ahtiainen 2012)

There are a number of demonstrated negative societal effects of algal blooms that have a significant economic impact on coastal communities (Hoagland et al., 2002; World Health Organization, 2002; ECOHARM, 2003; Hoagland and Scatasta, 2006). The European Commission supported program ECOHARM (2003) analyzed socioeconomic losses due to harmful algal blooms in Europe. ECOHARM calculated that the average annual economic loss of HABs in Europe was 813 million US dollars (2005 dollars). The results show that recreation and tourism (637 million \$) is the most important impact category.

Earlier studies have identified that *Phaeocystis* algae blooms and foam deposits on the beaches is a frequent event in the Belgian part of the North sea and along the Belgian coast, especially in spring. Surveys have indicated that tourists and beach users are affected by algae bloom. Although the majority does not find it a major issue, about 10 % of them indicate that they are heavily annoyed and 6 % to 10 % of them have considered to change holiday destination, beach or activity. As these algae blooms only occur in spring, they do not affect beach or sea water quality during the bathing season and the summer holidays. Nevertheless, also in spring, the Belgian coast attracts many visitors and tourists.

Within the European Threshold project, an economic valuation study surveying tourists and beach users along the Belgian coast, concluded that on average they are prepared to pay to avoid of algae blooms (Longo, 2006). The study also found that there is a complex relationship between duration of the algae blooms and level of foam on water and beach. These results have been used for a generic comparison of costs and benefits in Lancelot et al, 2011, but to our knowledge no systematic overview of the total impacts on tourism and recreation, nor an estimation of the expected welfare gain from a reduction in emissions of nutrients.

In this study we focus on the welfare loss for tourists and beach users, due to algae blooms. Second, we estimate the welfare benefits from emission reductions that lead to a decline of eutrophication and reduction of algae blooms. Third, we estimate the related impacts on the tourist sector. Finally, we discuss these results in the context of total benefits of improvement of ecological status of water bodies in Belgium and the costs of emission reductions.

To this purpose, we build further on the ISECA physical modelling study that quantifies the impacts of reductions of emission of nutrients on eutrophication and algae blooms (De Kok J.L., 2013) and the costs of emission reduction scenario's from the SPICOSA project (Vermaat et al, 2012).

1.2. LITERATURE OVERVIEW ON ECONOMIC VALUATION

Economic valuation studies in Europe and elsewhere have showed that on average people are annoyed by and/or concerned about eutrophication and related impacts (loss of amenity due to algae blooms , biodiversity, water quality and water clarity,...), and that they are willing to pay to reduce eutrophication and its impacts to prevent the related welfare losses (Ahtiainen, 2012; Bertram, 2012).

One indicator that economists use to measure the amount of welfare loss is expressed in willingness to pay (e.g. in euro/household year) to reduce eutrophication and its impacts. It indicates to which extent people have a preference for a situation without or with less eutrophication and related impacts and to which extent they are prepared to financially contribute to guarantee this reduction.

Ahtiainen has identified 20 studies in Europe that assess this indicator, using stated preferences methods. In these methods, people are asked directly or via choice experiments how much they are willing to contribute (pay) to ensure the implementation of policies that reduce eutrophication. The results range from 11 euro/person.year for Varna Bay, Black Sea, Bulgaria (Taylor, 2011) to more than 600 euro/person.year for the Baltic sea, Sweden (Soderqvist, 1996) (values adjusted for inflation, conversion rate and purchasing power by Ahtiainen, 2012). The Baltic sea has been studied the most, and the WTP for reduction in the Baltic sea is higher compared to other seas. It has to be noted that the impacts in the Baltic are different and higher (including blooms of toxic cyanobacteria posing a risk to bathing humans and domestic animals and reduction of sea water clarity and sight (EEA, 2010; Bertram, 2012). Based on a meta-analysis of these studies, Ahtiainen has developed a valuation function, that accounts for GDP level, the number of impacts (recreation, biodiversity, fishing) and location (Baltic, other European seas). Based on this meta-analysis function, a reduction of eutrophication in the Belgian North sea is estimated.

Only two studies refer to the North Sea, i.e. Le Goffe, 1995 and Longo, 2006. The valuation study by Le Goffe found a mean willingness to pay to avoid/reduce eutrophication impacts in Brest of 17,8 euro/person.year. The study by Longo, 2006 estimates WTP to reduce algae blooms along the Belgian coast using a choice experiment, and results in an average WTP of 14.4 euro/person.year (as recalculated by Ahtiainen).

For the US, estimates have been made of the economic impacts of harmful algae blooms for tourism and the economy for specific regions or states (esp. Florida) and the whole US, but these studies show large variations in the results (Alcock, 2007). As the type of algae is different and impacts are not the same as for the North Sea, these results are not transferable to the Belgian coast.

Data and elements that will be used in next steps include:

From the generic survey (IZEUT, 2004; Persoons, 1990's)

- A very limited understanding of the origins of algae bloom and foam
- In general, most people find it a nuisance, but it is not a priority concern
- Some people (10 %) find algae bloom a big nuisance
- 6 to 10 % would change holiday or beach to avoid algae foam

Studies willingness to pay to avoid algae bloom (Longo, 2006)

- People have on average a WTP to avoid long periods of high algae bloom
- A complex relationship between duration and level of foam
- WTP = 4,3 euro/day with medium levels of foam
= 5,7 euro/day with high levels of foam
= 0 euro/day with low levels of foam

(own calculations based on Longo, 2006)

Table 1
Studies included in the meta-regressions.

Study no.	Author(s) and publication year	Study year	Study area	Country	Valuation method ^a	Mean WTP/person/year in 2010 \$ ^b [number of observations]
1	Zylicz et al. (1995)	1994	Baltic Sea	Poland	CV	262.6 [1]
2	Le Goffe (1995)	1993	Brest, Bay of Biscay, Atlantic Ocean	France	CV	17.8 [1]
3	Söderqvist (1996)	1995	Baltic Sea	Sweden	CV	635.3 [1]
4	Frykblom (1998)	1996	Laholm Bay, Kattegat	Sweden	CV	102.1 [1]
5	Markowska and Zylitz (1999)	1994	Baltic Sea	Lithuania	CV	22.6 [1]
6	Markowska and Zylitz (1999)	1994	Baltic Sea	Poland	CV	49.8 [1]
7	Markowska and Zylitz (1999)	1994	Baltic Sea	Poland	CV	287.9 [1]
8	Markowska and Zylitz (1999)	1994	Baltic Sea	Poland	CV	201.0 [1]
9	Söderqvist and Scharin (2000)	1998	Stockholm archipelago, Baltic Sea	Sweden	CV	76.9 [1]
10	Kontogianni et al. (2003)	1999	Thermaikos Gulf, Aegean Sea	Greece	CV	30.3 [1]
11	Stolte et al. (2003)	2003	Along the coast of Riccione, the Mediterranean	Italy	CV	25.2 [1]
12	Stolte et al. (2003)	2003	Along the coast of Galway, Atlantic Ocean	Ireland	CV	37.7 [1]
13	Stolte et al. (2003)	2003	Along the coast of France, the Mediterranean	France	CV	10.8 [1]
14	Gustafsson and Stage (2004)	2002	Sea area around Åland Islands, Baltic Sea	Finland	CV	258.8 [1]
15	Kosenius (2004)	2003	Gulf of Finland, Baltic Sea	Finland	CV	28.7 [1]
16	Soutukorva (2005)	1998	Stockholm archipelago, Baltic Sea	Sweden	TCM	48.0 [1]
17	Longo et al. (2007)	2006	North Sea coast of Belgium	Belgium	CE	14.6 [3]
18	Atkins et al. (2007)	2003	Randers Fjord, Kattegat	Denmark	CV	63.2 [1]
19	Kosenius (2008, 2010)	2006	Gulf of Finland, Baltic Sea	Finland	CE	106.8 [7]
20	Taylor and Longo (2010)	2006	Varna Bay, Black Sea	Bulgaria	CE	11.3 [2]

^a CV = contingent valuation, CE = choice experiment, TCM = travel cost method.

^b Adjusted with purchasing power parity conversion rates and consumer price indices, both provided by the IMF (2011).

Figure 1-1 . Overview of studies and results in the meta analysis of Ahtiainen.

1.3. OVERVIEW OF THE METHODOLOGY TO ESTIMATE COSTS AND BENEFITS OF EUTROPHICATION POLICIES

This study applies a DPSIR framework or impact pathway approach to systematically map existing information on (see figure 1)

a) *emission scenario's*

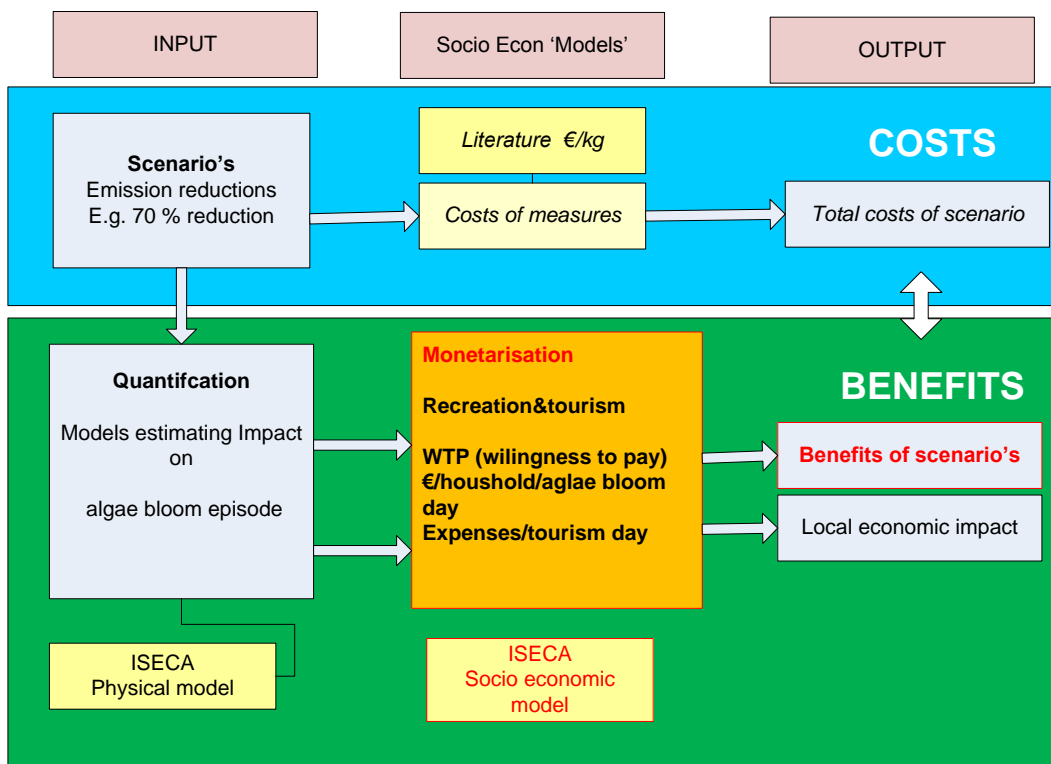
- emissions of nutrients in the Scheldt river basin ,

b) *ISECA physical model (quantification)*

- transport of nutrients to the North Sea and their interaction
- impact on eutrophication
- the impacts of emissions reductions on eutrophication
- and on algae bloom

c) *ISECA socio-economic model (Monetarisation)*

- the impact of algae bloom on welfare losses from beach visitors along Belgian coast (ISECA socio-economic model)
- the impact on the tourism industry
- the benefits for beach users from emission reductions
- the benefits for tourist industry from emission reductions



The blocks in red are the focus of this study.

Figure 1-2 . Overview of the methodology for the estimation of the benefits of emissions reductions on beach visitors and tourist industry.

The main approach is to estimate :

- quantification: the impact of emission reductions on the expected duration of the algae bloom episodes along the coast (in days)
- monetary valuation of a reduction of the expected number of days with algae bloom

There are many factors that determine the duration and intensity of algae blooms so that the concentrations of nutrients are not the only driving force that explains the large annual variation in algae blooms (De Prins, 2007). Consequently, the physical models are not accurate enough to estimate the exact number of days with algae blooms and the quantity of foam on beaches and water. Nevertheless, these models give us a fair understanding of the risk for a beach visitor that he or she may be confronted with foam on beach and water during a visit in spring, and how that – on average - affects his appreciation of that visit.

The objective of this study is to build on existing data and models, and to integrate them in a single consistent framework. This integrated analyses builds on a interdisciplinary methodological framework, that requires that the output of the quantification step can be used in the valuation step. To this purpose, we have to adapt the existing information and models. These modifications and/or additional assumptions are discussed below in the data section.

CHAPTER 2 DAMAGES OF ALGAE BLOOMS FOR BEACH VISITORS IN BELGIUM

Leo De Nocker, Jean-Luc De Kok (Vito)

2.1. ABSTRACT

First, A literature review on the socio-economic impacts, esp. the type of benefits associated with reduced eutrophication and benefits from reduced algae blooms for beach users. The review showed that there are very few studies for the North Sea area (only France and Belgium), and only the one for Belgium is recent and uses more recent valuation techniques (choice experiment modelling). The best studies allow to make an estimation in terms of willingness to pay for the reduction of number of days with algae bloom. However, it also shows the complexities involved, as WTP is a non-linear function of length of algae blooms periods (number of days), the size of the foam, and the period of the year. Based on the choice experiment from Longo, 2006, we estimate the WTP to avoid a week of algae blooms on the beach varies from 8 to 26 €/household.year, depending on the level of foam on the beach (low to high). We prefer this range, based on Longo, 2006, above the estimations based on the meta-analysis from Ahtiainen, 2013, that result in a range for WTP between 6 and 59 €/household.year.

Second, it has been explored to which extent these results from literature can be coupled with results from environmental models to estimate benefits from eutrophication reduction policies. It requires environmental model to produce results that can be expressed in number of days with algae blooms. In a case study for the Belgian coast, it has been demonstrated that it is possible to estimate the risks for days of algae bloom per year, and the impact of policies on this indicator, provided a number of simplifications and assumptions are made.

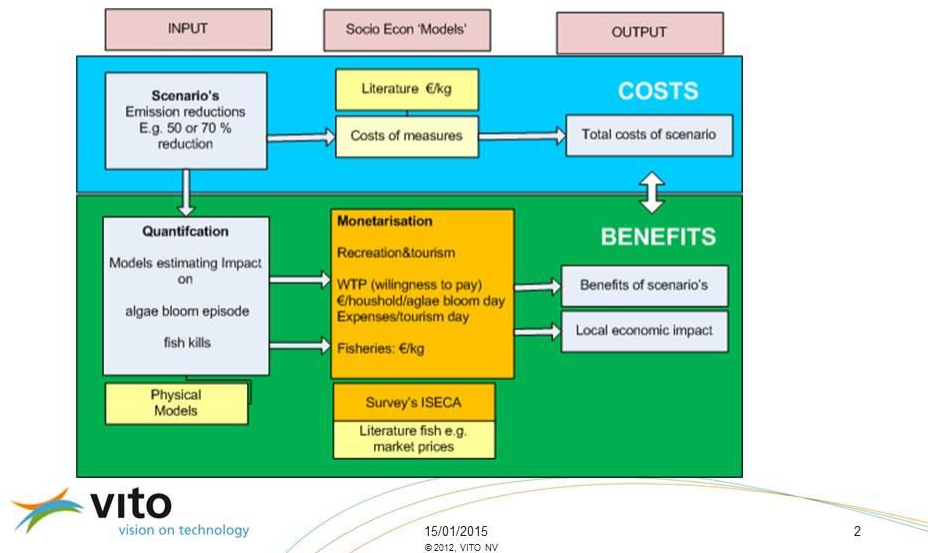
The Belgian case study also showed that it requires a lot of data and additional assumptions to estimate the number of people that are affected by the algae blooms. We estimate that the number of days with risks to some kind of algae bloom is 8 weeks or 77 days. This affects 10 to 20 million visits per year. It requires additional info and assumptions to estimate the total number of households affected. In this case study, this is estimated at 0,4 to 0,6 million households.

It was demonstrated that it is possible to estimate the economic benefit of eutrophication policies for beach visitors along the Belgian coast, but that the uncertainty boundaries are large. It is estimated that the reduction of N-emissions will lead to a reduction of the period with algae blooms with 1 week/year. The benefits associated with this reduction is 2 to 12 million euro/year. The total damages are more difficult to estimate and uncertainties are larger. The total damages range for 8 weeks of algae blooms amount to 30-60 millions euros/year. Major uncertainties relate to the level of the foam on the beach, and the length of algae bloom periods. Especially the damages for days with very low levels of foam are uncertain.

This detailed analysis suggests that benefits are much larger then estimated in earlier studies using more simplified data and assumptions. These benefits are small compared to the costs of the measures. However, as these benefits are only one part of the total benefits, more information is needed to perform a complete cost-benefit analysis

2.2. METHODS AND DATA USED

Objectives



Method

Steps	Reference scenario	Emission reduction scenario	Ref
Emissions	BAU	- 70 % (N)	Spicosa
Dispersion and interaction	Iseca – model	Iseca – model	Iseca – model
N° of days with phaeocystis algae bloom Belgian coast	77	? impact	
N° of people affected (visits to beach; days)	? million visits ? million households	? million visits ? million households	
Benefits	? million € damage	? Million benefits	
Comparison to costs			

Steps in estimation of the benefits

- » Total benefit (million €/year) = $I \times V/hh \times HH$
- 1) I = Indicator for environmental problem = number/year
 - » I_{BAU} = Indicator for 'business as usual'
 - » I_{S1} = Indicator for the policy scenario
 - » $I_{BS1} = I_{BAU} - I_{S1}$ = indicator for the benefit
- 2) V/hh = value of the benefit per household (€/hh.year)
- 3) HH = number of households affected (million households)
Seize of the population with benefits
- 4) Compare costs and benefits



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Information available

- » Total benefit (million €/year) = $I \times V/hh \times HH$
- 1) I = Indicator for environmental problem = number/year
 - $I_{BS1} = I_{BAU} - I_{S1}$ = indicator for the benefit
 - Weeks/year with algae bloom and risks for foam (ISECA)*
- 2) V/hh = value of the benefit per household (€/hh.year)
 - Willingness to pay/week foam.hh; for sample; CE-study, Longo, 2006*
 - WTP (length & size of foam) /hh ; sample ; CE-study, Longo , 2006*
 - WTP meta-analysis/scenario/hh (Ahtianen, 2012)*
- 3) HH = number of households affected (million households)
 - N° of households (from coastal region to Belgium)*
 - N° of visits to beaches-seadike*
 - Some info on impact from foam on visitors to coast*



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Information available : does it match ?

» Total benefit (million €/year) = $I \times V/hh \times HH$

1) I = Indicator for environmental problem = number/year

$I_{BS1} = I_{BAU} - I_{S1}$ = indicator for the benefit

Weeks/year with algae bloom and risks for foam (ISECA)

2) V/hh = value of the benefit per household (€/hh.year)

Willingness to pay/week foam.hh; for sample; CE-study, Longo, 2006

WTP (length & size of foam) /hh; sample; CE-study, Longo, 2006

WTP meta-analysis/scenario/hh (Ahtianen, 2012)

3) HH = number of households affected (million households)

N° of households (from coastal region to Belgium)

N° of visits to beaches-seadike

Some info on impact from foam on visitors to coast



Less attention for application of WTP values in economics

Prologue

“Once upon a time a group of eminent chefs were asked to prepare the finest Horse and Rabbit Stew for the King’s Birthday. For days they toiled and argued about how the rabbit should be prepared. Should it be roasted first or simply boiled, or perhaps jugged or marinated in a fine wine sauce. Finally they came to an agreement and as the birthday dawned they prepared the finest rabbit ever tasted for the stew. Sadly all their efforts were completely overwhelmed by the subsequent addition of the horse”.¹

The aggregation of environmental benefit values: welfare measures, distance decay and total WTP

IJ Bateman, BH Day, S Georgiou, I Lake - Ecological Economics, 2006



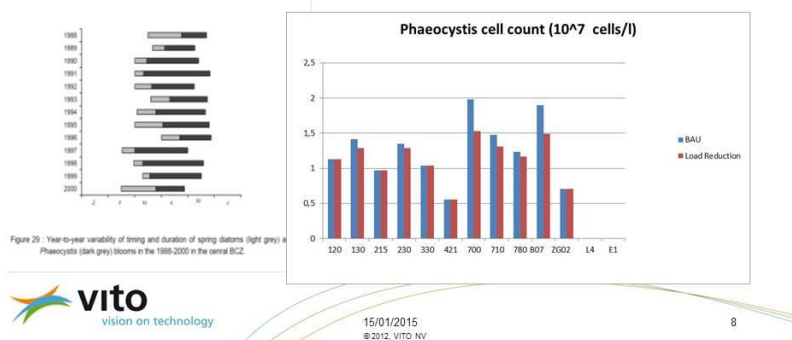
2.3. INDICATORS FOR THE ENVIRONMENTAL PROBLEM

1. Indicators for the environmental problem

A) The risk for Phaeocystis algae blooms:

BAU : 8 weeks

Scenario reduction (- 70 % N-load): - 2 weeks (ISECA)



1. Indicators for the environmental problem

B) Foam on beach :

- » duration, quantities (size), quality (smell,)
- » No direct indicators based on measurements
- » No indicators based on N° of people affected (e.g. noise)

C) Indirect info from Generic survey (IZEUT, 2004; Persoons, 1990's)

- » Survey among beach visitors in summer
- » A very limited understanding of the origins of algae bloom and foam
- » In general, most people find it a nuisance, but it is not a priority concern
- » Some people (10 %) find algae bloom a big nuisance
- » 6 to 10 % would change holiday or beach to avoid algae foam
- » Total damage: 1 million euro (but basics of estimate, method and data are not documented)

Method

Steps	Reference scenario	Emission reduction scenario	Ref
Emissions	BAU	- 70 % (N)	Spicosa
Dispersion and interaction	Iseca – model	Iseca – model	Iseca – model
N° of days with phaeocystis algae bloom Belgian coast	77 days 8 weeks	- 2 weeks (-70 %) - 1 weeks (-35 %)	
N° of people affected (visits to beach; days)			
Benefits			
Comparison to costs			

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2.4. ECONOMIC ANALYSIS: DAMAGES OF ALGAE BLOOMS FOR BEACH VISITORS

2.4.1. WELFARE ANALYSIS: WTP TO AVOID ALGAE BLOOM

2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

- » Choice experiment
- » Sample: 550, Belgian visitors of beach, period ?
 - » Very regular visitors to beaches (30 visits /year)
 - » Do not live near the coast (travel time 90 minutes)
 - » 50 % day visits, 50 % overnight tourists
 - » *Representative for Belgian household or beach user ?*
- » 63 % experienced algae blooms
- » 62 % algae blooms affect activities

Quantity of Foam



Low quantity

There is foam on the surface of the water.



Middle quantity

There is some foam deposit on the beach (small isolated patches)



High quantity

There is a lot of foam deposit on the beach (large continuous stretches)



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2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model
	WTP €/hh
duration (week)	11
low foam	8,4
middle	17,4
high	25,8
average	

2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model	Total damage for 8 week algae bloom	
	WTP €/hh	WTP €/hh	
duration (week)	11		
low foam	8,4	19	
middle	17,4	28	
high	25,8	37	
average		28	



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2.4.2. NUMBER OF VISITS AND HOUSEHOLDS AFFECTED

Visits to the beach-seadike

- » Number of visits to the beach (80 % of visits to coast)
- » Spring season is also very important (e.g. easter)
- » High share of people with second residence (overnight trips)

Visitors to the beach (million)	March-May	Feb-June	Jan-Dec	%	Source
tourists (daytrips)	3,9	5,9	14,9	32%	Westtoer
tourists (overnight trips)	6,9	10,7	26,0	55%	Westtoer
inhabitants coastal area	1,5	2,6	6,1	13%	Vito
Total	12,3	19,2	47,0	100%	
%	26%	41%	100%		
Average per week	0,95	0,89	0,90		



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2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model	Total damage for 8 week algae bloom	
		WTP €/hh	million €/yr
			visits
duration (week)	11		
low foam	8,4	19	31
middle	17,4	28	33
high	25,8	37	36
average		28	33

» Visits: estimation based on N° of visits to beach in March-May



2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model	Total damage for 8 week algae bloom		
		WTP €/hh	million €/yr	
			visits	coast
duration (week)	11			
low foam	8,4	19	31	37
middle	17,4	28	33	41
high	25,8	37	36	44
average		28	33	41

- » Visits: estimation based on N° of visits to beach in March-May
- » based on f N° of households in coastal regions + second homes,



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2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model	Total damage for 8 week algae bloom			
		WTP €/hh	million €/yr		
			visits	coast	W-Fland
duration (week)	11				
low foam	8,4	19	31	37	56
middle	17,4	28	33	41	62
high	25,8	37	36	44	67
average		28	33	41	62

- » Visits: estimation based on N° of visits to beach in March-May
- » based on f N° of households in coastal regions + second homes, W-Flanders



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2. Welfare impacts

1. willingness to pay to avoid algae bloom (Longo, 2006)

characteristics	Model	Total damage for 8 week algae bloom				
	WTP €/hh	WTP €/hh	million €/yr			
			visits	coast	W-Fland	Belgium
duration (week)	11					
low foam	8,4	19	31	37	56	434
middle	17,4	28	33	41	62	474
high	25,8	37	36	44	67	512
average		28	33	41	62	473

- » Visits: estimation based on N° of visits to beach in March-May
- » based on f N° of households in coastal regions + second homes, W-Flanders or Belgium



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2.5. ECONOMIC ANALYSIS OF EUTROPHICATION REDUCTION POLICIES

2.5.1. BENEFIT ESTIMATION BASED ON VALUATION STUDY IN BELGIUM

2. Welfare impacts: benefits week reduction

1. willingness to pay to avoid algae bloom (Longo, 2006)

assumption: 1 week reduction of algae bloom, with high quantity

characteristics	Model	Value week reduction high foam				
		WTP €/hh	WTP €/hh	million €/yr		
				visits	coast	W-Fland
duration (week)	11					
low foam	8,4					
middle	17,4					
high	25,8	19		6,1	7,5	11,4

- » Visits: estimation based on N° of visits to beach in March-May
- » based on f N° of households in coastal regions + second homes,



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2. Welfare impacts

2. willingness to pay to avoid algae bloom (Longo, 2006)

- » 2nd set of results show a more complex relationship between duration and level of foam
 - » Only WTP if algae bloom lasts longer then 6 weeks
 - » Suggests much lower values but these are hard to interpret and apply
 - » No comparisons with literature



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2.5.2. BENEFIT ESTIMATION BASED ON META-ANALYSIS STUDY

Welfare impact : meta analysis Ahtainen

The value of reducing eutrophication in European marine areas – A Bayesian meta-analysis

Heini Ahtainen^{a,*}, Jarno Vanhatalo^b

Table 1
Studies included in the meta-regressions.

Study no.	Author(s) and publication year	Study year	Study area	Country	Valuation method ^a	Mean WTP/person/year in 2010 \$ ^b [number of observations]
1	Zylicz et al. (1995)	1994	Baltic Sea	Poland	CV	262.6 [1]
2	Le Goffe (1995)	1993	Brest, Bay of Biscay, Atlantic Ocean	France	CV	17.8 [1]
3	Söderqvist (1996)	1995	Baltic Sea	Sweden	CV	635.3 [1]
4	Frykblom (1998)	1996	Laholm Bay, Kattegat	Sweden	CV	102.1 [1]
5	Markowska and Zyllicz (1999)	1994	Baltic Sea	Lithuania	CV	22.6 [1]
6	Markowska and Zyllicz (1999)	1994	Baltic Sea	Poland	CV	49.8 [1]
7	Markowska and Zyllicz (1999)	1994	Baltic Sea	Poland	CV	287.9 [1]
8	Markowska and Zyllicz (1999)	1994	Baltic Sea	Poland	CV	201.0 [1]
9	Söderqvist and Scharin (2000)	1998	Stockholm archipelago, Baltic Sea	Sweden	CV	76.9 [1]
10	Kontogianni et al. (2003)	1999	Thermaikos Gulf, Aegean Sea	Greece	CV	30.3 [1]
11	Stolte et al. (2003)	2003	Along the coast of Riccione, the Mediterranean	Italy	CV	25.2 [1]
12	Stolte et al. (2003)	2003	Along the coast of Galway, Atlantic Ocean	Ireland	CV	37.7 [1]
13	Stolte et al. (2003)	2003	Along the coast of France, the Mediterranean	France	CV	10.8 [1]
14	Gustafsson and Stage (2004)	2002	Sea area around Åland Islands, Baltic Sea	Finland	CV	258.8 [1]
15	Kosenius (2004)	2003	Gulf of Finland, Baltic Sea	Finland	CV	28.7 [1]
16	Soutukorva (2005)	1998	Stockholm archipelago, Baltic Sea	Sweden	TCM	48.0 [1]
17	Longo et al. (2007)	2006	North Sea coast of Belgium	Belgium	CE	14.6 [3]
18	Atkins et al. (2007)	2003	Randers Fjord, Kattegat	Denmark	CV	63.2 [1]
19	Kosenius (2008, 2010)	2006	Gulf of Finland, Baltic Sea	Finland	CE	106.8 [7]
20	Taylor and Longo (2010)	2006	Varna Bay, Black Sea	Bulgaria	CE	11.3 [2]

^a CV = contingent valuation, CE = choice experiment, TCM = travel cost method.

^b Adjusted with purchasing power parity conversion rates and consumer price indices, both provided by the IMF (2011).



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Welfare impact : meta analysis Ahtainen

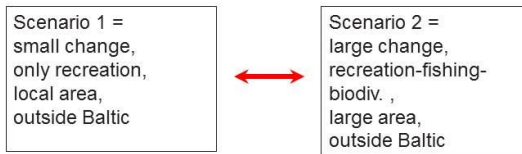


Table 6
Predicted willingness to pay (annual WTP per person in 2010 dollars).

Model	Scenario 1	Scenario 2
	Mean	Mean
Model 1	6.22	58.82
Model 2	3.05	160.30
Model 3	6.05	59.37
Model 4	3.10	164.46
Model 5	6.29	59.04
Model 6	3.13	159.44
Model 7	6.15	59.68
Model 8	2.15	162.16
Weighted average	6.19	59.45

H. Ahtainen, J. Vanhatalo / Ecological Economics 83 (2012) 1–10
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Welfare impact : meta analysis Ahtainen

characteristics	Model	Value week reduction high foam				
		WTP €/hh	WTP €/hh	million €/yr		
				visits	coast	W-Fland Belgium
duration (week)						
scenario 1		6	2,0	2,4	3,6	28
scenario 2		59	18,7	22,9	34,6	266

Reliable scenario ?

2.5.3. OVERVIEW OF RESULTS: DAMAGES AND BENEFITS OF REDUCTION OF ALGAE BLOOM

Method

Steps	Reference scenario	Emission reduction scenario	Ref
Emissions	BAU	- 35 % (N)	Spicosa
Dispersion and interaction	Iseca – model	Iseca – model	Iseca – model
N° of days with phaeocystis algae bloom Belgian coast	77 days 8 weeks	7 weeks = - 1 week compared to ref	
N° of people affected (visits to beach; days)	12 -20 million visits 0,4-0,6 million hh	1,5 – 2,4 million visits 0,4-0,6 million hh	
Damages	30-60 million€ (uncertain)		
Benefits		2 - 12 million€	
Comparison to costs			

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2.5.4. COMPARISON WITH COSTS OF MEASURES

Cost of policy scenario for 1 week reduction

Cost of policy scenario :
40% improvement in waste-water treatment efficiency: 233 million €/year

Policy measure	Proportion remaining of 2008 load (%)	Total N in 2038 (mg N/L)	Estimated cost of measure (million €/yr; idem per percent N load reduction)†
(1) Business as usual	88	4.0	Investment in manure processing plants: 396; 33
(2) 50% cattle stock reduction	74	3.4	Net foregone farmer income: 1686; 65
(3) 50% reduction in fertilizer and manure application	74	3.4	Net foregone farmer income: 151; 6
(4) 40% improvement in waste-water treatment efficiency	47	2.2‡	Investment in infrastructure§: 233; 4
(5) Implementation of buffer strips	78	3.5	Purchase of land along streams: 56; 2
(6) Combination of (2) to (5)	24	1.9‡	N/A
(7) Climate scenario G	88	4.0	N/A
(8) Climate scenario W+	86	4.3	N/A

†Costs from Broekx and De Kok (2010).

‡The standard of 2.5 mg N/L is reached in 2022 for measure

§At 108–147 € population equivalent⁻¹ yr⁻¹; cost and number of ha purchased by 2038.

Research, part of a Special Feature on A Systems Approach for Sustainable Development in Coastal Zones

Nitrogen Source Apportionment for the Catchment, Estuary, and Adjacent Coastal Waters of the River Scheldt

Jan E. Vermooten¹, Steven Broekx², Bert Van Eck³, Guy Engelen², Fritz Hellmann⁴, Jean-Luc De Kok², Hans Van der Kuist², Joachim Maes⁵, Wim Salomons⁴, and Willem Van Deursen⁶

Method

Steps	Reference scenario	Emission reduction scenario	Ref
Emissions	BAU	- 35 % (N)	Spicosa
Dispersion and interaction	Iseca – model	Iseca – model	Iseca – model
N° of days with phaeocystis algae bloom Belgian coast	77 days 8 weeks	7 weeks = - 1 week compared to ref	
N° of people affected (visits to beach; days)	12 -20 million visits 0,4-0,6 million hh	1,5 – 2,4 million visits 0,4-0,6 million hh	
Damages	30-60 million €		
Benefits		2 - 12 million €	
Comparison to costs		233 million €	

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2.6. ADDITIONAL EFFECTS , CHANGE OF DESTINATION

Welfare loss, change of destination

- » 6 % would consider changing holidays or destination
- » = 0,8 to 3,1 million visits (march-may or full year)
- » Welfare impact ?
 - » Assumption 1 : change beach location : + 20 km, + 0,5 h
 - » Travel costs = (3 € + 2,5 €) x2 = 11 €
 - » = 16 % -100 % of total value of beach visits (Whitehead, 2008, US)
 - » Total impact = 0,8 x 11 = 9 million €
 - » Cfr. Order of magnitude of 30-60 million € for total damage
 - » Assumption 2 : no visit to coast
 - » Loss of income for coastal region :
 - » Order of magnitude = 40 million €

2.7. OVERAL CONCLUSIONS

Conclusions

- » A new method has been applied to estimate the total costs (welfare losses) of algae bloom and foam on beaches on the Belgian coast, and the impacts and benefits (welfare gains) of reduction of emissions
- » It builds on the integration of physical models, data on recreation and valuation studies of amenity loss due to foam on beaches
- » It requires a number of assumptions to couple different sources of information
- » It allows to give an order of magnitude of the welfare gains from emission reduction scenario's
- » Estimated in the range of 2-12 million euro/year for total coast of BE.
- » It is more difficult to estimate the total welfare losses related to algae bloom and foam. Based on additional estimates, estimated in the range of 30-60 million euro/year.



CHAPTER 3 SOCIO-ECONOMIC ANALYSIS OF EUTROPHICATION IN SOLENT AREA, UK

Premachandra Wattage (CEMARE)

ABSTRACT

Cost-benefit analysis (CBA) attributes a social value to everything affected by an activity or a project. Some things are negatively affected (costs) and some are positively affected (benefits). CBA adds up the costs, and the benefits. However, for eutrophication there is no market value, hence, estimating cost and benefits are difficult. The choice experiment method can be used to estimate economic values for virtually any ecosystem or environmental service, and can be used to estimate non-use as well as use values. It is a hypothetical method – it asks people to make choices based on a hypothetical scenario. It does not directly ask people to state their monetary values; instead, values are inferred from the hypothetical choices or tradeoffs that people make.

The choice experiment method asks the respondent to state a preference between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Because it focuses on tradeoffs among scenarios with different characteristics, contingent choice is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, bad water quality in ocean will affect the quality of several services provided by the ocean, such as fishing, swimming, and biodiversity. In addition, while contingent choice can be used to estimate monetary values, the results may also be used to simply rank options, without focusing purely on monetary values.

In the choice experiment questionnaire of eutrophication in Solent water, UK, the case of pollution from sewage treatment and agricultural run-off that have impacts on human use of coastal waters and important habitat of several species of wildlife was investigated. Since there are several possible options for improving and preserving water quality, questions were asked from general public on their preference and perception on different options along with their associated willingness to pay. The first two attributes looked at two of the main anthropogenic causes of eutrophication. The first was upgrade of sewage treatment works (UPSTW) and it concerned the effects that incorrect or insufficient sewage treatment might have on the water quality. The second attribute involved reducing nutrient inputs to rivers and estuaries discharging to the Solent water (REDAGNUT), and it represents the number of farms which are compliant with the requirements of the Solent nitrate vulnerable zones (NVZ). The third and final attribute was the COST. It investigated the respondents' WTP for the improving of water quality in the Solent from eutrophication. Results indicate that the general public of Solent are in favour of both UPSTW and REDAGNUT.

Policy makers can use people's preferences to these options which can be weighed in terms of costs and benefits to the public. Again, because the area is widely used recreational area, many people actually visit it, or view the natural beauty that relies on it for habitat. Therefore, non-use values are the largest. The management agency in charge of the area could use the results of the study for water quality improvement.

CHAPTER 4 WELFARE LOSSES FROM ALGAE BLOOM ALONG THE BELGIAN COAST, EVIDENCE FROM THE ISECA SURVEY

Leo De Nocker, Jean-Luc De Kok (Vito), Carolien Knockaert, Annelies Goffin (VLIZ), Elise Chiroutre (Nausica), Premachandra Wattage (CEMARE)

4.1. WILLINGNESS TO PAY TO LIMIT EUTROPHICATION OF THE SEA AND ALGAE BLOOM (FOAM) ON THE BEACH

Table 1 gives a summary overview of the main results of this part of the survey. For 300 of 520 respondents in the 2 seas area, we are sure they are willing to pay a at least 20 € via a higher yearly water bill to prevent or limit eutrophication, and about half of them are willing to pay 35 €. From 55 respondents, we are sure they are not willing to pay because they don't care that much about this pollution, or because they don't have enough money. Both reasons are valid. 118 respondents did not reveal their true willingness to pay, because they indicated in the survey that others should pay (polluters or government). We did not include the results from students as they cannot decide on this question, related to the increase of the water bill for the household and paid by the family income.

Table 1 : Summary information from the ISECA survey relevant for estimation of WTP

Indicator	N° respondents	%
Willing to pay' at least (1)		
20 € - 35 €	162	85%
+ 35 €	138	39%
No WTP (2)	55	15%
Subtotal of which info on WTP (6)	355	100 %
Protest answer (3)	117	
Students (4)	48	
Total number of respondents (5)	520	

(1) Respondents at least willing to pay x €/year in their water bill to prevent eutrophication

(2) No WPT = respondents that indicated that they care less about water pollution or don't have money available for this issue

(3) protesters : respondents that indicated that polluters and/or government should pay.

In summary, 85 % of the people from whom we have usefull information, have a WTP of at least 20 € and 39 % a WTP of at least 35 €. This results in an average WTP of 23 €/household.year (table 2). In section 3, we compare these results with the literature.

Second, we estimate the WTP per visit day to the beach. On average, the respondents of the survey visit the beach 49 times a year. If we exclude the 6 % of respondents that visit the beach daily, the average is 29. This gives us an average WTP per visit of 0.47 to 0.79 €/visit. For respondents that visit the beach once a month, the WTP amounts to 1,9 €/visit.

Table 2: Estimates of WTP based on ISECA-survey

Indicator	Willingness To Pay
Mean WTP (€/household.year)(1)	23
WTP per beach visit	
frequent visitors(2)	0,47
average estimate (3)	0,79
non-frequent visitors (4)	1,9

(1) Based on WTP for full sample of respondents

(2) Based on average number of beach visits for all respondents (49 visits/year)

(3) Based on average number of beach visits/respondent for all respondents, excluding respondents that visit beach each day (6 % of respondents) (29/visits year)

(4) Based on average for respondents that visit beach once a month

The results of this survey are in line with some of our theoretical expectations and with data from literature:

- on average, respondents with a higher income have a higher WTP;
- respondents that perform beach activities with that involve more contact with water (swimming, surfing), have a higher WTP compared to respondents that walk along the beach.

On the other hand, it also shows that the relationships are complex, and this is also in line with literature (Longo et al, 2006).

- The WTP does not increase with number of visits to the beach, and is even a little lower for people that visit the beach more than once a week. This may indicate that these people are more familiar with the phenomenon, and can better estimate the real risks involved, e.g. related to human health. It may also indicate that they care less about a few days of foam on the beach, as they know they will have plenty of days without foam.
- Respondents that never visit the beach have a 50 % lower WTP. This is interesting, because it indicates that people with no use values for beach visits, also have a positive WTP. However, as there are too little respondents in this category, we cannot draw strong conclusions on this topic.
- Contrary to expectations, people that fish on the beach have a lower WTP, although eutrophication has additional impacts on fish stock and biodiversity (*Carolien, does this involve a lot of people*).
- There are no significant differences between socio-economic (other than income) characteristics and WTP. (*Prem, was there any significant relationship with income ?*)

Due to the nature of the survey and the small number of respondents it is not possible to make to estimate different values for different countries. The results suggest that the country of origin does not affect the WTP among the respondents.

4.2. USE OF THE SURVEY RESULTS TO ESTIMATE DAMAGES FROM ALGAE BLOOM ALONG BELGIAN COAST

In this part of the study, we test to which extent we can use these results for policy analysis. To this purpose, we estimate the total welfare losses from algae bloom along the Belgian coast.

A first approach is to estimate the total damages or welfare losses from algae bloom based on the number of households affected. This can be estimated as follows:

$$\text{Total damage (€/year)} = \text{WTP (€/household.year)} \times \text{number of households affected}$$

This requires information on the number of households affected, and that the respondents of the survey are representative for the total group of households affected. To this purpose, we use several assumptions to estimate a lower and upper bound for the number of households affected. For freshwater water bodies, it is common to use information on the distance decay to estimate the number of households affected, and it is expected that WTP will fall to zero after some distance. For protection of coastal waters, this is probably different, as the coast is frequently visited by people from all provinces in Flanders and from Brussels and Wallonia. As an example, 27 % of all day trips are spent on visits to the Belgian coast. The minimum estimate relates to the N° of households in the coastal province of West Flanders, the maximum includes all Belgian households and foreign tourists (table 2). This results in a broad range of damage estimates from 12 to 118 million €.year.

Table 3 : Welfare losses from algae bloom along the coast

Households affected	N° households (1)	Total damage
	Millions	Million €/year
Coastal area (West-Flanders)	0,5	12
Flanders	2,65	61
Belgium	4,70	108
Belgium + foreign tourists	5,14	118

(1) based on FOD economie + Westtoer (N° tourist)

A second approach is to estimate the total damages based on the number visits. This can be estimated as follows:

$$\text{Total damage (€/year)} = \text{WTP (€/visit)} \times \text{number of visits/year}$$

This requires information on the visits to the beach per year. Table 4 provides an estimate, accounting for visits by local people, day trips and tourists. The (daily) visits of local people have a much lower share in total visits compared to the sample of the survey. The range of damage following this approach is 22 million to 89 million €.year.

Table 4 : Welfare losses from algae bloom along the coast

Households affected	N° visits			
	Millions	0,47	0,79	1,9
WTP household				
inhabitants coastal area	6	3	5	11
visitors day trips	15	7	12	28
tourists (overnight trips)	26	12	21	49
Total	47	22	37	89

4.3. DISCUSSION

The ISECA survey confirms that the average households is confronted with algae blooms and has a willingness to pay to limit algae blooms and eutrophication. Most households (85 %) are willing to pay at least 20 €, and almost 40 % are willing to pay 35 € or more.

These results are in line with literature. Le Goffe, 1995, estimated a WTP related to eutrophication in France, Brest, of 18 €/hh.year. In a choice experiment related to algae blooms along the Belgian coast, a WTP was estimated ranging from 19 to 37 €/household (own calculations, based on WTP functions in Longo, 2006). Based on the functions of the meta-analysis of 20 studies in Europe (outside the 2seas area), the WTP is estimated to range 6 and 60 €/hh.year (Ahtianen, 2013).

The results of the ISECA questionnaire can be compared with valuation studies related to freshwater. The WTP to achieve good status of fresh water is on average 73 €/hh.year, for an household living within 20 km of that river (Liekens et al, 2008). The WTP to improve freshwater water quality is estimated at 92 to 113 €/household.year, based on the CE approach. Both these results are similar of other 2seas countries (Liekens et al, 2008) (Bateman et al, 2011). Due to differences in methods, the data are not fully comparable. At first glance, these data suggest that the welfare losses from algae bloom along the coast are somewhat smaller compared to those of inland freshwater.

The results also confirm that the relationship between WTP and the extent to which people are confronted with and familiar with algae bloom is a complex one. Contrary to first expectations, more frequent beach visitors do not have a higher WTP to limit or avoid eutrophication.

The results can be used as a start to estimate the total damage (welfare loss for the whole population), but the range of low and high estimates is still large. This is due to the fact that the sample of this survey differs significantly from the average Belgian households in terms of number of visits to the beach, and we do not know to which extent that affect the WTP. The case study of Belgium indicates that it is important to account for distance decay in valuation of coastal pollution. For a larger country with several coasts, e.g. France or the U.K., this factor will be even more important.

For Belgium, we were able to make reasonable assumptions, and we can compare results with literature. The results indicate that the welfare losses from eutrophication and algae blooms along the Belgian coasts are likely to be significant, ranging from 10 to 100 million euro's. This range is significantly higher compared to earlier estimates.

4.4. ANNEX : THE ISECA QUESTIONNAIRE OF THE SURVEY

The purpose of this survey is to determine the public's perception of water quality and its effects on public use. It also aims at better defining the public's willingness to contribute to improvements.

(Survey as part of the INTERREG IVA 2Seas "ISECA" project - Information System on the Eutrophication of our Coastal Areas)

1. How often do you visit the beach? *

- Daily
- Once a week
- Several times a week
- Once a month
- Several times a year
- Never

2. For what purpose (s) do you go to the beach? *

- Walk
- Run
- Swim
- Boating
- Work
- Fishing
- Windsurfing
- Other:

3. Have you ever seen foam / green algae like this? *



Photo credits (from left to right): Nausicaa / Anne Vernier, Adrien Delater, Thesupermat / Wikipedia

- Yes/No

If yes, how many times: ...per year

Do you know what it is caused by? *

- Yes/No

Do you know about the coastal water phenomenon called eutrophication? *

The eutrophication phenomenon is explained here (see annex 2)

- Not at all
- A little
- Very well

4. Tick the choice that best corresponds to your opinion: *

Strongly disagree Disagree Neutral Agree Strongly agree

I am interested in the marine environment

The Government should do more to improve water quality

I think that the local community has a responsibility for the protection of the marine environment

The water companies should do more to improve (sea) water quality

Before filling in this survey I was unaware of eutrophication in coastal waters

Water quality should be preserved for the benefit of my children and future generations

Agricultural and individual practices should reduce nutrient inputs to rivers and estuaries discharging

Upgrading sewage treatment works is the only way to reduce nutrients

I am ready to check if my sewer is properly connected to the water treatment plant

I am willing to pay more for my vegetables to encourage "sustainable" agriculture

Water quality should be better regarded as it improves the recreational quality of the marine environment (swimming, sailing,...)



It is possible to improve water quality and reduce impacts from eutrophication, but this will require additional measures related to waste water treatment and nutrient reductions from agriculture. These measures will lead to additional costs for farmers, industry and households. All households already pay for the treatment of their waste water, and these additional measures will increase that annual bill with a certain amount, which is specified below.

5. Would you be willing to accept an increase in the annual water bill to finance additional waste water measures to improve water quality and prevent eutrophication? *

- Yes/No

If yes, would you accept this if the water bill increases with:

Yes No

15 £ ☐ ☐

30 £ ☐ ☐

6. If you don't accept an increase of the water bill, which of the following best describes why you made this choice?

- I already pay too much tax
- I cannot afford to pay

- I don't use the beach
- I am not interested in water quality
- The marine service / government should pay out of existing budgets
- Polluters such as water companies should pay
- I would rather pay into a conservation trust fund
- I would prefer that my taxes are already allocated to the advantage of preserving the environment
- I would rather pay directly for scientific research and development
- Other:

WHO ARE YOU?

Information you provide in this section will remain strictly CONFIDENTIAL and will not be used for COMMERCIAL purposes

Are you? *

- Male
- Female

Do you have children? *

- Yes/No

Which of the following best describes your education level? *

- No formal education
- Primary level
- Secondary level
- Bachelor degree
- Master degree
- Doctorate
- Other:

In which country do you live? *

- United Kingdom
- Netherlands
- France
- Belgium
- Other:

What is your age? *

- Less than 18 years old
- 18-25 years
- 26-40 years
- 41-60 years
- 60+ years

What is your professional category? *

- Farmers
- Builders
- Employees
- Artisans, merchants and entrepreneurs
- Intermediate occupations
- Managerial and professional occupations
- Retired
- Student
- Other persons without occupation

Are you: *

- Teacher
- Scientific
- Fisherman
- Farmer

- Other:

What is your approximate annual household income before paying taxes? *

- UNDER £20,000
- £20,001 - £40,000
- £40,001 - £60,000
- £60,001 - £80,000
- £80,001 - £100,000
- OVER £100,000
- No idea

Are you a member of an environmental / marine conservation organization? *

- Yes/No

Do you or any member of your family work in the water treatment industry? *

- Yes/No

4.5. ANNEX: BACKGROUND INFO ON EUTROPHICATION FOR THE RESPONDENTS

Algae grow in the sea feeding on **nutrients** in the water. Algae grow better when more nutrients (nitrates and phosphates) are present in the water column. A small increase in algal biomass has no adverse effects on the ecosystem and can even lead to an increase of certain fish populations. An overgrowth however can lead to an **algal bloom** which may disturb the water. The algae may keep out the light and when they eventually die, they are decomposed by bacteria which consume oxygen in this process so that the water may become temporarily anoxic (hypoxia) which may be toxic to aquatic life. An enrichment by or excess of nutrients to the water is called **eutrophication** and may result in an explosive growth of algae. Depending on the environment (quiet bay or rough seas) and the type of algae (microscopic or macroscopic), a 'bloom' can be observed in different forms: foam or a green tide on the beach.



Foam on the beach due to a Phaeocystis bloom (Le Portel France: 04/2012)
(Photo credit: Nausicaa, Adrien Delater-Julien Legrand)



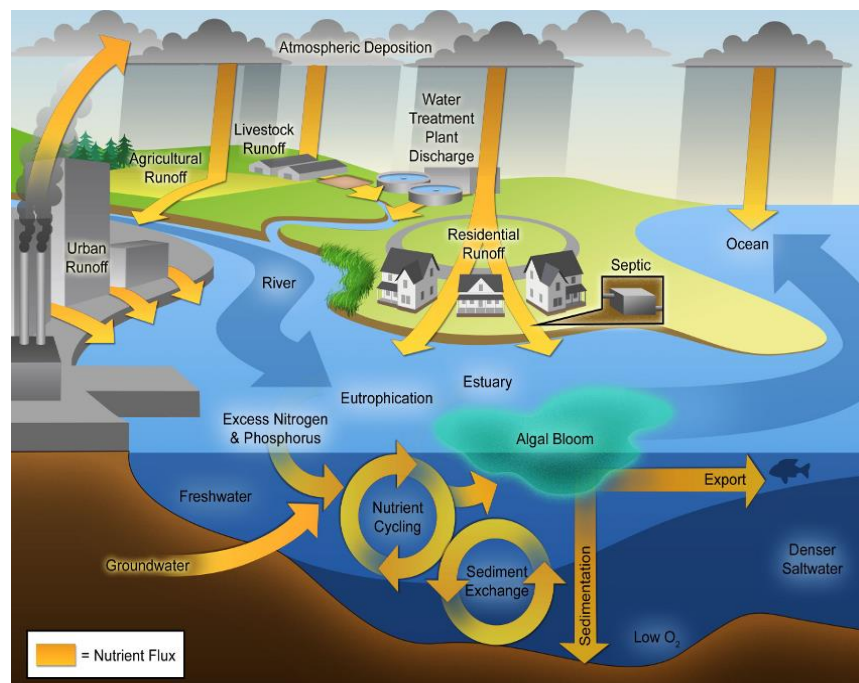
Green algae on the beach (Nord Finistère, Brittany-France)
(Photo credit: Thesupermat, Wikipedia)

Eutrophication is one of the causes of the deterioration of water quality. In the North Sea and the English Channel, this is mainly due to human activities. Nutrients can have a natural or anthropogenic origin and come from:

- Domestic wastewater
- Industrial waste
- Agriculture (fertilizer use) Atmospheric deposition of nitrogen (livestock and gases)

The overload of nitrogen, phosphorus and other organic material can result in a series of 'side effects'. The main effects of eutrophication are:

- Increasing biomass of phytoplankton resulting in 'algal blooms'.
- Hypoxia (reduced dissolved oxygen content of a body of water).
- An increasing number of incidents of fish kills.
- The water can have a bad taste, color and odour which has a negative impact on tourism. Governments have to invest more in waste water treatment.
- Decline or loss of species biodiversity (commercially important species may disappear).
- Some phytoplankton species produce toxins that cause severe symptoms such as diarrhea, memory loss, paralysis and in severe causes death.



Schematic diagram of the different pathways of nutrient deposition into coastal waters and ensuing processes leading to eutrophication (algal blooms) and hypoxia (Photo credit: Dr. Hans W. Paerl)

Such environmental problems have not only an effect on aquatic life, but can also have a negative impact on the economic activities of the sea (fishing, tourism, recreation ...). Past 20 years, all these issues have been extensively studied and have been the subject of many discussions ... The problem has been addressed in the Water Framework Directive and the European Union within the OSPAR Convention in 1992. Both agreements aim to establish a good management of our rivers and our coastal waters. To achieve these objectives, the parameters of water quality should be regularly monitored and published. Similarly, we must study the socio-economic effects on the areas subject to eutrophication and identify the necessary information to stakeholders (political, agricultural, industrial, tourism ...).

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ANNEX: SOCIO-ECONOMIC ANALYSIS OF EUTROPHICATION IN SOLENT AREA, UK, DETAILED REPORT

Dr. Premachandra Wattage (CEMARE, University of Portsmouth, UK)



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Socio-economic analysis of Eutrophication in Solent area, UK Preliminary report– ISECA Project

2013



P Wattage

**CEMARE, University of
Portsmouth, UK.**

1/1/2013

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Abstract

Cost-benefit analysis (CBA) attributes a social value to everything affected by an activity or a project. Some things are negatively affected (costs) and some are positively affected (benefits). CBA adds up the costs, and the benefits. However, for eutrophication there is no market value, hence, estimating cost and benefits are difficult. The choice experiment method can be used to estimate economic values for virtually any ecosystem or environmental service, and can be used to estimate non-use as well as use values. It is a hypothetical method – it asks people to make choices based on a hypothetical scenario. It does not directly ask people to state their monetary values; instead, values are inferred from the hypothetical choices or tradeoffs that people make.

The choice experiment method asks the respondent to state a preference between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Because it focuses on tradeoffs among scenarios with different characteristics, contingent choice is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, bad water quality in ocean will affect the quality of several services provided by the ocean, such as fishing, swimming, and biodiversity. In addition, while contingent choice can be used to estimate monetary values, the results may also be used to simply rank options, without focusing purely on monetary values.

In the choice experiment questionnaire of eutrophication in Solent water, UK, the case of pollution from sewage treatment and agricultural run-off that have impacts on human use of coastal waters and important habitat of several species of wildlife was investigated. Since there are several possible options for improving and preserving water quality, questions were asked from general public on their preference and perception on different options along with their associated willingness to pay. The first two attributes looked at two of the main anthropogenic causes of eutrophication. The first was upgrade of sewage treatment works (UPSTW) and it concerned the effects that incorrect or insufficient sewage treatment might have on the water quality. The second attribute involved reducing nutrient inputs to rivers and estuaries discharging to the Solent water (REDAGNUT), and it represents the number of farms which are compliant with the requirements of the Solent nitrate vulnerable zones (NVZ). The third and final attribute was the COST. It investigated the respondents' WTP for the improving of water quality in the Solent from eutrophication. Results indicate that the general public of Solent are in favour of both UPSTW and REDAGNUT.

Policy makers can use people's preferences to these options which can be weighed in terms of costs and benefits to the public. Again, because the area is widely used recreational area, many people actually visit it, or view the natural beauty that relies on it for habitat. Therefore, non-use values are the largest. The management agency in charge of the area could use the results of the study for water quality improvement.

1. Introduction

The coastal zone has a multitude of uses and users with differing interests and agendas causing multitude damages to coastal ecosystems. In addition, natural causes such as climate change impacts are also affecting the functions of ecosystems in coastal areas. Human alteration of marine ecosystems continues to grow as a result of anthropogenic threats such as the high concentration of people in coastal areas and their activities. Some of the key results are overexploitation of marine resources, loss of biological diversity, eutrophication and damage to natural habitats. Eutrophication is a result of agricultural runoff and pollution from waste, oil spills, and shipping. All of these anthropogenic effects act in a cumulative manner and often have diffuse effects. It has even been argued that human activities could potentially push the earth system outside the stable environmental state, with catastrophic consequences. Given the magnitude of human impacts on marine and other ecosystems in all over the globe, it is important to identify priorities for actions. In this context, coastal environmental services are critical to the functioning of coastal ecosystems, contributing significantly to human welfare and a significant portion of total economic value of coastal environments. The Millennium Ecosystem Assessment provides a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide. Further, it provides a scientific basis to understand the total economic value and for action to conserve them sustainably. The services of ecological systems and the natural capital stocks that produce them play a key role to the functioning of the earth's life support system.

Marine ecosystem services are however seriously undervalued due to poor awareness of the total value, resulting in underinvestment in conservation and loss of opportunities for economic growth. Considering the challenges of the sustainable uses of coastal ecosystem during rapid change, the scientific community is advocating a shift to ecosystem stewardship and Project ISECA is such an effort. This project offers a unique opportunity to bring together experts in resilience and ecosystem services to share interdisciplinary knowledge and developments in their fields, and to identify the factors that will lead to a sustainable future for social-ecological coastal ecosystem. This approach could be able to steer governance in a direction that reduce the risk of passing boundaries in order to address the Convention Biological Biodiversity (CBD) 2020 targets and the Stockholm Memorandum; in particular not only those classified as imminent biodiversity threats but also those scientific, socioeconomic, and institutional conditions required to meet CBD target in the long- term. The interdisciplinary approach across the fields of ecology, biology, economics, conservation, atmospheric changes and management of pollution (atmospheric, land and coastal), among others, to understand:

- Eutrophication impacts and recent advances in understanding of marine ecosystem services,
- Socio-economic valuation of eutrophication, resilience, adaptive capacity, transformability,
- Education on eutrophication, institutional and organizational changes,
- Social learning and networks and knowledge-system integration

The study investigates eutrophication related water quality revealing public opinion towards its improvement in the Solent area UK. It is very imperative due to the prevailing high demand for the use of Solent water and the variety of ways in which it is used. The area has been a magnet for tourism and recreation for 150 years since the railways allowed regular visitors from London to the area in ever increasing numbers. The Solent receives 4.2 million overnight visitor trips, 13.7 million visitor nights, and £716 million visitor spending annually. On top of this there are 31 million day visitor trips generating £690 million expenditure (Solent Forum, 2012). The beaches are an obvious attraction for tourism to the Solent and importance should be placed on their management.

Assessing the value associated with the improvement of water quality affected by eutrophication is the main aim of this research. This is to gain a more in depth understanding of the public perception and knowledge of eutrophication and willingness to pay (WTP) in the Solent area in the United Kingdom. The study was carried out in the Solent area as shown in Figure 1. Choice experiment is used as the main method to determine the WTP and the public perceptions.

1.1. Focus of the project and rational

Eutrophication is a major coastal problem of the oceans all over the globe (Xu et al., 2010; Rabalais & Turner, 2001; Nixon, 1995). The phenomenon occurs when there is an oversupply of nutrients from several sources and it has universal ecological effects on shallow coastal and estuarine territories (Rabalais & Turner, 2001). It is a natural process; however human induced eutrophication could have a strong impact on life in the seas as it is known to cause deoxygenation of the water and decreases the penetration of light through the water column (Ferreira et al., 2007).

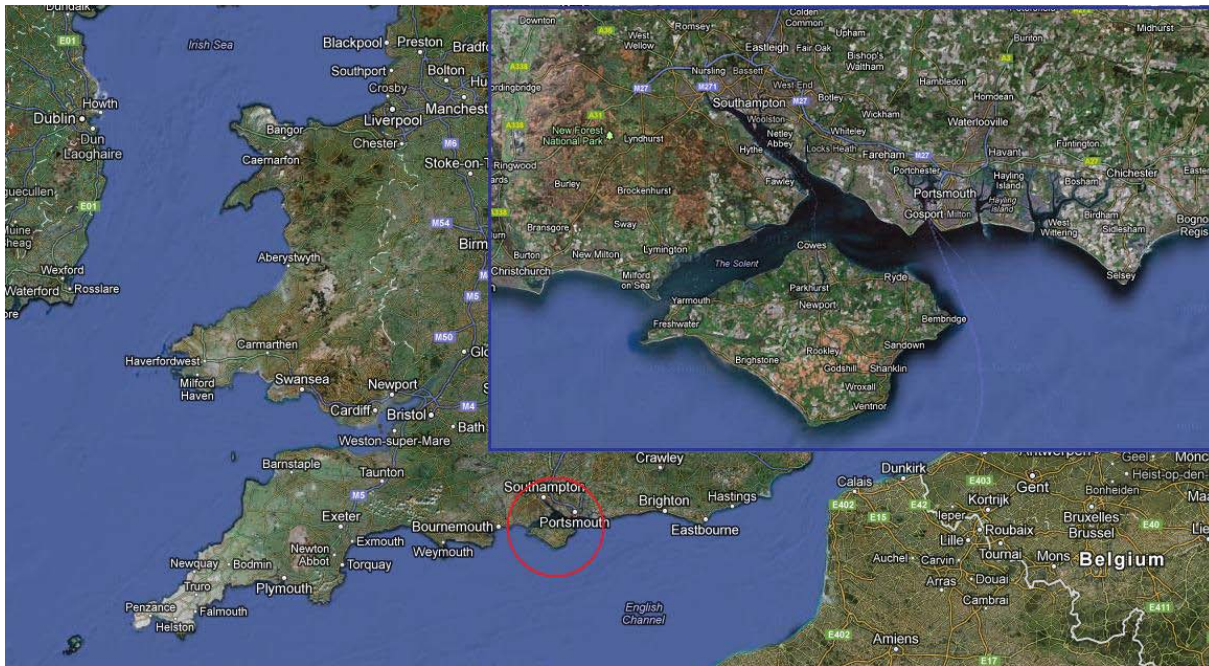


Figure 1: A map of the Solent area, UK (Google, 2012).

As described in the EU Urban Wastewater Directive 91/271/EEC eutrophication has implications for the protection and conservation of estuarine ecosystems. A key concern is the vulnerability of estuaries to eutrophication and impacts on ecosystem functions. The Directive classifies eutrophication as any water enriched by nutrients and in particular those that have compounds of nitrogen and phosphorus, which induce an accelerated growth of algae and higher forms of plant life to create an unwelcomed disturbance to the balance of organisms and the water quality in general. The Solent is a heavily used body of water and as a result it has a number of environmental pressures (Solent Forum, 2012). Widespread growth of green seaweeds occurs in many intertidal areas of the Solent. The large quantities of untreated sewage and farm fertilisers ending up in the sea are the main cause for the eutrophication (Derbyshire, 2009; Jha, 2009). The areas significantly affected were Worthing in West Sussex, Ventnor in the Isle of Wight and Langstone Harbour in Portsmouth (Derbyshire, 2009; Jha, 2009). Algal blooms began to appear in the 1960s; however, the algal bloom of 2009 was the worst yet according to the local people (Derbyshire, 2009). This was not a new phenomenon for the Solent, where there was abundant growth of green seaweed first recorded in Langstone Harbour in the early 1970s. This could be explained by the fact that high levels of nutrients along with ideal growing conditions, such as sheltered mudflats and sunny weather, allow the seaweeds to proliferate each summer. In the southern UK, harbours external inputs of nutrients could sustain the growth of macroalgae at the beginning of a growing season (Scanlan et al., 2007; Trimmer et al., 2000).

Through revealing public's perceptions on eutrophication and expressing willingness to pay this research has the potential to contribute to the improvement of the management of the Solent to maintain eutrophication free water quality. Furthermore, this study could supplement the existing literature on public attitudes and water quality.

1.2. Aims and objectives

The aim of this report is to investigate the socio-economic values of controlling eutrophication in the Solent area. In order to achieve this, the following objectives have been used:

1. To measure the socio-economic values using choice experiment methodology.
2. To ask the general public to value coastal resources in terms of willingness to pay (WTP).
WTP is used because there is no value for pollution damage such as eutrophication.
3. To reveal the perception of general public on eutrophication.

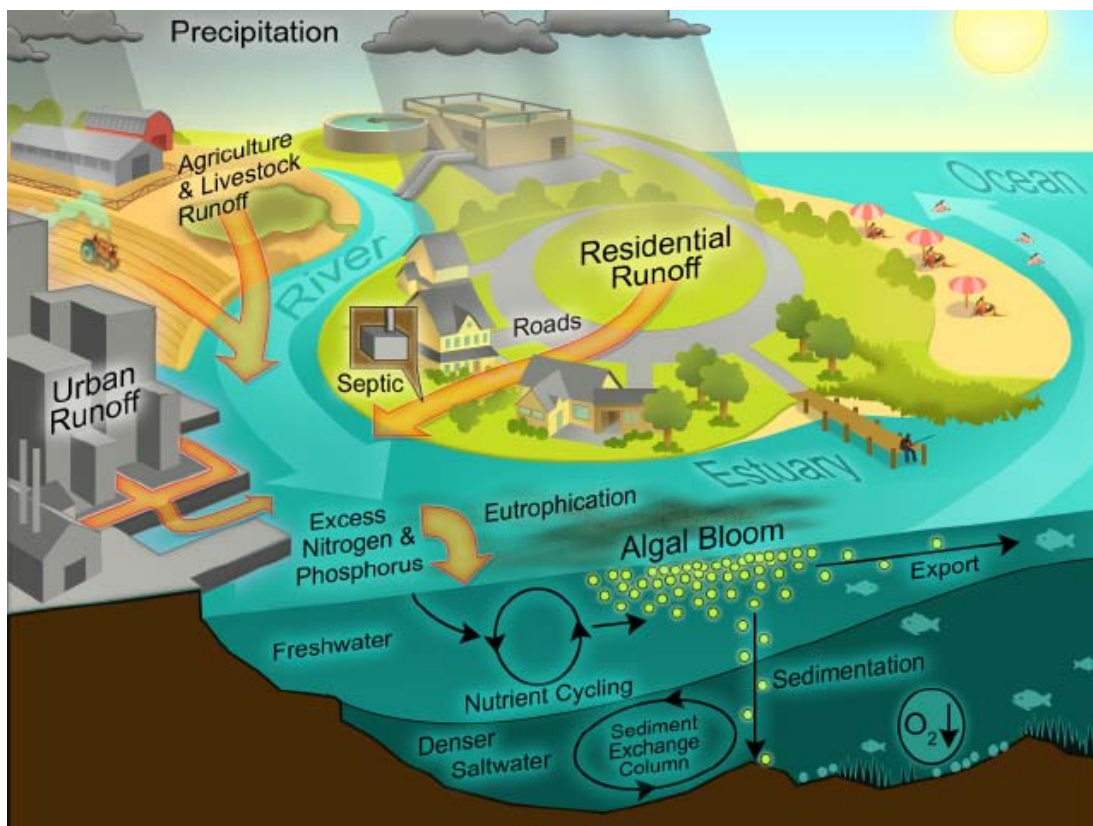
The report develops the idea of socio-economic analysis of controlling eutrophication, complementary to the other aspects of eutrophication developed under the project ISECA. Next section of this report provides information on coastal characteristics of Solent area, which is the area selected to investigate eutrophication in the English Channel, UK. The methodology section deals with the economic valuation techniques of market and non-market resources, which are not traded within formal markets and/or that, may have no prices at all. Next section, first describes the analysis followed by the discussion of the results. An in depth discussion of the findings of the study is also presented. The final section is providing a summary of the research. It presents conclusions drawn from the findings and offers recommendations.

2. Coastal eutrophication of Solent area

2.1. The definition of eutrophication

Eutrophication is a natural process where the coastal waters gain additional nutrients from the watershed and ocean causing the acceleration of algal growth (Ferreira et al., 2007; Bonsdorff et al., 1997). Eutrophication has been viewed as a problem in fresh water systems since the mid 1900s, however it was not identified as a threat in coastal and estuarine ecosystems until 1980s (Elliott and de Jonge, 2002). Increased influx of nutrients to water bodies causes algae to rapidly spread and as a result of its inherent genetical superiority, the algae tends to out-compete plants under these conditions, therefore causing some plant species to die (Das and Gazi, 2011). The nutrients enter the

aquatic environment through both point source discharges, such as waste water treatment plants, and diffuse sources, mainly from agricultural run-off (Atkins and Burdon, 2006). However, recently it has turned into a global environmental problem (Bricker and Stevenson, 1996) due to the increased nutrient loadings compared to the natural levels (Ferreira et al., 2007). The increase in nutrients has the potential to start an ecologically integrated complex of altered physical, chemical and trophic interactions which could create shifts in phytoplankton abundance, composition and algal bloom dynamics (Smayda, 2008). These changes and their outcomes are the result of the eutrophication process, which was initiated by the nutrient disturbance; however they are not the process itself (Smayda, 2008). The characteristics of the eutrophication process are similar to those of species succession, as it undergoes several stages which operate independently of the general ecological outcome (Smayda, 2008). A simple diagram of the eutrophication process is shown on Figure 2.



Source: http://www.tokresource.org/tok_classes/enviro/syllabus_content/5.4_eutrophication/index.htm

Figure 2: A diagram explaining the eutrophication process.

The algal blooms usually develop in periods and locations as shown in Figure 2, where there is nutrient enrichment causing the disturbance of the natural process. The increase in the nutrient concentration is more likely to be the indication of the potential for rather than the immediate evidence of

eutrophication. It could be only a short term result of transitory natural processes. The process of eutrophication has several definitions for example; nutrification, over-enrichment and hyper-enrichment are a few. In the Water Framework Directive (WFD) of the European Union (EU) there is a framework for the protection of estuaries and coastal waters from the process of eutrophication (Andersen et al., 2006). The levels of eutrophication as good, moderate and nutrient compromised habitat ecological status is most likely to be determined by the environmental management objectives. The Urban Waste Water Treatment (UWWT) Directive of the European Commission is attempting to reduce the adverse effects of urban waste water discharge and defines the eutrophication process as the nutrient enhancement of water and in particular compounds of nitrogen and phosphorus which create an increase in the growth of algae and higher forms of plant life to cause an undesirable disturbance to the balance of organisms and to water quality. The Nitrates Directive of the European Commission, concentrates on the loss of nitrogen caused by agriculture runoff and defined eutrophication as an intolerable deviation in the organization, purpose and stability of organisms in the water column and to the water quality as compared to reference conditions. Eutrophication has an effect on the nitrogen and phosphorus cycles, rates and levels of primary production, energy flow, assemblage structure, and species blooms. With each of these impacts there are shifts to different qualitative and quantitative levels while the disrupted ecosystem advances to, or from an oligotrophic, mesotrophic or eutrophic phase (Smayda, 2008). The prominent characteristic is that the process of eutrophication is not a fixed state because it is defined by various trophic phases and the duration, intensity. The changes caused by eutrophication could lead to overgrowth of seaweed and epiphytes, episodes of anoxia and hypoxia, nuisance and toxic algal blooms, and losses of submerged aquatic vegetation (Burkholder et al., 1992; Rabalais et al., 1996).

Eutrophication influence coastal organisms and coastal livelihood in different ways. The hypoxia and anoxia may cause fish kills and destruction of seagrass habitats and benthic organisms (Burkholder et al., 1992; Ferreira et al., 2007; Glasgow and Burkholder, 2000). It could cause long lasting negative effects on the abundance, diversity and harvest of fish in eutrophic systems (Breitburg, 2002; Ferreira et al., 2007). It has the potential to negatively affect the human health and disturb the ecosystem functioning (Diaz & Rosenberg, 2008; Ekholm & Lehtoranta, 2012; Ferreira et al., 2007). The algal toxins could be harmful if ingested in fish and shellfish tissue or inhaled directly (Anderson et al., 2000; Ferreira et al., 2007). From a socio-economic perspective they could lead to economic losses for seasonal tourism and the seafood industry (Anderson et al., 2000; Ferreira et al., 2007). The effects it could have on these industries are indirect and as a result difficult to determine (Ferreira et al., 2007; Turner et al., 1999). The presence of these nutrients in the environment could have different effects on

individual features of the ecosystem (Atkins & Burdon, 2006). These effects could be classified into two symptoms of eutrophication, primary and secondary (Bricker et al., 1999). The primary symptoms may consist of reduction in the light availability, alterations in the algal dominance and rise in the organic matter production. The secondary symptoms could consist of the loss of submerged aquatic vegetation, blooms of noxious and nuisance algae, macro-algal mats and low dissolved oxygen levels (Bricker et al., 1999; Atkins & Burdon, 2006).

Eutrophication could be influenced by soil erosion because the primary production that takes place in the marine environment is thought to be enhanced by phosphorus (P) coming from eroded soil from phosphorus amended agricultures (Ekholm & Lehtoranta, 2012; House et al., 1998; Pote et al., 1996). Soil erosion could be traced back to both natural processes and to human activities (Ekholm & Lehtoranta, 2012). The anthropogenic causes could include forestry, construction and agriculture (Ekholm & Lehtoranta, 2012). Agriculture is the most harmful of these as it causes both the greatest risk for soil erosion and the greatest potential for P reduction due to erosion (Ekholm & Lehtoranta (2012). For these risks to be decreased water protection measures such as preventing soil detachment and transport from cultivated fields have been established (Ekholm & Lehtoranta, 2012). Farmers from all over the world have been directed to choose reduced tillage, contour cropping, and cultivation of cover crops in order to create buffer zones and riparian areas, as well as constructing settling ponds and wetlands in order to reduce the loss of P (Boardman et al., 2009; Ekholm & Lehtoranta, 2012; Ekholm et al., 2007). Evidence suggests that it is point sources (effluent) instead of diffuse (agricultural) sources of phosphorus that pose the most significant threat for river eutrophication (Jarvie et al., 2006). This is also true for rural areas where the agricultural phosphorus losses are considerably higher. It is very difficult to determine which exactly the main cause for eutrophication as it could be the combination of different sources. In order to reduce eutrophication related problems the European Union adopted several key legislations which include the economic dimensions of eutrophication as well as traditional methods in order to increase the effectiveness of the future management strategies (Ferreira et al., 2007; Segerson & Walker, 2002).

Until recent years it was thought that UK waters were under threat from eutrophication based on measurements of winter concentrations of nitrate and phosphate and summer concentrations of phytoplankton chlorophyll (Tett et al., 2007). However, the nutrient enhancement and increased growth of algae are not dangerous; since the majority of these measurements do not offer sufficient information on the amount of change in the balance of organisms, they cannot accurately determine harmful outcomes of nutrient enrichment (Tett et al., 2007). The Solent receive input of nutrients from

a variety of sources which is an ever increasing problem, however, regular appearance of algal-generated foam in the waters and on the beaches are atypical. The English channel can be categorised as an area where tidal mixing and river runoff control nutrient distributions. Investigations by the Environment Agency (EA) resulted in the designation of Langstone, Chichester, Portsmouth, Pagham, Medina, Newtown and Hamble estuaries as both sensitive areas and polluted waters under the Urban Waste Water Treatment Directive and Nitrates Directive (Solent Forum, 2012). This study will be focusing closer on the macro-algal blooms that occur as a result of eutrophication because it is a more focused issue that has more visible signs that are obvious to the general public.

2.2. Eutrophication related issues in the Solent

Overall bathing water quality across the Solent is very good with two thirds of the bathing waters consistently achieving guideline compliance over the last five years (Solent Forum, 2010). However, there are some problems of bathing water quality in some areas due to the very wet weather conditions causing increases in freshwater inputs from streams and combined sewer outfalls. The impacts of eutrophication are, however, visible as algal blooms in Solent harbours caused by agricultural run-off and sewage discharge. As algal grows during the summer, demand for oxygen increases killing some aquatic life directly and depleting food for fish and birds.

2.2.1. Agricultural run-off and Nitrate Vulnerable Zones (NVZ)

NVZs are areas designated as being at risk from agricultural nitrate pollution. Member States of the European Commission have to identify waters which are or have the potential to become polluted by nitrates and to designate the territory draining to those waters, and contributing to the pollution, as NVZ (Environment Agency, 2012b). The presence of great quantities of nitrate in fresh water could lead to a number of harmful effects to rivers, streams and lakes (DEFRA, 2012). Similarly, the EU issued a special directive to deal with the issue of diffuse water pollution resulting from nitrates coming from agriculture, namely the Nitrates Directive in 1991. The purpose of the Nitrates Directive is also to protect waters against nitrate pollution caused by agricultural sources (Environment Agency, 2012b). Its aim is to control of excess use of materials containing nitrates and in particular animal manures which are only allowed to apply to the land when the risk of the nitrate polluting water is low (DEFRA, 2012). This is allowed only under two conditions i.e., the crops are actively growing and can use the existing nitrogen, and the ground is dry enough (DEFRA, 2012). The directive determines the criteria for identifying waters as polluted, as well as areas requiring monitoring (Environment Agency, 2012a). It also states that the designations for NVZ must be reviewed at least every four years (Environment Agency, 2012b).

Farmers of the vulnerable areas can also contribute to solve the problem by applying responsible amount of fertiliser when the risk of the nitrate polluting water is low. Particularly, in the areas where there is too much nitrate farmers should aim to utilise practices that decrease the risk of nitrates polluting the watercourses. These practices need to be enforced in designated NVZs, areas with strong risk of run-off into watercourses (DEFRA, 2012). NVZs are present in many parts of the UK as represented in Figure 3 a). The Solent area and Chichester in particular are also NVZs as is shown on Figure 3 b).

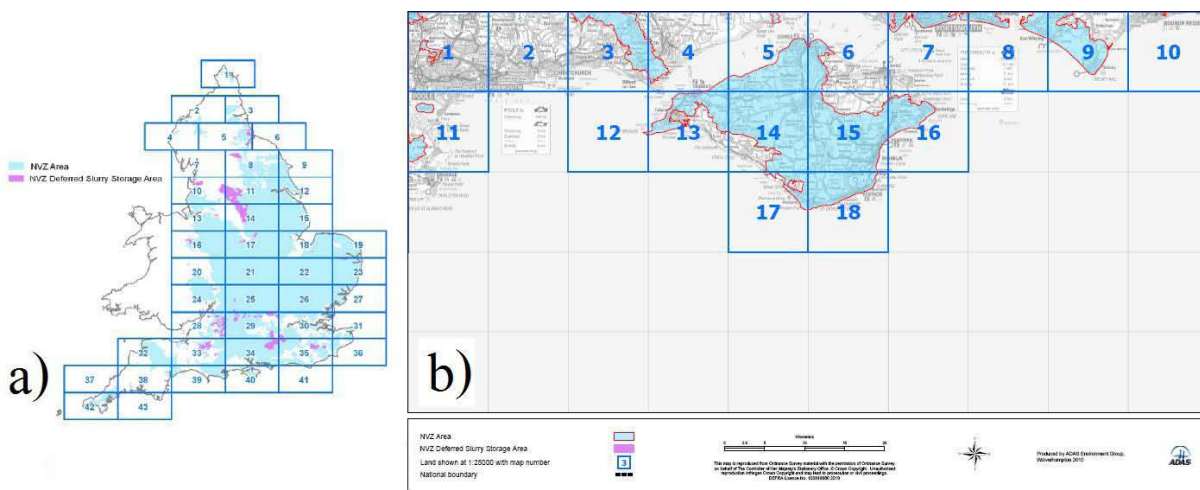


Figure 6. a) Map representing the NVZ in the UK; **b)** Map representing the NVZ in the Solent area (DEFRA, 2010).

2.2.2. Sewage discharge

According to the EU Nitrates Directive the majority of the nitrate in fresh water derives from agricultural sources (DEFRA, 2012). However, agriculture is responsible for 50% to 60% of the nitrate input to the water in England (DEFRA, 2012). The other main source of pollution in Solent waters is sewage discharge. Combined sewer overflows (CSOs) provide controlled spills of storm water and domestic sewage from a combined sewerage system during heavy rainfall (Solent Forum, 2010). CSOs are mainly owned and operated by water companies, however, regulated and monitored by the Environment Agency, UK and the European Urban Wastewater Treatment and Bathing Water Directives. Recent events such as increased annual rainfall and severe storm events driven by climate change are causing increased environmental impacts of CSOs unless measures are introduced to limit spill frequency and also to increase CSO storm storage capacity in the Solent area.

It is not economically feasible to construct the infrastructure that has the capacity to cope with the most extreme weather events (Solent Forum, 2010). The solution to avoid sewage discharge problem in Solent is to reduce the load to the sewers minimising the number of occasions of overflow. The

introduction of Sustainable Urban Drainage Systems (SUDS) is one solution in which replicate natural systems to drain away dirty and surface water run-off through collection, storage and cleaning before allowing it to be released slowly back into water courses (Solent Forum, 2010). The general public could contribute to solve the problem by participating in different ways. Water conservation (wise use), harvesting rain water and use of permeable paving which will reduce the volume of water in the sewerage system are some of the few methods. The Environment Agency on the other hand is trying to improve unsatisfactory CSOs in their five year programme (2010-2015). In this programme they have to add spill monitoring equipment to a large number of CSOs.

This study will be focusing closer on the macro-algal blooms that occur as a result of eutrophication caused by agriculture run-off and sewage disposal related activities. The socio-economic impacts of these activities will be measured by investigating perception and willingness to pay for the control of eutrophication of the general public.

3. Methodology

In socio-economic research eutrophication is considered as an externality associated with the use of water as an input to production systems. It could be excess nutrients run-off from agricultural activities or effluent from sewage water treatment. Thus, there are many institutional and regulatory mechanisms available to manage eutrophication. Some consideration is given to the discrepancies that persist among the private and the social interests related to water quality under the chosen methodology. This discrepancy is due to the differences in opportunity costs of individuals and society, particularly when related to environmental resources and ecological functions that are utilised, in one way or the other, in the processes of production and consumption. The concepts of economic value of controlled water pollution, as well as of externalities and other aspects associated with the eutrophication among uses and users, are emphasised. Some evidences are presented on the economic impacts of eutrophication through the estimation of costs and benefits of reducing eutrophication or improving water quality in general.

One of the default assumptions in economics has been that restrictions on economic activity are likely to reduce societal welfare unless there are compelling counter arguments (Farrow 1996). Eutrophication is an ideal example which restricts many economic activities in coastal areas affecting social welfare of residents. The quantification of those counter arguments has evolved in the form of cost-benefit analysis (CBA) and, in the case of projects and proposals with environmental connotations, environmental valuation techniques. The control of eutrophication fall within the

category of regulatory proposals for which CBA is increasingly required or used to help support their adoption. CBA is a pragmatic theory of welfare economics, the current frontiers of which are associated with modelling and measuring non-use benefits. In contrast to past efforts with intangibles, research on this topic remains almost as potentially controversial and innovative as twenty years ago, albeit helped by developments in the definitions of non-use benefits and a growing body of theoretical and real world applications using an expanding number of survey and model variations (Cicchetti and Wilde 1992; Bishop and Welsh 1992). Within CBA the determination of the economic benefits of controlling eutrophication is the difference between the net economic benefits derived from the pollution control and the net economic benefits derived from the resource without protection, with benefits being net of costs and including both use and non-use values (Dixon and Sherman 1990, Pendleton 1995). Taking a more holistic approach is more theoretically and technically challenging, made more so by the value of protection depends on time and the imminence of environmental degradation.

The application of CBA in eutrophication is depending on the estimation of the value associated with the protection. Without the existence of revealed preference data and the limited scope for recreation and tourism in conjunction with protection (which in itself is not an ideal basis for value determination as mentioned above), stated preference techniques within the area of environmental economics offers the principle tools of analysis. From the choice of the two main approaches, contingent valuation method (CVM) and choice experiments, the latter has been used in respect of the case of eutrophication. Although, CVM is widely used for eliciting respondents' preferences for un-priced benefits associated with coastal environmental quality, especially for the non-use values, the specific nature of the resource to be valued makes it difficult or rather impossible to use in this study. Flawed estimates are likely the outcome where the resource has never been seen or is difficult to imagine, such that the respondents' preferences in an economic sense for the good cannot be well-defined (Carson et al. 2001). Choice Experiments are not so constrained and has been selected in this study.

Choice experiments have seen a growing body of academic literature recently, partly in response to attempts to find alternatives to CVM and partly reflecting their own development. Choice experiments are viewed by some as an evolution of CVM given that both are stated choice approaches involving surveys of some sub-set of society and based on the economic theory of random utility (Adamowicz and Boxall 2001, Adamowicz et al 1998). However, the explicit use within choice experiments of attributes and levels in an experimental design and the construction of response surfaces from the data are major variations from contingent valuation and are more closely aligned with conjoint analysis,

which has its basis in market research (Carson et al. 1994). Solent eutrophication is a result of numerous anthropogenic activities of the area and ideally incorporates in a properly designed choice experiment design. The basic approach and its various forms used in this design have been developed since the early 1970s (Green and Srinivasan, 1978, 1990). However, choice experiments were only extended to the estimation of the impacts on economic welfare of altering the provision of public goods in the early 1990s (Viscusi et al 1991, Opaluch et al 1993, Adamowicz et al 1994). Since then they have become increasingly popular given their flexibility (Bennett and Blamey 2001, Farber et al 2002, Powe et al 2005).

In the field of coastal resources management, choice analysis has not been applied to any great extent. Aas et al (2000) used a choice modelling approach for evaluating various fisheries management alternatives and programs for harvest regulation in a recreational fishery in Eastern Norway. With an environmental dimension within the area of private goods, choice experiments have been applied to inter alia eco-labelling in fisheries by Wessells *et al.* (1999), Beckett *et al.* (1999) and Teisl *et al.* (1999). In the area of public environmental goods, notable works have been in respect of pollution and coastal values: visibility changes (Rae 1983, 1984), air pollution (Lareau and Rae, 1989), hunting trips (Mackenzie, 1990, 1992, 1993; Gan and Luzar, 1993; Boxall, *et al.* 1996), water-based recreational resources (Smith and Deasvouges 1986; Adamowicz, *et al.* 1994; Roe, *et al.* 1996; Adamowicz, *et al.* 1997), hazardous waste (Smith, *et al.* 1985), and landfill site selection (Opaluch, et al., 1993). These studies reveal that there is a growing appreciation of choice experiments in the area of environmental valuation, although there is still relatively little literature on its application to the issue in question. For a detailed list of applications of choice experiments see Adamowicz and Boxall (2001). More recent work includes the work of the project team on three EU projects, MISSFISH, MOFISH and PROTECT. Choice experiment was used to estimate the preferences for sustainably and quality labelled fish products within the MISSFISH project (Jaffry *et al.* 2004) and to evaluate three overriding fisheries management objectives in the English Channel within the MOFISH project (Wattage *et al.* 2005). More recently, choice experiment was used to elicit preferences for the conservation of deep sea corals in Irish waters under marine protected areas (Wattage, *et al.* 2011).

3.1. Experimental design of the eutrophication choice study

Measurement of the benefits and costs for improvement of water quality of eutrophication is often difficult. The effects on all parties concerned have to be taken into account, which might involve studying a local region or an entire country. As eutrophication increases, the productive potential for coastal water diminishes; the value, i.e, the utility of coastal users cannot be realised. The experimental

design of the choice study, if it is an appropriate design, can incorporate these different aspects of eutrophication.

Lancastrian consumer theory provides theoretical basis for choice experiments and the random utility theory with its contributions from psychological theories of information processing (judgement) and decision-making. Lancastrian consumer theory proposes that utilities for goods can be decomposed into separate utilities for their component characteristics or attributes. Random utility theory explicitly models the choice among substitute alternatives for a given occasion, with given constraints (income, time, etc.). The choice modelled is as a function of the characteristics of the substitute alternatives (Wattage, et. al., 2005). The random component takes into account, *inter alia*, the possibility that the analyst may have omitted variables or committed measurement errors, or that the consumer may have been inattentive during the choice process (Adamowicz et al 1998).

This economic foundation has made the elicitation method increasingly popular among economists. Being based on random utility theory from an economics point of view, choice experiments have a strong theoretical basis. They also have certain other attributes that make them particularly suitable to the application in the choice of eutrophication. Subjects relevant to eutrophication can be shown different sets of alternatives and will be used to choose or allocate resources between them. Choice model also can be estimated directly from choice data, thus avoiding the potentially unrealistic ad hoc assumptions about choice behaviour that are necessary with alternative formats. In particular, it permits the design of choice or allocation experiments that mimic real-life choice environments closely.

The only condition required in the design is that the response data should be discrete, either nominal or classificatory in level of measurement. There are, however, challenges associated with the method of analysis. Choice experiments are particularly challenging in their design as it requires two separate designs to be combined: the creation of the choice alternatives and then the choice sets. Both designs must satisfy certain statistical properties to estimate parameters and conduct statistical tests efficiently (Louviere and Woodworth 1983). Notably, the various combinations of attributes and alternatives must be varied according to specific criteria. Note, that the analysis is not interested in valuing the alternatives, only the individual attributes. The formulation of the choice alternatives enables the analysis to elicit the value of each of the attributes relative to other attributes. The complexity of designing choice sets is discussed in depth by DeShazo and Fermo (2002). The design issues, however, are not insurmountable, with a variety of factorial and fractional factorial designs to assist (for detail,

see Louviere 1988; Louviere and Woodworth 1983; Adamowicz, et al. 1994, Adamowicz and Boxall 2001).

The choice experiment mechanism and aim is to estimate the structure of an individual's preferences by establishing the relative importance of the different attributes as incorporated within a set of alternatives (pre-specified in terms of levels of attributes) presented in questionnaire format. The design aims to estimate in so doing (a) the relative importance of the individual attributes; (b) the trade-offs or marginal rates of substitution that individuals are willing to make between these attributes; and (c) the total satisfaction or utility scores for different combinations of attributes (Ryan 1996). The total utility that an individual derives from that alternative is determined by the utility to the individual of each of the attributes. Choice-experiments consider the number of alternatives while either holding the attribute levels associated with each alternative constant, or by varying them, thereby producing choice sets. The respondents' express their opinion by making a choice between the different combinations presented. Fixed choice set design is used in this study and is particularly widely used (Hensher 1994). In the implementation of a study, there are several steps and considerations that have to be completed, forming the basic framework of evaluation (Green and Srinivasan, 1978 & 1990). Firstly, a set of attributes ($p=1, \dots, t$) are chosen and the alternatives defined. This involves 3 key elements: understanding the decision problem and environment, identifying determinant attributes, and establishing attribute positioning measures. These elements involve the disaggregation of the management process into key attributes with different potential levels. Attribute positioning measures, such as the level of accomplishment of attributes, are developed that satisfy the research objectives and are meaningful to the individuals targeted for survey.

The survey incorporated the key features regarded as the most important in the implementation and management of eutrophication in the Solent area. In defining the model structure, care was taken to ensure completeness of the system, such that all major issues related to the eutrophication in Solent area were incorporated and identifiable in some level. A lengthy discussion and considerable time was given to clarifying the terms used for the attributes and their underlying implications so that the decision attributes developed were clear and concise. The 3 main attributes and the associated levels considered in the analysis are shown in table 1. The overriding objective of grouping them was to ensure the control of eutrophication in Solent area from the sources of pollution and to provide a better coastal ecosystem for the use of general public. The levels attached to the attributes have been developed to describe distinct policy scenarios for the coastal areas, including the area potentially covered by zoning, the nature of access by general public and levels of management charge. Having a

basis in reality should help guide management decision-making and help respondents express well founded choices.

Table 1: Levels of attributes and accompanying management objectives.

	Attributes	Level I	Level II	Level III
1.	<i>UPSTW – Upgrade sewage treatment works</i>	Status Quo (maintain current levels)	Improving (more treatment work to improve water to good level)	Significantly Improving (costs more but water at excellent level)
2.	<i>REDAGNUT – Reduce nutrient inputs to rivers and estuaries discharging to the Solent water</i>	Status Quo (current number of farms compliant with the requirements of the Solent NVZs)	Improved Compliance (the number of non-compliant farms is halved)	Full Compliance (all farms become compliant)
3.	<i>COST – Management and monitoring cost (this payment would be an additional yearly tax contribution per person)</i>	£0 (no additional tax)	£10 (additional yearly tax)	£25 (additional yearly tax)

The first two attributes of the choice experiment study look at two of the main anthropogenic causes of eutrophication. The first attribute is to upgrade sewage treatment works (UPSTW) which concerns the effects of improving treatment work compared to the status quo. Two levels of expected improvements might change the water quality up to “good” and “excellent” levels with an additional cost. The second attribute involves reducing nutrient inputs to rivers and estuaries discharging to the Solent water (REDAGNUT), which represents the number of farms which are compliant with the requirements of the Solent nitrate vulnerable zones (NVZ). The two levels of this attribute are expected to achieve “improved” compliance (the number of non-compliant farms is halved) and “full” compliance (all farms become compliant), compared to the “status quo”. Many other factors such as pollution from shipping or factories could lead to eutrophication of the area but they are not that significant in the Solent area. The third and final attribute is the cost. It reflects the respondents’ WTP for protecting the water quality in Solent from eutrophication. This hypothetical attribute is considering the cost of maintaining a good level of water quality through management and monitoring its current state while insuring the long term protection. Another reason this attribute is to be included in the survey is that it provides a standard to measure the public support for the methods for dealing with the risk from eutrophication listed above and the value they set on these options. Considering that the financing for utilising eutrophication preventative methods need to come from one source or another, a possible option is for the general public to have some increase in taxes, as an annual additional tax contribution

per person. The amount of tax increases to £10 and £25 from the status quo of £0. All revenues would be invested in the methods for ensuring the Solent water quality.

The three attributes and three levels (3^3) in table 1 produce a total of 27 different combinations using a main effects design. With the ADX Interface for design of Experiments (SAS 9.1) (an orthogonal main-effect design - where all interactions are assumed to be insignificant), this was subsequently reduced to 9 profiles for use in the study.¹ Orthogonality has been assumed (implying that the coefficients will have minimum variance), with the design ensuring that individual estimates of the respective attributes and levels are independent of each other (Aas et al., 2000). These 9 profiles with their component attributes and levels were then incorporated into a questionnaire format, using the most popular presentation approach - profile picture cards with a verbal description of the attributes and associated levels. The description of attributes is crucial to ensure that each respondent understands the meaning of each attribute. The questionnaire was designed to include all the 9 profiles/choices on one card (see appendix I), and respondents were asked to select a most preferred option out of the 9 presented to them. The design strategy of presenting all 9 choices in the one card was found during piloting to be acceptable without information overload. It is also easier for respondents to compare the options when they see all the available options on one card rather than one at a time. The data representation for such single choice selections consists of one observed choice and eight unobserved subsequent choices. The questionnaire also included a number of socio-economic questions important for the analysis, interpretation and validation of the results, was conducted during the summer of 2012. A randomly selected sample of 275 residents of Solent area was interviewed using a face-to-face survey. This sample size is large enough to achieve a margin of error of less than 5%, which with the questionnaire format generating 9 choice responses for each respondent creates a good sized dataset, potentially resulting in a margin of error of less than 2% (Mitchell and Carson 1989).

3.2. Methods of analysis

In the choice experiment format the respondent makes a discrete choice from a set of presented alternatives or choices, combined within choice sets, in contrast to the contingent valuation format where the respondent places a monetary value on a scenario. Each alternative in choice experiment is represented by a utility function that contains a deterministic component (V_i) and a stochastic component (e_i). The overall utility of alternative i , is represented as: $U_i = V_i + e_i$. A premise of this

¹ The 9 profiles given using an orthogonal main effects plan were arrived at by identifying a subset of the full set where each linear combination of attributes of the full set can be achieved. That is, the subset still enables the analysis of all alternatives to be made.

approach is that choices can be modelled as a function of the attributes of the alternatives relevant to a given choice problem using random utility theory. There are several methods that have been proposed for the estimation of the parameters, including MONANOVA (monotone analysis of variance) for full factorial designs and OLS and LOGIT-based approaches for fractional factorial designs.

In this socio-economic study, we used a Multinomial Logit Model (MLM).² The MLM model is derived from the assumption that the error terms of the utility functions are independent and identically Gumbel distributed.³ The independence from the irrelevant alternatives (IIA) assumption is a key property which infers that the ratio of the probabilities of any two alternatives is independent from the choice set, i.e. that the ratio of the probabilities of choosing any two options will be unaffected by the attributes or availability of other options. IIA to be a property of appropriately specified choice probabilities (Train, 2003) and (Luce, 1959), However, in general applications it is as a resulting property of the logit model that IIA is evaluated (Train, 2003), by fitting the model that contains cross-alternative effects and examining the significance of these effects. It may not be an appropriate test for all choice situations (Train, 2003). The MLM model gives the probability that individual i choose alternative j as a function of its individual characteristics and unknown parameters:

$$Pr_i(j) = \frac{e^{X_i\beta_j}}{\sum_{k=1}^J e^{X_i\beta_k}} \quad 1.1$$

Using multinomial logit estimation procedure, only $J-1$ of the parameters can be estimated as follows:

$$\frac{e^{X_i\beta_j}}{\sum_{k=1}^J e^{X_i\beta_k}} = \frac{1}{\sum_{k=1}^J e^{X_i(\beta_k - \beta_j)}} \quad 1.2$$

The MLM uses individual characteristics to explain the choice of alternatives, and estimates $J-1$ parameter vectors for $J-1$ of the alternatives.

An alternative, the Conditional Logit Model (CLM) gives the probability that individual i chooses alternative j as a function of the attributes varying for the alternatives and unknown parameters (McFadden, 1974). In CLM, X_{ij} is used as a vector of attributes site j and individual i , with the probability that individual i choose alternative j considered as:

$$Pr_i(j) = \frac{e^{X_{ij}\beta}}{\sum_{k=1}^J e^{X_{ik}\beta}} \quad 1.3$$

² Also termed conditional logit model (CLM).

³ The Gumbel distribution is used to find the minimum (or the maximum) of a number of samples of various probability distributions.

The analysis of preference for choices in the coral case study was first modelled using CLM and its more general version, the nested logit model. The analysis was carried out using the SAS MDC procedure. However, the results proved not to be significant and particularly the relationship of choices with the explanatory variables was highly insignificant. Consequently the less complex MLM approach was subsequently used. By selecting an appropriate functional form for the cumulative distribution, the systematic portion of the expected utility function can be estimated as specified, as is explained in detail in the next sub-section.

3.3. Solent case study application

This application of choice experiments in Solent area within the context of eutrophication is targeted at measuring the preferences of the Solent general public for the protection of coastal waters and associated values. As mentioned previously, coastal waters are polluted due to sewage discharge and agricultural runoff of the area. Thus, public perception and their preferences are sought for the control of these two activities along with their willingness to pay.

A survey questionnaire was designed including choice experiment cards, attitudinal questions and socio-economic profiles of respondents (see appendix I). The choice profiles with their component attributes and levels were incorporated into a questionnaire format, using the most popular presentation approach - profile picture cards with a verbal description of the attributes and associated levels. The description of attributes in a very simple manner is crucial to ensure that each respondent understands the meaning of each attribute and associated levels. The questionnaire was designed to include all the 9 profiles/choices on one card, and respondents were asked to select a most preferred option out of the 9 presented to them. The design strategy of presenting all 9 choices in one card was found feasible during piloting to be acceptable without information overload. It is also easier for respondents to compare the options when they see all the available options on one card rather than one at a time (Wattage et al., 2011). The data representation for such single choice selections consists of one observed choice and eight unobserved subsequent choices. The questionnaire also incorporated a number of socio-economic questions important for the analysis, interpretation and validation of the results and attitudinal questions, which was carried out during the summer of 2012.

A randomly selected sample of 275 residents of the Solent area was selected, ultimately achieving a response rate of around 250 suitable for the analysis. This sample size is large enough to achieve a margin of error of less than 5%.

3.4. Model estimation using SAS, PHREG procedure

The purpose of the model estimation is to reveal the preference of the general public of Solent on eutrophication. The survey conducted as part of ISECA was designed to collect observations for scenarios presented in table 1. It also incorporated the key features regarded as the most important in the implementation and controlling pollution sources. In defining the model structure, care was taken to ensure completeness of the system, such that all major issues related to the eutrophication were incorporated and identifiable in some level. Considerable time was given to clarifying the terms used in the attributes and their underlying implications so that the decision attributes developed were clear and concise. The three main attributes and the associated levels considered in the analysis are shown in table 1. The overriding objective grouping them all was to ensure protection of coastal waters while maintaining sustainable use of the coasts. While in this case study, only three attribute groups are employed, choice experiment models can generally consider even more attributes and associated levels.

3.4.1. Results of the PHREG procedure

The PHREG procedure of SAS software was used to fit the choice model to the data set and to determine the importance of each attribute. Using the method of partial likelihood, PHREG was modelled to do Cox regression analysis of continuous-time survival data to estimate the proportional hazards model. This section details the results of the choice experiment, which was analysed using the Conditional Logit PHREG procedure. Generalised and conditional logit models (CLM) are usually used to model consumer choices, while the cumulative logit model is used in situations where the response of an individual unit is restricted to one of a finite number of ordinal values. The SAS/STAT software does not have a procedure that is specially designed to fit the conditional logit models. However, the PHREG procedure can be used to fit these models with some modification to the data entry procedure. The use of MNL for the job has some limitations and it differs in two respects. The explanatory variables can include characteristics of the choice options as well as variables describing the relationship between the chooser and the option. Second, the set of available options can vary across individuals in the analysis. Preference elicitation for choices using the PHREG procedure has been well documented in the coastal applications. Choice modelling approach using PHREG was used to evaluate three overriding fisheries management objectives within English Channel fisheries (Wattage *et al.*, 2005) and also to evaluate objectives of marine protected areas in Irish Waters (Wattage *et al.*, 2011).

First, the importance of each attribute model was estimated using the PHREG⁴ procedure in SAS (SAS Institute Inc., 1999). PHREG was designed to do Cox regression analysis of continuous-time survival data, using the method of partial likelihood to estimate a proportional hazards model. The stratified partial likelihood function estimated is identical to the likelihood for CLM analysis. Further, PHREG has a unique option for handling tied data, such that the range of CLMs estimated is much broader than most Cox regression programmes or even programmes specifically designed to estimate discrete choices (Allison, 1999). The result proves that PHREG is one of the best procedures available in statistical tests for handling discrete choice problems.

The estimated chi-squared values for likelihood ratio, Score and Wald statistics indicate that the model is very highly significant (table 2). At a significance level of $\alpha = 0.01$, one would reject the null hypothesis of no relationship between choice and the attributes. In fact all three model tests indicate a high level of significance with probability <0.0001 , indicating that there is a strong relationship between choice and the attributes.

Table 2: Model test statistics (global $H_0: \beta = 0$).

Test	χ^2	DF	$\text{Pr}>\chi^2$
Likelihood ratio	159.69	6	<0.0001
Score	159.74	6	<0.0001
Wald	125.52	6	<0.0001

The significance of the model was carried out using several χ^2 likelihood ratio tests. The first one was the *likelihood ratio chi-square* obtained by comparing the log-likelihood for the fitted model with the log-likelihood for a model with no explanatory variables. The ratio was calculated by taking twice the positive difference in the two log-likelihoods. Taking the logistic values this produces $-2 \times \log$ -likelihood for each of the models. The chi-square is the difference between those two numbers. The *score* was the second test used in the model. This statistics is a function of the first and second derivatives of the log-likelihood function under the null hypothesis. The results of these two tests are generally similar in large samples and in this test they were 159.69 and 159.74. However, for smaller samples and samples with extreme data patterns the likelihood ratio chi-square test is superior over the score test (Jennings, 1986). *Wald* chi-squares are the third test in this category reported by the model

⁴ This procedure fits the Cox proportional hazards model to survival data. The partial likelihood of Breslow has the same form as the likelihood in a conditional logit model.

(125.52), which was calculated by dividing each coefficient of the maximum likelihood estimates by its standard errors and squaring the results.

Most significant part of modelling is the estimation of parameter values of the maximum likelihood model and their related statistics which are presented in table 3. As shown in the table, only the parameter value for the *COST* of £10 is not significant even at the $\alpha = 0.10$ level. Descriptive labels for all variables are presented along with the zero coefficients for the reference levels (i.e. status quo of area and activity and the zero cost). The other estimated coefficients of the model have values relative to the reference level. Under the attribute of *UPSTW*, the part-worth utility (i.e. the estimated coefficient) for the variable status quo (current situation) is a structural zero, while the part-worth utility for “improving” is + 1.32881 and “significantly improving” is + 1.78112. Hence, the “significantly improving” is preferred over both the “status quo” and the “improving” of “UPSTW”. The magnitude of the estimated coefficient indicates which objective is more preferred by the sample respondents. The success of the control of eutrophication generally depends upon the control of anthropogenic activities of the area. The survey finding confirms that out of the potential control options, the Solent public prefers the control of eutrophication by significantly upgrading sewage treatment work. Both parameters tested under this first attribute proved very highly significant as indicated by the $Pr > \chi^2$ values. Both values proved significant even at $\alpha = 0.01$ levels as $Pr > \chi^2$ is < 0.0001.

Table 3: Analysis of maximum likelihood estimates for the model

Parameter Variable	Estimate	Standard Error	χ^2	$Pr > \chi^2$
UPSTW				
Improving	1.32881	0.24956	28.3513	<0.0001
Significantly Improving	1.78112	0.23037	59.7778	<0.0001
Status Quo	0	-	-	-
REDAGNUT				
Improved Compliance	0.85993	0.20952	16.8472	<0.0001
Full Compliance	1.19491	0.20921	32.6218	<0.0001
Status Quo	0	-	-	-
COST				
£10	0.03931	0.16867	0.0543	0.8157
£25	-0.40528	0.18112	5.0069	0.0252
£0	0	-	-	-

The second management attribute tested in the model was the “REDAGNUT”, – Reduce nutrient inputs to rivers and estuaries discharging to the Solent water. When compared to the *status quo* (current

practices), *full compliance* for the reduction of nutrient input to rivers and estuaries discharging to the Solent water and *improved compliance* were preferred. The magnitude of the estimated parameter indicating that the full compliance (+1.19491) was preferred over improved compliance (+0.85993). Moreover, both parameters proved highly significant at $\alpha=0.01$ level (table 3), with the part-worth utility for the status quo. The general consensus of the Solent public is to implement full compliance in reducing nutrient inputs to rivers and estuaries discharging to the Solent water.

The third management attribute tested in the model was “*COST*” which is the management and monitoring cost. This willingness to pay (WTP) value was designed as a payment which would be an additional yearly tax contribution per person. The status quo was set as £0 (no additional cost) and compared to a £10 additional yearly tax and a £25 additional yearly tax. The results reveal that £10 (+0.03931) was favoured over the status quo and a £25 tax (-0.40528) less favourable than both the status quo and a £10 tax. However, parameter for £25 tax proved significant at the $\alpha=0.05$ level while the attribute of COST of £10 was not significant determinant of preference on this issue even at $\alpha=0.10$ level.

3.4.2. Probability associated with each choice

The parameter estimates given in table 3 were used to estimate the probability of each of the 9 choices presented being chosen. The estimated parameter values were applied to equation one⁵ and the probabilities for the 9 cards shown to respondents are given in table 4.

As indicated in table 4, the most preferred combination of attribute and the level is UPSTW significant improvement with a probability of 0.18471. This indicates that the significant improvement to sewage treatment work is the most preferred option according to the general public of Solent. The preference for this level is clear as it is the most profound action that will lead to the control of eutrophication in Solent. The second choice indicated by the probability is 0.16517 for full compliance of reduce nutrient inputs to rivers and estuaries discharging to the Solent water attribute (REDAGNUT). The third preference represented by the probability value of 0.12808 to the attribute of COST of £10. However, this variable is not significant in the model. The fourth level of probability is assigned to the COST £0 indicating that the general public is on a view that they are not responsible for sharing the cost associated with the improvement of eutrophication level.

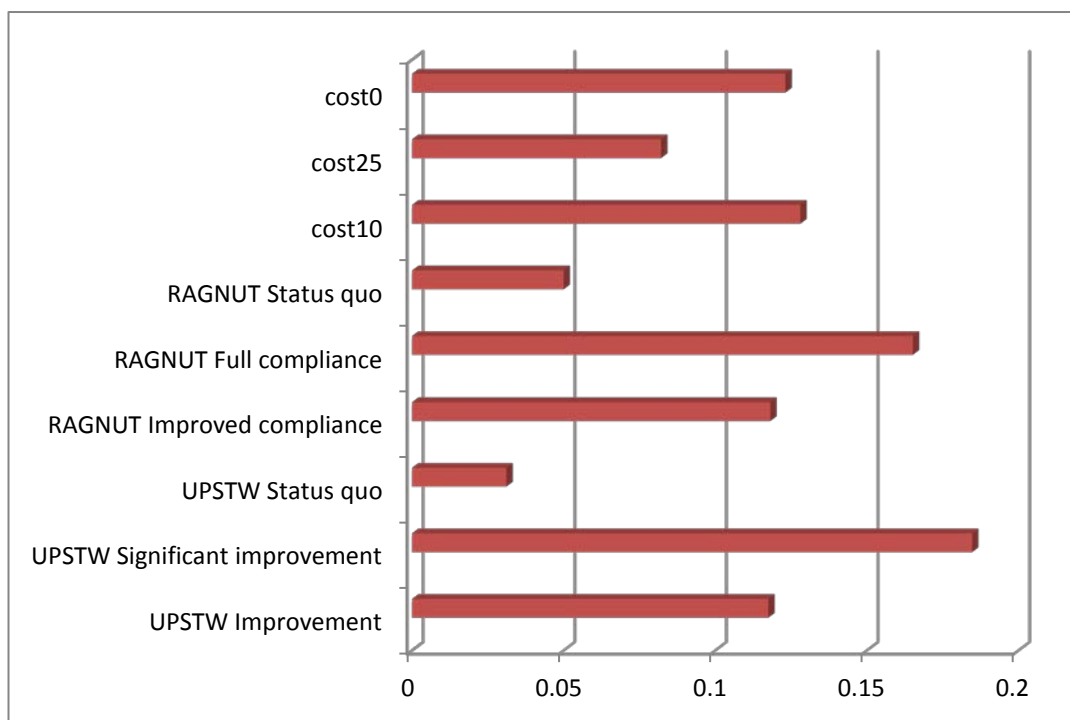
Table 4: Probability of choice

⁵ Probabilities for all 27 alternatives of the full design may be calculated in this way.

Attribute	Levels	Probability
UPSTW	Improvement	0.11752
	Significant Improvement	0.18471
	Status Quo	0.03111
RAGNUT	Improved Compliance	0.11816
	Full Compliance	0.16517
	Status Quo	0.05000
COST	£10	0.12808
	£25	0.08211
	Status Quo £0	0.12314

Looking to the consensus of opinion, using the choice probabilities, it is possible to get a crude indication of the importance/preference attached to each of the individual objectives arising out of consensus. One way of doing this is to take a simple average of probabilities for each attribute, the results of which are shown in figure 4.

Figure 4: Rough estimation of the degree of importance attached to each attribute (derived from the full set of 27 alternatives)



As shown in the figure 4, the ranking of attributes and levels suggests that the top 2 preferences for significant improvement of sewage water treatment and full compliance of reduce nutrient inputs to rivers and estuaries discharging to the Solent water. These results are largely as expected given the results of the maximum likelihood model and confirm the level of importance attached by the Solent public to control of eutrophication.

4. Results and conclusion

Sico-economic evaluation is necessary in restoration of water quality of coastal areas and/or in prevention of pollution leading to eutrophication of the water bodies. Many problems related to availability and quality of water originates from inefficient allocation of the resources among uses and users. Discrepancies in water allocation or externality caused by pollution that arise between private and social interests should be considered in planning of restoration of water. Water is environmental resource considered mostly in the economic concept as public good. Therefore any changes of use of available quality and quantity of water may have important effects on distribution of wealth.

In many cases of reforms in natural resources are causing nations to adopt economic instruments and market-based strategies for the development and protection of water resources. These strategies include estimating value or markets for water, markets for pollution abatement, and a variety of fees, taxes, or charges for water or pollution. Such strategies typically are used with regulations to govern overall levels of water use or pollution. This approach enables the water quality and quantity goals to be achieved with less disruption to economic growth in situations where there are no prices for natural resources. Furthermore, they can also generate revenues that can be used to support essential coastal public infrastructure, such as improved pollution control systems, cooperative treatment facilities for sewage and pollution, and better-equipped departments for the monitoring and management of water quality.

Economists have developed methodologies for measuring benefits and costs of natural resources. Assessment of the value of controlling eutrophication in the form of willingness to pay is a particular type of water resource challenge measuring economic benefits and costs. Nutrient enriched waters due to human activities may support growth of algal blooms, increasing threat to valuable fishes, aquatic plants, and other organisms. On the other hand, eutrophic waters generally are less attractive for recreation, aesthetics, water supply, and some high value fish and wildlife species. Once measured, the objective of public policies should be to balance those benefits and costs aiming for a set of uses and safeguards that achieves a eutrophic state that optimises the net benefit to society. The most beneficial

state of eutrophication will depend on the natural potentials of the water body along with the particular socio-economic context within which the water body is placed. This study has made an attempt to address the issue of eutrophication in socio-economic context.

Out of the pollution in Solent, point sources such as sewage treatment plants and industrial sources are easier to control but involve heavy investments. However, non-point agriculture based pollution sources usually account for very significant loading. With the EU and DEFRA regulations on coastal pollution and the pragmatic measures of general public may be sufficient for the control of non-point sources in the area. Use of economic instruments, such as reducing fertilizer subsidies or imposing taxes suggested in this study, and markets that allow point sources to seek out abatement by non-point sources may be helpful and cost-effective. Effective planning and management of coastal areas depends not only on a sound understanding of the physical and biological systems of these water bodies, but also of their value to people and the institutions that govern them. An understanding of economic benefits, costs, and policy instruments is vital for effective management.

There have been few significant real-world attempts to analyse the subsequent economic effects on eutrophication that arise from anthropogenic events. There are noticeable sources of eutrophication in the English Channel mainly due to agricultural runoff and the waste of sewage water treatment. The majority of socio-economic studies of eutrophication are generally of theoretical nature. Such studies have been receiving significant interest in the recent past; however, there is a greater need for practical application mainly to shape-up the policy with regard to pollution activities. Further, institutional objectives relating to the implementation of potential pollution control strategies can be evaluated.

The Environment Agency of the region carried out investigations of the harbours in the Solent area which resulted in the designation of several areas of Solent as sensitive Areas (eutrophic) and polluted waters (eutrophic) under both the Urban Waste Water Treatment Directive and the Nitrates Directive. As a result of these designations, Southern Water Services decided to upgrade the sewage treatment works in the Solent area in an attempt to reduce the nutrient inputs. Furthermore, targets have been placed on agriculture in an effort to decrease the nutrient input to rivers and estuaries which discharge in the Solent. For this purpose the Nitrate Vulnerable Zones (NVZs) were introduced, the catchment sensitive farming projects and a local diffuse pollution project aiming at streams discharging into the harbours. Findings of this research emphasize existing endeavours and confirm what the general public of Solent would expect from water authorities.

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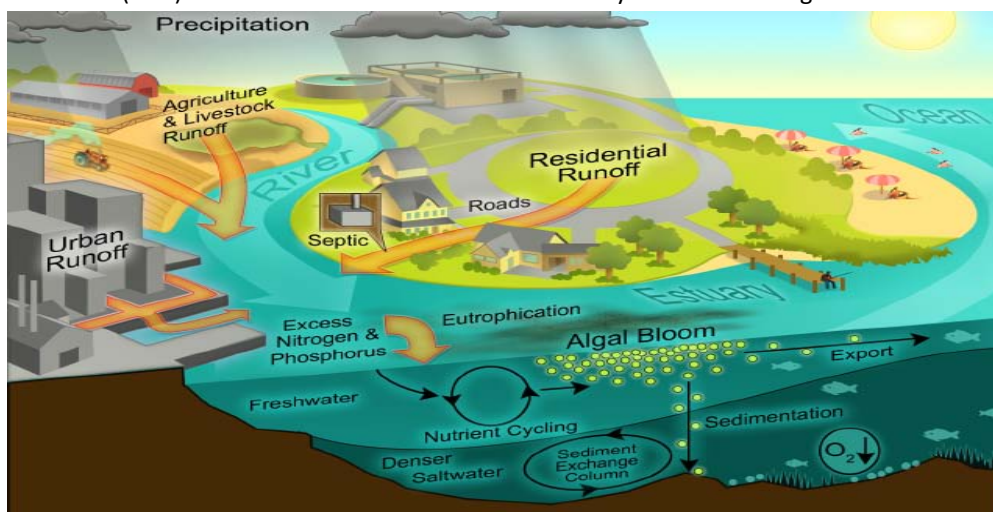
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Appendix I – Survey Questionnaire:

PUBLIC PERCEPTION ON EUTROPHICATION IN THE SOLENT

The Solent is a heavily used body of water and there are many environmental pressures inflicted upon it. Eutrophication is an issue that results from pollutants entering into the water. These pollutants include sewage, land run-off of fertilisers and pesticides which together cause phytoplankton to grow and reproduce more rapidly, resulting in large scale algal blooms. In the southern UK harbours external inputs of nutrients could sustain the growth of macroalgae at the beginning of a growing season. Widespread growth of green seaweeds occurs in many intertidal areas of the Solent. This has several knock-on effects on the ecosystem functioning, the most damaging being the using up of the oxygen in the water (Figure 1). The European Commission (EC) nitrates directive requires areas of land that drain directly into polluted waters to be designated Nitrate Vulnerable Zones (NVZ) and for the farmers to follow mandatory rules concerning nitrate loss from agriculture.



http://www.tokresource.org/tok_classes/enviro/syllabus_content/5.4_eutrophication/index.htm

Figure 1. A diagram representing the eutrophication process.

The purpose of this survey is to determine the public perception towards water quality in the Solent and its effects on public use and their willingness to contribute to improvements.

NOTES ON THE QUESTIONNAIRE

Please take a little time, using these notes, to familiarise yourself with the structure of the questionnaire before answering the questions.

In what follows we will present you with different options called choice sets. These are made up of the attributes and levels described below.

Attributes

UPSTW – Upgrade sewage treatment works

REDAGNUT – Reduce nutrient inputs from agriculture to rivers and estuaries discharging to the Solent water; Farms must comply with requirements from Solent Nitrate Vulnerable Zones (NVZ) schemes.

COST– Management and monitoring cost (this payment would be an additional yearly tax contribution per person)

In summary:

UPSTW – Upgrade sewage treatment works:

- STATUS QUO - maintain current levels
- IMPROVING - more treatment work to improve water to good level
- SIGNIFICANTLY IMPROVING - cost more but water at excellent level

REDAGNUT – Reduce nutrient inputs to rivers and estuaries discharging to the Solent water:

- STATUS QUO - current number of farms compliant with the requirements of the Solent NVZs

- IMPROVED COMPLIANCE - the number of non-compliant farms is halved
- FULL COMPLIANCE- all farms become compliant

COST – Management and monitoring cost (this payment would be an additional yearly tax contribution per person):

- £0 – no additional tax
- £10 – additional yearly tax
- £25 – additional yearly tax

Questionnaire Instructions

Green macro algal mats covering eelgrass resulting from large quantities of nutrients entering the solent

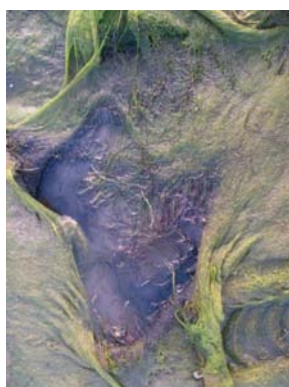




Photo courtesy of Hants and Wight Wildlife Trust

In the choices presented within the questionnaire ([section 1](#)), we will present to you the choice sets. These are made up of the elements described above. Please consider these carefully and select your preferred option.

In [section 2](#), questions are presented to find out more information about your wider preferences.

In [section 3](#), which will remain completely confidential, we ask you about yourself. This will help us to place your views in relation to others with both similar and different characteristics to yourself.

EXAMPLE OF A CHOICE SET REPRESENTING STATUS QUO (Please explain):



	UPSTW	REDAGNUT	COST	
1.			£0	THIS IS MY PREFERRED OPTION <input type="checkbox"/>

















The above choice set is one example of possible management of the area. It contains the 3 attributes (LEVEL OF REDAGNUT, UPSTW and COST) each at one specific level.

Each choice set shown, will consist of these elements at different levels. It is your decision to choose the best choice that matches your preferences regarding the management of the Solent. Therefore, on the [questionnaire](#), we would like to ask you to consider,

“which ONE option do you prefer the most!”

BEFORE TICKING YOUR PREFERRED CHOICE, PLEASE SPEND TIME CONSIDERING ALL OPTIONS.

	UPSTW:IMPROVING	REDAGNUT STATUS QUO	COST	
1.			£10	THIS IS MY PREFERRED OPTION <input type="checkbox"/>

	UPSTW: IMPROVING	REDAGNUT FULL COMP	COST	
2.		 Full Compliance	£25	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: SIG IMPROVING	REDAGNUT STATUS QUO	COST	
3.		 Status Quo	£25	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: IMPROVING	REDAGNUT IMP COMP	COST	
4.		 Improved Compliance	£0	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: SIG IMPROVING	REDAGNUT IMP COMP	COST	
5.		 Improved Compliance	£10	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: STATUS QUO	REDAGNUT IMP COMP	COST	
6.		 Improved Compliance	£25	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: SIG IMPROVING	REDAGNUT FULL COMP	COST	
7.		 Full Compliance	£0	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: STATUS QUO	REDAGNUT STATUS QUO	COST	
8.		 Status Quo	£0	THIS IS MY PREFERRED OPTION <input type="checkbox"/>
	UPSTW: STATUS QUO	REDAGNUT FULL COMP	COST	
9.		 Full Compliance	£10	THIS IS MY PREFERRED OPTION <input type="checkbox"/>

SECTION 1

Question 1. Preferred option number:

Question 2. If you selected an option which did not involve paying a fee in question 1, which one of the following best describes why you pick a choice that contains "0" cost. (Please circle)

1. I pay too much tax already
2. I cannot afford to pay
3. I would rather pay into a conservation trust fund
4. Polluters such as water companies should pay
5. I do not have an interest in recreation
6. I am not interested in water quality
7. The marine service/government should pay out of existing budgets
8. Other (briefly explain) _____

Question 3. In choosing your preferred options in section 1, did you read through and consider all nine options? (Please circle)

Yes/No

If "no", how many did you consider _____

SECTION 2

Question 1. In the following questions, please CIRCLE the number that best describes your level of agreement.

Question 1.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a) Before filling in this survey I was unaware of the eutrophication in the Solent	1	2	3	4	5
b) I have never come across any type of foam in the Solent water	1	2	3	4	5
c) I have an interest in recreational activities in the Solent area	1	2	3	4	5
d) I have little or no interest in the marine environment	1	2	3	4	5
e) I think that the local community has a responsibility for the protection of the marine environment in Solent waters	1	2	3	4	5
f) The Government should do more to improve water quality in the Solent	1	2	3	4	5
g) The Water companies should do more to improve water quality in the Solent	1	2	3	4	5
h) The Government should do more to protect the Solent coastal environment	1	2	3	4	5
i) Upgrading sewage treatment works is the only way to reduce nutrients	1	2	3	4	5
j) Agricultural practices should reduce nutrient inputs to rivers and estuaries discharging to the Solent area	1	2	3	4	5
k) Widespread growth of green seaweeds occurs in many intertidal areas of the Solent	1	2	3	4	5
l) I would be willing to pay more for a better water quality in Solent	1	2	3	4	5
m) Water quality should be better regarded as it improves the recreational quality of the marine environment	1	2	3	4	5
n) The water quality should be preserved so that we can personally have the option to use it in the future	1	2	3	4	5
o) The water quality should be preserved for the benefit of my children and future generations	1	2	3	4	5

Question 2. Do you use the beach in the Solent water? (Please circle)

- | | | |
|-----------------|-------------------------|----------------|
| 1. Daily | 2. Several times a week | 3. Once a week |
| 4. Once a month | 5. Several times a year | 6. Never |

Question 3. For what purpose do you use the beach? (Please circle)

- | | | |
|---------|--------------|----------------|
| 1. Walk | 2. Run | 3. Fishing |
| 4. Work | 5. Swim/boat | 6. Other _____ |

Question 4. Do you engage in water contact activities in the Solent water?

Yes/No

If Yes, Please specify: _____

Question 5. Have you seen foam in the Solent waters?

Yes/No

If Yes, How many times: _____/week/month/year

Question 6. Are you a member of an environmental /marine conservation organisation (Please circle)?

1. YES

2. NO

Question 7. Do you or any member of your family work in the water treatment industry (Please circle)?

1. YES

2. NO

SECTION 3

(Information you provide in this section will remain strictly CONFIDENTIAL)

Question 8. What is your age? (Please circle)

1. 18-25 years

2. 26-40 years

3. 41-60 years

4. 60+ years

Question 9. Are you? (Please circle)

1. FEMALE

2. MALE

Question 10. Do you have children? (Please circle)

1. YES

2. NO

Question 11. Which of the following best describes your education to date? (Please circle)

1. Post-graduate degree

2. Under-graduate degree/Professional (i.e. CIMA)

3. Secondary level

4. Primary level

5. No formal education

6. Other (_____)

Question 12. Which of the following best describes your occupation? (Please circle)

1. Professional

2. Teacher/Lecturer

3. Self-employed

4. Housewife/Homemaker

5. Student

6. Retired

7. Unemployed

8. Other (Please specify)_____

Question 13. What is your approximate annual household income before taxes? (Please circle)

- | | | |
|----------------------|-----------------------|----------------------|
| 1. UNDER £20,000 | 2. £20,001 - £40,000 | 3. £40,001 - £60,000 |
| 4. £60,001 - £80,000 | 5. £80,001 - £100,000 | 6. OVER £100,000 |

A summary of the results of this survey will be provided at <http://www.port.ac.uk/cecare/iseca>

Thank you for completing this survey your time is greatly appreciated!

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