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Coastal Research and Policy Integration

COREPOINT – EU-INTERREG IIIB

Activity 2.3

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NORTH WEST EUROPE

Foreword

Between 2005 and 2006, partners from the Corepoint project undertook to conduct three reviews of Integrated Coastal Management (ICM). The reviews focused on: International Approaches to ICM; European Legislation and Policies; and a Quantification of the Economic Benefits of Natural Coastal Ecosystems.

*This document, **Quantification of the Economic Benefits of Natural Coastal Ecosystems**, introduces the concepts and approaches to determining economic benefits of natural systems, and then develops an approach in which risk and economic return are assessed as a tool for planning within coastal areas. The risk-return approach is applied nationally to a number of NE European Members States and regionally to Durham Heritage Coast (England, UK).*

A "traditional" economic valuation of the coastal and marine resources of the Member States from NW Europe involved in the COREPOINT-INTERREG IIIB project was carried out. Using an ecosystem service value method for valuation, the analysis estimates the economic value in 2003 of the coastal and marine zone of Belgium as €256M, Ireland €11,700M, France €18,405M, Netherlands €4,005M and the UK as €65,325M. This equates to the following percentage of GNI (Global National Income); Ireland 9.6%, UK 3.4%, France 1.1%, Netherlands 0.8% and Belgium < 0.1%.

Whilst these valuations are useful for high-level strategic and policy considerations, they do not provide much insight for ICZM practitioners. Consequently, a method based on normative economics rather than ecological economics was designed; this method was called Biodiversity Portfolio Analysis. This method assesses the risk to the provision of ecosystem services and the economic return of those services, using the portfolio of different biomes types within the target Members State's coastal and marine zone. The analysis is based upon the interrelationships of risk and return between different biomes, weighted by area; it provides a comparative risk and return index for each Member State.

The Biodiversity Portfolio Analysis for the target Members States showed that risk and return were highly correlated in the studied Members States. The ranking of risk and return, with the highest first, was Ireland > UK > France = Netherlands > Belgium. For these Member States the risks to ecosystem service provision were positively correlated with GNI (Gross National Income); suggesting that the higher the economic importance of coastal and marine resources in a Member State the more at risk the resources are.

A local spatial scale case study is also presented from Durham Heritage Coast which illustrates the use of this technique in prioritisation of management actions at a local scale. Using stakeholder involvement to determine risks and returns, the case study identifies key biomes and key risks to those biomes which would negatively impact upon ecosystem service provision from the case study area. Using a number of scenario's, which were related to suites of action points as identified in the Durham Heritage Coast Management Plan, the impact of management on the risk and return for the coastal area was determined; some scenarios led to the lowering of risk for the coastal area. The portfolio method of valuation is useful as it permits coastal managers to strategically plan ahead for management of potential consequences of the identified threats for the entire portfolio of biomes due to awareness of the interactions between the risks and returns within the portfolio area.

The Biodiversity portfolio method of valuation provides an effective decision making tool for use within an ICZM framework at a local scale. Management of a portfolio can be based upon using this tool in the decision making process to maximise return at the minimum of risk, with the management implications being that ICZM resources should be targeted to certain biomes and it is possible that these are not the most valuable but those that negate the most risk. Thus the analysis of the portfolio provides an approach that doesn't necessarily weight biomes which are valuable irrespective of risk, but considers biomes at a landscape scale attempting to provide highest return at the minimum of risk.

Corepoint partnership
February 2007.

Acknowledgements: many thanks to Alice Newton and Peter Burbridge for their helpful comments on the report.

EXECUTIVE SUMMARY

- The European coastline includes a great diversity of geomorphologic features, ecosystem / biome types, socio-economic dynamics and culture. This report provides an economic valuation of the coastal and marine resources of the Member States from NW Europe involved in the COREPOINT-INTERREG IIIB project. Using an ecosystem service value method for valuation, the analysis estimates the economic value in 2003 of the coastal and marine zone of Belgium as €256M, Ireland €11,700M, France €18,405M, Netherlands €4,005M and the UK as €65,325M. This equates to the following percentage of GNI (Global National Income); Ireland 9.6%, UK 3.4%, France 1.1%, Netherlands 0.8% and Belgium < 0.1%,

- Whilst these valuations are useful for high-level strategic and policy considerations, they do not provide much insight for ICZM practitioners. Consequently, a method based on normative economics rather than ecological economics was designed; this method was called Biodiversity Portfolio Analysis. This method assesses the risk to the provision of ecosystem services and the economic return of those services, using the portfolio of different biomes types within the target Members State's coastal and marine zone. The analysis is based upon the interrelationships of risk and return between different biomes, weighted by area; it provides a comparative risk and return index for each Member State.

- The Biodiversity Portfolio Analysis for the target Members States showed that risk and return were highly correlated in the studied Members States. The ranking of risk and return, with the highest first, was Ireland > UK > France = Netherlands > Belgium. For these Member States the risks to ecosystem service provision were positively correlated with GNI ($r = 0.97$, $P<0.01$); suggesting that the higher the economic importance of coastal and marine resources in a Member State the more at risk the resources are.

- A smaller spatial scale case study is also presented from Durham Heritage Coast which illustrates the use of this technique in prioritisation of management actions at a local scale. Using stakeholder involvement to determine risks and returns, the case study identifies key biomes and key risks to those biomes which would negatively impact upon ecosystem service provision from the case study area.

- Although, the Biodiversity Portfolio Technique involves making a number of assumptions, it does provide coastal managers with a potential tool with which to strategically plan due to increased awareness of the interaction between the elements of the portfolio of biomes. It is proposed that this technique could be easily adapted for use at local or regional spatial scales in areas where ICZM initiatives are being implemented.

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CHAPTER 1: ECONOMIC VALUATION OF NW EUROPEAN COAST

1.1 Introduction

Although there are a number of methodologies for quantitative assessment of the value of the environment, these tend to give different results and there is a fundamental problem in assessing non-use values, in particular “existence” value. Coupled to methodological issues, there is also a scarcity of large scale data that can be used for such a valuation, for example, not all Member States of Europe have a detailed biodiversity/biotope map of their territorial waters. An additional problem is that, because so many “guesstimates” have to be used, then the “real” economic value in absolute terms is very questionable – and most ecological economists spend the majority of their time arguing over this. However, in order to decide management options that inevitably include an element of compromise between competing interests and goals, absolute values of environmental assets may be limited. A methodology that determines the relative value between management scenarios based on the portfolio of different elements of the environment present within a Member State’s boundaries and the dependence/interdependence between them is likely to be more insightful. In this report we summarise firstly the outcomes from a study to determine the value of Europe’s coasts as part of the EU ICZM Demonstration Project and, secondly, a proposed methodology that uses a biodiversity portfolio approach.

1.2 Economic valuation of biodiversity in NW Europe

There are over 350,000 km of coastline within the 13 “old”-EU Member States with direct access to the sea (Table 1); with a great diversity of coastline lengths, biome types and socio-economic structures. There is considerable variety in coastline length among the Member States of the COREPOINT partners, ranging from only 76Km for Belgium to over 19,000Km for the UK.

Table 1. Coastline and shelf zones of NW European countries (from: World Resources Institute; http://earthtrends.wri.org/; accessed May 2005). Length of Coastline was derived from the World Vector Shoreline database of the United States Mapping Agency; estimates calculated using a Geographic Information System (GIS) with a resolution of 1:250,000 kilometers and an underlying database consistent for the entire world.

Member State	Length coastline (Km)
Belgium	76
Ireland	6,437
France	7,330
Netherlands	1,914
UK	19,717
“OLD” EUROPE	**353,892**
WORLD	**1,634,701**

The most recent assessment of the value of coastal zones is by Firn Crichton Roberts Ltd and the Graduate School of Environmental Studies at the University of Strathclyde[1]. At the centre of their assessment was the use of the annual and capital values of ecosystem services using 12 biomes as identified by Costanza *et al.* in 1997[2] and present along Europe's coastlines. The study used the EU ICZM demonstration projects as a source of cost-benefit data, and then uses these to scale-up from 'hard' numbers to country-based estimates.

1.3 Annual Values of Ecosystem Service

The Costanza work (Costanza *et al.* 1997) identified over 100 research studies that had generated estimates of the monetary value of the ecosystem services generated by each biotope. The research defined 17 distinct types of ecosystem services, including gas and climate regulation; water regulation and supply; erosion and pollution prevention; biological controls; food and raw material production; genetic resources and pollination; and recreational and cultural services. This information allowed Firn Crichton Roberts to estimate a total value for coast and shelf areas of member states.

The values for the COREPOINT Member States of NW Europe, from data collected in 1988 (Firn Crichton Roberts), were updated to 2003 based on Member States inflation rate using compound inflation calculated annually and are shown in Table 2.

Table 2. Value of biomes by considering 17 ecosystem services of NW Europe member states from 1988 data and adjusted to 2003 values using Member State inflation rates.

Member State	Coast value M €	Shelf value M €	Total coastal value 1988 M €	Total coastal value 2003 M €
Belgium	**226**	**1**	**227**	**256**
Ireland	**5,116**	**4,095**	**9,211**	**11,700**
France	**12,107**	**4,810**	**16,917**	**18,405**
Netherlands	**451**	**2,762**	**3,213**	**4,004**
UK	**43,910**	**15,990**	**59,750**	**65,325**

These figures can be translated the value of the coast to each European citizen by country using values for Global National Income (GNI) (Table 3). GNI has superseded the old term Gross National Production (GNP) and is the gross national income, converted to US dollars using the World Bank Atlas method, divided by the mid-year population. GNI is the sum of value added by all resident producers plus the product taxes not included in the valuation output plus net receipts of

[1] An assessment of the socio-economic cost & benefits of Integrated Coastal Zone Mangement, Contract NO : B4-3040/99/134414/MAR/D2, Final report to the European Commission, November 2000.

[2] Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo. J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997) The value of the world's ecosystem services and natural capital. Nature 387, 253-260.

primary income from abroad. The difference between GNI and GNP is that GNI includes member State nationals who produce both for their nation's economy as well as foreign interests in other countries. The World Bank Atlas method for GNI averages inter-annual exchange rates for the target year, by the preceding two years, adjusted by inflation rates.

Table 3. Value of coastal ecosystems per capita.

Member State	Global National Income (GNI, €)*	Total value of coastal ecosystem services (€ M)	% of GNI from coastal ecosystem services	Annual value (€) of coastal ecosystems per capita
Belgium	29,177	**256**	0.08	23
Ireland	30,465	**11,700**	9.60	2925
France	27,990	**18,405**	1.11	311
Netherlands	29,730	**4,004**	0.84	250
UK	32,036	**65,325**	3.46	1108

* figures are for 2003 from the World Development Indicators published by the World Bank. They have been converted from US Dollars to Euros, by using the mean monthly average exchange rate during 2003 (US$1 = €0.885).

CHAPTER 2: BIODIVERSITY PORTFOLIO APPROACH

2.1 Introduction to portfolio method

Valuing the ecosystem service value for Member States is useful to make comparisons between the economic importance of the coastal and marine zone between Member States. However, it does not provide ready information on which to base management strategies or operations. As an alternative to estimating a total economic value for coastlines, we outline a methodology that provides insight into the economic affect of loss of coastal biodiversity, and provides managers with a tool that can be used for the basis of decision making within ICZM; this approach is based on normative economics rather than ecological economics.

It is possible, that Cost-Benefit Analysis (CBA) could be used at a local scale, but the overriding weighting of the very difficult to value "existence" costs for natural/protected area remains highly problematic. The innovative technique outlined in the following chapters, has never previously employed in coastal areas, is called portfolio modelling. The mathematics of portfolio analysis are well known and used widely in equity fund management, in which a portfolio is developed that has the highest return with the lowest risk.

The development of a biodiversity portfolio can be determined at the regional or national scale. Risks for biotopes can be identified through known suites of threats and returns based on previously published data adapted for use in the method. The key dynamics of the portfolio are then based on the type of interaction between the biotope components which can be positively or negatively correlated or display no significant association. Management of a biodiversity portfolio can then be based upon decision making to maximize return for the minimum of risk. The sort of management implications are that ICZM resources should be targeted to certain biotopes and it is possible that these resources are not the most valuable but those that negate the most risk. Thus, this analysis should provide an approach that doesn't necessarily weight biotopes that are valuable irrespective of the risk, but considers biotopes at a landscape scale and seeks to provide highest return at minimum risk.

2.2 Hypothetical Biodiversity Portfolio analysis

The hypothetical case illustrated below uses two Member States (MS) with equal area (100 units) but with different biodiversity portfolios based on the biomes identified by Constanza (Table 4).

Table 4. Biodiversity portfolio of 2 hypothetical Member States (biome categories as used by Costanza *et al.* 1997)

Biome	**Member State 1 - Area**	**Member State 2 - Area**
Open ocean	50	10
Continental Shelf	5	30
Tidal marshes	0	10
Floodplains	0	30
Temperate forest	30	0
Estuaries	15	20
TOTAL area	**100**	**100**

Each of the biomes provides a range of ecosystem services that are of value. Constanza broke these service values down into 17 "types" and valued each in terms the presence of service and extent of service. The service values varied between the biomes (Table 5). The table represents estimated values for biome function, as no more quantified data is available. The figures are agreed through the "expert opinion" of COREPOINT partners.

Table 5 Estimated ecosystem service function for the biomes present in the two hypothetical Member States. Scale from 0 = no or negligible ecosystem service provided; to 3 = extensive to complete service provided. Therefore, the maximum ecosystem "return" by any biome is 17 (no. of services) x 3 = 51.

	BIOME					
SERVICE	Open Ocean	Shelf	Marsh	Floodplain	Forest	Estuary
Gas regulation	3	2	2	1	1	2
Climate regulation	3	2	1	1	1	2
Disturbance regulation	2	2	2	2	0	3
Water regulation	1	1	2	3	2	3
Water supply	0	2	1	3	1	3
Erosion control & sediment retention	2	3	3	2	1	3
Soil formation	1	2	2	3	2	2
Nutrient cycling	3	3	3	2	1	3
Waste treatment	2	3	2	2	0	3
Pollution	2	3	3	3	1	3
Biological control	0	0	0	0	1	0
Refugia	2	2	2	2	1	2
Food production	1	3	1	3	0	2
Raw materials	2	2	1	1	2	0
Genetic resources	2	2	1	1	1	2
Recreation	1	3	2	3	3	3
Cultural	0	1	1	3	2	1
TOTAL (out of 51)	**27**	**36**	**29**	**35**	**20**	**37**

2.3 Risk to ecosystem service provision

Any changes to the environment within any given biome – whether natural or anthropogenic in origin – will produce a risk to the continuation of that service provision by the biome. Risk is defined as the sum of the threats – the higher the cumulative threat score, the greater the severity of threats, and consequent impact, the biome is likely to experience over time. Threat factors can be divided into a number of categories (Table 6) depending on whether they are (i) Systemic threat factors – larger than landscape scale risks that cannot be modified by management only mitigated against (taken from EU demonstration project), and (ii) Non-systemic threat factors – risk factors that are within landscape scale and risk factor can be modified in magnitude, or the impacts mitigated against. The scale of any impact resulting from a threat factor can be tracked onto each biome type present in the hypothetical Member State (Table 6). The value for each threat component for each biome is agreed through the "expert opinion" of the COREPOINT partners.

Table 6. Categories of Systemic and Non-systemic threats. 0 = threat factor has no impact; to 5 = threat could destroy biome function. The maximum cumulative impact resulting from the combined threat factors is 18 (no of threat factors) x 5 = 80.

	Open Ocean	Shelf	Marsh	Floodplain	Forest	Estuary
SYSTEMIC THREATS						
Climate change	1	1	3	4	2	2
Sea level rise	0	0	5	4	1	4
NON-SYSTEMIC THREAT						
Erosion	0	0	3	3	1	4
Sediment movement	0	0	4	3	1	5
Water pollution	0	1	2	3	0	4
Air pollution	0	0	1	1	1	1
Water shortage	0	0	0	3	1	3
Population growth	0	0	2	3	0	4
Tourism & recreation impact	0	3	2	4	1	4
Mineral extraction	2	3	1	1	0	2
Over-fishing	4	4	1	0	0	2
Transport congestion	0	3	0	0	0	5
Endangered species loss	2	2	1	1	1	3
Endangered migrants loss	0	1	4	3	1	4
Habitat loss	1	2	4	4	1	3
Urban expansion	0	3	2	5	2	4
TOTAL (out of possible 80)	**10**	**23**	**35**	**42**	**13**	**54**

Risk is the sum of the potential threat factors –Table 6 shows that an Open Ocean biome has less cumulative threat factors and thus lower risk (10 nominal risk units) compared to an Estuary biome (54).

The consequence of the risk faced by each hypothetical Member State to the provision of ecosystem services is dependent upon the area of the biome present and the return (i.e., "value" of the ecosystem services provided) provided by that biome. The **RISK – RETURN** profile of each Member State will therefore be determined by the biome risk and return weighted by area:

(Eq 1) Biome *Z* risk for Member State = ∑Biome *Z* risk x biome *Z* area in Member State

(Eq 2) Biome *Z* return for Member State = ∑Biome *Z* return (i.e. ecosystem service value) x biome *Z* area in Member State

The Biome portfolio risk and return are the cumulative weighted risk and returns for all the biomes of the Member State; the values for risk and return are nominal values and are comparative. A higher nominal risk value means that the biodiversity portfolio has a comparatively high associated risk. Similarly, a higher nominal return value means that the biodiversity portfolio has a relatively high comparative return.

The risk-return plot for each hypothetical Member State is based on its biodiversity portfolio by plotting biome risk and return and a cumulative total for the target Member State; as shown in Figure 1.

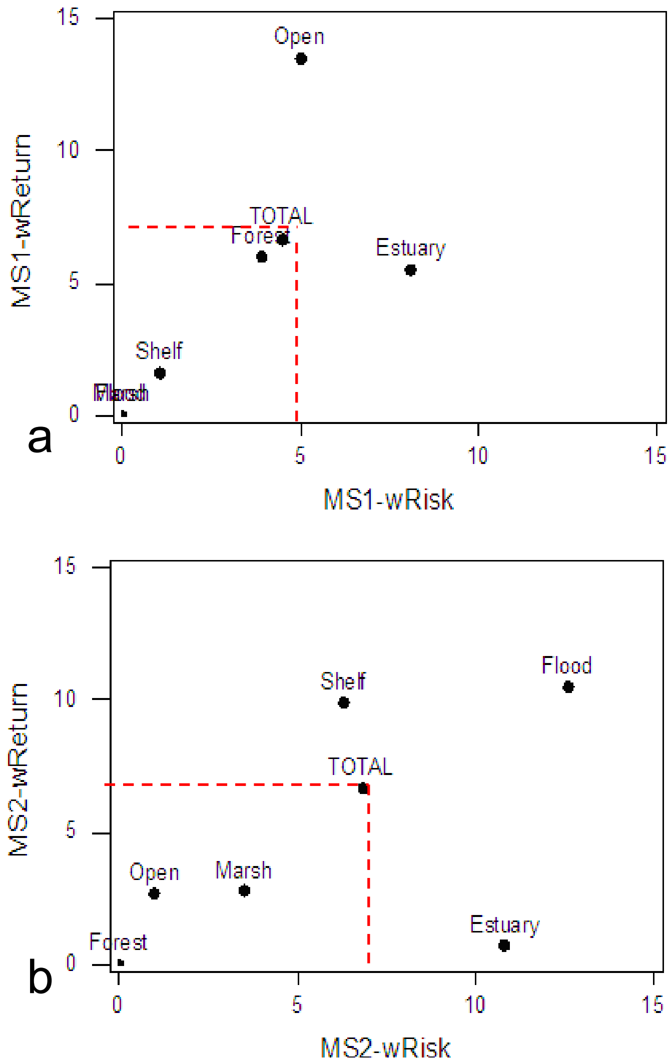

Figure 1. Risk-Return profile for each hypothetical Member State for each biome and cumulative (Total) for (a) Member State 1 and (b) Member State 2. The axes are nominal.

2.4 Interpretation of Risk-Return Profiles

Although the total return (ecosystem service value) for the biodiversity portfolio of both hypothetical Member State's is nearly the same (reference TOTAL in Fig.1 against Y axis), the risk is higher in Member State 2 compared to Member State 1 (reference TOTAL in Fig.1 against X axis). This is due to relatively large areas of floodplain and estuary that are relatively higher risk biomes. In contrast, in Member State 1 the large area of Open Ocean provides a relatively high level of return for minimal risk.

For a coastal manager, the biodiversity portfolio of Member State 1 is more attractive than that of Member State 2 because for the same return on ecosystem service provision, the associated risk from systemic and non-systemic threats is lower. However, in reality a coastal manager cannot affect the gross areas of different habitats (i.e. make estuaries in open ocean), but judicious management should allow threats to be managed and thus risks to be lowered. In a "real world" the limited availability of resources, means that management should be targeted at biomes which lead to the greatest reduction of risk. Further analysis of the biodiversity portfolio is thus required to identity which threat(s) should be targeted in which biomes in order to minimise risk and maximise return of the portfolio.

2.5 Trading off risks to maintain returns.

The key to the biodiversity portfolio is the way in which risk can be traded off, i.e. risk on one biome can balance risk on another. If a manager had only one biome then management would be clearly targeted at reducing the key threat or threats to the biome. However, if a manager had 2 biomes – would the risk profile be any better? This would depends on the way the two biomes relate to the threat – if they both respond to threats in the same way then the risk profile is the same as with one biome. However, assume another scenario in which one biome is resistant to a threat and one is impacted heavily by a threat – then the two biome portfolio has less risk than a single biome as it will still be producing a return even if the one of the biomes has been impacted by the threat. Thus using this logic, the overall risk of a portfolio of two biomes that respond differently to threats is lower compared to a portfolio with two biomes that respond in the same way; associated with this lower risk is also the maintenance of return from the biodiversity portfolio.

2.6 Correlation between risk factors

To determine which biomes respond in a similar way to threats, pairwise comparisons of biome responses to threats were calculated. Pairwise correlation of the risk factors for each of the biome pairs leads to the resultant matrix (Table 7) which provides information of the interaction between biomes by risk.

Table 7. Correlation between risk factors for each biome. (*) = significant; (NS) = non-significant.

	open	shelf	marsh	flood	forests
shelf	0.601 (*)				
marsh	-0.264 (NS)	-0.383 (NS)			
flood	-0.536 (*)	-0.317 (*)	0.631 (**)		
forests	-0.277 (NS)	-0.194 (NS)	0.374 (NS)	0.651 (**)	
estuaries	-0.544 (*)	-0.108 (NS)	0.302 (NS)	0.310 (NS)	-0.078 (NS)

Where the correlation between any pair of biomes is not significant, then the threat factors for these biomes are not related, i.e. they respond in an independent fashion to threat factors. These non associated pairs are termed INDEPENDENT pairs.

Where the correlation between risk factors for a pair of biomes is significant and positive, then the threat factors impact upon the biomes in a relatively similar way to the biomes, i.e. each of the two biomes respond to threats in a similar way. These positive significant biome associations are termed ASSOCIATED pairs.

Where the correlation between any pair of biomes is significant and negative, then threats that can greatly impact upon ecosystem services in one biome tend to have little impact upon the other biome. These are termed RESILIENT Pairs.

If an area had a portfolio made up of all INDEPENDENT pairs, then it would be possible to passively manage risk, as even if returns from one biome are affected by a threat then they are not associated to returns from others. In contrast, if a biome has a portfolio that consists only of ASSOCIATED pairs then threats will impact all of the biome service provision producing an inherently high risk portfolio. Alternatively, if a biome has a portfolio of RESILIENT biomes pairs then risk to one biome can be offset against maintained service provision from the remainder. In reality a real portfolio is likely to be a mix of different types of pairwise interactions that lead to portfolio-wide reduction of risk.

For the hypothetical Member States illustrated here, the largest biome of Member State 1 is Open Ocean (50 area units), which is ASSOCIATED to Shelf biomes (from Table 7.). The Estuary is RESILIENT to threats in the Open Ocean and the forest is INDEPENDENT. This means that realization of a threat in the Ocean will also impact be likely to impact the Coastal Shelf, but not likely to impact Estuary. The Forest may or may not be impacted, depending on the nature of the specific threat. Thus, the return from the portfolio is relatively robust to threats as the interactions between the biomes and risk factors are offset by resilient pairs.

It is possible to indicate portfolio impact sensitivity by the sum of RESILIENT (which minimize risks to returns) and INDEPENDENT (which are neutral) and pairs to ASSOCIATED pairs (which raise risk in combination). Portfolio impact sensitivity can be calculated by the sum of the pairings with scoring of: ASSOCIATED pairs= +1; RESILIENT pairs = -1; INDEPENDENT = 0. Thus for Member State 1 this is:

ASSOCIATED pairs = +1 (Ocean & shelf)

RESILIENT pairs = -1 (Ocean & estuary)

INDEPENDENT pairs = 0 (Ocean & forest; shelf & forest; shelf & estuary; estuary & forest)

Giving a Portfolio impact sensitivity = 0

If we assume a scenario in which the management aim for Member State 1 would be to maximize return and minimize the risk. Then taking the open Ocean, that has the highest biome return (low return but large area), and knowing that changes in the Ocean are positively linked to Shelf and that Estuaries are resilient to change in the open Ocean and that Forest act independently, then a ban on over-fishing would reduce the threat portfolio of the Open Ocean by 4, making the risk to ecosystem service change from 10 to 6. Reworking the weighted risk-return from the Member State shows the impact of this management strategy on the risk-return profile (Figure 2).

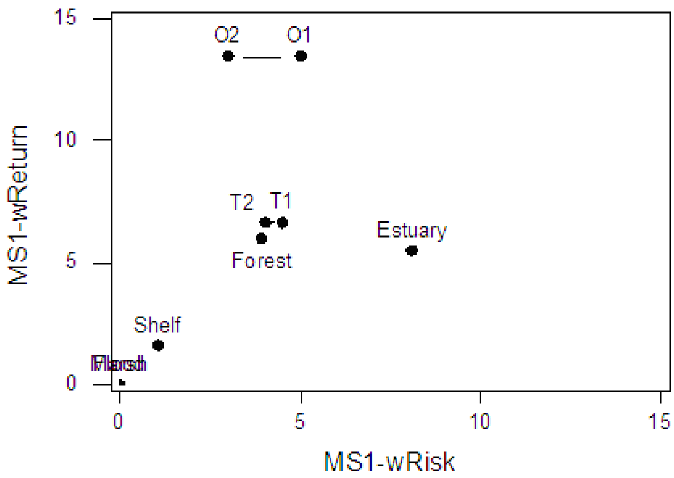

Figure 2.Revised Risk return graph for MS1 (open Ocean O1 for original, O2 with over fishing no more a threat; Total portfolio T1 original; T2 with no over fishing threat). The Shelf Biome will also have lower risk, but the difference is too small to be displayed on this graph.

The interpretation of this strategy is that through managing the threat of over-fishing the manager has reduced the risk to services provided by the Open Ocean, but also reduced the risk to the overall risk –return to all the biodiversity portfolio (T1 to T2).

For Member State 2, the risks are higher relative to Member State 1. Looking at the interaction in the biome profile we find that the:

ASSOCIATED pairs = +2 (Ocean & shelf; marsh & flood)

RESILIENT pairs = -3 (Ocean & flood; ocean estuary; shelf & flood)

INDEPENDENT pairs = 0 (Ocean & marsh; shelf & marsh; shelf estuary; flood & estuary)

Giving a Portfolio impact sensitivity = -1

This means that there is a relatively higher level of biome pair association, i.e. the portfolio does not lower risk because it has a relatively higher number of positive associated pairs that will respond in a similar fashion in response to threats. Therefore a manager is faced with a portfolio lacking robustness due to the association between biome pairs (or SECTORS). The priority for the manager is to minimise risks to both of the associated pairs (Ocean & Shelf; Marsh & Flood). Considering the threats table, one possibility is to choose a high impact threat that operates across both sectors (relatively easy as they have ASSOCIATED impacts). For example, using the similar calculations as above, assuming that the management strategy is to strictly control any tourism and recreation impact, this would drop the inherent portfolio risk (Total) from 6.84 to 6.20.

CHAPTER 3: BIODIVERSITY PORTFOLIO ANALYSIS OF NW EUROPE

3.1 Portfolio analysis

The previous Chapter has outlined the Biodiversity Portfolio method for two hypothetical Member States. This Chapter outlines a comparative analysis of the target Member States (COREPOINT partners) of NW Europe. Quantitative data availability for such an analysis remains a problem. This is due to: firstly, a lack of biotope classification systems that links directly into the Costanza Biotopes; and secondly to a lack of complete coverage of biotopes of the Members States, especially the marine zone.

However, data is available with adequate coverage for these Members States from the EU Demonstration Project from the work of Firn Crichton Roberts[3]. These data were "broad estimates" of the percentage of the Constanza biomes in the coastal areas. Consequently, these data represent an expert opinion, and remain to be validated by Europe-wide mapping in the future. As this represents the most cohesive dataset covering all of the target Members States, it is used for the following analysis. Raw data on the area of Costanza biomes from the EU Demonstration Project was kindly provided by Dr John Firm of Firn Crichton Roberts. From these data, the biomes with significant coastal inputs were selected: open ocean, continental shelf, tidal marsh, forest and estuaries. The coastal areas include other biomes such as agriculture, but as they are nominally influenced by coastal dynamics they were not considered. In addition, the area of open ocean was zero for all Members States as all of the European marine zone was within the continental shelf.

Areas of biomes were changed into proportions of total coastal area and risk–return estimates were calculated following precisely the method used in the previous chapter. However, due to the comparatively large area of the continental shelf biome (95% or more for all target Member States), the shelf biome had an overbearing influence on the risk and return estimates. Consequently, the continental shelf biome was removed from the analysis and thus the analysis concentrated on the remaining three coastal influenced biomes: tidal marsh, forest and estuaries. Risk return estimates were calculated for the target Member States using the three coastal biomes. The data is shown in Table 8 and the risk-return graph is shown in Fig. 3.

Table 8. Percentage of three coastal biomes in target Member States (data from EU Demonstration Project)

Member State	% of coastal biome		
	Estuary	Marsh	Forest
France	4	17	79
Ireland	3	85	12
Netherlands	4	16	80
Belgium	6	0	94
UK	18	21	61

[3] An assessment of the socio-economic cost & benefits of Integrated Coastal Zone Mangement, Contract NO : B4-3040/99/134414/MAR/D2, Final report to the European Commission, November 2000.

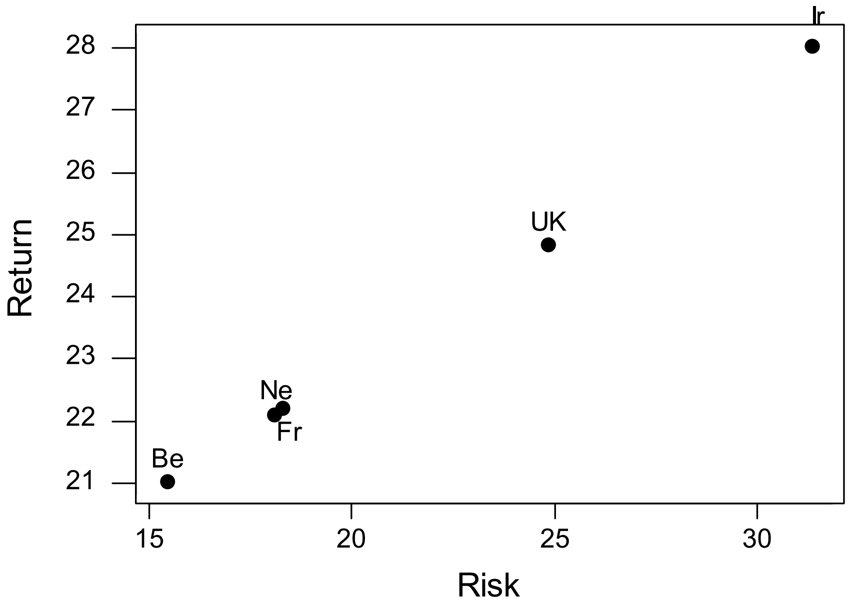

Figure 3. Risk return relationship for COREPOINT Member States. Continental shelf biomes removed. Axes are nominal values but comparative. (Key: Be, Belgium; Ne, Netherlands; Fr, France; UK, United kingdom and Ir, Ireland).

This analysis shows comparative differences in the risk-return status of the target Member States. The graph shows a number of features:

- There is a high correlation between risk and return shown by the high correlation in risk and return for the target Member States (r = 0.99, P<0.001). The underlying reason for this is correlation between the overall risk and return for the biomes (r = 0.72; Table 5 and Table 6; but r = 1.0 for the three biomes used in this analysis) and is a core characteristic of this approach. This analysis does support strongly the contention that return comes at a risk in terms of these biomes.
- There appears to be an ordering of Members States from high to low risk-return: Ireland > UK > Netherlands = France > Belgium. This suggests, for example, that the return from Ireland's resources is greater than the other Member States, in terms of ecosystem services, but it comes at an increased risk. The high return and risk can be linked to the large percentage (85% area) of tidal marsh which heavily weights the indexes. For the UK the relatively high risk and return can be associated with the relatively large proportion of estuarine area which has inherent high return but high risk (Tables 5 and 6).

- The comparative risk-return relationship between the Member States links to the economic importance of the coastal ecosystem services in terms of GNI. A plot of risk (or alternatively return as they are highly correlated) against GNI shows a positive relationship (r = 0.97, P<0.01). This relation between the risk-return status of a coastal biomes and GNI is significant. The data used in the GNI was from the economic valuation, whereas the data for the risk-return estimates were from experts estimates of risks and returns by biome. The only common link between the two compared data sets links to the areas of biomes, thus the relationship cannot be considered to have arisen due to a lack of independence of data.

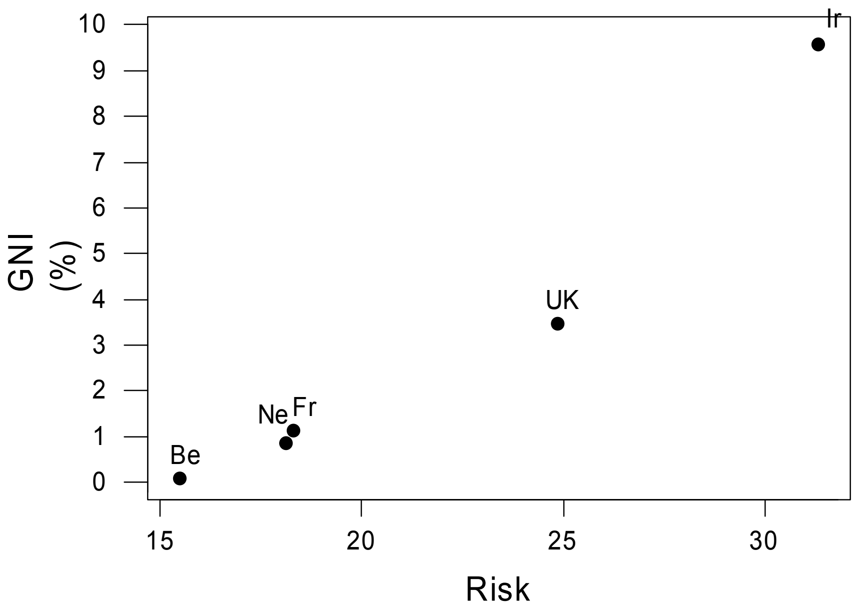

Figure 4. Positive relationship between risk and GNI for target Member States (r = 0.97, P<0.01) (Key: Be, Belgium; Ne, Netherlands; Fr, France; UK, United kingdom and Ir, Ireland).

The portfolio impact sensitivity for all the Member States is 0, as the three biomes used are all independent pairs. However, with such a limited number of biomes, the indicative value of assessing the interrelationship of impacts between biomes is low, and no conclusions should be drawn from this.

Care should also taken in using these results as it is assumed that all appropriate risks and returns are included. Expert consensus was used to try to ensure inclusion of all relevant factors, however, it may be that certain risks or returns have been missed out of the analysis, for example the risk associated with coastal flooding. Before the results of such an analysis are used for management, wider stakeholder involvement should be used to ensure inclusion of all relevant factors.

From this analysis it appears that the risk, return and value of the coastal biomes are associated. Member States that have a high proportion of GNI from coastal areas also tend to have biomes which have an inherent high return, but also high risk. The risk associated with high returns and economic importance means that Integrated Coastal Management becomes a key tool for management for economic and environmental sustainability and must include some appropriate risk analysis.

CHAPTER 4: MEMBER STATE SCALE APPLICATION OF THE BIODIVERSITY PORTFOLIO APPROACH

4.1 Assumptions of the Portfolio method.

The comparative analysis of the target Member States in the previous chapter involved a range of assumptions. Such assumptions are necessary for the analysis and a strong reliance on assumptions is a common feature of many economic analyses of natural resources. Awareness of the assumptions of this method is important for the subsequent assessment of application of this technique. The following were identified as key assumptions:

1. Biome economic return values. The biome return values (Table 5.) were estimated and then open to expert consideration for modifications to produce the final table. This was necessary due to lack of available quantitative data. These data assume that the economic return value of a biome is fixed per unit area, a similar assumption as used by Constanza. These data thus take no account of quality of the biome; for example whether it is pristine or degraded.

2. Biome risk value. Similar to the return values, the biome risk function was determined through estimation and expert confirmation and is thus not based on quantitative data. These data assume that potential impacts are similar for a specific biome irrespective of its geographical position within NW Europe; this is confounded as certain impacts are likely to be higher in certain geographical positions, for example on high energy shores compared to a low energy shoreline. Thus, the “average” risk assigned to each biome may not necessarily reflect the situation at any one site. Another assumption related to the risk function is that all present and future risks are included; it remains possible that new impact factors could become apparent, or that the severity of impact could change over time. Such variations in risk (and return as per 1 above) could be built into the methodology but this would add another layer of complexity and again, as data on these aspects is limited, necessitate further expert-led judgement.

3. Biome areas. The data for biome areas were supplied from the EU Demonstration Project and are based upon practitioner’s estimates for their Member States, and may well be incorrect or biased. The relative areas of biomes, as opposed to their presence and absence, are important for the determination of the weighting of the risk and return functions.

4. Portfolio impact sensitivity. The calculation of Portfolio impact sensitivity, through the summation of scorings of pairs of associated, resilient and independent biomes assumes a holistic interrelationship for each biome (Table 7). For example, the severity of impacts on tidal marsh and flood plain are always positively correlated, i.e. associated. It may be that in certain circumstances the fixed relationship between biomes in terms of their degree of association, resilience or independence is not maintained. It is also worth noting that the interrelatedness of biomes in terms of impacts is based on the significance and type

(positive / negative) of a correlation. However, in the significant correlation there remains some degree of unexplained variation which is disregarded in the portfolio analysis.

The strong reliance on the above assumptions does not invalidate the technique, but they do have an influence on how this technique can be used within an ICZM context.

4.2 Benefits of the Portfolio Method for ICZM.

The biodiversity portfolio method has a number of potential benefits for use as a tool within an ICZM framework:

- Illustrates to managers that returns are related to risk - so management effort should not just concentrated on high return areas but on overall risk management.
- Enables managers to strategically plan by raising awareness of the interaction between the elements of the portfolio of biomes in the target area.
- Allows managers to be cost effective since management decisions can be based on lowering the risk profile of the whole area, not just certain favoured biomes.
- Overall it provides a tool for strategic planning that directs management actions to stabilize returns from ecosystem services by reducing overall risk to those ecosystem services.

4.3 Application of the Portfolio Method for ICZM.

Although the technique can be used as a tool within ICZM, the comparative analysis presented in this document is of a too extensive nature (Members State) for use by ICZM practitioners who tend to operate at a smaller spatial scale (regional/local). It is proposed that for effective use within ICZM, the spatial scale area studied should be decreased to the scale of the area undergoing ICZM.

It is proposed that the risk, return and degree of correlation tables (Tables 5-7) are used as a basis for the implementation of this technique within an ICZM initiative. Through stakeholder discussion and involvement, the tables should be adapted to the local situation, this could be through:

- Modification of the scale of impacts from the generic NW European scale to the local situation.
- Modification of the biome returns reflecting local use and exploitation patterns.
- Addition of other biome types which are relevant to the resource exploitation patterns in the area.
- Review of the interrelationship between biome pairs (associated, resilient and independent).

The process of reviewing the generic tables is also likely to lead to identification of differences of perception between stakeholders and also identify the possible inadequacy of data for some aspects.

The generic tables on risk and return provided in this document should be modified through a process of stakeholder involvement to reflect relevant characteristics of the local situation where it is applied. This approach would also have the benefit of increasing levels of ownership by the involved stakeholders of the results. The method can then be used to assess the effect of management interventions through a range of possible scenarios and thus become a planning tool facilitating agreement between stakeholders for the optimal interventions leading to the maximisation of return from the coastal ecosystem whilst minimising the risk to that return.

The following chapter illustrates the use of the risk return methodology, at a more local scale and involving local stakeholders to determine and assess the risks and returns, to analyse an existing coastal management plan for a stretch of coast in the North East of England.

CHAPTER 5: A LOCAL-SCALE CASE STUDY USING THE BIODIVERSITY PORTFOLIO APPROACH

5.1 Durham Heritage Coast study area.

The Durham Heritage Coast (UK) is a varied coastal landscape stretching between the two main conurbations of Tyne and Wear and Teeside on the North East coast of England with much of the coast being of national and international conservation importance. The Heritage Coast lies within the local authorities of County Durham, District of Easington, and City of Sunderland with Hartlepool Borough Council included as an interested neighbour. Each of the local authorities involved in the Heritage Coast have formally committed to protecting the defined areas and to focussing management attention on the distinctive issues faced on the coast. The Durham Heritage Coast Management Plan for 2005-2010[4] gives the present status of the coast and also identifies the main concerns associated with the coast and policy recommendations that address these concerns. One of the key objectives of the plan is to integrate fully with adjoining areas within the region, to actively promote ICZM.

The Durham Heritage Coast stretches in three separate sections for 14km from Ryehope to Crimdon on the North East coast of England (Figure 5).

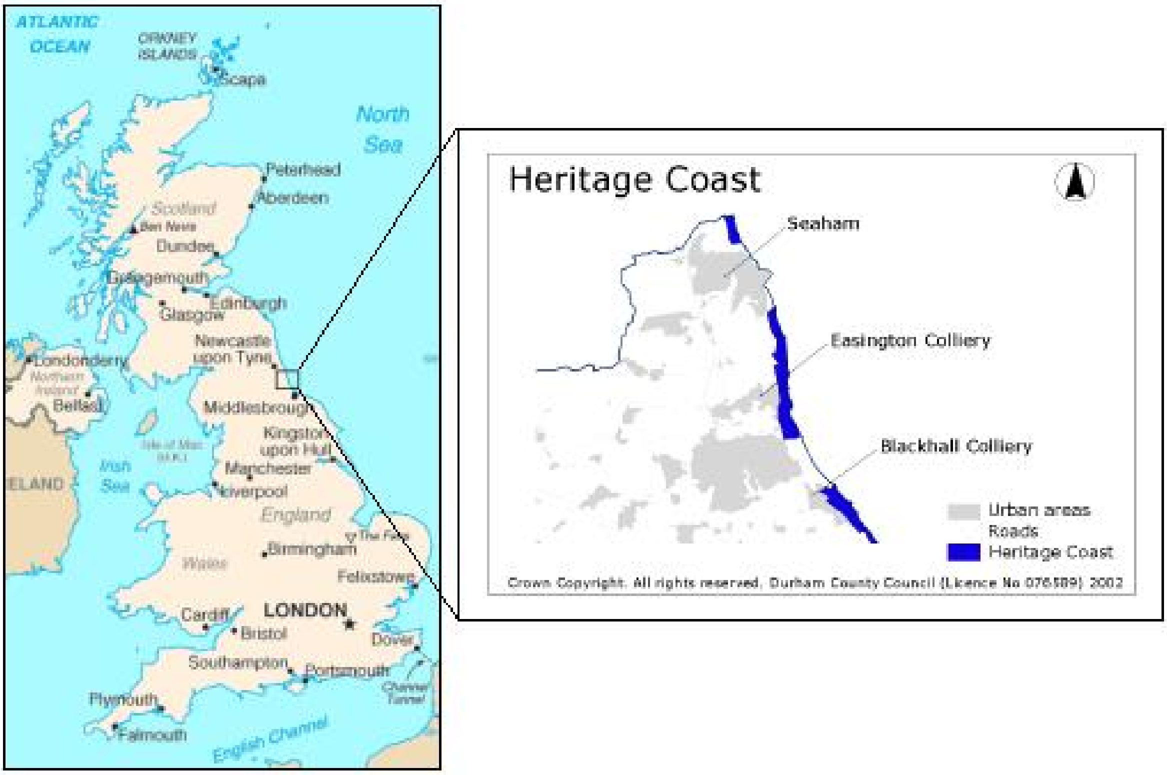

Figure 5. The location of the Durham Heritage Coast.

[4] Durham Heritage Coast Management Plan 2005-2010.
http://www.durhamheritagecoast.org/dhc/doclibrary.nsf/vwebdoc/163E1AD6410092CB802571E10057E2E9

5.2 Methodology

Between March and June 2006, semi-structured interviews and informal meetings were carried out with members of key stakeholder groups for the Durham Heritage Coast. Through stakeholder discussion: (i) a set of biomes which reflect local resource use and exploitation patterns of the area were identified, by modifying and adding to the list of biomes identified by Costanza *et al.* (1997), (ii) a list of ecosystem services which reflect the local use and dependency upon them was complied through modification of the list originally assembled by Costanza *et al.* (1997). The ecosystem services were subsequently rated on a scale of 0 to 3 (0 = no or negligible ecosystem service provided; 3 = extensive to complete service provided) and (iii) the threats used in the previous chapters were modified from the generic North West European scale to the local situation. The impact of each threat upon each biome was subsequently determined by rating each threat on a scale of 0 to 5 (0 = threat factor has no impact; 5 = threat could destroy biome function).

The risk to the provision of ecosystem services is dependant upon the area of the biome present and the return value. The risk-return profile of the Durham Heritage Coast was thus determined by calculating the risks to the biomes and the returns of each biome weighted by area using the following equations:

Biome A risk = ∑ Biome A risk x biome A area

Biome A return = ∑ Biome A return x biome A area

Pearson Product Moment Correlation of the stakeholder-defined risk factors for each biome was used to determine the interaction between the biomes (INDEPENDENT, ASSOCIATED or RESILIENT).

Using the knowledge of the interaction between biomes it was possible to test how certain management strategies affect the entire portfolio of biomes. The Durham Heritage Coast Plan for 2005-2010 outlines management strategies to be implemented. Using three different combinations of proposed management strategies together which were targeted at specifically managing some of the threats which affect particular biomes, the risk values for some of the biomes could be reduced, thus changing the weighted risk return. The re-working of the weighted risk-return values showed the impact that the suggested management strategies would have on the risk-return profile.

5.3 Results

Through stakeholder discussions and consensus, a set of biomes were derived along with a list of ecosystem services and a list of threats that affect the biomes, with corresponding ratings allocated to the severity of the threat and the provision of services (Tables 9 & 10).The provision of the ecosystem services both in terms and presence of service and extent of services varies between the biomes. The Woodland, Coastal Gills and Denes biome provided the most return (i.e. "value" of ecosystem services provided). The Sub-littoral Habitat and Reversion Grassland biomes provided the least return.

Table 9. Estimated ecosystem service function for the biomes present on the Durham Heritage Coast. Rating is on a scale from 0 = negligible ecosystem service provided to 3 = extensive to complete ecosystem service provided. The maximum cumulative ecosystem return by any biome is 9 (no. of services) x 3 = 27.

	BIOME					
SERVICE	Woodland and Coastal Gills and Denes	Magnesian Limestone Grasslands	Sand Dune	Reversion Grassland	Rocky Shore	Sub-Littoral Habitat
Nutrient cycling	2	2	1	1	2	2
Erosion control and sediment retention	3	2	2	2	2	1
Habitat provision	3	2	2	1	2	2
Conservation and scientific interest	3	3	1	2	2	2
Food production	1	1	0	0	1	0
Production of raw materials	1	1	0	0	1	2
Recreation	3	1	3	1	2	1
Tourism	2	1	2	0	1	0
Cultural/Educational	3	3	2	3	3	0
TOTAL (out of a possible 27)	21	16	13	10	16	10

Table 10. Categories of Systemic and Non-systemic threats. Rating is on a scale from 0 = threat factor has no impact to 5 = threat could destroy the biome function. The maximum cumulative impact resulting from the combined threat factors is 9 (no. of threat factors) x 5 = 45

	Woodland and Coastal Gill	**Magnesian Limestone Grasslands**	**Sand Dune**	**Reversion Grassland**	**Rocky Shore**	**Sub-Littoral Habitats**
SYSTEMIC THREATS						
Climate Change	3	3	4	3	3	2
Sea level rise	2	3	4	3	3	3
NON-SYSTEMIC THREAT						
Coastal erosion, sediment movement and other coastal processes.	1	3	5	2	3	3
Tourism and recreation impact	1	2	5	1	4	1
Population growth, urban expansion and development	2	2	4	3	4	1
Agriculture and land management	2	3	4	4	2	0
Vandalism and general misuse	2	2	4	1	1	0
Pollution	1	1	2	1	2	2
Over fishing and disturbance to the seabed	0	0	0	0	0	2
TOTAL(out of possible 45)	14	19	32	18	22	14

The risk-return profile for the Durham Heritage Coast (Fig. 6) illustrates that the Magnesian Limestone biome is the biome most at risk. The actual risk value for this biome is low compared to the other biomes (Table 10), however the profile value is as a result of a weighted calculation which considers area and consequently the Magnesian Limestone biome has one of the largest areas. In contrast to this, the Sand Dune biome has the greatest risk value (Table 10) but one of the smallest areas of coverage. The profile also illustrates that the Woodland, Coastal Gills and Denes biome is the biome that provides the most return with the Rocky Shore biome providing the least return.

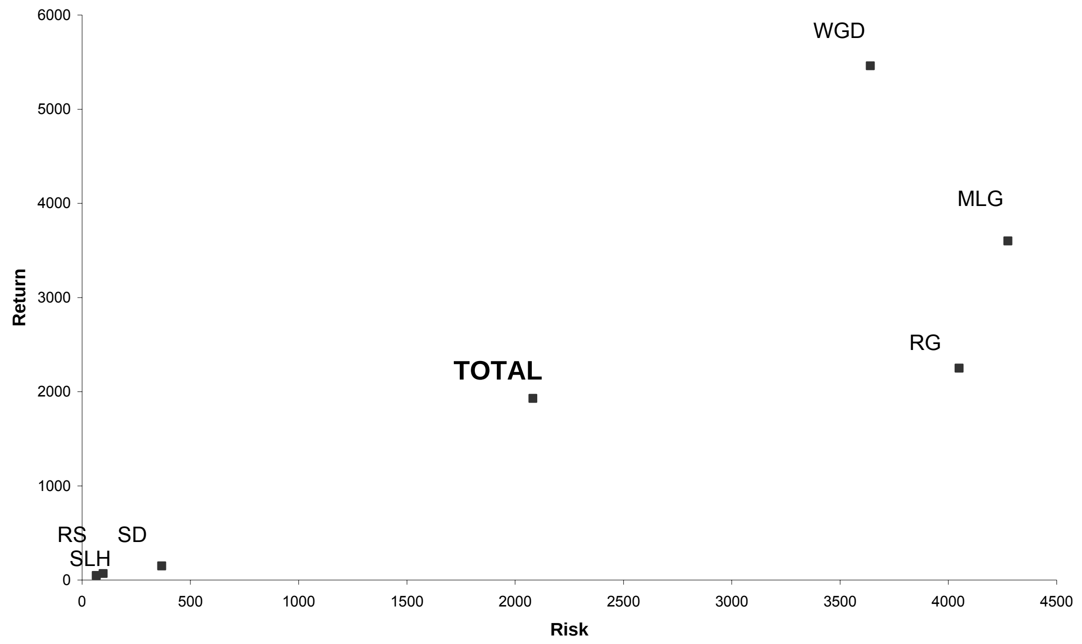

Figure 6. Risk-return profile for the Durham Heritage coast.
[a] RS: Rocky Shore, SLH: Sublittoral Habitat, SD: Sand Dunes, RG: Reversion Grassland, MLG: Magnesian Limestone Grassland, WGD, Woodland, Coastal Gills and Denes.
[b] (Arbitrary units used)

The outcome of the Pearson's correlation for threats (Table 11) resulted in 0 'Resilient' pairs, 9 'Independent' pairs of biomes (Table 12) and 6 'Associated' pairs of biomes (Table 13). The Portfolio Impact Sensitivity was thus + 6, reflecting a high positive association between of the impact of risks on biomes pairs.

Table 11. Pearson's correlation of the threat factors for each of the biomes leads to the resultant matrix of r^2 values (*) = significant; (NS) = non-significant (RS: Rocky Shore, SLH: Sub-littoral Habitat, SD: Sand Dunes, RG: Reversion Grassland, MLG: Magnesian Limestone Grassland, WGD: Woodland, Coastal Gills and Denes).

	WGD	MLG	SD	RG	RS
MLG	0.732 (*)				
SD	0.555 (NS)	0.854 (*)			
RG	0.750 (*)	0.807 (*)	0.535 (NS)		
RS	0.402 (NS)	0.583 (*)	0.753 (*)	0.496 (NS)	
SLH	-0.223 (NS)	0.047 (NS)	-0.124 (NS)	-0.084 (NS)	0.147 (NS)

Table 12. The 'Independent' pairs of biomes in the biodiversity portfolio.

1. Woodland, Coastal Gills and Denes & Sand Dunes
2. Woodland, Coastal Gills and Denes & Rocky Shore
3. Woodland, Coastal Gills and Denes & Sub-littoral Habitat
4. Magnesian Limestone Grassland & Sub-littoral Habitat
5. Sand Dunes & Reversion Grassland
6. Sand Dunes & Sub-littoral Habitat
7. Reversion Grassland & Rocky Shore
8. Reversion Grassland & Sub-littoral Habitat
9. Rocky Shore & Sub-littoral Habitat

Table 13. The 'Associated' pairs of biomes in the biodiversity portfolio

1. Woodland, Coastal Gills and Denes & Magnesian Limestone Grassland
2. Woodland, Coastal Gills and Denes & Reversion Grassland
3. Magnesian Limestone Grassland & Sand Dunes
4. Magnesian Limestone Grassland & Reversion Grassland
7. Magnesian Limestone Grassland & Rocky Shore
8. Sand Dunes & Rocky Shore

The positive association between quite a number of biomes suggests that management actions and resources should be focused on reducing the most highly rated risks that affect all the 'Associated' pairs. The resulting impact that managing these particular threats would have upon the entire portfolio (if they were managed to reduce the risk to provision of services to 0) can be observed in the re-worked risk-return profiles (Figures 7 & 8). Fig. 7 shows the risk-return plot for reducing the risk of recreation and tourism to 0 and Fig. 8 shows a similar plot but for reducing the risk of recreation and tourism as well as costal erosion and sediment movement to 0. The risk to services provided by certain biomes has been reduced and the total risk-return to the entire biodiversity portfolio risk drops from 2082 to 1673 (Figure 8) when hypothetical management actions are implemented simultaneously.

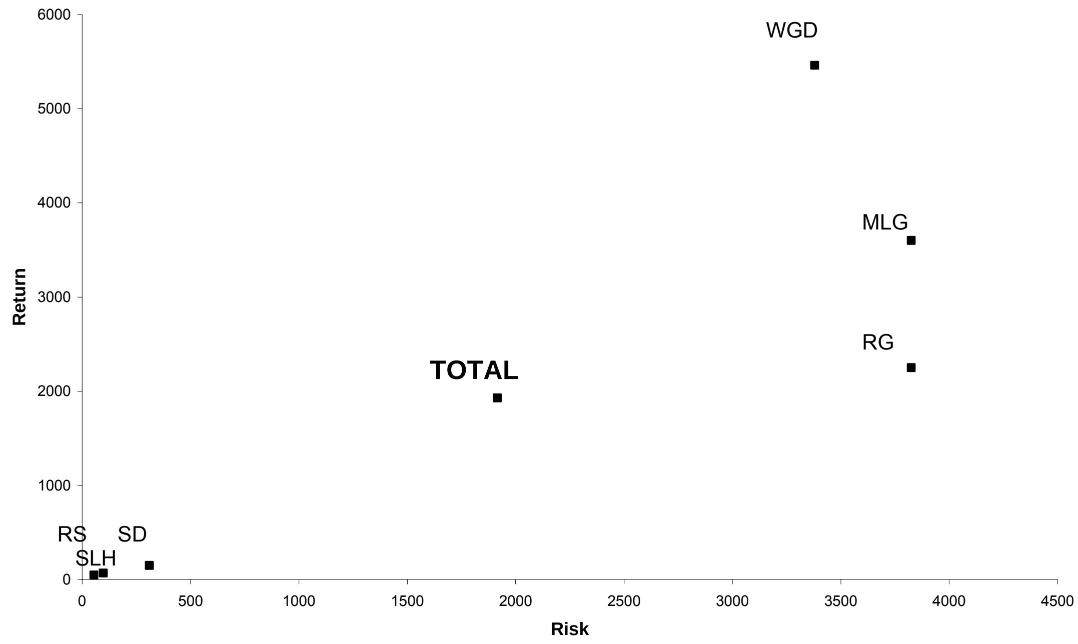

Figure 7. Re-worked risk-return profiles showing the impact of hypothetical management strategies aimed to target and reduce the risk of tourism and recreation impact.

[a] RS: Rocky Shore, SLH: Sub-littoral Habitat, SD: Sand Dunes, RG: Reversion Grassland, MLG: Magnesian Limestone Grassland, WGD, Woodland, Coastal Gills and Denes.

[b] (Arbitrary units used)

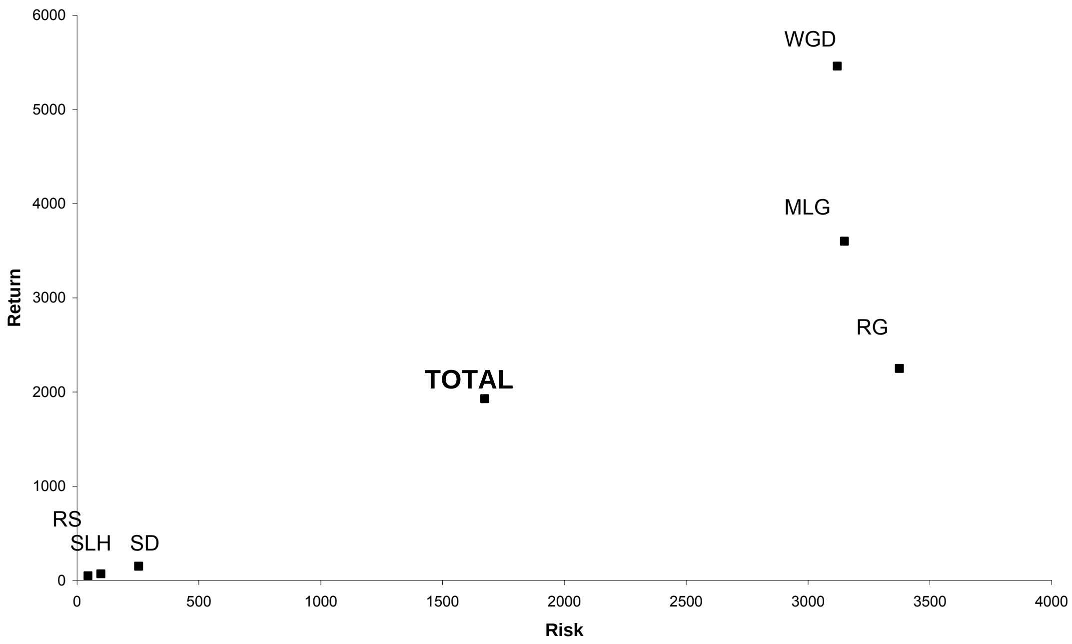

Figure 8. Re-worked risk-return profile showing the impact of hypothetical management strategies aimed to reduce the risk of tourism and recreation impact and coastal erosion and sediment movement processes.

[a] RS: Rocky Shore, SLH: Sub-littoral Habitat, SD: Sand Dunes, RG: Reversion Grassland, MLG: Magnesian Limestone Grassland, WGD, Woodland, Coastal Gills and Denes.

[b] (Arbitrary units used)

Using valid suggestions for management actions (taken from the Durham Heritage Coast management plan), different combinations* of suggested management strategies each targeting individual threats for individual biomes can be applied and the impact upon the risk return plot can be determined. Three alternative management scenarios were investigated which linked into achievement of a number of the action as identified in the Durham Heritage Coast Management Plan. The actions which were implemented in each of the three scenarios are identified in Table 12. The resulting risk return for each of the three scenarios can then be compared to determine the optimal approach for management and reduction of risk to the entire portfolio (Figure 9).

Table 12. The actions involved in the three coastal management scenarios. The codes refer to the action identified in the Durham Heritage Coast Plan. For each management scenario, a tick by an action means that this action is successfully implemented.

Action code	Action description	Manag. scenario		
		1	2	3
P1	Support regular monitoring programmes	√		
P2	Support and develop programmes to manage dune system	√	√	√
P4	Provide advisory point for coastal development and planning applications.	√		√
H1	Develop and support programmes to enhance protected habitats	√	√	
H2	Influence local planning processes to prevent and reduce threats to protected landscapes and coastal habitats			√
H4	Support improvement programmes to monitor streams flowing into coastal areas			√
H8	Develop and promote litter and pollution reducing projects		√	
R15	Support projects and initiatives that improve security		√	
S19	Support protection, management and consistency of approach along management areas.			√
G7	Support and strengthen penalties for unauthorised use of sites		√	

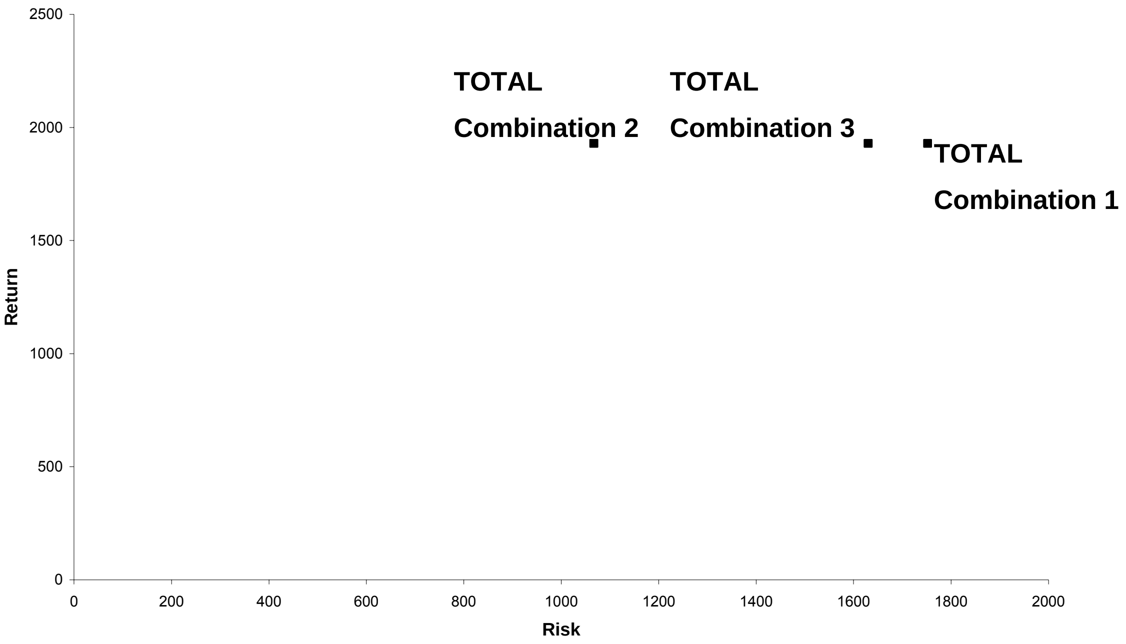

Figure 9. The total risk return values for the entire biodiversity portfolio of the Durham Heritage Coast when three different combinations of management strategies taken from the management plan are applied.

[a] (Arbitrary units used)

[b] (Combination 1 = policy recommendations P1, P2, P4 & H1. Combination 2 = policy recommendations P2, H1, R15, G7, H8. Combination 3 = policy recommendations P2, P4, H2, H4, S19. [*] see p 63-93 of the management plan for the outline of each policy recommendation or summary in Table 12.

5.4 Discussion and interpretation

The risk-return profile for the Durham Heritage Coast (Figure 6) illustrates how the returns for each biome are related to risk. The profile presents evidence that the biomes that are at the most risk and that are affecting the sensitivity of the entire portfolio are those with large areas (Magensian Limestone Grassland, Reversion Grassland and Woodland, Coastal Gills and Denes), even though the actual threat factors to these biomes are relatively small compared to other biomes such as the Sand Dune biome (Table 10). In reality a manager cannot affect the gross areas of different habitats, but judicious management should allow threats to be managed and thus risks that threaten the biomes to be lowered. Given that coastal managers are often faced with limited resources, they need to know which threats should be managed in which biomes in order to lead to the greatest reduction of risk within the risk return portfolio.

The Durham Heritage Coast case study raises an interesting issue related to reduction of overall risk in the portfolio. The risk return analysis proposes that the risks to the most heavily weighted (by area) biome are the key consideration to impact the overall risk of the portfolio. However, the importance of sand-dune, which is inherently high risk but of a very small area in reducing overall portfolio risk is minimal. The sand-dune area is however an important feature for the Durham Heritage Coast and can be considered as a "flagship" biome nationally. Herein lays the key aspect of the risk return approach: to reduce risks and maintain return from coastal area as a whole may mean that relative focus on "flagship" biomes is reduced. By looking at the whole of the biome landscape holistically, the focus in the risk return approach is on dealing with risks (especially between associated pairs, which is a cost effective approach) to reduce overall portfolio risk and thus maintain ecosystem service return. Viewing a coastal area as an economic generator, concentrating on ensuring the functioning and thus economic return of the main economic generation biomes makes sense. This however may lower the importance of "flagship" biomes which are traditionally favoured, not for economic reasons, but for a variety of other reasons such as biodiversity value as reflected in designations in the EU Habitats Directive. This partial contradiction in terms of management prioritisation between economic return and maintenance of other features, such as conservation, means that within any ICZM plan the goal needs to be realistically stated.

On the Durham Heritage Coast, the 'Independent' pairs of biomes signify that even if returns from one of the biome pairs are affected by a threat then they are not associated to returns from the other biome pair. The 'Associated' pairs of biomes signify that these biomes will respond in a similar fashion in response to threats. Due to the high level of biome pair association the portfolio for the Durham Heritage Coast (Portfolio Impact Sensitivity = +6) lacks robustness. Clearly the management of the coast needs to minimise risk to the associated pairs but as some of the biomes that are independently paired are then associated to other biomes i.e. Sand Dunes & Sub-littoral Habitat are paired independently from each other but Sand Dunes are then associated to Magnesian Limestone Grassland and Rocky Shore, it means that the management strategies need to be specifically targeted at individual threats. Figures 7 & 8 demonstrate how management actions targeted at reducing tourism impact, recreation impact and erosion and sediment movement across the whole portfolio of biomes reduces the entire portfolio risk.

The Durham Heritage Coast management plan for 2005-2010 provides comprehensive information on the threats which are currently affecting the coastline and presents policy recommendations to control and target these threats. The biodiversity portfolio method of valuation provides the managers of the Durham Heritage Coast with a decision making tool which enables the managers to consider the severity of the threats to each biome individually and also the threats that increase risk to the entire portfolio of biomes. As a decision making tool it also enables the managers to make choices as to which of the policy recommendations in their management plan should be implemented with regard to minimising risk and maximising the return of individual biomes whilst also considering the whole portfolio and reducing the overall risk. Figure 9 illustrates how allocating ICZM resources to different combinations of policy recommendations targeting different threats, can affect the entire risk value of the portfolio whilst still maintaining the same return.

Considering the threats table (Table 10) and the risk return profile (Figure 6), it is possible to identify certain threats that operate at high risk across the portfolio. The highest rated threats across the portfolio are the systemic threats of climate change and sea-level rise which unfortunately as threat, are impossible to manage in their entirety. Nonetheless some of the consequences of these threats can be managed.

The portfolio method of valuation is useful in this sense as it makes the coastal managers able to strategically plan ahead for management of potential consequences of these threats for the entire portfolio of biomes due to the awareness of the interaction between the elements within the portfolio area. The risk return profile (Figure 6) indicated that the biomes most at risk were the ones with large areas even thought the actual threat factors to them were not the highest when compared with the other biomes. The weighting with area here may be misleading, as the Sand Dune biome is highly threatened but due its small area it appears at a small risk when regarded within the full portfolio. In spite of this seeming limitation, the biodiversity portfolio method essentially highlights that whilst the Sand Dune may not be regarded as the biome that negates the most risk within the portfolio, the Sand Dune biome is still a priority which, with appropriate management of the risk will reduce the overall risk to the Durham Heritage Coast Portfolio.

The portfolio method can be used to assess the effect of management interventions through a range of possible scenarios and thus also become a planning tool facilitating agreement between stakeholders for optimal interventions. As described, using three different combinations of policy recommendations for management actions (that have been outlined in the Durham Heritage Coast management plan with the potential aim of targeting some of the threats that currently pose a problem), it is possible to evaluate the possible outcome of these actions against the threats to the biome and to observe the impact that these that management actions would have on the entire portfolio (Figure 9). The combinations of policy recommendations used were selected from the management plan to specifically target at least one more of the main threats affecting the each of the biomes.

To carry out this study, it was essential to conduct interviews with representatives of at least half the stakeholder groups involved with the Durham Heritage Coast. The necessity of this being to avoid bias due to the diverse nature of interests that each of the stakeholder groups hold. The stakeholder groups involved with the Durham Heritage Coast ranged from small local conservation groups (for example Groundwork based in East Durham) to borough councils and even national representative bodies such as English Nature. With this in mind, there was always going to be the inevitable consequence that each stakeholder group as a whole and even the attitudes, opinions and knowledge of the individual person representing the stakeholder group were going to be highly variable. The differences that became apparent through stakeholder discussion related to the following issues:

(i) the identification of biome types and the associated boundaries

(ii) identification and formation of a list of ecosystem services and threats relating to each biome
(iii) the rating of ecosystem services and threats for each biome.

The differences in opinions, perceptions and attitudes to the preceding issues may stem from a lack of knowledge and understanding about a specific biome and its related services, bias towards areas where the stakeholder group is heavily involved and failing to even consider or appreciate a certain component of value such as bequest or option value due to lack of understanding. The limitations that are brought about as an outcome of the differences is that the resulting total ratings of ecosystem service provided by and threats to some biomes due to a consensus, may not be entirely true to the Durham Heritage Coast.

5.5 Conclusions

The Biodiversity portfolio method of valuation provides an effective decision making tool for use within an ICZM framework at a local scale. Management of a portfolio can be based upon using this tool in the decision making process to maximise return at the minimum of risk, with the management implications being that ICZM resources should be targeted to certain biomes and it is possible that these are not the most valuable but those that negate the most risk. Thus the analysis of the portfolio provides an approach that doesn't necessarily weight biomes which are valuable irrespective of risk, but considers biomes at a landscape scale attempting to provide highest return at the minimum of risk.

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