NOTA DI LAVORO
22.2015

Macro-economic Impact Assessment of Future Changes in European Marine Ecosystem Services

By **Francesco Bosello,** Fondazione Eni Enrico Mattei, Centro Euro-Mediterraneo sui Cambiamenti Climatici and Università degli Studi di Milano
Elisa Delpiazzo, Centro Euro-Mediterraneo sui Cambiamenti Climatici
Fabio Eboli, Fondazione Eni Enrico Mattei and Centro Euro-Mediterraneo sui Cambiamenti Climatici

Climate Change and Sustainable Development
Series Editor: Carlo Carraro

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Summary

The present research has been developed within the EU FP7 VECTORS project (http://www.marine-vectors.eu/). The main scope of the project (2011-2015) has been to evaluate, from a multilateral perspective, drivers, pressures and vectors of changes in marine life of three main European seas (Baltic, Western Mediterranean, North), the mechanisms by which they do so and the impacts that they have on ecosystem structures and functioning as well as on economic activities and wellbeing. This paper describes the methodology, data elaboration and main results of a modelling exercise aiming to assess the economic effect of future changes in the EU marine ecosystem in the medium term (2030). We focus on those changes potentially affecting the fishing and the tourism sectors in two different IPCC SRES scenarios, the A2 and B1, varying in the future trends of population, GDP, prices, as well as the overall impact on environment. Sector-specific economic impacts are channeled through increases in fishing effort, due to lower availability of commercial fish species, and decrease in tourism demand following deterioration of marine ecosystem quality. Impacts on EU coastal countries Gross Domestic Product are negative and larger when the tourism sector is affected. This is explained by the much higher contribution of tourism than fishery in the production of value added. Negative impacts are also larger in the A2 than in the B1 scenario. The largest GDP losses due to adverse impacts on fishery are experienced by Spain (-0.13%), those related to tourism by Italy (almost -1%). Percent changes in sectoral production are notably larger than GDP ones: the largest contraction in fish sector production occurs in France (-24.7%). Notable decrease in coastal tourism demand occurs in Spain and the Netherlands. In general the Western Mediterranean is the most adversely affected region, whereas the Baltic Sea denotes a particular vulnerability to losses in tourism value added compared to the BAU. North Sea countries experience smaller losses.

The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 266445. Authors are solely responsible for errors and omissions.

Keywords: Impact Assessment, Computable General Equilibrium, Fisheries, Tourism, Marine Ecosystem
JEL Classification: C68, D58, L83, Q22, Q57

Address for correspondence:
Fabio Eboli
Fondazione Eni Enrico Mattei
Isola di San Giorgio Maggiore n.8
30124 Venice
Italy
E-mail: fabio.eboli@feem.it

Macro-economic impact assessment of future changes in European marine ecosystem services

Bosello Francesco[1,2,3], Delpiazzo Elisa[2], Eboli Fabio[1,2]

[1] Fondazione Eni Enrico Mattei
[2] Centro Euro-Mediterraneo sui Cambiamenti Climatici
[3] Università di Milano

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The present research has been developed within the EU FP7 VECTORS project (http://www.marine-vectors.eu/). The main scope of the project (2011-2015) has been to evaluate, from a multilateral perspective, drivers, pressures and vectors of changes in marine life of three main European seas (Baltic, Western Mediterranean, North), the mechanisms by which they do so and the impacts that they have on ecosystem structures and functioning as well as on economic activities and wellbeing.
This paper describes the methodology, data elaboration and main results of a modelling exercise aiming to assess the economic effect of future changes in the EU marine ecosystem in the medium term (2030). We focus on those changes potentially affecting the fishing and the tourism sectors in two different IPCC SRES scenarios, the A2 and B1, varying in the future trends of population, GDP, prices, as well as the overall impact on environment. Sector-specific economic impacts are channeled through increases in fishing effort, due to lower availability of commercial fish species, and decrease in tourism demand following deterioration of marine ecosystem quality.
Impacts on EU coastal countries Gross Domestic Product are negative and larger when the tourism sector is affected. This is explained by the much higher contribution of tourism than fishery in the production of value added. Negative impacts are also larger in the A2 than in the B1 scenario. The largest GDP losses due to adverse impacts on fishery are experienced by Spain (-0.13%), those related to tourism by Italy (almost -1%). Percent changes in sectoral production are notably larger than GDP ones: the largest contraction in fish sector production occurs in France (-24.7%). Notable decrease in coastal tourism demand occurs in Spain and the Netherlands. In general the Western Mediterranean is the most adversely affected region, whereas the Baltic Sea denotes a particular vulnerability to losses in tourism value added compared to the BAU. North Sea countries experience smaller losses.

Introduction
This study develops an economic assessment of changes in two relevant services provided by marine ecosystems in the Western Mediterranean Sea, North Sea and Baltic Sea in the medium-term future: changes in availability of commercial fish stock and changes in ecosystem quality in coastal zones.
This analysis is implemented using ICES, a computable general equilibrium (CGE) model, tailored to capture and highlight the production and consumption substitution processes at play in the socio-economic system as a response to economic shocks. Main distinctive features of the model are: inter-linkages across all markets; inter-sector factor mobility and international trade; a recursive-dynamic behavior where a sequence of static equilibria is intertemporally connected by endogenous investment decisions; international investment flows.
Model solutions take into account explicitly “market-driven adaptation” i.e. the reactions of economic agents to changes in relative prices allowing them to substitute commodities/production factors in demand and supply.
Inputs to the model are “drivers of change” linked to transformations of marine ecosystems computed by specific bottom-up methodologies in alternative scenarios, outputs are changes in economic variables such as gross domestic product, sectoral production, prices and so on.
It is evident that the economic assessment of a physical phenomenon, like a change in ecosystem, is possible only after two preliminary steps. The first is the detailed description of the physical phenomenon itself; the second is linking it to some activity relevant for human behavior, i.e. able to generating observable changes in some economic variables or market(able) activities that can be represented by the model used.
The deliverable is structured as follows. Section 2 describes the ICES model and the two social-economic scenarios considered. Section 3 gives a brief outlook of the baseline scenarios

and the main macroeconomic variables. Section 4 focuses on the impact of an increasing fishing effort due to climate change drivers. Here, after a concise description of the methodology followed to introduce differentials in effort as a driver for this analysis, the section describes the main findings of this exercise. Section 5 concentrates on the impacts of changes in coastal tourism demand due to changes in fishing overexploitation index. Finally, section 6 derives major conclusions.

2. Description of the Intertemporal Computable Equilibrium System (ICES) model and scenarios

The Intertemporal Computable Equilibrium System (ICES) model is a CGE model sharing the core structure of the GTAP-E model (Burniaux and Troung, 2002), which in turn is an extension of the basic GTAP model (Hertel, 1997). The model is recursive-dynamic: a series of static equilibria is linked by endogenous capital accumulation and other exogenous drivers such as population growth and productivity improvements.

The economic system features three agents' types: *n* industries, a representative household and the government. Industries are modelled through a representative cost-minimizing firm, acting in a perfect competitive framework (the so-called Walrasian perfect competition). In turn, output prices coincide with average production costs. Each firm is characterized by a general production functions, specified via a series of nested Constant Elasticity of Substitution (CES) functions to consider both primary factors (Natural Resources, Land, Labor, and the aggregate Capital and Energy bundle) and intermediates.

Similarly to GTAP-E, the energy inputs are isolated from intermediates and are considered as primary production factors in a nested level of substitution with capital. The purpose of this set up of the productive sector is to have more degree of freedom in specifying elasticities of substitution among productive inputs. As described in Burniaux and Troung (2002), the main innovation of GTAP-E with respect to GTAP is moving away from the assumption of a Leontief relationship between the set of primary factors and the group of intermediates for commodity production. Based on strong empirical evidence, energy sources are no longer considered a perfect complement of primary factors. Rather, they are at some extent substitutes of capital stock, through a CES function.

In addition, international trade is modelled according to the so-called “Armington assumption” (Armington, 1969), which considers product heterogeneity according to origins and/or destinations and cross hauling phenomena.

In general, inputs grouped together are more easily substitutable among themselves than with other elements outside the nest. For example, imports can more easily be substituted in terms of foreign production source, rather than between domestic production and one specific foreign country of origin. Analogously, composite energy inputs are more substitutable with capital than with other factors.

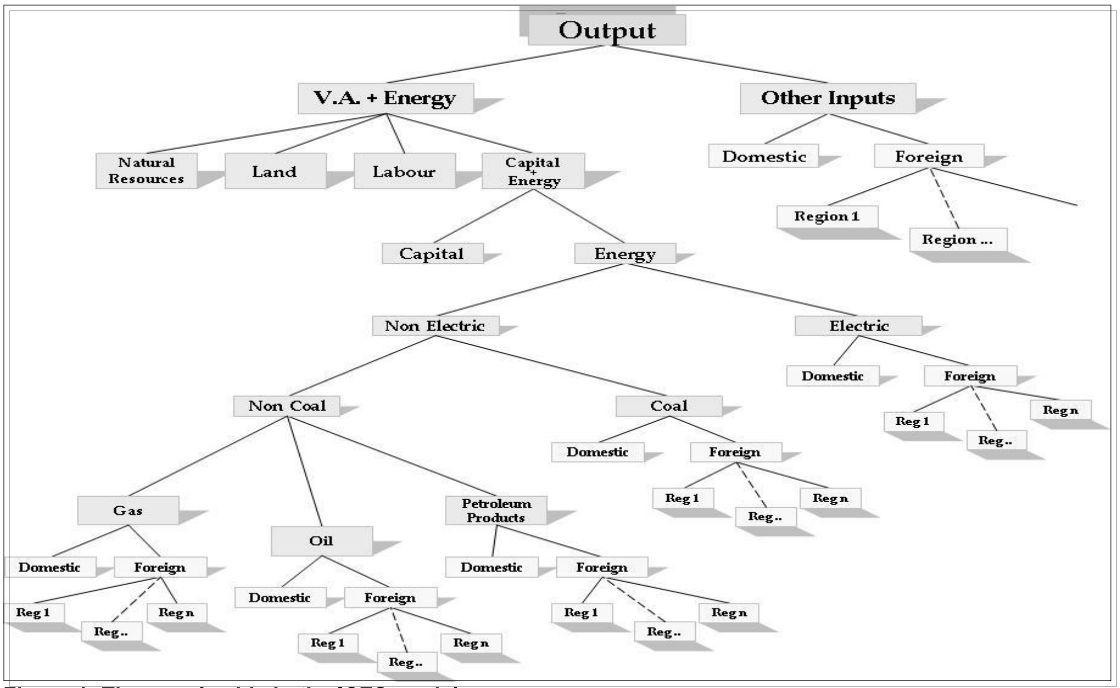


Figure 1: The supply side in the ICES model

Two industries are treated in a special way and are not related to any country, namely international transport and international investment. International transport is a world industry, which produces the transportation services associated with the movement of goods between origin and destination regions. Transport services are produced by means of factors submitted by all countries, in variable proportions.

A representative household in each region receives income, defined as the service value of national primary factors (natural resources, land, labor, capital). Capital and labor are perfectly mobile domestically but immobile internationally. Land and natural resources, on the other hand, are industry specific. This income is then used to finance three classes of expenditure: aggregate household consumption, public consumption and savings. The regional expenditure shares are generally fixed, which means that the top-level utility function has a Cobb-Douglas specification. However, differences occur in the definition of total government consumption or total private consumption.

Private consumption is analogously split into a series of alternative composite Armington aggregates. However, the functional specification used at this level is the Constant Difference in Elasticities (CDE) form: a non-homothetic function which is used to account for possible differences in income elasticities for the various consumer goods.

Public consumption is split into a series of alternative consumption items, according to a Cobb-Douglas specification. However, almost all expenditure is actually concentrated in a single industry: Public Services.

Investment is internationally mobile: savings from all regions are pooled in a Global Bank and then investment is allocated so as to achieve equality of expected rates of return to capital. In this way, savings and investments are equalized at world level but not at regional level. Because of accounting identities, any financial imbalance mirrors a trade deficit (or surplus) in each region.

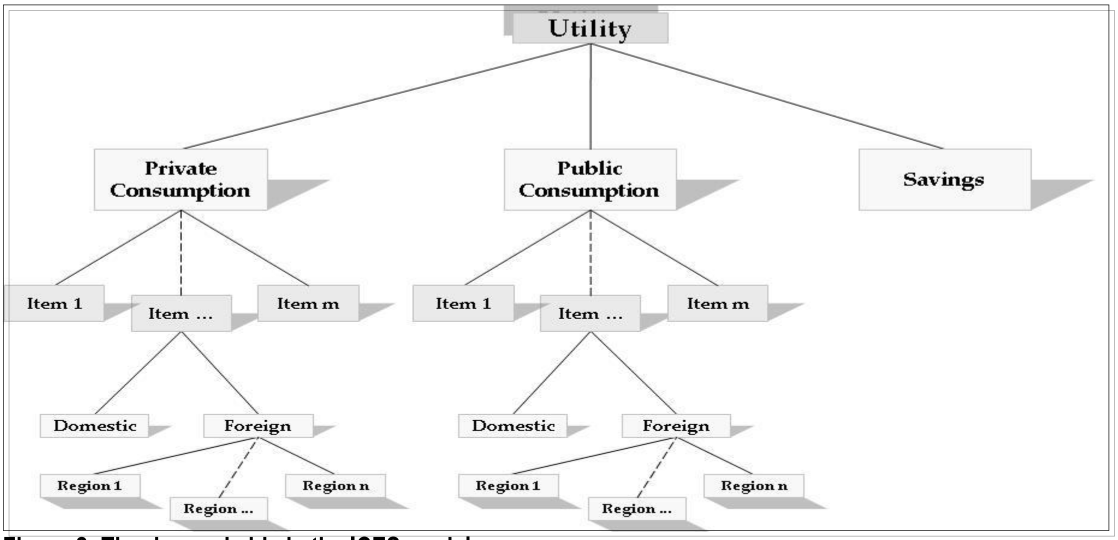


Figure 2: The demand side in the ICES model

Dynamics inside the ICES model are driven essentially by two different sources: one endogenous and one exogenous to the model. The first involves two components: one, the most important, is the capital and foreign debt evolution process governed by endogenous investment decisions. The other concerns a peculiar treatment of the evolution of natural resources stock. On the other hand, there is a set of assumptions concerning the changes in some key economic - mainly supply-side - parameters and exogenous variables, which are imposed to the model in order to reflect their possible evolution. These assumptions are made consistently with existing statistical sources, other modelling exercises and economic scenarios.

The model's base year is 2007 and data are extrapolated from GTAP database version 8 (Narayanan, 2012) where values are reported in millions of 2007 US dollars.

To respond to the needs of VECTORS analysis, ICES geographical and sectoral resolution has been tailored to represent 23 singled-out EU countries and 4 macro-aggregates for the rest of the word (see Table 1) allowing focusing on the "European Seas". Furthermore the ICES model improves the original GTAP sector specification disentangling the tourism sector. This required to estimate and extract the related quota of value added from all the sectors that in ICES contain part of tourism activity (trade, transport, recreation and other services), to re-aggregate them in a new sector and to specify its trade relations with all the pre-existing industries.

The final sectoral detail of ICES used for the VECTORS project is reported in Table 1.

Table 1: Geographical and sector disaggregation in the ICES model

Geographical localization	Country names in the database	Productive sectors
European Union (EU-28)		Agriculture
- *Western Mediterranean Sea area*		Timber
	France[1]	Fishing
	Italy	Coal
	Portugal	Oil
	Spain	Gas
- *North Sea area*		Petroleum products
	Belgium	Electricity from renewables
	Denmark	Electricity from fossil fuels
	Germany	Industry
	Netherlands	Transports
	United Kingdom	Residential services
- *Baltic Sea area*		Tourism
	Estonia	Market services
	Finland	Public service
	Latvia	
	Lithuania	
	Poland	
	Russia	
	Sweden	
Rest of EU countries		
	Austria	
	Belgium	
	Croatia	
	Czech republic	
	Greece	
	Hungary	
	Ireland	
	Rest of European Union (EU-28)	
Other non-EU 28 countries		
	Rest of OECD Countries	
	BICS Countries (Brazil, India, China, South Africa	
	Rest of the World	

3 Description of future scenarios

The social economic reference scenarios adopted for the economic assessment for the period 2007-2030, common to all the social economic analyses developed within the VECTORS project, are the IPCC Special Report on Emissions Scenarios (SRES) A2 and B1 scenarios (Nakicenowic and Swart, 2000). Table 2 briefly describes the main qualitative characteristics of these scenarios, also specifying the kind of general attitude to environmental protection.

[1] France has coasts both on the Western Mediterranean Sea and the North Sea. In this work we consider it as a part of the Western Mediterranean region since the value of fishing in the Mediterranean Sea is nearly 4/5 of total national value of landing, according to data from other project partners.

Table 2: Qualitative description of scenarios.

IPCC SRES Scenarios	Scenario Environmental-friendliness	Description of the storyline
A2	*Brown* Scenario	> Prevalence of a national cultural identity and an idea of national self-sufficiency; > National isolation and independence in economic, foreign and defence policy; > Protectionist attitude of the government respect to important industries; > Increasing pressure on marine ecosystems (by 2020); > Governments fail to give an answer to global (and environmental) issues.
B1	*Green* Scenario	> Prevalence of an attitude of international co-operation to solve global problems; > Environment is a fundamental aspect of sustainability; > Co-ordination of policies at the EU level and at the international level; > Improvements of the marine ecosystem situation with a reduction in the amount of pollution released in the seas.

ICES is thus calibrated to replicate the GDP and population projections for both scenarios following IIASA (2013). Results of the calibration procedure are reported in Figures 1,2,3,4.

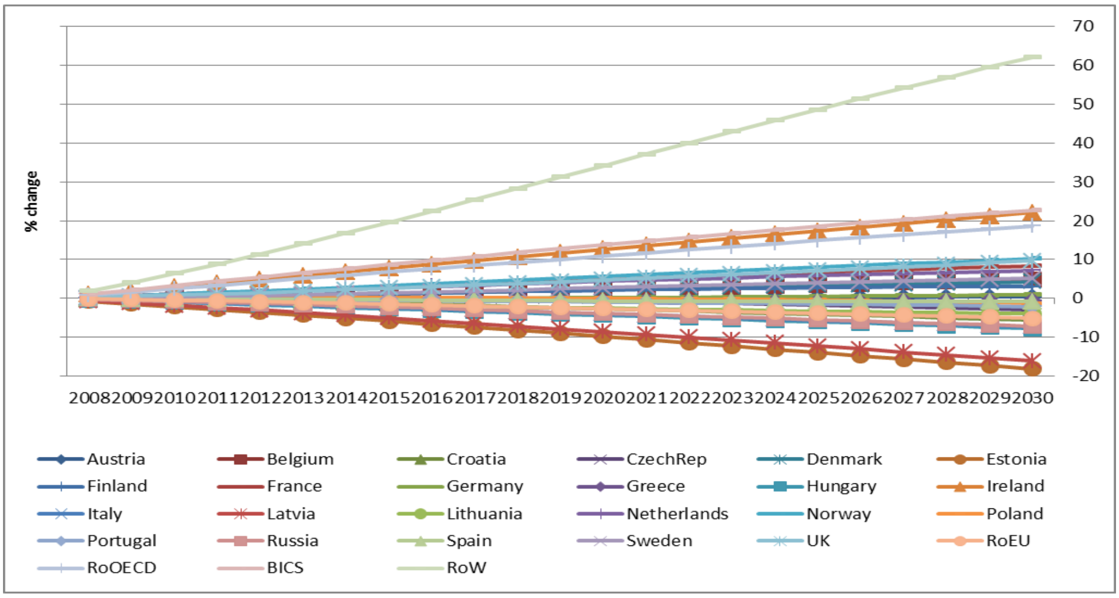


Figure 1: Population growth trajectories under IPCC SRES scenario A2
Source: IIASA (2013)

According to the A2 scenario, fertility patterns across regions converge very slowly, resulting in continuously increasing global population (Figure 1). The growth rate in the period 2007-2030 in the EU countries ranges between -18.2% (Estonia) and 22.0% (Ireland). Higher growth rates are shown in the case of the aggregates (rest of European Union, BICS, rest of OECD members and the rest of the world).

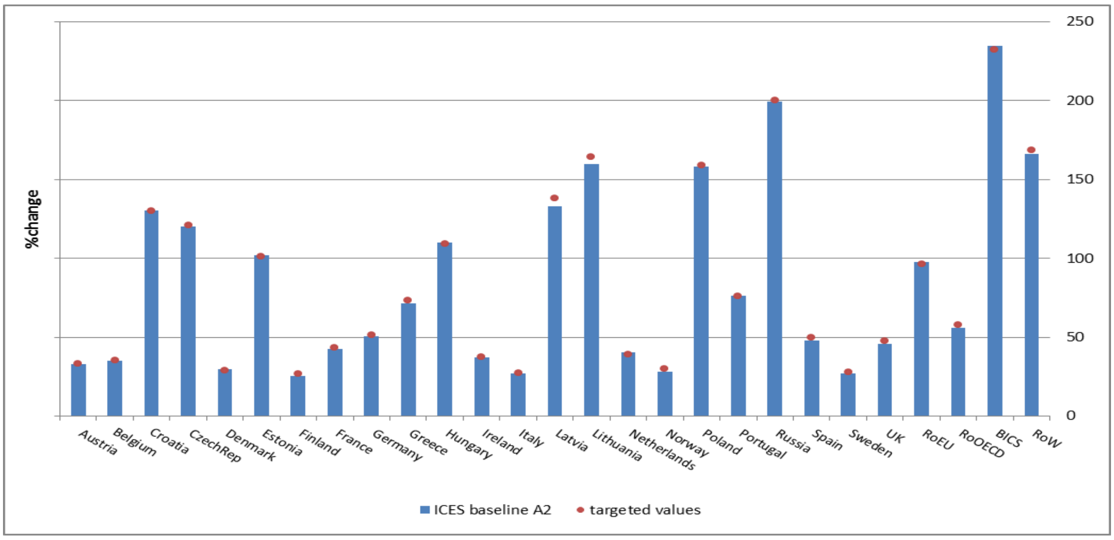


Figure 2: Comparison of GDP growth rates in the period 2007-2030 in ICES IPCC SRES scenario A2 baseline and targeted values
Source: ICES model and IIASA (2013)

In the A2 scenario economic growth is more fragmented and slower than in other storylines. There is thus a slower convergence of per-capita income among countries. Here, GDP growth in the period 2007-2030 is increasing in each country/region between 26.6% (Finland) and 200% (Russia). Aggregates show a higher growth rate with a maximum for the BICS group (232%)

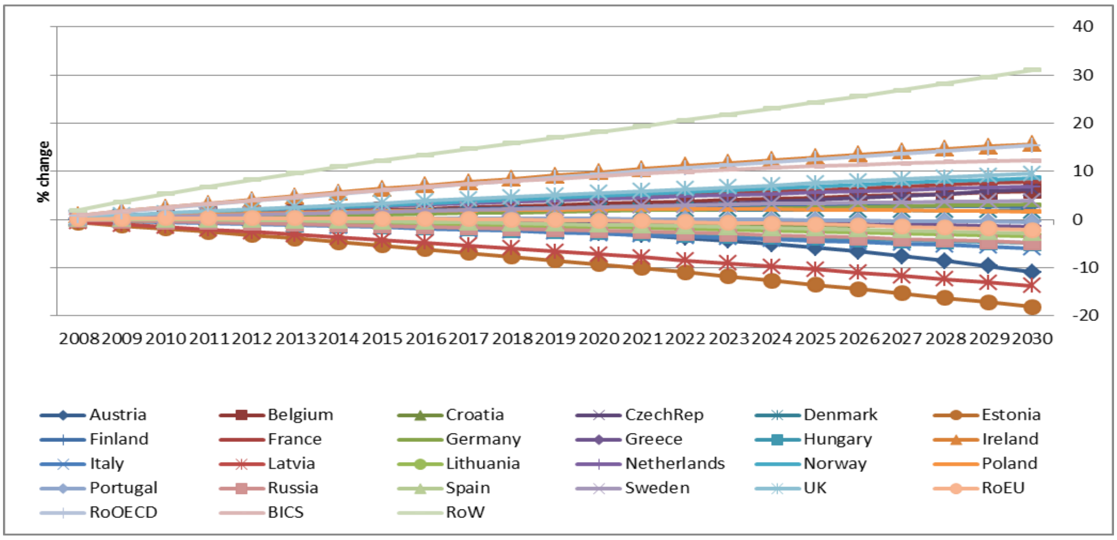


Figure 3: Population growth trajectories under scenario IPCC SRES B1
Source: IIASA (2013)

IPCC SRES scenario B1 represents a “green” storyline. It describes a convergent world with global population that peaks in mid-century and declines thereafter, therefore still continuously increasing until 2030 (Figure 3). In this scenario, population grows at a slower pace with respect to IPCC SRES scenario A2. Growth rates, in fact, vary between -18.2% (Estonia) and 15.7% (Ireland).

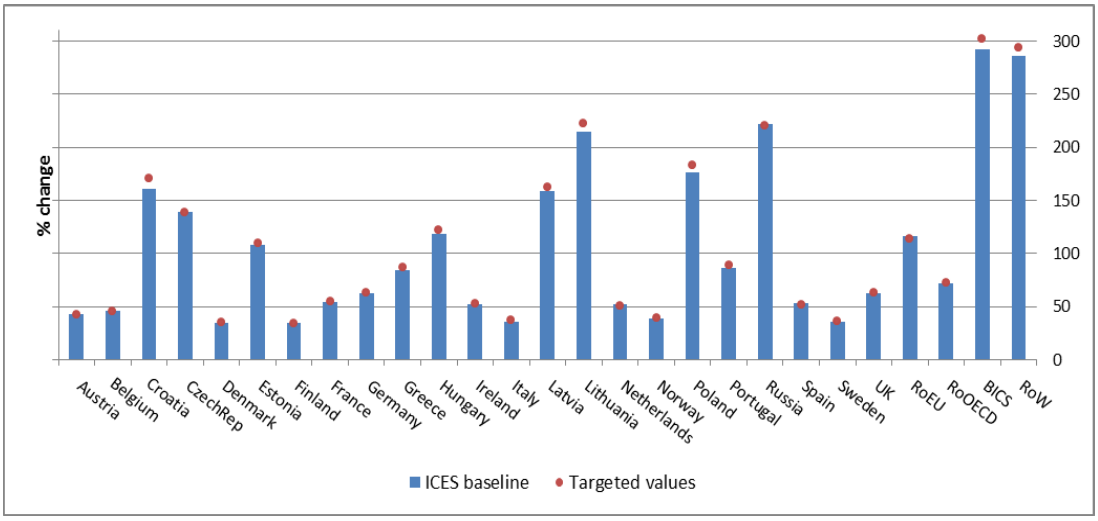


Figure 4: Comparison of GDP growth rates in the period 2007-2030 in ICES IPCC SRES scenario B1 baseline and targeted values
Source: ICES model and IIASA (2013)

IPCC SRES scenario B1 assumes a reduction in income gaps among countries with higher GDP growth rates for emerging and less developed countries (Figure 4). In fact, comparing Graphs 2 and 5, in the IPCC SRES B1 scenario the BICS group and the Rest of the World show higher rates in GDP growth (in the case of the BICS countries, for instance, the GDP growth rate moves from 232% to 301% in the period 2007-2030).

In addition to population and GDP other economic variables are of potential interest, not only fort the economic assessment conducted with ICES, but also for other VECTORS research groups. These are in particular the evolution trends of fossil fuel prices and of the "fish" natural resource. Assumptions used are detailed below.

a. World oil price
World oil prices are assumed to evolve in the B1 scenario according to EURELECTRIC (2010), and in the A2 scenario according to the "current policies" IEA (2011). The first depict a higher growth of oil prices, consistently with the "fossil oriented" development of the A2 storyline. In B1 oil prices are lower.

b. World coal and gas prices
World coal and gas prices, in each scenario, follow the mean value reported by the ASF and MiniCAM models (Nakicenowic and Swart, 2000). In the specific case of coal, this means a higher world price in IPCC SRES scenario B1 than in IPCC SRES scenario A2, while the opposite occurs in the case of gas.

c. World fish prices
World fish prices are based on projections for 2020 by Delgado *et al.* (2003) as agreed in Groeneveld *et al.* (2014). Although this source distinguishes different types of finfish, in our CGE model we have only one aggregated fishing sector. Therefore, we consider IPCC SRES A2 and IPCC SRES B1 trends for high-value finfish as representative for the whole sector. Data for the period 2007-2010 are missing thus we extrapolate that trend by linear approximation.

Price information is summarized in Table 3.

Table 3: Quantitative representation of world prices' changes according to VECTORS scenarios

	IPCC SRES scenario A2	IPCC SRES scenario B1
	% change in the period 2007-2030	
World oil price	68.8%	46.3%
World coal price	12.3%	17.9%
World gas price	68.5%	14.3%
World fish price	20.6%	8.5%

Source: Authors' own calculation based on Groeneveld *et al.* (2014)

4. Modelling and assessing climate change impacts on marine ecosystem production service: changes in fishing effort

According to the results of VECTORS Deliverable D33.1 (Buisman *et al.*, 2014) developing different assessments applying bio-economic modelling, both the A2 and B1 scenarios are consistent with an increase in the fishing effort following a generalized decrease in productivity/availability of the fish stock. This is due both to overfishing as well as natural drivers more related to climatic changes such as invasive species entering European seas and potentially affecting the trophic chain and the survival of commercial species.

In principle a change in effort may be implemented in different ways into a CGE model. Eventually the choice adopted is to decrease the parameter representing the productivity of all the input bundle (capital, labour and resources) used in the fishing industry production function.

It is worth clarifying that effort input data do not include the whole landed finfish, but only selected species namely: sole, plaice, shrimp and saithe for the North Sea; anchovy, hake, red mullet, red shrimp and sardine for the Western Mediterranean Sea; and finally the Baltic Sea is not covered. In the Western Mediterranean the species considered represent a percentage between 85% (France and Spain) and 40% (Italy) of total value of landings, while in the North Sea area they range between 11% (United Kingdom) and 67% (the Netherlands).

Another issue worth noticing is that the CGE model cannot differentiate across fish species featuring just one representative fishing sector per country. Therefore, effort data have been rescaled according to the share of these species on total national value of landings. This implicitly amounts to assume that other fish species are not affected by any anthropogenic or climate change related shock. All this implies that the final economic results presented represent a considerable underestimation of potential effects.

Table 4 compares the (already rescaled) shocks in the two reference scenarios; except the cases of Denmark and UK, shocks in the IPCC SRES A2 scenario are higher than in the IPCC SRES B1 scenario. This is particularly evident in the Western Mediterranean area. Furthermore, shocks in the Western Mediterranean countries are higher than the ones in the North Sea region.

Table 4: Percentage change in fish sector input productivity (following increase in fishing effort) in 2030

	IPCC SRES scenario A2	IPCC SRES scenario B1
North Sea region		
Denmark	-0.36	-0.93
Germany	-1.76	-1.09
Netherland	-4.68	-2.00
United Kingdom	-3.09	-3.16
Western Mediterranean Sea region		
France	-26.31	-12.07
Italy	-10.51	-2.68
Spain	-22.33	-5.69

Source: authors' own calculations

Table 5 depicts the main results from the macro-economic assessment in 2030 for both scenarios. In IPCC SRES scenario A2, impacts on the fishing sector have negative effects on GDP in 2030 in most of the impacted European countries. In percentage, these losses are limited and ranging between 0.009% (United Kingdom) and 0.136% (Spain). The results follows the impacts: the higher is the increase in fishing efforts (the higher the productivity loss) the stronger are GDP contractions. It is worth noting that the contribution of the fishing sector in total GDP is quite small (less than 1% on average), thus an impacts affecting this sector has a relatively low effect in term of GDP loss.

In percentage term Spain faces the higher GDP loss, however in absolute term the highest GDP loss is in France (-4.3 USD billion), followed by Spain (-2.8 USD billion). Interestingly, although an initial negative impact (-1.76%), Germany slightly increases its GDP. It is caused by the adjustments in international trade with its major partners, Denmark and the Netherlands. In fact, Germany increases its exports to both partners more than its imports causing an increase in GDP. This is due to the lower increase in fishing prices in the German country respect to trading partners.

In the North Sea region, the average weighted regional GDP loss is 0.005%, in the Western Mediterranean area nearly 0.1%.

Sector specific effects are much higher than GDP results. The value of fishing production in the Western Mediterranean reduces by 18.9% and dramatically falls especially in France and Spain (24.37% and 21.63%, respectively). In the North Sea area as a whole, there is a reduction of 1.31 percentage points mainly driven by the negative performance of the Netherlands (-3.25%). However, the regional fall is partially offset by the increase in fishing production in Denmark (+1.36%). The lower coverage of input data has also to be considered to explain the difference in results between the Mediterranean and the North Sea.

Finally it is worth commenting the case of Denmark and Germany: in the former, although a negative impact and a fall in GDP, the economic value of fishing production slightly increases; in the latter the reverse occurs. This is due to the relative predominance of either the price (increasing) or the quantity (decreasing) effects in the value of output. When the price effect is stronger, the change in the total economic value can be of different sign of the change in production quantity.

In the same scenario, domestic prices for fishing output increase. They range between 58.52% (France) and 10.74% (Germany) among impacted countries. In the Western Mediterranean area, the increase is more noticeable. Generally, Western Mediterranean countries have higher domestic prices because of the magnitude of the impacts. In fact, the change (namely, an increase) in fishing effort means a decrease in productivity and then a higher production cost to produce the same amount of output as before the impact.

Impacts on the fishing sector have negative effects on GDP growth in 2030 in many European countries in SRES scenario B1 as well. In percentage points, these losses are lower and ranging between 0.007% (Netherland) and 0.051% (France). These results are clearly dependent of impacts values and comparing them with the findings of the IPCC SRES scenario A2 there are lower changes, as impacts are lower in this scenario. France faces the higher GDP loss both in percentage terms and in 2007 USD billion (0.051%, and 2.0 USD billion), followed by Spain (0.034% or 0.7 USD billion)

Turning to the results at regional level, in 2030 the main contributor to the North Sea area GDP loss is Denmark, as in the IPCC SRES scenario A2, while in the Western Mediterranean area the situation changes and the main contributor is France. However, the total effect on regional GDP loss is lower than in the previous scenario. The total percentage decrease in GDP in the North Sea region does not change in the two scenarios, while in the Western Mediterranean sea region the percentage decrease changes from 0.10% to 0.03 %.

Fishing production unambiguously falls in all the countries affected by impacts. In the North Sea area, the drop in fishing production (-1.97%) is mainly due to the reduction in fishing production in the UK (-2.72%). As already stated, in Western Mediterranean countries the reduction in fishing production is more evident at the regional level (-6.6%). France faces the most evident fishing production decline with a -11.32%. As in the previous scenario Germany experience a reduction in fishing production (-0.8%) and a contemporaneous increase in GDP, although it is lower than in IPCC SRES A2 scenario (+0.001).
As in IPCC SRES scenario A2, there is a generalized increase in domestic fishing prices at the regional level and in impacted countries. They range between 20.49% (France) and 4.60% (Germany) among impacted countries. In this scenario, the average increase in both sea regions is lower than in IPCC SRES scenario A2. The greatest reduction in domestic prices is in Spain and Italy where prices drop by 21.5% and 14.8%, respectively.

Table 5: GDP, fish production and domestic fishing price changes in 2030 wrt reference scenario

	IPCC SRES scenario A2					IPCC SRES scenario B1				
	Real GDP growth		**Fishing production**		**Fishing domestic prices**	**Real GDP growth**		**Fishing production**		**Fishing domestic prices**
	% change	2007 million $	% change	2007 million $	% change	% change	2007 million $	% change	2007 million $	% change
North Sea area	**-0.005**		**-1.31**			**-0.005**		**-1.98**		
Denmark	-0.036	-143	1.36	17	10.88	-0.022	-91	-0.39	-5	4.84
Germany	0.002	90	-0.83	-6	10.74	0.001	35	-0.80	-6	4.60
Netherland	-0.013	-139	-3.25	-34	12.74	-0.007	-79	-1.52	-17	5.10
UK	-0.009	-384	-1.72	-70	14.69	-0.010	-444	-2.72	-126	7.78
WestMed area	**-0.099**		**-18.98**			**-0.035**		**-6.66**		
France	-0.116	-4373	-24.37	-1204	58.52	-0.051	-2054	-11.32	-576	20.49
Italy	-0.047	-1274	-8.99	-350	25.18	-0.013	-361	-2.21	-90	6.62
Spain	-0.136	-2884	-21.63	-1009	38.93	-0.034	-748	-5.44	-254	9.01

Source: ICES model

Comparing the two scenarios, in the Western Mediterranean area impacted countries reduce their GDP loss in IPCC SRES scenario B1, which is more than halved respect to SRES scenario A2. The situation for the North Sea region is quite different. Here the GDP loss is significantly unchanged in the two scenarios. This result may be explained at the country level, where the better performance in GDP in Denmark and the Netherlands is counterbalanced by a small decline in Germany and the United Kingdom. With reference to fishing production, the Western Mediterranean countries have a fall in fishing output more significant in IPCC SRES scenario A2, while in IPCC SRES scenario B1 each of them improves its position. In the North Sea area, findings highlight a reverse situation. In this case, most of the impacted countries (with the exception of the Netherlands) decrease their sector output more in IPCC SRES scenario B1 than in IPCC SRES scenario A2. Figure 5 shows a comparison of the performances of the two Sea regions in both scenarios.

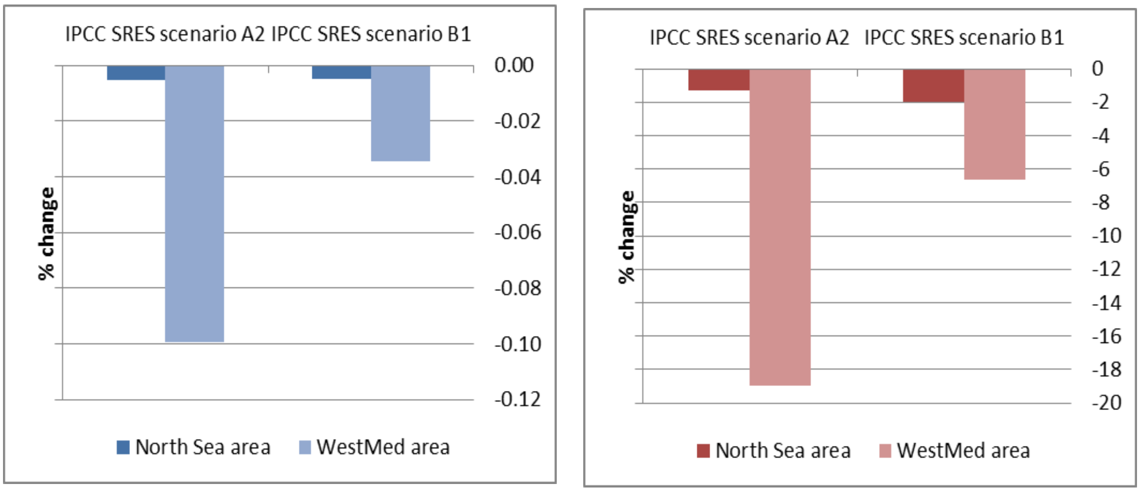


Figure 5: Comparison of effects on GDP (left) and fishing production (right) of an increase in fishing effort in VECTORS Sea regions in IPCC SRES scenarios A2 and B1
Source: ICES model

5. Modelling and assessing climate change impacts on marine ecosystem recreational service: change in coastal tourism demand

Although climate is by no means the only determinant of holiday destination choice (Crouch, 1995; Witt and Witt, 1995; Gossling and Hall, 2006; Bigano *et al.*, 2006a; Rossello *et al.*, 2005), the "amenity of climate" is recognised as one of the major determinants of tourism flows (Maddison, 2001; Lise and Tol, 2002; Bigano *et al.*, 2006b). Among the studies focusing on the relationship between climate and tourism demand, temperature is often considered as the most relevant climatic variable, since most climate parameters, such as humidity, cloudiness and weather extremes tend to depend on temperature (see Hamilton *et al.* (2005 a; b); Lise and Tol (2002)). Alternatively, environmental amenities (Wunder, 2000; Naidoo and Adamovicz, 2005), coastline and beach length (Maddison, 2001; Bigano *et al.*, 2006b), art and local culture, wine and gastronomic production (Medina, 2003; Hamilton, 2004, Brunori and Rossi, 2000; Telfer, 2001; Correia *et al.*, 2008), cultural and natural heritage (Poria *et al.*, 2003), Hamilton (2004)) are also considered by many studies as a relevant component of tourism demand determinants that can be influenced by a changing climate.
In general the relation between ecosystem quality and tourism demand has been analyzed to a quite limited extent (Onofri and Nunes, 2013; Song *et al.* 2003, 2008, 2010). This is particularly evident when marine ecosystems are concerned. More specifically, while the literature conducted at a micro (regional or site specific) level is rather ample (see e.g. Hall (2001), Davis

and Tisdell (1996), Harriott *et al.* (1997), Green and Donnelly (2003), among others) it is much more narrow at a macro (country) level, limited to our knowledge to Bigano *et al.* (2005) and Onofri and Nunes (2013).

Here, we focus on changes in coastal tourism demand driven by the fish overexploitation index. As confirmed by many studies and official documents (UNEP (2006), FAO (2013), IPCC (2014a,b) among others), marine resources are either overexploited or at a critical endangered level. Accordingly, the services they provide, including the support to/attractiveness for tourism industry, are also endangered. To capture the marine ecosystem quality, the fish stocks overexploited information is taken from the University of British Columbia Fisheries Centre. The historical time series for 19 European countries from 1962 to 2006 is available. Although the extremely volatility of the overexploitation index, we linearize this trend and extrapolate it until 2030. From Otrachshenko and Bosello (2013) part of VECTORS Task 3.2 we get a relationship between a percentage change in the index and the change in the number of coastal foreigner tourist arrivals. Then, for each of these 19 countries we rescaled the percentage change in coastal tourism demand by the share of national coastal tourism respect to total national tourism and the share of foreign tourists respect to total tourists. Since flow changes in tourism demand bring to a "zero sum game", the lower arrivals in the EU Countries mean a higher level of arrivals in other regions. Here we assume that extra-EU countries share the increased coastal tourism demand according to their share of per-capita income in the region.

Table 6 summaries the main inputs in the ICES model to study the impact of changes in coastal tourism. There are two aspects to be considered: the change in the number of arrivals and the change in expenditure because of changes in tourism flows. In SRES scenario A2 we suppose that in the period 2007-2030 the overexploitation of marine ecosystems does not change respect to its historical trend while in SRES scenario B1, more environmental friendly, we postulate half of the impacts on coastal tourism demand in 2030 respect to the one in A2.

Table 6: Percentage change in tourism demand in 2030

	IPCC SRES scenario A2		IPCC SRES scenario B1	
	% change in arrivals	Change in income (2007 $ million)	% change in arrivals	Change in income (2007 $ million)
France	5.04	285	2.52	84
Italy	-12.17	-33085	-6.08	-16399
Spain	-5.18	-18004	-2.59	-8522
Belgium	-0.60	-186	-0.30	-88
Denmark	-12.95	-3475	-6.47	-1559
Germany	-1.13	-2489	-0.57	-1117
Netherlands	-14.22	-11604	-7.11	-5514
UK	1.02	30	0.51	8
Estonia	-10.90	-422	-5.45	-158
Finland	-16.69	-3976	-8.34	-1821
Latvia	-4.72	-209	-2.36	-106
Lithuania	-11.68	-614	-5.84	-323
Poland	-4.60	-3298	-2.30	-1410
Sweden	-9.76	-3299	-4.88	-1526

Source: authors' own calculation

Table 7 below reports the outcomes of this impact analysis in terms of changes in GDP and changes in tourism sector production in IPCC SRES scenarios A2 and B1 in the EU "VECTORS seas" countries.

In IPCC SRES scenario A2, GDP unambiguously declines between 0.96% (Italy) and 0.19% (Estonia). Looking at GDP losses in absolute terms the most affected countries are Germany and the United Kingdom that face a GDP loss of 37.6 and 30 2007 USD billion.
Major drops in GDP are evident in the Baltic Sea and in the Western Mediterranean Sea that lose nearly 0.75%. The reduction in GDP in the North Sea region is slightly lower (-0.71%). It is worth noting that, although France and the United Kingdom have a positive impact on demand, they experience a negative impact on GDP growth in 2030 (-0.71% and -0.74%, respectively). Once again, sectoral impacts are larger than GDP effects. The decline in the value of production of the tourism sector is substantial; it ranges between 13.92% (Netherland) and 0.66% (Germany). In absolute terms, the two biggest production falls are in Italy and Spain (21.1 and 17.3 USD billion, respectively). The Baltic Sea area experiences the highest reduction in tourism sector value (-7.41%), while reductions in the North Sea region and the Western Mediterranean area are smaller (-2.23% and -3.40%, respectively). At the country level, increases are evident in France, Belgium, and the United Kingdom. France and the United Kingdom are affected by positive impacts that lower the GDP growth but at the same time, the tourism production increases. Belgium, instead, declines its tourism production together with a decline in its GDP.

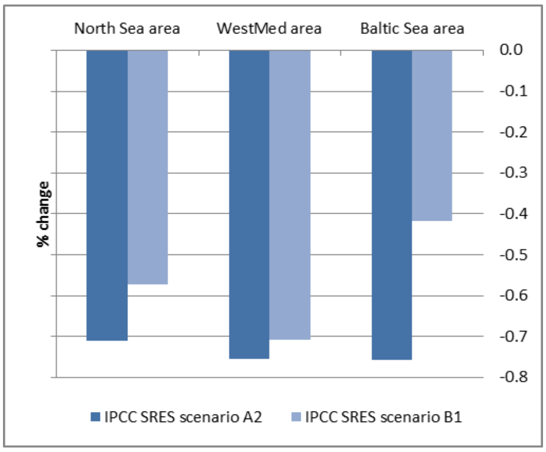
In SRES scenario B1, as in scenario A2, the impact of changes in tourism demand leads to a generalized reduction in GDP (ranging from -0.95% for Italy to -0.17% for Poland). In this scenario the percentage losses in GDP are lower; with respect to the previous scenario, the GDP reduction is more evident in the Western Mediterranean area (-0.71%) than in the North Sea area (-0.57%) and in the Baltic Sea area (-0.41%). At the single country level, no country has a positive effect on GDP. On average, losses are lower than 1%, with a decline in absolute terms up to 30.9 USD billion (Germany).
Production in the tourism sector mainly declines among countries. Only Belgium, France, and the United Kingdom increase their sector productions although this positive outcome is lower than in scenario A2. Belgium, France and the United Kingdom increase their production because of the positive impacts on their tourism demand: these countries are more attractive and thus to satisfy the increasing demand they produce more.
At regional scale, in terms of production losses the most evident drop is in the Baltic Sea area (-3.78%), while in the Western Mediterranean region the fall in production is lower (-2.31%). The drop in the North Sea area is the lower among the three VECTORS Sea regions (-1.37%). Comparing the output reduction in scenarios B1 and A2 we can clearly state that in terms of production scenario A2 is characterized by more strong decreases (with 5 countries with production reduction over -10%) than scenario B1 where no country experiences a reduction higher than 8%.

Table 7: GDP and tourism production changes in 2030 wrt reference scenario

	IPCC SRES scenario A2				IPCC SRES scenario B1			
	Real GDP growth		**Tourism production**		**Real GDP growth**		**Tourism production**	
	% change	2007 million $	% change	2007 million $	% change	2007 million $	% change	2007 million $
North Sea area	**-0.709**		**-2.230**		**-0.571**		**-1.371**	
Belgium	-0.490	-3034	1.277	285	-0.428	-2867	0.725	167
Denmark	-0.346	-1391	-10.943	-2098	-0.352	-1470	-6.109	-1228
Germany	-0.752	-37671	-0.660	-922	-0.571	-30910	-0.555	-908
Netherland	-0.664	-7248	-13.922	-7812	-0.544	-6446	-7.624	-4589
UK	-0.737	-30077	0.906	1518	-0.619	-28250	0.133	257
WestMed area	**-0.754**		**-3.393**		**-0.708**		**-2.307**	
France	-0.706	-26577	4.593	13343	-0.663	-26968	1.873	5990
Italy	-0.967	-25974	-12.585	-21116	-0.948	-27349	-7.057	-12702
Spain	-0.567	-12068	-6.142	-17373	-0.477	-10519	-3.853	-12012
Baltic Sea area	**-0.756**		**-7.414**		**-0.417**		**-3.787**	
Estonia	-0.193	-84	-9.705	-301	0.370	165	-3.980	-120
Finland	-0.838	-2597	-13.224	-2024	-0.815	-2703	-7.547	-1194
Latvia	-0.867	-581	-6.825	-228	-0.639	-475	-4.059	-161
Lithuania	-0.734	-746	-12.783	-622	-0.230	-283	-7.449	-451
Poland	-0.772	-8480	-5.326	-2780	-0.176	-2077	-2.087	-1088
Sweden	-0.715	-4205	-6.909	-1531	-0.725	-4541	-4.016	-919

Source: ICES model

Comparing the two scenarios, GDP decreases in both cases. In the Western Mediterranean area, however, impacted countries reduce their GDP loss in IPCC SRES scenario B1 respect to SRES scenario A2; however, the reduction is less evident than in the other VECTORS sea regions. The situation for the North Sea region is quite similar. The Baltic Sea area nearly halves its GDP loss in IPCC SRES scenario B1 with respect to IPCC SRES scenario A2. For tourism production, outcomes are quite similar: IPCC SRES scenario A2 shows a worse situation in each Sea region. Figure 6 shows a comparison of the performances of the three Sea regions in both scenarios.



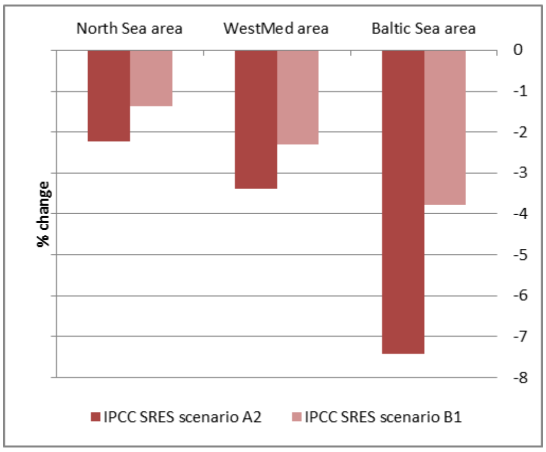


Figure 6: Comparison of effects on GDP (left) and tourism production (right) of changes in coastal tourism demand in VECTORS Sea regions in IPCC SRES scenarios A2 and B1
Source: ICES model

6. Conclusions

This paper describes the methodology, data elaboration and main results of a modelling exercise aiming to assess the economic effect of future changes in the EU marine ecosystem in the medium term (2030) in the Western Mediterranean, in the North Sea and in the Baltic. We focus on those changes potentially affecting the fishing and the tourism sectors in two different IPCC SRES scenarios, the A2 and B1, varying in the future trends of population, GDP, prices, as well as the overall impact on environment. Sector-specific economic impacts are channeled through increases in fishing effort, due to lower availability of commercial fish species, and decrease in tourism demand following deterioration of marine ecosystem quality.
Impacts on EU coastal countries Gross Domestic Product are negative and larger when the tourism sector is affected. This is explained by the much higher contribution of tourism than fishery in the production of value added. Negative impacts are also larger in the A2 than in the B1 scenario. The largest GDP losses due to adverse impacts on fishery are experienced by Spain (-0.13%), those related to tourism by Italy (almost -1%). Percent changes in sectoral production are notably larger than GDP ones: the largest contraction in fish sector production occurs in France (-24.7%). Notable decrease in coastal tourism demand occurs in Spain and the Netherlands. In general, the Western Mediterranean is the most adversely affected region, whereas the Baltic Sea denotes a particular vulnerability to losses in tourism value added compared to the BAU. North Sea countries experience smaller losses.

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