ANNEX

BACKGROUND PAPER No. 7

ON

CLIMATE CHANGE

Disclaimer:

The present document has been elaborated by European Commission services for the purpose of providing background material and information to supplement the Green Paper on Maritime Policy [COM(2006) 275].

This background document is therefore purely illustrative and is not intended to represent the political views, nor to indicate or announce possible future initiatives of the European Commission.

WORKING GROUP 7 - CLIMATE CHANGE

Summary of work of WG7

First meeting of the Working Group – clarification of the mandate	28 July
Second meeting of the Working Group – discussions on three main themes agreed on the basis of background documents prepared by WG members	8 September
Electronic iterations on existing contributions and production of summary documents highlighting issues of relevance for the Green Paper	By 30 September
Third meeting of the Working Group – agreement on key messages on climate change for the Green Paper	21 October
Finalisation of Working Group input	6 December

The mandate of Working Group 7 as defined by the Interservice Working Group on Maritime Policy in its note of 11 July 2005 (MPTF25bis) is as follows:

"Address the handling of climate change, both in terms of mitigation/addressing causes of climate change, and with respect to impacts of climate change."

In light of this mandate it was agreed during the first meeting of the Working Group held on 28 July to focus the work on three themes:

- Climate change impacts on oceans and seas
- Greenhouse emissions and maritime activities
- Mitigation and adaptation measures

Background papers were produced on each of the above themes which were discussed during the second meeting of the Working Group on 8 September 2005. On the basis of these discussions 1-page synthesis papers of these background papers were prepared, highlighting in particular areas where the Green Paper could add value to what is already being done. These papers were reviewed during the third meeting of the Working Group held on 21 October 2005 during which it was agreed to compile existing papers into a single, coherent document in order to finalise the work.

1. CLIMATE CHANGE IMPACTS ON OCEANS AND SEAS

1.1. Ocean and climate interactions

Oceans and seas play a key role in climate and weather patterns. Conversely, oceans and seas are particularly sensitive to climate variations:

– Oceans act as **climate regulators** through direct effects – e.g. transfer of heat (between tropical and polar areas by currents, climate regulation by reducing the temperature gradient between the tropics and the polar region) and indirect effects – e.g. CO_2 absorption.

– The marine environment and coastal zones are particularly vulnerable to human activities and the pressure from these activities is accelerating. These changes are exacerbated by climate change.

– The **land-ocean-atmosphere connection** plays an important role. Transport of sediments and nutrients from land to the ocean is an example of this connection.

1.2. Climate change impacts

According to the International Panel on Climate Change (IPCC), **global mean sea level** will rise between 9 to 88 cm by 2100 as compared to 2000. Data on sea tides indicate that the mean sea level has risen by 10 to 20 cm in the 20th century, which means a ten-fold increase compared to the past 3000 years[1].

There has also been an **increase in sea-surface temperatures**. The surface of sea-ice has diminished by 15% in the Northern Hemisphere since 1950[2]. As an illustration, the Arctic Ocean has lost nearly 10% of its permanent sea-ice cover every 10 years since 1980.

On average, climate warming of the Arctic region is two or three times more marked than elsewhere on the planet, with a 3°C increase over the past 50 years. Polar ice cover as well as inland ice sheets are shrinking as a consequence of warmer conditions and the negative balance between precipitation and melting, respectively. Currently, Greenland loses about 80 km^3 of ice each year. The consequences and impacts on the Arctic flora and fauna will be severe. The pack ice has already shrunk by 15-20% over the past 30 years. Populations of ringed seals and polar bears will of course be affected. The full food chain from single-cell algae to fish and seals will also change.

Finally, CO_2-induced **ocean acidification** is inevitable. If global CO_2 emissions continue to rise at current trends, acidity of the oceans will cause the pH to drop 0.3 to 0.4 units by 2100[3]. This pH value will be lower than it has been for millions of years in the past and proceeds at a rate 100-times faster than ever before[4].

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1 However, the rate of rise is still an order of magnitude lower than that occurring in the millennia immediately after the end of the ice ages.

2 http://www.ipcc.ch/

3 Nature, 29 September 2005.

4 KDM, IFREMER, National Oceanography Centre, Southampton – poster session – European Marine Scientific Research Conference, European Parliament, 17 October 2005.

The potential consequences of climate change on oceans and seas, the environment at large and in turn our economic prosperity and social well-being, are potentially far-reaching:

Current development linked to Climate Change	- Impacts
Increase in sea-surface temperatures	- Shrinking of the sea-ice cover in the Arctic, causing reduced albedo and additional warming of the polar lower atmosphere - Warming of deeper ocean layers, causing risks of destabilisation of methane ice on the sea bed leading to methane emissions - Thermal expansion of the ocean contributing to sea level rise - Shifts in species composition - Less CO2 intake by oceans - Potential Increased rainfall and fresh-water run-off leading to changes in water exchanges between seas areas – i.e. between the North Sea and the Baltic Sea - impacting ecosystems
Global sea-level rise	- Increased vulnerability to storm wave and flood risk and submergence (e.g. the 1 in 100 year flood factor may become a 1 in 10 year factor in the UK by 2100) - Salinisation of surface and ground waters - Morphological changes: changes in wave climate, storm waves and surges leading to greater land erosion, wetland loss, sediment loads to seas, and greater nutrient fluxes to seas. As an illustration, by 2080 estimates suggest that between 13% and 25% of the world's coastal wetlands could be lost due to sea level rise alone5.
Ocean acidification	- Worldwide decline of area favourable for coral reef growth - Major changes in marine ecosystems: the base of marine food chains will be affected - The carbon dioxide absorption function of oceans may be undermined. - The impact of pollutants on biota may change as acidity is a crucial factor in influencing chemical processes6.

5 Safeguarding our seas, Department of Environment, Food and Rural Affairs (DEFRA), UK, 2002.

6 Charting Progress – Report commissioned by the UK's Department for Environment, Food and Rural Affairs, March 2005.

Melting of Arctic ice	- Fresher northern waters weakening the Atlantic conveyer bringing warm waters to Western European from the Caribbean. This now looks unlikely in the foreseeable future7 but cannot be ruled out (some experts point to a 30% chance of cooling of Western Europe8). It would of course have a major impact.

As indicated in the above table, impacts on the marine environment are significant. The already stressed state of marine ecosystems is leading to a reduced resilience and ability to climate change. Major species shifts are to be anticipated. The species composition of phytoplankton, at the lowest level of the food web, is already changing and its magnitude has been described as a "*regime shift*"[9]. These changes will affect other species. Changes in salinity will affect certain marine species. Increased temperatures may disturb the reproductive cycles of species and therefore their distribution. Fish abundance and distribution of marine fish may be affected. Evidence suggests that the reproduction and growth of North Sea cod has been influenced by the warming of the North Sea over the past 10 years.

1.3. Potential costs

The magnitude of climate change impacts on marine and coastal environments described in the preceding section is such that important costs are to be expected for society as a whole. In particular:

– Taking into account sea-level rise in coastal protection.

– Adjustments in fisheries sector (e.g. reduced landings) that might follow changes in fish abundance and distribution.

– Impacts on tourism due to changing coastal landscape and climate. As coastal areas are the main interface to tourism and tourism is the world's largest economic sector with prospects of further expansion, the potential losses are considerable (e.g. degradation of infrastructure due to increased vulnerability to storm surges, loss of income due to extinction of coral reefs etc[10]).

– Potential loss of opportunities for marine research and bioprospecting linked to the change in distribution of certain marine species.

Quantification and valuation of these costs remains under-developed. However, some attempts have been made mainly by insurance companies who have established models assisting them in forecasting future costs based on high and low CO_2 emission rates[11]. By using models to simulate possible natural catastrophes and weighing these possibilities by chance of occurrence, the Association of British Insurers (ABI) states that a picture of costs

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7 Confronting the Bogeyman of The Climate System 21 October 2005 VOL 310 Science.

8 Presentation by Edward Hill (National Oceanographic Centre, Southampton) at European Marine Scientific Research Conference held at the European Parliament on 17 October 2005.

9 Ibid., p. 23. "*There has been increased primary productivity, merging of spring and autumn blooms and a switch in the dominant species. This has been accompanied by the northward movement of plankton species by about 10 degrees of latitude*."

10 The decline in seabird breeding linked to climate change in the Northern Isles has led to a decline in tourists.

11 Association of British Insurers. Financial Risks of Climate Change, Summary Report, June 2005.

can be developed. ABI acknowledges that factors such as population growth and increased monitoring capabilities raise the amount of recorded losses, but also provide figures on the impacts of climate change. ABI also states that further studies on the impacts of climate change as related to European windstorms and flooding is required.

In attributing costs, ABI looks at high and low emission scenarios, the high emissions defined as being a doubling in carbon dioxide concentrations by the 2080s, and a low emission scenario resulting where steps to limit carbon emissions are taken. Under the high emissions scenario, ABI states that climate change could increase the costs of flooding in the UK by 15 fold by the 2080s, which would result in losses of over $40 billion[12]. In advocating adaptation, the Association states that floods across Northern Europe may only increase 2-4 fold under low emissions scenarios as opposed to the potential 10-20 fold under the high emissions scenario, resulting in savings of some $120 billion each year by the 2080s[13].

The Association also gives examples of related losses which could be suffered in Europe[14]. It is projected that by the 2040s, half the European summers may be hotter than the summer of 2003 where the heat resulted in 22,000 deaths. Forestry and agriculture could also suffer such as the damages caused by windstorm Gudrun which were estimated at $2.5 billion in Sweden in 2005 and where crop failures due to the 1992 heat waves in Germany resulted in losses of $3.1 billion.

In its document on Storm Warning[15], Munich Re Group compares the 1960s with the 1990s, stating that the 1990s were witness to more than 4 times the major weather-related catastrophes as in the 1960s, and that the losses in the 1990s amounted to $430 billion dollars globally. This figure was deemed to be 8 times greater than costs of damages in the 1960s.

1.4. Role of the Green Paper on the future maritime policy

– Need for greater recognition of the role of oceans in regulating climate change and of the impact changes in the oceans will have on us. Improving knowledge of climate impacts on oceans and seas is essential not only for the marine environment but also for climate change policy in general and for our broader economic prosperity and well-being.

– Develop long-term datasets to identify relationships between climate fluctuations and both changes in species abundance and biodiversity and changes in the structure and functioning of both aquatic and terrestrial ecosystems. The proposed European Marine Observation and Data Network will provide a focus for these efforts.

– Maximise synergies with research efforts and strategies developed by partner countries that have or are developing Maritime Policy through existing policy dialogue mechanisms at EU level. Work out new mechanisms/processes to be established in order to operationalise these exchanges and cross-fertilisation.

[12] *Ibid*, p. 7.
[13] *Ibid*, p. 9.
[14] *Ibid*, p 33-35.
[15] Munich Re Group. Storm Warning: The Challenges of Climate Change: Research, Facts, Consequences. p. 33.

– Reduce uncertainties in potential sea-level rise and assess their impact taking into account other ongoing local processes – both natural and human-induced caused by continuing coastal and riverine development.

– Explore the relation between hurricane intensity and climate change with a regional, high-resolution, prediction model calibrated and validated using local time series of field measurement and satellite data.

– Step up research efforts on the climate/fisheries interface - in particular impacts on species composition, abundance and geographical distribution[16] in order to develop informed policy making.

– Contribute to the development of a strong and sustainable long-term monitoring programme of climate change impacts on the marine environment at global level - including through the identification of proxies and climate-sensitive keystone species (link with EU Marine Strategy and work of Working Group 4).

– Step up efforts to better understand near-shore sediment on variable time scales in order to better assess future coastal evolution.

2. GREENHOUSE GAS EMISSIONS FROM MARITIME ACTIVITIES

2.1. Maritime emissions: key sources, quantities and comparisons

The main direct and indirect greenhouse gas (GHG) emissions from maritime activities are as follows:

– **Carbon dioxide (CO_2) from ship fuel combustion in EU seas**: around 157m tonnes annually. This is higher than EU aviation, and more than total land emissions in many EU states.

– **CO_2 from offshore installations**: at least 12.5m tonnes annually (Danish, Dutch & UK oil and gas platforms, according to their national allocation plans for carbon dioxide).

– **Nitrogen oxides (NOx) from ship fuel combustion**: around 3.6m tonnes annually. Ships are biggest EU source, and without action will emit more than all land sources combined by 2020.

– **Fluorinated gases (mostly HFCs and HCFCs) from ship refrigeration systems leaks**: as yet unquantified, but research suggests that they are unjustifiably high, with average annual leakage of 50% (80% for fishing boats) c.f. 1% for land systems.

2.2. Key existing EU & international policies: timeline and description

EU and international milestones in addressing greenhouse gas emissions from maritime activities are as follows:

16 Global warming impacts the distribution of certain planctonic species determining the viability of fish larvae and, ultimately, the breeding sources and the areas of distribution of fish.

– **1997 Kyoto Protocol**. The Protocol sets targets for countries to reduce CO_2 emissions but does not cover international shipping. It calls on Parties to limit ship emissions working through IMO.

– **2001 EU White Paper on a Common Transport Policy**[17]. The White Paper proposes modal shift from road transport to shipping, mainly to reduce congestion, but also to reduce environmental impacts. It is accompanied by funding programmes - Motorways of the Sea and Marco Polo. This policy could reduce total CO_2 from transport, because ships are more fuel-efficient than other modes. However, increased transport demand and trend towards high-speed shipping could endanger this.

– **2002 EU strategy to reduce atmospheric emissions from seagoing ships**[18]. The proposed objective is to reduce ships' unitary emissions of CO_2, working with IMO.

– **2005 EU Emissions Trading Scheme**[19]. Includes CO_2 emissions from offshore installations, requiring MS to allocate allowances. This does not include shipping.

– **2005 IMO Guidelines on voluntary CO2 indexing**. The Guidelines define simple methodology for measuring ship CO_2 performance and fuel efficiency. The Guidelines take into account technical aspects such as hull design, anti-fouling, engine performance; and operational aspects such as speed and load.

2.3. Ongoing work in the Commission

Ongoing Commission work is focusing on the following five areas:

– DG ENV study assigning ship CO_2 to EU Member States; to consider including in national targets.

– EEA and DG ENV studies quantifying refrigerant gas leaks from ships.

– JRC is in the process of developing a model of energy consumption in the maritime sector.

– ENV study collating existing IMO CO_2 index results and promoting its take-up.

– ENV study assessing possible future EU policy options including mandatory CO_2 limits.

2.4. Role of the Green Paper on future maritime policy

– Awareness raising: explain maritime contribution to climate change, and impact climate change has on maritime

– Highlight opportunities for ships to reduce fuel use, thereby cutting costs as well as GHG

– Improve EU-wide data on ship movements (link with Working Group 6) and growth trends in different sectors

17 COM(2001) 370.
18 COM(2002) 595.
19 Based on Directive 2003/87/EC.

3. MITIGATION AND ADAPTATION MEASURES - INCLUDING ECONOMIC OPPORTUNITIES

3.1. Off-shore climate change mitigation technologies

Off-shore climate change mitigation technologies represent key opportunities for European companies. Several research projects supported under the 4th, 5th and 6th Framework Programmes have addressed different options including their practicality, environmental consequences and safety. The deployment of carbon sequestration technologies in electricity generation and hydrogen production will increase the production costs of these energy carriers. An assessment[20] has shown that the introduction of carbon sequestration technologies in Europe in 2020, will result in an increase in the production cost of electricity by coal and natural gas technologies of 30-55% depending on the electricity-generation technology used; gas turbines will remain the most competitive option for generating electricity; and integrated gasification combined cycle technology will become competitive. When carbon sequestration is coupled with natural-gas steam reforming or coal gasification for hydrogen production, the production cost will increase by 14-16%.

3.2. Off-shore carbon capture and storage

Storage of CO_2 in deep geological formations below the seafloor (e.g. underground storage in aquifers oil and gas fields, resp. saline formations) is one of the options currently being discussed as a cost-efficient technology to reduce the amount of greenhouse gases into the atmosphere. It uses many of the technologies that have been developed by the oil and gas industry and has been proven to be economically feasible under specific conditions for oil and gas fields and saline formations. It is estimated that by 2050 483 billion tonnes out of the projected 877 billion tonnes of total CO_2 emissions could be captured and stored[21].

The technology required for pre-combustion capture is widely applied in fertilizer manufacturing and in hydrogen production. Separation of CO2 in the natural gas processing industry, which uses similar technology, operates in a mature market. Three industrial-scale storage projects are in operation: the Sleipner project in an offshore saline formation in Norway, the Weyburn EOR project in Canada, and the In Salah project in a gas field in Algeria. Others are planned[22].

This activity represents a significant economic potential for European companies.

3.3. Offshore renewable energy

European coastlines possess significant opportunities for offshore renewable energy installations. Commission projections suggest that wind power could reach a total of 70,000 MW in 2010 (including 14,000 MW offshore).

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20 The impact of carbon sequestration on the production cost of electricity and hydrogen from coal and natural-gas technologies in Europe in the medium term – Evangelos Tzimas, Stathis D. Peteves Energy 30(2005)2672-2689.

21 http://www.ifp.fr/IFP/fr/espacepresse/Dossier_CO2/5_ADEME_FicheActionsCO2.pdf

22 IPCC Special Report on Carbon dioxide Capture and Storage Summary for Policymakers (http://www.ipcc.ch/activity/ccsspm.pdf)

Other emerging technologies known as ocean energy systems cover a wide range of applications (wave energy devices, tidal current turbines) that can be deployed on the shoreline and offshore. Salinity gradient systems are a recent development and could be deployed in many European river estuaries.

For example, the WAVEDRAGON project[23] focused on testing a prototype of off-shore wave energy converter for power production than can be deployed in large parks wherever a sufficient wave climate at a depth of more than 20 meters is available. The power of a full scale prototype could produce 4-10 MW.

3.4. Tourism

Coastal areas attract the highest density of tourists (link with Working Group 5). It is estimated that tourism directly employs about 8 million people in the EU, representing roughly 5% of total employment and of GDP, and 30% of total external trade in services. Above half of the EU tourists visit the sea. The Mediterranean region alone is the world's leading leisure tourism destination accounting for 30% of international tourist arrivals and for one fourth of the receipts from international tourism[24].

Extreme weather events can have disastrous consequences for coastal areas and latest climate change scenarios show an increase in the likelihood of such events. Some areas (principally in Southern Europe) may not sustain what is considered an ideal climate any longer, thus affecting tourism, as underlined in section 1.

On the other hand, parts of Northern Europe may become more attractive destinations and see their tourism capacity expand. This may lead to an increase in the volume of cruise shipping. Measures to mitigate any undesirable environmental consequences might need to be considered.

3.5. Coastal risks

Models from the IPCC suggest that average sea-level rise will be between 9 and 88 cm over the rest of this century (see section 1). . The local uncertainty is even higher and will depend both on oceanic circulation patterns and land processes such as post-glacial rebound. The impact of an increase in sea level on marine ecosystems, coastal wetlands and vulnerability to storms and other extreme events will also depend on local geology, landscape, tides and human settlement patterns. This calls for different coastal management and flood protection measures in each of these regions.

3.6. Insurance

An increase in the incidence of severe weather storms and flooding in Europe would have repercussions on coastal infrastructure, shipping, aquaculture, marine engineering projects (e.g. wave and tidal devices).

Public expenditure dedicated to coastline protection against the risk of erosion and flooding has reached an estimated €3.2 billion, compared to €2.5 billion in 1986. Studies carried out

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[23] Contract ENK5-CT-2002-00603.

[24] European Environment Agency, http://reports.eea.eu.int/92-9157-202-0/en/3.14.pdf

for the IPCC indicate that the cost of coastal erosion will average €5.4 billion a year for the period 1990-2020[25].

Lack of action to mitigate the risks would lead to higher insurance premiums.

Improving the resilience of buildings and infrastructures, improving coastal defences could result in considerable savings from extreme windstorms and floods.

The Association of British Insurers states that "Global damages from a 0.5 metre rise in sea-level have been estimated as $24-$42 billion per year. Adaptation, in the form of coastal defences, could bring these down to $8-$10 billion per year"[26].

3.7. Fisheries

As outlined in section 1, climate change is affecting commercial fish species, from reproduction, growth, migration to mortality. It is not yet possible to determine how the ecosystem will behave under these conditions and what this will mean in terms of sustainable catches, yields and profits in the fishing industry.

However, carefully monitoring and timely scientific advice will be required in order that the fisheries managers can detect these new conditions and react to them before it is too late.

3.8. The contribution of marine protected areas

Marine protected areas can have 'buffer' effects which need to be taken into consideration.

3.9. Role of the Green Paper on future maritime policy

– Increase the capacity of the EU to address adaptation – in particular highlight the need to fill existing gaps in terms of mitigation and adaptation measures (building upon the work being initiated as part of the European Climate Change Programme: working group on adaptation just set up which will deliver its contribution by mid-2006).

– Take steps to further encourage the development of carbon storage technology to create a first mover advantage for EU industry (links with Working Group 1 – competitiveness and with ongoing work on ETAP – Environmental Technology Action Plan). In particular, give priority to carbon storage and burial in oil/gas reservoirs at sea as part of measures on marine spatial planning (link with Working Group 3).

– Need to reduce uncertainty about climate change impacts to minimise economic impacts (e.g. current increase in insurance margins) – link with Working Group 4.

– Need to increase the safety of Europe's ocean margins – need for prevention and preparedness measures (establish suitable infrastructure; educate population in threatened areas; develop training and exercises; improve modelling of propagation and run-up etc) and improved response mechanisms at national and European level (Community civil protection mechanism).

– Need to improve techniques for the evaluation of damage caused to the environment.

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25 Eurosion, living with coastal erosion in Europe, 2004 – www.eurosion.org

26 *Supra*, note 12, p. 9.

- Tailor ICZM Strategies to climate change priorities – e.g. improve the resilience of coastal areas to adapt to change, provide space for coastal processes to operate and achieve a more equitable sharing of risks inter alia by using financial instruments. Beyond the impacts of climate change on natural hazards, prepare for changed climate conditions affecting coastal development.

- Engage in analysis of regional impact differences and need for regional differentiation in terms of adaptation and mitigation strategies.

- Seize opportunities presented by the continuous dialogue mechanisms that are a feature of EU co-operation in Neighbourhood countries – with a particular focus on the Mediterranean given the region's sensitivities to Climate Change.