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The twofold aspect of climate change on navigation: the search for new maritime routes and the challenge of reducing the carbon footprint of ships

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SUMMARY Climate Change (CC) is going to affect maritime transportation. Since a relevant anthropogenic contribution to CC has been assessed, also the implication holds: maritime transportation is one of the human activities contributing to the CC. Thus, the maritime sector should be involved in both CC adaptation and mitigation actions.

This transcription of the same titled talk given on Nov.24, 2014 on occasion of the International Workshop "Maritime and Security Implications of Climate Change", hosted in Venice by the naval school "F. Morosini" of the Italian Navy, briefly considers CC evidence relevant to the maritime transportation and the available mitigation options for the industry, in view of the statements of the major international organizations and the existing legal framework.

Related presentation can be downloaded from http://www.marina.difesa.it/EN/events/Documents/presentation_Mannarini.pdf.

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CC EVIDENCE

According to the fifth assessment report by IPCC [1], there is now a robust evidence of several CC effects related to the marine and coastal environment. They include: sea level rise, reduction in extent of Arctic sea ice during summer, land-surface air temperature rise, warming of the upper ocean (0 to 700 m depth), ocean acidification, decrease(increase) in number of cold(warm) days and nights, increase in the frequency of heat waves, increase in the frequency and/or intensity of heavy precipitation events. It is beyond the purpose of this paper reviewing such evidence in more detail. The IPCC report [1] is a comprehensive reference for such a purpose.

MARITIME TRANSPORTATION IMPLICATIONS OF CC

In 2010 the U.S. Navy identified the Arctic as the region where the influence of CC is most evident in shaping the operating environment [2]. In that year's summer, commercial exploitation of the Northern Sea route by non-Russian vessels occurred for the first time [3]. Indeed, routes from North-European ports to Northern China, Korea, or Japan (or viceversa) can be in terms of spatial distance about 30% shorter than traditional passages through the Suez Canal. While such strategic advantage is attenuated for routes involving ports in the Central and Eastern Mediterranean Sea, the Russian Federation is rapidly evolving its legislation for benefiting of CC effects on maritime transportation in the Arctic region [3].

A warmer ocean will indirectly affect navigation through hull fouling. Indeed, a study shows that the distribution of native and alien species in the fouling communities will change in response to water warming, with enhanced growth rate for all species [4]. Sea water acidification could

further modify the situation. In view of possible CC mitigation actions (see next section), it should be considered that frictional loss of vessel kinetic energy through fouling could easily offset the endeavours in increasing ship energetic efficiency.

The United Nations Economic Commission for Europe (UNECE) points out that seaports will be particularly impacted by CC [5]. This is due to their exposure to coastal events and to their dependance from the inland infrastructure: both factors indeed are expected to be affected by CC (e.g. via sea-level rise, storm surges, and floodings). The same document argues that services (e.g. maintenance, traffic conveyance and safety) will probably be hit by CC earlier than physical assets, since thresholds for delaying or cancelling services are lower than thresholds for causing damage to infrastructure [5]. Other implications of CC in the maritime sector according to the UNECE report include: higher energy consumption for cooling cargo; sedimentation and dredging issues in ports; necessity of quay upgrading due to sea level rise; indirect effects due to changes in tourism destinations and crop productivity; effects on insurance fees [5].

CC IMPLICATIONS OF MARITIME TRANSPORTATION

A robust finding of most climate models is that peak global warming is approximately proportional to cumulative emissions of greenhouse gases (GHG) [6]. Thus, there is a limited budget of GHG emissions in order to reach a given warming target with respect to a reference period ("climate stabilization"). The Copenhagen Accord has set such a target to 2°C land-surface air temperature warming by 2100 with respect to the preindustrial era [7]. According to [8], the residual GHG budget for a 50% chance of reaching such target is about 1600 GtCO₂e.



This figure should be compared with the global emissions of year 2007, that amounted to 47 GtCO₂e [9]. It follows that, in the (unrealistic) scenario of constant emissions, the whole carbon budget will be spent already by mid and not by end of the 21st century. This is why a mitigation pathway has to be devised. Depending on the socio-economic scenario, any mitigation pathway sooner or later implies a peaking of global emissions and, eventually, their nullification. However, due to the inertia of the climatic system, even such an effort will not prevent CC effects from lasting for centuries beyond present [1].

Waterborne is by far the most CO₂ efficient (emissions per transported mass per distance) freight transport mode [9]. Nevertheless, global CO₂ emissions by international shipping are larger than those by international aviation and, including also domestic shipping and fishing, they amounted to 3.3% of year 2007 global emissions [9]. This roughly corresponds to the CO₂ emissions of two Countries such as Italy and Germany together [10]. This is why a CC mitigation action should see a "fair and proportionate contribution" from the maritime sector too [11]. The shipowners reinforced this position by stating that the ships' reduction target should be "at least as ambitious as agreed under any new UNFCCC" [12]. Also the U.S. Navy in its 2010's position paper declared the willingness to reduce the Navy's carbon footprint [2]. This climate-friendly position may also be motivated by the fact that, for the sector of shipping, a reduction in CO₂ emissions often means lower fuel consumption, leading to savings in total operational costs [13].

However, legal and technological issues presently limit the implementation of such headline statements. First of all, the Kyoto Protocol policy of "common but differentiated responsibility" sets legally binding emission reduction

targets just for a subset ("Annex I") of world Countries, that notably does not include China, India, and Brazil and the developing Countries [14]. This is quite relevant, since about 3/4 of the world tonnage, by deadweight, of all merchant vessels engaged in international trade is registered in developing Countries [9].

Furthermore, the United Nations agency for Environmental Protection reports that more than 80% of emissions from shipping are international and not fully attributable to any particular Country [15]. International emissions have not been included in the Kyoto Protocol targets [14]. This is why a reasonable commitment should probably go through the recognition that shipping resembles a "sovereign State" and, hence, does not lend itself to inclusion in national CO₂ reductions targets [16].

The ambition of the European Community is to stay at the forefront of CC mitigation actions. Its position for including GHG emissions from shipping into EU mitigation commitment, is expressed in a recent communication of the Commission to the Parliament [13]. The first step of the proposed strategy for a new legal framework is a system for monitoring, reporting, and verification of emissions for all large ships (over 5000 gross tonnes) using EU ports, irrespective of where the ships are registered. Then, after definition of the reduction targets, in its strategy the EU considers application of market based measures.

The IMO strategy stated in its 2nd GHG study [9] has two cornerstones: improving ships energy efficiency by design and making energy savings by operations. In particular, an objective index (EEDI) is proposed for comparing technological solutions for energy efficiency of vessel. While a minimum efficiency level is required by EEDI, such index is mandatory just for new ships. Both for new and already operating vessels, IMO proposes a comprehensive



energy management plan (SEEMP), including: use of renewable energy sources (both on board and in the supply chain on shore); transition to Liquid Natural Gas (LNG) as a clean and more GHG emission-friendly fuel; voyage optimization; fleet and logistics optimized management. Both the EEDI and SEEMP have come into force since January 2013 and apply to all new ships of 400 gross tonnes and above.

In the 3rd GHG study [17] IMO presented an updated global inventory of shipping emissions. The method employed relies on a calculation of fuel consumption and emissions, starting from individual ship movements, as obtained from AIS. The study captures the effect of the financial crisis which began in 2008 and attempts to disentangle it from operational changes that have occurred in certain ship types. The adoption of slow steaming and an historical low in productivity (transport work per unit of capacity) are also observed.

CMCC, building also on its expertise on ocean and climate modeling, has been developing since 2012 a system for optimization of ship routes [18]. VISIR, the present version of the operational system, computes least times routes in the Mediterranean Sea, taking into account IMO guidelines for navigational safety [19]. The long-term aim is to extend VISIR to multi-objective optimization, including minimization of GHG emissions, on a global scale. Such a system could be an element of a SEEMP implementation.

In 2011 IMO commissioned to Lloyd's Register and DNV an evaluation of the effectiveness of EEDI and SEEMP [20]. The authors concluded that, while both measures will significantly contribute to a mitigation of the emissions from shipping, in none of the scenarios modelled an absolute reduction in total CO₂ level relative to year 2010 will be achieved. It should be noted that both Lloyd's Register and DNV were con-

tributing also to the IMO 2009 GHG study [9].

Based on the outcome of [20], Anderson and Bows observe that, considering the economic growth scenarios A1B and B2, emissions from shipping will double by 2050 with respect to 2010 levels, despite application of EEDI and SEEMP [8]. They also suggest that, in order shipping to make its proportionate contribution to the 2°C target, more severe measures should be taken. They include: mandatory reporting of fuel consumption, slow steaming for all vessels, a comprehensive program of low-carbon retrofit, an increase in the scrappage rate, as well as an increase in freight tariffs for changing demand and forcing shifts in customer practices.

A recent study on behalf of the German Federal Environment Agency confirms that the CO₂ emission reduction targets considered thereto require efficiency improvements beyond business-as-usual [21]. The authors recommend to increase the stringency of the existing efficiency measures and to consider the use of financial instruments to produce reductions in sectors other than shipping.

CONCLUSIONS

This short report would like to make the point that shipping is two-way linked to CC: CC will change shipping and shipping contributes to the anthropogenic component of CC. While there is still comparable little research on adaptation to CC for the transportation sector [5], the mitigation action should start the sooner, in consideration of the limited GHG emission budget available for avoiding too dangerous CC impacts.

In this respect, the present international legal framework on transportation and CC shows relevant limitations, hampering an effective implementation of the measures for reduction of



emissions from shipping. The COP21 of UN-FCCC starting in November 2015 in Paris [22] will be the next great chance for a legally binding improvement on this topic.

However, as CC scenarios mirrors economical

and societal scenarios, it is apparent that no huge advancements on this theme will be possible, unless an informed society, from the individuals to the relevant stakeholders, makes responsible collective as well as personal decisions for its present and future.

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