# 2. Mitigation

The IPCC defines mitigation as "a human intervention to reduce the sources or enhance the sinks of greenhouse gases."[87] Mitigation, including reducing greenhouse gas (GHG) emissions and investing in low-carbon energy supplies, is necessa to limit temperature increases and decrease CO2 concentrations. Even though mitigation strategies have grown in recent years, GHG emissions continue to increase, meaning additional efforts to reduce GHG emissions are necessary.[88] Key to achieving these emissions reductions are commitments made by countries as part of their intended nationally determined contributions (INDCs),[89] a roadmap for how each country plans to reduce emissions post-2020. There are other benefits to mitigation as well, including influencing societal goals such as human health, food security, biodiversity, and sustainable develop-ment.[90] For oceans in particular, mitigation strategies include implementing blue carbon policies, reducing CO2 emissions from ships, developing ocean-based renewable energy, and considering carbon capture and storage following appropriate research and under regulatory frameworks.

## Main Recommendations

**2.0 Further develop and apply mitigation measures using the oceans, including imple-menting "blue carbon" policies, reducing CO2 emissions from ships, developing ocean-based renewable energy, and considering (long-term/no-harm) ocean-based carbon capture and storage. Encourage all nations to reduce $CO_2$ emissions so that the Paris Agreement to limit emissions to well below 2ºC can be achieved.**

**2.1 Sustainably conserve and enhance coastal ecosystems as major carbon sinks and integrate the management of the coastal carbon ecosystems ("Blue Carbon") into the policy and financing processes of the UNFCCC, and account for these ecosystems in the national reports to the UNFCCC, the INDCs (Intended Nationally Determined Contributions).**

**Account for the contribution of coastal ecosystems as GHG emissions and removals in the Intended Nationally Determined Contributions**

**2.2 Further accelerate progress in addressing air emissions from ships**

**2.3 Sustainably develop ocean-based renewable energy (such as offshore wind power, wave energy, tidal power, and aquatic biofuels); and accelerate efforts to implement these approaches through integrated marine planning and enhanced regulatory frameworks**

**2.4 Consider the potential for ocean-based carbon capture and storage, and, if appropriate, further develop regulatory systems for ocean-based sequestration and marine engineering**

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**2.1 Sustainably conserve and enhance coastal ecosystems as major carbon sinks and integrate the management of the coastal carbon eco-systems ("Blue Carbon") into the policy and financing processes of the UNFCCC, and account for these ecosystems in the national reports to the UNFCCC, the INDCs (Intended Nationally Determined Contributions).**

### Current Status of the Issue

Many natural environments contain large stores of carbon deposited by vegetation and various natural processes over centuries. The ability of these vegetated ecosystems to remove carbon dioxide ($CO_2$) from the atmosphere make them significant net carbon sinks. If the ecosystems are however degraded or damaged directly or indirectly by human activities, their carbon sink capacity is lost or adversely affected, and the carbon stored in the soil is released resulting in emissions of $CO_2$ that contribute to climate change.

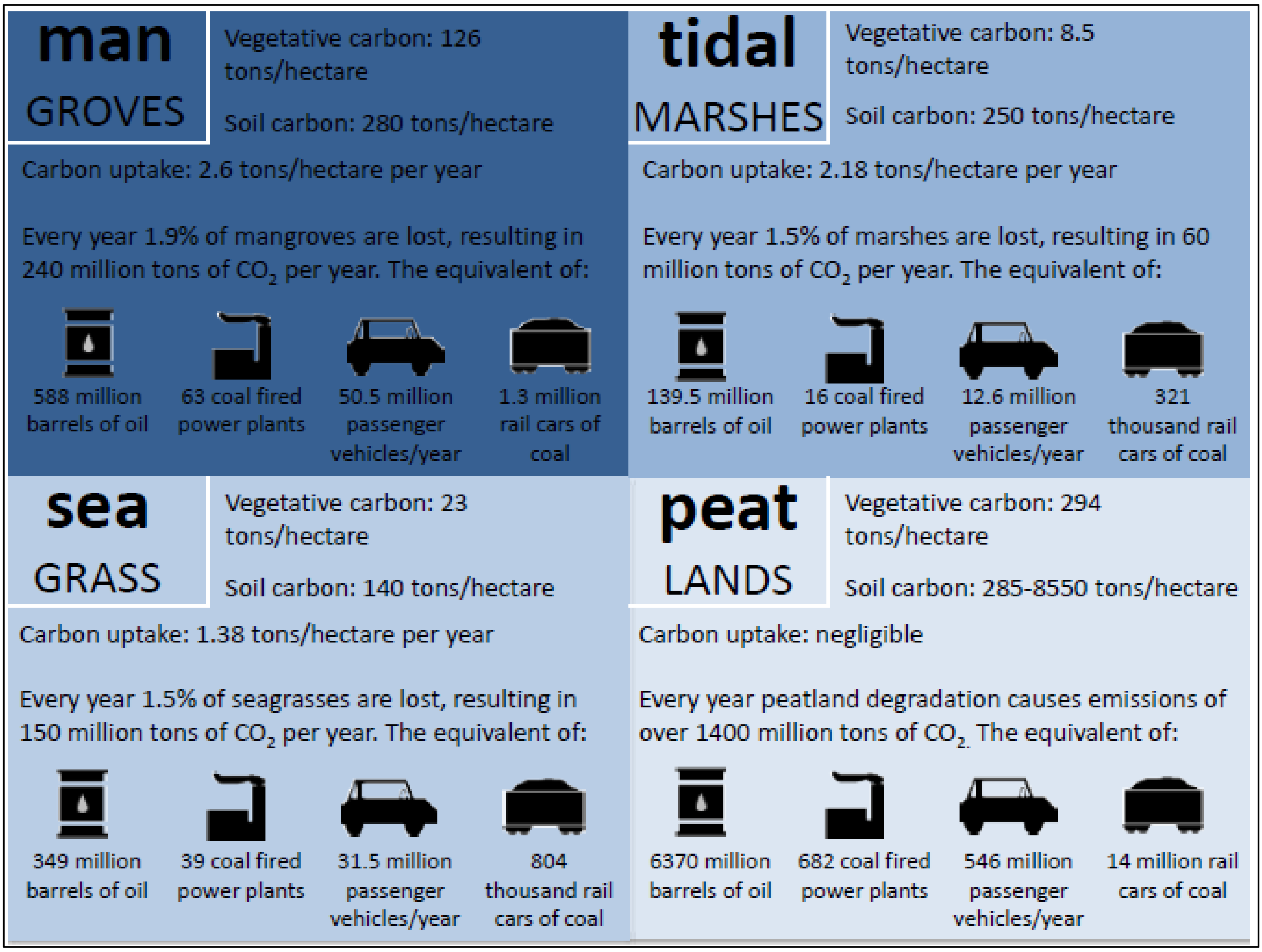


*Figure 2.1. Blue Carbon sinks. Source: Herr, D. et al. 2014*

The coastal ecosystems of mangroves, tidal marshes, and seagrass meadows provide numerous benefits and services that are essential for climate change adaptation along coasts globally, including coastal protection and food security for many coastal communities (Figure 2.1). Additionally, these eco-systems sequester and store more carbon per unit area than some terrestrial forests and are now being recognized for their role in mitigating climate change.

Despite their multiple benefits, coastal carbon ecosystems are some of the most threatened ecosystems on Earth, with an estimated 340,000 to 980,000 ha being destroyed each year. Although the historical extent of coastal carbon ecosystems is difficult to determine due to dramatic losses occurring before we could accurately measure these habitats, scientists have estimated that up to 67% of historical global mangrove range has been lost, and at least a 35% and 29% loss of global coverage for tidal marshes and seagrass meadows respectively.[91]

**Current State of Play of the Issue within the UNFCCC**

Conserving and restoring terrestrial forests, and more recently peatlands, has been recognized as an important component of climate change mitigation. Several countries are developing policies and programs in support of sustainable development through initiatives that reduce the carbon footprint associated with the growth of their economies, including actions to conserve and sustainably manage natural systems relevant to the UNFCCC, including through the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism.

These approaches are expanding to manage other natural systems, including marine and coastal systems, that contain rich carbon reservoirs and to reduce the potentially significant emissions from the conversion and degradation.

UNFCCC Article 4(d) calls for Parties to "promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including […] oceans as well as […] other coastal and marine ecosystems."

**Strategic Goals and Actions to Address the Issues**

Coastal carbon ecosystems need to be mapped, conserved and restored as globally significant carbon sinks. Despite their small extent relative to other ecosystems, they sequester and store globally significant amounts of carbon in their soil, sequestering an estimated 44.6 million tonnes per year.[92] Besides the loss of biodiversity, the ongoing destruction and loss of these systems also contributes to additional human induced GHGs. Alongside tropical forests and peatlands, coastal ecosystems demonstrate how nature can be used to enhance climate change mitigation strategies and therefore offer opportunities for countries to achieve their INDCs and to include the emissions and removals related to coastal ecosystems as part of their national GHG accounting.

Dedicated conservation efforts can ensure that **coastal ecosystems** continue to play their role as long-term carbon sinks by helping to ensure that no new emissions arise from their loss and degradation whilst stimulating new carbon sequestration through the restoration of previously carbon-rich coastal habitats.

**Opportunities and Pathways that may be Available within the UNFCCC to Advance the Issue in the Next Five Years**

On an implementation level, mangroves, saltmarshes and seagrasses can be included in national GHG accounting, now that the new 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) has been issued. Mangroves can also be included in REDD+, and all three ecosystems can be incorporated into NAMAs.[93] Some technical elements need to be fully integrated into these mechanisms to value the full coastal carbon potential, e.g. accounting for soil carbon. An expansion of the implementation of programmes and projects aimed at reducing the ongoing loss of these systems is still needed to reduce the resulting emissions.

**Opportunities and Pathways that may be Available outside of the UNFCCC to Advance the Issue**

Currently the management of **marine ecosystems** is not recognized as a climate mitigation option under the UNFCCC. Further debate and dialogues are now needed to analyse the usefulness and opportunities to develop an incentive mechanism for the open ocean under the Climate Convention.

An ecologically degraded ocean loses its capacity to support the carbon cycle and act broadly as a carbon sink; the pathways for this degradation are discussed in Section 2 of this brief. There may be opportunities for a UNFCCC oceans emissions work program to complement activities under other processes (e.g. UNCLOS,[94] CBD,[95] RFMOs)[96] which are concerned about the sustainable management of diverse marine resources and their services. MPAs[97] and other area-based management efforts are opportunities for no-regret climate change tools and are now needed more than ever for sustaining a functioning ocean, which continues to serve as a carbon sink.

Many countries have started to include **coastal ecosystem** management into their national climate change mitigation activities, including under REDD+, NAMAs and other mechanisms. These experiences show opportunities for further enhancement (e.g. on a technical level the accounting for soil carbon as part of REDD+ needs to be further advanced) as well as replication and expansion in other countries. More efforts now also try to link the mitigation and adaptation benefits of these systems (including through NAPs),[98] and to direct the appropriate management and policy responses through their national development goals as well as coastal planning efforts. Coastal ecosystem management for mitigation and adaptation may also be advanced under the Poznan Strategic Program on Technology Transfer and the through the work and services of the Technology Mechanism.

The role and implications of the importance of healthy **marine ecosystems** for a functioning ocean carbon cycle ought to be better incorporated into sectoral regulation and management regimes (e.g. fisheries, deep sea mining).[99]

The scientific understanding of the role of marine flora and fauna for climate change mitigation is increasing steadily and this needs to be further supported. However, a thoughtful debate is needed to determine if/how these elements should be addressed in future climate change strategies.

### Financing Considerations

Coastal carbon projects and programs can be financed through a variety of mechanisms.[100] A schematic overview is shown in Fig. 2.2 below. Possibilities exist through funds that are directly linked to a convention, for example the UNFCCC, Convention for Biological Diversity (CBD) or Ramsar, and managed via a dedicated institution, e.g. the GEF.

Other possibilities include national funds as well as funds from multilateral development banks. Both climate change and biodiversity related finance mechanisms can be accessed for coastal carbon activities. Other non-market mechanisms—the more traditional grant type funding—include phil-anthropic donors as well as debt-relief agreements. Additional to these non-market mechanisms, carbon offset crediting schemes or Payment for Ecosystems Services (PES) mechanisms that use a direct market to receive payments for specific activities, can be explored.

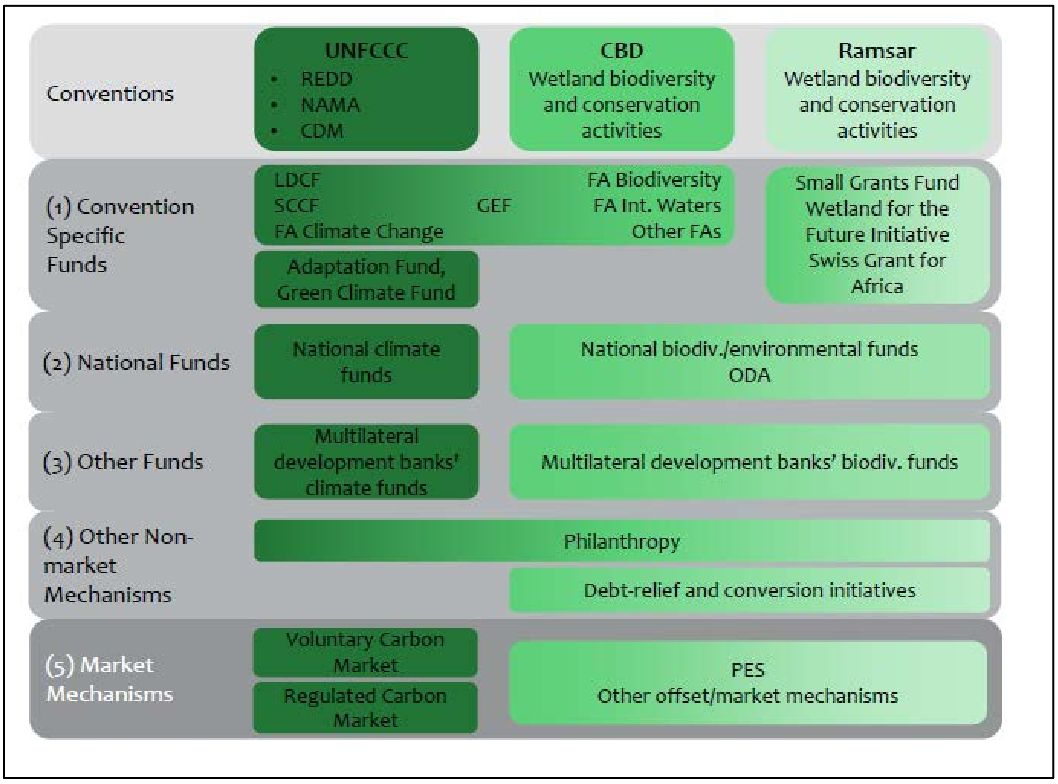


*Figure 2.2. Overview of the main climate (dark green) and biodiversity-related (lighter-green) finance mechanisms relevant for wetland carbon projects and programs. Source: Herr, D. et al. 2014*

## 2.2 Further accelerate progress in addressing air emissions from ships

### Current Status of the Issue

On 26 September 1997, the Conference of Parties to MARPOL 73/78 (the Air Pollution Conference) adopted a new Annex VI—Regulations for the Prevention of Air Pollution from Ships—and invited the International Maritime Organization (IMO) to undertake a study of $CO_2$ emissions from ships and to consider what reduction strategies may be feasible. The IMO has since commissioned three studies of GHGs from ships, with the most recent published in 2014, and adopted in a number of technical and operational measures to increase ship energy efficiency and reduce emissions from international shipping.

Estimates for GHG emissions from international shipping accounted for 796 million tonnes of $CO_2$ in 2012, which accounts about 2.2% of the total $CO_2$ emission volume for that year (Third IMO GHG Study 2014, approved by the sixty-seventh session of the IMO's Marine Environment Protection Committee (MEPC 67, October 2014)).[101] By contrast, in 2007, before the global economic downturn, international shipping is estimated to have emitted 885 million tonnes of $CO_2$, which represented 2.8% of the global emissions of $CO_2$ for that year. These percentages are all the more significant when considering that shipping is the principal carrier of world trade, carrying as much as 90% of all goods by volume and therefore providing a vital service to global economic development and prosperity.

Although international shipping is the most energy efficient mode of mass transportation, a global approach to further improve its energy efficiency and effective emission control is needed as, depending on future economic and energy developments, projections forecast a growth in $CO_2$ emissions for international maritime transport of 50% to 250% in the period up to 2050.

The IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping. IMO's regulatory framework covers all aspects of technical matters pertaining to the safety of ships and of life at sea, efficiency of navigation, and the prevention and control of marine and air pollution from ships. The original focus of IMO's environmental work was on the prevention of marine pollution by oil, resulting in the adoption of the first ever comprehensive anti-pollution convention, the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973. This has changed over the last few decades to include a much wider range of measures to prevent marine pollution, and the original MARPOL Convention was amended many times to also include requirements addressing pollution from chemicals, other harmful substances, garbage, sewage and, under an Annex VI adopted in 1997, air pollution and emissions from ships.

Emissions are not the only aspect of shipping which may affect ocean environments. The use of High Density Fuel Oil (HFO) by shipping in or near the Arctic poses a further threat to the polar environment. HFO use as fuel produces harmful and significantly higher emissions of sulphur and nitrogen oxides and black carbon than other fuels. Black carbon is transported according to regional meteorological conditions and strongly absorbs visible light. When it falls on light-coloured surfaces, such as Arctic snow and ice, the amount of sunlight reflected back into space is reduced and thus contributes to accelerated snow and ice melt. Phasing out of the use of HFO in the Arctic will help slow down the melting of Arctic Ice.[102]

### Current State of Play of the Issue within the UNFCCC

As already acknowledged by the Kyoto Protocol, $CO_2$ emissions from international shipping cannot be attributed to any particular national economy due to its global activities and complex operation. Article 2.2 of the Kyoto Protocol therefore states that the Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gas emissions not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization (ICAO) and IMO, respectively.

IMO's Assembly Resolution A.963(23) on "IMO Policies and Practices Related to the Reduction of Greenhouse Gas Emissions from ships" adopted in December 2003 sets out that the Organization should take the lead in developing GHG limitation and reduction strategies and mechanisms for international shipping and that, in doing so, it should co-operate with the Conference of the Parties to the UNFCCC.

No reference to the IMO nor the International Civil Aviation Organization (ICAO) is made in either the articles of the Paris Climate Change Agreement or the decisions to implement the agreement including on the pre-2020 ambition (the period between the Kyoto Protocol commitment period ending on 31 December 2020 and the new agreement entering into effect on 1 January 2020). The forty-third session of the Subsidiary Body for Scientific and Technological Advice (SBSTA), held during COP 21, took note of the information received from and progress reported by the secretariats of the ICAO and the IMO on their ongoing work on addressing emissions from fuel used for international aviation and maritime transport, and invited the secretariats to continue to report, at future sessions of the SBSTA, on relevant work on this issue.

**Strategic Goals and Actions to Address the Issues**

In July 2011, IMO adopted mandatory measures to improve the energy efficiency of international shipping, representing the first ever mandatory global energy efficiency standard for an international industry sector, and the first legally binding instrument to be adopted since the Kyoto Protocol that addresses greenhouse gas emissions.

The adopted measures add to Annex VI of the MARPOL Convention a new Chapter 4 entitled "Regulations on energy efficiency for ships." This package of technical and operational requirements, that apply to ships over 400 gross tonnage, requires new ships to be constructed to a mandatory design index, the Energy Efficiency Design Index (EEDI), which sets a minimum energy-efficiency level for the work undertaken (e.g. $CO_2$ emissions per tonne-mile) for different ship types and sizes.

The EEDI requirement aims to increase the energy efficiency of new ships over time. It is a non-prescriptive standard that leaves the choice of which technologies to use in a ship design to the stakeholders, as long as the required energy-efficiency level is attained, enabling the most cost-efficient solutions to be used. It is therefore intended to stimulate innovation in, and continued development of, the technical elements influencing the energy efficiency of a ship. Reduction factors are set until 2025 to the extent that ships constructed in 2025 will be required to be at least 30% more energy efficient than those constructed in 2014. The EEDI has been developed for the largest and most energy-intensive segments of the world merchant fleet and, following the inclusion of additional ship types, will embrace approximately 85% of emissions from international shipping.

The new regulations also make mandatory the Ship Energy Efficiency Management Plan (SEEMP) for all ships over 400 gross tonnage. The SEEMP is an operational measure that establishes a mechanism to improve the energy efficiency of a ship against business-as-usual, in a cost-effective manner and also provides an approach for monitoring ship and fleet efficiency performance over time, using, for example, the IMO's Energy Efficiency Operational Indicator (EEOI) as a monitoring and/or benchmarking tool.

Studies by IMO indicate that uptake of SEEMP measures will have significant effect in the short to medium term, while EEDI measures should have a greater impact in the longer term, as fleet renewal takes place and new technologies are adopted. Estimates (in a study by Lloyd's Register and DNV reported in October 2011) suggest that successful implementation of this energy-efficiency framework by 2050 could reduce shipping $CO_2$ emissions by up to 1.3 gigatonnes per year against the business-as-usual scenario (to put this in context, the Third IMO GHG Study 2014 estimated global $CO_2$ emissions to be 35.64 gigatonnes in 2012).

These mandatory energy efficiency requirements for international shipping have now been in force for almost three years. Data presented to MEPC 68 (May 2015) clearly identifies the improvements made, significant in many cases, in the energy efficiency of ships being designed and delivered today. This success story once again demonstrates the IMO's important role as the global standard setter for international shipping. For further information visit the IMO web-site:
http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Default.aspx

In addition to the energy efficiency requirements, the IMO has engaged in two partnership projects to further technical co-operation and technology transfer: Global Maritime Energy Efficiency Partnerships Project (GloMEEP) and the establishment of regional Maritime Technology Cooperation Centres (MTCCs).

The Global Maritime Energy Efficiency Partnerships Project (GloMEEP), an initiative of the Global Environment Facility (GEF), United Nations Development Programme (UNDP) and IMO, will focus in particular on building capacity to implement technical and operational measures in developing countries, where shipping is increasingly concentrated. The aim is to promote a low-carbon maritime sector, in order to minimize the adverse impacts of shipping emissions on climate change, ocean acidification and local air quality. IMO will execute the project, which marks the beginning of a new blueprint for creating global, regional and national partnerships to build the capacity to address maritime energy efficiency and for countries to mainstream this issue within their own development policies, programmes and dialogues.

Ten IMO Member States have signed up to the two-year GloMEEP project as lead pilot countries: Argentina, China, Georgia, India, Jamaica, Malaysia, Morocco, Panama, Philippines and South Africa. The lead pilot countries will be supported in taking a fast-track approach to pursuing relevant legal, policy and institutional reforms, driving national and regional government action and industry innovation to support the effective implementation of IMO's energy efficiency requirements.

The Maritime Technology Cooperation Centres (MTCCs) aim to become a global network of regional centres of excellence to promote the uptake of low-carbon technologies and operations in maritime transport. The five target regions - Africa, Asia, the Caribbean, Latin America and the Pacific - have been selected for their significant number of Least Developed Countries (LDCs) and Small Island Developing States (SIDSs).

This four-year project, administered by the IMO with €10 million in funding from the European Commission, is designed to help beneficiary countries limit and reduce GHG emissions from their shipping sectors through technical assistance and capacity building, while encouraging the uptake of innovative energy-efficiency technologies among a large number of users through the widespread dissemination of technical information and know-how. This will heighten the impact of technology transfer.

**Opportunities and Pathways that May be Available within the UNFCCC to Advance the Issue in the Next Five Years**

As requested by the IMO's Assembly Resolution A.963(23) on "IMO Policies and Practices Related to the Reduction of Greenhouse Gas Emissions from ships", and reiterated by IMO's Marine Environment Protection Committee (MEPC 68/21, paragraph 5.4), the IMO Secretariat should continue to report to the UNFCCC on IMO's work to address GHG emissions from international shipping.

The IMO Secretariat will continue reporting to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) under the agenda item on "Emissions from fuel used for international aviation and maritime transport", and participate in UN system activities including side events and other activities held parallel to COP meetings.

**Opportunities and Pathways that May be Available outside of the UNFCCC to Advance the Issue**

***IMO's Data Collection System***

IMO continues to consider further technical and operational measures to enhance the energy efficiency of ships. The complexity of optimizing the energy efficiency of existing ships requires that any future action is taken following the analysis of robust data.

IMO is therefore focusing on the development of a data collection system for ships and agreed that it should follow a three step approach: data collection, data analysis, followed by decision-making on what further measures, if any, are required. MEPC 68 (May 2015) also noted that one purpose of the data collection system was to analyze energy efficiency and that for this analysis to be effective some transport work data needs to be included. Therefore, work at MEPC 68 primarily focused on the development of the full language for a data collection system for fuel consumption, which can be readily used for voluntary or mandatory application of the system, and consideration was given to transport work and/or other proxies for inclusion in such a system.

***Contribution of the Shipping Sector***

This year is a crucial year in the IMO's efforts to address emissions from international shipping. The agreement reached in the IMO in April on a mandatory global data collection system on shipping emissions (the actual collection starting in 2019) is an important milestone. Having said that, based on earlier discussions in MEPC, it is clear that data collection on its own is not enough and further measures are needed.

The discussions started in the IMO in April on the contribution of the sector to the international efforts to address greenhouse gas emissions will continue in MEPC 70 (Marine Environment Protection Committee) in October. A working group should be set in MEPC 70 for the start of a process to define the contribution of the sector to the international emission reduction efforts and for adoption of a workplan and timetable for this process.[103]

***IMO's Technical Cooperation Program***

In order to support countries which lack the requisite resources, experience or skills to implement IMO treaties, the Organization has developed an Integrated Technical Co-operation Programme (ITCP) which is designed to assist Governments by helping them build the necessary capacity. Through technical co-operation and capacity building activities, IMO helps to transfer know-how to those countries that need it, thereby promoting wider and more effective implementation of IMO measures.

Chapter 4 to MARPOL Annex VI on Regulations on energy efficiency for ships recognized this need with a specific regulation on "Promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships". This regulation requires the relevant national Administrations, in co-operation with IMO and other international bodies, to promote and provide support to States, especially developing States, that request technical assistance. The regulation also requires the Administration of a Party to co-operate actively with other Parties, subject to its national laws, regulations and policies, to promote the development and transfer of technology and exchange of information to States, which request technical assistance, particularly developing States, in respect of the implementation of measures to fulfill the requirements of Chapter 4.

Further to this, in May 2013, IMO's Marine Environment Protection Committee (MEPC) adopted resolution MEPC.229(65) on "Promotion of Technical Co-operation and Transfer of Technology relating to the Improvement of Energy Efficiency of Ships" which, among other things, requests the Organization, through its various programmes, to provide technical assistance to Member States to enable cooperation in the transfer of energy-efficiency technologies to developing countries in particular; and further assist in the sourcing of funding for capacity building and support to States, in particular developing States, which have requested technology transfer. Examples include the cooperation agreement between KOICA and IMO on "Building Capacities in East Asia countries to address Greenhouse Gas Emissions from Ships" and the recently initiated UNDP-GEF-IMO Global Maritime Energy Efficiency Partnerships (Glo-MEEP) project.

In accordance with this resolution, MEPC 66 (April 2014) established the Ad Hoc Expert Working Group on Facilitation of Transfer of Technology for Ships (TT-EG) which reported to MEPC 69 on the following activities: 1) assess the potential implications and impacts of the implementation of the energy efficiency regulations in chapter 4 of MARPOL Annex VI, in particular on developing States, as a means to identify their technology transfer and financial needs; 2) identify and create an inventory of energy efficiency technologies for ships; 3) identify barriers to transfer of technology, in particular to developing States, including associated costs, and possible sources of funding; and 4) make recommendations, including the development of a model agreement enabling the transfer of financial and technological resources and capacity building between Parties, for the implementation of the energy efficiency regulations.

**2.3 Sustainably develop ocean-based renewable energy (such as offshore wind power, wave energy, tidal power, and aquatic biofuels); and accelerate efforts to implement these approaches through integrated marine planning and enhanced regulatory frameworks**

**Current Status of the Issue**

The pressing need to develop renewable sources of energy has intersected with the trend for ocean industrialization, driving interest in marine renewable energy (MRE) technologies. MRE is a term encompassing all of the renewable energy resources found in the oceans, including offshore wind and ocean energy technologies. Offshore wind is an extension of onshore wind technologies to the marine environment, while ocean energy technologies use the waves, tides, currents, heat or salinity of the ocean to generate electricity.[104] While offshore wind technology has standardized, ocean energy currently encompasses a wide range of technologies, with the current frontrunners being tidal stream and wave energy.

### *Offshore Wind*

Over 90% of the world's offshore wind power is installed in northern Europe, with much of the remaining capacity installed in two demonstration projects off China's east coast.[105] Capacity is expected to reach 75 GW worldwide by 2020, with significant additions in China and the United States.[106]

## Ocean Energy

### *Tidal*

There are two main approaches to tidal energy conversion: tidal barrages and tidal stream (hydrokinetic) technologies. A tidal barrage is a dam-like structure used to capture the potential energy created by the difference in sea level between high and low tides, while tidal stream technologies seek to exploit the kinetic energy from flow of tidal currents. The former are large-scale engineering projects more akin to traditional hydropower projects, while the latter will involve deployment of arrays of individual turbines.

The Rance Tidal Power Station in France (240MW)[107] and Sihwa Lake Tidal Power Station in South Korea (254MW)[108] account for almost all of installed capacity of tidal power, while a further 1,320MW installation is under construction in South Korea.[109] A lack of suitable locations and the intensive nature of such projects limit their future potential. Most tidal stream deployments have taken place at designated test centers, with no commercial projects currently operational. Many projects are under development, especially in the UK's where the Crown Estate has leased seabed with a potential capacity of almost 1.5GW.[110]

### *Wave*

Wave Energy Converters (WECs) transform energy from the kinetic and potential energy of ocean surface waves. Extraction of wave energy at useful scales and costs has proven challenging and it is only recently that developers have started to produce full-scale prototypes. Similar to tidal stream, the most wave energy deployments have been prototype devices deployed at designated test centers.

### *Thermal and Geothermal*

The natural temperature gradient that exists between the depths of the ocean and surface has to potential to be harnessed for power generation.[111] The process, frequently called ocean thermal energy conversion (OTEC), works best in tropical coastal areas and OTEC plants have existed since the 1930s.[112] These plants are not very widespread yet, but OTEC researchers believe that once the initial investment required to build a plant becomes cost-competitive, OTEC can be deployed with very few negative environmental impacts across hundreds of sites in the tropics.[113]

## Challenges

### *Technical*

Ensuring reliability and survivability is difficult in the harsh marine environment, and devices face high impacts from the energy sources they seek to exploit. Offshore wind has largely overcome its most pressing technical difficulties. Today the major challenge is to reduce costs as a move to deeper waters further offshore, with challenging bottom conditions and higher waves, has driven costs up faster than improvements in technology have reduced them.[114] Ocean energy still faces considerable hurdles. Optimism by device developers and pressure on the industry to attract the attention of policymakers and investors has caused overstatement of technology readiness, while challenging economic circumstances in leading European countries has led to reduced risk appetite amongst investors.[115] To date there is limited experience with arrays of ocean energy devices, raising questions as to how commercial-scale projects will function in practice.

### *Environmental*

The environmental interactions of offshore wind are now quite well understood,[116] and a range of potential environmental interactions of ocean energy devices has been identified.[117] Nonetheless, considerable knowledge gaps and uncertainties remain as the size of deployments grows. There are also likely to be some positive environmental interactions, though these are not yet well understood. For example MRE devices may act as fish-aggregation devices, arti-ficial reefs, or *de facto* marine-protected areas.[118] Detailed resource mapping is typically not available for MRE resources, restricting efforts to identify and develop projects.[119]

***Regulatory and Legal***

Regulatory processes have not been adapted to better support emerging MRE technologies. Environmental Impact Assessment (EIA) frameworks are not standardized[120] and MRE has attracted a much higher level of scrutiny from regulators than established marine industries.[121] Consenting processes for MRE projects have also proven problematic: considerable regulatory uncertainty remains in many jurisdictions and information regarding the relevant process is often very difficult to obtain.[122] The problematic elements of the consenting process include: the number of authorities involved and communication between them; lack of a consenting process tailored to the needs of ocean energy; integration of offshore and ancillary onshore structures; and the time taken to obtain consents.[123]

**Strategic Goals and Actions to Address the Issues**

***Resource-Mapping***

Policy makers should consider supporting resource-mapping exercises in order to understand the nature of MRE resources and which technologies are appropriate. Understanding the resource enables basic cost of energy modeling, sensitive siting of devices, and longer-term infrastructural planning and development.

***Funding***

Long-term revenue support should be given to offshore wind to encourage growth in the industry. For ocean energy, given the high technical risk and substantial capital requirements of prototype deployment and the development of the first arrays, funding is needed to support R&D activities. Initially funding should be in the form of capital grant funding for research and demonstration, while longer-term revenue support is needed as commercial deployment takes place.

***Integrated Marine Spatial Planning***

There is an established need, and a desire, for a plan-led and integrated approach, and Marine Spatial Planning (MSP) has emerged as the frontrunner concept for meeting this need.[124] MSP is intended to help reconcile potential conflicts between different uses of ocean space, while achieving sustainability. In doing so, MSP has the potential to ensure that MRE technologies are sustainably developed and integrated into a strategic plan for rational use of the marine environment.

***Enhanced Regulatory Frameworks***

Consenting processes must be adaptive and risk-based, and should reflect the scale of development and the level of risk posed. In particular this involves allowing for more permissive procedures for small scale, time-limited deployments in areas of low environmental sensitivity. Options include adaptive management and the "deploy and monitor" approach,[125] while Strategic Environmental Assessment could help identify the scope of potential impacts and information needs.[126] Countries should also transition towards integration of the various competent regulatory bodies in consenting processes.[127]

***Test Centers***

The European Marine Energy Centre (EMEC) has been at the center of technology development, while newer test centers in North America and Asia are starting to provide benefits. Demonstration at test centers can help to address many of the innovation needs of ocean energy technologies and so should be supported where possible.

***Sharing of Good Practices and Lessons Learnt***

Technology development can be accelerated by ensuring that best practice is shared on a global, regional and national level.[128] Policy makers can assist by joining and promoting relevant organizations and processes:[129]

- Globally: participate in the International Energy Agency's (IEA) Ocean Energy Systems (OES) programme.
- Regionally: participate in regional bodies such as the European Ocean Energy Association and the South East Asian collaboration for Ocean Renewable Energy
- Nationally: ensure that funding is contingent upon recipients meeting specified knowledge-sharing protocols ensuring that these are carefully framed to protect device developers' intellectual property rights.

**Opportunities and Pathways that May be Available Outside of the UNFCCC to Advance the Issue**

MRE remains a small and emerging industry. As such, it has not been directly addressed within the UNFCCC. The UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea (ICP) dedicated a session to these technologies, noting that MRE technologies:[130]

*"could foster increased energy security, generate employment and play a role in mitigating the impacts of climate change. At the same time, the importance of assessing and studying the impacts of [MRE], including on the marine environment, was stressed by several delegations [to the ICP]."*

Outside of these processes, there may be some useful pathways through which MRE can be advanced at the regional and international levels. As mentioned above, the IEA-OES has been one of the primary drivers of international cooperation, while the International Renewable Energy Agency (IRENA) has recently increased its engagement with MRE, for example by issuing a report on the status of the ocean energy industry.[131] In Europe the EU has invested heavily in offshore wind,[132] and has more recently developed an action plan to support the ocean energy sector, convening an Ocean Energy Forum with potential for the development of a European Industrial Initiative.[133]

### 2.4 Consider the potential for ocean-based carbon capture and storage, and, if appropriate, further develop regulatory systems for ocean-based sequestration and marine engineering

#### Current Status of the Issue

***Summary of $CO_2$ Capture and Storage under the London Protocol***[134]

Carbon Capture and Storage (CCS) is seen as one of the short term technological options for reducing net $CO_2$ emissions to the atmosphere by the Intergovernmental Panel on Climate Change (IPCC) (refer to IPCC Working Group III and 24 Session of the IPCC in Montreal, 26 Sep. 2005).[135] CCS, as well as other geoengineering methods, need to be conducted in a comprehensive regulatory framework, based on a risk assessment and management approach.[136] To that end, work by the Contracting Parties to the London Protocol has established a global regulatory mechanism for both CCS and marine geoengineering activities.

CS-SSGF technologies can reduce emissions to the atmosphere from power plants and factories to almost zero. The possibility of mitigating these impacts through $CO_2$ sequestration in sub-seabed geological formations is being investigated by a number of countries around the world. Within Europe for example, capacity for storing $CO_2$ in geological formations could be around 200 GtC, mostly under the North Sea and mainly in the Norwegian sector and the United Kingdom continental shelf. About 95% of this potential is in deep saline aquifers and about 5% in depleted oil and gas fields. In practical terms, there is significant potential for geological storage in formations beneath the oceans. Depleted oil and gas reservoirs and saline aquifers are expected to have the largest potential to accommodate safe, long-term storage. The aim is to retain $CO_2$ permanently. Because of the various trapping mechanisms, storage may, in some cases, become more secure over time.

Contracting Parties to the London Protocol started their discussions on $CO_2$ sequestration in earnest in 2005, as they were concerned about the implications for the marine environment of climate change and ocean acidification due to elevated concentrations of $CO_2$ in the atmosphere. In their view, $CO_2$ sequestration in sub-seabed geological formations is one of a portfolio of options to reduce the levels of atmospheric $CO_2$ and represents an important interim solution, while every effort should be made to further develop low-carbon forms of energy. The starting point of their discussion was—at that time—that the London Protocol prohibited $CO_2$ sequestration which is viewed as a dumping activity.

Since 2005, the following regulatory framework has been established:

1. Contracting Parties to the London Protocol adopted, on 2 November 2006, amendments to Annex 1[137] to the London Protocol to regulate $CO_2$ sequestration in sub-seabed geological formations. These amendments entered into force on 10 February 2007 for all Parties to the Protocol. The rules state that carbon dioxide streams may only be considered for dumping, if: (1) disposal is into a sub-seabed geological formation; (2) they consist overwhelmingly of carbon dioxide (they may contain incidental associated substances derived from the source material and the capture and sequestration

processes used); and (3) no waste is added for the purpose of its disposal. In other words, these rules do not permit $CO_2$ sequestration in the deep oceans themselves;

2. Contracting Parties to the London Protocol also endorsed, in the 2006 Meeting of Contracting Parties, the "Risk Assessment and Management Framework for $CO_2$ Sequestration in Sub-Seabed Geological Structures." This Framework was developed: (1) to ensure compatibility with Annex 2 to the London Protocol; (2) identify relevant gaps in knowledge; and (3) reach a view on the implications of this practice for the marine environment;

3. As sub-seabed geological sequestration of $CO_2$ is now subject to licensing under the Protocol, Contracting Parties furthermore adopted, on 9 November 2007, "Specific Guidelines for Assessment of Carbon Dioxide Streams for Disposal into Sub-seabed Geological Form-ations." These Guidelines advise Parties on how to capture and sequester $CO_2$ in a manner that meets all the requirements of the Protocol and is safe for the marine environment, over both the short and long terms;

4. A specific $CO_2$ sequestration reporting format was adopted in October 2008, as it is necessary to archive documentation so that future generations would be informed of the existence of the $CO_2$ sequestration reservoirs, as well as its history and the assessment process leading to their establishment. In 2011, a revised reporting format for all classes of wastes was adopted, where the 2008 format was incorporated and expanded;

5. In order to ensure that CS-SSGF translated into the effective, invaluable climate mitigation tool it was intended to be, Contracting Parties adopted, on 30 October 2009, an amendment to Article 6[138] of the London Protocol, conditionally enabling the export of carbon dioxide streams for the purpose of sequestration in sub-seabed geological formations. The amendment will enter into force for those Parties which have accepted it, on the 60th day after two-thirds of the Parties have deposited their instruments of acceptance with IMO; and

6. With a view to better guiding the transboundary issues (transboundary geo-logical formations, transboundary movement after injection, and export for sub-seabed sequestration), the Contracting Parties revised the "Specific Guidelines for Assessment of Carbon Dioxide Streams for Disposal into Sub-seabed Geological Formations" in 2012, and adopted the "Guidance on the implementation of article 6.2 on the export of carbon dioxide streams for disposal in sub-seabed geological formations for the purpose of sequestration," in 2013.

The 2006 and 2009 amendments to the London Protocol have created a legal basis in international environmental law to regulate CS-SSGF for permanent isolation of $CO_2$ waste streams as part of a suite of measures to tackle the challenge of climate change and ocean acidification, including, first and foremost, the need to further develop low carbon forms of energy. This practice would typically apply to large point sources of $CO_2$ emissions, including power plants and cement works. Note that the use of $CO_2$ waste streams for enhanced oil recovery is not regulated by the London Protocol because article 1.4.3 of the Protocol states that "the disposal or storage of wastes or other matter directly arising from, or related to the exploration, exploitation and associated offshore processing of seabed mineral resources is not covered by the provisions of this Protocol".

The guidance developed under the London Protocol advise Parties on how to capture, sequester and export $CO_2$ in a manner that meets requirements of the London Protocol and is safe for the marine environment, both for the short- and long-term.

***Summary of Developments to Regulate Marine Geoengineering under the London Protocol***

In June 2007, the Scientific Groups, established under the London Convention and Protocol, considered several submissions relating to large scale iron fertilization of the oceans to sequester CO2. This practice is aimed at drawing down an additional amount of surplus CO2 from the atmosphere in the oceans for sequestration purposes. In November 2007, the Contracting Parties endorsed the view that the scope of work of the London Convention and Protocol included ocean fertilization, as well as iron fertilization, and that these agreements were competent to address this issue due to their general objective to protect and preserve the marine environment from all sources. Recognizing that it was within the purview of each State to consider proposals on a case-by-case basis in accordance with the London Convention and Protocol, urged States to use the utmost caution when considering proposals for large-scale ocean fertilization operations.

In October 2008 the Contracting Parties developed and adopted the (non-binding) resolution on the regulation of ocean fertilization. By this resolution Parties have declared, inter alia, that, "given the present state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed." In addition, it was agreed to further consider a potential legally binding resolution or an amendment to the London Protocol on ocean fertilization in the future. Furthermore, the governing bodies commenced the preparation of a document, for the information of all Contracting Parties, summarizing the current state of knowledge on ocean fertilization, relevant to assessing impacts on the marine environment, taking into account the work done on this issue in other fora.

In 2010 they adopted resolution LC-LP.2(2010) on the "Assessment Framework for Scientific Research Involving Ocean Fertilization," the development of which was required under the 2008 resolution prohibiting ocean fertilization activities for purposes other than legitimate scientific research. The Assessment Framework guides Parties on how to assess proposals they receive for ocean fertilization research and provides criteria for an initial assessment of such proposals, including detailed steps for completion of an environmental assessment, which encompasses risk management and monitoring.

In 2013, the Contracting Parties to the London Protocol adopted resolution LP.4(8) on the Amendment to the London Protocol to regulate the placement of matter for ocean fertilization and other marine geoengineering activities. The amendment adds a new article 6bis which states that "Contracting Parties shall not allow the placement of matter into the sea from vessels, aircraft, platforms or other man-made structures at sea for marine geoengineering activities listed in Annex 4, unless the listing provides that the activity or the sub-category of an activity may be authorized under a permit."

Here marine geoengineering means "a deliberate intervention in the marine environment to manipulate natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the potential to result in deleterious effects, especially where those effects may be widespread, long lasting or severe."

A new Annex 4 on "Marine geoengineering" lists "Ocean fertilization," defined as "any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans. Ocean fertilization does not include conventional aquaculture, or mariculture, or the creation of artificial reefs. The Annex provides that all ocean fertilization activities other than those referred to above shall not be permitted. An ocean fertilization activity may only be considered for a permit if it is assessed as constituting legitimate scientific research taking into account any specific placement assessment framework.

A new Annex 5 adds the Assessment Framework for matter that may be considered for placement under Annex 4. The Assessment framework provides that Contracting Parties should consider any advice on proposals for activities listed from independent international experts or an independent international advisory group of experts. To date, no Parties have accepted the amendment.

GESAMP A Working Group under GESAMP[139] has been established on Marine Geoengineering, which aims to assist LP Parties to identify those marine geoengineering techniques that they may wish to consider for listing in the new annex 4 of the Protocol. The working group will conduct a study aimed at providing a better understanding of the potential ecological and social impacts of different marine geoengineering approaches. The working group, led by IMO, gained the support of the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the World Meteorological Organization (WMO).

Recent developments and related information can also be obtained at the London Protocol website: http://londonprotocol.imo.org .

## Current State of Play of the Issue Within the UNFCCC

UNFCCC has recognized the value of CCS in SBSTA as part of the Clean Development Mechanism (CDM) and a resolution has been adopted to this effect. It is envisaged that further discussion will take place to encourage the use of CCS (terrestrial or sub-sea) at a future date. In order to meet the targets for the agreed temperature ceiling, CCS will need to be accelerated in the short term.

As far as we are aware, issues surrounding marine geoengineering has not been addressed by UNFCCC. IPCC has identified a range of possible marine geoengineering mechanisms.

## Opportunities and Pathways that May be Available Outside of the UNFCCC to Advance the Issue

To increase the use of CCS, the remaining transboundary amendment must be come into force. The export amendment adopted in 2009 to allow export of $CO_2$ for geological storage requires two thirds of Parties to ratify before it comes into force. This currently means 29 countries need to ratify it. To date just three have done so (Norway, the Netherlands and the United Kingdom).