Water and Environment

Assessment of the role of coastal and marine ecosystems for carbon sequestration in a high CO_2 World

Rationale: Recent reports produced by the United Nations Environment Programme (UNEP) and International Union for Conservation of Nature (IUCN) have proposed that mangrove forests, saltwater marshlands and seagrass meadows are extremely effective at storing atmospheric carbon and mitigating climate change. These reports are titled 'Blue Carbon' and 'The Management of Natural Coastal Carbon Sinks,' respectively. However further investigations are required to more accurately determine their capabilities to sequester carbon. Nuclear technologies can play a very important role in the more accurate determination of carbon budgets for species of marine plants that are representative of mangrove forests, saltwater marshlands and seagrass meadows, under high CO_2 world scenarios.

Project Description: The objective of this project is to use radio-isotopic and stable isotopic techniques to accurately determine carbon budgets for representative species of marine plants and their coastal and marine ecosystems. Field and laboratory-based studies employing nuclear and related techniques would be used to give measurements of the parameters needed in the quantitative modelling of carbon kinetics and sinks associated with these marine ecosystems. The effects of ocean acidification and projected increases in sea temperatures would also be determined under simulated experimental conditions in relevant developing Member States through the mechanism of the TC programme, with support from the IAEA's Radioecology Laboratory.

Planned Activities

A. Developmental phase

Study the sources, pathways and transformation processes of the organic carbon in coastal areas by using stable isotopes and molecular biomarkers.

B. Application phase

Considering the transboundary nature of climate change, the methodologies and field investigations can be implemented through an inter-regional technical cooperation programme to be developed by the Secretariat as follows:

1. In collaboration with Member States, obtain measurements to determine carbon fluxes and variability from surface ocean waters, by using radionuclides, sediment traps and remote sensing techniques
2. In collaboration with Member States, develop, transfer and use new methods combining stable isotope labelling studies with biomarker analyses to investigate carbon cycling and trophic interactions in the oceans.

Project Outcomes/Outputs:

1. Reports on:

   a) the role of key coastal marine systems in the sequestration of atmospheric carbon in a high CO_2 world; and

   b) the applications of nuclear and isotopic techniques to estimate carbon kinetics and sequestration in key species under field and laboratory conditions.

Estimated budget per year: US $160 500 per year for three years

Total estimated budget: US $481 500

2) Ocean Acidification International Coordination

Rationale: Ocean Acidification (OA), the change in seawater chemistry resulting from the uptake of anthropogenic carbon dioxide (CO_2), is a key issue of global concern. As the CO_2 uptake continues into the future, further changes in ocean chemistry will occur, raising increasing concern for marine organisms, ecosystems and resources, and driving policy issues. Together with partners from the scientific, economic and development arenas, the IAEA contributes to advancing research and proposing solutions for adapting to or mitigating the impact of climate change. The IAEA has pioneered research on key indicators of OA, for which radiotracer techniques provide a unique tool. The world-class experimental radioecology facilities in Monaco allowed creating perfectly controlled conditions to study calcification rates of marine organisms using radiotracers. Thus for three years now, the IAEA has been working in collaboration with organizations from Monaco, France and the US, on key scientific and, further on, socio-economic aspects of OA. Discussions within the IAEA, as well as proposals stemming from several other institutes and organizations indicate the need of an international coordinating centre. Levering the greatest value out of national

research programme investments, and enabling coordinated international effort is now the key priority of the OA community worldwide.

Project Description: The IAEA will establish an OA International Coordinating Centre (OA-ICC) in Monaco for the duration of the project. The mandate of the ICC is to coordinate and deliver the key overarching activities across programmes at an international level, to generate a comprehensive understanding of the global effects of ocean acidification as quickly as possible levering value from existing research, and to achieve timely integration of such information with policy advice and action. Such coordination will facilitate sharing of know-how, equipment, and joint experiments while avoiding excessive redundancy.

The ICC will support a comprehensive approach for addressing OA emphasizing the sustainable development of water, energy and fisheries/seafood resources; and involving scientific research, economic valuation, training to reinforce knowledge in developing countries, and fellowships. The Office could function with a core staff of 3 full-time positions: one full-time unit head (P-4), one part-time (50%) team support staff (G-5), one full-time data manager (G-5) and one part-time (50%) web and blog master. A scientist well recognized in the field of OA research would be part-time (20%) seconded by his/her organization. The IAEA will provide the infrastructure through its Environment Laboratories in Monaco. Fellows, or additional experts supported by other funding sources, could be seconded to the OA-ICC as needed.

An Advisory Board would oversee the programme of the OA-ICC. This Board would include leading scientists, such as representative from the SOLAS/IMBER Ocean Acidification Working Group, and economists. An Executive Board would include representatives from the IAEA, Monaco, US, IOC/UNESCO etc.

The location of the OA-ICC at the IAEA in Monaco is a sustainable solution, given the commitment to climate-related programmes of the IAEA and that of Monaco, through actions and statements of SAS Prince Albert II, activities of the Prince Albert II Foundation and support of the Monegasque Government. This commitment is illustrated by recent international workshops and symposia, which were organized also with US support. The Prince Albert II Foundation has already supported a fellow working at the IAEA on OA. Through its US Office, the Foundation will support a follow-up of the 2010 Monaco workshop on OA/economic valuation, which could be hosted in the Scripps Institute of Oceanography in San Diego in 2011-2012.

A sustained scientific collaboration with leading Monegasque and French OA research groups, which actively involves senior and young scientists meeting regularly in seminars and workshops, has developed during the past 3 years. This group is also a valuable resource for the proposed OA-ICC.

Planned Activities

The core work would consist of a defined package of focused international activities which are not currently funded at national or international levels. These include (1) international coordination of research activities (ten actions) and (2) international dissemination activities (two actions). The activities will be coordinated through the OA-ICC.

1. International coordination of scientific activities

1.1. Observation network

In order to understand ocean acidification in open-ocean and coastal environments and its impacts on marine ecosystems, a coordinated multidisciplinary approach to observations and modeling is needed.

1. Joint platforms and facilities

Effective international research on ocean acidification requires common access to joint research platforms and large-scale facilities.

2. The socio-economic impact: collaboration between natural and social sciences

In order to understand the future global impacts of future ocean acidification on human society, to mitigate further ocean acidification, and to develop potential adaptation strategies, social science in general and economic research in particular must become an integral part of an overall international ocean acidification research agenda.

1.4. Exchange of students and postdocs

A key element of levering greatest value out of on-going research is effective capacity building, knowledge exchange and the use of best research practices amongst Member States through exchange of students and postdocs.

1.5. Intercomparison exercises

A thorough intercomparison of key measurements and indexes of ocean acidification and its impacts is essential to build a globally sound data set. The participation of IAEA Member States shall be organized through the TC programme.

1.6. Joint ocean acidification experiments

Progress in understanding ecosystem-level effects of ocean acidification will benefit greatly from an international task force approach that integrates disciplinary studies in joint experiments focusing on key fisheries or ecosystems. The IAEA, through its experimental radioecology facilities in Monaco, will be a focal point for radiotracer studies of ecosystem impacts of OA and will serve as a training platform.

1.7. Best practices in ocean acidification research and data reporting

It is important to develop, test and adopt internationally agreed, tested and standardized protocols for observational and experimental approaches, carbonate chemistry manipulations and measurements, and data reporting. Once the protocols are developed, these can be provided to MS via an interregional technical cooperation that will allow measurements and comprehensive data evaluation on a global scale.

1.8. Development of an on-line bibliographic database

1.9. Initiating the development of guiding principles for international management of ocean acidification data

Data have to be shared in an organized way and in a timely fashion and stored using internationally agreed common data formats.

1.10. Capacity building

Courses will be organized through the interreginal cooperation in various regions in response to the need for students and researchers to have skills that enable them to successfully address issues associated with the inter- and multidisciplinary field of ocean acidification.

2. International dissemination activities

2.1. International Ocean Acidification Reference User Group (RUG)

Ensuring that the latest information on ocean acidification is communicated to key stakeholders is essential in this rapidly emerging research area. The RUG approach ensures fast and effective dissemination to policy makers, marine managers and the general public. It also ensures a two way exchange of knowledge between the scientists and stakeholders from the beginning of the research projects thus ensuring that the science is policy relevant. All information dissemination products will be produced in at least 5 languages (English, French, Spanish, Arabic and Chinese).

2.2. Dissemination of ocean acidification news

A blog which disseminates information on research news, media products, job offers, and other information related to ocean acidification will be maintained. This blog has proven to be a highly valuable resource, with more than 500 subscribers, in a previous OA project (EPOCA).

Project Outcomes/Outputs:

The project will result in the international coordination needed to scale up, support and enable the understanding of OA. This coordination is made possible by the support received by this proposal from numerous national and international organisations and programmes and reputed scientists.

Outputs: Scientists trained on various themes related to OA through workshops, fellowships, scientific visits and training courses. Upgrade of laboratories through intercomparison exercises, experimental work at sea and in the laboratory. Publications, databases, a website and a blog

Estimated budget per year: US$ 642 000 per year for three years

Total estimated budget: US $1 926 000

Marine and Coastal Environments

3) Applications of Isotopic Measurements for Determination of Long Lived Radionuclides in Marine Environment

Rationale: Nuclear and isotopic techniques are currently providing a unique source of information for identifying long lived radionuclides and tracing their pathways in the environment and, potentially, for investigating their biological effects on organisms. They provide tools to investigate sea resources, oceanographic processes and marine contamination on a quantitative basis and at the same time address the problems of land-coastal zone management. Although other approaches can be used to obtain information about the isotopic composition of elements, mass spectrometric techniques clearly dominate the field of isotopic analysis. These features, in combination with the ability of the inductively coupled plasma source to ionize nearly all elements in the periodic table, have resulted in an increased use of Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) for isotopic measurements in marine sample matrices.

Project Description: This project will use nuclear techniques to study anthropogenic and natural radioisotopes in marine matrices by means of High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICPMS). This project will provide the methodological support to Member States laboratories through a complementary technical cooperation programme and assist them in developing and optimising their measurement strategies. The project has a strong applied component involving method development through the programme in NAEL and training as well as exchange of knowledge between Member States through the complementary TC programme.

This project will apply the latest developments in isotopic sciences to provide rapid, robust and more sensitive methods for determining low levels of toxic elements and long-lived radionuclides in the environment. This project is intended as a skeletal analytical horizontal support to sustain member states' development and implementation of QC/QA system of the results produced by national laboratories.

Planned Activities

1. Development of separation and preconcentration methods for low level long lived radionuclides.

Often long lived radionuclides present at trace levels in sea water and other marine samples cannot be measured directly, and must be separated from a wide range of sample components, and then concentrated.

Several methods for sample preparation, separation and preconcentration of the analytes of interest, based on solid-phase extraction (SPE) with nano size high surface oxides and chelate resins will be investigated. SPE involves generally fewer reagents in smaller amounts, requires smaller size samples (≤ g level) and is potentially faster and less tedious than most other approaches. High resolution mode of ICP-MS measurements will be alternatively used as the way for the validation of developed separation procedures. Studies on isotopic fractionations during the sample preparation process will be also undertaken.

2. Development and validation of analytical methods for long lived radionuclides

Analytical methods based on Isotope Dilution ICP-MS applied as a primary method of measurement will improve our knowledge for the level of long-lived radionuclides in the marine environment.

3. Development of methods for isotopic ratios analysis

Accurate analytical methods based on the solid metrological concepts (uncertainty, traceability and validation) would represent an important step in identification and enhancing our understanding of the pollution sources in the marine environment.

Outcomes/Outputs

1. Analytical methods based on isotopic measurements with High Resolution Sector Field ICP-MS technique for low level long lived radionuclides in samples of different origin (seawater, sediment and biota) These methods shall be transferred to MS through training programmes.Where appropriate regional laboratories shall be set up to facilitate the transfer of technologies and applications of the methods to field problems.
2. Methods for precise isotope ratio measurements, this can be used for source identification of artificial and natural isotopes in marine environment
3. Metrological concepts in the data interpretation in order to get traceable results
4. An analytical methodology to provide the basis for a general assessment of the level of pollution, pollution sources and inputs in the marine-land-coastal environment
5. The project has a strong applied component which could be also used for safety assessment of all sea resources – seawater, sediment, biota and sea foods.
6. Transfer knowledge transfer to Member States for effective coastal zone management.

Estimated budget per year: US $128 400

Total estimated budget: US $128 400

---

4) Implementation of a comprehensive sampling and analytical methodology to verify mid-ocean ballast water exchange (BWE) and investigate Ballast Water provenience.

Rationale: The introduction of invasive marine species into new environments by ships' ballast water attached to ships' hulls and via other vectors has been identified as one of the four greatest threats to the world's oceans. The other three are land-based sources of marine pollution, overexploitation of living marine resources and physical alteration/destruction of marine habitat. Shipping moves over 80% of the world's commodities and transfers approximately 3-5 billion tonnes of ballast water internationally each year. A similar volume may also be transferred domestically within countries and regions each year. Ballast water is absolutely essential to the safe and efficient operation of modern shipping, providing balance and stability to un-laden ships. However, it may also pose a serious ecological, economic and health threat. This has been phased by the initiation from the IMO and the member states to introduce the Ballast Water Management Convention to enter into force in the near future.

Currently, ballast water exchange is the only effective management tool to reduce the risk of ballast-mediated biological invasion. However, numerous ballast water treatment systems have been proposed to treat the ballast water by means of active substances, mechanical removal of organisms and other tools and approved ballast water management systems are already available. These systems have to receive approval from the GESAMP Expert group. For the time being, ballast water exchange involves replacing coastal water with open-ocean water during a voyage. This process reduces the density of coastal organisms in ballast tanks that may be able to invade a remote recipient port, replacing them with oceanic organisms with a lower probability of survival in nearshore waters. Ballast water exchange is a recommended measure by the International Maritime Organization (IMO) until the stricter Ballast Water Performance Standard as set forth in Regulation D-2 of the Convention applies.

Direct measurement of naturally or artificial occurring tracers in the ballast water offers a potentially powerful approach to BWE verification to deduce and verify, whether the tank was ballasted in a coastal or oceanic location. There are two prerequisites for this approach to succeed: first, there is a measurable and consistent difference or pattern between tracer levels in ballast water of coastal versus oceanic origin; and second, the implementation of BWE according to the specified guidelines will ensure a predictable water quality outcome. This

approach is both quantitative and flexible, since it allows us to set criteria for compliance according to biologically meaningful objectives.

Project Description: This project is aimed to implement and develop reliable and rapid sampling and analytical methodologies for measuring stable and radioactive isotopes as a typical pattern of coastal and ocean waters. One example could be radium (Ra) isotopes in ballast waters. Other radionuclides could be long-lived artificial radionuclides present in coastal areas, where discharges from nuclear reprocessing plants or past contamination from Chernobyl derived isotopes are detectable. Stable isotope pattern or typical organic micro-pollutants might also contribute to identify specific sea areas, where ballast water was first taken and subsequently exchanged. To verify mid-ocean ballast water exchange, it is essential to measure concentrations of naturally or artificial occurring chemical tracers. One example can be ^{223}Ra in the open ocean, which is is extremely low; ^{223}Ra is presumed to be virtually zero in both the Atlantic and the Pacific Oceans. Concentrations and ratios of a short-lived isotope of radium (^{223}Ra) and two long-lived isotopes (^{226}Ra, ^{228}Ra) can be used to verify ballast water exchange. Higher levels of ^{210}Pb in coastal areas compared to typical ocean water can also give an indication of ballast water exchange. Other examples could be the artificial radionuclides ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs and tritium, being present in the area of the European Seas as a consequence of the reprocessing plants Sellafield or La Hague, or the fallout from Chernobyl in the Baltic Sea and Black Sea. Tritium is enriched in coastal areas influenced by the global water cycle, but has low concentrations in mid-ocean waters.

Planned Activities

1. Develop rapid, selective and reproducible sampling methodologies of long-lived Ra isotopes in the ballast water. Co-precipitation, adsorption on nano-size TiO2 and Mn-fiber, cation exchange resins and solid phase extraction will be tested in the laboratory
2. Develop highly sensitive analytical methods of Ra and other isotopes reflecting typical coastal origin
3. Analyse ballast water samples collected with the support of MS together with coastal and mid-ocean water on tritium and other radionuclides as indicators of typical water masses
4. Test sampling methods in the field with the participating of MS. The sampling methods will be tested in the Atlantic and the Pacific Oceans on board
5. To search for typical pattern of stable isotopes and nuclides in coastal and mid-ocean waters to identify water masses in both, ballast water in ships and during the voyage

Outcomes/Outputs

1. Manuals of sampling and analytical methods will be published. These methods will be transferred to the Member States through trainings and fellowships via the Technical cooperation programme.

Estimated budget per year: US $214 000 per year for two years

Total estimated budget: US $428 000

5) CRP on assessing the impact of the 11 March earthquake and tsunami on the behaviour of radionuclides in the marine and coastal environment affected

The marine environment around the sea area affected by the tsunami on the 11 March has changed considerably in terms of dominate geochemical processes, food and nursery for fish population's current systems. The terrestrial soil deposited in the marine environment will change the marine geochemistry of elements, increasing the nutrient load, changing the dissolved oxygen levels, affecting the chemical speciation of the radionuclides that will have different distribution constants and transfer factors than radionuclides in the marine environment not affected by soil intrusion.

The CRP will be focused on the determination of the radiological parameters used in radiological investigations and will result in a better understanding of radionuclides mobility in the marine ecosystem and transfer into the marine food web in areas affected by tsunamis. It will last over four years and will be in collaboration with experts from Japan and other Pacific/Indian Ocean countries and NAFA division. Field missions might also be organised if needed.

Estimated budget per year: US $112 350 per year for four years

Total estimated budget: US $449 400

6) CRP on Benchmarking models for the ocean dispersion and transfer of radionuclide releases from Fukushima NPP

Following the nuclear accident in March 2011 at the Fukushima NPP, radionuclides were released into the environment, part of these into the ocean. Immediately after the accident, the Japanese authorities started environmental sampling and analyses. Measurements have to be

complemented by model predictions in order to fully assess dispersion and impact of radionuclides on ocean ecosystems, fisheries and human health. A range of circulation and dispersion models were implemented on various space-time scales with different levels of confidence, depending on the availability oceanographic data and model characteristics. Model analysis, sensitivity and uncertainty studies will allow an improved understanding of the model outputs. Model validation and comparison will be carried out based on a number of scenarios. The model predictions will be summarised in a report and in the open literature. Continuous progress in model development requires a co-ordinated effort and exchange of knowledge to improve the reliability of model predictions in the near-field (coastal Fukushima area), regional scale (wider Pacific) and global scale on various time-scales. The Agency will provide support to Member State institutes, assisting them in developing and optimising their models and assessment strategies, through coordination meetings, research contracts and agreements. It is expected that the CRP will run over 4 years and will involve 10-12 participants.

Estimated budget per year: US $112 350 per year for four years

Total estimated budget: US $449 400

7) Development of national hydrology networks for water resources assessment

Rationale: Global freshwater resources are coming under increasing strain due to population increase, agriculture activities and industrial growth. In addition, these valuable resources may be affected by negative climate change effects, and growing needs for energy. The Millennium Development goals seek to halve the proportion of the population without sustainable access to safe drinking water and reverse the loss of environmental resources by 2015, but efforts are falling far short of what is required to meet these objectives in certain areas of the developing world. Many Member States are lacking a comprehensive water resources assessment. Understanding how much water exists and its origin, how sustainable resources are and how vulnerable they are to pollution and climate change is essential in order to make sensible and informed water management choices. This information gap is particularly acute in respect to groundwater resources, which constitute the greatest proportion of the Earth´s available freshwater. Member States require support to identify gaps in hydrological data, clarify the expertise, technology and infrastructure assistance needed to fill such gaps, formulate and implement optimum methodologies for utilizing isotope techniques and develop a collaborative approach with multilateral and bilateral organizations to address assessment gaps.

Some of these issues mentioned above are dealt though the IAEA IWAVE initiative. However one important aspect not fully dealt by IWAVE is the access to the required technical and analytical expertise on long-term basis. A complementary element to the IWAVE initiative is the development and/or strengthening of national hydrological networks of professionals and institutes with a concrete mandate on water resource issues. The development of a long term approach for successfully conducting science-based hydrological assessments requires placing appropriate mechanisms to ensure the required interaction between professional and water institutes in Member States, providing easier access to the best technical expertise and analytical services. This complementary proposal within IWAVE aims at building national networks with the required technical expertise and capability in the use conventional and advanced techniques. These networks are expected to play a key role on long-term basis at national and probably also at regional level when dealing with shared water resources.

Project description: Implementation of this project will contribute to strengthen national capabilities and resources in Member States in which such networks of professionals and institutes are lacking - aiding in the implementation of local assessment projects both at the local and regional levels, using local expertise and local facilities. In this way, such networks would work as an integral part of IWAVE in identifying and filling information gaps. With the pilot testing of IWAVE in 2011-2012 in three countries, the experience can be expanded to the different regions via an interregional technical cooperation that can be developed through a joint initiative of the NA and TC departments.

National hydrology networks for integrated water resources assessment would not only supply the Member States in which they are located with a facility which can offer expertise and services previously required from outside, but can serve as a focal point for regional activities in the area of water resources assessment. The IAEA would support these centres through the transfer of technology and expertise, as well as on-going collaboration, expanding the approach that have been carried out through the technical cooperation programme. This would be accomplished through specialized training courses and workshops as well as the provision of educational materials and learning methods. Local experts would thus be able to provide a framework within which hydrological information gaps can be identified and appropriate measures taken to fill these gaps, in particular in relation to isotope techniques. Having laboratory capabilities in each facility would ensure the quick and affordable analysis of samples, bringing the goal of appropriate water management to countries in a more efficient manner. The IAEA would provide harmonized standard procedures for these

facilities so that information gathered and analysed can be used in national and international data banks.

The project can be developed in the countries where pilot water assessment projects are being implemented as part of the IWAVE initiative.

Estimated budget per year: US $321 000 per year for three years

Total estimated budget: US $963 000

8) CRP on contrasting and comparing radionuclide migration between Chernobyl and Fukushima and the role of seawater flooding

The fate and transport of radionuclides from the Fukushima power plant are important issues to be understood for the assessment of soil, river and groundwater contamination. While we know the behaviour of radionuclides released at Chernobyl (CRP in 1998-2000), the consequences of Fukushima incident are likely to be much different because of seawater flooding of the immediate area. Saline water in the soil may lead to a more rapid migration of radionuclides within and through the soil zone, impacting groundwater in the vicinity of the plant. This contaminated groundwater also may have the potential for migration into areas/aquifers used for drinking purposes. Member States both in the Asia-Pacific region and beyond may benefit from the experience in Japan for better protecting their water resources. Results will also be useful for adapting to climate change impacts in coastal areas.

Estimated budget per year: US $214 000 per year for three years
Total estimated budget: US $642 000