MEETING REPORT

Scoping Workshop

Ocean Carbon Capacities: Identifying priorities for collaborative action

21-22 October 2021

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JPI Oceans - Opportunities for Ocean Carbon Research Alignments

The main goals of the Scoping Workshop had been (1) to set the scene and present perspectives and opportunities for collaborations with ongoing initiatives, (2) the presentation of areas (prepared by JPI Oceans Expert Group) where action is urgently needed, and (3) an open discussion, exchange, and feedback from participating countries and partners for collaboration on the action plan for this proposed Joint Action.

Joachim Harms (Project Management Jülich, Germany) welcomed the participants and shortly reminded the audience that this topic is important, very timely, and of high scientific as well as political relevance. We need to improve our information products, observing systems and the knowledge base for decision-making.

From the JPI Oceans perspective we are looking for (1) relevant, exciting, scientific questions, (2) clear, achievable, and scalable plans and activities, and (3) broad authorship and participation from JPI Oceans member countries and partners.

Currently, 12 JPI Oceans member countries are participating in the proposed Joint Action. These countries nominated several experts with different areas of expertise so that two main tracks are in the focus: geographical and thematical scope.

Richard Sanders (NORCE, Norway) explained again the importance of the ocean as carbon sink and that there are still uncertainties in the size of surface fluxes and a lot of data is needed to define the spatially and temporally uptake and release.

In addition, we do not know what will happen when we reach net zero. The best estimates are highly variable and it is crucial to have a good observing system in place when we reach this point since past performance will become a poor guide to future behaviour. To get information about the ocean carbon sink in near real time across the ocean there is a need for clarification how the systems operate and what will happen to key pH sensitive components of the system.

Better knowledge on the ocean carbon sink will be valuable for looking at the economic benefits. It defers and reduces mitigation and adaptation costs. For example, Jun et al. (2020) suggest that the discounted net economic benefit of a putative 20-year scientific research program to narrow the range of uncertainty around the amount of carbon sequestered in the ocean is on the order of $0.5 trillion (USD).

Richard closed by mentioning the many initiatives and actors working in this field with slightly different foci in e.g. scale, mechanisms, and impacts. The JPI Oceans expert team developed ideas for action looking at these ongoing activities but focussing on

- What are the priorities?
- Where is action needed?
- What is the role of JPI?

Setting the Scene

Perspectives of the Global Ocean Observing System

Anya Waite (OFI, Canada) referred to the ocean as the most important global storage depot of carbon on Earth. It holds 50 times more carbon than the atmosphere soaking up more emissions than all the world's rainforests combined. However, the ocean is missing and this gap represents potentially the most significant miscalculation of climate policy by the numbers. Incomplete and insufficient data harms the credibility of climate targets, including global net-zero aspirations. It is still a challenge to link to policy makers and making our big ideas understood.

For example, climate calculations urgently need a focused carbon observation effort in the North Atlantic. Such an exemplar would allow decision makers to benefit from near real time assessment of how the ocean is changing the global carbon budget. Data produced will also create the scientific baseline to measure the effectiveness of innovative technologies including Carbon Dioxide Removal (CDR). For governments and financial institutions, it is essential that investments are focused in the best place to ensure climate targets are met.

The scientific community has identified a critical gap in climate target calculations - the ocean's uptake of carbon has not been taken into consideration. This risks the credibility of national net-zero ambitions and jeopardizes major international efforts to reach global climate targets. We need to be ambitious and change this. A start can be made by looking at the North Atlantic Ocean and establishing a Carbon Observatory.

G7 Future of the Seas and Oceans Initiative - A Surface Ocean CO_2 Monitoring Strategy

Maria Hood (EU Office of the G7 FSOI Coordination Centre) explained that the Surface Ocean CO_2 Monitoring Strategy is an activity being developed through the IOCCP (e.g., the GOOS biogeochemistry panel). For the IOCCP, this activity is being led by Richard Sanders which is giving us strong links to the JPI Oceans carbon community.

This project is focusing on developing an internationally-agreed strategy and implementation plan for a surface CO_2 monitoring network. The idea for this came from discussions with several G7 national focal points who said they would like to fund surface CO_2 programmes but currently have no way of knowing if a particular proposal represents a contribution to the global network. The goal for this project is for us to establish this recognized global network to provide information to G7 governments (and others) that they need to make funding decisions.

The focus is on the 'how to' of the strategy for monitoring surface CO_2. It will not cover ocean interior carbon (but will be a complementary piece of the puzzle) and will not repeat the background science or justification sections of recent ocean carbon plans like the IOC-R.

This project in many ways represents 'low-hanging fruit' because many of the elements already exist. The strategy will build on existing observing requirements for surface CO_2 already developed through GOOS and GCOS, and updated for some aspects through SOCONET and OASIS. It will focus on how to

develop an integrated multi-platform strategy that combines optimal use of networks and platforms including underway systems and moorings as well as making best use of BGC Argo, GO-SHIP, and combining the in-situ data with satellite data and modelling capability.

And the strategy will build on existing foundations to establish the network and the International Mission Team (following the model used by the BGC Argo community)

- We already have the IOCCP to link to GOOS, GCOS, the GCP, and the wider ocean CO_2 observing community,
- we have SOCONET focused on reference networks for air-sea fluxes of CO_2 from multiple platforms (along with OASIS), and
- we have SOCAT as a long-standing pseudo-operational data centre.

What is missing is pulling all of these elements together into an implementation plan and establishing an International Mission Team to oversee it.

The end-game of this exercise at the end of 2 years is to have:

- an international mission team for the surface CO_2 network,
- a full-time coordinator as part of the OceanOPS Centre (located at IOCCP), and
- funding to support and operationalize the data centre / SOCAT management (staff + operating costs).

The next step of this activity is to develop an initial drafting team for the strategy and implementation plan (lead for IOCCP is Richard Sanders), and we will have a 1st planning meeting for this at the IOCCP SSG meeting at the end of November. In the 1st half of 2022, we will host an international workshop to get full community input into this process. We look forward to working with the JPI-Oceans community on this.

Perspectives of the International Ocean Carbon Coordination Project (IOCCP)

Richard Sanders explained that IOCCP Is the Expert Panel for Biogeochemistry for GOOS and promotes the development of scientific programmes and a global network of ocean carbon observations in the fields of ocean acidification, hydrography, and underway pCO_2. In addition, it supports and coordinates synthesis activities, data products, standards and methods, instruments and sensors. It is co-sponsored by the Intergovernmental Oceanographic Commission (IOC) and the Scientific Committee on Oceanic Research (SCOR). In the G7 FSOI, IOCCP is leading the activity on 'Surface Ocean CO_2'.

The ideas below can be seen as activities linking up to the thematical scope 'Infrastructure Sharing/Observing System Design' of this proposed Joint Action.

- The G7 FSOI 'Surface Ocean CO_2' Task Team was established in summer 2021 and aims to 'produce a surface pCO_2 monitoring strategy' that is internationally accepted so that individual countries can pick up key elements. This strategy shall focus on the Ocean Carbon Value Chain

and can be only as strong as its weakest link. Since many observing elements are largely depend/based on research funding some links frighteningly weak.

    - Small scale investments include the support of JPI Oceans' participation in the G7 FSOI Surface Ocean CO_2 task team and task team activity more broadly. This would include the support of meetings for exchange within networks of GOA-ON, ICOS and Ferrybox in Europe and links to Non-European networks in Pacific, Arctic and Southern Ocean.

- One main challenge by looking at standards and methods is the lack of standardization labs. Most Deep Ocean CO_2 observations and coastal Ocean Acidification observations are referenced to standards coming out of one lab in the United States of America (US). The lead Investigator is close to retirement. Thus, JPI Ocean could support the establishment of an European Standard laboratory. For example, Europe already contains a laboratory making gas standards for atmospheric and oceanic observations. A seawater chemistry laboratory would be a very natural complement.
    - Medium scale investments include the building/establishment of an ocean CO_2 reference material laboratory and stabilizing the value chain approach by prioritising missing observations, possibly via the regional studies that will be proposed for the geographical scope of the Joint Action.
- A large scale investment can support transitional costs to create an operational system and research as required. For example, via an international, co-branded Ocean Decade, G7 FSOI, and GOOS activity/project.

Integrated Ocean Carbon Research (IOCR) Report

Rik Wanninkhof (NOAA, US) presented the main recommendations and results from the IOCR-Report, which is an effort by international science programs and [ocean] carbon scientists focusing on ocean carbon research needed in the next decade. The process was led by the Intergovernmental Oceanographic Commission (IOC) of UNESCO to address climate and ocean health implications of the changing ocean carbon cycle in support of the United Nations Decade of Ocean Science for Sustainable Development.

Four overarching questions are addressing this in more detail:

1. Will the ocean uptake of anthropogenic CO_2 continue as an abiotic process?
    - The ocean takes up 25 % of the anthropogenic CO_2; we would be "lost without it" [or at least a bit warmer].
    - For answering this questions we need to build on sustained ocean observations and new technologies and platform to improve our modelling and analysis capacities. In addition, we need integrated research incorporating modelling and analysis.
2. What is the role of biology in the ocean carbon cycle, and how is it changing?
    - This includes e.g. impacts of elevated CO_2 on marine biota through ocean acidification.
    - To tackle the question, we can build on incorporating biological sampling in observing schemes. To do this, we need to improve integrated research on living biota-organic carbon-inorganic carbon interactions.

3. What are the exchanges of carbon between the land-ocean-ice continuum and how are they evolving over time?
    - By getting answers for this question, we will identify the impacts which coastal ecosystems have e.g. as part of the socio-economic value of our Exclusive Economic Zone. In addition, we need to consider that the Arctic ice is melting.
    - What build on integrated coastal and open ocean carbon research including several Arctic initiatives.
    - We need to establish stronger links with other disciplines like fisheries, aquaculture, energy industry.
4. How are humans altering the ocean carbon cycle and resulting feedbacks, including purposeful carbon dioxide removal (CDR)?
    - For answering this question we can build on our increased understanding through observing the natural carbon cycle.
    - We need to understand the natural carbon system in order to understand its perturbation and we need to determine the efficacy and impacts of M-CDR. In addition, we to use all avenues available to increase this understanding including basic research, innovative ideas and careful assessment of the outcomes, process studies, and modelling

Canadian efforts: North Atlantic BioGeoChemical Carbon Pump

Andrew Stewart (Fisheries and Oceans Canada) presented the interest of Canada in pushing forward the idea and implementation process of a North Atlantic Carbon Observatory (NACO).

This activity arose from the G7 2030 Nature Compact that "we will convene scientific and policy experts to discuss the carbon absorption function of the ocean, furthering targeted and effective ocean action" in supporting the UN Decade of Ocean Science for Sustainable Development. The G7 Ocean Decade Navigation Plan will drive developments in transformational ocean science to protect and further our sustainable relationship with the ocean.

Additionally, on World Ocean Day 2021 Hon. Bernadette Jordan, Minister of Fisheries, Oceans and the Canadian Coast Guard, stated: "Where there are gaps in knowledge, we need to continue to take action, to learn more, and to strive for a better tomorrow. Canada would like to convene leading scientific and technical experts in coming months to discuss scaling up knowledge and monitoring of the North Atlantic Biological Carbon Pump." (The Blue Reset: Building resilient and equitable ocean based economies post COVID).

The high-level objectives of the scientific workshop on the North Atlantic BioGeoChemical Ocean Carbon Pump are:

- Advance ministerial commitments.
- Highlight the importance of unique environments in the carbon cycle, using the North Atlantic and its Arctic Gateways as an exemplar.
- Discuss the need to observe these areas and ways by which we could observe them.

This workshop will emphasize the critical importance of understanding ocean carbon as our nations aim for “net zero carbon” and the extent to which we need to account for this key variable in global climate prediction. Canada will convene the workshop with scientific, technical and policy experts from G7 countries and beyond discussing scaling up knowledge and monitoring of the North Atlantic Biogeochemical Carbon Pump. The workshop will most likely take place virtually on December 15 and 16, 2021.

Panel Discussion and Q&A

The panel discussion was moderated by Thorsten Kiefer (JPI Oceans, Belgium) and included questions from the audience.

- Gert Verreet (BE) asked “how well developed is the scientific understanding of critical processes (& uncertainties) that determine CO_2 uptake by the ocean in a downward emission scenarios situation, i.e. what are the areas where major advances in system understanding are needed to improve credibility of policy advice?”
  It was answered that the ocean carbon cycle is complex and we still not understood everything but parts of it. Therefore, we have to trace it from year to year to know what is going on and e.g. advise our policy makers. It is important to identify how much circulation is in the carbon cycle to develop and get better knowledge on what happens when we reach the net zero-emission scenario.
- Toste Tanhua (DE) asked how we can join up best and move our science more to the operational need?
  There was the suggestion to publish an Ocean Carbon Calendar via IOCCP with technical help from the G7 FSOI EU Coordination Centre. This could be a start in having one place where we can list all different activities and join up more easily.
- Anya Waite (CA) pointed to the outcomes of the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate which is referring a lot to Sea Level Rise impacts but not going into detail on the Ocean Carbon uptake which is highly impacted by anthropogenic pressures too.
- Toste Tanhua commented that we know more about the physical ocean carbon pump influences by looking e.g. at fluxes. Thus, scientific questions are much more going in the direction of understanding better the biological ocean carbon pump. We have big carbon fluxes but the net difference is pretty small. We need to identify where to observeto get better results.
  Reiner Steinfeldt (DE) added to this that we need models to decipher the effects of AMOC changes on CO_2 uptake and the Biogeochemical Carbon Pump
  Rik Wanninkhof (US) went even further by saying that our Earth and Carbon system is remarkebly constant because of negative feedbacks. Less transport with AMOC will mean less uptake but there might be more uptake on sea-surface uptake. Issues of thresholds and tipping points are important and with observations we can take a look at those.

Fatima Abrantes (PT) asked - in terms of the biological Carbon pump – if we should not also look into the past record, before the anthropogenic Carbon input started (1750 – 1859), so that a real baseline can be defined. This could be done by looking into climate archives, such as sediment cores, for times of natural climate variability.
Richard referred to a paper by Peter T. Spooner et al. in AGU Geophysical Research Letters that reconstructs some relevant parameters in the recent past (click here).

Short introduction of Joint Action and Project Pitches

Richard Sanders explained again that the goal of this Scoping Action is to identify areas and activities where JPI Oceans member and partner countries can work together, in small groups or collectively to support Ocean Carbon Research.

Thus, the activities our expert group identified needed to be

- Excellent, relevant, achievable, and scalable
- Link to other existing initiatives and actors
- Broadly supported

Richard pointed to the action area 'Blue Carbon' that was identified in the early stages of the process but is currently on hold but definitely of high importance. After the ideas for activities have been presented by the experts of this Scoping Action, we look for comments and feedback from participating countries and existing initiatives. These comments will be used for revising the Action Plan. Mid-November 2021 the Action Plan and proposed activities will be presented to the JPI Oceans Management Board and seek for decision on next steps and prioritized actions.

Model Synthesis

Roland Séféran (CNRM | University of Toulouse | Météo France | CNRS, France) explained the importance of biogeochemical models which are used to predict future changes, understand current processes resulting from heat and carbon uptake. To track changes in the marine BGC we can look at different models like the ones focusing on geochemical processes, NPZD, or dynamical green ocean processes. Today it becomes more and more important to look at these dynamic models which are looking at the different connections of the systems (atmosphere, land, sediments, margins, ice sheets, etc.). Currently, we have a lack in connecting river-coastal-open ocean processes as well as connections between the water column and sediment.
In the future, it is more and more important to improve the model-data fusion. In addition, we need a better integration of regional and global/open ocean models, take into account the role of the continental shelves.
JPI Oceans could help in supporting (1) its engagement in international CO_2 modelling activities, (2) improved merging of data and models, and (3) operational usage of model data assimilation techniques to assess real time carbon sink.

Comments

- Andy Watson (UK) indicated that the current set of IPCC models do not present the rapid increase in net uptake. The Global Carbon Project used models how much carbon is going into the ocean and increasingly the models diverse from the observation based estimates. Clear evidence that models are still evident and without observation we would not even know that.
- Jun She (DK) mentioned if we want to really fill in the key knowledge gaps the integrated modelling and observing approach would need to be cost-effective. The models currently cannot really explain the key processes.

Negative Emissions Technology / Carbon Dioxide Removal

Carolin Löscher (DIAS, University of Southern Denmark) presented the most important information and needs in the field of Negative Emission Technologies and Carbon Dioxide Removal. She pointed out that there is a massive increase in CO_2 over the last 150 years leading to a temperature increase by 0.7°C (today), which will become even higher in the coming decades. Therefore, our nations committed to net zero CO_2 emissions by 2050. For achieving this target we need to actively remove CO_2.

The ocean takes up 25% if CO_2 due to chemical dissolution and the biological carbon pump. However, we have to face ocean acidification and loss of biodiversity due to these processes. Thus, we need to find solutions that avoid ocean acidification and do not harm the oceans' biodiversity.

There are several NETs available (afforestation, reforestation, artificial upwelling, alkalinization, fertilization, geoengineering etc.). Carolin focused shortly on the ocean alkalinization enhancement (OEA) by mineral addition since it promotes CO_2 uptake by chemical dissolution, prevents ocean acidification, and protects primary producers. The research is already at the stage how to identify suitable minerals and looking at model-based quantification of additions. However, current knowledge gaps are around the dissolution kinetics, effectiveness, side effects, applicability and upscaling.

JPI Oceans could help in:

- Supporting a Knowledge Hub/Networking activity to link European and North American initiatives in NET, especially around Ocean Alkalinisation Enhancements (OAE), to include links to environmental agencies and political decision makers to set the legal framework.
- Supporting large scale multi-national field experiment with long term monitoring to look at side effects etc.
- Supporting with existing Knowledge Hub the installation of systems in collaboration with industry to monitor long term impacts and efficacy of OAE.

Comments

- Reiner Steinfeldt (DE) pointed to a German Research Mission that started in August this year (funded by BMBF) looking e.g. at OAE and its side effects etc. and further NETs.

- Rhodri Baines (UK) added to this that UK also funded small scale national activities including CO_2 removal from sea water. In an attempt to align existing national funding and activity, we need to make National Funding Institutes aware of this larger scale ambition.
- Roland Séféran (FR) pointed to a paper on 'Testing the climate intervention potential of ocean afforestation using the Great Atlantic Sargassum' Belt since macroalgae become more and more important in this field too. In addition, a lot of activities going on in Horizon Europe and have been supported via Horizon 2020.
- This topic will allow the opening to science-industry cooperation as well as development of standards.

Open North Atlantic Ocean

Andy Watson (University of Exeter, UK) developed together with nominated experts from Germany, Norway, Portugal, and Spain ideas for activities in the North Atlantic Ocean building on existing initiatives.

Andy explained that the North Atlantic Carbon Budget is the most intense ocean carbon sink region with a large "natural", pre-industrial sink and large anthropogenic sink. It has an intense annual phytoplankton bloom. The AMOC is crucial to both natural and anthropogenic components. Observations suggest rapid increase in the sink over the last 20 years, which is currently not captured that well in CMIP 5/6 models. Models suggest sink will asymptote over the course of this century.

Observing activities in this area include SOOP Lines, time series sites, GO-SHIP hydrographic sections, and biogeochemical Argo floats.

Following gaps can be identified in the North Atlantic Ocean:

- Lack of integration and interpretation actions for the ongoing activities.
- Lack of sustained funding, e.g. UK-Caribbean SOOP line, some Spanish observation programs.
- Geographical gaps: Substantial regions not well covered by existing activities,
    - central temperate zone,
    - Eastern tropics,
    - upwelling regions of N. African coast.
- Models do not capture well the trend of rapidly increasing sink for CO_2 seen in observations over the last 25 years in the N. Atlantic.
- Solutions needed to validate the BGC-Argo data.
- Inadequate study of connections between the surrounding shelf seas and the open North Atlantic

We already heard from Maria Hood and Andrew Stewart that the G7 FSOI is working on an ocean carbon observing scoping document and that Canada will host a scientific workshop on the "North Atlantic BGC Carbon Pump" in December 2021.

JPI Oceans could support

- A European contribution to North Atlantic Carbon Observatory (NACO) based on existing and future assets.
- A Pilot Study for NACO involving dedicated cruise to compare Saildrone/ other Autonomous Surface Vessels (ASV) and BGC Argo floats.
- Full engagement of JPI Oceans countries in NACO from MedSea and Baltic Outflow to Arctic including data synthesis, shipboard operations, modelling and remote sensing.

Comments

- Lars Arneborg (SE) emphasized again that models do not indicate the big sink the North Atlantic Ocean currently offers

  Andy answered that there is a paper on the mismatch of models with observations for the trend in CO_2 in the North Atlantic (Lebehot et al, click here). They found that if the models were initialised in the 80s with observed biogeochemical fields, they correctly got the trend in subsequent decades. However, IPCC models run in the historical mode in which they are initialised at the start of the industrial revolution, and then run forward with observed atmospheric CO_2 increase, did not get the trend right. So, the problem lies in the biogeochemistry drifting away from reality on that time scale.

Baltic Outflow – Carbon transformation and turnover in Kattegat-Skagerrak

Jun She (DMI, DK) presented the ideas he developed in cooperation with colleagues from Sweden and Norway. The study area has a very high ecosystem service economic value including blue energy, aqua farming, fisheries, and shipping. In addition, it is an area with high impact of human pressure which is indicated through increased algae bloom & hypoxia, reduction of eelgrass, etc. The area is affected by the Baltic Outflow, North North Atlantic inflow, and river discharges with complex carbon sources and sinks. Thus, it can be seen like an estuarian area too.

Estuaries represent only 0.3% of the Earth's ocean covered surface. However, estuaries are important by looking at the ocean carbon cycle. The Baltic Kattegat Skagerrak areas show less trend than North Sea as an increasing sink of CO_2. There is an increased trend on organic carbon loads in the region, both from terrestrial and Baltic Sea.

The surface carbon observations in this area are good (SOOP from ICOS, EuroGOOS FerryBox, SOCAT database) and new activities are planned.

However, major gaps (non exclusive) can be identified in the areas of observations, monitoring technologies, modelling and knowledge.

JPI Oceans could help in supporting

- the Integration of current observing networks (ICOS, FERRYBOX, GOAON, etc.).
- a PhD programme across participating countries to generate and exchange knowledge.
- A full Carbon cycle study using processes and models to address relationship between terrestrial Organic Carbon supply, Ocean Acidification, and coastal darkening.

By supporting this action area following Jun She and colleague foresee the following impacts:

- Improved understanding of coastal/shelf carbon cycle and its contribution to global carbon cycle
- Filling key knowledge gaps in regional carbon cycle, e.g., physical biogeochemical coupling processes in land water estuary coastal open sea carbon exchange, organic carbon remineralization and vertical carbon flux quantification, impact of Baltic outflow in the regional carbon cycle.
- Improved monitoring and modelling capacities on organic and inorganic carbon cycle in coastal estuary continuum, vertical carbon fluxes and carbon sedimentation
- Improved carbon data management and fit for the purpose monitoring network optimal design
- Improved knowledge and assessment on national and regional carbon budgets : air sea CO_2 flux, blue carbon, Baltic carbon outflow, organic and inorganic carbon budget
- Contribution to improved management measures for e.g., nutrient load and eutrophication by resolving and quantifying how anthropogenic activities influence potential carbon sequestration by natural systems.
- Contribute to regional Marine Protected Area network design by identifying environment and habitat areas with significant carbon sinks and correspondent management measures
- Contribute to international cooperation as a regional/national contribution to the UN Ocean Decade.

North West Europe Seas (North Sea, Irish Sea, Celtic Sea, English Channel)

Thanos Gkritzalis (VLIZ, BE) and colleagues from the Netherland, Norway, Germany, Ireland, and the United Kingdom identified the most pressing needs for this action area.

Shelf seas are a variable, but increasing contributor to global CO_2 sink. Of these seas, the North Western European shelf seas form one of the most dynamic and are acidifying at a much higher rate than the global average. The shelf sea carbon pump facilitates ocean CO_2 uptake in the northern North Sea, while the southern North Sea is either intermittently stratified or mixed year and appears generally to be a source of CO_2 to the atmosphere.

Thanos emphasized to assess changes in these carbon budgets and fluxes and their effect on shelf sea ecosystems and coastal communities, a sustained multi-national effort in ocean observations and coupled modeling is necessary. In addition, if science is to advise policy on what strategies to take, but also if these management strategies are making an impact, i.e. working, then continued, sustained monitoring using standardized best practices are needed.

This sustained support and activity is needed because, the capacity and utility is currently fragile and many elements of the ocean carbon value chain from ocean carbon measurements, via synthesis, interpretation, and quantification of ocean CO_2 uptake to policy advice are operating in a sub optimal and fragile manner and is poorly funded, and in the most part relies on the goodwill and 'volunteer' efforts of scientists.

Relevant policy and legislative bodies for this action area are the UNFCCC Global Stocktake and Conference of the Parties, OSPAR, MSFD, SDG 14.3.1 on Ocean acidification.
JPI Oceans can help in supporting

- A plan for a North Sea Carbon Observatory (NSCO) based on existing observing programmes.
- A pilot study for NSCO including estuarine and riverine campaigns and the installations on existing platforms.
- A full Carbon Cycle study addressing role of North Sea in European Carbon budget including role of Norwegian Trench as conduit for carbon from Baltic to North Atlantic.

Mediterranean Sea Carbon Sink and its Impact on Marine Ecosystems

Emma Huertas (ICMAN-CSIC, Spain) pointed out that the Mediterranean Sea is a hot spot of climate change: temperature increases, precipitations reduce, and extreme (and recurrent) events happen. In this area 30% of global tourism is hosted, and it is crossed by 25% of global sea borne trades by volume and ¼ by oil traffic (450 ports and terminals, 2nd largest market for cruise ships). The cultural diversity and geopolitical complexity is high causing safety and security issues, coastal pressures and resources exploitation. However, with 400 UNESCO sites and 236 Marine Protected Areas the unique biodiversity is starting to get protected.
It is the only basin away from polar regions where open-ocean deep convection reaching the ocean bottom, despite its location in temperate latitudes. It has been identified as an important region for anthropogenic carbon storage where the column inventory can be much higher than in the Atlantic or Pacific oceans. It is experiencing ocean acidification, even detectable in deep water masses, with major impact on biodiversity in iconic Mediterranean ecosystems.
Together with experts from Spain, France, Italy, Greece, Turkey, and Lebanon Emma started to identify the most pressing gaps in this area:

- **Knowledge**: Lack of support and underpinning actions, integration and interpretation of the ongoing observation activities. A better coordination will lead to improve the estimation of the anthropogenic carbon at the scale of the basin and sub-basins and solve the impact of meso and sub-meso scale processes on carbon biogeochemistry.
- **Observation**: Acquisition of CO_2 variables should be expanded in under-sampled geographic areas (e.g. central Mediterranean, Turkish and Lebanese seas etc.).
- **Technologies**: pH & pCO2 measurements from gliders and Argo floats equipped with pH sensors.
- **Management**: Data treatment (QC procedures) for real-time data acquisition.
- **Products**: Acidification and anthropogenic indicators.

JPI Oceans could help in supporting

- Robust and long-term contributions of Mediterranean Carbon data to long term climate archives in support of climate change research, Ocean Acifidication monitoring and ecosystem impacts.

- A full understanding and capacity to measure the whole Mediterranean C cycle, in support of national carbon budgeting and National Determined Contributions implementation involving nature-based solutions in the coastal zone.
- Full understanding of role of Mediterranean in global C cycle, including early warning system for changes linked to implications for mitigation and adaptation pathways.

Comments

- Fatima Abrantes (PT) mentioned that it would be great if our experts team can look for the connections between the basins proposed, meaning Mediterranean basin and North Sea, Celtic Sea and Irish Sea, regarding the carbon cycle.
- Eva Krasakopoulou (GR) mentioned that experts from e.g. Israel are missing are would be valuable for moving forward this Scoping Action.