Concept Paper

Partnership dialogue 3: Minimizing and addressing ocean acidification

Concept paper for Partnership dialogue 3, prepared in response to the General Assembly resolution 70/303 on minimizing and addressing ocean acidification, is covering SDG target 14.3. The concept paper for this partnership dialogue is based on inputs received from Member States, the UN system and other stakeholders. Given the word limit for the concept paper, not all inputs have been included in their entirety, but they can be accessed under: https://oceanconference.un.org/documents.

I. Introduction

Ocean acidification is a threat to marine organisms, ecosystems, services, and resources. It has potentially considerable ecological and socio-economic consequences, adding to multiple stressors on ocean ecosystems, including other climate-driven changes (e.g. ocean warming, sea level rise, and deoxygenation) and local pressures from pollution, overexploitation, and habitat destruction.

One fourth of the carbon dioxide released into the atmosphere from anthropogenic activities is absorbed by the ocean.[1] However, this vital service is not without consequence: when carbon dioxide enters the ocean it changes seawater chemistry, resulting in increased seawater acidity. That change severely affects biological processes, with potentially profound socio-economic impacts.

The long-term control of ocean acidification depends on the reduction of emissions of carbon dioxide into the atmosphere. In this regard, ratification and effective implementation of the Paris Agreement will be instrumental. Even if carbon dioxide emissions are reduced immediately, there will be a lag time before the acidity levels of oceans normalize, particularly since more acidic surface ocean waters mix with deep water over a cycle that lasts hundreds of years. Therefore, it is critical to build the resilience of ocean ecosystems and of the people that depend on them for their livelihoods to the effects of ocean acidification and climate change.

II. Status and trends

Since the industrial revolution about 375 billion tonnes of carbon have been emitted by humans

[1] Le Quéré, C., T. Takahashi, E. T. Buitenhuis, C. Rödenbeck, and S. C. Sutherland (2010), Impact of climate change and variability on the global oceanic sink of CO2, Global Biogeochem. Cycles, 24, GB4007, doi:10.1029/2009GB003599.

to the atmosphere as CO_2.[2] Globally averaged surface CO_2 reached new highs in 2015 at 400 parts per million (ppm), or 144% of pre-industrial (before 1750) levels.[3] The increase of CO_2 from 2014 to 2015 was larger than that observed from 2013 to 2014 and that averaged over the past 10 years. The El Niño event in 2015 contributed to the increased growth rate through complex two-way interactions between climate change and the carbon cycle.[4]

The main sinks for CO_2 emissions from fossil fuel combustion are the oceans and terrestrial biosphere. Since the beginning of the industrial revolution, oceans have become 27% more acidic,[5] and ocean acidity could increase by 150% by 2050.[6] This would give marine ecosystems a very short time for adaptation, as it would represent a rate of increase that is 100 times faster than that of any ocean acidity change experienced over the past 20 million years.[7]

Ocean acidification affects calcifying organisms, such as corals, because their ability to build shell or skeletal material depends on the acidity of the water. As acidification intensifies, this problem will become more widespread and occur in wild, as well as in cultured, stocks. Ocean acidification also affects other marine biota, including by reducing survival, development and growth rates. It therefore directly affects important components of the ocean food web, such as primary producers (plankton), coral reefs, shellfish and crustaceans; marine species that are important in capture fisheries and mariculture are also affected. Coral reefs, in particular, are very sensitive to ocean acidification, with 60% of reefs currently threatened, a number that will rise to 90% by 2030 and about 100% by 2050.[8] Socioeconomic impacts include impacts on food security and the livelihoods of fishing and aquaculture communities. Many such communities are especially vulnerable because they have fewer alternative livelihoods.[9]

In addition to acidification, most of the heat excess caused by increases in atmospheric greenhouse gases is absorbed by oceans, causing ocean warming and loss of oxygen. The deep seabed and overlying waters are particularly vulnerable to loss of oxygen. The most recent estimate indicates that the volume of water in the open ocean that is completely devoid of oxygen has quadrupled since 1960.[10] Many other areas experience oxygen shortage at dangerous

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[2] WMO Greenhouse Gas Bulletin No. 8 (2012).
[3] WMO Greenhouse Gas Bulletin No. 12 (2016).
[4] Ibid.
[5] Caldeira K, Wickett M.E 2003 Anthropogenic carbon and ocean pH. *Nature*. 425, 365 doi:10.1038/425365a.
[6] Secretariat of the Convention on Biological Diversity (2009). Scientific Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity. CBD Technical Series No. 46.
[7] Ibid.
[8] Burke, L., Reytar, K., Spalding, M. and Perry A. (2011). *Reefs at Risk Revisited*. World Resources Institute. Washington, DC.
[9] Oceans and the law of the sea, Report of the Secretary-General A/72/70, paras 30-31.
[10] Schmidtk, S. Stramma L. & M. Visbeck. (2017) Decline in global oceanic oxygen content during the past five decades. *Nature* 542: 335-339.

levels, which is already shown to significantly reduce the habitat of migratory fish species. Ocean acidification and ocean deoxygenation commonly occur together at depth of 200m to 1000m.[11] Increases in upwelling are bringing high CO_2,[12] low oxygen waters into shallow waters,[13] where they can have major impact on coastal fisheries and livelihoods.

Ocean acidification and deoxygenation must be observed and researched together with ocean warming, which is a master variable that affects oxygen limitation and response to acidification. The extra heat that oceans absorb due to increased atmospheric levels of greenhouse gases also directly affects ecosystems. Fisheries are starting to redistribute, for example by shifting away from the equator, while many coral reefs are experiencing major bleaching events. Habitat loss and loss of ecosystem services directly affects hundreds of millions of reef dependent people. Solutions must address all three problems (ocean acidification, loss of oxygen, and ocean warming) in concert.[14] Although the surface ocean is changing the fastest, the uptake of heat and CO_2 from the atmosphere is also rapidly changing the temperature, pH and oxygenation of the deep oceans with consequences for its ecosystems.[15]

III. Challenges and opportunities

Although ocean acidification is an observable and predictable consequence of increasing CO_2 emissions, the precise scope of its impact on the marine environment remains unclear. For example, many questions remain about the biological and biogeochemical consequences of acidification, and the accurate determination of subcritical levels, or "tipping points," for global marine species, ecosystems and services. Most of the understanding of biological impacts of ocean acidification is derived from studies of responses of individual organisms.

Ocean basins and their ecosystems have evolved separately, therefore, biological responses to changing pH levels, oxygen content and temperature are different. For example, the Northeast Pacific is experiencing greater changes than the northern Atlantic yet some organisms there may be more tolerant. There is therefore a need for information on impacts at the ecosystem level,

[11] Levin, L.A. and D. Breitburg. (2015) Connecting coasts and seas to address ocean deoxygenation. *Nature Climate Change*. 5: 401-403.

[12] Sydeman, W.J., Garcia-Reyes, M., Schoeman, D.S., Rykaczewski, R.R., Thompson, S.A., Black, B.A., Bograd, S.J., (2014) Climate change and wind intensification in coastal upwelling ecosystems. *Science* 345, 77-80.

[13] Feely, R. A., Sabine, C. L., Hernandez-Ayon, J. M., Ianson, D., Hales, B. (2008) Evidence for upwelling of corrosive "acidified" water onto the Continental Shelf, *Science*, 320: 1490–1492. doi: 10.1126/science.1155676

[14] Breitburg, D.L., J. Salisbury, J.M. Bernhard, W.J. Cai, S. Dupont, S. Doney, K. Kroeker, L.A. Levin, C. Long, L.M. Milke, S.H. Miller, B. Phelan, U. Passow, B. A. Seibel, A. E. Todgham, A. Tarrant. (2015) And on top of all that. . .Coping with ocean acidification in the midst of many stressors. *Oceanography* 28: 48-61

[15] Levin, L. A. and Nadine Le Bris. (2015) Deep oceans under climate change. *Science* 350: 766-768.

which would include the interaction of multiple stressors, including those related to climate change.

Whereas trends for open ocean pH are well-known, data are lacking in many locations, especially in coastal regions where natural variability can be large.[16] Thus in many cases, the direction of change is known, but uncertainty remains about the timing and rate of change, as well as its magnitude and spatial pattern. This calls for a better understanding of the system-level impacts of ocean acidification.

In that regard, it is important to develop indicators of the impact of ocean acidification in addition to the top level SDG target 14.3 indicator ("Average marine acidity (pH) measured at agreed suite of representative sampling stations"). For example, aragonite saturation state is arguably a more ecologically relevant measurement than marine acidity, while three-dimensional mapping of the distribution of sensitive species in ocean space may be as crucial as the measurement of acidity itself. Particularly valuable indicator systems are tropical coral reefs, cold water coral ecosystems, polar seas, and carbonate plankton based trophic chains. Developing a proper indicator framework for target 14.3 could improve tracking of progress as well as implementation of actions. This could, as far as possible, encompass water quality parameters (e.g. aragonite saturation, pH); physiological parameters (e.g. calcification, skeletal density, growth of indicator species); and ecosystem parameters (e.g. benthic composition and production/erosion rates). Development and implementation of indicators would require enhanced scientific cooperation.

Governments and academia are the primary drivers of ocean acidification monitoring and research but the private sector, with its great reach and technical capacity, should be more engaged. Global ocean acidification monitoring is too large a challenge to be achieved without the engagement of all sectors. Significant opportunities exist in the form of enhanced collaboration among countries, scientific programmes on ocean acidification, relevant intergovernmental bodies, such as regional fisheries management organizations and arrangements as well as Regional Seas Conventions and Action Plans, academia and civil society in conducting research to achieve an understanding of the impacts of, and risks associated with, climate change and ocean acidification.

An example of an innovative idea to foster the engagement of the private sector is the $2 million Wendy Schmidt Ocean Health XPRIZE, a competition for developing breakthrough ocean pH sensors to improve the understanding of ocean acidification. A number of the competing teams are now commercially producing state-of-the-art pH sensors, some of which are being deployed

[16] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

globally and on Argo Floats in the southern hemisphere. The opportunity exists to use these technologies to fully monitor the status of ocean acidification changes across the world's oceans, from the deep-sea to the coast, and in lakes and rivers. However, the complete implementation of such a global ocean acidification monitoring system remains a challenge.

There is also the need to improve the understanding of the social and economic impacts of ocean acidification, in particular to produce improved damage estimates, which can be used to support climate policy decisions, including mitigation and adaptation planning.

An analysis of the implications of ocean acidification for implementation of the 2030 agenda is warranted to identify which goals and targets is ocean acidification likely to pose additional challenges to. It could also identify how implementation of the agenda can address ocean acidification by reducing CO_2 emissions, enhancing ecosystem resilience to ocean acidification, locally mitigating its impacts or otherwise reducing economic and social vulnerability. Additionally, such an analysis could help explore the establishment of further targets at the global level as appropriate.

Climate change mitigation measures will play a crucial role in slowing ocean acidification and minimizing its impacts. Therefore, the two issues of ocean acidification and climate change (SDG 13) need to be considered in an integrated manner. In that regard, an opportunity to address ocean acidification is to consider it within the UNFCCC process, and in the context of the commitments made under the Paris Agreement, including by supporting the access to climate finance to address the impacts of climate change on the ocean and its resources, noting the need for simplified access and the special circumstances of Small Island Developing States (SIDS).

As a response to climate change, many States have initiated programmes for energy production from new and renewable resources (SDG 7). By reducing CO_2 emissions, an increased use of renewables would also address the impacts of ocean acidification. The oceans, a relatively unexploited source of energy, can be used to produce renewable energy from waves and tidal force, thereby contributing to sustainable development. Innovation and technological change can also provide new opportunities for economies to develop technologies that produce less CO_2 while increasing their economic benefit (e.g. wind energy, solar energy)[17].

Building resilience of ecological and socioeconomic systems could also contribute to minimizing the impacts of ocean acidification. This could be achieved by minimizing the impact of other anthropogenic stressors. For example, the effective implementation of the United Nations Convention on the Law of the Sea and other relevant legal instruments aimed at limiting marine pollution and curtail overfishing would have a positive effect on the ability of marine ecosystems to adapt to acidifying conditions.[18] Another way to build resilience is by maximizing the

[17]See A/67/79 and A/67/79/Corr.1
[18] See A/68/71.

likelihood of survival of the marine species by, for example, the conservation of coastal and marine areas to create refuges for important biodiversity.

Other opportunities to minimize and address the impact of ocean acidification exist in: a) science, by fostering joint experiments and research opportunities involving scientists from developing and developed countries, and by supporting dissemination of experimental results in highly visible publications; b) capacity building, by training and mentorship programs linking young researchers from developing countries to established experts in the field of ocean acidification; incentivizing industry to support research facilities in developing countries; and c) communication, by finding new ways to reach out to broader audiences, such as by developing a targeted international communication campaign on ocean acidification, and strengthening communication that addresses the needs of different stakeholders, including policymakers, environmental planners and managers and the private sector, which can support and enable action across sectors.

IV. Existing partnerships

Strategic partnerships between UN organizations, universities and research institutes are essential to effectively identify and address research and knowledge gaps, which still exist in areas highly vulnerable to ocean acidification, and to facilitate the implementation of SDG target 14.3.

Government and academic research are main actors with positive examples of successful networks and integrated projects. Government agencies typically sponsor long-term monitoring programmes, and many academics contribute through in-depth focussed projects. Several national and multinational research projects on ocean acidification have emerged in the past years, including the NOAA ocean acidification program, the United Kingdom ocean acidification programme, the New Zealand Pacific Partnership on Ocean Acidification (PPOA), the European Project on Ocean Acidification (EPOCA), and monitoring by the North Pacific Marine Science Organization (PICES), the International Council for the Exploration of the Sea (ICES), and the Pacific Islands Global Ocean Observing System (PI-GOOS).

Some international coordination platforms have been established to promote, facilitate and communicate global activities. For example, the Ocean Acidification International Coordination Centre (OA-ICC), under the auspices of the IAEA, was announced at the Rio +20 United Nations Conference on Sustainable Development and began its work in early 2013; a Framework for Ocean Observing was developed by the Global Ocean Observing System (GOOS) and the International Ocean Carbon Coordination Project (IOCCP) led by the Intergovernmental

Oceanographic Commission (IOC) of UNESCO;[19] and the International Alliance to Combat Ocean Acidification, a newly formed international network of organizations and governments (including Chile and France and states from Canada, Nigeria and the United States) built to address ocean acidification and other threats from changing ocean conditions. WMO and IAEA jointly organize annual meetings on Carbon Dioxide, other greenhouse gases and related Measurement Techniques (GGMT), and the 19th GGMT will include a session on ocean observations of greenhouse gases.

Building on the Framework for Ocean Observing, in 2012 the Global Ocean Acidification Observing Network (GOA-ON) was created to expand coverage of ocean acidification measurements to areas where there is currently little or no data, to provide a global understanding of ocean acidification conditions and ecosystem response, and to inform modelling efforts and ultimately policy development. GOA-ON has more than 350 members from 66 countries and organizations, and works closely with IOC, OA-ICC, and other relevant bodies. Since its launch, GOA-ON has significantly contributed to advancing ocean acidification monitoring worldwide, through engaging scientists from low-income countries, and providing training and guidance. A GOA-ON Data Portal is available, centralizing all existing and quality-controlled ocean acidification observing data, and would feed into the implementation of and reporting towards SDG target 14.3.

The Deep Ocean Observing Strategy, a program within the GOOS, is being developed to expand and integrate ocean acidification measurements in the deep ocean (i.e. below 200 m). This can inform deep-sea scientists about needs and opportunities, including collaboration with or capacity building for small island (large ocean) developing states which have large areas of deep sea, and are considering or have active use of deep water (e.g. for energy, mining, fishing). In addition, the Deep Ocean Stewardship Initiative brings together deep ocean scientists, industry, regulators, and policy experts and is able to address the intersection of climate-related ocean changes, including acidification, with societal uses of the ocean.

In terms of the impact of ocean acidification on ecosystems, an example of partnership is the Global Coral Reef Monitoring Network (GCRMN) of the International Coral Reef Initiative (ICRI), which works to strengthen the provision of best available scientific information on and communication of the status and trends of, coral reef ecosystems in order to assist their conservation and management. The main activity of GCRMN is the preparation of regional periodic assessments of coral reef status, trends and outlook, as well as global reports. Initiatives such as the IPCC special report on climate change and the oceans and the cryosphere are also expected to increase the knowledge on the impact of specific and combined effects of changes in

[19] Newton J.A., Feely R. A., Jewett E. B., Williamson P. & Mathis J., 2015. *Global Ocean Acidification Observing Network: Requirements and Governance Plan*. Second Edition, GOA-ON, http://www.goa-on.org/docs/GOA-ON_plan_print.pdf.

climate related variables (e.g., warming, acidification, oxygen loss, dust inputs) on productivity, species distribution and exclusion, habitat compression, and food webs.

In a global policy-making context, the United Nations General Assembly has addressed issues related to ocean acidification in its resolutions on oceans and the law of the sea, urging States to make significant efforts to tackle its causes, to further study and minimize its impacts and to enhance cooperation at all levels, including the sharing of relevant information and the development of worldwide capacity to measure ocean acidification. The outcome document of the 2016 resumed Review Conference on the United Nations Fish Stocks Agreement, calls for strengthening efforts to study and address adverse impacts of climate change and ocean acidification, and to explore ways to incorporate the consideration of these adverse impacts in decision-making processes related to the adoption of conservation and management measures. The United Nations Open-ended Informal Consultative Process, which at its fourteenth meeting in 2013 focused its discussions on the impacts of ocean acidification on the marine environment (see A/68/159), at its eighteenth meeting, 15-19 May 2017, will focus its discussions on the effects of climate change on oceans, including the issue of cooperation, coordination and partnerships.[20]

The Convention on Biological Diversity (CBD) has produced a scientific synthesis on the impacts of ocean acidification on marine and coastal biodiversity, as well as guidance for enhancing the resilience of ecosystems through a range of management measures.[21] In particular, the voluntary specific workplan on biodiversity in cold water areas within the jurisdictional scope of the Convention, adopted by the Conference of Parties (COP), includes actions focused on better understanding, as well as avoiding, minimizing and mitigating the combined and cumulative effects of multiple stressors, including ocean acidification, on biodiversity in cold-water areas.[22]

Partnerships to address socio-economic impacts of ocean acidification have been promoted by international organizations. For example, the Food and Agriculture Organization (FAO), together with a number of partners, have taken stock of the available knowledge on the impacts of climate change on the fisheries and aquaculture sector and the consequences for food security. In addition to flagship publications summarizing relevant information,[23] field projects have been developed in Africa, Asia, Latin America and the Caribbean to assess the vulnerability of coastal communities relying on fisheries and aquaculture resources, identify suitable adaptation options, and strengthen institutional and local capacities to foster adaptation. Wherever relevant, ocean

[20] See A/AC.259/L.18. See also A/72/70.
[21] See the CBD Technical Series 75: *An Updated Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity* (available at: https://www.cbd.int/doc/publications/cbd-ts-75-en.pdf).
[22] CBD COP decision XIII/11.
[23] FAO (2016), *Global strategies and knowledge on climate change and fisheries and aquaculture.*

acidification is addressed as one of the stressors affecting the coastal resources that sustain fisheries and aquaculture.

The International Organization for Migration (IOM) and the Ocean and Climate Platform (OCP), an international Ocean and Climate think tank gathering over 70 organizations established with the support from the IOC, have worked together to address the challenge posed by climate change to oceans and the degradation of marine ecosystems in terms of human migration impacts. In addition, IOM is working with the Ocean and Climate Initiatives Alliance to drive a momentum for concrete action and solutions and federate existing initiatives on issues related to climate and ocean.

Partnerships to ameliorate the impacts of ocean acidification include the International Blue Carbon Initiative (IBCI), which is coordinated by the IOC, Conservation International and the International Union for Conservation of Nature (IUCN), and works to protect and conserve coastal blue carbon ecosystems through scientific capacity building activities; as well as the International Partnership for Blue Carbon, focusing on awareness raising, exchange of knowledge and accelerating practical action.

V. Possible areas for new partnerships

It should be of high priority to all Member States to enhance close collaboration among countries, international organizations, including regional fisheries management organizations and arrangements as well as Regional Seas Conventions and Action Plans, scientific organizations, academia and civil society in conducting research to achieve an understanding of the impacts of, and risks associated with, climate change and ocean acidification.[24] Partnerships need to be ambitious enough to make meaningful progress in helping coastal communities and ecosystems adapt and build resilience to ocean acidification and climate change.

Some of the most pressing and emerging areas for possible new partnerships are related to strengthening the science of ocean acidification. This include supporting the establishment and operation of a global ocean observation and monitoring systems, particularly emphasizing integrated observation and monitoring in ocean physics, geobiochemistry, biology, and ecosystem, as well as comprehensive monitoring of climate change and its impacts. In that regard, it is important to strengthen existing ocean acidification monitoring and forecasting, including by building on and expanding the Global Ocean Acidification Observing Network (GOA-ON) geographically as well as institutionally, as well as regional ocean acidification networks (e.g. LAOCA and OA-AFRICA). Partnerships on modelling and forecasting could aim at improving the accuracy of projections regarding the timing and rate of change in climate change and ocean acidification, as well as magnitude and spatial patterns at a finer spatial resolution. Partnerships related to ocean acidification data could encourage open access to data

[24] A/CONF.210/2016/5.

and research, including promoting means for management and dissemination of data and information. There is also a gap in formal partnerships addressing ocean acidification in the deep ocean and high seas. In that regard, partnerships to establish deep-ocean focused ocean acidification programmes could be established, or this could be a subgroup within existing alliances such as the Deep Ocean Observing Strategy (within GOOS). Partnerships with industry could improve ocean observation of climate change, ocean acidification, and changes in marine biodiversity, as well as provide possible sustained funding for ocean observation and monitoring programmes.

Another area for new and strengthened partnerships is related to the assessment of the impact of ocean acidification on marine ecosystems. This includes partnerships: to assess the role of the ocean in critical processes such as carbon dioxide absorption and water cycle of the earth system, improving the knowledge on how the proportion of the CO_2 absorbed by the ocean will change in the future and consequences for ocean acidification, including climate system feedbacks; conducting research on the impacts of oceans' complex changes on marine ecosystem, in particular marine habitats, spawning sites and feeding grounds; constantly conducting monitoring, survey and impact assessment of the consequences of climate change with regard to oceans, including sea level rise, and taking active counter-policy measures to narrow the affected areas and scope of ocean acidification; supporting integrated vulnerability assessments focused on ecosystems and associated services, including evaluating the direct effects of ocean acidification on fish populations and improving knowledge of the food webs that support these; developing 'low cost' methodology to measure the impacts of climate change and ocean acidification on marine biodiversity and ecosystems; understanding and addressing cumulative impacts of ocean acidification and other stressors including deoxygenation, increased temperature, pollution, sea-level rise, reduced sea-ice cover, coastal erosion and over fishing; and assessing the vulnerability of sentinel marine species with economic, social, cultural importance and investing in case studies to provide a more in-depth understanding of the vulnerability of key resources to ocean acidification.

There is also a need to increase the understanding of and addressing the vulnerability of specific ecosystems (such as coral reefs and fragile ecosystems of the Polar Regions) to multiple stressors, as well as promoting ecosystem-based and holistic approaches for natural resources management, adaptation and mitigation, so as to address the multiplicity of drivers affecting oceans and coastal areas. In this regard, it is important to build on existing partnerships, including by strengthening the Global Coral Reef Monitoring Network (GCRMN) at the global, regional and national levels, including enhancing data and reporting services and the establishment of regional networks and nodes.

Addressing ocean acidification also requires new partnerships to assess its social and economic impacts, including the impact on livelihoods and food security of communities depending on marine ecosystems. New partnerships are needed to explore ways to incorporate in decision-making processes related to the adoption of conservation and management measures, in line with the precautionary approach, the consideration of the adverse impacts of climate change and ocean acidification and the uncertainties regarding such impacts on fisheries and fish stocks, including in relation to migration patterns and productivity as well as the vulnerabilities of individual species to changes in marine ecosystems.[25] These partnerships could work to identify options for reducing such risk and promoting the health and resilience of marine ecosystems, and sharing information and identifying and sharing best practices in this regard.[26]

There is also the need to assess the social and economic impacts of solutions to address ocean acidification. For example, new partnerships could assess the potential environmental and socio-economic impacts of different marine geoengineering approaches on the marine environment, in accordance with relevant legal and policy instruments.

In terms of adaptation to ocean acidification, partnerships could strengthen early warning systems as well as promote ecosystem based adaption approaches. This may include reducing other local stress factors such as land-based pollution, creating marine protected areas, blue carbon mitigation efforts, grey-green infrastructures, and incorporating ocean acidification into ecosystem-based and coastal zone management plans to increase the resilience of coastal ecosystems and communities. Partnerships could strengthen the dialogue between natural scientists and socio-economists to identify vulnerabilities and possibilities for adaptation, where relevant drawing on successful partnerships and lessons learned from other domains such as climate change. Partnerships could also increase the application of scientific results to improve marine economies[27].

In relation to mitigation, new partnerships are needed to work towards reducing emissions of greenhouse gases from the maritime and fisheries sectors. Partnerships could also explore utilizing ecosystem based mitigation approaches, grey-green infrastructures, blue carbon ecosystems and incorporate ocean acidification into ecosystem-based and coastal zone management plans to increase the resilience of coastal ecosystems and communities.

Partnerships could also be established to promote relevant policies and capacity building to address ocean acidification. This include partnerships to: encourage consideration of ocean acidification vulnerability in National Adaptation Plans; enhance technical capacity development of vulnerable countries through the establishment of regional training centers to increase cooperation among States on ocean-climate research and multi- disciplinary observation;[28] and

[25] A/CONF.210/2016/5.
[26] Ibid.
[27] A strategic alliance with the Global Partnership for Climate Change, Fisheries and Aquaculture (PaCFA) could be one possibility. The PaCFA is a voluntary partnership of governmental, non-governmental and civil society organizations, sharing a concern for better recognition of the sector in global climate change policy development and action, and recognising the need for coordinated action.
[28] A/RES/69/15, decision 58.f.

develop tools for integrated decision making, taking into consideration impacts of ocean acidification and climate change on marine biodiversity and ecosystems.

VI. Guiding questions for the dialogue

The following are the proposed questions to guide the discussions at the partnership dialogue:

- How to improve the measurements of ocean acidification at the national, regional and global level?
- What adaptive measures can be taken to improve the sustainability of resources and the ecosystems they rely on in the face of stress from ocean acidification?
- What effective mitigation and adaptation measures currently exist and what new ones can be put in place?
- How will partnerships help communities and ecosystems minimize and address the impacts of ocean acidification in a meaningful way?