Consensus statement from the Regional Action on Climate Change Symposium (RACC-16) held on Saturday 5 October 2024: An adjunct session of the Science, Technology and Society Forum (Kyoto)	

Emerging threats from climate change on our oceans demand proactive action

World Oceans under Stress

World ocean ecosystems are increasingly disrupted by human activities. However, converging stresses, amplified by global warming, remain largely unrecognised. Changes developing in the world ocean systems pose significant threats in the form of major economic and physical impacts on human populations of every continent.

World oceans are vital to human health and survival

- As a carbon sink holding some 60 times more carbon than the atmosphere, absorbing some 30% of all human caused CO2 emissions, accounting for 97% of the planet's water, and absorbing around 90% of the excess planetary heat.[1]

- As a food source, especially for the most disadvantaged populations; providing potential solutions to key problems on land, regulating risks from extreme weather events; and yielding a wide range of products including medicines, and potential plastic substitutes.

- As an enabler of major economic activities, representing some $2.3 trillion per year in goods and services,[2] including transport of some 49% of all goods,[3] providing small-scale livelihoods to nearly 500 million people, and 11% of agricultural trade by value, as well as transport of people, tourism, and recreation.

The life supporting capacities of the world oceans are increasingly threatened by global warming

Sea surface temperatures are already beyond the warning level of 1.1 degrees above pre-industrial levels and the rate of ocean warming appears to be increasing.

- The stored heat is unevenly distributed across the oceans affecting sea levels, extreme events, ocean conditions and ecosystems.

- Tropical storms – the leading cause of losses and damages in the tropics - and in particular cyclones, carrying additional energy, are intensifying in force and rapidity, reducing warning time. [4]

- Increases in atmospheric carbon dioxide are raising ocean acidity, already 30% higher than pre-industrial levels, with increasingly severe implications for marine life, and the rich ecosystems of coral reefs.[5]

- Stress caused by acidification is compounded by record-breaking ocean temperatures – already creating widespread coral bleaching[6] and severely affecting all calcifying organisms.

- The capacity of the oceans to absorb and retain carbon from the atmosphere is declining as oceans warm. Simultaneously, the warming water is expanding and, in conjunction with ice melt, is producing sea level rise, threatening many key areas of infrastructure.[7]

- Impacts from rapid changes to the oceans are compounding other stresses, namely overexploitation of fish stocks, inflows of some 5-12 million tonnes of plastic each year, unknown and unmeasured impacts of inflows of synthetic pollutants, and rapidly growing nitrogen pollution, expected to double in the next few decades, contributing to increasing algal blooms, ocean hypoxea, global warming, coastal eutrophication, and severe impacts on human health.[8]

- Accelerating interacting stresses, creating "cascading impacts on ecosystem structure and functioning"[9] involving a widening range of marine species, and long-term survival of major coral reef systems.[10]

The risks for human health and well-being and ecological sustainability of stressed oceans, are serious and growing:

- Increased storm intensity creates loss of life and property whilst increasing ocean turbulence and nutrient richness, resulting in more frequent massive algal blooms. These changes, coupled with rising sea surface temperatures,

enhance abundance of marine and estuarine pathogenic microbes, such as cholera and non-cholera *Vibrio* spp., with increased occurrence of infections and outbreaks of disease.

- The impacts of climate change on the hydrologic cycle[11] are adding to impacts from sea level rise. For example, in Asia and Africa, low level delta regions playing critical roles in food security, biodiversity and economy, and home to more than 500 million people, face impacts of increased river flooding combined with flooding and salinization from sea level rise.

- Melting of glaciers greatly sharpens these risks. For example, in Africa millions face consequential droughts and floods with glaciers in Tanzania and Uganda predicted to be gone in the 2040s[12] and with warming in the Hindu Kush Himalayas, three times faster than the global average, threatening water for drinking, irrigation and energy for some 3.3 billion people across 11 countries.[13]

Knowledge of the oceans remains limited.

Ocean sciences is a young discipline. Many of the interactions within the oceans, and between the oceans, land, atmosphere, ecosystems, and humans, and the relationship between ocean ecosystems and climate remain poorly understood. These include impacts of increased ocean acidification and effect of human actions on deep ocean ecology notably when deep sea floor mining is being proposed and implemented. As an urgent first step, further ocean monitoring and modelling technologies need to be strategically developed and deployed.

Major human populations, both coastal and inland, are dependent on the oceans and particularly vulnerable to multiple impacts of the changes that are occurring

Examples include:

- Compounding risks of sea level rise on the 11% of the global population (896 million in 2020) living in cities at low elevation[14] and the projected possible 5.2 billion coastal population by 2080[15].

- Impacts on agriculture with saline ingression for sea level rise, notably on crops in Asian mega deltas such as the Ganges and Mekong, and the African Nile and Niger.

- Indirect impact from changes in marine biodiversity and coastal ecosystems, including re-location of species caused by global warming, threatening coastal fisheries.[16]

- Disrupted food production in islands whose vulnerabilities include economic dependence on limited sectors, geographic isolation, and high disaster risk. Those populations face increasing loss and damage, cultural upheaval, loss of food and land from sea level rise, coastal erosion, and storm surge.

- Rapidly declining yields of fisheries, creating economic and social impact on coastal communities at "the frontline" of the "triple exposure": climate change; blue economy growth; and poorly planned area-based conservation. Rapid declines in ocean fish stocks threaten food security across all continents, whilst replacement land-based aquaculture increases stress on agricultural land.

These issues are not adequately factored into economic analyses governing decision making

A new and more holistic approach is needed to address costs and benefits of actions taken to govern human interaction with the oceans to acknowledge the reality that:

- Climate change impacts a rapidly growing "blue economy", e.g., fisheries, shipping, ocean energy production, and agriculture, but also increases dependency on it whilst at the same time depleting the natural capital it represents.

- Disproportionate losses and damages are suffered across the planet with greatest impact on the most vulnerable (those living in poverty in deltas and on small islands) who, despite low per-capita carbon emissions, face devastating impact, notably displacement. The need for just, fair and equitable collaborative actions to support these vulnerable populations is ever more evident.

- Despite much attention having been given to the economic consequences of natural disasters in recent research, in contrast there has been insufficient attention to establishing values for unmonetized environmental impacts such as biodiversity loss, and tipping points owing not just to the often stated role of non-linearities, but that of marginal impacts.

Collective research, innovation and action by governments, the private sector, and civil society at local, national, regional and global levels is needed to understand, expose, and reduce escalating stress on the oceans, including:

Locally

Support and encourage collaboration between communities and physical and social scientists and practioners to support bottom up-approaches (supporting social justice, equity and empowerment of women) and develop nature-based solutions, for example:

- build understanding of the importance of ocean health, utilising tools such as the Climate and Ocean Risk Vulnerability Index (CORVI) and sytems health approaches that develop best practices for tasks, e.g., maintaining mangroves, enhancing watershed management and restoration, identifying salt tolerant agricultural varieties, implementing nature-based solutions for water treatment, sustainably managing fisheries, reducing losses from tropical cyclones, and optimising benefits from loss and damage funds.

Nationally, regionally and globally

- support collaboration between earth and environmental science and engineering, public health, and policy making to prioritize development and deployment of early warning systems, data sharing, and integrated assessment and management methodologies to protect against increasing extreme events (especially for delta and small island communities).[17]

- promote the integration of aquatic foods into nationally determined contributions.[18]

- move beyond existing global processes (eg the Barcelona Statement 2024)[19] to include in governance frameworks regional alliances and collaborations such as the Regional Platform for Cooperation and Integration in East Asia and its associated networks, and African sustainable development initiatives, with much more proactive consideration of regional impacts on coasts, islands, fisheries and polar seas, as well as the open ocean.

- utilise in policy existing models which integrate multiple factors such as economics of ocean use, climate impacts and food production, to show the way to resilient pathways towards the SDG targets.

- in particular urgently develop and utilise in policy holistic, integrated systems approaches to serve as the basis for understanding the interaction between oceans, the economy and society. To this end, further develop digital twins[20] integrating oceans and economic sciences.

- invest in interventions which enhance the sustainability of the oceans as a climate change solution potentially yielding significant co-benefits, including protecting coastal communities from storms, providing jobs, protecting biodiversity and improving food security

- greatly strengthen international efforts (including with the vulnerable) to build understanding of the physical, social and economic impacts on land of ocean system disruption under climate change and how to minimise them.

- urgently progress global agreements to create alternatives to reshape existing economic incentives to over produce major ocean pollutants including, notably nitrogen, already emerging as "one of the most costly and challenging environmental problems"[21] but for which cost-effective solutions exist. And, seek a global treaty to develop alternative materials to achieve plastic free economies by 2050.

- support, strengthen and extend efforts of COPs (IPCC and IPBES) to create new multilateral agreements that address ocean-climate impacts. Reinforce international restoration of coastal ecosystems, including blue carbon, fisheries, and food.[22]

- build the above efforts on ecosystem-based approaches to extend at global scale active integrated sustainable adaptation action and the development of global governance structures more appropriate to regulating and protecting marine and coastal ecosystems.

- work to develop the necessary strong political will, innovative funding and mutual learning to address common challenges faced by coastal cities including seeking to avoid involuntary displacement by supporting measures for planned relocation.

- initiate innovative approaches, in the absence of a global institution needed to establish ocean governance, by focusing regional, national and non-traditional actors on emerging hotspots of degradation and, in particular, coastal communities, deltas and their rivers.[23] Integrate and support this through a research agenda, and global institutions facilitating (with accountability, and inclusivity) diverse frameworks for implementation, monitoring and management of ocean related actions.

A need for accelerated, prioritized action

Human well-being across the Earth depends, to an extensive but poorly recognised degree, on the stability of the planet's oceans whilst human impacts on them are effectively creating a ticking time-bomb, creating major vulnerabilities where humans live on land. These human impacts on the oceans and the resulting vulnerabilities are insufficiently well understood. Accordingly we urge all governments to give greater priority to controlling not only ocean areas within their jurisdiction, but also their contributions to the processes driving ocean destabilisation.

Escalating ocean stress is outpacing the development of governance processes that effectively regulate human activity in the ocean commons. In particular, urgent action is required from local to global to support the development of effective approaches that address and limit impacts, especially for the most vulnerable, from the multiple interacting stressors increasingly disrupting our planet's oceans.

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More details of the RACC and its International Advisory Committee are set out at https://www.stsforum.org/racc2024/iac/

[1] IPCC (2019), "Summary for Policymakers". IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–35. https://doi.org/10.1017/9781009157964.001.

[2] UNDP (2022), "Ocean Promise", https://www.undp.org/sites/g/files/zskgke326/files/2022-06/UNDP_Ocean_Promise_V2.pdf, viewed 7 November 2024.

[3] European Commission (2024), "Maritime Transport", Blue Economy Observatory, https://blue-economy-observatory.ec.europa.eu/eu-blue-economy-sectors/maritime-transport_en, viewed 7 November 2024.

[4] IPCC (2021), "Summary for Policymakers", Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)], B.2.

[5] United Nations (2024), The Sustainable Development Goals Report 2024, Goal 14, "Life below water", pp. 36-37.

[6] Ibid.

[7] IPCC (2019), Summary for Policymakers, op. cit., A.3.

[8] UNDP (2022), Ocean Promise, op. cit.

[9] IPCC (2019), Summary for Policymakers, op. cit., A.5.

[10] Henley, B.J., McGregor, H.V., King, A.D. et al. (2024), "Highest ocean heat in four centuries places Great Barrier Reef in danger", Nature 632 (8024), 320–326, https://doi.org/10.1038/s41586-024-07672-x.

[11] Falk, J., Gleick, P. H., Asayama, S., et al (2024), "Critical hydrologic impacts from climate change: addressing an urgent global need", Sustainability Science , 19, pp. 241-244, DOI: 10.1007/s11625-023-01428-8.

[12] Scown, M. W., Dunn, F., Dekker, S. C., van Vuuren, D. P., Karabil, S., Sutanudjaja, E. H., Santos, M. J., Minderhoud, P. S. J., Garmestani, A.S., Middelkoop, H. (2023). "Global change scenarios in coastal river deltas and their sustainable development implications." Global Environmental Change. 82 p. 102736, https://doi.org/10.1016/j.gloenvcha.2023.102736. ISSN 0959-3780.

[13] Wester, P., Mishra, A. , Mukherji, A. , Shrestha, A. B. eds (2019), The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People , Springer Nature Switzerland AG, Cham. ISBN 978-3-319-92288-1 (eBook). https://doi.org/10.1007/978-3-319-92288-1x.

[14] IPCC (2022), Summary for Policymakers [H.-O.Pörtner, D.C.Roberts, E.S.Poloczanska, K.Mintenbeck, M.Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O.Pörtner, D.C.Roberts, M.Tignor, E.S.Poloczanska, K.Mintenbeck, A.Alegría, M.Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, https://doi.org/10.1017/9781009325844.001. D.3.3.

[15]Mayewski, P. A. et al. (2020). Climate Change in the Hindu Kush Himalayas: Basis and Gaps. One Earth, Volume 3, Issue 5, 551 – 555. https://doi.org/10.1016/j.oneear.2020.10.007; Shrestha, S., Bae, DH., Hok, P. *et al.* (2021), Future hydrology and hydrological extremes under climate change in Asian river basins. Sci Rep **11**, 17089, https://doi.org/10.1038/s41598-021-96656-2.

[16] IPCC (2019), Summary for Policymakers, op. cit., A.5.

[17] Schaeffer, M., Baarsch, F. et al., 2014. Loss and Damage in Africa. A UNECA/ACPC report prepared by Climate Analytics. ClimDev-Africa. http://www.climdev-africa.org.

[18] Stanford Center for Ocean Solutions, WorldFish, FAO, Beijer Institute, CARE, and EDF (2024), Integrating blue foods into national climate strategies: Enhancing nationally determined contributions and strengthening climate action. Stanford Center for Ocean Solutions. https://doi.org/10.25740/cq607gn4098.

[19] The Barcelona Statement (2024), 2024 Ocean Decade Conference, https://oceanexpert.org/document/34098, viewed 7 November 2024.

[20] Tzachor, A., Hendel, O. and Richards, C. E. (2023), "Digital twins: a stepping stone to achieve ocean sustainability?". npj Ocean Sustain 2, 16, https://doi.org/10.1038/s44183-023-00023-9.

[21] Entry, J. A., (2018), "Matrix Based Fertilizers Reduce Nutrient and Pesticide Leaching", Journal of pesticides and bio fertilizers, 16 Feb 2018, https://doi.org/16.2018/1.10009.

[22] United Nations (2023), Cordano, J. and O'Dea, N., "Informal summary report of the ocean and climate Change dialogue 2023", https://unfccc.int/documents/631689, viewed 7 November 2024.

[23] European Commission (2022), International ocean governance, https://oceans-and-fisheries.ec.europa.eu/ocean/international-ocean-governance_en, viewed 7 November 2024.