Summary of the conclusions and recommendations of the international Earth system expert workshop on ocean stresses and impacts

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Between 11th and 13th April 2011 world experts on the ocean met at the Margaret Thatcher Conference Centre, Somerville College, University of Oxford. This event was led by the International Programme on the State of the Ocean (IPSO), in partnership with the International Union for Conservation of Nature (IUCN), and brought together a select group of world science leaders on ocean stresses and impacts to reflect on these, and propose creative solutions. The workshop provided a rare opportunity to interact with other disciplines to determine the net effect of what is already happening to the ocean and is projected to do so in the future.

Through two days of presentations, discussion and debate the participants concluded that not only are we already experiencing severe declines in many species to the point of commercial extinction in some cases, and an unparalleled rate of regional extinctions of habitat types (e.g. mangroves and seagrass meadows), but we now face losing marine species and entire marine ecosystems, such as coral reefs, within a single generation. **Unless action is taken now, the consequences of our activities are at a high risk of causing, through the combined effects of climate change, overexploitation, pollution and habitat loss, the next globally significant extinction event in the ocean. It is notable that the occurrence of multiple high intensity stressors has been a pre-requisite for all the five global extinction events of the past 600 million years (Barnosky et al., 2009).**

The key points underlying this conclusion are:

- **Human actions have resulted in warming and acidification of the oceans and are now causing increased hypoxia.**
  Studies of the Earth's past indicate that these are three symptoms that indicate disturbances of the carbon cycle associated with each of the previous five mass extinctions on Earth.

- **The speeds of many negative changes to the ocean are near to or are tracking the worst-case scenarios from IPCC and other predictions. Some are as predicted, but many are faster than anticipated, and many are still accelerating.**
  Consequences of current rates of change already matching those predicted under the "worst case scenario" include: the rate of decrease in Arctic Sea Ice and in the accelerated melting of both the Greenland ice sheet and Antarctic ice sheets; sea level rise; and release of trapped methane from the seabed. These 'worst case' effects are compounding other changes more consistent with predictions including: changes in the distribution and abundance of marine species; changes in primary production; changes in the distribution of harmful algal blooms; increases in health hazards in the oceans; and loss of large, long-lived fish species causing the simplification and destabilization of food webs in marine ecosystems.

- **The magnitude of the cumulative impacts on the ocean is greater than previously understood**
  Interactions between different impacts can be negatively synergistic (negative impact greater than sum of individual stressors) or they can be antagonistic (lowering the effects of individual

impacts). Examples of such interactions include: combinations of overfishing, physical disturbance, climate change effects, nutrient runoff and introductions of non-native species leading to explosions of these invasive species, including harmful algal blooms, and dead zones; increased temperature and acidification increasing the susceptibility of corals to bleaching and acting synergistically to impact the reproduction and development of other marine invertebrates; changes in the behavior, fate and toxicity of heavy metals with acidification; acidification may reduce the limiting effect of iron availability on primary production in some parts of the ocean; increased uptake of plastics by fauna, and increased bioavailability of pollutants through adsorption onto the surface of microplastic particles; and feedbacks of climate change impacts on the oceans (temperature rise, sea level rise, loss of ice cover, acidification, increased storm intensity, methane release) on their rate of CO_2 uptake and global warming.

- **Timelines for action are shrinking.**
  The longer the delay in reducing emissions the higher the annual reduction rate will have to be and the greater the financial cost. Delays will mean increased environmental damage with greater socioeconomic impacts and costs of mitigation and adaptation measures.

- **Resilience of the ocean to climate change impacts is severely compromised by the other stressors from human activities, including fisheries, pollution and habitat destruction.**
  Examples include the overfishing of reef grazers, nutrient runoff, and other forms of pollution (presence of pathogens or endocrine disrupting chemicals) reducing the recovery ability of reefs from temperature-induced mass coral bleaching. These multiple stressors promote the phase shift of reef ecosystems from being coral-dominated to algal dominated. The loss of genetic diversity from overfishing reduces ability to adapt to stressors.

- **Ecosystem collapse is occurring as a result of both current and emerging stressors.**
  Stressors include chemical pollutants, agriculture run-off, sediment loads and over-extraction of many components of food webs which singly and together severely impair the functioning of ecosystems. Consequences include the potential increase of harmful algal blooms in recent decades; the spread of oxygen depleted or dead zones; the disturbance of the structure and functioning of marine food webs, to the benefit of planktonic organisms of low nutritional value, such as jellyfish or other gelatinous-like organisms; dramatic changes in the microbial communities with negative impacts at the ecosystem scale; and the impact of emerging chemical contaminants in ecosystems. This impairment damages or eliminates the ability of ecosystems to support humans.

- **The extinction threat to marine species is rapidly increasing.**
  The main causes of extinctions of marine species to date are overexploitation and habitat loss. However climate change is an increasing threat to species, as evidenced by the recent IUCN Red List Assessment of reef-forming corals. Some other species ranges have already extended or shifted pole-wards and into deeper cooler waters; this may not be possible for some species to achieve, potentially leading to reduced habitats and more extinctions. Shifts in currents and temperatures will affect the food supply of animals, including at critical early stages, potentially testing their ability to survive.

Technical means to achieve the solutions to many of the problems the workshop identified already exist, but current societal values prevent humankind from addressing them effectively. Overcoming these barriers is core to the fundamental changes needed to achieve a sustainable and equitable

future for the generations to come and which preserves the natural ecosystems of the Earth that we benefit from and enjoy today. Participants recommended actions in four areas:

- **Immediate reduction in CO_2 emissions** coupled with significantly increased measures for mitigation of atmospheric CO_2 and to better manage coastal and marine carbon sinks to avoid additional emissions of greenhouse gases.
    - It is a matter of urgency that the ocean is considered as a priority in the deliberations of the IPCC and UNFCCC.

- **Urgent actions to restore the structure and function of marine ecosystems**, including the coordinated and concerted action in national waters and on the High Seas (the high seas water column and seabed Area beyond national jurisdiction) by states and regional bodies to:

    - reduce fishing effort to levels commensurate with long-term sustainability of fisheries and the marine environment;
    - close fisheries that are not demonstrably managed following sustainable principles, or which depend wholly on government subsidies;
    - establish a globally comprehensive and representative system of marine protected areas to conserve biodiversity, to build resilience, and to ensure ecologically sustainable fisheries with minimal ecological footprint;
    - prevent, reduce and strictly control inputs of substances that are harmful or toxic to marine organisms into the marine environment;
    - prevent, reduce and strictly control nutrient inputs into the marine environment through better land & river catchment management and sewage treatment;
    - avoid, reduce or at minimum, universally and stringently regulate oil, gas, aggregate and mineral extraction;
    - assess, monitor and control other uses of the marine environment such as renewable energy schemes or cable / pipeline installation through comprehensive spatial planning and impact assessments procedures.

- **Proper and universal implementation of the precautionary principle** by reversing the burden of proof so activities proceed only if they are shown not to harm the ocean singly or in combination with other activities.

- **Urgent introduction by the UN Security Council and the UN General Assembly of effective governance of the High Seas** beyond the jurisdiction of any individual nations. This should include a global body empowered to ensure compliance with the UN Convention on the Law of the Sea and other relevant legal duties and norms and to establish new rules, regulations and procedures where necessary to implement these requirements in an ecosystem-based and precautionary manner.

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