American Fisheries Society

Organized in 1870 to Promote the Conservation, Development and Wise Utilization of Fisheries

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Scott Bonar
President 2019-2020

Douglas J. Austen
Executive Director

June 9, 2020

Dear AFS Member,

The American Fisheries Society is teaming with other aquatic scientific societies worldwide to author a "*Statement of World Aquatic Societies on Human-Caused Climate Change*". This statement, which will be circulated to the media, highlights major scientific findings related to effects of climate change on aquatic ecosystems. It also provides recommended actions, based on scientific findings, to avoid further degradation. All findings in this statement are supported by peer-reviewed scientific studies. This is similar to statements that other organizations (American Geophysical Union, National Academies of Sciences from dozens of countries) have provided to continue to move the public and decision makers toward climate change action.

We would like to include you in this initiative. As members of a scientific society focused on aquatic ecosystems, you provide the best science to the public and decision makers about factors that degrade these ecosystems. You know that unless checked rapidly, climate change will continue to cause irreversible changes to the earth's aquatic ecosystems, societies and economies. To avoid the worst of these changes we must continue to emphasize what the science says about the urgency for action on this issue. The world response to the Covid19 pandemic shows widespread action is possible and effective.

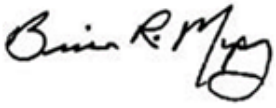
Please see attached draft. Check the statement for any needed major edits or needed further additions. We will only accept additions supported by peer-reviewed reference[s]. Also, please do not feel you have to add edits if not needed.

We are on a rapid timeline to see this statement is circulated and finalized. Therefore, could you please provide us with any edits you wish to include on the statement supported by a peer-reviewed reference(s), by email (scott_bonar@msn.com) by July 1, 2020.

Thank you for your participation in this important initiative. Evidence shows that scientists speaking out in support of science is critically important to educate the public and have scientific findings incorporated into decisions.

Sincerely,

Scott A. Bonar
President



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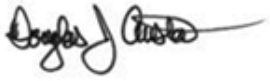

Douglas J. Austen
Executive Director

Michael E. Douglas
Chair, AFS Climate Outreach

Draft Statement of World Aquatic Societies on Human-Caused Climate Change

The Challenge

- Thousands of peer-reviewed studies by tens of thousands of scientists around the world have documented evidence for climate effects on aquatic systems that are already occurring and are extensive.
- Multiple sources including the American Geophysical Union, National Academies of Science from dozens of countries, the Intergovernmental Panel on Climate Change, and the 4th U.S. National Climate Assessment cite thousands of studies and/or support findings that increased atmospheric concentrations of greenhouse gases from fossil fuels (i.e., emissions) and deforestation are driving current climate change.
- Many of these changes are irreversible. There is no going back if we continue to allow them to occur.
- Impacts already occurring range from intensification of droughts, heat waves, floods, wildfires, increased frequency and severity of storms, melting glaciers, destabilization of major ice sheets, rising sea level, ocean acidification and deoxygenation, shifts in species ranges including expansion of invasive species, and more, with a mounting toll on vulnerable ecosystems, societies and local and global economies.
- These events are precursors of even more damages to fisheries, biodiversity and society at-large.
- Delaying action to address climate change will increase the economic, environmental and societal consequences.
- Scientific predictions of climate impacts on aquatic systems project a dire future unless immediate action is taken.
- We are near the tipping point. If humankind wishes to avoid calamitous consequences for our aquatic ecosystems, the time to control greenhouse gas emissions, sequester greenhouse gasses and adapt to an already changing climate is now. Intelligent, rapid movement toward such goals will provide great benefits to aquatic ecosystems and the humans that depend on them.
- Rapid global response is possible. Recent action by countries worldwide against the Covid19 virus demonstrated that the world can take rapid, effective, large-scale action if public and government commitment exists.

The Evidence: Effects on Marine Resources

- Shifts in species composition, behavior, abundance and biomass production are now occurring.
- Lobster, cod, mackerel, coral reef fishes, and others important to fisheries are either moving poleward, to deeper waters or declining.
- Coastal ecosystems including seagrass meadows and mangroves, warm-water corals, and kelp forests continue to decline.
- Effects of altered species compositions are cascading through entire ecosystems.
- Carbon emissions are linked to global ocean acidification, which is affecting the survival of organisms, especially shellfish.
- Reductions in global ocean dissolved oxygen concentrations have occurred over the last five decades.
- Climate change is interacting with other stressors such as excess nutrient input, overharvest, and novel species interactions to further suppress marine ecosystems.
- Global production of marine animals continues to decrease and shifts in species composition will increase unless emissions are reduced.

The Evidence: Effects on Freshwater Resources

- Freshwater ecosystems are among the most threatened on earth.
- The capacity of all freshwater ecosystems and fisheries to adapt is relatively low given the scale of impacts of climate change.
- Climate change is altering abundance, predator-prey dynamics, expansion of invasive species, growth, recruitment of species and novel species interactions leading to declines in the number and taxa of freshwater aquatic organisms.
- Increased evaporation in drought-prone areas is affecting the amount and quality of freshwater available for both aquatic organisms and humans.
- Changes in flow regimes, including increased flooding, impact native species with narrow ranges of flow requirements and provide vectors for the expansion of invasive species that affect recreational and commercial harvest of fishes and clog waterways. These changes threaten world economies and industries.
- Geographic ranges of many plants and animals have moved poleward and to higher altitudes and invasive species expand with the expansion of warmer habitats.
- Temporal shifts in seasonal cues such as spring runoff or monsoon seasons affect spawning success resulting in poor survival.
- Higher incidents of wildfire are affecting aquatic systems by making watersheds more susceptible to flooding and by reducing water quality.
- Higher temperatures and precipitation runoff have resulted in harmful algae blooms.
- Organisms dependent on snow melt and glacial streams are shifting distribution.
- Release of heavy metals such as mercury, currently stored in glaciers and the permafrost is projected to further affect freshwater organisms.
- These seemingly diverse and small-scale changes combine to create multiple, cumulatively stressful challenges to aquatic species.

The Evidence: Effects on World Society Dependent on Aquatic Resources.

- The need for clean and sufficient water is something all life-forms share.
- Fisheries provide quality protein sources not easily replaced by terrestrial sources. According to the Food and Agriculture Organization of the United Nations, fish accounts for 17% of animal protein consumed globally, fishing and aquaculture directly employ almost 60 million people, and global trade in fish products has reached USD $152 billion per year, with 54% originating in developing countries.
- In the short-term, new fisheries are appearing in some newly formed ice-free areas; however, overall fisheries catch is projected to decline related to increasing declines in water quality and primary production as a result of climate change, with corresponding effects on food security. Fish stock populations reestablishment is currently reducing 3% per decade and maximum catch potential has been decreasing 4.1% during the 21st century.
- Climate change impacts on aquatic ecosystems are affecting incomes, food security, key cultural dimensions and livelihoods of resource dependent communities.
- Species shifts are affecting traditional fisheries from the tropics to the polar regions through reduced access to fish stocks, fishing areas and loss of local knowledge.
- Climate change compounds impact of other practices such as pollution, overfishing and unsustainable coastal development. These combined impacts are projected to drive many small-scale fisheries and economies out of existence.
- Warming of waters affects seafood safety thorough elevated bioaccumulation of heavy metals and toxicants and an increased prevalence of waterborne pathogens affecting both human and animal health.
- Tourism and tourist sites are being affected in many areas that are dependent on local ecosystems. Sustainable diving, snorkeling, angling, marine mammal and bird watching, and other recreational activities and businesses depend on maintenance of healthy aquatic resources.

- Intact shoreline ecosystems such as mangroves and marshes protect coasts from erosion, storms, flooding, provide habitat and sequester carbon.
- Intact riparian ecosystems protect streams from flooding, provide shade and habitat, and sequester carbon and store water during high flow events.
- The level of fisheries impacts will be governed by the level of protective limits our nations place on future emissions combined with riparian and coastal zoning, and changes in fisheries management practices.

The Needed Responses

- We assert that rapid action is necessary to drastically curtail release of greenhouse gas emissions; and remove and store CO2 from the atmosphere to prevent the most calamitous consequences of human-caused climate change to aquatic ecosystems on which all humankind depends.
- Simply believing that climate change is occurring is not enough. Governments, the public, industry, academia and all other sectors of society must prioritize actions to halt human-caused climate change if they are to prevent dire consequences.
- We call for a rapid transition towards non-greenhouse gas emitting energy sources, other products and services that do not release greenhouse gases, and research and policies that favor an efficient transition if the considerable effects on aquatic systems described above are to be slowed.
- We call for robust adaptation measures to provide habitat for vulnerable aquatic organisms; additional research to better understand potential impacts and to arm natural resources agencies with the tools to help ease these impacts; and significant resources for data collection if we wish to help aquatic managers to better understand and plan for changes in aquatic ecosystems.
- Done intelligently, movement to curtail human-caused climate change can result in advanced, novel technologies; healthier aquatic ecosystems and higher food security and well-being for humans.

It is time to acknowledge the imminent need to act to address climate change. Delaying action to control greenhouse gas emissions is negligent if humankind wishes to conserve the world's aquatic resources and our society that depends on them.

Draft Statement of World Aquatic Societies on Human-Caused Climate Change with Peer-Reviewed Citations

The Challenge

- Thousands of peer-reviewed studies by tens of thousands of scientists around the world have documented evidence for climate effects on aquatic systems that are already occurring and are extensive.[1]
- Multiple sources including the American Geophysical Union,[2] National Academies of Science from dozens of countries,[3] the Intergovernmental Panel on Climate Change,[4] and the 4th U.S. National Climate Assessment[5] cite thousands of studies and/or support findings that increased atmospheric concentrations of greenhouse gases from fossil fuels (i.e., emissions) and deforestation are driving current climate change.
- Many of these changes are irreversible. There is no going back if we continue to allow them to occur.[6]
- Impacts already occurring range from intensification of droughts, heat waves, floods, wildfires, increased frequency and severity of storms, melting glaciers, destabilization of major ice sheets, rising sea level, ocean acidification and deoxygenation, shifts in species ranges including expansion of invasive species, and more, with a mounting toll on vulnerable ecosystems, societies and local and global economies.[7]
- These events are precursors of even more damages to fisheries, biodiversity and society at-large.[8]
- Delaying action to address climate change will increase the economic, environmental and societal consequences.[9]
- Scientific predictions of climate impacts on aquatic systems project a dire future unless immediate action is taken.[10]
- We are near the tipping point.[11] If humankind wishes to avoid calamitous consequences for our aquatic ecosystems, the time to control greenhouse gas emissions, sequester greenhouse gasses and adapt to an already changing climate is now. Intelligent, rapid movement toward such goals will provide great benefits to aquatic ecosystems and the humans that depend on them.
- Rapid global response is possible. Recent action by countries worldwide against the Covid19 virus demonstrated that the world can take rapid, effective, large-scale action if public and government commitment exists.[12]

The Evidence: Effects on Marine Resources

- Shifts in species composition, behavior, abundance and biomass production are now occurring.[13]
- Lobster,[14] cod,[15] mackerel,[16] coral reef fishes,[17] and others important to fisheries[18] are either moving poleward, to deeper waters or declining[19]
- Coastal ecosystems including seagrass meadows and mangroves,[20] warm-water corals,[21]and kelp forests[22] continue to decline.
- Effects of altered species compositions are cascading through entire ecosystems.[23]
- Carbon emissions are linked to global ocean acidification, which is affecting the survival of organisms, especially shellfish.[24]
- Reductions in global ocean dissolved oxygen concentrations have occurred over the last five decades.[25]
- Climate change is interacting with other stressors such as excess nutrient input,[26] overharvest,[27] and novel species interactions[28] to further suppress marine ecosystems.
- Global production of marine animals continues to decrease and shifts in species composition will increase unless emissions are reduced.[29]

The Evidence: Effects on Freshwater Resources

- Freshwater ecosystems are among the most threatened on earth.[30]
- The capacity of all freshwater ecosystems and fisheries to adapt is relatively low given the scale of impacts of climate change.[31]
- Climate change is altering abundance, predator-prey dynamics, expansion of invasive species, growth, recruitment of species and novel species interactions leading to declines in the number and taxa of freshwater aquatic organisms.[32]
- Increased evaporation in drought-prone areas is affecting the amount and quality of freshwater available for both aquatic organisms and humans.[33]
- Changes in flow regimes, including increased flooding, impact native species with narrow ranges of flow requirements and provide vectors for the expansion of invasive species that affect recreational and commercial harvest of fishes and clog waterways. These changes threaten world economies and industries.[34]
- Geographic ranges of many plants and animals have moved poleward and to higher altitudes and invasive species expand with the expansion of warmer habitats.[35]
- Temporal shifts in seasonal cues such as spring runoff or monsoon seasons affect spawning success resulting in poor survival.[36]
- Higher incidents of wildfire are affecting aquatic systems by making watersheds more susceptible to flooding and by reducing water quality.[37]
- Higher temperatures and precipitation runoff have resulted in harmful algae blooms.[38]
- Organisms dependent on snow melt and glacial streams are shifting distribution.[39]
- Release of heavy metals such as mercury, currently stored in glaciers and the permafrost is projected to further affect freshwater organisms.[40]
- These seemingly diverse and small-scale changes combine to create multiple, cumulatively stressful challenges to aquatic species.[41]

The Evidence: Effects on World Society Dependent on Aquatic Resources.

- The need for clean and sufficient water is something all life-forms share.
- Fisheries provide quality protein sources not easily replaced by terrestrial sources. According to the Food and Agriculture Organization of the United Nations, fish accounts for 17% of animal protein consumed globally, fishing and aquaculture directly employ almost 60 million people, and global trade in fish products has reached USD $152 billion per year, with 54% originating in developing countries.[42]
- In the short-term, new fisheries are appearing in some newly formed ice-free areas[43]; however, overall fisheries catch is projected to decline related to increasing declines in water quality and primary production as a result of climate change, with corresponding effects on food security.[44] Fish stock populations reestablishment is currently reducing 3% per decade and maximum catch potential has been decreasing 4.1% during the 21st century.[45]
- Climate change impacts on aquatic ecosystems are affecting incomes, food security, key cultural dimensions and livelihoods of resource dependent communities.[46]
- Species shifts are affecting traditional fisheries from the tropics to the polar regions through reduced access to fish stocks, fishing areas and loss of local knowledge.[47]
- Climate change compounds impact of other practices such as pollution, overfishing and unsustainable coastal development. These combined impacts are projected to drive many small-scale fisheries and economies out of existence.[48]
- Warming of waters affects seafood safety thorough elevated bioaccumulation of heavy metals and toxicants and an increased prevalence of waterborne pathogens affecting both human and animal health.[49]

- Tourism and tourist sites are being affected in many areas that are dependent on local ecosystems. Sustainable diving, snorkeling, angling, marine mammal and bird watching, and other recreational activities and businesses depend on maintenance of healthy aquatic resources.[50]
- Intact shoreline ecosystems such as mangroves and marshes protect coasts from erosion, storms, flooding, provide habitat and sequester carbon.[51]
- Intact riparian ecosystems protect streams from flooding, provide shade and habitat, and sequester carbon and store water during high flow events.[52]
- The level of fisheries impacts will be governed by the level of protective limits our nations place on future emissions combined with riparian and coastal zoning, and changes in fisheries management practices. [53]

The Needed Responses

- We assert that rapid action is necessary to drastically curtail release of greenhouse gas emissions; and remove and store CO2 from the atmosphere to prevent the most calamitous consequences of human-caused climate change to aquatic ecosystems on which all humankind depends.
- Simply believing that climate change is occurring is not enough. Governments, the public, industry, academia and all other sectors of society must prioritize actions to halt human-caused climate change if they are to prevent dire consequences.
- We call for a rapid transition towards non-greenhouse gas emitting energy sources, other products and services that do not release greenhouse gases, and research and policies that favor an efficient transition if the considerable effects on aquatic systems described above are to be slowed.
- We call for robust adaptation measures to provide habitat for vulnerable aquatic organisms; additional research to better understand potential impacts and to arm natural resources agencies with the tools to help ease these impacts; and significant resources for data collection if we wish to help aquatic managers to better understand and plan for changes in aquatic ecosystems.
- Done intelligently, movement to curtail human-caused climate change can result in advanced, novel technologies; healthier aquatic ecosystems and higher food security and well-being for humans.

It is time to acknowledge the imminent need to act to address climate change. Delaying action to control greenhouse gas emissions is negligent if humankind wishes to conserve the world's aquatic resources and our society that depends on them.

References

[1] The number of studies that have investigated effects of human-caused climate change on aquatic systems is vast. We only provide a few examples to demonstrate this statement. The largest report to date on aquatic systems with which we are familiar includes about 7,000 of references on effects of human-caused climate change on aquatic and ice-dependent systems. See: IPCC, 2019: *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.)]. In press. **The press release accompanying this report stated more than 100 authors from 36 countries referenced the about 7,000 scientific publications for this report.** Each of these reports had a list of scientists that contributed to the work. However, this is just the beginning of peer-reviewed studies and peer-reviewed compilations of studies that talk about human-caused climate change and the effects of climate change on aquatic ecosystems. **Others reports of note include:**

Fisheries. 2016. *Special Issue: Climate Change and North American Freshwater Fishes.* Volume 41, Issue 7, Fisheries, 41:7, 325-428, DOI: 10.1080/03632415.2016.1205860. **Full issue concerning effects of climate change on inland fishes containing over 90 authors and over 600 cited references.**

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. **Discusses the physical scientific evidence for change to both terrestrial and aquatic systems citing over 9200 scientific publications according to the Working Group 1 Fact Sheet.**

IPCC, 2014: *Climate Change 2014: Mitigation of Climate Change.* Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. **This report gives methods to control greenhouse gas emissions and other ways to "mitigate" or control the factors affecting climate change itself. Cites close to 10,000 studies.**

IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y .O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P .R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY , USA, 1132 pp; and IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y .O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P .R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY , USA, pp. 688. **Cites effects on a variety of systems including both aquatic and terrestrial. The fact sheet on these reports: Working Group II Fact Sheet on Climate Change 2014: Impacts, Adaptation, and Vulnerability state they cite over 12,000 scientific studies on climate change;**

IPCC, 2018: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R.

Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press. **Cites effects on a variety of systems including both aquatic and terrestrial. The press release accompanying this document states report cites more than 6,000 scientific references and resulted from contribution of thousands of expert and government reviewers worldwide**;

USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. **Cites effects on a variety of systems including both aquatic and terrestrial. Over 5600 references cited, mostly peer-reviewed, and data sets.**

USGCRP, 2017: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi: 10.7930/J0J964J6; **Cites effects on a variety of systems including both aquatic and terrestrial. Number of references not provided, but likely similar to USGCRP 2018.**

[2]American Geophysical Union (AGU). 2019. Society Must Address the Growing Climate Crisis Now. Position Statement.

[3]European Academy of Sciences 2015. Statement. Facing critical decisions on climate change in 2015; The Royal Society and the U.S National Academy of Sciences. N.D. Climate change evidence & causes. An overview from the Royal Society and the US National Academy of Sciences; Academies of Science for the G8+5 Countries. 2008. Joint science academies' statement: Climate change. Adaptation and the transition to a low carbon society; Academies of Science for the G8+5 Countries. 2007. Joint science academies' statement on growth and responsibility: Sustainability, energy efficiency and climate protection; Network of African Science Academies (NASAC). 2007. Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change; Interacademy Medical Panel (IAMP). N.D. Statement on the health co-benefits of policies to tackle climate change.

[4]See references in 1. IPCC references that cite the causes of climate change, including thorough discussions that show overwhelming evidence that emissions are the chief factor are found in IPCC, 2013; IPCC, 2014b; IPCC 2018

[5]See references in 1. USGCRP, 2017 is the primary of U.S. reports that discuss the physical basis of climate change.

[6]*"As a result of the large ocean inertia and the long lifetime of many greenhouse gases, primarily carbon dioxide, much of the warming would persist for centuries after greenhouse gas emissions have stopped."* From Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: 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.

See also IPCC, 2019: Technical Summary [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, E. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In: 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.)]. In press.

IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas

emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[7]See citations included in references in 1. Impacts are documented in vast numbers of studies in these citations.

[8]For increasing impacts on the world's oceans, freshwaters and societies start with:

Bindoff, N.L., W.W.L. Cheung, J.G. Kairo, J. Arístegui, V.A. Guinder, R. Hallberg, N. Hilmi, N. Jiao, M.S. Karim, L. Levin, S. O'Donoghue, S.R. Purca Cuicapusa, B. Rinkevich, T. Suga, A. Tagliabue, and P. Williamson, 2019: Changing Ocean, Marine Ecosystems, and Dependent Communities. In: 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.)]. In press.

Fleming, E., J. Payne, W. Sweet, M. Craghan, J. Haines, J.F. Hart, H. Stiller, and A. Sutton-Grier. 2018. Coastal Effects. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.CH8

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