Declaração das Sociedades Científicas de Ciências Aquáticas sobre a necessidade de tomar medidas urgentes contra as alterações climáticas causadas pelo homem, com base em evidências científicas

American Fisheries Society (AFS) • American Institute of Fishery Research Biologists • American Society of Ichthyologists and Herpetologists • American Water Resources Association • Asian Fisheries Society • Asociación de Oceanólogos de México, A.C. • Asociación Internacional de Hidrogeologos - Mexico Chapter • Asociatia Romana de Limnogeografei (Romanian Limnogeographical Association) • Association Française de Limnologie / French Limnological Association [EFFS member] • Associazione Italiana di Oceanologia e Limnologia [EFFS member*] • Australian Coral Reef Society • The Australian Freshwater Sciences Society • Australian Marine Sciences Association • Australian Meteorological and Oceanographic Society • Australian Society for Fish Biology • BirdLife Australia • Blue Ventures • The Brazilian Society of Ichthyology • British Phycological Society • Canadian Aquatic Resources Section (CARS) of AFS • Canadian Centre for Evidence-based Conservation • Canadian Conference for Fisheries Research • Canadian Society of Zoologists • Coastal & Estuarine Research Federation • Coastal Research and Education Society of Long Island (CRESLI) • The Coastal Society • Community of Arran Seabed Trust • Conchological Society of Great Britain and Ireland • Croatian Association of Freshwater Ecologists (CAFÉ, HUSEK) [EFFS member] • Czech Limnological Society [EFFS member*] • Deep Ocean Stewardship Initiative (Climate and Fisheries WG) • Desert Fishes Council • EFYR European Fresh and Young Scientists [EFFS member] • European Federation for Freshwater Sciences (EFFS) • Finnish Limnological Society [EFFS member] • Fisheries Society of the British Isles • The Freshwater Biological Association [EFFS member*] • Freshwater Fisheries Society of BC • Freshwater Mollusk Conservation Society • German Ichthyological Society • German Limnological Society (DGL) [EFFS member*] • Gilbert Ichthyological Society • Hungarian Hydrological Society [EFFS member] • Hydroecological Society of Ukraine • The Hydrographic Society of America • The Hydrozoan Society • Iberian Association of Limnology [EFFS member] • Ichthyological Society of Japan • Ichthyological Society of Ukraine • The Institute of Fisheries Management • International Association for Danube Research • International Association for Great Lakes Research (IAGLR) • International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC) • International Coral Reef Society • International Federation of Hydrographic Societies • International Peatland Society • International Phycological Society • International Seaweed Association • International Society of Limnology • International Water History Association • Irish Freshwater Sciences Association [EFFS member] • The Japanese Society of Fisheries Science • Lake Victoria Fisheries Association • The Limnological Society of Turkey [EFFS member] • Living Oceans Society • Macrolatinos@ Network • Malacological Society of London • Marine and Oceanographic Technology Network • The Marine Biological Association of India • Marine Biological Association of the United Kingdom • Marine Stewardship Council • National Association of Marine Laboratories (NAML) • Netherlands Malacological Society (Nederlandse Malacologische Vereniging) • The New Zealand Freshwater Sciences Society (NZFSS) • North American Lake Management Society • Oceania Chondrichthyan Society • Ocean Conservation Society • Philippine Association of Marine Science • Phycological Society of America • Polish Limnological Society [EFFS member*] • Romanian Ecological Society [EFFS member] • Scientific Committee on Antarctic Research • Serbian Water Pollution Control Society SWPCS [EFFS member] • SIL Austria [EFFS member*] Slovak Ichthyological Society • Slovak Limnological Society (SLS) [EFFS member*] • Sociedad Chilena de Limnología • Sociedad Científica Mexicana de Ecología, A.C. • Sociedad Iberica de Ictiologia • Sociedad Ictiológica Mexicana • Sociedad Mexicana de Planctologia A.C. • Sociedad Mexicana para el Estudio de los Florecimientos Algales Nocivos (SOMEFAN; Mexican Society for the Study of Harmful Algal Blooms • Sociedade Brasileira de Carcinologia • Société Française d'Ichtyologie • Society for Conservation Biology Marine Policy Section • Society for Freshwater Science • The Society for Marine Mammalogy • Society for the Study of Amphibians and Reptiles • Society of Canadian Limnologists/Société canadienne de Limnologie (SC) • Society of Wetland Scientists • Southern African Soc. Aquatic Scientists • Spanish Malacological Society (Sociedad Española de Malacología) • Swiss Hydrological and Limnological Society [EFFS member*] • Vietnam Fisheries Society (VINAFIS) • Western Indian Ocean Marine Science Association • Wild Oceans • World Aquaculture Society • The World Council of Fisheries Societies • World Sturgeon Conservation Society • Zoological Society of Pakistan*

** Denota parte da EFFS, que assinou, e uma sociedade que assinou individualmente*

A água é o recurso natural mais importante da Terra, pois é vital para a vida. Os ecossistemas aquáticos, marinhos ou de águas doces, fornecem vários benefícios para a sociedade humana, como o fornecimento de oxigénio, alimentos, água potável e recursos genéticos; regulação da composição atmosférica e do clima; purificação da água; proteção contra tempestades; mitigação de inundações / secas; áreas de recreação; e outros fins. A nossa existência e bem-estar dependem da saúde e do bom funcionamento dos ecossistemas aquáticos. As pessoas distribuem-se naturalmente em torno da água - aproximadamente 40% da população mundial vive num raio de 100 km de uma costa[1].

Os recursos aquáticos do mundo estão agora sob sua maior ameaça na história da humanidade. As alterações climáticas causadas pelos humanos estão a acelerar a degradação dos ecossistemas aquáticos e dos serviços que eles fornecem. Os ecossistemas aquáticos estão entre os mais afetados em todo o mundo (por exemplo, no caso dos ecossistemas de água doce, uma medida da biodiversidade, o "índice do planeta vivo de água doce para populações de espécies", diminuiu 83% de 1970 a 2014, enquanto até 90% dos recifes de coral desaparecerão em meados do século se as tendências atuais continuarem)[2].

Nós, cientistas aquáticos do mundo, passamos as nossas vidas a estudar estes sistemas. Estamos a ver alterações excecionais e perturbadoras nos ecossistemas aquáticos do mundo devido às alterações climáticas e acreditamos que temos o dever de partilhar as descobertas científicas validadas por pares com o público e legisladores para enfatizar a gravidade desta ameaça e a necessidade de ação imediata. Pela primeira vez, a avaliação de riscos globais conduzidos pelo Fórum Económico Mundial classificou o impacto de "falha da ação climática", "perda de biodiversidade" e "crise hídrica" entre os cinco principais riscos na próxima década[3]. Nos últimos anos, a migração aumentou e as tensões geopolíticas foram exacerbadas: entre 2008 e 2016, anualmente mais de 20 milhões de pessoas foram forçadas a se deslocar devido a eventos climáticos extremos, enquanto, de acordo com as Nações Unidas, em 2017, a água foi um importante fator de conflito em 45 países[3]. Estes efeitos negativos deverão aumentar com as tendências climáticas atuais. Por exemplo, nos Estados Unidos, o dano económico relacionado com clima é estimado em 10% do produto interno bruto até o final do século[3]. Na Europa, o custo mínimo da não adaptação às alterações climáticas é estimado em € 100 bilhões por ano em 2020 e € 250 bilhões em 2050[4].

Especialistas nas áreas ambiental, social e económica apontam coletivamente para uma crise ambiental e humanitária severa, com repercussões a nível global, a menos que ações climáticas mundialmente concertadas sejam implementadas com urgência.

Este documento resume as principais descobertas científicas, destacando o efeito das mudanças climáticas sobre os ecossistemas aquáticos. As descobertas fornecem evidências dos efeitos que estão a acontecer atualmente e por que razão os legisladores mundiais e toda a humanidade precisam agir em conjunto e lançar ações concertadas agora, se se quiser mitigar esses impactos.

O Desafio

- Milhares de estudos escrutinados por cientistas de instituições de elevada reputação mundial têm documentado evidências dos efeitos do clima nos sistemas aquáticos que estão em curso e são extensívos[5].

- Muitas fontes mundialmente respeitadas, incluindo a American Geophysical Union[6], Academias Nacionais de Ciências de dezenas de países[7], o Painel Intergovernamental sobre Mudanças Climáticas[8], e a Quarta Avaliação Nacional do Clima dos EUA[9] validam a descoberta que um aumento das concentrações atmosféricas de gases de efeito estufa provenientes da queima de combustíveis fósseis (ou seja, emissões) e as alterações no uso da terra, como a desflorestação, estão a impulsionar as mudanças climáticas atuais.
- Muitas dessas mudanças são e serão irreversíveis. Elas vão continuar a piorar se persistirmos na nossa trajetória atual[10].
- Os impactos que já ocorrem incluem aumento na frequência, intensificação e severidade das secas, ondas de calor, inundações, incêndios florestais e tempestades; derretimento de glaciares; desestabilização de grandes mantos de gelo; mudança nas correntes oceânicas, aumento do nível do mar; acidificação e desoxigenação do oceano; alterações na área de distribuição de espécies, incluindo a expansão de espécies exóticas invasoras; surtos de doenças em plantas aquáticas e animais selvagens; eventos de branqueamento massivo de corais; e mais, com um pedágio crescente em ecossistemas vulneráveis, sociedades humanas, e economias locais e globais[11].
- Estes eventos são precursores de danos ainda maiores à pesca, à biodiversidade e à sociedade humana[12].
- Atrasar ações para impedir as causas subjacentes da mudança climática agravará as consequências económicas, ambientais e sociais[13].
- Se a humanidade deseja evitar as consequências calamitosas para os nossos ecossistemas aquáticos e humanos que deles dependem, agora é o tempo para reduzir as emissões de gases de efeito estufa, sequestrar gases de efeito estufa e nos adaptarmos a um clima em mudança[14]. Um movimento rápido e inteligente em direção a esses objetivos proporcionará grandes benefícios aos ecossistemas aquáticos e aos humanos que deles dependem.
- Uma resposta global rápida e ações em larga escala são possíveis se existir um compromisso público e governamental[15].

A Evidência: Efeitos nos Recursos Marinhos

- Estão em curso alterações na composição das espécies, comportamento, abundância e produção de biomassa[16].
- As lagostas[17], o bacalhau[18], a cavala[19], os peixes de recifes de coral[20], e outras espécies importantes para a pesca[21] estão-se a movimentar em direção aos polos, para águas mais profundas ou em declínio[22].
- Os ecossistemas costeiros estão a ser transformados, degradados ou perdidos, maioritariamente[23] ou em parte devido às alterações climáticas. As alterações incluem os prados marinhos[24], mangais[25], recifes de coral[26], e florestas de algas[27].
- Os efeitos das alterações na composição de espécies estão a afetar todo o ecossistema[28].
- As emissões de carbono causam a acidificação global dos oceanos, o que está a afetar a sobrevivência dos organismos, especialmente crustáceos, e a acelerar a erosão dos recifes de coral[29].

- Tem sido documentado um aumento da frequência e intensidade das ondas de calor marinhas; prevê-se que estas ondas de calor continuem[30].
- Têm sido documentadas reduções nas concentrações globais de oxigénio dissolvido nos oceanos nas últimas cinco décadas[31].
- A alteração climática está a interagir com outros fatores de stress, como o excesso de entrada de nutrientes[32], pesca excessiva[33], e novas interações entre espécies[34] que suprimem ainda mais os ecossistemas marinhos.
- A alteração climática está ligada a surtos de doenças emergentes e re-emergentes na vida selvagem marinha e em espécies de plantas[35].
- A produção global de animais marinhos continua a diminuir e as alterações na composição das espécies irão aumentar, a menos que as emissões de gases de efeito estufa sejam reduzidas[36].
- As aves marinhas são reconhecidas como indicadores de alterações ambientais de longo prazo: quase três em cada quatro aves marinhas do mundo desapareceram desde 1950, e mais da metade das espécies restantes enfrentam ameaças substanciais[37]. Só na América do Norte, dois terços (389/604) das espécies de aves, o que inclui aves aquáticas, são moderadamente ou altamente vulneráveis às alterações climáticas num cenário de aumento da temperatura em 3°C[38].

A Evidência: Efeitos nos Recursos de Água Doce

- Os ecossistemas de água doce estão entre os mais ameaçados da Terra[39].
- Os ecossistemas de água doce cobrem menos de 1% da superfície do planeta, mas sustentam um terço das espécies de vertebrados e 10% de todas as espécies[40].
- A capacidade de adaptação de todos os ecossistemas de água doce é relativamente baixa, dada a natureza dos sistemas e a escala dos impactos das alterações climáticas[41].
- As alterações climáticas estão a alterar a abundância, a dinâmica predador-presa, a expansão de espécies invasoras, o crescimento, o recrutamento de espécies e novas interações entre espécies, levando ao declínio no número e diversidade de organismos aquáticos de água doce[42].
- O aumento da frequência, intensidade e duração da seca estão a afetar a quantidade e a qualidade da água doce disponível para os ecossistemas aquáticos e os seres humanos[43].
- As alterações climáticas afetam os regimes de caudal dos rios, incluindo tanto aumento de secas quanto os períodos de baixos caudais e ainda cheias. Estas alterações impactam principalmente espécies nativas que vivem em faixas estreitas de caudais e permitem a expansão de espécies exóticas invasoras, afetando assim a pesca recreativa e comercial de peixes e ainda as hidrovias[44].
- As variações geográficas de muitas plantas e animais mudaram em direção aos polos e para altitudes mais elevadas, enquanto espécies exóticas-invasoras se expandem com as condições cada vez mais quentes[45]. Ao contrário dos sistemas marinhos, a deslocação para outros habitats está frequentemente bloqueada, levando a extinções localizadas[46].
- Alterações temporais em sinais sazonais, como escoamento de primavera ou estações de monções, afetam o sucesso da desova de peixes, resultando em baixa sobrevivência[47].

- Uma incidência elevada de incêndios florestais está a afetar os sistemas aquáticos, tornando as bacias hidrográficas mais suscetíveis às inundações e reduzindo a qualidade da água, especialmente com cinzas pós-incêndio e deposição de sedimentos[48].
- A capacidade das zonas húmidas para armazenamento de carbono e mitigação das alterações climáticas está a ser deteriorada por mudanças ligadas a alterações no clima e outros componentes da mudança global, tais como alterações no uso do solo e incêndios[49].
- As temperaturas elevadas e o escoamento da precipitação promovem a proliferação de algas prejudiciais, que podem prejudicar peixes, mamíferos, aves e até mesmo os humanos[50].
- As mudanças climáticas podem agir sinergicamente com o incremento em nutrientes para aumentar a eutrofização e degradar ainda mais a qualidade da água e os serviços ecossistémicos, incluindo a disponibilidade de água potável[51].
- Os organismos dependentes de água proveniente do derretimento da neve e riachos glaciais estão a diminuir ou a alterar a sua distribuição[52].
- Projeta-se que a liberação de metais pesados como o mercúrio, atualmente armazenado nos glaciares e no permafrost vá afetar ainda mais os organismos de água doce[53].
- A mudança climática está ligada a surtos de doenças emergentes e re-emergentes na vida selvagem de água doce e em espécies de plantas[54].
- Estas alterações aparentemente diversas e de pequena escala combinam-se para criar stresses múltiplos e, cumulativamente que são um desafios para as espécies quáticas[55].

A Evidência: Efeitos Sobre a Sociedade Mundial Dependente dos Recursos Aquáticos

- Água limpa e em quantidade suficiente é necessária para todas as formas de vida.
- A pesca fornece fontes de proteína de qualidade que não são facilmente substituídas por fontes terrestres. De acordo com a Organização para Alimentos e Agricultura das Nações Unidas, o peixe é responsável por 17% da proteína animal que consumidos globalmente. A pesca e a aquicultura empregam diretamente quase 60 milhões de pessoas, e globalmente o comércio de produtos da pesca chega aos US $ 152 bilhões ao ano, sendo 54% originários de países em desenvolvimento[56].
- No curto prazo de tempo, novas pescarias aparecerão em algumas áreas livres de gelo recém-formadas[57]. Contudo, prevê-se que a captura global de peixes diminua em consequência do declínio crescente na qualidade da água e na produção primária como resultado das alterações climáticas, com efeitos correspondentes na segurança alimentar[58]. O aquecimento dos oceanos e as mudanças na produtividade primária estão relacionados com as mudanças na quantidade de peixes. O restabelecimento de populações de peixes diminuiu 3% por década, e o potencial máximo de captura diminuiu 4,1% ao longo do século 20[59]. Aumentos na temperatura da água devido às mudanças climáticas são projetados para exceder os limites de tolerância de 10-60% das espécies de água doce e marinhas até 2100, dependendo da quantidade de emissões de gases de efeito estufa permitidas[60].

- Os impactos das alterações climáticas nos ecossistemas aquáticos estão a afetar o rendimento, a segurança alimentar, aspetos culturais importantes e meios de subsistência de comunidades dependentes de recursos[61].
- Alterações na distribuição de espécies estão a afetar a pesca tradicional dos trópicos às regiões polares por meio da redução do acesso aos estoques de peixes, áreas de pesca e perda de conhecimento local[62].
- As alterações climáticas aumentam o impacto de outras práticas, como poluição, pesca excessiva e desenvolvimento costeiro insustentável. É esperado que esses impactos combinados conduzam ao fim de muitas atividades pesqueiras de pequena escala e da sua importância económica[63].
- O aquecimento das águas afeta a segurança dos recursos alimentares do mar por meio da elevada bioacumulação de metais pesados e poluentes e uma maior prevalência de organismos patogénicos transmitidos pela água e que afetam a saúde de humanos e animais[64].
- O turismo e os locais turísticos estão a ser afetados em muitas áreas que dependem dos ecossistemas locais. O mergulho sustentável, *snorkeling*, pesca, observação de mamíferos marinhos e aves e outras atividades recreativas e económicas dependem da manutenção de recursos aquáticos saudáveis[65].
- As alterações climáticas degradam os ecossistemas costeiros, como mangais, pradarias marinhas, pântanos, turfeiras e recifes de coral que prestam serviços aos humanos, como a proteção das costas contra a erosão, tempestades e inundações, fornecendo habitat essencial para a vida selvagem e sequestrando carbono[66].
- As alterações climáticas danificam os ecossistemas ribeirinhos que prestam serviços aos humanos, como protegendo os rios das cheias, intercetando poluentes, reduzindo a erosão, proporcionando sombra e habitat à vida selvagem, sequestrando carbono e armazenando água durante eventos de alto caudal[67].
- As alterações climáticas contribuem para prejudicar as zonas húmidas, que fornecem muitos dos mesmos serviços para humanos, como afirmado acima. As zonas húmidas desempenham um papel crítico no armazenamento e sequestro de carbono. Em particular, as turfeiras, apesar de ocuparem 3% da superfície terrestre, armazenam duas vezes mais carbono do que as florestas do mundo[68].
- O nível de impactos será governado pelo nível da proteção que nossas nações coloquem nas emissões futuras, combinadas com a zonação ripícola e costeira e as alterações nas práticas de gestão da pesca[69].

A Necessidade de Respostas

- Afirmamos que uma ação rápida é necessária para reduzir drasticamente a emissões de gases de efeito estufa e para remover e armazenar dióxido de carbono da atmosfera para evitar as consequências mais calamitosas das alterações climáticas causadas pela humanidade nos ecossistemas marinhos e de água doce, dos quais toda a humanidade depende.
- São necessárias metas globais e nacionais para proteger e restaurar ecossistemas densos em carbono, como turfeiras, pradarias marinhas e outras zonas húmidas para sequestrar carbono, prevenir as emissões de gases de efeito estufa e reduzir os impactos das alterações climáticas.

- Os governos, o público, a indústria, a academia e todos os restantes setores da sociedade devem priorizar ações e agir de forma concertada para travar as alterações climáticas causadas pela humanidade, se quiserem prevenir consequências indesejáveis.
- É necessária uma rápida transição para fontes de energia e outros produtos e serviços que não lancem gases de efeito estufa, investigações e políticas que favoreçam uma transição eficiente para um mundo de baixo carbono de forma a diminuir a degradação dos sistemas aquáticos, como acima indicado. Essa transição poderia ser realizada por todos os governos, agindo imediatamente sob o conselho de especialistas em tecnologia de energia verde, sequestro de carbono, marketing, educação, princípios socioeconómicos e disciplinas afins.
- É essencial tomar medidas de adaptação robustas, proceder à identificação e atenuação de outros agentes de stress ambiental que atuam sinergicamente com as alterações climáticas; e colocar recursos adicionais para recolha de dados, mapeamento e investigação para entender melhor os impactos potenciais e munir as agências de recursos naturais com ferramentas para mitigar esses impactos de forma a melhor compreender e planear para as alterações nos ecossistemas aquáticos.
- Feito de forma inteligente, o movimento para reduzir as alterações climáticas causadas pelo homem pode resultar em avanços, novas tecnologias; economias fortes; ecossistemas aquáticos mais saudáveis; maior segurança alimentar; e melhoria do bem-estar humano.

É hora de reconhecer a necessidade urgente de agir para enfrentar as alterações climáticas. Atrasando ações para controlar as emissões de gases de efeito estufa não é uma opção se a humanidade deseja conservar o meio aquático e segurança ambiental do mundo.

Notas

1. Center for International Earth Science Information Network. No date. Percentage of total population "living in coastal areas. Center for International Earth Science Information Network, Earth Institute, Columbia University, New York. Available: https://sedac.ciesin.columbia.edu/es/papers/Coastal_Zone_Pop_ Method.pdf. (July 2020).
2. Finlayson C. M., G. T. Davies, W. R. Moomaw, G. L. Chmura, S. M. Natali, J. E. Perry, N. Roulet, and A. E. Sutton-Grier. 2019. The second warning to humanity—providing a context for wetland management and policy. Wetlands 39:1–5.

Finlayson C. M., R. D'Cruz, and N. C. Davidson. 2005. Ecosystems and human well-being: wetlands and water, synthesis. World Resources Institute, Washington, D.C. Available: www.millenniumassessment. org/documents/document.358.aspx.pdf. (July 2020).

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World Wildlife Fund. 2018. Living planet report 2018: aiming higher. World Wildlife Fund, Gland, Switzerland [pages 75 and 54]. Available: https://wwf.panda.org/knowledge_hub/all_publications/ living_planet_report_2018/. (July 2020)

3. World Economic Forum. 2020. The global risks report 2020 [Figure II and page 31]. World Economic Fund, Geneva, Switzerland. Available: www.weforum.org/reports/the-global-risks-report-2020. (July 2020).
4. European Commission. 2020. The EU strategy on adaptation to climate change [fact sheet]. Available: https://ec.europa.eu/clima/sites/clima/files/docs/eu_strategy_en.pdf. (July 2020).
5. The number of studies that have investigated effects of human-caused climate change on aquatic systems is vast. Most literature compilations combine already observed effects with those projected. In three reports, we counted a total of more than 2,000 studies that reported observed effects on aquatic systems. We did not count projected effects. These reports are as follows:

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, editors. 2014. Climate change 2014—impacts, adaptation, and vulnerability: part B: regional aspects. Contribution of Working Group II to the fifth assessment report of the Intergovern-mental Panel on Climate Change. Cambridge University Press, New York.

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, editors. 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. Cambridge University Press, New York.

Krabbenhoft, T. J., B. J. E. Myers, J. P. Wong, C. Chu, R. W. Tingley, J. Falke, T. J. Kwak, C. P. Paukert, and A. J. Lynch. 2020. FiCli, the Fish and Climate Change Database, informs climate adaptation and manage-ment for freshwater fishes. Scientific Data 7:124.

Pörtner, H.-O., D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N. M. Weyer, editors. 2019. IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/srocc/home/. (July 2020).

These are just the beginning of peer-reviewed studies and peer-reviewed compilations of studies that discuss human-caused climate change and the effects of climate change on aquatic ecosystems. Other reports that include both projections and already observed effects on aquatic systems are as follows:

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, editors. 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. Cambridge University Press, New York. [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.]

Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufou-ma-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, editors. 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. Available: www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf. (September 2020). [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.]

Paukert, G. P., A. J. Lynch, and J. E. Whitney, editors. 2016. Effects of climate change on North American inland fishes. Fisheries 41(7). [Full issue concerning effects of climate change on inland fishes containing more than 90 authors and more than 600 cited references.]

Reidmiller, D. R., C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, editors. 2018. Impacts, risks, and adaptation in the United States: fourth national climate assessment, volume II. U.S. Global Change Research Program, Washington, D.C. [Cites effects on a variety of systems, including both aquatic and terrestrial. More than 5,600 references cited, mostly peer-reviewed, and data sets.]

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, editors. 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. Cambridge University Press, New York. [Discusses the physical scientific evidence for change to both terrestrial and aquatic systems, citing more than 9,200 scientific publications according to the Working Group 1 fact sheet.]

Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, editors. 2017. Climate science special report: fourth national climate assessment, volume I. U.S. Global Change Research Program, Washington, D.C. [Cites effects on a variety of systems, including both aquatic and terrestrial. Number of references not provided, but likely similar to U.S. Global Change Research Program 2018.]

6. American Geophysical Union (AGU). 2019. Society must address the growing climate crisis now. Position statement. AGU, Washington, D.C.
7. Statements from various academies of sciences include the following:

European Academy of Sciences. 2015. Statement. Facing critical decisions on climate change in 2015. Available: https://easac.eu/publications/details/facing-critical-decisions-on-climate-change-in-2015/. (September 2020).

The Royal Society and the U.S. National Academy of Sciences. 2020. Climate change evidence & causes: update 2020. An overview from the Royal Society and the US National Academy of Sciences. Avail-able: https://royalsociety.org/-/media/Royal_Society_Content/policy/projects/climate-evidence-causes/ climate-change-evidence-causes.pdf. (September 2020).

Academies of Science for the G8+5 Countries. 2008. Joint science academies' statement: climate change: adaptation and the transition to a low carbon society. Available: http://insaindia.res.in/pdf/Climate_05.08_W.pdf. (September 2020).

Academies of Science for the G8+5 Countries. 2007. Joint science academies' statement on growth and responsibility: sustainability, energy efficiency and climate protection. Available: www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-s4.pdf (September 2020).

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. Available: www.interacademies.org/sites/default/files/publication/nasac_g8_statement_07_-_low_res.pdf. (September 2020).

Interacademy Medical Panel (IAMP). 2010. Statement on the health co-benefits of policies to tackle climate change. Available: www.interacademies.org/statement/iamp-statement-health-co-benefits-policies-tackle-climate-change. (September 2020).

8. See references in 5. References that cite the causes of climate change, including thorough discussions that show overwhelming evidence that emissions are the chief factor, are found in Collins et al. (2013), Edenhofer et al. (2014), and Masson-Delmotte et al. (2018).
9. See references in 5. Wuebbles et al. (2017) is the primary U.S. report that discusses the physical basis of climate change.
10. "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. Pages 1029–1136 *in* T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editors. Climate change 2013: the physical science basis. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York.]

See also the following:

Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufou-ma-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, editors. 2018. Summary for policymakers. Pages 1–24 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. Available: www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_ report_HR.pdf. (September 2020).

Pörtner, H.-O., D. C. Roberts, V. Masson-Delmotte, P. Zhai, E. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N. M. Weyer, editors. 2019. Technical summary. Pages 37–69 in IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/site/assets/uploads/sites/3/2019/11/04_SROCC_TS_FINAL.pdf (September 2020).

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12. For increasing impacts on the world's oceans, freshwaters, and societies, start with the following:

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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, and N. M. Weyer, editors. IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/site/assets/uploads/sites/3/2019/11/09_SROCC_Ch05_FINAL-1.pdf. (September 2020).

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Fleming, E., J. Payne, W. Sweet, M. Craghan, J. Haines, J. F. Hart, H. Stiller, and A. Sutton-Grier. 2018. Coastal effects. Pages 322–352 in D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, editors. Impacts, risks, and adaptation in the United States: fourth national climate assessment, volume II. U.S. Global Change Research Program, Washington, D.C.

Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K. L. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou. 2018. Impacts of 1.5°C global warming on natural and human systems. Pages 175–311 in V. Masson-Delmotte, 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, editors. 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. Available: www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter3_Low_Res.pdf. (July 2020).

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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. Available: www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_ report_LR.pdf. (July 2020). [Pages 7–11.]

World Bank. 2019. Climate change and marine fisheries in Africa: assessing vulnerability and strengthening adaptation capacity. World Bank, Washington, D.C.

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