Declaratoria de las Sociedades Científicas Acuáticas del mundo sobre la necesidad de emprender acciones urgentes contra el cambio climático causado por las acciones humanas, usando la evidencia científica

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 – Capítulo Mexico • Asociatia Romana de Limnogeografei (Romanian Limnogeographical Association) • Association Française de Limnologie / French Limnological Association [miembro EFFS*] • Associazione Italiana di Oceanologia e Limnologia [miembro EFFS*] • 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) [miembro EFFS] • Czech Limnological Society [miembro EFFS*] • Deep Ocean Stewardship Initiative (Climate and Fisheries WG) • Desert Fishes Council • EFYR European Fresh and Young Scientists [miembro EFFS] • European Federation for Freshwater Sciences (EFFS) • Finnish Limnological Society [miembro EFFS] • Fisheries Society of the British Isles • The Freshwater Biological Association [miembro EFFS*] • Freshwater Fisheries Society of BC • Freshwater Mollusk Conservation Society • German Ichthyological Society • German Limnological Society (DGL) [miembro EFFS*] • Gilbert Ichthyological Society • Hungarian Hydrological Society [miembro EFFS] • Hydroecological Society of Ukraine • The Hydrographic Society of America • The Hydrozoan Society • Iberian Association of Limnology [miembro EFFS] • 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 [miembro EFFS] • The Japanese Society of Fisheries Science • Lake Victoria Fisheries Association • The Limnological Society of Turkey [miembro EFFS] • Living Oceans Society • Red Macrolatinos@ • 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 [miembro EFFS*] • Romanian Ecological Society [miembro EFFS] • Scientific Committee on Antarctic Research • Serbian Water Pollution Control Society SWPCS [EFFS member] • SIL Austria [miembro EFFS*] • Slovak Ichthyological Society • Slovak Limnological Society (SLS) [miembro EFFS*] • 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 [miembro EFFS*] • 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

* Ambas partes declaran que firman como EFFS y como Sociedad individual

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El agua es el recurso natural más importante del planeta, ya que es fundamental para la vida. Los ecosistemas acuáticos, dulces o marinos, proporcionan múltiples beneficios para la sociedad, incluyendo: producción de oxígeno, alimento, agua potable y recursos genéticos; regulación de la composición atmosférica y el clima; purificación del agua; amortiguamiento de tormentas; mitigación de inundaciones y sequías; y brindan áreas recreativas; entre otros propósitos. Nuestra existencia y calidad de vida dependen del estado y correcto funcionamiento de los ecosistemas acuáticos. Las sociedades se asientan espontáneamente alrededor de los cuerpos de agua –aproximadamente el 40% de la población mundial vive a menos de 100 km (62 millas) de alguna costa[1].

Los ecosistemas acuáticos del mundo se encuentran en el mayor estado de amenaza de la historia. Como consecuencia de las actividades antrópicas, el cambio climático acelera la degradación de los ecosistemas acuáticos y los servicios ecosistémicos que éstos proveen. Los ecosistemas acuáticos están entre los más afectados en todo el mundo. Por ejemplo, en el caso de los ecosistemas de agua dulce, una medición de biodiversidad –el índice de poblaciones de especies "*fresh living planet index*", decayó un 83% desde 1970 hasta 2014; mientras que, para mediados de siglo, en caso de que se mantengan las tendencias actuales, desaparecerán hasta un 90% de los arrecifes de coral del mundo[2].

Nosotros los científicos acuáticos dedicamos nuestras vidas a estudiar ecosistemas acuáticos. Vemos que los ecosistemas acuáticos del mundo están sufriendo cambios excepcionales y alarmantes debido al cambio climático. Entendemos que es nuestro deber continuar compartiendo hallazgos científicos -revisados por pares- con el público y decisores políticos del mundo, a fin de enfatizar la seriedad de la amenaza y la necesidad urgente de tomar medidas inmediatas. Por primera vez, la evaluación de riesgo global realizada por el Foro Económico Mundial determinó el impacto de "fracaso de acciones climáticas", "pérdida de biodiversidad" y "crisis del agua" entre los cinco riesgos más altos de la próxima década[3]. En los últimos años la migración aumentó y las tensiones geopolíticas se exacerbaron: entre 2008 y 2016, más de 20 millones de personas por año fueron forzadas a desplazarse debido a eventos climáticos extremos; mientras que, según las Naciones Unidas, en el año 2017, el agua fue un factor principal en conflictos en 45 países[3]. Se espera que, siguiendo tendencias climáticas actuales, los efectos negativos se incrementen. Por ejemplo, para los Estados Unidos, se estima que los daños económicos derivados de eventos climáticos alcanzarán el 10% del Producto Bruto Interno hacia fin de siglo. Para Europa, se estima que el costo mínimo de no tomar medidas de adaptación al cambio climático sería de €100 miles de millones para el año 2020 y €250 miles de millones para el año 2025[4].

Expertas y expertos en los campos ambientales, sociales y económicos coinciden en un pronóstico marcado por la crisis ambiental y humanitaria, con consecuencias a nivel mundial, sólo evitable mediante la urgente adopción de acciones climáticas a nivel mundial. En este documento se resumen los hallazgos científicos clave, haciendo énfasis en los efectos del cambio climático en ecosistemas acuáticos. Estos hallazgos proveen evidencia de aquellos efectos actuales y los motivos por los cuales, si se pretende mitigar estos impactos, decisores políticos del mundo y toda la humanidad, deberá actuar de manera conjunta y adoptar acciones concertadas inmediatas.

El Desafío

- Miles de estudios -revisados por pares- realizados por investigadoras e investigadores pertenecientes a instituciones de referencia en todo el mundo, han documentado evidencia de los efectos del clima sobre los ecosistemas acuáticos que actualmente ocurren y que a su vez son extensivos[5].
- Muchas fuentes respetadas a nivel mundial, incluyendo la Unión Geofísica de los Estados Unidos[6], las academias de ciencia de docenas de países[7], el Panel Intergubernamental sobre el Cambio Climático[8], y la 4° Evaluación Climática de los Estados Unidos[9] apoyan los hallazgos referidos a la incidencia en el cambio climático actual generada tanto por el incremento de la concentración de gases de efecto invernadero en la atmósfera debido al uso de combustibles fósiles (por ejemplo, emisiones), como los cambios de uso del suelo por actividades como la deforestación.
- Muchos de estos cambios son y serán irreversibles. Si mantenemos el rumbo actual también continuarán empeorando[10].
- Los impactos que ocurren actualmente van desde el incremento en la frecuencia, intensidad y severidad de sequías, olas de calor, inundaciones, incendios forestales y tormentas; derretimiento de glaciares; desestabilización de las mayores capas de hielo continental; cambios en las corrientes oceánicas e incremento del nivel del mar; acidificación y pérdida de oxígeno de océanos; cambios en la distribución de especies incluyendo diseminación de especies exóticas invasivas; epidemias de enfermedades en plantas y animales acuáticos; eventos masivos de blanqueo de corales; entre otros (todos estos con una gravedad exponencial dependiendo de la vulnerabilidad de los ecosistemas, sociedades, y economías locales y globales)[11].
- A su vez, estos eventos son precursores de mayores daños a recursos pesqueros, biodiversidad y la población mundial en su totalidad[12].
- Demorar en actuar para detener las causas subyacentes del cambio climático incrementará las consecuencias económicas, ambientales y sociales[13].
- Si la humanidad pretende evitar consecuencias catastróficas para los ecosistemas acuáticos y para las sociedades que de éstos dependen, es tiempo de disminuir las emisiones de gases de efecto invernadero, capturar gases de efecto invernadero y tomar medidas de adaptación a un clima actualmente en proceso de cambio[14]. Acciones rápidas e inteligentes hacia estos objetivos generarán grandes beneficios para los ecosistemas acuáticos y para las sociedades que de éstos dependen.
- Si existe un compromiso por parte del público y de los gobiernos, es posible adoptar respuestas rápidas a nivel global y acciones a gran escala[15].

Evidencia: Efectos en los recursos marinos

- Están ocurriendo cambios en la composición de especies, conducta, abundancia y producción de biomasa[16].
- Las langostas[17], bacalaos[18], caballas[19], peces de arrecifes de coral[20], y otras especies de importancia para los recursos pesqueros[21], o bien se están desplazando hacia aguas profundas, o bien decayendo su abundancia[22].

- Los ecosistemas costeros están siendo transformados, degradados o perdidos parcial o totalmente debido al cambio climático; incluyendo praderas de fanerógamas marinas[24], manglares[25], arrecifes de coral[26] y bosques de algas[27].
- Los efectos de la alteración en la composición de especies están afectando ecosistemas enteros[28].
- Las emisiones de carbono causan acidificación en los océanos del planeta, lo que afecta la supervivencia de organismos -especialmente crustáceos y moluscos- y acelera la erosión de arrecifes de coral[29].
- Se ha documentado el incremento en frecuencia e intensidad de corrientes cálidas marinas; lo que se prevé que continue[30].
- Durante las últimas cinco décadas se ha reducido la concentración de oxígeno disuelto en los océanos del planeta[31].
- El cambio climático actúa con otros factores de estrés (como el aporte de nutrientes[32], sobreexplotación de recursos[33], e interacción con especies introducidas[34]), generando una presión aún mayor sobre los ecosistemas marinos.
- El cambio climático está vinculado con la aparición y reaparición de brotes de enfermedades en la flora y fauna marina[35].
- A menos que se reduzcan las emisiones de gases de efecto invernadero, la producción global de animales marinos continuará decayendo y los cambios en la composición de especies continuarán incrementando[36].
- Las aves marinas son reconocidas como indicadores de cambios ambientales a largo plazo: alrededor de tres de cada cuatro especies de aves marinas de todo el mundo han desaparecido desde 1950; mientras que más de la mitad de las especies restantes enfrentan serias amenazas[37]. Sólo en Norte América, dos tercios de las especies de aves (389/604) –lo que incluye aves acuáticas- resultan moderada o altamente vulnerables al cambio climático en un escenario por debajo de los 3°C[38].

Evidencia: Efectos sobre los recursos de agua dulce

- Los ecosistemas de agua dulce se encuentran entre los más amenazados del planeta[39].
- Los ecosistemas de agua dulce cubren menos del 1% de la superficie del planeta, pero contienen un tercio de las especies de vertebrados y un 10% de todas las especies[40].
- La capacidad de todos los ecosistemas de agua dulce de adaptación es relativamente baja, dada la naturaleza de estos ecosistemas y la escala de los impactos del cambio climático[41].
- El cambio climático está alterando la abundancia, la dinámica entre predadores y sus presas, la expansión de especies invasoras, el crecimiento, la movilización de especies y las nuevas interacciones entre especies; lo que conduce a un decrecimiento en el número y la diversidad de los organismos acuáticos[42].
- La calidad y la cantidad de agua dulce disponible para ecosistemas acuáticos y consumo humano se encuentran afectadas por el incremento en la frecuencia, intensidad y duración de las sequías[43].
- Los impactos del cambio climático sobre los regímenes fluviales, incluyendo el incremento de sequías y períodos de baja descarga, y los aumentos en crecidas incrementan los impactos

sobre especies nativas con baja tolerancia a la variabilidad del caudal, mientras que favorecen la expansión de especies exóticas invasoras que afectan el uso recreativo y comercial de las pesquerías y obstruyen los canales de flujo[44].

- Los rangos geográficos de muchas plantas y animales han sido desplazados hacia los polos y hacia mayores altitudes, mientras que especies exóticas invasoras se expanden con las condiciones cada vez más cálidas[45]. A diferencia de los sistemas marinos, las vías migratorias hacia otros hábitats usualmente son bloqueadas, llevando a extinciones localizadas[46].
- Cambios temporales en las señales estacionales (como el incremento de la escorrentía en primavera o la temporada de monzones), afectan la efectividad en desoves de peces, resultando en bajas tasas de supervivencia[47].
- El aumento en la incidencia de incendios forestales está afectando ecosistemas acuáticos, dado que hacen de las cuencas sistemas más susceptibles a inundaciones y reducen la calidad del agua (especialmente con la deposición de ceniza y sedimentos luego de los incendios)[48].
- La capacidad de los humedales para captar carbono y para mitigar el cambio climático está siendo dañada por las alteraciones vinculadas al cambio climático y otros componentes del cambio global (como el incremento de desarrollos sobre los territrios e incendios)[49].
- Han incrementado eventos de floraciones de algas dañinas como consecuencia del incremento de las temperaturas y la escorrentía de precipitaciones. Estas floraciones son potencialmente tóxicas para peces, mamíferos, aves e incluso humanos[50].
- El cambio climático puede actuar de manera sinérgica con la disponibilidad de nutrientes y resultar en la magnificación de procesos de eutrofización. Esto conlleva a una mayor pérdida de calidad de agua y de servicios ecosistémicos, incluyendo efectos sobre el agua de consumo humano[51].
- Los organismos dependientes del deshielo y arroyos glaciales están disminuyendo o alternado su distribución[52].
- Se prevé un efecto complementario sobre los organismos de agua dulce proveniente de la liberación de metales pesados -como el mercurio- actualmente retenidos en glaciares y en el permafrost[53].
- Se vincula al cambio climático con la aparición y reaparición de enfermedades en especies de flora y fauna de sistemas de agua dulce[54].
- Estos cambios, aparentemente diversos y en pequeña escala, se combinan para crear múltiples desafíos cada vez más estresantes para las especies acuáticas[55].

Evidencia: Efectos sobre las sociedades del mundo dependientes de recursos acuáticos.

- Todas las formas de vida requieren una cantidad suficiente de agua pura.
- Los recursos pesqueros son una fuente de alta calidad de proteínas, las que no son fácilmente reemplazables mediante fuentes terrestres. Según la Organización de las Naciones Unidas para la Agricultura y la Alimentación, los recursos pesqueros aportan el 17% de las proteínas animales consumidas globalmente; la pesca y la acuicultura generan cerca de 60 millones de

empleos directos; y el mercado global de productos pesqueros alcanzó los US$ 152 miles de millones por año, de los que un 54% se originan en países en vías de desarrollo[56].

- En el corto plazo, nuevos sitios pesqueros están surgiendo en algunas áreas recientemente descongeladas[57]. No obstante, a consecuencia del cambio climático, se espera una disminución en la producción de recursos pesqueros -y sus implicancias en la seguridad alimentaria- relacionada con la pérdida de calidad tanto de agua como de producción primaria[58]. El incremento de la temperatura de los océanos y los cambios en la producción primaria se encuentran relacionados con los cambios en muchos bancos de peces. La recuperación de la abundancia de peces ha disminuido un 3% por década, mientras que el potencial de captura máximo disminuyó un 4,1% durante el siglo XX[59]. Dependiendo de la permisividad en la regulación de emisiones de gases de efecto invernadero, para el año 2100 se estima que el incremento de la temperatura del agua debido al cambio climático excederá los límites de tolerancia de especies marinas y de agua dulce (del 10 al 60%)[60].
- Los efectos del cambio climático sobre los ecosistemas acuáticos afectan ingresos, seguridad alimentaria, dimensiones culturales clave y supervivencia de comunidades dependientes de estos recursos[61].
- El desplazamiento de especies está afectando a la pesca tradicional, de los trópicos hasta las regiones polares, reduciendo la accesibilidad tanto a los bancos de pesca como a zonas de pesca, y provocando la pérdida de conocimientos locales[62].
- El cambio climático agrava también el impacto de otras conductas como la contaminación, sobreexplotación de los recursos pesqueros y desarrollos de proyectos costeros no sustentables. Se prevé que la combinación de estos impactos hará desaparecer numerosas actividades pesqueras y economías de pequeña escala[63].
- El calentamiento de las aguas afecta la seguridad de los alimentos marinos, elevando la bioacumulación de metales pesados y contaminantes, e incrementando la prevalencia de patógenos trasmitidos en el agua (los que afectan a la salud tanto humana como animal)[64].
- El turismo y los sitios turísticos están siendo afectados en numerosas áreas que dependen de los ecosistemas locales. El buceo sustentable, el snorkeling, la pesca deportiva, el avistamiento de mamíferos y aves marinas, y otras actividades recreativas y negocios dependen necesariamente de mantener recursos acuáticos sanos[65].
- El cambio climático degrada los ecosistemas costeros como manglares, pantanos, turberas y arrecifes de coral. Todos ellos proveen servicios ecosistémicos a los humanos incluyendo la protección de las costas de la erosión, tormentas e inundaciones, la provisión de hábitats fundamentales para la fauna y el secuestro carbono[66].
- El cambio climático daña los ecosistemas riparios. Estos ecosistemas proveen servicios a los humanos, como la protección de ríos y arroyos de inundaciones, interceptan contaminantes, reducen la erosión, proveen resguardo y hábitat para la fauna, secuestran carbono y regulan la descarga de agua durante las temporadas de lluvia[67].
- El cambio climático contribuye al deterioro de los humedales, los que también proveen muchos de los servicios ecosistémicos mencionados anteriormente. Los humedales tienen un rol fundamental en el secuestro y almacenamiento de carbono. En particular, las turberas -aunque sólo ocupan el 3% de la superficie continental- almacenan el doble del carbono que todas las selvas del mundo juntas[68].

- El nivel de los impactos dependerá del nivel de restricción en los límites de protección que nuestras naciones determinen para la combinación de futuras emisiones, zonificación de zonas riparias y costas, y con los cambios en las prácticas del manejo de los recursos pesqueros[69].

Respuestas necesarias

- Proclamamos que se debe actuar rápidamente para disminuir la emisión de gases de efecto invernadero y remover y almacenar el CO_2 de la atmósfera, a fin de prevenir que los ecosistemas marinos y de agua dulce -de los que toda la humanidad depende- sufran las peores consecuencias del cambio climático generado por la humanidad.
- Es menester definir objetivos nacionales y globales orientados a: proteger y recuperar ecosistemas con alta densidad de carbono (turberas, lechos de algas y otros humedales); capturar carbono de la atmósfera; prevenir la emisión de gases de efecto invernadero; y reducir los impactos del cambio climático.
- Para evitar la degradación mencionada en el apartado anterior, se requiere una transición rápida hacia fuentes energéticas y otros productos y servicios que no generen emisiones de gases de efecto invernadero; así como también se requiere investigación y políticas que favorezcan una transición eficiente a un sistema bajo en emisiones de carbono. La transición puede ser materializada por todos los gobiernos a partir de actuar siguiendo las recomendaciones de las y los especialistas en tecnologías de energías limpias, captura de carbono atmosférico, mercadeo, educación, principios socioeconómicos, y otras disciplinas afines.
- Para mejorar el entendimiento y planificar los cambios en los ecosistemas acuáticos, urge: adoptar medidas robustas de adaptación; identificar y atenuar otros estresores ambientales que actúan sinérgicamente con el cambio climático; incorporar fuentes adicionales de recopilación de datos, mapeos e investigación para mejorar el entendimiento de los impactos potenciales y para dotar a las autoridades ambientales con las herramientas que permitan mitigar los efectos del cambio climático.
- Concretado de manera inteligente, la reducción del cambio climático antrópico puede resultar en tecnologías novedosas y de avanzada, economías fuertes, ecosistemas acuáticos más sanos, mayor seguridad alimentaria, y mayor calidad de vida.

Es tiempo de reconocer la urgente necesidad de actuar contra el cambio climático. Si la humanidad pretende conservar los recursos acuáticos y la seguridad ambiental del mundo, no puede optar por retrasar acciones orientadas a controlar las emisiones de gases de efecto invernadero.

El documento completo y original se puede consultar y descargar desde la página de **American Fisheries Society**, en el siguiente enlace

Declaratoria mundial de sociedades científicas acuáticas

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Notes (no traducidas de la version original)

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.

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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).7 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 Intergovernmental 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 8 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. Available: 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).

11. See citations included in references in 5. Impacts are documented in vast numbers of studies in these citations.

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

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. Pages 447–587 *in* 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, 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).

Brugere C., D. M. Onuigbo, and K. L. Morgan. 2017. People matter in animal disease surveillance: challenges and opportunities for the aquaculture sector. Aquaculture 467:158–169.

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, Wash-ington, 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).

Lipton, D., M. A. Rubenstein, S. R. Weiskopf, S. Carter, J. Peterson, L. Crozier, M. Fogarty, S. Gaichas, K. J. W. Hyde, T. L. Morelli, J. Morisette, H. Moustahfid, R. Muñoz, R. Poudel, M. D. Staudinger, C. Stock, L. Thompson, R. Waples, and J. F. Weltzin. 2018. Ecosystems, ecosystem services, and biodiversity. Pages 268–321 *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.

Pershing, A. J., R. B. Griffis, E. B. Jewett, C. T. Armstrong, J. F. Bruno, D. S. Busch, A. C. Haynie, S. A. Siedlecki, and D. Tommasi. 2018. Oceans and marine resources. Pages 353–390 *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.

Pörtner, H.-O., D. M. Karl, P. W. Boyd, W. W. L. Cheung, S. E. Lluch-Cota, Y. Nojiri, D. N. Schmidt, and P. O. Zavialov. 2014. Ocean systems. Pages 411–484 in C. B. Field, 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. 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.

Settele, J., R. Scholes, R. Betts, S. Bunn, P. Leadley, D. Nepstad, J. T. Overpeck, and M. A. Taboada. 2014. Terrestrial and inland water systems. Pages 271–359 *in* C. B. Field, 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. 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.

Wong, P. P., I. J. Losada, J.-P. Gattuso, J. Hinkel, A. Khattabi, K. L. McInnes, Y. Saito, and A. Sallenger. 2014. Coastal systems and low-lying areas. Pages 361–409 in C. B. Field, 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. 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.

13. 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. Avail-able: 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.

14. 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 con text of strengthening the global response to the threat of climate change, sustainable development, and efforts

to eradicate pov-erty. Available: www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_ version_report_LR.pdf. (July 2020). [Page 4.]

15. Some examples of large-scale, rapid action in response to disease epidemics reported in the following:

Cheng, V. C. C., S. C. Wong, J. H. K. Chen, C. C. Y. Yip, V. W. M. Chuang, O. T. Y. Tsang, S. Sridhar, J. F. W. Chan, P. L. Ho, and K. Y. Yuen. 2020. Escalating infection control response to the rapidly evolving epidemiology of the coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. Infection Control and Hospital Epidemiology 41:493–498.

Smith, N., and M. Fraser. 2020. Straining the system: novel coronavirus (COVID-19) and preparedness for concomitant disasters. American Journal of Public Health 110:648–649.11

Sohrabi, C., Z. Alsafi, N. O'Neill, M. Khan, A. Kerwan, A. Al-Jabir, C. Iosifidis, and R. Agha. 2020. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19), International Journal of Surgery 76:71–76.

16. 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. Pages 447– 587 *in* 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, 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). [Pages 450–451, 478– 481.]

Burrows, M. T., D. S. Schoeman, A. J. Richardson, J. G. Molinos, A. Hoffmann, L. B. Buckley, P. J. Moore, C. J. Brown, J. F. Bruno, C. M. Duarte, B. S. Halpern, O. Hoegh-Guldberg, C. V. Kappel, W. Kiessling, M. I. O'Connor, J. M. Pandolfi, C. Parmesan, W. J. Sydeman, S. Ferrier, K. J. Williams, and E. S. Poloczanska. 2014. Geographical limits to species-range shifts are suggested by climate velocity. Nature 507:492–495.

Chambers, L. E., P. Dann, B. Cannell, and E. J. Woehler. 2014. Climate as a driver of phenological change in southern seabirds. International Journal of Biometeorology 58:603–612.

Chambers, L. E., C. A. Devney, B. C. Congdon, N. Dunlop, E. J. Woehler, and P. Dann. 2011. Observed and predicted impacts of climate on Australian seabirds. Emu 111:235–251.

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). [Pages 218, 222.]

Nagelkerken, I., and S. D. Connell, 2015: Global alteration of ocean ecosystem functioning due to increasing human CO2 emissions. Proceedings of the National Academy of Sciences of the United States of America 112:13272–13277.

Poloczanska, E. S., C. J. Brown, W. J. Sydeman, W. Kiessling, D. S. Schoeman, P. J. Moore, K. Brander, J. F. Bruno, L. B. Buckley, M. T. Burrows, C. M. Duarte, B. S. Halpern, J. Holding, C. V. Kappel, M. I. O'Connor, J. M. Pandolfi, C. Parmesan, F. Schwing, S. A. Thompson, and A. J. Richardson. 2013. Global imprint of climate change on marine life. Nature Climate Change 3:919–925.

Price C. A., K. Hartmann, T. J. Emery, E. J. Woehler, C. R. McMahon, M. A. Hindell. 2020. Climate variability and breeding parameters of a trans-hemispheric migratory seabird over seven decades. Marine Ecology Progress Series 642:191–205.

Vergés, A., P. D. Steinberg, M. E. Hay, A. G. B. Poore, A. H. Campbell, E. Ballesteros, K. L. Heck, D. J. Booth, M. A. Coleman, D. A. Feary, W. Figueira, T. Langlois, E. M. Marzinelli, T. Mizerek, P. J. Mumby, Y. Nakamura, M. Roughan, E. van Sebille, A. S. Gupta, D. A. Smale, F. Tomas, T. Wernberg, and S. K. Wilson, 2014. The tropicalization of temperate marine ecosystems: climate-mediated changes in herbivory and community phase shifts. Proceedings of the Royal Society B 281(1789):20140846.

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Gould, W. A., E. L. Díaz, (co-leads), N. L. Álvarez-Berríos, F. Aponte-González, W. Archibald, J. H. Bowden, L. Carrubba, W. Crespo, S. J. Fain, G. González, A. Goulbourne, E. Harmsen, E. Holup-chinski, A. H. Khalyani, J. Kossin, A. J. Leinberger, V. I. Marrero-Santiago, O. Martínez-Sánchez, K. McGinley, P. Méndez-Lázaro, J. Morell, M. M. Oyola, I. K. Parés-Ramos, R. Pulwarty, W. V. Sweet, A. Terando, and S. Torres-González, 2018: U.S. Caribbean. Pages 809–871 *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.

Le Bris, A., K. E. Mills, R. A. Wahle, Y. Chen, M. A. Alexander, A. J. Allyn, J. G. Schuetz, J. D. Scott, and A. J. Pershing. 2018. Climate vulnerability and resilience in the most valuable North American fishery. Proceedings of the National Academy of Sciences of the United States of America. 115:1831–1836.

18. Barbeaux, S., K. Aydin, B. Fissel, K. Holsman, W. Palsson, K. Shotwell, Q. Yang, and S. Zador. 2017. Assessment of the Pacific Cod stock in the Gulf of Alaska. Pages 189–332 *in* North Pacific Fisheries Management Council Gulf of Alaska SAFE (Stock Assessment and Fishery Evaluation) [council draft]. Available: www.city.kodiak.ak.us/sites/default/files/fileattachments/fisheries_workgroup/meeting/10388/2017_goa_pcod_stock_assessment.pdf. (July 2020).

19. Meredith, M., M. Sommerkorn, S. Cassotta, C. Derksen, A. Ekaykin, A. Hollowed, G. Kofinas, A. Mackintosh, J. Melbourne-Thomas, M. M. C. Muelbert, G. Ottersen, H. Pritchard, and E. A. G. Schuur. 2019. Polar regions. Pages 203–320 *in* 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, 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/3/2019/11/07_SROCC_Ch03_FINAL.pdf. (July 2020).

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