14. September 2020

Erklärung von mehr als 100 Fachgesellschaften für Wasserforschung weltweit zu den Auswirkungen des Klimawandels auf die Wasser-Ökosysteme

„Es ist dringend notwendig, Maßnahmen gegen den vom Menschen verursachten Klimawandel auf der Grundlage wissenschaftlicher Erkenntnisse zu ergreifen!“

Wasser ist die wichtigste natürliche Ressource, denn es ist für das Leben auf der Erde essenziell. Aquatische Ökosysteme, ob Süß- oder Meerwasserökosysteme, bieten der menschlichen Gesellschaft vielfältigen Nutzen. Dazu gehören u.a. die Versorgung mit Sauerstoff, Nahrung, Trinkwasser und genetischen Ressourcen, die Regulierung der Atmosphäre und des Klimas, die Wasserreinigung, das Abschwächen von Stürmen, die Eindämmung von Überschwemmungen und Dürren sowie das Bereitstellen von Erholungsgebieten. Unsere Existenz und unser Wohlbefinden hängen von der Gesundheit und dem guten Funktionieren der aquatischen Ökosysteme ab. Die Menschen siedeln um das Wasser herum – etwa 40 Prozent der Weltbevölkerung lebt innerhalb eines 100 km-Radius von einer Küste entfernt (1).

Die Wasserressourcen der Welt sind derzeit der stärksten Bedrohung in der Geschichte der Menschheit ausgesetzt. Der vom Menschen verursachte Klimawandel beschleunigt die Degradation der aquatischen Ökosysteme und der von ihnen erbrachten Dienstleistungen. Aquatische Ökosysteme gehören weltweit zu den am stärksten betroffenen Ökosystemen. Zum Beispiel wurde bei den Süßwasser-Ökosystemen zwischen 1970 und 2014 ein Rückgang des „freshwater living planet index für species and populations“, einem Maß zur Erfassung der globalen biologischen Vielfalt, um 83 Prozent verzeichnet, während bis zu 90 Prozent der Korallenriffe bis Mitte des Jahrhunderts verschwinden werden, wenn die derzeitigen Trends anhalten (2).

Wir, die Wasserforscher weltweit, verbringen unser Leben damit, diese Systeme zu untersuchen. Wir sehen außergewöhnliche und beunruhigende Veränderungen in den aquatischen Ökosystemen aufgrund des Klimawandels. Wir glauben, dass wir weiterhin wissenschaftliche Erkenntnisse mit der Öffentlichkeit und den politischen Entscheidungsträgern teilen müssen, um die Ernsthaftigkeit dieser Bedrohung und die Notwendigkeit sofortiger Maßnahmen hervorzuheben. Die vom Weltwirtschaftsforum durchgeführte Bewertung globaler Risiken stufte zum ersten Mal die Auswirkungen des "Versagens im Kampf gegen den Klimawandel", des "Verlusts der Biodiversität" und der "Wasserkrise" unter die Top 5-Risiken des nächsten Jahrzehnts ein (3). In den vergangenen Jahren hat die Migration zugenommen und die geopolitischen Spannungen haben sich verschärft: Zwischen 2008 und 2016 waren jährlich über 20 Millionen Menschen aufgrund extremer Wetterereignisse gezwungen, umzuziehen, während laut UNO im Jahr 2017 Wasser in 45 Ländern ein entscheidender Faktor für Konflikte war (3). Diese negativen Auswirkungen dürften unter den gegenwärtigen klimatischen Trends noch zunehmen. In den USA beispielsweise werden die klimabedingten wirtschaftlichen Schäden bis zum Ende des Jahrhunderts schätzungsweise 10 Prozent des Bruttoinlandsprodukts (BIP) erreichen (3). In Europa werden die Mindestkosten für die Nichtanpassung an den Klimawandel auf 100 Milliarden Euro pro Jahr im Jahr 2020 und 250 Milliarden Euro im Jahr 2050 geschätzt (4).

Experten der Umwelt-, Sozial- und Wirtschaftswissenschaften warnen gemeinsam vor einer schweren ökologischen und humanitären Krise mit globalen Auswirkungen, sollten nicht schnellstens weltweit konzertierte Klimaschutzmaßnahmen durchgeführt werden.

Dieses Dokument fasst die wichtigsten wissenschaftlichen Erkenntnisse zusammen, die die Auswirkungen von Klimaveränderungen auf aquatische Ökosysteme beleuchten. Diese Ergebnisse machen deutlich, warum politische Entscheidungsträger weltweit und die gesamte Menschheit jetzt gemeinsam handeln und konzertierte Aktionen einleiten müssen, wenn sie diese Auswirkungen abschwächen wollen.

Die Herausforderungen

- Tausende fachlich geprüfte Studien (peer-reviewed studies) von Wissenschaftlern maßgeblicher Institutionen weltweit haben Beweise für bereits jetzt auftretende, umfängliche Klimaauswirkungen auf aquatische Systeme dokumentiert (5).
- Viele weltweit anerkannte Quellen, einschließlich der American Geophysical Union (6), Nationale Akademien der Wissenschaften aus Dutzenden von Ländern (7), der Weltklimarat IPCC (8) und das vierte nationale Klima-Assessment der USA (9) unterstützen die Feststellung, dass die gestiegenen Treibhausgaskonzentrationen in der Atmosphäre aus fossilen Brennstoffen und der Landnutzungswandel, etwa durch Entwaldung, den derzeitigen Klimawandel vorantreiben.
- Viele dieser Veränderungen sind und werden nicht umkehrbar sein. Sie werden sich weiter verschlechtern, wenn wir an unserem derzeitigen Kurs festhalten. (10).
- Bereits jetzt auftretende Auswirkungen umfassen: die zunehmende Häufigkeit und Schwere von Dürren, Hitzewellen, Überschwemmungen, Waldbränden und Stür-

men; schmelzende Gletscher, die Destabilisierung der großen Eisschilde, die Verschiebung der Meeresströmungen, den Anstieg des Meeresspiegels, die Meeres-Versauerung und die Reduktion der Sauerstoffverfügbarkeit; Verschiebungen in der Artenzusammensetzung einschließlich der Ausbreitung gebietsfremder invasiver Arten; Ausbrüche von Wasserpflanzen- und Wildtier-Krankheiten; massenhafte Korallenbleiche; eine wachsende Belastung empfindlicher Ökosysteme, menschlicher Gesellschaften sowie der lokalen und globalen Wirtschaft (11).

- Diese Ereignisse sind Vorboten weiterer Schäden für die Fischerei, die Biodiversität und die menschliche Gesellschaft (12).
- Eine verzögerte Umsetzung der Maßnahmen zur Eindämmung der Ursachen des Klimawandels wird die wirtschaftlichen, ökologischen und gesellschaftlichen Folgen verstärken (13).
- Wenn die Menschheit katastrophale Folgen für unsere aquatischen Ökosysteme und für die Menschen, die von ihnen abhängen, vermeiden will, ist es jetzt an der Zeit, den Ausstoß von Treibhausgasen einzudämmen, Treibhausgase aus der Atmosphäre abzuscheiden und sich an das sich bereits verändernde Klima anzupassen (14). Intelligentes und rasches Handeln wird für die aquatischen Ökosysteme und die Menschen, die von ihnen abhängen, von großem Nutzen sein.
- Eine schnelle globale Reaktion und groß angelegtes Handeln sind möglich, wenn Öffentlichkeit und Regierungen sich zu den wissenschaftlichen Fakten bekennen (15).

Die Belege: Auswirkungen auf die marinen Ressourcen

- Bereits jetzt finden Verschiebungen in der Zusammensetzung der Arten, in deren Verhalten, ihrer Häufigkeit und ihrer Biomasse-Produktion statt (16).
- Hummer (17), Kabeljau (18), Makrele (19), Korallenrifffische (20) und andere für die Fischerei wichtige Arten (21) bewegen sich entweder polwärts, in tiefere Gewässer oder nehmen in ihrem Bestand ab (22).
- Aufgrund des Klimawandels werden Küstenökosysteme transformiert, degradiert oder gehen verloren (23). Dies schließt Seegras-Wiesen (24), Mangroven (25), Korallenriffe (26) und Algenwälder (27) ein.
- Die Auswirkungen veränderter Artenzusammensetzungen betreffen ganze Ökosysteme (28).
- Kohlenstoffemissionen verursachen die globale Versauerung der Ozeane. Das beeinflusst das Überleben von Organismen, insbesondere von Schalentieren, und beschleunigt die Degradation von Korallenriffen (29).
- Es wurde eine zunehmende Häufigkeit und Intensität mariner Hitzewellen dokumentiert – ein Trend, der sich voraussichtlich fortsetzen wird (30).
- In den vergangenen fünf Jahrzehnten haben sich die globalen Konzentrationen von gelöstem Sauerstoff in den Ozeanen verringert (31).

- Der Klimawandel interagiert mit anderen Stressoren wie einem erhöhten Nährstoffeintrag (32), der Überfischung (33) und Wechselwirkungen mit neuen invasiven Arten (34). Das führt zu einer weiteren Belastung mariner Ökosysteme.
- Der Klimawandel steht im Zusammenhang mit neuen und sich wiederholenden Krankheitsausbrüchen bei Meerestieren und -pflanzen (35).
- Die Abnahme der globalen Biomasse-Produktion von Meerestieren und die Verschiebung in der Artenzusammensetzung verstärken sich, wenn Treibhausgasemissionen nicht reduziert werden (36).
- Seevögel gelten als Indikatoren für langfristige Umweltveränderungen: Fast drei von vier weltweit vorkommenden Seevögeln sind seit 1950 verschwunden, und mehr als die Hälfte der verbliebenen Arten sind erheblich bedroht (37). Allein in Nordamerika wären bei Annahme des 3°C-Szenarios zwei Drittel (389/604) der Vogelarten, zu denen auch Wasservögel gehören, mäßig oder stark durch den Klimawandel gefährdet (38).

Die Belege: Auswirkungen auf Süßwasser-Ressourcen

- Süßwasser-Ökosysteme gehören zu den am stärksten bedrohten Ökosystemen auf der Erde (39).
- Süßwasser-Ökosysteme bedecken weniger als 1 Prozent der Oberfläche des Planeten, stellen aber den Lebensraum für ein Drittel der Wirbeltierarten und 10 Prozent aller Arten (40).
- Die Anpassungsfähigkeit der Süßwasser-Ökosysteme ist angesichts ihrer Beschaffenheit und des Ausmaßes der Auswirkungen des Klimawandels relativ gering (41).
- Der Klimawandel verändert die Häufigkeit von Arten, die Räuber-Beute-Dynamik, die Ausbreitung invasiver Arten, das Wachstum und die Rekrutierung von Arten sowie Interaktionen mit gebietsfremden Arten. Das führt insgesamt zu Rückgängen in der Anzahl und der Vielfalt von Süßwasser-Organismen (42).
- Die zunehmende Häufigkeit, die Intensität und die Dauer von Dürren beeinflussen die Menge und Qualität des sowohl für aquatische Ökosysteme als auch den Menschen zur Verfügung stehenden Süßwassers (43).
- Der Klimawandel wirkt sich auf die Abflussregime der Flüsse aus, einschließlich verstärkter Dürren und Niedrigwasserperioden sowie vermehrter Überschwemmungen. Dies beeinflusst Arten mit spezifischen Strömungsanforderungen und erlaubt eine Ausdehnung von gebietsfremden invasiven Arten, welche z.B. die Fischerträge sowohl von Anglern als auch kommerziellen Fischern beeinflussen und Wasserwege blockieren (44).
- Die geografische Ausbreitung vieler Pflanzen und Tiere hat sich polwärts und in höhere Lagen verlagert, während sich gebietsfremde invasive Arten unter zunehmend warmen Bedingungen ausbreiten (45). Im Gegensatz zu marinen Systemen sind in Süßwasser-Ökosystemen die Wege in andere Lebensräume oft blockiert, was zu lokalem Aussterben führt (46).

- Zeitliche Verschiebungen saisonaler Ereignisse wie Frühjahrhochwässer oder Monsun beeinflussen den Laicherfolg von Fischen. Das verringert deren Überlebensraten (47).
- Das verstärkte Auftreten von Waldbränden beeinträchtigt aquatische Ökosysteme, indem es die Wassereinzugsgebiete anfälliger für Überschwemmungen macht und die Wasserqualität verringert, insbesondere durch Asche- und Sedimentablagerungen nach Bränden (48).
- Die Kapazität von Feuchtgebieten zur Kohlenstoffspeicherung und zur Eindämmung des Klimawandels wird durch andere Komponenten des globalen Wandels, wie z.B. zunehmende Landerschließung und Brände, herabgesetzt (49).
- Höhere Temperaturen und veränderter Niederschlagsabfluss können zu einer Vermehrung schädlicher Algenblüten führen, die sich negativ auf Fische, Säugetiere, Vögel und sogar Menschen auswirken können (50).
- Die Kombination von Klimawandel und Nährstoffen kann die Eutrophierung verstärken und Wasserqualität und Ökosystemleistungen verschlechtern – mit Auswirkungen auf das Trinkwasser (51).
- Organismen, die von Schneeschmelze und Gletscherbächen abhängen, werden weniger oder verlagern ihre Verbreitung (52).
- Die Freisetzung von Schwermetallen wie Quecksilber, das derzeit in Gletschern und Permafrostböden gebunden ist, wird voraussichtlich zusätzliche Auswirkungen auf Süßwasser-Organismen haben (53).
- Der Klimawandel steht im Zusammenhang mit neuen und sich wiederholenden Krankheitsausbrüchen bei Tieren und Pflanzen des Süßwassers (54).
- Diese scheinbar vielfältigen und kleinräumigen Veränderungen führen insgesamt zu einer multiplen, kumulativen Belastung aquatischer Arten (55).

Die Belege: Auswirkungen auf die von aquatischen Ressourcen abhängige Weltgemeinschaft

- Alle Lebensformen benötigen ausreichend und sauberes Wasser.
- Die Fischerei liefert hochwertiges Protein, das nicht leicht durch terrestrische Quellen ersetzt werden kann. Nach Angaben der Ernährungs- und Landwirtschaftsorganisation der Vereinten Nationen (FAO) macht Fisch 17 Prozent des weltweit verbrauchten tierischen Eiweißes aus. Fischerei und Aquakultur beschäftigen direkt fast 60 Millionen Menschen. Der weltweite Handel mit Fischprodukten erreicht 152 Milliarden USD pro Jahr, wovon 54 Prozent in Entwicklungsländern stattfindet (56).
- Kurzfristig entstehen in neuen eisfreien Gebieten neue Fischfanggebiete (57). Dennoch wird erwartet, dass die Gesamtfangmenge der Fischerei durch die klimabedingte zunehmende Verschlechterung der Wasserqualität und veränderter Primärproduktion zurückgeht – mit entsprechenden Auswirkungen für die Ernährungssicherheit (58). Die Veränderung vieler Fischbestände steht dabei in Bezug zur Erwärmung der Ozeane und den Veränderungen der Primärproduktion. Die Erholung von Fischpopulationen ist um 3 Prozent pro Jahrzehnt zurückgegangen und das

maximale Fangpotenzial war im 20. Jahrhundert um 4,1 Prozent rückläufig (59). Der Anstieg der Wassertemperatur aufgrund des Klimawandels wird voraussichtlich die Toleranzgrenzen von 10-60 Prozent der Süßwasser- und Meeresarten bis zum Jahr 2100 übersteigen – in Abhängigkeit von der Menge der erlaubten Treibhausgasemissionen (60).

- Die Effekte des Klimawandels auf aquatische Ökosysteme wirken sich auf die Einkommen, die Ernährungssicherheit, wichtige kulturelle Bereiche und die Lebensgrundlagen der von Ressourcen abhängigen Bevölkerungsgemeinschaften aus (61).
- Artenverschiebungen beeinträchtigen die traditionelle Fischerei von den Tropen bis zu den Polarregionen durch eingeschränkten Zugang zu Fischbeständen und den Fischerei-Gebieten sowie den Verlust von lokalem Wissen (62).
- Der Klimawandel verstärkt auch andere Prozesse, wie Verschmutzung, Überfischung und nicht nachhaltige Küstenentwicklung. Zusammen mit dem Klimawandel werden sie dazu beitragen, dass viele kleine Fischereibetriebe und Volkswirtschaften ihre Existenz verlieren (63).
- Die Erwärmung der Gewässer beeinträchtigt die Unbedenklichkeit von Meeresfrüchten durch erhöhte Bioakkumulation von Schwermetallen und anderen Schadstoffen. Die Erwärmung trägt zur erhöhten Verbreitung von Krankheitserregern im Wasser bei, die sowohl Menschen als auch Tiere befallen können (64).
- Tourismus und touristische Stätten sind in vielen Bereichen betroffen, die von lokalen Ökosystemen abhängig sind. Nachhaltiges Tauchen, Schnorcheln, Angeln, Meeressäuger- und Vogelbeobachtung sowie andere Freizeitaktivitäten und Geschäfte hängen von der Erhaltung gesunder aquatischer Systeme ab (65).
- Durch den Klimawandel werden Küstenökosysteme wie Mangroven, Seegrasbestände, Sumpfgebiete, Torfmoore und Korallenriffe, die Dienstleistungen für den Menschen erbringen, geschädigt. Zu den Dienstleistungen zählen z.B. der Schutz der Küsten vor Erosion, Stürmen und Überschwemmungen, die Bereitstellung von wichtigem Lebensraum für Tiere und die Bindung von Kohlenstoff (66).
- Der Klimawandel schädigt Uferökosysteme, die Ökosystemleistungen für den Menschen erbringen. Dazu gehört der Schutz vor Überschwemmungen, das Abfangen von Schadstoffen, die Verringerung der Erosion, die Beschattung und Bereitstellung von wichtigen Lebensräumen für Tiere, die Bindung von Kohlenstoff und der Wasserrückhalt bei Hochwasserereignissen (67).
- Der Klimawandel trägt zur Schädigung von Feuchtgebieten bei, die viele der oben genannten Leistungen für den Menschen erbringen. Feuchtgebiete spielen eine entscheidende Rolle bei der Kohlenstoffbindung und -speicherung. Torfgebiete zum Beispiel binden doppelt so viel Kohlenstoff wie die weltweiten Wälder – obwohl sie nur 3 Prozent der Landfläche einnehmen (68).
- Das Ausmaß der Auswirkungen des Klimawandels wird durch die Emissionsgrenzen bestimmt, auf die sich die Weltgemeinschaft künftig festlegt – in Verbindung mit der Ausweisung von zu schützenden Ufer- und Küstengebieten und der Änderungen der Praktiken der Fischereiwirtschaft (69).

Die notwendigen Antworten

- Wir bekräftigen, dass rasches Handeln erforderlich ist, um die Treibhausgasemissionen drastisch einzudämmen sowie CO_2 aus der Atmosphäre zu entfernen und zu speichern. Nur so wird es gelingen, die katastrophalsten Folgen des vom Menschen verursachten Klimawandels für Meeres- und Süßwasser-Ökosysteme, auf die die gesamte Menschheit angewiesen ist, zu verhindern.
- Es sind globale und nationale Zielvorgaben notwendig, um kohlenstoffreiche Ökosysteme, wie Torfmoore, Seegraswiesen und andere Kohlenstoff speichernde Feuchtgebiete zu ertüchtigen und zu schützen, um Treibhausgasemissionen zu verhindern und die Auswirkungen des Klimawandels abzumildern.
- Regierungen, die Öffentlichkeit, die Industrie, die Wissenschaft und alle anderen Bereiche der Gesellschaft müssen Prioritäten setzen und konzertiert handeln, um den vom Menschen verursachten Klimawandel aufzuhalten und schlimme Folgen zu verhindern.
- Um die Degradation aquatischer Systeme wie oben beschrieben zu verlangsamen, ist ein rascher Übergang zu Energiequellen und anderen Produkten und Dienstleistungen, die keine Treibhausgase freisetzen, erforderlich. Außerdem bedarf es Forschung und Politik, die einen effizienten Übergang zu einer kohlenstoffarmen Welt begünstigen – und die auf den Empfehlungen der Spezialisten verschiedener Disziplinen basieren.
- Essenziell für ein besseres Verständnis aquatischer Ökosysteme und das Management von Veränderungen sind: Robuste Anpassungsmaßnahmen; Identifizierung und Entlastung von anderen Umweltstressoren, die synergistisch mit der Klimaänderung wirken; zusätzliche Ressourcen für Datenerfassung, Kartierung und Forschung zum besseren Verständnis potenzieller Auswirkungen des Klimawandels und zur Unterstützung von Umweltbehörden.
- Intelligent gemacht, kann eine Bewegung hin zur Eindämmung des vom Menschen verursachten Klimawandels zu fortschrittlichen und neuartigen Technologien führen, die die Wirtschaft stärken sowie zu gesünderen aquatischen Ökosystemen, größerer Ernährungssicherheit und menschlichem Wohlbefinden beitragen.

Es ist an der Zeit anzuerkennen, dass Maßnahmen gegen den Klimawandel dringend notwendig sind. Ein Aufschub der Maßnahmen zur Kontrolle der Treibhausgasemissionen ist keine Option, wenn die Menschheit die Wasser-Ressourcen und eine sichere Umwelt auf der Erde erhalten möchte.

Der vorliegende Text ist eine Übersetzung der englischsprachigen Erklärung, die durch das Helmholtz-Zentrum für Umweltforschung (UFZ) angefertigt wurde. Im Falle von inhaltlichen Widersprüchen zwischen dem deutschen und dem englischen Text hat der englische Originaltext Priorität.

Fachgesellschaften, die sich der Erklärung angeschlossen haben:

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 of 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 (EFS 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 Condrichthyan 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

** Diese Gesellschaften sind als Mitglieder der European Federation for Freshwater Sciences (EFFS) Teil der Unterzeichner und haben das Statement zusätzlich individuell unterzeichnet.*

Literatur

(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).

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, editors. In press. 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_LR.pdf (July 2020).

Ramsar Convention on Wetlands 2018. Global wetland outlook: state of the world's wetlands and their ecosystem services. Ramsar Convention, Gland, Switzerland. Available: www.global-wetland-outlook.ramsar.org (July 2020).

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 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 management 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. 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. In press.

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 (July 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:

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.

(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 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 (July 2020).

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, editors. In press. 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_LR.pdf (July 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. In press. 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 (July 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, 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. In press. Impacts of 1.5ºC 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. 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. In press. 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_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. 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. In press. 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_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.

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. In press. 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 (July 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. In press. Impacts of 1.5ºC 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 CO_2 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.

(17) Caputi, N., R. Melville-Smith, S. de Lestang, A. Pearce, and M. Feng. 2010. The effect of climate change on the western rock lobster (*/Panulirus cygnus/*) fishery of Western Australia. Canadian Journal of Fisheries and Aquatic Sciences 67:85–96.

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. Holupchinski, 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. Kun-

kel, 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. In press. 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).

(20) Nicholas A. J. Graham, N. A. J., S. K. Wilson, S. Jennings, N. V. C. Polunin, J. P. Bijoux, J. Robinson.2006. Dynamic fragility of oceanic coral reef ecosystems. Proceedings of the National Academy of Sciences 103:8425–8429.

(21) 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.

(22) Dulvy, N. K., S. I. Rogers, S. Jennings, V. Stelzenmüller, S. R. Dye, and H. R. Skjoldal. 2008. Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas. Journal of Applied Ecology 45:1029–1039.

Hastings, R. A., L. A. Rutterford, J. J. Freer, R. A. Collins, S. D. Simpson, and M. J. Genner. 2020. Climate change drives poleward increases and equatorward declines in marine species. Current Biology 30:1572–1577.

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. [Pages 358, 362].

(23) Babcock, R. C., R. H. Bustamante, E. A. Fulton, D. J. Fulton, M. D. E. Haywood, A. J. Hobday, R. Kenyon, R. J. Matear, E. Plaganyi, A. J. Richardson, and M. Vanderklift. 2019. Severe continental-scale impacts of climate change are happening now: extreme climate events impact marine habitat forming communities along 45% of the Australian coast. Frontiers in Marine Science 6:411.

(24) 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. [Page 331].

Kaladharan, P and A. Koya. 2019. Shrinking seagrass meadows observations from four lagoons of Lakshadweep archipelago. Journal of the Marine Biological Association of India 61:47–51.

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 [Page 377]

(25) 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. [Page 331].

Friess, D. A., K. Rogers, C. E. Lovelock, K. W. Krauss, S. E. Hamilton, S. Y. Lee, R. Lucas, J. Primavera, A. Rajkaran, and S. Shi. 2019. The state of the world's mangrove forests: past, present and future. Annual Review of Environment and Resources 44:16.1–16.27.

Jennerjahn, T. C., E. Gillman, K. W. Krauss, L. D. Lacerda, I. Nordhaus, and E. Wolanski. 2017. Mangrove ecosystems under climate change. Pages 211–244 */in/* V. H. Rivera-Monroy, S. Y. Lee, E. Kristensen, and R. R. Twilley, editors. Mangrove ecosystems: a global biogeographic perspective.

Oppenheimer, M., B. C. Glavovic , J. Hinkel, R. van de Wal, A. K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R. M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari. In press. Sea level rise and implications for low-lying islands, coasts and communities. Pages 321–445 */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/3/2019/11/08_SROCC_Ch04_FINAL.pdf (July 2020).

Saintilan, N., N. S. Khan, E. Ashe, J. J. Kelleway, K. Rogers, C. D. Woodroffe, and B. P. Horton. 2020. Thresholds of mangrove survival under rapid sea level rise. Science 368:1118–1121.

(26) 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. In press. Impacts of 1.5ºC 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 229–230].

Gattuso, J.-P., A. Magnan, R. Billé, W. W. L. Cheung, E. L. Howes, F. Joos, D. Allemand, L. Bopp, S. R. Cooley, C. M. Eakin, O. Hoegh-Guldberg, R. P. Kelly, H.-O. Pörtner, A. D. Rogers, J. M. Baxter, D. Laffoley, D. Osborn, A. Rankovic, J. Rochette, U. R. Sumaila, S. Treyer, and C. Turley. 2015. Contrasting futures for ocean and society from different anthropogenic CO_2 emissions scenarios. Science 349(6243):aac4722.

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. Holupchinski, 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. [Pages 827–831].

Hughes, T. P., K. D. Anderson, S. R. Connolly, S. F. Heron, J. T. Kerry, J. M. Lough, A. H. Baird, J. K. Baum, M. L. Berumen, T. C. Bridge, D. C. Claar, C. M. Eakin, J. P. Gilmour, N. A. J. Graham, H. Harrison, J. P. A. Hobbs, A. S. Hoey, M. Hoogenboom, R. J. Lowe, M. T. McCulloch, J. M. Pandolfi, M. Pratchett, V. Schoepf, G. Torda, and S. K. Wilson. 2018. Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science 359:80–83.

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. [Page 359].

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. [Pages 378–379].

(27) 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. In press. 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 (July 2020) [Pages 499–500].

Krumhansl, K. A., D. K. Okamoto, A. Rassweiler, M. Novak, J. J. Bolton, K. C. Cavanaugh, S. D. Connell, C. R. Johnson, B. Konar, S. D. Ling, F. Micheli, K. M. Norderhaug, A. Pérez-Matus, I. Sousa-Pinto, D. C. Reed, A. K. Salomon, N. T. Shears, T. Wernberg, R. J. Anderson, N. S. Barrett, A. H. Buschmann, M. H. Carr, J. E. Caselle, S. Derrien-Courtel, G. J. Edgar, M. Edwards, J. A. Estes, C. Goodwin, M. C. Kenner, D. J. Kushner, F. E. Moy, J.

Nunn, R. S. Steneck, J. Vásquez, J. Watson, J. D. Witman, and J. E. K. Byrnes. 2016. Global patterns of kelp forest change over the past half-century. Proceedings of the National Academy of Science of the United States of America 113:13785–13790.

Voerman, S. E., E. Llera, and J. M. Rico. 2013. Climate driven changes in subtidal kelp forest communities in NW Spain. Marine Environmental Research 90:119–127.

Wernberg, T., K. Krumhansl, K. Filbee-Dexter, and M. F. Pedersen. 2019. Status and trends for the world's kelp forests. Pages 57–78 */in/* C. Sheppard, editor. World seas: an environmental evaluation. Elsevier, 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. [Pages 377–378].

(28) Babcock, R. C., R. H. Bustamante, E. A. Fulton, D. J. Fulton, M. D. E. Haywood, A. J. Hobday, R. Kenyon, R. J. Matear, E. Plaganyi, A. J. Richardson, and M. Vanderklift. 2019. Severe continental-scale impacts of climate change are happening now: extreme climate events impact marine habitat forming communities along 45% of the Australian coast. Frontiers in Marine Science 6:411.

Gattuso, J.-P., A. Magnan, R. Billé, W. W. L. Cheung, E. L. Howes, F. Joos, D. Allemand, L. Bopp, S. R. Cooley, C. M. Eakin, O. Hoegh-Guldberg, R. P. Kelly, H.-O. Pörtner, A. D. Rogers, J. M. Baxter, D. Laffoley, D. Osborn, A. Rankovic, J. Rochette, U. R. Sumaila, S. Treyer, and C. Turley. 2015. Contrasting futures for ocean and society from different anthropogenic CO_2 emissions scenarios. Science 349(6243):aac4722.

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. Holupchinski, 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, D. R., 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.
Hughes, T. P., K. D. Anderson, S. R. Connolly, S. F. Heron, J. T. Kerry, J. M. Lough, A. H. Baird, J. K. Baum, M. L. Berumen, T. C. Bridge, D. C. Claar, C. M. Eakin, J. P. Gilmour, N. A. J. Graham, H. Harrison, J. P. A. Hobbs, A. S. Hoey, M. Hoogenboom, R. J. Lowe, M. T. McCulloch, J. M. Pandolfi, M. Pratchett, V. Schoepf, G. Torda, and S. K. Wilson. 2018. Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science 359:80–83.

Levin, L., M. Baker and A. Thompson, editors. 2019. Deep-ocean climate change impacts on habitat, fish and fisheries. FAO Fisheries and Aquaculture Technical Paper No. 638. Rome.

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 (July 2020) [Page 61].

(29) Bednaršek, N., R. A. Feely, M. W. Beck, S. R. Alin, S. A. Siedlecki, P. Calosi, E. L. Norton, C. Saenger, J. Štrus, D. Greeley, N. P. Nezlin, M. Roethler, and J. I.Spicer. 2020. Exoskeleton dissolution with mechanoreceptor damage in larval Dungeness crab related to severity of present-day ocean acidification vertical gradients. Science of The Total Environment 716:136610.

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. [Page 357].

Rhein, M., S. R. Rintoul, S. Aoki, E. Campos, D. Chambers, R. A. Feely, S. Gulev, G. C. Johnson, S. A. Josey, A. Kostianoy, C. Mauritzen, D. Roemmich, L. D. Talley, and F. Wang. 2013. Observations: ocean. Pages 255–267 */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.

Wisshak M., C. H. L. Schönberg, A. Form, and A. Freiwald. 2012. Ocean acidification accelerates reef bioerosion. PLOS (Public Library of Science) ONE 7(9):e45124.

(30) Hobday, A. J., E. C. J. Oliver, A. S. Gupta, J. A. Benthuysen, M. T. Burrows, M. G. Donat, N. J. Holbrook, P. J. Moore, M. S. Thomsen, T. Wernberg, and D. A. Smale. 2018. Categorizing and naming marine heatwaves. Oceanography 31:162–173.

Holbrook, N. J., H. A. Scannell, A. S. Gupta, J. A. Benthuysen, M. Feng, E. C. J. Oliver, L. V. Alexander, M. T. Burrows, M. G. Donat, A. J. Hobday, P. J. Moore, S. E. Perkins-Kirkpatrick, D. A. Smale, S. C. Straub and T. Wernberg. 2019. A global assessment of marine heatwaves and their drivers. Nature Communications 10:2624.

Oliver, E. C. J., M. T. Burrows, M. G. Donat, A. S. Gupta, L. V. Alexander, S. E. Perkins-Kirkpatrick, J. A. Benthuysen, A. J. Hobday, N. J. Holbrook, P. J. Moore, M. S. Thomsen, and T. W. D. A. Smale. 2019. Projected marine heatwaves in the 21st century and the potential for ecological impact. Frontiers in Marine Science 6:734.

Oliver, E. C. J., M. G. Donat, M. T. Burrows, P. J. Moore, D. A. Smale, L. V. Alexander, J. A. Benthuysen, M. Feng, A. Sen Gupta, A. J. Hobday, N. J. Holbrook, S. E. Perkins-Kirkpatrick, H. A. Scannell, S. C. Straub, and T. Wernberg. 2018. Ocean warming brings longer and more frequent marine heatwaves. Nature Communications 9:1324.

(31) 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. [Pages 355, 357].

Rhein, M., S. R. Rintoul, S. Aoki, E. Campos, D. Chambers, R. A. Feely, S. Gulev, G. C. Johnson, S. A. Josey, A. Kostianoy, C. Mauritzen, D. Roemmich, L. D. Talley, and F. Wang. 2013. Observations: ocean. Pages 255–267 */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. [Pages 294–296].

Schmidtko, S., L. Stramma, and M. Visbeck. 2017. Decline in global oceanic oxygen content during the past five decades. Nature 542:336–339.

(32) 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. In press. 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 (July 2020) [Pages 451, 494–498].

Wiedenmann, J., C. D'Angelo, E. G. Smith, A. N. Hunt, F. E. Legiret, A. D. Postle and E. P. Achterberg. 2013. Nutrient enrichment can increase the susceptibility of reef corals to bleaching. Nature Climate Change 3:160–164.

(33) 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. In press. 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 (July 2020) [Pages 512–513].

Free, C. M., J. T. Thorson, M. L. Pinsky, K. L. Oken, J. Widenmann, and O. P. Jensen. 2019. Impacts of historical warming on marine fisheries production. Science 363:979–983.

(34) 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. In press. 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 (July 2020) [Pages 450–451,478–502].

Lurgi, M., B. C. Lopez, and J. M. Montoya. 2012. Novel communities from climate change. Philosophical Transactions of the Royal Society B 367:2913–2922.

(35) Burge, C. A., and P. K. Hershberger. 2020. Climate change can drive marine diseases. Pages 83–94 */in/* D. C. Behringer, B. R. Silliman, and K. D. Lafferty, editors. Marine disease ecology. Oxford University Press, Oxford, UK.

Harvell, C. D., and J. B. Lamb. 2020. Disease outbreaks can threaten marine biodiversity. Pages 141–158 */in/* D. C. Behringer, B. R. Silliman, and K. D. Lafferty, editors. Marine disease ecology. Oxford University Press, Oxford, UK.

Lamb, J.B., J. A. J. M. Van de Water, D. G. Bourne, C. Altier, M. Y. Hein, E. A. Fiorenza, N. Abu, J. Jomba, and C. D. Harvell. 2017. Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates. Science 355:731–733.

Sokolow, S. 2009. Effects of a changing climate on the dynamics of coral infectious disease: a review of the evidence. Diseases of Aquatic Organisms 87:5–18.

(36) 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. In press. 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 (July 2020) [Pages 450–454, 478–502].

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. In press. Impacts of 1.5ºC 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 226–230].

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, editors. In press. 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_LR.pdf (July 2020) [Pages 12, 22].

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. [Pages 358–361]

Porter, J. R., L. Xie, A. J. Challinor, K. Cochrane, S. M. Howden, M. M. Iqbal, D. B. Lobell, and M. I. Travasso. 2014. Food security and food production systems. Pages 485–533 /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.

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. [Pages 456–459]

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. Summary for policymakers. Pages 1–35 */in/* IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/site/assets/uploads/sites/3/2019/11/03_SROCC_SPM_FINAL.pdf (July 2020).

(37) North American Bird Conservation Initiative. 2016. The state of North America's birds 2016. Environment and Climate Change Canada, Ottawa.

Paleczny, M., E. Hammill, V. Karpouzi, and D. Pauly. 2015. Population trend of the world's monitored seabirds, 1950–2010. PLOS (Public Library of Science) ONE 10(6):e0129342.

(38) Bateman, B. L., C. Wilsey, L. Taylor, J. Wu, G. S. LeBaron, and G. Langham. 2020. North American birds require mitigation and adaptation to reduce vulnerability to climate change. Conservation Science and Practice, https://doi.org/10.1111/csp2.242.

(39) Of the 29,500 freshwater dependent species so far assessed for the IUCN Red List, 27% are threatened with extinction. See Tickner, D., J. J. Opperman, R. Abell, M. Acreman, A. H. Arthington, S. E. Bunn, S. J. Cooke, J. Dalton, W. Darwall, G. Edwards, I. Harrison, K. Hughes, T. Jones, D. Leclére, A. J. Lynch, P. Leonard, M. E. McClaine, D. Muruven, J. D. Olden, S. J. Ormerod, J. Robinson, R. E. Tharme, M. Thieme, K. Tockner, M. Wright, and L. Young. 2020. Bending the curve of global freshwater biodiversity loss: an emergency recovery plan. BioScience 70:330–342.

Also, see Dudgeon, D., A. H.Arthington, M. O. Gessner, Z. I. Kawabata, D. J. Knowler, C. Leveque, R. J. Naiman, A. H. Prieur-Richard, D. Soto, M. L. J. Stiassny, and C. A. Sullivan. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological Reviews 81:163–182.

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. [Page 312.]

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. R. Liermann, and P. M. Davies, 2010. Global threats to human water security and river biodiversity. Nature 467:555–561.

(40) Strayer, D. L., and D. Dudgeon. 2010. Freshwater biodiversity conservation: recent progress and future challenges. Journal of the North American Benthological Society 29:344–358.

(41) Harrod, C., A. Ramírez, J. Valbo-Jørgensen and S. Funge-Smith. 2018. How climate change impacts inland fisheries. Pages 375–391 */in/* M. Barange, T. Bahri, M. C. M. Beveridge, K. L. Cochrane, S. Funge-Smith, and F. Poulain, editors. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. Food and Agricultural Organization of the United Nations, Fisheries and Aquaculture Technical Paper 627, Rome.

Bloesch, J., C. Sandu, and J. Janning. 2012. Challenges of an integrative water protection and river basin management policy: the Danube case. River Systems 20:129–144.

(42) Alexander, J. E., Jr., and K. C. Wagoner. 2016. Respiratory response to temperature variability in the river snail */Lithasia obovata/* and its relevance to the potential impacts of climate change on freshwater gastropods. American Malacological Bulletin 34:1–14.

Bănăduc D., M. Joy, H. Olosutean, S. Afanasyev, and A. Curtean-Bănăduc. 2020. Natural and anthropogenic driving forces as key elements in the Lower Danube basin – southeastern Carpathians–north-western Black Sea coast area lakes: a broken stepping stones for fish in a climatic change scenario? Environmental Science Europe 32: article 7.

Ferreira-Rodrıguez, N. 2019. Spatial aggregation of native with non-native freshwater bivalves and activity depletion under summer heat waves: 'dangerous liaisons' in a climate change context. Hydrobiologia 834:75–85.

Ganser, A. M., T. J. Newton, and R. J. Haro. 2013. The effects of elevated water temperature on native juvenile mussels: implications for climate change. Freshwater Science 32:1168–1177.

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. [Pages 273–279]

Lynch, A. J., B. J. E. Myers, C. Chu, L. A. Eby, J. A. Falke, R. P. Kovach, T. J. Krabbenhoft, T. J. Kwak, J. Lyons, C. P. Paukert, and J. E. Whitney. 2016. Climate change effects on North American inland fish populations and assemblages. Fisheries 41:346–361.

Markovic, D., S. Carrizo, J. Freyhof, N. Cid, S. Lengyel, M. Scholz, H. Kasperdius, and W. Darwall. 2014. Europe's freshwater biodiversity under climate change: distribution shifts and conservation needs. Diversity and Distributions 20:1097–1107.

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. [Pages 312–314].

(43) Dai, A. 2013. Increasing drought under global warming in observations and models. Nature Climate Change 3:52–58.

Gonzalez, P., G. M. Garfin, D. D. Breshears, K. M. Brooks, H. E. Brown, E. H. Elias, A. Gunasekara, N. Huntly, J. K. Maldonado, N. J. Mantua, H. G. Margolis, S. McAfee, B. R. Middleton, and B. H. Udall. 2018. Southwest. Pages 1101–1184 */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.

Jiménez Cisneros, B. E., T. Oki, N. W. Arnell, G. Benito, J. G. Cogley, P. Döll, T. Jiang, and S. S. Mwakalila. 2014. Freshwater resources. Pages 229–269 /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.

Vertessy, R., D. Barma, L. Baumgartner, S. Mitrovic, F. Sheldon, and N. Bond. 2019. Independent assessment of the 2018–19 fish deaths in the lower Darling. Final Report. Available: www.mdba.gov.au/sites/default/files/pubs/Final-Report-Independent-Panel-fish-deaths-lower%20Darling_4.pdf (July 2020).

(44) Center, T. D., and N. R. Spencer. 1981. The phenology and growth of water hyacinth (*/Eichhornia crassipes/* (Mart.) Solms) in a eutrophic north-central Florida lake. Aquatic Botany 10:1–32.

Döll, P., and S. E. Bunn. 2014. Cross-chapter box on the impact of climate change on freshwater ecosystems due to altered river flow regimes. Pages 143–146 */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.

Rahel, F. J., and J. D. Olden. 2008. Assessing the effects of climate change on aquatic invasive species. Conservation Biology 22:521–533.

Rehage, J. S., and J. R. Blanchard. 2016. What can we expect from climate change for species invasions? Fisheries 405–407.

Oliver, J. D. 1993. A review of the biology of giant salvinia (/Salvinia molesta/ Mitchell). Journal of Aquatic Plant Mangement 31:227–231.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273–288.

(45) Alahuhta, J., J. Heino, and M. Luoto, 2011: Climate change and the future distributions of aquatic macrophytes across boreal catchments. Journal of Biogeography 38:383–393.

Comte, L., and G. Grenouillet, 2013. Do stream fish track climate change? Assessing distribution shifts in recent decades. Ecography 36:1236–1246.

Galego de Oliveira, A., D. Bailly, F. A. S. Cassemiro, E. V. d. Couto, N. Bond, D. Gilligan, T. F. Rangel, A. A. Agostinho, and M. J. Kennard. 2019. Coupling environment and physiology to predict effects of climate change on the taxonomic and functional diversity of fish assemblages in the Murray–Darling basin, Australia. PLOS (Public Library of Science) ONE 14(11):e0225128.

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. [Pages 275, 276–277, 281.]

Rahel, F. J., and J. D. Olden. 2008. Assessing the effects of climate change on aquatic invasive species. Conservation Biology 22:521–533.

Rehage, J. S., and J. R. Blanchard. 2016. What can we expect from climate change for species invasions? Fisheries 405–407.

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 [Pages 295, 312–314, 295].

Sorte, C. J. B., I. Ibáñez, D. M. Blumenthal, N. A. Molinari, L. P. Miller, E. D. Grosholz, J. M. Diez, C. M. D'Antoniao, J. D. Olden, S. J. Jones, and J. S. Dukes. 2013. Poised to prosper? A cross-system comparison of climate change effects on native and non-native species performance. Ecology Letters 16:261–270.

(46) 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 [Pages 295, 312–314].

(47) 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. [Page 285].

Lynch, A. J., B. J. E. Myers, C. Chu, L. A. Eby, J. A. Falke, R. P. Kovach, T. J. Krabbenhoft, T. J. Kwak, J. Lyons, C. P. Paukert, and J. E. Whitney. 2016. Climate change effects on North American inland fish populations and assemblages. Fisheries 41:346–361.

Whitney, J. E., R. Al-Chokhachy, D. B. Bunnell, C. A. Caldwell, S. J. Cooke, E. J. Ellason, M. Rogers, A. J. Lynch, and C. P. Paukert. 2016. Physiological basis of climate change impacts on North American inland fishes. Fisheries 41:332–345.

(48) Goode, J. R., C. H. Luce, and J. M. Buffington. 2012. Enhanced sediment delivery in a changing climate in semi-arid mountain basins: implications for water resource management and aquatic habitat in the northern Rocky Mountains. Geomorphology 139–140:1–15.

Lall, U., T. Johnson, P. Colohan, A. Aghakouchak, C. Brown, G. McCabe, R. Pulwarty, and A. Sankarasubramanian. 2018. Water. Pages 145–173 */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.

Lyon, J. P., and J. P. O'Connor. 2008. Smoke on the water: can riverine fish populations recover following a catastrophic fire-related sediment slug? Austral Ecology 33:794–806.

Vose, J. M., D. L. Peterson, G. M. Domke, C. J. Fettig, L. A. Joyce, R. E. Keane, C. H. Luce, J. P. Prestemon, L. E. Band, J. S. Clark, N. E. Cooley, A. D'Amato, and J. E. Halofsky. 2018. Forests. Pages 232–267 */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.

(49) Morant, D., A. Picazo, C. Rochera, A. C. Santamans, J. Miralles-Lorenzo, A. Camacho-Santamans, C. Ibañez, M. Martınez-Eixarch, and A. Camacho. 2020. The role of ecological features and conservation status on the carbon cycle and methane emissions in the Ebro Delta wetlands. PLOS (Public Library of Science) One 15(4):e0231713.

Hooijer, A., S. Page, J. Jauhiainen, W. A. Lee, X. X. Lu, A. Idris, and G. Anshari. 2011. Subsidence and carbon loss in drained tropical peatland: reducing uncertainty and implications for CO_2 emission reduction options. Biogeosciences Discussions 8:931–935.

Page, S. E., and A. Hooijer. 2016. In the line of fire: the peatlands of Southeast Asia. Philosophical Transactions of the Royal Society B 371:20150176.

Turetsky, M. R., B. Benscoter, S. Page, G. Rein, G. R. van dr Werf, and A. Watts. 2014. Global vulnerability of peatlands to fire and carbon loss. Nature Geoscience 8:11–14.

(50) Chapra, S. C., B. Boehlert, C. Fant, V. J. Bierman, J. Henderson, D. Mills, D. M. L. Mas, L. Rennels, L. Jantarasami, J. Martinich, K. M. Strzepek, and H. W. Paerl. 2017. Climate change impacts on harmful algal blooms in U.S. freshwaters: a screening-level assessment. Environmental Science and Technology 51:8933–8943.

Jöhnk, K. D., J. Huisman, J. Sharples, B. Sommeijer, P. M. Visser, and J. M. Stroom, 2008. Summer heatwaves promote blooms of harmful cyanobacteria. Global Change Biology 14:495–512.

Michalak, A. M., E. J. Anderson, D. Beletsky, S. Boland, N. S. Bosch, T. B. Bridgeman, J. D. Chaffin, K. Cho, R. Confesor, I. Daloğlu, J. V. DePinto, M. A. Evans, G. L. Fahnenstiel, L. He, J. C. Ho, L. Jenkins, T. H. Johengen, K. C. Kuo, E. LaPorte, X. Liu, M. R. McWilliams, M. R. Moore, D. J. Posselt, R. P. Richards, D. Scavia, A. L. Steiner, E. Verhamme, D. M. Wright, and M. A. Zagorski. 2013. Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. Proceedings of the National Academy of Sciences of the United States of America 110:6448–6452.

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 [Page 291].

(51) Gordon, L., C. M. Finlayson, and M. Falkenmark. 2010. Managing water in agriculture to deal with trade-offs and find synergies among food production and other ecosystem services. Agricultural Water Management 97:512–519.

Jenny, J.-P., O. Anneville, F. Arnaud, Y. Baulaz, D. Bouffard, I. Domaizon, S. A. Bocaniov, N. Chèvre, M. Dittrich, J.-M. Dorioz, E. S. Dunlop, G. Dur, J. Guillard, T. Guinaldo, S.

Jacquet, A. Jamoneau, Z. Jawed, E. Jeppesen, G. Krantzberg, J. Lenters, B. Leoni, M. Meybeck, V. Nava, T. Nõges, P. Nõges, M. Patelli, V. Pebbles, M.-E. Perga, S. Rasconi, C. R. Ruetz III, L. Rudstam, N. Salmaso, S. Sapna, D. Straile, O. Tammeorg, M. R. Twiss, D. G. Uzarski, A.-M. Ventelä, W. F. Vincent, S. W. Wilhelm, S.-Å. Wängberg, and G. A. Weyhenmeyer. In press. Scientists' warning to humanity: rapid degradation of the world's large lakes. Journal of Great Lakes Research, https://doi.org/10.1016/j.jglr.2020.05.006.

(52) Heim, K. C., M. S. Wipfli, M. S. Whitman, C. D. Arp, J. Adams, and J. A. Falke. 2016. Seasonal cues of Arctic Grayling movement in a small Arctic stream: the importance of surface water connectivity. Environmental Biology of Fishes 99:49–65.

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. In press. 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) [Page 256].

Poesch, M. S., L. Chavarie, C. Chu, S. N. Pandit, and W. Tonn. 2016. Climate change impacts on freshwater fishes: a Canadian perspective. Fisheries 41:385–391.

(53) Hock, R., G. Rasul, C. Adler, B. Cáceres, S. Gruber, Y. Hirabayashi, M. Jackson, A. Kääb, S. Kang, S. Kutuzov, A. Milner, U. Molau, S. Morin, B. Orlove, and H. Steltzer. 2019. High mountain areas. */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, N. M. Weyer, editors. IPCC special report on the ocean and cryosphere in a changing climate. In Press.

Zhang, Q., J. Huang, F. Wang, L. Mark, J. Xu, D. Armstrong, C. Li, Y. Zhang, and S. Kang. 2012. Mercury distribution and deposition in glacier snow over western China. Environmental Science and Technology 46:5404–5413.

(54) Marcos-Lopéz, M., P. Gale, B. C. Oidtmann, and E. J. Peeler. 2010. Assessing the impact of climate change on disease emergence in freshwater fish in the United Kingdom. Transboundary and Emerging Diseases 57:293–304.

Olusanya, H. O., and M. van Zyll de Jong. 2018. Assessing the vulnerability of freshwater fishes to climate change in Newfoundland and Labrador. PLOS (Public Library of Science) ONE 13(12):e0208182.

Viana, D. S. 2017. Can aquatic plants keep pace with climate change? Frontiers in Plant Science 8:1906.

(55) 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. [Pages 282–283].

Ormerod, S. J., M. Dobson, A. G. Hildrew, and C. R. Townsend. 2010. Multiple stressors in freshwater ecosystems. Freshwater Biology 55(s1).

Tockner, K., M. Pusch, D. Borchardt, and M. S. Lorang. 2010. Multiple stressors in coupled river–floodplain ecosystems. Freshwater Biology 55(s1):135–151.

(56) Food and Agriculture Organization of the United Nations (FAO). 2018. The state of world fisheries and aquaculture 2018: meeting the sustainable development goals. FAO, Rome.

(57) 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. In press. 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) [Pages 256–257, 261–262].

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. In press. Impacts of 1.5ºC 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 222, 239].

(58) 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. In press. Technical summary. Pages 37–69 */in/* IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/srocc/home/ (July 2020) [Pages 61, 65].

(59) Magnan, A. K., M. Garschagen, J.-P. Gattuso, J. E. Hay, N. Hilmi, E. Holland, F. Isla, G. Kofinas, I. J. Losada, J. Petzold, B. Ratter, T. Schuur, T. Tabe, and R. van de Wal. In press. Cross-chapter box 9: integrative cross-chapter box on low-lying islands and coasts. Pages 657–674 */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/3/2019/11/11_SROCC_CCB9-LLIC_FINAL.pdf (2020).

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. In press. Technical summary. Pages 37–69 */in/* IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/srocc/home/ (July 2020) [Page 61].

(60) Dahlke, F. T., S. Wohlrab, M. Butzin, and H.-O. Pörtner. 2020. Thermal bottlenecks in the life cycle define climate vulnerability of fish. Science 369:65–70.

(61) 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. In press. 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 (July 2020) [Pages 451, 502–503].

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. In press. Impacts of 1.5ºC 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 180, 212, 230, 237–238].

Junk, W. J., S. An, C. M. Finlayson, B. Gopal, J. Květ, S. A. Mitchell, W. J. Mitsch, and R. D. Robarts. 2013. Current state of knowledge regarding the world's wetlands and their future under global climate change: a synthesis. Aquatic Sciences 75:151–167.

Magnan, A. K., M. Garschagen, J.-P. Gattuso, J. E. Hay, N. Hilmi, E. Holland, F. Isla, G. Kofinas, I. J. Losada, J. Petzold, B. Ratter, T. Schuur, T. Tabe, and R. van de Wal. In press. Cross-chapter box 9: integrative cross-chapter box on low-lying islands and coasts. Pages 657–674 */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/3/2019/11/11_SROCC_CCB9-LLIC_FINAL.pdf (2020) [Page 664].

Markon, C., S. Gray, M. Berman, L. Eerkes-Medrano, T. Hennessy, H. Huntington, J. Littell, M. McCammon, R. Thoman, and S. Trainor. 2018. Alaska. Pages 1185–1241 */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.

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. In press. 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) [Pages 260, 262–263].

Pendleton, L., A. Comte, C. Langdon, J. A. Ekstrom, S. R. Cooley, L. Suatoni, M. W. Beck, L. M. Brander, L. Burke, J. E. Cinner, C. Doherty, P. E. T. Edwards, D. Gledhill, L.-Q. Jiang, R. J. van Hooidonk, L. The, G. G. Waldbusser, and J. Ritter. 2016. Coral reefs and people in a high-CO_2 world: where can science make a difference to people? PLOS (Public Library of Science) ONE 11(11):e0164699.

Pershing, A. J., M. A. Alexander, C. M. Hernandez, L. A. Kerr, A. Le Bris, K. E. Mills, J. A. Nye, N. R. Record, H. A. Scannell, J. D. Scott, G. D. Sherwood, and A. C. Thomas. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science 350:809–812.

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. [Pages 361–362, 365–366]

(62) Barange, M., T. Bahri, M. C. M. Beveridge, K. L. Cochrane, S. Funge-Smith, and F. Poulain, editors. 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Technical Paper 627, Rome.

Markon, C., S. Gray, M. Berman, L. Eerkes-Medrano, T. Hennessy, H. Huntington, J. Littell, M. McCammon, R. Thoman, and S. Trainor. 2018. Alaska. Pages 1185–1241 */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 [Pages 1204–1206]

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) [Pages 15–16].

(63) Cheung, W. W. L., V. W. Y. Lam, J. L. Sarmiento, K. Kearney, R. Watson, Z. Zeller, and D. Pauly. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology 16:24–35.

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. In press. Impacts of 1.5ºC 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 230, 237].

McClanahan, T.R., E. H. Allison, and J. E. Cinner. 2015. Managing fisheries for human and food security. Fish and Fisheries 16:78–103.

(64) Alava, J. J., W. W. L. Cheung, P. S. Ross, and U. Rashid Sumaila. 2017. Climate change–contaminant interactions in marine food webs: toward a conceptual framework. Global Change Biology 23:3984–4001.

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. In press. 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 (July 2020) [Pages 509–512].

Vezzulli, L., C. Grande, P. C. Reid, P. Hélaouët, M. Edwards, M. G. Höfle, I. Brettar, R. R. Colwell, and C. Pruzzo. 2016. Climate influence on */Vibrio/* and associated human diseases during the past half-century in the coastal North Atlantic. Proceedings of the National Academy of Sciences of the United States of America 113:E5062–E5071.

(65) 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. In press. 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 (July 2020) [Pages 516–517].

Chen, P.-Y., C.-C. Chen, L. Chu, and B. McCarl. 2015. Evaluating the economic damage of climate change on global coral reefs. Global Environmental Change 30:12–20.

Cisneros-Montemayor, A. M., and U. R. Sumaila, 2010: A global estimate of benefits from ecosystem-based marine recreation: potential impacts and implications for management. Journal of Bioeconomics 12:245–268.

Gattuso, J.-P., O. Hoegh-Guldberg, and H.-O. Pörtner. 2014. Cross-chapter box on coral reefs. Pages 97–100 */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.

Markham, A., E. Osipova, K. Lafrenz Samuels, and A. Caldas. 2016. World heritage and tourism in a changing climate. United Nations Environment Programme, Nairobi, Kenya and United Nations Educational, Scientific and Cultural Organization, Paris, France.

(66) Alexandrov, G. A., V. A. Brovkin, T. Kleinen, and Z. Yu. 2020. The capacity of northern peatlands for long-term carbon sequestration. Biogeosciences 17:47–54.

Alongi, D. M. 2008. Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. Estuarine, Coastal and Shelf Science 76:1–13.

Kaladharan, P., A. M. Amalu, and S. Revathy, 2019. Role of seaweeds in neutralizing the impact of seawater acidification: a laboratory study with beached shells of certain bivalves and spines of a sea urchin. Journal of the Marine Biological Association of India 61:94–99.

Nahlik A. M., and M. S. Fennessy. 2016. Carbon storage in US wetlands. Nature Communications. 7:1–9.

Oppenheimer, M., B. C. Glavovic , J. Hinkel, R. van de Wal, A. K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R. M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari. In press. Sea level rise and implications for low-lying islands, coasts and communities. Pages 321–445 */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/3/2019/11/08_SROCC_Ch04_FINAL.pdf (July 2020) [Pages 380, 411].

Orth, R. J., T. J. B. Carruthers, W. C. Dennison, C. M. Duarte, J. W. Fourqurean, K. L. Heck, Jr., A. R. Hughes, G. A. Kendrick, W. J. Kenworthy, S. Olyarnik, F. T. Short, M.

Waycott, and S. L. Williams. 2006. A global crisis for seagrass ecosystems. BioScience 56:987–996.

Pendleton, L., D. C. Donato, B. C. Murray, S. Crooks, W. A. Jenkins, S. Sifleet, C. Craft, J. W. Fourqurean, J. B. Kauffman, N. Marbá, P. Megonigal, E. Pidgeon, D. Herr, D. Gordon, and A. Baldera. 2012. Estimating global “blue carbon” emissions from conversion and degradation of vegetated coastal ecosystems. PLOS (Public Library of Science) ONE 7(9):e43542.

Reguero, B. G., M. W. Beck, V. N. Agostini, P. Kramer, and B. Hancock. 2018. Coral reefs for coastal protection: a new methodological approach and engineering case study in Grenada. Journal of Environmental Management 210:146–161.

Waycotta M., C. M. Duarte, T. J. B. Carruthers, R. J. Orth, W. C. Dennison, S. Olyarnike, A. Calladinea, J. W. Fourqurean, K. L. Heck, Jr., A. R. Hughese, G. A. Kendrick, W. J. Kenworthy, F. T. Short, and S. L. Williams.2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences of the United States of America 106:12377–12381.

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. [Pages 386–388.]

(67) Dargie, G. C. 2017. Age, extent and carbon storage of the central Congo Basin peatland complex. Nature 542:86–90.

Davies, P. M. 2010. Climate change implications for river restoration in global biodiversity hotspots. Restoration Ecology 18:261–268.

Feld, C. K., M. R. Fernandes, M. T. Ferreira, D. Hering, S. J. Ormerod, M. Venohr, and C. Gutiérrez-Cánovas. 2018. Evaluating riparian solutions to multiple stressor problems in river ecosystems—a conceptual study. Water Research 139:381–394.

Gundersen, P., A. Laurén, L. Finér, E. Ring, H. Koivusalo, M. Sætersdal, J. O. Weslien, B. D. Sigurdsson, L. Högbom, J. Laine, and K. Hansen. 2010. Environmental services provided from riparian forests in the Nordic countries. Ambio 39:555–566.

Baker, J. P., and S. A. Bonar. 2019. Using a mechanistic model to develop management strategies to cool Apache Trout streams under the threat of climate change. North American Journal of Fisheries Management 39:849–867.

Vose, J. M., D. L. Peterson, G. M. Domke, C. J. Fettig, L. A. Joyce, R. E. Keane, C. H. Luce, J. P. Prestemon, L. E. Band, J. S. Clark, N. E. Cooley, A. D’Amato, and J. E. Halofsky. 2018. Forests. Pages 232–267 */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. [Page 246.]

(68) Alexandrov, G. A., V. A. Brovkin, T. Kleinen, and Z. Yu. 2020. The capacity of northern peatlands for long-term carbon sequestration. Biogeosciences 17:47–54.

Camacho, A., A. Picazo, C. Rochera, A. C. Santamans, D. Morant, J. Miralles-Lorenzo, and A. Castillo-Escriva. 2017. Methane emissions in Spanish saline lakes: current rates,

temperature and salinity responses, and evolution under different climate change scenarios. Water 9:659.

Crump, J., editor. 2017. Smoke on water: countering global threats from peatland loss and degradation—a rapid response assessment. United Nations Environment Programme, Nairobi, Kenya and GRID-Arendal, Arendal, Norway.

Leifeld, J., and L. Menichetti. 2018. The underappreciated potential of peatlands in global climate change mitigation strategies. Nature Communications 9:article 1071.

Ramsar Convention on Wetlands. 2018. Global wetland outlook: state of the world's wetlands and their services to people. Ramsar Convention Secretariat, Gland, Switzerland.

(69) 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, editors. In press. 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_LR.pdf (July 2020) [Pages 7–11].

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. [Pages 362, 364].

Porter, J. R., L. Xie, A. J. Challinor, K. Cochrane, S. M. Howden, M. M. Iqbal, D. B. Lobell, and M. I. Travasso. 2014. Food security and food production systems. Pages 485–533 /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 [Pages 516–517].

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. In press. IPCC special report on the ocean and cryosphere in a changing climate. Available: www.ipcc.ch/srocc/home/ (July 2020) [Pages 17–28, 31–33].