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WESTERN CENTRAL ATLANTIC FISHERY COMMISSION (WECAFC)
SEVENTEENTH SESSION
Miami, United States of America, 15-18 July 2019
Impacts of Climate Change on Western Central Atlantic marine fisheries

Suggested action by the Commission:

The Commission is invited to:

- take stock of the state of knowledge on climate change implications for marine fisheries in the Western Central Atlantic and provide any update that it considers relevant
- discuss adaptation and mitigation priorities for the near future
- request members to strengthen institutional coordination at national level to foster adaptation and mitigation of the fisheries sector
- consider the support that can be provided by international organizations on climate finance

Introduction

1. FAO released the fisheries and aquaculture technical paper 627 "Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options"[1] in July 2018. The publication provides a comprehensive compilation of the latest knowledge available on climate change implications for fisheries and aquaculture worldwide and describes the vulnerabilities of fisheries and aquaculture-dependent communities. The Technical paper also describes adaptation and mitigation options that managers and policy makers can implement to reduce these vulnerabilities.

2. Among the twenty-eight chapters included in the technical paper, chapter 9[2] deals specifically with marine fisheries in the Western Central Atlantic and provided the basis of this meeting document. The purpose is to inform the Commission about the most recent compilation of knowledge on the matter and raise awareness on the importance of framing discussions relating to fisheries development and management in the overall context of the observed and expected changes in the sector as a result of climate change.

Climate change stressors

3. The climate change stressors on the marine environment of greatest significance to fisheries in the Western Central Atlantic are increasing sea surface temperature (SST), ocean acidification (OA), sea level rise (SLR) and increased frequency of extreme weather events (e.g. storms, hurricanes, precipitation anomalies). The projections published in the most recent assessment reports (AR) (AR5 2013 to 2014) of the Intergovernmental Panel on Climate Change (IPCC) are considered here, together with global climate change models downscaled to smaller regional scales where available.

4. Regional downscaling of global models indicates that the present spatial heterogeneity of SST in the Caribbean basin will change during this century from a seasonal warm pool that expands out from the Western Caribbean each spring/summer and retracts each fall/winter, to be replaced by two warm pools centred over the Western and Eastern Caribbean that will merge, blanketing the entire region[3]. As a result, the small annual range in SST, characteristic of this area, will continue to decrease from a current average of 3.3 °C to just 2.3 °C by the end of the century, such that seasonal "warm" and "cool" periods will become less differentiated over the coming decades. Increasing SSTs over most of the region will mean stronger ocean temperature stratification and reduced oxygen content in the upper layers.

5. A shallowing of the oxygen minimum layer (representing a hypoxic habitat boundary for high oxygen demand species) has already been observed in the tropical Atlantic[4], diminished upwelling and increased stratification have been recorded in the southern Caribbean off the

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[1] Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F., eds. 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. *FAO Fisheries and Aquaculture Technical Paper No. 627*. Rome, FAO (http://www.fao.org/3/i9705en/i9705en.pdf)

[2] Oxenford, H. A. and Monnereau, I. 2018. Climate change impacts, vulnerabilities and adaptations: Western Central Atlantic marine fisheries. In Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F. (eds). 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. *FAO Fisheries and Aquaculture Technical Paper No. 627*. Rome, FAO

[3] Nurse, L.A. & Charlery, J.L. 2016. Projected SST trends across the Caribbean Sea based on PRECIS downscaling of ECHAM4, under the SRES A2 and B2 scenarios. *Theoretical and Applied Climatology*, 123(1): 199–215. (also available at https://doi.org/10.1007/ s00704-014-1346-1)

[4] Stramma, L., Prince, E.D., Schmidtko, S., Luo, J., Hoolihan, J.P., Visbeck, M., Wallace, D.W.R., Brandt, P. & Körtzinger, A. 2012. Expansion of oxygen minimum zone may reduce available habitat for tropical pelagic fishes. *Nature Climate Change*, 2: 33–37. (also available at https://doi.org/10.1038/nclimate1304)

Bolivarian Republic of Venezuela[5] and seasonal dead zones (lacking sufficient oxygen) in the northern Gulf of Mexico are continuing to expand every summer[6]. In addition, the Atlantic meridional overturning circulation (AMOC), a branch of the global thermohaline circulation is predicted to slow down under future climate change. This will further affect the North Brazil Current, the dominant feature of the North Brazil Large Marine Ecosystem (LME) and responsible for bringing episodic nutrient-enriched, lower salinity, South Atlantic water (and pelagic sargassum seaweed) into the Caribbean, because it is strongly linked to the AMOC and to surface winds[7].

6. In the Western Central Atlantic, a recorded decrease in the pH of the open sea has followed the global trend and has been accompanied by a sustained decrease in the aragonite saturation state (Ωar) (albeit seasonally and spatially variable as influenced by SST and salinity) from an annual mean value of Ωar 4.05 to 3.39 in just 11 years (1996 to 2006). With increases in mean atmospheric pCO2 to 450 µatm, the Ωar values in this region are expected to reach 3.0–3.5, whilst pCO2 reaching 550 µatm will reduce Ωar to <3.0, a value associated with net erosion of coral reef framework[8].

7. Over the last six decades the mean SLR of 1.8±0.1 mm/yr recorded for the wider Caribbean region has tracked the global mean value[9]. However, the annual rate of SLR has increased significantly in this century and for the Western Central Atlantic mean sea level is projected to increase by between 0.35 to 0.65 m (depending on which emissions scenario is followed) by the end of this century (2081 to 2100) relative to the period 1986 to 2005[10]. The multiple factors affecting local SLR vary across the Western Central Atlantic (e.g. the Mississippi delta is experiencing relative SLR three times greater than world average) and the coastal impact of increases in mean sea level also varies regionally with tidal range and frequency of storm surges (SS)[11]. This implies that the Caribbean and the Gulf of Mexico, both of which experience micro-tides and increasing SS, will be most affected, whilst the North Brazil LME with its macro-tides and lower storm frequency will be least affected. Comparing the decades of 1950 to 1960 and 1998 to 2008, SLR has already led to a significant increase (20 percent to 60 percent) in

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[5] Taylor, G.T., Muller-Karger, F.E., Thunell, R.C., Scranton, M.I, Astor, Y., Varela, R. et al. 2012. Ecosystem responses in the southern Caribbean Sea to global climate change. Proceedings of the National Academy of Sciences, 109(47): 19315–9320. (also available at https://doi.org/10.1073/pnas.1207514109)

[6] Helleman, S. & Rabalais, N. 2009. Gulf of Mexico: LME No. 5. In K. Sherman & G. Hempel, eds. 2009. The UNEP Large marine ecosystem report: A perspective on changing conditions in LMEs of the world's regional seas, UNEP Regional Seas Report and Studies No. 182, 15 pp. Nairobi, United Nations Environment Programme.

[7] Rühs, S., Getzlaff, K., Durgadoo, J.V., Biastoch, A. & Böning, C.W. 2015. On the suitability of North Brazil Current transport estimates for monitoring basin-scale AMOC changes. Geophysical Research Letters, 42(19): 8072–8080. (also available at https://doi.org/10.1002/2015GL065695)

[8] Gledhill, D.K., Wanninkhof, R., Millero, F.J. & Eakin, M. 2008. Ocean acidification of the Greater Caribbean Region 1996–2006. Journal of Geophysical Research, 113: C10031. (also available at https://doi.org/10.1029/2007JC004629)

[9] Palanisamy, H., Becker, M., Meyssignac, B., Henry, O. & Cazenave, A. 2012. Regional sea level change and variability in the Caribbean Sea since 1950. Journal of Geodetic Science, 2(2): 125–123. (also available at https://doi.org/10.2478/v10156-011-0029-4)

[10] Church, J.A., Clark, P.U., Cazenave, A., Gregory, J.M., Jevrejeva, S., Levermann, A., Merrifield, M.A. et al. 2013. Sea level change. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 1137–1216. Cambridge, UK and New York, USA, Cambridge University Press. (also available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Frontmatter_FINAL.pdf)

[11] Losada, I.J., Reguero, B.G., Méndez, F.J., Castanedo, S. Abascal, A.J. & Mínguez, R. 2013. Long-term changes in sea-level components in Latin America and the Caribbean. Global and Planetary Change, 104: 34–50. (also available at https://doi.org/10.1016/j.gloplacha.2013.02.006)

the frequency of sea level extremes across the Caribbean, whilst there has been little to no change along the North Brazil Shelf.

8. The IPCC AR5 recognizes that unusual extreme weather events have been affecting the Western Central Atlantic (especially the Caribbean, the Gulf of Mexico and South East USA) region over the last few decades[12]. There is also evidence that more tropical storms in the Atlantic are developing into dangerous category four and five hurricanes[13]. Projections indicate that further enhanced hurricane intensity is likely in this region under climate change with continued increases in SSTs, although the current understanding of tropical cyclone generation and frequency is still limited.

Implications for marine fishery resources and fisheries

9. The key climate change stressors will have numerous interrelated impacts on commercially important fishery species in the Western Central Atlantic, through 1) direct effects on their physiology and life processes (e.g. neurotransmission, respiration, growth and development rate, reproduction, longevity); and 2) indirect effects arising from significant impacts to essential habitats affecting nursery areas, living space, refuge and predator-prey relationships; and from physical and biological oceanographic changes affecting survival, dispersal and settlement of early life history stages, and migration and distribution ranges of adults, inter alia. Together these are expected to significantly affect the distribution, abundance, seasonality and fisheries production of the key fishery resources in the Western Central Atlantic[14]. Although there is a relative dearth of studies on the impacts of climate change specifically on fishery species in the Western Central Atlantic, implications can be drawn from the literature covering similar species from outside the region and projections for climate change stressors within the Western Central Atlantic. Here we consider implications for the main fishery species groups important to the Western Central Atlantic.

10. Impacts on fisheries resources are expected to differ between species groups. The coastal benthic and reef associated species (reef fishes, mollusks, spiny lobster and crabs) is particularly vulnerable because of the high reliance of the species of this group to critical coastal habitats that are already undergoing stress from anthropogenic activities that hamper their resilience (coastal development, pollution, fishing pressure). Moreover, the reproduction of most of the species of this group shows a high sensitivity to sea surface temperature, with effects on spawning behaviour, quantity and quality of reproductive outputs (eggs & larvae) and the dispersal, survival and settlement success of larvae in suitable habitats. In addition, growth rate of adult tropical fish has shown to slow down when SST increases.

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[12] Magrin, G.O., Marengo, J.A., Boulanger, J-P., Buckeridge, M.S., Castellanos, E., Poveda, G., Scarano, F.R. & Vicuña, S. 2014. Central and South America. In V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, et al., eds. 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, pp. 1499–1566. Cambridge, UK and New York, Cambridge University Press. (also available at https://www.ipcc.ch/pdf/ assessment-report/ar5/wg2/WGIIAR5-Chap27_FINAL.pdf)

[13] Murakami, H., Mizuta, R. & Shindo, E. 2012. Future changes in tropical cyclone activity projected by multi-physics and multi-SST ensemble experiments using the 60-km-mesh MRI-AGCM. Climate Dynamics, 39: 2569–2584. (also available as https://doi.org/10.1007/s00382-011-1223-x)

[14] Oxenford, H.A. & Monnereau, I. 2017. Impacts of climate change on fish and shellfish in the coastal and marine environments of Caribbean Small Island Developing States (SIDS). Commonwealth Marine Economies Programme: Caribbean marine climate change report card: science review, 2017: 83–114. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/605075/8._Fish_and_Shellfish.pdf)

11. Disease outbreaks can be attributable to the increase of SST (e.g. oysters in the Gulf of Mexico) and changes in hydrology as a result of climate change is susceptible to foster the spread of diseases, as in the case of PaV1 affecting the Caribbean Spiny lobster.

12. Ocean acidification has been shown to result in impairment of a diverse suite of sensory and behavioural abilities in reef fishes, especially the early life history stages which affect the ability to escape predation, habitat selection and timing of settlement to coral reef habitats[15].
13. Increased storminess, changes in precipitation and seal level rise have already impacted important reef or benthic species, as for instance oysters in the Gulf of Mexico smothered by sediments as a result of hurricanes, or blue crabs that showed a high sensitivity to changes in precipitation patterns.

14. Overall, reduced population sizes and productivity are expected across this multi-species group under near-future climate change, with significant impacts on production of SSFs across the region, particularly in the SIDS of the Caribbean LME where reef-associated species are often exclusively targeted.

15. Coastal pelagic schooling species (e.g. menhaden, sardinella, anchovies) have short life spans and are highly sensitive to the variation in environmental parameters. Therefore, response time of populations to climate change is expected to be rapid. Localized (subregional) reductions and increased inter-annual variability in productivity of these coastal pelagic species are expected under near-future climate change across the Western Central Atlantic, significantly affecting fisheries production in the Gulf of Mexico and North Brazil Shelf LMEs with large industrial fisheries for these species.

16. The penaeid shrimp and groundfish (e.g. weakfishes, croakers, sea catfish) species mostly rely on estuarine nursery areas, and offshore deeper soft bottom areas as adults. The early life stages are expected to be particularly vulnerable to further degradation of estuarine habitats expected under climate change and continuing eutrophication (e.g. changes to salinity, increased hypoxia). The adult habitats will likely be less impacted by climate change and adults could probably move to deeper offshore soft-bottom habitats. However, Penaeid shrimps in the northern Gulf of Mexico where the development of seasonal hypoxic areas is particularly severe and increasing under climate change are expected to suffer significant impacts, since the adults will be unable to pass through the hypoxic zones to spawn in open water. Overall, declining productivity of shrimp and groundfish populations are expected over the near- to medium-term with significant reductions in fisheries production in the North Brazil Shelf, continental countries of the Caribbean, and the Gulf of Mexico.

17. Climate change impacts on deep slope species are expected to be similar to, or perhaps slightly less severe than, the coastal reef-associated species group, with likely declines over the near- to medium term abundance that will affect fisheries production.

[15] Devine, B.M., Munday, P.L. & Jones, G.P. 2012. Homing ability of adult cardinalfish is affected by elevated carbon dioxide. Oecologia, 168: 269–276. (also available at https://doi.org/10.1007/s00442-011-2081-2)

18. Oceanic pelagic species (billfishes, large tunas, dolphinfish, wahoo, mackerels, small tunas) will likely be less impacted by climate change, at least in the short-term, than other species groups. However, increases in SST will affect the productivity and distribution of many species, as they will likely move to areas with more favourable temperatures. Therefore, reductions in productivity of the oceanic pelagic species are expected over the medium- to long-term, affecting fisheries production across the Western Central Atlantic.

Social and economic implications: food security, livelihoods and income

19. There is a lack of quantitative information on impacts of climate change on fisheries production and there are very few impact studies focussed on social and economic implications for the fisheries sector. However, climate change is expected to negatively affect food security by reducing species' productivity and availability. The impacts on food security are expected to be greatest in low income fishing communities where subsistence fishing is still important (or where at least some of the commercial catch is always retained by the crew for personal consumption); where fish are generally consumed locally, or sold and used for income; and where populations are often already vulnerable and food insecure. More intense and frequent extreme weather events are also expected to have negative impacts on food availability, accessibility, stability and utilization. The poor will face the greatest risk of food insecurity as a result of loss of assets (e.g. fishing boats, engines and gear) and lack of adequate insurance coverage. In addition, increasing SSTs and extreme weather events such as hurricanes are expected to increase the geographic extent and occurrence of ciguatoxic reef fish.

20. Expected reductions in the productivity of the region's fishery resources (especially in the reef-associated group), increased inter-annual variation in availability (especially in the coastal pelagics group), and changes to their distribution (to cooler water) as a result of climate change means that fishers in the Western Central Atlantic are expected to face declining catches, lower CPUE, lower fishery-related income and increased levels of conflict. This would especially affect the large number of small-scale coastal fishers targeting benthic, reef associated species in the region, as they would be forced to fish longer and may need to travel further and/or fish deeper, change their target to offshore pelagic species or find alternative employment outside the fishery sector to maintain their income. The implications include: reduced fisher safety (e.g. travelling further offshore, diving longer and deeper); the need to invest in training and new gear (e.g. mechanized reels, fish aggregating devices) and new and/or larger boats and engines; and increased levels of income uncertainty. Climate change stressors such as SLR and increased severity of hurricanes in this region will continue to have significant negative impacts on: fisheries infrastructure (safe harbours, jetties, coastal markets, landing sites); gear (boats, fishing equipment); and coastal fishing communities (housing, facilities), especially in the micro-tidal, storm-prone Caribbean and the Gulf of Mexico LMEs. This will translate into significant economic losses especially for SSFs since most small-scale fishing enterprises, particularly in the Caribbean, are privately owned and currently have no access to affordable insurance. Fishers could very well be left without a safety net or access to financial resources to cope with an increasingly difficult economic situation.

21. The ability of fisherfolk to cope with climate change depends on a variety of factors including the existing cultural and policy context, as well as socio-economic factors such as social cohesion, household composition, gender, age, and the availability and distribution of assets and economic alternatives. In the Caribbean area whilst men typically dominate the harvest sector, women play a critical role in the post-harvest sector in fish processing and trade and also in ancillary activities, such as financing[16]. As such, in this area as well as the North Brazil LME, women will be the most disadvantaged by the negative impacts of climate change in the post-harvest sector.
22. As fisheries resources become less available in the Western Central Atlantic and the risks related to extreme events increase, investments in the fisheries sector will become less attractive. The consequences for economic development can be expected to differ by country, especially given the diversity of countries in this region (from some of the world's richest to poorest). These include impacts on export and import trade volumes and on national economies and foreign exchange. Fish supply for the tourism industry is also likely to be affected, as well as local economies relying on processing plants supplied by local fish.

Fisheries management

23. Fisheries resources in this region are typically transboundary and shared among multiple nations over short distances (especially in the North Brazil and Caribbean LMEs). Climate-induced changes to their distribution and abundance could therefore impact fisher access under current management arrangements, and may require changes to multi-lateral or international agreements and quotas, as well as the revision of current management plans and fisheries regulations. For example, the recent influxes of sargassum have raised concern about the large numbers of small juvenile dolphinfish that are now being caught by pelagic fleets in the Lesser Antilles, which has highlighted the need to agree upon and impose a minimum legal size for dolphinfish in this subregion[17].

24. Climate change is expected to increasingly exacerbate the ongoing decline of fish resources in the region, caused largely by overfishing and degradation of the marine environment. With over 50 percent of commercially important stocks already collapsed or overfished in the Western Central Atlantic, there is clearly a need for more effective and flexible fisheries management and fisheries policies in the region, that take climate change impacts into consideration.

Vulnerability of the main fisheries

25. The impact of climate change in the Western Central Atlantic is expected to be considerable because of the high level of exposure to climate change variables, the high economic dependence on the fisheries sector, and the low adaptive capacity of many of the countries in the region[18]. This is especially true for the Caribbean SIDS because of their specific

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[16] McConney, P., Nicholls, V. & Simmons, B. 2013. Women in a fish market in Barbados. Proceedings of the Gulf and Caribbean Fisheries Institute, 65: 26–29. (also available at http://proceedings.gcfi.org/sites/default/files/procs/GCFI_65-5.pdf)

[17] Monnereau, I. & Oxenford, H.A. 2017. Impacts of climate change on fisheries in the coastal and marine environments of Caribbean Small Island Developing States (SIDS). Commonwealth Marine Economies Programme: Caribbean marine climate change report card: science review, 2017: 124–154. (also available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/605077/10._Fisheries_combined.pdf).

[18] Monnereau, I., Mahon, R., McConney, P., Nurse, L., Turner, R. & Vallès, H. 2017. The impact of methodological choices on the outcome of national-level climate change vulnerability assessments: An example from the global fisheries sector. Fish and Fisheries, 18(4): 717–731. (also available at https://doi.org/10.1111/faf.12199)

characteristics such as small size, susceptibility to natural disasters, vulnerability to external shocks, concentration of population and infrastructure in the coastal zone, high dependence on limited resources including marine resources; fragile environments, and excessive dependence on international trade[19] (Figure 1).

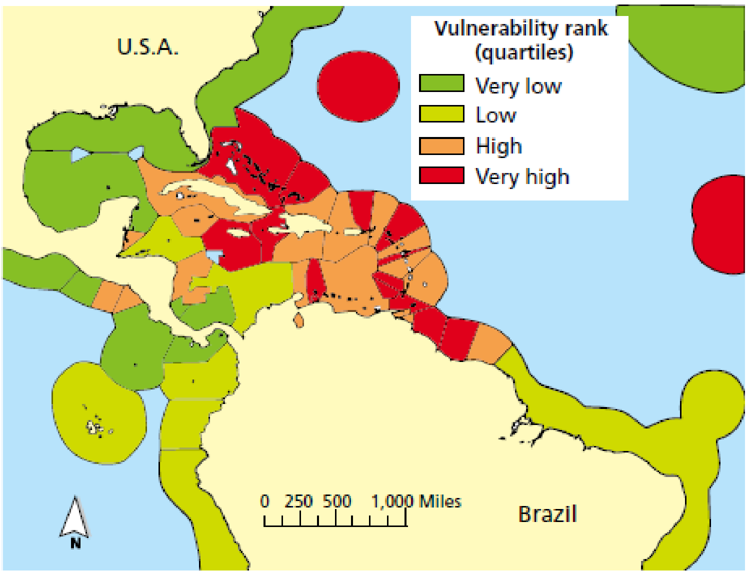

Figure 1. Results of a vulnerability assessment of the fisheries sector to climate change for the Western Central Atlantic based on 35 indicators. Each country is delimited by its EEZ boundary. Colours represent relative vulnerability ranked across 173 countries[20].

Adaptation and responses

26. One of the novelties of the Paris Climate Agreement is the inclusion of a long-term adaptation goal – *to increase the ability to adapt to the adverse impacts of climate change and foster climate resilience .../... in a manner that does not threaten food production* – alongside the goal for mitigation. It also notes that the level of adaptation needed will be determined by the success of mitigation activities. To implement the Agreement member states are required to prepare, communicate and maintain successive Nationally Determined Contributions (NDCs), submitted every five years to the UNFCCC secretariat to set their adaptation and mitigation priorities. The next round of NDCs (new or updated) is to be submitted by 2020.

27. Within the Western Central Atlantic, 24 independent nations have submitted NDCs of which 14 (mostly the Caribbean SIDS) specifically mention the fisheries sector, but mostly only in the context of highlighting its vulnerability to climate change. Only two of these countries make

[19] Nurse, L.A., McLean, R.F., Agard, J., Briguglio, L., Duvat-Magnan, V., Pelesikoti, N., Tompkins, E. & Webb, A. 2014. Small islands. In V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee et al., eds. 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, UK and New York, Cambridge University Press. pp. 1613–1654. (also available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5Chap29_FINAL.pdf)

[20] Monnereau, I., Mahon, R., McConney, P., Nurse, L., Turner, R. & Vallès, H. 2017. The impact of methodological choices on the outcome of national-level climate change vulnerability assessments: An example from the global fisheries sector. Fish and Fisheries, 18(4): 717–731. (also available at https://doi.org/10.1111/faf.12199)

specific reference to fisheries in terms of mitigation, although ten countries mention fisheries in their adaptation plans.

28. Proposed actions include: general improvements in fishery habitats (through implementation of marine protected areas, rehabilitation of mangroves, seagrasses and coral reefs; improved environmental impact assessments; and integrated coastal zone management); paying greater attention to the role of fisheries in food security; implementing updated fishery legislation; and considering alternative livelihood opportunities. Only in a few cases are concrete and specific measures listed such as provision of affordable insurance schemes for fishers (in Dominica, and Antigua and Barbuda). In several NDCs the need for additional (international) financing is highlighted, as well as the need for technical support, including capacity building and technology transfer in order to carry out the mitigation and adaptation measures. Further, there is no specific mention of the fisheries sector in the nationally appropriate mitigation actions prepared and submitted to the UNFCCC by six of the developing nations within the Western Central Atlantic, nor in the very few national adaptation plans.

29. Factors that can influence the success of adaptation include raising awareness of climate change impacts on the fisheries sector and coastal communities, as well as awareness on possible adaptation measures for the fisheries sector. Better communication and information sharing on these issues can, and in some cases already has, fostered innovative solutions and development opportunities within the sector. Other factors affecting success include capacity building activities through training and education which empower local stakeholders and facilitate collective self-governing action (e.g. by fisherfolk organizations). Mainstreaming climate change adaptation (CCA) and disaster risk management (DRM) into new or improved fisheries legislation, policies and plans is also important[21].

30. Although there is a wide range of tools and approaches that are being or can be used to respond to change in the fisheries and aquaculture sector, many of them will have to be modified to increase flexibility and reduce surprise/unanticipated outcomes. The recently released FAO technical paper provides guidance specifically aimed at developing adaptation strategies for fisheries. It includes an adaptation toolbox (chapter 25 "Methods and tools for climate change adaptation in fisheries and aquaculture")[22] that provides a portfolio of available tools and approaches recommended and currently available, as well as guidance for selecting, implementing and monitoring the effectiveness of adaptation actions while limiting maladaptation. Adaptation tools and measures are organized in three broad categories: institutional adaptation, livelihoods adaptation and risk reduction & management for resilience.

31. A select number of adaptation measures which are already taking place or currently being developed in the region are summarized here. These activities include anticipatory and reactive

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[21] McConney, P., Charlery, J., Pena, M., Phillips, T., van Anrooy, R., Poulain, F. & Bahri, T. 2015. Disaster risk management and climate change adaptation in the CARICOM and wider Caribbean region – Strategy and action plan. Rome, FAO. 29 pp. (also available at http://www.fao.org/3/a-i4382e.pdf)

[22] Poulain, F, Himes-Cornell, A and Shelton, C. (2018). Chapter 25: Methods and tools for climate change adaptation in fisheries and aquaculture. In Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F., eds. 2018. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. *FAO Fisheries and Aquaculture Technical Paper No. 627*. Rome, FAO. (http://www.fao.org/3/i9705en/i9705en.pdf)

measures as well as private and public initiatives, and are grouped here under three broad categories.

Innovation and capacity building:

- Development of innovative context-appropriate mobile applications designed to improve early warning and safety of small-scale fishers with regard to approaching storms and hurricanes inter alia, as well as improving responses to crisis (e.g. training in methods of recording of damage and losses post-disaster).
- Improvement in adaptive capacity and resilience of the fishery sector to climate change through improved safety, improved earnings and savings, and better access to assets insurance and social security

Improving physical environment:

- Investments in safer harbours and boat hauling sites as well as other climate-proof fisheries infrastructure to protect fisheries assets and prevent disruption in the fisheries market chain
- Mitigation of local-level, human-induced stressors that are degrading critical fishery habitats, and rehabilitation of damaged coastal ecosystems (e.g. coral reefs, seagrasses, mangroves and saltmarshes) to improve their resilience to future climate change and maintain their natural ecosystem services

Recommendations

32. Member States are invited to ensure that the fisheries (and aquaculture) sector is adequately referred to in the updated Nationally Determined Contributions that will be submitted in 2020 to the United Nations Framework Convention on Climate Change. In this respect, a national coordination between relevant institutions and Ministries is essential.

33. The attention of the Member States is drawn to the fact that climate change observed and expected impacts need to be accounted for in the current fisheries development and management practices. For most resources, global warming will reshape harvest and post-harvest sub-sectors. This will require the development and implementation of adequate adaptation plans and the incorporation of climate change into fisheries and coastal development policies, plans and legislation.

34. Member States are encouraged to use the existing guidance on adaptation and adaptation planning (adaptation toolbox) and note the possibility to request FAO's assistance for project formulation and access to climate finance.