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# THE DEVIL'S IN THE DEEP

## MARINE FISHERIES, ECOLOGICAL TIPPING POINT RISKS, AND MARITIME SECURITY

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Escalating human pressures are transforming the world's seas. Habitat destruction, biodiversity loss, pollution, resource depletion, and the mounting effects of global climate change increasingly threaten ocean ecosystems. Many stresses interact, generating compound risks that could push marine systems over tipping points past which they cannot readily recover. For countries and communities reliant on ocean resources, the ramifications could be considerable, jeopardizing the livelihoods, security, and welfare of millions of people.

## THE SUSTAINING SEAS

Healthy ocean ecosystems are essential to human well-being. Together, the world's seas provide society with a vast array of vital goods and natural resources. Fisheries and aquaculture directly employ 58.5 million people. When small-scale and subsistence fishing, workers in secondary sectors such as processing and boatbuilding, and their dependents are accounted for, estimates suggest that 600 million livelihoods depend in whole or in part on the fishing sector.[1] Fisheries contribute substantially to national economies, representing 3.2% of developing countries' GDP on average.[2]

1 FAO, *The State of World Fisheries and Aquaculture 2022* (Rome: United Nations Food and Agriculture Organization, 2022), p.xvi, https://www.fao.org/3/cc0461en/cc0461en.pdf.

2 World Bank, *Hidden Harvest: The Global Contribution of Capture Fisheries*, Economic and Sector Work 66469-GLB (Washington, DC: World Bank, May 2012), p. 57, http://hdl.handle.net/10986/11873.

Fisheries also nourish much of the world. Fish provide over 3.3 billion people with at least 20% of their average per capita consumption of animal proteins. In several island and coastal countries, half of dietary animal proteins consumed come from fish. Since the 1960s, global fish production has quadrupled to 178 million metric tons in 2020, while annual consumption has grown twofold to 20.2 kg per person.[3] As the world searches for strategies to feed an additional 2 billion inhabitants in 2050, many experts project global demand for "blue foods" from aquatic sources will nearly double by mid-century.[4]

## TAKING STOCK: INCREASING EXPLOITATION OF MARINE RESOURCES

Yet relentlessly rising demand increasingly risks overstretching the ocean's resources. The UN Food and Agriculture Organization estimates that 57.3% of ocean fish stocks are now fished to their maximum sustainable levels. Some 35.4% of stocks are overfished, exploited *beyond* biologically sustainable capacities, up from 10% in the 1970s.[5] Under current management regimes, business-as-usual practices could push 84% of global fisheries past sustainable thresholds by 2050.[6] Even these figures may not fully capture the strains on world fisheries. Most fisheries, and half of global marine landings (the portion of the catch brought to shore),[7] remain scientifically "unassessed" due to inadequate data. Available evidence suggests the sustainability of these stocks is likely poor and, in many cases, declining.[8]

Consumer demand fuels the strains on global fisheries, but so too do public policies. Governments worldwide poured USD $35.4 billion into fisheries subsidies in 2018,[9] equal to one quarter of capture fisheries' total production value.[10] Many subsidies undermine long-term sustainability. By enabling fleets to fish in areas and catch types

3 FAO (2022), pp.xx, 1, 4. FAO consumption data for "aquatic food" include all types of fish, crustaceans, and molluscs, but not aquatic mammals, reptiles, or algaes.

4 Rosamund L. Naylor et al., "Blue food demand across geographic and temporal scales," *Nature Communications* 12, no.1 (September 2021) 5413, https://www.nature.com/articles/s41467-021-25516-4.

5 FAO (2022), p.46.

6 Christopher Costello et al., "Global fishery prospects under contrasting management regimes," *Proceedings of the National Academy of Sciences* 113, no.8 (May 2016), p.5128, https://www.pnas.org/doi/full/10.1073/pnas.1520420113.

7 Fishing activities often take in "bycatch" of untargeted or unwanted species that may not be kept. Global studies estimate that about 11% of the world fish catch is discarded at sea. See E. Gilman et al., "Benchmarking global fisheries discards," *Scientific Reports* 10 (August 2020) 14017, https://doi.org/10.1038/s41598-020-71021-x.

8 Ray Hilborn et al., "Effective fisheries management instrumental in improving fish stock status," *Proceedings of the National Academy of Sciences* 117, no.4 (January 2020), pp.2218-2224, https://doi.org/10.1073/pnas.1909726116.

9 U. Rashid Sumaila et al., "Updated estimates and analysis of global fisheries subsidies," *Marine Policy* 109 (November 2019) 103695, https://doi.org/10.1016/j.marpol.2019.103695.

10 FAO, *The State of World Fisheries and Aquaculture 2020* (Rome: United Nations Food and Agriculture Organization, 2020), p.2, https://www.fao.org/3/ca9229en/ca9229en.pdf.

and quantities of fish that would not be profitable otherwise, harmful subsidies encourage both overcapacity and overfishing. Too many vessels take too many fish, beyond what is economically or ecologically viable.[11]

Subsidies can also serve to incentivize illicit fishing practices such as disregarding catch quotas, flouting conservation regulations, and concealing catches. Under international law, so-called flag states are accountable for regulating fishing activities by vessels registered or licensed under their jurisdiction. Yet substantial fishing is conducted in contravention of established management measures, goes unreported to authorities, or takes place in areas outside of any management regimes. Many flag states have proven unable or unwilling to maintain applicable norms and controls for their home waters or their distant water fleets. A significant number lack the necessary legislative, monitoring, and enforcement capacities. Some may turn a blind eye to harmful practices to advantage their own fishing industries. A few actively recruit foreign fishing companies to their registries, deliberately providing flags of convenience allowing them to conduct illicit fishing on the high seas and in other countries' territories with impunity.[12]

**ILLEGAL FISHING** refers to fishing activities by national or foreign vessels in waters within a state's Exclusive Economic Zone or within the jurisdiction of a Regional Fisheries Management Organization (RFMO) that is conducted in contravention of the state's or RFMO's regulations.

**UNREPORTED FISHING** refers to fishing activities that are not reported or are misreported to authorities.

**UNREGULATED FISHING** refers to fishing activities in areas or for stocks without any fisheries management or conservation regulations in place, including the high seas and areas not managed by a RFMO. Fishing vessels without nationality or vessels of a country not party to a RFMO are also considered to be participating in unregulated fishing.

*Adapted from*: *Temple et al., p.1*

Illegal, unreported, and unregulated (IUU) fishing may amount to as much as one-third of the global catch.[13] The global economic losses have been estimated as high as USD $50 billion.[14] IUU fishing happens in all the world's fisheries and at all scales from artisanal fishers to industrial fleets, often alongside legitimate fishing. Widespread IUU fishing significantly contributes to over-exploitation. It undercuts legitimate fishing economies, diminishing the resource base and depriving states of revenues and bona fide fishers of income.

11 Roger Martini and James Innes, "Relative effects of fisheries support policies," *OECD Food, Agriculture and Fisheries Papers*, no.115 (Paris: OECD, December 2018), https://doi.org/10.1787/bd9b0dc3-en.

12 Eve de Coning, "Why are some flag states unable or unwilling to address IUU fishing?" *International Community Law Review* 22, nos.3–4 (August 2020), pp.487–512, https://doi.org/10.1163/18719732-12341444.

13 Daniel Pauly and Dirk Zeller, "Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining," *Nature Communications* 7, no.1 (January 2016) 10244, https://doi.org/10.1038/ncomms10244.

14 Alfonso Daniels et al., *Fishy Networks: Uncovering the Companies and Individuals behind Illegal Fishing Globally* (Boston: Financial Transparency Coalition, October 2022), p.6, https://financialtransparency.org/wp-content/uploads/2022/10/FTC-fishy-Network-OCT-2022-Final.pdf.

Subverting sustainable management, it weakens food security and may displace or destabilize small-scale and artisanal fisher communities.[15] IUU fishing often takes advantage of areas of state fragility, weak governance, and limited enforcement capabilities. Many analysts fear that the organized criminality and climates of corruption perpetuated by IUU fishing can also contribute to eroding governance capacities, progressively undermining the credibility and authority of domestic political systems and state institutions.[16]

## IN HOT WATER: CLIMATE IMPACTS ON MARINE FISHERIES

Climate change imposes multiple risks to marine ecologies and resources. Global warming will drive higher sea levels, stronger tropical cyclones, larger storm surges, climbing sea surface temperatures, and increasing acidification and deoxygenation of ocean waters.[17] Worsening climate impacts threaten fisheries and fishing communities at sea and ashore.

As global warming boosts global average temperatures, the seas absorb heat from the atmosphere. So far, the oceans have soaked up 90% of this additional heat, raising sea surface temperatures by 0.88oC above pre-industrial averages.[18] Extreme marine heat waves, which fuel coral bleaching and toxic algal blooms, have multiplied more than 20-fold.[19] Warming also alters the chemical content and thermal structure of the ocean. Warmer seawater can hold less oxygen. Shifting "stratification" of the sea in different temperature layers inhibits the circulation of oxygen and essential nutrients between the surface and the deeper ocean. Current assessments indicate oxygen levels have dipped as much as 2.1% in the surface ocean and 3.3% at greater depths (100-600 meters) since the 1970s.[20]

Similarly, as humanity's greenhouse gas (GHG) production has soared, the ocean has absorbed one-third of total CO2 emissions. Rising CO2 content renders seawater more acidic. Since the Industrial Revolution, surface ocean acidity has spiked 26%— a change ten times faster than any in the past 300 million years.[21] If climate

15 Andrew J. Temple et al., "Illegal, unregulated and unreported fishing impacts: A systemic review of evidence and proposed future agenda," *Marine Policy* 139 (May 2022) 105033, https://doi.org/10.1016/j.marpol.2022.105033.

16 Cathy Haenlein, *Below the Surface: How Illegal, Unreported and Unregulated Fishing Threatens our Security*, RUSI Occasional Paper (London: Royal United Services Institute, July 2017), https://static.rusi.org/201707_rusi_below_the_surface_haenlein.pdf.

17 Paola A. Arias et al., "Technical Summary," in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds V. Masson-Delmotte et al., (Cambridge: Cambridge University Press, 2021), https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_TS.pdf

18 Arias et al., p.74.

19 Charlotte Laufkötter, Jakob Zscheischler, and Thomas L. Frölicher, "High-impact marine heatwaves attributable to human-induced global warming," *Science* 369, no.6511 (September 2020), pp.1621-1625, https://www.science.org/doi/10.1126/science.aba0690.

20 Nathaniel L. Bindhoff et al, "Changing Ocean, Marine Ecosystems, and Dependent Communities," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, eds. H.-O. Pörtner et al. (Cambridge: Cambridge University Press, 2019), p.471, https://www.ipcc.ch/srocc/chapter/chapter-5/.

21 Catriona L. Hurd et al., "Current understanding and challenges for oceans in a higher-CO2 world," *Nature Climate Change* 8, no.8 (July 2018), pp.686-694, https://www.nature.com/articles/s41558-018-0211-0.

change and greenhouse emissions continue unabated, sea surface waters could be 3.5oC warmer and 2.5 times more acidic than pre-industrial levels by the end of the 21st century.[22]

In addition to GHG emissions, the seas absorb myriad other pollutants. Plastics, persistent organic pollutants, toxic metals, pharmaceuticals, and other contaminants have been detected in every corner of the ocean.[23] Rains, snowfalls, and sewer systems carry pollutants from human activities into streams and rivers that then transport them to the sea. Runoff from agricultural wastes and fertilizers, for example, has washed millions of metric tons of excess nutrients—primarily nitrogen and phosphorus—into the oceans. There they feed biochemical processes of eutrophication that progressively deplete ocean waters of the oxygen needed for biological functions. Since the 1960s, hundreds of coastal "dead zones" worldwide have spread over 4.5 million km2, an area larger than the Gulf of Mexico and Caribbean Sea combined.[24]

Ocean warming, acidification, and deoxygenation jeopardize marine ecologies, threatening to disrupt the growth, reproduction, and mortality of individual species as well as the relations between species and their habitats, food sources, competitors, predators, and pathogens.[25] Some marine populations will succeed in adapting. Others will migrate to more hospitable habitats. Many, though, may not survive. In the tropical ocean, extensive coral loss and reef habitat collapse could, in extreme cases, slash species abundance and biodiversity by more than 60%.[26]

22 Lester Kwiatkowski et al., "Twenty-first century ocean warming, acidification, deoxygenation, and upper-ocean nutrient and primary production decline from CMIP6 model projections," *Biogeosciences* 17, no.13 (July 2020), pp. 3439–3470, https://bg.copernicus.org/articles/17/3439/2020/.

23 United Nations, *Second World Ocean Assessment*, Vol.2 (New York: United Nations, 2021), https://www.un.org/regularprocess/sites/www.un.org.regularprocess/files/2011859-e-woa-ii-vol-ii.pdf.

24 Global Ocean Oxygen Network, *The Ocean Is Losing Its Breath: Declining Oxygen in the World's Ocean and Coastal Waters*, Summary for Policymakers (Paris: Intergovernmental Oceanographic Commission-UNESCO, 2018), p.7, https://en.unesco.org/sites/default/files/265196eng.pdf.

25 Bindhoff et al.

26 M.S. Pratchett et al., "Effects of coral bleaching and coral loss on the structure and function of reef fish assemblages," in *Coral Bleaching*, Ecological Studies, vol. 233, eds. M. van Oppen and J. Lough (Cham: Springer, 2018), p.285, https://link.springer.com/chapter/10.1007/978-3-319-75393-5_11.

# CASCADING RISKS AND SOCIOECOLOGICAL TIPPING POINTS

No part of the global ocean escapes human influence. Nearly the entirety of the ocean (97.7%) suffers multiple stresses simultaneously.[27] The scope and intensity of these pressures raise increasing risks that human drivers could push key ocean systems past critical "tipping points".[28] Tipping points occur when the level of change in system properties crosses a threshold beyond which the system rapidly shifts to a qualitatively different state or condition. These changes may then be difficult or impossible to reverse.

Ocean warming, acidification, and deoxygenation each pose perilous tipping points to marine species and ecosystems.[29] All species of marine life have different optimal ranges for ocean temperature, acidity, and oxygen content. Outside these tolerance niches, the organism's biological functions and survival are increasingly compromised. The deoxygenated dead zones spawned by coastal pollution exemplify this tipping dynamic.

Beyond the pressures exerted by individual drivers, the combination of multiple stressors can substantially exacerbate tipping point risks. One analysis calculates that, under current GHG emissions trajectories, the compounding impacts of global warming and marine pollution will tip phytoplankton production into decline across half the tropical ocean by 2100.[30] Another study projects that, if climate change reaches 1.5oC, cumulative ocean warming and acidification would trigger the collapse of 70-90% of tropical and subtropical coral reefs.[31] Phytoplankton represents the base of ocean food webs. Coral reefs constitute essential marine habitats. Crossing such critical thresholds for the building blocks of ocean ecologies could risk setting off cascades of further tipping points destabilizing larger marine systems.[32]

Environmental stresses on the sea could in turn reverberate through ocean-dependent communities on shore. Human activities can interact with ecological processes to amplify (or dampen) pressures on marine resources, potentially generating "socioecological" tipping points with significant societal ramifications.[33] Overfishing, for instance, depletes and weakens fish populations, increasing their vulnerability to climate impacts.[34] Climate

27 Benjamin S. Halpern. et al., "Spatial and temporal changes in cumulative human impacts on the world's ocean," *Nature Communications* 6, 7615 (July 2015), p.3, https://www.nature.com/articles/ncomms8615.

28 Christoph Heinze et al., "The quiet crossing of ocean tipping points," *Proceedings of the National Academy of Sciences* 118, no.9 (March 2021) e2008478118, https://doi.org/10.1073/pnas.2008478118.

29 Heinze et al.

30 Zhan Ban, Xianganh Hu, and Jinghong Li, "Tipping points of marine phytoplankton to multiple environmental stressors," *Nature Climate Change* 12, no.11 (October 2022), pp.1045-1051, https://www.nature.com/articles/s41558-022-01489-0.

31 David I. Armstrong McKay et al., "Exceeding 1.5oC global warming could trigger multiple climate tipping points," *Science* 377, no.6611 (September 2022), https://www.science.org/doi/10.1126/science.abn7950.

32 Christian Möllmann et al., "Marine regime shifts around the globe: theory, drivers, and impacts," *Philosophical Transactions of the Royal Society* B 370, no.1659 (January 2015), https://doi.org/10.1098/rstb.2013.0260.

33 Benjamin S. Halpern, "Addressing socioecological tipping points and safe operating spaces in the Anthropocene," in *Conservation for the Anthropocene Ocean*, eds. P.S. Levin and M.R. Poe (London: Academic Press, 2017), pp.271-286, https://doi.org/10.1016/B978-0-12-805375-1.00013-1.

34 Malin L. Pinsky and David Byler, "Fishing, fast growth and climate variability increase the risk of collapse," *Proceedings of the Royal Society B* 282, no.1813 (August 2015), https://doi.org/10.1098/rspb.2015.1053.

impacts stress fish stocks and their surrounding environment, heightening their vulnerability to fishing pressures and hampering their ability to recover from over-exploitation.[35] Overfishing and climate change could thus combine to precipitate the collapse of fishing stocks. (Fisheries collapse can be defined as an abrupt, substantial, and prolonged decline in the abundance of a fish stock.)[36] Stock collapses may then entrain serious disruptions to fishing communities and livelihoods, imperiling food security, incomes, jobs, trade, and social capital.[37] Small island and coastal developing states could prove disproportionately vulnerable. These nations tend to have higher nutritional and economic dependencies on fisheries, higher levels of food insecurity, greater exposure to climate impacts, lower adaptive capacities, and weaker governance mechanisms to manage ocean resources.[38]

## AN OCEANIC TINDERBOX?

Climate pressures can contribute to reducing marine species abundance overall and to scrambling species' ranges as impacted populations move to more hospitable waters. Consequently, global warming could soon engender major shifts in both fishery catch sizes and locations. Under "business-as-usual scenarios," the maximum catch potential of global Exclusive Economic Zones (EEZs)[39] could drop 7-12% by 2050 relative to 2000 levels. Importantly, the projected changes vary greatly from region to region.[40] (Figure 1) Throughout the tropics and the temperate Atlantic, catch potentials could tumble by 30-40% and further. Arctic fisheries, in contrast, could see catch potentials swell 25-50% or more as species migrate poleward from their historical ranges.[41] By 2060, 18-23% of EEZs will host new transboundary fishery stocks driven to their waters by climate stresses.[42]

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35 Gregory L. Britten et al., "Extended fisheries recovery timelines in a changing environment," *Nature Communications* 8 (May 2017) 15325, https://doi.org/10.1038/ncomms15325.

36 Adapted from J. Yletyinen et al., "When is a fish stock collapsed?" *bioRxiv* (May 2018), p.5, https://www.biorxiv.org/content/10.1101/329979v1.full. There is no single unified definition of fisheries stock collapse.

37 Elena Ojea, Sarah E. Lester, and Diego Salgueiro-Otero, "Adaptation of fishing communities to climate-driven shifts in target species," *One Earth* 2, no.6 (June 2020), pp.544-556, https://doi.org/10.1016/j.oneear.2020.05.012.

38 Nadine Heck et al., "Global climate change risk to fisheries—a multi-risk assessment," *Marine Policy* 148 (February 2023) 105404, https://doi.org/10.1016/j.marpol.2022.105404.

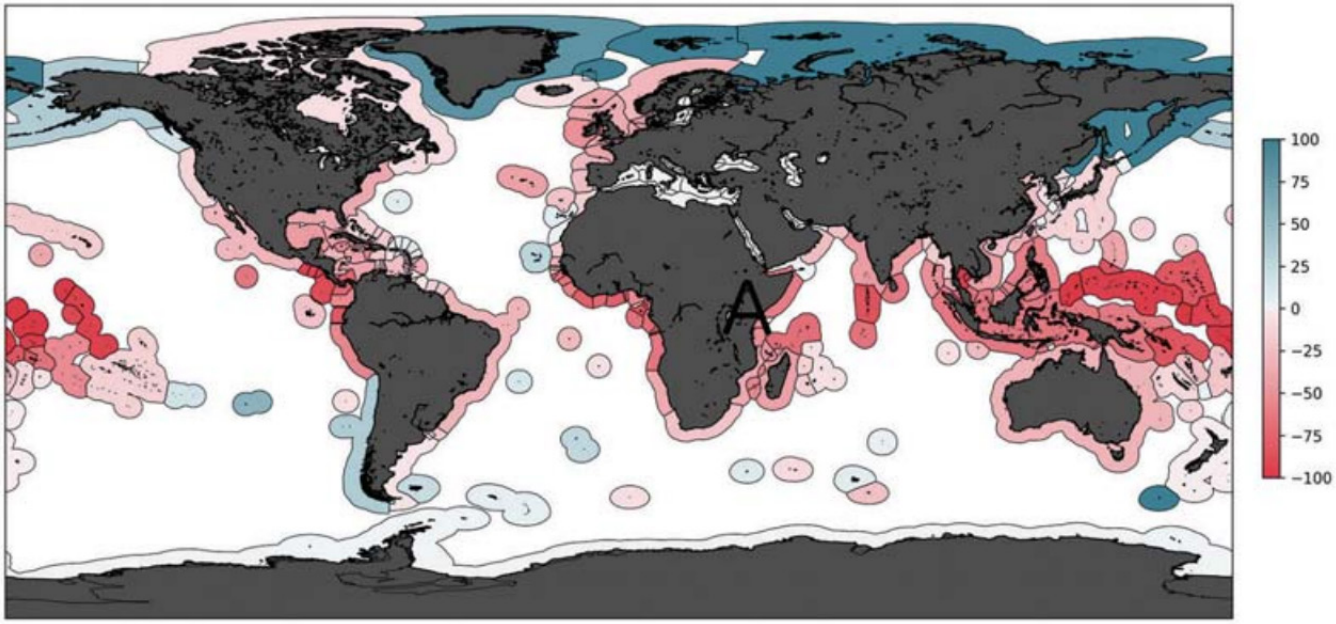
39 An EEZ is the area of the sea, typically extending 200 nautical miles from a country's coastline, to which that country retains sovereign rights to the exploration, exploitation, conservation, and management of natural resources under the UN Convention on the Law of the Sea.

40 Marine aquaculture is expected to experience similar impacts. Production potential could expand in some high-latitude EEZs. But the major producer countries in Asia are projected to see deepening declines by mid-century. Halley E. Froelich, Rebecca R. Gentry, and Benjamin S. Halpern, "Global change in marine aquaculture production potential under climate change," *Nature Ecology & Evolution* 2, no.11 (Nov. 2018), https://doi.org/10.1038/s41559-018-0669-1.

41 William W. L. Cheung, Jorn Bruggeman, and Momme Butenschön, "Projected changes in global and national potential marine fisheries catch under climate change scenarios in the twenty-first century," in *Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of Current Knowledge, Adaptation and Mitigation Options*, Technical Paper 627, eds. M. Barange et al. (Rome: United Nations Food and Agriculture Organization, 2018), pp.63-86, https://www.fao.org/3/i9705en/i9705en.pdf.

42 Malin L. Pinsky et al., "Preparing ocean governance for species on the move," *Science* 360, no. 6394 (June 2018), p.1189, https://www.science.org/doi/10.1126/science.aat2360.

## FIGURE 1




**Changes in maximum catch potential (%) by 2046-2055 under IPCC Scenario RCP 8.5 "business-as-usual," projected by Dynamic Bioclimate Envelope Model (DBEM).**

Source: William W. L. Cheung, Jorn Bruggeman, and Momme Butenschön, "Projected changes in global and national potential marine fisheries catch under climate change scenarios in the twenty-first century," in Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of Current Knowledge, Adaptation and Mitigation Options, Technical Paper 627, eds. M. Barange et al. (Rome: United Nations Food and Agriculture Organization, 2018), p,70, https://www.fao.org/3/i9705en/i9705en.pdf.

Such a sizable reshuffle of fishing potential could substantially remake global fisheries politics and development. Competition over marine resources already helps stoke maritime tensions around the world's oceans. International fisheries conflicts have proliferated six-fold since the 1970s. Many have produced violent confrontations. Several have been militarized.[43]

Intensifying pressures on the oceans could catalyze future fisheries conflicts. Much of the global ocean is only weakly managed. Established national and international governance arrangements are largely premised on relatively stable fish populations with catch allocations based on historical distribution patterns and clear boundaries dividing fisheries into zones of national territorial control. Where stocks straddle or migrate between EEZs or the high seas, their ranges are presumed durable. Most fisheries conflicts revolve around disputes as to what parties are allowed to catch which species in what quantities, and where. The compounding risks of climate pressures and unsustainable fishing practices muddle these questions. Current governance mechanisms are

43 Jessica Spijkers et al., "Global patterns of fisheries conflict: forty years of data," *Global Environmental Change* 57 (July 2019) 101921, https://doi.org/10.1016/j.gloenvcha.2019.05.005.

poorly equipped to manage the challenges looming when stocks collapse in the territorial fishing grounds of some states and grow in those of others.[44]

Large-scale redistributions in the sources and sizes of world fish catches threaten to create winners and losers.[45] Where fish populations plummet, contending claimants may race to pre-emptively capture their share, fueling "panic-based" overfishing that could further deplete shrinking stocks and accelerate fisheries collapse.[46] Where fish populations rise, new parties may spar to cast their nets. Claims to valuable fishing rights could motivate or exacerbate opposing assertions of sovereign control over disputed maritime territories such as the South China Sea. Where fish migrate between EEZs, tensions may flare over the allocation or reallocation of the shifting stocks. The history of maritime resource confrontations suggests that conflict risks rise under just such conditions, when fishers look to make up for waning catches in domestic waters by increasing fishing abroad.[47]

The same dynamics may shape IUU fishing. Dwindling catches could squeeze fisheries-dependent livelihoods, pushing some fishers toward IUU activities. Unprecedented stock migrations will unsettle existing management and enforcement frameworks and boost opportunities and incentives for illicit practices. IUU fishing in turn often intertwines with other unlawful undertakings—including human rights violations in the fisheries labor force; smuggling drugs, arms, and people; and marine piracy—presenting significant security risks.[48] Clashes around illicit fishing and enforcement have thus become important drivers of potentially combustible maritime conflicts. Just in the past five years, for example, Indonesia alone has seized and sunk over 570 foreign fishing boats in an effort to curb IUU activities.[49]

44 Kimberly L. Oremus, "Governance challenges for tropical nations losing fish species due to climate change," *Nature Sustainability* 3 (April 2020), pp. 277-280, https://doi.org/10.1038/s41893-020-0476-y.

45 Elizabeth Mendenhall et al., "Climate change increases the risk of fisheries conflict," *Marine Policy* 117 (July 2020) 103954, https://doi.org/10.1016/j.marpol.2020.103954.

46 Sareh Vosooghi, "Panic-based overfishing in transboundary fisheries," *Environmental and Resource Economics* 73 (August 2019), pp.1287-1313, https://doi.org/10.1007/s10640-018-0299-8.

47 Jessica Spijkers et al., "Identifying predictors of international fisheries conflict," *Fish and Fisheries* 22, no. 4 (July 2021), pp.834-850, https://doi.org/10.1111/faf.12554.

48 Lauren Young et al., *Future Illegal, Unreported and Unregulated Fishing Trends in a Warming World*, RUSI Occasional Paper (London: Royal United Services Institute, March 2023), https://static.rusi.org/future-iuu-fishing-in-a-warming-world-a-global-horizon-scan.pdf.

49 Helen Wieffering, "Fights over illegal fishing lead to armed conflicts, deaths," *AP News*, 31 March 2022, https://apnews.com/article/business-environment-middle-east-fish-only-on-ap-88e59a1748ba76fdc5847cc7a44e3fa6.

# CASE STUDY: WEST AFRICA

West Africa exemplifies these emerging maritime security challenges. Fisheries play key roles in the region's economies and food security. For the nineteen island and coastal nations stretching around the Gulf of Guinea from Senegal to Angola, small scale fisheries represent 6.7% of GDP on average and ensure the livelihoods of more than 6.2 million artisanal and subsistence fishers and their dependents.[50] Crucially, fisheries supply more than 20% of average per capita consumption of animal proteins across West Africa, and over 60% in several countries.[51]

Yet the region's marine resources face increasing human and environmental strains. Ocean circulation patterns render the Gulf of Guinea especially susceptible to potential tipping points for marine deoxygenation that could strangle coastal fisheries.[52] Of the twenty-five countries worldwide most vulnerable to climate pressures on marine fisheries, nine lie along the Gulf of Guinea.[53] Climate change impacts are projected to steeply reduce the region's fish stocks, cutting maximum catch potentials by 17-34% for Nigeria's EEZ, 26-35% for Ghana, and 48-64% for Gabon by 2050.[54] Employment in marine fisheries could drop by half.[55]

Today, nearly all the region's assessed fish stocks are already fully exploited or heavily overfished.[56] Since the 1990s, foreign industrial fishing fleets, largely from the European Union and China, have almost completely supplanted domestic industrial fleets in West African waters. The transition has brought extensive IUU fishing. Between 2000 and 2010, the EU and China respectively reported only 29% and 8% of their total West African catches.[57] Two-fifths to two-thirds of all fish caught in the region are taken illegally.[58] Competition from foreign distant-water fleets has diminished regional fish stocks, pushing local small-scale fishers farther out to sea for longer periods to harvest their catch. Relative to their inputs of time and labor, the "per-unit-of-effort" catch brought home by artisanal fishers plunged more than three-fold between the 1950s and 2000s. Hundreds

50 Derived from Dyhia Belhabib, U. Rashid Sumaila, and Daniel Pauly, "Feeding the poor: Contribution of West African fisheries to employment and food security," *Ocean & Coastal Management*," 111 (July 2015), pp.77,78, http://dx.doi.org/10.1016/j.ocecoaman.2015.04.010.

51 FAO (2022), p.89; Ifesinachi Okafor-Yarwood et al., *Stable Seas: Gulf of Guinea* (Broomfield, CO: Stable Seas/One Earth Future, March 2020), p.31, http://dx.doi.org/10.18289/OEF.2020.043.

52 Heinze et al.

53 Robert Blasiak et al., "Climate change and marine fisheries: least developed countries top global index of vulnerability," *PLoS ONE* 12, no.6 (June 2017), p.8, https://doi.org/10.1371/journal.pone.0179632.

54 Cheung, Bruggeman, and Butenschön, Table 4.1.

55 Anika Seggel and Cassandra De Young, Climate Change Implications for Fisheries and Aquaculture: Summary of the Findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report, FAO Fisheries and Aquaculture Circular no. C1122 (Rome: United Nations Food and Agriculture Organization, 2016), p.27, http://www.fao.org/3/a-i5707e.pdf.

56 Dyhia Belhabib, U. Rashid Sumaila, and Phillipe Le Billon, "The fisheries of Africa: Exploitation, policy, and maritime security trends," *Marine Policy* 101 (March 2019), pp.82,83, https://doi.org/10.1016/j.marpol.2018.12.021.

57 Temple et al., p.3.

58 Okafor-Yarwood et al., p.30.

of thousands of small-scale fishers find themselves tipped into precarity, ensnared in a vicious cycle of increasing fishing effort and rising costs for decreasing returns and unsustainable catches.[59]

Sharpening resource competition has spurred conflicts around the activities of foreign fleets as well as among small-scale fishers. It has also contributed to driving many artisanal fishers to engage in illicit practices. Ghanaian boats operating illegally in neighboring waters now account for one-quarter of Liberia's losses to IUU fishing.[60] Increased industrial and IUU fishing likewise appears to have helped fuel an increase in marine piracy. Shrinking economic opportunities and declining food security for fishers and their families have compelled some artisanal fishers to piracy to maintain their livelihoods.[61] In the ten years 2013-2022, the Gulf of Guinea saw 509 actual or attempted attacks, representing 26% of piracy incidents worldwide.[62]

Nigeria accounts for the bulk of piracy in the region. Many factors underpin the country's maritime criminality, including corruption, ineffective governance, and political and economic marginalization.[63] But maritime analysts and pirates themselves name environmental degradation as a key driver. Some 80% of Nigeria's ocean fisheries are collapsed, over-exploited, or fully exploited.[64] Intensive petroleum development has generated more than 11,000 offshore oil spills, contaminating fish hatcheries and habitats, and depressing fisheries production.[65] A single spill in 2011 contaminated 185 kilometers of coast, suspending fishing for months and upending the livelihoods of 28,000 fishers.[66] Nigerian pirates have justified their attacks both as reactions against illegal fishing by foreign fleets and against foreign oil companies blamed for pollution poisoning coastal fisheries in the Niger River Delta.[67] Indeed, destruction of their common environmental resources (and exclusion from the benefits of the oil economy) has alienated many coastal communities, galvanizing broader separatist insurgencies and mobilizing popular

59 Souad Kifani et al., "Climate change impacts, vulnerabilities and adaptations: Eastern Central Atlantic marine fisheries," in *Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of Current Knowledge, Adaptation and Mitigation Options*, Technical Paper 627, eds. M. Barange et al. (Rome: United Nations Food and Agriculture Organization, 2018), p.160, https://www.fao.org/3/i9705en/i9705en.pdf.

60 Belhabib, Sumaila, and Le Billon, pp.82, 86-87.

61 Ginger L. Denton and Jonathan R. Harris, "The impact of illegal fishing on maritime piracy: evidence from West Africa," *Studies in Conflict & Terrorism* 44, no.11 (November 2021), pp.938-957, https://doi.org/10.1080/1057610X.2019.1594660

62 Derived from ICC-IMB, Piracy and Armed Robbery Against Ships—Annual Report 2017 (London: ICC International Maritime Bureau, January 2018), pp.6-7, https://www.icc-ccs.org/reports/2017-Annual-IMB-Piracy-Report.pdf, and ICC-IMB, Piracy and Armed Robbery Against Ships—Annual Report 2022 (London: ICC International Maritime Bureau, January 2023), p.6, https://www.icc-ccs.org/reports/2022%20Annual%20IMB%20Piracy%20and%20Armed%20Robbery%20Report.pdf. Piracy incidents are widely recognized to be under-reported.

63 Chijoke J. Nwalozie, "Exploring contemporary sea piracy in Nigeria, the Niger Delta, and the Gulf of Guinea," Journal of Transportation Security 13 (December 2020), pp.159-178, https://doi.org/10.1007/s12198-020-00218-y.

64 Tunde Adebola and Kim de Mutert, "Investigating fishing impacts in Nigerian coastal waters using marine trophic index analysis," *Marine and Coastal Fisheries* 11, no.4 (August 2019), p.288, https://doi.org/10.1002/mcf2.10077.

65 Eze Simpson Osuagwu and Eseoghena Olaifa, "Effects of oils pills on fish production in the Niger Delta," PLoS ONE 13, no.10 (2018) e0205114, https://doi.org/10.1371/journal.pone.0205114.

66 Ifesinachi Okafor-Yarwood, "The effects of oil pollution on the marine environment in the Gulf of Guinea—the Bonga Oil Field example," Transnational Legal Theory 9, nos.3-4 (December 2018), p.259, https://doi.org/10.1080/20414005.2018.1562287.

67 Marc-Antoine Pérouse de Montclos, "Maritime piracy in Nigeria: Old wine in new bottles," *Studies in Conflict & Terrorism* 35, nos.7-8 (August 2012), pp.531-541, http://dx.doi.org/10.1080/1057610X.2012.684651.

support for recurring anti-government violence.[68] The apparent impunity of many pirate bands increasingly implicates high-level corruption, electoral protection, and the political instrumentalization by different factions of maritime violence, sapping the legitimacy of the Nigerian state.[69]

Nigeria's maritime insecurity reverberates throughout the region. Nigerian pirates increasingly range beyond domestic waters, clashing with Nigerian and other states' security services, and imperiling maritime livelihoods and economies across the Gulf of Guinea. Fishers are among the first to suffer. Fear that pirates may hijack their vessels, rob, or ransom their crews dissuade fishers from putting to sea. At the height of attacks on Nigerian fishers in 2013, 32 of the country's 40 commercial fishing companies discontinued operations. Artisanal fleets fishing farther afield to avoid pirates in Nigerian territory find themselves in confrontation with local fishers in neighboring waters. Piracy likewise dislocates maritime traffic generally, deterring trade and redirecting shipping to safer harbors, a significant blow to nations like Benin and Togo that derive substantial shares of national GDP from port fees and customs charges. Rough estimates suggest that piracy deprives West African countries of USD $2.4-3.4 billion annually in lost port and tariff revenues.[70] The UN Security Council judges piracy in the Gulf of Guinea to be a "grave and persistent threat... to international navigation, security, and sustainable development of States in the region".[71] Recognizing the collective risks, the Gulf of Guinea states have established several intra-Africa initiatives to enhance maritime security, including the Yaoundé Code of Conduct for the suppression of piracy, as well as multiple external cooperative engagements with the United States, European Union, and others.[72]

## CONCLUSION

Mounting pressures from environmental degradation and human exploitation increasingly risk tipping marine fisheries toward collapse and fisher communities toward insecurity. The window for securing a more sustainable future is closing, but effective governance can make a difference.

Better data, for instance, can support better policy. Lack of data impedes active management. Regions with less developed management, in turn, experience harvest rates three times greater and host half the population abundance compared to regions where fish stocks are effectively assessed and managed.[73] Increasingly, advanced

68 Carlo Koos, "Which grievances make people support violence against the state? Evidence from the Niger Delta," *International Interactions* 44, no.3 (2018), pp.437-462, ttps://doi.org/10.1080/03050629.2017.1369411.

69 UNODC, Pirates of the Niger Delta: Between Brown and Blue Waters (New York: United Nations Office on Drugs and Crime, 2021), https://unodc.org/res/piracy/index_html/UNODC_GMCP_Pirates_of_the_Niger_Delta_between_brown_and_blue_waters.pdf

70 See Curtis Bell et al., "Pirates of the Gulf of Guinea: A Cost Analysis for Coastal States," Stable Seas, November 2021, https://www.stableseas.org/post/pirates-of-the-gulf-of-guinea-a-cost-analysis-for-coastal-states.

71 United Nations Security Council, Resolution 2634 (2022), S/RES/2634(2022), 31 May 2022, http://unscr.com/en/resolutions/doc/2634.

72 See Okafor-Yarwood et al.

73 Hilborn et al.

technologies such as satellite tracking permit more accurate stock evaluations and closer monitoring to help avert overfishing and counter IUU activities.[74]

Better information about fisheries stock status and exploitation also facilitates more cooperative fisheries governance. Specifically, narrowing uncertainties about stock abundance, exploitation rates (including IUU activities), and the location of possible tipping points to avoid can help cement collaborative management agreements for shared fisheries and prevent preemptive or panic-based overfishing.[75] Improved information and cooperation across stakeholders enables more holistic ecosystem-based management techniques, increasing fisheries resilience by expanding management approaches beyond individual target stocks to sustain multiple species and their supporting ecosystems.[76] By the same token, more integrated approaches to maritime security must address the systemic interconnections and often shared socioeconomic dynamics driving overfishing, IUU fishing, and maritime piracy. Ultimately, answering 21st century challenges to marine ecologies and maritime security will require adaptive policies recognizing the interconnectedness of social-ecological systems and enhancing the resilience of both fisheries and fishing communities together.

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74 Darcy Bradley et al., "Opportunities to improve fisheries management through innovative technology and advanced data systems," *Fish and Fisheries* 20, no.3 (May 2019), pp.564-583, https://doi.org/10.1111/faf.12361.

75 Vosooghi; Scott Barrett and Astrid Dannenberg, "Sensitivity of collective action to uncertainty about climate tipping points," *Nature Climate Change* 4 (January 2014), pp.36-39, https://doi.org/10.1038/nclimate2059.

76 K.K. Holsman et al., "Ecosystem-based fisheries management forestalls climate-driven collapse," *Nature Communications* 11 (2020) 4579, https://doi.org/10.1038/s41467-020-18300-3.