Rebuilding marine biodiversity

Jean-Pierre Gattuso
Laboratoire d'Océanographie de Villefranche, France
&
Carlos Duarte
King Abdullah University of Science and Technology, Saudi Arabia

Review

Rebuilding marine life

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Carlos M. Duarte[1,2,3]✉, Susana Agusti[1], Edward Barbier[4], Gregory L. Britten[5], Juan Carlos Castilla[6], Jean-Pierre Gattuso[7,8,9], Robinson W. Fulweiler[10,11], Terry P. Hughes[12], Nancy Knowlton[13], Catherine E. Lovelock[14], Heike K. Lotze[15], Milica Predragovic[1], Elvira Poloczanska[16], Callum Roberts[17] & Boris Worm[15]

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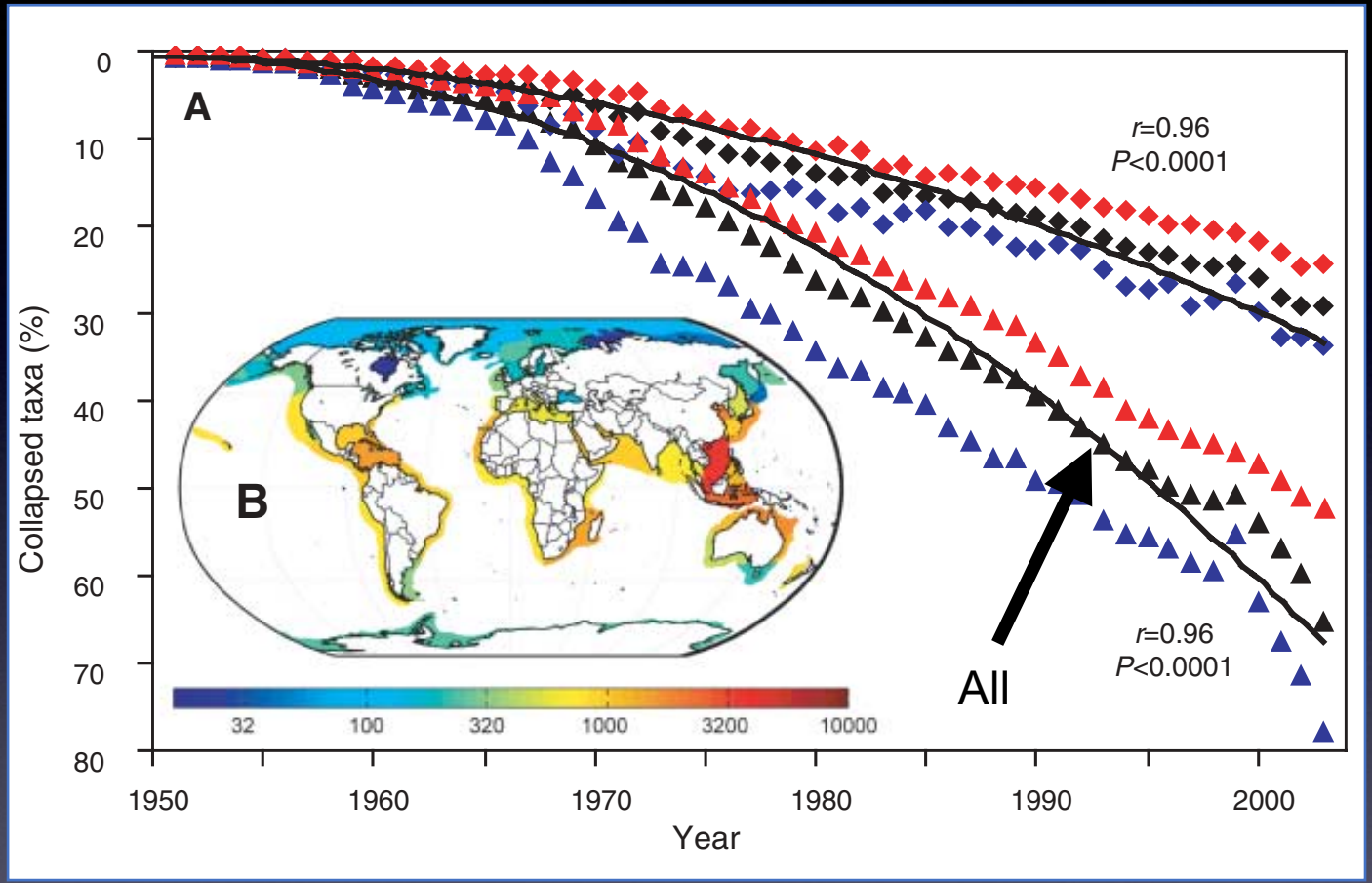
Earth's sixth mass extinction event under way, scientists warn
The Guardian
International edit

Global marine biodiversity loss

- 20 species extinct in historic times
- 830 species of conservation concern
- 89% decline in exploited marine megafauna
- 1/3 of fisheries overexploited
- 2/3 of fisheries below targets
- 42-66% loss of biomass of exploited fish stocks
- >35% of mangrove area lost
- >29% of seagrass area lost
- >16% of tidal flats lost
- >85% of oyster reefs lost
- >2/3 of salt-marshes lost
- 40% of coral reefs lost or degraded



Worm et al. (2006)

Depletion of whales

Humpback whales: from pre-exploitation population sizes of more than 50,000 to a few hundred in 1970

Whale hunting, thousands of individuals across species hunted per year in Antarctica (peak 50,000 per year)

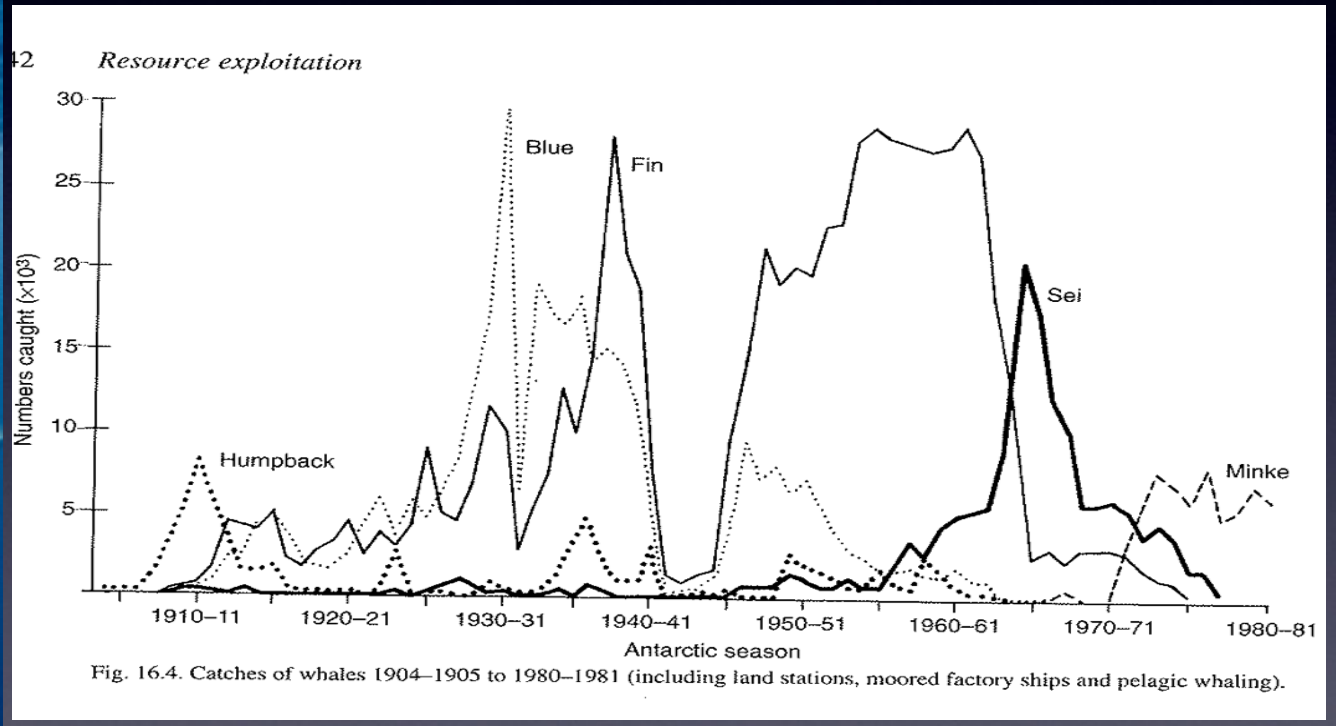


Fig. 16.4. Catches of whales 1904–1905 to 1980–1981 (including land stations, moored factory ships and pelagic whaling).

Smetacek (2007)

Pessimistic views of the ocean abound

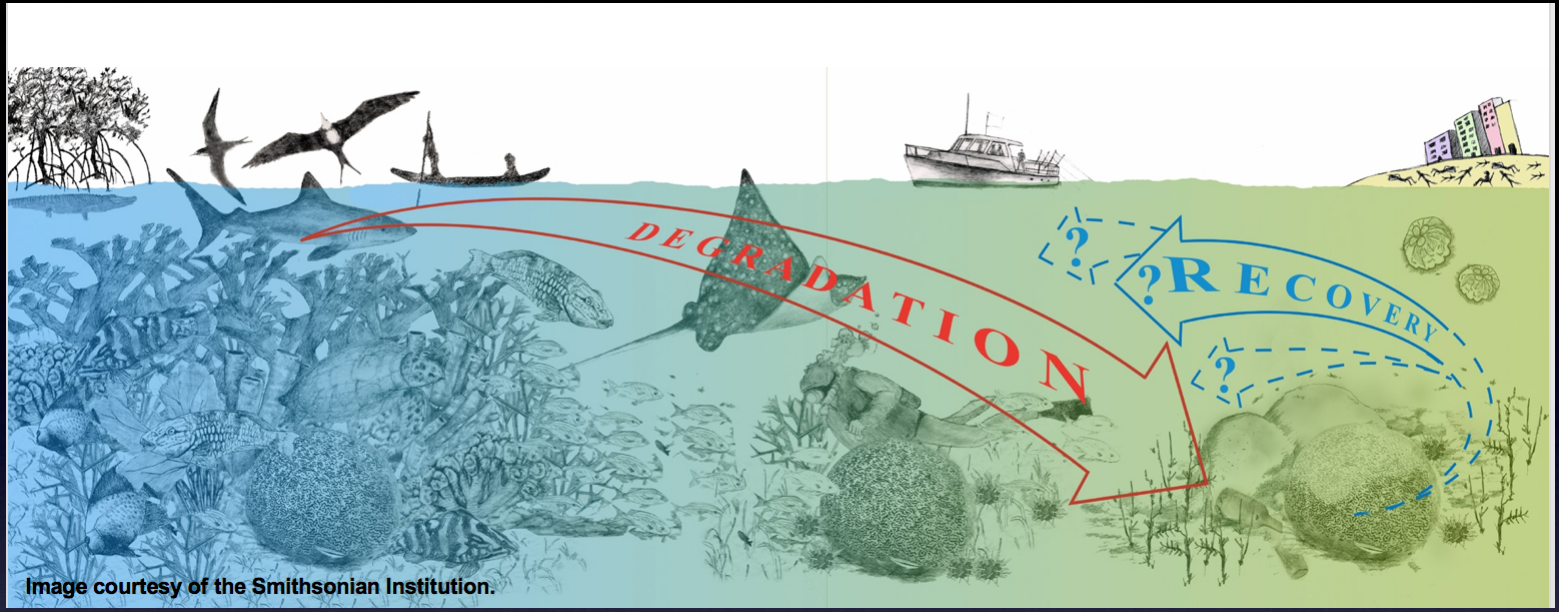
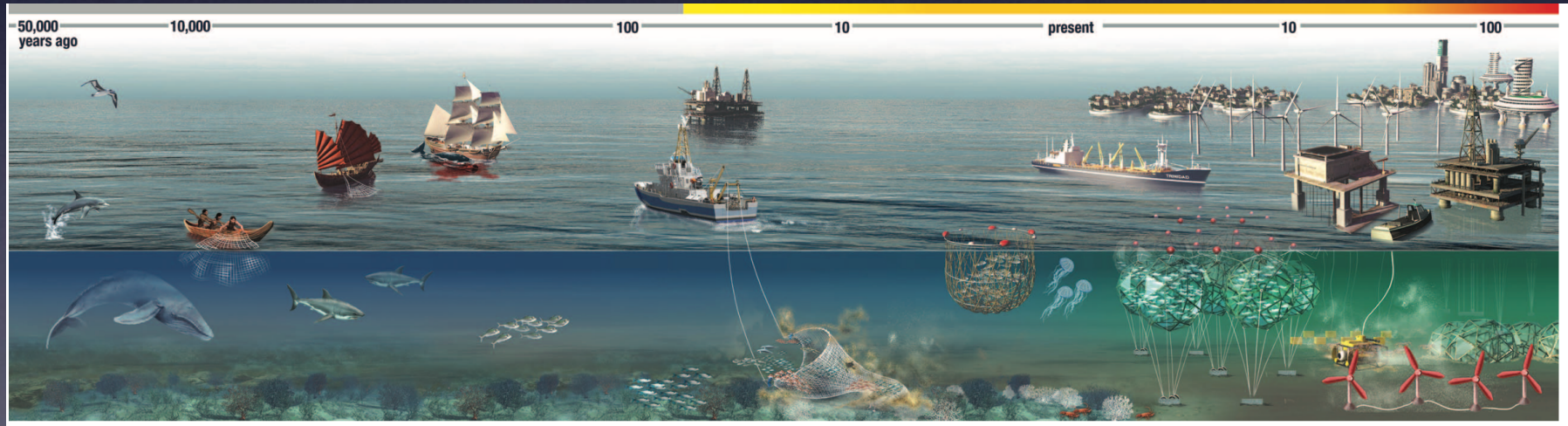


Image courtesy of the Smithsonian Institution.

J. Jackson



Timeline (log scale) of marine and terrestrial defaunation. The marine defaunation experience is much less advanced, even though humans have been harvesting ocean wildlife for thousands of years. The recent industrialization of this harvest, however, initiated an era of intense marine wildlife declines. If left unmanaged, we predict that marine habitat alteration, along with climate change (colored bar: IPCC warming), will exacerbate marine defaunation.

McCauley et al (2015)

Recovery: whales

Globally > 50%above 1940 estimates; IUCN down-listed from Vulnerable to Least Concern

Out of 92 marine mammal populations (Roman et al. 2015):

- 42% increasing
- 10% decreasing
- remainder: no change

Recovery: Restoration Mekong Delta mangrove forest

The reforestation of the Mekong Delta, the largest mangrove forest in the world, 15 years after its destruction by the US Air Force is the largest-scale ecosystem restoration ever undertaken (Duarte et al., 2008)

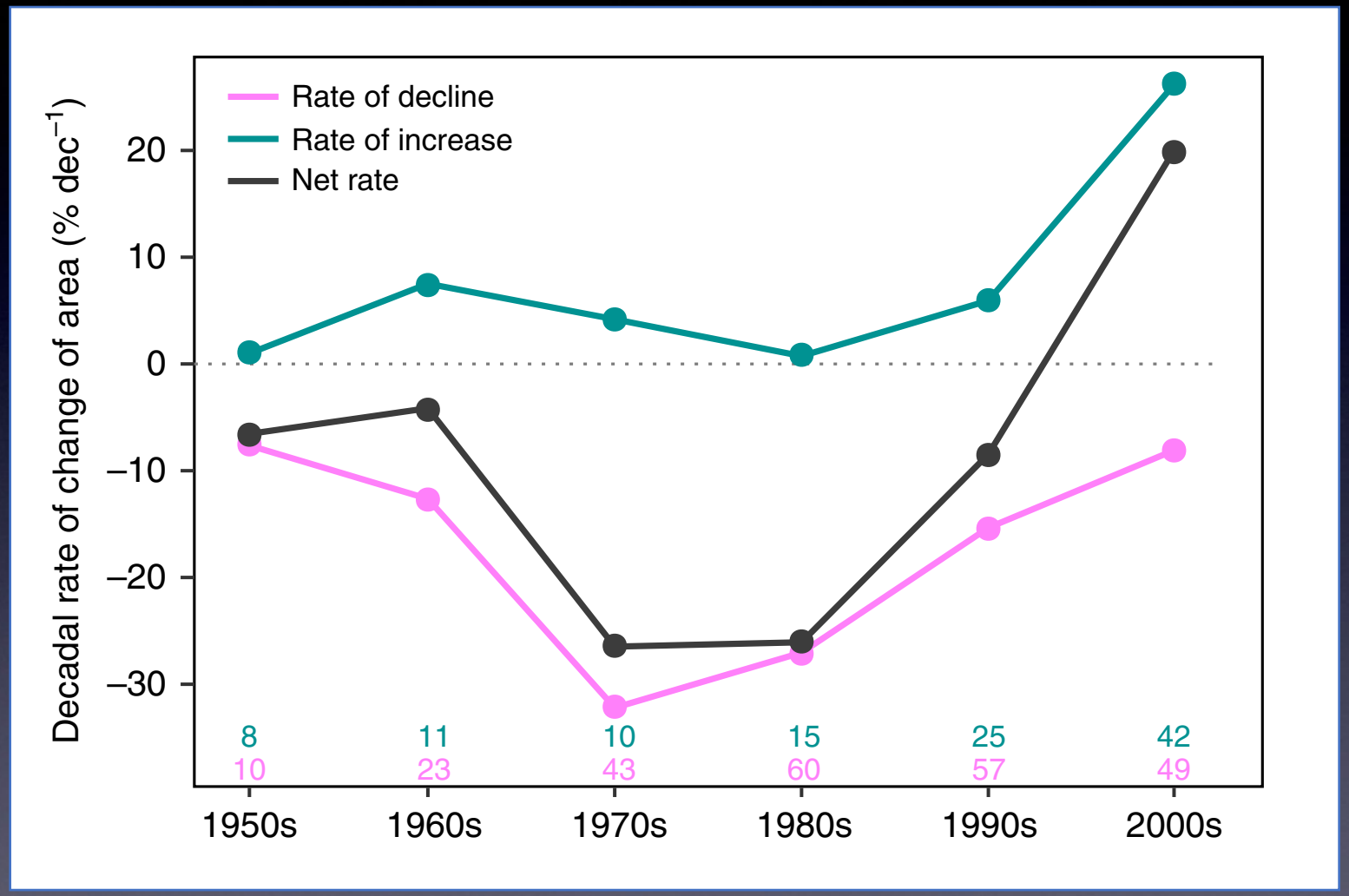
- 1964 and 1970: 57% of all Mekong Delta Mangrove Forest destroyed
- 1978-1998: 2700 km^2 planted
- Carbon storage (Nam et al., 2016):
  - restored mangrove: 889 ± 111 MgC ha^{-1}
  - natural mangrove: 844 ± 58 MgC ha^{-1}

Recovery: salt marsh restoration

Williams and Orr (2002)

- Salt marsh restoration is well proven and can often be achieved by restoring tidal flows
- Restored breached levee salt marshes in San Francisco Bay Estuary
- Recovery in one decade

Recovery: European seagrass



de los Santos et al. (2019)

- **1/3 of European seagrass area lost**, loss peaking in the 1970s and 1980s
- **Loss rates slowed down** for most of the species and fast-growing species recovered in some locations
- **Net rate of change reversed** in the 2000s
- Density metrics improved or remained stable in most sites
- In contrast with global assessments, **seagrass decline is no longer a generalised state in Europe**
- Deceleration and reversal of declining trends is possible

Recovery: coral reefs following nuclear tests

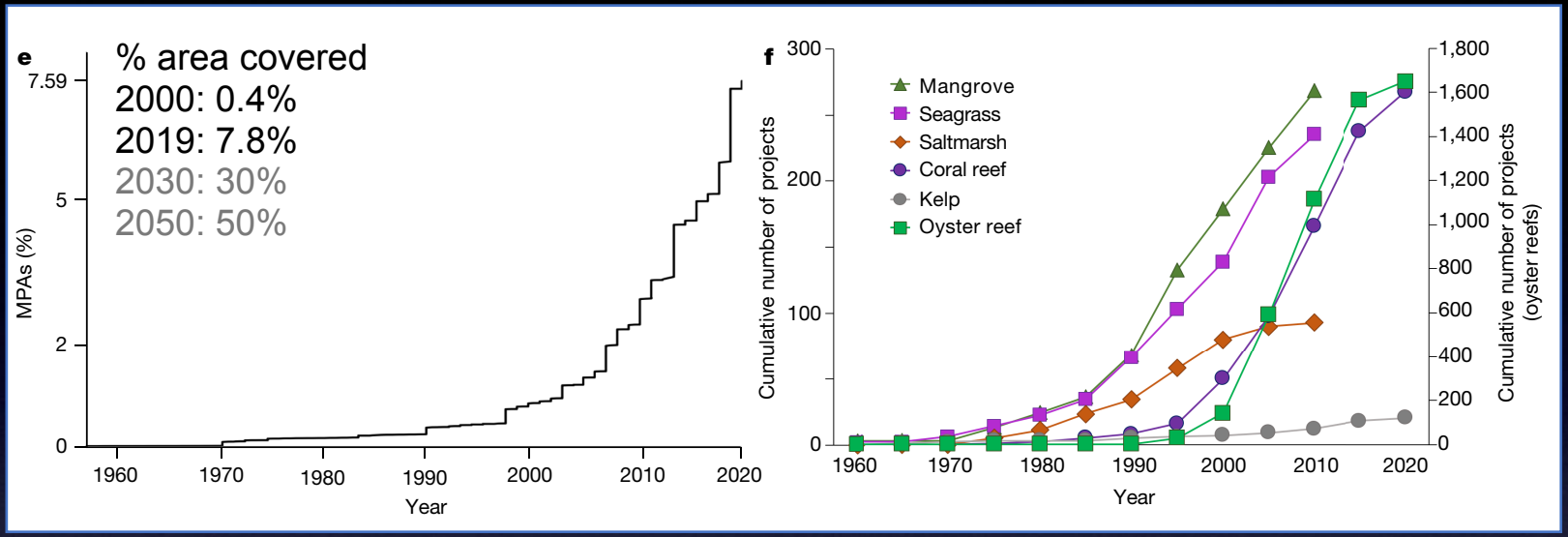
- 76.3 megatons (TNT equivalent) were conducted across seven test sites (1946 to 1958)
- Five craters were created
- Surface seawater temperatures raised by 55,000 °C after air-borne tests
- Blast waves with speeds of up to 8 m/s; and shock and surface waves up to 30 m high with blast columns reaching the floor of the lagoon (approximately 70 m depth)
- **Coral reefs in the Bikini Atoll recovered 40 years after the end of tests, although with some biodiversity changes** (Richards et al. 2008)
- "*While nuclear testing is devastating on an acute timescale, it may prove to be beneficial to the local ecosystem over a more chronic duration through human exclusion*" (Lawrence et al. 2015)

Recovery: coral reefs following nuclear tests

See Nancy's presentation

- 76.3 megatons (TNT equivalent) were conducted across seven test sites (1946 to 1958)
- Five craters were created
- Surface seawater temperatures raised by 15,000 °C after air-borne tests
- Blast waves with speeds of up to 8 m/s; and shock and surface waves up to 30 m high with blast columns reaching the floor of the lagoon (approximately 70 m depth)
- **Coral reefs in the Bikini Atoll recovered 40 years after the end of tests, although with some biodiversity changes** (Richards et al. 2008)
- "*While nuclear testing is devastating on an acute timescale, it may prove to be beneficial to the local ecosystem over a more chronic duration through human exclusion*" (Lawrence et al. 2015)

MPAs and restoration projects



Duarte et al. (2020)

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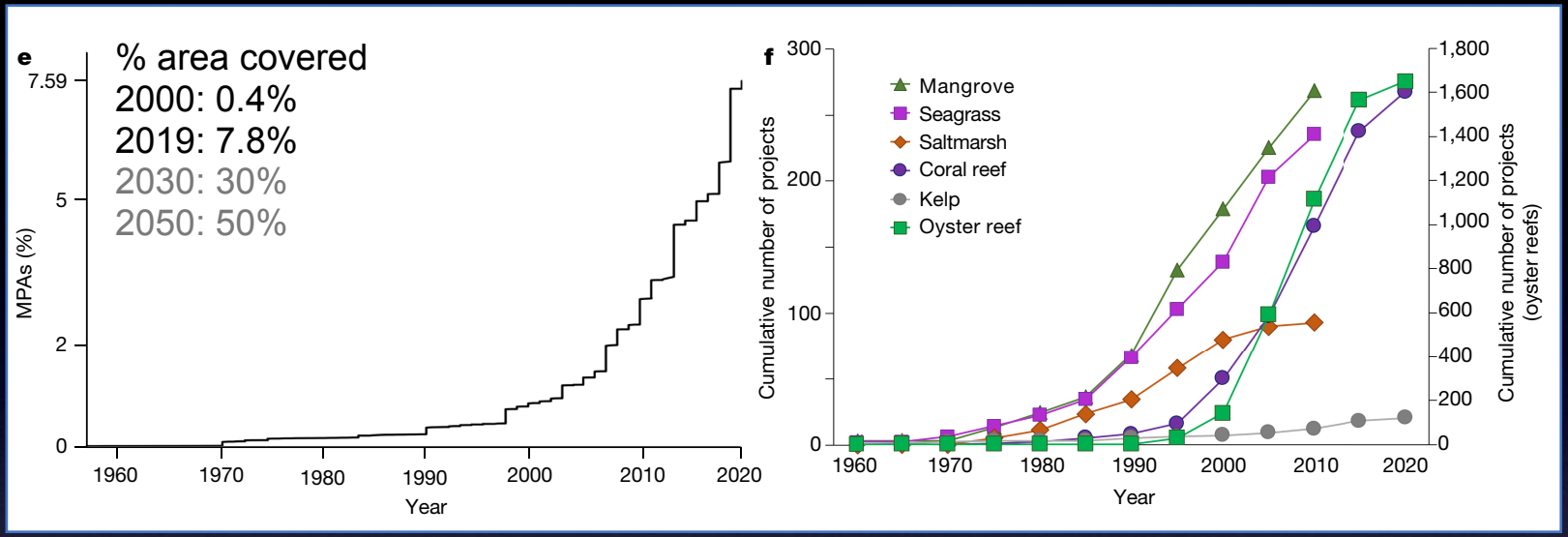

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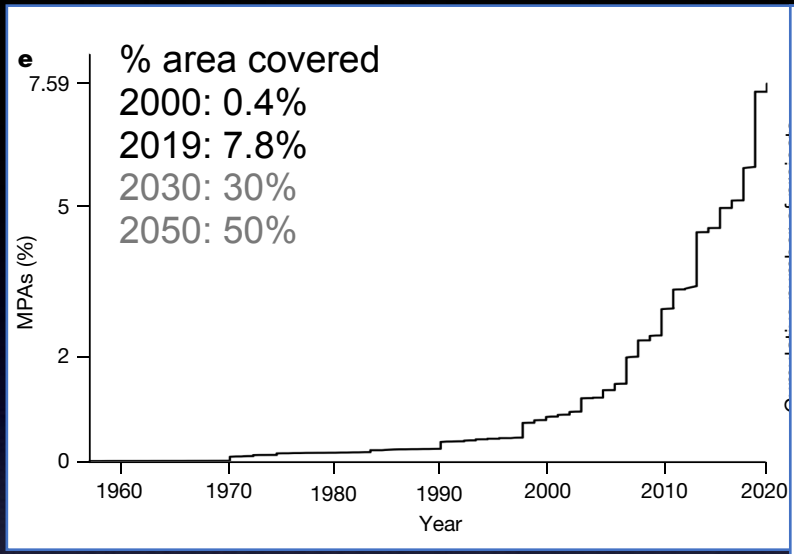
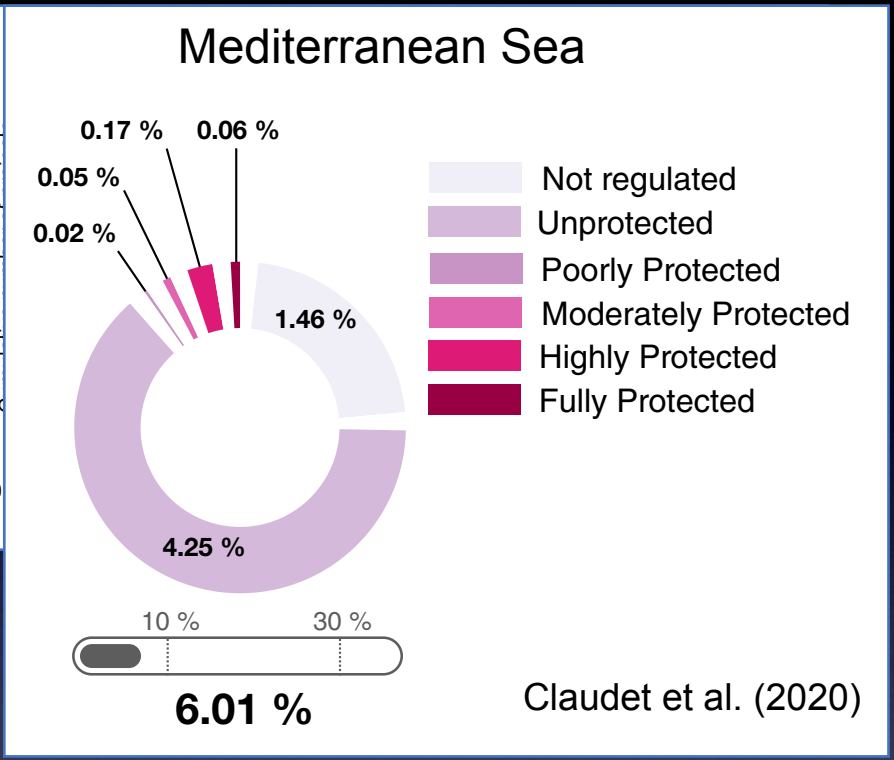
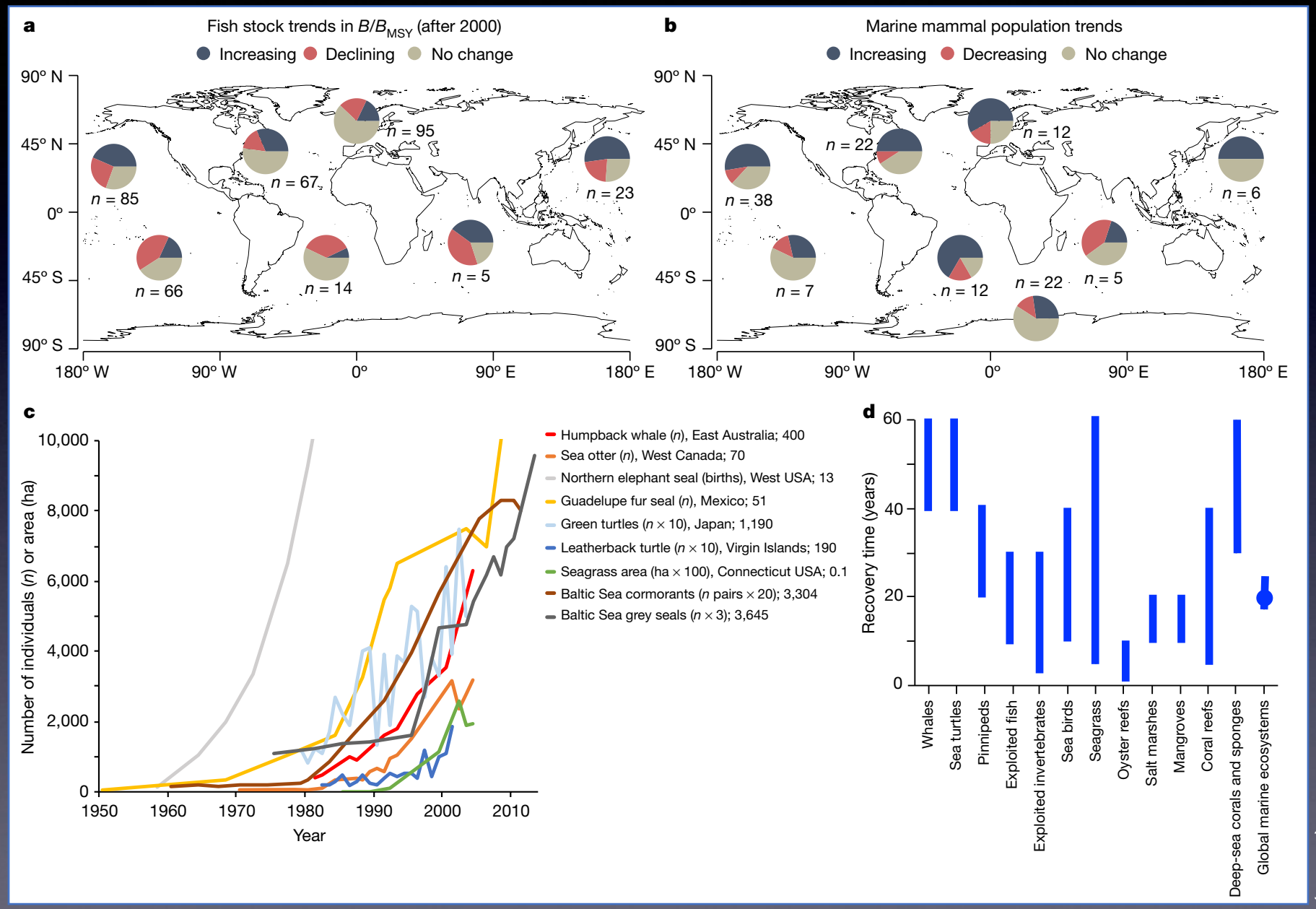




Recoveries



Duarte et al. (2020)

Recovery wedges

- **No single solution** for achieving substantial (50-90% of past metrics) recovery of marine life by 2050
- Recovery requires the strategic stacking of a number of complementary actions, here termed **recovery wedges**:
  - protecting vulnerable habitats and species
  - adopting cautionary harvesting strategies
  - restoring habitats
  - reducing pollution
  - mitigating climate change
- The strength of the contribution of each of these wedges vary across species and ecosystems
- For instance, mitigating climate change is the critical wedge to set coral reefs on a recovery trajectory, whereas improved habitat protection and fisheries management are the critical wedges for the recovery of marine vertebrates and deep-sea habitats

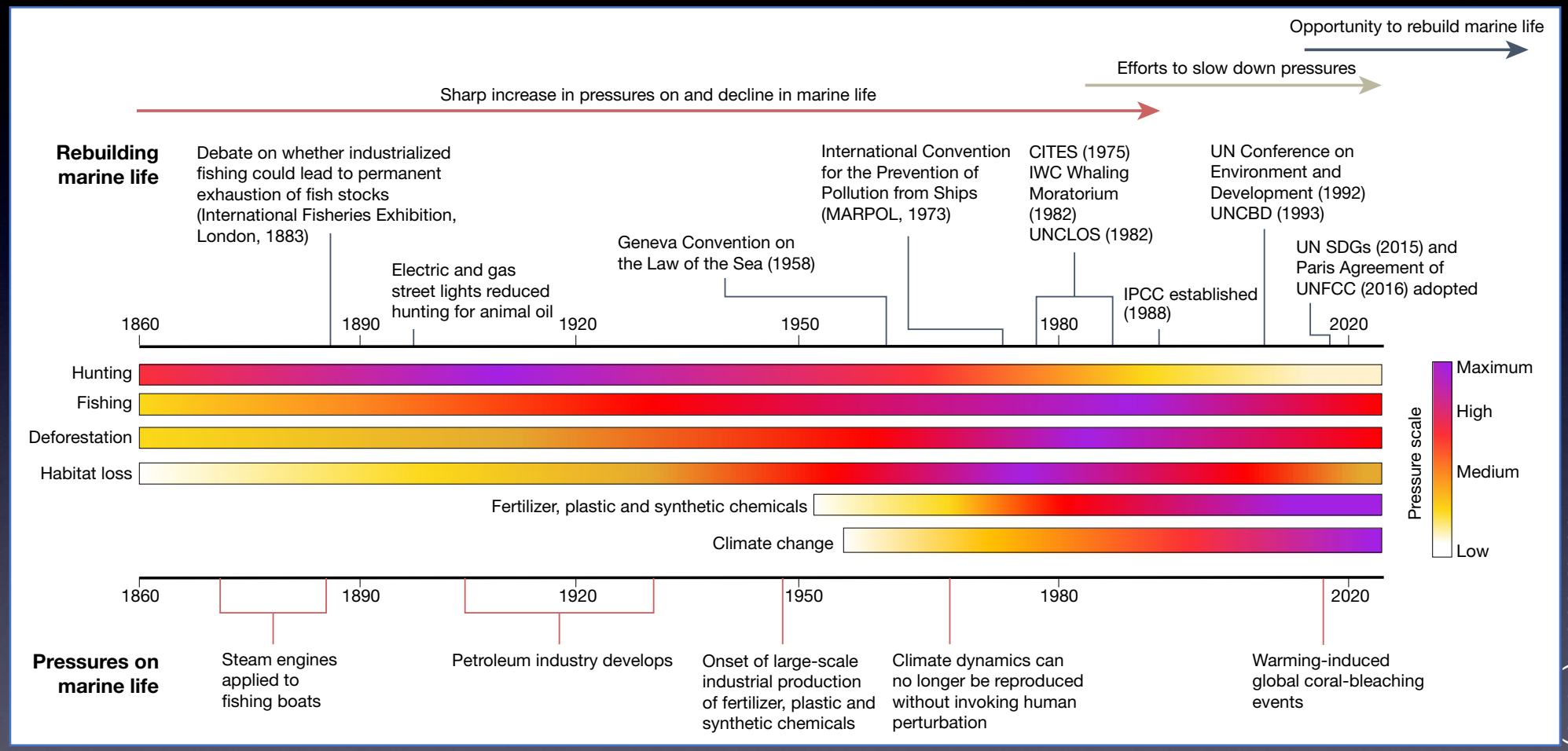
Roadblocks

- A number of roadblocks may delay or prevent recovery of some of the critical components:
  - **Climate change** is the critical backdrop against which all rebuilding efforts will play out. Much stronger efforts to reduce the gap between target and projected emissions under the present voluntary NDCs is a challenging but not impossible task
  - Need to **consider unavoidable impacts** brought about by ocean warming, acidification and sea-level rise already committed by past emissions, even if the climate mitigation wedge, represented by the Paris Agreement, is fully implemented.
  - **Natural variability** and intensification of environmental **extremes**
  - **failure to reduce pressures** other than climate change mitigation
  - unexpected **natural or social events**
  - **growing human population** will create additional demands for seafood, coastal space and other ocean resources
- **Substantial to complete recovery** (60-100% increase relative to the present) appears realistic and achievable for most components
- **Partial to substantial recovery** (10 to >50%) can be targeted for deep-sea habitats, where slow recovery rates lead to a modest rebuilding scope by 2050, and for coral reefs, where existing and projected climate change severely limits the rebuilding prospects

Necessary investments and expected returns

- Substantial rebuilding of marine life by 2050 requires **sustained effort and financial support**:
  - at least US$10–20 billion per year to reach protection of 50% of the ocean space plus substantial additional funds for restoration
- **Benefits**: considerable economic return (x10) and in excess of one million new jobs:
  - Rebuilding fish stocks can be achieved by **market-based instruments**, such as rationalizing global fishing subsidies, taxes and catch shares, to end perverse incentives and by the growth of truly sustainable aquaculture to reduce pressure on wild stocks
  - Whereas most regulatory measures focus on **commercial** fisheries, **subsistence and recreational fishing** are also globally relevant and need to be aligned with rebuilding efforts to achieve sustainability
  - Rebuilt fisheries alone could increase the annual profits of the **global seafood industry** by US$53 billion
  - A global rebuilding of exploited fish stocks could **increase fishing yields** by 15% and **profits** by about 80% while reducing bycatch mortality
  - Conserving coastal wetlands could save the **insurance industry** US$52 billion annually while providing additional benefits of carbon sequestration, income and subsistence from harvesting, and from fisheries
- **Ecotourism** in protected areas provides 4-12 times greater economic returns than fishing without reserves (for example, AUS$5.5 billion annually and 53,800 full time jobs in the Great Barrier Reef Marine Park)

Global pressures on marine life and governance



Duarte et al. (2020)

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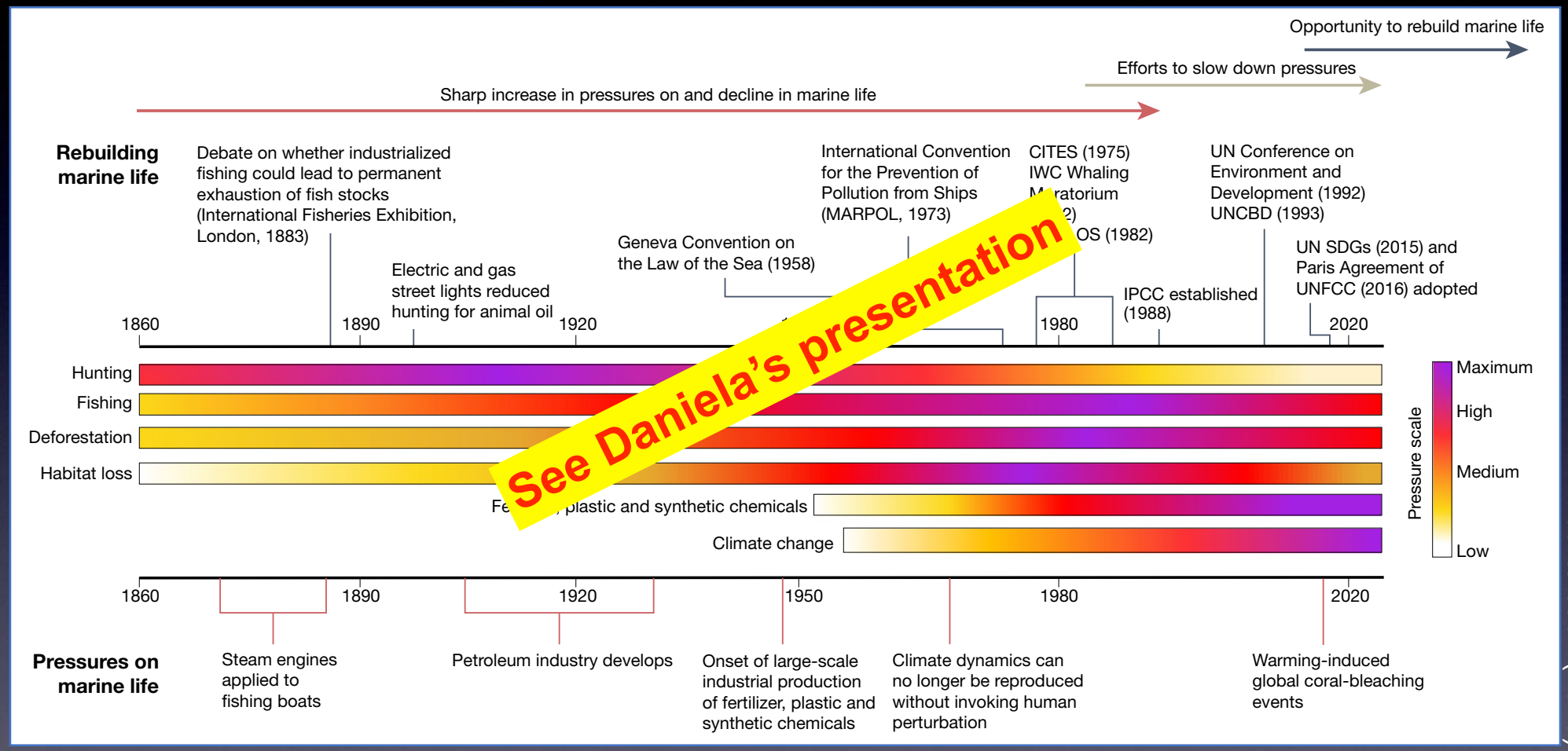
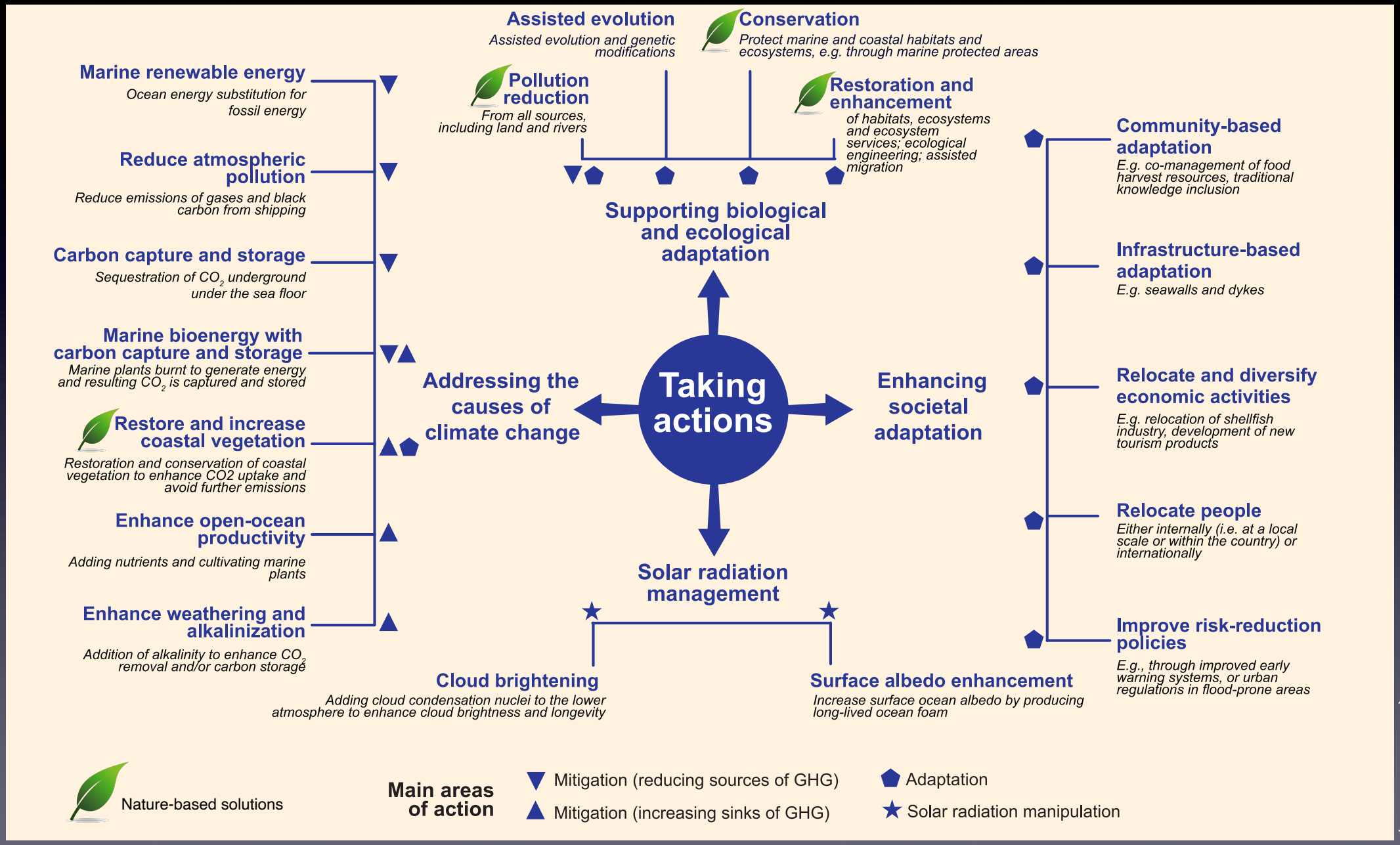


See Daniela's presentation

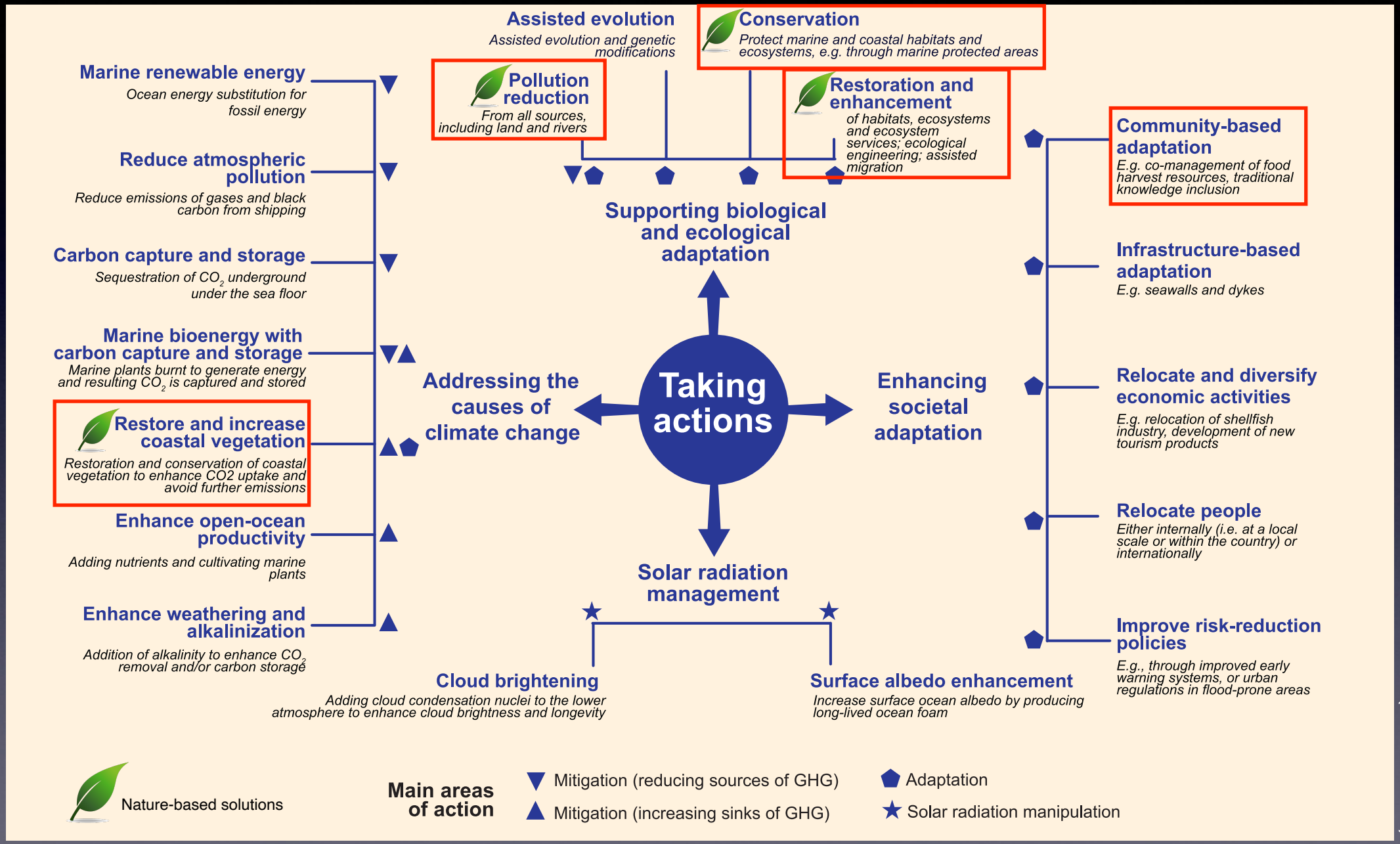
Duarte et al. (2020)

Assessment— 18 ocean-based measures



Gattuso et al. (2018, 2019)

Assessment— 18 ocean-based measures



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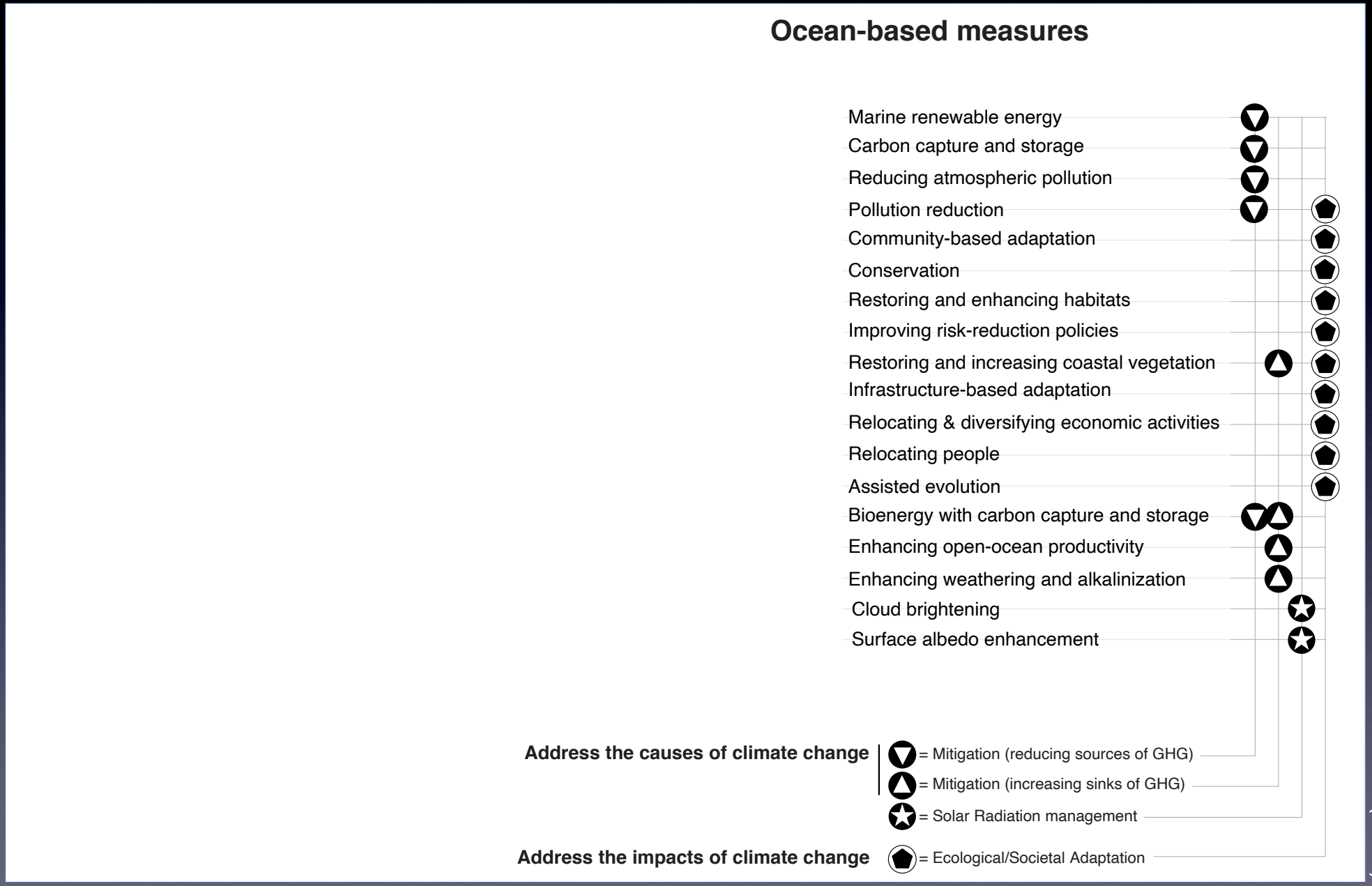
Clusters of ocean actions



Gattuso et al. (2019)

Clusters of ocean actions

Policy clusters

Decisive

- Already implemented in the real-world
- High effectiveness to reduce climate-related ocean drivers globally (for mitigation actions)
- Range of low to high effectiveness to reduce impacts/risks locally
- Relatively limited uncertainties, and few disbenefits

Low Regret

- Already implemented in the real-world
- Low effectiveness to reduce climate-related ocean drivers globally
- Moderate-to-high effectiveness to reduce impacts/risks locally
- High non-climatic co-benefits and no-to-very-limited disbenefits

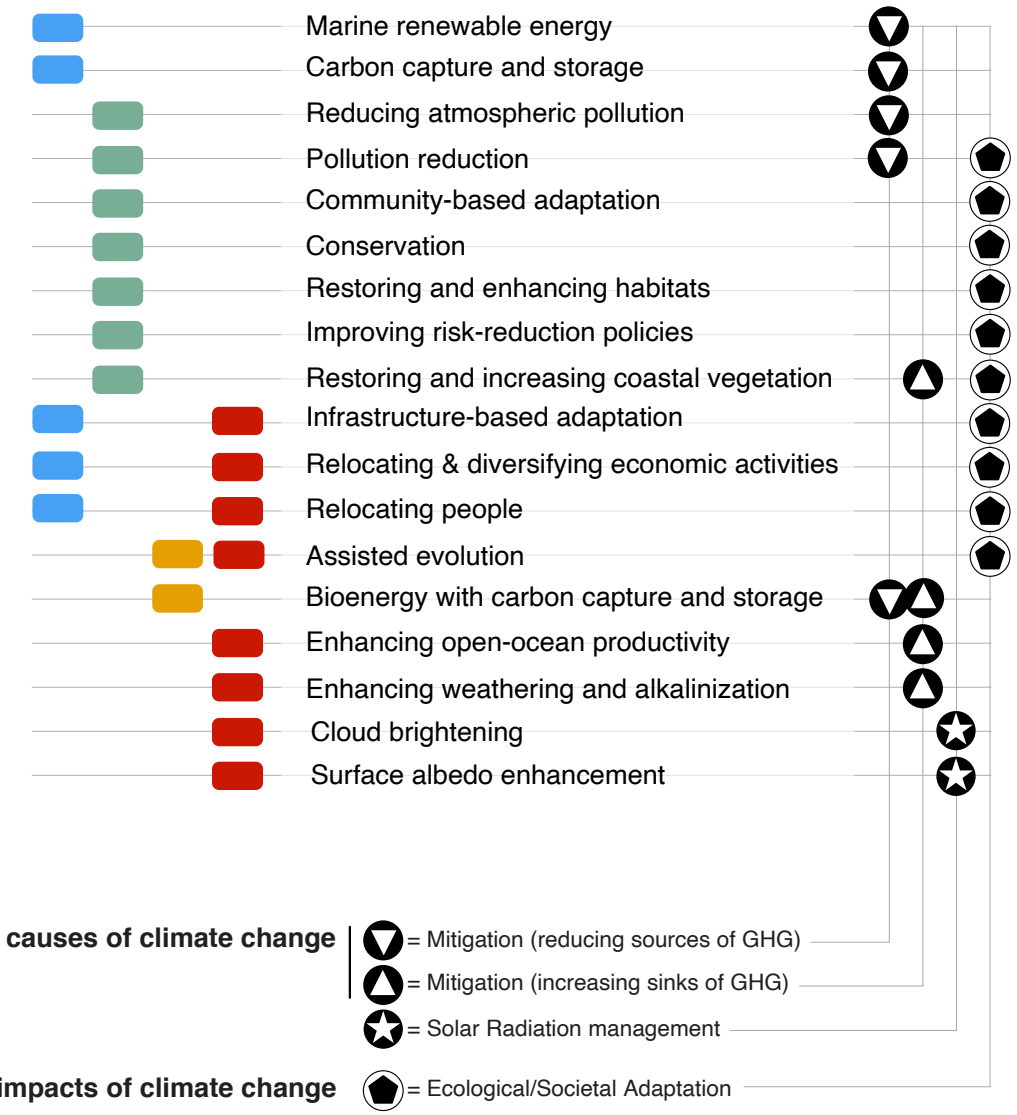
Unproven

- Currently at concept stage
- Potentially low to moderate effectiveness to reduce climate-related ocean drivers globally
- Potentially low to moderate effectiveness to reduce impacts/risks locally
- Potentially low-to-moderate disbenefits

Risky

- Currently at concept stage
- Potentially high effectiveness to reduce climate-related ocean drivers globally
- Potentially low to high effectiveness to reduce impacts/risks locally
- Potentially high disbenefits

Ocean-based measures



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Key messages

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- Conserve and sustain what is left: no longer acceptable
- **Sustainable Development Goal 14** of the United Nations aims to "*conserve and sustainably use the oceans, seas and marine resources for sustainable development*"
- Here we document the **recovery** of marine populations, habitats and ecosystems following past conservation interventions
- Recovery rates across studies suggest that **substantial recovery** of the abundance, structure and function of marine life **could be achieved by 2050**, if major pressures—including climate change—are mitigated
- Rebuilding marine life represents a **doable Grand Challenge** for humanity, an **ethical obligation** and a **smart economic objective** to achieve a sustainable future