

THE OCEAN AND US

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HUMAN EXPLOITATION OF MARINE ECOSYSTEMS

Pre-history



- *Homo habilis* & *H. erectus* may have harvested fish and shellfish ~800,000 yrs BP.
- *Homo sapiens* South Africa – Middle Stone age, evidence of harvesting fish 160,000 yrs BP
- Neanderthals 125,000 - 30,000 yrs BP

Indigenous Fisheries



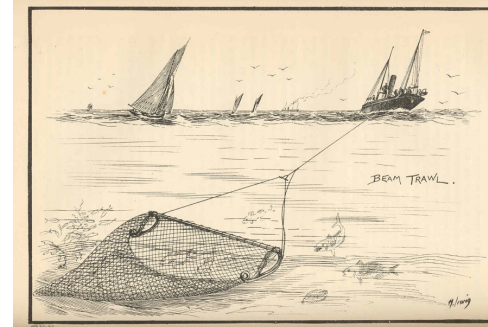
- Primitive watercraft and fishing technologies.
- Evidence of overfishing (depletion of prey populations, reduction in prey size. e.g. Chumash people, NE Pacific; Polynesia (Micronesia 3,000-4,000 BP followed by Hawaii, New Zealand and Easter Island 1000 BP)

Medieval Event Horizon



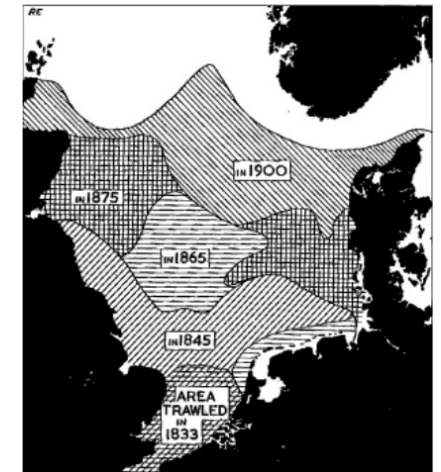
- Population growth and urbanisation
- Depletion of FW fisheries and environment
- Cultural / religious factors
- Fisheries move offshore (cod & herring in Europe)
- Invention of trawling (14th C)

Trawling Invented



- Beam trawls invented 14th Century
- Complaints that they destroy marine ecosystems and fisheries by fishers
- Regulation against trawling including capital punishment 14th – 16th Century

Industrialisation/ Colonial Fishing



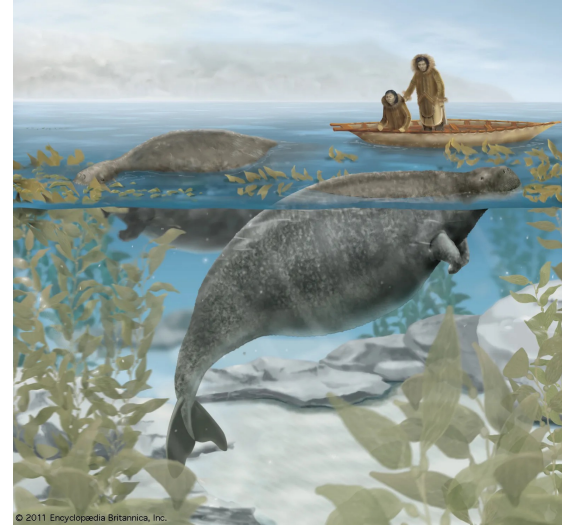
- Steam power
- Preservation & transport
- Fishing technology
- Market economy
- Aggressive, unregulated exploitation of fisheries



THE FIRST RECORDED HISTORICAL MARINE EXTINCTIONS

- Sea mink (*Mustela macrodon*)
- Stellar's sea cow (*Hydrodamalis gigas*) and parasites
- Caribbean monk seal (*Monachus tropicalis*)
- Atlantic grey whale (*Eschrichtius robustus*)
- Great auk (*Alca impennis*)
- Pallas' cormorant (*Phalacrocorax perspicillatus*)
- Auckland Islands merganser (*Mergus australis*)

Dulvy et al (2009) In Turvey (Ed) Holocene Extinctions; Carlton et al (1999) Annual Review of Ecology and Systematics 30: 515-538; Carlton (2023) Diversity 15: 782.



Joseph Wulf



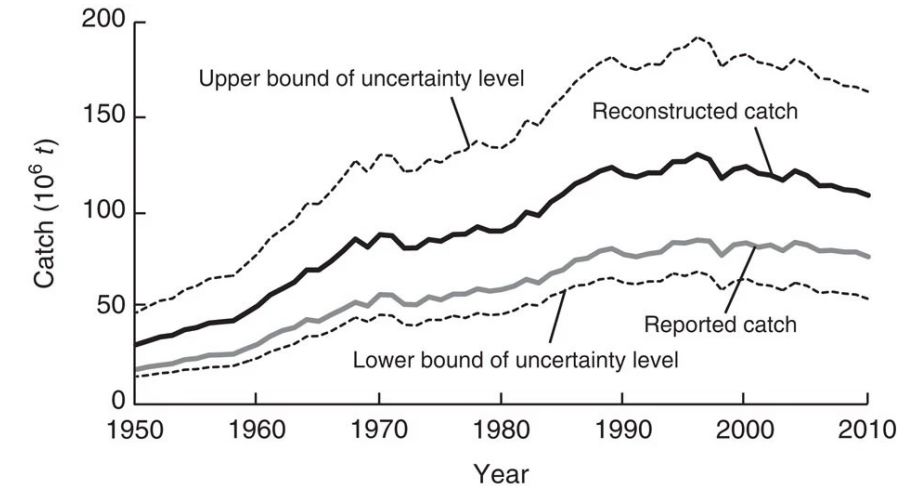
John Gerrard Keulemans



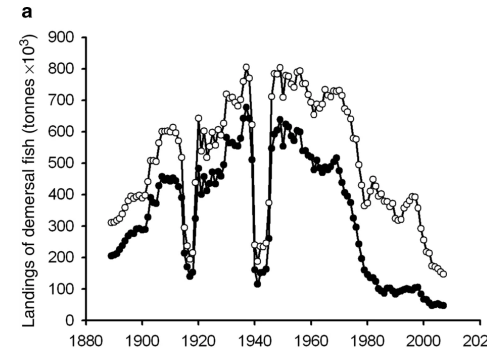
Smithsonian Institution

THE GREAT ACCELERATION

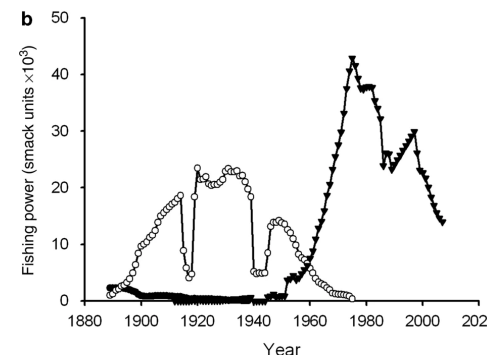
- 1945 British fishing fleet depleted by losses during WWII – looked on initially as an opportunity to limit fleet size
- Other nations looked on fishing as a means to feed growing populations and develop the economy
- Subsidies funded the integration of new technologies into fishing vessels (e.g. acoustics) and for some nations surplus warships converted to fishing
- Huge increase in fishing power in global fleets
- Issues with MSY – focused on harvesting an undifferentiated stock; concerns of biodiversity impacts, ecological interactions and evolution of targeted species of lower priority



Global catch reconstruction rose to 86M t by 1996 then declined to 77M t by 2010 (~1.22M t yr⁻¹) Pauly & Zeller (2015) Nature Communications 7: 10244



(a) Total landings 1889 – 2007 for United Kingdom (open circles) and England and Wales (closed circles)



(b) Total fishing power of large trawlers 1889-2007. Closed circles = sailing trawlers, open circles = steam trawlers, closed triangles = motor trawlers

Thurstan et al. (2010) Nature Communications 1: 15

Oceanic sharks and rays

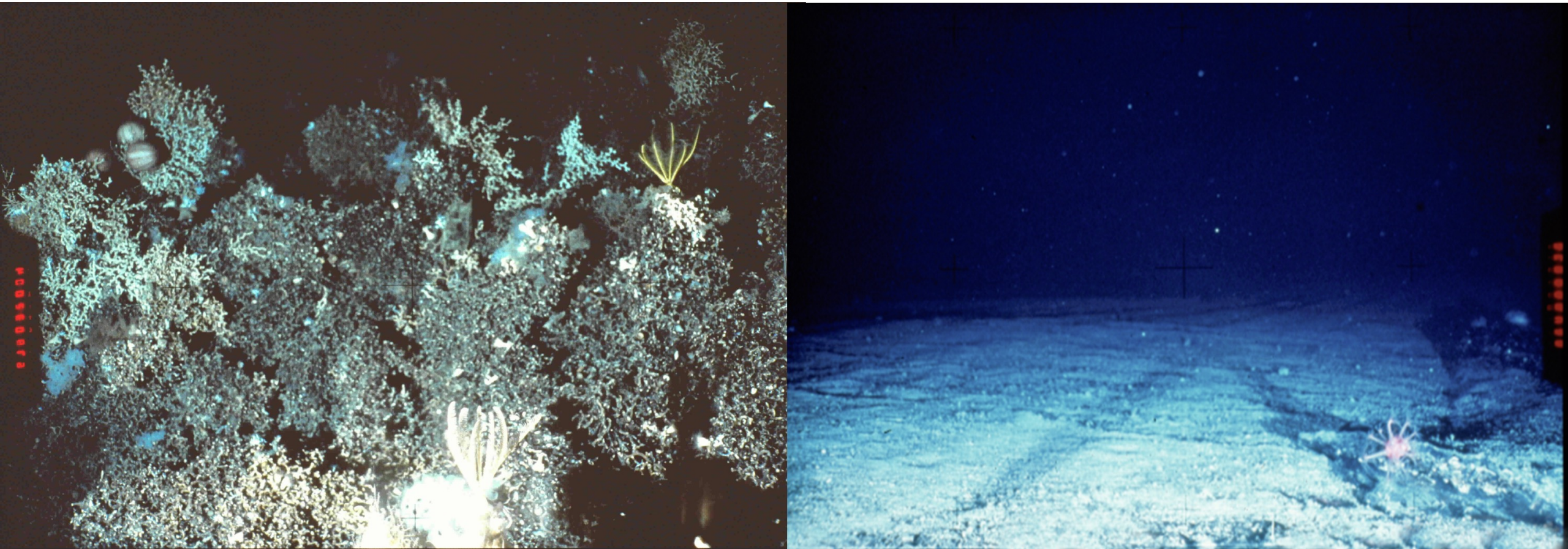
71% decline since 1970s

More than 75% threatened
by extinction

Pacoureau et al (2021)
Nature 589: 568-571



HABITAT DESTRUCTION IN THE DEEP SEA



Orange roughy bycatch and trawl fishing impacts: Chatham Rise (Probert et al., 1997 *Aquat. Cons.* 7: 27-40);
South Australia Seamounts (Koslow et al., 2001 *Mar. Ecol. Prog. Ser.* 213: 111-125).



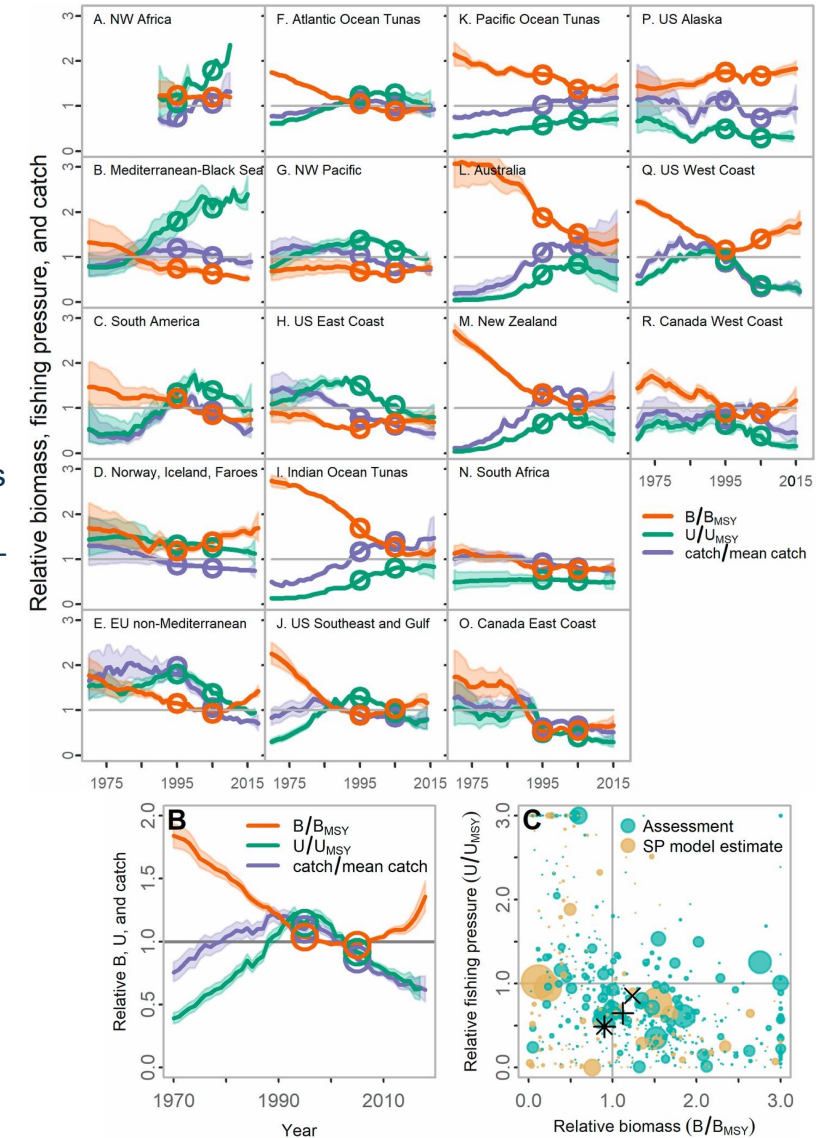
[https://doi.org/10.1002/\(SICI\)1099-0755\(199703\)7:1<27::AID-AQC214>3.0.CO;2-9](https://doi.org/10.1002/(SICI)1099-0755(199703)7:1<27::AID-AQC214>3.0.CO;2-9) ; <https://doi.org/10.3354/meps213111>

THE PRESENT PICTURE

- Stock assessment approaches have advanced from biomass dynamics and yield-per-recruit models to virtual population analysis and integrated assessments (IA)
- The most sophisticated IAs include multiple stocks, spatial structure and movement
- Fisheries Commissions have adopted (to varying degrees) measures to protect the ecosystem (e.g. technical measures to prevent seabird bycatch by CCAMLR)
- Evidence that in parts of the world surviving fish stocks are stable or recovering but in other areas overexploitation is still taking place and stocks are in decline. FAO statistics indicate the number of depleted and overfished stocks is still increasing.
- Many smaller stocks / fisheries as well as those where management capacity is limited likely unassessed.
- Still significant issues of IUU fishing (e.g. squid in ABNJ)

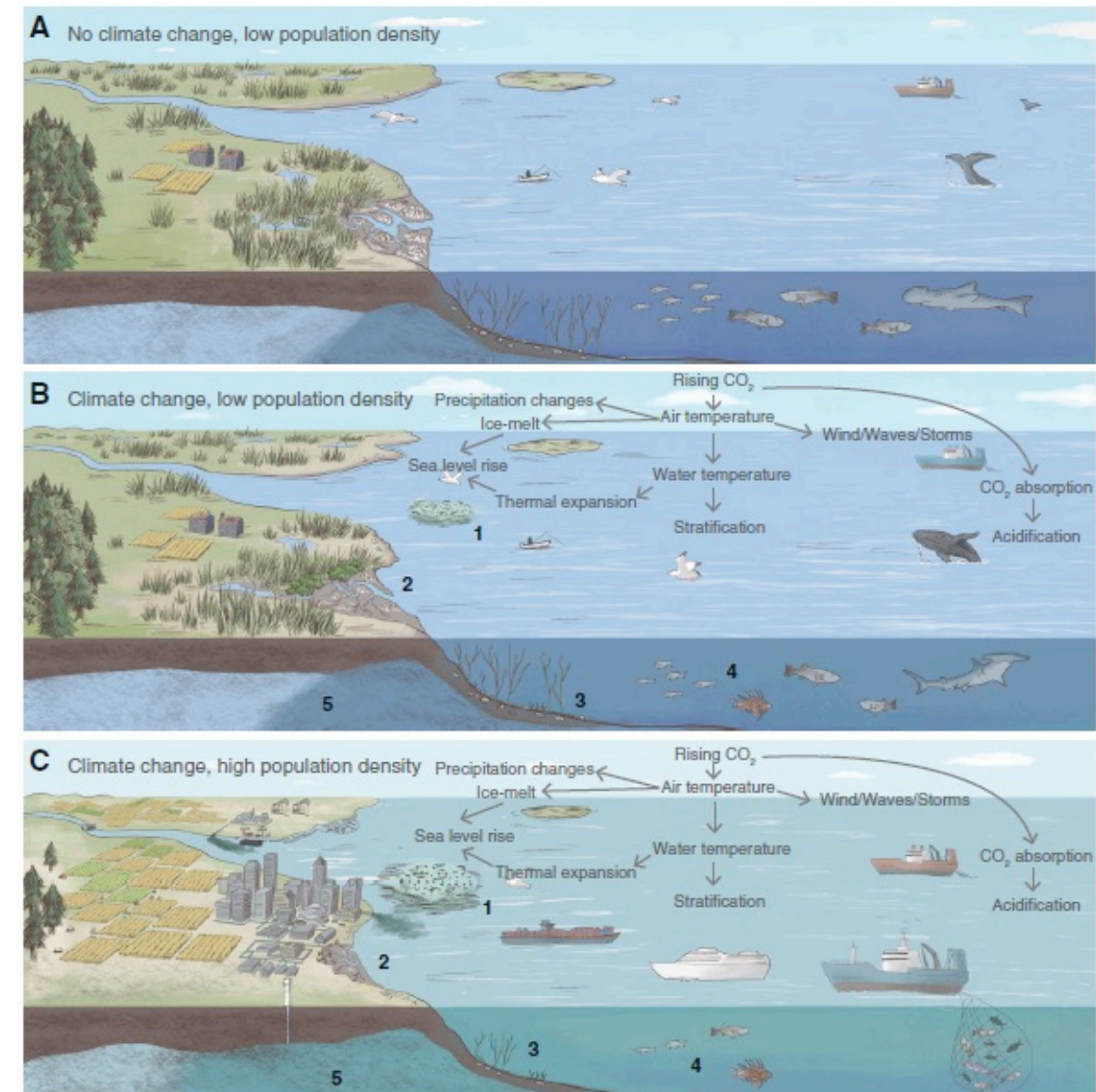
Analysis of changes in catch, Biomass / Biomass at MSY and fishing mortality (U) at MSY regionally and (B) globally. (C) Shows status of individual stocks in latest year of assessment.

Hilborn et al (2020) Proceedings of the national Academy of Sciences of the USA 117: 2218–2224



REGIONAL IMPACTS ON COASTAL ECOSYSTEMS

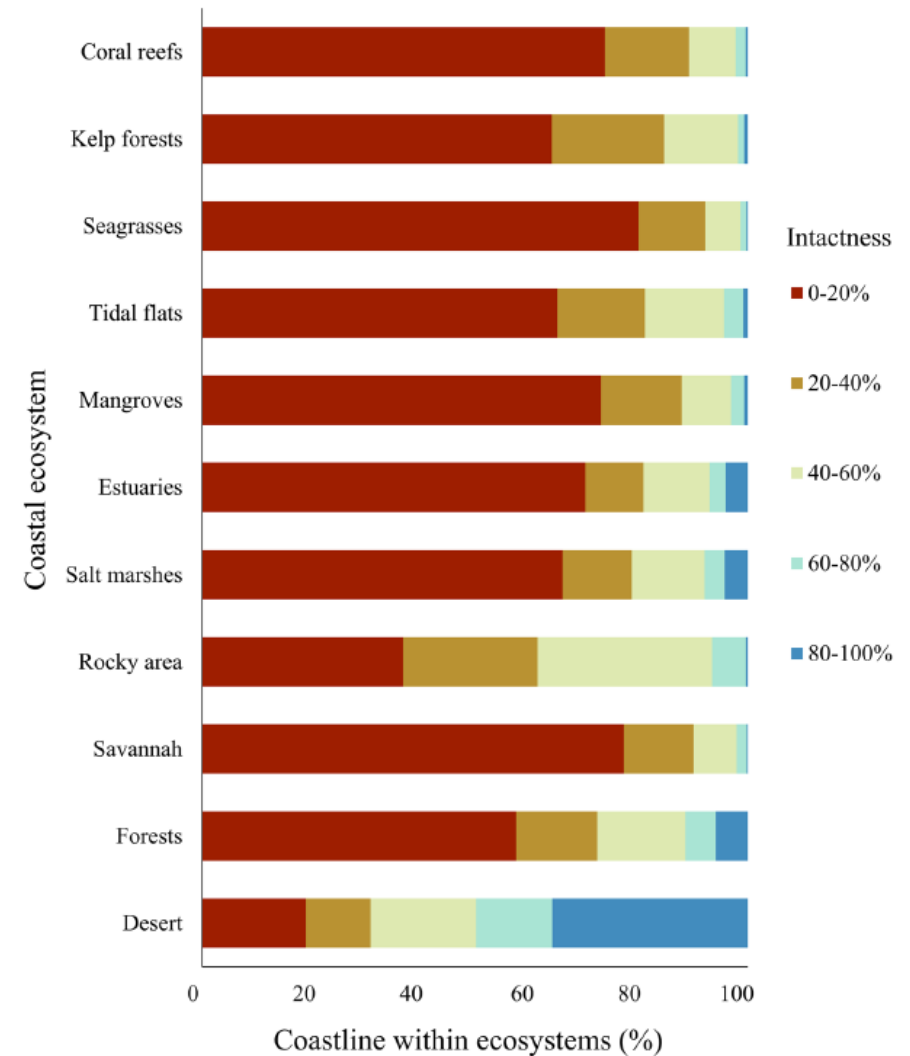
- Coastal zones are densely populated with a heavy reliance on ecosystem services
- Biodiversity rich with many unique ecosystems and species
- Multiple human impacts: pollution, coastal reclamation or hardening of shorelines, development, aquaculture, exploitation of fisheries, wood and other products, renewables
- Many key coastal ecosystems have been subject to major declines (coral reefs – 50% since 1870, mangroves – 40%, saltmarshes – 60%)
- Local impacts superimposed on the impacts of climate change



INTACTNESS OF COASTAL ECOSYSTEMS

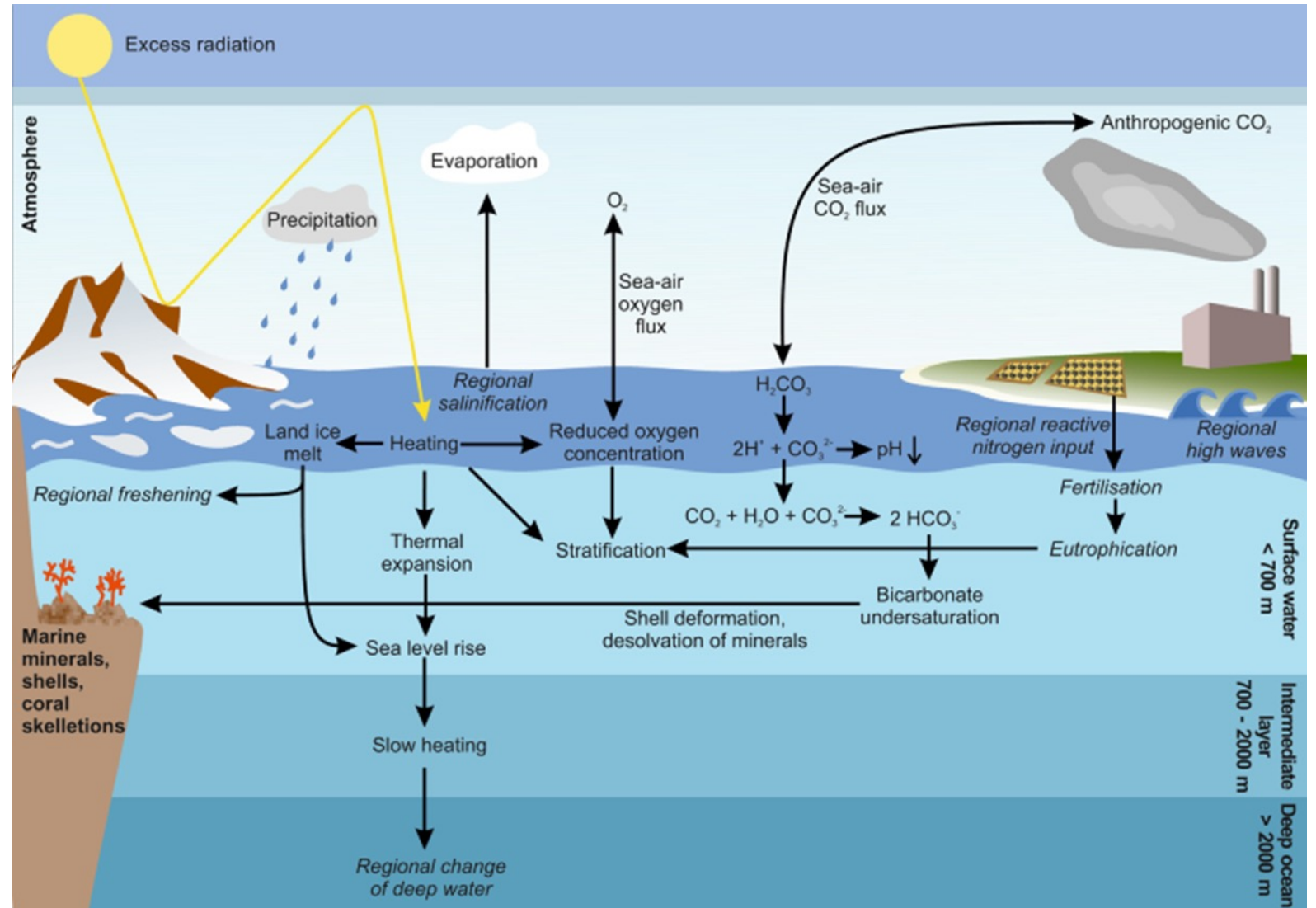
- Globally only 15.5% of coastal ecosystems have a low level of human impact
- 47.9% of coastal ecosystems heavily impacted by human activity and for 84.1% of countries more than 50% of coastal ecosystems are degraded
- Human pressures highest in areas where seagrasses, coral reefs and savannah was present

Williams, B.A. et al. (2021) Conservation Biology 36: e13874



GLOBAL CLIMATE IMPACTS ON THE OCEAN

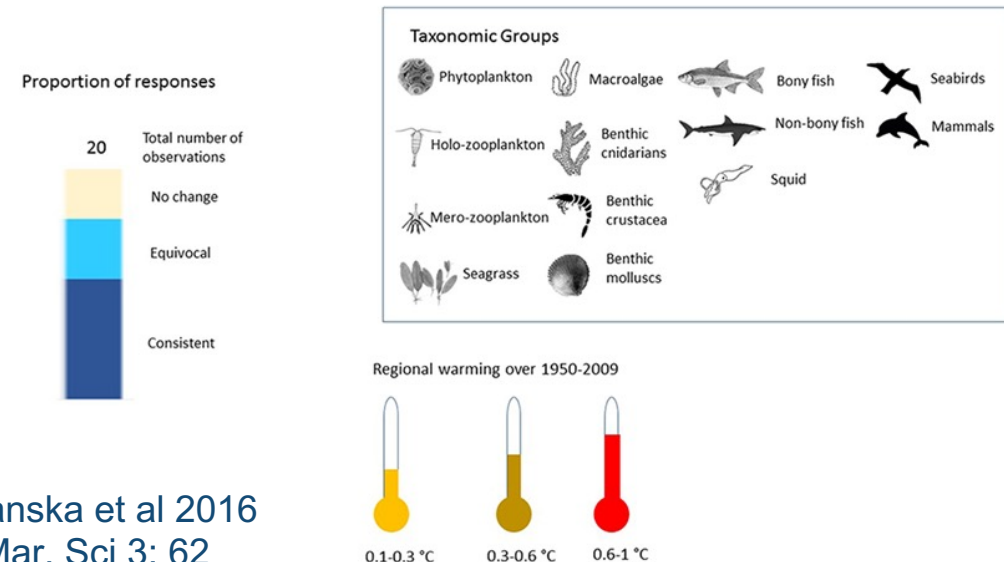
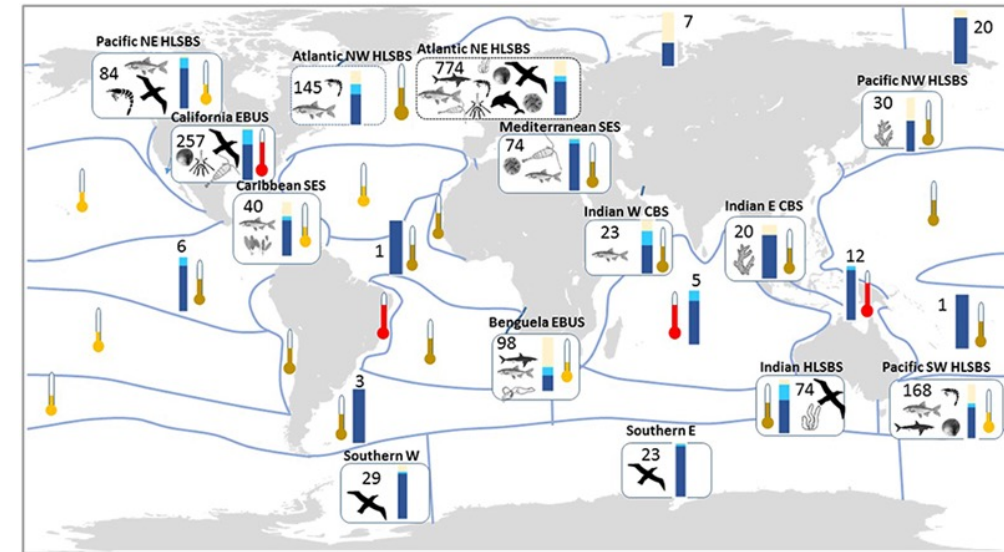
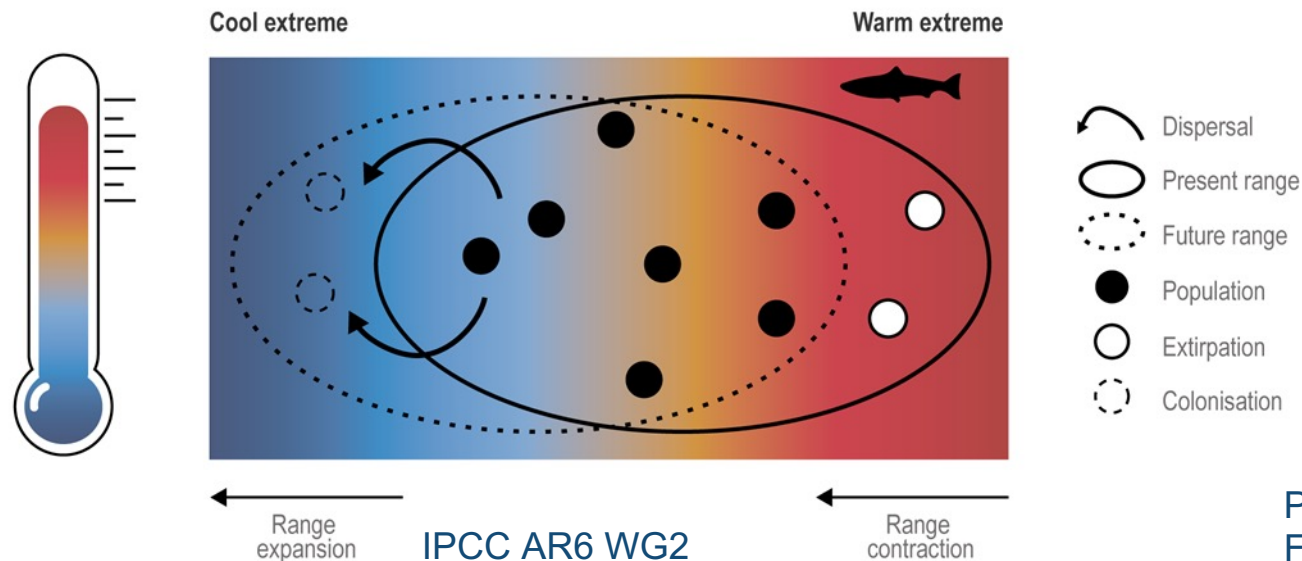
- Ocean heating
 - Increased stratification
 - Decreased nutrients
 - Reduction in primary production
 - Cryosphere impacts
- Deoxygenation
 - Physiological impacts
 - Greenhouse gases
- Acidification
 - Impacts on shell/skeleton forming taxa
 - Complex interactions with chemistry and physiology



CLIMATE IMPACTS ON SPECIES DISTRIBUTIONS

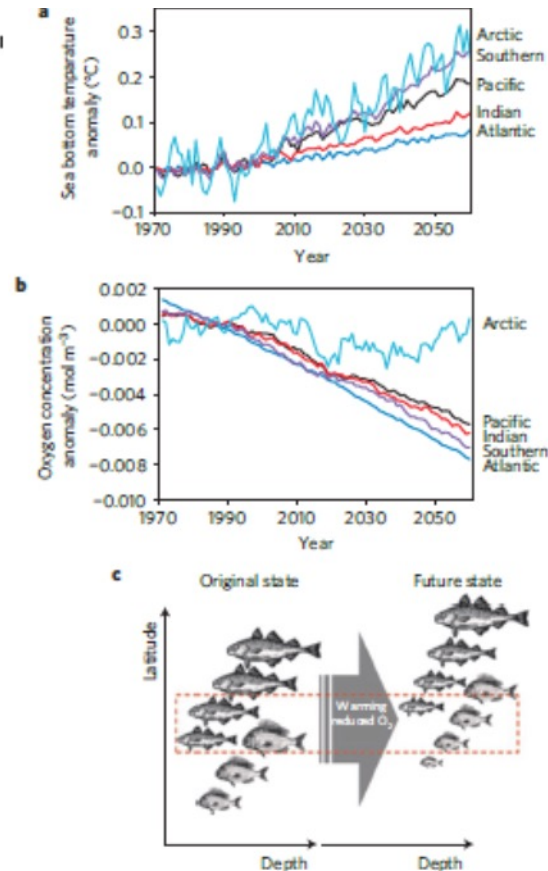
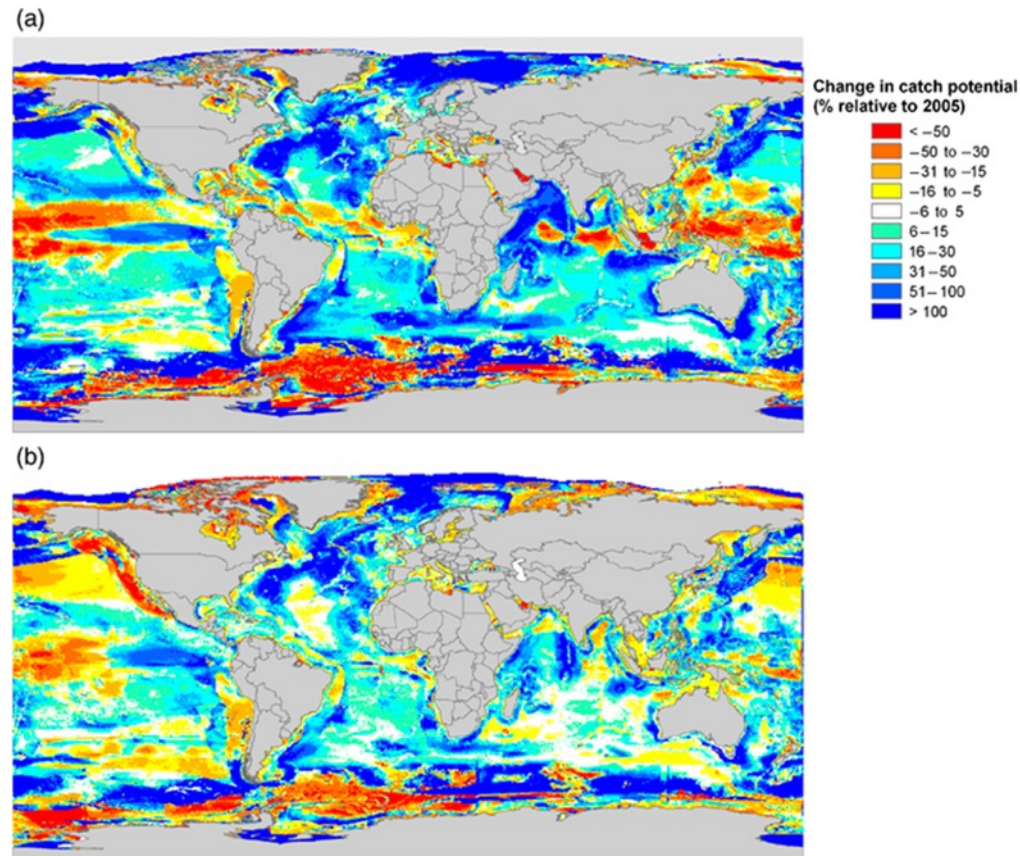
- As thermal maxima are exceeded for species at their equatorward limit ranges shift towards the poles
- Broadly consistent with observations
- Also changes in phenology (timing) of ecological cycles

Schematic of range-shift dynamics in marine ectotherms in response to climate warming



CLIMATE CHANGE IMPACTS ON FISHERIES

- For fisheries decline in catch potential in the tropics and at high latitudes as temperatures exceed thermal limits
- Also, the combined effects of increasing temperature and decreasing oxygen lead to smaller size of fish (especially at low-mid latitudes)
- Doesn't take into account habitat loss (e.g. reefs) or other human impacts

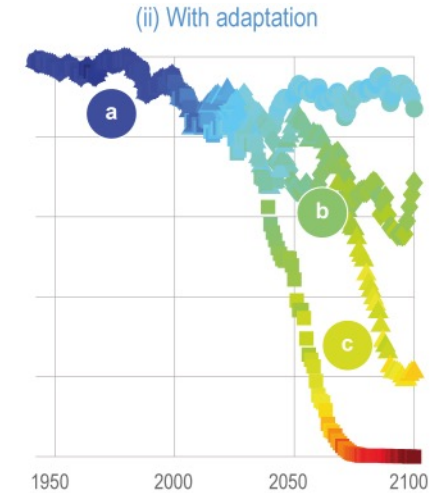
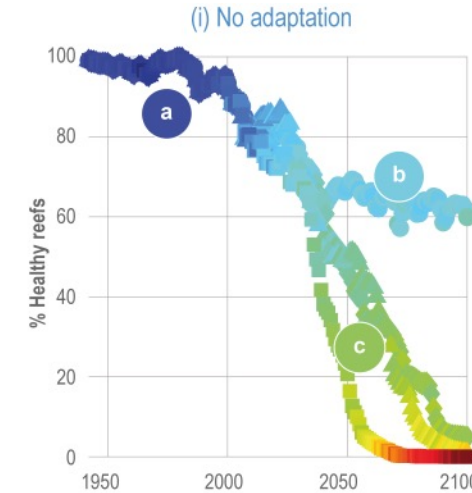
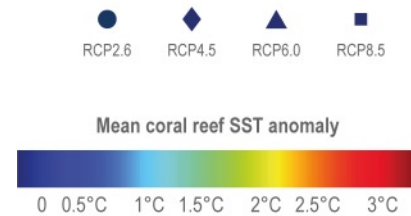


Cheung et al., 2010 Global Change Biol. 16: 24-35
Cheung et al., 2013 Nature Climate Change 3: 254-258

CLIMATE CHANGE AND CORAL REEFS

- Coral reefs are particularly vulnerable to warming but also ocean acidification and sea level rise
- Mass coral bleaching first detected in late 1970s is a major cause of reef decline
- Caused by disruption of the coral-algal symbiosis
- As temperatures become more extreme, also direct coral mortality
- Acidification effects carbonate accretion/dissolution rates at reef level

Coral reef futures
with and without adaptation



(a) Historical coral reef



High coral cover and diversity; high physical complexity and reef growth; high fish biomass and diversity

(b) Low diversity reef



Moderate cover composed of few, heat-tolerant taxa; lower complexity and growth rate; lower fish diversity

(c) Degraded coral reef

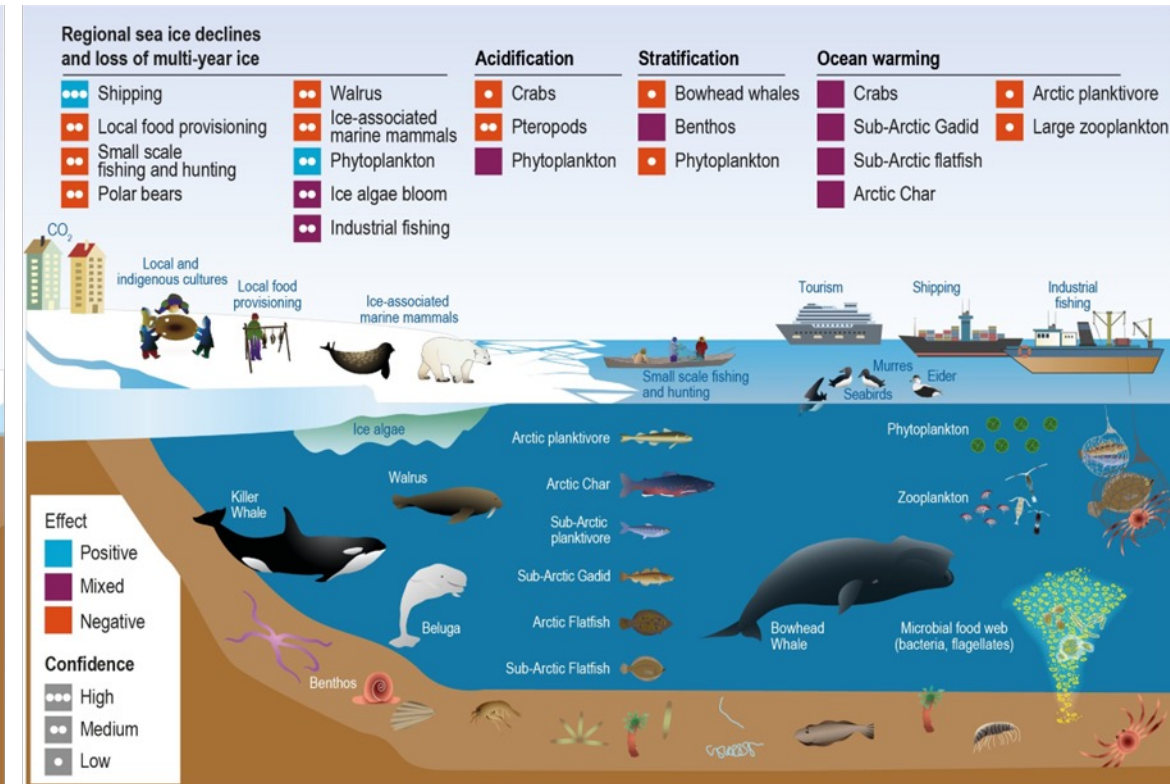
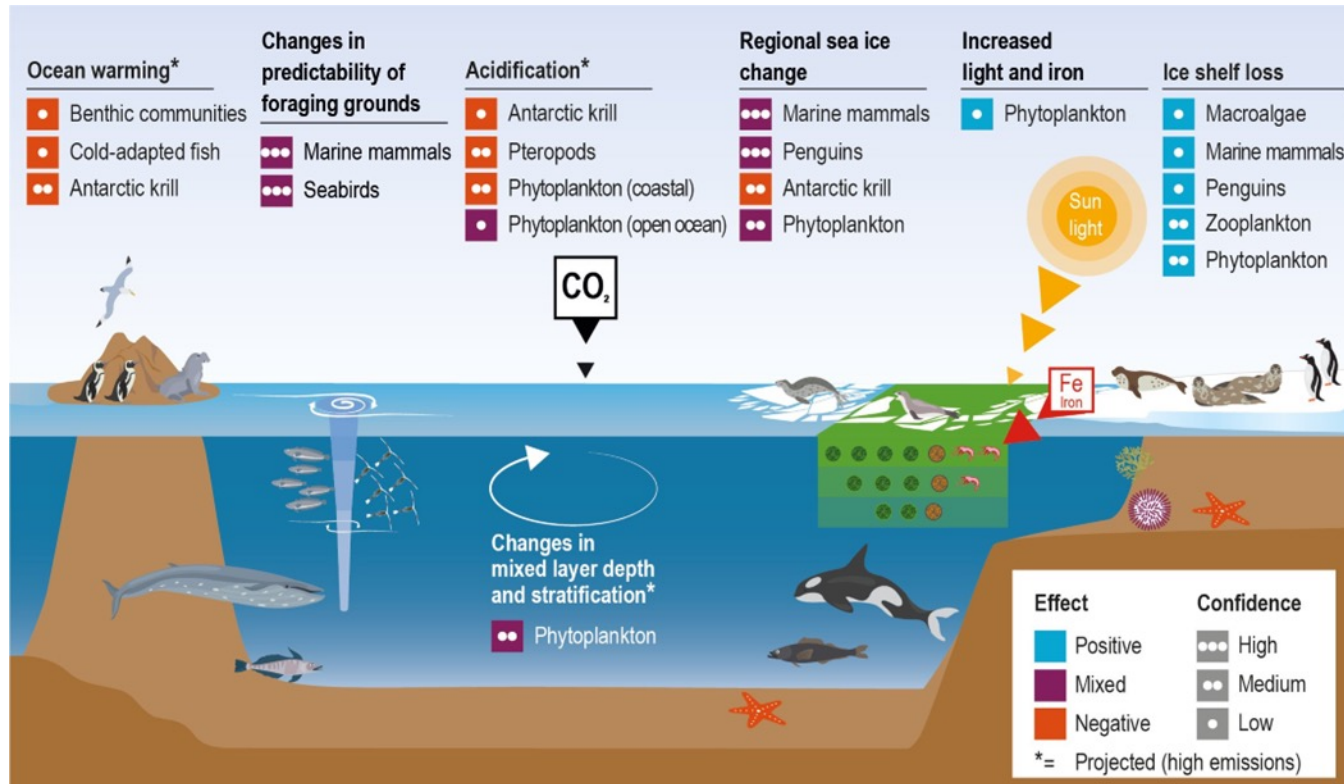


Limited cover with few species; low complexity with limited growth; low fish biomass and diversity

IPCC AR6 WG2 Models of coral reef futures without (i) and with (ii) symbiont adaptation and under three different climate scenarios.



CLIMATE CHANGE AND POLAR ECOSYSTEMS



- Antarctica has a high biodiversity and endemism compared to much lower diversity in the Arctic.
- Both are still poorly explored ecosystems, and the biota has a high vulnerability to changes in physical conditions (stenothermal).



The Kunming-Montreal Biodiversity Framework

Adopted 2022

Conserve 30% of terrestrial, freshwater, coastal and marine ecosystems through connected, ecologically coherent spatial conservation measures

Restore 30% of degraded ecosystems



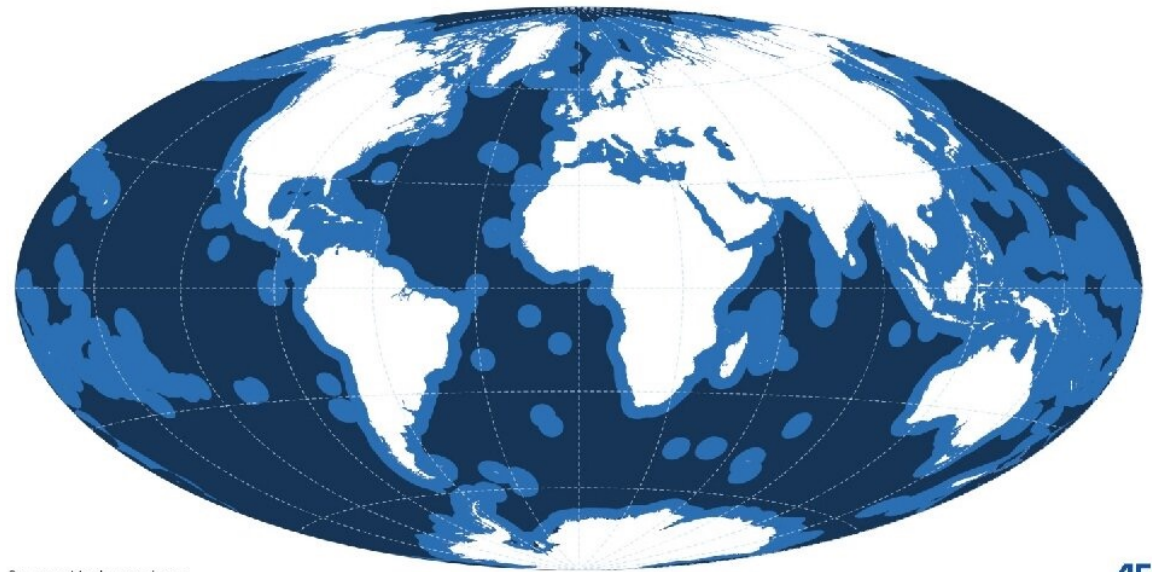
BBNJ AGREEMENT

- Adopted June 2023
- Entered into force January 17th 2026
- 45% of the Earth's surface, 54% of the seafloor and 95% of the volume of the ocean (1.2B km³ of ocean)
- Four parts to the Agreement
 - Marine genetic resources
 - Area based management tools (ABMTs; Pt 3)
 - Environmental Impact Assessment
 - Capacity Building and Transfer of Marine Technology



Ocean jurisdictions

■ national Exclusive Economic Zones (EEZs) ■ High seas (international waters)



Source: Marine regions

SUMMARY

Fisheries have undergone many transformations through time including through an Aboriginal Phase, the Medieval Even-Horizon, Colonial Phase and Global Phase. Fisheries sustainability has improved regionally, globally, still in decline.

Regionally, multiple human impacts have led to severe depletion of coastal ecosystems. The global impacts of climate change are physical, biogeochemical and biological and impact severely on nature's benefits to people.

Our efforts to improve ocean governance have met with success, most notably with the GBF and the new BBNJ Agreement. However, implementation requires multilateral governance in a world of increasing geopolitical conflict.



**THANK YOU FOR
LISTENING!**

ANY QUESTIONS?



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