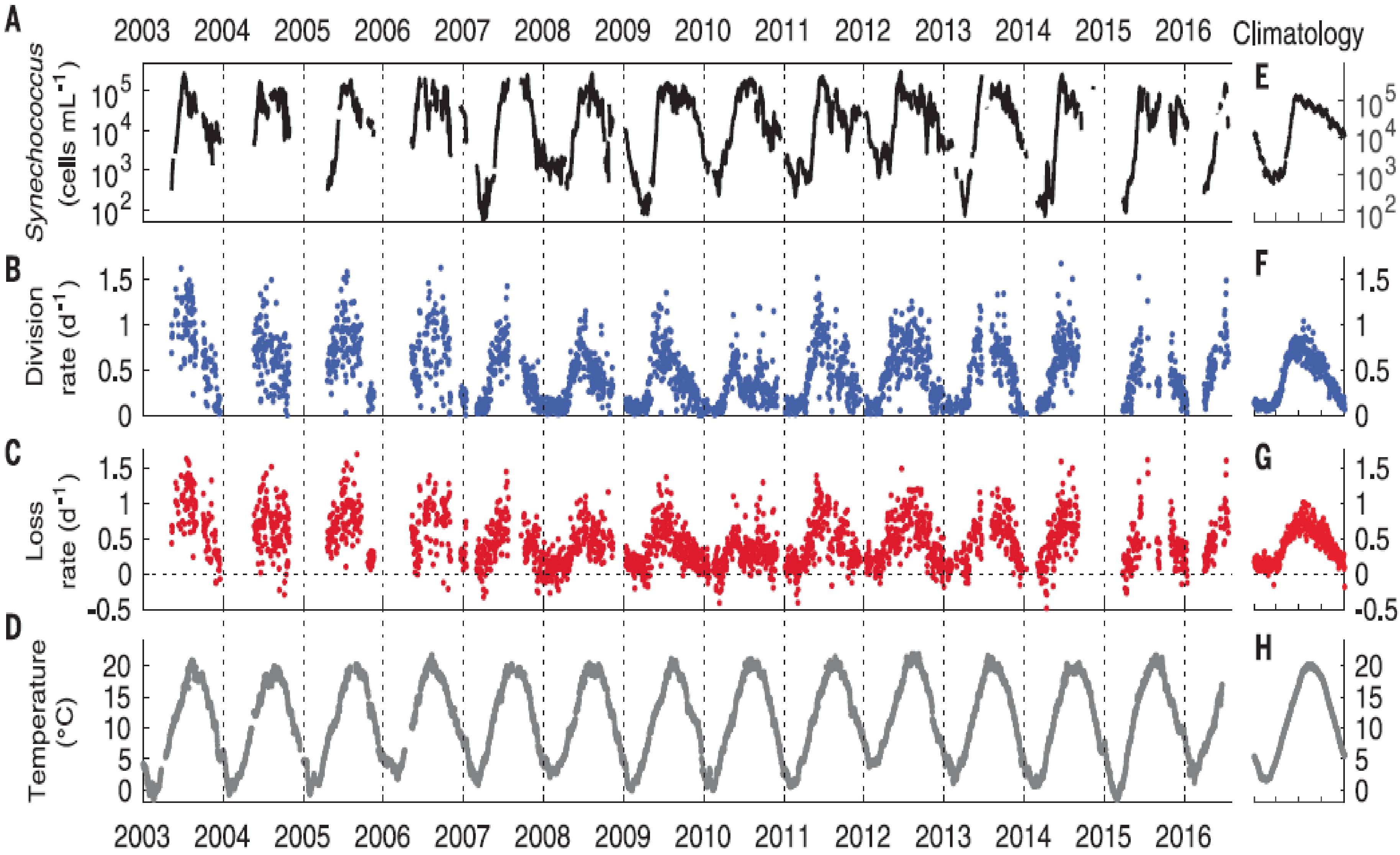
Ecosystem Responses

Figure 2 Some examples of range extensions and contractions in rocky intertidal species along the Californian coast. Arrows indicate the limit to which each of the species ranges have reached and the direction of shift (Zacherl *et al.*, 2003; Dawson *et al.*, 2010; Fenberg and Rivadeneira, 2011; Fenberg *et al.*, 2014).

Planting vegetation offers one way to reduce erosion at some sites. Top photo shows a pre-project shoreline on Wye Island in Queen Anne's County, Maryland. Marsh grass was planted on sand fill and short, stone groins were added. Middle photo is three months after installation. Bottom photo is six years after installation. (Image from Virginia Institute of Marine Science)

How do we separate the physical and biological drivers of change? How will we separate local and remote effects? Natural and Forced?



Not all species respond the same way

Is there anything to learn by studying resilient species?

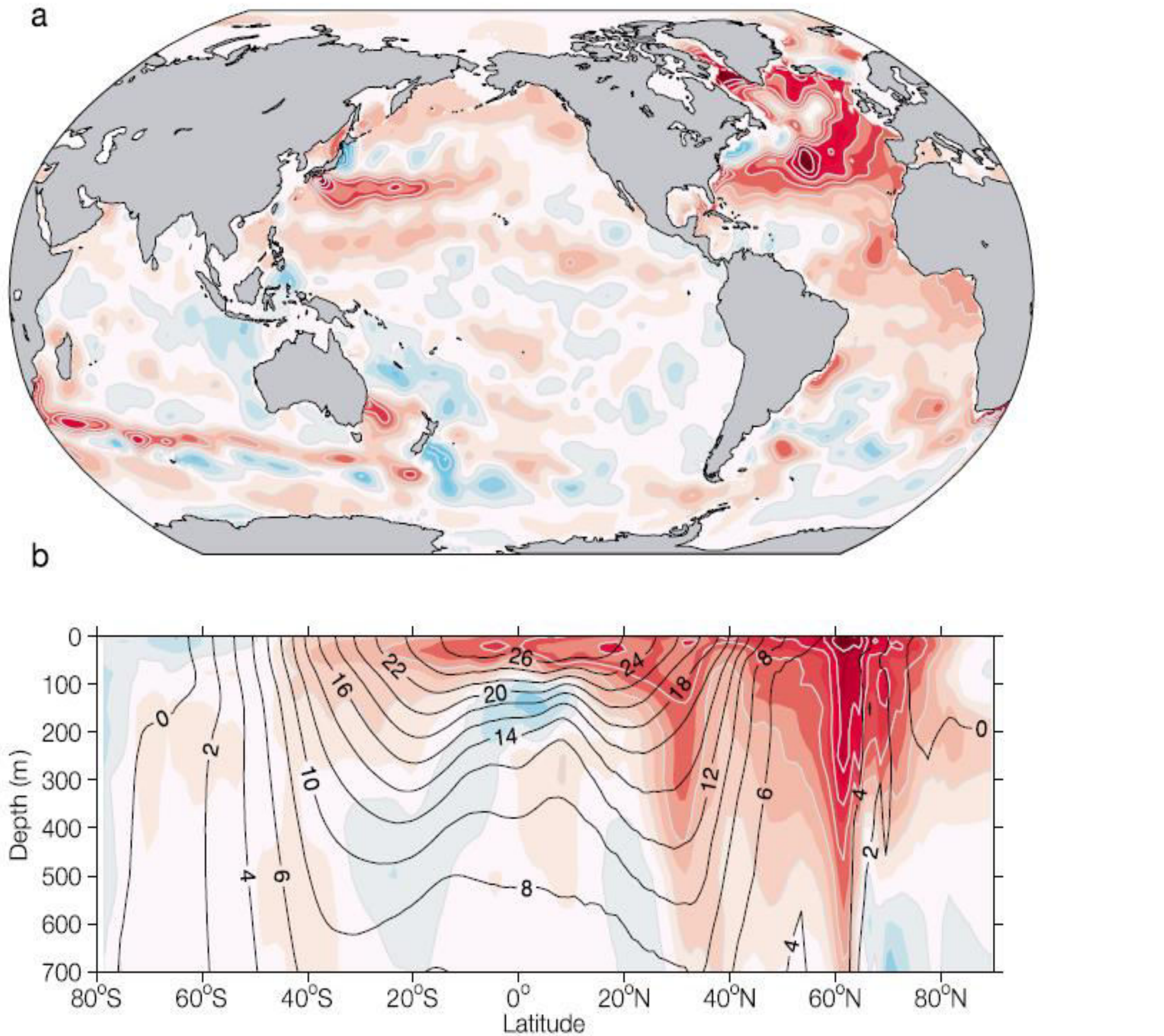
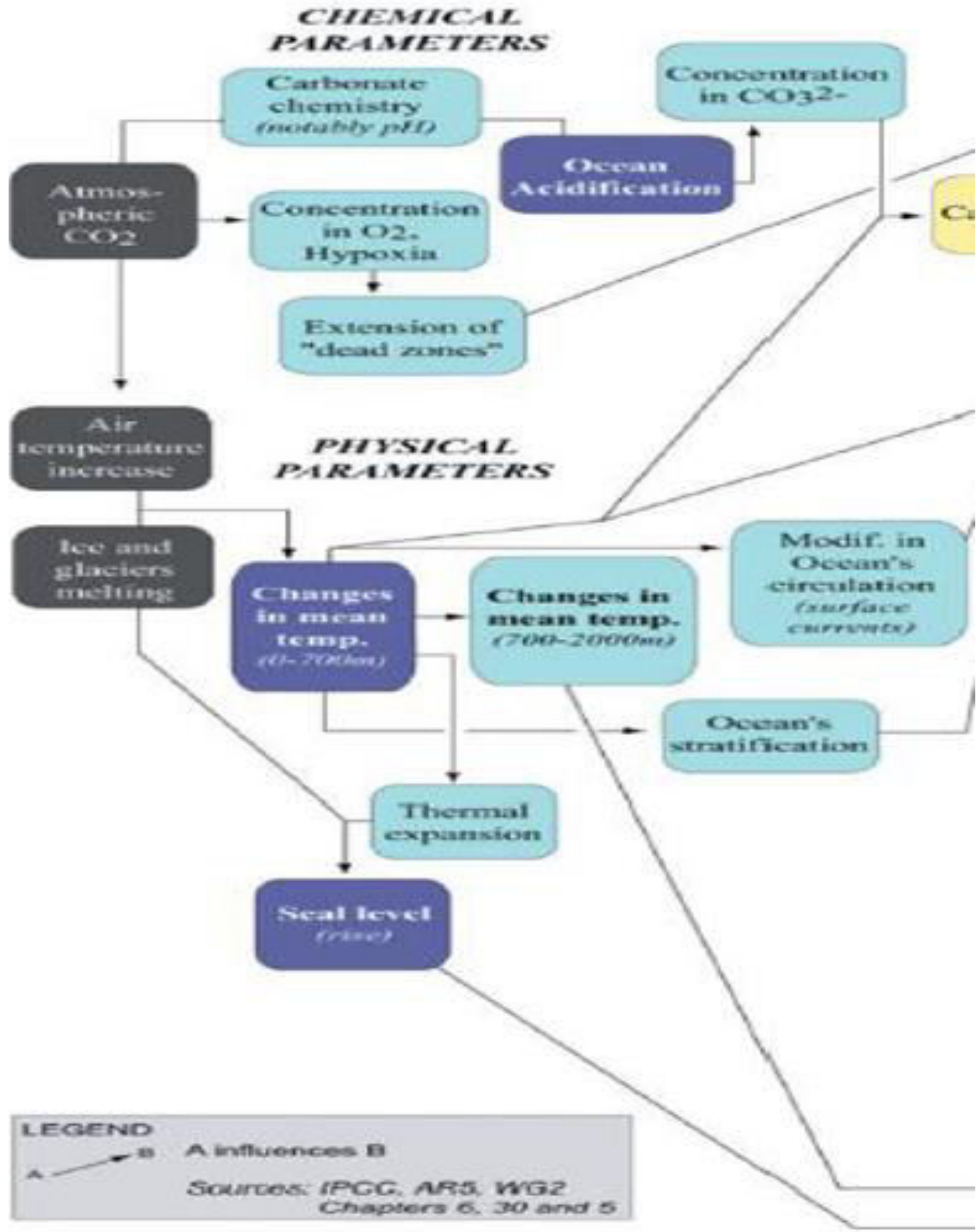
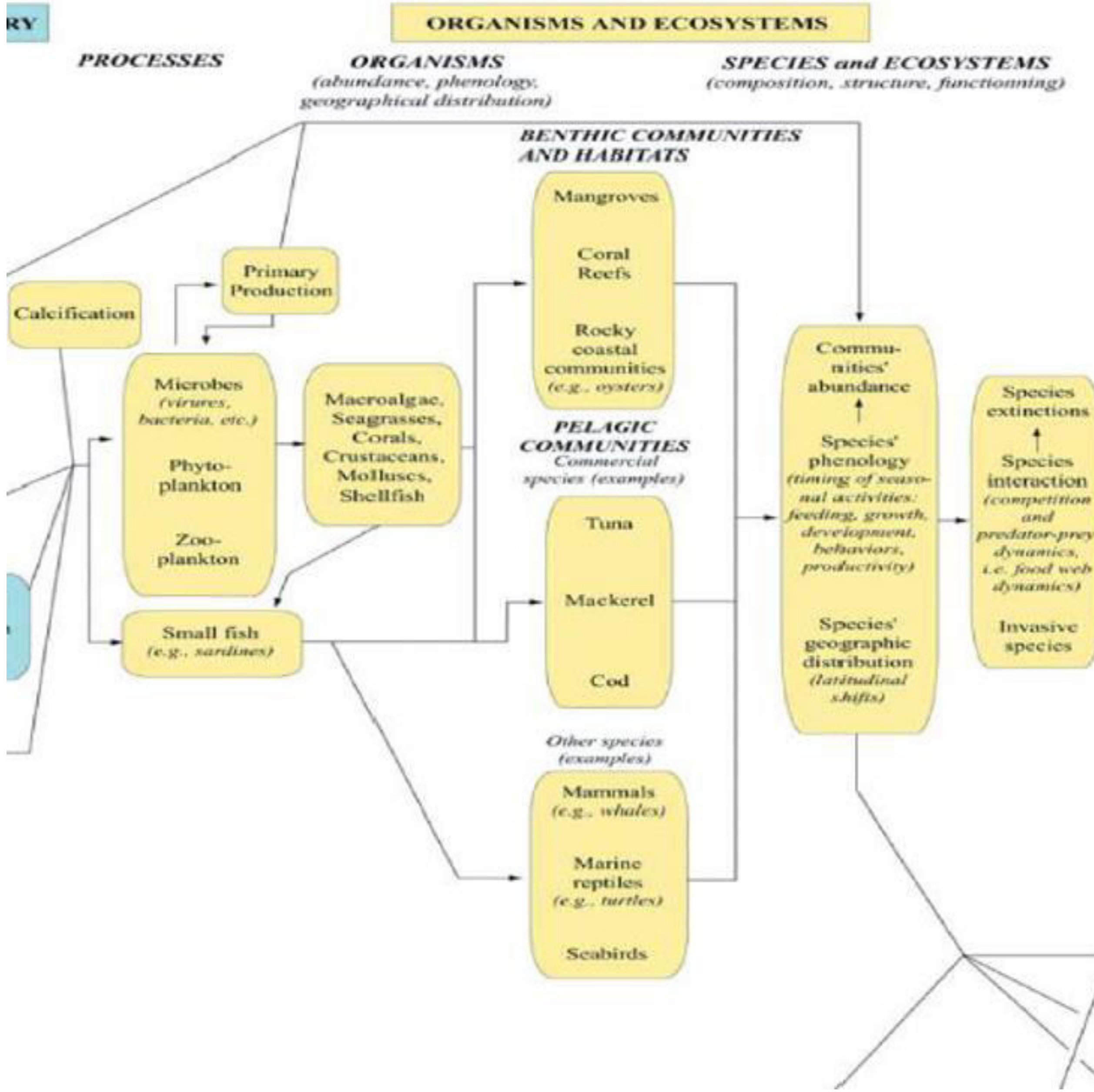


Figure 1.11 a. Depth-averaged 0 to 700 m OHC trend for 1971–2010, based on a grid of 2° longitude by 4° latitude, colours and grey contours in degrees Celsius per decade. From IPCC AR5 (Rhein *et al.*, 2013); b. Zonally averaged temperature trends (latitude versus depth). Colours and grey contours in degrees Celsius per decade for 1971–2010 with zonally averaged mean temperature over-plotted (black contours in degrees Celsius).'

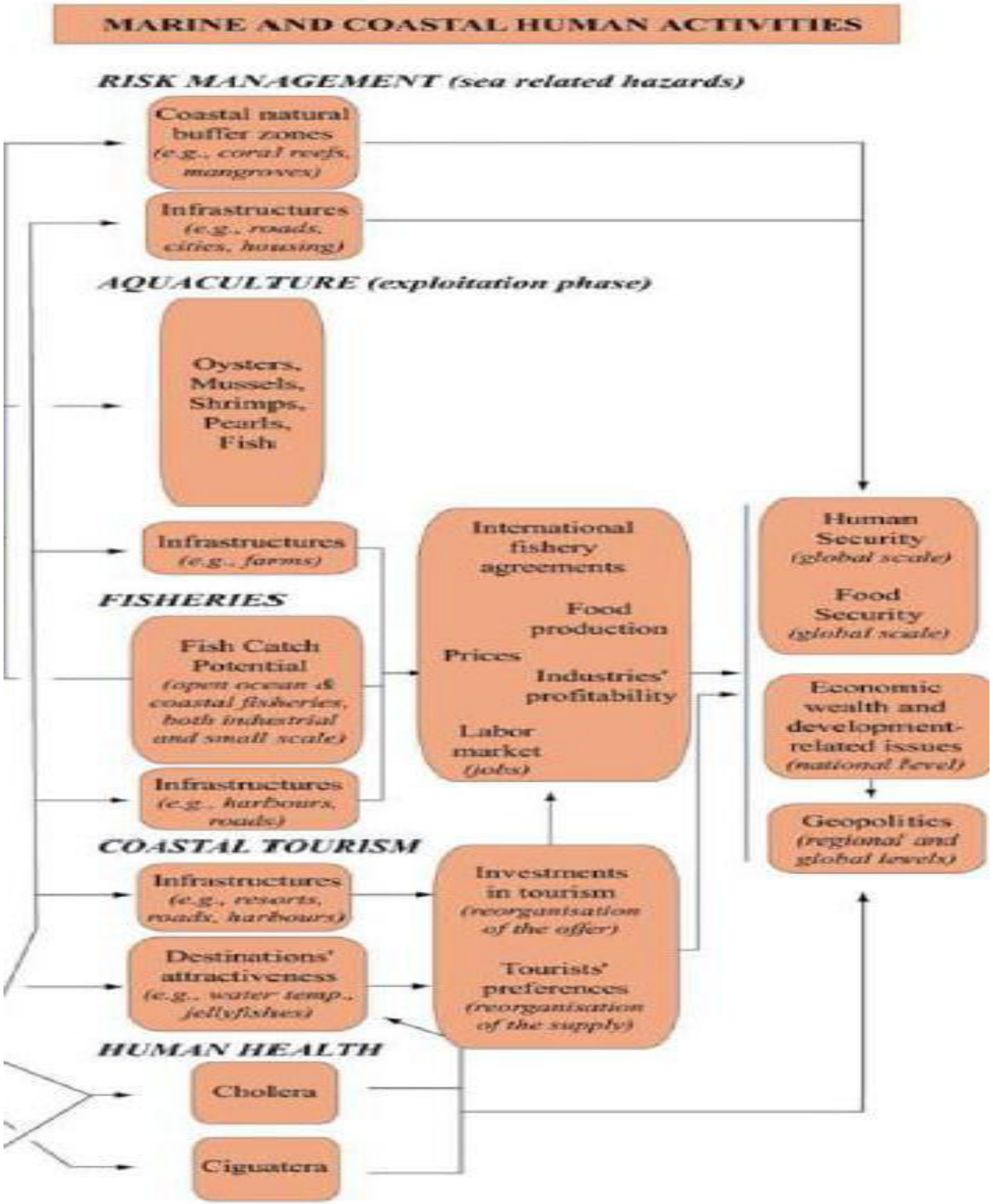
Cascades of Physical, Chemical, ecosystem Impacts are complex and complicated

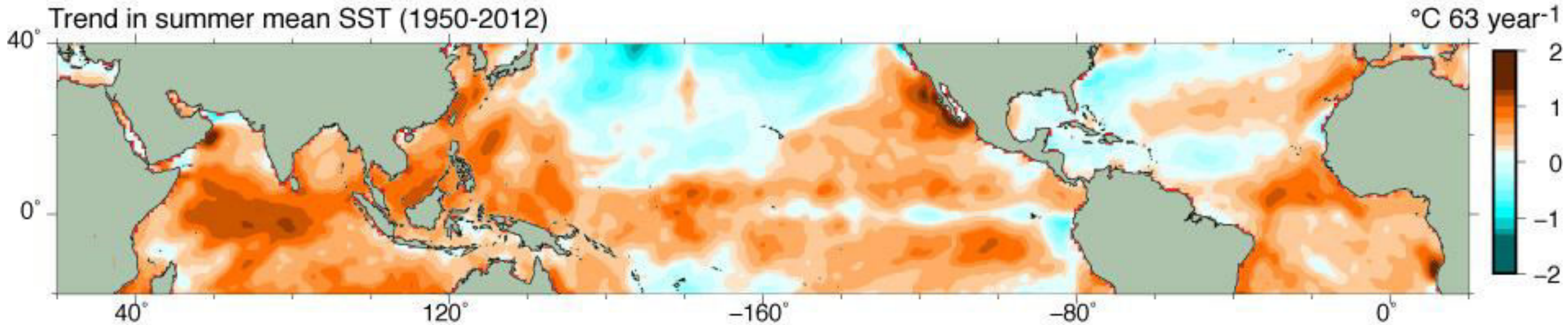


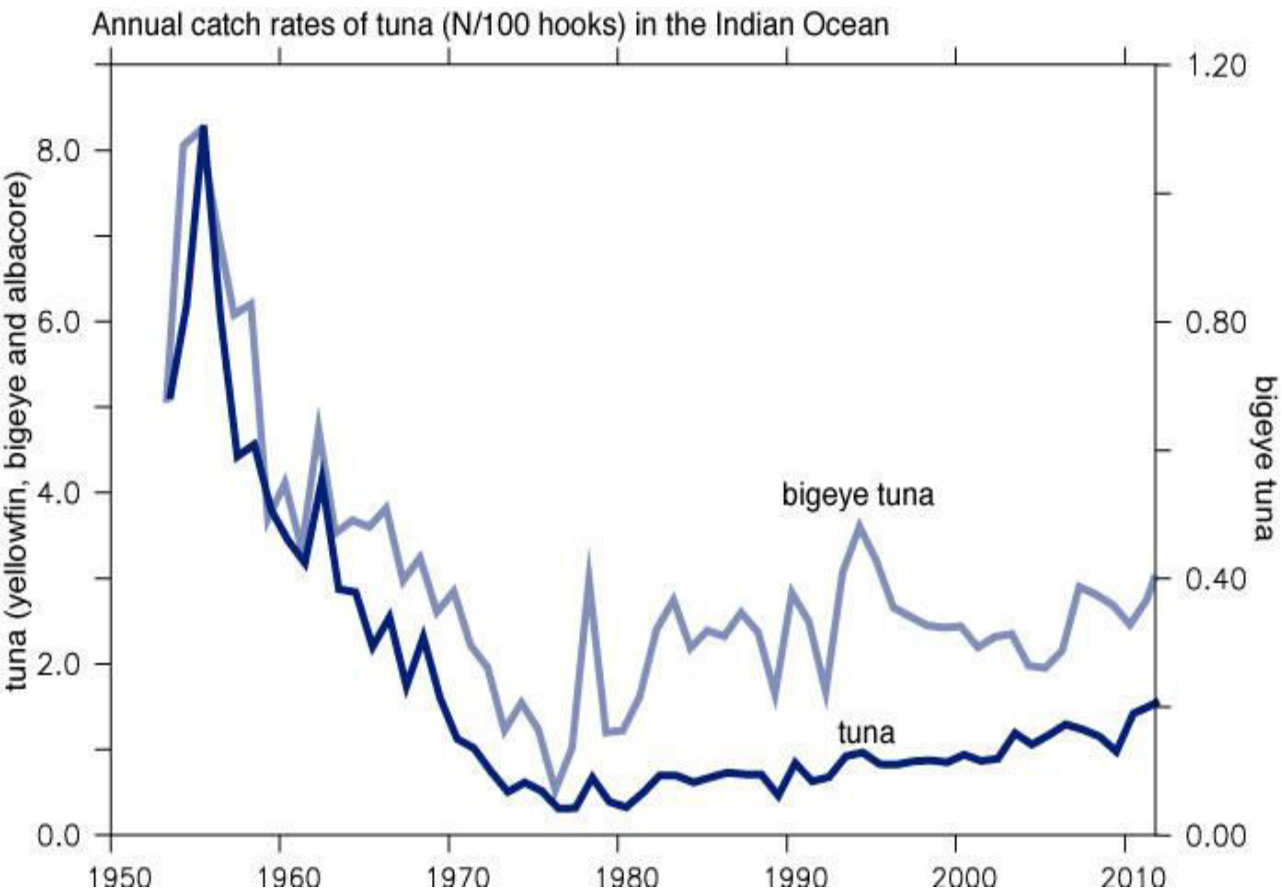
Water-Food-Energy-Health Nexus and the role of marine ecosystems in Food Security are far from understood under GM variability and Trends



Global Monsoon predictions and projections downscaled to the coasts can serve the goals of Mitigation and Adaptation of GM impacts on the coasts







GM Impacts will exacerbate pre-existing vulnerabilities in food, water, energy and health sectors.

Impacts on Armed and Civil Conflicts??

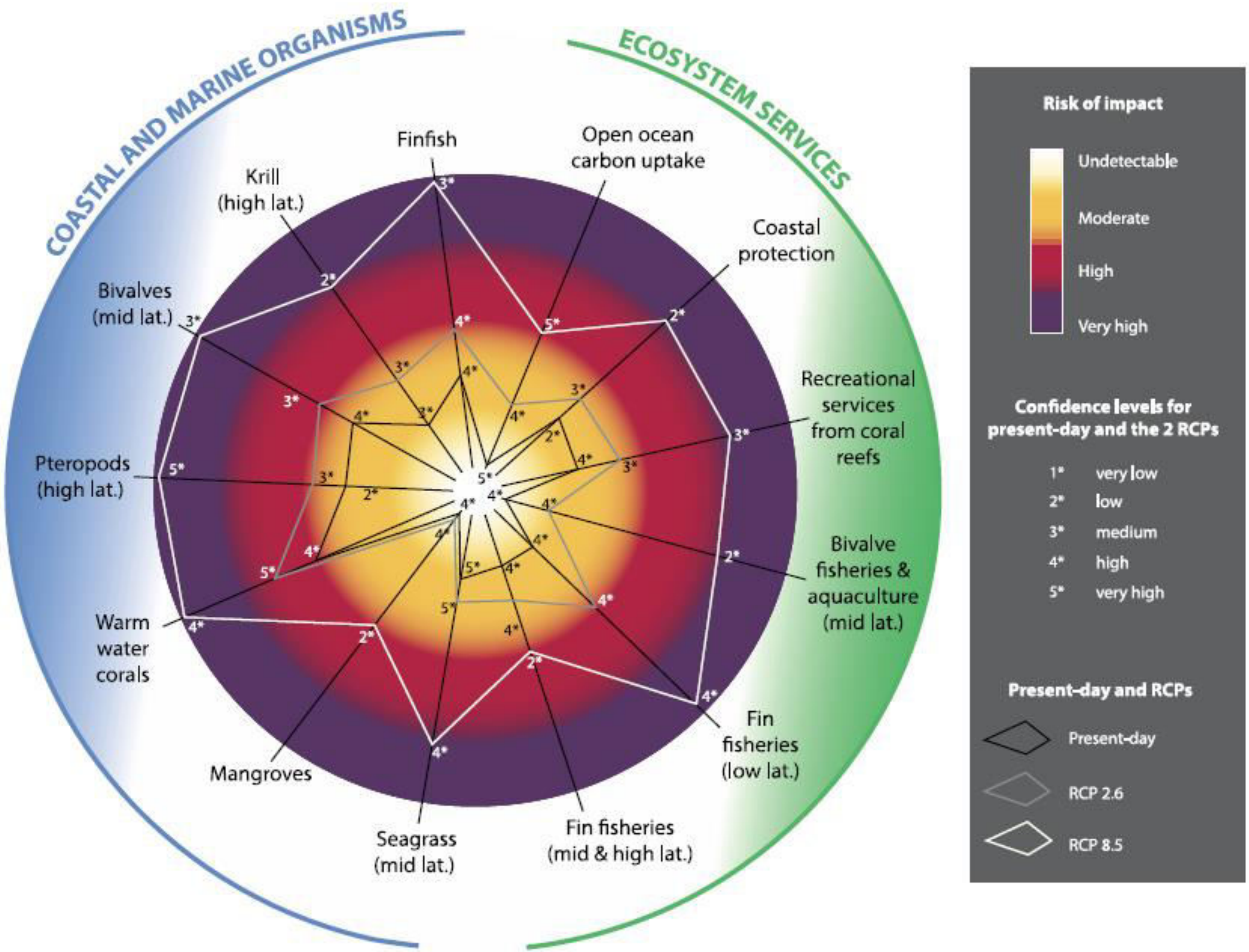


Figure 2.3 Contrasting risk of impacts to ocean and society from different anthropogenic CO_2 emissions. Source: the authors, adapted from Gattuso *et al.* (2015).

Biggest unknown is Disease Pressure changes due to warming

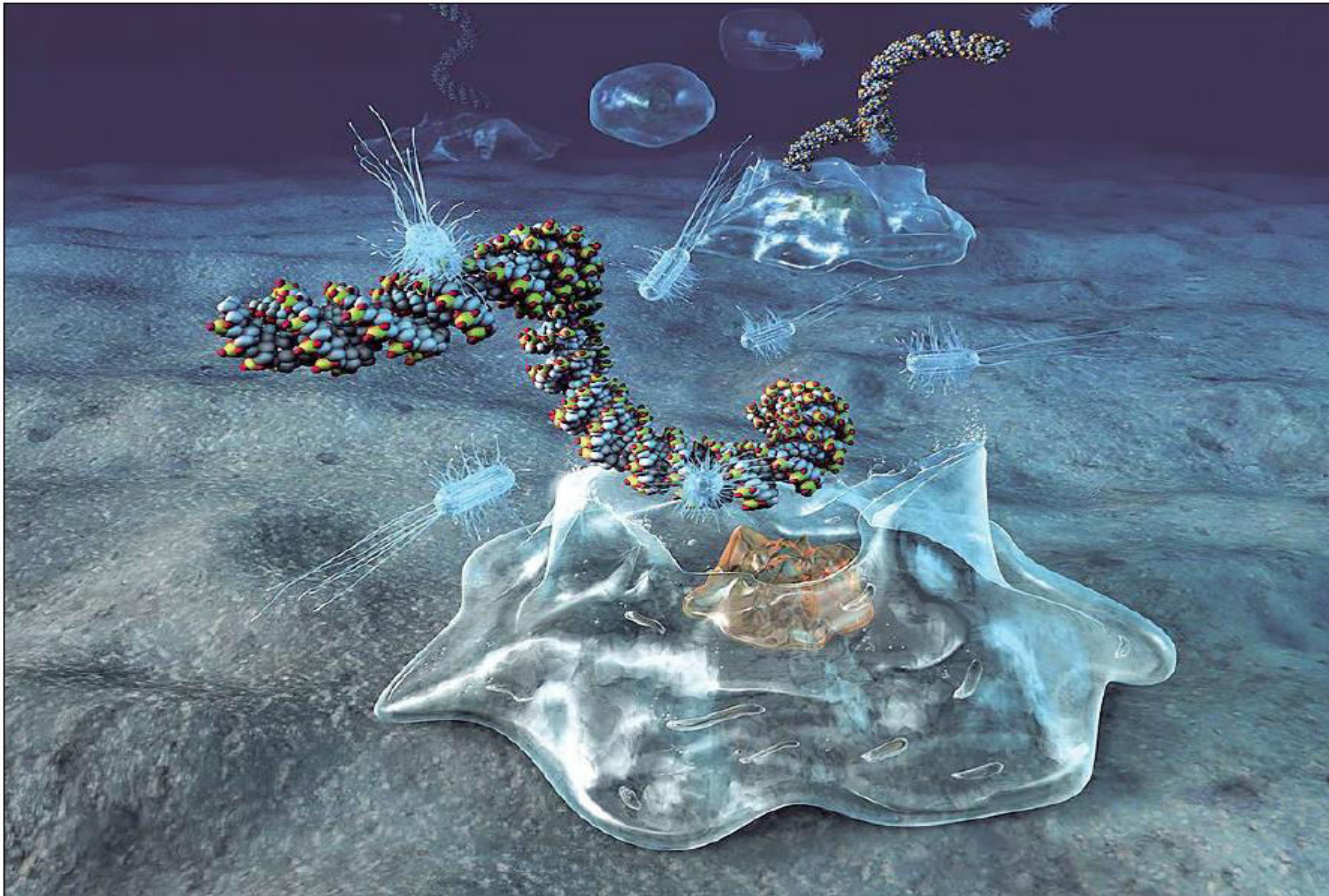


Figure 3.1.4 The lysis of microbial cells releases not only cellular components but also the DNA that is contained into the cells. This DNA, once out of the cells, is named extracellular DNA. (Graphic Michael Tangherlini).

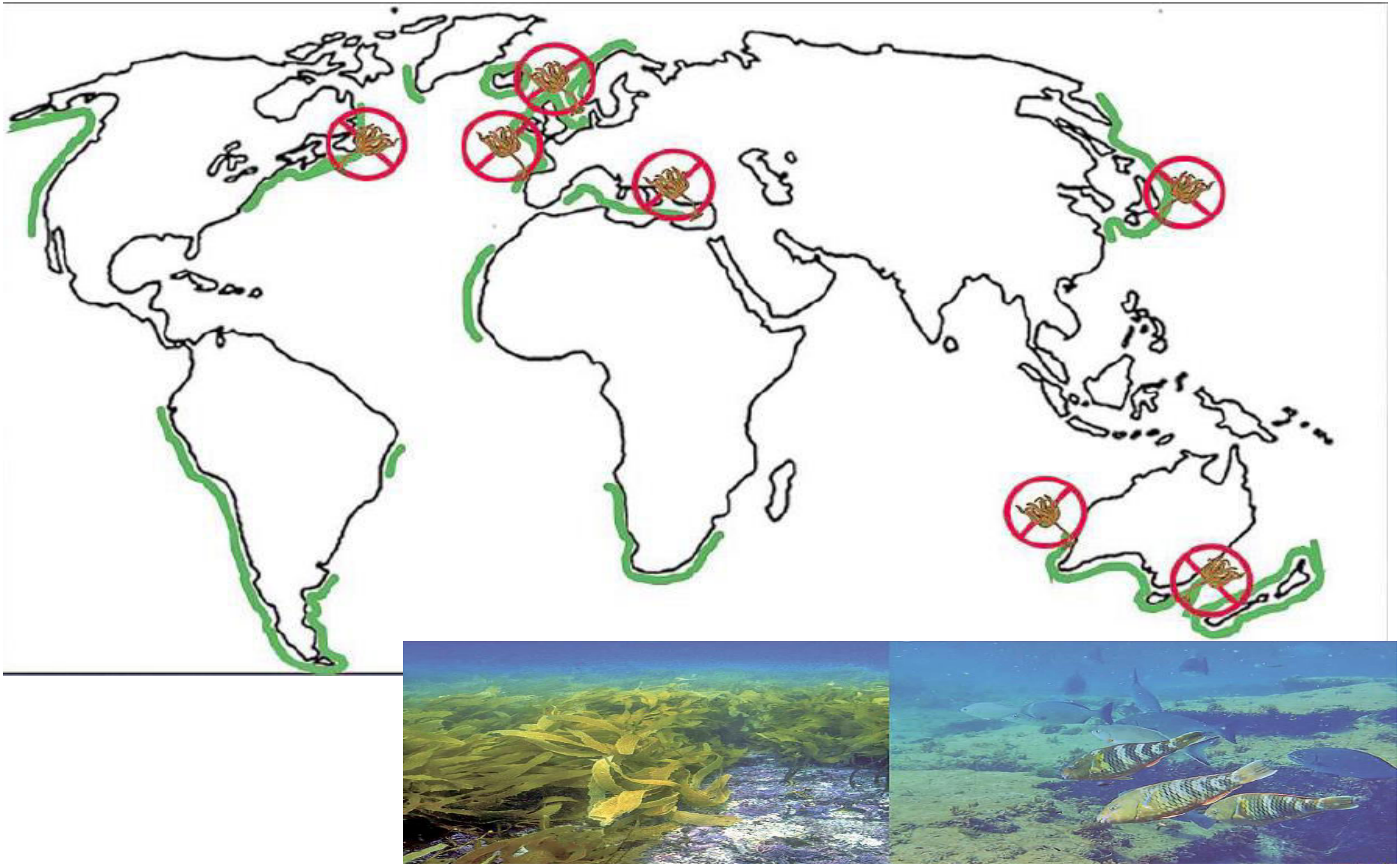
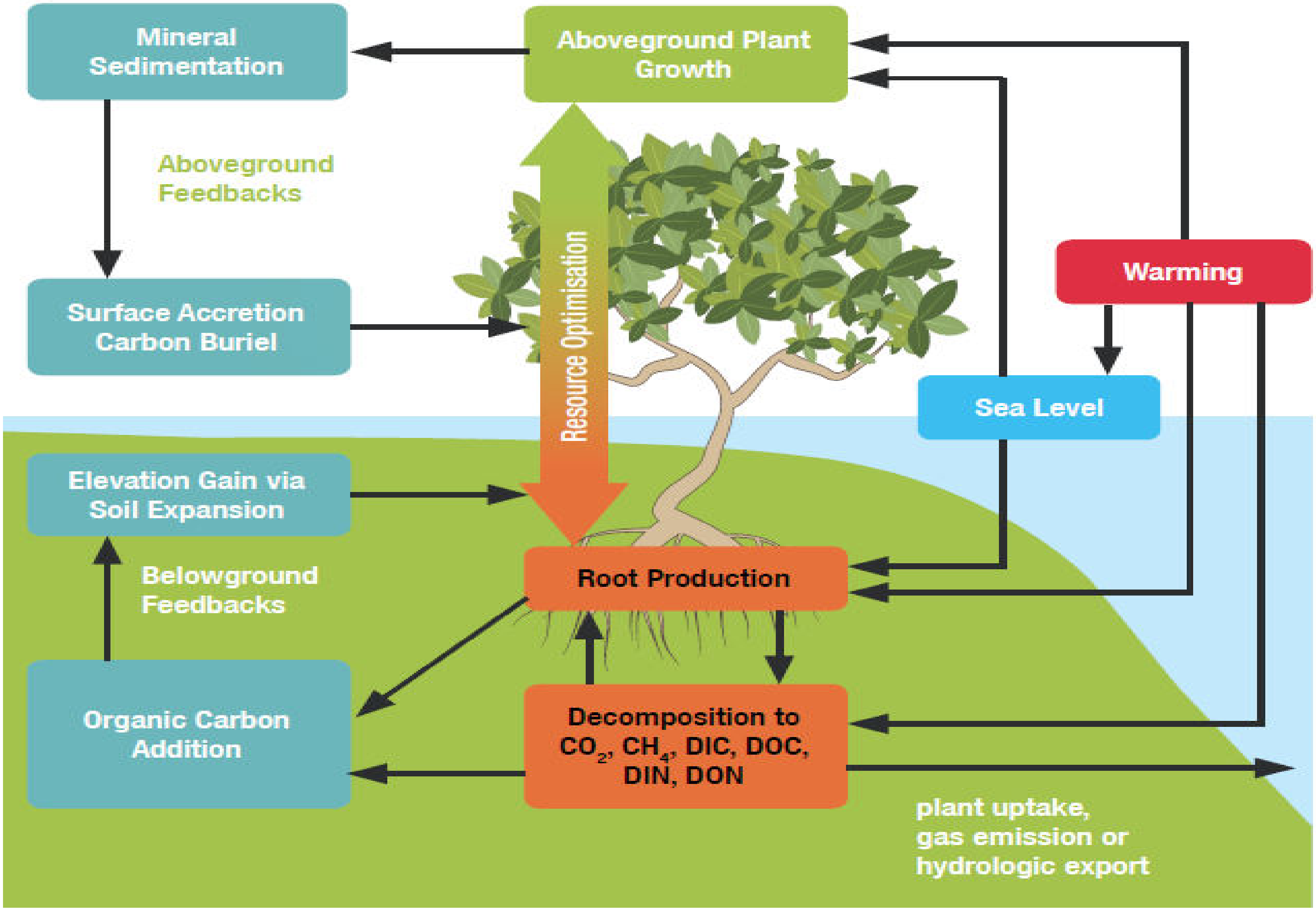


Figure 3.3.2 Seaweeds dominate intertidal and shallow subtidal rocky reefs along ~25% of the world's coastline. The map show the global distribution of seaweed forests (green, adapted from Steneck and Johnson, 2013). However, ocean warming has led to regime-shifts in several regions (red symbols), where complex, highly productive seaweed forests have been lost and replaced by structurally simple coralline crusts, filamentous turf or small foliose seaweeds. The photos show rocky reef habitats in Western Australia before (2005) and after (2013) a marine heatwave caused a 100 km range contraction of kelp (*Ecklonia radiata*). At the same time, subtropical and tropical herbivorous fishes such as parrotfish (*Scarus* sp.) increased substantially in abundance and they now suppress the recovery of kelp forests (Wernberg *et al.*, 2016a). © T. Wernberg.

Continuous monitoring is needed to track the warming of impacts and global monsoon changes

Figure 3.4.1 The global distribution of salt marshes and relative abundance. Saltmarshes are far less abundant in the tropics (areas in grey) where mangroves dominate. An interactive version can be found at http://maps.tnc.org/globalmaps.html. Hoekstra *et al.*, 2010.

Land-Ocean Interactions in the Coastal Zone: Modeling and Data needs are a HUGE challenge for navigating the future



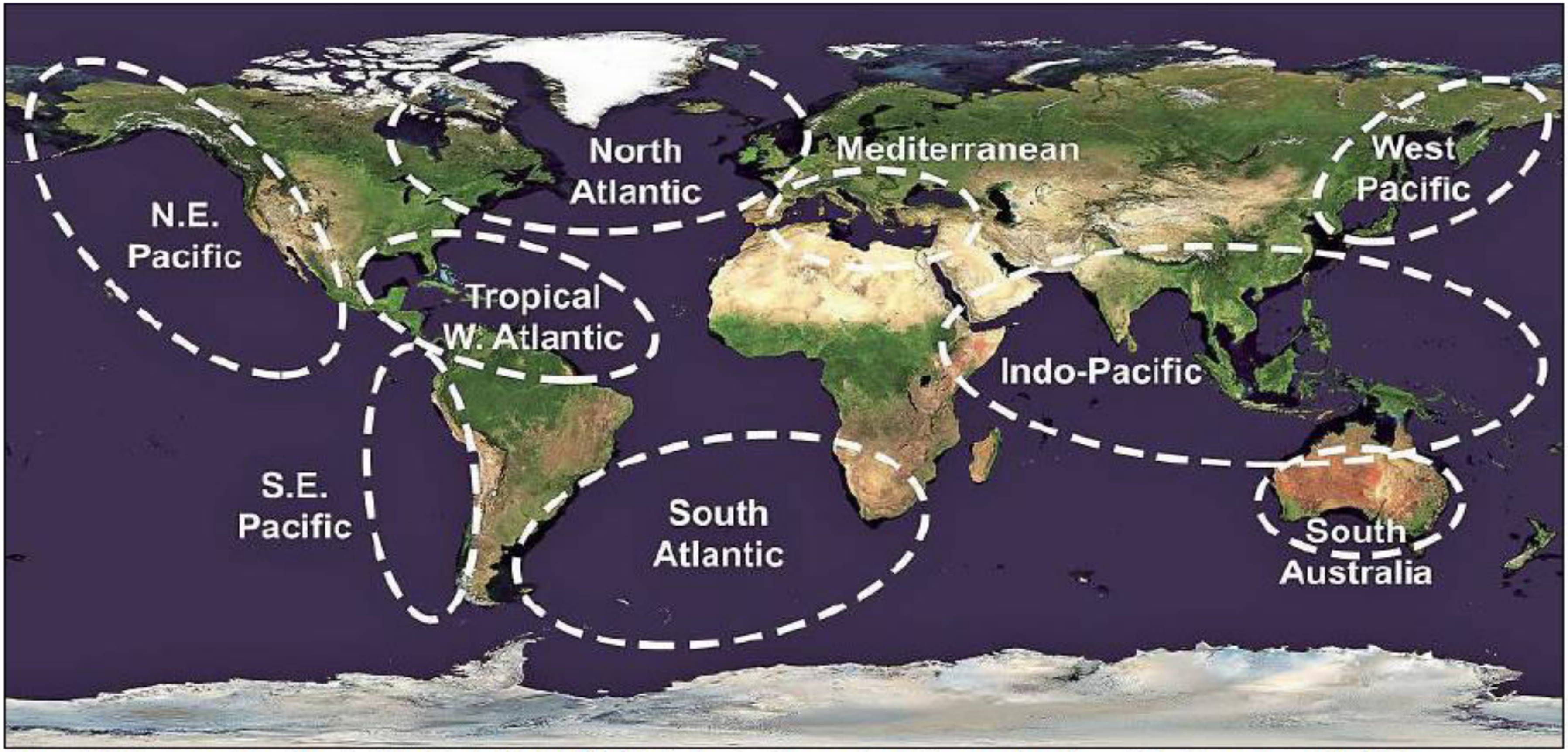
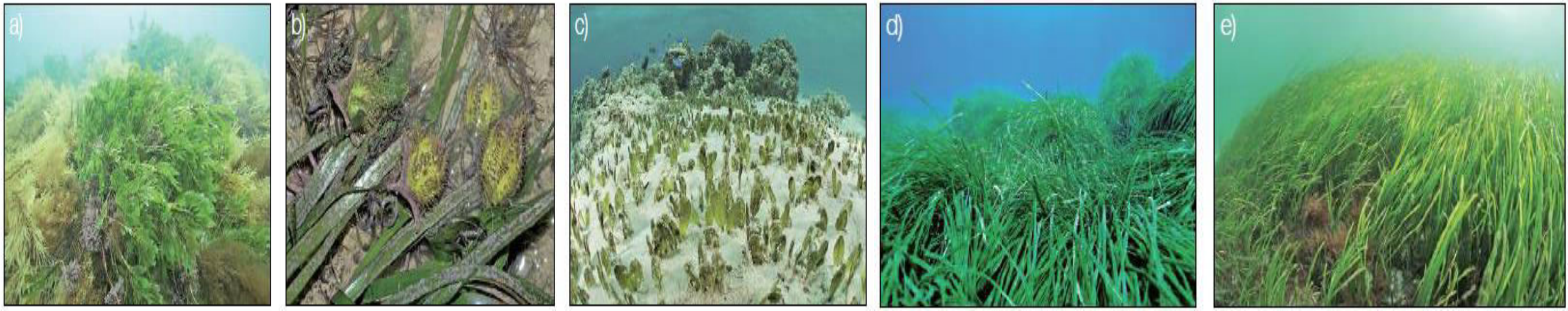


Figure 3.5.3 Seagrass bioregions depicting their global distribution in tropical, temperate and lower polar regions (after Fourqurean *et al.*, 2012).



We know very little about Thresholds and Tipping Points in GM

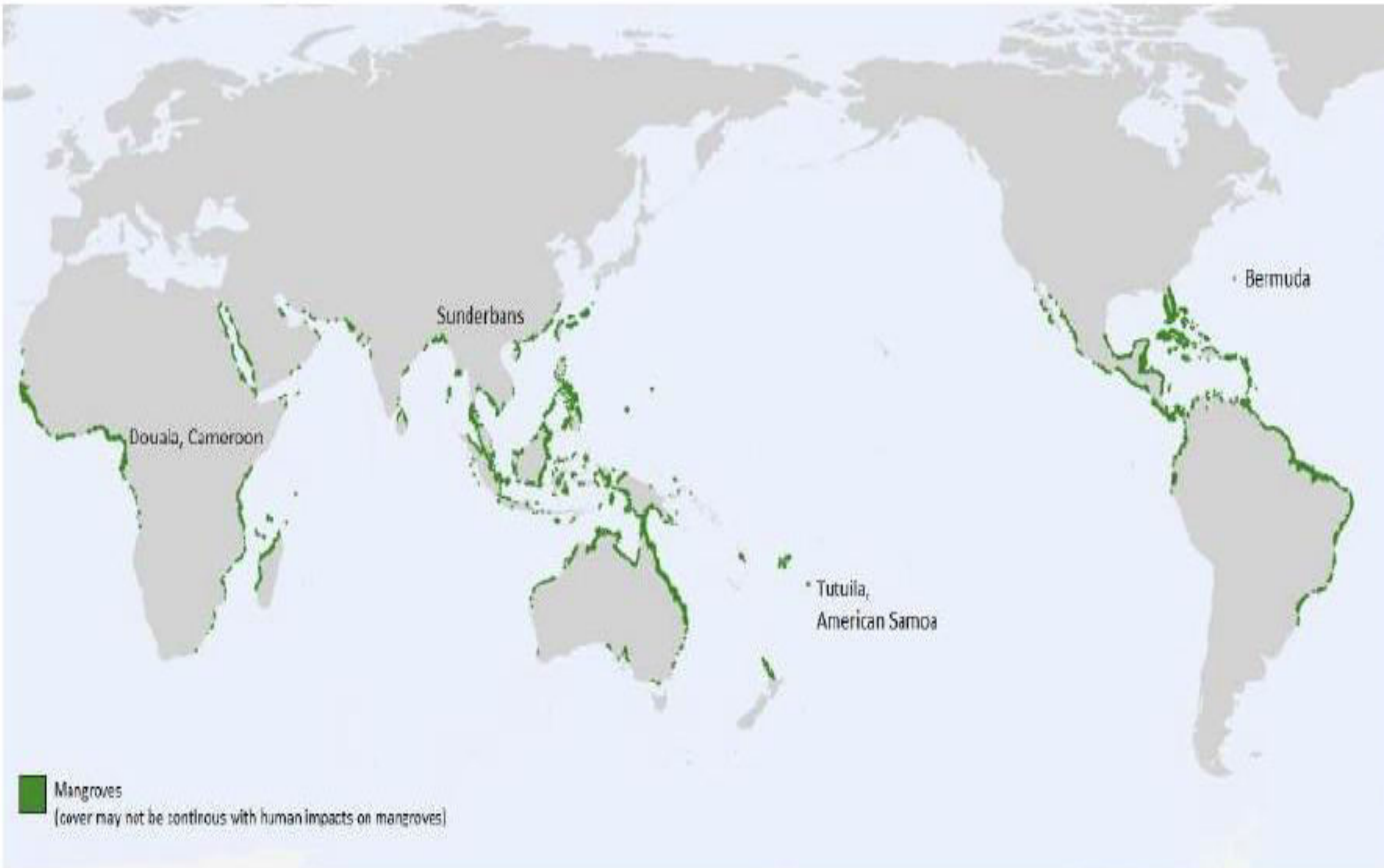


Figure 3.6.7 Locations with seaward edge dieback of mangroves owing to relative sea-level rise.

We don't know most of the biological loopholes. Mechanistic models needed

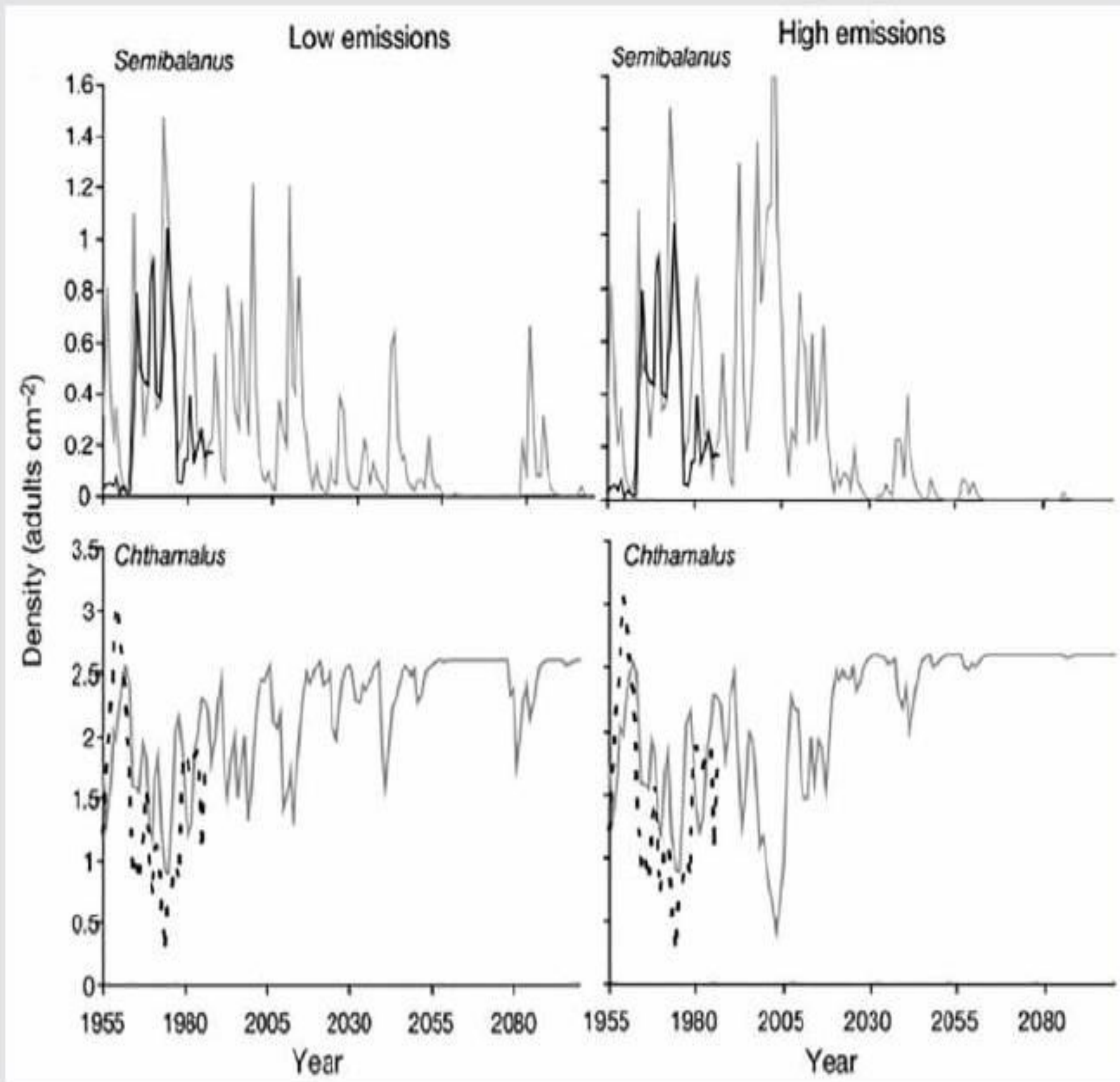


Figure 1 Competition-based model simulating future populations of the northern barnacle species *Semibalanus balanoides* and the southern species *Chthamalus* spp. under high and low emissions scenarios (Hawkins *et al.*, 2009, adapted from Poloczanska *et al.*, 2008).

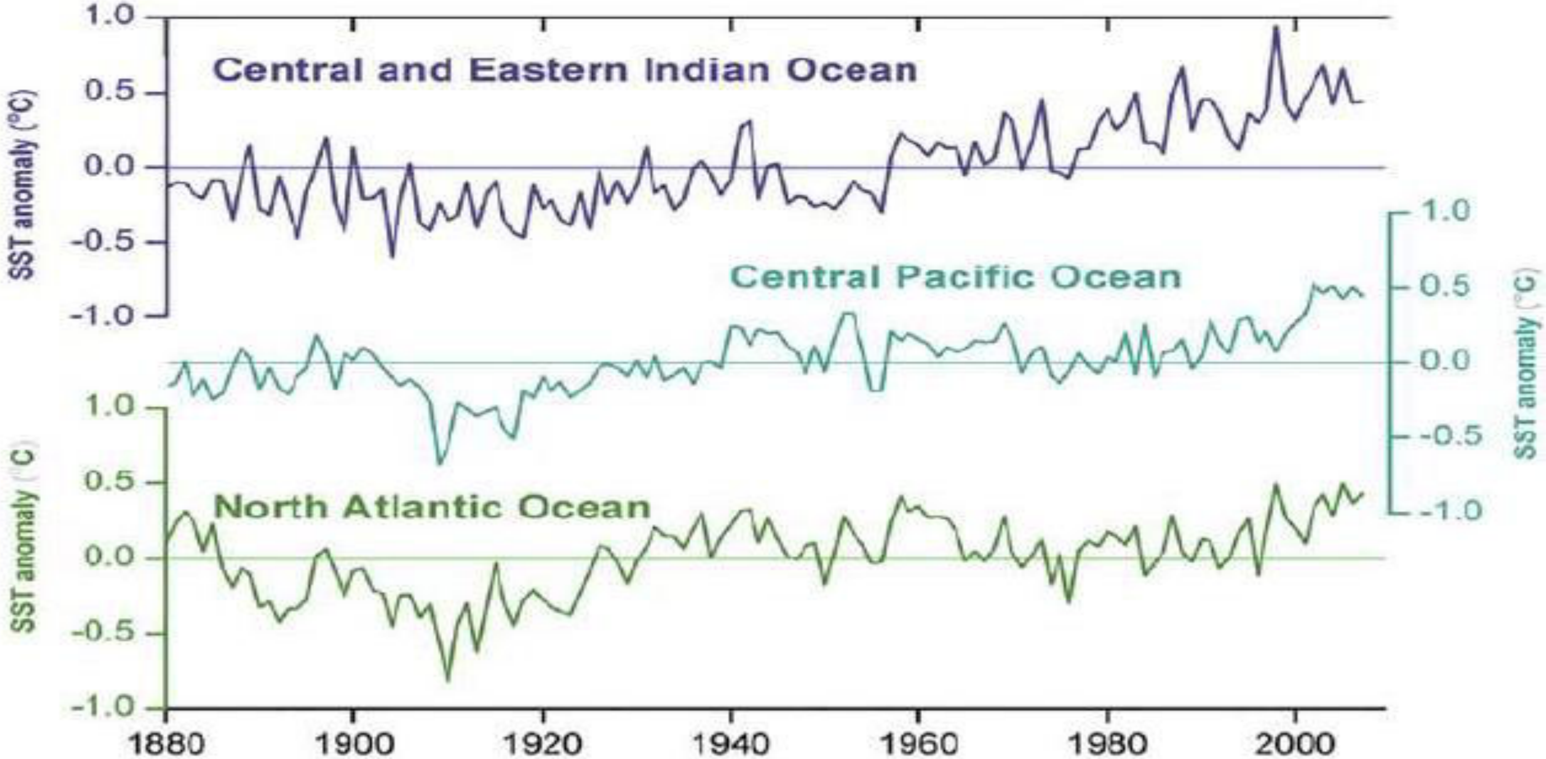


Figure 3.8.3 Sea-surface temperature (SST) time-series for reef-containing locations within three regions showing trend of increasing temperatures through the period 1880-2007. After Heron *et al.* (2009).

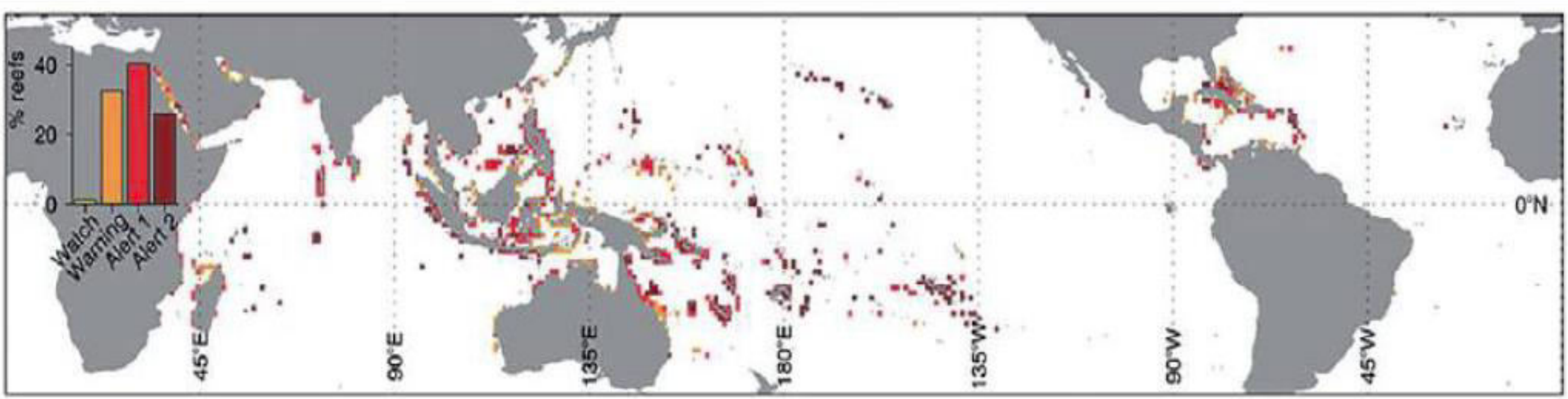


Figure 2 Coral reef thermal stress levels.Data source: NOAA OISST, mapped at 1° resolution

May be we will have mechanistic models of corals in the future

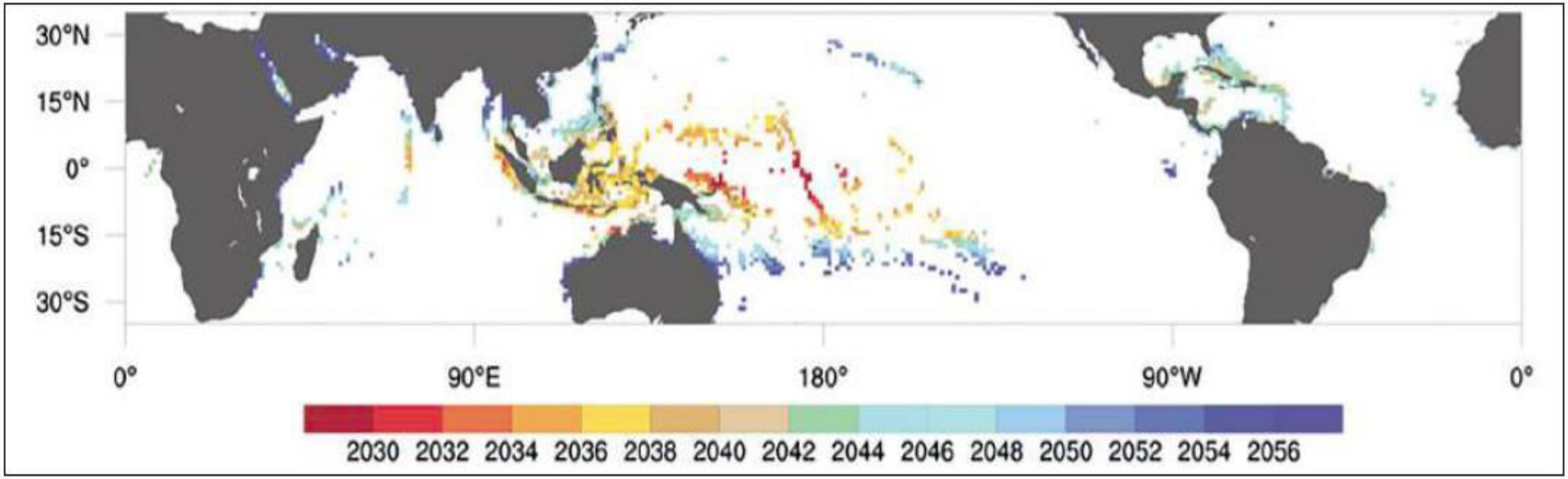


Figure 3.8.7 Global projections of the year annual severe bleaching conditions start for all reef locations under Representative Concentration Pathway (RCP) 8.5. After van Hooidonk *et al.* (2014).

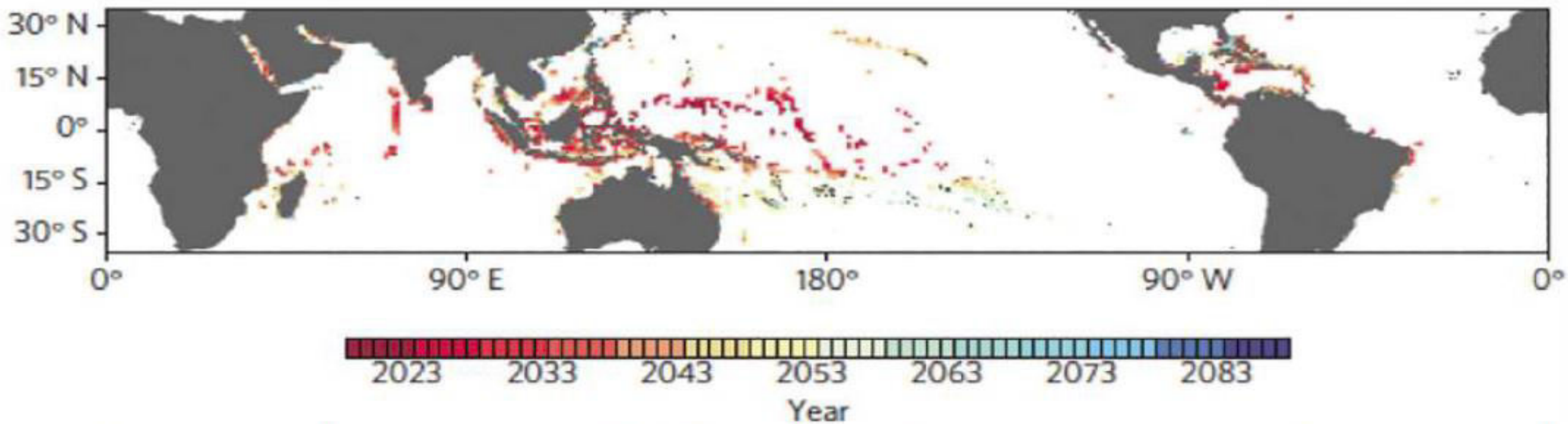
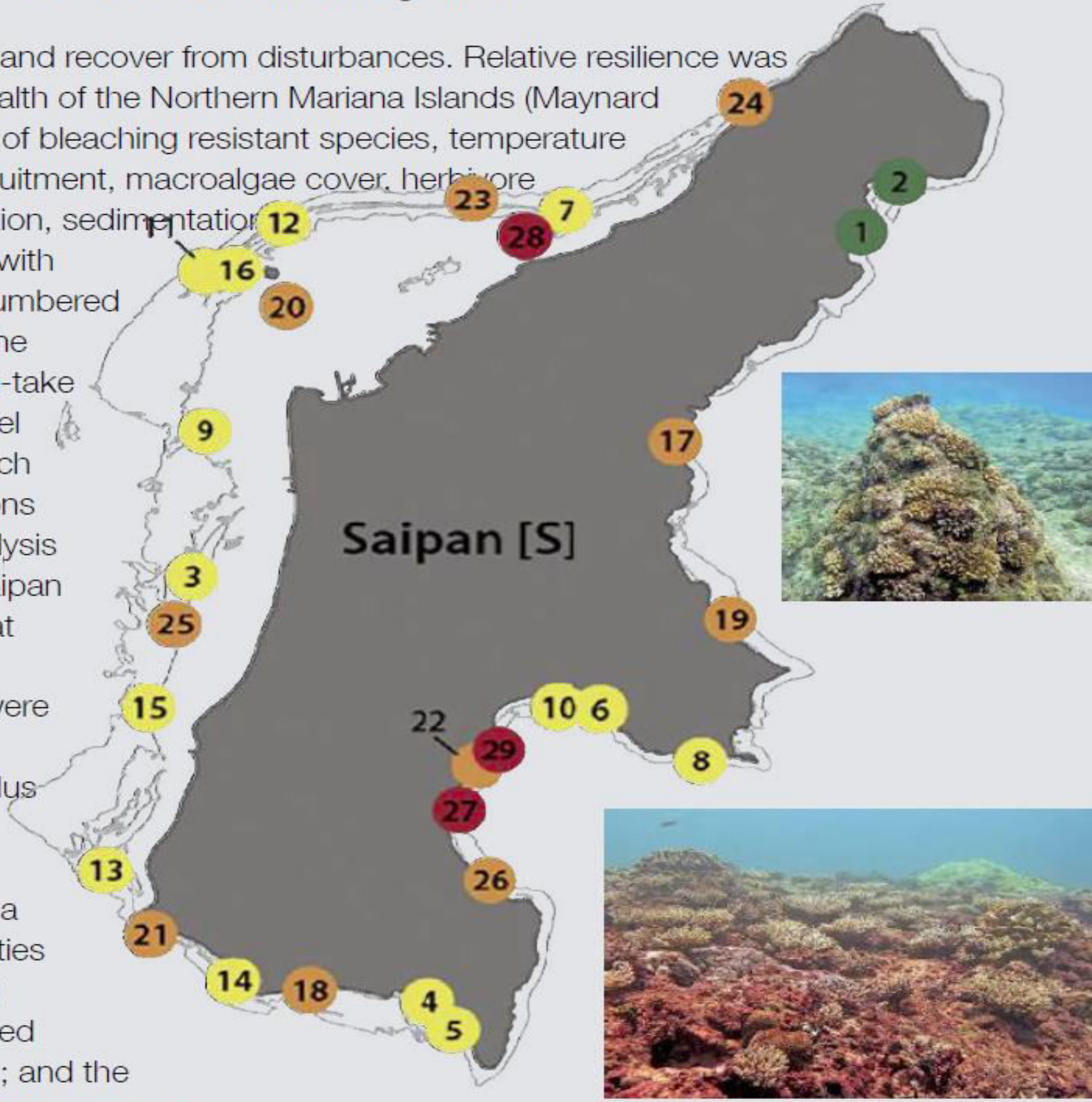


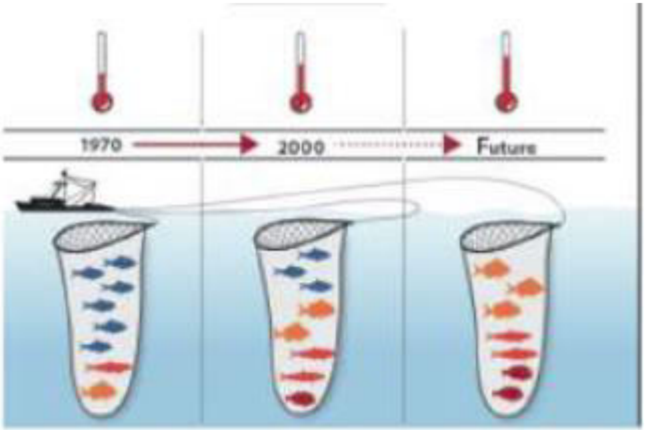
Figure 3.8.9 The year in which three temperature factors related to disease outbreak (host susceptibility, pathogen abundance, pathogen virulence) were all projected to occur. After Maynard *et al.* (2015b).

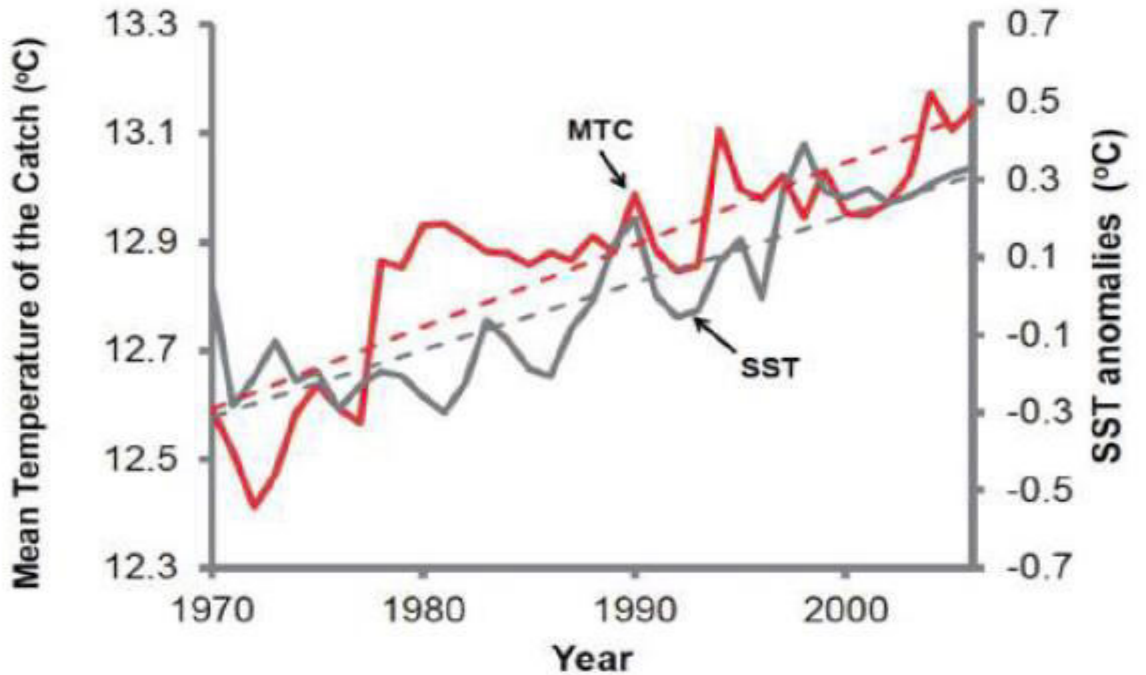
Box 3.8.3 Reef resilience – local-scale assessment and management

Resilience is the capacity to resist and recover from disturbances. Relative resilience was assessed for Saipan, Commonwealth of the Northern Mariana Islands (Maynard *et al.*, 2015a) based on: presence of bleaching resistant species, temperature variability, coral diversity, coral recruitment, macroalgae cover, herbivore diversity, herbivore biomass, pollution, sedimentation and fishing access. The two sites with the highest assessed resilience (numbered 1 and 2, at right) were located in the Bird Island Marine Sanctuary, a no-take marine protected area – a high level of management protection for which no further local management actions could therefore be employed. Analysis of the two least resilient sites in Saipan identified management actions that could reduce vulnerability of reefs. At Achugao (#28), these actions were the management, regulation and enforcement of fishery activities; plus bleaching monitoring and actions to support post-bleaching recovery. At Tuturam (#29), any of a broad range of conservation activities could enhance resilience including reducing terrestrial run-off; increased tourism outreach and stewardship; and the actions listed for Achuago. Including managers and reef stakeholders throughout the resilience assessment maximized support for the process and for the implementation of identified management actions.

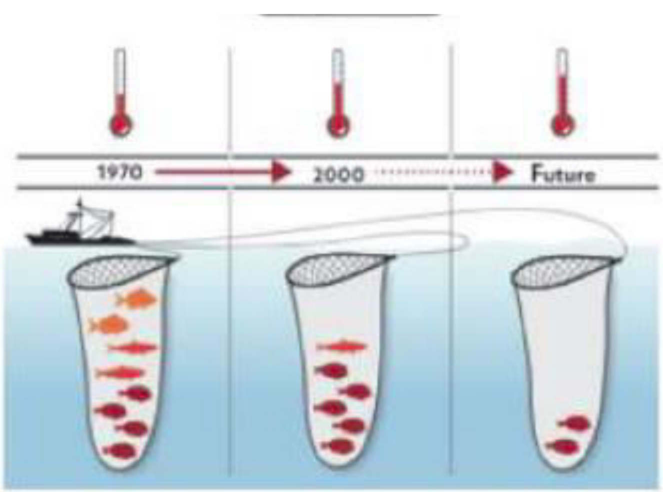


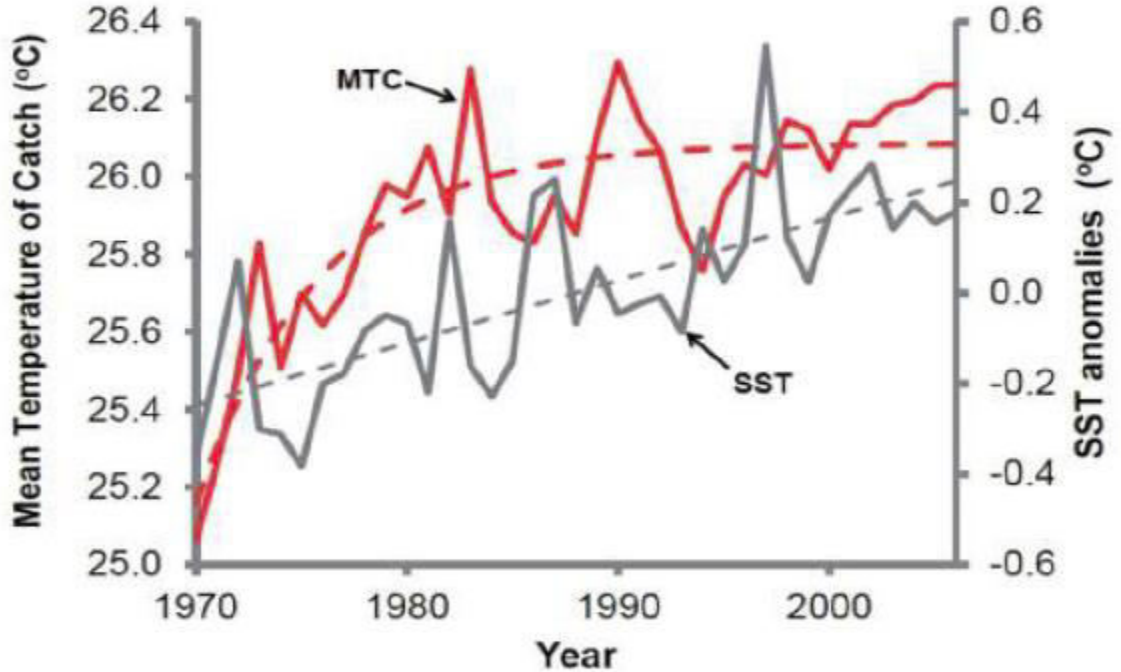
© J. Maynard



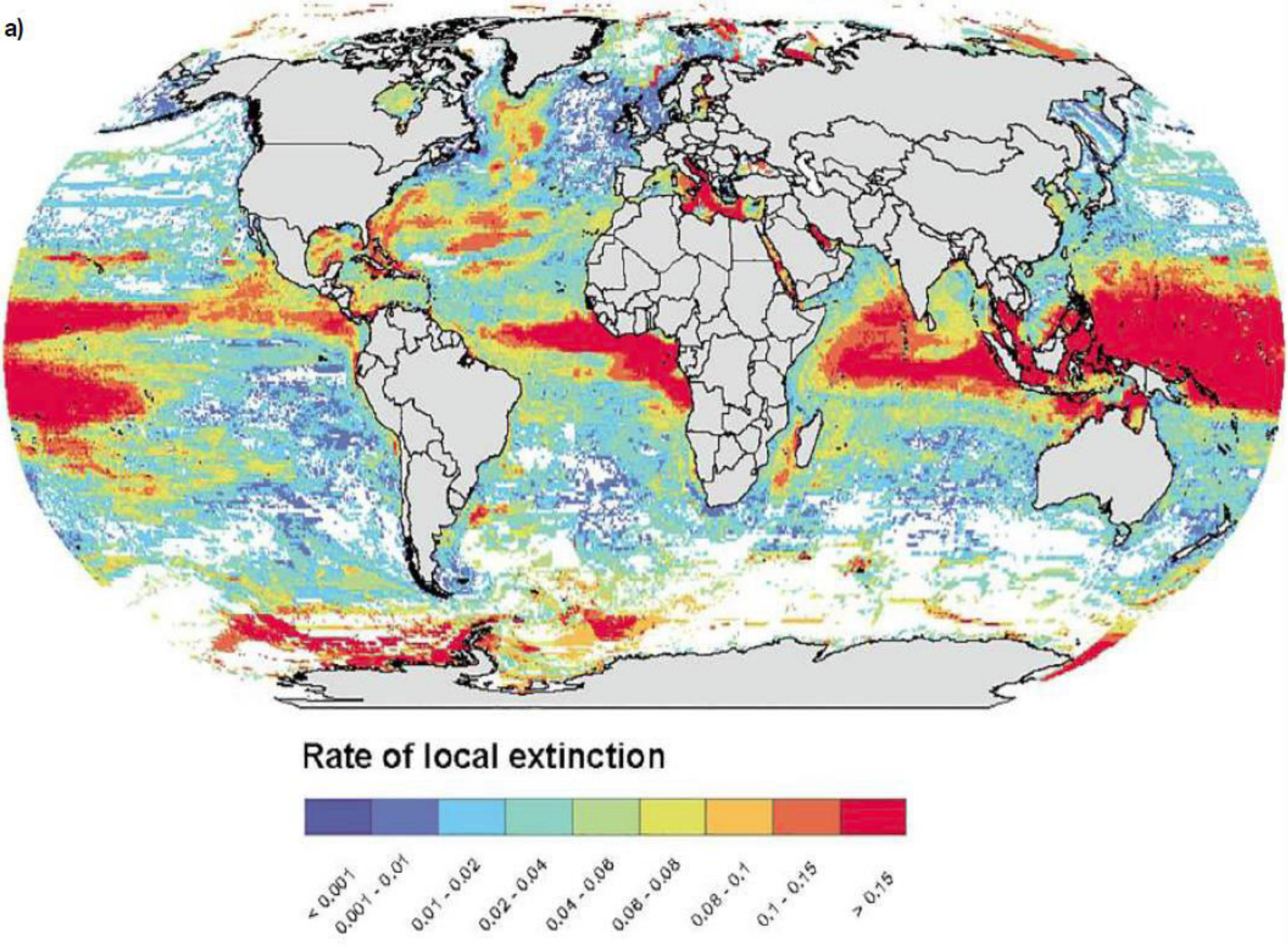


Non-tropical and tropical Large Fish



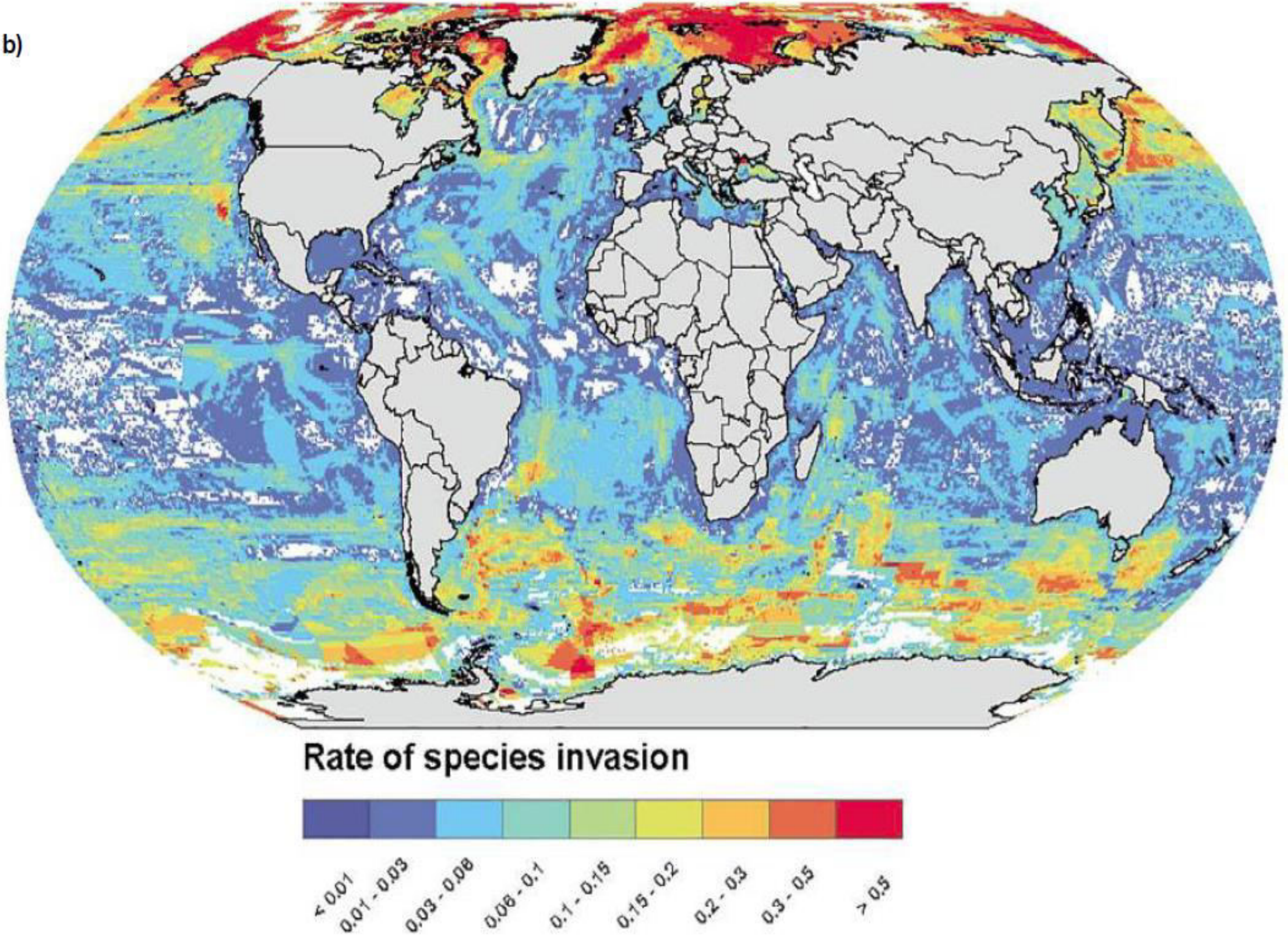


a)



Rate of local extinction
< 0.001
0.001 - 0.01
0.01 - 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.1
0.1 - 0.15
> 0.15

b)


Rate of species invasion
< 0.01
0.01 - 0.03
0.03 - 0.06
0.06 - 0.1
0.1 - 0.15
0.15 - 0.2
0.2 - 0.3
0.3 - 0.5
> 0.5

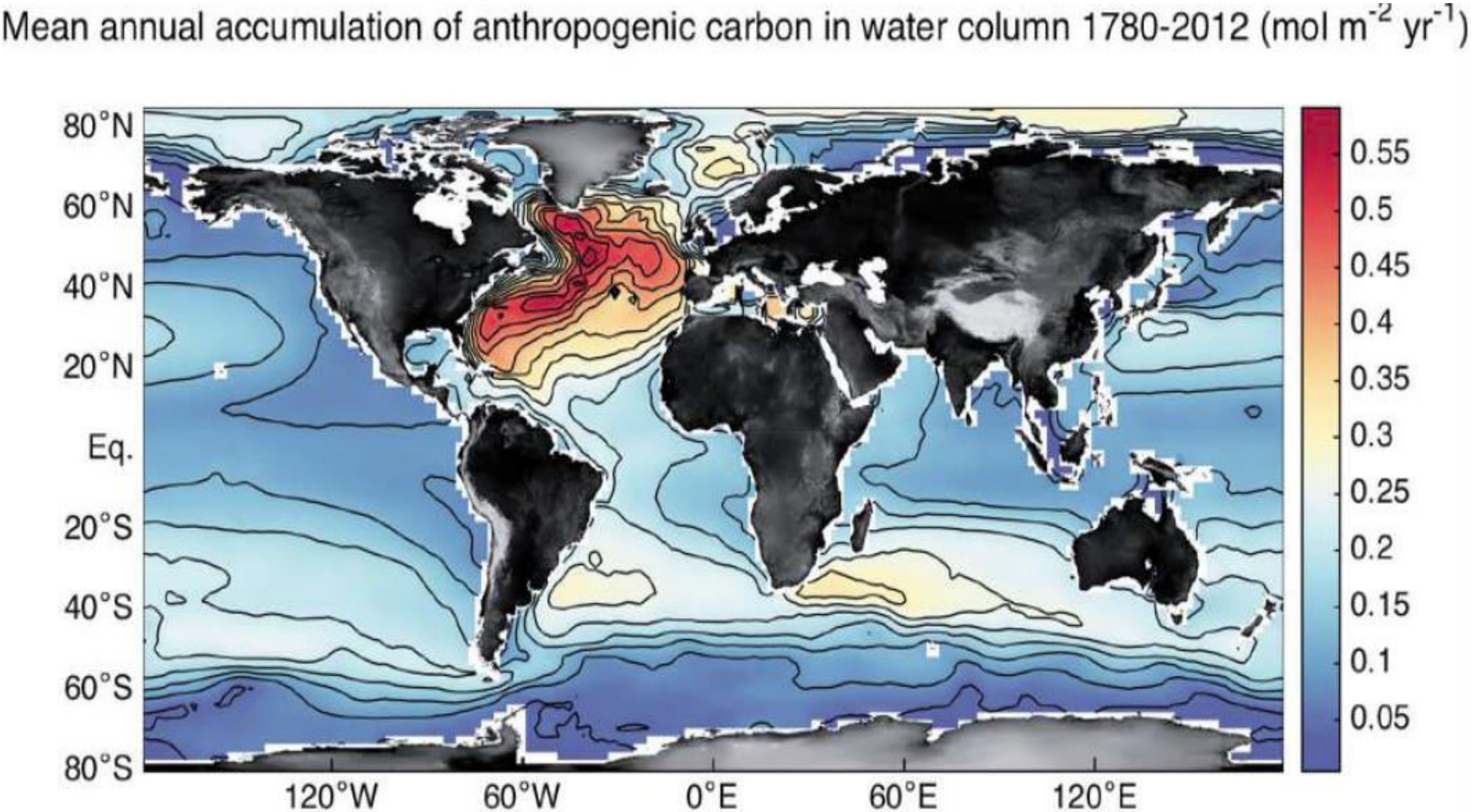


Figure 4.2.2 Estimated accumulation of anthropogenic carbon in the water column. Contours are every 0.043 mol m^{-2} yr^{-1}. Adapted from control run of ocean assimilation model of DeVries (2014).

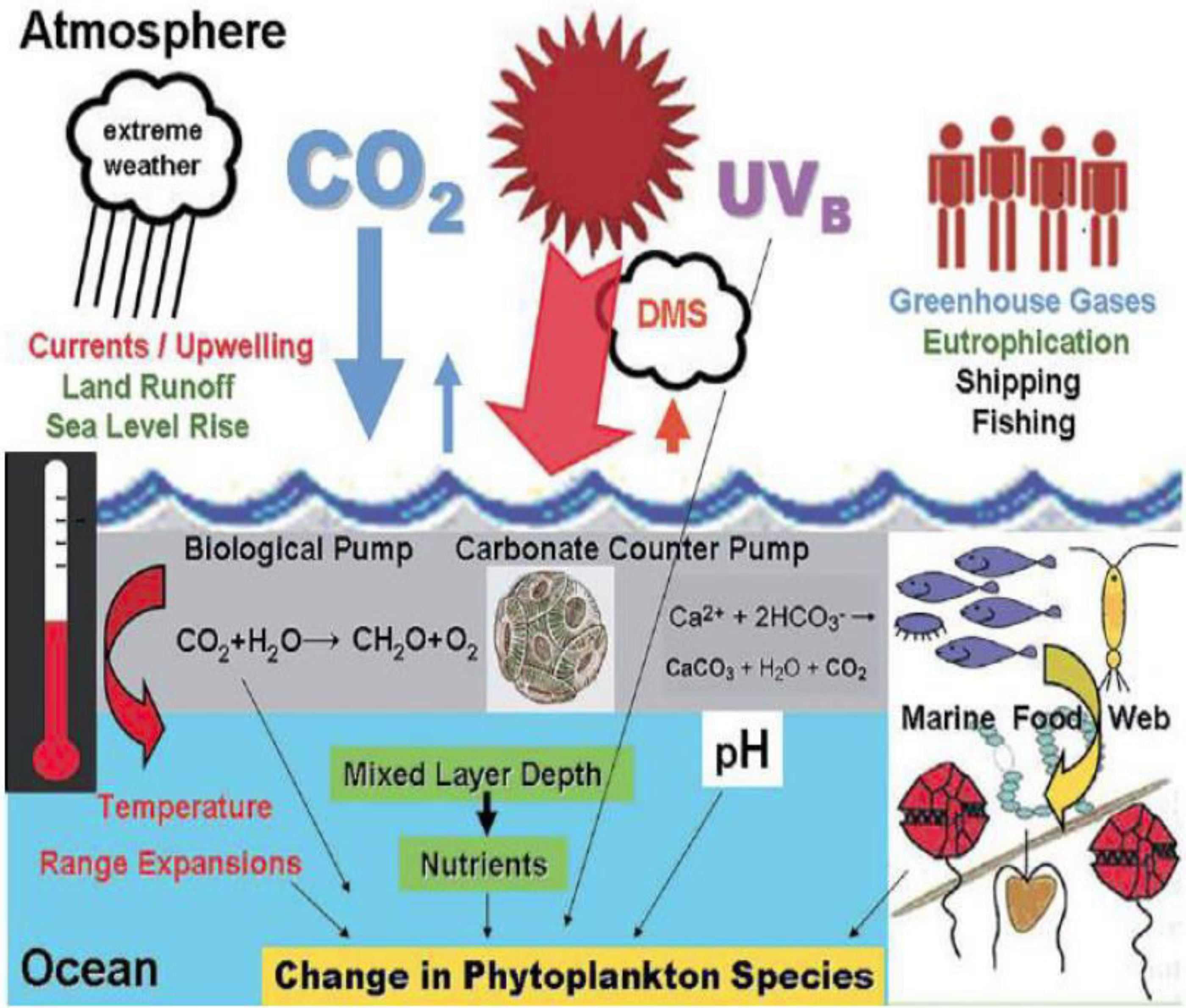


Figure 4.4.1 Climate change is multifactorial. Ocean warming, water column stratification, and associated changes in light penetration (increased ultraviolet exposure), nutrient availability, but also carbonate chemistry (pH) all drive changes in phytoplankton species composition. Human population pressures on the marine environment through nutrient pollution, ship ballast water introduction of invasive species, and marine food web alteration from overfishing represent additional stressors (adopted from Hallegraeff, 2010).

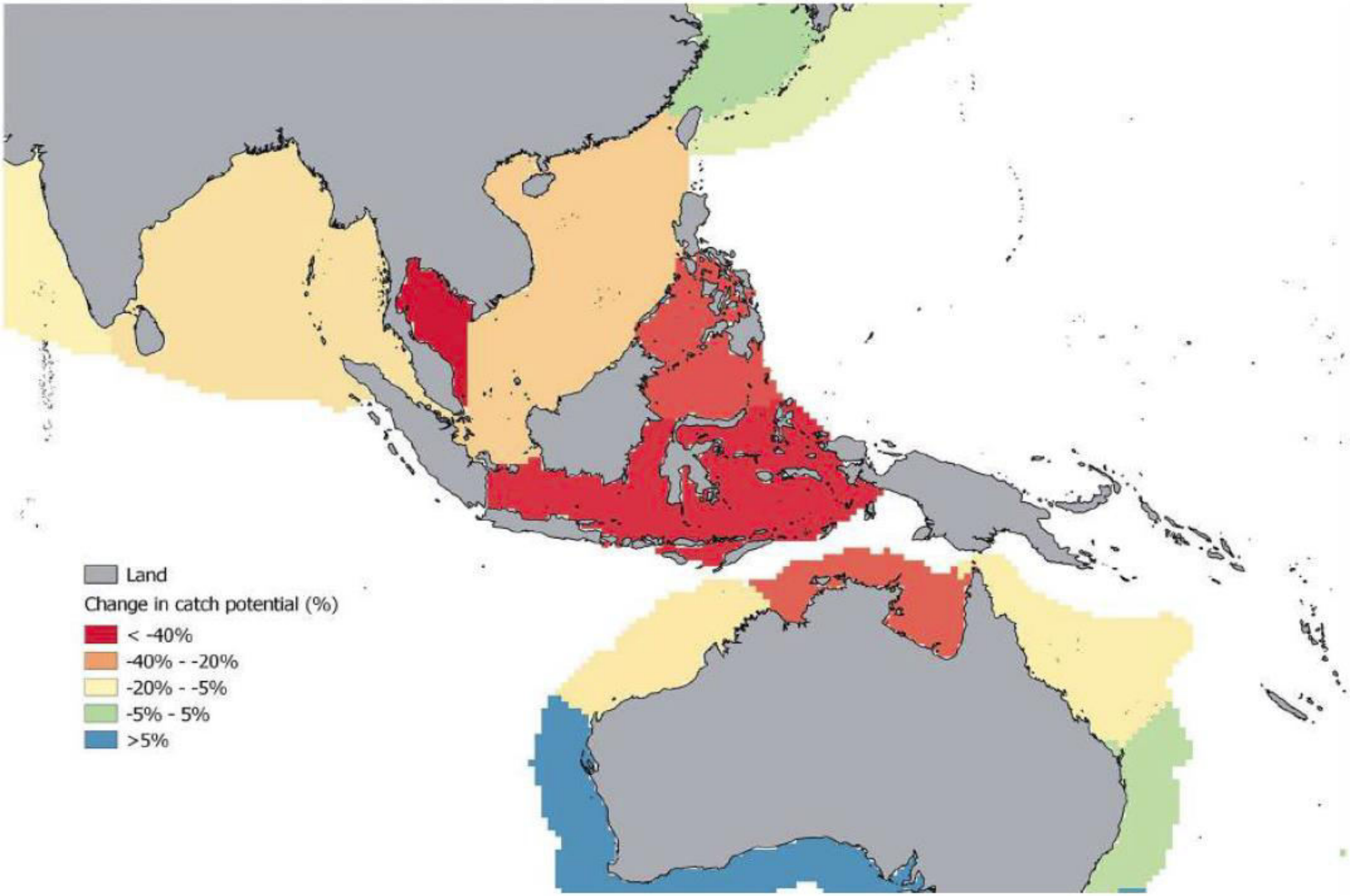


Figure 4.5.5 Multi-model ensemble projections of mean percentage changes in potential fish catch from South-east Asia by 2050, relative to recent catch levels (1971–2000), under the RCP 8.5 emissions scenario (source: Cheung *et al.*, 2016a).

Global Monsoons and Ocean Triads

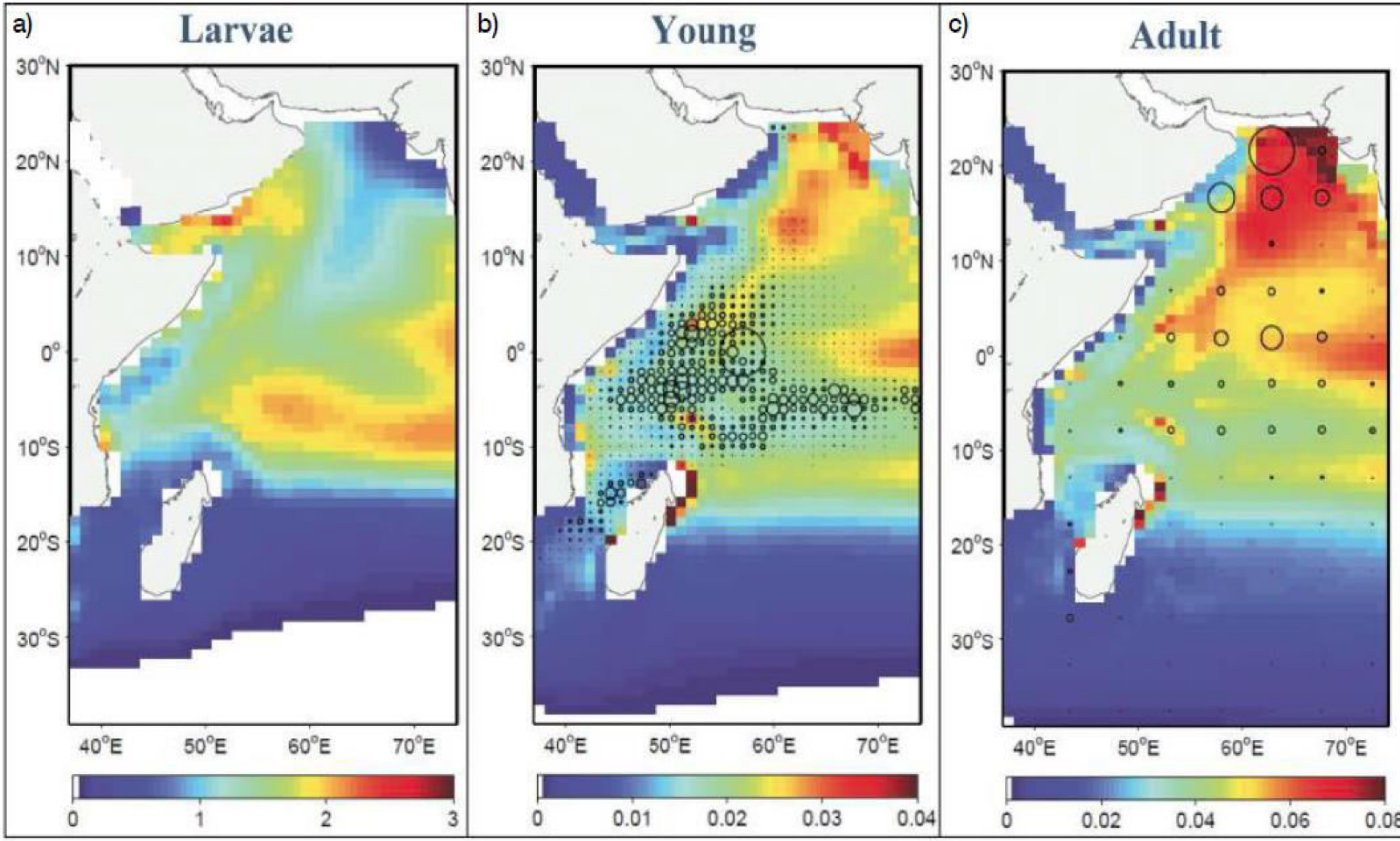


Figure 4.5.6 Reconstruction of the history of yellowfin tuna dynamics and fisheries in the Western Indian Ocean using the SEAPODYM model and results presented in Senina *et al.* (2015). The panels show the average spatial distribution of yellowfin tuna density for three different life history stages: a) larvae, b)young fish caught by purse seine, and c) adults caught by longline. The locations of catches of young fish made by purse seine are shown with circles on panel b) (largest circle radius corresponds to a catch of 200 tonnes) and the locations of catches of adults by longline are shown with circles on panel c) (largest circle radius corresponds to a catch of 10 tonnes).

Ecosystem-Based Management: Global Monsoons to Microbes

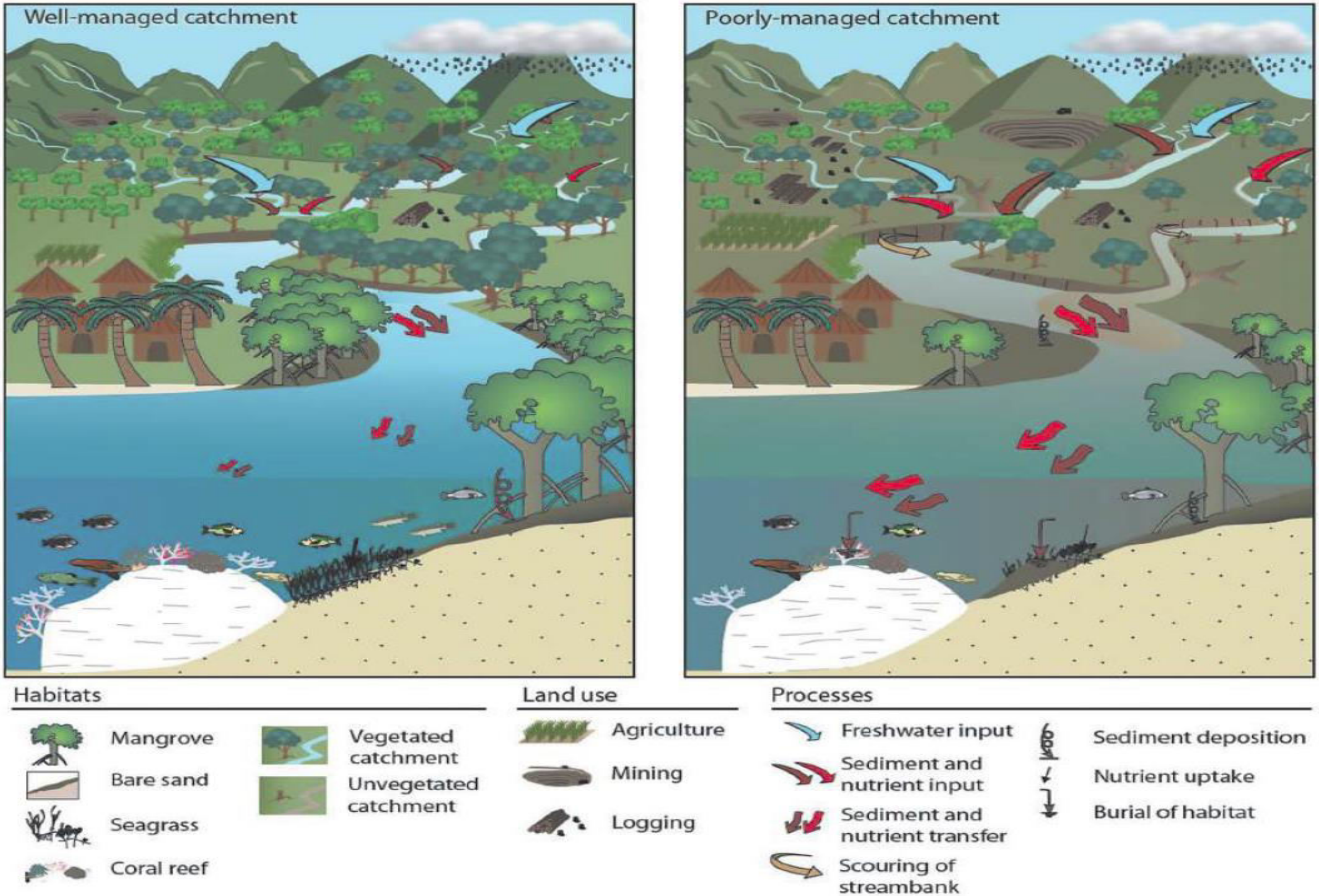
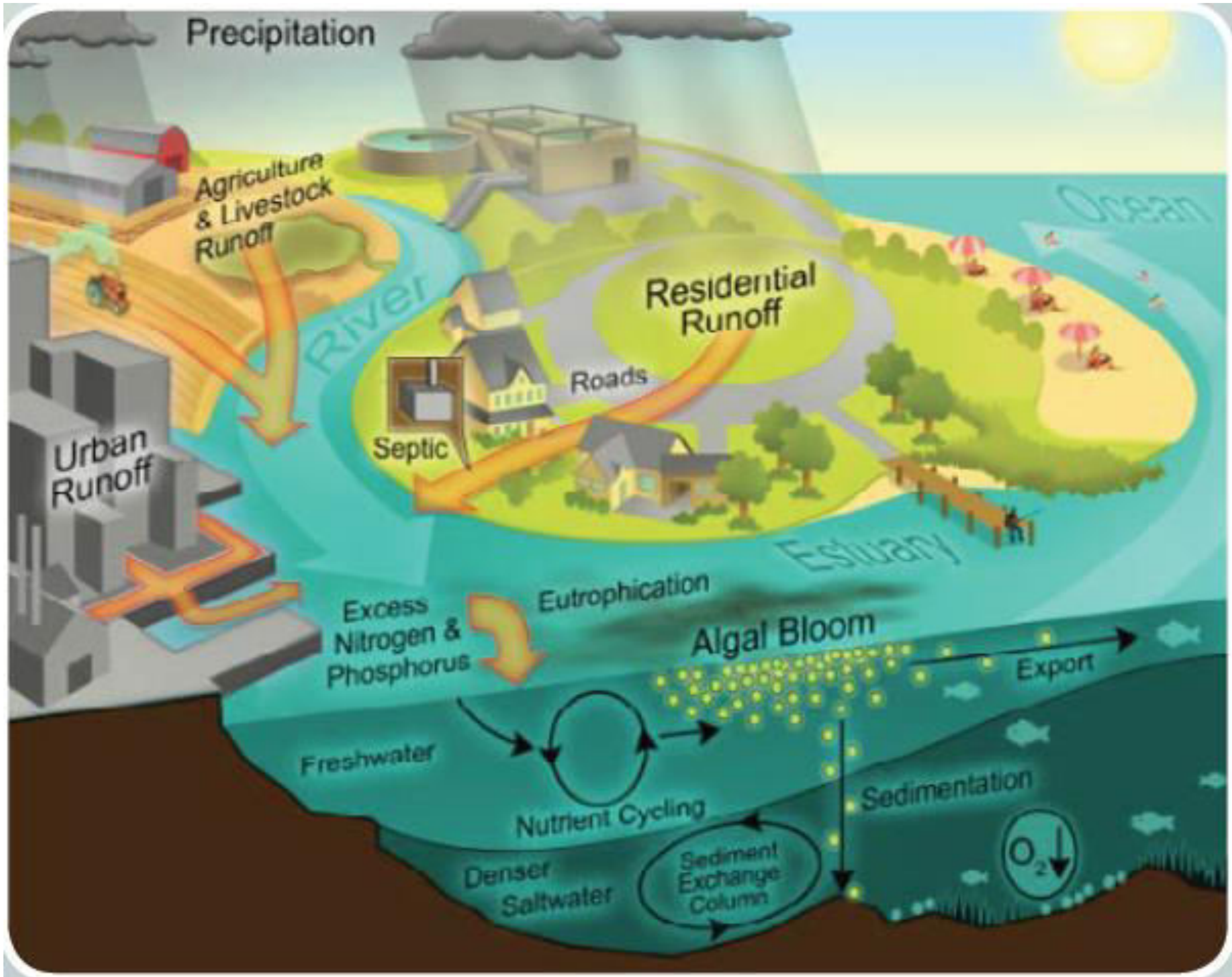
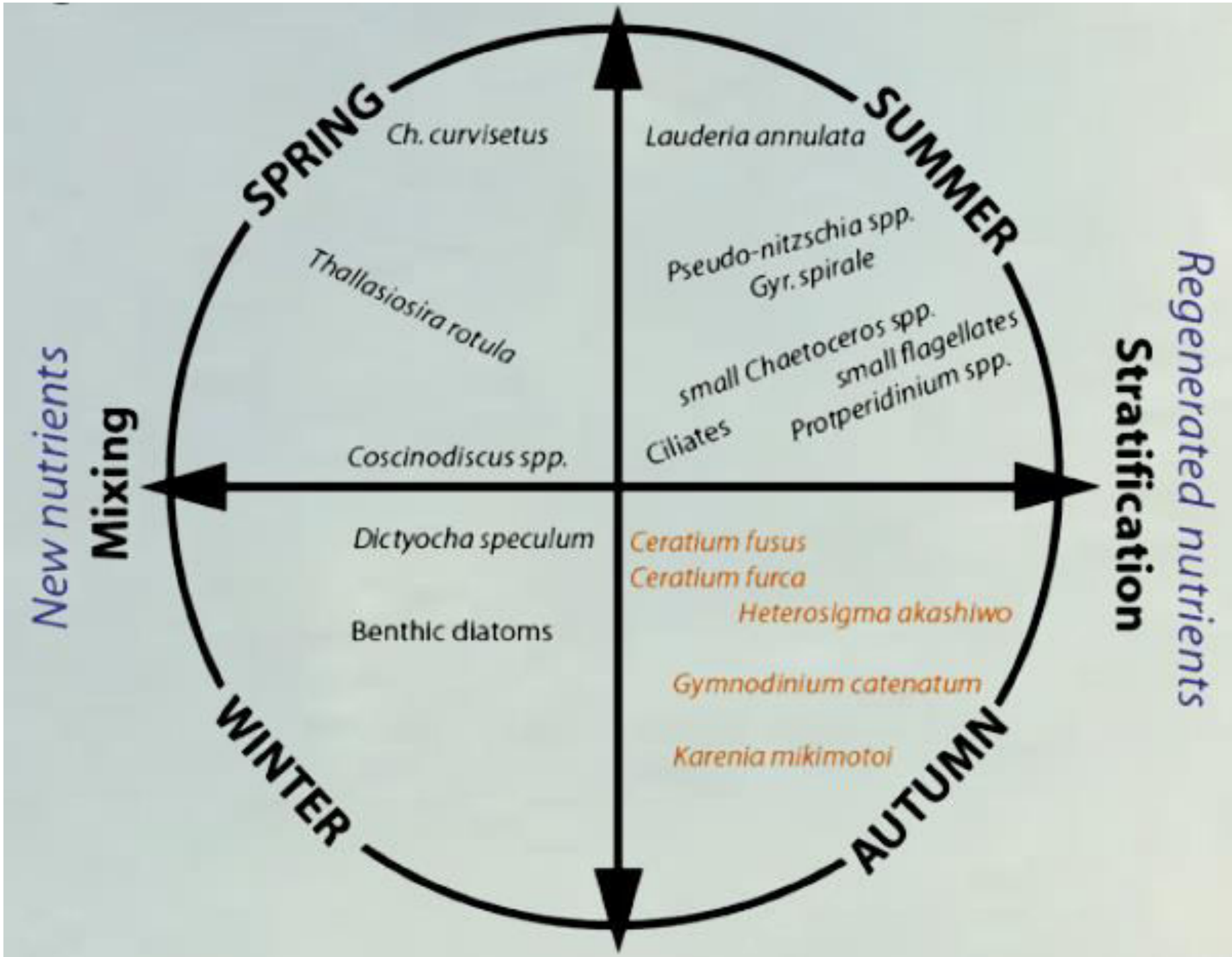


Figure 4.5.16 Differences in the quality of coastal fish habitats when catchments are managed well or managed poorly (source: Bell *et al.*, 2011c).

Dead zones and HABs are a consequence of warming and global monsoon changes (Extremes)



Seasonality of the monsoons determine physical processes and HAB species



Global Monsoon is a Challenging Science Problem

Global Warming Impact on GM is full of Uncertainties

All Global Warming is Local

All GM Impacts are also local

Land-Ocean Interactions in the Coastal Zone must be a focus for Sustained Observational, Modeling, Predictions and Projections