Current and Future Situation of Australian Fisheries to Climate Change

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Collaborators

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- Fisheries in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)
- Evidence of Impacts on marine species and consequences for fisheries
- Projections for biodiversity
- Situation Analysis for Australian Fisheries

Headlines from IPCC AR5 WGII Summary for Policymakers

Observed impacts of climate change are widespread and substantial.

People, places, and ecosystems in poor and rich countries around the world are vulnerable and exposed to climate change, in different ways.

Climate-change adaptation is beginning to occur.

Responding to climate change is a challenge in managing risks.

Climate-related risks are much greater with continued high emissions than with ambitious mitigation. Unchecked emissions increase the likelihood of severe and pervasive impacts that may be irreversible or unanticipated.

Effective and inclusive climate-change adaptation can help build a richer, more resilient world in the near-term and beyond.

Changes to ocean temperature, chemistry and other factors are generating new challenges for fisheries, as well as benefits

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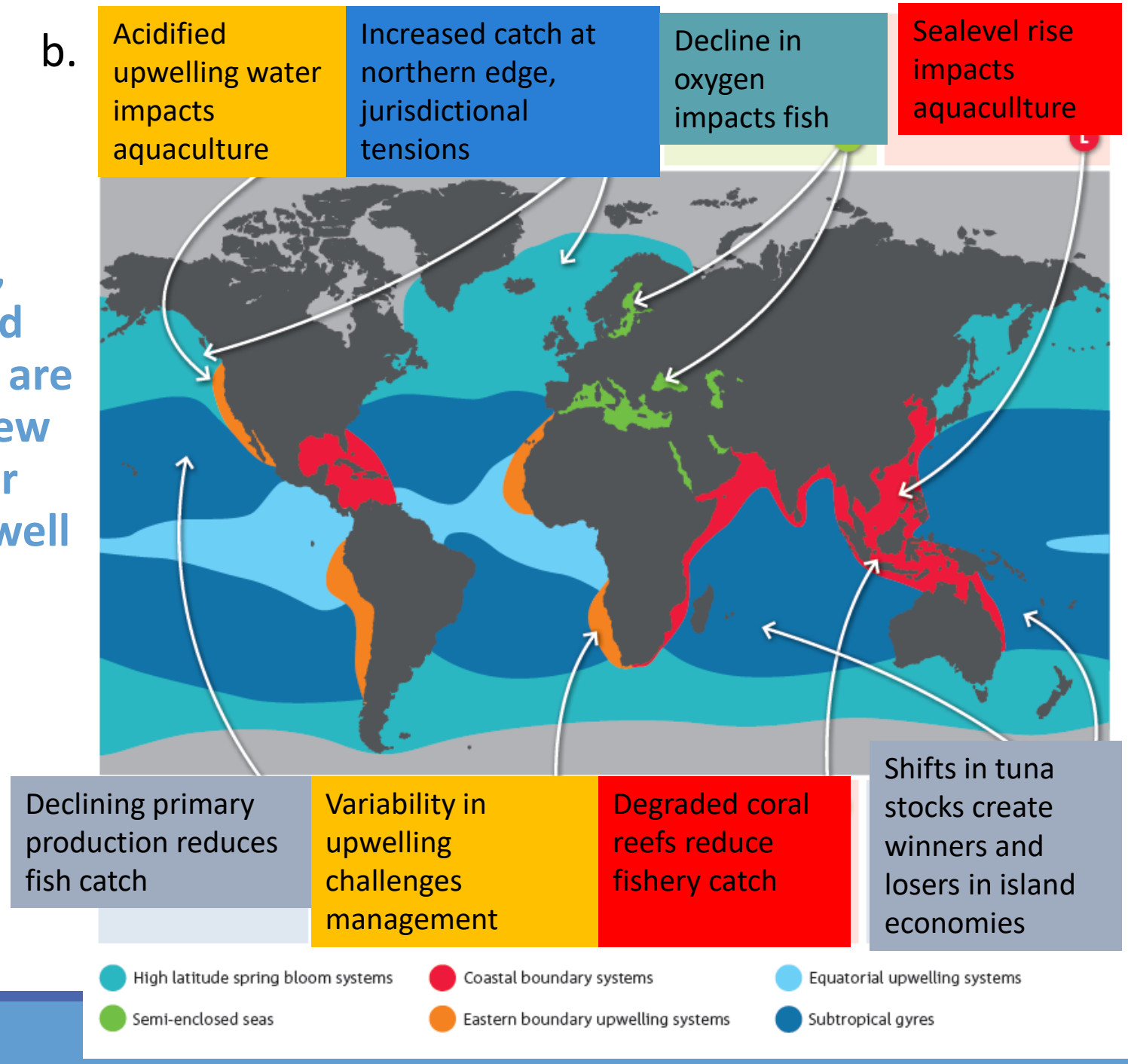
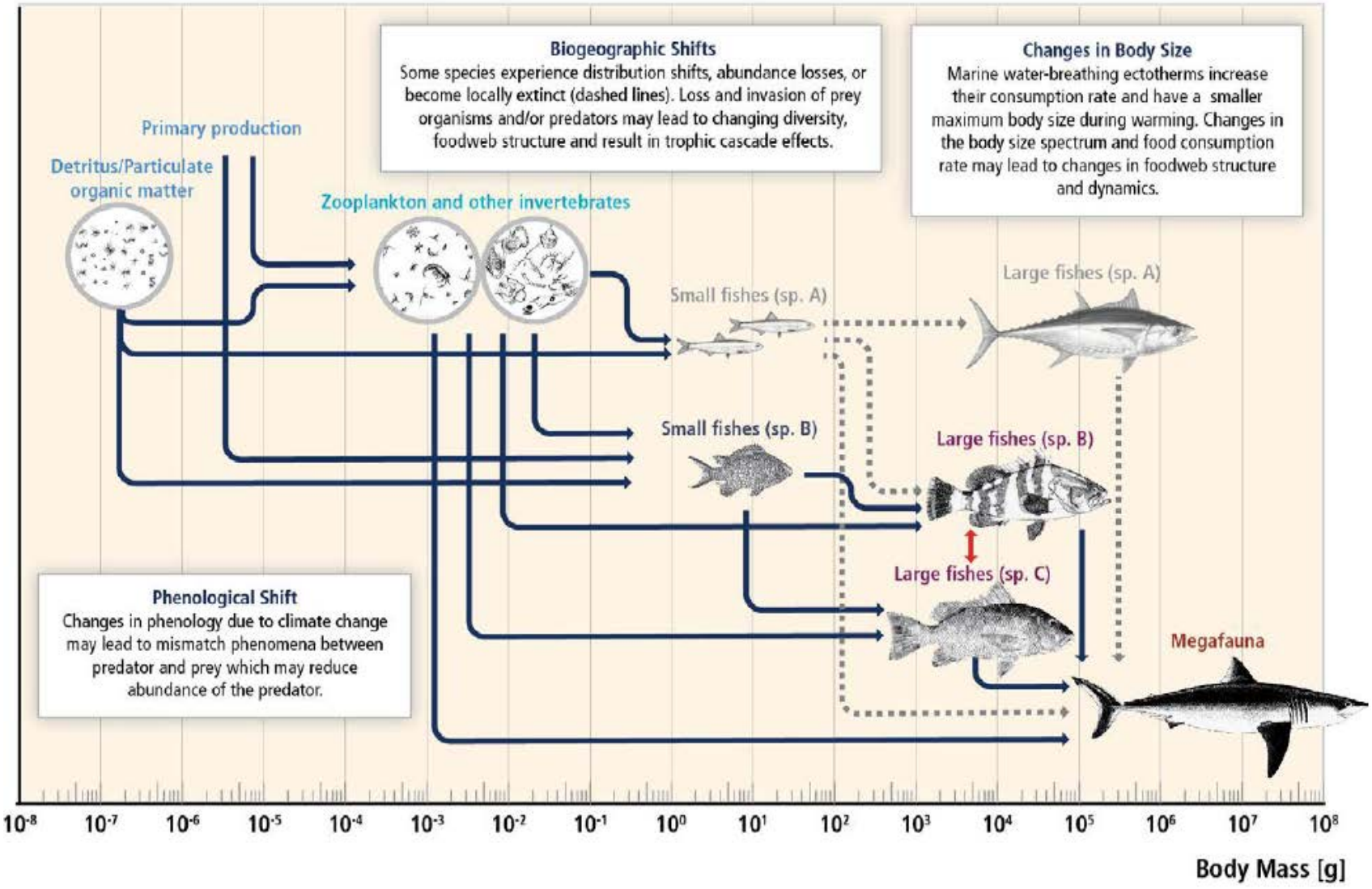
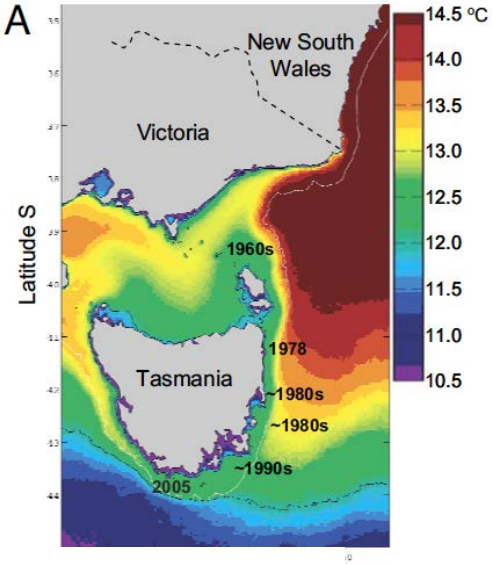


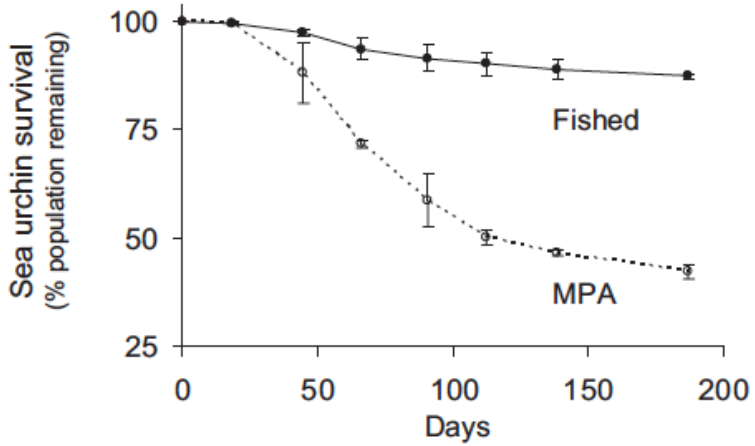
Relatively small changes in temperature and other variables can result in often large biological responses that range from simple linear trends to more complex non-linear outcomes

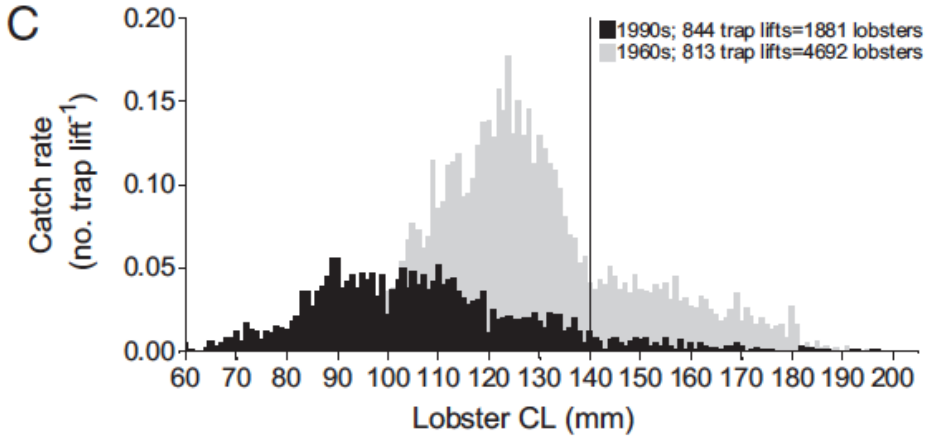


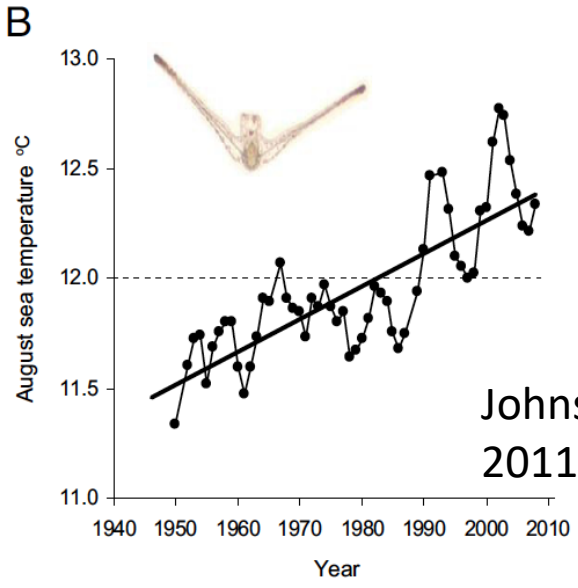
Sea urchins, kelp beds and rock lobsters

Ling et al 2009 PNAS



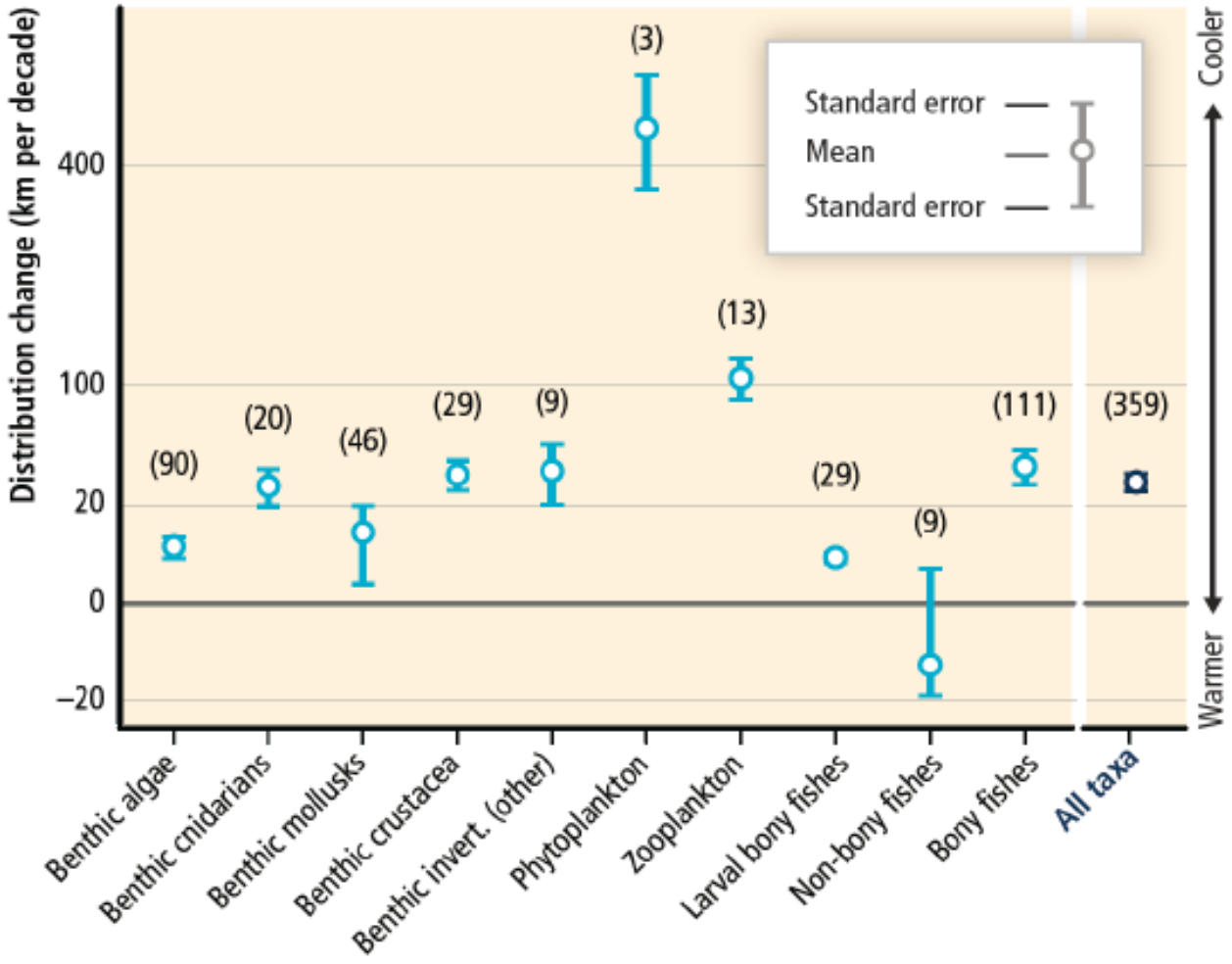






Johnson et al 2011 JEMBE

Climate-driven range shifts are observed from every ocean



Leading edge expansion

Ocean
72 km dec^{-1}
Land
6 km dec^{-1}

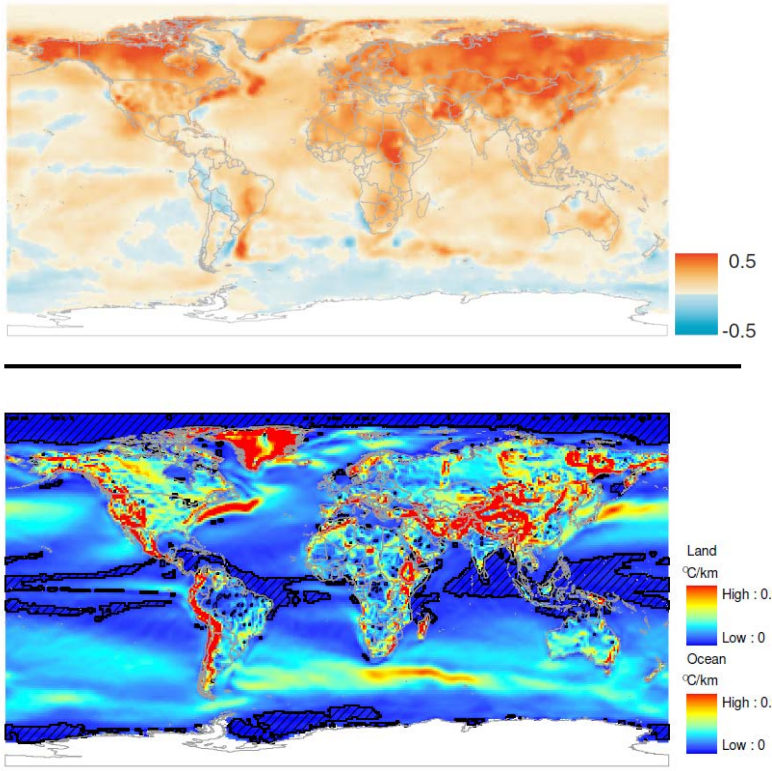
Poloczanska et al 2013 Nature Climate Change, IPCC WGII SPM

The velocity of climate change

How fast and in which direction are isotherms shifting?

$$\text{Velocity} = \frac{\text{Temperature trend}}{\text{Spatial gradient}}$$

1960 to 2009

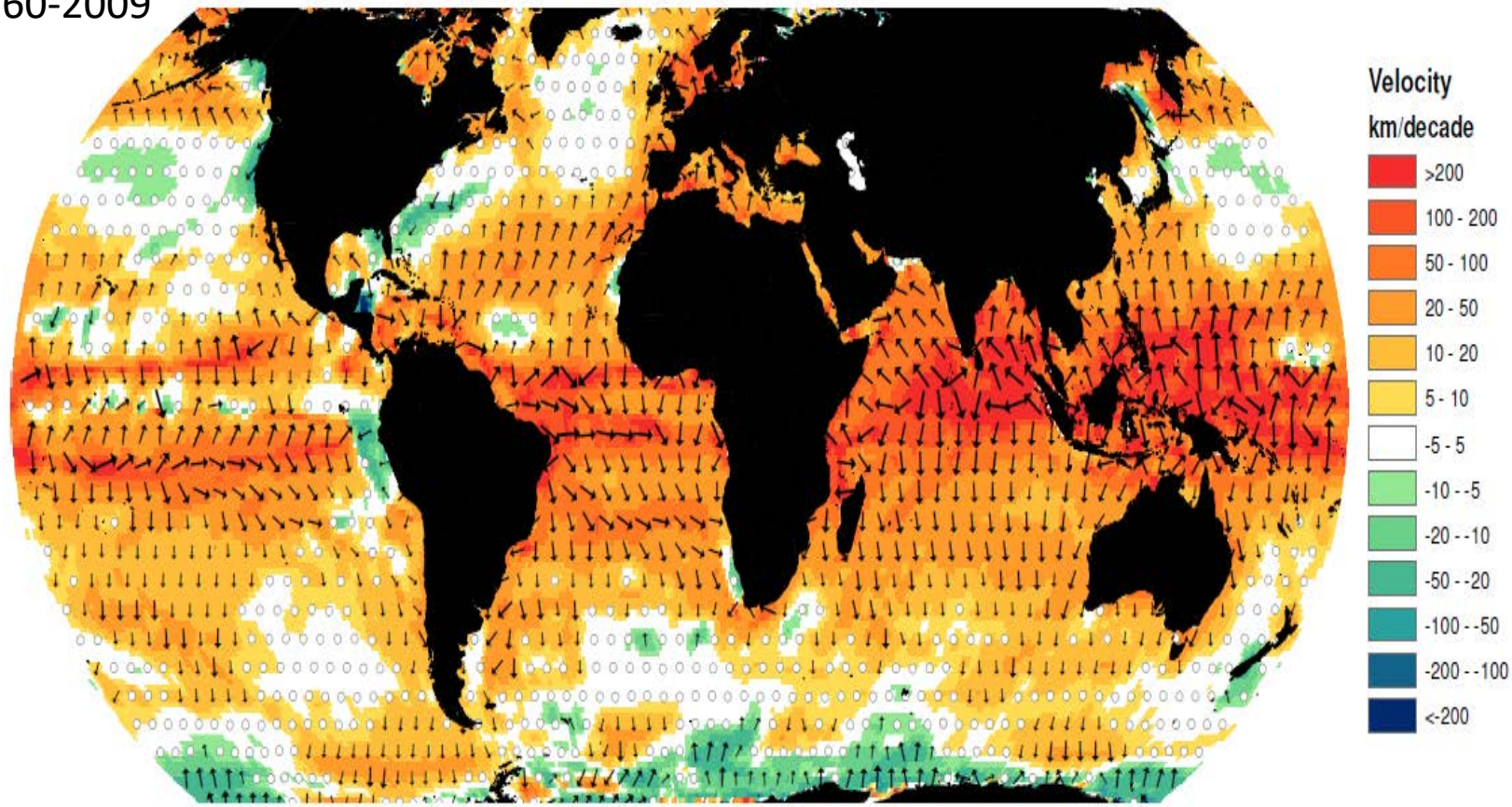


$$\text{km/yr} = \frac{\text{°C/year}}{\text{°C/km}}$$

1960-2009 surface temperatures

Burrows et al 2011 Science 334

1960-2009



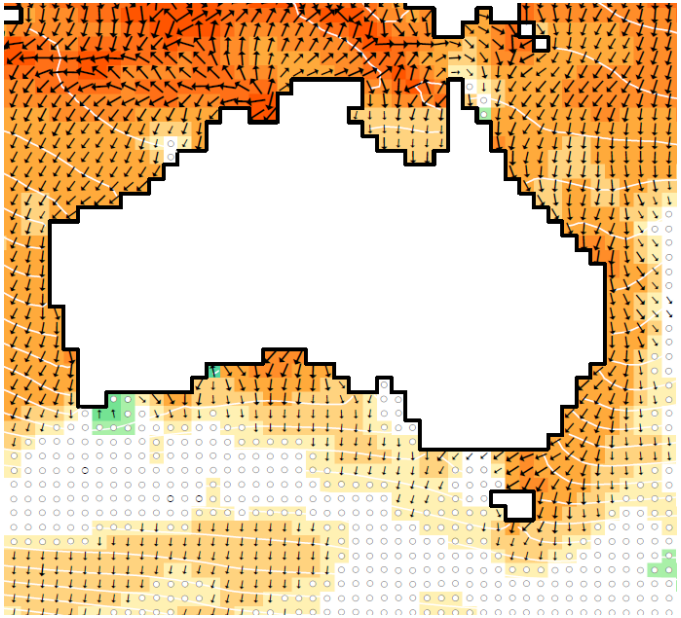
Fast velocity: shallow spatial gradients or rapid warming

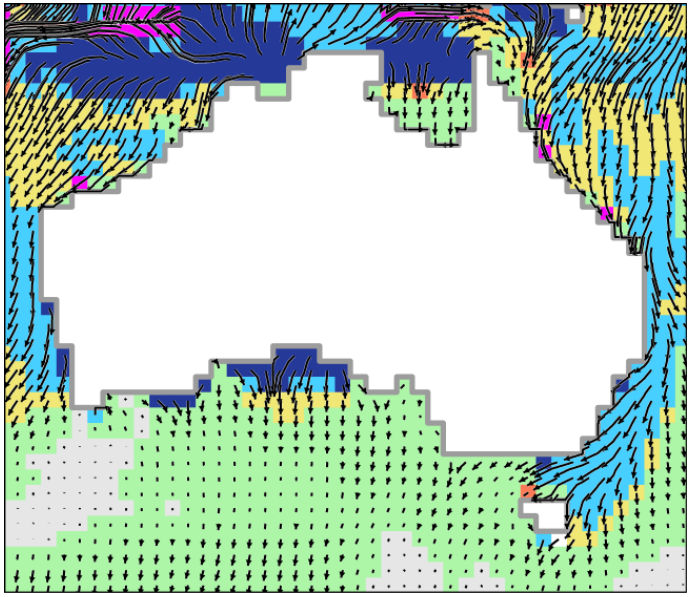
Slow velocity: sharp spatial gradients or slow warming

Negative velocity: regional cooling

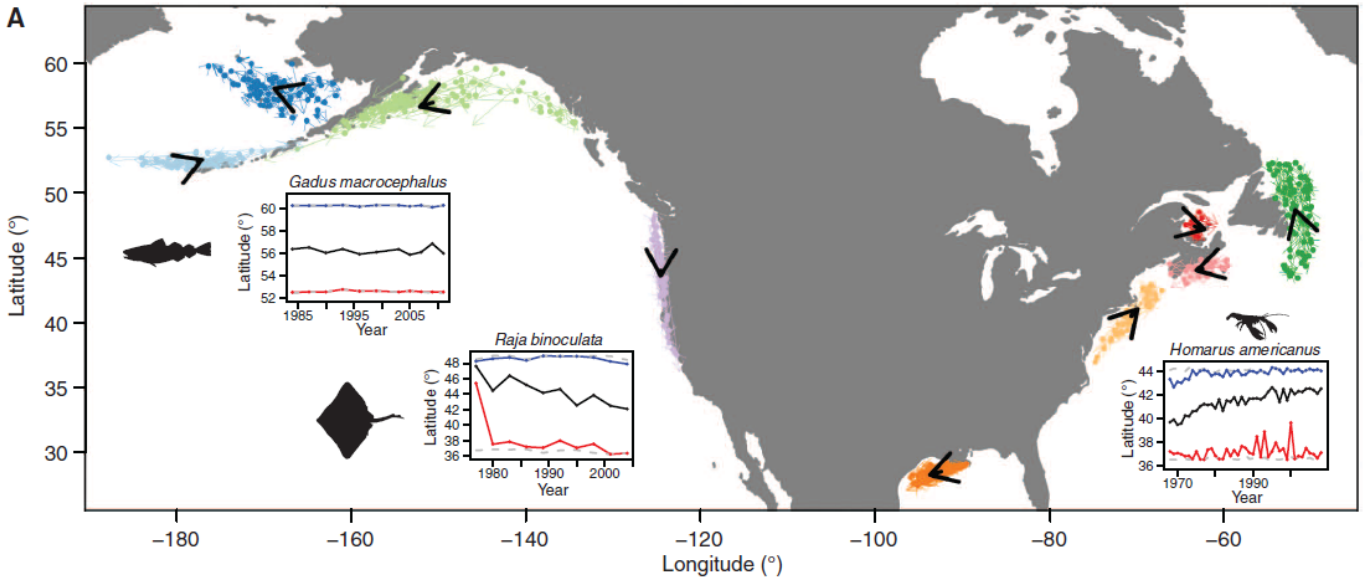
Burrows et al 2011 Science 334

Velocities to trajectories….

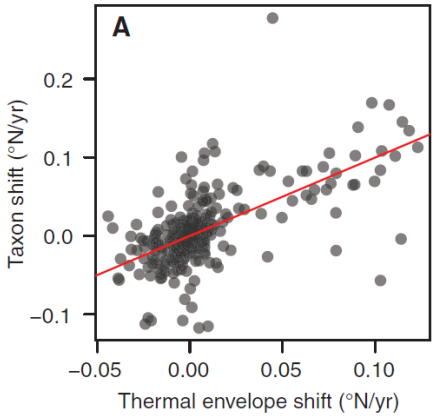




Does velocity predict shifts???



128 million individuals across 360 marine taxa sampled from 1968-2011



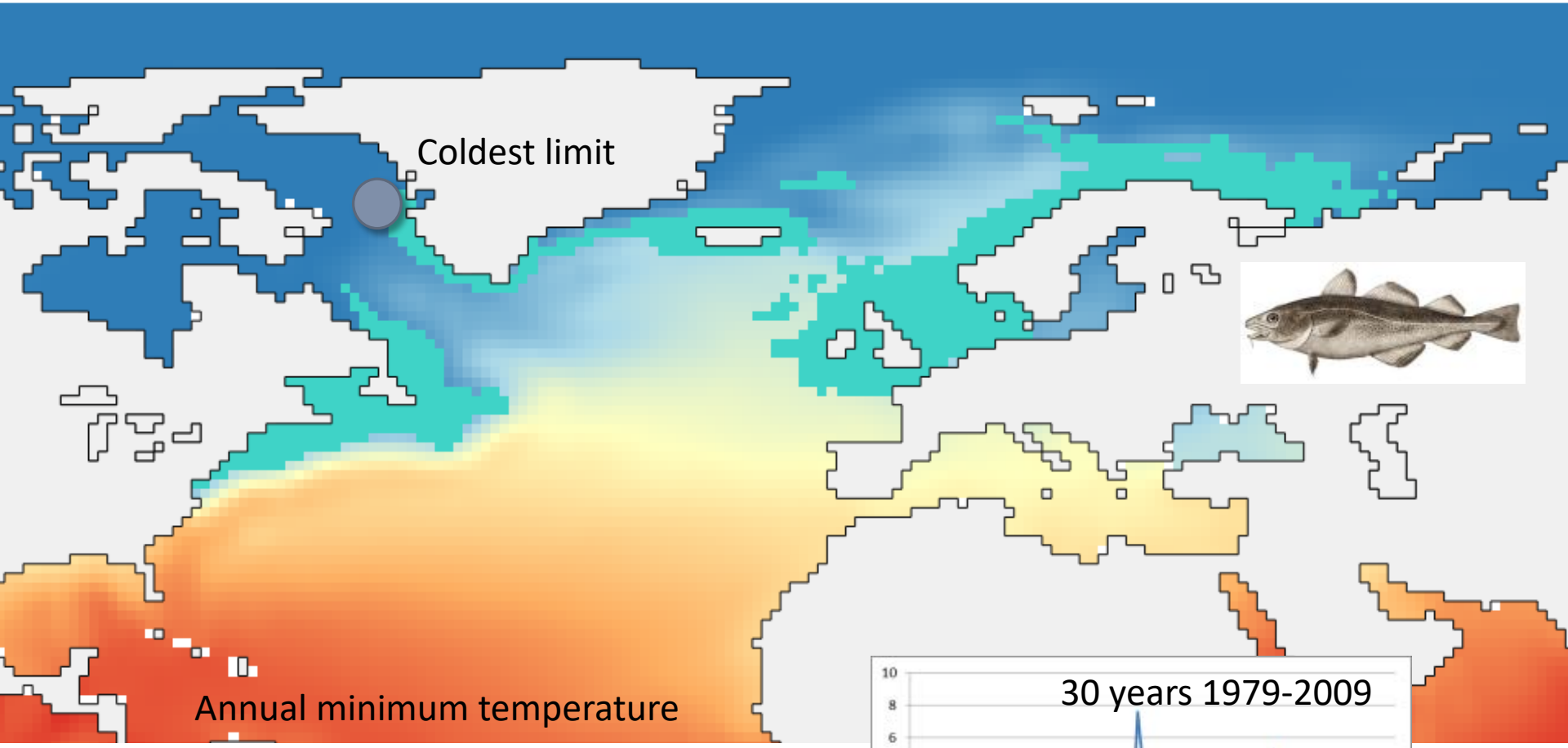
Pinsky et al 2013 Science 341

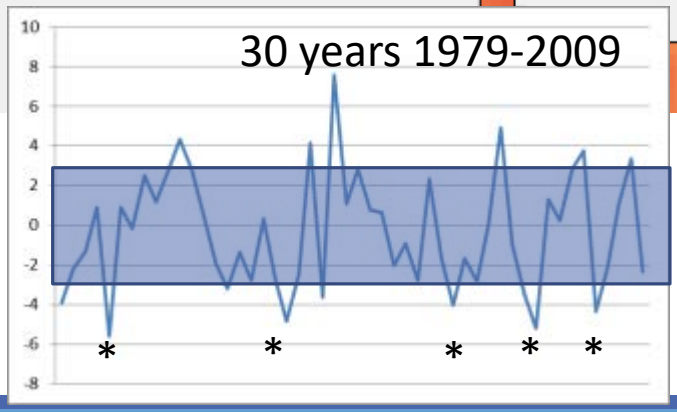
Basic premise: Species track their shifting thermal niches

Maps of species presence, “advected” along lines of projected shifts in isotherms

Above: Atlantic Cod distribution from Aquamaps (Kaschner et al 2013) with 1960-2009 VoCC

García Molinos et al 2015 Nature Climate Change



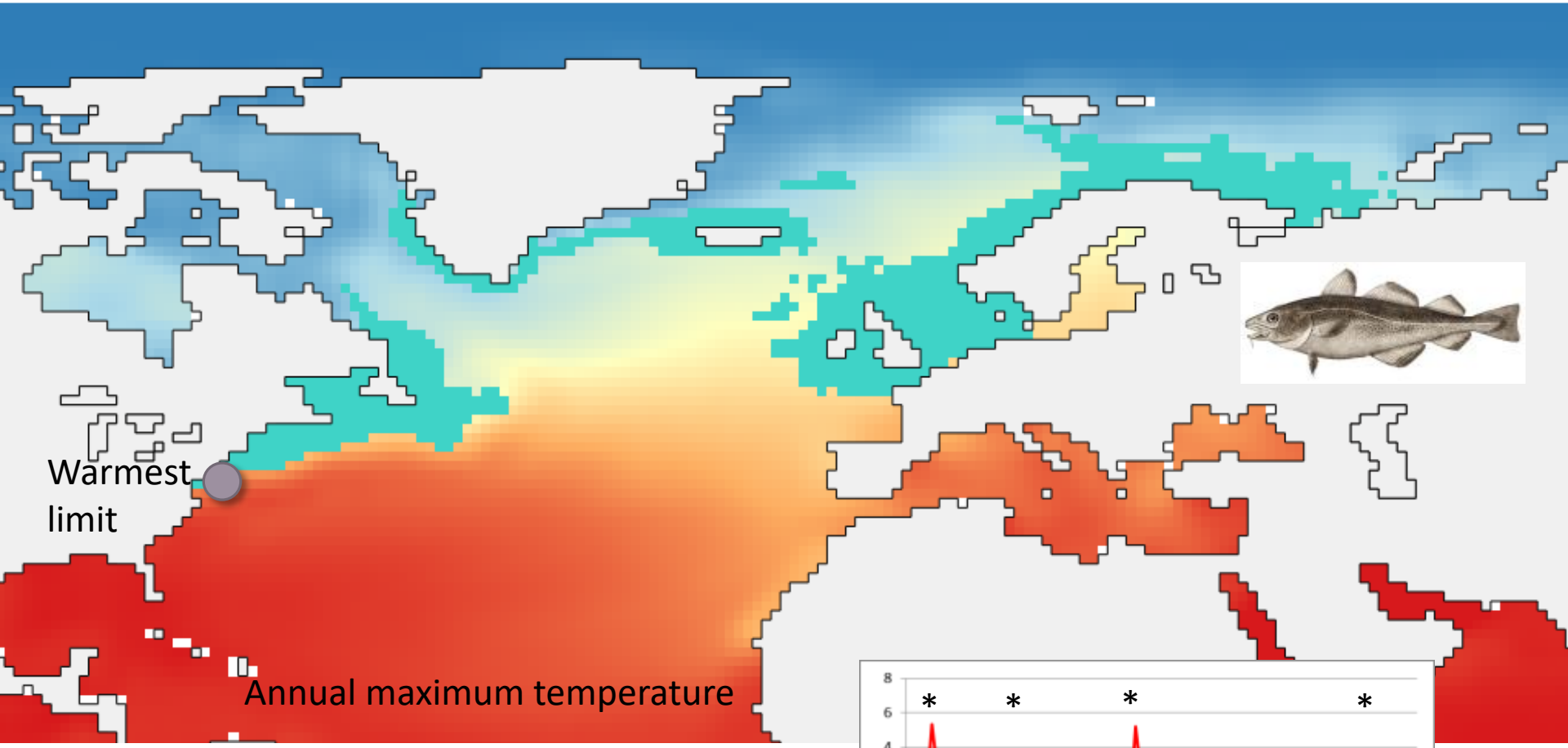


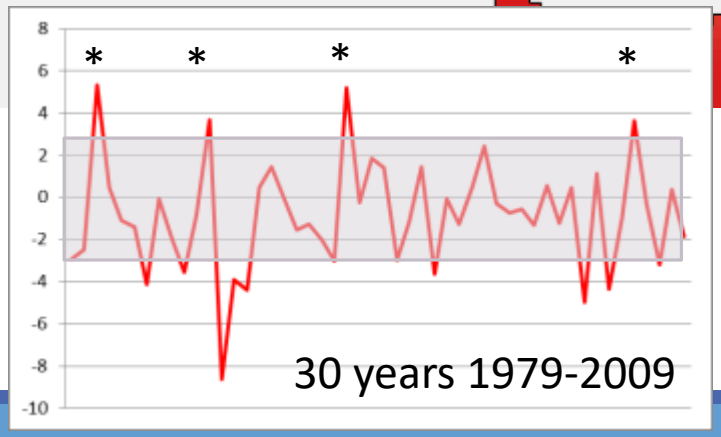
Lower thermal limit (Th_{min}) for the species is set at the lowest annual minimum temperature *minus* the 30yr standard deviation in temperature at that site

30yr SD

García Molinos et al 2015 Nature Climate Change

* = cold death events

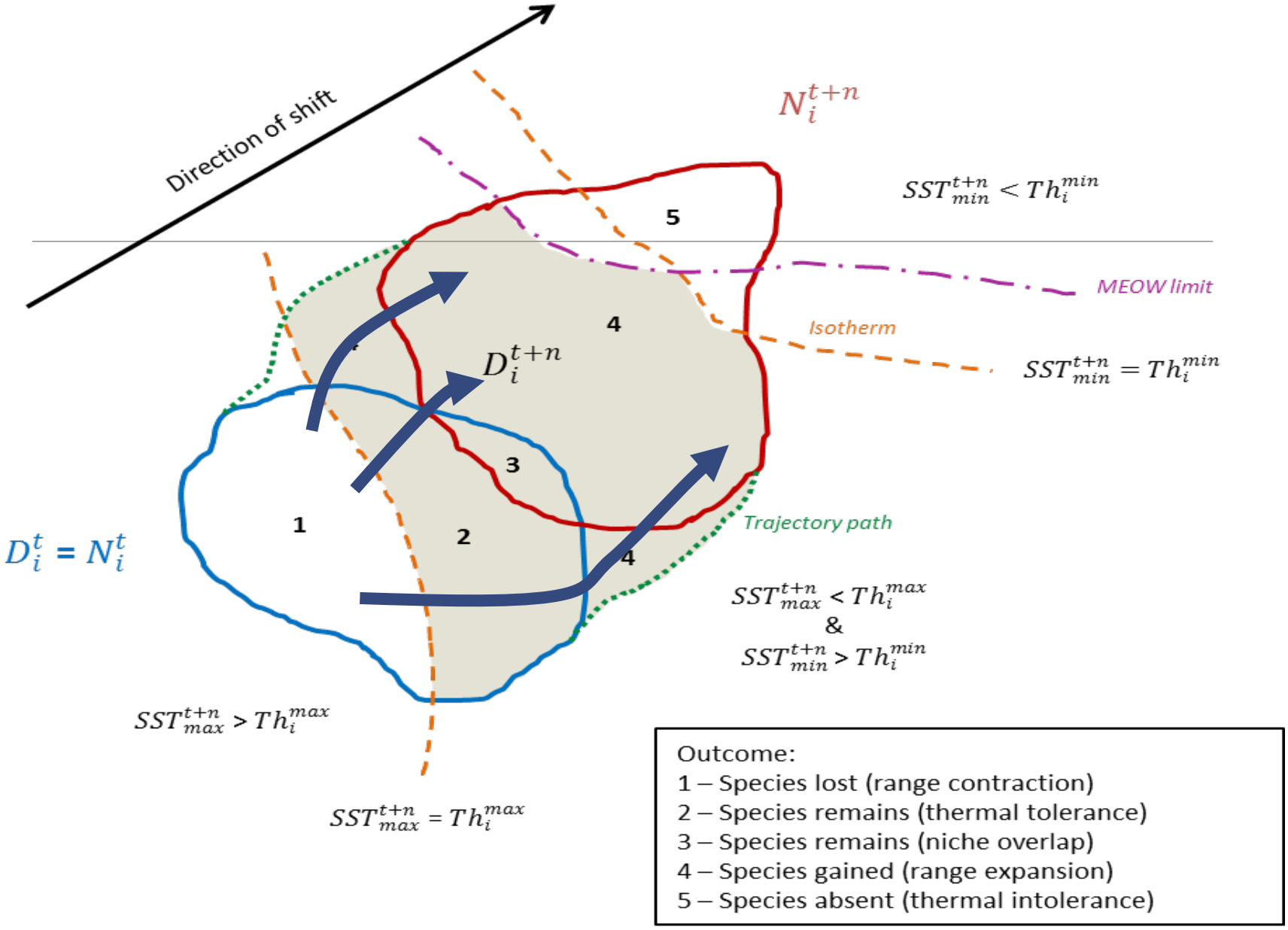




Upper thermal limit (Th_{max}) for the species assumed at the highest annual maximum temperature *plus* the 30yr standard deviation in temperature at that site

García Molinos et al 2015 Nature Climate Change

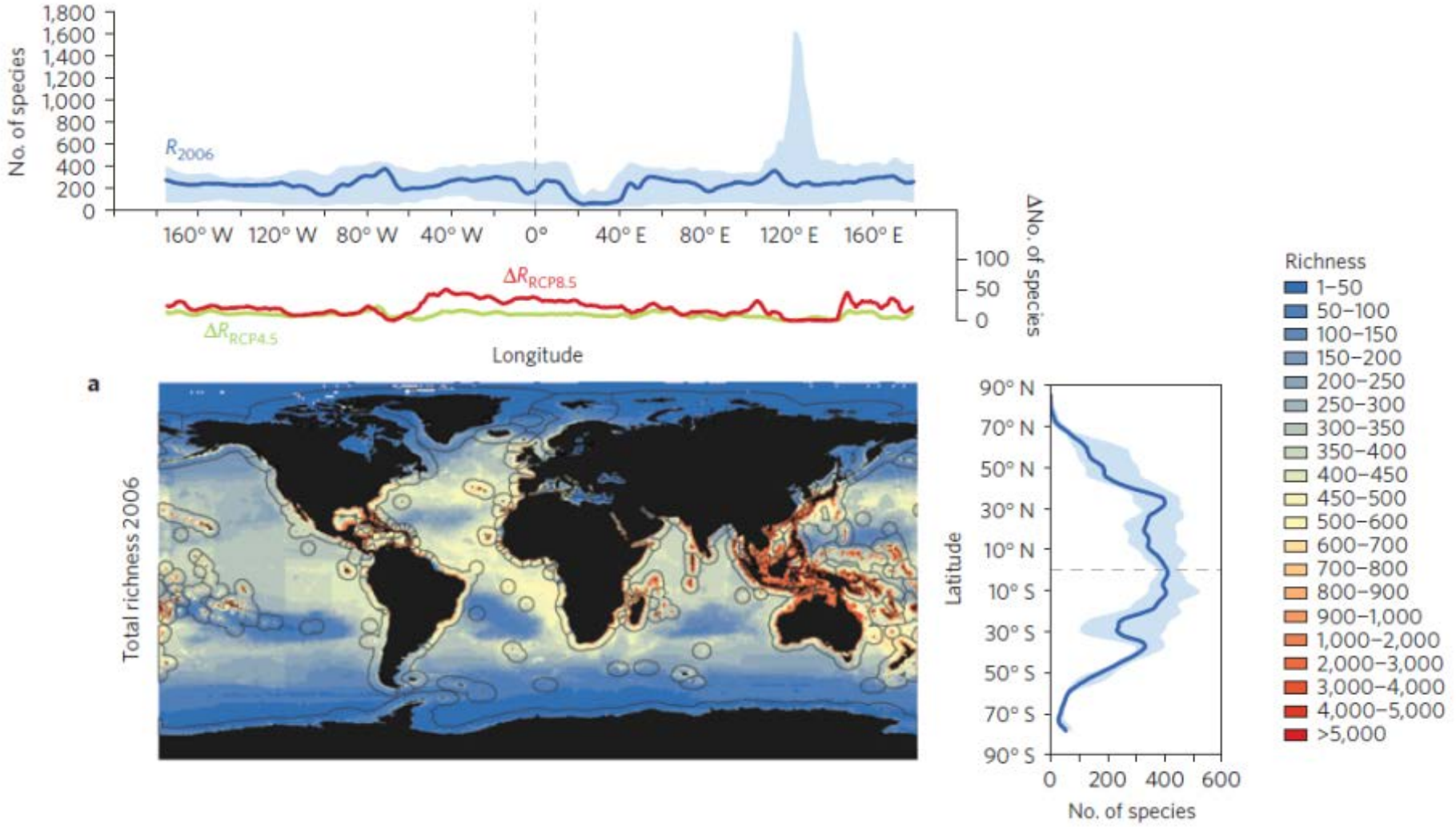
* = heat death events



Outcome:
1 – Species lost (range contraction)
2 – Species remains (thermal tolerance)
3 – Species remains (niche overlap)
4 – Species gained (range expansion)
5 – Species absent (thermal intolerance)

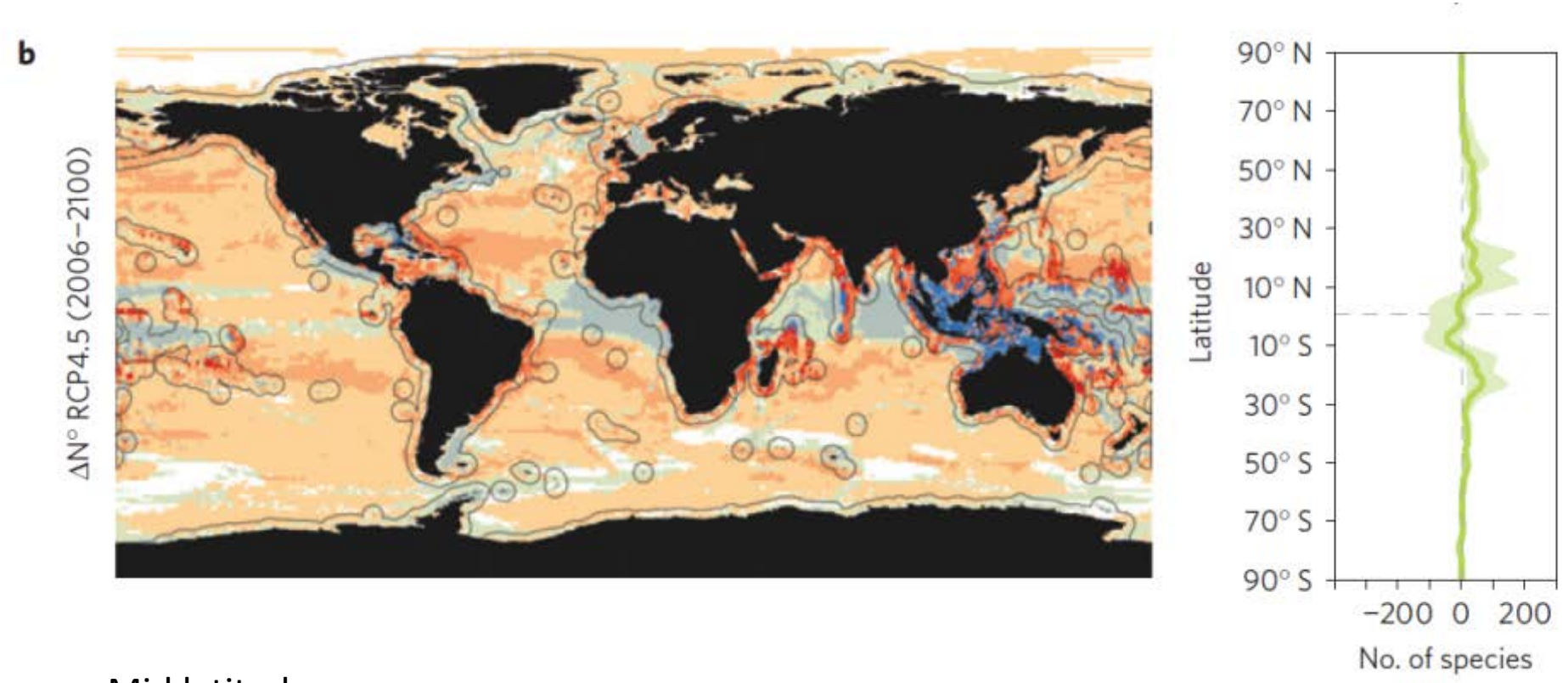
García Molinos et al 2015 Nature Climate Change

Total species richness based on ~13,000 Aquamaps species



García Molinos et al 2015 Nature Climate Change

Projected change in total species richness: 2006 to 2100 RCP 4.5

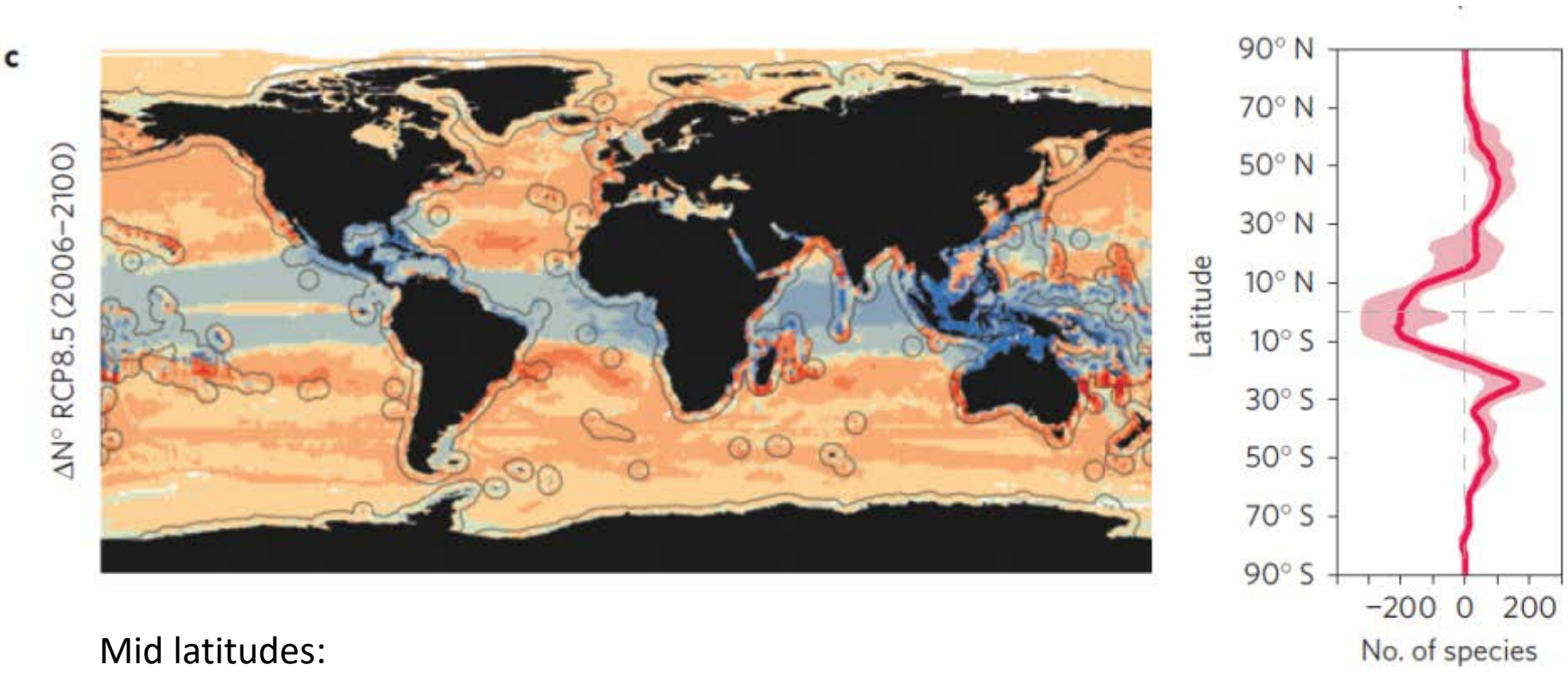


Mid latitudes:
increases in diversity

Losses in the tropics
Latitudinal peaks ~20° N/S

García Molinos et al 2015 Nature Climate Change

Projected change in total species richness: 2006 to 2100 RCP 8.5



Mid latitudes:
larger local increases in diversity

Much greater and more widespread losses in the tropics
Latitudinal peaks ~30-40° N/S
Mid century (2040-2065) diverge from net gain to net loss

Potential for wide-spread redistribution of biodiversity

Losses in species richness in the tropics

Changes are more pronounced under high emission (~4°C warming by 2100) than low emission scenario (~2°C warming by 2100)

Patterns emerge by mid century

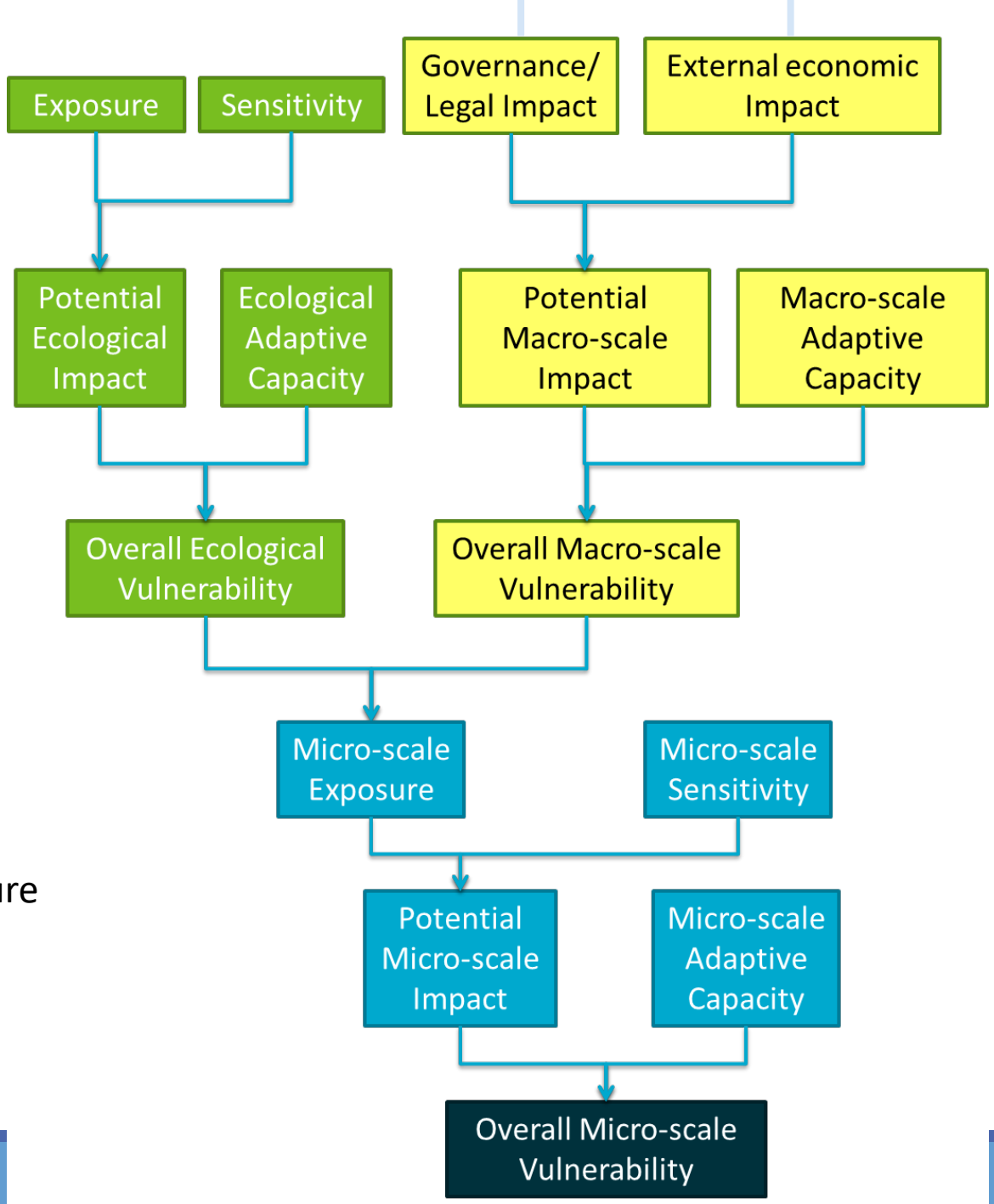
Fisheries need to be prepared…….

How prepared are fisheries?

To document the current situation (e.g. governance, management arrangements, operations and scientific support) for adaptation of Great Barrier Reef fisheries and assess current and potential impacts on preparedness for ongoing changes.

To develop a model for scenario development for fisheries futures to inform decision-making

BBN Structure




GREAT BARRIER REEF
MARINE PARK
PAPUA
NEW
GUINEA
Port Moresby
145°E
150°E
10°S
15°S
20°S
25°S
Thursday
Island
Bamaga
Lockhart
River
CORAL SEA
Cooktown
Port Douglas
Cairns
Innisfail
Mission Beach
Ingham
Townsville
Ayr
Bowen
Proserpine
Mackay
QUEENSLAND
Tropic of Capricorn (23°26'30"S)
Yeppoon
Rockhampton
Gladstone
Bundaberg
Hervey Bay
Nambour
BRISBANE
N
0 100 200 300
Kilometres
Map Datum: GDA94
Map No. SDC 030403a April 2004

Fisheries in the Great Barrier Reef Region

- Trawl (otter, beam)
- Line (Coral Reef Fin Fish, Spanish Mackerel, line component of East Coast Inshore Fin Fish)
- Net (East Coast Inshore Fin Fish)
- Pot (Mud, Blue Swimmer and Spanner Crabs)
- Diver-based (aquarium fish, coral, sea cucumber)

Typologies based on licence and harvest data for the GBR commercial fisheries showing the number of fishing businesses in each group ("size")

Label	Size	Name	Description
A	88	Roaming trawlers	Larger boats and high GVP, fishing many regions – mainly trawlers
B	123	Homing trawlers	Like A but smaller boats and GVP, preferring the south
C	63	Big reef-liners	High GVP, quota holdings and landings and large number of dories – mainly line fishers
D	120	Small reef-liners	Like C but with smaller boats, and smaller GVP, quota holdings and landings
E	92	Roaming specialists	Medium boats fishing many regions but focussing mainly on a single method – a diverse group covering all methods
F	86	Homing specialists	Like E but also staying in a single region and little quota holdings – all methods except line and pot
G	109	Homing quota generalists	Very diverse methods yielding moderate quota landings while staying in a single region – a diverse group tending to pot and net
H	90	Homing non-quota generalists	Like G but focussing on non-quota species only – almost exclusively potters and netters
J	36	Roaming generalists	Uniquely diverse in methods and regions and tending to hold a large number of licences – like E, a diverse group covering all methods
K	145	Non-quota specialists	Single method landing non-quota species – almost exclusively pot, net and harvest fisheries including all worm licences
L	83	Sleepers	Inactive businesses

Heat map of the quota data after grouping the businesses. Rows denote quota species, columns denote business typologies. Colour (red – low, yellow – high) represents quota amount.

Unpublished data removed

Challenges

Basecase: 2016 Future: change to 2035

Ecological

Higher sea surface temperatures

Ocean acidification (OA)

Sea level rise

Changed rainfall patterns and associated run-off (RP)

Increased tropical storm intensity and flooding

Altered ocean circulation

Macro Economic

Energy price increase

Governance actions

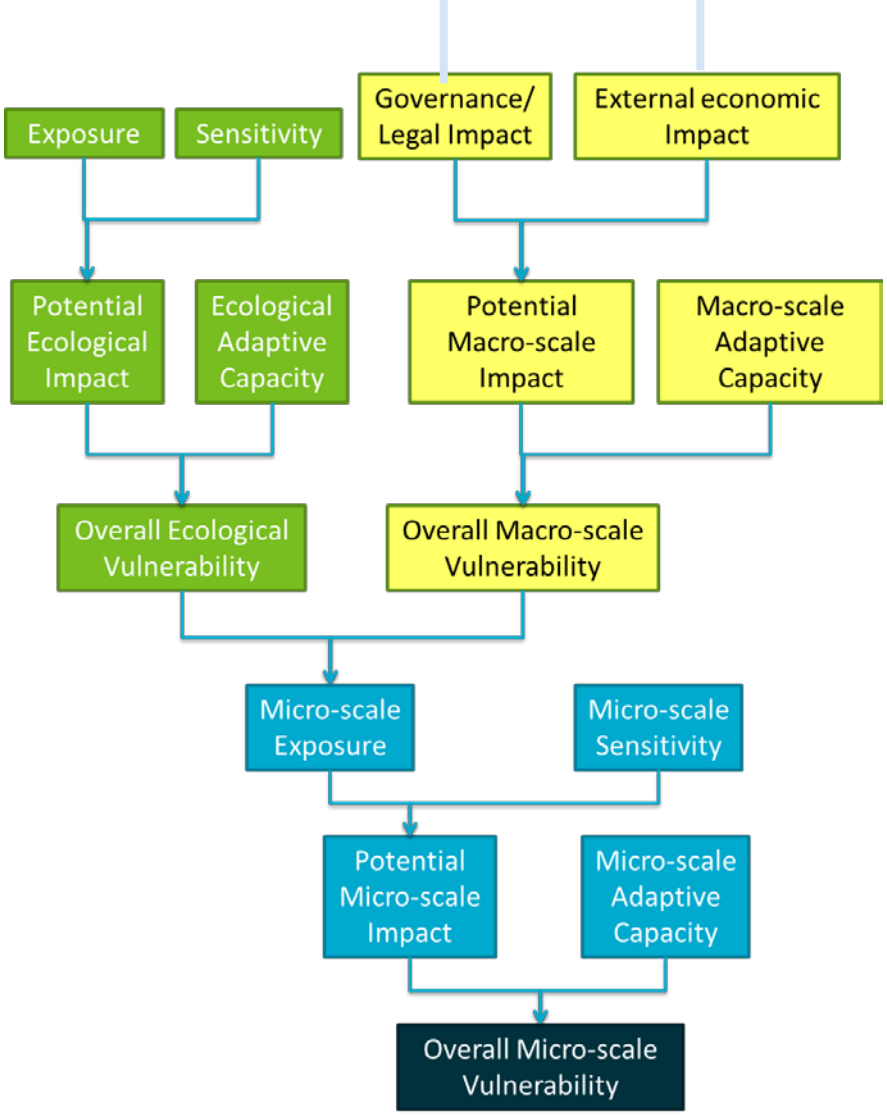
Absence of a clear overarching policy…('exposure to poor management')

Unpublished data removed

A – Roaming Trawlers
B – Homing Trawlers
C – Big Reef-Liners
D – Small Reef-Liners
F – Homing Specialists
G – Homing Quota Generalists
H – Homing Non-Quota Generalists

Tool to Explore

- Where can regulators have the greatest positive impact?
- What can fisheries do to increase their resilience?
- What are the biggest drivers of vulnerability?



Thank You

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IPCC Special Reports: calls opening

Climate Change and Oceans and Atmosphere
http://www.ipcc.ch/report/srocc/
Call for Author nominations open 10 April 2017

Impacts of warming of 1.5C above preindustrial and related global greenhouse gas emission pathways
http://www.ipcc.ch/report/sr15/
Call for Author nominations open 31 October 2016

Climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems
http://www.ipcc.ch/report/sr2/
Call for scoping nominations open
Call for Author nominations open 10 April 2017

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