Professor Gretta Pecl

Climate-driven species re-distribution in marine coastal systems

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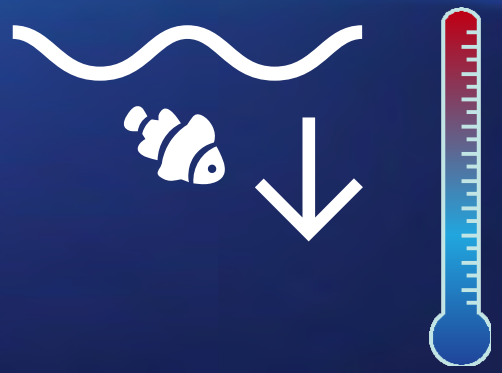
Climate-driven global re-distribution of species

Poleward movement
17km dec^{-1} on land
72 km dec^{-1} in ocean

(Poloczanska et al. 2013)

Higher elevations

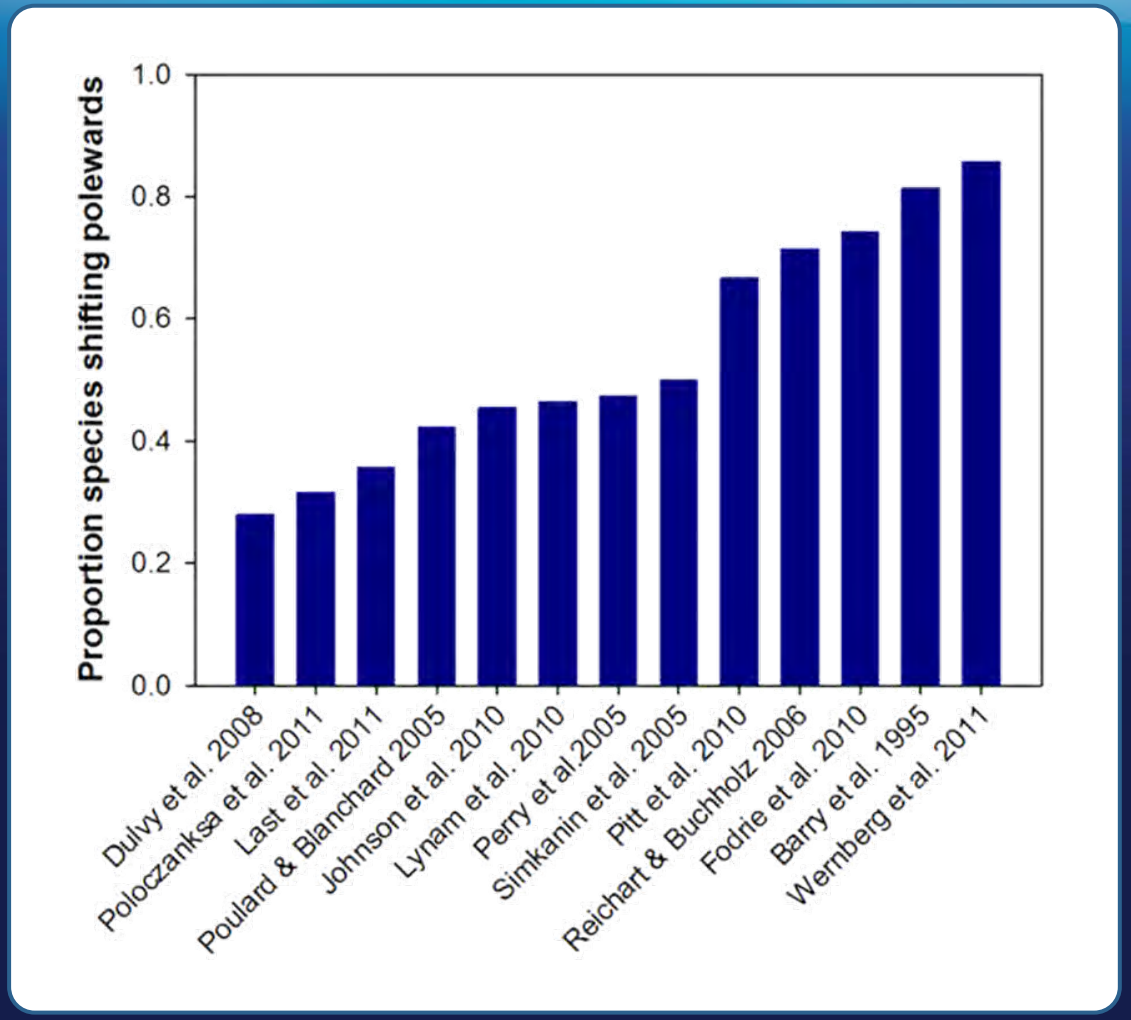


Deeper in ocean

(Dulvy et al. 2008)

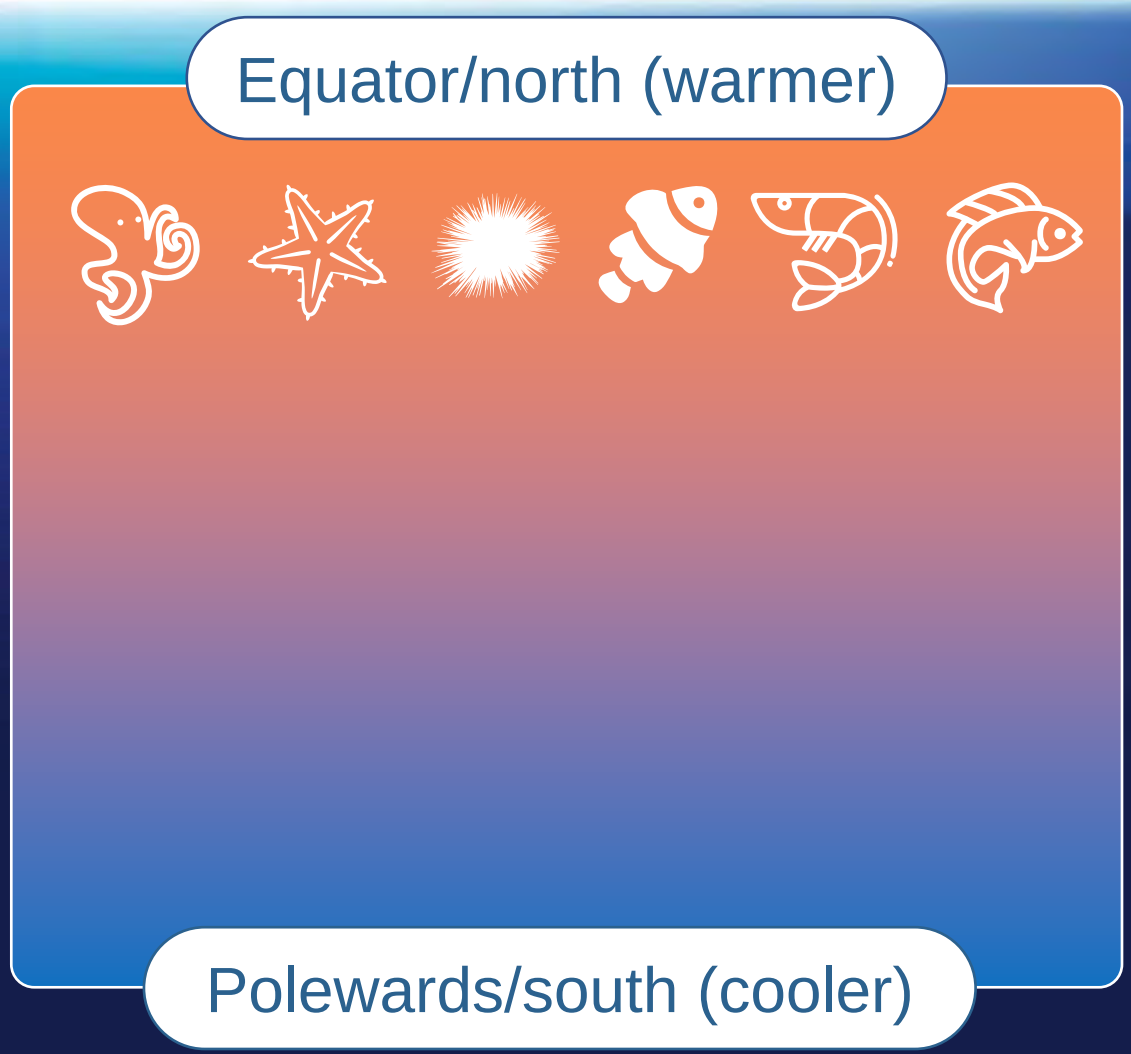
Shifts greatest where climate has warmed the most

Between 25-85% of species are already shifting

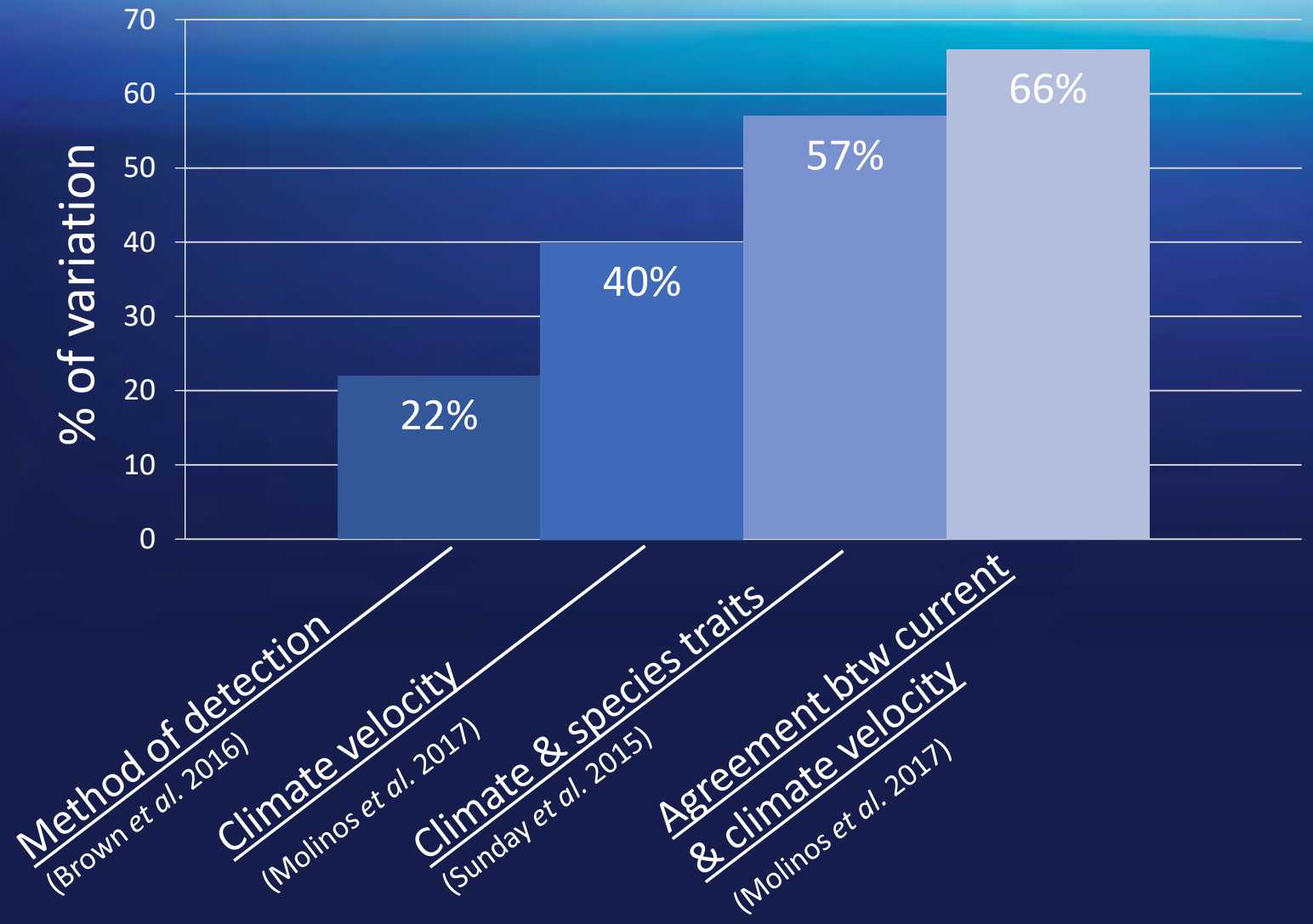


Variation in timing & pace of species shifts

- Confounding factors, influences other than climate
- Detectability
- Not all species can/will shift – adapt, move or die
- Species shift at different rates



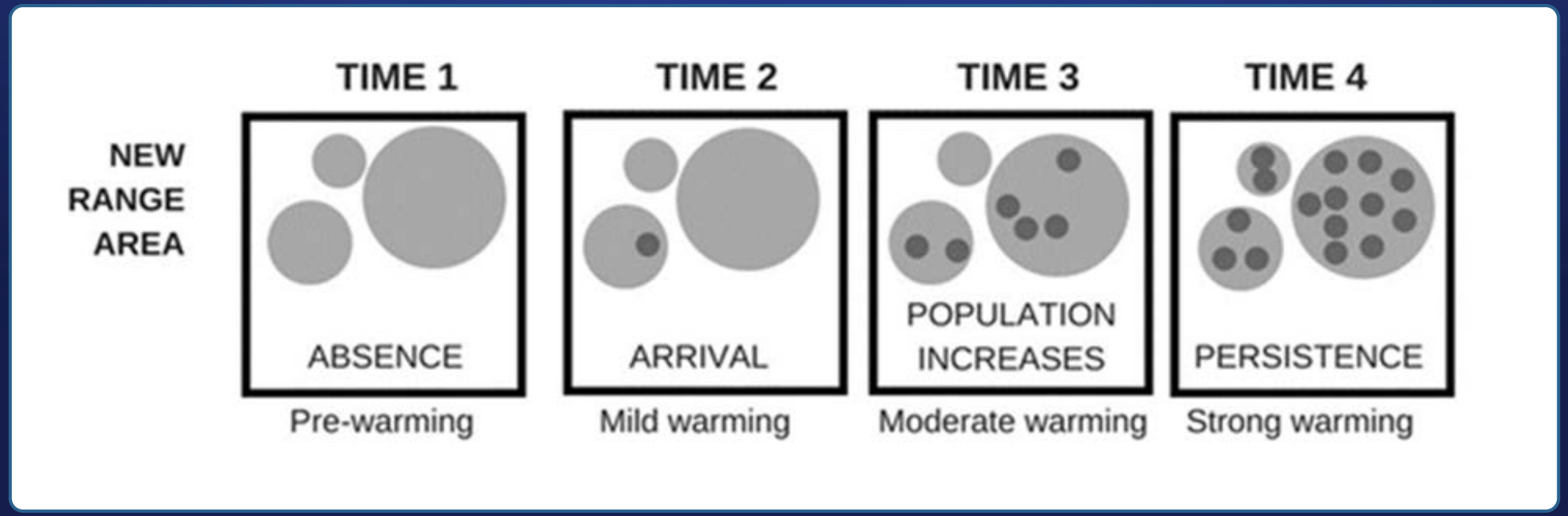
Variation in rate and magnitude of shifts



- Ecological interactions
- Habitat availability
- Stage of shift being measured?

Variation in rate and magnitude of shifts

Measuring different stages of range extension?
(Bates, Pecl *et al.* 2014)



Currently very species focussed

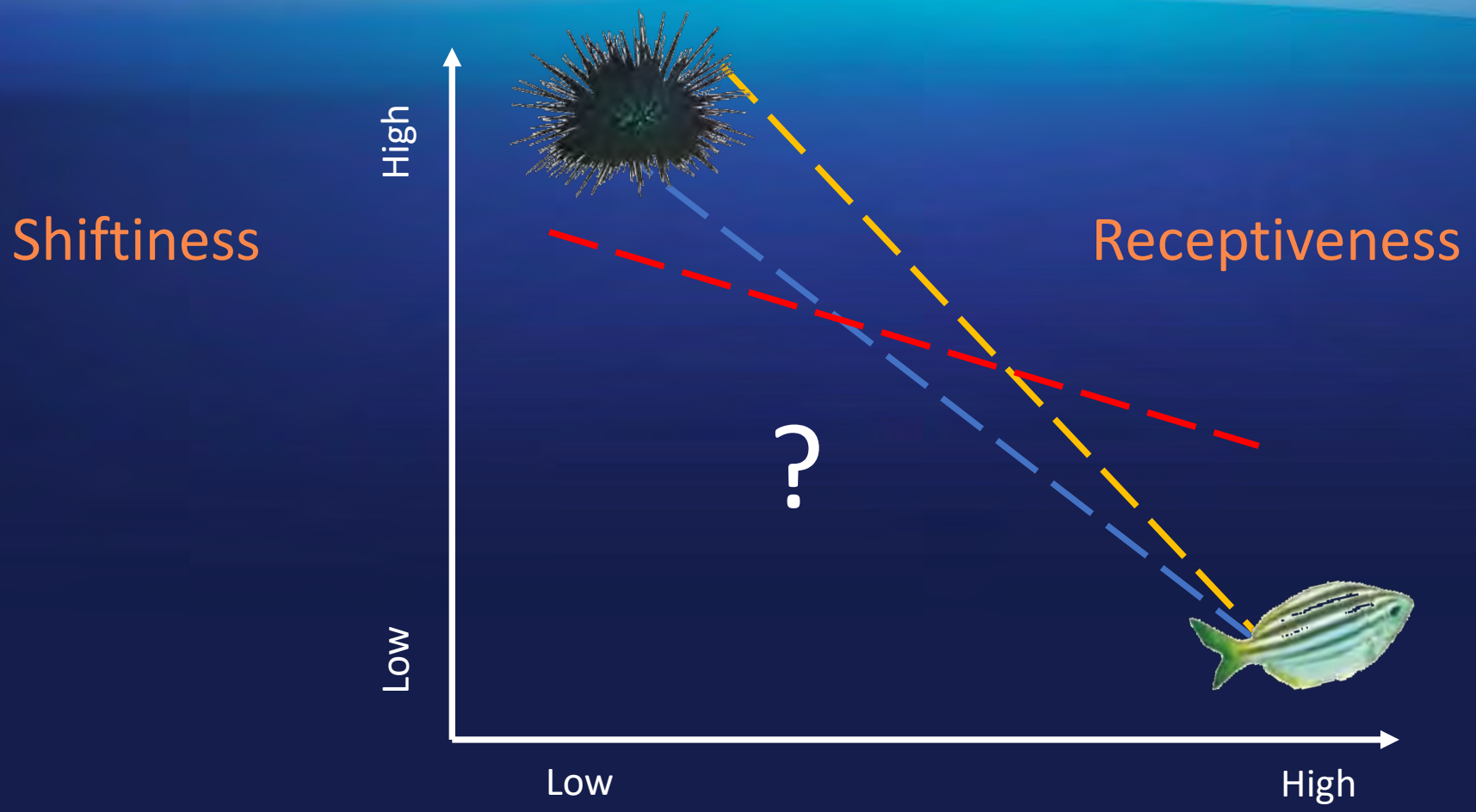
"Shiftiness" of species

- Local climate velocity
- Life history traits
- Physiological responses
- Direct interactions

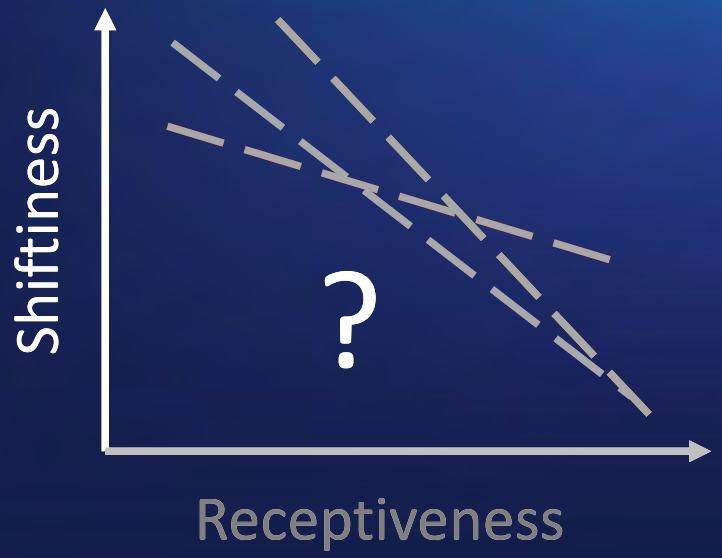
"Receptiveness"
of receiving community?

- Dependent on resident ecological network
- Opportunity niche in trait space?
- Network instability?
- Emerging properties of system?

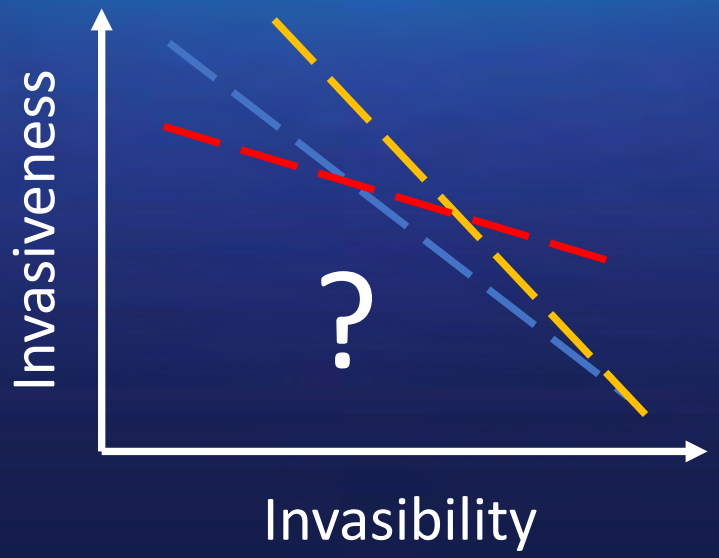
Range shift = ‘shiftiness’ + ‘receptiveness’



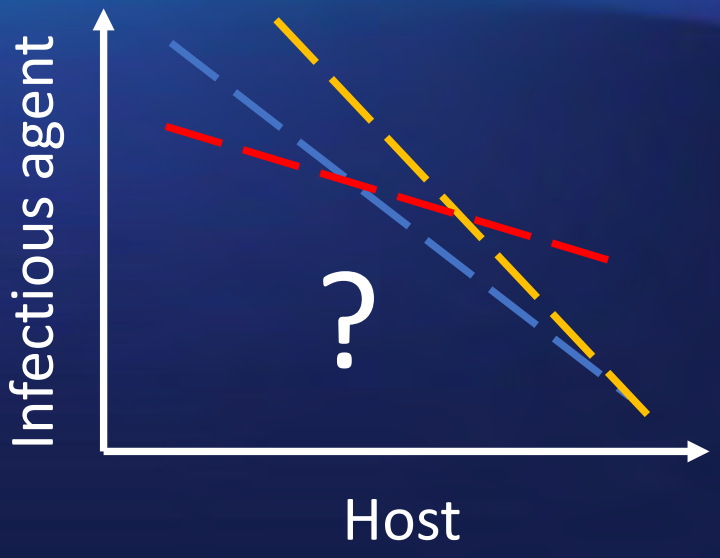
Parallels with other processes & research fields



Range shift



Invasion

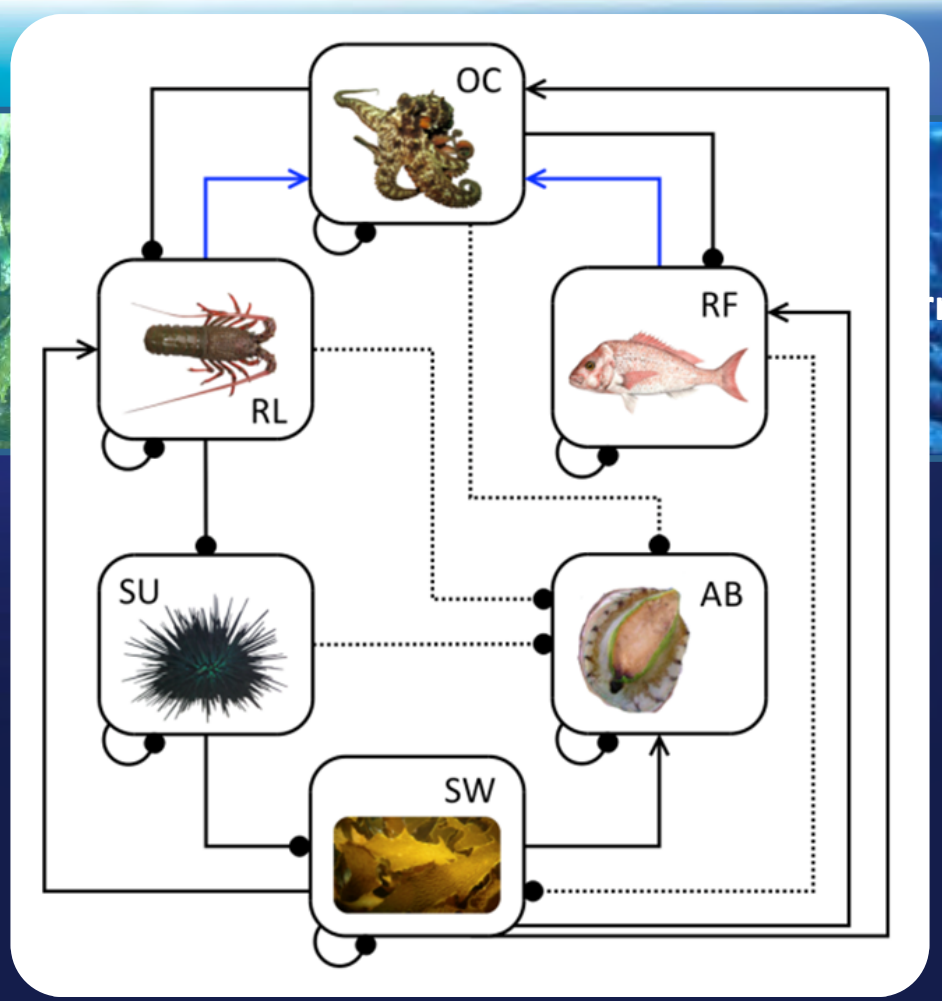


Disease

Ecological consequences of ‘shifters’

- Impacts *can* be equivalent to invasive species (Ling 2008)
- Current focus on individual species rather than collective impacts of multiple shifters (Bonebrake et al Pecl 2017)

25-85% species shifting….



(Marzloff, van Putten, Pecl et al 2016)

Why do these shifts in distribution matter?

Ecosystem structure & function

Food security

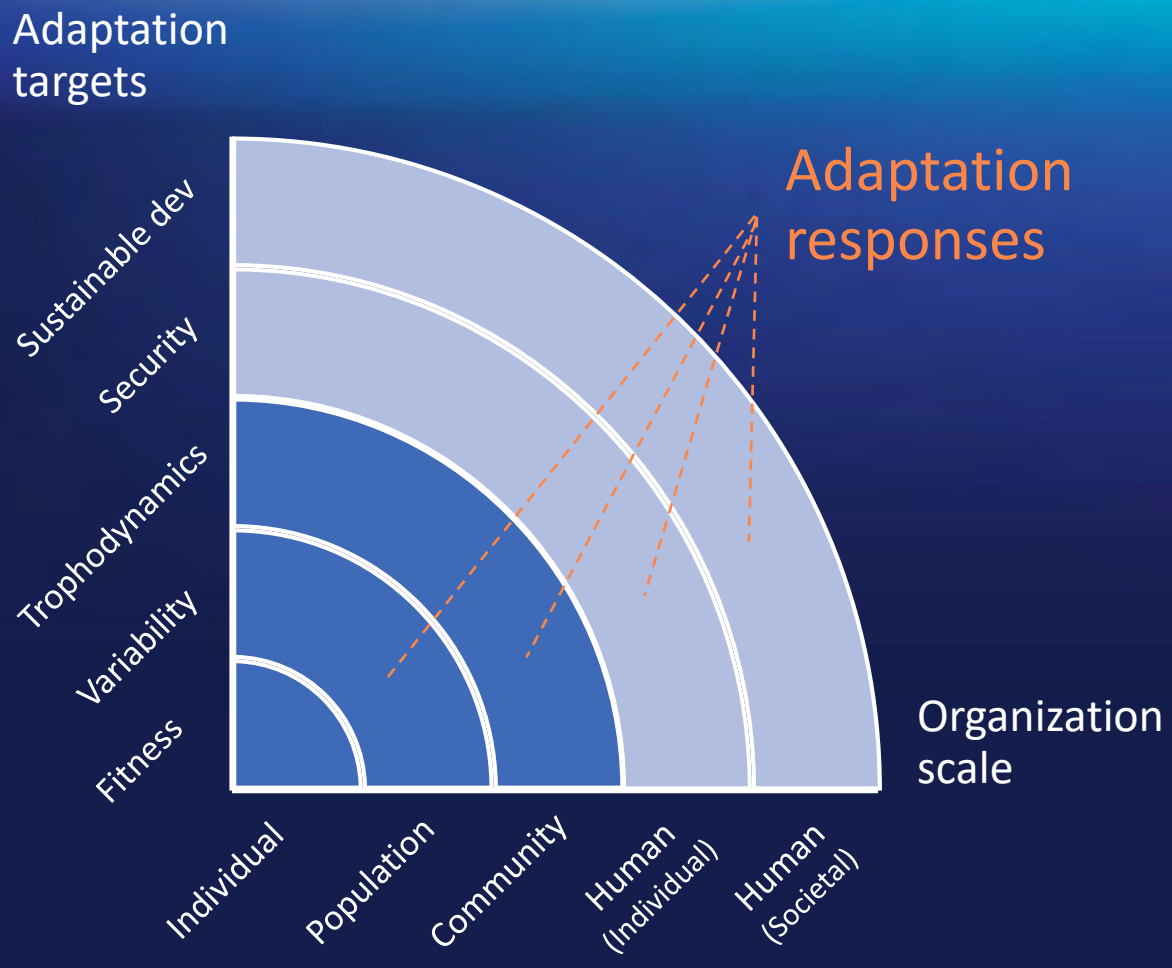
Human health

Livelihoods

Feedbacks to the climate system

Culture

Adaptation & ‘Species on the Move’?

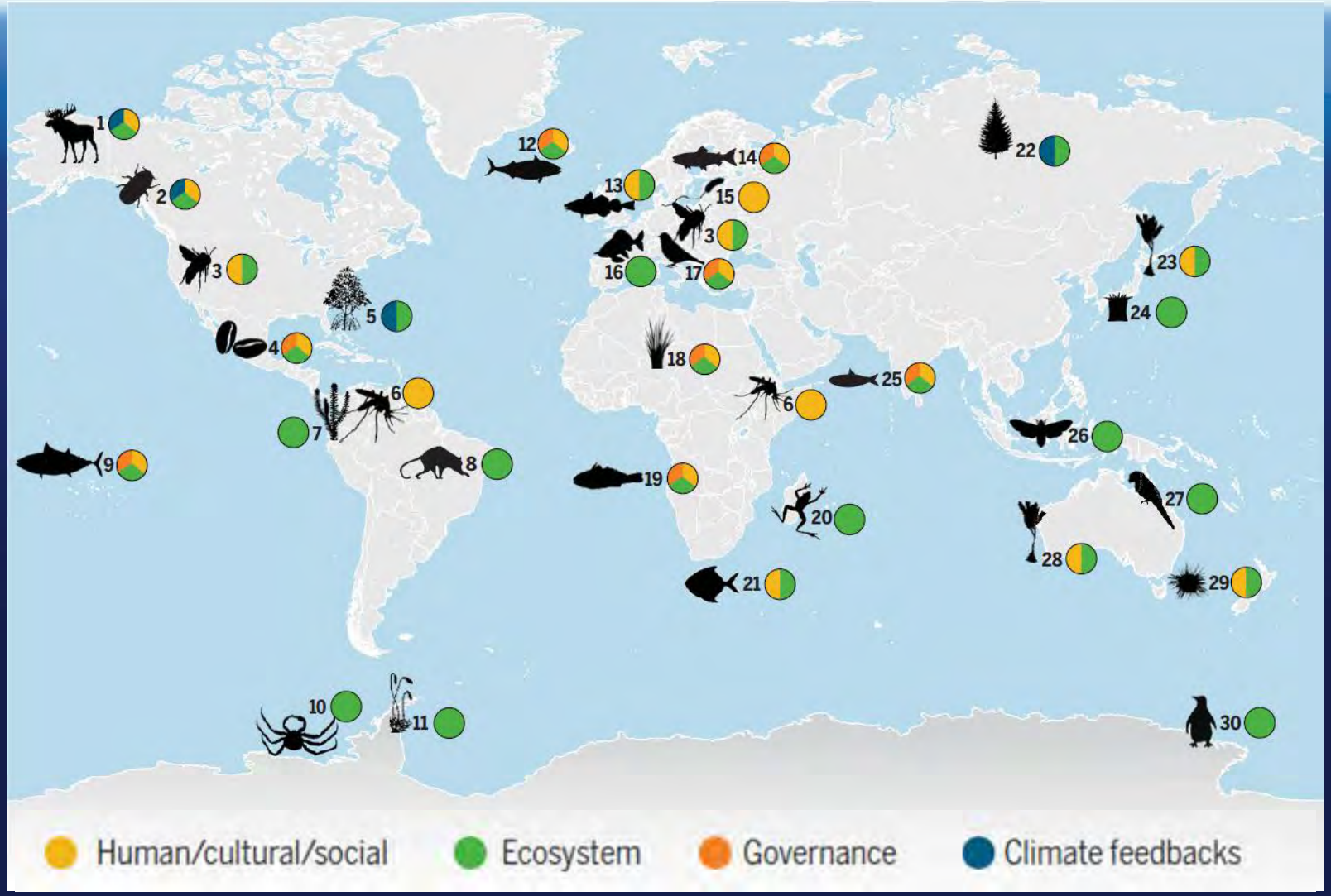


(re-drawn from Miller *et al.,* 2017)

- ★ Global
- Country/Federal Government
- High Seas (Sumby, Pecl – poster!)
- Regional fisheries
- ★ Local community
- Conservation approaches (Bonebrake *et al.,* Pecl 2017)

Global biodiversity redistribution:

Impacts on ecosystems, human well-being, governance and climate feedbacks



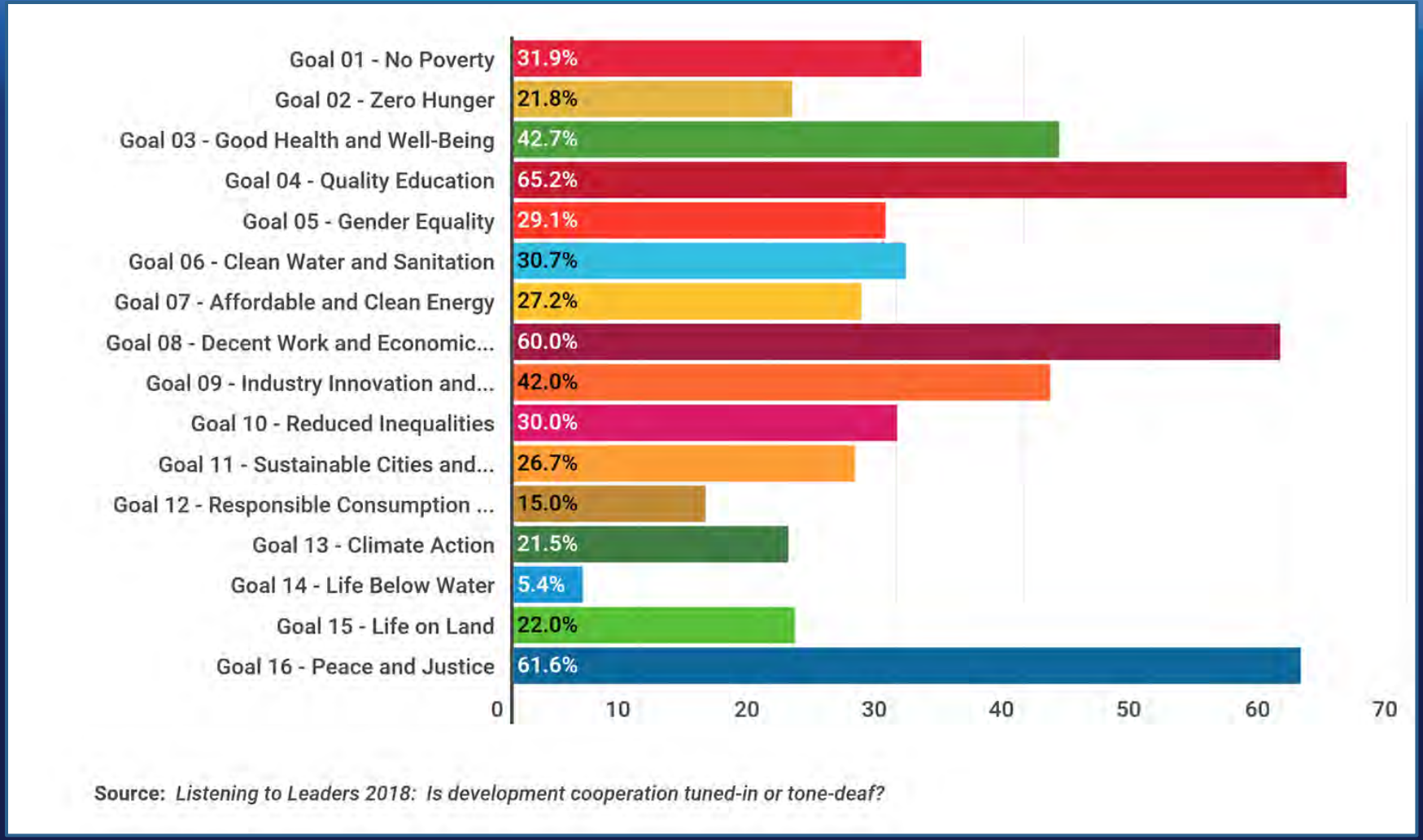
Pecl et al Science 2017

- Access to natural resources change
- Change in distribution of pathogens, parasites
- Wetlands, coastal areas particularly important for vulnerable people in rural areas

- Skipjack tuna (9)
- Atlantic salmon (14)
- Tropical fish (21)
- Oil sardine (25)

‘Species on the move’ interact with almost EVERY SDG
but not explicitly considered in any SDG

3,500 leaders - SDG14 is the least important goal



Source: *Listening to Leaders 2018: Is development cooperation tuned-in or tone-deaf?*

Local level –climate change & adaptation in Tasmania

- High rate (29.3%) recreational fishing
- Highest value of seafood nationally
- Seafood 1/3 value of agricultural production
- Diverse communities of temperate marine life
- Warming almost 4x global average (Hobday & Pecl 2014)

Local changes associated with temperature increase

Poleward expansion of sea urchins - loss of kelp forests
(Ling et al., 2009)

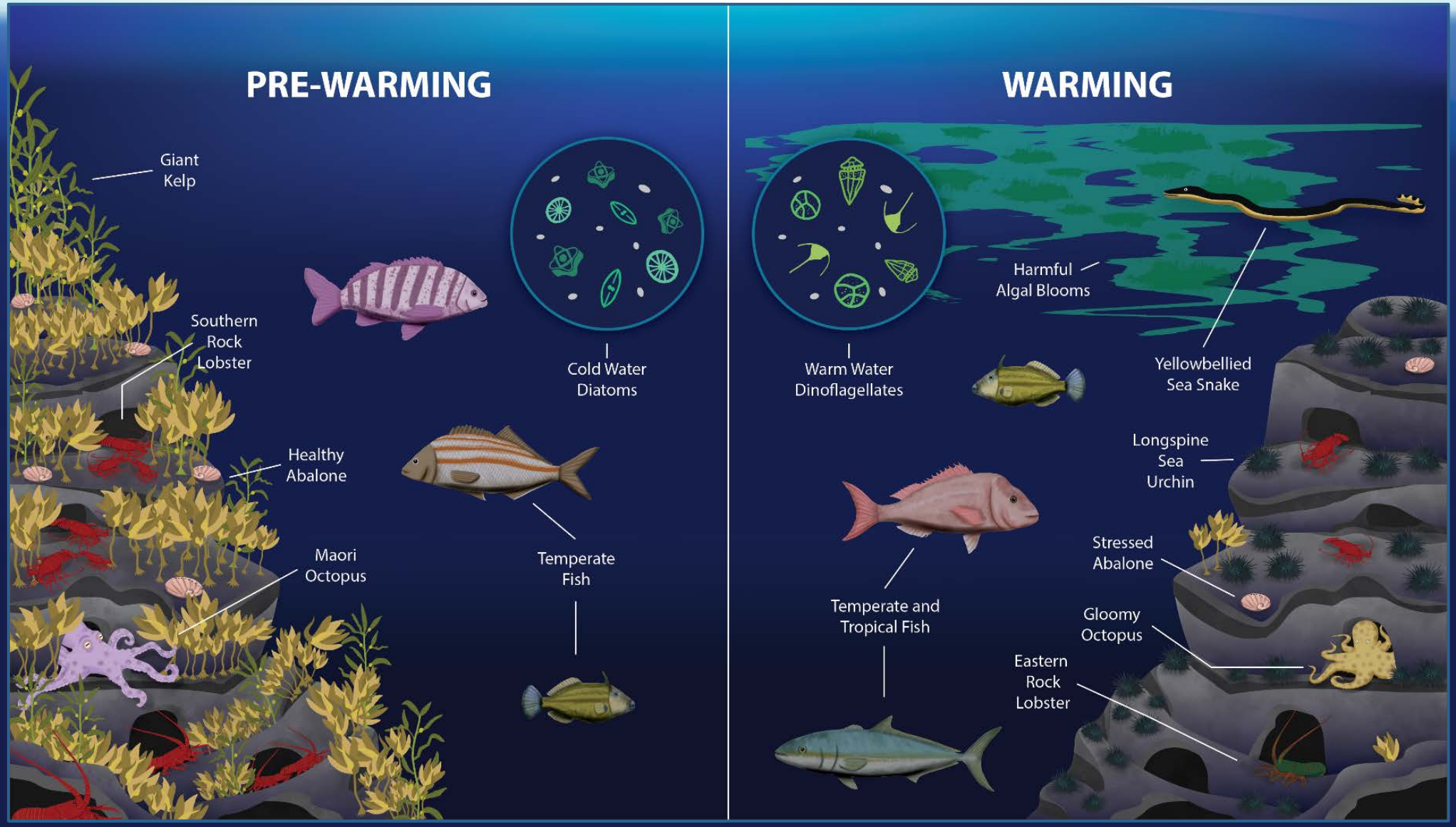
'New' octopus species (Ramos et al., 2014a & b, 2018)

50% intertidal species moved poleward over last 50 years
(Pitt et al., 2010)

Dozens fish species - major distributional changes (Last et al., 2011, Sunday et al., 2015, Robinson et al., 2015 - www.redmap.org.au)

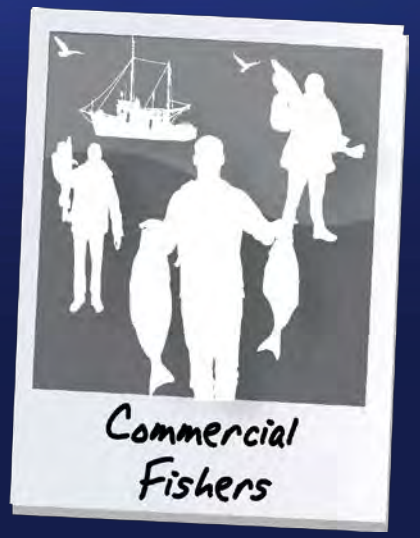
85% of seaweeds found further poleward on east coast from 1940
(Wernberg et al., 2011)

Significant changes linked to warming on the east coast of Tasmania Pecl et al in review



What has been the response to these changes?

- Limited Government *action* on fisheries globally (Miller *et al.,* 2017)
- Started collating the autonomous adaptation actions of marine sectors (Pecl *et al.,* in review)



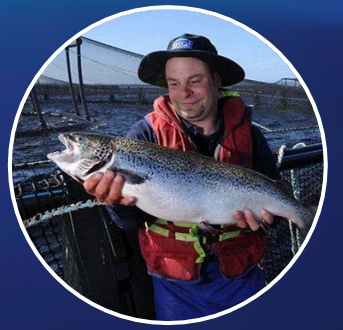
And charter operators, salmonid aquaculture & shellfish aquaculture

Many ‘autonomous’ or ‘bottom-up’ adaptation actions

Charter operators advertising trips for ‘new’ species

Changes to product handling & landing practices

Changing farming practices



Using seasonal forecasting for farm management

Individuals, organisations and communities may adjust their behaviour more readily?

Pecl et al in review

Characterising adaptations

Typology adapted from Biagini *et al.*, 2014

Capacity building

Management and planning

Practice change

Public policy

Information

Physical infrastructure

Warning or observing systems

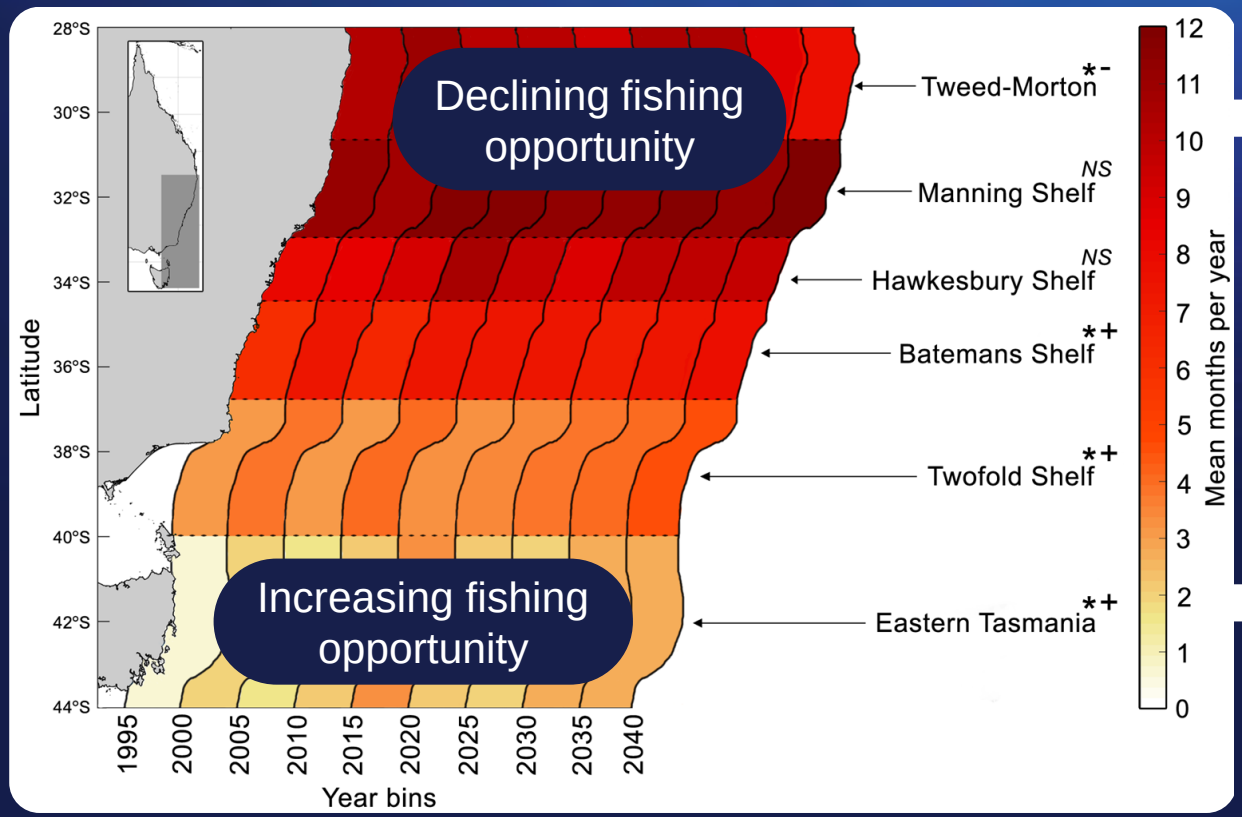
Green infrastructure

Technology

Half the autonomous adaptations were potentially countervailing to planned government-led adaptations

Research to assist stakeholder planning to temporal changes in species redistributions

Habitat suitability modelling under near-future climate conditions to inform adaptation



1996 = 11 months suitable per year
2018 = 10 months suitable per year
2040 = 9 months suitable per year

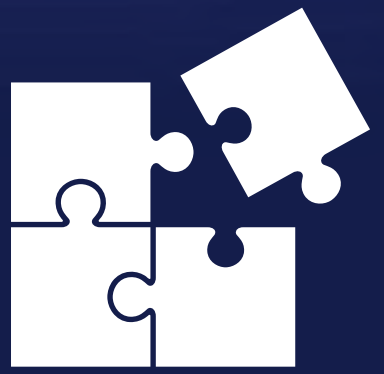
1996 = 1 month suitable per year
2018 = 2.5 months suitable per year
2040 = 3.5 months suitable per year

*denotes significant regional shifts

In press: Curtis Champion, Hobday, Pecl *et al*. 2018 *Mar Freshw Res*

Adaptation to climate change is complicated & messy

- Limited gov level planned adaptation action
- Low awareness of non-gov adaptations
- Multi-sector, multi-stakeholder, competing values & interests
- Winners and losers, trade-offs, value-based decisions….. who makes the decisions?
- Interdisciplinary, participatory & integrated approaches essential



Some implications of climate-driven biodiversity changes cannot be adapted to

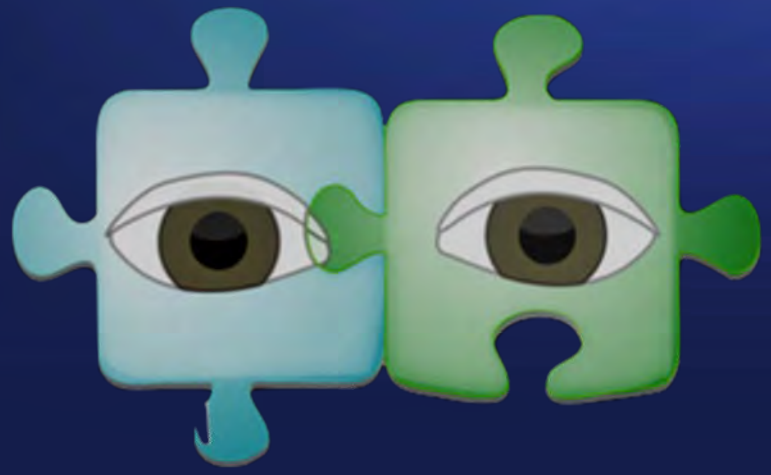
"When kelp and weed beds are dying and the rainbow kelp shells are depleted in rapid numbers, then women feel the cultural loss of governance and connections to sea country"

(tebrakunna country and Lee 2017).

In Pecl et al (in review) & used with permission from Dr Emma Lee, trawlwulwuy woman of tebrakunna country and Research Fellow at CMS UTAS

Adapting to global species redistribution requires ‘all hands on deck’

Catalyst for respect, collaboration, exchange & integration of Indigenous, Industry, Community-based and formal/academic science



‘Two-Eyed Seeing’ (Mi'kmaw Elder Albert Marshall, 2004)

‘Species on the move’ – visual – opportunity for engagement, communication & collaboration on climate change

eg citizen science project www.redmap.org.au

An invitation

More today on range shifting species, Session 10, Columbia (9 & 10)

Please join us for the second interdisciplinary international *Species on the Move* conference in July 2019 at Kruger National Park in South Africa

www.speciesonthemove.com

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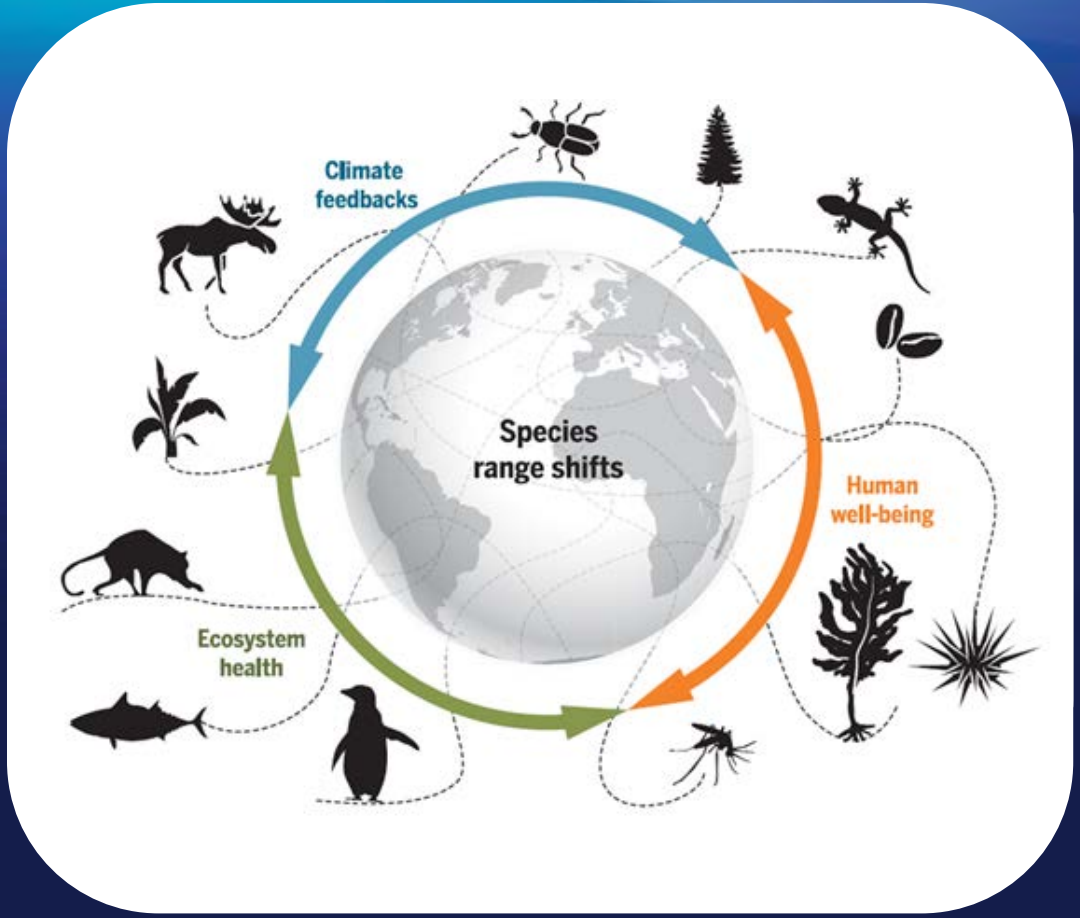
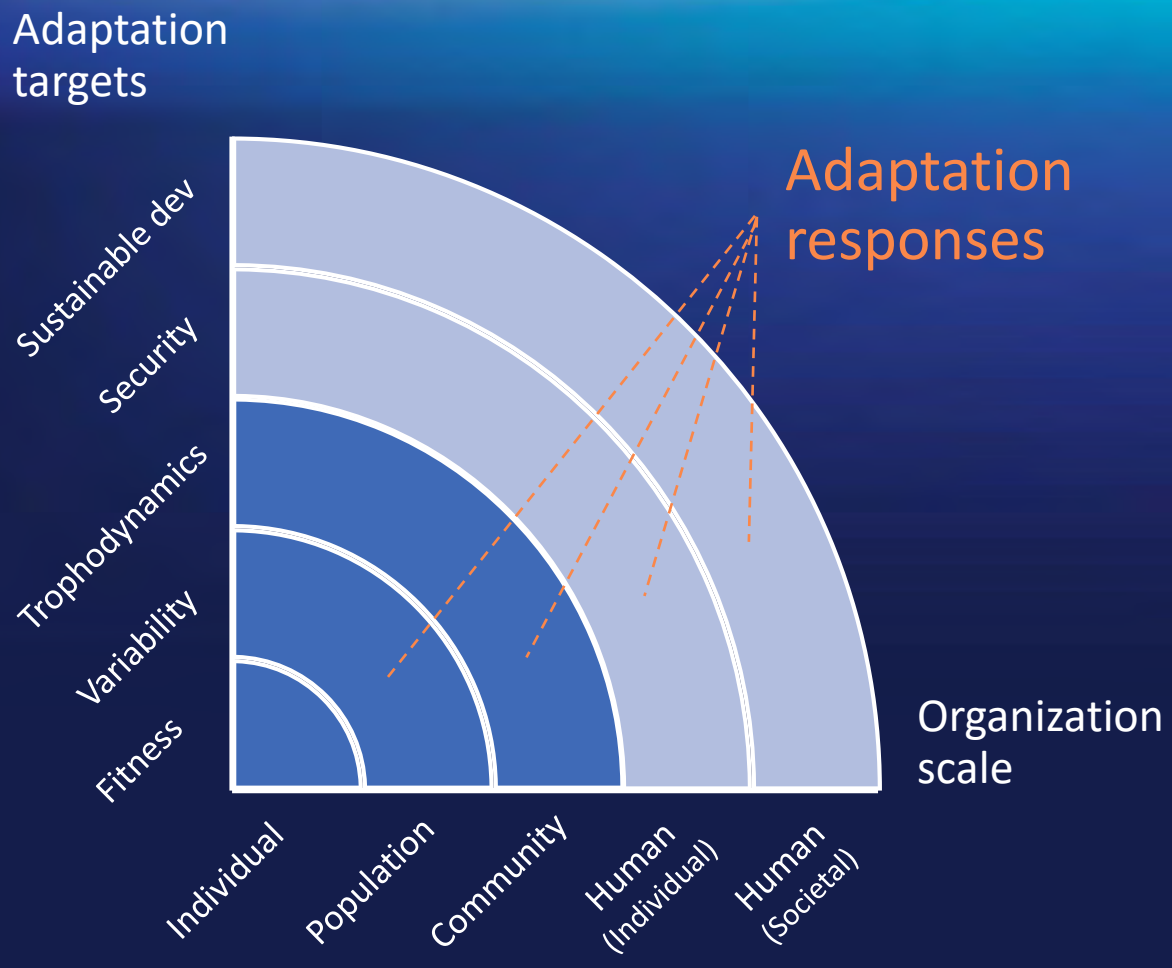
Major challenges & major opportunities

- Fascinating & unprecedented learning opportunity for ecology & evolution
- We can learn more from marine species than terrestrial



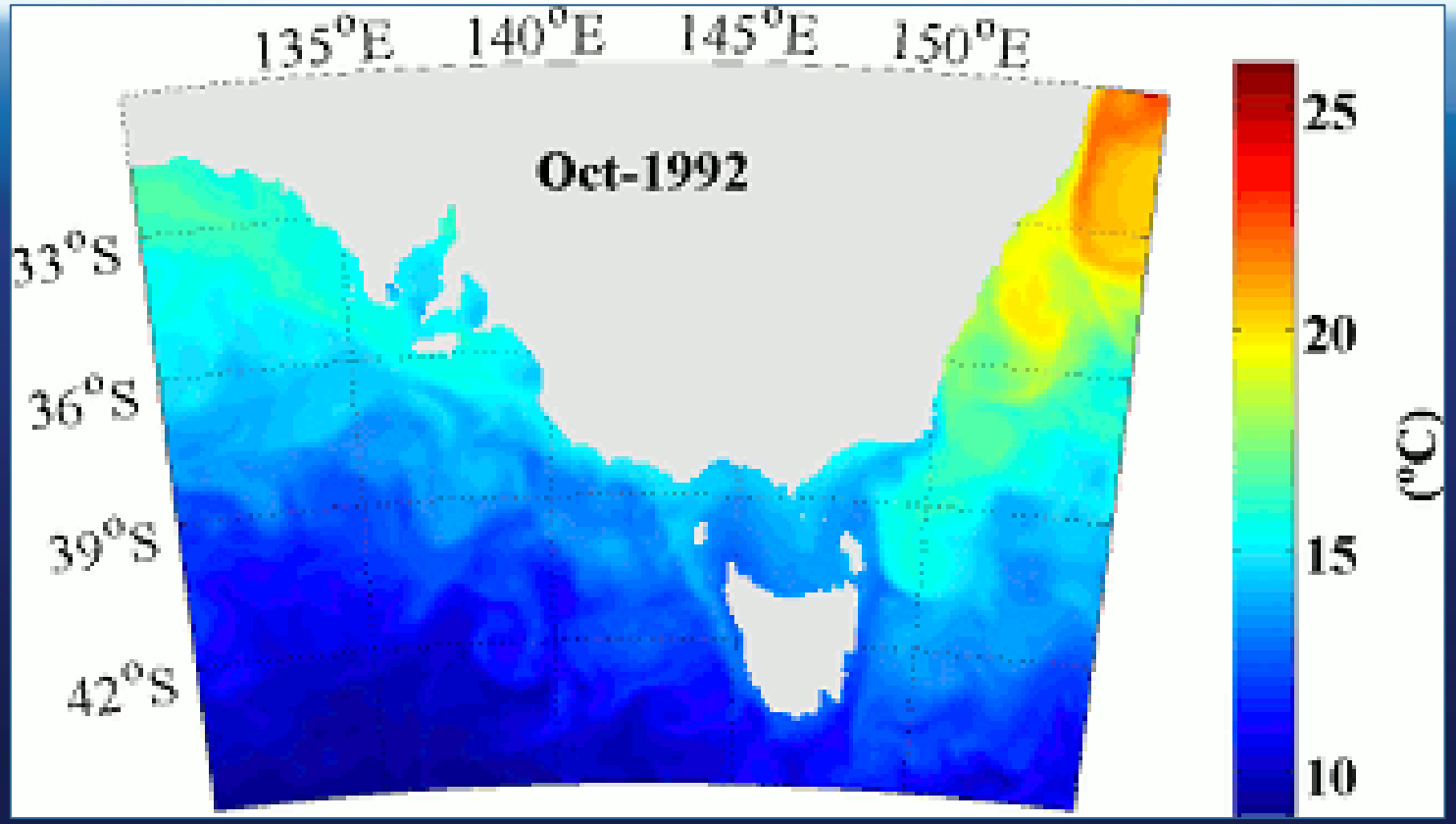
What are we doing about ‘Species on the Move’?



(re-drawn from Miller *et al.,* 2017)

- ★ Global Strategies (Pecl *et al.,* 2017)
- ★ Country/Federal Gov level (Pecl *et al.,* in prep)
- High Seas (Sumby, Pecl –poster!)
- Regional fisheries adaptation (Pecl et al 2014)
- ★ Human local community level adaptation (Pecl *et al.,* in review)
- Conservation approaches (Bonebrake *et al.,* Pecl 2017)

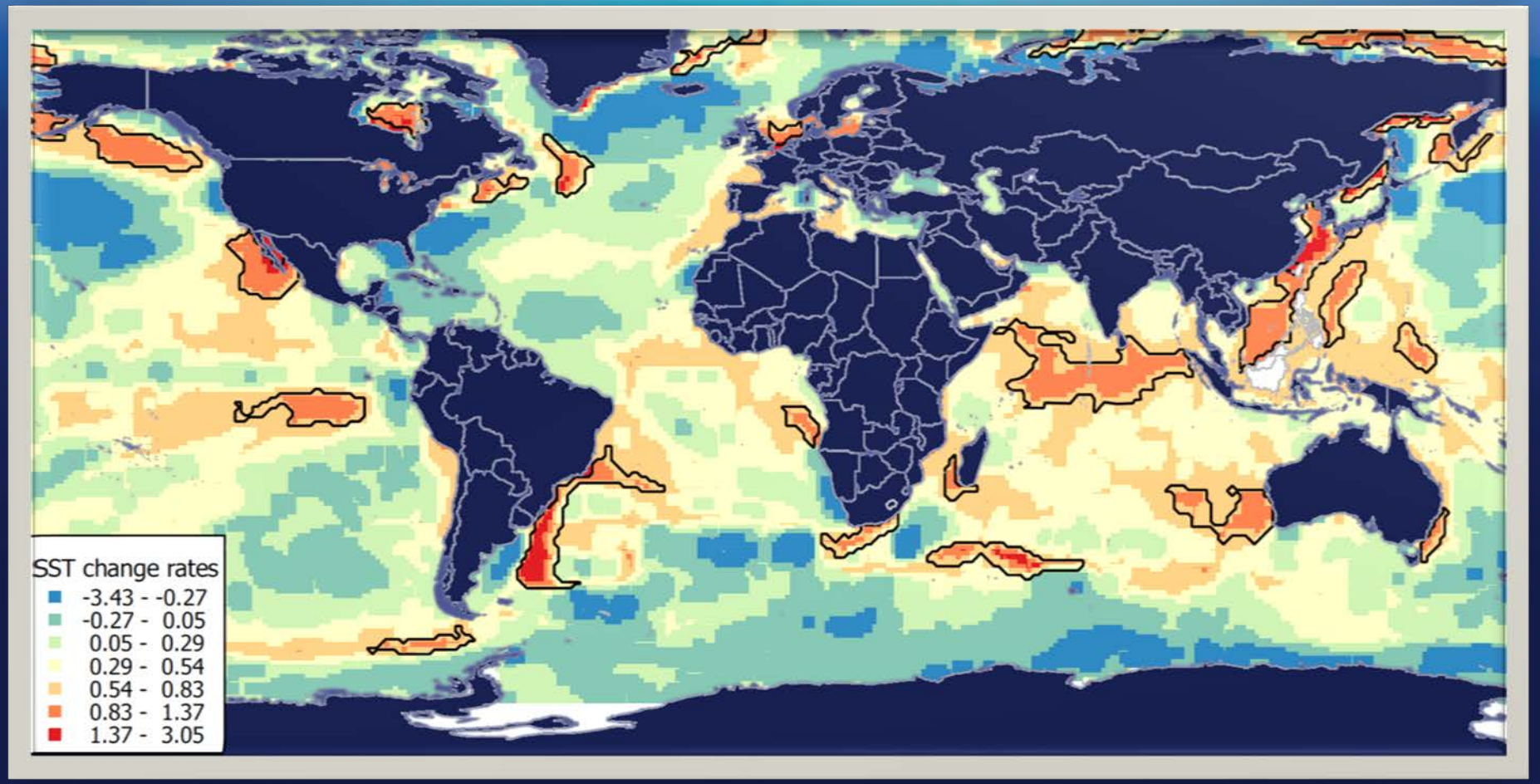
Warming almost 4 x global average



One of the fastest warming regions globally and will likely remain so in the future

Animation courtesy of CSIRO

Government level adaptation planning: in countries with fastest-warming seas



Areas of rapid ocean warming (top 10% change in SST, Hobday & Pecl 2014)

Government level adaptation planning in countries with fastest-warming seas

HIGH

Degree of planning

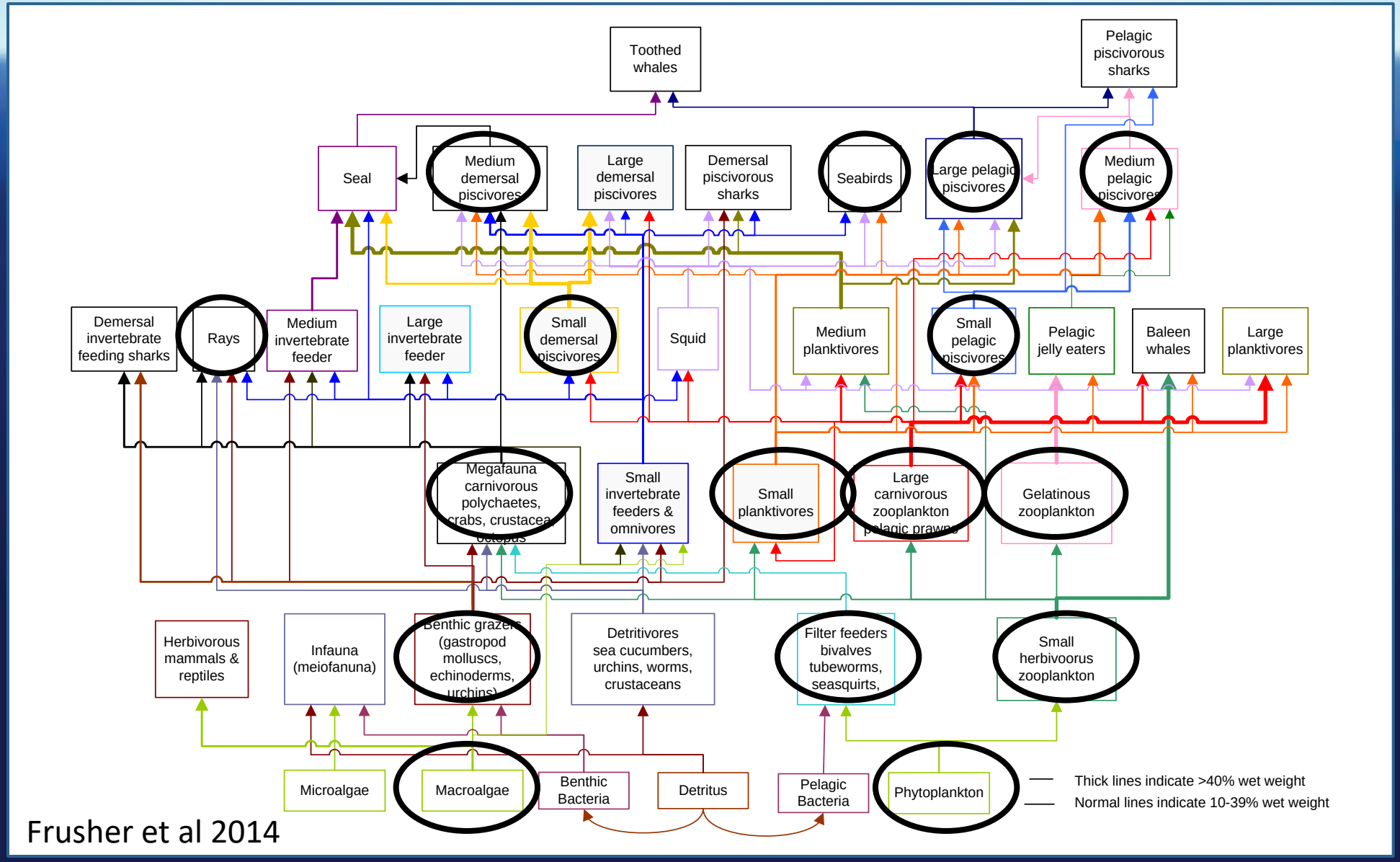
- Specific sectoral plan for marine biodiversity/fisheries
  Actions: Recommended – Planned –Undertaken
- ‘National adaptation plan’ for all sectors combined
  - Mentioned fisheries/marine biodiversity
  - Some detail of specific marine/fisheries actions
- Brief/cursory mention of adaptation for fisheries/marine biodiversity

LOW

- No mention of adaptation for fisheries/marine biodiversity

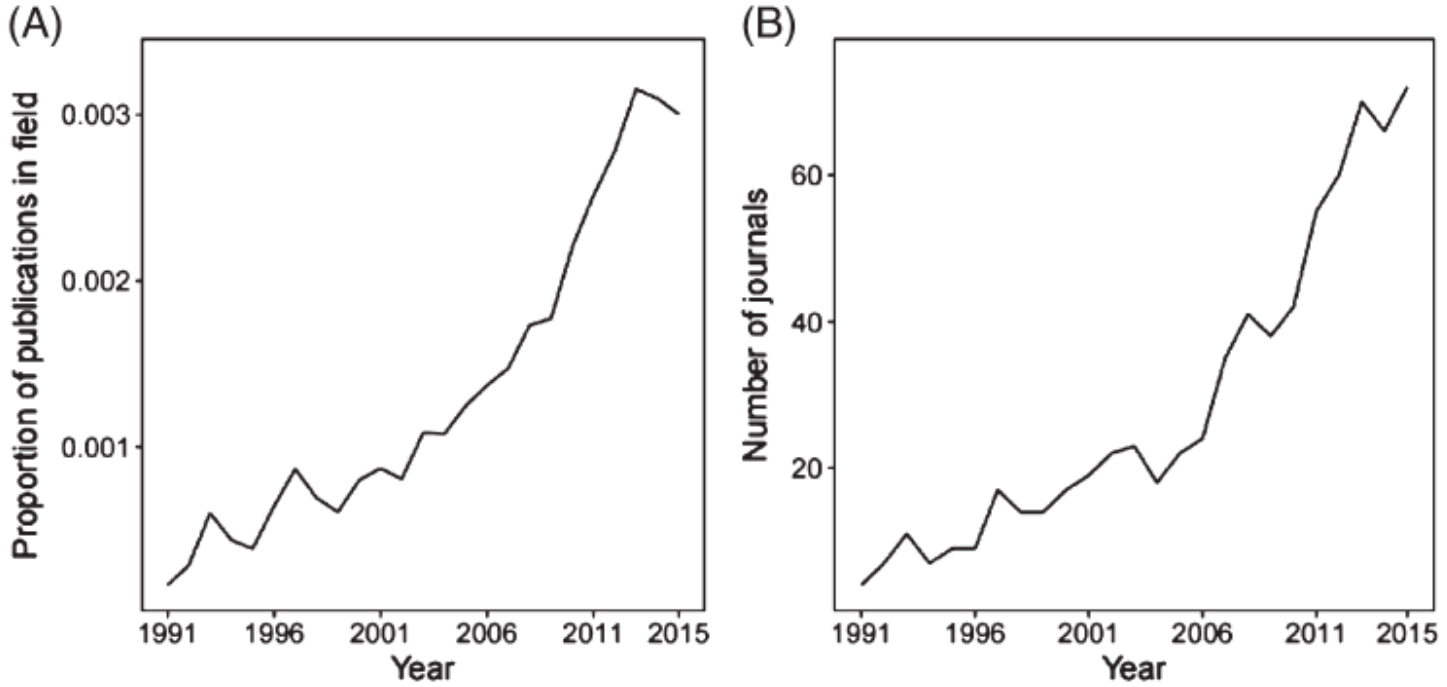
42 countries
Pecl et al in prep

Climate change impacts through-out food web



Frusher et al 2014

Rapidly growing research field……



Bonebrake et al & Pecl 2017, Biological Reviews

- Fascinating & unprecedented learning opportunity for ecology & evolution
- Need to understand (explanatory ecology) & predict (anticipatory ecology)

Climate change will bring opportunities as well as negative implications

- Some increases in abundance & changes in distribution will be favourable

- HOWEVER, even opportunities may require management and/or planning to ensure maximising these

Citizen science observation sent in to www.redmap.org.au