

# The Long Hot Summer: Getting Ahead of the Heatwave



IMAS & CMS special online webinar series

9:10am -10am every morning Mon 11<sup>th</sup> – Fri 15<sup>th</sup> December 2023

**Fisheries research to support  
preparedness for climate change**



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# MARINE HEATWAVES

MHW are extended periods of regional ocean warming. They have major impacts on marine life and human society.

## EXTREME WEATHER

Warm waters increase tropical storms and hurricanes



## INCREASED OCEAN STRESSORS

- Stratification
- Acidification
- Deoxygenation



## BIODIVERSITY & HABITAT LOSS

- Habitat compression
- Food web disruption
- Species migration
- Mass mortalities



## ECONOMIC LOSS

Increased mortality of economically important species



**10x** intensity compared to pre-industrial times

**50%** increase in MHWs in the past 10 years

**20-50** more MHWs by 2100



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Institute for Marine and Antarctic Studies

# MARINE HEATWAVES + climate change can have significant impacts on fisheries

Possible changes in: recruitment, catchability, species composition, natural mortality, onset of maturity, growth, post-harvest survival, ecosystem changes, HABs & seafood safety

## Fish Distribution & Behaviour

- migrate to cooler waters or change their behaviour
- can affect fishing patterns = challenging to locate/catch certain species.



## Impacts on Fish Reproduction & Growth

- affect reproductive cycles -> potential decline in spawning success
- might accelerate metabolic rates - affecting growth rates/size

## Shifts in Marine Ecosystems

- disrupt marine ecosystems balance - favour growth of certain species - while impacting others negatively
- can have cascading effects - food web - influencing prey availability for commercially valuable fish species

## Habitat stress - e.g., reefs, seagrass beds

- nurseries & feeding grounds for many species
- degradation can significantly impact fisheries

Economic Impact - reduced fish stocks & changes in availability of commercially important species = economic consequences for fishing industries and communities that rely on seafood for livelihoods & sustenance



## Losers



**Subarctic copepods, krill**  
Lack of food reduced population,  
distribution moved northward

**Market squid 2015-2016**  
Reduced in south as distribution  
moved far north



**Dungeness crab and mussels**  
Fishery closed due to toxicity

**Salmon**  
Warm temperatures decreased  
recruitment for some species



**Groundfish**  
Potential loss of habitat due to hypoxia



**Seabirds, seals, and sea lions**  
Massive die-offs due to lack of food



**Baleen whales**  
Expected to decline due to lack of food



## Winners

**Toxic phytoplankton**  
Massive bloom closed important fisheries



**Tropical, subtropical copepods**  
Northward range expansion with warm water



**Market squid 2014-2015**  
Increased fishery in north caused by range expansion

**Rockfish**  
Increased recruitment in California



**Tuna**  
Increased abundances along coast  
with increased sport fishing

**Orcas**  
Increased birth rate caused by increased  
salmon abundances in some regions  
through population movements



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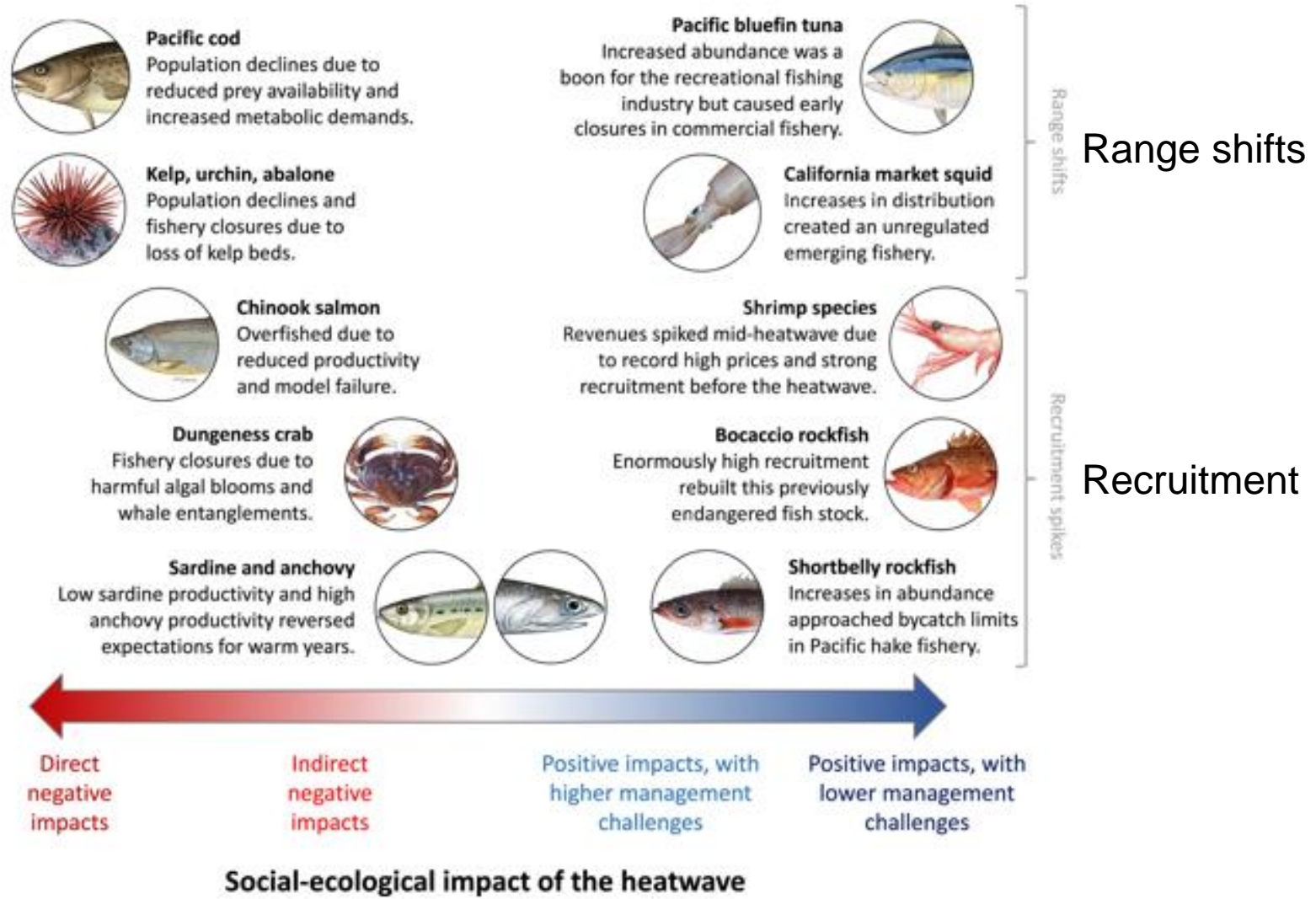


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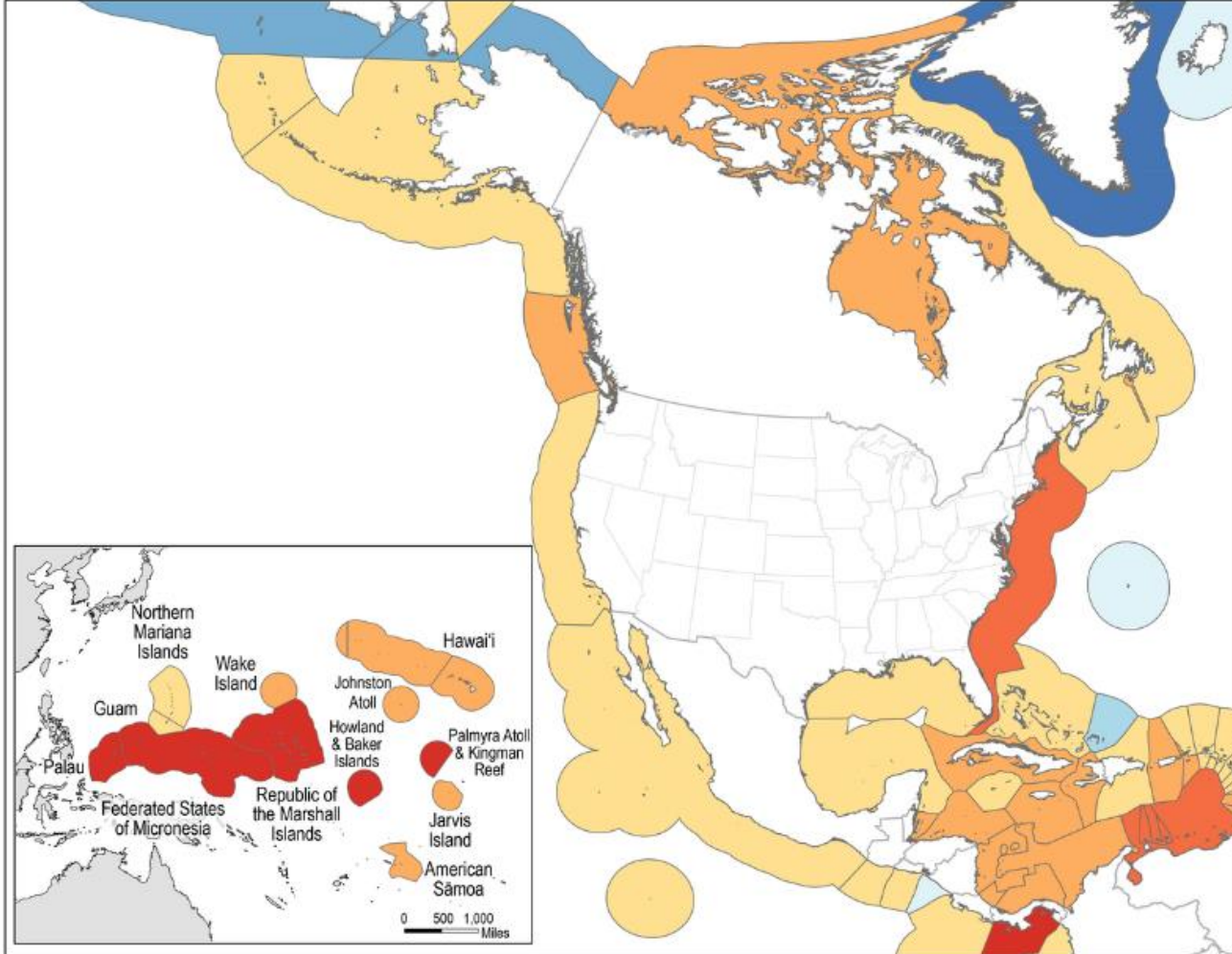


# MARINE HEATWAVE 2014-2016 – US & Canada West Coast fisheries

## Surprises & lessons – key case studies



# Projected changes in Max. Fish Catch Potential (U.S.A.)



Average Change  
in Maximum Catch Potential (%)

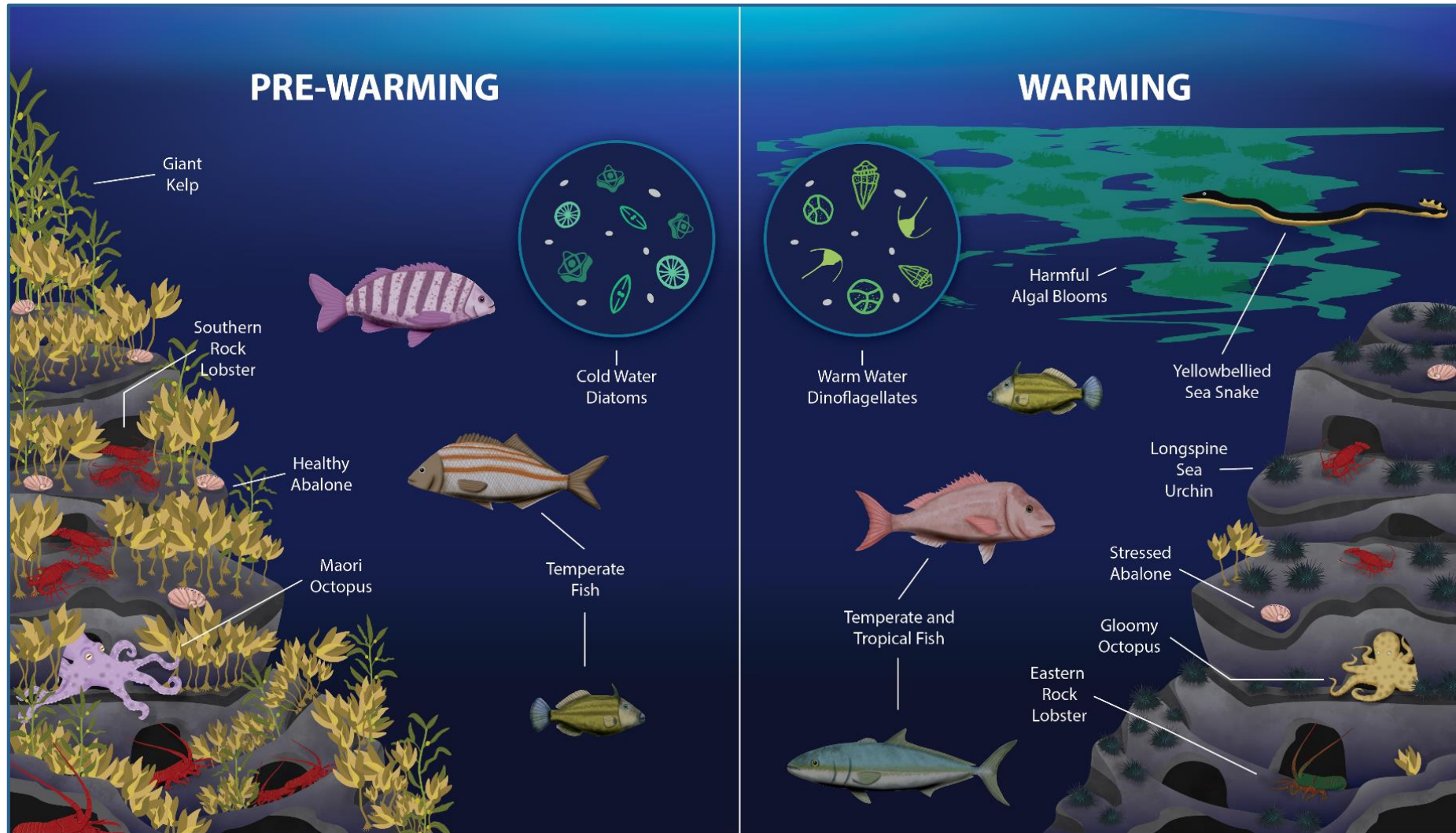


Projected changes: 2041 – 2060  
relative to 1991 – 2010

All large U.S.A. marine ecosystems  
(except Alaska Arctic) are expected  
to see declining fishery catches



# Significant changes linked to warming on the east coast of Tasmania



- shifts to temperate + tropical fish
- stressed abalone
- harmful algal blooms
- more long-spine sea urchin, gloomy octopus, & eastern rock lobster
- giant kelp loss

# Fisheries research - supporting preparedness for climate change + MHWs

## **Understanding Climate Change Impacts:** specific impacts of climate change

- including rising sea temperatures, ocean acidification, altered currents, & changing weather patterns
- impacts on fish populations, habitats, & ecosystems
- involves long-term monitoring, data collection & modelling to assess how these changes affect fisheries.

## **Species Vulnerability Assessment:**

- determine which species most at risk due to temp. changes, habitat loss, or shifts in prey availability
- guides management efforts to prioritize species for conservation or management interventions

## **Ecosystem Modelling & Predictive Tools:** essential for forecasting impacts of climate change on fisheries

- simulate potential scenarios under different climate change scenarios
- aids in understanding how fish populations & ecosystems might respond to future conditions.

## **Adaptive Management Strategies:**

- adjusting fishing quotas, altering fishing practices, establishing marine protected areas, & implementing regulations
- account for changing environmental conditions to ensure sustainable exploitation of fish stocks

## **Enhancing Resilience & Adaptation:** identify strategies to enhance resilience of fisheries and fishing communities

- diversification of fishing practices, promoting ecosystem-based approaches to management, supporting alternative livelihoods, & community engagement in adaptation measures.

## **International Collaboration & Policy:**

- Collaboration among researchers, policymakers, & stakeholders at national/international levels
- Research findings contribute to policy discussions & international agreements aimed at mitigating climate change, reducing carbon emissions, & protecting marine ecosystems





# Dr Camille White & Team

Development of a temperature monitoring framework for Tasmania's seafood industry during marine heatwaves

## Summer 2023/24 - Environmental monitoring

Ambient temperature monitoring at industry-relevant locations/depths

= integral part of the MHW response

- Deployment of temp loggers across seafood supply chain
- Octopus, abalone & rock lobster fisheries
- industry-relevant temperature monitoring methods for future MHW events
- data for government/industry - aid in future fisheries management in MHW conditions

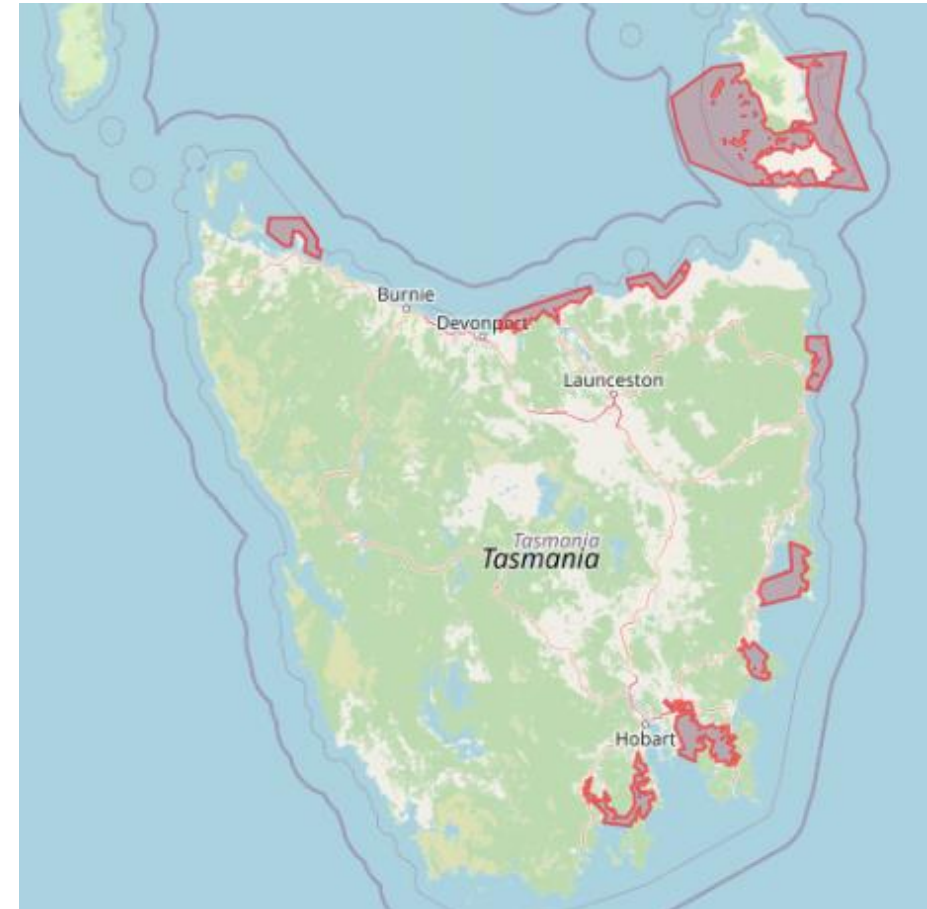
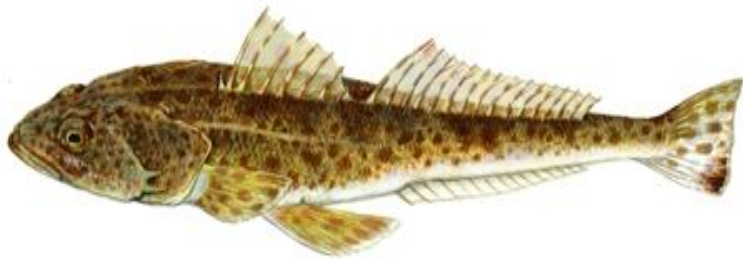


# IMAS Fishery Independent Surveys

Annual fish samples from 2012 - 2023

Southern sand flathead –

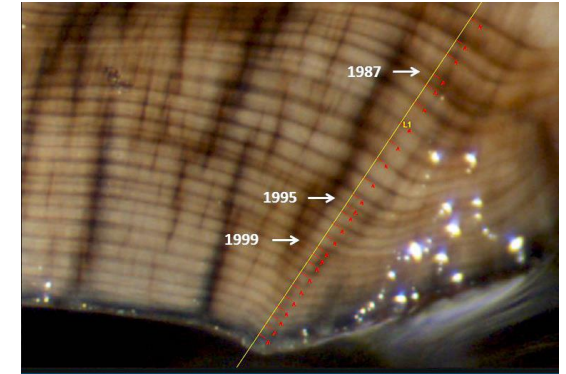
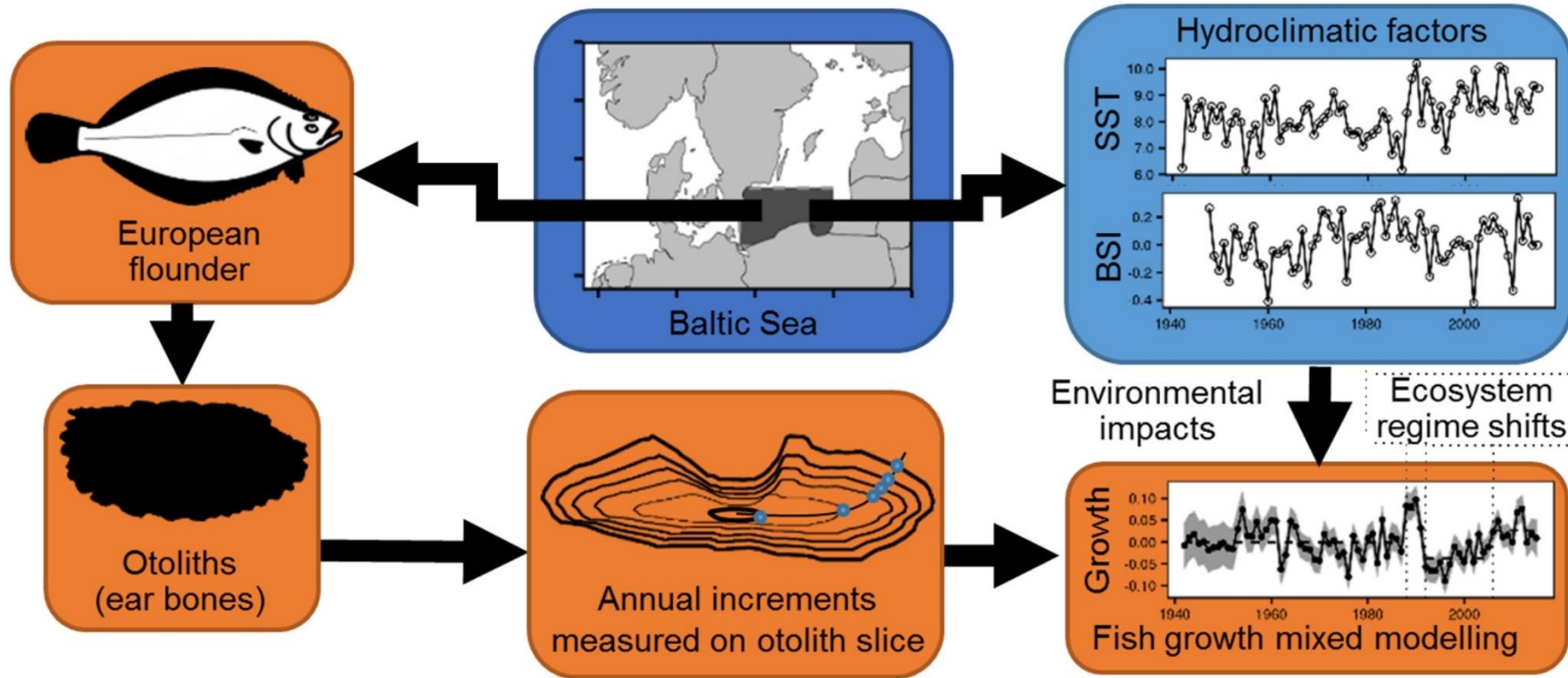
otolith (ear bone) biochronology (time series - biological events)





# Otolith biochronology

- Indicator of marine fish responses to hydroclimatic conditions & ecosystem regime shifts



<https://www.sciencedirect.com/science/article/pii/S1470160X17302042#fig0030>

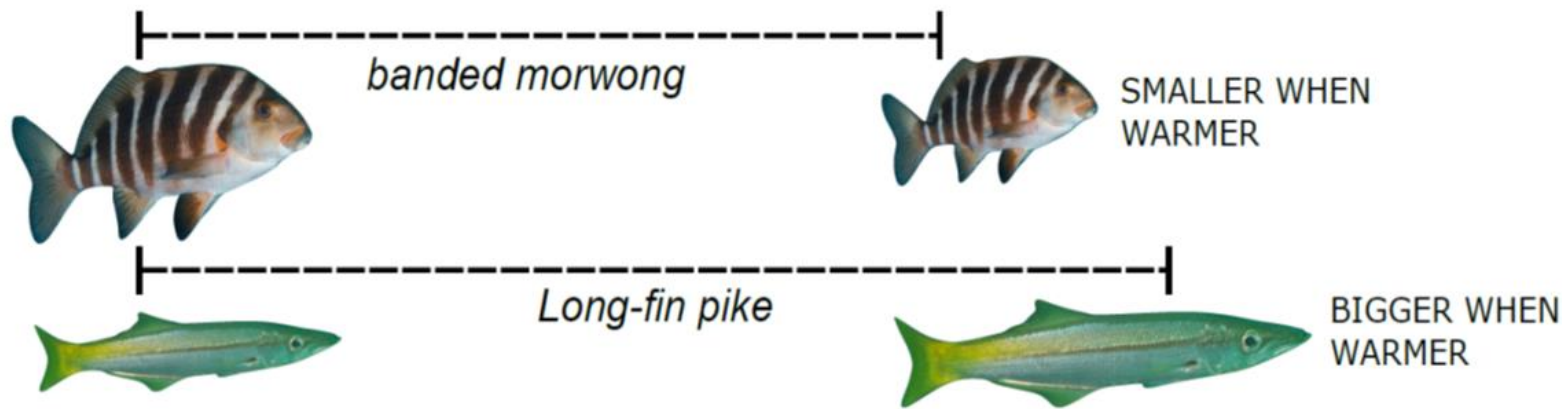


# Changes in body size with warming



## Fish body sizes change with temperature but not all species shrink with warming

Asta Audzijonyte<sup>1,2</sup>✉, Shane A. Richards<sup>3</sup>, Rick D. Stuart-Smith<sup>1</sup>, Gretta Pecl<sup>1,2</sup>,  
Graham J. Edgar<sup>1</sup>, Neville S. Barrett<sup>1</sup>, Nicholas Payne<sup>4</sup> and Julia L. Blanchard<sup>1,2</sup>

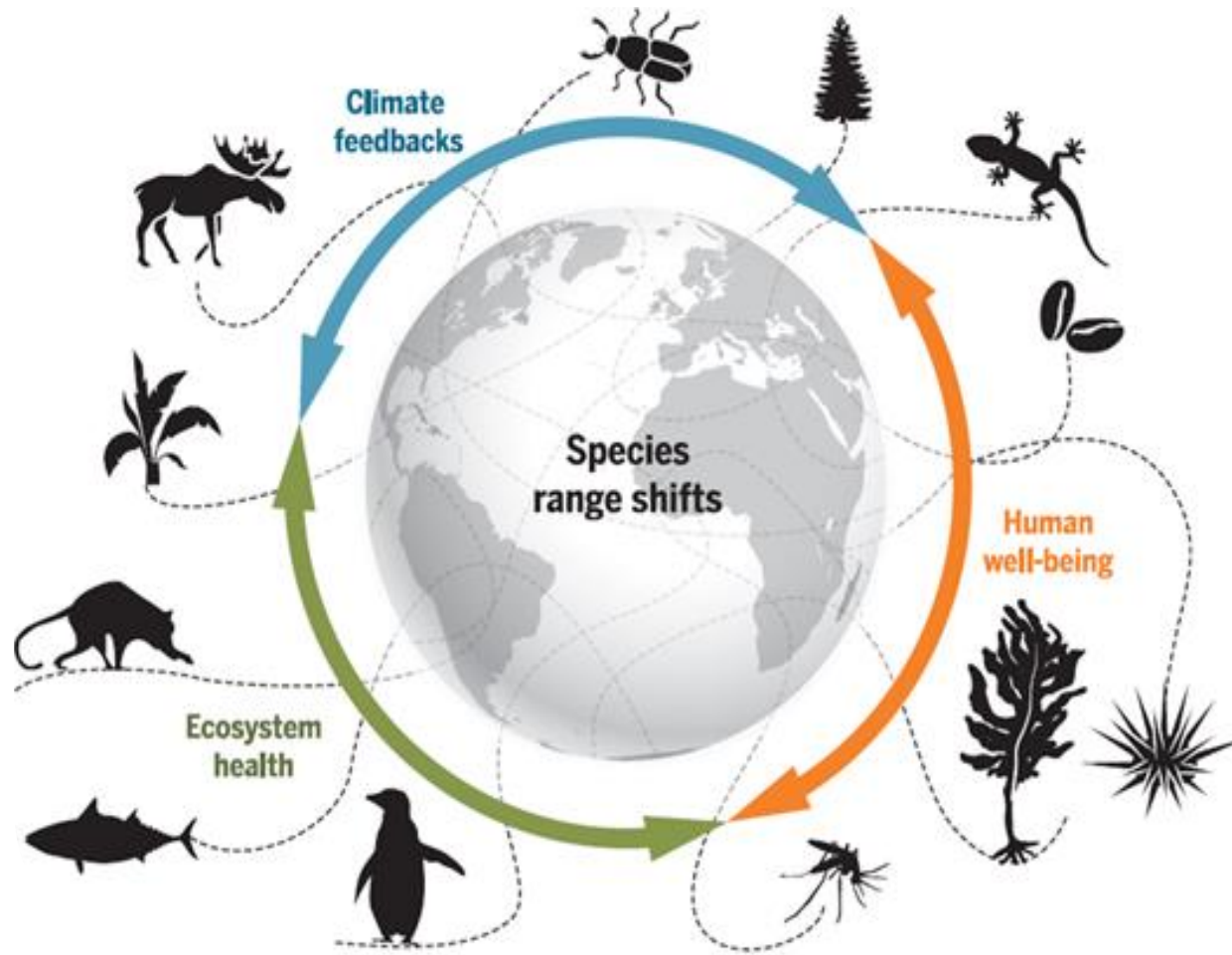


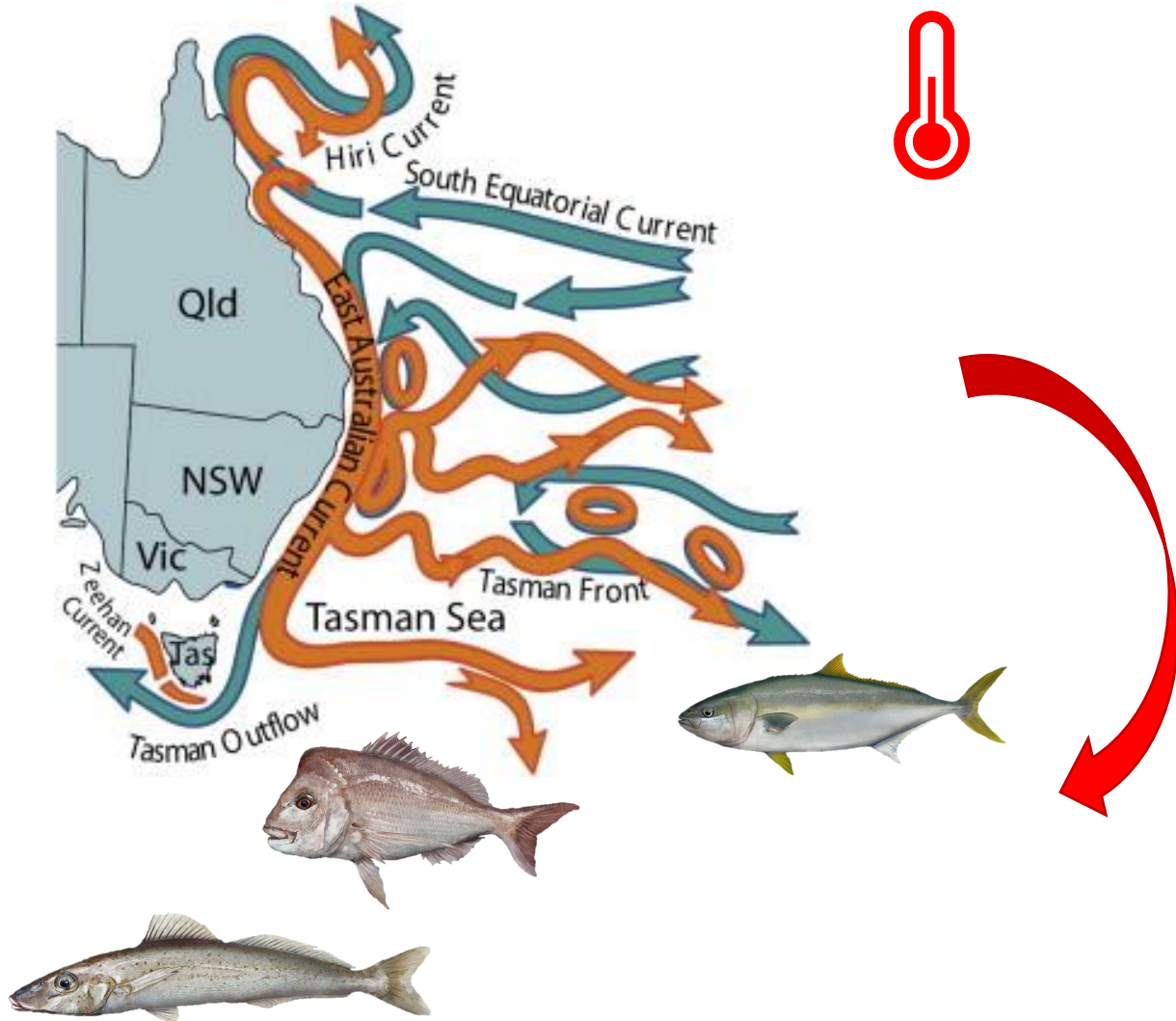
Cooler water

Warmer water

- 55% of species were smaller in warmer waters (especially among small-bodied species)
- ~40% change in body size per 1 °C change
- Rapid and variable responses of fish size to warming - unexpected impacts on ecosystem restructuring, with potentially greater consequences than if all species were shrinking.

# Major effects of climate change = changes in distribution (species range shifts)





**Tasmania** = more records of range shifting species than any other region of Australia's surrounding ocean (Gervais et al. 2021)



# Fisheries impacts of 'Species on the Move'



- *Centrostephanus* first detected in Tasmania in 1978, by 2017 - 20 million individuals & barrens cover of ~15% of rocky reefs (Ling and Keane 2018)
- Negative impact on abalone and rock lobster
- Catch of urchins almost 600 tonnes (1.8 million urchins) in 2019 alone

# Opportunities and impacts of range extending scalefish species

Understanding population dynamics, ecosystem impacts  
and management needs

Alexia Graba-Landry, Curtis Champion, James Haddy, Jeremy Lyle, David Mossop, Rod Pearn, Gretta Pecl, Heidi Pethybridge, Barrett Wolfe and Sean Tracey



May 2022

FRDC Project No. 2018/070



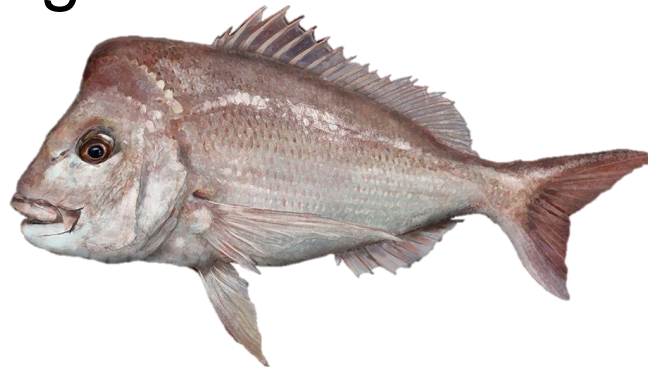
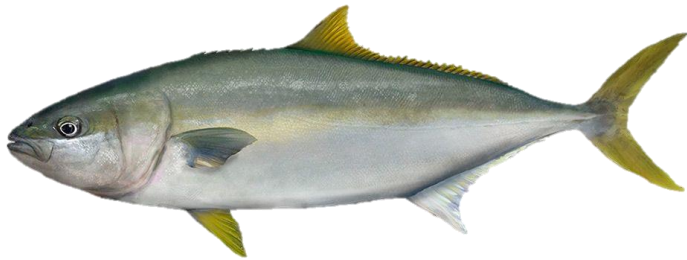


# AIM

Understand the **life history, biology, distribution and potential shifts** of

**Yellowtail Kingfish, Snapper & King George Whiting**

& their ecological impacts to inform management of these potential emerging fisheries in Tasmania





# Range-Extending Species

ABC RURAL

## Fish species opting for a sea change are making Tasmanian fishers happy

ABC Rural / By Fiona Breen

Posted Sat 13 Aug 2022 at 11:38am



## Gloomy octopuses 'happy, healthy' in warming Tasmanian waters, marine science study finds

By Emily Bryan

Posted Thu 28 Jun 2018 at 5:29pm, updated Fri 29 Jun 2018 at 10:22am



<https://www.abc.net.au/news/2018-06-28/gloomy-octopus-migrating-to-tasmania-due-to-climate-warming/9919122>

<https://www.abc.net.au/news/rural/2022-08-13/fish-species-move-tasmania-snapper-kingfish/101327780>



# Marine citizen science

## WHAT'S ON THE MOVE AROUND AUSTRALIA?

As waters warm with climate change, Australia's species are shifting in response.

**redmap**  
SPOT. LOG. MAP.

Redmap (Range Extension Database and Mapping Project) has documented over a decade (2012-2022) of out-of-range marine species sightings with the help of Australia's citizen scientists.

**479** 2018 NOVEMBER report covered 12 months of marine sightings

**2045** The total number of marine species sightings

**205** MARINE SPECIES covered by our out-of-range sightings

**91** SCIENTISTS in 2018 NOVEMBER who reported sightings

How confident are we that a species' range is shifting? HIGH MEDIUM LOW

Confidence that a species' range is shifting was assessed as 'High', 'Medium' or 'Low' by combining the strength of evidence provided by citizen scientist observations with our confidence in each species' known southern range limit.

Scan QR code for more info about the assessment methods.

www.redmap.org.au

Contributions from Australian fishers, divers, and scientists



redmap SPOT. LOG. MAP.

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LOG A SIGHTING

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Latest sighting:  
Yellowtail Kingfish  
Spotted by Brett Perry

Spot. Log. Map.

Redmap (Range Extension Database & Mapping project) invites the Australian community to spot, log and map marine species that are uncommon in Australia, or along particular parts of our coast.

FIND OUT MORE

Map data ©2023 Google Terms of Use

## TASMANIA REPORT CARD

Over the past decade (2013–2022), Redmap (Range Extension Database & Mapping Project) has recorded out-of-range marine species with the help of observant citizen scientists across the state.

Marine species are moving further south

The East Australian Current, which transports warm, tropical water south along the east coast of Australia, has strengthened over the past several decades. As a result, south-eastern Australia is one of the fastest warming regions of the world's oceans. In response to warming waters, some marine species are extending their ranges south. In recent years, the Tasmanian community has spotted many species south of their usual ranges, for example:

- 1 Since 2014, beachcombers have found a number of Greater Argonaut (*Argonauta argo*) shells across Tasmania's east and south coasts. This warm-water open ocean octopus relative uses its shell to carry its eggs and maintain buoyancy.
- 2 Fishers have been surprised by catches of several species further south than expected, such as Tiger Sharks (*Galeocerdo cuvier*), which have been caught and released offshore as far south as St. Helens.
- 3 Divers and snorkelers have spotted a number of species new to Tasmania or in new areas further south. For example, the Gloomy Octopus (*Octopus teiricus*), which was reported from the Bass Strait in our original 2013 report card, has now been spotted as far south as Falmouth on Tassie's east coast.

Image credits: (1) J. Mueller, (2) S. Boag, (3) D. Lee

CITIZEN SCIENCE HELPS DETECT SPECIES RANGE SHIFTS

Thank you to Tasmania's citizen scientists (beachcombers, boaters, divers, and fishers), who since 2009 have been logging 'out-of-range' species sightings like those above with Redmap. These observations can provide an early indication of how species distributions are changing, improving our ability to predict and prepare for the challenges and opportunities range extending species may deliver. By contributing to citizen science programs like Redmap, anyone with a camera can become an 'ecological detective', helping to uncover which species are on the move and how their local region may be changing in response to ocean warming.

# Key points

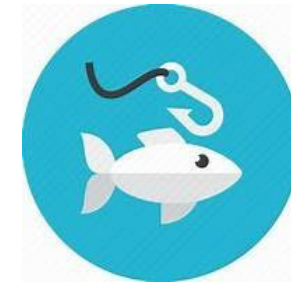
- Small changes in physical environment = large biological changes
- Whether that effect is 'negative' or 'positive' depends on the species & its range
- Exposure and sensitivity to physical changes will vary across life stages





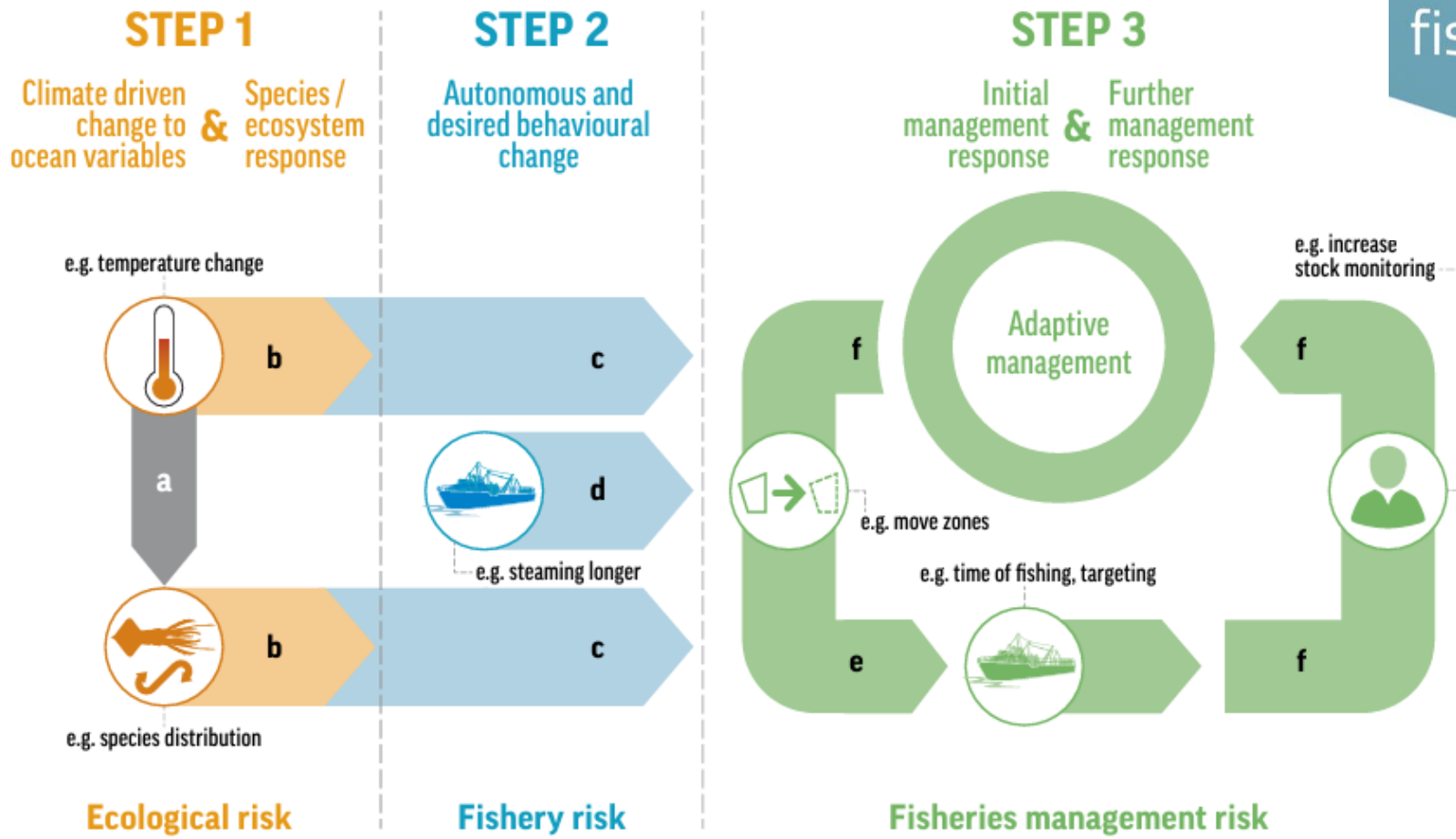
# Summary

## MARINE HEATWAVES + climate change



- MHWs/CC can lead to **unpredictable fluctuations** in fish populations
- MHWs/CC can **severely disrupt fisheries**, affecting fish populations, ecosystem dynamics, & economic well-being of communities dependent on fishing industries
- MHWs/CC pose **challenges for fisheries management** - fisheries management authorities may need to adapt regulations/policies to account for rapid environmental changes
- Addressing impacts of MHWs/CC on fisheries **requires proactive measures**
  - adaptive management strategies, conservation efforts
  - global initiatives to mitigate climate change & reduce ocean warming

**FIGURE 2-1** Schematic representation of why a risk assessment needs to be undertaken – showing the relationship between climate change, autonomous fleet adaptation and response and any management responses.



Adaptation of fisheries management to climate change  
**HANDBOOK**

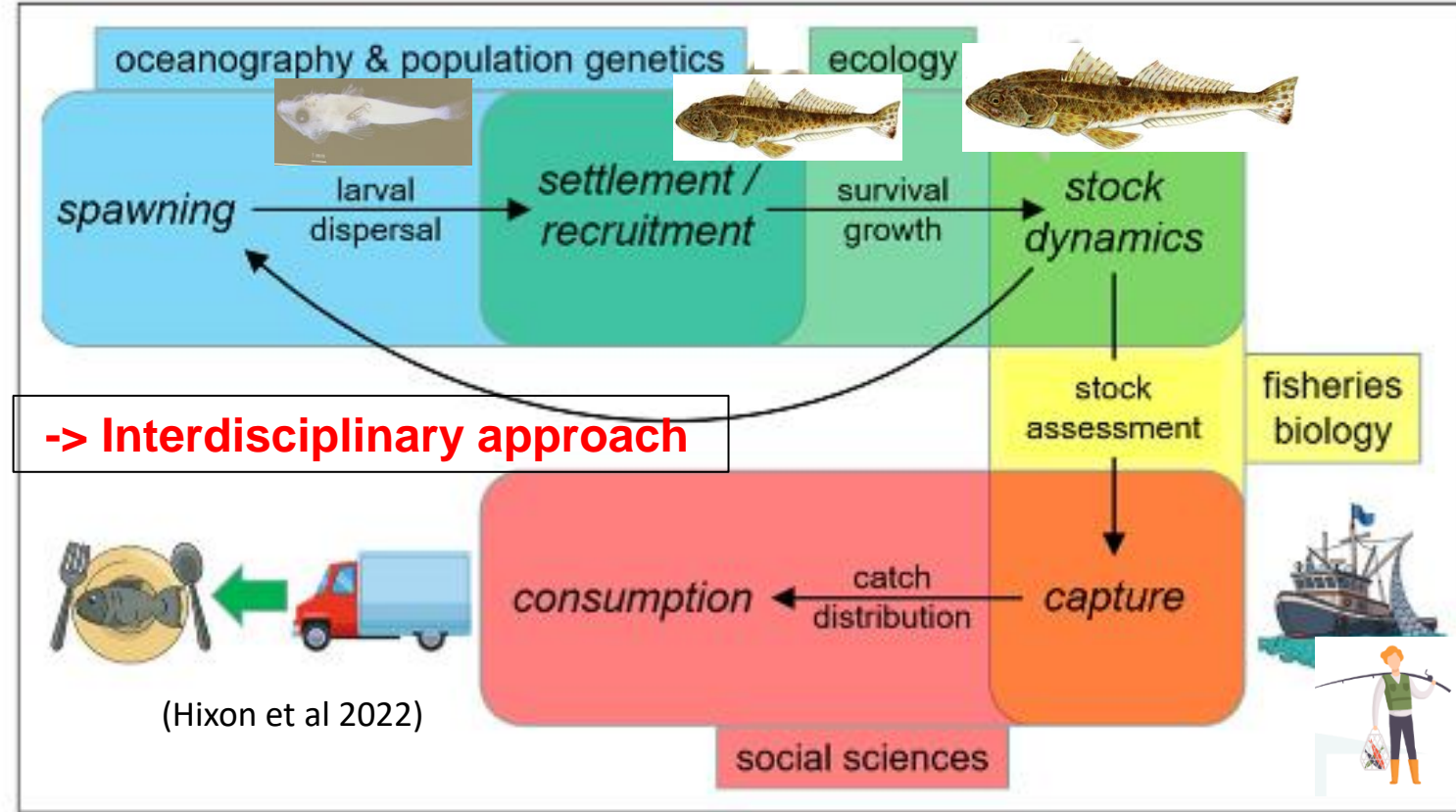


<https://research.csiro.au/cor/research-domains/climate-impacts-adaptation/climate-adaptation-handbook/>

**CITATION**  
Fulton EA, van Putten EI, Dutra LXC, Melbourne-Thomas J, Ogier E, Thomas L, Murphy RP, Butler I, Ghebregabhier D, Hobday AJ, Rayns N (2020) Adaptation of fisheries management to climate change Handbook, CSIRO, Australia.



“Managing fisheries is hard: it’s like managing a forest, in which the trees are invisible and keep moving around”  
John Shepherd (unpublished lecture at Princeton University, 1978)





<https://tasfisheriesresearch.org>

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**Redmap Australia**

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<https://www.imas.utas.edu.au/research/fisheries-and-aquaculture/publications-and-resources>

**Thank you**



CENTRE FOR MARINE SOCIOECOLOGY

# Species redistribution - challenges & opportunities for marine species & human communities

- Species shifts are fundamentally changing natural & managed systems
- Species on the move – ‘status quo’ for the foreseeable future
- Almost everything is changing all at once
- We need mechanistic process-based understanding in order to project future changes
- Human systems are already having major challenges
- Adaptation (within limits) is possible BUT needs strategic planning



(Melbourne-Thomas et al Pecl 2021, Reviews in Fish Biology & Fisheries)

# Climate, currents and species traits contribute to early stages of marine species redistribution

[Jorge García Molinos](#), [Heather L. Hunt](#) , [Madeline E. Green](#), [Curtis Champion](#), [Jason R. Hartog](#) & [Gretta T.](#)

[Pecl](#)

[Communications Biology](#) 5, Article number: 1329 (2022) | [Cite this article](#)

## Species biological identity

- influences responses to warming
- based on traits related to
  - adults/larvae dispersal
  - dependency on specific habitats
  - trophic category
  - historical range size

<https://www.nature.com/articles/s42003-022-04273-0>

