Research on Effects of Climate Change on tuna: the example of Atlantic bluefin tuna and marine heat waves

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Results from several EU projects finished and EU data framework collection

PERSEUS
POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

CERES

PANDORA

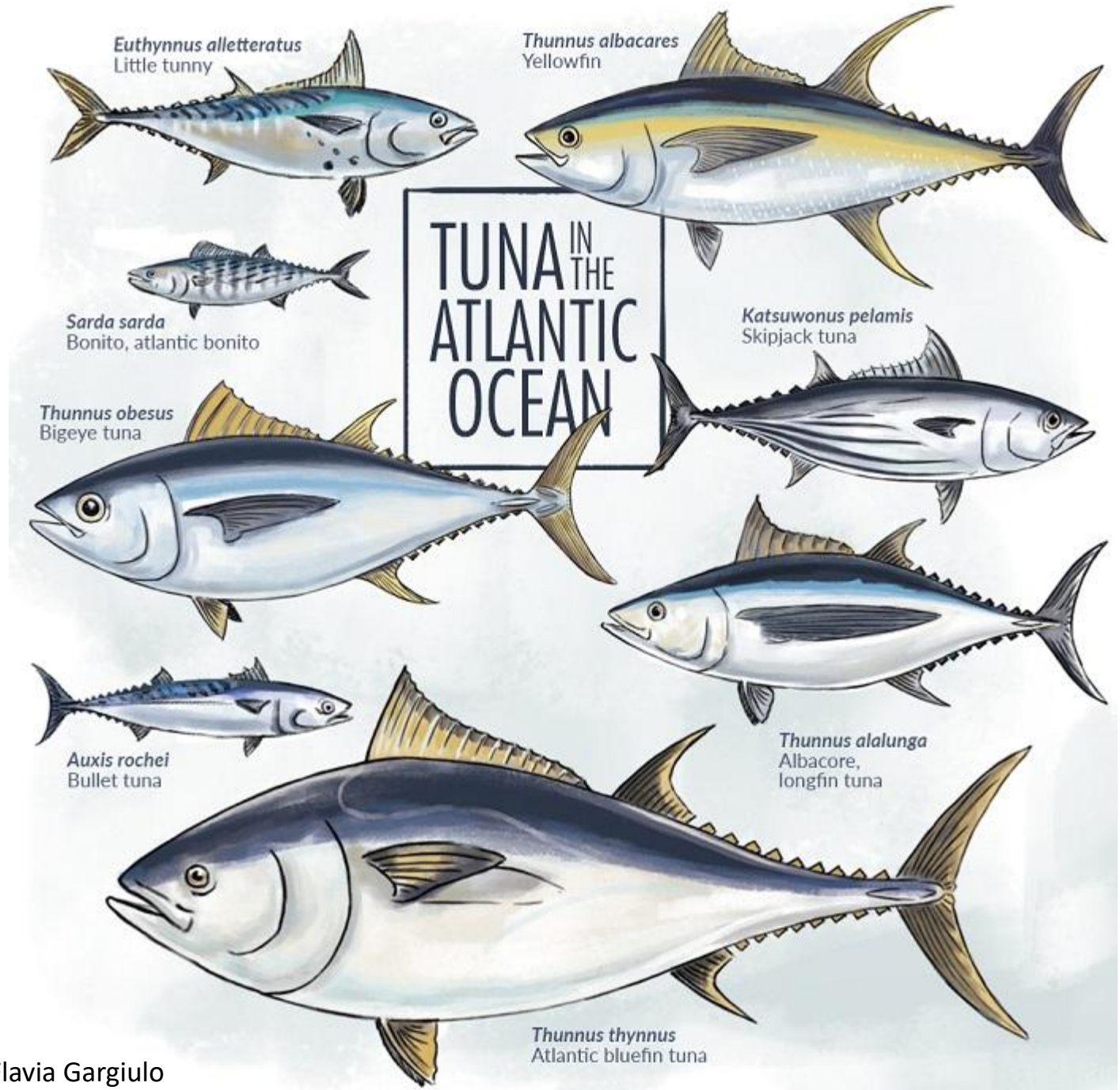
TUNIBAL

Illustrations and infograhics

Planet tuna

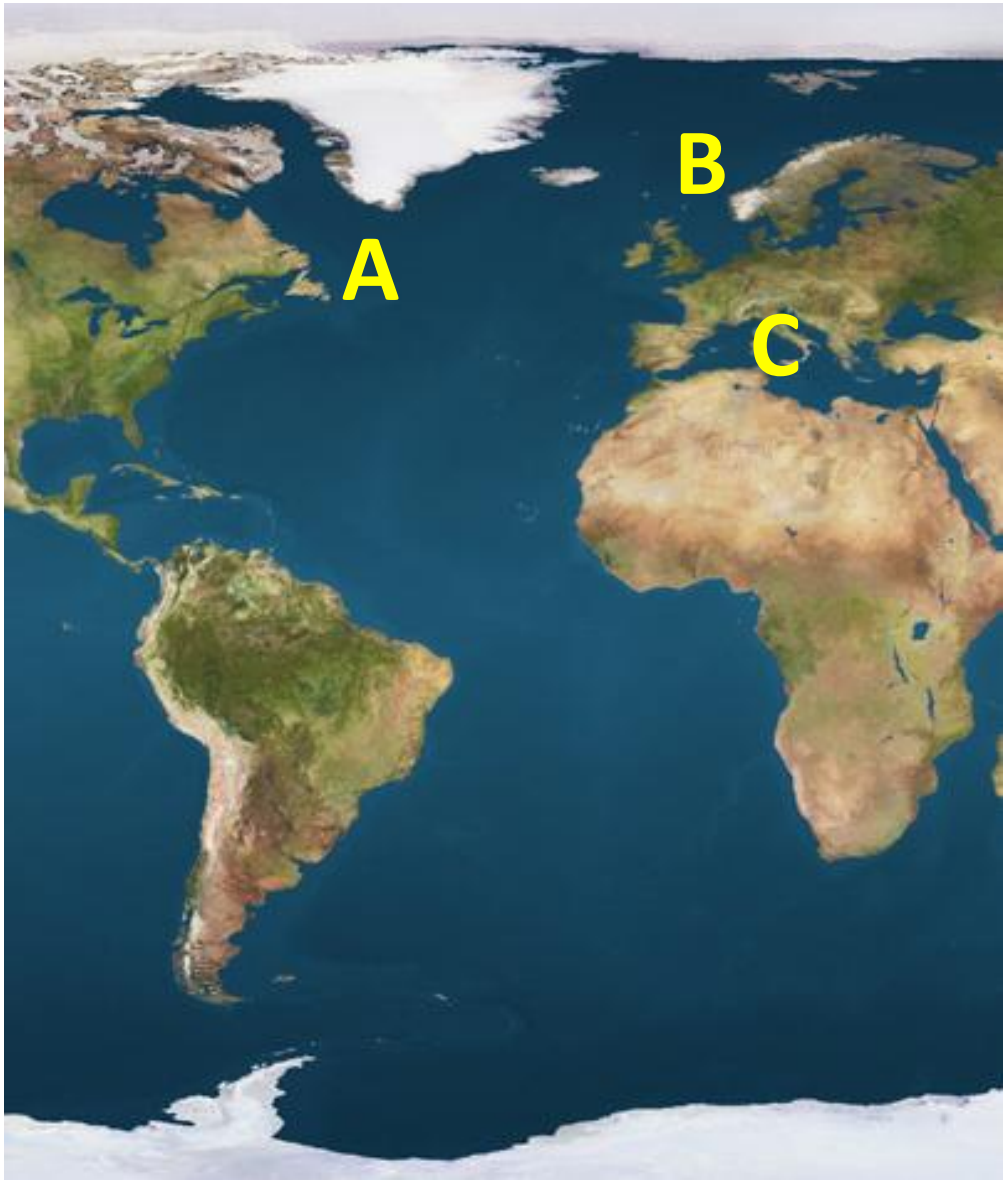
Planettuna.com

Illustrator: Flavia Gargiulo



Flavia Gargiulo

Some changes in ecology of Atlantic Bluefin Tuna



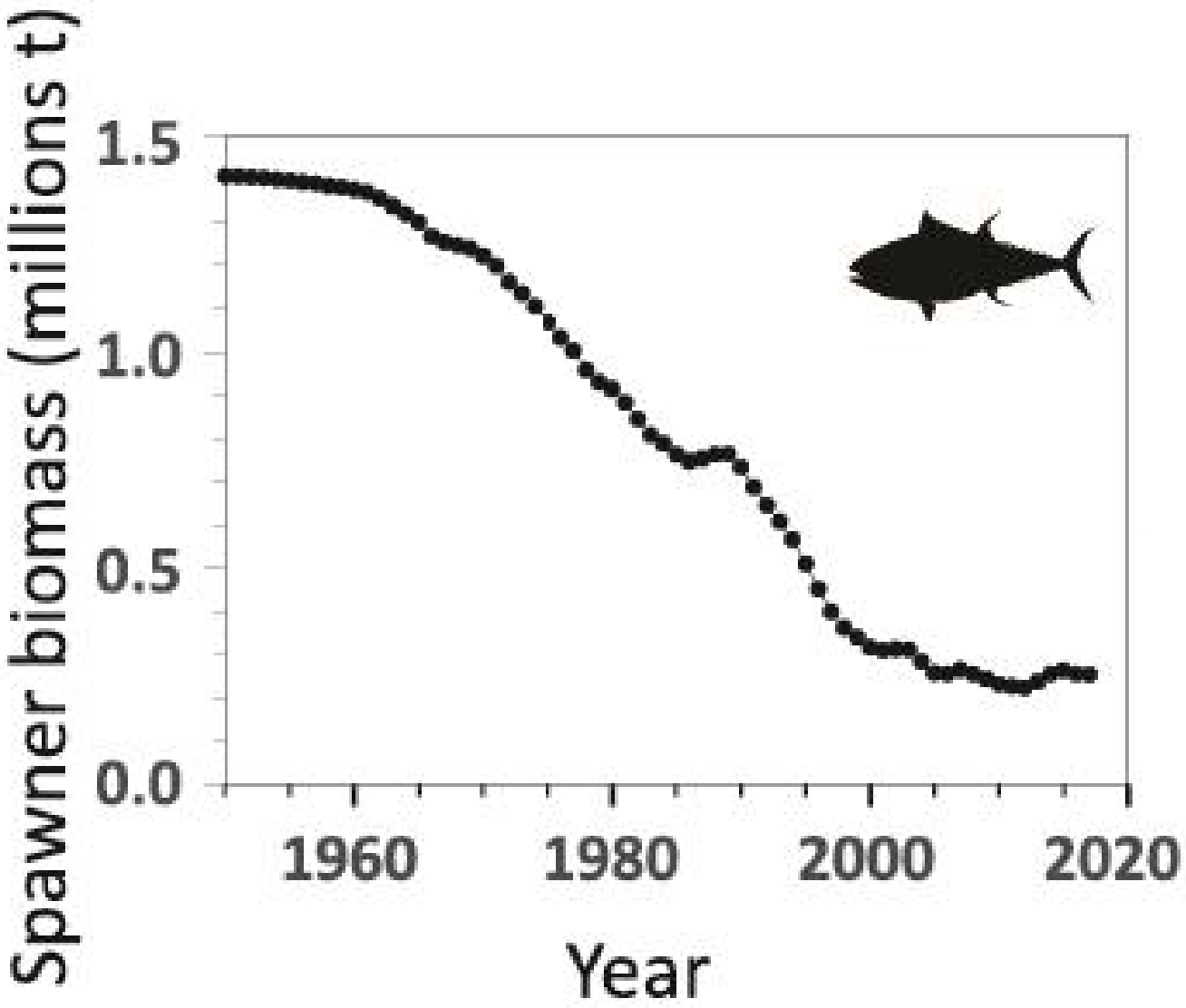
A. Summer range expansion to new areas 2012+

B. Return to summer habitat after 50 years

C. Tipping point: Recruitment associated to mesoscale oceanography and marine heatwaves

Source map: wikipedia

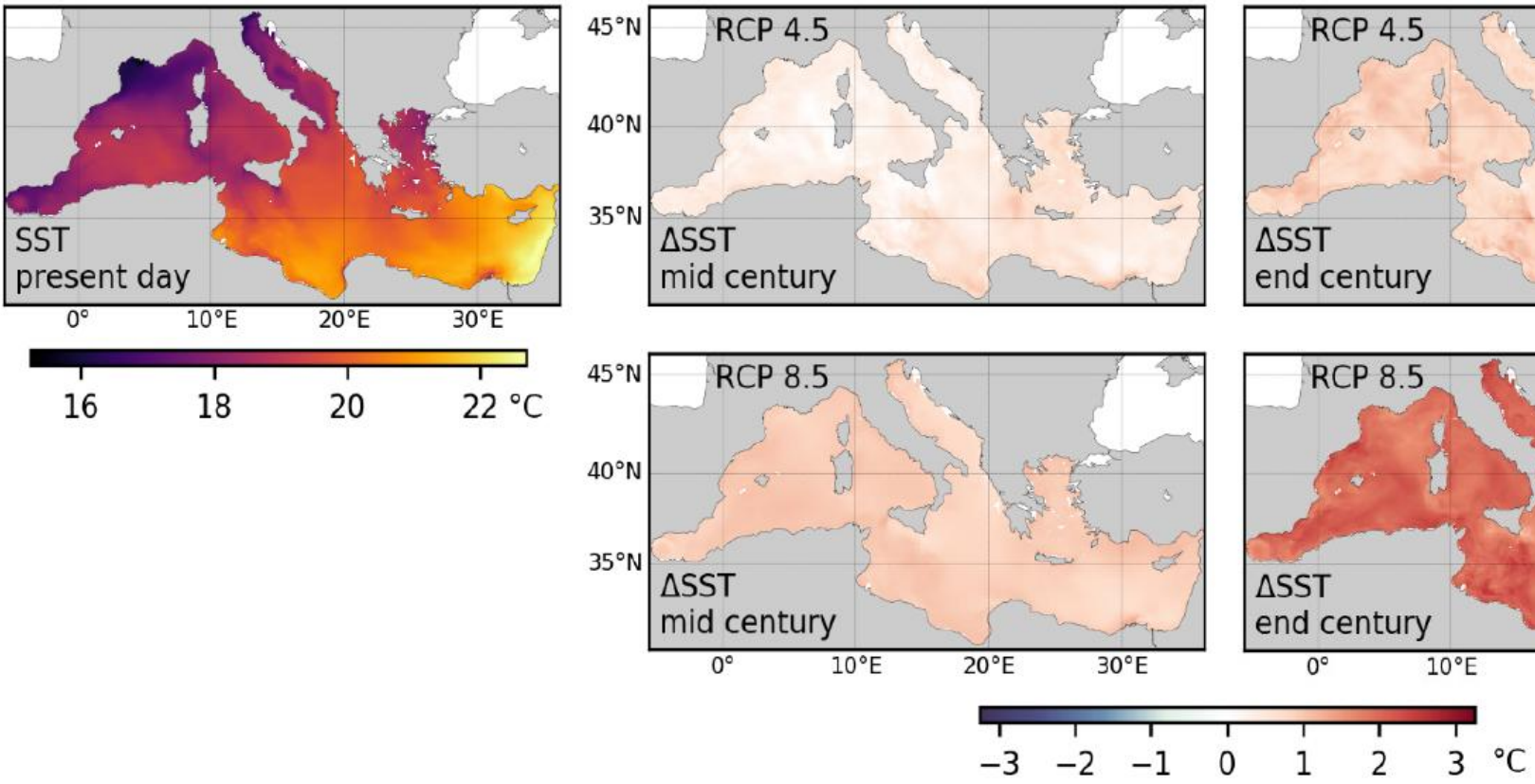
Overfishing of bigeye tuna in the Atlantic Ocean



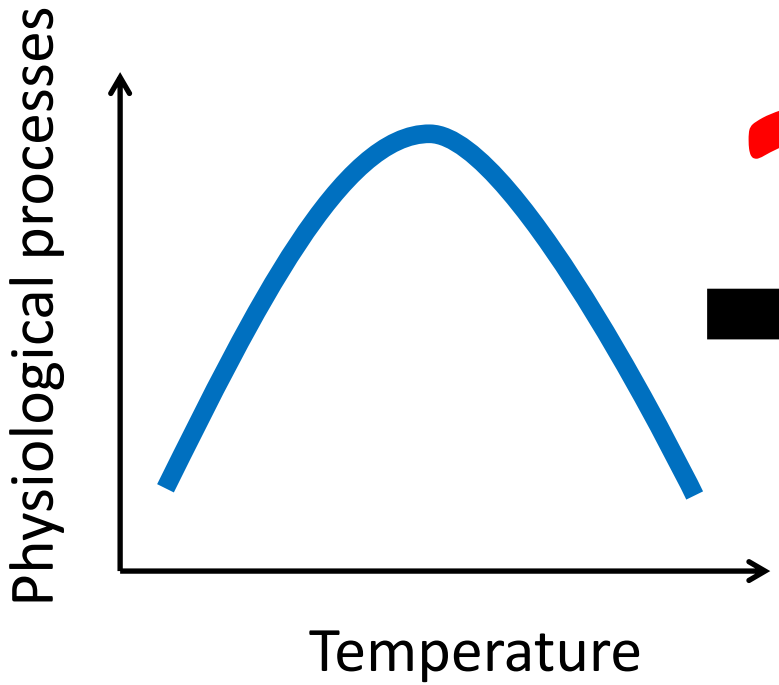
Source of data: ICCAT.

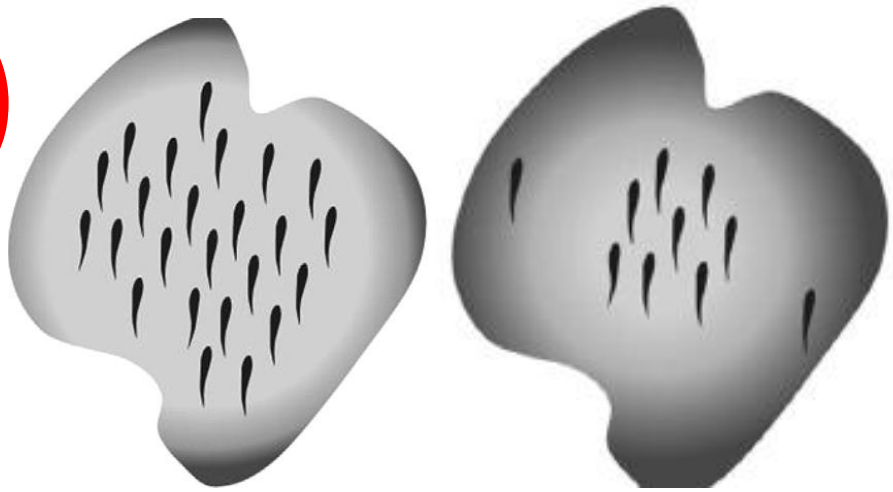
The reasons are often unresolved but are believed to be due to complex interactions between exploitation and **climate/ocean variability**

Climate change: increasing temperatures



Underlying processes that can trigger changes in ADULTS

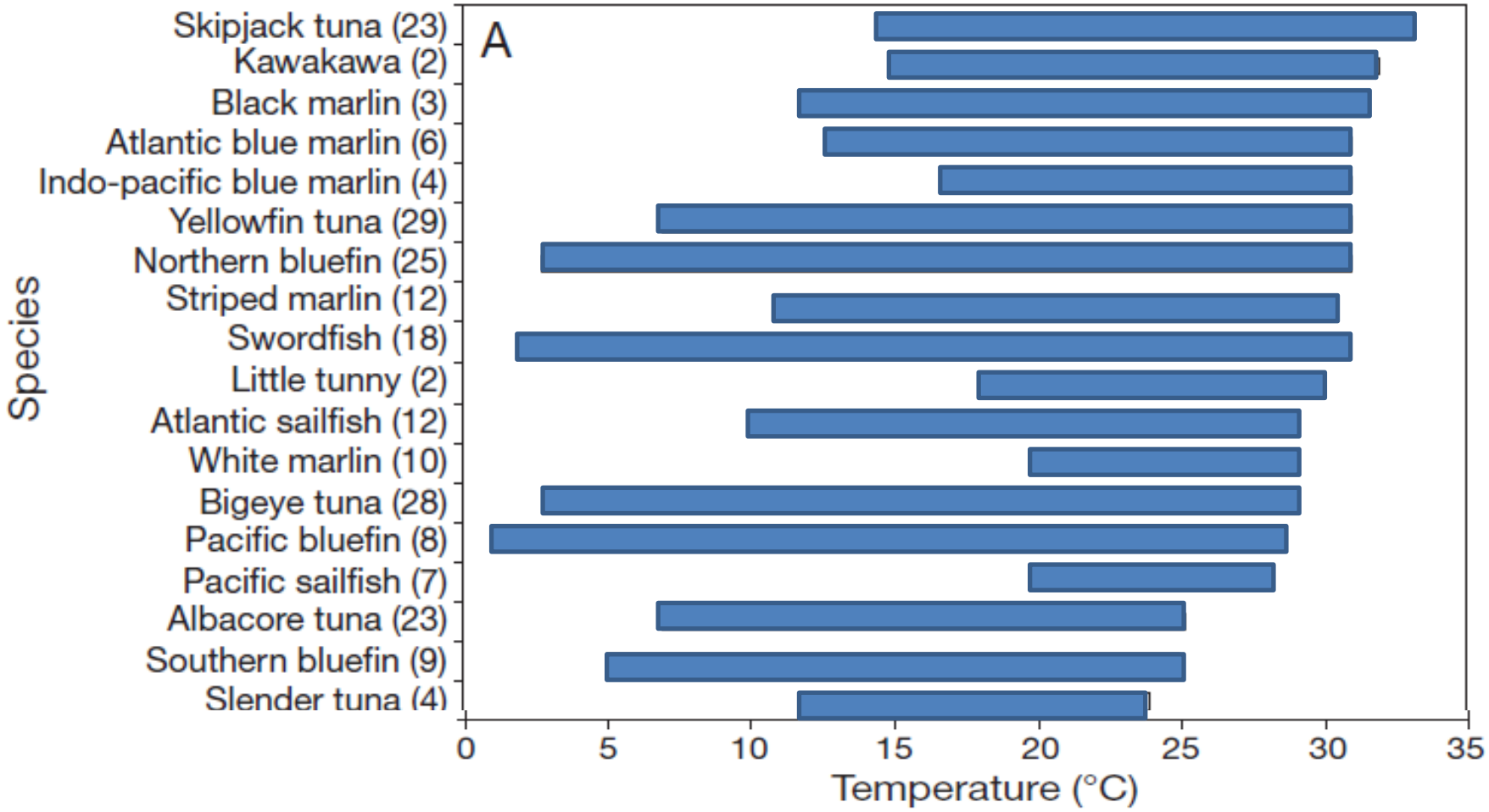




- Species redistribution according to adaptability
- Timing of life history events
- Survival

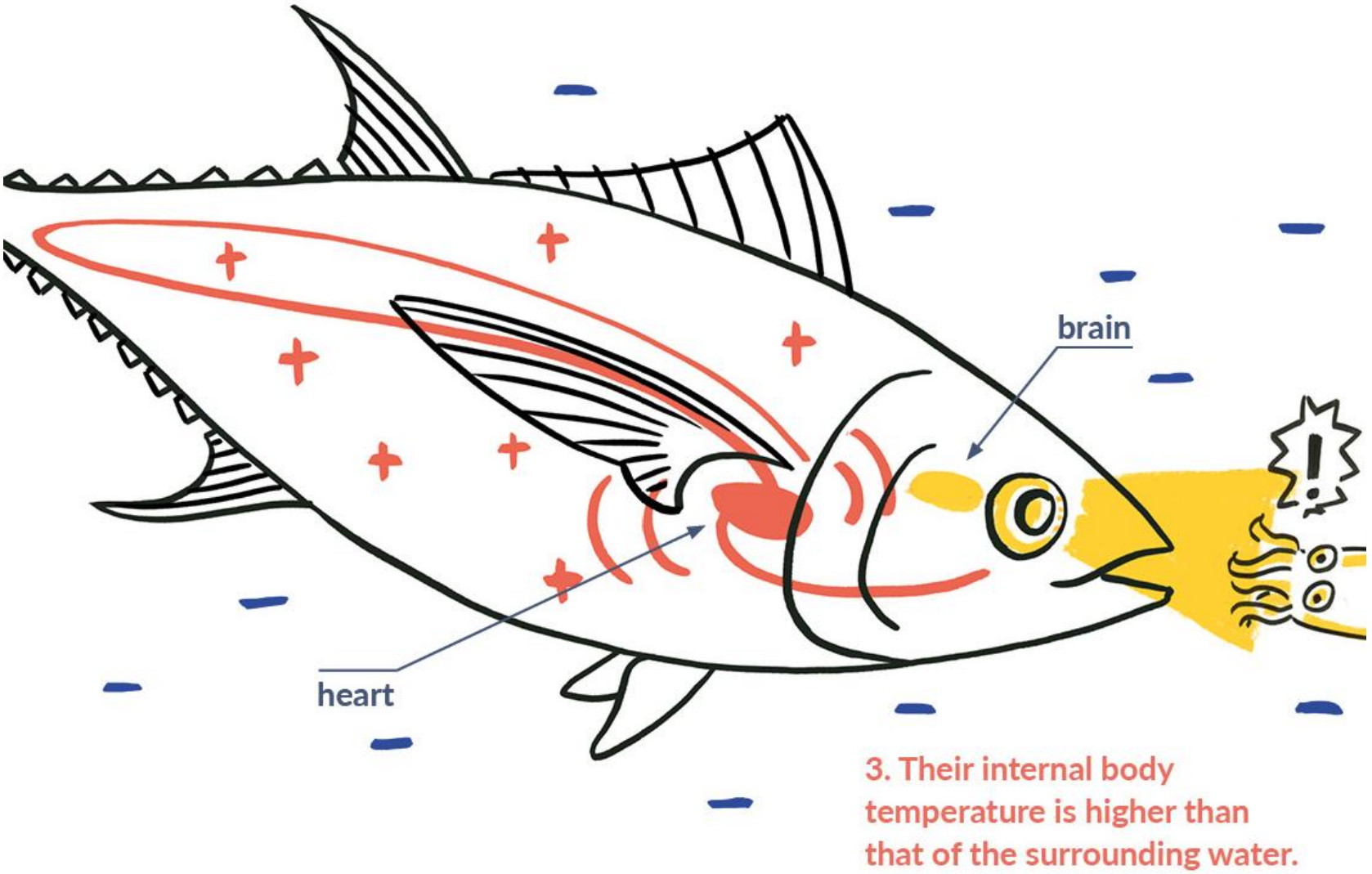
Modified from Teal et al. 2018

Wide thermal range: overall temperatures



Adapted from Boyce et al. 2008

Endothermy



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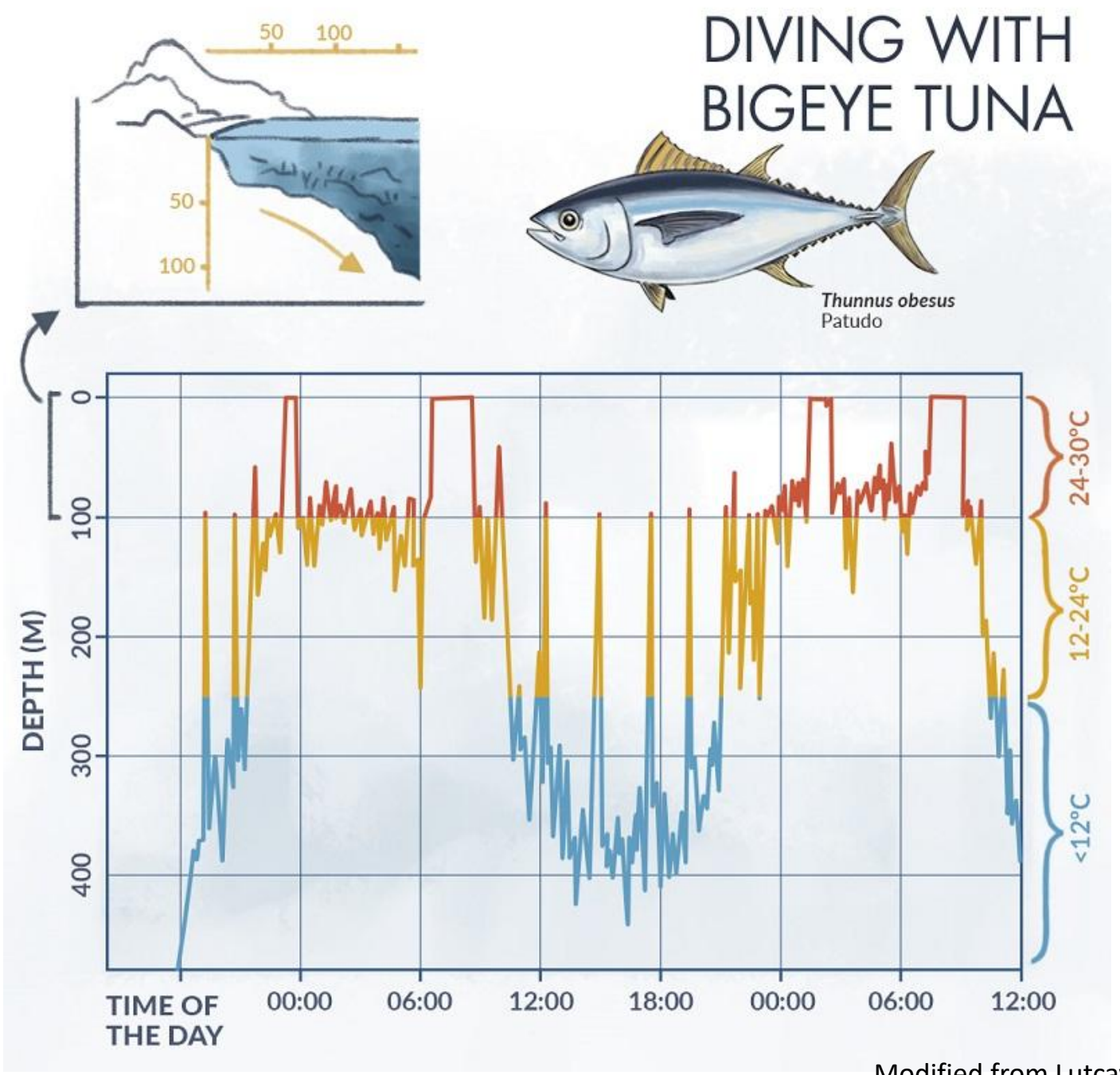

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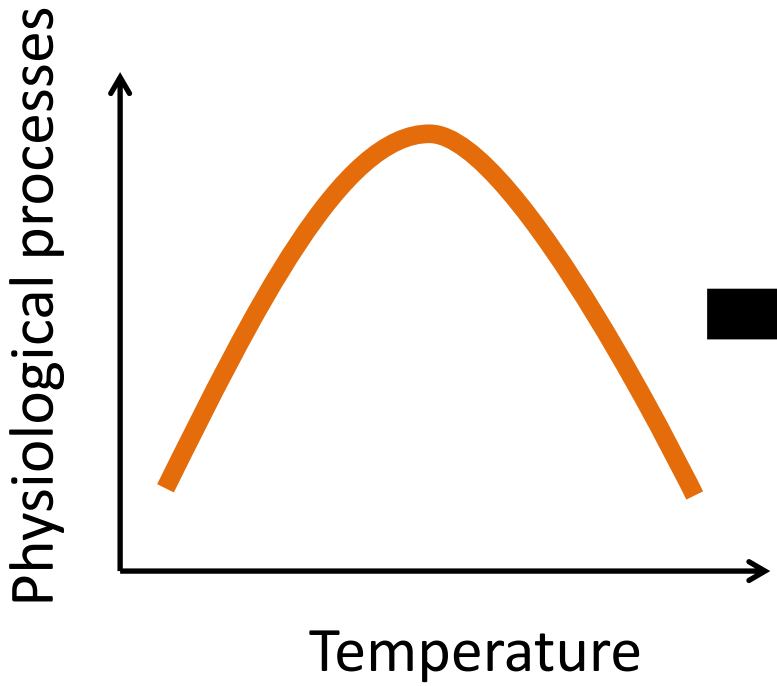
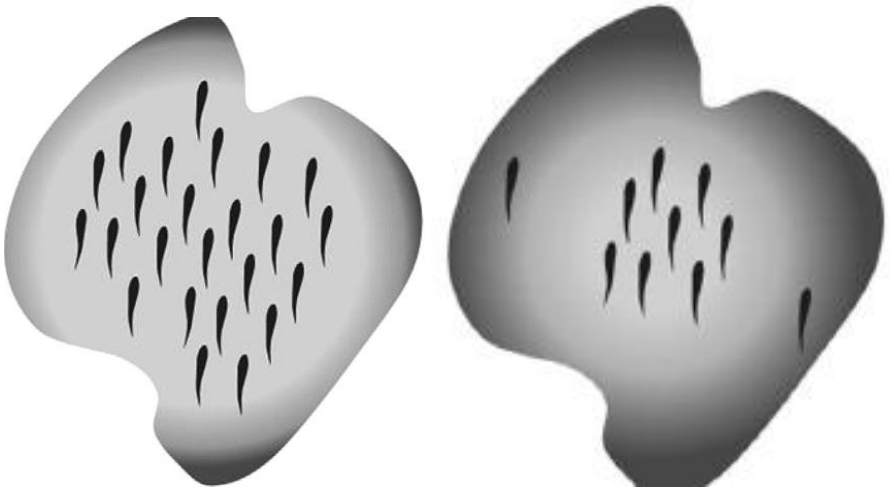
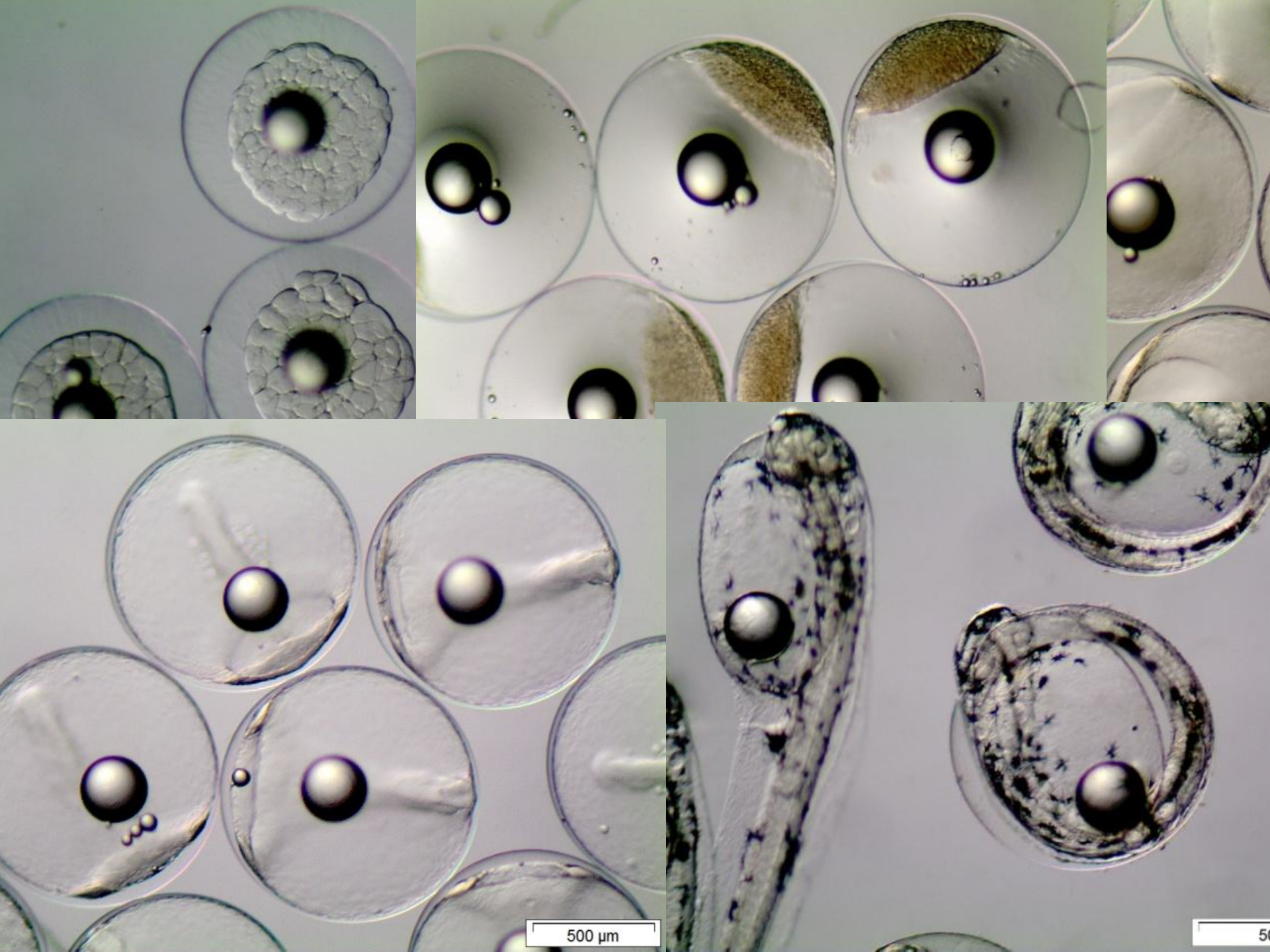
Modified from Lutcavage et al.

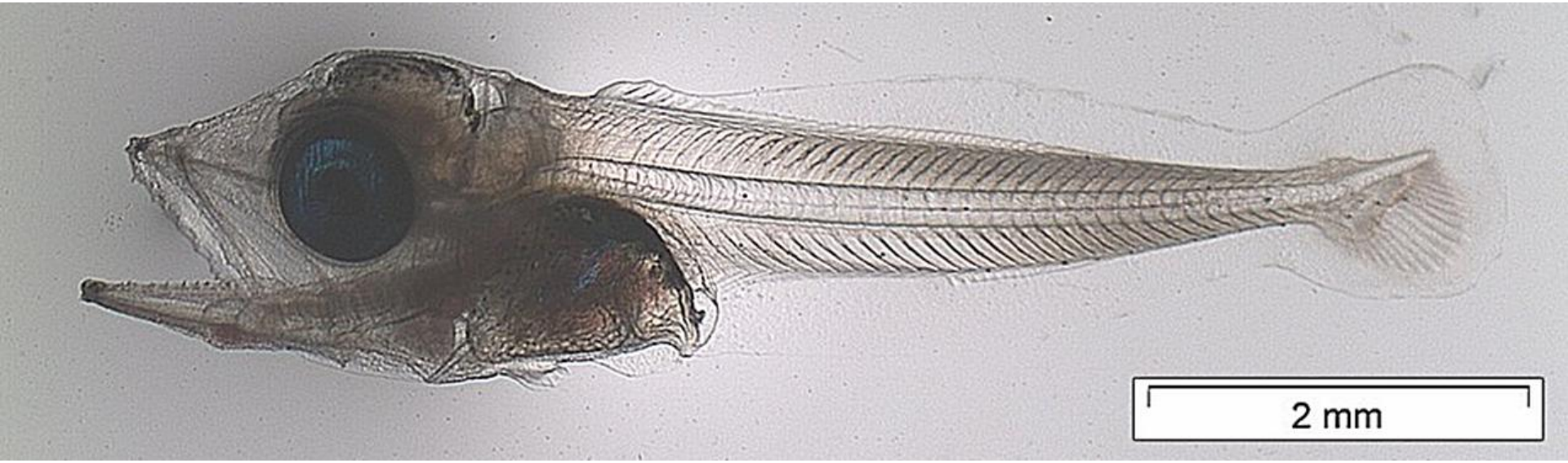
Underlying processes that can trigger changes in EGGS and LARVAE



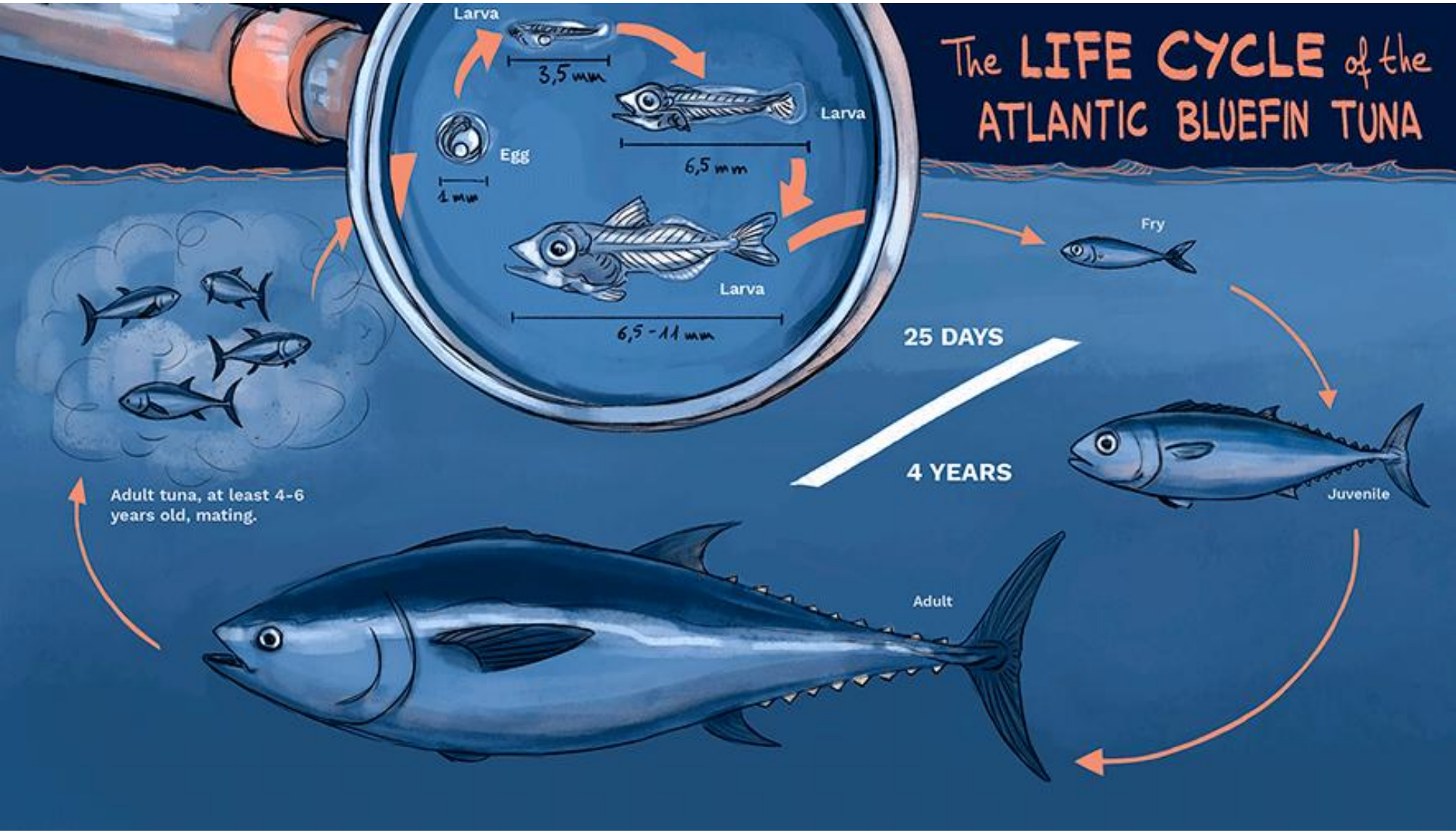


Modified from Teal et al. 2018


500 µm



Pictures: Fernando de la Gándara



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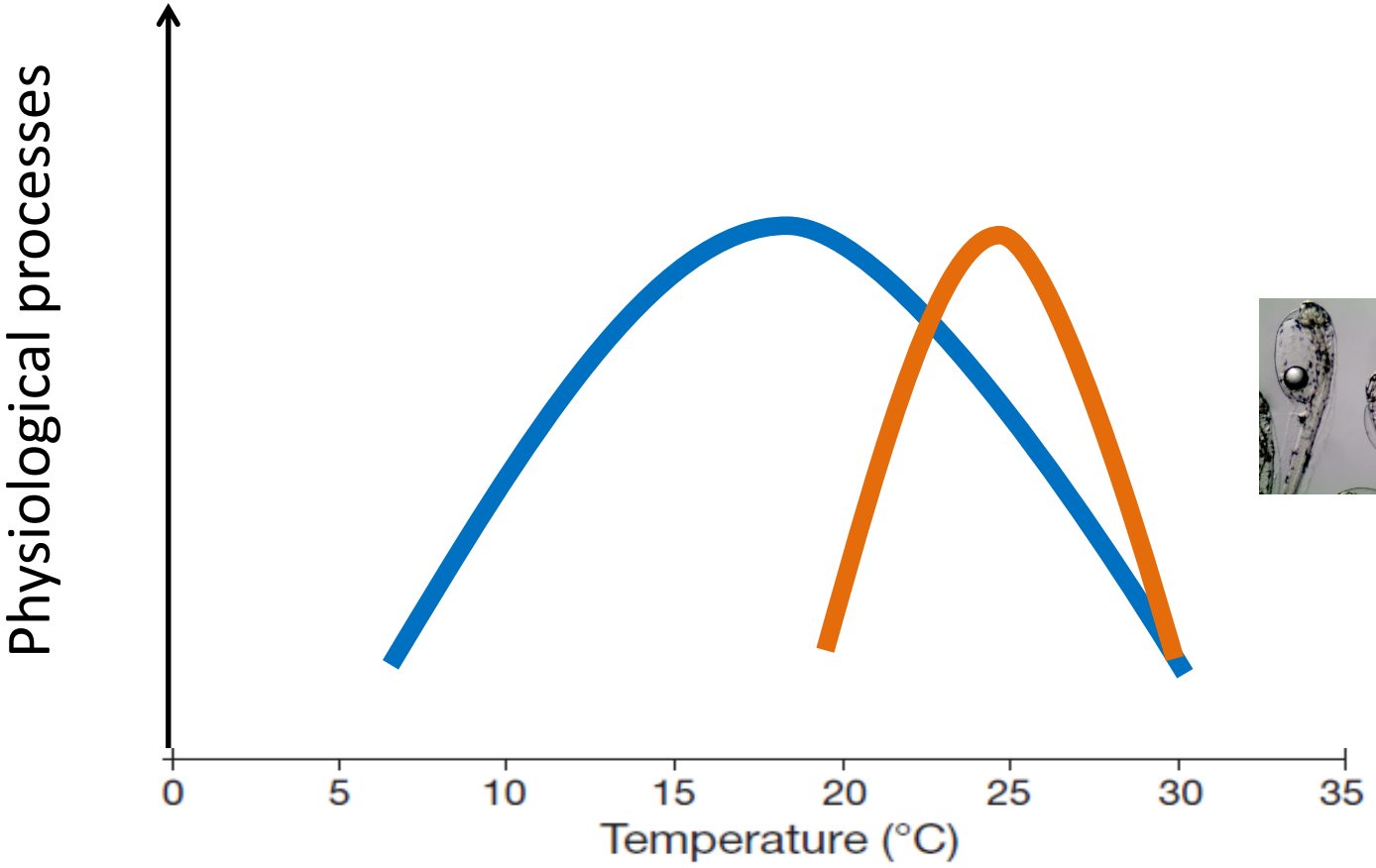
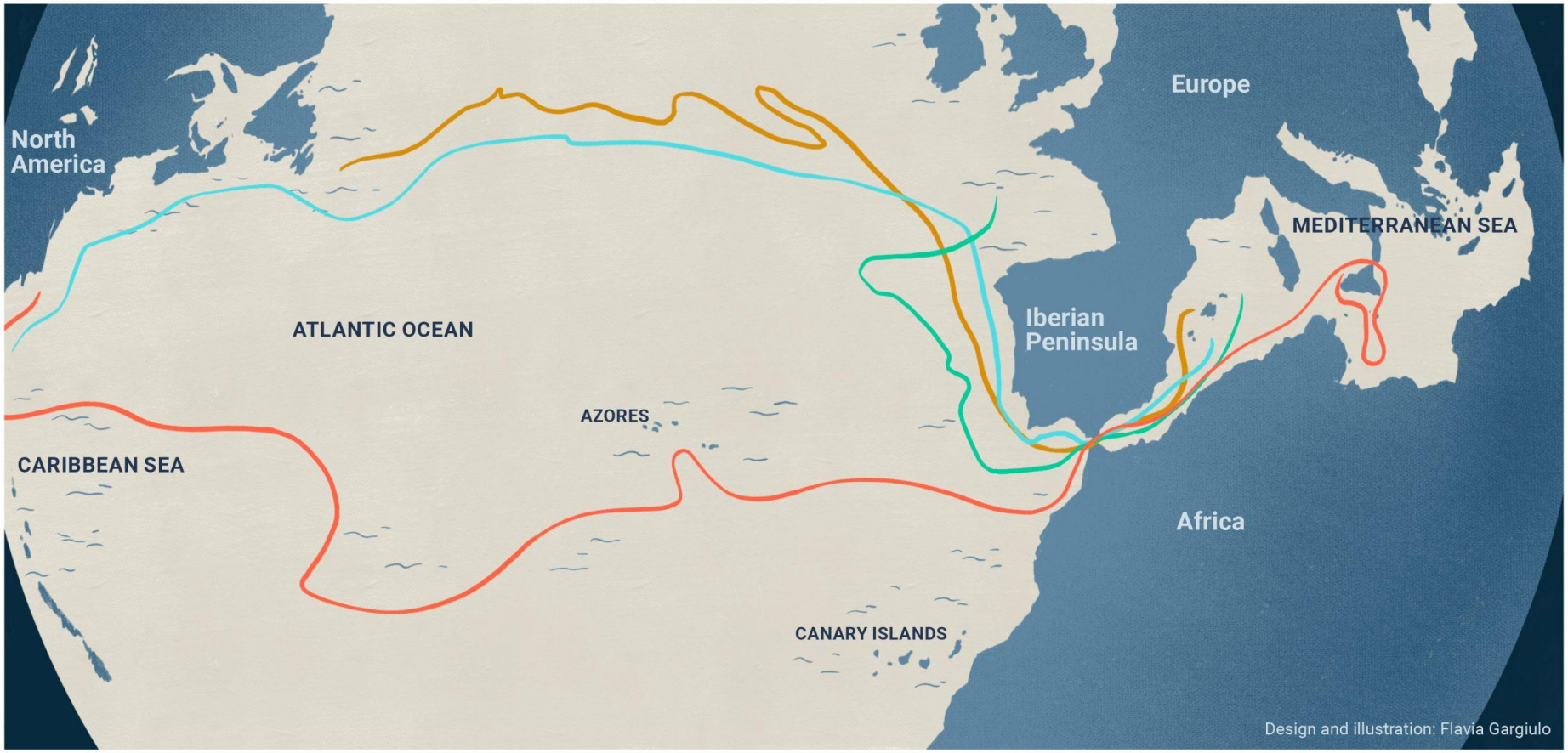
Tuna typically spawn in some of the warmest temperatures worldwide because of the eggs and larva



The Mediterranean Sea is one major spawning area for bluefin tuna

Source map: wikipedia



The great Atlantic bluefin tuna migration

Some examples of routes that have been monitored over periods of several years.

Entry route to Mediterranean, 1999.
Rooker et al. 2007. Reviews in Fisheries Science, 15, 265-310.

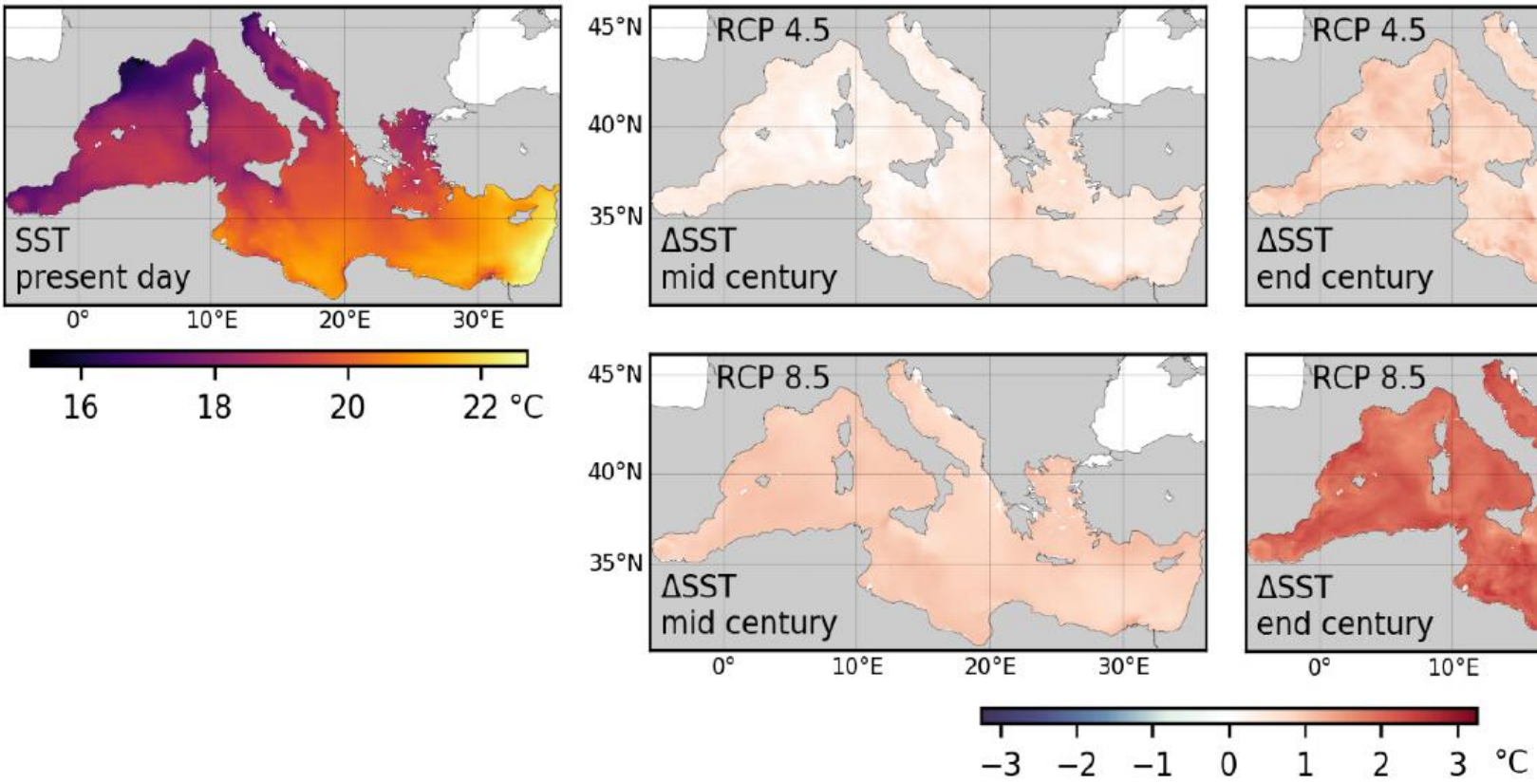
Entry route to Mediterranean, 2001.
Rooker et al. 2007. Reviews in Fisheries Science, 15, 265-310.

Exit route from Mediterranean, 2013.
Badia et al 2016. Peer J Preprints 4:e1813v1.

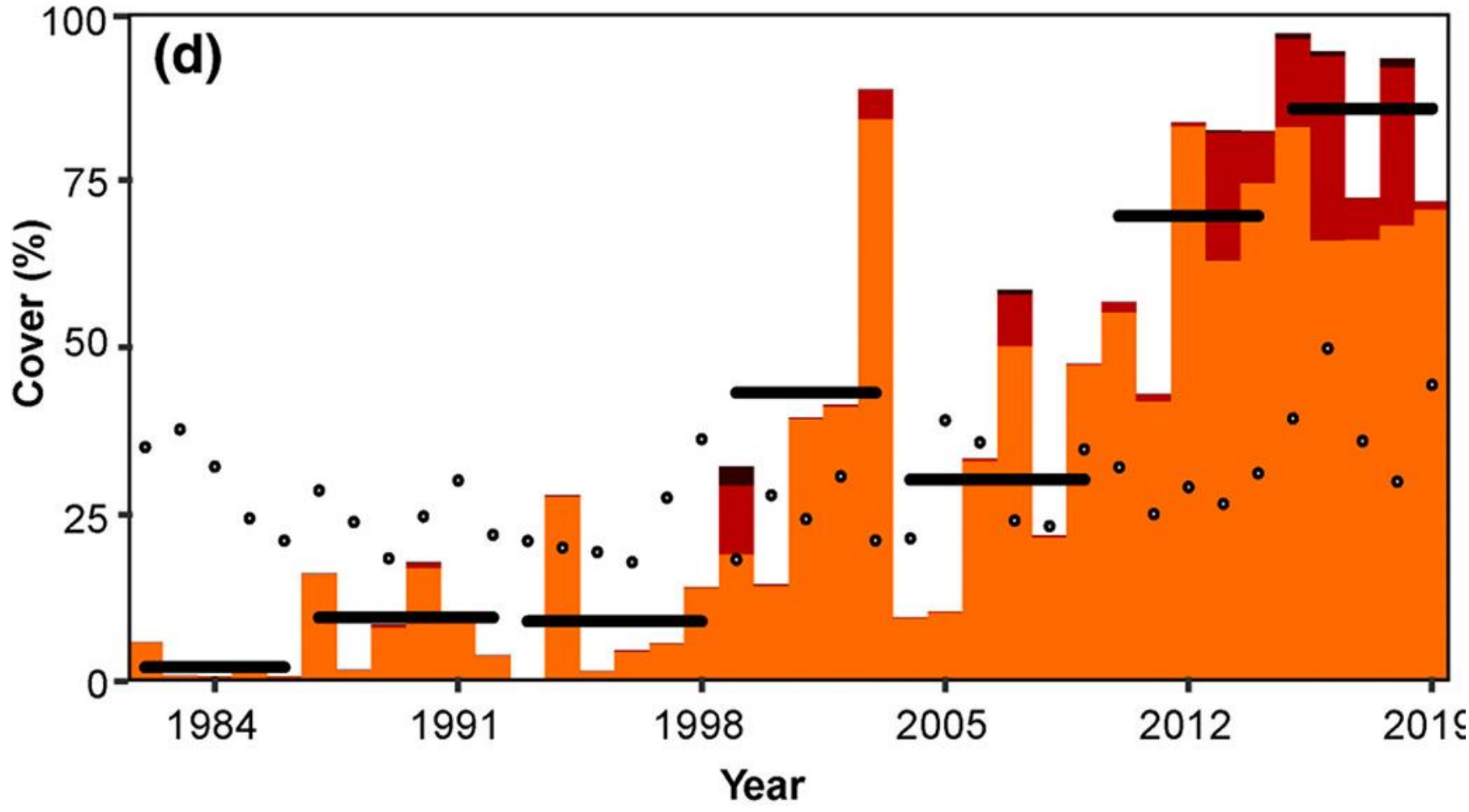
Entry route to Mediterranean, 2004.
Data supplied by Molly and Tim Molly Lutcavage and Tim Lam.

Planet tuna

The Mediterranean sea is warming

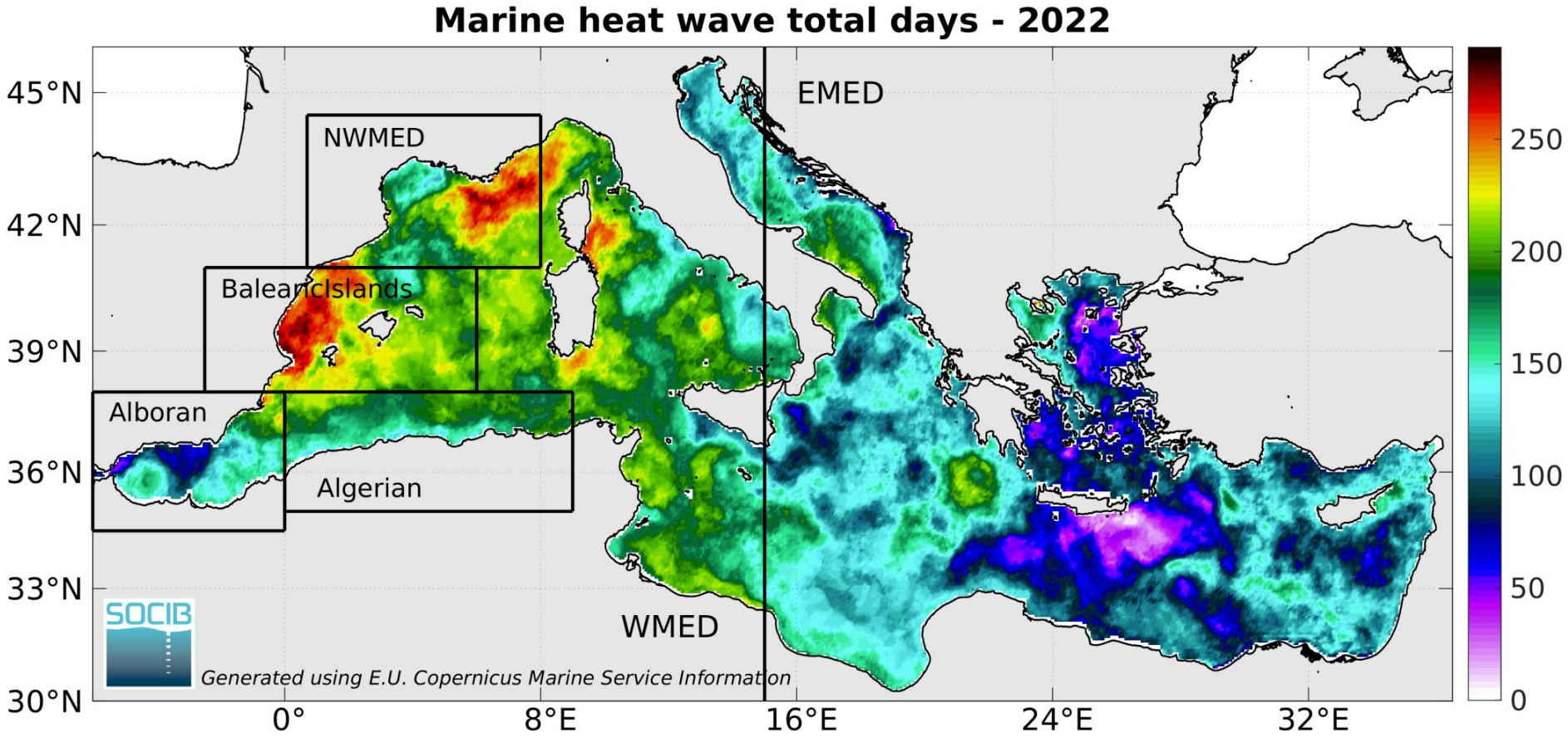


Marine heatwaves in the Med: min 5 days, 3—4ºC above average



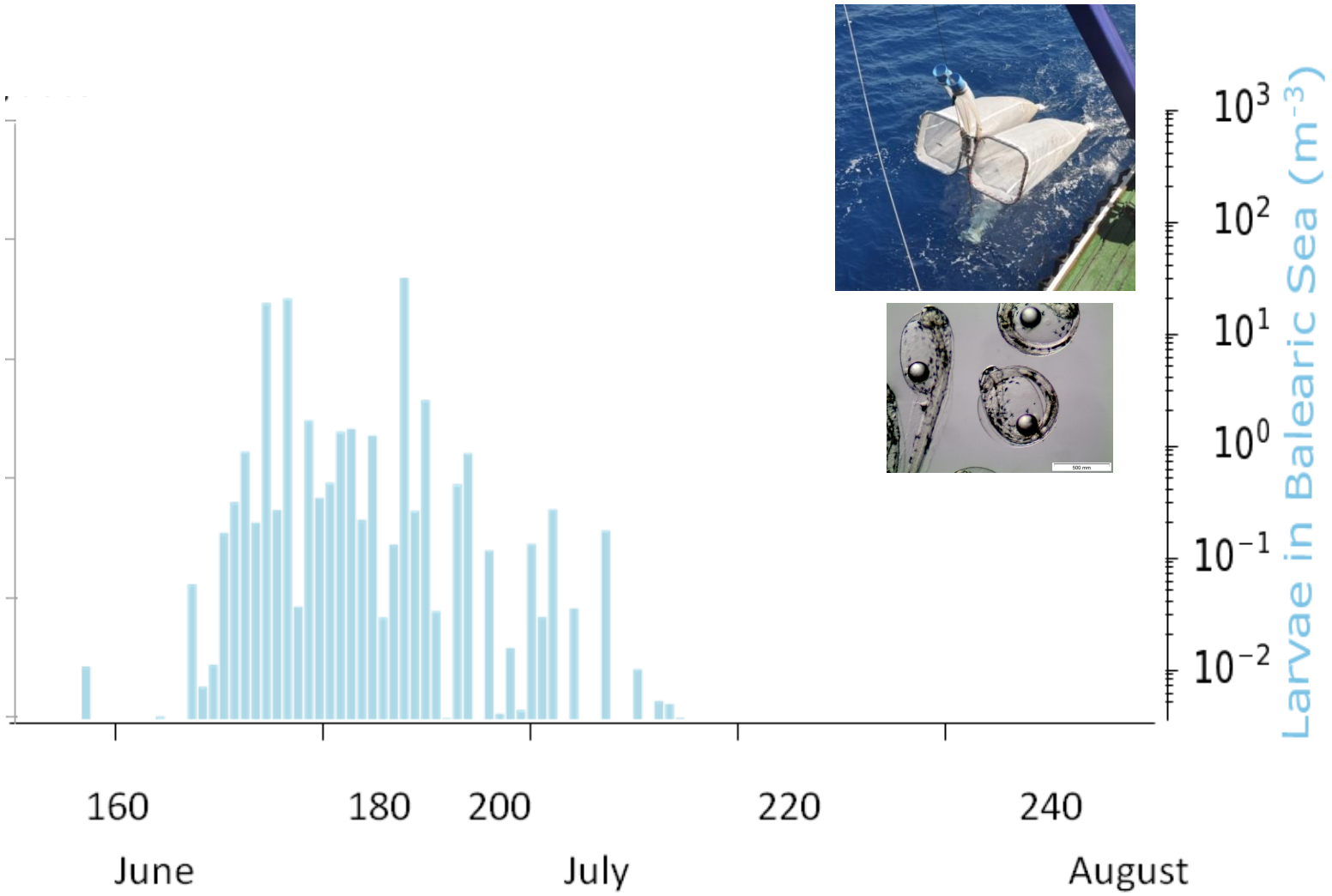
Garrabou et al. 2022

Marine heatwaves in the Med

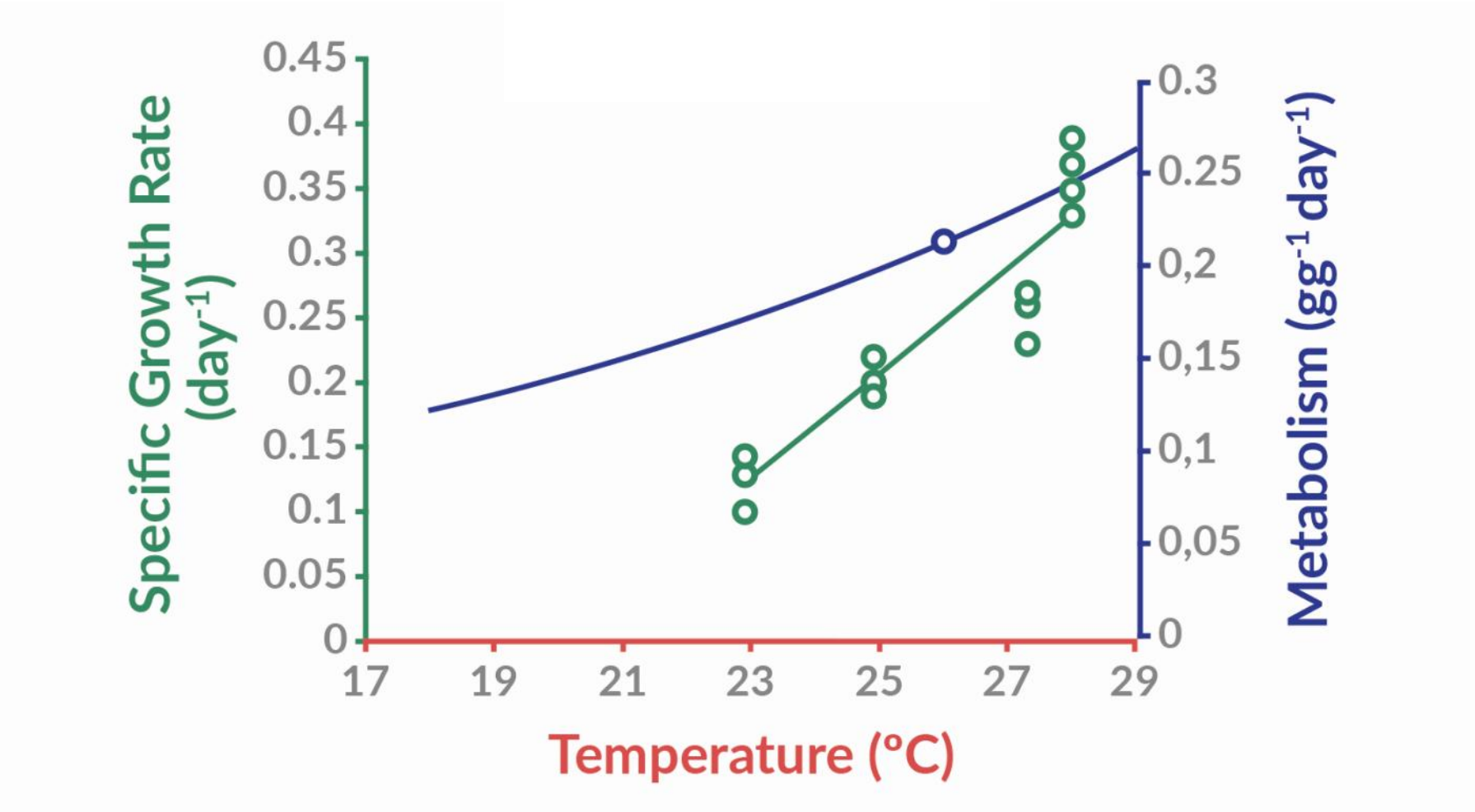


https://apps.socib.es/subregmed-marine-heat waves_indices.htm

Marine heatwaves: often over a restricted time period relevant for the egg/larval stages



High temperatures increase larval growth, metabolism



Fiksen and Reglero 2022

High temperatures increase larval growth, metabolism and food needs

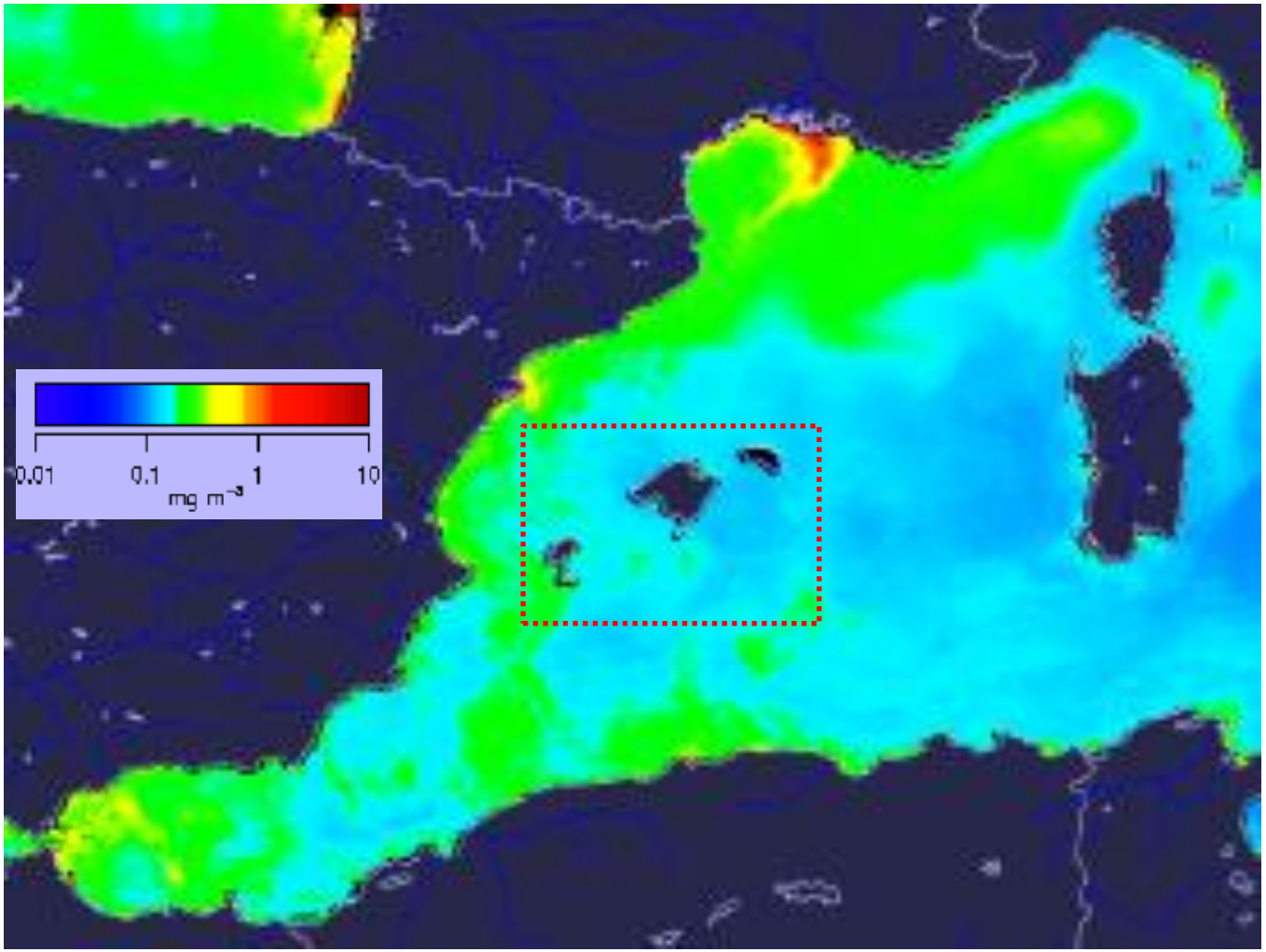
Nauplia

Copepod

Cladocera

Tuna larvae
(yolk sac and preflexion)

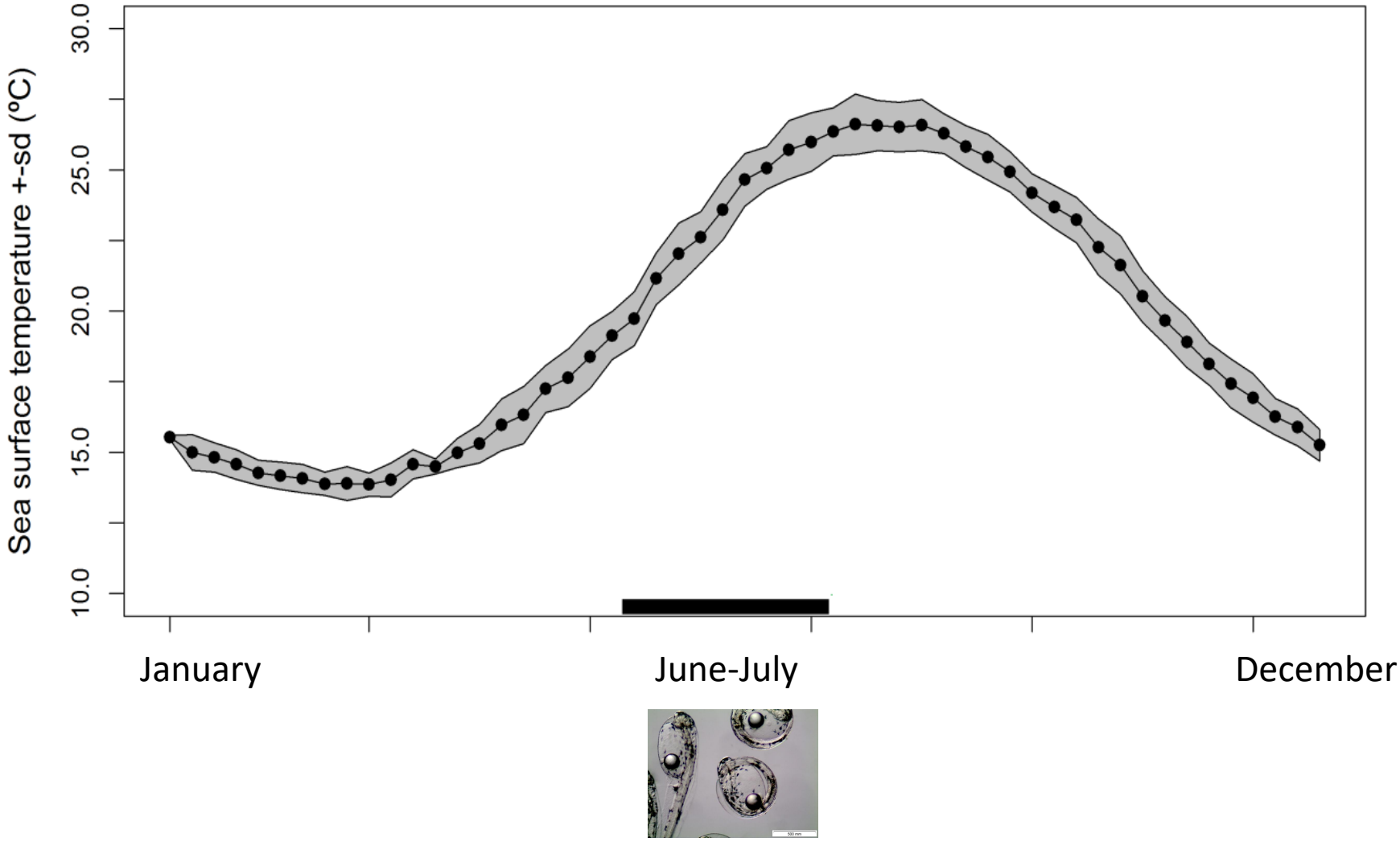
Low food availability in spawning areas

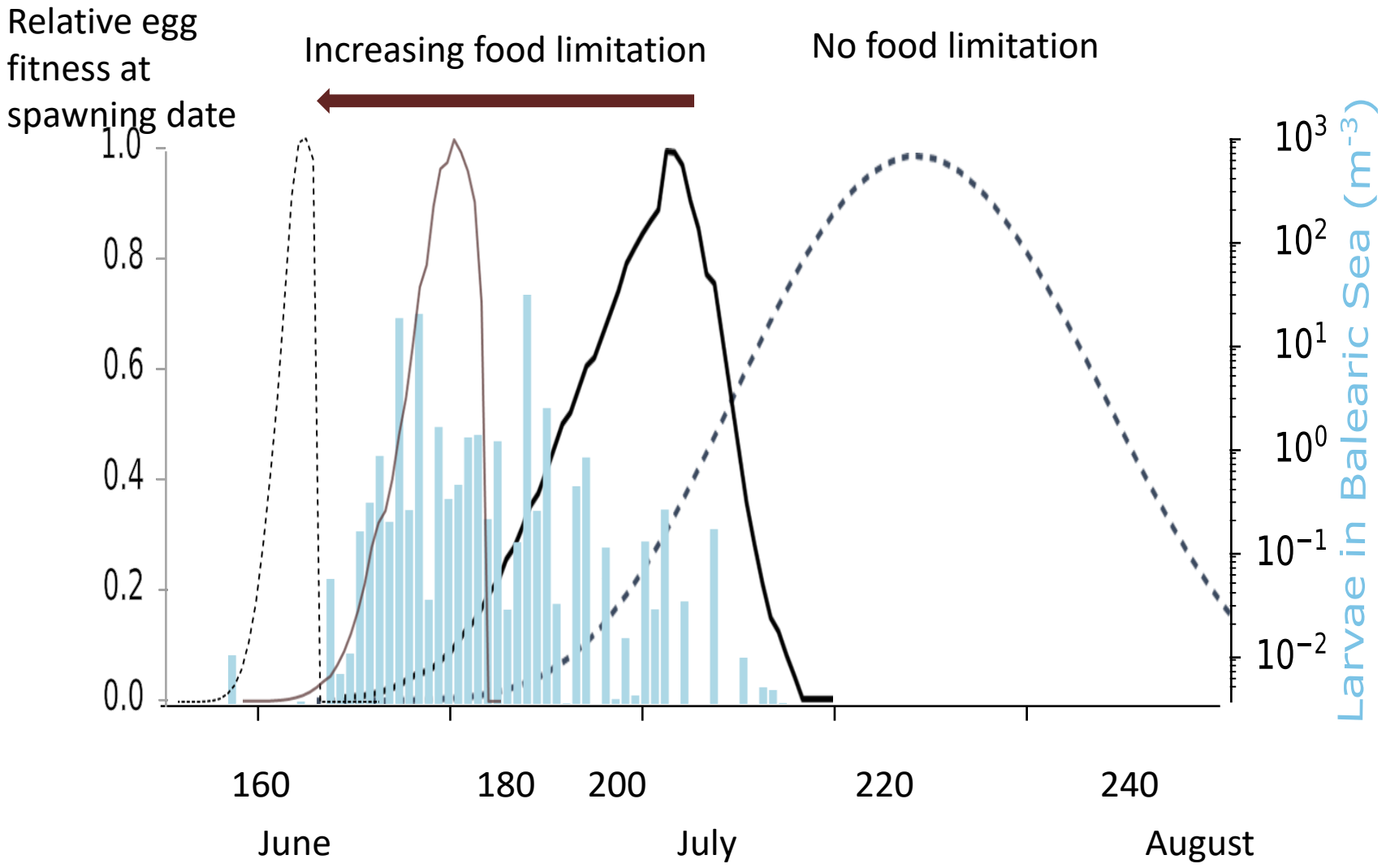


Newport line summer zoop biomass: 25-50 mg DW m^{-3}. High values ~ 60 mg DW m^{-3}

Food and temperature determines the timing of reproduction and the survival of Bluefin tuna

Tuna spawning when temperatures rise

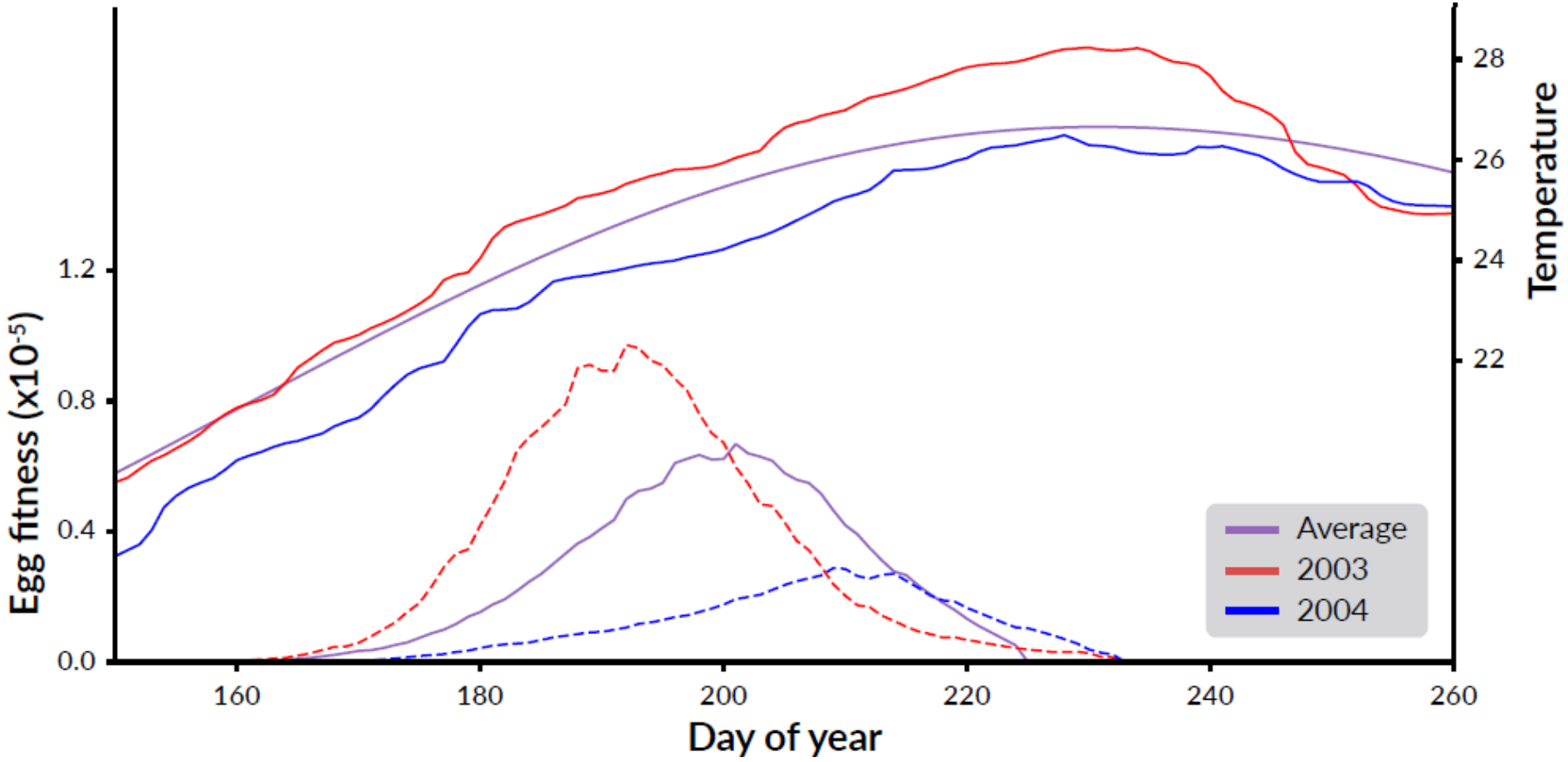




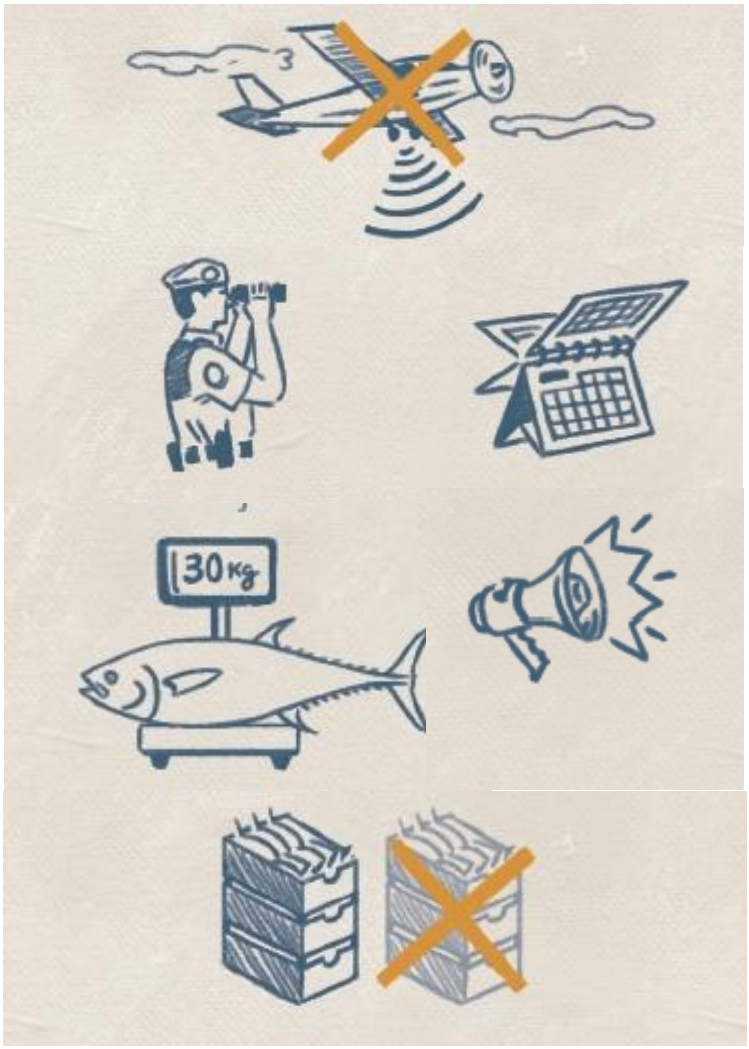
Fiksen and Reglero 2022

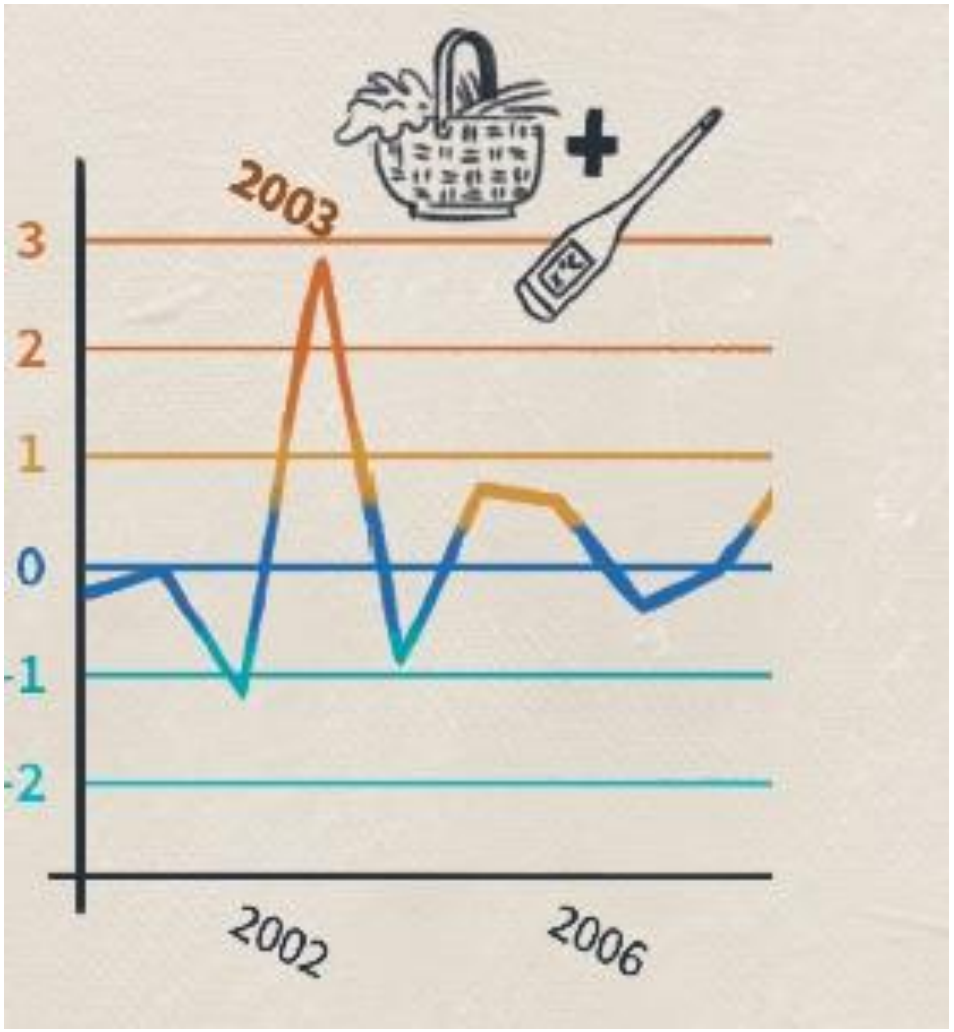
The mechanism:
With very warm temperatures the energy needs exceed the larvae feeding rates

Warm years (red) vs “cold” years (blue)



Reasons for recovery of Atlantic Bluefin tuna





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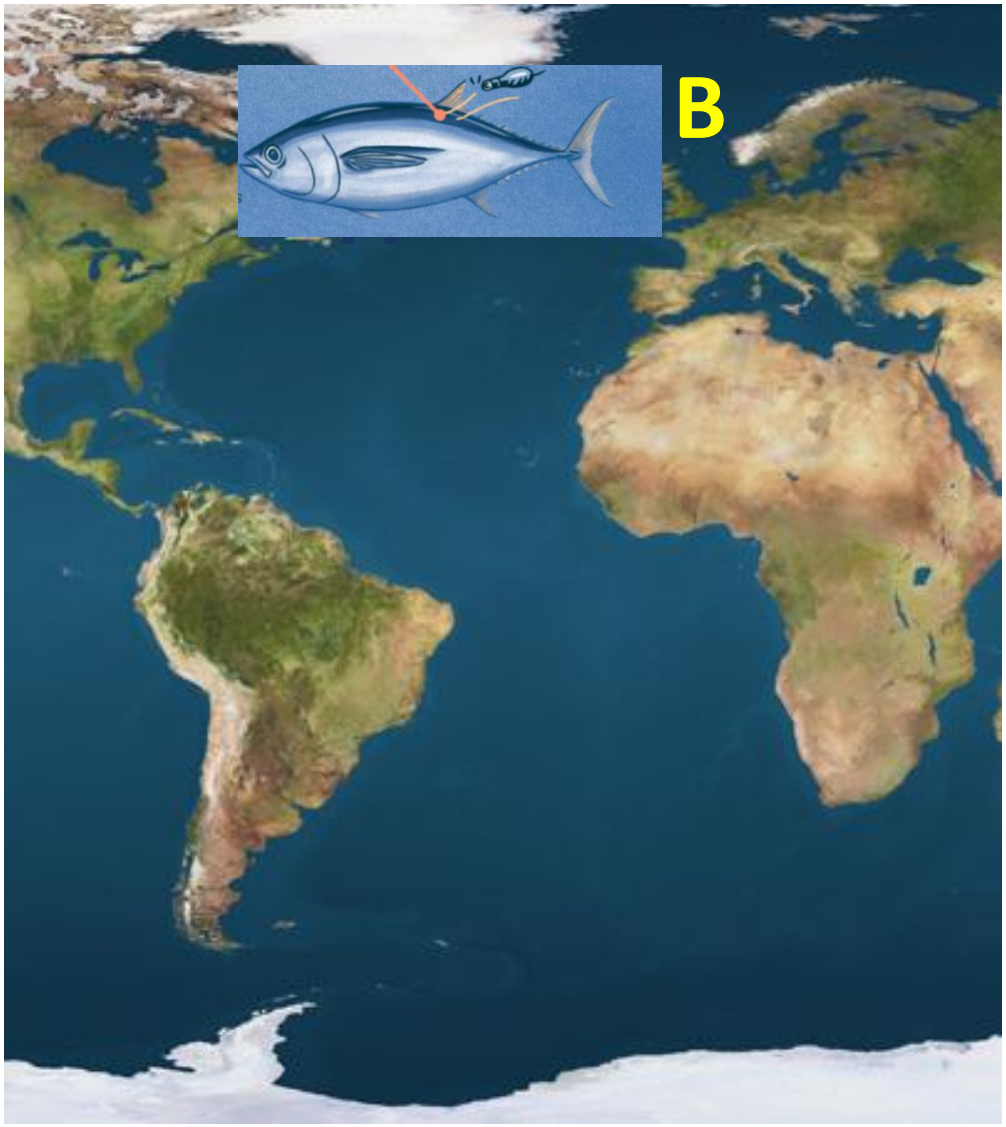
Could strong recruitments affect tuna migrations later in life?



Source map: wikipedia

B. Return to summer habitat after 50 years: tuna are assigned to the Med (220-250 cm, 12-15 years)

Aarestrup et al. 2022. Tagging data from fish in Scandinavia

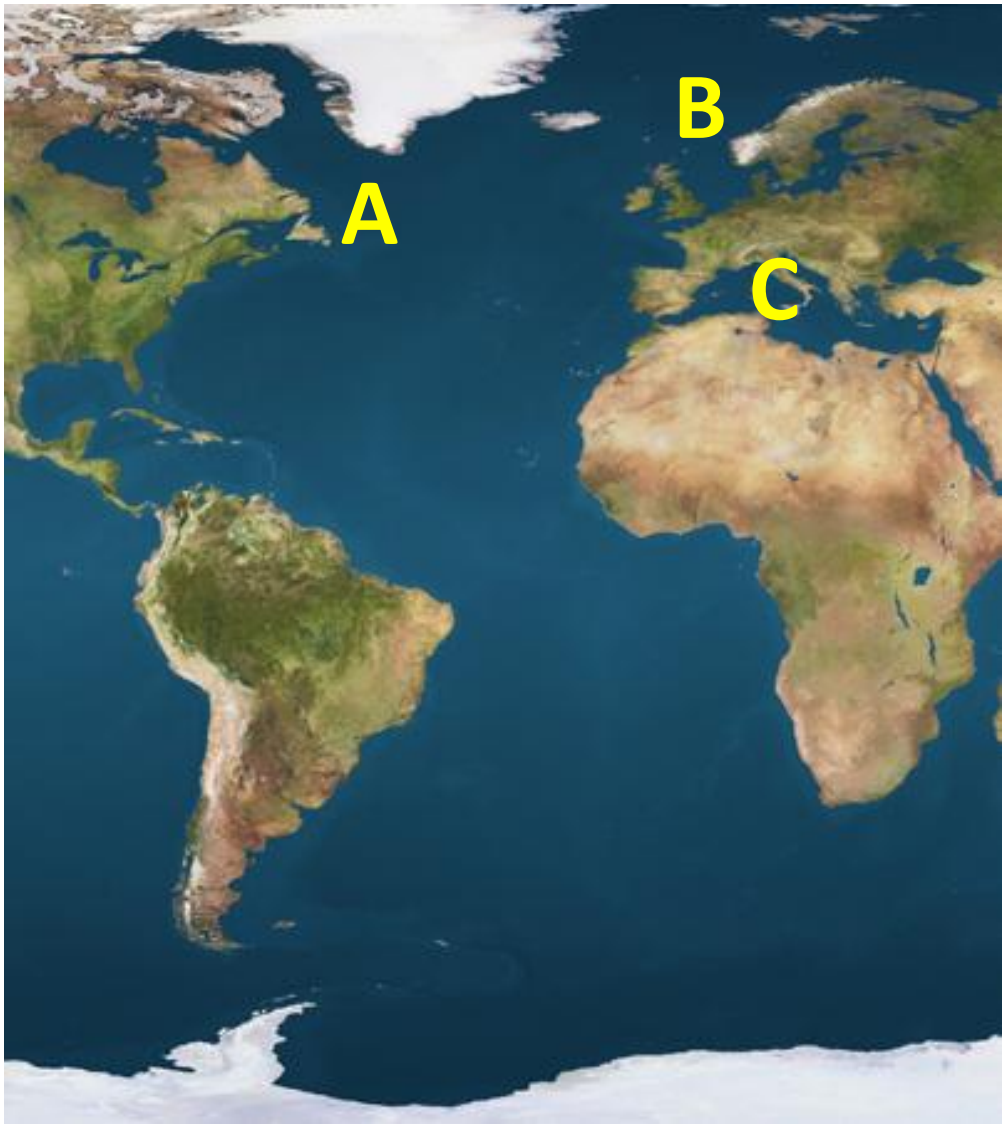
Could strong recruitments affect tuna migrations later in life?

A. Summer range expansion to new areas 2012+: part of tuna in the Slope sea are assigned to the Med

Source map: wikipedia

GBYP report

The Mediterranean Sea



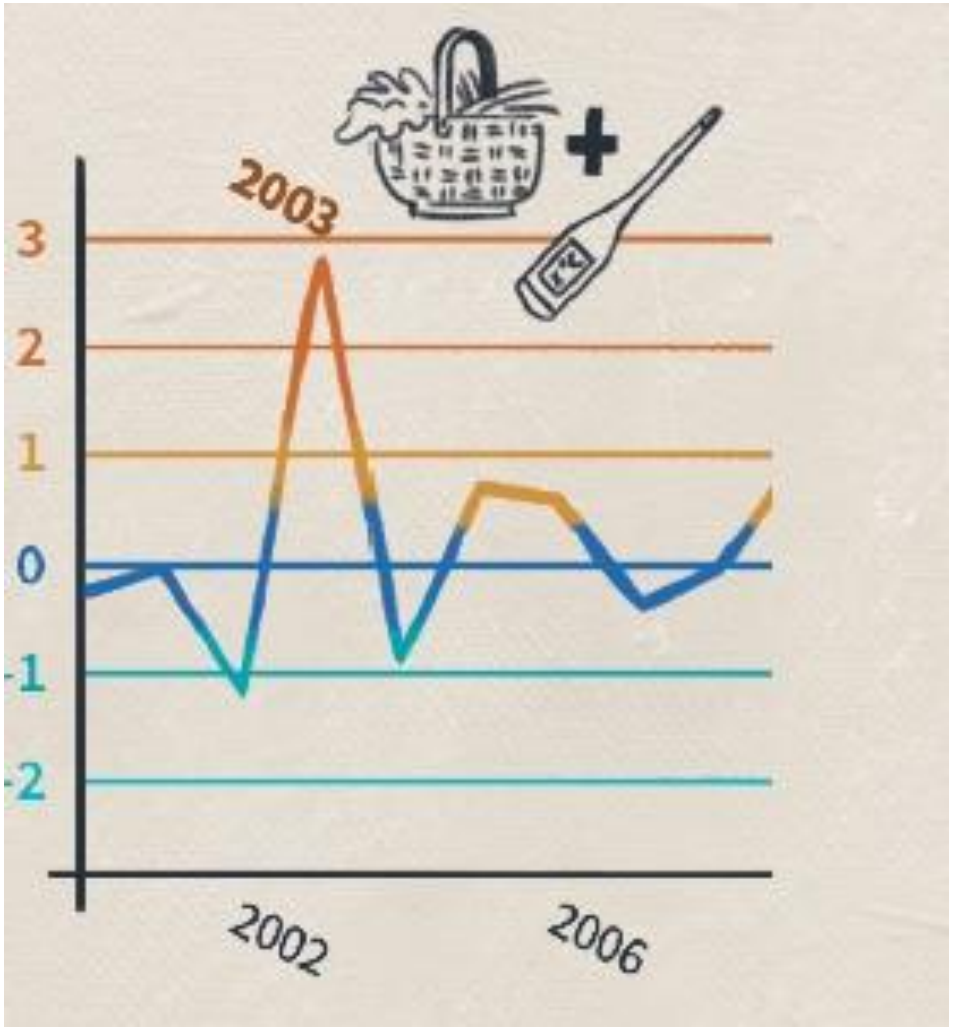
A. Summer range expansion to new areas 2012+

B. Return to summer habitat after 50 years

C. Recruitment associated to mesoscale oceanography and marine heatwaves

Source map: wikipedia

Can we generalize the effect of heatwaves on bluefin tuna recruitment?



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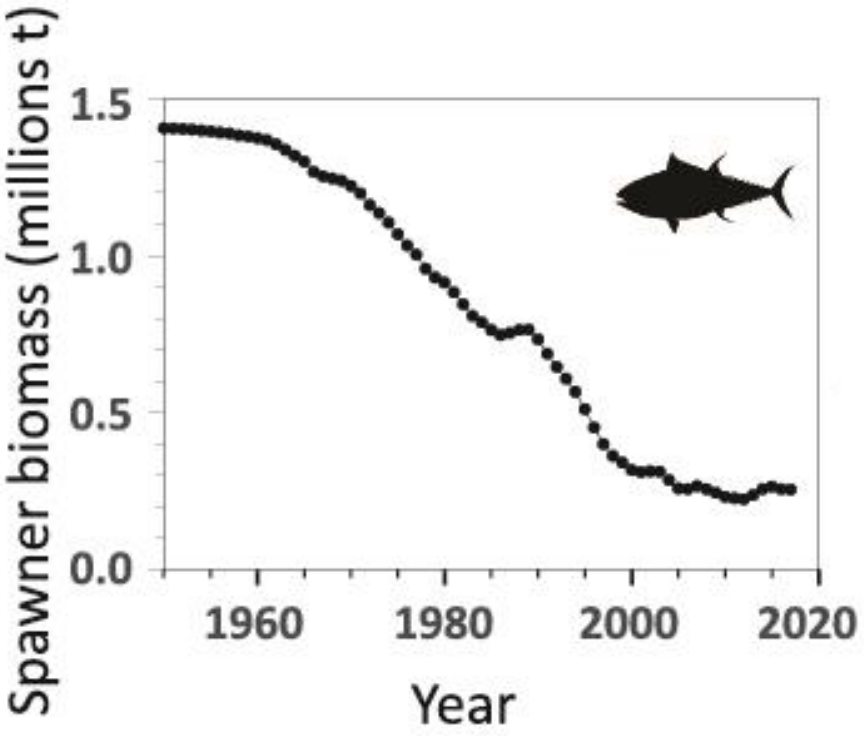
What about bigeye tuna?



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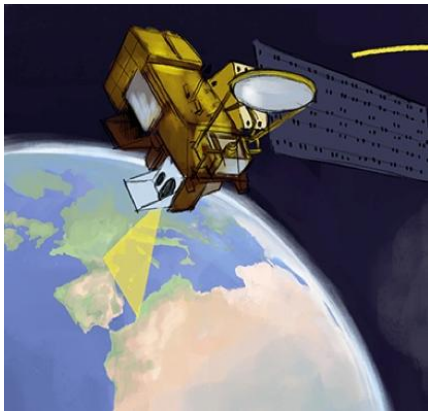
Subcommittee on ecosystems
Ecosystem Report Card



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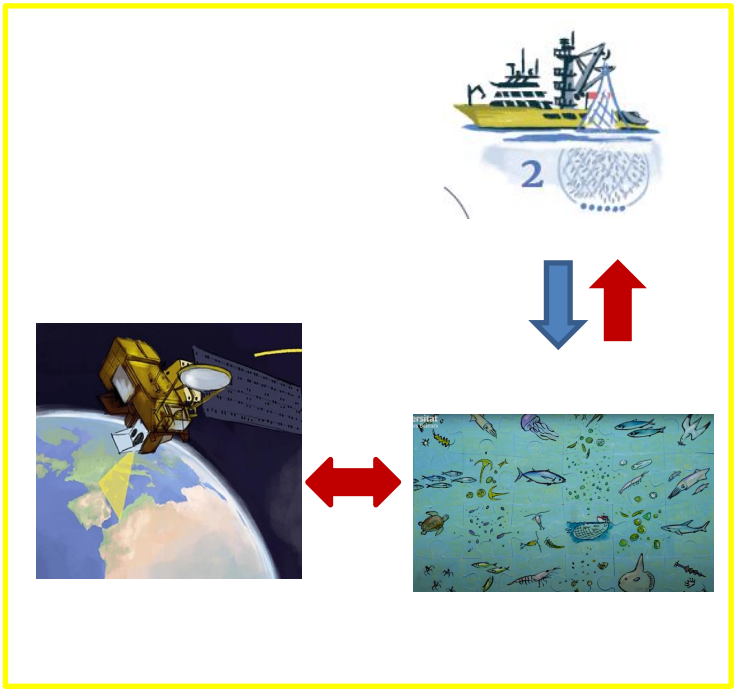
Alvarez-Berastegui et al.

Mediterranean observatory



Alvarez-Berastegui et al. 2023

Resolution by ICCAT on climate change (2022)

It is necessary to evaluate the impact of changing oceanographic conditions resulting from climate change when managing tuna stocks, species, and ecosystems

Future operating model reconditioning in Bluefin tuna MSE

It may include more explicit environmental linkages to specific biological process, which might allow for incorporation of climate change scenarios as well as the potential development of climate-informed management procedures, responding to ICCAT Rec 22-13

GBYP meeting, Palermo 2022

The IPCC's Sixth Assessment Report (2021)

Chapter 3 raises warnings about the vulnerability of marine ecosystems to future increases in the intensity and duration of marine heat waves.

The report also flags the need to assess potential phenological shifts and trophic mismatches in key marine species.

Summary

-Identify species, ecosystem and environmental tipping points and underlying processes that can trigger changes in ecosystem productivity.

-Mediterranean: main spawning ground can control populations in the feeding grounds of the north and central Atlantic oceans

-Process-based knowledge and mechanistic understanding of processes

-Early life history in life cycles

-Monitoring environmental and ecological changes

-Heatwaves are difficult to predict

-Assessments: Work on the new ICCAT resolution and keep insisting on including environmental variability in the assessments.

-Improve communication

Particular thanks to collaborators for today's presentation

Oyvind Fiksen
Edurne Blanco
Diego Alvarez-Berastegui
Melissa Martin
Daniel Ottmann
Francisco Javier Abascal
Asvin Perez-Torres
Pilar Tugores,
Aurelio Ortega,
Fernando de la Gándara
Mar Santandreu,
Nelly Calcina

People in PERSEUS, CERES, PANDORA, TUNIBAL
People in Planet Tuna


Thank you!
500 µm