

BLUEFIN TUNA MIGRATIONS IN THE FACE OF CLIMATE CHANGE

PRELIMINARY RESULTS AND PERSPECTIVES FROM THE PROMPT AND FISHCHIP PROJECTS

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Climate impact on Bluefin tuna



An immediate problem for Bluefin tuna (BFT) exploitation and conservation

- Highly migratory species
- Movements/habitat affected by environmental conditions
- Most of the exploitation based on migrations into the Med for spawning

-> Understand migrations in the face of climate change (CC) is essential

Background

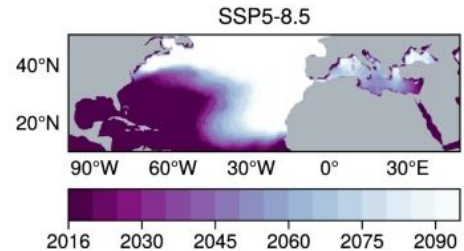
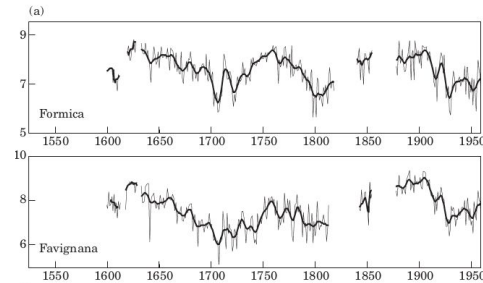
- Sea Surface Temperature could affect migrations in the Mediterranean (Ravier and Fromentin 2004)
- Climate could affect productivity and habitat, for instance AMO phases (Failletaz et al. 2019)
- Shifts in distribution in western stock explained by Sea Surface Temperature (Hansell et al. 2022)
- Areas becoming physiologically challenging with CC (Trueman et al. 2023)
- Impact on management (Dell'Apa et al. 2018, Carruthers et al. 2024, SCRS/2024/104)
- Gets into tuna RFMOs: Report of the ICCAT Climate Change Experts Meeting (July 2023)

-> Consensus on the potential effects CC on many aspects of BFT, but mechanisms still unclear

Recent observations

- Return of BFT in higher latitudes
- BFT staying longer in some areas, new feeding grounds
- Surprising events (e.g. lack of large fish in the Med during 2024 season, new spawning grounds, increase in larvae, residency in some areas ...)

-> Are we witnessing the effects of CC on migration/movements ?



Our approach



PROMPT project

- Funded by France Filière Pêche
- Dig into the processes affecting migrations

-> Getting a mechanistic understanding of the effects of CC on migrations

Describe migrations: tagging

- What are current migrations ?
- Structure within the Mediterranean and in the Atlantic ?

-> Adopt a tagging strategy representative of the exploitation

Physiology of migration: experiments

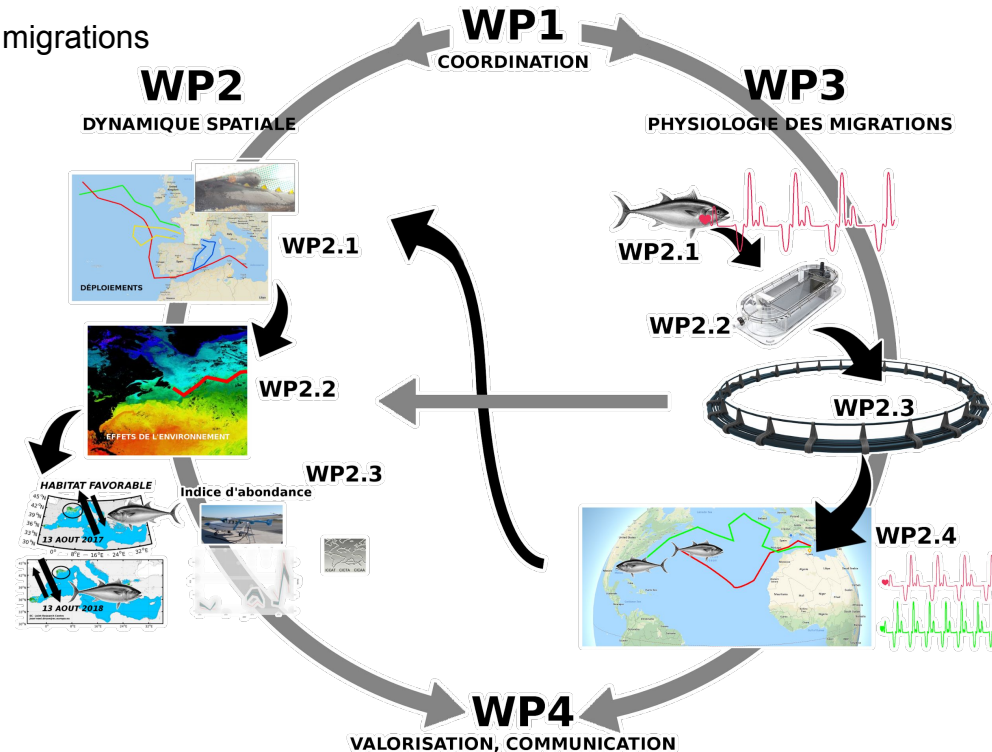
- What is the energy consumption for movement ?
- What are the physiological optimal conditions ?
- How the environment will affect this ?

-> Get a mechanistic understanding

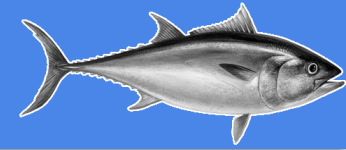
Integrating information: DEB end-to-end modeling

- Model complete life cycle and physiological effect
- Integrate environmental forcing
- Integrate behavioural aspects

-> Explain current behavior and project it into the future




Tagging confirm size-based movements

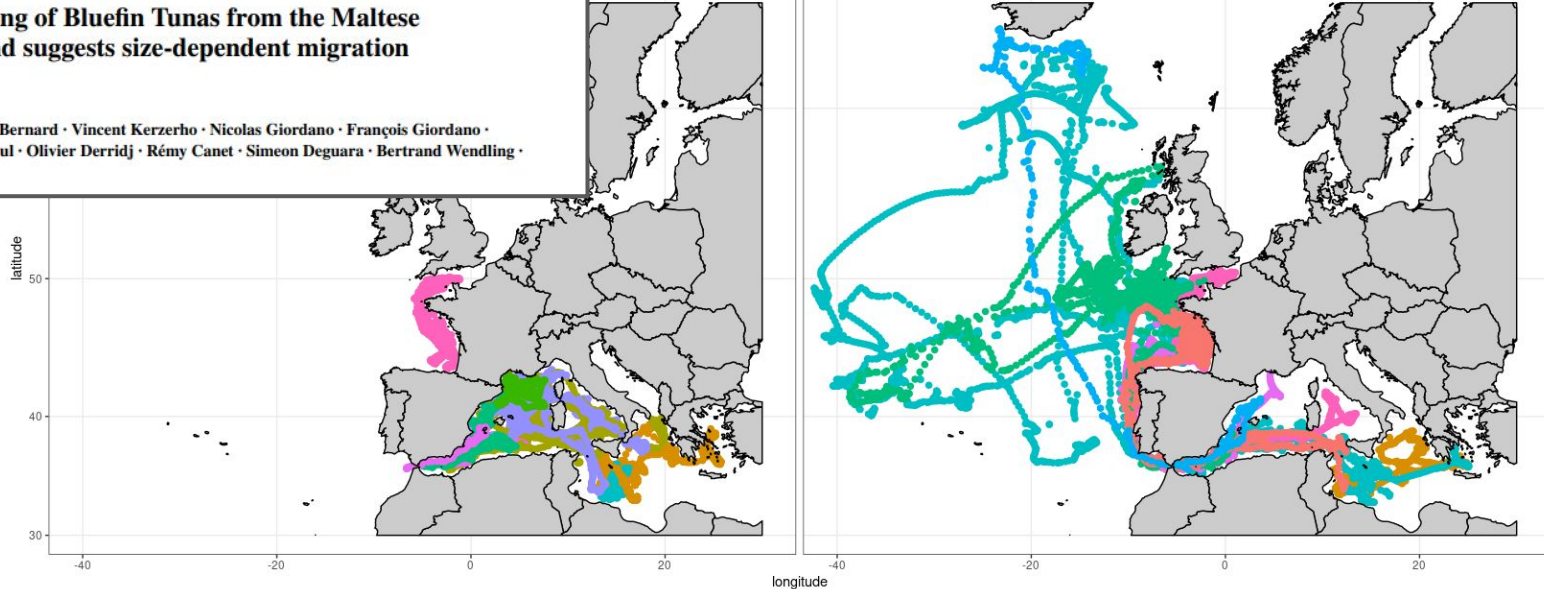


Environ Biol Fish (2022) 105:635–644
<https://doi.org/10.1007/s10641-022-01262-4>



Electronic tagging of Bluefin Tunas from the Maltese spawning ground suggests size-dependent migration dynamics

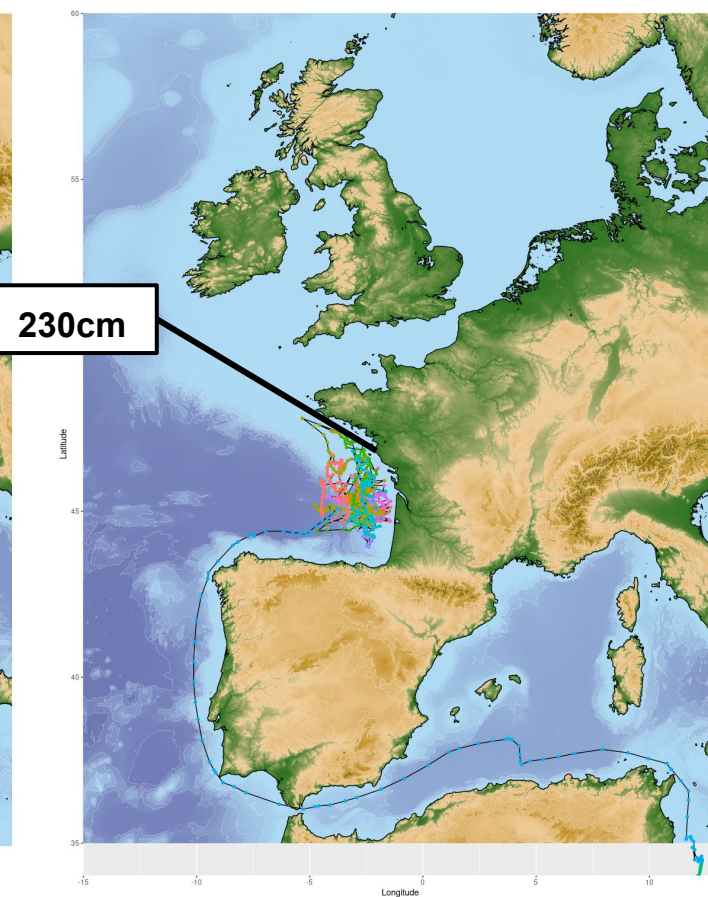
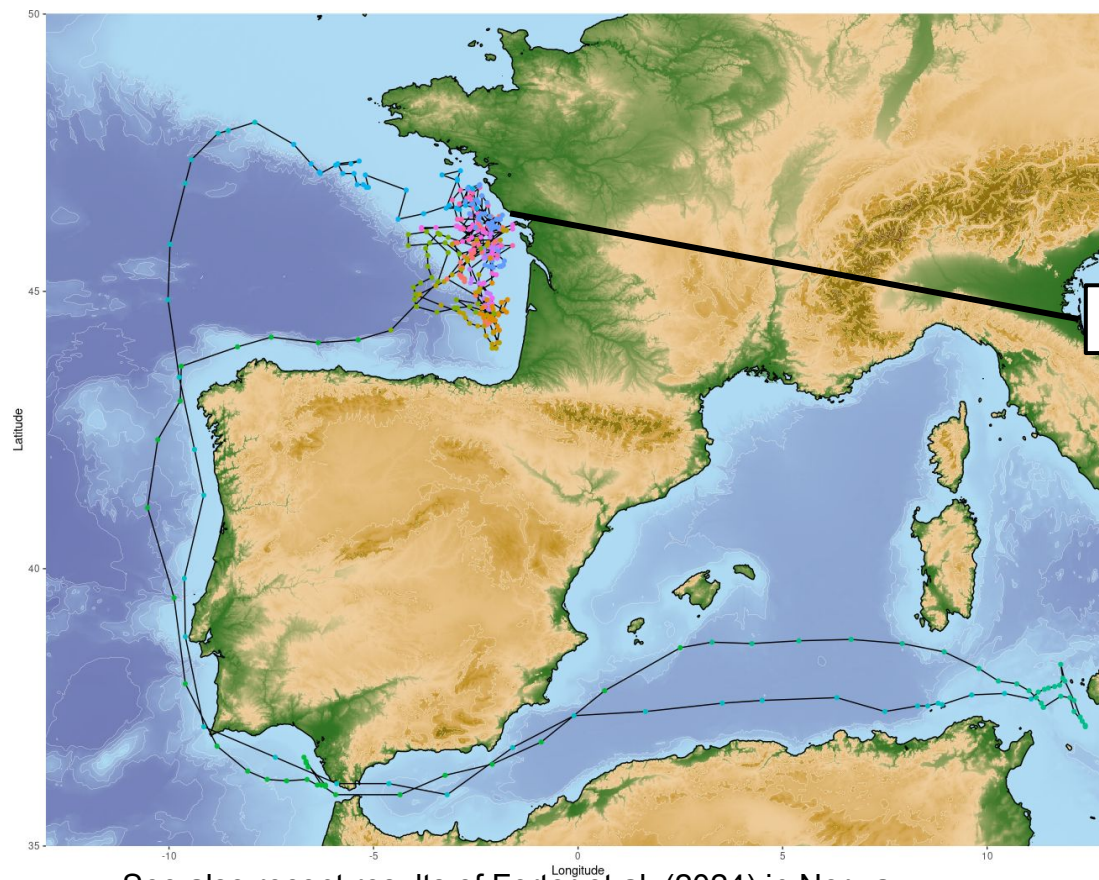
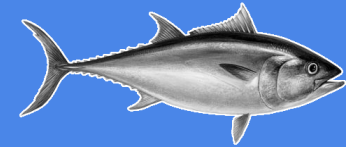
Tristan Rouyer  · Serge Bernard · Vincent Kerzerho · Nicolas Giordano · François Giordano · Salvu Ellul · Giovanni Ellul · Olivier Derridj · Rémy Canet · Simeon Deguara · Bertrand Wendling · Sylvain Bonhommeau



Many aspects

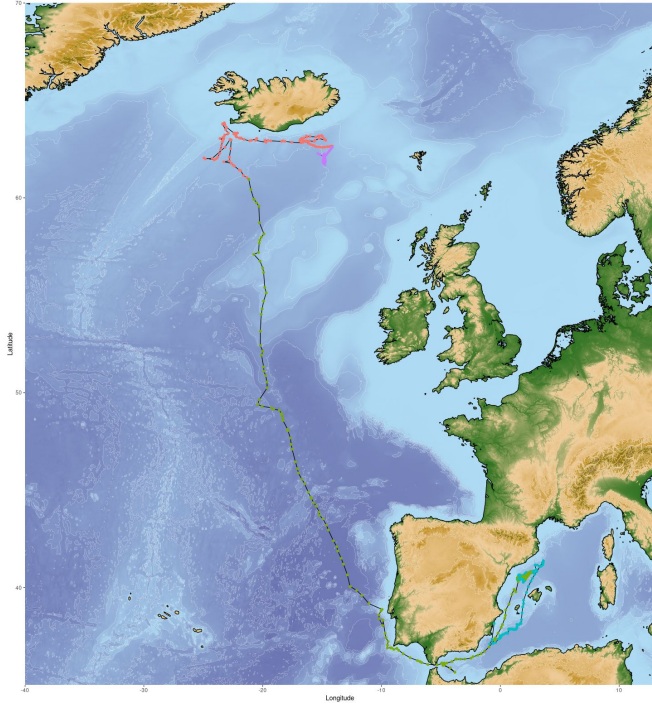
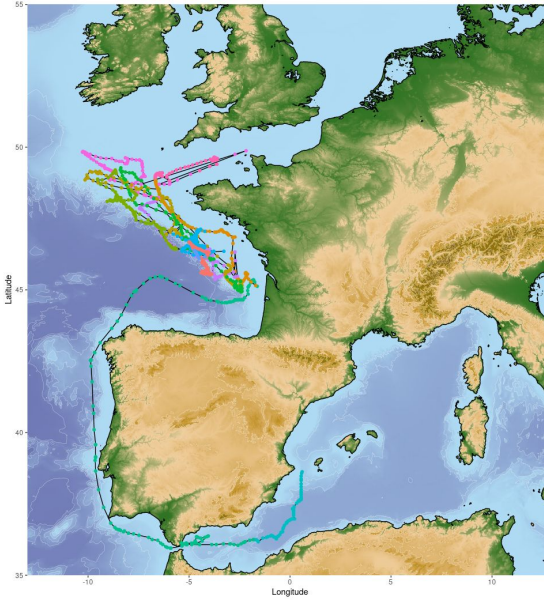
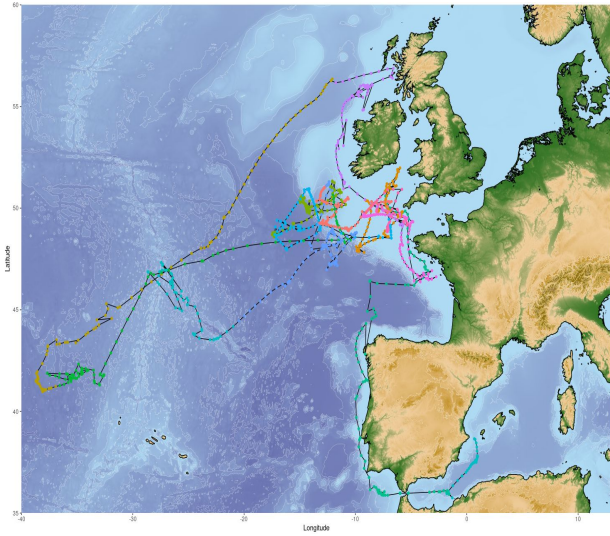
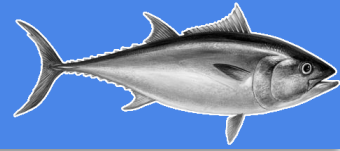
- Different movements small/large fish
- Small fish from the Med stay in the Med.
- Large fish get out after spawning, some of them don't come back in the Med. Fidelity to feeding.

Tagging from feeding areas: fidelity



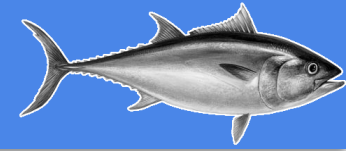
See also recent results of Ferter et al. (2024) in Norway

Tagging from spawning ground: diversity



- > More tags to come, also aiming for multiple years: coming back to the same spawning ground ?
- > Residency in the Mediterranean ?

Physiology: logging heart rate



Received: 1 June 2023 | Revised: 13 July 2023 | Accepted: 19 July 2023

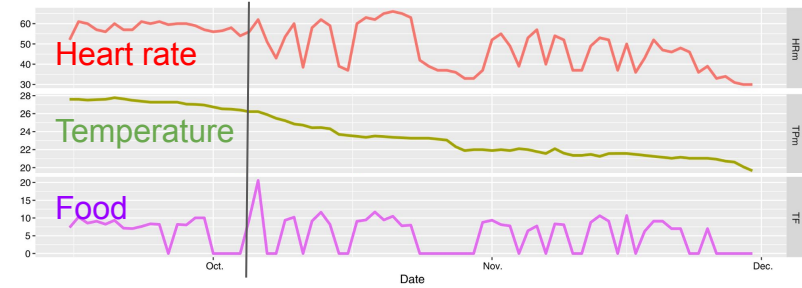
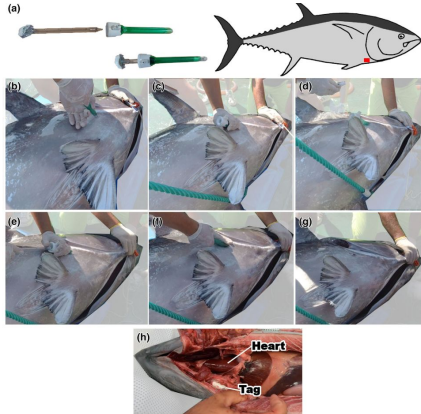
DOI: 10.1111/jfb.15507

REGULAR ARTICLE

JOURNAL OF FISH BIOLOGY

A novel protocol for rapid deployment of heart rate data storage tags in Atlantic bluefin tuna *Thunnus thynnus* reveals cardiac responses to temperature and feeding

T. Rouyer¹ | S. Bonhommeau² | S. Bernard³ | V. Kerzerho³ | O. Derridj¹ |
Á. Bjarnason⁴ | H. Allal⁵ | J. F. Steffensen⁶ | S. Deguara⁷ | B. Wendling⁸ |
G. Bal⁹ | D. Thambithurai¹ | D. J. McKenzie¹



Threshold:
Date at which T° goes below
25°C

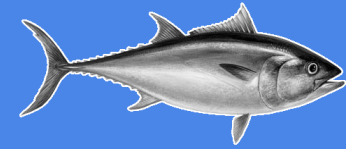
Heart rate: a challenge

- A building block for fish physiology
 - A challenge for BFT
- > Development of a new method

Observed variations of heart rate over 2.5 months

- Effect of temperature and food
 - Effect of food seems to decrease above 25°C
- > Suggested a potential temperature threshold

Physiology: large scale experiment



<https://vimeo.com/787590263/4731615c97>

With english subtitles: <https://vimeo.com/803406307>

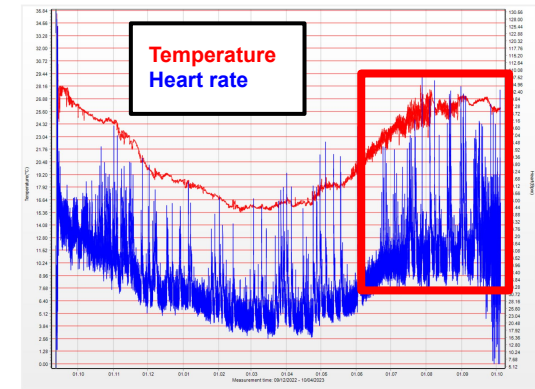
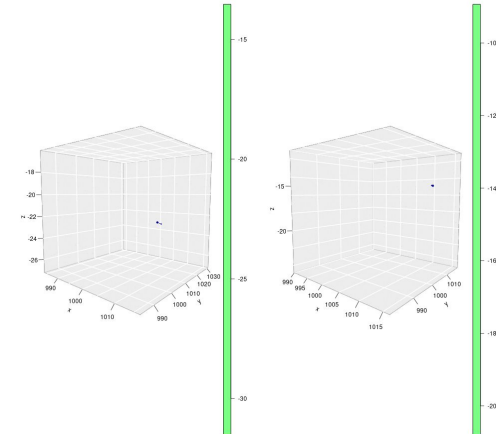


Successful experiment

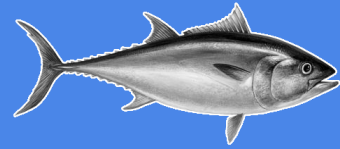
- Heatwave in summer 2023
 - Looking at its effects on activity, heart rate, group behaviour ...
 - Clear effect of temperature, can we see a threshold at 25°C ?
- > Under investigation, very large dataset

27 tunas (20-200kg) over 1 year, Malta

- Movement
- Heart rate
- Activity
- Energy...



Physiology: respirometer and energetics



Respirometry

- Trying to estimate O₂ necessary for swimming
- Link it to heart-rate

-> Energy consumption

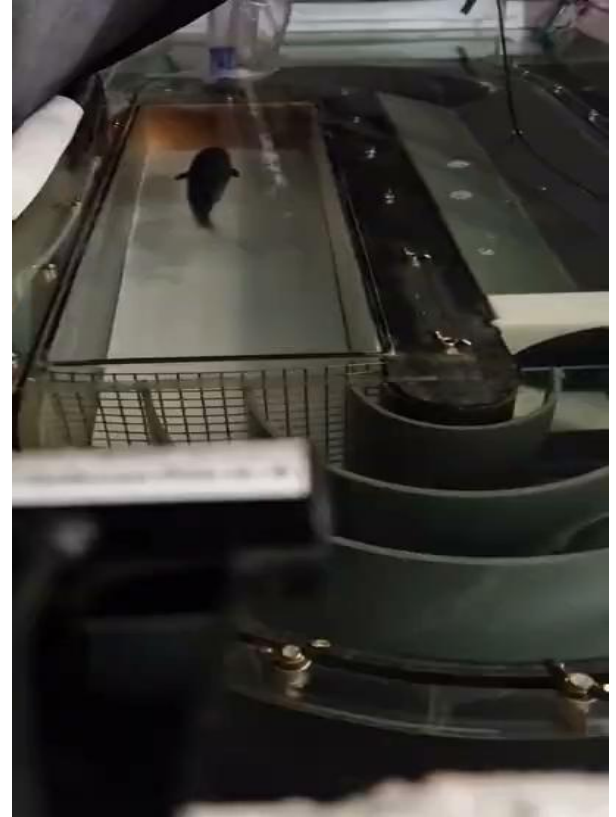
In theory it works...

- Initial plan was on big fish in Malta
- Attempts on small fish in Spain in 2023
- In 2024, doing HRT + respirometry

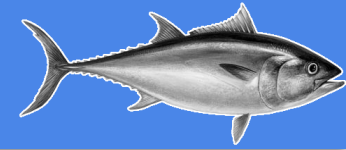
-> Then we know how much O₂ through HR

Moving to trying different temperatures, sizes...

-> Energetic cost of movements depending on conditions



What do we learn at this stage ?



Migrations

- Size based spawning transitions in both directions
- > Meaning of the size ? Young mature stay in the Bay of Biscay ?
- Strong fidelity to feeding ground: Same group returning to the same area ?
- > Implications for migratory routes

Contingent hypothesis

- Group migrate to feeding ground (when > 175cm)
 - If energetically interesting (food) then come back
- > Could explain historical pattern... and recent ?

Effect of temperature on key physiological metrics

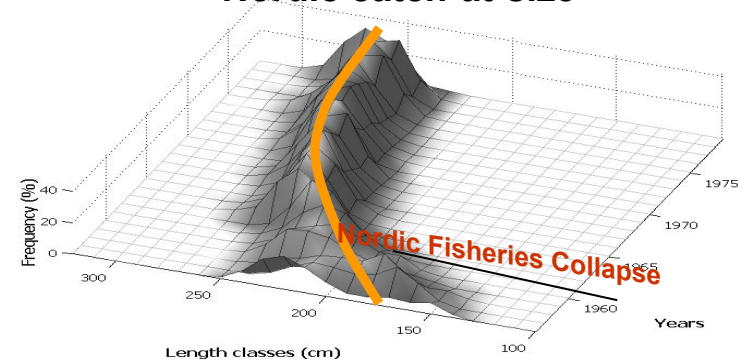
- Heart-rate -> Feeding behavior, affected by temperature
 - Energetic consumption, activity...
 - BFT thermoregulation
- > Results under investigation

Effect of CC on migrations ?

- No clear and fast change in spawning/feeding habitat (Druon et al. SCRS/P/2024/107)
 - Rebuilding of the stock might promote more 175 cm fish exploring new migratory routes within favourable environment
 - Suspect a strong behavioral component in migratory routes
 - Physiology might be impacted by high temperatures: change in energetic cost of migratory routes
- > Testing in end-to-end modeling



Nordic catch-at-size

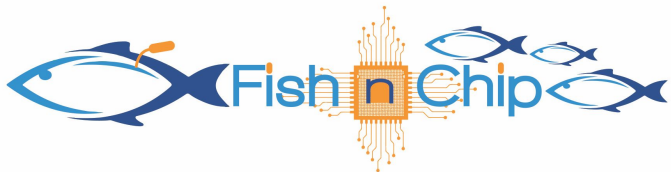


Thank you



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Tagging: size-based migrations



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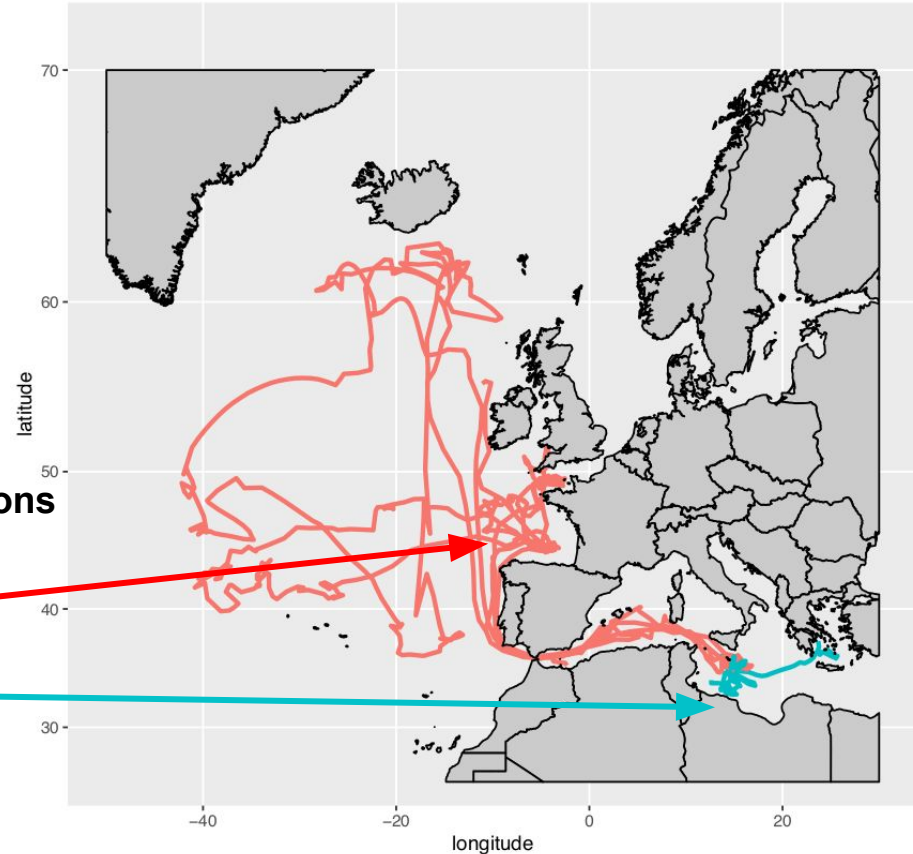
Electronic tagging of Bluefin Tunas from the Maltese spawning ground suggests size-dependent migration dynamics

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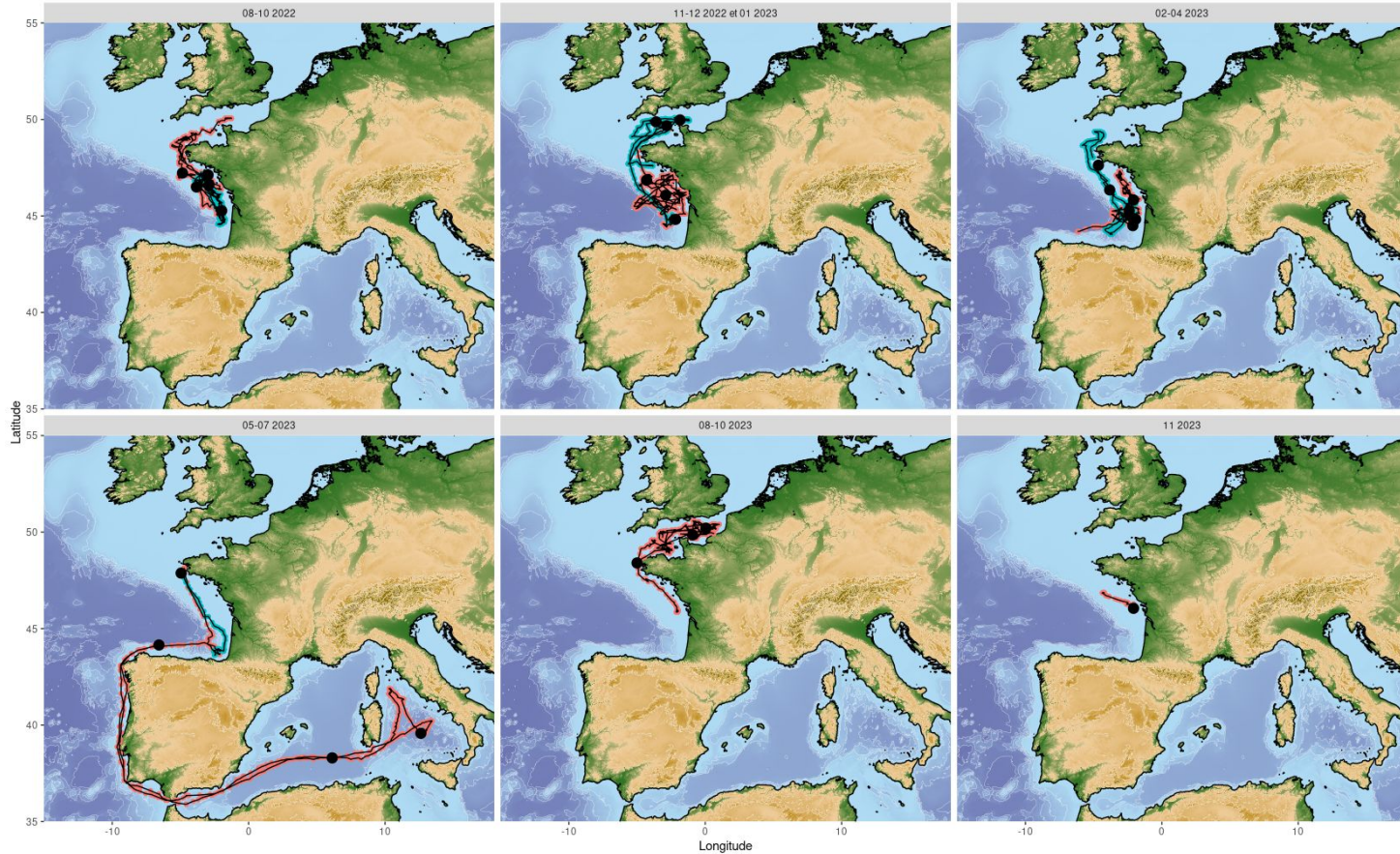
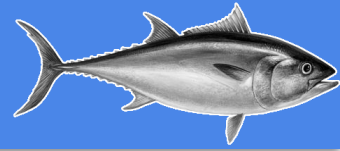
Previous results: size-based differences in migrations

- Tagging from PS in 2018-2019
- 2 years, 2 sets, 8 fish
- 4 fish > 200 cm: **transition**
- 4 fish < 200 cm: **no transition**

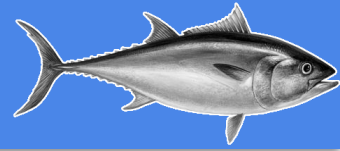
Changing migrations with size ? Residency ?



Tagging from feeding areas: fidelity

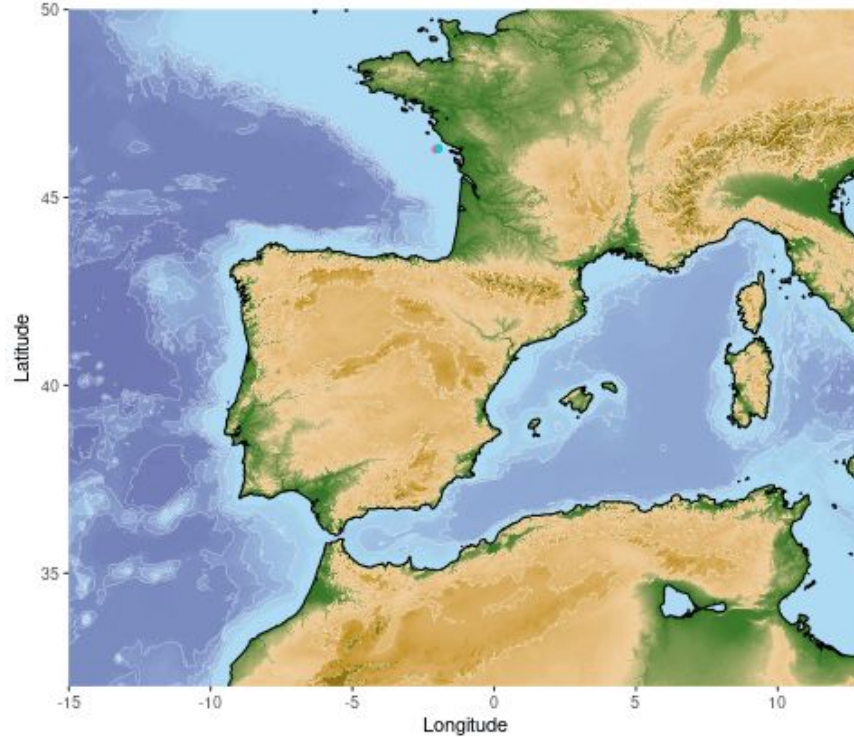


Tagging from feeding areas: synchrony

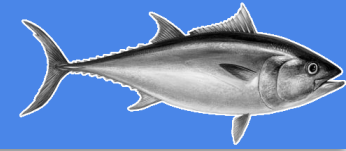


Date: 2023-09-09

Frame 1 of 386

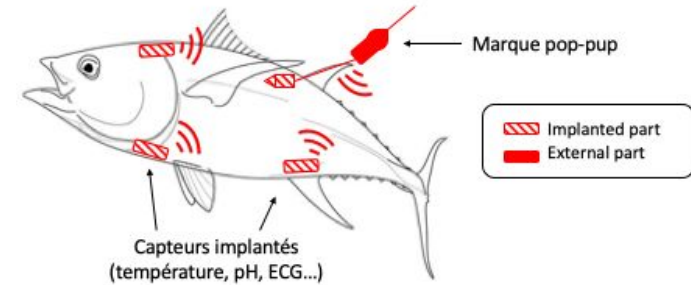


Future: physiology in the wild



Would it be possible to do heart rate and other physiological measurements on wild fish ?

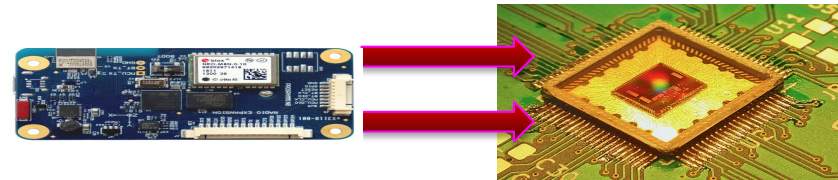
- Problem: get the data back
 - Solution: use a pop up tag
- Problem: the heart rate tag is inside, the pop up is outside
 - Solution: Transfer the data to the pop up
- Problem: it can't be any wire
 - Solution: use the body as a wire



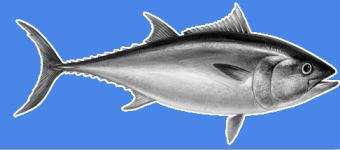
Test the potential for intra-body transmission

- Test different transmission protocols
- Trials and experiments on live fish

-> Direct measures for physiological parameters



Aiming for tracks over multiple years



Questions involving long-term programs and multiple years

- Changing migrations with size
- Fidelity (spawning / feeding)
- Response to disturbances: Climate change, wind farms...

-> Need long-term tracks

Psats

- Recent problems, expensive
- 1.5-2 years max

-> Alternative ?

Archival long-term tags (LT)

- No transmission, hard to deploy with surgery for large fish
- Cheaper, smaller, longer-term (up to 4 years)

-> Using archival tags like Psats tags

General strategy

- Favour large fish with Psat: be patient one year
- Favour young fish with archival: be very patient



Return in the northern latitudes



Is it the same story today ?

Paper showing a link to AMO

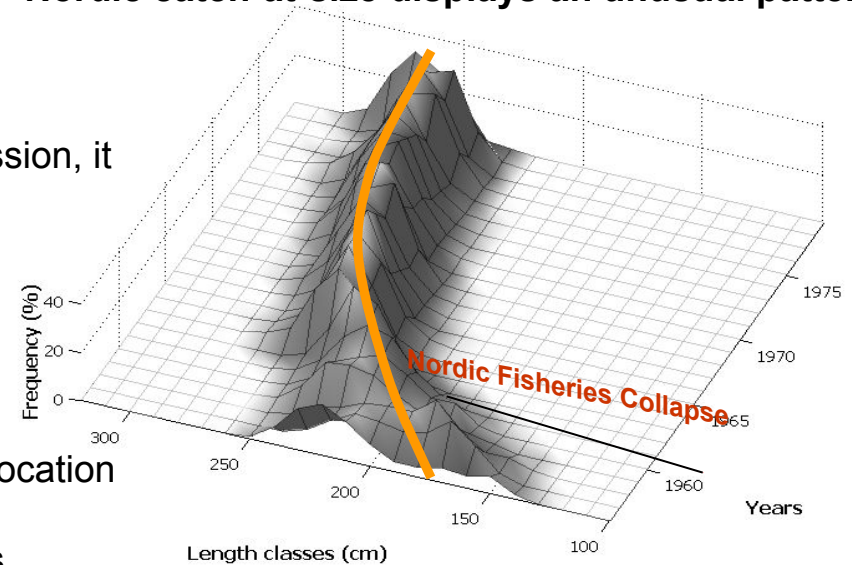
However, whereas this might be a component of the discussion, it might not be the full answer to explain the return

Druon et al. No habitat expansion in the North

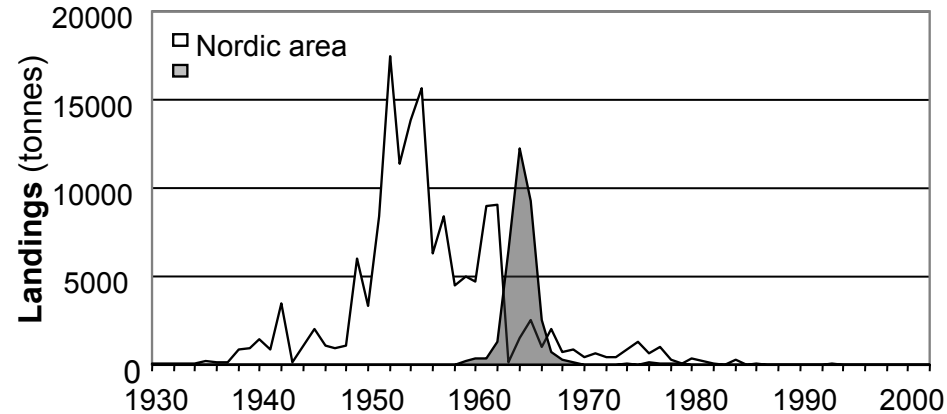
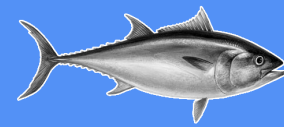
Our hypothesis

- Groups of similar sizes
- Feeding ground = one group coming back to similar location (examples)
- Every year larger/older: observed in various locations

Nordic catch-at-size displays an unusual pattern



Return in the northern latitudes



Historical fisheries

- Scandinavian countries, UK, Brittany 1930-1970
- : be very patient



SCRS/2008/059



Collect. Vol. Sci. Pap. ICCAT, 63: 69-78 (2009)

BLUEFIN FISHING BY SPORT FISHERMEN OFF THE TREBEURDEN BAY, NORTHERN BRITTANY, DURING THE 1946-1953 PERIOD

Alain Fonteneau¹ and André Le Person

SUMMARY

This paper describes and analyses the short history of the giant bluefin seasonal sport fishery that took place in the Trebeurden Bay, Brittany, France, after World War 2. This fishery was clearly linked with a now vanished sardine local resource and artisanal fishery, and it was targeting giant bluefin that were probably migrating back from the North Sea and Norway. The history of these sardine and tuna fisheries is discussed in relation with the potential tuna migrations. The end of the bluefin fishery in 1953 was probably related to the local extinction of the sardine stock. This event confirms the great interest to analyse data from bluefin sport fisheries, and the paper recommends doing more data mining targeting the recovery of historical sport fishery data.