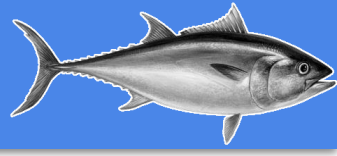
PROMPT

POTENTIAL MIGRATORY PROCESSES FOR ATLANTIC BLUEFIN TUNA

ANNUAL MEETING

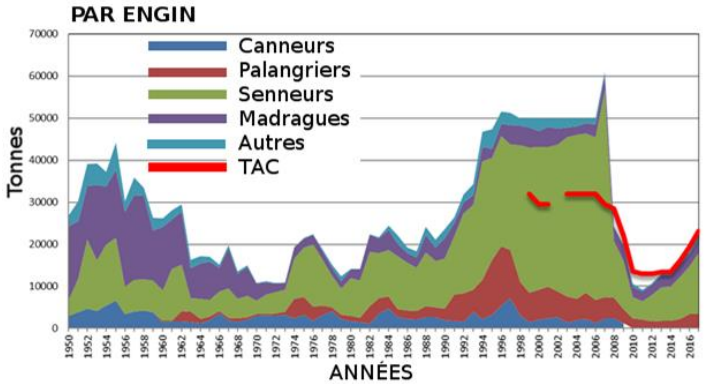
An emblematic species for the french fisheries



France is a key international player for BFT exploitation :

- Exploitation everywhere around France
- Second/first country (~Spain): 16% of the TAC
- First purse seine fishery (14.5% of the TAC)
- Purse seine = 60% of the TAC

A major country for exploitation and conservation



BFT exploitation is affected by migrations:

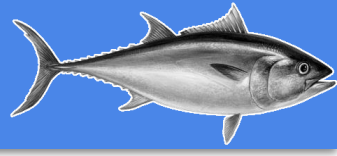
- Spawning in Med in May-June-July: purse seiners
- Feeding and foraging in the Atlantic and Gulf of Lions: Longliners, baitboats, pelagic trawlers

Changing migratory routes

- Brittany, English channel, Nordic countries
- BFT back the past few years where it hasn't been in 60 years
- Effect of environment ? And climate change ?
- Impact on fisheries and management ?

Understanding BFT migrations and underlying processes is of key importance

Effects of climate change



Impacts through different aspects

- Behavior -> Migrations/movements (e.g. bluefin back in northern areas ?)
- Productivity -> abundance (e.g. an increased egg production and survival ?)
- Temporal scale: fast or slow ? Depends on the process affected (production slow, migration fast)…

Need to describe changes and to understand mechanisms

- Describe changes: tagging, data analysis, abundance index
- Understand mechanisms: experiments, physiology

Impact of climate change on migrations

Modelling physiology under the different climate change scenarios

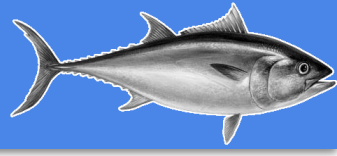
PROMPT is a first project in a more general research context to tackle climate change, objectives:

- Perform extensive tagging operations to describe migrations from **important fisheries/locations**
- Initiate challenging experiments to understand the physiology of tunas

Other activities

- Integrated modeling of Bluefin tuna dynamics, including its bioenergetics
- Improving abundance index for young bluefin tuna

Scientific questions: PROMPT

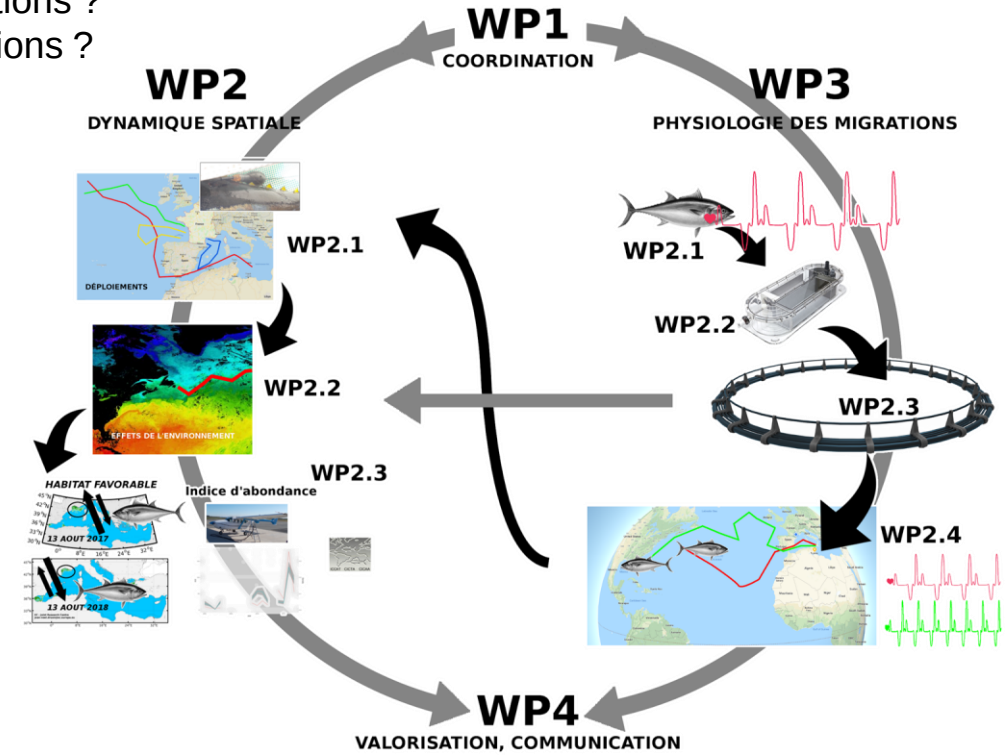


Bluefin tuna exploitation depends upon its migrations:

- What are migrations of tuna exploited by french fisheries (and international) ?
- How is the environment affecting these migrations ?
- How current climate change can affect migrations ?
- What are the biological processes at play ?
- How to integrate these within stock status ?

1. **WP1. Spatial dynamics**
    1. Tagging database and operations
    2. Compare to environment
    3. Identify effects on migrations

1. **WP2. Mechanisms**
    1. Physiology to understand migrations
    2. Energy stored / used
    3. Energy along a migratory path
    4. Trans-body data transmission



WP2. Spatial dynamics

Build an extensive picture of migrations

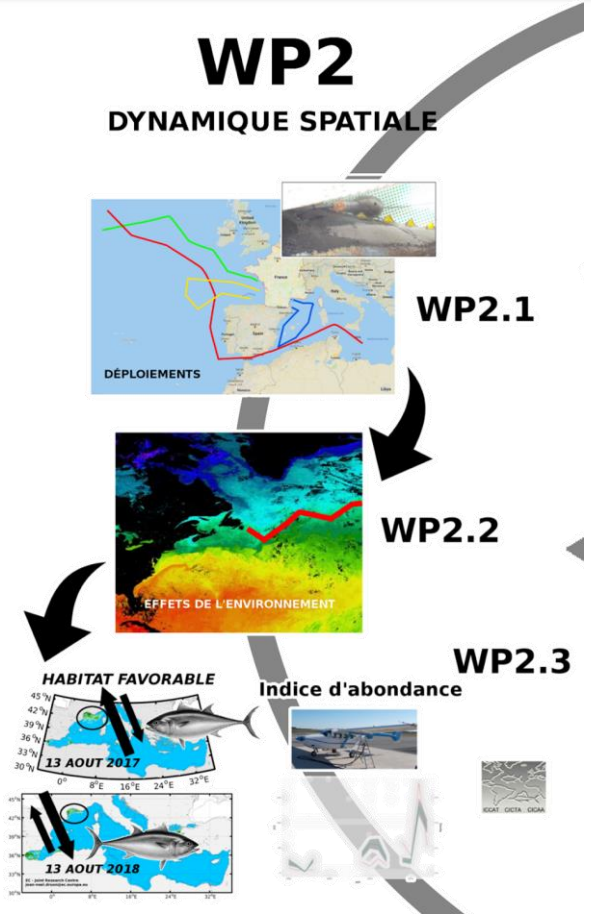
- Collect a comprehensive database
- Build a new database:
  - Tagging in the Atlantic (reduced info)
  - Tagging from cages
  - Tagging from Gulf of Lions
  - Tagging from spawning grounds

Identify effects of the environment

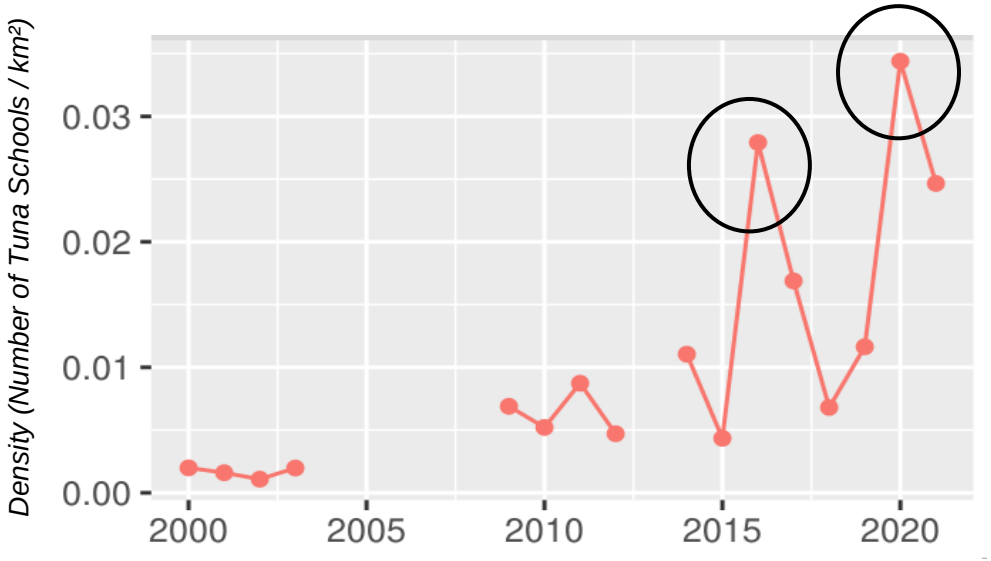
- Origin of variability in migratory routes: age, area, season, …
- Compare to environment in the area and along the route
- Identify oceanographic features that affect migrations

Include these effects within the french abundance index

- Gulf of Lions: Migrations depend on the environment
- Affect the amount of detections during the survey
- Less schools detected:
  - less fish
  - habitat not as favourable and fish elsewhere ?



Results : Abundance index



ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

The environment drives Atlantic bluefin tuna availability in the Gulf of Lions

Tristan Rouyer[1] | Sylvain Bonhommeau[2] | Guilaume Bal[3] | Olivier Derridj[1] | Jean-Marc Fromentin[1]

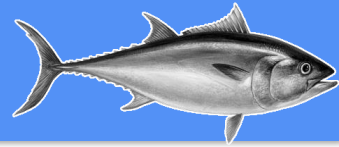
Northern Wind affects tuna availability in the Gulf of Lion

Strong Northern wind in July -> High availability of Tunas

-> *Wind affects yearly short-term post-spawning migration ?*

Long-term positive SST trend: increase in abundance ?

Results: Size-dependent migrations ?

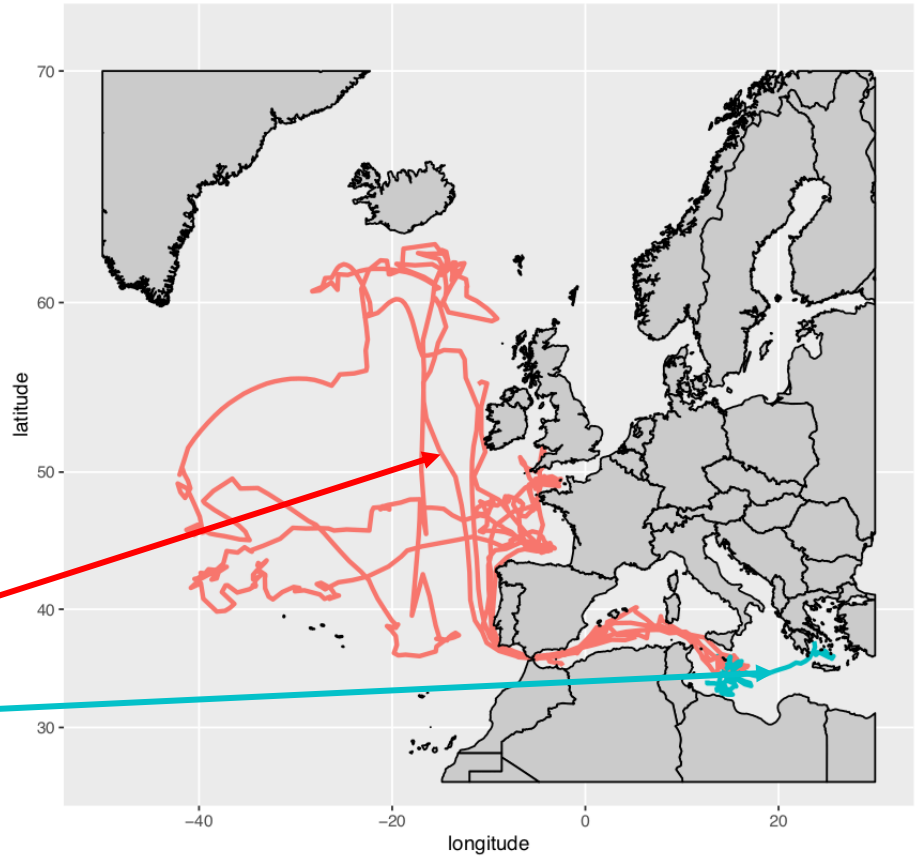


Environ Biol Fish (2022) 105:635–644
https://doi.org/10.1007/s10641-022-01262-4

Check for updates

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

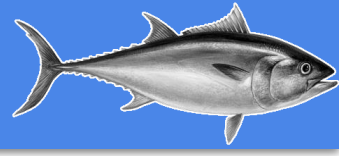


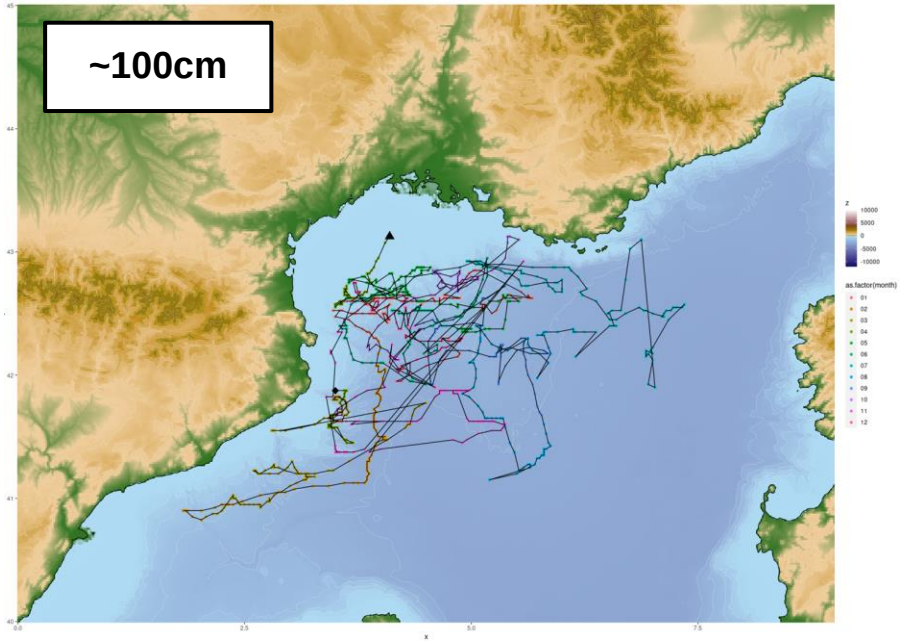
Rouyer et al. (2022)

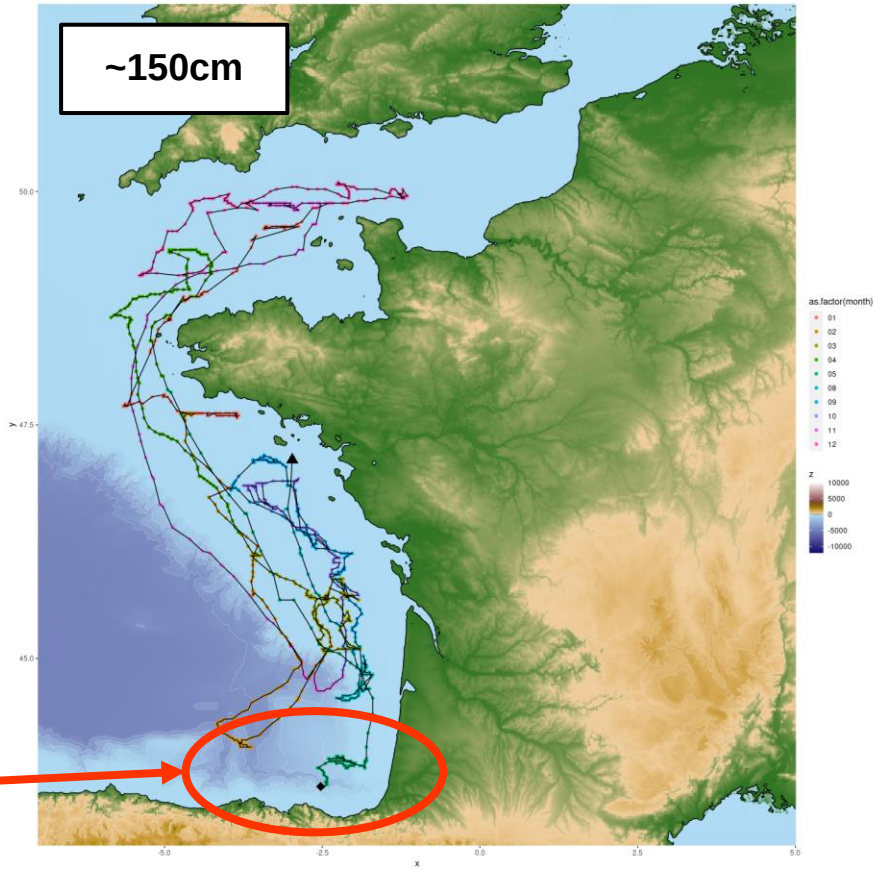
- Tagging with PS
- 2 years, 8 fish
- 4 tunas > 200 cm: **transition**
- 4 tunas < 200 cm: **no transition**

Changing migrations with size

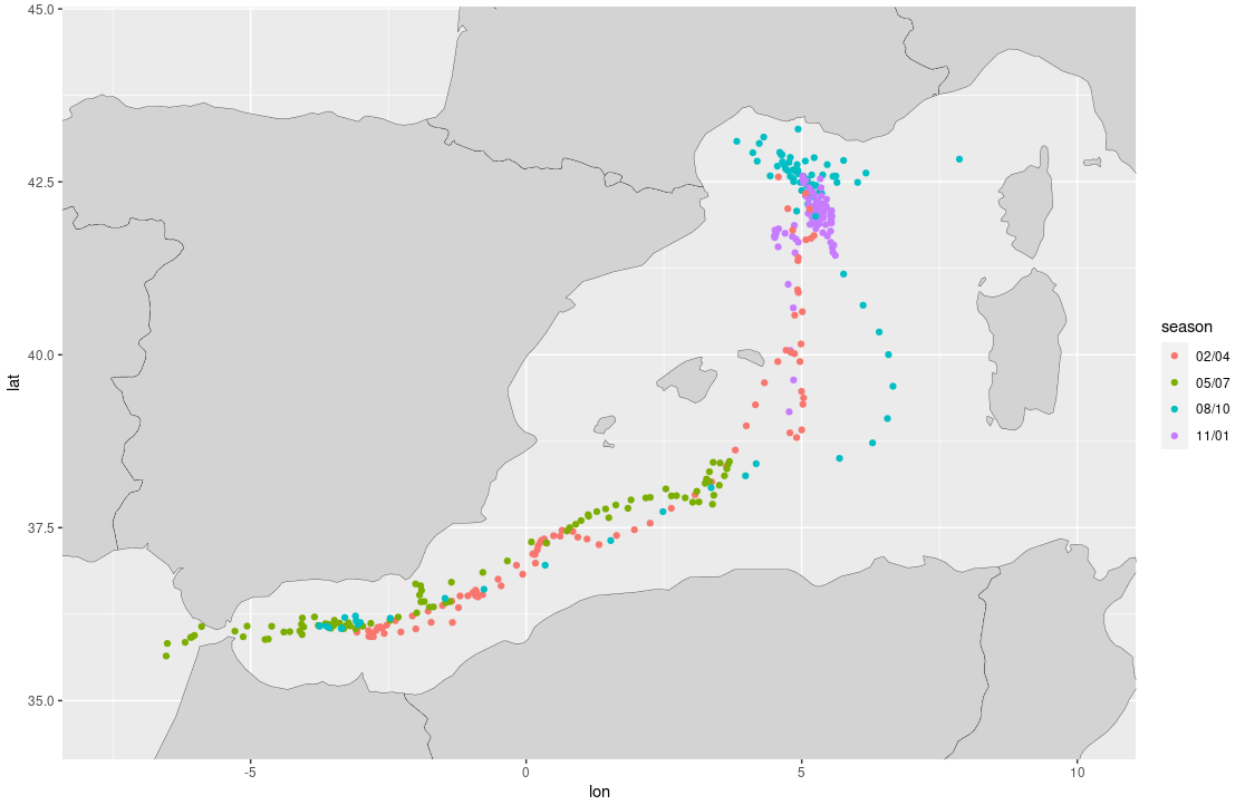
Young tunas, 1m (Med.) and 1.5m (Atl.)



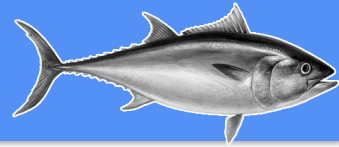


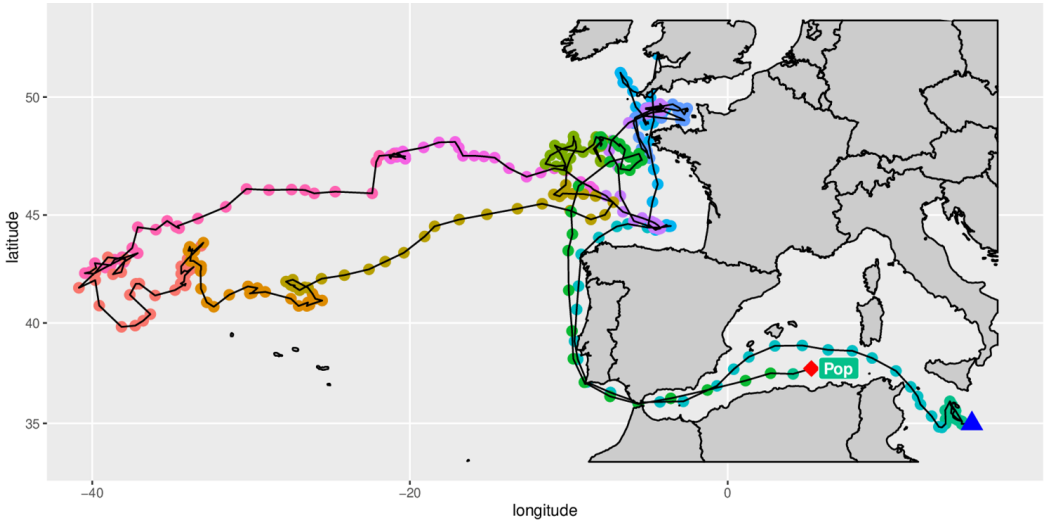


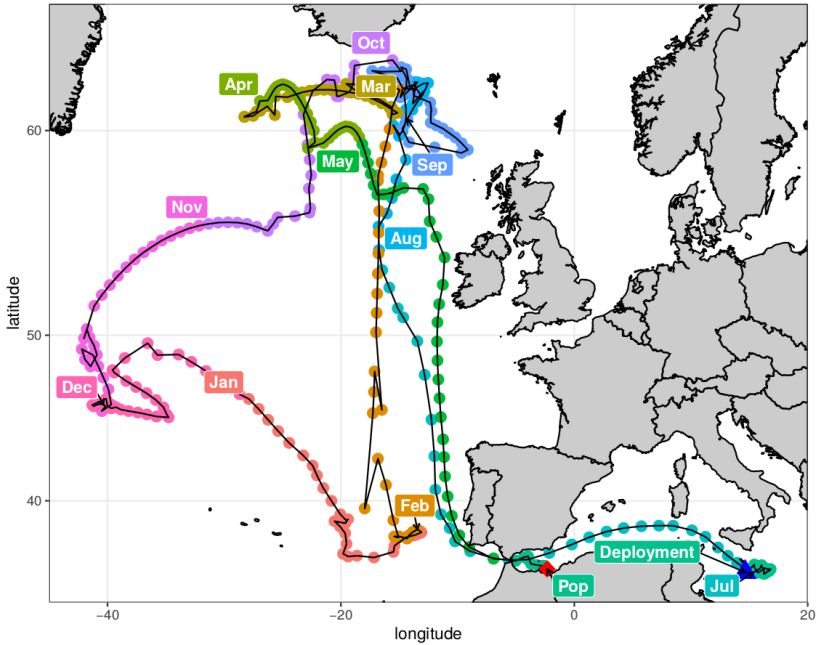
A bit larger, 180 cm, Gulf of Lion



Size > 2m tagged in Malta

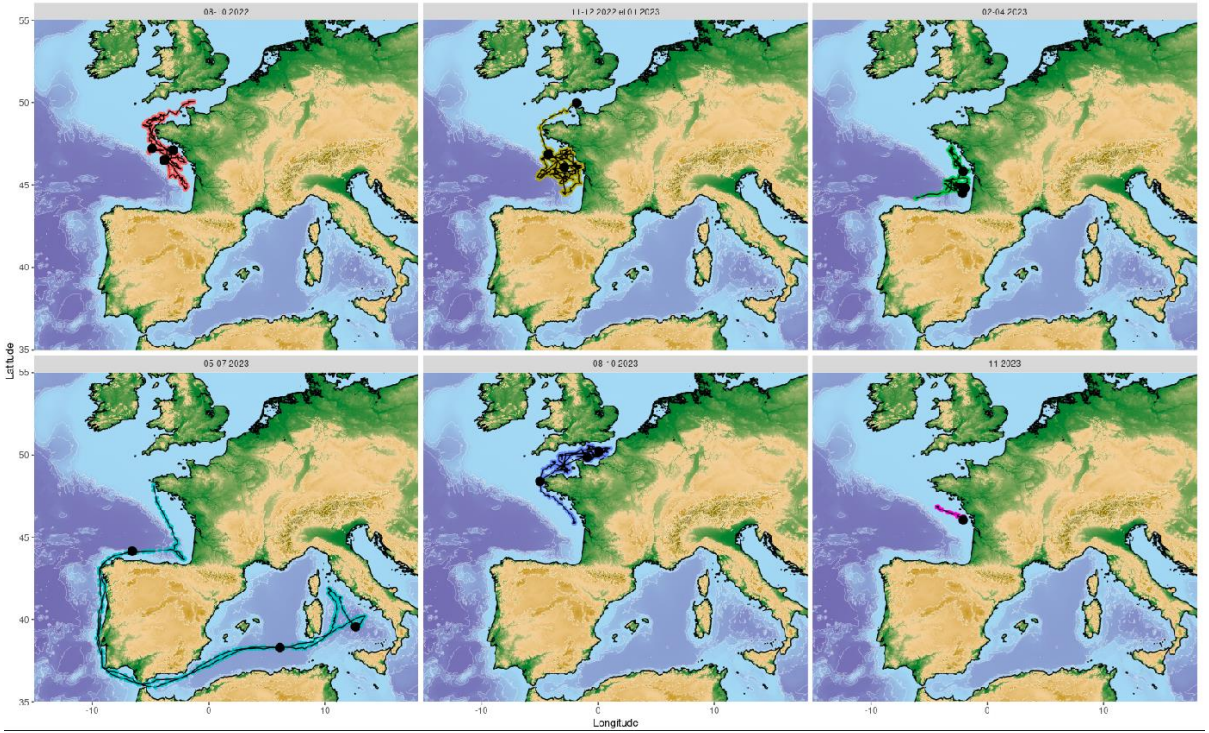






Atlantic tagging: 175cm

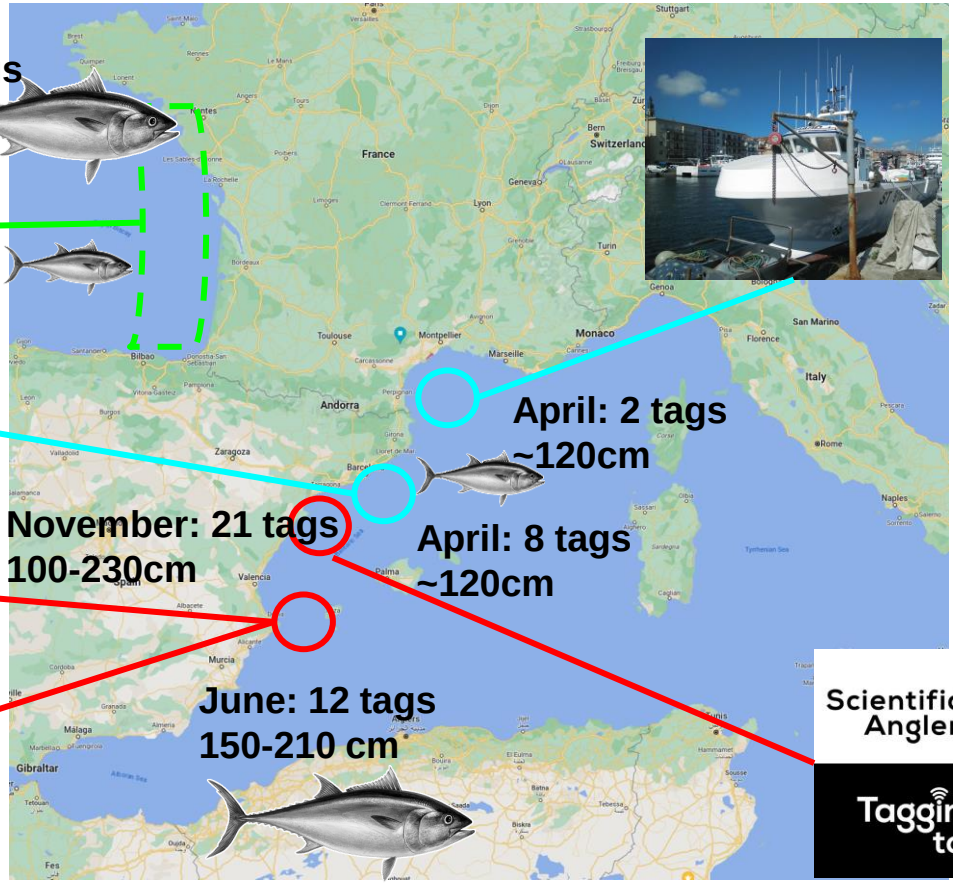
452 days at large
Goes in the
Mediterranean



SCRS/2023/043 Collect. Vol. Sci. Pap. ICCAT, 80(9): 25-53 (2023)
Using the whole international tagging database, Rouyer et al. confirmed that bluefin starts Mediterranean/Atlantic transitions at about 175cm and show residency at smaller sizes (unpublished)

Tagging in 2023

Septembre: 8 tags
150-230cm



Scientific Angler
Tagging tour

April: 2 tags
~120cm

November: 21 tags
100-230cm

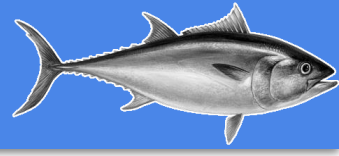
April: 8 tags
~120cm

Scientific Angler
Tagging tour

June: 12 tags
150-210 cm

Scientific Angler
Tagging tour

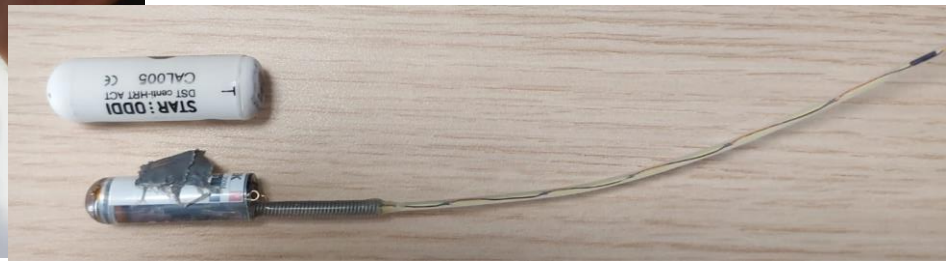
Diversification of tagging techniques



1 yr / Sat transmission

-> Annual cycle

- **Migrations ?**
- **Spawning ?**

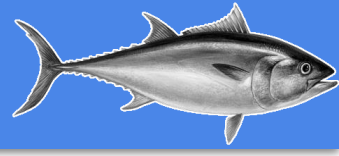


4.5 yrs / no transmission

-> Changing migrations

- **Change in areas ?**
- **Spawning site fidelity ?**
- **Change in size structure in the GoL ?**
- **Climate change**

WP3.Trying to understand mechanisms



For tuna, migrating is swimming
swimming costs energy, even more so in the higher latitudes
Is it worth it ? What about under climate change effects ?

Describe patterns of metabolic activity

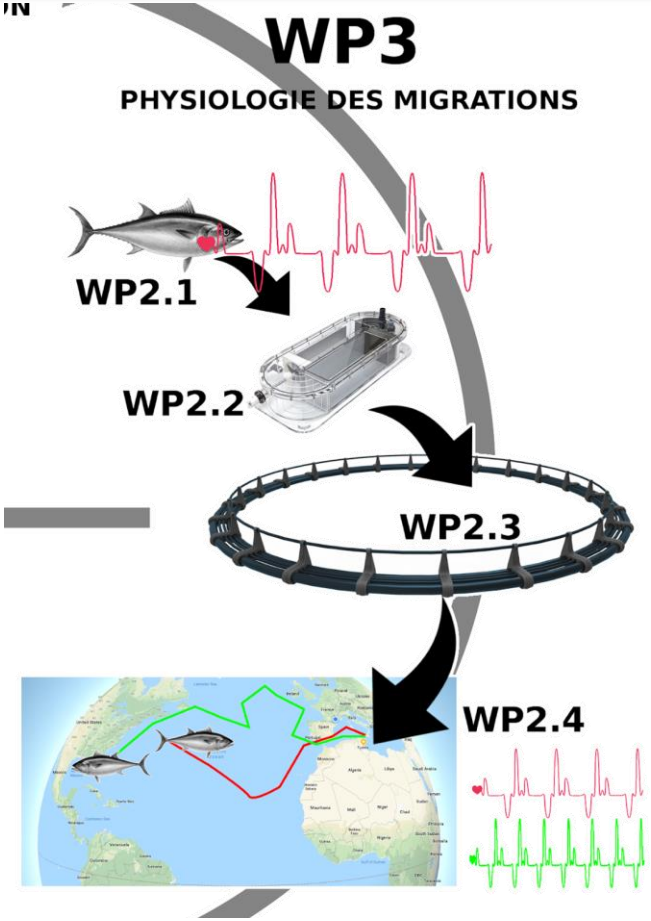
- Swimming tunnel: heart rate vs metabolic rate vs swimming
- Monitor heart rate of caged fish vs growth and conditions
- -> How much energy it costs to migrate

Challenges

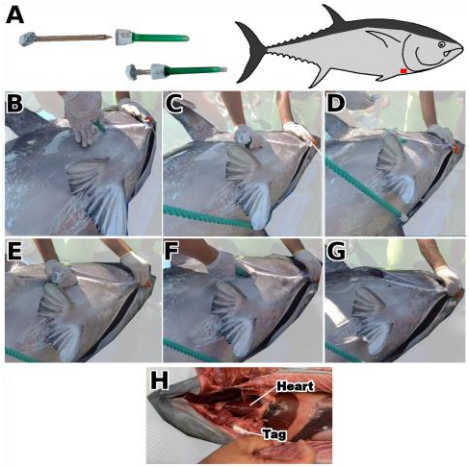
- A swimming tunnel for tuna ?
- Setting-up large scale experiment
- Reliable heart rate measurements

Estimate the energetic costs along the migratory routes

- Compare routes on that basis
- Compared to random, observed routes minimize energetic costs ?
- Investigate potential routes under climate change scenarios
- DEB modelling



Results : A first paper on HRT implantation



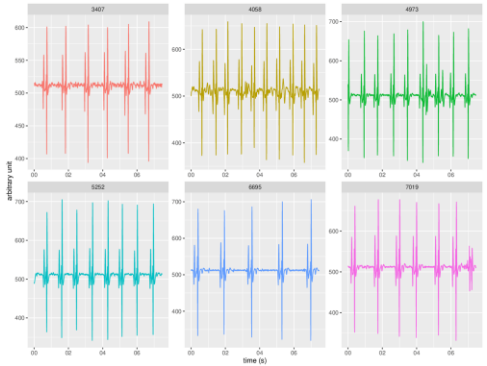
Received: 1 June 2023 | Revised: 13 July 2023 | Accepted: 19 July 2023
DOI: 10.1111/jfb.15507

REGULAR ARTICLE

JOURNAL OF FISH BIOLOGY fsbi

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

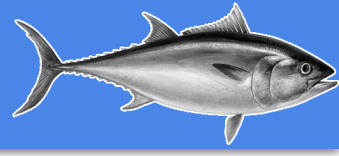
T. Rouyer[1] | S. Bonhommeau[2] | S. Bernard[3] | V. Kerzerho[3] | O. Derridj[1] | Á. Bjarnason[4] | H. Allal[5] | J. F. Steffensen[6] | S. Deguara[7] | B. Wendling[8] | G. Bal[9] | D. Thambithurai[1] | D. J. Mckenzie[1]

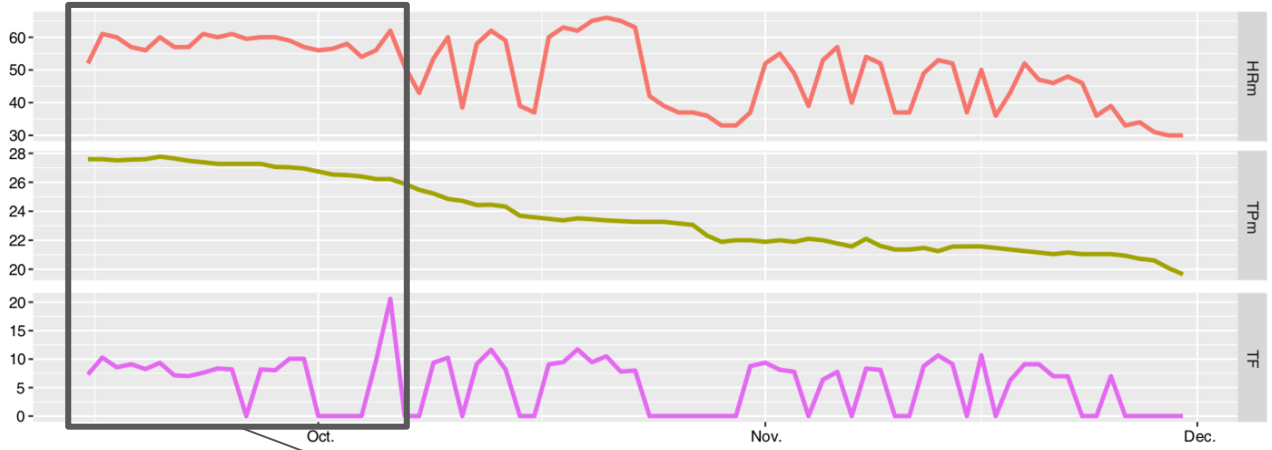


Results

- New technique for tagging
- Long-term deployments
- Perspectives for tagging

A first paper on HRT implantation





Daily heart rate

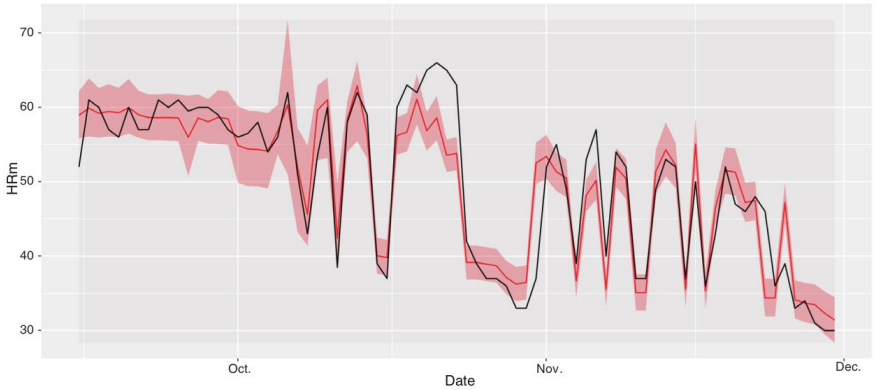
Temperature

Food

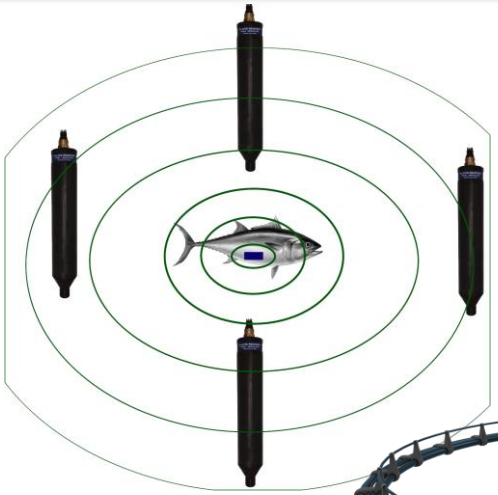
Model:
Heart rate = food + temperature
Effect of temperature disappears when temperature > 25°C
-> Heart rate seems to reach a maximum

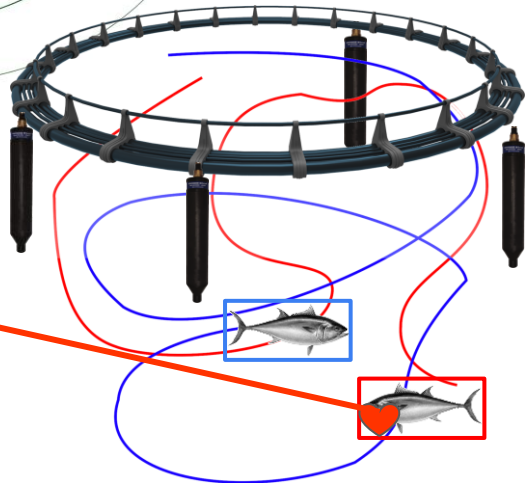
-> Is BFT physiologically affected by higher temperatures ?
-> Consequences on migrations ?

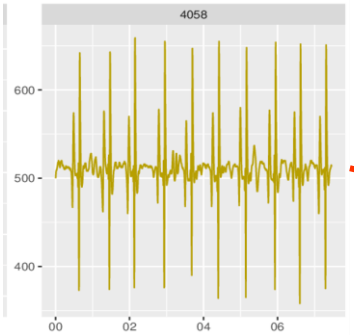
-> Large scale caging experiment



CAGING EXPERIMENT IN 2022-2023







Tags

- Acoustic: Give 3D movement of the fish
- Heart rate/accelerometer
- For the whole year
- 27 tunas tagged: 40kg - > 200kg

What do we study ?

- Movements
- Activity: feeding, spawning
- Link to growth/fat and energy (heart rate)
- Group behavior
- All the time ?
- Period for growth ?
- Some of them growing faster ?
- Some of them more fat ?
- …

-> IMPACT OF HEATWAVE

-> Climate change impact on physiology and behavior

CAGING EXPERIMENT IN 2022

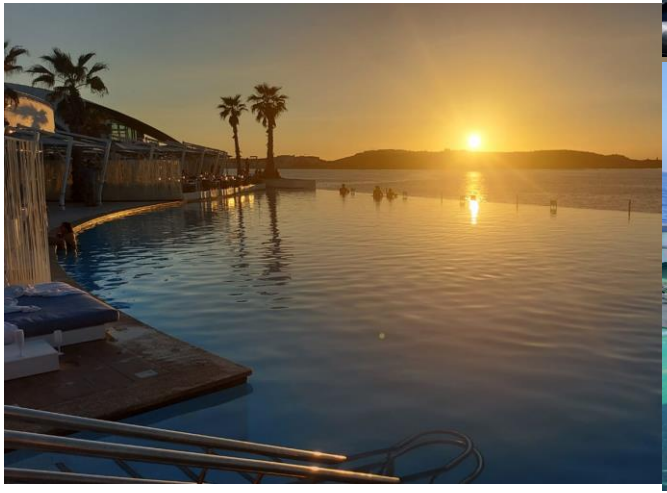
VIDEO FROM SATHOAN https://vimeo.com/787590263/4731615c97
Exists with english subtitles: https://vimeo.com/803406307

CAGING EXPERIMENT IN 2022

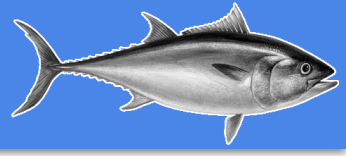
SUCCESS !!!

CAGING EXPERIMENT IN 2022

SUCCESS !!!



Caging experiment



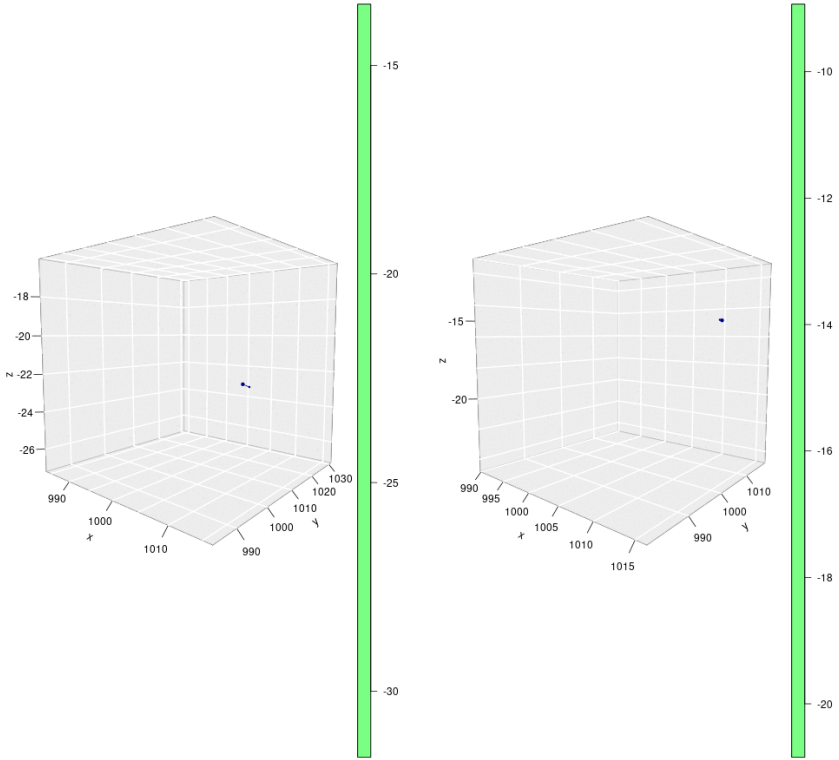
Overview

- 19 tags HRT tags retrieved after 1 yr
- Acoustic data for 12 Months ok

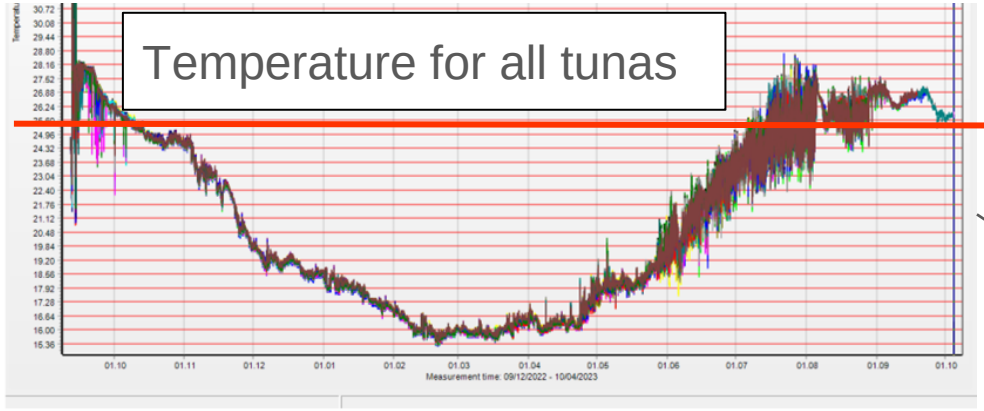
3-yr Postdoc started to work on it

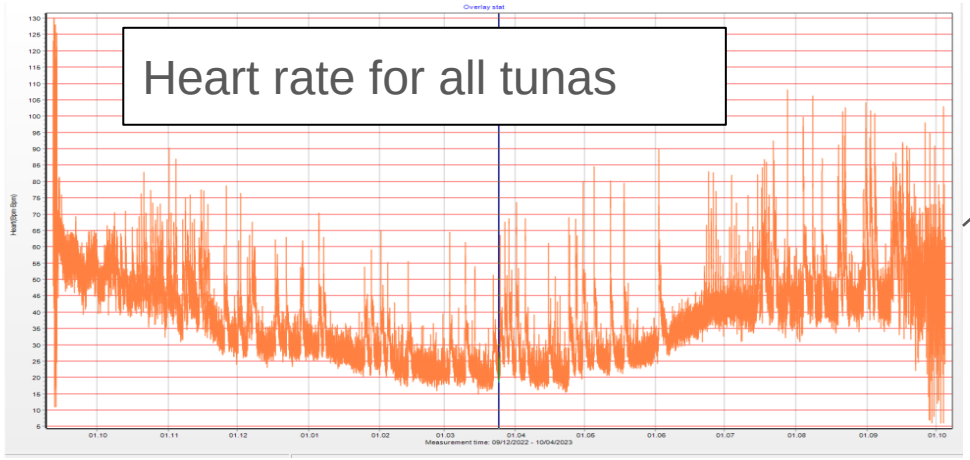
Questions

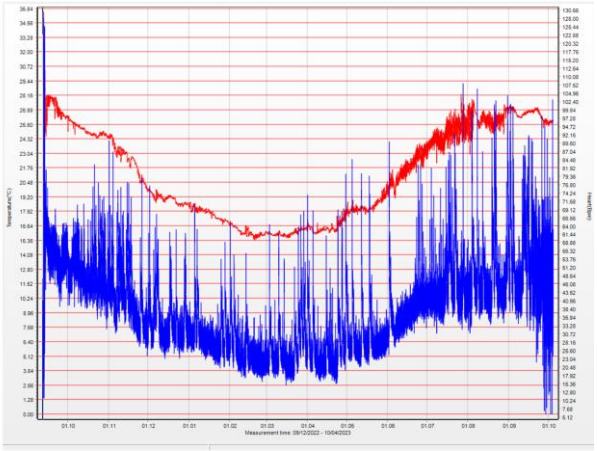
- Heatwave impact
- Movement from acoustic tags vs HR variations
- Feeding event vs SDA response between fishes
- % of tagged fish that fed during events ?
- Heatwave impact on behavior, storms…
- Spawning ?
- Group behavior ?
- Compare to electronic tags (moon)
- …



Caging experiment: HR data







Direct effect of temperature on heart rate

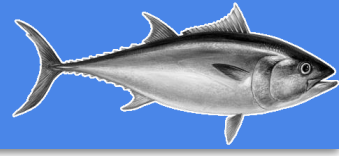
What about small fish ? ICRA, Mazarron

In-vivo physiological energetics of Atlantic bluefin
Juveniles, bred in captivity, around 5 months old, 500 g

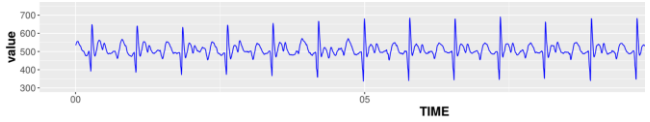
Expectations about the physiological energetics of Atlantic bluefin tuna (ABFT)

- **A high performance fish**
  - High maximum swimming speed (aerobic and anaerobic)
  - High maximum metabolic rate
  - High aerobic metabolic scope
  - Elevated standard metabolic rate
  - High optimal swimming speed

WP3.Getting wild

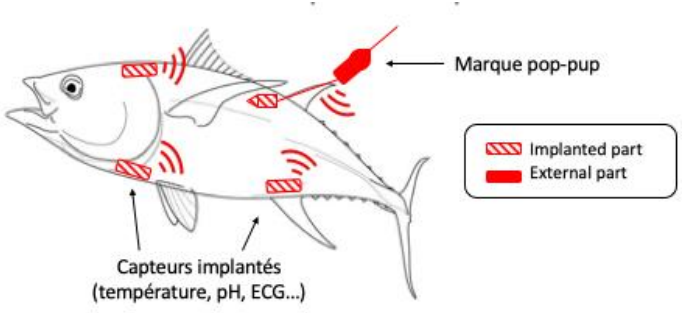


How to get physiological information from wild animals ?



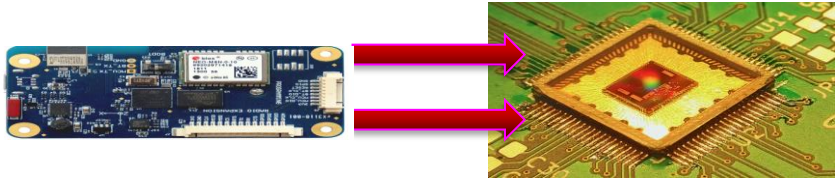
Would it be possible to do heart rate and other physiological measurements on wild fish ?

- 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: go wireless



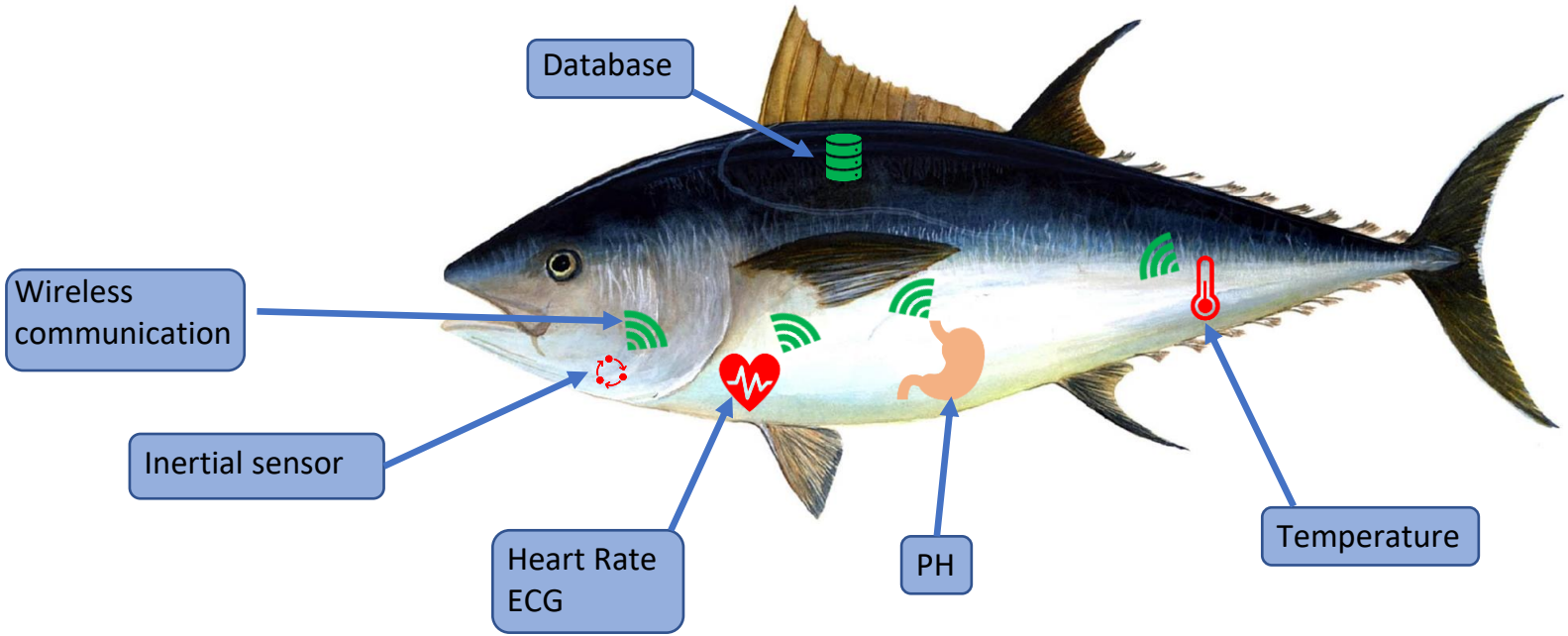
Test the potential for intra-body transmission

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

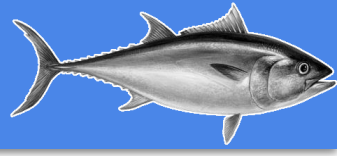


CONTEXT AND OBJECTIVES

- Monitor physiological parameters over the long term in any environment (pond or wild)

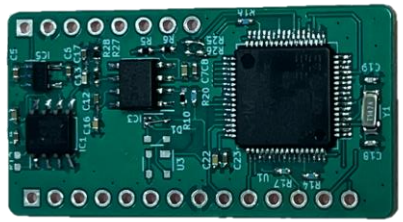


CONSTRAINTS FOR IMPLANTABLE WIRELESS COMMUNICATION SYSTEM

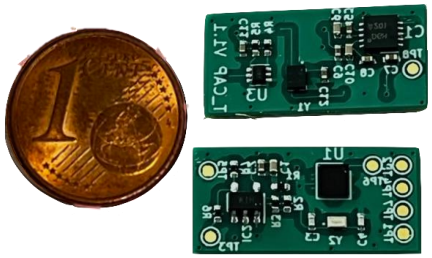


- Implantable (small size)
- Communication range (2cm to 2m)
- Autonomy from 6 months to 1 year
- Transmission in a living medium (biocompatibility), non-homogeneous (complex medium modeling), and a conductive, pressurized environment (marine).

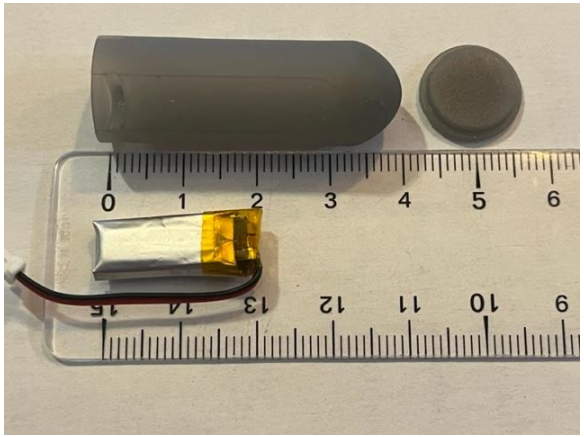
First prototype



b - Rx board

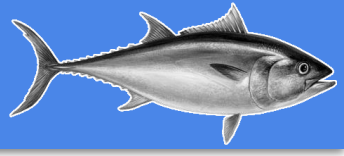


a - Tx board
(implantable)



First experiments done in 2024

Conclusion: what do we learn ?



Migrations are complex but some patterns emerge

- Age/size of the fish
- Environmental aspects: short-term effect on migrations
- Behavior (e.g. spatial learning, fidelity to feeding ground)

-> Continuing to describe Mediterranean migrations is key

Physiology

- Experiments are challenging, but are key to understand
- Heart rate seems to be affected by temperature: thermal stress at high temperatures ?
- First experimental results on small fish in swimming tunnel

Developing physiological sensors for wild fish will provide new and further insights into migrations

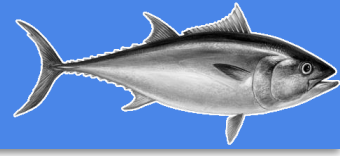
PROMPT finishing in 2025, looking into getting funding

- Continue tagging and experiments
- Ongoing collaboration to look into change in habitat (J.N Druon)
- Move on with the integrated modeling

-> Providing scenarios for migrations under the current climate change

Thank you !

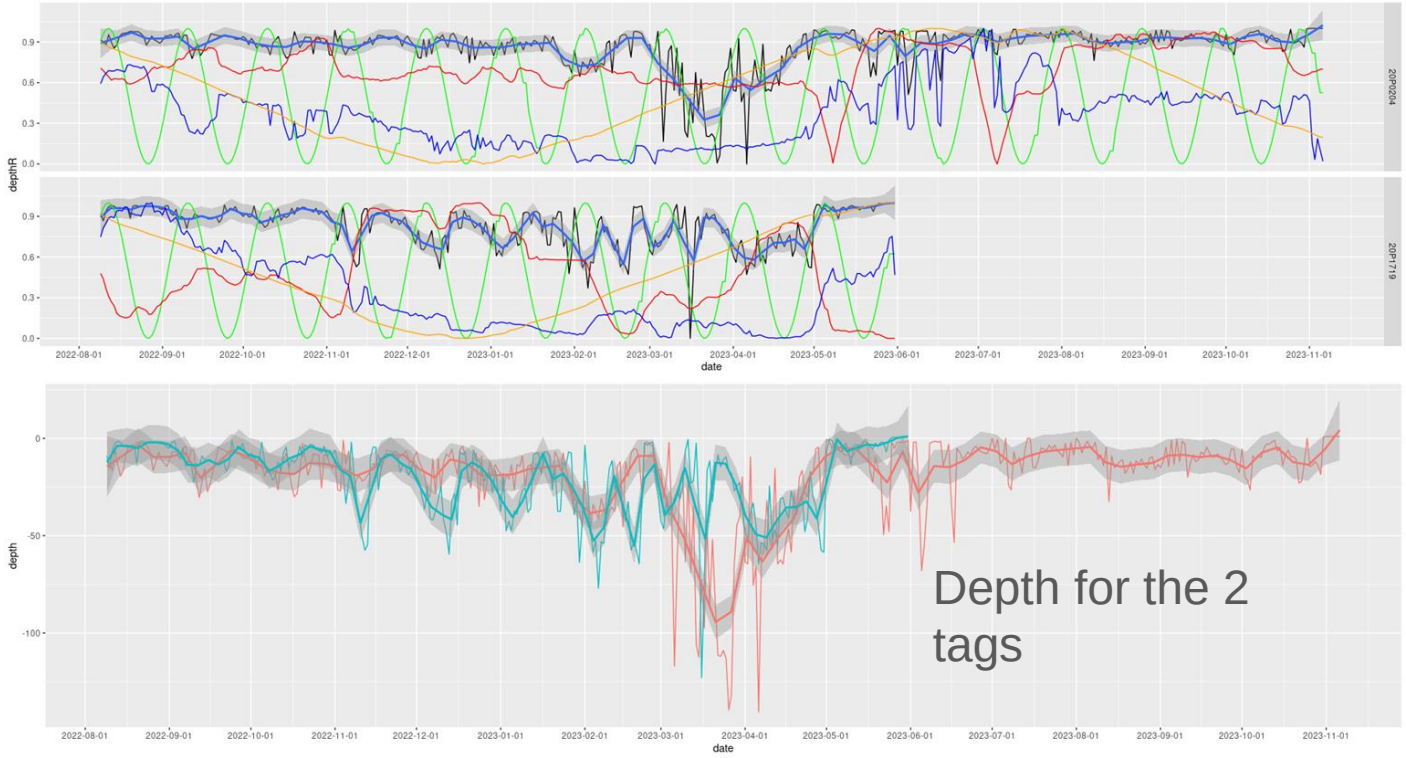
Atlantic tagging 09/08/2022



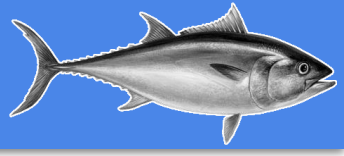
Lots of information

- Moon
- Depth
- Distance Gibraltar
- Temperature
- Length of Day

Rich synchronies



Caging experiment



A lot more questions…

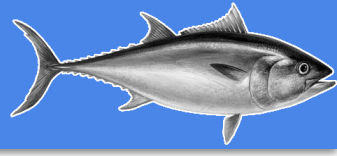
To estimate some **behaviour metrics** (e.g. space use, swim speed, social interactions) from movement trajectories

Other behaviours (e.g. spawning, depth use, feeding)

Environmental variables (e.g. temperature, moon cycles)

Individual physiology (heart rate)

WP2. Spatial dynamics



Build an extensive picture of migrations

- Collect a comprehensive database ← All Med. Data + extra data. Larger analysis with ALL tags
- Build a new database: ← Started in 2023, 44 tags deployed (66 tunas in total)
  - Tagging in the Atlantic (reduced info) ←
  - Tagging from cages ← Not done. Overlap with other operations. To evaluate for 2024/2025.
  - Tagging from Gulf of Lions ←
  - Tagging from spawning grounds ←

Identify effects of the environment ← Ongoing analysis (PhD)

- Origin of variability in migratory routes: age, area, season, …
- Compare to environment in the area and along the route
- Identify oceanographic features that affect migrations

  - Very large dataset
  - Difficulties

Include these effects within the french abundance index ← Ongoing analysis (T. Rouyer / G. Bal) -> Paper 2024

- Gulf of Lions: Migrations depend on the environment
- Affect the amount of detections during the survey
- Less schools detected: ← Trainee (T. Rouyer / SATHOAN) Nicolas Cabrol + someone else Work on CPUE data
  - less fish
  - habitat not as favourable and fish elsewhere ?