Biotelemetry – A panoramic view into the aquatic world and a potent tool in the fishery manager's toolbox

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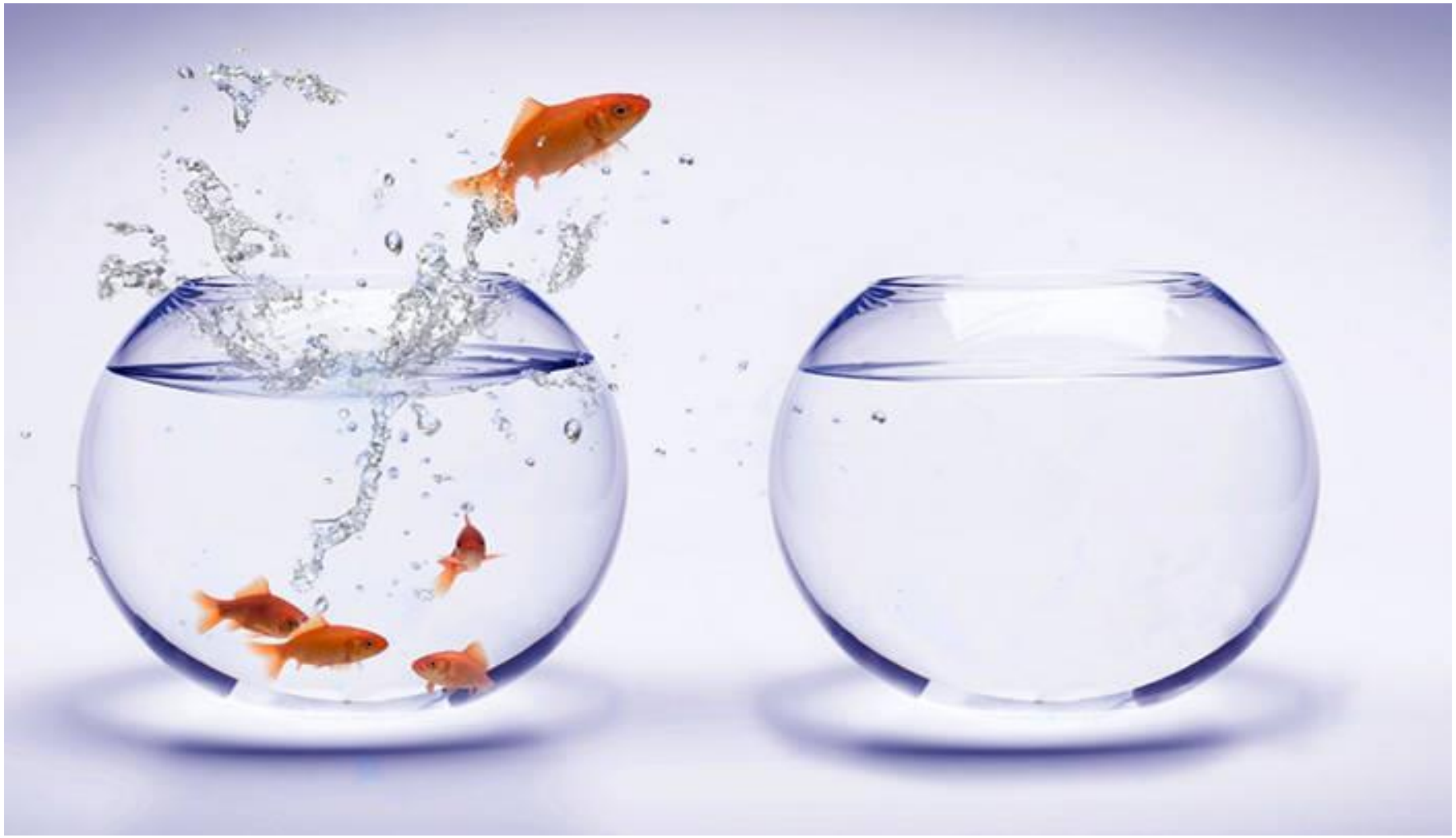
1. The importance of movement and migration
2. Biotelemetry and why it is groundbreaking
3. Examples of use to inform science and management

DTU Technical University of Denmark

All animals needs to move!



Different types of movement

- **Home range:** Where animals restrict their activities to a well-defined region or space
- **Dispersal and longer range exploratory movements:** Leave home range to explore new areas. Areas with better resources can be discovered and utilised. May result in adoption of new home ranges.
- **Migration:** Numerous definitions (Heape 1931, Baker 1979, Dingle 1980, 1996, Lucas & Baras 2001). Three forms – reproductive, feeding & refuge

***Migration* can take very different forms in different species**

There is no simple accepted definition of *migration*

Animal migration defined

- **Lucas & Baras (2001).**

"*a strategy of **adaptive value**, involving movement of part or all of a population in time, **between discrete sites** existing in an n-dimensional hypervolume of biotic and abiotic factors, usually but not necessarily involving predictability or synchronicity in time, since interindividual variation is a fundamental component of populations*"

TELEMETRY DEFINED

Derived from:

tele = remote - **metron** = measure

Technology that allows data measurements to be made at a distance

What we are talking about: Biotelemetry

TYPES OF ELECTRONIC TAGS:

1. Radio and acoustic transmitters
2. Data storage / archival tags (DST)
3. Pop-up satellite tags (PSAT)
4. Passive integrated transponder tags (PIT)

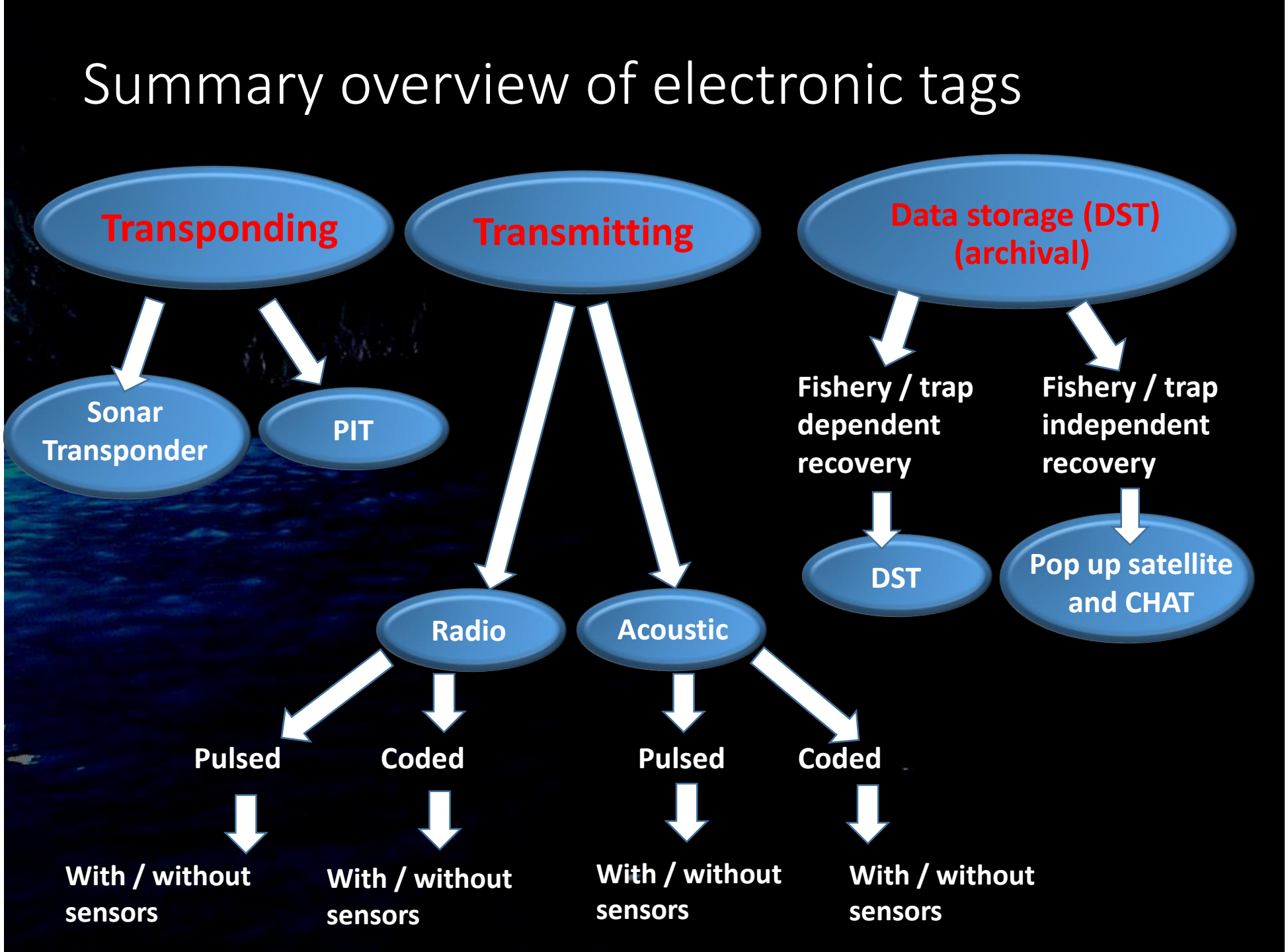
History of fish telemetry

- First acoustic equipment developed in 1956 for examining salmon passage of dam in Columbia River, USA (Trefethen 1956, Trefethen et al. 1957)
- By 1967, acoustic transmitters routinely used
- Radio transmitters first used in 1968 (Lonsdale & Baxter 1968). Increased use during the 1970s.

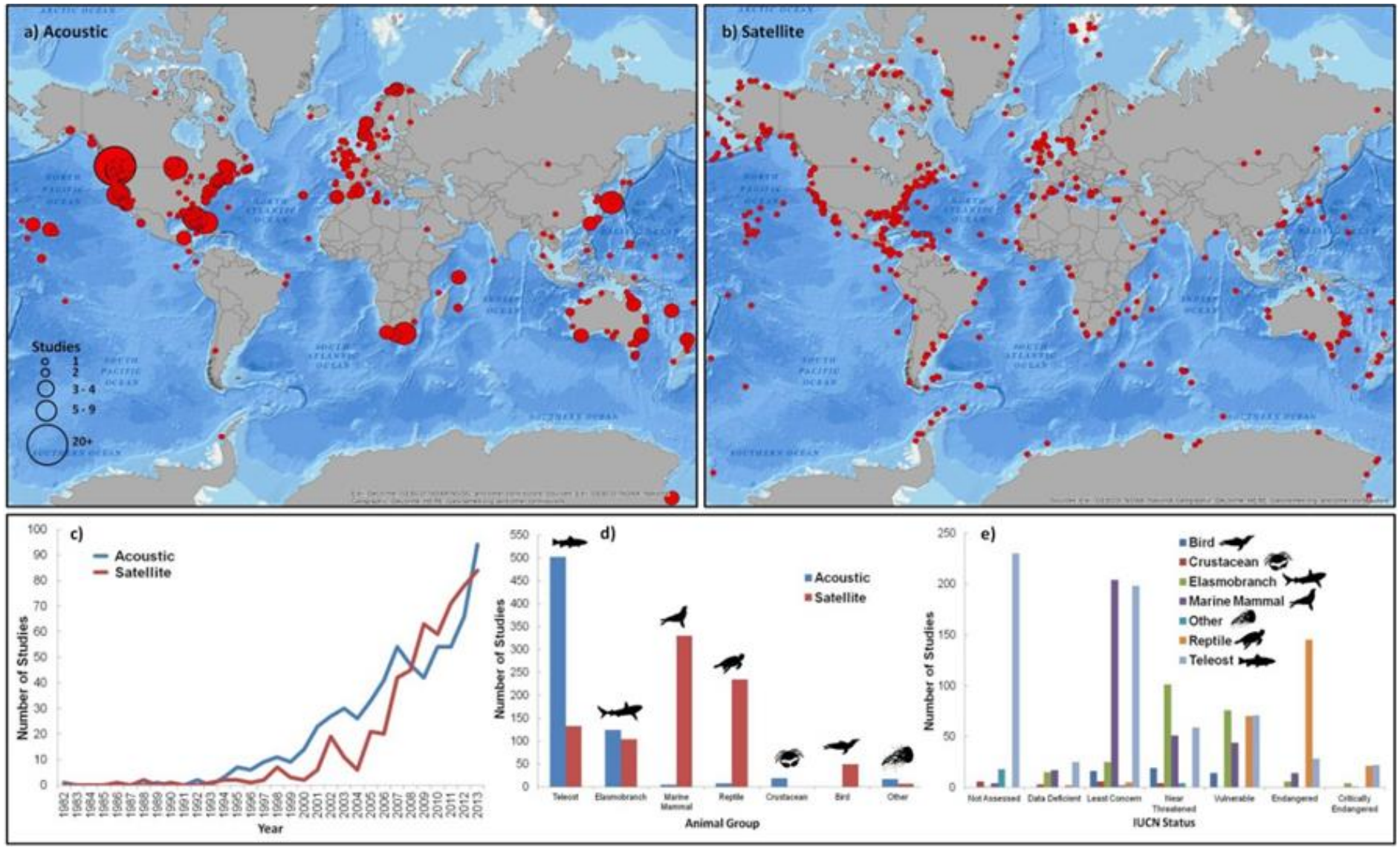
Why telemetry?

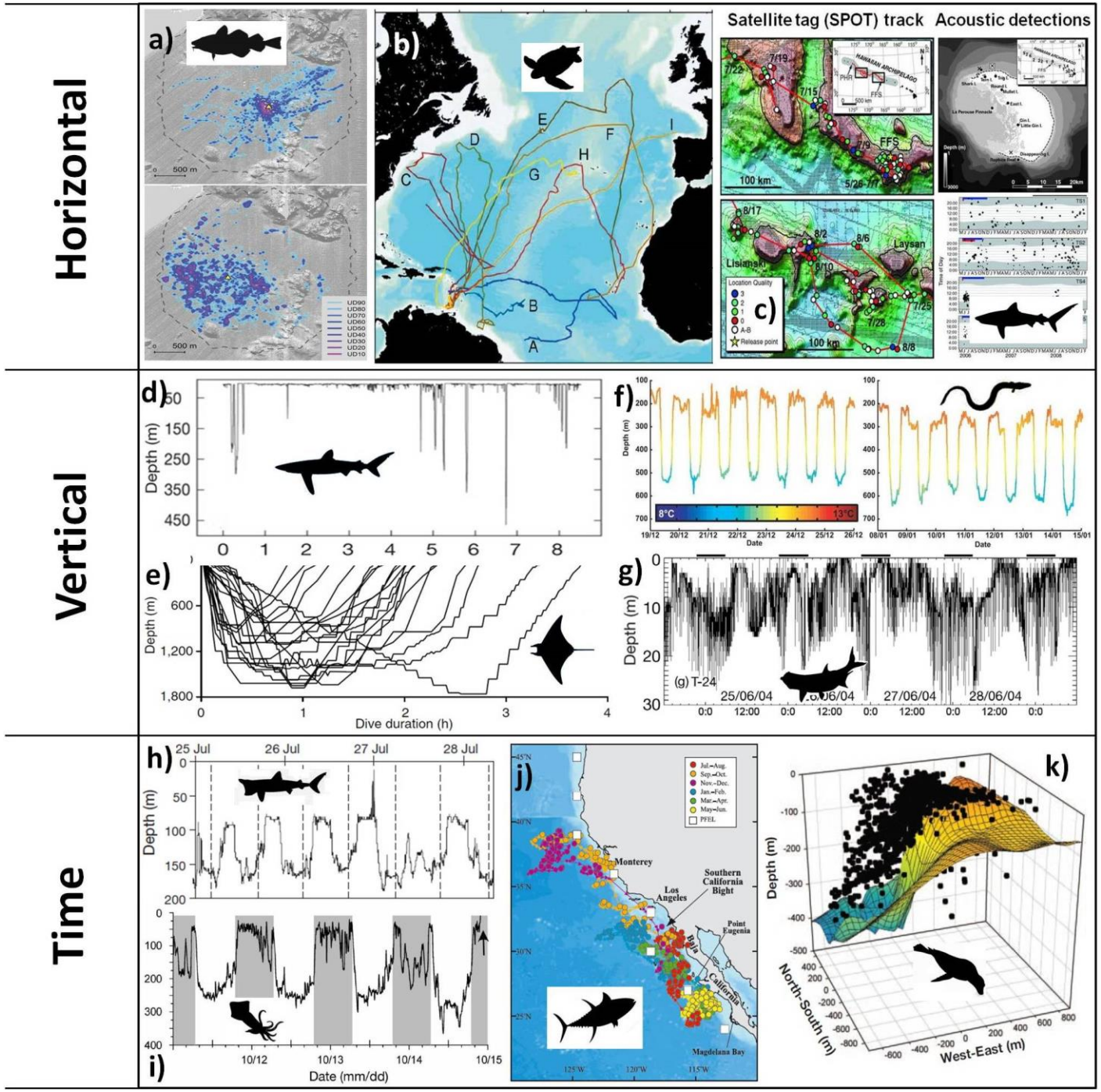
- Relaying information back from otherwise non-observable animals in multiple dimensions
- Repeated observations from the same animal
- Easily explainable
- A range of methods applicable in various situations (physical properties, species, size)

Summary overview of electronic tags



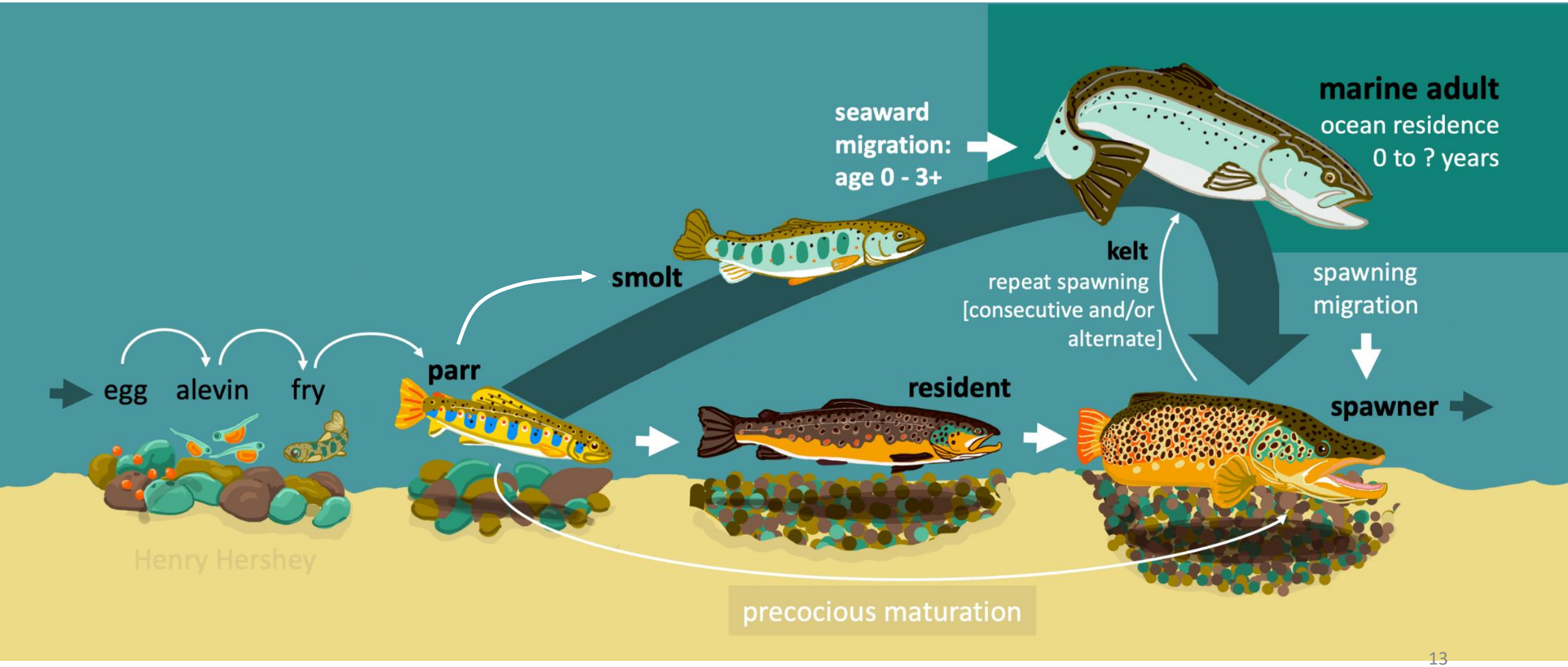
Development geographically and over time




Horizontal
Vertical
Time
Satellite tag (SPOT) track
Acoustic detections
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
Depth (m)
Dive duration (h)
Date (mm/dd)
Monterey
Los Angeles
Southern California Bight
Point Eugenia
Baja California
Magdelena Bay
North-South (m)
West-East (m)

Biotelemetry Example 1: PIT telemetry

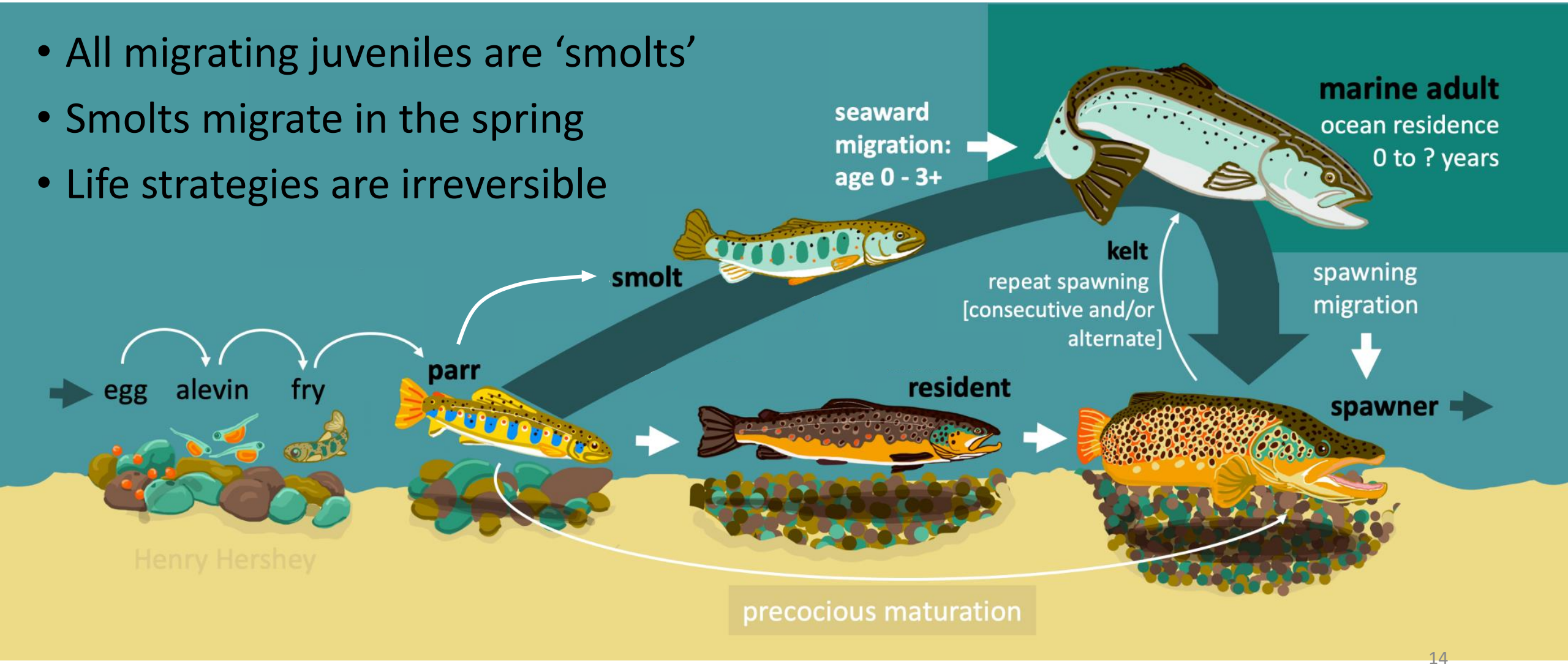
The brown trout lifecycle **that you know**



Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

Assumptions in this ‘normal’ lifecycle

- All migrating juveniles are ‘smolts’
- Smolts migrate in the spring
- Life strategies are irreversible



Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

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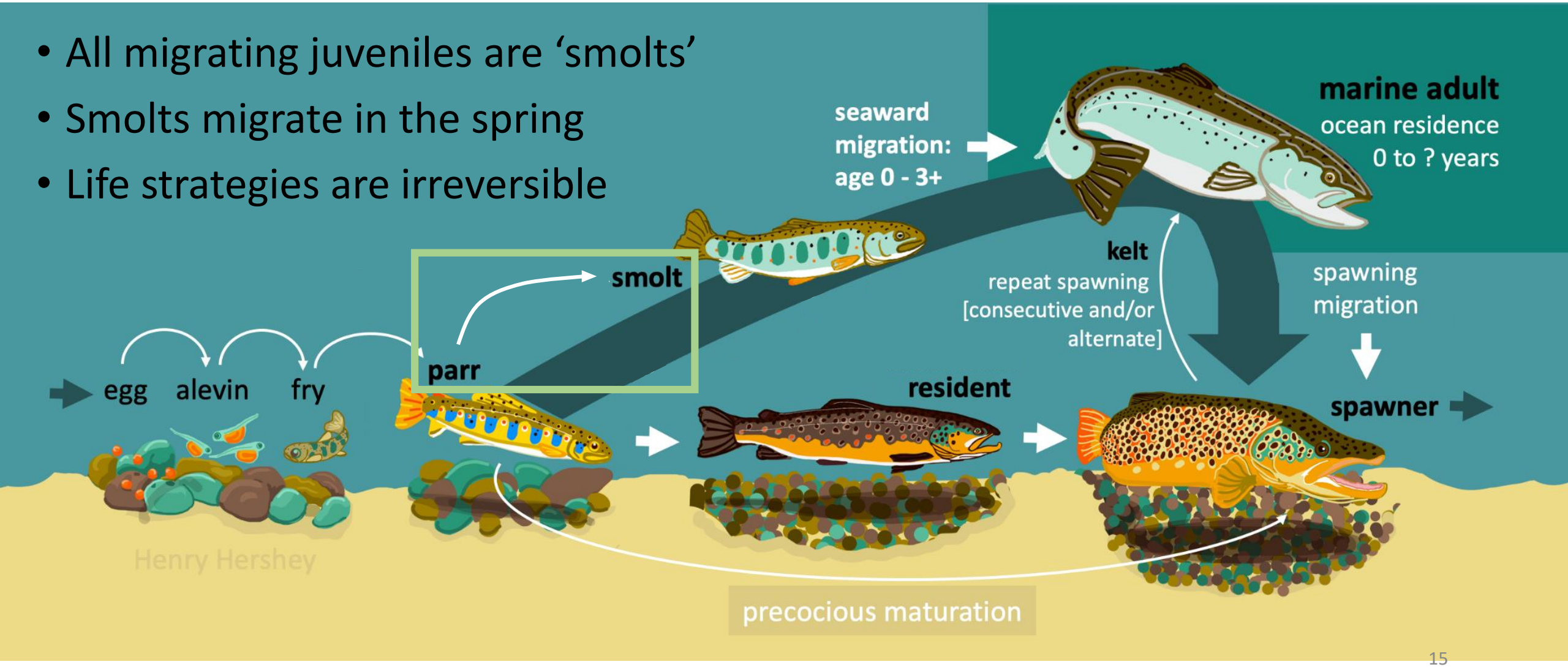
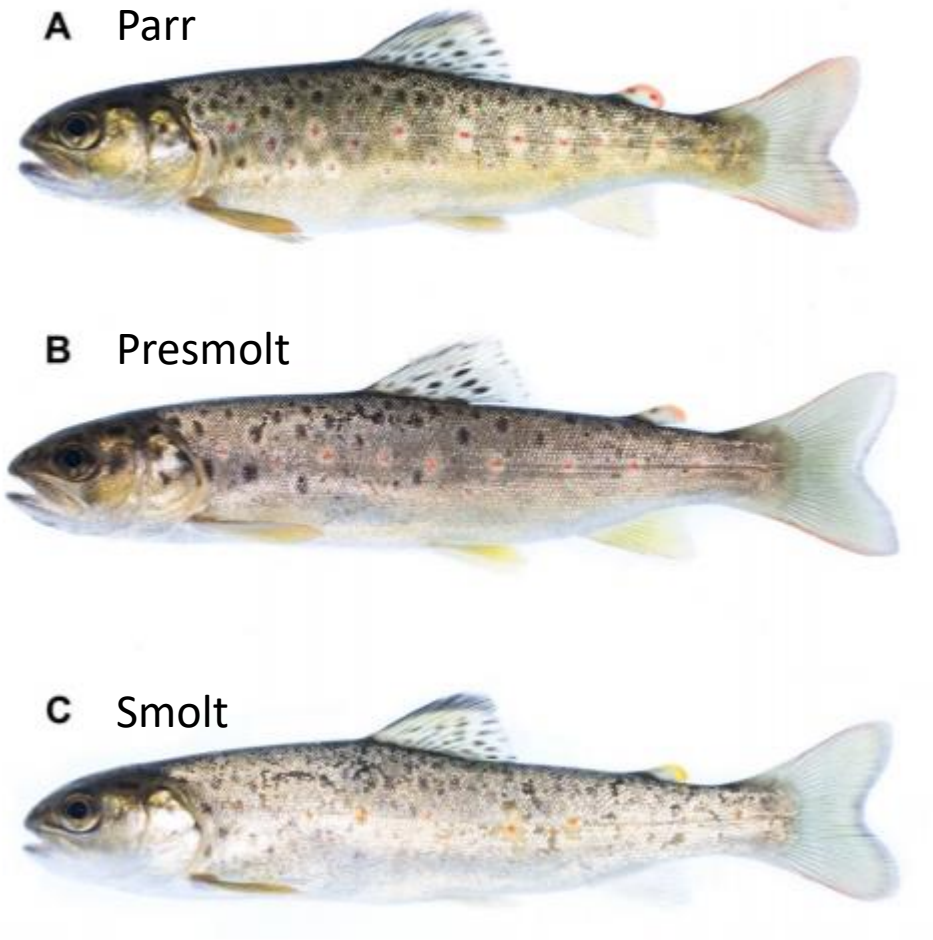


Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

Assumption #1 – All migrating juveniles are ‘smolts’

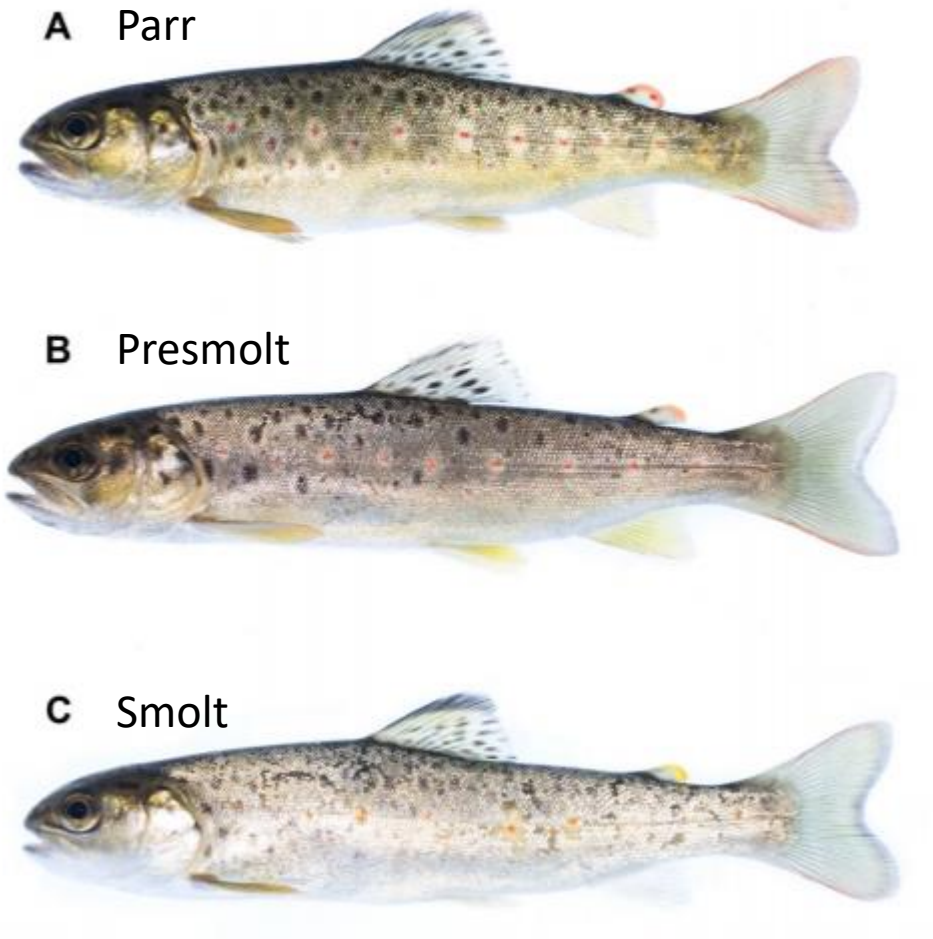


Do **not** migrate

Might migrate

Definitely migrate!

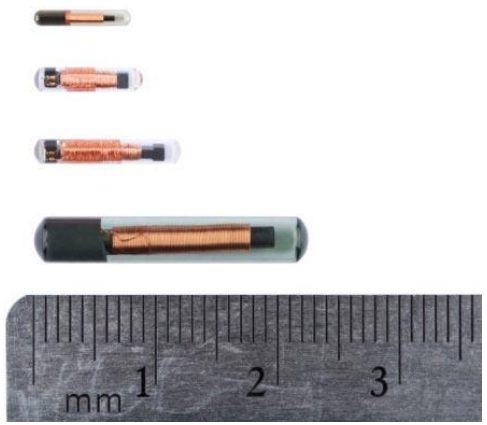
Assumption #1 – All migrating juveniles are ‘smolts’



The influence of initial developmental status on the life-history of sea trout (*Salmo trutta*)

Diego del Villar-Guerra[1], Martin H. Larsen[2], Henrik Baktoft[3], Anders Koed[3] & Kim Aarestrup[3]

PIT-tagged



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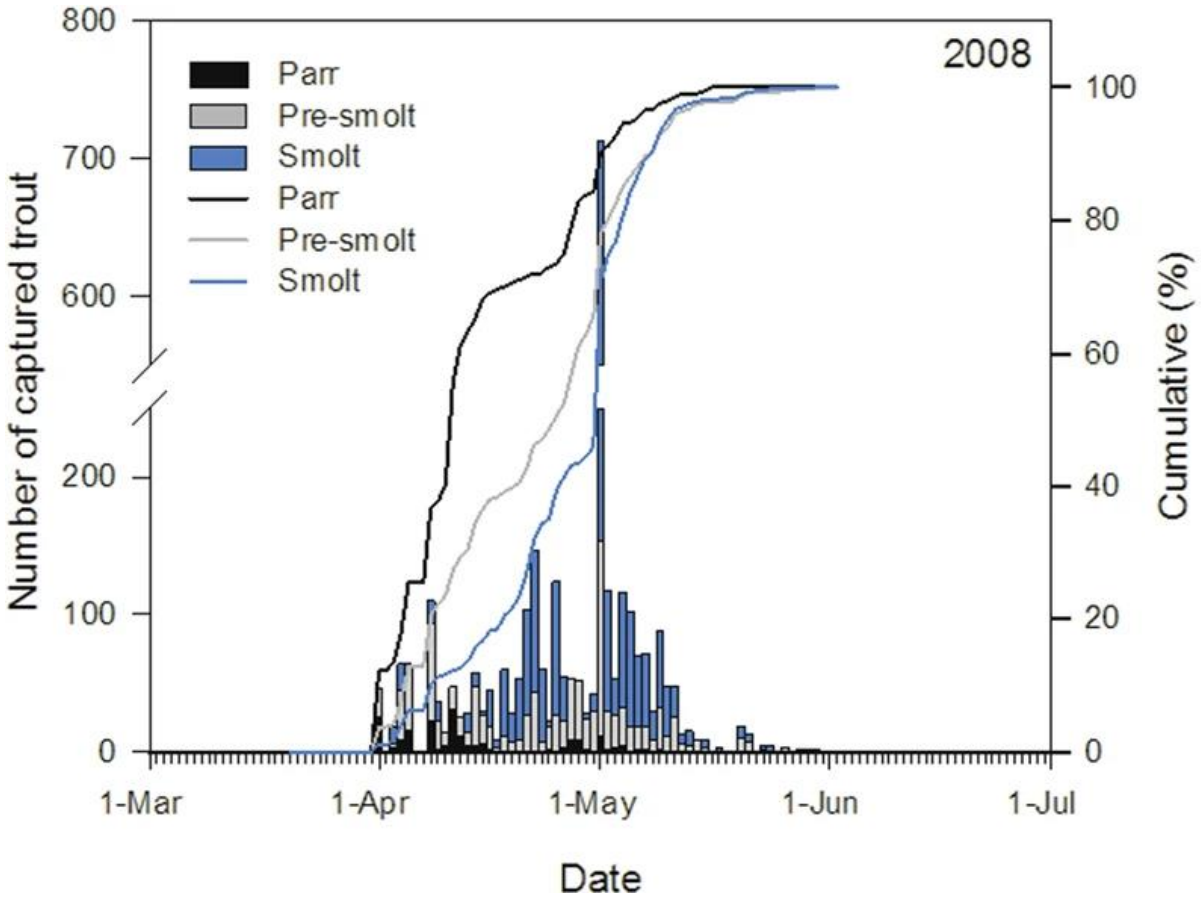

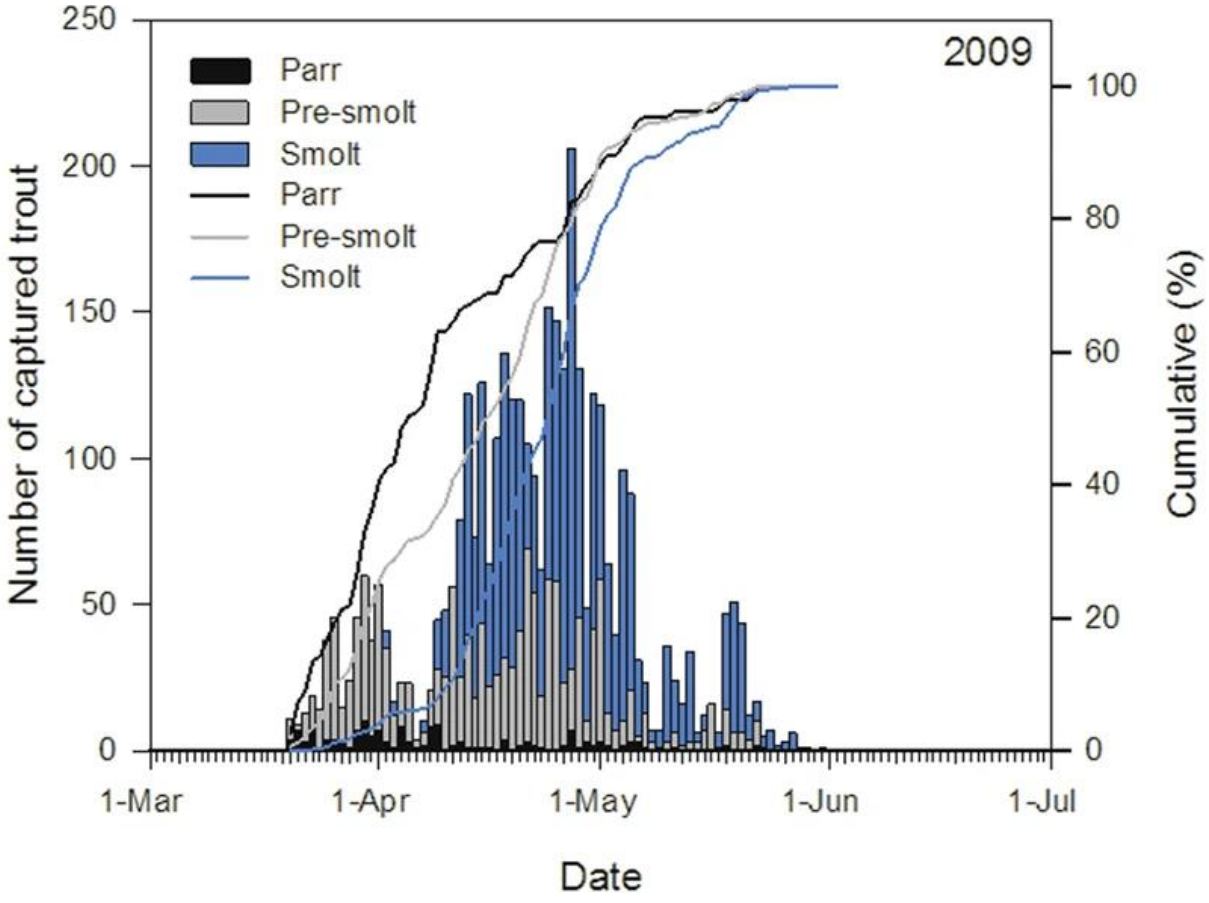

del Villar-Guerra et al. 2019 *Sci Rep*

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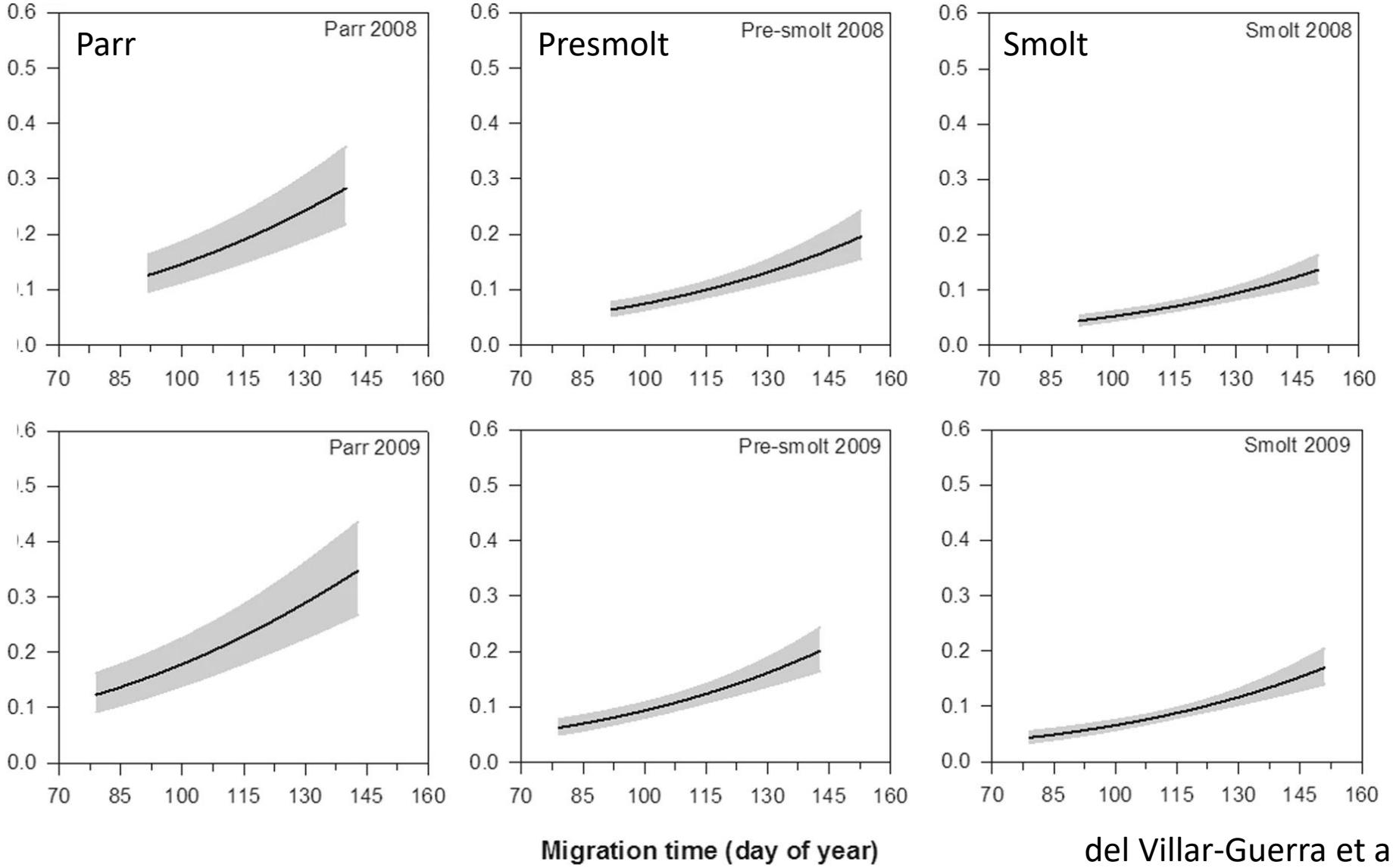

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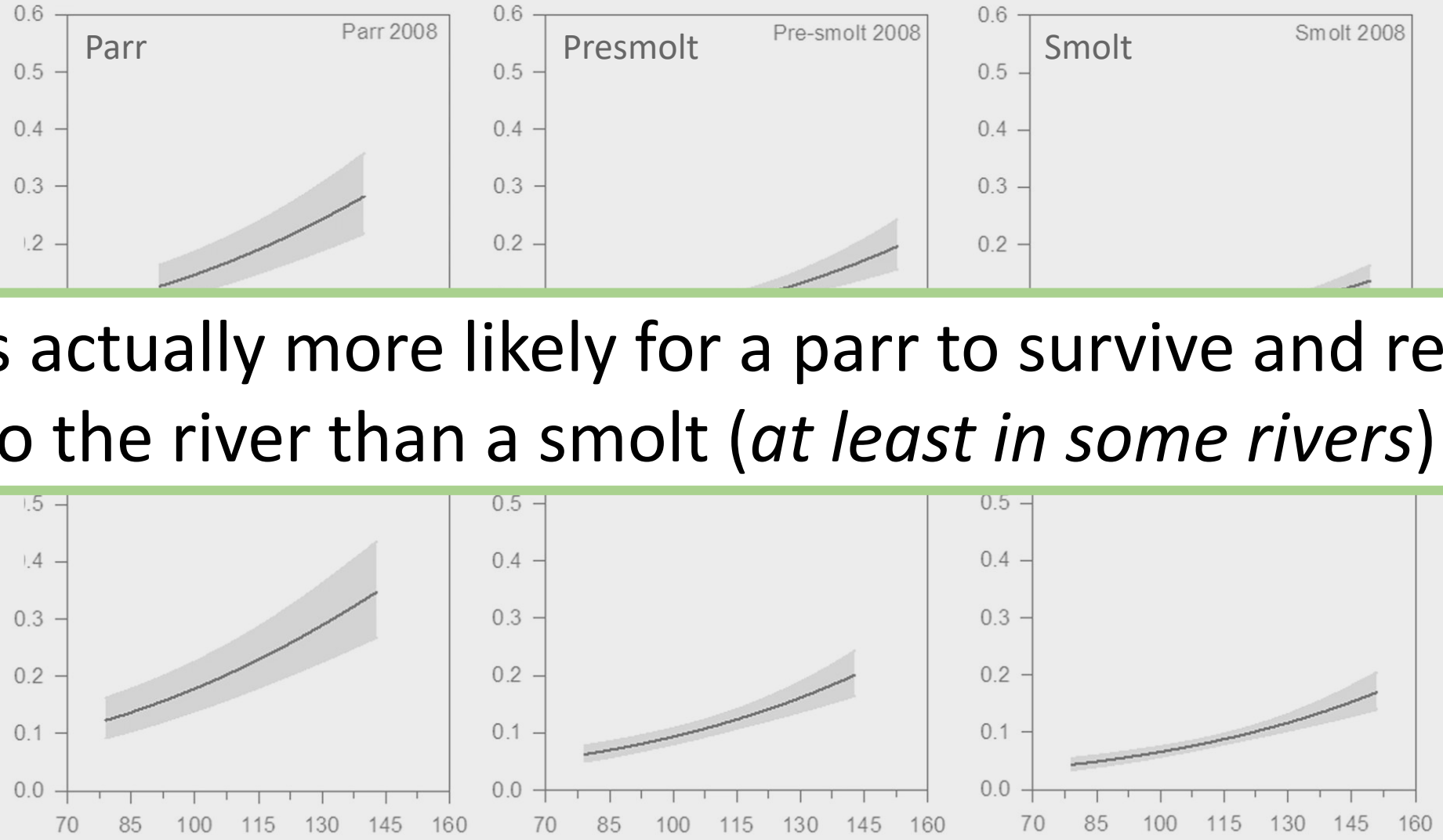
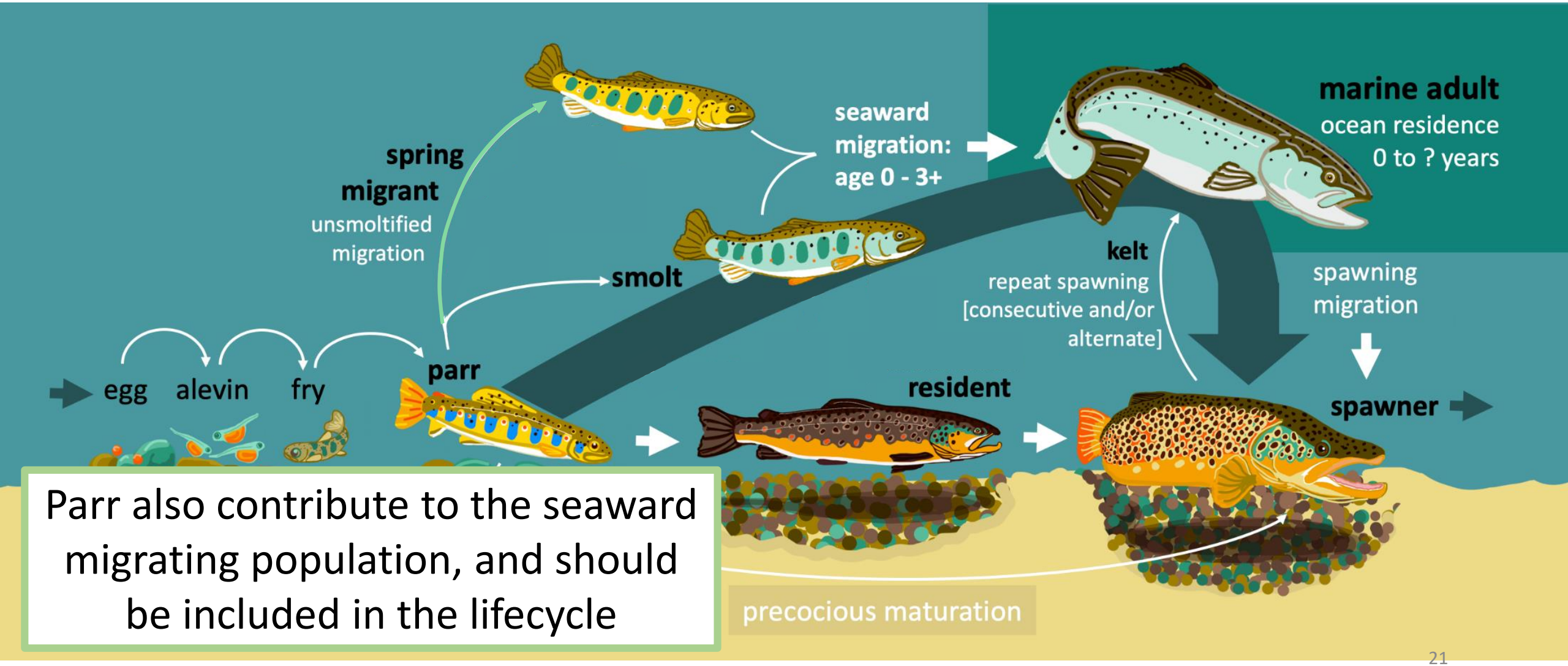


So, it’s actually more likely for a parr to survive and return to the river than a smolt (*at least in some rivers*)

del Villar-Guerra et al. 2019 *Sci Rep*

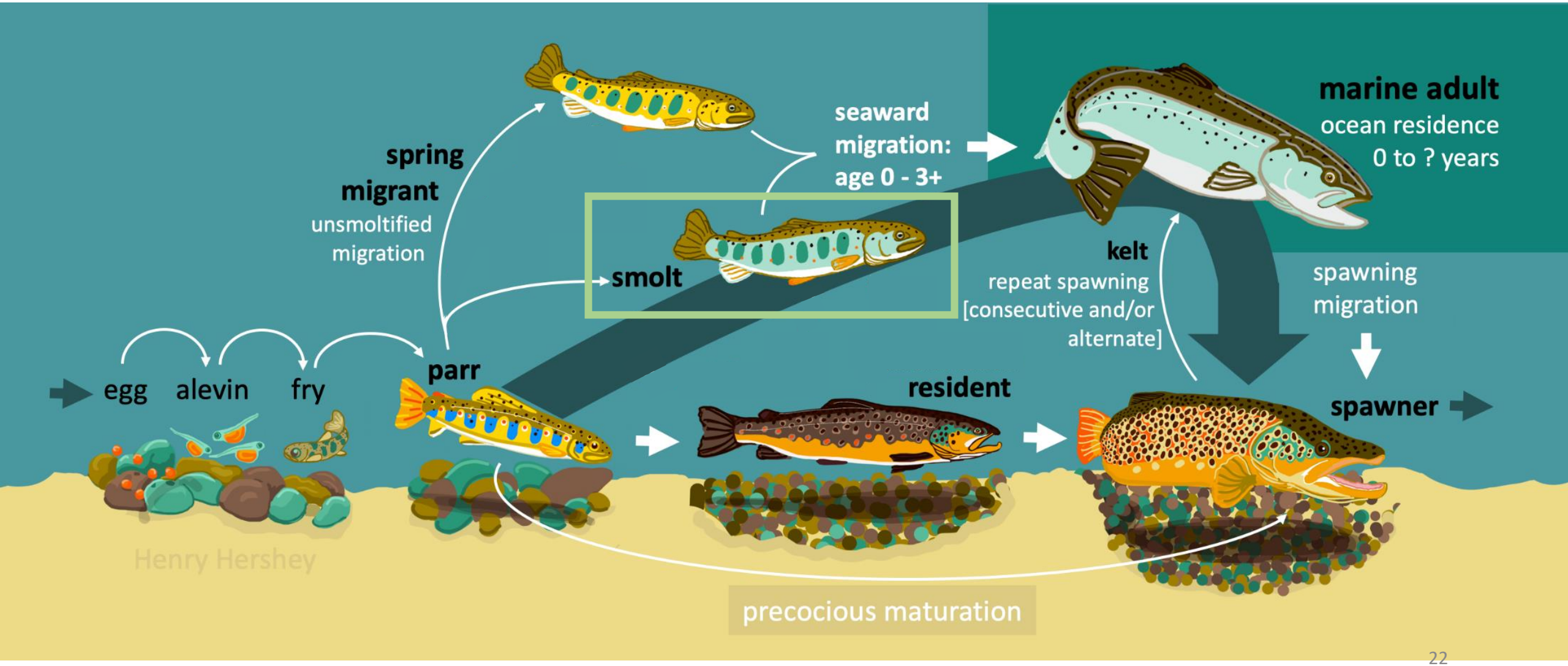
What does it mean?



Parr also contribute to the seaward migrating population, and should be included in the lifecycle

Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

Assumption #2 – Smolts migrate in the spring



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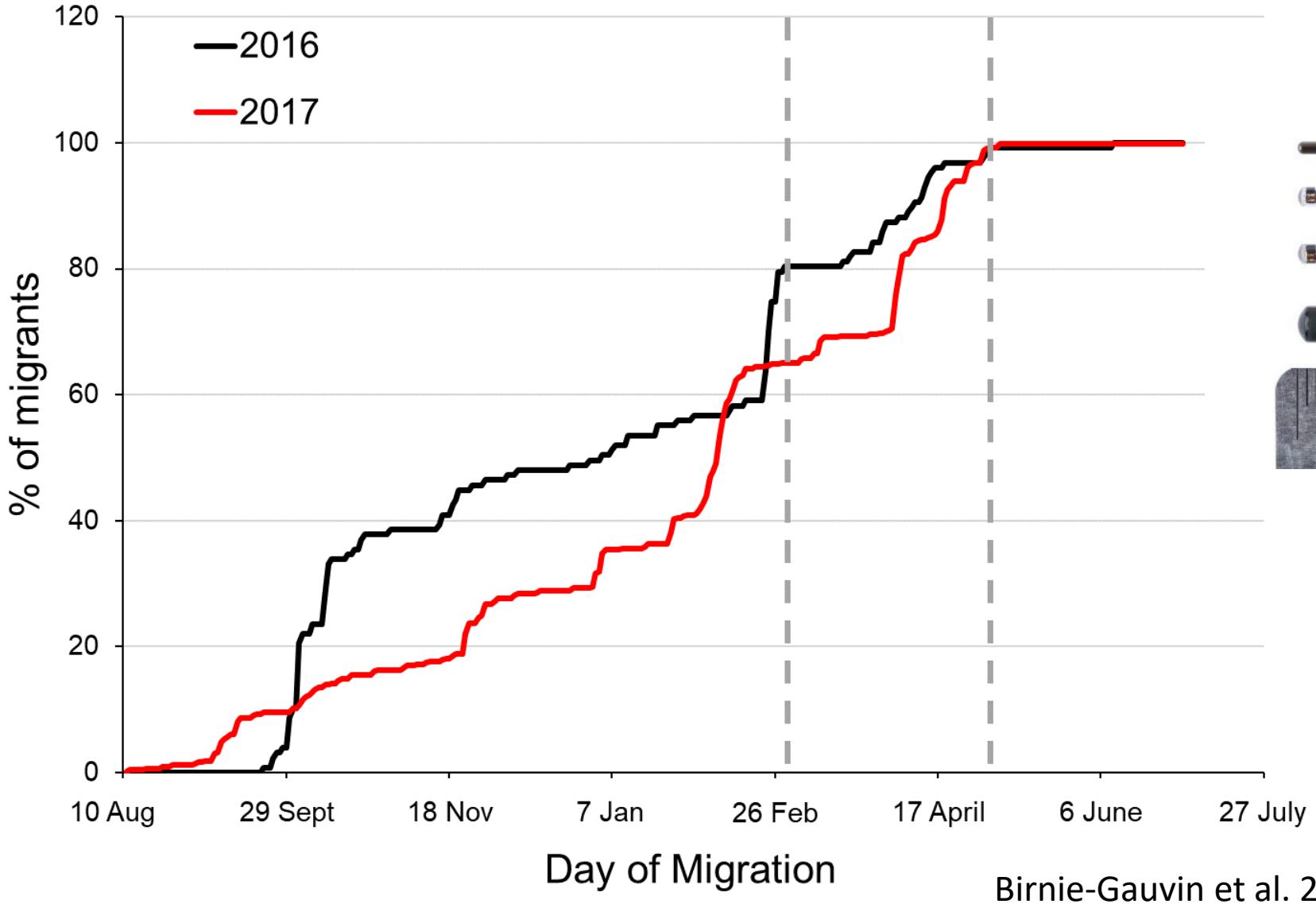

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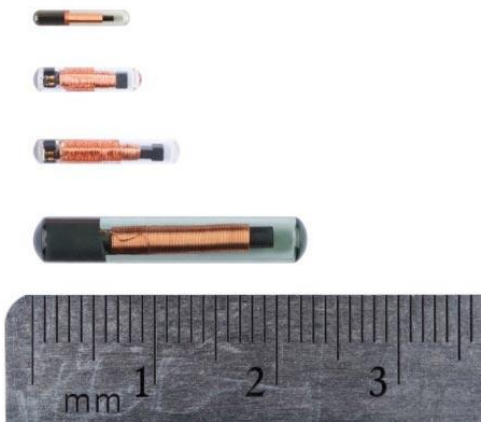

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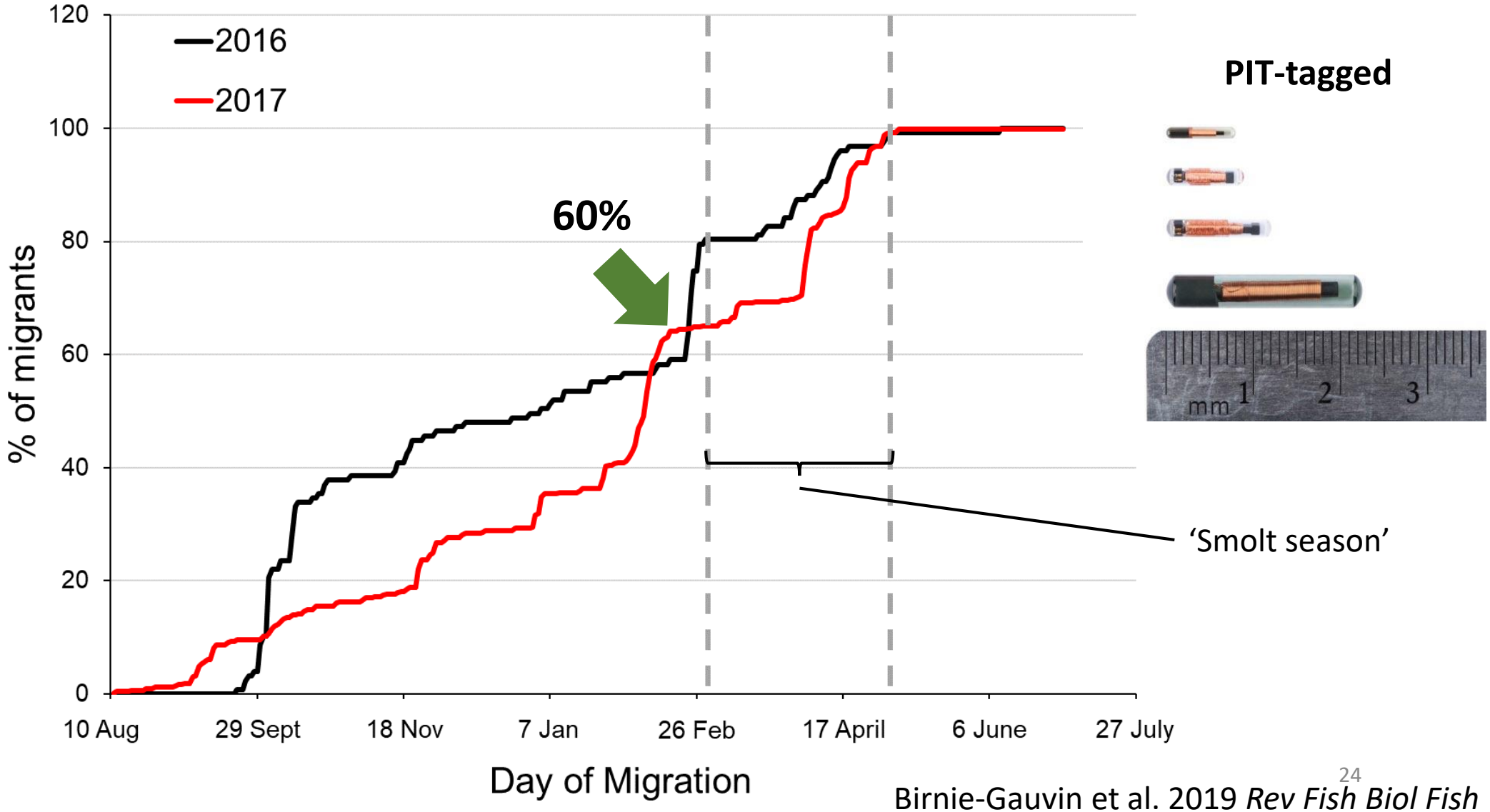
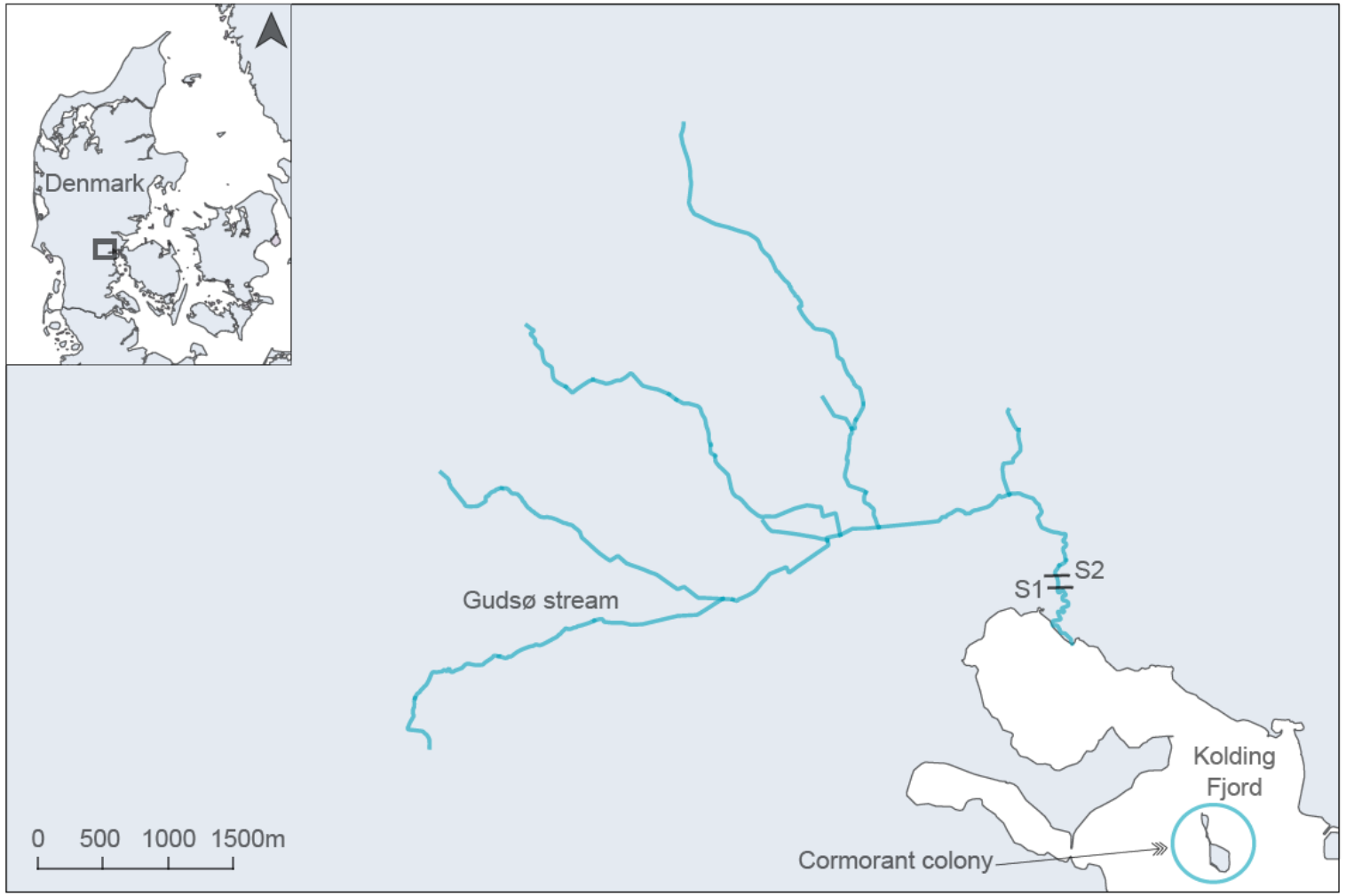


Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

According to the books…

- It’s unlikely they are truly migrating – it’s just ‘in-stream’ movement
- Even if they are migrating, autumn migrants are unprepared for entry in salt water, so it’s unlikely they will survive

Autumn migrants, do they survive?

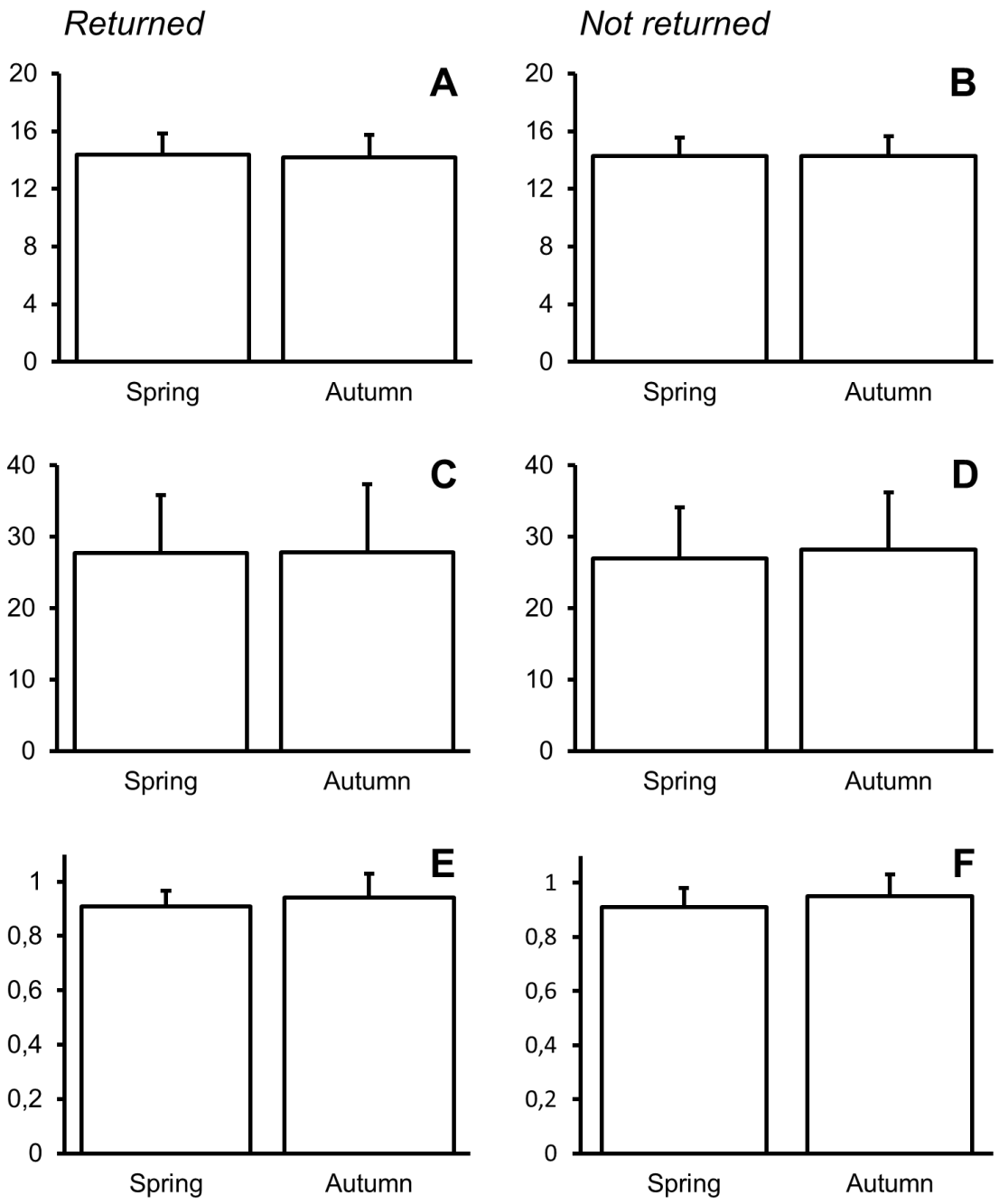


Birnie-Gauvin and Aarestrup 2018 *Ecol Fresh Fish*

Length

Mass

Condition



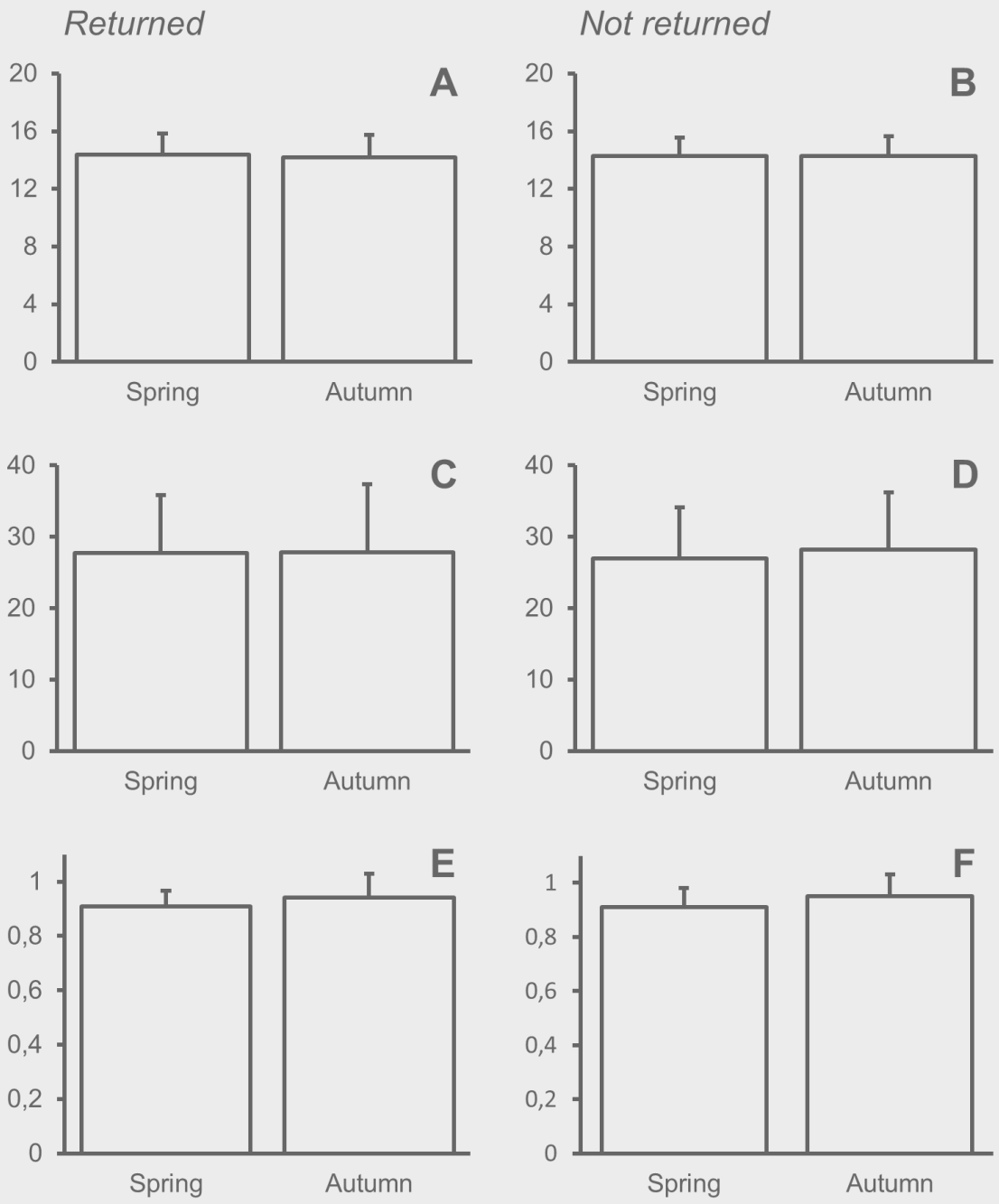
N = 413

Birnie-Gauvin and Aarestrup 2018 *Ecol Fresh Fish*

Length

Mass

Condition

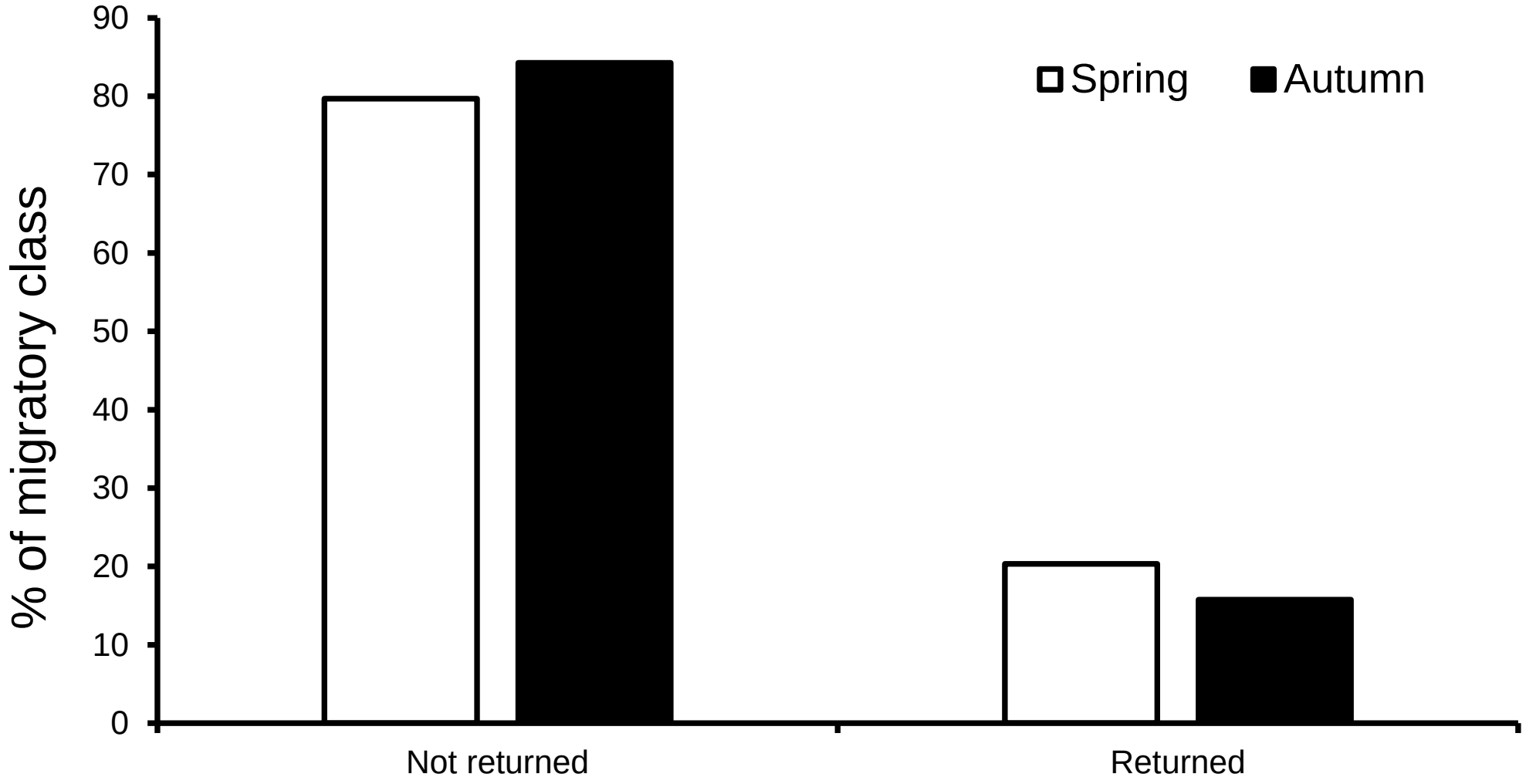


N = 413

Maybe physiological differences, but no differences in these broad criteria

Birnie-Gauvin and Aarestrup 2018 *Ecol Fresh Fish*

Survival at sea



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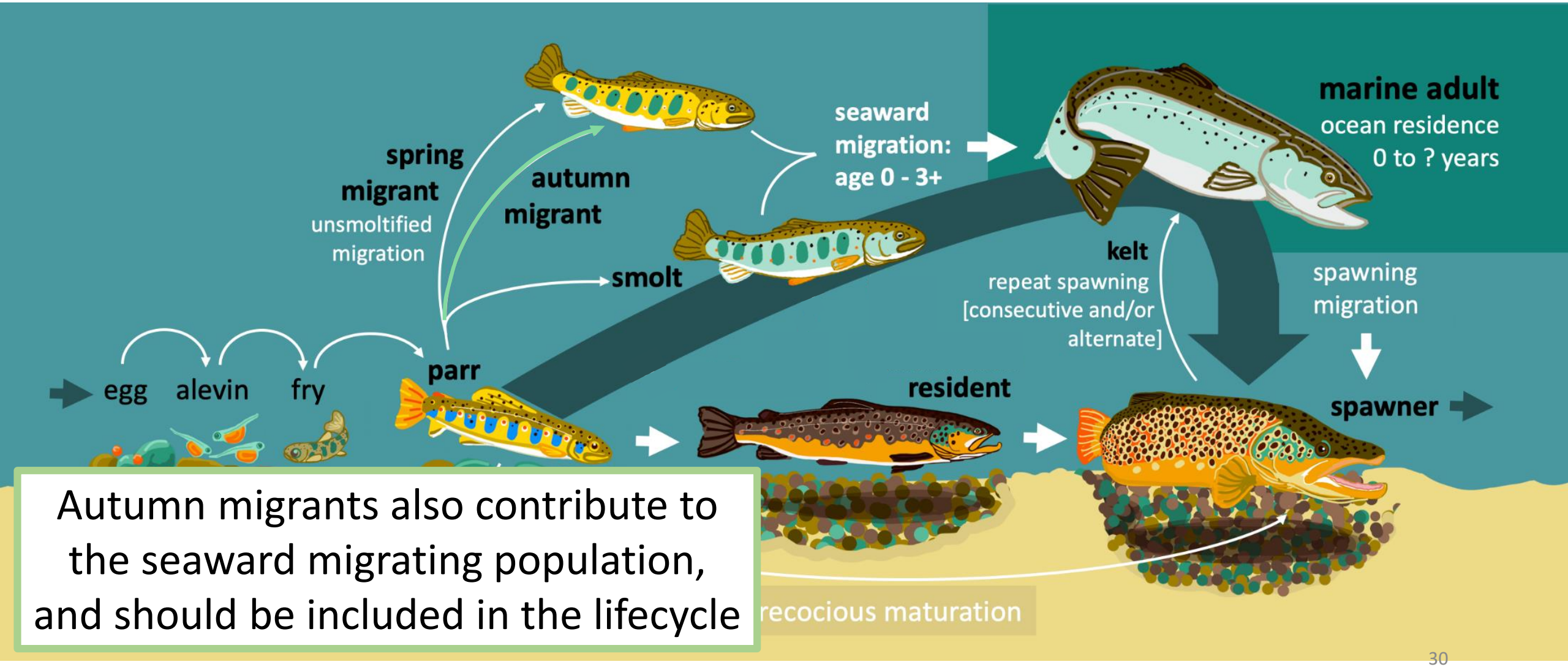

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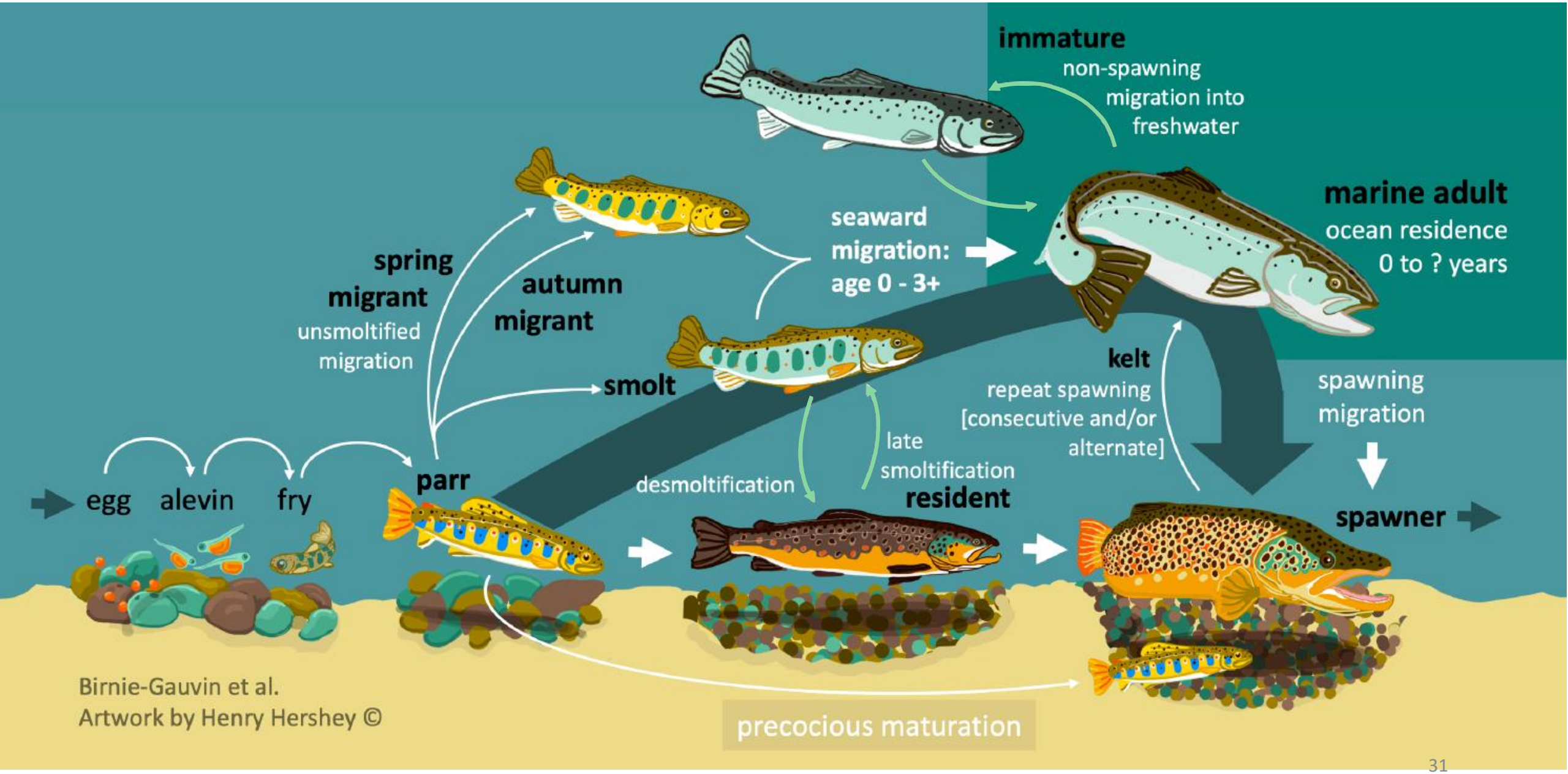
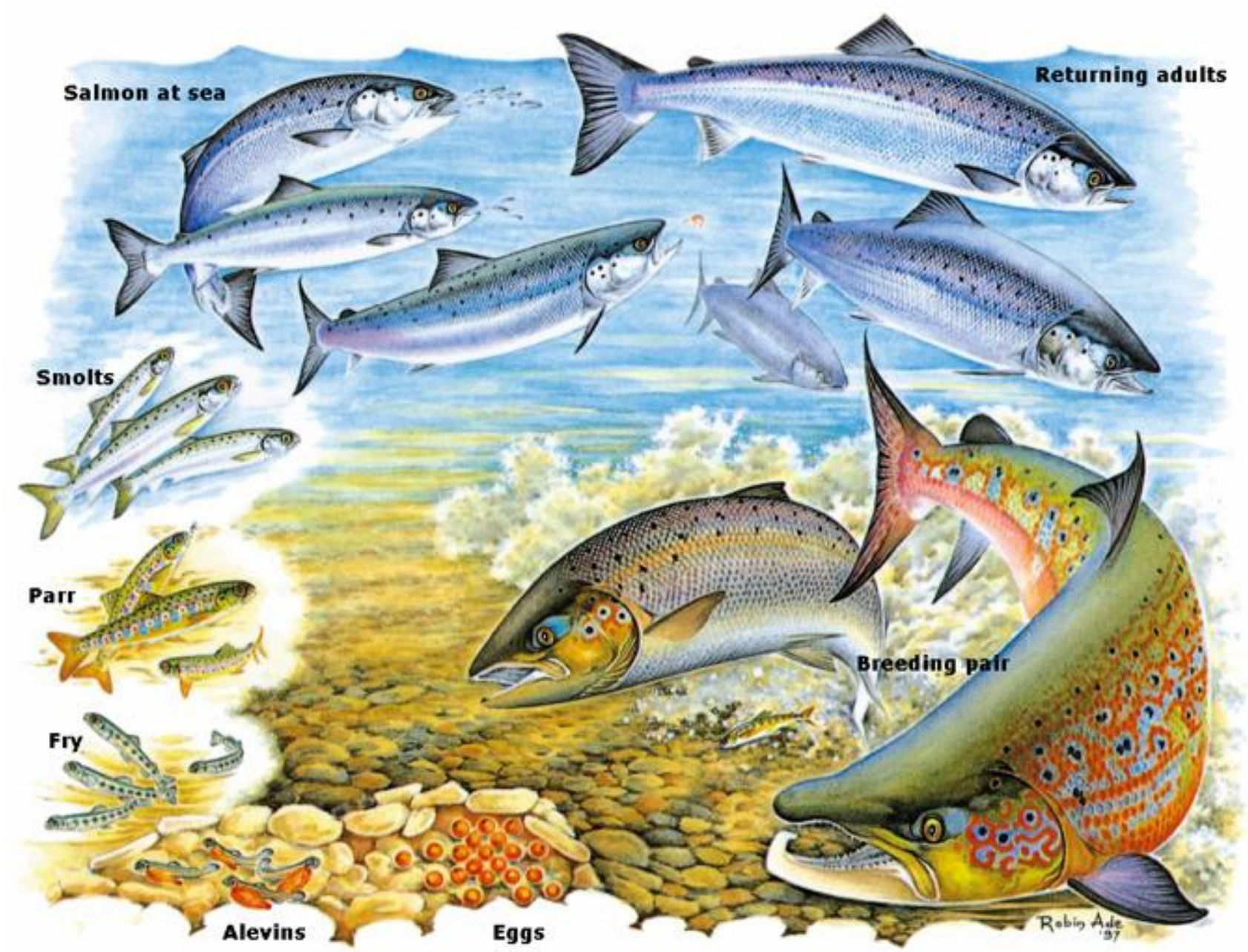


Birnie-Gauvin et al. 2019 *Rev Fish Biol Fish*

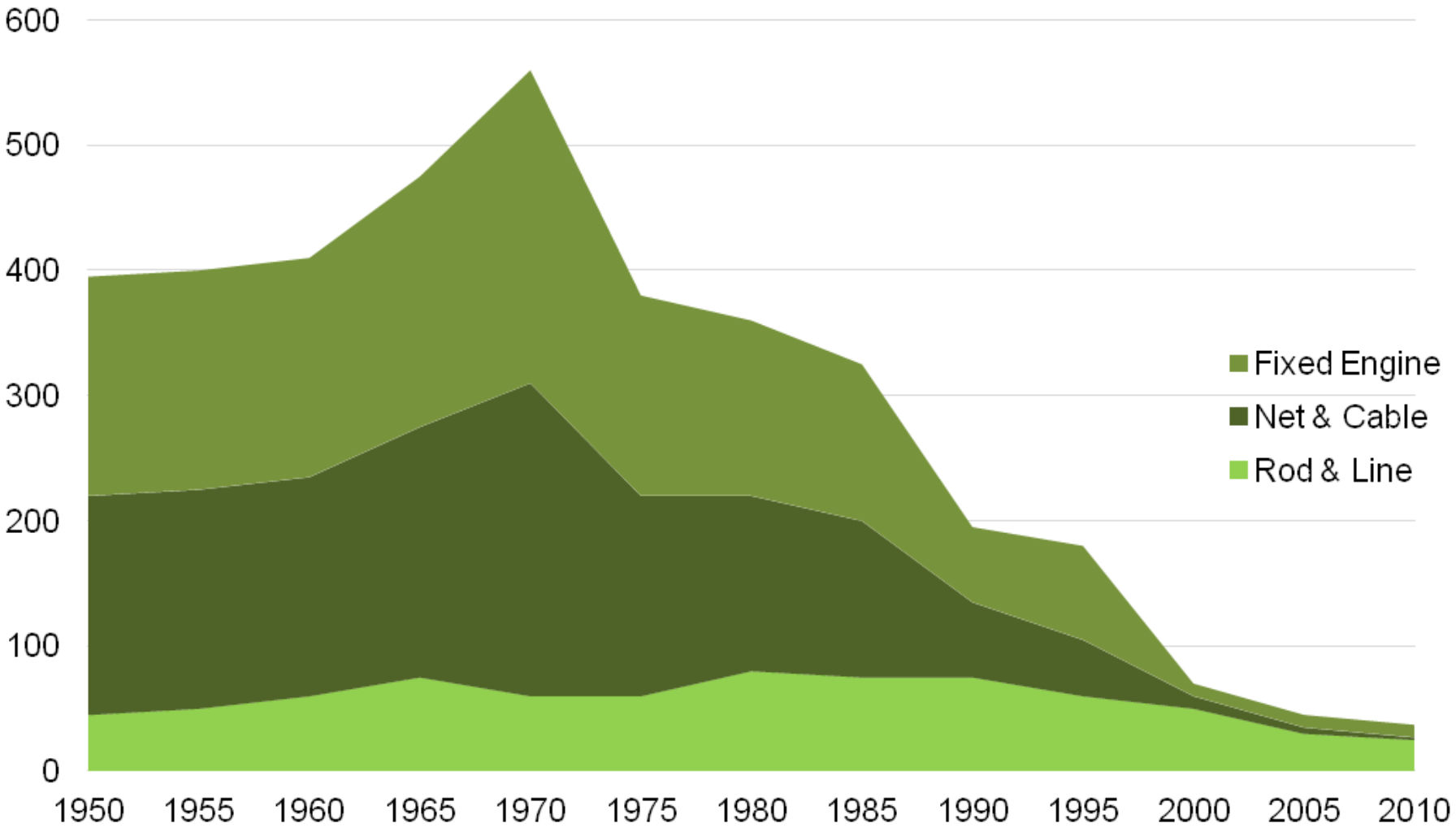
Biotelemetry Example 2: Radio Telemetry



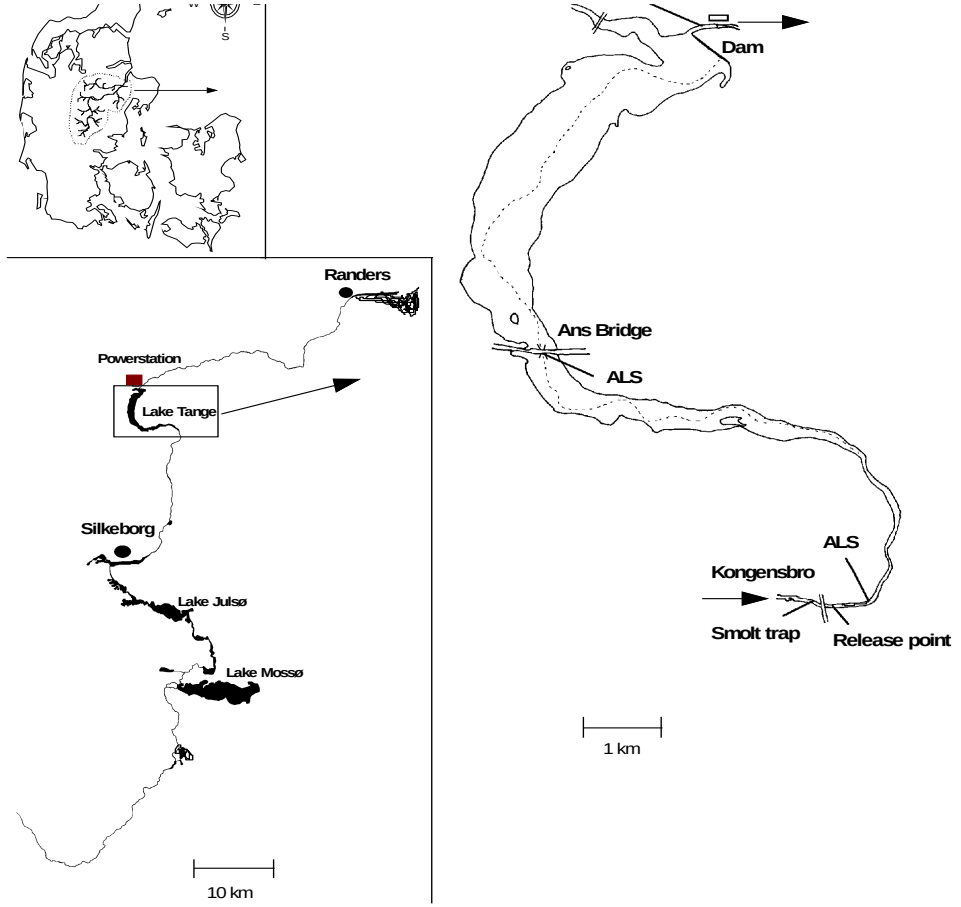
Anadromous Lifecycle



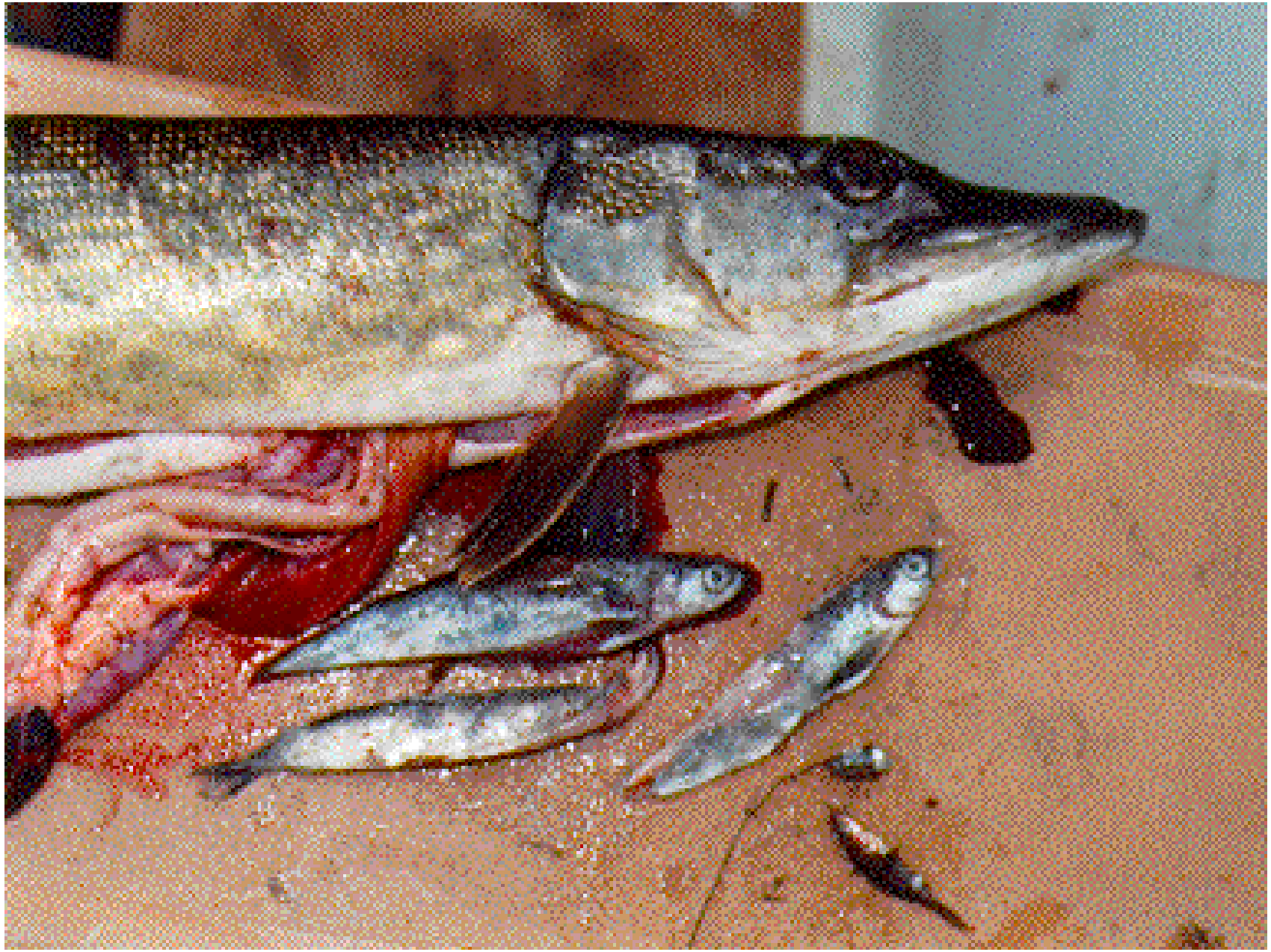
Wild capture of Atlantic salmon (t) in Scotland

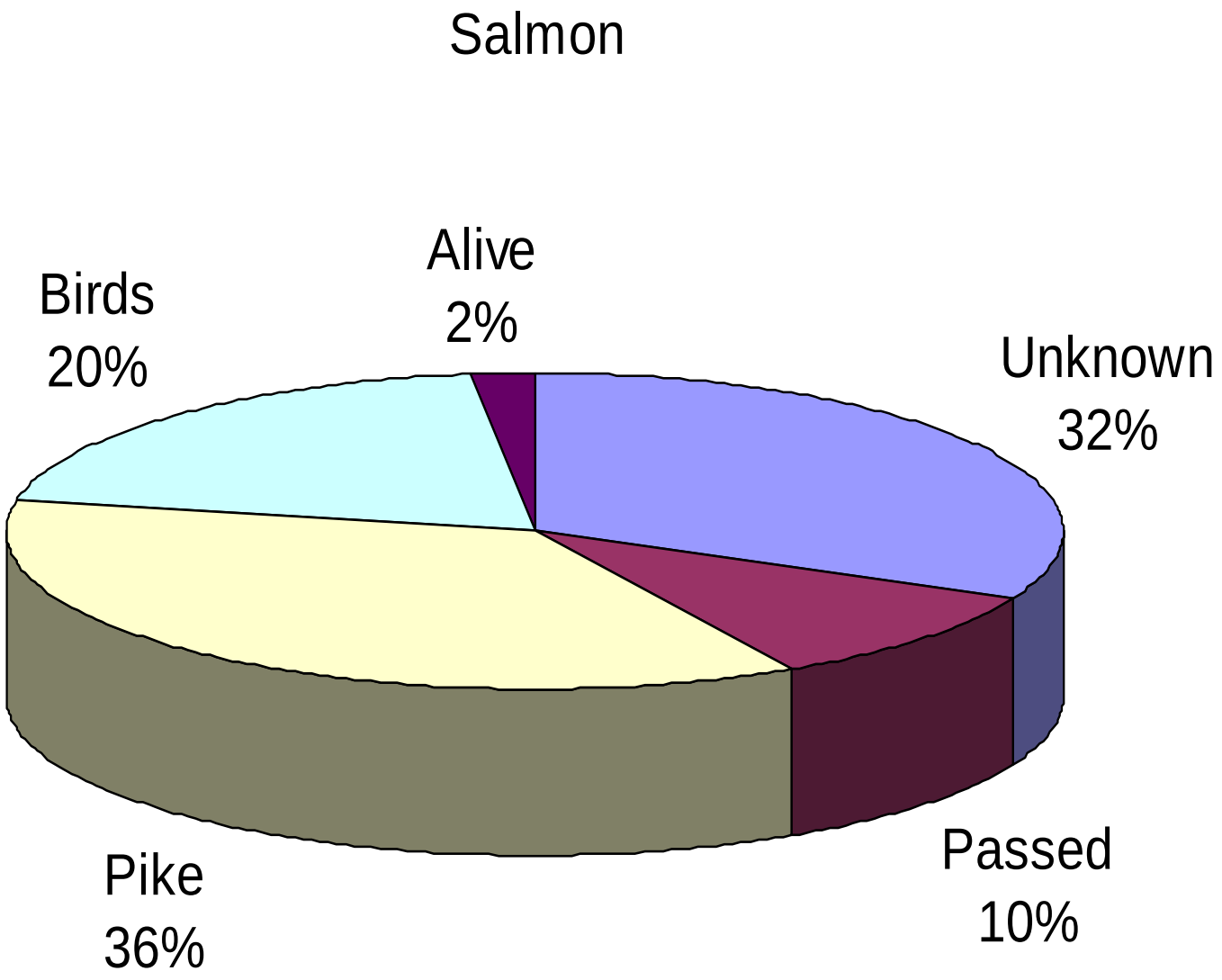


Tange Reservoir Study



Jepsen et al. 1998; Aarestrup et al. 1999




Salmon
Alive
2%
Birds
20%
Unknown
32%
Pike
36%
Passed
10%

Different estimates of salmon- and trout smolt mortality in Tange reservoir 1996, based on **8715** released salmon smolts (from hatchery), **50** radiotagged salmon smolts, **4560** wild trout smolts, **24** radiotagged wild trout.

	Salmon (hatchery)	Trout (wild)
Mortality (calculated from trap catch)	86.4 %	81.8 %
Mortality (radiotagged smolts)	87.5%	87.5 %
Mortality pr. km. (trap catch)	15.2 %	13.2 %
Mortality pr. km. (radiotagged)	15.9 %	15.9 %

Smolt loss at barriers

Types	Number investigated	Avg. smolt loss (%)
Mills	5	30
Fish farms	38	42
Hydro Power stations	7	82

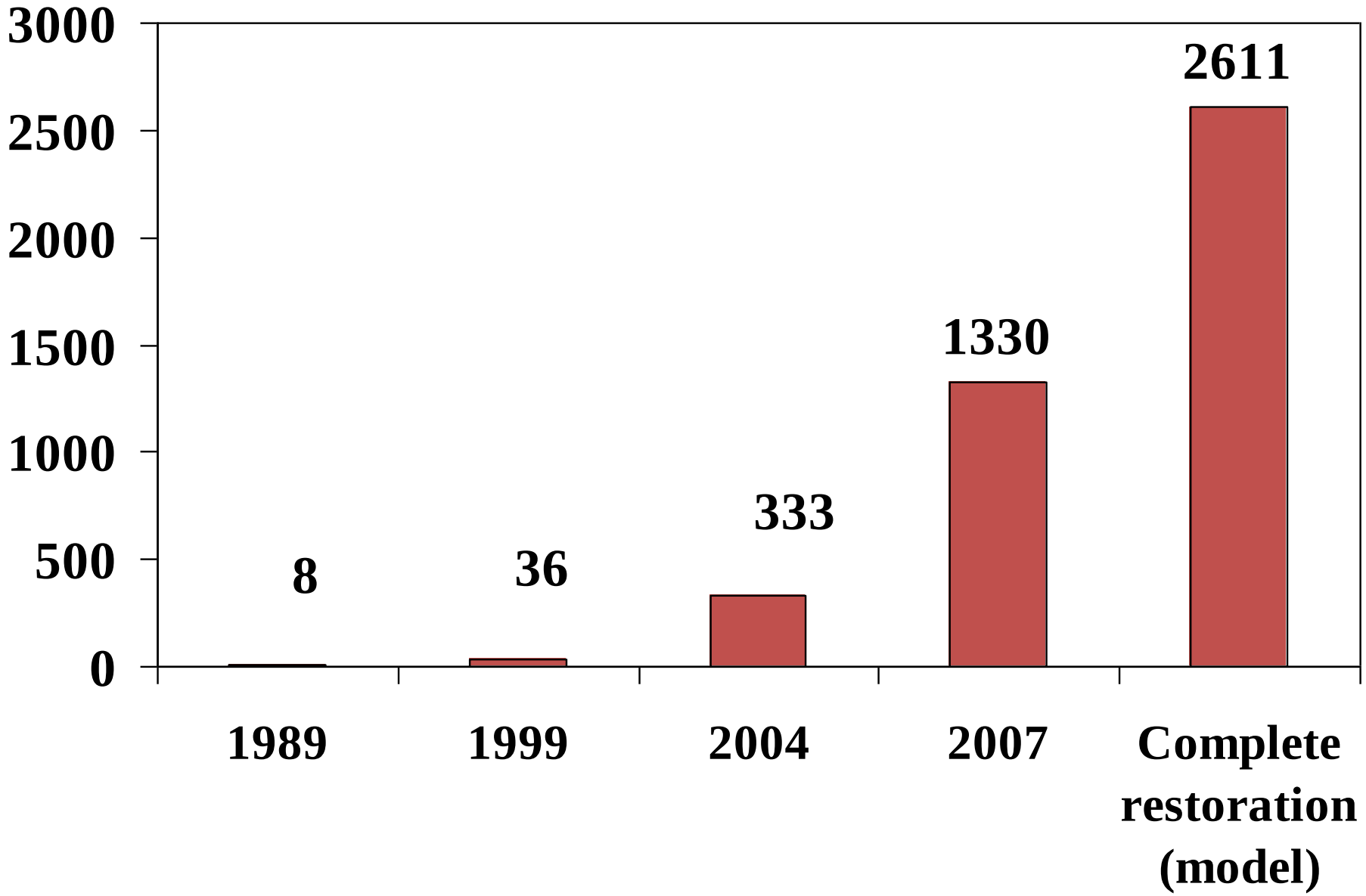
Loss when passing 3 fish farms in a river: $(1-(1-0.42)^3)= 80\ \%$!

Management recommendations

- Remove weirs including hydropower stations
- If not, try harder and remove weirs including hydropower stations!
- At the very least, a grid with 6mm spacing at the inlet, and allocate as much water as possible for passage

..migration barriers have been removed and habitats restored

Population development sea trout – River Villestrup



Biotelemetry Example 3: Pop up Satellite Archival Tags (PSAT)

Traditional studies have relied on:

- Carlin tags, wait for recapture
- Gather fishery data
  - Both effort-dependent

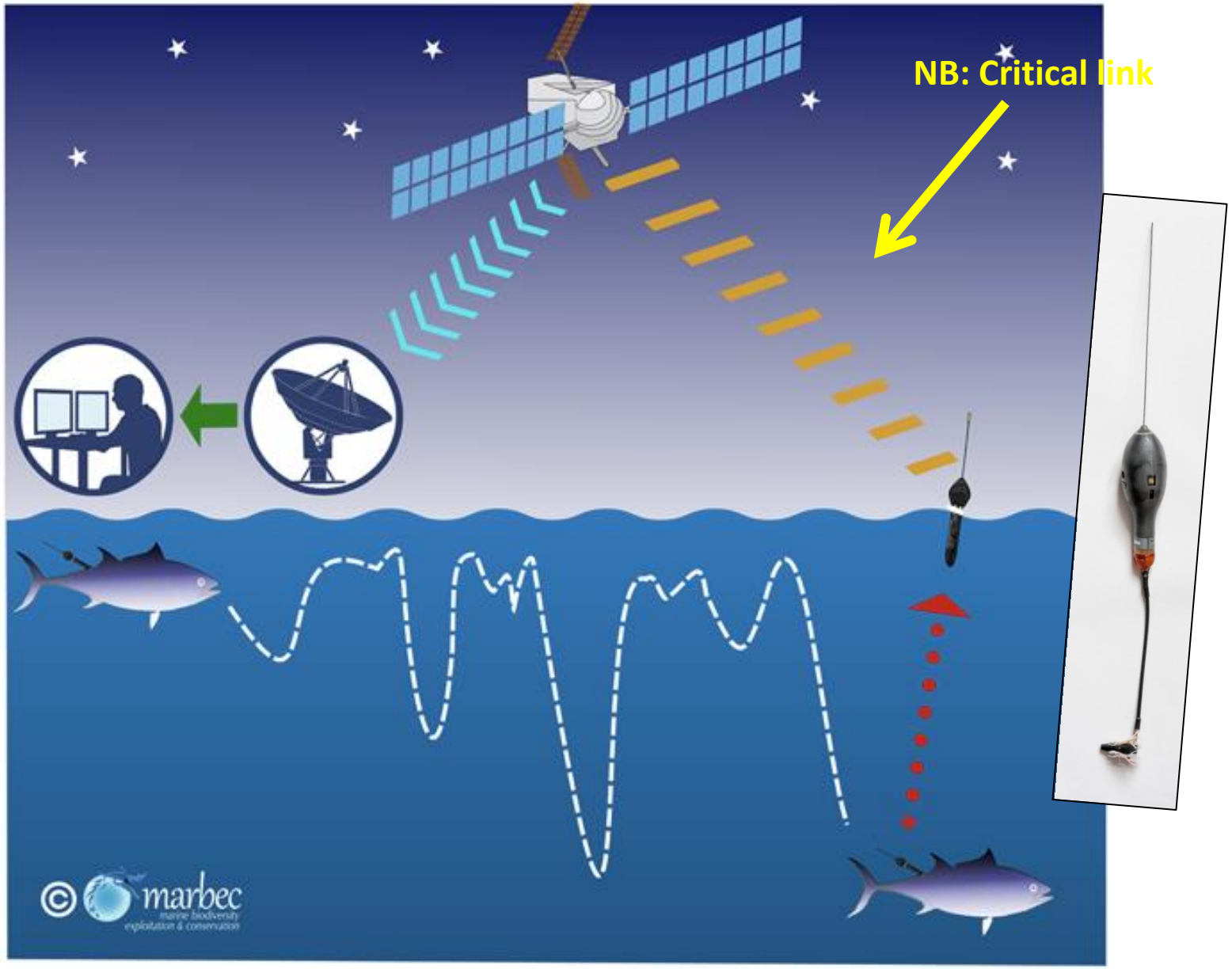
- Marine expeditions

But what about biotelemetry?

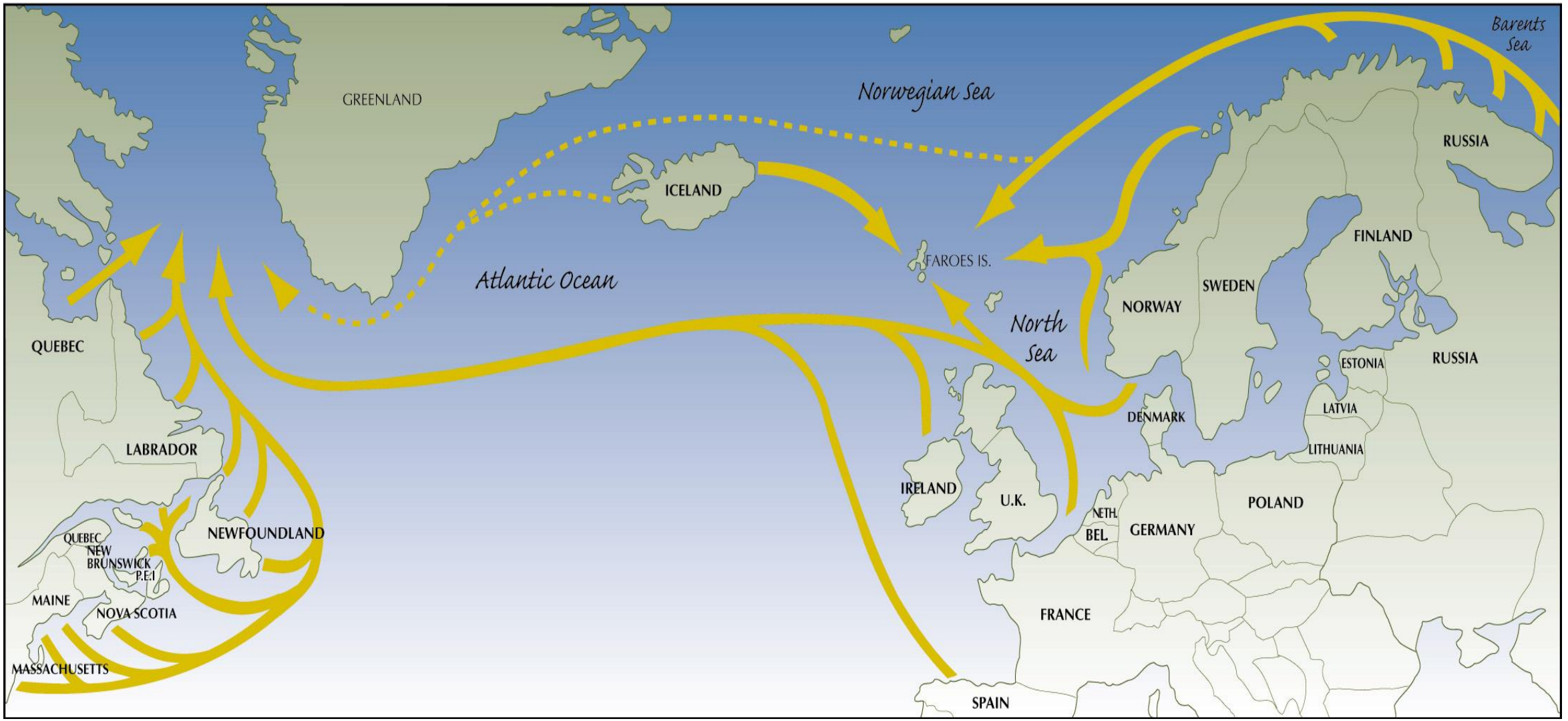
Pop up Satellite Archival Tags (PSAT)

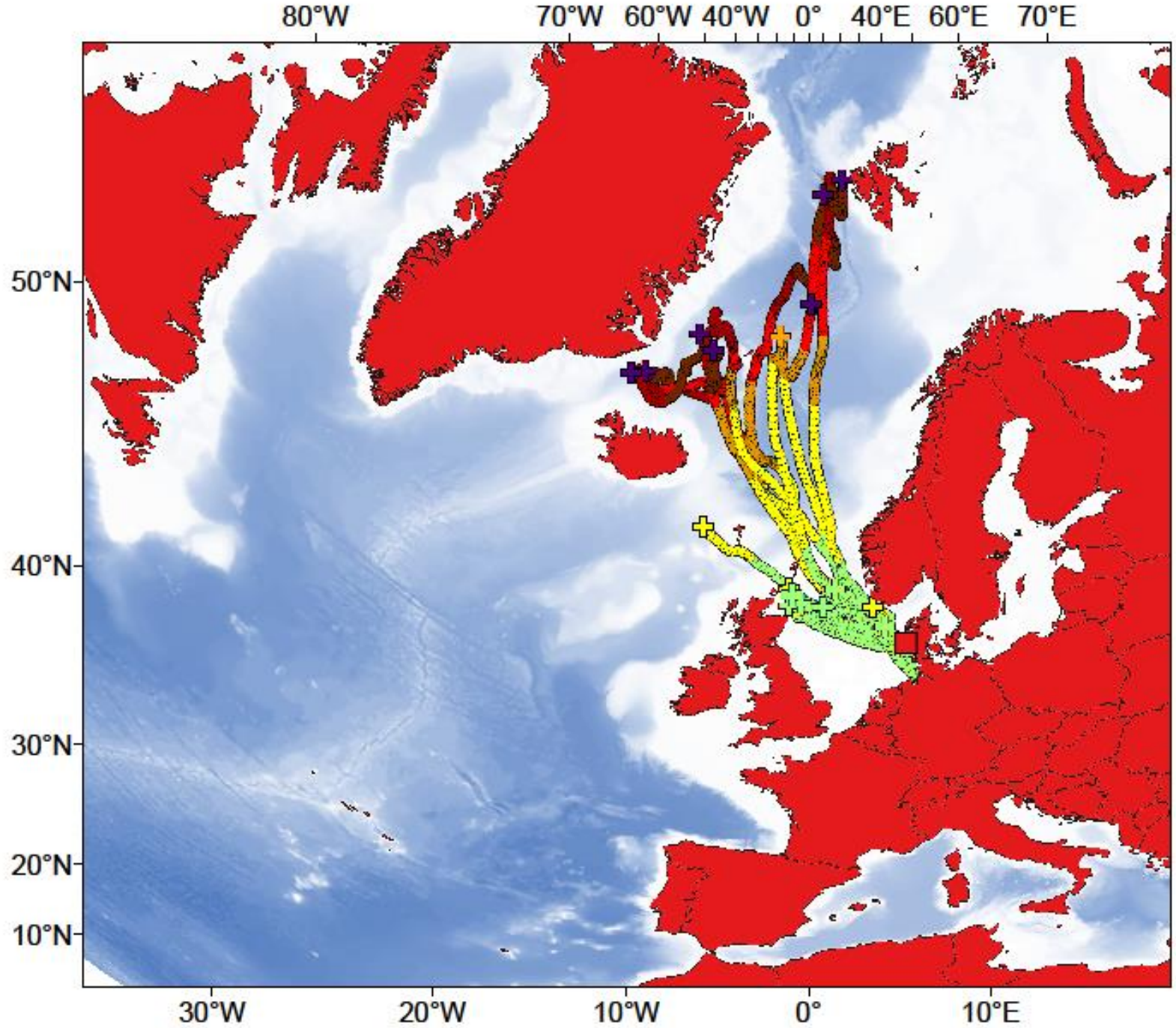
- Electronic tag that measures light, temperature and depth
- Programmed to release at a specific time
- Once at surface, transmit a subset of data to ARGOS satellites
- Data can be used to model position and describe behaviour

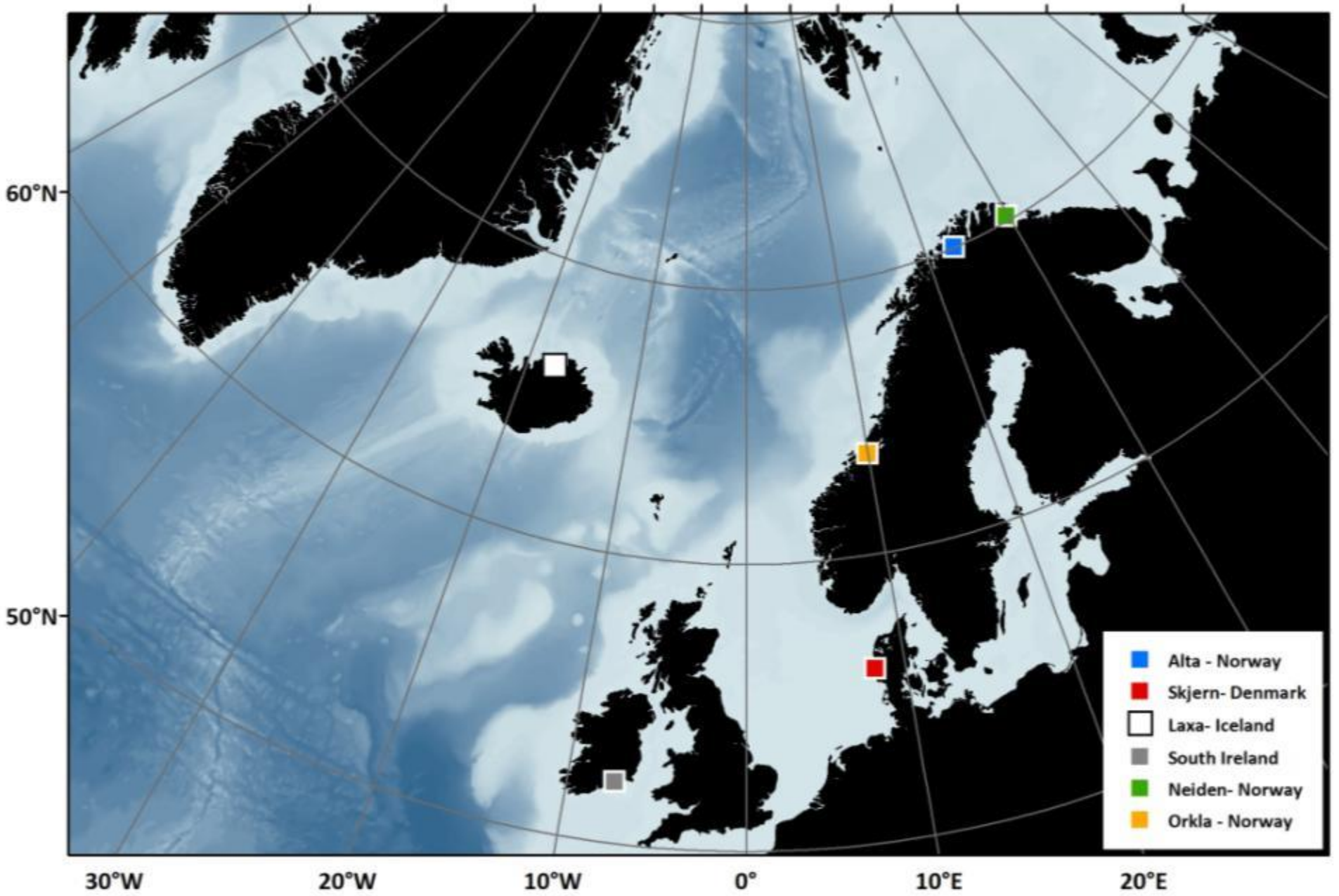
Pop up Satellite Archival Tag (PSAT)



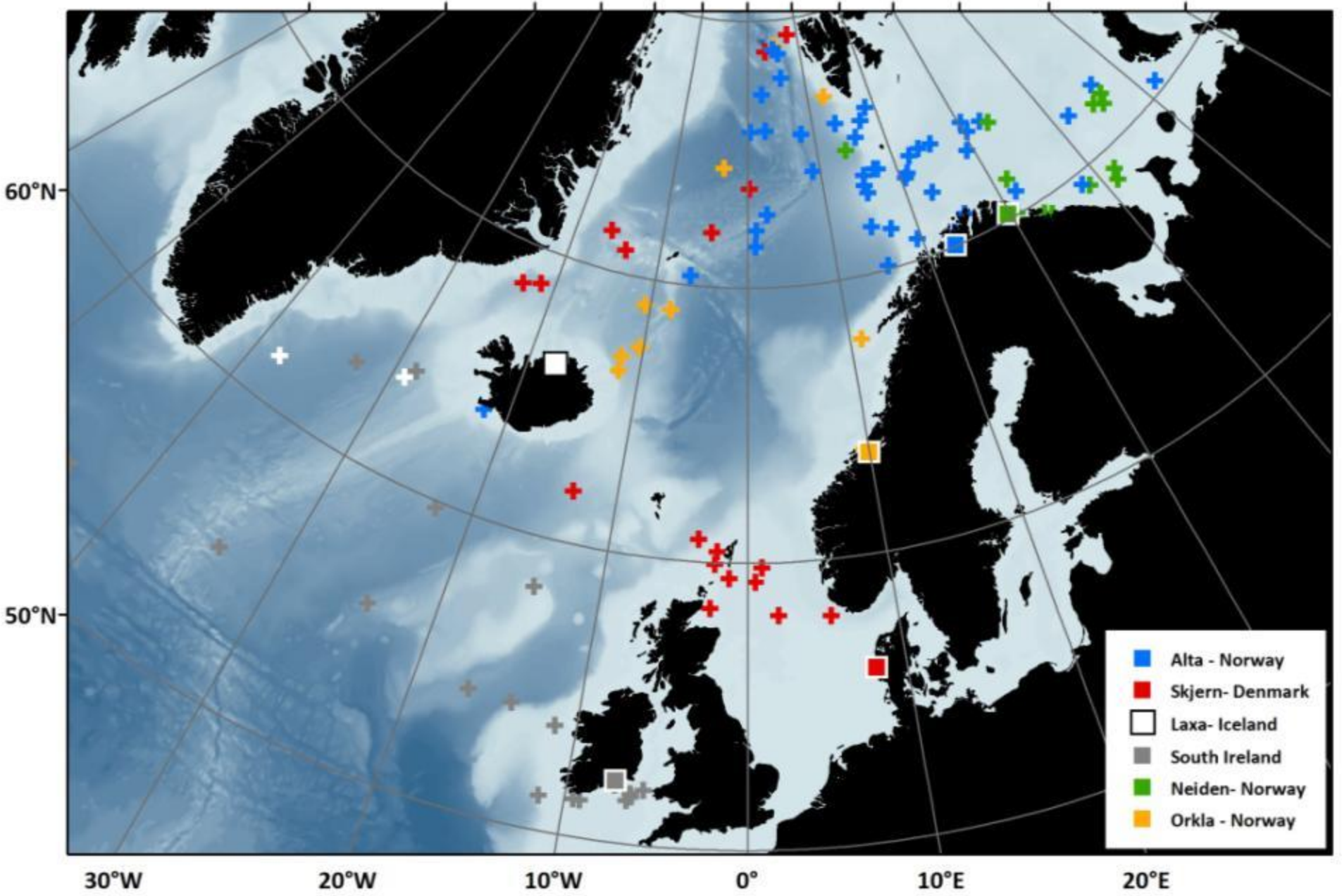
Historical Salmon distribution & migrations at sea



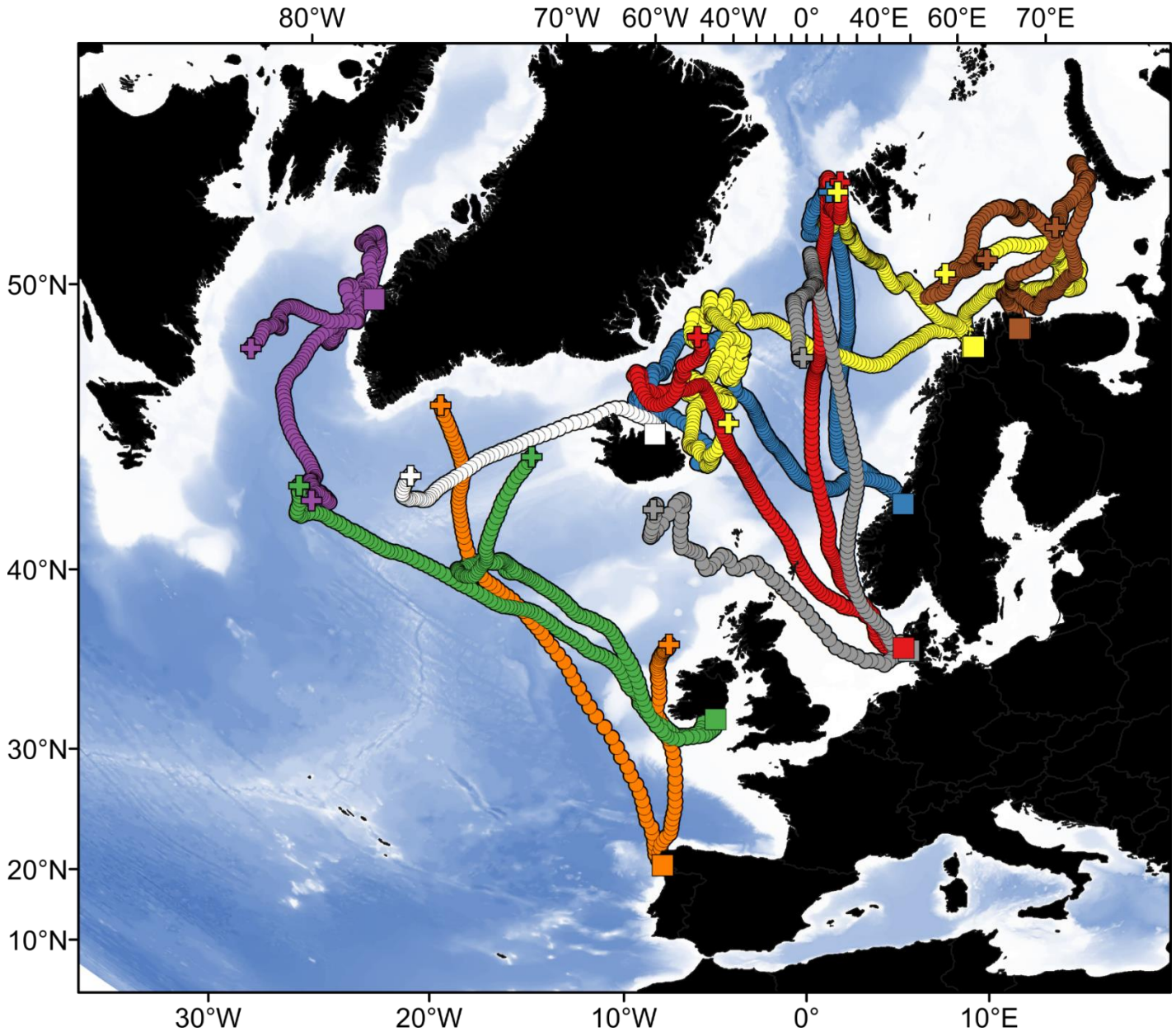

80°W
70°W
60°W
40°W
0°
40°E
60°E
70°E
50°N
40°N
30°N
20°N
10°N
30°W
20°W
10°W
0°
10°E

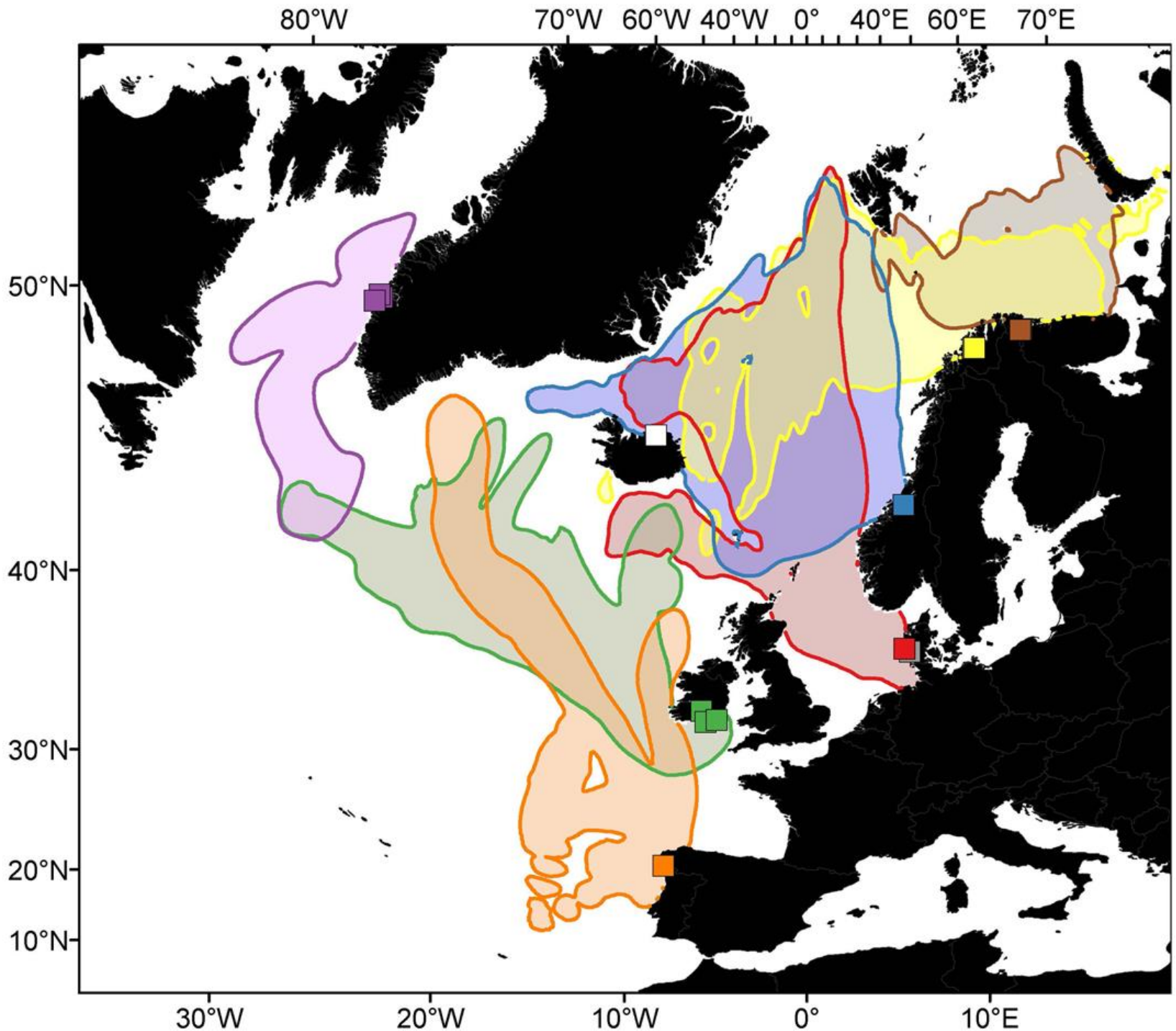


170 kelts from different rivers tagged from 2008-2012



125 tags sending data


80°W
70°W
60°W
40°W
0°
40°E
60°E
70°E
50°N
40°N
30°N
20°N
10°N
30°W
20°W
10°W
0°
10°E


80°W
70°W
60°W
40°W
0°
40°E
60°E
70°E
50°N
40°N
30°N
20°N
10°N
30°W
20°W
10°W
0°
10°E

World Record

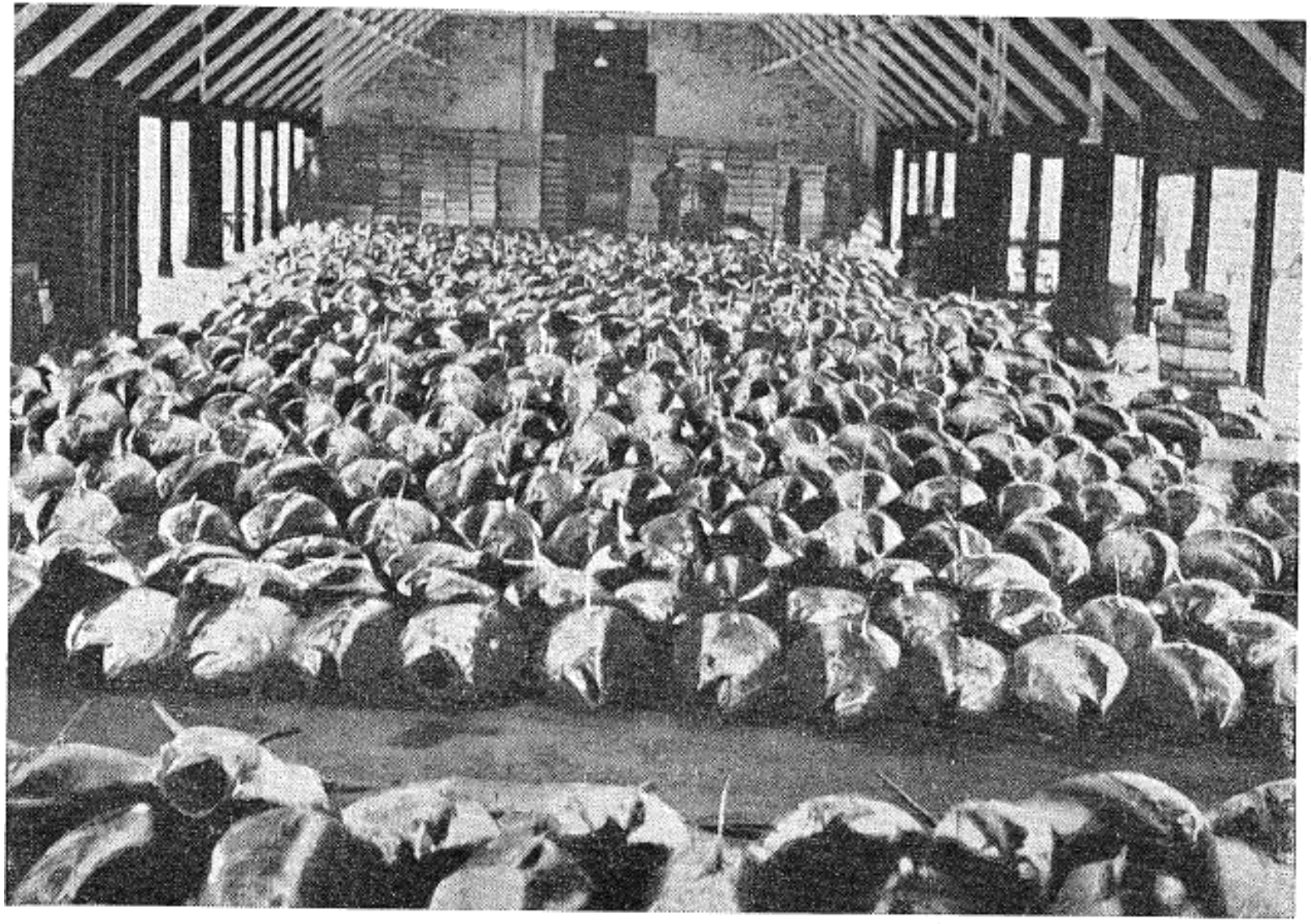
Nova Scotia

26. October 1979

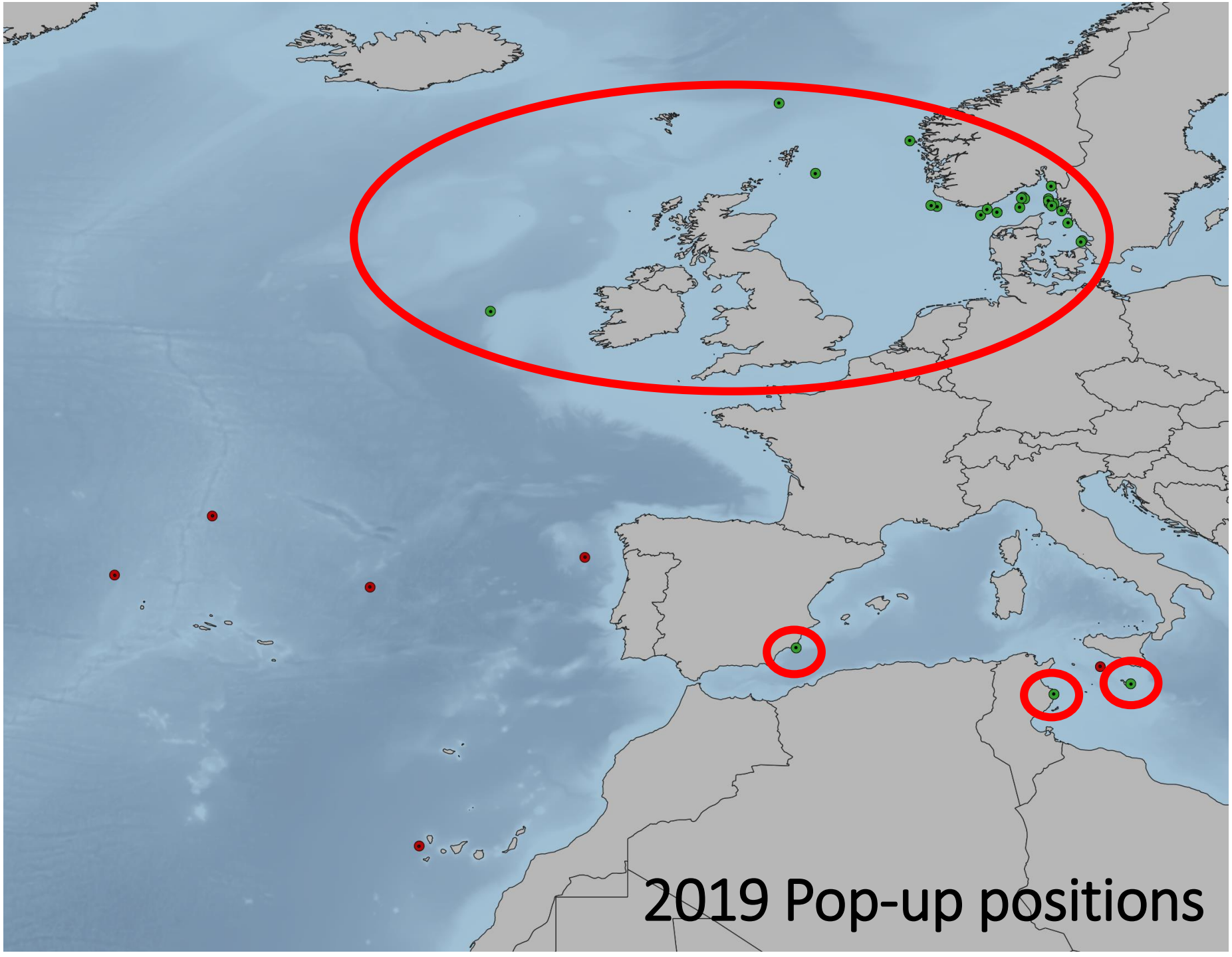
1496lbs (678kg)

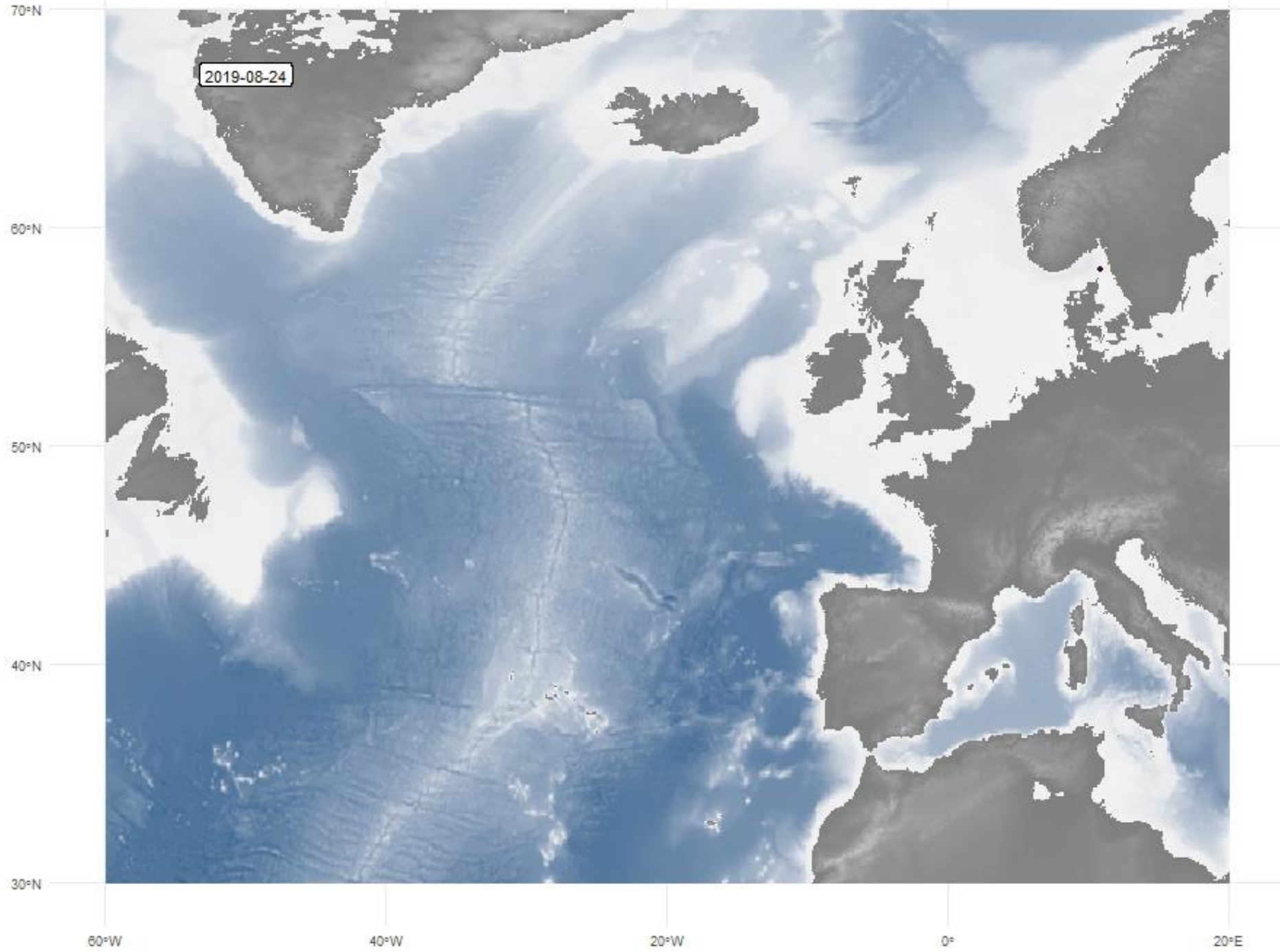
(Glynn Gorick & DTU Aqua)

The Danish tuna fishery

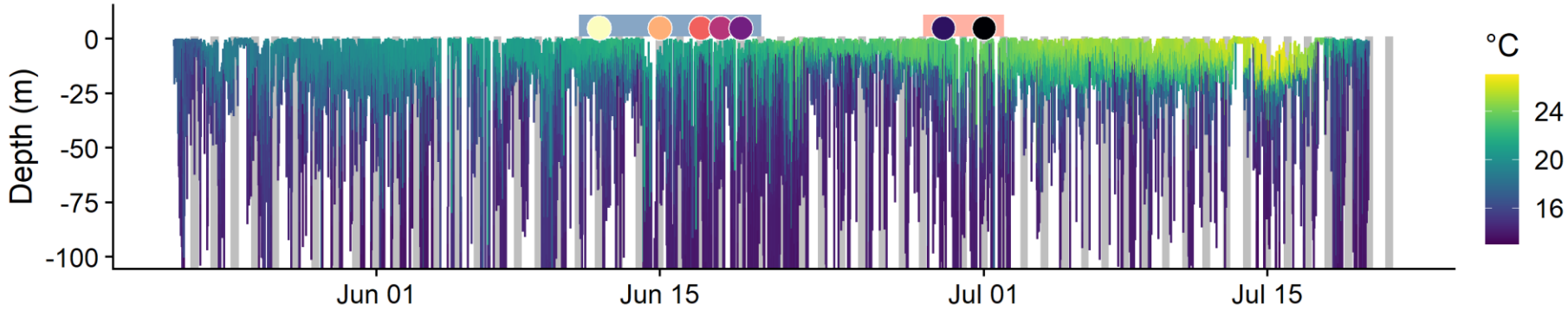


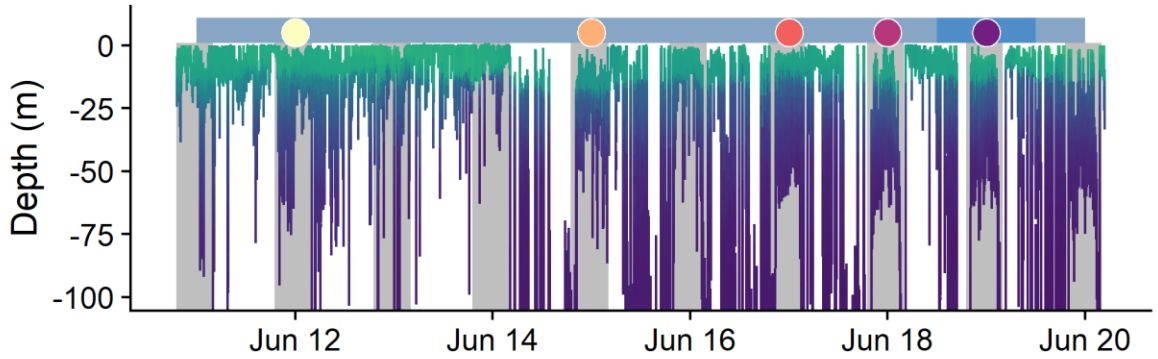
1100 Tunfisk i Auktionshallen paa Skagen. Foto: A. H.

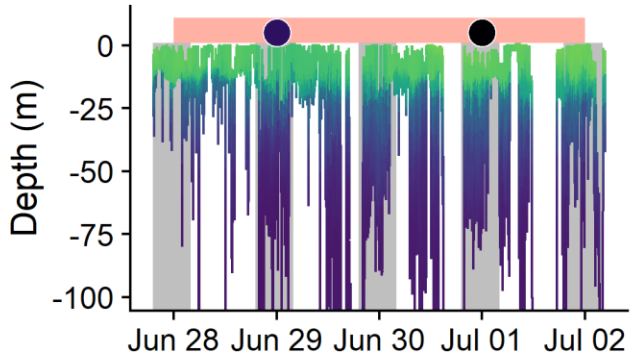

2019 Pop-up positions

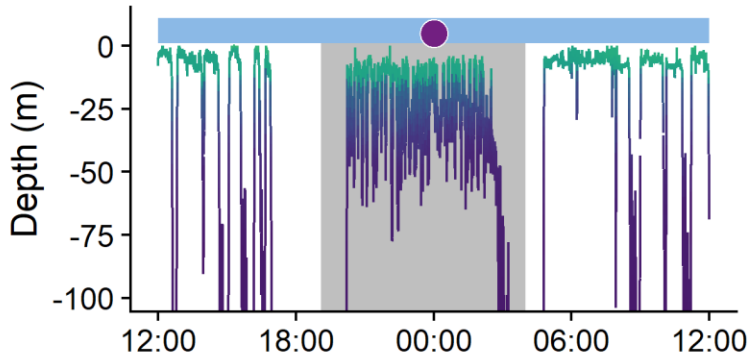

2019-08-24
70°N
60°N
50°N
40°N
30°N
60°W
40°W
20°W
0°
20°E

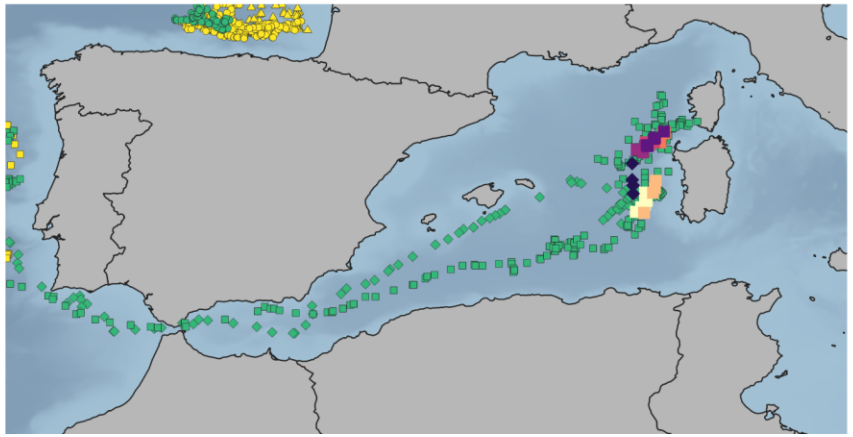
Detailed analysis of the behaviour











Biotelemetry Rocks

- Telemetry is very useful for answering a number of management questions in relation to biology – it has advanced the present and future management of important fish populations tremendously.
- The primary advantages are potential for direct observation and easily understandable results
- The range of methods now makes it realistic to go from very local studies to studies over a broad geographical scale
- The methods are consistently developing, to address even more advanced problems

Thanks for listening!
Don’t hesitate to contact me for questions!

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