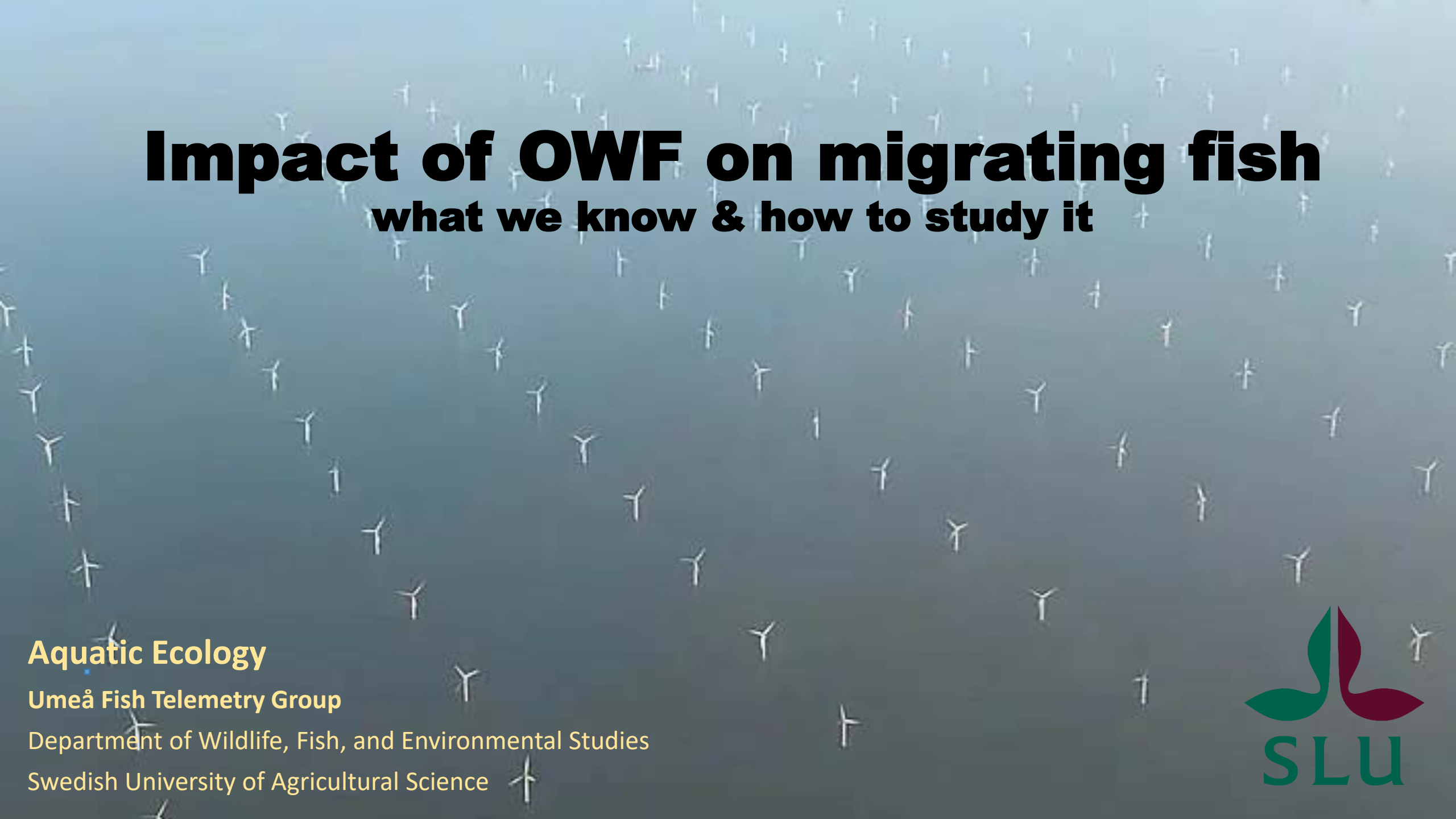

SLU
SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Impact of OWF on migrating fish

what we know & how to study it



Aquatic Ecology

Umeå Fish Telemetry Group

Department of Wildlife, Fish, and Environmental Studies

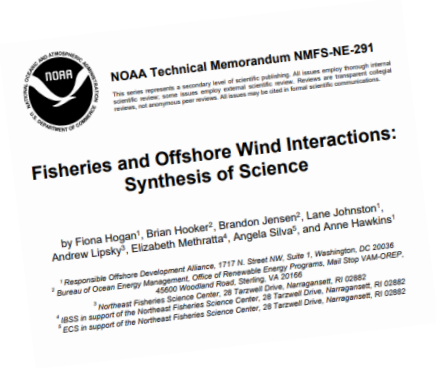
Swedish University of Agricultural Science

OWF have a net positive effect on fish?

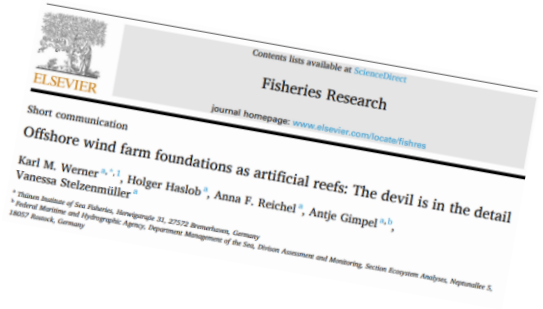
- Increase in biodiversity of demersal fish
- Ban on destructive bottom trawling improve habitat
- Artificial reef effect

- Increased production (or just spatial relocation?)
- Serves as a refuge from fisheries (or as an ecological trap?)

- Construction phase only temporary effects?
- No effect of noise / vibration during operation?


NOAA Technical Memorandum NMFS-NE-291

Fisheries and Offshore Wind Interactions: Synthesis of Science


Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

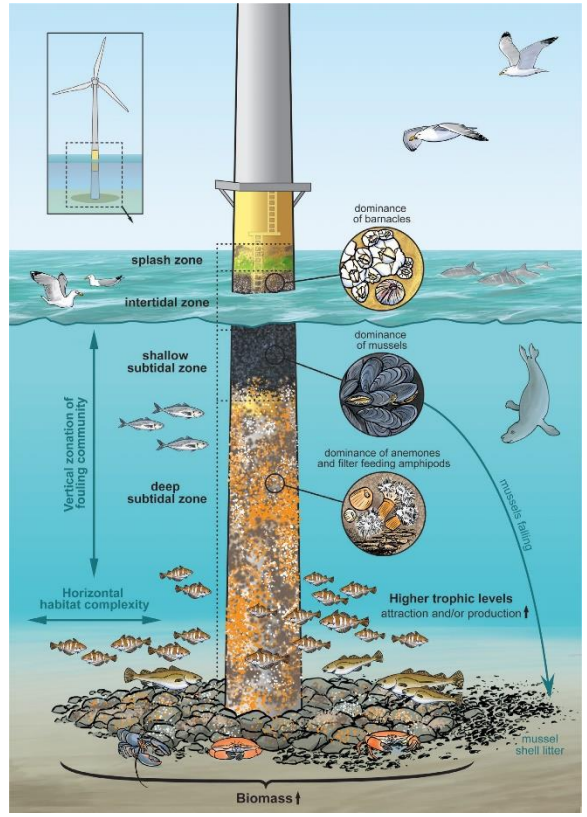
Short communication

Offshore wind farm foundations as artificial reefs: The devil is in the detail


Aquaculture and Fisheries

journal homepage: www.keaipublishing.com/en/journals/aquaculture-and-fisheries

A bibliometric review on the implications of renewable offshore marine energy development on marine species



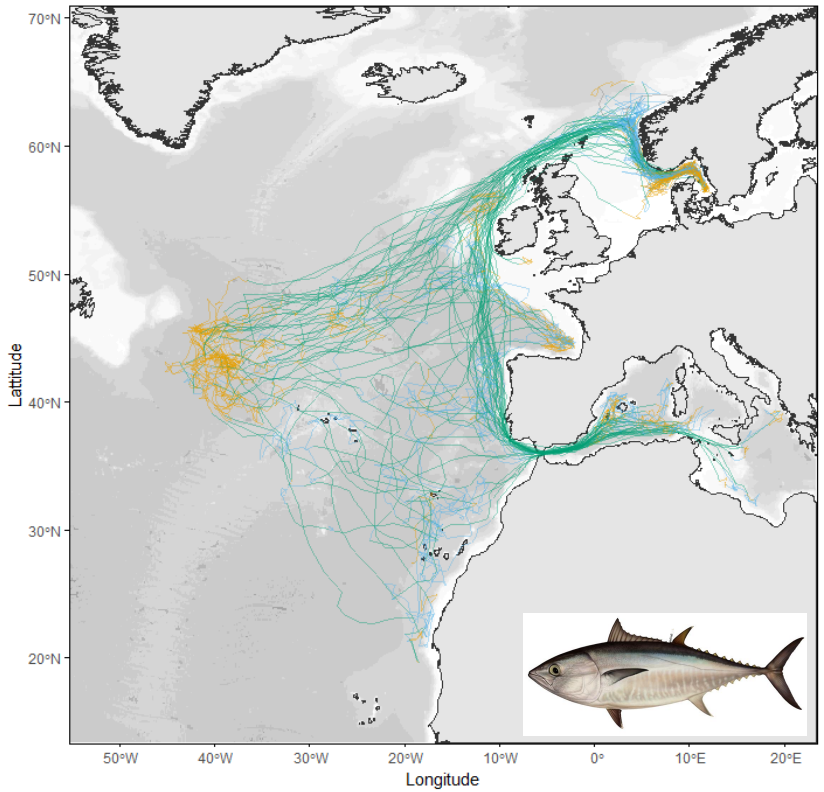
But what about migrating fish?

Collect. Vol. Sci. Pap. ICCAT, 81(4), SCRS/2024/092: 1-21 (2024)

OFFSHORE WIND ENERGY DEVELOPMENT AND HIGHLY MIGRATORY SPECIES: ECOLOGICAL, FISHERY AND MANAGEMENT IMPLICATIONS

R. Hendon[1], J. Serafy[2], J. Walter[2], A. Lipsky[3], T. Curtis[4], A. Di Natale[5], T. Rouyer[6], A. Hanke[7], D. Alvarez-Berastegui[8], E. Orbesen[2], M. Lauretta[2], V. Stelzenmüller[9]

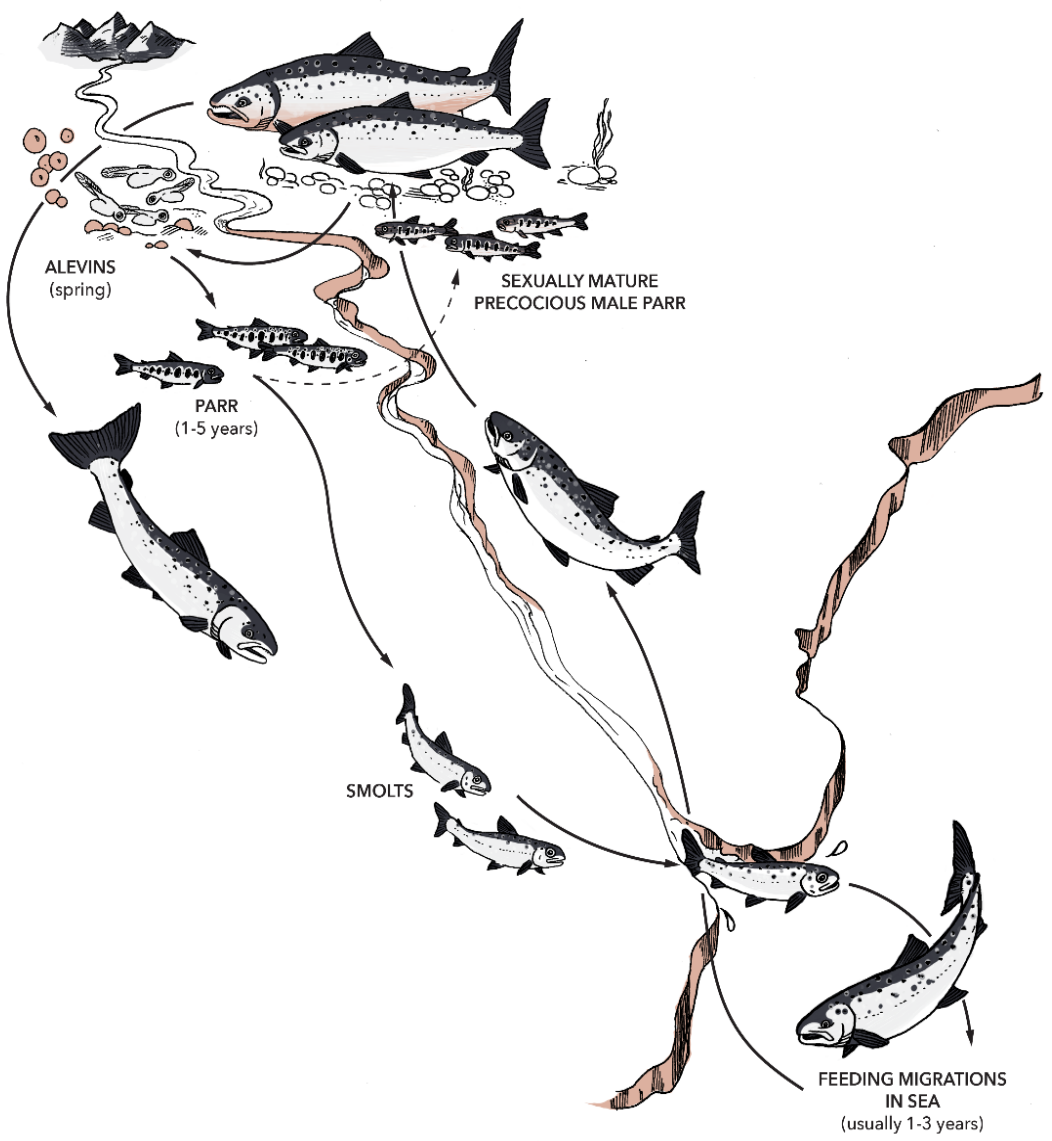
- Lots of research on impact on migrating birds and flyways
- Very little known about impact on migrating fish
- Most fish migrate, some are highly migratory
- More and more evidence for distinct migration routes/corridors for fish in the sea
- Migration timing and routes are thought to be adaptive



Types of migration:

- Spawning Migration
- Feeding migration
- Refuge Migration

- Diel Vertical Migration
- Range expansion/exploration
- Active vs. Passive/drift



Factors effecting migration & navigation

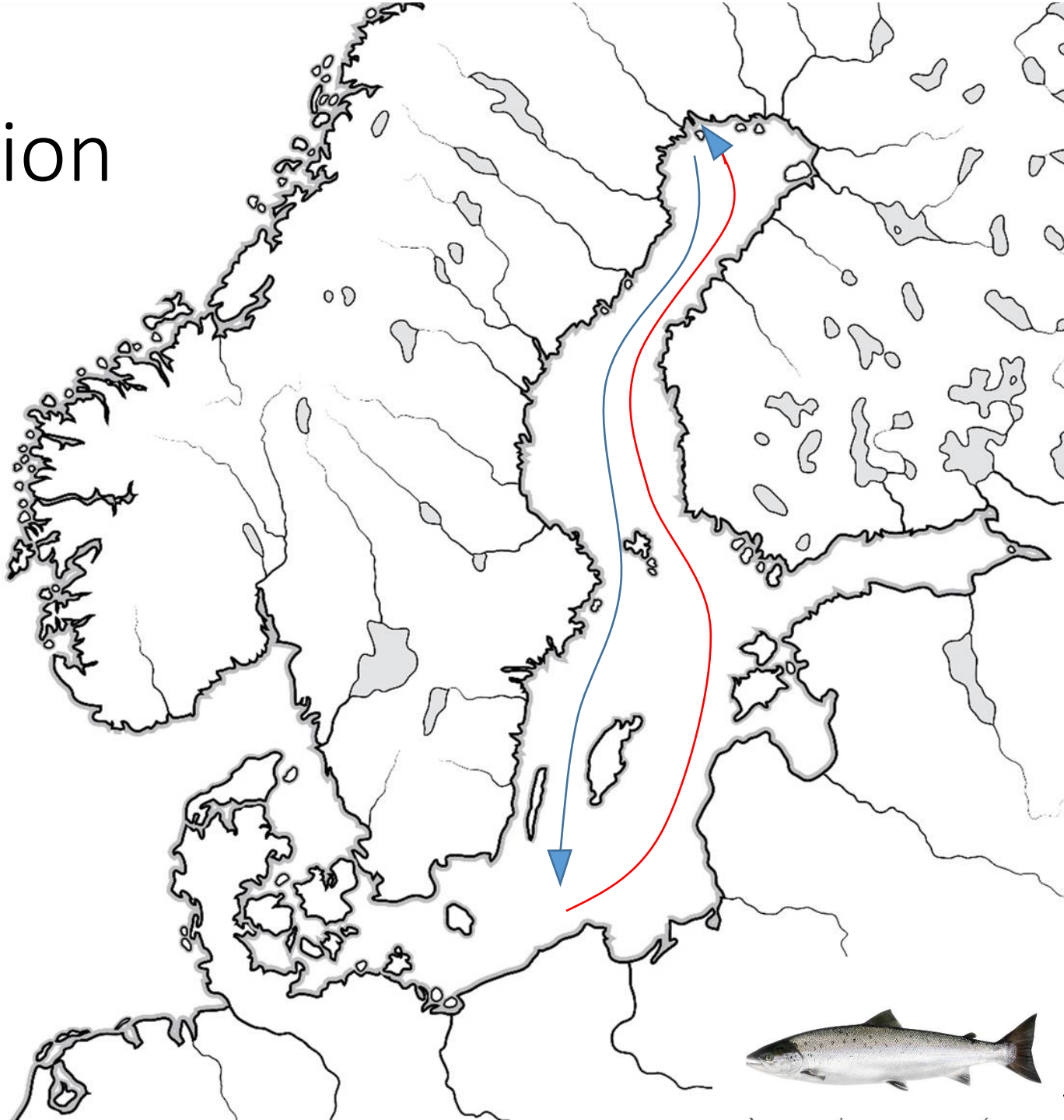
- Seasonal changes in Light & Temperature
- Hydrology
- Water quality
- Food availability
- Tidal dynamics
- Moon Phases

- Ontogenetic & State-dependent

Factors hindering migration

- Obstacles/Barriers
- Fisheries
- Temperature
- Water quality
- Flow conditions
- Predation
- Food availability

- Noise
- Vibrations
- Artificial light
- Electromagnetic disturbances

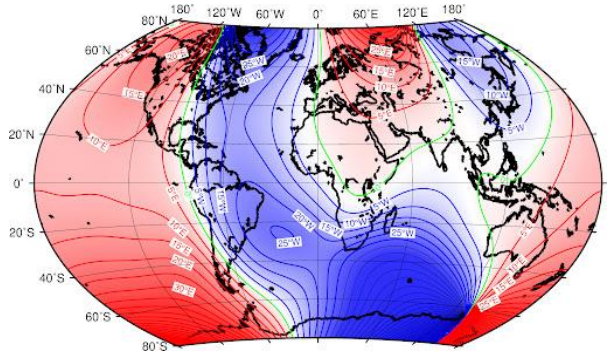


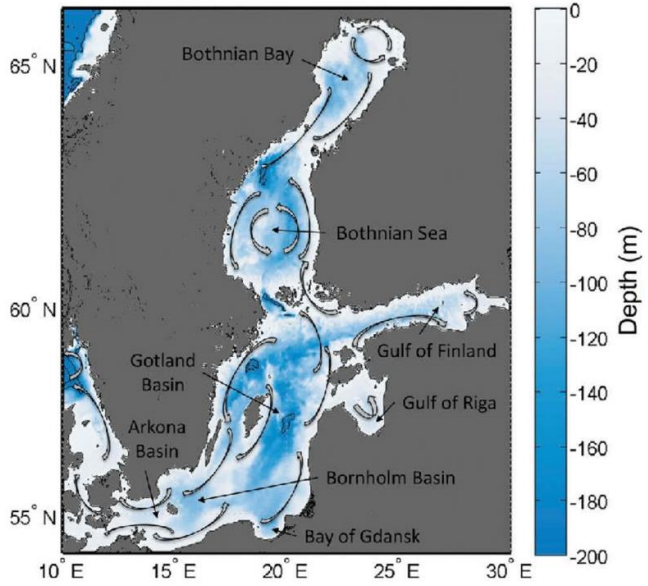
How do migrating fish find their way?

Cues:

- Geomagnetic Fields
- Celestial
- Currents
- Auditory
- Chemical (Olfaction, Gustation)
- Hydrological gradients
- Landmarks & topology

- Social learning

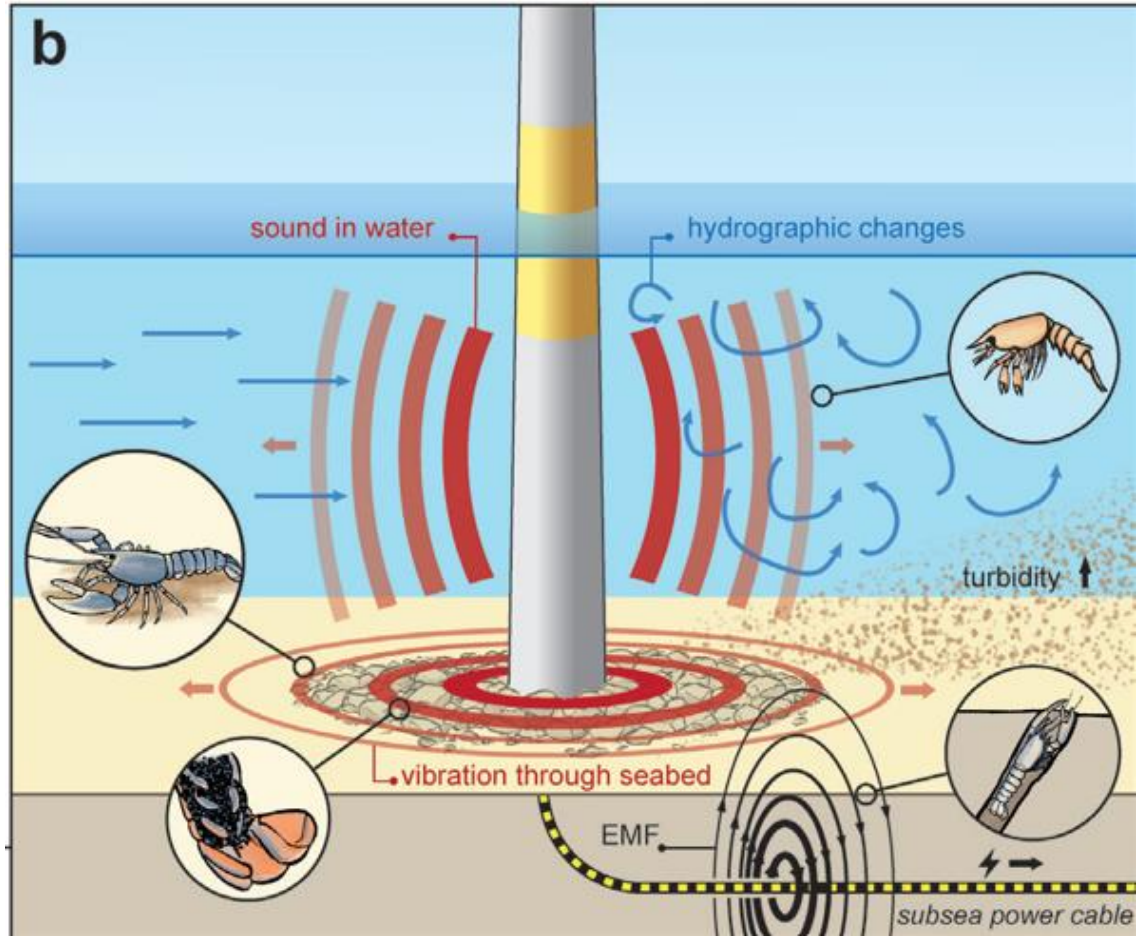




Potential effects of OWF on fish migration

Is the OWF area spawning/feeding ground or a pass-through area?

- Prey & Predation environment (the blooming desert hypothesis)
- Noise / Vibration pollution
- Habitat destruction
- Electromagnetic fields



Potential effects of OWF on fish migration

Consequences:

- Delays
- Change in migration route
- Forced to abort

- Increased predation
- Altered feeding / reproduction success
- Prime habitat lower incentive for migration

- Cummulative impact
- Impact may vary depending on life-stage

- Increased Hydropeaking in regulated rivers


Renewable and Sustainable Energy Reviews 143 (2021) 110885

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: http://www.elsevier.com/locate/rser

Wind energy's bycatch: Offshore wind deployment impacts on hydropower operation and migratory fish

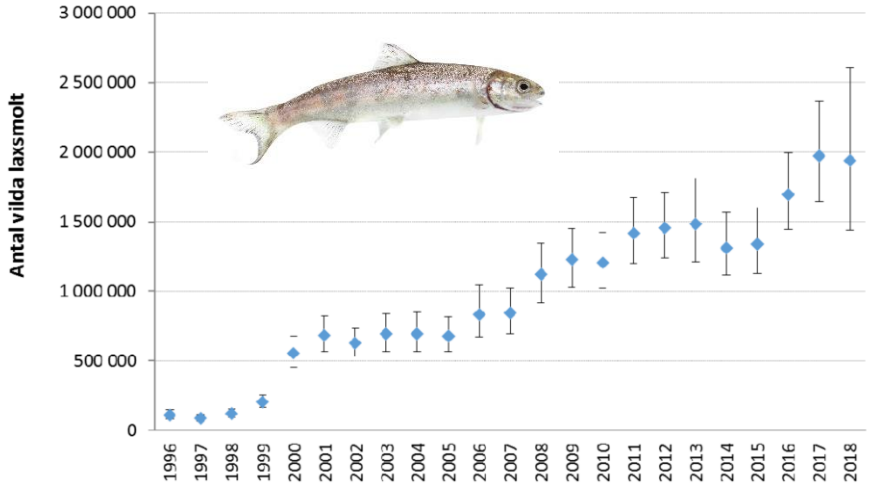
Olivia Pfeiffer[a], Destenie Nock, PhD[b,*], Erin Baker, PhD[c]

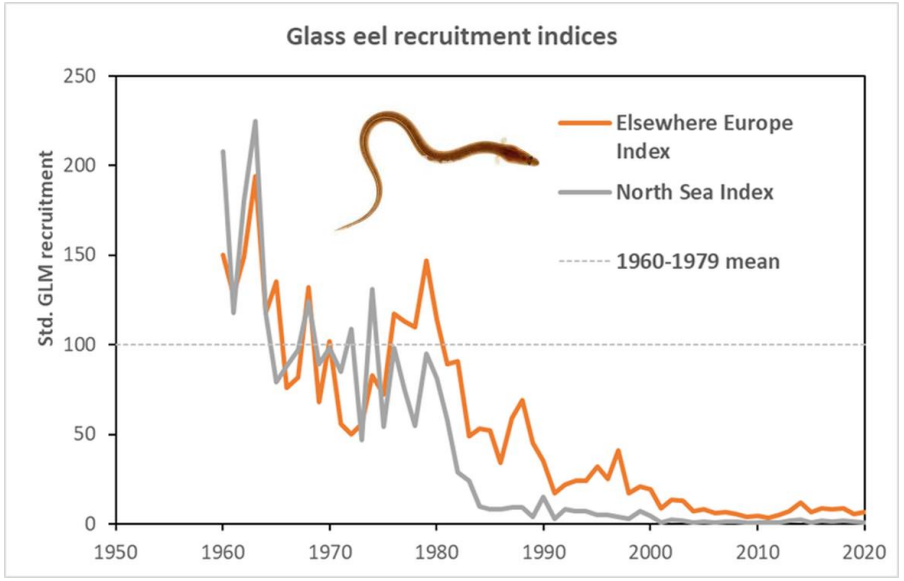
[a] Institute for Data, Systems, and Society, Massachusetts Institute of Technology, USA
[b] Department of Engineering & Public Policy, Department of Civil & Environmental Engineering, Carnegie Mellon University, USA
[c] Department of Mechanical and Industrial Engineering, University of Massachusetts Amherst, USA

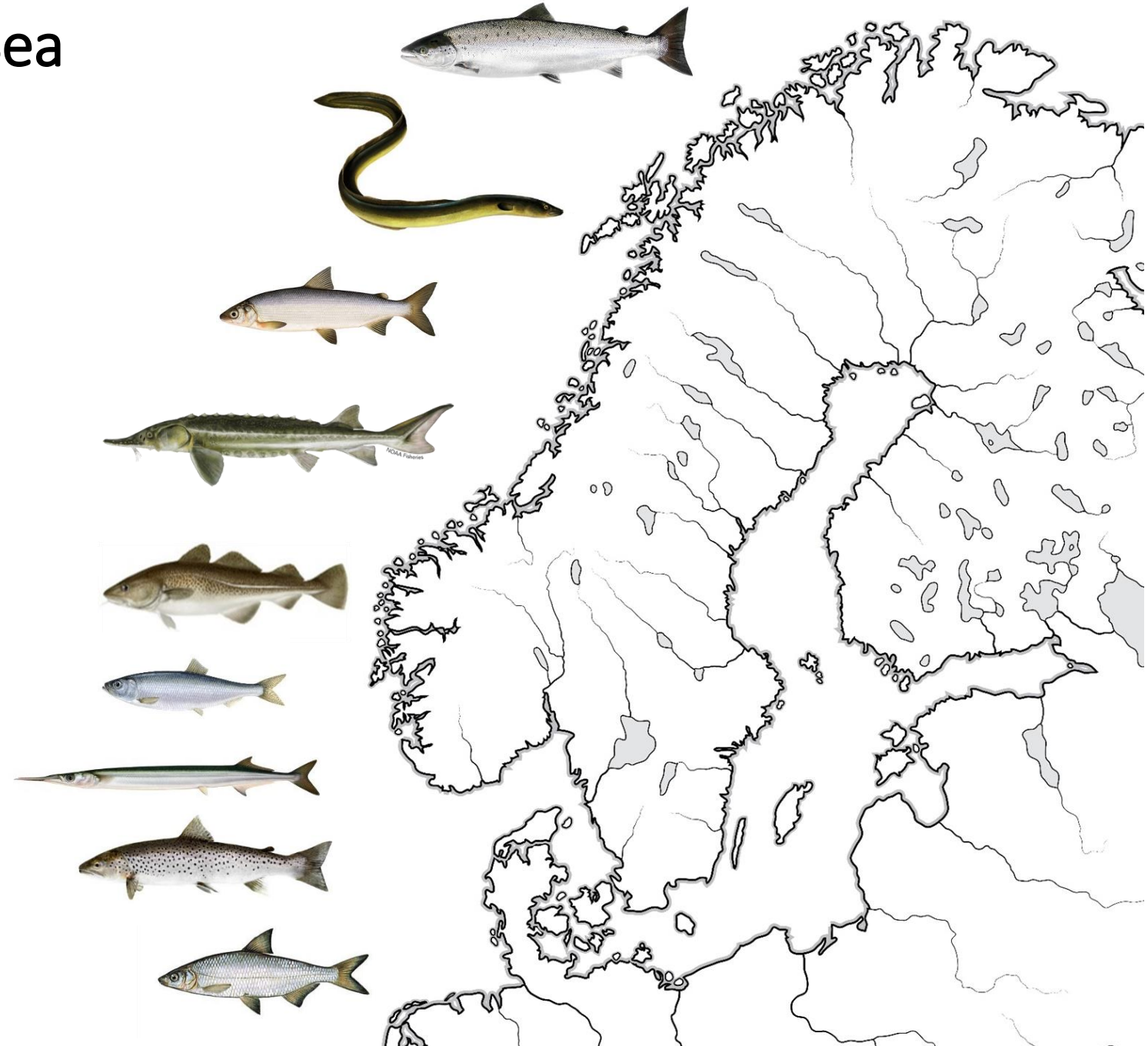
Table 1. Potential causative factors of OSW and likely effects on HMS for ecological considerations. ◍ = at least one related reference; ◐ = no published studies but likely effect; ◎ = unknown status or not applicable.

Groups		Potentially Affected HMS		
Potential Causative Factor	Potential Ecological Effect	Billfishes	Tunas	
Elasmobranchs				
Introduction of novel structure	Artificial reef effect (+/-)	◍	◍	◍
	– altered habitat use	◍	◍	◍
	– altered migratory patterns	◐	◐	◐
	– altered trophic dynamics	◐	◍	◐
	– altered fitness	◐	◐	◐
	– altered spawning behavior	◐	◐	◐
	– attraction versus production	◎	◎	◎
	Avoidance	◐	◐	◐
	– altered habitat use	◐	◐	◐
	– altered migratory patterns	◐	◐	◐
	– altered fitness	◐	◐	◐
Electromagnetic fields	Behavioral and physiological responses (electroreception)	◐	◐	◍
	Behavioral and physiological responses (magnetoreception)	◐	◐	◍
	Altered migratory patterns	◐	◐	◐
	Ecosystem shifts	◐	◐	◐
Heat	Behavioral and physiological responses	◐	◐	◐
	Altered migratory patterns	◐	◐	◐
	Ecosystem shifts	◐	◐	◐
Sound pressure	Behavioral and physiological responses	◐	◍	◍
	Altered migratory patterns	◐	◐	◐
	Ecosystem shifts	◐	◐	◐
Altered hydrodynamics	Changes in water column stratification	◎	◎	◎
	Altered migratory patterns	◐	◐	◐
	Ecosystem shifts	◐	◐	◐
	Changes in trophic interactions	◐	◐	◐

Migratory Fish in the Baltic Sea







Study impact of OWF on migration

Before studies important to establish baseline
What is the natural migration season and pathway?
How long do migrating species spent in the OWF area?
Is the OWF area important feeding and reproduction habitat for migrating fish?
What is the natural survival for migrating fish in the OWF area?

What factors are causing mortality and delay during migration?

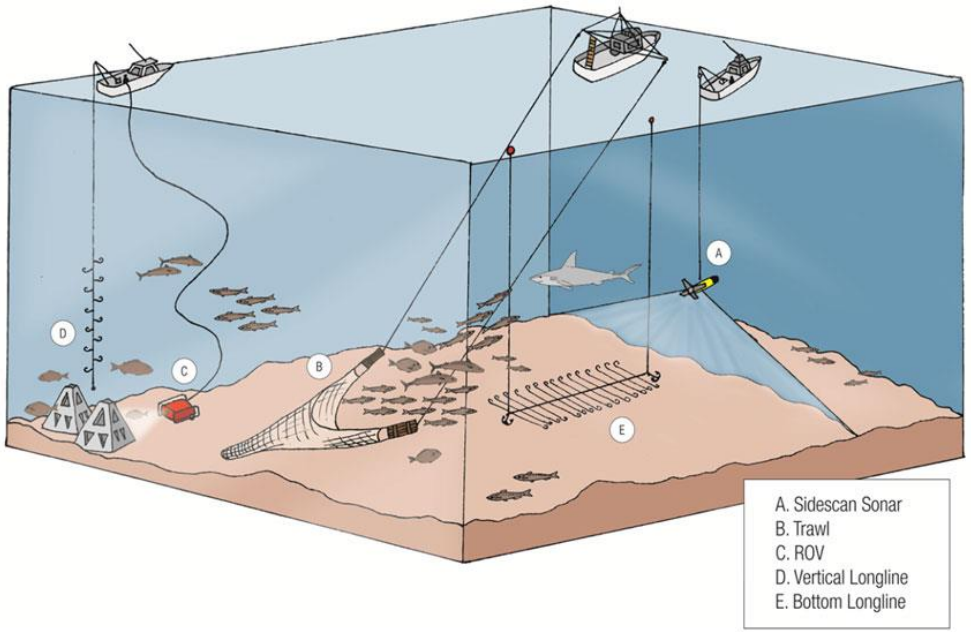
Laboratory studies (e.g reaction to noise**)**

Monitoring methods:

- Historical fisheries catch records
- Gillnet & Trawl surveys
- Conventional tag-reporting
- eDNA
- Telemetry

Type of data :

- Prescence in the OWF area over seasons and years
- Survival inside and outside the OFW area over time
- Spatial data on locations over time (telemetry)
- Behavior in the OWF area
- Catch data CPU / Biomass estimates



ICES Journal of Marine Science, 2024, Vol. 0, Issue 0, 1–18
https://doi.org/10.1093/icesjms/fsae017
Received: 31 May 2023; **revised:** 15 January 2024; **accepted:** 16 January 2024
Food for Thought

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

Ecological indicators to monitor offshore wind interactions with fisheries resources

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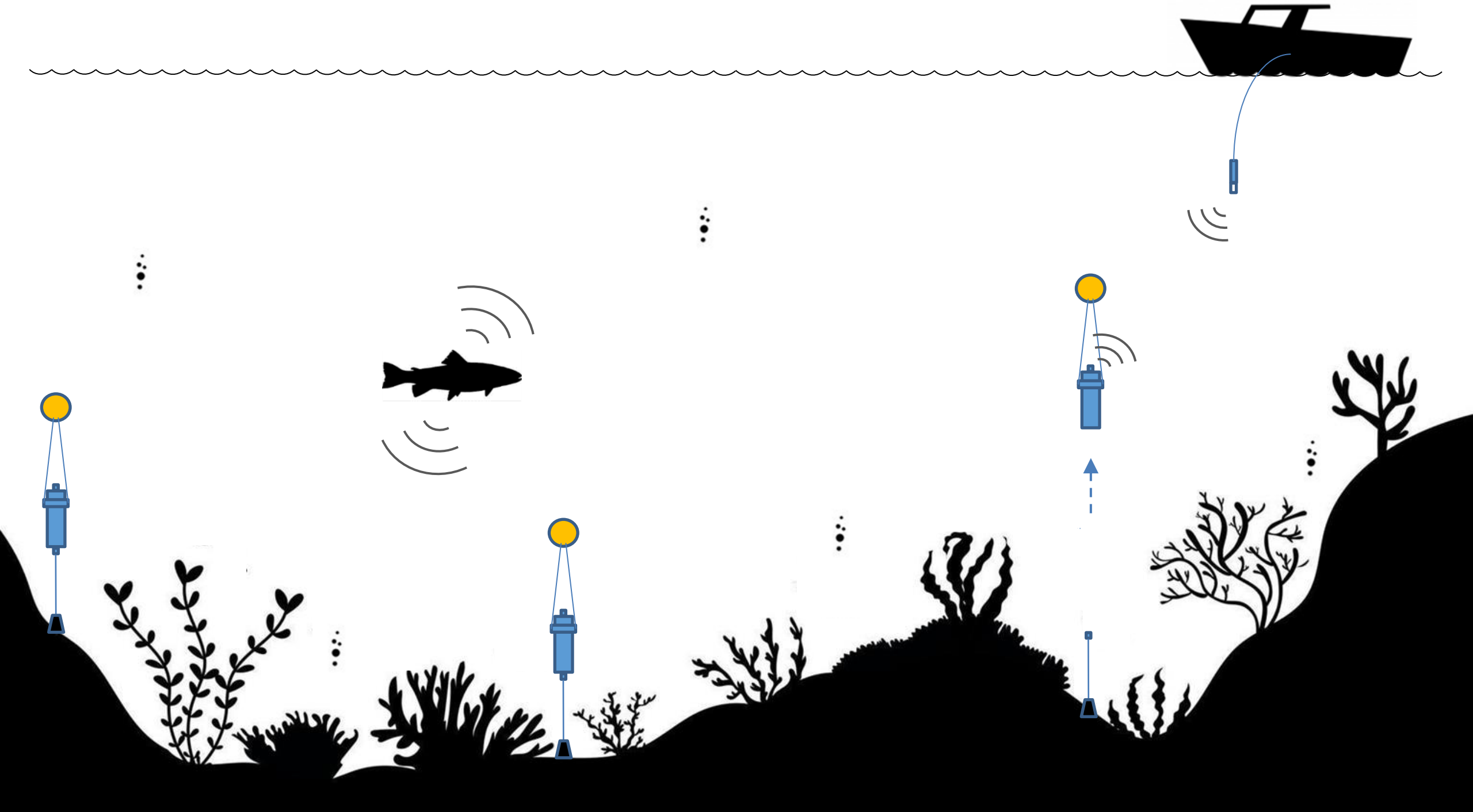
Acoustic telemetry



OCS Study
BOEM 2022-059

Passive Acoustic Telemetry as a Tool to Monitor the Baseline Presence and Persistence of Highly Migratory Fish Species in Popular Recreational Fishing Grounds within the Southern New England Wind Energy Area

September 2022

Authors:
Brian Gervelis[1]
Jeff Kneebone, PhD[2]

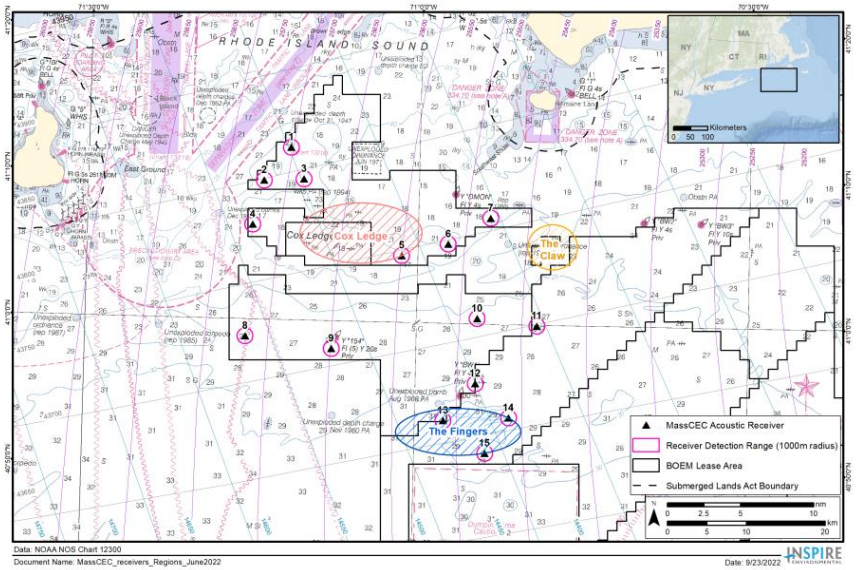
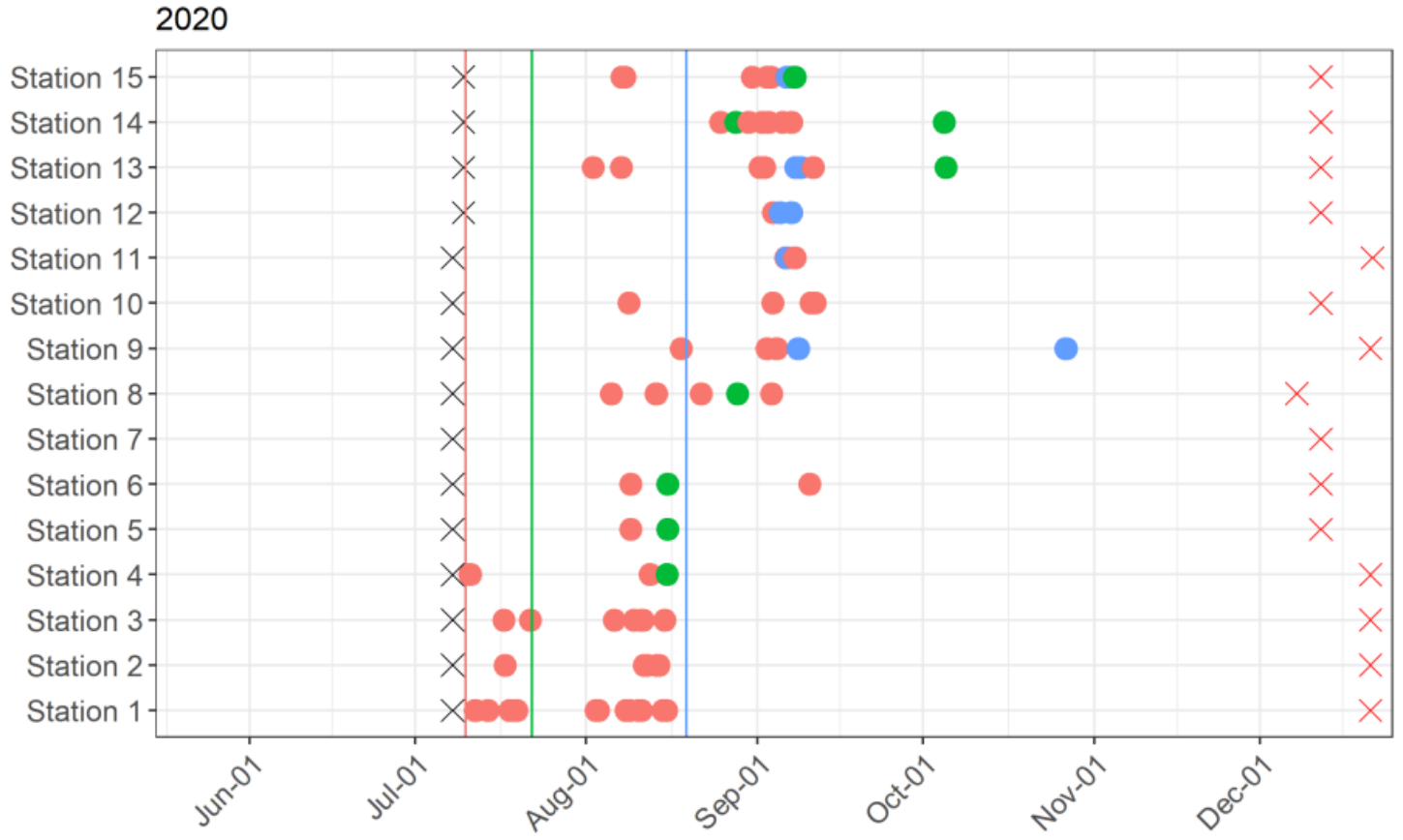


Figure 1. Map of the study site showing the location of the 15 acoustic receiver stations in relation to existing wind energy lease areas and three popular HMS recreational fishing locations in southern New England as identified in Kneebone and Capizzano (2020).



RESEARCH ARTICLE

Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway

Ella R. Rothermel[1]*, Matthew T. Balazik[2,3], Jessica E. Best[4,5], Matthew W. Breece[6], Dewayne A. Fox[7], Benjamin I. Gahagan[8], Danielle E. Haulsee[9], Amanda L. Higgs[4,5], Michael H. P. O'Brien[1], Matthew J. Oliver[6], Ian A. Park[10], David H. Secor[1]

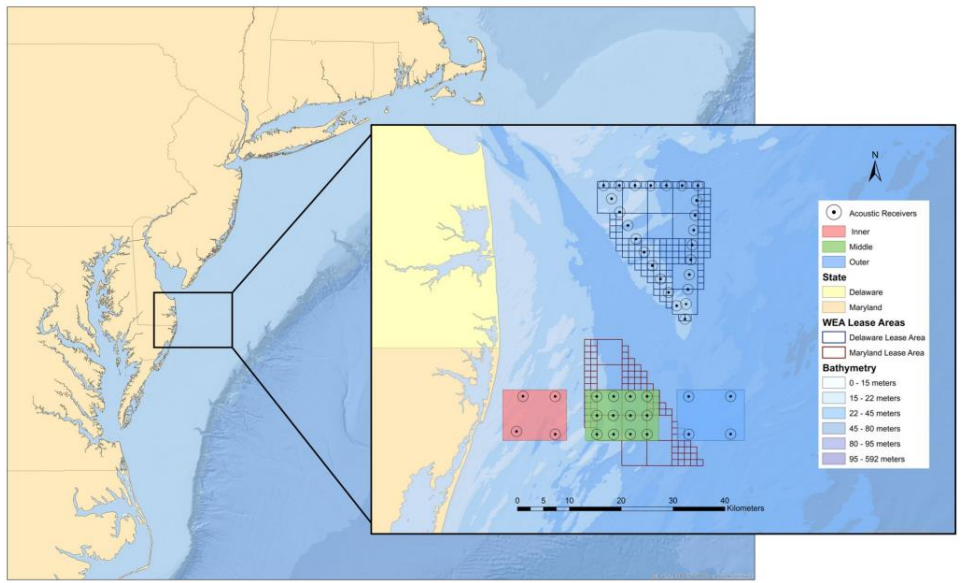


Fig 1. Mid-Atlantic bight study region and acoustic telemetry receiver array design. Delaware (north) and Maryland (south) Wind Energy Areas with respective receiver locations and depth contours are shown. Circles around each receiver represent the expected ~1000 meter maximum detection radius.

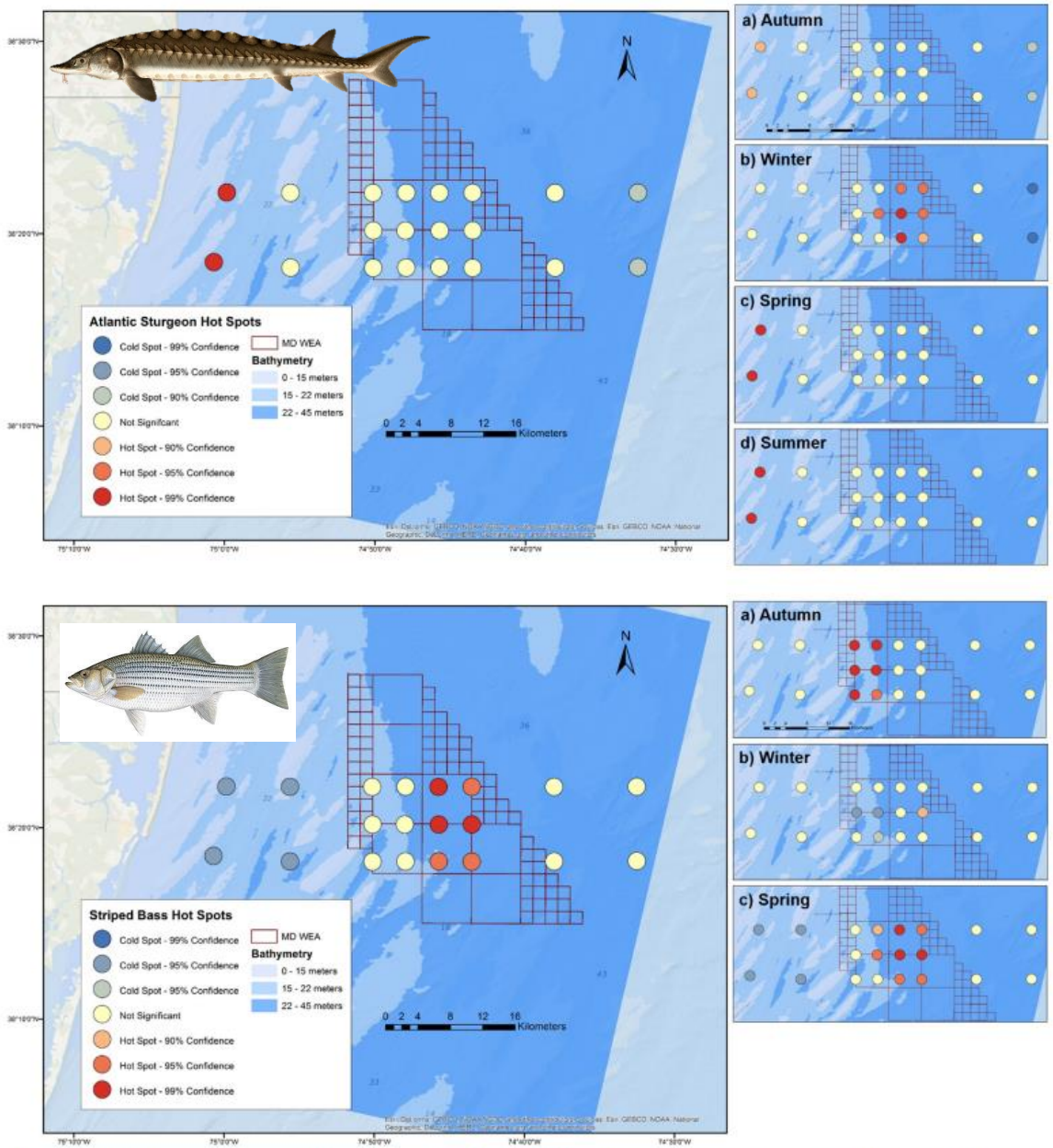


Fig 4. Hot spots of species occurrence across the acoustic receiver array. Results reflect annual (left) and seasonal (insets, right) numbers of individual Atlantic sturgeon (top) and striped bass (bottom) detected per receiver.

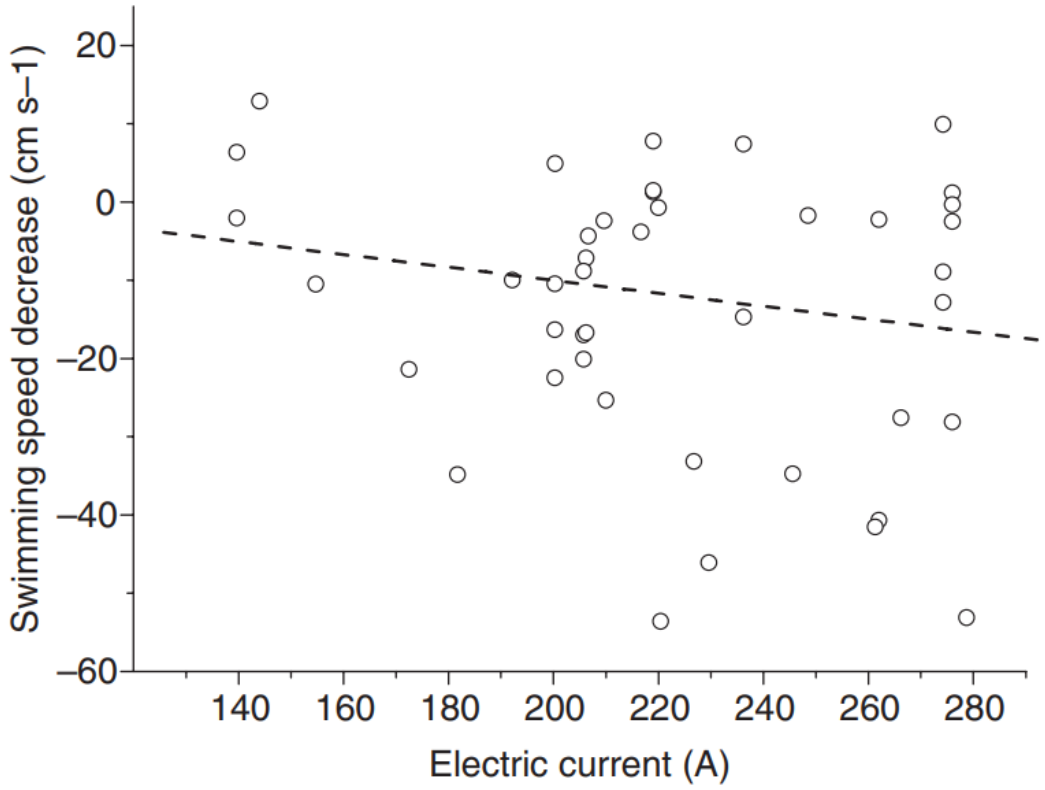
Fisheries Management and Ecology

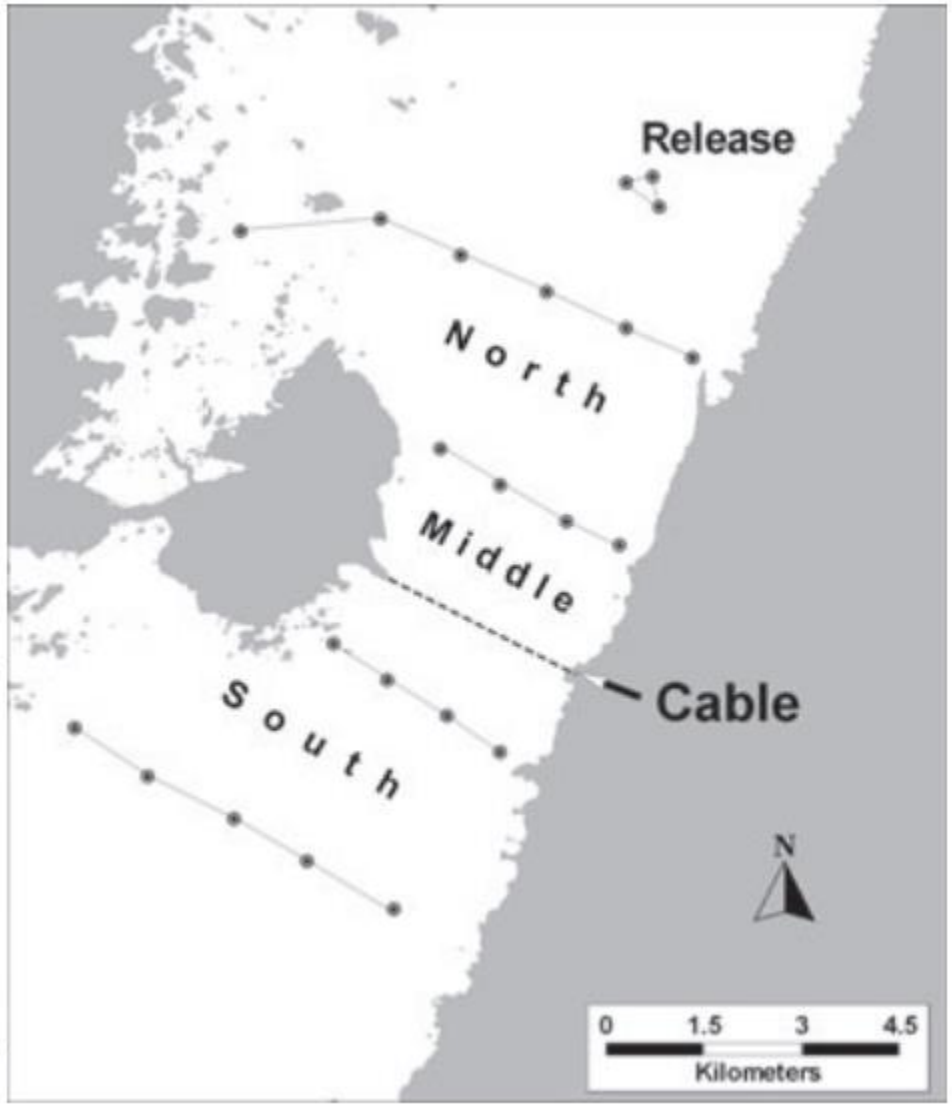
Sub-sea power cables and the migration behaviour of the European eel

H. WESTERBERG, I. LAGENFELT

First published: 22 October 2008 | https://doi.org/10.1111/j.1365-2400.2008.00630.x | Citations: 54

Håkan Westerberg, Swedish Board of Fisheries, PO Box 324, SE 40126 Göteborg, Sweden (e-mail: Hakan.westerberg@fiskeriverket.se)





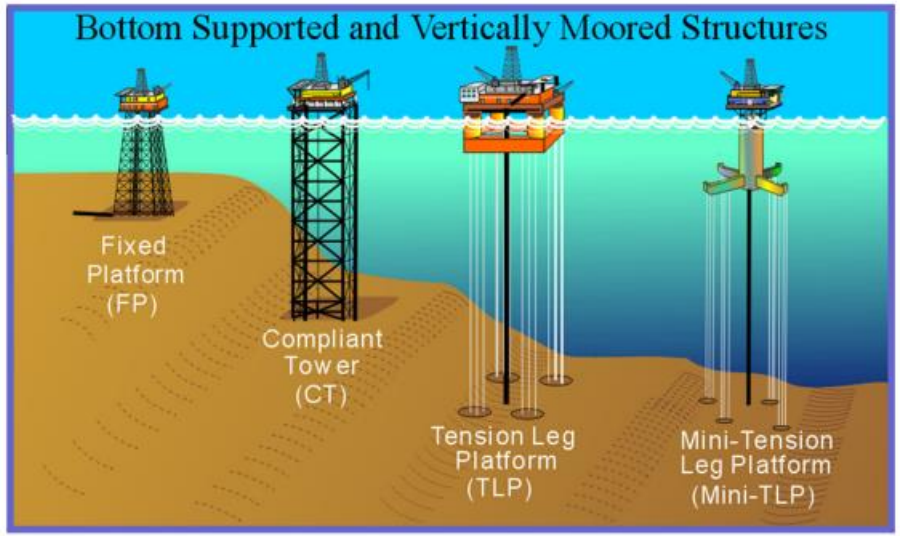
Rev Fish Biol Fisheries (2020) 30:405–422
https://doi.org/10.1007/s11160-020-09605-z

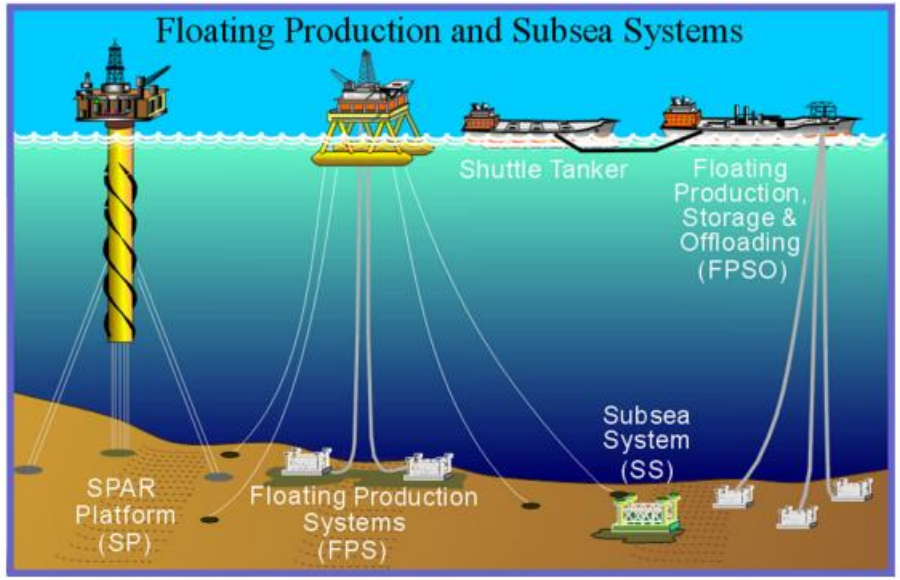
REVIEWS

Potential impacts of oil production platforms and their function as fish aggregating devices on the biology of highly migratory fish species

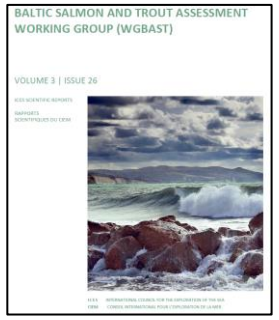
Derke J. G. Snodgrass · Eric S. Orbesen · John F. Walter III · John P. Hoolihan · Craig A. Brown

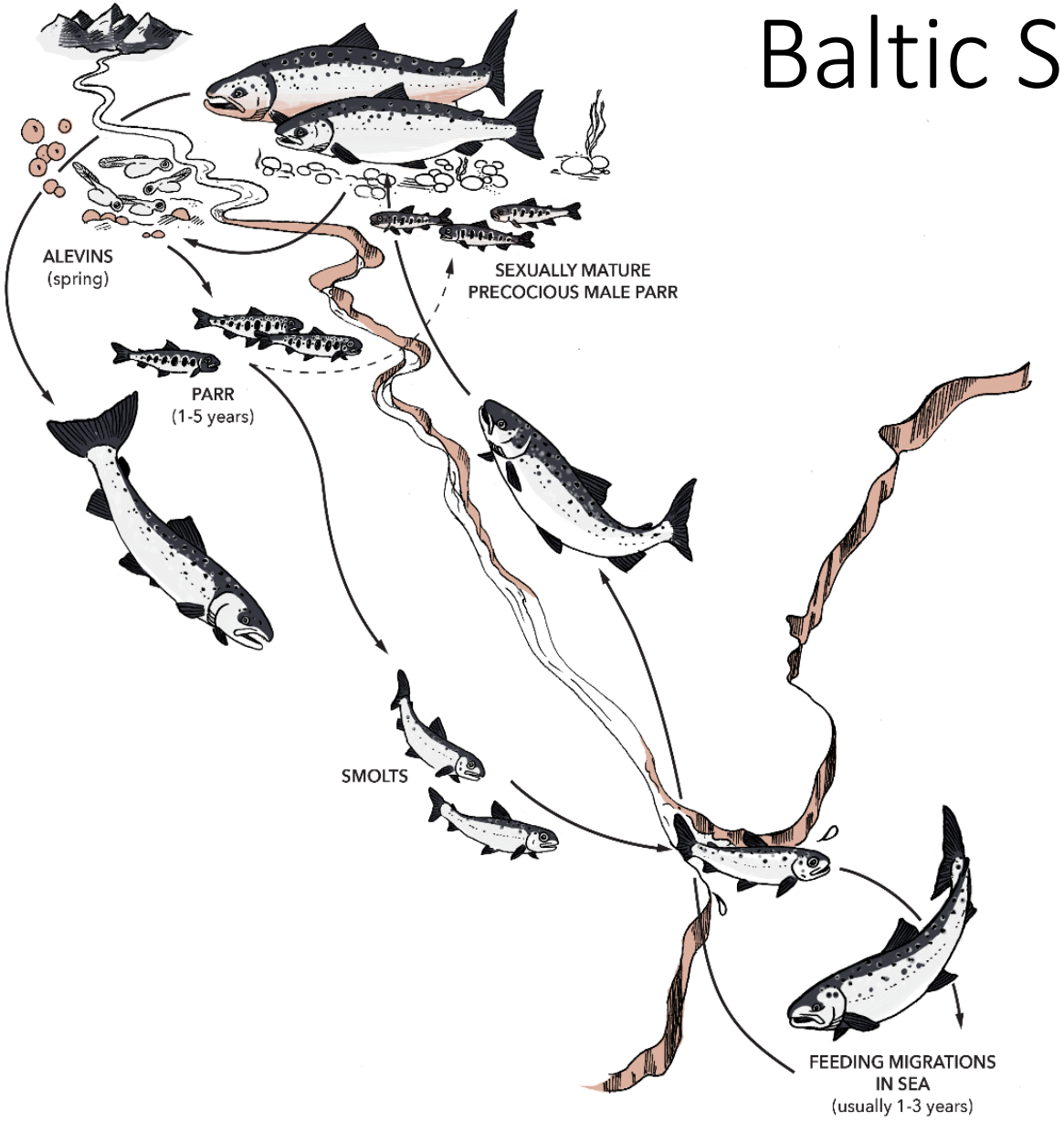
- Negligible impact on populations
- Prime feeding habitat – skipped migration
- Increased production
- Potential spawning grounds

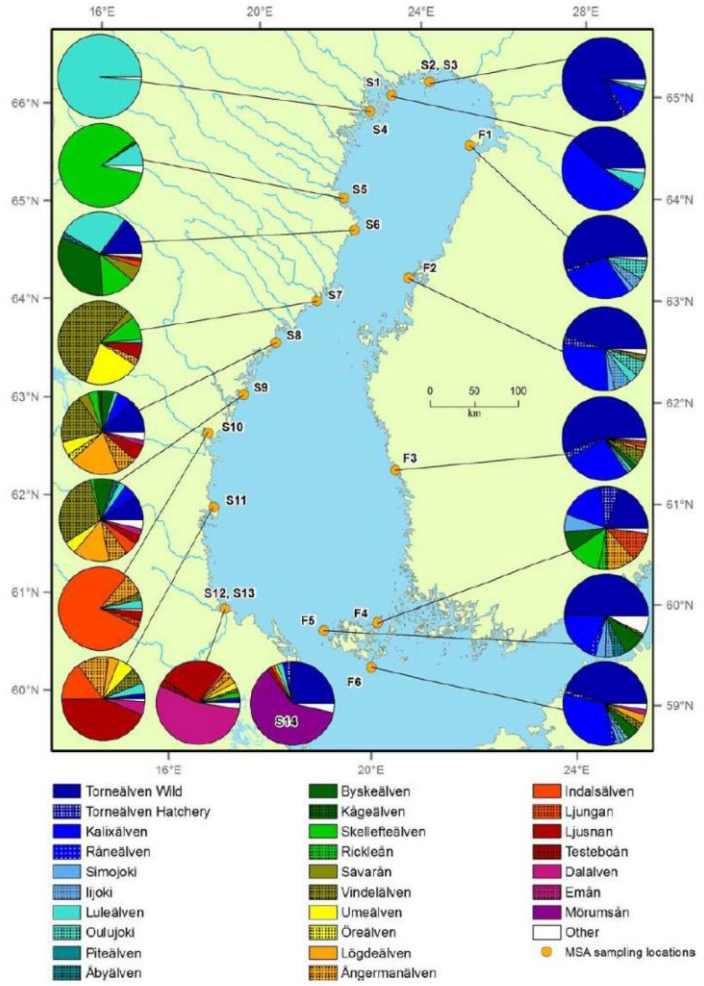




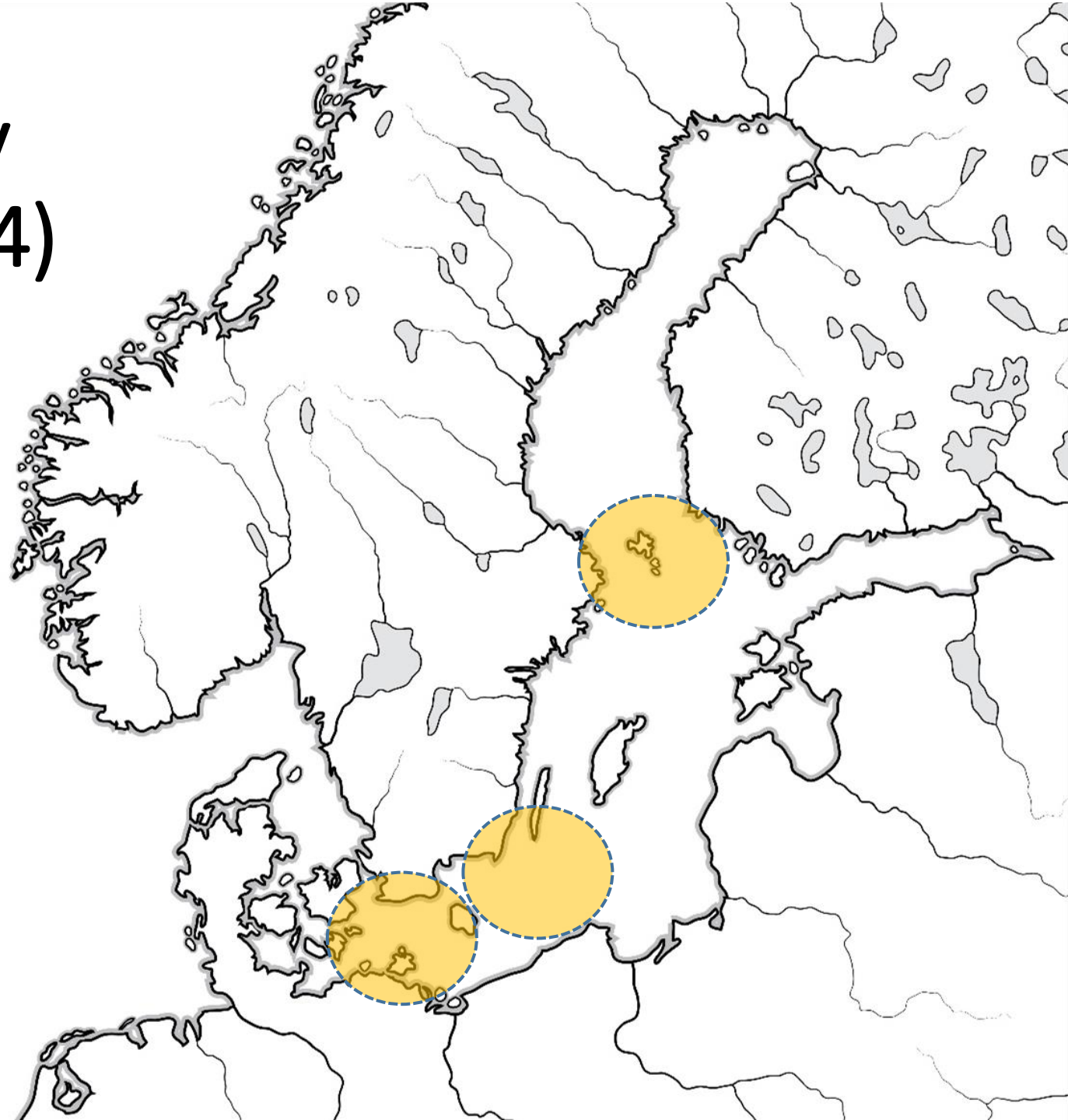
Baltic Salmon migration

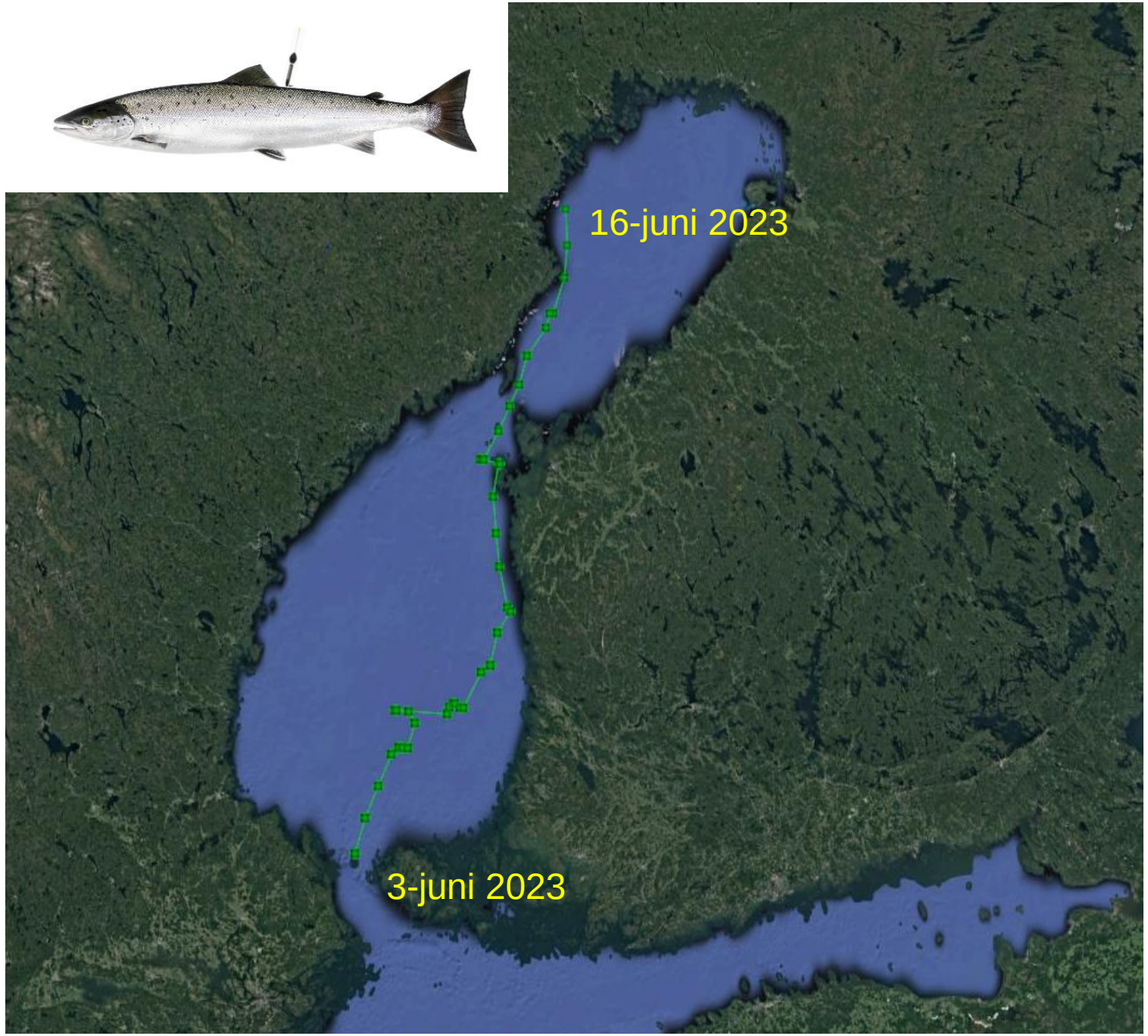






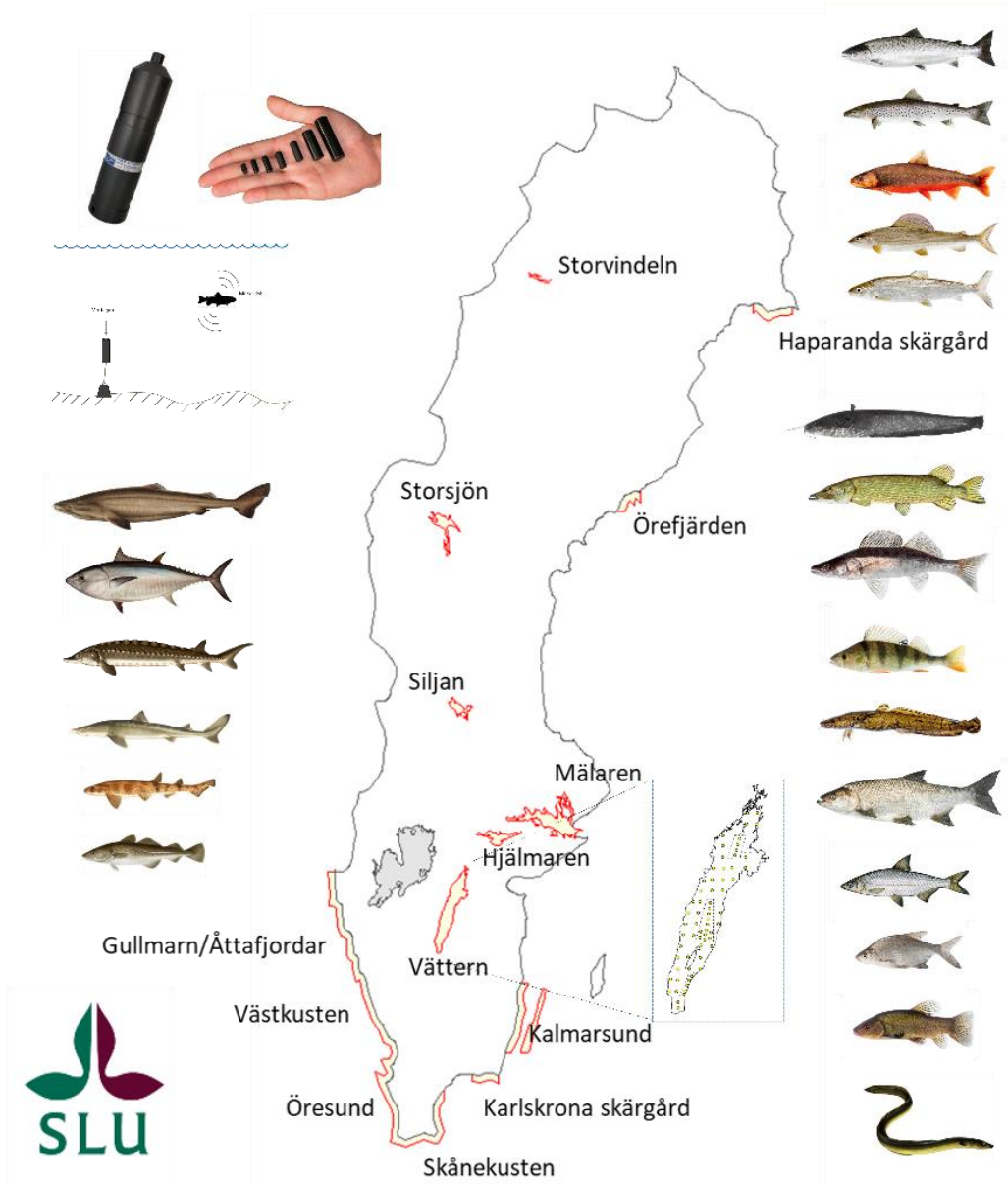
Satellite tracking study
Baltic Salmon (2023-24)




16-juni 2023
3-juni 2023

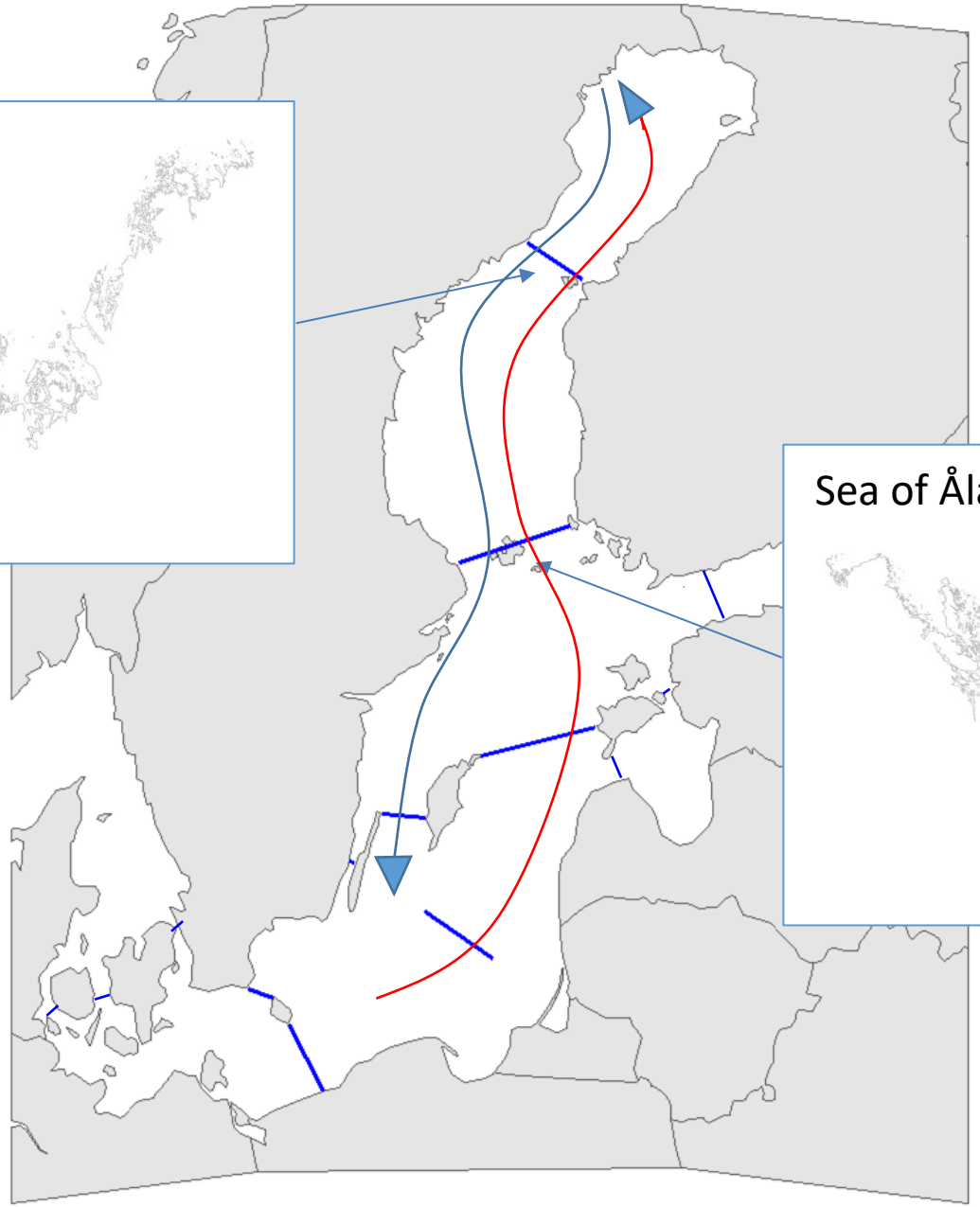
96
Finland
Gulf of Bothnia
Päijänne
Helsinki
Gulf of Finland

The Swedish Fish Tracking Network

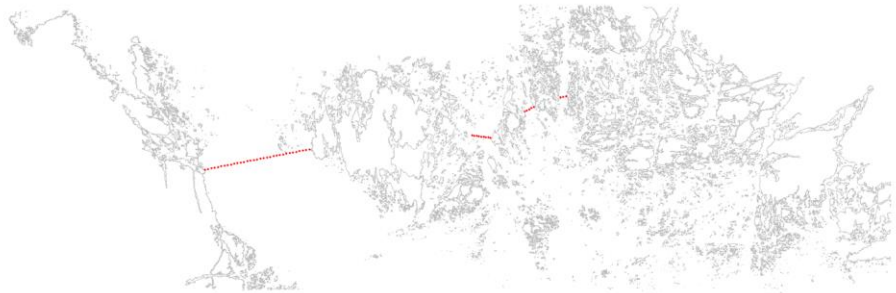


BALTIC SEA TRACKING NETWORK

Kvarken



Sea of Åland



Ongoing projects on fish migration and OWF in North-East Atlantic

Improving Marine Habitat Status by Considering Ecosystem Dynamics

Digital Twin of the Ocean - Animal Tracking

Northeast Atlantic Tracking Marine Tracking Network

Rymdstyrelsen
Swedish National Space Agency

HORIZON EUROPE

Sustainable Blue Economy Partnership

biodiversa+
European Biodiversity Partnership

Co-funded by the European Union

OCEAN TRACKING NETWORK

EUROPEAN TRACKING NETWORK ETN

A Baltic Sea Initiative on OWF and migrating fish is needed!

- **Coordinated studies with multiple partners**
  - **Universities**
  - **National and regional Gov. Agencies**
  - **Companies**
  - **Consultants**
  - **NGOs**
- **Need to start asap to get baseline data**
- **Horizon, Biodiversa, Interreg, Vinnova**


SLU
SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Studying migrating fish in the sea

Opportunitets & Challenges with regards to offshore wind power

Aquatic Ecology

Umeå Fish Telemetry Group

Department of Wildlife, Fish, and Environmental Studies

Swedish University of Agricultural Science

Potential impacting factors

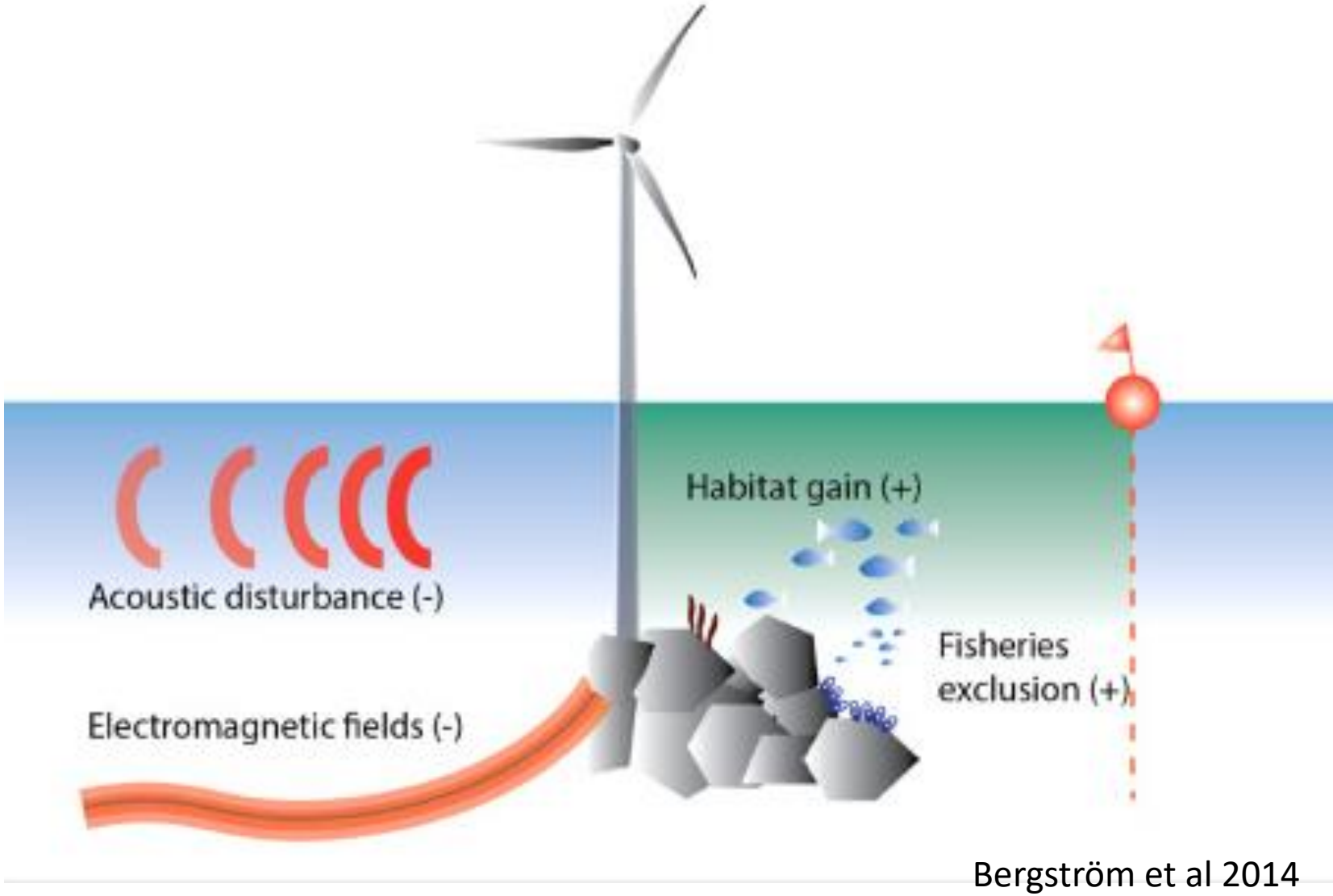
- Noise
- Turbidity
- Electromagnetic field
- Habitat /Regulations

Potential general effects

- Behaviour
- Mortality
- Residency
- Spawning

Potential effects on migration

- Delay
- Reroute
- Abort
- Predation

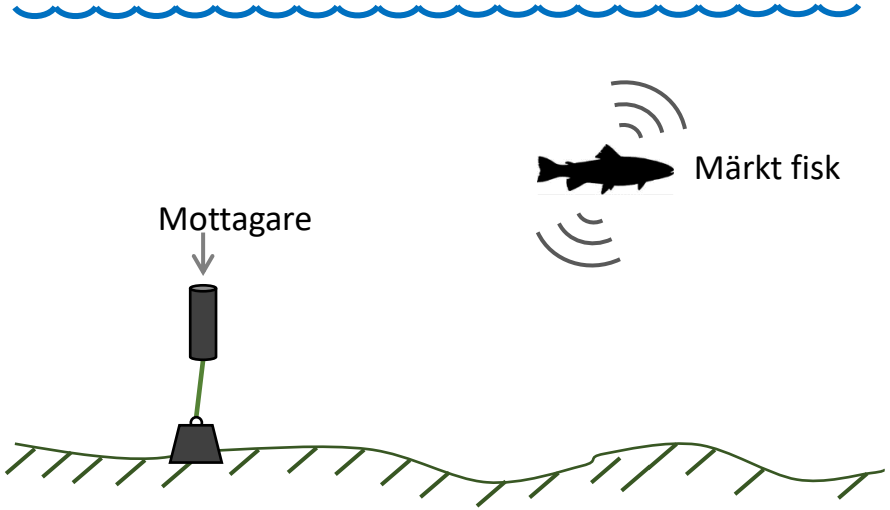


Bergström et al 2014

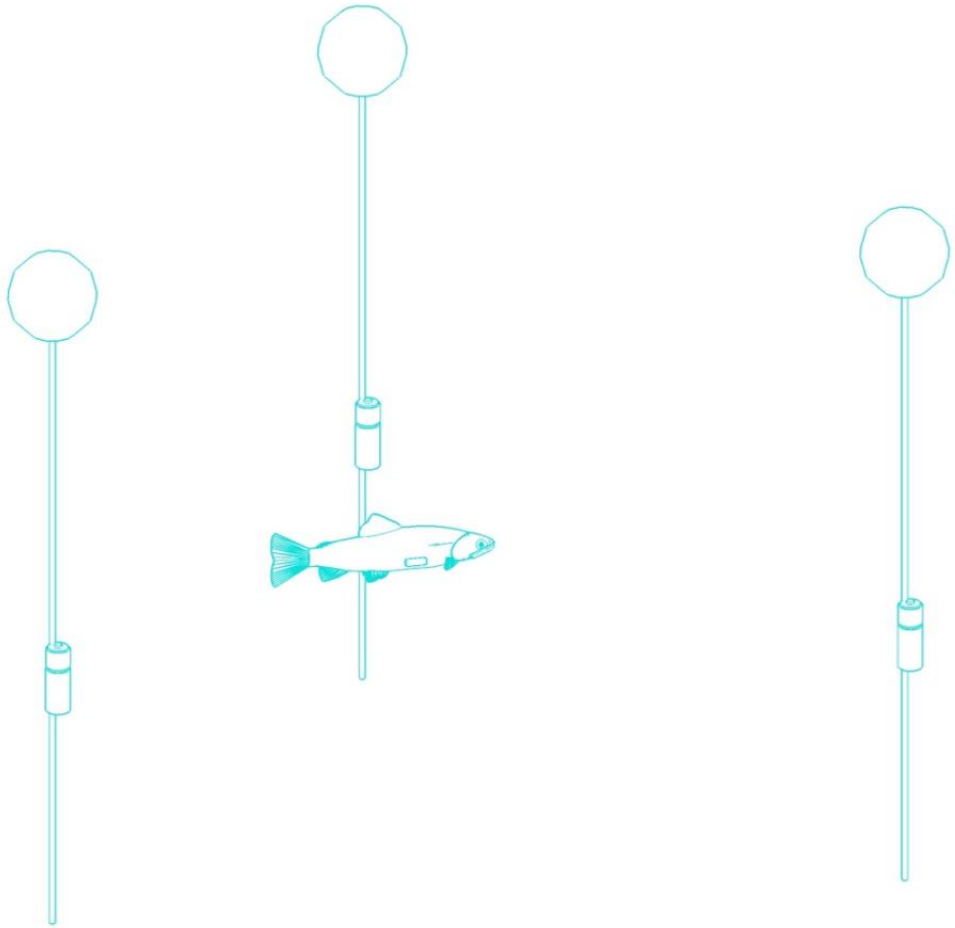
Fish Tracking Technologies

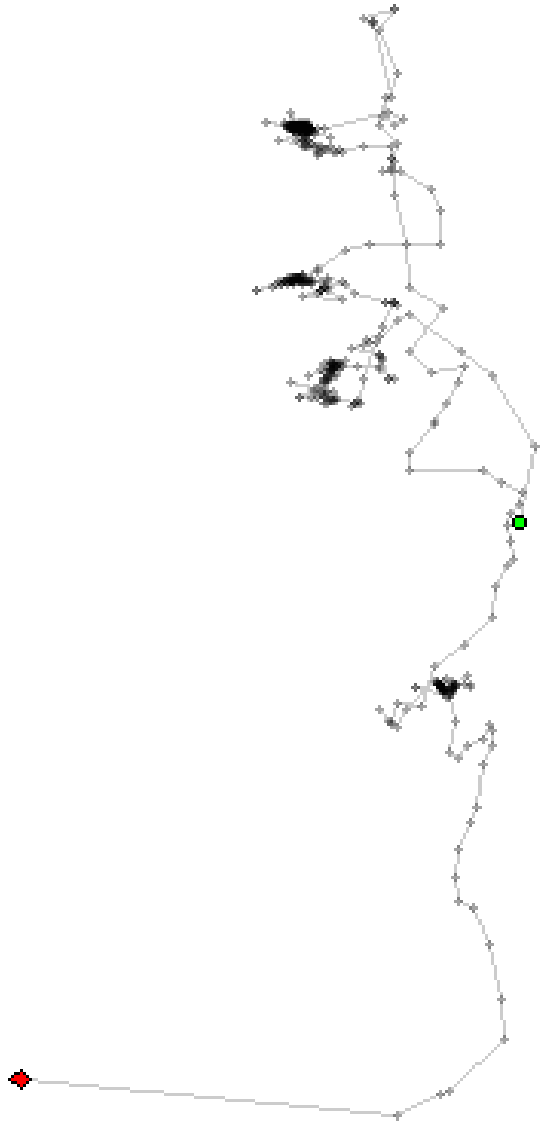
- Size of animal
- Tracking environment
- Size and location of tracking area
- Spatial and temporal resolution of data
- Length of tracking period
- Sample size

Acoustic Telemetry



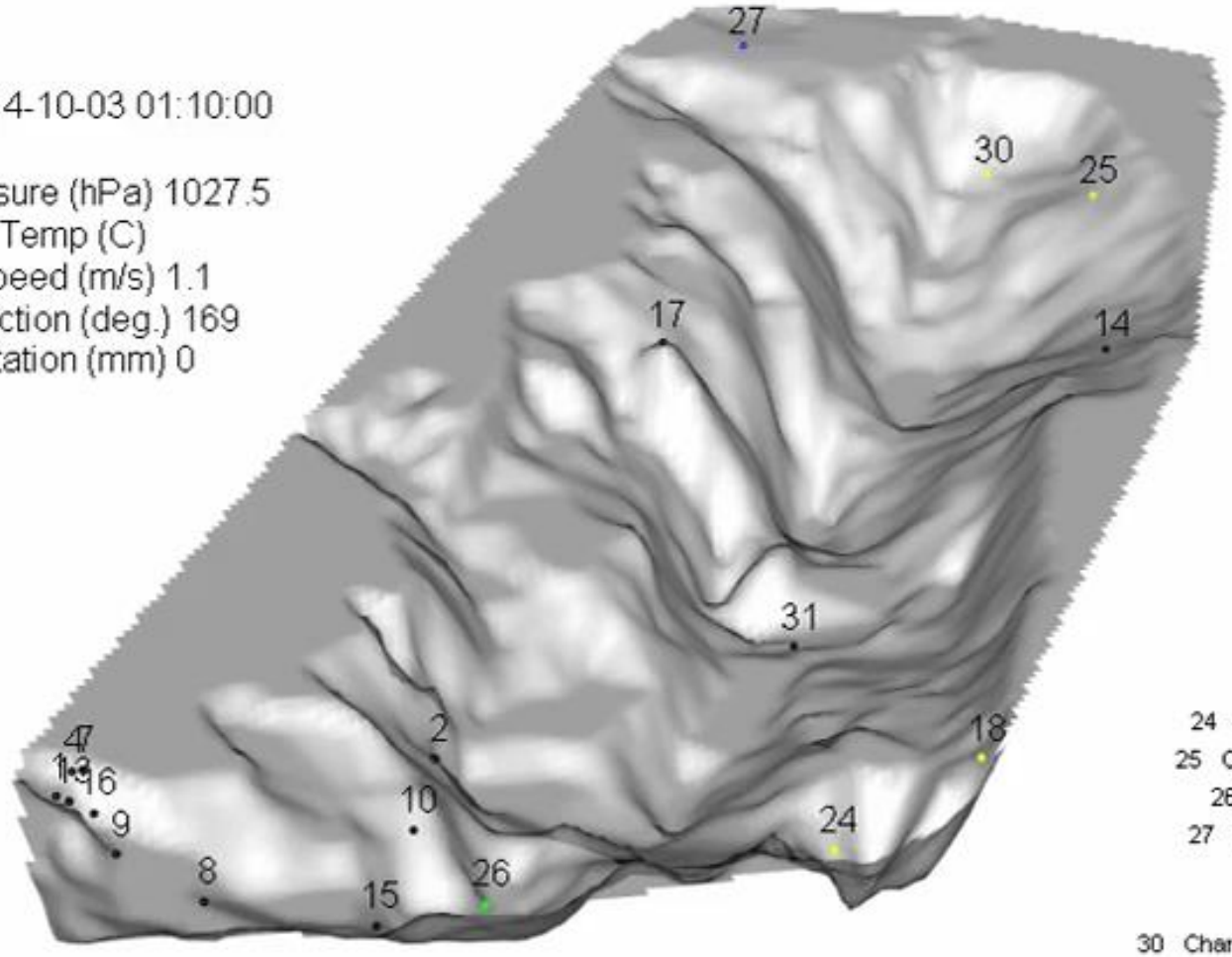
Fine-scale positioning





Date 2014-10-03 01:10:00

Atm. pressure (hPa) 1027.5
Air Temp (C)
Wind speed (m/s) 1.1
Wind direction (deg.) 169
Precipitation (mm) 0



1 LakeTrout 97cm Depth (m) 4 (1.3) Temp (C) 7.6
2 LakeTrout 80cm Depth (m) 16 (3.4) Temp (C) 7.4

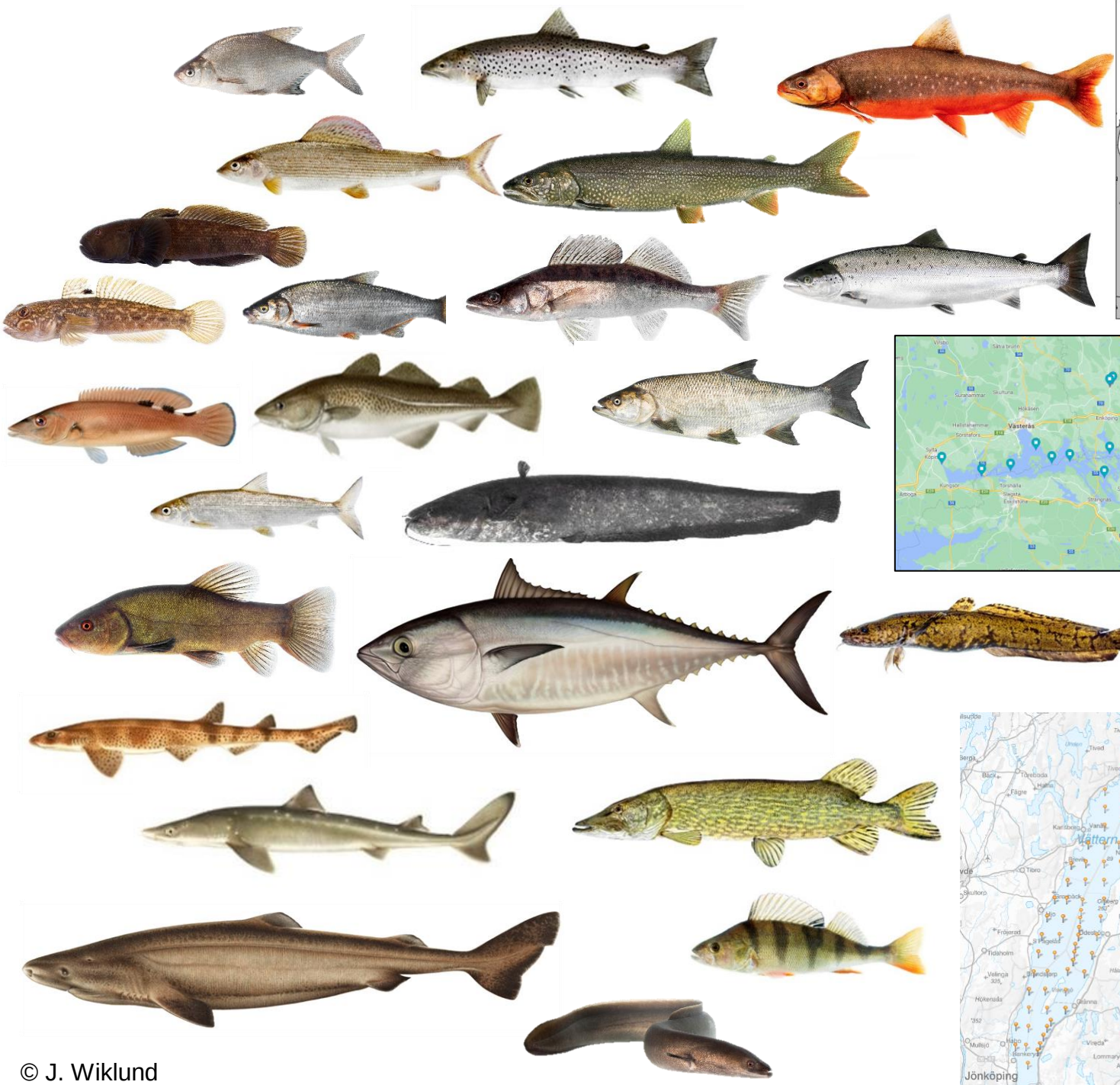
4 LakeTrout 60cm Depth (m) 0 (5.5) Temp (C) 7.5

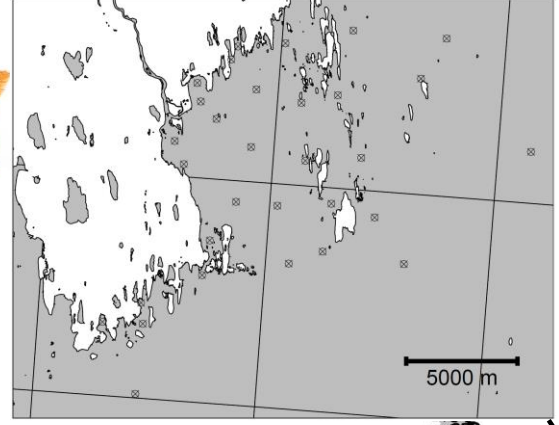
7 LakeTrout 73cm Depth (m) 0 (6.8) Temp (C) 7.5
8 LakeTrout 67cm Depth (m) 10 (0.5) Temp (C) 7.6
9 LakeTrout 56cm Depth (m) 8 (1) Temp (C) 7.6
10 LakeTrout 78cm Depth (m) 13 (0.5) Temp (C) 7.4

13 LakeTrout 78cm Depth (m) 1 (0.5) Temp (C) 7.2
14 LakeTrout 64cm Depth (m) 13 (0.5) Temp (C) 7.3
15 LakeTrout 73cm Depth (m) 18 (0.5) Temp (C) 7.1
16 LakeTrout 76cm Depth (m) 3 (4.6) Temp (C) 7.7
17 LakeTrout 84cm Depth (m) 3 (4) Temp (C) 7.7
18 Charr(Wild) 45cm Depth (m) 0 (10.9) Temp (C) 7.7

24 Charr(Wild) 48cm Depth (m) 2 (2.9) Temp (C) 7.7
25 Charr(Wild) 52cm Depth (m) 3 (13.4) Temp (C) 7.5
26 Pike 85cm Depth (m) 0 (3.4) Temp (C) 7.7
27 Grayling 42cm Depth (m) 0 (1) Temp (C) 6.6

30 Charr(Wild) 40cm Depth (m) 0 (37) Temp (C) 7.2



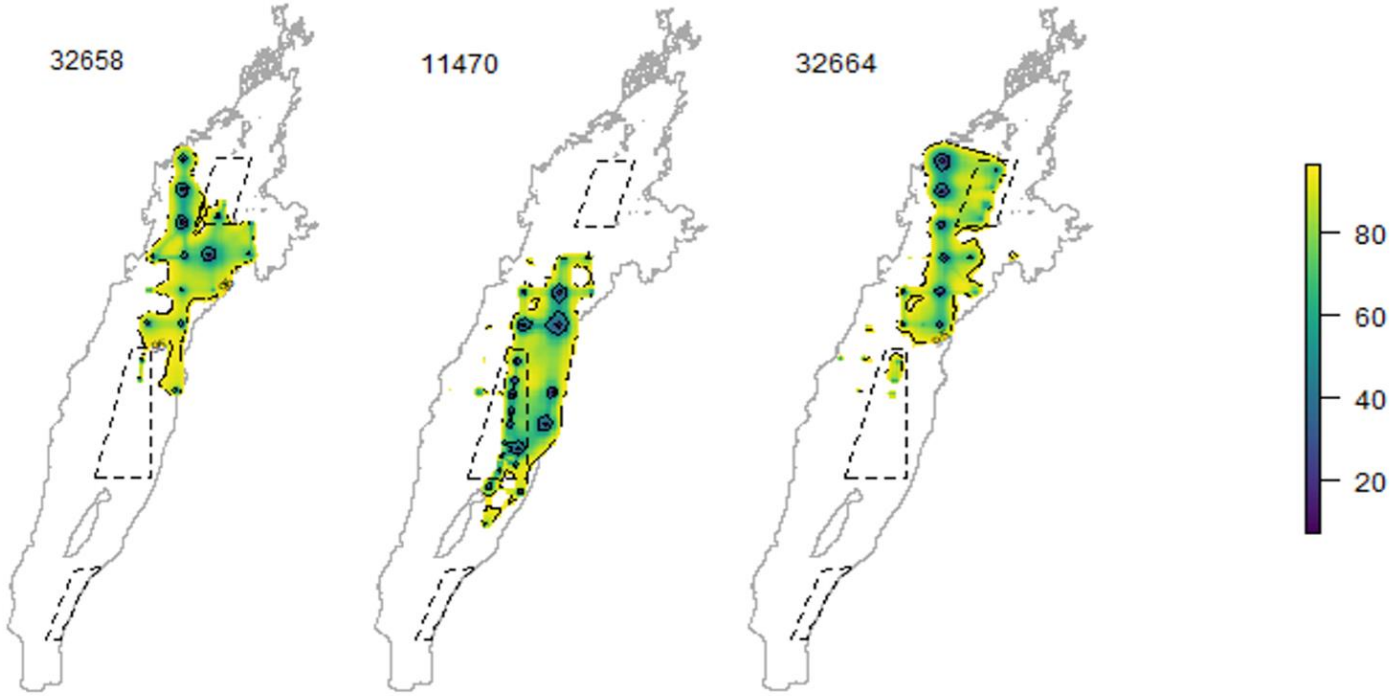

5000 m

Uppsala
Västerås
Stockholm

Vättern
Motala
Tranås
Jönköping

Detailed data on behavior and survival

- **Home range**
- **Habitat preferences**
- Survival
- Migrations
- Aggregations
- Behavior
- Spawning
- Foraging
- Thermal niche
- Subpopulation dynamics



Detailed data on behavior and survival

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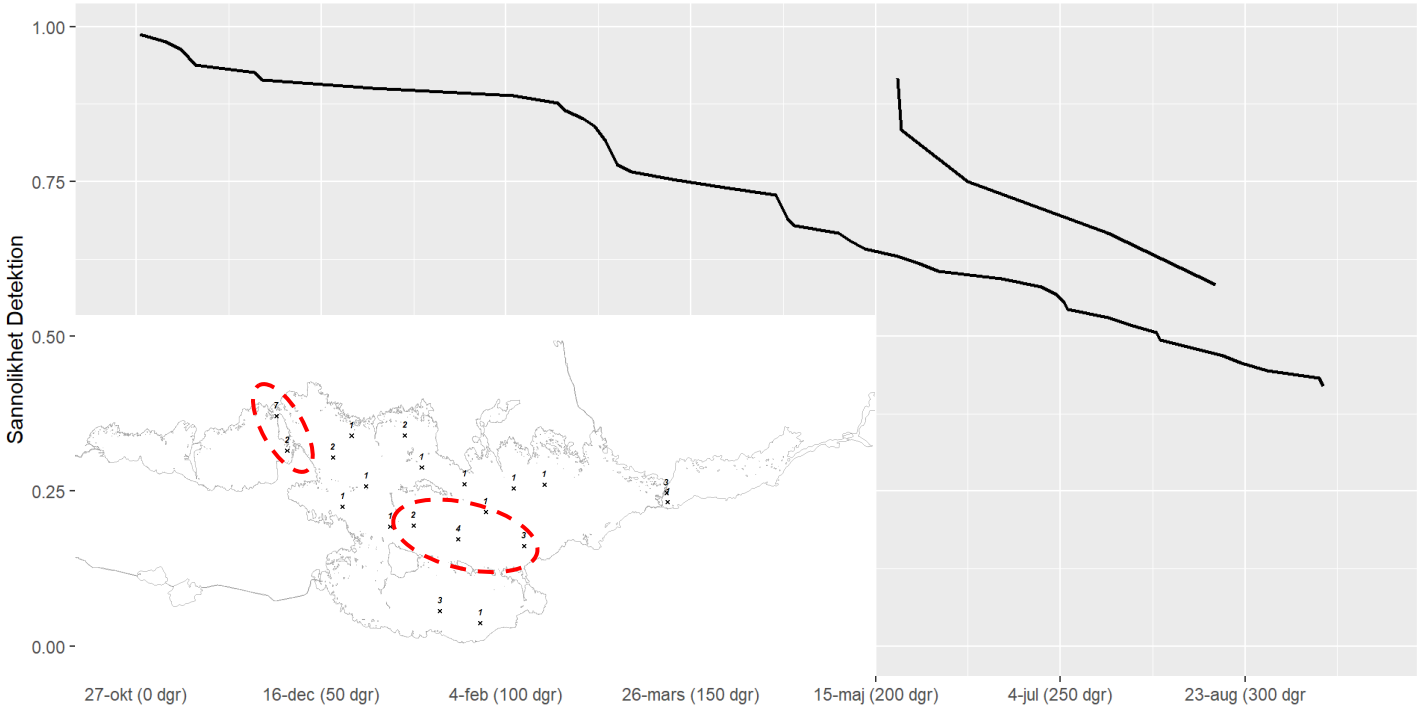

Detailed data on behavior and survival

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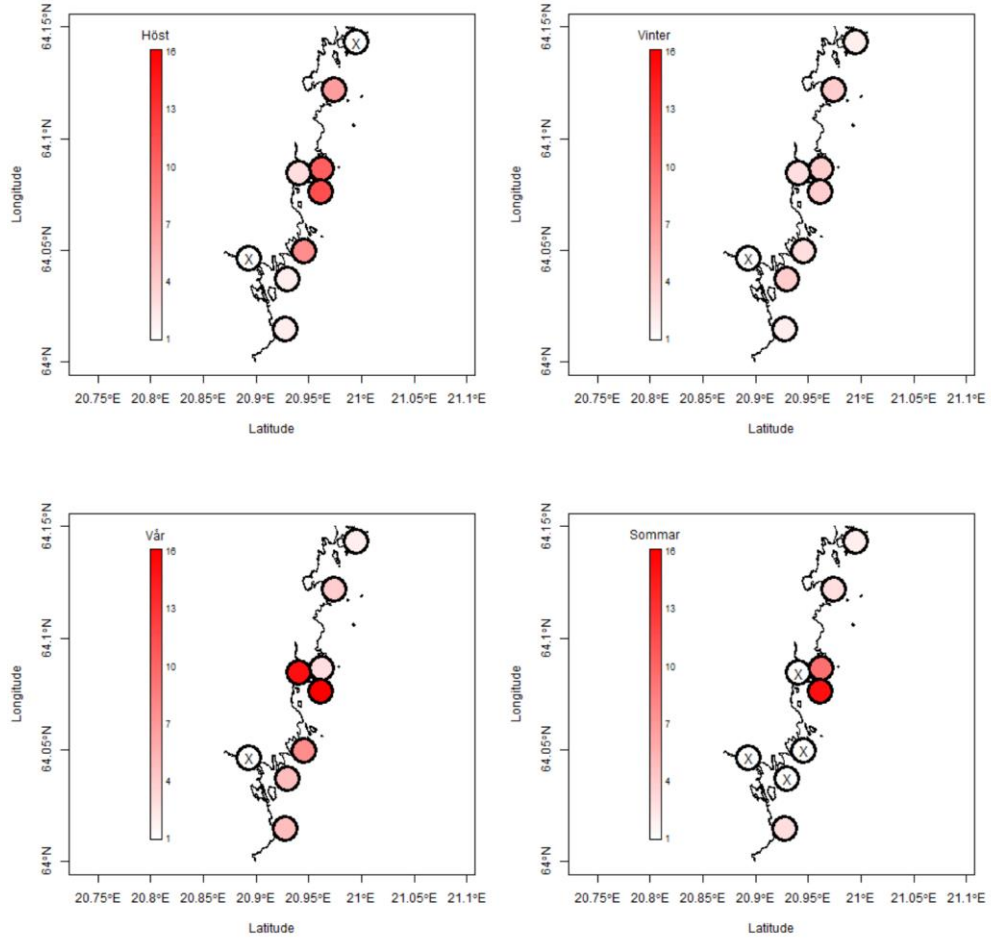

Detailed data on behavior and survival

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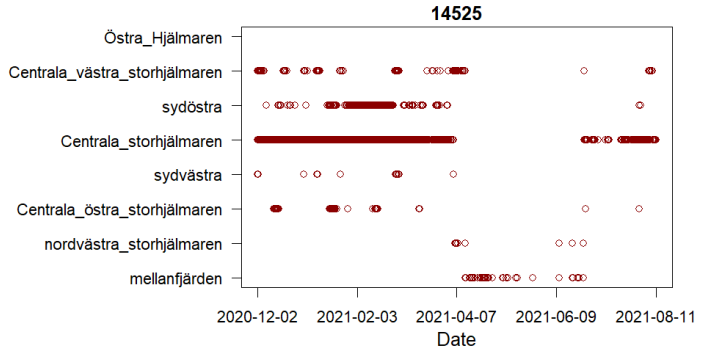

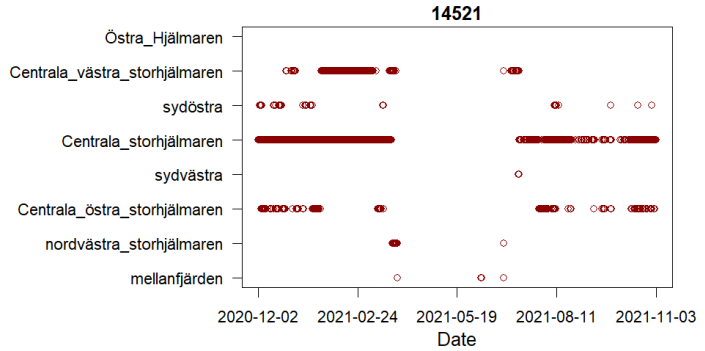

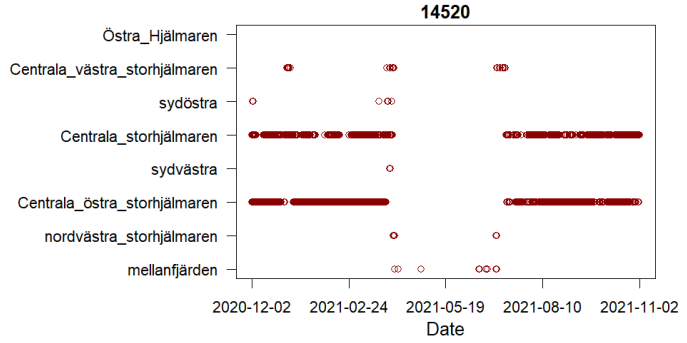

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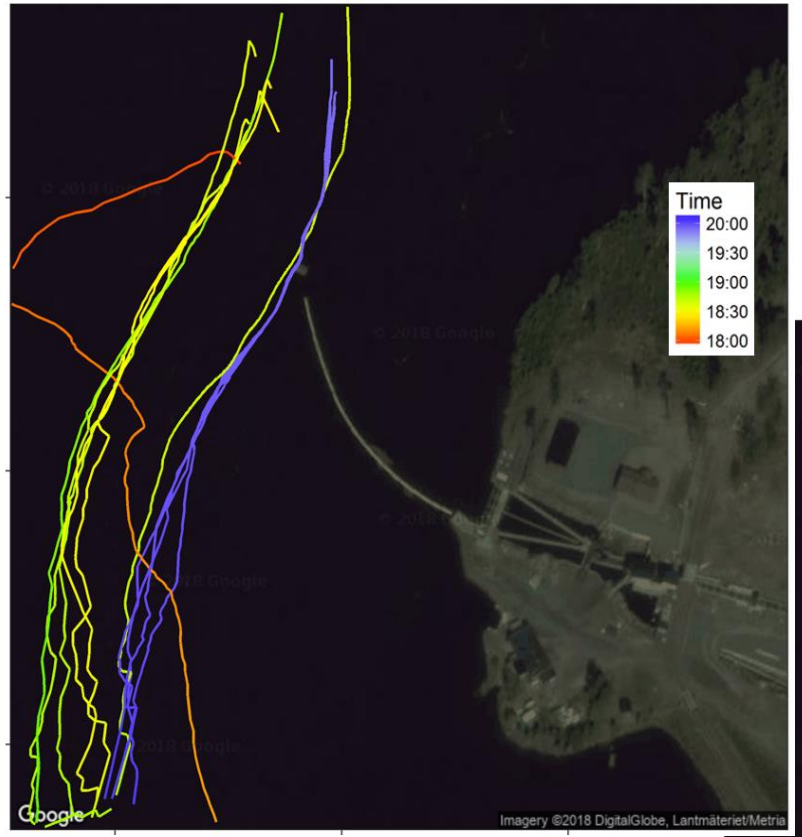

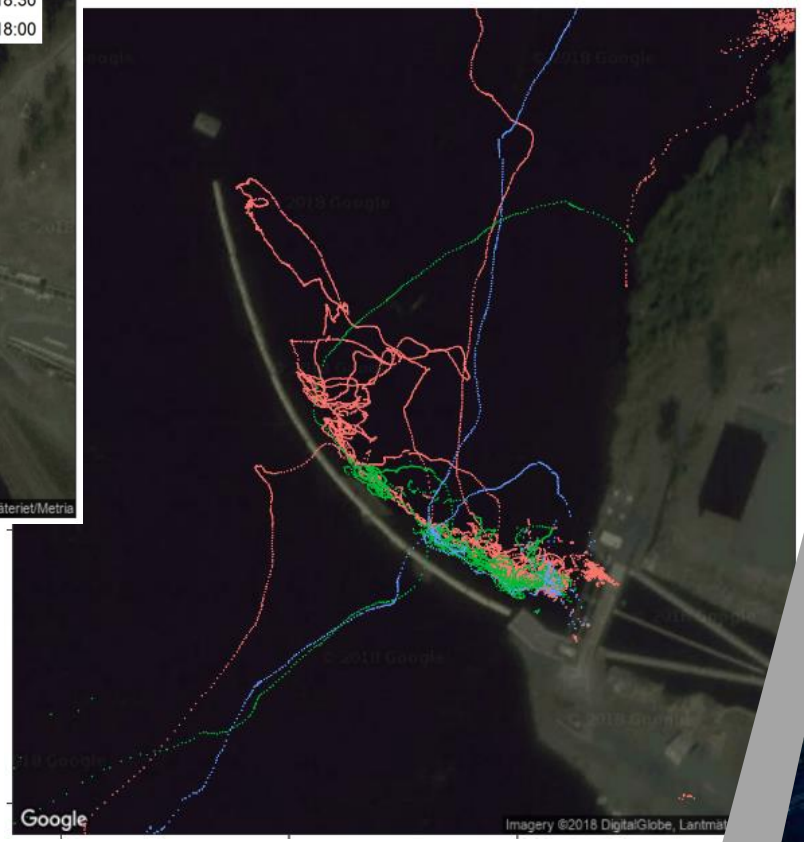

Detailed data on behavior and survival

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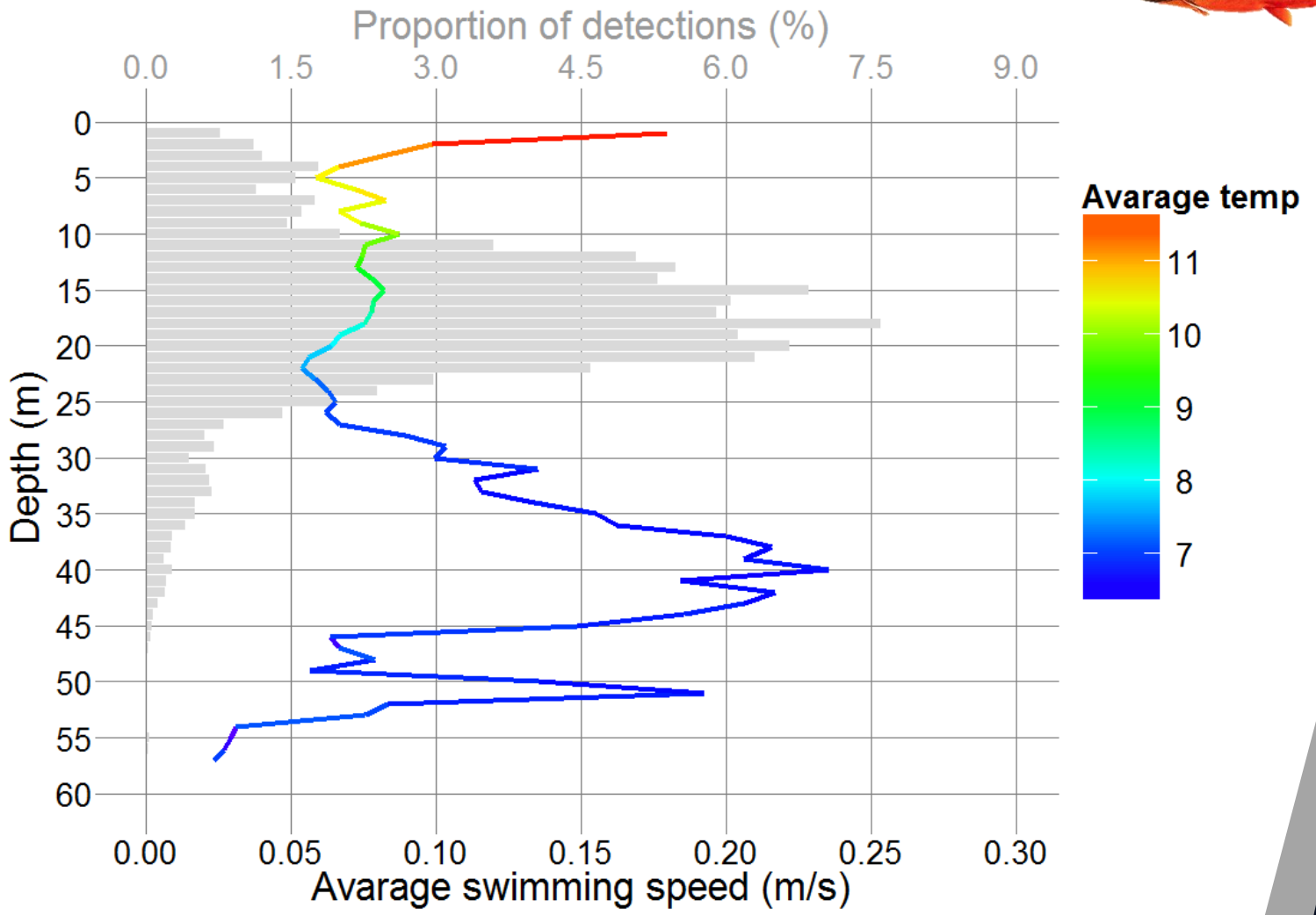
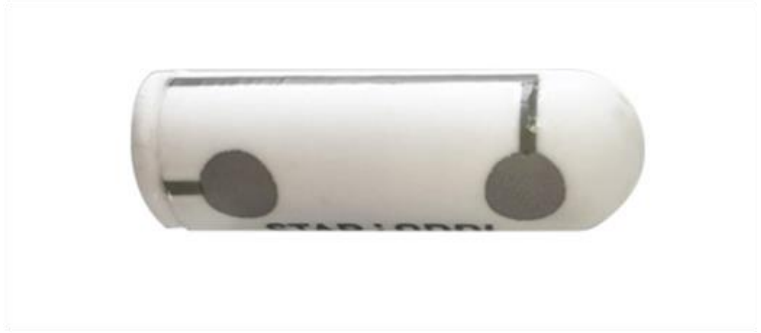
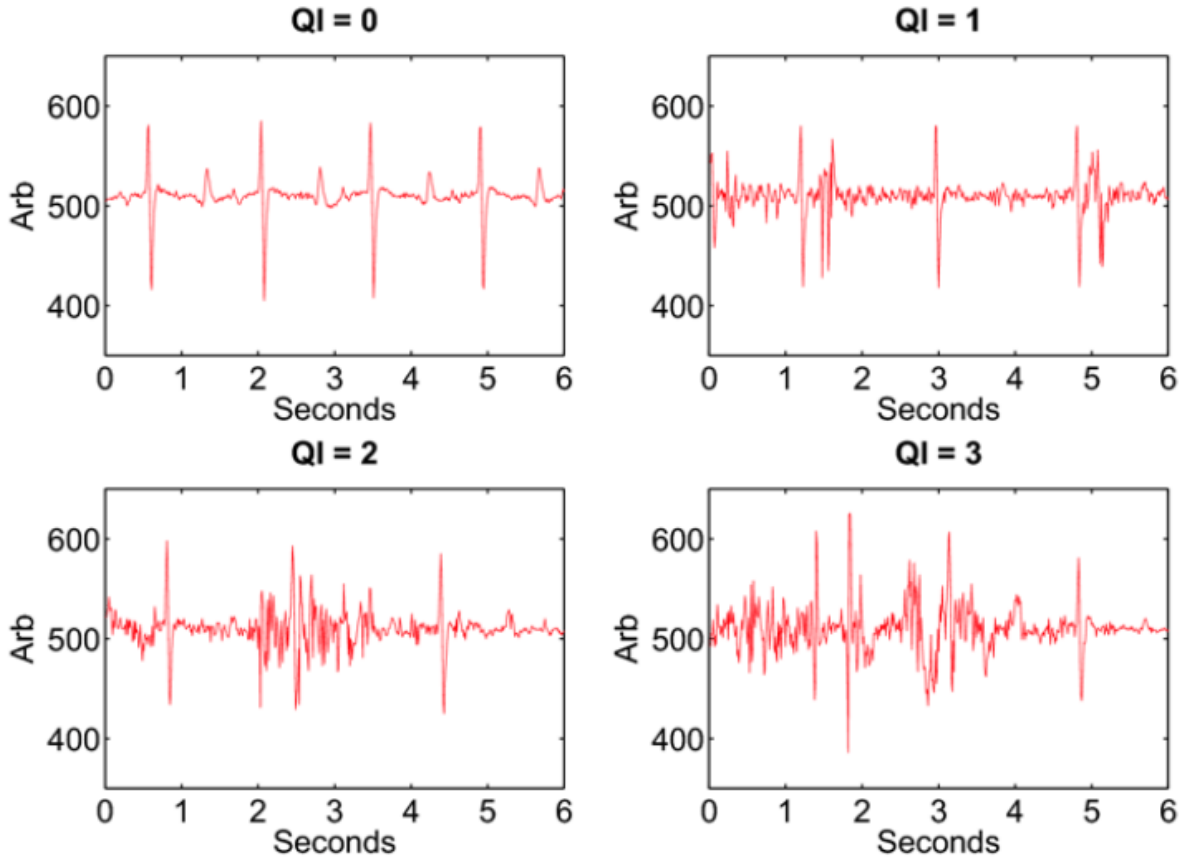
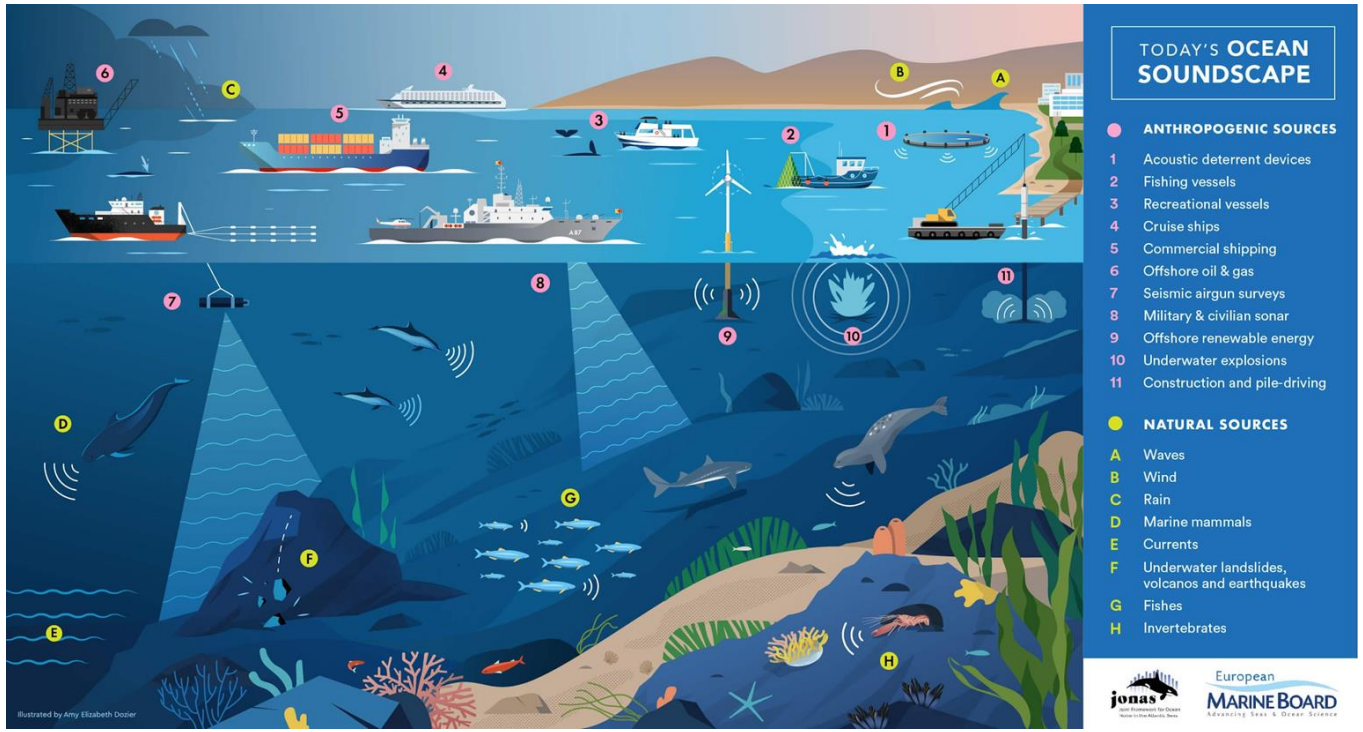


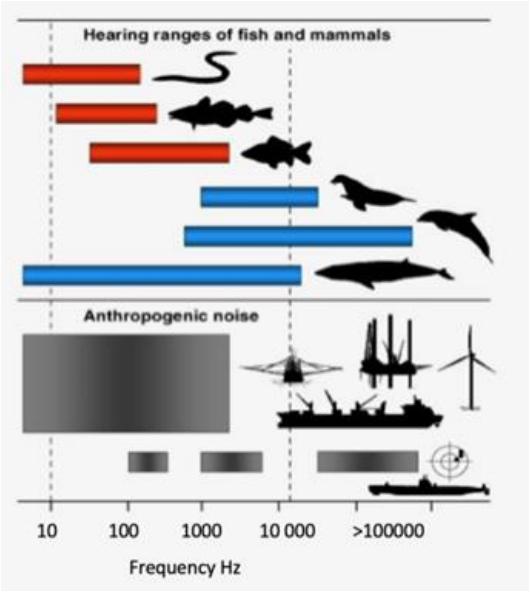
Biologging – Stress & High Res. Behaviour

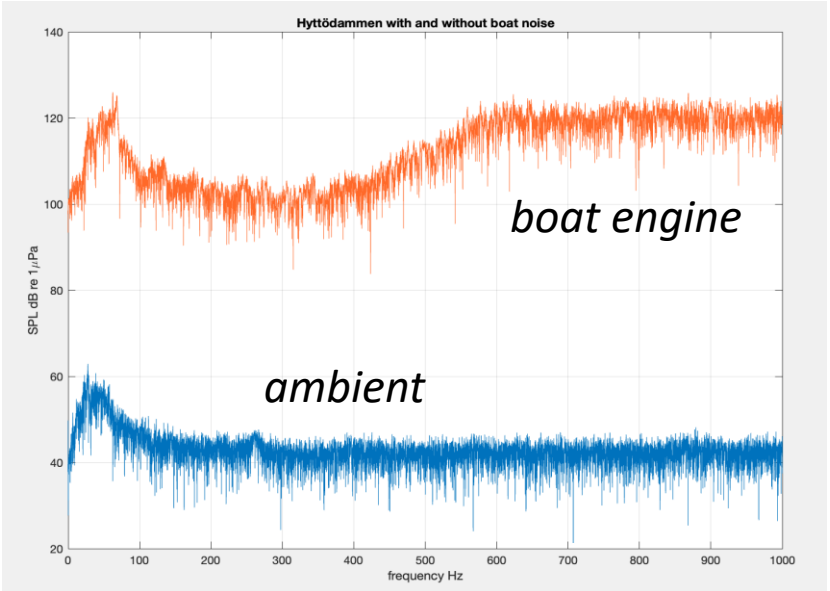


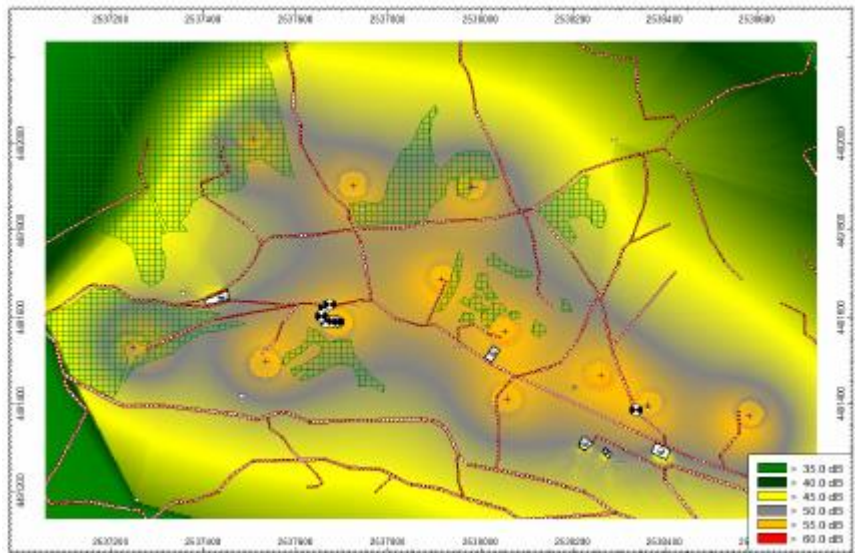


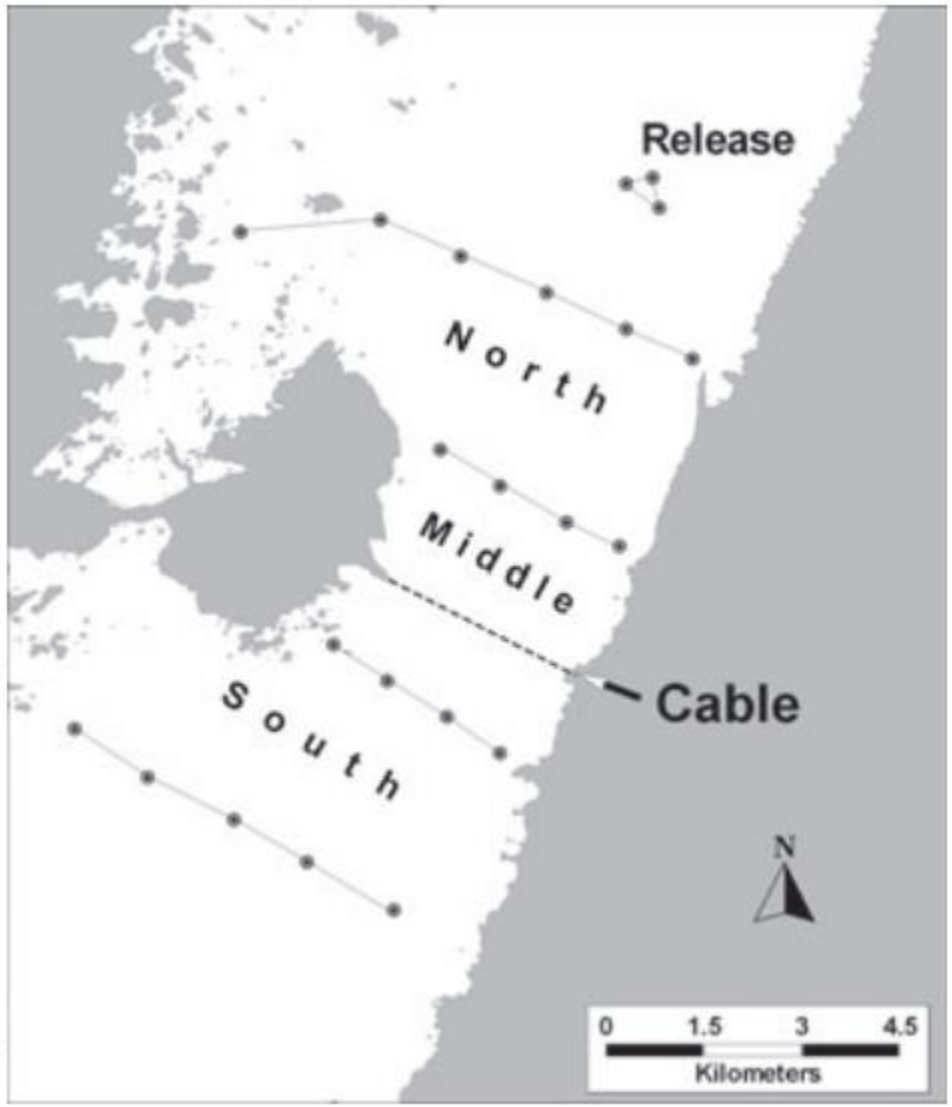
Noise Pollution











Fisheries Management and Ecology

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Sub-sea power cables and the migration behaviour of the European eel

H. WESTERBERG, I. LAGENFELT

First published: 22 October 2008 | https://doi.org/10.1111/j.1365-2400.2008.00630.x | Citations: 54

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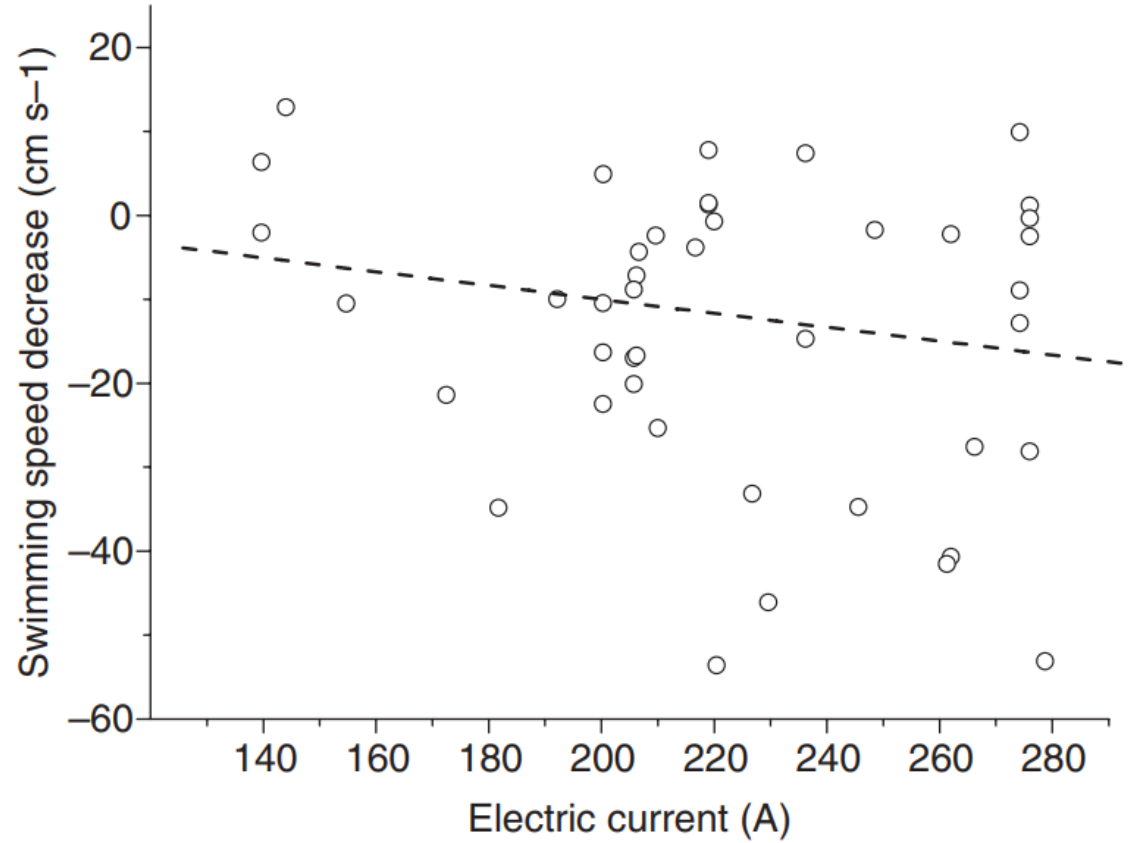
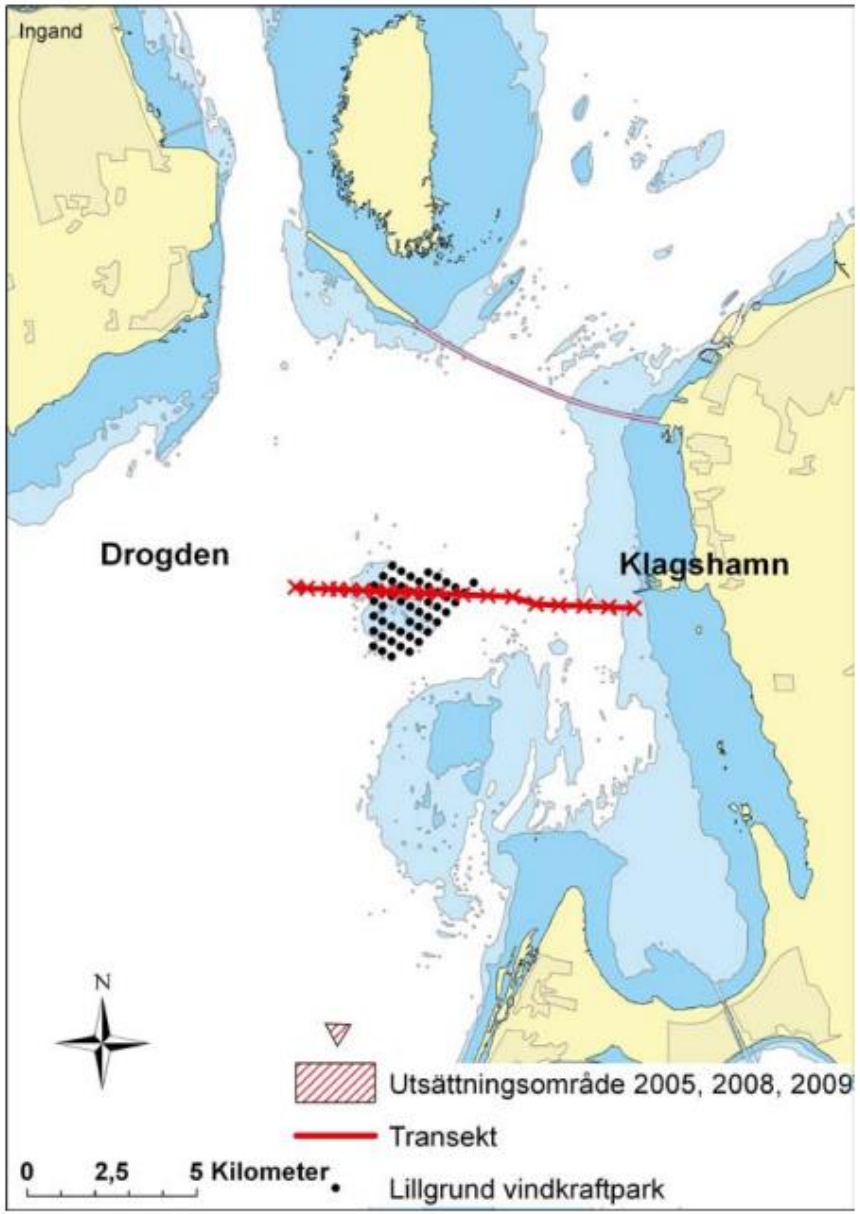
Håkan Westerberg, Swedish Board of Fisheries, PO Box 324, SE 40126 Göteborg, Sweden (e-mail: Hakan.westerberg@fiskeriverket.se)




Ingand
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Klagshamn
N
Utsättningsområde 2005, 2008, 2009
Transekt
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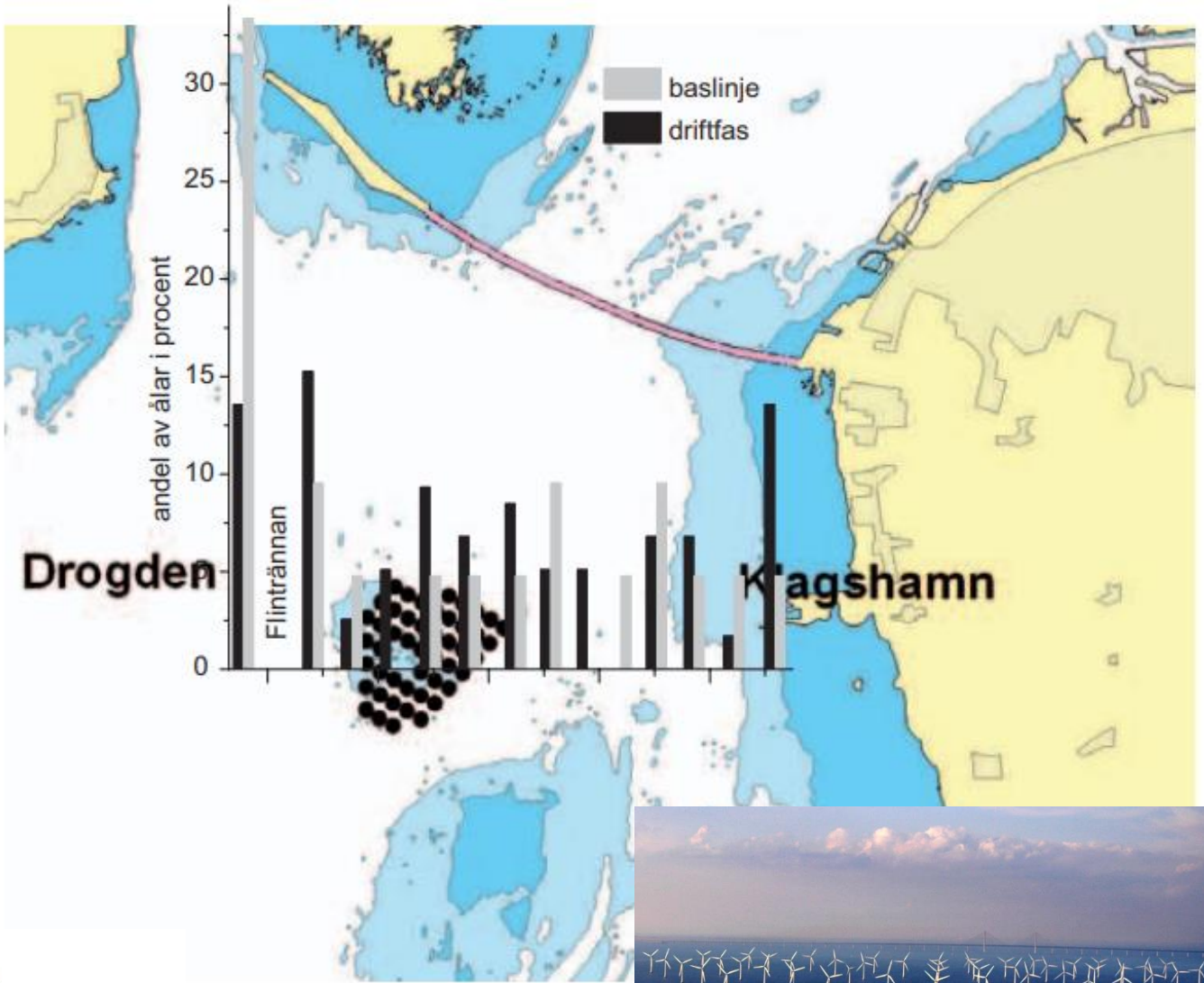
Lillgrund vindkraftpark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Drogden
K'agshamn

Journal of Sea Research
Volume 85, January 2014, Pages 214-221

Diel variation in feeding and movement patterns of juvenile Atlantic cod at offshore wind farms

Jan T. Reubens [a], Maarten De Rijcke [a], Steven Degraer [a b], Magda Vincx [a]

Contents lists available at ScienceDirect
Marine Environmental Research
journal homepage: www.elsevier.com/locate/marenvrev

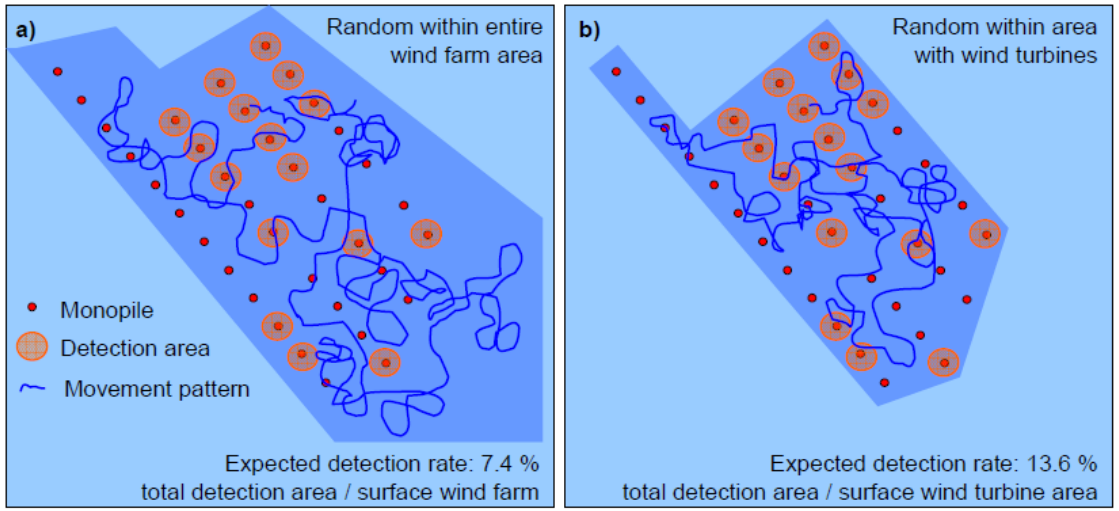
Residency, site fidelity and habitat use of Atlantic cod (*Gadus morhua*) at an offshore wind farm using acoustic telemetry

Jan T. Reubens [a,*], Francesca Pasotti [a], Steven Degraer [a,b], Magda Vincx [a]

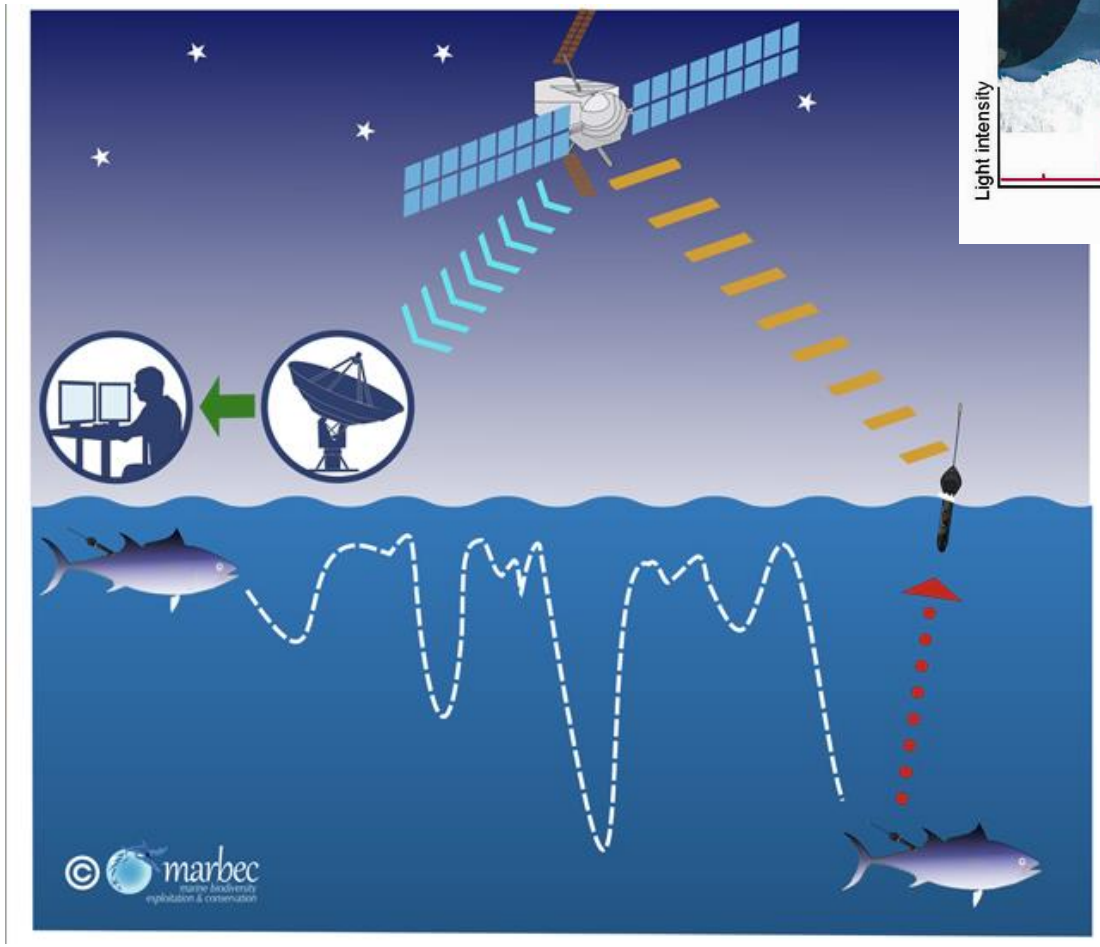
[a] Ghent University, Department of Biology, Marine Biology Research Group, Krijgslaan 281/S8, 9000 Gent, Belgium
[b] Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models (MUMM), Marine Ecosystem Management Section, Gulledelle 100, 1200 Brussels, Belgium

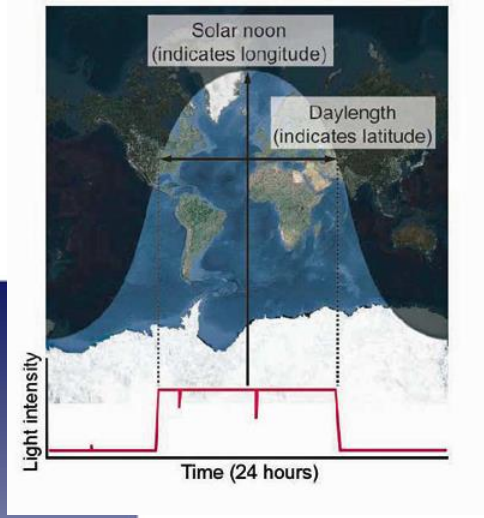
Movement pattern of red seabream *Pagrus major* and yellowtail *Seriola quinqueradiata* around Offshore Wind Turbine and the neighboring habitats in the waters near Goto Islands, Japan

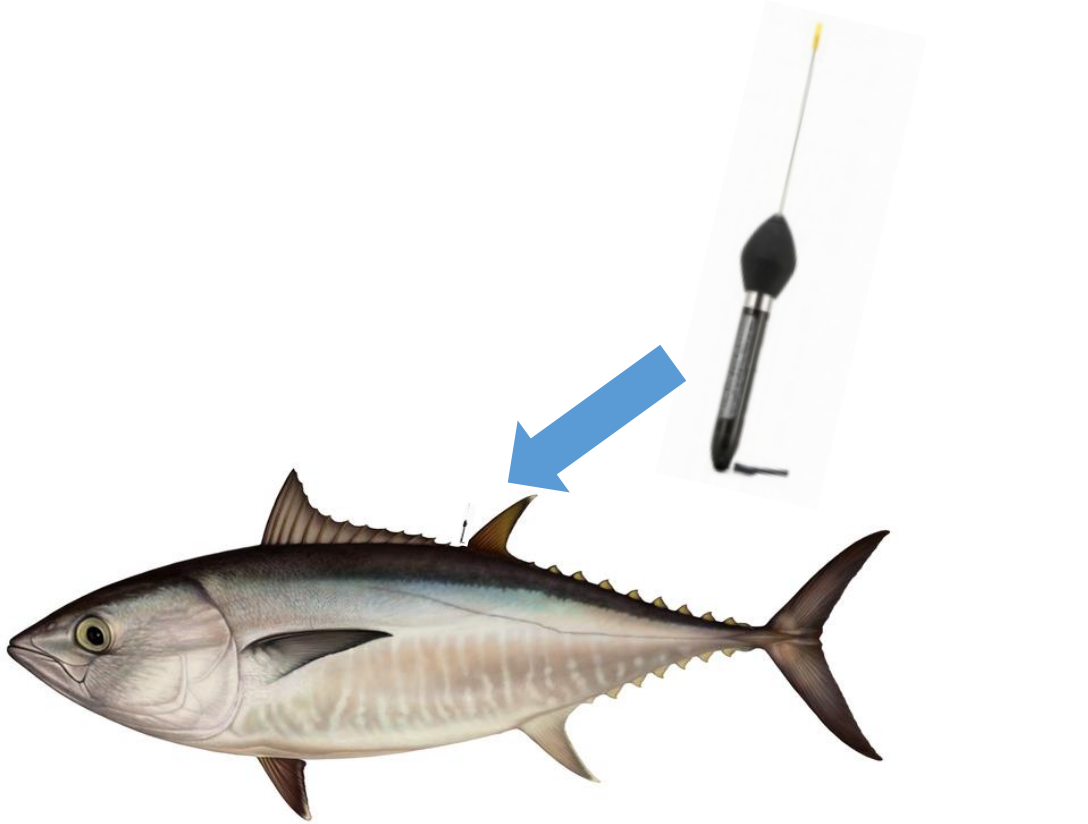
Khyria Swaleh Karama [a b], Yoshiki Matsushita [a c], Masahiro Inoue [d], Kenta Kojima [e], Kazuki Tone [a], Itsumi Nakamura [f], Ryo Kawabe [f]

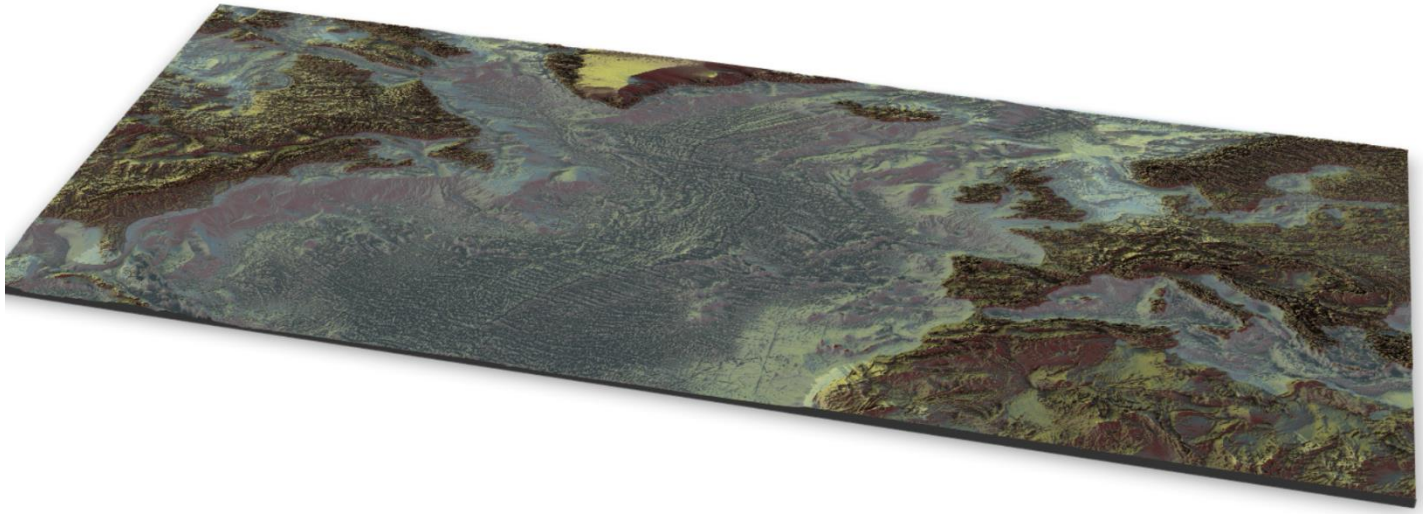


Satellite tags
PSAT



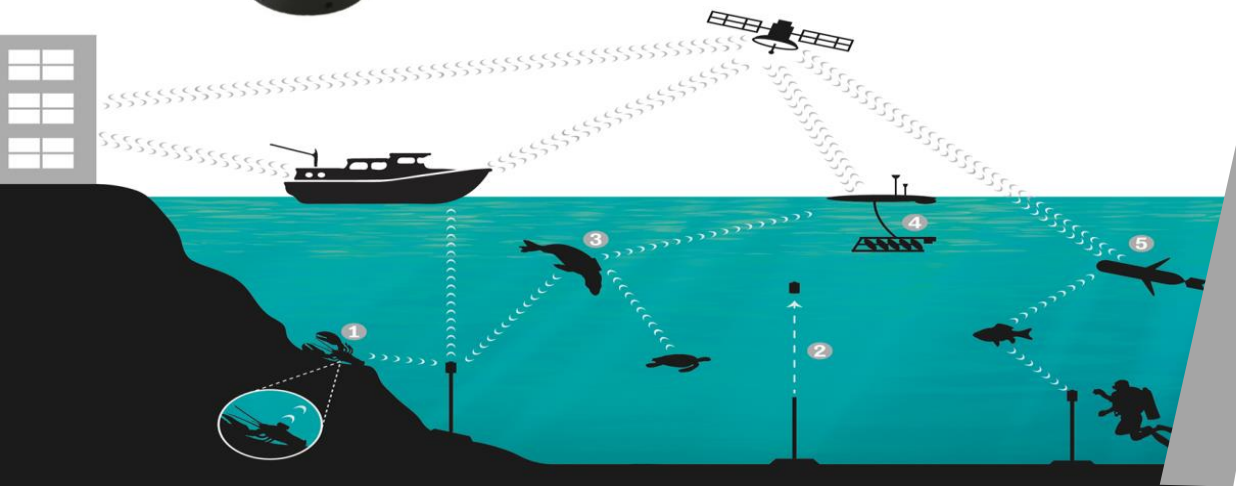






Satellite tracking Baltic Salmon 2023


Release lug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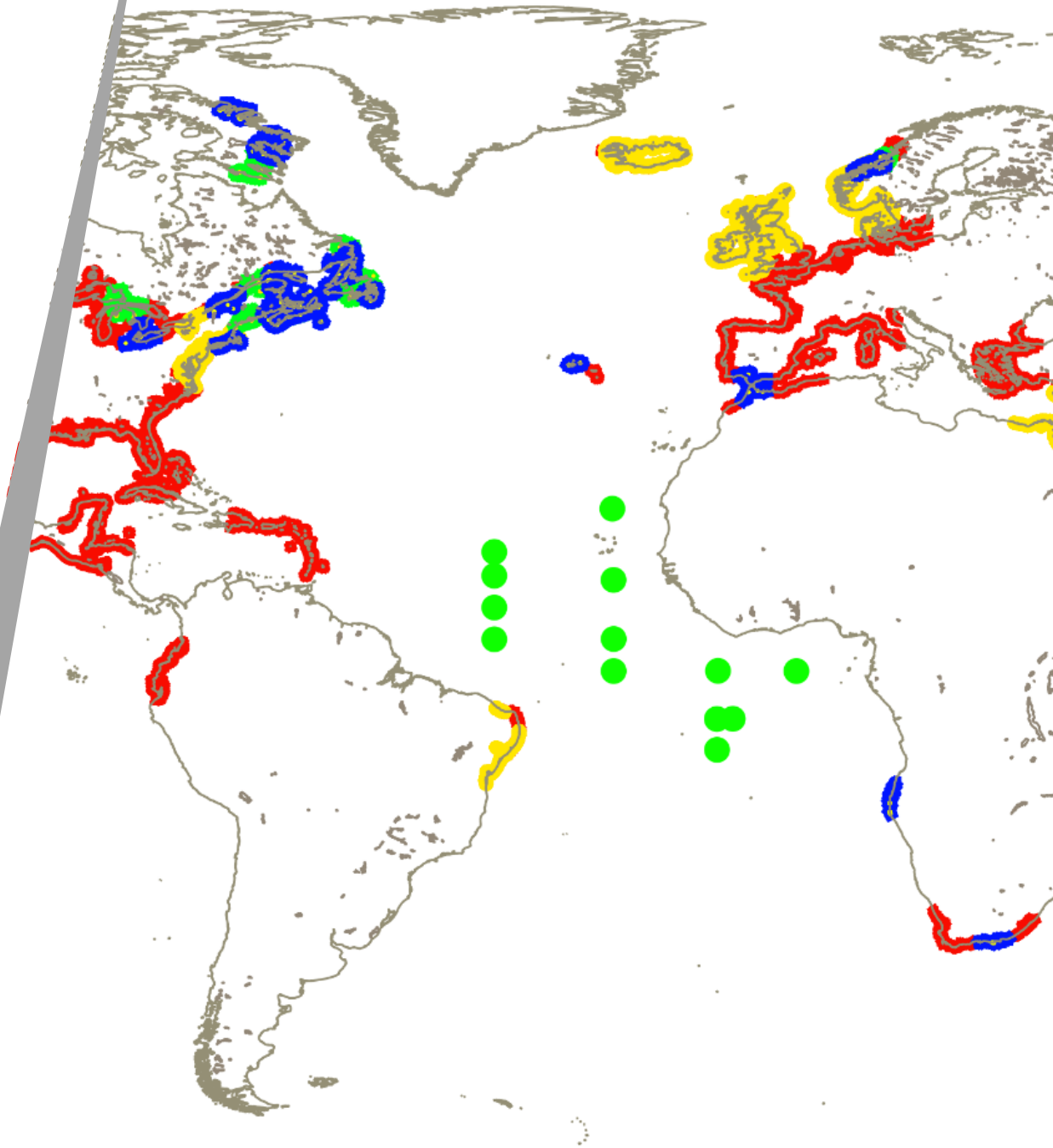
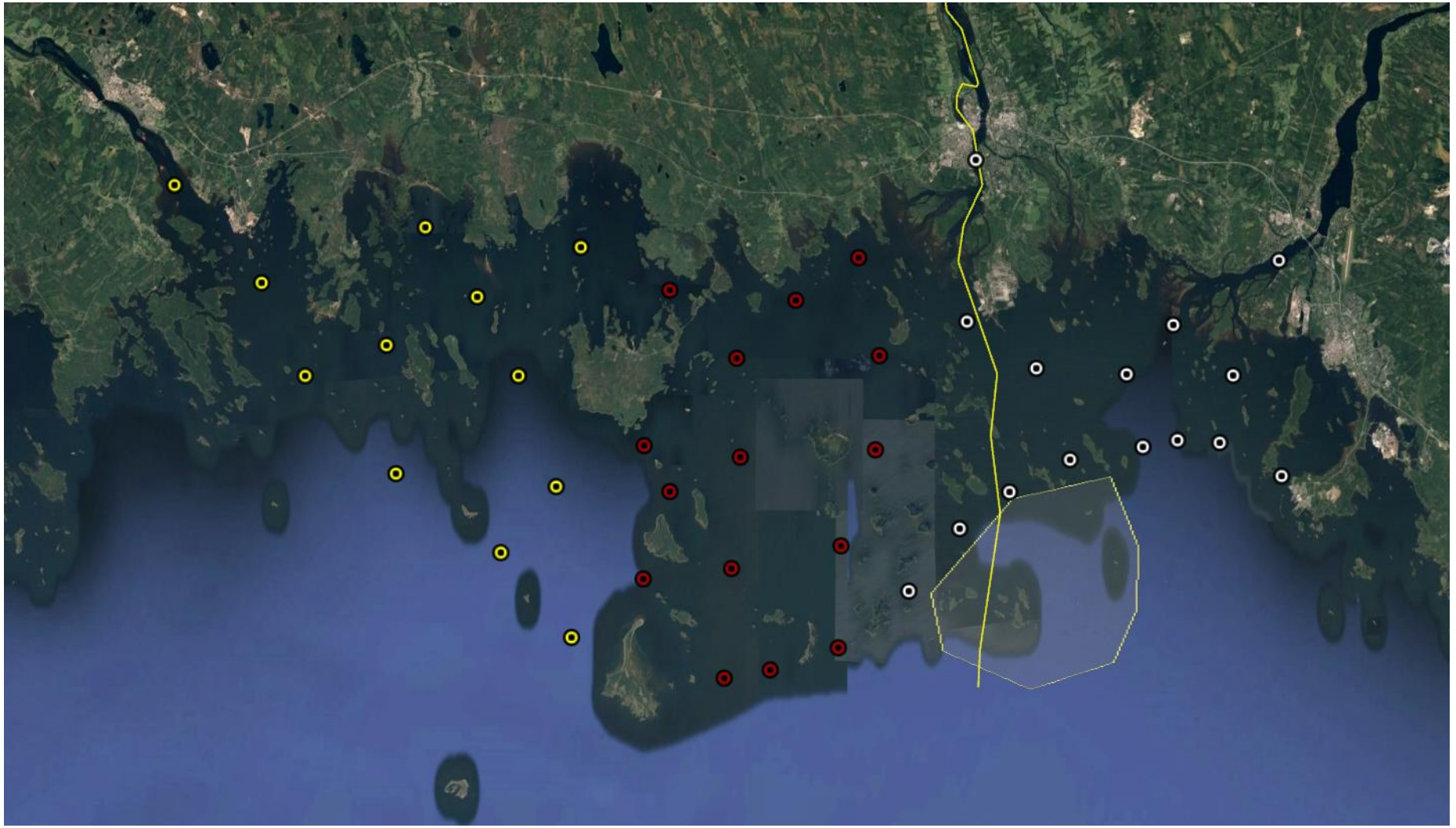


Baltic Sea Tracking Network

Coastal Tracking Project 2023

Haparanda Archipelago



- **Telemetry is a great tool to study effects on migration**

- **Coordinated studies with multiple partners**
  - **Universities**
  - **National and regional Agencies**
  - **Companies**
  - **Consultants**
  - **NGOs**

- **Need to start asap to get baseline data**

- **Horizon, Biodiversa, Interreg, Vinnova**

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