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Session C5: Downstream Migration of the European Eel (*A. anguilla*): Movement Patterns and the Potential Impact of Environmental Factors

Florian Stein

University of Potsdam; Technical University of Braunschweig; Karlstad University

Peer Doering-Arjes

Humboldt-Universität zu Berlin

Erik Fladung

Institute of Inland Fisheries Potsdam- Sacrow

Uwe Brämick

Institute of Inland Fisheries in Potsdam-Sacrow

Barry Bendal

The Rivers Trust

See next page for additional authors

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Presenter Information

Florian Stein, Peer Doering-Arjes, Erik Fladung, Uwe Brämick, Barry Bendal, and Boris Schroder



Downstream migration of the European Eel (*A. anguilla*): movement patterns and the potential impact of environmental factors

**STEIN F, DOERING-ARJES P, FLADUNG E,
BRÄMICK U, BENDALL B, SCHRÖDER B**



Institute of Inland Fisheries in Potsdam-Sacrow



Technische
Universität
Braunschweig



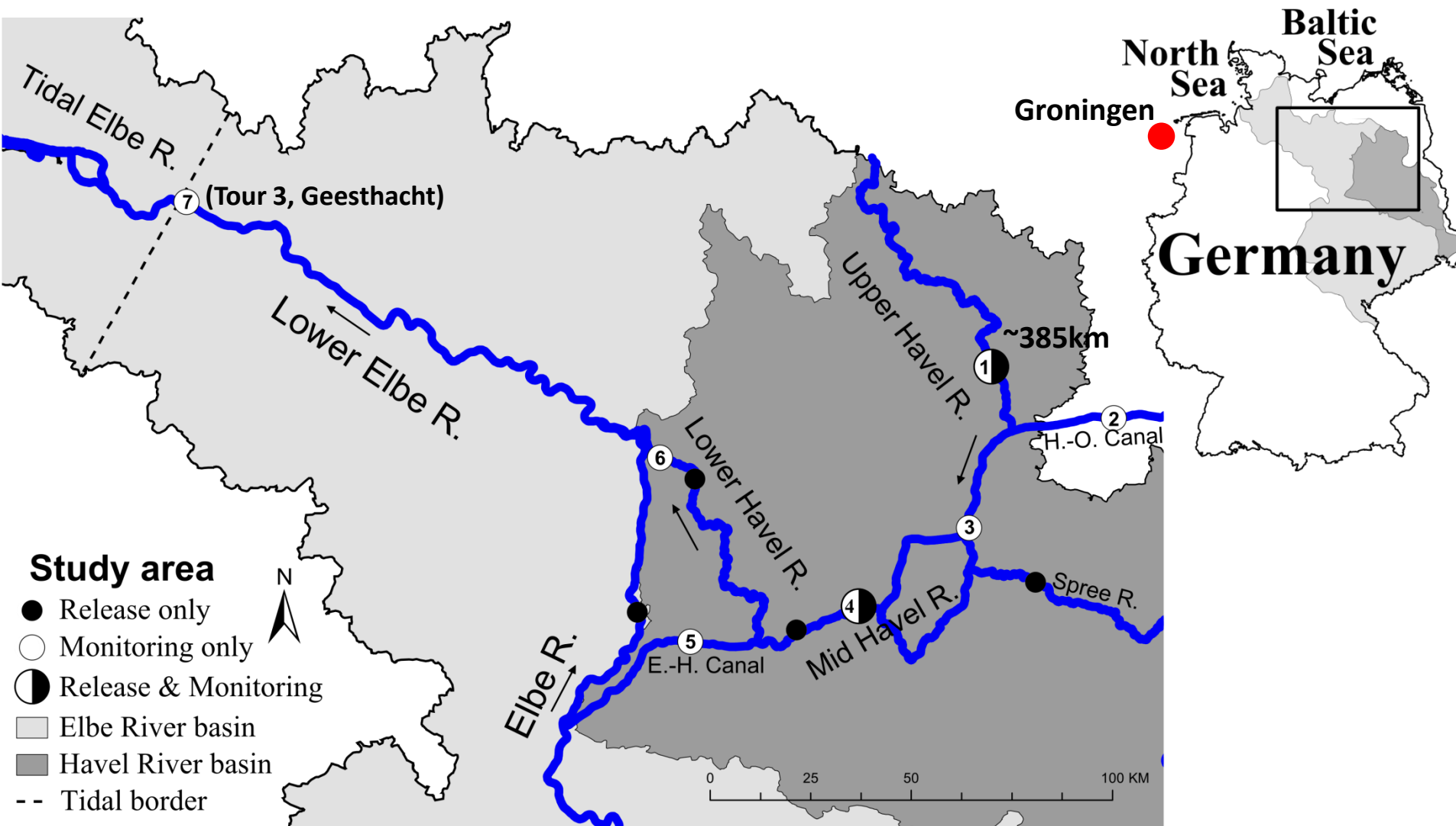


Obtain knowledge about:

- preferable environmental conditions
and resulting migration patterns
- Management of endangered species
- achieve the EU targets (EC No 1100/2007)



METHODS: Study area & Telemetry system



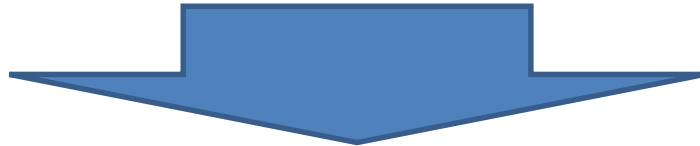


METHODS: Data aggregation

399 eels detected at 28 receivers
(7 MS) between 2007 & 2011



> 1.5 Mio Detections



Extraction



Arrival

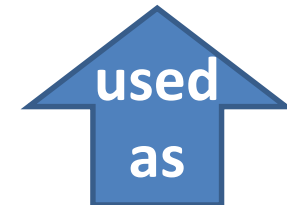
FIRST detect. of
the same eel at the
same MS within 24 h

Departure

LAST detect. of
the same eel at the
same MS within 24 h



**Model
Response**



**Movement
Activity**



METHODS: Analyses and Modelling

MODEL	DATA	RESPONSE
Complete	Entire study period	Movement activity
Spring /Autumn	1 Jan – 30 July 1 Aug – 31 Dec	Movement activity
River sections	Upper H, Mid H Lower H, Elbe	Movement activity



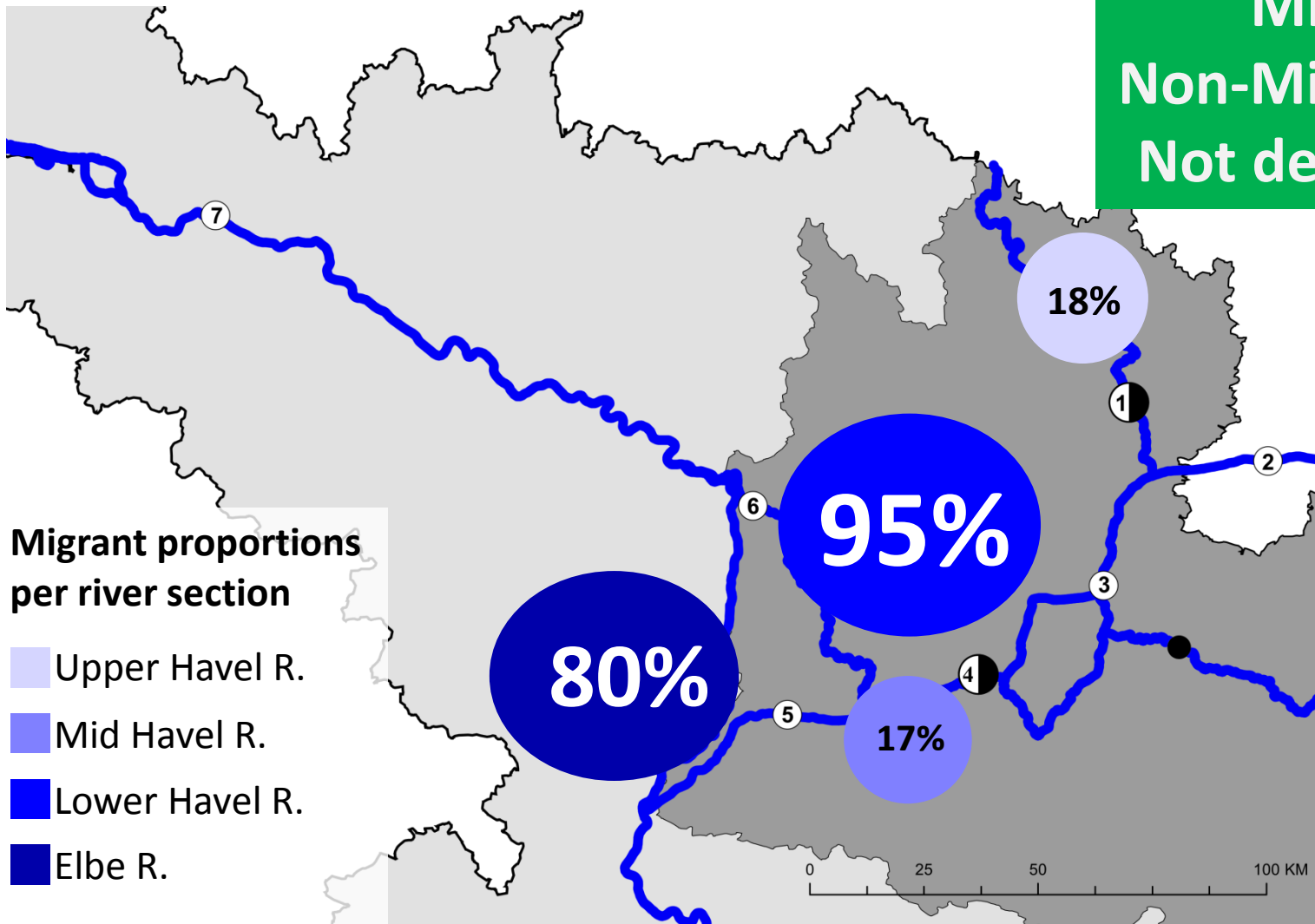
METHODS: Analyses and Modelling

MODEL	DATA	RESPONSE	PREDICTORS
Complete	Entire study period	Movement activity	Moonlight [fraction] Sunshine [h D ⁻¹]
Spring /Autumn	1 Jan – 30 July 1 Aug – 31 Dec	Movement activity	Discharge [m ³ s ⁻¹] Flow velocity [km ⁻¹]
River sections	Upper H, Mid H Lower H, Elbe	Movement activity	Water temperature [°C] Barometric pressure [hPa] Precipitation [mm D ⁻¹]
Migration probability	Migrant or Non-migrant?	Success or failure?	Distance [km] Holding period [D] Silver index



RESULTS: Migrant proportions

Migrants: 28 %
Non-Migrants: 55 %
Not detected: 17 %



MIGRANTS

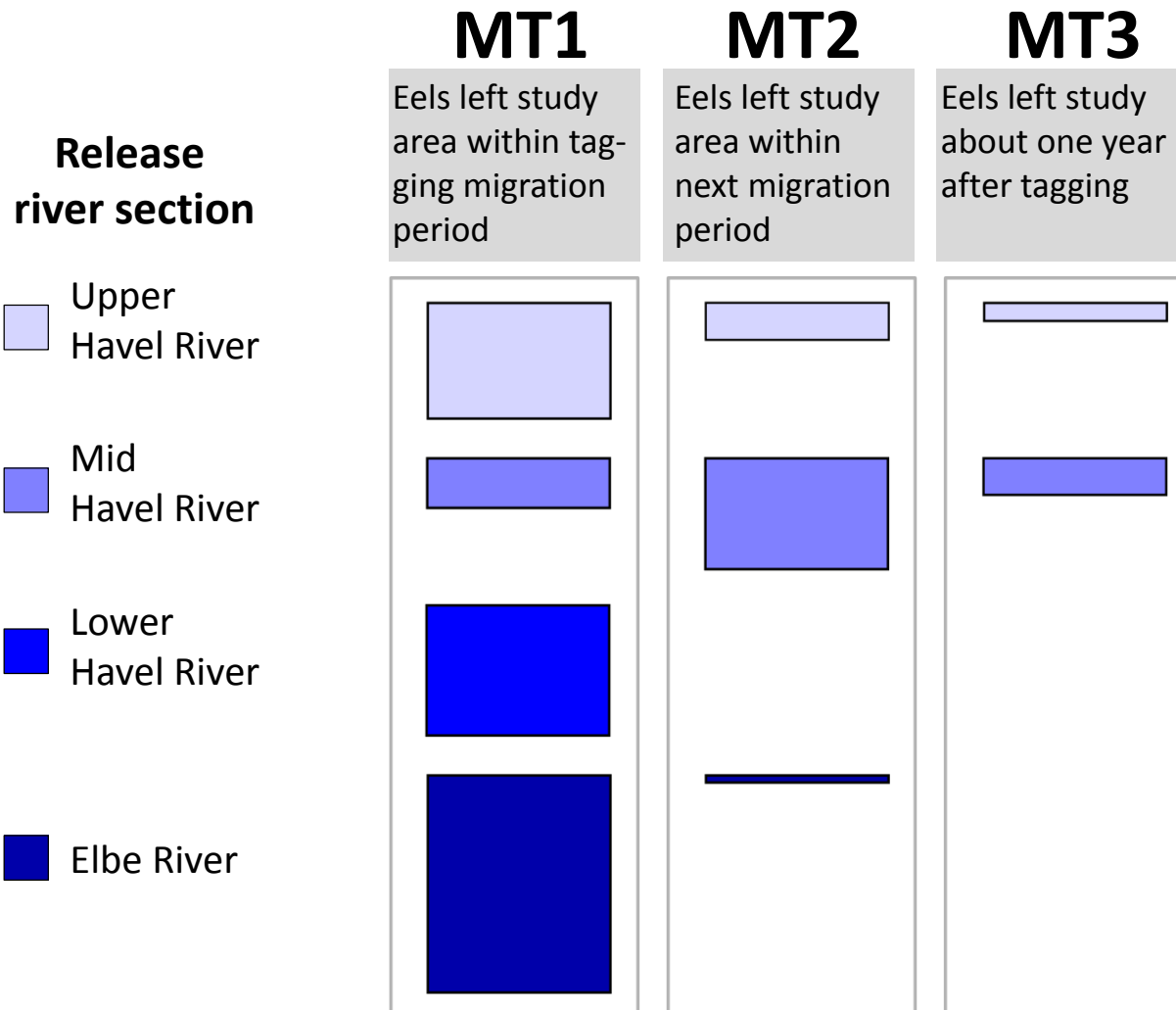
detected
sequentially
on at least two
downstream MS

or

released into the
Elbe and detected
at the last MS

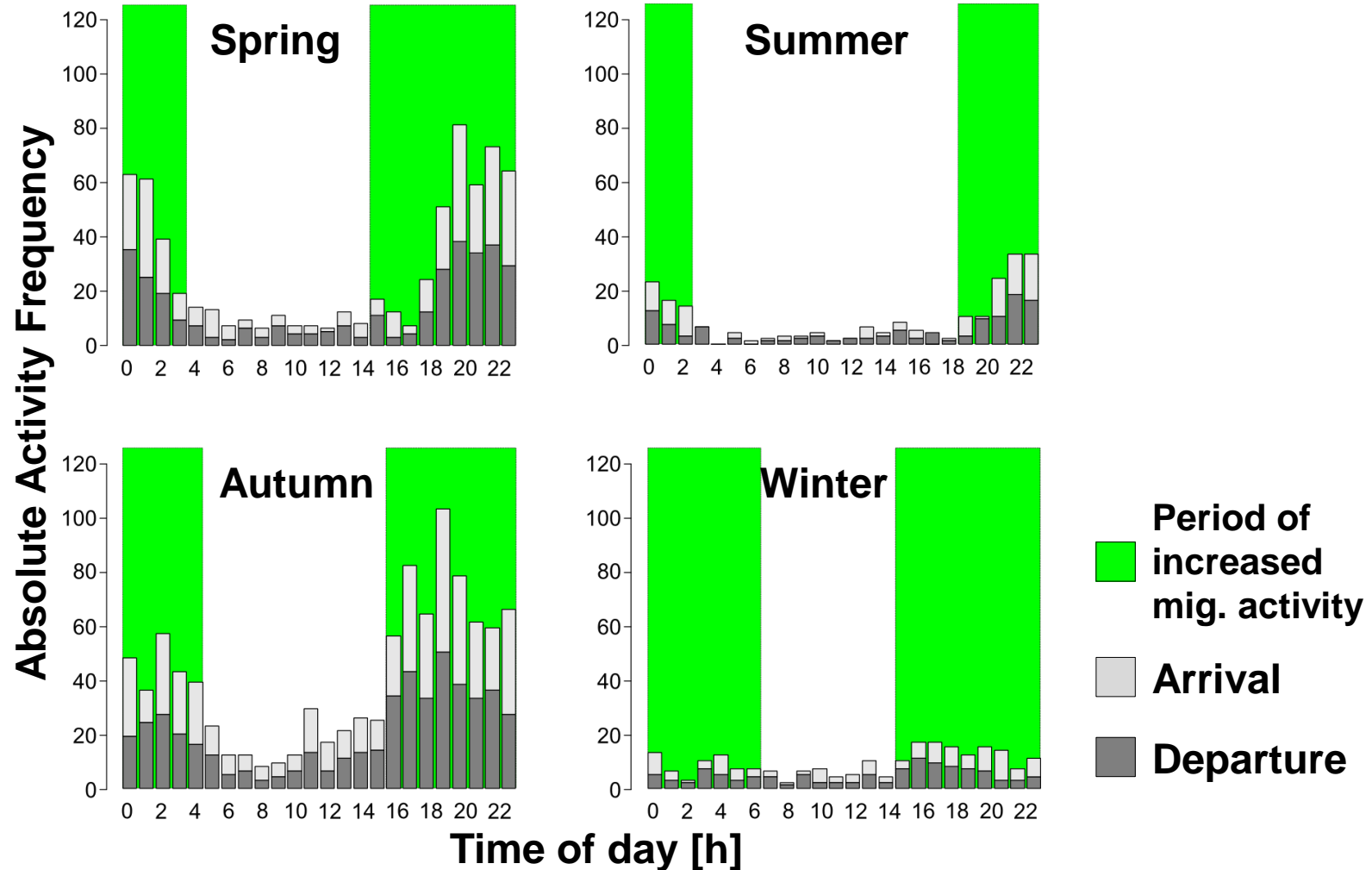


RESULTS: Migration types



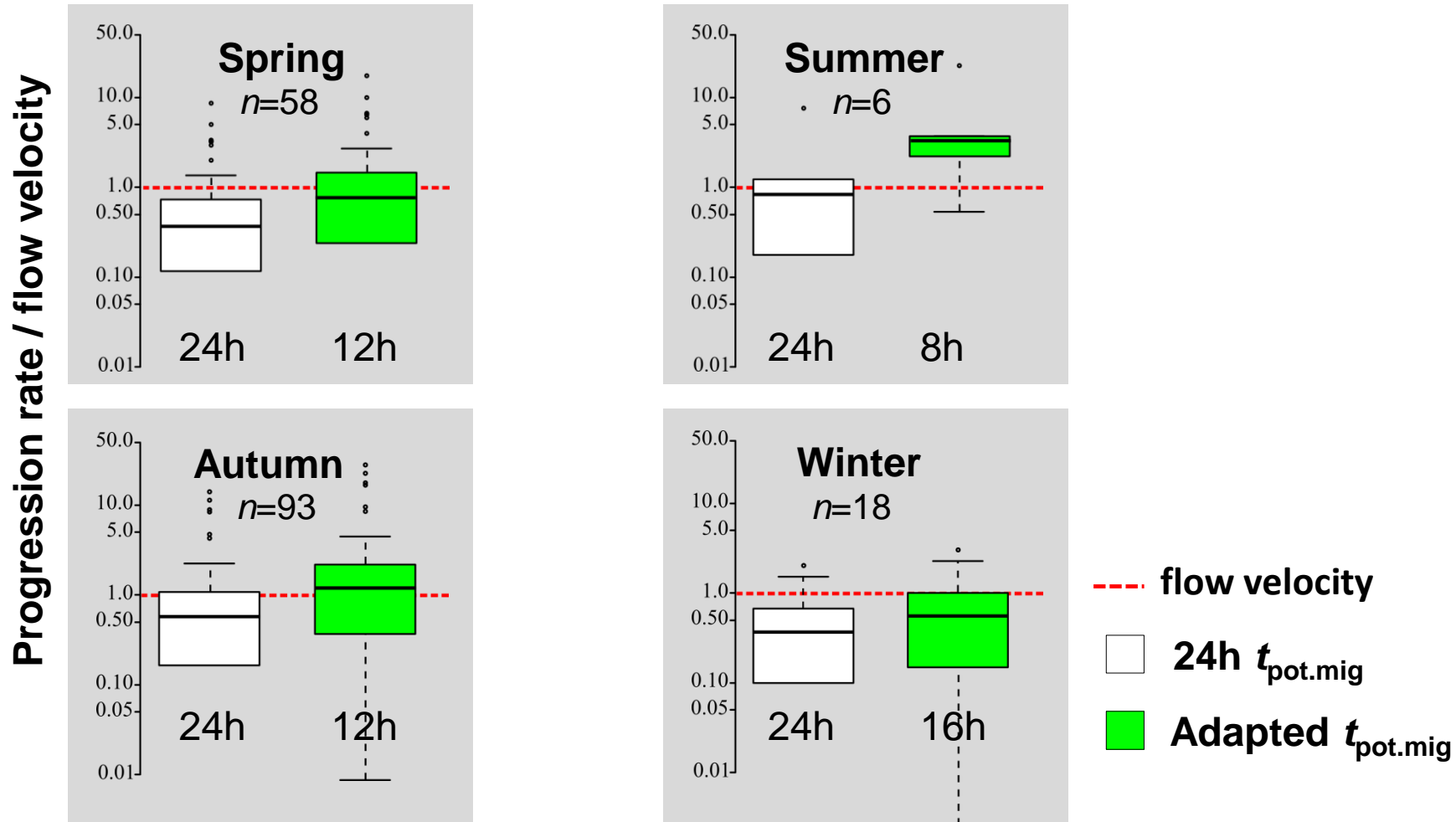


RESULTS: Diel periodicity of mig. activity



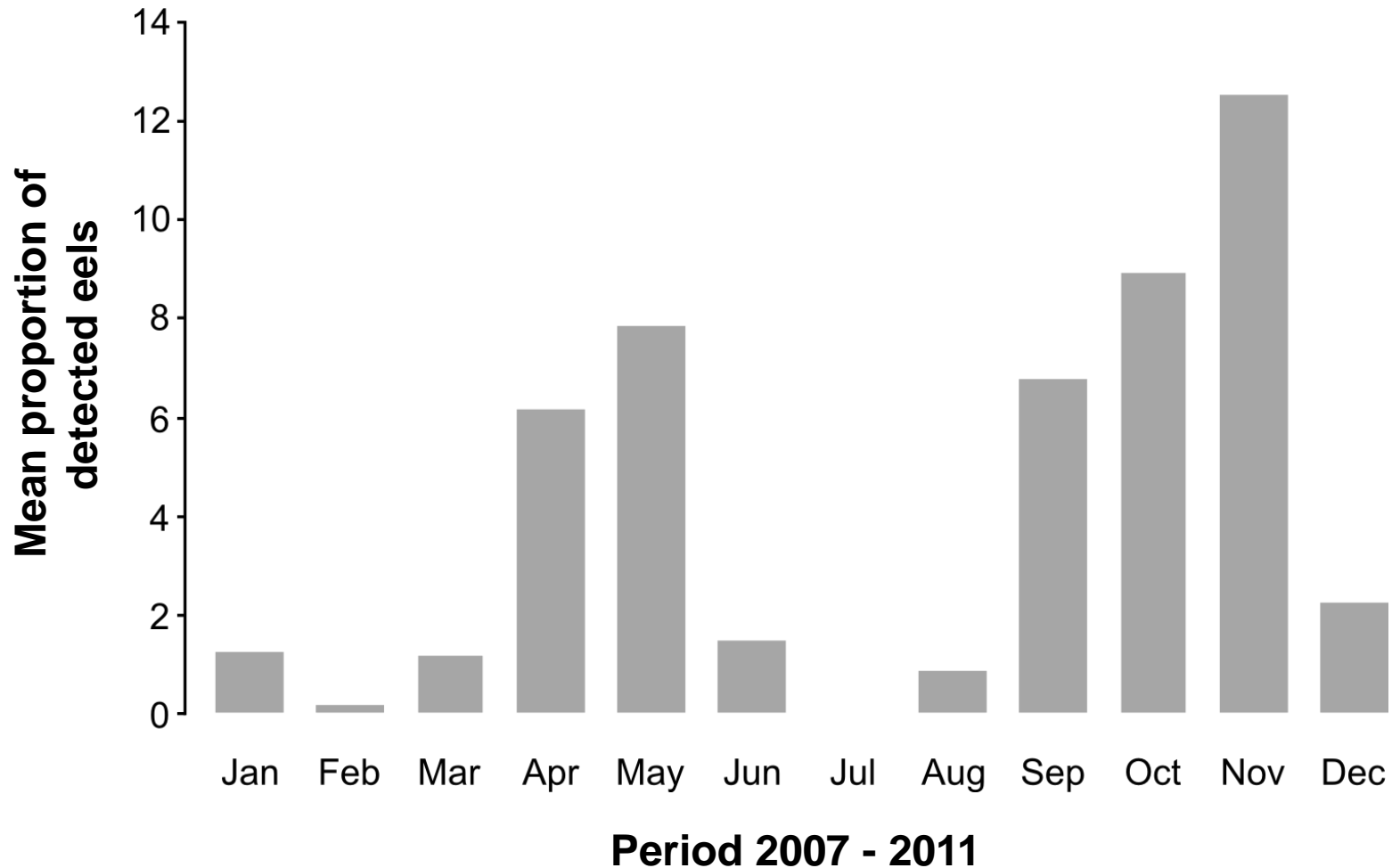


RESULTS: Progression rates








RESULTS: Seasonal migration

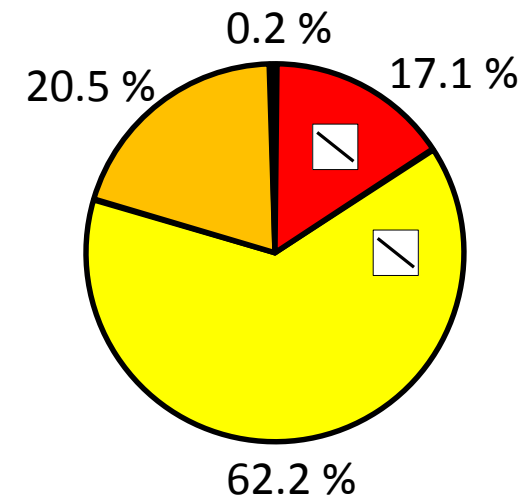
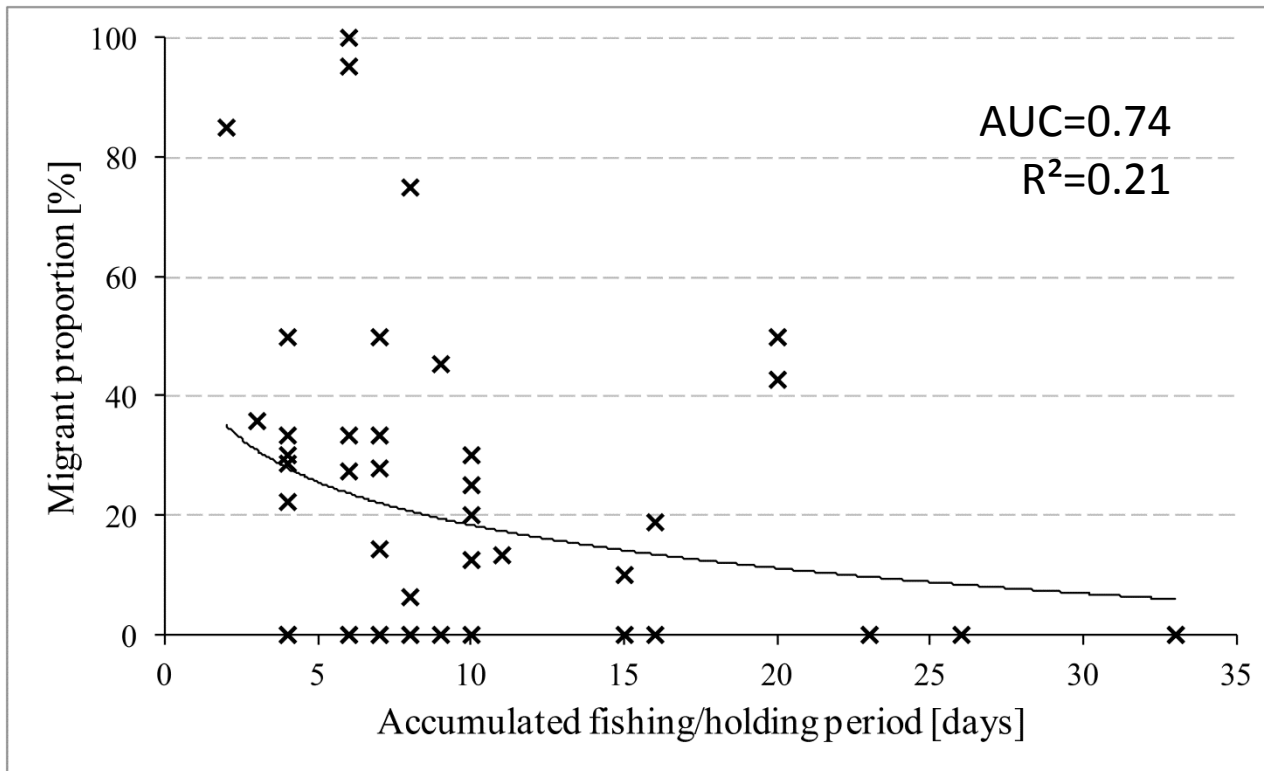








RESULTS: Effects on migration probability

Relationship

-  Unimodal
-  Positive
-  Negative

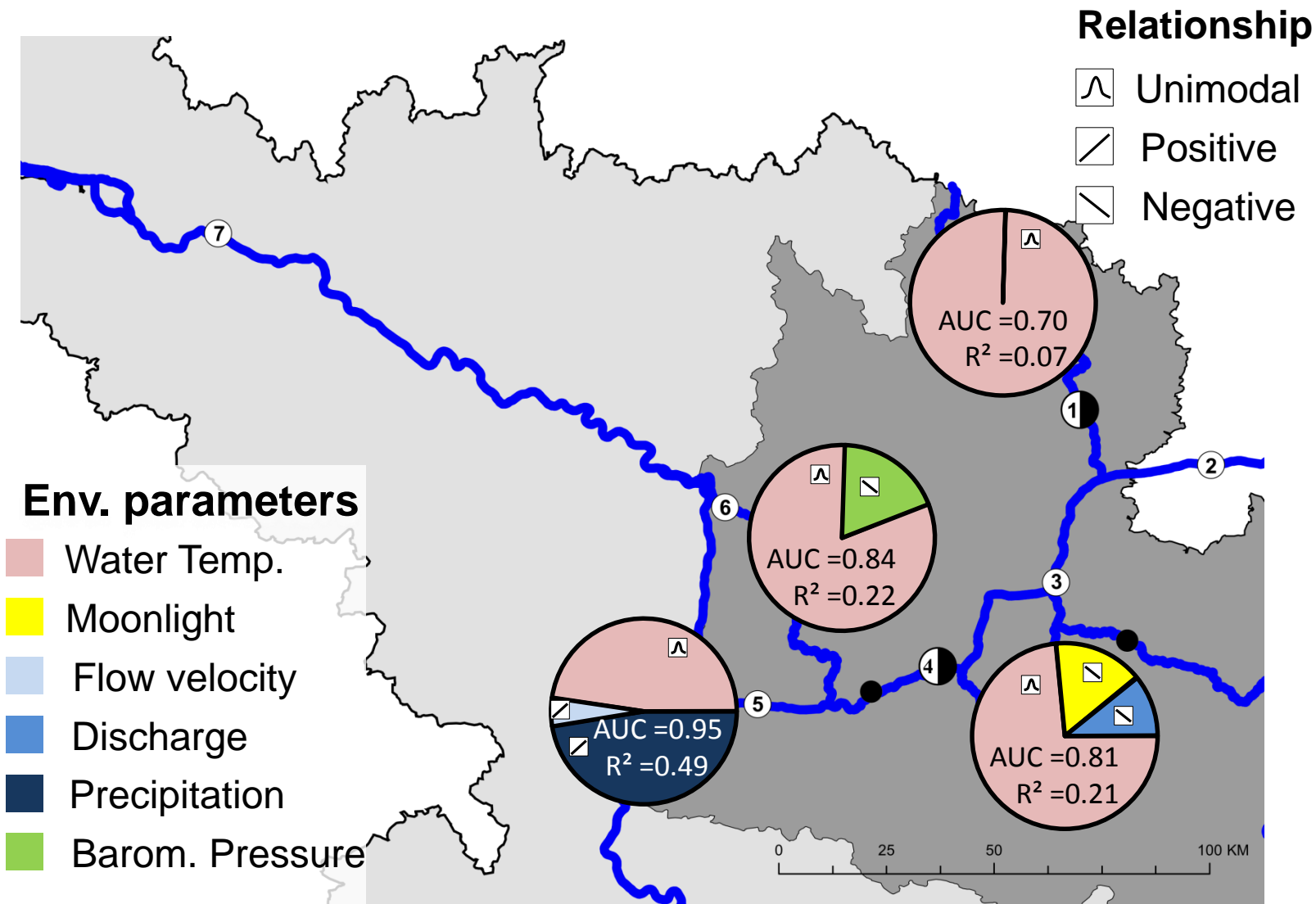


Parameters

-  Distance to Sea
-  Holding & Fish. Period
-  Distance * Holding
-  Silver index

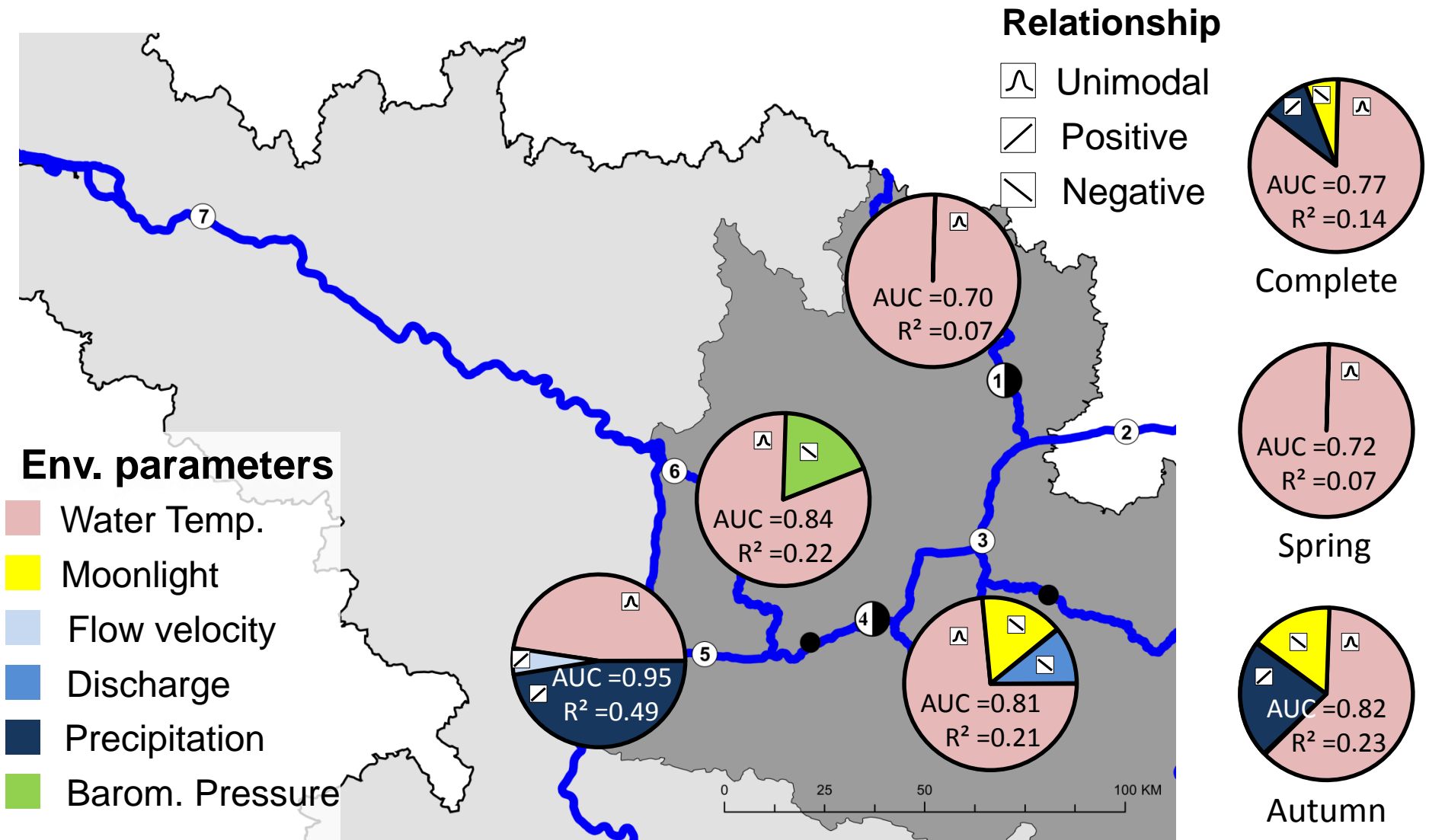


RESULTS: Factors affecting eel migration





RESULTS: Factors affecting eel migration





CONCLUSIONS

- Distinct diel and seasonal migration pattern
- Increased activity under nocturnal and new moon conditions (strategy to minimize predation risk?)
- Migration probability increases by shortened Distance from the Sea and shortened holding periods (Handling effect)



CONCLUSIONS

- Stepwise migration: low progression rates (stopovers) and migration periods exceeding one mig. season
- Spring & Upstream location > Water temperature only
- Autumn & Downstream locations > Water temperature + additional parameters
- Not-detected (17 %) + Non-migrants (55 %): Mortality & Reversal to earlier non-migratory stage



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Variable groups	Variable specification	Variable names	Number of variables
	Sunshine duation [h D ⁻¹]	Sunshine	1
	Fraction of the moon illuminated [0..1]	Moonlight	1
Hydrological and climate predictors	Flow velocity [kmD ⁻¹]	$v, v_{dif1}, v_{dif2}, v_{dif3}, v_{dif4}, v_{dif5}, v_{dif6}, v_{dif7}$	8
	Discharge [m ³ /s]	$Q, Q_{dif1}, Q_{dif2}, Q_{dif3}, Q_{dif4}, Q_{dif5}, Q_{dif6}, Q_{dif7}$	8
	Precipitation [mm/day]	$P, P_{cum1}, P_{cum2}, P_{cum3}, P_{cum4}, P_{cum5}, P_{cum6}, P_{cum7}$	8
	Barometric pressure [hPa]	$Baro, Baro_{dif1}, Baro_{dif2}, Baro_{dif3}, Baro_{dif4}, Baro_{dif5}, Baro_{dif6}, Baro_{dif7}$	8
Water temperature variables	Water temperature [°C]	$T_{water}, T_{water.dif1}, T_{water.dif2}, T_{water.dif3}, T_{water.dif4}, T_{water.dif5}, T_{water.dif6}, T_{water.dif7}$	8

We generated variables for cumulative precipitation (covering the preceding 7 days up through the present) as well as the differences between the present and the preceding 7 days for all hydrological and climate predictors. These additional variables were added to the data set as independent potential predictors.

Variable selection

- one variable of every variable group
- backward stepwise selection based on AIC (Akaike Information Criterion)

External Factors

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	4.25	1.29	3.30	9e-4 ***	
SI [III-V]	0.14	0.20	0.71	0.48	0.2
Fishing/holding [days]	-0.34	0.15	-2.24	0.03 *	17.1
Distance [km]	-0.02	0.00	-4.74	2.1e-06 ***	62.2
Fishing/holding * Distance	0.00	0.00	1.86	0.06 .	20.5
Model performance	$R^2_N = 0.21$		AUC = 0.74		

Auch diese Folien sollten lesbar sein und ansprechend formatiert

Complete

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-5.19	0.27	-19.36	< 2e-16 ***	
T _{water} [°C]	0.62	0.05	12.43	< 2e-16 ***	81.4
T _{water} ² [°C]	-0.03	0.00	-12.65	< 2e-16 ***	
P _{cum7} [mm D ⁻¹]	0.01	0.00	3.58	3e-4 ***	10.5
Moonlight [0..1]	-0.74	0.17	-4.38	1.2e-05 ***	8.1
Model performance	$R^2_N = 0.14$		AUC = 0.77		

Autumn

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-5.30	0.45	-11.80	< 2e-16 ***	
T _{water} [°C]	0.76	0.09	8.82	< 2e-16 ***	62.3
T _{water} ² [°C]	-0.04	0.00	-9.39	< 2e-16 ***	
P _{cum3} [mm S ⁻¹]	0.04	0.01	5.26	1.4e-07 ***	20.7
Moonlight [0..1]	-1.28	0.23	-5.50	3.8e-08 ***	17.0
Model performance	$R^2_N = 0.23$		AUC = 0.82		

Spring

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-5.10	0.32	-15.92	< 2e-16 ***	
T _{water} [°C]	0.44	0.06	6.88	6.0e-12 ***	
T ² _{water} [°C]	-0.02	0.00	-6.16	7.1e-10 ***	-
Model performance	$R^2_N = 0.07$	AUC = 0.72			

Upper Havel

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-3.92	0.28	-14.02	< 2e-16 ***	
T _{water} [°C]	0.36	0.07	5.38	7.6e-08 ***	
T _{water} ² [°C]	-0.02	0.00	-5.95	2.7e-09 ***	-
Model performance	$R^2_N = 0.07$ AUC = 0.70				

Mid Havel

Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-4.03	0.77	-5.20	2.0e-07 ***	
T _{water} [°C]	0.74	0.11	6.78	1.2e-11 ***	
T _{water} ² [°C]	-0.03	0.00	-7.34	2.1e-13 ***	73.1
D [m ³ S ⁻¹]	-0.02	0.00	-3.50	4e-4 ***	11.9
Moonlight [0..1]	-1.34	0.34	-3.98	6.9e-05 ***	14.5
Model performance	$R^2_N = 0.21$ AUC = 0.81				

Lower Havel					
Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-7.53	0.95	-7.96	1.8e-15 ***	80.3
T _{water} [°C]	0.99	0.17	5.80	6.5e-09 ***	
T ² _{water} [°C]	-0.04	0.01	-5.85	5.0e-09 ***	
Baro _{dif7} [hPa]	-0.04	0.01	-3.71	2e-04 ***	19.7
Model performance	$R^2_N = 0.22$ AUC = 0.84				

Elbe River					
Model Coefficients	Estimate	Std. Error	z value	Pr(> z)	Independent effect [%]
(Intercept)	-27.99	3.53	-7.93	2.2e-15 ***	48.3
T _{water} [°C]	3.50	0.50	7.07	1.6e-12 ***	
T ² _{water} [°C]	-0.14	0.02	-7.09	1.4e-12 ***	
P _{cum7} [mm D ⁻¹]	0.08	0.01	7.99	1.3e-15 ***	47.1
v [km D ⁻¹]	0.05	0.01	4.31	1.6e-05 ***	4.6
Model performance	$R^2_N = 0.49$ AUC = 0.95				