Jun 23rd, 2:00 PM - 2:15 PM

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

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

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AIMS

Obtain knowledge about:

- preferable environmental conditions and resulting migration patterns

➢ Management of endangered species

➢ achieve the EU targets (EC No 1100/2007)

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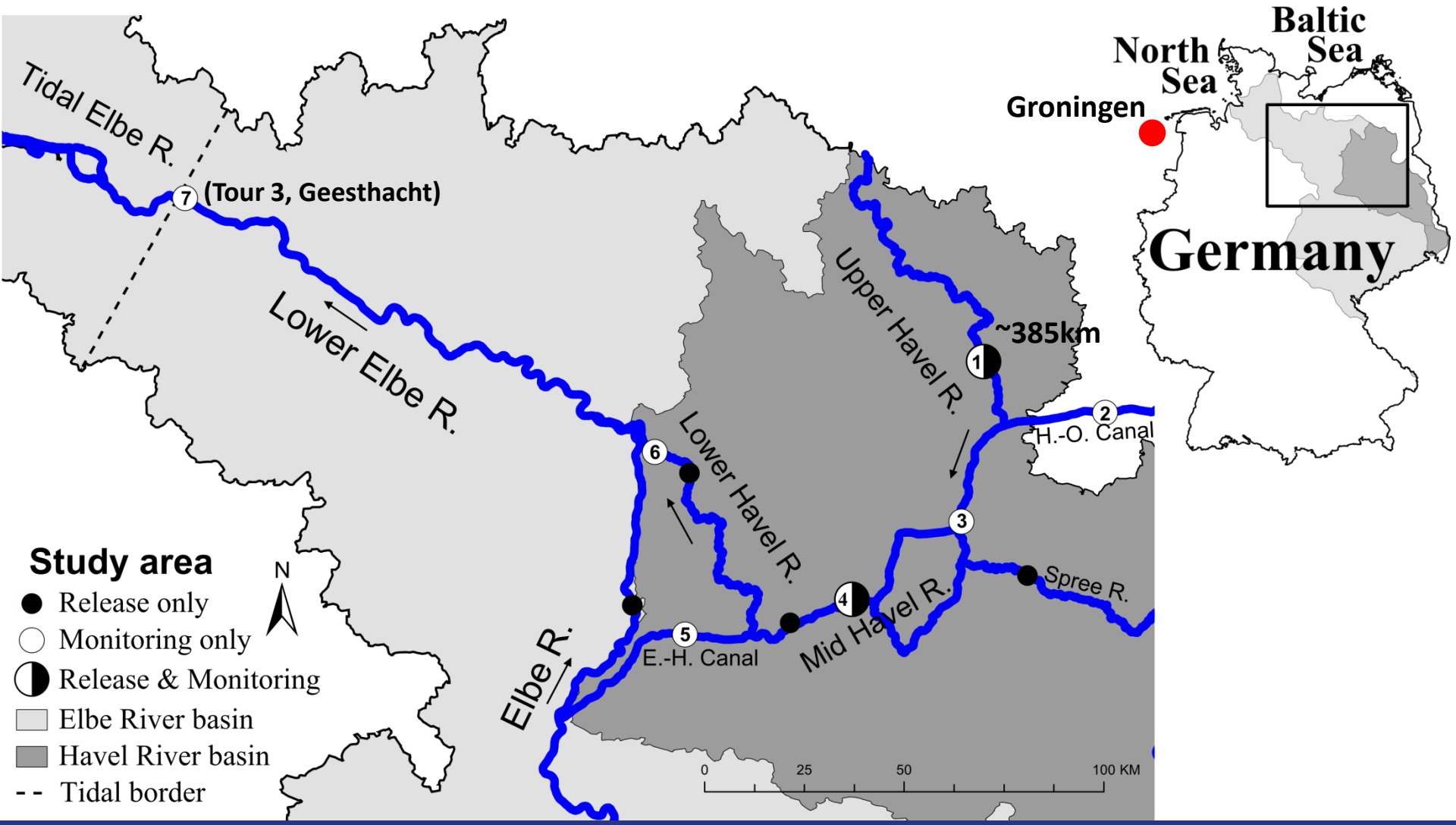
METHODS: Study area & Telemetry system



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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

Proxy

Movement Activity

used as

Model Response

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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

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METHODS: Analyses and Modelling

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

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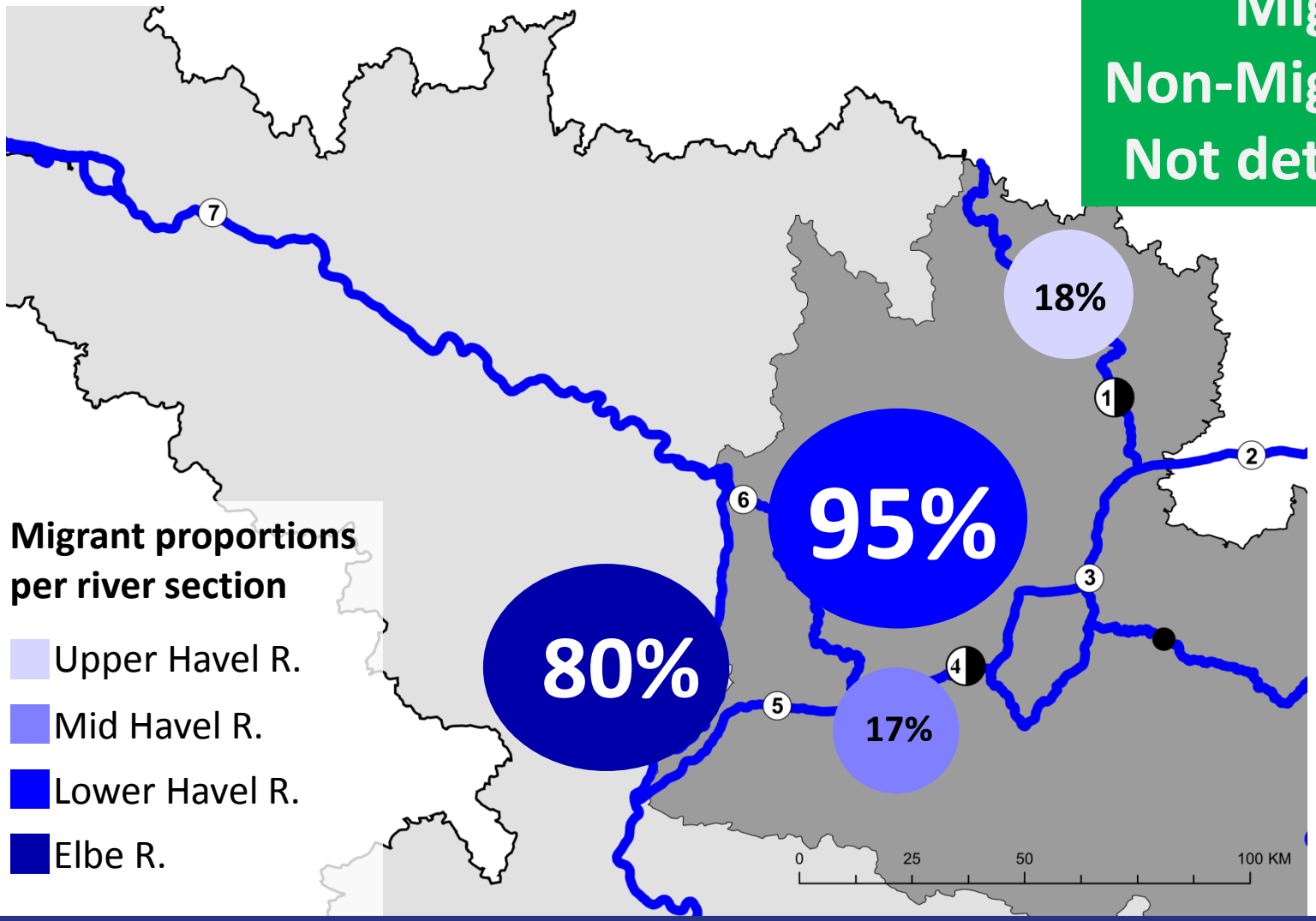
RESULTS: Migrant proportions

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

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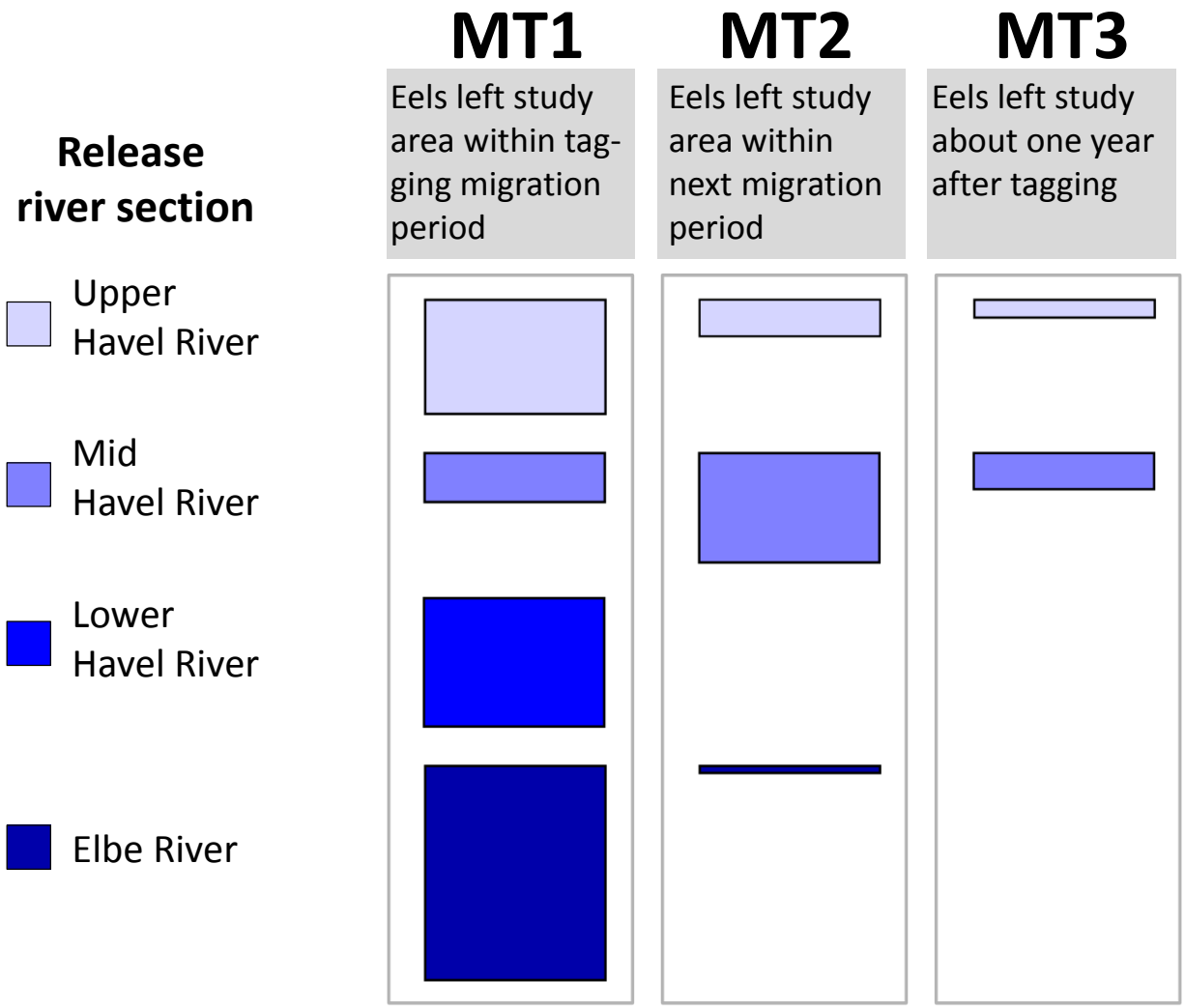
RESULTS: Migration types



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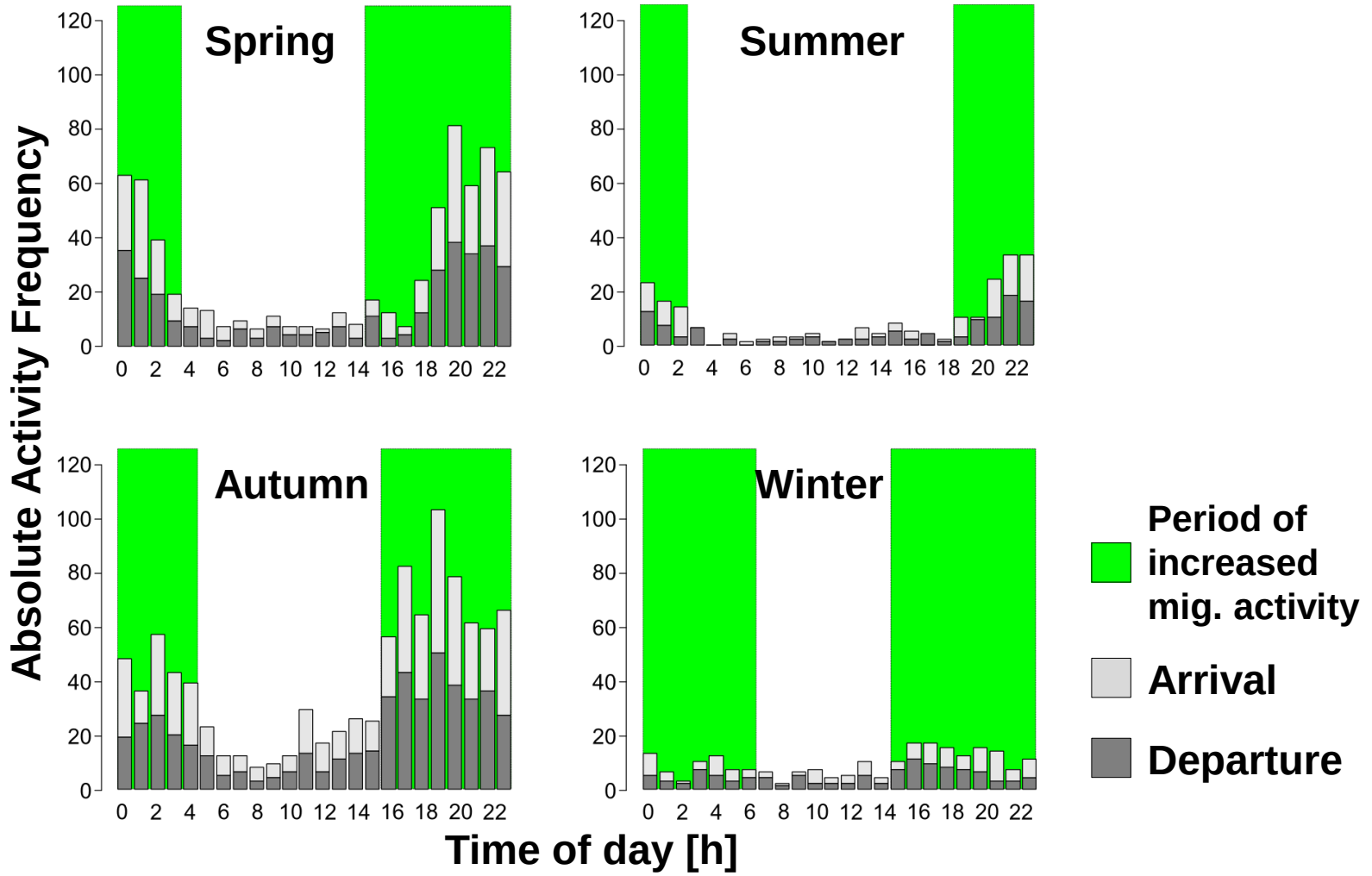
RESULTS: Diel periodicity of mig. activity



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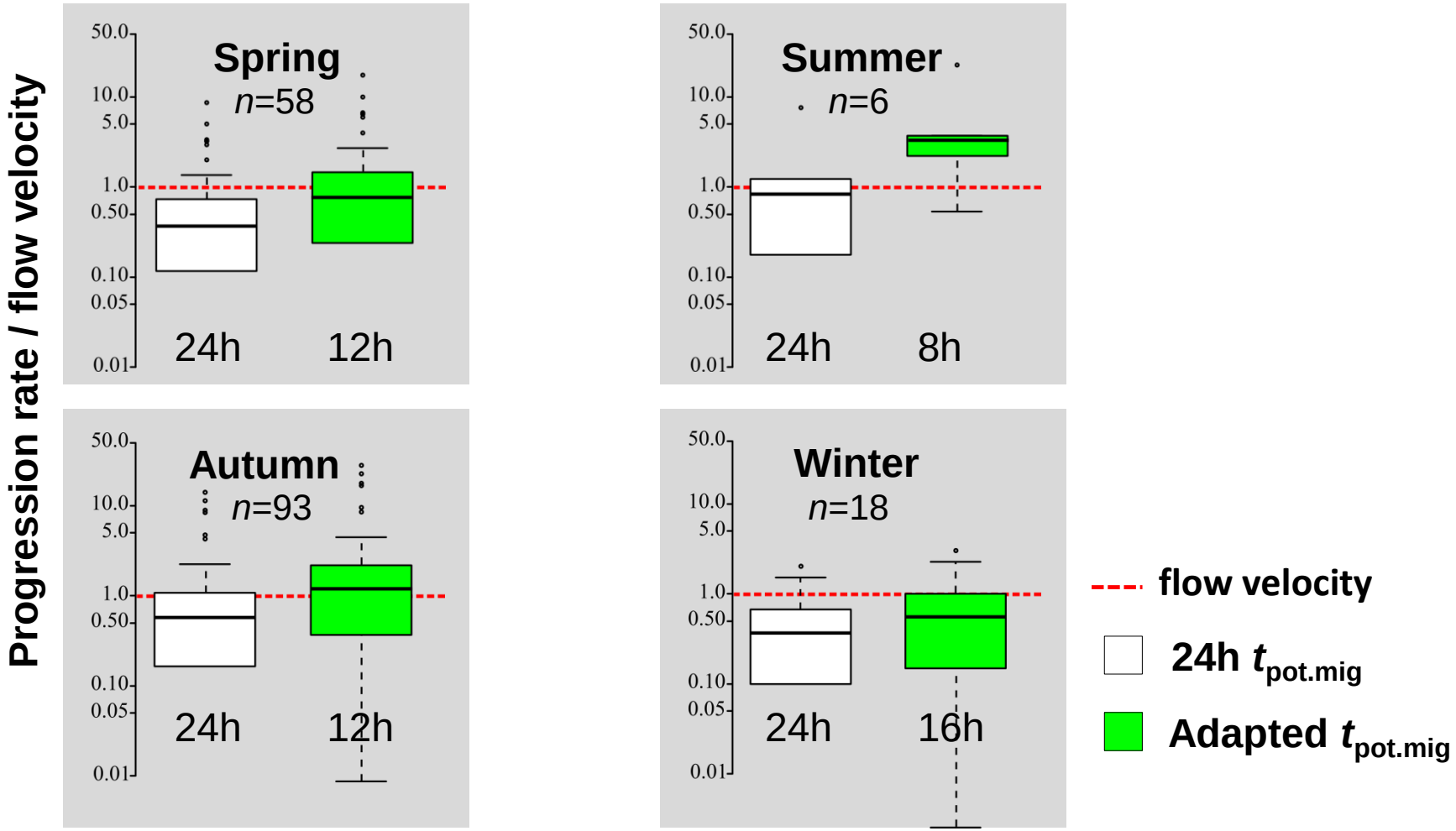
RESULTS: Progression rates



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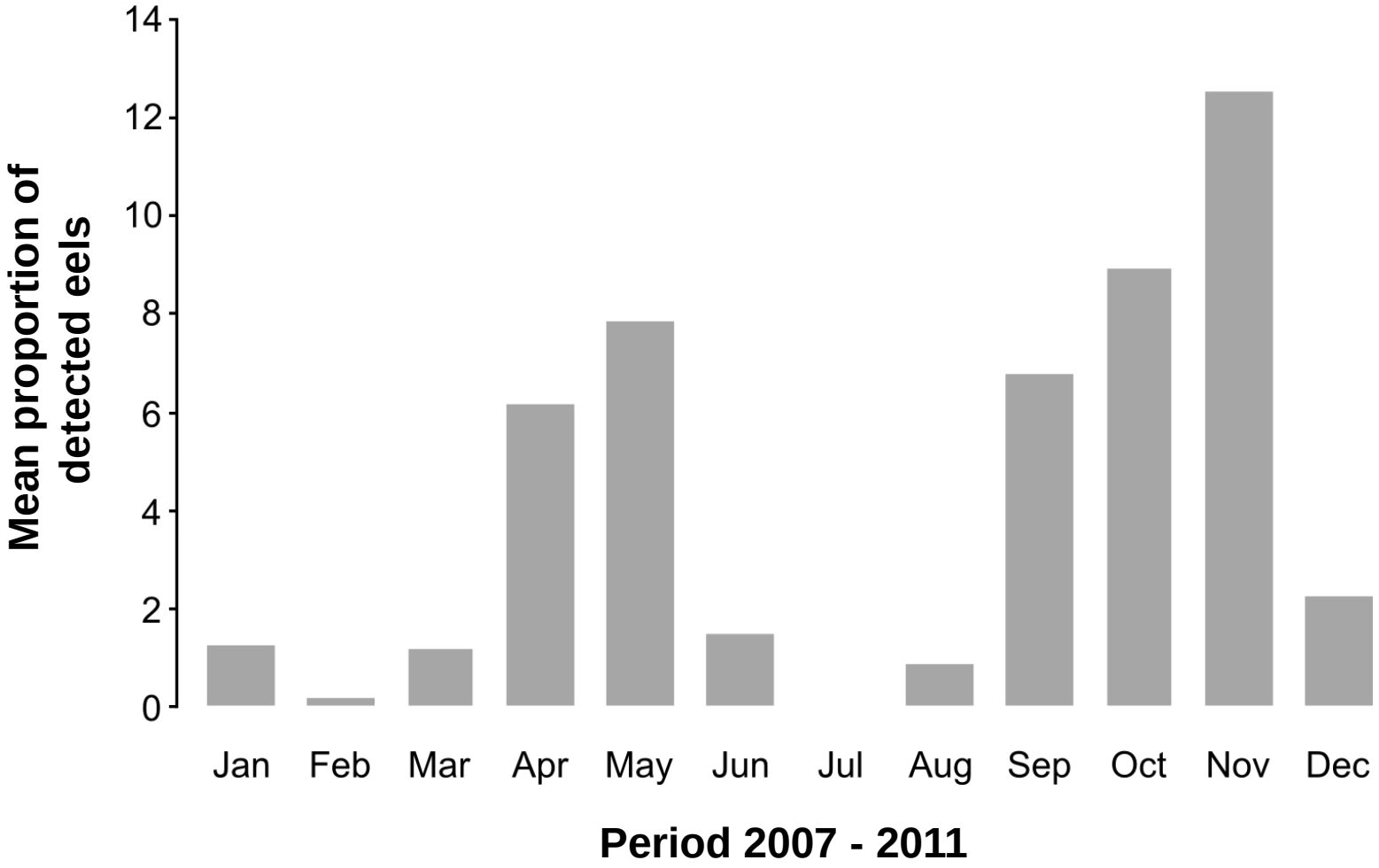
RESULTS: Seasonal migration



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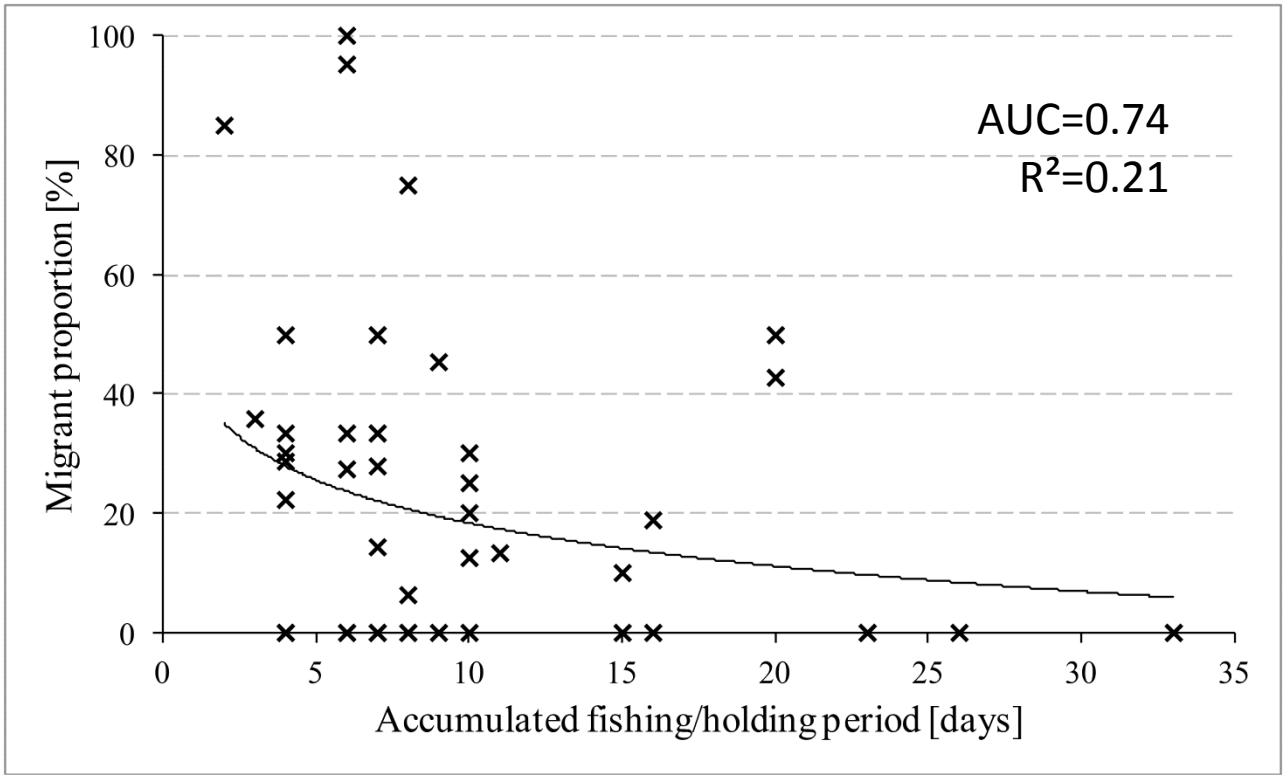
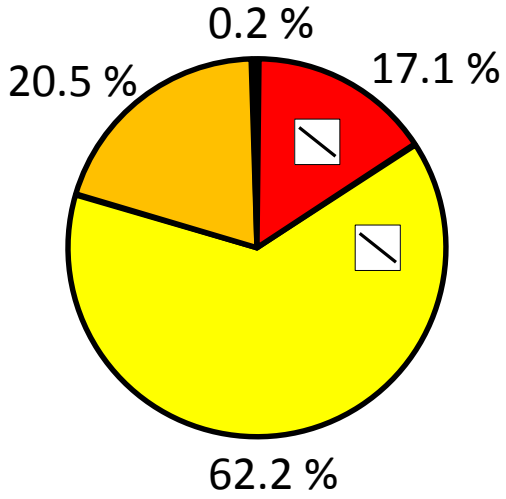
RESULTS: Effects on migration probability

Relationship

- Unimodal
- Positive
- Negative





Parameters

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

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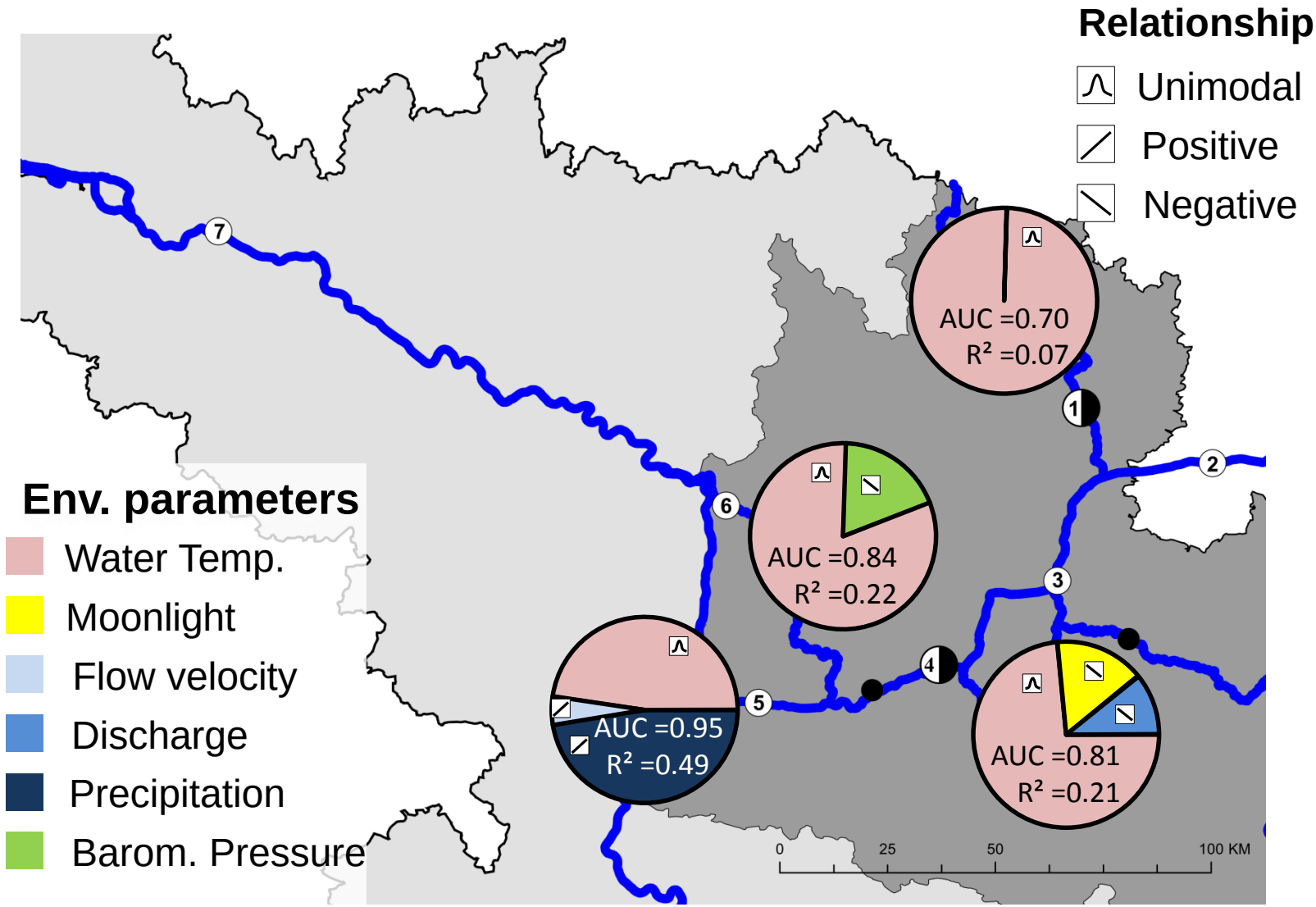
RESULTS: Factors affecting eel migration



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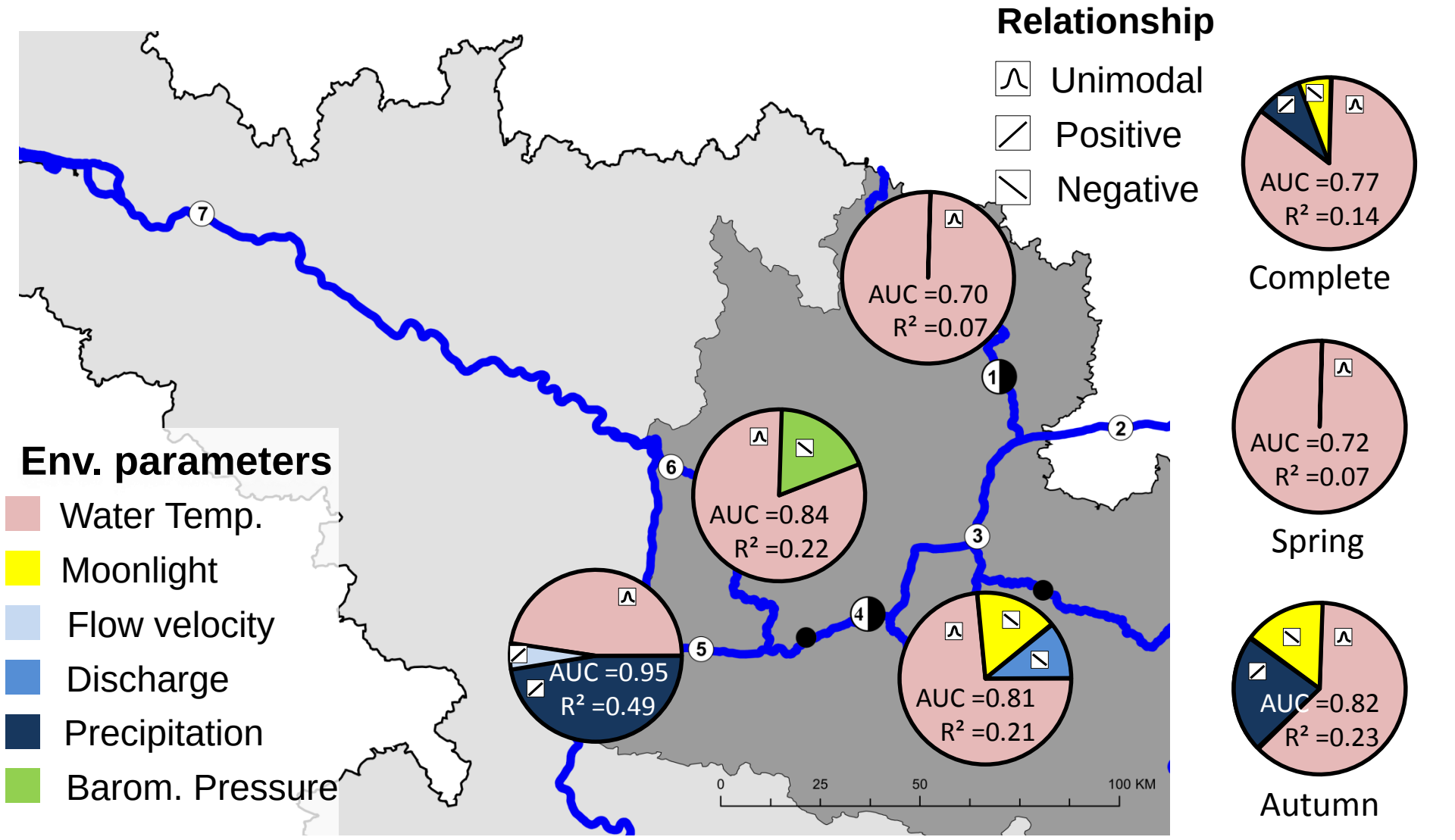
RESULTS: Factors affecting eel migration



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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)

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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^2_{water} [°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^2_{water} [°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^2_{water} [°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 ***	**73.1**
T^2_{water} [°C]	-0.03	0.00	-7.34	2.1e-13 ***	
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 ***	
T_{water} [°C]	0.99	0.17	5.80	6.5e-09 ***	**80.3**
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 ***	
T_{water} [°C]	3.50	0.50	7.07	1.6e-12 ***	**48.3**
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**				