Life Maifisch Grande Alose Elft

Colloque international sur l'étude, la restauration et la gestion de l'alose
International symposium on restoration and conservation of shads

Migration estuarienne de la grande alose (*Alosa alosa)* et impact potentiel du bouchon vaseux.

Suivi par télémétrie acoustique en estuaire de Loire en 2011 et 2012.

Estuarine migration of Allis shad (*Alosa alosa)* and potential impact of the Estuarine Turbidity Maximum.

Acoustic telemetry study in the Loire Estuary in 2011 and 2012.

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Introduction

• **Disruption of connectivity** ➔ a major cause of freshwater biodiversity loss, especially for fish (Pringle et al. 2000, Lucas and Baras 2001)

Physical obstacles (dams, weirs…)

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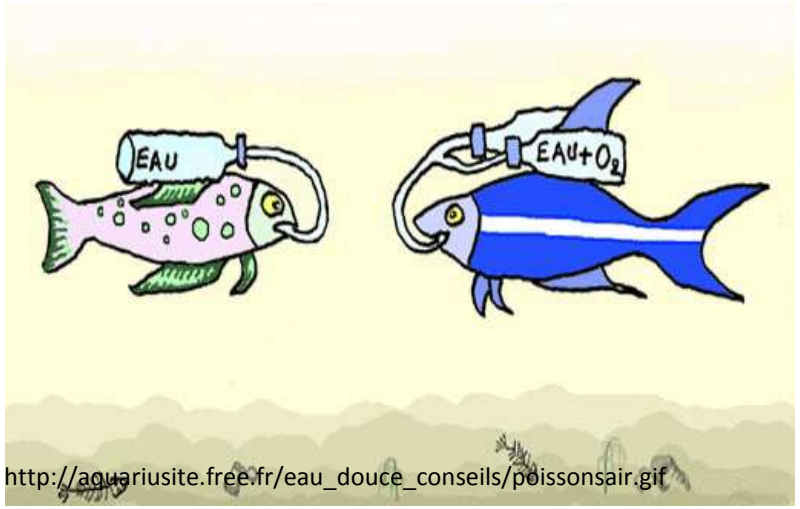


http://aquariusite.free.fr/eau_douce_conseils/poissonsair.gif

Physico-chemical conditions → Less studied (difficult to assess)


http://whenonearth.net/meeting-two-rivers-rhone-arve-geneva-switzerland/

- Dissolved oxygen, suspended matter or temperature, can also limit or even impede fish movements (Buysse and others 2008; Lucas and Baras 2001; Maes and others 2008)

• **Estuarine Turbidity Maximum (ETM)** ➔ natural phenomenon in macrotidal estuaries:

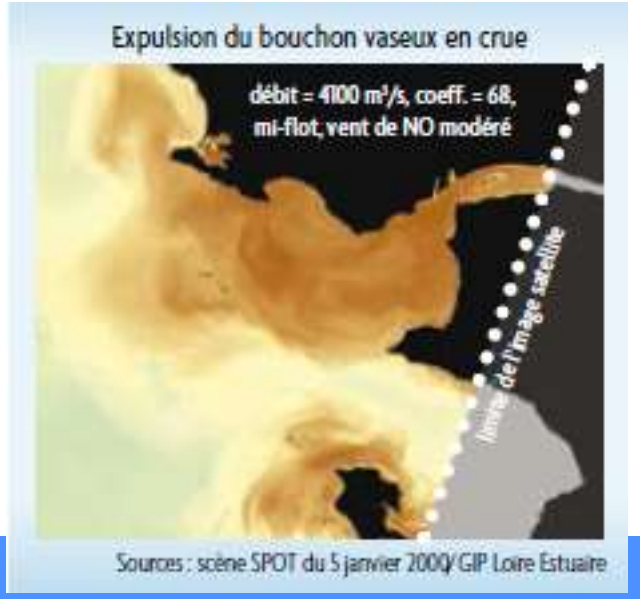
  • Conjunction of tide and river flow ➔ resuspension of fine particles (from both sources + organic matter (OM) coming from the watershed

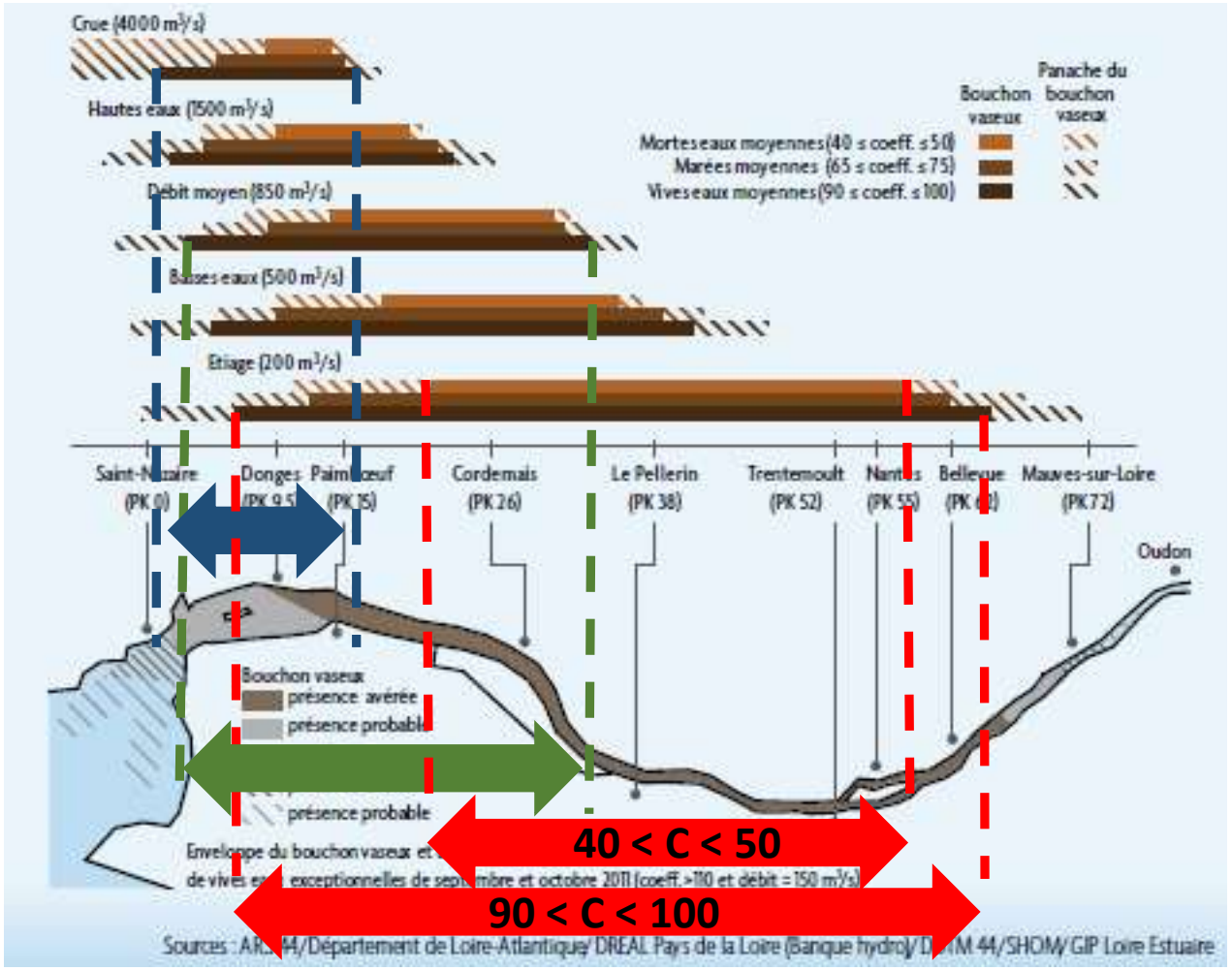
  • Salinity ➔ death of aquatic organisms ➔ OM increases and flocculates

  • High turbidity ➔ Reduces photosynthesis / OM available ➔ high bacterial activity ➔ oxygen consumption

  • Can lead to hypoxic and even anoxic conditions, especially under high temperatures and low river flow (Abril and others 1999, Talke and others 2009).

• Its geographical extent is controlled by the river flow and the magnitude of the tide (extreme situation: spring tide + very low flow ➔ sept/Oct 2011 ➔ 55 km (from Donges KP 9.5 to ~ Bellevue KP 62)





Most frequent location of ETM in the Loire Estuary in 2007-2013 function of discharge and tide coefficient in St Nazaire (GIP Loire estuaire)

- **Estuarine Turbidity Maximum (ETM)**
➔ coincidence with amphibiotic species migration periods

- An important part of the migration period of shads can be impacted

- Dissolved oxygen can inhibit migration

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Allis shad (adult)			←	—	—	→						
Allis shad (juvenile)						←	—	—	→			
Alosa fallax (adult)			←	—	—	→						
Atlantic salmon (adult)		←	—	—	—	→				←	—	→
Atlantic salmon (smolts)				←	—	→						
European eel (adult)	←	→							←	—	—	→
European eel (glass eel)	←	—	—	—	→							
Sea lamprey (adult)	←	—	—	—	→							
HYPOXIA OR ANOXIA POSSIBLE					←	—	—	—	—	→		

Concentration en O_2	Impact sur les poissons
plus de 5 mg/l	Absence d'effets à long terme. Passage de l'ensemble des espèces migratrices
de 4 à 5 mg/l	Salmonidés : migration incertaine, croissance alterée
de 3 à 4 mg/l	
de 2 à 3 mg/l	Survie des juvéniles incertaine. Croissance et fécondité altérées. Arrêt ou retard du développement embryonnaire. Migration impossible pour beaucoup d'amphihalins. Mortalité des salmonidés
de 1 à 2 mg/l	Mortalité pour la plupart des espèces
moins de 1 mg/l	Milieu azoïque

Seuil sensible hypoxie

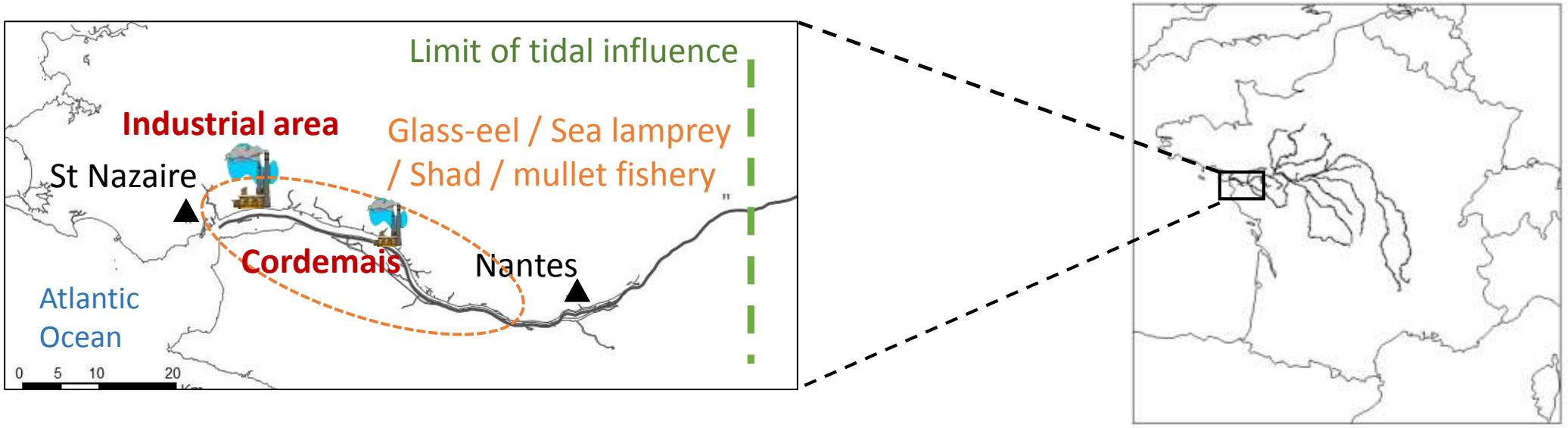
Seuil critique

Seuil létal

From GIP Loire Estuaire: l'oxygène de l'eau

- **How does Allis shad migrate throughout the Loire Estuary ?**
- **Impact of ETM ?**

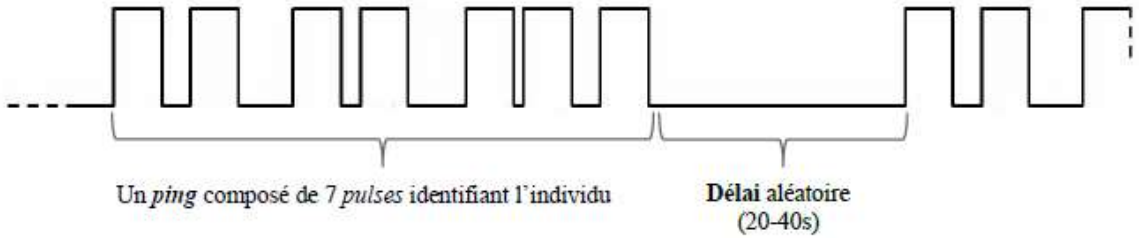
Materials and methods: Study area



- The Loire River catchment is the largest in France (1012 km long / drainage area - 117 000 km²)
- The Loire Estuary is about 80 km long. Width varies from 4000 (river mouth) to 200 m (limit of tidal influence). On average, discharge at the catchment mouth is about 850 $m^3.s^{-1}$.
- The estuary has a relatively important industrial activity (St Nazaire, Donges, Cordemais)
- Allis shad, Sea lamprey and mullet fishery with trammel nets in Spring / glass-eel fishery in Winter

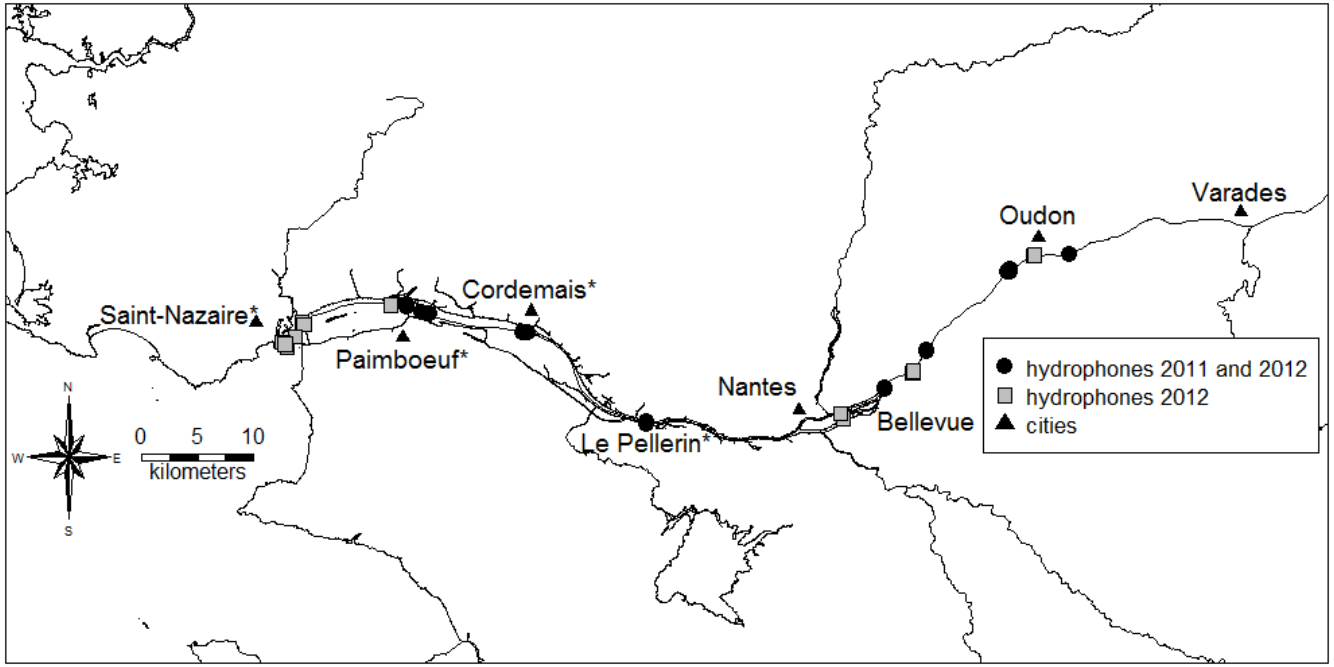
Materials and methods: acoustic telemetry

- Coded acoustic signal ➔ simultaneous listening of multiple tags on the same frequency (Thorstad et al., 2000)
- No antenna ➔ relatively small tags/ easier to tag fish (Priede, 1991)
- Hydroacoustic telemetry particularly well suited for salt or brackish waters (Priede, 1991)



(http://www.thelmabiotel.com/index.php?parent=453&groupid=463)

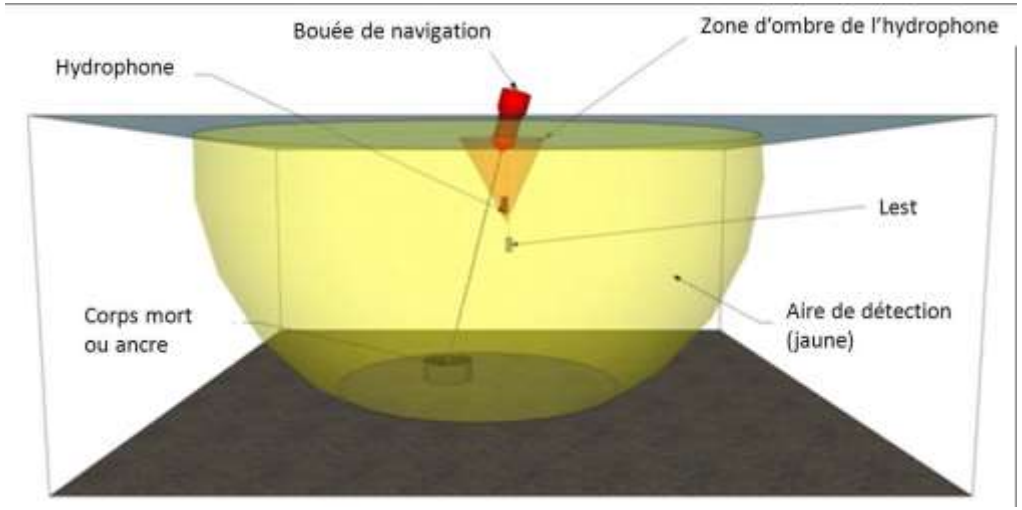
Materials and methods: telemetry array



Telemetry array in the Loire Estuary (from Tétard et al. In press)

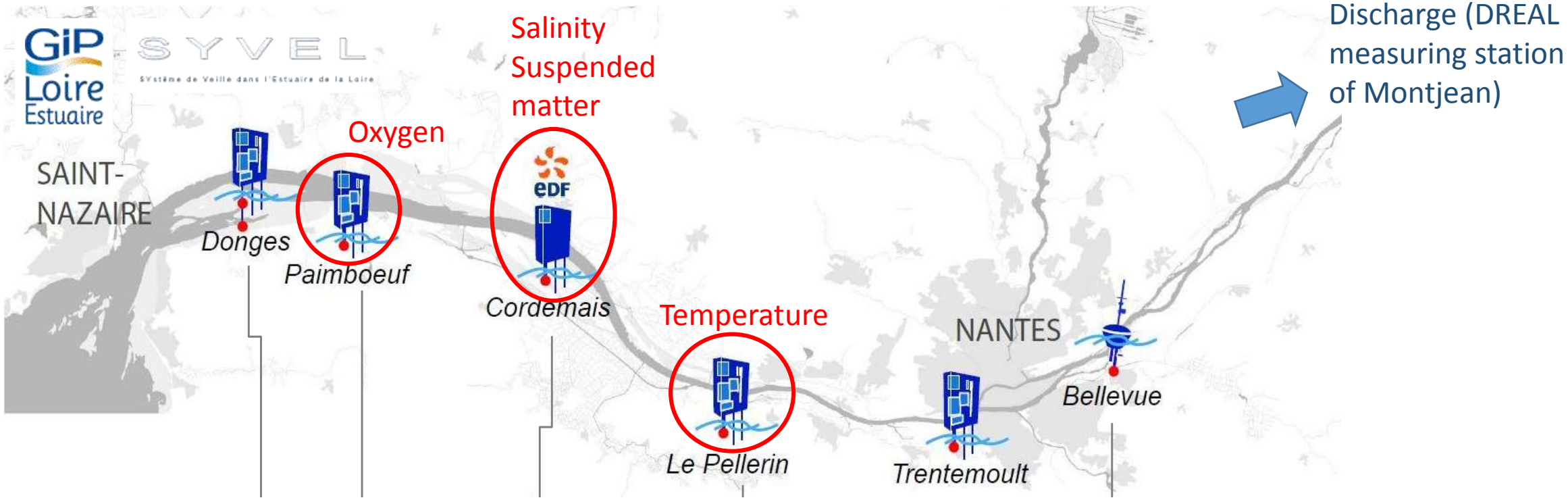
- 34 hydrophones deployed within 110 km from the upper part of the Estuary (Oudon) to the river mouth (St Nazaire) (17 in 2011 + 17 in 2012)

- Acoustic lines with 2 to 6 units



(from Acou A., Lasne E., Réveillac E., Robinet T. & Feunteun E. (2013)

Materials and methods: environmental data



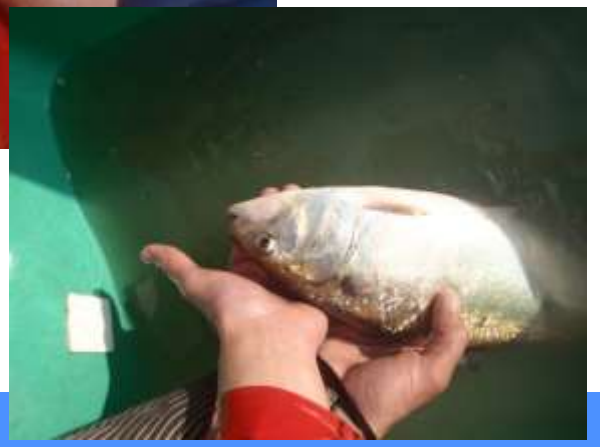
Location of measuring stations from the SYVEL network + EDF (GIP Loire Estuaire)

Materials and methods: fish catching and tagging

- Capture using a trammel net (Mesh = 60 mm) with professional fishermen between Paimboeuf and Cordemais

- Shads stored on board in a 500 l tank + air diffuser in hot conditions

- Intra-stomachal tagging (No anesthesia) of 51 shads in 2011 and 27 in 2012



- External spaghetti tag (commercial species)

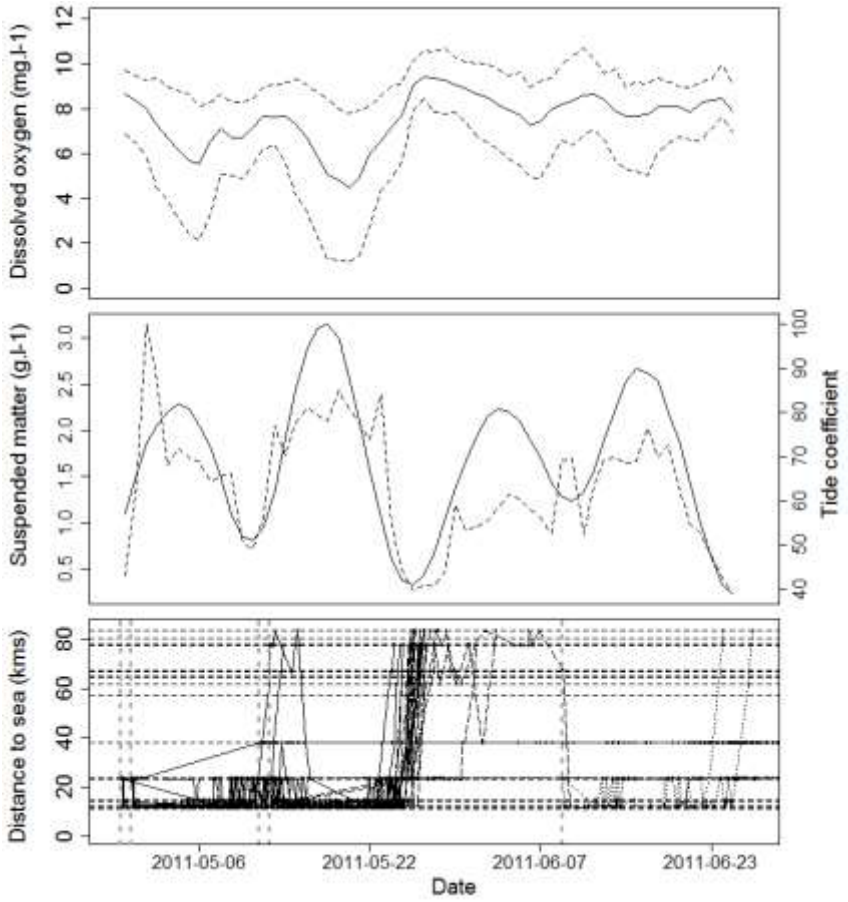
Materials and methods: Data analysis

1. First approach ➔ Comparing migration profiles and classifying them in a typology based on pattern similarity

2. Second approach ➔ Trans-estuarine migration triggering / preliminary analysis suggested that migratory activity could be related to tide / suspended matter and oxygen

- Signal of migration linked to signal of environmental variables ? Maximum Entropy Spectral Analysis (Burg 1967; 1968)

- Which proxy of the migration ?



From top to bottom: dissolved oxygen, suspended matter and tide coefficient, Shad movements (from Tétard et al. In press)

Materials and methods: Trans-estuarine migration triggering

Erratic detection data (kilometric point associated with a date)

Regulation (R function 'regul')

Individual daily distance travelled

Overall migration proxy

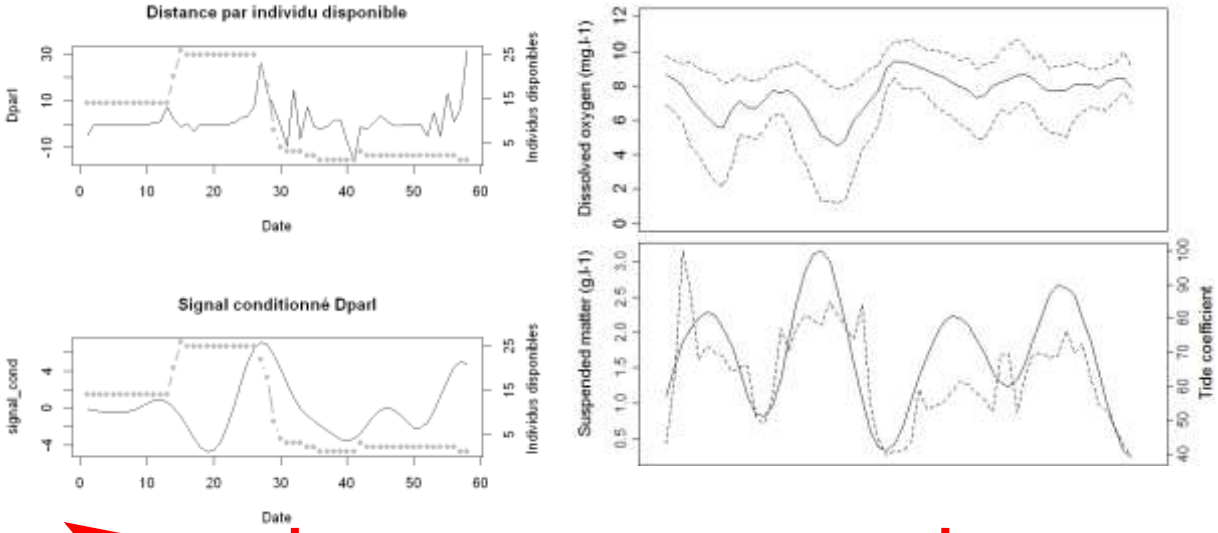
Total daily distance travelled

Weighting ➔ taking account availability for a fish to migrate

Total daily distance per 'available shad'

Pass band Butterworth filter

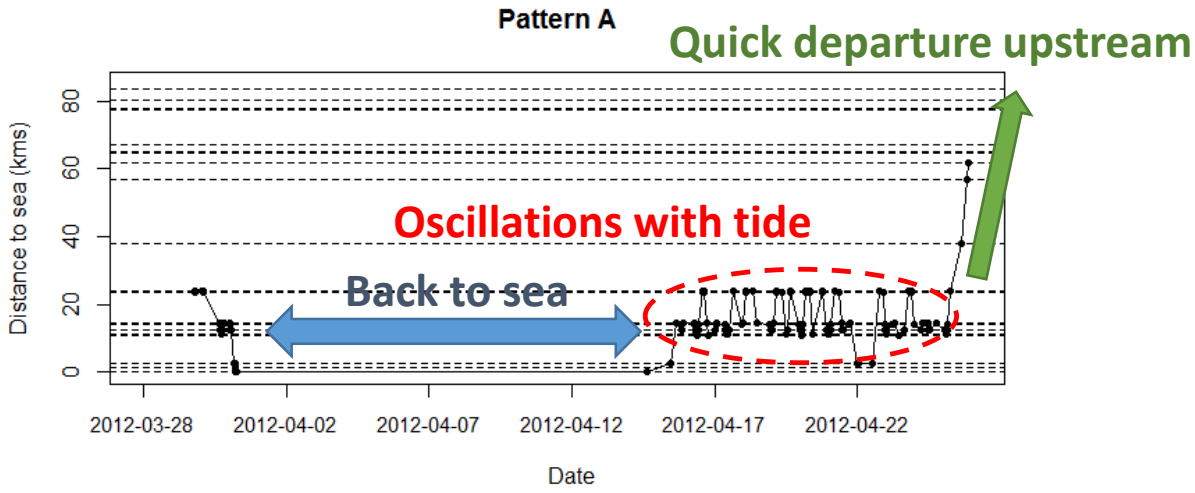
Stationnary signal

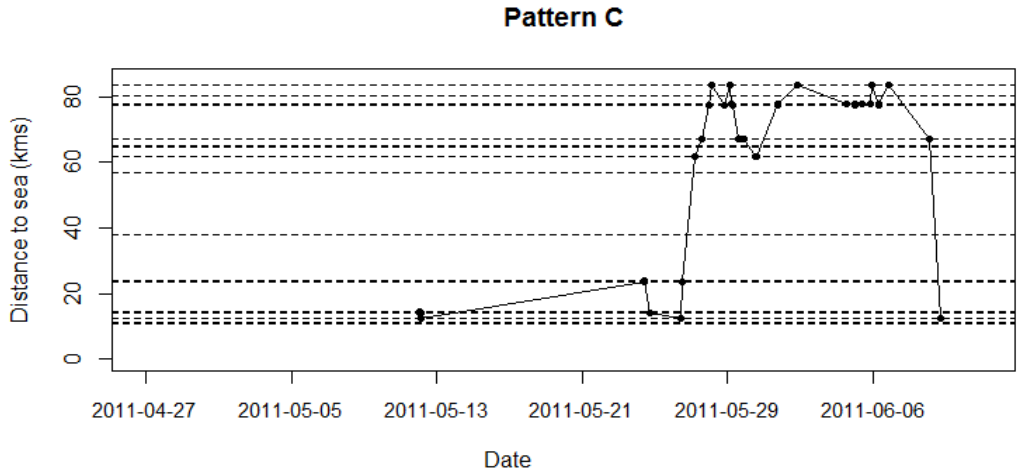


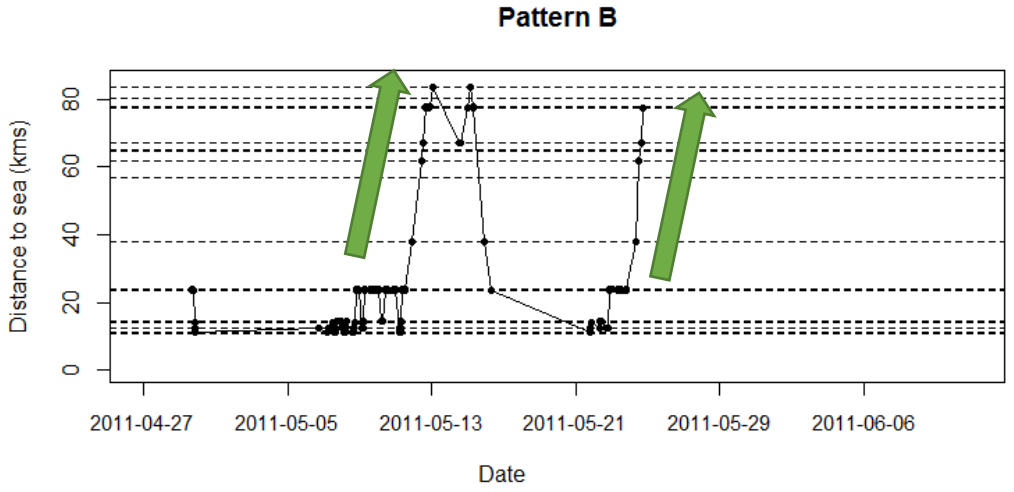
MESA (shad migration proxy) + MESA (02,SM,T°C,Q, tide, salinity)

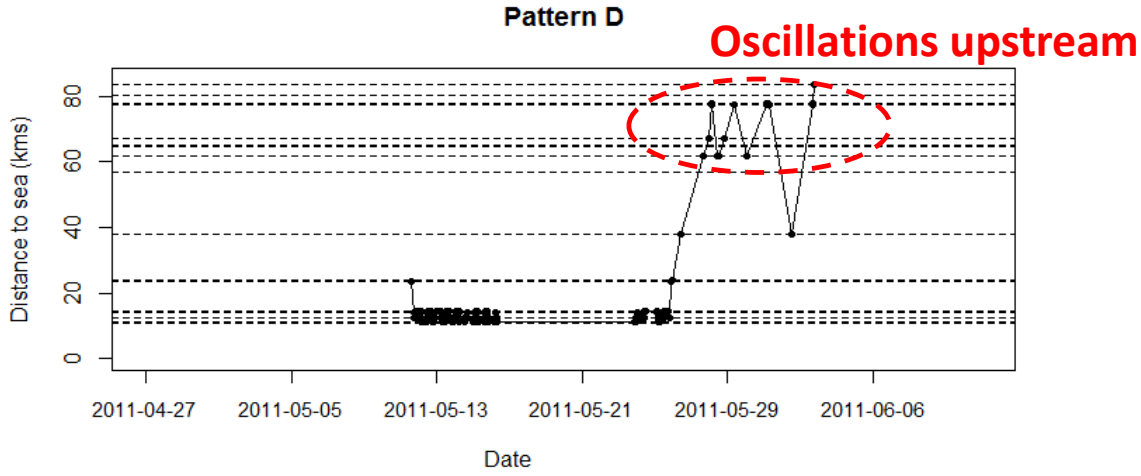
Common periodicities ?

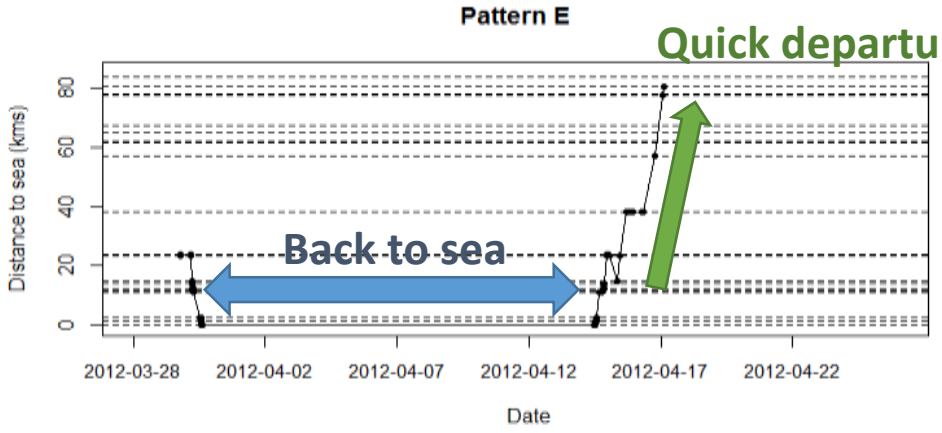
Results: Migration patterns





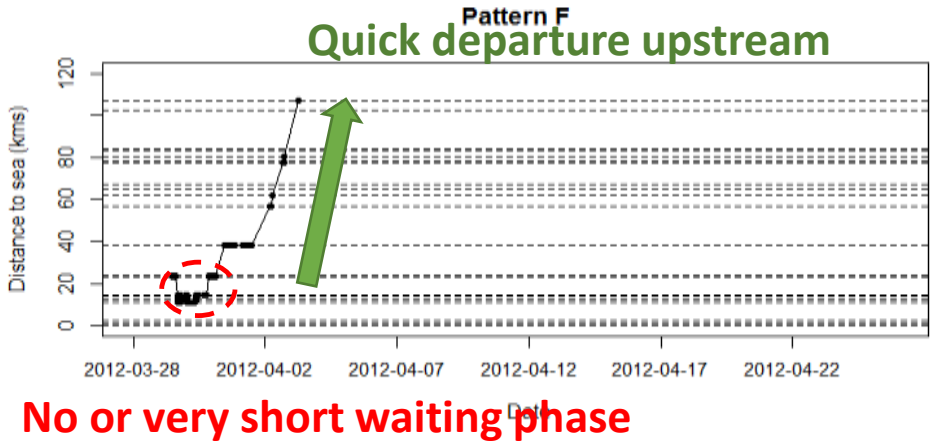






Quick departure upstream

Back to sea



Quick departure upstream

No or very short waiting phase

Number and frequency of occurrence of the different patterns observed (from Tétard et al.in press)

	2011		2012		Total
Pattern	*Number*	*Frequency*	*Number*	*Frequency*	*Frequency*
A	21	47.73 %	2	11.11 %	37.10 %
B	1	2.27 %	1	5.55 %	3.23 %
C	1	2.27 %	0	0 %	1.61 %
D	1	2.27 %	0	0 %	1.61 %
E	5	11.36 %	2	11.11 %	11.29 %
F	0	0 %	1	5.55 %	1.61 %
G	0	0 %	3	16.67 %	4.84 %
H	1	2.27 %	0	0 %	1.61 %
I	14	31.82 %	9	50 %	37.10 %

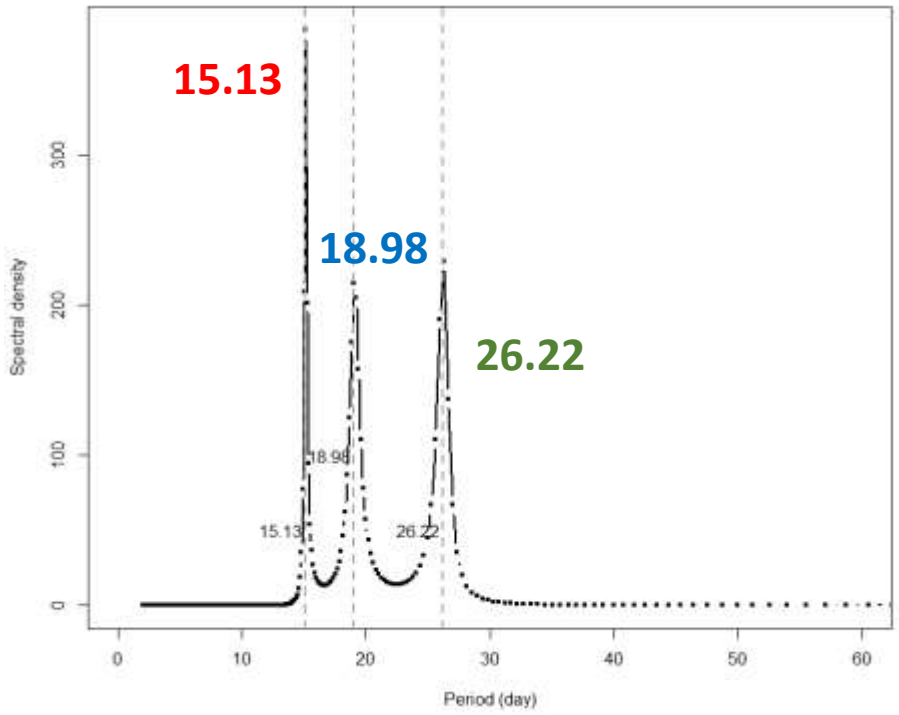
Non migrants patterns (detected only near release + downstream : G, dysfunctioning: H, only near release site: I

Results: Residence time downstream / Migration speeds

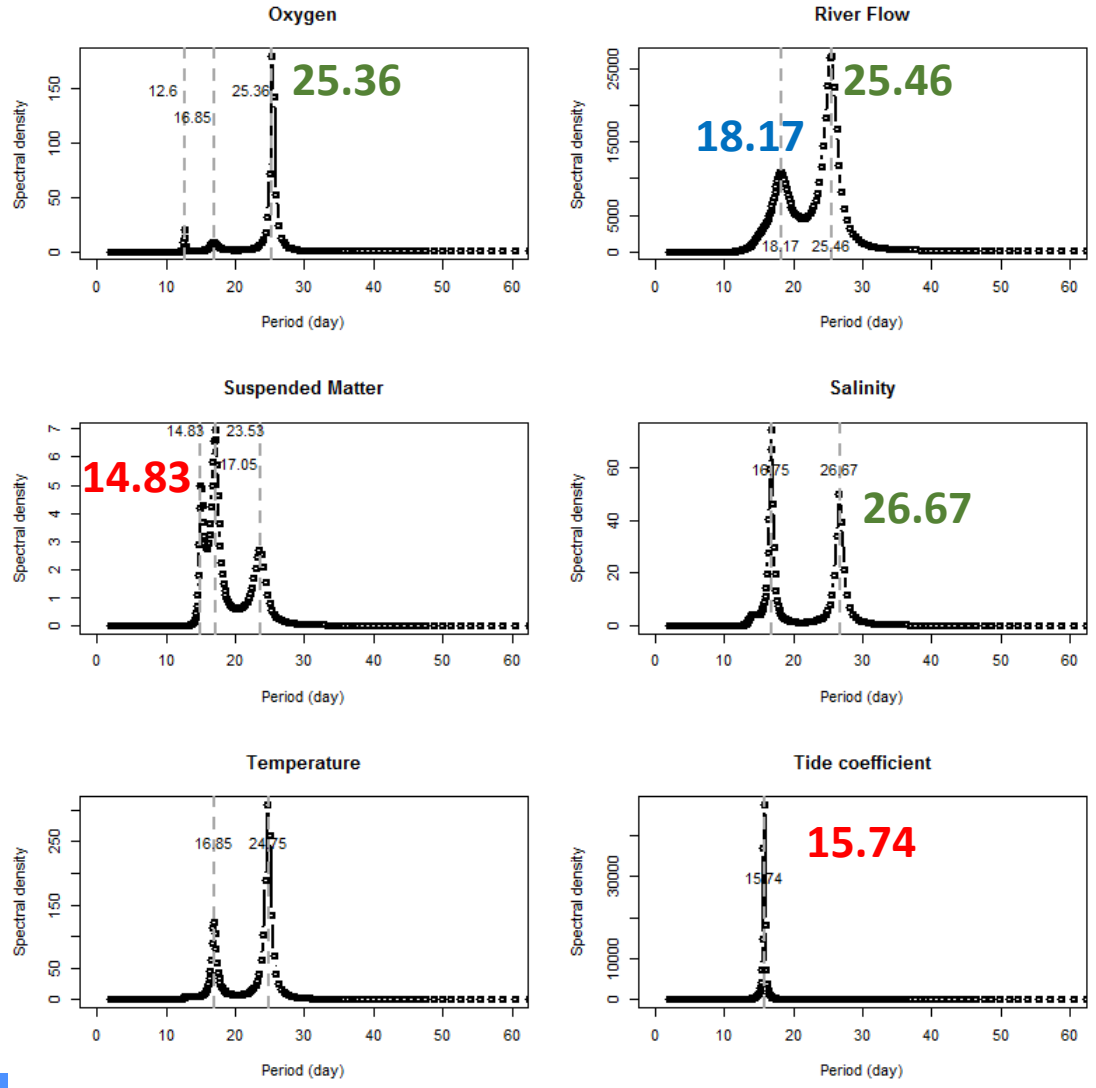
- Mean residence time in the downstream part (before quick departure): 18.5 days (±7.28 d, range 1.8-27.1 d)
- No influence of length and bodyweight (ANOVA, $p>0.05$)

- Mean migration speeds (from Cordemais to Oudon): 51.6 km.d^{-1} (±17.38 km. d^{-1}, range 21.13-91.43 km. d^{-1})
- No relationship with length (ANOVA, $p>0.05$). Bodyweight did influence the migration speed. Heavier shads migrated faster (ANOVA, $p<0.05$)

Results: spectral density and rhythms (2011)



Spectral density for the distance travelled in 2011. The three main rhythms are highlighted in grey (15.13, 18.98 and 26.22 days) (from Tétard et al. in press)



Results: Trans-estuarine migration triggering

- Rhythms found are close to lunar (29.53) and semi lunar (14.7) revolution period
- Trans-estuarine migration occured at neap tides when oxygen was high, salinity lower than during spring tides and suspended matter low
- Migration positively linked to the discharge
- Results in 2012 (only 6 shads) roughly similar to 2011

Conclusion / Discussion

- Waiting phase: probably both an adaptation phase and a waiting phase for a favourable window (physico chemical conditions probably buffered downstream and at sea).

- Migration during neap tides ➔ tidal magnitude is the main driver of environmental conditions ➔ shift in a set of covariates to trigger it

- In 2011 (warm year) ➔ river flow had a positive impact on migration. Likely that freshwater inputs reduce ETM (Brenon and Le Hir 1999)

Conclusion / Discussion

- Global warming + urbanization: ETM will probably increase (Lanoux and others 2013)

- Maybe earlier too in spring ➔ impact on shad population ? (also on Atlantic salmon and Sea Lamprey…)

- Management actions mainly devoted to freshwater habitats (dam removal, fishpasses, habitat restoration) ➔ all of these actions could be counterbalanced by estuarine connectivity loss.

THANK YOU FOR YOUR ATTENTION !

MERCI !