Dispersal capacities of Allis Shad (*Alosa alosa*) under global change: insights of innovative otolith microchemistry analysis

Jean Martin**, Françoise Daverat**
Quentin Rougemont, Hilaire Drouineau, Sophie Launey, Philippe Jatteau, Gilles Bareille, Sylvain Berail, Christophe Pécheyran, Eric Feunteun, Séverine Roques, David Clavé, David Jose Nachón , Carlos Antunes, Micaela Mota

14 et 15 octobre 2015 Colloque Alose Restitution Life Plus

Objectives

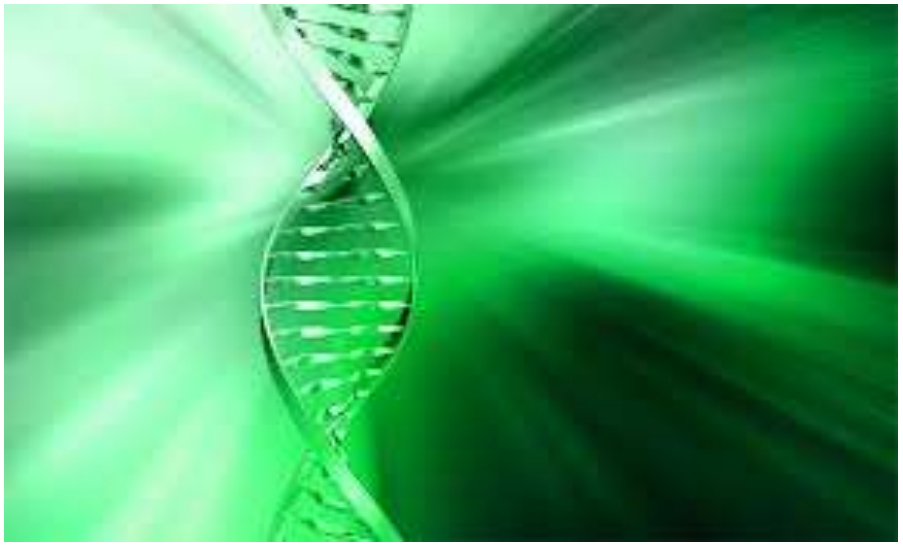
The recovery of collapsed fish stock depends on:

1) the resilience of local population
2) on the possible contribution of fish that disperse from other populations

Thus, understanding this straying behavioral diversity at the individual scale may be necessary to ensure anadromous fishes resilience in the face of anthropogenic threats and changing environments

This work will evaluate the dispersal capacity of Allis shad throughout its current range

Materials et Methods

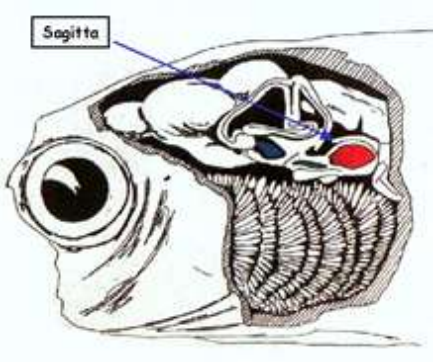


Combination of multiple tools

Genetic markers

Population structure

Otolith fingerprints



Natal origin

Patterns of connectivity among populations at different scales:

Large spatial scale

Long-term connectivity patterns on evolutionary time scales

Fine spatial scale

Dispersal patterns within the time scale of an individual lifetime

By using both techniques on the same individuals, we may obtain information about the **dispersal pattern of a given fish together with its natal origin and heredity**

Sampling

Water

Rivers	(*n*)
Adour E.	—
Adour R.	3
Aulne	3
Blavet	3
Dordogne	3
Garonne	4
Lima	3
Loire	5
Minho	6
Mondego	3
Nivelle	4
Saison	3
Scorff	3
Vilaine	3
Vire	3
Charente	3
Oloron	5
Nive	4

60

Adults

Rivers	2009	2010	2011	2012	2013	Total
Adour E.			2		29	31
Adour R.					6	6
Aulne					12	12
Blavet					7	7
Dordogne				5	66	71
Garonne				27	37	64
Lima					4	4
Loire			4		24	28
Minho	24	21	25		17	87
Mondego					15	15
Nivelle	16					16
Saison					6	6
Scorff					10	10
Vilaine		3	10		6	19
Vire			7		27	34

410

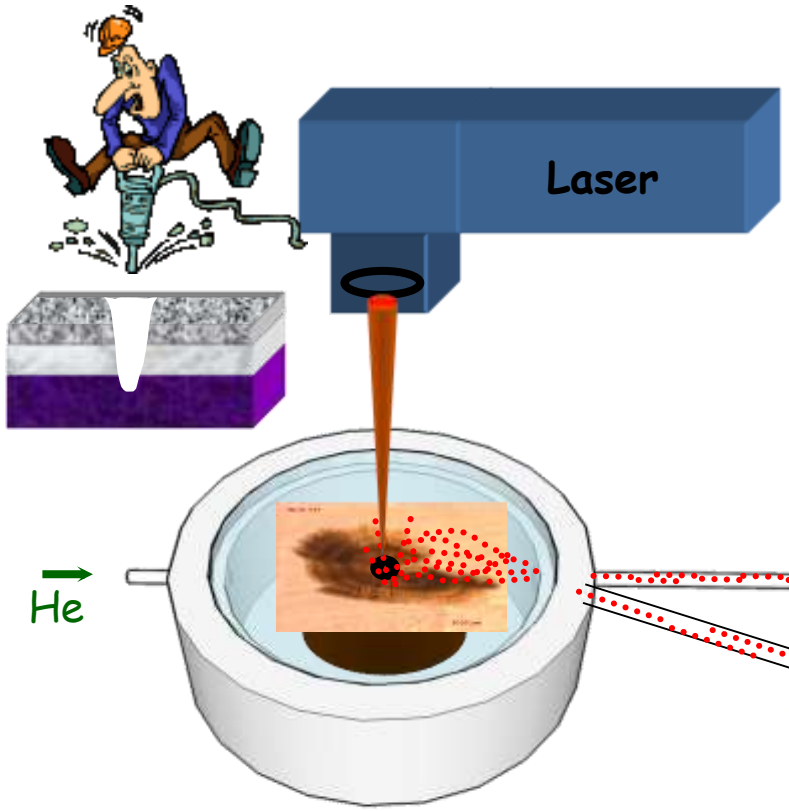
Juveniles

Rivers	2009	2011	2012	2013	Total
Adour E.					
Adour R.					
Aulne					
Blavet				16	16
Dordogne				3	3
Garonne					
Lima					
Loire				4	4
Minho	10	4	6		20
Mondego					
Nivelle					
Saison					
Scorff					
Vilaine				1	1
Vire					

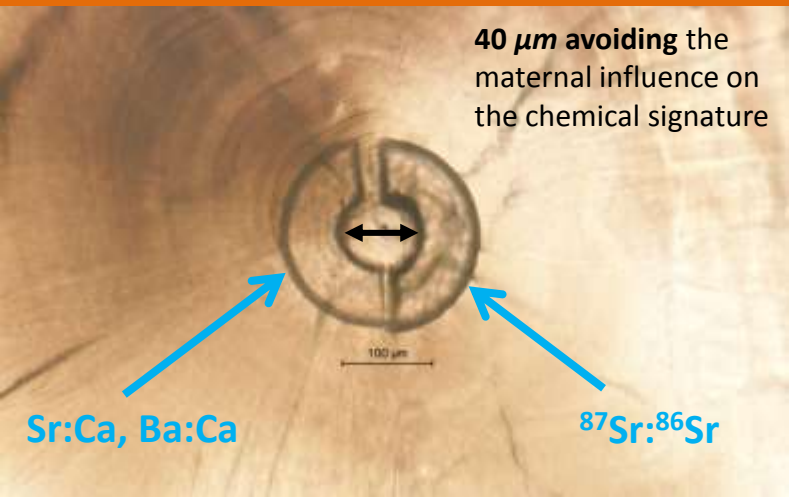
44

At each river, water samples were collected from late May to September 2013, close to historic spawning area of Allis shad.

Otolith analysis



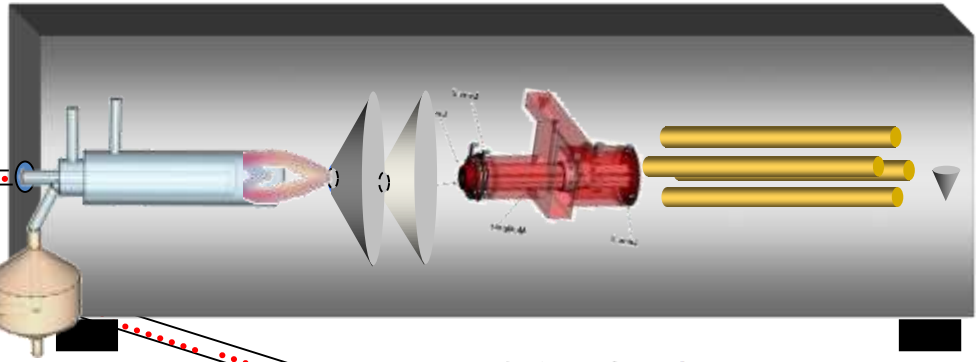
A C-shaped ablation trajectory centered on the primordium

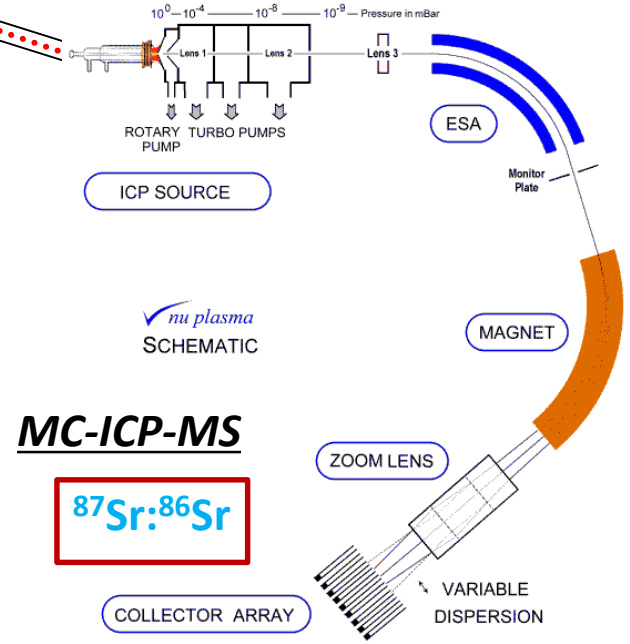


40 *µm* avoiding the maternal influence on the chemical signature

ICP-MS

Sr:Ca, Ba:Ca





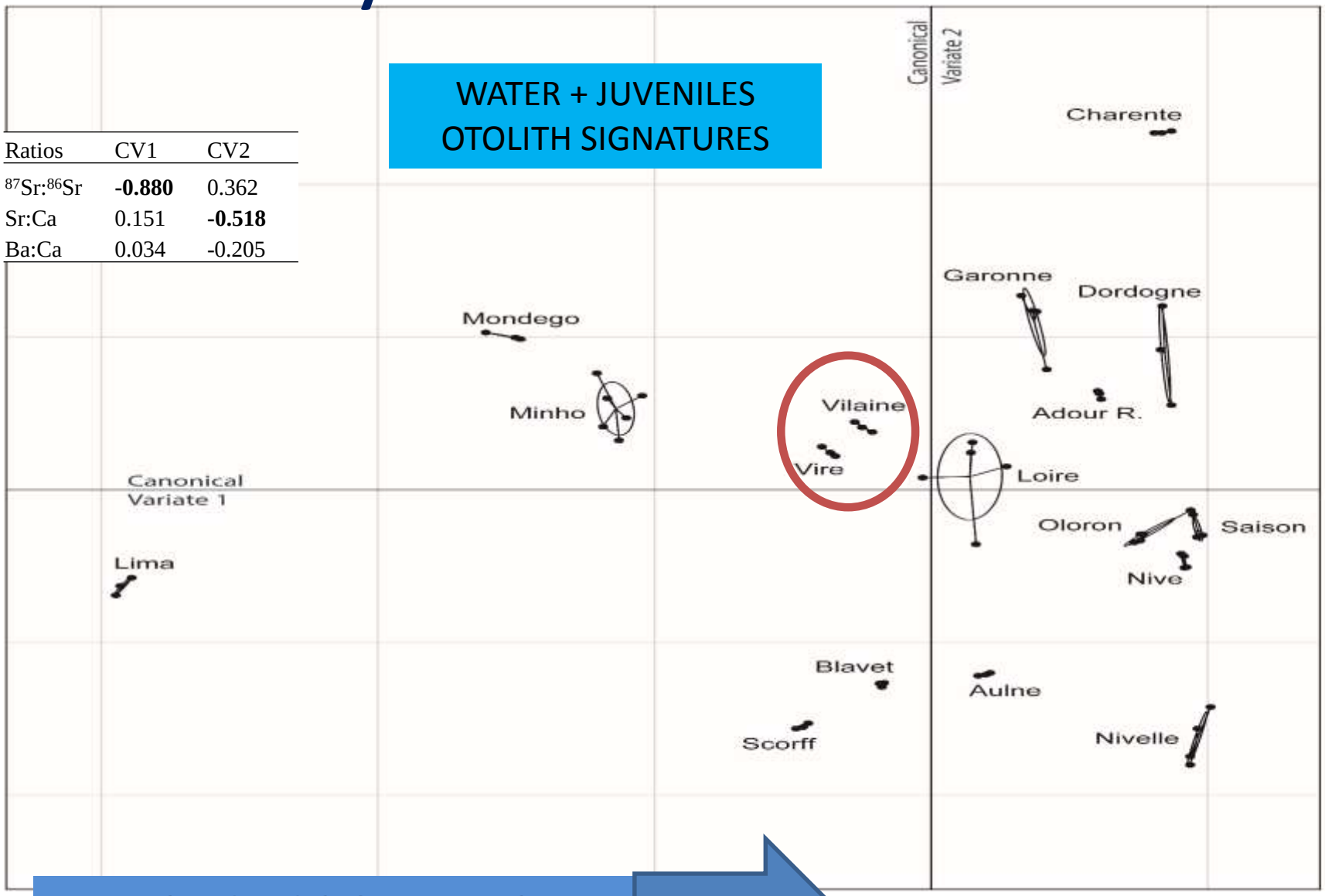
MC-ICP-MS

$^{87}Sr:^{86}Sr$

Bayesian hierarchical mixture model

Ratios	CV1	CV2
$^{87}Sr:^{86}Sr$	**-0.880**	0.362
Sr:Ca	0.151	**-0.518**
Ba:Ca	0.034	-0.205

WATER + JUVENILES
OTOLITH SIGNATURES



RIVER SPECIFIC SIGNATURES

Natal origin of ADULTS, *assignment probabilities were higher than 0.80 for 85% of fish*

Adult Allis shad allocations to natal rivers

Posterior conditional assignment probabilities were higher than 0.80 for 85% of fish

	Natal river																	
Collection site	Vire	Aulne	Scorff	Blavet	Vilaine	Loire	Charente	Dordogne	Garonne	Adour R.	Oloron	Saison	Nive	Nivelle	Minho	Lima	Mondego	Undetermined
Vire (34)				3	31													
Aulne (12)		**11 (92%)**																1
Scorff (10)				**9 (90%)**														1
Blavet (7)				**7 (100%)**														
Vilaine (19)			1	2	**16 (84%)**													
Loire (28)					3	**24 (86%)**												1
Dordogne (71)								**61 (86%)**										10
Garonne (64)								**46 (72%)**		11				3				4
Adour R. (6)		1								**5 (83%)**								
Adour E. (31)		1								**13 (42%)**	**17 (55%)**							
Saison (6)										**3 (50%)**				3				
Nivelle (16)														**16 (100%)**				
Minho (87)					1										**86 (99%)**			
Lima (4)															2	**2 (50%)**		
Mondego (15)	2								1					1	11			

17 adults (4%) were classified as “undetermined” indicating that those individuals represent heterogeneous signatures not well represented in the training data

% of Allocation to natal origin (Otolith signature, model)

Collection site	Aulne	Blavet	Vilaine	Loire	Dordogne	Nivelle	Minho
Aulne	92%						
Blavet		100%					
Vilaine			84%				
Loire				86%			
Dordogne					86%		
Nivelle						100%	
Minho							99%

HOMING at TRIBUTARY SCALE

% of Allocation to natal origin (Otolith signature, model)

Collection site	Garonne	Dordogne	Adour river	Oloron	Blavet
Garonne		**72%**			
Dordogne		**86%**			
Adour estuary			**42%**	**55%**	
Saison			**50%**		
Blavet					**100%**
Scorff					**90%**

HOMING at RIVER BASIN SCALE

% of Allocation to natal origin (Otolith signature, model)

Collection site	Aulne	Vilaine	Loire	Adour	Nivelle	Minho
Loire		**18%**				
Garonne				**25%**	**11%**	
Adour river basin	**3%**				**8%**	
Minho		**1%**				
Mondego					**7%**	**73%**

STRAYING occured first from close river basins but also occured from distant river basins (at least 47 out of 410 shads sampled)

% of Allocation to natal origin (Otolith signature, model)

Collection site	Garonne	Dordogne	Adour	Nivelle	Un-determined
Dordogne 2012 & 2013		**61**			**10**
Garonne 2012 & 2013		**46**	**11**	**3**	**4**

Specific case of Garonne and Dordogne

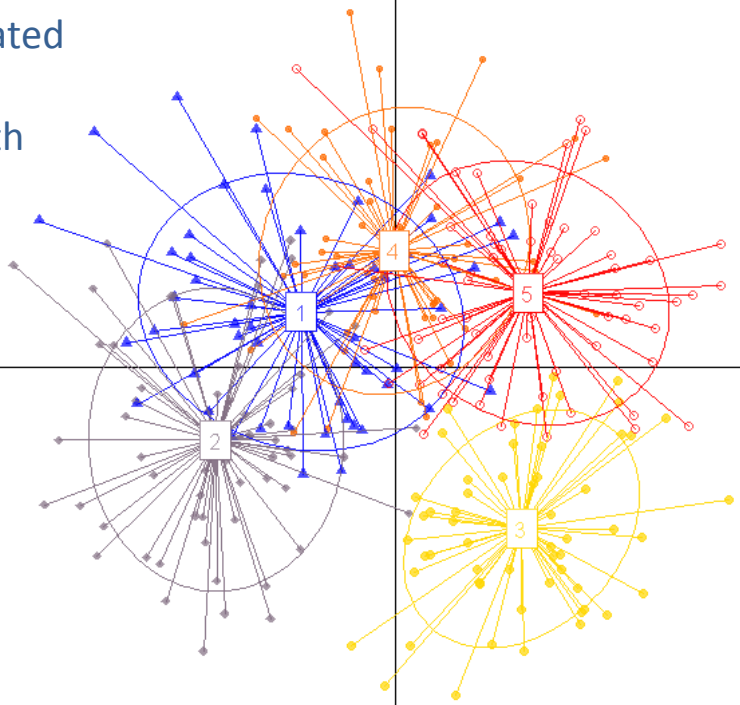
Absence of Garonne natal origin in adults born in 2007 and 2008

2007 & 2008 low abundance years of adults

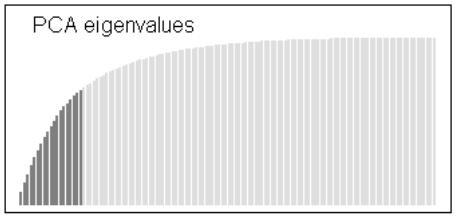
Genetic structure

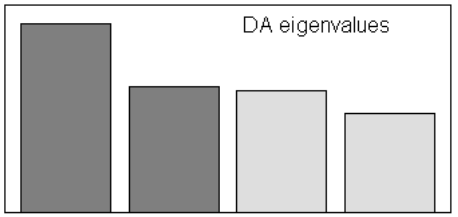
The D.A.P.C. analysis indicated the existence of 5 genetically distinct groups that were moderately differentiated

These groups were widely admixed, not well differentiated and showed no clear relation with geographical origin of the samples



Present estimates of Fst: 0.032 (ranging from -0.0004 to 0.0745) may indicate that rates of straying in shad exceed those of other anadromous fishes





Extensive gene flow between populations of Allis shad were already suggested in French rivers using allozymes markers (Alexandrino et al. 2006) and mtDNA (Faria et al. 2012)

Conclusions

We provided a valuable qualitative view on the dispersal and homing patterns of Allis shad.

Bayesian tools useful to determine geographical origins of individuals (incorporate several sources of information).
Based on the relationship between water and otolith signatures, the model allowed us to **predict otolith chemistry** for rivers where juveniles were not available *(Pflugeisen 2013)*

Most shads of our sample returned to spawn in their natal RiVER BASIN
The scale of the **homing behavior** of *A. alosa* is the **RIVER BASIN**

A.alosa exhibited **a straying behaviour outside their natal River Basin (>10% of our sample)**, which was supported by a **weak spatial genetic structure** at the population level (**on evolutionary timescales**)

Straying mostly occurred between **neighbor rivers (importance of spatial connectivity)**

Garonne and **Dordogne** River cases: specific **2007** and **2008** cohorts weakness or ?


Thanks for your attention