More free publications from Archimer

Response to divergent selection for resistance to summer mortality in Pacific oyster spat: genetic parameters and correlated responses with subsequent survival and growth.

Pierre Boudry [1], Edouard Bédier [2], Bruno Ernande [3], Lionel Dégremont [1]

[1] Ifremer, Laboratoire de Génétique et Pathologie, 17390 La Tremblade, France

[2] Ifremer, LRRMPL ,17 rue des Résistants, B.P. 86, 56470 La Trinité sur Mer, France

[3] Ifremer, Laboratoire Ressources Halieutiques, Ifremer, F-14520 Port en Bessin, France

Introduction

- **To date, the main contribution of genetics to the improvement of Pacific oyster is the production triploids. This is even more significant since the development of tetraploid oysters, allowing the production of "natural" triploids (*i.e.* 2n x 4n).**
- **Oysters are good candidates for selective breeding (Gosling, 2003), as confirmed by the programs currently initiated in USA, Australia and New Zeland.**
- **Knowledge about heritability and genetic correlations between traits of aquacultural interest is essential to establish selective breeding programs**
- **In bivalves, most of the available heritability estimates concern growth related traits. Quantitative genetic studies on survival traits are far less common.**

Ifremer

Main objectives of this study:

- **Determine if the variation observed for survival of spat over the summer period is heritable**

- **If yes, is it possible to select oysters to improve/decrease their survival?**

- **Is spat survival (negatively) correlated with other traits, such as growth or survival at later stages ?**

Ifremer

2000-2005 : 4 successive generations

- Determine if the variation observed for survival of spat over the summer period is heritable
  - **G1 (2001) : estimation of genetic parameters for spat survival and growth**

- If yes, is it possible to select oysters to improve/decrease their survival?
  - **G2 (2002) : response one generation of divergent selection : 'R' & 'S' oysters**
  - **G3 et G4 (2003-2005) : repeatability of this response**

- Is spat survival correlated with other traits, such as growth or survival at later stages?

	2001	2002	2003	2004	2005
G1	× (red)	× (black)			
G2		× (red)	× (black)		
G3			× (red)	× (black)	
G4				× (red)	× (red)

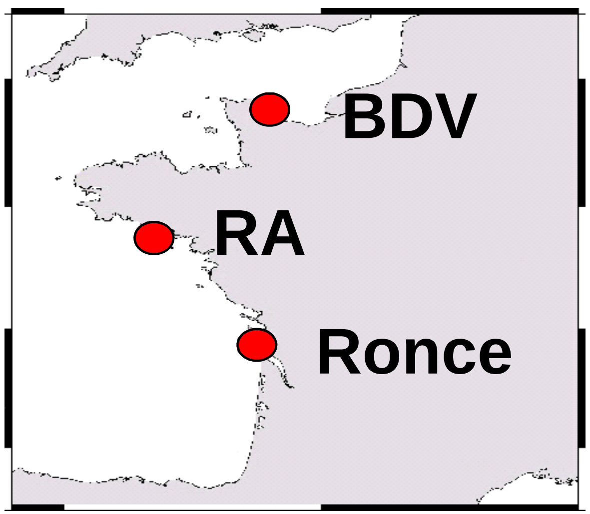
(× first summer ; × second summer)

Ifremer

Studied material:

- Bi-parental (G1) and multi-parental (G2-G4) progenies
- inbred and outbred progenies
- Diploids / triploids
- High selected 'R' / control / low selected 'S'

3 study sites:



Field trials

Lab trials

Genetic basis of spat survival over the summer period

Série 1

	M1	M2	M3	M4	M5	M6
F1	F1-1					
F2	F1-2					
F3	F1-3					
F4	F1-4					
F5		F2-5				
F6		F2-6				
F7		F2-7				
F8		F2-8				
F9			F3-9			
F10			F3-10			
F11			F3-11			
F12			F3-12			
F13				F4-13		
F14				F4-14		
F15				F4-15		
F16				F4-16		
F17					F5-17	
F18					F5-18	
F19					F5-19	
F20					F5-20	
F21						F6-21
F22						F6-22
F23						F6-23
F24						F6-24

Série 2

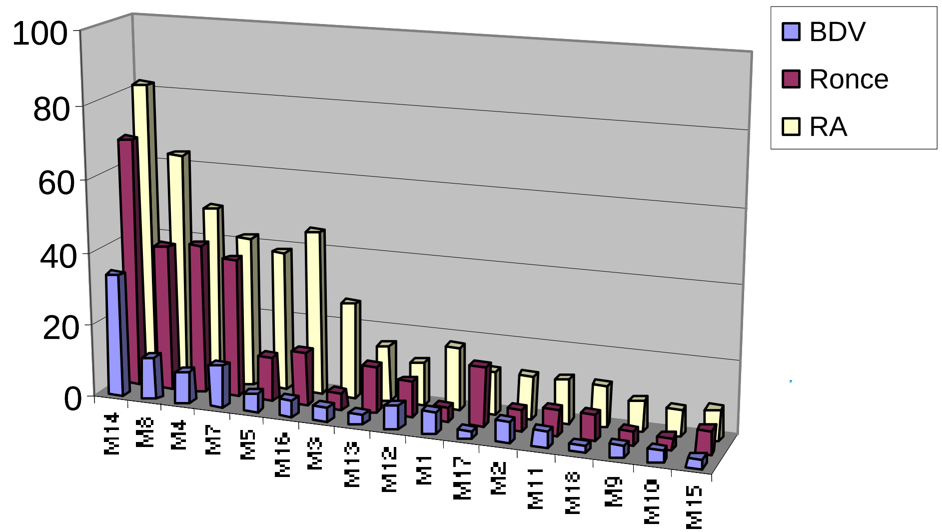
	M7	M8	M9	M10	M11	M12
F25	F7-25					
F26	F7-26					
F27	F7-27					
F28	F7-28					
F29		F8-29				
F30		F8-30				
F31		F8-31				
F32		F8-32				
F33			F9-33			
F34			F9-34			
F35			F9-35			
F36			F9-36			
F37				F10-37		
F38				F10-38		
F39				F10-39		
F40				F10-40		
F41					F11-41	
F42					F11-42	
F43					F11-43	
F44					F11-44	
F45						F12-45
F46						F12-46
F47						F12-47
F48						F12-48

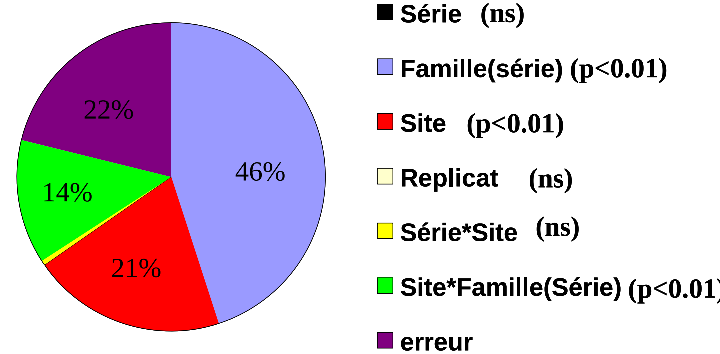
Série 3

	M13	M14	M15	M16	M17	M18
F49	F13-49					
F50	F13-50					
F51	F13-51					
F52	F13-52					
F53		F14-53				
F54		F14-54				
F55		F14-55				
F56		F14-56				
F57			F15-57			
F58			F15-58			
F59			F15-59			
F60			F15-60			
F61				F16-61		
F62				F16-62		
F63				F16-63		
F64				F16-64		
F65					F17-65	
F66					F17-66	
F67					F17-67	
F68					F17-68	
F69						F18-69
F70						F18-70
F71						F18-71
F72						F18-72

Série	déc-00	janv-01	févr-01	mars-01	avr-01	mai-01	juin-01	juil-01	août-01	sept-01	oct-01
1	maturation			EL (0-16) / micro nurserie (16-44)	nurserie (44-134)			site (135-239)			
2		maturation			EL (0-16) / micro nurserie (16-44)	nurserie (44-121)			site (122-211)		
3			maturation			EL (0-16) / micro nurserie (16-42)	nurserie (42-107)		site (108-164)		

Genetic basis of spat survival over the summer period





(Dégremont et al., 2005)

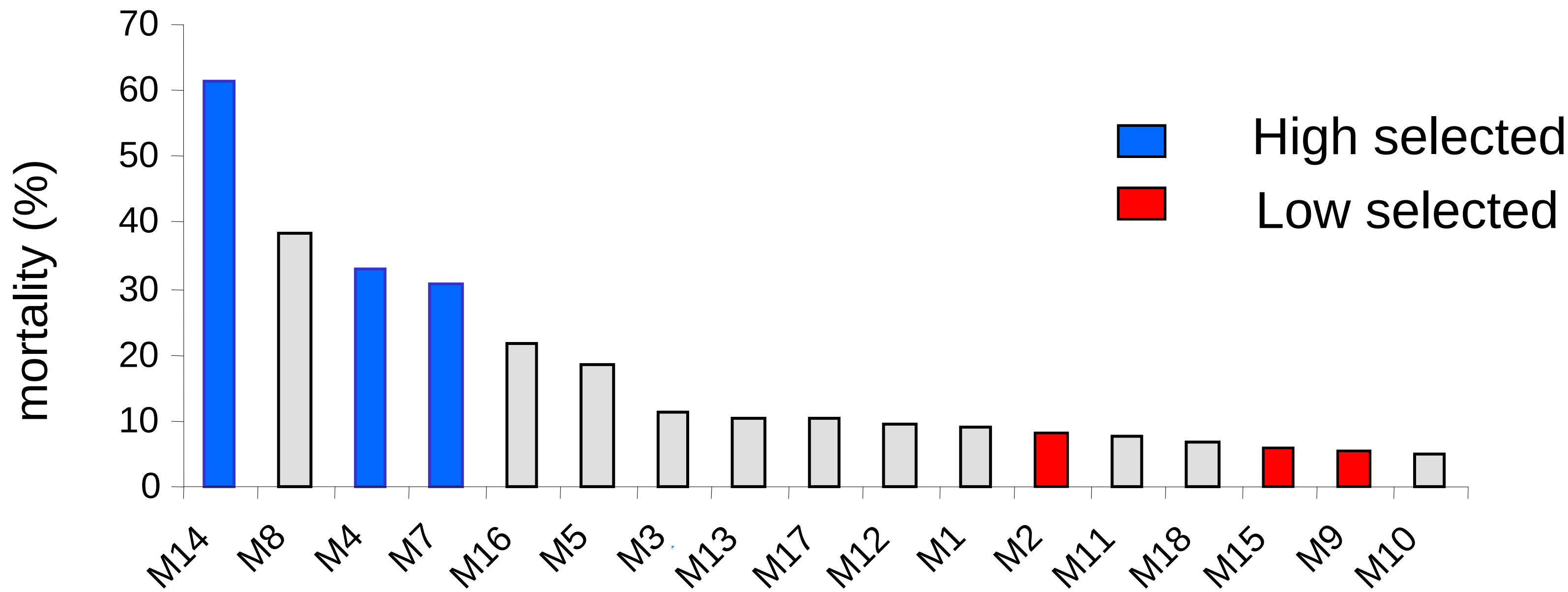
Heritability estimates (± standard error) :

- **Ronce : 1.05 ± 0.44***
- **RA : 0.86 ± 0.38***
- **BDV: 0.46 ± 0.20****

- **All sites together: 0.83 ± 0.40***

(Dégremont et al., submitted)

Divergent selection

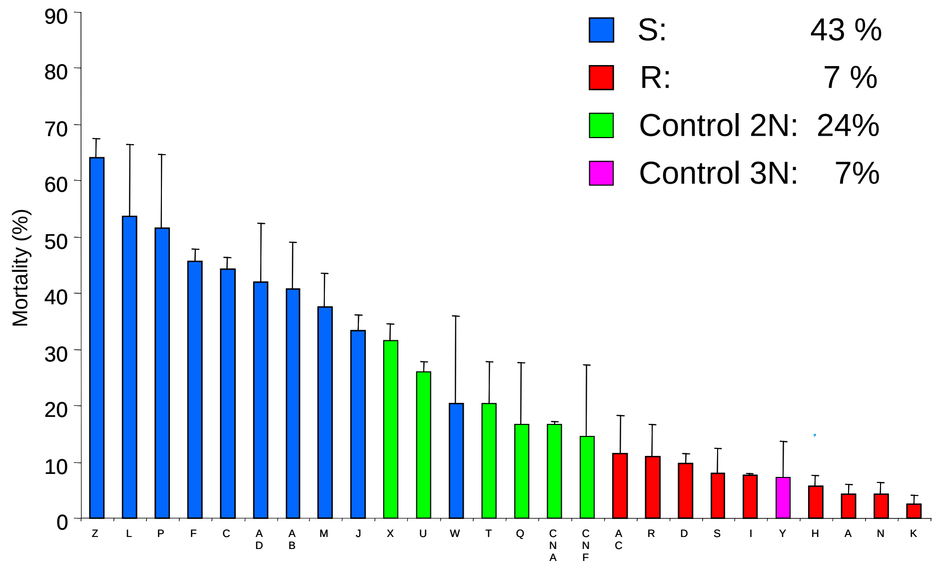


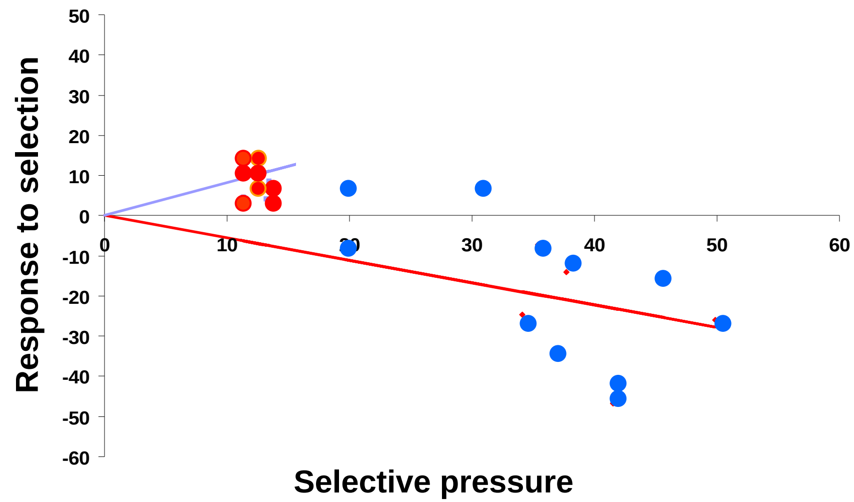
Best and worst family selected within each G1 set

Within and among family crosses generating inbred and outbred ‘R’ or ‘S’ progenies

➢ **2002**	**G2S, G2cS**	**G2R, G2cR**
➢ **2003**	**G3S, G3cS, G3c²S, G3S3n**	**G3R, G3cR, G3c²R, G3R3n**
➢ **2004/2005**	**G4S, G4cS, G4S3n**	**G4R, G4cR, G4R3n**

Response to divergent selection





Realized heritability (± standard error):

- **Ronce : 0.64 ± 0.09 ***
- **RA : 0.65 ± 0.08 ***
- **BDV : 0.82 ± 0.24 ****

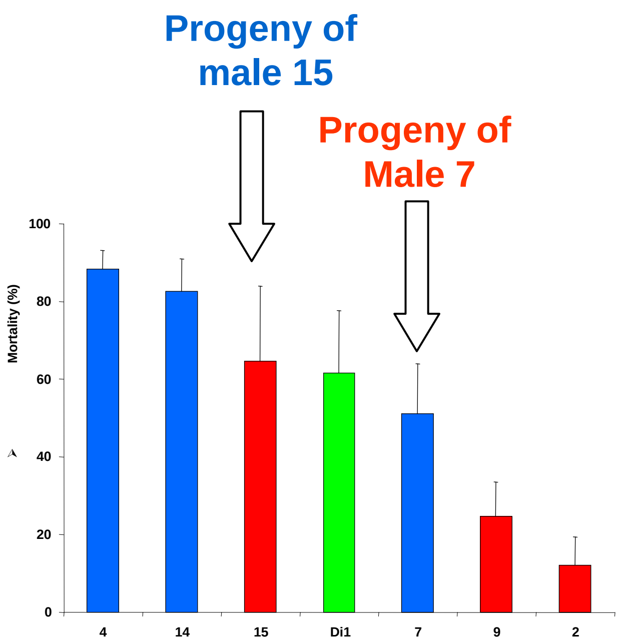
Is this response to selection repeatable over years?

		Ronce (R t S)	RA (R t S)	BDV (R t S)
Outbreed progenies	G2	5 = 8 < 33	7 < 24 < 43	7 = 6 < 19
	G3	27 < 47 < 72		
	G4	18 < 57 < 70		
Inbred progenies	G2c	4 = 4 < 43		
	G3c	30 = 24 < 60		
	G3c²	34 < 61 < 73		
	G4c	8 < 24 < 42		
Triploids	G3 3n		35 < 50 < 58	
	G4 3n		5 = 4 = 9	

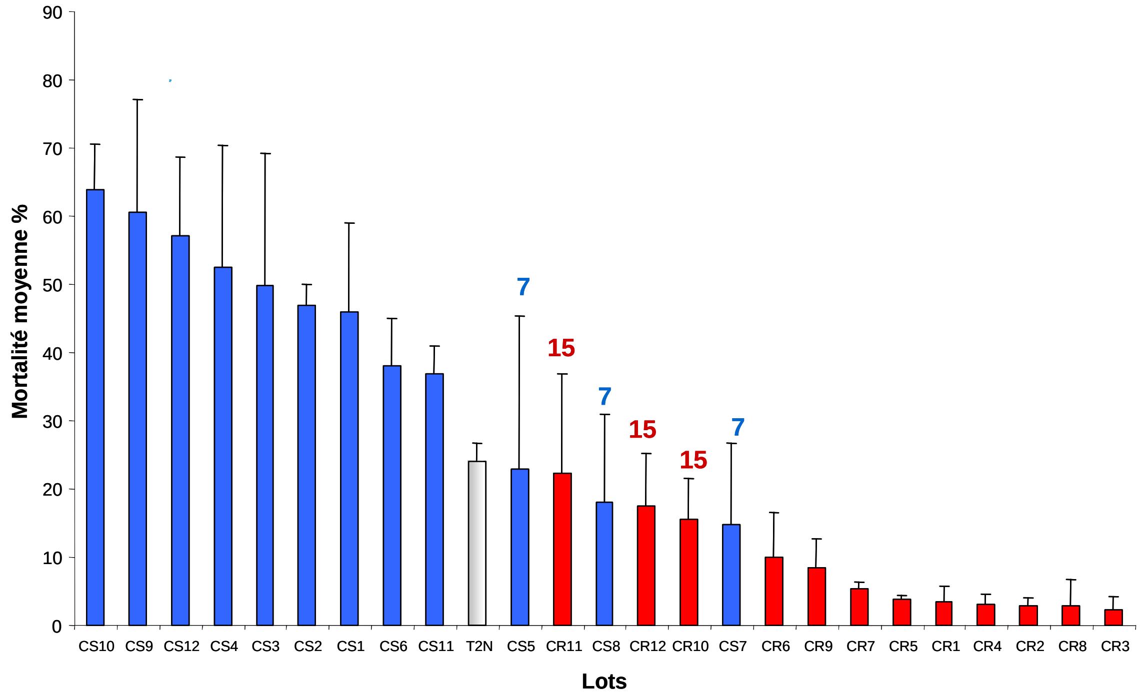
- **When mortality in controls were above 10%, survival of R progenies was always significantly higher than those of the control progenies**
- **Mortality of S progenies were always higher than in the control progenies (and of than in the R progenies).**

Is this response to selection repeatable over years?

Mean mortality per male in the third generation of inbreeding tested in Ronce (2003)



Mean mortality in the forth generation of inbreeding tested in Ronce (2004)



Ifremer

What about survival during the second summer?

		Ronce R	Ronce S	RA R		RA S	BDV R		BDV S
2 successive summers in the fields	G1 6 mo.	4		7	<	52	3	<	15
	G1 18 mo.	5		8	=	7	24		
	G2 6 mo.			6	<	48			
	G2 18 mo.			6	=	7			
	G3 6 mo.			38	<	83	2	<	6
	G3 18 mo.			7	=	8	20	<	42
1st summer in nursery, 2nd summer In the field	G1 18 mo.			4	<	14			
	G2 18 mo.			6	<	14			
	G3 18 mo.			22	=	27	12	<	33

- **In Ronce and RA, most mortality occurred during the first summer and survival of R and S progenies were similar in their second summer**
- **In BDV, mortality was higher in the second summer, and survival of R progenies was higher that in S progenies**

What about survival in the lab?

		Nb. tested progenies R	Nb. tested progenies S	Mortality R		control		S	Correlation with mortality in the field	
G2	L1	9	9	28	<	38	<	53	r = 0.43 (p=0.06)	RA
G2	L2	6	5	18	<	44	=	49	r = 0.58 (p=0.02)	RA
G2	L3	11	11	26	=	25	<	53	r = 0.63 (p<0.01)	RA
									r = 0.47 (p=0.01)	Ronce
G2c	L4	10	8	18	<	35	<	58	r = 0.94 (p<0.001)	Ronce
G3	L5	12	12	31	<	52	=	53	r = 0.85 (p<0.001)	RA
G3c²	L6	12	11	45	<	68	<	76	r = 0.84 (p<0.001)	Ronce
G3c	L7	12	12	14	=	36	<	44	r = 0.94 (p<0.001)	Ronce
G4c	L8	3	3	7	=	8	=	8	ns	

- In most cases, survival of R progenies was higher than those of the control progenies
- In most cases, mortality of S progenies was higher than those of the control progenies (and tos of R progenies).
- In most cases, data in the field and in the lab were well correlated

Ifremer

What about growth?

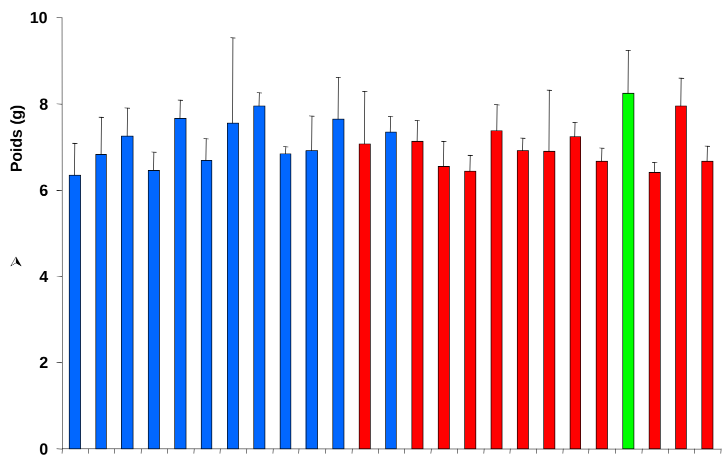
- **G1 : estimates of genetic correlation between growth and survival**

  - **Ronce : 0.24 ± 0.11***
  - **RA : - 0.01 ± 0.09 ns**
  - **BDV: 0.17 ± 0.11 ns**

  - **All sites together : - 0.17 ± 0.14 ns**

- **G2, G3, G4 : no significant difference in growth between R et S progenies**

eg. $G3c^2$ in Ronce



Ifremer

Main conclusions :

- ≈ 50% of the observed variability for spat survival is between families (Dégremont et al., 2005 ; Evans & Langdon, in press).

- Heritability of spat survival is high (Dégremont et al., submitted) and this trait can efficiently be selected for.

- Among the different hypothesis that could explain the mainteance of additive variance for survival, the existence of a trade-off between reproduction and survival is favored (Ernande et al. 2004)

- Physiological differences observed between R and S progenies (under laboratory and field conditions) and better survival of triploids support this hypothesis.

Ifremer

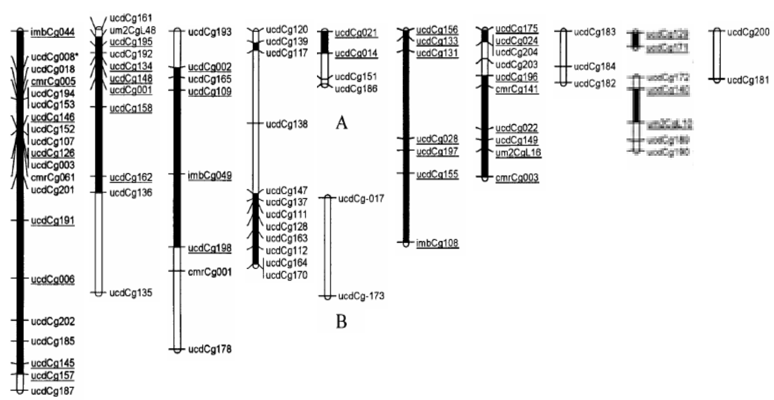
Current research and projects:

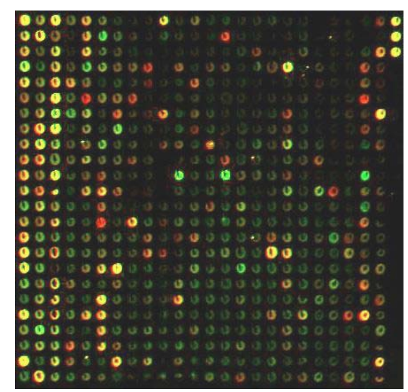
❖ QTL mapping of resistance to summer mortality

❖ Production and progeny testing of 'R' and 'S' tetraploid oysters

❖ Establishment of a full-scale breeding program together with the industry

❖ Functional genomics of 'R' and 'S' lines





Acknowledgements:

Basse Normandie Conseil Régional
Conseil Général Calvados
Région Bretagne
Région Pays de la Loire
Région Poitou Charentes La démocratie participative
UE- IFOP

Oyster pounds, Seudre River, La Tremblade, Charente –Maritime, France