Oyster population genetics: Tracing introductions and understanding natural populations

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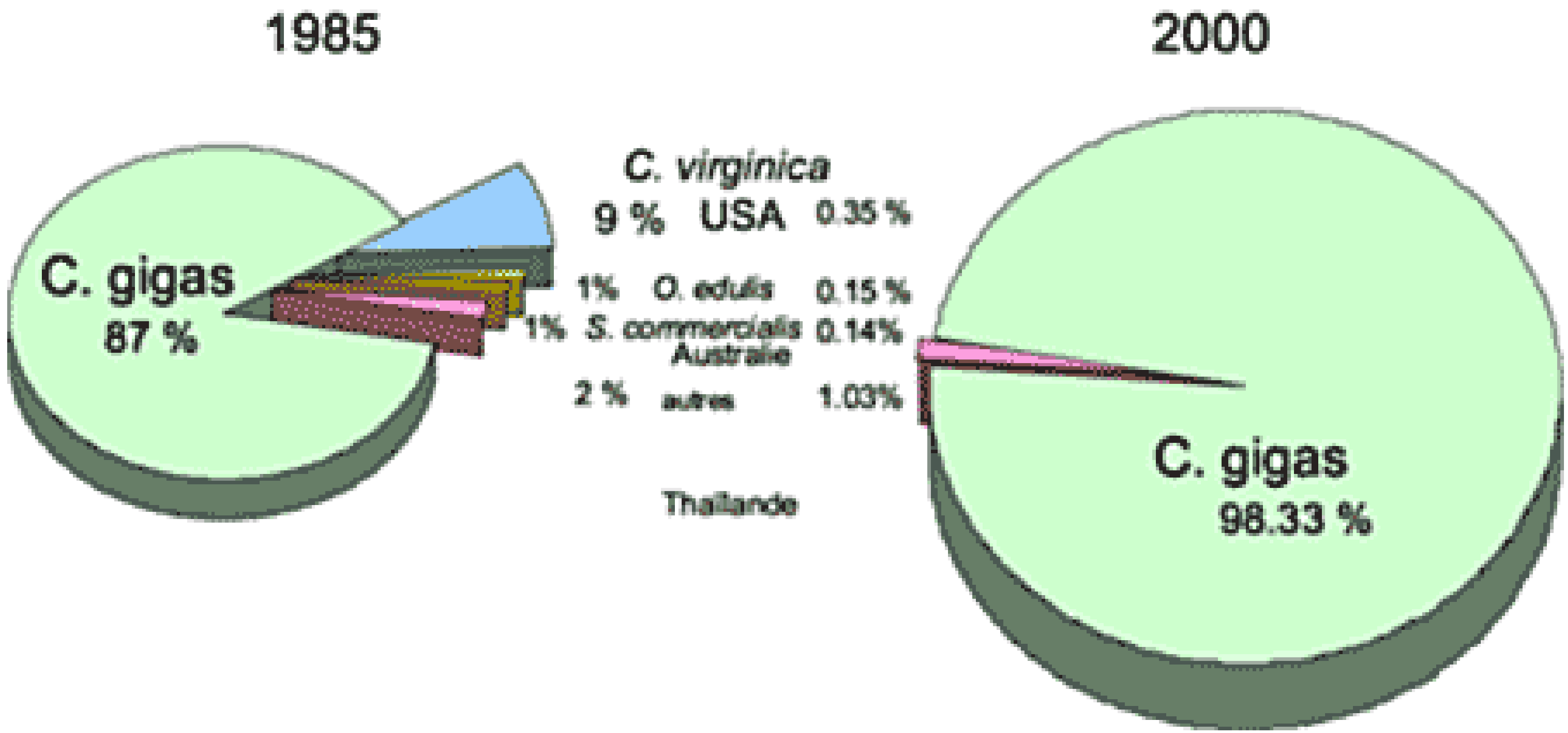
Oysters in the world

About 100 leaving Ostreidae species
At least 18 species consumed by humans

Graphe 17



Introductions

Elton, 1958: "The greatest agency of all that spreads marine animals to new quarters of the world must be the business of oyster culture."

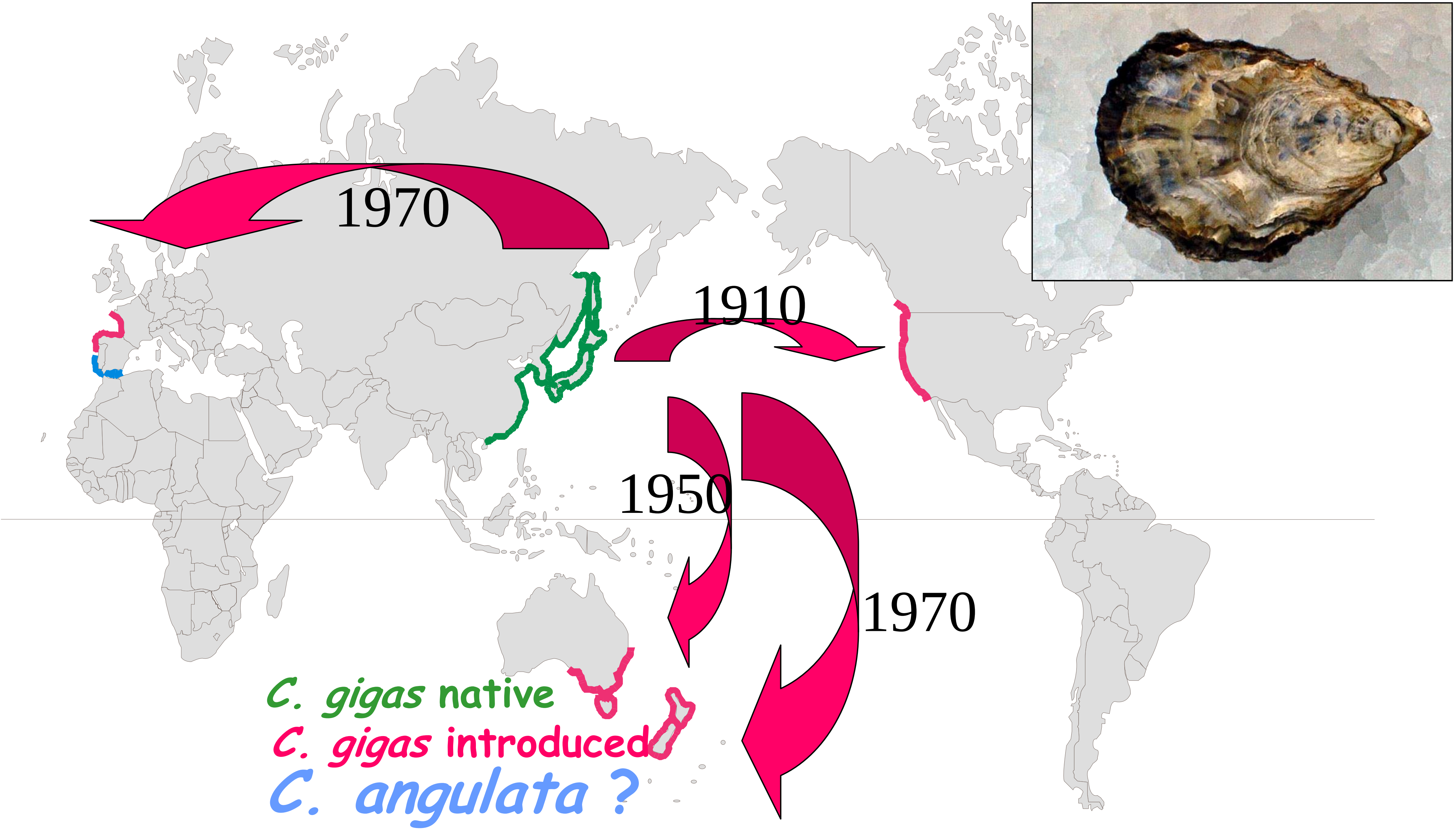
Ruesink et al. (2005) review:
182 records of introduction in 73 countries or smaller regions
66 were of *C. gigas*
France has been the recipient of the most introduced species

Population genetics tracing not "recorded" introductions for reliable oyster farming

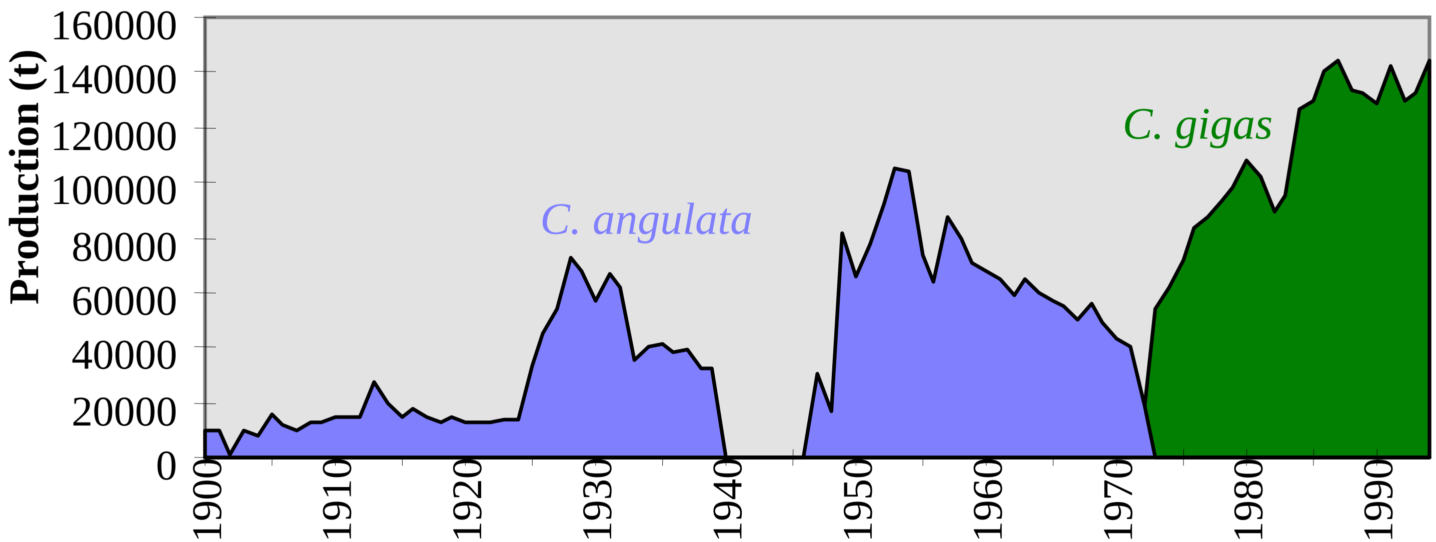
Examples

- *Crassostrea gigas* and *C. angulata*
- *Crassostrea gasar*
- *Ostrea stentina*
- *Ostrea edulis*

Crassostrea gigas and *C. angulata*



Crassostrea angulata

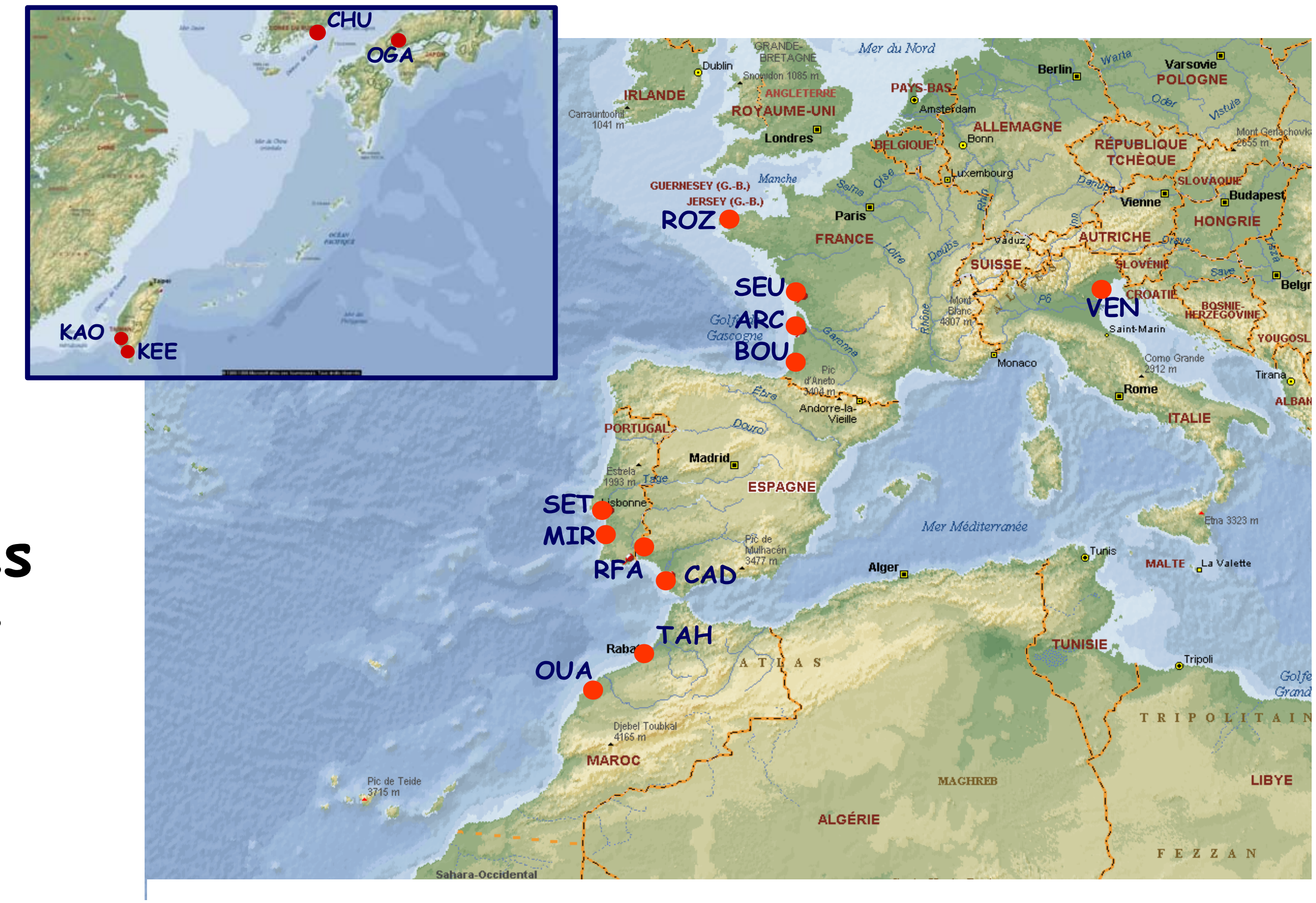


1819 : Lamarck named the Portuguese oyster « *C. angulata* »
1868 : Introduction of *C. angulata* from Portugal
1970 : Gill disease and subsequent introduction of *C. gigas*
1974 : "Portuguese and Japanese oysters are the same species" (Menzel) (Buroker et al., 1979) (Huvet et al., 2001)

Pacific and Portuguese oysters: origin and relationships

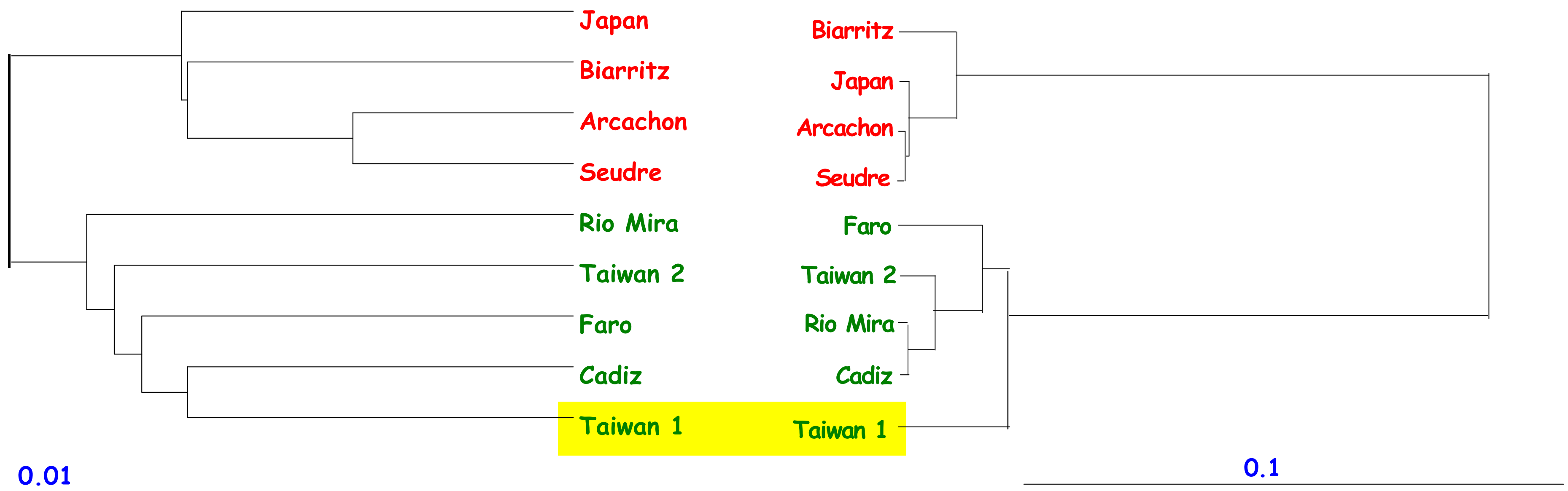
- 15 populations
- 595 individuals

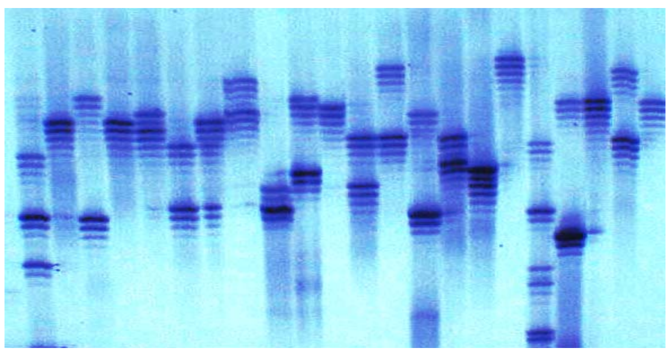
- 6 mtDNA haplotypes
- 3 microsatellite loci



C. angulata ≠ *C. gigas*

the Asian origin of *C. angulata*

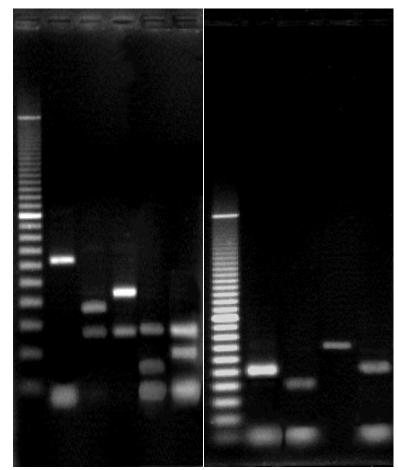




(Huvet et al., 2000)

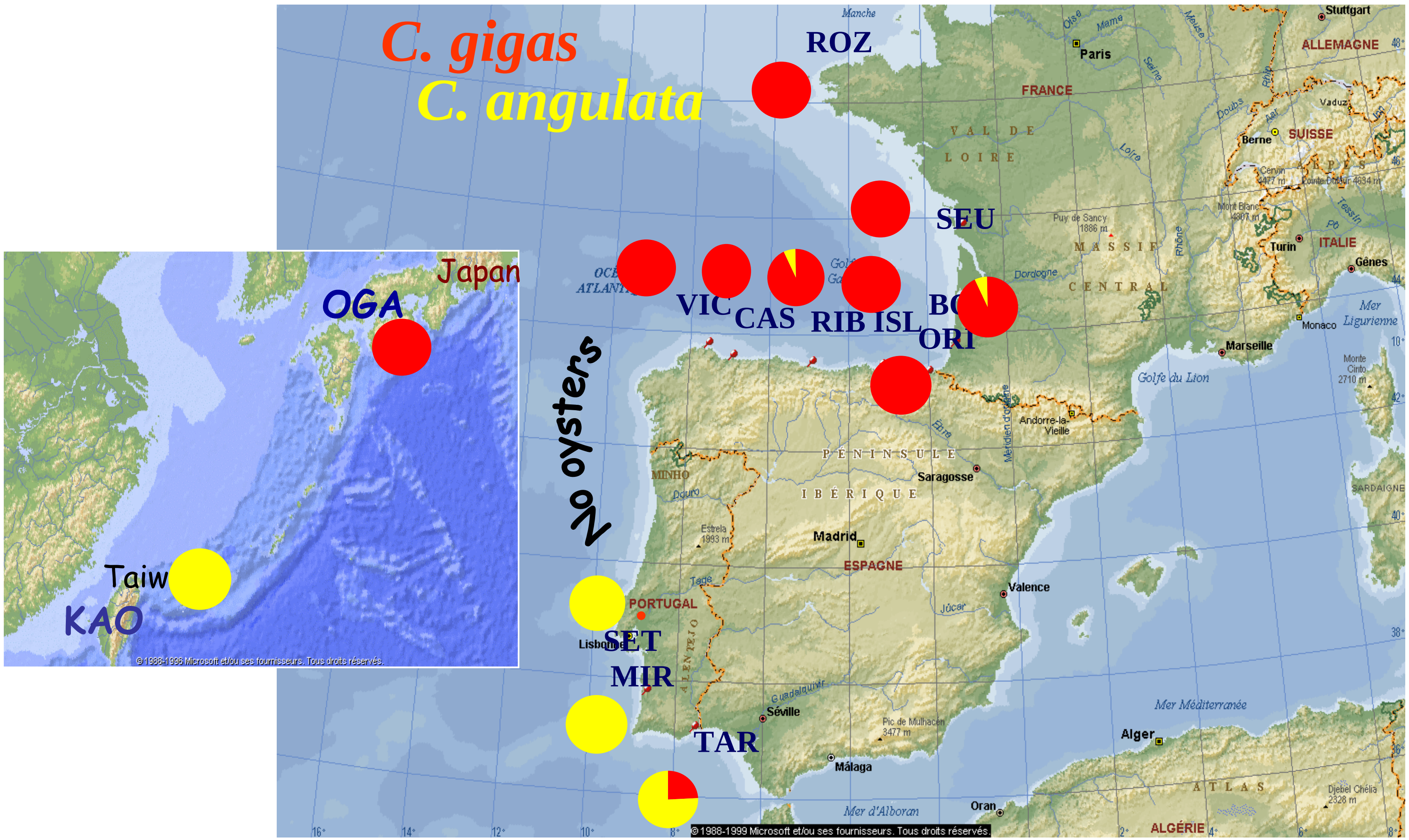
15 populations
595 individuals

6 mtDNA haplotypes
3 microsatellite loci



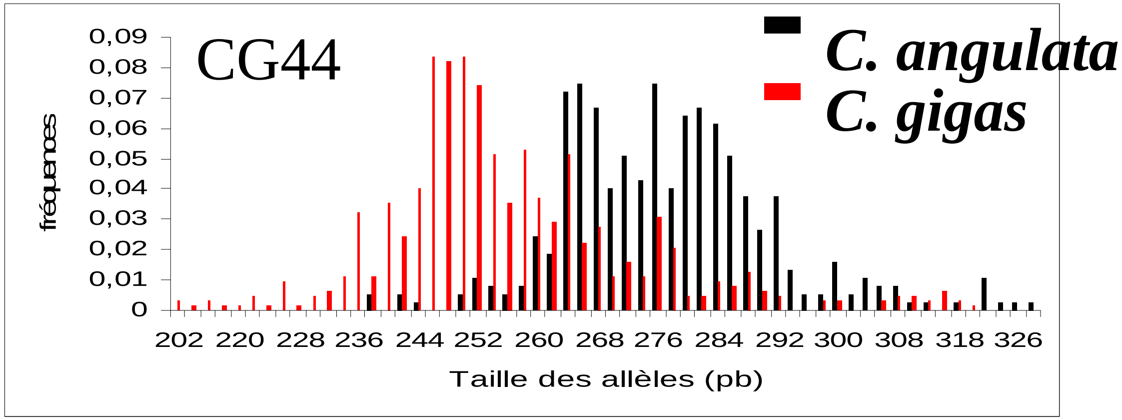
(Boudry et al., 1998)

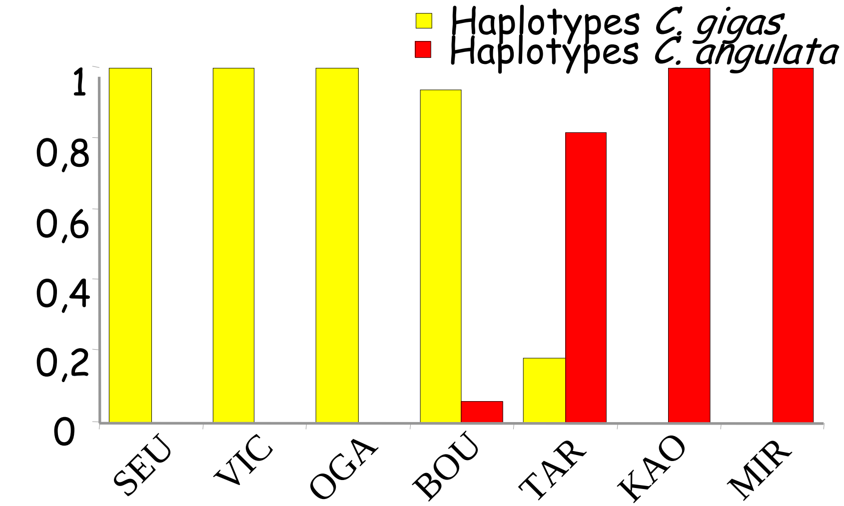
Crassostrea angulata endangered in Europe ?

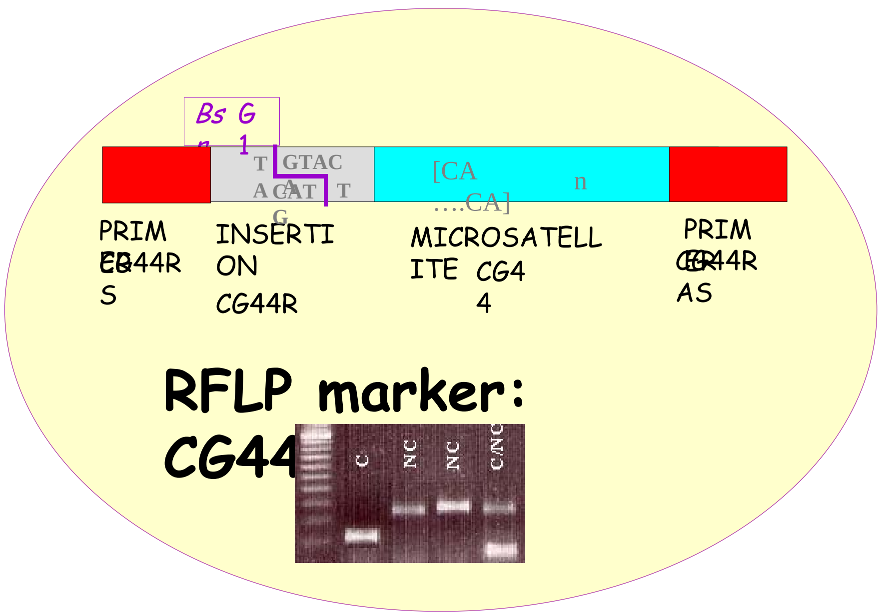


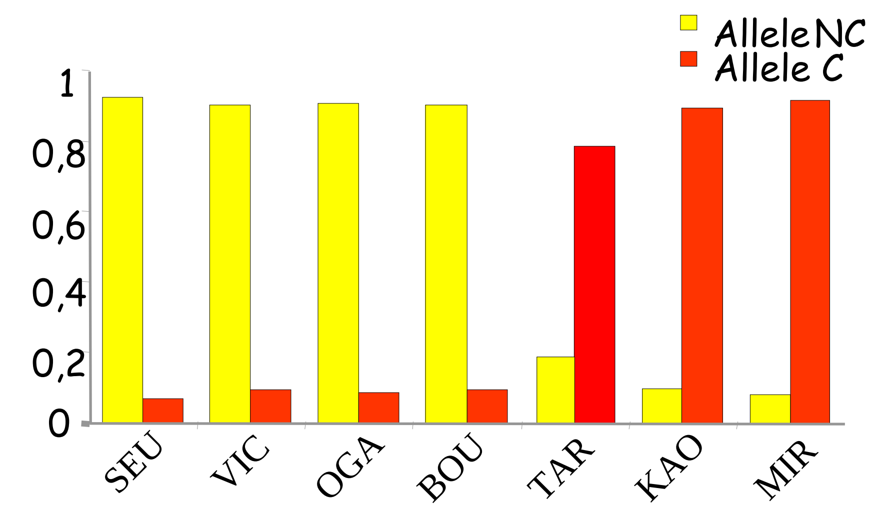
(Fabioux et al., 2002)

C. angulata and *C. gigas* hybridizing in natural populations in Europe ?





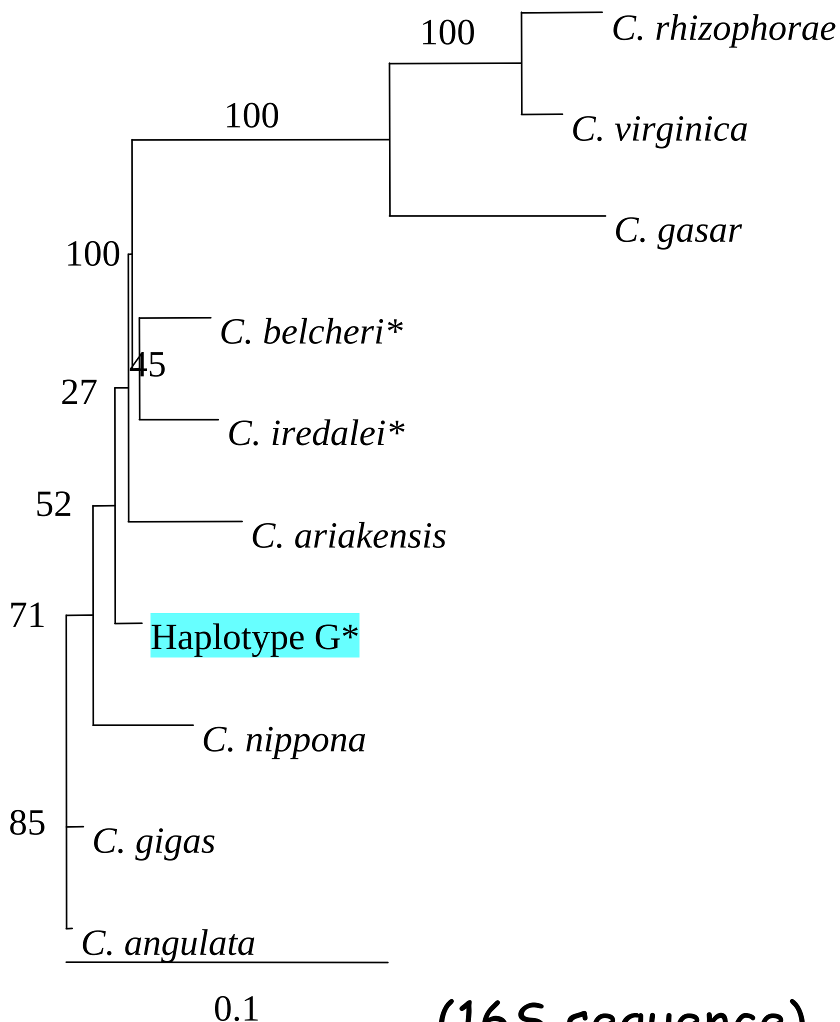




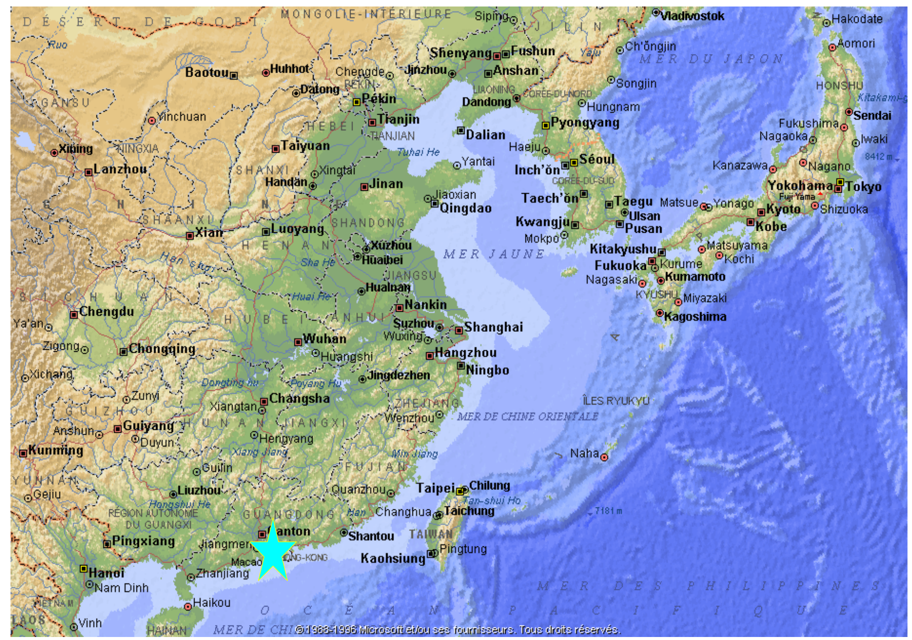
(Huvet et al., 2004)

Crassostrea angulata in China ?

C. hongkongensis ? (Lam & Morton, 2003)



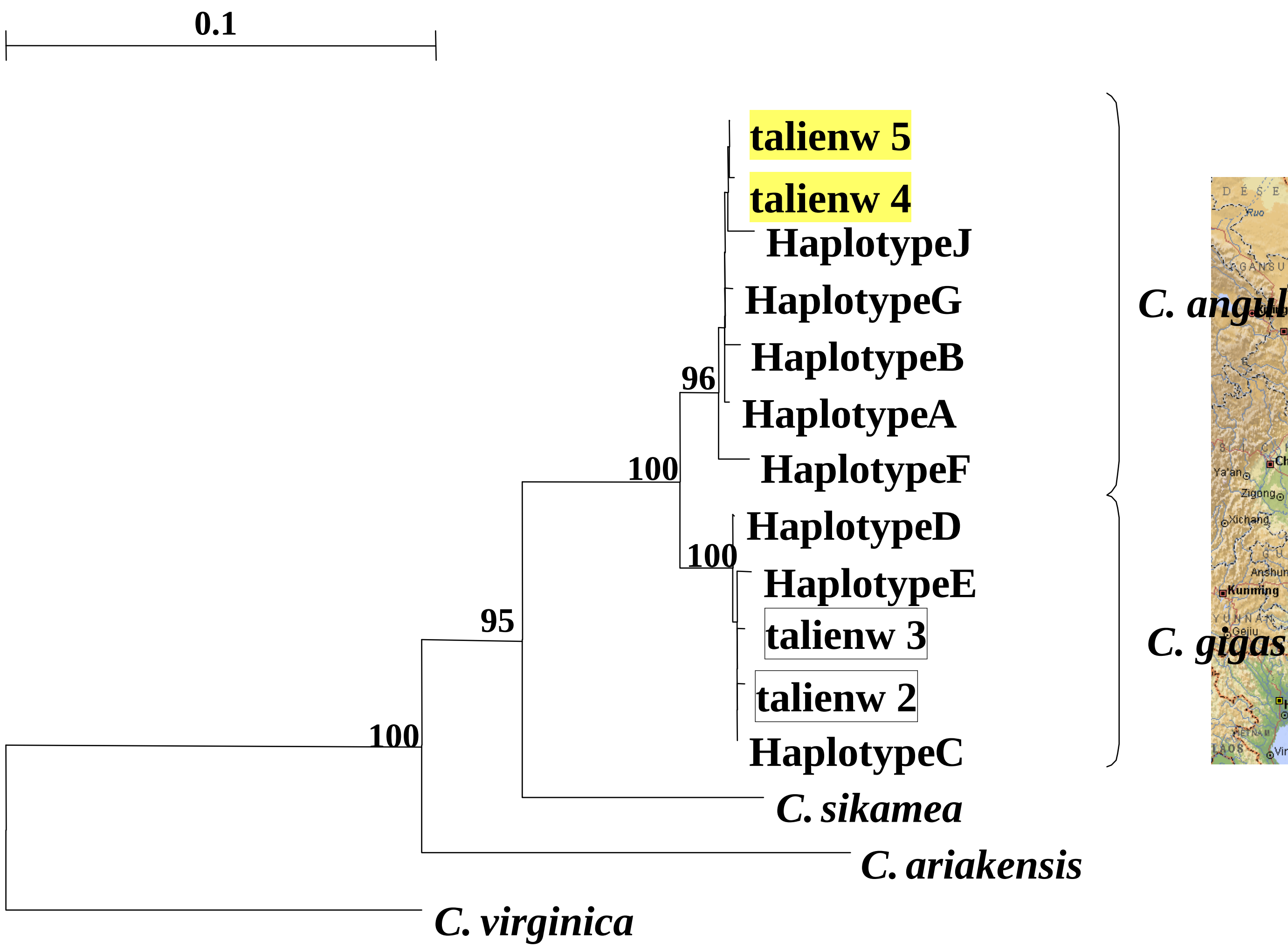
(16S sequence)



(Boudry et al., 2003)

Crassostrea angulata in China ?

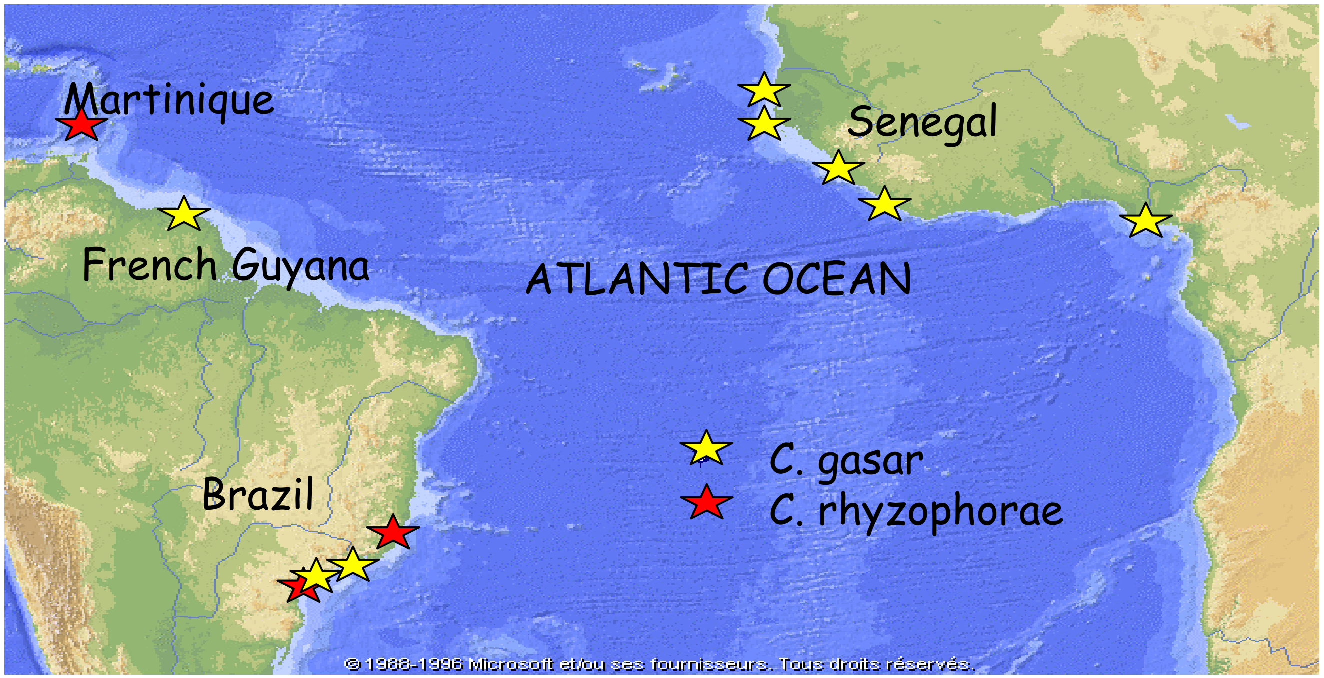
« Daliawan oyster » *C. talienwhanensis* (Yu et al., 2003)

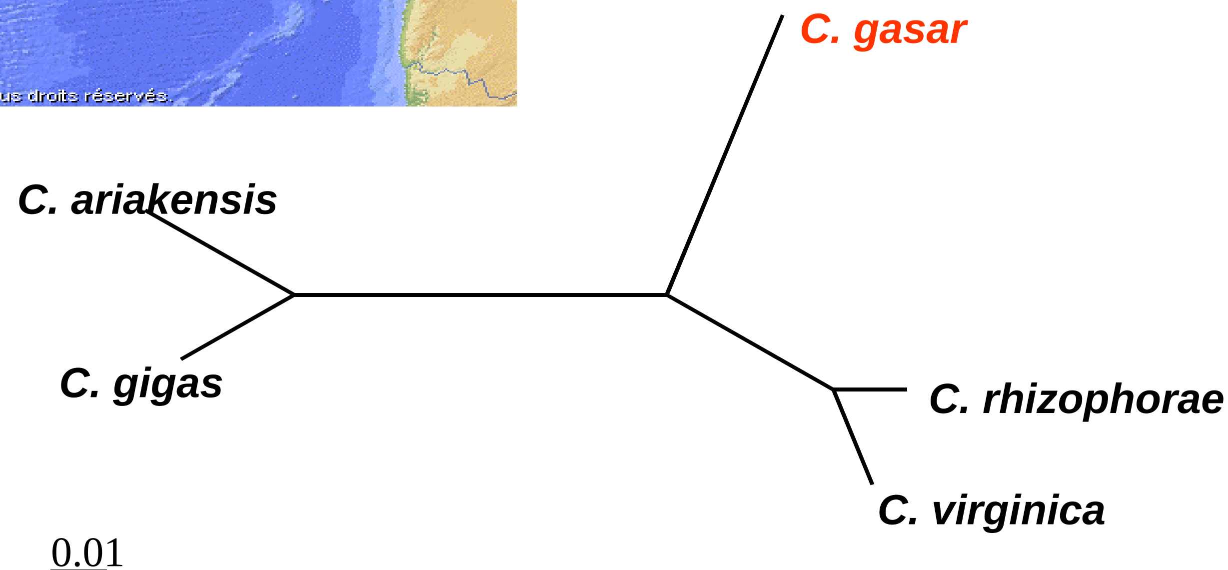


(COI sequence)

(Lapègue et al., 2004)

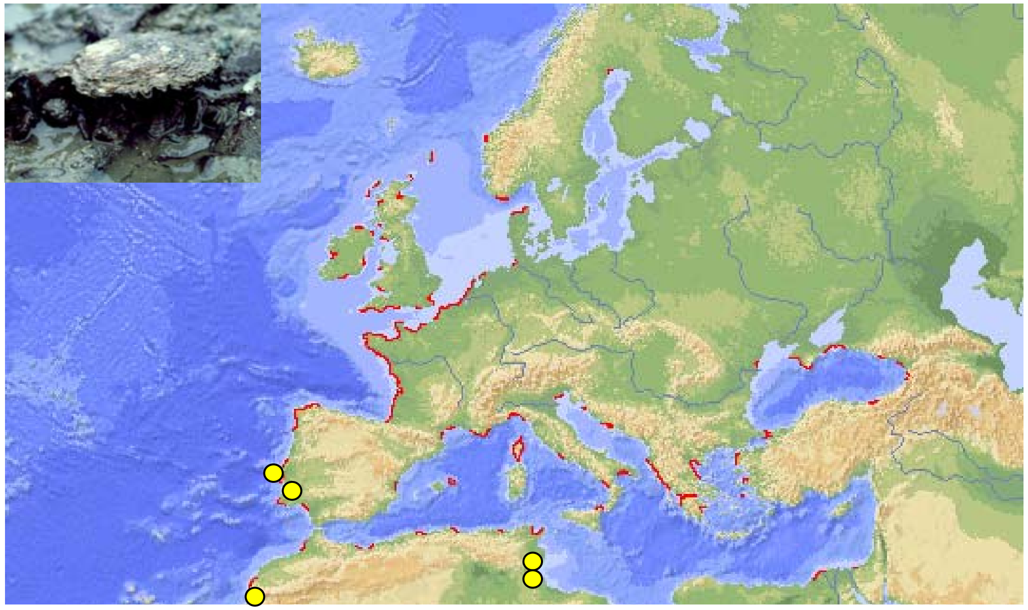
The « mangrove » oyster *Crassostrea gasar* is not only present in Africa

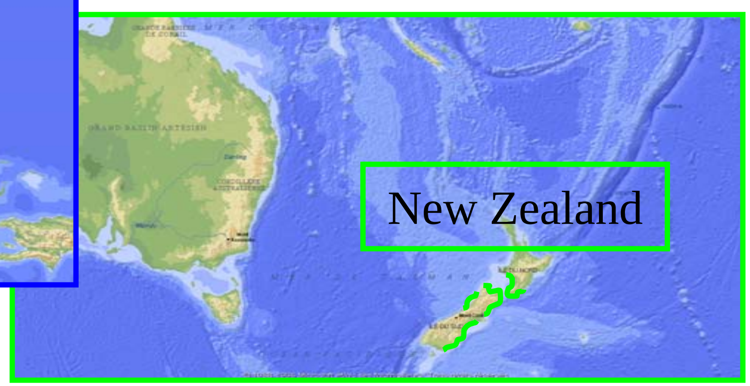


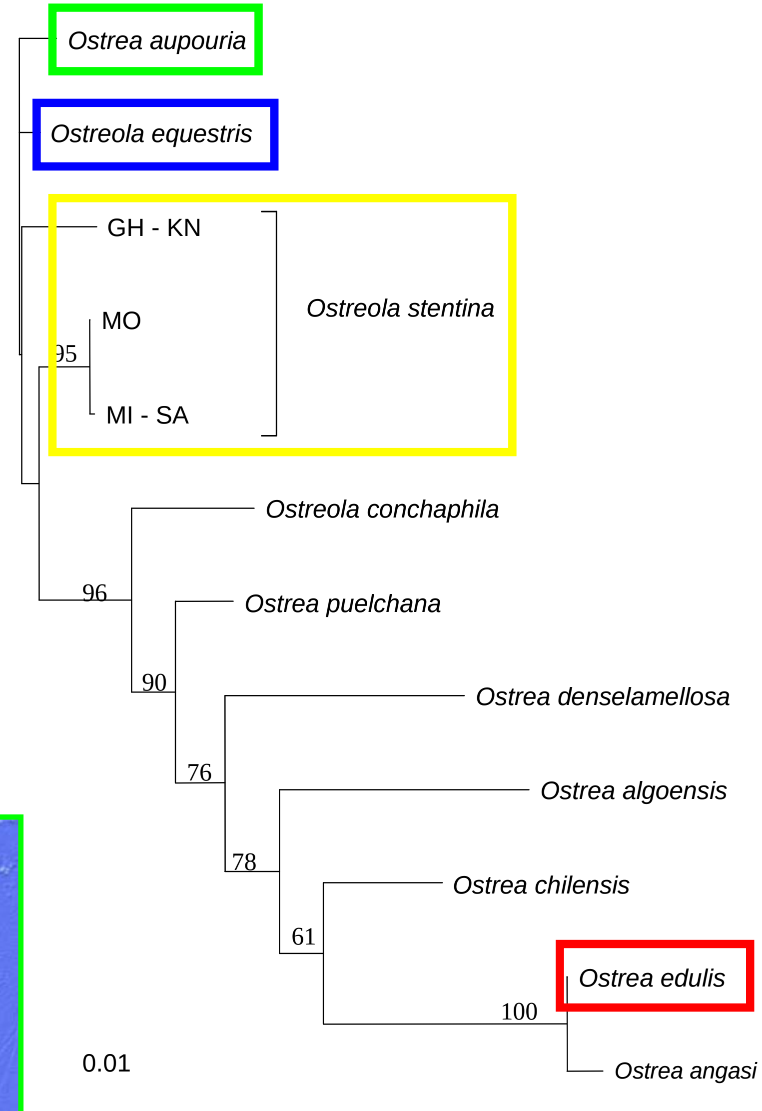


(Lapègue et al., 2002)

O. edulis et *O. stentina*, two very different « European » flat oyster

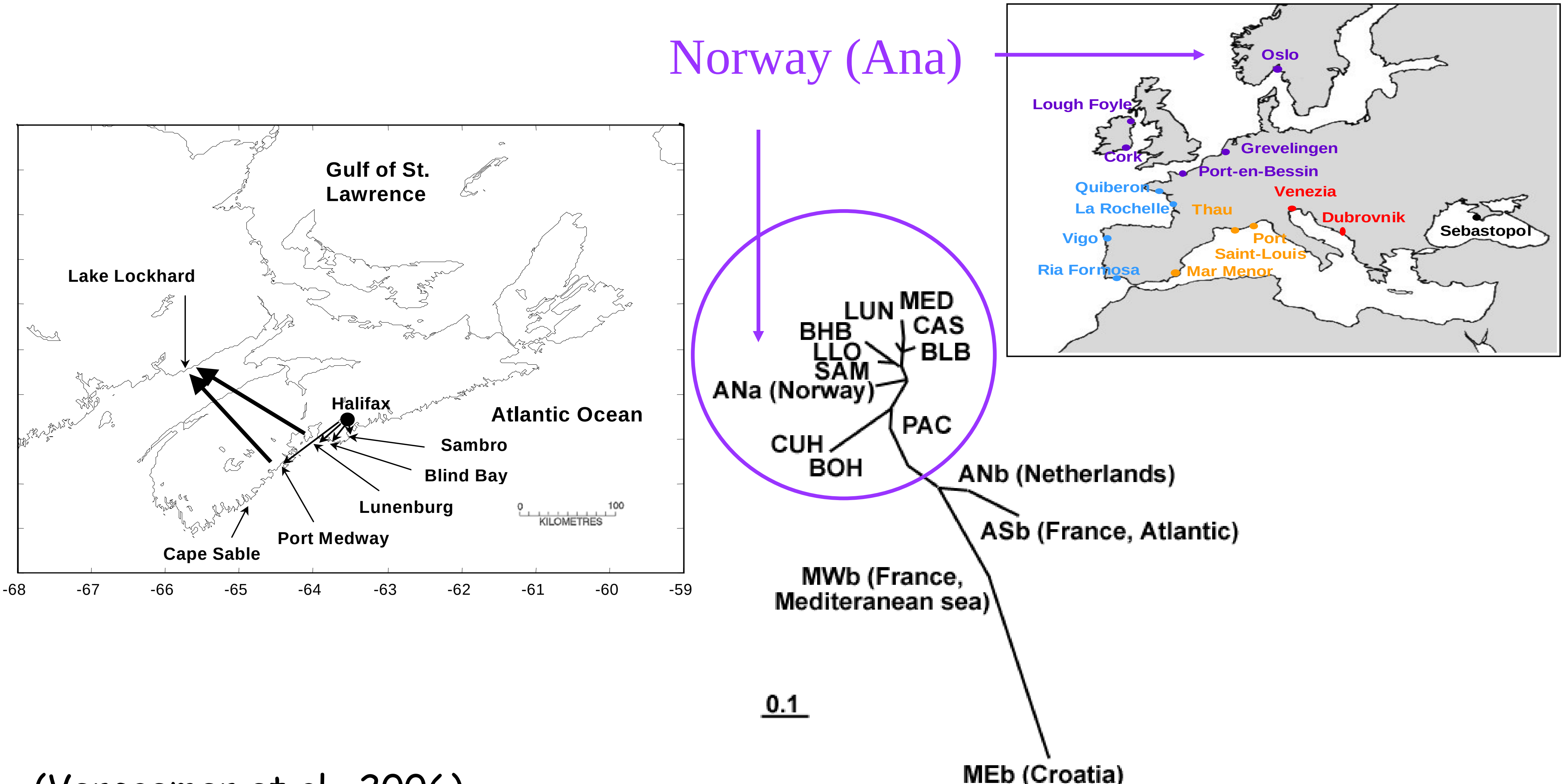






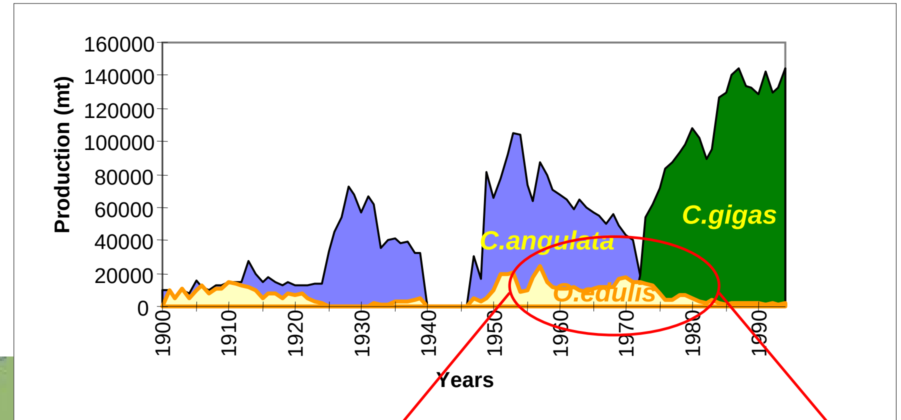
(Lapègue et al., 2006)

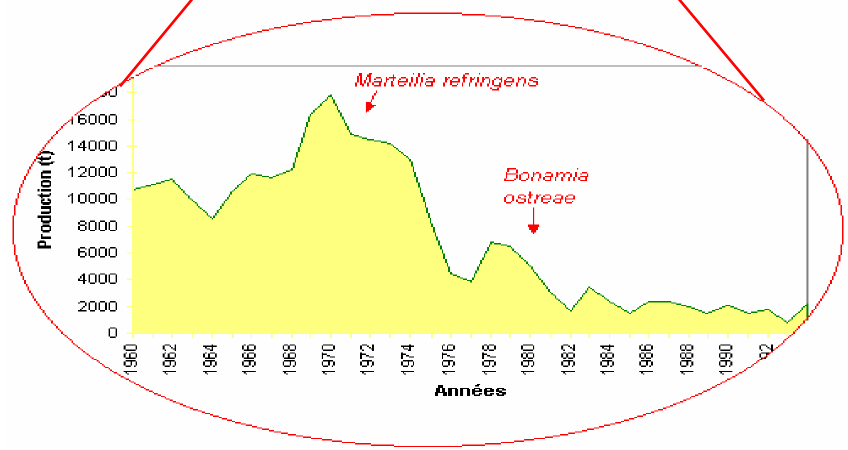
The European flat oyster introduced in Nova Scotia, Canada

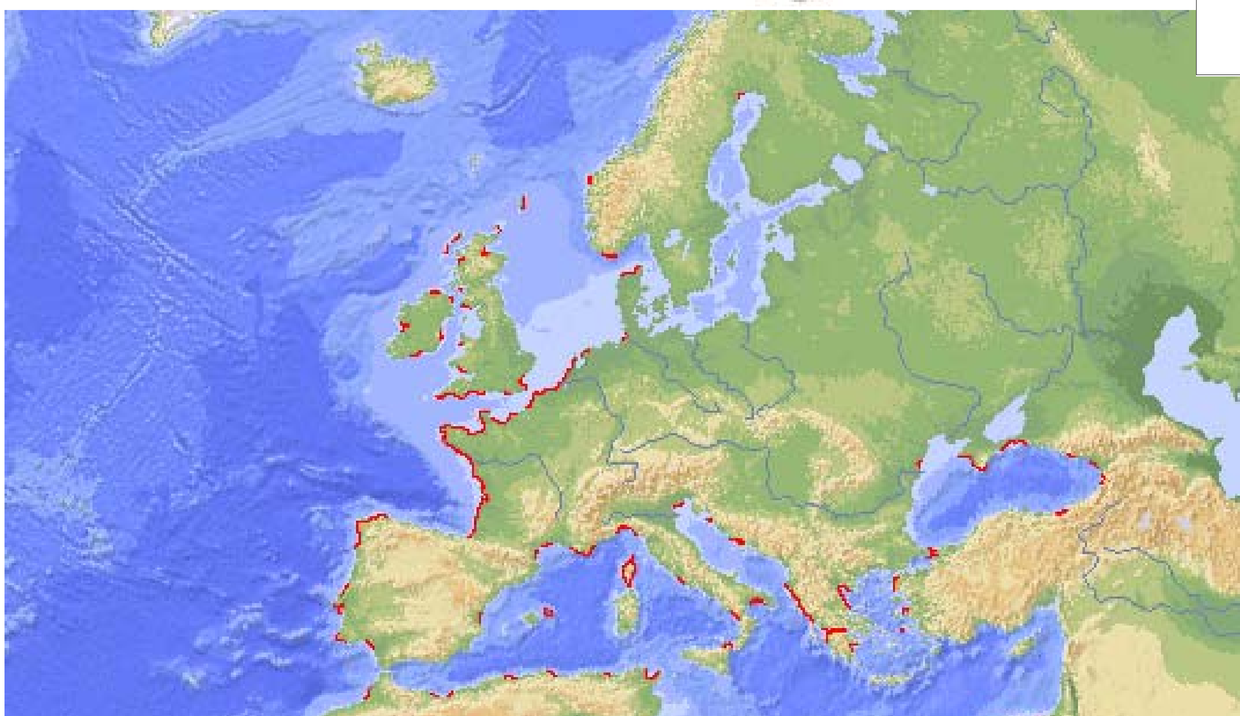


(Vercaemer et al., 2006)

Understanding natural populations as potential resources for breeding





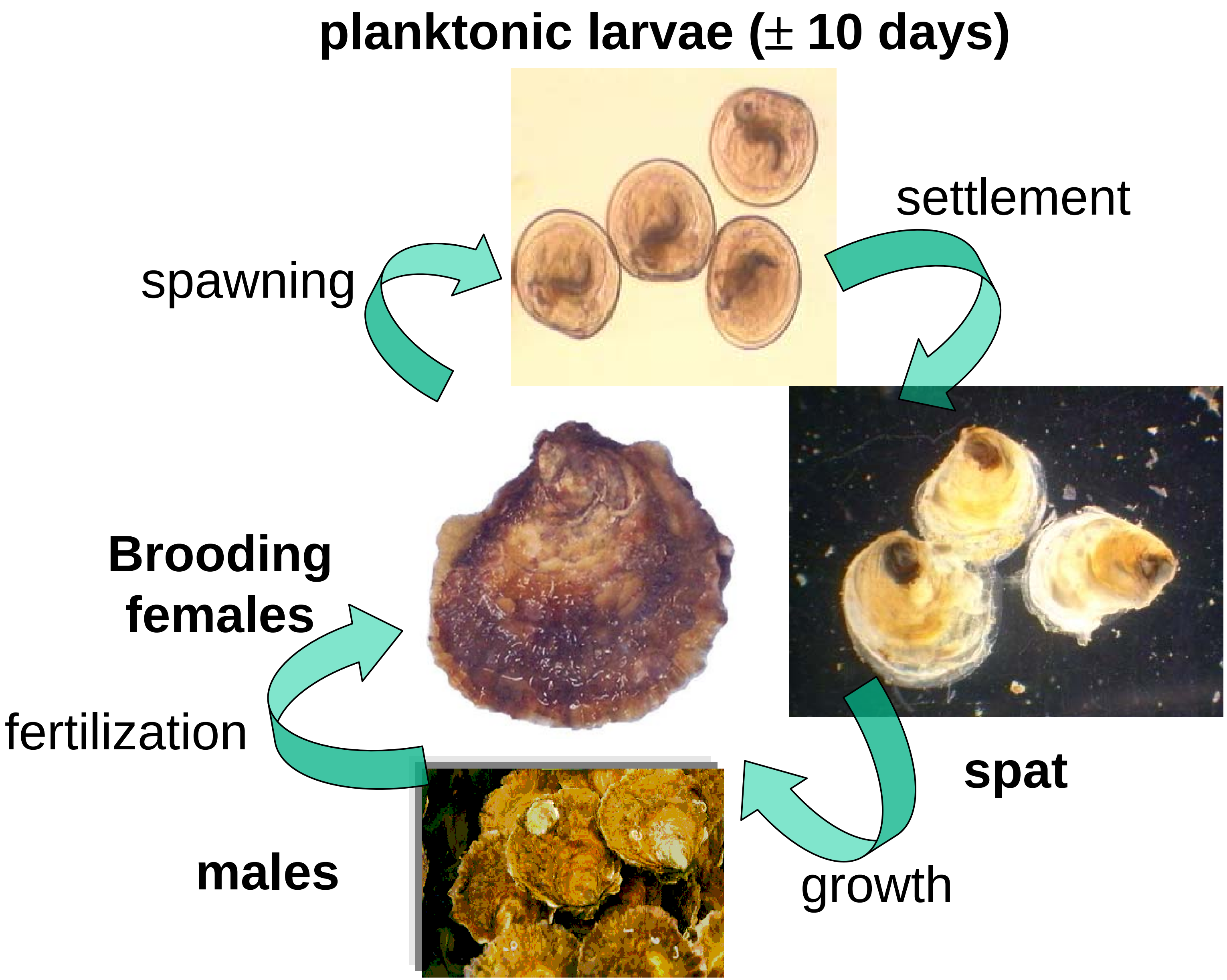


(Jaziri, 1985)

Ostrea edulis in 2004 :

World production = 5.100 t/y
French production = 1.500 t/y

Reproductive cycle



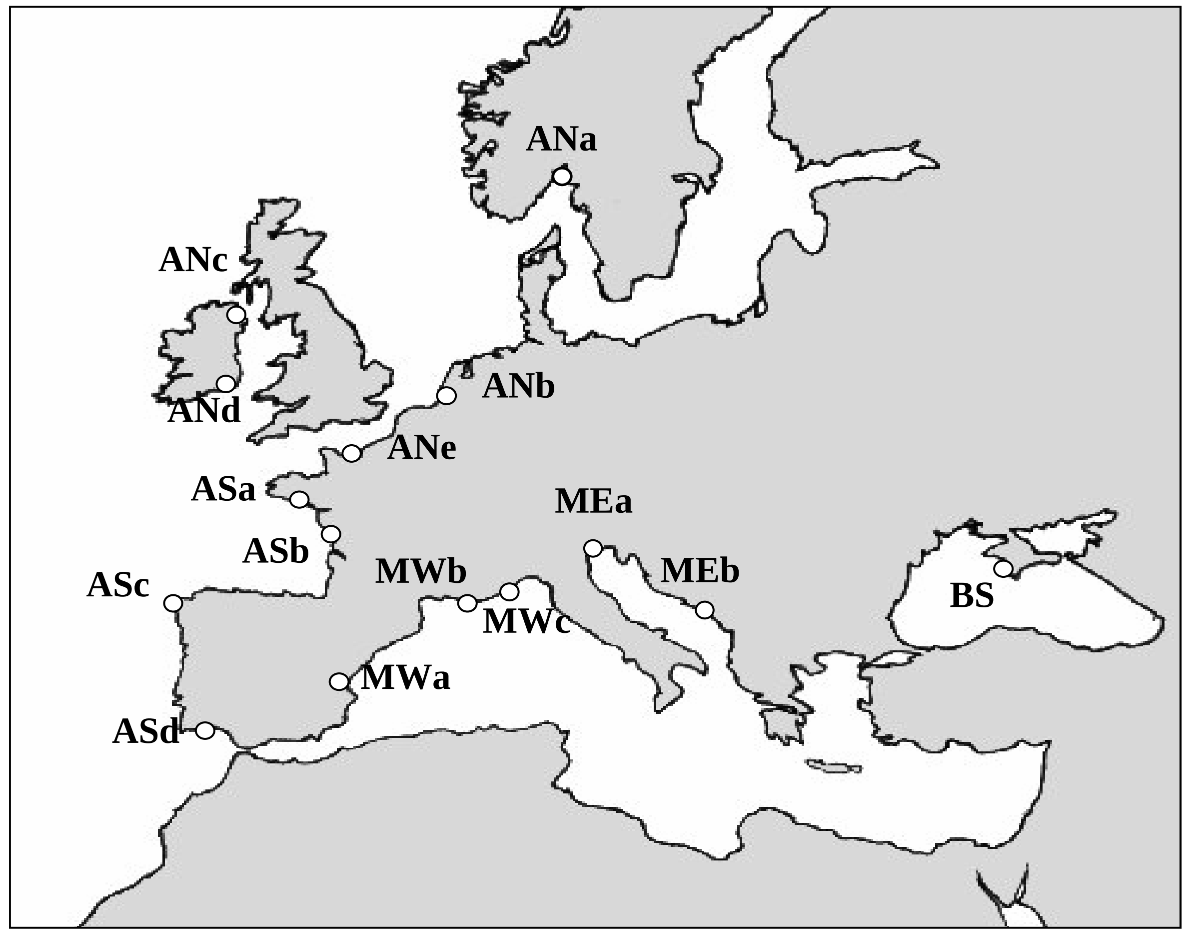
European sampling

Markers

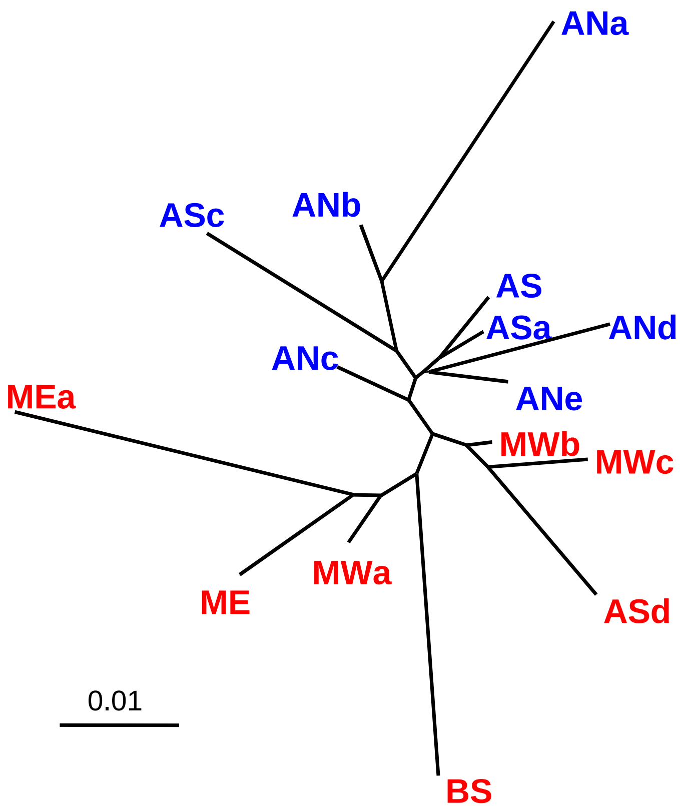
- Allozyme loci (Saavedra *et al.*, 1993, 1995)
- microsatellite loci (Launey *et al.*, 2002)
- 12S rRNA SSCP (Diaz Almela *et al.*, 2004)

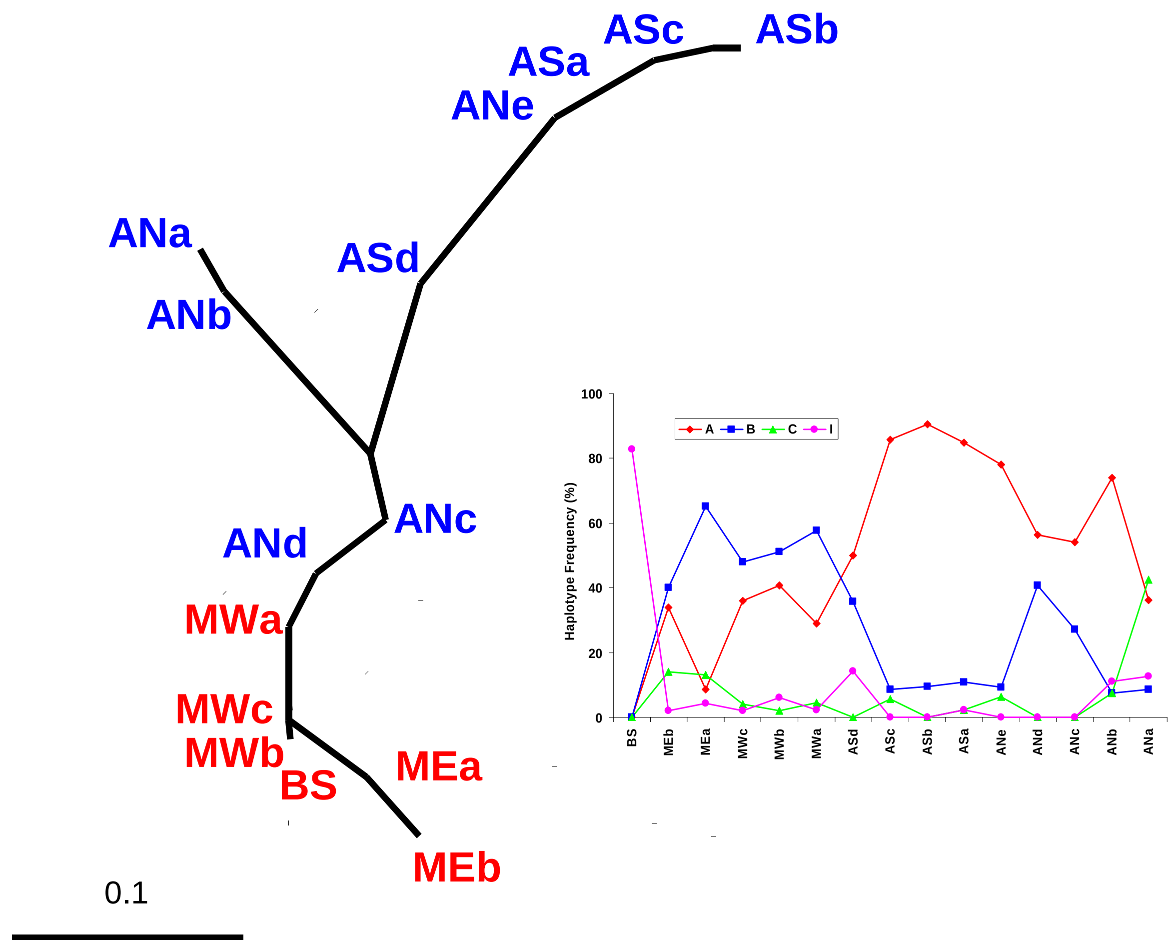
Sampling

- 15 populations sampled
- 14 to 50 individuals per location



Mediterranean sea versus Atlantic ocean differentiation

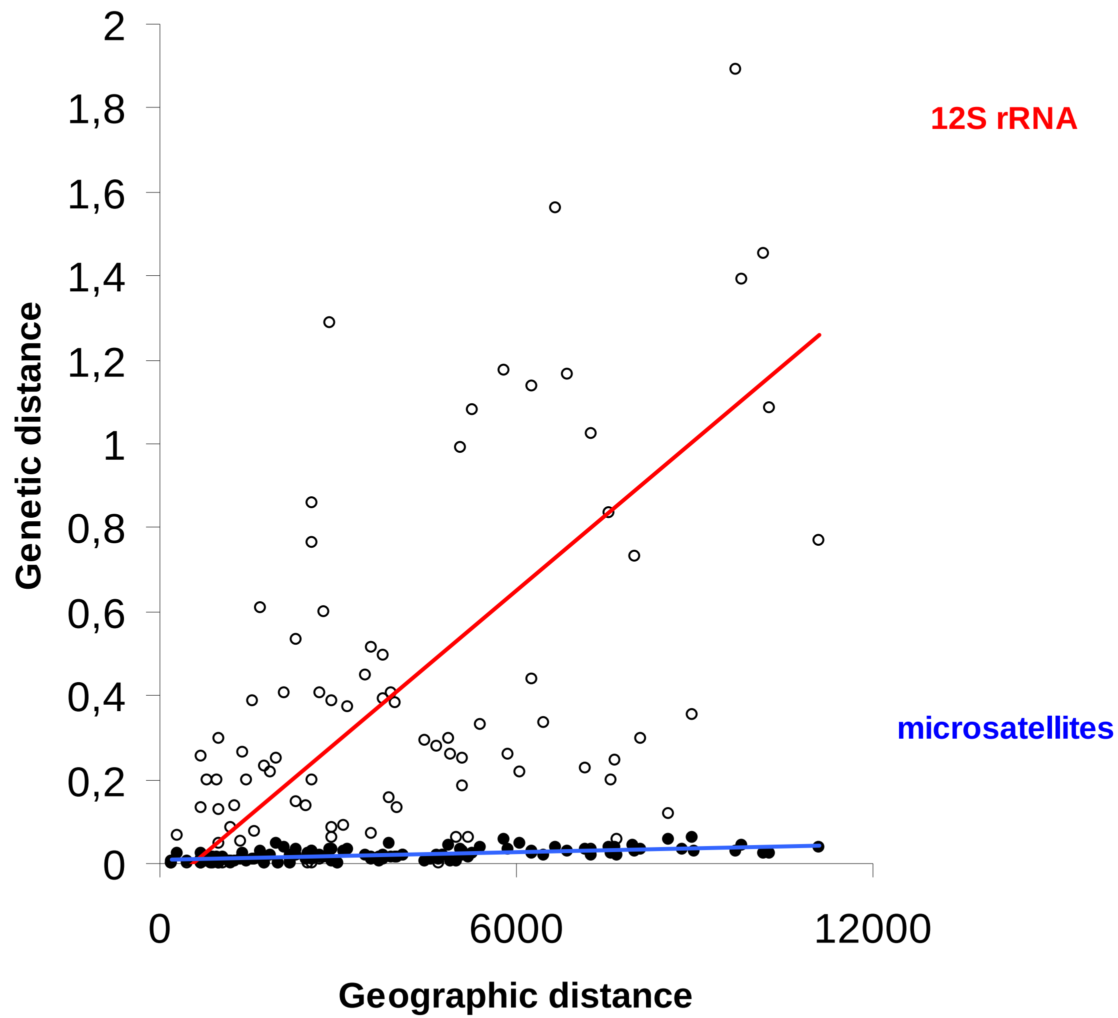




Microsatellites

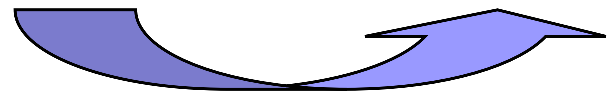
12S rRNA

Isolation by distance



Microsatellites
Fst = 0.019***

12S rRNA
Fst = 0.224***



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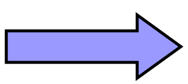


Higher variance in reproductive success in the female than in the male ?

Sweepstake hypothesis

Great fecundity, very high larval mortality

↓

variance in the number of offspring contributed by adults to subsequent generations.

Hedgecock et al.,2006 :
Cohort sampled during 10 days near Sète

	adult	cohort
number of alleles	23	14
		family structure

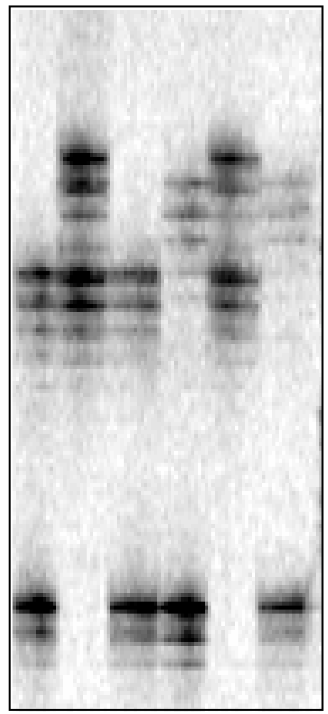
Parentage analyses

Natural population

Locus OeduU2

Allele 188

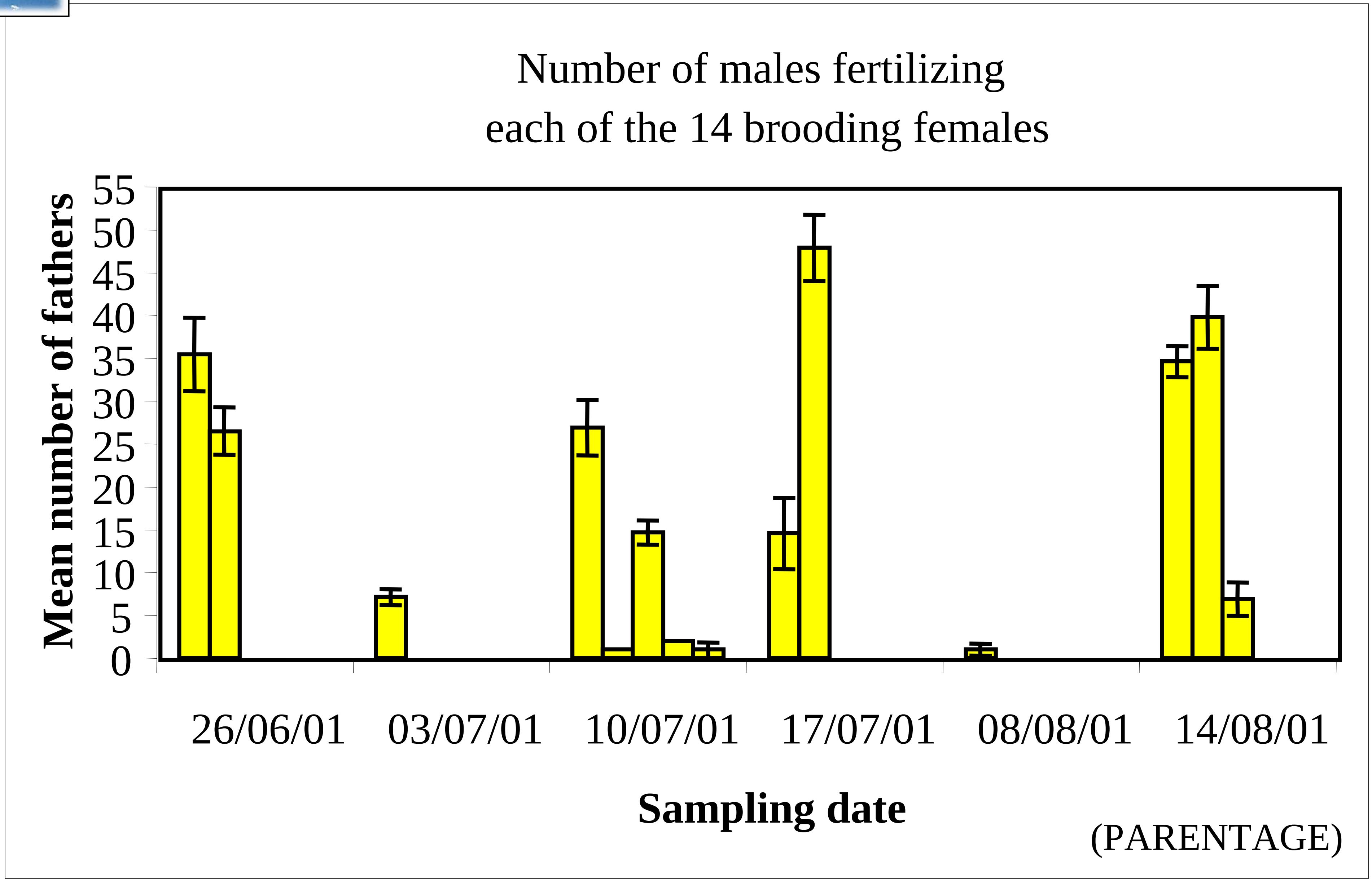
Allele 156



Experimental population

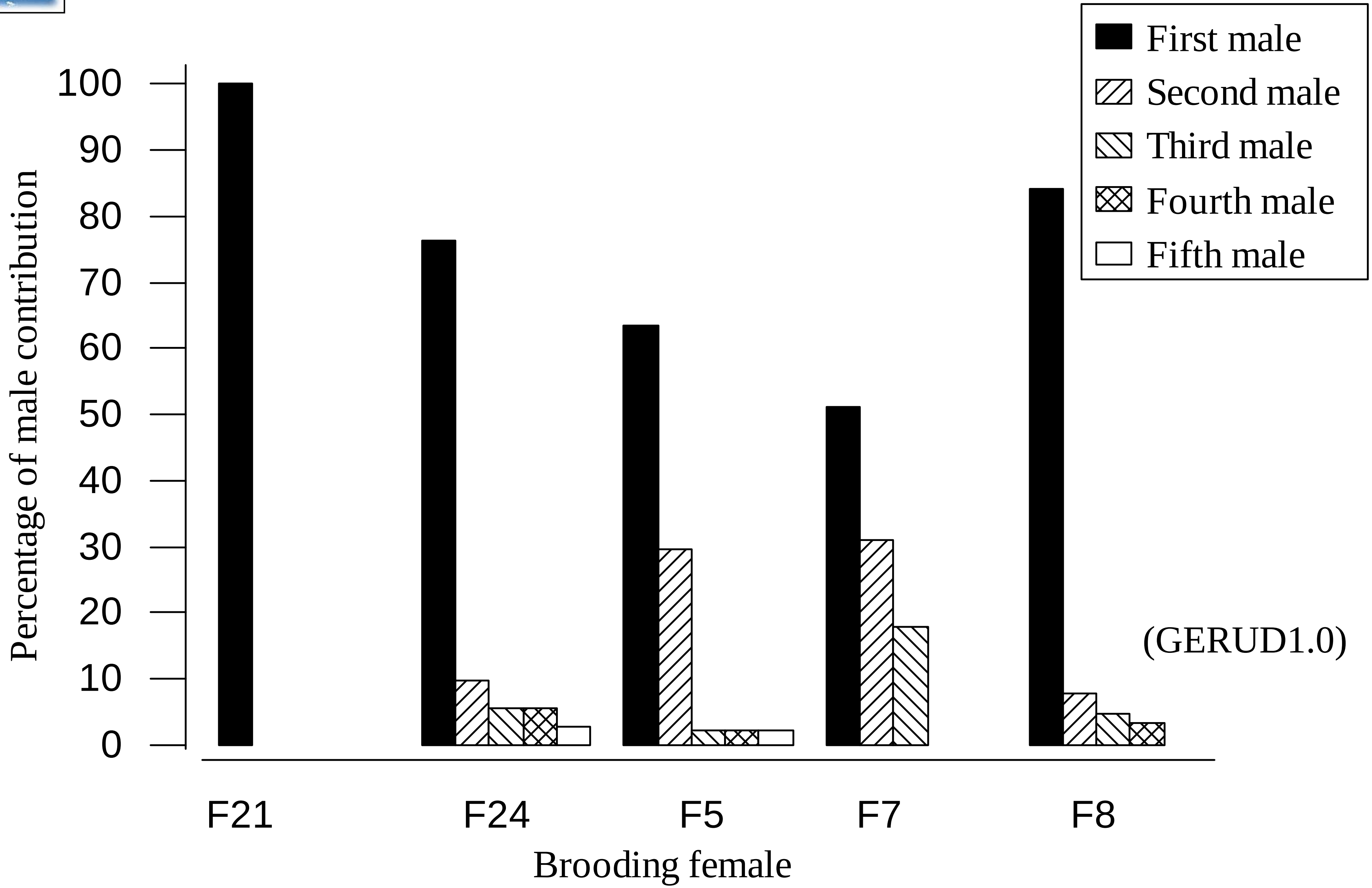
(Lallias et al., in prep)

How many males / female ?



Very variable number of males / female (1 to >40)

Male contribution within a female



Variance in individual male contribution : male with the highest contribution fathered from 51 to 100% of larvae

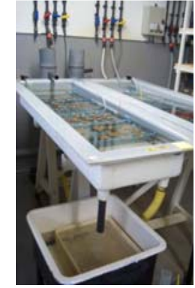
From the individual to the population

These results are of limited value to answer our inital question because :

- The population size is poorly known
- The effective population size is difficult to estimate
- The spatial distribution of males and females is unknown
- The effective sex ratio unknown
- …

What about experimental (hatchery) populations ?

Differentiation of the 6 mass spawnings



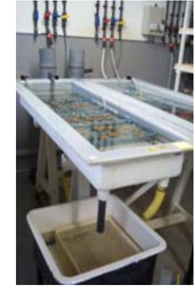
Fst x 100

	14/03/03	17/03/03	20/03/03	22/03/03	28/03/03	30/03/03
Adults	3***	5.5***	3.1***	1.5***	1.3***	1.2***
14/03/03	-	11.9***	7.1***	5.9***	5***	5.1***
17/03/03	-	-	9.8***	6.8***	7.9***	7.8***
20/03/03	-	-	-	0.7**	4.2***	4.5***
22/03/03	-	-	-	-	3***	3***
28/03/03	-	-	-	-	-	1.8***

	14	14+17	14+17+20	14+17+20+22	14+17+20+22+28	14+17+20+22+28+30
Adult	3***	1.1***	0.6**	0.6**	0.3*	0.2NS

- Highly significant genetic differentiations (1-12%)
- While pooling, genetic differentiation becomes blurred

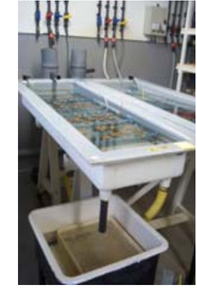
Effective population size

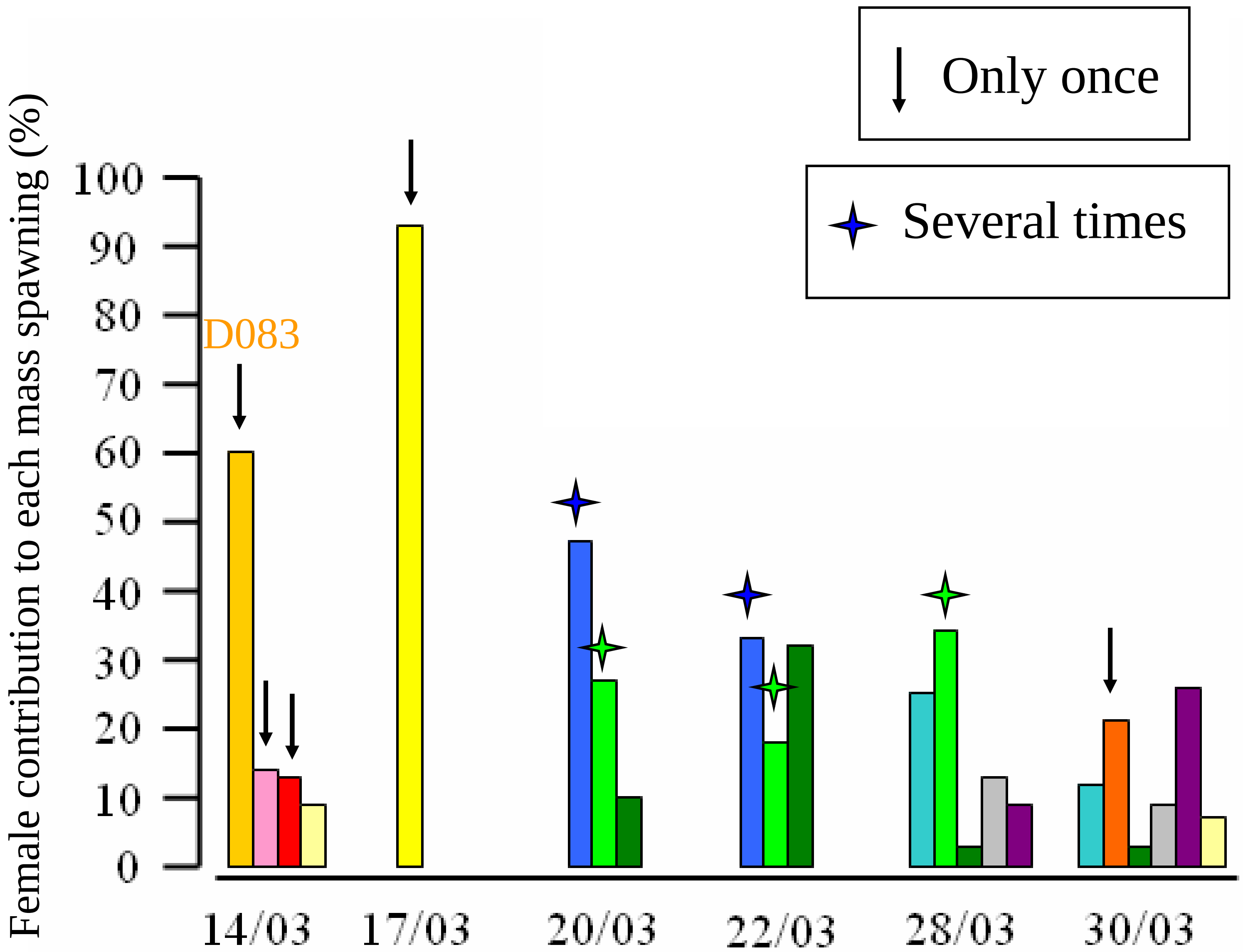


	Ne (temporal method)
14/03/03	21.0 [12.4 36.2]
17/03/03	12.5 [7.8 19.6]
20/03/03	21.0 [12.3 36.5]
22/03/03	22.3 [12.9 39.6]
28/03/03	33.2 [17.8 70.1]
30/03/03	29.6 [16.3 58.9]

- Relatively small Ne (12-33)
  - Genetic variability of a cohort : Ne<20 (Hedgecock *et al.*, 2006)
- Large 95% CI : small number of markers

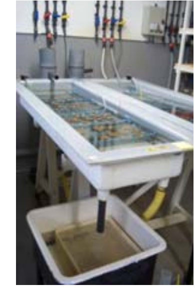
Female contribution

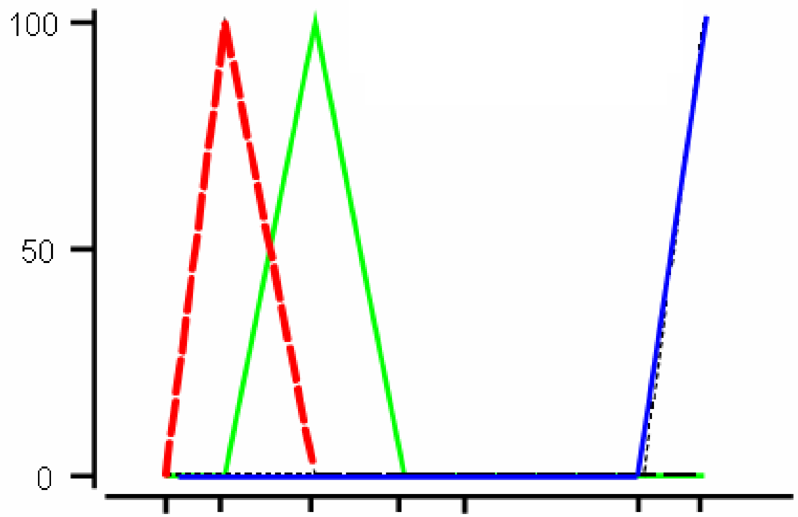




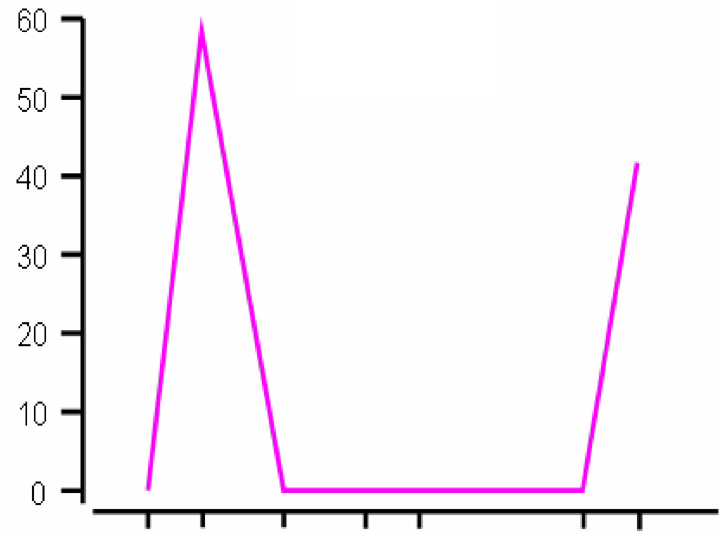
(PAPA)

Dynamics of Female release

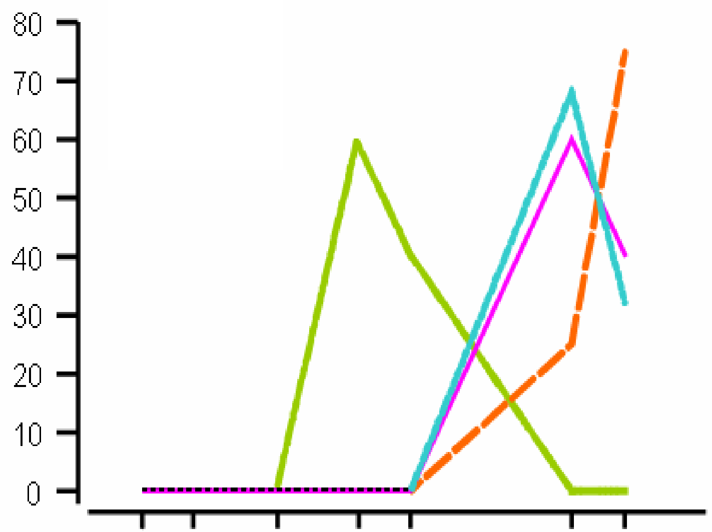




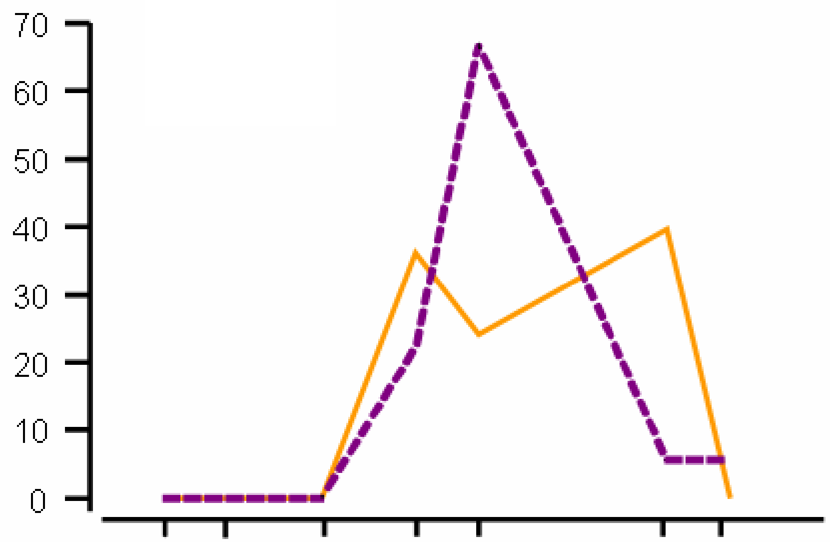
In 1 mass spawning



In 2 spaced mass spawning



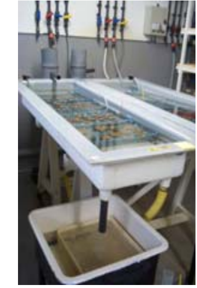
In 2 successive mass spawning

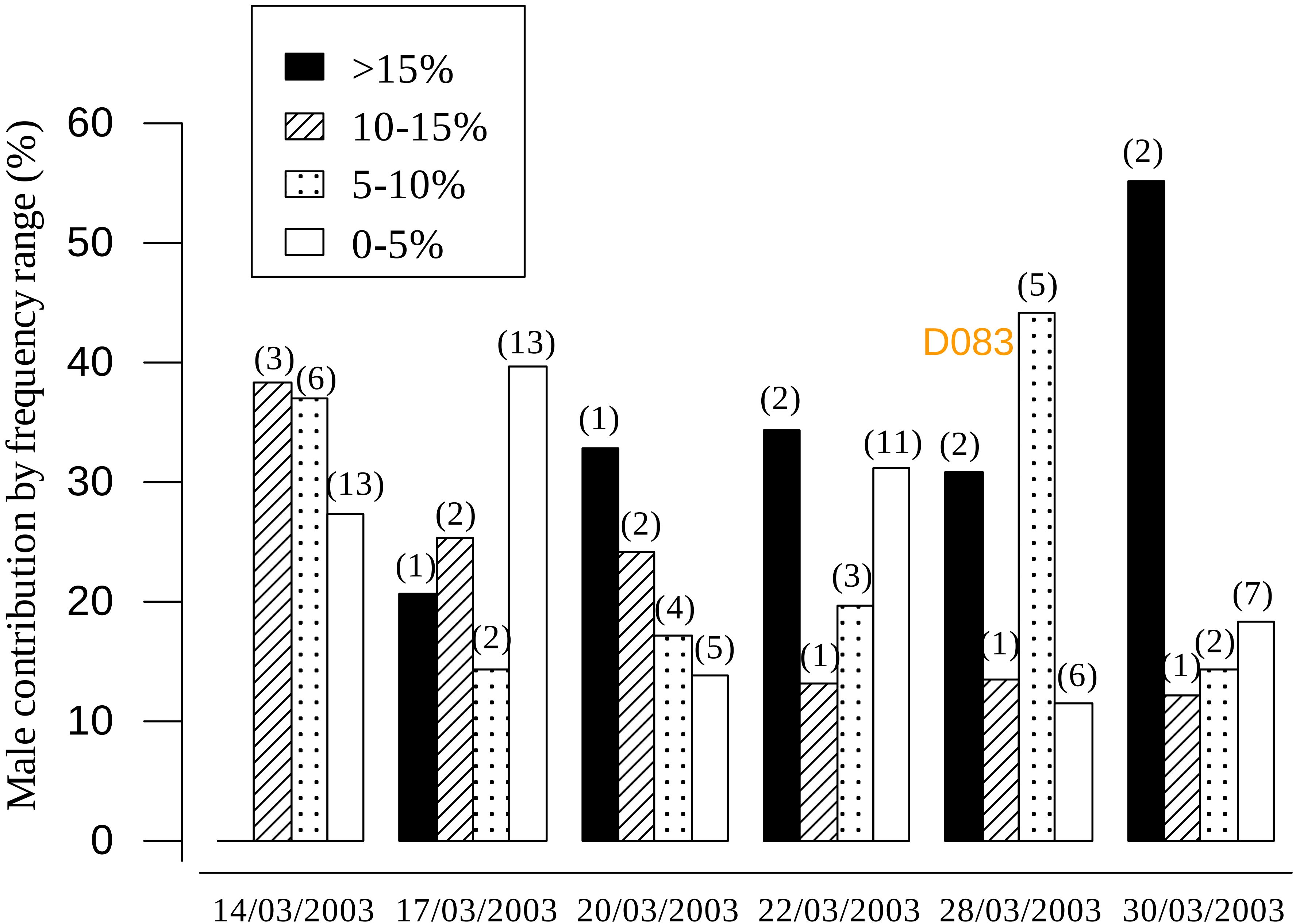


In 3 or 4 mass spawning

→ Variable extension in time of larval release and its dynamics

Male contribution





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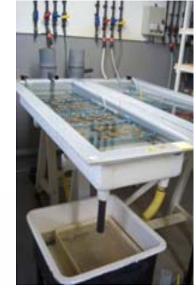
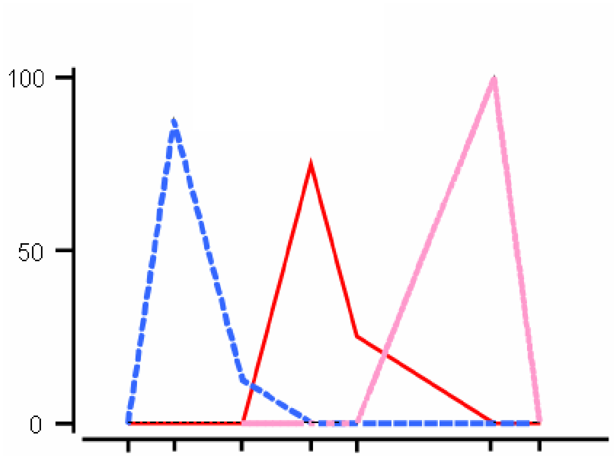
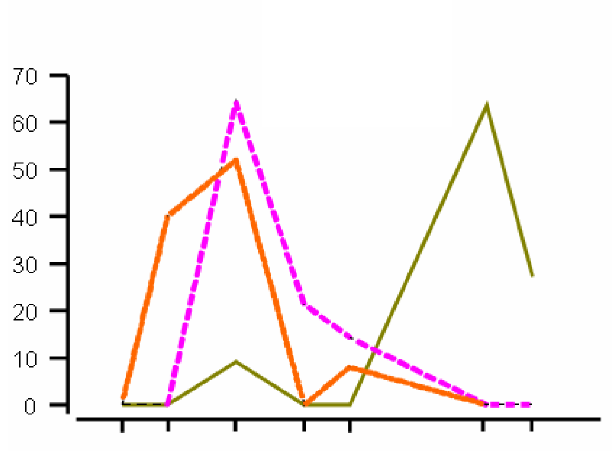
Dynamics of Male release

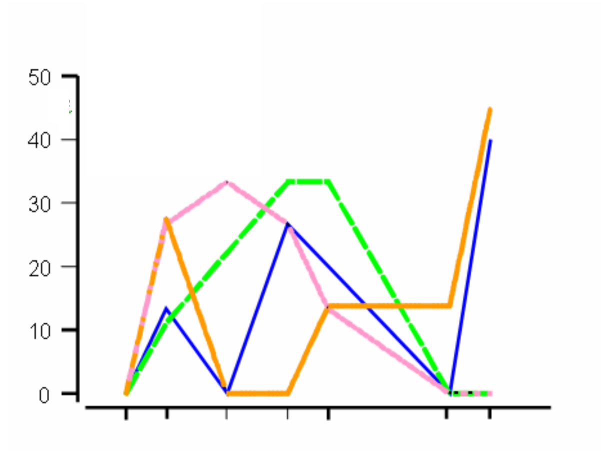




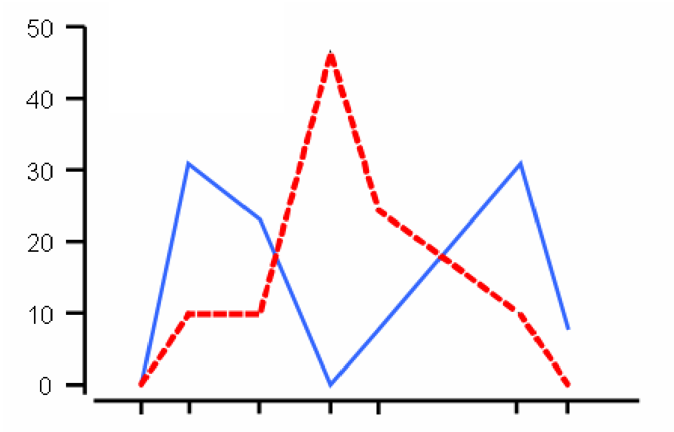
In 1 or 2 mass spawning



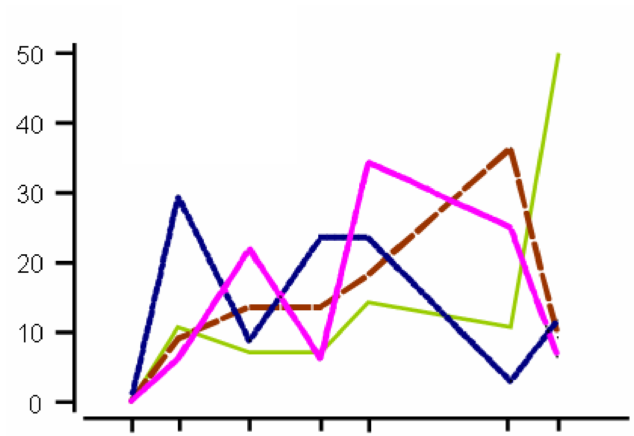
In 3 mass spawning



In 4 mass spawning



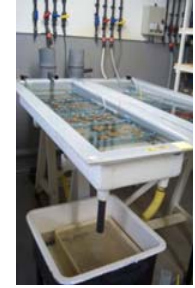
In 5 mass spawning



In 6 mass spawning

- More complex pattern
- Sperm release can be extended in time

Conclusions



- **Better knowledge of reproductive biology of *O. edulis***
  - Ability to change of sex very quickly (maturation of 2 types of gametes simultaneous)
  - Spawning of one individual does not stimulate the others
  - High variability in the temporal dynamics of emission of gametes and larvae

- **Relative variance in reproductive success in males and females**
  - For most females, spawning events are constituted by the progeny of several males (especially in our hatchery experiment)
  - Most males fertilize several females (hatchery experiment)
  - Effective reproductive period is longer for males that for females (hatchery experiment)

→ Higher variance in reproductive success in females than in males


Thank you for your attention