History and Economic Consequences of Species Invasions on Atlantic coast: *'good' & 'bad' examples*

P. Goulletquer, Ifremer - Direction Prospective & Stratégie Scientifique /
Prospective & Scientific Strategy Division in charge of Marine Biodiversity

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Biological Invasions - Decision-making and governance context

- One of top 4 negative anthropogenic impacts on the oceans…including severe loss of biodiversity !
- Recognized at the CBD level as a top priority (Decision VI/23 – CBD Convention, Article 8(h)
- Only 3 documented success of shellfish eradication at the worldwide level, and N^{ber} of invasive species increasing trend …. in spite of numerous instruments & international guidelines (CBD, FAO, ICES, IMO…)
  - **Lack of efficiency in addressing the issue !……*why & what should be done ?***

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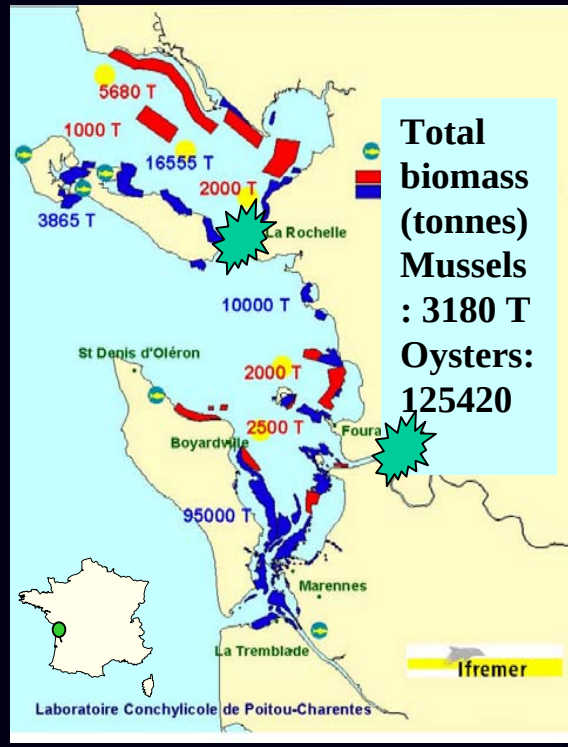
Vectors of Introductions along the Atlantic Coastline…

- Voluntary – deliberate introductions
  - **Aquaculture** (**Shellfish Production**: oyster batch transfers among regions - clam *T. philippinarum* (wild beds & leasing grounds)
  - **Commercial Trade** : import-export between Mediterranean countries and Atlantic areas.
- Unintentional Introductions
  - Escapees (from aquaculture, research, aquarium…)
  - Hitchikers (commensal, parasites, ballast waters & sediment, fouling organisms…. from s**hipping & sailing activities (**significant increase over the last decades and very limited number of dry-docks)
- Global change – change in distribution range - (presently without any status & not listed !)

One of the main vector of exotic species introduction….ballast waters & sediment

- Worldwide issue of ballast waters & sediments release in commercial harbors
  - XIXème = solid ballasts (e.g., sand, rocks, leading to plants & insects' introductions
  - XXème = liquid ballasts leading to invertebrate, shellfish, finfish, algae introductions
- Intensification of maritime transport : + 460% since the 1960 s !
- In France, 22M m^3/year without preventive treatment (*Masson pers. Com.*) :
  - High potential risks including public health
  - La Rochelle = 1,2 M^3/year in-between large shellfish leasing grounds areas – facilitating secondary introductions…
- IMO Convention regarding the management of ballast waters & sediments (13.02.04)……although not enforced and no facilities available to address the issue…



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E. I. S. in a Marine Environment …What kind of management ???

- Several responses to address the E.I.S. issue… ….

Increasing Associated Costs !!!

- **Prevention** (e.g., control of introduction vector - - ballast waters in open sea, ballast treatment, strenghtening rearing structures, sterile species for aquaculture, new regulation…)
- **Early Detection – Rapid Response** (e.g., monitoring network – role of scientific expertise!)
- **Control options** (e.g., limit the expansion, population management…)
- **Eradication** = almost impossible in open sea – only 3 case studies (in semi closed systems) !
- *Or…. NO Action …event more costly in the long term…!*

A case study : Trends of marine alien species in the Celtic -Biscay Shelf - Data availability and trends

- Census updated on a regular basis using scientific data (publications) and information exchange with scientists
  - 2002: 104 non indigeneous species
  - 2006: #160 species accounted for (4-5 new exotic species/year)
- Around 1/3 directly related to shipping activities
- About 10% showing an invasive pattern. The latest being :
  - A new genus-species sponge : *Celtodoryx girardae* (Gulf of Morbihan) (origin ?)
  - A new muricid *Trunculariopsis trunculus* (Bay of Arcachon) (origin Medit. or/and Algarve)
  - A red algae, *Polyopes lancifolius* (= *Grateloupia okamurai*) (Gulf of Morbihan – 2008) established on rocks and gravels near fine sand at low tide level and deeper (Japanese origin..)
- Around 10 species causing harmful economical & ecosystem side effects
- In contrast, at least four exotic species of major economic interest for coastal communities

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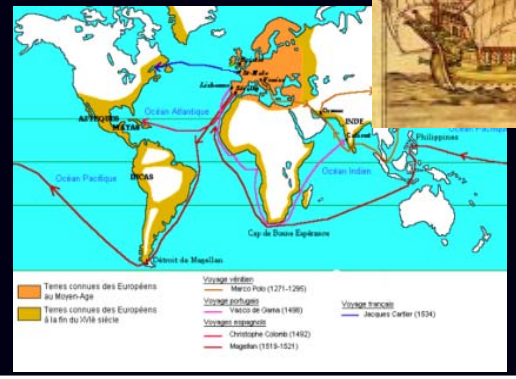
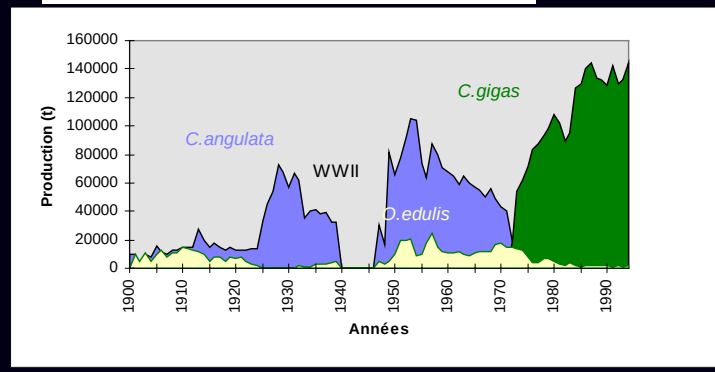
European shellfish economy based upon exotics over the XIXth & XXiest century….

- As a reminder, oyster culture & economy has been based upon the Portuguese *C. angulata* then the Pacific cupped oyster,*C. gigas* both exotics unintentionnally & intentionnally introduced ….
- Still, the French oyster industry [3750 companies, >10,000 labor-force, 110,000 tons landings] relies on exotics…(Agreste, 2005)
- Similarly, clam production is based upon *Mercenaria mercenaria* & *Tapes philippinarum* (escapees from shellfish culture to built significant wild beds >5,000t - Atlantic)

Portuguese explorations





French oyster landings…

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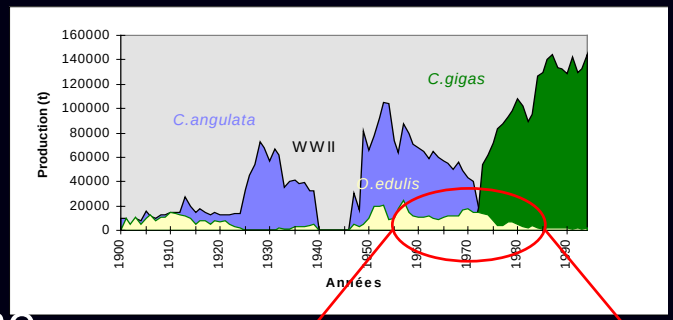
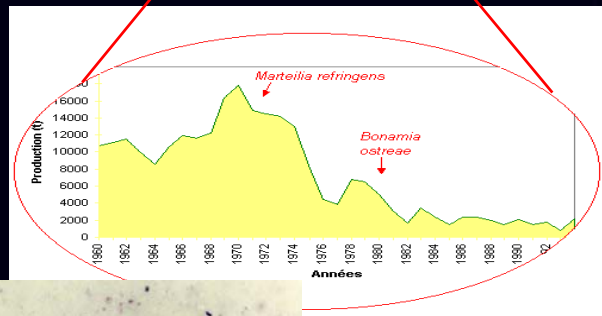
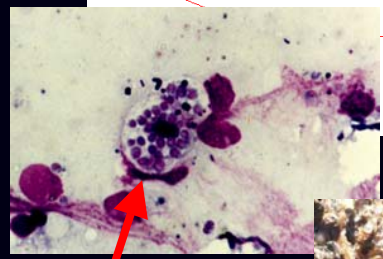
Concomitant side-effects to this industry

- *commercial activities & transfers.*

- Iridovirus origin causing the *C. angulata* collapse ?
- Protistan parasite *B. ostrearia* (from California, USA) – responsible for the European flat oyster industry collapse during the 80s' – no recovery-
- Asian Drillers: - shellfish predators – gastropods
  - *O. inornatus*, - initial introduction concomitantly to C. gigas (70s') – invasive pattern since 1990's – numerous 2ndary transfers due to oyster culture
  - *R. venosa* (15cm length) (*introduced into US Chesapeake Bay by ballast waters)* & in Southern Brittany by clam transfers from Adriatic



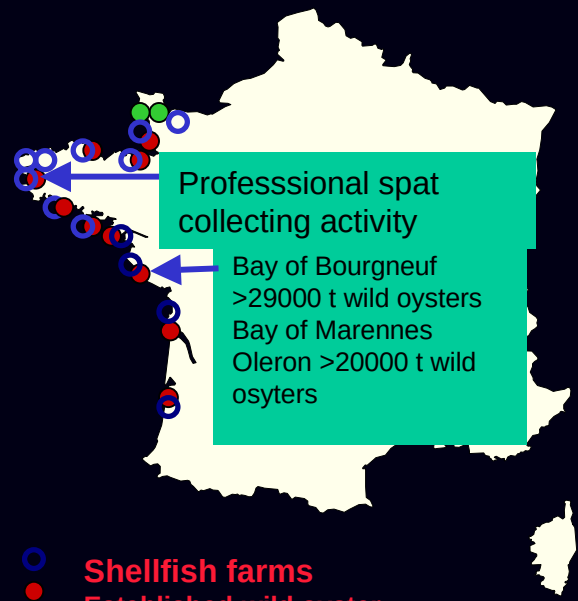




Bonamia

Recent invasive pattern for the *C. Gigas* population in European waters … (major changes since the 1990's)

- Massive introduction during the 70s' to sustain the collapsing oyster industry (*C. angulata*)
- Natural repoduction below the Loire estuary until the 1990s'
- Out of control since then … in France as well as in European waters (UK, Netherlands…)…Major ecosystem disruption by overstocking – although no biodiversity initial loss
  - *Beyond a T°C threshold..the trigger to shift from 'exotic' to 'invasive' ??*
  - *Increased physiological activity due to climate change …..& Carrying capacity (1.5°C # 15000 t oysters) in the Marennes Oleron Bay)*
  - *Overstocking & food web changes*



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New management practices to limit the C. Gigas population expansion & side effects


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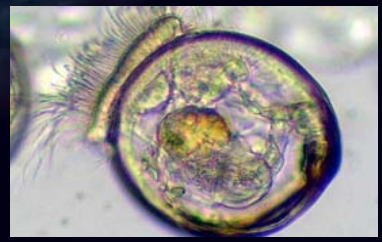


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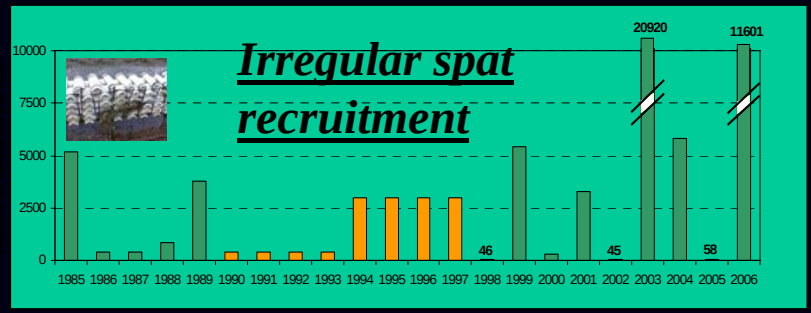
- Significant economic impacts
- A monitoring network for wild oyster populations
- Industrial equipement to remove oyster wild beds - clean & restructured leasing grounds
- Yearly management over the last 25years
  - 77 ha cleaned per year in the Bay of Marennes Oleron
  - 55% of the leasing grounds restructured over the last 10 years (*Miossec & Coic, 2008)*

(Pouvreau & Bernard, 2008)




SRC MO

The Slimper limpet *Crepidula fornicata*

(subtidal & tidal)

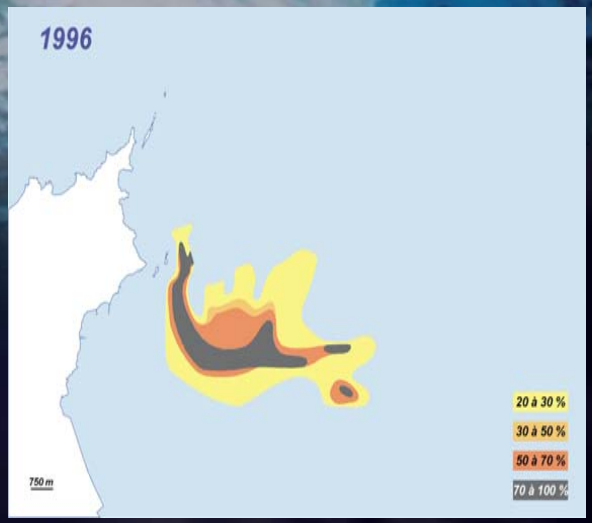
- ***Crepidula fornicata*… still has a major impact on scallop fishery and protected habitat after the initial introduction more than 1 century ago, and the susbsequent colonization along European coastline…**

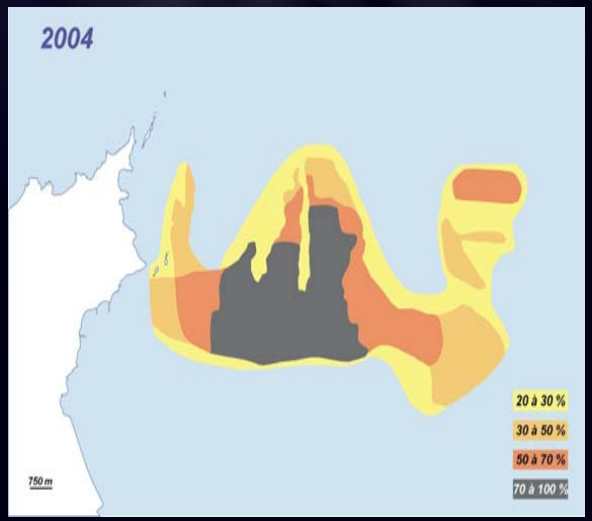
- **Overall trends in the Bay of Mt St Michel without management *(Hamon, 2008 - Blanchard et al., 2008)***
  - **1996 = 100 000 t.**
  - **2004 = 150,000 t**

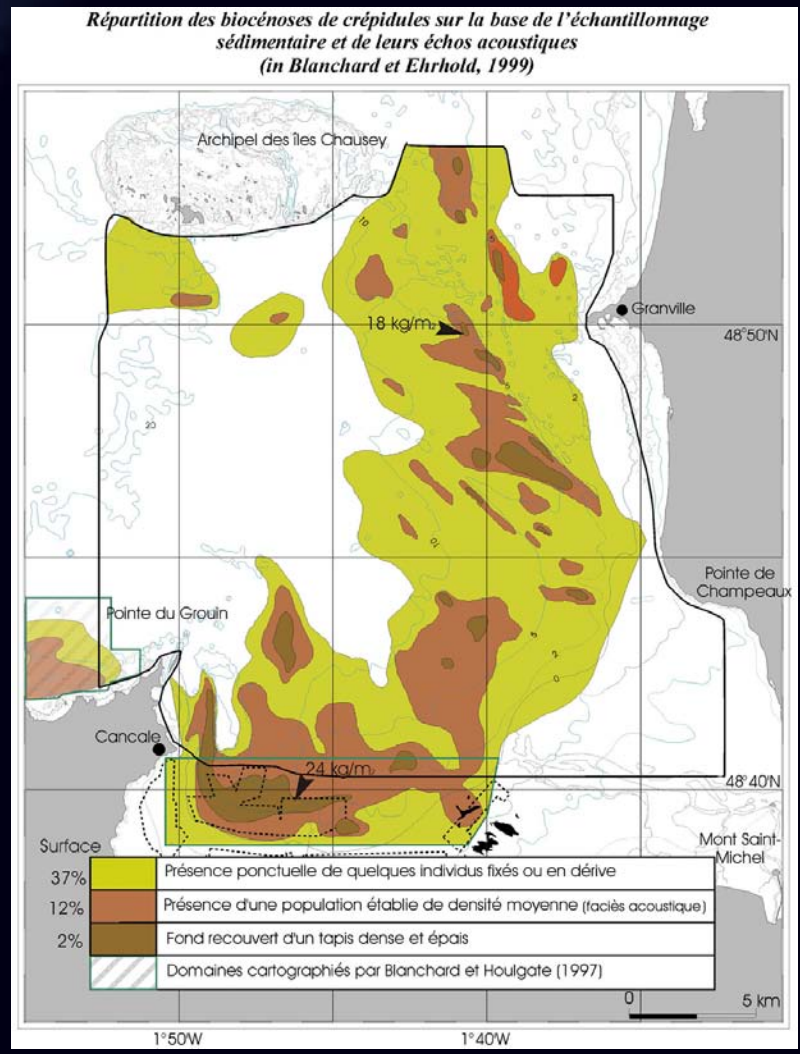
- **50 % increase over 8 y & on-going spatial expansion**

Two exotics Styela clava on *Crepidula in* the Bay of Mt St Michel, Fr (Le Mao, 2008)

Credipula fornicata invasive pattern…







Expansion trends

Chausey Islands –200 000 t. stocking biomass

(Blanchard et Ehrhold, 1999)

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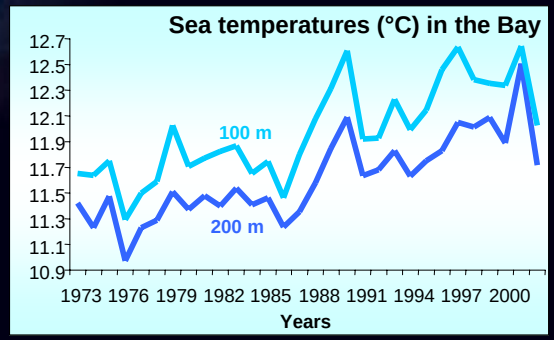
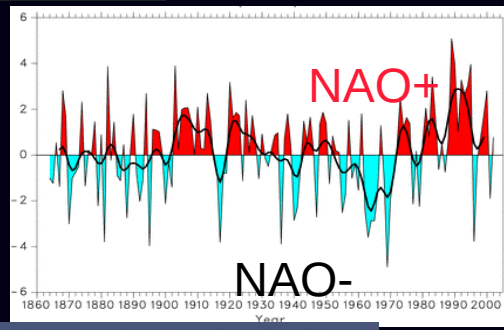
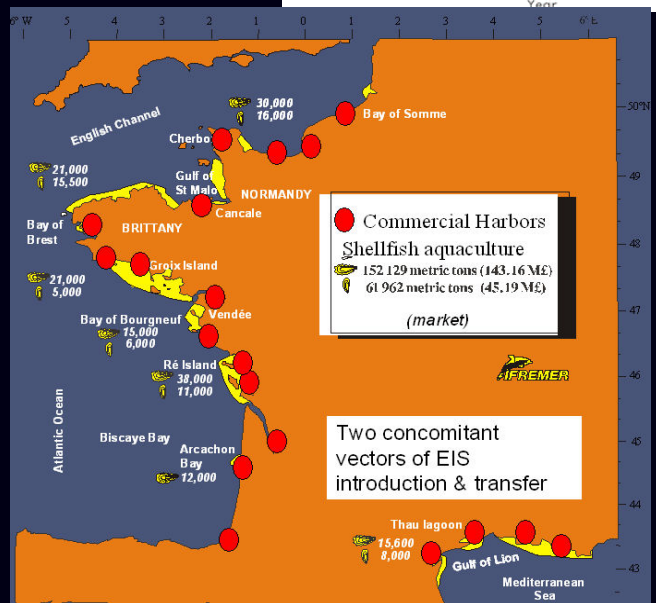
Species Invasions & Global Change

- Bay of Biscaye is facing at least three major changes:
  - Seawater temperature increase (°1,5°C over the last 25y) & variability
  - NAO positive trends…
  - Drastic decline of freshwater inputs (quality & quantity) due to weather change & concomitant watershed activities modifications (e.agriculture-irrigation)
- 'Marinization' of estuaries leading to increased potential risks for new invasions due to harbor location…
- New subtropical species (cf. HAB & dinoflagellate *F. duplocampanaeforme* (Nézan & Chomérat, 2009)







Ecosystemic Approach & Research needs

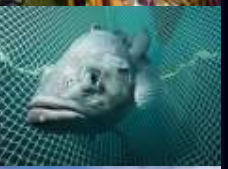
- Stil uncertainties regarding **vector of introduction** & **species origins**…
- Previous examples demonstrate the need to better analyze and understand **interactions & synergetic effects** among vectors…& develop risk analysis approach to optimize management options…
- Biogeography studies using population genetic approach with genomic mapping & microsatellites markers helpful to develop further management :
  - *Alexandrium tamarense* complex in Mediterranean seaside 3 species : climate change vs ballast vector of introduction) (UMR ECOLAG-Ifremer 2009)

Governance issues….

- EU regulation on the use of exotics in aquaculture
- MFSD Marine Framework Strategy Directive (2008)….one of the descriptor = Invasive species
- Requirement for monitoring & reaching Good Ecological Status !
- IMO Convention 2004: to implement & enforce ‘asap’….although no regulation yet regarding hull fouling (underestimated issue !)
- New trans-sectorial regulation (shellfish transfer vs environnement)
- Biodiversity economic value: development of banking system & compensation system…(cf carbon market).
- Increase public awareness and training to facilitate ‘Prevention‘ management option …

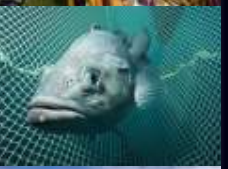


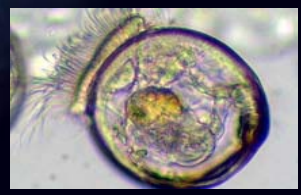



Conclusions

- Species Invasions along the Atlantic coastline have provided numerous ‘good’ as well as ‘bad’ examples for the environment & the economy
- Several living resources economics are based upon the species ‘invasiveness’ pattern – e.g. Shellfish aquaculture & fisheries
- Historical cases demonstrated that initial ‘Undercontrol’ does not mean permanent ‘Undercontrol’…(even with a time lapse of 20 years !)
- Understanding ‘interactions’ among human activities, ecosystems & global changes is critical for further management options [including biogeography research]
- Once established, the situation is irreversible therefore requiring very skillfull preliminary assessment
- New approaches should be developped to prevent any unintentional introduction as well as to limit side effects of on-going invasions
- Present situation is deteriorating and underestimated..!





- Thank you for your attention….