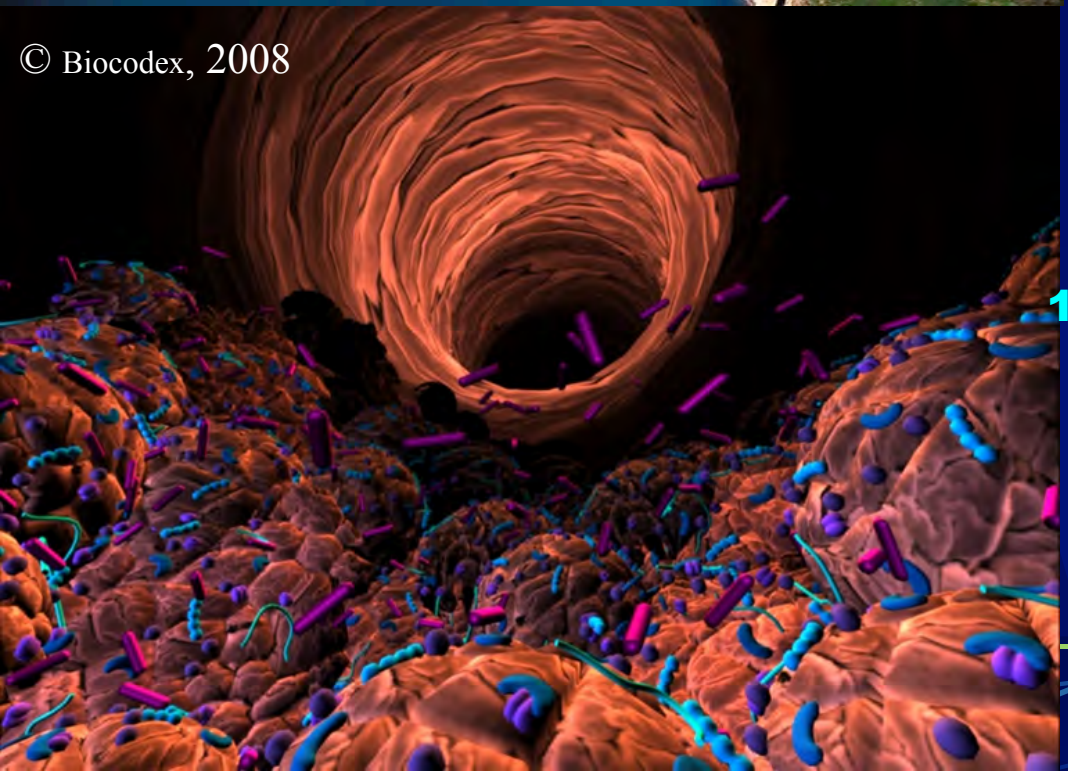


You said... Biodiversity?

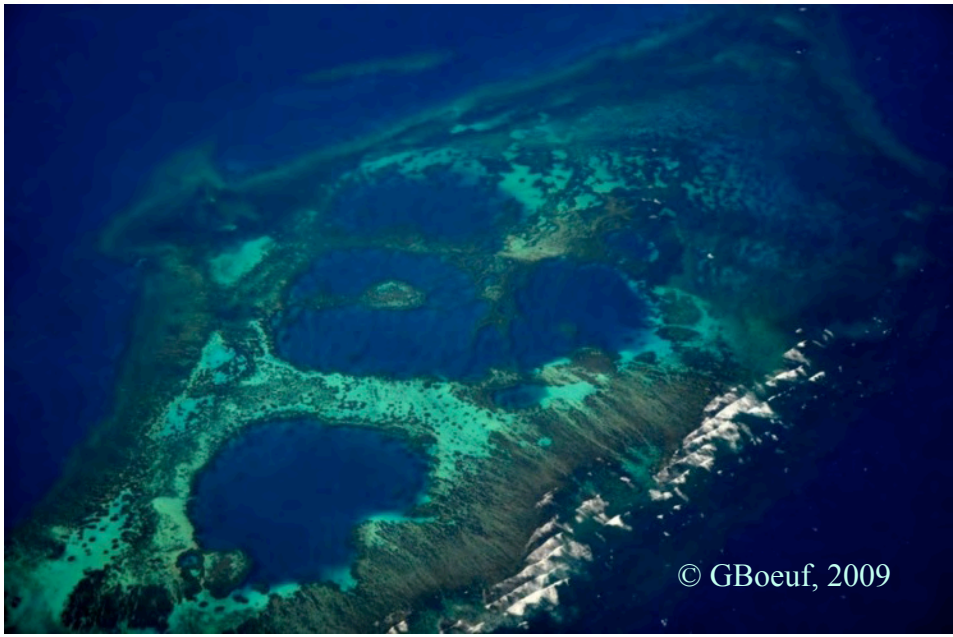
2010-2020: why international 10 years dedicated to Biodiversity?

Gilles Boeuf, Laboratory Arago,
University Pierre and Marie Curie/
CNRS ,Banyuls-sur-mer
Muséum national d'Histoire naturelle, Paris

Vienna, EGU April 2011

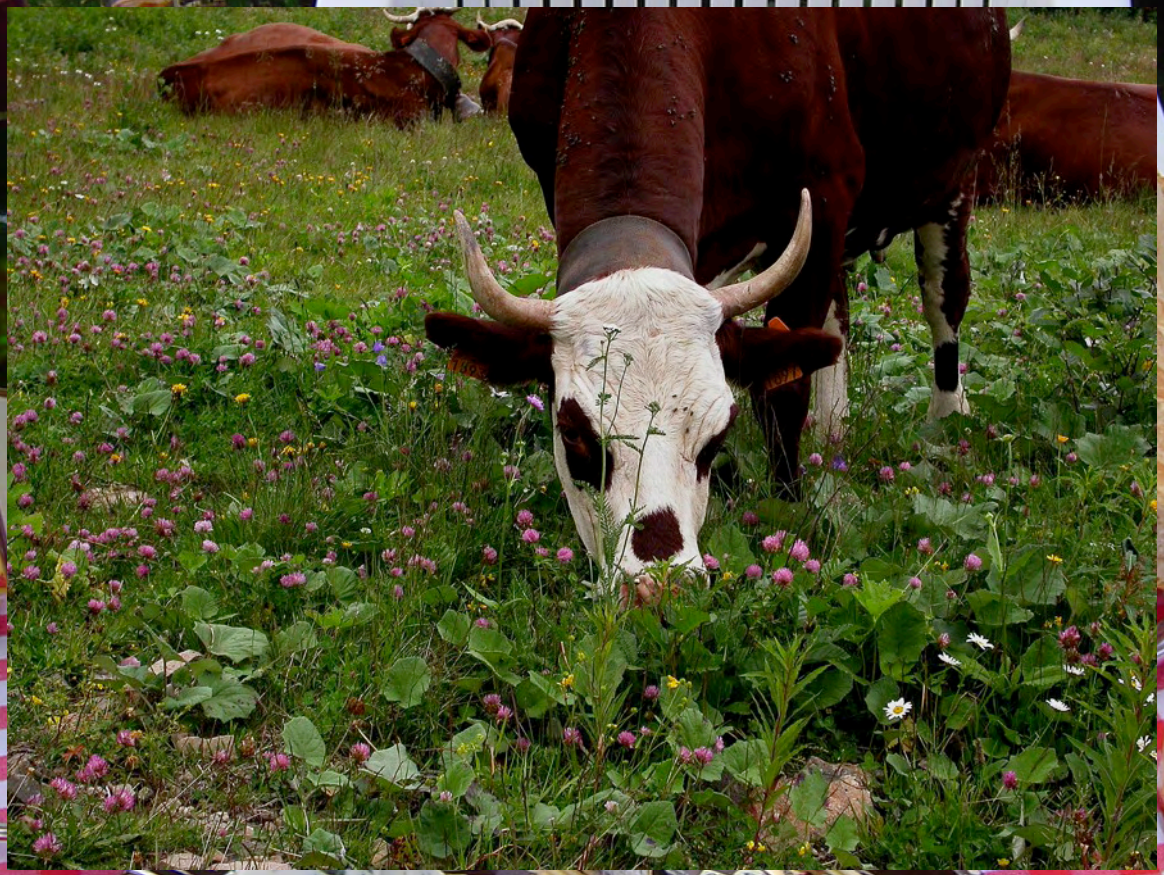
Biodiversity?

> 1.6 million of continental species



< 0.3 million of marine species

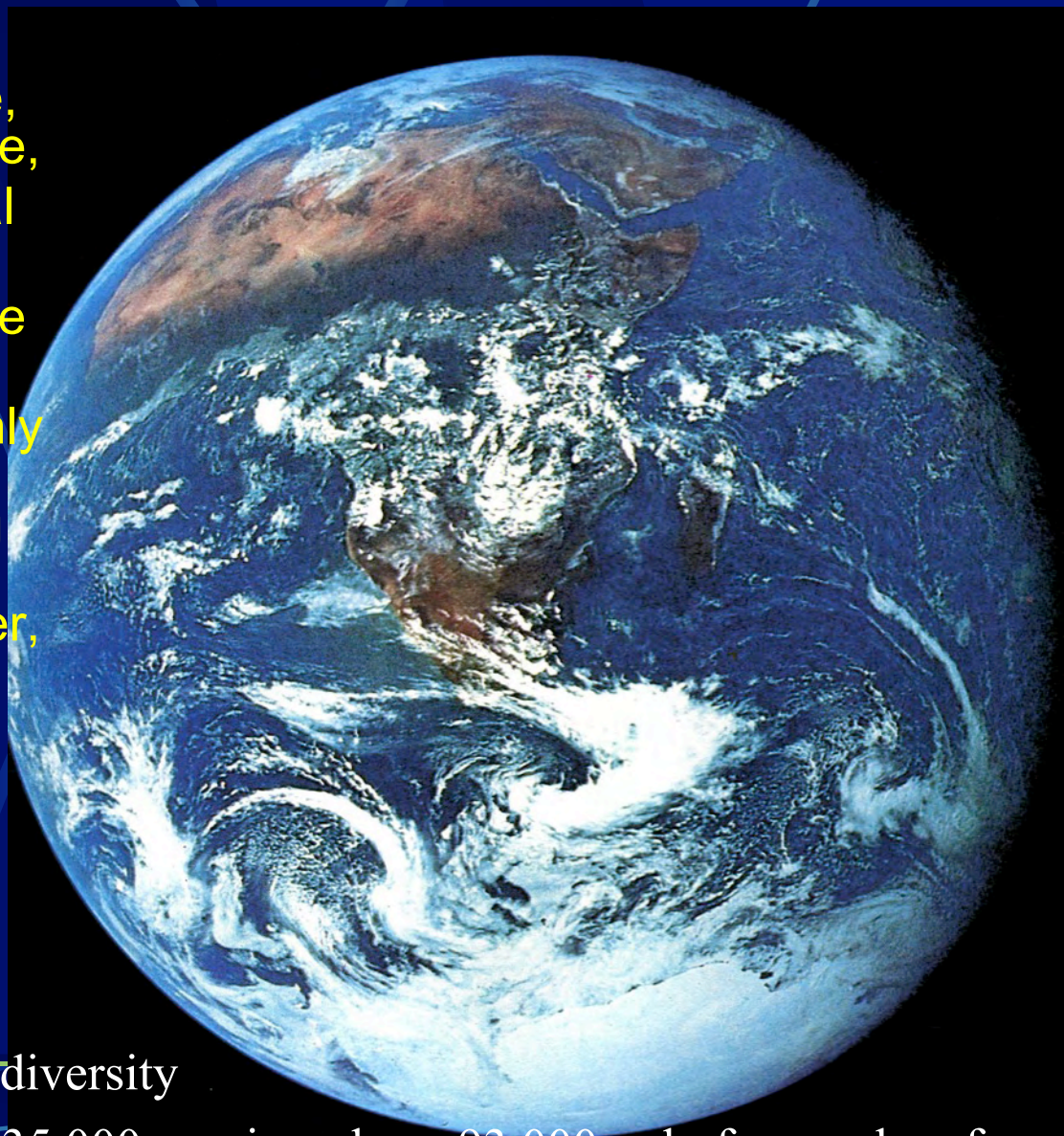
It is the living part of Nature, the living in its diversity and complexity


Château de
VIN JAU
1990
TOKAJI
ÁSZÚ
Clos Chevrel

Blue Planet

- Seas and oceans cover more than 71 % of the Earth surface, the blue planet, 99 % in volume,
- Life emerged in the « ancestral Ocean »,
- Salted water characteristics are very specific,
- 12 animal phyla (on 31) are only marine, 13 % of the known species, but 10 % of the living carbon biomass are due to bacteria of the subsurface layer, >50 % for phytoplankton!

CSMonaco, 2004



Species diversity

235 000 species whose 93 000 only for coral reefs

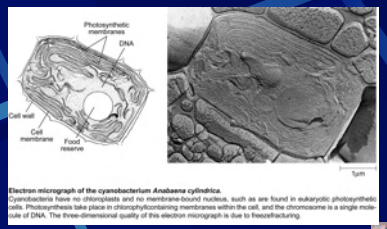
I
Life Story


Légende photo : Baie de Yaté
Mention obligatoire de copyright du photographe à apposer en marge de la photo : © Sébastien Mérion / Tikiwaka.com


©MTaquet, Ifremer, 2004

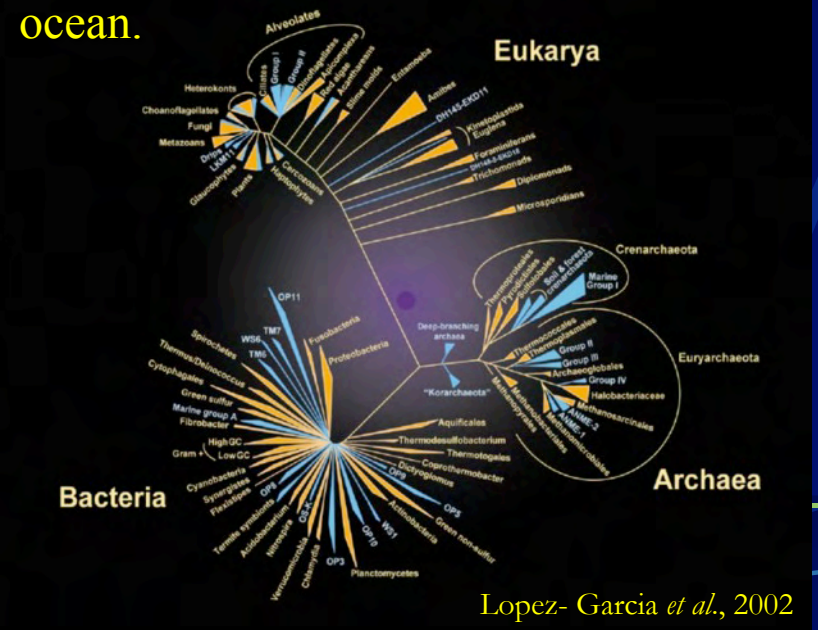
Origin and evolution of Life

Protocells emergence
RNA world
Cyanobacteria 3.5 BY ago



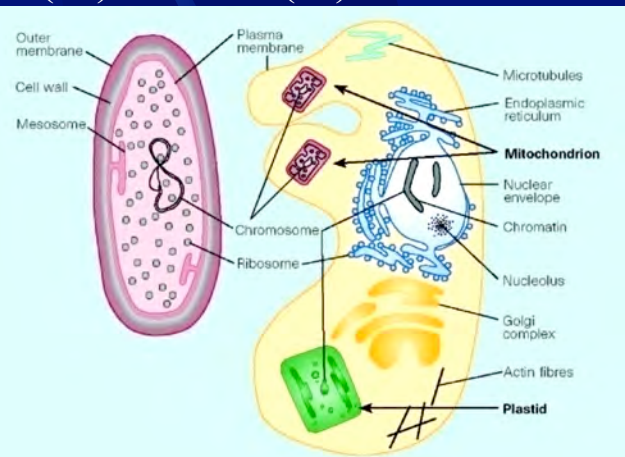
Critical events for the future occured in the ocean: development of the nucleus, « pluricellularity » (metazoans), capture of micro-organisms by cells which became afterwards organelles through symbiosis, mitochondria and plastid,
Later on, sex (1.5 By) also developped in the ocean.

Prokaryotics-Eukaryotics, 2 .2 BY,
Protozoans-metazoans, 2.1 BY
Organelles, 1900 (M) et 1400 (Pl) MY



Lopez- Garcia *et al.*, 2002

El Albani *et al.*, 2010



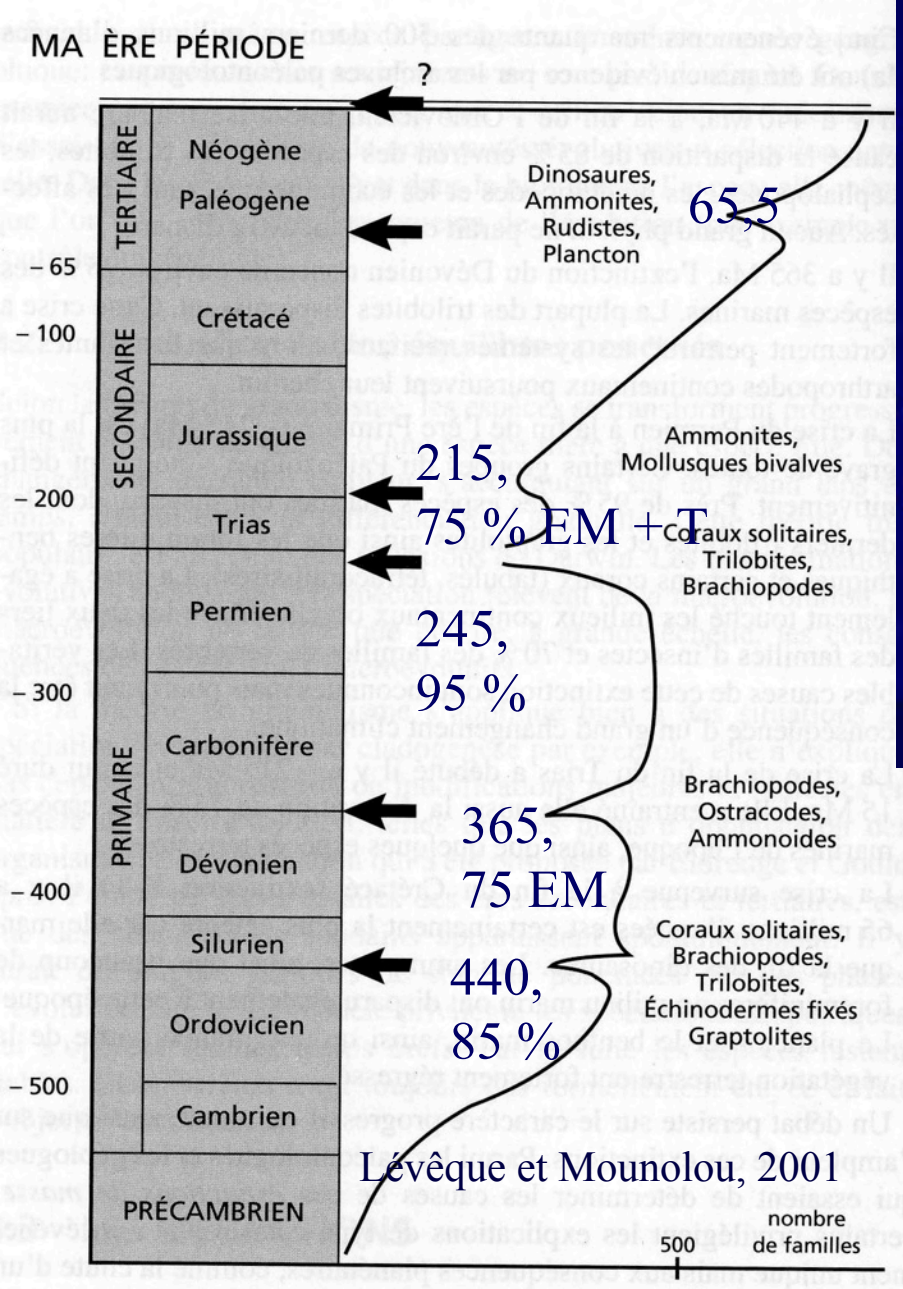


Figure 3.1 Les différentes périodes géologiques et les principales extinctions de masse mises en évidence par la paléontologie.

The largest mass extinction occurred at the end of Permian (ca. 250 million years ago)

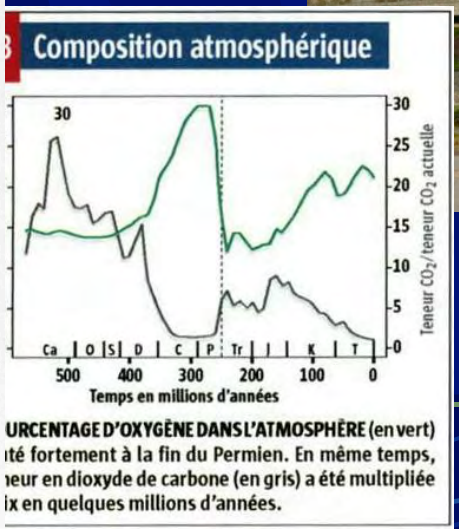
- It was caused by asteroid impact, intense volcanic activity, atmospheric warming (6°C) and methane emission from oceanic gases hydrate deposits.
- Ca. 95% of species died off in less than 4 million years.
- One hundred million years were needed to bring back biodiversity to its previous level.

Benton & Twitchett, 2003

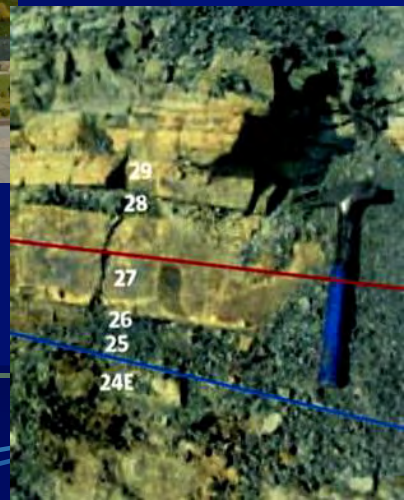
Gaston & Spicer 1998.

Crasquin, 2006
© La Recherche

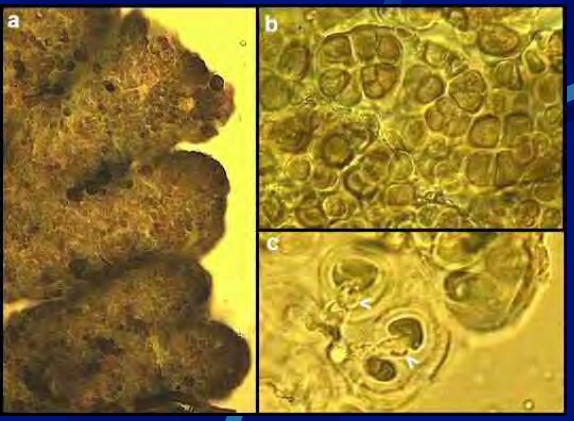
Meishan in China
bed 25 free of fossils!

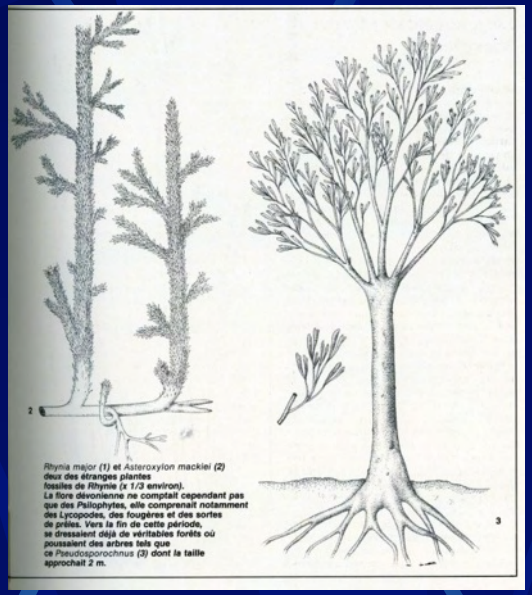


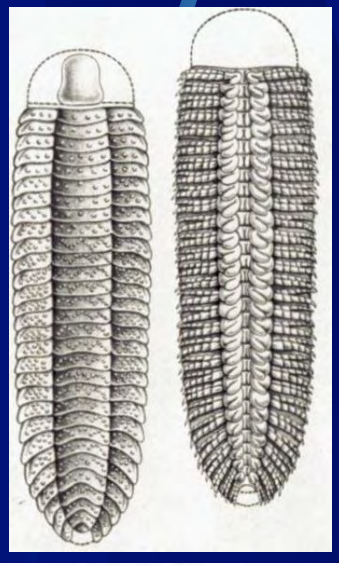
URCENTAGE D'OXYGÈNE DANS L'ATMOSPHÈRE (en vert)
ité fortement à la fin du Permien. En même temps,
neur en dioxyde de carbone (en gris) a été multipliée
ix en quelques millions d'années.

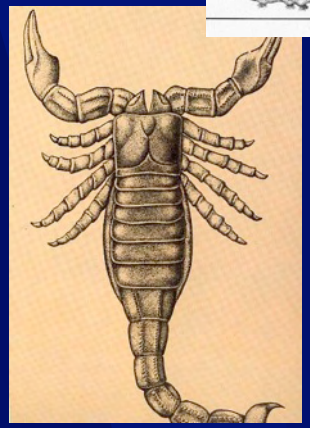


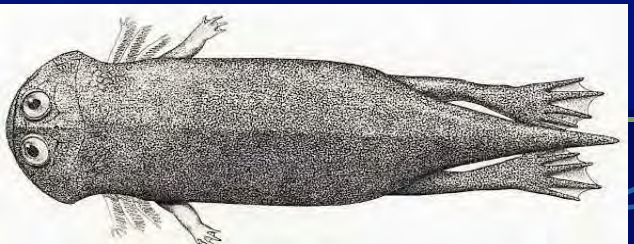
Getting out of the oceans











© JJHublin, 1979

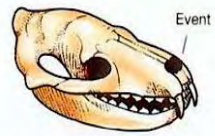
440 MY

Go back to the ocean

Gingerich et al., 2001

Rhodocetus, 47

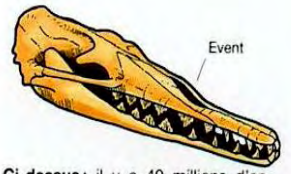
Pakicetus
50 MY



i-dessus: il y a 50 millions d'an-ées, le *Mesonyx* possédait un crâne obuste et relativement peu spécia-sé, caractéristique des mammifères rrestres.

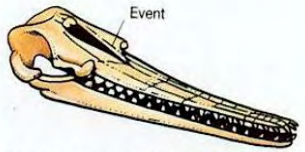
Ci-dessus: 5 millions d'années plus ard, les protocétidés révèlent déjà de nombreuses adaptations à la vie ma-ine, dont l'allongement du crâne en un « bec » ou « rostre ».

Indohyus
53 MY



Ci-dessus: il y a 40 millions d'années, les dorudontidés étaient parfaitement adaptés à une vie marine — un rostre bien défini s'est développé et les narines reculent vers le sommet du crâne.

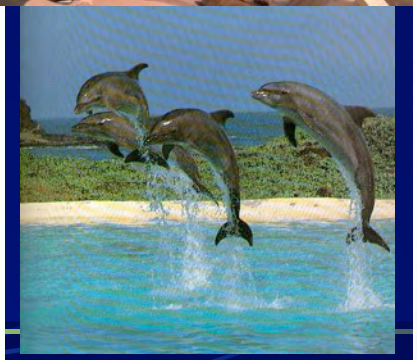
Ambulocetus natans
Archeocete from the middle Eocene, in Pakistan
Thewissen *et al.*, 2001

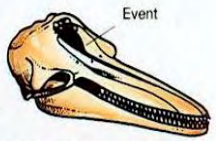


Ci-dessus: il y a 25 millions d'années, les squalodontes (dauphins à dents de requin) présentent de nombreux traits communs avec les cétacés à dents modernes, y compris l'évent proche du sommet du crâne.

38 MY

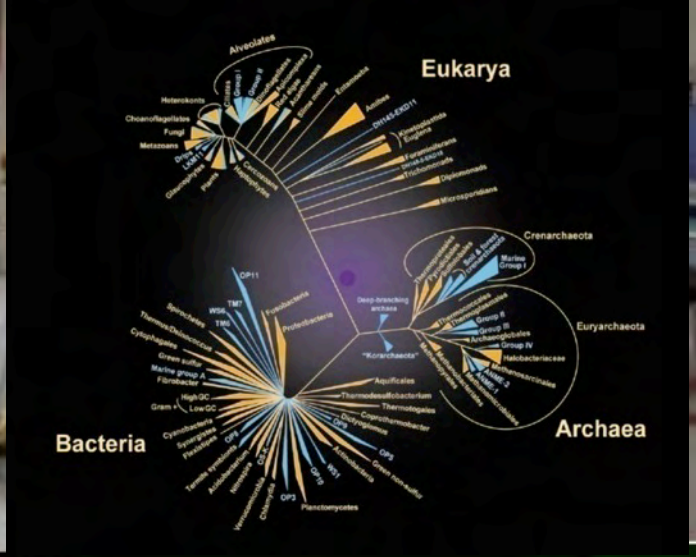
48 MY





Ci-dessus: au moment où les dauphins modernes apparaissent, il y a 15 millions d'années, la forme du crâne est bien établie et les dents se sont multipliées tout en perdant leur complexité structurale.

De Muizon, 2008



Naegleria fowleri

Giardia spp.

Cryptosporidium parvum

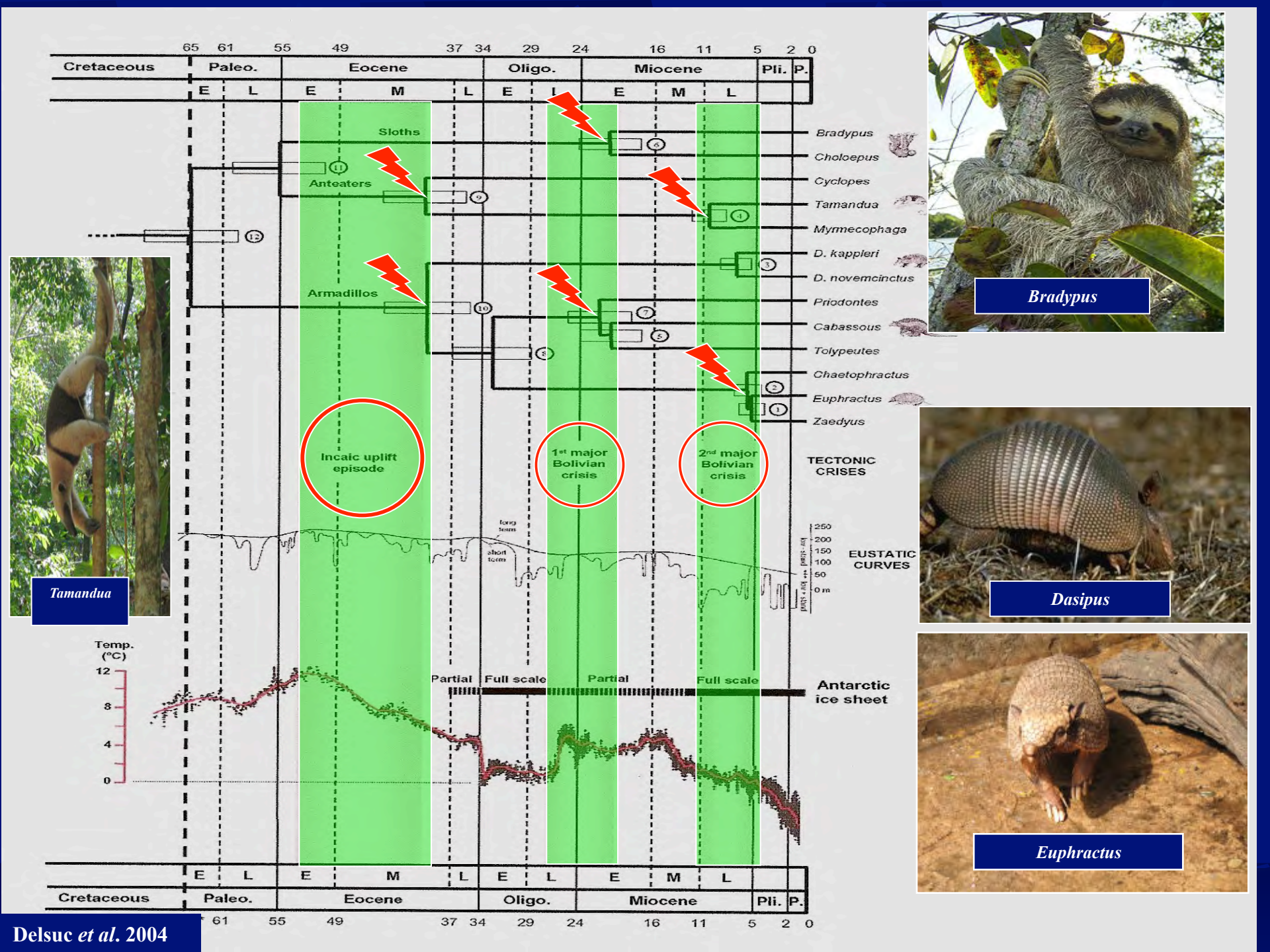
P Lebaron,, Lab Arago, Banyuls 2002

Legionella pneumophila

Escherichia coli

Virus et bactéries
Eau de mer naturelle

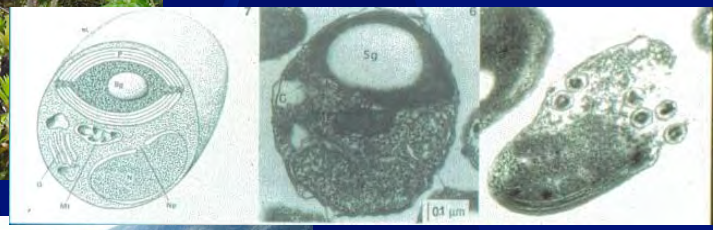
« …*Most organisms smaller than 1 mm occur worldwide wherever their required habitats are realised. This is a consequence of ubiquitous dispersal driven by huge population sizes . Metapopulations of microbial eukaryotes are cosmopolitan*…" Finlay & Fenchel 2004. "…*Current evidence confirms that, as proposed by the Baas-Becking hypothesis, 'the environment selects' and is, in part, responsible for spatial variation in microbial diversity. However, recent studies also dispute the idea that 'everything is everywhere' …** ». .Martiny *et al*., 2006.

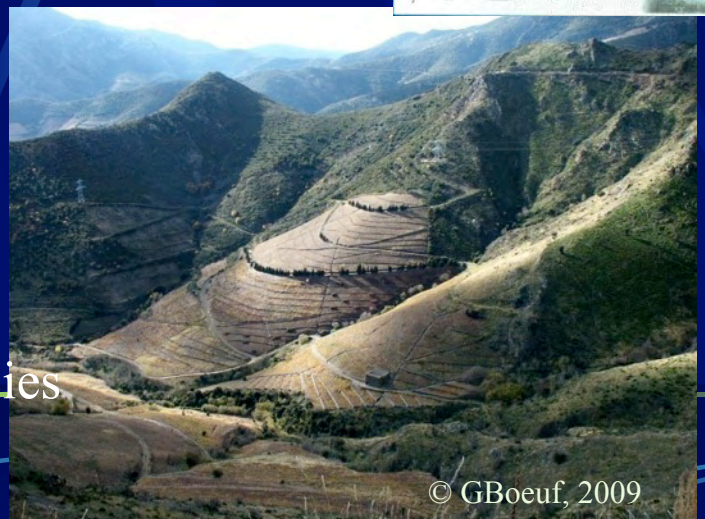


Delsuc *et al.* 2004

How to estimate the biological diversity?

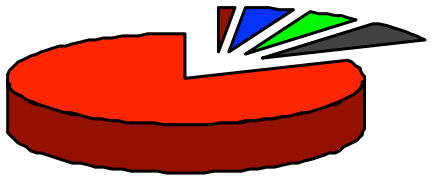
- Counting of species,
- Molecular ecology (small sub-unit 16S of the ribosomal DNA) reveals extraordinary diversity in procaryotics and small eukaryotics, totally unexpected,
- « Metagenomics » (C. Venter)
- Estimation of the relative abundance of species in a specific environment
- « Genetic measurements » number of allels on the same locus, relative frequency, heterozygoty degree…
- Habitats characteristics…



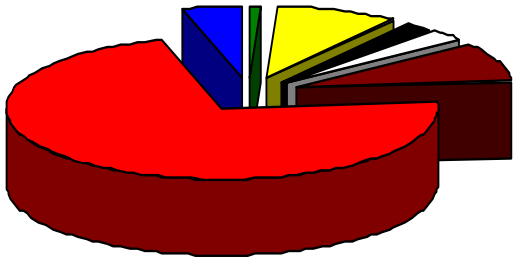


The present number of species corresponds roughly to
1 to 1.5 % of the total number of species since the beginning of Life

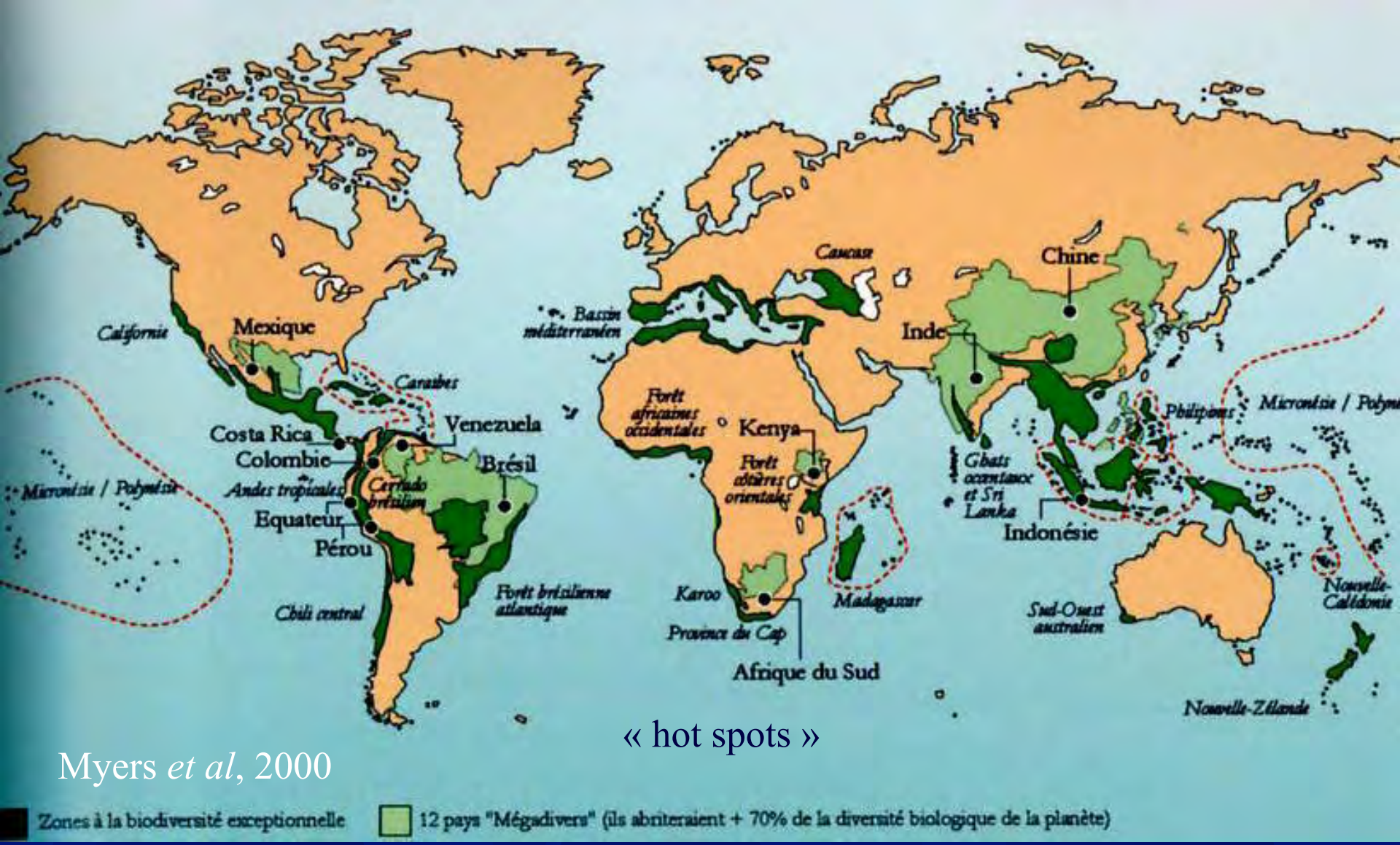
II
Biodiversity today



Protozoaires	= 100
Algues	= 300
Plantes	= 320
Champignons	= 500
Animaux	= 5570



Vertébrés	= 50
Nématodes	= 500
Mollusques	= 120
Crustacés	= 150
Arachnides	= 500
Insectes	= 4000
Autres	= 250



« hot spots »

Myers *et al*, 2000

50 % of sp on 7 % of the emerged lands, about 90 % on 10 %

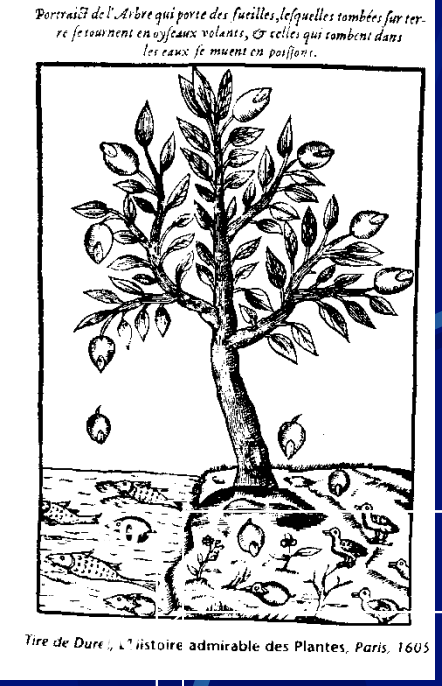
Dubois, 2004

Biological diversity is very unequally distributed: 14 biomes used. There might be up to 14 M species on Earth (*Gaston & Spicer 1998. Biodiversity, an introduction)*

Why so many differences between sea and land?

- In term of species numbers, 5-7 times more on lands,
- It is quite recent, 110M years ago, with land plants, associated pollinators, fungi, herbivores and carnivores (Grosberg and R. Vermeij, 2010; Pennisi, 2010),
- Low populations densities for individual species on lands, « rare species »,
- Questions of endemism and dispersion (Benton, 2001; Kamel *et al.*, 2010; Boeuf, 2011).

© J Lecomte, CNRS Lab Arago



Tire de Dure , L'Histoire admirable des Plantes, *Paris*, 1605

Human impacts

Vitousek *et al*., 1997, *Science*

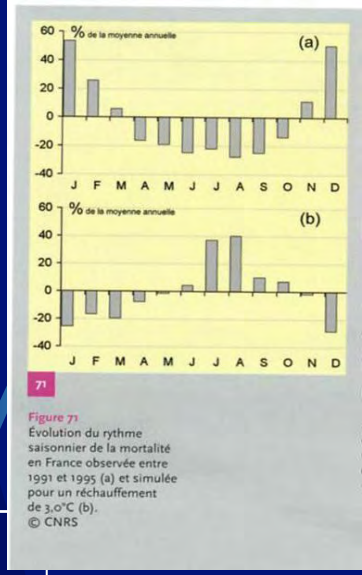
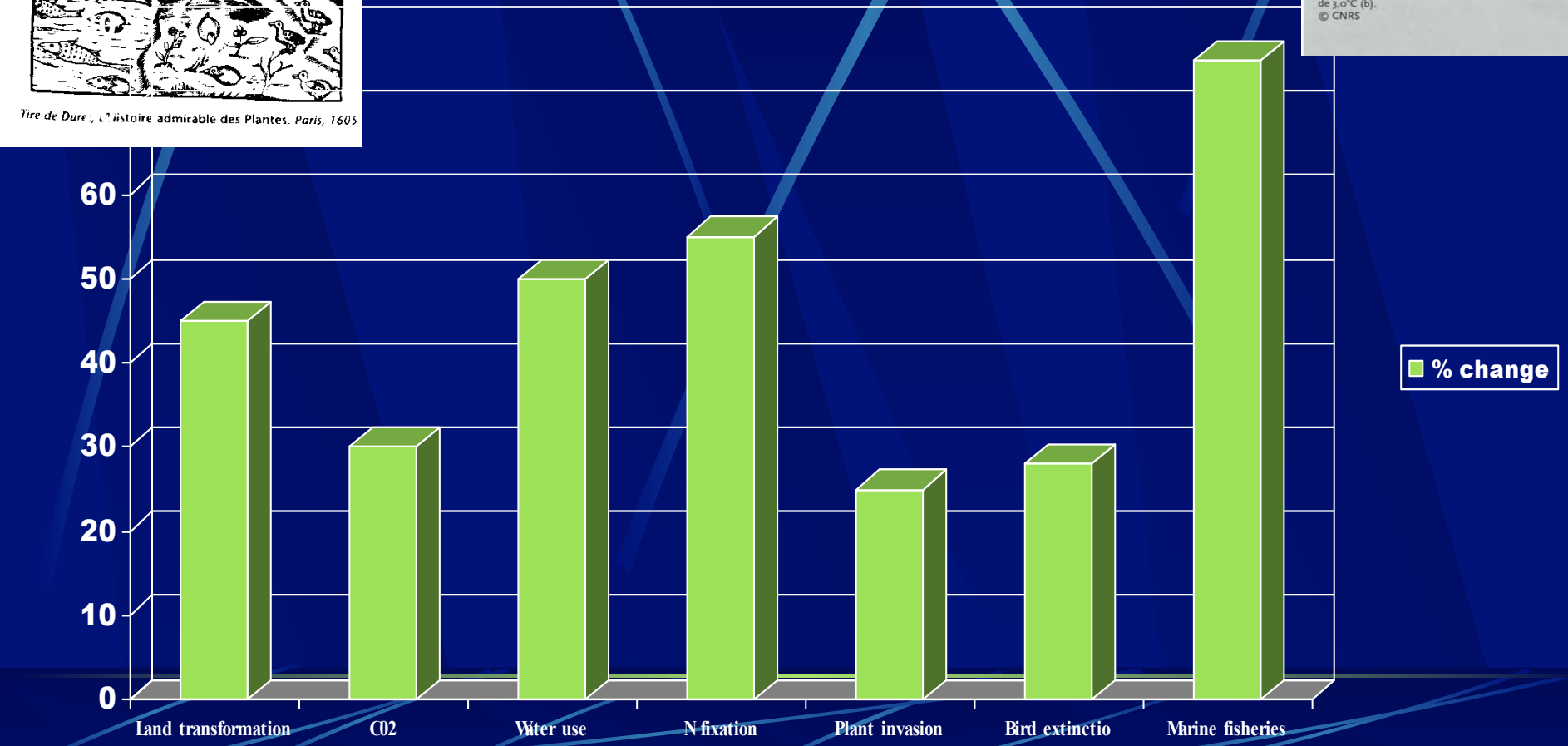
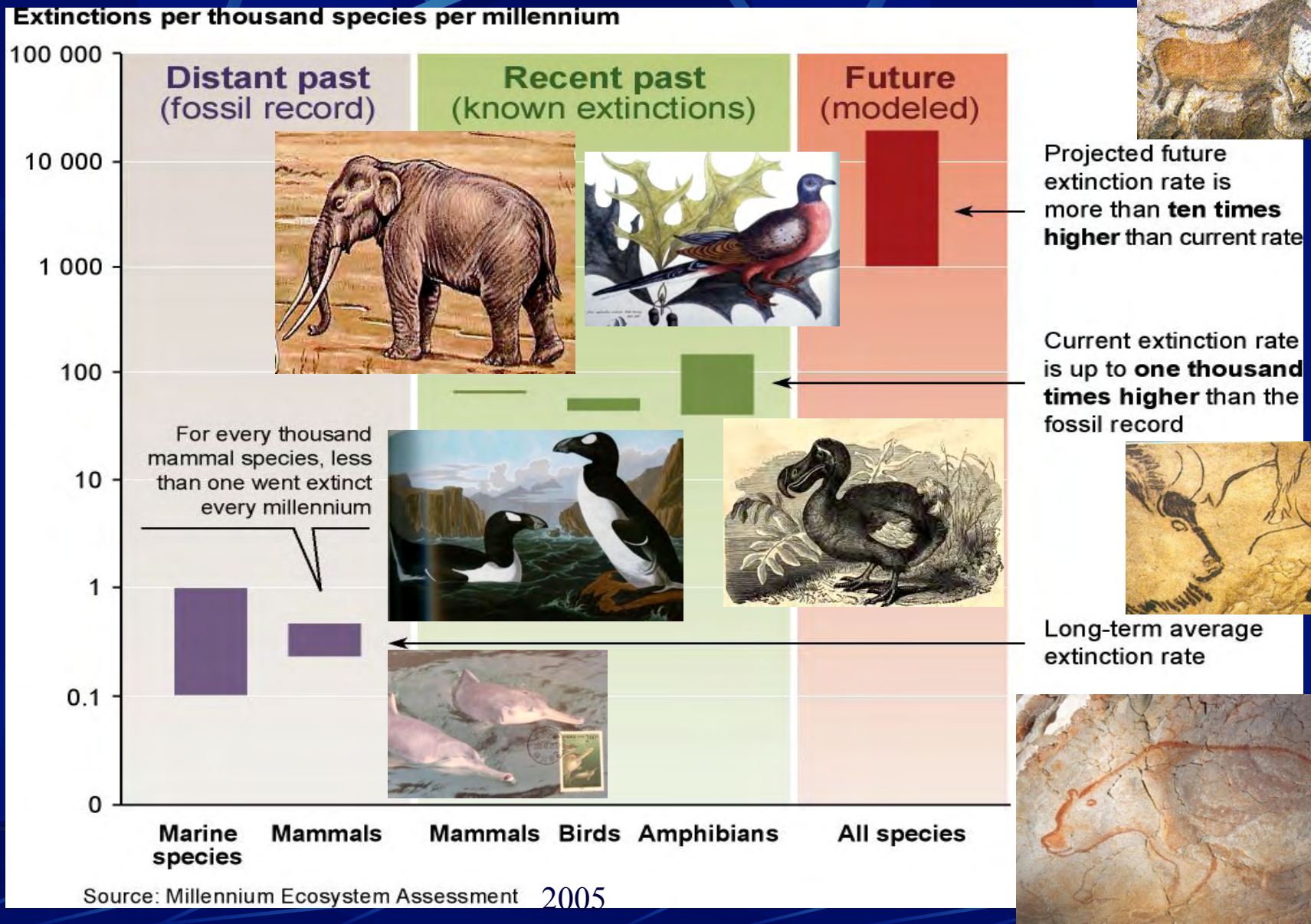


Figure 71
Évolution du rythme saisonnier de la mortalité en France observée entre 1991 et 1995 (a) et simulée pour un réchauffement de 3,0°C (b).
© CNRS



Extinction rates through Earth story



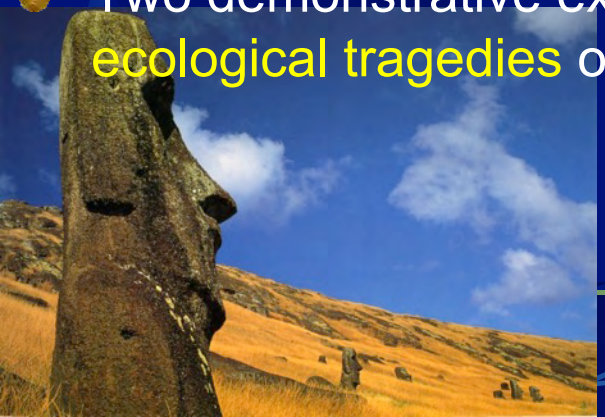
Projected future extinction rate is more than **ten times higher** than current rate

Current extinction rate is up to **one thousand times higher** than the fossil record

Long-term average extinction rate

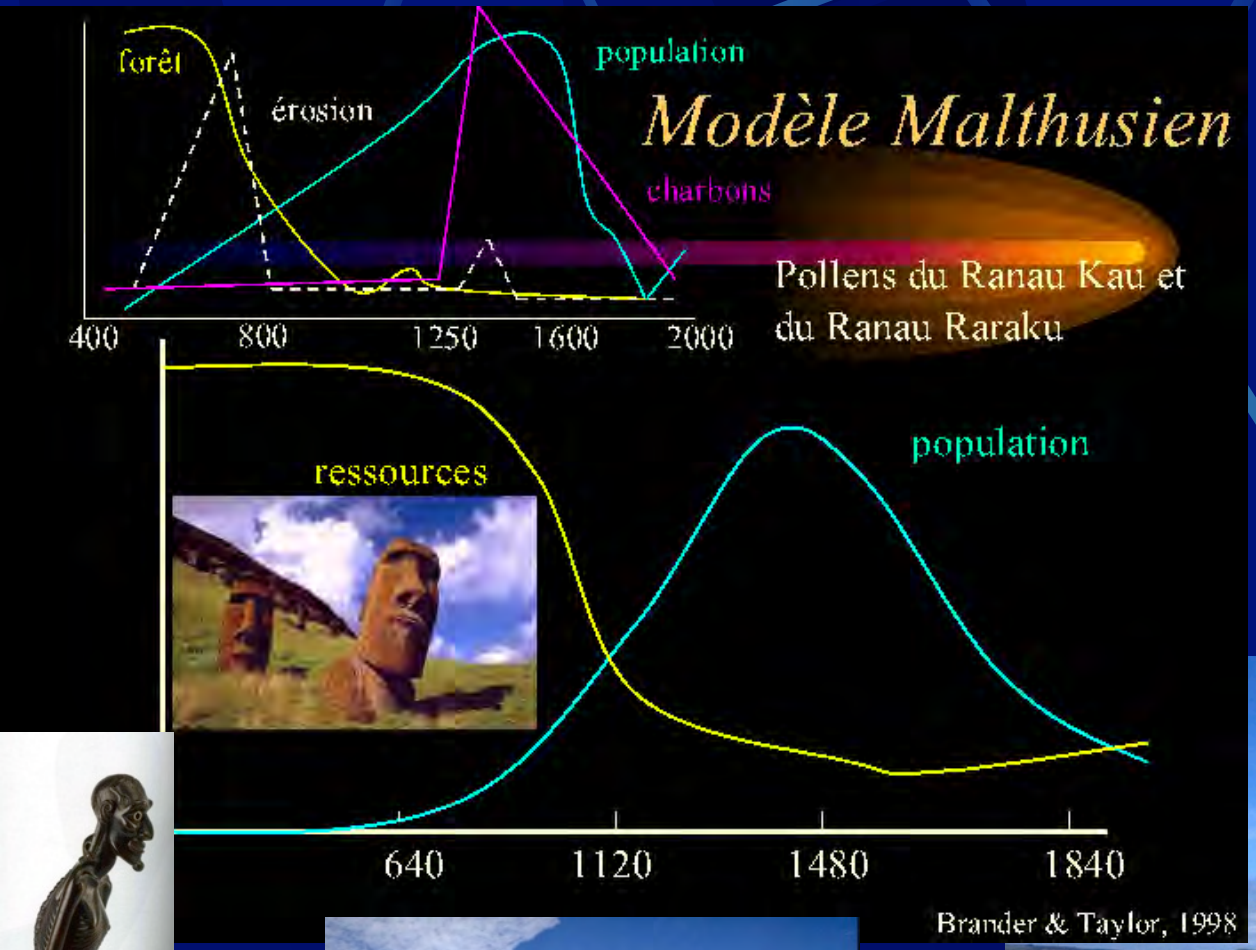
Human impacts: Anthropocene?

- In 3 centuries, population and urbanization multiplied by 10, a lot of fossil combustible beds have disappeared,
- 160 t annual S dioxyde (X 2), > 2 times fixed N, > 30 % for CO_2, > 150 % for CH_4,
- 40 % emerged lands transformed, half of water resources is used, climate and biodiversity affected,
- Five major actions on the planet: biogeochimical cycles; structure, stability and productivity of ecosystems; composition of faunas and floras; physiology, demography and genetics of living species; health, wellfare and life quality,
- Two demonstrative examples: ancient, Easter Island; recent, Aral Sea, ecological tragedies on the Planet!

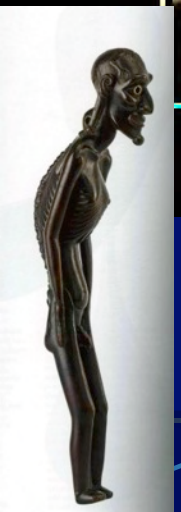


R. Barbault, 2006

Ecological disaster in Rapa Nui



Anakaï Tangata



Eradication of *Sophora toromiro*

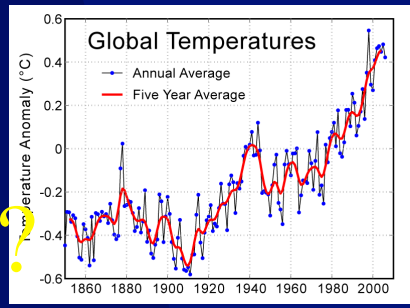
Threatened Biodiversity

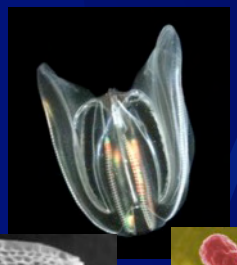
The 'fishing down' effect is ubiquitous. It describes the systematic extirpation of marine megafauna

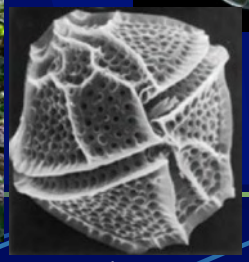
1 Destruction and pollution

2 Overexploitation

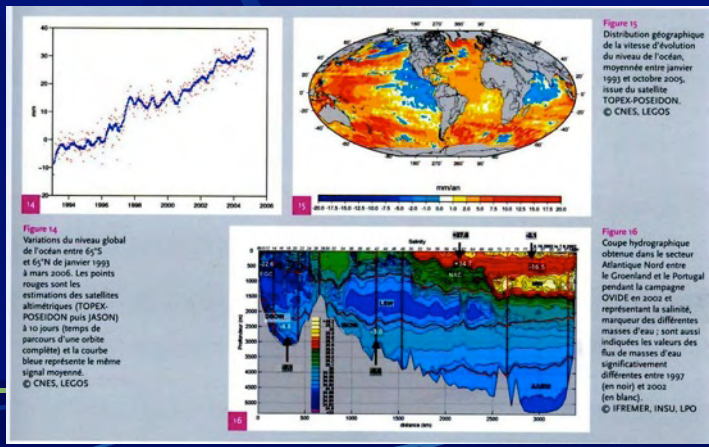
Has the Earth's sixth mass extinction already arrived?





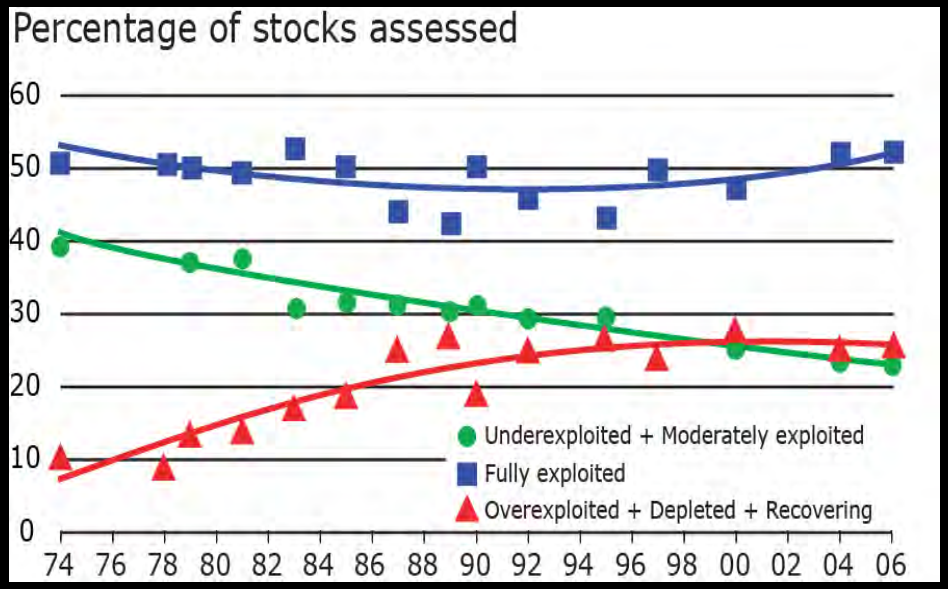


3 Alien invasive species

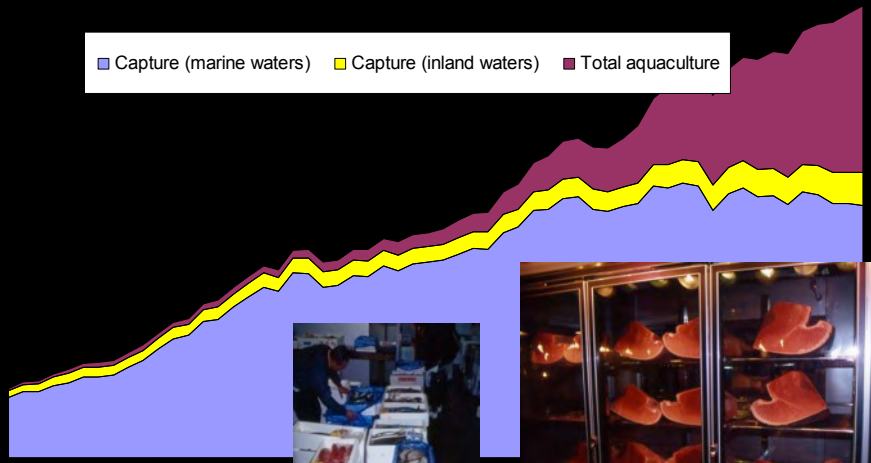


4 Climatic Change

Data 2008, FAO, 2010



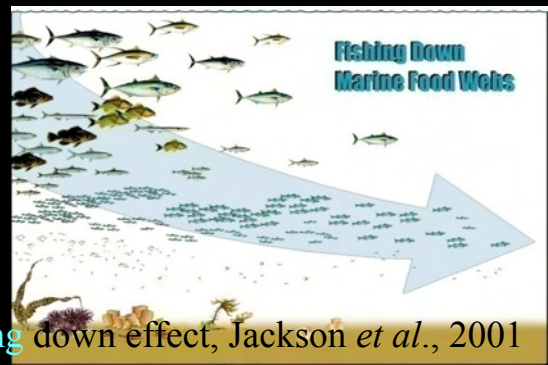
Fisheries and aquaculture production (1951-2008)



© GBoeuf, 1999

World captures and rearings

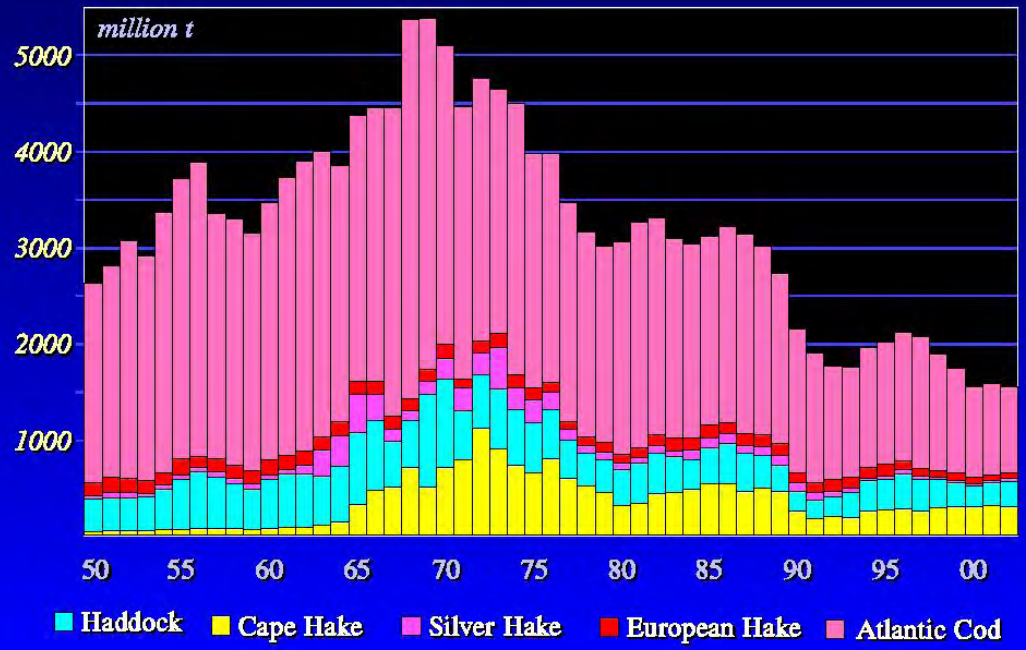
- 10 millions mt for continental fisheries, (90 % in Africa and Asia); declining of 30 % in Europe since 1999,
- 83.2 M mt from seas and oceans, fluctuating with catches from Peru and Chile,
- 66.7 M mt from aquaculture, 87 Bil $,
- Of which 16.2 M mt with aquatic plants, 7.4 Bil $.
- In total, 93.2 M mt of catches, 66.7 aquaculture, 160.



Fishing down effect, Jackson *et al.*, 2001

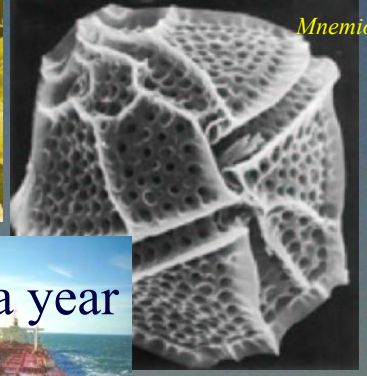
Catch of major demersal fish

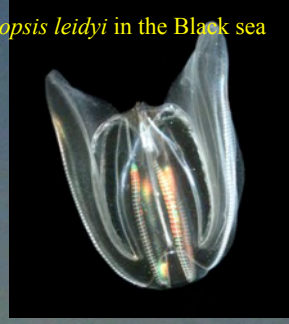
Y. Harache, IFREMER



(FAO, 2004)

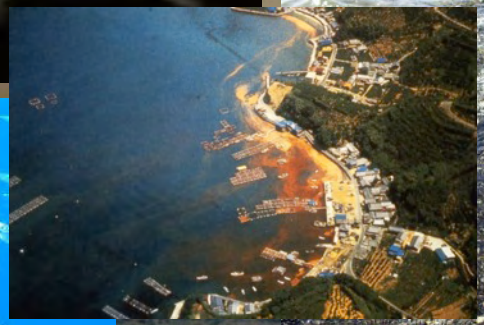
After 500 years of fishery, moratory in Canada NE, 40 000 suppressed employments, 20 years, still no cod!

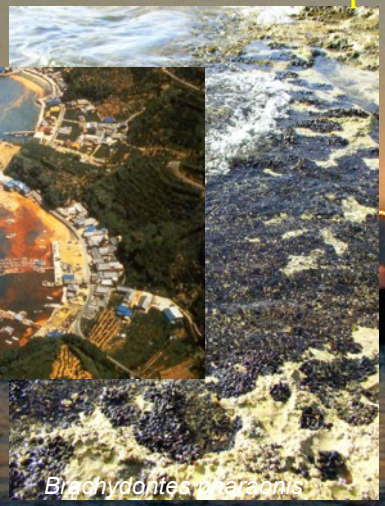




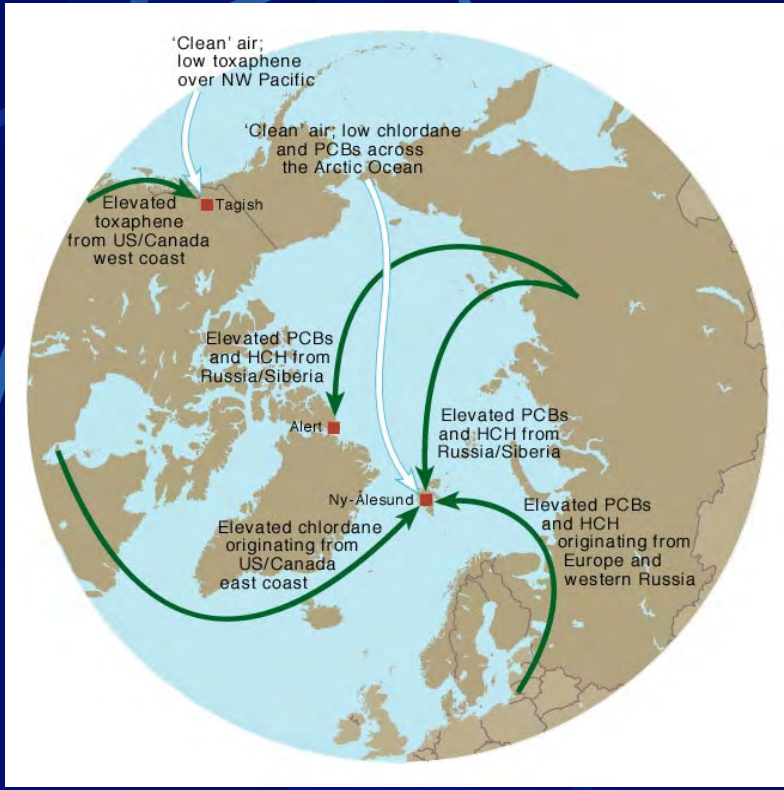
Toxic efflorescences

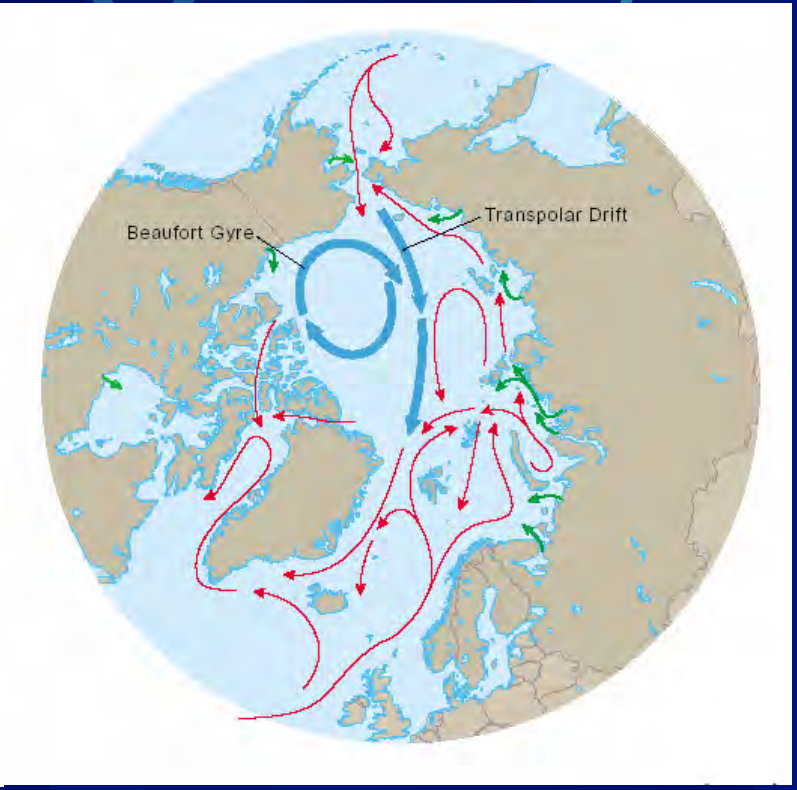
3 000 sp transported a day!





Transportation of pollutants into the Arctic





Air – the fast route

Rivers, oceans & sea ice

Source: AMAP 1997

J Mc Glade, 2009

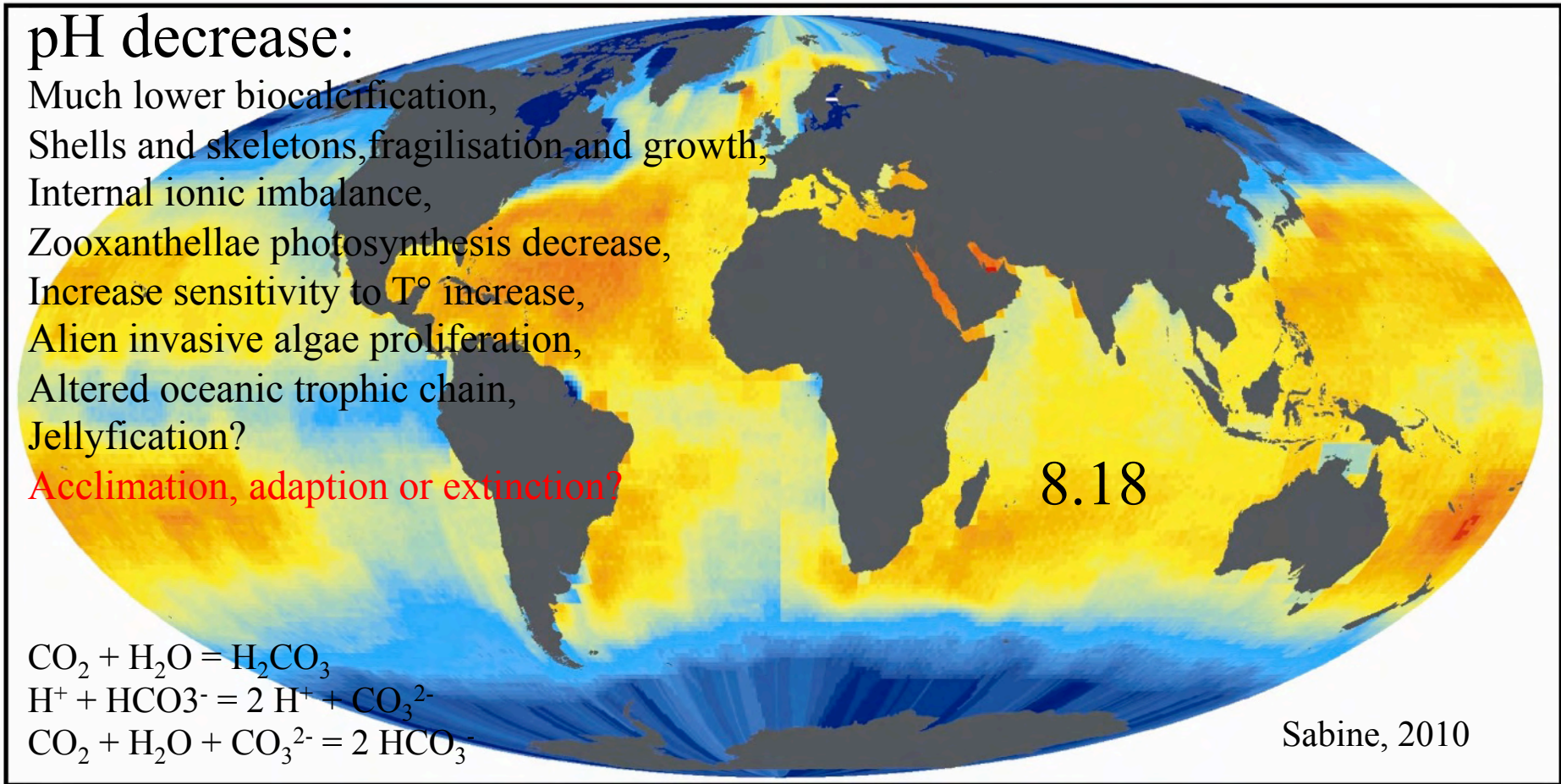
Climate change stressors: ocean acidification

- 0.1 since the pre-industrial period

-0.3 to 0.4 for the end of the 21rd Century?

pH decrease:

Much lower biocalcification,
Shells and skeletons,fragilisation and growth,
Internal ionic imbalance,
Zooxanthellae photosynthesis decrease,
Increase sensitivity to T° increase,
Alien invasive algae proliferation,
Altered oceanic trophic chain,
Jellyfication?
Acclimation, adaption or extinction?



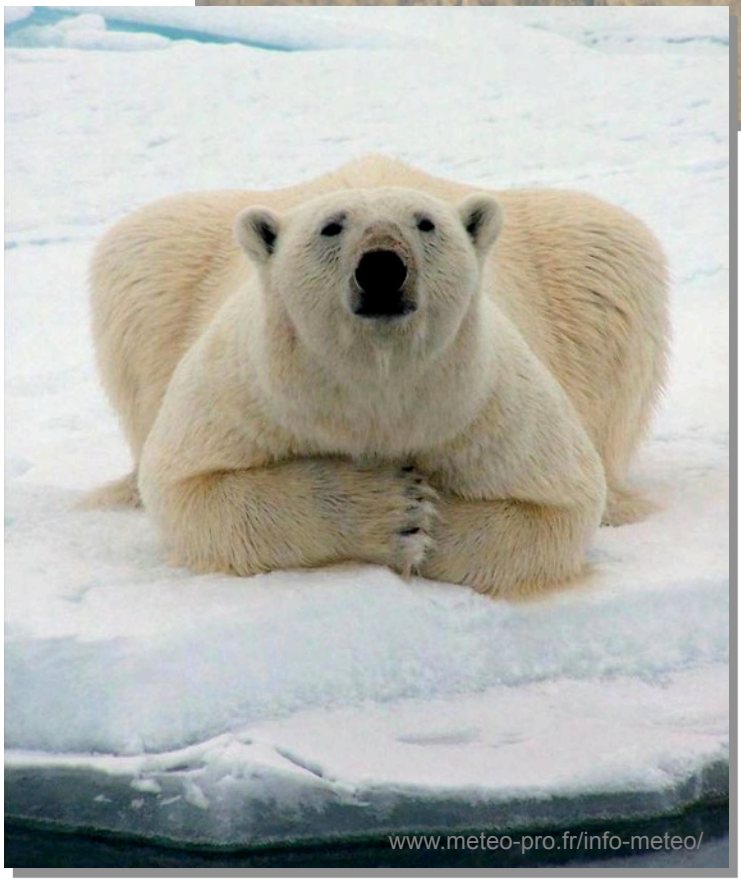
$CO_2 + H_2O = H_2CO_3$
$H^+ + HCO3^- = 2\ H^+ + CO_3^{2-}$
$CO_2 + H_2O + CO_3^{2-} = 2\ HCO_3^-$

Sabine, 2010

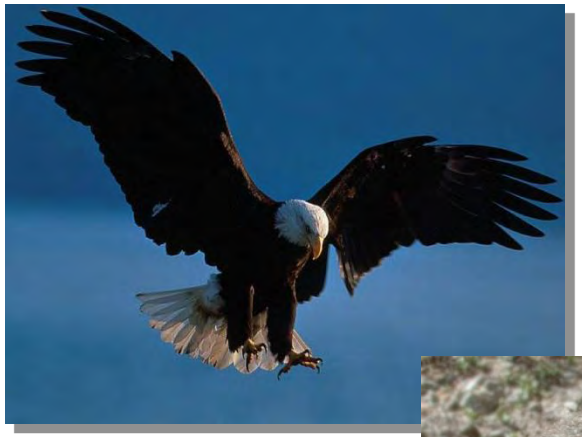
Contributed by John Guinotte

Totally linked with CO_2 emissions

J Mc Glade, 2009



« remarked » species?



« general » specific diversity?

Only one species?

The Biodiversity knowledge base: taxonomy today and tomorrow for environmental sustainability and human well-being: an introduction

1 Relevance of taxonomy for biodiversity and human well-being

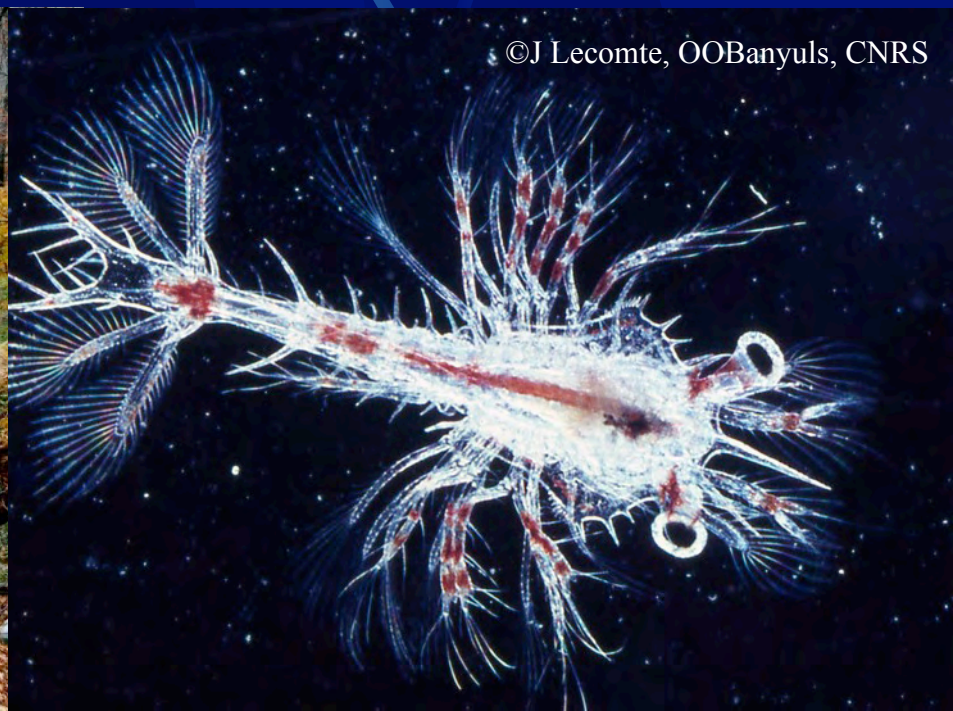
2 New ways to accelerate the discovery and application of taxonomic knowledge

3 New demands and overcoming barriers in education and communication

Unesco, 27th January 2010

III
Why saving Biodiversity?

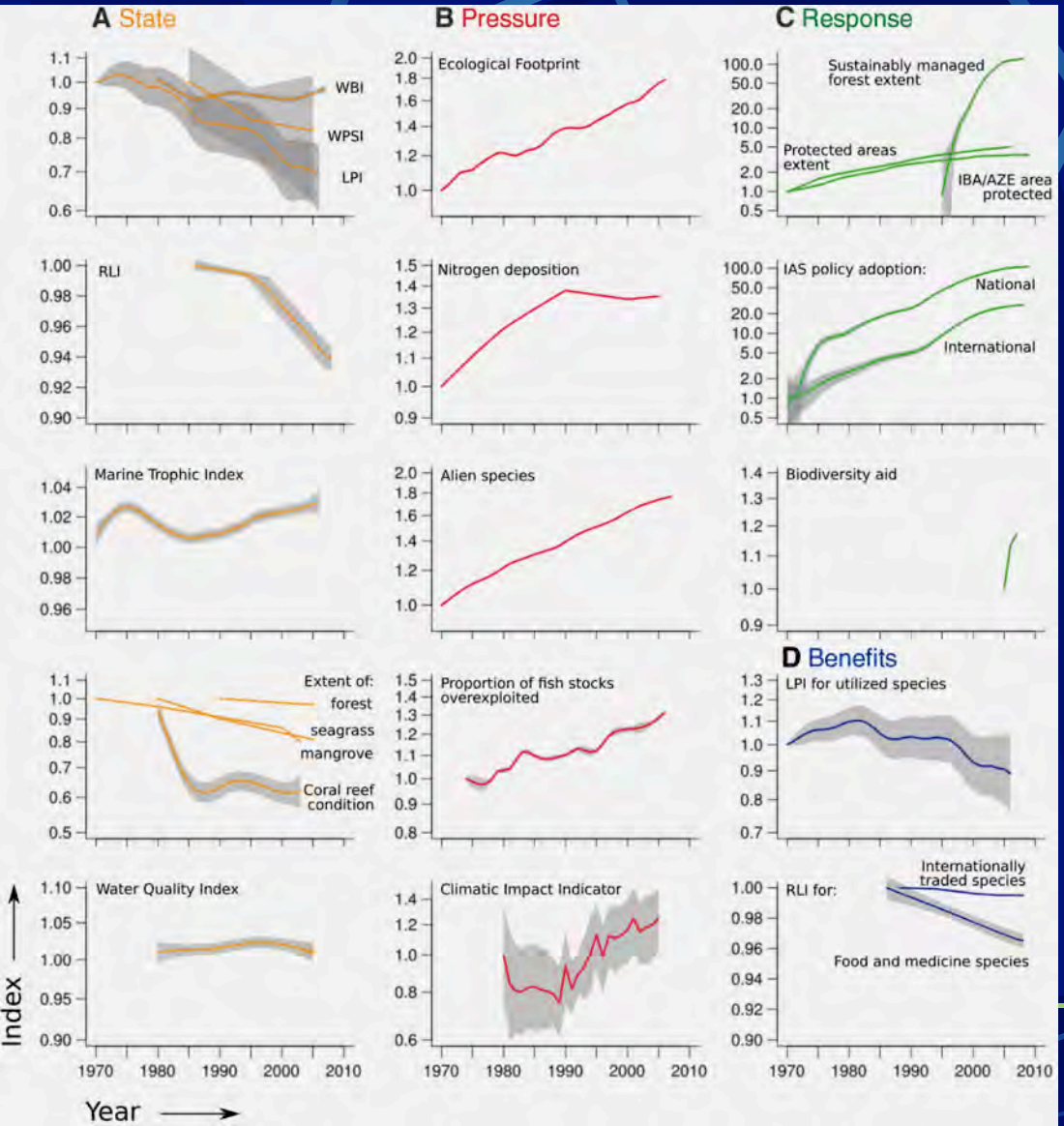
The Present is saturated by the Past and in gestation of the Future, Leibniz



Conference of Rio, June 1992,
Conference of Johannesburg, August 2002,
Conference of Paris, January 2005,
Conference of Unesco, Paris Januaray 2010,
Rio + 20?

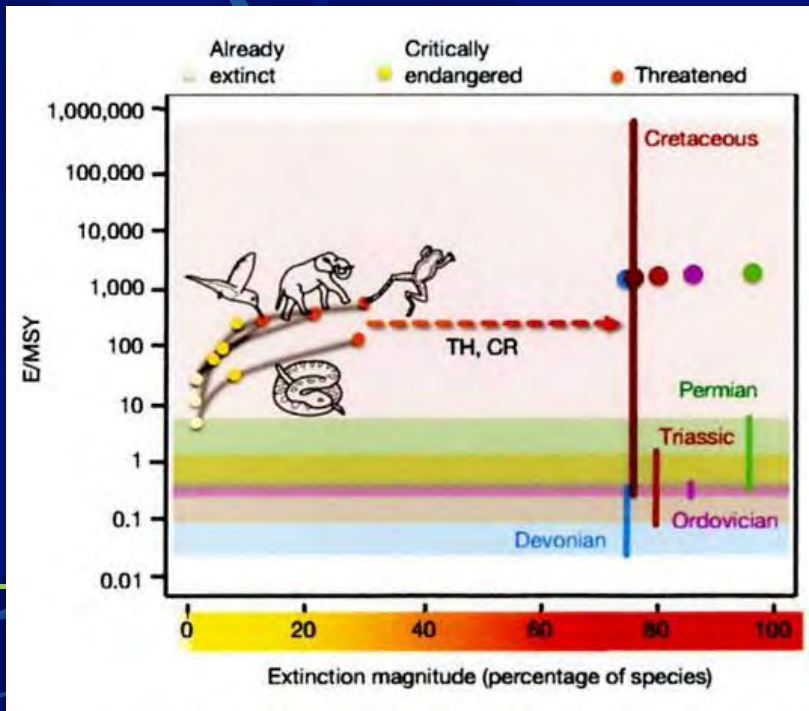
After eight years of « efforts »?

Butchart *et al.*, Science, 2010



Indicators trends for: A the state of biodiversity, B pressures upon it, C responses to address its loss, D the benefits human derive from it.

Barnosky *et al.*, Nature, 2011

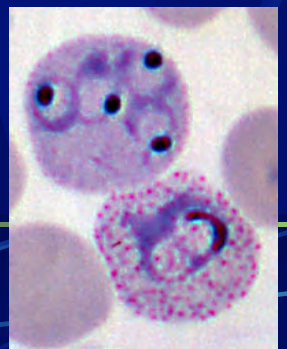


Biodiversity and health

- *"…Mounting evidence indicates that biodiversity loss frequently increases disease transmission. In contrast, areas of naturally high biodiversity may serve as a source pool for new pathogens.*
- *Overall, despite many remaining questions, current evidence indicates that preserving intact ecosystems and their endemic biodiversity should generally reduce the prevalence of infectious diseases…"*

Keesing *et al*., Nature, Dec 2010

Specific diversity, host and pathogens supports,
Eroded diversity, « free field » for opportunistic species, virulence and dispersion,
Unconsidered disseminations, volontary or not, host changes,
Climatic change and health, « need of Nature ».

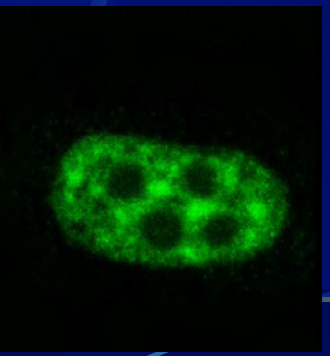


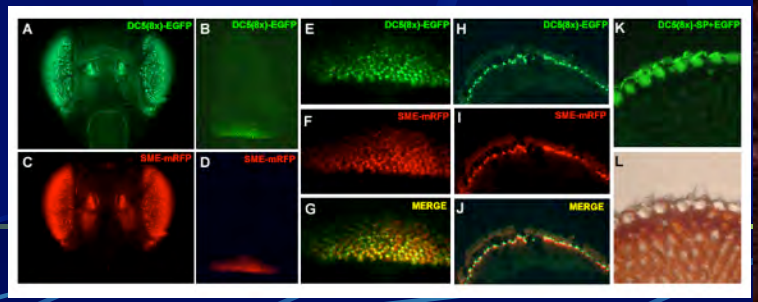
Why must we preserve the biological diversity?

- Economical value of the biological diversity, biotechnologies, agrosylvopastoral resources, cosmetics and pharmacology…
- Basic role in the great equilibriums of the biosphère, biogeochemistry,
- Biodiversity increases productivity: how do will work the system with many less species?
- Brake to Alien invasive species… More an ecosystem has found a sustainable status with high biodiversity, better it is able to prevent invasive species to come: the cost of the fight against the only invasive plants is >400 B € for the world,
- Intelligent management of resources for a « sustainable development »,
- Ethical perception of nature (« Why do save the African elephant? »)
- Preserve *in situ* or *ex situ* ? Conservation of species or ecosystems?
- Very strong conflict North-South during the elaboration on the Convention on the Biological Diversity (1992).

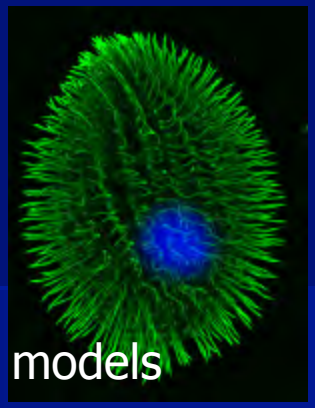
Molecules of pharmacological interest

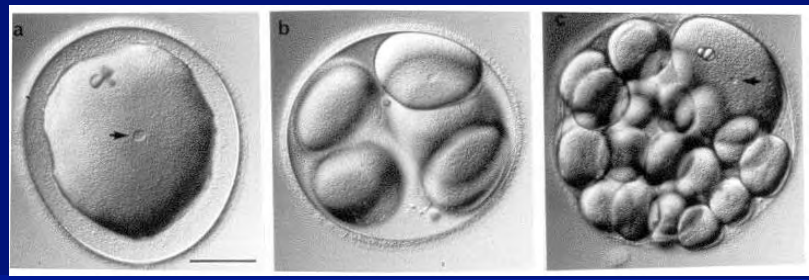
- Around 50% of the active molecules used in pharmacology are extracted or synthesized from natural components,
- Marine organisms provided us with more than 15,000 molecules to use. Some of them are used frequently : anticancer Ara-C (acute myelocytic leukaemia and non-Hodgkin lymphome), AZT (from fish milt), anti-viral Ara-A (herpes virus), nucleosides extracted from sponges, bryostatin (from bryozoa), antivirus from bacterias (anti-HIV)... molecular probes, hexopolysaccharide HE 800, antitumoral eicteinascidin 743, discodermolide…
- Anti-cancer, antibiotics, antiviral, anti-fungi, immunostimulators, immunosuppressives, growth factors, bone regenerators… molecular tools (polymerases, fluorescent proteins… *etc*…)
- 30 % of them were found in sponges.





Cellular cycle control and cancer

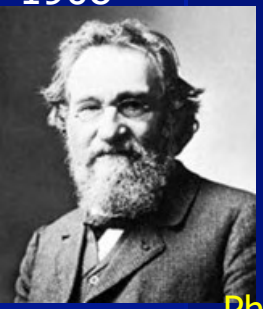




Vée *et al.*, *J. Cell Science*, 2001

Eleven Nobel laureates from aquatic models

E Metchnikoff 1908



O von Warburg 1931

J W Szostak

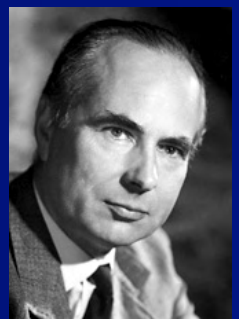
EH Blackburn 2009

C W Greider

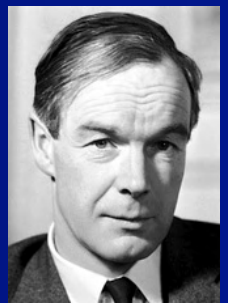
Phagocytosis, anaphylactic shock, intra-cellular calcic waves, nervous influx transmission patterns, molecular bases of the memory, key-molecules for cancer, green fluorescent protein in jellyfish, telomerase enzyme and aging, first membrane receptor for a neurotransmitter, recognition nof itself and non-itself, immune combinatory system, …

C Richet 1913

A Hodgkin 1963



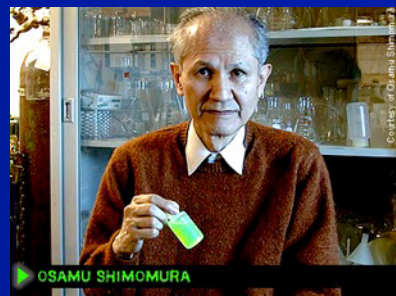
A Huxley



E Kandel 2000

T Hunt 2001

O Shimomura 2008



- To abandon the conception of conservation of Nature out of the human! We are inside it!
- Analyze of the « *ecological print* »,
- Ecology revisited through economical models: 40% of the present world economy are based on biological products and ecological processes!

Economy and Ecology: time for reconciliation?

And mainly, to better share the resources!

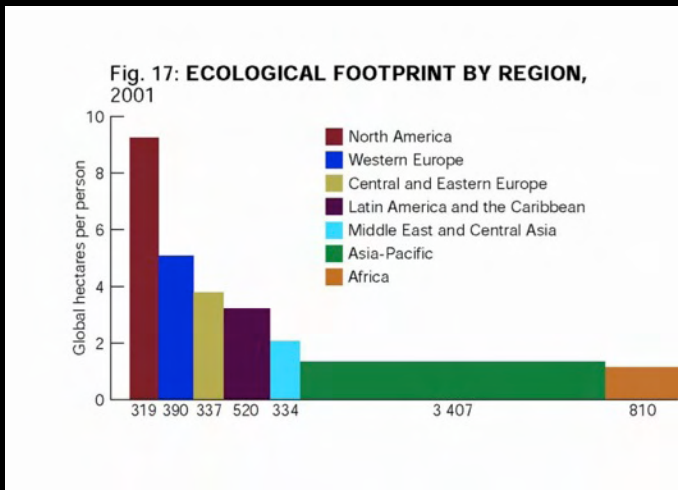
How to continue in such a world where 20 % of the human control, manage and use 80 % of the resources?

Call of 20 July 2006 in *Nature*

Appel de Paris le 3 février 2007, ONUE

©GBoeuf, 1992

Grenelle de l'environnement, octobre 2007, Grenelle de la mer, juin 2009



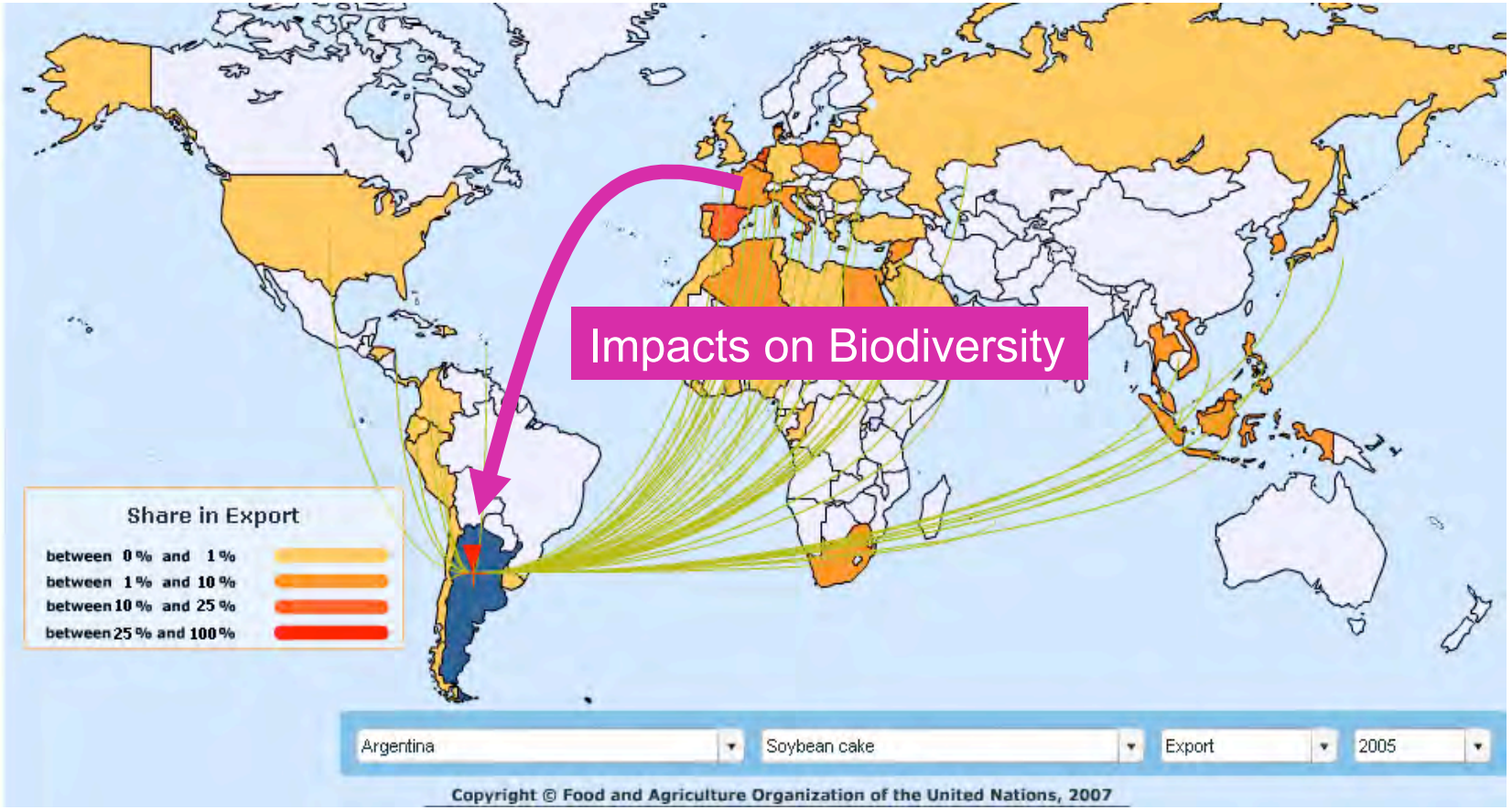
GLOBAL?
LOCAL?
GLOCAL!

System based on maïs or soya

(Jacques Baudry - IFB Tours Dec. 2007)

GLOBAL? LOCAL? *GLOCAL*!

World Trade: Exportation of Argentinean soya



(Jacques Baudry - IFB Tours Dec. 2007)

Argentinean *pampa*

Argentinean *pampa* cultivated in soya

(Jacques Baudry - IFB Tours Dec. 2007)

On a practical point of view, it is:

J Blondel, 2007

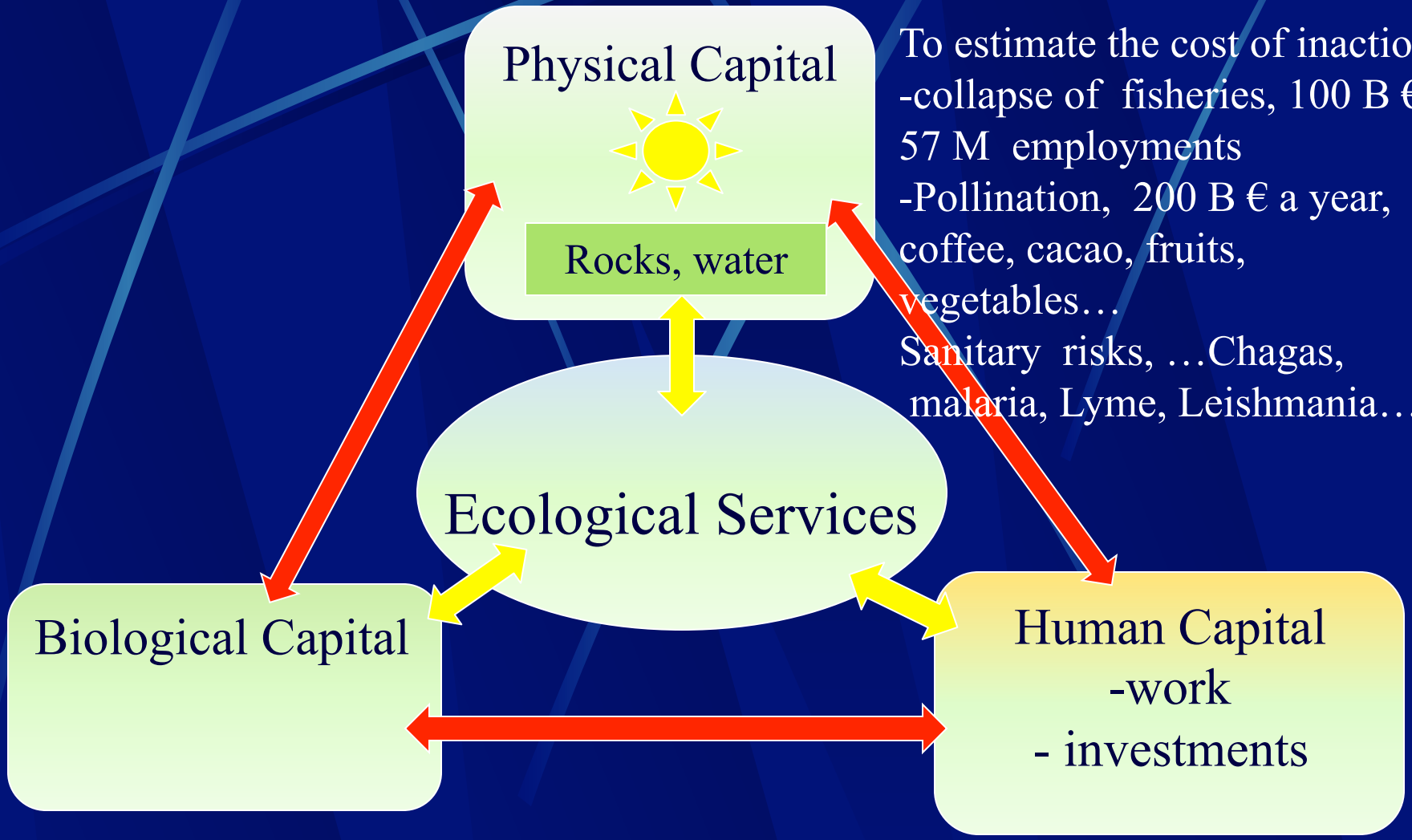
- **A scientific priority (understand its genesis, functions, and stop its erosion)**
- **An economical stake (genetic and biological resources to use and share)**
- **An ethical stake (living species Rights)**
- **A social stake (common values and advantages)**

(terms of the CBD)

GBoeuf, 2009

Such a concept thouroghly associates both natural sciences and society and human sciences

Economical stakes



To estimate the cost of inaction:
-collapse of fisheries, 100 B €, 57 M employments
-Pollination, 200 B € a year, coffee, cacao, fruits, vegetables…
Sanitary risks, …Chagas, malaria, Lyme, Leishmania…

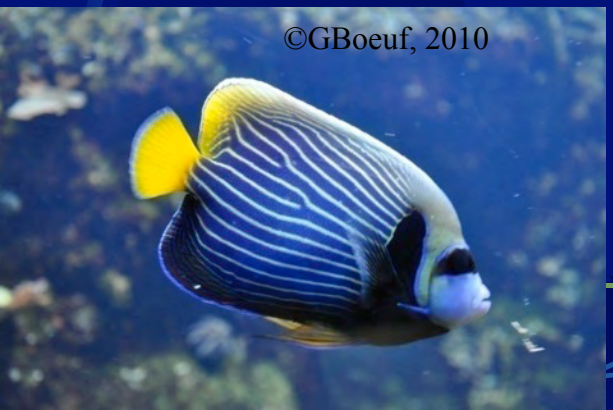
« It would be crucial to remunerate these different capitals according to their respective contribution to the production of the ecosystemic services »
Chevassus *et al.*, 2009

Conference of Paris for a global ecological governance

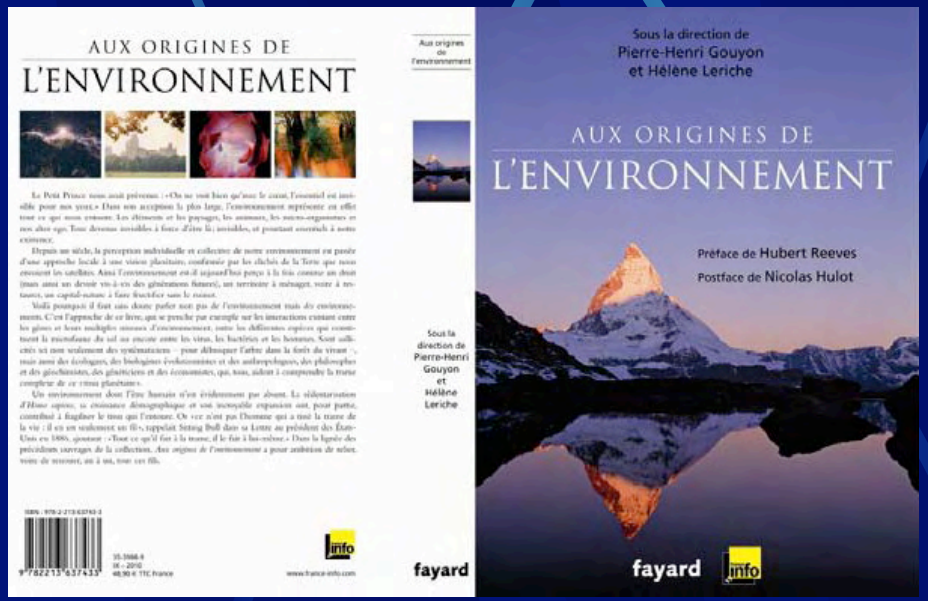
CITOYENS DE LA TERRE
Conférence de Paris pour une gouvernance écologique mondiale
2 – 3 février 2007

1. Fight against global warming
2. Act together to preserve biodiversity
3. Reduce pollution and preserve public health
4. Make water a shared stake
5. Invent ecological growth: change ways of thinking, production, and consumption
6. Enhance the international governance for the environment

Call of Paris for UNEP



Is the human able to adapt to himself?



canal-insep.fr

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