A conceptual tool for the appraisal of societal responses to global change in marine systems: the I-ADApT framework

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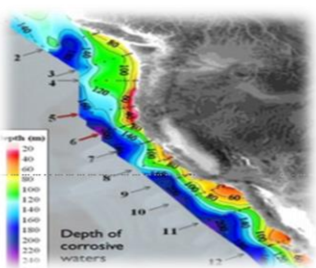

DOCKSIDE workshop, October 18th 2017

The Human Dimensions Working Group















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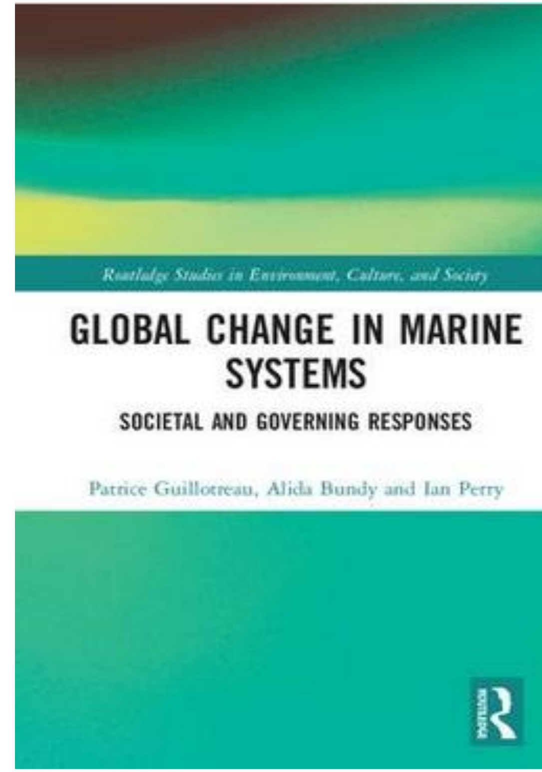

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Content

1. Several analytical frameworks to assess vulnerability of marine Social and Ecological Systems (SES)

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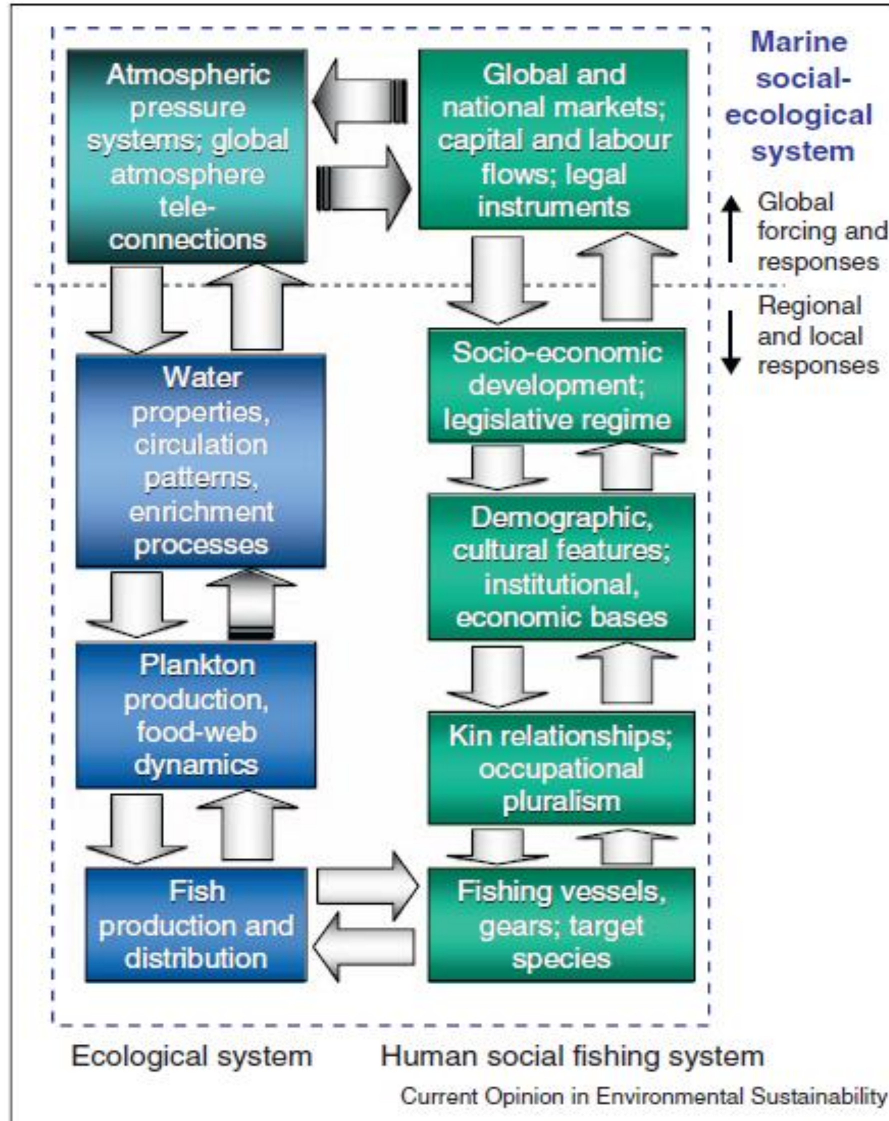
3. The concept of resilience extended from I-ADApT

4. Application of I-ADApT to massive mortalities of shellfi

1. Several analytical frameworks to assess vulnerability of marine Social and Ecological Systems (SES)

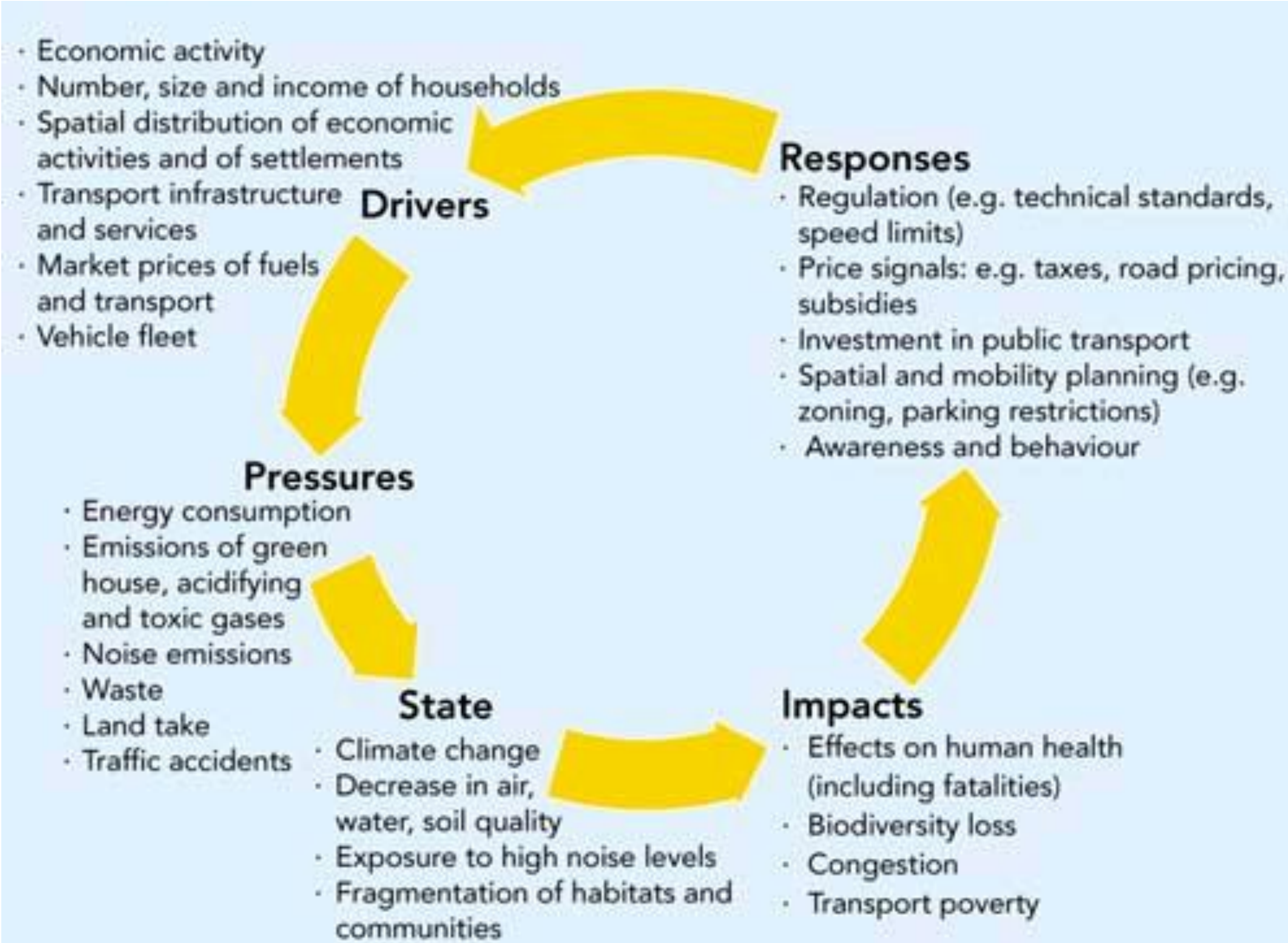
1.1 A systemic approach

- Systems thinking approach, eg. linked social-ecological systems, human-environment systems, “humans-in-nature”, etc....



Perry RI, Ommer R. *et al.*, 2010. Interactions between changes in marine ecosystems and human communities. In Marine Ecosystems and Global Change, Edited by Barange M. *et al.*, pp . 221-252

1.2 DPSIR model (Driver-Pressure-State-Impact-Response)



OECD Burkhard B. and F. Müller (2008) Driver–Pressure–State–Impact–Response. In: Ecological Indicators (eds S.E. Jørgensen and B. Fath) Vol. [2] of Encyclopedia of Ecology. 5 vols. Elsevier. Oxford. pp. 967–970.

1.3 Interactive Governance – qualities of "Governing Systems" and "Systems to be governed"

Step 1: Describe the **state** of the natural and social systems in terms of diversity, complexity, dynamics and scale

Step 2: Identify **drivers**

Step 3: Determine what stress or **pressures** these drivers cause to the ecosystem

Step 4: Determine the **change** in the systems (as a result of the pressure)

Step 5: Assess the **impact** of these changes on ecosystem values and functions

Step 6: Describe the '**state**' of the governing systems in terms of diversity, complexity, dynamics and scale

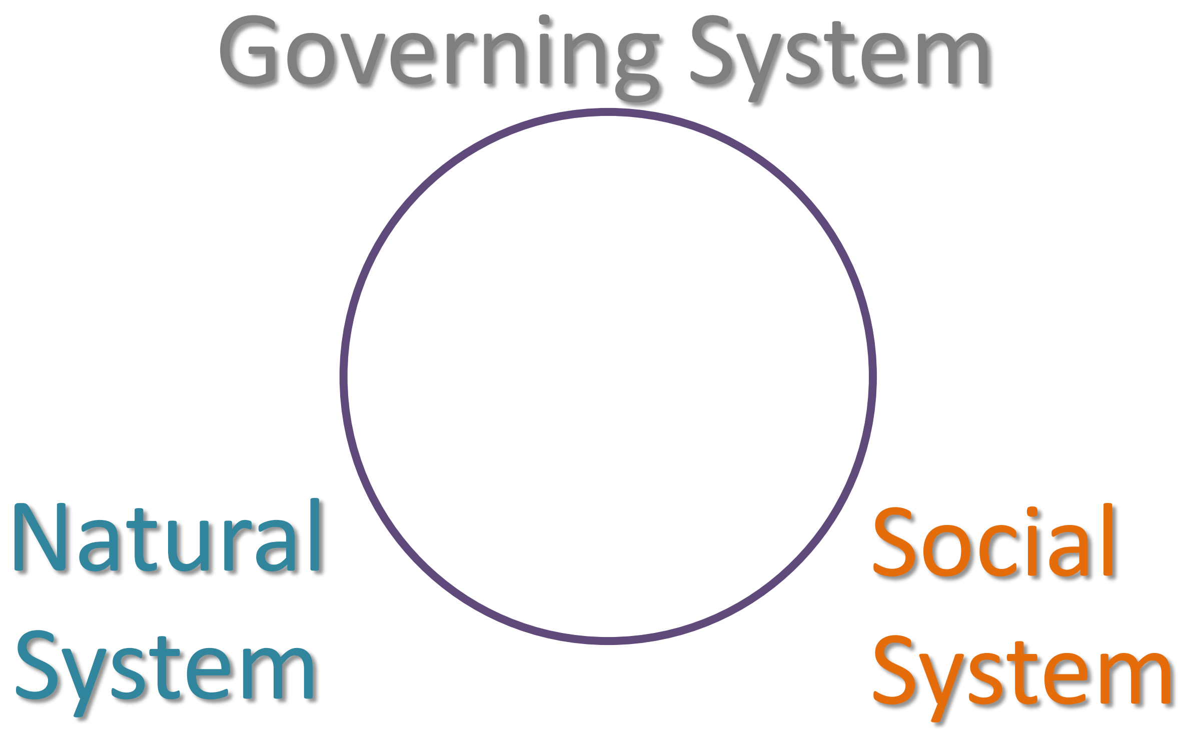
Step 7: Assess the '**capability**' of the governing systems to address the changes and impacts

Step 8: Determine the **responses** by the governing system to mitigate the impacts

Kooiman. K.. Bavinck. J.. Jentoft. B. and Pullin. R.S.V. (eds) (2005) Fish for Life: Interactive Governance for Fisheries. Amsterdam University Press. Amsterdam. 400 p.

Chuenpagdee. R. (2011) Interactive governance for marine conservation: an illustration. Bull. of Marine Science 87. 197–211.

3. The **I-ADApT** tool and typology (**A**ssessment based on **D**escription, responses, and **Ap**praisal for a **T**ypology)



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THE I-ADApT FRAMEWORK

(*IMBeR – Assessment based on Description, responses and Appraisal for a Typology*)

Background

Crises of all kinds striking marine social-ecological systems (SES): hurricanes, tsunami, disease, SST warming, acidification, pollution,…

Objectives

- Description of the crises affecting marine SES and of the responses from coastal communities (governance) ;
- Appraisal of responses in terms of means, objectives and achievements (outputs, outcomes) through a typology of case studies.

Goal

- Produce an operational system to assist and guide cost-effective policy and governing responses to marine resource crises.

Possible Issues:

- Over exploitation
- Warming temperatures
- Ocean acidification
- Hypoxia, eutrophication
- Mass mortality
- Invasive species
- Pollution
- Typhoons, storms, earthquakes
- Population growth

What to do?

New regulations?

Stop activity?

Technological innovation?

Alternative livelihoods?

Co-management?

I-ADApT Case Study Template

A. Background information
B. Description of the stressors and their impacts
C. Vulnerability
D. Governance and governability
E. Response
F. Appraisal

- Focus on marine fisheries and aquaculture
- 30 questions on the N,S,G systems

http://www.imber.info/Science/Working-Groups/Human-Dimensions/I-MBER-ADApT

Key Questions – Vulnerability

- Productivity of the system?
- Ecological status of the affected ecosystem?
- Main stressors that affect this ecological system?
- Size of affected human population as % of total population?
- Main livelihood activities
- Alternative livelihood opportunities?
- % of total catch/production used for household consumption?
- Proportion of household income from local sales of fish catches and post-processing activities?

Key Questions – Governability

- Scale of issue?
- Relationship between different sectors?
- Who dominates social power?
- Structural changes in the governing organisation(s)?
- Key rules, regulations, instruments and measures employed to achieve the management objectives?
- Changes to these key rules, regulations, instruments, or new ones introduced over time?
- Informal rules or measures that play an important role in the governance of fisheries and aquaculture?

Key Questions – Response

- How did affected natural, social, and governing systems respond to the Main Issue – in the short term?
- How did affected natural, social, and governing systems respond to the Main Issue – in the long term?
- What factors contributed to any successful results?
- What factors prevented successful results from being fully achieved?

Key Questions – Appraisal

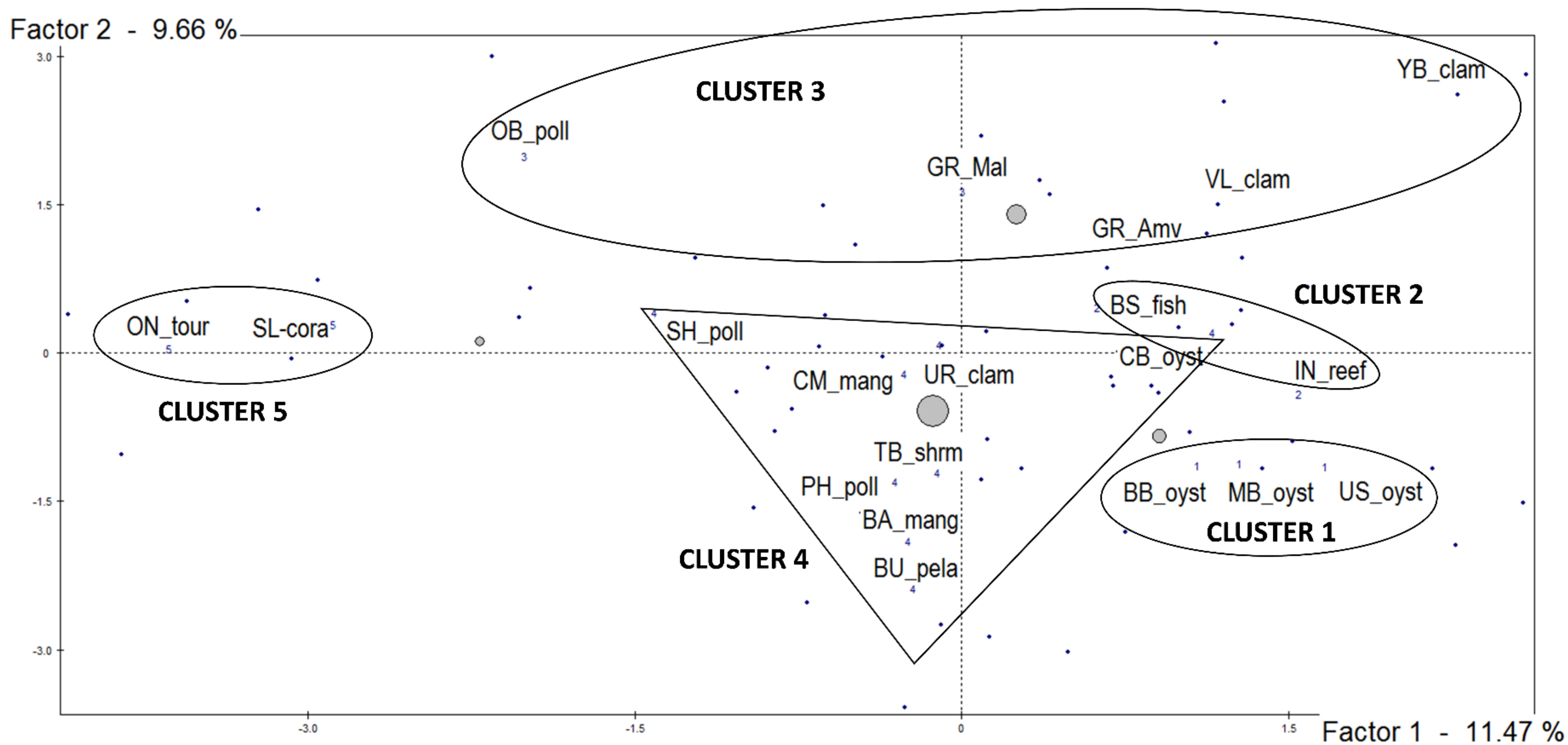
- What were the results of the response for the natural, social and governing systems in the short and long term?
- Was the Main Issue addressed?
- Has there been a formal evaluation of the response?
- What were the benefits related to the costs of the response?
- Were other options considered?

Typology based on 20 case studies in the forthcoming book

Guillotreau et al. 2017, Routledge

<u>Examples</u> : Maliakos and Amvrakikos gulfs (ratio N/P), Bay Bengal mangroves (typhoons) and Cameroon (habitat destruction), Jin-Shanzui Shanghai (polluted water), Bays Bourgneuf, Matsushima & Chesapeake (oyster disease), Okinawa (redclay outflow), La Coronilla-Uruguay (freshwater runoffs), Southern Benguela (regime shift), Puget Sound (acidification), Baltic sea (anoxia), Venice lagoon (alien species and lack of property rights),...

Scoring (5-point Likert scale) + Factorial and clustering analyses by MFA & AHC



1. **Oyster Farming Systems Under Stress** (3 CS) - Fragile monoculture systems, short-term responses and unsolved issues
2. **Vulnerable Mixed Fisheries** (2 CS) - Variety of stressors for large-scale social-ecological systems, adverse conditions and limited achievement
3. **Coastal Water Quality Issues** (5 CS) – Local water quality issues affecting coastal systems, lower sensitivity to global change, and mitigated success of societal responses
4. **Overexploited And Weakly Governable Fisheries** (8 CS) - Degraded systems due to anthropogenic pressures, conflicting governance levels, and resulting problems of governability
5. **Habitat Restoration Programs** (2 CS) - Habitat deterioration issues, high sensitivity to fisheries and tourism, successful restoration and management plans

Factorial and clustering analyses by MFA & AHC

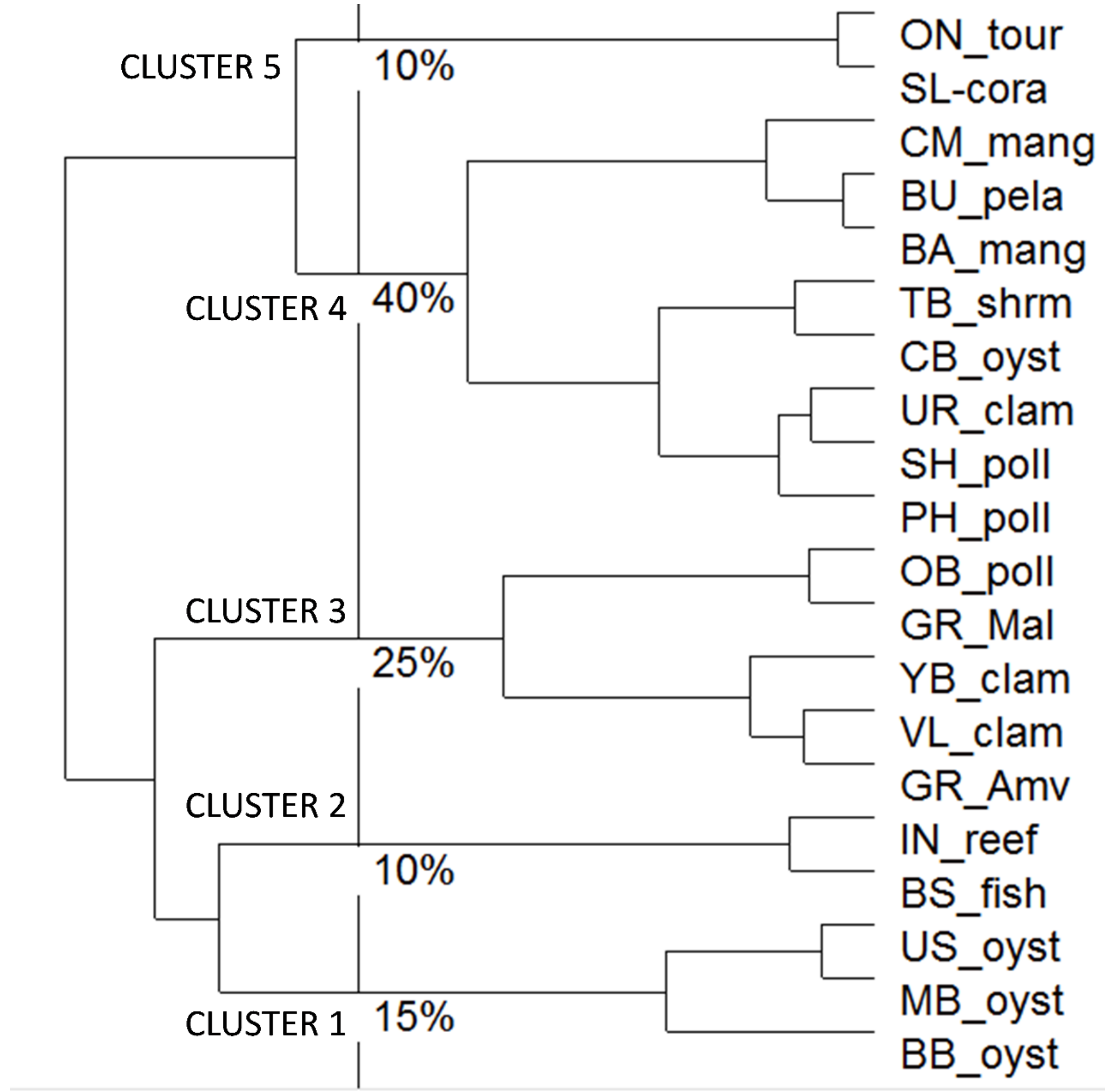
MFA

32 questions converted in a 5-point Likert scale (A to E) through a Delphi method

4 groups of variables :
- Vulnerability (8 var.)
- Governability (11)
- Responses (6)
- Appraisal (7)

3 active groups (V, G, R) and 1 supplementary (E)

AHC
Optimum of 5 clusters



PRELIMINARY RESULTS

- *Systems are unpredictable, changes irreversible and pressures growing* (*regime shifts, tipping points*)
- *Population growth in tandem with increasing dependence on the blue economy*
- *Increasing inter-sectoral tensions* (farming/fishing, tourism/fish, mangrove wood/fishing, urbanisation, industrialisation,…)
- *Is there any appropriate level and type of governance for the system-to-be-governed? Move from top-down to co-management generally works but not always. No panacea (Ostrom 2007).*
- *Need for a minimum public support and group cohesion (voluntary action) in case of extreme event (Serafini et al. 2017), function of wealth and facilities in the country.*
- *Ambiguous role of social power (too much or too little); e.g. patron-client relations.*
- *Role of technology and markets (eg unexpected outcome after a disaster).*

FACTORS OF FAILURE AND SUCCESS

- Failure factor = Lack of trust and transparency in the governing system (Nakayachi 2015) → Public trust must pre-exist the disaster!
- Success factor: clear roles and responsibilities (integrated management). Performance indicators and transparent criteria, multi-stake-holder consultative policy.
- Dynamic and flexible rules because ecosystems are not static. Simple rules are better to avoid misunderstanding.
- Information and science availability (eg. Spermond vs Baltic sea). Warning systems (eg. HAB, water quality). Blind faith in technology (eg. replenishment, hatcheries)
- Develop co-management (government & communities) and integration of scientific and local ecological knowledge.

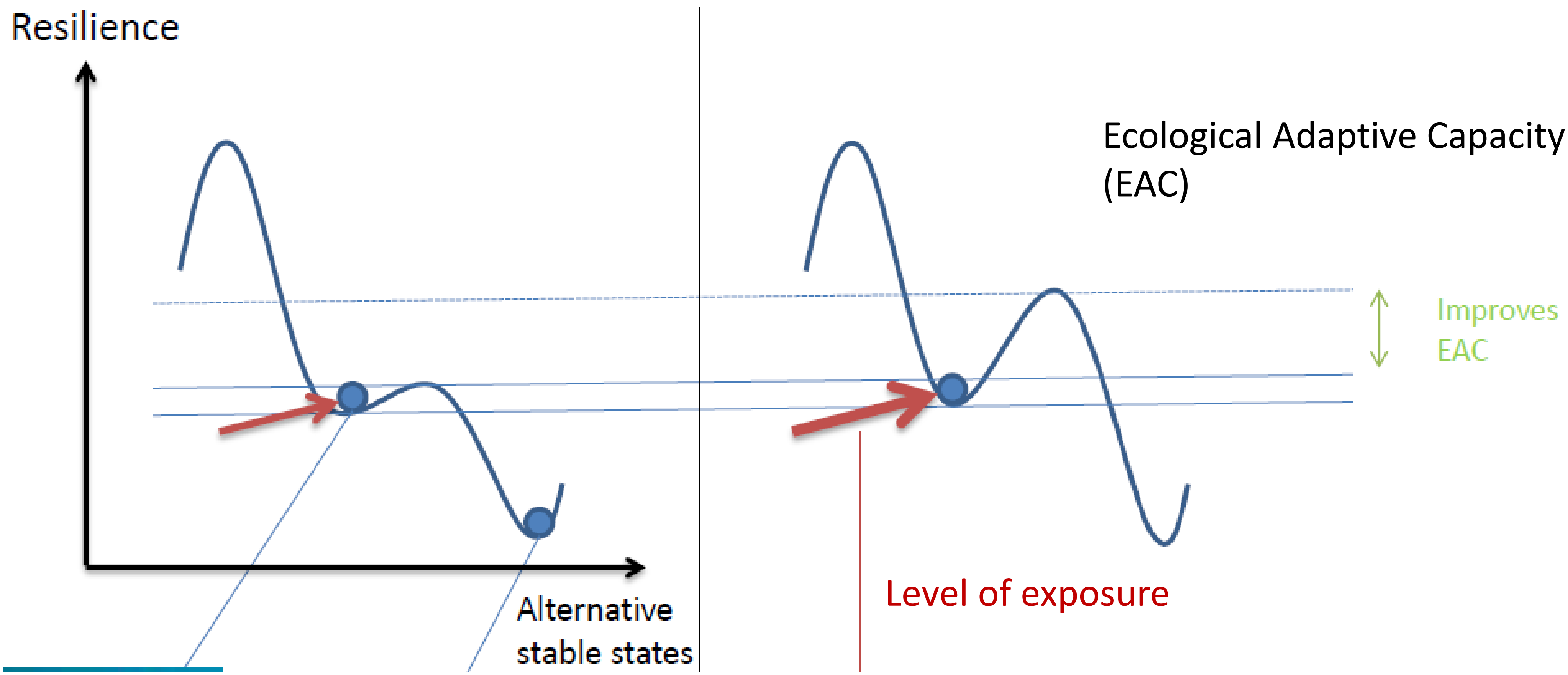
We need you to expand the database!

Thank you

http://www.imber.info/Science/Working-Groups/Human-Dimensions/I-MBER-ADApT

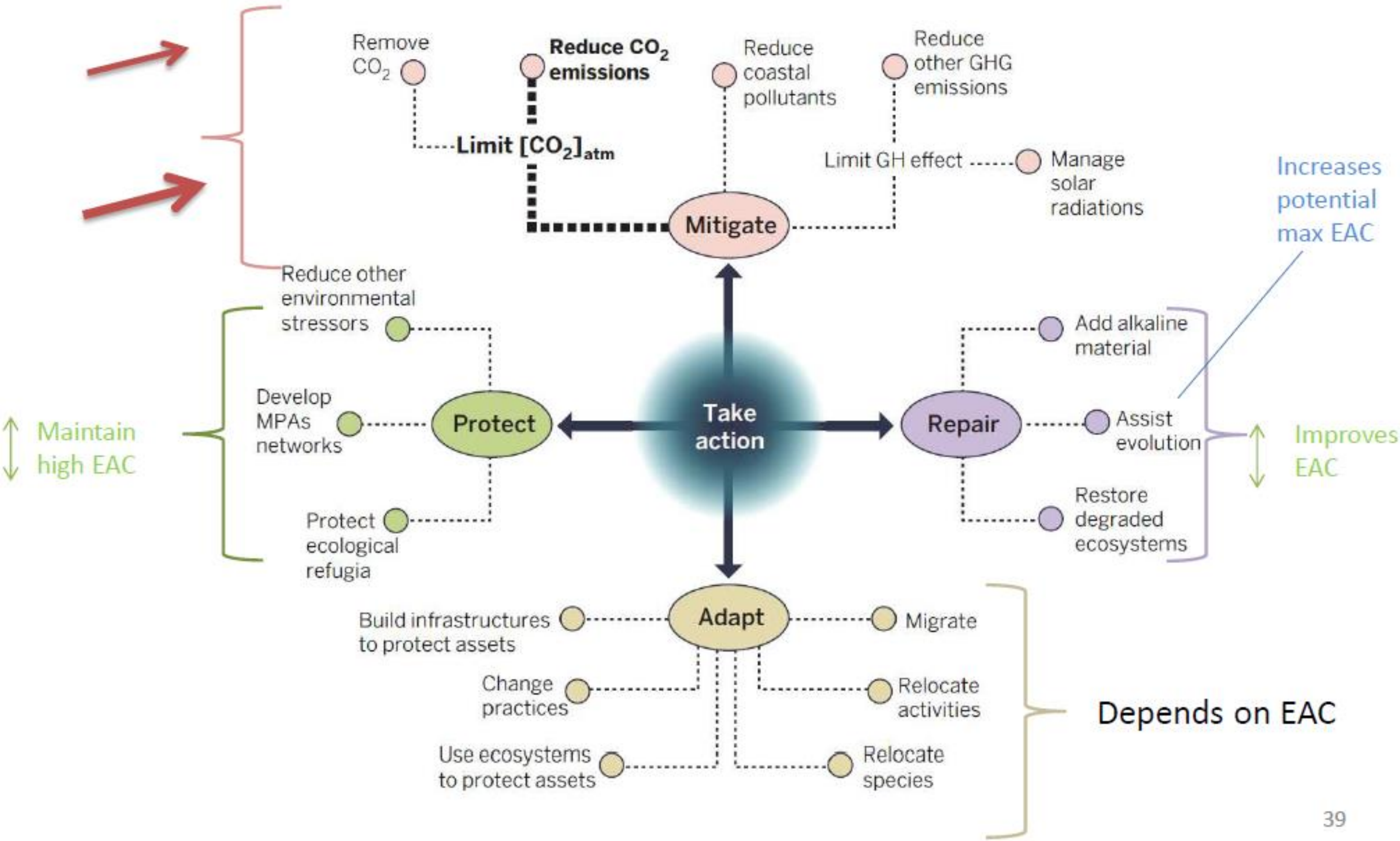
4) The concept of Resilience extended from I-ADApT

Resilience = capacity of a marine system to recover after a perturbation (Holling 1973).



Folke. C. (2006). Resilience: the emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* 16 (3): 253–67.

Example of ocean acidification on coral reefs or shellfish:



Gattuso *et al.* 2015. Science

What is a resilient system?

Some definitions of the concept:

Holling (1973) (ecosystem resilience): Capability of ecosystems to absorb unexpected disturbance and still persist

Pimm (1984): **(engineering resilience)** how fast a variable that has been displaced from equilibrium returns to it

Carpenter *et al.* (2001) (**socio-ecological resilience**):

(i) the amount of disturbance a system can absorb and still retain the same structure and function (~Holling)

(ii) the degree to which the system is capable of self-organization

(iii) the degree to which the system can build and increase the capacity for learning and adapting

Hertzler and Harris (2010) (economic resilience): "The expected time until a system switches from one system state to another" (Static and dynamic resilience)

Kajitani and Tatano (2009): "Resilience option" = decisions that help reducing the business interruption after a disaster while restoring the ecosystemic functions.

Hughes et al. (2005) : 4 key actions:

- Embracing uncertainty and change → Capacity of innovation
- Knowledge about ecosystem dynamics
- Management practices that measure. interpret and respond to ecosystem feedback → test, learn and modify
- Flexible institutions and social networks in a multi-governance system → collaboration between stake-holders

Biggs. R.. M. Schlüter. and M.L. Schoon (Eds). 2015. Principles for building resilience. Sustainable ecosystem services in social-ecological systems. Cambridge University Press. UK.

7 key principles of resilience for Social-Ecological Systems (SES):

Principle 1: Maintain diversity and redundancy

Principle 2: Manage connectivity

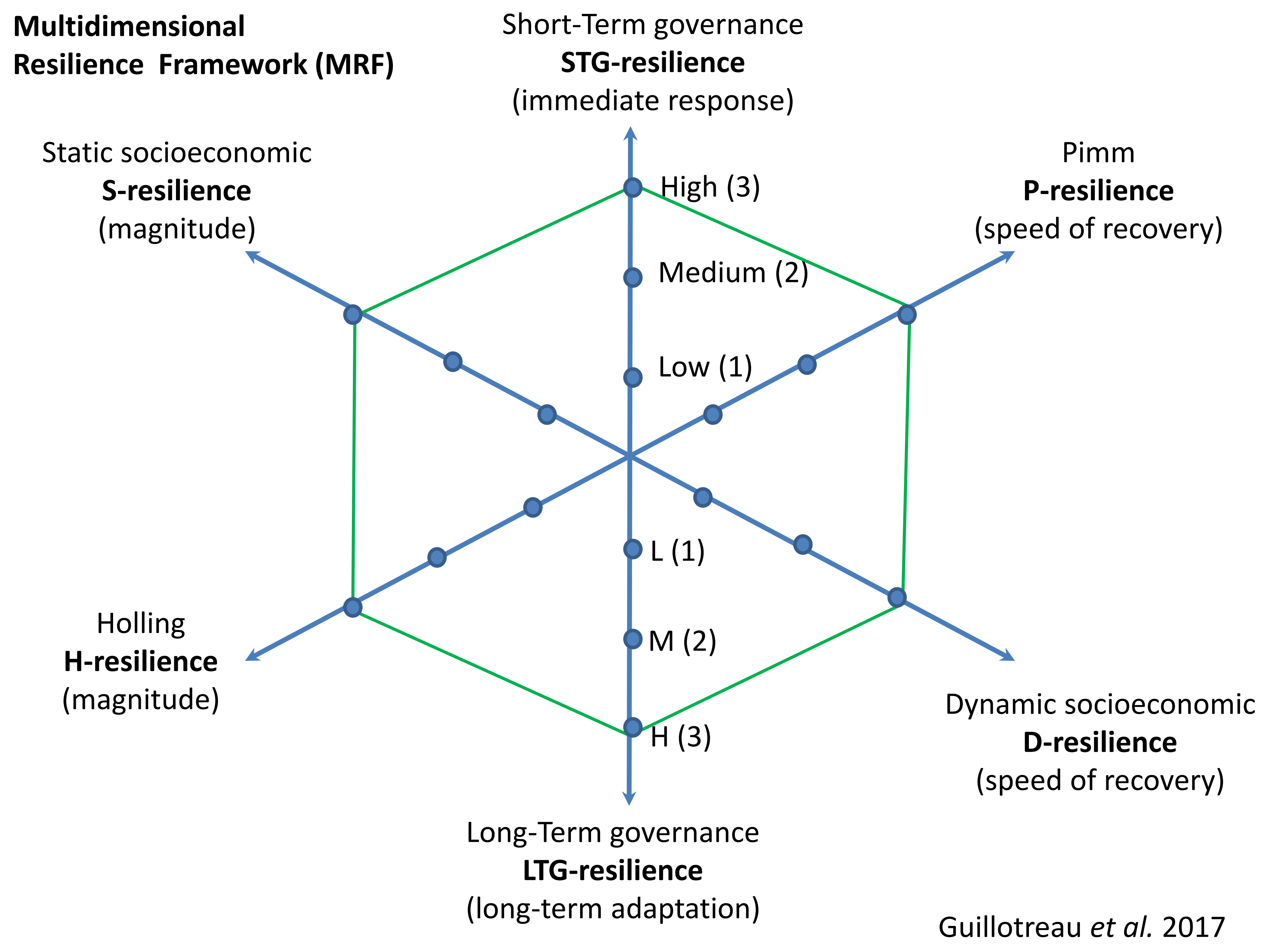
Principle 3: Manage slow variables and feedback

Principle 4: Foster complex adaptive systems thinking

Principle 5: Encourage learning

Principle 6: Broaden participation

Principle 7: Promote polycentric governance



Multidimensional
Resilience Framework (MRF)
Short-Term governance
STG-resilience
(immediate response)
Static socioeconomic
S-resilience
(magnitude)
Pimm
P-resilience
(speed of recovery)
High (3)
Medium (2)
Low (1)
L (1)
M (2)
H (3)
Holling
H-resilience
(magnitude)
Dynamic socioeconomic
D-resilience
(speed of recovery)
Long-Term governance
LTG-resilience
(long-term adaptation)
Guillotreau *et al.* 2017

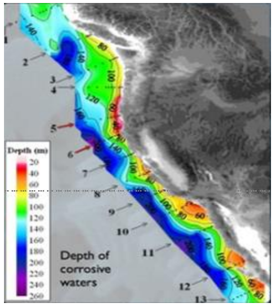
5. Application to Mass Mortality of Shellfish (MMS)

- 6 MMS case studies: 2 in France. 2 in the USA (NW and NE). 1 in Uruguay and 1 in Japan.

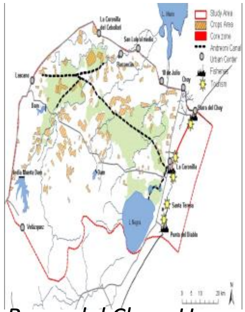
I see dead oysters !!!

Matsushima Bay. Japan

Bay of Bourgneuf. France



Puget Sound. USA



Barra del Chuy. Uruguay

Bay of Quiberon. France

Chesapeake Bay. USA

MMS outbreaks: an increasing global issue?

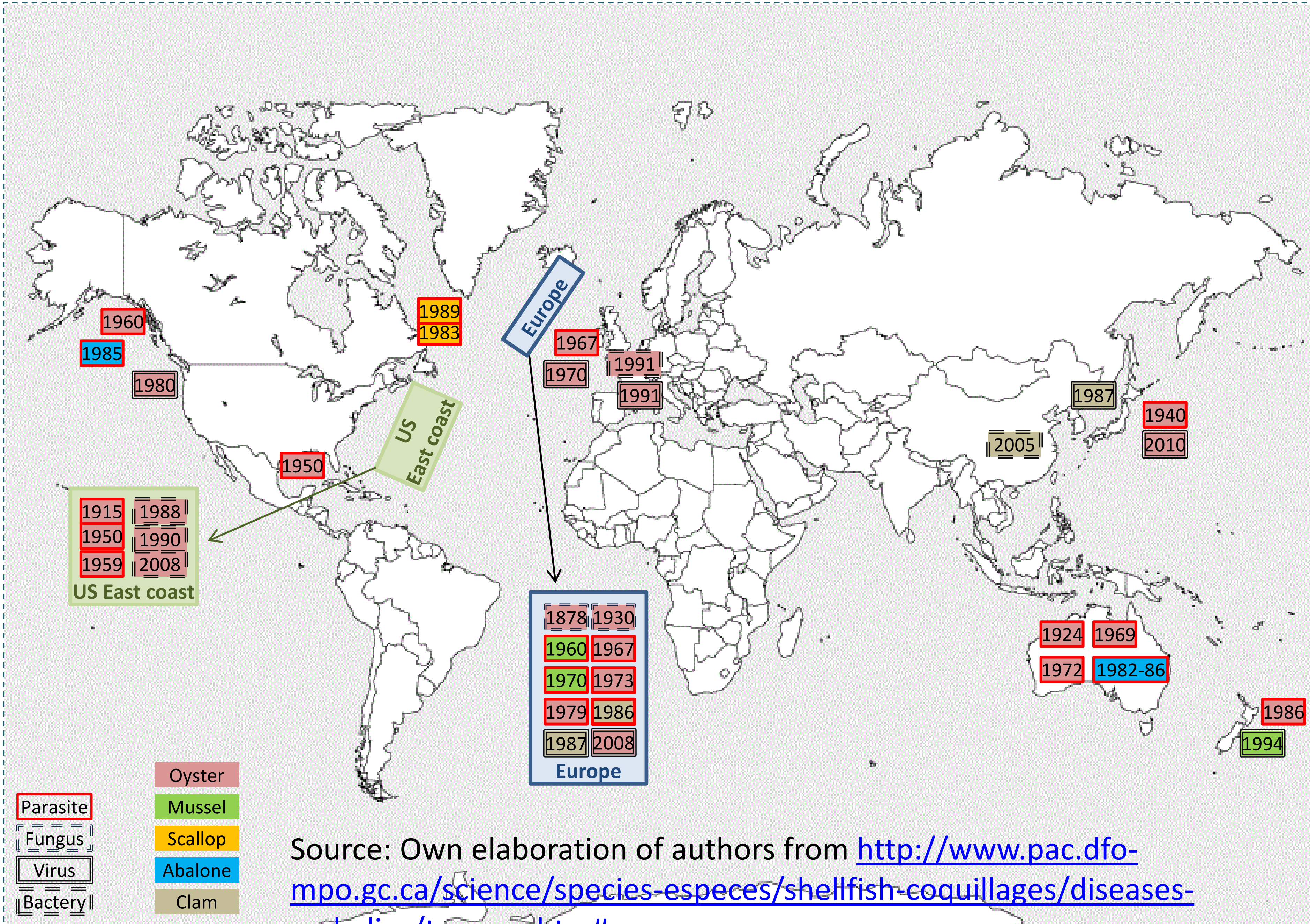
- Ancient and abundant literature (1878). showing a widespread phenomenon in time and space.

- Various causes behind MMS with strong interactions:
- **biogeochemical conditions** (salinity. turbidity. pH. oxygen. pollution…)
- **invasive species** (HAB) or **predators**
- **pathogens** (virus. bacteria. parasites. fungi)
- **stock density**

- Several common stressors increase vulnerability to MMS:
  - Higher sea temperatures (summer mortalities)
  - Rates of salinity
  - Density of cultured stocks
  - Prevalent MMS in eutrophic and nutrient-enriched waters
  - Link with gametogenic cycles

- The evidence suggests that disease outbreaks have increased over time since the 1960s (possible link with maritime transport – Hulme 2009)

Mass Mortality of Shellfish (MMS) Cases from pathogen issues



Source: Own elaboration of authors from http://www.pac.dfo-mpo.gc.ca/science/species-especes/shellfish-coquillages/diseases-maladies/toc-eng.htm#mus

Broad range of responses found in the litterature

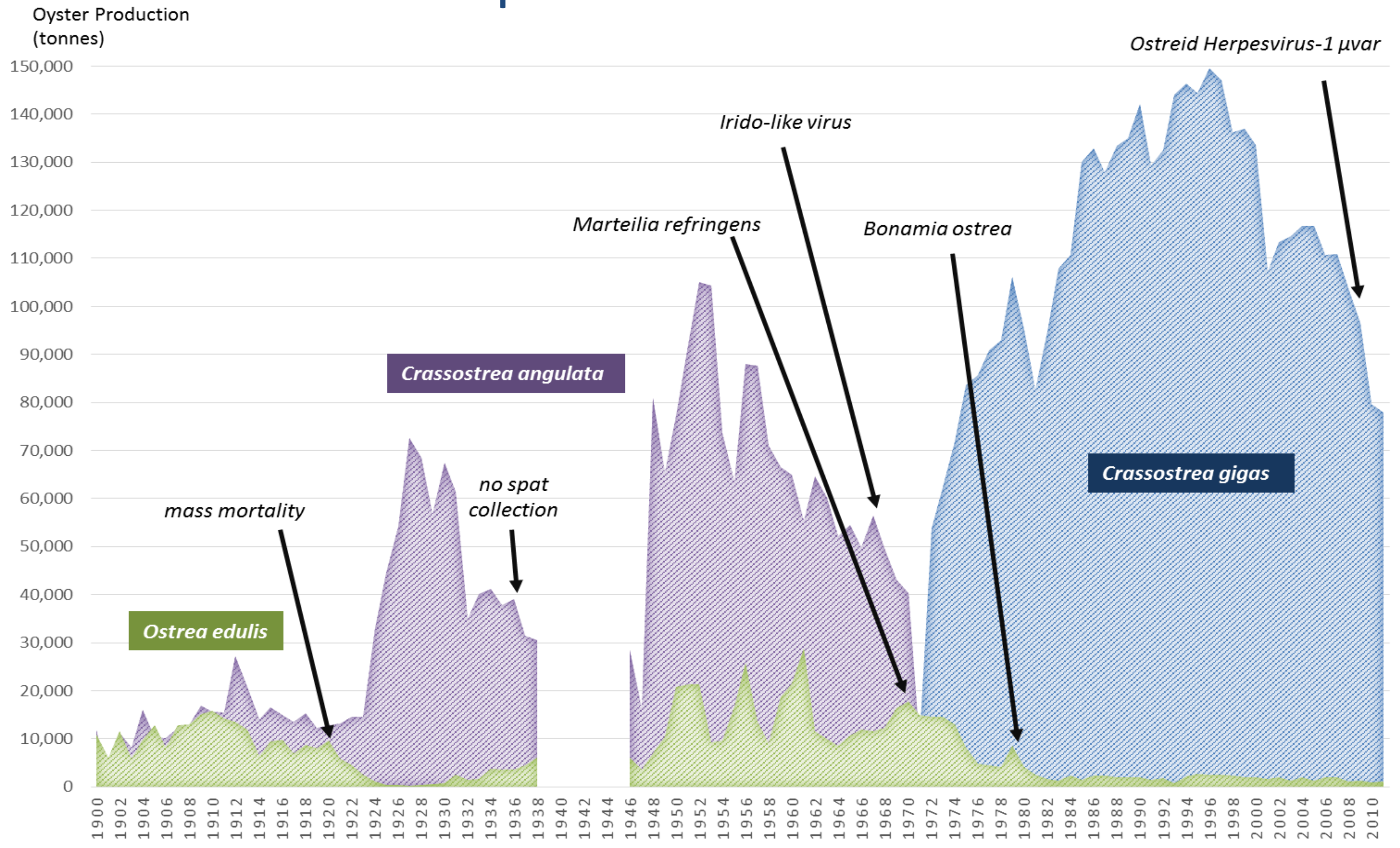
Study	MMS causes	Responses
Di Salvo, Blecka, Zebal (1978; USA)	Larval mortality in a Californian *Ostrea edulis* hatchery (*Vibrio*)	Use of penicillin to avoid mass mortality of oyster larvae in hatchery.
Grizel (1983, France)	80-90% mortality of oysters (*O. edulis*) in 1974 due to *Marteilia* and *Bonamia*	Culture in deeper water; lower density of stocks; public safeguard scheme (1.77 M€); introduction of new species (*C. gigas*)
Ewart and Ford (1993; USA)	MSX and Dermo diseases on oyster stocks	Grow oysters in low salinity zones (< 15 PPT), Increase monitoring and diagnosis, select resistant species in hatcheries.
Matsuyama (1999; Japan)	Harmful algal blooms on shellfish aquaculture	Algal Monitoring systems since 1992 (*Heterocapsa circularisquama*): density, SST, cell density… Prevention techniques (active clay, hydrogen peroxide and coagulants, etc.); transfer of animals during bloom periods.
Smith I.R., Nell J.A., Adlard R. (2001; Australia)	Winter mortality caused by low temperature, high salinity, parasite (*Mikrocytos roughleyi*)	Growing culture height (300 mm higher) on intertidal lease reduces mortality rates of oysters (*Saccostrea glomerata*) from 35% to 9% in Winter (but no difference between single seed –cultchless- and oysters grown on sticks).
Hine, Cohennec-Laureau, Berthe (2001; New Zealand)	*Bonamia exitiosus* infecting flat oysters *Ostrea chilensis* in a New Zealand fishery (60 to 90% mortality 1985-93)	Closure of the fishery having a severe impact on local communities.
Mydlarz *et al.* (2006), Worldwide review	Environmental factors affecting the immune response of invertebrates	Addition of immunostimulants (glucans, bacterial cell walls) to the diets of the farm-raised invertebrates (e.g. lobsters)
Cassis *et al.* (2011; Canada)	Growth and mortality of young Pacific oysters.	Increase the depth of cultured stocks (3m, 10m, 15m): lower mortality rates obtained, but lower growth rates.

(……..)

5 types of responses:

- New or R-species
- Physical/Chemical means
- Prevention measures
- Compensation measures
- New practices and rules

Example of MMS in France



Major crises affecting the oyster farming industry in France (oyster output in mt)

Source : C. Lupo (Ifremer) et V. Le Bihan (LEMNA) with data from Ifremer (Buestel et al. 2009) and DPMA-BSPA

Main features of the 6 systems

	Issue	Production (mt)	Number of users	Area
Matsushima Bay Japan (oyst.)	Human health (Noro-virus)	5.760	112 households	35.3 km^2
Chesapeake Bay USA (oyst.)	Oyster diseases (parasites)	n.a.	32 small-scale fishers	1.2 km^2
Bay of Quiberon France (oyst.)	Hypoxia caused by weather	15.000	60 farms (10 after outbreak)	30 km^2
Barra del Chuy Uruguay (clams)	Mass mortality of clams	20	35	2.3 km^2
US North-West coast (oyst.)	Ocean acidification	29.718	3.200	49.000 km^2
Bay of Bourgneuf France (oyst.)	Spat mortality (OsHV1-µvar)	10.000	283 farms (~600 FT jobs)	100 km^2

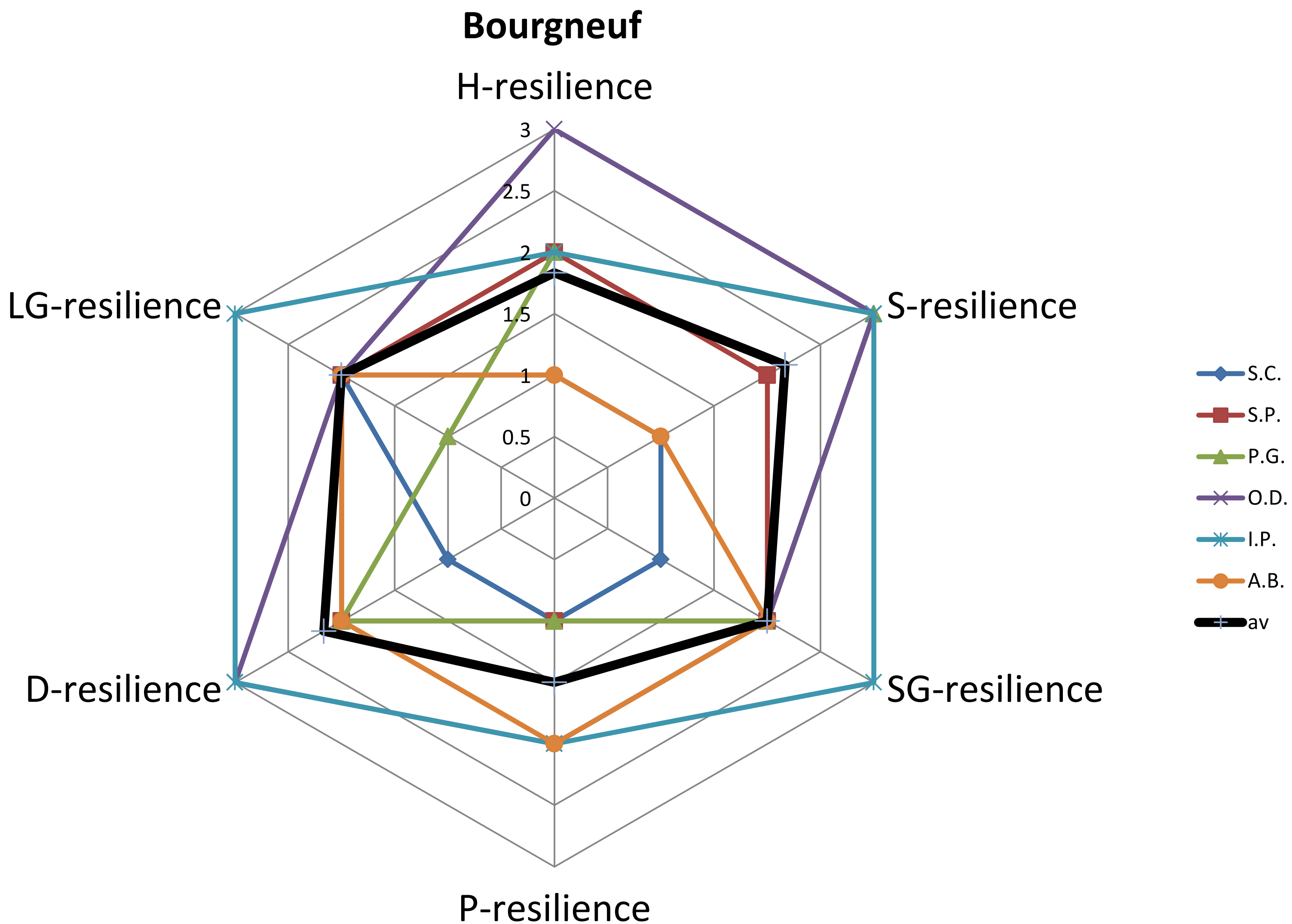
Appraisal

Case study	
MB_oyst	7% decrease of farms since 2011. Massive public investment in new sewage facilities after the Tsunami, but with long-term effects.
CB_oyst	Significant aid from the state (replenishment plan and rotational system + mgt measures) →In 2013, harvest level of 26 years ago
US_oyst	Good short-term response (BRP) to increase awareness about OA + technical measures resulting in higher costs.
BU_clam	Fishery closed for 13 years (fishers had to find alternative jobs) and better management plan after re-opening (high level of knowledge).
BQ_oyst	60 down to 10 leaseholders (transfer to other basins).
BB_oyst	30% loss of output, but higher investment in triploid spat, higher market prices, integration and diversification…

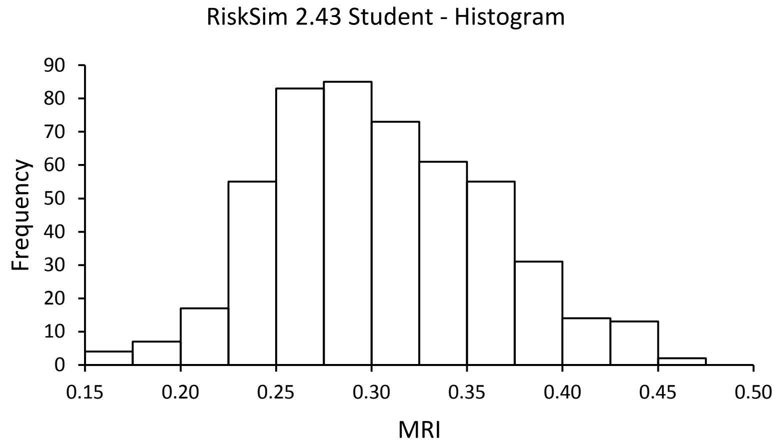
Example of the Bay of Bourgneuf case study, scored independently by 6 co-authors of the Ecology & Society article (Delphi method; Dalkey and Helmer 1963):

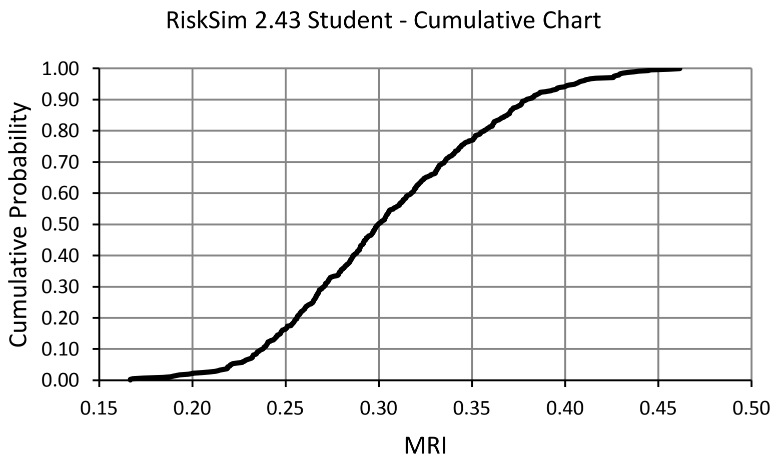
	STG-resilience	P-resilience	D-resilience	LTG-resilience	H-resilience	S-resilience
S.C.	1	1	1	2	1	1
S.P.	2	1	2	2	1	2
P.G.	2	1	2	1	1	3
O.D.	2	1	3	2	2	3
I.P.	3	2	3	3	2	3
A.B.	2	1	2	2	1	2
Mean	1.89	1.20	2.75	2.14	1.78	2.02
St.-dev.	0.63	0.41	0.75	0.63	0.52	0.82

Independent scoring by 6 experts showing interpretative discrepencies



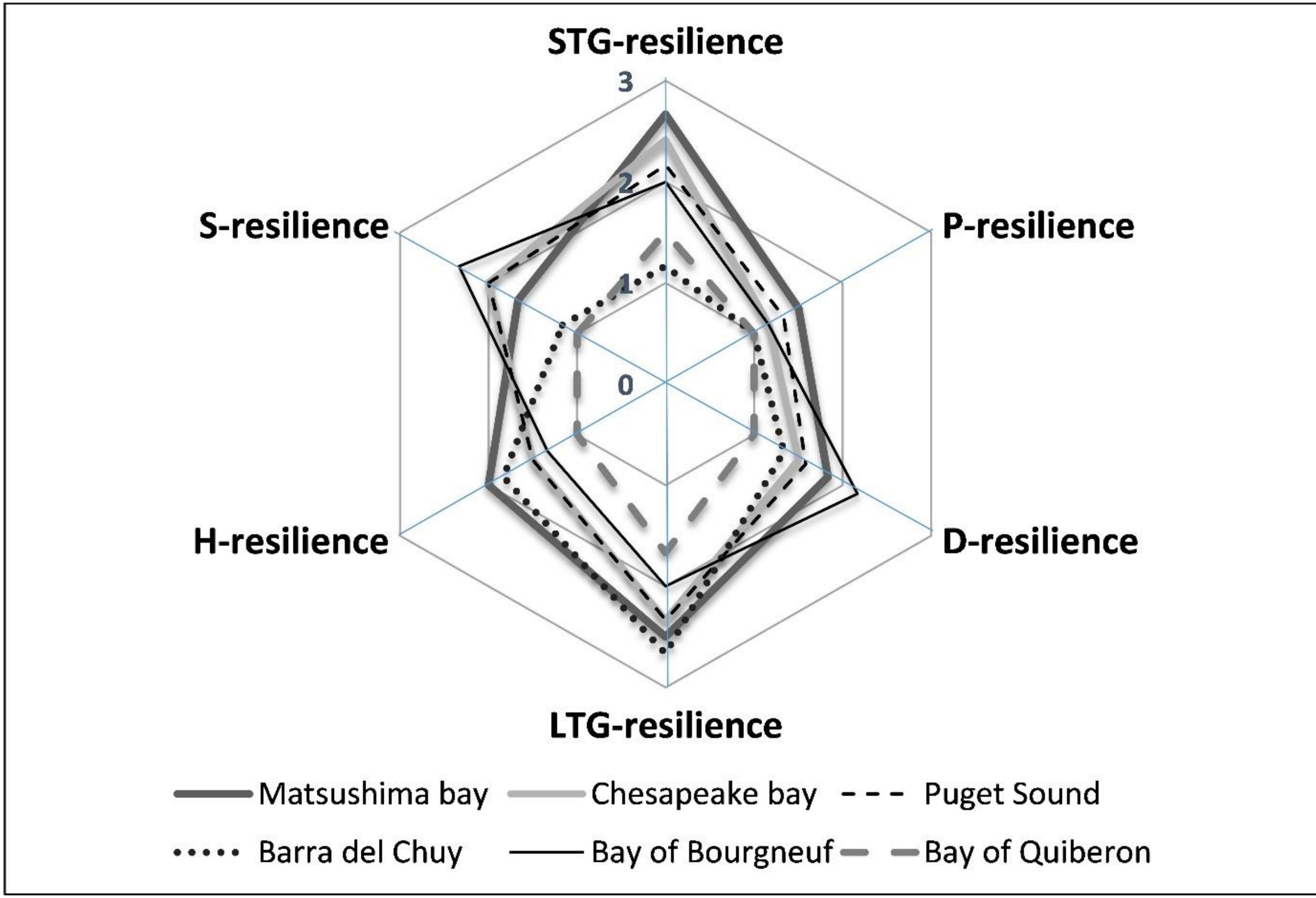
A Monte Carlo approach is used to draw random values from a uniform law within the range of min and max values given by experts. 500 trials of the MRI index run for each case study, resulting in a distribution of the MRI value rather than a single average score.





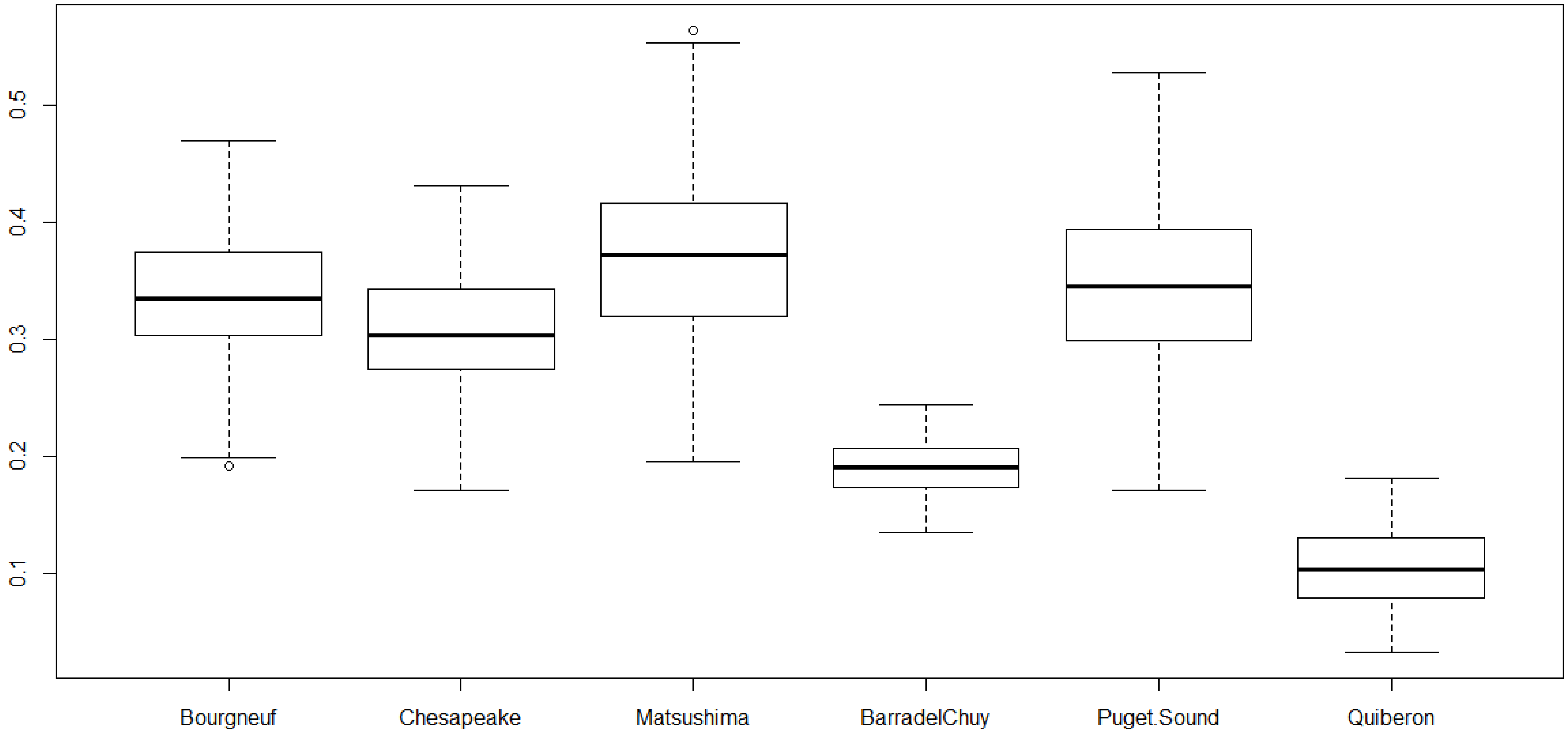
Mean	0.31
St. Dev.	0.06
Mean St. Error	0.00
Minimum	0.17
First Quartile	0.26
Median	0.30
Third Quartile	0.34
Maximum	0.46
Skewness	0.24
Kurtosis	-0.33

How resilient are systems after MMS outbreaks?



Multi-dimensional Resilience Framework applied to six MMB case studies

Estimated MRI for the 6 case studies



Guillotreau et al. (2017)

Discussion

- Increasing mass mortality of bivalves outbreaks since the 1960s.

- Large variety of causes, but also of responses (introduction of resistant/alien species, chemical/physical measures, prevention, compensation, changes of breeding practices, new management rules…)

- The case of Bourgneuf Bay farmed oysters: a century of resilience to mass mortality problems (mainly through new imported species)

- Introduction of a Multi-dimensional Resilience Framework (G,N,S static and dynamic dimensions) → list of criteria (ongoing definition)

- Scoring the resilience dimensions to compare case studies across borders and sectors. Definition of a Multi-dimensional Resilience Index.

Conclusion

- Scale : global issues (acidification, increase of SST…) cannot be correctly addressed at the local level + different time horizons (e.g. scientists *vs* industry). System governability?
- Organisational response for fisheries and technical ones for aquaculture (higher degree of control over production). Innovative capacity innovation or rebound effect?
- The state plays a key role in terms of « resilience option ».
- Resilient systems show a better capacity to innovate, to anticipate changes, and have more flexible institutions.

- Case studies resulting from the IMBER-ADApT framework can be resolved into different “Types”. This “Typology” provides a first-order entry point to compare marine social-ecological resource crises and identify solutions which may, or may not, have worked elsewhere
- Most common short-term response was ‘more research’. Generally too early to evaluate effectiveness of long-term responses
- Few, if any, alternative responses were considered. Generally no evaluations of effectiveness of responses
- A few key-factors of success emerge despite the idiosyncratic case studies (no panacea, responses culturally embedded, like *Sato-Umi*).
- Expand CS Database (Thank you !!!) :

‘Uki-yo-e’, Hiroshige Utagawa, 1834

http://www.imber.info/Science/Working-Groups/Human-Dimensions/I-MBER-ADApT