

Session 6: Transition zones in coastal habitats

# Climate change, the challenge of fisheries management and the need of a change of paradigm: ecosystem reference levels for sustainable fisheries



Francisco Arreguín-Sánchez\*



Pablo del Monte-Luna



Manuel J. Zetina-Rejón



T. Mónica Ruiz-Barreiro



Mirtha O. Albañez-Lucero

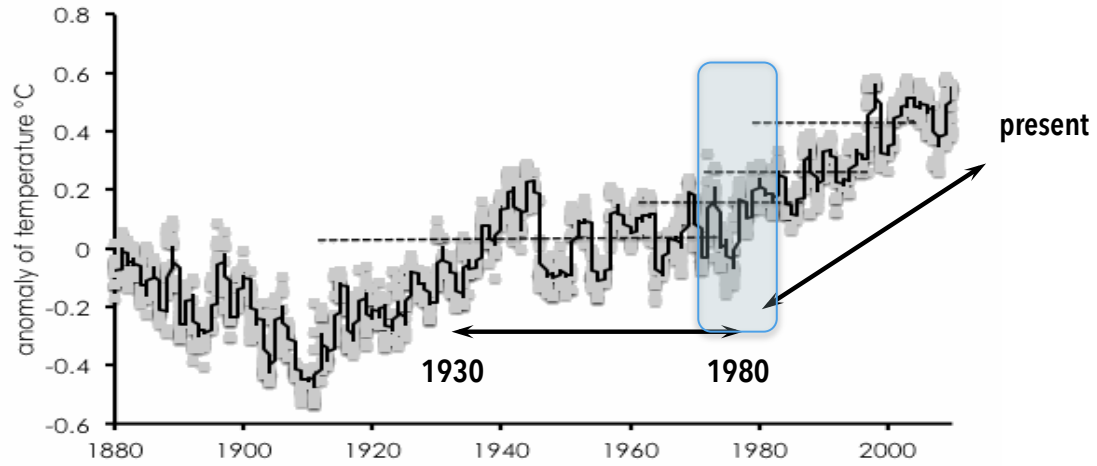


Arturo Tripp-Valdez



Session 6: Transition zones in coastal habitats

... about climate change





Session 6: Transition zones in coastal habitats

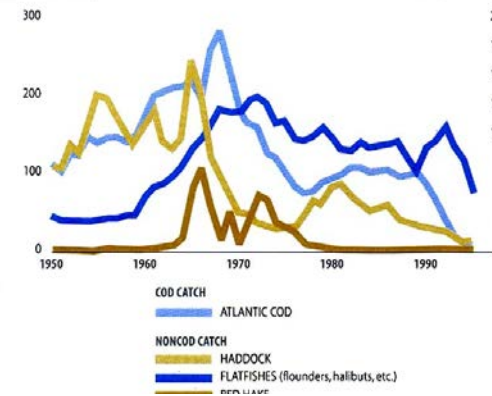
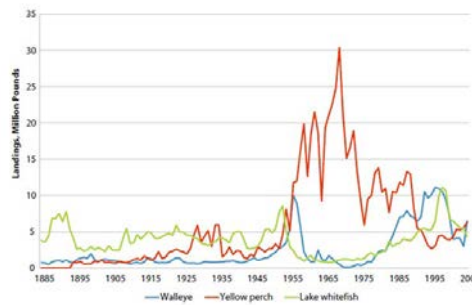
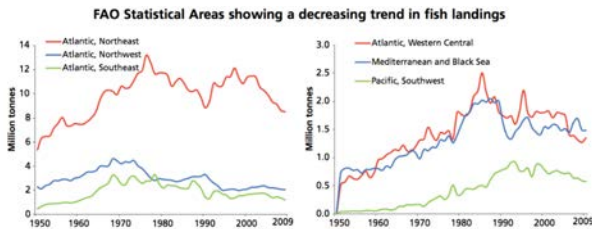
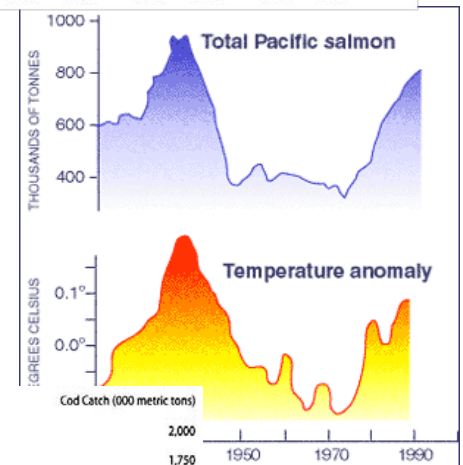
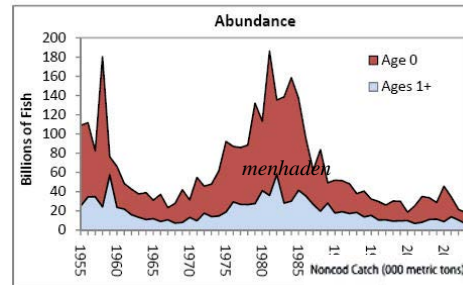
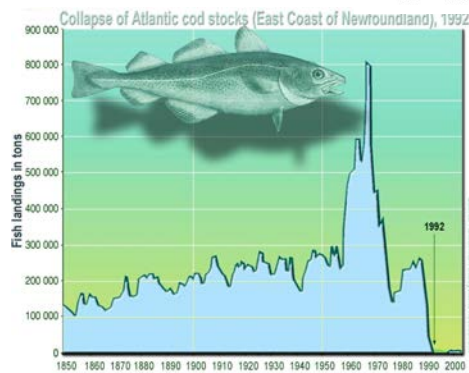
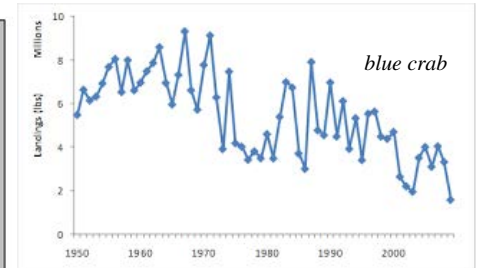
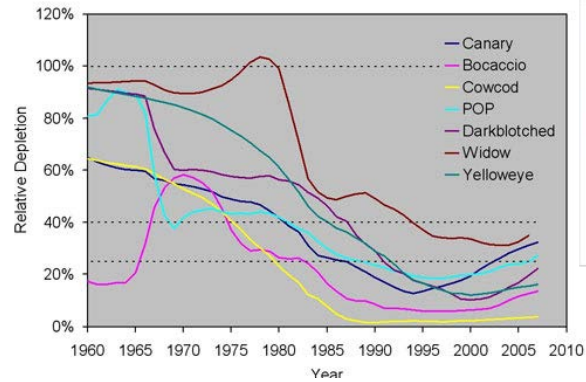
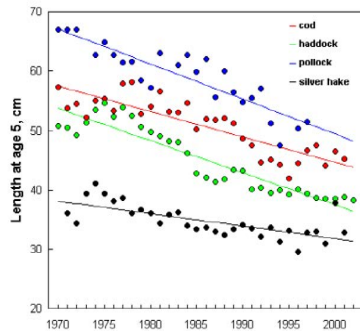
# The Problem, ... concerning the state of the fisheries ... diagnosis ...

Depletion,  
Overfishing



Session 6: Transition zones in coastal habitats

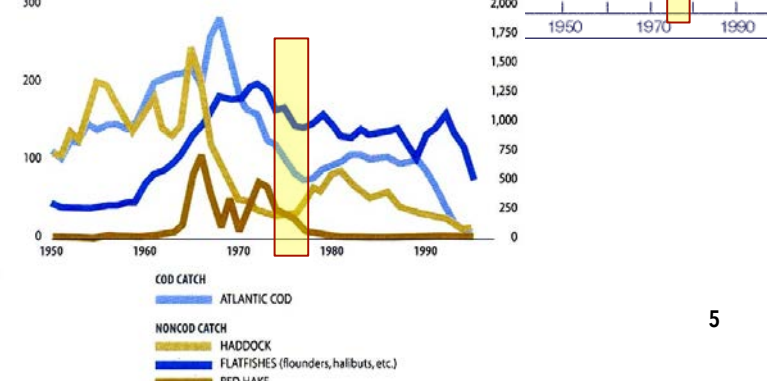
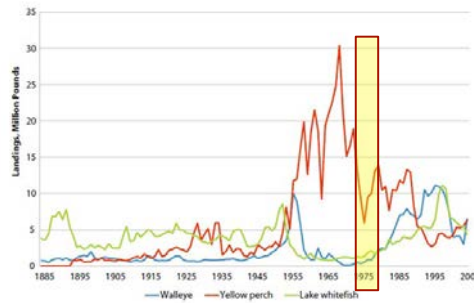
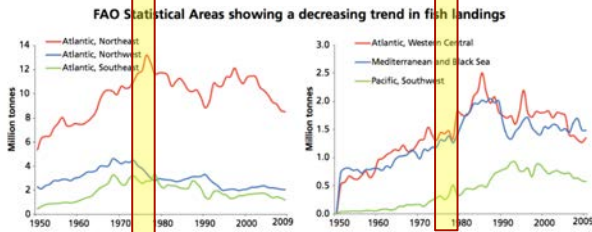
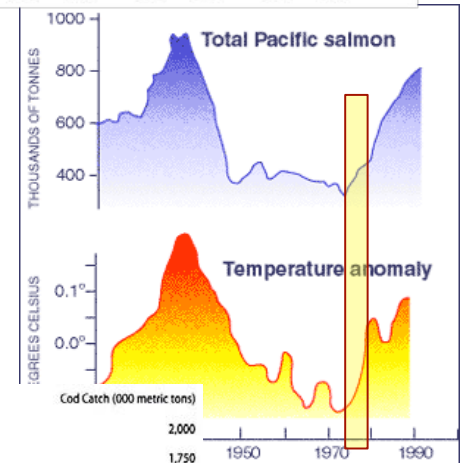
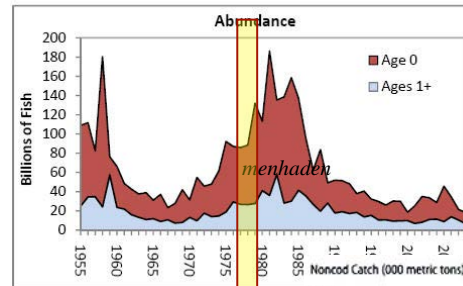
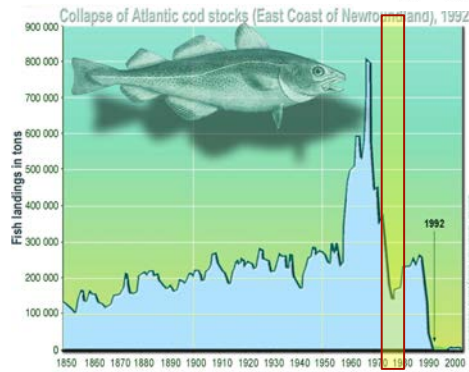
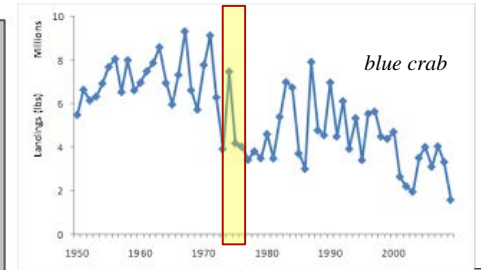
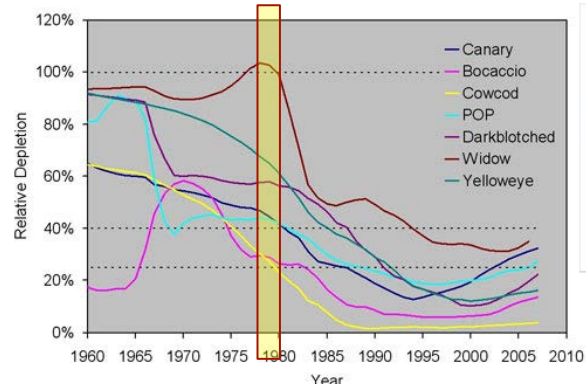
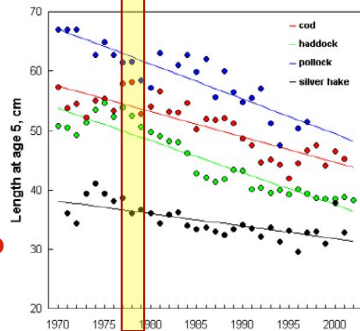
# The Problem, Depletion, Overfishing





Session 6: Transition zones in coastal habitats

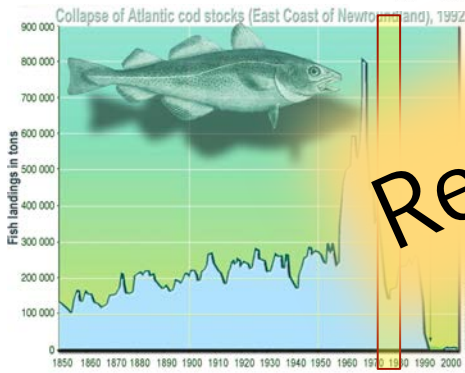
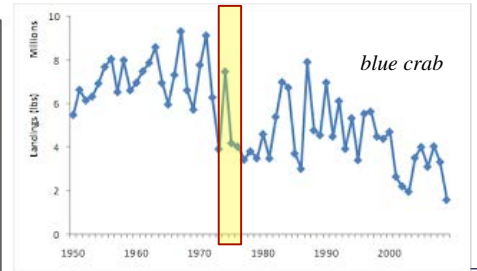
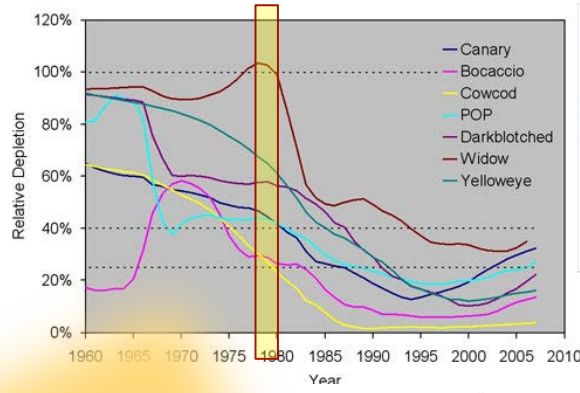
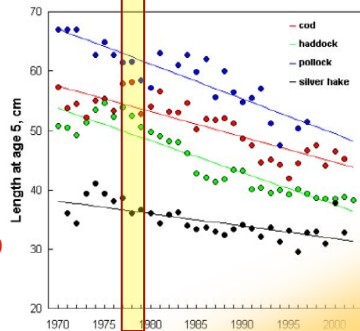
# The Problem, Depletion, Overfishing?



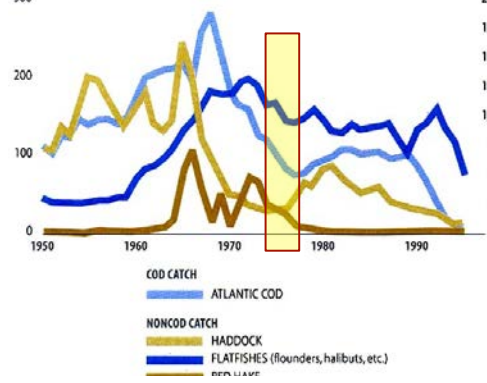
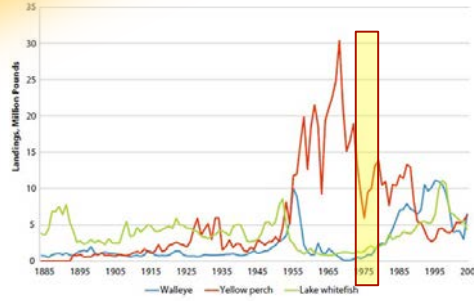
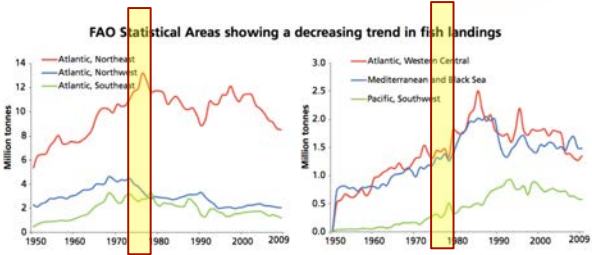
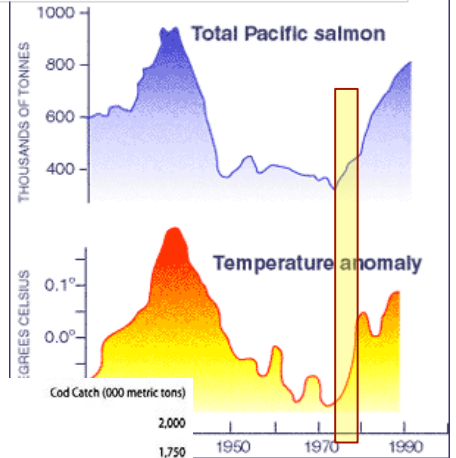
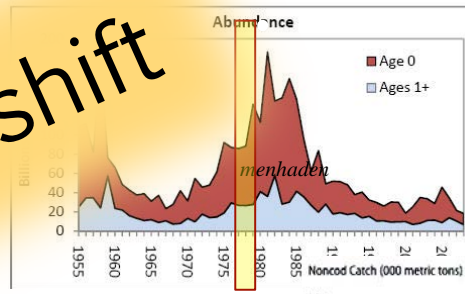


Session 6: Transition zones in coastal habitats

# The Problem, Depletion, Overfishing?



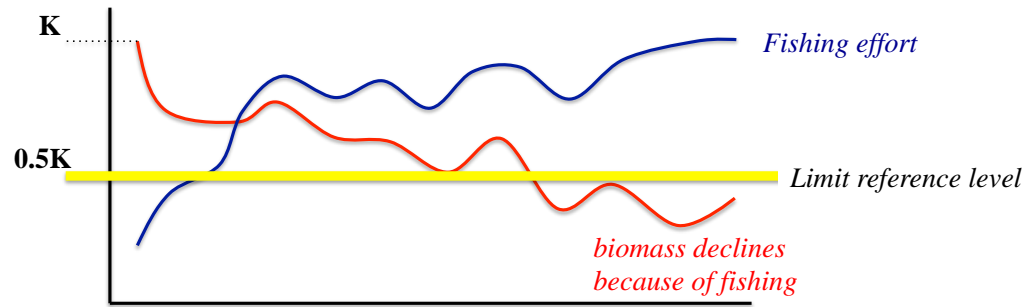
Regime shift





scientific bases of conventional (stock based) management

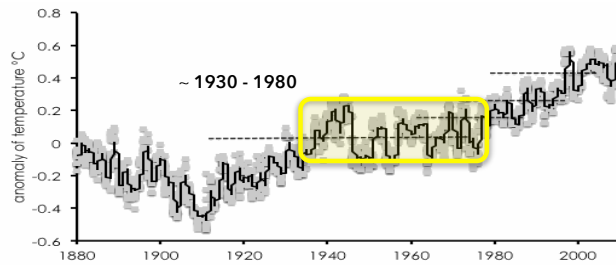
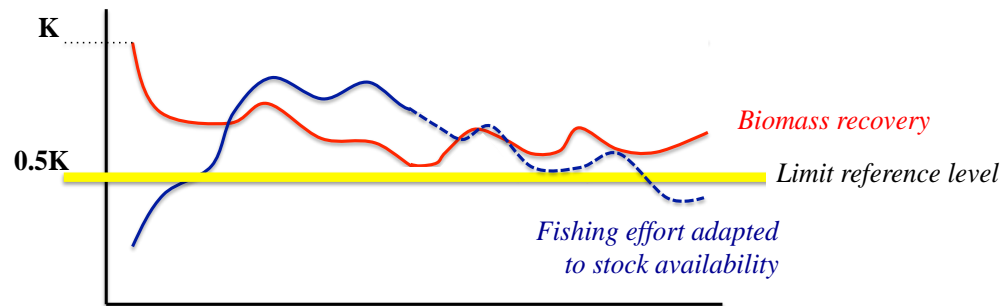
Session 6: Transition zones in coastal habitats





scientific bases of conventional (stock based) management

Session 6: Transition zones in coastal habitats



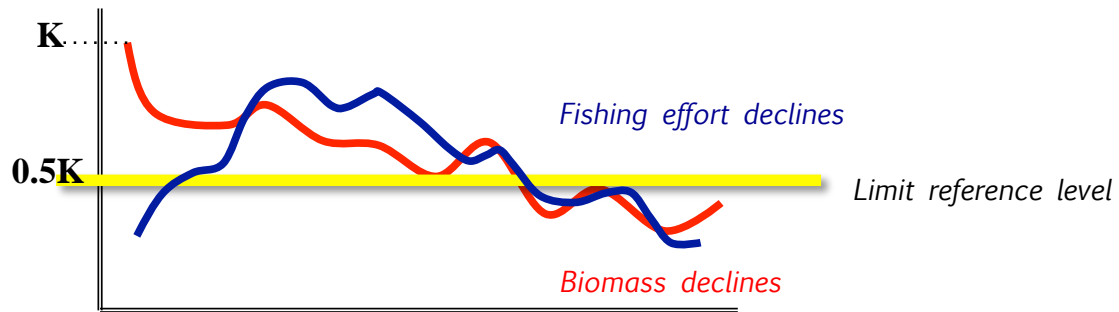
Assumptions

- Stable carrying capacity
- What means stable ecosystems
- Fleet management is effective
- variability without tendency





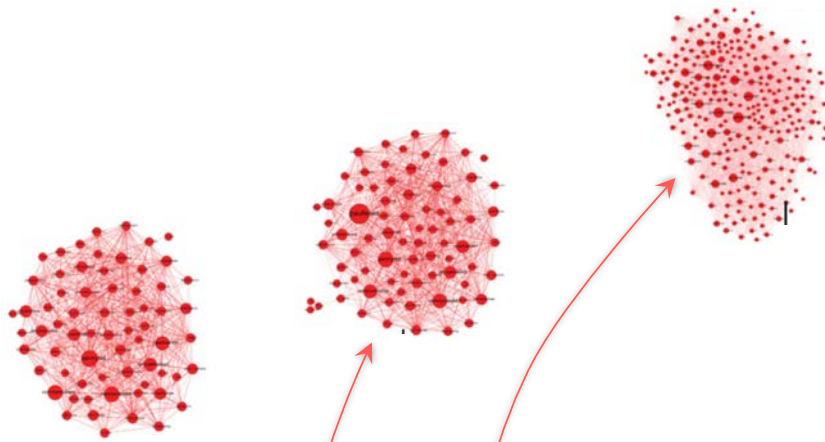
Session 6: Transition zones in coastal habitats



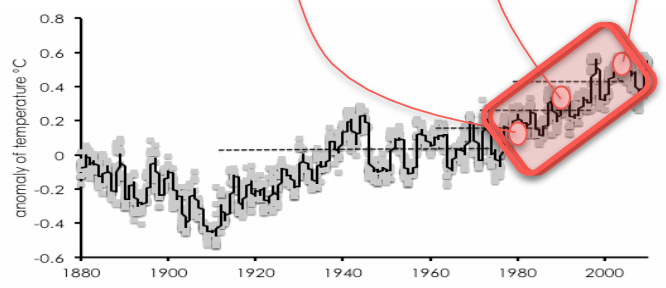
BUT, if fishing effort decreases and biomass also continue diminishing, it means that there is another source(s) of variation, other than fishing, which is(are) negatively forcing production



Session 6: Transition zones in coastal habitats



ecosystems are in continuous reconfiguration  
(*the ecosystem evolves*)



**Non-stable** carrying capacity  
 What means **non-stable ecosystems (relative to constancy)**  
 Fleet management is **not** effective as before / as expected  
 variability **with** (plus) tendency

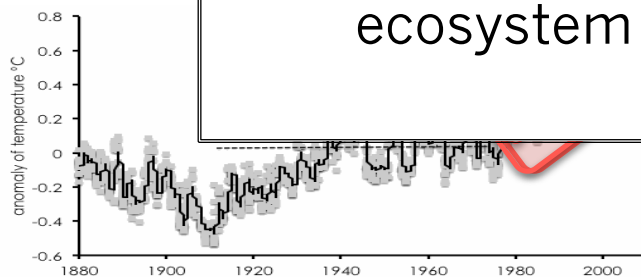


Session 6: Transition zones in coastal habitats

ecosystem in continuous reconfiguration

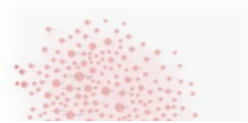
We can observe changes in biomasses, in flows, and in the network configuration; but also, in ecosystem attributes as its organization, coherence, modularity, resilience, etc., that give ecosystem its ability to endure over time

constancy)  
expected



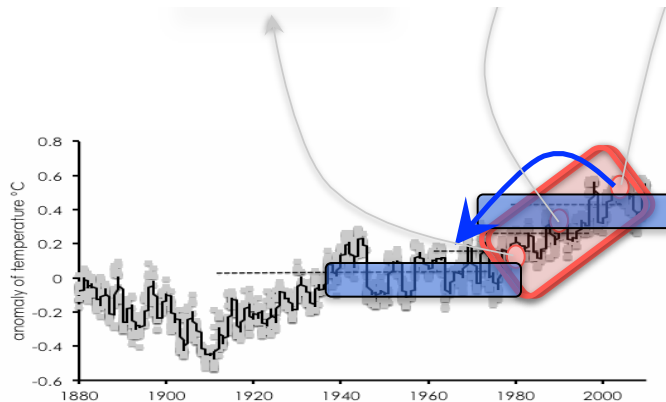


Session 6: Transition zones in coastal habitats



ecosystem in continuous reconfiguration  
*(the ecosystem evolves)*

**IF ecosystems are evolving in a natural way,  
The success of policies based on maintaining, recovering  
or rebuilding previous states are highly doubtful  
if intended to maintain a previous state over time**



Non-stable carrying capacity

What means **non-stable ecosystems** (relative to constancy)



Fleet management is **not** effective as before / as expected  
variability **with** (plus) tendency

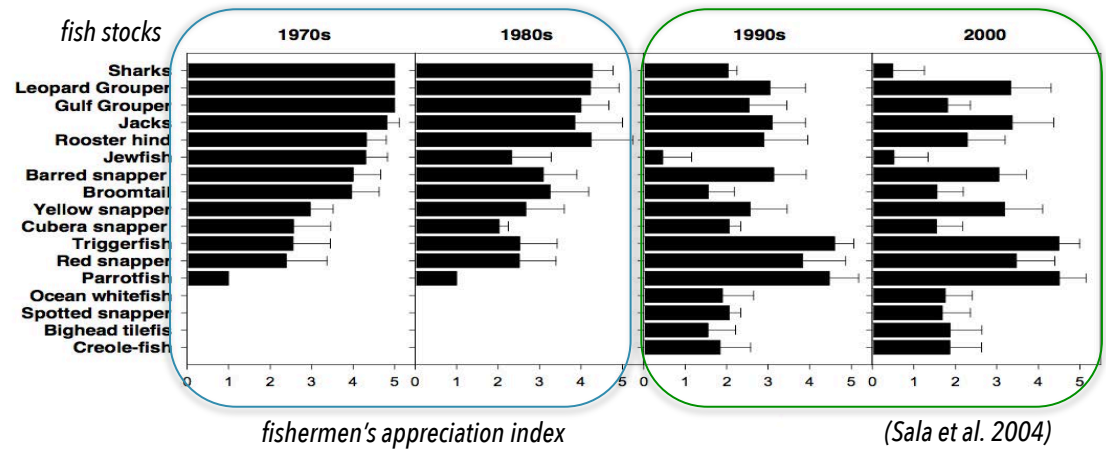


Session 6: Transition zones in coastal habitats

## a controversial example

Changes over time of some fish stocks

## Gulf of California



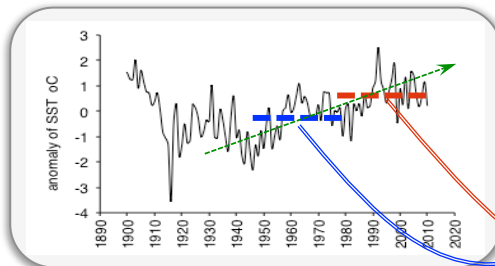
*authors argue stock's depletion is because of overfishing; ... and these kind of arguments are used to decide limits of fishing; or even closure of fish activities*



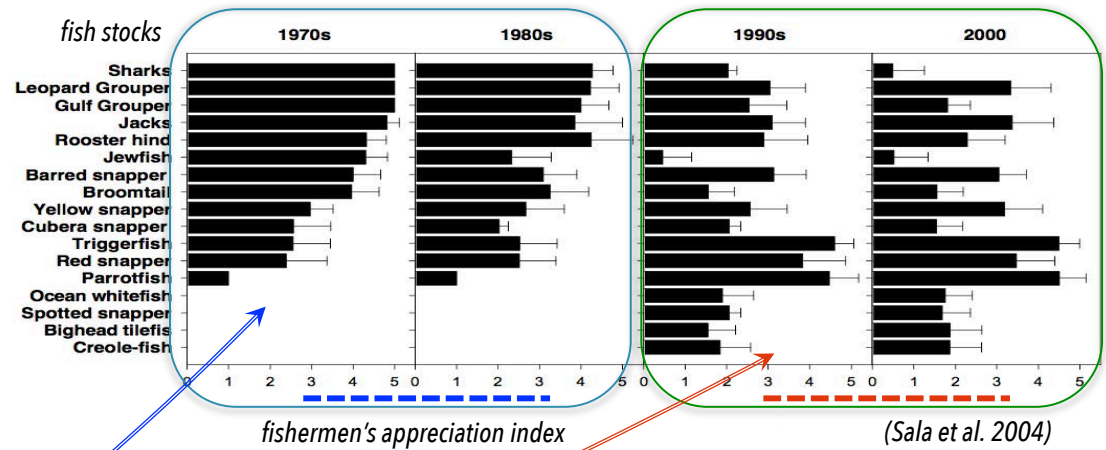
Session 6: Transition zones in coastal habitats

## Gulf of California

### a controversial example



(Arreguín-Sánchez et al. 2017)



(Sala et al. 2004)

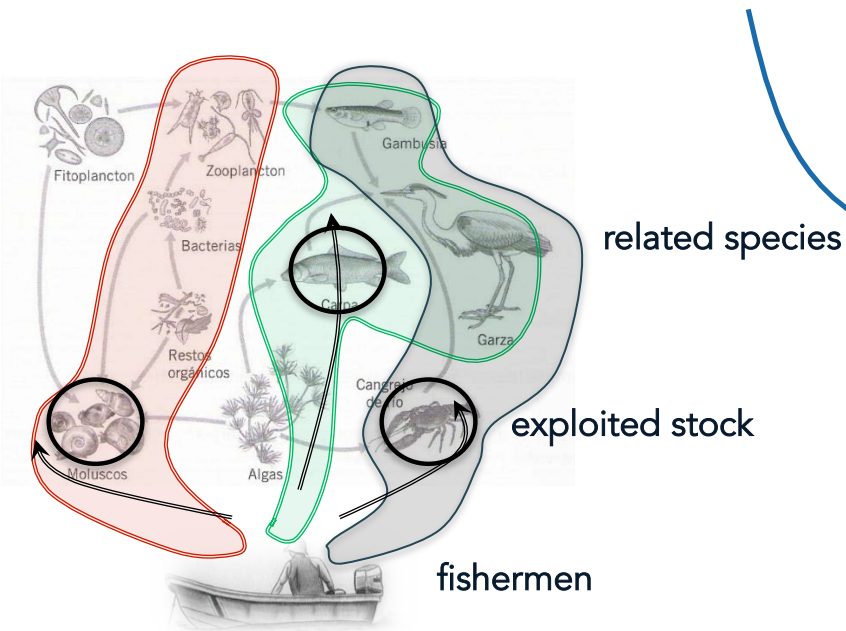
*authors argue stock's depletion is because of overfishing; ... and these kind of arguments are used to decide limits of fishing; or even closure of fish activities*

***BUT this is not necessarily true, time periods appears to pertain to different climate regimes as part of a tendency; stocks and ecosystems change and evolve; and fisheries management should consider such evolve (variability + tendency) and adapt harvest accordingly***

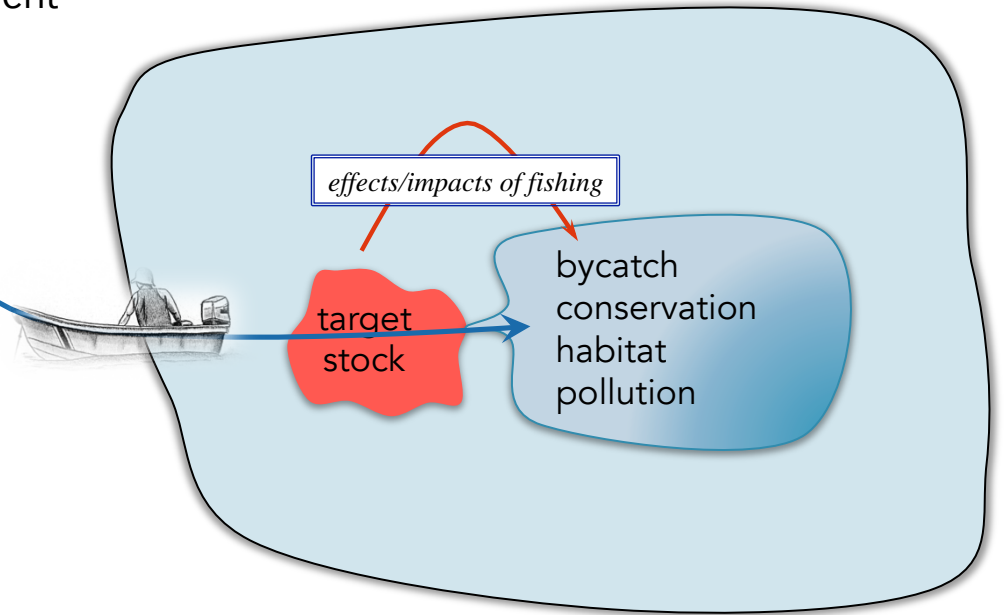


Session 6: Transition zones in coastal habitats

## Present (practice) of ecosystem approach to fisheries management



**Incomplete view of the ecosystem**



**Ecosystem as a framework for reference**

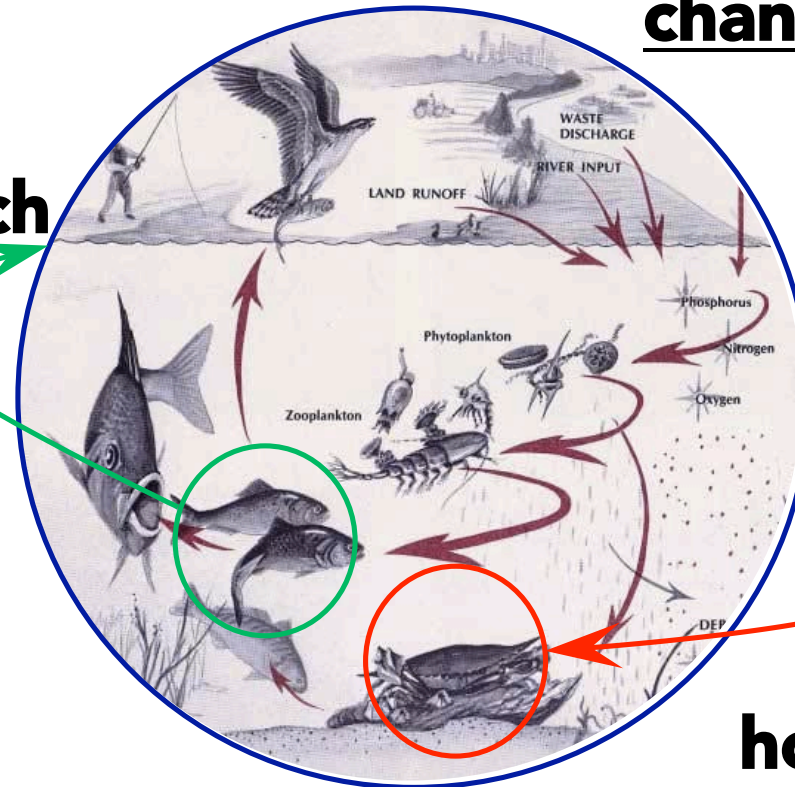


Session 6: Transition zones in coastal habitats

# for taken decision process change of paradigm

**present approach**

*“from individual stocks to ecosystem”*



*“from ecosystem to individual stocks”*

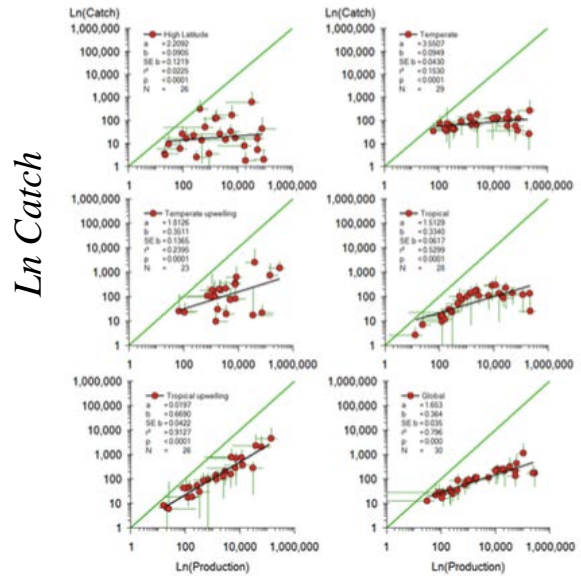
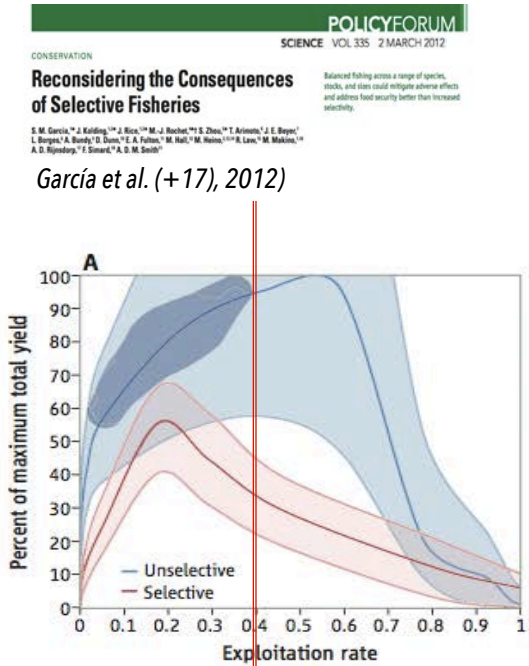
**holistic approach**





Session 6: Transition zones in coastal habitats

## “balanced harvest” concept



Ln Production

Kolding et al. 2015)

Concept developed throughout simulation experiments harvesting stocks and considering the balance between ecosystem production and the captures by fishing

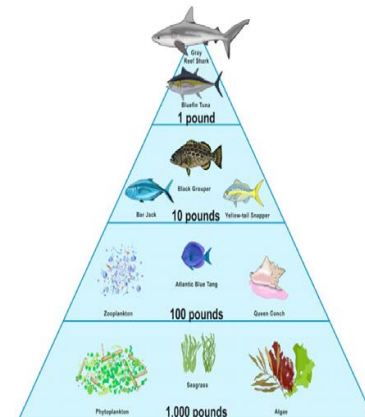
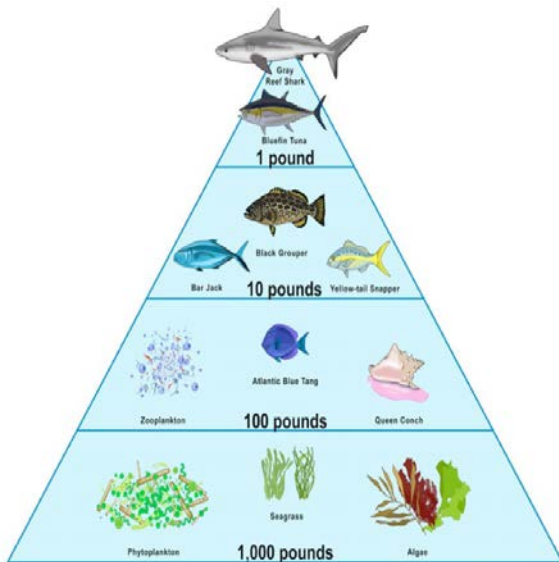
Green line balanced catch.  
 Red points observed catches



Session 6: Transition zones in coastal habitats

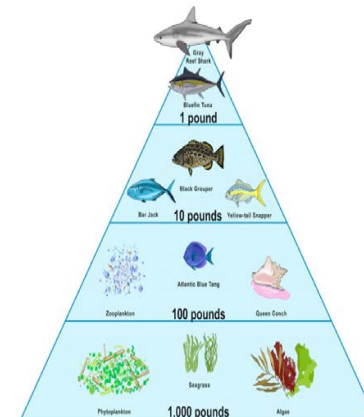
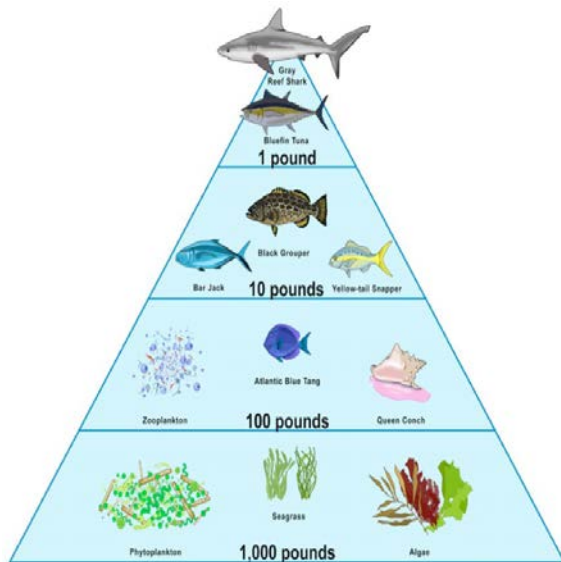
the concept

Balanced harvesting ... calls for fishing across the widest possible range of species, stocks, and sizes in an ecosystem, in proportion to their natural productivity



Balanced harvesting ... **strongly criticized**; for example, it involves harvesting over all trophic levels ignoring the ontogeny;

*i.e.* considers harvesting on zooplankton, including larvae / juveniles of top predators



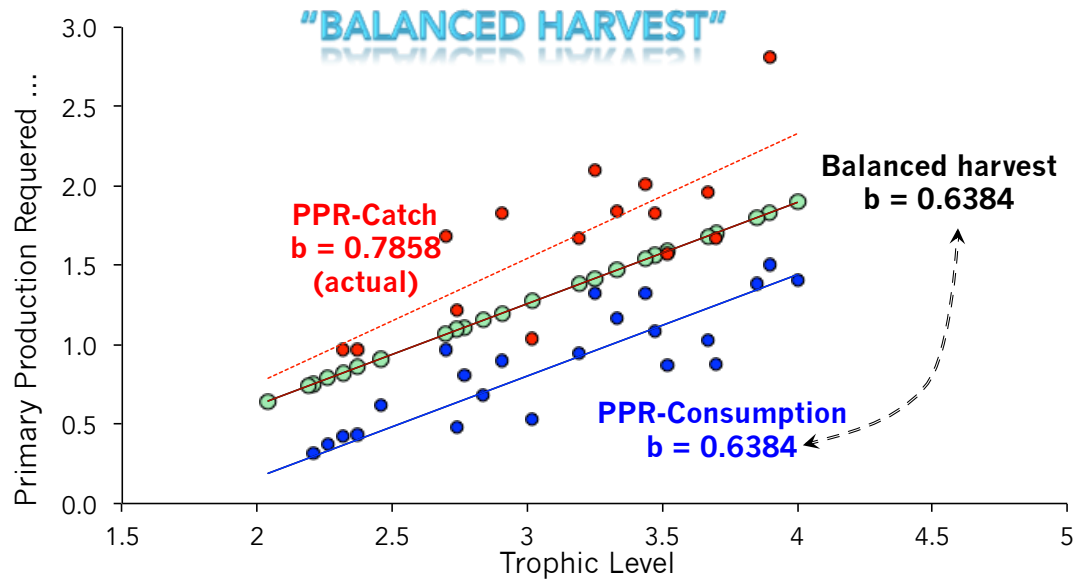


Session 6: Transition zones in coastal habitats

## Central Gulf of California

*an alternative rational ...*

fishing uses the production capacity of the ecosystem  
in the same way it does to sustain consumption





Session 6: Transition zones in coastal habitats

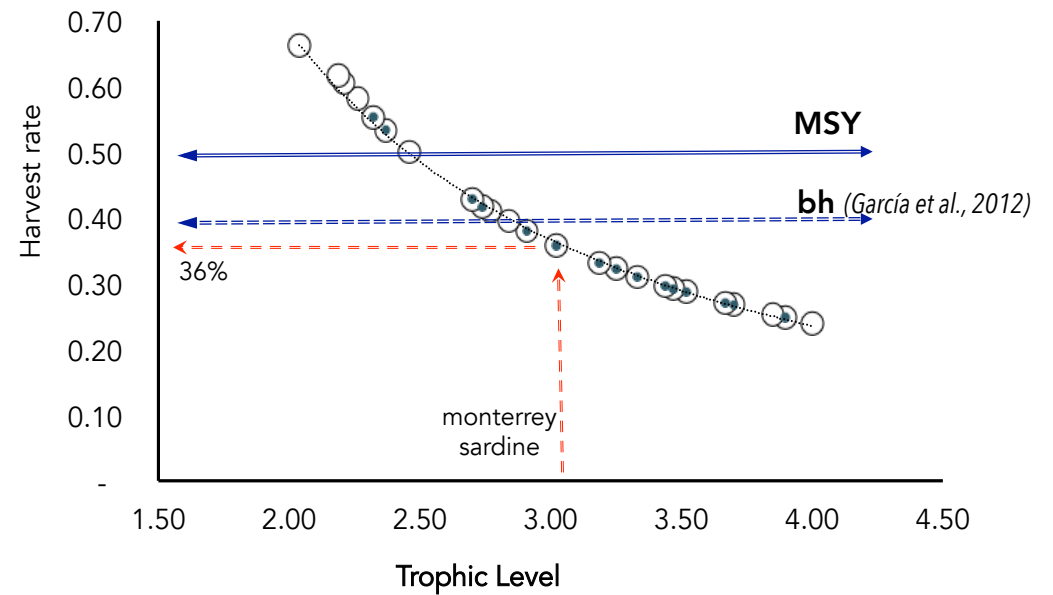
## Centro del Golfo de California “balanced harvest”

*an alternative rational ...*

harvest rates (HR) are in accordance with the life histories;

> HR for low trophic levels, and

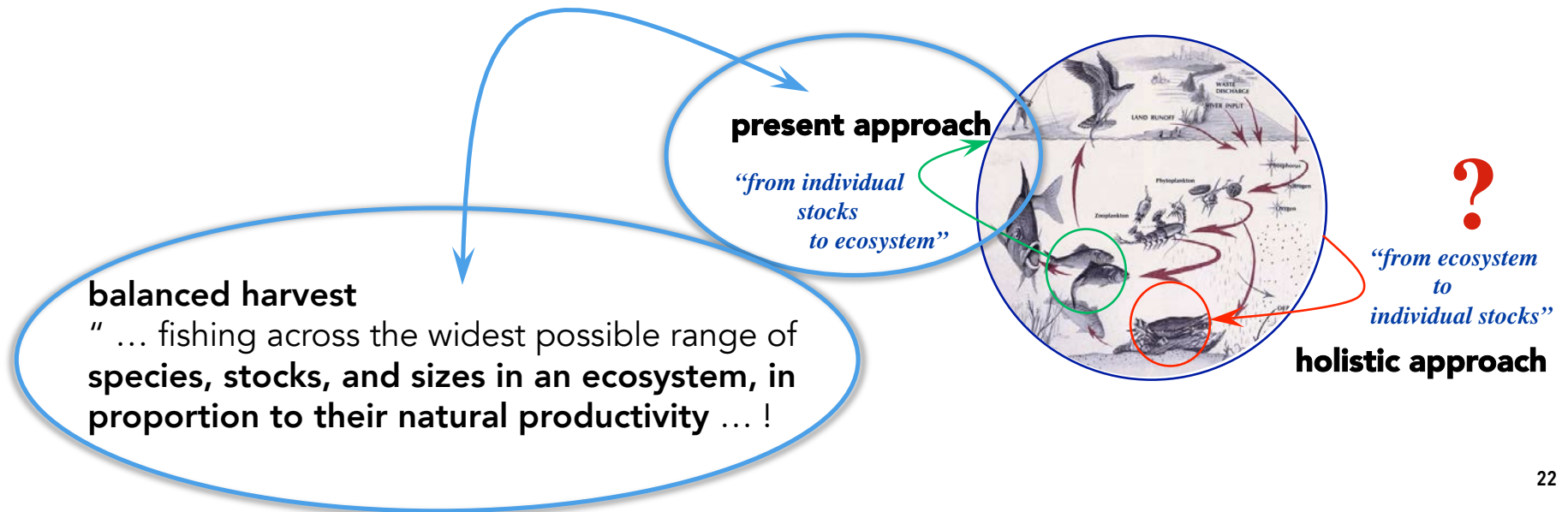
< HR for higher trophic levels





Session 6: Transition zones in coastal habitats

Balanced harvest concept refers to production capacity of the species within the ecosystem, but it is not an ecosystem **holistic** attribute





Session 6: Transition zones in coastal habitats

Definition:

“a holistic indicator refers to a property or attribute derived from the entire ecosystem”



Session 6: Transition zones in coastal habitats

towards a holistic approach

## Noxicline (a novel concept)

is defined as the limit of increase of **entropy** of the ecosystem,  
after which, the system can not recover its initial state of order / organization

ecosystem **order** =  $A/C$   
then, **entropy**, =  $1-A/C$

A = Ascendency  
C = Capacity of Development

*A/C defined by Ulanowicz (1986, 2009),  
(based on ecosystem flows of biomass / energy)*

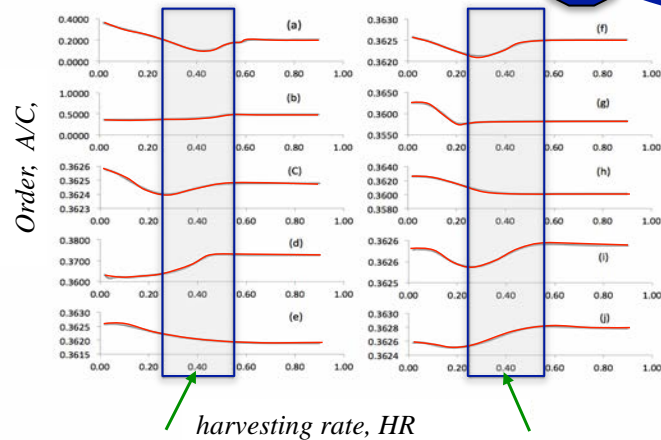
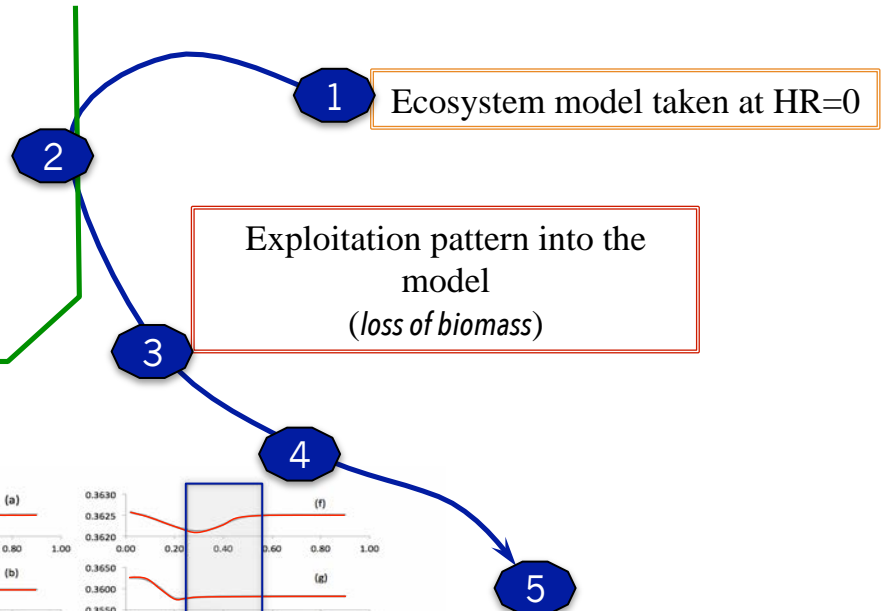
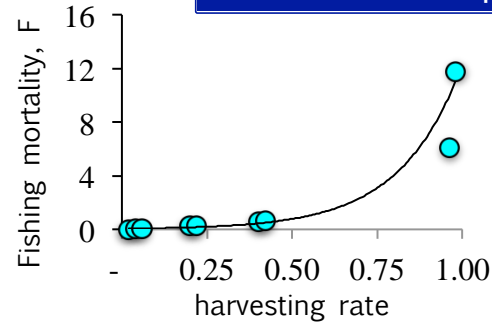




Session 6: Transition zones in coastal habitats

# simulation experiment towards a holistic approach

HR*	Fest
0.02	0.0227
0.04	0.0460
0.06	0.0698
0.20	0.2534
0.22	0.2825
0.40	0.5883
0.42	0.6284
0.96	6.0424
0.98	11.7637



$$* HR = \frac{F}{M+F} [1 - \exp^{-(M+F)}]$$

$M = 0.24$

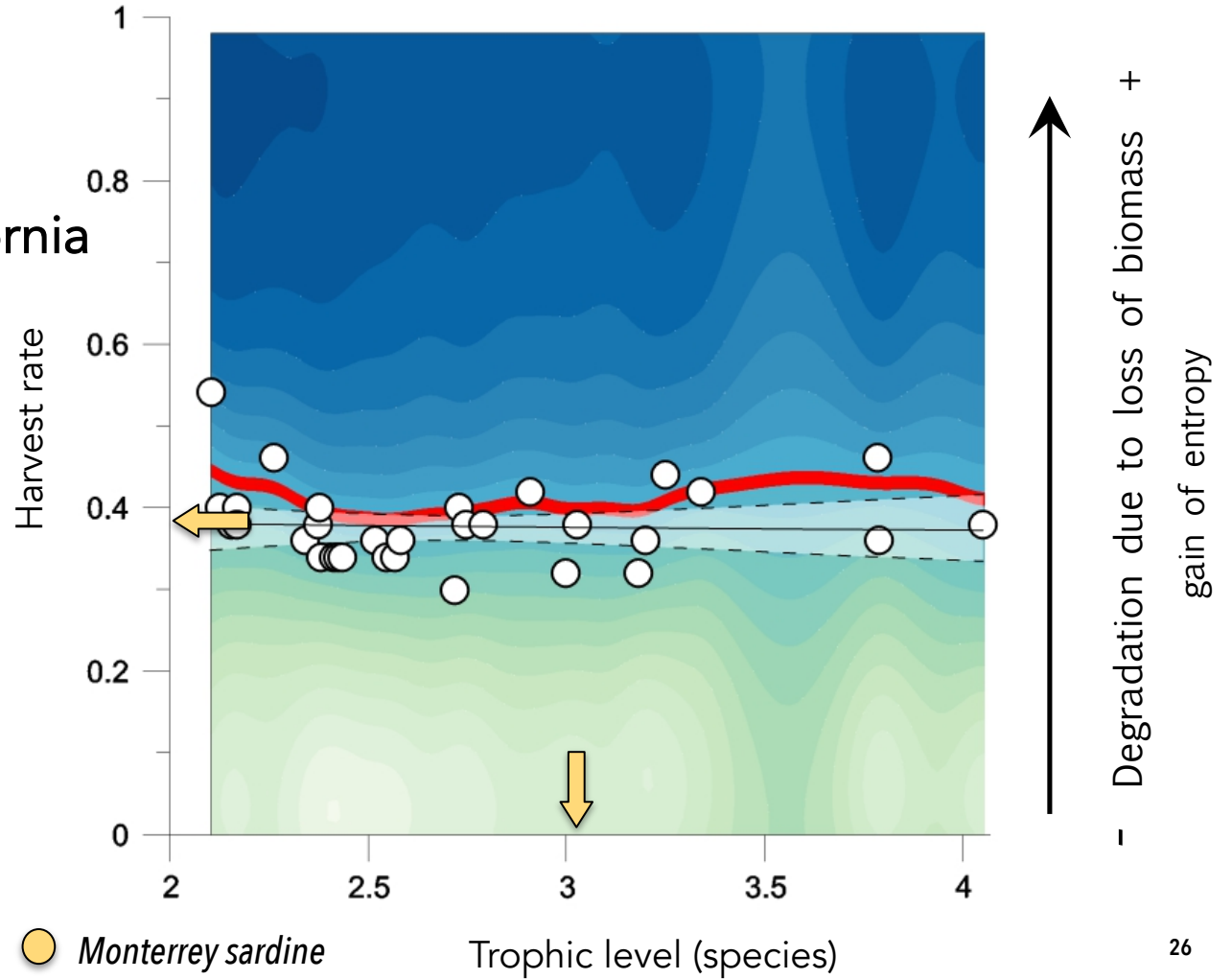


Session 6: Transition zones in coastal habitats

# Northern Gulf of California

isonoxas diagram  
and  
**noxicline**

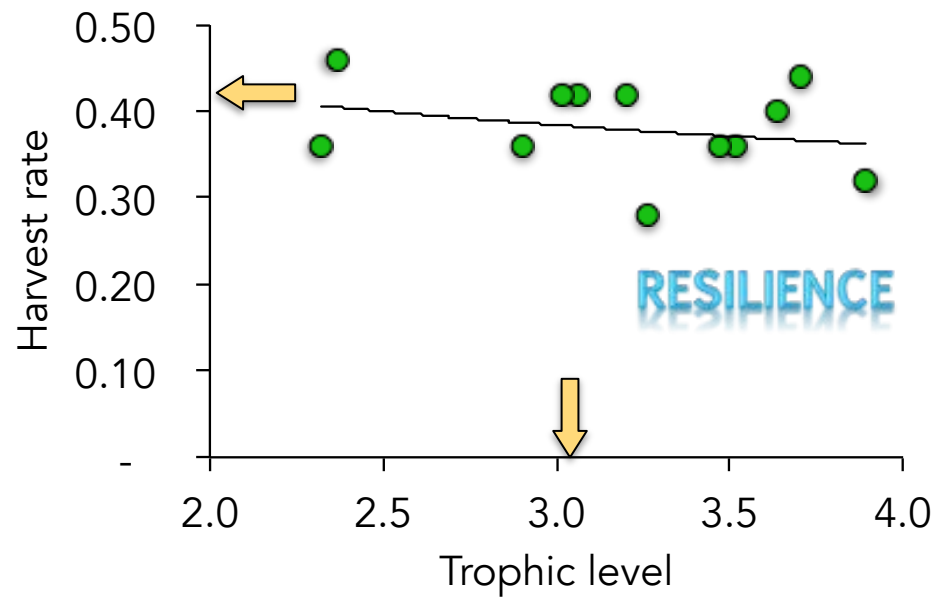
*isonoxa = isoline of entropy*





Session 6: Transition zones in coastal habitats

## Central Gulf of California



● *Monterrey sardine*



Session 6: Transition zones in coastal habitats

## holistic indicators vs. climate change

holistic indicators are referred to harvest rates to each stock

*from ecosystem*                      *to*                      *individual stock*  
~~from ecosystem~~                      ~~to~~                      ~~individual stock~~

**Harvest rate** is represented by  $C_t/B_t$

If biomass increases, catch increases

If biomass decreases, catch decreases

Adaptive management strategy can be adopted to control effort / catch to maintain HR;  
but we need to know the available biomass at the beginning of the fishing seasons



Session 6: Transition zones in coastal habitats

## Considerations for implementation

### Holistic Reference Level (HRL) ...

... holistic properties are not tangibles like biomass or effort,

... take holistic indicators as precautionary (*ecosystem-*) reference levels  
(not absolute),

... consider HRL together with stock-based biological reference points

*many thanks*



*La Paz, Baja California Sur, México*



Session 6: Transition zones in coastal habitats

# acknowledgements

