Qualitative model of environmental indicators for the fisheries integrated management in protected marine areas: The upper Gulf of California and Colorado River Delta Biosphere Reserve as a study case

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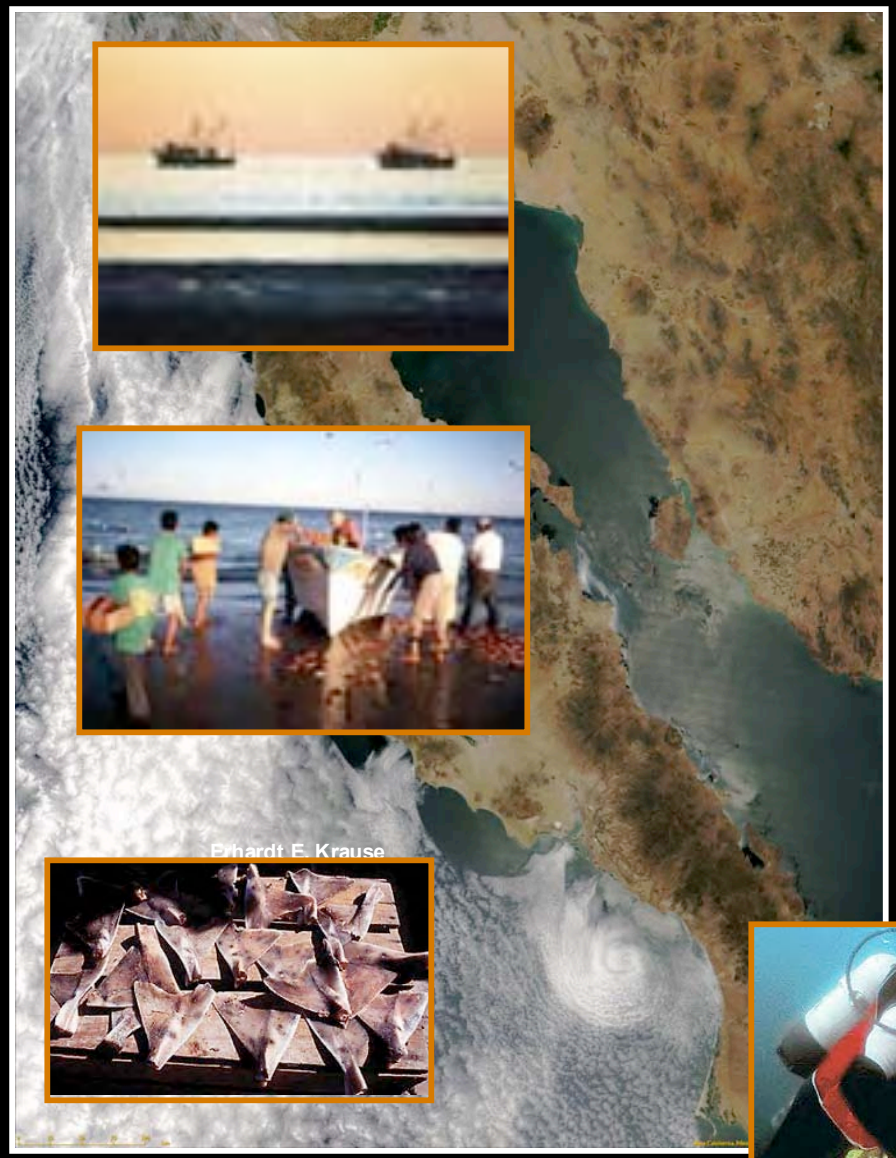
- The Gulf of California is considered one of the marine ecosystems with more biodiversity of the world (Sala *et al*., 2002)

- Due to their environmental characteristics, the UGCRD is an important reproduction and raising habitat of multiple species (Hastings *et al*., 2004).

A deterioration of the biodiversity has been associated with human activities of great impact:

a) *Disruption of the Colorado river*
b) *Intense fishing activity*



The Upper Gulf contributes around 15 % of the economic production of the fisheries sector in the country

Two main fleets: artisanal and industrial (shrimp, corvina and shark)

Sport or tourist fisheries

To diminish the fishing impact, several management strategies have been implemented:

Temporal and spatial closure, minimum quotes, limited entrance, etc.

The effectiveness of these policies has been insufficient (Cisneros-Mata, 2004) due to:


José Luis Villegas

- The quality of the data bases (inconsistency, underestimation, etc.) (Ramos-Montiel *et al*., 1999)

- Specific studies from a population perspective (Hendricx, 1985)

- Existing fisheries even in the core zone!

Objective

Design alternative models using fishing indicators to analyze the behavior of the system for management purposes

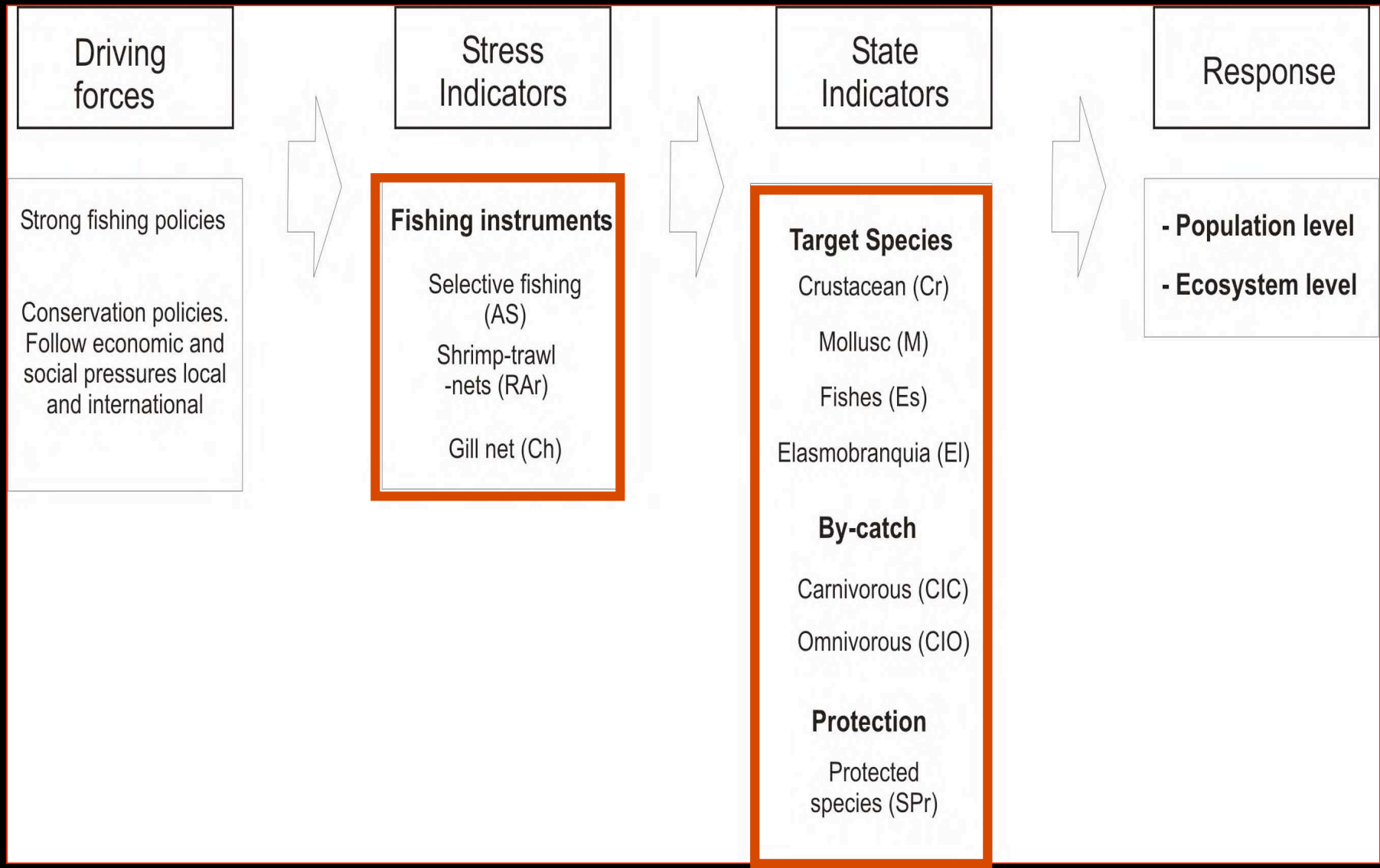
Premises

a) Include ecological and socioeconomic aspects of the fisheries to analyze the systems in a holistic approach

b) Promote management strategies from an ecosystem perspective

c) The use of qualitative data to guide the development of the fisheries to complement the quantitative information that has been used for a decision making process

Environmental indicators model used by OCED to measure sustainable development. Modified for this study case.



Indicator “fishes”

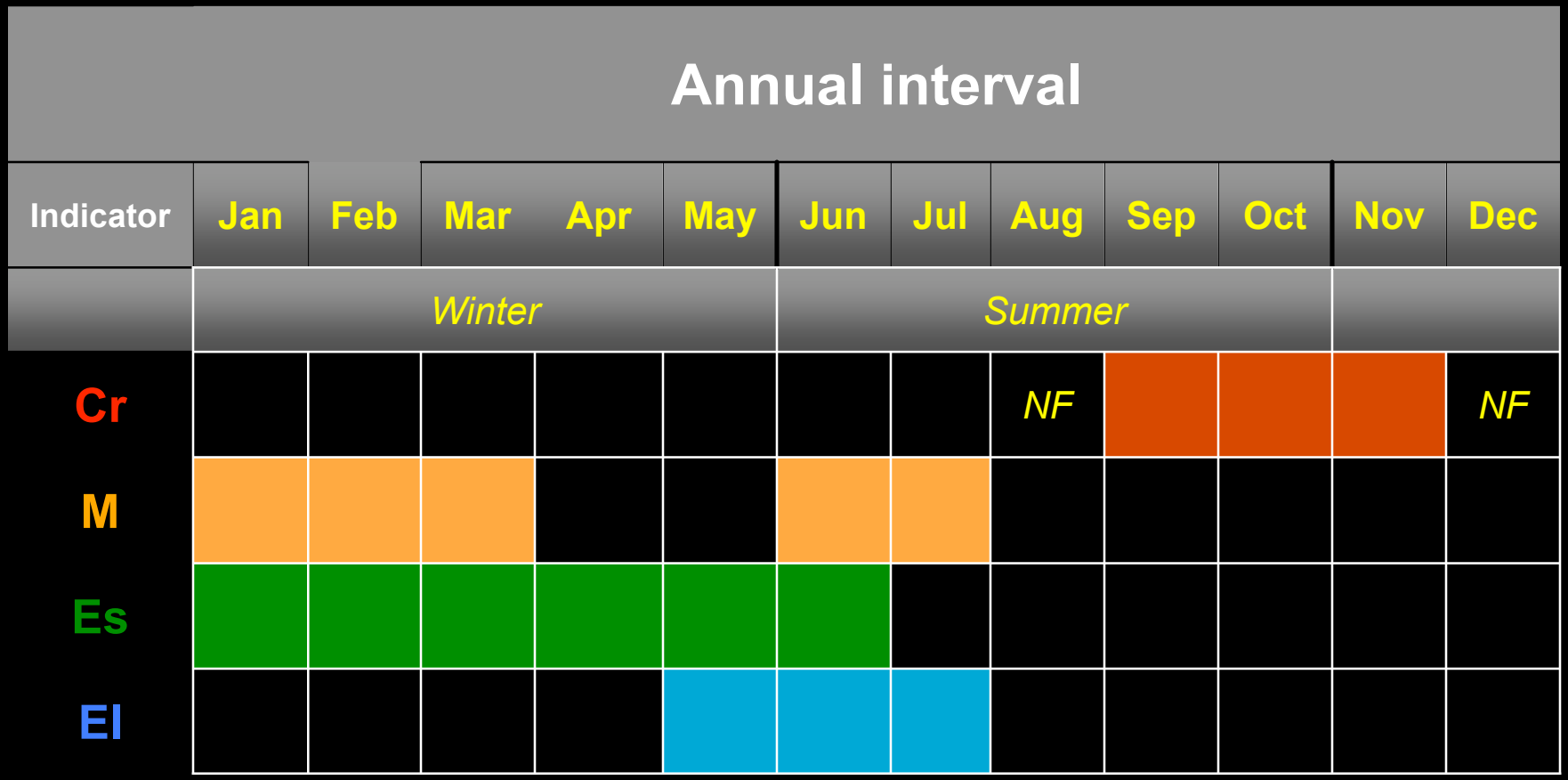
Resource	Scientific name	Hábitos alimenticios	Production 1993-1998 (tons)	Fishing instruments	Locality
Chano	*Micropogonias megalops*	Carnivores (macroinvertebrates crustáceos y peces)	10,710.5	Gill net and line	Golfo de Santa Clara San Felipe Puerto Peñasco
Corvina	*Cynoscion othonopterus*	Carnivores (crustaceans and fishes)	7,410.6	Beach Seine	Golfo de Santa Clara San Felipe Puerto Peñasco
Sierra	*Scomberomus sierra*	Carnivores (crustaceans and fishes)	2,356.6	Gill net	Golfo de Santa Clara San Felipe Puerto Peñasco
Baqueta	*Epinephelus acanthistius*	Carnivores (crustaceans, mollusk and fishes)	1,140.7	Hook line	Puerto Peñasco San Felipe Golfo de Santa Clara
Extranjero	*Paralabrax auroguttatus*	Carnivores (crustaceans and fishes)	56.5	Hook line	San Felipe

Relations among variables

Prey\predator	ClO	Cr	M	ClC	Es	El	SPr
Indicators State-State							
ClO				X			
Cr		X		X			
M			X			X	X
ClC				X	X	X	X
Es							X
El						X	
SPr							X
Instruments\target	**Indicators State-Stress**						
AS			X		X		
Ch		X		X	X	X	X
RAr		X		X	X	X	X

ClO= omnivorous and ClC=carnivorous incidental capture; Cr= Crustacean; M= Mollusks; Es= fishes; El= Elasmobranquia; SPr= protected species; AS= Selective fishing instruments; Ch= gill net; RAr= shrimp-trawl-nets

Temporal variation

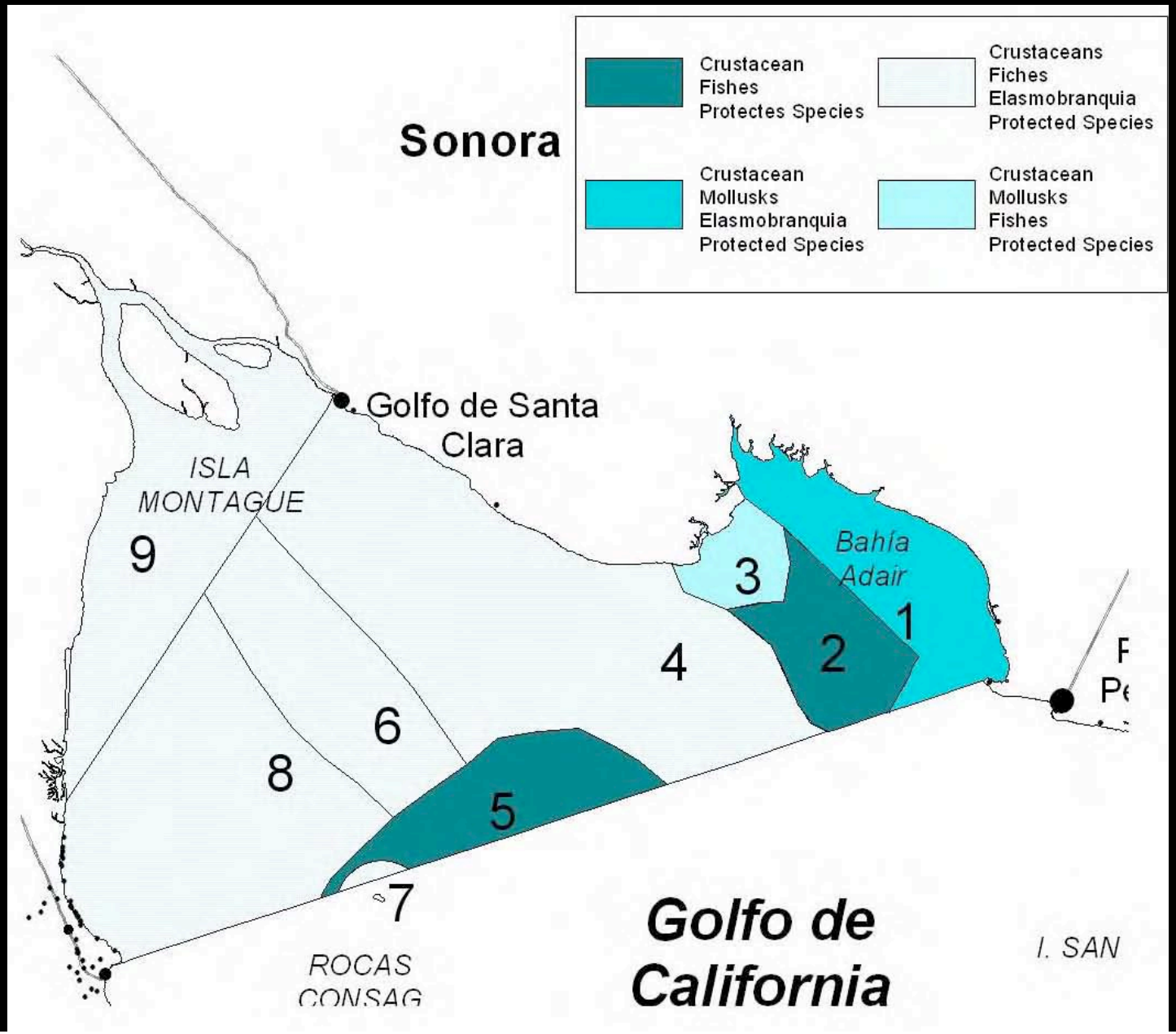


Cr= Crustacean; M= Mollusks; Es= fishes
El= Elasmobranquia; SPr= protected species
NF = No fishery

Zoning System

Class					
	Level 1 (~region)	**Level 2 (~ system)**	**Level 3 (~subsystem)**	**Space fishing seascape**	**Temporal fishing seascape**
Criteria	Geographic	Intensity of use	Population status of the protected species	Macro ecological	Macro ecological
Attribute	Upper Gulf	Fishing zones	Presence / Absence of protected species	Spatial distribution of fishing resources	Temporal distribution of fishing resources

Fishes Indicators arrangement



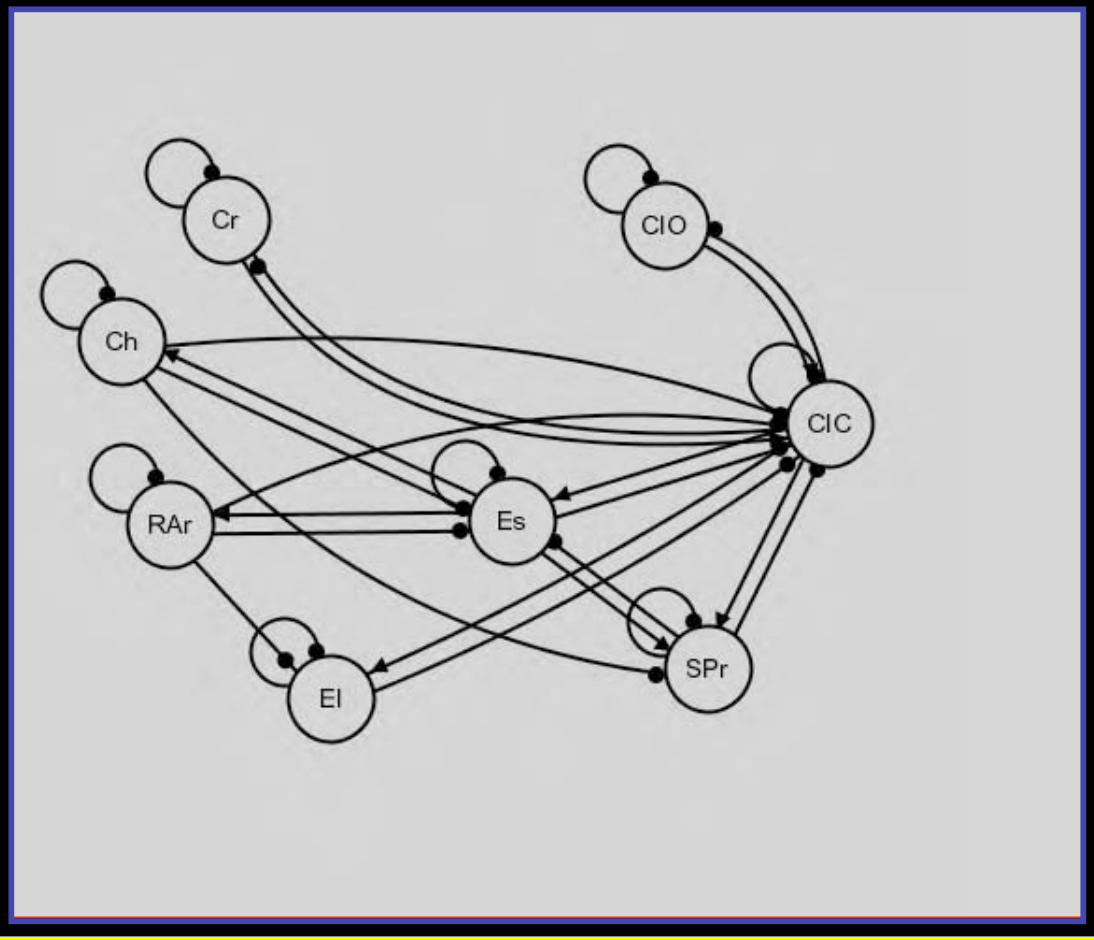
Spatial Fisheries seascape

Temporal Fisheries seascape

Space fishing landscape	Temporal fishing landscape
A. Crustacean and fishes	1. Crustacean 2. Fishes 3. No fishery
B. Crustacean, mollusks, elasmobranquia	4. Mollusks 5. No fishery 6. Elasmobranquia 7. Mollusks-Elasmobranquia 8. Crustacean
C. Crustacean, mollusks and fishes	9. Mollusks-Fishes 10. Fishes 11. Mollusks 12. No fishery 13.Crustacean
D. Crustacean, fishes and elasmobranquia	14. Fishes 15. Fishes-Elasmobranquia 16. Elasmobranquia 17. No fishery 18. Crustácean

Fishing seascape D: *Crustaceans, fishes, elasmobranquia* and *protected species*

Fishing seasons: *Fishes (January-April)*



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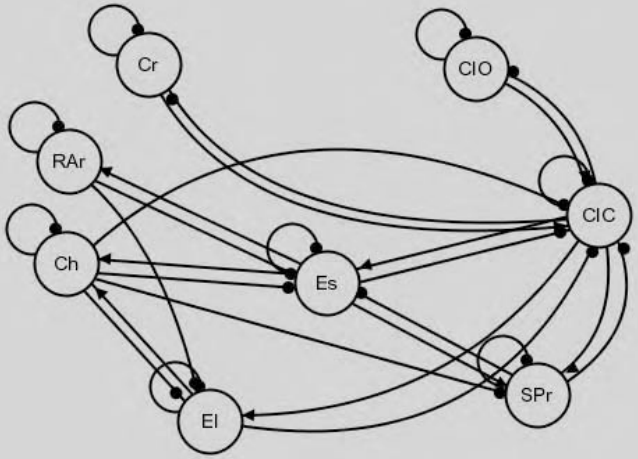
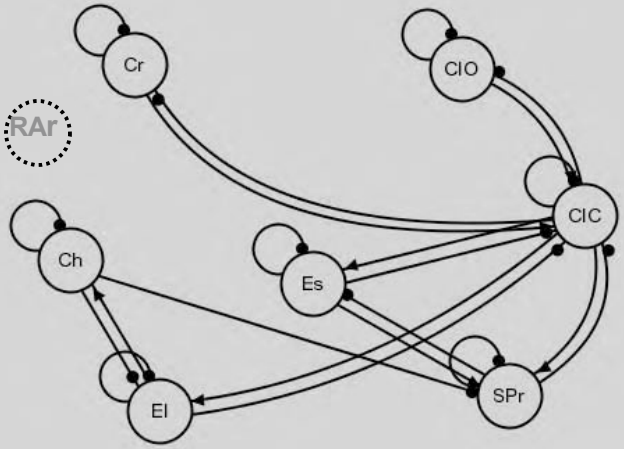
Fishes and elasmobranquia



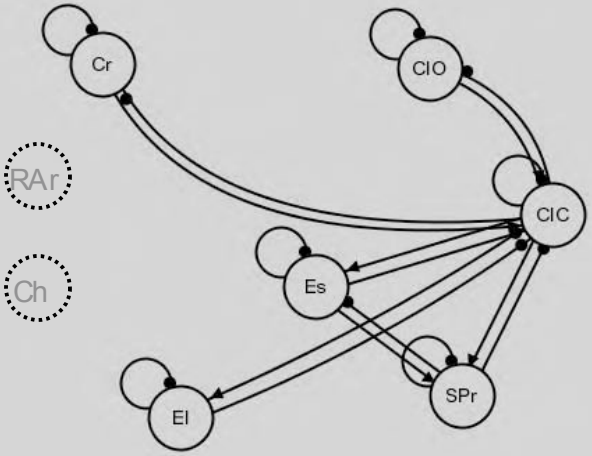
May - June

Elasmobranquia



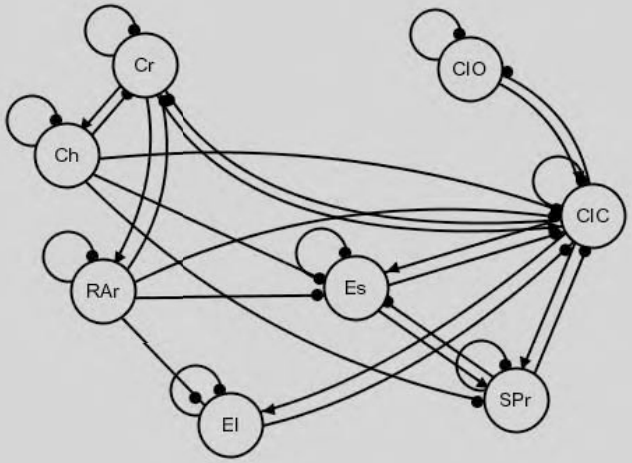
July

No fishing



August and December

Crustacean



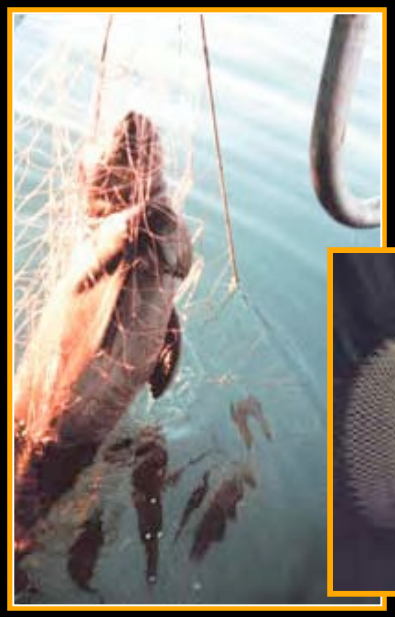
September-November

Analyzed Impacts:

Published literature and technical qualitative (participant investigation and semi-structured interviews)

a) Resources <u>increase</u> (Positive Input)

1. ***By-catch: Carnivores (CIC)***
2. ***Protected species (SPr)***



b) <u>Decrease</u> of the fishing gear (Negative Input)

3. **Gill net (Ch)**
4. **Shrimp-trawl-nets (RAr)**

Increase of the protected species

Endemic endangered species:

Vaquita (*Phocoena sinus*)
Totoaba (*Totoaba macdonaldi*)
Sea turtle (several species)
Sea lions (*Zalophus californianus*)

Management Strategies:
Total closure

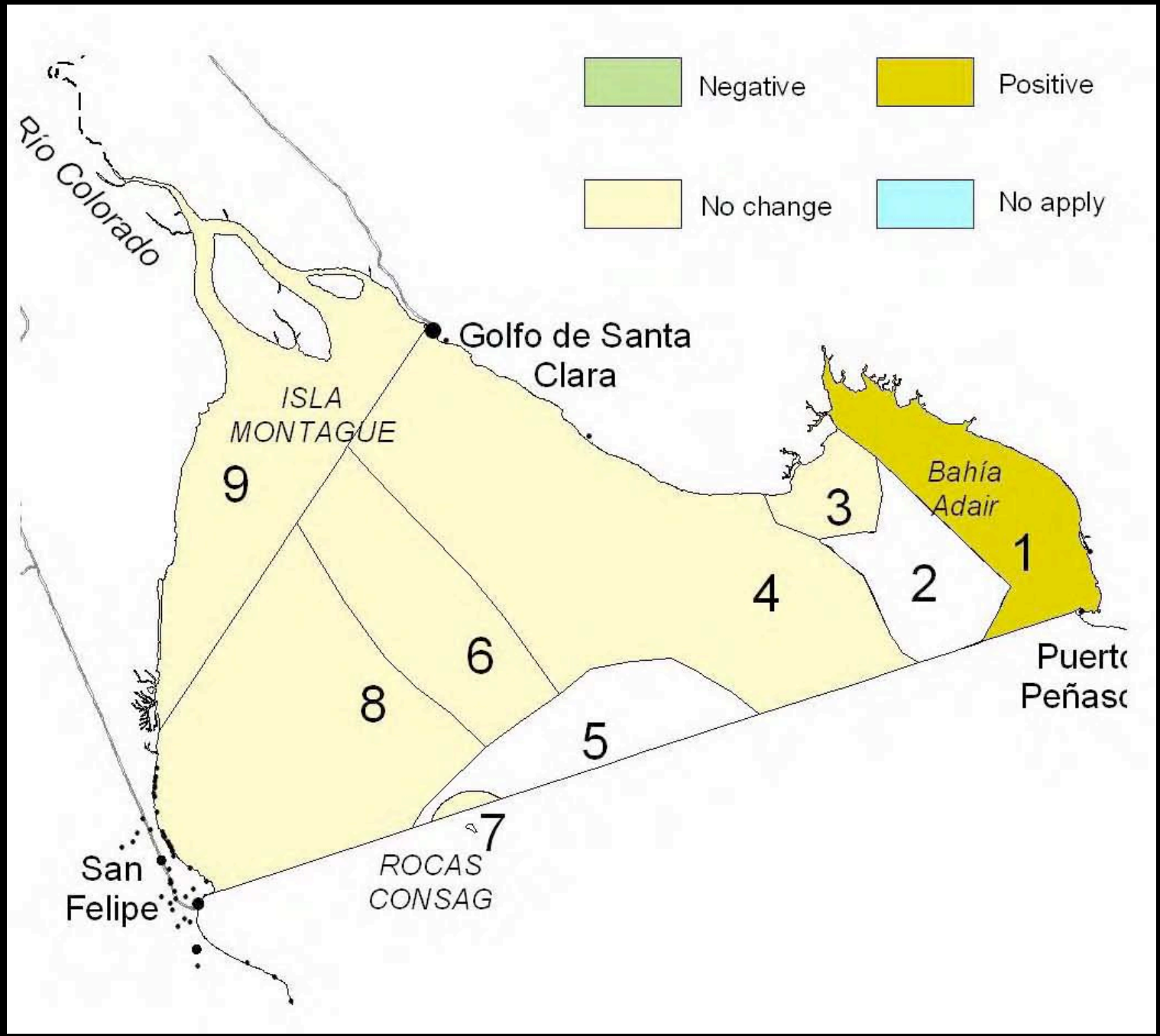
Predictions

Fishing seascape	B	C	D
Fishing fragment	1	3	4, 6 - 9
Fishing models	4 - 8	9 - 13	14 - 18
	State indicators		
ClO	↑ (3/5) / ↑* *(2/5)*	0 (5/5)	0 (3/5)
Cr	↑ (3/5) / ↑* *(2/5)*	0 (5/5)	0 (3/5)
M	↓ (5/5)	↓ (5/5)	NA
ClC	↓ (3/5) / ↓ *(2/5)	0 (5/5)	0 (3/5)
Es	NA	↓ (5/5)	↓
El	↓ (5/5)	NA	0 (3/5)
	Press indicators		
AS	↓ (5/5)	↓ (5/5)	NA
Ch	↓ (4/5)	↓ (4/5)	↓ (4/5)
RAr	NA	↓ (4/5)	↓ (4/5)

Prey

Prey/ Competitors

Greater competition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ISLA MONTAGUE
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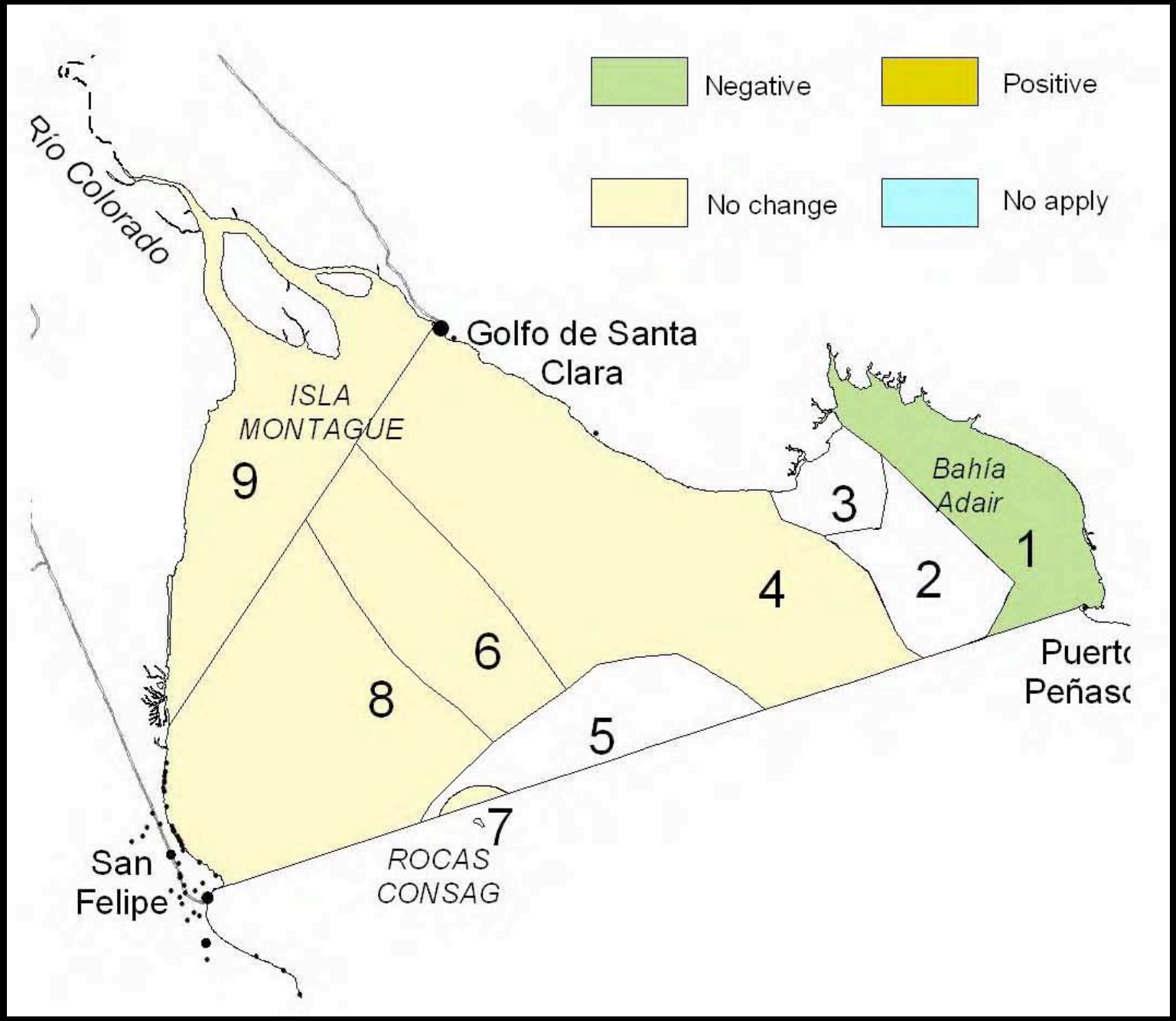
San Felipe
Puerto Peñasco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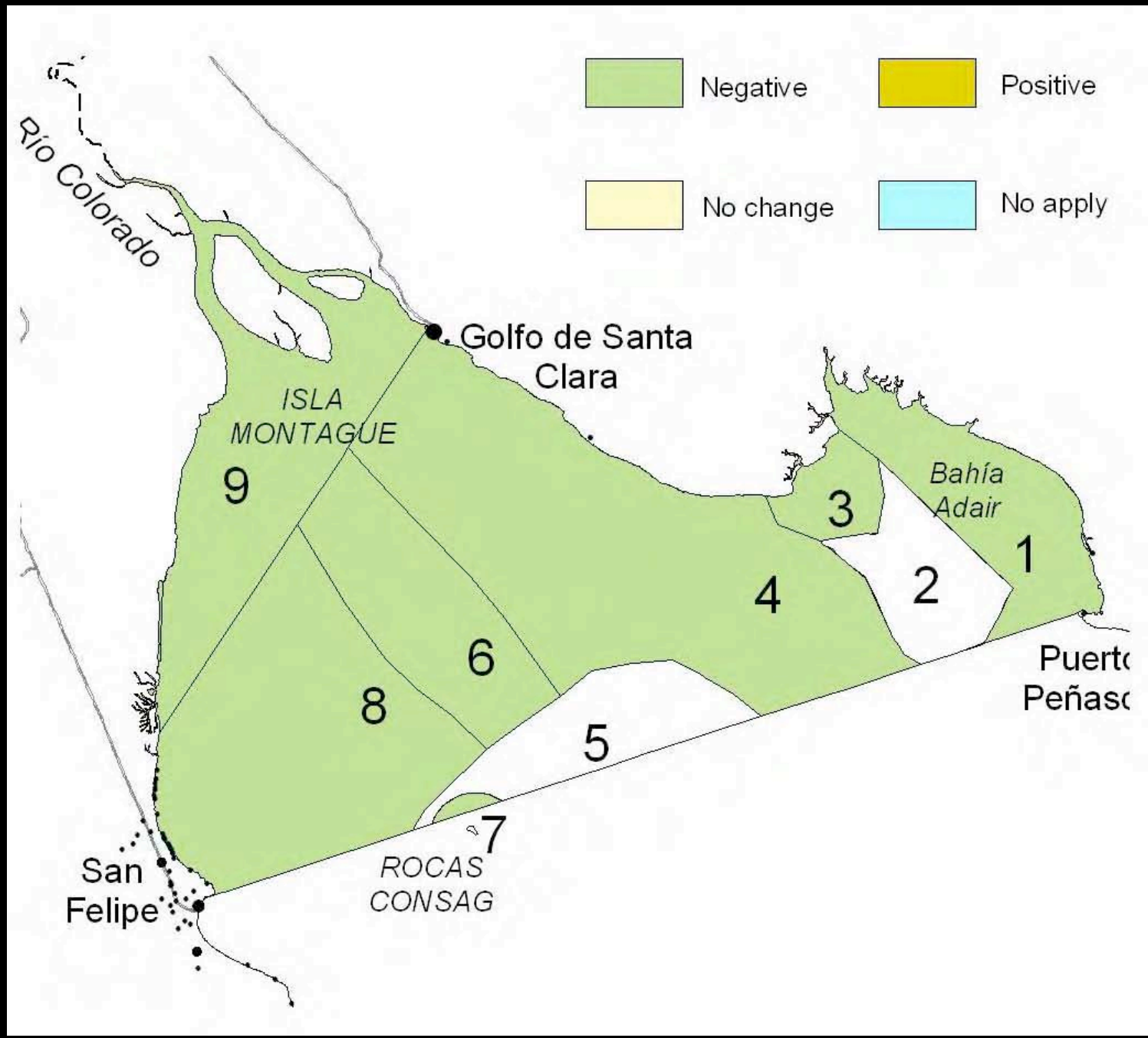
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Puerto Peñasco
San Felipe
ROCAS CONSAG

Management recommendations

- The crustaceans and omnivorous of the by-catch and elasmobranquia are slightly sensitive to population changes of the protected species.

- Adair Bay represents only 8.7 % of the total cover, but it is the most sensible unit to this impact.

- The fishing gear and the protected species compete for resources, so the success in protection programs would mean less resources for fishing.

Conclusions

- The use of qualitative analysis allowed to integrate variables of different nature (biological and social) to find direct and indirect effects influencing the response of the fishing system.
- Although the information of the models is complicated, the analysis allowed to directly exemplify the results and to generate relatively simple management hypotheses for the decision making process.
- Although a quantitative modeling approach has been used for the Biosphere Reserve (Arreguín-Sánchez *et al*., 1999; Morales-Zarate, 2001; Sala *et al*., 2002), this modeling technique compares in its usefulness with the quantitative methodology, using qualitative data only.
- Qualitative analysis was adaptable to the GIS. Such combination of techniques offer a novel potential tool for fisheries management and the conservation of natural resources.

Proposal

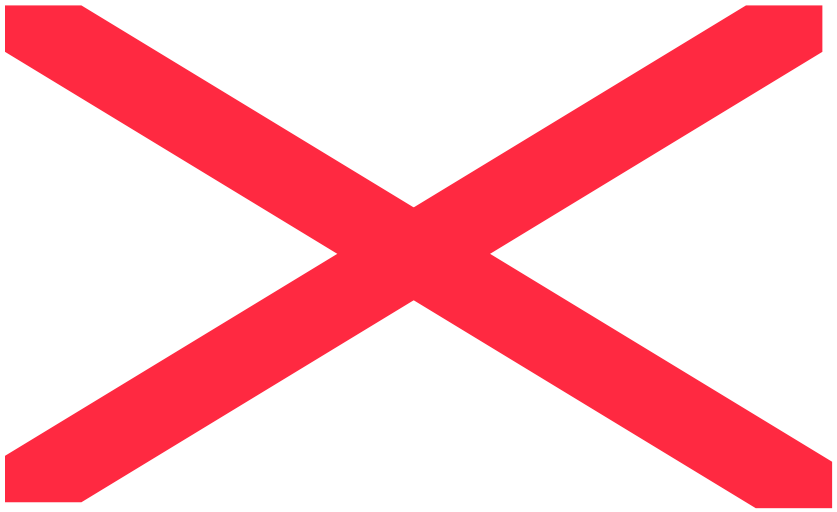
- The use of this method could be used to join heterogeneous data bases such as Canada´s, United States and Mexico´s.

- We propose the use of models using qualitative shared indicators as a tool for comparing large data bases or different protected areas.

- Selected indicators can be a useful tool for monitoring the effectiveness of the Northamerican Pacific coast marine protected areas.

- The stress-state response model from OCED provides an integrated vision of MPAs and their context in terms of social issues, natural resources and political responses.

Acknowledgements



Group of shark's fisheries

Sonora Direction