NEAMPAN Workshop on Advancing Marine Protected Areas for Climate Action, Biodiversity and Sustainable Development

Marine conservation planning

in a ecological-economic-social dynamic perspective

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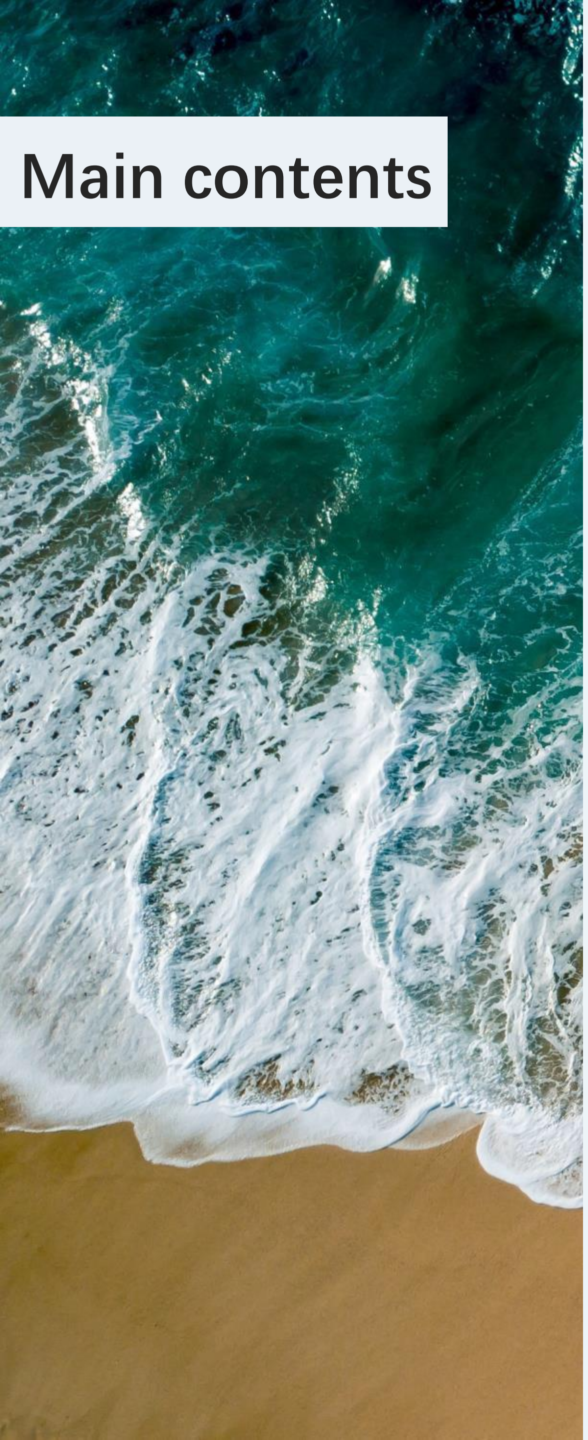
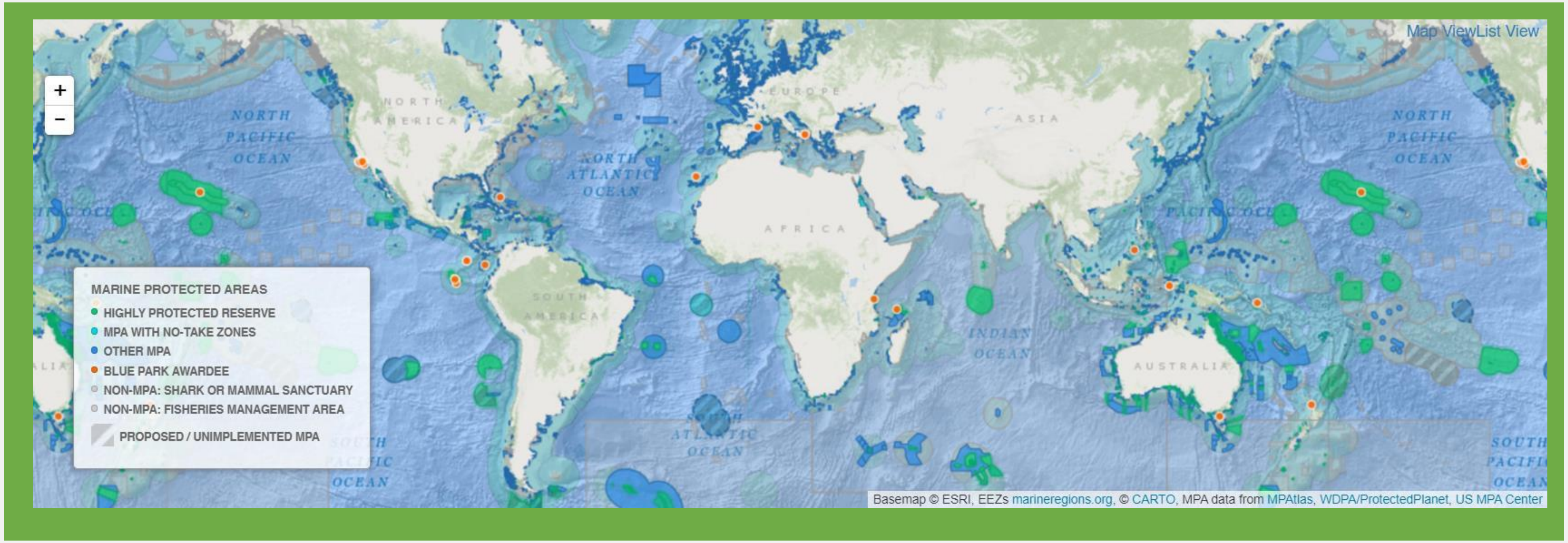


Main contents

- Research background
- 1. Developing MPAs with multiple objectives
- 2. Incorporating biological dynamics
- 3. Minimizing socio-economic costs

Research background

- Stimulated by the recognition of declining marine natural resources, marine protected areas (MPAs) have been increasingly promoted as an important tool for conservation marine biodiversity and assisting fisheries management in the world's oceans.
- Numerous benefits have been observed from MPA practices, including protecting critical habitats, species and ecological functions, increasing number and size of fish inside the reserve, and exporting fish beyond the reserve boundaries (spill-over effects).



The conceptual development of conservation strategies

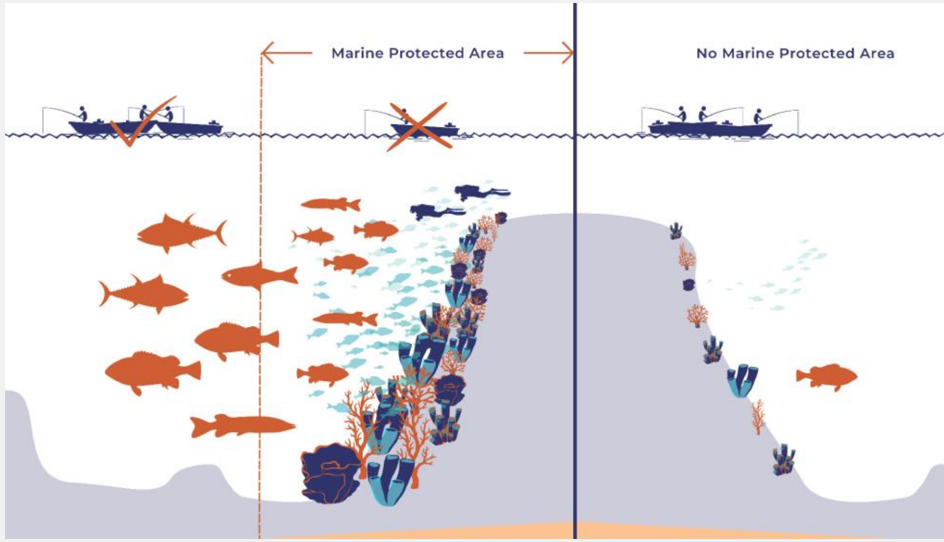
- The utility of MPAs has evolved significantly over the past years, moving beyond single-species conservation to ecosystem-based conservation with socio-economic considerations

early 20th century — single-species conservation — the first MPA

early 2000s — ecosystem-based conservation

social-ecological system framework

- To maximize the conservation benefits of MPAs, studies explored ecological criteria to design an effective marine reserve, which highlight that socio-economic features, such as community acceptance and economic feasibility, are more decisive to the success of MPAs.



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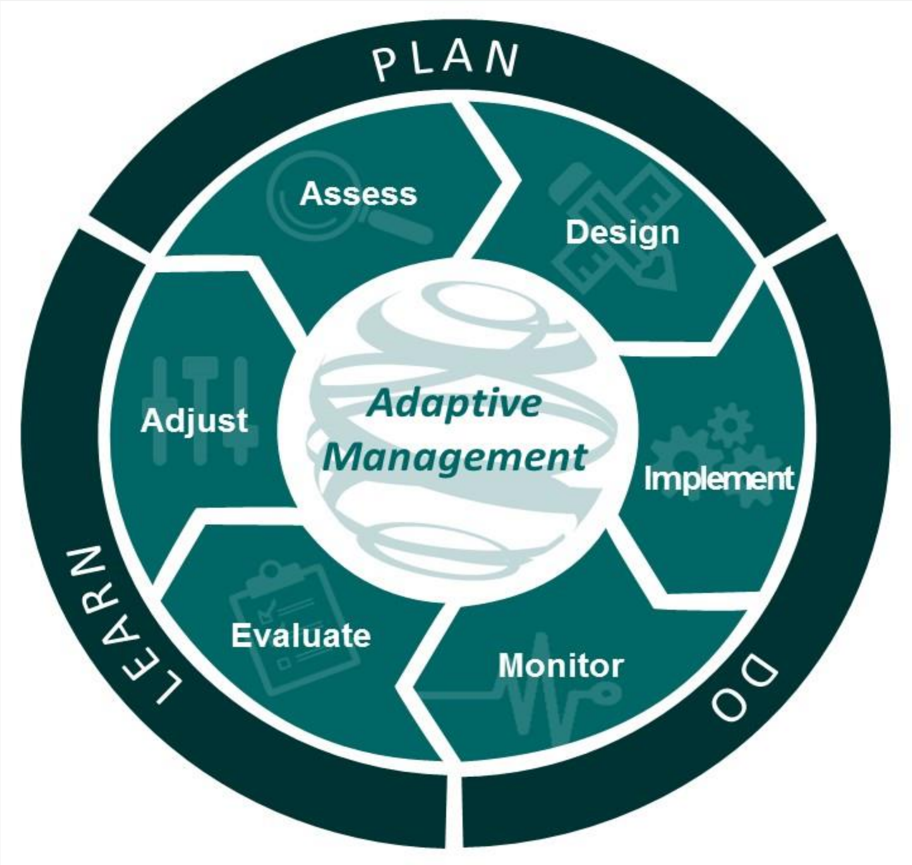
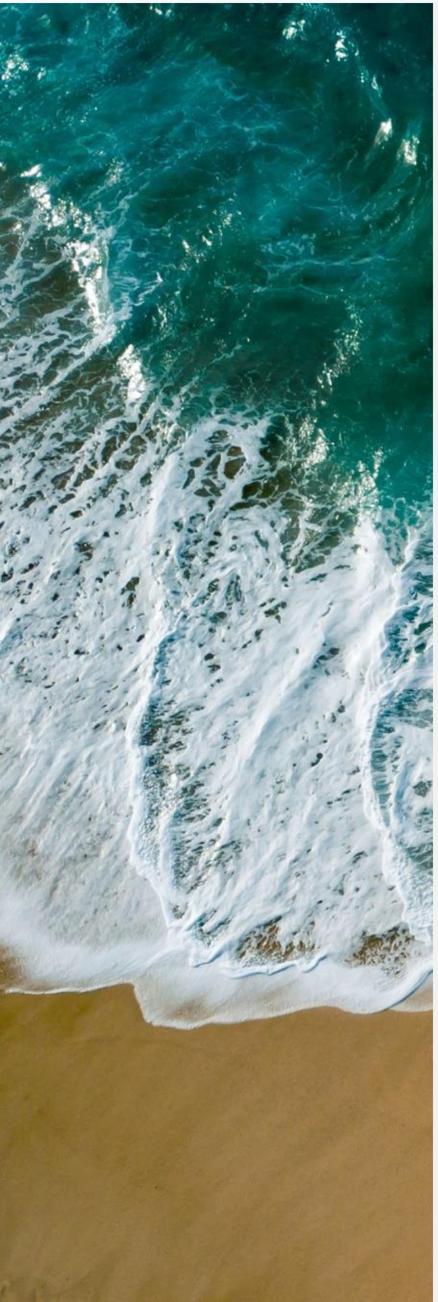
Many challenges remain

- conservation objectives that protects representative habitats and economically and ecologically important species
- socio-economic objectives that minimizes the impact on existing marine uses
- a evaluation tools to dynamically inform and test potential socio-ecological consequences of conservation plans

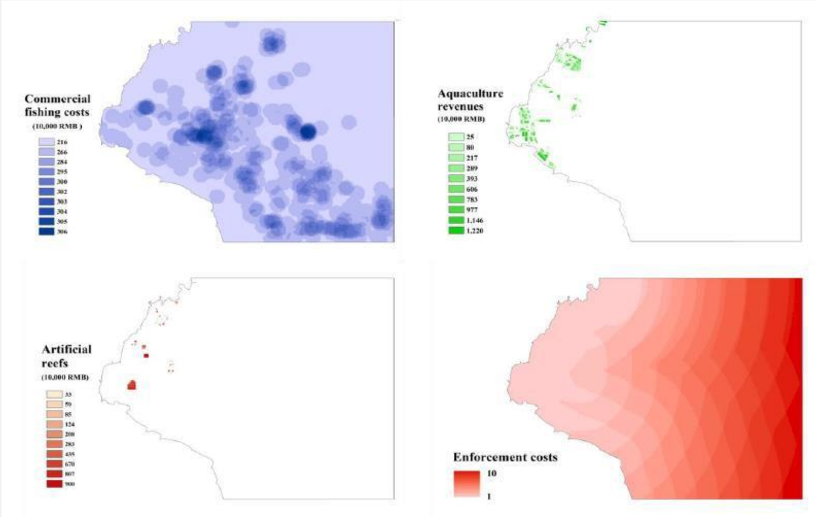
Adaptive management framework

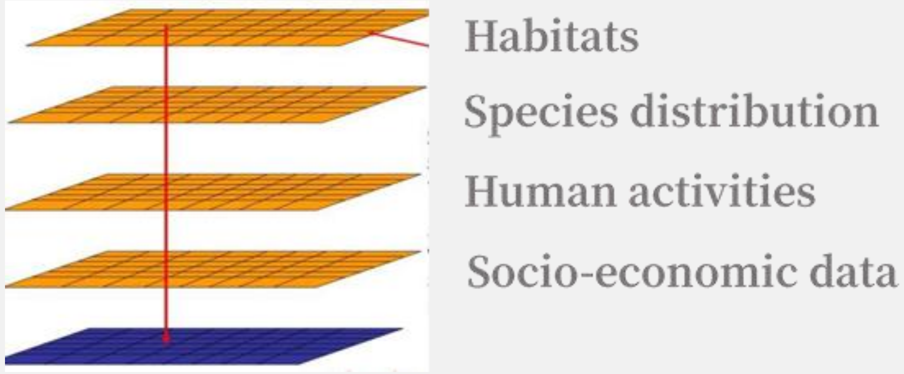


1. Systematic conservation planning for MPAs with multiple objectives



- To identify the conservation priorities with multiple objectives, we adopted the systematic conservation planning (SCP) theory
- SCP requires explicit and quantifiable goals, clear and appropriate choices of surrogates, as well as transparent and adaptive planning processes that involves stakeholders
- Marxan was developed to solve the minimum set problem with the algorithm of simulated annealing, and with its application in conservation prioritization, we can find a range of solutions that meet the management targets while minimizing the costs.





Methods

- Define the conservation area
- Clarify the MPA objectives

Four objectives were specified for the design of the MPA network:

(1) conservation objective: important species and habitats (spawning grounds)

(2) socio-economic cost：conflict with commercial fishing and marine aquaculture

(3) socio-economic compatibility: Benefits from aquaculture and artificial reefs

(4) enforcement costs

Scenarios	Objectives	Conservation features	Targets	Fishing	Aquaculture	Artificial reefs	Enforcement
I	Conservation	Biodiversity, ecologically and economically important species, and key commercial species' spawning grounds	20% for habitats and species, and 40% for the spawning grounds of three key commercial species	**N**	**N**	**N**	**N**
IIa	Socio-economic (conflicting)			-	-	**N**	**N**
IIb	Socio-economic (compatibility)			-	+	+	**N**
III	Enforcement			**N**	**N**	**N**	-

Identify conservation priority

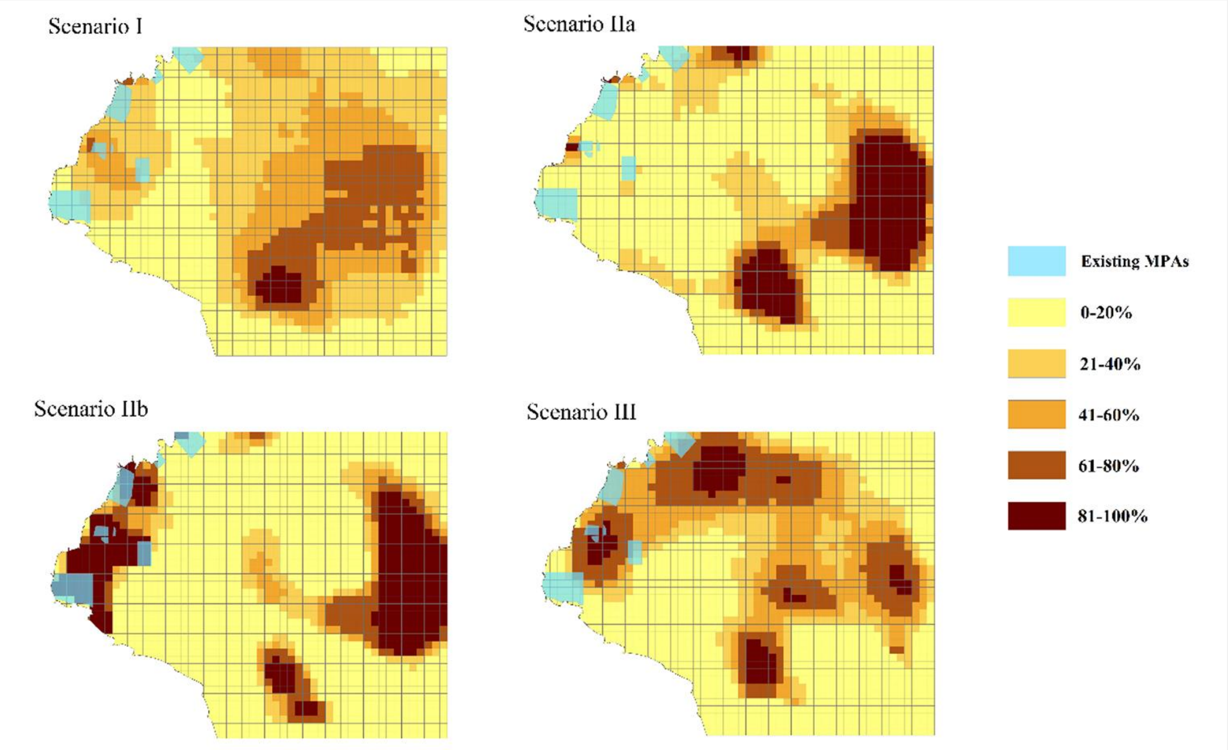
By comparing different scenarios of MPA objectives, we presented the variation of conservation prioritization by incorporating multiple considerations in the MPA network design.

- In scenario I, the middle area and a small portion of coastal areas were selected as conservation priorities

- In scenario IIa, two large areas in the southeast and one small area in the north were selected as priorities

- In scenario IIb, coastal areas were selected in addition to the southeast area

- In scenario III, five patches were identified as priorities, forming a network from the coast to offshore regions.



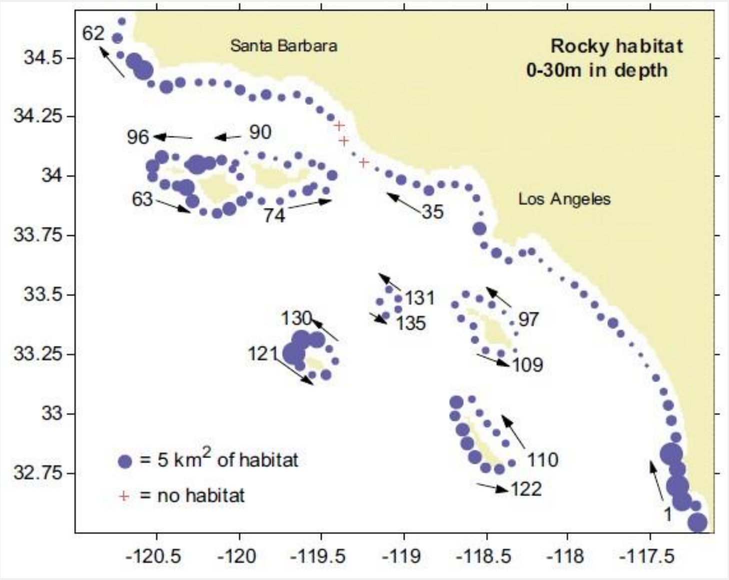
The frequency of being selected by Marxan in different scenarios (conservation priority)

2. A grid-base model to reflect biological dynamics

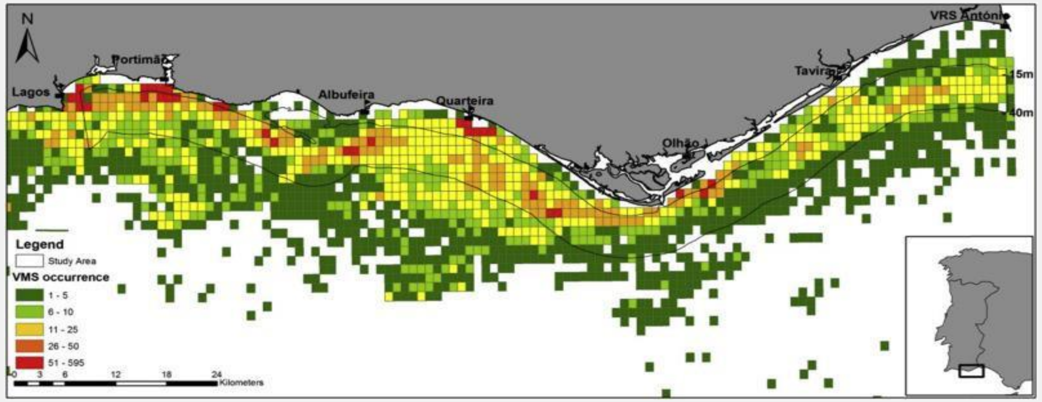
- Evaluation of MPAs can be achieved by models at various operational resolution levels, ranging from the simplest two-patch population model to more complex ecological models.

- The conservation feature such as biodiversity are commonly treated as static in MPA planning, while the spatial and temporal dynamics of fish populations and fleet tend to be ignored.

- We proposed a grid-based dynamic model (Grid-DM) that links spatial conservation prioritization tools with tactical fisheries management at the population level.

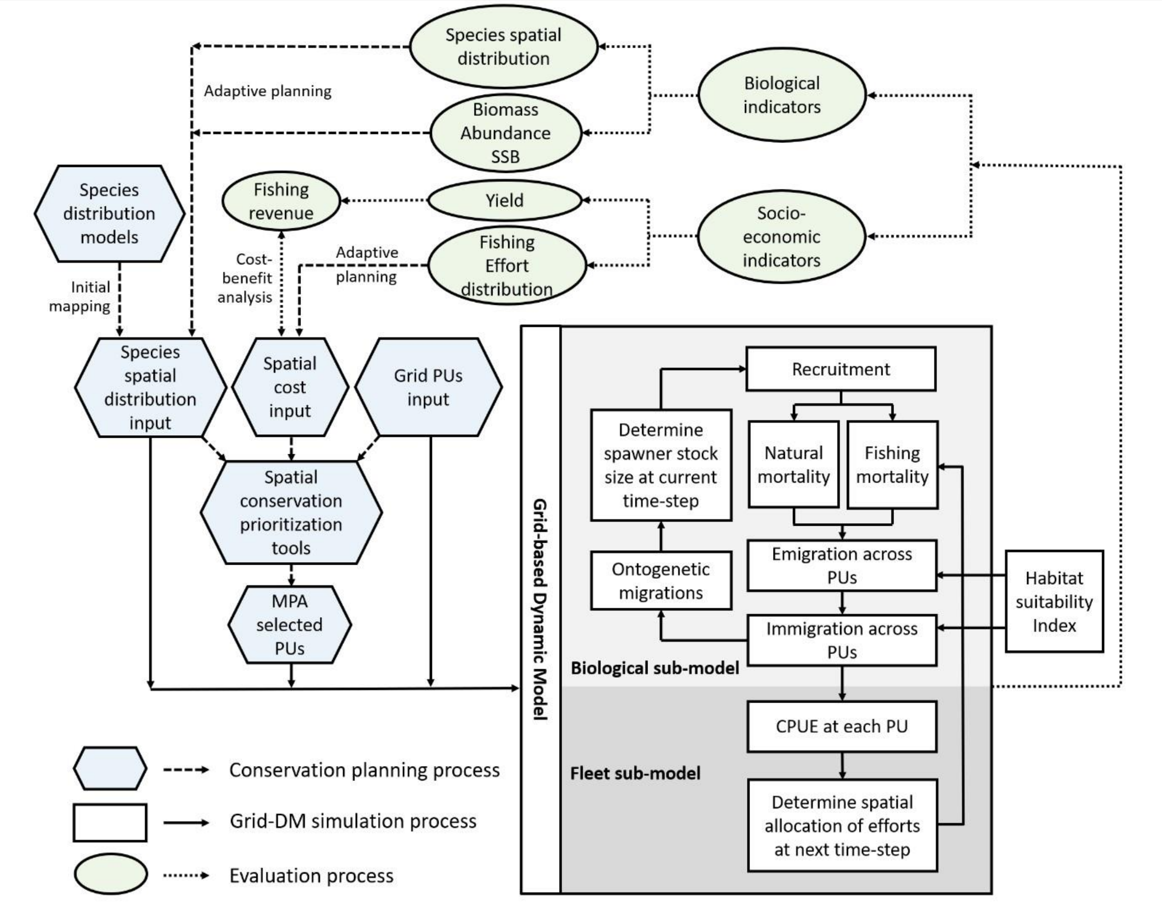


Rassweiler et al. (2012)



The grid-based dynamic modelling framework

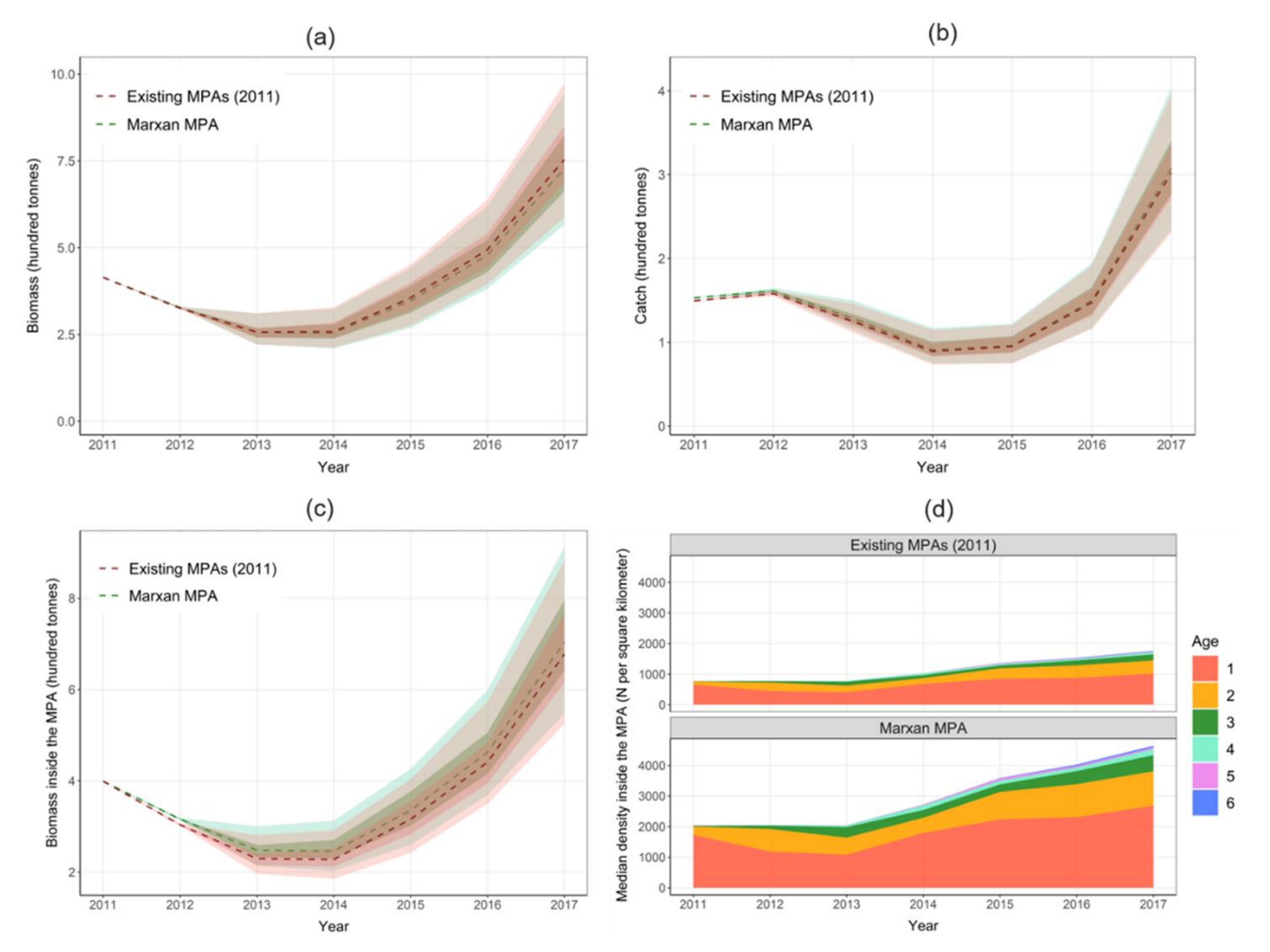
The framework consists of three components, including
1) the conservation planning component with the support of spatial conservation prioritization tools,
2) the simulation component using a 2D spatially explicit dynamical model, and
3) the evaluation component based on performance metrics.

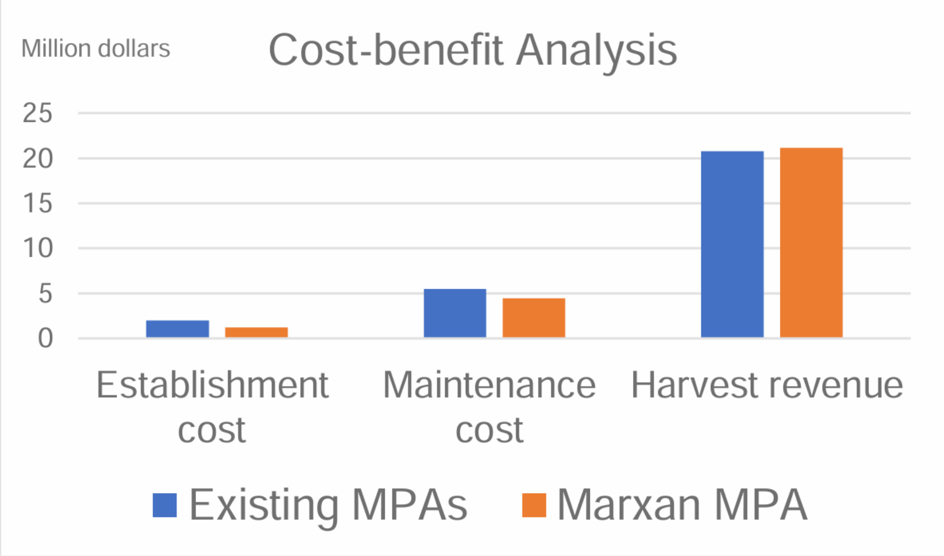


- The framework can support systematic evaluation of MPAs by integrating species distribution models, spatial conservation prioritization tools, and dynamic evaluation models.
- A biological sub-model simulates the spatio-temporal dynamics of the fish stock, including ontogenetic migrations.
- A fleet sub-model aims to simulate the dynamics of fleet and determine the allocation of fishing effort

Performances of implementing existing MPAs and Marxan-derived alternative MPA

- With the designed targets, the optimized MPA reduced the protected areas to nearly 40% of the existing MPAs, while led to nearly 4% lower of total biomass, 2% higher of total catch, and more biomass inside the MPA.





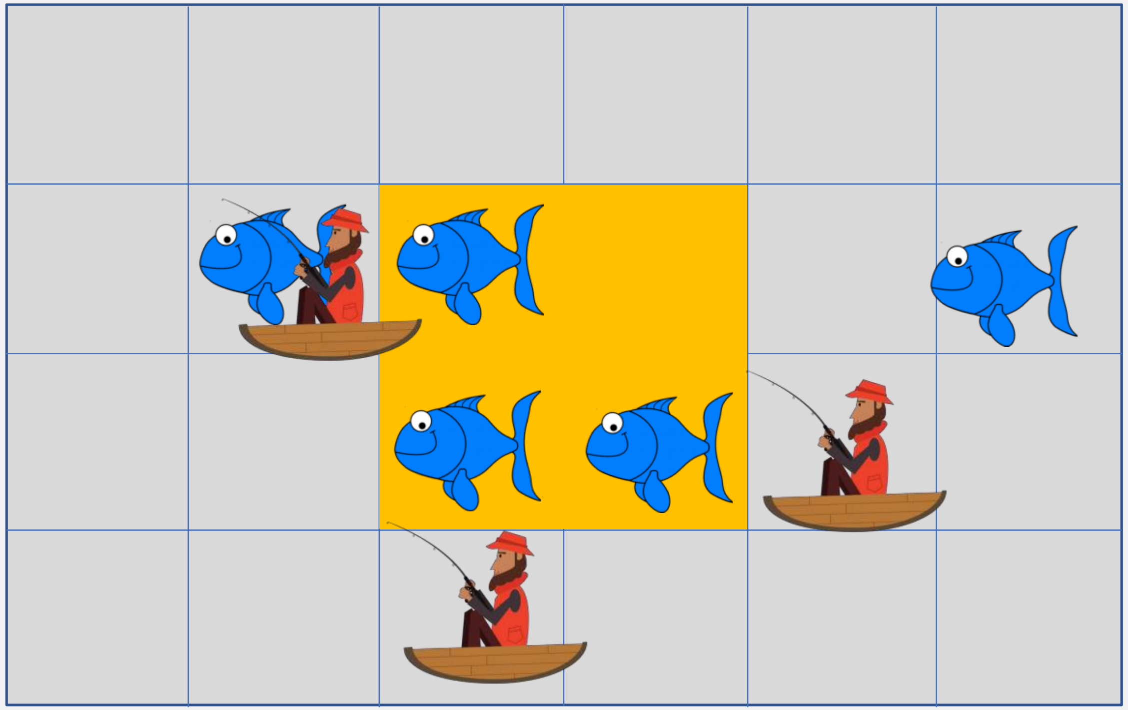
- the optimized MPA solution reduces the management cost without much compromise of biological and economic benefits

3. Minimizing socio-economic dynamic costs by accounting for fishermen behaviors

- Incremental approaches are receiving popularity in MPA/marine reserve practices to lower socio-economic burdens on fishermen and management budgets.

- Many existing conservation prioritization tools tend to minimize the short-term cost on fishers through static models or algorithms (snapshots).

- Fishermen usually adaptively respond to conservation measures to gain more profits, such as redistributing efforts adjacent to MPAs.



It is necessary to evaluate socio-economic costs through a dynamic approach to ensure its adequacy in devising cost-effective conservation strategies.

Regarding fishermen responses to conservation strategies, we assumed:

(1) fishers tended to aggregate in the area with high CPUE

(2) fishers tended to aggregate within the reserve when the closed area was re-opened.

Three commonly-used conservation approaches aiming to reduce socio-economic costs:

(1) placement of a permanent marine reserve,

(2) an incremental increase in a seasonal closure, and

(3) an incremental increase in a spatial closure.

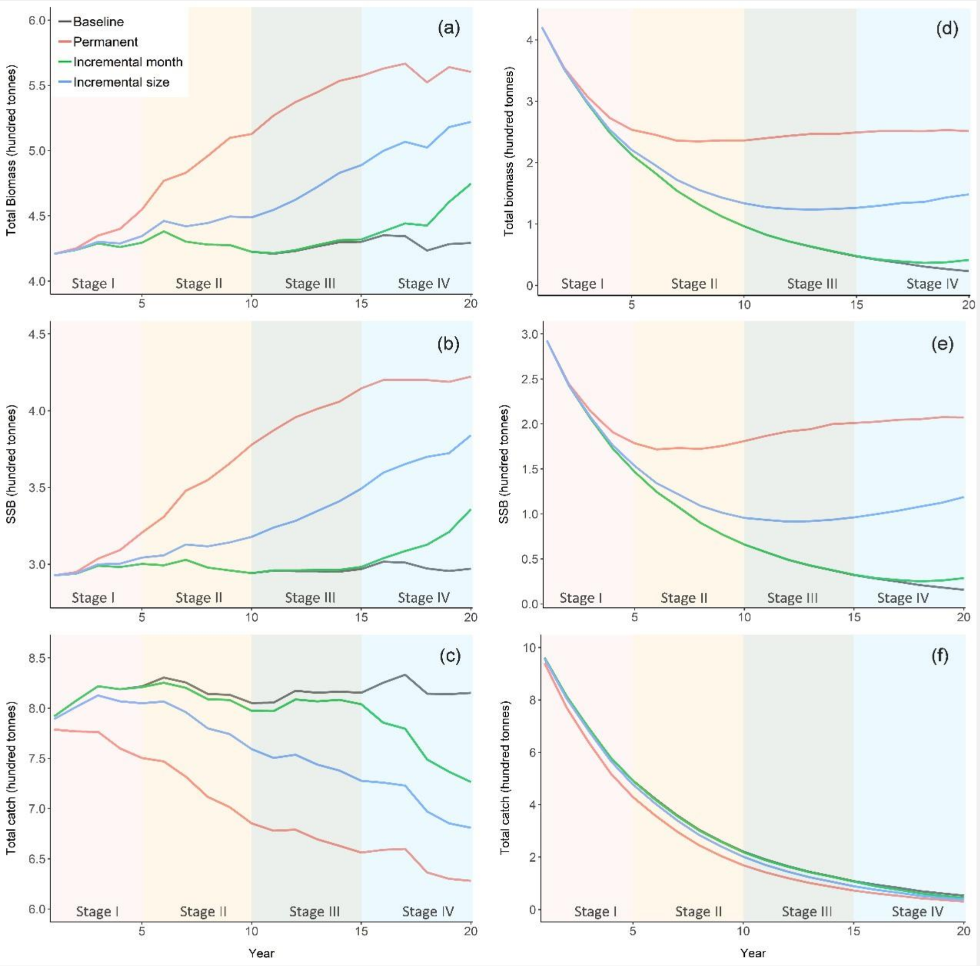
Multiple uncertainties were incorporated in the stochastic runs, including recruitment fluctuations, fish movement variations, imperfect knowledge of fishermen to locate a productive fishing ground, and various effort aggregation levels when a reserve was re-opened.

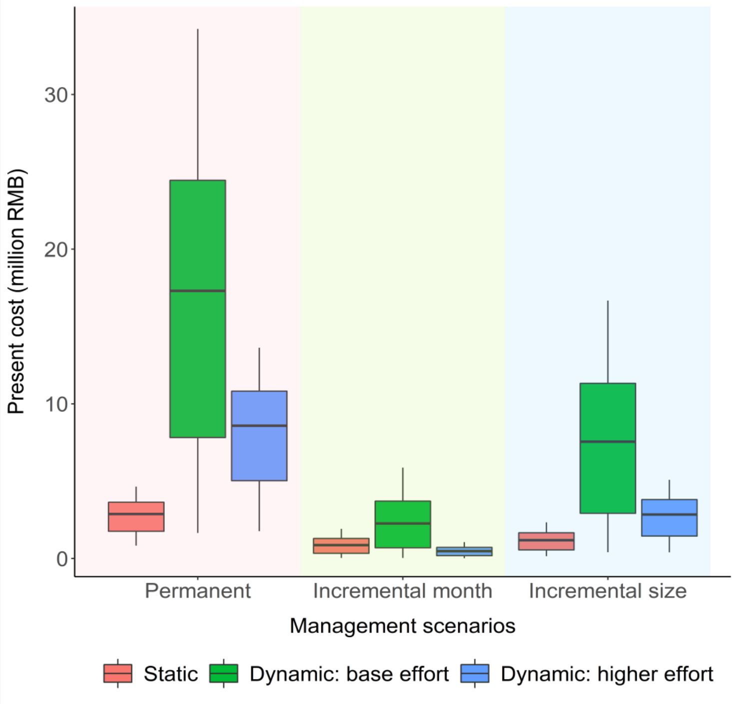
Cost-minimization conservation scenarios

1. Baseline	No marine reserve			
2. Permanent	Year-round marine reserve with 40% target			
3. Incremental month	Closed from May to Aug. with 40% target	Closed from Apr. to Sep. with 40% target	Closed from Feb to Oct. with 40% target	Year-round closure with 40% target
4. Incremental size	10% target	20% target	30% target	40% target
	1st-5st year	6st-10st year	11st-15st year	16st-20st year

Comparison between the conservation scenarios with static and dynamic costs

Permanent marine reserve scenario generated the highest biomass and SSB, and caused the largest decrease in catch



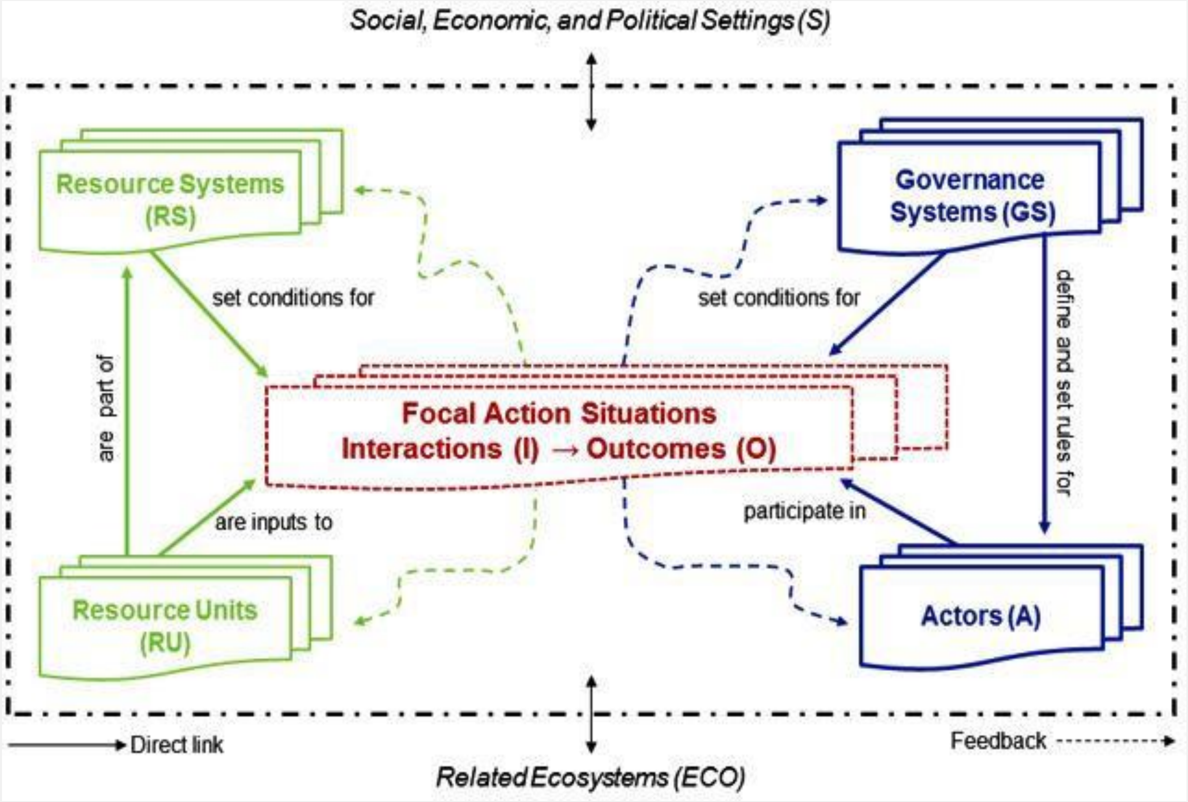


- The Permanent marine reserve was the most expensive strategy while the Incremental month strategy had the lowest cost

- The static approach tended to estimate a much lower opportunity cost than the dynamic approach

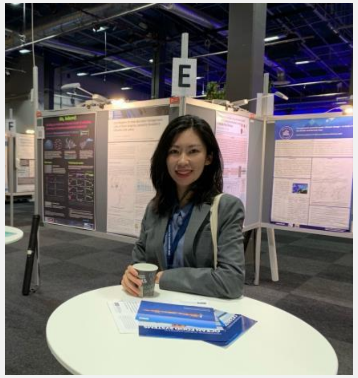
- using static opportunity cost as a criterion to guide conservation practices can be misleading as it mainly focuses on the revenue loss due to marine reserve, instead of overarching social-ecological objectives.

Further thoughts



Conceptualization of the social-ecological systems framework from McGinnis and Ostrom (2014).

Thanks for Your Attention！



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