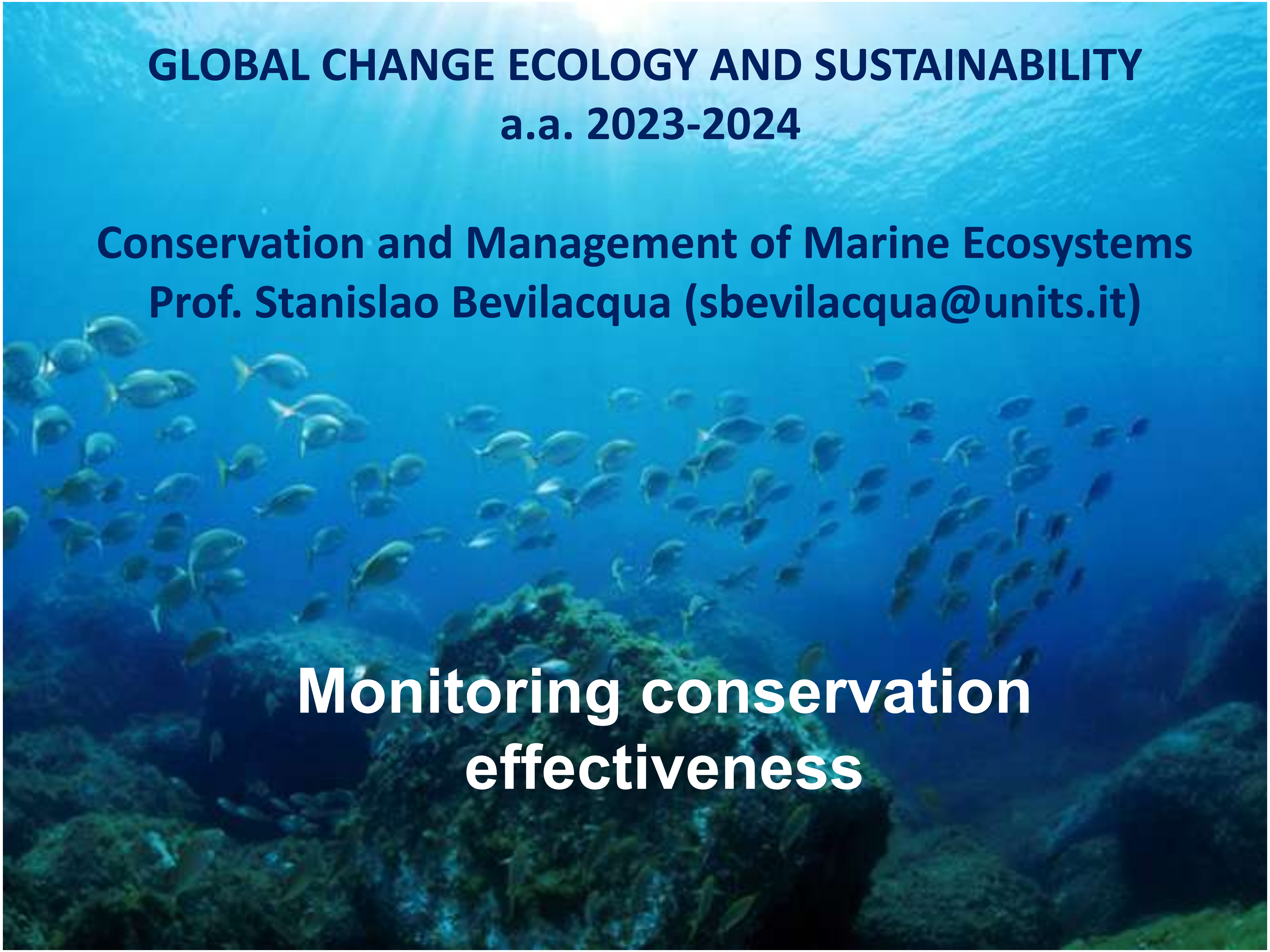

GLOBAL CHANGE ECOLOGY AND SUSTAINABILITY
a.a. 2023-2024

Conservation and Management of Marine Ecosystems

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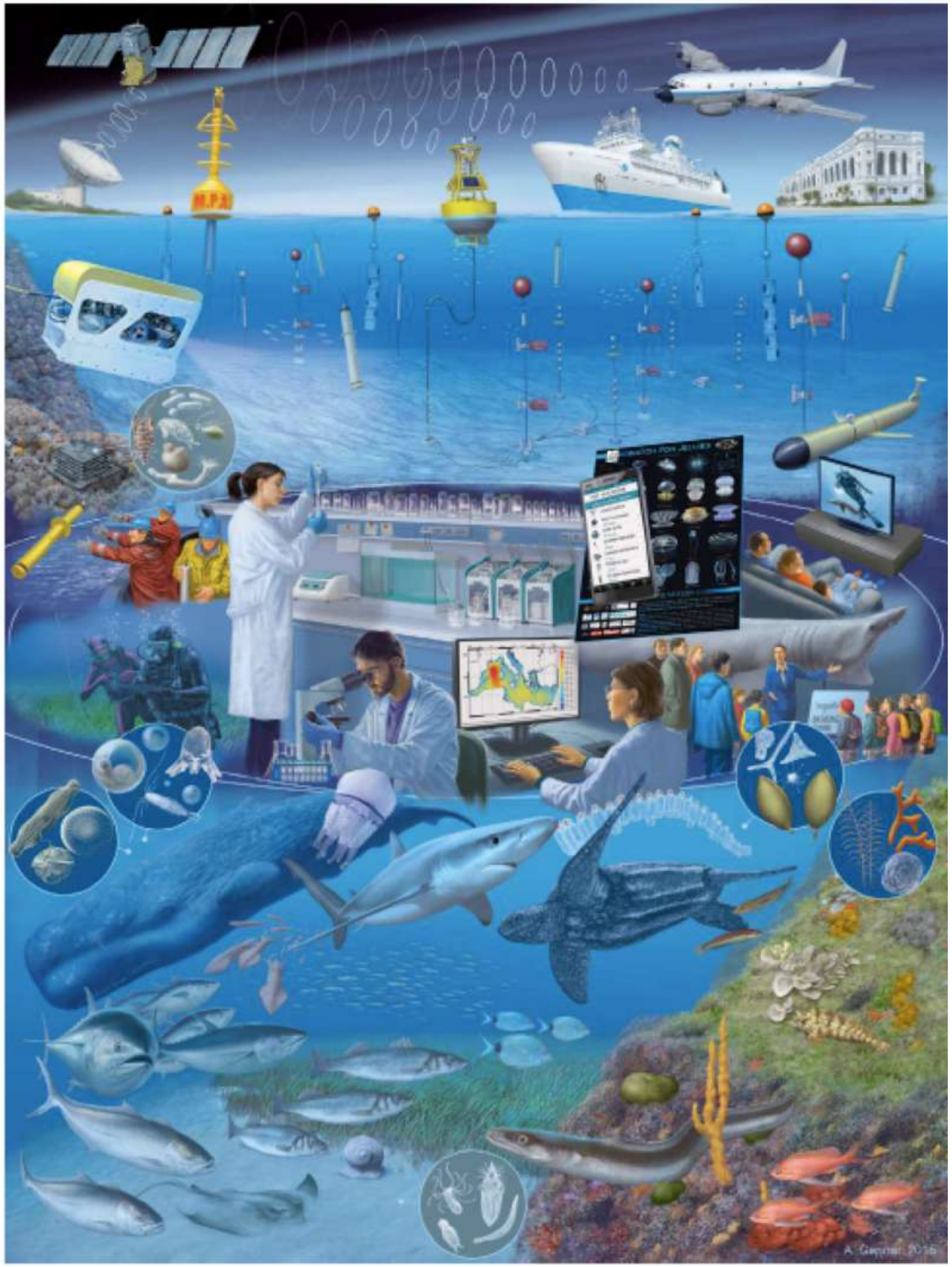
Monitoring conservation effectiveness

The importance of monitoring

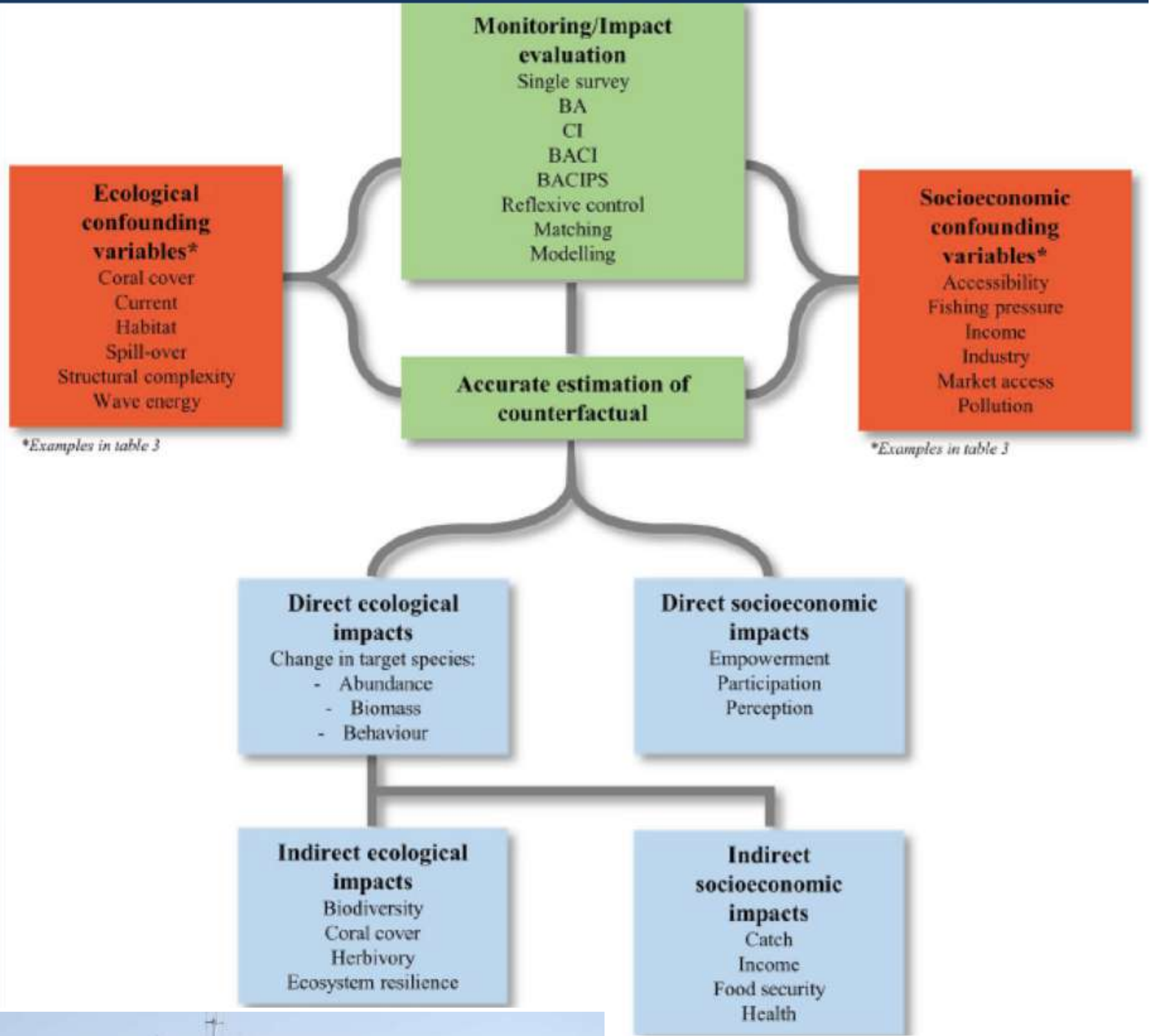
Monitoring is at the core of applied ecological research, providing invaluable insights on patterns and processes underlying the dynamics of ecosystems. Monitoring is also essential for environmental policy, since systematic collections of data are necessary to inform the adaptive management of environmental issues, whether concerning the assessment and mitigation of human impacts, the effectiveness of conservation strategies, the success of restoration actions or the surveillance of the ecological quality status of ecosystems.

The concept of monitoring intrinsically implies performing replicated observations through time, since single assessments cannot provide a comprehensive characterization of systems being investigated. This because communities and ecosystems are not static entities, which are subject to a complex interplay of processes acting at a range of spatial, but also, temporal scales, and historical data are often a prerequisite for a deeper understanding of mechanisms driving ecological changes

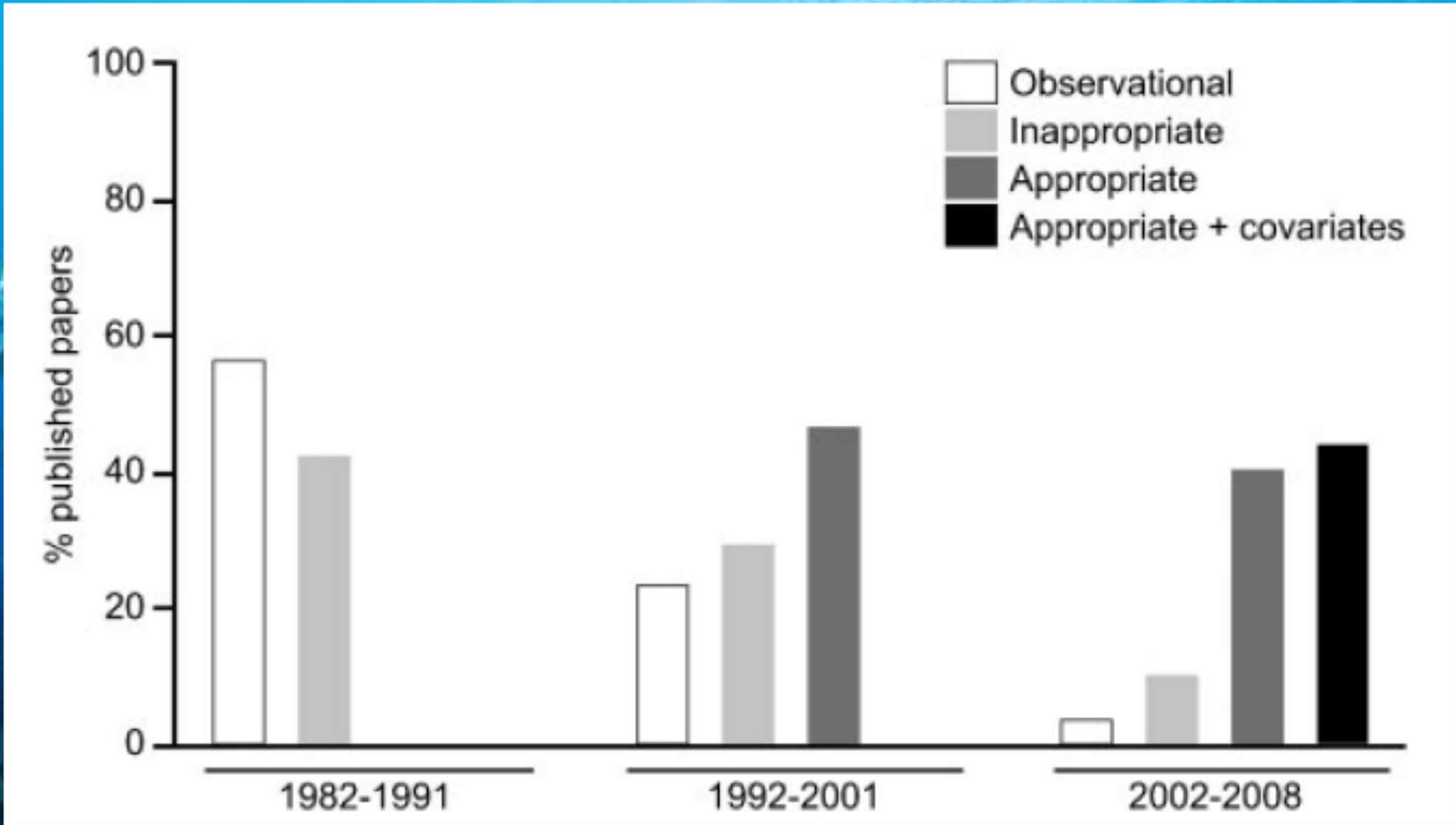


Monitoring what and how

A number of monitoring strategies exists depending on the aspect of conservation under study.
Monitoring is not only related to bio-physical effects, but also to socio-economic consequences of protection and governance effectiveness



Appropriateness of MPA studies



Guidetti & Claudet 2010

Potential confounding effects

Estimating the effect of MPAs could be confounded by erroneus selection of appropriate control sites or due to intrinsic features of the MPA/controls

Smallhorn-west et al. 2019

Potential confounders	Examples of how poorly chosen control sites can lead to over- or under-estimation of impact
Coral cover and structural complexity	Greater coral cover and complexity increases the carrying capacity of an ecosystem. An MPA is configured to protect areas with exceptional coral cover. Subsequent control-intervention studies that fail to account for high coral cover will overestimate impact
Displaced fishing effort	An MPA displaces current fishing activity to a nearby reef, which is subsequently used as a control site. Displaced fishing effort from the MPA will result in variables of interest declining in nearby areas, with overestimation of impact, even though the net stock remains the same
Education	Education about ecological recovery is introduced by an NGO along with an MPA. Perceptions of ecosystem health in the MPA community therefore increase. At the same time they also conduct educational outreach in a nearby control village with no MPA, thereby increasing their understanding of the damage fishing is causing. Impact is overestimated because the difference in perceived change between MPA and control villages is the result of additional educational programs and not the implementation of the MPA
Fishing pressure	Control sites are selected in areas with higher fishing pressure than would have occurred in MPAs, overestimating impact. Sites with high fishing pressure do not represent an accurate counterfactual unless the MPA sites would also have had equally high fishing pressure in the absence of management. (e.g. Wantiez et al. 1997; Goetze et al. 2011, 2015; Goetze and Fullwood 2013)
Habitat quality	High/Low-quality habitats are selected for protection by MPAs, which have a higher/lower carrying capacity of target species than control sites. Subsequent control-intervention studies over/under-estimate impact. (e.g. Jupiter et al. 2012)
Income	A village with high average income is used as a control for an MPA village with low income. Fishing in the high-income village is conducted with new equipment and faster boats than the MPA village. Economic impact is underestimated because of failure to account for difference in fishing efficiency

Potential confounding effects

Industry	A tuna canning factory is introduced near a village heavily reliant on fishing. The factory employs people from a nearby village with an MPA but not from the village acting as the control. Dependence on fishing decreases in the MPA village but remains stable in the control village. Income rises in the MPA village. The biological impact of the MPA is overestimated because the number of people fishing in the MPA village has decreased. The economic impact of the MPA is overestimated because increased income stems from employment in the factory
Market access	A non-MPA village has excellent access to a large market in the capital city. A nearby MPA village has greater catch rates, but economic impact is underestimated because they receive less income for their catch due to unequal market connection
Politics	A recent election has empowered many community members in an MPA village to participate in village affairs. Social impact of the MPA is overestimated because empowerment was not the result of the MPA, but of the recent election

Pollution	Sedimentation from a nearby agricultural enterprise has increased algal proliferation on an MPA reef. Impact is underestimated compared to a healthy control site
Spillover from adjacent MPA	Control sites are located too close to MPA, within the radius of target species spillover. Surveys record a smaller difference between control and MPA sites and ultimately underestimate impact
Wave energy and current	High-current environments (e.g. lagoon entrances) can have greater abundances of fish than surrounding areas. An MPA is in the middle of a reef but the lagoon entrance is used as a control site. Greater species abundance at the lagoon entrance results in an underestimation of impact

Guidelines for improving biological monitoring

1) The social factors are seldom explicitly considered or quantitatively evaluated. When protection was not enforced and fishing continued to occur within the MPA, an MPA is just a paper park and no protection effects should be expected. Actual enforcement and compliance, and not the formal MPA establishment, must be considered as the true starting point of protection.

2) The choice of the indicators should be clearly linked to the MPA goal(s), the hypothesis tested and the pre-existing knowledge. For example, species richness, which seldom responds to protection, should be used only when the specific MPA goal is to enhance biodiversity. On the other hand, indicators that perform well in responding to cessation of fishing (e.g. density and size of commercial fish) should only be used when the specific MPA goal is the recovery of target populations.

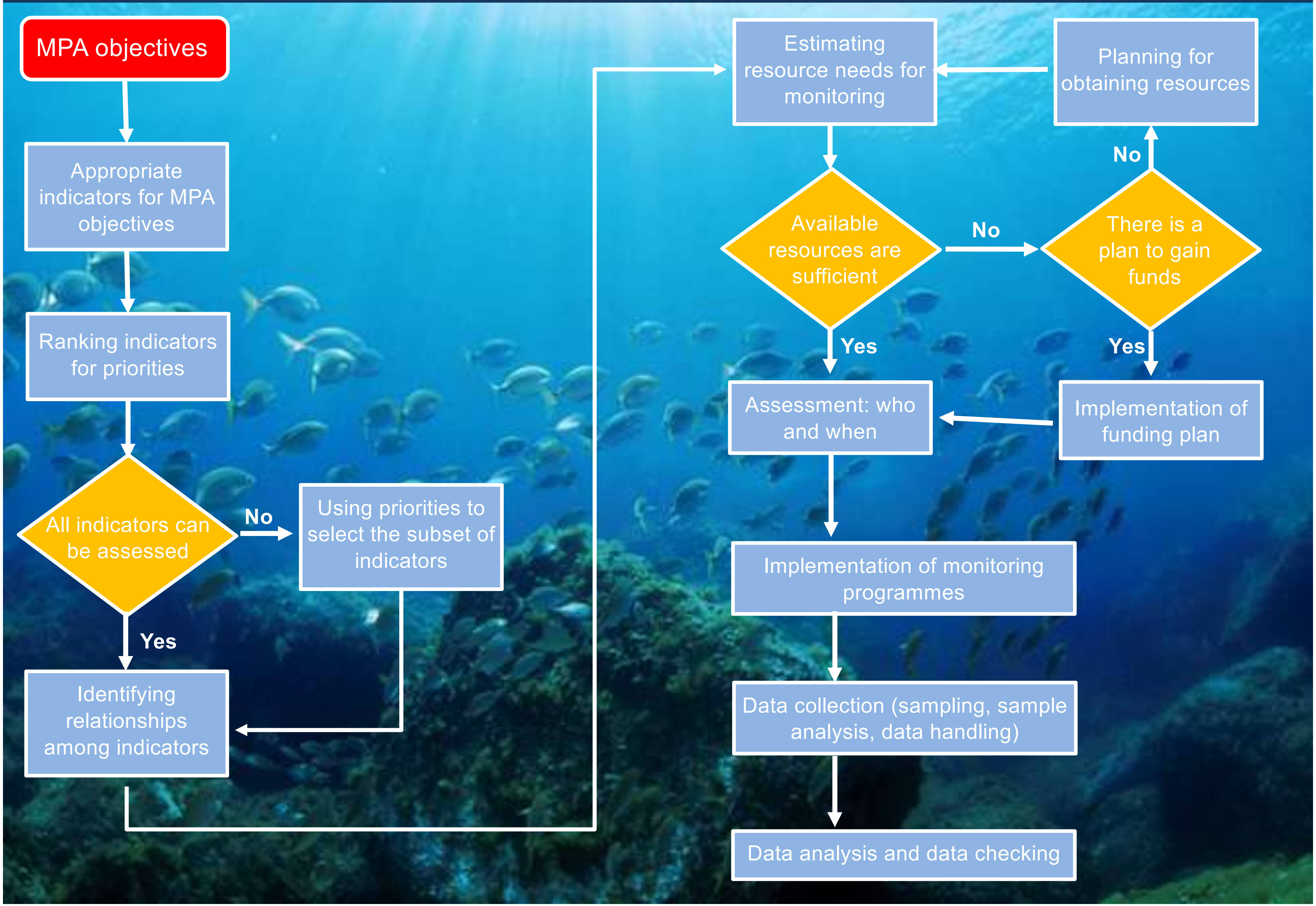
3) Habitat structure (both heterogeneity and complexity) affects indicators of the response to protection. Since MPAs are often established in complex and heterogeneous habitats, we need to distill the effects of protection from those attributable to habitat features.

4) MPA size and age may exert a strong influence on the response to protection of fish, invertebrates and the whole marine community

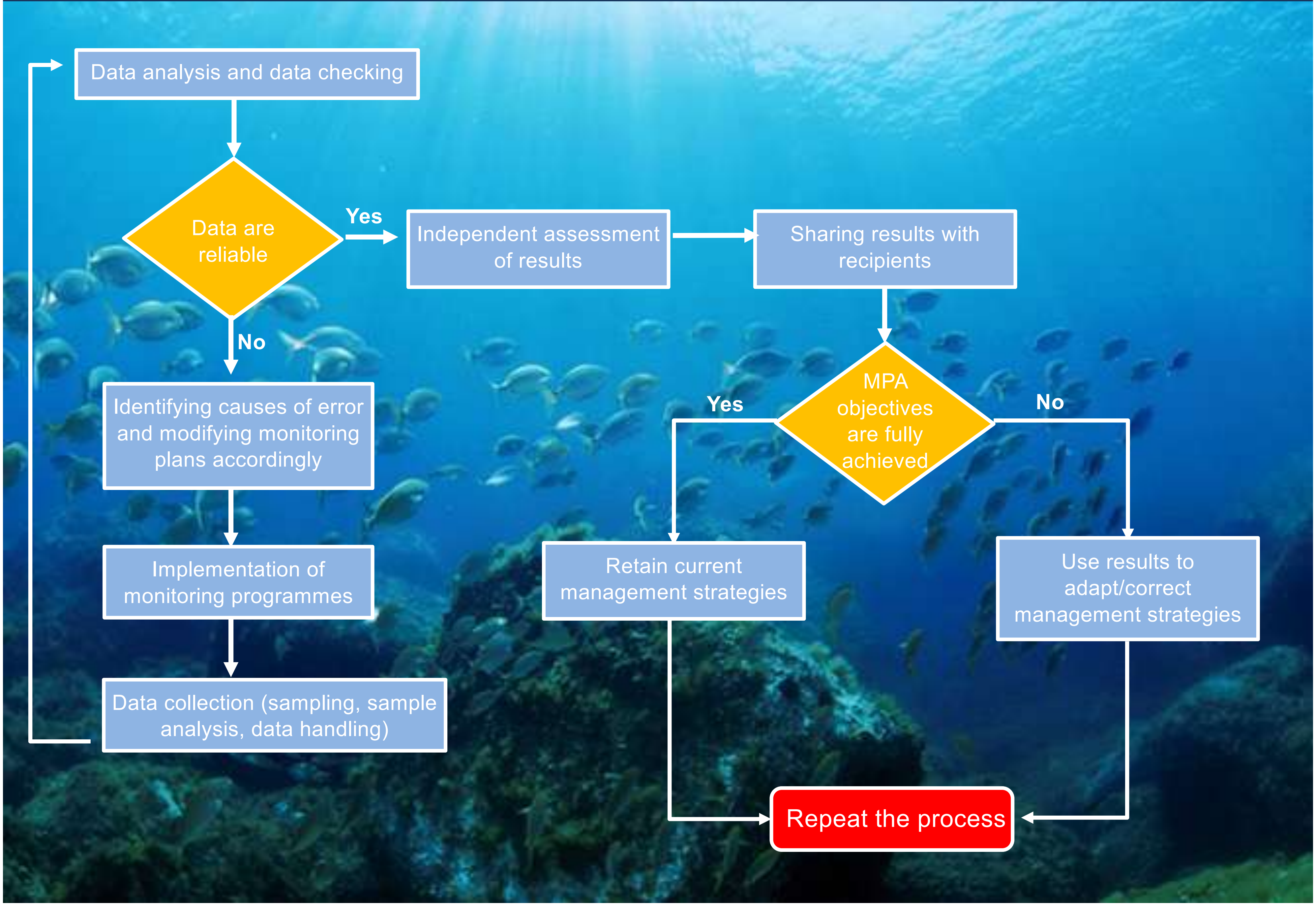
5) Quantifying the actual fishing pressure occurring outside a MPA, the potential spillover across MPA boundaries, as well as human behaviour in control areas (e.g. displacement effects) is essential for an appropriate assessment of MPA effectiveness

Guidetti & Claudet 2010

Work flow for monitoring plan



Work flow for monitoring plan



MPA biophysical scopes

Scopo 1 Sostentamento o protezione delle risorse marine

1 A Le popolazioni di specie-bersaglio ad uso estrattivo o non-estrattivo sono riportate o vengono mantenute a un dato livello prestabilito.

1 B Vengono evitate perdite di biodiversità o di elementi funzionali o strutturali dell'ecosistema.

1 C È vietata la raccolta delle specie-bersaglio ad uso estrattivo o non-estrattivo nei luoghi e/o nelle fasi del ciclo vitale maggiormente vulnerabili.

1 D L'eccessivo sfruttamento delle risorse marine, viventi e non viventi, viene ridotto al minimo, evitato o totalmente proibito.

1 E Le catture di pesce aumentano o si mantengono costanti nelle zone di pesca adiacenti all'AMP.

1 F Il tasso di reclutamento negli stock ittici aumenta o si mantiene costante all'interno dell'AMP.

Scopo 2 Protezione della diversità biologica

2 A Gli ecosistemi, le comunità, gli habitat, le specie e il pool genetico all'interno del sito sono adeguatamente rappresentati e protetti.

2 B La funzionalità dell'ecosistema è conservata.

2 C Le specie rare, locali o endemiche sono protette.

2 D Si proteggono aree essenziali alle fasi del ciclo vitale delle specie.

2 E Le minacce non naturali e gli effetti dell'attività dell'uomo vengono eliminati o ridotti al minimo all'interno e/o all'esterno dell'AMP.

2 F Il rischio di fattori di disturbo non controllabili è uniformemente distribuito su tutta l'AMP.

2 G Genotipi e specie aliene e invasive sono rimossi, o ne viene impedito l'attecchimento.

Scopo 3 Protezione di specie particolari

3 A L'abbondanza di specie focali aumenta o viene mantenuta.

3 B Vengono ristabiliti o mantenuti l'habitat e le funzioni ecosistemiche necessarie alla sopravvivenza delle specie focali.

3 C Le minacce non naturali e gli effetti dell'attività dell'uomo vengono eliminati o ridotti al minimo all'interno e/o all'esterno dell'AMP.

3 D Genotipi e specie aliene e invasive sono rimossi dall'area o ne viene impedito l'attecchimento.

Scopo 4 Protezione degli habitat

4 A La qualità e/o la quantità di habitat aumenta o viene mantenuta.

4 B I processi ecologici essenziali al funzionamento degli habitat vengono tutelati.

4 C Le minacce non naturali e gli effetti dell'attività dell'uomo vengono eliminati o ridotti al minimo all'interno e/o all'esterno dell'AMP.

4 D Genotipi e specie aliene e invasive sono rimossi o ne viene impedito l'attecchimento.

Scopo 5 Ripristino di aree degradate

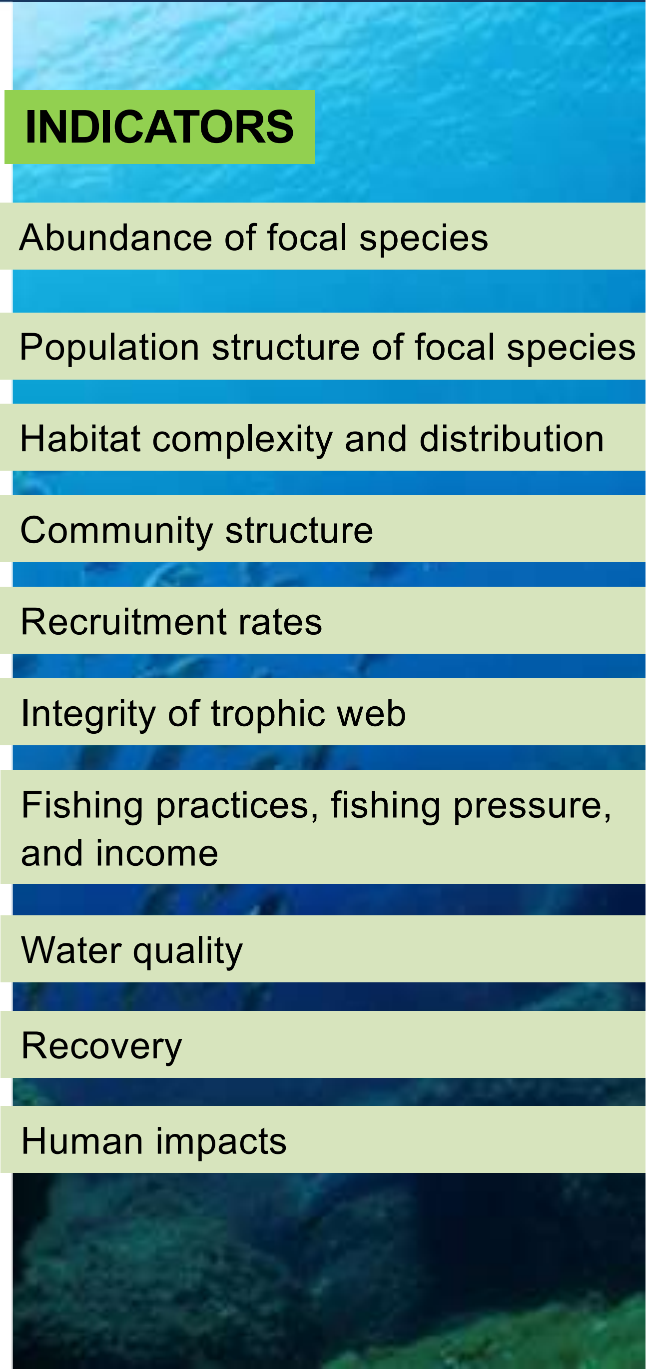
5 A Le popolazioni di specie originarie sono ripristinate nei punti di riferimento voluti.

5 B Le funzioni ecosistemiche sono ripristinate.

5 C La qualità e/o la quantità di habitat aumenta o viene mantenuta.

5 D Le minacce non naturali e gli effetti dell'attività dell'uomo vengono eliminati o ridotti al minimo all'interno e/o all'esterno dell'AMP.

5 E Genotipi e specie aliene e invasive sono rimossi o ne viene impedito l'attecchimento.



INDICATORS

- Abundance of focal species
- Population structure of focal species
- Habitat complexity and distribution
- Community structure
- Recruitment rates
- Integrity of trophic web
- Fishing practices, fishing pressure, and income
- Water quality
- Recovery
- Human impacts

An example

Aims / Objectives / Indicators

1. Conservation of marine resources

- 1A. Populations or target species are maintained
  - I1. Abundance of focal species
  - I2. Population structure of focal species
  - I5. Fishing pressure and incomes
- 1B. Biodiversity loss or disruption of structural and functional components of ecosystems is prevented
  - I3. Habitat distribution and complexity
  - I4. Community structure
  - I6. Water quality
- 1C. The exploitation of target species is avoided in critical areas or periods
  - I1. Abundance of focal species
  - I7. Human impacts are reduced or absent
  - I2. Population structure of focal species
  - I4. Community structure
  - I5. Fishing pressure and incomes
- 1D. Recruitment of fish stock increase or is maintained within the MPA
  - I1. Abundance of focal species
  - I2. Population structure of focal species
  - I5. Fishing pressure and incomes

2. Conservation of marine biodiversity

- 2A. Human threats are reduced or prevented within and outside the MPAs
  - I4. Community structure
  - I6. Water quality
  - I7. Human impacts are reduced or absent

Recrutment rates
Integrity of trophic web
Recovery

Indicators used

I1. Abundance of focal species

***Diplodus sargus* – *Diplodus vulgaris* – *Paracentrotus lividus* – *Arbacia lixula* – *Posidonia oceanica* – *Cystoseira* spp. – other inverterbrates**

I.2 Population structure of focal species

Size classes in populations of focal species

I3. Habitat complexity and distribution

Habitat mapping and comparison with previous assessment

I4. Community structure

Species composition and relative abundances in fish and benthic assemblages

I5. Fishing practices, fishing pressure, and income

Analysis of fish catches and economic value of landed catches

I6. Water quality

Monitoring of water quality (pollutants, organic, etc.)

I7. Human impacts

Analysis of human impacts in the area, cumulative pressure mapping

Focal species

Cystoseira spp.: habitat former, SPAMI protocol

Caulerpa cylindracea: invasive species

Posidonia oceanica: ecological importance, Habitat Directive, SPAMI protocol

Paracentrotus lividus, Arbacia lixula: ecological role as herbivores, potential cascading effects, exploitation regulated SPAMI protocol

Axinella spp.: protected SPAMI protocol

Cladocora caespitosa: endemic, SPA-BD protocol

Eunicella spp.: ecological relevance

Diplodus sargus, D. vulgaris, Sparus aurata, Dentex dentex, Dicentrarchus labrax: ecological relevance as predators, commercial species

Epinephelus marginatus, Sciaena umbra: species of natural interest, commercial target, regulated SPAMI protocol

Socio-economic indicators

- Use of local marine resources
- Local belief on marine resources
- Awareness of human impact on resources
- Perception of availability of fish resources
- Perception on the exploitation of local resources
- Perception of non-use value
- Life style
- Quality of public health
- Knowledge of natural history
- Position of leadership of stakeholders
- Changes in conditions of historical or natural monument/features
- Distribution and sources of income
- Employement types
- Infrastructures and public activities
- Market

Indicators for governance

- Conflicts on marine resource uses
- Existence of a magement body and decision making
- Existence of a management plan
- Existence of MPA regulation
- Local understading of MPA regulation
- Availability of administrative resources
- Scientific research and guidance
- Existence and activity of other bodies
- Clarity of regulations
- Interaction among the MPA and stakeholders
- Position of leadership of stakeholders
- Sensitiveness of stakeholders to sustainability
- Environmental education initiatives for stakeholders
- Participation and compliance of stakeholders to MPA regulation and management actions
- Involvement of stakeholders in surveillance of MPA regulations
- Enforcement
- Level of information to increase compliance and participation