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Marine conservation planning in practice: lessons learned from the Gulf of California

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ABSTRACT

1. Overfishing, pollution, coastal development and climate change threaten marine biodiversity globally and compromise the services that marine ecosystems provide. Systematic conservation planning (SCP) provides a framework to identify areas where actions can be effective in addressing these threats, while minimizing the costs of interventions. This study investigated the application of SCP in the Gulf of California, a marine hotspot where seven prioritization exercises have been undertaken.

2. The review of planning exercises showed that the use of SCP methods has progressed slowly (gaps include planning for land–sea connections and ecosystem services) and highlighted benefits and difficulties of applying SCP principles and tools.

3. Despite some convergence, important spatial differences were found in priorities between plans. Convergence was evident in well-studied shallow and benthic marine ecosystems. There were also important differences related to the planning approach, methods and extent. Divergence between methodological and spatial similarities between plans suggests that additional factors (e.g. manually delineating priority areas, incorporating updated datasets, random error), in addition to data and objectives, play an important role in defining the distribution of conservation priorities.

4. According to expert opinion, the implementation of new marine protected areas (MPAs) in the region has been influenced by some of the planning exercises. However, uptake of planning outputs has progressed slowly for many reasons (e.g. conflicting mandates and interests between organizations, limited technical capacities and resources, insufficient political commitment). Other benefits of planning included: developing institutional skills and knowledge; improving collaboration and coordination between organizations (including agencies, and local, regional and national NGOs); converging on the need to assess priorities for marine conservation in regional context; and building trust among organizations.

5. The existence of multiple marine conservation plans in the Gulf of California also highlighted some of the complexities and benefits of having multiple sets of priorities.

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INTRODUCTION

Biodiversity conservation of marine ecosystems remains a global priority (Spalding *et al.*, 2010) because fish stocks continue to decline (Worm *et al.*, 2009), eutrophication of coastal areas is ongoing (Howarth, 2008), and extinctions of marine species

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continue (Sala and Knowlton, 2006). The services provided by marine ecosystems (e.g. food provisioning, water quality, coastal protection) are also being compromised (Worm *et al.*, 2006; Aburto-Oropeza *et al.*, 2008). Ongoing conservation efforts, including marine protected areas (MPAs) (Lester *et al.*, 2009; McCook *et al.*, 2010; Spalding *et al.*, 2010), fisheries management (Mora *et al.*, 2009; Worm *et al.*, 2009), and ecosystem-based spatial planning and management (Leslie and McLeod, 2007; Foley *et al.*, 2010), are providing some benefits to protect marine biodiversity, but are not yet sufficient to halt or reverse the declines. The expansion of threats to the oceans and the limited resources available for conservation thus call for effective, transparent, and cost-effective strategies to protect biodiversity and maximize benefits for human livelihoods.

Systematic conservation planning (SCP) provides a framework to identify areas where conservation actions can be effective at achieving conservation objectives, while minimizing the costs of interventions (Pressey and Bottrill, 2009). Benefits beyond guiding effective investment in conservation areas include increasing socio-ecological knowledge relevant to biodiversity conservation, building institutional and individual capacity, facilitating collaboration among stakeholders, and increasing awareness of the need for urgent action to prevent biodiversity loss (Pressey and Bottrill, 2009; Bottrill *et al.*, 2012; Bottrill and Pressey, 2012). Conditions for successful implementation of actions in conservation areas – as identified through SCP exercises – have been shown to include integration of ecological and socioeconomic criteria into designs of conservation areas (Fernandes *et al.*, 2005; Green *et al.*, 2009), stakeholder ownership and support (Gleason *et al.*, 2010), input from managers and experts (Fernandes *et al.*, 2009), effective participation and engagement with local communities (Game *et al.*, 2011; Baker *et al.*, 2011), consideration of practical aspects of implementation (e.g. simple boundaries of conservation areas) (Fernandes *et al.*, 2005; Lombard *et al.*, 2007), adaptive management (McCook *et al.*, 2010), transparency during planning, and effective communication strategies (Day, 2002).

Given the increasing recognition of the value of systematic planning for marine conservation, research in the field is advancing rapidly (Leslie, 2005). The initial limited focus on representation of biodiversity patterns is expanding to include planning for ecological processes and socioeconomic considerations. Major recent advances include planning for several kinds of dynamics and interactions: the persistence of dynamic oceanographic processes and pelagic biodiversity (Lombard *et al.*, 2007; Game *et al.*, 2009; Grantham *et al.*, 2011), connectivity between different habitats (Beger *et al.*, 2010; Edwards *et al.*, 2010), planning for ecosystem services (Granek *et al.*, 2010), adaptation to climate change (Green *et al.*, 2009; McLeod *et al.*, 2009), land–sea integration (Tallis *et al.*, 2008; Klein *et al.*, 2010), and socioeconomic considerations (Ban and Klein, 2009; Baker *et al.*, 2011). These advances have guided some recent conservation strategies (Green *et al.*, 2009; Baker *et al.*, 2011).

While theory in conservation planning is developing quickly, there has been no assessment of the influence of new ideas on applications of marine conservation. Previous studies have reviewed aspects of MPA design that led to successful conservation actions (Lundquist and Granek, 2005; Osmond *et al.*, 2010) and there are retrospectives on particular planning exercises, e.g. the Great Barrier Reef Marine Park rezoning (Fernandes *et al.*, 2005) and the Northern Central California MPA network design (Gleason *et al.*, 2010). However, we are aware of no previous studies that assessed multiple marine planning initiatives within a single region, using a comprehensive SCP framework for review and comparison.

The Gulf of California is ideal for comparative studies of marine conservation planning, with seven marine planning exercises undertaken in the past 15 years. This study investigated how SCP principles have guided marine prioritization in the region, identified missing components of the planning process, and discussed the benefits and difficulties of applying SCP principles and tools. The similarities and differences between planning exercises were examined in terms of data, methods and outputs, how identified priorities match the existing MPA system, and whether plans have guided conservation and management actions. Difficulties and opportunities for conservation planners and practitioners are discussed when multiple planning initiatives coexist.

METHODS

Study region

The Gulf of California is a marine conservation hotspot (Olson and Dinerstein, 2002; Roberts *et al.*, 2002), globally recognized for its outstanding marine biodiversity (Brusca *et al*., 2005; Lluch-Cota *et al*., 2007). Oceanographic processes, including gyres, fronts, and upwellings (Lavín and Marinone, 2003), contribute to high levels of primary production that sustain rich coastal and marine communities and important fisheries (Beman *et al*., 2005; Lluch-Cota *et al*., 2007; Aburto-Oropeza *et al*., 2008). The Gulf is an important feeding, breeding and nursery area for 36 marine mammals (Morgan *et al*., 2005; Lluch-Cota *et al*., 2007), including the critically endangered and endemic vaquita, *Phocoena sinus* (Jaramillo-Legorreta *et al*., 2007). The Gulf supports large portions of the world's populations of several marine bird species (Lluch-Cota *et al*., 2007) and provides critical habitat for migrating birds (Glenn *et al*., 2006). The islands of the Gulf of California have ~655 plant species, 28 of which can be found nowhere else (Rebman *et al*., 2002). Comparable levels of endemicity have been recorded for marine fauna, including 766 invertebrate and 87 fish species (Brusca *et al*., 2005).

The rapid expansion and intensification of human activities in the Gulf of California are threatening its biodiversity and associated ecosystem services. Human population density is relatively low in the western coast's catchments draining into the Gulf of California (i.e. the Baja California Peninsula), but rapidly increasing, with associated increases in threats to the marine environment (Lluch-Cota *et al*., 2007). While the western coast of the Gulf remains comparatively undisturbed, many eastern coastal areas and catchments draining into the Gulf are affected by aquaculture, industry, agriculture, and urban development (Beman *et al*., 2005; Páez-Osuna and Ruiz-Fernández, 2005; Lluch-Cota *et al*., 2007). Intensive use of pesticides in agricultural areas is also a concern (Gutierrez-Galindo *et al*., 1992; Galindo-Reyes *et al*., 1999; Niño-Torres *et al*., 2010). Alteration of freshwater and sediment inputs from the Colorado River has modified the habitat for commercial and endangered species (Carriquiry and Sánchez, 1999; All, 2006; Rowell *et al*., 2008). Saltgrass marshes and mangrove forests are being reduced and degraded by coastal development, land-based pollution, and shrimp farms (INE, 2005; Glenn *et al*., 2006; Aburto-Oropeza *et al*., 2008). Deposition of atmospheric pollution and point sources of mercury (e.g. mining, urban and industrial sewage) are also affecting marine food webs (García-Hernández *et al*., 2007). Finally, the dramatic increase in fishing effort and inadequate management of fisheries have led to substantial declines of many fish stocks, changes in populations of targeted species, and composition of fish communities (Sala *et al*., 2004), which in turn have affected regional and local economies (Erisman *et al*., 2010).

Data collection and sources

Spatial marine conservation planning exercises were the focus of this study, excluding policy, regulation, and education initiatives. Seven planning exercises were identified and reviewed that prioritized coastal or marine conservation areas in the Gulf of California. The extents of these exercises, developed between 1998 and 2006, ranged from sub-continental (B2B: Morgan *et al*., 2005), to national (RMP: Arriaga-Cabrera *et al*., 1998; SPM: CONABIO, 2007), regional (i.e. Gulf-wide) (CSGC: Enríquez-Andrade *et al*., 2005; ERA: Ulloa *et al*., 2006), and sub-regional initiatives (i.e. covering portions of the Gulf) (BCP: Enríquez-Andrade and Danemann, 1998; MRN: Sala *et al*., 2002). Table 1 contains full names for acronyms and brief descriptions of the exercises. Information sources included published and unpublished reports and digital information. A digital map of marine priority conservation areas (hereafter 'priority areas') and details of datasets were not available for one plan (BCP). This plan included only the Baja Peninsula and a portion of the Gulf of California, and defined priority areas based on modifications to the National Marine Priority Regions (RMP). For these reasons, spatial analyses were focused on the other six planning exercises. However, key elements of this seventh planning process were summarized and discussed. A comprehensive description of the methods and planning stages for each plan, as well the maps of priority areas, are provided in Appendices 1 and 2 (Supplementary material).

Review of approaches to marine conservation planning

Key aspects of a systematic conservation planning framework developed by Alvarez-Romero *et al*. (2011) were used to identify commonalities and differences in approaches and methods between the seven marine conservation plans (Table 1), and to identify missing elements or stages (see Appendix 1, Supplementary material for details). This framework includes key components in planning (e.g. conservation goals and objectives, stakeholder participation, threats, and costs) and emerging issues in conservation planning (e.g. planning for

Table 1. Selected aspects of planning exercises that have identified marine priority conservation areas in the Gulf of California

Plan	Extent (km^2)	Goals[#]	Objectives	Approach/methods	Stakeholder participation	Biodiversity: patterns and processes	Threats and costs
Baja to Bering - B2B (Morgan *et al.*, 2005)	Sub-continental (7,165,359)	1, 2, 3	Qualitative	Expert-based, considering continental endemism, high beta-diversity, significance to migratory species, and productivity. Priority Conservation Areas selected based on significant threats and conservation opportunities. Areas selected by working groups (benthos, pelagic environment, planning and management) were overlayed to identify spatial overlap. Other selection criteria included connectivity and minimum area.	Based on a workshop with the participation of agencies, NGOs, universities, and some fishermen. Participants provided input on: conservation objectives; data availability; and selection, delineation, and documentation of priority areas.	Patterns: endangered, protected, endemic, migratory, and keystone species (birds and mammals); critical breeding and feeding habitat for multiple species; deep sea corals; seamounts; benthic complexity model; beta-diversity. Processes: ocean fronts, currents, eddies, primary productivity, and migration corridors.	Expert-based assessment of threats affecting priority areas: land- and sea-based organic and inorganic pollution; subsistence, commercial and recreational fishing; aquaculture; damming; tourism; coastline alteration; coastal development and urbanization. Experts also ranked relative intensity of threats. Costs were not incorporated.
Marine Priority Regions - RMP (Arriaga-Cabrera *et al.*, 1998)	National (3,290,584)	1, 2, 3	Not explicitly stated	Expert-based identification of priority areas during two workshops subdivided by expertise (e.g. chordates, fish, benthic invertebrates, oceanographic processes). Software to facilitate decision-making by consensus was used. Areas identified were used to analyse use patterns and potential conflicts between use and conservation of biodiversity; establish priorities; and make conservation recommendations.	Participants in the workshop included public and private research institutions, agencies, NGOs, MPA managers, and international organizations. Participants identified and delineated areas where conservation features occur, identified potential trade-offs, defined the priority status, and formulated general recommendations.	Patterns: macroalgae, marine invertebrates, fish, sea turtles, marine mammals, birds and corals; mangroves, coastal dunes, algae, seagrass, and wetlands. Processes: primary productivity areas (i.e. phyto/zooplankton, fishing areas); physical, chemical and geologic oceanographic processes.	Threats were not explicitly and systematically used in the priority regions selection process. Major threats to biodiversity and mitigation strategies were identified and documented for priority regions. Costs were not incorporated.
Marine Priority Sites - SPM (CONABIO, 2007)	National (3,152,985)	1, 2	Qualitative	Expert-based selection based on representativeness and viability, fisheries sustainability, high diversity, ecological processes, species habitat, connectivity,	Expert-based participatory workshop included researchers, national and regional environmental NGOs and agencies. Major inputs from participants included additional data, selection of conservation objectives, selection and delineation of priority areas,	Patterns: priority areas for endangered, endemic, and protected species (vertebrates and invertebrates), habitats (coast types, reefs, seagrass, kelp forests), and special elements	Threats were analysed after delineating priority sites, and therefore not used as a criteria for the selection of conservation areas. Costs were not incorporated.

				ecosystem services and cultural or research value. Priority areas delineated in working groups (vertebrates, benthos, plankton and fisheries, processes, and coastal vegetation) were overlapped. Representation of features of interest across all bioregions guided prioritization.	threat assessment, and documentation of priority areas and islands.	(aggregation areas, refugees, seamounts, rift zones, bacteria mats, minimum oxygen zones). Processes: upwellings, fronts, vertical mixing, gyres and eddies, currents, and river discharges.	
Coalition for the Sustainability of the Gulf of California - CSGC (Enríquez-Andrade *et al*., 2005)	Regional (902,225)	1	Qualitative	Expert-based selection of biologically important areas (AIB) to sustain viable populations and represent selected groups (land flora, land fauna, marine biota, and wetlands). Priority areas were defined by an overlap of more than two or three AIBs. Design criteria also included representing important ecosystems and habitat for multiple species and inclusion of important physical and ecological processes.	Highly participatory consensus-based process with international, national, regional and local stakeholders from NGOs, academia, MPA management bodies, and agencies. Participants set goals, selected conservation features, provided information, participated in the analysis and priority area portfolio design, and developed maps of anthropogenic threats to biodiversity and potential social conflict (between uses and conservation).	Patterns: selected species aggregated and analysed by group (fish, mammals, sea turtles, invertebrates, macroalgae, birds, and land flora and fauna); selection criteria included population and habitat condition, endemism, distribution range, threats and trends. Processes: oceanographic (upwellings, oceanic fronts, and currents) and ecological processes were mapped by experts. Reproduction, larvae dispersal, recruitment, and migration were also considered.	Threats were not used to guide or modify the selection of priority areas, but were one of the criteria considered by experts to delineate viable conservation areas. Current and near future (5 year scenario) threats were mapped. A threat index was developed to identify the feasibility of implementing conservation programmes or protected areas, but was not used to define priority sites. Post-hoc 'costs' assessment based on potential social conflict.
Ecoregional Assessment - ERA (Ulloa *et al*., 2006)	Regional (361,375)	1, 2	Quantitative	Prioritization was based on representation of species, communities, and systems within the ecoregion. The process follows a fine-filter and coarse-filter approach. (Groves *et al*., 2002) Domain was stratified in sub-ecoregions based on a SST model. A draft portfolio of conservation areas was	The planning team defined the general goals, objectives, and methodology. Support and input was given by experts, managers and conservation organizations. The major input from fishermen was information on fishing areas via interviews. During a workshop the planning process and portfolio was presented for external expert review.	Patterns: important areas (interpolated occurrences/planning unit) and occurrences of protected, threatened, endemic, migratory, and keystone species (*Sargassum*, seagrass, fish, corals, sea turtles, sea mammals, seabirds); mangroves; coast types; benthic complexity; reefs; seamounts;	A "cost" layer was constructed based on the summed values of individual threats (tourism, population marginality and size, aquaculture, different fishing types, navigation routes and ports). Threats were rated in terms of their potential impacts on biodiversity and used in Marxan to

(*Continues*)

Table 1. (*Continued*)

Plan	Extent (km^2)	Goals#	Objectives	Approach/methods	Stakeholder participation	Biodiversity: patterns and processes	Threats and costs
				constructed with Marxan (Ball *et al*., 2009) and further refined based on expert opinion. General design criteria (connectivity and viability of conservation features) were used to refine portfolio.		rhodolith beds; species aggregations; sardine recruitment areas; important invertebrate areas. Processes: primary productivity and upwelling zones.	minimize the 'cost' for each planning unit (i.e. avoid highly threatened areas and minimize conflict with fisheries and other uses).
Baja California Peninsula Priorities - BCP (Enríquez-Andrade and Danemann, 1998	Sub-regional (237,653)	1, 2, 3, 4	Qualitative	Important areas for coastal-marine conservation, as well as key problems/threats and actions (not only spatial) were identified and prioritized by experts based on qualitative multi-criteria analysis. Previous national priorities (RMP) served as a guide. Preference was given to areas with higher ecological value, larger size, stronger threats, lower conservation opportunities (except preexistent protection), higher economic importance and historical/cultural values.	Expert-based participatory workshop included researchers, industry, tradesmen, businessmen, agencies, MPA managers, and conservation organizations. Natural resource users (fishermen and tourism), were interviewed regarding resource uses. Stakeholders also attended workshops to review conservation and management problems, and to propose and identify priority actions to address them. A selected group of researchers identified and prioritized conservation areas.	Spatial data on biodiversity patters or processes were not used to identify priority conservation areas. However, biological criteria (ecological integrity, ecosystem diversity, endemicity, richness, number of endangered species) guided area prioritization. Processes considered by experts in area prioritization included primary productivity, upwellings, migrations and biological corridors.	Literature/expert-based assessment and prioritization of problems/threats related to fisheries, coastal zone use, ecotourism and use of islands, and protected areas. Identified problems included access to resources (illegal fishing, overexploitation, conflict); management (inadequate planning, regulation and enforcement, jurisdictional fragmentation/overlap, poor data); market (resources and services valuation, incentives); economic (migration); fisheries organisation and infrastructure; and research-management gap. Costs were not incorporated.
Marine Reserves Network - MRN (Sala *et al*., 2002)	Sub-regional (132,176)	@1, 2	Qualitative, Quantitative	Prioritization focused on reef fish, but included coastal vegetation and invertebrate biodiversity. Marine reserve design principles were: protect representative and rare habitats; include areas with high species richness; maximize ecosystem functioning	The planning exercise was an academic process organized by two research centres and one NGO. Input from artisanal fishermen was important for mapping fishing areas.	Patterns: Reef fish richness (134 spp.); habitats (sandy bottoms, seamounts, rhodolith beds, *Sargassum* beds, and black coral beds) used as surrogate for plant and invertebrate biodiversity and important reef fish habitat; coral	A 'cost' layer was developed to be included in analyses using SITES to avoid/minimize social conflict with artisanal fisheries. Artisanal (small) boat fishing pressure (density boats/km^2) was used to minimise conflict between fishermen and

(protect larval sources and nurseries for targeted fish; ensure population connectivity through larval dispersal; minimum reserve size to ensure self-recruitment; and minimize conflict with fisheries). A decision-support tool was used (SITES; Ball *et al*., 2009). Domain was stratified in zoogeographic regions following fish abundance.	communities and seagrass beds; fish nurseries (mangroves); important larval sources and spawning aggregations of commercial fish. Processes: Population connectivity incorporated though general design criteria (max. distance between priority sites: 100 km) and implemented via reserve selection rule.	potential marine reserves.

#1. Biodiversity conservation; 2. Natural resource management; 3. Research priorities; and 4. Livelihoods.
@Primarily an academic planning exercise.

ecological processes, ecosystem services and land–sea interactions).

Assessment of methodological and spatial similarity

Methodological similarity between planning exercises was calculated based on the Jaccard coefficient (which adds up the total number of items that are different, excluding instances of zero ties), focusing on conservation objectives and data because these were assumed to be most influential in the selection of priority areas. First, conservation objectives and data for features of interest were coded as binary attributes (1 = used; 0 = not used). When planning exercises used datasets differently (e.g. extent, resolution, date) or when data were grouped or disaggregated differently, data types were matched with the most equivalent elements in other exercises or grouped in the same way as in other exercises. Based on an overlay of the maps (a.k.a. portfolios) of priority areas (hereafter 'priority maps'), areas of coincidence were identified and spatial similarity between pairs of priority maps were measured with the Kappa statistic using the Map Comparison Kit (Visser and de Nijs, 2006). Kappa similarity is adequate and commonly used for assessing agreement between categorical maps (Wilson *et al*., 2005; Edwards *et al*., 2010). The Jaccard coefficient and Kappa statistic were displayed with similarity phenograms based on hierarchical clustering, also applied previously (Ban, 2009; Weeks *et al*., 2010b). In addition, the spatial configuration of priority maps (i.e. number, size, perimeter, and spacing) and the sizes of the planning domains were also compared. A second spatial analysis focused on how areas of convergence between the six planning exercises were related spatially to existing MPAs (CONANP, 2010), marine bioregions (CEC, 2006), and selected ecosystems and seascape features (Lugo-Hubp and Fernandez Córdova, 1990; Ulloa *et al*., 2006; CONABIO, 2008; UNEP-WCMC, 2010).

Evaluation of achievement of goals and benefits of planning

Interviews were carried out with 13 experts, selected based on their expertise in marine conservation in the region and their involvement in one or more of the planning processes discussed here. Affiliation of interviewees included national agencies, regional and international NGOs, and research centres. During these interviews, experts identified both reported and unreported planning goals (from a predefined list, supplemented with their responses; see Appendix 3 Supplementary material) and indicated the extent to which these goals had been achieved (using a 5-point Likert scale). Further, experts assessed how planning outputs guided or influenced spatial implementation of conservation actions by identifying (from a list) which actions have been implemented (e.g. establishment of multiple-use MPAs and no-take areas, fisheries zoning, restoration, surveillance). Experts also described the main factors perceived to facilitate or constrain actions (open-ended questions). In addition, other perceived benefits of the planning processes (besides spatial actions) were identified from a preliminary list modified from Bottrill *et al.* (2012), as well as the existence of any formal assessments of outcomes, and intentions for revising plans. Interviews were supported by a written survey (Appendix 3 Supplementary material).

RESULTS

Approaches to marine conservation planning

All seven planning exercises included fundamental elements of systematic conservation planning (e.g. involving stakeholders, setting conservation objectives, assessing threats and conservation costs, and delineating new priority areas), but differed widely in the way they addressed these elements (see Table 1 and Appendix 1 Supplementary material). Notable differences included the way costs were incorporated (e.g. least-cost solutions vs. prioritization of highly threatened areas) and methods for identifying priority areas (e.g. expert-based vs. software). In the following sections the most relevant similarities and differences are summarized and discussed.

Stakeholders

Stakeholder participation varied considerably between planning exercises (Table 1). Participation of researchers was prominent in all cases, and input from agencies, conservation non-governmental organizations (NGOs) and MPA managers was substantial in most exercises. Two planning processes (B2B and SPM) also included some representatives of the fishing and tourism sectors. A contribution by resource users was to provide information on areas of economic importance, such as fishing grounds (Ulloa *et al.*, 2006). Stakeholder involvement in one planning exercise (MRN) was restricted to academics and conservation NGOs. In the four expert-based processes, representatives from agencies, academia and NGOs actively participated and contributed to different stages of the planning process.

Conservation objectives

Approaches to setting conservation objectives were diverse (Table 1). A coarse/fine-filter approach to identifying conservation features (i.e. targeting communities/ecosystems and individual species/features independently) (Groves *et al.*, 2002) was taken in most exercises, but there were also important differences. Quantitative objectives were set for only two planning exercises (MRN and ERA), both of which also defined separate objectives for conservation features occurring in more than one bioregion. Qualitative objectives were common to all planning exercises. Qualitative objectives included selecting areas with high species richness and abundance or endemic, endangered or protected species, and ensuring connectivity between areas.

Threats and costs

There were major differences between planning exercises in the treatment of threats and costs. In two exercises (SPM and CSGC), important threats to coastal and marine ecosystems were identified independently of the prioritization process and therefore had no influence on the selection of priority areas. One exercise (CSGC) mapped current and near-future (5-year projection) threats to inform the feasibility of implementing conservation actions, as well as to identify potential areas of conflict. Threats and potential mitigation strategies were documented for the national marine priority regions (RMP) after these were delineated by experts. For the B2B exercise, a qualitative ranking of the intensity and trend of threats was developed by experts to identify areas with both threats and conservation opportunities (e.g. ongoing conservation or management efforts). In contrast, the two planning exercises supported by conservation planning software (MRN and ERA) used data on threats to achieve objectives while minimizing conflicts and/or conservation costs (Ban and Klein, 2009) by placing priority areas away from highly threatened or heavily used (e.g. fishing) areas, where possible.

Emerging issues

Uptake of recent advances in conservation planning (e.g. planning for ecosystem services, land–sea interactions, and climate change) was limited, despite their relevance to address major environmental problems in the Gulf of California (Table 2); an exception was the consideration of ecological processes (Appendix 1 Supplementary material). Generic design criteria such as minimum area size and connectivity guided the selection of priority areas to address some processes. To maintain larval dispersal, the MRN exercise used software to ensure that distances between priority areas did not exceed 100 km. For the B2B exercise, experts applied generic design criteria, supported by available information on processes such as migration routes and areas of high productivity, to delineate priority areas. Ecological processes linking land and sea, such as nutrient flows from rivers, were considered by experts in the national marine gap analysis (SPM), but no spatially-explicit models were available. Cross-system threats (e.g. land-based pollution and coastal development) were considered by experts in B2B and, in the ERA exercise, simple spatial models of land-based threats

Table 2. Significance of emerging issues in marine conservation planning, with examples from the Gulf of California

Topic	Significance in conservation planning	Examples of importance in the region
Ecosystem services	Planning for ecosystem services aims to maintain the various benefits provided by coastal and marine ecosystems (e.g. food provision, pollution buffering, coastal protection, nutrient cycling, recreation) and the economic gains associated with these (e.g. fisheries, tourism); the need to consider ecosystem services in marine planning is well recognized (Granek *et al*., 2010; Silvestri and Kershaw, 2010).	Mangroves increase fisheries landings by providing habitat used by many commercial species as nursery and/or feeding grounds, thus providing important economic benefits to local communities and impacting the regional economy. However, these ecosystems continue to be degraded by coastal development in the Gulf of California (INE, 2005; Aburto-Oropeza *et al*., 2008; Ezcurra *et al*., 2009).
Land–sea integration	Integrated land–sea planning aims to mitigate threats originating beyond the boundaries of marine conservation areas (e.g. land-based threats to coastal-marine ecosystems) and maintain the ecological linkages between land and sea that support species and ecological processes occurring across terrestrial, freshwater, and marine realms (Tallis *et al*., 2008; Alvarez-Romero *et al*., 2011).	Many eastern coastal areas of the Gulf of California are affected by land-based threats, including agriculture, urbanization, aquaculture, and damming (Páez-Osuna and Ruiz-Fernández, 2005; Lluch-Cota *et al*., 2007). Intensive use of pesticides in agricultural areas is a particular concern (Galindo-Reyes *et al*., 1999; Niño-Torres *et al*., 2010). In some cases, the potential impacts of these threats can extend hundreds of kilometers from the coast (Beman *et al*., 2005).
Ecological processes	Incorporating ecological processes is critical to maintain connectivity (e.g. through recruitment and spillover) between conservation and fishing areas, as well as to identify persistent high productivity areas (e.g. associated with upwellings or ocean fronts) and to minimize the likelihood of MPAs within a region being affected by single disturbance events (Allison *et al*., 2003; Almany *et al*., 2009).	Persistent oceanographic processes, including upwellings, contribute to the occurrence of areas of high productivity in the Gulf of California, where major commercial, artisanal, and recreational fisheries occur (Lluch-Cota *et al*., 2007). Ocean currents contribute to the ecological connectivity between protected and fished areas (e.g. through larval dispersal), thus emphasizing the significance of connectivity for conservation and fisheries planning in the region (Cudney-Bueno *et al*., 2009).
Climate change	Designing networks of marine protected areas that are resilient to climate change is considered a global priority. Strategies to deal with predicted changes include: design criteria (e.g. size, spacing, shape); spreading risk through representation and replication; identifying and protecting refugia for species, habitats, and special features (e.g. species aggregations); reducing other impacts (e.g. pollutants runoff) to improve the resilience of ecosystems; and maintaining ecological connectivity through networks of MPAs (Green *et al*., 2009; McLeod *et al*., 2009).	The ecological impacts of climate change in the Gulf of California are still poorly understood, but changes in temperature and precipitation are expected, along with fluctuations in runoff and fisheries (Lluch-Cota *et al*., 2007, 2010). Predicted increase in temperature forecasts changes in abundance of species with limited capacity for acclimation due to thermal stress (Stillman, 2003). On the other hand, ENSO episodes are expected to increase in frequency and intensity, with potential impacts on marine populations, communities, and fisheries of highly commercial species (Velarde *et al*., 2004; Aburto-Oropeza *et al*., 2010b).
Scheduling and zoning	In addition to identifying priority conservation areas, planners need to decide in which areas to invest first considering limited resources (not all can be protected immediately) and pervasive threats (values of marine ecosystems continue to degrade due to current and future threats). Spatial distribution of biodiversity/fisheries values, threats, costs, investments returns and data uncertainty play a role in scheduling conservation interventions (Wilson *et al*. 2006, 2007).	Limited human and financial resources have delayed the implementation of conservation actions in the Gulf of California. The lack of immediate intervention in some cases could mean the extinction of threatened species, such as the vaquita (Jaramillo-Legorreta *et al*., 2007) or the loss of critical ecosystems, such as mangroves, that sustain important fisheries in the region (Aburto-Oropeza *et al*., 2008). Prioritizing areas and actions within proposed portfolios of conservation areas and identifying no-take areas in the already established MPAs could help to mitigate these negative impacts (Rife *et al*., 2012).

(i.e. multiple-ring buffers associated with higher conservation costs) were incorporated. Only one planning exercise (CSGC) explicitly targeted ecological linkages between terrestrial, freshwater and marine priority areas. In the national marine gap analysis, a *post hoc* integration with terrestrial and freshwater priorities was recommended for the future. None of the studies recommended a sequential allocation (i.e. scheduling) of investments in delineated priority areas, e.g. to act first in areas facing imminent threats (Wilson *et al.*, 2009). However, one exercise (SPM) assigned priority levels, based on expert advice, to priority areas after they were delineated and another (ERA) recommended scheduling.

Similarity and spatial coincidence between planning exercises

Methodological similarity

Clustering of exercises based on objectives and datasets (Figure 1(a)) showed that the exercise emphasizing protection of fish (MRN) was very different to the others, which also considered other taxonomic groups and oceanographic processes. Likewise, similarity values between the sub-continental exercise (B2B) and other plans were relatively low. B2B focused on species of conservation concern throughout North America, not on those more typical of the Gulf, and also considered processes operating over larger geographic extents (e.g. migratory corridors) than the Gulf. Common to both MRN and B2B was their focus on a few species and key habitats. Also notable was the similarity between the two regional-scale exercises (CSGC and ERA) which, despite differences in methodology (expert-based vs. software-driven), shared many conservation objectives, and used similar data. Similarity between the two national-scale exercises (RMP and SPM) was relatively low. The analysis placed SPM closer to the regional plans and RMP somewhere between the regional and the sub-continental exercises. This is consistent with both B2B and RMP identifying regions, rather than specific areas, for marine conservation and their use of data appropriate for that purpose.

Spatial similarity

Overall spatial similarity (Figure 1(b)), accounting for spatial overlap of priority areas and their relative proportions in the region, revealed two

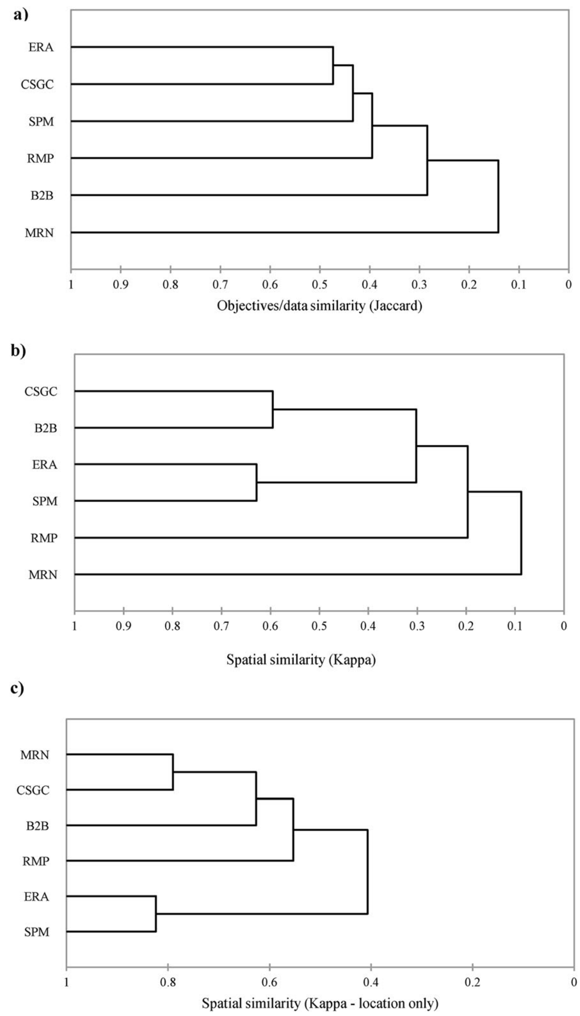

Figure 1. Similarity phenograms for marine planning exercises constructed through agglomerative hierarchical clustering analysis (unweighted pair-group average). B2B: Baja-to-Bering; RMP: Marine Priority Regions; SPM: Marine Priority Sites; CSGC: Coalition's Important Conservation Areas; ERA: Eco-regional Assessment; MRN: Marine Reserves Network. (a) Methodological similarity based on planning objectives and datasets (Jaccard coefficient); (b) overall spatial similarity based on location of priority areas and relative proportions (Kappa statistic); and (c) location-only similarity (K-loc statistic: Visser, 2004). Spatial similarity varied, but general strength of agreement between pairs of priority maps was fair based on overall similarity (mean Kappa = 0.24) and moderate for similarity in location-only (mean K-loc = 0.52). A value of 1 means identical priority maps, while 0 indicates no more overlap than expected by chance. A significance analysis based on random constraint match models (Visser and de Nijs, 2006) indicated that Kappa values between pairs of maps were significant when compared to similarity with random maps (0.066–0.074), $P < 0.001$.

subgroups (CSGC-B2B and ERA-SPM) and two planning exercises that were substantially different from the rest (RMP and MRN). Spatial similarity based only on the locations of priority and non-priority areas (K-loc), and not their relative proportions (Figure 1(c)), showed higher values but also a different clustering pattern. For instance, MRN – isolated based on overall Kappa – formed a new subgroup with CSGC based on K-loc. This cluster could result from priority areas from MRN being almost entirely contained within CSGC and, in both exercises, the preferential location of priority areas in coastal and nearshore environments. On the other hand, the subgroup formed by ERA and SPM based on overall spatial similarity (Figure 1(b)) remained in the location-only phenogram (Figure 1(c)), but was stronger for location-only, possibly due to the inclusion (with minor adjustments) of some of the ERA priority areas into the SPM priority map.

Configuration of priority areas

There was an asymptotic increase in the mean size and perimeter of priority areas as the extents of planning domains increased, with significant variation within each plan (Figure 2(a), (b)). There was an inverse relationship between the number of priority areas and the extent of the planning domain, though the strength of this relationship was fairly low (Figure 2(c)). Excluding the values corresponding to MRN – the exercise that focused on fish protection (formed by relatively few, small priority areas intended to form a network of no-take zones) – appreciably increased the fit between number of priority areas and extent of domain. The tendency for larger planning domains to be associated with larger and fewer priority areas (Figure 2(a)–(c)) was related to coarser data resolution, larger planning units being assessed and compared for conservation, and more extensive targeting of ecological processes.

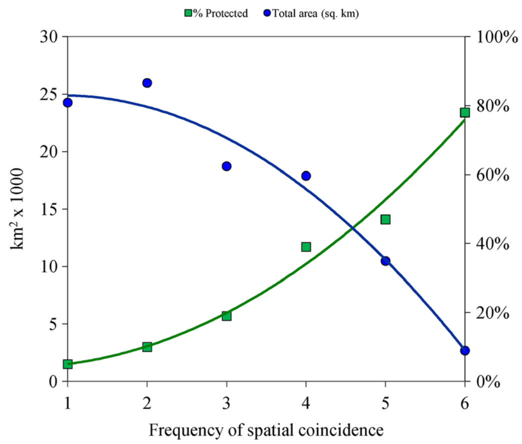

Figure 3. Frequency of spatial coincidence between the priority maps (number of plans identifying an area as a priority) and two variables: total area covered by each frequency value of spatial coincidence (blue dots and line); and proportion of the total extent of existing MPAs identified as priority areas (green squares and line). Fitted lines correspond to second-order polynomial regressions.

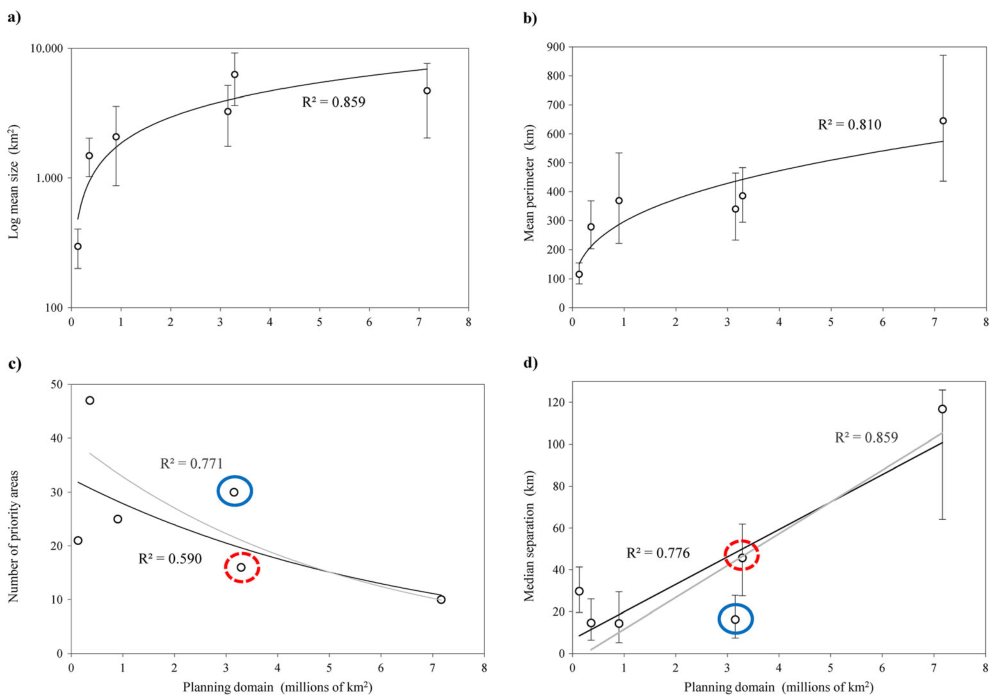

Figure 2. Comparison of selected features of priority maps in relation to the full planning domain extent (values on Y axes correspond to priority areas within the Gulf of California only): (a) mean size and (b) mean perimeter of priority areas; (c) total number of priority areas comprising each priority map; and (d) median separation between nearest priority areas (use of median responds to highly skewed distributions). Points corresponding to the national-scale exercises are marked by blue (SPM) and red/dashed (RMP) circles. Fitted trend lines correspond to power (a, b), exponential (c) and linear (d) types; light-grey lines show an improved fit when MRN is excluded from the analysis (see text). Error bars represent the 95% C.I. for the mean ($P < 0.0001$) estimated by Monte Carlo simulation (a, b) and the first and third quartiles (d).

The extent of the planning domain was positively correlated with the separation between priority areas and therefore with lower potential connectivity (Figure 2(d)). Again, excluding MRN improved curve-fitting because its proposed marine reserves were considerably smaller than all other exercises, and thus were relatively widely spaced relative to the extent of the planning domain. Also evident from Figure 2(c), (d) is that RMP identified fewer and significantly more separated priority areas than SPM. In these aspects, RMP was more similar to the sub-continental exercise (B2B) than to the other national plan, consistent with the methodological similarity discussed above.

Overall spatial coincidence, ecological representativeness and MPA coverage

The combined (summed) priority maps covered ~100 000 km^2, but relatively little of the summed area was consistently identified as having priority for marine conservation. About 31% of the summed area was identified by at least four plans and only 3% was selected by all plans. This was reflected in the negative relationship between the

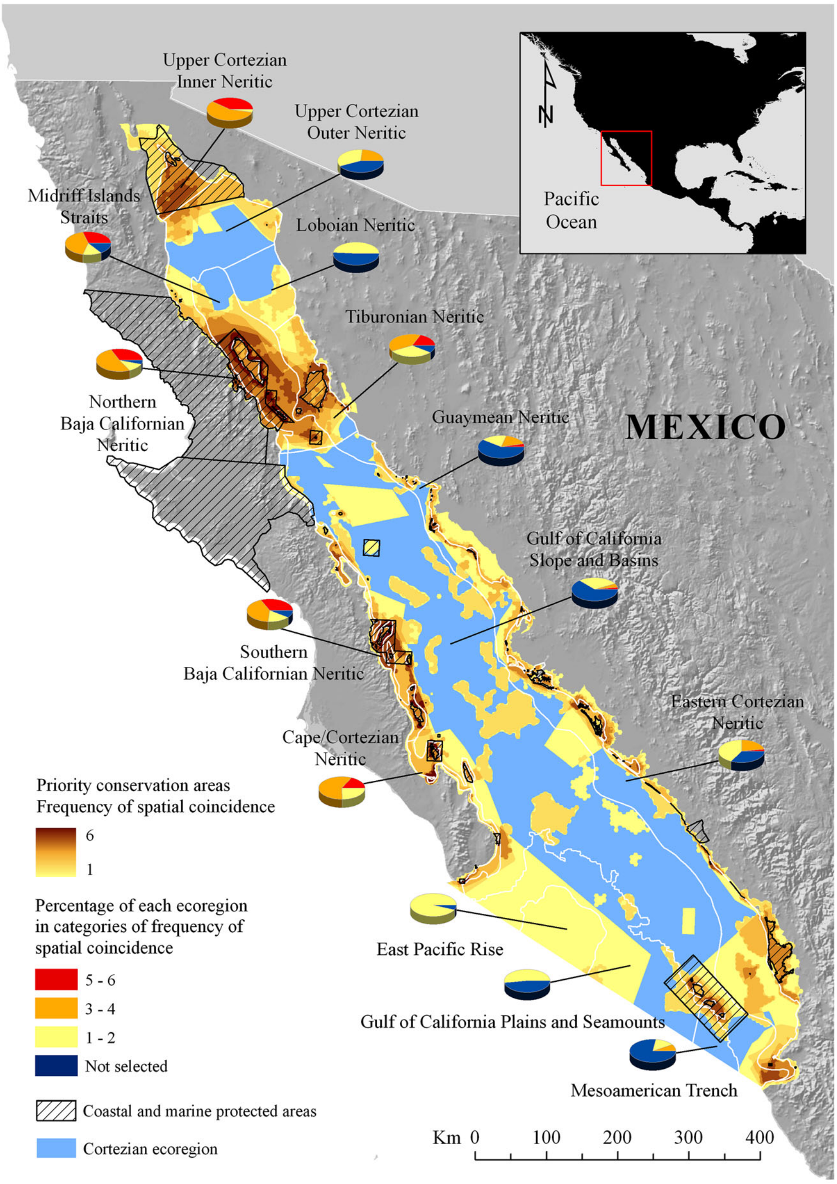

Figure 4. Spatial coincidence of priority areas between planning exercises in the Gulf of California. For overall frequencies, darker areas were identified as priorities in more plans. Pie charts represent the percentages of each marine bioregion in three classes of frequency of spatial coincidence across plans, from none (dark blue) to most plans (red).

frequency of spatial coincidence and the total priority area in each frequency (Figure 3). Conversely, the percentage of existing MPAs covered by priority areas increased with the frequency of spatial coincidence. This means that a large proportion of the areas consistently identified as priorities have also been granted some type of legal protection (Figures 3 and 4), although, in some areas protection preceded prioritization exercises. Spatial coincidence was generally higher in the northern Gulf and western coast (Figure 4).

Representation of marine bioregions varied markedly among plans (Figure 4). About one-third of the 14 bioregions within the Gulf of California were covered almost entirely by selected priority areas of most plans, including the highly productive Upper Cortezian Inner Neritic and Midriff Islands Straits. In contrast, significant portions of other bioregions, including the Slope and Basins, the Guaymean Neritic, and the East Pacific Rise were only partially incorporated into priority maps.

Priority areas were concentrated in coastal and shallow areas (<300 m depth), with frequency of prioritization decreasing with depth. This is evident in the biased coverage of geomorphological features (Figure 5(a)), with priority areas more often identified on the continental shelf. Features such as trenches, submarine canyons, and valleys were often omitted. Ecosystems were also unevenly represented (Figure 5(b)). Coral reefs, seagrasses, and rhodolith and *Sargassum* beds were more often included in plans, while others such as seamounts were rarely included, probably because of limited information. Mangroves were included to some extent in most plans, but the portion of mangrove covered by high coincidence of priority areas (i.e. overlaps >4 exercises) was minimal. Partial inclusion of mangroves can be related to their occurrence along the land–sea interface (planning has largely focused on marine ecosystems) and to their relatively wide distribution along the coast, making their frequently represented areas small in percentage terms.

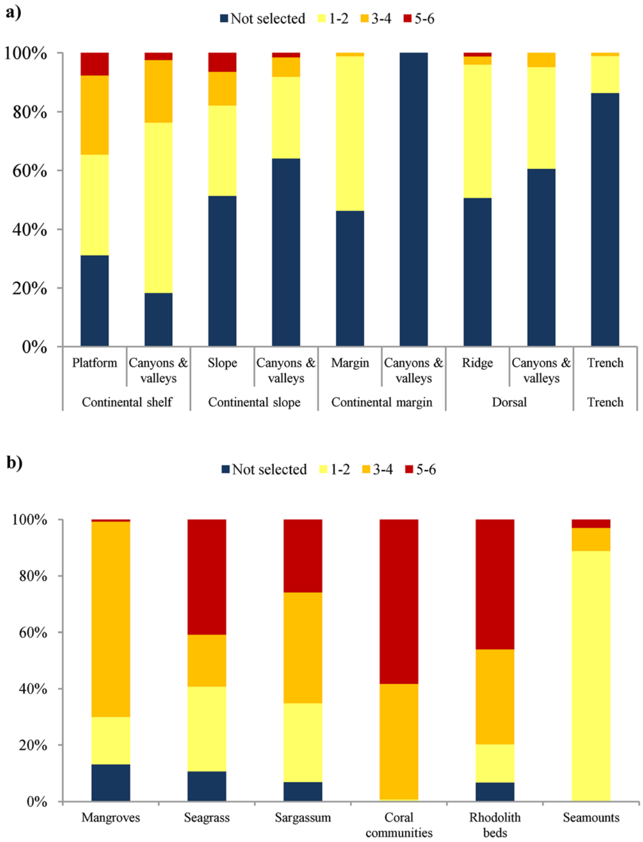

Figure 5. Representation of geomorphology classes and ecosystems within different levels of overlap of priority conservation areas. Graphs show the percentages of the total area of (a) marine geomorphology classes and subclasses and (b) selected coastal and marine ecosystems that correspond to three classes of frequency of spatial coincidence: low (1–2), medium (3–4), and high (5–6).

Achievement of goals, implementation of spatial actions, and benefits of planning

Through interviews and surveys, experts assessed the reported and implicit goals of the planning exercises in the Gulf of California, and the extent to which these had been achieved (Figure 6). An explicit goal cited by all experts was identifying generic priority areas for conservation, while identifying the particular conservation actions required within these areas was generally considered to be implicit. Other explicit goals indicated by most experts were to document and assess biodiversity and threats and/or conflicts with human activities, as well as to guide conservation and resource use planning. The majority of experts agreed that, overall, reported goals had been achieved satisfactorily. Some experts disagreed with this perception, mostly because the application of planning outputs had progressed very slowly beyond local ongoing initiatives that lacked the perspective potentially provided by the planning exercises. Opinions regarding implicit goals were more varied. The use of existing priority maps by later plans was commonly perceived as a positive outcome from planning, but never reported or mentioned as an implicit goal.

Despite differences in opinions, experts commonly indicated that plans had guided or in some way influenced the implementation of spatial actions

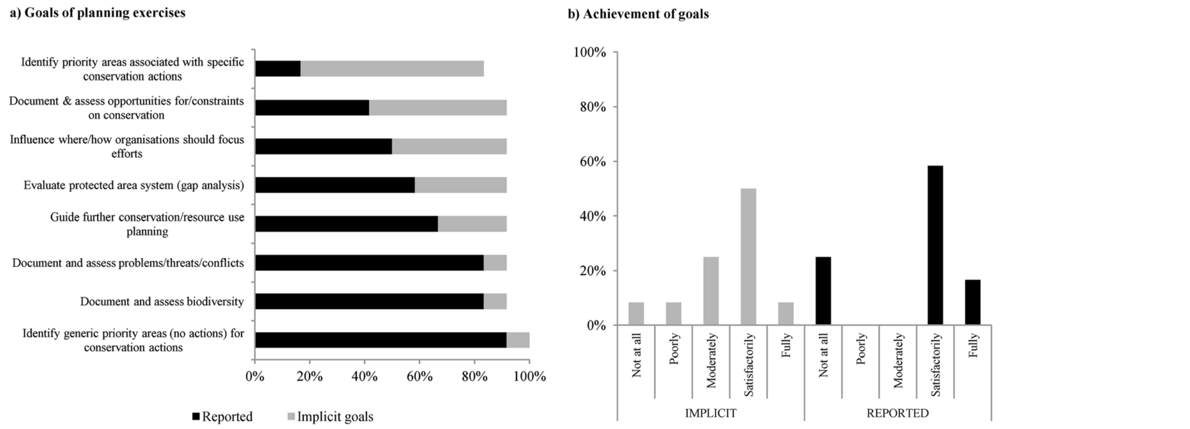

Figure 6. Expert opinion on reported and implicit planning goals. (a) Percentages of experts (N = 13) that identified the described planning goals as being explicitly reported (black portion of the bar) or implicitly considered (grey portion) by planners when developing the planning exercises; only the last goal was common to all planning exercises (either implicitly or explicitly). (b) Percentages of experts that considered the overall achievement of goals within each level of achievement, from 'Not at all' (experts strongly disagreed that goals were achieved) to 'Fully' (experts completely agreed that overall goals were met).

within priority areas (Figure 7). According to more than half of the experts interviewed, a common outcome of plans was the implementation of multiple-use protected areas (e.g. Bahia de los Angeles, Espiritu Santo National Park, San Lorenzo Archipelago National Park, San Pedro Martir Biosphere Reserve). Two actions, although only cited a few times, were the creation of no-take zones (e.g. Guaymas Hydrothermal Vents) and the promotion of socio-ecological monitoring or research projects within priority areas (e.g. PANGAS: http://pangas.arizona.edu/es/inicio). To a lesser extent, experts also considered that plans had contributed to informing coastal-marine informing and zoning plans, mainly by providing information to agencies and industry regarding the location of areas of conservation value.

According to experts, factors that facilitated spatial implementation included: bringing priority areas to the attention of agencies, organizations, and general public; having a regional or national spatial framework that provided sound scientific support for ongoing marine conservation efforts and supported decisions by agencies regarding the creation or zoning of MPAs; and participation of multiple stakeholders in planning, in particular those directly influencing conservation decisions in the region. On the other hand, some factors were perceived as major constraints on the implementation of plans or causes of the slow uptake of plans in general, including: conflicting mandates or priorities between conservation and natural resource management agencies and organizations; limited technical capacities and public conservation resources (particularly at the municipal and State levels); insufficient political determination (e.g. from State governments) to implement MPAs; the need to further refine the design of conservation areas (e.g. incorporate socioeconomic constraints, biological connectivity, zones) and schedule their implementation; and the fact that plans have not been incorporated by relevant agencies into their strategic plans and annual work programmes, particularly agencies not directly related to conservation, e.g. tourism, water management, infrastructure, and development.

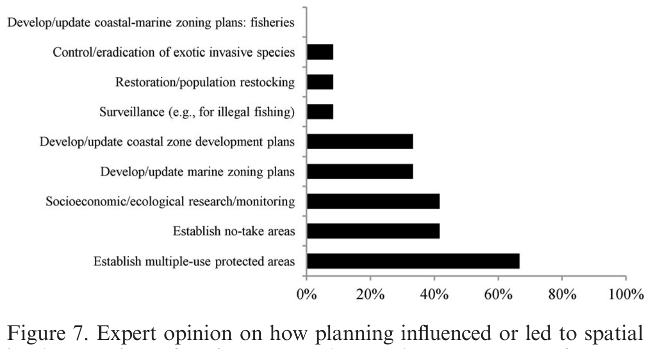

Figure 7. Expert opinion on how planning influenced or led to spatial implementation of actions. Bars denote the percentages of experts (N = 13) that considered the described actions as being implemented as a result of planning, either directly or indirectly.

In addition to spatial actions, experts considered that planning brought other benefits within the region (Figure 8). Despite differences in opinions, enhancing institutional and knowledge/skills was commonly perceived as a benefit of planning. Institutional benefits included: standardizing or having more rigorous planning processes, facilitating the development/implementation of regional or local conservation strategies, and influencing conservation strategies and actions by

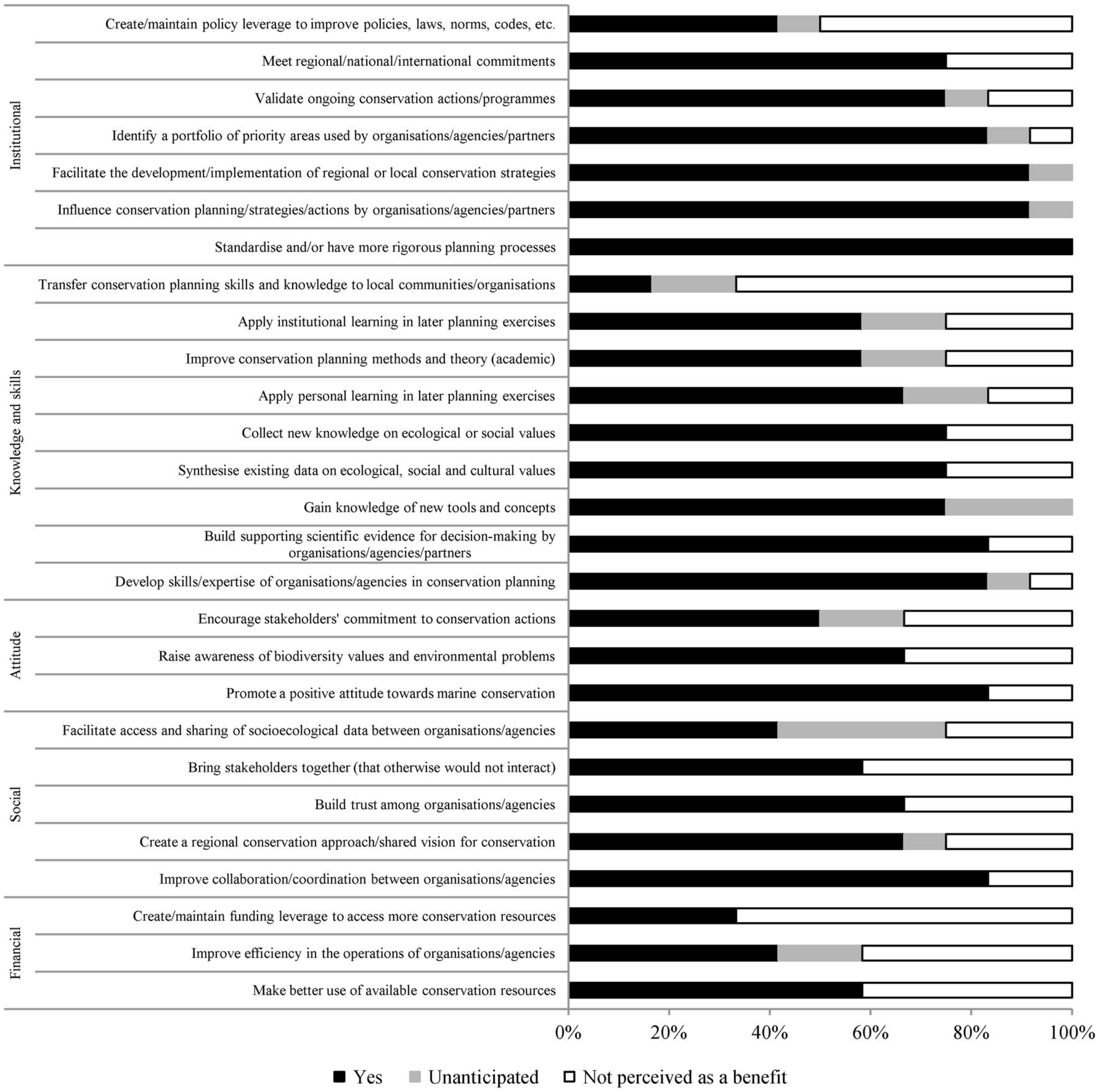

Figure 8. Expert opinion on the benefits of planning apart from spatial implementation of actions. The black portion of each bar represents the percentages of experts (N = 13) that considered the described benefits were a result of planning; the grey portion depicts the percentages that indicated that those benefits were unexpected; white represents the percentages of experts not citing those benefits as outcomes of planning.

organizations/agencies/partners, guided by the priority maps. Other important benefits identified were developing skills/expertise of organizations in conservation planning and building the supporting scientific evidence for decision-making by participating organizations, agencies or partners. Among the social benefits, improving collaboration and coordination between organizations, creating a regional conservation approach for conservation, and building trust among organizations were apparent common outcomes. In comparison, direct financial benefits (e.g. making better use of available conservation resources, improving efficiency in the operations of organizations) were less commonly noted.

DISCUSSION

The state of marine conservation planning in the Gulf of California

Despite the growing number of studies and marine applications of systematic conservation planning methods and tools, uptake has been relatively limited in the Gulf of California. Only two planning exercises (Sala *et al*., 2002; Ulloa *et al*., 2006) used conservation planning software to find least-cost solutions that achieved conservation objectives, even though these tools have been readily available for more than 10 years (Ball *et al*., 2009), with applications to marine planning dating back to 1999 (Leslie, 2005). Emerging issues, including targeting of ecosystem services and consideration of land–sea connections, have also received limited attention in the Gulf. Notably, none of the planning exercises dealt with climate change or scheduling of conservation actions.

Conservation plans in the Gulf of California followed some best-practices regarding stakeholder involvement but fell short for others. Stakeholder input was decisive in five stages of planning: identifying broad goals; setting objectives; defining selection criteria for priority areas; supplying, validating, and generating spatial data to represent conservation features; and identifying priority areas (see Pomeroy and Douvere (2008) for a review on stakeholder participation in marine planning). Expert workshops facilitated stakeholder involvement in decision-making processes in the Gulf of California and contributed to filling gaps concerning ecological and socioeconomic data (Wheeler *et al*., 2008). In addition, highly participatory processes (e.g. SPM and CSGC) also contributed to building common visions of conservation problems and opportunities. In expert-driven processes, tools other than conservation planning software helped to visualize spatial data (Enríquez-Andrade *et al*., 2005; CONABIO, 2007), facilitate group decision-making (Arriaga-Cabrera *et al*., 1998), and delineate priority areas (Morgan *et al*., 2005). A notable gap in most exercises was the limited input from natural resource users and industry, which was mostly restricted to providing information on highly used areas. Including all stakeholders, but particularly resource users, from the outset of planning helps to build ownership and support (Lundquist and Granek, 2005; Gilliland and Laffoley, 2008), and has been pivotal in successful regional-scale exercises in marine planning (Fernandes *et al*., 2005; Gleason *et al*., 2010).

Only two planning exercises set quantitative objectives (Sala *et al*., 2002; Ulloa *et al*., 2006), which contributed to more explicit, transparent, and justifiable decision-making processes (Margules and Pressey, 2000). While qualitative objectives (e.g. maximize species richness) were common to all exercises, only Sala *et al*. (2002) quantified and targeted species richness (for fish species). Both exercises that used quantitative objectives also partitioned these objectives between occurrences of the same features in different bioregions. Incorporating bioregional representativeness as a conservation objective is critical to ensuring that MPA networks capture the variety of biological assemblages, including species that are poorly recorded or undescribed (Roberts *et al*., 2003a). Bioregional representation has been fundamental to other marine planning initiatives, e.g. the California Channel Islands Marine Reserves (Airame *et al*., 2003) and the Great Barrier Reef Marine Park rezoning (Fernandes *et al*., 2005).

Incorporating spatially explicit socioeconomic data (e.g. human activities, opportunity costs associated with use restrictions, and costs of managing MPAs) in marine planning is critical to minimizing the costs of interventions (Klein *et al*., 2008; Ban and Klein, 2009). Exercises from the Gulf of California illustrate contrasting approaches to incorporating threats and costs in planning. The two exercises that used conservation planning software explicitly avoided threatened areas and minimized conflict with fisheries (Sala *et al*., 2002; Ulloa *et al*., 2006). In both cases, field data on fishing effort informed the cost layers. Despite potential limitations and coarse spatial resolution of these data, they are likely to be more accurate than surrogates for socioeconomic variables (Weeks *et al*., 2010b). In contrast, the B2B exercise (Morgan *et al*., 2005) focused on areas where conservation features of interest and threats intersected (i.e. prioritized vulnerable areas), an approach that aims to reduce further loss of conservation features. Although these approaches might seem opposite, they are likely to converge. Application of actions following selection of areas such as those by Sala *et al.* (2002) and Ulloa *et al.* (2006) would require scheduling, in which areas of both high irreplaceability and high threat would need to be prioritized (Pressey and Bottrill, 2008). Surprisingly, most exercises identified priority areas independently of their vulnerability or level of use, either assessing threats independently (Enríquez-Andrade *et al*., 2005) or designing strategies to address threats after priorities were set (Arriaga-Cabrera *et al*., 1998; Enríquez-Andrade and Danemann, 1998; CONABIO, 2007).

An interesting finding of the CSGC exercise (Enríquez-Andrade *et al*., 2005) was that priority areas tended to be heavily used or highly threatened, indicating that conservation management in some used and threatened areas might be inevitable. This emphasizes the need for better data on threats and costs and an understanding of management actions that are feasible and effective in contested parts of the Gulf. Conflict over conservation and extractive uses can be reduced, but not altogether avoided, by explicitly incorporating costs and threats in the prioritization process. Combining multiple costs (e.g. to different stakeholder groups) is challenging for marine planners (Ban and Klein, 2009), but should be considered in the Gulf of California.

Despite spatial data limitations, ecological processes (e.g. migrations and oceanographic phenomena associated with high productivity) were considered by most planning exercises. Readily-available biological and oceanographic data (e.g. satellite-derived data on spatial variability of high-productivity areas) (Hidalgo-González and Alvarez-Borrego, 2011), combined with existing oceanographic-ecological models (Marinone *et al.*, 2008; Cudney-Bueno *et al.*, 2009), can help to improve planning for processes in the Gulf of California and elsewhere. Recent spatial planning that could be adapted to the Gulf has incorporated extensive pelagic and oceanographic phenomena (Grantham *et al.*, 2011) and considered the effects of climate change (Hobday, 2011). These approaches will help to ensure local functionality of priority areas as well as contributing to regional-scale conservation objectives (Roberts *et al.*, 2003b), including those related to fisheries.

Notwithstanding the global importance and degradation of the services provided by coastal marine ecosystems (Worm *et al.*, 2006; Barbier *et al.*, 2010), particularly in the Gulf of California (Aburto-Oropeza *et al.*, 2008; Ezcurra *et al.*, 2009), these were not considered explicitly by any of the planning exercises. This gap might have been partially addressed, however, by targeting conservation features based on their potential economic value, including: areas of high productivity and plankton abundance for fisheries (Arriaga-Cabrera *et al.*, 1998; CONABIO, 2007); coastal ecosystems (e.g. coral reefs and kelp forest) that provide protection to sandy beaches against wave action; estuaries and marshes as exporters of nutrients/energy and buffers against land-based threats (Enríquez-Andrade and Danemann, 1998; Morgan *et al.*, 2005); and mangroves as nurseries for commercial fish and invertebrates (Sala *et al.*, 2002; Enríquez-Andrade *et al.*, 2005). The omission of ecosystem services is common in marine spatial planning (Leslie, 2005; Granek *et al.*, 2010), although there have been recent advances in their valuation and mapping (Tallis and Polasky, 2009; Silvestri and Kershaw, 2010). Further research is needed for marine applications (Chan and Ruckelshaus, 2010).

The importance of land–sea interactions was recognized by most planning exercises, both in terms of cross-system threats and ecological connections. However, spatial data on, or models of, land-based threats were very limited and only used in a couple of plans. Prioritization of catchments to mitigate land-based threats was not considered by any plan. Considering land-based threats can alter marine priority areas (e.g. by locating them away from imminent land-based sources of pollution when possible) (Tallis *et al.*, 2008), but can also help to integrate terrestrial and marine planning and facilitate marine management (Klein *et al.*, 2010). Only one exercise (Enríquez-Andrade *et al.*, 2005) explicitly targeted freshwater and terrestrial areas important to maintaining ecological processes connecting land and sea. Adjustments of priority maps can also be required to plan for land–sea processes, e.g. species migrations between disjunct terrestrial and marine habitats (Hazlitt *et al.*, 2010) or input of marine-derived nutrients into coastal and insular ecosystems (Lombard *et al.*, 2007). The lack of consideration of land–sea connections in the National Protected Area System of Mexico was emphasized by Ortiz-Lozano *et al.* (2009), and highlights the need to improve data and models on spatial and temporal occurrence of land–sea processes and cross-system threats for marine planning (Alvarez-Romero *et al.*, 2011).

Convergence and divergence between plans

Based on a spatial overlay of priority maps, Aburto-Oropeza and Lopez-Sagastegui (2006) noted important spatial coincidences between the outputs of different marine planning exercises in the Gulf. These similarities have led to a general perception among conservation practitioners in the region that planning exercises identified the same priority areas. The present analysis shows that, despite areas of convergence, there are important differences, some of which can be related to the planning approach, methods and extent. The small overlap between all exercises raises the question of whether the convergence of multiple independent plans is in fact pointing to areas that hold valuable biodiversity features and processes that have been recognized widely by planners. In some cases, areas commonly identified as marine priorities seem to be located in better studied areas (e.g. Upper Gulf, Midriff Islands, Loreto, La Paz Bay), a common outcome in marine planning in general

(Ardron *et al*., 2008) and a plausible explanation of why these areas also overlap with existing MPAs (Weeks *et al*., 2010a), some of which were established before prioritization exercises.

The similarities and differences in plans might be explained by commonalities between them, including similar data, similar approaches (e.g. expert-based vs. data driven, prioritization of threatened areas with biodiversity value, focus on nearshore environments), the use of priority maps from previous exercises, and the resolution of data and targeted conservation features. Contrary to expectations, clustering based on spatial similarity did not show clear differences between priority maps developed at different spatial scales. An important result from the Kappa location analysis was the greater similarity values among all exercises compared with the overall Kappa. This indicates that the relative proportions/size of priority areas (which can be related to the extent of planning domain) can be an important driver of overall spatial similarity between overlapping priority maps.

Interestingly, grouping based on spatial similarity did not closely match that based on planning objectives and datasets. Divergence between the methodological and spatial similarity phenograms suggests that other factors, in addition to data and objectives, played an important role in defining the distribution of conservation priorities. These could include inaccuracy in manual delineation of priority areas from expert-based exercises, incorporation of updated datasets, and random error. Unfortunately, the limited and fragmented spatial data available from these studies did not allow further investigation of these differences.

Size and perimeter have important design implications, both biologically and practically (Roberts *et al*., 2001; Leslie *et al*., 2003). Remarkably, priority areas proposed by the only exercise that explicitly included minimum size as a design criterion (Sala *et al*., 2002) were significantly smaller than those from other exercises (Figure 2(a)). In part, this is explained by the reduced number of planning units, but also reflects differences in objectives and how these can influence priority area design.

Convergence of priorities was observed in well studied shallow and benthic marine ecosystems (e.g. coral reefs, seagrass, *Sargassum* beds). Coastal ecosystems were also represented in established MPAs, some of which were established at least partially in response to the exercises reviewed here. The recent addition of an MPA in the Gulf of California to protect the benthic communities (hydrothermal vents) in the Guaymas Basin – an area identified as a marine priority by only one exercise – is an exception to the general trend. The under-representation of deep-ocean and pelagic environments in the Gulf of California, in comparison with nearshore/shallow ecosystems, reflects the relatively limited data for deep-ocean and pelagic environments in general (Glover and Smith, 2003; Webb *et al*., 2010) and the emphasis on the protection of near-shore ecosystems (Wood *et al*., 2008; Spalding *et al*., 2010). Among the solutions, vertical zoning (i.e. implementing different use restrictions along the water column) provides a way of designing priority areas suitable for protecting pelagic and/or benthic environments as required (Grober-Dunsmore *et al*., 2008). New technologies are allowing the exploration of deeper environments in the Gulf of California (Aburto-Oropeza *et al*., 2010a) and the data from these studies should be used to update marine planning exercises.

Uptake of planning: implementation of spatial actions and other benefits

Assessing the implementation of plans was not an objective of this study. However, based on the information provided by experts, the implementation of new MPAs in the region has been influenced by some of these planning exercises. It seems that monitoring and research activities have resulted from the long history of prioritizing conservation areas in the region. However, as the experts noted, enforcement and many other problems (Rife *et al*., 2012) indicate that MPAs are not necessarily fulfilling the objectives stated in their decrees.

An element regarded by some experts as a constraint on the implementation of spatial actions was the lack of regard for ongoing refinement of priority area designs to maximize the likelihood of implementation. Such refinements include defining simple and readily recognizable boundaries to maximize compliance and facilitate enforcement. These refinements have been applied in other regions to maximize implementation feasibility, thus leading to the successful application of planning outputs (Fernandes *et al*., 2005, 2009; Lombard *et al*., 2007). These exercises also illustrate the need to work with stakeholders once preliminary priority maps are proposed. The execution of specific actions such as surveillance, species recovery, and invasive species eradication/control programmes within priority areas were seldom mentioned by experts as being implemented following planning. This suggests that the failure to identify specific actions within priority areas (to address problems associated with particular areas) may also be limiting the direct application of conservation plans because further work to identify adequate interventions is needed. Interestingly, none of the interviewees mentioned actions related to fisheries management, which could in part reflect the limited participation of the fisheries sector in planning and the general disconnect between this sector with the national and regional conservation agenda.

The implementation of MPAs in the Gulf of California, as everywhere in Mexico (Bezaury-Creel, 2005), has been mostly opportunistic, thus limiting the uptake of marine planning outputs. Reasons underlying this approach include incomplete and biased socioecological data, accelerated degradation of certain areas (and reactive local efforts to protect them), and concurrence of suitable socioeconomic and political conditions. These elements can, however, be considered and incorporated into SCP initiatives by following an adaptive approach. Adaptive conservation planning is critical to make the best use available socioecological data, deal with ongoing loss of biodiversity, and take advantage of emerging conservation opportunities (Grantham *et al.*, 2010). Some key requirements to adaptive planning are: setting explicit and preferably quantitative conservation objectives (critical to the transparency, traceability and revision of planning decisions); developing spatial data infrastructures (needed to organize and share data to revise the plans or to inform other plans, as well as to continuously and systematically update socioecological data derived from monitoring and research); and assessing the effectiveness or response of socioecological systems to conservation interventions (essential to adjust objectives, priority area design, and implementation strategies). Unfortunately, few long-term monitoring programmes (a pre-requisite to adaptive management) exist in the region today, and there are no explicit intentions to update the plans, even when information from these programmes is available. The lack of these two strategies is a major limitation of marine planning in the Gulf of California. Conservation planning initiatives in South Africa exemplify how national and regional-scale plans are being documented, updated and implemented under a national multi-scale planning framework (e.g. South African National Biodiversity GIS: http://cpu.uwc.ac.za/). Additional elements that have constrained or facilitated implementation include institutional continuity, funding availability, and political trends, so these need to be considered by planners.

CONCLUSIONS

The Gulf of California has seen seven marine planning exercises in the past decade. Yet uptake of marine applications of systematic conservation planning methods and tools has been relatively limited, and the existence of multiple plans within the region pointed to some difficulties as well as benefits. On one hand, multiple plans have contributed to uncertainty, confusion and tension between stakeholders. Multiple plans may have also contributed to the spreading and inefficient use of financial and human resources, as well as to unnecessary redundancy in actions. Despite good intentions, the coexistence of multiple plans (particularly when these are developed without considering pre-existing plans) can hamper the goal to create a common approach and focus for conservation, thus resulting in uncoordinated actions undertaken by the different stakeholders. On the other hand, the existence of multiple planning processes and plans seems to have contributed to improved methods, data and tools, as well as being the basis for more robust and refined plans developed later.

Given that the National Marine Gap Analysis (CONABIO, 2007) considered the outputs of previous plans (incorporating some priority areas delineated in previous exercises) and engaged with stakeholders who participated in previous exercises, this plan has now been widely accepted and is considered (at least by environmental organizations and agencies) the national framework for marine conservation in Mexico, including the Gulf of California. Thus, the logical next step is to build on this plan and refine priority areas (which provide the required regional context) into conservation areas associated with specific actions (e.g. through zoning) appropriate to address current threats, maintaining connectivity incorporating local socioeconomic data, and ensuring participation of local stakeholders. This refinement should include integration with terrestrial and freshwater priorities, in particular for areas where important land–sea connections have been identified (Enríquez-Andrade *et al*., 2005) or where land-based threats are a concern. A stronger commitment of agencies from different sectors (environment, fishing, tourism, water management, infrastructure and development) is also needed to incorporate planning results into the relevant policies, regulations and annual programs, as well as to continue participating in the refinement of plans. Increased coordination between organizations (from local to international) will be fundamental to implement a functional network of MPAs that contributes to achieving conservation goals and the sustainable use of natural resources in the Gulf of California.

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