



Testing a recipe for effective recovery plan design: a marine turtle case study

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ABSTRACT: Managing impacts to threatened species is challenging, because it is intrinsically linked to resources, knowledge, capacity and public and government will. A key tool often used in species conservation is a recovery or management plan. Yet all too often, plans are not designed for evaluation and not tested against quantitative criteria. Our study takes a novel approach to recovery plan assessment by assembling a worldwide database of recovery plans for a single taxon. We obtained 79 recovery or management plans for marine turtles and then designed criteria to assess and compare them for their ability to be evaluated and thus successfully implemented. We then used expert opinion of marine turtle specialists to weigh our 18 criteria. Overall, we found that the failure to adequately integrate adaptive management into plan design was a major shortcoming of marine turtle recovery planning (>90% of plans). Other common gaps included inadequacy of measurable objectives (75% of plans) and an absence of timelines (50% of plans). We highlight knowledge gaps relating to status trends, critical habitat and a lack of incorporation of social aspects such as stewardship and education. Our research underlines the importance of recovery planning from multiple scales and provides a step towards designing recovery plans that include SMART (specific, measurable, achievable, realistic and time-bound) objectives; scientific information; social aspects; and evaluation. We highlight the importance of national and multi-national planning processes to produce internationally relevant plans that will maximise conservation efforts for a globally threatened marine species.

KEY WORDS: Marine turtles · Recovery planning · Threatened species · SMART

INTRODUCTION

It is now well established that biodiversity in both marine and terrestrial ecosystems is declining and that financial resources and knowledge influence mitigation of future losses (Jackson et al. 2001, Butchart et al. 2010, Hooper et al. 2012). Consequently, there is a growing body of work advocating for systematic conservation planning (e.g. Leslie 2005, Sarkar et al. 2006). Reports such as recovery, management or action plans have become key documents providing the frameworks for structured decision making and thus a guide for future conservation and management efforts (Boersma et al. 2001). At a smaller scale, species-specific recovery plans have become an integral tool

available to managers, decision makers and funding bodies to guide conservation of threatened species (Ortega-Argueta et al. 2011). In addition, species-based recovery plans are often required by national governments under environmental legislation and are sometimes required by international treaties.

Species-based management plans can be powerful conservation tools because they can provide a structured, prioritised and organised framework to ensure consistency in decisions, assignment of responsibilities and avoidance of uncertainty, whilst also acting to influence political and public pressure (Hoekstra et al. 2002). Yet recovery planning is often criticised because biodiversity losses remain despite decades of protection and planning. Key issues of concern are

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that management plans are not often designed concurrently with a funding model, which makes implementation difficult, and that future evaluation is often not considered; thus, plans are seldom tested for effectiveness (Pullin & Knight 2001, Bottrill et al. 2011). These flaws undermine conservation practice, making it difficult to argue for continued conservation action in the face of economic development or social change (Pullin & Knight 2001).

Effectiveness of management planning is closely linked to plan quality as well as plan implementation and evaluation (Clark et al. 2002). Plan implementation is often challenging (Knight et al. 2006). It is critical for managers to ensure a well-researched and relevant plan from the outset so it can provide a sound base for on-the-ground implementation. Consensus is that a correctly conceived and designed recovery plan should state clear specific, measurable, achievable, realistic and time-bound (SMART) objectives that are linked both to the environmental well-being of the species in question and to the socioeconomic well-being of the stakeholders that depend on it (Adams et al. 2004, Knight et al. 2006, Kaimowitz & Sheil 2007, Foley et al. 2010, Wood 2011). In addition, high-quality recovery plans should be based on published scientific knowledge (Pullin & Knight 2001) supplemented with local and/or expert knowledge and be compatible with local culture (Regan et al. 2004). Ideally, plans would incorporate all known information on habitat needs critical to the species, an estimation of population size/status (Eckert 1999) and information on mortality and indirect threats to the species or population in the relevant geographical area (Lawler et al. 2002, Hooker & Gerber 2004). This is particularly challenging for wide-ranging species or species for which there are substantial knowledge gaps.

A systematic review of recovery plans can provide a good foundation for the improvement of future planning because it will inform managers about what strategies work under different circumstances (Foin et al. 1998, Boersma et al. 2001, Clark et al. 2002, Hoekstra et al. 2002). A review also allows for comparison of successes across plans and of strategies and methods used across regions and/or nations. Although comparative analyses have been done across taxa at a national level in both the United States (Boersma et al. 2001, Clark et al. 2002) and Australia (Bottrill et al. 2011, Ortega-Argueta et al. 2011), there have not been any reviews conducted for a single taxon of organisms on a global basis. Marine turtles are ideal candidates for review due to their migratory nature, worldwide distribution and threatened species status and because of the abundance of plans

dedicated to them at varying spatial and temporal scales. Marine turtle management plans are common, but it is unclear how effective these plans have been, specifically with respect to which plans, or aspects of plans, have worked or are working. To effectively protect/conservate marine turtles, it is crucial that future marine turtle management is informed by the successes and failures of past initiatives. This should help to prevent repeated mistakes and could aid in the adoption of effective management practices (Mortimer 2000).

Therefore, the objectives of our study were to (1) determine the extent and distribution of marine turtle recovery planning, (2) draw conclusions about the quality of current management plan design for marine turtles and identify strengths and shortcomings (as they appear in the plans), (3) examine the relationships between plan quality and national development and (4) use the experience of experts to create a weighted matrix to guide future management plan design.

METHODS

Compiling the database

An online search was performed to find all publicly available recovery or action plans pertaining to marine turtles. This search was conducted in 5 languages (English, French, Spanish, Portuguese, Italian). We also conducted an additional online search to obtain names and details for potential contacts that may have had knowledge of, and access to, further management plans, thereby creating a comprehensive dataset of plans. Emails were sent out to these contacts requesting copies of any action plans existing within their region. Non-English plans were translated into English using native speakers.

Each plan was examined for the following content attributes: date of plan/last revision, scale of plan (local/state/many states, national/territory, regional [collaboration between ≤ 3 nations], or international [collaboration between > 3 nations]), geographical location, whether the plan pertained to 1 or multiple species, whether the nation(s) involved were party to relevant international treaties (CITES and Convention on the Conservation of Migratory Species of Wild Animals), Human Development Index (HDI) of the corresponding nation and whether the plan was supported by management at other spatial scales. We used the HDI as a basic, general proxy for a nation's social and economic development.

Evaluating existing plans according to criteria

Prior to evaluation, a system of standards was developed for each of 18 criteria falling within 5 broad categories: (1) objectives, (2) scientific information, (3) social aspects, (4) evaluation and (5) legislation and implementation (Table 1). We selected the 18 criteria using existing literature on sea turtle manage-

ment, including research manuals and national legislation for recovery planning. Our selected criteria were intentionally broad to allow application across multiple scales of planning and to different types of recovery plans (endangered population, risk abatement, etc.).

We scored each of the 18 criteria using 3 coded responses (nominal variables): a score of 0 was allo-

Table 1. List of the 18 criteria evaluated for each marine turtle recovery plan, rationale for including each criterion and relevant source(s)

Criterion	Rationale	Source
(1) Objectives		
Plan objectives should be specific	Objectives should be well defined and should help to direct behaviour towards a reduced number of outcomes	van Herten & Gunning-Schepers (2000)
Plan objectives should be measurable	Objectives and targets should be quantitative in some way, and data must be available to monitor progress towards the target	Balmford (2003), Wood (2011)
Plan objectives should be achievable	Objectives should be action oriented, and those implementing the actions should have the necessary skills, experience and knowledge	Wood (2011)
Plan objectives should be realistic	Level of change required to meet objectives should be ambitious but not so high as to cause frustration and inaction	Wood (2011)
Plan objectives should be linked to timeframes	Objectives should have explicitly stated timelines	Wood (2011)
(2) Evaluation		
Monitoring actions present and linked to outcomes	Without adequate monitoring, one cannot judge success or learn from failure; for long-lived, late-maturing organisms, well-designed, statistically robust monitoring consistently implemented for a long timeframe is essential to determine status trends; we acknowledge that monitoring can vary in its frequency (annual, biennial or other)	Eckert (1999), Campbell et al. (2002), Clark et al. (2002)
Capacity for and acknowledgement of adaptive management	Cyclic, learning-by-doing approach is more effective than a linear approach; it is necessary to review and change procedures and objectives periodically	Foin et al. (1998), Hocking et al. (2000), Jones (2000), Margules & Pressey (2000), Boersma et al. (2001)
(3) Social aspects		
Objectives are linked to the social and economic well-being of stakeholders	Socioeconomic needs and well-being of local human populations that interact with sea turtle populations should be integrated into planning objectives	Eckert (1999), Adams et al. (2004)
Stakeholder participation at all levels of planning	Collaboration among stakeholders is recognised as an important component of effective conservation practice and can minimise and resolve conflicts	Sayer & Campbell (2004), Knight et al. (2006), Reed (2008)
Integration of local knowledge	Local people often have integral knowledge about sea turtle population trends, habitat and behaviours	Sayer & Campbell (2004), Reed (2008)
Education and stewardship	Making the average citizen concerned about the species at hand is crucial	Eckert (1999)
Incentives	Incentive-driven conservation can facilitate longer-term protection of species, and the use of appropriate incentives can increase community support for conservation efforts	Abensberg-Traun (2009)

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Table 1 (continued)

Criterion	Rationale	Source
(4) Scientific information		
Major sources of sea turtle mortality in geographical area are identified and discussed	Direct and indirect threats should be a primary focus of plans and should drive appropriate management actions and monitoring; recovery of endangered populations depends on the identification and mitigation or removal of threats; lack of understanding of the nature and extent of threats and/or a lack of actions to address these may undermine recovery efforts	Eckert (1999), Clark et al. (2002), Lawler et al. (2002), Hooker & Gerber (2004)
Indirect threats and pressures in geographical area identified and discussed	Same as above	Eckert (1999), Clark et al. (2002), Lawler et al. (2002), Hooker & Gerber (2004)
Population size and status trends are identified	Accurate estimation of population size is a key variable in informing management decisions; this should include status trends of a population whether it is stable, decreasing or increasing	Eckert (1999)
Critical nesting habitat is identified	Assessment of distribution and status of critical nesting habitat and protection of this habitat from existing and anticipated threats is fundamental; we acknowledge that the critical foraging habitats for most species are often unknown and are key knowledge gaps	Eckert (1999)
(5) Legislation and implementation		
Protective national legislation	Protective legislation for species at hand can strengthen recovery planning	
Resources for implementation identified with plan development	Conservation of species entails costs and therefore requires indications of established resource commitment	Naidoo et al. (2006)

cated if the plan did not contain any information about the criteria, a score of 1 was allocated if the plan contained partial or incomplete information and a score of 2 was allocated if the plan contained thorough information relating to the criteria in question (Table 2). We then compiled scores for each criterion (absent/incomplete/complete) and examined relative score frequency to identify trends, strengths and weaknesses for marine turtle recovery planning.

To obtain a score of complete on the stewardship criterion, a plan had to integrate procedures for initiation or continuation of education and awareness raising of stakeholders into the plan and tie this in with the importance of stewardship. The mention of education (of fishermen, local people, children, labourers, employees) within a plan was sufficient to achieve a score of incomplete/partially addressed on the criterion. A score of complete was only allocated for the integration of external knowledge criterion if the plan contained clear discussion of how knowledge was integrated and/or multiple clear references of how this was done in the plan at hand. External knowledge could be obtained from local communities, indigenous

groups, fishers, researchers, etc., and could include knowledge on distribution, threats, challenges and culture.

We included legal protection by agencies/state and whether resources such as commitment to fund aspects of the plan or commitment to allocate staff towards projects are available for implementation as criteria. Although they are not generally components of recovery planning, they are factors that likely affect plan success.

Marine turtle expert survey and weighted matrix for marine turtle recovery plan design

To obtain an overall score for each plan, it was essential to provide a relative weight to each of the criteria depending on their perceived importance. A voluntary survey was sent via email to 50 marine turtle experts (they were approached based on their turtle conservation-related publication records and/or known experience working in marine turtle management for government agencies, industry or non-

Table 2. Criteria used to assess the design of each of 79 marine turtle recovery plans, with point scheme for each criterion (0 = absent, 1 = incomplete, 2 = complete)

Category	Score of 0	Score of 1	Score 2
Link between objectives and socio-economic well-being of stakeholders	No reference to or discussion of implications of plan costs and benefits for stakeholders	Some (vague or ambiguous) reference to costs and benefits for stakeholders; links unclear or poorly defined	Clear descriptions of potential costs and benefits for stakeholders; clear connections made between these and plan components
Objectives are specific	Goals not presented or are overly vague or ambiguous	Some specific goals are included; some goals are vague or ambiguous	All (or large majority of) goals are presented in sufficient detail
Objectives are measurable	Goals are not quantitative in nature; no performance indicators are used (or no goals presented)	Some goals are quantitative and measurable; others lack this quality	All (or large majority of) goals are clearly measurable, and/or quantitative performance indicators are used
Objectives include or are paired with steps for achieving them	No presentation of steps towards achieving plan goals; no steps, strategies or actions presented (or no goals presented)	Steps, strategies and actions are presented for some goals and not others and/or steps and strategies are presented but are vague or incomplete	Steps towards achievement of all (or large majority of) goals or actions/strategies for achievement of all goals presented
Objectives fit with available resources	Goals are not realistic, i.e. no mention of finances, resources or manpower available or are inappropriate to scale of project (or no goals presented)	Some goals are realistic, finances and resources are mentioned in conjunction with some goals or some mention of finances and resources overall but ambiguous/unclear	All (or large majority of) goals are realistic (finances, resources, manpower available) and described within plan
Objectives are time-bound	No timelines and/or frequencies presented for goals (or no goals presented)	Some timelines presented for goals	Timelines and frequencies presented for all (or large majority of) goals
Monitoring actions present and linked to outcomes	No mention of ongoing and/or long-term monitoring	Monitoring protocol presented but not linked to desired outcomes	Ongoing monitoring protocol presented and clearly linked to conservation outcomes
Adaptive management	No mention of adaptive management and no real capacity for the plan to adapt in response to new knowledge	No mention of adaptive management but capacity of plan to adapt in response to new knowledge	Acknowledgement of importance of adaptive management and clear integration of adaptive techniques into plan
Stakeholder participation at all levels	No mention of various stakeholder groups or importance of their participation	Enumeration of stakeholder groups at some levels or no clear breakdown of objectives or tasks between stakeholders	Clear mention of importance of stakeholder consultation at all levels, breakdown of which stakeholders are involved for different tasks
Integration of local and scientific knowledge	No mention of importance of local (indigenous if relevant) knowledge in the design or implementation of the plan	Mention of local knowledge indirectly or at one point in plan, without discussing its importance	Direct mention and discussion of the importance of integrating local and scientific knowledge and how it has been done in the plan at hand or multiple clear references of integration of local knowledge into the plan
Stewardship	No mention of stewardship or its importance and no evidence of integration into plan	Evidence of education in planning without direct mention of stewardship or vague discussion without clear integration into plan	Procedures for education of stakeholders detailed and importance of stewardship discussed and integrated into plan
Incentives	No mention of incentives to local population for conserving species	Mention of incentive(s) but no clarification or elaboration on their use	Clear discussion of incentives to local populations, how they are to be used/dispersed and who should receive them

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Table 2 (continued)

Category	Score of 0	Score of 1	Score 2
Major sources of mortality identified in geographical area	No mention of direct sources of mortality	Mention of sources of mortality but no discussion/comprehensive description	In-depth discussion and description of direct sources of mortality in the area
Major threats and pressures identified in geographical area of plan	No mention of indirect threats and pressures	Mention of indirect threats and pressures but no discussion or comprehensive description	In-depth discussion and description of indirect threats and pressures to marine turtles in area at hand
Population size and trends	No identification of estimated numbers or population trends for region in question	Identification of either estimated numbers or trends in abundance for each species in question in the region or information lacking altogether for some species but present for others	Identification (for each species in question) of estimated numbers and trends in the region
Critical habitat	No identification of any essential habitat	Knowledge of critical nesting habitat presented but lack of information on essential foraging, breeding or internesting habitat or lack of clear objectives outlining how these will be identified as a top priority	Clear identification of essential nesting habitat and some mention and discussion (presentation of past studies) of foraging, breeding and/or internesting habitat or clear objectives delineating how this will be identified as a top priority
Resources for implementation are secured with development	No mention of resources for implementation	Details of agencies/departments which should be approached to enable funding for implementation and clear intent to follow through	Resources for implementation secured either in part or in full
Existing legislation	No legal protection of species in question in region	Some legal protection of species in question without full protection (seasonal closures, maximum/minimum take limits, ban on eggs but hunt still allowed), indigenous hunt permitted, etc.	Full legal protection afforded to species in question

government organisations). Respondents were asked to rate the importance of each of the criteria described in Table 1 using a scale from 1 to 5, with 1 being the least important in recovery plan design and 5 being the most important in recovery plan design.

A median importance score (1 to 5) was then calculated for each criterion based on techniques commonly used to evaluate marine protected areas (e.g. Hocking et al. 2000, Pomeroy et al. 2005, Al-Agwan 2015). The numerical score a plan received for each criterion (0, 1 or 2) was then multiplied by the importance score to give a weighted score for that criterion. The weighted scores for all criteria were summed, and the total was converted into a percentage value for each of the 79 plans. Using this system enabled us to develop a technique to address differing perceptions of criterion importance by experts.

RESULTS

Extent and distribution of marine turtle management

We obtained and reviewed 79 plans, including 16 plans at the subnational (local, state or multiple state) level, 40 at the national level and 23 at the multinational level. We only included plans specifically related to marine turtles and did not include broader biodiversity or threat mitigation plans for which marine turtles were one of many species or habitats.

National planning

We found that 43 (20.8%) of the world's 207 non-landlocked countries and territories possessed at

least 1 national/territory plan pertaining exclusively to marine turtles (Fig. 1a). Some nations had >1 plan, where species-specific plans have been devised for each of the marine turtle species present within the same nation. National planning was found to be concentrated predominantly in Central America and the Caribbean ($n = 21$), Africa ($n = 11$) and South America ($n = 5$). We obtained 1 national plan each from Oceania and Europe and 3 from Asia.

We identified 3 countries (Sri Lanka, Jordan and Myanmar) that had national marine turtle recovery plans, but we were not able to obtain copies. These 3 were included in the national planning distribution map (Fig. 1) but were not evaluated further.

Regional planning

We define regional plans as those that encompass 2 or more nations. Our results suggest that regional management plans are more common than national plans in both North and South America, the Indian Ocean region, the Mediterranean and Oceania (Fig. 2).

Analysis of marine turtle recovery plan criteria: trends, strengths and shortcomings

Objectives

Our data demonstrate that presence of the 5 objectives criteria in the plans obtained (Table 1) varied greatly. Achievability of objectives was the most commonly addressed criterion (present in over 60% of plans), followed by specificity of objectives (present in 44% of plans) and feasibility of objectives (present in 32% of plans). In contrast, we found measurability and time boundaries (e.g. the dates actions are to be completed by or the years data

should be compared back to) to be partially present or absent in 75 and 73% of plans, respectively. We also found that almost 50% of plans lacked clear timelines (Fig. 3a).



Fig. 1. Extent and distribution of marine turtle recovery planning at national/territory level; nations and territories in dark grey possess a plan: (a) global ($n = 43$), (b) Caribbean and central America ($n = 14$) and (c) Africa ($n = 11$)

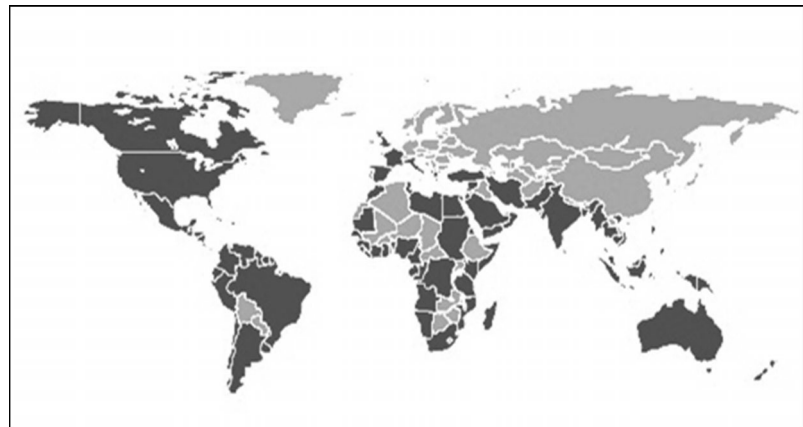


Fig. 2. Extent and distribution of marine turtle recovery planning at the international/regional level, with nations and territories included in at least 1 regional plan shown here in dark grey ($n = 138$ nations/territories included within 22 plans)

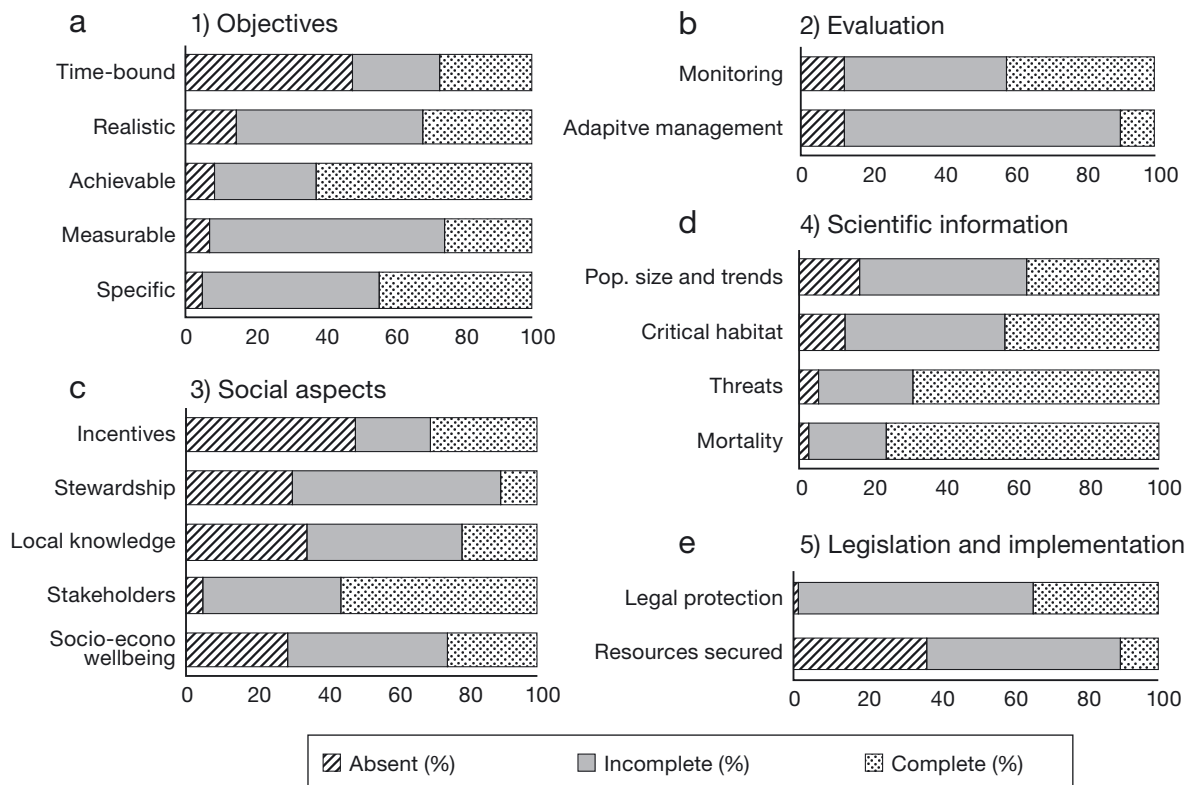


Fig. 3. Degree of fulfillment of 18 criteria falling under 5 broad categories (see Table 1) within marine turtle recovery plans: (a) objectives, (b) evaluation, (c) social aspects, (d) scientific information and (e) legislation and implementation (n = 79 plans)

Evaluation

The presence of monitoring actions with links to outcomes occurred in 42% of the plans obtained. In most cases, detailed monitoring procedures were present (79% of plans), but they were often not linked to desired outcomes.

We found that adaptive management was the least incorporated criterion in the plans obtained (10% complete). In particular, only 10% of plans mentioned the integration of adaptive management into the planning process (Fig. 3b).

Social aspects

We found this category typically received few details in most plans. Although the need for stakeholder participation at all levels of planning was integrated into plans (56% complete), both integration of external knowledge and stewardship and education were rarely included (only 22 and 10%, respectively). In relation to livelihoods, we found that objectives linked to improving socioeconomic well-being

occurred in 25% of plans, and incentives were listed in 30% of plans.

Scientific information

Overall, we found this category had a high but variable degree of complete fulfillment of the associated criteria. Of the criteria we examined, major sources of mortality in geographical area received in-depth coverage (complete) in 76% of plans, secondary threats and pressures were thoroughly discussed in 68% of plans and identification of critical habitat was deemed complete in 43% of cases. Furthermore, while 87% of plans identified critical nesting habitat, less than half (43%) of the plans identified additional habitats deemed critical for marine turtle survival (breeding, foraging, internesting or migratory habitat).

Population size and trends was the least fulfilled criterion in this category. Although 84% of plans provided evidence for some parameter of marine turtle population size (number of mature females was most often used) or identified the status trend of the population (decreasing, stable or increasing) with sup-

porting evidence, only 37% contained empirical information about both population size and status trends (Fig. 3d).

Legislation and implementation potential

We found 34% of national- and subnational-level plans were supported by full legal protection of marine turtles throughout their jurisdiction. In another 65% of plans, marine turtles were afforded some legal protection (i.e. setting spatial and/or temporal restrictions or providing a legal framework to manage bycatch or traditional/sustainable use); 1 national-level plan existed with no specific legislation for the protection of marine turtles, but the development of legislation was an objective of the plan.

Marine turtle expert survey: Mean weights for each of 18 criteria

We received 16 completed surveys from 50 requests to marine turtle experts around the world, for a participation rate of 32%. Respondents were asked to provide a score from 1 to 5 in response to each question (1 being the lowest and 5 being the highest).

The response scores ranged from 3 to 5 (i.e. no scores of 1 to 2 were recorded), indicating that experts perceive all 18 criteria to be at least of medium importance in marine turtle recovery planning (Table 3).

All criteria pertaining to SMART objectives as well as threat identification and ongoing monitoring were considered important (mean scores above 4). Of these, respondents suggested via their answers that the measurability of objectives is the single most important of the criteria we presented them with, giving it a mean score of 4.7. Social aspects were rated as being less important (3.1 to 4.1) than the other 4 categories.

Mean scores from the survey were then factored into the criteria and plan scores for each of the 79 management plans. Overall, weighted plan scores ranged from 23 to 85%, with an average plan score of $59 \pm 14.6\%$.

Marine turtle management planning and HDI: Relationship and difference in management priorities

The plans we collected and analysed seem to suggest that marine turtle recovery planning at the national level alone is most prevalent in developed

Table 3. Median importance score allocated by marine turtle experts (n = 16) to each of 18 characteristics of recovery plan design

Criterion	Median importance score	Interquartile range
(1) Objectives		
Plan objectives should be specific	5	4.5–5
Plan objectives should be measurable	5	4–5
Plan objectives should be achievable	5	4–5
Plan objectives should be realistic	4	4–4
Plan objectives should be linked to timeframes	4	4–4
(2) Evaluation		
Monitoring actions present and linked to outcomes	4	4–4
Capacity for and acknowledgement of adaptive management	4	3–4
(3) Social aspects		
Objectives linked to socioeconomic well-being of stakeholders	3	2–3
Stakeholder participation at all levels of planning	3	2.5–3
Integration of local knowledge	4	3–4
Education and stewardship	4	2–4
Incentives	4	3.75–4
(4) Scientific information		
Major sources of mortality in geographical area identified and discussed	4	4–4
Indirect threats and pressures in geographical area identified and discussed	4	4–4
Population size and status trend are identified	3	3–3
Critical habitat is identified	3	3–3
(5) Legislation and resources		
Protective national legislation	5	4–5
Resources for implementation secured with plan development	4	4–4

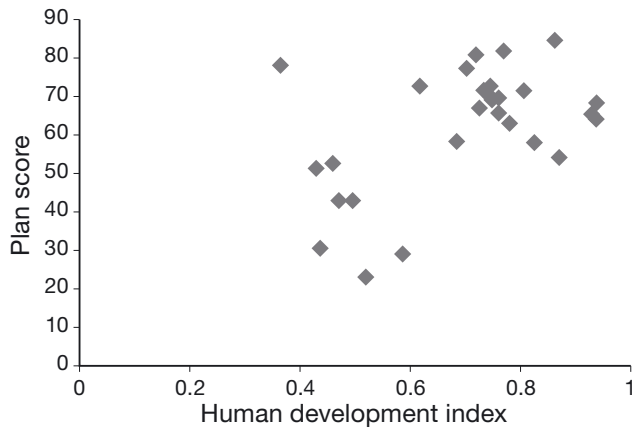


Fig. 4. Relationship between Human Development Index and marine turtle recovery plan design score (n = 28)

nations, as demonstrated by the thick cluster of points in the upper right-hand corner of Fig. 4. The plans in this region of the graph also tended to score relatively highly (54 to 84%), with no scores <50%. Meanwhile, recovery plans from nations with an HDI value below 0.7 were allocated scores across a wide range (22 to 75%).

Although there appears to be a positive association between the variables, the statistical relationship between a nation's HDI and the overall plan score was weak (Spearman's $\rho[28] = 0.302$, $p = 0.06$).

DISCUSSION

We examined 79 plans aimed at improving management of marine turtles from across the globe. Based on the plans we examined, most national-level planning, as represented in the texts of the plans we read, is not sufficient to guide management across the spatial and temporal extent of a species or population. Overall, we found that the large majority of plans stated their objectives clearly, which is a crucial first step in recovery planning (Reed 2008). Most plans listed actions necessary to fulfill objectives and specified the expertise of trained personnel. However, we also found that objectives were not likely to be adequately measurable in 75% of cases and that timelines were entirely absent in 50% of marine turtle plans. Collectively, these findings indicate that although plans generally do not prescribe methods for evaluation, the lack of clear and timely objectives implies that agencies designing and implementing plans will be less able to evaluate success across the breadth of a management plan (Jones 2000).

Our analysis suggests that long-term ability to understand, measure and improve upon most of the plans we examined is hindered by the lack of inclusion in the plans of adaptive management elements and/or planned reviews/re-evaluations. The omission of the need for evaluation capacity and process as part of the overall management suggested in plans is potentially most detrimental to the planning process. Further, the lack of greater integration of evaluation into the plans highlights the need for greater incorporation of SMART objectives. Doing so would enable both evaluation methods to be established and adaptive learning to be incorporated. Both are key elements of ongoing evaluation of management and planning and would benefit marine turtle management programs (Hamann et al. 2010).

An additional shortcoming of the plans we reviewed is that approximately one-third were designed over 10 yr ago and had no evidence of subsequent review or incorporation of new knowledge, suggesting that they may be out of date and/or out of touch with sea turtle conservation priorities at various scales. Both this shortcoming and the lack of evaluation considerations in the plans are disappointing results, especially in the plans designed over the past 10 yr. The lack of a transparent review cycle in the plans we examined is consistent with the findings of other studies on recovery plans (Bisbal 2001, Ferraro & Pattanayak 2006, Ortega-Argueta et al. 2011). However, we do not know the current status of the turtle population covered by most of the plans. It could be that older plans have not been reviewed because the turtle populations in their jurisdiction are now recovering, stable, etc., and/or relevant government agencies no longer see planning for marine turtles as a priority. Furthermore, while we advocate for adaptive management, it is a relatively new concept; thus, we acknowledge it may not be present in older plans.

Despite known advantages of including evaluation components in plans, conservation initiatives are rarely subjected to in-depth evaluation and review because these processes can be costly or difficult or provide suggestions and recommendations that are challenging to accept or implement (Kleiman et al. 2000). Evaluation also requires considerable foresight and initiative by the planners (often different from implementers) because of the need to design suitable indicators, objectives and targets. These obstacles should not, however, detract from integration of evaluation into planning because if correctly employed, adaptive management benefits from reliable knowledge and direct experience rather than the

inefficient, less scrutinised knowledge obtained from unexamined error (Lee 1999).

One of the strengths of the plans we reviewed was that 75% of them include general marine turtle monitoring procedures. This differs from previous studies that found monitoring procedures to be incomplete or absent in most recovery planning (Clark et al. 2002, Ortega-Argueta et al. 2011). This could be because marine turtle monitoring techniques are quite well established (see Eckert et al. 1999) and can be generally applied across species and locations. However, while most plans identified and described monitoring procedures, they lacked adequate detail on monitoring indicators, monitoring goals or criteria for their assessment. These aspects of monitoring are critical to allow for both recording and robust assessment of whether (or not) the plans' objectives and targets are being met.

Our research suggests that most of the plans we reviewed (78 of 79) are accompanied by partial or full national-level legislative protection for marine turtles. However, we acknowledge that in many countries, the legal situation is complex because the responsibility for managing impacts to marine resources and species often falls under the legal mandate of several government agencies or different internal jurisdictions (e.g. states/provinces) (Upadhyay & Upadhyay 2002). Furthermore, because of the complex national-level legislation, and the multiple agencies that can be involved in managing impacts on marine and coastal environments, intra- and international policy conflicts can occur and hinder plan development, implementation or assessment. These governance issues and how they affect threatened species conservation warrant further research.

Although national planning plays a guiding role in the protection of marine turtles, many governments whose plans we examined are also signatories to multi-national plans. This larger scale of cooperation is important given the large ecological ranges of marine turtles, but there is variation in how the multi-national plans are organised, developed and governed in relation to national-scale planning (e.g. they are not always legally binding) (see Frazier 2002). Furthermore, the links between national and multi-national planning are rarely highlighted in national-scale plans. Here, and as others have done (e.g. Richardson et al. 2006a), we advocate that a well-structured national-level planning process could provide that critical link between local-scale threat management and international broad-scale planning.

We found that social and economic factors were not adequately incorporated into the texts of marine tur-

tle management plans that we reviewed. This is consistent with previous recovery plan reviews (Ortega-Argueta et al. 2011). This may be a vestige of conservation and management planning typically focusing on biological factors (Scott et al. 1995) and adopting top-down approaches, but it does not align with current thinking regarding how best to plan for effective conservation (Margules & Pressey 2000, Pomeroy & Douvère 2008, Bryan et al. 2011). Sea turtles are important to people in various ways, and most threats to them are also anthropogenic, suggesting it would be wise to incorporate greater attention to the human dimensions of sea turtle threats and recovery into such plans. For example, effective mitigation of threats requires improved understanding of local economies, education and stewardship cultures and the capacities to cope with changes (socioeconomic, cultural, environmental), and evaluating threat mitigation actions requires inclusion of social and economic indicators as well as ecological indicators.

Improved stakeholder input and collaboration could help bridge the gap because it is now established that when community participation and support for conservation is absent, marine turtle management often fails (Senko et al. 2011, Mutalib et al. 2013). For instance, stakeholder collaboration can aid in early identification of potential areas of conflict with respect to conservation goals, local use expectations and community enhancement goals (Reed 2008, Kamrowski et al. 2015). In addition, local and indigenous peoples often have many generations of experience with local environments and resources and can be invaluable sources of knowledge on local habitat of sea turtles and their biology, sizes and status or trends. Despite these convincing examples and our greater recognition of local populations as knowledgeable, such knowledge is often underused in recovery planning in general (Stratos 2006, Ortega-Argueta et al. 2011) as well as in marine turtle planning (Weiss et al. 2012, 2013). Understanding how to improve these social and economic aspects of conservation warrants attention.

One of the shared strengths among the plans we reviewed was the clear identification of sources of mortality and indirect threats to marine turtles. This contrasts with results from reviews of other plans, which suggested limited demonstration of knowledge of threats, and the authors of other reviews viewed this as a major obstacle in planning (Clark et al. 2002, Lawler et al. 2002). A continued emphasis on quantifying threats and sources of mortality, and better understanding of new threats such as marine plastics (Vegter et al. 2014, Schuyler et al. 2014,

Nelms et al. 2015) and climate change (Hawkes et al. 2007), should be a focus in marine turtle management planning. However, threats to marine turtles are spatially diverse in their magnitude and impact and occur across multiple geopolitical boundaries, and their likely impact varies considerably across age classes and species (Wallace et al. 2010, 2011, Riskas et al. 2016). Hence, while it is necessary for national-level plans to understand threats, multi-national plans are needed to provide relevance of national initiatives at the ecological scale, and planning processes should increasingly address cumulative impacts.

It is widely accepted that poverty and biodiversity loss are linked and that developing nations do not always have the required funding or capacity to conserve natural resources in the same way as developed nations (Adams et al. 2004, Díaz et al. 2006). Our data supported this to some extent, but the relationship was not straightforward. The majority of plans we reviewed belonged to developed nations, suggesting that capacity for recovery planning is occurring in nations with higher levels of development. The plans that scored lower were mostly those from less affluent countries or territories, but in some cases, high-quality plans arose from developing nations, indicating that at least for marine turtles, conservation potential may be greater than previously thought in some less developed areas and that a country's capacity to prioritise conservation can be independent of its level of development. In particular, the plan for Guinea-Bissau, whose HDI index was the lowest of all nations in our study, had an overall score comparable to the best plans from developed nations. While level of development undoubtedly plays a role for marine turtle management, international aid and support from non-governmental organisations for flagship species such as marine turtles is helping to create and build inter- and intranational relationships and capacity for species recovery. These finance and capacity issues, plus the level of dependence on financial resources from out of country sources and how they affect threatened species conservation, warrant further research.

The ultimate goal of most plans is to minimise risk to marine turtle species or populations and prevent further species declines. Thus, at plan completion, or at intermediate periods, demonstration of decreased anthropogenic threats, a decreased rate of loss or increasing population trajectory could all be deemed as indicators of success. However, this is challenging to evaluate because they all require a comparison with a robust baseline dataset, which for most spe-

cies and locations does not exist. Another complication is that plans often cover more than 1 species, and this makes it hard to use population status as an indicator of plan success. For example, in some cases, there are data indicating different population trajectories, e.g. in eastern Australia, hawksbill turtles are declining (Dobbs et al. 1999), and green turtles are increasing (Chaloupka & Limpus 2001); in other cases, there is evidence of success in several populations, e.g. along the Atlantic coast of the United States, all nesting populations appear to be increasing (Chaloupka et al. 2008, Conant et al. 2009, Stewart et al. 2011), and in the broader Caribbean, there are accounts of increasing leatherback (Dutton et al. 2005), hawksbill (Richardson et al. 2006b, Beggs et al. 2007) and green turtles (Troëng & Rankin 2005). However, the determination of marine turtle status, especially at a national level, is not currently possible for most of the countries with plans that we evaluated, either because baseline levels of abundance are not available or reliable, monitoring programs have recently started, and they do not have enough data, natural variability in numbers of nesting animals makes robust empirical assessment challenging, or a combination of low sampling duration, high variability and small population sizes reduces the statistical power of trend analysis. A key emphasis of plan design should focus on the development of a robust sampling strategy or investigate the applicability of other techniques such as potential biological removal.

Our intent was to use existing plans coupled with expert opinion to gain insight into aspects related to the quality of current management plan design for marine turtles and in doing so to identify strengths and shortcomings. We acknowledge that (1) our assessment may not adequately capture the complexity of conservation planning and the external factors that drive conservation programs and (2) there are challenges associated with using and interpreting expert opinion (e.g. Krueger et al. 2012). However, we developed a scoring system which can be easily adapted and applied to future plans, or plans for other taxa, and this can provide a useful platform for both understanding the shortcomings of planning and improving future plans.

Recovery planning has become an important part of threatened species conservation and is often required under environmental legislation. However, the review of 79 plans that we present here suggests that most marine turtle recovery plan texts lack key aspects for long-term successful and holistic planning and implementation. A noted absence is the

included requirement for plan re-evaluation based on plan-related data and feedback. This seems like a key omission in an era where adaptive management is recognised to be a desirable best practice for conservation (Margules & Pressey 2000, Pressey et al. 2007). While our review suggests some encouraging trends, such as the inclusion of monitoring and clarification of threats, it also reminds us that a lot of work remains to be done. Since the plans we reviewed are diverse, with disparate inclusions, we propose that proactive and global perspectives on recovery planning could provide useful unifying elements across national and multi-national planning and the documents that comprise it. There is much to be learned from management efforts around the world, conducted at all scales. Information on plan content attributes and planning effectiveness should be freely available, shared and discussed widely (beyond academic circles) to inform the creation of superior and more harmonised plans and to assist plan writers and implementers to make informed decisions about resources, uses and related conservation efforts. Given this, we recognise the potential roles for international organisations and agreements (e.g. South-East Asian Marine Turtle Memorandum of Understanding and Inter-American Convention for the Protection and Conservation of Sea Turtles) and/or international non-governmental organisations in facilitating knowledge and working towards more harmonised efforts across jurisdictions, governments and geographic areas to improve international conservation of sea turtles.

Acknowledgements. We thank Ruth Kamrowski and 2 anonymous reviewers for providing valuable input.

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Editorial responsibility: Kartik Shanker, Bangalore, India

*Submitted: December 2, 2015; Accepted: July 28, 2016
Proofs received from author(s): October 6, 2016*