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An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries

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ABSTRACT

The performance of 33 countries was evaluated for ecosystem-based management (EBM) of fisheries in three fields (principles, criteria and implementation) using quantitative ordination including uncertainty. No country rated overall as 'good', only four countries were 'adequate', while over half received 'fail' grades. A few developing countries performed better than many developed nations. Two case studies test the method. In Indonesia, Raja Ampat and Papua, rated similar to the national evaluation, but better performance might follow successful implementation of a planned EBM initiative. A workshop in Australia rated regional fisheries managed by New South Wales 20% lower for EBM than federally managed fisheries.

1. Introduction

There has been a recent trend towards adopting ecosystem-based fishery management (EBFM). Although there are a bewildering number of different definitions and shades of meaning of ecosystem-based management (EBM) [1,2], there is widespread agreement about the need to move towards a new fishery management system that recognises explicitly how food web linkages and human interventions may affect sustainability in aquatic ecosystems [3–5]. This paper attempts to evaluate the current status of the implementation of EBM in fisheries worldwide.

Many of the issues now considered vital for EBM are implicit in the FAO (UN) Code of Conduct for Responsible Fisheries [6]. There is an urgent need to manage fisheries in a more ecologically sensitive manner and this is the strength of the overarching concept of EBM. Aiming to operationalise this concept, FAO has also issued guidelines for an ecosystem approach to fisheries [7]. Implementation, however, of the stock-specific 'traffic light' reference points approach from the FAO guidelines will be difficult until clear and simply measured EBFM indicators for management are agreed by the international community [8,9], a task that has proved more difficult than some envisaged, especially in data-poor fisheries [10,11]. In the meantime, a simple, practical approach published by Ward et al. [12] is easier to adapt as a basis for evaluating status. Many wish to distinguish EBM from EBFM or the ecosystem approach to fishery management (EAFM): as in Ward et al. [12], we use EBM to denote a holistic approach to the management of fisheries, but not the management nor control of pollution, shipping lanes, recreation and other non-fisheries issues.

In fact, the Ward et al. [12] framework is largely based upon the FAO Code of Conduct which, although it originated in the early 1990s before ecosystem thinking became widespread, provides a very robust scheme of key elements such as ecological health, stakeholder involvement and spatial management. As there is already a published analysis of compliance of over 50 countries with the Code of Conduct [13], we were able to use extracts from this material, together with its estimated uncertainties, to score whether the fisheries are managed in accordance with the WWF framework proposed in Ward et al. [12]. In short, we used the scores countries received under the Code of Conduct assessment to evaluate the specific EBM issues identified in the WWF framework.

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2. Methods

2.1. Selection of countries

Our analysis was based on countries and not on individual fisheries, since under the Law of the Sea Convention (UNCLOS) nation states have a legal responsibility for the control of all fisheries within their EEZs and for their vessels on the High Seas.

We have chosen 33 countries for the main analysis as representing the top 90% of the world fish catch (see Table 2, the world catch in 1999 is taken as the reference point [13]). In addition, Australia (number 46 in the world catch) is included as a case-study example.

2.2. Scoring

Fishery management in the 33 countries was scored against the three main sets of the listed attributes from Ward et al. [12]. These were, overall principles (5 attributes; Table 2, p. 19 in Ward et al.); criteria for success (6 attributes; Table 3, pp. 19–20 in Ward et al.); and implementation steps (12 attributes; Table 6, pp. 50–51 in Ward et al.). Evaluation fields were set up for each of these by assessing material from published country reports on the compliance of over 50 countries with the Code of Conduct for Responsible Fisheries (13) against the criteria detailed in Table 2. Performance scores were allocated on a scale of 0–10, together with their likely ranges: these were set out on individual scorecards for each country. Scores over of 7/10 and above were considered 'good' and hence likely to lead to reasonably effective implementation of EBM, while scores of 4/10 or less are taken as unacceptable or 'fail grades'.

As a test of the utility and consistency of the method, two additional case studies were undertaken. First, scores for NSW and Australian fisheries were obtained from nine expert fisheries scientists, who participated in an ecosystem-based fisheries workshop[1] in July 2007 where a scoring framework similar to Table 1 was distributed. Experts canvassed were from New South Wales Fisheries, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and local universities. Of the nine individual sets of scores, one was discarded as their scores were completely uncorrelated to all the others; the rest exhibited similar ranges and patterns and hence were averaged.

The second test case was in Indonesia. Raja Ampat, an area of over 600 islands covering an area of about 45,000 km^2 in the "Coral Triangle" [14], is the site of a recent initiative in EBM set up by The Nature Conservancy, Conservation International and WWF-Indonesia with the local regency government [see 15]. Two of us (DV, TJP) have been involved with field teams of ecologists, social scientists and local universities in ecosystem modelling and analysis of field survey and interview data in support of this project. We have taken the opportunity to use this material to score the current fisheries in Raja Ampat against the criteria in Table 1. In addition, we estimated what the scores and their ranges might be after a successful implementation of the EBM project [16].

2.3. Analysis

For each of the three evaluation fields, raw scores were standardised using fixed reference points of zero and 10/10 and then entered into a non-metric multi-dimensional scaling [17] that incorporates a set of fixed anchor points from the 0 to 10 scoring range. Initial results were rotated to lie congruent with the fixed axis [the 'Rapfish' technique, 18]. The anchored and rotated MDS ordination can be thought of as extracting from the multidimensional raw data (in which each scored attribute represents a dimension) a single-dimension congruent with the original performance scores that maximises the differences among the data points along a scale from 0% to 100%. A second axis, normal to the first, is also extracted and may be thought of as expressing differing patterns of scores that achieve the same performance rating in different ways. This technique provided performance ratings on a percentage scale for each country, in each of the three evaluation fields. Uncertainty in the resulting ordination was allowed for by entering the upper and lower extreme values for each attribute score into a Monte Carlo simulation [19], which employed 500 iterations to estimate the upper and lower 95% tiles on the performance rating of each country.

3. Results

Scores allocated to each attribute are tabulated in Table 2. Following the method outlined above, final ordination results are shown in Fig. 1a–c. In these figures two-dimensional ordination plots show the differences in EBM Principles, Indicators and Implementation among the countries. Differences along the *x*-axis relate to the differences in EBM performance; differences in the vertical direction relate to the differences among the countries that are not due to EBM performance.

Fig. 2 shows how different countries score against the EBM performance rating scale (the *x*-axis on Fig. 1). Ratings over 70% were considered 'good' and likely to lead to reasonably effective implementation of EBM, while performance ratings of 40% or less represent 'fail grades' that are unlikely to help the implementation of EBM. Scores over 60% but $<70\%$ were considered 'acceptable' but in need of improvement.

For the five WWF EBM principles, there are no outstanding good performance ratings, and only six countries (USA, Norway, New Zealand, South Africa, Australia and Canada) have confidence limits that overlap the 'good' 70% threshold. Three countries (Iceland, Japan and Malaysia) have 'acceptable' scores over 60%. It is disappointing that almost half (14) of the 33 countries have 'fail grades' (Chile, China, UK, Argentina, Brazil, Pakistan, Indonesia, Morocco, Taiwan, Turkey, Viet Nam, Thailand, Russia and Myanmar).

For the six EBM indicators, four countries (Norway, New Zealand, USA and Iceland) achieve 'good' ratings than span the 70% threshold; while three countries (Canada, South Africa and Japan) have 'acceptable' performance levels over 60%. Over half (17) of the 33 countries have 'fail grades' (Mexico, France, Ecuador, UK, India, China, Argentina, Pakistan, Brazil, Indonesia, Morocco, Taiwan, Turkey, Russia, Myanmar, Viet Nam and Thailand).

For the twelve EBM implementation steps, no countries achieve 'good' performance ratings over 70%; while just two (USA and Canada) have 'acceptable' scores over 60%. In this evaluation field, two-thirds (21) of the 33 countries have 'fail grades' (Ecuador, Japan, Denmark, Brazil, Argentina, Malaysia, UK, Netherlands, France, Philippines, India, Indonesia, Pakistan, China, Taiwan, Myanmar, Turkey, Viet Nam, Morocco, Thailand and Russia).

Overall scores for EBM (totalled over the three evaluation fields) show that only two countries have 'good' performance ratings over 70% (Norway and USA), while four countries have 'acceptable' grades between 60% and 70% (Iceland, South Africa, Canada and Australia). But about half (16) of the 33 countries have

[1] "Towards Ecosystem-based Fishery Management in New South Wales"; New South Wales Government Fisheries Research Centre, Department of Primary Industry, Cronulla, NSW, Australia, 25–26 July 2007.

Table 1
Scoring framework used in the EBM performance evaluation

Evaluation Field 1: Five principles of the EBM framework	Score 0–10	Score range
• The central focus is maintaining the natural structure and function of ecosystems, including the biodiversity and productivity of natural systems and identified the important species • Human use and values of ecosystems are central to establishing objectives for the use and management of natural resources • Ecosystems are dynamic; their attributes and boundaries are constantly changing and consequently, the interactions with human uses also are dynamic • Natural resources are best managed within a management system that is based on a shared vision and a set of objectives developed amongst stakeholders • Successful management is adaptive and based on the scientific knowledge, continual learning and embedded monitoring processes		

Evaluation Field 2: Six indicators of successful EBM

Key element	Expression in the fishery (objectives)	Mechanisms and enabling processes	Performance indicators	Score 0–10	Score range
The fishery operates in an effective policy framework	The management system has effective linkages to the conservation and socio-economic policies and strategies for the ecosystems where the fishery operates. The management system appropriately reflects national and international goals and objectives for conservation and sustainable use. Subsidies and incentives lead to improved EBM outcomes in the fishery	Review of regional and national policies and strategies to ensure consistency with EBM principles. Inter-agency procedures are efficient, effective and accountable. New subsidies and incentives reviewed by stakeholders to confirm ecological viability	The absence of policy inconsistencies that will prevent a fishery from achieving EBM. Inter-agency cooperation is effective and efficient. The absence of perverse subsidies and incentives in the fishery system		
Social, economic and cultural context of the fishery is incorporated	Stakeholders are identified from all areas of relevance to the fishery, and effectively participate in the management system. The management system and the implementation of objectives and targets are agreed across all stakeholders for both stock management and ecosystem integrity. Institutional changes result in increased integration and cooperation amongst stakeholders. Management decisions are based on the long-term social, economic and cultural benefits of the society	Procedures are in place for effective participation of stakeholders in all aspects of the management system (such as Management Advisory Committees, Consultative Councils). Management procedures are publicly accessible, and implemented according to a publicly available plan of the management. Regular review and revision procedures are in place to identify improvements to the management system. This should include professional assessment that is independent of the fishery and management agency	The fishery management plan is easily available and is periodically (at agreed regular intervals) open to public review and assessment. Fisheries status reports that include stock and ecosystem performance reports are periodically (at agreed regular intervals) distributed for public review and evaluation		
Ecological values are incorporated	Ecosystem values are identified, including ecosystem connections, conservation status, state of ecosystem integrity and critical habitat for utilised and non-utilised species. Agreed objectives, targets, strategies and performance indicators for enhancing or maintaining ecosystem integrity are developed and implemented. Achievement of the ecosystem objectives is assessed within the fishery management system in partnership with conservation and research sectors	Ecosystems have been mapped where the fishery operates, and the conservation status of important species and habitats determined. Habitats, species and ecosystem function vulnerability to fishery impacts have been assessed, and the targets and harvest strategy adjusted to be precautionary. Assessment of the fishery performance for ecological objectives is undertaken in conjunction with stakeholders, and procedures and outcomes are made public	The ecological integrity of specified sensitive habitats is not declining. Species considered at high or medium risk from fishing (or their surrogates) are identified and their status used as performance indicators. Populations of non-utilised (specified) species vulnerable to fishing impacts are not declining. The bycatch of (specified) protected or otherwise icon species is declining by an agreed proportion each year, or reduced to an agreed level considered acceptable		
Knowledge of utilised species is adequate	Agreed objectives, targets, strategies and performance indicators for stock status are developed and implemented. Achievement of fishery objectives is assessed within the fishery management system through comprehensive consultative structures Ecosystem dynamics are fully incorporated into stock assessment models and decisions are cautious. Effective	Stock assessments are timely, open to stakeholder participation, and fully transparent and accountable. Harvest strategies are cautious, and well-buffered against unpredicted failure of assumptions. No take zones' and marine-protected areas are designed to	Target and limit reference points are set at a precautionary level. Limit reference points for stock size and structure are not violated. The age structure and natural distributional range of the population are minimally altered. Stock assessments are open, inclusive and		

Table 1 (*continued*)

Evaluation Field 2: Six indicators of successful EBM

Key element	Expression in the fishery (objectives)	Mechanisms and enabling processes	Performance indicators	Score 0–10	Score range
	no-take zones are implemented as 'insurance' against unpredicted failure of the management system in respect of the target stock, associated non-target catch and bycatch, and wider ecosystem values	benefit both fisheries management and broad ecosystem goals. Catch levels are set within ecologically defined limits that are understood and agreed	participatory. No-take zones are agreed and adequately implemented as part of the fishery management system		
The resource management system is comprehensive and inclusive, based on reliable data and knowledge, and uses an adaptive approach	The fishery management system is structured using ecological classification (such as ecoregions, bioregions, and habitat classes). Baseline data or benchmarks are available for each performance indicator. Management data are collected for stock management and ecosystem integrity parameters. Arrangements are in place to facilitate the use of data from partner agencies, research collaborators or other sources. Stock and environmental assessments are conducted in collaboration with fishery operators, partner conservation agencies and other stakeholders e.g. Environmental Non-Government Organisations (ENGOs). The management system responds to new information and data in a timely and effective way. Procedures are in place to recognize and adopt new knowledge or data of importance to ecosystem integrity or stock management. Ecological risks are assessed in a comprehensive manner, and a precautionary decision-making framework is used to manage risks. Gaps in knowledge related to high or medium risks are given priority for research funding and implementation	An ongoing research programme is in place to improve basic knowledge of the life history characteristics of target species, associated and dependent species and the wider ecosystem where the fishery operates. The management system includes monitoring to evaluate the status of ecological indicators. Stakeholders participate in management decisions. Ecological risks are continuously reviewed to provide for alteration to the harvest strategy as appropriate	The amount and type of fishing effort in each habitat class. The amount and type of bycatch and discards is declining by an agreed proportion each year, or reduced to an agreed level. Bycatch of protected species is declining by an agreed proportion each year, or reduced to an agreed level. Research projects reflect the key ecological issues in the fishery. Comprehensive fishery data monitoring system on targeted species and bycatch is in place. The amount and type of fishing effort on each level of the population of the target species		
Environmental externalities are incorporated.	Cross-boundary issues are identified, and addressed within the management system. The long-term dynamics of ecosystems are incorporated into the development of objectives and targets. The management system considers the full range of human uses and aspirations for the ecosystems being managed	Statutory or other procedures are in place to ensure that fisheries managers are involved in management decisions that may affect the stock or the ecosystems where the fishery operates. Ecological risks and harvest strategies contain measures to assess and incorporate risks from long-term changes in ecosystems or the effects of their uses. Fishery managers and operators understand and are accountable for their decisions and actions and the impacts of these 'in the water'	Critical habitat for the fishery and identified key ecosystem components are protected from water pollution, coastal development or other externalities. Environment-protection strategies take into account the use by fisheries of coastal areas. Allocation of resources for harvest (of exploitable stocks) is made equitably across all legitimate claimants (e.g. requirements of the ecosystem; traditional, subsistence, recreational and commercial fishers) and recognises ecological constraints		

Evaluation Field 3: Twelve steps in implementing EBM

Component step	Involving	Intended outcomes	Score 0–10	Score range
Identify stakeholder community	Fishery management agencies, conservation agencies, conservation NGOs, local community groups, scientific/academic research community, fisher associations or cooperatives, higher and lower levels of government, fish processing/distribution groups, Indigenous representatives	A formal network of interested parties with whom the fishery representatives will participate to prepare and review the management of the fishery. A transparent and fully accountable process enabling the participation of all interested parties in the process of managing the fishery		
Prepare a map of ecoregions and habitats	Conducted by the fishers, research community, fishery managers, stakeholders and partners. Covers the full area of fishery operations. The focus is on areas where the fishes are, where they	Maps of the ecosystems throughout the fishery at scales of resolution consistent with the scale of the fishery. Resolved habitats at a scale consistent with the potential impacts of the		

	are fished, and any specific spawning, nursery or similar obligate habitats or locations. High resolution is needed in benthic primary producer habitats (such as algal beds, seagrasses, mangroves, coral reefs)	fishery. Coherent with other ecosystem classification initiatives (at both larger and smaller scales). Major features and exceptions documented (e.g. highly migratory species, oceanographic currents or features, boundary mismatches between taxa). Major uncertainties identified and documented as guidance for research and investigation programmes
3. Identify partners and their interests/ responsibilities	Conservation, environment protection, and coastal planning agencies from all levels of government. Major users and managers of other, possibly co-located, resources (e.g. tourism, mining, oil/gas, transport, and communications). Directly affected local communities	Clarify specific roles and responsibilities for management in the marine environment. Engage with other supportive interests. Promote the opportunity for coordination and integration, improved efficiency across government and better outcomes for marine management, better agency outcomes for lower cost, more accountability in government, more effective long-term solutions to marine ecological problems, and shared approaches to problems held in common
Establish ecosystem values	Fishers, research community, fishery managers, stakeholders, partners and the public; designed to identify all major uses and all major natural and ecosystem values throughout the area where the fishery operates	A detailed distributional analysis of the main attributes of the ecosystem where the fishery operates. A clear and agreed expression of the natural and use values, which could include: highly valued habitats; representative areas dedicated as reserves; protected species feeding, breeding, or resting grounds; fishing, spawning grounds, recruitment areas and migration paths for commercial species; highly productive areas such as upwellings; areas popular for recreational fishing or diving; areas used for ports and harbours; areas of high scenic and wilderness amenity; high cultural and historic value; traditional hunting grounds for indigenous peoples; areas of high tourism value; areas used for dumping of dredge wastes, military training, etc.
Determine major factors influencing ecosystem values	Establishing cause–effect relationships; consider factors both internal and external to the fishery management system. Conducted by the fishers, research community, fishery managers, stakeholders and partners	Identified hazards to marine ecosystems and their values from the full range of actual and potential human impacts that occur in the fishery region. These could include: extent of loss/damage of marine habitats; effects of specific fishing gear on benthic habitats; effects of pollution from coastal rivers on inshore habitats; risk of marine pest invasion and disruption to critical habitat or fishing operations; effects of the removal of the biomass of harvested species (in all fisheries) on trophically dependent species
Conduct ecological risk assessment	ERA conducted with participation of all stakeholders and partners, fishers, research community and the fishery manager: uses broad multi-disciplinary knowledge base; identifies key areas of uncertainty; open for public scrutiny and review; fully peer reviewed by independent authorities	Agreed estimates of high, medium and low risks of the fishery to the ecosystem values identified in step 5, such as the risk of the fishery to the protected species, and to the ecosystem, habitats, species and genetic diversity
Establish objectives and targets	Fishers, research community, fishery managers, stakeholders and partners. Performance objectives and targets established for: high- and medium-priority risks from the ERA; important aspects of the ecosystems (including protected species, critical habitat); stocks	Agreed and shared goals for specific elements of ecosystems. Specific performance objectives and targets for important elements of the ecosystem. Objectives and targets that are comprehensive and precautionary in terms of valued aspects of the ecosystems. Could include: maintaining or recovering population sizes of protected species; maintaining the distribution, area, species diversity and trophic structure of important habitats; reducing fishing effort in specific areas to help protect populations of benthic fauna; increasing the distribution and diversity of benthic fauna considered to be affected by fishing; rehabilitating marine ecosystems to a past (healthier) condition
Establish strategies for achieving targets	Fishers, research community, fishery managers, stakeholders and partners. Focus is on identifying appropriate and workable strategies to achieve objectives and targets, and on specific capacity matched to responsibilities for implementing strategies.	Series of prioritised strategies that define workable activities and responses to achieve specific objectives and targets identified in Step 7. Includes who is responsible, what funds and time frames are involved, what controls are needed and where data/outcomes

Table 1 (*continued*)

Evaluation Field 3: Twelve steps in implementing EBM				
Component step	Involving	Intended outcomes	Score 0–10	Score range
	Strategies designed based on best understanding of the cause–effect relationships developed in Step 5, and matched to highest-priority needs for corrective actions identified in Step 6 (ERA). Use of incremental strategies where necessary and unavoidable	are reported and assessed. Strategies could include: declaring a network of sanctuary-protected zones; establishing buffer zones, where only specific uses, or types of fishing, are permitted research on improving gear design to reduce impacts on a sensitive habitat, or reduce the bycatch of an important species; improved fishery independent monitoring of catch, or bycatch; reducing pollution from coastal rivers; constructing fish escapement panels in trawl nets to avoid catch of a certain type and size of fish, or to reduce overall fish bycatch; implementing an industry code of practice to reduce risks of bait discards to bird populations		
Design information system, including monitoring	Fishers, research community, fishery managers, stakeholders and partners. Focus is on capture of appropriate data/information to determine if strategies are working as expected; objectives and targets are being achieved; cause–effect models are correct; fishery impacts are being reduced. Collaboration and contributions from partners identified	Efficient and effective fishery information system that provides data and information on stock and ecosystem performance (additional to information needed for stock management); identifies specific effects of fishery strategies on ecosystem values. Could include: Periodic mapping of important habitat distributions; population census of important protected species; species diversity in fished habitats; distribution of fishing effort by gear types and fine spatial scale; size/age classes in harvested species; species diversity in closed areas		
Establish research and information needs and priorities	Fishers, research community, fishery managers, stakeholders and partners. Focus is on identifying specific high-priority areas of uncertainty, and on quality science outcomes, for both stock and ecosystem issues. Collaboration and contributions from partners identified. Research strategies are fully peer reviewed or independently audited	Comprehensive research programmes targeted at resolving key ecosystem and stock issues in the fishery. Could include: habitat mapping; impact of fishing on specific habitat types; effects of coastal development on recruitment of harvested species; design of monitoring programmes to resolve important changes in habitats; biological data of key species (both utilised and nonutilised); determining the dietary preferences of harvested species and their major predators; species composition of bycatch with different gear types used in the fishery		
Design performance assessment and review processes	Fishers, research community, fishery managers, stakeholders and partners. Focus is on a process that is participatory and inclusive. The locations, timing and resourcing enables partner and stakeholder participation in reviews of performance of the fishery in relation to stock and ecosystem values. Performance outcomes peer reviewed by independent authorities	Periodic (but regular) forum for discussion, review and assessment of fishery performance by partners, stakeholders and the public. Periodic (but regular) forum for review, assessment and revision of monitoring data, objectives and targets by stakeholders and partners		
Prepare education and training package for fishers	Fishers, fishery managers, extension experts and stakeholders and partners	Outreach programme to provide training and support for fishers about new fishery management, ecosystem or other EBM initiatives, and provide local technical support for assessment and resolution of ecosystem issues		

Details of the three evaluation fields were taken from Ward et al. (2002). For each attribute, scores and ranges were allocated based on material in the Code of Conduct country reports (Pitcher et al. 2006). Scores of 7/10 and above were considered ''good''; scores of 4/10 and below represented poor or ''fail'' grades.

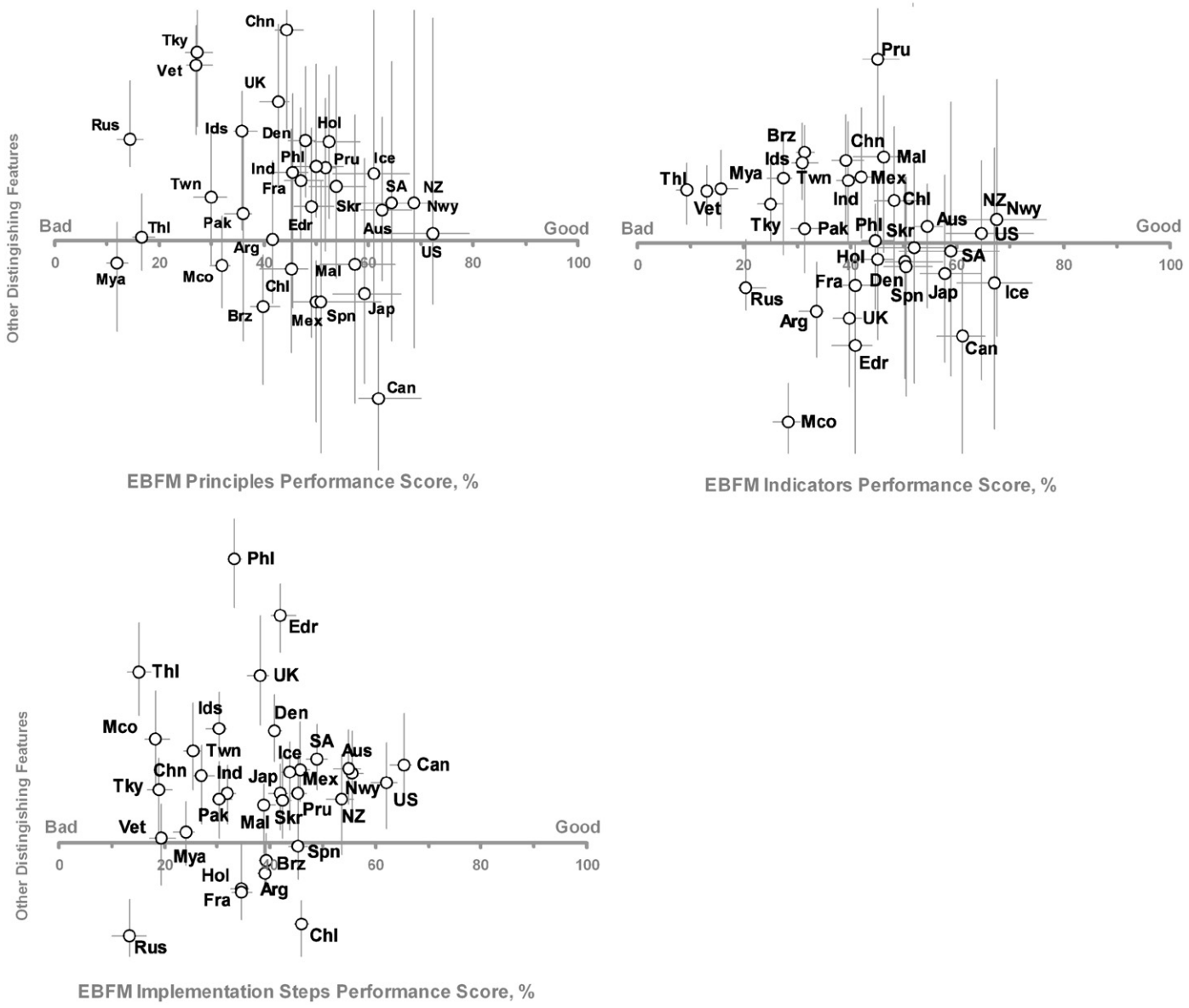

Fig. 1. EBM performance ratings for fisheries in 33 countries in three evaluation fields: principles, indicators and implementation steps, taken from Ward et al. (2002). Figure shows two-dimensional ordination plots from the MDS analyses; horizontal axis indicates performance score on a percentage scale; vertical position relates to the other distinguishing features among countries; thin lines are 95% tiles from Monte Carlo simulations using errors on each score. Country abbreviations as below: Arg = Argentina, Aus = Australia. Brz = Brazil, Can = Canada, Chl = Chile, Chn = China (Peoples Republic), Den = Denmark, Edr = Ecuador, Fra = France, Ice = Iceland, Ind = India, Ids = Indonesia, Jap = Japan, Mal = Malaysia, Mex = Mexico, Mco = Morocco, Mya = Myanmar, Hol = Netherlands, NZ = New Zealand, Nwy = Norway, Pak = Pakistan, Pru = Peru, Phl = Philipinnes, Rus = Russia, SA = South Africa, Skr = South Korea, Spn = Spain, Twn = Taiwan, Thl = Thailand, Tky = Turkey, UK = United Kingdom, US = United States of America, Vet = Viet Nam.

'fail grades' of 40% and less (UK, Argentina, France, India, China, Brazil, Pakistan, Indonesia, Taiwan, Morocco, Turkey, Viet Nam, Myanmar, Russia and Thailand).

3.1. Test cases

Fig. 3 shows the results from the test cases plotted on two-dimensional ordinations against a background of the overall final results from Fig. 1. It is evident that the EBM performance rating for New South Wales fisheries is some 10–15% lower than fisheries managed by the Australian Commonwealth. As all Australian fisheries share similar features, we see only small differences on the vertical axis between New South Wales and Australian Commonwealth fisheries.

In all three cases, the Raja Ampat ratings of today's performance in EBM are not significantly different from the overall Indonesian value along the EBM performance axis. Unsurprisingly, there are, however, large differences the vertical axis that express differences between this small region of Papua and Indonesia as a whole. Fig. 3 also shows our projections of what ratings Raja Ampat might achieve if the present EBM plans were to be fully implemented.

4. Discussion: the challenge of implementing EBM worldwide

The comparison of Indonesian scores for Raja Ampat and the overall values for Indonesia, which were independently arrived at, show similarities that provide encouraging validation for the

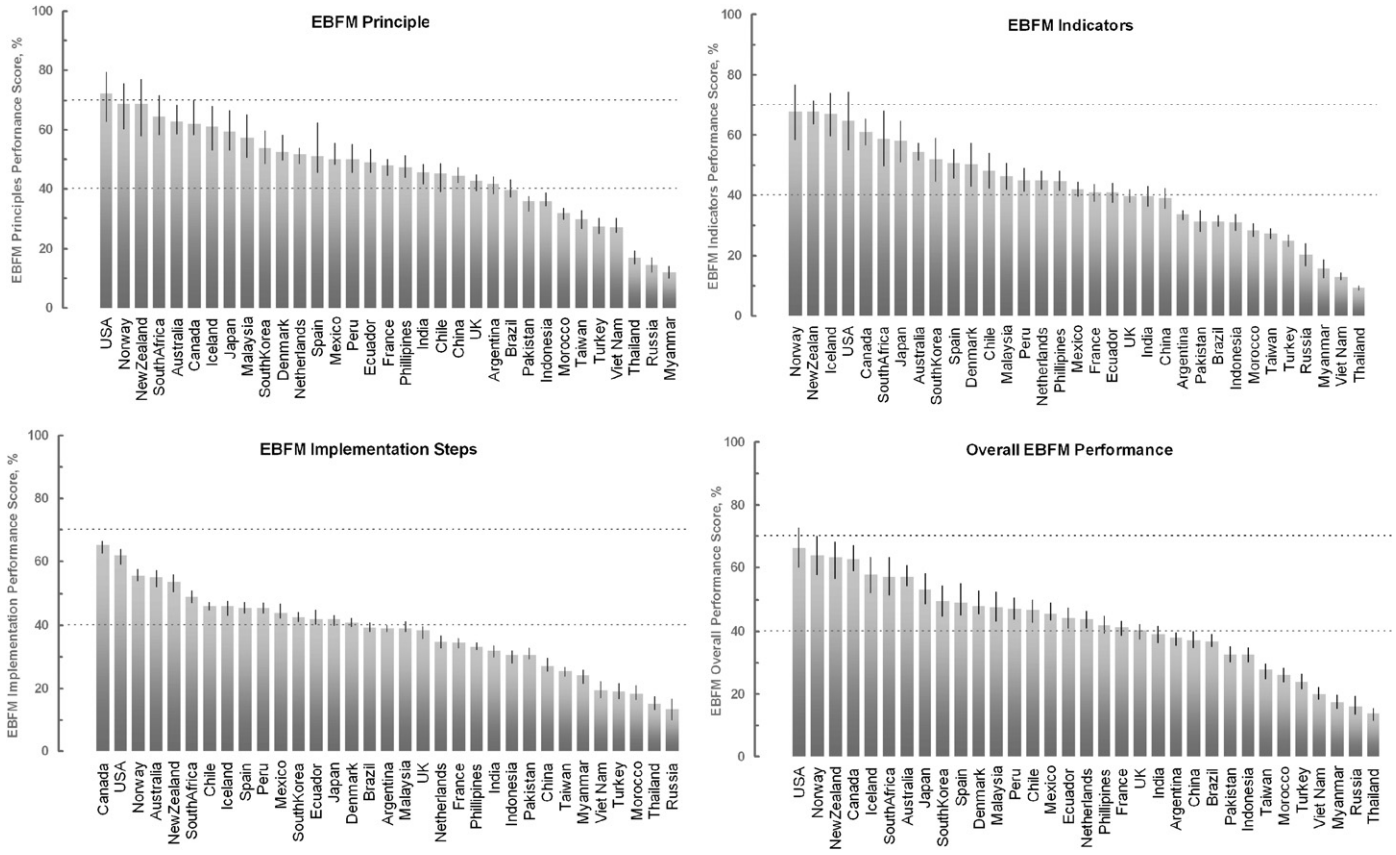

Fig. 2. EBM performance ratings (vertical bars) for fisheries in 33 countries in three evaluation fields: principles, indicators and implementation steps, taken from Ward et al. (2002), and an overall rating that averages the other three scores. Countries are shown in order of performance rating from left to right: thin lines are 95% tiles from Monte Carlo simulations using errors on each score. Upper broken line indicates "good' ratings or 70% or more; lower broken line shows "poor" or "fail" scores of 40% or lower.

method. Moreover, vertical axis results, expressing differences among fisheries, are also encouraging for the method. For example, there are only small differences on the vertical axis between New South Wales and Australian Commonwealth fisheries. Although Indonesia falls in the lower quartile of "fail" grades overall, Fig. 3 shows that the Raja Ampat region of Papua might achieve EBM ratings as high as the top five developed countries if present plans were to be successfully and fully implemented.

Most countries achieved lower ratings for Indicators than for EBM principles (evaluation field 2: 22/33); while almost all countries had lower ratings for implementation steps (evaluation field 3: 30/33). This finding is not surprising as it is easier to publish good intentions for EBM principles than to actually achieve the tangible steps towards EBM scored in evaluation field 3. On average ratings were 9.7% lower for implementation steps. One country, Myanmar, went significantly against this trend by having 12% higher performance on implementation steps, presumably reflecting the difficulty in finding any published principles for this country, as opposed to documented brave conservation efforts by a few individuals.

One of the EBM implementation steps has especially low scores in our analysis. "Setting up training courses in EBM for fishers and managers" averages only 1.0/10 (1.3 standard deviations below the mean), while 19/33 countries score zero. This 'training course' action would likely be a final implementation step in EBM, so that only countries that have already moved some way towards EBM will be able to achieve a reasonable score. Two other low-scoring questions are the "implementation of ecological risk assessment" (average 2.7/10; 7 countries with 0), and "strategies agreed among all stakeholders" (average 2.9/10: 7 countries with 0).

Our analysis reveals that only a few countries in the developed world are clearly moving towards EBM, but it is most interesting that several developing countries rank above their more developed neighbours (e.g., Malaysia, Peru, Mexico, Ecuador and South Africa), especially in Field 1 covering EBM Principles even if their ratings on Field 3, implementation steps, are generally lower. This may represent the actions of a few brave and progressive fishery legislators and managers in these countries and the more community-based nature of local fisheries management. Indeed, moving towards participatory fisheries management is a key aspect for success in implementing EBM. Many developing countries recognise that, in spite of some achievements towards the implementation of such approach, there is a need for capacity-building through awareness and direct technical assistance to help build their national capacity for the task [20].

Notable among the EBM scores are the dismal ratings of many developed European countries in spite of the Common Fisheries Policy undergoing an ecosystem-based reform in 2002. This can be seen graphically as a long horizontal cluster of high Human Development Index (HDI) countries to the left of the highest-ranking countries in Fig. 4. Despite academic excellence, widespread awareness of the issues and policy work emphasising the need to move towards EBM, to date it does not seem to have led to much clear regulation or action to implement tangible actions. Some may speculate on the reasons for this lamentable inertia among developed countries that undoubtedly have the resources for implementation. Bianchi et al. [20] suggest that such failures

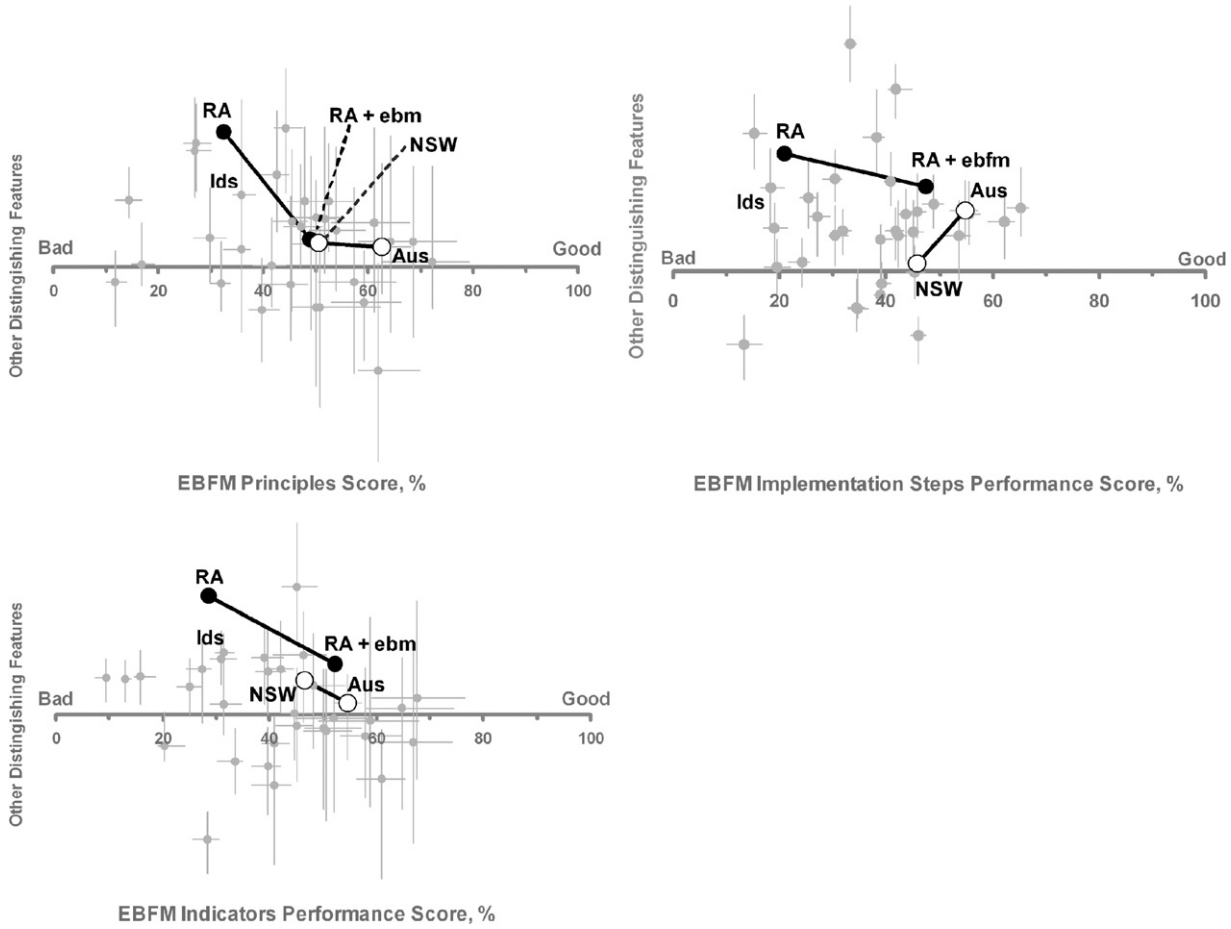

Fig. 3. Three fields of EBM performance ratings for Australian and Indonesian fisheries test cases. Main axes, symbols and confidence limits as in Fig. 1. For clarity, countries are unlabelled in this plot apart from Indonesia (Ids) and Australia (Aus). Rating for the state of New South Wales (NSW) is shown connected to the overall Australia values (open circles). Raja Ampat rating (closed circles, RA) is shown connected to hypothetical rating if a recent EBM initiative were to be successful (RA+EBFM) (see text for more details).

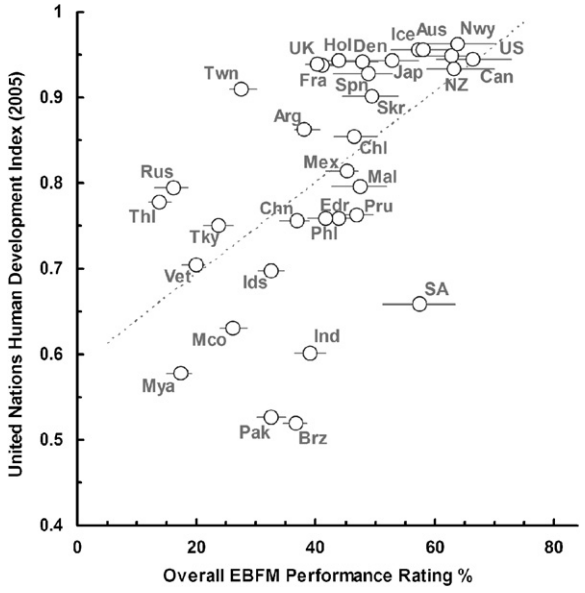

Fig. 4. Plot of United Nations Human Development Index for 33 countries (2005 data) against estimated overall EBM performance ratings. Thin horizontal bars are 95% limits of EBM values. Broken line: regression of HDI on EBM; sig at 99% level; COD = 0.29***.

may result from responding piecemeal to specific international agreements, advocacy pressure, trade requirements or immediate crises and not as a result of the development of a comprehensive, EBM plans for all fisheries in an ecosystem. EBM is increasingly recognised as providing the principles and methodology for area-based management or marine spatial planning for all maritime users. Whilst the late nineties also saw the blossoming of 'Oceans' approaches aimed at developing and applying EBM principles to multiple sectors in multi-stakeholder processes, the gradual pace of these reforms and their perceived expense has meant that few have been implemented. The South East Regional Marine Plan in Australia and the Benguela Current Commission are the two successful examples. What is evident, however, is that these processes are needed to implement comprehensive marine-protected area networks and to restructure fisheries, and this remains a key political challenge.

Our analysis is based on the jurisdictional role of countries, while an alternative approach would focus on the undoubtedly differing performances of individual fisheries in achieving EBM, but this approach would take a lot of resources to develop a global picture. Overall, however, our EBM performance ratings correlates quite well with UN Human Development Index (HDI, Fig. 4), although the correlation is not a strong one (COD = 0.29%, $P<0.01$). This creates a considerable challenge for international agencies, governments and NGOs that wish to encourage the adoption of EBM.

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