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RAP – AN ECOSYSTEM LEVEL APPROACH TO BIODIVERSITY PROTECTION PLANNING

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Abstract: The Representative Areas Program (RAP) aims to increase the protection of the biodiversity of the Great Barrier Reef Marine Park, an area of over 345,000 km^2. The RAP involves a rezoning of the entire Great Barrier Reef Marine Park and the protection of 'representative' examples of the range of habitats and communities within the Marine Park in a network of no-take areas that prohibit extractive uses.

This presentation will outline a number of key aspects of the RAP and the lessons learned that might be of interest to other MPA managers and planners operating at the ecosystem scale (i.e. 1000s of km^2). The approach being taken is a more holistic and systematic basis to broad-scale planning than has been applied previously within the Great Barrier Reef.

Firstly, the process of classifying the biodiversity and the development of the bioregionalisation is outlined, as this is the cornerstone of the RAP approach. A comprehensive range of biological and physical information was used to define 70 reef and non-reef bioregions across the entire Marine Park.

Secondly, the development and application of a set of endorsed biophysical operating principles and a set of socio-economic-cultural and management feasibility principles has greatly assisted the development of a new network of 'no-take' areas, providing clear and transparent guidance for the design of a network which achieves the best possible outcomes.

Thirdly, the public consultation taken in the first formal Community Participation phase of RAP is discussed, and how the public response of over 10,000 written submissions was handled and used to help develop a Draft Zoning Plan.

Lastly, the approach taken to identify options for no-take area networks using a combination of expert opinion, stakeholder involvement and computer-based analytical approaches is outlined. Marine reserve design software has been adapted and expanded for use in the RAP and this is assisting the GBRMPA to achieve its RAP goal while maximising beneficial impacts and minimising any negative economic, cultural and social impacts upon the community and users.

Keywords marine biodiversity, no-take area, representative area, MPA planning, bioregion, Great Barrier Reef

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Introduction
Since its declaration in 1975, the Great Barrier Reef Marine Park (GBRMP) has provided different levels of protection for different areas and broad-scale habitats within the park boundaries. A variety of management tools (e.g. zoning plans, permits, management plans, public education) [1], and collaboration with catchment and fisheries management agencies, have been used to help achieve ecological protection and other management objectives. A multiple-use zoning approach [2] has provided high levels of protection for specific areas whilst allowing other uses, including a variety of fishing activities, to continue in other zones.

About 16,000 km^2 of the GBRMP is currently zoned as 'no take' areas (National Park Zones), and there are some very small 'no-go' areas (Preservation Zones ~ 0.13% of the MPA). The no-take and no-go areas equate to only 4.7% of the Marine Park and the location of these zones reflects an historical focus on coral reefs and more remote 'pristine' areas.

The Representative Areas Program (RAP) is being undertaken by the Great Barrier Reef Marine Park Authority (GBRMPA) due to an increasing awareness about the value of an ecosystem-approach to management and the level of 'interconnectedness' between the wide range of habitats, species and communities that exist in the GBRMP [3]. While such habitats as coral reefs, mangroves, seagrasses, algal beds, sponge gardens and deep-water oceanic communities all occur elsewhere, no other MPA contains such biodiversity. As the world's largest coral reef ecosystem, the GBRMP is a critical global resource. The RAP is one of the key management strategies that will contributes to protection of the GBRMP and aims to help:

- maintain biological diversity at the ecosystem, habitat, species, population and genetic levels;
- allow species to function undisturbed in some areas
- provide an ecological safety margin against human-induced and natural disasters;
- provide a solid ecological base from which threatened species or habitats can recover or repair themselves; and
- maintain ecological processes and systems [3].

If 'representative' examples of all known habitat and community types are able to be identified and adequately protected within a network of no-take areas, then these areas should conserve examples of most species together with the habitats and ecological processes upon which they depend. The fact is we know astonishingly little about marine biodiversity [4] and a considerable proportion of marine species have yet to be discovered. This 'representative' approach will help ensure protection for the species we know and will minimise the risk of failing to protect biodiversity that we have not yet described or discovered.

Furthermore this ecosystem-scale and representative planning approach is a more systematic and holistic methodology than has been applied previously in the GBRMP.

In the following paper, some of the lessons learnt from the RAP approach to planning and zoning the entire GBRMP are discussed. While the GBRMP is not a typical MPA in terms of its size or its complexity[1], it is considered that the experience gained in the GBRMP has relevance to many other MPAs and it is recognised that, internationally, there are increasing moves toward ecosystem-level planning.

Planning the Great Barrier Reef Marine Park
Since the first GBR zoning plan was prepared in 1981, zoning has been widely regarded as the cornerstone of GBRMP planning and management [2].

[1] The Great Barrier Reef Marine Park covers 345,000 square kilometres – for comparison, about the size of Japan or about half the State of Texas. It is a critical part of Australia's economy, with some A$1 billion per annum being directly attributable to the GBR. It is complex jurisdictionally, with both the Federal and State Governments involved in management of the waters and islands within the outer boundaries.

Broad-area integrated management with zoning within a large marine protected area (MPA) is more effective than a series of small isolated highly protected areas within a broader unmanaged area [2,5] because:

- *ecologically* - it recognises temporal/spatial scales at which ecological systems operate and ensures the entire MPA remains viable as a functioning ecosystem;
- *practically* - it is easier to manage; it buffers and dilutes the impacts of activities in areas adjacent to highly protected 'core' areas;
- *socially* – can help to resolve and separate conflicting uses and ensure all reasonable uses can occur with minimal conflict, and can minimize confusion in that a single management agency has responsibility rather than a multitude of differing agencies; and
- *economically* – integration within a larger area will generally have lower management costs per spatial area, than a series of small MPAs managed separately.

The broad objectives of zoning in the GBR Marine Park are set out in the legislation [6] and zoning plans are required by the *Great Barrier Reef Marine Park Act* to define the purposes for which certain areas of the Marine Park may be used or entered. Zoning allows reasonable activities, such as tourism, fishing, boating, diving and research to occur in specific areas, but also separates conflicting uses and determines the appropriateness of various extractive activities [2].

While the zoning approach being applied to implement the RAP is similar to that undertaken for previous zoning tasks by GBRMPA, there are some major differences, including the fact that planning is simultaneously occurring across the entire GBRMP, there is a greater emphasis on protecting biodiversity and an increased use of technological tools (e.g. Geographic Information Systems, computer-based algorithms, etc) to assist with the planning task.

The phases of RAP can be summarised [3] as:

- *Classification* - describe the biological diversity of the entire GBRMP through development of a bioregionalisation and the depiction of bioregions.
- *Review* - evaluate the adequacy of the existing network of no-take areas.
- *Identification* - identify potential networks of no-take areas that achieve the ecological and socio-economic objectives of RAP.
- *Selection* - select from amongst the potential networks to maximise beneficial and minimise detrimental impacts considering social, economic, cultural and management implications.
- *Draft zoning plan* – prepare, and release for public comment, a draft zoning plan depicting the results of RAP.
- *Final zoning plan* prepared and implemented

The RAP relies heavily upon collaboration between planners, managers, scientists and stakeholders to help protect the range of biological diversity within the GBRMP.

Key aspects of the RAP planning approach

Key aspects in the RAP planning approach which differ from previous zoning tasks include:

1. **The development of the GBR-wide bioregionalisation**

A comprehensive range of biological and physical information was used to define 30 reef and 40 non-reef bioregions across the GBRMP.

The process by which this was undertaken [3] included information from numerous scientists with expert knowledge of the GBR, analyses using classification and regression tree analysis to spatially cluster areas of similar species composition [8] and a number of workshops. The workshops were crucial, during which reef and non-reef experts used their experience in the

GBR Region, the physical and biological datasets, and the classification and regression tree analyses, to spatially describe the biodiversity of the GBR at a scale that was considered appropriate to reflect the gradients of change.

It was decided to map diversity at the scale of 10s to 100s of kilometres because this was a scale over which habitats change markedly, it was a scale at which much relevant information was available and it was also a meaningful scale for subsequent planning and management. Areas of relative homogeneity were labelled 'bioregions' to facilitate communication with stakeholders. Bioregions have habitats, communities (e.g. areas of seagrass) and physical features (e.g. sediment type, depth) that are more similar within the bioregion than those occurring in other bioregions.

2. The development of clear and transparent operating principles

Eleven biophysical operational principles [3] were developed through literature searches, interviews with scientists and over 12 months of iteration between a Scientific Steering Committee and expert panels (details of these principles can be found in specific 'Technical Information Sheets' on the RAP website – see Appendix 1)

The biophysical principles included recommendations for amounts of 'no-take' areas for each bioregion and each known habitat type. Given the uncertainty about what amounts would be adequate for effective conservation, the recommendations were considered to be the minimum, in the context of global experience with marine reserves. Reef experts described the minimum amount in terms of minimum numbers of reefs, distribution of reefs, proportion of reef area and of reef perimeter for each bioregion. Non-reef experts considered the minimum and maximum sized bioregions, their limited knowledge of viable population sizes and habitat diversity to define a proportion of each bioregion to be protected. In all cases, the experts recommended replication throughout the bioregion, wherever the size of the bioregion permitted.

A set of social, economic and cultural operational principles was similarly defined and agreed by a Social, Economic and Cultural Steering Committee [3] – also see Appendix 1.

3. The level of, and approach to, public consultation

The approach to public consultation in RAP is broadly set out in legislation (s. 32 of the *Act* [6]) but also builds upon the experience learnt from previous GBRMPA planning tasks. The first formal Community Participation phase (CP1) of RAP was extremely resource-intensive, and involved a variety of techniques (see Appendix 1) to ensure the widest possible cross section of the community was aware of RAP and made comments or provided submissions.

Many elements of CP1 were extremely successful, in particular the community information sessions. Some statistics for CP1 included:

- community information programs undertaken in 22 regional centres
- over 200 meetings, engaging over 5,000 people face-to-face about RAP
- 33,000 submissions brochures distributed
- over 4,000 telephone calls to the GBRMPA free-call number.
- over 1,500 Community Service Announcements on television
- newspaper articles (over 100)
- newspaper advertisements (about 70 at beginning and end of CP1)
- radio (over 60) and TV spots (approximately 10)
- 6,800 visits (~38,000 hits) to the RAP area on the GBRMPA website

As a result of this high level of community engagement, 10,190 written submissions were received from the general public, the largest number ever received by the GBRMPA for a zoning or management planning exercise. The unprecedented level of publicity about the rezoning program and the large number of written submissions required a number of innovative

ways to handle the huge amount of information and use it to help GBRMPA to develop a Draft Zoning Plan.

4. Identifying options for no-take area networks

The approach taken to identify options for no-take area networks is using a combination of expert opinion, stakeholder involvement and analytical approaches. The analytical approaches comprise marine reserve design software, adapted and expended for use in RAP, and a suite of GIS-based spatial analysis tools.

A number of existing algorithms and reserve design approaches were examined for their applicability to RAP, including methods which are essentially manual with computer support. Given the size of the computational problem in the GBRMP (the numerous data layers and the division of the GBRMP into >16,000 planning units), the most suitable algorithms were 'simulated annealing' as implemented in MarXan [7], and iterative selection / removal algorithms based on the utility of multi-variate regression trees [8]. The latter was used highly effectively as an exploratory tool for examination of the broad implications of RAP and to explore assumptions regarding trade-offs.

MarXan was considered the most useful and available software package available for the RAP task because it is a proven, simple (the software is a single executable file), well-documented algorithm capable of rapidly producing, for any given set of inputs, many near-optimal reserve networks [9]. Thus MarXan can simultaneously consider many conservation features to produce a range of options meeting the biodiversity objectives critical to the RAP. By integrating a series of data layers representing social and economic values, these too can be considered when developing options.

Regardless of the reserve selection method used, being able to determine to what extent a 'candidate' reserve network meets the biophysical operating principles, and how much it impacts on the known socio-economic values reflected in available data layers, is an invaluable aspect of the analytical approach. To enable this, GBRMPA developed an extensive 'post-hoc reporting' system based on spatial analysis and a database.

Reserve selection and GIS-based spatial analysis tools have greatly assisted the GBRMPA to achieve its RAP goal while maximising beneficial impacts and minimising economic, cultural and social impacts upon the community and users.

Lessons learnt during the RAP

Following is a list of some of the lessons learned from the RAP planning approach for the GBRMP. Their inclusion does mean to imply they were not considered from the outset, but more to emphasise their importance to planners and managers.

1. Lessons learnt when developing a bioregionalisation

a) Experts alone will not develop a regionalisation that is useful for broad-scale planning

There was an initial reticence amongst some experts about defining bioregions given their imperfect knowledge and the varying levels of information for the entire GBR. The park planners were able to convince them that working together to develop a regionalisation using best available information was far more effective, and the outcome was preferable, than if the planners alone attempted to do it in isolation.

It is important to note however, that the data layers themselves did not lead directly to, or 'construct' the regionalisation, as some would believe. The iterative workshops were crucial, during which the reef and non-reef experts used their experience in the GBR Region, all the available physical and biological datasets, and the classification and regression tree analyses, to spatially depict the biodiversity of the GBR.

The bioregions were therefore finalised only after numerous iterations and advice from a wide range of experts, various steering committees and public input, which altogether took some 18 months to complete.

b) There is never 'perfect' information for a regionalisation

The park planners were fortunate in that considerable data exists for the GBR; however there were also considerable gaps, and the use of the classification and regression tree analyses [8], combined with expert opinion, was invaluable [10]. As the independent reviewer noted for the final regionalisation [11]:

> *"The multivariate regression tree approach is state-of the-art and builds on a long history of multivariate classification methods used in ecology to make maps of similar types of habitat. These multivariate methods, combined with the use of expert opinion when data are scarce or absent, seems to be a very powerful approach that makes best use of all available information".*

The best available information was used, with an explicit acknowledgement that better information in the future may mean the bioregions could be improved over time. A draft version of the bioregionalisation was also made widely available for public comment recognising that many local 'experts', including commercial and recreational fishers, coastal residents, park rangers, and other experts do have specialist knowledge about the level of variability of the GBR. This led to additional information and nine refinements to the draft regionalisation [12].

c) Don't get 'hung up' on trying to determine perfect bioregion boundaries

While some bioregion boundaries were distinct and easy to define (e.g. the windward edge of ribbon reefs), others, and particularly the non-reef bioregions, had boundaries that divided ecological continua or were imprecise reflecting incomplete data [10]. Most of the boundaries between the reef and non-reef bioregions were classified as 'fuzzy' due in part to an understanding of the connectivity of the regions and in part due to incomplete knowledge.

d) The value of a robust regionalisation

The bioregionalisation [12] is a critical component of the RAP planning approach. It was considered worth refining it as far as was possible before proceeding as it provides an essential foundation upon which all subsequent planning is built – if there are stakeholder concerns about the regionalisation, then it is much harder to use it as a basis for planning.

In the GBRMP, the bioregions reflect the huge diversity of broad-scale habitats and communities and the variation between reef and non-reef areas, the considerable latitudinal diversity, and the obvious differences between inshore and offshore areas.

As the independent reviewer noted for the final regionalisation [11]:

> *"…. the classification of spatial patterns in biodiversity in the GBR is of very high quality and has produced a robust regionalisation".*

> *"… this regionalisation should be made widely available so that other spatial mapping, monitoring and management programs can make use of the information. To the extent possible, given constraints of data ownership and availability, the underlying data for the regionalisation should also be made available. …. the chance of cooperative interaction and synergy between researchers, industry and managers is more likely if they are using a common map base".*

2. Lessons learnt about developing operating principles

a) A clear and transparent set of operating principles assists everyone

Implementation of both sets of principles has greatly assisted with the identification of a new network of 'no-take' areas, and has provided clear and transparent guidance for the design of a network that meets the biodiversity objectives of RAP and achieves the best possible outcomes.

b) All the operating principles need to be considered as a 'package', and not in isolation

The biophysical operational principles must be treated as a package to underpin the choice of what number, size and location of no-take areas to implement. If all these principles are implemented in full, the expects consider that around 25-30% of the total area of the GBRMP will be protected in a network of no-take areas – however they recognise that in some bioregions there will be more and others less.

The 20% figure alone has been quoted elsewhere as the minimum proportion of a type of ecosystem that must be delineated as no-take in order for an MPA to be effective in protecting natural resources [13]. The final percentage protection recommended per bioregion in the RAP is the outcome of implementing all the biophysical operating principles (including those principles which refer to each bioregion) as well as the principles referring to specific levels of protection for different habitats, communities and special and unique areas.

c) The operating principles are not targets or 'ideal' amounts

These biophysical operational principles refer to recommended minimum amounts of protection. The experts consider that to achieve the objectives of RAP, the GBRMPA should protect at least these amounts in each bioregion and each habitat – none of these recommendations are for 'ideal' or 'desired' amounts. Ideal or desired amounts required for full protection are likely to be greater than indicated by the biophysical operational principles.

d) The operating principles are based on the best available advice and can always be improved

The biophysical operational principles are considered the best estimates of the requirements to provide minimum protection through declaration of no-take areas, and are based upon current knowledge of the GBR ecosystem, available literature and expert knowledge, but may require review as new information becomes available.

3. Lessons learnt about public participation

a) There is no simple way of creating a conflict-free consultative mechanisms for large complex areas

While many decision-makers would like to have consensus-based decision making, *"consensus is not an achievable goal for stakeholder processes dealing with issues of this magnitude"* [14]. There are so many conflicting views about RAP and its outcomes that no solution will totally satisfy all the users and stakeholders.

b) ***People needed to understand there was a problem before accepting that a solution is required***

GBRMPA needed to inform stakeholders that the GBR was 'under pressure' and that the level of protection of the biodiversity was insufficient before stakeholders were willing to accept RAP as part of the solution.

c) Many stakeholders had little understanding of the key issues

Many people had never heard the word 'biodiversity', or did not understand its importance for the future of the GBR or for the everyday uses that depend on the GBRMP. GBRMPA therefore used the following definition to communicate in layman's terms:

> *"Biodiversity means all plants and animals together with the places they live and the natural processes that keep them alive".*

Another example was trying to explain in simple terms how the GBR 'worked' and the importance of 'connectivity' in the marine environment. This information was most effectively presented in summary form by a poster entitled '*Crossing the Blue Highway'* (see Appendix 1). It showed, using a combination of digital art, photography and words, the connectivity concept between land and sea, and within the habitats of the GBR that together reinforced the need for a 'representative' approach to zoning.

d) RAP is not about managing fisheries but rather about protecting biodiversity

There were many outspoken critics who maintained that increasing no-take areas would not benefit fisheries and would more likely have adverse impacts on the distribution of fishing effort. Such people needed to be continually reminded that RAP was not about fisheries management, but was about protecting biodiversity. However if RAP is undertaken as planned, it is likely it will have positive benefits for fish stocks despite the fact this was not the prime objective.

e) Different messages for different target audiences (a strategic approach)

Different stakeholder groups have interests in different aspects of the RAP so communication messages were appropriately tailored. For example, targeting of elected representatives and the media with information specifically formatted for their needs was useful. This was done prior to the formal launch of RAP, and during the CP1. A 'Leader's Guide' was written and delivered to all key State and Federal members along the Queensland coast and, where appropriate, personal briefings were undertaken by senior GBRMPA staff. Contacting these people prior to CP1 was a pre-emptive effort, which in general worked very well. Whether or not such representatives agreed with the RAP, personal briefings helped to ensure that had the correct information, had materials to give to their constituents, and had a personal contact within GBRMPA if further information was required.

f) Some elements of the CP1 were more successful than others

The Community Information Sessions in regional and local centres were particularly successful. These were information 'displays' set up and manned in regional centres (generally for a half-day period of 3-7pm) to enable any interested person to obtain information, make their comments or hear what the GBRMPA was proposing in an informative and inclusive environment. While these sessions required a high degree of organisation and a large commitment in terms of resources and staff, including senior levels of management, the response and results indicated it was well worth the effort. The format was non-threatening for the public and more informal and effective than public meetings. It was successful in meeting its objectives of information exchange and promoting understanding of the RAP program and its objectives. It was also an opportunity for staff from the principal management agencies to share ideas and issues.

The quantity, style and level of information that was produced to support RAP and respond to public enquiries were considered to be very successful. A blend of technical, scientific and layman's information was produced and made widely available (refer to Appendix 1).

Adequate advertising about forthcoming Community Information Sessions in local media ahead of time was important, as was the choice of suitable time and venue in each location.

We also learned, through CP1, that more local communities should have been targeted for Community Information Sessions

g) There are those that support the proposed increase in the level of protection but who will not overtly state their views

The silent majority can often be 'drowned-out' by the vocal minority who are highly motivated to voice their concerns. The format of the Community Information Sessions assisted in ensuring that all interested parties had an opportunity to be heard and ask questions. In terms of submissions, many supporters do not make the effort to voice their approval of increased protection. If they think things are going okay, they are not motivated to act.

A planning process, such as the RAP, can draw emotive responses from some segments of the community but nothing from other groups. This can be due to a range of factors that include but are not limited to a lack of understanding and or information about the issue, limited institutional capacity to respond, or an assumption by some parties that themselves will not be negatively affected by the proposed changes.

h) Dealing with such a huge number of submissions

Submissions were received in a number of formats: letters, reports, pro-formas, petitions, GBRMPA's submission form; of these, some 4,000 submissions contained spatial information on maps.

Anticipating a considerable number of submissions, an Oracle database with an Access interface was specifically developed to facilitate and manage the analysis of the submissions [15]. Procedures for handling and processing of submissions, including data entry standards for maps, were also developed. This was a complex process that required fine-tuning to the end. The database provided the capacity for many types of queries to be made of the information contained in the submissions (for example, what were the comments from a single sector or what were the comments from a geographical area, a particular location or about a specific issue).

All submissions were analysed by application of a content / thematic method [15]. This method is a standard approach for qualitative analysis and for the analysis of large volumes of information, such as presented by over 10,000 submissions, and is the most efficient method for drawing out the issues contained in the submissions.

Seven key themes with linked sub-themes were identified from a geographically stratified sample of 1,200 submissions drawn from all the submissions [15].

- maintain take/access
- consequences
- communication
- other issues
- protection
- alternatives
- enforcement

For each key theme, there were a number of sub-themes, which collectively encompassed virtually all the comments made in the submissions. All 10,190 submissions were then coded against the relevant sub-themes that enabled analysis at a number of thematic levels. A set of pre-determined attributes (e.g. postcode, type of submission, primary interest, secondary interest, etc) was also assigned to each submission when they were analysed.

i) Dealing with spatial submissions (maps)

Over 4,000 submissions contained maps (mostly in a format provided by GBRMPA), indicating places that people wanted to maintain or introduce as no-take zones, did not want as no-take zones or wanted to have some other zoning. This spatial information was

allocated to map units by a manual overlay and interpretation process following standard rules, allowing the data to be entered into the submissions database by simple key-stroke entry. More detailed submissions were digitised directly to preserve specific boundaries for future reference.

The spatial allowed us to use the submissions directly in the analytical process to help guide the location of new no-take zones.

j) Can these submissions be considered as a sample of views?

When considering the information presented by written submissions in such a public process, it must be borne in mind that there are particular constraints as to the use of the information. The content of the submissions does not represent a set of responses from a sample population drawn from either local communities or communities with interest/s in the Great Barrier Reef. Significantly therefore, importance must be given to the substance of the content of each submission rather than the number of times a comment was submitted.

From the content of the submissions there is an overall assumption that the re-zoning of the GBRMP is polarised into those for or against the introduction of no-take zones. Many other issues related to the re-zoning, such as the inclusion and zoning of new areas, and coordinate-based mapping in the Marine Park, were not addressed as comprehensively in the submissions as they might have been if the emphasis of debate about the intent of the re-zoning been different.

For the GBRMPA re-zoning process, each submission will be considered on its own merits. Essentially, the data base application developed to manage and store the information in the submissions provides greater scope for GBRMPA planners and other interested parties to interact with and understand the detail of all the submissions. It must also be noted that any summary of the content of such a large number of submissions cannot do justice to the depth of information presented by many individual submissions.

4. Identifying options for no-take area networks

a) Can terrestrial approaches of reserve design be applied in marine situations?

The ecological issues in reserve design for marine systems differ from those in terrestrial systems. Ecological connectivity, meta-populations, and directional flows affecting breeding populations and recruits are typically more dominant in marine systems than in terrestrial systems, so marine reserve design processes must be spatially explicit. While spatially explicit approaches to terrestrial reserve design date from 1993 [16], the driving force behind the development of MarXan was to improve the representation of spatial relationships for simulated annealing.

Simulated annealing is a well-established optimisation approach, extensively adapted and applied analytically to a number of terrestrial reserve design problems in Australia [7]. A basic algorithm (SpeXan) has been used in a variety of applications to address a number of terrestrial reserve design problems, and is the basis for the optimisation routines in other approaches. SpeXan, and its marine version MarXan, uses an iterative randomisation to converge on a near-optimal solution [9]. The algorithm is used to minimise an objective function, which represents the conservation objectives (i.e. maximising the biophysical principles) and costs (i.e. minimising the socio-economic costs) to determining a 'candidate area' network.

b) Why was the optimising algorithm approach chosen for RAP?

The propensity for near-optimal solutions based on problems that include both biodiversity/conservation principles and costs, and some measures of persistence, means that optimising algorithms and their related approaches are preferable for the GBRMP situation [9]. However it is important to remember that there are many solutions that meet any particular set of optimisation goals.

c) Has this approach been used elsewhere?

There has been a similar application of MarXan [7] in selection of MPAs in the Channel Islands (California) and Florida Keys, and MarXan is currently being used to develop priority areas in Australia's South East Regional Marine Plan. Beyond these applications, and a number of research projects, few applications of the optimisation approaches are known for marine reserves.

d) How is the analytical approach depicted spatially?

The algorithms are interfaced to GIS software. The GIS provides variously pre-processing of data, and input data to the algorithm 'kernel', followed by post-processing and map displays of the outputs. GBRMPA has developed a large GIS spatial analysis infrastructure to support the reserve design software.

All Draft Zoning Plan maps will be in the coordinate-based mapping format (i.e. latitude/longitude or GPS points) and an algorithm has been developed (Adam Lewis, pers comm.) which readily coverts any proposed 'candidate area' network developed by the analytical approach into a coordinate-based mapping format.

e) Will the optimising algorithm approach produce the final solution?

The analytical approach alone will <u>not</u> provide the final, pragmatic, solution. There is still a considerable amount of 'fine-tuning' that can only be done by manual methods to achieve the final zoning plan. What it does do is allow many layers of data to be assessed against ecological criteria to generate hundreds of options. This allows some flexibility in the design of a final 'candidate area' network. As the information included in the optimisation process improves, the options it generates become more and more realistic, approaching the final solution.

f) Post-hoc accounting is an invaluable aspect of the analytical approach

While one of the most optimal solutions may be chosen initially, this is inevitably refined when socio-economic values not represented in the data are introduced. The post-hoc accounting enables a clear and rapid indication of the consequences of various options.

g) A logical framework to achieve defendable outcomes

While the biophysical and socio-economic data are crucial elements of the RAP analytical approach, having access to this technical detail alone is insufficient. Without a framework and guidance on how to deal with such individual datasets, the overall RAP outcomes would be at risk of being biased by specific individual datasets, by specific science interests and agendas, or by politically influential scientists. Establishing with scientists and stakeholders an agreed approach, framework and principles upon which to proceed, as well as agreeing on the datasets to be used, were crucial elements of ensuring the technical community, and the stakeholders with technical interests, were kept fully informed of the RAP analytical process. Without this, the RAP outcomes would be open to further criticism on the grounds of technical bias.

h) Technical depth of the analytical process

The optimisation approach uses various data layers, including biophysical data, the bioregions, and information about various uses. To ensure the scientific acceptability of the final outcomes, it was considered appropriate to adopt a technically robust approach.

Many local scientists from the GBR region were involved in providing advice and support for the RAP process, and while the scientific basis for RAP was never the only basis for choosing appropriate areas, it is an important component.

While the final outcome of the RAP is not totally dictated by the technical analysis process, it does underpin the decision process, and makes the outcomes more explicit and acceptable to all stakeholders including scientists. Without this level of transparency and acceptability, the RAP may have become much more technically controversial, and this may have influenced the views of many other non-expert stakeholders. Overall, the detailed technical basis for the RAP has been a prudent investment in ensuring the technical acceptability of the overall RAP outcomes. The technical aspects are designed to ensure that the process is not science-controlled, but is science-supported.

How applicable might the RAP approach be in other marine planning situations?
While the various approaches applied in the RAP as outlined above have worked well in the GBRMP, this is not to suggest that all these aspects are essential to undertake effective marine planning elsewhere in the world. The GBRMP is fortunate in that there is substantial information available (particularly compared to many other marine areas) and the available resources and expertise are also considerable relative to other areas. Furthermore the expert input and computer-based approaches are 'world's best practice'. Nevertheless many of the planning concepts can still be applied in areas where there may be less resources or where access to sophisticated analytical tools may not exist

For example, it is conceptually a relatively simple analysis that the software implements for us. The 'layering' of different kinds of information about biological, physical, social, economic, cultural values and uses can be done using simple overlay techniques with maps on a light table trying to avoid conflicts between these information layers and build on areas where the management of the values complement each other. Obviously the more complex the problem (i.e. the geographically bigger or more information), then the more useful a GIS or other computer-based decision-support system will be. All the lack of this computer-based approach means is that a 'solution' may be less optimal when assessed against all the data; however if there are few datasets and much information in people's heads, then a manual application of the concept can still achieve an optimal solution in reality.

Where to from here with RAP?
The Draft Zoning Plan (DZP) is scheduled to be released as a major part of the second Community Participation phase (CP2) in mid-2003. The main outputs in CP2 will include:

- the **Draft Zoning Plan** (this will include maps as well as the statutory draft plan provisions)
- a **Regulatory Impact Statement** (required by Australian law)
- **Reef-wide maps** (4 full colour maps, same size as current Introductory Guides)
- a '**Basis for Zoning'** document, which:
    - provides a summary of the public submissions from CP1;
    - addresses the key issues raised in the submissions; and
    - highlights the main zone amendments proposed in the DZP
- **Information papers** on key issues
- **Submission form** (self-mailer).

As occurred in CP1, it is intended to conduct a series of Community Information sessions in important coastal centres along the GBR coast. However experience from CP1 means these sessions will be expanded in CP2 to take in some 40-50 centres including a number of smaller but important coastal communities.

It is intended that all the above products (DZP, maps etc) will be readily accessible on the GBRMPA website, be widely available at selected locations (e.g. National Park offices, Local Council offices and municipal libraries) and will also be available at all of the community information sessions.

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Appendix 1

Summary of materials used in first formal Community Participation phase of the Representative Areas Program (RAP)

Bioregions Map – Colour map showing reef and non-reef bioregions of the Great Barrier Reef World Heritage Area. Used extensively for all public contact work. Updated in March 2001 based on community feedback –available on the web http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/documents/bioregions_2001_06.pdf

'Pie-chart' maps - colour maps showing the percentage of existing 'no-take' areas within reef and non-reef bioregions. Available on the web at http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/documents/reef.jpg http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/documents/nonreef.jpg

Introductory brochure – mailed out to stakeholders with a letter from the GBRMPA Chairperson at the start of the formal phase advising that the GBRMPA was reviewing the zoning of the Marine Park and how to get a Submissions Brochure.

Submissions Brochure – sent out upon request and also available on the RAP website; included a questionnaire and information about how to obtain more detailed maps to help gather information for decision-making.

Detailed maps – 18 detailed maps covering the full extent of the GBR coastline designed to get detailed spatial information from submittees as to where new 'no-take' areas (or Green Zones) should, or should not, be located.

Leaders Guide – developed to introduce representatives of peak bodies and politicians at local State and Federal level to the RAP.

Website – the RAP website included virtually all the publicly available information http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/index.html and was highlighted on the GBRMPA homepage.

Technical Information sheets – ' stand-alone' information sheets covering the following topics, but also available on the web at http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/info_sheets.html,:

- Biodiversity and why it's important
- How the Great Barrier Reef Marine Park is managed now
- Zoning in the Great Barrier Reef Marine Park
- Do no-take areas work?
- Benefits of no-take areas
- What is the Representative Areas Program
- Biophysical operational principles
- Social, economic, cultural and management operational principles
- Review of zoning plans - the process
- New coastal areas of the Great Barrier Reef Marine Park
- Information collected to assist in the Representative Areas Program
- Summary of social and economic data for the GBR coastal communities
- Our environmental commitments - national and international
- Frequently-asked questions
- List of sources for more information

Update brochures – periodically released (Number 6 prepared in March 2003) to keep stakeholders informed of progress; also available on the RAP website http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/updates.html

'Crossing the Blue Highway' Poster – This poster provided a unique visual representation of the 'connectivity' concept, which underpins the RAP, and was extremely useful as an educational tool for a wide range of stakeholders. Also available on the web http://abc.net.au/science/bluehighway/

Television commercials – raised awareness among the broader community of the Marine Park and biodiversity and to increase the perception of risk to the Marine Park. This went to air two weeks prior to commencement of the formal phase, regionally as a paid advertisement and nationally as a Community Service Announcement.

Advertisements in regional newspapers – advised the general public that the GBRMPA was reviewing the zoning of the Marine Park and how to contact the GBRMPA.

Radio spots in regional centres – advised the general public that the GBRMPA was reviewing the zoning of the Marine Park and how to contact the GBRMPA.

Bioregion information sheets –one for each bioregion (70 in total); A4 stand-alone sheets with biophysical descriptions of each bioregion on one side and a map of the bioregion on the reverse.

Frequently Asked Questions (FAQs) - based of feedback from the informal consultation answers to the most commonly asked questions from stakeholders were developed. These FAQs were made available at meetings and presentations and on the web site.