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I M. Dutton

Peter Saenger
Southern Cross University

T Perry

Greg O. Luker
Southern Cross University

G L. Worboys

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An Integrated Approach to the Management of Coastal Aquatic Resources - A Case Study from Jervis Bay, Australia.

I. M. Dutton *, P. Saenger **, T. Perry, G. Luker and G. L.Worboys ***

Centre for Coastal Management,
University of New England - Northern Rivers,
PO. Box 157,
Lismore NSW 2480

* Present address (until 7/93):

Marine Science Education Project, Universitas Diponegoro, Semarang, C Java, I Indonesia.

** Contact author for editorial purposes
*** Manager - South east Region, New South Wales National Parks and Wildlife Service, Queanbeyan NSW (TP to supply full address for contact purposes)

ABSTRACT

1. Coastal aquatic resources are under mounting pressure from human population growth and development activities. The types of pressures evident in coastal regions are typified by the Jervis Bay region in south-eastern Australia. Despite a long history of human occupation, Jervis Bay remains largely undisturbed and rich in natural and cultural heritage values. How much longer those values and the ecological processes which sustain them will remain viable is questionable - development pressures in the region are growing at an unprecedented rate.

2. This paper describes a study which was designed to develop a conservation management strategy which overtly sought to develop an integrated approach to management of the terrestrial and marine resources of the Bay region. A geographic information system (GIS) was developed for the region, using the raster-based E-RMS GIS software system.

3. A continuum of conservation management options for the region was defined, ranging from no change to the presently limited protected area system (which covers only 7.5% of the region), to almost complete reservation. The preferred option was derived using a landscape ecology approach and comprises a mix of management areas which cover the entire marine compartment of the study area and 65% of the terrestrial area. Known as the Jervis Bay Conservation Zone, the preferred option involves a co-ordinated approach to conservation management by private and public agencies and individuals, with variable levels of control on use of core habitat and adjacent land/sea areas.

4. The study approach employed can be easily applied to other coastal areas. Three specific findings of relevance to management of coastal aquatic resources elsewhere were that traditional "reservation-based" approaches to conservation management are not likely to be effective in conserving biodiversity over time, that the planning process should be open for review by non-technical audiences to facilitate community understanding and support, and that GIS can be a very useful tool for data organisation and analysis. Ultimately, however, even comprehensive approaches such as that used in this study must be integrated with action at all scales if conservation management is to be effective.

INTRODUCTION

Aquatic resources play a vital role in the social, economic and ecological well-being of coastal communities. They are also subject to rapidly increasing pressures associated with coastal development (GESAMP, 1990). Fortunately, there is now growing recognition that sustainable utilisation of these resources (WCED, 1987; ESDSC, 1992) will require both a fundamental change in traditionally exploitative attitudes (Adam, 1985) and greater co-ordination of management actions (Dutton, 1990).

The types of pressures evident throughout the coastal zones of world, as well as the needs for improved conservation management regimes are typified by the Jervis Bay region in south-eastern Australia (Figure 1). Jervis Bay is a large, deepwater harbour, widely renowned (Catford, 1987; Beckmann, 1991) for its diverse marine ecosystems and high water quality. The Bay catchment is small (425 km^2) and contains a mixture of rural and urban land uses. Despite a long history of human occupation, parts of the region remain largely undisturbed and rich in natural and cultural heritage. There is mounting concern, however, about whether those values can be conserved in perpetuity (Kristo, 1989), because demands on the resources of the region are increasing at an unprecedented level (Department of Planning, 1992).

There have been many proposals for conservation management of Jervis Bay (e.g. ALS, 1973; Catford, 1987; Davies, 1987; Kristo, 1989; NPA, 1991; NSW Department of Planning, 1992) and there is a growing recognition of the fundamental importance of integrative coastal management (HORSCERA, 1991). Despite these initiatives, however, the Bay remains highly vulnerable to "*ad hoc*" development pressure. Present management effort is limited in geographic scope and, for a variety of reasons, tends to be largely ineffective at the regional scale. These limitations are now being acknowledged by management agencies and have stimulated interest in developing a comprehensive approach to conservation management of the Jervis Bay region. Specifically, this paper describes a study (CCM, 1992) which was directed " … to determine the range of practical options for the conservation of the marine and terrestrial environments (including natural and cultural values of the Jervis Bay Region".

The study involved development of a comprehensive geographic information system comprised of physical, biological and social attributes of the region, as a basis for definition and analysis of conservation management options. A wide range of attribute layers were developed and used in the later generation of conservation management options and analysis of option performance.

The following sections outline the conservation management needs of the Bay region, and describe the approach used in addressing those needs. The paper concludes with an overview of the resultant conservation strategy and recommendations on approaches which could be employed to address similar issues elsewhere.

It should be noted that while many of the issues (e.g. biodiversity conservation) described have global linkages, the types af conservation management choices available in an area like Jervis Bay are possibly greater than for comparable areas in other developed or developing countries. Thus, while the study approach described is relevant for wider use, the actual conservation management measures described should be carefully re-evaluated in the context of local circumstances before application elsewhere, especially in developing countries, where resources are typically more limited.

OVERVIEW OF THE JERVIS BAY REGION

Location and Regional Setting

The Jervis Bay region is located approximately 200 kilometres south of Sydney on the south coast of New South Wales. The Bay is located in the northern part of the fast growing Shoalhaven area, approximately 20 kilometres from Nowra, the closest city.

The Jervis Bay region, as described in the study (CCM, 1992) reported here, encompasses the entire catchment of Jervis Bay, the Bay proper and a three nautical mile (previously State Territorial waters) area between Sussex Inlet and the Crookhaven River (see Figure 1). This area comprises some 843 square kilometres which is almost evenly divided between marine (425 km^2) and terrestrial (418 km^2) systems.

INSERT FIGURE 1 HERE

Conservation Values

The Jervis Bay region is rich in natural and cultural heritage, and recently has been nominated for listing on the Register of the National Estate (a national system for recognition of significant heritage sites, but which does not provide for specific protection to the same extent as say National Park status). There are at present two formally defined protected areas - the Jervis Bay

National Park and the Gurumbi Nature Reserve which jointly cover 13% of the terrestrial part of the region and 2% of the marine part.

According to Catford (1987), the combination of syncline, faulting and Permian rocks make Jervis Bay unique, at least on the East Coast of Australia. Because of limited modification of large tracts of the Bay catchment, the terrestrial ecosystems of the Bay are diverse and support a diverse flora and fauna. The NSW National Parks and Wildlife Service (1987) notes that many of the plant communities of the Bay area are of high conservation value, and support a wide diversity of animal life, including some 40 species considered rare, or of special interest.

The marine ecosystems of the Bay are similarly rich. According to West (1987), littoral and sub-littoral plant communities of the Bay are of both local and State-wide significance. Of particular value are the seagrass beds containing the species *Posidonia australis* - Jervis Bay has the largest area of this species in NSW.

Freary (1986) observes that the area is unparalleled on the NSW south coast for its Aboriginal cultural heritage, with over 300 sites so far recorded. In terms of European heritage, there are numerous sites of historical significance within the region, particularly defence and navigation structures in the vicinity of the Bay foreshores.

The high amenity value of marine and coastal landscapes within the Bay is further enhanced, relative to other parts of the NSW coastline, by the limited extent of development within the Bay area. Tourism is a dominant land use within the region, with Jervis Bay receiving some 800,000 visitors per annum. Urban development is generally confined to small settlements at the head of the Bay, with a total permanent population of less than 20 000 people.

The catchment is characterised by a mosaic of predominantly rural and forestry land uses. Exploitation of the marine resources of the Bay is largely unregulated (except for Defence activities) and is dominated by recreational and commercial fishing. Another popular use of the Bay is recreational diving, with the Bay characterised as one of the finest in NSW (Ivanovici, 1987) for this pursuit.

In summary, Jervis Bay provides a wide range of attractions for a diverse range of pursuits and potentially is suitable for a wide range of land uses. All of these attractions are dependent on the ecological, heritage and amenity values of the region. Table 1 below summarises the relative significance of these values at a range of scales.

TABLE 1 GOES HERE

Management Issues

It is uncertain how much longer those features of Jervis Bay that society considers valuable are likely to remain. Demands on the Bay are increasing, prompting concern such as that expressed by Kristo (1989), that the region may "die the death of a thousand cuts, as piecemeal and inappropriate developments cumulatively threaten the attractions of the Bay. Kristo (1989) goes on to observe that "a regional plan of management is required to ensure that we hand on this legacy in equal or better condition than it exists today. The exceptional natural values of Jervis Bay demand a regional, integrated environmental approach to development planning".

Although there have been many proposals for conservation management of Jervis Bay and there is a growing recognition of the fundamental importance of integrative coastal management (e.g. HORSCERA, 1991), at present, the Bay remain highly vulnerable to '*ad hoc*' development pressure. Present conservation management effort is limited in geographic scope and, for a variety of reasons, particularly the unique division of administration between Commonwealth, State and local governments, tends to be largely ineffective.

Recent interest in the conservation of Jervis Bay has been stimulated by defence development proposals (associated with relocation of a major naval base from Sydney - a proposal which has since been abandoned), but these are merely symptomatic of the many pressures which the Bay has faced, and will continue to be subject to, as a result of population growth in Shoalhaven City and because of the location as well as the environmental and economic attractions of the Bay area. While major development proposals such as the Murrays Beach nuclear power plant, the ARMCO steelworks and the Naval Base relocation (Department of Planning, 1992) have not eventuated, potential remains for significant development.

Present State of Knowledge

In order to provide a more satisfactory database for future planning of Jervis Bay, there has been a significant increase in research into the biophysical and socio-economic resources of the Bay area. This research, including ongoing studies studies by the national research agency, CSIRO, commissioned by the Department of Defence at a reported cost of some A$4.5 million (Beckmann, 1991) will contribute to a more complete description of the resources and functional ecology of the Bay.

Unfortunately, despite these efforts, large areas of the Bay waters and catchment remain poorly studied. There are significant gaps in basic knowledge of most terrestrial areas and, of even greatest concern (from a managerial perspective), little understanding of inter-relationships between system components. Even for those areas which have been well studied, there has generally been little emphasis on synthesis of results over broader scales. This, in turn, has led to what can be described as a dichotomous planning information base in which much is known about small areas, and a small amount is known about large areas.

Despite these inadequacies, development pressures are such that decision must be made, even in areas for which incomplete information exists. Such a situation is not unique to Jervis Bay - the recent House of Representatives Inquiry into Coastal management in Australia (HORSCERA, 1991) noted that "there is still a lack of understanding and knowledge of coastal processes, despite the significant investment in environmental research over the decade since the 1980 Coastal Zone lnquiry, in which it was observed that there is a serious lack of information on the coastal zone".

In order to redress these deficiencies, particularly those which arise from the lack of integration of available information, several reports have been prepared over the past decade which sought to compile available information and present a broadscale approach to planning of the Bay region (e.g. Davies, 1987; ACF, 1990; Mills and Associates, 1991; NPA, 1991).

The most recent of these has been a Regional Planning Exercise (henceforth RPE) undertaken jointly between the local government (Shoalhaven City Council) and the NSW State Department of Planning (together with input from other agencies) which investigated the development potential of the Bay region (NSW Department of Planning, 1992). The RPE study evaluated a wide range of planning issues and provided for considerable public involvement in information gathering and option evaluation.

The latter period of the RPE study overlapped with the inauguration of this study (CCM, 1992). Importantly, the RPE study provided useful, up-to-date information on aspects of the Jervis Bay region of interest in the context of the study. In particular, the study of wildlife corridors in the Jervis Bay region (Mills and Associates, 1991) provided a valuable synthesis of information on fauna distribution and habitat requirements. The Conservation Management Strategy (CCM, 1992) described below will form, in turn, an input to the further development of the RPE study.

STUDY APPROACH

Study Context

Although there have been numerous attempts to document the conservation values of the Bay and then relate these to management requirements, these have been typically incomplete, either in subject or geographic coverage, and/or inadequately linked with statutory requirements for land use planning. As a consequence, present conservation management in the Jervis Bay region is characterised by:

a. fragmentation - management effort is divided between a range of Authorities divided between four governments at three levels: national, state and local). This division is unique in the Australian coastal zone and is due to the historical establishment of an Australian Capital Territory (ACT) at the turn of this century. The selection of a landlocked national capital (Canberra) prompted a desire to provide secure sea access to the newly created capital, and resulted in Jervis Bay being set aside for this purpose. As a consequence of this, and related national intervention (mainly for defence purposes), the administration of Jervis Bay is divided between a range of authorities, each of which has jurisdiction for limited areas;

b. reactive management - conservation is not a primary objective for management of much of the Bay region, and areas which may be of special conservation significance are extremely vulnerable to either direct modification (e.g. vegetation clearing in areas not formally protected by national park status), or the indirect effects of development (e.g. changes in water quality caused by upstream development);

c. competition - resources available for management are limited and unevenly distributed within and between management authorities; and

d. uncertainty - the limited knowledge of the conservation resources of the Bay has a twofold effect. Firstly, it means that management decisions often are made on the basis of inadequate information, and secondly, it means that even where information is adequate, it may not reflect necessarily the broader context of decision-making (e.g. overall conservation priorities).

To try and resolve these problems, the two State-level nature conservation organisations, the ACT Parks and Conservation Service and the NSW National Parks and Wildlife Service sought the support af the Australian National Parks and Wildlife Service (national nature conservation authority) to inaugurate the present study.

Study Methods

The study basically comprised two interwoven stages - a review of existing information on the Bay (no new data were to be collected) and definition of conservation management options. Figure 2 sets out the broad study sequence, and indicates key study inputs and outputs.

FIGURE 2 GOES HERE

After preliminary analysis of task requirements, it was decided that the most appropriate tool for both data review and option development was a computer-based geographic information system (GIS). Surprisingly, no such system had been developed for the Jervis Bay region previously, although some attributes of the Bay had been recorded in GIS format (e.g. land tenure).

Budget and time limitations required the selection of a GIS system which allowed:

* easy data capture (incorporating available coverages and simple digitiser entry);
* an adequate level of spatial resolution (20m accuracy was selected);
* capacity to be manipulated by non-expert 'end-users';
* prediction of areas of conservation interest for which incomplete information existed; and
* automated interrogation of the efficacy of management options.

After a review of available systems, the E-RMS GIS package, developed by the NSW National Parks and Wildlife Service (NSW NPWS, 1989), was selected as it most closely met these needs. The E-RMS package is a raster-based system and hence less flexible than more sophisticated vector-based systems such as the widely used ARC/INFO package (Franklin, 1992). Nonetheless, E-RMS was deemed adequate for the tasks identified, was consistent with the limited resources available for the study and had the advantage of being readily transferred to end users (who employ E-RMS in day-to-day workplace applications). Vector-derived layers (in ARC/INFO format) can also be incorporated into E-RMS, thus increasing the cost-effectiveness and flexibility of data capture.

GIS Structure

Figure 3 below sets out the ultimate structure of the GIS database. In all, some 30 layers were developed and incorporated into the development of conservation management options. Numerous additional 'dummy layers' were also trialled during strategy development, and an infinite number of 'synthetic layers' can now be generated using database combinations, as noted in the Figure.

FIGURE 3 GOES SOMEWHERE NEAR HERE

One novel feature of the GIS database is the incorporation of a Digital Terrain Model (DTM), which was supplied by the NSW Land Information Centre. This was the first DTM supplied in E-RMS format and required complex data transformations before deriving an accurate representation of slope, elevation and aspect layers. These attributes proved essential in developing the derived layers outlined in Figure 3.

Conservation Management Options

After preliminary screening of GIS attribute layers and background literature, particularly recent broad-scale studies in landscape ecology such as Saunders and Hobbs (1991) and Ray and Gregg (1991), it was possible to develop a set of strategic aims for conservation management and then define a continuum of conservation management options. The strategic aims emphasized the need for an integrated approach to management of marine and terrestrial system of Jervis Bay. Additionally, unlike previous studies, priority was given to delineation of the most ecologically effective conservation management option, rather than the most administratively convenient option. While it was recognised that both are interrelated considerations in conservation management, it was considered that the many previous conservation proposals for Jervis Bay had failed largely because of an over-emphasis on administrative considerations (CCM, 1992).

The final set of management options were then clarified using a range of evaluative criteria, based on the pioneering work of Bolton and Specht (1983), which proposed five key criteria for reserve selection; naturalness, effectiveness (as a conservation unit), rarity, diversity and representativeness. Because of the lack of a comparative information, the latter three criteria proved to be of little use in the final derivation of options, however, considerations inherent in each criteria were taken into account as far as possible, and modified in the light of administrative and other factors.

Figure 4 depicts the resultant options and their essential characteristics. As schematised in the Figure, the five options are effectively a set of "nested" stages in conservation management, similar to the landscape ecology approach proposed by Noss and Harris (1986), and range from "No Change" to almost complete reservation of the study area. A key feature of the continuum is that unlike more traditional conservation planning methods such as proposed by Bolton and Specht (1983) or Mackey *et al.* (1988), this schema recognises the interdependence of conservation and development over both spatial and temporal scales. Such an approach was considered essential if the limitations of traditional protected area management scheme (e.g. Janzen, 1983) were to be avoided.

FIGURE 4 GOES NEAR HERE

Selecting a Preferred Conservation Management Option

As Westman (1984) noted, there are a wide range of techniques available for land use suitability assessment, ranging from simple non-parametric techniques to elaborate appraisal measures such as linear programming. While each have relative merits and disadvantages, ultimately the selection of an appraisal method depends on the circumstances of application. In the case of the Jervis Bay study, the specification of clear strategic aims and a need to ensure that the appraisal method would be reviewed by non-technical audiences led to the employment of an approach based on the goals-achievement matrix method (Compagnoni, 1986).

RESULTS

Table 2 outlines the performance of each option relative to the strategic aims. Option 4 achieved the highest policy satisfaction rating, followed in order by Options 3, 5, 2 and 1. Clearly, the only completely inferior option is the no change option (1), with the others satisfying more than 50% of the conservation management aims.

In view of their inherent emphasis on integrated conservation management, the most suitable options are Options 4 and 3. Structurally, Option 4 is very similar to Option 3, being based on the same network. The major difference between the two is the greater emphasis in Option 4 on management of lands adjacent to the network. However, because of difficulties in developing acceptable regulations on control of land use on lands adjacent to the network, Option 4 was discounted in favour of Option 3 as the preferred option at this stage. Option 4 may, however, be achievable in the longer term, depending on the results of the RPE study (Department of Planning, 1992).

TABLE 2 GOES NEAR HERE

Figure 5 outlines the basic extent of the preferred option, known as the Jervis Bay Conservation Zone, which covers some 65% of the terrestrial part of the study area and the entire marine compartment. The preferred option comprises several existing conservation reserves, as well as a range of new conservation areas and various land/sea use management restrictions.

For simplicity of presentation, the Figure does not include details of the types of management regime to be applied to each element within the JBCZ. However, it should be recognised that, consistent with the conceptual intent of the preferred option, priority is given to delineation of core conservation areas and their interconnecting elements. Thus, isolated habitats are to be interconnected by a range of wildlife corridors, and all perennial creeks and waterbodies are to be protected by riparian corridors. In the case of the marine compartment, a zoning scheme was developed which gives greatest protection to core (sanctuary) areas. A key feature of the JBCZ is that the aquatic resources of the Bay are to be managed in a complementary fashion e.g. as proposed by Dutton and Stewart, 1988 at both the catchment and compartment (offshore marine area) scales.

FIGURE 5 GOES HERE

In addition to the JBCZ outlined in Figure 4, the study also recommended a range of further studies and actions on the part of implementing authorities. These were basically designed to confirm the accuracy of data on which various GIS modelling procedures were based and to obtain data on areas and species for which available information proved inadequate. A number of studies designed to improve the potential of the Strategy to ultimately realise the provisions of Option 4 were also proposed, including:

* studies on Aboriginal heritage and co-operative approaches to heritage management;
* studies into economic and planning measures which would encourage the co-operation of private land holders in conservation management on freehold land; and
* design studies for development of a conservation monitoring system, based on the GIS, which is capable of assisting in contributing to an improved understanding of ecological processes, in a manner similar to that proposed by Noss (1990).

DISCUSSION

Overview

This CCM (1992) study of Jervis Bay generated a considerable volume of information and provide a timely opportunity to evaluate recent developments in conservation theory and planning technology. The experience gained is of widespread value to the management of coastal aquatic resources globally, however, for convenience, only three key aspects of that experience are discussed below. These topics are considered of most interest in the extent of transferability of the results of this study.

Towards Integrated Management

With increasing attention being given to the need for conservation of biodiversity (Bridgewater, *et al.,* 1992), there is growing recognition that traditional approaches to conservation management are inadequate in addressing the holistic needs of ecological systems and in enabling these systems to respond to change. Bridgewater *et al.* (1992) argued that nature conservation strategies must be developed and implemented outside reserves - on land that is used for a variety of purposes. Their arguments emphasize a need to see protected areas and their surrounding landscapes in terms of "ecological infrastructure". This infrastructure, they argued, allows biodiversity to occur, maintains the diversity and permits change within the wider environment.

While such views are theoretically defensible, the Jervis Bay Conservation Management Strategy study has shown just how difficult it is to operationalise the concept of landscape ecology. Few precedents exist, either globally, or in Australia in which coastal ecosystems have been successfully managed on an integrated basis, although there are a number of highly promising attempts to develop this type of approach (e.g. Noss and Harris, 1986; Kelleher, 1986; May *et al.*, 1988; ES&S, 1991). Even in these studies, it has proven difficult to fully reconcile the inevitably competing demands of nature conservation and human development, although each have attempted, like the Jervis Bay study to articulate the notion espoused in the Brundtland Report (WCED, 1987) that conservation and development represent an inter-related continuum of management choices.

A key feature of this study which is potentially relevant to future studies of this type was the overt emphasis given to ecological parameters and socio-political parameters in establishing initial management options. The continuum presented in Figure 4 provides an essential first step in both clarifying conservation choices and determining their inter-relationships. Obviously, such choices may not be present in all circumstances because of past or ongoing disturbance; however, this approach may provide useful insights into critical ecological processes and landscape patterns even in highly degraded landscapes, (Noss and Harris, 1986; Ray and Gregg, 1991).

One limitation of this approach which does, however, require further consideration is the question of scale. The Jervis Bay study area covered the entire Bay catchment - a requirement which recent planning studies (e.g. May *et al.*, 1988; ES&S; 1991) have shown is essential if adequate control on terrestrial influences on aquatic resources is to be established. Despite this, significant linkages at local (e.g. faunal dispersal), regional (e.g. vegetation communities) and wider scales could not be adequately accounted for in the preferred management option. For example, Jervis Bay contains internationally significant wader habitat (Mills, 1991). The strategy outlined in this paper should ensure that wader habitat in the immediate Jervis Bay region is protected in perpetuity. Similar action is now needed to protect the habitat of wader species throughout the remainder of their habitat in coastal Australia and their Asia-Pacific range. This need could be fulfilled, as Ray and Gregg (1991) suggested, by the establishment of a network of coastal biosphere reserves.

Clarifying the Planning Process

Once basic ecological relationships and conservation opportunities are defined, it is then appropriate to overlay these with socio-political parameters and developed a management scheme which is both defensible (on scientific, legal and socio-economic grounds) and achievable.

As Sorenson and Auster (1989) noted, failure to observe either need is likely to undermine the ultimate efficiency of any plan.

Defensibility implies not just an ability to defend a logic process using the usual scientific conventions (Underwood, 1990), but also a commitment to communication with key interest groups in the planning process (O'Riordan, 1976). In the case of Jervis Bay, any planning study builds upon a significant body of past work and, in many cases, dashed expectations. For this reason, the planning process must be open to scrutiny, reveal the basis for decision-making and be cognisant of differing perceptions of resource values.

While, ideally, the Jervis Bay Strategy study could have made provision for extensive public participation such as was used in the Trinity Inlet Study by ES&S (1991), it was decided to adopt a more selective approach to consultation so as to avoid confusion with the ongoing RPE study. This approach proved adequate to meet the needs of nature conservation management authorities in their first attempt to address "off-park" conservation issues. As the RPE (Department of Planning, 1992) develops, the strategy will become a valuable basis for educating the public on the perspectives and views of the various nature conservation agencies. For future studies to play a similar role in encouraging public understanding and involvement in resource planning, it is vital for the information processing system to be made as open as possible.

In terms of the second criterion (achievability), it is significant to note that even in a comparatively well funded conservation management regime such as found at Jervis Bay (CCM, 1992), resources are never likely to be adequate to meet the broadest range of conservation management needs. To resolve this problem, managers must prioritise their objectives (Dutton, 1990) and seek cost-effective approaches to resource management. In setting priorities, guidance should be obtained from planning studies, but these may need to be modified in the light of changing socio-political circumstances. In this respect, an educated public can play a significant role in helping to define factors which affect priority-setting, and can greatly help conservation management agencies in reviewing development proposals which may have significance beyond the immediate boundaries of established protected areas. This role has already been evident in the Jervis Bay region (e.g. ACF, 1990; NPA, 1991). If this role is to continue or be further stimulated, then it is vital for conservation management agencies to make information available to interest groups such as is planned (ANPWS, 1992) to occur as a result of this strategy - the GIS developed during this study should become a valuable reference resource for conservation, community and other interest groups.

ln terms of developing cost-effective approaches to nature conservation, (Kelleher 1988) noted that the public can also play a major role in both providing support to management agencies and reducing the costs of management. The Jervis Bay Strategy sought to incorporate both roles by developing co-operative approaches to conservation management between private and public sector agencies and individuals. As Bridgewater *et al.* (1991) observed, such approaches are likely to become more commonplace as more holistic approaches to biodiversity conservation are implemented.

Information Organisation and Processing

The GIS developed for the Jervis Bay Study proved extremely valuable in allowing a wide range of data to be easily accessed and manipulated. While such manipulations can be performed manually, an automated GIS allows the rapid input of most of the data types necessary to evaluate management options (Franklin, 1992), from a range of readily accessible media (e.g. air photos, maps, reports).

Secondly, the GIS allowed for testing of options under a range of scenarios (what if ? type questions) in a manner which would not have been possible using conventional (manual) data analysis approaches. Finally, the GIS allowed for establishment of a benchmark synthesis of known information - the database will be maintained by conservation management agencies and is expected to provide a key input to future conservation management and monitoring effort at local planning scales. The GIS will also become a powerful tool in ongoing regional planning and has already been used as a key input to the Regional Planning Exercise.

Despite these benefits, there were also some drawbacks associated with GIS use. Delays in development of Digital Terrain Model layers (Figure 3) meant that the study schedule was extended. In addition, while E-RMS has the potential to perform useful predictive modelling, the incompleteness of input layers (especially terrestrial flora and fauna) made these predictions of questionable value. This limitation was, however, offset to some extent in that the process of database development and analysis allowed clarification of information gaps and further research needs (Dutton *et al.*, 1992).

One further difficulty associated with the use of the GIS database is the lack of systematic coupling between the database development and planning analysis phases of the study (Figure

2). During the study, situations were encountered where data were entirely inadequate (e.g. on fauna distribution) or where a key layer could not be generated using available E-RMS routines (e.g on assessing the likely effectiveness of conservation management options). In these situations, supplementation of database inputs was made by manual analysis which proved time consuming and cumbersome.

Such situations are possibly inevitable where data sources are limited, however, it is considered that some of these limitations could be overcome by linking of the GIS to an expert system such as proposed by McDonald *et al.* (1991). Availability of an expert system may also serve to more clearly define data input needs a *priori* - without such initial guidance on data needs, considerable effort can be wasted on the capture of unnecessary data. For example, some 10 attribute layers generated were of little use in final strategy development.

CONCLUSION

The Jervis Bay Conservation Strategy is a pioneering approach to integrated land and water management. There are very few similar examples in Australia of planning studies which have overtly sought to establish a conservation management framework which pays equal recognition to marine and terrestrial systems and their linkages.

Because the Jervis Bay Conservation Strategy is only partially implemented, it is not possible to evaluate the efficacy of the strategy at this stage. Preliminary indications (ANPWS, 1992) suggest, however, that the strategy has already played a significant role in the regional conservation planning activities of nature conservation authorities. This role is likely to be expanded as other resource management agencies, development agencies, and the regional public become involved with strategy development and implementation via formal regional planning processes.

While the detail of the conservation management strategy for Jervis Bay is specific to Australian circumstances, the general study approach is considered to have wide potential applicability. Indeed, as GESAMP (1990) suggested, it is to be hoped that such approaches will become more commonplace as truly integrated conservation management is an urgent priority at all scales.

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Table 1: Significance of the Natural Environments of Jervis Bay

Scale	Value/Attribute Example
International	Migratory Birds (species subject to international agreement with China and Japan)
National	Marine Recreation Environments - SCUBA training National Botanic Gardens (Annex) Aboriginal Heritage Sites Jervis Bay National Park
State	Deepwater Harbour Extensive Seagrass Beds Tallest Sea Cliffs Penguin Rookery Wetlands (designated under a State Environmental Planning Policy) Rare and Endangered Animal Species (e.g. Powerful Owl) Gurumbi Nature Reserve
Regional	Bait Fish Stocks Coastal Bush Camping sites Flora of Special Significance (e.g. Heath Communities) High Marine Water Quality
Local	High Visual Amenity Recreation Opportunities (fishing and diving)

Table 2: Assessment of Conservation Management Options

Strategic Aim	Rating of Options 1: NC	2: NOD	3: NET	4: SUST	5: FRES
a. Integrated Mgt.	1	2	3	5	4
b. Protect values	2	3	4	4	4
c. Inter-relationships	1	2	4	5	3
d. Practicality	3	3	4	3	2
e. Co-operation	3	3	4	4	3
f. Co-ordination	2	3	4	5	3
g. Flexibility	1	2	3	4	4
RAW SUM (/35)	13	18	26	30	22
% SATISFACTION	37	51	74	85	62

Notes:

1. Ratings made by expert panel, with scores based on scale of 1 (low) to 5 (high).
2. Summary of aim only - all self explanatory, except for (c) which seeks overtly to recognise and protect key processes and not just specific landscape/ecosystem features. Aims (e) and (f) separated because of the nature of mixed public and private sector involvement in management. Aims not prioritised or weighted.
3. Option acronyms: NC = no change (from present management system), NOD = reservation of conservation nodes, NET = network inter-relating nodes, SUST = as for NET plus additional policy controls on adjacent land uses, 5 = almost complete reservation of region as formal protected area as per NPA (1991) proposal.