ELSEVIER

Ocean & Coastal Management, Vol. 26, No. 2, pp. 119–131, 1995
Copyright © 1995 Elsevier Science Ltd
Printed in Northern Ireland. All rights reserved
0964-5691/95 $9·50 + 0·00

0964-5691(95)00007-0

Valuing coral reef protection

Linwood H. Pendleton

Yale School of Forestry and Environmental Studies, New Haven, CT 06511, USA

(Received 15 November 1993; revised 13 February 1995)

ABSTRACT

Past economic valuations of tropical marine parks inaccurately measure their economic benefits because they value the resource protected and not the protection provided. Instead, the economic benefit of a marine park should be measured as the savings from avoided losses in reef value that would result in the absence of park protection, net of any costs of protection. Proponents of marine parks posit that reef quality will decline in the absence of active park protection. The economic benefit of the marine park is the value of avoided reef degradation. An economic framework is developed to show how marine parks and protected areas ought to be valued. An example using data from the Bonaire Marine Park is given.

1. INTRODUCTION

Coral reefs are a valued natural resource because they support a variety of benefit streams that include cultural, social, biological, and economic values. The economic benefits that come from reef ecosystems accrue to local economies and citizens around the globe. Locally, reefs support fisheries, attract SCUBA and snorkeling tourism, are a source of calcium carbonate, and provide important shoreline protection. Globally, the reef is valued for its role in the carbon cycle, for its inherent existence value, and the consumer surplus enjoyed by SCUBA divers. In recognition of the value of coral reefs, approximately 60 countries have moved to establish official protection for nearly 300 coral reef areas.[1] Marine protection, however, does not come without a price:

marine parks require buildings, boats, administration, and field personnel. Despite the potentially high cost of marine protection, analysts find that the economic benefits of marine protection outweigh the costs of protection—often by more than an order of magnitude.[2–4] Closer scrutiny, however, shows that most economic studies of marine protection are not properly valuing the actual services that protection provides.

Previous valuations of tropical marine parks consistently measure inaccurately the economic benefit of park protection because they value the resource protected and not the park.[2–4] Posner *et al.*[4] base their analysis of the Virgin Islands Marine Park on the expenditures of tourists that visit the Virgin Islands National Park. Gross expenditures by tourists to St Johns, USVI, are adjusted by a multiplier designed to capture the importance of the park in the vacationers' decision to visit the Virgin Islands. Similar estimates are made for boat charters and cruise ship visitors. Posner *et al.* estimate that the Virgin Islands National Park yields an annual benefit-to-cost ratio of 11·1 to 1.

More recent studies examine the economic benefits of the Bonaire Marine Park. Post[3] uses annual tourism taxes, park permits, and gross tourism expenditures to justify the costs of the Bonaire Marine Park. Similarly, Dixon *et al.*[2] and Dixon[5] also present an economic analysis of the Bonaire Marine Park. Like Post, this most recent analysis uses gross expenditures on divers' fees, hotels, restaurants, and other tourism-related expenditures (US$23·2 million/annum), plus taxes, to justify the start-up costs (US$0·52 million) and annual operating budget (US$0·15 million) of the Bonaire Marine Park.[2]

In theory, a marine park provides benefits (in this paper referred to simply as value) by sustaining non-consumptive recreational uses over time.[6,7] The studies mentioned above examined economic flows from marine parks only during a single year. These studies concluded implicitly that the entire benefit stream would be lost without the park. During the late 1980s, the Bonaire Marine Park did in fact cease to exist as an effective protected area due to a shortage of operating funds.[2,3] Nevertheless, tourism—primarily SCUBA tourism—continued to grow each year.[8] Clearly, the loss of the marine park did not result in a total loss of the resource and hence did not result in the loss of all tourism.

The economic benefit of marine protection should be measured as the savings from avoided losses in reef value that would result in the absence of protection, net of any costs of protection. Many of the authors cited above recognize this fact,[9] yet still justify marine protection in terms of gross tourism expenditures. As a result, large

investments in marine park infrastructure and operations are justified based on analyses that do not properly value the true impact of marine protection. Admittedly, these authors chose to measure gross tourism expenditures because these data are usually the only ones available. Nevertheless, the justification of protection costs as a percentage of gross revenues is misleading. This paper offers a framework in which to value the recreation benefits of marine protection by valuing the benefits of avoided changes in reef quality.

2. USING SHIFTS IN RECREATION DEMAND TO VALUE MARINE PARKS

2.1. Static considerations

The value of a marine park comes from the protection it provides for the marine resource. (Herein, park will be used synonymously with protection.) The park must not be confused with the resource that it protects. A marine park, or the protection of any natural area, acts to slow the expected rate of negative environmental change in a habitat and possibly even enhance environmental quality. If protection actually slows environmental deterioration, then marine protection should allow the marine resource to provide economic goods and services that are of greater value than if there were no such protection. The economic value of marine protection is the difference in the value of net economic benefits with and without marine protection.

While the benefit stream that comes from the reef resource includes use and non-use values, most economic studies of marine protection focus on the value of reef-related tourism. While somewhat restrictive, the consideration of only tourism benefits is a good start for the valuation of protection. Many marine parks, especially coral reef parks, often are created with tourism in mind. Furthermore, coral reef tourism is an increasingly important component of coastal economies. Beach tourism in the Caribbean generated over US$8·9 billion in 1990.[10] In Bonaire, a small coral-fringed island in the Dutch Antilles, nearly half of the gross domestic product comes from tourism revenues.[2] Like others, the discussion in this paper is confined primarily to the value of marine recreation (i.e. tourism) but the basic lessons apply to all aspects of the marine economy.

The recreation value of the marine resource (not the park) includes

two principal components. First, local economies benefit from the reef resource through the expenditures of vacationers. While gross revenues are often cited as the local benefits of tourism, only a fraction of these expenditures are true economic benefits. As a first approximation, we could claim that net benefits to the local economy from reef-related tourism could be measured by the net revenues of locally-owned businesses and taxes on foreigners. The true calculation of local economic benefits, however, would require a more sophisticated calculation of shadow prices. The second component of recreational value comes from the fact that vacationers derive benefits from recreation that actually exceed the total costs of visiting a site. This second value is known as the vacationers' consumer surplus.

The benefits of recreation can be determined by considering the demand function for marine recreation. The demand function relates the number of visits to a site as a function of the costs of getting to and staying at a site, the characteristics of the site, and socio-economic characteristics of the vacationer. From this demand function, we can derive an inverse demand function in which vacation costs are interpreted as the willingness of vacationers to pay to enjoy a recreation site. Figure 1 gives a hypothetical 'inverse' demand curve for the demand function in which the visitation rate (visitors/population) from any origin to a marine destination is a function of the summed costs of travel and travel time (TC) and accommodation costs (AC), all denoted as R. Visitation also is a function of the quality of the marine resource (z). The inclusion of accommodation costs, AC, is optional and depends on whether vacationers have a real choice in accommodation. When the market for accommodation is competitive, then the expenditures on AC reflect the willingness to pay for a particular kind of accommodation and should not be included in the demand function. If a reef destination has only limited accommodation opportunities, the demand function should include accommodation costs. In this latter

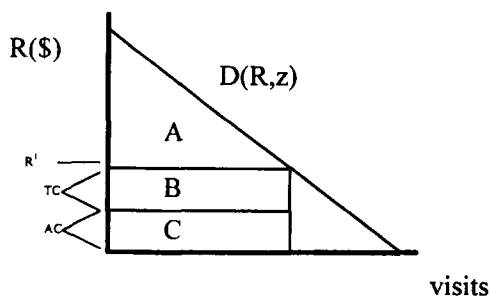

Fig. 1. Inverse demand curve for reef recreation.

case, the costs of accommodation are part of the total cost of accessing the reef.

Each origin of travel falls along a different place on the inverse demand curve depending on the costs of a vacation from that origin. In Fig. 1, we can imagine the case for an origin with vacation costs equal to R^1. Area ABC represents the gross benefit to visitors from 'origin 1' of the marine resource. Area A, also known as the consumer's surplus, represents the maximum aggregate willingness to pay of all visitors from 'origin 1' beyond the costs that actually are incurred. Area C represents gross in-country expenditures that are directly related to reef tourism (e.g. park fees, transport to the site, and accommodation costs when alternative lodging is limited) and area B represents travel cost and travel time. Area C is the quantity given by earlier studies as a proxy for the value of protection. The studies mentioned earlier estimate area C because it reflects the gross value of tourism to the local economy. In fact, area C is an overestimate of the local benefits of recreation since it ignores the costs of providing recreation services. The true local benefits of recreation are only a fraction of area C (see any one of a number of texts on project appraisal for an exposition of the calculation of shadow prices and net benefit estimation). When travel expenditures accrue to local airlines, part of area B can represent additional gross benefits of recreation. Like other tourist expenditures, only a fraction of this area actually is a net benefit to the local economy.

Over time, we would expect the level of environmental quality in the reef and surrounding marine areas to be higher with a park than without. A change in environmental quality, z, would cause a subsequent shift in the demand curve. Preliminary results support the hypothesis of an environment-related shift in demand. Research in Roatán, Honduras,[11] shows that dive site visitation is a negative function of cost (measured as time) and a positive function of coral quality (measured as live coral cover). Figure 2 demonstrates the

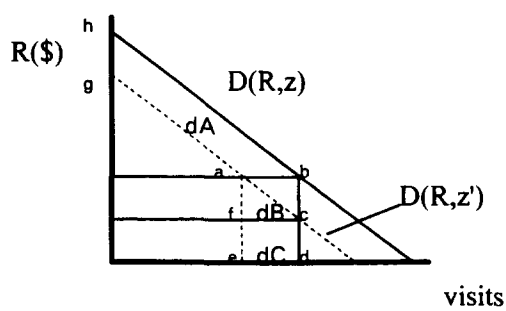

Fig. 2. Alternative valuation of marine protection.

demand curve shift that might result from a negative change in z (i.e. an environmental degradation). The shift in the demand curve results in a loss in net consumer benefits dA (area ghba), a loss in gross in-country revenues dC (area fcde), and a reduction in total travel expenditures dB (area abcf). The net economic impact of the environmental change for reef recreationists is dA. The net economic impact of environmental change for the local economy is a fraction of areas dB and dC (adjusted for shadow prices and the degree to which services benefit local producers). The value of protection is the value of the losses avoided by prohibiting a shift in the demand curve. Through management, the park might yield a level of z even greater than the current level. The economic benefit of management then would be measured by an outward shift in the demand curve. The value of management would be added directly to the value of protection.

2.2. Dynamic considerations

The value of protection depends on time and the imminence of environmental degradation. Protection would not be warranted if there were no signs of impending negative environmental change. Even with impending negative change, it is unlikely that the resource or its economic benefit stream will disappear overnight. Yet, this is the implicit assumption of past studies. More correctly, one should expect the environmental quality of the resource to change over time. In the absence of a park (or reserve), the quality of the environment will decline faster than if there were a park. Figure 3 depicts the flow of environmental/economic benefits for two generic scenarios: 'with' and 'without' marine protection. The value of protection is the difference in

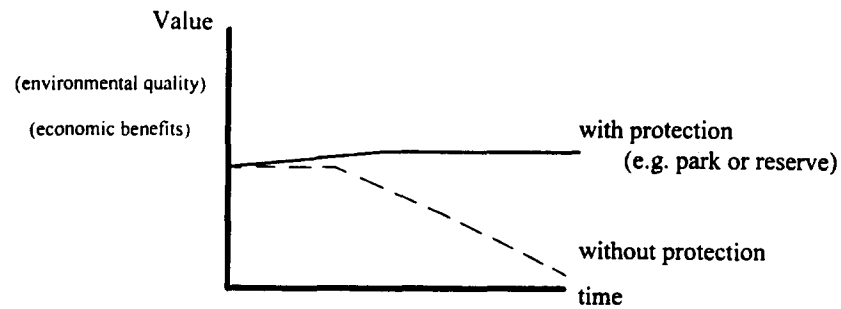

Fig. 3. The flow of environmental benefits 'without' and 'with' marine protection.

economic flows 'with' and 'without' the protection (the area under the 'with protection' line and above the 'without protection' line). The present value of protection is this area discounted by the appropriate discount rate. At any point, the distance between the 'with' and 'without' protection lines is equal to $dA_t + \beta dB_t + \phi dC_t$, where dA, dB, and dC are the same areas as in Fig. 1; the subscript t represents the year. Note that areas dB and dC are adjusted by β and ϕ respectively. These adjustments indicate that not all of the change in reef-related spending and travel would be an economic cost or benefit (due to shadow pricing). Alternatively, the value of protection can be determined separately for consumers, using dA_t and the local economy using $\beta dB_t + \phi dC_t$.

3. AN EXAMPLE

3.1. The local value of the reef resource in Bonaire

Both Post[3] and Dixon *et al.*[2] give values for the economic benefits associated with the Bonaire Marine Park. Post presents the value of the marine park in 1991 as the sum of gross dive tourism expenditures (US$21 million) and an uncalculated fraction of government taxes on dive tourism (US$340 000). This estimate is roughly analogous to the sum of all 'area Cs' in Fig. 1 for each origin of travel. Dixon *et al.*[2] use similar estimates to find that the gross economic benefits associated with the marine park include direct park fees (US$0·19 million); indirect revenues from hotels, dive operations, restaurants, and air transport (US$23·2 million), and an uncalculated fraction of government revenues (US$8·7 million, listed as transfers). [Post[3] and Dixon *et al.*[2] derive their figures from the same World Bank mission to Bonaire (Dixon, personal communication)]. From these gross benefits, the authors deduct the costs of protection (US$0·52 million for initial costs and recurring costs of US$0·15 million) and an uncalculated fraction of island imports (US$34·4 million). This value is approximately analogous to the sum of all 'area Cs' and some fraction of the sum of 'area Bs' in Fig. 1 for all origins (this fraction of area B represents the expenditures on local airlines). The authors refrain from giving a final value for the park or the reef resource.

As mentioned earlier, the true measure of the local benefits of recreation should not be measured in terms of gross expenditures.

Ideally, we would need to know the shadow prices of all inputs and outputs in the dive tourism sector to find the local net economic benefit of reef recreation in Bonaire. In the absence of these data, estimates about net profits and local ownership can give an approximation of the net value of reef tourism. Data provided by the Bonaire Department of Revenue and the Tourism Corporation Bonaire and estimates about local profits allow for an approximate calculation of the net benefits of dive recreation to Bonaire. We estimate that the *net* annual benefits of dive-related tourism for 1991 were approximately US$7 924 000 to US$8 799 000. These figures are based on net profits that accrue to reef-related businesses owned and operated by Bonaireans or permanent residents and taxes levied on foreign-owned reef-related businesses. Table 1 provides a breakdown of the estimates from Dixon *et al.*[12] and our alternative estimate.

3.2. The value of the reef resource to dive tourists

We also estimate a simple travel cost model for reef-oriented vacationers using marine park permit data and surveys of vacationers to the Bonaire Marine Park. The marine park data consists of city and state information for 4064 permits drawn randomly from a total of approximately 20 000 permits collected for the period May 1993–May 1994. Because park regulations require that every reef user must purchase a permit, these data provide a very accurate estimate of the number of vacationers that visit Bonaire from each of the 48 contiguous states in the USA and many countries in Europe and the Americas. In all, data from 76 origins are included in the analysis. The number of visitors from each state, or country for areas outside the USA, is divided by the population of the corresponding origin. This visitation rate is then regressed upon travel costs and other explanatory variables. (We do not include accommodation costs for Bonaire because there are many accommodation opportunities on the island that vary in both price and luxury.) For our demand function, only travel cost is a significant explanatory variable. The simplified demand for reef-oriented vacations to Bonaire is given by the equation:

$$\frac{\text{visits from an origin}}{\text{population of origin}} = \underset{(8{\cdot}55 \times 10^{-3})}{7{\cdot}25 \times 10^{-2}} - \underset{(8{\cdot}91 \times 10^{-6})}{3{\cdot}73 \times 10^{-5}} \text{ travel cost}$$

where standard errors are given parenthetically. All results are significant at the 0·01 level. Based on this estimated demand function, the travel costs from each region, and assuming annual visits to the marine park of 20 000, the total consumer surplus of all visitors to the Bonaire Marine Park is approximately US$19 184 000 annually.

TABLE 1
Calculating the local benefits of dive tourism (all values in US$)

	Dixon, Scura and van't Hof	*Pendleton and Wahlig*	(*Sources for Pendleton and Wahlig*)
(1) Benefits from tourism revenues			
Hotels and dive operations			(GOB[a])
Foreign-owned		466 000	(Tax only)
Bonaire-owned		3 830 000	(Before tax net)
Jointly owned hotel/dive operations			
Bonaire shares		2 071 000	(Before tax net)
Foreign shares		350 000	(Tax only)
Sub-total	15 200 000 (gross)		
Car rentals, restaurants, etc.[b]	4 700 000 (gross)	512 000–1 024 000	(10–20% profit)
Local air[b]	3 300 000 (gross)	363 000–726 000	(10–20% profit)
Sub-total	23 200 000	7 592 000–8 467 000	
(2) Benefits from taxation			
Income, wage, business, land use	(8 400 000) presented as a transfer in Table 1 (Dixon, Scura, van't Hof)	0	(TCB[c])
Room		186 000	
Casino		70 000	
Departure Tax		76 000	
Total	340 000	332 000	
Total benefits from taxation	340 000	332 000	
Total benefits from dive tourism	23 540 000	7 924 000–8 799 000	
Important figures and calculations			
(a) Number of divers	17 000	18 617	(TCB[c])
(b) Total tourist arrivals	(26 153) given implicitly	44 860	(TCB[c])

[a]Government of Bonaire, Department of Revenue. [b]Scura and van't Hof. [c]Tourism Corporation Bonaire.

3.3. Putting the costs of marine protection into perspective

Above, we calculate the annual net economic value of reef recreation to vacationers and to the local economy. While we cannot directly estimate the degree to which the Bonaire Marine Park prevents a shift in the demand curve, we can put the costs of the park into perspective by considering the costs as a fraction of the net benefits. Most of the costs of the park are borne by vacationers in the form of park permit fees (approximately US$200 000 per year). It is tempting to say that the Bonaire Marine Park is clearly worth the costs of park permits, otherwise vacationers would refuse to pay the fee. This, however, confuses the willingness to pay for access to the resource with any true benefit that is realized from the park. After all, if the park was ineffective at protecting the environment then it would be better to simply charge the fee and put the proceeds directly into the treasury. A better approach is to ask whether the park is likely to affect the environment enough to justify its cost to vacationers. Indeed, since the total cost to vacationers is a mere 1·04% of the annual consumer surplus enjoyed by these vacationers, it is probably reasonable to assume that the annual value of the Bonaire Marine Park is warranted from the vacationers' perspective.

A more inclusive view of the benefits of reef tourism is required to determine whether the total costs of the park (establishment costs, recurring costs, and opportunity costs) are justified. Dixon *et al.*[2] report that the establishment costs for the park were approximately US$518 000 and recurring costs are approximately US$150 000. Let us imagine, for simplicity of exposition, that the park were to be established today. The present value of the costs and operation of such a park would be approximately US$1·77 million over 20 years at a real discount rate of 10%. The net present value of local net benefits for that period would be US$74·21 million (assuming 1991 levels of tourist expenditures) and the net benefits to tourists (i.e. consumer surplus) would be US$179·66 million (assuming 1993 levels of consumer surplus). [The 1991 expenditures could be adjusted up slightly (by a factor of 1·07) to make the annual number of tourist arrivals equal for both the consumer surplus and local benefit analyses. The difference is small.] Therefore, the present value of costs of protection would be approximately 0·7% of the net benefits that come from reef tourism. Even if we add the opportunity costs of foregone development in the park zone (e.g. port development or oil refineries), it would appear that the marine park would be justified even if it had only a modest effect on the quality of the environment and thus tourism.

4. CONCLUSION

Past economic analyses of marine parks focused on the value of the resource protected and not the actual value of the services that marine parks provide—protection and management. Usually these studies equate the value of tourism-related expenditures with the value of protection. Furthermore, past studies ignore the importance of time in evaluating the benefits of marine parks. Most of the benefits of protection and management come in the future. As a result, the valuation of a park must take a dynamic perspective. Future benefits and costs must be discounted back to the present.

This paper applies basic economic principles to the theory of valuing the recreation benefit of marine parks. The approach here is not entirely new. The theory draws upon principles common to project appraisal and environmental economics in order to redefine the way marine park benefits are valued. Environmental economics tell us that the value of protection is the difference in the value of the resource with and without protection. Project appraisal then requires us to discount the value of future benefits in order to compare them with the current and future costs of protection. In the end, we must estimate a present value with which we can assess the benefit of marine protection for the local and global economies. The framework given here demonstrates how the impact of marine protection on recreation should be measured. This focus only on recreation provides a conservative basis for the estimation of the total value of marine protection. Clearly, marine protection also would have a similar effect on other use and non-use economic values.

The challenge now is for project analysts to show in practice how the value of a resource is changed due to protection and management. Unfortunately, estimating shifts in the demand curve is not easy. Revealed preference methods, including the hedonic travel cost method and discrete choice random utility analysis, can be used to determine the economic value of environmental changes in reef destinations. These methods, however, require a large set of environmental and economic data from many islands. Even more serious is the lack of scientific study that shows how marine protection actually affects the environment. The negative impacts of divers on the reef have been demonstrated.[2] Nevertheless, it does not follow that the presence of a marine park would lead to the total avoidance of diver-induced damages. Furthermore, the most serious future threats to the reef environment will come from coastal development, oceanic nutrification, pollution, and potentially global warming. If marine parks are unable

to stop the degradation from these sources then the avoided environmental change that results from marine protection may be insignificant.

Until appropriate economic and environmental studies are available, analysts will be forced to make educated guesses about the value of marine protection. This paper shows that it is theoretically inappropriate to justify marine protection costs in terms of gross domestic reef-related revenues. Instead, analysts should compare protection expenditures with the consumer surplus of reef recreationists and the net value of domestic reef-related revenues. While the two approaches give similar results for Bonaire, it is impossible to tell, a priori, whether this will be the case for any given marine park.

In the absence of better information, the analyst's primary goal should be to determine whether marine protection is likely to affect demand enough to justify the direct and indirect costs of marine protection. If the analysis is to be done solely from the perspective of the recreationists, then consumer surplus alone is the relevant measure for comparison. Likewise, an analysis from the local perspective ought to focus on the net value of domestic reef-related expenditures. If the costs of protection are a small fraction of these measures, then reef protection may be economically justified.

ACKNOWLEDGEMENTS

The author would like to thank Anne Wahlig, Yale University, for her invaluable help in the collection and analysis of many of the data relevant to Bonaire. A full exposition of these data can be found in her senior thesis (Yale Economics Department). He also acknowledges the following institutions for their help in providing data: The Bonaire Marine Park, The Tourism Corporation Bonaire, and the Government of Bonaire. Finally, he would like to thank the reviewers for their suggestions.

REFERENCES

1. Wells, S., Coral reefs: Undersea gardens lose their sheen. *International Wildlife*, **20**(2) (1990) 8–9.
2. Dixon, J., Scura, L. F. & vant Hof, T., Meeting ecological and economic goals: Marine parks in the Caribbean. *Ambio*, **22**(2–3) (1993) 117–25.
3. Post, J., The economic feasibility and ecological sustainability of the

Bonaire Marine Park. Paper presented at the World Parks Congress, Caracas, 1992.
4. Posner, B., Cuthbertson, C., Towle, E. & Reeder, C., *Economic Impact Analysis for the Virgin Islands Marine Park*. Island Resources Foundation, St Thomas, 1981.
5. Dixon, J., Economic benefits of marine protected areas. *Oceanus*, **36** (3) (1993) 35–41.
6. vant Hof, T., The economic benefits of marine parks and protected areas in the Caribbean Region. In *Proc. 5th International Coral Reef Congress*, Tahiti, 1985.
7. Goodwin, M. & Wilson, M., *Caribbean Marine Resources: Opportunities for Economic Development and Management.* USAID and NOAA, Washington, DC, 1986.
8. McElroy, J. & de Albuquerque, K., Tourism styles and policy responses in the open economy closed environment context. In *Caribbean Economics and Ecology*. Caribbean Conservation Association, Barbados, 1991.
9. Dixon, J. & Sherman, P., *Economics of Protected Areas*. Island Press, Washington, DC, 1990.
10. Holder, J. S., Managing the Caribbean environment as tourism's resource. Paper presented at the seminar on Tourism, Health, and the Environment. PAHO, Tobago, 31 October–3 November 1991 (also cited in Ref. 2).
11. Pendleton, L., Environmental quality and recreation demand in a Caribbean coral reef. *Coastal Management*, **22**(4) (1994) 399–404.
12. Dixon, J., Scura, L. F. & vant Hof, T., Meeting ecological and economic goals: Marine parks in the Caribbean. *Ambio*, **22**(2–3) (1993) 2–3.