Policy Issues in Protected Area Management: An Examination of Dugong Protection

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ABSTRACT

Threats to dugong survival include direct mortality from boat strikes, drowning in nets and loss of habitat. Dugong sanctuaries were introduced in 1998 to protect declining dugong numbers by recognising important seagrass habitat areas. Nonpoint source pollutants such as dissolved nutrients, pesticides and suspended sediment have the potential to affect the species composition of seagrass and the extent of seagrass beds that support dugong. We explore the nature of pollution costs to society and their implications on land uses in catchments adjacent to these protected areas. Policy options available to mitigate social externalities are examined recognising the influence of market failure.

Introduction

Conservation of biological, cultural and landscape diversity is now recognised by the majority of governments throughout the world as a fundamental necessity to ensure the future well-being of society. Conservation policies attempt to achieve this objective through planned use of natural resources including careful use of biological resources, and by designating areas of cultural, biological and landscape value as protected areas. The focus is to manage these areas for society's enjoyment and scientific knowledge in their original state, by protecting them from continued human transformation.

Every nation has areas of natural beauty and cultural significance. These areas almost always contain valuable and interesting plants and animals, cultural monuments and landscapes that are often unique to each place. The setting aside of natural habitats free from human exploitation has a long history in social development. In 1872 the United States government established the Yellowstone National Park. It was the first national park in the western world. Sri Lanka has a history of establishing protected areas from the 3rd century BC. Currently, there are about 4,500 protected areas worldwide. As with the number of protected areas, their geographic distribution has widened with the increase in global interest for their establishment as a priority for protecting biodiversity. Their management presents significant policy issues that are of interest in themselves.

The purpose in this paper is to examine the factors influencing the management of Dugong Protected Areas near the Great Barrier Reef and to explore policy options available to mitigate social externalities arising from terrestrial land uses that impinge on dugong protection strategies.

Protected Area Management

The traditional basis of protected area management primarily reflected cultural and recreational interests. For instance, designation of national parks identified the needs of recreation users. Exclusion of areas of natural beauty from development activities by government offered a basis to provide recreational opportunities to public, as the public themselves are unlikely to maintain such reserves individually for greater public use. The nature of non-excludability of parks as a public good and the difficulty of apportioning benefits, or non-divisibility, provided the economic basis for such allocation by the government (Olson 1971; Cornes and Sandler 1996).

On the one hand, protected areas have come under increasing pressure from competition for land because of an increase in global population and an increasing demand for goods and services. On the other hand, social development, fuelled by industrialisation and growth in markets, has led to a reduction in natural areas and a progressive build up of waste material that poses a threat to natural ecosystems. This conflict in supply and demand has meant that while the world's protected areas have an increasing value to society, mere designation of such areas as protected areas does not ensure effective protection. Moreover, given inability of governments to afford necessary funds to manage protected areas under increasing threats, the role and management of protected areas have changed in recent times. The emerging management focus acknowledges the multiple demands on resources, and the management problem is to devise flexible strategies to ensure optimal resource utilisation and efficient sharing of benefits. The management focus of the Great Barrier Reef Marine Park, for example, endorses such a strategy with the use of different zones within the World Heritage Area, to minimise the risk of conflict amongst different use sectors (Craik 1996).

Management concerns

There are two main sources of concern with protected area management. Firstly, designation of areas was intended to preserve natural habitats and their species in a near pristine condition, and activities that may impinge on the functioning of the designated ecosystem pose a threat to its management. These include both natural events such as fires, floods, droughts and cyclones, and predominantly human assisted events such as industrial pollution, soil erosion and chemical contaminations linked to agricultural land use. Second, establishment of protected areas has created conflicts with local populations adjacent to these areas, because they are now devoid of the opportunity to gain access to these areas for food, recreation or commercial purposes, or/and they are required to change their usual practices because such practices may pose a threat to the management of the protected area. Although these social costs imposed on local populations were believed to be offset by the benefits to society (from the establishment of the protected area), conflicts with other land users are usually the most important cause of management concern in protected areas.

From a management viewpoint, both sources of concern can be treated as transboundary problems. Designation of the boundaries to the protected area, based usually on administrative demarcations with geographic reference, do not necessarily isolate it from an ecosystem viewpoint. Therefore, despite its assignment of protective status, the asset remains exposed to forces of nature, whether influenced by humans or not, and thus stands the risk of change. For instance, (Colding 2000) cites Balee (1992) and Posey (1992) as evidence to indicate that humans have modified ecosystems in remote rainforests, that previously were believed to be untouched by humans. On the other hand, fire can completely disrupt habitats to extinction, thus endangering the survival of certain species, irrespective of the area's conservation status. Therefore, the implied level of protection can only be attained if the agents of change isolated by the means of protection were to be the critical elements that engender change on the protected system.

This highlights an ethical issue, not explored in this paper, whether by trying to isolate a particular segment of an ecosystem as a protected area, are we depriving that particular system the opportunity to evolve within the changing environment, and thereby pose a risk to its very survival. Management approaches thus need to appreciate evolutionary aspects of ecological instability, and uncertainty of knowledge in an ever-changing natural, social and economic environment.

Marine Protection Areas

A marine protected area is an area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features, reserved by law (Kelleher and Kenchington 1992). Marine protected areas are also typically highly biologically productive. Tropical algae are among the highest primary producers of food in all ecosystems.

Marine environments provide multiple benefits. Under normal access, they have been used as a source of food, pleasure, medium of transport and a source of raw material for many industries. One way of achieving conservation goals under growing resource use pressures is to allow multiple use to continue in Marine Protected Areas. The protected area manager seeks to ensure that ecosystem processes and species lifecycles are not compromised, allowing areas for use within operating constraints, such as licences, input control, bag limits, monitoring and compulsory reporting. Other parts of protected areas might be closed off completely to public use and used for research and monitoring. This is standard practice in the Great Barrier Reef Marine Park.

While the goals of marine protected areas are similar to terrestrial protected areas such as forests, transboundary problems are particularly acute for marine protected areas due to their strong natural interconnectedness, creating an ‘open system’ (Fairweather and McNeill 1993). Even a very large marine park such as the Great Barrier Reef Marine Park is subjected to significant ecological influences on habitat such as oceanic upswelling, waves, tides, currents, river flows and atmospheric deposition.

Marine reserves may afford protection to marine species in specific ways or at critical life cycle stages rather than the full range of habitat because of these environmental conditions. Australian marine Reserves have provided for the protection of marine mammals (such as the Australian Sea Lion *Neophoca cinerea* – on Kangaroo Island) and mangrove and seagrass areas (habitat for commercial fish species). These reserves aim to protect species at vulnerable times, such as juvenile breeding grounds for fish.

Open system aspects are indicative of a greater degree of connectedness among habitats and places in the sea (Fairweather and McNeill 1993). This leaves reserved areas open to impacts, these impacts are typically below the surface and thus invisible to the general population.

Major biophysical linkages also provide a challenge to management, in terms of how to reduce opportunities for adjacent uses to diminish values. The primary manner in which the managers have met these challenges is by seeking to maintain compatible uses, and to discourage incompatible uses through exclusionary mechanisms, joint ownership structures, and penalty regimes (Tietenberg 2000). These can work well within particular areas, but fail to account for transboundary aspects such as terrestrial influences effectively. The primary problem facing the policy maker is the property rights issue, where there are no effective ways of internalising the externalities across the marine-terrestrial interface. The second issue that constrain effective management is the uncertainty attached to information that relate to various processes of a complex ecosystem, that we are trying to manage (Costanza et al. 1993).

Nevertheless, economics can provide some tools that may assist in managing such impacts in the presence of uncertainty. These tools can specifically address ways of sharing the burden of management and explore avenues to develop incentive mechanisms to minimise externality burden (OECD 1999). The remainder of this paper is used to explore such opportunities in the context of Dugong Protection in Australia’s Great Barrier Reef.

Dugong Protection

Dugong

The dugong (*Dugong dugon*) inhabits shallow waters of tropical seas off the coasts of East Africa, Australia, India, the Philippines, and other islands in the South Pacific (UNEP 2000). Manatees and dugongs have existed for more than 60 million years, coinciding with the time of dinosaurs. Manatees and dugongs are marine mammals belongs to the biological family named Sirenians, which also included Stellar's sea cow that went into extinction about 230 years ago. Dugongs can live over 70 years of age, and are particularly susceptible to environmental pressures because of their naturally slow population growth rates (estimated at 5%) and specific habitat requirements. Seagrass is the primary source of food for dugongs. An adult dugong consumes approximately 25 kg per day.

Habitat connectivity and distance between habitats occupied by dugong may be an important factor in maintaining genetic resilience. Increased rates of habitat change as a result of human activity may exceed the ability of dugongs to evolve and adapt to accelerated environmental changes. Threats to dugong include habitat degradation and loss, mesh-nets, shark nets set for bather protection, hunting, boat strikes and defence training activities.

Habitat Management

Among the direct and indirect threats to dugong survival, loss of sea grass habitat is of primary importance. Environmental factors determine the species of seagrass that grow at particular sites, and some species are thought to be favoured food of dugong. The implications of different species of seagrass on dugong reproduction and health have not yet been determined. Studies on the response of seagrass ecosystems to natural and human factors may assist in establishing the acceptable levels of change and the critical parameters of such change (Veldkamp and Fresco 1997).

Dugong decline around the world has been attributed to accidental death, human harvesting and habitat destruction. Although their protection is widely supported, dugong habitats in Asian, African and Pacific regions are less well targeted for protection due to other conflicting human development priorities. Australia's economic development status places it in an opportune position to contribute to dugong conservation. Fortunately significant remnant populations occur in Australian waters. The Great Barrier Reef World Heritage Area contains an estimated 15% of Australia's known populations of dugongs.

Although the dugong is listed on the IUCN Red List as 'Vulnerable to Extinction', the status of populations around the Australian coast differ by region. Major populations remaining in the Great Barrier Reef World Heritage Area include Hinchinbrook Channel, Cleveland Bay to Upstart Bay and Shoalwater Bay.

A sharp and significant decline (50%) in dugong numbers was detected in the Great Barrier Reef World Heritage Area south of Cooktown in the decade from the mid 1980's. The Great Barrier Reef Ministerial Council responded to this evidence by seeking to protect dugong habitat areas. Sixteen Dugong Protection Areas (DPAs) along the Queensland coast were declared in January 1998. Seven of these areas are zone 'A' with restrictions on types of netting aimed at reducing fatalities from drowning. Offshore set and drift nets, foreshore set nets and river set nets can be used with altered practices in zone 'B' DPAs.

Selection of the DPAs and their boundaries were on the basis of scientific advice that considered species abundance, seagrass status and geo-spatial issues that required some connectivity to facilitate gene flow, re-colonisation of depleted areas and access to remote food sources in the event of local fluctuations. However, these decisions were taken within constraints imposed by a paucity of relevant scientific information (Oliver and Berkelmans 1999).

Concern over the decline in dugong numbers also led to a voluntary moratorium on hunting of dugongs by a number of traditional owners and other Aboriginal and Torres Strait Islander groups. The use of shark nets, which are potentially fatal to dugongs, have also been reduced in favour of baited hooks in most locations.

Habitat risk assessment

The Great Barrier Reef Marine Park Authority recently conducted a risk assessment of Dugong Protection Areas. They considered a number of critical factors that impinge on the health of seagrass beds (Schaffelke, Waterhouse and Christie Unpublished (2000)). Factors considered critical were:

- Presence of the mouth of a major river inside the DPA (rated 0 or 1);
- Influence of the Burdekin or Fitzroy Rivers (rated 0 or 1);
- Presence of an urban area close to the DPA (rated low 1, medium 2 or high 3);
- Presence of an industrial area or port close to the DPA (rated low, medium or high);
- Fertiliser use on adjacent catchments (low < 1 kg N 1000 ML^{-1} & < 0.1 kg P 1000 ML^{-1}, medium 1 – 5 kg N 1000 ML^{-1} & 0.1 – 0.5 kg P 1000 ML^{-1} or high > 5 kg N 1000 ML^{-1} & > 0.5 kg P 1000 ML^{-1});
- Pesticide use on adjacent catchments (< 10 g/ha rated low, medium 10 – 100 g/ha, or high > 100 g/ha);
- Sediment export from adjacent catchments (using estimates from Moss and Neil & Yu, rated low, medium or high).

The assessment of threats to seagrass ecosystem underscores the nature of pollution threats – carried primarily by water. In particular, policy for nonpoint source pollution mitigation for a Dugong Sanctuary needs to consider issues relevant to wider land use impacts on the Great Barrier Reef Marine Park. The natural variability of such a complex natural system makes definitive evidence of pollution effects difficult to uncover. Nevertheless, the common law principle of testing the ‘balance of probabilities’ applied to scientific evidence favours action to prevent manifestation of detrimental impacts from pollution.

Risk mitigation strategies

The primary focus of the current management approach of the Great Barrier Reef Marine Park Authority is to minimise the risk of damage to the marine environment through access control and information sharing to achieve compliance with set standards. These principles have recently been extended within a firmer economic basis to develop market based instruments such as quota arrangements and tradable entitlements, and collective exchange opportunities such as voluntary restrictions based on industry codes of practice (OECD 1999; Brunton 1999; Tietenberg 2000).

The general thrust of these arrangements today, is to develop systems that are consistent with changing community attitudes. The community is increasingly more informed of environmental consequences of developments, and there is a general call for greater involvement of stakeholders in decision-making. As a result, the command-and-control policies of the past are increasingly being supplemented with policies that allow greater participation of decision agents in voluntary management regimes that are linked to achieving agreed objectives (Department of Environmental Protection 1996; Kanninen 1998). Resource management therefore reflects strategic management rather than past reactive management characterised by penalty-dominated regimes. This emerging multi faceted approach aims to promote greater compliance through incentive structures, reward mechanisms and the role of regulatory exclusions and penalties are delegated to second place to be used as instruments of last resort (Mallawaarachchi et al. 2001).

These developments are particularly important for industries located at the fringe of these protected areas, because the community expects those industries to demonstrate a duty of care on the environment as required under the *Environmental Protection Act 1997*, for example. For instance, following an environmental audit in 1996 the sugar industry developed a code of practice for sustainable cane growing in 1998 (Canegrowers 1998). The code is aimed at mitigating the adverse environmental effects of on-farm practices. The code is voluntary, and it is aimed at a general level of compliance within the guidelines available in existing legislation for land clearing, soil conservation, environmental protection and waste management.

In some circumstances, such voluntary industry action may come short of requirements, if the costs of implementing voluntary compliance are likely to be high. On the other hand, there is no firm evidence to determine the level of compliance required to bring an effective level of protection on the marine environment. Economic studies can therefore shed light on the cost-effectiveness of mitigatory strategies and explore ways of minimising the cost burden on industries such as the sugar industry, which in the process of economic production may jointly produce external costs. An optimal level of management could be achieved if the costs of protective strategies were to match the benefits of protection.

In the following section, we present an outline of a case study to explore opportunities to develop an economic approach to minimise the externality burden on the community while optimising resource use efficiency for sugar production[1].

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[1] A more detailed discussion on the management of externalities in the sugar industry is given in Mallawaarachchi et al (2001).

A case study on dugong area management

The study area

Managing threats to Dugong Protection Areas such as from agricultural pollution has two aspects. Reducing current activity impacts and ensuring that future development does not impinge upon key characteristics of the protected area. Before a study area was selected its suitability for the study was evaluated *apriori*, based on its relevance in terms of addressing the objectives of protected area management.

Thus selecting a study area considered areas likely to involve future agricultural activity. Significant amounts of information were investigated on the impact pathways of diffuse agricultural pollution to find the most suitable characteristics for this study. It was concluded that the pollution pathways from an irrigated area were important and proximity to seagrass beds increased the probability of harmful effects.

The discussion of nonpoint source pollution mitigation examines the cost of incorporating options at the planning stage of a possible future extension of irrigated farm area. Two small potential future cane production areas adjacent to Upstart Bay were chosen. The study area is adjacent to existing cane production areas and has a high potential for development. The nearby production area has been extensively monitored for pollution outflows, and this allows for realistic testing of pollution mitigation options within the study area.

The seagrass distribution in Upstart Bay includes significant seagrass beds in shallow intertidal areas. Pollutant impact pathways in shallow intertidal areas are more likely to be sediment based, with combined impacts from nutrient and pesticides likely to be important particularly if they occur in the dry season. Irrigated areas have the potential to cause these types of effects by altering natural flow patterns in watercourses by producing dry season flows in streams that would otherwise dry completely.

Due to the possible close proximity to the sea and high level of fertiliser and herbicides use per unit area, altering management practices in cane farming in the study area would be an important component of pollution mitigation policy. The investigation will focus on linking an ecological pollution mitigation model with a farm scale return model. This allows a discussion of mitigation as well as discussion of the most appropriate instruments to achieve a reduction. It allows modelling to extrapolate to regional issues without consideration of complex and sensitive compensation issues that arise when dealing with existing land uses.

Analytical approach

To manage protected areas, society needs to consider the full economic costs and benefits of use impacts by adequately defining and quantifying them. Agricultural activities impinge on water quality. Water quality is a key determinant of the health of near shore marine ecosystems. In this study, different contributors to water quality degradation are considered in a case study area adjacent to Upstart Bay Dugong Sanctuary on the Queensland coast. Economic policy options will be assessed for addressing sugar cane production externalities. We outline the most likely combination of policy options to control nonpoint source pollution in a potential cane producing area considering mitigation, command and control, and market based instruments.

Economics of pollution abatement

The basic notion of the *first law of thermodynamics* – that energy and matter cannot be created or destroyed highlights the importance of considering the waste stream consequences of production in policies for the management of protected areas. Waste goods decrease social welfare because of the public good nature of the receiving environment. Indivisibility and non-excludability are key property right characteristics of public goods. It may be in no one’s private interest to reduce the amount of waste good produced. The traditional approach to address externalities was the intervention by governments through imposition of taxes to limit the externality generating activity (Pigou 1932).

The economic basis of the social cost of pollution is represented in figure 1. The amount of waste good produced in the absence of appropriate price signals (W*) will result in a dead weight loss to society (shaded area).

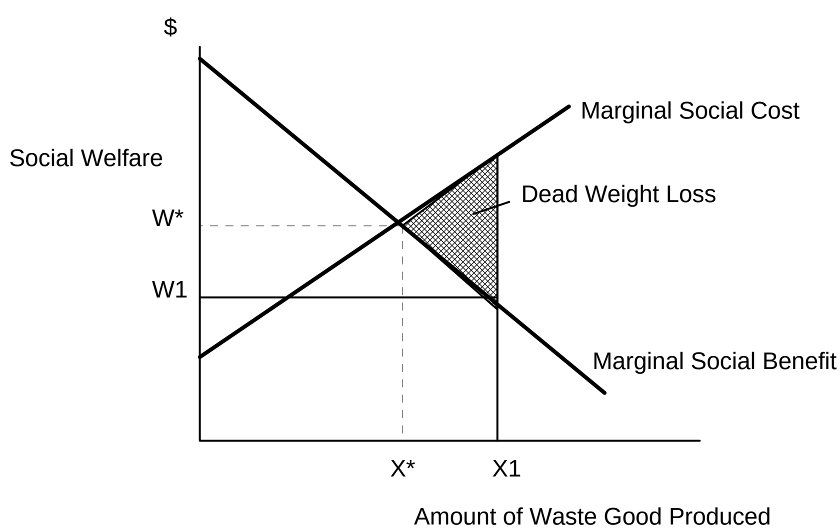

Figure 1 Social Cost of Pollution

Even if we accept that market signals may not result in the optimal amount of pollution (X^*), it may not be intuitively obvious why the optimal amount of pollution will be non-zero. The quantity of pollution can be represented as a trade-off between the marginal cost of pollution control and the marginal benefit from pollution (Figure 2).

We assume that the marginal damage caused by a unit of pollution increases with the amount emitted. We also assume that the marginal costs of control increase with the amount controlled. Thus the increasing slope moving along the marginal cost of control from right to left refers to greater control and less pollution. The efficient allocation is conceptually easily identified (Q*), being the point at which the damage caused by the marginal unit of pollution is exactly equal to the marginal cost of avoiding it.

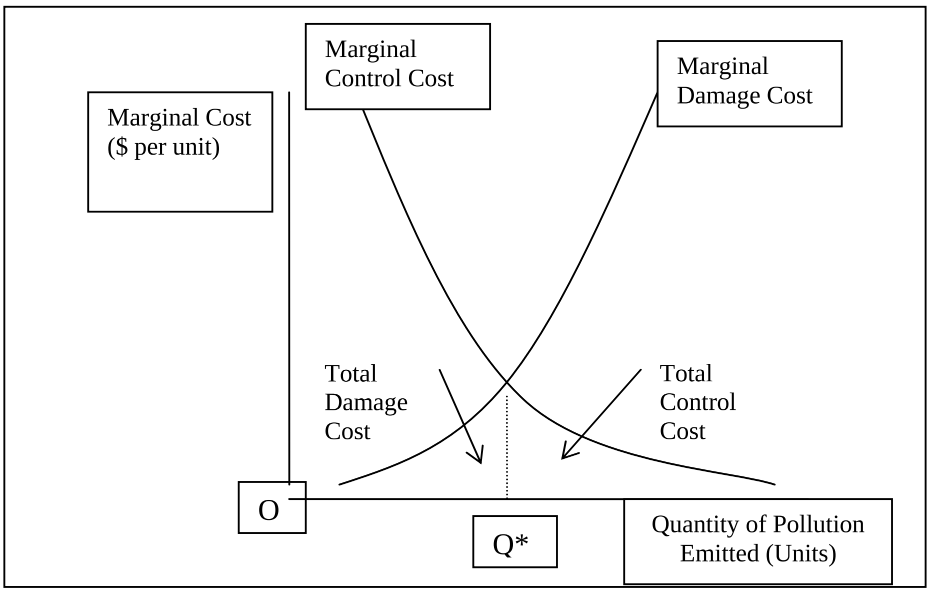

Figure 2 Optimal Quantity of Pollution

This also implies that efficient policy options will allow different levels of pollution in different regions. Areas that are more sensitive to pollution (or have higher social value) will require higher levels of pollution control than others.

If we assume that current levels of pollution involve a net cost to society the economic questions become the appropriate quantity of emission, and efficiency and equity of options to achieve that reduction. The primary problem however is how to allocate the cost burden when there are no well-defined property rights. In this regard, Coase (1960) argued that in a world with full information, low transaction costs, and strict enforcement of contracts, the distortions resulting from an externality could be resolved by the clear definition of property rights.

A tradeable permit, a property rights structure, provides an intuitively attractive way to allow firms to allocate pollution abatement activity to those most efficiently able to do so (as can be seen in Figure 3). If each firm were given a permit to emit a level of pollution then by allowing trading, firms for whom it is more costly to control pollution will trade reduction quantities. In Figure 3 the firm whose marginal cost of control is higher (MC_2), will trade with the firm whose marginal cost of control is less where they are both granted an initial allocation (Qb). At that level the cost to firm 2 is C, and the cost to firm 1 is A. As trades occur the total emissions are reduced with minimised marginal cost of control (Qa).

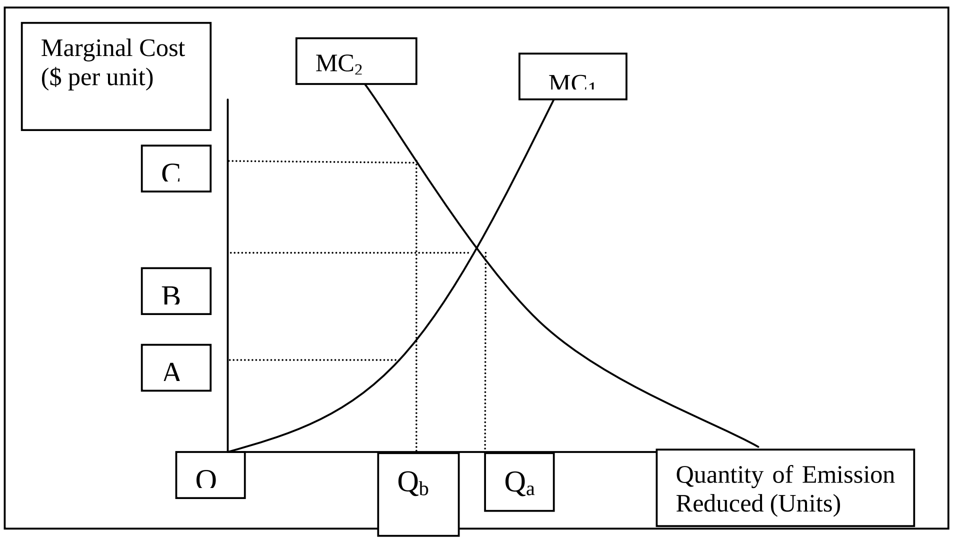

Figure 3 Differing Pollution Abatement Costs Among Producers

Critical for the development of pollution mitigation model is the mixing of pollutants across spatial and time bounds. If pollutant effects differ by location, then policy must address the non-uniform effects specifically. In this study, the small size of the study area and thus characteristics of the delivery of pollutants of interest (little time for natural processes to mitigate) indicate that pollution can be assumed to be uniform.

Policy options for dugong area management

Addressing the appropriate level of the waste flow as well as how to achieve the quantity among alternative approaches requires information specific to the problem (Batterham and MacAulay 1991). The characteristics of the catchment selected as the study area as well as the attributes of the pollutants of interest have implication for the detailed construction of policy. Different geomorphological areas are expected to yield different pollutant pathways from land use impacts. Due to differences in the characteristics of areas and pollution mitigation costs different levels of pollution may be acceptable, implying that different policy instruments may be necessary for different areas.

The options for pollution reduction strategies include information and education, direct controls and market based solutions. The focus of this discussion will be on the merits of market based solutions, comprised of both price and quantity controls. While priced based instruments such as fees and charges are likely to be more efficient than direct controls such as quantity restrictions in efficient markets, quantitative restrictions have the advantage that the level of pollutant produced is kept to a limit. Following Arnold (1994) we argue that the most efficient way to reduce the dead weight loss from under priced public goods will be to set a mix of appropriate price and quantitative restrictions, encouraging market forces to seek out optimal investments in pollution mitigation activity.

Carlin (1992) notes the potential advantages of fees and charges over direct controls. Incentives provide a cost per unit of waste good above and below the desired quantity while a direct control only imposes a cost on pollution produced above a particular set standard (illustrated in Figure 4), assuming that the fines and penalties are faced on each occasion a breach is detected and successfully prosecuted.

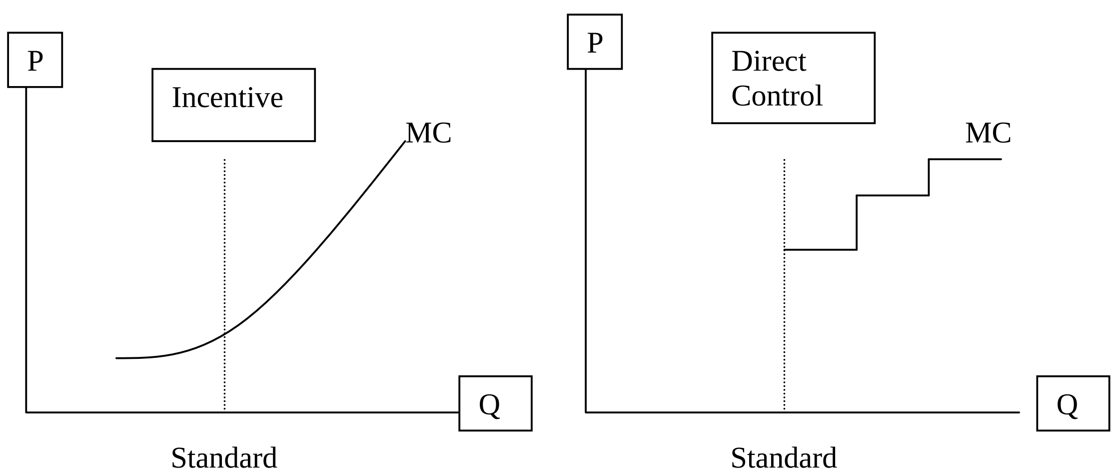

Figure 4: Firm Marginal Costs Under Incentives and Direct Controls

The unit cost of pollution implied by incentives provides a stimulus for innovation and technical change. As firms face a new marginal cost curves they act in their economic interest that also advances environmental goals. As the incentive does not necessarily impose a specific technology the firm has flexibility to meet environmental responsibilities.

Quantity incentive systems involve specification of limits for pollutants allowing trading between sources to meet restrictions. The agency control over the market has the ability to provide more certainty over total quantities of pollution produced compared to fees and charges. The level of fees and charges are not necessarily set at appropriate levels reflecting the full social cost of externalities.

Price based incentives provide the opportunity to set the marginal cost of pollution abatement equal to the full social cost of pollution damages. This would enable effectively internalise the social costs of pollution maximising social welfare.

Quantitative restrictions are either credit or allowance types (Carlin 1992). A credit type is where emitting less than a designated limit creates a credit. This unused portion can then be traded. An allowance on the other hand involves the trading of the right to emit a certain level. Rather than waiting until an unused portion of a set limit is created, the allowance is traded in advance of the polluting activity. Tradeable rights are usually grandfathered leaving the firm to meet only the cost of mitigation activities.

As firms may face different marginal cost curves a marketable incentive allows the attainment of desired pollution levels at least cost (Figure 3). Firms with lower costs of pollution abatement have the ability to sell the spare allowable emissions to firms with higher costs of abatement. Therefore while a fee based system has the potential to more fully reflect social costs marketable instruments are more attractive to polluters. The political considerations are likely to favour marketable instruments over price-based instruments (Arnold 1994).

Having considered the mechanism for efficiency gains we now briefly discuss the nature of these gains. The main source of efficiency gains of tradeable permits over command and control options is the site-specific nature of nonpoint source pollution. Efficiency gains stem from private actors' possession of the detailed information necessary to reduce pollution rather than a government agency seeking the detailed information required for a command and control approach to pollution (Carlin 1992; Ribaudo, Horan and Smith 1999).

Government agencies are not in the best position to have the optimal knowledge of possible process changes, input changes, behavioural changes or all available control technologies that could reduce pollution in varying circumstances. Marketable permits are particularly useful in situations where there are many actors contributing to a single pollution problem. Diffuse run-off in the case study area can have design features that enable tradeable permits to be discussed. Following the current farm design in the adjacent irrigation area drainage outflow can be channelled through tailwater recycling dams (large enough to hold a specific rainfall event – acting as a sediment trap). This results in drainage outflow from one point on each farm, thus allowing for monitoring for a tradeable permit system. The final aspect to be considered will be the use of wetlands for pollution mitigation.

(Braden and Segerson 1991) outline attributes of nonpoint source pollution that have implications for mitigation policy. They include:

- Pollution varies with practices, and physical characteristics of site;
- Pollution is highly variable at an individual site;
- Pollution is impacted by weather; connectedness to other locations, and
- Pollution has complex environmental fates

The factors that need to be considered for a nonpoint source tradeable permit system (de Lucia 1974) are:

- The method of distribution of initial permits;
- Pollutants or ambient conditions covered by the permit;
- The term and rules for issuing additional or retiring permits;
- The eligibility conditions to hold a permit;
- The relation of control to variation in hydrologic or water conditions (what happens when it floods);
- Trading rules and procedures;
- Method of monitoring discharges, enforcing compliance to conditions and rules;
- Description of the physical boundaries of the sub catchment; and
- Source of funding for administration & use of funds collected.

The important ecological and economic result of any policy will be that total pollution is capped at some level (Brunton 1999). The policy option to be investigated in this study will focus at a sub-catchment level and include the use of constructed wetlands for nonpoint source pollution abatement in conjunction with tradeable permits that limit the quantity of pollution entering the wetland.

Conclusion

Policy objective for the management of externalities is to minimise the net social costs. The social cost of externalities imposed on society through activities that pollute Dugong Protection Area's can either be considered directly, or indirectly. Direct measurement may involve non-market valuation of community preferences, while the indirect approach entails decisions regarding efficient level of mitigation to be undertaken. This research explores the costs of implementing measures to improve water quality in two sub-catchments adjacent to a dugong protection area. In particular tradeable permits and constructed wetlands policy options for pollution mitigation will be considered as a case study. The strategies being investigated will provide information to help both the sugar industry and the general community to explore opportunities to manage the natural resources that are committed to both sugar production and dugong protection are used in the most efficient manner.

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