ECONOMIC ISSUES RELATED TO BLAST FISHING ON INDONESIAN CORAL REEFS

C. PET-SOEDE
Fish Culture and Fisheries Group, Wageningen Institute of Animal Sciences (WIAS) Wageningen Agricultural University, PO Box 338, 6700 AH Wageningen, The Netherlands
H.S.J. CESAR
World Bank, Environment Sector Unit for East Asia and the Pacific (EASEN), 1818 H Street NW, Washington DC 20433, USA
Institute of Environmental Studies, Free University Amsterdam, Boelelaan 1115, 1081 HV Amsterdam,The Netherlands
and
J.S. PET
The Nature Conservancy, Indonesia Program, Jl. Hang Tuah Raya No. 42, Lantai II, Kebayoran Baru Jakarta 12120, Indonesia.

ABSTRACT

Characteristics, impact and economic costs and benefits of blast fishing were studied in Indonesia, at the scale of individual fishing households and of the Indonesian society as a whole. Although illegal and highly destructive to coral reefs, blast fishing provides income and fish to a vast number of coastal fishers who claim that they have no alternative to make a living. Crew members in small-, medium- and large-scale blast fishing operations earn net incomes per month of US$ 55, 146 and 197 respectively. Boat owners in the same types of operations earn US$ 55, 393 and 1,100 respectively. These incomes are comparable to the highest incomes in the conventional coastal fisheries. At the individual household level, the differences between the three types of operations show clear incentives for scale enlargement. The cost-benefit balance at the society level was calculated with an economic model. This analysis showed a net loss after 20 years of blast fishing of US$ 306,800 per km^2 of coral reef where there is a high potential value of tourism and coastal protection and US$ 33,900 per km^2 coral reef where there is a low potential value. The main quantifiable costs are through loss of the coastal protection function, foregone benefits of tourism, and foregone benefits of non-destructive fisheries. The economic costs to society are 4 times higher than the total net private benefits from blast fishing in areas with high potential value of tourism and coastal protection. This analysis of characteristics, impact and economics of blast fishing should help to raise the political will for truly banning blast fishing from Indonesian waters. Moreover, it allows for an evaluation of possible management solutions, taking into account their costs and the socio-economic framework that caused coastal fishers to start using explosives.
Keywords: Indonesia, blast fishing, socio-economics, coral reefs

ABSTRAK

Karakteristik, dampak serta biaya dan manfaat ekonomi dari penangkapan ikan dengan bahan peledak telah dikaji di Indonesia, baik pada tingkat individu rumah tangga nelayan maupun pada tingkat masyarakat Indonesia secara keseluruhan. Meskipun ilegal dan sangat merusak terumbu karang, penangkapan ikan dengan bahan peledak memberikan penghasilan dan ikan bagi sejumlah besar nelayan pantai, yang mengaku bahwa mereka tidak punya pilihan lain untuk mencari nafkah. Anggota tim operasi penangkapan ikan dengan bahan peledak dalam skala kecil, menengah dan besar memperoleh pendapatan bersih per bulan masing-masing sebesar US$ 55,146 dan 197. Pemilik kapal dalam skala operasi seperti di atas, menerima masing-masing US$ 55,393 dan 1.100. Pendapatan ini setara dengan tingkat pendapatan tertinggi pada usaha sektor perikanan pantai yang konvensional. Pada tingkatan individu rumah tangga nelayan, perbedaan penerimaan antara ketiga skala usaha di atas jelas memperlihatkan adanya insentif untuk skala yang diperluas. Keseimbangan antara biaya dan manfaat pada tingkat masyarakat dihitung dengan suatu model ekonomi. Analisis ini memperlihatkan besarnya kerugian bersih penangkapan ikan dengan bahan peledak setelah 20 tahun sebesar US$ 306. 800 per km^2 terumbu karang untuk tempat-tempat yang memiliki nilai potensi tinggi bagi pariwisata, dan perlindungan pantai sebesar US$ 33.900 per km^2 terumbu karang untuk daerah-daerah yang nilai potensinya rendah.

Biaya-biaya utama yang dapat dikuantifikasikan adalah kerugian akibat hilangnya fungsi perlindungan pantai, lenyapnya keuntungan dari usaha pariwisata, dan hilangnya keuntungan-keuntungan yang (semula) didapat dari usaha perikanan yang ramah lingkungan. Biaya ekonomi yang ditanggung masyarakat adalah empat kali lebih tinggi daripada total keuntungan bersih yang hanya diperoleh pengusaha dari usaha penangkapan ikan dengan bahan peledak pada daerah-daerah yang memiliki potensi tinggi untuk pariwisata dan perlindungan pantai. Analisis karakteristik, dampak dan ekonomi dari penangkapan ikan dengan bahan peledak seharusnya membantu meningkatkan kemauan politik/kebijakan untuk sungguh-sungguh melarang penangkapan ikan dengan bahan peledak di perairan Indonesia. Lebih lanjut hasil analisis ini memungkinkan diadakannya suatu evaluasi dari alternatif-alternatif penyelesaian masalah di bidang pengelolaan, dengan memasukkan parameter biaya serta kerangka sosial-ekonomi yang telah membuat para nelayan pantai mulai menggunakan bahan-bahan peledak dalam penangkapan ikan.

Kata-kata kunci: Indonesia, penangkapan dengan bahan peledak, sosial ekonomi, terumbu karang

INTRODUCTION

Blast fishing was introduced in the Indonesian Archipelago in World War II as an easy and profitable way to catch schooling reef fish. Nowadays, due to generally declining catches in other sectors of coastal fisheries, the ranks of blast fishers are joined by fishers who consider blast fishing the last opportunity to catch and earn enough to feed their families. The explosives were originally taken from old WW-II ammunition shells, which were dug up by fishers. Presently, bombs are mostly made with artificial (chemical) fertilizers such as ammonium- and potassium nitrate (NH_4NO_3; KNO_3). Sometimes, dynamite obtained from police, military personnel, mining companies, or civil engineering projects is also used.

Blast fishing is considered one of the most destructive anthropogenic threats to coral reef ecosystems and the damaging effects are numerous. First is the direct effect on fish and invertebrates that inhabit a reef. Not only the preferred sizes and species are killed, but commercially unattractive organisms, species and size-classes (juveniles) fall victim to the explosion as well. Also reefs no longer function to provide food and shelter to marine organisms. Furthermore, once the reef structure is destroyed, functions in protecting coastlines can not be sustained. Last but not least, reef-related tourism, which holds great promise for alternative income generation on reefs that are not too remote, can not be developed in areas that are being blasted. Even sporadic blast fishing can destroy the reputation of a SCUBA-diving area.

In Indonesia, awareness has increased at national as well as local levels, but this has not resulted in a reduction of the use of destructive fishing methods. Although considerable attention has been drawn to the damaging effects of blast fishing on reef habitats, a management and enforcement strategy to ban this illegal practice has yet to be developed and implemented. Even though officially forbidden by law and despite the dangers to the fishers themselves, home-made bombs remain a popular fishing gear in Indonesia. Enforcement of the laws in remote areas and on sea is expensive and rarely implemented effectively. Local law enforcers often lack the means and will to patrol and make arrests at sea.

The present paper serves as an extensive summary of a scientific economic analysis of blast fishing as published in Environmental Conservation (Pet-Soede *et al,* 1999) with less use of scientific terminology. The economic analysis focuses on the three functions of coral reef ecosystems that can be estimated with valuation techniques based on market prices: fisheries, tourism and coastal protection. Also, a study of the costs and benefits at the individual household level is given that may help managers understand the incentives for using destructive methods.

METHODS

Study area and characteristics of the fishery

From May 1995 until January 1997, fishing activities in Spermonde Archipelago off SW Sulawesi, Indonesia were monitored at sea. The practice of blast fishing was studied, the number of bombs and the catch biomass were recorded, and on-site interviews were held. The size of blast impacts on the corals was estimated by direct observation under water. Interviews were held with blast-fishers and their middlemen, to collect data on the number of trips that were made each month, the costs of the operations, and on profit sharing systems. During these visits, logbooks were distributed to several fishers that subsequently recorded their daily catches for 2 months. Fish auctions were attended to collect prices for those fish categories that were found in blast catches. Prices in Indonesian Rupiah were converted to US$ at a rate of RP 2,500 per US$ 1.

Three types of blast fishing operations were observed: small-, medium-, and large scale. The large-scale operations used vessels 10-15 m in length with a crew typically of 15-20 men, who embarked on week-long trips to patch reefs or fringing reefs of uninhabited islands up to several hundred kilometers from their origin. Bombs were thrown from 3-4 small canoes that were launched from the mother ship. Divers used hoses from hookah compressors on the large ship to collect fish up to a maximum depth of 40 m. These compressors were also used for the collection of sea cucumber (*Holothuria* spp.), lobsters (*Panilurus* spp.) and in cyanide-fishing for live groupers (Serranidae). The fish was stored on ice and sold upon arrival at major landing places. The medium-scale operations worked similarly, but operated closer to their place of origin and often targeted schooling pelagic fish, away from the damaged reefs. They departed for day-long trips with smaller boats (8-10 m) and a maximum of 5 crew. Small-scale, single blast fishers used 4m long, wooden canoes with one outrigger, with a four HP outboard engine, and operated close to their home-islands. Fish were retrieved by free-diving with mask or goggles, and hence small-scale operations were restricted to sites which were no deeper than 10-12 m. Only small-scale operations typically operated within the same small area for long periods of time (over many years). Fishing on highly damaged reefs was not attractive to the medium- and large-scale operations.

The model and its input parameters

A model was developed to calculate the costs and benefits of blast fishing at the level of the Indonesian society as a whole. This model calculated costs and benefits for a hypothetical situation on 1 km^2 of coral reef, which was in pristine condition, and which was without other concurrent threats. The economic analysis was based on the differences in the 'with' and 'without' scenarios for blast fishing. In the 'without' scenario only sustainable non-destructive reef fisheries take place. In the 'with' scenario only blast fishing occurs. Calculations were carried out for two cases, a 'high value' and a 'low value' scenario. In the 'high value' scenario coastal infrastructure is well developed, there is considerable coastal construction and tourism potential is high. In the 'low value' scenario the opposite holds, which is often the case in remote rural areas.

Profits of blast fishing differed between the small, medium and large-scale operations because of scale-specific costs and revenues (Table 1). The fish caught by blast fishers was typically meant for local markets because of its poor or medium quality. Prices for blast caught fish varied from US$ 1.00 to US$ 1.50 per kg in 1997, depending on whether the fish were chilled on ice or not. The costs of fishing were not high for blast fishing operations and included bombs, fuel, depreciation costs for maintenance and repairs of the boat (Table 2). The average net profits per boat-owner per month in the blast fishery were estimated for boat owners in 1997 at US$ 55 for the small-scale operations (where the owner was the sole crew member), US$ 393 for medium-scale operations (where the owner was part of the crew) and US$ 1,100 for large-scale operations (where the owner was not part of the crew). Crew members earned average incomes per month of US$ 55 in small-scale operations, US$ 146 in medium-scale operations and US$ 197 in large-scale operations (Table 3).

For the 'without' scenario where only a subsistence fishery was present, it was assumed that many fishers were involved on a part-time basis and this was transformed to 10 full-time fishers per km^2 in line with estimates by McManus *et al* (1992). Average catch per fisher was 5 kg, totaling 15 t/km^2/yr for 10 operations fishing 300 days per year (Russ, 1991; McManus *et al*, 1992; Cesar, 1996). The operational costs were estimated at US$ 30 per year for unmotorized fishers or US$ 300 per km^2 per year for 10 full-time fishers. The opportunity costs of labour for unskilled rural workers were around US$ 0.9 per worker per day or US$ 2,700 per year for 10 full-time fishers per km^2 (World Bank, 1998).

Reef related tourism in coral reef areas encompassed diving and snorkeling and benefits

Table 1. Financial data for three types of blast fishing in 1997

	Large-scale	Medium-scale	Small-scale
No. crew/boat	1 (=owner)	4 (incl. Owner)	16 (exc. owner)
No. days/trip	1	1	8
No. trips/month	20	15	2.5
Costs [1] (US$)/trip	3.25	9.5	400
Catch[2](kg)/trip	8	75	1,500
Consumed (kg)/trip	2	10	100
Subsistence[3] (%)	25	13	7
Sold (kg)/trip	6	65	1,400
Price (US$)/kg	1	1	1.5
Owner share[4] (%)	100	40	40

(1) see Table 2 for calculation of costs per trip. Prices showed no variance and were considered standard in 1997. (2) Sample size (n), and standard error (s.e.) for small-, medium-, and large-scale respectively were n=151, 13, 3 and s.e.=0 kg, 3 kg, and 12 kg. (3) % subsistence is percentage of catch consumed. (4) Owner = single crew in 'small-scale'. Owner takes both 'crew-cut' and 'owner-cut' in 'medium-scale'. Owner is not in crew in 'large-scale' (no 'crew-cut for owner'). Income is shared as follows: 3/5 (60%) for crew, 1/5 (20%) for owner, 1/5 (20%) for 'boat'. In practice this means 40% for owner, out of which he pays all costs involved.

Table 2. Costs per trip for three types of blast fishing in spring 1997

Type	Depreciation time[a] (yr)	Type of costs	Total amount[b] (US$)	Costs per trip[b] (US$)
Small-scale	10	boat+engine	500	0.25
		2-3 bombs		2.50
		2 l diesel fuel		0.50
Medium-scale	10	boat+engine	3,000	1.50
		2*compressor	500	0.25
		dive gear	100	0.05
		4-5 bombs		4.50
		5 l diesel fuel		1.20
		ice		2
Large-scale	10	boat+engine	10,000	40
		6*compressor	1,500	6
		dive gear	2,250	9
		50 bombs		50
		225 l diesel		50
		ice		45
		food/cigarettes		100
		police'fines'		100

(a) Depreciation for small-, medium-, and large-scale blast fishing in 10 years respectively: 2000 day-trips, 2000 day-trips, and 250 week-trips. (b) Prices showed no variance and were considered standard in 1997.

Table 3. Estimated net income (US$/month) for crew members and boat owners from blast fishing

	Small-scale	Medium-scale	Large-scale
Fish sold (kg)	120	975	3,500
Revenue	120	975	5,250
Costs	65	142	1,000
Income crew	55	585[1]	3,150[1]
Net income/crew member	55	146.25	197
Net income/boat owner	55	393[2]	1,100[3]

(1) 60% crew cut of total (revenue-costs); (2) (40% owner cut +crew member cut) - costs per month;
(3) 40% owner cut - costs per month.

differed among sites, depending on accessibility among other things. The annual net value of a coral reef for tourism potential depended on the level of coral destruction and decreased linearly from the initial value, reaching zero when no corals were left. The annual net value of a coral reef for coastal protection also depended on the level of coral destruction and decreased linearly from the initial value reaching zero when no corals were left. Initial values of tourism potential and coastal protection for the 'high value' and 'low value' scenarios were extracted from Cesar (1996). In his paper, Cesar combined data from Riopelle (1995), field interviews, and published market data on agricultural yields in Indonesia and used a variety of valuation techniques including the loss of productivity approach and the replacement cost approach (Dixon and Sherman, 1990). The present values of tourism per km^2 of coral reef were annualized to US$ 55,900 representing a 'high value' and US$ 333 for a 'low value' situation. Similarly, the annualized values for coastal protection were US$ 61,100 for the 'high value' scenario and US$ 2,800 for the 'low value' scenario.

The size of the coral area destroyed by a single blast depended on the size of the bomb and the position of the explosion relative to the coral reef. Our observations showed that a beer bottle bomb shattered stony corals in an area of approximately 5 m in diameter. The radius of coral kill per blast was 2.5 m, hence the area affected per blast was 19.6 m^2. With 2-3 bombs per small-scale operation and 2 operations, 20 days per month, 10 months per year, the total number of blasts was estimated at 800-1,200 per year per km^2. Assuming a coral cover in the target patch of 100% and an average coral cover of the entire km^2 of 50 to 55% in the pristine situation, the rate of coral loss was 3.75% (points) per year. With this rate it took 20 years to destroy 75% of the coral on a reef and thus the analysis was carried out over a 20 year time period.

RESULTS

Model output

At the level of individual fishing households, the net income per person in small scale blast fishing operations decreased in 20 years from US$ 6,450 to US$ 550. The high income in year 1 when blast fishing was newly introduced formed the incentive to start blast fishing. Comparison with non-destructive fishing in an area without blast fishing, where each of 10 full-time fishers had an annual income of US$ 1,470, showed that blast fishing in the initial years was 4 times more rewarding than non-destructive fishing (Figure 1). This difference was only sustained for a short period, in the long run (more than 20 years) the income from blast fishing will reach the level of opportunity costs. In year 20 the income from blast fishing was only one fifth of what could have been derived if blast fishing had not been introduced (Figure1). The motorized and well-equipped medium- and large-scale operations that explore pristine reef areas find high revenues that will likely compensate their exploration costs.

At the level of the society as a whole both the 'high value' and 'low value' scenarios showed that costs of blast fishing through loss of tourism potential and coastal protection were higher than the total net benefits from blast fishing (Figure 2). After 20 years of blast fishing forgone benefits from tourism totalled US$ 134,000 per km^2 of reef in an area with a high potential for tourism and coastal protection and US$ 800 per km^2 in an area with a low potential. Explosives fishing generated a net loss to society of US$ 306,800 per km^2 of reef in the 'high value' scenario and US$ 33,900 per km^2 in the 'low value' scenario. The quantifiable costs of blast fishing in the 'high value' scenario were quite evenly distributed between the forgone net benefits of fishing, tourism, and coastal protection. In the 'low value' scenario, the forgone net benefits of fishing became the main costs of blast fishing.

DISCUSSION

Blast fishing is destructive to the coral reef ecosystem and can lead to the collapse of coral reef fisheries (McManus *et al*, 1997). Heavily damaged reef areas are obviously less attractive for reef-related tourism, and foregone benefits of this type of tourism form a considerable part of the economic losses due to blast fishing. The coastal protection function is also affected by this practice, as coral reefs will gradually erode through physical and biological processes. In areas with a high value of coral reefs for tourism and coastal protection, the net loss to society of blast fishing was estimated at US$ 306,800 per km^2 of coral reef and the economic costs to society were 4 times higher than the net private benefits to blast fishers. Due to the difficulty of translating qualitative natural assets into quantitative monetary values, many non-quantifiable costs of blast fishing have not been taken into account in the economic model. Therefore, the above estimates for economic losses are quite conservative. It can be concluded that blast fishing results in large economic losses to the Indonesian society, especially when taking into account the vast areas of coral reefs that are threatened in this country.

Nevertheless, for individual fishers, the financial incentives to start blast fishing are obvious, especially in a situation with pristine coral reefs. The financial analysis at the individual household level also shows clear incentives for scale-enlargement. Both crew members and boat owners had the highest net income per month in the large-scale blast fishing operations with US$ 197 and US$ 1,100 respectively. Medium-scale and large-scale operations typically work in pristine areas and therefore blast fishing will continue to spread into the most remote areas unless very firm action is taken to combat this practice. For the individual fisher involved in blast fishing, the net income is all that matters and he does not take his contribution to ecosystem damage into account.

Interventions to ban blast fishing must include the development of alternative livelihoods for local fishers. When enforcement programs are effective in pushing the blast fishers out of their practice, other income opportunities need to be available. Indonesia, with its many islands, long coastline and productive marine waters, has always been a fishing nation. It has been concluded, however, that most of Indonesia's coral reef resources are presently over-exploited (Venema, 1997). Yet there is still sufficient scope to shift from coral reef fisheries into pelagic fisheries. Furthermore, Indonesia has a large potential for the development of mariculture. Applied research in the field of coastal resources management is needed to support decision-making processes at all levels of management. Effective management is impossible without a constant flow of information on the resources and exploitation patterns.

The traditional aim of intensification in coastal resource exploitation needs to be changed in goals of conservation and sustainable use. The open access nature of the sea can be regarded as one of the major problems that lead to destructive fishing practices. Privatization of common property is seen as the future in natural resources management (Jentoft and McCay, 1995), but this needs the imbedding of definitions of property rights in a legal framework (Pomeroy and Carlos, 1997), which is a tedious process. Traditional communal property rights are usually not written down (Ruddle, 1993; Zerner, 1993), and have eroded during the last decades (Kendrick, 1993; Zerner, 1993). It is the role of the government to specify, legitimize and enforce the security of property rights to local resources. Exclusive fishing rights can only lead to improved management when actively supported by the government.

If the Indonesian government is serious about combatting the destruction of its coral reefs, it should implement effective enforcement programs, develop legislation to restrict the open access to fisheries resources, and support the development of sustainable fisheries, mariculture and tourism. It may be obvious that considerable financial resources are needed to implement the required management interventions, but the economic analysis of blast fishing and the level of the losses clearly show that investments in integrated management are fully justified. Political will needs to be generated to make these resources available. This political will can only be created by presenting the economic picture (Medley *et al*, 1993). Taking into account the economic reality, a national government striving for economic growth, low unemployment and social stability, will have to acknowledge the value of undamaged and well-managed coral reefs.

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