

Abalone Conservation in the Presence of Drug Use and Corruption

*Implications for Its Management in
South Africa*

Edwin Muchapondwa, Kerri Brick, and Martine Visser



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Abstract

The illegal exploitation of wild abalone in South Africa has been escalating since 1994, despite increased enforcement, leading to collapse in some sections of its range. South Africa banned all wild abalone fishing in 2008 but controversially reopened it in 2010. This paper formulates a poacher's model, taking into account the realities of the abalone terrain in South Africa—the prevalence of bribery, corruption, use of recreational drugs, and the high value of abalone—to explore why poaching has not subsided. The paper suggests two additional measures that might help ameliorate the situation: eliminating the demand side through enforcement targeted on organized crime, and ceding the resource to the local coastal communities. However, local communities need to be empowered to deal with organised crime groups. Complementary measures to bring back community patriotism will also be needed given the tattered social fabric of the local coastal communities.

Key Words: abalone, bribery, coastal communities, corruption, poaching, recreational drugs

JEL Classification: Q22, Q28, Q57

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Introduction

Abalone meat is considered a delicacy and an aphrodisiac, and people in some Asian countries think it can delay senility and increase fertility (Hauck and Sweijd 1999; Burgener 2005). The high financial value of abalone, coupled with the fact that it lives in the shallow intertidal zone, makes it particularly vulnerable to overexploitation and environmental factors (Hauck and Sweijd 1999; Plagányi and Butterworth 2009). By 2003, global abalone production levels fell to less than 10,000 tonnes, about one-third of the level three decades previously (Prince et al. 2008, as cited in Plagányi and Butterworth 2009).

The South African abalone fishery dates back to 1949 and is one of the oldest commercial abalone fisheries in the world (Tarr 1992). It ranks as one of the top five to ten wild abalone fisheries in the world, behind the abalone fisheries of Australia and Japan (Tarbath et al. 2003, as cited in Plagányi and Butterworth 2009). The South African abalone fishery is reliant on a single gastropod species, *H. midae* (locally called perlemoen), which lives in shallow beds of kelp, *Ecklonia maxima* (Tarr 1993). The commercial fishery is located on South Africa's west coast from Cape Columbine to Quoin Point.¹ Since the early 1990s, the South African abalone fishery has declined considerably, due to a combination of two factors: an ecosystem change from the movement of West Coast rock lobsters (*Jasus lalandii*) into a section of its range and very high levels of illegal fishing (Plagányi and Butterworth 2009).²

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¹ South Africa has 13 abalone farms, which currently produce about 1,000 tonnes of abalone (Burgener 2009).

² The rock lobster feeds on the sea urchins *Parechinus angulosus*, which usually provide juvenile abalone (3–35 mm in length) with protection against predators and a supplementary diet. The ecosystem change results in abalone recruitment failure.

In a bid to counter illegal harvesting, the fisheries authority, the Department of Marine and Coastal Management (MCM), has invested significantly more in fisheries compliance since the mid-1990s. Hauck and Kroese (2006) documented how MCM strengthened law enforcement in the late 1990s, creating a specialised unit that focused on marine offenses and increased shoreline patrolling. Formal and informal partnerships were established with other government departments to conduct joint investigations, and an Environmental Court was established in 2003, primarily to try abalone cases. MCM also instituted measures to minimize corruption, such as increasing the salaries of fishery control officers and setting up a telephone hotline. In addition to these initiatives, it also attempted to decrease fishing effort by systematically reducing the total allowable catch (TAC), which was reduced from 500 tonnes in 1999-2000 to 75 tonnes towards the end of 2007 (Tarr 2003).

However, these traditional management measures proved relatively ineffective. Abalone poaching remained widespread at high levels. By 2007, nearly the entire abalone catch of over 2,000 tonnes was estimated to be caught illegally (Raemaekers and Britz 2009).³ Indeed, the abalone fishery is extremely difficult to manage given the suite of factors simultaneously at play: the increased predation of sea urchins by West Coast rock lobster, the high value of the resource, the presence of highly-organised poaching syndicates, and the discontent with lack of proper redistribution of access rights following South Africa's transition to democracy (Hauck and Sweijd 1999; Steinberg 2005; Hauck and Kroese 2006; Raemaekers and Britz 2009).

The commercially fished area is divided into seven fishing zones, with four main fishing zones. The inshore region is particularly depleted: inshore abalone stocks have crashed in two of the zones and are predicted to be heavily depleted in the others. Plagányi and Butterworth (2009) suggested that there is little hope of medium-term recovery of the resource in the zones where it has crashed, even if illegal fishing were stopped. However, they further suggested that if illegal fishing could be appreciably curtailed, these zones might show some recovery. The commercial fishery was closed in February 2008 but reopened in July 2010 as the ban was not effective.

³ While international trade data showed an apparent decrease in poached abalone from South Africa for the period 2004–2008, this could be due to either a reduction in the volume of illegal harvest and trade or an increase in mis-declarations in international trade. Decline in the volume of abalone exports from South Africa may also have been due to a decrease in the average size of poached abalone. *H. midae* was listed in Appendix 3 of the “Convention on International Trade in Endangered Species of Wild Fauna and Flora” in May 2007, which may cause an increase in mis-declarations of illegal abalone consignments (Burgener 2009).

The rationalist approach to compliance assumes that fishermen base their decision to comply with regulation on economic gains, the probability of detection, and the severity of punishment. In this context, the role of law enforcement and deterrence in facilitating compliance is widely recognized (Hauck 2009). In fact, the policing effort has not been constant over time because, for example, in some years the government provided additional resources in an effort to curb the escalating poaching levels (Plagányi and Butterworth 2009). However, increased law enforcement alone has not substantially reduced poaching. The abalone stock assessment model by Plagányi and Butterworth (2009) highlighted large increases in illegal harvest over time. Their model also suggested that, on average, only 14% of all poached abalone are confiscated. Alternate explanations for illegal behavior must be explored in order to design appropriate responses to the abalone poaching problem.

In this context, we developed a dynamic model of abalone poaching to assess why increased enforcement has failed to achieve better compliance with the abalone fishery regulations. Drawing on the work of Becker (1968), Ehrlich (1973), Messer (2000), and Abbott (2008), we formulated a specific South African model consisting of two agents: the conservation agency, MCM, which is responsible for protecting the abalone resource through enforcement activities; and the poacher, who divides time between legitimate employment and illegal abalone harvesting. We analyze why increased enforcement efforts have failed to curb illegal abalone harvesting by considering additional factors behind the illegal exploitation of abalone.

Our model allowed us to explore the relationship between abalone poaching, the high value of the abalone resource, corruption in enforcement structures, and other livelihood pressures whose resolution requires the use of harvested abalone (e.g., the trade of abalone in exchange for methamphetamines, consumption of which is inelastic because it is addictive). The inclusion of these additional factors enabled us to explain continued abalone poaching in the face of increased law enforcement effort and to suggest possible future policy directions. The paper proceeds as follows. The section that follows gives more background information. Next, the model is outlined, then relevant policy implications are discussed. The last section concludes.

Background

Abalone spawns by broadcasting. The planktonic larvae typically drift with the sea currents for about a week. They settle mostly in shallow inshore waters, where they seek shelter under boulders, narrow rock crevices, or under the spines of sea urchins *Parechinus angulosus*. At around 100 mm shell size (a sufficiently large size to have some protection from predation), they emerge and find a suitable habitat to attach to and let food come to them by water

movements. As their size slowly increases, the abalone may gradually disperse into deeper water (Plagányi and Butterworth 2009). They are slow growing, requiring a period of about seven years to attain 100% sexual maturity, and eight to nine years to attain the legal minimum catch size of 114 mm shell breadth.

Widespread poaching was prevalent during South Africa's transition to democracy in 1994. The 1994 "abalone war," which entailed violent confrontations between poachers, police, community members, and commercial divers, has evolved into a highly organized illegal transnational trading operation involving Chinese organized crime syndicates (Hauck and Kroese 2006). Gastrow (2001) described police investigations that revealed that illicit abalone trading constituted a significant share of the business of Chinese organized crime. Steinberg (2005) attributed the rapid growth in illicit abalone trading in the 1990s to a number of factors: weakness of the South African rand against the U.S. dollar, which provided significant incentive to ramp up the export of high-value, dollar-denominated commodities; an entrenched Chinese organized crime network in South Africa, with illicit trade routes between East Asia and South Africa, which bartered drugs for abalone;⁴ South Africa's difficulty with effective border control; and, finally, increased tolerance towards poaching by previously disadvantaged coastal communities frustrated by the perceived slow racial transformation of the country's fisheries. The presence of street gangs and international syndicates has not only increased pressure on the abalone resource, but also has compounded the complexity of resource management (Hauck 2009a).

The link between abalone and drug use is well documented. Steinberg (2005) described how, in the mid-1990s, players from the Western Cape's gang-based drug trade moved to abalone-rich fishing communities, taking control of huge segments of the abalone market. During this time, large quantities of the chemical ingredients for methaqualone—then the drug of choice in the Cape Flats—were being smuggled into South Africa from East Asia. It was clear by the late 1990s that methaqualone was being bartered for abalone, and had been for some time (Steinberg 2005).

Abalone was completely intertwined in the illicit economy in the Western Cape: Chinese organized crime bartered cheap chemical precursors for methaqualone for valuable abalone;

⁴ Bartering facilitates the trade of a high-value, dollar-denominated commodity, such as abalone, which is exported for other high-value commodities, such as imported drugs (Steinberg 2005).

Western Cape drug dealers bartered cheaply-acquired abalone for high value drugs; and poachers exchanged abalone for drugs for resale or their own consumption (Steinberg 2005). Chinese organized crime still remains entangled in the Cape Flats drug market amid the rise in popularity of another recreational drug, colloquially called *tik*, or crystal methamphetamine (Steinberg 2005). Hauck (2009a) argued that the illegal exploitation of abalone has evolved into its own organized illicit industry controlled by street gangs at the shore and transnational syndicates which export the abalone to the Far East.

The international trade in abalone is primarily driven by demand in Asia. The main importers of abalone are Hong Kong, China, Japan, Malaysia, South Korea, Philippines, Singapore, and Taiwan, with Hong Kong as the largest importer (Allen et al. 2006; Burgener 2009).

As for exports of abalone, Allen et al. (2006) used trade statistics from the Hong Kong Census and Statistics Department to break down the countries of origin of preserved abalone imported into Hong Kong between 1998 and 2002. South Africa's and Mozambique's contributions were 19% and 11%, respectively. Nine countries categorised as "others" contributed an estimated 12%. The majority of "others" are African countries: Madagascar, Mauritius, Namibia, Senegal, Swaziland, Zambia, and Zimbabwe. Allen et al. (2006) noted that abalone is not indigenous to these countries, with the exception of Namibia, so it is likely that the abalone was poached in South Africa, smuggled into these other African countries, and exported from them to Hong Kong. The authors estimated that, factoring in the movement of abalone from other countries to South Africa, South Africa contributes around 40% of Hong Kong's preserved abalone imports.

Steinberg (2005) concluded that, while it is not possible to quantify the amount of abalone being smuggled across South Africa's borders, the majority of abalone is smuggled across its uncontrolled and commercial land borders and on unlogged air flights. Once the abalone has crossed over into neighboring states—where there is no law against the transportation or shipment of abalone without a permit—it is exported from sea and air ports. The latest data reported by Burgener (2009) confirms the presence of abalone exports from Kenya, Mozambique, Swaziland, and Zimbabwe, where abalone is not native.

H. midae was listed in Appendix 3 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in May 2007, which may have caused an increase in fraudulent declarations of abalone consignments. Indeed, international trade data reflected an apparent decrease in poached abalone from South Africa for the period 2004–2008, which could

be due to either a reduction in the volume of illegal harvest and trade or an increase in mis-declarations in international trade. The decline in the volume of abalone exports from South Africa might also be due to a decrease in the average size of poached abalone. Furthermore, all poached abalone may not be exported immediately; it can be dried and sold later when anti-poaching enforcement becomes easier to evade (Burgener 2009). Based on the results from Plagányi and Butterworth (2009), abalone poaching is still strong and confiscation rates are low. There is thus a need and an opportunity for authorities to better understand the poaching problem and design more effective responses.

The Model

Emphasising the similarity between the traditional household choice problem and the decision to commit an offense, the literature on the economics of crime applies choice theory to the study of illicit activities (Block and Heineke 1975). In his seminal article, Becker (1968) assumed that individuals will commit a crime (offense) if the expected utility from committing that crime is greater than the utility obtained from devoting their time and resources to alternative activities. As noted by Becker (1968), “Some persons become ‘criminals’ ...not because their basic motivations differ from that of other persons, but because their benefits and costs differ” (Becker 1968, cited in Block and Heinke 1975: 314).

Ehrlich (1973) formulated a more comprehensive model by incorporating the costs and gains from licit and illicit activities (as opposed to the cost of punishment alone). In this way, “it links formally the theory of participation in illegitimate activities with the general theory of occupational choices by presenting the offender’s decision problem as one of an optimal allocation of resources under uncertainty to competing activities both inside and outside the market sector, rather than as a choice between mutually exclusive activities” (Ehrlich 1973: 522). Thus, a model of choice between legal and illegal activities can be formulated within the framework of the usual economic theory of choice under uncertainty.

This paper draws on Messer (2000) and Abbott (2008) in formulating a South African-specific model with two agents: 1) the conservation agency, which is responsible for protecting the abalone resource; and 2) the poacher, who has to make decisions about allocating his labour to legitimate employment or illegal abalone harvesting. The poacher’s motive in illegally harvesting the abalone is to supply it to the lucrative black market (Hauck and Sweijd 1999). A major innovation of our model, compared to previous ones, is that it also looks at the interactions between abalone poaching and use of demand-inelastic drugs, as well as the role of bribery and general corruption in abalone poaching.

The conservation agency is tasked with the preservation of the abalone resource and there is a ban on resource harvesting. Let x be the stock of the abalone that is still in the water. The existence value of the resource is a function of its stock: $T(x)$, $T_x > 0$, and $T_{xx} < 0$. (The signs of all partial derivatives of interest are noted in the appendix, rather than in the text). There is a lucrative market for harvested abalone. The existence of such a market motivates illegal harvesting (poaching) of the resource by people external to the conservation agency. To counter such illegal harvesting, the conservation agency invests in anti-poaching enforcement e .⁵ Anti-poaching enforcement comes at a cost of $f(e)$. Even though the conservation agency does not proactively participate in the market for the harvested abalone, it supplies the market with abalone confiscated from poachers to defray costs.

We assume that the conservation agency selects an optimal level of anti-poaching enforcement e in order to maximize the present value of net benefits from the resource.⁶ In any given period, the net benefits from the resource are made up of the existence value of the resource $T(x)$, the anti-poaching enforcement costs $f(e)$, revenues from any fines imposed on apprehended illegal harvesters F , and the proceeds from sale of confiscated illegal harvests C .⁷ Thus, the objective of the conservation agency can be concisely written as:

$$\text{Max}_e \int_0^\infty T(x) - f(e) + \pi(e, \omega)(1 - \theta)[F + C]e^{-rt} dt, \quad (1)$$

where π denotes the probability with which illegal harvesters will be apprehended. It is assumed here that the likelihood of apprehending illegal harvesters is increased by anti-poaching enforcement and reduced by the presence of corruption among enforcement officers.

The presence of different aspects of corruption helps facilitate the activities of organized crime: Gastrow (2001) described how Chinese syndicates targeted corrupt customs officials to clear illicitly imported goods and airport officials to facilitate illicit abalone exports. In addition, Hauck (2009), citing an anonymous referee, noted instances where police patrol vehicles were used to transport abalone. Various media sources refer to police involvement in abalone

⁵ Anti-poaching enforcement aims to reduce illegal abalone harvesting, increase confiscation of harvested abalone, and apprehend the culprits involved. Ideally, the size of anti-poaching enforcement should depend on the size of the resource and the extent of the threat of illegal harvesting of the resource.

⁶ This seems to be a plausible assumption, given the tendency by South African authorities to sell any confiscated poachers' loot to defray costs, rather than discarding it to help starve the market.

⁷ The values of F and C will be fully characterized below, once we have explored the behavior of the illegal harvesters and their interaction with anti-poaching enforcement.

poaching, including warning poachers of road blocks and other police operations (DEAT 2007; Gosling 2004; Anonymous 2008). As such, we assumed the existence of a general corruption index ω , which assigns higher values for more corruption. Thus, π is a function of e and ω . Note that apprehension in this context refers to the poacher being subdued by the anti-poaching enforcement officers.

Corruption is not limited to apprehension of poachers. For example, seven police officers, who were arrested in 2004 on suspicion of conspiring with abalone poachers, were charged with accepting bribes in exchange for poachers' cases being dropped or dockets being lost, among other charges (Gosling 2004). Given the presence of corruption in general and the payment of bribes⁸ in particular, the anti-poaching enforcement officers will take one of two courses of action once they have apprehended the poacher: make a formal arrest or accept a bribe. It is assumed that bribery will take place with a probability of θ . Thus, if the poacher is formally arrested, then his loot will be confiscated and he will be fined. The poacher's total financial cost of the fine F will be paid with a probability of $(1 - \theta)$. The poacher's total expected revenue loss from the confiscated loot C will also occur with probability $(1 - \theta)$. Similarly, the conservation agency will receive revenues from fines F and proceeds from sale of confiscated illegal harvests C with probability $\pi(e, \omega)(1 - \theta)$.

To maximize net benefits, the conservation agency will need to take the abalone stock dynamics into account. The dynamics of the stock of abalone that is still in the water is governed by its natural growth g and the illegal harvest h . Thus:

$$\dot{x} = g - h \quad (2)$$

The natural growth g , whose functional form is assumed to be a logistic, depends on the stock sizes of the abalone x and rock lobster l . The illegal harvest h depends on the size of the stock of abalone, the amount of effort directed toward abalone poaching, other livelihood pressures whose resolution requires the use of harvested abalone, and the effectiveness of anti-poaching enforcement. In order to know the exact magnitude of h , we need to fully characterize the amount of effort directed toward abalone poaching and the other livelihood pressures, whose resolution requires the use of harvested abalone. This can be done by exploring the behavior of the illegal harvesters.

⁸ It is assumed that corruption is a broad class which encompasses bribery. Some of the corrupt practices that do not involve bribes include turning a blind eye to friends and relatives who are involved in illegal activities.

The local illegal abalone industry consists of divers, middlemen, and processors. The divers are usually from the local coastal communities and do the actual harvesting. The middlemen are usually gang operatives, who buy and collect the poached abalone from the divers, then sell and deliver it to the processors. The processors are usually Chinese entities. They buy and dry the abalone from the middlemen then transport and sell it to international markets in Hong Kong, China, Japan, Singapore, and Taiwan, for example.

The local illegal abalone market consists of the demand and supply sides. One plausible way of describing the two sides would be to put those involved in the pre-processing stages on one side and those involved in the processing and beyond on the other side. Thus, the category with divers and middlemen is the supply side, while the processors represent the ultimate demand side of the abalone market. Therefore, for purposes of our model, we define the actors on the supply side as the poachers.

The middlemen in the abalone trade have been dominated by gangs, who look for easy income to bankroll their activities. One of the needs of the gangs in carrying out their activities is recreational drugs. Thus, dealing in illegal abalone helps gangs to generate financial resources to secure drugs, usually for own consumption, but also for sale to others. The drugs are often addictive and are therefore generally assumed to have inelastic demand. Thus, if a significant section of the abalone market supply side consumes drugs and finances its demand for drugs through illegally harvested abalone, then the value of drugs consumed, D , is one of the factors affecting the abalone poaching function. Thus, the use of drugs can be characterized as a livelihood pressure whose resolution requires the use of harvested abalone. For example, when the price of drugs q rises, poachers will not reduce their demand for drugs because drugs are highly price inelastic. Instead, poachers will harvest more abalone to assure themselves of almost the same quantity of drugs. Thus, even if increased anti-poaching enforcement reduced the illegal harvest levels, if it happened to coincide with rising drug prices, it would be ineffective.

The major way that the poacher affects the abalone resource is by selecting the amount of effort to put into abalone poaching. The abalone poacher is assumed to have an initial income endowment of y_0 and can use his own labour to generate additional income by allocating it to either poaching, or legitimate employment, or both. Thus, the poacher derives income from the proceeds of sale of the poached harvest and from a wage w at the legitimate employment. The fraction of time spent poaching is given by τ .

As indicated earlier, the illegal harvest h depends on the size of the stock of abalone x ; the amount of effort directed toward abalone poaching, which is represented by the fraction of

time spent poaching τ ; other livelihood pressures whose resolution requires the use of harvested abalone, such as the value of drugs consumed $D(q)$; and the effectiveness of anti-poaching enforcement, which is represented by the size of the anti-poaching enforcement e . Thus, the poaching function is given by $h(\tau, x, D(q), e)$.

The poached harvest can be sold at a unit price of p . The financial benefit set to be made in the event of a successful sale will be $ph(\tau, x, D(q), e)$. However, given the presence of anti-poaching enforcement, the poacher may be apprehended before selling his loot. As indicated earlier, apprehension in this context refers to the poacher being subdued by the anti-poaching enforcement officers, after which they can take one of two courses of action: make a formal arrest or accept a bribe. On one hand, if the poacher is formally arrested, then his loot $h(\tau, x, D(q), e)$ will be confiscated and he will be fined δ per unit of the confiscated loot. The poacher's total financial cost of the fine F will be $\delta h(\tau, x, D(q), e)$ and will be paid with a probability of $(1 - \theta)$. The poacher's total expected revenue loss from the confiscated loot C will be $ph(\tau, x, D(q), e)$, also with probability $(1 - \theta)$. Similarly, the conservation agency will receive revenues from fines F , and proceeds from sale of confiscated illegal harvests C with probability $\pi(e, \omega)(1 - \theta)$. On the other hand, if the anti-poaching enforcement officers accept a bribe, then the poacher pays a bribe of B per unit of his loot and keeps the loot, $h(\tau, x, D(q), e)$.⁹ The total financial cost of the bribe will be $Bh(\tau, x, D(q), e)$ and will be paid with a probability of θ , given apprehension. As pointed out earlier, it is assumed that the poacher is apprehended with probability $\pi(e, \omega)$.

The problem of the poacher is thus to decide the amount of poaching effort to exert. Because poachers do not have property rights over the resource, they will not take the stock dynamics into account. The poacher's problem can thus be written:

$$\begin{aligned} \underset{\tau}{Max} \quad & \pi(e, \omega)[y_0 + w(1 - \tau) - [(1 - \theta)\delta + \theta B]h(\tau, x, D(q), e)] + \\ & (1 - \pi(e, \omega))[y_0 + w(1 - \tau) + ph(\tau, x, D(q), e)] \end{aligned} \quad (3)$$

The first order condition consistent with positive time spent poaching is:

$$h_{\tau}(\tau, x, D(q), e)[(1 - \pi(e, \omega))p - \pi(e, \omega)[(1 - \theta)\delta + \theta B]] = w, \quad (4)$$

⁹ It is expected that B will be less than δ , which is why poachers are enticed to collabourate with the bribery-seeking officers, instead of preferring to be formally arrested. While some may argue that the bribe only needs to be smaller than $\delta + p$, we argue that p will not feature in this decision because it does not necessarily help with the current cash flow on which bribery is usually supported.

from which one can solve for τ^* as a function of $x^*, D(q), p, \pi, \delta, w, \omega, \theta, B$ and e^* , if given specific functional forms.¹⁰ The first order condition simply says that labour will be allocated to poaching until the marginal benefit from poaching (i.e., the expected value of the additional harvest $h_\tau(\tau, x, D(q), e)[(1 - \pi(e, \omega))p - \pi(e, \omega)[(1 - \theta)\delta + \theta B]]$) is equal to the marginal cost of such a labour deployment (i.e., the forgone wage w). The values of x^* and e^* are determined from the conservation agency's problem.

Going back to the conservation agency, we assume that it selects an optimal level of anti-poaching enforcement e in order to maximize the present value of net benefits from the resource, taking the abalone stock dynamics into account. The conservation agency's problem can be comprehensively written as:

$$\begin{aligned} \text{Max}_e \int_0^\infty T(x) - f(e) + \pi(e, \omega)(1 - \theta)[\delta(h(\tau, x, D(q), e)) + ph(\tau, x, D(q), e)]e^{-rt} dt \\ \text{s.t. } \dot{x} = g(x, l) - h(\tau, x, D(q), e) . \end{aligned} \quad (5)$$

The Pontryagin's maximum principle consistent with positive anti-poaching enforcement by the conservation agency is given by:

$$\begin{aligned} f_e(e) &= \pi_e(e, \omega)(1 - \theta)[\delta + p]h(\tau, x, D(q), e) + [\pi(e, \omega)(1 - \theta)(\delta + p) - \lambda]h_e(\tau, x, D(q), e) \\ \dot{\lambda} &= r\lambda - T_x(x) - \lambda g_x(x, l) - [\pi(e, \omega)(1 - \theta)(\delta + p) - \lambda]h_x(\tau, x, D(q), e) \\ \dot{x} &= g(x, l) - h(\tau, x, D(q), e) , \end{aligned} \quad (6)$$

from which one can solve for steady-state values of e^* and x^* as functions of $\tau^*, x^*, D(q), p, \pi, \delta, w, \omega, \theta$, and e^* , if given specific functional forms. The steady state equilibrium requires that $\dot{x} = 0$ and $\dot{\lambda} = 0$. It should be noted that the value of τ^* is determined from the poacher's problem. Thus, it is evident that one can solve for τ^*, x^* , and e^* from the two agents' problems. The first condition simply says that the conservation agency will invest in anti-poaching enforcement until the marginal benefit from enforcement is equal to the marginal cost of enforcement. The marginal benefit is the sum of the expected additional revenue from fines and sale of confiscated loot after more successful enforcement, $\pi_e(e, \omega)(1 - \theta)[\delta + p]h(\tau, x, D(q), e)$, and the additional value from the resource that is still in the

¹⁰ It should be noted that $(1 - \pi(e, \omega))p > \pi(e, \omega)[(1 - \theta)\delta + \theta B]$ because h_τ and w are positive.

water after more successful enforcement has reduced the harvest, $[\pi(e, \omega)(1 - \theta)(\delta + p) - \lambda]h_e(\tau, x, D(q), e)]$ The marginal cost is the cost of additional enforcement, $f_e(e)$.

Policy Implications

This section considers the various aspects of the model and draws implications for policy. Many models on poaching are usually quick to suggest increases in anti-poaching enforcement and fines to curb illegal harvesting. The model formulated above also gives the same impression, *prima facie*, as $\tau_e < 0$ and $\tau_\delta < 0$. However, as we argue below, while these actions constitute a move in a desirable direction, more measures are needed to curb illegal abalone harvesting in South Africa.

South Africa's regulation of the abalone industry began in earnest with the imposition of a quota. However, the quota compounded the problems of anti-poaching enforcement because it was difficult to distinguish between legal and illegal harvests. This was the prime motivation for imposing a ban in 2008 on all harvesting. We investigate the effect of increased enforcement by considering the comparative statics:

$$\tau_e = \frac{\pi_e[(1 - \theta)\delta + \theta B + p]h_\tau - [(1 - \pi)p - \pi[(1 - \theta)\delta + \theta B]]h_{\tau e}}{[(1 - \pi)p - \pi[(1 - \theta)\delta + \theta B]]h_{\tau\tau}} < 0$$

$$\tau_\delta = \frac{\pi h_\tau}{[(1 - \pi)p - \pi[(1 - \theta)\delta + \theta B]]h_{\tau\tau}} < 0 \quad (7)$$

With greater enforcement, there will be 1) a reduction in harvest, as the poachers are forced to stay out of the water; and 2) an increase in the probability of apprehending the poachers. It would seem that, with a ban, enforcement will be enhanced because anyone seen with abalone will have obtained it illegally and must necessarily be a poacher. Thus, the 2008 ban coupled with enhanced anti-poaching enforcement should ultimately have reduced the poaching effort and illegal harvest, all things being equal.

However, when we consider the reality in South Africa, there is no evidence that the ban reduced illegal harvest. The model in our paper offers four possible explanations as to why poaching continued unabated, despite the ban and the implied enhanced enforcement. It is true that enforcement affects the probability of detection and thus the harvest levels. It is also the case that other factors are at work through the same variables, but in a way contrary to the aims of anti-poaching enforcement. These factors, which are also incorporated in the model and which yield the comparative statics given below, are a) the role of drugs, such as methamphetamine; b)

general corruption in the anti-poaching enforcement system; c) the prevalence of bribery in the anti-poaching enforcement system; and d) the high value of the abalone products on the market, respectively:

$$\begin{aligned}
 \text{a) } \tau_q &= -\frac{h_{\pi D} D_q}{h_{\pi\pi}} > 0, \\
 \text{b) } \tau_\omega &= \frac{\pi_\omega [(1-\theta)\delta + \theta B + p] h_\tau}{[(1-\pi)p - \pi[(1-\theta)\delta + \theta B]] h_{\pi\pi}} > 0, \\
 \text{c) } \tau_\theta &= -\frac{\pi(\delta - B) h_\tau}{[(1-\pi)p - \pi[(1-\theta)\delta + \theta B]] h_{\pi\pi}} > 0, \text{ and} \\
 \text{d) } \tau_p &= -\frac{(1-\pi) h_\tau}{[(1-\pi)p - \pi[(1-\theta)\delta + \theta B]] h_{\pi\pi}} > 0.
 \end{aligned}$$

As pointed out earlier, abalone poaching is entangled with drugs. Abalone is an easy source of income for gang members with which to buy the drugs necessary for gang activities. There has been a reported increase in the prevalence of drug use in South Africa, especially methamphetamines. Such a surge in the demand for drugs results in a rise in their prices. Because the quantity of drugs demanded does not respond much when prices rise, drug users have to secure additional income to finance the drug price increase. It is believed that the source of this additional finance has been dealing in illegal abalone, fueling continued poaching despite enforcement efforts. Thus, a fight against abalone poaching will necessarily be a fight against drug use, especially methamphetamine use with its intimate relationship with abalone poaching.

Almost all of the illegally harvested abalone in South Africa is exported to Hong Kong. The delivery of illegally harvested abalone to local processing houses and to ports for export should be very difficult with alert enforcement efforts, given the vast distances involved. It appears, then, that enforcement is being compromised somehow, which aids the unabated and illicit abalone trade. There have been reports of police vehicles being used to transport poached abalone in order to avoid capture while in transit. In some cases, top political figures have been implicated in facilitating abalone movements. The role of this general corruption is then to reduce the probability of apprehension, allow poaching (effort) to continue and to further degrade the resource.

Another specific type of corruption, reported to be prevalent in South Africa, is bribery. In the presence of bribery possibilities, the investment in enforcement is rendered ineffective.

Anti-poaching enforcement officers use paid time to earn additional income from apprehended poachers, whom they decide to let go scot-free after paying them bribes. Eventually, the poachers internalize the bribes as any other ordinary cost of their harvesting activities. Thus, the prevalence of bribes increases poaching effort and consequently leads to over-exploitation of the resource.

Due to the existence of a number of factors that hinder anti-poaching enforcement, the size of anti-poaching enforcement is not necessarily related to its effectiveness. There might be ways of raising the probability of apprehension without necessarily increasing anti-poaching enforcement. With corruption, the effectiveness of any level of anti-poaching enforcement will be lower. By getting rid of corruption, the effectiveness of anti-poaching effort would increase.

So, what mechanisms can one use to get rid of corruption? In real life, one needs another enforcement activity—an anti-corruption enforcement effort and expense. However, a simpler way is to preach ethical behavior to the enforcement officials, hoping that they will change their own behavior. Investment in community education about the ecology and socioeconomics of abalone might also encourage the community to become involved and assist government enforcement.

The last factor influencing the dynamics of poaching behavior is the price of abalone. At present, abalone demand is inelastic, due to its association with status in Asia; thus, there is always big money to be made from the abalone business. When this is put against the background of the alternative sources of income to which poachers have access, there is no doubt that the lucrative abalone poaching will continue unless drastic measures are taken to curb it.

One option for dealing with abalone poaching would be to eliminate the demand side. The gangs act as monopsony by buying abalone from the local divers and monopoly by supplying abalone to the Chinese dealers. If enforcement were focused on gangs and on the Chinese dealers, or at least on their abalone activities, then one could eradicate the source of income for abalone poachers and remove their incentives to harvest. This is likely to work, given that most of the abalone is harvested by local harvesters for sale rather than own consumption.

Drastic measures focusing on creating an effective monitoring and enforcement mechanism are also needed. One option is to give local coastal communities the authority to manage the resource. This would also address the previous concern of community alienation from the abalone resource. Under such an arrangement, the government could cede property rights of particular sea beds to the coastal communities, ask them to manage the resource, and let them experience the consequences of their management actions. Thus, all net benefits from the

resource will accrue to the coastal communities. Given the need to protect income-generating opportunities for some members, such as divers, the coastal communities might elect some of themselves as harvesters. These harvesters could pay rents to the rest of the community. If exploitation is not restrained, then communities themselves will suffer direct losses over time in terms of reduced rents.

In fact, South African authorities once flirted with this idea, but never fleshed it out. There are obvious challenges that have to be addressed for this co-management arrangement to work. As the model above shows, the poacher group is made up of divers from the local coastal communities and gang members. With co-management, the property rights will become entrenched in the local coastal communities. This arrangement gives resource monitoring responsibilities to the local coastal communities and paves the way for self-monitoring. However, the challenge is how to handle the gang members, who are usually external to the local coastal communities.

Co-management would alienate one powerful interest group, the gangs. In addition, the members of the coastal communities themselves are not homogenous. Some are divers, whose livelihoods depend on being in the water, while others are not. While divers can easily be allocated a harvesting quota and required to pay rent to the broader community, the same arrangement is not likely to be enforceable with gangs, which are powerful stakeholders. The gangs will readily disregard any local rules and regulations that the local community may put in place and will resort to violence. They may threaten any members of the community involved in policing or enforcement.

Thus, if co-management is to work, local communities must be empowered to deal with competing interest groups that want access to the resource, some of whom have access to weapons. A specialized police force might be created to assist the local community in tackling gangs determined to keep their access to the abalone resource. The key role of the coastal communities might be as little as being informants. Complementary measures to restore the common will of the community will also be needed, because the history of illegal abalone fishing has left the social fabric of the local coastal communities tattered.

Conclusion

The illegal exploitation of abalone in South Africa has been escalating since the early 1990s. The South African government issued a ban on all wild abalone fishing in South Africa, effective February 2008, but controversially reopened in July 2010. This study explores the

relationship between abalone poaching, use of methamphetamine drugs, criminal activity in the coastal communities of South Africa, and the associated implications for co-management of the abalone resource. The study formulates a model which is used to identify and appraise the likely effects of various policy instruments in curbing abalone poaching.

Like many other studies, this paper also includes increased anti-poaching enforcement and higher fines as ways to curb illegal harvesting. However, we also argue for more measures to curb illegal abalone harvesting in the South African context. The paper puts forward the role of drugs, general corruption, the prevalence of bribery, and the high value of abalone as possible explanations for why poaching has continued unabated. Two suggestions for dealing with abalone poaching are eliminating the demand side through targeted enforcement and ceding the resource to the local coastal communities. However, local communities need to be empowered to deal with criminal interest groups with access to instruments of violence. Complementary measures to bring back the community common is also needed, given the fragmented social situation of the local coastal communities.

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Appendix

Signs of Partial Derivatives

$D_q = dD/dq > 0$
$\tau_e = d\tau/de < 0$
$\tau_\delta = d\tau/d\delta < 0$
$\tau_q = d\tau/dq > 0$
$\tau_p = d\tau/dp > 0$
$\tau_\omega = d\tau/d\omega > 0$
$\tau_\theta = d\tau/d\theta > 0$
$f_e = df/de > 0$
$g_x = dg/dx > 0$
$g_l = dg/dl < 0$
$\pi_e = d\pi/de > 0$
$\pi_\omega = d\pi/d\omega < 0$
$h_\tau = dh/d\tau > 0$
$h_x = dh/dx > 0$
$h_D = dh/dD > 0$
$h_e = dh/de < 0$
$h_{\tau\tau} = d^2h/d\tau^2 < 0$
$h_{\tau e} = d^2h/d\tau de < 0$
$h_{\tau D} = d^2h/d\tau dD > 0$
$T_x = dT/dx > 0$
$T_{xx} = d^2T/dx^2 < 0$