<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Editorial</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Putting a price tag on whales: Are conservation markets a viable conservation tool?</td>
<td>Timothy Essington and Keith Criddle</td>
</tr>
<tr>
<td>4</td>
<td>Conservation markets for wildlife management with case studies from whaling</td>
<td>Leah R. Gerber, Christopher Costello, and Steven D. Gaines</td>
</tr>
<tr>
<td>15</td>
<td>Will a catch share for whales improve social welfare?</td>
<td>Martin D. Smith, Frank Asche, Lori S. Bennear, Elizabeth Hovice, Andrew J. Read, and Dale Squires</td>
</tr>
<tr>
<td>23</td>
<td>Facilitate, don’t forbid, trade between conservationists and resource harvesters</td>
<td>Leah R. Gerber, Christopher Costello, and Steven D. Gaines</td>
</tr>
<tr>
<td>38</td>
<td>Life-history plasticity and sustainable exploitation: a theory of growth compensation applied to walleye management</td>
<td>Nigel P. Lester, Brian J. Shuter, Paul Venturrell, and Daniel Nadeau</td>
</tr>
<tr>
<td>55</td>
<td>Accounting for escape mortality in fisheries: implications for stock productivity and optimal management</td>
<td>Matthew R. Baker, Daniel E. Schindler, Timothy E. Essington, and Ray Hilborn</td>
</tr>
<tr>
<td>71</td>
<td>Prediction of fishing effort distributions using boosted regression trees</td>
<td>Cédric A. Baldeck, Michael S. Colgan, J.-B. Fétét, S. B. Levick, B. E. Martin, and G. P. Aigner</td>
</tr>
<tr>
<td>84</td>
<td>Landscape-scale variation in plant community composition of an African savanna from airborne species mapping</td>
<td>C. A. Baldeck, M. S. Colgan, J. -B. Fétét, S. B. Levick, B. E. Martin, and G. P. Aigner</td>
</tr>
<tr>
<td>94</td>
<td>Long-term effects of fire severity on oak-conifer dynamics in the southern Cascades</td>
<td>Mathew I. Cocking, J. Morgan Varney, and Eric E. Knappe</td>
</tr>
<tr>
<td>108</td>
<td>Allee effects and the spatial dynamics of a locally endangered butterfly: the high brown fritillary (Argynnis adippe)</td>
<td>Michael B. Bonsall, Claire A. Dooley, Anna Kasprson, Tom Bierston, David B. Roy, and Jeremy A. Thomas</td>
</tr>
<tr>
<td>121</td>
<td>Fire, humans, and climate: modeling distribution dynamics of boreal forest waterbirds</td>
<td>Luca Börger and Thomas D. Nudds</td>
</tr>
<tr>
<td>142</td>
<td>Maximizing colonial waterbirds’ breeding events using identified ecological thresholds and environmental flow management</td>
<td>Gilad Bino, Celine Steinfield, and Richard T. Kingsford</td>
</tr>
<tr>
<td>158</td>
<td>Consistency in bird use of tree cover across tropical agricultural landscapes</td>
<td>Sergio Vilchez-Mendoza, Celia A. Harvey, Joel C. Sáenz, Fernando Casanoves, Jose Pablo Caraval, Jorge Gonzalez Villalobos, Blas Hernandez Arruolo Medina, Jorge Moreno, Dalia Sánchez-Merlo, and Fergus L. Sinclair</td>
</tr>
<tr>
<td>169</td>
<td>Effects of landscape composition and configuration on migrating songbirds: inference from an individual based model</td>
<td>Emily B. Cohen, Scott M. Pearson, and Frank R. Moore</td>
</tr>
<tr>
<td>181</td>
<td>Beyond simple linear mixing models: process-based isotope partitioning of ecological processes</td>
<td>Kiona Ogle, Colin Tucker, and Jessica M. Cable</td>
</tr>
<tr>
<td>196</td>
<td>Reconstructing historical habitat data with predictive models</td>
<td>Christina L. Zweig and Wiley M. Kitchens</td>
</tr>
</tbody>
</table>

Contents continued on inside of back cover
January
Vol. 24, No. 1

Cover Photo: While many large whales, such as the North Pacific humpback Megaptera novaeangliae, are increasing in abundance following the cessation of commercial whaling, “scientific” whaling and commercial whaling under “objection” continue. In this issue, Gerber and colleagues propose a market mechanism for more efficient global management of whales (see the Forum on pp. 3-24). Photo credit: L. R. Gerber.
Putting a price tag on whales: Are conservation markets a viable conservation tool?1

Conservation and management of species often are confounded by the presumption of choice between “economies” and “ecology.” That is, conservation of species is presumed to come at a price that is measured in human welfare. Consequently, battles over protection of charismatic species (whales, elephants, polar bears) are waged with rhetoric that exaggerates this trade-off (pro-use) or ignores it altogether (pro-conservation). Management decisions are then decided by a political process that rarely arrives at an optimal, or even desirable, compromise between stakeholders’ values and desires.

Market-based approaches to conservation have been widely developed as an antidote to this perception of “people vs. the environment.” Put simply, the idea is to create economic incentives for actions that foster ecological or conservation goals. Eco-labeling, cap and trade, and pollution taxes are familiar market-based tools. Advocates of market-based tools envision increasingly broader application of an even more diverse toolbox. At the same time, there remains spirited debate about the effectiveness of some of these tools. For example, in marine fisheries, the ecological benefits of market-based “catch shares” are well identified, but the social inequities that they may generate are off-putting to some.

The exchanges presented here highlight important components to the debate on the effectiveness of market-based tools for conservation. Here, Gerber et al. detail a market-based approach to improve conservation of charismatic and highly valued species that are also subjected to hunting or fishing. Namely, they propose the creation of conservation markets whereby individuals who wish to protect species may simply buy species protection, and individuals who wish to engage in fishing or hunting (or, in this case, whaling) can buy access to them. This idea is put to the test for three whale species via a series of bioeconomic models that demonstrate whether “whale shares” would improve whale harvest management and human welfare. Smith et al. offer a counterpoint to these conclusions. As the saying goes, the devil is in the details, and they illustrate through case studies how the details of economic, ecological, and management system might eliminate welfare benefits that whale shares might otherwise generate.

The authors’ thoughtful exchange provides a glimpse into the complexity of implementing management actions, and the difficulties in predicting outcomes with certainty. Of course, this set of papers and responses will not be the last word on the subject. This exchange does provide a thoughtful and reasoned overview of viewpoints and perspectives that should substantially assist in guiding future discussion and scientific inquiry.

—TIMOTHY ESSINGTON
University of Washington

KEITH CRIDDLE
University of Washington
Guest Editor

Key words: marine conservation; rights-based management; whaling.

© 2014 by the Ecological Society of America

1 Reprints of this 22-page Forum are available for $10.00 each, either as PDF files or as hard copy. Prepayment is required. Order reprints from the Ecological Society of America, Attention: Reprint Department, 1990 M Street, N.W., Suite 700, Washington, D.C. 20036 (esaHQ@esa.org).
Conservation markets for wildlife management with case studies from whaling

LEAH R. GERBER,1,3 CHRISTOPHER COSTELLO,2 AND STEVEN D. GAINES2

1Ecology, Evolution and Environmental Science, School of Life Sciences, Arizona State University, Box 874501, Tempe, Arizona 85287-4501 USA
2Bren School of Environmental Science and Management, University of California, Santa Barbara, California 93106 USA

Abstract. Although market-based incentives have helped resolve many environmental challenges, conservation markets still play a relatively minor role in wildlife management. Establishing property rights for environmental goods and allowing trade between resource extractors and resource conservationists may offer a path forward in conserving charismatic species like whales, wolves, turtles, and sharks. In this paper, we provide a conceptual model for implementing a conservation market for wildlife and evaluate how such a market could be applied to three case studies for whales (minke [Balaenoptera acutorostrata], bowhead [Balaena mysticetus], and gray [Eschrictius robustus]). We show that, if designed and operated properly, such a market could ensure persistence of imperiled populations, while simultaneously improving the welfare of resource harvesters.

Key words: Balaena mysticetus; Balaenoptera acutorostrata; bowhead whale; conservation; conservation market; Eschrictius robustus; gray whale; minke whale; tradable harvest quota; whaling.

INTRODUCTION

Wildlife conservation programs face diverse threats, including habitat destruction, overexploitation, pollution, and climate change (Soule and Orians 2001). Collectively, these challenges can put species at risk of extinction. Even when the viability of a species is not at risk, there can be strong conflicts driven by the disparate perspectives and values of resource extractors and resource conservationists. To date, most efforts to meet these challenges have focused on regulatory and educational solutions (Armstrong and McCarthy 2007, Knight et al. 2008, Heller and Zavaleta 2009). By contrast, environmental markets play a relatively minor role in this arena. Market-based incentives, such as cap and trade (Sumaila et al. 2008, Flachsland et al. 2011), have helped resolve a number of environmental challenges. For example, in the management of natural resources, catch shares in fisheries (Costello et al. 2008, Abbott et al. 2010) have enhanced the sustainability of harvest in a number of settings. However, since such programs typically only allow participation by resource extractors, they have played little role in resolving the ethical debates that arise in the hunting of more charismatic species. Establishing property rights for environmental goods that allow trade to occur between resource extractors and resource conservationists may offer a path forward in conserving charismatic species like whales, wolves, turtles, and sharks. In this paper, we provide a conceptual model for implementing a conservation market for wildlife and evaluate how such a market could be applied to three case studies for whales (minke [Balaenoptera acutorostrata], bowhead [Balaena mysticetus], and gray [Eschrictius robustus]) whales.

How many animals should be killed is a key question for any hunted species. At a minimum, the question involves setting sustainable limits on harvest that allow harvests to be replaced by the productivity of the population. When there are strong ethical debates about the appropriateness of harvest, target levels may be substantially below those driven solely by a goal of sustainable harvests. Indeed, in such settings, many people may seek permanent bans on hunting. The issue of whale hunting provides a salient example (Perry et al. 1999, Clapham et al. 2007). The International Whaling Commission (IWC), charged with the global conservation and sustainable use of whales, introduced a moratorium on commercial whaling in 1986 as a temporary strategy to conserve depleted whale stocks while a more long-term plan was developed to manage whales. Fueled by interests who challenge the ethics of whaling, the ban has not been temporary. But, it has also not been effective. Despite the moratorium, scientific whaling (~1000 whales/year), whaling under objection to the IWC (~590 whales/year), and subsi-
CONSERVATION MARKETS: A VIABLE TOOL?

Table 1. Model parameters used to calculate conservation and whaler welfare for case studies.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Bering–Chuchki–Beaufort bowhead</th>
<th>Central north Atlantic minke</th>
<th>Eastern north Pacific gray whale</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>whaler demand parameter reflecting the number of whales desired to be hunted</td>
<td>15056</td>
<td>15056</td>
<td>15056</td>
</tr>
<tr>
<td>$B$</td>
<td>whaler demand parameter reflecting the slope of the demand curve</td>
<td>1.37</td>
<td>1.37</td>
<td>1.37</td>
</tr>
<tr>
<td>$m$</td>
<td>conservationist demand parameter reflecting the marginal willingness to pay to conserve the last extant whale</td>
<td>116000</td>
<td>116000</td>
<td>116000</td>
</tr>
<tr>
<td>$K$</td>
<td>carrying capacity of the whale population</td>
<td>13858</td>
<td>72130</td>
<td>25808</td>
</tr>
<tr>
<td>$N_0$</td>
<td>initial population size</td>
<td>11800</td>
<td>72130</td>
<td>19126</td>
</tr>
</tbody>
</table>

Notes: Data for bowheads (Balaena mysticetus) are from Brandon et al. (2007) and Gerber et al. (2007); for gray whale (Eschrichtius robustus), data are from Loomis and Larson (1994), Gerber et al. (1999), Laake et al. (2009), and Punt and Wade (2010); and for minke whales (Balaenoptera acutorostrata), data are from Amundsen et al. (1995), Bulte and vanKooten (1997), Bulte et al. (1998), NAMMCO (1998), Horan and Shortle (1999), and Laake et al. (2009).

tence whaling (~350 whales/year) continue today (IWC 2011a). Overall, whaling has more than doubled in the past 20 years. The lack of resolution despite decades of negotiations between pro- and anti-whaling nations has called into question the future of the IWC as a path to resolution (Gambell 1993, Holt 2002, Clapham et al. 2007). Under a general conservation market, quotas for the hunting of a target species would be traded in global markets. But unlike most catch share programs in fisheries, the conservation market would not restrict participation in the market; both pro- and anti-whaling interests could own and trade quota. The maximum potential harvest for any hunted species in any given year would be established in a transparent, scientifically defensible manner that ensures sustainability of the marketed species and maintains their functional roles in the ecosystem. The actual harvest, however, would depend on who owns the quota. In its simplest form, a conservation market would cap the maximum harvest at its existing level, and would provide a platform for conservationists to approach whalers with a financial offer to reduce their whale harvest. But other forms are possible; we discuss some of these issues here.

We attempt to spell out how such a conservation market might operate for whaling; similar analysis and insights apply to ethically charged debates concerning other hunted species. At one extreme (where whalers purchase all of the quotas), the harvest would equal the maximum sustainable level. At the other extreme (where conservationists purchase all quota), the harvest could be reduced to zero. Initially, “whale shares” would be allocated or auctioned to member nations of IWC (both pro- and anti-whaling). Owners of whale quota could exercise it, retire it, or trade it. Could such a market provide a transparent and effective vehicle for better resolution of the ongoing global debate on the ethics and appropriate levels of whaling? Is it possible for all stakeholders to be better off relative to the status quo? To answer these questions, we developed a simulation model that explores the performance of a whale conservation market.

METHODS

General approach

Our model consists of three components: (1) a biological model of whale population dynamics, (2) an economic model of the conservation and whaling demand for whales, and (3) an allocation rule for quota shares, which are transferable. Our intent is to illustrate a general approach that can be refined as data on biological and economic parameters become available; for simplicity, we assumed that market behavior is static (i.e., without dynamic strategic behavior), though even these simple annual decisions give rise to interesting dynamics.

Whale population dynamics

Following Taylor et al. (Taylor et al. 2000), we assumed the whale population dynamics follow a deterministic, discrete time difference equation:

$$N_{t+1} = N_t + rN_t \left(1 - \left(\frac{N_t}{K}\right)^\theta\right) - Q_t \quad (1)$$

where $N_t$ is the whale population at the beginning of period $t$, $r$ represents the intrinsic rate of increase of a population, $K$ depicts carrying capacity, $\theta$ indicates the shape of the biological production function, and $Q_t$ is the harvest of whales in year $t$. Table 1 summarizes biological and economic parameter values.

Allocation of rights

In our model, a manager would use a decision rule to stipulate a maximum allowable harvest of ($\bar{Q}$). A very simple decision rule is simply to set the cap at the current level of harvest (if this is deemed safe for the population), but more sophisticated rules are also possible. While a variety of algorithms could be employed to identify a sustainable harvest level (Porch and Fox 1990, Cooke 1999, Givens 1999, McAllister and Kirchner 2001, Reeves 2002, Brandon et al. 2007, Smith et al. 2008, Haltuch et al. 2009, Hillary 2009), we used...
the potential biological removal (PBR) approach as an illustrative example, because it is transparent, conservative, and already used to manage marine mammals in the USA (Taylor et al. 2000).

We used the PBR calculation (Taylor et al. 2000):

\[ \hat{Q}_t = 0.5N_t rF_t \]  

(2)

where \( N_t \) and \( r \) are as defined in the previous section, and the scalar \( F_t \) is a recovery factor between 0 and 1 (Taylor et al. 2000). We scaled the recovery factor such that \( F_t = 0.1 + 0.4N_t/K \) so \( F_t \) cannot exceed 0.5 (this permits, at a maximum, a very conservative maximum level of harvest). However it is set, a total of \( \hat{Q}_t \) whale shares are issued in year \( t \). These are allocated among whalers (who receive \( a\hat{Q}_t \) ) and conservationists (who receive \( (1-a)\hat{Q}_t \)). The allocated shares are then traded between whalers and conservationists, depending on their demand curves for whale shares, resulting in a final harvest of whales \( Q_t \leq \hat{Q}_t \).

**Estimating welfare to whalers**

We developed a simple simulation model of a whale conservation market to predict the consequences of various market designs on (1) whale populations, (2) whale hunting, (3) costs and benefits to whalers, and (4) costs and benefits to conservationists. To investigate whether whaling and anti-whaling stakeholders could simultaneously benefit under such a whale conservation market, we explored the expected buying, selling, and equilibrium price of whale conservation quota shares. In our model, two players compete for whale shares: We assumed that “whalers” derive value from the harvest of whales, and “conservationists” derive value from the unharvested whale population. We also assumed that these values are static; generalizations of this model would allow the demand for harvest rights to change over time, or even to evolve endogenously within the model.

Following Horan and Shortle (1999), the whaler’s demand for hunting whales takes the linear form:

\[ Q = A - B \times P, \]

where \( A \) is a demand parameter reflecting the maximum number of whales that whalers would like to hunt, \( B \) governs the change in value as subsequent whales are harvested, and \( P \) is the marginal value of each whale harvested (Fig. 1). This is the whaler’s demand curve for harvest rights in a given year, which reflects the profitability of harvesting subsequent whales. Its negative slope reflects the fact that, at least beyond some point, each subsequently harvested whale brings in lower net benefits to harvesters.

To maintain simplicity, we also assumed that conservation demand is linear, but it is a function of the whale population size (because the model is in discrete time, we must measure this at a consistent point in the season; we adopted the convention of measuring it postharvest, but pre-growth). The conservationist’s inverse demand for whaling permits takes the form

\[ P = m = m/K(N - \bar{Q}), \]

where \( m \) is the willingness to pay to conserve the last whale in the population (i.e., the maximum amount a conservationist is willing to pay to save a whale), \( K \) is the carrying capacity of the population, and \( N = \bar{Q} \) is the postharvest whale population size. While we have assumed simple linear forms here, one could derive these demand curves from a more sophisticated dynamic optimization by the whalers and/or the conservationists.

Our model implicitly assumes that a conservationist would not be willing to pay to increase the whale population above the carrying capacity, that a larger whale population leads to a higher conservation welfare (though at a diminishing rate), and that the conservationist receives some positive utility from a whale population of any size \( > 0 \). For a given set of parameter values, these demand curves define a market in which we calculate the whale quota share trading price and quantity of whales harvested in market equilibrium \((P^*, \bar{Q}^*)\). This equilibrium outcome will vary annually as the whale population size fluctuates. The actual harvest is \( \bar{Q}^* \); a corner solution emerges when \( \bar{Q}^* \leq 0 \), in which case the conservation demand is greater than the whaler demand, so conservationists buy all quota and no harvest takes place.

Having specified the allocation rule and demand functions, we can now calculate the welfare impacts on each player in each period. Whaler welfare represents the benefits from selling shares to conservationists \( a\bar{Q}_t - \hat{Q}_t \) and from harvesting the whales \( \bar{Q}_t \). If whalers sell shares at price \( P_t \), then their welfare is the revenue from those sales, which is \( P_t(a\bar{Q}_t - \hat{Q}_t) \), plus the welfare they gain from being allowed to harvest the \( \bar{Q}_t \) whales they end up harvesting. By contrast, if whalers buy shares at price \( P_t \), then their welfare is the welfare from harvesting \( \bar{Q}_t \), minus what they had to pay to secure the permits.

Whaler welfare from harvesting \( \bar{Q}_t \) is illustrated in the gray area in Fig. 1a. Integrating under the whaler demand curve gives welfare:

\[
\int_0^{\bar{Q}_t} \frac{A - Q}{B} dQ = \frac{AQ_t - 0.5Q_t^2}{B}.
\]

Thus, the total whaler welfare in a period under a conservation market is

\[ W_w^{\text{market}} = P_t(a\bar{Q}_t - \hat{Q}_t) + \frac{AQ_t - 0.5Q_t^2}{B}. \]

As a basis for comparison, we also computed the whaler’s welfare without a whale conservation market. Under the assumption that whalers harvest the full \( \hat{Q}_t \) every year, whaler welfare is

\[ W_w^{\text{no\_take}} = \hat{Q}_t(A - 0.5\hat{Q}_t)/B. \]

Whaler welfare under a complete ban on whaling is

\[ W_w^{\text{no\_take}} = 0. \]

**Estimating welfare to conservationists**

Conservationists derive welfare from the existence and size of the (living) whale population. But conservationists also derive welfare from the ability to buy (or sell) rights in a conservation market. The downward-sloping
demand curve reflects the fact that adding a whale to the population increases conservation welfare, but at a diminishing rate. The population of live whales is the total number minus the harvest (Fig. 1b). Conservation welfare is simply the area under the conservation demand curve to point \( \frac{N_t}{C_0} \bar{Q}_t + Q_c t \), which is

\[
\int_0^{N - Q_c} \left( m - \frac{m}{K} x \right) dy = m (Q_c^e - \bar{Q}_t + N_t) \left( 1 - 0.5 \frac{(Q_c^e - \bar{Q}_t + N_t)}{K} \right)
\]

plus or minus any rights sold (or bought), at price \( P_c \), from whalers, \( P_c ((1 - \alpha) \bar{Q}_t - Q_c^e) \). Thus, conservation welfare under a whale conservation market is

\[
W_c^{\text{market}} = P_c ((1 - \alpha) \bar{Q}_t - Q_c^e) + m (Q_c^e - \bar{Q}_t + N_t) \left( 1 - 0.5 \frac{(Q_c^e - \bar{Q}_t + N_t)}{K} \right)
\]

where \( Q_c^e \) is the number of whales conserved. Without a whale conservation market, whalers hunt the full quota, \( Q_c^e \), and conservation welfare can be calculated based on the live population, \( N_t - \bar{Q}_t \):

\[
W_c^Q = \int_0^{N - Q_c^e} \left( m - \frac{m}{K} x \right) dy = m (N_t - Q_c^e) \left( 1 - 0.5 \frac{(N_t - Q_c^e)}{K} \right).
\]

For a moratorium, where no whales are harvested, the welfare is shown as the gray area in Fig. 1b, or

\[
W_c^{\text{no-take}} = \int_0^{N_t} \left( m - \frac{m}{K} x \right) dy = N_t \left( m - 0.5 m N_t \right).
\]

Thus, conservation welfare under a complete moratorium can be compared to welfare under a market- or a quota-based system.

**Simulations**

To illustrate some hypothetical scenarios for how this kind of market might operate, we developed a very
simple simulation. This model can be used to predict the consequences of various market designs on (1) whale populations, (2) whale hunting, (3) costs and benefits to whalers, and (4) costs and benefits to conservationists. The equilibrium quantity of whales that are actually harvested, \( Q^\ast \), is a function of demand parameters and whale population size, which can change over time. For a given set of parameter values, we calculated the market equilibrium (Fig. 1c), allowing for the possibility of corner solutions \( Q = 0 \) (conservationists end up with all of the rights), and \( Q = \bar{Q} \) (whalers end up with all of the rights). We also calculated the marginal willingness to pay for each party in equilibrium, \( P_r \).

In our model, the value of a whale and the possibility for trading quotas is determined by the market, which changes every year (i.e., each year the regulator sets a cap and the two sides trade to a new equilibrium, which affects the population and the next year’s quota). For our case studies, we simulated the model over time until the population reaches steady state (i.e., \( N_{t+1} = N_t \)) and document the population size and whaler and conservation demand (Fig. 2). In order to quantitatively examine the performance of alternative management strategies on both conservation and whaling welfare, we compared whaler and conservation welfare to a no-trading quota-based system (Fig. 3). Each year, a new equilibrium is achieved based on the changing whale population size, which, in turn, influences the annual market equilibrium. For any market transaction, the price is the equilibrium price in the case of an interior solution. A corner solution indicates that the conservation demand curve is above the whaler demand curve and conservationists will buy all quotas from whalers. Here, we assumed that there is no market power for each agent in the market, and they will trade at a fair price, namely the average price between \( \frac{A}{B} \) and \( \frac{m}{m/K} \times N \). Finally, given the sparse economic data available, we also evaluated the sensitivity of model results to alternative assumptions about parameters \( A, B, \) and \( m \).

To provide real-world context for how a whale conservation market might play out, we ran simulations to estimate the cost associated with saving all whales over a 20-year period. With the total \( \bar{Q} \) available, market transactions dictate the number of whales saved by conservationists and the number of whales harvested by whalers. For this simulation, we assumed that whalers are allocated all quotas (\( \bar{Q} \)) each year. The cost for each year depends on the market equilibrium, which is influenced by whale population status, as well as whaler and conservation demand. There are three possible outcomes of market behavior in any given year: (1) Conservationists will buy all quotas (corner solution) from the whaler (this is the case if the conservation demand curve is above the whaling demand curve and the equilibrium harvest level \( Q^\ast \) is smaller than zero); (2) whalers will harvest all \( \bar{Q} \) (corner solution; this is the case if whalers value the last unit of harvest more highly than conservationists value the first unit of conservation); and (3) whalers end up harvesting less than the maximum, which suggests that \( \bar{Q} \) is greater than the equilibrium harvest level \( Q^\ast \); hence, the conservationist will buy \( \bar{Q} - Q^\ast \) from whalers (under the scenario when all quotas are allocated to whalers).
Estimating anti-whaling budgets and conservationist willingness to pay

Would conservationists be willing to pay something to reduce whale harvest? Because no platform for such transactions currently exists, it is hard to say. But as a basis for comparison to the market-based approach, here we estimated roughly how much anti-whaling constituents currently spend annually to achieve their objective. Several nonprofit organizations conduct anti-whaling campaigns around the world. The larger of these organizations (e.g., World Wildlife Fund [WWF] and Greenpeace) have offices in multiple countries, operating with separate, but related, campaigns and budgets. All organizations working on anti-whaling reported that it is nearly impossible to estimate an accurate annual budget for their efforts. A comprehensive literature review suggests that the reported total annual expenditures for Greenpeace USA, Greenpeace International, Sea Shepard, WWF-International, and WWF-UK is $25,000,000 (all currency in U.S. dollars), which represents a conservative estimate of money spent by nonprofit organizations on anti-whaling each year (L. Peavey, unpublished data).

Our example is only meant to be illustrative, since we have not conducted primary surveys or other means to estimate the parameters of the conservation demand curve. Rather, we took as a starting point estimates reported in the literature for conserving gray whales. To obtain a conservative estimate for the parameter \( m \), we used the consumer price index to inflate the willingness to pay (WTP) estimates from Loomis and Larson (1994), and scaled up to the number of households in California (where their survey was based). We then calculated the linear demand curve for whale conservation that produced the WTP estimates reported in the paper. The resulting choke price is \( m = 116,000 \), which

![Graphs showing model prediction of whaler and conservationist welfare over time under market- vs. quota-based systems.](image-url)
is the maximum willingness to pay to conserve a single whale. This rough estimate admittedly glosses over many complexities in deriving an estimate for $m$, such as the relevant population over which to aggregate, the public goods nature of demand, and so on. That said, the choke price is conservative, as the household survey by Loomis and Larson (1994) did not consider the efforts of conservation groups. To estimate whaler demand parameters $A$ and $B$, we relied on values reported for minke whales from Amundsen et al. (1995) and Horan and Shortle (1999).

### RESULTS

**Whaler and conservationist market equilibrium**

To illustrate how our approach might apply to real-world management, we considered three case studies (Fig. 3). We chose our case studies based on stocks that are experiencing some level of whaling and for which there are reliable data available for population size and carrying capacity. First, the Bering–Chukchi–Beaufort stock of bowhead whales represents an example of the application of our approach to aboriginal subsistence whaling. Second, Eastern North Atlantic minke whales highlight the possible consequences for whaling under scientific permit. Third, we applied our approach to Eastern North Pacific gray whales, which are currently taken under objection. For each case study, we estimated the market equilibrium in the first year and steady state (Table 2, Fig. 2), whaler and conservation welfare over time (Fig. 3), and the cost to purchase shares.

The bowhead whale was heavily exploited by pre-20th-century whaling. The Bering–Chukchi–Beaufort Seas stock has been increasing at an annual rate of over 3% since 1978, when reliable census data were first collected (Gerber et al. 2007). For bowhead whales, there are a number of political issues surrounding whether or not the moratorium should be supported. Most IWC member nations (including the United States) support aboriginal subsistence whaling (ASW). Approximately 70 whales are taken annually. Assuming the initial allocation would be to ASW, it would be the prerogative of ASW to decide if and how many whale shares would be sold to conservationists. If quota is traded, the market equilibrium points $P^*$ and $Q^*$ can be identified where these two demand curves cross (Fig. 2). Fig. 2 illustrates the market equilibrium for $P^*$ and $Q^*$ for the parameters in Table 1 and the equations $Q = A - B \times P$ and $P = m - m/K(N - Q)$ (Table 2). These assumptions give rise to an equilibrium price ($P^*$) for buying a Bowhead whale of $10,957 for a steady-state population size of 12,591. While we assumed a linear demand curve, if some level of harvest is perceived as "necessary" for tribal subsistence or cultural reasons, whalers would not sell beyond that point. If we assume that there is an extremely high value to harvest even a few whales, the choke price grows, suggesting that the ASW will not sell all quota (Fig. 3). To put these figures into context, the recent (2012) IWC meeting focused largely on ASW, and this meeting cost ~$2,000,000 (IWC 2011b).

North Atlantic minke whales highlight the possible consequences of a whale conservation market for commercial whaling. Minke whales are globally protected by the moratorium, with the significant exceptions of commercial catches under objection and subsistence catches in the North Atlantic and scientific whaling in the North Pacific. In the North Atlantic, stocks are thought to be in a healthy state (NAMMCO 1998). The current best estimate of the Central North Atlantic stock of minke whales numbers 72,130 and is approaching carrying capacity (NAMMCO 1998). Approximately 550 are harvested each year (IWC, data available online). Our model suggests that a market-derived equilibrium price ($P^*$) is $10,818 for buying a minke whale for a steady-state population size of 65,639 (current population size is 72,130). Here, because the steady-state population size is less than initial abundance, potential biological removal (PBR) declines with time.

Finally, eastern North Pacific gray whales have been protected since the 1930s, apart from some subsistence whaling (Gerber et al. 1999). The eastern North Pacific population includes ~19,000 individuals (Laake et al. 2009), with a pre-exploitation level of ~25,000 (Punt and Wade 2010). This stock was recently delisted from the Endangered Species Act (ESA; Gerber et al. 1999). Recent data indicate that ~120 whales are taken annually for aboriginal subsistence by Russia (IWC 2012). Our model suggests that an equilibrium price ($P^*$)

### Table 2. Market equilibrium in year 1 and steady state (SS).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bowhead</th>
<th>Minke</th>
<th>Gray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilibrium price ($P$)</td>
<td>11,487</td>
<td>7,558</td>
<td>13,650</td>
</tr>
<tr>
<td>Equilibrium quotas ($Q$)</td>
<td>-682</td>
<td>4700</td>
<td>67,429</td>
</tr>
<tr>
<td>Population size ($N$)</td>
<td>11,800</td>
<td>67,429</td>
<td>65,639</td>
</tr>
</tbody>
</table>

Notes: The negative values indicate a corner solution, suggesting that the conservationists will buy all potential biological removal (PBR) from the whalers. Negative equilibrium quotas indicate a corner solution where conservationists buy all shares and no harvest will occur.

---

4 http://iwc.int/catches#comm
CONSERVATION MARKETS: A VIABLE TOOL?

January 2014

Table 3. Sensitivity of model results to small changes (−10%; +10%) in A, B, and m, while holding other parameters constant.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilibrium price (P*)</td>
<td>9860; 12052</td>
<td>12170; 9963</td>
<td>10953; 10959</td>
</tr>
<tr>
<td>Equilibrium quotas (Q*)</td>
<td>42; 50</td>
<td>50; 42</td>
<td>50; 42</td>
</tr>
<tr>
<td>Population size (N*)</td>
<td>12722; 12468</td>
<td>12455; 12710</td>
<td>12455; 12710</td>
</tr>
</tbody>
</table>

Note: See Table 1 for variable definitions.

for buying a gray whale is $10,929 for a steady-state population size of 23,461.

These numbers are not meant to predict the specific outcome of a whale conservation market, but rather to illustrate the concept of a whale conservation market with believable input data. Given uncertainty in economic parameters, we also examined the sensitivity of model results to small changes in A, B, and m (i.e., we considered elasticity as 10% change of a single parameter while holding other parameters constant). Equilibrium quotas and population size are not sensitive to small changes in these three parameters, and parameter B and m have the same effect on equilibrium quotas and population size (Table 3).

Modeling whaler and conservation welfare

We used our model to examine whether conservationists and whalers could be made better off (i.e., increased welfare) relative to both a no-harvest scenario and a quota-based system without conservation ownership. While the shape of the welfare functions vary for each stock, a whale conservation market leads to reduced take compared to the quota-based approach without conservation ownership for all case studies (Fig. 3). More importantly, a well-designed whale conservation market simultaneously enhances conservation welfare and whaler welfare relative to the status quo. In some sense this is unsurprising: Allowing voluntary trade, rather than forbidding it, tends to make both parties in an economic transaction better off.

For minke whales, because the initial population is at carrying capacity, conservationists have no incentive to buy shares, since the market equilibrium harvest level is always greater than the PBR; hence, for the first 10 years, the whalers harvest all the PBR. Here, harvest declines over time from a PBR level of 721 to 236 in year 20 (for context, current harvest is ~500 whales per year). At year 11, the population declines to a level where PBR is greater than market harvest equilibrium, and conservationists begin to purchase quotas from the whalers in order to buffer the declining population.

It is interesting to note that the equilibrium price is quite similar for the three case studies. This is partially an artifact of our parameter choices, which are similar (or the same) across species. However, for both bowhead and gray whales, the initial population is smaller than the carrying capacity and the steady-state population, so conservationists buy all quota from the whalers until year 13 and 30, respectively. The welfare for the whaler abruptly changes at this point, when an interior solution is achieved (for corner solutions, equilibrium price is assumed as the average of the whaler and conservationist price). At this point, PBR is greater than the market equilibrium harvested level; thus, the conservationist will purchase progressively fewer whales from the whalers at a decreasing price (i.e., conservation welfare increases and then stabilizes). For all case studies, conservationists are made better off by the increased whale population and whalers are made better off by more efficiently allocating the quota between selling to conservationists and harvesting the whales to sell in the market. For example, for gray whales, welfare under a quota system increases and eventually stabilizes, but never exceeds, the welfare level derived from the market approach. Furthermore, welfare for both whaling and conservation increases with whale population size, highlighting both the conservation and whaling benefits of our approach.

How much does it cost to save the whales?

Our results suggest that the per-whale opportunity cost to whalers from reducing harvest would depend on the species, but could be in the ballpark of $10,000 for gray, minke, and bowhead whales. We also used our model to estimate the cumulative cost of purchasing all whale shares over a 20-year period (i.e., the annual cost is calculated as the product of the equilibrium price and the number of whales traded in the market). This 20-year cost is roughly $114 million (saving a total of $8424 whales). The framework can also be applied to estimate the cost of reducing mortality by a fixed percentage for individual stocks.

While our model assumes that a conservationist would not be willing to pay to increase the whale population above the carrying capacity, it is possible that some conservation constituencies may be willing to pay to conserve whales regardless of population status. Although we assumed downward-sloping demand, this curve may be more elastic for people with strongly held moral objections to whaling. Thus, we also considered the scenario where conservationists will pay any price to end whaling and that current harvest levels can never be exceeded. Under that objective, the equilibrium price is irrelevant, because there ultimately is no market. Rather, the conservationist would have to pay the whaler his capitalized opportunity cost of whaling (i.e.,
the area under the whaling demand curve; Fig. 1a). The resulting cost of eliminating harvest of all bowhead, minke, and gray whales, respectively, over the next 20 years is $149 million (13,800 whales). This cost of approximately $7.5 million per year can be compared to our conservative estimate of annual expenditures on anti-whaling organizations ($25 million).

**DISCUSSION**

We have described a broad participation conservation market as a mechanism to regulate the harvest of charismatic species such as whales. The approach can be generally applied to other sources of whale mortality, such as fisheries interactions, ship strikes, and climate change, though obvious challenges exist and market design, monitoring, and enforcement will be crucial. For example, it has been argued that one justification for whaling is that whales consume resources that could otherwise be available for consumption by humans (Gerber et al. 2009). If whalers are willing to pay more for a whale than are conservationists, a whale conservation market would allow a country to increase whaling to a sustainable level given a perceived conflict with fisheries. Similarly, a whale conservation market could be designed to encourage fishing techniques that reduced whale bycatch. If fishing companies that incidentally catch whales had to buy whale quota to compensate for their bycatch, there would be a strong financial incentive for fisheries to adopt strategies and technologies that reduce whale bycatch. Ship strikes could be handled similarly by requiring differential fees based on certified adherence to operating practices designed to reduce the frequency of impacts, or through adopting certified monitoring equipment that would catalog actual strikes and bill vessels accordingly. Such an approach would provide a strong financial incentive for ships to avoid whale strikes. Finally, if climate change influences the viability of whales (e.g., if whale’s food supply decreases), then the quota must be adjusted for the market to continue to function in the new reality of an altered climate.

Under current international law, any country may opt out of whaling agreements (Gambell 1993, McDorman 1998, Holt 2002, 2007). It may be precisely because no price tag exists that anti-whaling operations have lacked widespread success. Furthermore, the evidence suggests that both whalers and anti-whalers have already put a price tag on whales. Whalers expend millions of dollars annually to harvest whales, many of which are traded in global markets. Available data suggest that a minimum value for annual profit from all global whaling activity is on the order of $31 million. A conservative estimate of money spent annually by nonprofit organizations on anti-whaling is $25 million, suggesting that these two competing values of whales are of similar magnitudes (Costello et al. 2012). Have these large expenditures had measurable conservation impacts? A generous estimate of the efficacy of anti-whaling campaigns is the self-report by the Sea Shepherd Society, which estimates their multi-million-dollar 2008 campaign saved about 350 minke whales in Antarctic waters (Costello et al. 2012). Our results indicate that it may be possible for anti-whaling interests to purchase a considerable fraction of the whale shares for comparable investments in a whale conservation market.

Similarly, nations and indigenous people with a long history of whaling assert a cultural right to hunt whales for food or spiritual reasons (~19% of total whale harvest). Under the current system, these groups are increasingly ostracized in a battle of competing ethical beliefs. Under a whale shares market, firmly held beliefs would be expressed as holding shares for whale quota even in the face of lucrative offers to sell. Rather than opting out of international agreements and setting their own standards under the guise of “scientific whaling,” proponents of whaling could be assured that the whale quota they choose not to sell provides a valid right to harvest that number of whales.

Others may argue that whaling countries may never sell their shares to conservationists, or that conservationists may never sell their shares. For the market to function as we have articulated, whale conservation shares must flow to the party who values the shares the most. For example, if a whaling nation is allocated $n$ shares of whale based on historical use, conservationists could offer to pay to reduce their harvest to $n - 1$. Our models suggest that the value of $n$ to a whaler might be quite low, while the value to a conservationist of saving that first whale (i.e., reducing the harvest from $n$ to $n - 1$) might be quite high. There is little evidence from other markets that no trading would occur: In every environmental market we are aware of, an interior equilibrium is reached where environmental damage is reduced to some extent, though typically not to zero. The possibility of whale market failure could be addressed by auctioning some of the shares or by several options for initial allocation of the whale quota.

Empirical work on conservation willingness to pay across various stakeholder groups is an important next step in applying our model. In this paper, we relied on published literature to provide illustrative calculations, but we have not directly attempted to estimate the aggregate demand curve for conservation, nor have we explicitly modeled the public good nature of whales or the free-rider problem. In fact, there is likely variation in WTP for different species (Richardson and Loomis 2008, Eiswerth and Kooten 2009, Wallimo and Lew 2011), which may have important consequences for market equilibrium.

While data are not available to accurately estimate either whaler or conservation demand, the shape and slope of these curves may have important implications for market equilibrium. For example, it is possible that some conservation constituencies may be willing to pay to conserve whales regardless of population status (i.e., the demand curve is flat), or that there is a more
complex, nonlinear shape to this curve. This underscores the importance of future research on both whaler and conservation demand.

It is also important to recognize that whale harvesters are not homogeneous in the character of their objective functions or in the cost of their hunting and processing activities. Thus, another interesting extension of our model would be to include multiple categories of harvesters (e.g., commercial and noncommercial; Criddle 2004), and to separately model their equilibrium harvest levels. With empirical data on whaler and conservation demand this could be modeled as an optimal control problem (Smith et al. 2008). For instance, Bulte et al. (1998) found that an annual static model may generate different management strategies compared to a dynamic approach. A fully dynamic model specification would allow for forward-looking whaling firms and/or conservationists to engage in market behavior that improved their long-run position in the market by manipulating the current price and population levels.

Another important concern with the efficiency of a whale market is that, on one side, ownership is a private good (a dead whale benefits the whaler who hunts it), whereas on the other side, ownership is a public good (a live whale benefits everyone who values living whales, including whalers). This asymmetry will likely lead to whales for conservation being undervalued in this market. While it is possible that this “free riding” by environmentalists on such defensive purchases of credits (Stewart 1988, Horan and Bulte 2004, Blanco et al. 2009) would weaken the conservation demand for whales, allowing trade will converge closer to the socially optimal solution than a simple “cap” without trade. Furthermore, the same concern applies to the private conservation of land, yet The Nature Conservancy is now the third largest private landowner on the planet. Perhaps most importantly, we have not argued that a conservation market like the one proposed here will lead to a socially optimal harvest level, but rather that it can improve the welfare of both harvesters and conservationists.

Examples of nontrivial ethical debates being resolved through international agreements are rare in practice (Guzman and Landsidle 2008), which underscores the need for alternative solutions that respond to changing norms of international behavior (Weeks 2009). A well-designed whale conservation market could address many of these important challenges and would do so in a more effective, rapid, and efficient manner than has the status quo. More generally, establishing property rights for environmental goods and allowing trade to occur between resource extractors and resource conservationists may apply to a much broader class of environmental and resource challenges facing society today and into the future.

ACKNOWLEDGMENTS

We thank Ray Hilborn, Doug DeMaster, Monica Medina, and Ryan Wulff for insightful discussions on the manuscript. We are grateful to Biao Huang and Lindsey Peavey, who contributed to many insightful discussions and assisted with model implementation and data collection.

LITERATURE CITED


Criddle, K. 2004. Economic principles of sustainable multi-use fisheries management, with a case history economic model for Pacific halibut. American Fisheries Society, Bethesda, Maryland, USA.


Will a catch share for whales improve social welfare?

MARTIN D. SMITH,1,2,8 FRANK ASCHE,3 LORI S. BENNEAR,1,2,4 ELIZABETH HAVICE,5 ANDREW J. READ,6 AND DALE SQUIRES7

1Nicholas School of the Environment, Duke University, Box 90328, Durham, North Carolina 27708 USA
2Department of Economics, Duke University, Box 90097, Durham, North Carolina 27708 USA
3Department of Industrial Economics, University of Stavanger, 4036 Stavanger, Norway
4Sanford School of Public Policy, Duke University, Rubenstein Hall, Durham, North Carolina 27708 USA
5Department of Geography, University of North Carolina, Saunders Hall, Campus Box 3220, Chapel Hill, North Carolina 27599-3220 USA
6Duke Marine Lab, Nicholas School of the Environment, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA
7NOAA Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, California 92037-1023 USA

Abstract. We critique a proposal to use catch shares to manage transboundary wildlife resources with potentially high non-extractive values, and we focus on the case of whales. Because whales are impure public goods, a policy that fails to capture all nonmarket benefits (due to free riding) could lead to a suboptimal outcome. Even if free riding were overcome, whale shares would face four implementation challenges. First, a whale share could legitimize the international trade in whale meat and expand the whale meat market. Second, a legal whale trade creates monitoring and enforcement challenges similar to those of organizations that manage highly migratory species such as tuna. Third, a whale share could create a new political economy of management that changes incentives and increases costs for nongovernmental organizations (NGOs) to achieve the current level of conservation. Fourth, a whale share program creates new logistical challenges for quota definition and allocation regardless of whether the market for whale products expands or contracts. Each of these issues, if left unaddressed, could result in lower overall welfare for society than under the status quo.

Key words: catch shares; free riding; impure public goods; International Whaling Commission; marine conservation; market-based regulation; whale meat; whaling.

Gerber, Costello, and Gaines (GCG) propose using catch share markets for conservation of wildlife. The rationale for a tradable quota system draws on the logic of catch shares to manage fisheries harvest and permit trading to control air and water pollution. In many cases, such systems have improved management and lowered costs. GCG argue that catch shares can also lead to efficient conservation outcomes by allowing environmental groups (nongovernmental organizations [NGOs]) to purchase and retire permits and thereby reduce the commercial harvest activity. They investigate the potential to generate conservation gains through a catch share system to manage whales.

It is well established that creating tradable quota markets can be an effective tool for environmental management, although the success of the market (e.g., “effectiveness”) depends on a range of factors including the institutional setting, the policy design, the specific environmental issue in question, and whose values and definitions of “effective outcomes” such programs are based upon. The purpose of this paper is to highlight features that would influence the outcome of introducing a quota for whales that GCG do not address. These concerns are applicable for other possible uses of wildlife conservation markets such as elephants, tigers, and birds that are largely transboundary and require multilateral conservation approaches. We argue that the choice to use whales to develop a model for market-based conservation requires engagement with the specifics of whales and whale management. More generally, any market approach to conservation should carefully consider the specifics of the case in question to ensure that the appropriate conservation tool is selected and applied.

There are two distinct strands to our critique of GCG’s analysis. The first strand focuses on GCG’s novel use of the market to incorporate conservation values as a method for determining the level of conservation. We argue that this is akin to using the market to set the level of the “cap,” rather than solely using the market to allocate permits under the cap. Use of market-based mechanisms to both set the level of harvest and allocate that harvest has never been tried...
before and its success hinges critically on the ability of the market to accurately reflect all values of the managed species, both for private consumption and public conservation. This is particularly problematic because most wildlife to which their model may apply, including their example of whales, are impure public goods that require multilateral conservation across jurisdictions and multiple states. In economics, we use the term impure public goods to refer to goods that generate both private value for an individual consumer or firm (e.g., someone who eats whale meat or harvests whales) and public value that is shared by all consumers (e.g., the intrinsic value of keeping a whale in the ocean).

To illustrate the concept further, consider the choice between an organically grown apple and a conventionally grown apple sprayed with pesticides. We consider the organic apple an impure public good because it provides private value to the consumer in the form of enjoyment, nutrition from eating the apple, and potential health benefits from avoiding pesticide residues. But it also provides public value in the form of avoided pesticide runoff that, in turn, benefits the ecosystem downstream. These ecosystem benefits are enjoyed by all consumers and not just by the purchaser of the apple. The impure public goods feature of whales has important ramifications for the outcome of the modeling exercise in GCG because this feature makes it difficult to raise funds to reflect the full value of conservation.

The second strand of critique focuses on four implementation issues that relate more specifically to whales that are not accounted for in GCG’s proposal and model; similar issues emerge for other internationally shared wildlife populations. First, the creation of a whale share would legitimize the international trade in whale meat, which could expand the whale meat market. Consumers of whale products would be better off, but individuals who value whale conservation would be worse off because it becomes harder for conservationists to buy out quota and represent conservation values in the market. Second, a legal whale trade creates monitoring and enforcement challenges similar to those of organizations that manage highly migratory species like tuna and exotic threatened species like rhinoceros. The market for whale products may or may not expand in size, but it will be qualitatively different. Third, introducing a catch share will likely create a new political economy of management that could change incentives and make it significantly more costly for NGOs to achieve the current level of conservation. Unlike market legitimation on the demand side, this feature may add pressure to increase harvest and expand the market for whale products from the supply side. The political economy of management is considerably more complicated in international arenas than in national settings, where quota systems are most commonly used. Fourth, a whale share program creates new logistical challenges for quota definition and allocation regardless of whether the market for whale products expands or contracts. For instance, should the quota be set to achieve maximum sustainable yield (MSY)? Most fisheries management defaults to this objective, including the U.S. Magnuson-Stevens Fishery Conservation and Management Act.

We assess the relevance of each of these issues to GCG’s proposal as applied to whales, drawing on relevant examples and issues for international fisheries of high value such as the management of tuna stocks with Regional Fisheries Management Organizations (RFMOs). Tuna RFMOs, while a clear improvement over no international management efforts, highlight some of the challenges that a whale shares program would likely face. We assert that controlling these issues is outside of the scope of the proposed conservation tool (a quota system). Each issue, if left unaddressed, could generate lower overall welfare for society and potentially greater threats to marine mammal conservation than the status quo, complicating GCG’s assertion that the quota system will definitively yield maximum efficiency.

Our analysis is neither prescriptive nor empirical (that is, we are not asserting that any one outcome will come to fruition), rather, it is designed to highlight that the use of quotas for conservation is not a black-and-white issue, and that treating it as such in the whale context obscures the relevance of the contested international politics and economics that have driven calls for alternative solutions to the fragile International Whaling Commission (IWC) ban in the first place.

We begin with an overarching critique of GCG’s proposal for the use of cap-and-trade programs for conservation. Our critique hinges on the fact that catch share programs (aka individual transferable quotas [ITQ]) and other cap-and-trade systems are not designed to set an efficient cap; they rely on the ability of a regulatory agency or organization to set and enforce the cap (for fisheries, this is the total allowable catch) and rely on the market to allocate the shares under that cap. Using the market to allocate resources under a cap, for pollution or for fish, can improve management and lower costs (Grafton 1996, Stavins 1998, Costello et al. 2008). However, catch shares do not address optimal management of whole ecosystems (Arnason 2012), and apparent biological gains from catch shares may be attributable other factors, namely the cap itself (as opposed to the trading; Bromley 2009) or changes in reporting systems (Nowlis and Van Benthem 2012). Comparing fisheries with catch shares to fisheries with just caps suggests no gains in mean biological reference points, but benefits in the form reduced variability (Essington 2010). Above all, having a binding cap that reduces pollution or fishing mortality is critical to gain support for these programs from environmental groups (Keohane et al. 1998, Stavins 1998, Chan et al. 2012).

GCG are proposing something different: Allow the setting of the cap based on some unspecified scientific criteria, and then use the market to shift the actual
harvest level to approximate the socially efficient harvest level. While some cap-and-trade pollution permit systems (in particular, the program regulating SO₂ emissions in the United States) allow environmental groups to purchase permits and retire them, no system of tradable permits has ever relied on this mechanism to determine where the cap should be. Retirement of SO₂ permits has been low, not because environmentalists do not care about SO₂ pollution, but because they successfully lobbied for a binding cap in the first place. In short, prior catch share and cap-and-trade systems have been used to reach an agreed upon cap cost effectively; they have not been used to try to assess where the efficient cap should be.

GCG’s proposal to use the market to determine the level of conservation and the level of consumption hinges on the ability of the market to reflect demand for conservation accurately. However, this outcome is questionable because most conservation goods, including whales, are impure public goods (Kurosumi and Tisdell 1993) that have features of private and public goods. Consumption of whales has private features because a whale harvested by one vessel cannot be harvested again by another. In contrast, a public good can be enjoyed by many (or all) individuals simultaneously. Whales also meet this definition in that more than one individual may simultaneously value the existence of the same whale. So, when a whale is harvested, its existence value is lost not just by one consumer but by all consumers. Similar claims could be made for other charismatic marine and terrestrial species. Moreover, multiple individuals can enjoy viewing the same whale on a whale-watching trip (either simultaneously or on separate trips). Harvesting a whale is a loss to not just one whale watcher, but to all whale watchers who may see this animal. For public goods, the total value of a unit is the sum of values across all individuals. The policy problem resulting from public goods is that too few of these goods will be produced by the free market because of free-rider and collective action problems.

The free-rider problem is one where individuals do not pay their true values because they can still gain use of the resource without paying; they can free ride on the contributions of others (Samuelson 1954). Consider, for example, an individual who values air quality and chooses between taking the bus to work or driving a private car. The car produces more pollution and reduces air quality relative to the bus, but driving the car is less costly to the individual because she can get to work faster. For the individual, the benefit to the environment of taking the bus is imperceptibly small, but the cost (in terms of time) is noticeable, so the individual often chooses the dirty alternative and drives. The imperceptibly small benefit to the environment is a benefit to everyone and not just the individual making the choice. But the incentives are set up for her to ignore the benefits to others and let others choose the cleaner alternative. Because other consumers follow the same logic, the air quality ends up being lower than everyone would agree it should be. This is the essence of the free-rider problem.

The collective action problem results from difficulty in coordinating individuals and pooling resources for public goods provision. Consider the car and bus choice again. People do not want to choose the bus alternative to get a tiny increase in air quality, but they might be willing to do it if there were a substantial increase in air quality. If everyone coordinated and took the bus, the air quality would substantially improve. This is the collective action problem. Correcting the free-rider and collective action problems typically requires government provision and taxation. Catch share programs do not correct free-rider or collective action problems for public goods provision. Even sole ownership or privatization of an impure public good does not ensure the efficient outcome, as private interests could diverge from social interests and drive a stock to extinction (Clark 1973).

GCG acknowledge the public goods nature of conservation and the potential for free riding. They suggest that their proposed catch share program could address the public goods problem by allowing environmental NGOs the opportunity to use funds to purchase shares, thereby reflecting public demand for conservation. However, this ex-post incorporation of conservation demands through the free market is unlikely to result in an efficient level of whaling, as it will include revealed private demand only, not social demand for conservation. Private demand reflects voluntary contributions to a public good summed across individuals (donations to NGOs in this case). These contributions are subject to free riding and understate total social demand, which captures the total value to society of the public good. For species that are less charismatic than whales, we would expect the extent of free riding to be more severe, suggesting even more limitations of the use of catch shares to conserve non-extractive uses of wildlife.

Fig. 1 illustrates this point using the market for whale shares as an example. The figure demonstrates that the market would underprovide whale conservation because the private revealed demand (i.e., demand reflecting voluntary contributions to NGOs) lies below the social demand. Consistent with GCG, we assume that the IWC or another institution sets a safe minimum population level and that this population is at least as large as the population that produces MSY. As such, equilibrium harvest is strictly decreasing in the whale population; as population increases from the MSY level toward carrying capacity, the surplus production available for harvest decreases. Allowing NGOs to raise funds for conservation and purchase shares would result in a stock of whales at the market equilibrium that is below the social optimum.

One might argue that the free-rider problem is small for whales. GCG suggest that this may be true because
voluntary contributions to whale conservation appear high in absolute terms, perhaps indicating that NGOs have successfully gotten contributors to donate close to their true values. However, large contributions do not necessarily indicate that NGOs have overcome free riding because NGOs have no sovereign authority to tax; large contributions could mean that NGOs have raised a small fraction of a very large social demand for conservation. Consistent with a potentially very large willingness to pay for whale conservation, Lew et al. (2010) show that willingness to pay for conservation of another marine mammal, Steller sea lion, is in the range of $10 billion per year for U.S. households (all currency shown in U.S. dollars). If NGOs were able to raise this level of funding for each whale species and other species of wildlife managed with catch shares, the issue of free riding would be much less of a concern. Moreover, as in the case of U.S. SO2 trading, NGOs may find it more cost effective to lobby for lower whale total allowable catches (TAC) rather than using funds to purchase whale shares from harvesters.

The use of a market to establish the level of harvest could be efficient if there were some mechanism to capture consumers’ true willingness to pay for conservation. In other contexts, such as water markets, this mechanism has not materialized; allocation of water to the environment is done by government (not NGOs), and water trading is a means to allocate what is left for agricultural and municipal uses cost-effectively. Debates about wildlife whaling to new demand for whaling decreases the equilibrium whale population from A to B. Consumers of whale products gain area ABCF. Conservation interests lose area ABDE. The net loss to society would be area FCDE. How large or small this loss would be is an empirical question. (c) A minimum population level above the free market outcome incentivizes illegal harvest. Consider three possible minimum population levels: N_min (below market equilibrium), N_min1 (between market equilibrium and the social optimum), and N_min2 (above the social optimum). At N_min, trade could increase social welfare by moving in the direction of the social optimum but would stop short at point A with no incentive for illegal harvest. The net gain is an artifact of setting the minimum population level below the market equilibrium and allocating rights to the harvest industry. With N_min1, private demand for conservation is below the demand for whaling. At equilibrium population N_min1, the price wedge between private demand for conservation and demand for whaling incentivizes illegal harvest. Illegal harvest would decrease the population further away from the social optimum. Incentives for illegal harvest are larger at N_min2 (a larger wedge). Illegal harvest and associated decreases in the whale population could move the population toward (and not away from) the social optimum. This perversion suggests that welfare gains are not associated with the whale share program, but rather with the way it happens to create incentives for illegal harvest that end up pushing the system closer to the social optimum. Of course, depending on the extent of illegal whaling, the population could diminish below the social optimum, and social welfare could be lower. At N_min1 and N_min2, demand growth exacerbates these problems, creating larger price incentives for illegal harvest.
catch shares thus mirror debates about water trading: “...attention must be paid to water’s unique and public good characteristics. Those who caution against haphazard market formation are not necessarily opponents; once basic uses of water (human and environmental water needs) are met, water markets are an efficient mechanism for dealing with the scarcity of the remaining elective uses of water” (Chong and Sunding 2006:260).

As one of the few acceptable deviations from the IWC moratorium on whaling, aboriginal subsistence whaling (ASW) raises a different set of public goods issues. ASW is acceptable because whaling is essential to maintain these cultures, so cultures themselves become public goods in the discourse. Under the current IWC, these cultural public goods are deemed more desirable than the environmental public goods lost from whales taken by ASW. In the Results, GCG make a distinction between two different uses of whales when stating, “If we assume that there is an extremely high value to harvest even a few whales, the choke price grows, suggesting that the ASW will not sell all quota.” GCG do not appear to acknowledge the public good nature of the aboriginal whaling as a means to maintain the culture and the world’s value of these cultures. The rest of the world attaches some value to preservation of aboriginal cultures and not just members of aboriginal societies.

A separate but related question is whether cultural heritage of commercial whaling has a public good component. The past decisions of IWC suggest that allocation of quota to aboriginals is acceptable, but it is not acceptable to sustain coastal cultures by allowing whaling in modern societies like Japan and Norway. This record reinforces our claim that the only reason for allocating whale quotas for ASW is the public good aspect. If any group that has been allocated quota under these circumstances has anything to sell, this implies that the IWC has awarded them too much quota or that the aboriginals are willing to give up their culture for a large enough sum of money while the international society will not let them. This potential conflict raises questions of sovereignty that are beyond our scope.

We now turn to the second strand of our critique, which emphasizes four implementation issues specific to the GCG proposal as applied to whales, but with broad relevance to international wildlife conservation. First, a resumption of internationally sanctioned whaling beyond indigenous and scientific use could stimulate demand for whale meat and other products. Currently, whales are caught and commercially consumed in only four countries: Iceland, Japan, Norway, and South Korea. All whales are listed by CITES such that trade is illegal except for countries entering “reservations” (more information available online). With legal harvesting under sustainable management, whale meat could expand into new markets. A counterpoint to this concern is the claim that the general decline in market value of whale products is largely responsible for stabilized whale populations (Schneider and Pearce 2004).

Other species provide examples of the power of increased demand. In fisheries, Atlantic bluefin tuna (Thunnus thynnus) illustrates both sides of the issue. Prior to the 1970s, a commercial fishery for Atlantic bluefin tuna did not exist in the United States because the United States did not have access to the Japanese market (Bestor 2001). Technological innovations and changing trade relations allowed a growing U.S. fishery to access the high-value Japanese market, generating significant fishery values. When the Japanese economy weakened in the 1990s, a domestic U.S. market emerged in conjunction with growing U.S. consumer taste for sushi (Bestor 2001). Now Atlantic bluefin face significant conservation challenges. Would society have been better off without the development of the fishery and diffusion of taste for sushi tuna? The answer depends in part on whether the charismatic bluefin contribute significant value as public goods and whether these values outweigh the expanded private values from sushi tuna consumption. Product development, improved logistics, and better refrigeration similarly have expanded global markets for many other seafood species (Asche et al. 2011), albeit ones that do not appear to be as charismatic as elephants, whales, and Atlantic bluefin.

There are two mechanisms through which market legitimation could stimulate demand and lower welfare. The first is the concept of experience goods: Consumers tend to consume more of products with which they have experience. Currently, consumers in most of the world have no opportunity to experience whale products, but they may gain these opportunities under a whale shares program. There has been dramatic globalization of the international seafood trade in the past several decades (Smith et al. 2010), suggesting possibilities for trade in whale products are far greater than they were before the IWC moratorium. There are competing behavioral explanations for the experience goods phenomenon. One is that consumer tastes are malleable and can be shaped by framing and other manipulations of marketers (Thaler and Sunstein 2008). The other explanation is that consumer tastes for product attributes are unchanging, but by trying new products people gain knowledge or appreciation for the attributes of a product and then demand more (Stigler and Becker 1977). We do not take sides in this behavioral debate, but point out that both views support the possibility of increased market demand for whale products. Although the current demand for whale meat in Japan is relatively small, there exists a high-end premium market (Onozaka and Uchida 2011). Whether consumer interest in whale meat would diffuse internationally as consumers gain access to experience eating...
whales is an open question, but experiences with sushi products suggest this possibility.

The second mechanism through which market legitimization could stimulate demand and lower welfare is how the creation of a price for whale would affect consumer social norms. Currently, there is no whale meat price for consumers in most of the world. Behavioral economists have shown that creating a price for something where previously behavior was regulated by social norms can have the unintended consequence of increasing consumption. A classic example is the use of late fees in Israeli daycares; when there were no late fees, parents were more likely to pick up their kids on time, so creating the price incentive backfired (Gneezy and Rustichini 2000). A whale share effectively prices whales where no prices existed before, and this pricing may send a signal that consumption is socially acceptable.

Despite the potential benefits to consumers when demand for whale products increases, overall social welfare can decrease if policy makers have not set the TAC low enough (Fig. 1b). Any growth in private demand, holding everything else constant, could only lead to harvesting more whales in equilibrium. This outcome will always lower social welfare as long as the public goods value of conserving an additional whale exceeds the private value of consuming it.

Our second implementation critique is that creation of a whale share program will legitimize whaling in the international community and create new monitoring and enforcement challenges. Under the status quo, there is very limited legal international trade in whale products; whale products traded internationally are illegal other than trades between countries registering reservations under CITES. A legal trade in whale products would raise the many challenges associated with controlling illegal, unreported, and unregulated (IUU) fishing (Sumaila et al. 2006). Among these is the difficulty distinguishing between legally caught and illegally caught whale meat and other products. Certification would potentially aid in delineating legal and illegal harvest, but this suggests that a well-functioning whale share program would require developing new institutions. Moreover, the efficacy of these new institutions would be a concern, as genetic testing suggests certification in fisheries does not ensure a clean supply chain (Marko et al. 2011). International management of other charismatic wildlife species faces similar challenges. For example, there is empirical evidence that trade bans for ivory would be more effective in promoting elephant conservation than allowing legal ivory trade despite theoretical arguments for and against bans (Bulte and Van Kooten 2006). A catch share for whales with a trade ban would likely produce very different outcomes than the same catch share without a trade ban.

Fig. 1c demonstrates how a whale share program creates incentives for illegal harvest. Whale shares decrease social welfare in most scenarios, and social welfare improvements are not attributable to share trading, but instead are artifacts of setting safe minimum standards, initial allocations, or, providing perverse incentives for illegal trade.

Enforcement also hinges on the ability of the IWC to set and enforce a cap. In their 2012 paper, Costello, Gaines, and Gerber assert that the IWC is “up to the task” (Costello et al. 2012:140). However, by their own account, since the 1990s and under the auspices of the IWC’s moratorium on commercial whaling, the number of whales taken has more than doubled, many populations of whales have been severely depleted and continue to be threatened by what GCG call “largely unregulated” whaling and an IWC “long hamstrung by management and ethics issues” (Costello et al. 2012:139). This is an important context because the IWC’s fragility is the reason that GCG have made their proposal, but the fragility is ignored in their model. Another critical enforcement issue is that rights-based management must be self-enforcing because without a supranational sovereign body, multilateral cooperation, compliance, and enforcement are through voluntary agreement among IWC members (Barrett 2003). A trade that shifts the quota in either direction under GCG’s proposal would not require agreement among IWC members, raising questions about the stability of the catch share program.

This analysis illustrates that there are a number of cases in which a whale share program could lower social welfare. Most importantly, cases in which whale shares would increase welfare are artifacts of setting the cap and not of the trading program. Thus, the dynamics that determine the cap become a crucial dimension for evaluating the potential for a whale share program to improve the status quo. To the extent that the current political economy of setting caps in the IWC is problematic, a whale share program does not appear to change this dynamic. Thus, our third implementation critique surrounds the political challenges to establishing the cap in an already politically fraught international arena.

A key concern for a new cap-and-trade program is how implementing a cap and an intention to allocate access and catch rights can generate a scramble to secure a share of the resource. Experience from cooperatively managed tuna fisheries is illustrative. When the International Commission on the Conservation of Atlantic Tunas (ICCAT) was established, commission members with bluefin fleets negotiated measures to exclude outsiders and codify historically and geographically determined access rights (Webster 2010). There were few new entrants until ICCAT established country-specific quotas in the mid-1990s. ICCAT membership had hovered between 10 and 20 from 1970–1995, but after the cap was introduced (and tuna value increased) membership jumped dramatically.
to 48 member countries by 2010 (data available online). Similarly, when the Western and Central Pacific Fisheries Commission (WCPFC) was negotiated, fishing nations in Europe and Latin America that were not regularly active in the region sought membership and participation rights.

While the United Nations Fish Stocks Agreement (UNFSA) establishes that participation in such programs for fish should be open to those with a “real interest,” the criterion of “real interest” is not defined in the UNFSA. Real interest has not been defined for whales, and whales may be considered part of the global heritage of humanity in a manner similar to the International Seabed Authority (ISA) and sovereignty and management of the area. Although there are frameworks that limit participation in regional fisheries management organizations, the IWC is open to all states, greatly complicating the issues of “real interest,” closure, and allocation. Do entrants after the initial allocation have legitimate interests in rights and how should they participate? Undoubtedly, participation in the IWC will increase with catch shares, raising issues of recurring reallocation, duration, and divisibility of the right. The resulting uncertainty for rights holders could lower the value of the property rights and hinders investment for both commercial whalers and NGOs. States formally objecting to their allocation might not be bound by any cap. The creation of rights with real value could even prompt a revision to the IWC akin to the ISA in which whales are redefined to constitute part of the global heritage of all states. Whales would then be collectively managed as a global public good, similar to minerals in the deep seabed by the ISA, including payments of royalties and conservation requirements. This is not an argument against whale shares per se, but suggests that potential gains are qualitatively different from those modeled in GCG.

Moreover, geopolitical interests that may diverge or be distinct from the management objectives at hand can influence the cap and quota allocation in unpredictable ways, particularly in an international negotiating arena. This dynamic is familiar at the IWC where votes become political capital that small states use to derive economic benefit from those IWC members with vested interest in outcomes (Stringer 2006). Replacing the IWC’s fragile moratorium with cap and trade does not guarantee that the geopolitical entanglements that have generated the current stalemate will be eliminated. To draw on one example, geopolitical influences on participation and voting have contributed to frustrated efforts to limit mortality on tuna species at the WCPFC. Further, where effort controls are in place, allocation processes introduce a second layer of geopolitical considerations: Fishing nations use management and access negotiations to earn regional influence; offers of aid, investment, and infrastructure are reported to reduce the stringency of enforcement (Havice and Campling 2010).

The fourth implementation issue is that a whale share program creates new logistical challenges for quota definition and allocation regardless of whether the market for whale products expands or contracts. Once whaling is legitimized in the international community, pressure might well grow to manage whale stocks for MSY, the default approach for most fisheries management. While admittedly speculative, such a policy would greatly increase the total allowable catch of whales relative to the status quo for species such as minke whales and could exacerbate under-provision of public goods as Fig. 1 illustrates. To the extent that stocks of other whale species recover, pressure could be brought to open these stocks to harvest.

The selection of whale species subject to a catch share is complex. Harvesting species under rebuilding programs or at critically low population levels can be counterproductive. Catch shares on species with low population levels can mean that the number of vessels exceeds the desired limit, catches are rare events, it is not possible to allocate the total catch across vessels, and group rather than individual rights are required (Segerson 2011). Fleets under whale shares may need to pool shares and coordinate efforts. Whether to specify catch shares to individual species or groups of species (e.g., “blue whale units”) raises the rare events problem again and discordance between catch limits and mortality rates for individual species and substitution between species in a composite unit.

Catch rights in international agreements are complicated because they include two rights in a multilateral self-enforcing commission: The catch right and an access right (Squires et al., in press). The access right can be to exclusive economic zones (EEZs), reflecting individual national sovereignty or to the high seas under IWC auspices. The catch right may be bundled with, or separate from, the access right. Rights may have to be issued first to states, and then to individuals because of the sovereignty of states both within their EEZs and as the primary actors in the IWC. If rights are first issued to individuals, then states may well assert their sovereignty as with the Inter-American Tropical Tuna Commission’s capacity program.

Allocation is the most contentious element of any catch share program. Are rights allocated to nations and then vessels or directly to vessels? Which nations can receive allocations, and do coastal developing states receive particular consideration because of their EEZs in which whales spend all or part of their lives? It is essential to start an allocation of rights by closing the pool of participants to which rights are allocated but allow entry by new states. Limited duration can accommodate entry into the process and mitigates the tensions that otherwise arise when states perceive their sovereignty to have been circumscribed. Compliance and enforcement are necessary components of any
allocation agreement, and must be considered as part of the agreement and initial allocation. Because the IWC is voluntary and requires multilateral cooperation for success (Barrett 2003), failure to solve the allocation issue would undermine self-enforcement.

In conclusion, market-based policies like catch shares have an important role to play in marine conservation, but the details are tremendously important, particularly in the international arena for global impure public goods. In the case of whale shares, the policy will be unable to achieve a social optimum unless the IWC happens to set the cap close to the optimal level. Only under these circumstances do potential gains from quota trading emerge because NGOs can raise sufficient funds to move the quota. The potential for catch shares to mimic the social optimum is considerably lower for less charismatic species, as NGOs have more difficulty fund raising in these cases. Qualitatively, there are many possible pathways through which the policy would lower social welfare: free riding in the private demand for conservation, stimulating demand for whale products that move the market outcome further from the social optimum, creating new enforcement challenges, and additional pressures on the political economy of setting the cap and allocation of the rights. Catch shares in the international arena face very different circumstances than national programs, and the latter do not simply translate to the international arena. Several key factors differ from national programs: multiple jurisdictions, international law, the sovereignty of nations, and the necessity of self-enforcing multilateral cooperation. Establishing who has “real interest” will be crucial, and may well evolve with the introduction of rights.

A successful whale share policy, at minimum, requires a mechanism to collect voluntary contributions to whale conservation that do not fall short of the social demand due to free riding and an enforcement mechanism that can distinguish between legally and illegally traded whale products. These features would require major institutional development beyond setting up a whale shares program. In contrast, there are only a handful of pathways through which whale shares even with these features would increase social welfare, and these pathways are artifacts of where the cap is set and not attributable to trading shares per se. Nevertheless, no one can say with certainty what the outcome of a whale shares proposal would be for whale stocks and marine conservation more broadly. There is risk in staying with the status quo stalemate, but there is also risk in adopting a new policy approach. Empirically understanding the pathways through which a whale share would increase or decrease social welfare is an important direction for future consideration.

ACKNOWLEDGMENTS

The authors thank two anonymous reviewers for helpful comments on an earlier draft.

LITERATURE CITED


Facilitate, don’t forbid, trade between conservationists and resource harvesters

LEAH R. GERBER,1,3 CHRISTOPHER COSTELLO,2 AND STEVEN D. GAINES2

1Ecology, Evolution and Environmental Science, School of Life Sciences, Arizona State University, Box 874501, Tempe, Arizona 85287-4501 USA
2Bren School of Environmental Science and Management, University of California, Santa Barbara, California 93106 USA

We are glad our recent paper in Ecological Applications has stimulated new discussion on the role of conservation markets in wildlife management. In their response, Smith et al. identify four important challenges to implementing a whale conservation market. We agree that the details of market-based policies are important and highlighted several challenges in our paper in the market design for whales. But we believe the challenges highlighted by Smith et al. (and indeed by our own analysis) will be present under any institutional regime and are surmountable in a market with appropriate design. The purpose of our paper was to propose a general framework for how a market for wildlife species such as whales might perform in order to stimulate new thinking on the many complexities associated with a market-based approach. We are delighted that our paper has accomplished this so quickly, and remain enthusiastic about the exciting research ahead.

The overall concern raised by Smith et al. is that, because whales are an impure public good, any policy that fails to capture all nonmarket benefits and potential free riding will lead to a suboptimal outcome. We agree that any approach that ignores nonmarket and external benefits could lead to a suboptimal outcome. Importantly, we never claimed that a conservation market would lead to a socially optimal outcome. Rather, we proposed that it could be Pareto improving (make both sides better off) relative to the status quo. Furthermore, if conservationists purchase all of the shares (which may well occur), then indeed this solution may be socially optimal; an important (and perhaps likely) scenario that Smith et al. failed to recognize. A simple version of the market, which has been mirrored for in-stream flow water rights, is to cap the whale harvest at the current level of take (provided it is biologically safe), and to provide a platform where conservationists can compensate whalers to reduce harvest from that point. If such trade occurs, and we have strong evidence that it could, it would improve the welfare of both sides. More complicated market designs are also possible, and our simulations illustrate several cases. That said, we think the impure public good nature of whales could lead to interesting new research and insights about market design and outcomes (compared to some reasonable counterfactual) in these contexts.

In addition to this general concern about free riding, below we briefly address each of Smith et al.’s four suggested impediments:

1) The creation of a whale share would legitimize the international trade in whale meat and expand the whale meat market.

This is an interesting idea that may, or may not, come to pass. The design of the market will matter. If, for example the “market” is set to allow only conservation reductions from current harvest levels, we doubt this

Manuscript received 8 August 2013; accepted 16 August 2013. Corresponding Editor: T. E. Essington. For reprints of this Forum, see footnote 1, p. 3.
3 E-mail: leah.gerber@asu.edu
simple change will stimulate an increase in demand for whale meat. But we agree in principle that a global, fully functioning whale conservation market could to some extent legitimize whaling and could thus increase demand for whale meat. This could raise some interesting challenges of welfare measurement that neither we, nor Smith et al. address. Regardless, if the quota is set in a safe manner (as described in the paper), then conservation cannot be compromised. Our illustrative simulations show that, under a whale conservation market, the actual harvest may be substantially lower than what is caught now by Japan, Norway, and Iceland. That said, we agree that empirical research on consumer behaviors in the legal market and black market resulting from the potentially stimulated demand is an important avenue for future research. These effects could be incorporated into a model used for designing and regulating such a market.

2) A legal whale trade creates new monitoring and enforcement challenges similar to those of organizations that manage highly migratory species.

Monitoring and enforcement pose significant challenges whether or not one adopts a market approach. Indeed, one could argue that these challenges are even greater under the current system. Despite the challenges, we suggest that our proposed market may streamline many of the issues, because it would clearly define who was permitted to take whales, what whales they could take, and where they could take them. Furthermore, it is harder to “hide” the illegal harvest of a whale than it is to hide the illegal harvest of a fish: Whales are large and easily observable and whaling ships are specially designed and easier to track. Furthermore, under any governance system, the conservationists will have an incentive to monitor whaling behavior; under a conservation market, they would be able to flag, and presumably spur enforcement over violations.

3) Introducing a catch share will likely create a new political economy of management that changes incentives and increases costs for NGOs to achieve the current level of conservation.

It is almost certainly true that the setting of the quota will attract significant political attention from all interested parties. But this is nothing new: These kinds of debates will exist under any system (indeed, even under the existing “moratorium”). Because current harvest levels for most whales are low relative to maximum sustainable yield (MSY) values, we think a practical possibility that may be acceptable to all sides is to adopt a very conservative cap. One possibility is to set the cap at the current level of take (when it is safe); in the paper, we discuss other possible formulas for setting the cap. Once the cap is set, a nongovernmental organization (NGO) could either buy permits from the tradable market or from an auction. We have provided evidence that this approach will be considerably less expensive (per whale saved) than is the status quo approach to conservation. Clearly, this is an important issue that merits future research.

4) A whale share program creates new logistical challenges for quota definition and allocation regardless of whether the market for whale products expands or contracts.

We agree that there are important logistical challenges that will need to be debated, analyzed, and overcome to design and operate any effective conservation market. However, many of these challenges have already been addressed in other contexts, such as air pollution, wetlands, and water quality trading programs. There is a wealth of experience that could, and should, be drawn from these programs.

Overall, in addition to the many issues highlighted in our paper, Smith et al. have raised some important challenges in the design and operation of a conservation market that must be addressed in any plan that moves forward. Importantly, though, most of those challenges will exist under any governance regime, so it would be a mistake to view those challenges as evidence against the adoption of a conservation market. Nevertheless, we do not cavalierly believe that conservation markets will miraculously solve all of the world’s wildlife management challenges. Rather, we are motivated by the basic economic intuition that providing a platform for trade between commercial interests and conservation interests can make both sides better off than by forbidding trade. For example, under the current system, suppose a United States-based NGO and a Japanese whaling company wanted to make a private agreement in which the NGO paid the whaler $10,000 to reduce their whale harvest by one whale. This is a simple manifestation of the market mechanism we have proposed. Surely Smith et al. would agree that such a private contract should be allowed. Unfortunately, this kind of transaction is unlikely in the current system, because no firm cap exists against which to judge reductions in harvest. Thus, we proposed a formal market structure.

In summary, we agree in principle with Smith et al. that for whale conservation markets to become a practical, politically feasible solution that respects all stakeholders will indeed require much continued thought. Naturally, we encourage continued discussion about the role of conservation markets in managing wildlife. And while we appreciate Smith et al.’s insights, and think they could help improve the design of conservation markets, we question the relevance of these concerns to moving beyond the current stalemate in whale conservation. In our view, our paper’s original message is unchanged: Conservation markets for wildlife are certainly no panacea, but can likely be designed to improve substantially on the status quo.