

# **The socio-cultural benefits and costs of the traditional hunting of dugongs *Dugong dugon* and green turtles *Chelonia mydas* in Torres Strait, Australia**

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SUPPLEMENTARY MATERIAL 1 An example of the application of the methodology: estimating the market value of hunting dugongs *Dugong dugon* and green turtles *Chelonia mydas* in the communities of Mabuiag and St Paul's, Torres Strait, Australia.

## **Introduction**

We demonstrate how our method for estimating the costs and benefits of traditional hunting could be used for estimating a lower bound for the monetary worth of the cultural services associated with hunting of dugongs *Dugong dugon* and green turtles *Chelonia mydas* in Torres Strait, without needing to value such services directly. Direct valuation is contentious (Venn & Quiggin, 2007; Steenstra, 2009; Winthrop, 2014) and is intrinsically difficult because of the problem of overlapping values (Balmford et al., 2011) and the tenuous or non-existent links to market prices (Daniel et al., 2012).

## **Methodology**

The market costs and benefits of hunting were ascertained by determining the time and effort taken to capture animals, the average amount of fuel used on each trip, the number of hunters participating in trips, and the average success rate of trips. This information was collected during the field trips to Mabuiag and St Paul's. We also determined the use of the animals caught (i.e. general consumption, ceremony, or for sharing with kin in other Torres Strait communities and on the mainland).

One of the groups of separable benefits (family benefits, Table 1) was associated with sustenance (a provisioning service, if using the classification of ecosystem services), so we were able to use the information above and on the use of the animals caught to generate estimates of (1) the total harvest within each community, (2) the approximate cost of obtaining that harvest, and (3) the market value of the meat consumed for non-ceremonial purposes. Specifically, we used the replacement cost technique to monetize the family benefits associated with the market. We then used information about the relative importance of the other separable benefits (one of which was cultural services) and about the monetized value of provisioning services to generate lower-bound estimates of the (financial) worth of cultural services without needing to monetize them directly.

We interviewed hunters in both communities, collecting information about:

- How often they went hunting and how frequently they were successful;
- How many people they went hunting with, how much time (on average) each trip took, and (approximately) how much fuel was used on each trip;
- What was done with the animals after they were caught (e.g. distributed amongst kin, used for ceremony or other).

Information about the number of times each person went hunting each year was multiplied by the percentage of successful trips, to generate estimates of the total number of animals caught by each hunter each year. Through informal discussions, we estimated that the sample of hunters who participated in the study accounted for c. 80% of the total harvest within each community. Total community harvests were thus calculated by dividing the estimated total catch of study participants by 0.8.

We estimated the total cost of capturing a dugong or turtle conservatively, using only fuel and time costs. The fuel costs for each trip were estimated by multiplying the mean price per litre of fuel by the (mean) amount of fuel used on each trip. Time costs were calculated at AUD 25 per hour, for each hunter, multiplied by the mean duration of each trip. This hourly rate was used by Queensland courts to calculate the level of compensation appropriate for the families of indigenous hunters who were victims of an air crash in 2005. Trip-cost data were divided by the proportion of successful trips to generate an estimate of the cost of the ‘average successful’ hunting trip, equivalent to an estimate of the cost of obtaining an animal. The total (annual) cost of all harvests was then calculated by multiplying the costs of a successful trip by estimates of the total harvest.

Because the meat cannot be sold, the market value of the harvest was assessed using the replacement cost technique (Jackson et al., 2014); i.e. by multiplying the kilograms of meat harvested by the mean price of meat products in the community shop (AUD 19.81 per kg). Turtles provide, on average, 50 kg of edible meat, and dugongs provide 115 kg (Nietschmann, 1982). The replacement value of each turtle was estimated to be c. AUD 990, and of each dugong c. AUD 2,280. The total market value of the entire harvest was thus calculated by multiplying these values by the total harvest.

The provisioning benefit (family benefits in the article) of the harvest was estimated as the market value of the harvest that was not used for ceremony or shared outside the community, as family benefits included food for home consumption only, and not ceremonies (part of cultural services). We multiplied the mean price per kg of meat products by the estimated kg of meat consumed at home on the islands. We then generated an estimate of the net market value of provisioning services associated with hunting dugongs and turtles by subtracting total (market) harvest costs from the total (market) harvest value.

We interviewed 75% of all active hunters in our sample communities. We used information about the frequency of hunting trips and the success rate of each hunter to estimate the number of dugongs and green turtles caught by each hunter on a yearly basis (not reported

here, to maintain the confidentiality of respondents). Only 3–4 hunters per island were responsible for undertaking most of the hunting trips and accounted for >50% of the community catch, a result consistent with the findings of Kwan et al. (2006).

## Results and Discussion

On average, each hunting party comprised three people and took 5 hours to catch a dugong (range 3–12 hours) and 3.5 hours to catch a turtle. The time costs associated with hunting were thus estimated as:

- $3 \times 5 \times \text{AUD } 25 = \text{AUD } 375$  for a dugong hunting trip
- $3 \times 3.5 \times \text{AUD } 25 = \text{AUD } 262.50$  for a turtle hunting trip

Each hunting party required, on average, 40–60 litres of fuel. At AUD 2 per litre (a conservative estimate, as the cost of fuel was more than AUD 3 per litre on some islands in 2012), fuel costs were AUD 80–120 per trip. Thus the total costs of a hunting trip were estimated to be AUD 455–495 for a dugong hunting trip and AUD 343–383 for a turtle hunting trip.

Overall, two-thirds of trips were successful (although success rates were highly variable), so the mean cost of a successful hunt was c. AUD 675–750 for a dugong (hereafter we used the mean, AUD 713) and AUD 520–580 for a turtle (mean AUD 550).

Combining this information with information about the total number of animals caught in each community each year, and the replacement value of that catch, we were able to generate estimates of the market value of the total harvests within each community (Supplementary Table S1).

Approximately 17% of the total annual harvest for dugongs and c. 33% of the turtle harvest was for ceremony (food and feasts). If a dugong or green turtle was landed for purposes other than community feasting and celebrations, there was a 70% chance that at least one-twelfth of the dugong meat and an 80% chance that one-sixth of the turtle meat would be sent outside the community. We were thus also able to generate an estimate of the market value of the provisioning benefit of the meat used for general consumption (i.e. not for the maintenance of culture either through sharing or ceremony).

Our replacement cost exercise determined how much money would need to be given to our hunting communities to ensure that they could purchase meat from their local shops, should they no longer be able to hunt. These amounts were c. AUD 320,000 for Mabuiag and c. AUD 180,000 for St Paul's, providing an estimate of the compensation that would have been required in 2010 should these communities have lost the provisioning services associated with traditional hunting.

If communities were no longer able to hunt, other benefits would also be foregone, and our research indicates that these other benefits (most notably cultural services or community benefits) are more important than those associated with provisioning services (i.e. family benefits). If one uses only results from valuation studies that consider only provisioning services, then estimates of fair compensation for the loss of hunting rights will be clearly inadequate. We are confident that the value of the cultural services associated with hunting exceeds AUD 500,000 per annum across both communities. This is a lower-bound estimate only; we have no way of assessing the upper bound.

We cannot assume that the ratio of dollar values is equivalent to the ratio of importance values, so did not attempt to generate more precise estimates. Nevertheless, we can assert that the collective value of provisioning services, cultural services and the benefits our communities termed ‘individual benefits’ will exceed AUD 640,000 per annum on Mabuiag and AUD 360,000 per annum in St Paul’s. These estimates are conservative because we have used an implicit value of zero for individual benefits (which are less important than provisioning services, but we do not know how much less) and a value for cultural services that is equal to those of provisioning services (despite the fact that we know they are more important). To the extent that individual benefits are valued at more than zero, and that cultural services are valued at more than AUD 500,000, then the collective value of all benefits across both communities will exceed AUD 1,000,000 per annum. If these benefits could be applied pro-rata (something that would need to be confirmed in subsequent research), the collective benefit across all Torres Strait communities would exceed AUD 12,370,000 per annum. This compares favourably with the AUD 1,725,000 per annum government investment in the turtle and dugong management components of the Indigenous Ranger Program (Shaun Barclay, Torres Strait Regional Authority, pers. comm).

We were unable to conduct a similar monetary exercise for costs, as our cognitive mapping exercises did not separate clearly market and non-market costs: fuel and time costs (both linked to the market) grouped together with ‘pressure for results when in need of food and or when asked to go hunting’ (in a group termed family costs). But even here, community costs were deemed to be significantly greater than family costs, confirming previous observations that socio-cultural (community) values (be they thought of in terms of costs or benefits) are more important than market values. People are motivated by both extrinsic and intrinsic factors (Gneezy et al., 2011), and these findings suggest that intrinsic motivations are likely to be strongly associated with culture. The important policy implication of this finding is that policy makers need to be careful that extrinsic incentives designed to alter hunting behaviours do not negatively affect these intrinsic (cultural) motivations.

Moreover, it is clear that banning traditional hunting of dugongs and turtles in Torres Strait and compensating only for the value of meat foregone would highlight a poor understanding of the multidimensional benefits gained by indigenous communities involved in traditional hunting. Our findings reinforce the call of previous researchers (Gregory et al., 2007; Turner

et al. 2008) to consider socio-cultural issues when devising natural resource management strategies. Our technique also provides an alternative solution to make a range of costs and benefits outside the market more visible to policy makers.

SUPPLEMENTARY TABLE S1 Annual market costs and market benefits of hunting dugongs *Dugong dugon* and green turtles *Chelonia mydas* in the communities of Mabuia and St Paul's, Torres Strait, Australia.

| Annual estimates                         | Mabuia  |               | St Paul's |               |
|--|---------|---------------|-----------|---------------|
|  | Dugongs | Green turtles | Dugongs   | Green turtles |
| Cost of all hunting trips (AUD)          | 78,375  | 42,350        | 35,625    | 36,850        |
| Market value of harvest (AUD)            | 250,800 | 76,230        | 114,000   | 66,330        |
| Net market value of entire harvest (AUD) | 172,425 | 33,880        | 78,375    | 29,480        |
| Market costs per community (AUD)         | 120,725 |               | 72,475    |               |
| Market benefit per community (AUD)       | 327,030 |               | 180,330   |               |
| Net market value per community (AUD)     | 206,305 |               | 107,855   |               |

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