Current status and distribution of the Vulnerable common hippopotamus *Hippopotamus amphibius* in Mozambique

Charles S. Mackie, Kevin M. Dunham and Andrea Ghiurghi

Abstract Populations of the common hippopotamus *Hippopotamus amphibius* in Mozambique were surveyed in 2010 during a national survey of the crocodile *Crocodylus niloticus*. Numbers of hippos seen during aerial counts along major rivers and lake shores were corrected to allow for undercounting of groups and these data were supplemented with the results of other recent surveys. There are now estimated to be c. 3,000 hippos in Mozambique and c. 50% of these live in Lake Cabora Bassa or the Zambezi River. The national total is much lower than the figure of 16,000–20,500 hippos estimated in 1986, used for the latest (v. 2012.1) IUCN Red List. The 1986 total included an estimated 10,000–12,000 in Marromeu Complex, an area that includes the southern Zambezi delta. We review the results of past surveys and find that the number of hippos in Marromeu Complex in 1986 was probably three times fewer than estimated. Although the number of hippos in this area declined markedly during the 1980s we believe that the 1986 overestimate of hippos in Marromeu Complex is an error that has been perpetuated for 25 years. Particular care should be taken when Red List assessments roll-over old and unsupported estimates of numbers. Even if an old estimate was accurate there comes a time when it should not simply be rolled-over. The 2007 IUCN Species Survival Commission's African Elephant Status Report provides a model for future assessments of the status of the common hippopotamus, categorizing the numbers of a species according to the type of survey, its reliability, and how long ago it was conducted.

Keywords Aerial survey, *Hippopotamus amphibius*, human–wildlife conflict, Mozambique, population trend, Red List, status

Introduction

The common hippopotamus *Hippopotamus amphibius* (hereafter simply the hippo) is large, easily recognizable and confined to aquatic habitats during the daytime yet its status within its range in Africa is poorly known in many locations. The hippo is categorized as Vulnerable on the IUCN Red List (Lewison & Oliver, 2008) but for Mozambique the current assessment of its national status is still based on figures from 1986, when L. Tello (cited by Lewison & Oliver, 2008) estimated there were 16,000–20,500 hippos in the country, with a mean estimate of 18,000.

In 2010 the Direcção Nacional de Terras e Florestas (National Directorate of Land and Forests) of Mozambique's Ministry of Agriculture commissioned a national survey of the crocodile *Crocodylus niloticus* (Fergusson, 2010) because this species is a major cause of human–wildlife conflict in the country (Dunham et al., 2010). The hippo is also a conflict species, occasionally attacking people and often damaging crops near the aquatic habitats where hippos occur (Mkanda, 1994; Dunham et al., 2010; Kendall, 2011). Crocodiles and hippos are both found in perennial rivers, lakes and impoundments, and in seasonal rivers with large, permanent pools.

Total counts conducted from small aircraft flown slowly at low level are common and appropriate methods for counting both hippos and large crocodiles (Graham, 1987; Caughley & Sinclair, 1994). Hence the 2010 aerial count of large crocodiles in Mozambique provided an opportunity to collect information on the number and distribution of hippos at little extra cost. The results of that survey are presented here and are supplemented with information from other recent wildlife surveys to present an up-to-date assessment of the number and distribution of hippos in Mozambique.

Methods

Aerial surveys of selected rivers, lakes and dams in Mozambique were conducted from 16 October to 6 November 2010 in 19 areas, including four contiguous subdivisions of the Zambezi River (Fig. 1, Table 1). The selected survey areas were those thought most likely to have the greatest potential as habitat for hippos and crocodiles and for which there was no recent, reliable information. These are bodies of water that are lightly settled or not settled by people because they form the boundaries of protected areas such as Niassa National Reserve, Maputo Special Reserve and Zinave and Limpopo National Parks.

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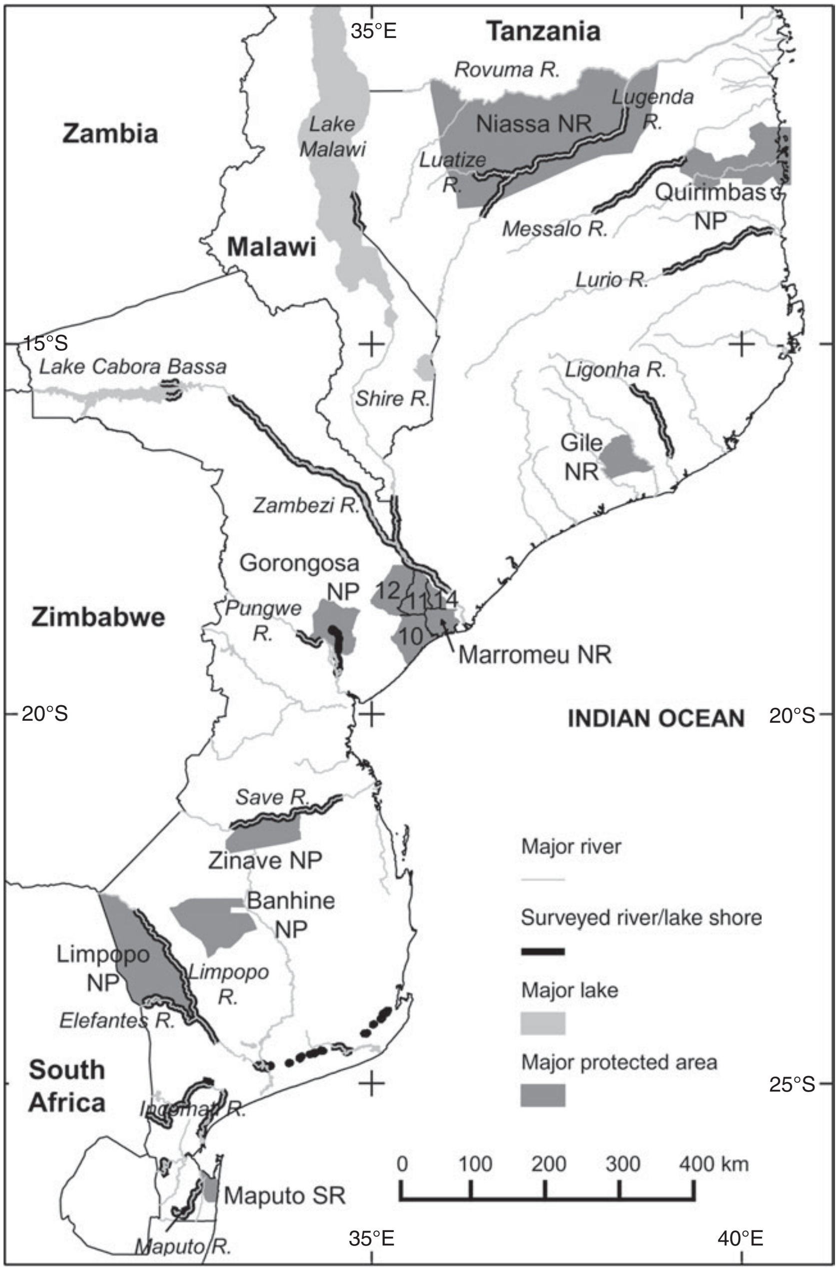

FIG. 1 Mozambique, showing selected conservation areas (NP, National Park; NR, National Reserve; SR, Special Reserve) and major rivers and lakes. The rivers and lake shores that we surveyed in 2010 are highlighted in black: 10, 11, 12, 14 indicate *Coutadas* 10, 11, 12 and 14, respectively.

A Piper Super Cub was used for the surveys. This two-seater, high-winged aircraft is suited to slow, low-level flight, is readily manoeuvrable, and has relatively low fuel consumption. The pilot and observer sit in tandem, enabling both to have uninterrupted views on both sides and below the aircraft. The nominal flying speed was 100 km per hour, but ground speed was reduced when flying into the wind. The flying height was c. 100 m above the water but was occasionally greater when the presence of hills, gorges, or electricity transmission lines made it unsafe to fly this low.

The aircraft was flown so as to maximize the visibility of the water's edge for the pilot and observer on one or both sides of the aircraft, as appropriate. Generally the aircraft was flown along the centre of a river channel and the pilot and observer searched for and counted hippos and crocodiles on both banks. If counts by the pilot and observer differed, the greater of the two was noted. The observer recorded all sightings and used a global positioning system (GPS) to record, as a waypoint, the location of each sighting. The flight path of the aircraft was recorded as a GPS tracklog and GPS data were downloaded to a computer daily.

Along the Zambezi River, which is too wide to allow both banks to be searched simultaneously, the aircraft was flown so that either the observer or the pilot could search the shoreline while the other searched between the aircraft and the mid-line of the river. In these wide sections each bank was searched in a separate flight and the results were the

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TABLE 1 The numbers of common hippopotamus *Hippopotamus amphibius* in Mozambique, by river or lake survey location (ordered approximately north to south). We surveyed 19 locations and included data from other surveys of five locations.

Survey location	Length of surveyed section (km)	Number counted	Correction factor	Corrected estimate of number	Data source
Lake Malawi (S section of Mozambique shoreline)	55	0		0	This study
Rovuma and Luchulingo Rivers (Niassa National Reserve)		36[1]	1.2	43	Craig (2009)
Rovuma River—downstream of Niassa National Reserve	259	45[2]	1.2	54	AGRECO (2008)
Lugenda & Luatize Rivers (Niassa National Reserve)	338	299	1.2	359	This study
Messalo River	177	0		0	This study
Lurio River	184	0		0	This study
Ligonha River	135	0		0	This study
Cabora Bassa East (N bank)	53	0		0	This study
Cabora Bassa (S bank)	1,033	911[3]	1.3	1,184	Dunham (2010)
Zambezi River (Cabora Bassa to Tete)	73	41	1.3	53	This study
Zambezi River (Tete to Chemba)	210	150	1.3	195	This study
Zambezi River (Chemba to Zambezi/Shire confluence)	84	110	1.3	143	This study
Zambezi River (downstream of Zambezi/Shire confluence)	103	13	1.6	21	This study
Zambezi delta		252[4]	1.3	328	Beilfuss et al. (2010)
Shire River	75	0		0	This study
Pungwe River & Lake Urema	131	62	1.6	99	This study
Save River	201	129	1.2	155	This study
Limpopo River	129	20	1.2	24	This study
Massingir Dam & Elefantes River	70	12	1.2	14	This study
Inhambane inland lakes	118	0		0	This study
Incomati River	42	16	1.2	19	This study
Lebombo Dam	39	0		0	This study
Maputo River	117	74	1.8	133	This study
Maputo Special Reserve		179[5]	1.0	179	Matthews & Nemane (2006)
Total		2,349		3,003	

[1]In 2009 36 hippos were counted in the Rovuma and Luchulingo Rivers during a survey of wildlife in Niassa National Reserve (Craig, 2009).
[2]In 2008 45 hippos were counted along the lower Rovuma River during an aerial total count of hippos and crocodiles (AGRECO, 2008).
[3]In 2010 the number of hippos along the south bank of Lake Cabora Bassa was estimated during an aerial sample survey of wildlife to the south of this lake (Dunham, 2010). The estimated number of hippos was 911 (95% confidence limits 468–1354): 188 hippos were seen in the sample strips.
[4]In May 2009 Beilfuss et al. (2010) conducted a total area count, by helicopter, of elephant and buffalo and a 40% sample survey of other large herbivores. The population estimate was 243 hippos (97 seen) in floodplain strata, with nine hippos seen in ecotone strata.
[5]In 2006 Matthews & Nemane (2006) conducted a total area count, by helicopter, of the wildlife in Maputo Special Reserve. When a large group of hippos was seen the helicopter left the flight path and was flown over the group so that the animals could be counted.

sum of the two counts. Along lake shores the aircraft was positioned so that the pilot and observer had clear views of the shore. It was important to minimize the effect of reflected sunlight by positioning the aircraft to avoid animals being missed as a consequence of reflections.

To maximize the area searched during the survey hippo pods were not circled but numbers of individual hippos within pods were usually estimated during a single fly-pass. We tested the consistency of the survey technique when one 286 km section of river (the Lugenda downstream of its confluence with the Luatize River) was surveyed twice for logistical reasons. The number of hippos counted was 203 during the first survey and 218 during the second, on the following day.

The initial estimate of the number of hippos in each river or lake was simply the sum of the number of individuals seen along that water body. These summed counts were then adjusted by a correction factor that accounted for both the undercounting of the number of individuals in large groups and for visibility bias (when hippos submerged in dirty or turbulent water may be missed by an observer). Correction factors for hippo surveys may be as great as 2.6, i.e. the estimated number of hippos is 2.6 times the number counted (Table 2). We chose to use correction factors of

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TABLE 2 Correction factors derived from earlier surveys of hippopotamus populations.

Location*	Correction factor	Data source
Virunga National Park, DRC	1.25–1.42	Aerial, bank counts (Delvingt, 1978, cited by Mackie, 1992)
Semliki, Virunga National Park, DRC	1.25	Comparison of bank counts & aerial counts (Mackie, 1989)
Rutshuru & Rwindi Rivers, Virunga National Park, DRC	1.25–1.62	Comparison of bank counts & aerial counts (Mackie, 1989)
Lake Edward, Queen Elizabeth National Park, Uganda	1.91–2.60	Comparison of aerial counts & aerial photographs (Mackie, 1992)
Mara River, Kenya	1.15–2.65	Comparison of bank counts & aerial counts (Olivier & Laurie, 1974)
Mweya Peninsula, Queen Elizabeth National Park, Uganda	1.32	Comparison of bank counts & number removed during cull (Bere, 1959)
Luangwa River, South Luangwa National Park, Zambia	1.22–1.33	Comparison of bank counts & aerial photographs of hippo pods (Marshall & Sayer, 1976)

*DRC, Democratic Republic of Congo

1.2 where the water was shallow, clear and only mildly turbulent (Rovuma, Luchulingo, Lugenda, Luatize, Save, Limpopo, Elefantes and Incomati Rivers and Massingir Dam), 1.3 where the water was dark, deep and turbulent, and counting conditions windy (Lake Cabora Bassa and Zambezi River upstream of the Shire confluence), 1.6 where the water was dark, cloudy or dirty, and turbulent, and conditions windy (Zambezi River downstream of Shire confluence, Pungwe River and Lake Urema), and 1.8 where the water was dirty, fast-flowing and turbulent (Maputo River). These values were derived from previous research (Mackie, 1973, 1976, 1992; Olivier & Laurie, 1974; Marshall & Sayer, 1976; Delvingt, 1978) conducted under conditions similar to those in this study. The correction factor used for each surveyed area is given in Table 1.

The results of our surveys were combined with data from other surveys conducted in Mozambique since 2006. We applied the same correction factors to these data (Table 1). The 2010 Cabora Bassa and 2009 Zambezi delta surveys were designed primarily to estimate the numbers of wildlife species other than hippo and so may have underestimated hippo numbers. But the confidence intervals of sample survey estimates are often large and thus likely to include the true population number.

Results

No hippos were observed in the surveyed regions of Lake Malawi, the north bank of Lake Cabora Bassa, the Messalo, Lurio, Ligonha and Shire Rivers, the Inhambane inland lakes, or Lebombo Dam. We counted 926 hippos in 11 survey areas, including the four subdivisions of the Zambezi River (Table 1). After applying correction factors to the counts and combining our survey data with the results of other surveys conducted since 2006 we estimate that there are c. 3,000 hippos in Mozambique. More than 50% of these inhabit Lake Cabora Bassa or the Zambezi River and > 25% live in three other river systems, the Lugenda, the Save and the Maputo (Fig. 2).

Discussion

Number of hippos in Mozambique

Our study shows that the number of hippos in Mozambique, c. 3,000, is well below the 2012 Red List estimate of 18,000 (Lewison & Oliver, 2008). There are several limitations of our data set (e.g. the primary focus of the 2010 river counts was the crocodile; the estimate of hippo numbers along the south shoreline of Lake Cabora Bassa was from a survey designed to count the land-based wildlife; the estimate of hippo numbers in Maputo Special Reserve was from 5 years earlier). Also, small numbers of hippos may live in areas for which we have no recent information, e.g. the Buzi and Lucite Rivers in southern Manica province (Ghiurghi & Pariela, 2007; Ghiurghi et al., 2010) and in some districts in southern Zambezia, south-eastern Gaza and southern Inhambane provinces, where human–hippo conflict occurs (Dunham et al., 2010). But neither the limitations of our data set, nor any gaps in it, can account for the discrepancy between our estimate of hippo numbers and that used in the IUCN Red List.

The 2012 Red List figure is based on a 1986 estimate of 18,000 hippos in Mozambique. Of the 18,000, most (10,000–12,000) were reported to be in the 'Zambezi Wildlife Utilization Area, which includes Marromeu Reserve and four safari hunting blocks' (L. Tello, cited by Lewison & Oliver, 2008). Marromeu National Reserve (1,500 km^2) and *coutadas* (hunting areas) 10, 11, 12 and 14 (total area 8,252 km^2) form a single block of land (Tinley et al., 1976) sometimes called the Zambezi Wildlife Utilization Area (Fig. 1). It includes the southern side of the delta of the Zambezi River and adjacent uplands and, together with commercial sugar plantations, subsistence agriculture and grazing lands along the south bank of the Zambezi River, and coastal mangroves, forms the 11,000 km^2 Marromeu Complex (Beilfuss & Brown, 2006). Past surveys (Table 3) showed that the number of hippos in the Complex declined from 1,000–3,000 during the late 1970s to < 100 between

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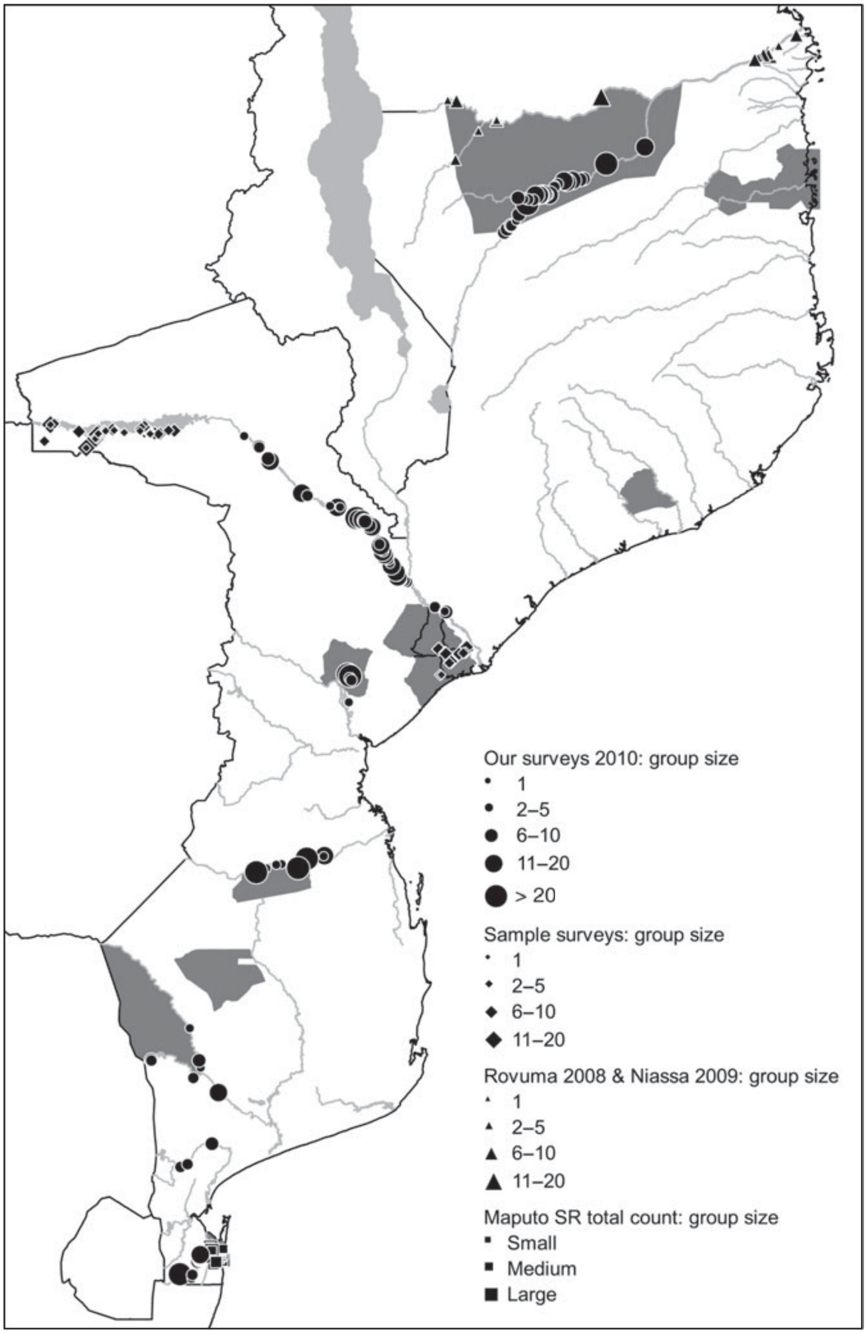

FIG. 2 Current distribution of the common hippopotamus *Hippopotamus amphibius* in Mozambique. Circles represent hippo groups seen during aerial counts in 2010; triangles represent other groups seen during recent surveys along the Rovuma River; diamonds represent groups seen during the sample surveys of wildlife south of Lake Cabora Bassa and in the Zambezi delta; squares represent groups seen during a total count in Maputo Special Reserve (SR) in 2006. Symbol size is proportional to number of hippos in the group.

1998 and 2001. Recently, the estimated number has increased slightly (Beilfuss et al., 2010). Although we do not have access to all the original reports to check the compatibility of survey methods and study areas, two things are clear. Firstly, the hippo population of Marromeu Complex declined to a low number sometime during the 1980s. Buffalo *Syncerus caffer* and waterbuck *Kobus ellipsiprymnus* populations (which both numbered > 30,000 animals during the late 1970s) also experienced declines as a consequence of hunting by military forces during Mozambique's 1980–1992 civil war (Hatton et al., 2001). Secondly, the number of hippos in Marromeu Complex never exceeded 3,000 (Table 3), in other words it was always less than one-third of the 10,000–12,000 reported to occur there in 1986. The origin of the estimate of 10,000–12,000 hippos is a mystery to us and maybe it was simply an error: perhaps the area of the Complex was mistaken for its hippo population? Whatever its origin, this error has been perpetuated for 25 years.

Trend in hippo numbers in Mozambique

While we dispute the estimate of 18,000 hippos in Mozambique in 1986 we agree with the Red List assessment that the number has declined since the 1970s. The decrease

Table 3 Temporal trend in the number of hippos in the Marromeu Complex, as summarised by Hatton et al. (2001) for 1977–1998 and Beilfuss et al. (2010) for 2000–2009.

Year	Number of hippos
1977	2,820
1978	1,010
1979	1,770
1990	260
1998	12
2000	48
2001	68
2008	115
2009	252

in Marromeu was accompanied by a similar decline in Gorongosa National Park, where Mozambique's largest hippo population of > 3,000 animals was almost eliminated during 1979–1993 (Hatton et al., 2001).

Mozambique has widespread and diverse wetland systems consisting of rivers, natural lakes and depressions, and man-made impoundments. The fact that hippos previously occurred widely across the country (Smithers & Lobão Tello, 1976) suggests that many of these wetlands are, or were, ecologically suitable for hippos. The reduction in the distribution of the hippo in Mozambique is probably anthropogenic, partly because of conflicts with agriculturalists (Smithers & Lobão Tello, 1976), but now also owing to conflicts with fishermen and to disturbance by miners digging in river beds for alluvial gold.

Management of hippos in Mozambique

Most of Mozambique's hippos live outside protected areas. Those that are within a protected area often inhabit a river that forms the area's boundary (e.g. the Save River is the northern border of Zinave National Park and the Rovuma River is the northern border of Niassa National Reserve) and thus hippos may move outside the protected area to feed at night. Furthermore, many protected areas in Mozambique, e.g. Zinave National Park, are inhabited by subsistence farmers. Hence, although hippos are legally protected, their habitat often is not.

The total number of hippos on hunting quotas in Mozambique during 2011 was 276, which represents c. 9% of the national population. This percentage is similar to the 11% population growth rate recorded for hippos in the Luangwa Valley, Zambia (Marshall & Sayer, 1976) and is probably close to the maximum sustainable offtake that a hippo population can withstand (10%; Martin & Thomas, 1991). The quota represents the maximum number that may be killed legally and we do not know the number actually killed. However, given that hippos in Mozambique live in a few, isolated subpopulations (Fig. 2), it is important that subpopulation offtakes, both legal and illegal, and not just the total national offtake, are monitored annually.

Conservation implications

One aim of the IUCN Red List is to establish a baseline from which to monitor changes in the status of plants and animals (IUCN, 2012). While the importance of basing assessments on current and accurate data is obvious this is not always possible. Our study has revealed one danger of relying on old data: not only is the population estimate inaccurate now but it was inaccurate when first made, perhaps at a time when Red List assessments were less rigorous. Despite searching, we found no document that provided estimates of hippo numbers in Mozambique in 1986 and we recommend that particular care must be taken when Red List assessments roll-over old and unsupported (e.g. by survey reports) estimates of population number. Even if an old estimate was accurate, there comes a time when it should not simply be rolled-over. The IUCN Species Survival Commission African Elephant Status Report (Blanc et al., 2007) provides a model for future assessments of the status of the common hippopotamus, and many other species, by categorizing animal numbers according to the type of survey and its reliability, with population estimates > 10 years old categorized as speculative.

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Biographical sketches

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