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POPULATION MONITORING OF THE CRITICALLY ENDANGERED MEKONG DOLPHIN BASED ON MARK-RESIGHT MODELS

Phan Channa, Hang Sereyvuth, Tan Someth Bunwath and Lor Kimsan, September 2015

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The study on population estimate of the Mekong Irrawaddy Dolphins would not have been possible without collaborative efforts of the survey team from FiA and WWF, particularly the main support from HSBC and WWF Switzerland.

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KEY FINDING

The Mekong dolphin population is estimated **at 80 individuals in 2015**, with a 95% confidence interval of 64–100.

The Average annual population growth rate is estimated at 0.98; an average annual decline of 1.6% per year between 2007 and 2015. Earlier studies suggested annual decline of 7% between 2004 and 2007 and 2.2% between 2007 and 2010. **Therefore probable that rate of population decline is slowing**.

Average annual survival is estimated at 0.98 (95% CI 0.90-0.99), or 2.4% mortality per year

Recruitment is estimated at 0.8% per year. Prior to 2013 recruitment was estimated zero. We now have evidence of limited recruitment **but it is still less than mortality**.

Overall, these results suggest that whilst the population continues to decline the rate of decline appears to be slowing. The increase is ongoing recruitment rate gives hope of recovery if the levels of **mortality can be reversed**.

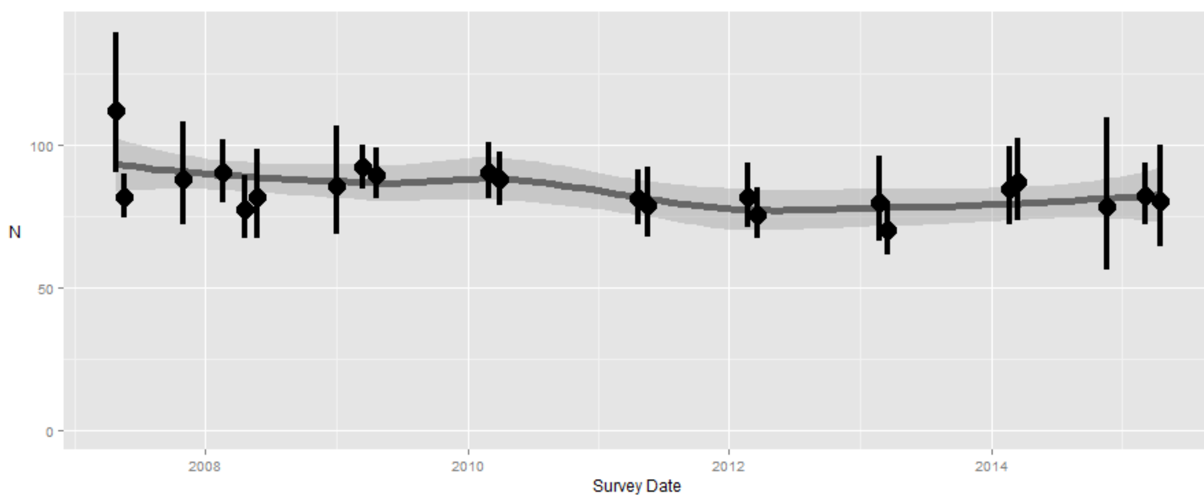

Figure 1: Estimated population size and 95% Confidence Interval (points), with smoothed population mean and confidence interval (ribbon) between 2007 and 2015.

Introduction

Irrawaddy dolphins (Orcaella brevirostris) occur in coastal areas associated with the muddy, brackish water at the river mouths throughout Asia (Stacey and Arnold 1999). Fresh water Irrawaddy dolphin subpopulations are found in three main rivers (Mahakam, Ayeyarwady, and Mekong Rivers) and two inland lakes (Songkhla and Chilka Lakes). All these fresh water subpopulation are listed as critically endangered species by IUCN, apart from subpopulation in Chilka Lakes which has not been formally assessed (Kreb and Smith 2000; Smith 2004; Smith and Beasely 2004a, b). Both estuarine and freshwater dolphins are threatened by human activities that occur in these environments. Threats include direct mortality from fisheries interaction, particularly gillnet entanglement vessel strikes (Smith *et al*. 2007b; Beasley *et al*. 2007a; Kreb *et al*. 2007; Smith et al. 2005; Smith et al. 2004) and habitat loss and degradation, declining or altered freshwater flows due to dam and embankment construction (Anon. 2007) As a result of the numerous anthropogenic threats facing all fresh water river dolphin populations comprehensive understanding of their population dynamics is required for effective long term monitoring and evaluation of implemented management strategies. However dedicated monitoring programs need to ensure that sampling methodology and effort are appropriate to achieve robust estimates of abundance.

Table 1: Previously estimates of the population size of Mekong dolphins in the Mekong River.

Year	1997	2005	2007	2010	2013	2015
Estimate	≤200	127	93	85	70	80
Confidence Interval	-	108-146	86–101	78–91	62–80	64-100
Method	Direct observation and guess	Photo-ID Mark-Recapture	Photo-ID Mark-Recapture	Photo-ID Mark-Resight	Photo-ID Mark-Resight	Photo-ID Mark-Resight
Reference:	(Baird & Beasley 2005)	(Beasley *et al*. 2009)	(Beasley *et al*. 2012)	(Ryan *et al*. 2011)	(Ryan. 2015)	(Phan *et al*. this report)

One of the most extensively studied river dolphin populations in Asia is the Irrawaddy dolphin population that inhabits the lower Mekong River (hereafter Mekong dolphin population) of Northeastern Cambodia and Lao PD (table1). The first survey by Baird estimated no more than 200 individuals in 1997 in the Mekong River and tributaries, through this was essentially a guess informed by direct count of around 40 individuals (Baird & Beasely 2005). Photograph surveys of individuals from 2001 to 2005, (Beasely and colleagues) estimated the population at 127 individuals based on closed capture-recapture model as of April 2005 (Beasely *et al*. 2009). The same study of photographically identified individuals from 2004 to 2007 (Beasely and colleagues) estimated the population at 93 individuals in the end of study, and the decline of around 7% per year (Beasely *et al*. 2012), equating to an annual population growth rate of 0.93. A similar study of photographically identified individuals from 2007 to 2010 estimated the population at 85 individuals in the end of study, the population growth rate of 0.98 with no recruitment (Ryan *et al*. 2011). Together these studies provide strong evidence of a decline in Mekong dolphin populations.

In this study we report on the estimate of Mekong dolphins abundance, survivorship, recruitment, population growth rate and population trend using photo-identification of individual dolphins (extrapolating Mark-resighting estimates to total population size based on incorporation of unmarked animal) collected between 2007 and 2015, provide recommendations for future population monitoring and conservation strategies, and highlight the critical conservation situation now facing the Mekong dolphin population.

Study Area

The Mekong River is the largest river in Southeast Asia and it supports a major inland fishery. It is large seasonal flood plain which includes deep pools and a Ramsar wetland site. Deep pools (10-60 m) in this river section are important fish spawning sites and habitats for numerous flora and fauna during the dry season, many of which are endangered, or extinct in the other areas throughout their range (Chan *et al*. 2003; Viravong *et al*. 2005) and a Ramsar wetland site that provides habitat for several globally threatened species (Bezuijen *et al*. 2008). Boat surveys were undertaken along the Mekong River section of the main channel from Kratie Township, Kratie province, Cambodia to southern of Khone Falls complex in Champassak province, Lao PDR and back again; a distance each survey route of around 190 km. Each survey took between 9 and 10 days (table 2). Previous extensive surveys suggest this area is the current extent of Mekong dolphins occur in the Mekong River (Baird and Mounsouphom 1997, Beasley *et al*. 2007 and Beasley *et al*. 2009), with Mekong dolphin's never having been recorded above Khone falls in recent history (Baird *et al*. 1994). Thus the survey areas covered all dolphins' range which supports the assumption of demographic and geographic closer for abundance estimation.

Methods

Field Survey

Field methods follow those described by Dove and colleagues (Dove *et al*. 2008) and Ryan and colleagues (Ryan *et al*. 2011). Twenty two primary survey periods were conducted between April 2007 and April 2015, each primary survey period taking typically nine to ten days and consisted of two secondary survey periods one upstream and one downstream. In total, 44 secondary survey periods were made between 2007 and 2015 (table 2). Each primary survey began at the Kratie township, Cambodia, proceeded upstream to the Khone Falls, Laos/Cambodia international border (one secondary survey), and returned downstream to Kratie township (second secondary survey) (fig 2). Surveys used a 9 m, narrow wooden boat with a long-tail outboard engine, and the route followed a system of concrete channel-markers installed by former French colonial government. The boat travelled slowly at about 5-10 km per hour up the main channel of the river searching for dolphins, following a zig-zag pattern from bank to bank in the wider reaches to cover more of the surface area. At least six active observers Included the driver were present, with two on the bow looking forward and two in the center looking behind and either side as well as, and two included stern looking to either side.

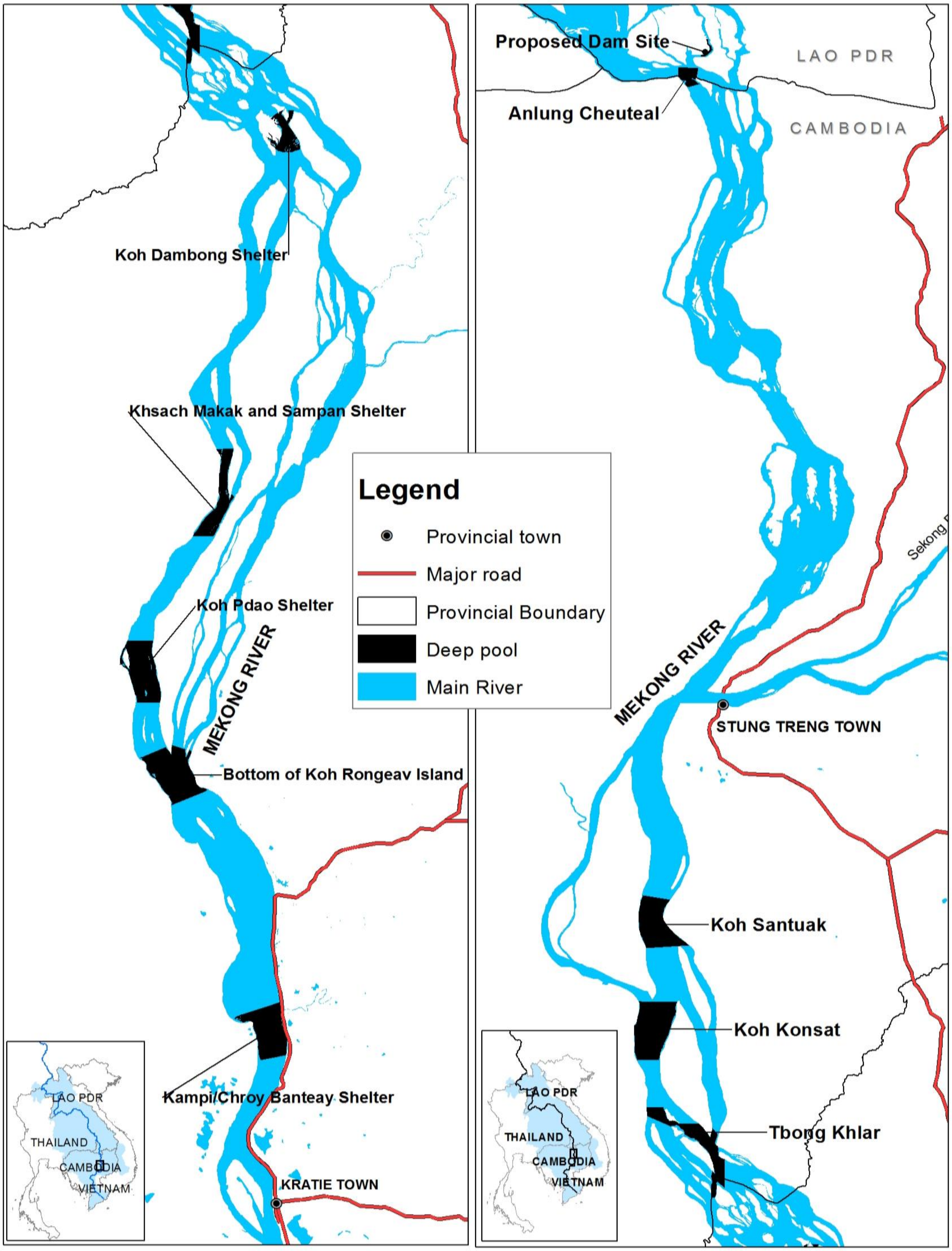

Figure 2: Map showing the study area in the lower Mekong River. The survey began at the Kratie township to Khone Falls, Lao/Cambodia international border.

When dolphins were sighted the engine was stopped; usually stopping upstream and, by oar to approach cautiously to within around 100 m. Dolphins were photographed by one or two photographers using typically two digital camera with a large zoom len, included models of Canon 350D, 450D, 50D, 60D, and 7D, fitted with 100–400 mm optical zoom L-series lenses (and a Sigma lens in 2007–9 of similar focal length). Photographers aimed for photographs where the dorsal fins could be seen. Groups of dolphins were photographed for at least 30 minutes until both photographers felt they had photographs of all animals present, for up to 120 minutes. Each encounter session was independent, and used as the basic unit of measurement for analysis. Survey days were constrained by light, and observations finished at 16:00. Each day the boat began in the place it ended the afternoon before, incrementally working up, and then down-stream within the study area.

Photo Identification

Surveys took large numbers of photographs of which only a small number of high quality shots were retained. Only those photographs where dorsal fins were close to perpendicular to camera, in clear focus, showing the entire dorsal fin and at close-to 90 degree angle to the animals were used. Individuals were identified based on the profile shape of the fin, supplemented by deformities, pigmentation, scarring and lesions, and compared with a developing base catalogue (Dove *et al*. 2008). High quality photographs of unmarked animals were recorded in a database in a similar way to marked animal. Such photographs should enable the distinction of any subtle markings and therefore ensure heterogeneity of detection regardless of the level of distinctiveness of a fin, thus avoiding biasing modelled estimates.

As marks on dolphin are naturally occurring and acquired over time; calves are born without marking and most unmarked animals are believed to be young. Further young calves (<1 year) are more boat shy than older animals, and therefore more difficult to resight and the main assumption of main modeling effort is that the marked individuals are representative of the whole population in terms of sighting probabilities. For this reason unmarked photographs thought to be calves (by size next to its mother) were excluded from further analysis, as per similar studies (Silva *et al*. 2009, Ryan *et al*. 2011).

Analytical Methods

Encounters of individuals identified, and encounters of unmarked individuals were modelled using the (zero-truncated) Poisson log-normal estimator (ZPNE) mark-resight framework of McClintock and colleagues (McClintock & White 2009; McClintock *et al*. 2009) as available in Program MARK (White and Burham 1999). We used the same model formulations as Ryan and colleagues (Ryan *et al*. 2011) to estimate: the number of unmarked individuals in the population during each primary survey period (U_t), the mean resighting probability for each primary period (α_t) on the log-scale, additional variance in resighting due to individual heterogeneity ($\sigma^2{}_t$) on the log-scale, apparent survival between primary survey periods (φ_t), the probability of transitioning from an observable to unobservable state between primary survey periods given an individual was present to be observed (Υ''_t), and the probability of remaining in an unobservable state (i.e., the probability of returning to an observable state) given an individual was not present to be observed (Υ'_t). From this we derived the overall mean resighting rate for each primary survey period as well as the population size (N_t) at each primary period.

U was estimated as a function of survey, i.e., assuming there would be a different number of unmarked individuals for each survey so that we would not enforce a situation where changes in population size would only come from the marked population. Resighting probability was modelled as a constant across surveys ($\alpha.$) as well as a function of survey (α_t). Individual heterogeneity was modelled as a constant ($\sigma^2.$), as function of survey ($\sigma^2{}_t$), as well as equal to zero ($\sigma^2=0$). Survival was modelled as a constant ($\varphi.$) and as a function of survey (φ_t). Transition probabilities were modelled as constant, (Y″. and Y′.) and either separate or equal to each other. This totaled a set of 24 models, which were compared using Akaike's Information Criterion with a correction for small sample size (AICC) to compare models (Burnham and Anderson 2002). To estimate seniority (ρ) and thus population growth rate (ʎ), using a reverse-time analysis of the top model and derive estimates following methods used in Ryan and colleagues (Ryan *et al.* 2011). In total, twenty two primary survey periods and 44 secondary survey periods collected between April 2007 and April 2015 by Dove and colleagues for the first (Dove *et al.* 2008), Ryan and colleagues (Ryan *et al.* 2011) and compile with our data were used for the modelling.

RESULTS

A total of 95 individual marked Mekong dolphins were identified from the 22 primary survey periods, including over 353 encounter occasions and 1816 resightings (table2).

Table2: The survey dates, number of individuals seen, survey sighting, and survey sighting rate of Mekong dolphin from 2007 to 2015 during each primary survey.

Year	Individuals seen	Survey Sighting	Survey Sighting Rate
Apr-07	61	93	1.52
May-07	61	123	2.02
Oct-07	42	55	1.31
Feb-08	60	92	1.53
Apr-08	48	78	1.63
May-08	41	58	1.41
Dec-08	38	47	1.24
Mar-09	70	132	1.89
Apr-09	64	119	1.86
Mar-10	63	113	1.79
Mar-10	62	111	1.79
Apr-11	56	94	1.68
May-11	47	71	1.51
Feb-12	53	79	1.49
Mar-12	53	95	1.79
Feb-13	42	66	1.57
Mar-13	47	84	1.79
Feb-14	49	69	1.41
Mar-14	50	70	1.4
Nov-14	23	29	1.26
Mar-15	54	87	1.61
Apr-15	37	51	1.38

The top model estimated resighting by survey, individual heterogeneity fixed at zero, survival as constant, and that the probability of transitioning to an unobservable state between surveys (Y") was different than the probability of remaining unobservable (Y'; Table3). The second-best model was identical to the top model except the heterogeneity as constant was allowed to be estimated versus being fixed to zero, thus an additional parameter was estimated in this second model. These two models account for most of the support. The results of these models were extremely close, with virtually identical population estimates, and the estimates of transitioning into an unobservable state were effectively zero in both models. Therefore I choose to present results from the top model only.

Table 3: Models with ΔAICc, weighting, and number of parameters, ranked in order from most to least supported.

Model	Parameters	ΔAICc	weight
mod.alpha.t.sigma.zero.U.t.phi.dot.GDP.dot.GP.dot	47	0.00	0.75
mod.alpha.t.sigma.dot.U.t.phi.dot.GDP.dot.GP.dot	48	2.18	0.25
mod.alpha.t.sigma.zero.U.t.phi.t.GDP.dot.GP.dot	70	44.30	0.00
mod.alpha.t.sigma.dot.U.t.phi.t.GDP.dot.GP.dot	71	46.59	0.00
mod.alpha.t.sigma.t.U.t.phi.dot.GDP.dot.GP.dot	69	50.62	0.00
mod.alpha.t.sigma.zero.U.t.phi.dot.GDP.s	46	66.61	0.00
mod.alpha.t.sigma.dot.U.t.phi.dot.GDP.s	47	68.79	0.00
mod.alpha.t.sigma.t.U.t.phi.t.GDP.dot.GP.dot	92	94.81	0.00
mod.alpha.t.sigma.zero.U.t.phi.t.GDP.s	69	107.46	0.00
mod.alpha.t.sigma.dot.U.t.phi.t.GDP.s	70	109.74	0.00
mod.alpha.t.sigma.t.U.t.phi.dot.GDP.s	68	114.89	0.00
mod.alpha.dot.sigma.dot.U.t.phi.dot.GDP.dot.GP.dot	27	117.87	0.00
mod.alpha.dot.sigma.t.U.t.phi.dot.GDP.dot.GP.dot	48	138.18	0.00
mod.alpha.dot.sigma.zero.U.t.phi.t.GDP.dot.GP.dot	49	150.49	0.00
mod.alpha.dot.sigma.dot.U.t.phi.t.GDP.dot.GP.dot	50	152.67	0.00
mod.alpha.t.sigma.t.U.t.phi.t.GDP.s	91	158.21	0.00
mod.alpha.dot.sigma.zero.U.t.phi.dot.GDP.s	25	175.42	0.00
mod.alpha.dot.sigma.dot.U.t.phi.dot.GDP.s	26	177.51	0.00
mod.alpha.dot.sigma.t.U.t.phi.t.GDP.dot.GP.dot	71	180.27	0.00
mod.alpha.dot.sigma.t.U.t.phi.dot.GDP.s	47	195.68	0.00
mod.alpha.dot.sigma.zero.U.t.phi.t.GDP.s	48	210.24	0.00
mod.alpha.dot.sigma.dot.U.t.phi.t.GDP.s	49	213.93	0.00
mod.alpha.dot.sigma.t.U.t.phi.t.GDP.s	70	235.44	0.00

The best and second modeled suggested that clear evidence existed for resighting rate variation across primary survey periods (table 3). The mean of times an individual was resighting for each primary period was lowest at 0.46 in November 2014 and highest at 1.76 in March 2009 with much variability across the surveys. Resighting rates increased from 2009 to 2014 surveys as compared to prior to this and during the last survey in 2015 (fig 3).

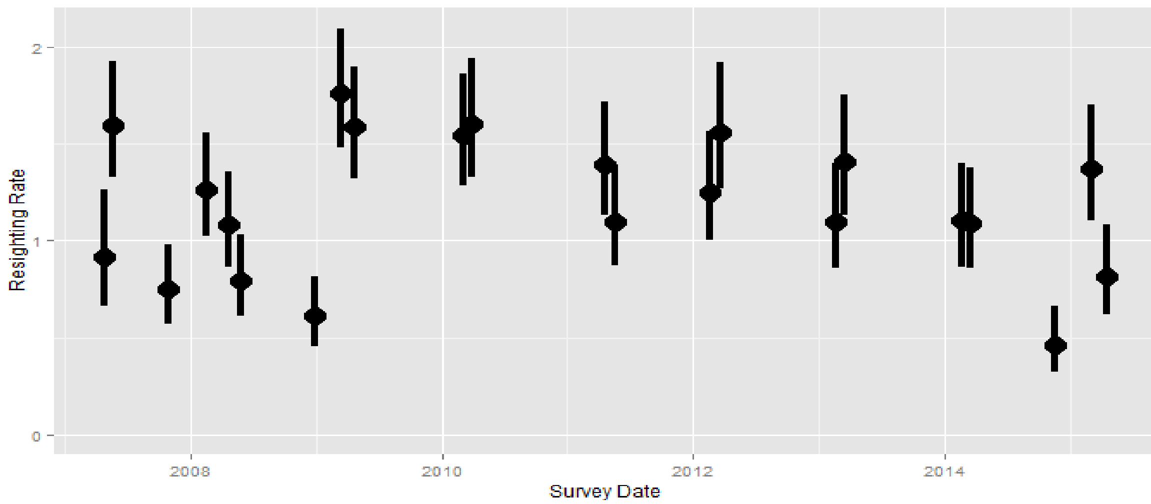

Figure 3: Estimated average resighting rate and 95% Confidence Interval (points).

The population was estimated at **80 individuals in April 2015, with a 95% confidence interval of 64-100 individuals** (fig 4). The population growth rate was estimated at 0.984, suggesting an average annual decline of 1.6% per year since 2007. Survival was estimated at 0.976, with a 95% confidence interval of 0.901-0.995, and seniority—the probability that an animal present in a given year was present in the previous year - at 0.991 (95% CI 0.917-0.999). The probability of transitioning to an observable state, given a marked individual was unobservable (Y') was 0.939 (95%CI 0.835-0.979) and the probability of marked individuals transitioning to an unobservable state between primary survey periods (Y") was 0.025 (95% CI 0.013-0.046). Recruitment was estimated at 0.008, or around 0.8% per year. The apparent survival, recruitment and population growth rate apply only to marked individuals.

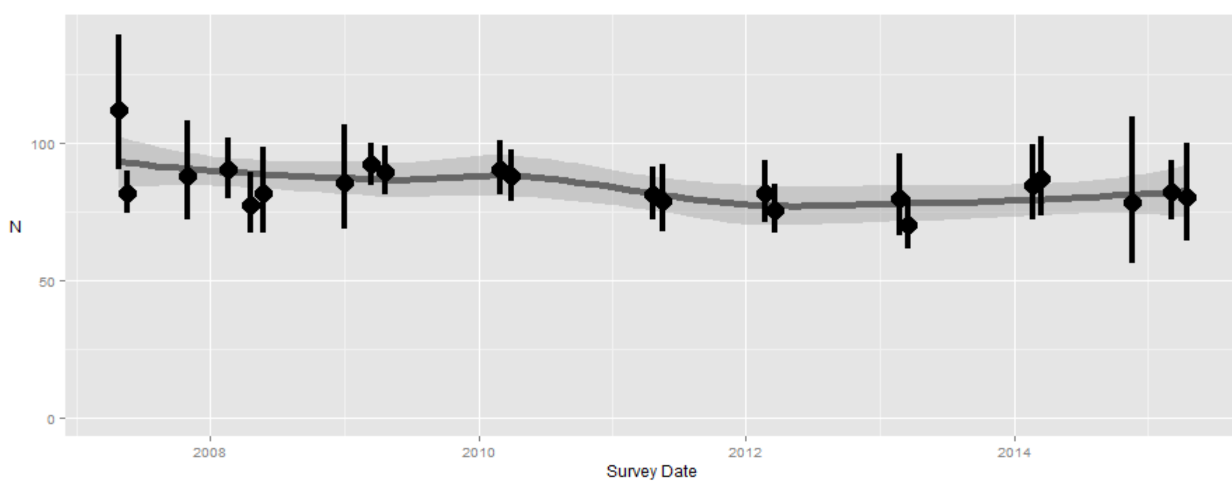

Figure 4: Estimated population size and 95% Confidence Interval (points), with smoothed population mean and confidence interval (ribbon).

Estimates of the number of unmarked individuals in the population ranged from 2.4 in late 2008 to 16.8 in early 2013. The number of unmarked individuals estimate was < 10 individuals from 2007 to 2012, and highest estimated number of unmarked individuals was >10 from 2013 to 2015 (fig 5).

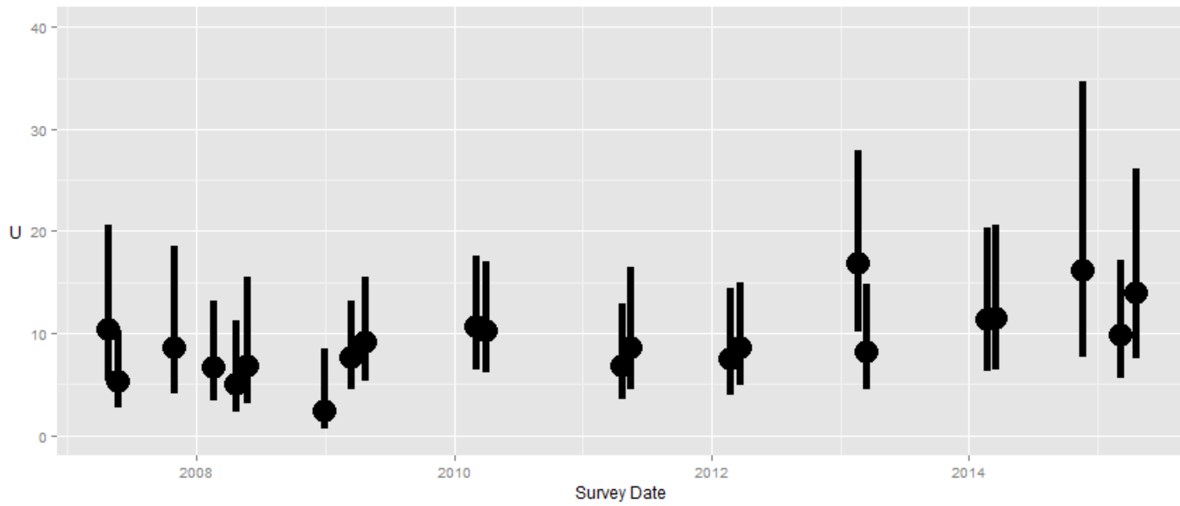

Figure 5: estimated number of unmarked individuals in the population with a 95% Confidence Interval (points).

DISCUSSION AND CONCLUSION

The best population estimate for Mekong dolphin in 2015 at 80 is individuals which includes both marked and unmarked animals. The mean population estimates since 2007 vary between 70 individuals (2013) and 92 individuals (2009) but overlapping confidence intervals make interpreting trends difficult. However for the first 5-10 years of 21st century there is clear evidence of population decline. Between 2004 and 2007 Beasley estimated annual decline at 7% (Beasely *et al.* 2012). Since then the rate of population decline has slowed with our current estimate of 1.6% per year compared with 2.2% based on analysis of data between 2007 and 2010 (Ryan *et al.* 2011).

Additional signs of encouragement are from the increasing modeled estimates of numbers of unmarked dolphins; these are presumably young individuals in the population. Moreover a modeled estimate of recruitment is 0.8% per year. This was previously estimated as zero (Ryan *et al.* 2011). We thus now have evidence of limited recruitment. This recruitment has occurred in recent years where several new marked individuals have been recorded whilst the number of unmarked individuals is on average higher than previous estimated.

These results match well with the previous work of Ryan and colleagues (Ryan *et al.* 2011) as well they should; they are based on the same data set, albeit with a small number of minor corrections. The transition rates are into and out-of an unobservable state were very close to zero as likely to move into an observable state as move out. This result is consistent with previous estimate and suggests that survey area is complete representation of the Mekong dolphin's dry season range in the Mekong River, and that minor side channels probably do not represent important habitat. In this case, we can conclude from these estimates that the surveys do capture the entire the Mekong dolphin's range. The high probability of staying unobservable once an individual dolphin becomes unobservable might indicate that some dolphins are especially boat shy or cryptic (Ryan *et al.* 2011).

Unmarked animals are likely to be largely made up of younger individuals that are yet to accrue marking on their fins. This is corroborated by observations in the field of young unmarked individuals appearing in the same locations over serval years. Previously, Ryan and colleagues (2011) excluded very young calves from analyses, and older individuals were included in analysis. This was because it was suggested that young animals may be boat-shy, and therefore have a different resighting probability from marked individuals. Ryan (2013) reconsidered that the differentiation between age classes is likely to be highly arbitrary and non-repeatable, and the assumption that newborn individuals, such as those within e.g. one month of birth, may well have a lower resighting probability than marked adults. More extensive experience in the field, and reviewing of photographs suggests that even fairly young individuals probably have a similar resighting rate as marked individuals. Therefore all unmarked encounters were included in this analysis.

Resighting rates were variable, but notably higher in 2009 to the first of 2015 surveys. We believe that the use of two photographers since 2009, and significantly improved equipment in 2009 probably accounted for much of this variation. We also note that our modeling assumes that marked and unmarked animals have similar sighting probabilities. We believe we met this assumption well as photographs were not taken in relation to whether an individual was marked or not. In fact, taking photos was a fast reactive activity in which individual identifiers were only noted after examining the photos. Further, photographs of young calves, which may differ in sight ability from older animals, were excluded from the analyses.

In conclusion, we have clear evidence of an increase in unmarked individuals which are likely largely made up of younger dolphins. However whilst there is clear evidence of the continued decline of the population of dolphin hope of recovery remains: recruitment is evident. If mortality rate can be arrested, the population will stabilize and recover in the long term.

Recommendations

- Given current mortality levels, it is critically to maintain and improve the current improved levels of law enforcement and awareness outreach.
- Continue robust monitoring of the Mekong river dolphin population as it is as one of the longest running fresh water monitoring programs for river dolphins and it is providing critical data for monitoring management effectiveness.
- Through estimating seniority, survivorship and recruitment capture mark-resighting analysis can identify demographic factor of driving on population changed.

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APPENDICES

Table A: The number of individuals with a 95% confidence interval which estimated from each survey date.

Survey Year	N	95%confidence Interval	
		Lower	Upper
26-Apr-2007	112	90	140
21-May-2007	82	75	90
29-Oct-2007	88	72	108
18-Feb-2008	90	80	102
21-Apr-2008	78	67	89
25-May-2008	82	67	99
30-Dec-2008	86	69	107
13-Mar-2009	92	85	100
21-Apr-2009	90	81	99
2-Mar-2010	91	81	101
31-Mar-2010	88	79	98
21-Apr-2011	81	72	91
17-May-2011	79	68	92
21-Feb-2012	82	71	94
21-Mar-2012	76	67	85
21-Feb-2013	80	66	96
16-Mar-2013	70	62	80
20-Feb-2014	85	72	100
17-Mar-2014	87	74	102
19-Nov-2014	78	56	110
5-Mar-2015	82	72	94
18-Apr-2015	80	64	100

Table B: The number of unmarked individuals with a 95% confidence interval which estimated from each survey date.

Year	Number Unmarked	95%confidence Interval	
		Lower	Upper
26-Apr-2007	10.42	5.28	20.57
21-May-2007	5.32	2.75	10.31
29-Oct-2007	8.67	4.05	18.56
18-Feb-2008	6.73	3.46	13.11
21-Apr-2008	5.06	2.27	11.26
25-May-2008	6.90	3.07	15.50
30-Dec-2008	2.41	0.68	8.48
13-Mar-2009	7.67	4.47	13.18
21-Apr-2009	9.15	5.40	15.51
2-Mar-2010	10.66	6.45	17.62
31-Mar-2010	10.28	6.21	17.00
21-Apr-2011	6.81	3.60	12.88
17-May-2011	8.64	4.53	16.48
21-Feb-2012	7.59	4.00	14.43
21-Mar-2012	8.65	4.98	15.01
21-Feb-2013	16.87	10.19	27.95
16-Mar-2013	8.16	4.51	14.76
20-Feb-2014	11.34	6.34	20.30
17-Mar-2014	11.50	6.43	20.56
19-Nov-2014	16.26	7.63	34.65
5-Mar-2015	9.84	5.65	17.15
18-Apr-2015	14.07	7.59	26.07

Table C: The average of resighting rate over all surveys period with a 95% confidence interval which estimated from each survey date.

Year	Mean Resighting	95%confidence Interval	
		Lower	Upper
26-Apr-07	0.912	0.660	1.262
21-May-07	1.598	1.326	1.926
29-Oct-07	0.750	0.572	0.983
18-Feb-08	1.264	1.026	1.557
21-Apr-08	1.085	0.866	1.360
25-May-08	0.796	0.613	1.033
30-Dec-08	0.609	0.453	0.818
13-Mar-09	1.760	1.481	2.092
21-Apr-09	1.586	1.322	1.902
2-Mar-10	1.548	1.285	1.866
31-Mar-10	1.606	1.329	1.940
21-Apr-11	1.396	1.134	1.719
17-May-11	1.100	0.870	1.391
21-Feb-12	1.252	1.001	1.567
21-Mar-12	1.562	1.272	1.918
21-Feb-13	1.097	0.857	1.403
16-Mar-13	1.411	1.133	1.756
20-Feb-14	1.103	0.867	1.402
17-Mar-14	1.088	0.857	1.382
19-Nov-14	0.462	0.320	0.665
5-Mar-15	1.372	1.106	1.703
18-Apr-15	0.818	0.617	1.084

Data sheet 1: Event and environmental conditions coding

EVENTS		បើក
S	Start effort	ចាប់ផ្តើម
E	End effort	បញ្ចប់
D	30 minutes of regular survey	៣០នាទីនៃការអង្កេតទៀងទាត់
O	Dolphin observation	ការសង្កេតផ្សោត
STATE OF THE RIVER		**សភាពទន្លេ**
1	Calm	ស្ងប់
2	Moderate / Ripples	រលកតិច
3	Wavy	រលកខ្លាំង
SIGHTABILITY		**កម្រិតឃើញ**
1	Excellent / very good	ល្អណាស់
2	Good	ល្អ
3	Fair	មធ្យម
4	Poor	មិនច្បាស់
5	Very bad	មិនច្បាស់សោះ
GLARE		**ចំណាំងពន្លឺ**
0	No glare	គ្មាន
1	Some glare	តិចតួច
2	Moderate	មធ្យម
3	Severe glare	ខ្លាំង
DOLPHIN ACTIVITY		**សកម្មភាពផ្សោត**
1	Feeding	ចាប់ចំណី
2	Travelling	ធ្វើដំណើរ
3	Mating / sexual	បង្កាត់ពូជ
4	Playing / social	ហែលលេង
5	Spitting	ផ្លុំទឹក
6	Milling	ហែលត្រឡប់ខ្លួន
7	Not defined	មិនកំណត់បាន
DOLPHIN LOCATION		**ទីតាំងឃើញផ្សោត**
1	close to shore	ក្បែរច្រាំង
2	middle of river	កណ្តាលទន្លេ
3	near boat	ជិតទូក
ENGINE SPEED		**ល្បឿនម៉ាស៊ីន**
0	OFF	ពន្លត់
1	< 5 km/h	< 5 គ.ម/ម៉
2	> 5 km/h	> 5 គ.ម/ម៉

BANK TYPE		ប្រភេទច្រាំង
1	Steep bank - degraded/cleare	ច្រាំងរិចរិល ឬវាល (កាប់ព្រៃអស់)
2	Steep bank - vegetated	ច្រាំងមានរុក្ខជាតិ
3	Sand	ខ្សាច់
4	Flooded Forest	ព្រៃលិចទឹក
5	Rock - with low vegetation	ថ្ម និងរុក្ខជាតិតូចៗ

STRATUM CODE		
I	Main River	ទន្លេមេ
II	Pool	អន្លង់
III	Tributary	ដៃទន្លេ
IV	Narrow channel	ព្រែកតូចៗ
V	Island	កោះ
STRATUM NO.		
Pools		**អន្លង់**
1	Kampi & Chroy Banteay	កាំពី និង ជ្រោយបន្ទាយ
2	South of Koh Rongeav	កន្ទុយកោះរងាវ
3	Koh Pdao	កោះផ្ដៅ
4	Khsach Makak & Sampan	ខ្សាច់ម្កាក់ និង សំប៉ាន
5	Koh Dambong	កោះដំបង
6	Tbong Klah	ត្បូងខ្លា
7	Koh Konsat	កោះកូនសត្វ
8	Koh Santuk	កោះសន្ទុក
9	Cheuteal	ឈើទាល
River		**ទន្លេ**
A	South of Kampi	ខាងត្បូងកាំពី
B	Kampi > S. of Koh Rongeav	កាំពី > កន្ទុយកោះរងាវ
C	S. of Koh Rongeav > Koh Pdao	កន្ទុយកោះរងាវ > កោះផ្ដៅ
D	Koh Pdao > Ksach Makak	កោះផ្ដៅ > ខ្សាច់ម្កាក់
E	Ksach Makak > Koh Dambong	ខ្សាច់ម្កាក់ > កោះដំបង
F	Koh Dambong > Tbong Klah	កោះដំបង > ត្បូងខ្លា
G	Tbong Klah > Koh Konsat	ត្បូងខ្លា > កោះកូនសត្វ
H	Koh Konsat > Koh Santuk	កោះកូនសត្វ > កោះសន្ទុក
I	Koh Santuk > Cheuteal	កោះសន្ទុក > ឈើទាល
J	Cheuteal > Kong Falls	ឈើទាល > ល្បាក់ខោន

HABITAT AND ENVIRONMENTAL DATA ទិន្នន័យបរិស្ថាន និងទីជម្រក
Channel Width: record actual width if <1000 m or >1000 m ទទឹងទន្លេ៖ កត់ត្រាប្រវែងទទឹងជាក់ស្តែងប្រសិនបើ <1000 m ឬ >1000 m
Depth: record actual depth ជម្រៅ៖ កត់ត្រាជម្រៅជាក់ស្តែង
Near confluence: record actual distance if <1000 m, or - if not នៅជិតចំណុចប្រសព្វ៖ កត់ត្រាចម្ងាយជាក់ស្តែងបើ <1000 m ឬ សញ្ញា - បើអត់នៅជិត
Near island: record actual distance if <1000 m, or - if not នៅជិតកោះ៖ កត់ត្រាចម្ងាយជាក់ស្តែងបើ <1000 m ឬ សញ្ញា - បើអត់នៅជិត
Eddies? (Y/N): If visible on water surface when standing record Y, if not N ទឹកវិល៖ បើអាចមើលឃើញនៅពេលឈរ ចូរកត់ Y ។ បើអត់ ចូរកត់ N
Disturbance: If agriculture on or near bank or boats nearby, Y, otherwise N ការរំខាន៖ បើមានសកម្មភាពកសិកម្មលើ ឬជិតច្រាំង ឬមានទូកនៅក្បែរ ចូរកត់ Y ។ បើអត់ ចូរកត់ N

Why stop set: 1 - Photographed all dolphins; **2** - lost dolpins; **3** - bad light; **4** - rain; **5** - stopped by authorities; **6** - other (please write in notes)
បញ្ចប់ព្រោះ៖ **1** - ថតរូបបានគ្រប់ផ្សោតទាំងអស់ **2** - លែងឃើញផ្សោត **3** - ពន្លឺមិនល្អ **4** - ភ្លៀង **5** - អាជ្ញាធរបញ្ឈប់ **6** - ផ្សេងៗ (សូមសរសេរក្នុងកំណត់សម្គាល់)

Data sheet 2: Event, habitat every 30 minutes and dolphin sighting record

តារាងទិន្នន័យចំនួនផ្សោតសរុប និងទីជម្រក
Abundance and Habitat Datasheet

Name(ឈ្មោះ):_______________ Capture/Recapture

កាលបរិច្ឆេទ Date	ម៉ោង Time	Event	Set No.	Stratum		GPS		Direct Count			Composition			Dolphin Activity	Dolphin Location	Speed	River State	Glare	Sightability	Depth	Channel width	Near confluence	Near Island	Eddies? (Y/N)	Disturbance	Bank type	Notes
				Code	No	48P	UTM	L	B	H	A	J	C														
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Data sheet 3: Summary survey effort and number photos taken for secondary survey period

Photo ID—Survey Summary Sheet

តារាងសង្ខេបនៃការអង្កេតអត្តសញ្ញាណរូបថត

អ្នកកត់ត្រា Recorder

អ្នកចូលរួមអង្កេត Survey participants	ចំនួនថ្ងៃ Days surveyed

កម្ពស់ទឹក Water Levels	ក្រចេះ Kratie	ស្ទឹងត្រែង Stung Treng
ចាប់ផ្តើម Start		
បញ្ចប់ Finish		

	កាលបរិច្ឆេទ Dates	ចំនួនថ្ងៃ Days	ចំនួនរូបថត Photos Taken	រយៈពេលអង្កេត Survey Time	ចម្ងាយ Distance Travelled	ចំនួនផ្សោតឃើញ Dolphins seen	ចំនួនកូនផ្សោតឃើញ Calves Seen	ចំនួនផ្សោតជំទង់ឃើញ Juveniles Seen	ចំនួនក្រុម Sets
Capture									
Recapture									
សរុប Total									

សម្គាល់ Notes

Data sheet 4: Daily summary events of survey effort

Photo ID—Daily Summary Sheet
តារាងសង្ខេបនៃការអង្កេតអត្តសញ្ញាណរូបថតប្រចាំថ្ងៃ

អ្នកកត់ត្រា Recorder:	អ្នកចូលរួម Participants:

កាលបរិច្ឆេទ Date	ថ្ងៃ Survey Day	ឡើង/ចុះ Capture/ recapture	ម៉ោងចាប់ផ្តើម Start time	បាយថ្ងៃត្រង់ ចាប់ផ្តើម Lunch start:	បាយថ្ងៃត្រង់ បញ្ចប់ Lunch finish:	សម្រាកផ្សេងៗ (រយៈពេលសរុប) Other breaks (total time)	ម៉ោងបញ្ចប់ Finish time	រយៈពេលសរុប total survey time	លេខអន្លង់/ ទន្លេ River sections surveyed	ចំនួនរូបថត No. Photos Taken	ចំនួនក្រុម ផ្សោត Set Nos.	ចម្ងាយ Distance travelled

ទីតាំងចាប់ផ្តើម (ឈ្មោះភូមិ) Start location (village name)	ទីតាំងបញ្ចប់ (ឈ្មោះភូមិ) Finish location (village name)	ចាប់ផ្តើម Start 48P	ចាប់ផ្តើម Start UTM	បញ្ចប់ Finish 48P	បញ្ចប់ Finish UTM	ចំនួនផ្សោតឃើញ No. dolphins seen	កំណត់សម្គាល់ធាតុអាកាស Weather notes

កំណត់សម្គាល់ប្រចាំថ្ងៃ Day notes:

អ្នកកត់ត្រា Recorder:	អ្នកចូលរួម Participants:

កាលបរិច្ឆេទ Date	ថ្ងៃ Survey Day	ឡើង/ចុះ Capture/ recapture	ម៉ោងចាប់ផ្តើម Start time	បាយថ្ងៃត្រង់ ចាប់ផ្តើម Lunch start:	បាយថ្ងៃត្រង់ បញ្ចប់ Lunch finish:	សម្រាកផ្សេងៗ (រយៈពេលសរុប) Other breaks (total time)	ម៉ោងបញ្ចប់ Finish time	រយៈពេលសរុប total survey time	លេខអន្លង់/ ទន្លេ River sections surveyed	ចំនួនរូបថត No. Photos Taken	ចំនួនក្រុម ផ្សោត Set Nos.	ចម្ងាយ Distance travelled

ទីតាំងចាប់ផ្តើម (ឈ្មោះភូមិ) Start location (village name)	ទីតាំងបញ្ចប់ (ឈ្មោះភូមិ) Finish location (village name)	ចាប់ផ្តើម Start 48P	ចាប់ផ្តើម Start UTM	បញ្ចប់ Finish 48P	បញ្ចប់ Finish UTM	ចំនួនផ្សោតឃើញ No. dolphins seen	កំណត់សម្គាល់ធាតុអាកាស Weather notes

កំណត់សម្គាល់ប្រចាំថ្ងៃ Day notes:

Data sheet 5: Photo identification sighting record

Photo ID Datasheet
តារាងទិន្នន័យអត្តសញ្ញាណរូបថត

កាលបរិច្ឆេទ Date	លេខក្រុមផ្សោត Set No.	អ្នកកត់ត្រា Recorder	ឡើង/ចុះ Cap/Recap	ម៉ោងចាប់ផ្តើម Start Time	បញ្ចប់ End	មូលហេតុបញ្ចប់ Why finished set?	លេខកូដ Stratum Code	លេខកូដទន្លេ Stratum No	៤៨ភី Lat. 48P	យូធីអឹម Long. UTM	ចំនួនផ្សោតល្អបំផុត No. dolphins best	ចំនួនកូនផ្សោត No. calves	ចំនួនផ្សោតជំទង់ No. Juveniles	ចំនួនផ្សោតទាបបំផុត No. dolphins low	ចំនួនផ្សោតខ្ពស់បំផុត No. dolphins high

ម៉ាស៊ីនថតរូប	លេខម៉ាស៊ីនថតរូប	រូបថតដំបូង 1st photo	រូបថតចុងក្រោយ Last photo	អ្នកថត Who?	រូបថតដំបូង (ទី២) 1st photo (2nd)	រូបថតចុងក្រោយ (ទី២) Last photo (2nd)	អ្នកថត (ទី២) Who? (2nd)	រូបថតដំបូង (ទី៣)1st photo (3rd)	រូបថតចុងក្រោយ (ទី៣) Last photo (3rd)	អ្នកថត (ទី៣) Who? (3rd)	រូបថតសរុប Total photos
Camera	50D										
Camera	450D										
Camera	60D										
Camera											

សត្វផ្សោតដែលបានឃើញ Known dolphins seen/shapes	កំណត់សម្គាល់ Set notes:

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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