The following supplements accompany the article

Long-term trends in habitat use and site fidelity by Australian humpback dolphins *Sousa sahulensis* in a near-urban embayment

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Supplement 1: compilation of historical sightings data

Spatially-referenced sightings of humpback dolphins were sourced from scientific publications, reports, PhD theses and Queensland Government datasets for the period from January 1977 to December 2016. Over this 40-year time period, four major systematic vessel-based surveys of dolphins have been undertaken in Moreton Bay. The first was the study by Corkeron (1989) from 1984 to 1987; the second was by Hale *et al.* (1998) in 1996, the third was by Ansmann (2013) from 2008 to 2010 and the fourth from 2014 to 2016 as described herein. Locations of humpback dolphin groups in Moreton Bay have also been recorded in two aerial surveys, the first in 1977 (Lear & Bryden 1980) and the second in 1995 (Lanyon & Morrice 1997). Locations of humpback dolphins from the Corkeron (1989) study were taken from WildNet (the Queensland Government wildlife database); locations from the Hale (1998), Lear and Bryden (1980) and Lanyon and Morrice (1997) were taken from published maps that were scanned, orthorectified and digitised. The vessel surveys of Ansmann (2013) are described in detail in Ansmann et al. (2013).

The first step was to select the area where most survey effort was undertaken using a bounding box (4,877 km^2) and to exclude sightings outside of this area (Fig. S1). We then assessed whether the spatial coverage was comparable between the vessel-based surveys. For surveys undertaken before 2007, vessel GPS tracks were not available and the search area was instead estimated using an approach based on target-group sampling (Phillips et al. 2009). The area surveyed was estimated by a minimum convex polygon (constrained by land areas) fitted to the combined distribution of humpback dolphins and a more abundant species reported using the same survey methodology (Indo-Pacific bottlenose dolphins, *Tursiops aduncus*) (Figs. S2 and S3). For surveys after 2007, vessel GPS tracks were compared (Figs. S4 and S5).

This analysis indicated that the 1984-87 survey (Corkeron 1989; Corkeron 1990) had insufficient coverage of the western and southern sections of Moreton Bay compared to the latter surveys. Similarly, the flight paths of the 1977 aerial surveys (Lear & Bryden 1980) did not cover the western areas of Moreton Bay. We therefore excluded the 1977 to 1987 time period from further analyses.

Finally, we selected three time periods that were considered to have comparable spatial-temporal coverage: Period 1 (1992-99, total number of sightings, *n,* = 167), Period 2 (2003-11, *n* = 114) and Period 3 (2012-16, *n* = 234).

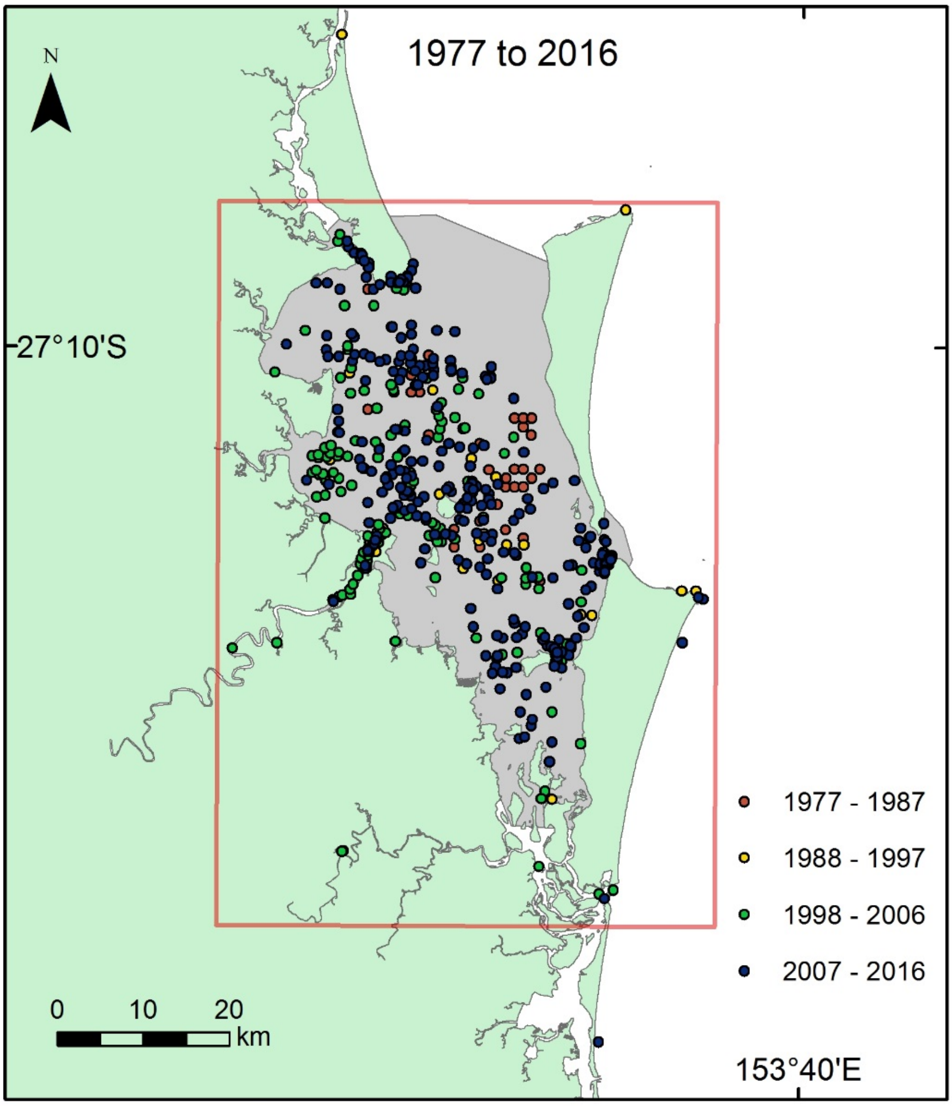

Fig. S1. Sightings of Australian humpback dolphins across all time periods. We first excluded sightings outside of the red box, we then removed sightings earlier than 1988 (red circles). The grey area represents the sightings used for the ecological niche models and defines the background extent for the pseudo-absences.

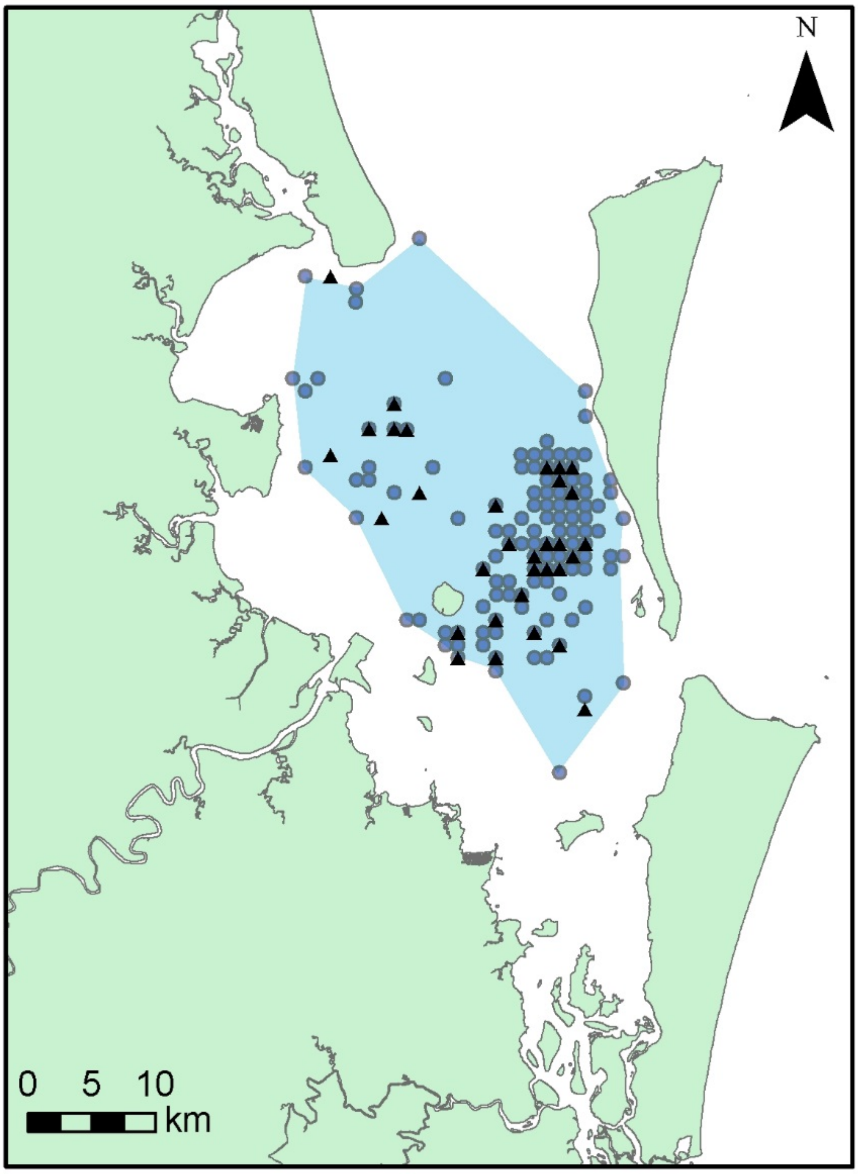

Fig. S2. The 1984-87 vessel-based surveys (86 survey days, Corkeron 1989), showing locations of groups of humpback dolphins (triangles) and bottlenose dolphins (circles). The blue polygon denotes the assumed sampling area based on a minimum convex polygon constrained by land areas. Note that because sightings were recorded within a 1 km^2 grid, the geographic centre of each grid cell was used as the location for a given sighting.

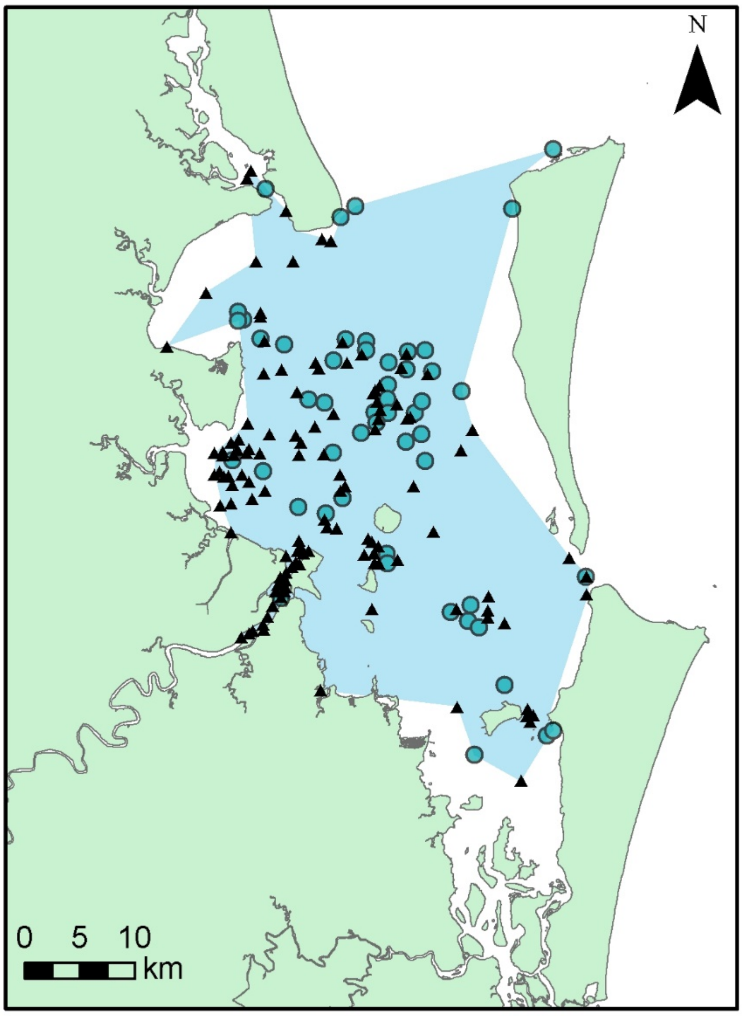

Fig. S3. The 1996 vessel-based survey (51 survey days, Hale et al. 1998), showing locations of groups of humpback dolphins (triangles) and bottlenose dolphins (circles). The blue polygon denotes the assumed sampling area based on a minimum convex polygon constrained by land areas. This survey was included in Period 1 (1992-99).

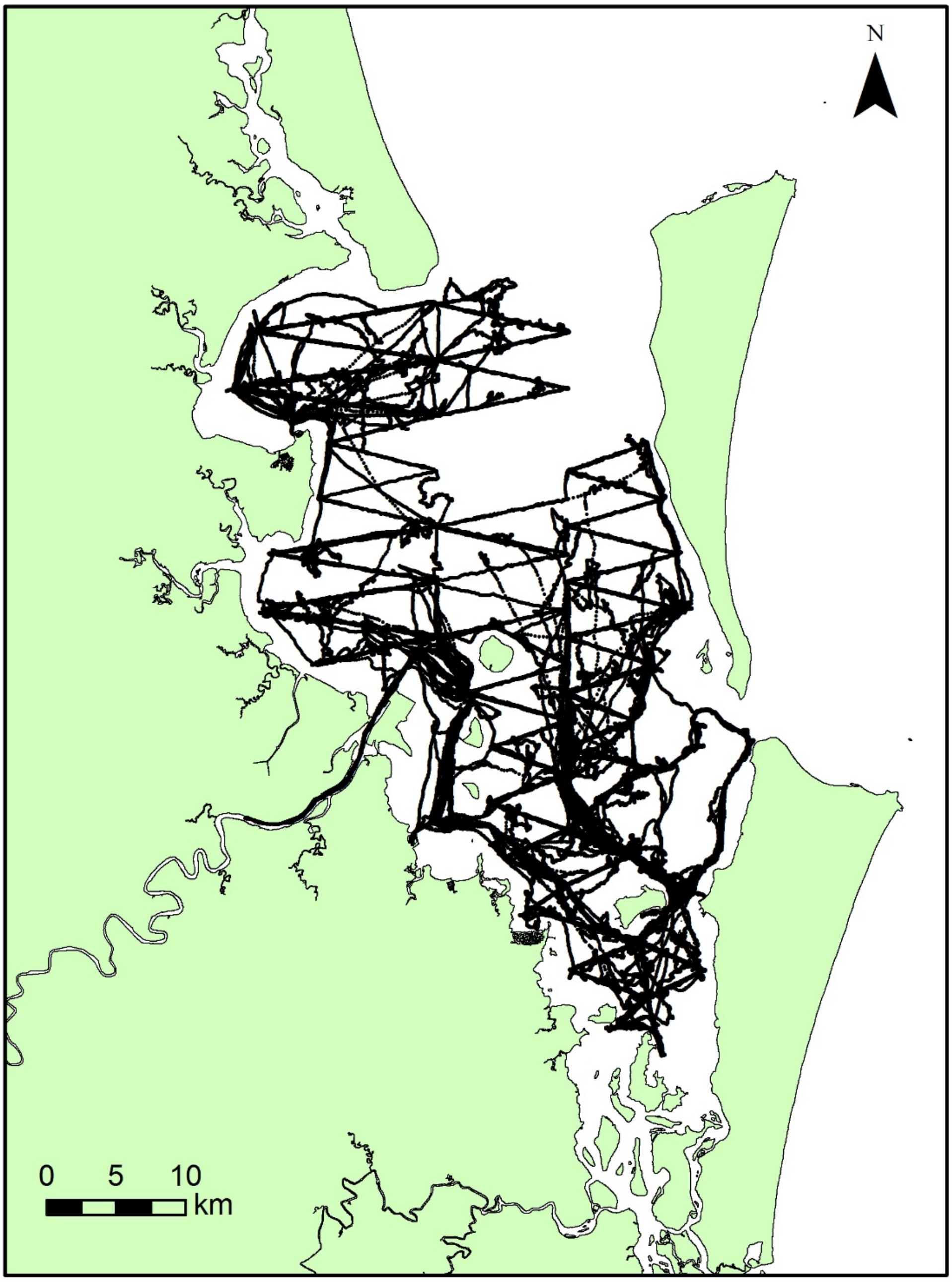

Fig. S4. The vessel-based surveys undertaken from July 2008 to March 2010 (86 survey days, Ansmann et al. 2013). This survey was included in Period 2 (2003-11).

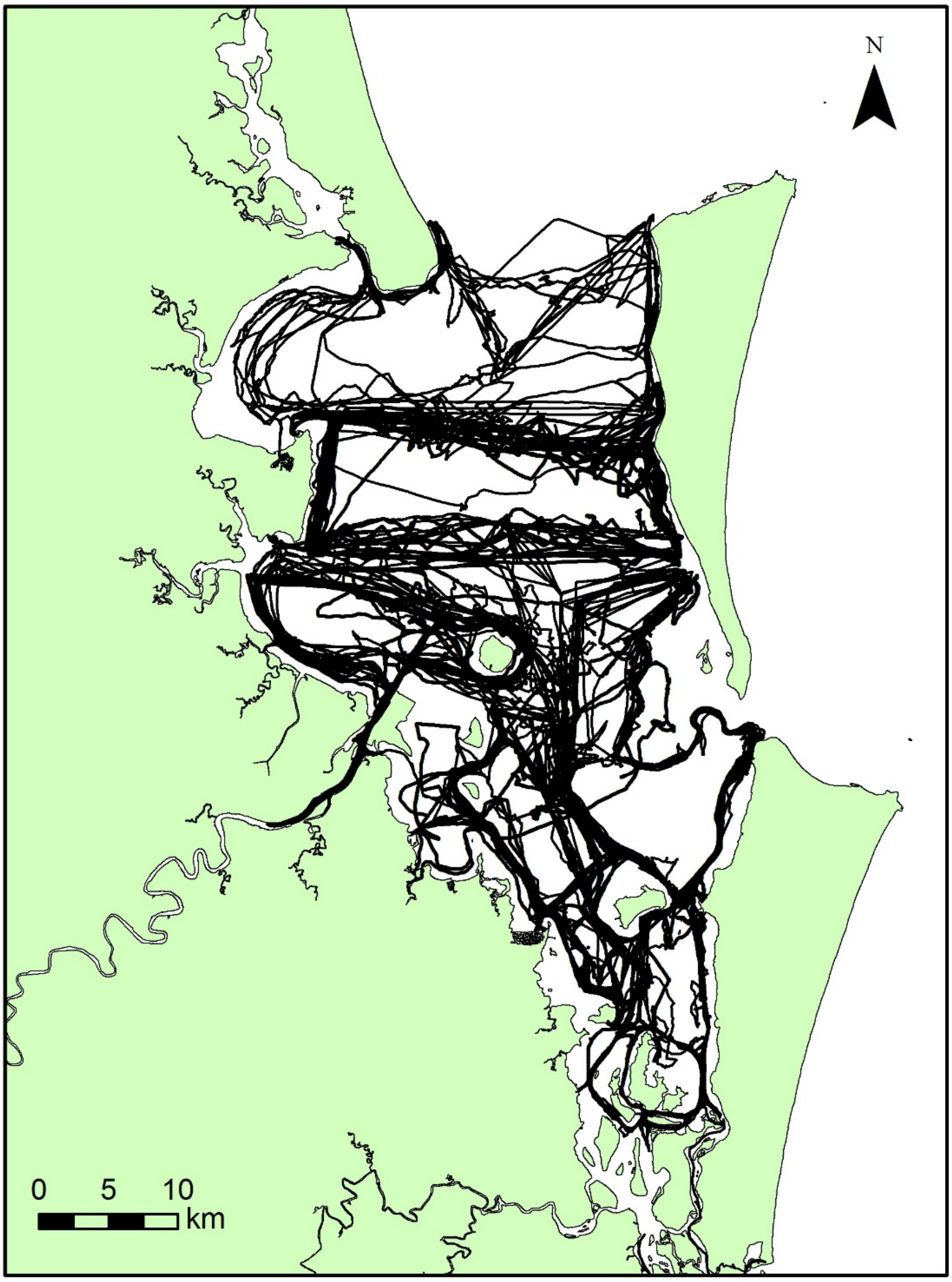

Fig. S5. The vessel-based surveys from July 2014 to August 2016 (127 survey days). This map underestimates actual coverage because vessel GPS plotters were not available to map vessel transit paths on all surveys. This survey was included in Period 3 (2012-16).

Supplement 2: selection, validation and tuning of Environmental Niche Models

The ENMeval routine in R was used to select and tune (i.e. balance goodness of fit with model complexity) MaxEnt models (Muscarella et al. 2014), based on random *k* folds cross validation. Candidate model sets included linear (L), quadratic (Q), hinge (H), product (P) and threshold (T) features, and regularisation coefficients (RC) in increments of 0.5 from 0.5 to 4. Because this method was based on minimising AICc (Akaike's lnformation criterion with small sample correction) we used standard information theoretic approaches when more than one model was within the 95% confidence intervals of the candidate model set (following Burnham & Anderson 2002). We also visually compared the predicted surface of the models against the observed sightings, and calculated measures of goodness of fit (mean area under receiver operating curve, AUC) and overfitting (minimum training presence omission rate, OR^{min}).

For Period 1, the best model had LQHP features and a RC of 3 (AIC weight of evidence, w_i = 0.507), although a RC of 3.5 also had some support (w_i = 0.318) (Table S1). However, because predictor variables had a similar ranking of importance and a similar influence on predictions in each model (Table S1), we used the model with the lowest AICc value.

For Period 2, 8 models were included in the 95% confidence interval set, two models with LQH features and 6 models with LQ features. Relative w_i for LQ features (sum w_i = 0.721) was much higher than for models with LQH features (sum w_i = 0.276). RC values in the 95% confidence interval set ranged from 0.5 to 4, and examination of fitted models indicated that the 'distance from shore' variable was the most influenced by the choice of RC. We therefore estimated RC from the 95% confidence interval set using model averaging (1.6, following Burnham & Anderson 2002), and used LQ features in the final model.

For Period 3, the model with the highest w_i (0.959) included LQHPT features. A visual examination of the predicted surface against the observed sightings indicated an abrupt and unrealistic prediction gradient on the north-western side of Moreton Bay (Fig. S6). This was because of the threshold feature for 'distance from inshore reefs'. Threshold features allow a 'step' in the fitted function (Elith et al. 2011). We therefore excluded threshold features from the candidate model set. The contribution of predictor variables was similar in both models (Table S1).

Table S1. Selection criteria for MaxEnt models. The value given for each predictor variable is the permutation importance (as a regularised percentage), with bold text highlighting the most important variable. AUC: area under curve based of the receiver operating characteristic plot based on the test data (higher values indicated better fit). The minimum training presence omission rate (OR^{min}) is a measure of overfitting relative to the expectation of zero (no overfitting, Muscarella et al. 2014). [A] model used for predictions.

Model fit/variable	Period 1		Period 2		Period 3	
	Model 1[A]	Model 2	Model 1	Model 2 (model averaged)[A]	Model 1	Model 2[A]
Weight of evidence (w_i)	0.507	0.318	0.163	-	0.960	0.954
Mean AUC	0.764	0.763	0.768	0.803	0.804	0.797
Mean OR^{min}	0	0	0.02	0	0.018	0.009
Regularisation parameter	3	3.5	4	1.6	4	3.5
Features	LQHP	LQHP	LQ	LQ	LQHPT	LQHP
Distance from rivers	**20.5**	**27.4**	4.9	2.6	8.5	4.8
Depth	20.1	21.2	21.8	26	12.6	13.3
Distance from inshore reef	19	15.7	**36.3**	**43.9**	22.6	20.2
Distance from 10 m depth contour	14.5	14.8	5.3	1.2	**29.7**	**32.4**
Bathymetric slope	6	3.7	14.9	5.4	2.9	3
Distance from shore	8	9.5	8.7	18.4	14.6	15.3
Distance from mangroves	11.9	7.7	0	2.5	9	11.1

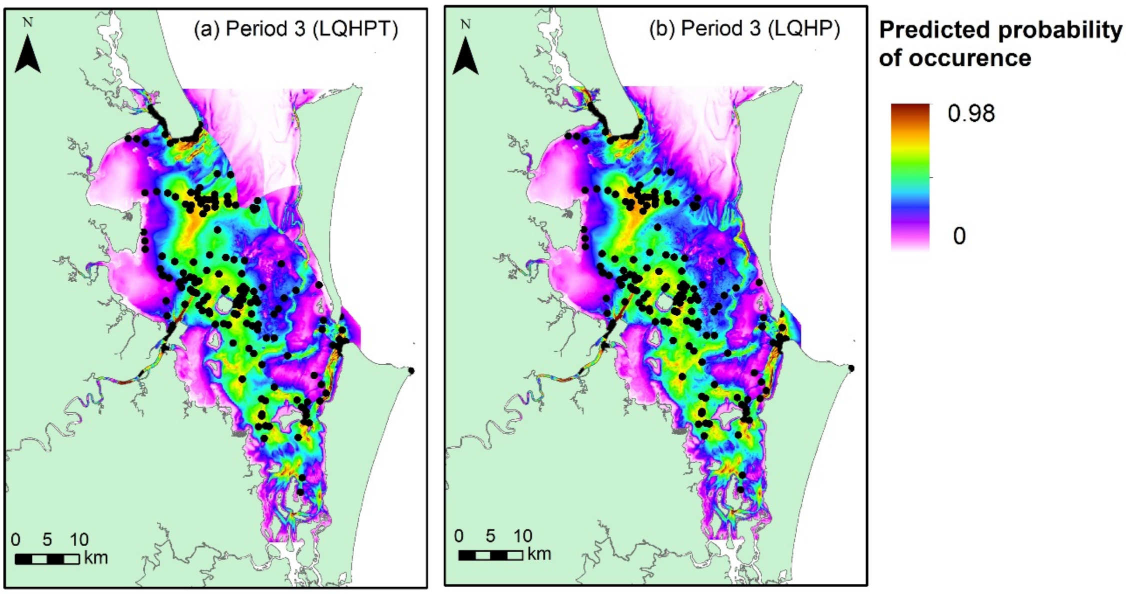

Fig. S6. Fit of ENMs to Period 3 (2012-16), where the black circles are the sightings data. (a) with threshold features and (b) without threshold features. Although model (a) had by far the greatest support from the ENM model selection criteria ($w_i = 0.959$, AIC = 4987) compared to model (b) ($w_i < 0.01$, AIC = 5020), the steep transition in predicted occurrence probabilities on the upper right of panel (a) was not considered very realistic for a highly mobile species that can range over a large area. We therefore used model (b) for Period 3.

Supplement 3: definitions of behavioural states

Table S2. Definition of behavioural states observed during vessel-based group focal follows (2014-16). 'Behavioural state' represented the predominant behavioural pattern of the focal dolphin(s) over the observational period, i.e. > 50% of the dolphins exhibited the behaviour for >50% of the observational period. This was determined by 'scan sampling' or a rapid census of the behaviour of all individuals at 2 minute intervals during the focal follow (Altmann 1974). Here we analysed only the initial location of the group and the behavioural state first exhibited by the group.

Behavioural state	**Description**
Travelling	Dolphin(s) moves in a consistent direction with regular surfacing intervals. Typically with consistent breathing pattern and dive times.
Socialising	Two or more dolphins are clearly interacting with each other by direct physical contact such as body rolls, petting and tail slapping. Frequent splashes and disturbance at the surface.
Resting	Group frequently changes travel direction (no consistent travel direction). Individuals may surface facing different directions. Dolphins have slow movements with variable, but frequent, dive intervals and often remain floating at the surface for a short amount of time between dives. This behaviour also including milling.
Foraging	Dolphins are actively pursuing prey and/or feeding (often confirmed by visual observation of fish or prey item). Usually associated with deep diving (fluke-up dives), fast swims or porpoising, frequent changes in travel direction and inconsistent inter-breath intervals. Group may be in a circular formation, spread over a wide area and individuals surface facing different directions. This also includes dolphins that are foraging whilst travelling in a consistent direction, which is often characterised by long submergence and bottom feeding.

Supplement 4: water quality monitoring in Moreton Bay from 2000 to 2016

Table S3. Historical environmental condition grades from the Ecosystem Health Monitoring Program (http://hlw.org.au, accessed 23/03/17). Grades are derived from water quality and ecological indicators that include water clarity, nutrient loads, chlorophyll a, dissolved oxygen and seagrass depth range. Grades are reported as (A) Excellent: critical habitats are in near pristine condition; (B) Good: most critical habitats are intact; (C) Fair: critical habitats are impacted; (D) Poor: most critical habitats are impacted and (F) Fail: most critical habitats are severely impacted.

Year	**Brisbane Estuary**	**Western Bay**			**Central Bay**	**Eastern Bay**	**Southern Bay**
		Bramble Bay	**Deception Bay**	**Overall**			
2000*	D	F	D to D-	-	B	B-	C-
2001	D-	F	D to D-	-	B	A-	C-
2002	D-	D	C-	-	A-	A	C+
2003	D-	D	C+	-	A-	A	C+
2004	D-	D	C+	-	A-	A	C+
2005	D-	D+	D+	-	B	A	D+
2006	D-	D+	C-	-	C-	A	D
2007	D+	D+	D	-	C	A-	B-
2008	D+	C	D	-	C	A-	C
2009	D	F	D-	-	D	B-	F
2010	D	D+	D+	-	D	B	F
2011	D	D-	D+	-	D+	B-	F
2012	D+	D+	C-	-	A-	A-	D
2013	D+	F	D+	-	C+	B+	D
2014	D+	D-	B-	-	B-	A-	D+
2015*	-	-	-	B	B+	A-	B+
2016*	-	-	-	B	B+	A-	B

*Changes in reporting: from 2000-01 Deception Bay was subdivided into two sites; from 2015 Deception, Bramble and Waterloo Bay were reported as the Western Bay and the Brisbane River estuary was not reported separately.

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