Survival or extinction of a declining population? Indo-Pacific humpback dolphins at the brink in Hong Kong and the Pearl River Estuary

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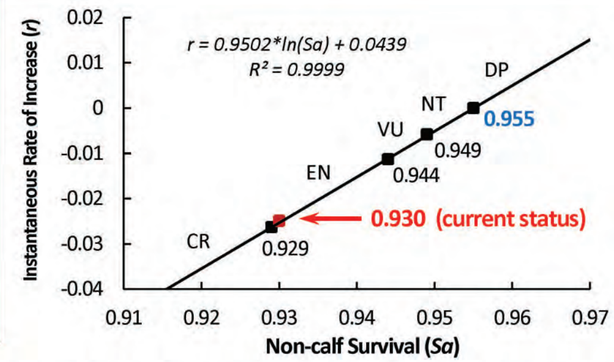


Fig. 4. The current conservation status of the PRE population **nears Critically Endangered (CR)** under the IUCN criteria, assessed based on the natural-log relation between instantaneous rate of increase (*r*) and non-calf survival rate (*Sa*). If the current annual decline (2.5%) continues, nearly 74% of the population will be lost in the lifespan of three generations (< 60 years).

Introduction: The Indo-Pacific humpback dolphins (*Sousa chinensis*) inhabiting the Pearl River Estuary (PRE), southeast China, are among the world's most anthropogenically impacted coastal delphinids. We used multi-year photo-ID data collected in Hong Kong waters to generate a socio-demographic mark-recapture model system that quantifies the population processes, parameters, size and structure, and projects the eco-demographic threshold of population long-term persistence.

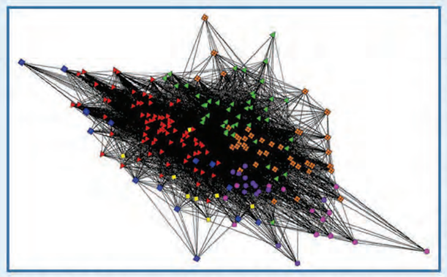
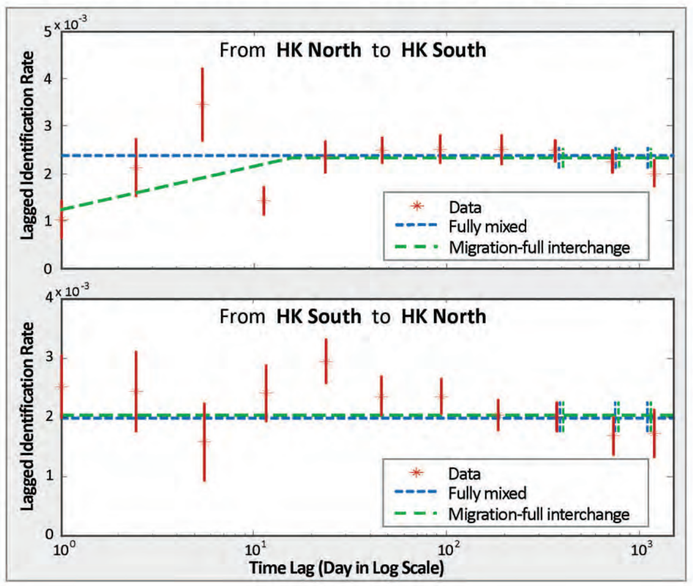


Fig. 1. Network analyses indicate that in the eastern reaches of the Pearl River Estuary, humpback dolphins form **at least seven closely interacting social clusters**. Associations among individuals within each cluster are significantly stronger than between clusters (Two-tailed mantel test, t = 45.07, p=1), but interactions between clusters are frequent.

Total super-population size (total number of dolphins that used Hong Kong waters as part of their range during the study period)	N_t = **368** (320-422)
Seasonal abundance (number of dolphins in Hong Kong waters in 2-month periods per season)	Winter: N_w = **87** (47-162) **to 111** (91-135) Summer: N_s = **144** (114-182) **to 231** (198-270)
Apparent survival rate (considering true survival *and* emigration)	Summer-Winter: $\phi_{s\text{-}w}$ = **0.905** (S.E. = 0.038) Winter-Summer*: $\phi_{w\text{-}s}$ = **0.980** (S.E.= 0.034)

Table 1. Estimates of population parameters (with 95% C.I.) in Hong Kong waters from a suite of POPAN open population and robust design models using program MARK. The true survival rate approximates the Winter-Summer estimate* when it is the least influenced by emigration (*see **Fig. 3***).

Fig. 2. Movement models suggest that individuals at different key habitats across the main body of the estuary are **fully mixed within days**, at the most weeks. The example shown below indicates movements between northern and southern Hong Kong waters.



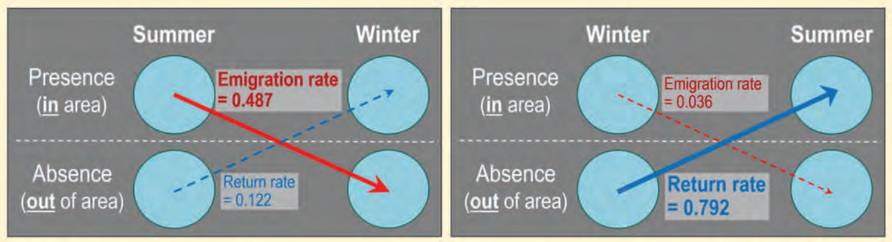


Fig. 3. Temporary emigration from Hong Kong waters is higher during Summer-Winter transition, while the opposite is true in Winter-Summer intervals, with high residence rate (1 - 0.036 = 0.964). This movement pattern **corresponds with the seasonal prey availability** which in Hong Kong peaks in summer, increasing seasonal habitat capacity and lowering foraging competition.

	–5% mortality		Stationary (*Sa = 0.955*)		+5% mortality	
	VORTEX	IBSM	VORTEX	IBSM	VORTEX	IBSM
Minimum viable population in carrying capacity (MVP_k)	752	675	**2039**	**1932**	7490	8036
Minimum area of critical habitat (MACH; km²)	1090	978	**2955**	**2800**	10855	11646
Current total area of MPAs in the PRE (km²)			**580**			

Table 2. Both VORTEX and individual-based stage model (IBSM) indicate that, under the optimal (stationary) demographic scenario, the PRE population would have to be at least 2000 strong with access to at least 3000 km² of key habitats to withstand demographic stochasticity and persist across 40 generations. Even slight increase in adult mortality may have major implications on the population viability. Currently, **neither the population size, nor area of protected habitat or non-calf survival rate in the PRE meet the optimal scenario**, whilst ongoing/proposed coastal development projects are likely to further deteriorate the state of the local environment.

Conclusions: With the current trend of ~2.5% decline per annum, all our demographic model projections indicate that the population is doomed to extinction, unless management shortcomings are acknowledged and new effective conservation measures are implemented to reverse the situation.

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