Tourism affects the behavioural budget of common dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand

Stockin, K.A.[(1)], Lusseau, D.[(2)], Binedell, V.[(1)], Wiseman, N.[(3)] and Orams, M.B.[(1)]

(1) Coastal-Marine Research Group, Massey University, Private Bag 102 904, North Shore MSC, Auckland, New Zealand

(2) Biology Department, Dalhousie University, Halifax, Nova Scotia B3H 4JI, Canada

(3) Laboratory of Molecular Biology and Evolution, University of Auckland, Private Bag 92019, Auckland, New Zealand

Email: k.a.stockin@massey.ac.nz

INTRODUCTION

Many studies have reported short-term behavioural changes of cetaceans to tourism activities (Corkeron 1995, Bejder et al. 1999, Scarpaci et al. 2003, Williams et al. 2002, Lusseau 2003a, Constantine et al. 2004, Bejder et al. 2006a). Additionally, longer-term impacts including area avoidance and declines in relative abundance have also been reported (Lusseau 2005, Bejder et al. 2006b). Under the Marine Mammals Protection Act (1978) and Marine Mammals Protection Regulations (1992), the New Zealand Department of Conservation (DoC) is charged with ensuring that dedicated dolphin tourism operations do not have a detrimental impact on New Zealand marine mammals. However, recent research suggests increasing exposure to commercial tourism can be detrimental to bottlenose dolphins (*Tursiops truncatus*) (Constantine et al. 2004, Lusseau 2004) and Hector's dolphins (*Cephalorhynchus hectori*) (Bejder et al. 1999). Such coastal species are highly susceptible to inshore anthropogenic influences. Common dolphins (*Delphinus* sp.) in New Zealand waters are typically a pelagic species (Neumann 2001), and thus considered less vulnerable to cumulative coastal impacts e.g. dolphin tourism (Neumann & Orams 2006). However, this study took place in the Hauraki Gulf, New Zealand (see Fig. 1), where a population of common dolphins occur within inshore waters year-round. This region has been identified as an important feeding area for common dolphins (Stockin unpubl. data).

The aim of this study was to investigate the potential effects of dolphin tourism on common dolphins in the Hauraki Gulf. Using Markov chains (Lusseau 2003b), we examined whether tour boat interactions cause variations in activity budget. Particularly, we were interested in identifying any potentially detrimental long-term effects for this population e.g. decreased foraging opportunities or increased energy expenditures.

METHODS & MATERIALS

- Non-systematic surveys were conducted in the Hauraki Gulf from an independent research boat (a 5.5 m RIB powered by a 90hp, 4 stroke outboard engine) between February 2003 and January 2005.
- During focal-follows, the behavioural state (see Table 1) of a school was determined every three min using focal-group scan sampling (Altmann 1974). The behavioural state of each focal group was determined based on the activity of >50% of individuals within the school.
- Data collected in isolation of all boats other than the research RIB was treated as control sequences. Data collected in the presence of only the research RIB and tour boat (see Fig. 2) was treated as impact sequences.
- Two two-way contingency tables (preceding vs. succeeding behavioural state) were developed, as described in Lusseau (2003b).
- Log-linear analysis was applied to the compared tables to assess the independence of behavioural transitions from boat presence.
- Differences in behavioural transitions, time taken to return to initial behaviour and bout length were calculated (refer to Lusseau 2003b).

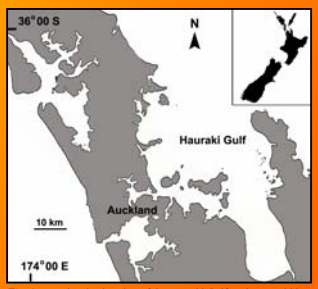

Fig. 1: Map showing location of the Hauraki Gulf study area within New Zealand

Table 1: Definitions of the behavioural states of common dolphin schools with abbreviations given in parentheses

Behavioural state	Definition
Forage (FOR)	Dolphins engaged in any effort to pursue, capture and/or consume prey, as defined by observations of fish chasing, co-ordinated deep-diving and rapid circle swimming. Prey frequently observed at the surface during foraging activity.
Rest (RE)	Dolphins observed in tight groups (<1 body length apart), engaged in slow manoeuvres (slower than idle speed of observing vessel) with little evidence of forward propulsion. Surfacings appear slow and are generally more predictable than those observed in other behavioural states.
Travel (TR)	Dolphins engaged in persistent, directional movement, making noticeable headway along a specific compass bearing. Group dispersion varies and individuals swim with short, relatively constant dive intervals.
Mill (MI)	Dolphins exhibiting non-directional movement, frequent changes in heading prevent animals from making headway in any specific direction. No net movement. Individuals surface facing different directions.
Social (SOC)	Dolphins observed in diverse interactive events such as chasing, copulating and/or engaged in any other physical contact with other dolphins (excluding mother-calf pairs). Aerial behaviours such as breaching frequently observed.

RESULTS

Survey effort

- Survey effort - 46 days (86 hrs) were spent undertaking focal-group follows of common dolphins in the Hauraki Gulf, New Zealand.
- 63 boat interactions were observed, with dolphins spending 28.9% (95%CI=27.6-30.1%) of the time observed in the presence of the tour boat.
- 1566 behavioural transitions were recorded involving 1118 control and 448 impact scenarios.
- Control sequences lasted on average 74.5 min (median=67.5, SE=5.7, range=30-210).
- Impact sequences lasted on average 61.4 min (median=51.0, SE=5.7, range=30-150).

Fig. 2: *Dolphin Explorer* – the only permitted dolphin-tour boat operational in the Hauraki Gulf during the present study.

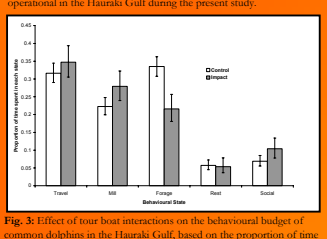

Fig. 3: Effect of tour boat interactions on the behavioural budget of common dolphins in the Hauraki Gulf, based on the proportion of time spent in each behavioural state (Error bars show 95% CI).

Effect of tour boat on behavioural budget

- The overall time spent foraging was significantly reduced ($z=4.95$, $p<0.001$) in the presence of the tour boat by 11.9% (95% CI=7.1-16.6%, see Fig. 3).
- Resting behaviour was marginally reduced in the presence of the tour boat by 2.7% (95% CI=-28.2-22.6%, see Fig. 3).
- Travel, mill and social behaviours all increased in the presence of the tour boat (see Fig. 3).
- Statistically, a 5% increase in tourism activity would result in no overlap of confidence intervals, thus an overall significant difference between the control and impact behavioural budgets.

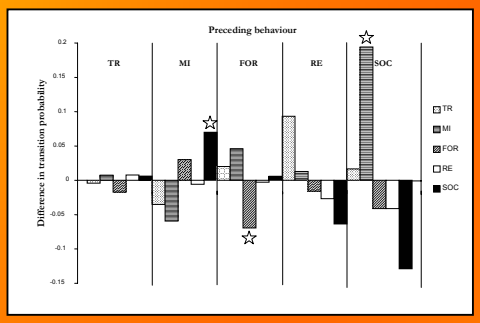

Fig. 4: Effect of boat interactions on transitions in behavioural state of dolphins, based on differences in transition probabilities (p_{ij}(impact)-p_{ij}(control)). Therefore, a negative value means that the behavioural transition of the control chain is superior to that of the impact chain. The graph is composed of five parts, one for each preceding state, separated by vertical lines. In each part, bars correspond to succeeding behavioural states (see legend). Transitions with a significant difference ($p<0.05$) are marked with a star.

Effect of tour boat on behavioural transitions

- Tour boat interactions affected behavioural state transitions ($\Delta G2=106.6$, $df=16$, $p<0.001$).
- Overall, the presence of the tour boat significantly changed three behavioural transitions (see Fig. 4).
- The probability of foraging dolphins remaining in forage behaviour ($p_{for\text{-}for}$) after a tour boat interaction decreased significantly ($z=-1.82$, $p=0.0069$) by 6.9%.
- The probability of resting dolphins remaining in rest behaviour ($p_{rest\text{-}rest}$) after a tour boat interaction marginally decreased by 2.7%.

Effect of tour boat on time taken to return to initial behaviour

- The average time taken for dolphins to return to their initial behavioural state varied between control and impact scenarios (see Table 2).
- Foraging dolphins took 13.9 min to return to foraging in the presence of the tour boat – a significant time increase of 54% (see Table 2).
- Dolphins showed an increased tendency to shift behaviour to mill, social and travel after a tour boat interaction (see Table 2 and Fig. 3).

Effect of tour boat on average bout lengths

- The average bout length (t_{ii}) for foraging and socialising dolphins decreased significantly in the presence of the tour boat (see Table 3).
- The average bout length for travelling, milling and resting dolphins reduced marginally in the presence of the boat. No bout lengths increased in the presence of the tour boat (see Table 3).

Table 2: Probability, time units and average time (min) required to return to initial behavioural categories during (a) control scenarios i.e. presence of research RIB only and (b) during impact scenarios i.e. presence of tour and research boats only.

(a)

Behaviour	π_i (Probability of being in a particular behavioural state)	$E(T_i)$ (Average number of time units taken to return to a behavioural state)	Average time (min) to return to a behaviour once tour boat has approached
Travel	0.316	3.2	9.5
Mill	0.223	4.5	13.5
Forage	0.335	3.0	9.0
Rest	0.057	17.5	52.6
Social	0.069	14.5	43.4

(b)

Behaviour	π_i (Probability of being in a particular behavioural state)	$E(T_i)$ (Average number of time units taken to return to a behavioural state)	Average time (min) to return to a behaviour once tour boat has approached
Travel	0.347	2.9	8.6
Mill	0.279	3.6	10.7
Forage	0.216	4.6	13.9
Rest	0.054	18.6	55.7
Social	0.104	9.6	28.9

Table 3: Average bout length (t_{ii}) during control i.e. presence of research RIB only and impact scenarios i.e. presence of tour and research boats only.

Behaviour	Control t_{ii} (Average bout length in control scenarios)	Impact t_{ii} (Average bout length in control scenarios)
Travel	5.31	5.20
Mill	3.38	2.96
Forage	9.84	5.85
Rest	3.50	3.20
Social	4.29	2.76

DISCUSSION

- The overall time dolphins spent foraging was significantly reduced in the presence of the tour boat.
- Foraging dolphins took significantly more time to return to foraging after an interaction with the tour boat.
- Foraging and resting bouts were disrupted by tour boat interactions to a level that raises concern regarding the sustainability of this impact.
- Dolphins showed an increased tendency to travel, mill and socialise in the presence of the tour boat, to the detriment of forage and rest behaviours.

CONCLUSIONS

- Common dolphins are frequently targeted by tourism operations in New Zealand, yet there remains a paucity in the data regarding potential impacts on this species.
- Currently, two dedicated dolphin tour boats operate year-round in the Hauraki Gulf. However, this study was conducted prior to the establishment of the second permit and thus, considers only the effects of one tour boat – *Dolphin Explorer*.
- Impacts identified in the present study from low-level tourism are similar to those previously reported for coastal species, typically considered more susceptible to cumulative anthropogenic impacts.
- The impacts associated with foraging could be potentially detrimental for this population, since the Hauraki Gulf has been identified as an important feeding area for this species.
- Further tourism-impact research in the Hauraki Gulf is necessary since the recent addition of a second tour boat is likely to have exacerbated the impacts identified here.

REFERENCES

Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour*, 49, 227-267.
Bejder, L., Dawson, S. M., & Harraway, J. A. (1999). Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science*, 15, 738-750.
Bejder, L., Samuels, A., Whitehead, H., & Gales, N. (2006a). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour*, 72, 1149-1158.
Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J., Flaherty, C., & Krützen, M. (2006b). Decline in the relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, 20, 1791-1798.
Constantine, R., Brunton, D. H., & Dennis, T. (2004). Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. *Biological Conservation*, 117, 299-307.
Corkeron, P. J. (1995). Humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Queensland; behaviour and responses to whale-watching vessels. *Canadian Journal of Zoology*, 73, 1290-1299.
Lusseau, D. (2003a). Male and female bottlenose dolphins *Tursiops* spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. *Marine Ecology Progress Series*, 257, 267-274.
Lusseau, D. (2003b). Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. *Conservation Biology*, 17, 1785-1793.
Lusseau, D. (2004). The hidden cost of tourism: Detecting long-term effects of tourism using behavioural information. *Ecology and Society*, 9(1).
Neumann, D. R. (2001). Seasonal movements of short-beaked common dolphins (*Delphinus delphis*) in the north-western Bay of Plenty, New Zealand; Influence of sea surface temperatures and El Nino/La Nina. *New Zealand Journal of Marine and Freshwater Research*, 35, 371-374.
Neumann, D. R., & Orams, M. B. (2006). The impacts of tourism on common dolphins in the Bay of Plenty, New Zealand. *Aquatic Mammals*, 32, 1-9.
Scarpaci, C., Dayantis, N., & Corkeron, P. J. (2003). Compliance with regulation by "swim-with-dolphins" operations in Port Phillip Bay, Victoria, Australia. *Environmental Management*, 31, 342-347.
Williams, R., Trites, A. W., & Bain, D. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: opportunistic observations and experimental approaches. *Journal of Zoology*, 256, 255-270.