

Tourism affects the behavioural budget of common dolphins (*Delphinus* spp.) in the Hauraki Gulf, New Zealand[†]

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ABSTRACT

Common dolphins (*Delphinus* spp) are one of several species frequently targeted by tourism operations in New Zealand waters, yet there remains a distinct paucity in the data regarding potential impacts of tourism faced by this species. Transition matrix models have been widely used in population ecology and more recently applied to behavioural transitions to provide successful management guidelines. Herein, we detail the use of Markov chain models to undertake an impact assessment of tourism activities on the behavioural state of common dolphins in the Hauraki Gulf, New Zealand. First-order time discrete Markov chain models were used to describe transition probabilities in both control and impact scenarios. The effect of boat interactions was quantified by comparing transition probabilities of both control and impact chains. Foraging and resting bouts were disrupted by boat interactions to a level that raises concern regarding the sustainability of this impact. Both the duration of bouts and the time spent in both these behavioural states were substantially decreased. Foraging and resting dolphins took significantly longer to return to their initial behavioural state in the presence of the tour vessel. There was also an increased preference to shift behaviour to socialising after tour boat interactions. Impacts identified in the present study are similar to those previously reported for bottlenose dolphins, a coastal species typically considered to be more susceptible to cumulative anthropogenic impacts.

Keywords: Markov-chain models, disturbance, foraging, New Zealand

1. Introduction

A particular form of nature-based tourism, the viewing of and interaction with marine mammals in the wild, has undergone dramatic growth in recent decades (Hoyt, 2001). Interactions between cetaceans and tour vessels are increasing, with the number of people involved in cetacean-watching activities reported to have exceeded nine million tourists in 1998 (Hoyt, 2001). To date, several studies have investigated the effects of such tourism on the behaviour of targeted animals, with short-term behavioural changes reported for a number of cetacean species including Pacific humpback dolphins (*Sousa chinensis*), humpback whales (*Megaptera novaeangliae*), killer whales (*Orcinus orca*), Hector's dolphins (*Cephalorhynchus hectori*) and bottlenose dolphins (*Tursiops* spp.). Responses observed included variations in vocalisations, increase in dive intervals, horizontal avoidance, increase in speed, and decrease in resting behaviour (Bejder et al., 1999, 2006b; Constantine et al., 2004; Corkeron, 1995;

48 Janik and Thompson, 1996; Lusseau, 2003b; Nowacek et al., 2001; Van Parijs and Corkeron, 2001;
49 Williams et al., 2002). In addition to such responses, longer term impacts including area avoidance and
50 declines in relative abundance have also been reported (Bejder et al., 2006b; Lusseau, 2005).

51
52 Recent New Zealand-based research suggests increasing exposure to commercial tourism can
53 be detrimental to coastal species such as bottlenose dolphins (Constantine et al., 2004; Lusseau, 2004)
54 and Hector's dolphins (Bejder et al., 1999). The inshore distribution of such species results in their
55 higher susceptibility to coastal anthropogenic influences, thus placing them more at risk than offshore
56 species. Typically common dolphins are a pelagic species in New Zealand (Gaskin, 1968), and thus
57 considered to be less at risk from cumulative impacts such as those associated with dolphin tourism.

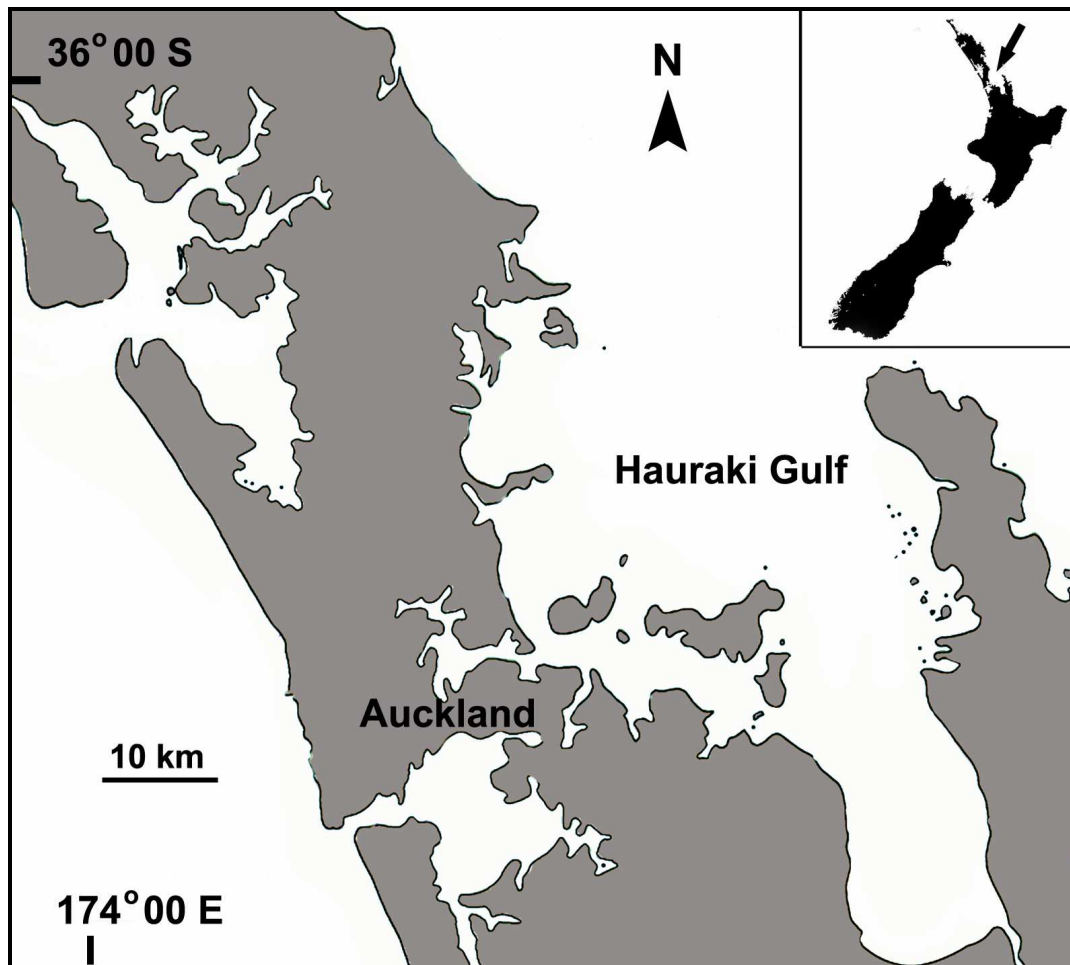
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59 The study reported here took place in the Hauraki Gulf, New Zealand (see Figure 1), where a
60 population of common dolphins (*Delphinus* spp) can be found year-round (Stockin, 2007). This
61 population is currently considered to be an open community, based on the home range of known
62 catalogued individuals (Stockin, 2007). Dolphin tourism within this area has developed relatively
63 recently compared to other regions around New Zealand. The New Zealand Department of
64 Conservation issued the first dolphin tourism permit for the Hauraki Gulf in September 2000.
65 Currently, two dedicated dolphin tourism businesses operate year-round within the Gulf, although this
66 study was conducted prior to the establishment of the second permit in December 2005 and thus, only
67 considers the effects of one tourism vessel. Under the Marine Mammals Protection Act (1978) and the
68 Marine Mammals Protection Regulations (1992), the New Zealand Department of Conservation is
69 charged with ensuring that tourism operations do not have a detrimental impact on marine mammals.

70
71 We investigated the effects of tourism activities on the behavioural budget of common
72 dolphins, a typically offshore dolphin species targeted in the Hauraki Gulf. As with previous studies
73 that have focused on coastal species (Bejder et al., 2006a; Constantine et al., 2004; Lusseau, 2004), we
74 were particularly interested in understanding whether tour boat interactions were causing variations in
75 the populations activity budget which could have detrimental long-term effects such as decreased
76 foraging opportunities, or increased energy expenditures.

77 78 **2. Materials and Methods**

79 *2.1 Study Site*

80 Auckland (36°51'S; 174°46'E, Fig.1) is situated in the North Island and is, with over 1.4 million
81 inhabitants, New Zealand's largest city. Bordering its north eastern coastline, the Hauraki Gulf is a
82 shallow semi-enclosed coastal sea extending from Bream Head to Cape Colville, Coromandel Peninsula
83 on the east coast (36°10'S and 36°60'S). A warm temperate region influenced by the East Auckland
84 Current (EAU), the Gulf is an extremely productive ecosystem that exhibits a high degree of
85 biodiversity, particularly with regard to seabirds and marine mammals (Owen and Owen, 1999). With a
86 maximum depth of just 60 m, the Hauraki Gulf provides a surprisingly shallow environment for
87 common dolphins, which are typically considered to be a pelagic species associated with the deep
88 waters of the continental shelf and beyond (Gaskin, 1992). Despite an apparently open population, the
89 Hauraki Gulf has proven to be an important feeding area for this species (Stockin, 2007) which may
90 explain the year-round occurrence of common dolphins in this region. Resighting rates of known
91 marked individuals suggest site fidelity is relatively high for this species in this area (Stockin, 2007).



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96 **Fig. 1-** Map showing location of the study area in New Zealand
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98 Marine traffic in the Hauraki Gulf consists of a wide variety of boats, from large commercial
99 ships and fishing vessels to ferries, cruise liners, recreational power boats, tour boats, yachts, and
100 kayaks. During weekends and public holidays there is a marked increase in boat numbers, in particular
101 sailing boats, personal water craft (jet skis) and recreational fishing vessels. Here we report the effects
102 of just one tour boat, the only permitted dolphin tour vessel operational at the time of the present study.
103 This tour boat operated year-round, undertaking one trip per day except during peak summer, when
104 occasionally two trips per day occurred.

105
106 *2.2 Data Collection*

107 Non-systematic surveys were conducted in the Hauraki Gulf from an independent research vessel (a
108 5.5 m rigid-hulled inflatable boat powered by a 90hp, 4 stroke outboard engine), between February
109 2003 and January 2005. Once a school of dolphins was detected, the research boat was manoeuvred
110 towards the group in a manner which best minimised any potential effects of the observation boat
111 (Lusseau, 2003a). This resulted in focal schools being approached from the side and aback, in the
112 same direction as the movement of the school. Vessel speed and direction was consistent with that
113 of the school, which in the majority of cases was idle speed (less than five knots). Schools were

114 followed at distances ranging from 50 to 200 m, although where possible a distance of 50 m was
 115 maintained. In an attempt to minimise our potential disturbance, a four-stroke engine was chosen
 116 for reduced noise and exhaust emissions.

117
 118 During a focal-follow, the behavioural state of the focal school was determined every three
 119 minutes using a focal-group scan sampling methodology (Altmann, 1974). A school was defined as
 120 any number of dolphins engaged in a similar activity, moving in a uniform direction and within five
 121 body-lengths of any other dolphin. The primary activity of the school was determined using
 122 behavioural categories modelled on Shane et al. (1986), defined in Table 1. The behavioural state
 123 of each focal group was determined by the predominant (>50%) activity of individuals in the
 124 school.

125
 126
 127 **Table 1-** Definitions of the behavioural states of common dolphin schools in the Hauraki Gulf, with
 128 abbreviations for each state are given in parenthesis
 129

State	Definition
Travel (TR)	Dolphins engaged in persistent, directional movement, making noticeable headway along a specific compass heading. The group spacing varies and individuals swim with short, relatively constant dive intervals.
Rest (RE)	Dolphins observed in a tight groups (< 1 body length between individuals), engaged in slow manoeuvres (slower than the idle speed of the observing vessel) with little evidence of forward propulsion. Surfacing appear slow and are generally more predictable than those observed in other behavioural states.
Mill (MI)	Dolphins exhibiting non-directional movement, frequent changes in heading prevent animals from making headway in any specific direction. No net movement. Individuals are surfacing facing different directions.
Forage (FOR)	Dolphins involved 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 the foraging activity of the dolphins.
Social (SO)	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.

130
 131 Focal schools were sampled to understand the effect of boat interactions at the school,
 132 rather than at the individual level. Common dolphins in the Hauraki Gulf form comparatively large
 133 schools (mean=48 animals, see Stockin, 2007) when compared to coastal species such a bottlenose
 134 dolphins, so focal school follows were deemed more appropriate than focal animal follows (Mann,
 135 2000). Scan sampling of individuals was not possible within larger schools due to the relatively
 136 low mark rate of individuals, so a focal group sampling methodology was employed (Mann 2000).
 137 Observations ended when the focal school was lost or the weather deteriorated, therefore the end of
 138 a sequence of observations was not dependent on the behaviour of the focal school. This protocol
 139 was maintained during interactions with the tour vessel, and thus the state of the observing vessel
 140 remained consistent throughout all control and impact scenarios. Consequently, any differences
 141 observed related only to the presence of the tour boat, not the observing vessel. Vessels
 142 approaching to within 300 m of the focal school (as determined by TASCO OFFSHORE 7x50
 143 reticule binoculars) were deemed as interactions and treated as impact sequences. This distance is
 144 consistent with the New Zealand Marine Mammals Protection Regulations (1992).

145

146 2.3 Markov chains

147 First developed by Markov (1906), Markov chains have been widely used in population ecology
148 (Brault and Caswell, 1993; Fujiwara and Caswell, 2001; Hill and Caswell, 2001; Senata, 1966;
149 Werner and Caswell, 1977). To date, only a handful of tourism impact studies (Bain et al., 2006;
150 Lusseau, 2003a, 2004; Williams et al., 2006) have applied the principals of such models to
151 conservation behaviour (Blumstein, 2004). Since Markov chains quantify the dependence of an
152 event on the preceding ones, they can be used to provide probabilities of transition from one event
153 to another when mutually exclusive behavioural categories are defined.

154

155 Two two-way contingency tables (preceding behavioural state vs. succeeding behavioural
156 state) were developed, as described in Lusseau (2003a). If no tour boat interaction occurred
157 between two behavioural samples, the transition between these two samples was tallied in a control
158 table. If a tour boat interaction occurred between two samples, the transition was tallied in an
159 impact table. As reported in Lusseau (2003a), we removed the transition between a sample
160 succeeding an interaction and the following sample since it was not possible to determine the extent
161 of the potential impact. Control and impact tables were then compared in order to detect the effect
162 of tour boat interactions. A log-linear analysis was applied to assess the independence of the
163 behaviour transitions from boat presence. We used the difference in goodness of fit between the
164 saturated model and the model considering all two-way interactions to test for the effect of boat
165 presence on the behavioural transitions ($\Delta G^2 = G^2_{2way} - G^2_{saturated}$, Lusseau 2003a).

166

167 Transition probabilities (from preceding to succeeding behaviour) were determined in both
168 control and impact chains by

169

$$170 \quad p_{ij} = \frac{a_{ij}}{\sum_{j=1}^5 a_{ij}}, \quad \sum_{j=1}^5 p_{ij} = 1 \quad (1)$$

171

172 where i is the preceding behaviour, j is the succeeding behaviour (i and j range from 1 to 5, because
173 there are five behavioural states in the repertoire), a_{ij} is the number of transitions observed from
174 behaviour i to j , and p_{ij} is the transition probability from i to j in the Markov chain. Each transition
175 is a proportion of time a succeeding behaviour was observed following a preceding behaviour (Eq.
176 1). Therefore, the effect of tour boat interactions on the behaviour transition probability matrix was
177 tested using a z-test for proportions (Fleiss, 1981). Each control transition was compared to its
178 impact counterpart. The expected number of transitions it took the dolphins to return to each
179 behavioural state was approximated for both control and impact chains (Higgins and Keller-
180 McNulty, 1995)

181

$$182 \quad E(T_j) = \frac{1}{\pi_j} \quad (2)$$

183

184 where (T_j) denotes the time (i.e. number of transitions) it takes to return to state j given that the
185 dolphins are currently in state j and π is the steady-state probability of each behaviour in the chain.
186 The expected number of transitions (Eq. 2) was multiplied by the length of each transition unit (i.e.
187 three minutes) in order to calculate the average time (min) it took the dolphins to return to each

188 initial behavioural state. These average times were compared between control and impact scenarios
189 in order to assess the effect of tour boat interactions on the behavioural states of the dolphins.
190

191 Following the Perron-Frobenius theorem, the behavioural budget in each situation (control
192 and impact) was approximated by the eigenvector of the dominant eigenvalue of the transitions
193 matrices (Lusseau, 2003a). Differences observed in the budget were inherent to interactions with
194 the tour boat. Differences between the two behavioural budgets were tested using binomial z-test
195 for proportions (Fleiss, 1981) and 95% confidence intervals calculated. Finally, the average bout
196 length of each behavioural state, \bar{t}_{ii} was approximated following Lusseau (2003a)

199 3. Results

200 3.1 Field effort

201 During the study period, a total of 46 days (86 hours) was spent following focal schools. A total of
202 63 boat interactions were observed, with dolphins spending 28.9% of the time they were followed
203 by the observing research vessel in the presence of the tour vessel. Over the study period 1566
204 behavioural transitions were recorded, of which 1118 were considered as control and 448 as impact.
205 These transitions were collected over 52 control sequences and 23 impact sequences. Control
206 sequences lasted 74.5 min on average (median=67.5 min, SE=5.7, range=30-210) and impact
207 sequences averaged 61.4 min (median=51 min, SE=6.7, range=30-150). Despite the intensity of
208 vessel traffic in the region, the time dolphins spent interacting with other vessels was relatively low
209 when compared with the tourism boat. While dolphins spent 28.9% of the time we spent following
210 them interacting with the tour vessel, only 1.8% of this time was spent interacting with other
211 vessels. These interactions also tended to be shorter (mean=25.5 min). Due to sample size, all
212 observations of dolphin behaviour with vessels other than the tour vessel were excluded from the
213 analysis.
214

215 3.2 Effect of boat interactions

216 Tour boat interactions affected behavioural state transitions ($\Delta G^2 = 106.6$, $df = 16$, $p < 0.001$). While
217 these interactions had an effect on the transitions in behavioural states of common dolphins (Table
218 2), observed effects did not appear homogeneous throughout all transitions. Overall, the presence
219 of the tour vessel significantly changed three transitions (Figure 2). The likelihood of staying
220 foraging when foraging was significantly decreased in the presence of the tour boat. Meanwhile,
221 transitions Mill \rightarrow Social and Social \rightarrow Mill both significantly increased when tour boats were
222 interacting with dolphins (Figure 2). In most cases where an increase in transition probability was
223 detected, travel was the succeeding behavioural state. The probability of staying in either foraging
224 ($p_{\text{for for}}$) or resting states ($p_{\text{rest rest}}$) decreased by 6.9% and 2.7% respectively during the presence of
225 the tour vessel (Table 2).
226

227 The average time taken for dolphins to return to their initial behavioural state altered in the
228 presence of the tour vessel. Generally, foraging and resting dolphins took longer to return to their
229 initial behavioural state in the presence of the tour vessel, with the time required to return to
230 foraging activity extending by over 60% to 13.9 min (Table 2). The behavioural budget of dolphins
231 was different when tour boat interactions occurred (Figure 3). Overall dolphins spent more time
232 travelling, milling and socialising when the tour boat was present to the detriment of feeding and
233 resting states. The time spent feeding was significantly reduced in the presence of the tour boat by
234 11.9% ($Z = 4.95$, $P < 0.001$).
235

236 **Table 2-** Probability, time units and average time (min) required to return to initial behavioural
 237 categories during (a) control scenarios i.e. presence of research vessel only and (b) during impact
 238 scenarios i.e. presence of tour vessel and research vessel only.

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 240 (a)
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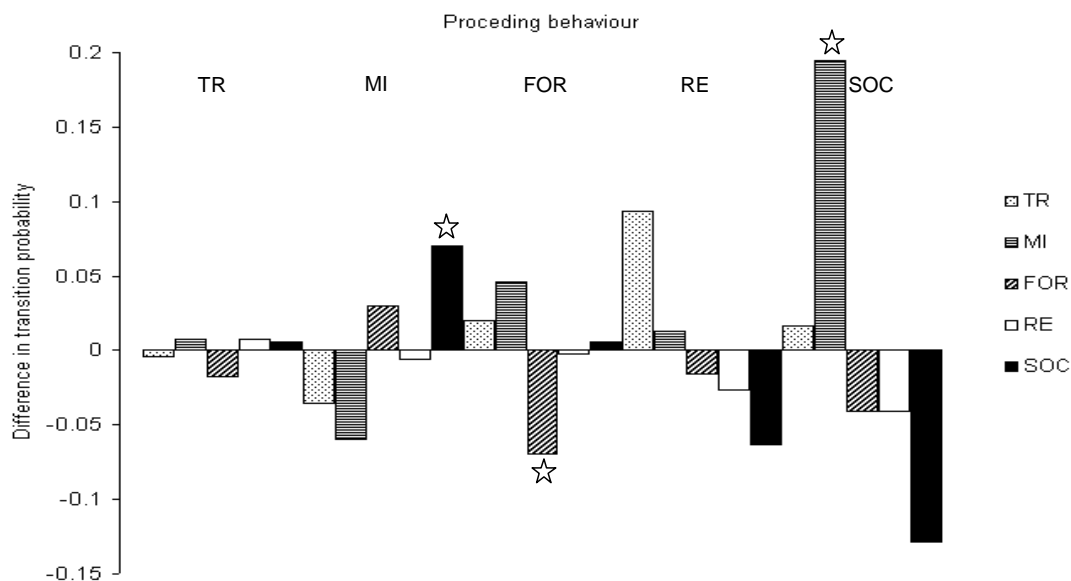
Behaviour	π_j (Probability of being in a particular behavioural state)	E(T_j) (Average number of time units taken to return to a behavioural state)	Average time (min) to return to a behaviour when vessel has come upon them
Travel	0.316	3.2	9.5
Mill	0.223	4.5	13.5
Forage	0.335	3.0	9.0
Rest	0.057	17.5	52.6
Social	0.069	14.5	43.4

242
 243 (b)
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Behaviour	π_j (Probability of being in a particular behavioural state)	E(T_j) (Average number of time units taken to return to a behavioural state)	Average time (min) to return to a behaviour when vessel has come upon them
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

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Given that dolphins spent 28.9% of their time interacting with the tour boat, their overall behavioural budget (compiled from the time spent in control, 71.1%, and impact, 28.9%, situations) did not significantly change compared to their control behavioural budget. However, it is worth noting that the amount of time they spent foraging overall was lower by 10% compared to their control budget (proportion of time spent feeding, control budget: 33.5% (30.8%-36.3%), overall budget: 30% (27.9%-32.4%); range are 95% confidence intervals). The difference between these two proportions becomes significant if dolphins were to spend at least 31% of their time interacting with tour boats (a 5% increase in tourism activity). The confidence intervals of these two proportions no longer overlap if dolphins were to spend at least 40% of their time interacting with tour boats (a 38% increase in tourism activities).



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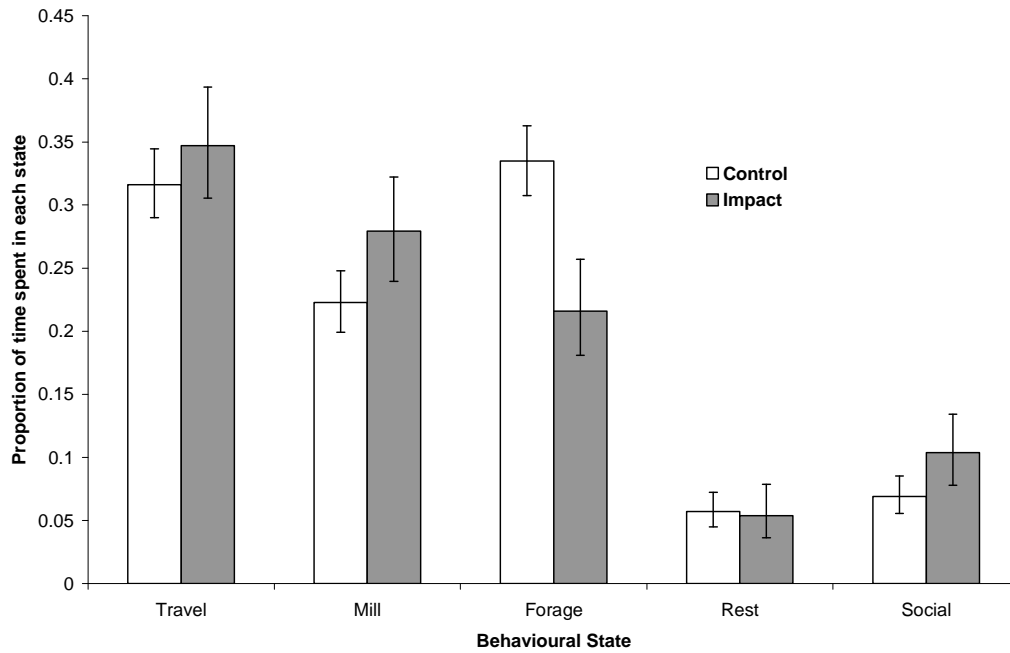
Fig. 2- Effect of boat interactions on transitions in behavioural state of dolphins, based on differences in transition probabilities ($p_{ij(\text{impact})} - p_{ij(\text{control})}$). Therefore, a negative value means that the behavioural transition of the control chain is superior to the one of the 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.

3. Discussion

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269 The growth of cetacean-based tourism in New Zealand has been relatively recent. For example,
270 watching sperm whales in Kaikoura did not start until 1987 (Donoghue, 1996) and dolphin-based
271 tourism really only appeared by the beginning of the 1990s. Growth has been spectacular and today
272 there are over 80 cetacean-based marine mammal tourism permits issued in New Zealand – almost
273 all of them for dolphin watching and/or swimming (Department of Conservation 2006). It is clear
274 that dolphins and whales have become an important “selling point” used by Tourism New Zealand
275 to attract visitors to the country, with a significant proportion of the over two million annual
276 international visitors to New Zealand participating in dolphin watching and swim-with dolphin
277 activities (Orams, 2003).

278
279 While many view and promote whale and dolphin watching as a sustainable ‘use’ of marine
280 mammals, recent widespread concern has been growing regarding the potential impacts associated
281 with this tourism activity (Constantine, 2001, 2004; Gordon et al., 1992; Lusseau, 2003a, b; Orams,
282 2004; Phillips and Baird, 1993; Scarpaci et al., 2003). The study reported here provides additional
283 evidence which supports the concerns expressed by these authors. As is the case with almost every
284 reported study which has examined the behaviour of dolphins targeted by tourism operators to date,
285 we also found significant changes in behaviour of the dolphins as a consequence of tour boat
286 interactions. Our transition analyses using Markov chains identified that tour boat approaches and
287 interactions did significantly change the behavioural state of common dolphins in the Hauraki Gulf.

288 More specifically, the results show that the common dolphins targeted for tourism in this region
 289 were significantly less likely to continue feeding and less likely to continue resting after the
 290 approach of the tour boat. These changes affected the behavioural budget of dolphins when they
 291 were interacting with the tour boat. Just a small increase in tourism activities would lead to a
 292 significant alteration of the overall behavioural budget of this population, disrupting the amount of
 293 time dolphins spend foraging and hence seriously jeopardising the sustainability of this industry in
 294 the Hauraki Gulf.
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 298 **Fig. 3-** Effect of boat interactions on the behavioural budget of common dolphins in the Hauraki
 299 Gulf. Proportion of time spent in each behavioural state depending on the presence of the tour boat.
 300 Error bars are 95% confidence intervals (Lusseau, 2003a)
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303 These results illustrate that changes in dolphin behaviour following tour boat interactions
 304 impacted not only the average duration of feeding bouts, but also the entire behavioural repertoire
 305 of the dolphin community. This change in behaviour has important and potentially detrimental
 306 implications for this population of dolphins. Foraging and feeding are critical components of any
 307 predator’s behavioural repertoire and disturbance or disruption can have major consequences
 308 (Boggs, 1992). For dolphins, foraging and feeding are highly developed behaviours which are
 309 usually thought to have evolved in the context of the local ecosystem (Würsig, 1986). The foraging
 310 behaviour of this species in this location has recently been examined and has been shown to be
 311 important not only for the dolphins, but also for other species such as the Australasian gannet
 312 (*Morus serrator*) and Bryde’s whales (*Balaenoptera brydeii*) who ‘key’ on the dolphins for the
 313 benefit of their own feeding activities (Burgess, 2007). Thus, disruption of foraging and feeding
 314 behaviours of common dolphins in the Hauraki Gulf has implications which have potential
 315 significance not only for the dolphins, but also for other predators and the wider ecosystem.
 316

317 The disruption of resting could also have important implications, although disturbance of
318 resting activity during daylight hours is possibly less problematic than the disruption of foraging
319 and feeding. Activity budgets compiled by Neumann (2001a) for common dolphins in Mercury
320 Bay, New Zealand, showed that only a small proportion (0.7%) of daylight time was spent resting.
321 It is therefore assumed that most resting occurs at night, although, no empirical data is available to
322 confirm this hypothesis. Two possible inferences can be made with regard to disturbance of resting
323 by the tour boat. First, since common dolphins spend such a small proportion of their time resting
324 during daylight it can be assumed that this is not a critical part of their daytime activities. Thus,
325 change from resting to other behavioural states as a consequence of the presence of the tour boat is
326 unlikely to be disadvantageous. Second, and conversely, because so little time is spent resting
327 during the day, this limited time is important and thus any disturbance could be detrimental.
328 Irrespective, what is clear is that tourism activity focused on common dolphins in the Hauraki Gulf
329 does have impacts on their behaviour. Furthermore, it seems likely that such impacts, particularly
330 any disruption to foraging activities, could have detrimental long-term consequences for this
331 population and potentially the wider Hauraki Gulf ecosystem.

332 333 334 **4. Conclusions**

335 Since common dolphins are the most frequently sighted cetacean in the Hauraki Gulf (Stockin,
336 2007), they are the primary target species of both tour vessels currently operating in the area and as
337 such, are the economic crux of the marine mammal tourism industry in this region. Bryde's whales
338 are also targeted by the tour boats in this region, although to a lesser extent owing to their seasonal
339 occurrence (Wiseman, 2007). While inshore-offshore movements of common dolphins have been
340 recorded in New Zealand waters (Neumann, 2001b), common dolphins remain present within the
341 Hauraki Gulf year-round. The significance of these waters for feeding (Stockin, 2007) and the high
342 occurrence of young calves throughout much of the spring and summer (Schaffar-Delaney, 2004)
343 highlight the importance of the Hauraki Gulf for this population. Foraging activity in this region, as
344 determined by activity budget, is significantly higher (Stockin, 2007) than that reported in a
345 comparable study conducted in the neighbouring waters of the Bay of Plenty, New Zealand
346 (Neumann, 2001a). It can be concluded from the present study that tourism based on common
347 dolphins in the Hauraki Gulf is not benign and that continued operation of dolphin-watch vessels in
348 the area needs to be carefully monitored, particularly given that a second permit is now in full-time
349 operation.

350
351 From a management perspective several possible mitigation measures should be
352 contemplated. Firstly, tour vessels could be prohibited from approaching common dolphins when
353 the dolphins are foraging or feeding. An implication of this approach would be the training of tour
354 vessel skippers to ensure successful identification of foraging and feeding activity from a distance.
355 However, tour boats would still have to come within close range of dolphins in order to determine
356 their behavioural state. Alternatively, another option would be to identify the time and/or location
357 at which dolphins are more likely to be foraging and to prevent tour vessel interactions during these
358 periods or in these locations (Higham and Lusseau, 2004).

359
360 The Hauraki Gulf has been identified as a marine ecosystem of national significance for
361 New Zealand. In addition, the New Zealand Marine Mammals Protection Act (1978) clearly states
362 that tourism operations should not have a detrimental impact on marine mammals. This study
363 reports detrimental impacts on common dolphins experiencing relatively low-levels of tourism.
364 Our findings suggest tourism impacts faced by common dolphins in the Hauraki Gulf are similar to
365 those previously reported for bottlenose dolphins, a coastal species typically considered to be more

366 susceptible to cumulative anthropogenic impacts. It is likely that the disturbance shown in this
367 study from only one tour vessel will have been exacerbated by the recent expansion of tourism in
368 this region. We recommend the management agency responsible for marine mammal conservation
369 in New Zealand, as well as the tourism industry, itself take action to minimise the impacts
370 highlighted by this study.

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