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## Behaviour of free-ranging short-beaked common dolphins (*Delphinus delphis*) in Gulf St Vincent, South Australia

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**Abstract.** Common dolphins are subject to large-scale fishing activity and tourism operations in South Australia; however, there is a paucity of data on this species. Understanding the behaviour of a population can contribute greatly to our knowledge of a species and how to manage potential population-level threats. This paper describes the behaviour of short-beaked common dolphins (*Delphinus delphis*) in Australian waters for the first time. Data were collected from 109 independent dolphin groups during boat-based surveys conducted in Gulf St Vincent, South Australia, between September 2005 and May 2008. Activity budgets were used to assess behaviour of common dolphins in relation to diel patterns, season, water depth, sea surface temperature (SST), group size and composition. Foraging (33.9%) and resting (2.8%) were the most and least frequently observed behaviours, respectively. Travelling (33.0%), socialising (20.2%) and milling (10.1%) accounted for the remainder of the activity budget. Diurnal differences were detected, with foraging (59.5%) and socialising (31.8%) groups most frequently observed from 10.00 to 11.59 hours. Behaviour did not vary seasonally or with water depth, SST, group size or composition. Behaviour varied significantly between single- and multispecies aggregations. Foraging was more frequent in multispecies aggregations, as 78.4% of all foraging behaviour observed for common dolphins occurred in the presence of other species. Multispecies aggregations were most frequently observed with flesh-footed shearwaters (*Puffinus carneipes*), which were present during 29.4% of common dolphin encounters. Behaviour varied significantly during aggregations with shearwaters, as 62.2% of foraging groups occurred in the presence of shearwaters. Resting, milling or socialising was rarely observed in the presence of any other species, indicating that the primary mechanism for aggregations is likely prey-related.

**Additional keyword:** foraging.

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### Introduction

Little is known about the behaviour of free-ranging common dolphins (*Delphinus* spp.) worldwide. Some studies offer insights into the behaviour of common dolphins (e.g. Bearzi 2005; Bearzi 2006; Cañadas and Hammond 2008; Oviedo *et al.* 2010); however, currently only two activity budgets for the genus appear in the published literature (Neumann 2001; Stockin *et al.* 2009), both relating to New Zealand *Delphinus*. Behavioural data can offer insight into potential effects that tourism, fisheries interactions and other human-induced impacts may have on a population and are necessary for understanding short-term and long-term changes at population levels for numerous delphinid species (e.g. Lusseau and Bejder 2007; Carrera *et al.* 2008; Dans *et al.* 2008; Courbis and Timmel 2009; Arcangeli *et al.* 2009; Lusseau *et al.* 2009). Common dolphins have been subject to

tourism effects in other parts of their range (Neumann and Orams 2006; Stockin *et al.* 2008). Thus, given the recent introduction of dolphin tourism in Gulf St Vincent (GSV), it is important to assess the behaviour of common dolphins in this region. Herein the behaviour of common dolphins in Australian waters is described for the first time.

Australian common dolphins have been the subject of few field-based studies (e.g. Bilgmann *et al.* 2008; Hamer *et al.* 2008; Filby *et al.* 2010), with most current information originating from stranded and bycaught carcasses (e.g. Kemper and Gibbs 2001; Kemper *et al.* 2005; Ross 2006; Lavery *et al.* 2008; Tomo *et al.* 2010). Although common dolphins exhibit extensive morphological and genetic variation across Australia, the South Australian common dolphin has been taxonomically classified as the short-beaked form *Delphinus delphis* (Bilgmann *et al.*

2008). Despite being one of the most abundant cetacean species in GSV (Filby *et al.* 2010), little is known about the potential importance of these waters for common dolphins. However, research indicates that common dolphins are exposed to large-scale fishing activity and tourism operations in South Australia (Bilgmann *et al.* 2008; Hamer *et al.* 2008). Thus, to better understand the use of GSV waters, the activity budget of common dolphins in this region was examined. The behaviour of common dolphins was assessed in relation to diel patterns, season, water depth, sea surface temperature (SST), group size and composition. Additionally, behavioural differences between single- and multispecies aggregations were investigated using

presence/absence of flesh-footed shearwaters (*Puffinus carneipes*). The proportion of time dolphins spent devoted to key activity states (foraging, travelling, socialising, milling, resting) was examined.

## Materials and methods

### Study site

Gulf St Vincent (GSV) (Fig. 1), on the south coast of Australia ( $35^{\circ}1'0''\text{S}$ ,  $138^{\circ}4'0''\text{E}$ ) is a shallow (45 m maximum depth), semienclosed body of temperate water that is a tidal inverse estuary (Nunes and Lennon 1986). Influenced by the Leeuwin

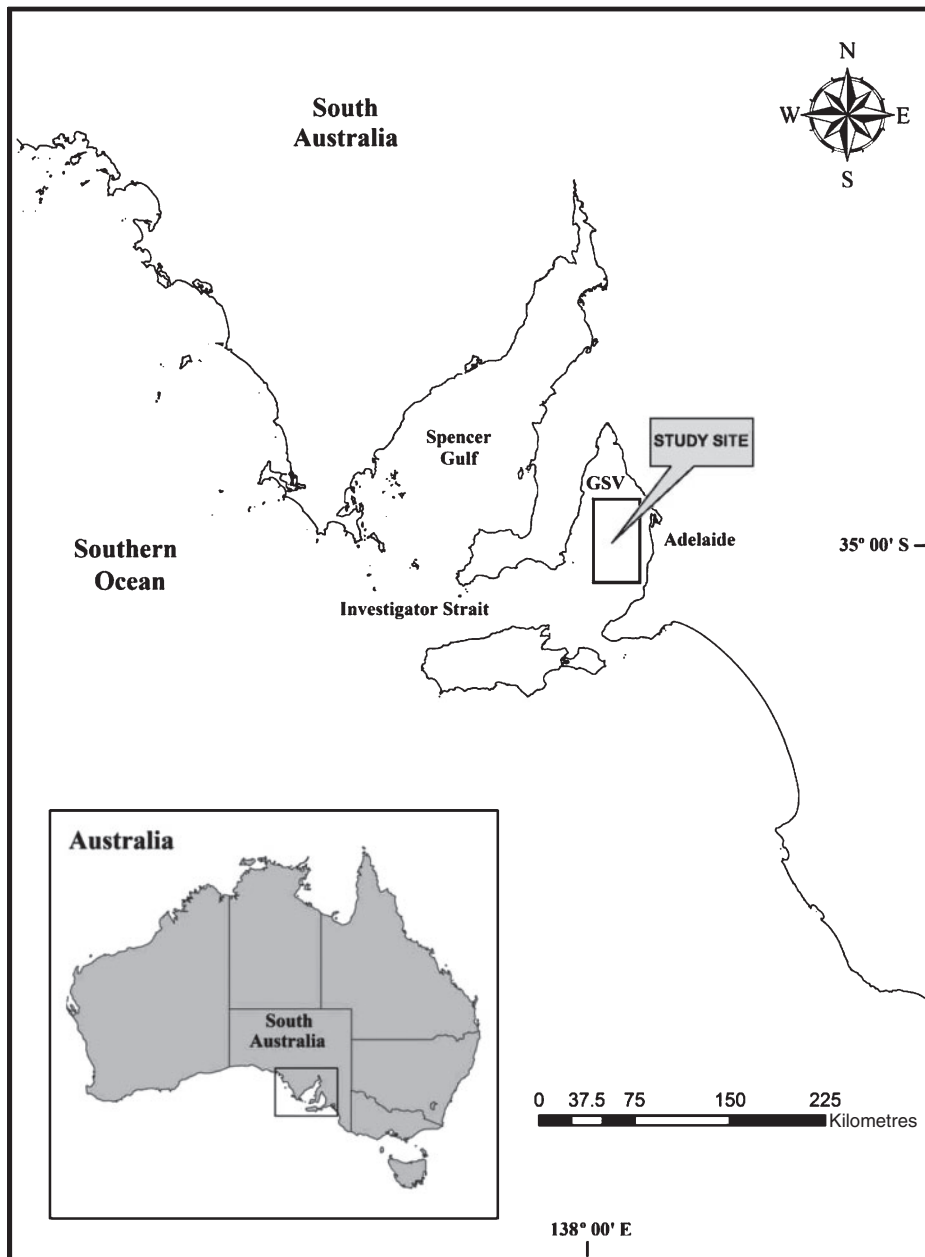


Fig. 1. Study site location within Gulf St Vincent, South Australia.

Current, GSV is a productive ecosystem exhibiting high biodiversity (Pearce 1997; de Silva Samarasinghe 1998). Common dolphins occur within GSV year-round (Kemper *et al.* 2008; Filby *et al.* 2010) and are susceptible to coastal accumulative impacts (e.g. fisheries by-catch and metal contamination) (Kemper *et al.* 2005; Bilgmann *et al.* 2008; Hamer *et al.* 2008; Lavery *et al.* 2008).

#### Data collection

Behavioural observations of dolphins in GSV were conducted between September 2005 and May 2008 during boat surveys on-board *Silverback*, an Arvor 6.2-m diesel inboard boat, with a 90-horsepower engine. The study area encompassed 2592 km<sup>2</sup>, which was subdivided into nine overlapping grid cells, each with a circumference of 86 km (length = 27.7 km, width = 15.3 km) (Fig. 2). One grid cell was surveyed per day, and the grid to be surveyed was determined using a random number generator. Grid cell size was limited by distances that could be covered by the research vessel during a single survey in daylight hours. Only surveys conducted in good visibility ( $\geq 1$  km) and in Beaufort 3 or less were used in the analysis.

Whilst surveying, observations by naked eye were conducted by a minimum of two experienced observers who visually scanned the sea surface for animals while on the survey grid cell track at a speed of 10–12 kn. Observations of seabirds were used in addition to surface activity of dolphins (i.e. breaching) to detect dolphin groups (Filby *et al.* 2010). Once dolphins were detected, the research vessel slowed to an approach speed (~2–4 kn) and start time, GPS coordinates, behavioural data, group size and composition were recorded. Environmental parameters (i.e. water depth) were also noted, as was the presence of any other species. GPS coordinates of dolphin groups were recorded using a Navman TRACKER 5500. Water depth (m) was recorded using a Navman FISH 4500 Fish Finder/Sounder. After each survey, average SST for GSV was acquired from the Bureau of Meteorology (<http://www.bom.gov.au/nmoc/archives/SST/>).

When a group was first encountered, it was followed (focal follows), with behaviour assessed via instantaneous scan sampling of the group's predominant behaviour (Altmann 1974; Mann 1999). Behaviour was recorded within the first minute of encountering dolphins. All animals within the group were scanned and the predominant behaviour was determined as the behavioural state in which more than 50% of the animals were involved (Neumann 2001; Stockin *et al.* 2008, 2009). Five behavioural states were used (Table 1), modified from the definitions used by Stockin *et al.* (2009). A *group* was defined as any number of animals observed within five body lengths of any other dolphin, moving in the same direction and engaged in the same activity (Shane 1990; Fertl 1994). A group could consist of one or more different age classes including: neonate, calf, juvenile and adult (Table 2). *Multispecies aggregations* were defined as other cetacean or avian species observed <100 m from the focal group (Bearzi 2006). The research vessel remained with the larger group when one or more individuals departed the original focal group, as larger groups were easier to follow. Focal follows ended when animals were lost, or when sea conditions or visibility deteriorated.

The research vessel remained with the focal group and was manoeuvred in a consistent manner to minimise the potential impacts associated with the boat. Photoidentification of individuals within a focal group was undertaken (Würsig and Jefferson 1990). All behavioural data were collected by a single observer (NEF) to standardise observations between focal groups. Following completion of recording behavioural information, the survey track-line was rejoined in a convergent course to avoid the potential of resampling the same individuals. When more than one independent focal group was encountered during a survey, focal groups were considered independent only if they were separated spatially to a degree that would prevent individuals becoming resampled during a second focal follow (>5 km), and when subsequent photoidentification analysis revealed no matches between the respective focal group members.

#### Data analysis

Diurnal and seasonal patterns in activity budget and relationships with environmental variables (i.e. water depth, SST) were investigated. The relationships between behaviour and group size and composition were also examined. Finally, behavioural differences between single-species groups and multispecies aggregations were assessed, using presence/absence of flesh-footed shearwaters.

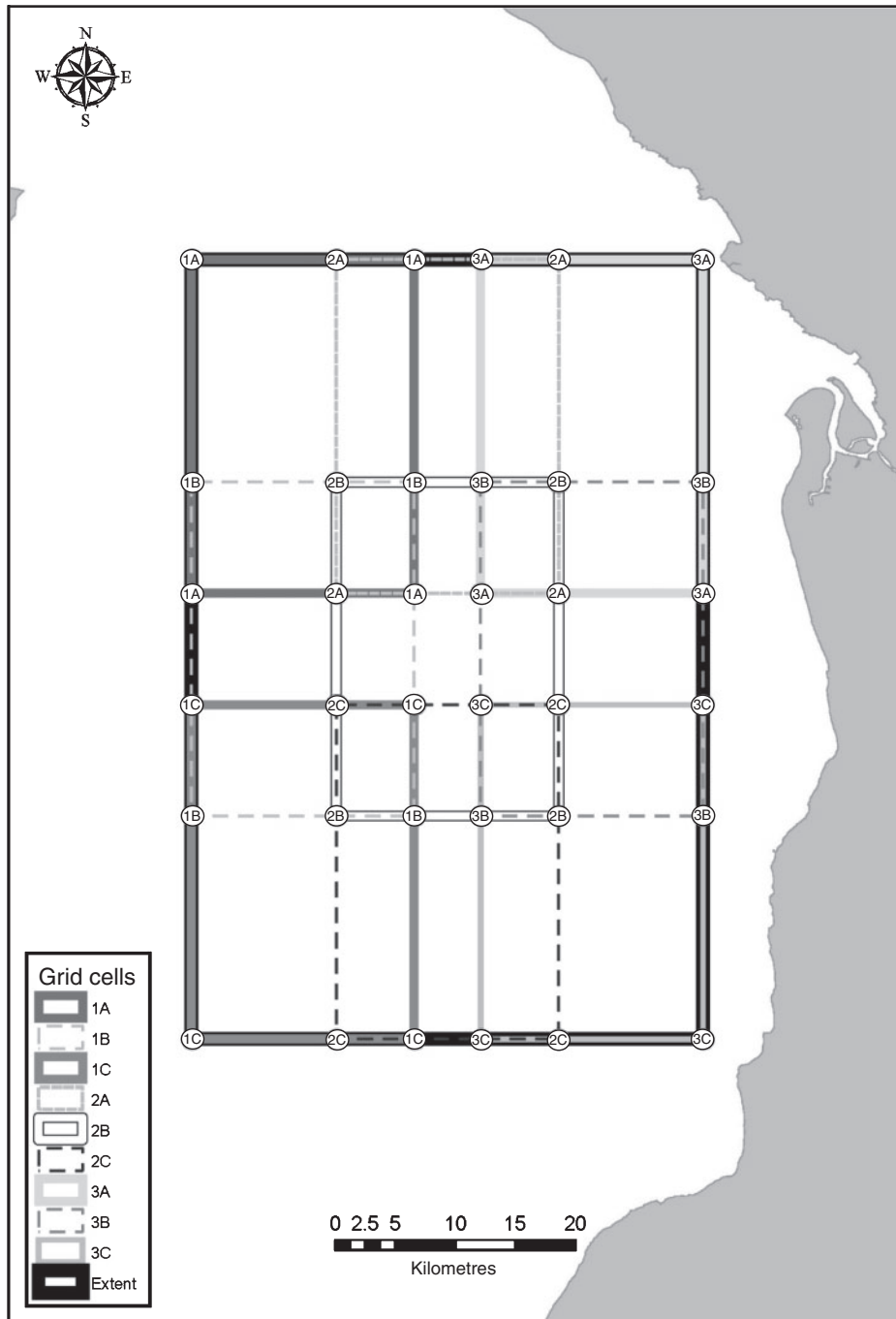
Diurnal patterns were investigated by assigning each observation to a 2-h period (i.e. 0600–0759, 0800–0959 through to 1600–1759 hours). Seasonal analyses were based on the austral seasons: spring (September–November), summer (December–February), and autumn (March–May). On the basis of natural separation of the data, group size was classified as either small ( $\leq 10$  animals) or large ( $\geq 11$  animals). Group composition was categorised and analysed by the youngest age class present within a group (i.e. groups containing calves and adults was classified as *calves*) as per Stockin *et al.* (2009). Water depth and sea surface temperature were analysed as continuous raw data.

Statistical analysis was carried out using SPSS 19. The distributions of continuous variables (water depth, SST) were tested for normality and homogeneity (Zar 1996). Distribution of data was non-normal so the non-parametric Kruskal–Wallis test was applied to the dataset, Pearson Chi-square tests were used to assess categorical variables (e.g. group size and composition).  $P \leq 0.05$  was the level at which results were considered statistically significant. Activity budgets were defined only on the *initial* behaviour since (1) this reduced the likelihood of an impact from the observing boat and (2) it allowed comparisons to be made with other activity budgets of *Delphinus*.

## Results

### Field effort

Between September 2005 and May 2008, 27 boat-based surveys were conducted, with an on-effort distance travelled of 1850 km (mean = 77.5 km per survey). Behaviour was recorded for 109 independent common dolphin encounters, with 569 individuals sighted. While effort was distributed as uniformly as possible across the study site, uncontrollable circumstances (e.g. military exclusions) resulted in unequal survey effort between grid cells.



**Fig. 2.** Grid cell locations with the study site, Gulf St Vincent, South Australia. Nine grid cells are depicted within the study site: 1 = western section of GSV, 2 = middle section, 3 = eastern section. A = northern section of GSV, B = middle section, C = southern section.

Due to weather constraints, greatest effort occurred during February ( $n = 6$ ) and March ( $n = 6$ ), with no surveys conducted in October or winter months.

*Activity budget*

Overall, foraging (33.9%;  $n = 37$ ) and travelling (33.0%;  $n = 36$ ) were the most frequently recorded behavioural states. Social

behaviour was observed for 20.2% ( $n = 22$ ) of encounters, while resting (2.8%;  $n = 3$ ) and milling (10.1%;  $n = 11$ ) were the behaviours observed least (Fig. 3).

*Temporal variation*

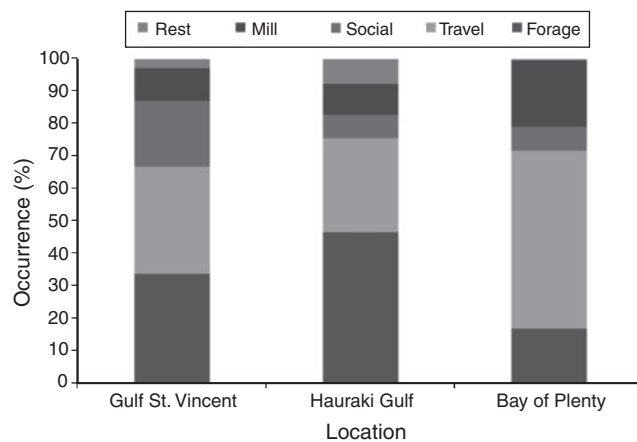
Diurnal differences in behaviour were detected ( $\chi^2_{20} = 40.301$ ,  $P = 0.005$ ), with foraging (59.5%;  $n = 22$ ) and socialising

**Table 1. Definitions of behavioural states recorded between 2005 and 2008 for common dolphins in Gulf St Vincent, South Australia**

| State       | Definition   |
|-------------|--|
| Travelling  | Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing. Group spacing varied and individuals swam with short (<20 s), relatively constant dive intervals.   |
| Foraging    | Dolphins involved in any effort to pursue, capture and/or consume prey, as defined by observations of two or more of the following: fish chasing; erratic movements at the surface; multidirectional diving; coordinated deep diving; and rapid circle swimming. Prey often observed at the surface. |
| Milling     | Dolphin exhibited non-directional movement. Frequent changes in bearing prevented dolphins from making headway in any specific direction.  |
| Resting     | Dolphins observed in a tight group (<1 body length between individuals), engaged in slow manoeuvres (slower than the idle speed of the observing boat) with little evidence of forward propulsion. Surfacing slow and more predictable than those observed in other behavioural states.              |
| Socialising | Dolphins observed chasing, copulating and/or engaged in any other physical contact with other dolphins, such as rubbing and touching. Aerial behaviours such as breaching frequently observed.   |

**Table 2. Definitions of age categories used to assess common dolphin groups within Gulf St Vincent, South Australia (modified from Stockin *et al.* 2008)**

| Age class | Definition  |
|-----------|---|
| Adult     | Apparently fully grown individuals (>1.8 m).  |
| Juvenile  | Approximately two-thirds the length of an adult and did not travel in the typical calf position alongside an adult individual.  |
| Calf      | Approximately half the length of an adult and travelling in the typical calf position alongside an adult individual.  |
| Neonate   | Young calves ~80–120 cm, that showed foetal folds, presence of a floppy dorsal fin, extreme buoyancy or were always positioned in close relation to an adult (presumed to be its mother). When surfacing lifted the whole head above water. |

**Fig. 3.** Activity budget for common dolphins in Gulf St Vincent, South Australia, Hauraki Gulf, New Zealand (Stockin *et al.* 2009) and the Bay of Plenty, New Zealand (Neumann 2001).

(31.8%;  $n=7$ ) groups most frequently observed between 1000 and 1159 hours and travelling groups (38.9%;  $n=14$ ) most prevalent between 0800 and 0959 hours (Fig. 4a). Resting groups were encountered only during 0600–0759 hours and 1200–1359 hours. Milling (45.5%;  $n=5$ ) was most frequent during 1200–1359 hours. No seasonal variation in behaviour was evident ( $\chi^2_8=10.494$ ,  $P=0.232$ ), although travelling and milling groups were typical in spring and autumn, respectively (Fig. 4b). Resting groups (66.7%;  $n=2$ ) were most prevalent in spring, while foraging (48.6%;  $n=18$ ) and socialising groups (50.0%;  $n=11$ ) were observed more frequently during summer.

#### Water depth and SST

Behaviour did not vary significantly with water depth (Kruskal–Wallis  $h_4=3.966$ ,  $P=0.411$ ). Travelling dolphins were observed in median water depths of 35.1 m (IQR=7.6,  $n=36$ ) and resting animals were observed in median water depths of 30.8 m (IQR=6.8,  $n=3$ ). Socialising and milling groups were observed in median water depths of 33.6 m (IQR=7.5,  $n=22$ , range=21.0–38.8 m) and 31.0 m (IQR=7.8,  $n=11$ , range=21.6–38.6 m), respectively. Foraging groups were observed at a median water depth of 31.6 m (IQR=8.2,  $n=37$ ) and were found in the shallowest and deepest waters (range=14.0–39.6 m).

Behaviour did not vary significantly with SST (Kruskal–Wallis  $h_4=5.900$ ,  $P=0.207$ ), with resting groups being observed in the coolest (median=18.0°C, IQR=1.7,  $n=3$ ) and foraging groups in the warmest (median=21.4°C, IQR=1.7,  $n=37$ ) waters, respectively. Milling common dolphins were observed at a median water temperature of 21.3°C (IQR=1.6,  $n=11$ ). Travelling and socialising groups were observed at median temperatures of 20.5°C (IQR=3.4,  $n=36$ ) and 19.5°C (IQR=2.3,  $n=22$ ), respectively.

#### Group size and composition

Common dolphins were observed in small groups of 2–21 animals (mean=5.26, s.d.=3.687), with groups containing  $\leq 10$  animals ( $n=99$ ) accounting for 90.8% of independent encounters. Less than 15% of observed groups contained only adults, over 85% of observed groups included immature animals (juveniles, calves and neonates) ( $n=215$ ), and over 50% of groups contained calves. Groups containing neonates accounted for almost 20% of groups encountered that also

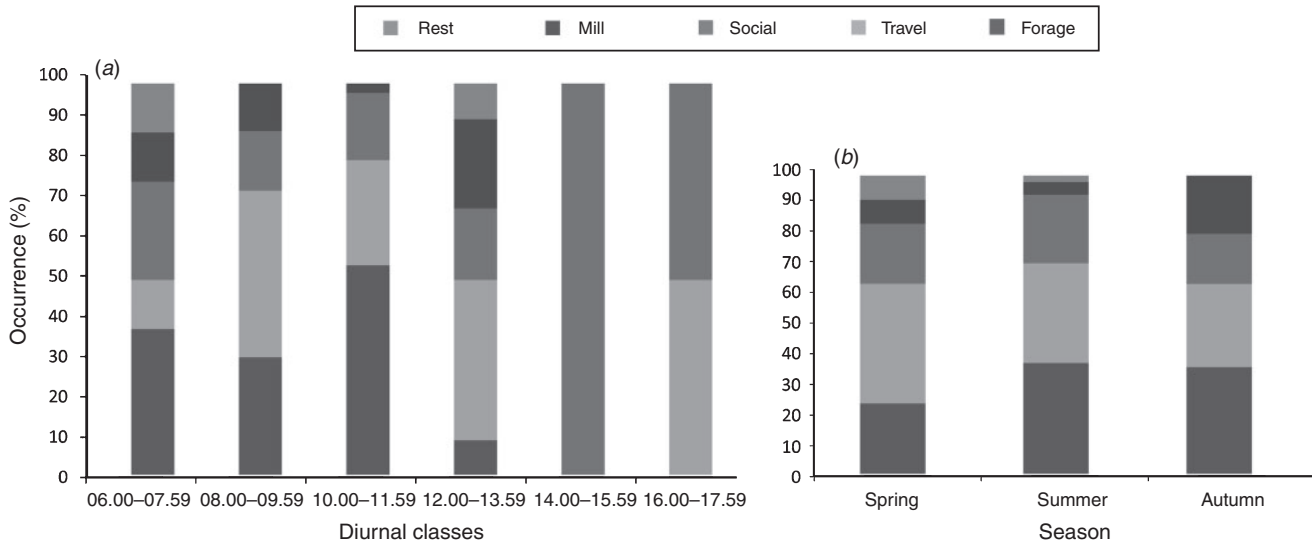


Fig. 4. Temporal variation of behaviour for common dolphin groups ( $n = 109$ ) observed between 2005 and 2008 in Gulf St Vincent, South Australia: (a) diurnal, (b) seasonal.

contained calves. Adults were the most frequently encountered age class in this population (60.3%). Groups containing neonates (mean group size = 8.6, s.d. = 6.3) or calves (mean group size = 6.9, s.d. = 4.3) as their youngest component were larger than groups containing adults (mean group size = 5.3, s.d. = 3.7) or juveniles (mean group size = 5.7, s.d. = 4) as their youngest component.

Behaviour did not vary significantly with group size ( $\chi^2_4 = 3.969$ ,  $P = 0.410$ ). Foraging ( $n = 3$ ) and socialising ( $n = 3$ ) groups accounted for 67% of all large groups observed, while foraging ( $n = 34$ ) and travelling ( $n = 35$ ) comprised the largest proportion of small groups, accounting for 34% and 35%, respectively. Resting was only encountered in small groups (100%;  $n = 3$ ), while milling and socialising were frequently recorded in small groups (81.8%;  $n = 9$  and 86.4%;  $n = 19$ , respectively).

Behaviour did not vary significantly with group composition ( $\chi^2_{12} = 17.499$ ,  $P = 0.132$ ), although groups comprising neonates or calves as the youngest component engaged in foraging more often than any other behavioural activity, 62.5% and 47.1% respectively. Groups comprising adults only engaged in travelling most frequently, accounting for 57.9% of observed groups. Overall, milling behaviour was mostly observed in groups that comprised calves (45.5%;  $n = 5$ ) or juveniles (45.5%;  $n = 5$ ). Groups containing juveniles as their youngest component accounted for 66.7% of all resting groups observed ( $n = 2$ ). Social (54.5%,  $n = 12$ ) behaviours were observed most in groups that contained juveniles as the youngest component, and least for groups comprising adults only (9.1%;  $n = 2$ ).

#### Multispecies aggregations

Common dolphins were observed in aggregations with the following species: bottlenose dolphin (*Tursiops* spp.), flesh-footed shearwater (*Puffinus carneipes*), Australasian gannet

(*Morus serrator*), crested tern (*Sterna bergii*), black-faced cormorant (*Leucocarbo fuscescens*) and blue penguin (*Eudyptula minor novaehollandiae*). Due to the limited sample size of most aggregations, only the presence/absence of flesh-footed shearwaters is discussed.

Common dolphin-only groups were observed during 58.7% of encounters ( $n = 64$ ). Behaviour varied significantly between single-species groups and multispecies aggregations ( $\chi^2_4 = 35.004$ ,  $P < 0.001$ ), with 78.4% of all foraging behaviour observed for common dolphins ( $n = 37$ ) occurring in the presence of other species. Travelling ( $n = 30$ ) and socialising ( $n = 18$ ) were more prominent in single-species groups than multispecies aggregations, with single-species groups accounting for 83.3% and 81.8% of all travelling and socialising groups, respectively. The majority of resting common dolphin groups (66.7%,  $n = 2$ ) were observed in the absence of other species. Milling was observed almost equally between single-species groups (54.5%,  $n = 6$ ) and multispecies aggregations (45.5%,  $n = 5$ ).

Flesh-footed shearwaters were observed in aggregations with common dolphins during 29.4% of dolphin encounters ( $n = 32$ ). Behaviour of common dolphins varied significantly when shearwaters were present ( $\chi^2_4 = 29.802$ ,  $P < 0.001$ ), with 62.2% of foraging common dolphin groups ( $n = 23$ ) occurring in the presence of shearwaters. Shearwaters were observed following dolphins, flying to locations where dolphins surfaced. Once dolphins began actively feeding, shearwaters would typically commence diving, frequently surfacing with prey visible in their beaks.

#### Discussion

Effective conservation of a population requires understanding spatial and temporal fluctuations in behaviour, as this provides insight into how a population uses its environment. In GSV there was a significant relationship between the behaviour of common

dolphins and diurnal cycles, and between behaviour and the presence of associated species. However, season, water depth, SST and group size and composition had no apparent relationship with behaviour of common dolphins. This study provides first insights into the behaviour of common dolphins in the coastal waters of GSV. However, as this is the first study to examine the activity budget of common dolphins in Australian waters, there is no opportunity to examine similarities and differences between GSV and other Australian regions.

Food availability is regarded as the most important factor in determining an animals' activity budget (e.g. Powers and McKee 1994; Bertolino *et al.* 2004; Hanya 2004). Behavioural data presented here reveal foraging and travelling to be the most prevalent behavioural states, accounting for 33.9% and 33% of the activity budget for GSV common dolphins, respectively. This is almost double the amount of foraging reported by Neumann (2001) (17%) for common dolphins of the Bay of Plenty (BOP). The comparatively lower proportion of foraging and higher proportion of time devoted to travelling (55.6%) in the BOP compared with GSV likely reflects differences between the two environments, e.g. open seas of the BOP versus relatively enclosed waters of GSV. Cribb *et al.* (2008) suggested that prey distribution is the key factor that determines cetacean distribution in GSV, not the physical and chemical properties of the environment, and thus it is likely that differences in common dolphin foraging and travelling times between the BOP and GSV reflects differences in prey type, distribution and abundance. GSV is an area of high marine biodiversity and the availability of key prey species within GSV waters (e.g. Kemper *et al.* 2005) potentially explains why dolphins spend more time foraging with reduced travelling within GSV. Bearzi (2003) reported that dolphins (*Delphinus* spp.) of Santa Monica Bay, California, spend ~30% of their time foraging and diving, a proportion considered high and a likely consequence of available primary productivity (Bearzi 2005). Thus, it would appear reasonable to suggest that the productive waters of GSV offer similar foraging opportunities to Australian common dolphins.

Diurnal peaks in foraging activity have been frequently reported for other cetacean species (e.g. Azevedo *et al.* 2007; Miller *et al.* 2010). Within GSV, common dolphins had a high frequency of morning feeding activity although, as Neumann (2001) hypothesised, a second offshore nocturnal peak was possibly undetected. This suggestion is supported by Meynier *et al.* (2008), who found both inshore and offshore prey species within the stomach contents of common dolphins examined post-mortem from the Hauraki Gulf. Furthermore, in many populations worldwide, common dolphins have been shown to feed on species found in the deep-scattering layer (e.g. Young and Cockcroft 1994; Scott and Cattanaach 1998). Investigations into the diet of Australian common dolphins concur, indicating that common dolphins in South Australian waters exhibit a high degree of foraging plasticity (Kemper and Gibbs 2001).

Seasonal variation in foraging activity was not evident in GSV; however, foraging behaviour was observed most frequently in groups that contained calves or neonates, supporting the suggestion that groups containing mothers have high energetic requirements (Kastelein *et al.* 2002). While uneven distribution

of survey effort across seasons and limited behavioural sample sizes inhibit any meaningful conclusions from being drawn, a former study that assessed the proportion of immature dolphins (juveniles, calves and/or neonates) within GSV indicates that this area is likely important for nursing common dolphins (Filby *et al.* 2010).

In GSV, resting accounted for just 2.8% of the activity budget, which is comparable to the 0.4% reported by Neumann (2001) for New Zealand common dolphins. However, this result is possibly an under-representation given the inconspicuous surface activity of resting common dolphins. The approach of the research vessel may initiate a change from resting to other behaviours, thus producing a bias. For example, common dolphins are known to be attracted to vessels to bow ride and therefore may change their behaviour from resting to travelling (Filby *et al.* 2010). This bias was minimised in the current study since behaviour was assessed on initial sighting of the group, i.e. before any apparent reaction to the vessel. Resting was observed predominantly in the early hours of the morning, indicating that common dolphins may use this time to recover from nocturnal foraging bouts, as has been suggested for numerous delphinid species (e.g. Evans 1971; Mate *et al.* 1995; Elwen *et al.* 2009). Resting behaviour was observed only in groups that contained juveniles or adults, but the small sample size constrains interpretation of the findings. Due to heavy commercial and recreational traffic (Lavery *et al.* 2008), GSV is not well suited for resting dolphins.

Approximately 10% of the activity budget for GSV common dolphins was attributed to milling behaviour, comparable to the 9.5% reported for common dolphins from the Hauraki Gulf (Stockin *et al.* 2009), but considerably less than the 20.5% reported for BOP by Neumann (2001), who suggested that milling may often act as a transitory state before the onset of foraging. Given that more foraging was observed within GSV compared with the BOP, it would appear that this suggestion is plausible.

Social behaviour accounted for 20.2% of the activity budget for common dolphins in GSV. This is slightly higher than that previously reported for this species (Neumann 2001; Stockin *et al.* 2009). Social behavioural events observed during the present study included: rubbing of the pectoral flippers and belly-to-belly contact (with and without copulation). In GSV, socialising occurred in smaller group sizes, more frequently during summer and in groups comprising juveniles as the youngest group component.

Foraging common dolphin groups were observed 78% of the time in the presence of other species, namely shearwaters. A bias in both the amount of foraging behaviour and multispecies aggregations recorded was anticipated since birds were commonly used as sighting cues for the observers to detect dolphin groups. However, Stockin *et al.* (2009) reported no significant differences in the prevalence of conspicuous surface behaviours (e.g. feeding) for New Zealand common dolphins when comparing *initial* versus *lagged* behavioural states. Thus it is plausible that the prevalence of foraging behaviour in GSV is not a bias, but rather a representation of the feeding importance of GSV to the population.

Multispecies aggregations have frequently been reported for mammals, and serve various functions including: increased



predator protection; foraging opportunities and/or to provide a social advantage (see Stensland *et al.* 2003 for a review). Delphinids are frequently observed in multispecies aggregations containing other cetaceans (Frantzis and Herzing 2002; Querouil *et al.* 2008) and have also been reported in aggregations containing large tuna (*Thunnus* spp.) (e.g. Buckland *et al.* 1992; Das *et al.* 2003; Rogan and Mackey 2007) and various avian species (e.g. Evans 1982; Martin 1986; Clua and Grosvalet 2001; Svane 2005; Finn and Calver 2008). Results presented herein suggest that the main determinant of mixed-species aggregations for common dolphins in GSV is probably food related, as dolphins engaged in mixed-species aggregations were primarily engaged in foraging activities. Resting, milling and social behaviours were rarely observed for GSV common dolphins in the presence of any other species, further supporting feeding as being the primary mechanism for these multispecies aggregations.

Vaughn *et al.* (2008) found that dusky dolphins (*Lagenorhynchus obscurus*) in New Zealand waters increased prey accessibility for bird species by decreasing depth and mobility of prey, and making it easier for the seabirds to locate prey. The high frequency with which shearwaters feed with common dolphins in GSV suggests that a similar pattern may be occurring. The results of this study indicate that feeding aggregations are a consistent feature of the foraging ecology of common dolphins and shearwaters in GSV.

The activity budget obtained herein offers first insights into the behaviour of Australian common dolphins, indicating that GSV is likely an important foraging ground for common dolphins. As this population is vulnerable to adverse impacts from the large-scale fishing operations in this region (Hamer *et al.* 2008), future research is required to monitor dietary requirements and interactions with fisheries to assess whether fishing management measures need to be implemented within South Australian waters. Outcomes from this research could be used to implement 'no go zones' for commercial fishing fleets where common dolphins frequently forage if needed, to prevent a decline in the population, as occurred to the common dolphin population in the Mediterranean Sea (Bearzi *et al.* 2008).

Given the recent introduction of dolphin tourism in GSV and the apparent susceptibility of foraging common dolphins to tour boat interactions in New Zealand (reduced foraging bouts when tour vessels are present) (Stockin *et al.* 2008), it is important to understand the importance of GSV waters for foraging common dolphins. This is of notable importance given that, worldwide, a variety of short-term changes in behaviour in response to tourism activity has been detected for numerous cetacean species (Lemon *et al.* 2006; Stamation *et al.* 2007; Williams and Ashe 2007; Carrera *et al.* 2008; Dans *et al.* 2008; Duprey *et al.* 2008; Stockin *et al.* 2008; Arcangeli *et al.* 2009; Lusseau *et al.* 2009). Long-term studies indicate that these short-term behavioural changes can lead to detrimental long-term consequences (e.g. decreased foraging opportunities or increased energy expenditures (Stockin *et al.* 2008), decreased reproductive success (Bejder 2005) and increases in mortality rates (Dans *et al.* 2008; Courbis and Timmel 2009)) for individuals and their populations (Lusseau and Bejder 2007).

This study provides first insights into the behaviour of common dolphins in Australian waters, but further research into the behaviour of common dolphins within GSV and South Australian waters is recommended. More extensive behavioural sampling is required to determine whether any short-term behavioural changes are occurring as a result of human-induced impacts (e.g. dolphin tourism or fishing industries), so that appropriate management actions can be initiated (e.g. restriction on the timing of dolphin tour interactions to times when they are less likely to be foraging and/or implementation of 'no go zones' for commercial fishing industries). It is recommended that future research examines the interactions between dolphins and the tourism industry, via before-, during-, and after-tourism interactions behavioural studies. Wise management of GSV's marine resources will help prevent short-term changes leading to potential population effects for common dolphins in this region.

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