The Activity budget of free-ranging common dolphins (*Delphinus delphis*) in the northwestern Bay of Plenty, New Zealand

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Abstract

This study presents findings on seasonal and diurnal behavioural patterns of short-beaked common dolphins (*Delphinus delphis*) off the east coast of New Zealand's North Island. Data on the activity state of focal groups were collected by instantaneous scan-sampling at 3 min intervals from a 5.5 m rigid-hull inflatable boat. Predominant group activity was classified as one of 5 categories. The overall proportion of time spent in these activities was 54.8% traveling, 20.5% milling, 17% feeding. 7.3% socializing, and 0.4% resting. Comparisons with activity budgets of bottlenose dolphins indicated a roughly similar pattern. Time-of-day and time of low tide appeared to influence diurnal common dolphin behaviour. Seasonal fluctuations in activity budget did not show a consistent trend. The role of sea surface temperature and prey availability in affecting common dolphin movements is discussed. Mean group size peaked in late summer at 140 individuals. Overall, the average number of individuals in a group was 55.1. Group composition appeared to be rather fluid, because fission and fusion of groups were observed frequently. Low photo-identification resighting rates suggested a large, possibly transient population. The present activity budget provides valuable information on the behaviour of free-ranging common dolphins, which could be useful in the conservation and management of this species.
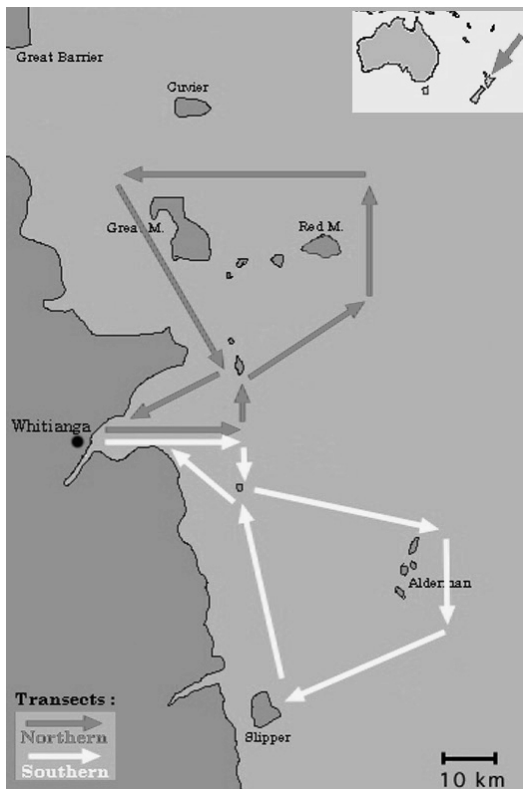
Key words: common dolphin, *Delphinus delphis*, behaviour, activity budget, distribution, traveling, feeding, group formation.

Introduction

Activity budgets can provide valuable insights into how animals interact with each other and their environment. They provide information on how a population is affected by changes in habitat, food supply, reproductive efforts, and many other physiological, social, or environmental parameters.

Activity budgets have contributed to a better understanding of a wide range of species: from birds (Mock, 1991; Stock & Hofeditz, 1996) to squirrels (Wauters *et al.*, 1992), antelope (Maher, 1997), moose (Miquelle, 1990), bighorn sheep (Goodson *et al.*, 1991), otters (Ostfeld *et al.*, 1989), and bats (Charle-Dominique, 1991). Studies on primates have linked variations in activity budgets to habitat differences (Isbell & Young, 1993; Watts, 1988; Defler, 1996), food availability (Adeyemo, 1997), predation pressure (van Schaik *et al.*, 1983), or sex and age of the animals (Marsh, 1981; Post, 1981; Baldellou & Adan, 1997). In cetaceans, activity budgets helped identify behavioural patterns for killer whales, *Orcinus orca*, (Heimlich-Boran, 1987), Pacific white-sided dolphins, *Lagenorhynchus obliquidens* (Black, 1994), dusky dolphins, *Lagenorhynchus obscurus* (Würsig & Würsig, 1980), harbour porpoises, *Phocoena phocoena*, (Sekiguchi, 1995), and bottlenose dolphins, *Tursiops truncatus*, (Shane, 1990*a,b*; Hanson & Defran, 1993; Waples, 1995; Bearzi *et al.*, 1999). This study provides the first activity budget for free-ranging common dolphins, *Delphinus delphis*.

Information on the activity budget of common dolphins was collected as part of a long-term study on the behaviour and ecology of this species in the greater Mercury Bay area, off Coromandel Peninsula, New Zealand (37°48′S, 175°53′E). Common dolphins can be found in all the world's oceans, particularly along the continental shelf regions (Gaskin, 1992). In New Zealand, the southern limit of their distribution is thought to be around 44°S near Banks Peninsula, with abundance presumed to increase towards the equator (Gaskin, 1968). Recently, morphological and genetic evidence led to the recognition of two distinct morphotypes, the short-beaked (*Delphinus delphis*), and the long-beaked common dolphin (*D. capensis*) as separate species (Heyning & Perrin, 1994). These occur sympatrically in many locations (Rosel *et al.*, 1994). Only the short-beaked form, has been reliably documented for the Mercury Bay study area, and hence is the subject of this study.

Figure 1. Study area showing typical survey routes. In top right, arrow indicates location of study area.

of the transect was then abandoned on most occasions. Surveys were only conducted in sea conditions of Beaufort 2 or less.

Data collection
To allow comparisons with other activity budget studies, sampling techniques were deliberately tailored after those employed by Shane (1990*a,b*) and Waples (1995) who studied the activity budgets of bottlenose dolphins. The instantaneous scan-sampling protocol follows Altmann (1974), and the terminology for sampling methods used below follows Mann (1999).

Focal group-follows with instantaneous scan-sampling of the predominant group activity formed the basis for the activity budget. Many researchers favour focal individual-follows over group-follows, because they tend to provide more accurate infor-mation and data are based on the "natural unit for analysis" (Mann, 1999). However, this was not the most appropriate option for this study for two reasons. First, groups were often large (>50 indi-viduals), and individuals were rarely recognizable from natural markings in the field, (although many could be distinguished after sightings, when looking at highly detailed photographs). Second, individ-uals frequently changed their position within the group. It would not have been possible to follow one individual continuously without driving the boat through the group, potentially causing considerable disturbance.

Instantaneous scan-sampling—To collect activity budget information, we scanned the focal group every 3 min and recorded data on the following variables:
activity state: This established the activity state in which more than 50% of the animals were involved at each time instantaneous sample. Five distinct activity states were identified. Their definition follows closely the "list of activities and surface behaviors" used by Shane for bottlenose dolphins (1990*a*):
resting–the animals stay close to the surface, surface at regular intervals and in a coordinated fashion, either not propelling themselves at all, or very slowly.
milling–animals frequently change direction, pre-venting them from making headway in any one direction and they remain in the same area. Often different individuals will be swimming in different directions, but frequent directional changes keep them together in a group.
traveling–animals propel themselves at a sustained speed, all swimming in the same direction and making noticeable headway.
feeding–animal chases or captures prey items close to the surface.

Materials and Methods

Study area and surveying
Observations were conducted in the greater Mercury Bay area, based from Whitianga, on the east coast of Coromandel Peninsula, North Island, New Zealand (Fig. 1).

The research vessel "Aihe", a 5.5 m centre-console, rigid-hull inflatable with a 90 hp outboard served as observation platform. Boat-based obser-vations were the only option in this study, because common dolphins in this area spend most of their time >10 km from the nearest shoreline.

The search for dolphins was conducted along two basic transect lines, a northern one and a southern one (Fig. 1). Because the entire study area could not be covered on one tank of fuel, surveys alternated between the two transect lines. On transect, the waters were continuously scanned for signs of dol-phins, particularly dorsal fins and splashes, but also feeding gannets because of their known association with feeding common dolphins (Gallo, 1991). The first group of dolphins encountered on these sur-veys served as the focal group, and the remainder

socializing–physical interactions among animals (except mothers and calves), ranging from chasing to body contact, or copulation.

Number of animals in the group—The number of dolphins was recorded in three age-group categories:
newborns–young calves still with fetal folds, or such animals that were of typical "fetal-fold" size, but folds were not apparent.
calves–dolphins ranging in size from 1.5 times that of a newborn to 75% of adult size, as long as they were still traveling in the typical calf position alongside an adult female.
adults–any dolphin not belonging to either of the two categories above. These are apparently fully grown individuals (1.8 to 2.2 m in length)— physically mature, but not necessarily sexually mature (Collet & St. Girons, 1984). Estimates of the number of dolphins in a group were conservative, and always based on the minimum number of positively identified individuals.
Environmental variables—Sea-state, including wind-direction and -speed, sea surface temperature (30 cm below the surface with a hand-held swimming pool thermometer), and the time of the nearest low-tide for each sighting were also recorded. The group's latitude/longitude coordinates were recorded with a hand-held GPS, and later the depth at these locations was taken from the area's navigational charts.

Photo-identification
This non-intrusive method for identifying individual animals is well-established for dolphins and other cetaceans (Würsig & Würsig, 1977; Würsig & Jefferson, 1990). It is based on the observation that each dolphin's dorsal fin has a unique shape and pattern of nicks, notches, and scars. Compared to bottlenose dolphins, common dolphins showed very few nicks and notches in their dorsal fins, which made photo-identification much more difficult. However, these animals showed a great variation in fin coloration. It ranged from black all over to a white central area with a dark rim. Observations of captive common dolphins in Marineland, Napier, New Zealand, confirmed that these colour patterns are stable over long periods (several years, D. Kyngdon, pers. comm.). However, they are not necessarily mirror images on either side of the fin, therefore right-side and left-side views had to be analyzed independently. The uniqueness of a dorsal fin's outline (including nicks and notches), combined with its colour pattern was used for identification in this study. Opportunistic photographs were taken close to the boat during group-follows with a Canon EOS 300 camera with a 35–200 mm zoom lens on Fujichrome 100 ASA slide film.

Statistical analysis
Over 1500 individual data points were collected in 3-min interval scan samples. However, data collected subsequently on the same group cannot be assumed to be independent, and were therefore not used individually in the analysis. Only each focal group follow was regarded as an independent sample, and these were used as the units for statistical treatments (n=72).

T-tests, simple linear regressions, and chi-square goodness-of-fit tests were used to analyze data (Sokal & Rohlf, 1981).

Results

Field effort
Common dolphins were observed from December 1998 to April 1999, and from September 1999 to April 2000 in the greater Mercury Bay area, Coromandel Peninsula. Over the first field season (December 1998–April 1999, henceforth referred to as "season A"), a total of 109 hr were spent on the water in search of dolphins. This field effort resulted in 24.7 hr (=23%) spent observing focal groups of dolphins. Field effort over the second field season (September 1999–April 2000="season B") was 261 hr, 54.3 hr (=21%) of which were spent in focal group-follows of dolphins. Adverse sea conditions over the winter months (May–August) did not allow sampling to take place during that season.

Distribution
Dolphin groups were most frequently encountered outside the mouth of Mercury Bay. Sighting locations were concentrated around Castle Rock in season A, and in the area south of Ohinau in season B (Fig. 2). Dolphins were most commonly found in waters over 50 m in depth. Their distance to the nearest mainland shoreline varied considerably from 2 to 32 km.

Sighting success
While most sightings occurred in late summer, the success rate of encountering dolphins decreased over the field season (Fig. 3). A simple linear regression showed a significant decrease in encounter rate from September to April (r=0.88, df=7, P<0.01).

Time-of-day also played a role in sighting success. The later in the afternoon, the less likely we were to find dolphins (Fig. 4). Because of this, field effort was directed towards a.m.-hours. However, a chi-square test failed to show an association between time-of-day and sighting success at the P<0.05 level (χ^2=5.1, df=3).

A similar trend was observed for the relationship between sighting success and time of the nearest low tide (Fig. 5). The New Zealand coastline is subject
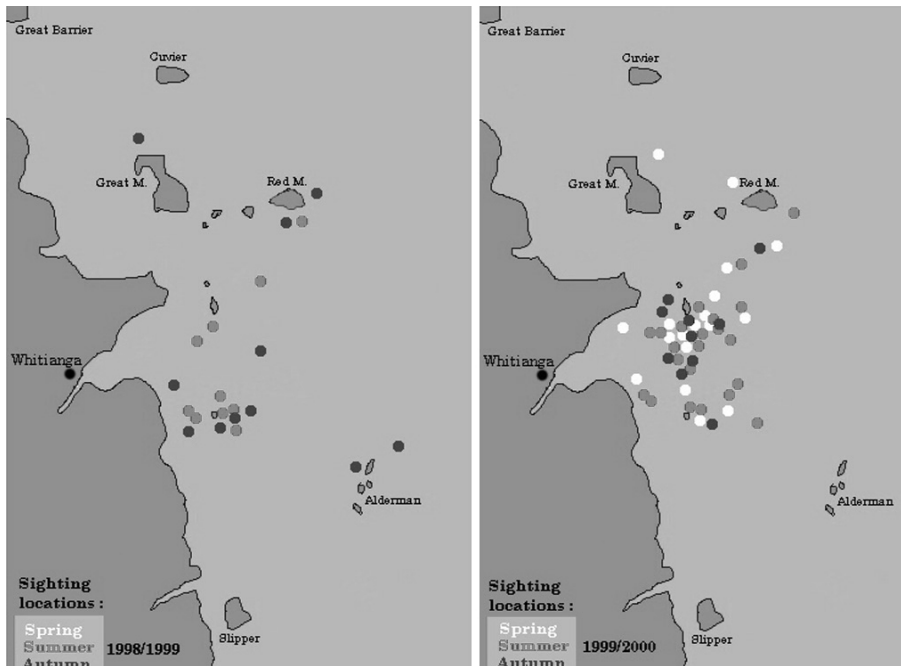
Figure 2. Distribution of common dolphin focal groups in the study area in 1998/1999 (left) and 1999/2000 (right).
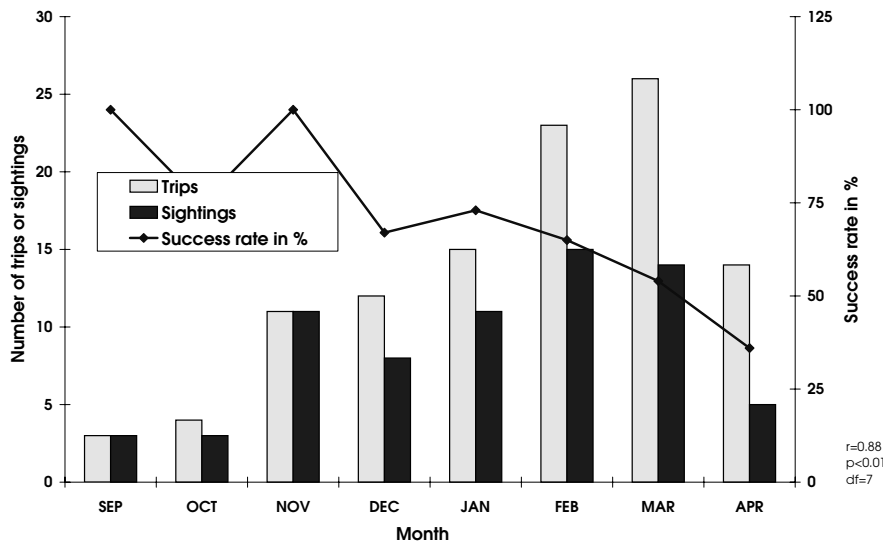

Figure 3. Seasonal fluctuations in sightings of common dolphins on survey trips.

to a diurnal tidal flow with 2 high tides and 2 low tides in any 24-hr period. Therefore, the maximum time between a sighting and the nearest low tide could never exceed 6 hr. Most sightings occurred closer to the time of low-tide, rather than later. However, this association was not statistically significant at the $P<0.05$ level ($\chi^2=5.16$, df=2, $P<0.1$).

Population demographics

Over the two study seasons, the number of individuals in focal groups encountered ranged from 3 to *ca*. 300, with a mean of 55.1 (SD=69.7, n=72). Mean group size varied seasonally, with the largest groups encountered in late summer/early autumn (Fig. 6). Photo-identification efforts resulted in a
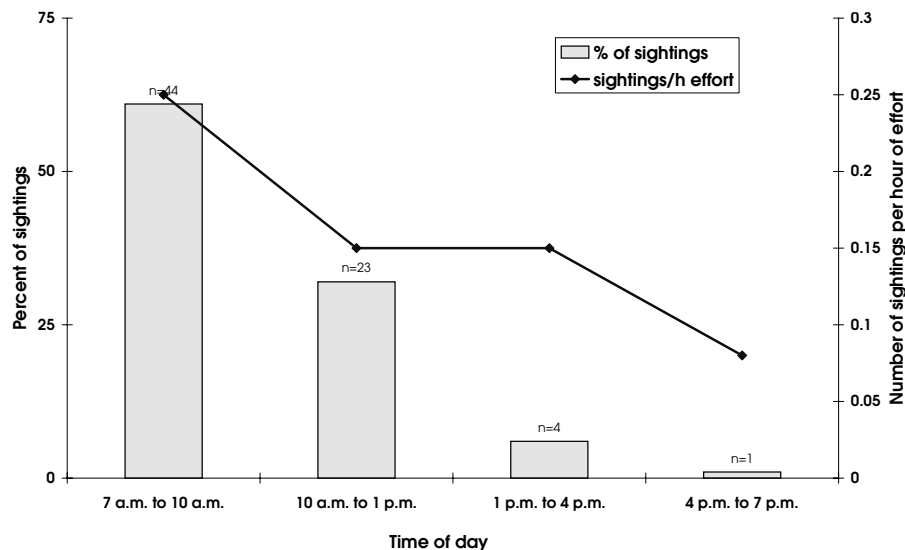
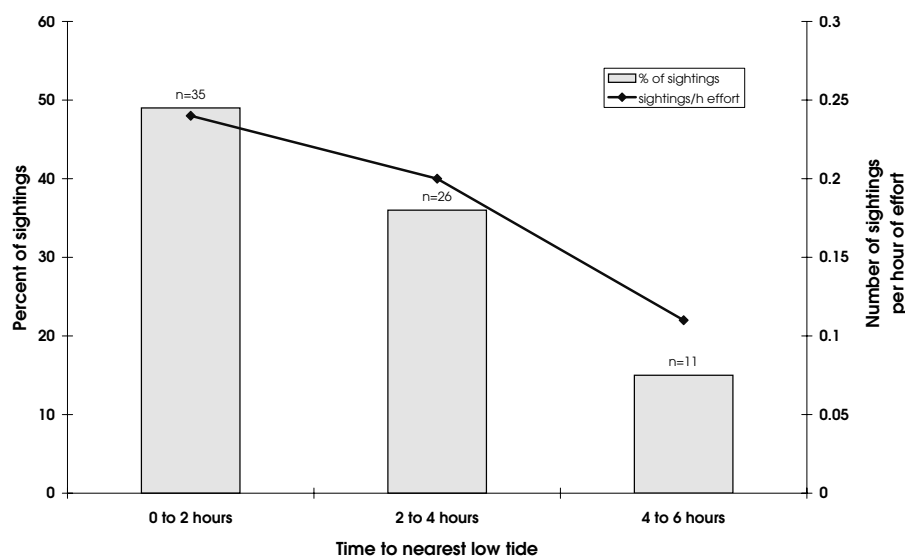**Figure 4.** Diurnal fluctuations in sightings.

Figure 5. Influence of tidal flow on sighting success of bottlenose dolphins.

catalogue of 411 identifiable individuals. This number most certainly does not represent the total population size. While photo-identification is often used for mark-recapture analyses in estimating abundance (Wells & Scott, 1990), this was not possible in this study, due to the large group sizes which made it impossible to photograph an adequate number of individuals for this purpose. There were only 8 resightings in season A and 14 in season B. From one season to the next, 8 matches were found. The "discovery rate" of new individuals did not approach an asymptote (Constantine &

Baker, 1997). Overall, this suggests a large, and likely transient population.

The number of calves in each group ranged from 0 to 15 with a mean of 1.9 per sighting (SD=10.4, n=72) (Fig. 7). The number of newborns in each group ranged from 0 to 6 with a mean of 1.6 per sighting (SD=5.6, n=72). While the number of newborns per group increased over the study season, this trend was not statistically significant (Fig. 8). It is however, worthwhile to note, that calves with fetal folds were observed throughout most of the field season (as early as October and as late as
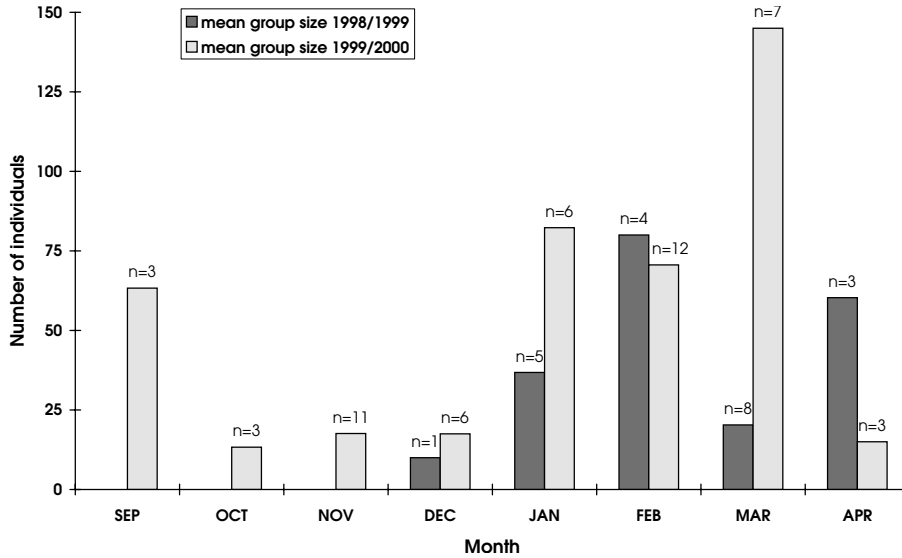
D. R. Neumann

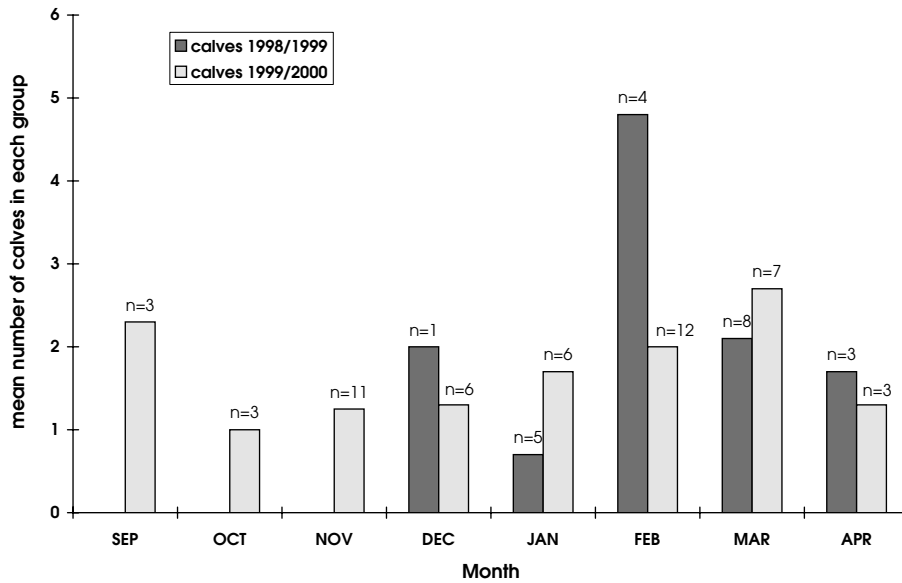**Figure 6.** Mean number of bottlenose dolphins in focal groups by month.

Figure 7. Mean number of bottlenose dolphin calves in focal groups by month.

April), suggesting that parturition for common dolphins in this area is not highly seasonal.

Activity budget
The time spent in each activity category during a sighting was calculated from the 3-min interval samples. The time spent in each category was added for all the sightings and the percent of time spent on each activity during focal group-follows

calculated. Common dolphins spent 54.8% of their time traveling, 20.5% milling, 17% feeding, 7.3% socializing, and 0.4% resting (Fig. 9).

Seasonal changes in activity
While the time spent in each activity category varied considerably from month to month, there is no statistically significant relationship between the time-of-year and certain activities (Fig. 10). The
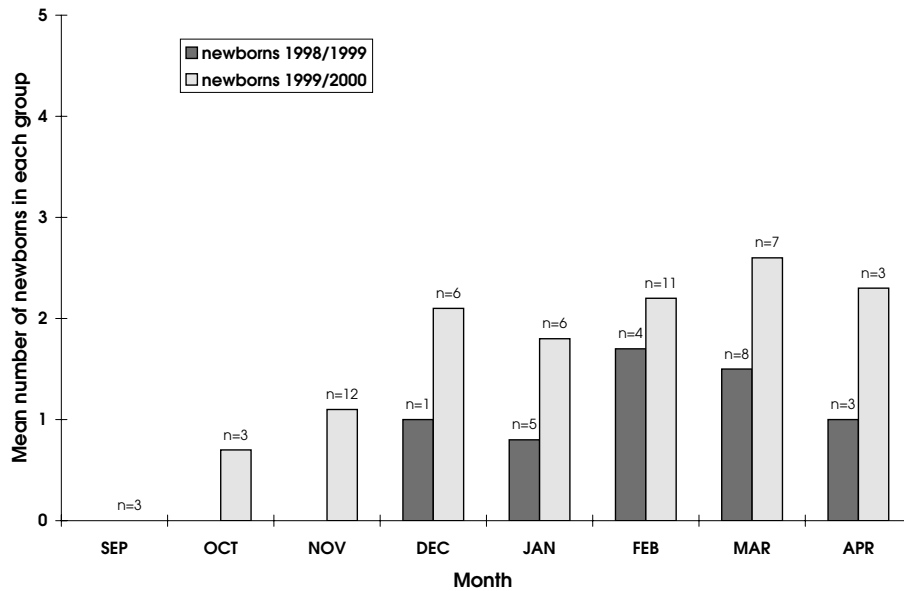
Figure 8. Mean number of newborn bottlenose dolphins in focal groups by month.
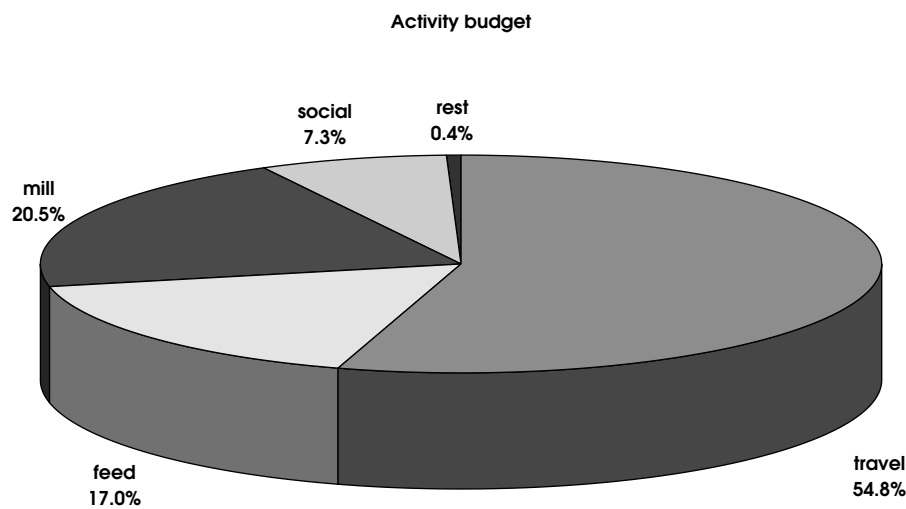

Figure 9. Budget of predominant group activity expressed as the percentage of time spent in each of 5 categories.

predominance of feeding over all other activities in September was notable, but requires further investigation, because it is based on a sample size of only n=3.

Activity and group size
A breakdown of the activity budget by group size showed that larger groups seem to be more involved in traveling (Fig. 11). Feeding activity was often observed when two smaller groups merged. Groups of more than 100 individuals showed a large proportion of feeding (21%), but so did medium-sized groups of 20–50 individuals (33%).

Groups of dolphins were observed to merge temporarily on 44 occasions (fusion). On 45 occasions, a group of dolphins split-up into 2 or more separate, smaller groups (fission). Fusion was usually followed by a change in behaviour. Thirteen times (30%) fusion was followed by sexual activity
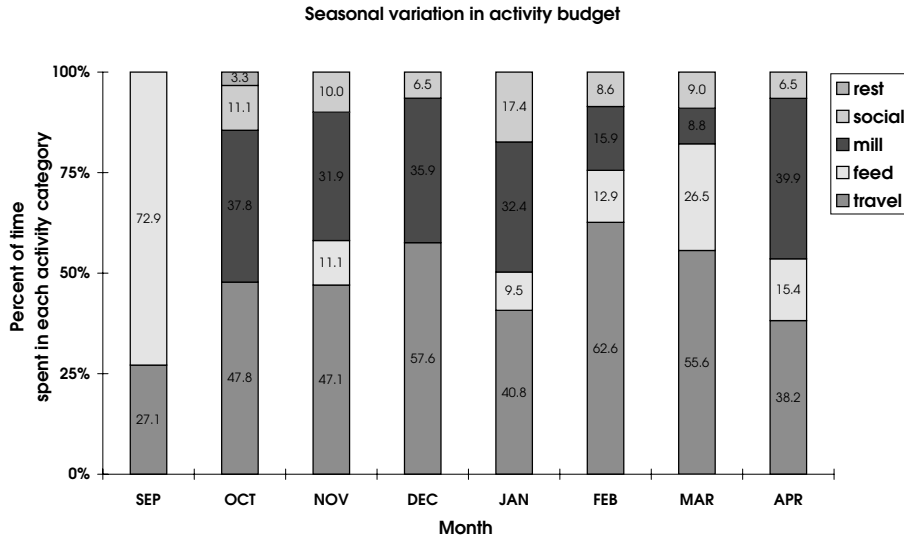
Seasonal variation in activity budget

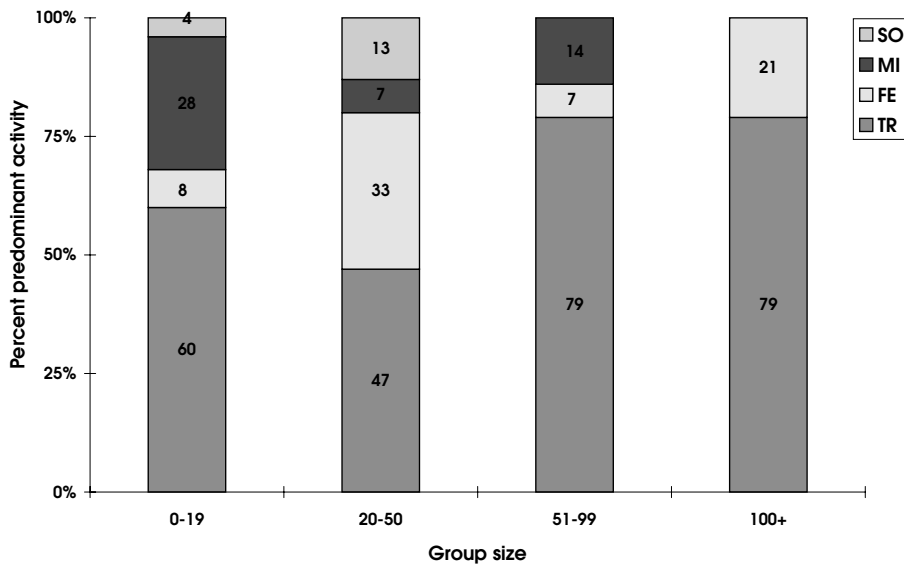Figure 10. Changes in activity budgets of bottlenose dolphin groups by month.

Figure 11. Variations in average activity budgets due to bottlenose dolphin group size.

among the members of the now enlarged group, eighteen times (40%) it was followed by cooperative feeding (Fig. 12). This change of behaviour occurred almost instantaneously after groups merged. In all cases, the focal group was initially either milling or feeding, when it was joined by additional dolphins. The association between fusion and a change to either sexual or feeding behaviour is highly significant ($\chi^2 = 8.49$, df=2, $P<0.025$).

There was an almost identical relationship between fission and sexual or feeding behaviour. Groups split-up significantly more often after

they had changed their original activity to sexual socializing or feeding ($\chi^2 = 9.61$, df=2, $P<0.01$). Only 30% of the time did fission occur without a prior change in activity to either sex or feeding (Fig. 13).

Discussion

Traveling and feeding

The activity budget showed that dolphins spent most of their time traveling (54.8%). This was no surprise, because daily and seasonal movements are

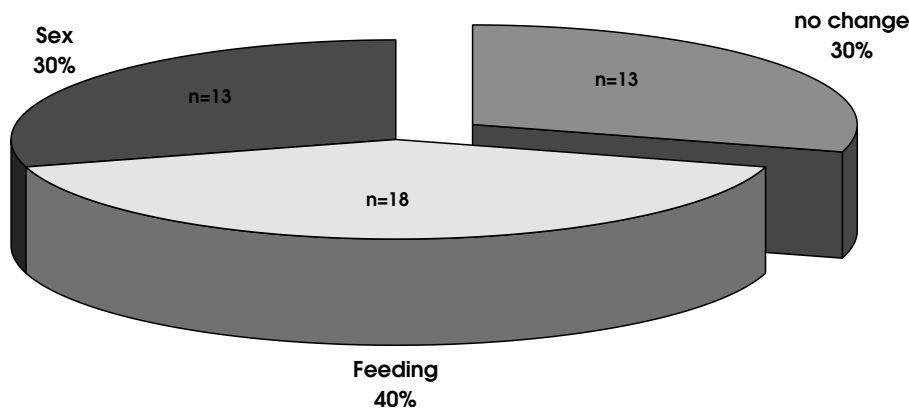**Percent of group fusion followed by change in activity**

Figure 12. Changes in activity immediately following the merging of two bottlenose dolphin groups.

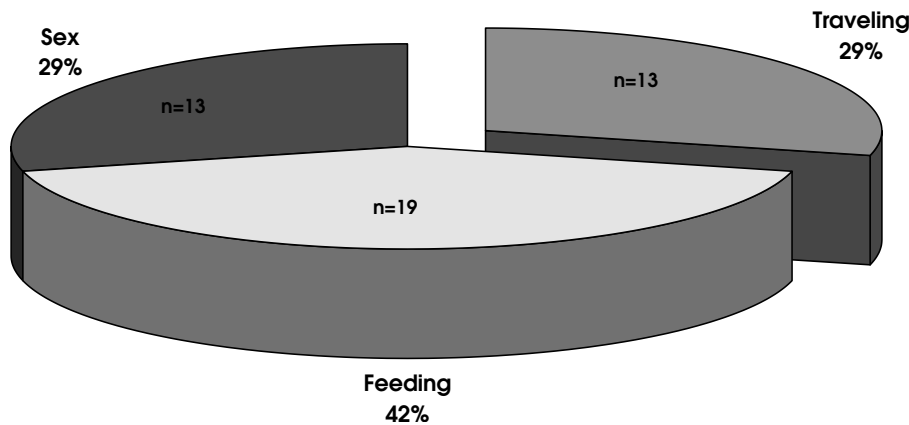**Percent of fission occurring after these activities**

Figure 13. Changes in activity immediately following the splitting-up of a focal bottlenose dolphin group into two or more smaller groups.

likely governed by the distribution and availability of prey. Food resources are rarely uniformly distributed throughout the environment. This necessitates travel between foraging locations. Because of this connection between traveling and feeding, the two activities are discussed here in the same section.

Access to special habitats or conspecifics could also play a role in common dolphin travel. The search for mating opportunities influences the movement patterns of bottlenose dolphins (Waples *et al.*, 1998). Many baleen whales seek special environments to give birth and to mate (Rice & Wolman, 1971; Clapham, 1996). Some bottlenose

dolphin mothers seek sheltered, shallow bays, during the first few weeks of the calves' life (Barco et al., 1999). However, such behaviours were not evident for common dolphins in this study.

Food availability is the single most important factor in determining an animal's activity budget (for examples see Goodson et al., 1991; Shepherdson et al., 1993; Westerterp et al., 1995; Stock & Hofeditz 1996; Adeyemo, 1997; Baldellou & Adan, 1997). Other activities can be assumed to become more frequent, only after nutritional needs have been satisfied (Doenier et al., 1997).

Common dolphins spent 17% of their time feeding. In bottlenose dolphins, daily food requirements have been calculated to range between 4–6% of body weight (Shapunov, 1971; Shane, 1990b). Assuming the same kind of range for common dolphins and a typical adult weight of 100 kg (Collet & St. Girons, 1984) this would work out to about 5 kg of prey per day. Whether or not 17% of a common dolphin's daily activity budget would be sufficient to catch that amount of prey is a matter of speculation. On some occasions, prolonged feeding sessions that lasted over 40 min were observed, while on others the dolphins were involved in short 2–5 min bouts of "snacking". Again, prey abundance is probably the critical factor. When dolphins cooperatively round up a large school of fish [as described by Bel'kovich et al. (1991) as "carouseling" and also observed in this study], individual prey intake is probably very high and would require little time.

Due to the conspicuous surface activity during feeding, and the frequent presence of gannets (acting as "beacons"), it could be argued that feeding is overrepresented in this activity budget, because the likelihood of spotting dolphins was greater when they were feeding. However, I suspect that this study actually missed a large proportion of the dolphins' feeding activity, namely at night. Several studies on stomach contents of Delphinus stress the importance of various species of the deep-scattering-layer in their diet, particularly squid (Young & Cockcroft, 1994, 1995; Walker & Macko, 1999). Squid and myctophid lanternfish are known to undertake diurnal vertical migrations, rising closer to the surface at night, thereby becoming available to the dolphins. Squid is commercially fished in this area, and could play a role in the diet of Mercury Bay common dolphins. Unfortunately, we were unable to conduct night-time observations, which would help investigate this hypothesis.

Overall, common dolphins appear to be rather opportunistic feeders, with prey items varying, according to whichever species happens to be in great abundance at a given time (Young & Cockckroft, 1994). While knowledge of prey species in Mercury Bay is limited to 7 sightings during which prey species could be identified visually (Francis, 1996),

this rather opportunistic feeding pattern is supported by my observations. Fish species that were observed to be taken by common dolphins were kahawai (Arripis trutta), jack mackerel (Trachurus novaezelandiae), yellow-eyed mullet (Aldrichetta forsteri), flying fish (Cypselurus lineatus), parore (Girella tricuspidata), and garfish (Hyporamphus ihi).

While common dolphins were encountered in the 500 km^2 study area on a regular basis over several months, this does not necessarily indicate that these dolphins are resident. The low frequency of individual resightings suggests a succession of more or less transient dolphin groups over time. Defran et al. (1999) found that bottlenose dolphins in the Southern California Bight travel back and forth along the coast for distances of up to 470 km and possibly beyond. They remain in a very narrow corridor within 1 km from shore and do not appear to mingle with bottlenose dolphins around the Channel Islands, 42 km from shore (Defran & Weller, 1999). Defran et al. (1999) attributed the need to cover large distances in this area to low food abundance and patchy prey distribution.

Distribution and abundance of small fishes is strongly tied to a number of environmental variables. For example, fish often aggregate around any kind of structure, fixed or floating, possibly for shelter (T. Mulligan, pers. comm.). Areas of rapidly changing seafloor relief (e.g., seamounts) can also act as such structures. Depending on upwelling-conditions, such areas may not only provide shelter, but may also be richer in nutrients. There were two "hot spots" for dolphin sightings in Mercury Bay: south of the island of Ohinau, and around Castle Rock (Fig. 2). Castle Rock rises almost vertically from a depth of 50 m. Southeast of Ohinau are two undersea rises that extend from a depth of 50–70 m to within 12 and 24 m of the surface, respectively. These two locations present areas of high sea floor relief, which common dolphins have been shown to prefer in various studies, probably because fish tend to concentrate there (Hui, 1979; Selzer & Payne, 1988).

Sea temperature is a further factor in determining fish abundance and distribution. Some fish species can only survive within a very narrow temperature spectrum (Rose & Leggett, 1988). Rapid drops in temperature can kill-off entire fish populations (Hanekom et al., 1989), while a slight increase of sea surface temperature (SST) due to an El Niño event increased the reproductive output of herring (Tanasichuk & Ware, 1987). While data on the abundance and distribution of dolphin prey in the study area were not available, the dolphins' movements seemed to be closely linked to SST. While the waters were warm in mid-summer, dolphins were found relatively close to shore. As SST dropped in
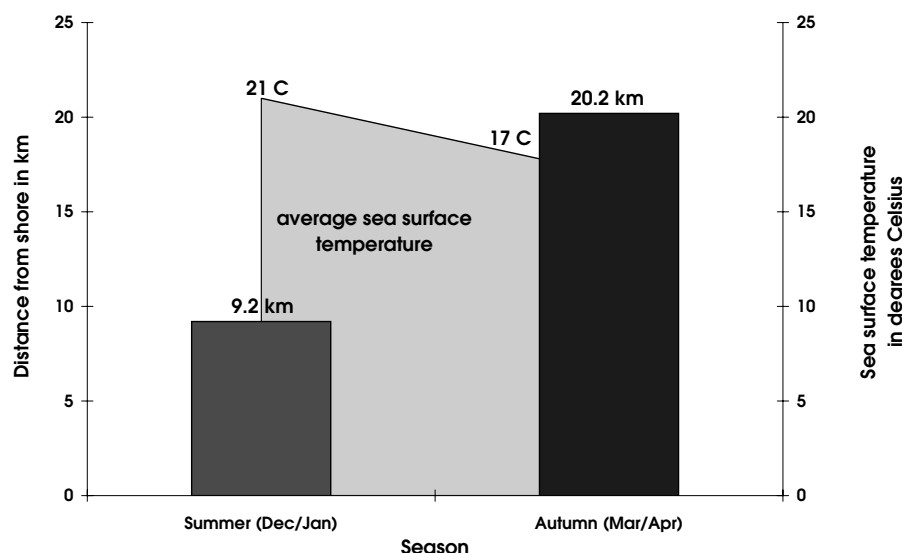
Figure 14. Seasonal changes in the average distance of bottlenose dolphins from the mainland shoreline at which focal groups were encountered.

autumn, dolphins were found increasingly farther from shore (Fig. 14). Constantine and Baker (1997) also found a correlation between common dolphin distribution and SST in the Bay of Islands. There, the trend was exactly reversed. Common dolphins were in shallow water during winter months, when SST was lowest. In summer, when SST was highest, they were seen in deep water outside the Bay. It is possible that the oceanographic patterns in the Bay of Islands created a nutrient- and prey distribution different from that in the much more exposed Mercury Bay area.

Common dolphins are found throughout a wide range of sea temperatures, from equatorial waters, to high latitudes. As a result, I consider it unlikely that SST is the primary factor influencing their distribution. A more likely explanation is that SST affects the distribution of common dolphin prey species, in turn causing the dolphins' seasonal movements (Neumann, 2001). Common dolphins follow the temperature-driven migrations of prey along the South-east coast of South Africa, where they follow the seasonal migration of pilchards (*Sardinops ocellatus*) (Cockcroft & Peddemors, 1990). The findings of recreational and commercial fishermen in my study area suggested that this is a possibility for the common dolphins in the Bay of Plenty, as well. Fishermen also have to move farther offshore in autumn and winter in pursuit of commercial fish species, such as tuna and marlin, which are thought to share a number of prey species with common dolphins—in this area mainly kahawai (*Arripis trutta*) and jack mackerel

(*Trachurus novaezelandiae*) (A. Hansford & R. Rae, pers. comm.).

Milling
Milling was the second-most frequent activity (20.5%), but its role is difficult to assess. All that is noticeable from the surface during milling, is that the group does not make significant progress in any one direction. Their heading frequently changes, and they are not observed to feed, socialize, or rest during those times. Milling has been widely accepted as a behavioural category in the dolphin-literature (Shane, 1990*a,b*), but few attempts have been made at explaining its biological significance. Milling could mark a stage of foraging, when dolphins have reached a promising location and are now investigating a given area more closely for prey. Conversely, milling could be a brief rest-stop between bouts of traveling, or it could represent a transitional stage between traveling and resting/socializing/feeding. One could argue that milling is probably caused by all of the above, and happens to manifest itself to the observer in the characteristic non-directed movement classified as "milling".

Socializing
The focal group's activity was scored as socializing (7.3%) when more than 50% of the group were involved in conspecific interactions. These primarily involved sexual behaviour, signaled by belly-to-belly contact (with or without actual intromission). Chasing one another (which in rare cases included bites directed at the tailflukes, pectoral, or dorsal

fin) was also scored as a social activity. How much time can be devoted to socializing probably depends on how easily other more immediate requirements (e.g., food) can be satisfied. One might expect the time devoted to socializing to increase when prey is particularly abundant, and/or when females are receptive. Time devoted to socializing varied from month to month in this study, *albeit* without a consistent seasonal trend. Since data on dolphin prey abundance in this area, or on the reproductive state of female individuals were not available, I cannot determine whether these were correlated to the frequency of socializing.

Common dolphins engaged much more often in sexual contact than would be required for breeding. Homosexual behaviour and sexual activity by immature animals were observed frequently. This suggests that sexual behaviour in common dolphins might be used to establish social bonds, perhaps even dominance hierarchies, as has been hypothesized for bottlenose dolphins (Östmann, 1991). The fact that sexual activity was observed mainly after two groups merged would further support this hypothesis (see below).

Resting
Only 0.4% of time was spent resting, but this was most likely an underrepresentation. When resting, dolphins showed virtually no conspicuous surface activity, which makes it difficult for an observer to spot such groups. Secondly, the approach of the research boat could have triggered a change in behaviour from resting to any of the other 4 remaining categories. Interestingly, when resting was observed, it occurred between 10:35 a.m. and 11:50 a.m. in both season A (n=2) and season B (n=3). The small sample size precludes any statistical analysis, but it could pay to examine this time-frame more closely in the future, to find out if this might be a preferred resting period for common dolphins.

Seasonal changes in activity
Common dolphin behaviour did not indicate a consistent relationship between the time-of-year and certain activities.

Bräger (1993) attributed a seasonal increase in feeding activity by *Tursiops* in coastal Texas to higher energy requirements in colder winter waters and/or decreased availability of prey. Bighorn sheep increased their foraging time, when the nutrient value of available food decreased in winter (Goodson *et al.*, 1991). Adeyemo (1997) found that green monkeys traveled more, to forage throughout a greater area, when food was less abundant during the dry season. For common dolphins in this study, foraging effort itself does not appear to change seasonally. It is rather the foraging location that

changes with decreasing water temperatures in autumn (Neumann, 2001).

Diurnal activity patterns
Common dolphins were encountered much more frequently in the morning, than in the afternoon. This could be the result of:

(1) dolphins spending most of their afternoons outside the study area, or
(2) dolphins remaining in the study area, but becoming less conspicuous to the observers because they were either engaging in more sedate activities (e.g., resting), or had split into smaller groups, or both. Smaller groups are more difficult to spot over long distances than are larger groups. Scott & Cattanach (1998) reported an increase of mean group size of common dolphins in the Eastern Pacific from morning to early afternoon, followed by a decrease in the evening. This does not seem to be the case in this study area.

In various locations bottlenose dolphins exhibit two diurnal peaks in feeding activity—one in the early morning, and one in the late afternoon (Bräger, 1993; Hanson & Defran, 1993). There was also a high frequency of early-morning feeding for common dolphins in this study. Feeding activity could peak again in the late afternoon, but this does not appear to occur within the study area. If one assumes that common dolphins here also feed on species of the deep-scattering layer as they do elsewhere (Young & Cockcroft, 1994, 1995; Scott & Cattanach, 1998), then this second feeding peak could appear around dusk or shortly thereafter, once the deep-scattering layer rises close to the surface. One group of dolphins observed in the late afternoon, was traveling at a sustained high speed directly towards the continental shelf, and never deviated from this heading. This group-follow had to be abandoned because of the increasing distance from shore, but if the dolphins maintained the same speed and heading, it would have put them right over the continental shelf (200 m isobath) at sunset. This is where deep-scattering layer species presumably would be abundant. In a study based on acoustic recordings of common dolphin sounds, Goold (2000) found acoustic contact to peak in the middle of the night, and reach a low in the late afternoon, before it started to increase again around dusk. He attributed this to increased sound production during night-time feeding.

Group formation
Groups of dolphins were observed to merge temporarily on 44 occasions (fusion). On 45 occasions, a group of dolphins split-up into 2 or more separate, smaller groups (fission). Fusion was usually

followed by a change in behaviour. Thirteen times (30%) fusion was followed by sexual activity among the members of the now enlarged group, eighteen times (40%) it was followed by cooperative feeding (Fig. 12). This change of behaviour occurred almost instantaneously after groups merged. In all cases, the focal group was initially either milling or feeding, when it was joined by additional dolphins. The association between fusion and a change to either sexual or feeding behaviour is highly significant ($\chi^2=8.49$, df=2, p<0.025).

There was an almost identical relationship between fission and sexual or feeding behaviour. Groups split-up significantly more often after they had changed their original activity to sexual socializing or feeding ($\chi^2=9.61$, df=2, p<0.01). Only 30% of the time did fission occur without a prior change in activity to either sex or feeding (Fig. 13).

Merging of groups was, in most cases, directly followed by either sexual activity, or feeding. When groups split into smaller groups, this fission occurred mostly directly after mating or feeding. This suggests that groups of dolphins seek other groups specifically for the purposes of mating or feeding. An increase in sexual activity upon the fusion of groups has also been observed by Slooten (1994) for Hector's dolphins, and by Würsig & Würsig (1979) for bottlenose dolphins. If sexual behaviour was just part of a social "greeting ritual", marking the encounter of two groups, one would not expect the groups to split again right after a sexual bout, as they did in this study.

A change in activity to feeding was observed in the focal groups, after they joined a second group that was already feeding. As a cooperative effort, feeding should be facilitated by a large number of dolphins joining forces. This is only true, however, as long as prey is abundant enough for each group member to profit. If prey are distributed in a large number of patches, each containing a small number of prey items, it probably becomes more efficient for dolphins to forage in smaller groups. Indeed, a large group could be forced to split-up and forage in separate areas to avoid competition. Scott & Cattanach (1998) suggested that common dolphins regularly split-up into smaller groups at night, when prey species become more widely dispersed.

While the maximum size of a group is probably determined by the availability of prey, there are likely selective pressures to form the largest possible group that can be sustained. Forming a group has obvious advantages: ready access to mates, cooperative foraging, but most importantly protection from predation (da Silva & Terhune, 1988). Common dolphins form much larger groups than bottlenose dolphins in the same area. Common dolphins are also much smaller than bottlenose dolphins, and therefore presumably more vulner-able to predation. Group formation could work as an antipredator-strategy. The more animals in a group, the less likely it becomes for each individual to be taken by a predator ("dilution effect" according to McWilliams *et al.*, 1994). Antipredator vigilance is also increased, while decreasing the "vigilance-workload" of each individual (Jarman & Wright, 1993; Scott & Cattanach, 1998).

Summary
To the best of my knowledge, no other study on the activity budget of common dolphins has yet been published. This is unfortunate, because it would provide an opportunity to examine similarities and differences between different populations, and perhaps determine how variations in habitat, or prey availability affect the behaviour of common dolphins. The best studied cetacean is probably the bottlenose dolphin. Variations in sampling protocols among authors make comparisons to this species difficult. Bearzi *et al.* (1999) collected data on focal groups of bottlenose dolphins in the Mediterranean in the same way as this study, but they classified the dolphins' behaviour as belonging to one of 9 separate categories. This mainly served to interpret the diving behaviour of the species, an aspect not focused on in this study. Hanson & Defran (1993) also used instantaneous sampling of focal group activity at 3-min intervals. Their values for traveling (63%) and feeding (19%) in the activity budget of Pacific coast *Tursiops* were similar to the results of this study. However, they did not recognize milling as a behavioural state. Instead, "playing" was included. With 3%, considerably more resting was observed than in this study (0.4%). This might be due to the fact that the Hanson & Defran (1993) study was shore-based, therefore eliminating the factor of potentially disturbing resting dolphins through the approach of a research vessel. Waples' (1995) results for *Tursiops* in Sarasota Bay are the product of boat-based focal individual sampling. She observed bottlenose dolphins spent an average of 67% of their time traveling, 14% milling, 13% feeding, 4% socializing, and 2% resting. Shane (1990b), using focal group-follows, found similar values in her Texas study area, compared to less traveling (48%) and more feeding (36%) at Sanibel Island, Florida.

Considering the obvious differences in data collection, habitat, group structure, and general ecology, it is remarkable that the activity budgets of bottlenose dolphins are similar to the one produced for common dolphins in this study. This is possibly an indication that, even though they are different species in different habitats, they are still faced with similar environmental pressures that lead the animals to pursue similar survival strategies.

This activity budget produced a "first look" at typical behavioural patterns of wild common dolphins and could serve as a baseline against which the influence of environmental, or demographic factors can be tested. It also will prove valuable in determining the effects of human disturbance on the behaviour of common dolphins. Activity budget studies can play an important role in species conservation and management, as proven by Stock & Hofeditz (1996).

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