Interactions between bottlenose dolphins and tour vessels in Port Phillip Bay, Victoria

Report to the Department of Natural Resources and Environment, Victoria
for the Sustainable Dolphin Tourism Program

October, 2001

Compiled by
Wendy Dunn, Ánika Goldsworthy, Deb Glencross & Kate Charlton
Dolphin Research Institute

Dolphin Research Institute Western Port Marina PO Box 77 Hastings Victoria 3915

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1. Introduction

This report contains a summary of data collected by the Dolphin Research Institute between the years 1997 and 2001. It was collected from a number of platforms including shore-based sites, Dolphin Research Institute vessels, and tour operator vessels. The summary data presented here was prepared as part of the Department of Natural Resources and Environment's Sustainable Dolphin Tourism Program and the completion of this report was funded under this program.

2. The bottlenose dolphin population in Port Phillip Bay

2.1 Background

There have been numerous studies on the bottlenose dolphin (*Tursiops truncatus*), making it one of the most studied cetaceans in the world. The species' range includes temperate and tropical waters worldwide, within open ocean or coastal waters including embayments, making them easy accessible for observation in the wild (Leatherwood and Reeves, 1990). The bottlenose dolphin is distributed continuously around the Australian coastline (Ross and Cockcroft, 1990) however, there have been only a handful of detailed studies on bottlenose dolphin populations (eg. Corkeron, 1990, 1997; Mandelc, 1997; Möller and Harcourt, 1998; Smolker, *et al.*, 1992). Most of these are populations from subtropical waters, including Shark Bay (WA), Moreton Bay (Qld), and Jervis Bay (NSW). In regards to dolphins in temperate Victorian waters, there have been few studies published and no population studies at all.

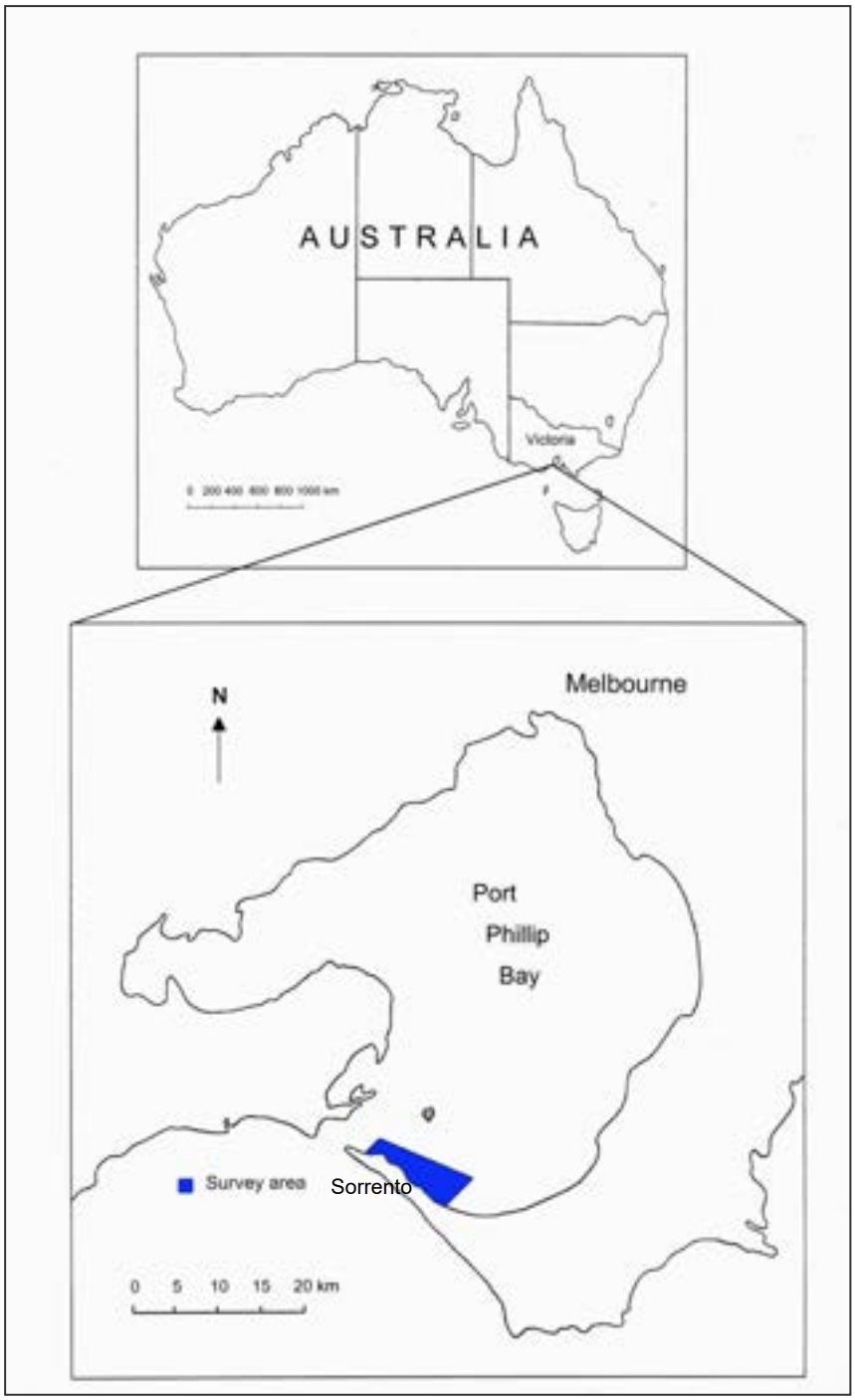
Bottlenose dolphins can be observed throughout most of Port Phillip Bay, particularly in the southern area where the entrance to Bass Strait is located. However, little was known about the population structure, social dynamics or site fidelity of the dolphins in that area. The Dolphin Research Institute began population studies in 1993 through photo-identification of individual dolphins. Photo-identification is one of the most common methods employed in cetacean research (Hammond, *et al.* 1990). It can be used to provide information on population size, structure and movements as well as reproductive and survival rates, and association patterns within populations (eg. Ballance, 1990; Defran & Weller, 1999; Defran, *et al.*, 1999; Felix, 1997; Hansen, 1990; Maze & Würsig, 1999; Williams *et al.*, 1993; Wilson, *et al.*, 1999; Würsig and Harris, 1990). The Institute has used photo-identification to estimate population size and site fidelity of dolphins in southern Port Phillip Bay.

2.2 Study Methods

Port Phillip Bay is approximately 1942km^2 in size, however the research programs of the Institute have focussed on the southern region of the Bay (Figure 2.1), an area measuring around 42km^2. This area seems to have a higher proportion of dolphins compared to the rest of the Bay, particularly over the summer months. Dolphins may be located very close inshore (<10m) or up to several kilometres offshore. Water depths vary greatly in this region of Port Phillip with large expanses of sandbar (reaching as low as 0.3m on the lowest tide), a major shipping channel (the South Channel is maintained to a depth of 12.5m), and depths of around 70m at the entrance of Port Phillip.

The entrance of Port Phillip Bay is defined by Pt Nepean to the west and Pt Lonsdale to the east, and is just over 2km wide. This is quite narrow when considering the large volume of water moving through it. Subsequently, the tides and currents in southern Port Phillip are complex. Tidal flows through the entrance can reach 5-8kts and flow rate can be greatly influenced by wind. The substrate of the area is mainly sandy, however there are sections of rocky reef and seagrass beds.

Figure 2.1: Location of Port Phillip Bay, Victoria, Australia



2.2.1 Data Collection

Since 1993, the Institute has undertaken photo-identification surveys each January and February. Presented here are the results of five survey periods between 1997 and 2001 (photographs taken between 1993 and 1996 are yet to be analysed). On launching from Sorrento, survey routes generally focussed on the coast between Sorrento and Pt Nepean, and offshore to the shipping channel. Between the years of 1997-1999, dolphins were located opportunistically or through association with tour vessels. If researchers were unable to locate dolphins in that area, routes were extended to the east (generally as far as Rye) and further north/north-east towards Queenscliff. New search methodologies in the form of point sampling, were developed during the winter of 1999 and used as standard techniques since the summer of 2000.

A field day averaged around six hours, falling between the hours of 07:00 to 19:00. Surveys were conducted up to a Beaufort Sea State of 3, at which point they would be abandoned due to decreased visibility (Appendix 1 – Beaufort Sea State). Extra surveys were conducted outside of the summer research season in some years and included March/April 1997, June/August/September/December 1999, August/November/December 2000 and March/April/July 2001. The 1999 surveys were conducted partly to review methodologies, as well as to try and determine the level of dolphin presence during the colder months. The Institute now conducts research year-round, rather than intensive summer efforts. The data for these additional surveys have been analysed and will be discussed, but note that population size estimation is based on the January and February data of each year only.

Once dolphins were located, the time of sighting, location (GPS position), group size and behaviour were recorded, and updated as necessary by an observer into a dictaphone (Appendix. 2 - Behaviour definitions). Group size was determined by a number of visual counts during the sighting, and was often recorded as a range, with the number of calves present also estimated (Appendix 3 - Group size and calf definitions). The research vessel would approach the dolphins as close as possible to take dorsal fin photographs, employing standard photo-identification methods (Würsig & Jefferson, 1990). Photographs were taken until it was considered that most of the group had been captured on film, or if dolphins showed avoidance behaviour. The cameras used were Canon EOS 100 and EOS 50 SLRs, equipped with a 100-300mm zoom lens and databack, using colour slide film (Fuji 400ASA in 1997, AGFA 200 1998-2000, Kodak 200 in 2001).

2.2.2 Photo-identification analysis

A photo-identification catalogue was developed, based on that used by the Sarasota Dolphin Research Program (Urian and Wells, 1996). In the catalogue, marked dolphins are sorted into categories depending on the type of marking (scarring, notches, bent fins) and the location of such markings. The best image of each identified dolphin is enlarged to at least one of three standard sizes, traced and mounted (both sides of the fin where possible). The tracings and mounted slides are then used as reference when sorting through photographs. Potential new dolphins are checked against the entire catalogue by two experienced researchers before being added, and the catalogue is reviewed regularly for potential mis-identifications.

In the photo-analysis process, each photo is given a quality score based on the clarity, contrast and angle of the image. On completion of a sighting, the group size was analysed based on the following: number of dolphins identified; those that were questionable due to poor photo quality; those visually confirmed in the field only; and the minimum and maximum that were not identified at all (including calves). All photo-identification data has been entered into a Microsoft Access database. Only photos with a medium to high quality score have been used in analysis and only dolphins with long-lasting marks, as scarring tends to heal within a year.

2.2.3 Population size estimation

To manage a species adequately, it is imperative to have at least some basic information about the population. Photo-identification is one method of monitoring a population not only at the individual level, but also as a whole. Mark-recapture models can be utilised with photo-identification data to provide estimates on population size, allowing changes to be monitored yearly. There are a number of models available and which is chosen depends on features of the population. There are four main assumptions that need to be identified, including geographical closure, demographic closure, permanence of markings and equal catchability probability (Hammond *et al.*, 1990). For example, a population would be considered geographically closed if the whole population or a subset of the population is known to return to an area on a regular basis. Demographic closure refers to births, deaths, and permanent immigration/emigration. An open population model (eg. Jolly-Seber) allows for such changes, whereas a closed population model does not (although this assumption can sometimes be relaxed) (Hammond *et al.*, 1990). The permanence of markings can affect estimates, for example if a dolphins' marks change there is the possibility that it may be identified as a new dolphin, leading to an over-estimation of the population. We acknowledge there may be some mis-identifications, however the catalogue is regularly reviewed and we have found that such errors are very rare (less than 10% error rate).

Finally, unequal capture probabilities is the one assumption that most models incorporate being that "all animals are equally likely to be captured within a sampling occasion" (Hammond, *et al.*, 1990). This assumption may be affected by the presence of dolphins that are habituated to boats (similar to 'trap happy'), thus resulting in some animals becoming more or less likely to be photographed. This will cause an underestimate of population size. Anecdotally, there have been cases where some individuals (which are easily recognisable in the field) have repeatedly approached the research vessel. However, researchers have always made an effort to photograph the whole group. This assumption can also be violated in the analysis process, for example when a photo is included based on its identifiability rather than photographic quality (Hammond, 1986). Again, this has been minimised where possible. For example, individuals that were visually recorded in the field but not captured on film were not included in the analysis and analyses has been restricted to photographs of standard quality.

There are a number of computer programs designed for mark-recapture data, containing many models within them, however they are only giving an estimate on the number of dolphins with long-lasting marks (dolphins with scarring should not be included as scars tend to heal within a year). Wilson, *et al.* (1999) incorporated the proportion of individuals with long-lasting marks with estimates provided by such a model, to estimate the total population size. This method has been utilised in this report, with the program MARK ver 2.0 (G.C. White, Colorado State University) to generate the population estimate based on marked individuals.

2.3 Results

2.3.1 Field effort

A total of 126 boat surveys comprising 603.516 hours were conducted during January and February of 1997 to 2001 inclusive (Table 2.1). Dolphins were encountered on 89.7% of all boat surveys and there were 82 surveys (65.1%) that had more than one sighting, hence the total 318 sightings. During this time there were 5,014 photographs were taken, of which 46.15% had dorsal fins that could be identified. When taking into account the fact that multiple identifications can be made from one photograph, then 66.49% of photographs were useable. Of these, 67.94% were of a good enough quality (medium to high photo quality) to be included in analysis. Another 1,526 photographs were taken during the additional surveys outside of the summer research period, of which similar proportions contained identifiable dorsal fins.

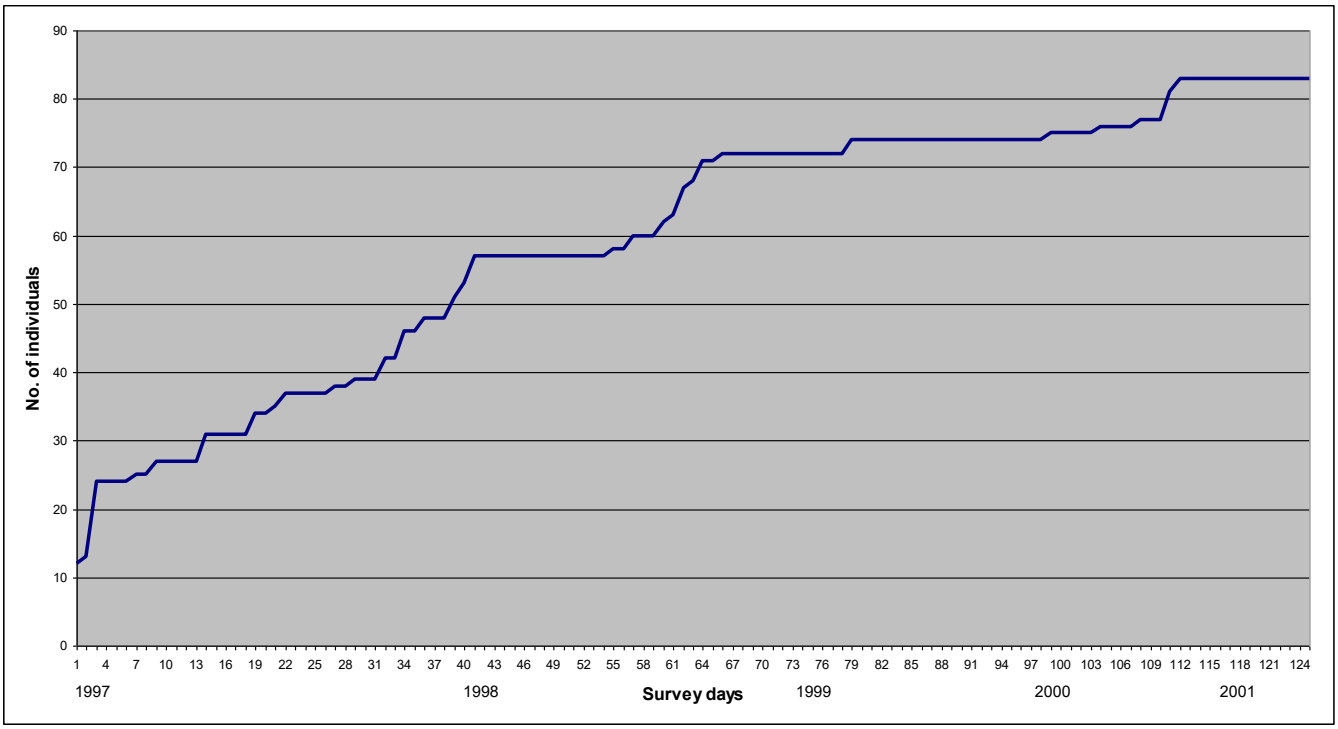
Table 2.1: Field effort and dolphin sightings for the research vessel, January/February 1997 - 2001

Boat Surveys	Surveys	Field hours	Sighting Days	Dolphin sightings	Sighting duration (hrs)
Total	126	603.516	113	318	113.05
Mean/year	25.2	120.703	22.6	63.6	22.61

2.3.2 Photo-identification analysis

Eighty-three dolphins were identified through long-lasting marks (plus 27 identified by scarring only). Most dolphins had been identified by about the 64th survey day (February 1998) (Fig. 2.2), after which identifications plateau. Increases in the number of marked animals since then could be attributed to calves or previously unmarked dolphins becoming marked, or the presence of transient dolphins. The identification of four new dolphins in February 2000 may have in part, been a case of transient dolphins entering the Bay, as two of the new dolphins have not been observed since that day (or again within that research season). One of the others was a calf that became marked that season.

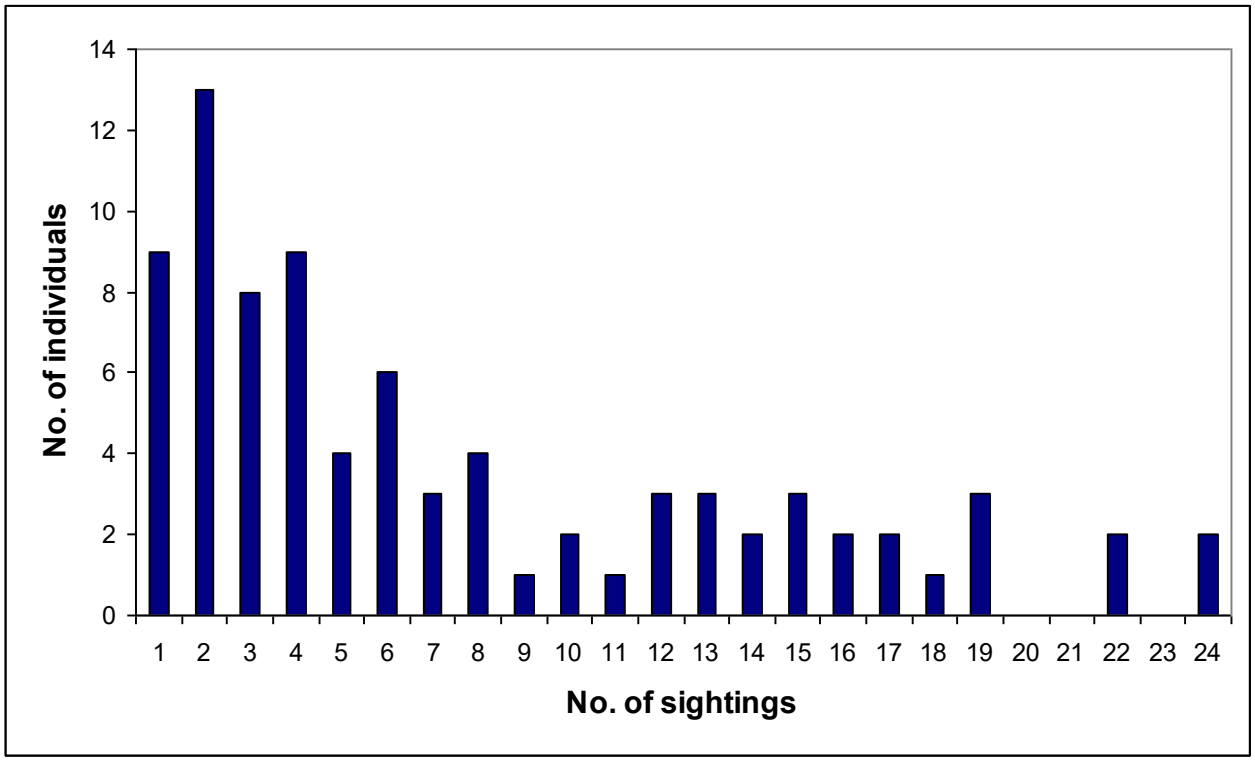
Figure 2.2: Discovery curve for identified dolphins, 1997-2001 (n = 83)



The number of total sightings for each individual over the five seasons ranged from 1-24 (Fig 2.3). This equates to a mean of 7.53 sightings per individual and 91.1% of individuals were sighted more than once. Looking at sightings within the sample years, 17 individuals (20.5%) were observed at least once in each of the five summer research seasons. Twenty-one individuals were observed in one season only (25.3%), 20 in two seasons (24.1%), 10 in three seasons (12.1%), and 15 in four summer seasons (18.1%). These results strongly suggest that the dolphin population in southern Port Phillip Bay is seasonally resident.

It should be noted that two identified dolphins are known to have died. Both were sighted in the summers of 1997 and 1998 before they washed ashore in late 1998. An adult female was found on Port Melbourne beach in November and an adult male floating off Brighton in late December.

Figure 2.3: Number of times individually identified dolphins were sighted during the summer research seasons of 1997-2001 (n = 667)

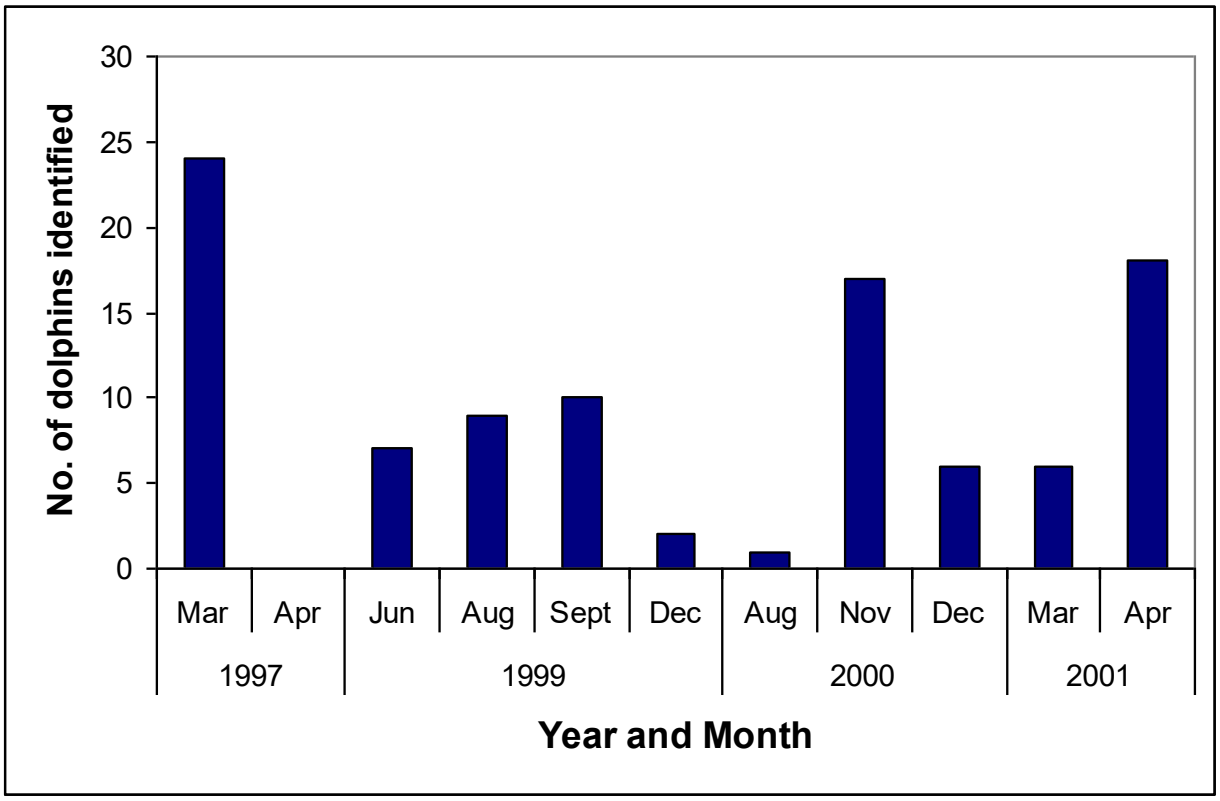


2.3.2.1 Dolphins sighted during additional surveys

A total of 23 additional surveys have been conducted outside of the usual summer research effort since 1997. Although the effort is lower than the summer months, dolphins were encountered on 87% of surveys, which is comparable with 89.7% for the summer boat surveys. These surveys have increased and are now part of the year-round research program.

The number of dolphins identified in any one sighting over this time (based on photographs of medium to high quality), ranged from 1-24 individuals (Fig 2.4). There were six dolphins identified in March 1997 that had not been identified during the previous two months, however these dolphins were all seen again in subsequent years. Since then, there have been only two new identifications made and one of these individuals has not been sighted since (August 1999).

Figure 2.4: Numbers of dolphins identified in additional photo-identification surveys (n = 100)



Combining the additional survey results with those from summer research efforts, brings the rate of individuals sighted more than once to 92.54%. Not only have the additional surveys and the year-round research program allowed us to confirm the presence of dolphins during other seasons, results also showed it was the same dolphins. This suggests that the population may be resident to southern Port Phillip Bay throughout the year. Two of the additional surveys were conducted outside of the usual sampling area, in Mornington during March 1997 and Frankston during August 1999. Previously identified dolphins were present on both occasions, suggesting that the dolphins move through other areas of the Bay. Anecdotally, certain individuals that are easily identifiable in the field have been sighted at the northern end of the Bay off Middle Park and in the embayment to the east of Port Phillip Bay (Western Port). Further surveys are required outside of the current sampling area to understand the dolphins' use of both bays.

2.3.3 Population size estimation

A closed population model was used to estimate the population size of the bottlenose dolphins in southern Port Phillip Bay. This was based on the definitions of geographical closure, in that the whole population or a subset of the population returns to the same area on a regular basis. Furthermore, the discovery curve for individuals identified by natural markings (Fig 2.2), suggests that the population may be closed to permanent immigration. The slight increases present in the last three summers most likely represent surviving calves that have obtained markings. Additionally, studies have found that closed population models tend to yield more precise estimates compared to open models (Fairfield, 1990; Wilson, *et al.*, 1999).

Population estimates have been based on summer data and only dolphins with long-lasting marks were included. Dolphins identified by scarring only were excluded due to the fact that scars can heal within a year. Calves were also excluded as their presence is not independent of their mother's. A total of 80 dolphins were classified as having long-lasting marks, which comprised 75% of the total identified. The results from the mark-recapture program (MARK) were calculated from all 5 research seasons and the estimate produced by the closed population model was 80.2 individuals. The proportion of dolphins with long-lasting marks and the population estimate generated by MARK were used to obtain the total estimate. The total population estimate for the dolphins of southern Port Phillip Bay is 107 animals ($\pm$ 29).

2.4 Discussion

Based on five years of photo-identification surveys between 1997 and 2001, there is evidence to suggest that there is a seasonally resident population of bottlenose dolphins in southern Port Phillip Bay. Additional surveys conducted throughout the years have shown that dolphins can be found in the area year-round and this suggests that the population is permanently resident. However, further surveys throughout the seasons are required confirm this and to determine their use of other areas. The population appears to be relatively stable, with 83 dolphins identified by long-lasting marks (81 when taking into account those known to have died). Additions to the number of marked individuals has been relatively low over the last three years, however some growth would be expected as calves obtain marks or due to the presence of transient individuals at times. The population estimate based on the proportion of marked individuals and the computer generated estimate, place the population at 107 animals, which is consistent with the Institute's past estimates.

There appear to be two types of coastal bottlenose dolphin populations documented in the literature. The larger, more open populations that have low resighting rates such as in Galveston Bay, Texas where in a study by Bräger (1993), over 1,000 individual dolphins were photographed. Many of these were transient dolphins and it was suggested that there was probably a resident population of about 200 individuals. In Lower Tampa Bay, Florida (Weigle, 1990) 246 dolphins were identified but only 30.5% were sighted more than once. It was suggested that the population was open, with transient dolphins using the area in summer months for feeding. On the other hand, there are cases of populations such as that in southern Port Phillip Bay. These are small, closed populations that appear to show site fidelity as indicated by high resighting rates over the years. Over 90% of identified dolphins in Port Phillip Bay were seen more than once over the five years, which is one of the highest resighting rates compared to other studies. For example, in Jervis Bay Mandelc (1997) had identified 76 dolphins over three years with a 72% resighting rate; population estimates in Doubtful Sound, New Zealand (Williams *et al.*, 1993) were 58 with 72.5% resighting rates; and, in the Bay of Islands, New Zealand (Constantine and Baker, 1997), 265 dolphins were identified with 76% seen more than once.

Although the sighting frequencies suggest that the population spends a significant amount of time in southern Port Phillip Bay, further research is required to examine the range of the population outside of this area, including the rest of the Bay and Western Port. Being a relatively small, closed population makes it vulnerable to any sudden change from which it may not recover easily. This population also shows high site fidelity to a region that has large amounts of boat traffic and a dolphin-swim tourism industry. Therefore it important that photo-identification studies continue for monitoring purposes.

3. The impacts of dolphin-based tourism

3.1 Background

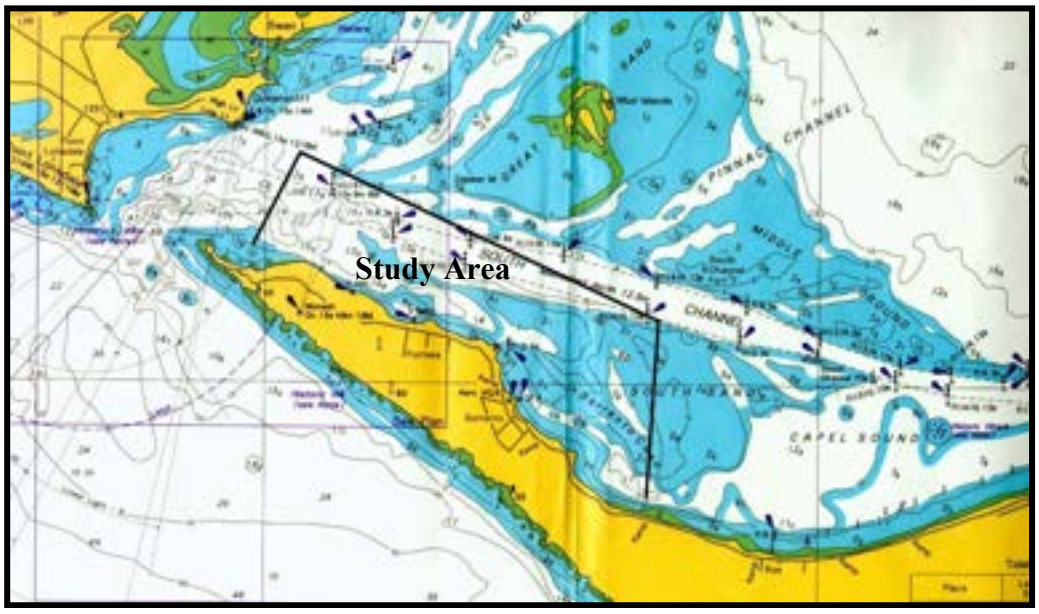
Southern Port Phillip Bay is subject to varying levels of boat traffic ranging from container ships through to recreational vessels. Large container ships constitute regular traffic as they travel along the South Shipping channel on their way to Port Melbourne, Australia's busiest shipping port on a daily basis. In addition to this, other frequent commercial traffic, in the form of two car ferries, two passenger ferries, commercial fishing vessels and charter vessels also occurs in southern Port Phillip Bay throughout the year. Recreational vessels are also common, utilising the area for activities such as fishing, water-skiing and diving.

Added to this, the Mornington Peninsula is one of Victoria's most popular tourist destinations, particularly during the summer months. Typically tourism activity builds from late October to a peak in January, steadily declining through to April. During this time, recreational boating activity also peaks as large numbers of speed-boats, water-skiers, jet skis and sailing craft take advantage of the warm weather. Commercial boating activity also increases as charter vessels and passenger ferries take out large numbers of tourists to participate in various activities throughout the area. These include dolphin-based tours.

Currently there are five companies with permits to conduct dolphin swim tours. Four of these conduct tours on a regular basis, the remaining operator only on an opportunistic basis. In addition to these swim tours, three vessels hold permits to conduct dolphin-watching tours. These dolphin watching tours include both passenger ferries that regularly interact with dolphins as they transport passengers between Sorrento and Portsea. These ferries also act as dolphin "spotters" for the other dolphin tours.

The majority of dolphin interactions occur within the area between Portsea and Blairgowrie, inshore of the South Shipping Channel (see Figure 3.1), although some interactions have been recorded off Queenscliff, The Great Sands and off Tootgarook. The distance that tour vessels can travel to locate dolphins is limited by a combination of time constraints associated with running multiple trips and by the maximum speed that the tour vessels can travel. The interaction area is further limited by the presence of extensive shallow areas through which many of the tour vessels cannot travel.

Figure 3.1: Chart of southern Port Phillip Bay with study area marked



3.2 Study Methods

Regular observations were collected from five swim tour vessels during two swim seasons, 1998/1999 and 1999/2000. Each season commenced in October and terminated during April. Attempts were made to observe each vessel equally and throughout all time periods.
Tour vessels were chosen as research platforms since they allowed researchers to collect data without directly influencing the dolphins. They also allowed observers to collect detailed information on dolphin responses, including individual dolphin interactions. This was not possible from any other platform.

Due to the presence of wheelhouses or cabins on all the observation platforms, data was collected from either the roof or fly-bridge of each vessel. This allowed an uninterrupted 360-degree view of the water surrounding the vessel that was not available from the deck. Two researchers were present on each trip, one to collect observations and the other to collect dorsal fin photographs. This ensured that the overall observation area could be divided equally between the two researchers, ensuring better coverage. Gerber 10X50 binoculars were used to assist with the observational data and distances were estimated using the known length of each vessel (including mermaid lines), landmarks and Tasco LRF 600 range finder binoculars fitted with laser sights.

3.2.1 General Observations

At the beginning of the tour, the following were noted; start time, name of the vessel, name of the vessel captain, wind direction and speed, and sea conditions (using the Beaufort Sea State Scale – see Appendix One). Sea State and wind data was updated as it changed.
In addition to the above, the start and end time for any other non-dolphin related activities (seal swim, reef snorkel) was also recorded and was later deducted to calculate total "dolphin seeking activity". Details were also recorded of the search path utilised by the observation platform and of any other dolphin tourism vessels out at the time.

3.2.2 Behavioural Observations

At the first sighting of dolphins the following was noted; position, distance from shore, distance from the observation platform, dolphin behaviour (see Appendix Two), group size estimates (minimum & maximum estimates, including calves), the presence and number of any other vessels, the direction of movement and how the group was sighted. As the tour vessel came within 400m of the nearest dolphin, it was considered to be "interacting" and detailed observations were commenced. It was determined that 400m was the maximum distance that observations could be reliably collected from these platforms. This is consistent with Constantine's (1997) study.

During each sighting the following were observed and recorded using a continuous recording technique. Overall dolphin behaviour, distance from dolphins, distance from shore (for the dolphins and the platform), direction of movement, observation platform behaviour and dolphin dive behaviour were recorded. Also recorded was the presence, behaviour and number of other vessels (including vessels travelling through), dolphin avoidance responses and dolphin/vessel interactions. Observations were updated as any of the above changed.

Dolphin behaviour was determined by scan sampling for predominant group activity with the behaviour of 2/3 of the group being recorded. Predominant group activity sampling as defined by Mann (1999) was used rather than the "focal pod" sampling method utilised by other studies (Shane 1990a, 1990b) due to difficulties in reliably tracking individuals and the dynamic nature of the dolphin sub-groups. This technique has been utilised successfully in other studies (eg Neumann, 2001). Details of the Institute's group and calf definitions can be found in Appendix Three.
Tour vessel behaviour was recorded as one of four categories (Table 3.1)

Table 3.1: Tour Operator Behaviour Categories

Tour Behaviour	**Description**
Idle/Observe	Vessel in neutral or cut motor and was >100m from dolphins but was still within 400m of nearest dolphin.
Travel/Observe	Vessel was in motion >100m from dolphins but less than 400m from the nearest dolphin. Often vessel was travelling alongside.
Approaching	Vessel was approaching dolphins <100m or was in the path of dolphins.
Travelling	Vessel was travelling but was >400m from nearest dolphin.

A tour vessel approach was defined as when a tour vessel came within 100 metres of any dolphin, or placed the vessel in the path of the dolphins. The following approach types were used, Direct, Parallel, Intercept and Neutral (see Table 3.2), modified from those used by Constantine (1997). During each approach, the duration of the approach and dolphin response was noted. If a swim was attempted, this was also recorded.

Table 3.2: Vessel Approach Strategies

Approach Type	**Description**
Parallel	Vessel approached dolphins parallel to their path and positioned ahead and to the side of the dolphins' path.
Intercept	Vessel "intercepted" the path of the dolphins, travelling parallel to the group but then crossing over to place the vessel in the direct line of the dolphins path.
Direct	Vessel moved through/over the dolphin group to place the vessel immediately in the path of the dolphins.
Neutral	Vessel was moved to within 100m of the dolphins, dolphins had no obvious direction of movement.

Once swimmers were placed in the water, the swim duration, number of swimmers and dolphin response was noted. Details of response categories are in Table 3.3. When dolphins interacted with both the swimmers and the vessel, it was recorded as a swimmer/vessel interaction.

Table 3.3: Dolphin Response Categories

Response Type	Description
Vessel Interaction	Dolphins either on bow, surfing alongside or in wake or approaching vessel to a distance of <10m.
Swimmer Interaction	Dolphins swam either through or under lines or within 5 metres of the mermaid lines. Interaction lasted <1 minute.
Sustained Swimmer Interaction	Dolphins swam through or under the lines and remained within 5 metres of mermaid lines for >1 minute.
Avoidance	Dolphins either dove & surfaced at a distance from the vessel, changed direction or dove and changed direction.
Neutral	Dolphins either exhibited no apparent response to the vessel or swam past at a distance >10m.

All observations were recorded on a micro-cassette recorder and transcribed later onto coded data sheets. This ensured that the dolphins could be observed continuously. Data was then stored on an MS Access relational database.

3.2.3 Individual Dolphin Data

Once the vessel came within 100 metres of the dolphins, photographs of those in the vicinity of the observation platform were collected using a Canon EOS 100 or EOS 50 with a 100-300mm lens and 200ASA AGFA slide film. In addition, identifiable "marked" dolphins were confirmed by each researcher on the vessel and recorded as "visual" identifications. Where possible, dolphins observed to interact with or avoid either the vessel or the swimmers were also photographed or visually identified. Individual dolphins were then identified from the photographs and catalogued using the techniques described in Section 2.2.2.

3.2.4 Other Vessels

There has long been the suggestion that recreational vessels are spending significant time with dolphins, particularly over the summer months. To ascertain if this was the case, details were collected on all other vessels, both recreational and commercial, within 400m of the dolphins. This included details of vessels that were travelling through, fishing, diving, anchored or water-skiing. A vessel was only recorded as "interacting" if it stopped to view the dolphins or travelled either through or within 100m of the dolphins. For vessels observed to be interacting with the dolphins, the identity (registration, if observable) and behaviour of the vessel was recorded, along with any dolphin responses were attributed to that vessel. Observations included any observable breaches of the *Wildlife (Whales) Regulations 1998*. The duration of the interaction was also recorded for any vessel deemed to be interacting with the dolphins.

3.3 Results

During the course of the study, researchers completed 136 surveys on the tour vessels. This equated to 424 hours of field time for both seasons. In total, 146 dolphin sightings were recorded comprising 100 hours of behavioural observations. The success rate for sighting dolphins was 76% for the first season and 73% for the second season. A total of 711 approaches by tour vessels were monitored and 300 swims were observed over the two seasons.

Table 3.4: Survey & sighting duration and number of approaches and swims observed during each season, all vessels (n=136 surveys)

	Total Field Time (Hours)	Total Observation Time (hours)	Total Approaches	Total Swims
1998/1999	236.6	51	285	130
1999/2000	187.3	49	426	170

There was some variation between years in respect to field time, sighting duration, number of approaches and number of swims (Table 3.4). The 1998/1999 field season recorded the highest field time with 236.6 hours compared to 187.3 hours. The number of approaches and total number of swims increased in the 1999/2000 season, accounting for 60% of all approaches and 57% of all swims observed. The total amount of time spent observing dolphins (observation duration) was slightly higher for the second season, but still comparable.

Although the overall dolphin observation time was similar for both seasons, the mean sighting duration was slightly higher during the 1998/1999 season at 44.7 minutes per sighting, compared to 40.7 minutes per sighting for the second season (Table 3.5). Mean field time (per survey) was comparable between the years. The main difference was that a larger number of approach attempts were observed during the second year.

Table 3.5: Mean survey & sighting duration, number of approaches & swims (per sighting) all vessels

	Mean Field Time, per survey (Hours)	Mean Observation Duration (mins)	Mean # Approaches per sighting	Mean # of swims per sighting
1998/1999	226.3	44.7	4.8	2.2
1999/2000	217	40.6	6.1	2.5

Three of the tours run 2 trips per day during the peak season. The remaining operator runs 3 trips per day. During January/February, considering the number of operator trips and the above data, each tour would, on average, spend approximately 7 hours per day on the water (based on 2 trips per operator). Of this, an average of 1.5 hours per day, per vessel, would be spent interacting with dolphins. On days when all operators were running, this equates to a cumulative total of 6 hours interacting with dolphins during daylight hours. Since most tours run multiple trips and trip start and end times are "staggered" with operators all running to different schedules, tours are on the water continuously between 8am and 7pm. Occasionally some operators also conduct dawn and sunset tours.

3.3.1 Dolphin Responses to vessel approaches

Figure 3.2 shows the proportion of approaches that resulted in swimmers being deployed. During 1998/1999, swimmers were placed in the water on 49% of all approaches. In contrast, during the 1999/2000 season, swimmers were only deployed on 40% of all approaches. This equates to a swimmer deployment only occurring for every second approach during the first season and 2.5 approaches occurring for every swim during the second season.

Figure 3.2: Percentage of approaches where swimmers were deployed (n=711)

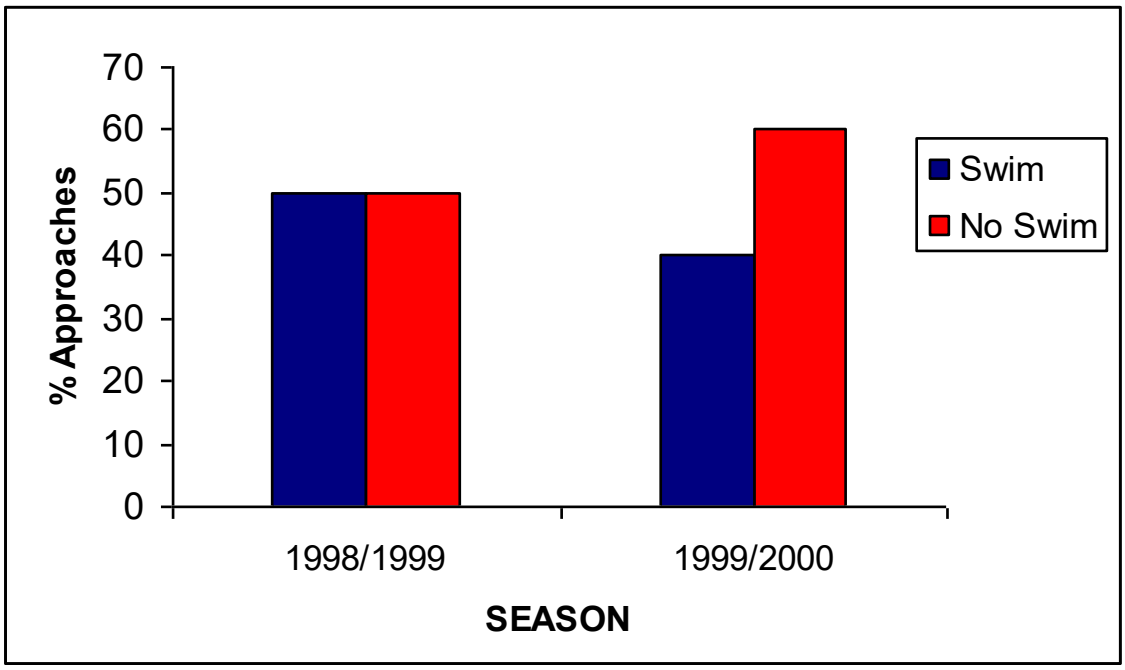
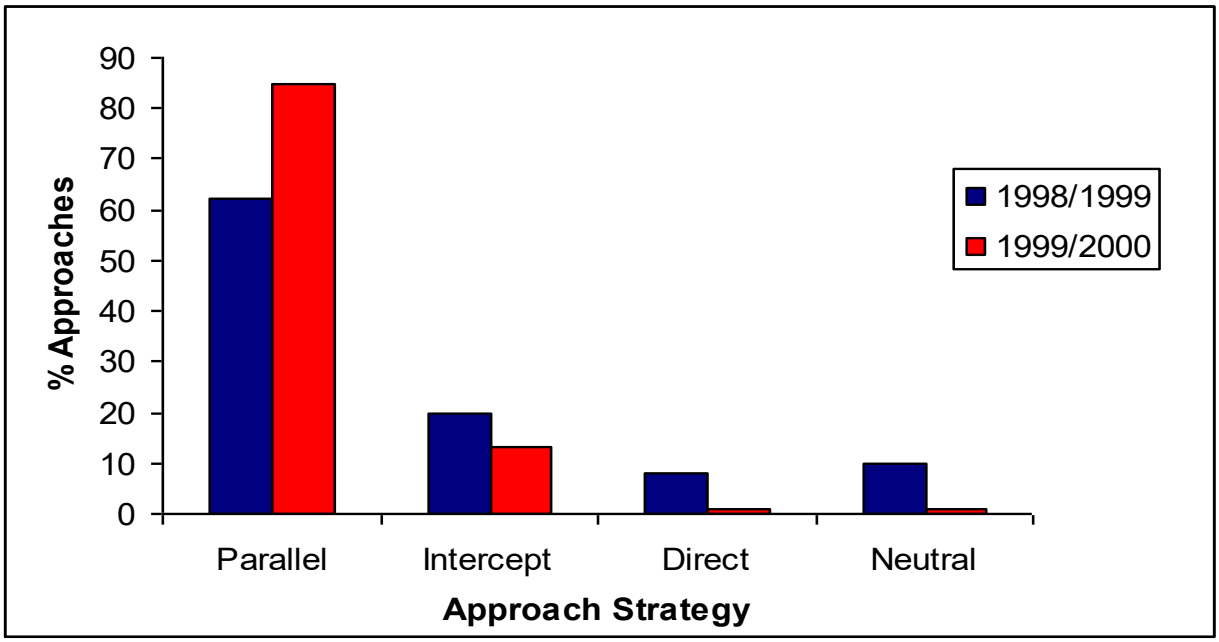


Figure 3.3 depicts the relative occurrence of each of the approach strategies. The parallel approach strategy was the most frequent strategy utilised by the operators during each season, accounting for 63% of all approaches in the 1998/1999 swim season and 82% of all approaches for the 1999/2000 swim season (Figure 3.3). The next most frequently used approach strategy was the "Intercept" approach, accounting for 20% of approaches during the first season and 13% during the second season. The incidence of both the "Neutral" and "Direct" approach was observed to decrease during the second season, accounting for <10% of all approaches observed for that season (as opposed to 20% for 1998/1999).

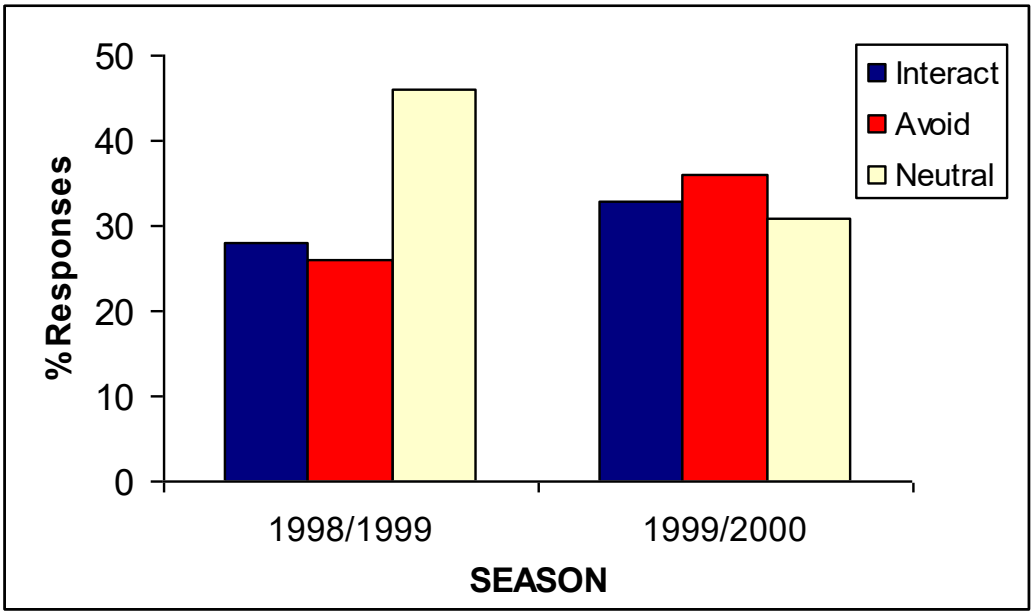
Figure 3.3: Relative proportion of approach strategies for each research season (n=711)



Dolphin responses were grouped into three categories; interaction, avoidance and neutral, (as described in Table 3.3) with vessel and swimmer interactions being grouped into a single category, "interactions". These were then compared between the two seasons (Figure 3.4). Since only a small proportion of "Direct" and "Neutral" approaches were observed during both research seasons, only responses to the Intercept and Parallel approaches were considered individually. Figure 3.4 shows the influence of the parallel approach strategy on dolphin response. Data for the intercept approach strategy is in Figure 3.5.

The data in Figure 3.4 is for approaches in which the "parallel" approach strategy was used only.

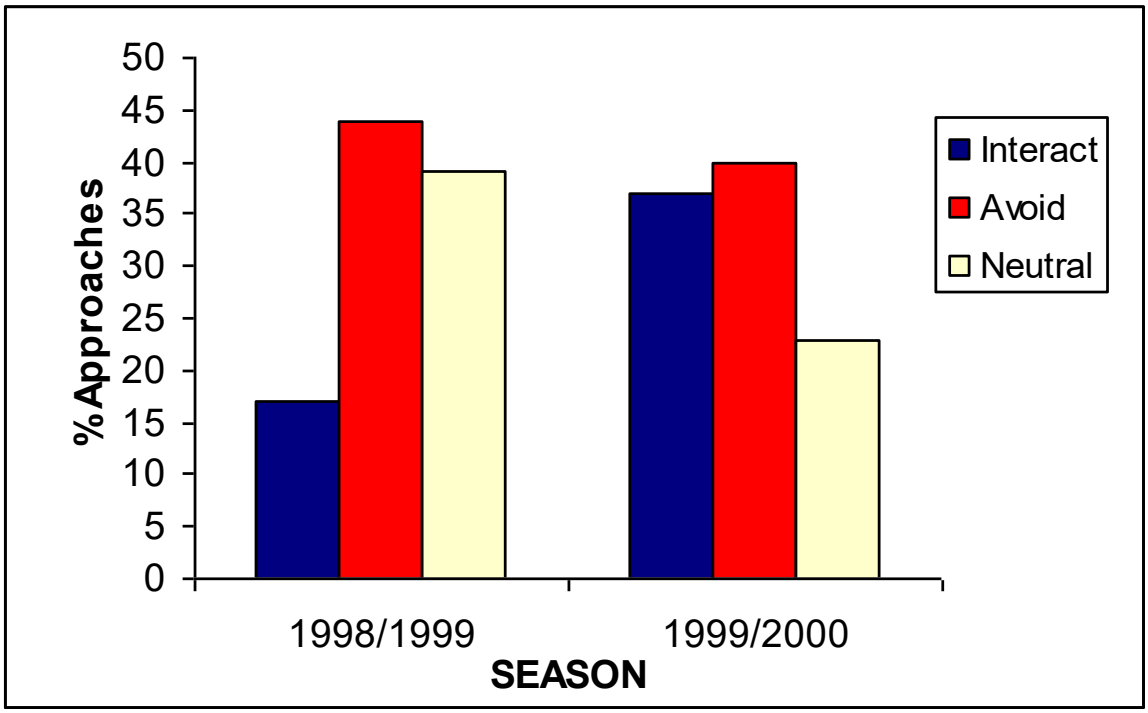
Figure 3.4: Dolphin responses to parallel approach strategy, for each season (% approaches for each season, n=519)



The main difference in dolphin response for the parallel approach strategy, between the two research seasons was a decrease in the "neutral" response during the second season. The overall proportion of "neutral" responses was observed to decline from 46% to 27% between the two seasons. During the second season, both the proportion of interactions and proportion of avoidance responses were observed to increase. In the case of avoidance, the increase was from 26% to 36% and the interaction increase was from 28% to 37%. The relative number of interaction versus avoidance responses was also different between the seasons. In the first season, interaction responses occurred more frequently than avoidance responses. This was reversed during the second season. The difference in responses between seasons was found to be significant $X^2 = 11.53$ (df=2); $p < 0.01$

Observed dolphin responses to the intercept approach strategy also differed between each season. Although avoidance decreased slightly between seasons, neutral responses were observed to decline from 39% to 23%. This difference was also found to be significant $X^2 = 7.159$ (df = 2); $p < .0.05$. This decline can be attributed to a higher proportion of interactions recorded for the intercept approach strategy during the second season. Dolphin interactions were observed to increase from 17% to 37% between the two seasons. This is in contrast to the parallel approach strategy where the incidence of both avoidance responses and interactions was observed to increase.

Figure 3.5: Dolphin responses to intercept approach strategy, for each season (% approaches for each season, n=109)



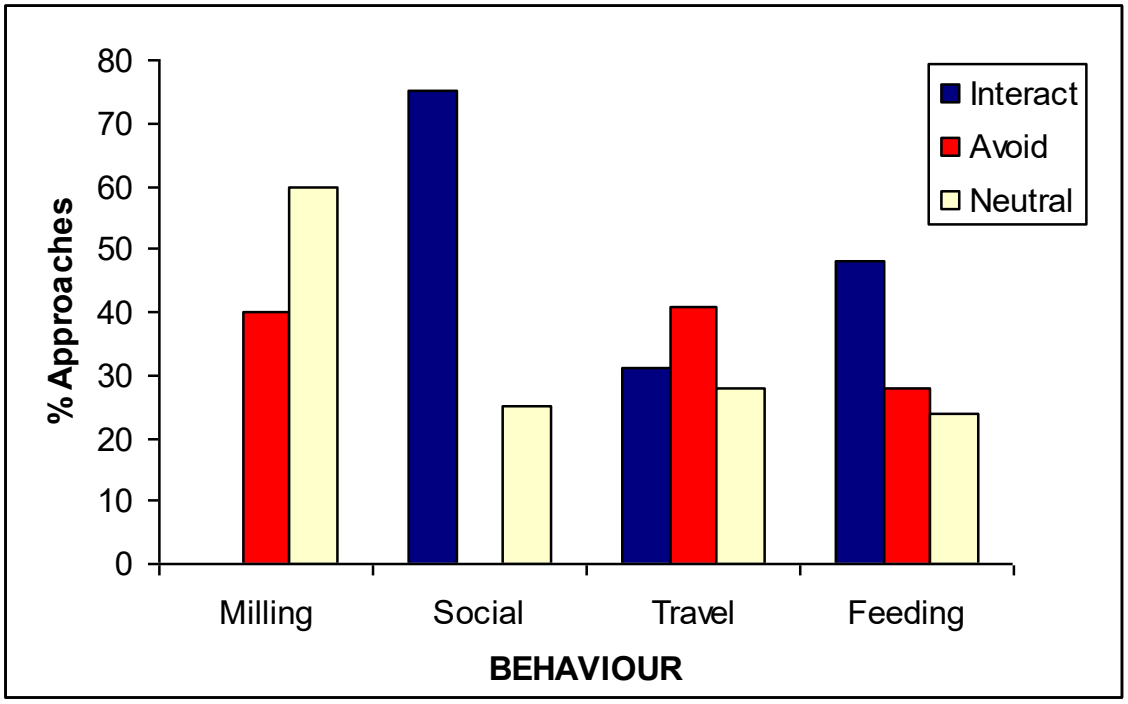
Avoidance behaviours were the most frequent response to this approach strategy for each season. When compared to the parallel approach strategy, the intercept approach was associated with a higher proportion of avoidance responses for both seasons. Avoidance responses were recorded for the intercept approach strategy for 44% during the first season and 40% during the second season, compared to 26% avoidance for the parallel approach strategy (Figure 3.4) in the first season and 36% (parallel) during the second season.

This increase in both avoidance and interaction responses indicates a higher level of dolphin disturbance during the second season of the study as the dolphins changed behaviour to either interact with or avoid the tours.

3.3.2 Influence of dolphin behavioural state on dolphin response

Data in Figure 3.6 depict dolphin response with overall behavioural state as a factor. The data included in this figure are only from the first interaction recorded for each of the sightings, and includes data for both seasons. No other tour vessels were present in any of the cases recorded.

Figure 3.6: The Influence of overall behavioural state on dolphin response (n=70)

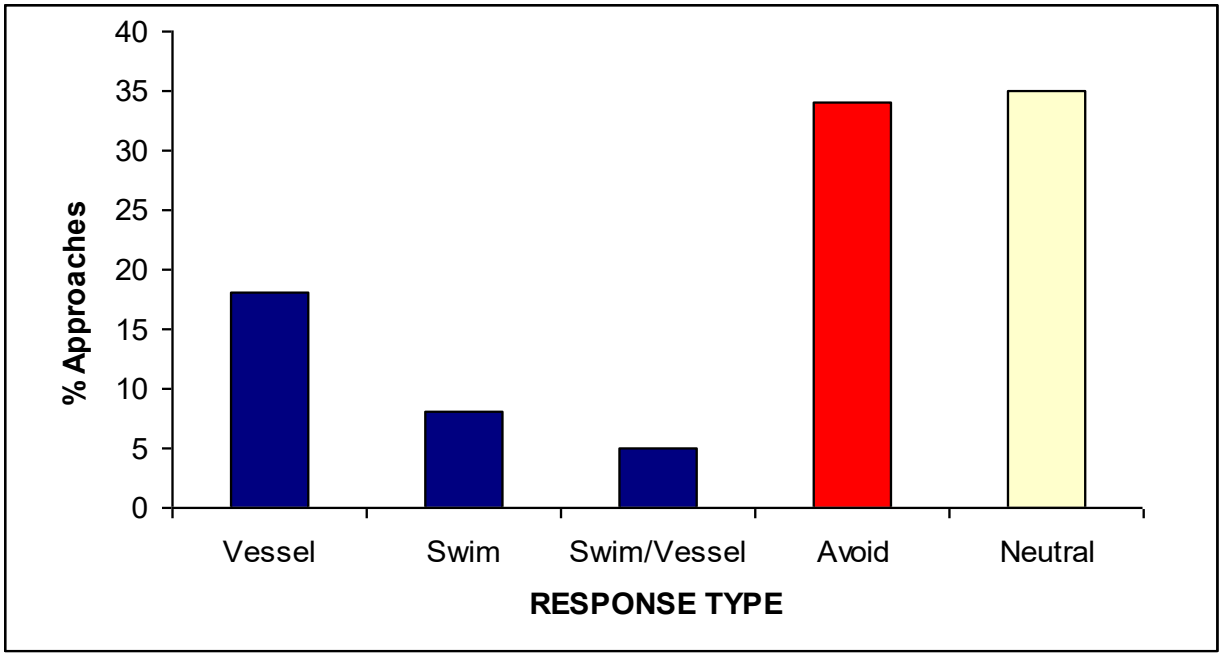


Dolphins were most likely to interact during social and feeding behaviour (75% & 48% respectively). Interactions in all of these cases included both vessel and swimmer interactions. In the case of social behaviour, no avoidance responses were recorded. During travel behaviour, dolphins appeared more likely to avoid (41%) than either interact (31%) or ignore (28%) the tours. During approaches that occurred when dolphins were milling, the neutral response was the most frequent (60%) followed by avoidance (40%). No interaction was recorded for milling behaviour. The influence of behaviour on response type was found to be significant, $X^2 = 13.66$ (df=6); $p<0.05$.

3.3.3 Vessel versus swimmer interactions

Figure 3.7 depicts pooled data for both seasons showing the relative proportion of specific responses to tour vessel approaches. In this graph, the "interaction" data from Figure 3.3 has been divided into 3 sub-categories; swimmer interaction, vessel interaction and combined vessel/swimmer interaction to determine if dolphins are interacting more frequently with the vessels or the swimmers (see Table 3.3 for definitions). Avoidance and neutral categories have also been included, for reference.

Figure 3.7: Dolphin response to tour vessel approaches pooled for both seasons (n=711)



Dolphins interacted with the tour vessels more frequently than with the swimmers. For every swimmer interaction, 2.1 vessel interactions were recorded. Dolphins were observed to interact with both the vessel and swimmers during the same approach during 5% of all approaches. Of interest, is the interaction rate as compared to the avoidance rate. For every swimmer interaction, there were 3.9 avoidance responses. For every vessel interaction, there were 1.9 avoidance responses. When compared to the overall number of approach attempts for both years, a swim interaction occurs only once for every 6.9 approaches.

The interaction time for vessel interactions was also greater than the interaction duration for swim interactions. Table 3.6 depicts mean duration for each of the interaction types and the number of extended interactions recorded for each interaction type. Overall, during both seasons, only 3 observations occurred where dolphins were observed to interact with swimmers for longer than 1 minute. In contrast, extended interactions with vessels were observed on 35 occasions. In many of these cases, the interaction was terminated by the operator, eg. the operator stopping the vessel to deploy swimmers.

Table 3.6: Comparison of interaction durations versus interaction type – swimmer or vessel, pooled for both seasons (n=205)

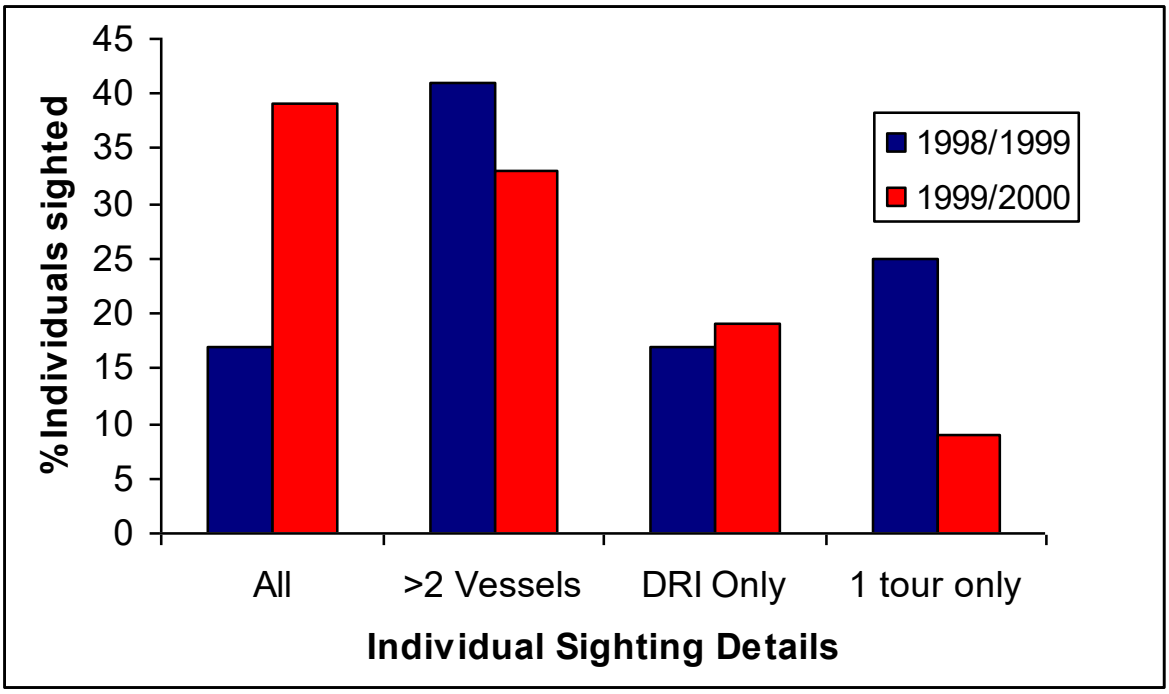
	Mean Duration	Min/Max	# > 60 seconds
Swimmer Interaction	40 secs	10 –180	3
Vessel Interaction	123 secs	23 – 549	35

3.3.4 Impacts on individual dolphins

A total of 1,693 photographs of individuals were catalogued over the two seasons, 813 from the 1998/1999 season and 880 from the 1999/2000 season. Fifty-nine individual dolphins were identified from the tour vessel platforms and the Institute's research vessel during 1998/1999. In the 1999/2000 season, 67 individuals were identified from all platforms. Figure 3.8 shows detail of the proportion of individuals that were sighted from more than one platform (pooled data). For both seasons, the majority of individuals were sighted from more than one research platform, although the proportion of dolphins sighted from multiple platforms increased during the second season from 58% in 1998/1999 to 72% in 1999/2000.

The number of individuals that were sighted from every platform also increased between the two seasons. Only 15% of individuals were sighted from all platforms during the 1998/1999 season. This increased to 40% during the second season. There was also an overall decrease from 25% to 9% of individuals who were only sighted by one tour during the second season.

Figure 3.8: Proportion of individual dolphins sighted from single or multiple research platforms during each season (n = 310)



Key

"All" = dolphins sighted from all platforms.

">2" = dolphins sighted from 2 or more, but not all, platforms.

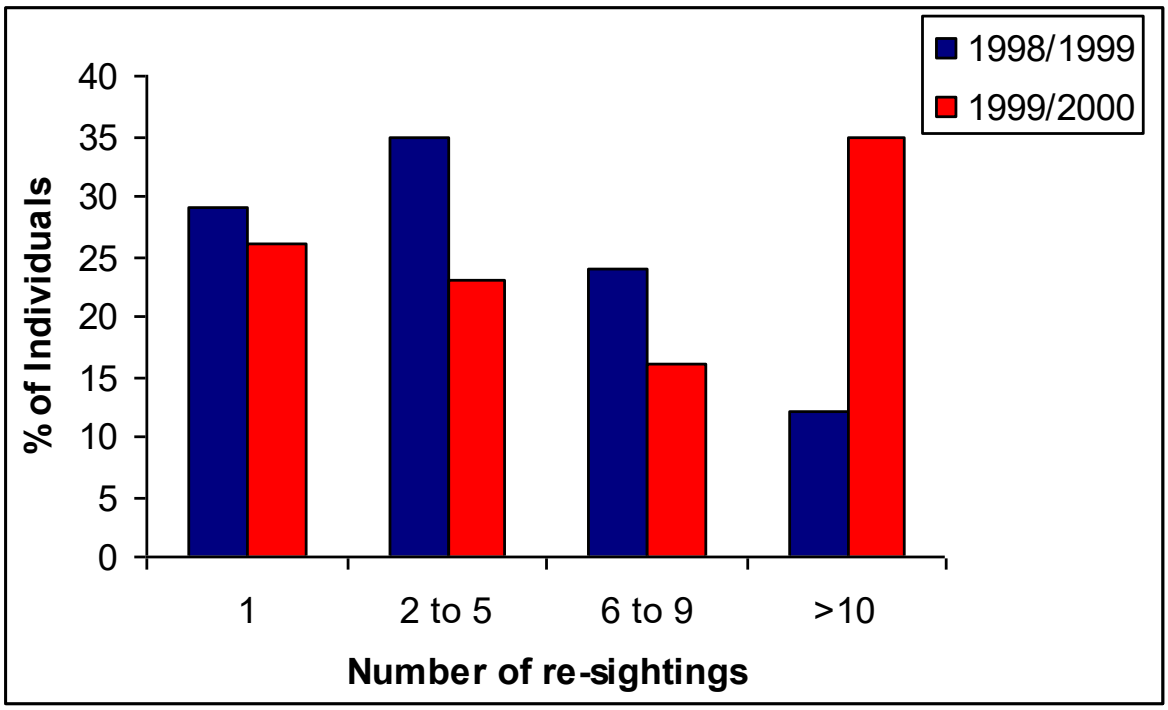
"DRI only" = dolphins only sighted from research vessel.

"1 tour only" = dolphins only sighted from one tour vessel.

During both seasons,17% and 19% of dolphins respectively, were only sighted by the Institute's vessel. Overall, the data appears to indicate, that tour operators interacted frequently with the same individuals, particularly during the second season. It also indicates that a small proportion of the population did not interact with the tours. Data taken from the Institute's vessel will need to be examined in more detail to ascertain if any of these individuals were consistent between the two seasons.

Figure 3.9 illustrates the re-sighting rates for individual dolphins sighted from pooled tour operator data. This data does not include re-sighting rates from the DRI research vessel.
The proportion of individuals only sighted only on a single occasion remained constant between the two seasons (29% and 26% respectively). The main difference between seasons was the increase in the number of dolphins sighted more than 10 times. This increased from 12% during the first season, to 35% during the second season with the highest proportion of dolphins (35%) being sighted greater than 10 times during 1999/2000. This is in contrast to the first season, where the highest proportion of dolphins was sighted between two and four times (35%).

Figure 3.9: Comparison of re-sighting rates of individual dolphins for each season, tour vessels only (n = 521)

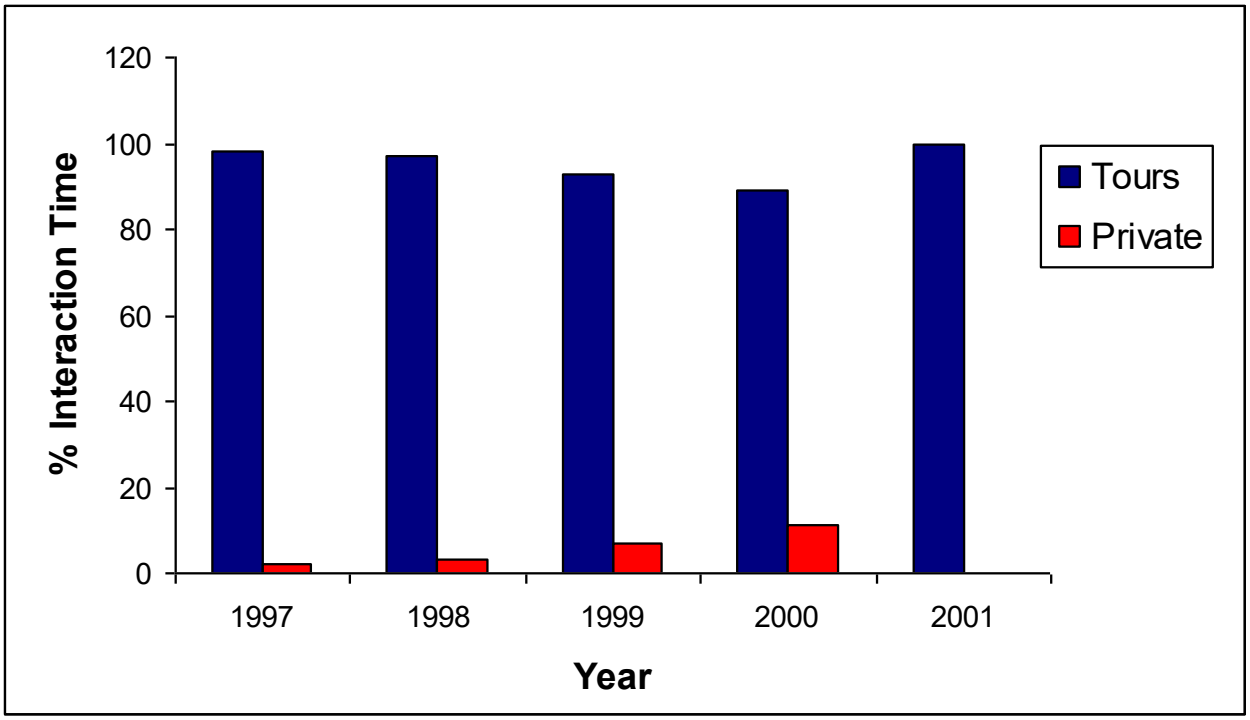


From this data, it appears that, overall, 58% (1998/1999) and 72% (1999/2000) of the population was being interacted with on more than one occasion, by at least 2 vessels during the course of the study.

3.3.5 Recreational and other vessels

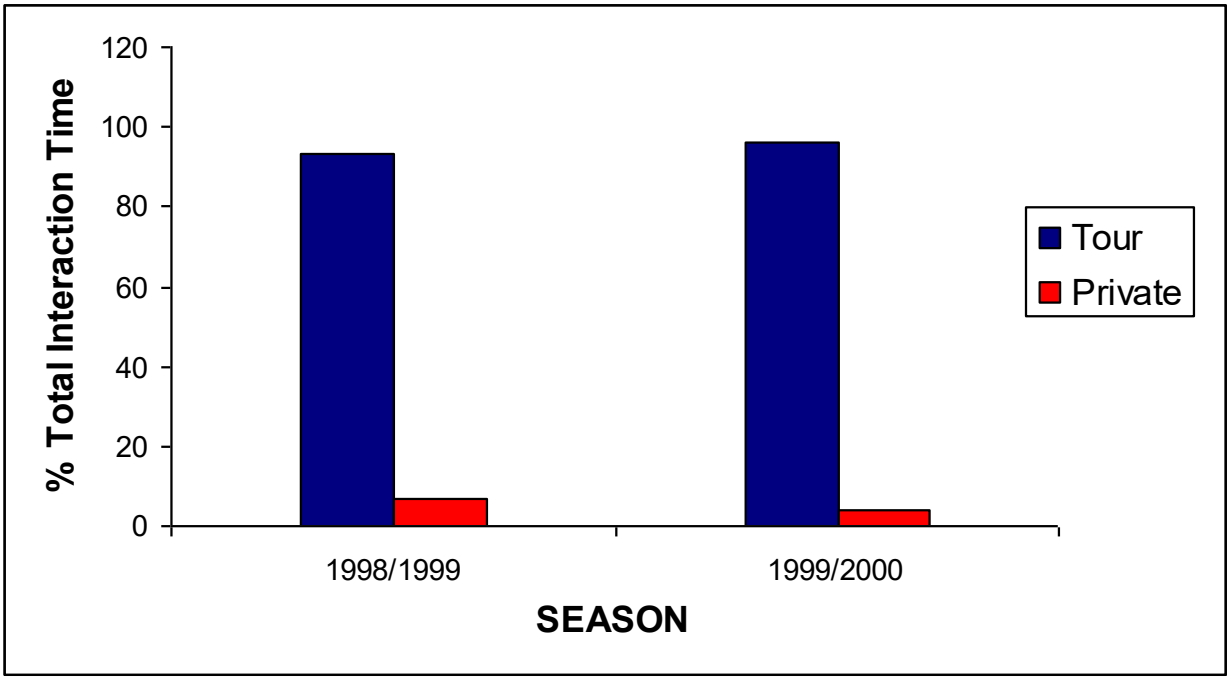
All data collected on vessel interactions from 1997-2001 was converted to total durations for private boats and tour boats respectively. This was then pooled for each season for both shore based platforms and the Institute's research vessel and the relative proportions of interaction time were calculated for both the tour vessels and private vessels (Figure 3.10). Durational data collected from the tour vessel platforms was collated separately. For all seasons, tour vessel interactions accounted for the majority of observed interactions between dolphins and vessels accounting for 95% of interaction time overall.

Figure 3.10: Proportion of interaction time for tour vessels and recreational vessels – shore and DRI vessel data only



Tour vessel and private vessel interaction data collected from the tour vessel platforms are depicted in Figure 3.11. Note that the data only includes details on other tour vessel interaction time. *It does not include the interaction time for the observation platform*.

Figure 3.11: Proportion of interaction time for tour vessels and recreational vessels – tour vessel platforms only



As for the data in Figure 3.10, tour vessel interactions accounted for the largest proportion of overall interaction time, 95% of all interaction time for both seasons. Private vessels were observed during 25% of sightings during the first season and 15% during the second season. In contrast, another tour vessel was present during 51% of sightings during the first season. This figure increased to 68% during the second season (Table 3.7)

Table 3.7: Proportion of time other tours were present during a sighting for each season

1998/1999		**1999/2000**	
Total Sightings	51%	Total Sightings	68%
1 Vessel	17%	1 Vessel	32%
2 Vessels	19%	2 Vessels	22%
3 Vessels	13%	3 Vessels	8%
> 3 Vessels	3%	> 3 Vessels	3%

3.4 Discussion

Overall, a significant increase in disturbance to the dolphins between the seasons was observed, as evidenced by the overall decrease of responses in the "neutral" category. This increase in disturbance was observable as an increased proportion of avoidance responses and an increased rate of interaction during approaches that utilised the parallel approach strategy. The change in the incidence of neutral behaviour was also evident during the frequently utilised intercept approach strategy, although in the case of this strategy, the change was totally manifested as increased interactions between the seasons.

The possible reasons for this increased disturbance are unclear, the sighting rate was relatively constant between each season, as was interaction duration. The main difference between the seasons was the increase in the average number of approaches per sighting during the second season. It is possible that the increased pressure associated with a greater number of approaches has influenced dolphin response, however, the increased number of approaches may also have been in response to avoidance behaviours and may reflect the difficultly of getting a swim due to the dolphins not wanting to interact for other reasons.

This overall increase is even more striking when you compare the comparative proportion of approach strategies between the years. The "parallel" approach strategy is usually considered a benign strategy and has been associated with low incidences of avoidance in other studies (Constantine 1997). During the first season, responses were consistent with those found by Constantine (1997), although a higher avoidance rate was recorded for this study. The incidence of this strategy increased during the second season as did the disturbance, suggesting that other factors are involved in this increase in disturbance other than approach strategy. The increase in avoidance and interaction responses may also be associated with the increase in the number of sightings where multiple vessels were interacting with the dolphins. The incidence, per sighting, of multiple tours interacting with the dolphins increased from 51% during the first year to 68% during the second year.

It is also valid to note that dolphin/vessel interactions may not necessarily be "positive" responses. Institute researchers have observed many interactions that appeared to be decoy responses (Dunn & Goldsworthy 2001). Decoy responses occur when one or more dolphins approach a vessel and interact, while the rest of the group moves away. The exact extent of the occurrence of this behaviour in the Port Phillip Bay population, as a response to tour vessel interactions, is still unclear.

Detailed analysis of data from both years is still required to determine the influence of consecutive interactions on dolphin response, the extent of "decoy" behaviour and the influence of multiple vessels.

3.4.1 Influence of Approach Strategy

Four approach strategies were observed during the course of this study, but only two of these were examined in detail. The parallel and intercept approach strategies accounted for 83% of approaches during the first season and 95% during the second season. During the first season, the main dolphin response observed for the parallel approach strategy was "neutral". A response was classified as "neutral" when the dolphins continued their activity undisturbed, showing no observable response to the tour vessel approach. The next most frequent response was an interaction response followed by an avoidance response. During the second season, the relative proportion of responses changed and dolphins were observed to avoid the tours most frequently followed by interaction. Neutral responses declined significantly.

The intercept approach was associated with similar frequency of avoidance responses for both seasons, however there was a slight reduction in avoidance responses during the second season. Interaction responses were observed to increase and neutral responses decreased. For both seasons, avoidance was the most frequently recorded response to this approach strategy. The intercept approach strategy is clearly illegal since it involved placing the vessel in the path of the dolphins which is a breach of the Whale Watching (1998) Regulations. It is also the strategy associated with the highest frequency of avoidance. By placing the vessel in the path of the dolphins, they generally have to choose to interact or avoid. The presence of the vessel in the path demands a response.

In contrast, the parallel approach allows the dolphins to "control" the interaction since they are able to ignore the tour vessel approach and continue their previous behaviour, if they choose. From the data presented in this report, it appears clear that approach strategy alone does not necessarily influence dolphin response. It is likely that the influence of other factors including dolphin behavioural state, presence of calves, number of vessels and consecutive approaches has impacted on these recorded responses.

3.4.2 Influence of behavioural state on dolphin response

Dolphins were observed to interact more frequently with tour vessels when feeding or socialising. During milling behaviour, no observed interactions were recorded and during travel behaviour, the dolphins were more likely to avoid than interact. During social behaviour, no avoidance responses were observed. This overall pattern was the same for each season.

Of interest, are the responses associated with milling and feeding behaviour. Milling is close to a "resting" behaviour. It is a behaviour associated with low activity and often occurs after a high activity behaviour such as feeding. Shore-based behavioural data indicated that dolphins were observed to be milling fewer times in the presence of tour operators than when tours were present. These combined results may indicate that dolphins are more sensitive to tour vessel interactions when milling. In the case of feeding, the data needs to be examined in more detail to determine how interaction frequency or feeding behaviour changes throughout the course of a sighting. For all behaviours, further analysis is required to determine how responses change through time and in the presence of multiple vessels.

3.4.3 Swim Success

As the data is section 3.3 shows, swimmer interactions are not the most frequent dolphin/vessel interactions in southern Port Phillip Bay. Both vessel interactions and avoidance responses occur more frequently than swimmer interactions. The overall success rate for swimmers was 42% *once in the water* which is comparable with Constantine's (1997) finding of 48%. Interaction durations for swimmers were much lower than those recorded by Constantine, however with the average duration being <60 secs with only 3 occasions occurring whereby the dolphins remained near the swimmers for longer than 1 minute. In Constantine's (1997) New Zealand study, dolphins interacted with swimmers for an average of 4.2 minutes.

The effectiveness of conducting swims must be considered in light of the effort required to obtain a "successful" swim where dolphins interact with swimmers. In Port Phillip Bay, a swimmer interaction, only occurred once for approximately, every 6.9 approaches. For each of these interactions, 3.9 avoidance responses were recorded. Vessel interactions are twice as frequent in southern Port Phillip Bay than swimmer interactions, two vessel interactions were recorded for each swimmer interaction. In many cases, the tour vessels themselves terminated the vessel interaction by stopping to place swimmers in the water.

The huge amount of effort involved to even deploy swimmers, coupled with the low rate of interaction and high level of avoidance should raise questions about the sustainability of this industry as it exists. The amount of effort required to obtain a successful swim, when compared to the average number of approaches per swim means that many passengers (the majority) did not see dolphins in the water at all. This number is further reduced by the limited interaction time. In contrast, vessel interactions were far more common and often dolphin initiated. They required less effort and the majority of passengers had the opportunity to view dolphins. From this data, the wisdom of allowing any expansion of this industry clearly has to be questioned.

3.4.4 Impact on individual dolphins

For both seasons, the majority of dolphins identified in southern Port Phillip Bay during each season were observed to interact with the tours, although the proportion increased during the second season. Of these, most were observed to interact with more than one tour operator. During the second season, the majority of individual dolphins were encountered more than 10 times. There is therefore, no evidence in the data at this stage, to suggest that specific dolphins interact only with particular tour vessels. There does appear to be some evidence, however, that some dolphins may only interact with the DRI vessel. There was a consistent number of dolphins that were sighted only from the research vessel during both seasons although the data will need to be analysed further to determine the rate of re-sightings of these and to determine if any of the same individuals were identified during both seasons.

What is clear from this data, is that the same individual dolphins were encountered more frequently during the second season. A greater number of individuals were also interacted with by more than one vessel during the second season. Previous analysis of the 1998/1999 data (Dunn & Goldsworthy 2001) indicated a "continuum" of interactions for the Port Phillip Bay dolphins. Of those examined that had been sighted frequently, some interacted frequently with the vessels, some interacted, or didn't interact equally, and others were more likely not to interact.

3.4.5 Private vessel versus swim tour interactions

There is no doubt that boat traffic in southern Port Phillip Bay increases significantly during summer, however for the level of traffic there were comparatively very few occasions where private vessels spent any significant time interacting with dolphins. Most of the private vessel/dolphin interactions that were recorded were brief. In contrast, tour vessels were observed to spend a significant amount of time interacting with dolphins and accounted for 95% of all vessel interaction time.

This clearly ratifies the current approach by Natural Resources and Environment to manage the tours sustainably because they are clearly the greatest impact on the dolphins at present.
It is important to remember, however, that private vessels do have an impact and this needs to be factored in. The nature of this impact is unclear at present, but does not appear to be as direct or as large as the impacts associated with dolphin-swim tour vessels. The main impacts are associated with the levels of background traffic of private and other non-swim, commercial traffic.

The background level of other boat traffic may influence dolphin location and behaviour, particularly on busy days. Dolphins respond regularly to all boat traffic, they may dive or change direction to avoid a vessel travelling through or may be required to change direction to move around a stationary vessel. Private vessels have never been observed to spend the 1.5-hour per day interaction time with dolphins that the tours regularly do. Even when all non-dolphin swim boat traffic is added up, it is unlikely that it would equal the average 6-hour per day interaction time that the tours represent. Although data exists on "background" levels of traffic, this was not examined for this report.

4. Tour operator compliance to the Wildlife Regulations

4.1 Background

The first dolphin swim tour commenced operation in the late 1980's. At the time, the industry was composed of a single operator who conducted swims to help fund research into the bottlenose dolphin population in Port Phillip Bay. Support of the swim tours by the Conservation Minister of the time placed the control and management of the swims into a "grey" area from the start. Technically, the tours should have been operating under the *Wildlife (Whales) Regulations 1990*, but the support of the Minister created a some difficulty in regards to management of this industry. Coupled with this, the existing legislation at the time did not allow for tour operator permits, so the industry continued unchecked, for several years.

The industry soon expanded, with three dedicated swim operators conducting dolphin swims by 1994. At this time, the operators came together in a forum with NRE representatives to develop principles for tour operator behaviour around the dolphins. These meetings were initially chaired by the Dolphin Research Institute. The outcome of the forum was the development of a Code of Practice for the 1994/1995 summer. This Code was reviewed in 1995 and officially endorsed by NRE for the 1996 summer. During 1997, a review of the industry took place resulting in an amendment to the *Wildlife Act 1975*. This allowed for tour operator permits to be issued. Suitable legislation was developed to manage the tours and was enacted in time for the 1997/1998 summer. This Legislation was based on the original Code of Practice.

The Legislation was reviewed during 1998 as part of the Regulatory Impact Process and the minor amendments to the Legislation were enacted in time for the 1998/1999 summer. Currently there are five dolphin swim permits, and three sight-seeing permits. Only four of the five swim permit holders run regular dolphin swims and the majority of sightseeing activity originates from the two passenger ferries, operating under a sight-seeing permit. Other commercial vessels also interact with the dolphins on an opportunistic basis.

Institute researchers started collecting data on tour operator compliance during the 1996/1997 summer. Initially, compliance data was collected solely from the Institute's research vessel and shore-based platforms. In 1998, the Institute started a major investigation into the impacts of dolphin tours and observations were collected from the tour operator vessels themselves.

4.2 Study Methods

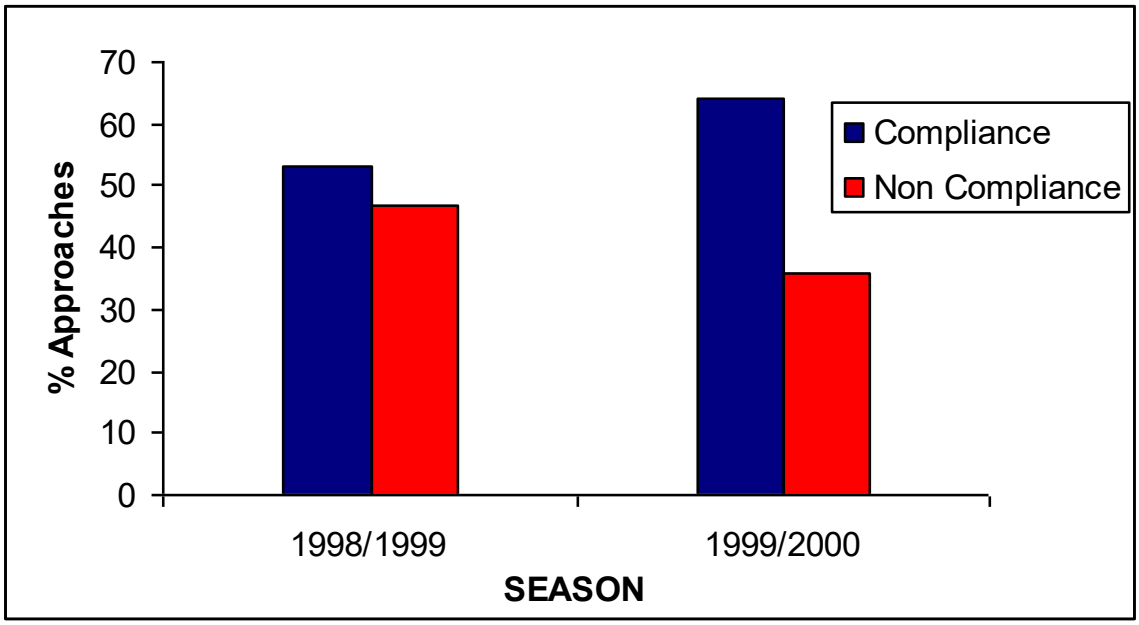
Compliance data was collected simultaneously with data on dolphin/vessel interactions. Once the observation platform moved to within 400m of the dolphins, observations commenced. Wherever possible, data on other vessels interacting with the dolphins were also collected although the primary focus was the observation platform. Only selected sections of the Regulations were monitored, all of which were associated with vessel behaviour, swimmer placement and approach strategies. Observed regulations are shown in Appendix 4.

Observations were only collected during an approach. If a breach was observed, the breach detail was recorded, if no breach was observed it was recorded as "no obvious breach". In the case of several breaches being observed during one approach, details of each breach were recorded. Any breach that could not be reliably placed in the "breach" category was recorded in the "compliance" category. Observations requiring distance estimation utilised vessel size and mermaid line length as a "yard stick" for comparison. Researchers also used Tasco LFR600 range finder binoculars with laser sights to determine distances.

4.3 Results

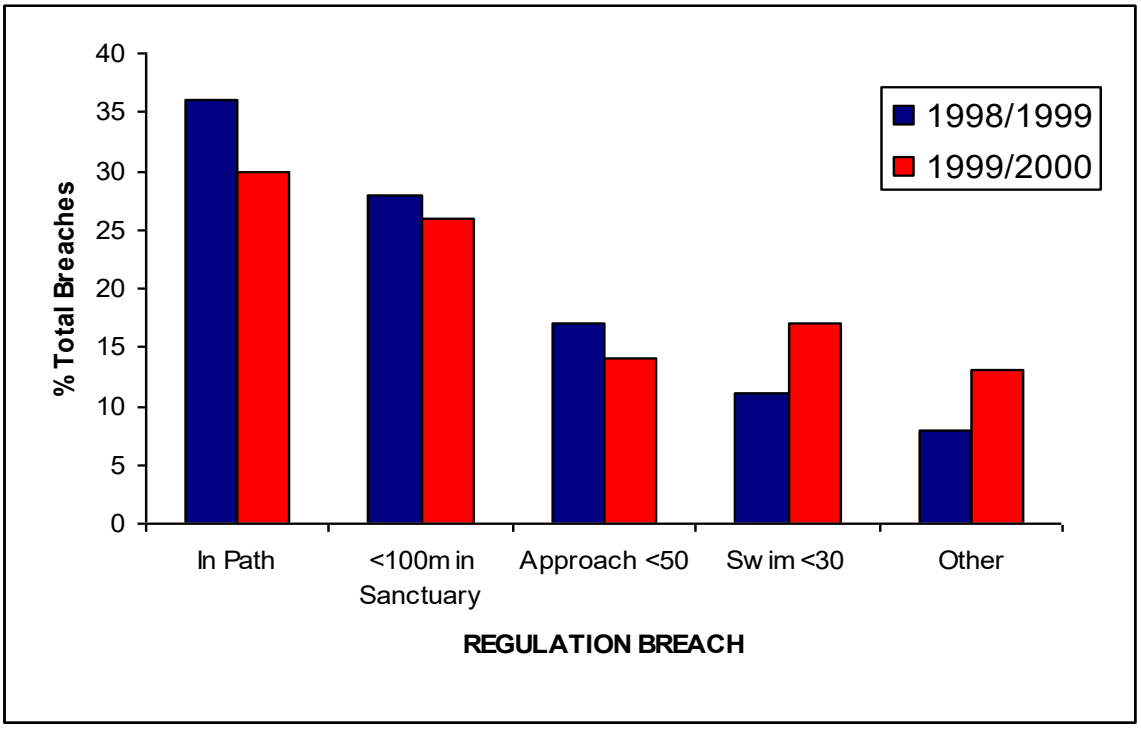
Compliance was monitored on 711 approaches over two swim seasons. Data was collected for each approach and pooled for all operators. Figure 4.1 depicts the proportion of overall compliance for each season.

Figure 4.1: Compliance data for each season (n=711)



During the first season, overall compliance to the Regulations was observed for 51% of approaches. The compliance rate improved during the second season with an overall compliance rate of 63% being recorded.

Figure 4.2: Compliance to individual regulations for each season (n=711)



For both seasons, the most frequent breaches were placing the vessel in the path of the dolphins (36% & 30%) and approaching dolphins <100m in the Sanctuary Zone (28% & 26%) (Fig 4.2). There was a general decline in all breaches for the 1999/2000 season, except for one Regulation. The number of breaches on deployment of swimmers <30 metres from the dolphins increased as did towing swimmers (accounted for 10% of breaches in the "other" category). Data on breaches associated with the distance between tour vessels are not shown since this was a difficult factor to document. Breaches to this particular regulation occurred during 100% of sightings where more than one operator was present. These breaches occurred repeatedly during sightings as operators approached the same dolphins and moved around one another to interact with the dolphins.

In respect to swim attempt duration, under the legislation tours were not to place swimmers in the water, on any swim attempt, for longer than 20 minutes. In the Regulations, a swim is deemed to commence once mermaid lines have been placed in the water. Data collected for swim duration indicates that swimmers are only in the water, on average, for 5 minutes therefore this Regulation was only breached on one occasion. When the amount of time that mermaid lines were in the water was considered, this Regulation was breached during all sightings that lasted longer than 20 minutes, particularly during the second season

During the first season, operators initially made attempts to ensure the lines were not in the water longer than 20 minutes by removing them temporarily before re-deploying them. This did not reduce their overall interaction time with the dolphins. During the second year, operators simply left the lines in the water for the duration of the sighting. This Regulation does not appear to be an effective tool for reducing the overall interaction time since tours interacted with dolphins, on average for 40-44 minutes per sighting.

4.4 Discussion

Overall, the compliance rate improved between the two seasons, although much of this improvement can be attributed to the improved behaviour of one vessel. Of concern, is the level of compliance to "key" Regulations that have the greatest potential to impact on the dolphins, in particular, the use of the Intercept approach and breaches of approach distances. Both of these approaches remove control of the interactions from the dolphins since they result in greater disturbance to the dolphins through "forcing" the dolphins to either interact or avoid the tours.

Another major issue with the dolphin swims is the need to separate operators. During the second year of observations, more than one tour was interacting with the same group of dolphins during 68% of all sightings. Vessels did not maintain a 200 metre distance from vessels already within 100 metres of dolphins during these simultaneous interactions. This often resulted in the dolphins being "herded" between the vessels as vessels "leap-frogged" one another to move ahead and place swimmers in before being overtaken by another vessel.

The low level of compliance in the area designated the Ticonderoga Bay Sanctuary Zone is also of concern. In most cases, operators approached and conducted swims as they would for any other area, still approaching the dolphins to a distance less than 100 metres. Shore-based data has shown that dolphins tend to spend more time in the area designated as the Ticonderoga Bay Sanctuary Zone. This cannot be interpreted to infer that they are only found in this zone.

Dolphins are sighted at similar frequencies off Portsea and Sorrento, they just do not spend the same amounts of time in these areas. The reasons for this disparity in time spent between these two areas are unclear. It does appear however, that the area within the Ticonderoga Bay Sanctuary Zone is favoured by the dolphins. Further research may help to understand this.

4.5 Recommendations

1. Limit interaction time for individual vessels

The current legislation does not effectively limit the amount of time each operator can interact with a single group of dolphins. On many days, all tour vessels would interact with a single group, either consecutively or simultaneously. Occasionally, one vessel would return two or three times to interact with the same group of dolphins, during a single trip.

It would be possible to reduce total interaction by setting an easily identifiable limit. For example, the total number of swims that can be attempted during a single trip can be limited. This is not open to interpretation and is easily quantifiable.

2. Separate tours in time and or space.

Tour operators were interacting with the same group of dolphins, simultaneously during 68% of all sightings. Situations still occur whereby 5 or 6 vessels (tour & recreational) interact simultaneously with a single group of dolphins. The current separation distance of 200 metres does not stop operators from interacting with the same group of dolphins

This issue could be addressed by only allowing a pre-determined number of operators to interact at one time, or by increasing the minimum distance between operators. The presence of private boats also needs to be factored in. Tour operators should not be able to approach dolphins when large numbers of private vessels are also interacting.

3 Create "tour free" space and times.

At present, tours are on the water continuously between 8am and 7pm during the summer peak season. Some occasionally interact from dawn to dusk. Although the Ticonderoga Bay Sanctuary Zone been designated by Legislation, tours are still able to, and do conduct swims in this area.

Tour free time could be achieved by designating times during the day during which tours cannot interact with the dolphins, such as early morning, evening and middle of the day. Tour Free Space can be achieved by either making the Ticonderoga Bay Sanctuary Zone area a "no interaction" zone for operators or by increasing the distance to which tours can approach dolphins in this zone. Imposing an overall speed limit in this zone will minimise disturbance caused by speedboats and water-skiers.

5. Behavioural study on the Port Phillip Bay dolphins

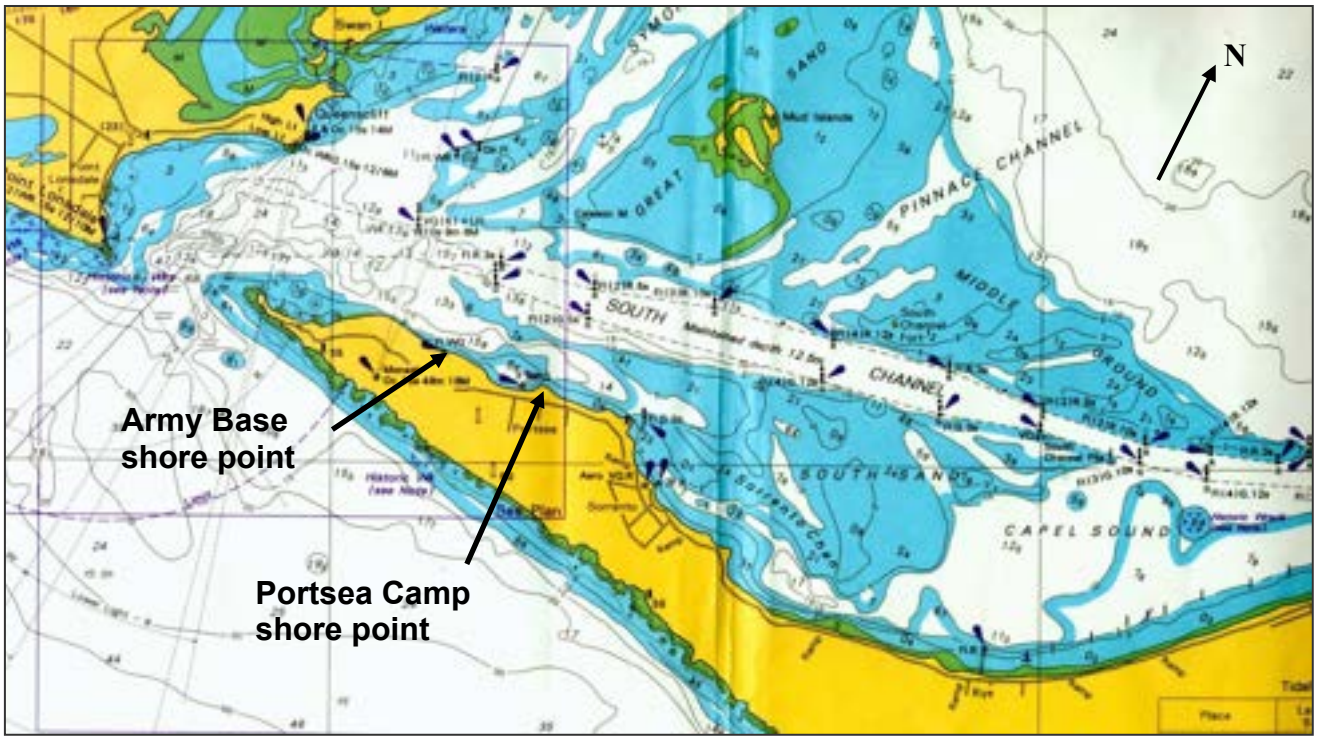
5.1 Background

Understanding the behaviour of the dolphin population has been one of the main research aims of the Institute and has been undertaken in a number of ways. Behavioural data has been collected from both research vessels and shore-based locations, however results in this section focus on the shore-based component of these studies. Although time-intensive, shore-based behavioural observations are the only way to collect data without impacting directly on the dolphins and affecting their behaviour. Such observations allow researchers to see how dolphins behave in the presence and absence of boats, the latter of which can be used as a control to compare with data collected in the presence of boats. Only then can a true understanding of boat impact on behaviour be gained. A number of dolphin studies utilise shore-based methodologies for a number of purposes, such as site fidelity, habitat use and behaviour (eg. Bristow and Rees, 2001; Bristow, *et al.*, 2001; Connor and Smolker, 1985; Gregory and Rowden, 2001; Harzen, 1998; Karczmarski, *et al.*, 2000; Shane, 1990b). The Institute has utilised shore-based fieldwork to understand more about habitat use, behaviour, impacts of boats (commercial and recreational) on behaviour, and general boat traffic. Data was collected by Institute researchers and volunteers, however results in this section have been based on observations collected only by researchers.

5.2 Study methods

Presented here are preliminary results from data collected during the summer research seasons of 1998-2000 inclusive. There were two elevated shore-based locations from which observations were made, being Norris Barracks (known as the Army Base) located west of Portsea, and Portsea Camp located directly to the east of Portsea Pier (Fig 5.1). The Army Base site allows an uninterrupted view west to Observatory Point, north to the channel and east towards Police Point (note that Police Point itself is not visible). The Portsea Camp site has views west to Police Point, all of the waters directly off Portsea out to the channel, and east to Point Franklin. There is also a secondary site within Portsea Camp that can be utilised when dolphins move out of view to the east, which is located on Point Franklin itself. This site has views of Shelley Beach to the east, towards Point MacArthur, and west to Police Point. This site was not used over entire survey periods as it is more exposed to weather, particularly the sun.

Figure 5.1: Southern Port Phillip Bay, including shore-based locations



Surveys were conducted in six-hour blocks and times were rotated between 07:00 and 19:00, to ensure that all time-periods were covered. During each survey, researchers would keep the observation area under constant surveillance including a detailed scan of the area with binoculars, every 15 minutes. Sea Conditions were based on the Beaufort Sea State Scale (Appendix 1) and were updated as conditions were observed to change. All observations were collected using 16 x 50 (mounted on a tripod) and 12 x 50 Pentax binoculars. Observations were either recorded on a micro-cassette recorder and transcribed later or were immediately recorded onto coded data sheets. Distance from shore was estimated in two ways. At the start of the study, the Institute's research vessel was used to "sight in" distance from shore by moving to pre-arranged distances to indicate the distance from shore. Landmarks were also utilised, particularly for the Portsea Camp observation site.

Once dolphins were sighted, the following observations were noted; position within the study area, group size (including the presence of any calves) (Appendix 3), dolphin behaviour (Appendix 2), vessel presence (both commercial and private), dolphin distance from shore and the direction of movement. At this point two forms of data were collected, being time-budget and continuous data.

5.2.1 Time-budget data

Time-activity (time-budget) data was collected from both shore-based sites during January and February for all years between 1998-2001. Once dolphins were sighted and the initial details were recorded, observations were then recorded at regular intervals using a technique modified from Shane (1990a). Observations were recorded at these intervals (point sampling) even if there was no observed change in behaviour or position. When the observational interval coincided with an extended dive, this was noted as "dive" and the behaviour immediately prior to the dive was recorded. Similar techniques have been utilised successfully in several published studies (Altmann, 1974; Bearzi *et al.*, 1999; Neumann, 2001; Shane, 1990b).

Time-budget data was collected for a set time from the beginning of each sighting. However, if researchers suspected that the next sighting was the same group of dolphins returned to the observation area, then time-budget was not collected again. At the end of the time-budget period, researchers continued to collect data in a continuous form.

5.2.2 Continuous data

Continuous data is a systematic record of frequencies or durations for specified behaviour and may also be called event or frequency sampling (Mann, 1999; Altmann, 1974). Continuous data was collected for as long as the dolphins were in the observation area. Updates would be made when the dolphins changed behaviour, position (including distance offshore) or group size. The presence of boats (commercial and recreational) in the area would be noted, including their behaviour and dolphin response to them, if any.

Any boat traffic through the survey area was collected, even when dolphins were not present, to give an indication of levels through the area and to assess any correlation with dolphin presence. For the purposes of this report, results are presented on how boat presence influences dolphin behaviour and cases of dolphins displaying avoidance behaviour to vessels.

5.3 Results

5.3.1 Field effort

A total of 204 surveys were conducted on the shore-based sites combined, comprising of 121 surveys at the Army Base and 83 at Portsea Camp (Table 5.1). There was a relatively equal chance of sighting dolphins from both sites at 65.3% and 69.9% of all surveys for the Army Base and Portsea Camp respectively, and a total of 67.2% for the shore sites combined.

Although the sighting rates were similar between sites, the mean sighting duration was higher at the Army Base. It would appear that the dolphins spend almost double the time per year on average in the Army Base than Portsea Camp (15.01 hours compared to 8.62 hours respectively).

Table 5.1: Field effort and dolphin sightings for shore-based sites, January/February 1997 - 2001

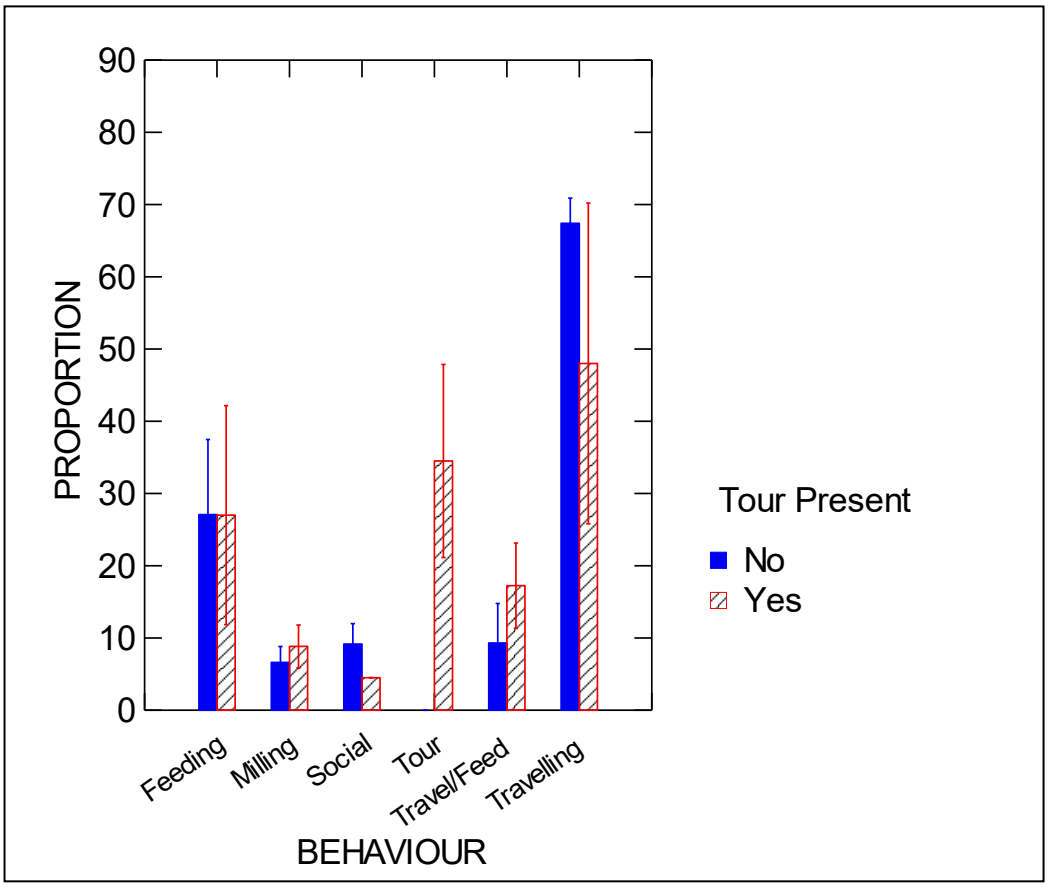
Shore Surveys	Surveys	Field hours	Sighting Days	Dolphin sightings	Sighting duration (hrs)
Army Base	121	541.683	79	150	75.05
Mean/year	24.2	108.34	15.8	30	15.01
Portsea Camp	83	371.95	58	96	43.12
Mean/year	16.6	74.39	11.6	19.2	8.62
Total	**204**	**913.633**	**137**	**246**	**118**

The Army Base has been covered consistently over the years and a conscious effort was made to do this, as it is arguably the best site for shore observations. Hence, Portsea Camp was generally covered when there were enough researchers available to be present at both sites. For this reason, all data in this section has been based on Army Base observations only for the years 1998 to 2000.

5.3.2 Time-budget behavioural data

Time-budget effort falls within the general shore based effort, however there are less sightings as only complete time-budget surveys have been analysed. There was a total of 84 dolphin sightings, accounting for 420 time budget observations and 997 minutes of observations. Travelling was the most frequent behaviour recorded, accounting for 58% of all observations, although some variation was present between years (Fig 5.2). Feeding was the second most observed behaviour accounting for 27% of all observations with a high level of variability between years. The frequency of behaviour did not appear to be influenced by tour operator presence, except in the case of social and milling behaviour, however the sample size is limited for these behaviours.

Figure 5.2: Pooled time-budget data for 1998-2000 (n = 295)



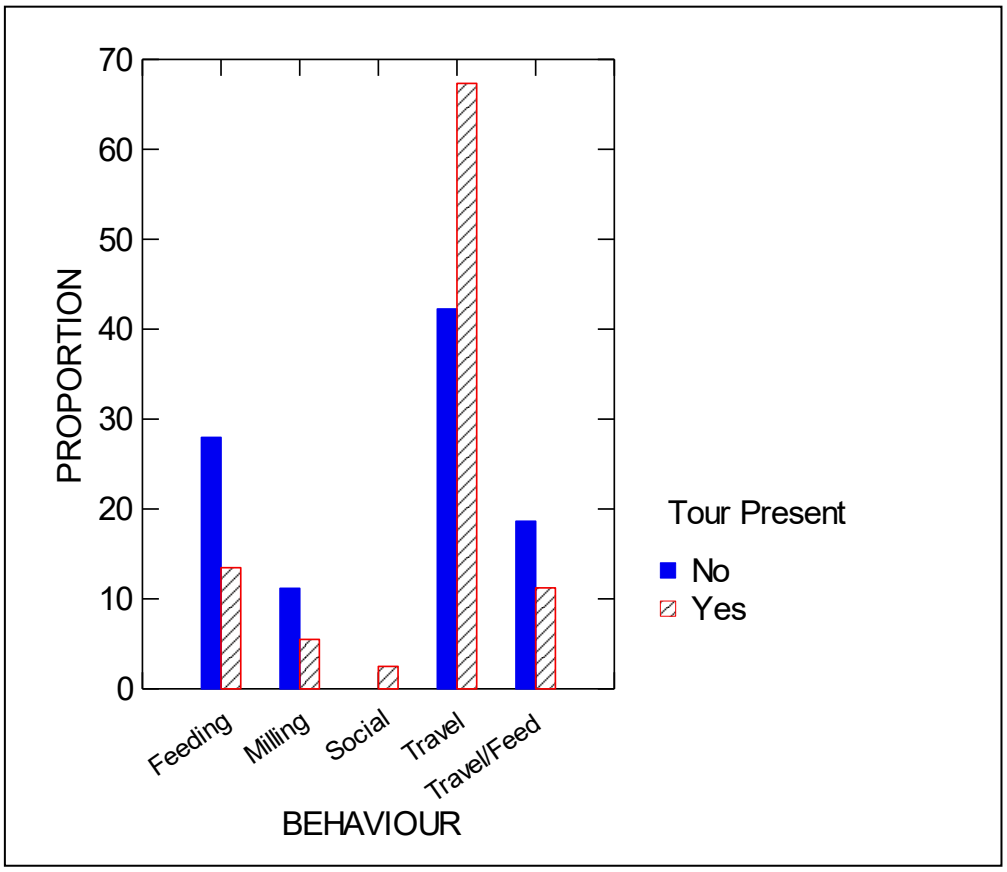
Time budget will be continued as a methodology within the Institute's behavioural studies to further build on the results above. The use of this method from the research vessel is also important so that comparisons can be made between the two platforms, in particular determining any differences caused by the boat.

5.3.3 Continuous behavioural data

Analysis of continuous data at this stage, has been based on the first ten minutes of each sighting, over the years 1998-2000. There were a total of 97 observations from the Army Base and 40 observations from Portsea Camp. As the Army Base was a larger data set, the following analyses have been based on only that data. Durations of behaviour were analysed as a proportion of sightings in the presence or absence of tour vessels (including passenger ferries). A total of 24,060 minutes (401 hours) of behavioural observations were recorded in the presence of tour vessels and 9,660 minutes (161 hours) in their absence, resulting in tour vessels being present for 71.4% of observations.

When tour vessels were present, dolphins were most often travelling (67.33%) compared to other behaviours (Fig 5.3). This was also the most common behaviour observed in the absence of tour vessels, but not at such a high proportion (42.24%). Dolphins were more likely to be seen feeding, travel/feeding or milling in the absence of tour vessels.

Figure 5.3: Behaviours displayed by dolphins in the presence/absence of tour vessels, Army Base 1998-2000 (n = 97)

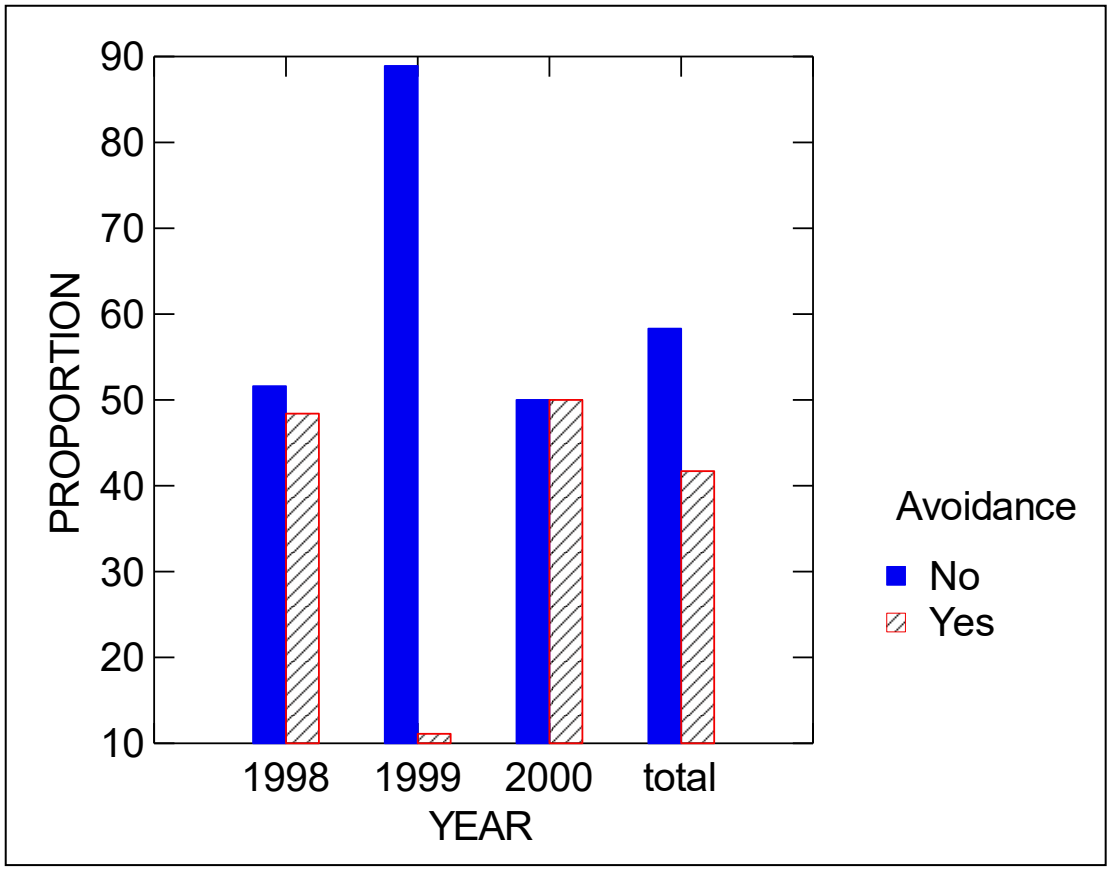


These results appear different to the time-budget data, however it should be noted that time-budget is the frequency of behaviours, whilst the continuous data has looked at the duration of behaviours. So, although the frequency of behaviours did not appear to be influenced by tour vessels, the duration of behaviours was.

Future analysis needs to look at the rate of behaviour change in the presence and absence of tour and private vessels, as well as the changes in behaviour made directly in response to the presence of tour vessels. Preliminary analysis of the first 10 minutes of observation showed eight cases (14%) where the dolphins changed behaviour when a tour vessel arrived or left, which does not include avoidance responses (from the Army Base only, 1998-2000). Further analysis is required to determine how often this happens during an entire sighting and future research plans to examine this in more detail.

Avoidance behaviour exhibited in response to tour and private vessels in the first ten minutes of shore observations was also analysed (Fig 5.4). Avoidance behaviour is defined by deep dives and changes in direction in response to a vessel. Of the total observations made with tour operators present, avoidance was recorded in 39.1% of cases. Avoidance was either recorded as a change in direction (10.9%), deep dive (8.7%), or as a combination of both (19.6%). Within years, 1998 and 2000 were almost identical in the rates of avoidance/no avoidance. Results in 1999 showed a greater rate of no avoidance to tours, however the tour vessels were encountering dolphins further offshore and were often outside the limits of the survey areas during that year.

Figure 5.4: Avoidance behaviours exhibited in the presence of tour vessels, during the first 10 minutes (n = 46)



Any level of avoidance by the dolphins is undesirable and these rates are quite high, especially considering that these were cases in only the first ten minutes of observation. Tours are known to interact with dolphins for long periods and further analysis is required to determine how the rates of avoidance change as time with tour vessels increases.

5.4 Discussion

The behaviour frequency results are remarkably similar to those found for bottlenose dolphins in other areas of Australia and the world (Moller & Harcourt 1998, Shane 1990a, 1990b). For both studies, travelling behaviour was observed most frequently (63% for Shane 1990a, 1990b; 61% for Moller & Harcourt 1998). Feeding behaviour frequency was also remarkably consistent (29% Moller & Harcourt, 1998; 21%, Shane 1990a). Milling and social behaviour was more variable between studies with social behaviour being observed in 8% (Moller & Harcourt, 1998) and 17% (Shane 1990a) of observations. One behaviour rarely recorded in Port Phillip Bay is resting behaviour. This has been recorded by other researchers (Constantine 1997; Shane 1990a, 1990b), but has only been observed on two occasions in the Port Phillip Bay dolphins.

The initial results of durational data suggest that vessels impact on dolphin behaviour in some way. The extent of these affects is yet to be determined and the implications for the dolphins remains poorly understood. Data on the first ten minutes of observations alone suggests that dolphins may favour particular behaviours in the absence of tour vessels. As mentioned above, resting behaviour has been rarely observed with the closest behaviour being milling. This was a behaviour that was displayed more in the absence of tour vessels. The fact that any sort of resting behaviour is rarely seen is interesting in itself, but as to whether this is a factor of boats is difficult to determine due to the low number of cases observed. Feeding did appear to be the main behaviour that dolphins are more likely to do in the absence of tour vessels. This should be investigated more in future analysis, as feeding is of particular significance to the dolphins and interruption by vessels into this behaviour should be avoided. In addition to these differences in behavioural durations, avoidance of tour vessels was found to occur in up to 40% of cases. There was also anecdotal evidence of dolphins changing behaviour as tour vessels arrived or departed. Further analysis is required to determine if behaviour changes and avoidance 7responses increase as time with tour vessels increases, plus the impact of multiple tour vessels.

6. Report summary

Dolphin swim tour operators in southern Port Phillip Bay interact on a daily basis with a small, resident population of approximately 107 bottlenose dolphins. The re-sighting rate of dolphins within this population was found to be greater than for other populations around Australia and the world. This population is considered to be a "closed" population with little evidence of immigration from outside populations.

During the period from October to May every year, multiple tours interact with up to 73% of the population on a regular basis. Therefore, the majority of dolphins will be subject to interactions from multiple vessels. These interactions increase during summer as tourism activity increases on the Mornington Peninsula. Modelling of data available on interaction duration and tour operator trip frequency suggest that each tour spent 7 hours per day on the water on average, during the peak time in January/February. Of this 1.5 hours were spent interacting with the dolphins. This equated to 6 hours total dolphin/tour vessel interaction time per day.

Recreational and other commercial (non-dolphin tour) activity also increased over the summer period, however analysis of private vessel and swim vessel interaction duration from shore-based sites, the Institute's vessel and the tour vessels, indicated that dolphin swim tours are responsible for the vast majority of interactions. It was determined that the impacts of private and other vessels need to be taken into account since they provide "background" traffic which may result in some disturbance, however not at the same levels as the tours.

Data collected on dolphin responses to tours showed that tours do impact dolphin behaviour and this impact was observed to increase significantly between the two seasons. The reasons for this increase were unclear, however there was an associated increase in simultaneous tour vessel interactions during the second season. There was also an increase in approach effort during the second season and the proportion of dolphins subjected to repeated interactions.

What was clear for both seasons, was that avoidance and dolphin/vessel interactions occur more frequently than dolphin/swimmer interactions. In many cases, swimmers did not have the opportunity to view dolphins in the water. The average duration of swimmer interactions was also small, being much lower than durations recorded in other areas (Constantine, 1997) and less than the recorded average dolphin/vessel interaction duration in Port Phillip Bay. Evidence exists to suggest that at least some of the interactions recorded between vessels and dolphins may be "decoy" responses and that some individual dolphins may interact preferentially while others may actively avoid the tours.

Behavioural data collected from the shore indicated that the duration of specific behaviours was affected by tour operator presence with particular behaviours occurring for longer when tours were not present. Behavioural data collected from the tours suggested that dolphin behavioural state significantly influenced dolphin response. Specific behaviours were associated with high interactions whilst others were associated with high levels of avoidance.

The majority of data presented in this report is primarily summary data and needs to be further analysed to understand the impacts of dolphin-based tourism on the dolphins in Port Phillip Bay.

7. References

Altmann, J. (1974) Observational study of behaviour: sampling methods. *Behaviour* **49(3-4)**: 227-267.

Ballance, L.T. (1990) Residence patterns, group organisation, and surfacing associations of bottlenose dolphins in Kino Bay, Gulf of California, Mexico. Pages 267-283 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Barco, S.G., Swingle, W.M., McLellan, W.A., Harris, R.N. and Pabst, D.A. (1999) Local abundance and distribution of bottlenose dolphins (*Tursiops truncatus*) in the nearshore waters of Virginia Beach, Virginia. *Marine Mammal Science* **15(2)**: 394-408.

Bearzi, G., Politi, E. and Di Sciara, G.N. (1999) Diurnal behaviour of free-ranging bottlenose dolphins in the Kvarnerić (Northern Adriatic Sea). *Marine Mammal Science* **15(4)**: 1065-1097.

Bräger, S. (1993) Diurnal and seasonal behaviour patterns of bottlenose dolphins (*Tursiops truncatus*). *Marine Mammal Science* **9(4)**: 434-438.

Bristow, T. and Rees, E.I.S. (2001) Site fidelity and behaviour of bottlenose dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales. *Aquatic Mammals* **27(1)**: 1-10.

Bristow, T., Glanville, N. and Hopkins, J. (2001) Shore-based monitoring of bottlenose dolphins (*Tursiops truncatus*) by trained volunteers in Cardigan Bay, Wales. *Aquatic Mammals* **27(2)**: 115-120.

Connor, R.C. and Smolker, R.S. (1985) Habituated dolphins (*Tursiops* sp.) in Western Australia. *Journal of Mammalogy* **66(2)**: 398-400.

Constantine, R. and Baker, C.S. (1997*) Monitoring the commercial swim-with-dolphins operations in the Bay of Islands.* Science for Conservation: 56. Department of Conservation, Wellington New Zealand.

Corkeron, P. (1990) Aspects of the behavioural ecology of inshore dolphins *Tursiops truncatus* and *Sousa chinensis* in Moreton Bay, Australia. Pages 285-293 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Corkeron, P. (1997) Bottlenose dolphins *Tursiops truncatus* in south-east Queensland waters: social structure and conservation biology. Pages 1-10 *in* M. Hindell and C. Kemper, eds. *Marine mammal research in the southern hemisphere: status, ecology and medicine. Volume 1.* Surrey Beatty and Sons, Chipping Norton Australia.

Defran, R.H. and Weller, D.W. (1999) Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. *Marine Mammal Science* **15(2)**: 366-380.

Defran, R.H., Weller, D.W., Kelly, D.L. and Espinosa, M.A. (1999) Range characteristics of Pacific coast bottlenose dolphins (*Tursiops truncatus*) in the southern California Bight. *Marine Mammal Science* **15(2)**: 381-393.

Dunn, W. and Goldsworthy, A. (2001) The occurrence of habituation and decoy behaviour in bottlenose dolphins (*Tursiops truncatus*) exposed to dolphin-based tourism. Poster presented at Southern Hemisphere Marine Mammal Conference, Phillip Island, 2001. Dolphin Research Institute, Frankston Australia.

Fairfield, C.P. (1990) Comparison of abundance estimation tecnhiques for the Western North Atlantic Right Whale (*Eubalaena glacialis*). *Rep. int. Whal. Commn* (special issue 12), 119-126.

Felix, F. (1997) Organisation and social structure of the coastal bottlenose dolphin *Tursiops truncatus* in the Gulf de Guayaquil, Ecuador. *Aquatic Mammals* **23(1)**: 1-16.

Gregory, P.R. and Rowden, A.A. (2001) Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquatic Mammals* **27(2)**: 105-113.

Hammond, P.S. (1986) Estimating the size of naturally marked whale populations using capture-recapture techniques. *Rep. int. Whal. Commn* (special issue 8), 253-282.

Hammond, P.S., Mizroch, S.A. and Donovan, G.P. Eds. (1990) *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters.* International Whaling Commission, Cambridge UK.

Hansen, L.J. (1990) California coastal bottlenose dolphins. Pages 403-420 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Harzen, S. (1998) Habitat use by the bottlenosed dolphin (*Tursiops truncatus*) in the Sado Estuary, Portugal. *Aquatic Mammals* **24(3)**: 117-128.

Karczmarski, L., Cockcroft, V.G. and McLachlan, A. (2000) Habitat use and preferences of Indo-Pacific humpback dolphins *Sousa chinensis* in Algoa Bay, South Africa. *Marine Mammal Science* **16(1)**: 65-79.

Leatherwood, S. and Reeves, R.R. Eds. (1990) *The Bottlenose Dolphin.* Academic Press, San Diego USA.

Mandelc, F. (1997) Ecology and Conservation of the Bottlenose Dolphin *Tursiops truncatus* in Jervis Bay, NSW. PhD dissertation, Macquarie University, Sydney Australia.

Mann, J. (1999) Behavioural sampling methods for cetacean: a review and critique. *Marine Mammal Science* **15(1)**: 102-122.

Maze, K.S. and Wursig, B. (1999) Bottlenose dolphins of San Luis Pass, Texas: occurrence patterns, site-fidelity, and habitat use. *Aquatic Mammals* **25(2)**: 91-103.

Neumann, D.R. (2001) Activity budget of free-ranging common dolphins. *Aquatic Mammals* **27(2)**; 121-136.

Ross, G.J.B. and Cockcroft, V.G. (1990) Comments on Australian bottlenose dolphins and the taxonomic status of *Tursiops aduncus* (Ehrenberg, 1832). Pages 101-128 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Shane, S.H. (1990b) Comparison of bottlenose dolphin behaviour in Texas and Florida, with a critique of methods for studying dolphin behaviour. Pages 541-558 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Shane, S.H. (1990a) Behaviour and ecology of the bottlenose dolphin at Sanibel Island, Florida. Pages 245-265 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Smolker, R.A., Richards, A.F., Connor, R.C. and Pepper, J.W. (1992) Sex differences in patterns of association among Indian bottlenose dolphins. *Behaviour* **123**: 38-69.

Urian, K.W. and Wells, R.S. (1996) *Bottlenose dolphin photo-identification workshop: March 21-22, 1996.* Charleston, South Carolina; Final Report to the National Marine Fisheries Service, Charleston Laboratory, Contract No. 40EUNF500587, National Marine Fisheries Service, Charleston, SC. NOAA Tech. Mem. NMFS-SEFSC-393.

Weigle, B. (1990) Abundance, distribution and movements of bottlenose dolphins (*Tursiops truncatus*) in Lower Tampa Bay, Florida. *Rep. int. Whal. Commn* (special issue 12), 195-201.

Williams, J., Dawson, S.M. and Slooten, E. (1993) The abundance and distribution of bottlenosed dolphins (*Tursiops truncatus*) in Doubtful Sound, New Zealand. *Can. J. Zool.* **71**: 2080-2088.

Wilson, B., Hammond, P.S. and Thompson, P.M. (1999) Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications* **9(1)**: 288-300.

Würsig, B. and Harris, G. (1990) Site and association fidelity in bottlenose dolphins off Argentina. Pages 361-365 *in* S. Leatherwood and R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, San Diego USA.

Wursig, B. and Jefferson, T. A. (1990) Methods of photo-identification for small cetaceans. *Rep. int. Whal. Commn* (special issue 12), 43-52.

8. Appendices

Appendix 1
Beaufort sea state

Beaufort Number	Sea Criterion	Probable Height of Waves	
		Feet	Metres
0	Sea Like a Mirror.	-	-
1	Ripples with the appearance of scales are formed but without foam crests.	1/4	0.1
2	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.	1/2	0.2
3	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white caps.	2	0.6
4	Small waves, becoming longer: fairly frequent caps.	3 ½	1
5	Moderate waves, taking amore pronounced long form: many white caps are formed (? some spray).	6	1.8
6	Large waves begin to form; the white foam crests are more extensive everywhere (spray present).	9 ½	2.8
7	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	13 ½	4

Appendix 2
Behaviour definitions

The following behavioural states were defined for the bottlenose dolphin population in Port Phillip Bay. These definitions are similar to those developed by other researchers (Neumann 2001; Constantine 1997; Shane 1990a)

Travelling

This behaviour is defined by a dolphin or group of dolphins moving in a consistent and clear direction. It is characterized by dolphins doing several "porpoise" dives followed by longer "extended" deep dives which may last for 2-3 minutes. Dolphins are also observed to change position.

Feeding

Feeding can, at times be difficult to discern and has therefore been divided into 2 categories

1. Surface Feeding

   Dolphins are usually dispersed over a relatively wide area and are generally observed to keep a distance from one another while feeding. There is usually no clear direction of movement and many characteristic surface behaviours are observed. These include circling, rapid, marked changes in direction and rapid, low leaps across the surface of the water. Often fish are observed "leaping" from the water as dolphins chase them and other species such as sea birds and seals may also be present.

2. Benthic Feeding

   Dolphins are usually dispersed but are observed to dive to depth regularly. They may also exhibit rapid changes in direction and speed as they chase fish further down in the water column or in the benthos. Often the animal may be observed to dive repeatedly in one area. This behaviour is common with small groups and lone dolphins

Social

Social behaviour involves there being some form of physical contact between dolphins**.** During this behaviour, dolphins are observed to roll over one another, chase each other, and may be observed to leap out of the water. Dolphins may also be observed to execute high leaps out of the water or low fast leaps as they chase one another.

Milling

Dolphins that are "milling" are generally observed to remain in an area, they may change direction to swim up and down within an area but no surface activity is present. Extended deep dives are rare and dolphins are usually in a tight group. This behaviour is always a "low activity" behaviour in that the dolphins don't exhibit any of the rapid movements associated with feeding or social behaviour.

Human Interaction

This behaviour involves dolphin/vessel interactions. It simply defines any interactions that the dolphins have with boats and is divided into several categories.

1. Bowriding: dolphins are observed to be riding on the bow wave of a vessel.
2. Surfing: dolphins are observed surfing either alongside, or more commonly, in the wake of a vessel.
3. Interacting – dolphins approach the vessel and interact (ie swim around it) but are not surfing or bowriding.

Appendix 3
Group and calf definitions

Dolphin Groups

A dolphin group was defined as any group of dolphins who were observed to be moving in the same direction and/or engaged in the same behaviour. A single group may be dispersed over several hundred metres, particularly while feeding.

Group sizes were calculated by estimating the minimum and maximum number of dolphins present over the duration of a sighting to reach a final "best" estimate. This included the number of calves present, also as a minimum and maximum.

Calves

A calf is defined as measuring between half to two-thirds the length of an adult. Foetal fold calves (newborns) were also noted. They can be defined by a number of features:

a) presence of foetal folds;
b) size being less than half the length of the accompanying adult;
c) presence of a floppy dorsal fin;
d) dark colour;
e) extreme buoyancy (head "pops up" when surfacing); and/or
f) being in the "infant" or "in-calf" position (in relation to an adult, presumed to be its mother) (Barco, *et al.*, 1999).

Appendix 4
Wildlife (Whales) Regulations 1998 observed for compliance

Regulation	Regulations Section	Details
Distance between tour vessels	5(2)(a)	Must not approach or remain within 200m of another tour vessel if that tour is within 100m of dolphins
Approach distance	5(2)(b)	Must ensure the tour vessel does not approach a dolphin within a distance less than 50m
Vessel in path	5(2)(h)(i-iv)	Must ensure the tour vessel does not approach dolphins head on; is not in the path of a dolphin; does not separate dolphin groups; does not come between a mother and calf
<100m in Sanctuary Zone	5(2)(j)	While in the Ticonderoga Bay Sanctuary Zone, must ensure the tour vessel does not approach within a distance less than 100m
<100m of shoreline	6(2)(a)	Must ensure that a dolphin swim is not conducted within 100m of the shoreline
Swim duration	6(2)(b)	Must ensure that a dolphin swim does not continue for more than 20 minutes
Swimmers off mermaid lines	6(2)(c)(iii)	Any person taking part in a dolphin swim (excluding permit holder and staff) must hold onto the mermaid line at all times
Instructors off mermaid lines	6(2)(d)(i-ii)	Permit holder or staff, whilst in the water to assist persons taking part in a dolphin swim, must remain within 10 metres of the mermaid line (except in an emergency)
Repositioning during a swim	6(2)(e)	Must not reposition a tour vessel during a swim
Swim distance and approach	6(2)(f) 6(2)(h)	Must not enter, and must ensure that no person on the tour vessel, enters the water at a distance of less than 30 metres from a dolphin, or approaches the dolphins at a distance less than 30 metres
Foetal fold calf	6(2)(i) 6(2)(j)	Must ensure that a dolphin swim does not commence if a foetal fold calf is present; if a swim has commenced and a foetal fold calf is detected, all persons involved in the swim must reboard immediately

9 Acknowledgements

The authors would like to thank the staff, scholarship students and volunteers of the Dolphin Research Institute for assistance with collection of data over the years and support during the completion of this report, in particular Jeff Weir for his comments and support.

In addition the authors would like to thank the following tour operators for providing spaces on their vessels: Moonraker, Polperro, Rip Charters and Sea-All Charters.

All data has been collected under research permits issued by the Department of Natural Resources and Environment, Victoria. Permit Numbers: RP-97-006; RP-97-234; 10000262; 10000681; and 10001108.