THE RESPONSES OF TWO ATLANTIC WHITE-SIDED DOLPHINS (Lagenorhynchus acutus) TO OBJECTS: AN ANALYSIS OF BEHAVIOUR PATTERNS WITH RESPECT TO INCIDENTAL ENTRAPMENT IN FISHING GEAR

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The Responses of Two Atlantic White-Sided Dolphins (*Lagenorhynchus acutus*) to Objects: An Analysis of Behaviour Patterns with Respect to Incidental Entrapment in Fishing Gear.

by

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Abstract

Incidental entrapment of cetaceans in fishing gear poses serious problems for fishermen due to the time required to disentangle the animals and to repair damaged gear. Entrapment can also result in drastic losses to cetacean populations.

The factors which may influence entrapment are discussed in this paper. One basic question which has received little experimental attention is how cetaceans respond to fishing gear, or objects in general, and whether the response depends upon object type or familiarity. The main objectives of this study were to promote awareness of the work needed on this topic, to develop a workable methodology that will answer the questions involved, and to exemplify the types of information that can be gained. This study also served to categorize and quantify some aspects of the behavioural lexicon of two captive Atlantic white-sided dolphins (*Lagenorhynchus acutus*). The study animals had originally been found stranded, and were being rehabilitated at an aquarium for eventual release. They were housed together in an outside pool 12 m in diameter and 3 m deep.

Introduction of an object to the pool appeared to increase the arousal level of the dolphins, and also resulted in avoidance of the object's immediate vicinity. Response was greatest to a rope lying across the surface of the water, which the dolphins would not swim underneath. Rope avoidance disappeared within several hours, although it reappeared on subsequent days for one of the dolphins. After four days, there was no response to the rope from either dolphin, and there was no dishabituation after the rope has been absent for twelve days.

Objects in or under water were infrequently contacted. A rope stretched above the surface was repeatedly hit as the dolphins rose to breathe, although collisions decreased with time. All contacts with objects appeared to be accidental and seemed to be caused either by a lack of attention or through misjudging distances. Reactions to collisions were minimal.

The dolphins exhibited a high degree of social cohesiveness and engaged in complex forms of social interaction which may not have been recorded before. Several other behaviours were also observed which do not seem to have been documented elsewhere.

The results from this study must be viewed with caution, as the health of the dolphins was not stable while the experiment was conducted.

Key Words: incidental entrapment, marine mammals, cetaceans, whales, Atlantic white-sided dolphin, *Lagenorhynchus acutus*, behaviour, novel objects

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1. Introduction

The incidental entrapment of cetaceans in fishing gear is a global phenomenon (Brownell Jr. *et al.* 1989; Donovan & Perrin, in press; Hofman 1990; Northridge & Pilleri 1986). The number of cetaceans caught varies widely, from a few to many thousands of animals. For example, as many as 38,000 cetaceans may become entangled in gillnets off the coast of Sri Lanka every year (Alling 1987). Presently, incidental catches of cetaceans exceed any directed hunting (Perrin 1988).

In addition to cetaceans, seabirds (Lien *et al.* 1989; Piatt & Nettleship 1987), seals (Bonner 1982; Gilbert & Wynne 1983; Lien *et al.* 1988, 1989 & 1990a; Piatt & Nettleship 1987), sharks (Lien *et al.* 1988, 1989 & 1990a) marine turtles (Lien *et al.* 1988 & 1990a; Paterson 1979), and dugongs (Paterson 1979), are all known to become incidentally entangled in fishing gear, resulting in high levels of mortality.

Population declines or shifts in population structure resulting from high levels of net mortality have been witnessed or predicted for the vaquita (*Phocoena sinus*) (Barlow 1986), certain populations of seabirds (Piatt & Nettleship 1987), harbour porpoises (*Phocoena phocoena*) (Diamond & Hanan 1986; Gaskin 1984; Hanan *et al.* 1987; Read & Gaskin 1988; Skora *et al.* 1988), and Hector's dolphins (*Cephalorhynchus hectori*) (Dawson 1991a), as well as others (Northridge & Pilleri 1986). A comprehensive, world-wide assessment of impact can be found in Donovan and Perrin (in press).

Besides resulting in drastic losses to animal populations, incidental captures can be a serious problem for fishermen due to the time required to disentangle the animals and to repair or replace damaged gear (Ohsumi 1975). For example, it has been estimated that fishermen in Newfoundland suffer losses, in terms of damage to nets and down-time during repair from whale entanglements, of approximately one-half million Canadian dollars annually; the amount may sometimes be as high as two million dollars per year (Lien *et al.* 1990b).

There are many different factors that influence cetacean entrapment, most of which are interrelated and incompletely understood. Incidental entrapment can be affected by the distribution and movement patterns of cetacean species, their behaviour and sensory capacities, and the characteristics of different types of fishing gear. A comprehensive discussion of known and suspected factors affecting cetacean entanglement can be found in Appendix A, along with a discussion of possible solutions to the problem. Donovan and Perrin (in press) also provide a thorough review of incidental entrapment.

The purpose of this study was to systematically investigate basic questions about how cetaceans respond to objects, to better understand and predict how they may react to nets. The reaction of cetaceans to nets may be an important component of the entrapment phenomenon, but it has received little experimental attention.

An encounter between a cetacean and a net (or any object) may elicit avoidance, exploration, play, habituation, or some combination thereof. The specific behaviours displayed will probably depend upon such factors as species, age, and previous experience with nets (Defran & Pryor 1980; Norris 1969). Reactions may also depend upon the physical characteristics of the object itself.

This study assessed the influence of object type and familiarity on the reactions of two captive Atlantic white-sided dolphins (*Lagenorhynchus acutus*). Specifically, the following questions were addressed:

(1) How does the presence of an object affect the dolphins' behaviour?

(2) Do the dolphins react differently to different objects?

(3) Do reactions change as objects become more familiar?

To answer these questions, important baseline information about the two dolphins was needed first. To this end, the following questions were analyzed with no objects present:

(1) Are there differences in behaviour between the two dolphins?

(2) Are behaviours exhibited with the same frequency on different days?

(3) Is there a periodicity to any behaviours?

(4) Are any behaviours confined to particular areas of the pool?

To my knowledge, this study represents the first systematic effort to examine reactions of cetaceans to various objects. As such, some of the main objectives of this study are to promote awareness of the work needed on this topic, to develop a workable methodology that will answer the questions involved, and to exemplify the types of information that can be gained.

This study may also be the first to categorize and quantify some aspects of the behavioural lexicon of the Atlantic white-sided dolphin (Figure 1). There are few published details about the biology and behaviour of this species. It is generally found in the offshore, cooler temperate waters of the North Atlantic, entering warmer inshore waters in summer (Leatherwood & Reeves 1983; St. Aubin & Geraci 1979). Congregations of several hundred individuals have been observed, although strandings are usually of smaller groups numbering 9-12 animals (Leatherwood *et al.* 1976; Leatherwood & Reeves 1983; St. Aubin & Geraci 1979).

Males of this species are generally larger than females, and attain sexual maturity at approximately five years of age, when they are about 240 cm in length (Leatherwood & Reeves 1983; Sergeant *et al.* 1980; St. Aubin & Geraci 1979). Females mature at the same age, when they are approximately 210 cm in length (Leatherwood & Reeves 1983; Sergeant *et al.* 1980; St. Aubin & Geraci 1979). Young animals remain with the breeding schools until they are weaned at about two years of age (Sergeant *et al.* 1980). At this point they may form their own groups or join other species until mature (Sergeant *et al.* 1980). Atlantic white-sided dolphins have been found in association with pilot whales (*Globicephala* sp.), fin whales (*Balaenoptera physalus*), and killer whales (*Orcinus orca*), and are generally wary of boats (Leatherwood *et al.* 1976; Leatherwood & Reeves 1983; Sergeant *et al.* 1980; Sergeant & Fisher 1957). Prey species include short-finned squid (*Illex illecebrosus*), herring, (*Clupea harengus*), smelt (*Osmarus mordax*), silver hake (*Merluccius bilinearis*), and various species of shrimp (Sergeant & Fisher 1957; Sergeant *et al.* 1980; St. Aubin & Geraci 1979).

Atlantic white-sided dolphins have rarely been maintained in captivity. Defran and Pryor (1980) list New England, probably referring to the New England Aquarium in Massachusetts and the Mystic Marinelife Aquarium in Connecticut, as the only locale to have held this species in captivity. This study appears to represent the first documented report of captive behaviour for this species.

2. Cetacean Behaviour

2.1 Field vs Captive Studies

Much of what is known about cetacean behaviour has come from work with captive animals, usually bottlenose dolphins (*Tursiops truncatus*). Given the fact that cetaceans have been kept in captivity since the 1860s (Defran & Pryor 1980), the number of behavioural studies that have been conducted is surprisingly small, especially considering the wealth of information that has been gathered for cetacean sensory systems (for recent examples, consult Nachtigall & Moore 1988).

Captivity provides the opportunity to gather details of cetacean behaviour that would be impossible to observe in the field. Unfortunately, the captive environment undoubtedly constrains and modifies the normal behaviour patterns cetaceans exhibit in the wild. Such effects are not well-understood, although Defran and Pryor (1980) have postulated that

> "captive circumstances may alter the hierarchies of displayed behaviors, exclude from occurrence certain behavioral categories such as cooperative foraging, amplify the occurrence or the form of certain other behavioral categories such as in-air vocalizing or complex leaping, and perhaps modify the social structure."

Field studies with bottlenose dolphins have indicated that their group composition is much more dynamic than the typical dominance hierarchies observed in captive populations (Shane *et al.* 1986). In addition, the types of sound emitted in captivity may differ from those in the wild (Evans *et al.* 1988; Hatakeyama & Soeda 1990; Watkins 1980).

There is evidence, however, that species-typical behaviours are still present in the captive environment. Defran and Pryor (1980) conducted an extensive survey of the behaviours exhibited by 11 species of cetaceans held in captivity, and found that in many cases they correlated well with behavioural descriptions of these species in the wild. Of particular interest to this study, spinner dolphins (*Stenella longirostris*), common dolphins (*Delphinus delphis*) and bottlenose dolphins were rated highest in several fear indices including avoidance of new objects and high-speed swimming, while beluga (*Delphinapterus leucas*), pilot whales, and boutu (*Inia geoffrensis*) rated lowest. Killer whales, Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), false killer whales (*Pseudorca crassidens*), and rough-toothed dolphins (*Steno bredanensis*) were rated as "intermediate". Other studies mentioned by Defran and Pryor (1980) indicate that harbour porpoises are fearful of novel stimuli, while pygmy killer whales (*Feresa attenuata*) exhibit little or no fear. Bottlenose dolphins, rough-toothed dolphins, killer whales, and false killer whales all rated high on measures involving object manipulation.

Generally, Defran and Pryor (1980) found that behavioural patterns in captivity paralleled those related to group size in the wild. Cetaceans forming large groups such as spinner dolphins, which are often found in groups of several hundred, display high levels of social and fear behaviours in captivity, and low levels of curiosity and object manipulation. Cetaceans forming small groups of 20 or fewer animals, such as *Globicephala* species, show low levels of social, fear, and curiosity behaviours. Finally, species forming mid-sized groups such as bottlenose dolphins generally exhibit high levels of social behaviour and curiosity, and a low level of fear.

Only in recent years has it has become feasible to study cetaceans in their own environment over extended periods of time. To date, most information which has been acquired for wild cetaceans deals with broad aspects of their behaviour such as daily or seasonal movement patterns, feeding habits, social structures, and the frequencies of specific categories of behaviour such as "mating" or "resting" (Dos Santos *et al.* 1990; Evans 1987; Leatherwood & Reeves 1983; Saayman *et al.* 1973; Shane *et al.* 1986).

In summary, there is still a dearth of knowledge about most aspects of cetacean behaviour, and what is known can not necessarily be applied across species or situations. Although long-term field studies of cetaceans are becoming more feasible, captive situations may still offer the best opportunities for detailed analyses of cetacean behaviour. Captive studies undoubtedly suffer from the effects of a restrictive environment, yet they can provide insight on species-typical behaviours.

2.2 Reactions to Nets

Very little is yet known about how cetaceans react to nets. It is now believed that odontocetes should be able to detect nets under most conditions (Donovan & Perrin, in press). However, it can not be assumed that cetaceans will automatically avoid nets once they are detected. The idea of a "barrier" may be foreign to an animal living in the open sea, and the sensory cues provided by a net may resemble a penetrable feature such as the deep scattering layer (Au & Jones 1991).

It does appears that some species have a concept of barriers, however. Captive cetaceans including bottlenose dolphins, Pacific white-sided dolphins, spinner dolphins, harbour porpoises, Dall's porpoises (*Phocoenoides dalli*), and false killer whales have been observed to stay away from nets and/or hesitate to swim under a rope lying on the surface of the water (Hatakeyama 1986a; Hatakeyama *et al.* 1988; Hatakeyama & Ishii 1987; Hatakeyama & Shimizu 1985; Hatakeyama & Soeda 1990: Kasuya 1978; Perrin & Hunter 1972). Interestingly, one study indicated that captive harbour porpoises rapidly became accustomed to a net in their enclosure, and after about four minutes one animal approached close enough to become entangled (Hatakeyama & Soeda 1990).

Even if nets are perceived as barriers, cetaceans probably have to learn through experience that they are dangerous. While this may be possible for larger whales that are sometimes able to break free after entanglement, most smaller cetaceans die when entrapped. To learn that nets are dangerous, small cetaceans would either have to observe other individuals being caught and relate this experience to themselves, or be fortunate enough to escape. How cetaceans react when members of their school become entrapped has not been studied, although it is postulated that trapped animals may release an "alarm" chemical which would warn other animals away (Klinowska 1990a). Further, young Hector's dolphins and La Plata dolphins (*Pontoporia blainvillei*) trapped in nets sometimes bear fresh scrapes which are thought to result from the mothers' attempts to free them (S.M. Dawson, pers. comm.; Pilleri 1971).

Even if cetaceans recognize nets as being dangerous, they may perceive them as stretching endlessly in all directions. Lacking any other perceived choice, cetaceans may attempt to go through a net (A.D. Goodson, pers. comm.). Alternatively, some species may not have the behavioural repertoire necessary to circumnavigate a net. Differences may be found, especially between cetaceans which live near shore in shallow water, and those inhabiting deeper, and more "barrier-free", waters. For example, while coastal bottlenose dolphins can maneuver in tight quarters such as mangrove swamps and tidal flats,

> "for *Stenella*, backing up is physically difficult and psychologically inconceivable. Thus a *Stenella* who pokes his rostrum into a mesh hole in the net is doomed. . . he cannot back up the necessary six inches to save himself, nor does he comprehend enough of his situation to try. He can only continue to swim forward. To turn around. . . is not in the *Stenella* behavioral lexicon" (Pryor & Norris 1978).

Cetaceans may, in some cases, be attracted to nets out of curiosity (Dawson 1991b; Lien 1980; Peddemors *et al.*, in press). They may also feed on organisms in and around the net (Dawson 1991b; Hofman 1990). Minke whales (*Balaenoptera acutorostrata*) are known to use nets as an aid to increase prey density as they feed (Lien *et al.* 1985). Habituation to nets may be a problem if cetaceans regularly encounter them without being caught.

2.3 Reactions to Objects

To more fully understand the reactions of cetaceans to fishing gear, the more fundamental concept of reactions to objects must first be investigated. To date, nearly all information regarding the reactions of cetaceans to objects has come from purely anecdotal accounts. There have been no rigorous, systematic studies in this area.

McBride and Hebb (1948) and McBride and Kritzler (1951) observed groups of captive bottlenose dolphins and found that they were wary of objects placed in their pool. They reacted by gathering in a tight group far from the object. If the object was familiar the group would rapidly break up, but if it were novel, they would remain in a group and swim rapidly around the tank while emitting much loud "whistling". This behaviour would abate within an hour or two, although the object might still be avoided for days. In one particular instance when a wooden frame was built out over the water, none of the dolphins would jump for approximately 48 hours. A two-foot diameter ball floating on the surface elicited the same response. Tiger sharks introduced to the pool were also avoided, although in two cases the sharks were immediately attacked and killed.

Rapid swimming and bunching together in response to novel objects has also been observed in a captive group of one spotted dolphin (*Stenella attenuata*), and two bottlenose dolphins (D.L. Nelson, unpublished data). It is apparently a common response to fearful or stressful situations found among several different cetacean species, although abnormally slow swimming may also be observed in response to fear (Defran & Pryor 1980; Jones *et al.* 1988; Perrin & Hunter 1972).

Kellogg (1958) indicated that objects tossed into a pool containing bottlenose dolphins were immediately scanned with echolocation pulses. However, Kellogg's trials were conducted in very muddy water which prevented the dolphins from investigating objects visually. The manner by which cetaceans visually inspect novel objects is unknown.

McBride and Kritzler (1951) and Tavolga and Essapian (1957) documented the behavioural development of several bottlenose dolphins born in captivity. They first began to move away from their mothers at an age of about two weeks, although they were not permitted to go more than a few feet away until they were about six weeks old. At this age the young began to take an interest in objects in the tank, and were allowed to investigate and play with them without interference. If an unfamiliar object was approached, however, the mother became agitated and moved the young dolphin away while producing many vocalizations. This type of behaviour was strongest in the first few months of the infants' lives, but was observed to some extent throughout the first year.

Object play in captive cetaceans can be complex, but often involves mouthing and tossing of objects, rubbing against objects, or chasing and nipping other animals (Brown 1962; Defran & Pryor 1980; McBride & Hebb 1948; McBride & Kritzler 1951; Saayman *et al.* 1973; Tavolga & Essapian 1957; Townsend 1914). Young animals tend to imitate the behaviours of adults, with most forms of activity appearing within the first six months of life (Defran & Pryor 1980; McBride & Hebb 1948; McBride & Kritzler 1951).

To summarize, anecdotal information about object interactions suggests that novel objects are generally avoided, although young animals may show more curiosity than fear. Familiar objects can be the source of complicated play behaviour. The intensity of reactions such as avoidance and play varies among species (Defran and Pryor 1980). Cetaceans forming large groups in the wild appear to be more fearful and less curious, while smaller groups appear less fearful, and possibly more curious. These findings are very general, and represent information from only a few sources. Intensive, systematic study in this area is necessary to truly classify and quantify reactions of cetaceans to objects. Such knowledge will form the basis for evaluating how different cetaceans may interact with fishing gear in varying circumstances, and will suggest how gear might be modified to reduce the probability of entrapment.

3. Methodology

This study represents the first known attempt to quantify aspects of cetacean behaviour towards different objects. It was conducted at the Mystic Marinelife Aquarium in Mystic Connecticut, from 28 April to 1 June, 1991.

The two subjects for this study, one male and one female Atlantic white-sided dolphins, were found stranded off Wellfleet, Massachusetts on 15 February, 1991. Upon being brought into captivity, the male weighed 173.2 kg and was 241 cm in length, while the female weighed 118.6 kg and was 207 cm in length. The dolphins were thought to be mature. The aquarium considered their health to be critical and unstable (T. Binder, pers. comm.). Both dolphins lost weight continuously; by 29 May the male weighed 157.2 kg and the female 113.7 kg. Repeated physical examinations failed to find any pathological problems, although each had fungal infections on various portions of their bodies. It was not known if the infections represented a significant health problem. The female died on 9 June, eight days after the study concluded. A necropsy revealed a deep abscess in her right lung which she may have harboured since stranding. The male dolphin was released on 25 October, 1991, at which time he showed no evidence of behavioural problems, physical disorders, or clinical signs of disease (N. Overstrom, pers. comm.).

From their arrival until 4 March, the dolphins were housed in SP4; one of two round, 12 m diameter, 3 m deep pools that was situated by one side of the aquarium. They were maintained with a female harbour porpoise calf from 21-26 February, and originally had access to various toys such as hoops and balls, but showed no interest in them (T. Binder, pers. comm.). On 4 March the dolphins were moved to the second pool; SP3. The dolphins were housed in SP3 until 9 May, at which time they were moved back to SP4. Most of the study was carried out with the dolphins in SP4, which was more quiet and provided more shade than the other pool.

All observations were conducted from the roof of the adjacent aquarium which was approximately 15 m high. A Sony 8 mm VA camcorder was set on a tripod and fitted with a wide-angle lens so that most of the pool could be recorded on film. Because SP4 was very close to the side of the aquarium, it was possible to film almost straight down into it. SP3 was more distant and was viewed at a considerable angle (compare Figure 2a with 2b).

Filming sessions originally began each day at 0800 hrs. The test object was placed in the pool immediately before this time and was removed when filming concluded for the day. The 0800 hr. session lasted 30 min., while other sessions took place daily on the hour from 1000 hrs. to 1500 hrs., and lasted for 15 min. each. Because the dolphins were fed daily from 0900 hrs. to 1000 hrs., no filming was conducted during this time period.

This schedule was revised after 12 May because the presence of the test object (a rope) disturbed the dolphins to such a degree that they would not eat. It was decided that no objects would be placed in the pool until after feeding had concluded. Thus, the schedule for the remainder of the study began with introducing an object at the end of the morning feeding, filming for 30 min., then filming for 15 min. on the hour from 1100 hrs. to 1500 hrs. The exact timing of the first session varied each day depending upon when feeding ended, although it generally began between 0950 hrs. and 1000 hrs.

Six objects were tested separately for a total of 16 days. Each object is described in section 3.1. In addition, eight days were filmed with no objects in the pool. These "Blank days" were interspersed throughout the study and generally fell directly before and after each experimental condition. The testing schedule is shown in Table 1.

Information on the pool temperature, amount of food consumed by the dolphins, and behaviour during feeding was also collected daily.

3.1 Objects Tested

The experimental objects used in this study are summarized here, in the order of testing. The testing schedule for the study is shown in Table 1.

(1) Hydrophone (6 May):

Originally, it was planned to use a Gould CU180 hydrophone to record the dolphins' vocal activity during the experiment. The hydrophone was tested for one day, during which time it was found to be inoperative. This test day was included in the analysis to determine whether the dolphins reacted to the hydrophone. It was placed approximately 1 m below the surface and 1 m from the side of the pool by means of a pole which hung out over the surface of the water (see Figure 2a).

(2) Rope (12-16 & 28 May):

This was a green, 1 cm diameter, multifilament rope. It was placed across the pool on the surface of the water slightly to one side of center, so that there was more space on one side of it. After four days of testing in this position (position 1), the rope was moved and tested in a position perpendicular to this, for one day (position 2). On 28 May, the rope was filmed again in position 1. The positions of the rope can be seen in Figure 2b. Because of the slight angle in filming, it is not apparent from the figure that there was more space on the far side of the rope in position 1.

To place the rope in the pool, it was first tied off at one side. The other end was then taken around the edge of the pool and pulled taut at the other side, so that it straightened out and floated on the surface. It was then tied off at this side as well. This process usually took less than one min.

(3) Framework (18 May):

This was constructed to anchor objects in the pool for testing, and was first presented alone to the dolphins for one day. The rope described above was anchored on either side of the pool above the surface of the water. A second rope hung down from the first approximately 3 m from the side of the pool, and was anchored to a cement block at the bottom of the pool. Objects were tied to this rope during testing. The position of the framework can be seen in Figure 2c, and Figure 3.

The framework was introduced into the pool by first lowering the anchored cement block into the pool at one edge. Then, the rope was tied off in the same manner as described above, except that it was pulled very taut. This lifted the rope from the surface and pulled the cement block into position. This process usually took less than one min.

(4) Yellow buoy (19-21 May):

This was a solid, cylindrical buoy with a diameter of 16 cm, and a length of 20 cm. The buoy was anchored approximately 1 m below the water's surface. After two days of testing in position 1, the buoy was moved and tested for one day in position 2, which was opposite to the first. These are shown in Figure 2d.

(5) Red buoy (23, 25, 26 May):

The red buoy was hollow, round, and had a diameter of 20 cm at its widest point. It was anchored at the water's surface, and was tested in the same manner as the yellow buoy. It is shown in Figure 2e.

(6) Metal buoy "Whale Alert" (31 May, 1 June):

This was a round, metal buoy of 10 cm diameter that had been modified internally to contain a solenoid which would strike a pipe approximately every five sec., producing a 2 kHz sound. These "Whale Alerts" are currently being tested in Newfoundland waters as possible warning devices to prevent baleen whales from becoming entangled in fishing gear (Guigné *et al.* 1990). Figure 2f indicates the placement of the metal buoy in the pool. On 31 May, it was tested without being turned on. The buoy was operating when tested on 1 June.

4. Analysis

The dolphins were filmed for a total of 42 hours. For analysis of the tapes, each filming session was broken into three min. segments. For each segment, the frequency and duration (where applicable) of every behaviour were recorded, as well as the location of the dolphin in the pool when exhibiting the behaviour. These data were collapsed into 15 min. intervals for subsequent analysis because most behaviours were too infrequent to analyze at the three-min. level. I viewed all footage twice, and 10% of it a third time. There were no other observers.

During the first viewing, information on respiration rates and interaction bouts were recorded in a notebook along with descriptions of all other behaviours. Each behaviour was given a name to distinguish it from the others. All behaviours are described in Table 2; some are illustrated in Figure 4.

During the second viewing, each instance of a particular behaviour was recorded on a diagram of the pool, to indicate the location of the dolphin when that behaviour took place. This was done by placing a gridded sheet of clear plastic over the television screen, pausing the film when a behaviour took place, and transferring the location of the dolphin's head at that moment to a similarly gridded diagram of the pool. The grid was used for location purposes only; it did not correspond to any physical measurement of the pools. SP3 was divided into roughly 28 squares, which turned out to be a far smaller grid than was necessary to accurately pinpoint the behaviour locations. Therefore, SP4 was divided into only 8 squares for analysis.

Instances of behaviours that were unclear were viewed several times until a decision could be reached as to their identity. Locations were not recorded for breaths, which were too frequent to make this procedure feasible, or for interaction bouts. Because interaction bouts could last from a few seconds to several minutes, during which time the dolphins might circle the pool once or more, the occurrence of a bout could not be summarized by a single dot.

Approximately 10% of the tapes were viewed a third time to check for reliability of the observations. One 15 min. filming session per day was randomly selected, 12 min. of which were reviewed; this resulted in a third viewing of 4 hours and 48 min. All behaviours except for breaths, interaction bouts, and contacts were re-scored for each dolphin. A paired t-test between the scores for the second and third viewings indicated that there were no significant differences between them ($t_{20} = -.623$, $p = .5402$). Thus, the observations were reliable.

The movement patterns of the dolphins were analyzed only for Object days. Blank days were not included in this analysis. First, the number of passes each dolphin made underneath the rope was tabulated for all Rope days. In each case, it was determined whether the dolphins swam under together (within three sec. of each other) or alone. These measurements were taken during the initial viewing of the film. In addition, a five min. section from the first, middle, and last filming sessions of each Object day were further analyzed. A plastic sheet was placed on the television screen, and the movement of each dolphin was traced with a pen for five min. The pen tip was positioned in the middle of the dolphin's head for tracing. The resulting patterns are contained in Appendix B. For all objects except the rope, the number of circuits both dolphins made around the pool in each five min. period was counted. As each circuit passed near the test object, it was categorized as being either an "outside" pass (*eg.* a pass between the wall and the object), or an "inside" pass.

Appendix C summarizes behavioural changes over the entire study period. All contacts made between a dolphin and a test object are recorded in Table 3. Some of the statistical analyses subsequently performed on behavioural data are detailed in Appendix D. All tests used in these analyses are explained below.

5. Blank Days

There were a total of eight Blank days interspersed throughout the study. Generally, Blank days fell directly before and after each experimental condition. Table 1 lists the study schedule.

The Blank days provide a description of the typical, daily activities of the two dolphins, and serve as a baseline against which to compare experimental data. Four major questions were assessed with the Blank day data. These questions, and the statistical tests used to answer them, are described in 5.1. Results are discussed in detail under 5.2.

5.1 Questions and Analysis

Because one of the goals of this study was to develop a methodology for future work, the statistical analyses used are described in some detail.

Question 1 Are there differences in behaviour between the two dolphins?

A One-Factor ANOVA with the two dolphins as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable was performed separately for every behaviour. This test was chosen because it allows for unequal numbers of scores in the various "treatments". A summary of results is shown in Figure 5 and the RATE column of Table 4.

All subsequent analyses in this study were performed separately for each dolphin, regardless of whether this test indicated significant differences between them. It was recognized that one of the assumptions of the ANOVA - the independence of observations - would be violated if male and female data were combined together.

Question 2 Are behaviours exhibited with the same frequency on all Blank days?

One of the purposes of the Blank days was to serve as a baseline against which to compare experimental data. To test whether there were differences among these eight days, a One-Factor ANOVA with the Blank days as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable was performed separately for each behaviour. When significant differences were indicated by this test, the data were analyzed further using Sheffé's S test to determine where the differences occurred. Sheffé's S test was chosen because it is the most conservative post-hoc test. Because there were only two subjects in this study, and because there appeared to be a high level of random variation in the frequency of behaviours, the use of a conservative post-hoc test seemed warranted. Results are summarized in the DAYS column of Table 4, while specifics may be found in Appendix D, Table D1.

Question 3 Is there a periodicity to any behaviours?

This question refers to frequency changes occurring regularly each day. For example, Saayman *et al.* (1973) found that social interactions among both captive and wild bottlenose dolphins were generally more frequent in the middle of the day than at other times. In this study, each 15 min. filming session (0800-0815 hrs., 0815-0830 hrs. etc.) was compared across all Blank days to determine if there were any diurnal rhythms. A One-Factor ANOVA with "session" as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable was carried out separately for each behaviour. Results are summarized in the **DIURNAL** column of Table 4, while significant results are shown in Figure 6. Non-significant statistics are not reported.

Question 4 Are any behaviours confined to particular areas of the pool?

The introduction of an object to the pool might result in a redistribution of behaviours within the pool. If the dolphins play with or explore the object, then certain behaviours should be more common in the vicinity of the object. If the dolphins avoid the object, then most behaviours will occur away from the object. To determine how spatial patterns of behaviour change with the introduction of objects, the patterns present on Blank days must first be investigated.

Because the views of the two pools in this study were not the same, the analyses was carried out separately for each pool. Each behaviour was also analyzed separately. Pool diagrams showing behaviour positions were divided into quarters, termed upper left, upper right, lower left, and lower right. These labels reflect the view of the pool as seen by the camera, and were not related in any way to the positions of objects in the pool. A Chi-square analysis was used to determine whether the occurrences of the behaviours were equal in all four quarters. Significant results are found in Figures 7 and 8, while all results are summarized in the POOL column of Table 4. Non-significant statistics are not reported.

5.2 Results

Each behaviour will be discussed in turn. Refer to Table 4 for a summary.

5.2.1 Breaths

Individual differences: There was no significant difference in the respiration rate between the two dolphins (Figure 5). Each took an average of 48 breaths per 15 min., and 82% of these were synchronous (Table 4).

Days: There were significant differences for each dolphin in respiration rate, and percentage of synchronized breaths, among the Blank days (Table 4). The number of breaths taken was lower on 27 May than earlier in the study for each dolphin, while for both dolphins there was a lower percentage of synchronized breaths on 11 May and 22 May than on several other days (Appendix C; Appendix D, Table D1).

Diurnal Rhythms: There was a diurnal rhythm in breathing rate (Figure 6). Both dolphins showed an increase in breathing rate during the middle of the day.

5.2.2 Twists

Individual differences: There was a significant difference in rates of twisting between the two dolphins (Figure 5). The male twisted, on average, two times per 15 min., while the female twisted once per 15 min. (Table 4).

Days: There was a significant difference in twisting rates for the female among Blank days, although Sheffé's S test showed no significance (Appendix D, Table D1).

Diurnal Rhythms: There were no diurnal rhythms observed for this behaviour.

Distribution: There were non-random distributions of this behaviour in SP3 for each dolphin (Figure 7). Male twists were most common on the right side of the pool, while female twists were most common in the lower part of the pool.

5.2.3 Tail-Downs

Individual differences: There was no significant difference in the rate of tail-down displays between the two dolphins (Figure 5). Each displayed, on average, two times every 15 min. (Table 4).

Days: The female showed a significant difference in the rate of tail-down displays among the Blank days, although Sheffé's S test indicated no significance (Appendix D, Table D1).

Diurnal Rhythms: There was a diurnal rhythm in the rate of tail-downs for the male (Figure 6). This behaviour was higher around 1000 hrs. than during the rest of the day.

Distribution: The male showed a non-random distribution of tail-down displays in both SP3 and SP4 (Figures 7 & 8). In SP3, displays were most common in the upper portion of the pool, while in SP4 they were most prevalent in the upper right portion of the pool.

5.2.4 Tail-Ups

Individual differences: There was a significant difference in the rate of tail-up displays between the two dolphins (Figure 5). The female displayed about once per 15 min., while the male only displayed about once every 45 min. (Table 4).

Days: There were no differences among days.

Diurnal Rhythms: There were no diurnal rhythms observed.

Distribution: The female showed a non-random distribution of tail-up displays in both pools (Figures 7 & 8). In SP3, they were concentrated in the lower left corner, while in SP4 they were most common in the lower portion of the pool (Figures 7 & 8).

5.2.5 Throwbacks

Individual differences: There were significant individual differences in the number of throwbacks (Figure 5). The male averaged one throwback per 15 min. interval, while the female exhibited this display only twice in all the Blank days (Table 4).

Days: There were differences in the occurrence of this behaviour among Blank days for the male, although no significance was indicated by Sheffé's S test (Appendix D, Table D1).

Diurnal Rhythms: There were no diurnal rhythms.

Distribution: Distribution of this behaviour appeared to be random.

5.2.6 Tail-Wags

Individual differences: There were no individual differences for this behaviour (Figure 5). The rate averaged less than one tail-wag per 15 min. (Table 4).

Days: There were no differences in frequency among Blank days.

Diurnal Rhythms: No diurnal rhythms were observed.

Distribution: There was a non-random distribution for the female in SP3, with the behaviour being concentrated in the lower left corner of the pool (Figure 7).

5.2.7 Side-Swims

Individual differences: The female exhibited more of this behaviour than the male (Figure 5). She averaged one side-swim per 15 min., while the male's rate was much lower than this (Table 4).

Days: There was a difference in rate among Blank days for the female, although Sheffé's S test showed no significance (Appendix D, Table D1).

Diurnal Rhythms: There were no diurnal rhythms observed for this behaviour.

Distribution: Female side-swims were concentrated in the upper left area of SP4 (Figure 8).

5.2.8 Jerks

There were no significant statistics for this infrequent behaviour, which was observed less than once every 15 min. (Table 4).

5.2.9 Arches

Individual differences: The male exhibited much more arching behaviour than the female (Figure 5), averaging nearly one arch every 15 min. (Table 4). The female was only observed to arch once during Blank days.

No other statistics were significant for this behaviour.

5.2.10 Startles

Startling were quite rare (Table 4). There were no significant statistics.

5.2.11 Rolls

Rolls were observed only three times by the female (Table 4). There were no significant statistics.

5.2.12 Penis Displays

This behaviour was observed only four times during Blank days (Table 4). The only significant statistic was a difference among the days (Appendix D, Table D1); this was simply a result of the very low rate of occurrence of the behaviour (Appendix C).

5.2.13 Interaction

Individual differences: The female initiated more interaction bouts than the male (Figure 5). On average, the female initiated 40% of the bouts during each 15 min. interval, while the male initiated only 7% (Table 4). Each bout lasted an average of 26 sec. The dolphins interacted for approximately one and a half minutes out of every 15 min. interval (Table 4).

Days: There were no differences among days for the amount of interaction, although the length of bouts did vary significantly (Appendix D, Table D1). Bout lengths were exceptionally long on 29 April (Appendix C), although the only significance was between 29 April and 11 May (Appendix D, Table D1).

Diurnal Rhythms: There was no diurnal rhythm in the amount of interaction. However, bout lengths were longer at the beginning and end of each day (Figure 6).

5.2.14 Food Consumed

Each dolphin consumed an average of 11 kg of food daily (Table 4). There was no difference in the amount of food consumed over the Blank days.

6. Object Days

The Object days were designed to answer three main questions, which are discussed under 6.1. Results are summarized in 6.2.

6.1 Questions and Analysis

The three main questions asked are:

Question 1 How does the presence of an object affect the dolphins' behaviour?

Question 2 Do the dolphins react differently to different objects?

Question 3 Do reactions change as each object becomes more familiar?

One possible way to detect the effect of an object is by a change in behaviour frequency. For example, a behaviour such as spy-hopping might increase if an object is suspended over the water, or perhaps food intake might decrease when an object is placed in the water. To determine if such changes took place, behaviour on Object days must be compared with behaviour on Blank days. This was done by performing a One-Factor ANOVA with "condition" as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable. The predictor was composed of all conditions - blank, hydrophone, rope, framework, yellow buoy, red buoy, and metal buoy. A separate test was performed for each behaviour. When significant differences were found, the data were analyzed further using Sheffé's S test, to determine where the differences were. Table 5 contains a summary of results, while significance values are listed in Appendix D, Table D2. Not only did this test compare Object days with Blank days, but also compared all of the objects amongst themselves, thus addressing Question 2.

It must be noted that since the former test compares the mean values for each condition, certain problems arise. Some behaviours varied significantly during Blank days, so using a mean value to compare with Object days in these cases may not be warranted. In such cases, it may have been better to compare behaviour frequencies for a particular condition to the Blank day just before and after that condition, rather than to a mean for all Blank days. The choice was made to use means because there was generally a high degree of day-to-day variability, and it was felt that using a mean for Blank days would produce a more conservative test.

Another problem arises through the use of means. In most cases, objects were presented to the dolphins for several days, so the mean value takes into account several day's worth of behavioural data. If a particular response to an object is strong but disappears quickly as the object becomes familiar, it may not show up as significantly different from other objects with the former test. Thus, habituation would be "hidden" within a mean score. Further, the more days within a condition, the more likely that strong but quick-to-disappear reactions will not be noticed. To resolve this problem, the days within each condition were considered separately. A One-Factor ANOVA with "day" as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable was performed separately for each behaviour within a condition. Each condition was considered separately. When significant differences were indicated by this test, the data were analyzed further using Sheffé's S test to determine where the differences occurred. Results are summarized in the DAYS column of Tables 6-9, while significance values can be found in Appendix D, Tables D3-D6. Because the hydrophone and framework were each only presented for one day, this analysis could not be conducted for these objects.

The preceding test served to clarify situations where behavioural responses disappear within a day. There is also the possibility that responses might disappear more quickly, perhaps even on the order of a few minutes. However, the data were inadequate to allow for such an analysis.

When Blank days were analyzed, some behaviours were found to have diurnal rhythms. For example, respiration rate was highest at midday and lower at the beginning and end of each day. The object conditions were also analyzed for diurnal rhythms. Each 15 min. filming session was compared across all days within a condition to determine if any behaviours generally changed in frequency over the course of a day. A One-Factor ANOVA with the 15 min. filming sessions as the predictor and the occurrence rate of a behaviour per 15 min. as the dependent variable was performed separately for each behaviour. Results are summarized in the DIURNAL columns of Tables 6-8. Significant results are shown in Figures 9 & 10. Because there was only one day for both the hydrophone and framework conditions, this test could not be carried out for these conditions. Further, filming intervals on the Metal days varied too much from each other for this test to be performed.

The presence of an object can affect not only the frequency of a behaviour, but also spatial distribution of that behaviour. For example, the number of leaps that a dolphin exhibits may not change when a ball is lowered at one side of a pool, yet if the dolphin originally leaped near a viewing platform and now leaps near the ball, its behaviour has been affected. Behaviours which generally occur near objects may be an indication of exploration, manipulation, or play. For this study, Chi-square analyses were used in the same manner as for Blank days (see question 4 in section 8.1). In the case of the behaviour "turn-under", a Chi-Square test was employed which only divided the pool into an upper and lower portion. The right-left position of this behaviour was fixed, as it occurred only in response to the rope, so it was not considered in the test. Significant results for Chi-squares are shown in Figures 11-15, and are summarized in the POSITION or CONDITION columns in Tables 6 -9, and in Table 10. Results for all turn-unders are found in Figure 15.

Finally, in addition to behaviour frequencies and distribution patterns, movement patterns can be affected by the presence of an object. A dolphin can choose to avoid an object, ignore it, or actively seek it out. Any of these will result in different patterns of movement around the object in question. Appendix B contains the raw data for movement patterns on Object days. Figure 16 summarizes some of the information contained in these figures. Statistical analyses included tests similar to those performed for other data, and results can be found in the appropriate tables in Appendix D. For the rope data, One-Factor Analyses of Variance with "day" as the predictor were conducted separately for the dependent variables (1) number of times under the rope alone; (2) number of times under together; and (3) number of times under total. This allowed determination of whether the number of passes under the rope changed significantly over the days that it was presented. For all other data, One-Factor Analyses of Variance with "day" as the predictor were conducted separately for each condition, with the percentage of circuits classified as "outside" passes per 5 min. as the dependent variable. An outside pass was a circuit of the pool in which the dolphin passed between the test object and the wall of the pool. This test allowed for determination of whether the number of outside passes varied significantly among the days within each condition. Further, a One-Factor ANOVA with "condition" as the predictor and the percentage of outside passes as the dependent variable was also conducted. This determined whether the percentage of outside passes varied among the conditions.

The diagrams in Appendix B were also inspected visually.

6.2 Results

Each object will be discussed in turn. Rather than describing every behaviour separately, as for Blank days (see sections under 5.2), all significant results are discussed together under the appropriate heading for each object type. However, each behaviour is discussed separately in the summary section 6.2.8.

6.2.1 Rope (12-16 & 28 May)

For a summary of results for Rope days, see Table 6.

Days: (Appendix C; Appendix D, Table D3)
The percentage of synchronized breaths was significantly lower for both dolphins on the last Rope day than for any other day in this condition.

Tail-downs, startles, and male respiration and arches all showed showed differences in occurrence among the Rope days, but were not significant when assessed with Sheffé's S test.

The amount of interaction was highest on 14 May, the third Rope day. This day showed the second-highest level of interaction for the entire study. In addition, the lengths of interaction bouts were longer on this day than on most other Rope days.

The female ate less food on the first day that the rope was introduced than on any other day in the study. Food intake of the female was disrupted to such an extent that, after the initial trial, introduction of the rope had to be delayed until feeding was concluded.

Diurnal Rhythms: (Figure 9)

Interaction bouts were generally shorter, and varied less, during the first half of the day than during the time from 1200 - 1500 hrs. Further, the male initiated far more bouts in the first session of the day than at any other time. When no objects were present, the male generally initiated only 7% of all bouts. This increased to 67% in the first 15 min. that the rope was present, and was still as high as 40% for the next 15 min. Although the female appeared to initiate fewer bouts during these times, from a normal percentage of 39% to a low of 14% for the first 15 min. and 27% for the next 15 min., this was not a great enough difference to be significant. After the first Rope day, the increase in male initiation was still present, although to a lesser degree; the male generally initiating 18% of the bouts in the first 15 min. of rope presentation for the remainder of this object condition.

Tail-down displays were more prevalent at 1000 hrs. than at any other time during Rope days. This variation is similar to that found on Blank days, and so did not seem to be affected by the presence of the rope (compare Figure 9 with Figure 6).

A significant diurnal rhythm observed for male tail-wags resulted from the fact that this rare behaviour was more common in the one early session when the rope was first introduced on 12 May. Even then, however, the behaviour took place only once every 15 min.

Distribution: (Figure 11)

Male twists, female tail-ups and side-swims, and tail-downs for both dolphins all showed some degree of non-random distribution during Rope days. However, male tail-downs and female side-swims showed distributions similar to those on Blank days, suggesting that the introduction of the rope did not affect distribution of these behaviours (compare Figure 11 to Figure 8). Male twists, female tail-ups, and female tail-downs were all most prevalent in the larger half of the pool. In the case of the female, these distributions can probably be explained by the fact that she spent more time in the larger half of the pool (see next section on swimming patterns).

Swimming Patterns: (Appendix B)

When the rope was first introduced on 12 May, the male swam underneath it only four times, while the female swam under only once. Both stayed on the larger half of the pool. By 1200 hrs., the male was swimming freely under the rope, and by the end of the day was utilizing the full pool. The female did not habituate as quickly, although by the end of the day she was swimming under the rope on almost all circuits of the pool. On subsequent Rope days, the male went under the rope on almost all circuits of the pool, whereas the female's response varied greatly. On 13 and 15 May she generally remained on the larger side of the pool, while on 14 May she habituated to the rope during the course of the day. She passed under the rope on nearly all circuits of the pool during 16 and 28 May.

The number of times that the female went under the rope alone did not change significantly over the Rope days (Figure 16; Appendix D, Table D3). She rarely went under alone, in contrast to the male (Figure 16). On 16 and 28 May 16, she went under more often in total than during the other Rope days (Appendix D, Table D3). The male went under less often on the first Rope day than on 14, 15, or 28 May (Figure 16; Appendix D, Table D3).

6.2.2 Yellow Buoy (19-21 May)

For a summary of results for Yellow days, see Table 7.

Days: (Appendix C; Appendix D, Table D4)

The percentage of synchronized respiration was significantly higher for the male on the second Yellow day than the last day.

Tail-down displays by the male were less common on the second Yellow day than on the first.

There was more interaction on the last Yellow day than for the other days in this condition, and interaction bouts were longer on the last day than on the second.

There were differences in the number of startles among Yellow days, but there was no significance when Sheffé's S test was used.

Tail-wags did not differ significantly among the days, although there were far more tail-wags by the female on 21 May than any other day. Ninety-two percent (55 out of 60) of her tail-wags for that day took place during the 1300-1315 hrs. filming session, during which time there was a very high level of noise from a salt delivery truck parked next to the pool. This response was not found for the male.

Diurnal Rhythms:

There were no significant diurnal rhythms during Yellow days.

Distribution: (Figures 12 and 15)

Non-random pool distributions for the buoy in position 1 were found for male turn-unders. Female tail-downs, tail-wags and side-swims were distributed non-randomly when the buoy was in position 2. Side-swims did not appear to be affected by the presence of the object, as the distribution was similar to that found for Blank days. Tail-downs were concentrated in the upper right corner of the pool, a distribution which is not clearly related to the position of the buoy. In contrast, tail-wags appeared to be more common near the buoy.

Swimming Patterns:

Both dolphins generally swam to the inside of the yellow buoy (Figure 16). There were no significant differences in the percentage of outside circuits for Yellow days (Appendix D, Table D4).

6.2.3 Red Buoy (23, 25, 26 May)

For a summary of results for Red days, see Table 8.

Days: (Appendix C; Appendix D, Table D5)

The percentage of synchronized respiration for the female was significantly lower on the last Red day than on the first.

Male side-swims were higher on the first Red day than any other day in the study. However, Sheffé's S test did not indicate any significance among the days.

Diurnal Rhythms: (Figure 10)

Female side-swims were quite high on the second Red day, on which feeding ran late and the sessions could not be started until 1026 hrs. This produced the significant diurnal rhythm shown in Figure 10.

Interaction bouts were shorter in the early part of the day, and were more variable later in the day. This pattern was also found with Rope days (compare Figures 9 & 10).

Distribution: (Figures 13 and 15)

Although female side-swims showed a non-random distribution, it was the same as that found for Blank days.

Male throwbacks and side-swims were most common in the upper half of the pool for position 1. These distributions were not clearly related to the position of the object.

Turn-unders for the male were distributed opposite to the buoy for position 1, and for the female when the buoy was in position 2.

Swimming Patterns:

Both dolphins swam to the outside of the buoy more often than the inside, although there was much variation (Appendix B). The male swam to the outside of the buoy for a greater percentage of the time on 25 May than on any other day in the study (Figure 16). There were no differences between Red days for the female.

6.2.4 Metal Buoy (31 May, 1 June)

For a summary of results for Metal days, see Table 9.

Days: (Appendix C; Appendix D, Table D6)
Interaction bout lengths were longer on 31 May than 1 June, or for any other day in the study.

Distribution: (Figure 14)
Male tail-up displays were concentrated on the left side of the pool on 31 May. This pattern was not obviously related to the presence of the buoy.

Swimming Patterns: (Figure 16)
The male never swam to the outside of the metal buoy, and appeared to swim farther from it on 1 June than 31 May. The female generally swam to the outside of the buoy on 31 May, while the pattern was opposite on 1 June. These two days were significantly different for the female (Appendix D, Table D6).

6.2.5 Hydrophone and Framework (6, 18 May)

These two conditions are discussed together because few data were collected for either individually. Table 10 summarizes results for these days.

Distribution: (Figure 14)

Female tail-downs were prevalent in the lower right corner for the Hydrophone day. Female tail-ups and side-swims were concentrated in the left side of the pool for the Framework day. Side-swims did not appear to be affected by the object, since the distribution pattern was the same as that for Blank days. The distributions of tail-downs and tail-ups were not obviously related to the presence of the hydrophone or framework.

Swimming Patterns: (Figure 16; Appendix B)

Both generally swam to the inside of the objects, although the female made more outside passes than the male. In the case of the hydrophone, the female swam to the outside twice during the last 5 min. segment.

6.2.6 Condition Differences

(Refer to Appendix D, Table D2).

Most differences occurred between the red buoy and other object conditions. Respiration for both dolphins and synchronized breaths for the male were all lower on Red days than on Blank or Rope days for both sexes. Respiration rates were also lower on the Framework day than on the Red days for the male. In addition, male twists were fewer, and interaction bouts were shorter, on Red days than Blank. There were significantly more side-swims for the male on the Red days than the Rope days, and this was due to the anomalously high level of this behaviour observed on the first Red day. The male dolphin made more outside passes to the red buoy than the hydrophone, yellow, or metal buoys (Figure 16, Appendix D, Table D2). The red buoy was the only object for which the male sometimes exhibited more than 50% outside circuits. Finally, female tail-downs were less common on Red days than the Framework or Rope days.

Tail-downs were more frequent for the male on the single Framework day than on any other day in the study, while they were also quite high for the female on this day. Further, there were more tail-ups on Metal days for the male than at any other time in the study.

The amount of interaction was much higher on the single Hydrophone day than at any other time, and the bout length was generally longer on this day as well.

There were far more object contacts on the Framework day than for any other object.

The only significant differences in swimming patterns among conditions was a greater percentage of outside circuits for the male on Red days than at any other time in the study. Both dolphins generally swam to the inside of the yellow buoy, the hydrophone, and the framework, while the male also swam to the inside of the metal buoy (Appendix C). Response to the red buoy was more variable, although both usually swam to the outside. The female swam to the outside of the metal buoy on 31 May, and to the inside on 1 June. In general, there were more outside circuits later in the study.

When diurnal rhythms are compared, it can be seen that the general midday increase in breathing rate observed for Blank days was not reproduced for any object conditions (Figure 6). In addition, only on Blank days did interaction bouts decrease in length during the mid-portion of the day (Figure 6). On Rope and Red days, interaction bouts were shorter, and varied less, during the first few hours of the day (Figures 9 and 10). On Blank days, the average morning bout length was 24 sec., whereas on Rope and Red days it was only five sec. Finally, the peak of male tail-downs observed at 1000 hrs. on Blank days was also found on Rope days (compare Figures 6 and 9). The 1000 hrs. filming period took place directly after the morning feeding.

6.2.7 Summary of Results

Results are summarized for each behaviour separately. Throwbacks, jerks, arches, startles, rolls, and penis displays did not seem to be affected by the presence of objects.

Breaths: The general midday increase in breathing rate observed for Blank days was absent for all object conditions. Further, the rate of breathing was lower than for Blank or Rope days.

Synchronicity of breathing showed some degree of variability within object conditions. Synchronicity was lower on the last Rope day for both dolphins than for other Rope days, lower on the last Red day than the first for the female, and lower on the last Yellow day than the second for the male. There were no strong differences in synchronized respiration among conditions, however, except for a decrease on Red days for the male in comparison to Blank or Rope days.

Twists: Twists were not strongly affected by the presence of objects. The only significant results were fewer male twists on Red days than Blank days, and a concentration of male twists on the larger side of the pool for one rope condition.

Tail-Downs: The framework may have had an affect on this behaviour. Male tail-downs were higher on the Framework day than any other day in the study, while this behaviour was also quite high for the female as well.

Other significant findings include a decrease in frequency for the male between the first and second Yellow days, and a concentration of the behaviour for the female on the larger side of the pool in the presence of the rope. This last finding probably resulted from the fact that the female spent more of her time on the larger side of the pool.

Tail-Ups: This behaviour may have been affected by the metal buoy. Tail-up displays by the male were more frequent on both Metal days than any other days in the study.

The only other significant finding was a concentration of the behaviour for the female on the larger side of the pool in the presence of the rope, probably explained by the fact that she spent more time on this side.

Tail-Wags: This behaviour was exhibited 55 times by the female during a 15 min. interval of high ambient noise. For the female during this time period, the behaviour appeared to be more common near the yellow buoy.

Side-Swims: Side-swims were much higher for the male on the first Red day than any other day in the study.

Interaction: The amount of interaction showed some degree of variability within object conditions. It was higher on the third Rope day than other Rope days, and bout lengths were generally longer as well. There was more interaction, and longer bouts, on the last Yellow day than other Yellow days. Interaction bouts were longer on the first Metal day than the second.

The only difference between conditions, however, was a higher level of interaction on the Hydrophone day than any other condition, and shorter bouts on Red days than Blank days.

The male initiated fewer bouts when the rope was first introduced. Interaction bouts were generally shorter, and varied less in length, during the first few hours after both the rope and red buoy were introduced than for the rest of the day.

Food Consumed: Introduction of the rope seriously decreased food intake by the female. The rope was so disruptive that the schedule of introduction had to be changed to allow for feeding.

Object Contacts: The framework was contacted far more than any other object. As can be seen from Table 3, 85% of all contacts observed were between a dolphin's dorsal fin and the overhead line of the framework, and took place when the dolphin rose to breathe. Reactions to collisions were generally minor.

Turn-Unders: Although statistical results for this behaviour were generally nonsignificant, it can be seen from Figure 15 that turn-unders usually occurred on the side of the pool opposite from the test object.

Swimming Patterns: Neither dolphin was willing to swim underneath the rope when it was introduced, and both preferred to stay on the larger side of the pool. The male habituated quickly, while the female's response was more varied. The female rarely swam underneath the rope alone.

Both dolphins generally swam to the inside of the yellow buoy, the hydrophone, and the framework, while the male also swam to the inside of the metal buoy. Response to the red buoy was more variable, although both usually swam to the outside. There were generally more outside circuits later in the study.

The male dolphin swam farther from the metal buoy when it was operating. There were no other clear relationships between object and distance.

7. Discussion

No records concerning the behavioural repertoire of the Atlantic white-sided dolphin appear to exist. Therefore, comparisons must be made with studies of other species. The Pacific white-sided dolphin is a closely related species which has been maintained in captivity in Japan, New Zealand, and the west coast of the U.S.A (Defran and Pryor 1980). The degree of behavioural similarity between the two species is not known, but because they are closely related and inhabit similar environments (*eg.* temperate offshore waters), they may show some similarities in their behaviour. However, any comparisons must be made with caution since so little is known about Atlantic white-sided dolphins. All comparisons made in this discussion are tentative.

Defran and Pryor (1980) characterize several behavioural aspects of Pacific white-sided dolphins in captivity. They have high cohesive schooling tendencies, rarely show aggression or sexual behaviour, and have been observed to help injured companions. They are considered difficult to train, although they readily perform synchronized behaviours such as unison swimming. When overall behavioural ratings are compared, this species is most similar to common and spinner dolphins. The group as a whole rates high in affiliative tendencies and shows much surface behaviour such as leaping. They show low levels of curiosity, object manipulation, and play, while rating high on several indices of fear, including bunching together when alarmed. Pacific white-sided dolphins, however, were rated as often approaching new objects. Defran and Pryor (1980) concluded that behavioural similarities in many cetaceans tend to parallel group size, with those forming large groups such as common, spinner, and Pacific white-sided dolphins displaying high levels of social and fear behaviours in captivity, and low levels of curiosity and object manipulation. Atlantic white-sided dolphins are also known to form large groups in the wild (Leatherwood & Reeves 1983).

Using the above information as a guideline, it might be expected that Atlantic white-sided dolphins would show high levels of cohesiveness and synchronicity of behaviour, low levels of curiosity-related activities, and a relatively high level of fear toward new objects.

7.1 Social Behaviour

The dolphins in this study did show a high level of synchronicity. They usually swam in close proximity to each other and breathed in unison 82% of the time. The dolphins were in actual physical contact about 17% of the time, with interactions consisting of a complicated and varied set of behaviours involving rubbing, stroking, and various body positions. Sexual intercourse was never observed, however, and penis displays were rare.

Few studies provide similarly detailed accounts of social interactions with which to compare these results. Belly-to-belly swimming has been seen in other pairs of this species (T. Binder, pers. comm.). Swimming with pectoral fins touching is a social behaviour known to occur in several species, and may represent a form of bonding (Defran & Pryor 1980). Several sources also indicate that using flippers or flukes to stroke another individual is commonly seen (Defran & Pryor 1980; McBride and Hebb 1948; Puente & Dewsbury 1976; Saayman *et al.* 1973; Shane *et al.* 1986; Tavolga & Essapian 1957; Townsend 1914).

Tavolga and Essapian (1957) detail the social interactions of a group of bottlenose dolphins which parallel some of the findings in this study. In particular, their descriptions of "stroking" closely match interaction types 1, 4, 5, and 7 identified here (Table 2). They considered stroking to be the least vigorous and energetic type of sexual activity. In addition, Saayman *et al.* (1973) describe "rubbing" in bottlenose dolphins similar to interaction types 1 and 4.

Another courtship behaviour documented in bottlenose dolphins is "displaying", where the female exposes her underside to another by rolling onto her side (Puente & Dewsbury 1976; Saayman *et al.* 1973). It has also been characterized as a form of greeting or a sign of submission (Pryor 1990; Würsig *et al.* 1990). This kind of display might correspond to "rolls" or "side-swims" in this study. Rolls were only exhibited by the female, and she engaged in side-swims more often than the male (about once per 15 min.). The purpose of these two behaviours was not obvious, however. No reaction to either behaviour was ever noted, while in some instances it did not even appear as if the second animal would be able to view the display. In fact, side-swims often involved turning toward the side of the pool and away from the other dolphin.

The "arch" display observed in this study appears to be the same behaviour as "posturing" described by Tavolga and Essapian (1957) for bottlenose dolphins. Posturing was performed by the male in view of the female and indicated "that precopulatory activities were about to become more intense". However, Puente & Dewsbury (1976) rarely observed this behaviour. When it was seen, it was usually performed by the female "just before the male gained intromission". The differences observed between these two studies remain to be explained. My observations appear to relate more closely to those of Tavolga and Essapian (1957), since the male arched commonly (about once every 15 min.) and far more often than the female. As with rolls and side-swims, however, arches did not appear related to any other behaviours or actions.

Several types of social behaviour which have been described elsewhere were not seen in this study. These include mouthing of appendages, nuzzling of the closed mouth against another individual, head butting, leaping, display swimming (swimming inverted at high speeds just below the surface), and chasing (Puente & Dewsbury 1976; Saayman *et al.* 1973; Tavolga & Essapian 1957). In addition, both Tavolga and Essapian (1957), and McBride and Hebb (1948) indicate that male bottlenose dolphins generally initiate most sexual activity. These findings are at variance with this study, which found that the male initiated only 7% of interaction bouts.

Finally, the two dolphins exhibited a variety of behaviours which do not appear to have been observed in other studies. I was unable to find any mention of behaviours analogous to this study's twists, tail-downs, tail-ups, throwbacks, or tail-wags. Dolphins are known to use many types of non-acoustic communication, including body postures (Pryor 1990; Würsig *et al.* 1990). It is possible that some of these displays had communicative value. For example, tail-wags may be an indication of stress or annoyance, as the female exhibited this behaviour 55 times during one 15 min. interval when the level of ambient noise was extremely high. At other times, tail-wags took place less than once every 15 min. Tail-down displays may bear some relationship to feeding, as the frequency of this behaviour was generally greater for the male in the filming session directly after feeding ended. The preceding points are merely speculation, and do not explain why the changes in behaviour frequencies for both tail-wags and tail-downs were only found in one of the two dolphins.

It is also unclear why some behaviours showed non-random distributions within the pool. These distributions rarely seemed related to the presence of a test object. The only other known "reference points" for the dolphins in the circular pool were a small viewing window in one wall, and the connections to the filtration system (Figure 2). It was interesting that female side-swims usually occurred near the filtration system (Figures

8, 11, 12, 13, 14). However, other behaviours that were non-randomly distributed showed considerable variation in their location. It is possible that there were reference points used by the dolphins which were not apparent, such as differences in sound intensity or texture variations in the walls or bottom of the tank. There is also the possibility that some behaviours were simply more obvious when performed in a particular area of the pool, and were therefore rated as only occurring in that area. Although this possibility can not be discounted, it is considered unlikely.

It is important to remember that the health of the two dolphins in this study had not stabilized when the experiment was conducted, and that the female subsequently died. Some activities may have been the result of illness rather than reflecting species-typical behaviours. For example, it seems likely that "jerks" indicated a reaction to some discomfort. Unfortunately, because so little is known about the behavioural repertoire of Atlantic white-sided dolphins, it is impossible to differentiate between the two at this time.

Other than the health state of the animals, uncontrollable variables such as weather, water temperature, and the amount of human activity near the pools could have affected the dolphin's responses. For example, aquarium employees noted that during the first three months of captivity, the dolphins would not eat when construction was taking place around the tanks or when the pool filters were operating. Conversely, the dolphins' behaviour did not seem to be affected by heavy rain which fell on 30 April and 6 May. On 21 May, the female accidentally received two doses of medicine (prednisolone). Logs kept by employees indicated that the female was "ravenous", "trembling", and swimming "very fast" on 22 May, which may have been a reaction to the medicine. The only strong difference noted in behavioural measures on this day was a higher level of side-swims than at any other time in the study. As noted before, a very high level of tail-wags by the female coincided with the arrival of a very loud delivery truck. Finally, the pool temperature may have played a role in regulating the dolphins' behaviours, as it was several degrees higher than optimum for most of the study. Unfortunately, temperature generally increased throughout the study, thus it is not possible to separate the factor of "time" from the factor of "temperature" in considering behavioural effects.

7.2 Reactions to Objects

The main objective of this study was to determine how the dolphins reacted to novel objects, and how these reactions changed as they became more familiar with the objects. If behaviourally similar to Pacific white-sided dolphins, Atlantic white-sided dolphins might be expected to show low levels of curiosity behaviours and high levels of fear toward new objects.

The rope elicited the greatest amount of response from the two dolphins. When no objects were present they constantly circled their pool in a clockwise direction, but when the rope was placed on the surface both dolphins remained to one side of it and resumed their circling on the larger half of the pool. They did not attempt to stay away from the rope, but swam along it as if it were a barrier. These results parallel other studies which suggest that surface ropes act as barriers to dolphins (Hatakeyama 1986a; Hatakeyama & Shimizu 1985; Perrin & Hunter 1972).

The presence of the rope disrupted the dolphins to such an extent that they would not eat. The female, in particular, ate very little even in the afternoon feeding when the rope had been removed. There was also a dramatic increase in the percentage of interaction bouts initiated by the male when the rope was first introduced.

The male dolphin habituated to the rope within four hours, and thereafter usually circled the entire pool regardless of the rope's presence. The female's response was more variable. She appeared to have habituated after seven hours on the first day, yet when the rope was presented the following day she rarely swam underneath it. On the third day she again appeared to habituate after seven hours, and yet on the fourth day she swam underneath very few times. Even when the female did swim under the rope, she usually accompanied the male. This fact, coupled with her variable response, seems to indicate that she was more wary of the rope than the male dolphin.

Neither dolphin reacted strongly to a change in rope position on the fifth day. Further, no dishabituation to the rope had taken place after it was absent for 12 days.

Much less reaction was observed to all other objects. Most of the variability which existed within and between conditions can not be obviously attributed to the presence or absence of objects. Only those behaviours that did appear to vary in relation to objects, and which could have a bearing on the problem of entrapment, will be discussed here.

Synchronicity of respiration showed an interesting pattern of variability within object conditions. It was lower on the last Rope day for both dolphins, lower on the last Red day than the first for the female, and lower on the last Yellow day than the second for the male. These results suggest the possibility that breathing is more synchronous when objects are novel, but decreases as familiarity increases. Synchronicity of respiration could be related to the bunching together of cetaceans in response to fearful situations which was discussed in section 2.3. This has been found with captive killer whales (J. Ford, pers. comm.).There were no strong differences in synchronized breaths among conditions, however, except for a decrease on Red days for the male in comparison to Blank or Rope days.

On Blank days, there was a general increase in breathing rate during the middle of the day. Interaction bouts were also shorter at midday, although there was no change in the amount of interaction overall. Tavolga and

Essapian (1957) indicated that "stroking" in captive bottlenose dolphins, a type of social behaviour similar to that found in this study, took place most often when the dolphins were resting. In this study, longer bouts of "stroking" at the beginning and end of each day, coupled with a lower breathing rate at these times, may be indicative of more restful periods for the dolphins. Saayman *et al.* (1973) found a midday increase in the level of social interactions for both captive and wild bottlenose dolphins. No change in the amount of interaction at midday was noted here, although shorter bouts of interaction plus higher breathing rates may indicate a more active state at this time.

The introduction of objects appeared to affect the arousal of the dolphins, as the above patterns were not duplicated in any object conditions. On Rope and Red days in particular, bout lengths were much shorter during the beginning portion of the day, which could indicate a higher level of arousal at these times. Bout lengths were normal in the afternoon, however, possibly indicating habituation to the objects. The fact that the amount of interaction was greater overall, and the length of bouts was longer, on the third Rope day and last Yellow day may also reflect habituation over a period of days. When object conditions were compared, the Hydrophone day showed a greater amount of interaction, and longer bouts, than other object conditions. The Hydrophone day was most similar to Blank days, probably indicating that the dolphins were minimally affected by the presence of the hydrophone. Finally, interaction bouts were generally shorter on Red days than Blank, possibly indicating greater arousal on these days. The breathing rate was generally lower on Red days, however, which is inconsistent with the above argument.

Only two behaviours in this study, turn-unders and contacts, had a direct and obvious relationship to the test objects themselves. Turn-unders, which were quick turns onto the side sometimes accompanied by twitching, took place when the dolphins swam underneath the overhead line of the framework. The dolphins appeared to be suddenly startled by the line as they swam close to it, and turned onto their sides with some twitching. However, they did not avoid swimming underneath the line as they had with the rope. Turn-unders were actually quite rare, occurring less than once every 15 min. This behaviour may have represented lapses in the attention of the dolphins, or possibly a type of exploration, with the dolphins turning onto their sides to look at the line as they passed underneath. It is interesting to note that this behaviour rarely occurred when the dolphins swam under the line near the object (Figure 15). This could mean that, when the dolphins passed near an object, they paid more attention to it than to the overhead line.

Eighty-five percent of all contacts observed in the study were between a dolphin's dorsal fin and the overhead line of the framework, and took place when the dolphin rose to breathe. Only 15% of collisions were with objects on or below the water's surface. This may indicate that submerged objects are more easily detected, and therefore avoided. The few contacts with submerged objects appeared to result either from a lack of attention or through misjudging the distance between the animal and the object (Table 3). No contacts with objects appeared to be deliberate. It is interesting to note that reactions to collisions were generally minor, and did not appear to result in immediate avoidance or exploration of the object. Sixty-four percent of all observed collisions took place on the first day that the framework was presented. Since collisions decreased after this day, it appears that the dolphins became familiar with the framework's presence and learned to avoid it. The fact that collisions did not cease entirely may indicate that although the dolphins were generally aware of the framework, they were not always attending to it. Thus, lack of attention may have resulted either in collisions or turn-unders.

Swimming patterns were affected by the presence of objects. The effect caused by the rope was strongest, and has already been discussed. Considering the other objects, in each circuit of the pool the dolphins had a choice of either passing to the outside of the object (*eg.* between the wall and the object), or to the inside. If the dolphins wished to avoid the test object, then it seems likely that they would choose to stay to the inside of it. Outside passes would force the dolphins to swim near the object, as well as placing the object between the dolphins and the majority of the pool; a seemingly "risky" behaviour if the dolphins are afraid of the object. The number of outside passes would be expected to increase as the object became more familiar. In addition, one would expect the dolphins to stay further away from objects when they are more novel. The male did swim farther from the metal buoy when it was operating, suggesting that he was more wary of it at this time. Except for the rope, which has already been discussed, there were no other strong patterns of response to objects. There were more outside circuits in the latter half of the study, however, which may indicate that the dolphins were habituating to the testing set up in general (Figure 16). It is interesting to note that the female usually passed to the outside of the object more often than the male. Given that she responded more strongly to the rope than the male, one might expect her to be more wary of other objects as well. The results indicate that either she was not more wary, or that outside circuits were not a good measure of "wariness". In no cases did the dolphins change their circling pattern in ways that would indicate exploration of the objects. Indeed, no behaviours classified by Defran and Pryor (1980) as expressing exploration or curiosity were observed in this study.

8. Summary

The introduction of test objects did affect the two dolphins in this study, and reactions did vary with the objects used and the level of familiarity. A rope placed on the surface of the water elicited the strongest response. Both dolphins acted as if it were a barrier, a result which has been found in other studies. The female dolphin refused to eat when the rope was present, while the male initiated a greater percentage of interaction bouts when the rope was first introduced. Further, there were indications that the arousal level of the dolphins was greater than normal when the rope was first introduced. The male habituated to the rope within four hours. The female's reaction varied, although she appeared to have habituated after five days. No dishabituation to the rope took place for either dolphin after a period of 12 days.

Responses to other objects were much weaker. The dolphins generally avoided the immediate vicinity of the objects, indicating that they were aware of them. There were indications that the introduction of an object to the pool caused an increase in arousal level, as a normal decrease in breathing rate at the beginning and end of the day was not witnessed when objects were present. Passes between an object and the wall of the pool became more frequent as the study progressed, possibly indicating habituation to the testing set up.

Eighty-five percent of all contacts with objects were with the overhead line of the framework, while submerged objects were rarely struck. Collisions were most frequent on the first day that the framework was placed in the pool, which may indicate that the dolphins learned to avoid it thereafter. All collisions appeared accidental, and seemed to be caused by a lack of attention or through misjudging distances. Reactions to collisions were minor.

There were no obvious indications of exploratory or play behaviours, although the rare occurrence of turn-unders in response to the overhead line may have been related to exploration. If this species is similar to the closely-related Pacific white-sided dolphin, then a lack of play behaviour may be expected.

The dolphins exhibited a high degree of social cohesiveness and engaged in complex forms of social interaction which may not have been recorded before for other cetacean species. Several other behaviours were also observed which do not seem to have been documented elsewhere. Differences in behaviour patterns existed between the two dolphins, although it was not possible to determine whether these were the result of individual variations, sex-related variations, or differences in health between the two dolphins.

As the dolphins in this study showed the greatest reaction to a rope on the surface of the water, this suggests that the head rope of a net may be an important cue to cetaceans. It also appears that lack of attention can be one factor leading to entanglement. There was no evidence to support the idea that cetaceans become entangled when exploring or playing with nets, as the two dolphins appeared to perform neither of these activities. However, there was also no strong avoidance of any objects, even one producing a loud noise. It must be remembered that these observations represent data collected from only two dolphins, both of which were in poor health throughout the study. As such, these results are only suggestive of possible entrapment scenarios.

This study was unique in two respects. First, it provides a more detailed description of Atlantic white-sided dolphin social behaviour than previous studies. Further, this is the only known study to attempt a systematic examination of the reaction of cetaceans to objects. Although this last point means that the results documented here may be fresh and exciting, it also means that there were no previous studies from which to formulate a workable methodology, and few existing results with which to compare. This study also operated under the real constraints of time, money, and the limited availability of suitable subject animals (*eg.* those which were not "domesticated" and already familiar with many types of objects in the form of toys or props). The results reported here do not provide any definitive answers about object responses, and in many cases the data are limited and simply pose new questions. The purpose of this study was to provide the beginnings of a workable methodology for studying cetacean reactions to objects, and to exemplify the kinds of information that can be gathered in this area.

It is hoped that this study will stimulate others to continue research into the neglected topics of both cetacean behaviour in general, and cetacean responses to objects in particular. As a first step, existing descriptions of the behavioural repertoires of captive species should be broadened. There is a need for more detailed accounts of cetacean behaviour which do not clump information together under such headings as "interaction" or "swimming", and which include information on diurnal rhythms. Descriptions should be precise to avoid confusion among studies which may refer to the same behaviour in different ways.

There are numerous areas of research to be pursued when considering cetacean reactions to objects. Other than the effects of habituation and object type addressed in this study, differences in response relating to the age of cetaceans need to be analyzed. It would be especially interesting to determine whether the strong reaction to a floating rope is found across many cetacean species and ages, and how the composition of a floating object might affect the response. Most importantly, experiments involving actual nets need to be conducted. Such experiments will have to be constructed carefully to maximize information gathered while minimizing the risk to the study animals. Such experiments may be of great importance in attempting to understand and reduce the incidental entrapment of cetaceans.

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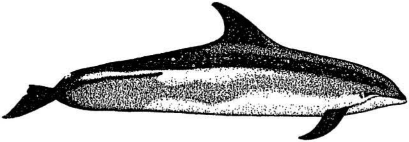


Figure 1. Atlantic white-sided dolphin, *Lagenorhynchus acutus.*

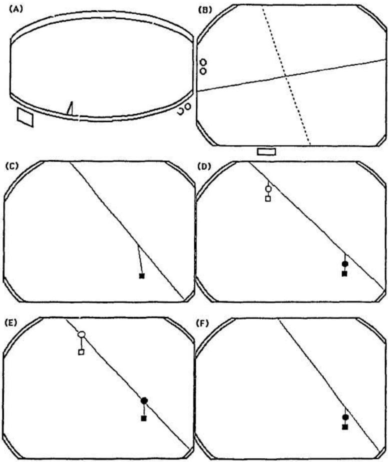


Figure 2. Positions of experimental objects in the pools. Each diagram represents the view obtained through the camcorder. Curved borders mark the edge of the pool while straight borders delineate the field of view of the camcorder. The squares in (A) and (B) indicate positions of small viewing windows in the sides of the two pools, while the double circles indicate positions of the filters.

(A) hydrophone
(B) rope: solid line = position 1, dotted line = position 2
(C) framework
(D) yellow buoy: black icon = position 1, white icon = position 2
(E) red buoy: black icon = position 1, white icon = position 2
(F) metal buoy

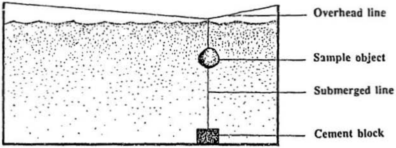


Figure 3. Cross-sectional view of the pool showing the framework and a sample object. Diagram is not to scale.

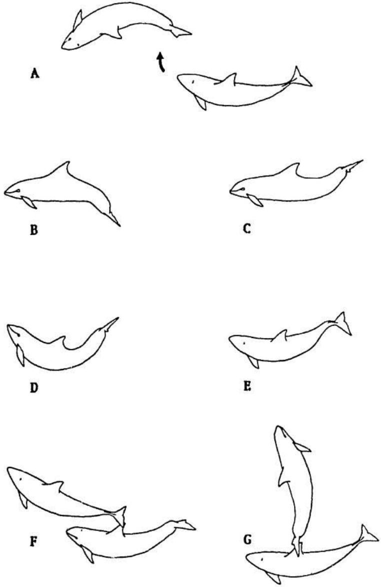


Figure 4. Various behaviours. **(A)** twist; **(B)** tail-down; **(C)** tail-up; **(D)** throwback; **(E)** arch; **(F)** & **(G)** interaction type 10 (see Table 2).

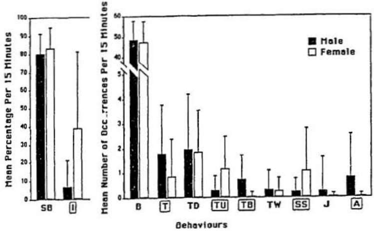


Figure 5. Individual differences in behaviour combined for all blank days (mean per 15 minutes + 1 S.D.). Behaviours which are boxed indicate significant results. The amount of food consumed daily (not shown) was not significantly different between the two dolphins ($F_{(1,14)} = .261$, $p = .6175$).

SB = percentage of breaths taken by each dolphin that were synchronized with breaths taken by the other; ($F_{(1,110)} = 2.021$, $p = .158$)
I = percentage of interaction bouts that were initiated by each dolphin; ($F_{(1,110)} = 29.165$, $p = .0001$)
B = breaths; ($F_{(1,110)} = .578$, $p = .4487$)
T = twists; ($F_{(1,110)} = 7.512$, $p = .0072$)
TD = tail-downs; $F_{(1,110)} = .111$, $p = .7395$)
TU = tail-ups; ($F_{(1,110)} = 20.011$, $p = .0001$)
TB = throwbacks; ($F_{(1,110)} = 25.619$ $p = .0001$)
TW = tail-wags; ($F_{(1,110)} = .176$, $p = .676$)
SS = side-swims; ($F_{(1,110)} = 12.632$, $p = .0006$)
J = jerks; ($F_{(1,110)} = 1.636$, $p = .2036$)
A = arches; ($F_{(1,110)} = 10.783$, $p = .0014$)

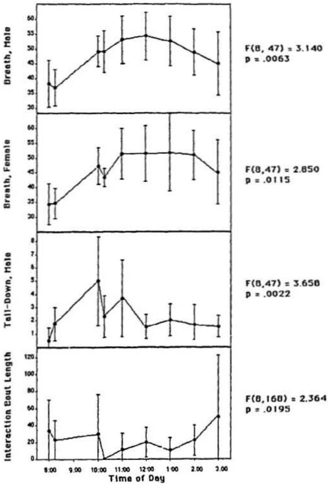


Figure 6. Behaviours which showed significant diurnal rhythms on Blank days. For the first three, the graph indicates the mean number of occurrences per 15 minutes, + 1 S.D. For interaction bout length, the graph indicates the mean bout length in seconds per 15 minutes, ± 1 S.D. Significance values are to the right of the graphs.

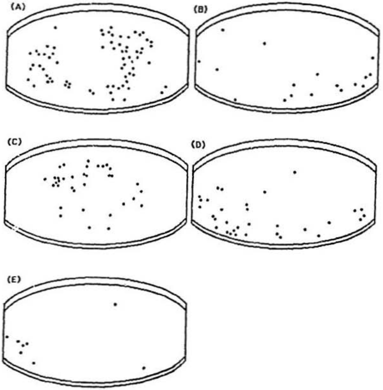


Figure 7. Behaviours which showed significant, non-random distributions of occurrence in SP3 on Blank days.

(A) twist (male)	x^2 (3, n=71) = 8.268, p = .0408
(B) twist (female)	x^2 (3, n=17) = 11.471, p = .0094
(C) tail-down (male)	x^2 (3, n=35) = 14.029, p = .0029
(D) tail-up (female)	x^2 (3, n=32) = 30.5, p = .0001
(E) tail-wag (female)	x^2 (3, n=8) = 11, p = .0117

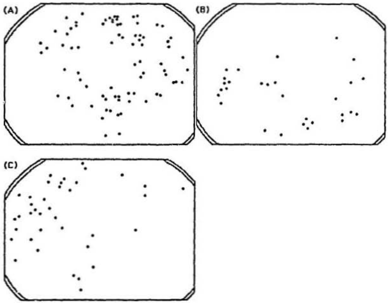
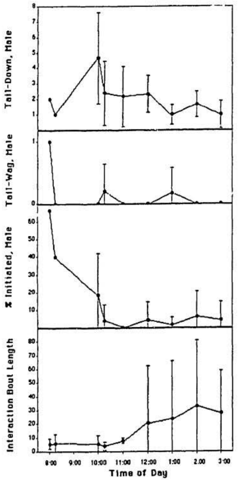


Figure 8. Behaviours which showed significant, non-random distributions of occurrence in SP4 on Blank days.

(A) tail-down, male x^2 (3, n=79) = 21.911, p = .0001
(B) tail-up, female x^2 (3, n=29) = 12.793, p = .0051
(C) side-swim, female x^2 (3, n=38) = 27.474, p = .0001



F(8,34) = 2.528
p = .0282

F(8,34) = 3.012
p = .0115

F(8,34) = 4.782
p = .0005

F(8,144) = 2.710
p = .0083

Figure 9. Behaviours which showed significant diurnal rhythms on Rope days. For the first two, the graph indicates the mean number of occurrences per 15 minutes, ± 1 S.D. The third graph indicates the mean percentage of interaction bouts initiated by the male per 15 minutes, ± 1 S.D. For interaction bout length, the graph indicates the mean bout length in seconds per 15 minutes, ± 1 S.D. Significance values are to the right of the graphs. Certain points have no error bars because the data they represent were collected from only one 15 minute interval, and no mean could be generated.

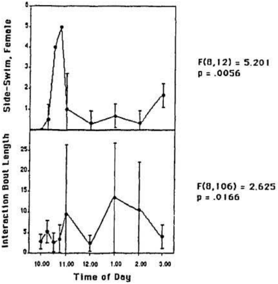


Figure 10. Behaviours which showed significant diurnal rhythms on Red days. The first graph indicates the mean number of female side swims per 15 minutes, + 1 S.D. The second graph indicates the mean length of interaction bouts in seconds per 15 minutes, ± 1 S.D. Significance values are to the right of the graphs. Certain points have no error bars because the data they represent were collected from only one 15 minute interval, and no mean could be generated.

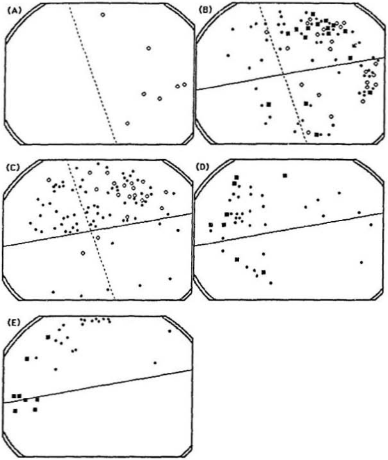


Figure 11. Behaviours which showed significant, non-random distributions of occurrence on Rope days. Position 1 days = solid dots, position 2 days = open dots, position 1 on May 28 = squares.

(A) twist, male	(position 2)	x^2 (3, n=8) = 12, p = .0074
(B) tail-down, male	(position 1)	x^2 (3, n=53) = 12.615, p = .0055
	(position 2)	x^2 (3, n=22) = 15.455, p = .0015
	(May 28)	x^2 (3, n=17) = 19.471, p = .0002
(C) tail-down, female	(position 1)	x^2 (3, n=72) = 38.667, p = .0001
	(position 2)	x^2 (3, n=19) =24.579, p = .0001
(D) tail-up, female	(position 1)	x^2 (3, n=33) = 18.515, p = .0074
	(May 28)	x^2 (3, n=8) = 12, p = .0074
(E) side-swim, female	(position 1)	x^2 (3, n=20) = 26.4, p = .0001
	(May 28)	x^2 (3, n=8) = 12, p = .0074

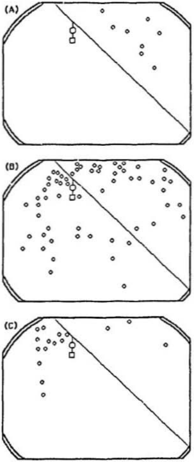


Figure 12. Behaviours which showed significant, non-random distributions of occurrence on Yellow days. Only Position 2 days were significant.

(A) tail-down, female x^2 (3, n=8) = 24, p = .0001
(B) tail-wag, female x^2 (3, n=60) = 20.4, p = .0001
(C) side-swim, female x^2 (3, n=16) = 22.5, p = .0001

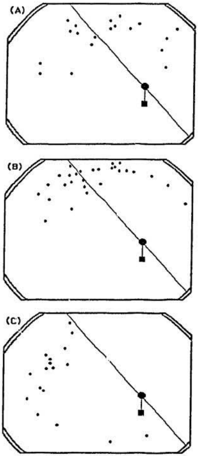


Figure 13. Behaviours which showed significant, non-random distributions of occurrence on Red days. Only Position 1 days were significant.

(A) throwback, male $x^2 (3, n=19) = 19.105, p = .0003$

(B) side-swim, male $x^2 (3, n=28) = 30.571, p = .0001$

(C) side-swim, female $x^2 (3, n=17) = 13.353, p = .0039$

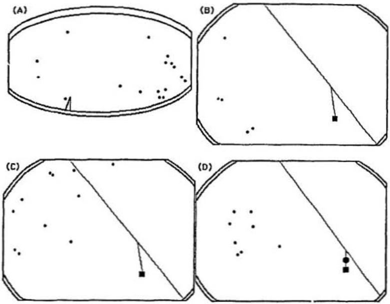


Figure 14. Behaviours which showed significant, non-random distributions of occurrence on Hydrophone **(A)**, Framework **(B)** & **(C)**, and Metal **(D)** days.

(A) tail-down, female	x^2 (3, n=17) = 14.765, p = .002
(B) tail-up, female	x^2 (3, n=5) = 8.6, p = .0351
(C) side-swim, female	x^2 (3, n=11) = 10.455, p = .0151
(D) tail-up, male	(31 May) x^2 (3, n=8) = 8, p = .046

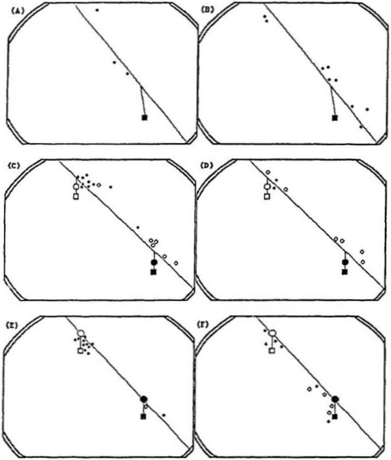


Figure 15. Turn-unders for all days. **(A)**, **(C)**, and **(E)** refer to the male on the Framework, Yellow, and Red days, while **(B)**, **(D)**, and **(F)** refer to the female for the same days. Position 1 days = solid dots, position 2 days = open dots. Significant results are as follows:

(C) (Yellow, position 1, male) x^2 (1, n=10) = 10, p = .0016
(E) (Red, position 1, male) x^2 (1, n=11) = 7.364, p = .0067
(F) (Red, position 2, female) x^2 (1, n=4) = 4, p = .0455

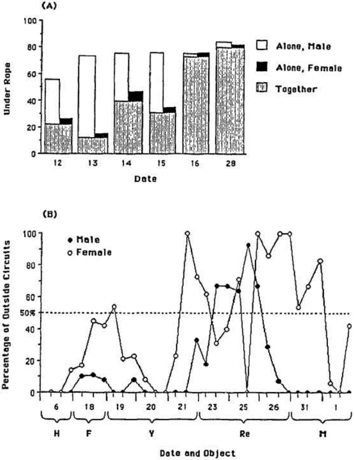


Figure 16. Summary of movement pattern data.

(A) The average number of times per 15 minutes that both dolphins went under the rope alone and together for each day that the rope was presented. These data were tabulated from all 42 hours of film.

(B) The percentage of pool circuits per each five minute interval classified as "outside". These data were tabulated from the movement patterns contained in Appendix C. Each condition is divided into days, and each day is divided into the three sessions shown in Appendix C. H = hydrophone, F = framework, Y = yellow buoy, Re = red buoy, M = metal buoy.

Table 1. Schedule of testing for the study.

Date	Condition	Comments
28 April	blank, SP3	testing began at 1000 hrs dolphins were fed from 1115 - 1145 hrs.
29 - 30 April	blank, SP3	
6 May	hydrophone, SP3	
9 May	blank, SP3	
10 May	---	no testing, dolphins moved to SP4 all subsequent testing done in SP4
11 May	blank	
12 May	rope, position 1	last day of testing from 0800 - 0830 hrs.
13 - 15 May	rope, position 1	beginning of testing from 1015 - 1030 hrs.
16 May	rope, position 2	
17 May	blank	
18 May	framework	
19 - 20 May	yellow buoy, position 1	
21 May	yellow buoy, position 2	
22 May	blank	
23 May	red buoy, position 1	
24 May	---	physical exam of dolphins, no testing
25 May	red buoy, position 1	
26 May	red buoy, position 2	
27 May	blank	
28 May	rope, position 1	
29 May	---	chiller being installed in pool, no testing
30 May	---	work still progressing on pool, no testing
31 May	metal buoy, off	late feeding, testing delayed until 1130 hrs.
1 June	metal buoy, on	testing stopped after 1200 session

Table 2. Behaviours observed during the study.

Breath: The dolphin rose to the surface and took a breath. When breaths of the two dolphins came within two seconds of each other, they were considered synchronous. For analysis, the percentage of breaths taken by each dolphin that were synchronous with breaths taken by the other was determined.

Twist: The dolphin turned its head and tail alternately from one side to the other. This movement was sometimes exaggerated to such a degree that the dolphin would roll onto its side when turning (see Figure 4a).

Tail-Down: The dolphin lowered its tail stock while holding its flukes relatively horizontal, keeping this position for a second or longer. This may or may not have been accompanied by lowering or raising of the head (see Figure 4b).

Tail-Up: The dolphin raised its tail stock and held this position for a second or longer. This may or may not have been accompanied by lowering of the head (see Figure 4c).

Throwback: The dolphin rapidly lifted both head and tail to an exaggerated degree, possibly turning on its side at the same time (see Figure 4d).

Tail-Wag: The dolphin rapidly moved its flukes from side to side.

Side-Swim: The dolphin swam on its side.

Jerk: This behaviour consisted of any slight, rapid jerking of the body.

Arch: The dolphin lifted its head while arching its tail stock and twisting it to one side (see Figure 4e).

Startle: The dolphin suddenly jolted forward with a quick burst of speed. Except for one case when the female startled on her own, this behavior always occurred simultaneously between the two animals. Usually, there was no apparent cause for the behaviour, although once it appeared to be caused by the shadow of a bird that passed directly overhead, and another time by a caretaker inadvertently hitting the edge of the pool.

Roll: This was observed rarely, and only by the female. She would quickly and forcefully roll her body onto its side.

Penis Display: The male's penis became erect. The male was not observed to position himself near the female while displaying. No reaction was ever noted by the female to such a display.

(continued)

Table 2. (continued)

Turn-Under: This was almost exclusively exhibited in response to the overhead rope of the framework, although it was observed once by the female when the rope lay on the surface of the water. It consisted of the dolphin turning quickly onto its side while going under the rope, and/or exhibiting some amount of twitching, as if startled.

Contact: The dolphin touched either the experimental object or the framework with some part of its body.

Interaction: This consisted of any behaviours which involved physical contact between the two animals. A "bout" of interaction began when one dolphin touched the other, and continued until they moved greater than one body length apart. If one dolphin clearly approached the other to begin interacting, that dolphin was labeled the initiator of the bout. If the initiator was not clear, the bout was considered to have been initiated by both dolphins. For analysis, the percentage of bouts initiated by each dolphin was determined.

There were several different kinds of interaction. The most commonly seen form of each is described here, although there were variations, such as which role each individual played in the encounter. No distinction was made between the different types of interaction during analysis. Often, a single bout of interaction would consist of several of the following. No sexual intercourse was observed during the study.

1) Male swam up and down the female's body while touching her with a pectoral flipper.
2) Male swam in back of the female and touched her tail with a pectoral flipper.
3) Male swam in back, and to the side, of the female, and stroked the side of her tail stock with a pectoral flipper.
4) Male swam in back, and to the side, of the female, while she moved her flukes sideways to rub them against one of his pectoral flippers.
5) Female swam underneath male, rubbing her head against one of his pectoral flippers.
6) Male and female swam side-by-side with a pectoral flipper of each touching.
7) Female swam upside-down underneath male with her pectoral flippers touching his.
8) Male swam alongside female on his side, "holding" her in back of her dorsal fin with his pectoral flippers.
9) Male swam behind female with a pectoral flipper touching her flukes, while both ceased swimming and glided along, turning onto their sides.
10) Female touched her flukes to the male's dorsal fin, while both ceased swimming and glided along. See Figure 4f & g for two different examples of this behaviour.
11) Male and female stopped swimming, and glided along side-by-side with only their flukes touching.

Table 3. All contacts between a dolphin and a test object observed during the study. TIME refers to the 15 min. interval in which the contact occurred.

Date	Time	Dolphin	Comments
14 May	1400	female	hit rope with flukes while twisting; no reaction.
16 May	1500	male	hit rope with dorsal fin; no reaction.
18 May	1015	male	hit overhead rope with dorsal fin; slight twitch.
	1015	male	hit overhead rope with dorsal fin; turned on side.
	1100	female	hit submerged rope with pectoral fin or side; slight twitch.
	1100	male	hit overhead rope with dorsal fin; no reaction.
	1100	male	hit overhead rope with dorsal fin; slight turn onto side.
	1100	male	hit overhead rope with dorsal fin; slight turn onto side.
	1100	male	hit overhead rope with dorsal fin; slight turn onto side.
	1200	male	hit overhead rope with dorsal fin; no reaction.
	1200	male	hit overhead rope with dorsal fin; slight turn onto side.
	1200	female	hit submerged rope with pectoral fin; slight twitch.
	1300	male	hit overhead rope with dorsal fin; no reaction.
	1300	male	hit overhead rope with dorsal fin; slight twitch.
	1300	male	hit overhead rope with dorsal fin; no reaction.
	1400	male	hit overhead rope with dorsal fin; no reaction.
	1400	male	hit overhead rope with dorsal fin and possibly back; no reaction.
	1400	male	hit overhead rope with dorsal fin and back; no reaction.
	1400	male	hit overhead rope with dorsal fin and back; no reaction
	1400	male	hit overhead rope with dorsal fin; no reaction.
	1400	female	hit overhead rope with dorsal fin; started forward.
	1500	female	hit overhead rope with dorsal fin; started forward forcefully.
	1500	male	hit overhead rope with dorsal fin; no reaction.
19 May	1400	male	hit overhead rope with dorsal fin; no reaction.
20 May	1300	male	hit overhead rope with dorsal fin; no reaction.
21 May	1015	male	hit overhead rope with dorsal fin; slight twitch.
	1300	male	hit overhead rope with dorsal fin; slight twitch.
	1500	female	hit overhead rope with dorsal fin; twitched strongly and turned on side.
23 May	1400	male	hit submerged rope head on; twitched to side.
25 May	1400	female	slightly touched submerged rope with tail; no reaction.
	1400	female	hit overhead rope with dorsal fin; twitched strongly.
26 May	1300	female	hit overhead rope with dorsal fin; no reaction.
31 May	1500	female	moved to one side to avoid hitting submerged rope head on, hit it with side instead.

Table 4. Summary of behaviour statistics for Blank days. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results.

RATE indicates the average number of occurrences, amounts, or percentages per 15 min. In the case of Food, RATE indicated the amount eaten per day. RATE numbers that are bold indicate significant differences between the two dolphins. Numbers in parenthesis indicate the actual number of times that a behaviour was observed (shown when behaviours occurred very rarely).

DAYS indicates whether there were significant differences in the rate of a behaviour among the Blank days. Asterisks indicate results that were significant when assessed with Sheffé's S test.

DIURNAL indicates whether there were diurnal changes in the rate of a behaviour.

POOL indicates whether there was a non-random distribution of behaviour occurrences in either SP3 or SP4. Blank spaces in this column denote behaviours for which this type of data was not collected, or behaviours which were too rare to assess for this condition.

Behaviour	Rate	Days	Diurnal	Pool	
				SP3	SP4
Breath	48.7	Y *	Y	--	--
	47.3	Y *	Y	--	--
% Synchronized Breaths	80	Y *	n	--	--
	83	Y *	n	--	--
Twist	**1.8**	n	n	Y	n
	0.8	Y	n	Y	n
Tail-Down	1.9	n	Y	Y	Y
	1.8	Y	n	n	n
Tail-Up	**0.3**	n	n	n	n
	1.1	n	n	Y	Y
Throwback	**0.7**	Y	n	n	n
	0.04 (2)	n	n	--	--
Tail-Wag	0.3	n	n	n	n
	0.3	n	n	Y	n
Side-Swim	**0.2**	n	n	n	--
	1.1	Y	n	n	Y
Jerk	0.3	n	n	n	--
	0.02 (1)	n	n	--	--
Arch	**0.8**	n	n	n	n
	0.02 (1)	n	n	--	--
Startle	0.2	n	n	n	n
				n	n
Roll (female only)	0.05 (3)	n	n	--	--
Penis Display (male only)	0.07 (4)	Y	n	--	--
Amount of Interaction	82 sec.	n	n	--	--
% Initiation of Interaction	**6.8**	n	n	--	--
	38.9	n	n	--	--
Length of Interaction Bouts	26 sec.	Y *	Y	--	
Food Consumed	11.6 kg	n	--	--	--
	10.8 kg	n	--	--	--

Table 5. Summary of results for all One-Factor ANOVA and Sheffé's S tests conducted with "condition" as the predictor (*eg.* blank, hydrophone, rope, frame., yellow, red, metal) and the occurrence rate of behaviours per 15 min. as the dependent variable. Each behaviour was tested separately. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates there were significant differences among conditions for particular behaviours. Asterisks indicate results that were significant when assessed with Sheffe's S test. A small n indicates non-significant results.

Behaviour	**Differences Among Conditions?**
Breath	Y *
	Y *
% Synchronized Breaths	Y *
	n
Twist	Y*
	Y
Tail-Down	Y *
	Y *
Tail-Up	Y *
	Y
Throwback	n
	n
Tail-Wag	n
	n
Side-Swim	Y *
	n
Jerk	n
	n
Arch	n
	n
Startle	n
Roll	n
Penis Display	n
Amount of Interaction	Y *
% Initiation of Interaction	n
	n
Length of Interaction Bouts	Y *
% of Outside Circuits	Y *
	n
Turn-Unders	n
	n
Contacts	Y *
	Y *
Food Consumed	n
	n

Table 6. Summary of behaviour statistics for Rope days. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results.

DAYS indicates whether there were significant differences in the rate of a behaviour among the Rope days. Asterisks indicate results that were significant when assessed with Sheffé's S test.

DIURNAL indicates whether there were diurnal changes in the rate of a behaviour.

POSITION indicates whether there was a non-random distribution of behaviour occurrences for the different rope positions. Blank spaces in this column denote behaviours for which this type of data was not collected, or behaviours were too rare to assess for this condition.

Behaviour	**Days**	**Diurnal**	**Position**		
			1	2	1
Breath	Y	n	--	--	--
	n	n	--	--	--
% Synchronized Breaths	Y*	n	--	--	--
	Y*	n	--	--	--
Twist	n	n	n	Y	--
	n	n	n	n	--
Tail-Down	Y	Y	Y	Y	Y
	Y	n	Y	Y	--
Tail-Up	n	n	n	--	--
	n	n	Y	n	Y
Throwback	n	n	n	n	n
	n	n	--	--	--
Tail-Wag	n	Y	--	--	--
	n	n	n	--	--
Side-Swim	n	n	--	--	--
	n	n	Y	n	Y
Jerk	n	n	--	--	--
	n	n	--	--	--
Arch	Y	n	n	--	--
	n	n	--	--	--
Startle	Y	n	n	n	--
			n	n	--
Roll	n	n	--	--	--
Penis Display	n	n	--	--	--
Amount of Interaction	Y*	n	--	--	--
% Initiation of Interaction	n	Y	--	--	--
	n	n	--	--	--
Length of Interaction Bouts	Y*	Y	--	--	--
Under Rope Alone	Y*	n	--	--	--
	n	n	--	--	--
Under Rope Together	Y*	n	--	--	--
Under Rope Total	Y*	n	--	--	--
	Y*	n	--	--	--
Contacts	n	n	--	--	--
	n	n	--	--	--
Food Consumed	n	n	--	--	--
	Y*	n	--	--	--

Table 7. Summary of behaviour statistics for Yellow days. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results.

DAYS indicates whether there were significant differences in the rate of a behaviour among the Yellow days. Blank spaces in this column indicate behaviours which were not observed during Yellow days. Asterisks indicate results that were significant when assessed with Sheffé's S test.

DIURNAL indicates whether there were diurnal changes in the rate of a behaviour.

POSITION indicates whether there was a non-random distribution of behaviour occurrences for the different object positions. Blank spaces in this column denote behaviours for which this type of data was not collected, or behaviours that were too rare to assess for this condition.

Behaviour	Days	Diurnal	Position	
			1	2
Breath	n	n	--	--
	n	n	--	--
% Synchronized Breaths	Y*	n	--	--
	n	n	--	--
Twist	n	n	n	n
	n	n	--	--
Tail-Down	Y*	n	n	n
	n	n	n	Y
Tail-Up	n	n	n	--
	n	n	n	n
Throwback	n	n	n	n
	n	n	--	--
Tail-Wag	--	--	--	--
	n	n	--	Y
Side-Swim	--	--	--	--
	n	n	n	Y
Jerk	--	--	--	--
	--	--	--	--
Arch	n	n	--	--
	--	--	--	--
Startle	Y	n	n	--
			n	--
Roll	--	--	--	--
Penis Display	n	n	--	--
Amount of Interaction	Y*	n	--	--
% Initiation of Interaction	n	n	--	--
	n	n	--	--
Length of Interaction Bouts	Y*	n	--	--
% of Outside Circuits	n	--	--	--
	n	--	--	--
Turn-Unders	n	n	Y	n
	n	n	n	n
Contacts	n	n	--	--
	n	n	--	--
Food Consumed	n	n	--	--
	n	n	--	--

Table 8. Summary of behaviour statistics for Red days. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results.

DAYS indicates whether there were significant differences in the rate of a behaviour among the Red days. Blank spaces in this column indicate behaviours which were not observed duing Red days. Asterisks indicate results that were significant when assessed with Sheffé's S test.

DIURNAL indicates whether there were diurnal changes in the rate of a behaviour.

POSITION indicates whether there was a non-random distribution of behaviour occurrences for the different object positions. Blank spaces in this column denote behaviours for which this type of data was not collected, or behaviours that were too rare to assess for this condition.

Behaviour	Days	Diurnal	Position	
			1	2
Breath	n	n	--	--
	n	n	--	--
% Synchronized Breaths	n	n	--	--
	Y *	n	--	--
Twist	n	n	n	--
	n	n	n	--
Tail-Down	n	n	n	n
	n	n	n	n
Tail-Up	n	n	--	n
	n	n	n	n
Throwback	n	n	Y	--
	--	--	--	--
Tail-Wag	n	n	--	--
	n	n	--	--
Side-Swim	Y	n	Y	--
	n	Y	Y	n
Jerk	n	n	--	--
	--	--	--	--
Arch	n	n	n	n
	--	--	--	--
Startle	n	n	n	n
			n	n
Roll	--	--	--	--
Penis Display	--	--	--	--
Amount of Interaction	n	n	--	--
% Initiation of Interaction	n	n	--	--
	n	n	--	--
Length of Interaction Bouts	n	Y	--	--
% of Outside Circuits	Y *	--	--	--
	n	--	--	--
Turn-Unders	n	n	Y	n
	n	n	n	Y
Contacts	n	n	--	--
	n	n	--	--
Food Consumed	n	n	--	--
	n	n	--	--

Table 9. Summary of behaviour statistics for Metal days. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results.

DAYS indicates whether there were significant differences in the rate of a behaviour between the two days. Blank spaces in this column indicate behaviours which were not observed during Metal days.

CONDITION indicates whether there was a non-random distribution of behaviour occurrences when the alarm was off and on. Blank spaces in this column denote behaviours for which this type of data was not collected, or behaviours that were too rare to assess for this condition.

Behaviour	**Days**	**Condition**	
		off	**on**
Breath	n	--	--
	n	--	--
% Synchronized Breaths	n	--	--
	n	--	--
Twist	n	n	--
	--	--	--
Tail-Down	n	n	n
	n	--	n
Tail-Up	n	Y	n
	n	n	--
Throwback	n	n	n
	--	--	--
Tail-Wag	--	--	--
	--	--	--
Side-Swim	--	--	--
	n	n	--
Jerk	n	--	--
	--	--	--
Arch	n	n	n
	--	--	--
Startle	n	--	n
		--	n
Roll	--	--	--
Penis Display	n		
Amount of Interaction	n	--	--
% Initiation of Interaction	n	--	--
	n	--	--
Length of Interaction Bouts	Y	--	--
% of Outside Circuits	--	--	--
	Y	--	--
Turn-Unders	--	--	--
	--	--	--
Contacts	--	--	--
	n	--	--
Food Consumed	n	--	--
	n	--	--

Table 10. Summary of behaviour statistics for Hydrophone (H) and Framework (F) days. The table indicates whether there was a non-random distribution of behaviour occurrences in the pool for each condition. Where results are paired, the top value is for the male and the bottom value is for the female. Y indicates significant results, n indicates non-significant results. Blank spaces denote behaviours for which this type of data was not collected, or behaviours which were too rare to assess for these conditions.

Behaviour	**H**	**F**
Breath	--	--
	--	--
% Synchronized Breaths	--	--
	--	--
Twist	n	n
	n	n
Tail-Down	n	n
	Y	n
Tail-Up	n	n
	n	Y
Throwback	n	n
	--	--
Tail-Wag	--	--
	n	--
Side-Swim	--	--
	n	Y
Jerk	--	--
	--	--
Arch	n	n
	--	--
Startle	--	n
		n
Roll	--	--
Penis Display	--	--
Amount of Interaction	--	--
% Initiation of Interaction	--	--
	--	--
Length of Interaction Bouts	--	--
Turn-Unders	--	--
	--	--
Contacts	--	--
	--	--
Food Consumed	--	--
	--	--

Appendices

Appendix A. Factors affecting entrapment, and proposed solutions.

This appendix discusses factors which are known or suspected to affect entrapment of cetaceans in fishing gear. Although each is presented separately for the sake of clarity, any entrapment situation is likely to be the result of a combination of many factors. Proposed solutions to the entrapment problem are also discussed.

Factors Affecting Entrapment

Species Distribution

The frequency with which a species is caught appears related to the abundance of that species in the fished area. Cetaceans such as the harbour porpoise which are generally found near shore may be particularly susceptible to entrapment, when compared with off-shore species, because inshore areas are often heavily fished. For example, shark nets in Natal which are employed to protect bathers from shark attacks catch approximately four percent of the nearshore populations of cetaceans such as bottlenose (*Tursiops truncatus*) and humpback dolphins (*Sousa plumbea*), while more pelagic species such as spinner dolphins (*Stenella longirostris*) are rarely taken (Cockcroft 1990).

Incidental entanglement of cetaceans can also be greater in those areas within a species' distribution where animals congregate (Piatt & Nettleship 1987), although in some cases the reverse is true. Dolphins are caught more regularly in Natal shark nets which are stationed outside of their "preferred" areas, possibly because the animals learn the positions of nets in places they frequent, and are therefore able to avoid these nets more easily (Cockcroft 1990). The tendency to learn locations of nets has also been postulated for humpback whales (*Megaptera novaeangliae*), which are more likely to collide with cod traps on the first day a trap is placed on its berth. (Lien 1980; Lien *et al.* 1990b).

Movement Patterns

Migration: Whether or not a particular species is present in a region throughout the year will affect how susceptible it is to net entrapment at different times: a relationship exists between peak rates of entanglement and migration of cetaceans, such as harbour and Dall's porpoise (*Phocoenoides dalli*) into a fished area (Gaskin 1984; Lear 1975; Ohsumi 1975).

Prey Abundance: Fluctuations in cetacean numbers can often be linked to changes in food abundance (Evans 1971; Kinne 1975; Norris 1967). In Newfoundland, inshore gillnet fisheries are common during the summer spawning period of capelin (*Mallotus villosus*). As predators follow the capelin inshore, they become more susceptible to capture in this gear; thus the mortality of some seabirds, seals, and cetaceans peaks when capelin are spawning (Lien *et al.* 1989; Piatt & Nettleship 1987). Similarly, it has been suggested that the large increase in humpback whales seen inshore around Newfoundland during 1977-78 was caused by a collapse in immature capelin stocks offshore that caused the whales to come inshore and feed on mature spawning capelin (Whitehead & Carscadden 1985; Whitehead & Lien 1982). In another example, bottlenose and humpback dolphins are killed throughout the year in Natal shark nets, while common dolphin (*Delphinus delphis*) captures are seasonal and probably related to the annual inshore migration of pilchard (*Sardinops ocellatus*), which are a major prey item in their diet (Cockcroft 1990). A slight increase in bottlenose dolphin captures in winter may also be related to a redistribution of prey species inshore (Cockcroft 1990). In fact, most bottlenose dolphins caught in the nets have full stomachs, indicating that they were feeding in the vicinity of the nets prior to capture (Cockcroft, in press).

Prey-related distribution patterns have also been proposed for other populations of bottlenose dolphins (Irvine *et al.* 1981; Shane *et al.* 1986), harbour porpoises (Smith *et al.* 1983) and common dolphins (Evans 1980).

The entrapment problem may be exacerbated by the fact that some prey species tend to congregate near nets, thus increasing the chance that a foraging predator will encounter a net (Cockcroft, in press; Lien 1989).

Daily Movements: Along with large seasonal variations, smaller day-to-day fluctuations in prey abundance and the daily movement patterns of cetaceans can also have an impact on the level of cetacean entrapment (Cockcroft & Peddemors 1990; Piatt & Nettleship 1987). Collisions of some cetaceans are more common at night (Lien *et al.* 1990b; Smith *et al.* 1983), and while this may be related to the diurnal migration of prey species, there is some evidence that cetaceans will approach nets more closely at night in the absence of prey (Hatakeyama & Ishii 1987). The reason for this is not understood.

Cetacean Behaviour

Group Segregation: Many cetaceans are known to form age and gender-related groups for at least some portion of the year (Johnson & Norris 1986; Kasuya & Jones 1984; Leatherwood & Reeves 1983; Michael *et al.* 1990; Shane 1990; Shane *et al.* 1986; for a summary see Evans 1987). The differing habits of these segregated groups can make them more or less susceptible to entrapment (Ferrero & Jones 1986; Pryor & Norris

1978; Wells *et al.* 1980). For example, while lactating bottlenose dolphins with their calves feed closer to the Natal shore than other groups and are thus predisposed to entrapment, the majority of humpback dolphins killed in nets are adolescents and large males, which suggests that lactating mothers of this species may not frequent near-shore areas (Cockcroft 1990).

Age Effects: A disproportionate number of calves or juveniles killed in nets has been reported for many cetacean species, including spinner, Risso's (*Grampus griseus*), and spotted dolphins (*Stenella attenuata*) (Alling 1987), harbour porpoises (Smith *et al.* 1983), Hector's dolphins (Dawson 1991a), Dall's porpoises (Ferrero & Jones 1986; Kasuya 1978), bottlenose dolphins (Cockcroft 1990; Wells & Scott 1990), fransiscana (*Pontoporia blainvillei*) (Pinedo 1990), and humpback whales (Lien 1980). In some instances, this phenomenon may result from a coincidence of calving periods with increased fishing effort (Alling 1987). Young odontocetes may also be predisposed to entrapment because they probably lack the full use of their echolocation abilities and can not detect nets as readily as adults (Awbrey *et al.* 1979; Cockcroft & Ross, in press; Dawson 1991a; Smith *et al.* 1983). Studies have shown that young bottlenose dolphins may not begin to echolocate until over a month and a half of age, and that this ability apparently progresses through several stages of development (Cockcroft & Ross 1990; Reiss 1988). Further, Evans and Awbrey (1988) found that young bottlenose dolphins have difficulty navigating when their vision is blocked. This may indicate that they rely more on vision than echolocation at a young age.

It is possible that young cetaceans may be more curious and more willing to engage in risky behaviour than adults, and this, in combination with the fact that young cetaceans have had less experience with nets, may also increase the probability that young cetaceans will become entangled in fishing gear (Cockcroft & Peddemors 1990).

Group Effects: Animals which forage in dense groups such as pilot whales (*Globicephala melas*) and common dolphins, as well as harp seals (*Pagophilus groenlandicus*) and many seabird species also make up a significant proportion of by-catch in some fisheries (Piatt & Nettleship 1987). The reasons for this phenomenon are not known, although it is possible that social interactions create distractions which contribute to entanglement. It has been further proposed that cetaceans within a group act as a single unit, thus increasing the chance that if one becomes entangled, others will as well (Johnson & Norris 1986). However, the effects of an entrapment or collision on group behaviour has not been investigated.

Species Differences: Reactions to stressful situations vary among cetaceans. For example, because *Stenella* species are relatively "nervous" in comparison with other dolphins, they may be more likely to panic around a net and become entangled (Pryor & Norris 1978). Similarly, humpback whales can often be released from nets unharmed since they usually remain quiet after an initial struggle, while minke whales (*Balaenoptera acutorostrata*) caught in nets usually become agitated, continue to struggle, and die (J. Lien, pers. comm.).

Sensory Capacities

Echolocation: Echolocation characteristics are known to vary among and within cetacean species, possibly as a function of the acoustical characteristics of their habitat and type of prey species, (Beamish & Mitchell 1971 & 1973; Evans 1973). This variation may help to explain why some species or populations within a species seem to be more susceptible to entrapment than others (Awbrey *et al.* 1979; Evans 1973; Moore 1988; Ohsumi 1975; Pilleri *et al.* 1981; also see Kamminga 1988).

It has been suggested that monofilament nets are acoustically undetectable to cetaceans (*e.g.* Awbrey *et al.* 1979; Gaskin 1984; Ohsumi 1975; Smith *et al.* 1983; Hembree & Harwood 1987; Pilleri 1971), There is, however, some evidence to the contrary. Dall's porpoise and bottlenose dolphins should theoretically be able to detect monofilament nets at distances great enough to avoid entanglement (Au 1990a & b; Au & Jones 1991; Hatakeyama & Ishii 1987; Takagi 1987). Other studies have indicated that captive harbour porpoises, bottlenose dolphins, Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), false killer whales (*Pseudorca crassidens*), and beluga (*Delphinapterus leucas*) can indeed detect net filaments, although detection ability may vary depending upon the distance, diameter and possibly colour of the filaments (Dubrovskiy *et al.* 1970; Hatakeyama 1986a; Hatakeyama *et al.* 1986; McBride 1956; Soeda *et al.* 1986). Further, free-ranging Dall's porpoises have been observed to avoid capture in nets easily, and to swim through holes in the net (Hatakeyama 1986a; Kasuya 1978). The behaviour of bottlenose dolphins around shark nets in Natal also suggests that they are aware of the nets (Cockcroft & Ross, in press).

Pence (1986) concluded, however, that although nets may be detectable in some instances, the strength of the signal is not very great and depends upon the angle at which the cetacean is approaching. Since nets are constantly in motion, their angle in relation to a cetacean's echolocation beam is also constantly changing, and this may cause their detectability to fluctuate. Since the acoustic reflection of a net is probably made up of many singular points of reflection, the situation may be analogous to "the appearance of sequins on a moving dress when a spotlight picks them out randomly as they move" (A.D. Goodson, pers. comm.).

Even if the mesh is hard to detect, other components of a net such as supporting ropes, buoys, and the knots between meshes should enhance the net's detectability to cetacean sonar (Pence 1986). In such cases, however, the framework presented by float and lead lines may actually be perceived as an open gap through which to swim (see, for example Perrin & Hunter 1972, also Prado & Smith 1990).

Most of the debates over the echolocation abilities of cetaceans have failed to take into account the possibility that cetaceans do not constantly use this sense. In schools of spinner dolphins, only one-third of the individuals are thought to echolocate at any one time during active periods, while during rest the entire school may rely more on vision than acoustics (K.S. Norris, pers. comm.). Hatakeyama (1986a) related accounts where the lead individuals of small Dall's porpoise groups avoided capture by diving below a net while the following individuals swam directly into it, suggesting that these animals were either not echolocating, or not paying attention. Norris (pers. comm.) suggested that since Dall's porpoises often swim in rough surface waters full of tiny bubbles which render the water acoustically opaque, they may often travel without the use of echolocation. Similarly, Hector's dolphins are known to navigate in familiar areas without acoustic aid, even when waters are turbid (Dawson 1991b). Bottlenose dolphins may be silent when travelling, or when passing by boats or "sensitive areas" such as river mouths (Dos Santos *et al.* 1990).

Some cetaceans may commonly forage by attending to naturally-produced noises rather than by scanning the surroundings with echolocation clicks; a system called "passive sonar" (Dawson 1988; Kinne 1975; Lien *et al.* 1990b; Wood & Evans 1980). For example, Diercks *et al.* (1971) discovered that a blindfolded bottlenose dolphin was able to follow and catch a live fish repeatedly without emitting any sounds. Since many fish produce underwater sounds, passive listening could be a viable way for a cetacean to hunt without giving away its own presence.

If cetaceans are perceiving their environment through the noises they hear, then the amount and type of noise that a net produces and the level of ambient noise will influence whether or not a cetacean can detect the net. The acoustical properties of nets can vary substantially depending upon differences in twine material, twine diameter, drag coefficient, mesh size, hanging ratio, rope diameter, biological fouling, and the presence of fish in the net (Lien *et al.* 1990b; Pence 1986; Prado & Smith 1990; Todd 1991). Capelin netting, which has a strong acoustic signal, entangles fewer humpback whales off the Newfoundland coast than other types of nets which are acoustically "quiet" (Lien *et al.* 1990b; Todd 1991). In contrast, monofilament gillnets probably do not produce much of a signal for cetaceans to detect because of their smooth fibers (Awbrey *et al.* 1979; Lien *et al.* 1990b), and this may be one reason why monofilament gillnets are recognized as one of the largest sources of incidental entanglements (Lien *et al.* 1989).

The level of ambient noise will be affected by wave action on coastal features, tidal flow action on the seabed, composition of the seabed, wind and rain, marine organisms, and human activity (Goodson 1990; Wenz 1962).

Vision: Although vision was once considered relatively unimportant, it is now known that cetaceans have visual abilities comparable to many terrestrial mammals (Fobes & Smock 1981; Herman 1990; Klinowska 1990a; Madsen & Herman 1980; Pryor 1990; Watkins & Wartzok 1985). Vision is known to be an important sensory modality for many cetaceans (Mobley, Jr. & Helweg 1990; Würsig *et al.* 1990). In fact, Norris (1969) found that when initially deprived of vision for the first time, captive common dolphins and a Pacific white-sided dolphin exhibited severe disorientation and swam into the walls of the tank.

Sight may be especially important for young animals whose echolocation abilities are still developing (Evans & Awbrey 1988). Only one study to date has looked at the ability of cetaceans to detect nets through vision alone, and it determined that a captive beluga was able to see monofilaments of 0.6mm diameter (Soeda *et al.* 1986). It has been speculated that, when closing in on a prey item, cetaceans may switch from echolocation to vision in the last meter or so (Pryor 1990).

The characteristics of nets listed above as potential factors affecting acoustic detection will also affect visual detection (Prado & Smith 1990). Under ideal conditions, cetaceans would probably not be able to detect netting by vision until closer than 20 meters (Goodson *et al.* 1990). Lien *et* *al.* (1990b), after investigating the visual properties of various types of gear in Newfoundland waters, concluded that humpback whales were probably not orientating visually. Visibility depended more upon water clarity than the properties of the objects, and was often very limited (Lien 1980).

Chemoreception: It is thought that mysticetes lack a sense of taste, although several species of odontocetes are known or presumed to have this sense (Fobes & Smock 1981; Friedl *et al.* 1990; Klinowska 1990a; Kuznetzov 1990; Watkins & Wartzok 1985). Chemoreception could be used to detect nets made from natural fibers which are treated with a variety of oils and tars to prevent them from rotting, since these substances probably leave distinctive chemical trails in the water (Klinowska & Goodson 1990). Although synthetic substances probably do not carry taste cues, all nets will produce chemical signals from the fish they have captured (Klinowska & Goodson 1990). Whether or not such signals act as repellents is not known, although if cetaceans feed on organisms trapped in, or congregated around, nets, these cues may actually act as attractants (Klinowska & Goodson 1990).

Many cetacean species have glands or pores which probably emit chemical signals to relay social information such as reproductive state (Klinowska 1990a). There is some anecdotal evidence that cetaceans produce an "alarm" chemical when stressed, which could serve to warn them about nets if other individuals have recently become entangled (Klinowska 1990a).

In any event, the use of chemoreception would depend upon maintaining chemical gradients in the water, which is only possible under certain environmental conditions such as a stable water mass with little mixing (Lien *et al.* 1990b)

Attention

Although the number of cetaceans killed in fishing gear is high, it is thought that they usually avoid entanglement (Awbrey *et al.* 1979; Hatakeyama 1986a). This suggests that entrapments may result more from failures to attend to the information that is available than from an inability to detect a net.

Selective attention may be defined as processing certain information rather than other information that is simultaneously being presented (Hirst

1986). Animals may attend to particular stimuli over others both because the ability to process information is limited, and through more "voluntary" control over their attentional capacity (Roitblat 1987, chapter 3).

It is possible that foraging cetaceans selectively attend to the signals produced by prey species, and do not process signals produced by non-prey items such as nets (Cockcroft & Peddemors 1990; Dudok van Heel 1962; Evans *et al.* 1988; Goodson 1990). Such selective attention to prey may be enhanced by the fact that the target strength of fish caught in a gillnet or congregating around a net is stronger than the target strength of the net itself (Au & Jones 1991; Lien *et al.* 1990b; Pence 1986; Read *et al.* 1990).

Lack of attention could be a factor in the disproportionate numbers of young animals caught, as it is likely that they would be less wary and more easily distracted than older, more experienced animals. Similarly, the observation that cetaceans which forage in large groups are more vulnerable to entrapment may indicate that social interactions within a group serve to divert attention from environmental signals.

Dolphins can selectively attend to relevant aspects of training procedures, even when distracting elements are introduced (Herman 1990). Further, it has been shown that the attention given to a task can vary according to the expected outcome. When a bottlenose dolphin, previously trained to differentiate between two targets, was given a similar yet unsolvable task, subsequent performance on the solvable task decreased (Schusterman *et al.* 1980). It was thought that the dolphin's expectations of failure diminished its attention to the previously learned task. Similarly, Au *et al.* (1982) and Au & Penner (1981) monitored echolocation emissions and found that during an unsolvable or difficult echolocation task dolphins did not echolocate on 14-41% of the trials, indicating that they were not paying attention during these trials.

Penner (1988) measured the distance at which a dolphin was actively scanning with its sonar by measuring the time between echolocation pulses, and found that when a target was consistently presented at a certain distance the dolphin would only attend to that distance, even on trials when no target was present. However, if the distance of the target was varied between trials the dolphin would scan the entire distance to search for objects. This indicates that the dolphin was selectively attending to particular distances depending upon where it expected the target to be. These results lend support to the theory that foraging dolphins "lock" their echolocation onto a target, thereby reducing the attention given to echoes from greater ranges and decreasing their ability to detect fishing gear (Goodson *et al.* 1990).

Unfortunately, studies which have found that cetaceans can detect nets have generally been performed in captive situations where attention to the net was required by the animal. Possible distractors such as stress, environmental fluctuations, and social interactions have not been systematically assessed for their impact on net detection.

Net Characteristics

Previously, it was discussed how various properties of nets can affect their detectability. Some characteristics, such as the mesh size and strength of a net, can result in selective capture of particular species or age classes of cetaceans. For example, Cockcroft (1990) indicated that the majority of bottlenose dolphin calves caught in shark nets had width and height dimensions equal to or greater than the maximum size of the net mesh, implying that younger dolphins are not caught because they are smaller than the mesh and can pass through. Further, the species of cetaceans caught by a particular type of net will depend partly upon the strength of the net, as some species will be strong enough to break free while others are not (Alling & Whitehead 1987). Drift nets are especially hazardous to cetaceans because of their great flexibility; a trapped animal will have greater difficulty breaking free because of the "give" in the net (J. Lien, pers. comm.).

The setting strategy of nets is another factor which can influence the numbers and species of cetaceans caught. Lowering a surface net by a few meters may result in fewer cetaceans being caught, possibly because a submerged floatline provides a strong acoustic target (A.D. Goodson, pers. comm.), or because the net is moved out of the path of surface-traveling animals, and an "escape path" over the top of the net is created (Prado & Smith 1990), although it may also reduce the directed catch (Hayase *et al.* 1990; Hembree & Harwood 1987; Kingsley 1982; Prado & Smith 1990). Further, some cetaceans may be more commonly caught in gillnets set in deeper waters (Jones 1984; Lindstedt 1990; Read & Gaskin 1988). It has also been suggested that nets which are set to drift may be more dangerous to cetaceans than those that are anchored (Lear 1975), possibly because the animals can not predict where drift nets will be; some cetaceans do appear to learn and avoid the locations of non-mobile nets and traps (Lien 1980).

Proposed Solutions

Several methods for reducing by catch have been attempted or proposed. While some seem promising, others have been criticized as being ineffective, unrealistic, or not cost-effective. Many studies suffer from a lack of baseline data, incomplete or nonexistent specifications of the nets used, low catch rates of cetaceans per unit fishing effort, or a lack of applicability to other areas or under different conditions (Dawson 1991b; Peddemors *et al.*, in press; Prado & Smith 1990).

Modify fishing gear

There are several types of gear modification which have been attempted or proposed, all of which fall into two general categories; modifications to enhance gear detectability, or modifications which will increase the chance that cetaceans will escape if they do become entangled.

Passive Reflectors: Passive reflectors are additions to gear, or modifications in the gear itself, which theoretically increase the gear's detectability to cetacean sonar (Goodson 1990). While certain studies have shown that captive dolphins are able to detect nets modified with passive reflectors more easily than unmodified nets (Hatakeyama 1986a; Hembree & Harwood 1987), and another study found that wild harbour porpoises were turned away by a curtain of metallic spheres or surgical tubing (Silber 1989), most passive devices that have been tested in the field have proven to be ineffective and/or unmanageable for various reasons (Todd & Nelson, in press).

Whether or not passive reflectors work depends upon whether cetaceans are actively using echolocation to detect nets. Because there is some evidence to the contrary, passive reflectors will probably not be effective under many circumstances.

Active Sound Generators: Sound generators are electrical or mechanical devices which produce noises in an attempt to frighten cetaceans away, or simply to mark the presence of a net. Dall's porpoises have shown avoidance behaviour at distances of up to 40 m in response to sounds of certain strengths and frequencies (Hatakeyama 1986a,1986b; Taketomi *et al.* 1985), yet most studies to date with sound generators have produced ambiguous or negative results (Todd & Nelson, in press).

Sound generators have been effectively employed in Newfoundland waters to decrease humpback collisions with cod traps (Lien *et al.* 1990b). Recent tests of sound generators indicate that they may reduce collisions by large cetaceans with codtraps by 50% or more (Lien *et al.* 1991a). Unfortunately, this work was done with relatively small numbers of stationary fishing gear. It is probably not economically feasible to attach many sound generators to kilometers of drift nets (Gaskin 1984). Furthermore, such devices must be specially designed to avoid requiring frequent recharging and maintenance, net entanglement, corrosion, and expense (Awbrey *et al.* 1979; Hatakeyama 1986b & 1987; Lien *et al.* 1990b).

Perhaps the most serious drawback to both active and passive devices is that they have no inherent biologically relevant meaning; cetaceans have to learn that the devices are associated with nets, as well as associating nets with danger. Data obtained for large cetaceans has shown that they will attend to novel sounds, such as those produced by an active sound generator, by orientation and approach (Todd *et al.* 1992). However, whether the whales can learn to associate such novel sounds with nets has not been demonstrated.

Other devices: The detectability of gear might be enhanced by making it more visually or chemically obvious. Lights which are presently used on some driftnets to attract fish have the potential to make cetaceans more aware of the gear, although how cetaceans react to lights is not known (Prado & Smith 1990). Some passive reflectors have the added potential of increasing the visibility of nets, although since fish also utilize sight, these may interfere with the directed catch of the fishery by allowing fish to avoid the nets as well (Klinowska & Goodson 1990). In any event, visual enhancements will not be effective in turbid conditions.

Water is an excellent medium for dissolving and carrying chemical substances, and odontocetes are known to have some taste sensation (Fobes & Smock 1981; Klinowska & Goodson 1990; Watkins & Wartzok 1985). Because of this, it may be feasible to develop "cetacean chasers" similar in theory to shark repellents, although these would be less likely to work in well-mixed waters (Lien *et al.* 1990b; Prado & Smith 1990)

Setting Strategies: Lowering a surface net by a few meters can result in fewer cetaceans being caught (Prado & Smith 1990), although it may also decrease the directed catch (Hayase *et al.* 1990; Hembree & Harwood 1987; Kingsley 1982; Prado & Smith 1990). However, lowering nets also has the potential to actually increasing fishing efficiency if the position of fish in the water layer can be determined and the nets set at this level (Prado & Smith 1990).

It has been suggested that cetaceans might use water currents, temperature gradients, bottom topography, or magnetic fields as orientation cues (Evans 1971; Kirschvink 1990; Kirschvink *et al.* 1986; Klinowska 1990a & b; Klinowska & Goodson 1990; Watkins & Wartzok 1985). If this is the case, then it might be possible to reduce entrapments by orienting gear parallel to, rather than across, such cues (Klinowska & Goodson 1990). This would not be feasible, however, if the target species of the fishery is orientating by the same cue as the cetacean (Klinowska & Goodson 1990).

Changes in mesh size: The probability of entanglement may be less for small mesh nets because the flippers and flukes of cetaceans are not able to pass through small meshes and become ensnared (Prado & Smith 1990). In addition, the detectability of small mesh nets is probably greater (Lien *et al.* 1990b). However, since the particular mesh size of a net is chosen to catch certain types of prey, changes in mesh size will influence not only the net's ability to entangle cetaceans, but also its effectiveness in securing the target catch (see, for example Peddemors *et al.*, in press).

Breakaway designs: Fishing gear could be designed so that it has a low breaking strength, allowing entangled cetaceans to break free (Lien *et al.* 1989; Prado & Smith 1990). Care would have to be taken, however, to insure that little or no directed catch can escape as well. Breakaway nets might also result in cetaceans carrying away parts of the gear, which could predispose them to further entanglement or continued debilitation (J. Lien, pers. comm.).

Removal of entangled cetaceans

If cetaceans can be removed from nets before they die, the impact of entanglement on cetacean populations could be substantially reduced. An entrapment assistance program for fishermen in Newfoundland and Labrador has been in operation since 1978 (Lien 1989; Lien *et al.* 1988 & 1990a). Fishermen report whale and shark entrapments by a widely advertised toll-free number, and an experienced team is sent out to help remove animals from the gear. Cetacean mortality and damage to fishing gear have been substantially reduced by these efforts.

Such a system would be less useful for smaller cetaceans which survive for only a few minutes after entanglement, whereas larger whales may survive entrapment for a period of months (Lien 1989). Fisheries which operate many kilometers of nets would have to employ small, high-speed boats to continuously monitor the nets, and even then it might be difficult to differentiate the movements of small cetaceans from those of entangled fish (Prado & Smith 1990). Prado and Smith (1990) indicate that a device is being developed in the U.S.A. which, when attached to the headline of a net, will sense the movements of cetaceans in the net and transmit this information to the vessel.

Regulations and Management

There are a variety possible management options for reducing the level of cetacean by-catch, such as quotas, time and arca restrictions, and gear restrictions or implementations.

Quotas: The use of quotas is thoroughly reviewed by Smolowitz and Goudey (1990); the information provided here is a summary of their work. Quotas impose an upper limit on by-catch for particular fisheries, which if exceeded, result in such penalties as fines, seizure of catch, or loss of licence. The by-catch limit can be set at zero to prevent any mortality, or a tolerable level can be set taking into account such factors as the size and value of the fishery, the status of the affected cetacean species, and the level of cetacean mortality from other sources. The limit can be set so that the fishery approaches it slowly over a period of several fishing seasons, to allow time for the development of alternative methods which do not threaten cetaceans.

Quotas can be either fishery-wide or directed at individual fishermen. The latter provides a stronger incentive for fishermen to develop by-catch solutions, because fishery-wide quotas require all participants in the fishery to cease operation when an industry quota is reached, regardless of how careful an individual was to prevent by-catch. Individual quotas could be the same for all vessels in a fishery, based upon each vessel's prior by-catch record, or they could be transferrable; fishermen could be allocated portions of the fishery's total quota which could be sold or bought among fishery participants according to need. Alternatively, quotas could be sold to each vessel as needed, or they could be auctioned to help pay regulatory costs.

Finally, it may be possible to utilize quotas for other species to reduce the levels of cetacean by-catch. For example, since both halibut and harbour porpoises are incidentally caught in come coastal gillnet fisheries, controls to limit the by-catch of halibut (and thereby protect the commercial halibut fishery) might also reduce the take of harbour porpoises (Coe 1990).

The disadvantage of any quota system is the fact that observers may have to be present on all boats to insure that the level of by-catch is not being underreported. This would be costly, and may not be feasible in some cases such as passive net and trap fisheries (Smolowitz & Goudey 1990).

Time and area restrictions: Limiting the time or place in which fishing activities can occur could be an effective measure for protecting cetaceans that occupy specific areas at specific times, such as migrating populations. Recent developments in satellite transmitter technology which allow the tracking of vessels far offshore make it feasible to apply restrictions even to large-scale fisheries (Coe 1990). However, difficulties arise if the target species of the fishery occupies an area at the same time as the cetaceans (see, for example Cockcroft *et al.* 1989 and Lien *et al.* 1990b).

Gear restrictions/implementations: If a certain type of fishing technology or gear is considered particularly harmful, the use of it could be banned (Dawson 1991b). Alternatively, the use of gear which reduces by-catch could be made mandatory. In its most extreme form, this would mean switching to an entirely different type of gear. For example, hook and line fisheries could be used to reduce shark numbers around Australian beaches rather than nets (Paterson 1979). There is a general trend in fishing gear design to develop more selective forms of gear as well as to utilize existing gear which is more efficient (Prado & Smith 1990). For example, Canadian fishermen in some areas are being subsidized to switch from gillnets to longlines in order to enhance selectivity and quality of groundfish catches, and this switch should be beneficial to cetaceans as well (Gaskin 1984).

Research and Education

The effectiveness of any measures taken to prevent entanglement will depend upon the amount of information available about both cetaceans and nets, as well as the support of the public and fishermen in particular.

Knowledge about cetaceans is limited in many respects, especially when considering incidental entrapments. Studies must be continued in captivity and with natural populations to determine what behaviours lead to entrapment, how cetaceans react to nets and whether those reactions can be modified, how entrapment actually occurs, why some species are more prone to entanglement than others, and what populations are becoming seriously depleted.

Further, more work must be done to understand the sensory cues provided by nets and how these change under varying environmental conditions.

In the event that some management options are put into force, it is essential that the fishing community be well-educated as to the nature of the problem and the purpose of the regulations. The handling procedures for any new types of gear must be thoroughly understood by those who will use it, otherwise it may be mishandled and damaged (Hatakeyama 1986b; Lien *et al.* 1990b). Any regulations which have, or are perceived as having, a negative impact on the economic productivity of the target fishery will probably result in fishermen seeking ways to avoid the regulations (Gaskin 1984; Smolowitz & Goudey 1990). Therefore, it is imperative that fishermen play an integral part in the designing of by-catch solutions; they must see themselves as initiators of the changes rather than merely receivers of mandates "from above". If they are provided with education about the entrapment problem and understand that their assistance in finding solutions is welcomed, if not essential, then some friction between fishermen and regulation authorities may be eased and more effort can be spent to develop feasible management options.

In addition to fishermen, many other organizations help to determine the acceptability of proposed regulations. These include fish processors, financial backers, cannery workers unions, conservation advocates, consumer advocates, regional fisheries organizations, federal and local agencies, recreational fishing organizations, fishery biologists, fishery managers, and fishery economists (Coe 1990). While it will not be possible to prevent conflict between so many groups with such a variety of interests, thorough education about the threat of incidental entrapment of marine mammals will at least insure that all groups are operating with the same information, and may reveal shared principles on which solutions can be developed.

Appendix B. Diagrams of movement patterns.

Each individual pool diagram represents the path traveled by one dolphin during a five-minute-interval from either the beginning, middle, or end of a filming day. In the majority of cases, (A), (C), and (E) refer to the male for the time periods beginning at approximately 1000, 1200, and 1500 hrs. respectively. Likewise, (B), (D), and (F) refer to the female for the same time periods. For some days, the time periods recorded are different from the majority. These are:

6 & 12 May: 0800, 1200, 1500 hrs.
31 May: 1130, 1300, 1500 hrs.
1 June: 0930, 1000, 1200 hrs.

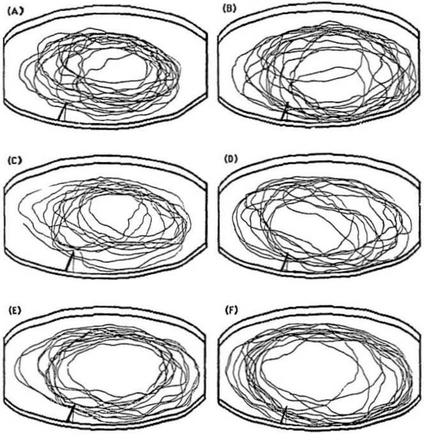


Figure B1. 6 May; hydrophone.

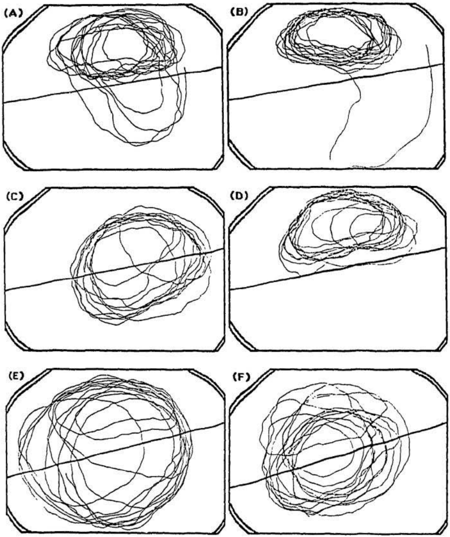


Figure B2. 12 May; rope, first day.

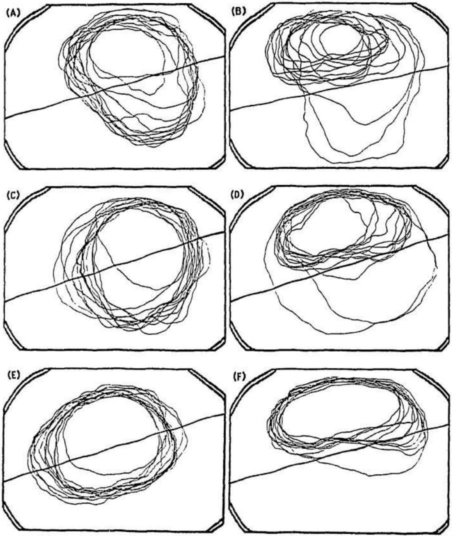


Figure B3. 13 May: rope, second day.

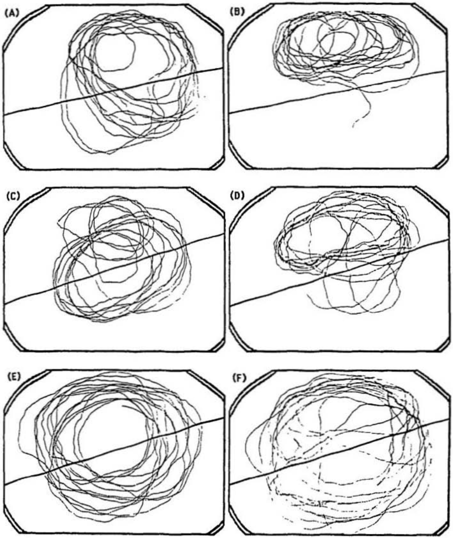


Figure B4. 14 May; rope, third day.

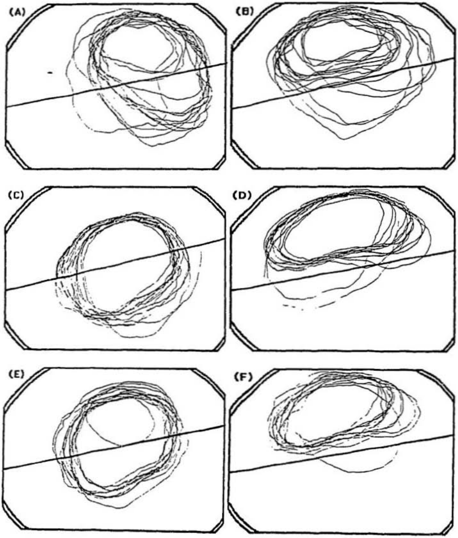


Figure B5. 15 May; rope, fourth day.

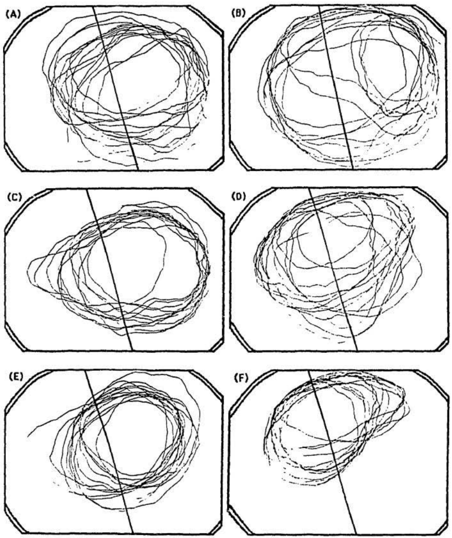


Figure B6. 16 May; rope, fifth day (position 2).

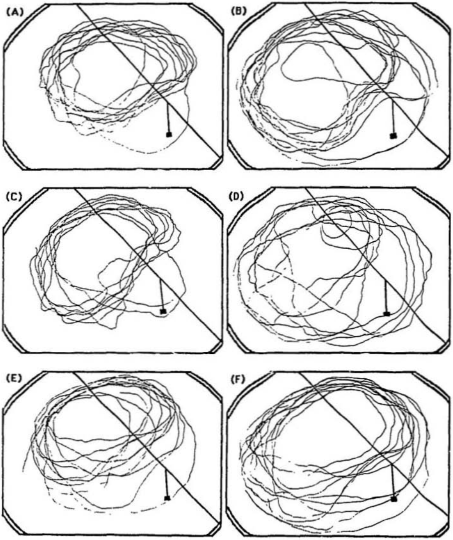


Figure B7. 18 May; framework.

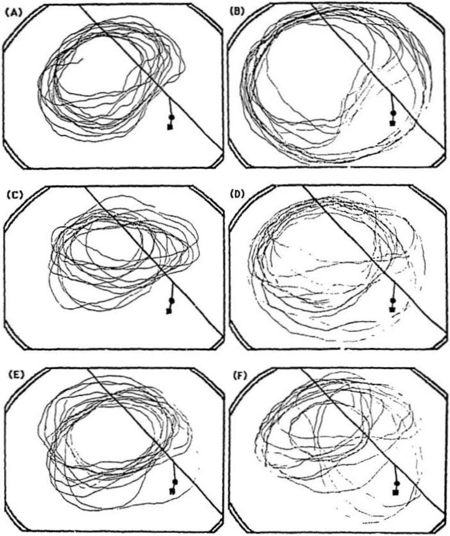


Figure B8. 19 May; yellow buoy, first day.

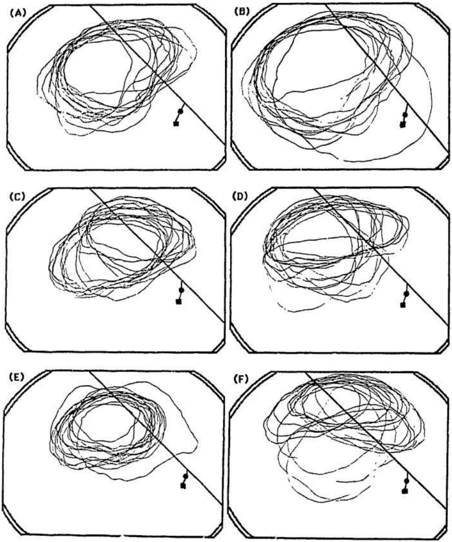


Figure B9. 20 May; yellow buoy, second day.

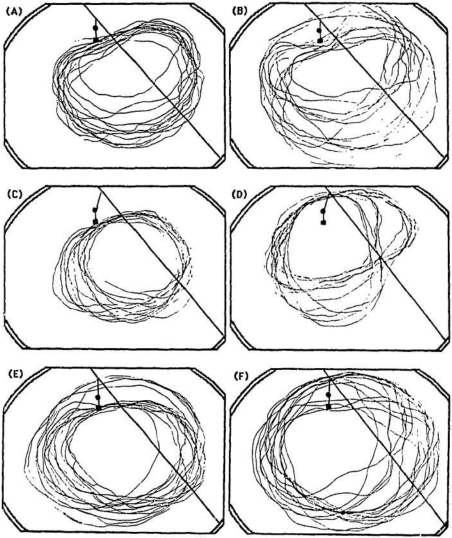


Figure B10. 21 May; yellow buoy, third day (position 2).

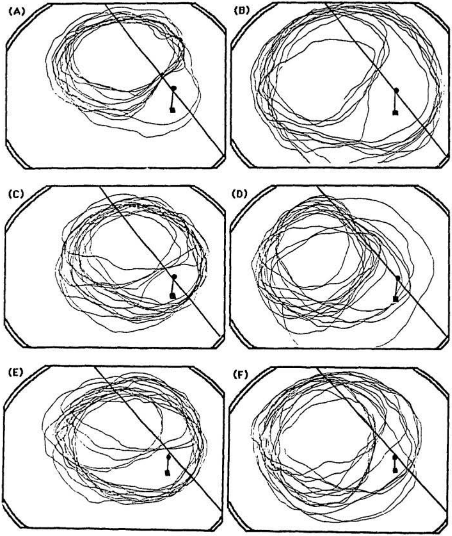


Figure B11. 23 May; red buoy, first day.

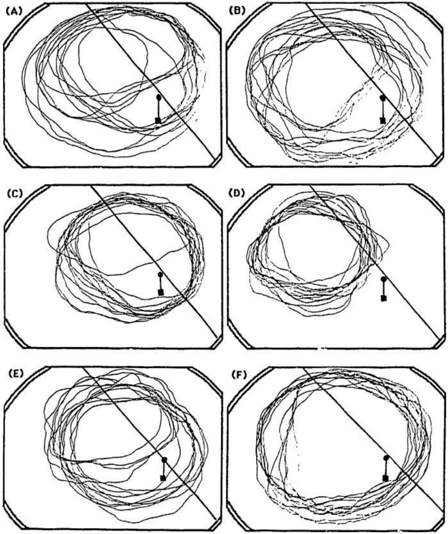


Figure B12. 25 May; red buoy, second day.

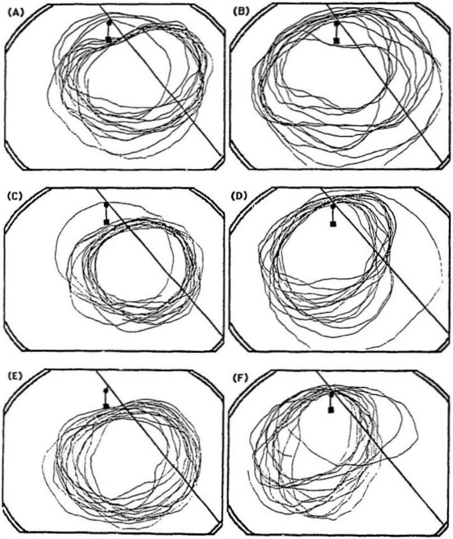


Figure B13. 26 May; red buoy, third day (position 2).

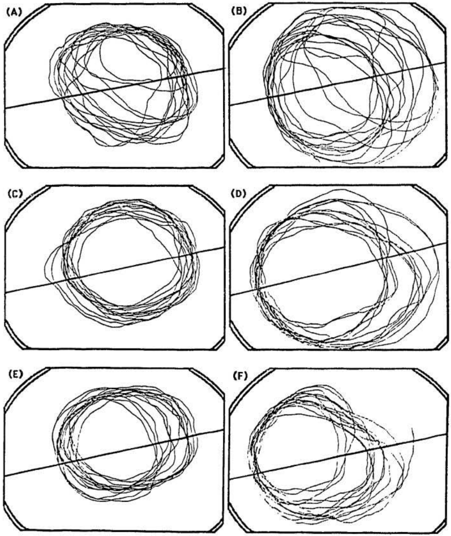


Figure B14. 28 May; rope, sixth day.

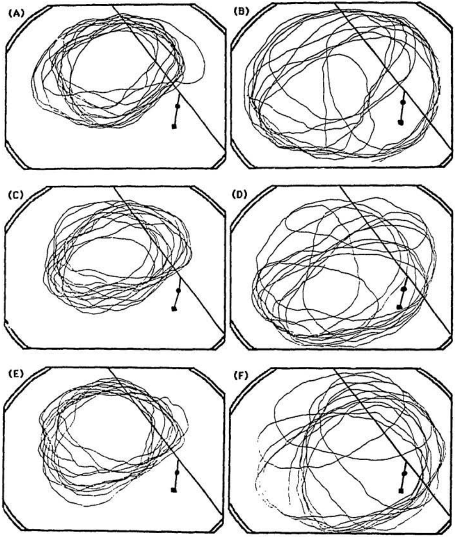


Figure B15. 31 May; metal buoy, first day (off).

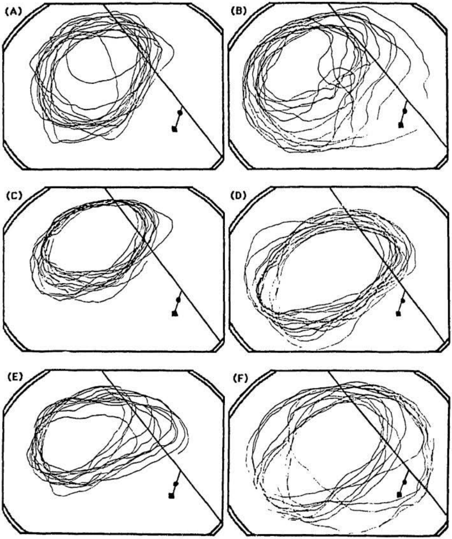


Figure B16. 1 June 1; metal buoy, second day (on).

Appendix C. Behavioural changes over the study period.

This appendix graphically summarizes the change in frequency of each behaviour over the entire study period. Black circles refer to the male while white circles refer to the female. Vertical, dashed lines indicate the first and last day of presentation of an object, as indicated by the letters at the top of the graph: H = hydrophone; R = rope; F = framework; Y = yellow buoy; Re = red buoy; M = metal buoy.

In the majority of cases, the graphs indicate the average number of occurrences of a behaviour per 15 min. for each day in the study. Exceptions are as follows:

Synchronized Breaths = average percentage of synchronized breaths per 15 min. for each study day.

Initiation of Interaction = average percentage of bouts initiated per dolphin per 15 min. for each study day.

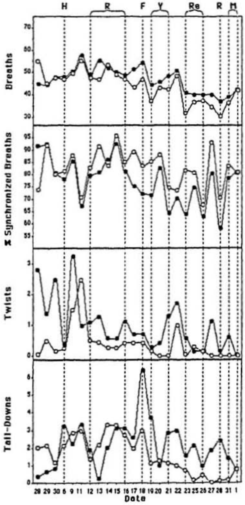
Amount of Interaction = average amount of interaction per 15 min. for each study day.

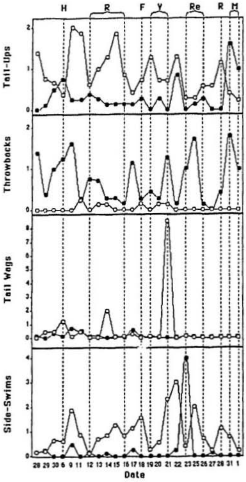
Length of Bouts = average bout length in seconds per 15 min. for each study day.

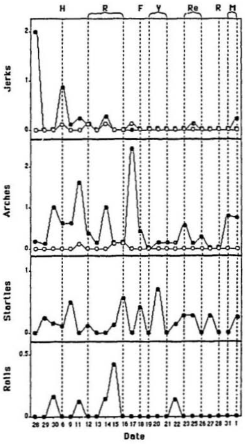
Food Consumed = total amount consumed for each study day.

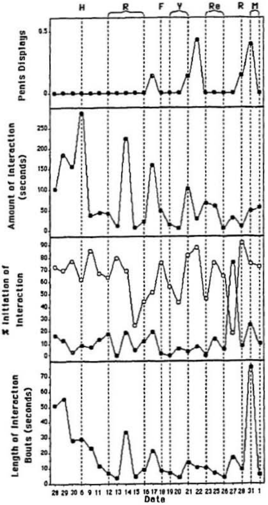
Contacts = total number of contacts for each study day.

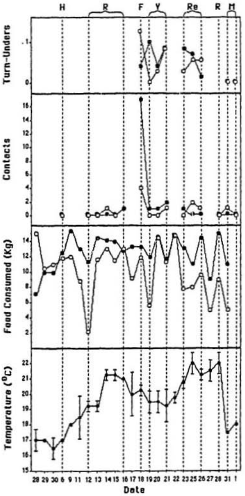
Temperature = average temperature (± 1 S.D.) of the pool water in °C for each study day.


H
R
F
Y
Re
R
M
Breaths
70
60
50
40
30
% Synchronized Breaths
95
90
85
80
75
70
65
60
55
Twists
3
2
1
0
Tail-Downs
6
5
4
3
2
1
0
28 29 30 6 9 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27 28 31 1
Date


H
R
F
Y
Re
R
M
Tail-Ups
2
1
0
Throwbacks
2
1
0
Tail Wags
8
7
6
5
4
3
2
1
0
Side-Swims
4
3
2
1
0
28 29 30 6 9 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27 28 31 1
Date


H
R
F
Y
Re
R
M
Jerks
2
1
0
Arches
2
1
0
Startles
1
0
Rolls
0.5
0
28 29 30 6 9 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27 28 31 1
Date


H
R
F
Y
Re
R
M
Penis Displays
0.5
0
Amount of Interaction (seconds)
250
200
150
100
50
0
% Initiation of Interaction
90
80
70
60
50
40
30
20
10
0
Length of Interaction Bouts (seconds)
70
60
50
40
30
20
10
0
28 29 30 6 9 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27 28 31 1
Date


H
R
F
Y
Re
R
M
Turn-Unders
.1
0
Contacts
16
14
12
10
8
6
4
2
0
Food Consumed (Kg)
14
12
10
8
6
4
2
Temperature (°C)
22
21
20
19
18
17
16
15
28 29 30 6 9 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27 28 31 1
Date

Appendix D. Statistical analyses

This appendix summarizes all One-Factor ANOVA and Sheffé's S tests performed on the data.

Table D1. Results for all One-Factor ANOVA and Sheffé's S tests conducted with Blank days as the predictor and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female.

Behaviour	**One-Factor ANOVA**	**Sheffé's S Test**	
Breath	F(7, 48) = 3.645, p = .0031	27 May < 11 May	p = .0164
	F(7, 48) = 4.385, p = .0008	27 May < 28 April	p = .0292
		27 May < 11 May	p = .0064
% Synchronized Breaths	F(7, 48) = 10.482, p = .0001	11 May < 28 April	p = .0008
		11 May < 29 April	p = .0001
		11 May < 9 May	p = .0063
		17 May < 29 April	p = .0218
		22 May < 28 April	p = .0062
		22 May < 29 April	p = .0005
	F(7, 48) = 9.143, p = .0001	11 May < 29 April	p = .0361
		11 May < 9 May	p = .0018
		11 May < 17 May	p = .0223
		11 May < 27 May	p = .0149
		22 May < 29 April	p = .0011
		22 May < 27 May	p = .0146
		27 May > 28 April	p = .0091
Twist	F(7, 48) = 1.628, p = .1503		
	F(7, 48) = 2.890, p = .0133	no significance	
Tail-Down	F(7, 48) = 1.974, p = .0784		
	F(7, 48) = 3.261, p = .0065	no significance	
Tail-Up	F(7, 48) = 1.562, p = .1697		
	F(7, 48) = 1.683, p = .1357		
Throwback	F(7, 48) = 3.867, p = .0021	no significance	
	F(7, 48) = 1.959, p = .0806		
Tail-Wag	F(7, 48) = 1.049, p = .4102		
	F(7, 48) = 1.339, p = .2528		
Side-Swim	F(7, 48) = .606, p = .7483		
	F(7, 48) = .2730, p = .0181	no significance	
Jerk	F(7, 48) = 1.446, p = .2095		
	F(7, 48) = 1.000, p = .4430		
Arch	F(7, 48) = 1.974, p = 0783		
	F(7, 48) = .840, p = .5602		
Startle	F(7, 48) = 1.269, p = .2856		
Roll	F(7, 48) = .734, p = .6459		
Penis Display	F(7, 48) = 3.048, p = .0098	no significance	
Amount of Interaction	F(7, 48) = 1.081, p = .3902		
% Initiation of Interaction	F(7, 48) = 1.316, p = .2634		
	F(7, 48) = 1.561, p = .1701		
Length of Interaction Bouts	F(7, 169) =3.833 , p = .0007	29 April > 11 May	p = .0369
Food Consumed	F(7, 8) = 1.51, p = .2872		
	F(7, 8) = 1.483, p = .2953		

Table D2. Results for all One-Factor ANOVA and Sheffé's S tests conducted with "condition" as the predictor (*eg.* blank, hydrophone, rope, framework, yellow, red, metal) and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female.

Behaviour	One-Factor ANOVA	Sheffé's S Test	
Breath	F(6,158) = 5.194, p = .0001	red < blank	p = .0154
		red < frame.	p = .0153
		red < rope	p = .0232
	F(6,158) = 6.656, p = .0001	red < blank	p = .0001
		red < rope	p = .0025
% Synchronized Breaths	F(6,158) = 3.816, p = .0014	red < blank	p = .0132
		red < rope	p = .0262
	F(6,158) = 1.174, p = .3230		
Twist	F(6,158) = 4.295, p = .0005	red < blank	p = .0194
	F(6,158) = 2.766, p = .0139	no significance	
Tail-Down	F(6,158) = 6.548, p = .0001	frame. > blank	p = .0001
		frame. > rope	p = .0003
		frame. > yellow	p = .0043
		frame. > red	p = .0001
		frame. > metal	p = .0003
	F(6,158) = 4.998, p = .0001	red < rope	p = .0146
		red < frame.	p = .0369
Tail-Up	F(6,158) = 6.859, p = .0001	metal > blank	p = .0003
		metal > rope	p = .0001
		metal > frame.	p = .0421
		metal > yellow	p = .0001
		metal > red	p = .0002
	F(6,158) = 2.393, p = .0306	no significance	
Throwback	F(6,158) = 1.749, p = .1129		
	F(6,158) = .813, p = .5611		
Tail-Wag	F(6,158) = 1.661, p = .1340		
	F(6,158) = 1.192, p = .3132		
Side-Swim	F(6,158) = 2.737, p = .0148	red > rope	p = .0475
	F(6,158) = .377, p = .8926		
Jerk	F(6,158) = 1.096, p = .3671		
	F(6,158) = .972, p = .4462		
Arch	F(6,158) = 1.407, p = .2152		
	F(6,158) = .513, p = .7975		
Startle	F(6,158) = .566, p = .7570		
Roll	F(6,158) = .733, p = .6234		
Penis Display	F(6,158) = 1.511, p = .1777		

(continued)

Table D2 (continued)

Amount of Interaction	F(6,158) = 4.015, p = .0009	hydro. > blank	p = .0313
		hydro. > rope	p = .0045
		hydro. > yellow	p = .0064
		hydro. > red	p = .0075
% Initiation of Interaction	F(6,108) = 1.450, p = .2024		
	F(6,108) = .269, p = .9504		
Length of Interaction Bouts	F(6,679) = 8.077, p = .0001	hydro. > rope	p = .0478
		hydro. > frame.	p = .0360
		hydro. > yellow	p = .0228
		hydro. > red	p = .0004
		red < blank	p = .0003
% of Outside Circuits	F(4, 25) = 7.592, p = .0004	red > hydro.	p = .0339
		red > yellow	p = .0042
		red > metal	p = .0045
	F(4, 25) = 2.403, p = .0766		
Turn-Unders	F(3,54) = 2.210, p = .0975		
	F(3,54) = 1.761, p = .1655		
Contacts	F(5,103) = 33.55, p = .0001	frame. > hydro.	p = .0001
		frame. > rope	p = .0001
		frame. > yellow	p = .0001
		frame. > red	p = .0001
		frame. > metal	p = .0001
	F(5,103) = 4.475, p = .0010	frame. > hydro.	p = .0222
		frame. > rope	p = .0020
		frame. > yellow	p = .0090
Food Consumed	F(6,16) = .587, p = .7361		
	F(6,16) = .566, p = .7513		

Table D3. Results for all One-Factor ANOVA and Sheffé's S tests conducted with Rope days as the predictor and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female.

Behaviour	**One-Factor ANOVA**	**Sheffé's S**	
Breath	F(5, 37) = 2.749, p = .0329	no significance	
	F(5, 37) = .832, p = .5355		
% Synchronized Breaths	F(5, 37) = 6.706, p = .0002	28 May < 12 May	p = .0145
		28 May < 13 May	p = .0027
		28 May < 14 May	p = .0018
		28 May < 15 May	p = .0063
		28 May < 16 May	p = .0222
	F(5, 37) = 14.088, p = .0001	28 May < 12 May	p = .0001
		28 May < 13 May	p = .0003
		28 May < 14 May	p = .0001
		28 May < 15 May	p = .0001
		28 May < 16 May	p = .0004
Twist	F(5, 37) = .753, p = .5894		
	F(5, 37) = .525, p = .7555		
Tail-Down	F(5, 37) = 2.566, p = .0433	no significance	
	F(5, 37) = 3.525, p = .0105	no significance	
Tail-Up	F(5, 37) = .802, p = .5556		
	F(5, 37) = 1.214, p = .3217		
Throwback	F(5, 37) = .877, p = .5060		
	F(5, 37) = .832, p = .5355		
Tail-Wag	F(5, 37) = .576, p = .7182		
	F(5, 37) = 1.648, p = .1716		
Side-Swim	F(5, 37) = .747, p = .5935		
	F(5, 37) = 1.623, p = .1781		
Jerk	F(5, 37) = .838, p = .5316		
	F(5, 37) = .747, p = .5935		
Arch	F(5, 37) = 2.749, p = .0329	no significance	
	F(5, 37) = .832, p = .5355		
Startle	F(5, 37) = 3.685, p = .0083	no significance	
Roll	F(5, 37) = 1.710, p = .1565		
Penis Display	F(5, 37) = 1.033, p = .4130		
Amount of Interaction	F(5, 37) = 4.676, p = .0021	14 May > 12 May	p = .0356
		14 May > 13 May	p = .0271
		14 May > 15 May	p = .0232
		14 May > 16 May	p = .0381
		14 May > 28 May	p = .0268

(continued)

Table D3 (continued)

% Initiation of Interaction	$F_{(5, 37)} = 1.091$, $p = .3815$		
	$F_{(5, 37)} = .996$, $p = .4333$		
Length of Interaction Bouts	$F_{(5, 147)} = 6.569$, $p = .0001$	14 May > 12 May	$p = .0003$
		14 May > 13 May	$p = .0058$
		14 May > 15 May	$p = .0453$
Under Rope Alone	$F_{(5, 37)} = 12.963$, $p = .0001$	16 May < 12 May	$p = .0484$
		16 May < 13 May	$p = .0001$
		16 May < 14 May	$p = .0321$
		16 May < 15 May	$p = .0031$
		28 May < 13 May	$p = .0001$
		28 May < 15 May	$p = .0054$
	$F_{(5, 37)} = 1.209$, $p = .3243$		
Under Rope Together	$F_{(5. 37)} = 13.401$, $p = .0001$	16 May > 12 May	$p = .0018$
		16 May > 13 May	$p = .0002$
		16 May > 15 May	$p = .0219$
		28 May > 12 May	$p = .0003$
		28 May > 13 May	$p = .0001$
		28 May > 14 May	$p = .0296$
		28 May > 15 May	$p = .0047$
Under Rope Total	$F_{(5, 37)} = 5.772$, $p = .0005$	12 May < 14 May	$p = .0459$
		12 May < 15 May	$p = .0369$
		12 May < 28 May	$p = .0012$
	$F_{(5, 37)} = 11.471$, $p = .0001$	16 May > 12 May	$p = .0052$
		16 May > 13 May	$p = .0005$
		16 May > 15 May	$p = .0392$
		28 May > 12 May	$p = .0013$
		28 May > 13 May	$p = .0001$
		28 May > 15 May	$p = .0117$
Contacts	$F_{(5, 37)} = 1.033$, $p = .4130$		
	$F_{(5, 37)} = 1.033$, $p = .4130$		
Food Consumed	$F_{(5, 6)} = .762$, $p = .6084$		
	$F_{(5, 6)} = 28.588$, $p = .0004$	12 May < 13 May	$p = .0026$
		12 May < 14 May	$p = .0012$
		12 May < 15 May	$p = .0026$
		12 May < 16 May	$p = .0012$
		12 May < 28 May	$p = .0131$

Table D4. Results for all One-Factor ANOVA and Sheffé's S tests conducted with Yellow days as the predictor and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female.

Behaviour	One-Factor ANOVA	Sheffé's S	
Breath	$F_{(2,18)} = 1.445$, $p = .2619$		
	$F_{(2,18)} = 2.467$, $p = .1130$		
% Synchronized Breaths	$F_{(2,18)} = 9.224$, $p = .0017$	20 May > 21 May	$p = .0018$
	$F_{(2,18)} = 3.054$, $p = .0721$		
Twist	$F_{(2,18)} = 2.932$, $p = .0790$		
	$F_{(2,18)} = 1.000$, $p = .3874$		
Tail-Down	$F_{(2,18)} = 4.468$, $p = .0266$	19 May > 20 May	$p = .0303$
	$F_{(2,18)} = .050$, $p = .9514$		
Tail-Up	$F_{(2,18)} = 1.000$, $p = .3874$		
	$F_{(2,18)} = 1.116$, $p = .3491$		
Throwback	$F_{(2,18)} = 3.486$, $p = .0525$		
	$F_{(2,18)} = .500$, $p = .6147$		
Tail-Wag	there were none		
	$F_{(2,18)} = 1.204$, $p = .3230$		
Side-Swim	there were none		
	$F_{(2,18)} = .758$, $p = .4831$		
Jerk	there were none		
	there were none		
Arch	$F_{(2,18)} = .500$, $p = .6147$		
	there were none		
Startle	$F_{(2,18)} = 3.947$, $p = .0379$	no significance	
Roll	there were none		
Penis Display	$F_{(2,18)} = 1.000$, $p = .3874$		
Amount of Interaction	$F_{(2,18)} = 5.312$, $p = .0154$	21 May > 19 May 21 May > 20 May	$p = .0457$ $p = .0304$
% Initiation of Interaction	$F_{(2,18)} = .538$, $p = .5928$		
	$F_{(2,18)} = 1.069$, $p = .3642$		
Length of Interaction Bouts	$F_{(2,72)} = 4.487$, $p = .0146$	21 May > 20 May	$p = .0477$
% of Outside Circuits	$F_{(2,6)} = .771$, $p = .5035$		
	$F_{(2,6)} = 4.678$, $p = .0597$		
Turn-Unders	$F_{(2,18)} = 2.210$, $p = .0975$		
	$F_{(2,18)} = 1.761$, $p = .1655$		
Contacts	$F_{(2,18)} = .273$, $p = .7644$		
	$F_{(2,18)} = 1.000$, $p = .3874$		
Food Consumed	$F_{(2,3)} = .636$, $p = .5886$		
	$F_{(2,3)} = 2.645$, $p = .2177$		

Table D5. Results for all One-Factor ANOVA and Sheffé's S tests conducted with Red days as the predictor and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female.

Behaviour	**One-Factor ANOVA**	**Sheffé's S**	
Breath	$F(2,18) = .014$, $p = .9863$		
	$F(2,18) = 3.327$, $p = .0590$		
% Synchronized Breaths	$F(2,18) = 2.985$, $p = .0759$		
	$F(2,18) = 4.582$, $p = .0246$	23 May > 26 May	$p = .0441$
Twist	$F(2,18) = 1.412$, $p = .2673$		
	$F(2,18) = 1.125$, $p = .3464$		
Tail-Down	$F(2,18) = 1.346$, $p = .2853$		
	$F(2,18) = 1.286$, $p = .3007$		
Tail-Up	$F(2,18) = 1.125$, $p = .3464$		
	$F(2,18) = .750$, $p = .4866$		
Throwback	$F(2,18) = 1.079$, $p = .3609$		
	there were none		
Tail-Wag	$F(2,18) = 1.000$, $p = .3874$		
	$F(2,18) = 1.000$, $p = .3874$		
Side-Swim	$F(2,18) = 3.574$, $p = .0493$	no significance	
	$F(2,18) = 2.835$, $p = .0851$		
Jerk	$F(2,18) = 1.000$, $p = .3874$		
	there were none		
Arch	$F(2,18) = 1.000$, $p = .3874$		
	there were none		
Startle	$F(2,18) = 1.200$, $p = .3242$		
Roll	there were none		
Penis Display	there were none		
Amount of Interaction	$F(2,18) = 1.373$, $p = .2787$		
% Initiation of Interaction	$F(2,18) = 1.882$, $p = .1811$		
	$F(2,18) = 2.176$, $p = .1424$		
Length of Interaction Bouts	$F(2,112) = 1.689$, $p = .1895$		
% of Outside Circuits	$F(2,6) = 7.009$, $p = .0269$	25 May > 26 May	$p = .0280$
	$F(2,6) = 2.139$, $p = .1989$		
Turn-Unders	$F(2,18) = 1.969$, $p = .1686$		
	$F(2,18) = .231$, $p = .7962$		
Contacts	$F(2,18) = 1.000$, $p = .3874$		
	$F(2,18) = .600$, $p = .5594$		
Food Consumed	$F(2,3) = .340$, $p = .7361$		
	$F(2,3) = .202$, $p = .8276$		

Table D6. Results for all One-Factor ANOVA tests conducted with Metal days as the predictor and the occurrence rate of behaviours per 15 min. as the dependent variable. All behaviours were tested separately. When results are paired for a behaviour, top values refer to the male and bottom values refer to the female. Significant results are bolded.

Behaviour	**One-Factor ANOVA**
Breath	F(1,7) = 5.343, p = .0541
	F(1,7) = 3.881, p = .0895
% Synchronized Breaths	F(1,7) = .109, p = .7509
	F(1,7) = .207, p = .6630
Twist	F(1,7) = .240, p = .6394
	there were none
Tail-Down	F(1,7) = .550, p = .4825
	F(1,7) = 3.036, p = .1250
Tail-Up	F(1,7) = .500, p = .5024
	F(1,7) = .179, p = .6845
Throwback	F(1,7) = 1.131, p = .3228
	there were none
Tail-Wag	there were none
	there were none
Side-Swim	there were none
	F(1,7) = .623, p = .4557
Jerk	F(1,7) = 1.296, p = .2924
	there were none
Arch	F(1,7) = .007, p = .9356
	there were none
Startle	F(1,7) = 1.296, p = .2924
Roll	there were none
Penis Display	F(1,7) = 2.074, p = .1930
Amount of Interaction	F(1,7) = .021, p = .8896
% Initiation of Interaction	F(1,7) = .002, p = .9649
	F(1,7) = 2.626, p = .1491
Length of Interaction Bouts	**F(1,49) = 35.033, p = .0001**
% of Outside Circuits	there were none
	F(1, 4) = 11.158, p = .0288
Turn-Unders	there were none
	there were none
Contacts	there were none
	F(1,7) = .778, p = .4071
Food Consumed	F(1,1) = .528, p = .6001
	F(1,1) = .994 p = .5009