CHAPTER 12

EVALUATING THE EFFECTS OF NATURE-BASED TOURISM ON CETACEANS

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INTRODUCTION

Public demand for close-up experiences with whales, dolphins and porpoises at sea is at an all time high. Commercial tourist ventures include opportunities for people to observe, swim with, touch, or feed wild cetaceans from shore, sea or air. In 1998, a total of 87 nations and territories offered commercial tourist activities that target wild cetaceans, with more than nine million people participating (Hoyt 2001). Current projections indicate a continued annual growth of well beyond 5% over the next several years (Hoyt 2001).

Is this good news for marine mammals in the wild? Wildlife tourism, including tourism that focuses on free-ranging cetaceans, is generally perceived to be inherently beneficial, and so tends to be considered 'ecotourism.' While cetacean-focused tourism and ecotourism are both subsets of nature-based tourism, they are not necessarily overlapping. Nature-based tourism encompasses a variety of ways for people to enjoy nature, whereas ecotourism additionally requires that there be contributions to the conservation of species or habitats (Goodwin 1996). Strictly defined, ecotourism is environmentally responsible travel that contributes to conservation of biodiversity, sustains the well being of local people, stresses local involvement, includes learning experiences for tourists, involves responsible action on the part of tourists and the tourism industry, and requires the lowest possible consumption of nonrenewable resources (e.g. UNEP 2002). With respect to cetacean-focused tourism, the advantages for the humans involved are clear. This form of tourism promises considerable economic rewards, as illustrated by recent global revenues in excess of one billion USD per year (Hoyt 2001). Other benefits include local employment opportunities (IFAW 1999) and logistical support for scientific research (Robbins and Mattila 2000). However, for all nature-based tourism, it is open for debate as to whether the effects on animals are negligible and whether tourists actually achieve heightened appreciation of the environment that is long lasting (e.g. Manfredo *et al.* 1995; Goodwin 1996; Ross and Wall 1999; Isaacs 2000). As noted by Berle (1990):

> 'Ecotourism is big business. It can provide foreign exchange and economic reward for the preservation of natural systems and wildlife. But ecotourism also threatens to destroy the resources on which it depends. …[S]hutterbugs harass wildlife in national parks, hordes of us trample fragile areas. This frenzied activity threatens the viability of natural systems. At times we seem to be loving nature to death.'

A one-time encounter with tourists is unlikely to cause major complications for wild cetaceans. However, the character of cetacean-focused tourism is such that specific communities of animals are repeatedly sought out for sometimes prolonged, close-up encounters. In addition, some tourists are increasingly dissatisfied with just observing wildlife – they crave interaction with wild animals. Thus, there is a potential for detrimental consequences for targeted animals, with effects that are cumulative rather than catastrophic (Duffus and Deardon 1990). For example, repeated disruption to breeding, social, feeding or resting behaviour can have deleterious effects on reproductive success, health, distribution and ranging patterns, or access to preferred habitat. Indeed, a few recent studies have demonstrated harmful outcomes for some subjects of tourism (e.g. Samuels and Bejder 1998, in press; Mann *et al.* 2000). These findings clearly place the human activities outside the bounds of ecotourism. Therefore, as tourists desire more frequent and more intimate encounters with wild cetaceans, there is a pressing need for research that will evaluate the effects of such activities on the animals.

Unfortunately, assessment techniques, as applied to understanding the effects of cetacean tourism on free-ranging cetaceans, are still relatively rudimentary. There are several explanations for the emergent nature of this aspect of cetacean behavioural biology. For wildlife in general, there are a number of obstacles to identifying the effects of human activity. Often, baseline data are unavailable, or unobtainable, precluding comparison of behaviour under experimental situations (the presence of tourists) with behaviour prior to commencement of human activity and/or under undisturbed conditions. In addition, spatial and temporal discontinuities between cause and effect may make it difficult to tease apart which observed changes are due to human activity, which are due to ecological factors, and which are due to natural variability. Given the complexity of interactions within ecosystems, difficulties arise in pinpointing those components that contribute to observed impacts (Vaske *et al.* 1995). In addition, factors such as species, age, gender, reproductive condition, and degree of habituation may influence, either singly or in combination, how individual animals respond to anthropogenic activity. Moreover, although the ultimate goal is to identify long-term responses that have biological significance for the animals, it is the short-term reactions that are more readily related to a potential source of impact (IFAW 1995). Whether, and in what ways, such short-term responses are linked to long-term consequences has rarely been documented.

Quantifying the effects of human activity for cetaceans is further confounded by methodological obstacles of trying to find, follow and observe the behaviour of mobile marine animals at sea. For example, it can be difficult to track continuously, and in detail, the movements and behaviour of cetaceans because they are out of sight underwater for prolonged periods of time, many species range over large areas, and some are found in groups numbering in the hundreds (Mann 1999). Furthermore, as a prerequisite for recognising 'disturbed' behaviour, a comprehensive catalogue of 'normal' behaviour is needed, something that is lacking for nearly all species of cetaceans. Finally, it is relatively recently, in comparison with studies of the behaviour of terrestrial animals, that hypothesis testing and quantitative behavioural sampling techniques have been widely applied to studies of cetacean behaviour (reviewed in Samuels and Tyack 2000). As a result, many who attempt to study impacts of human activity on cetaceans are:

> '… dissatisfied with research into whale [and dolphin] disturbance, both in terms of the overall methodological aspects and the product of the research. Simply stated, the researchers have not obtained answers that satisfy themselves or managers. Difficulties with this kind of research are manifold. Researchers regularly fend off issues of scale, both in time and space, problems in research design, a lack of baseline data for comparative analysis, natural levels of variation…' (IFAW 1995:14).

Dissatisfaction notwithstanding, a considerable body of research does exist and this serves as the foundation for present-day management of cetacean-focused tourism. In some locations, management takes the form of legislated, enforced regulations; elsewhere, voluntary guidelines or codes of conduct have been set up (reviewed in Carlson 1998). For example, the finding that Hector's dolphins (*Cephalorhynchus hectori*) in Porpoise Bay, New Zealand, avoided tour vessels after lengthy encounters (Bejder *et al.* 1999) resulted in proposed permit conditions to restrict encounter durations and the number of tour operators (H. Kettles personal communication 2001). In another example, voluntary guidelines were instituted by tour operators to protect resting dusky dolphins (*Lagenorhynchus obscurus*) near Kaikoura, New Zealand (Yin 1999), following the finding that dolphins were disturbed by tourist activities during their normal rest period (Barr and Slooten 1998).

More often than not, however, regulations and guidelines have been based on evidence that is anecdotal, scientific but insufficient, or entirely lacking. In addition, management policies are typically not specific to species, gender, age class, habitat, behaviour, or group composition of the targeted animals (but see Constantine (1999) regarding New Zealand's Marine Mammals Protection Act of 1978 prohibiting swimming with cetacean calves or any whale species). Many of these attributes have been shown to influence cetacean responsiveness to human activity and vessels (Watkins 1986; Richardson *et al.* 1995; Constantine 2001, Nowacek *et al.* 2001a). Shortcomings like these led to the conclusion that '… intense popular demand for swim-with activities [and other cetacean-focused tourist ventures] is pushing the growth of the industry beyond the limits of what current data can justify' (Chapter 14, this volume). In particular, many researchers have noted that the interpretation of findings is often limited by methodology (Constantine and Baker 1997; Barr and Slooten 1998; Yin 1999). While certain factors that confound identification of anthropogenic impacts cannot be eliminated, others may be reduced through studies that are rigorously and meticulously planned. In particular, by building upon the extensive foundation of existing research, research designs can be refined to carry out more in-depth, comprehensive and longitudinal studies. In this way, there will be improved likelihood that any effects of nature-based tourism on marine animals can be detected, identified and quantified in a timely fashion.

Now is an opportune time to take this step because a number of biologists are already moving in this direction. To promote this trend, in this chapter, we present a collection of such studies and discuss their methodological merits, as a guide for those who wish to embark on research pertaining to cetacean-focused tourism. It is important to clarify at the onset what the boundaries of this chapter are. Specifically, this is not intended as a comprehensive review of the literature pertaining to studies of the impacts of cetacean-focused tourism, nor is it meant as a critique of such research. The chapter is not intended as an inventory of research methods for cetacean studies (Whitehead *et al.* 2000), nor is it a primer for behavioural sampling techniques (Altmann 1974; Martin and Bateson 1986; Mann 1999). Instead, our goal is to promote careful research designs for investigating effects of human activity (tourism and otherwise) on the behaviour of free-ranging cetaceans. Thus, our focus is on well-designed studies, and for each case study we present, we emphasise the particular methodological significance. These examples can be used as templates or starting points for planning research to evaluate potential effects of cetacean-focused tourism in the wild.

In compiling this collection, we endeavoured to select studies that are specific to cetacean-focused tourism and published in accessible peer-reviewed scientific journals. We departed from these selection criteria only when we were unable to locate appropriate examples of particular methodological attributes from those sources. In such cases, we have included some examples from the grey literature (several of which are peer-reviewed) and/or from the literature pertaining to anthropogenic effects on cetaceans from sources unrelated to tourism.

The studies we selected illustrate key components in the planning and execution of effective research. In the body of the chapter, we present analyses of research techniques used in the case studies, organised by methodological features. We present and discuss strong attributes of key studies with respect to the selection of study design, analytical design, study subjects, research platforms, and response measures (Table 1). In an appendix, we also provide abstracts for each case study, composed by us (not the original authors) with the specific objective of elaborating on the methods used (Appendix 1).

By selecting studies that use rigorous methodologies, we hope to influence the quality of research dedicated to this aspect of cetacean biology, and thereby, to minimise effects of tourism on the behaviour of free-ranging cetaceans by promoting management that is informed by sound scientific evidence.

STUDY DESIGN

In impact assessment studies, it is important to select a study design that is appropriate for the research question, situation, and platform. Richter *et al.* (2000) provide a review of study designs used in assessing the short-term effects of boats on cetaceans. Under certain conditions, it is possible to design 'controlled experiments' that 'minimize the number of plausible alternative hypotheses that are consistent with the data' (Altmann 1974). Controlled experiments require a certain amount of background knowledge regarding the study animals, study site and potential response(s). When *a priori* knowledge requirements are met, this approach allows for data collection on the same animals under both control and experimental exposures while minimising confounding influences of environmental variables, facilitating the interpretation of results. More often, however, the special conditions needed for experimental design cannot be met, and then 'opportunistic observations' are used. This approach is logistically easier and requires less prior knowledge about dependent and independent variables, attributes that make opportunistic observations especially suitable for pilot studies (Richter *et al.* 2000). A major drawback however of opportunistic observations is the potential for violating the fundamental assumption that nothing other than the factor of interest changes between control and experimental conditions. Large sample sizes are therefore needed to identify which variable is responsible for observed effects. In contrast, the experimental approach is a more efficient way to obtain adequate sample size because confounding influences are reduced.

Because cetaceans are long-lived and there are limits to research time and funding, studies that are explicitly designed to monitor long-term effects are rare. One method used to circumvent the obstacles to longitudinal data collection is the compilation and analysis of existing 'historical data' collected over the long-term in the course of studies conducted for other purposes. In some instances, researchers have designed follow-up studies in which data are collected explicitly for comparison with historical records. Only rarely are adequate historical records available from the time prior to the advent of the human activity under study, and rarer still that changes in cetacean behaviour or ranging patterns can be directly attributed to increases in activity. This underscores the importance of collecting pre-tourism data to provide a foundation for 'before and after' comparisons.

Table 1 Key components in the planning and execution of effective research to assess effects of human activity on wild cetaceans.

Study design	
1	Controlled experiments
2	Opportunistic observations
3	Historical data
Analytical design	
1	Within effect comparison
2	Control vs. impact comparison
3	Before/ during/ after comparison
Study subjects	
1	Focus on the individual
2	Focus on the group
Research platforms	
1	Land-based
2	Commercial tour vessel
3	Independent vessel
4	Underwater
4a	Visual observations
4b	Acoustic recordings
5.	Aerial
Measuring responses	
1	Short-term measures
1a	Non-vocal behaviour
i	Surface, ventilation and dive patterns
ii	Swim speed, course and orientation
iii	Group dispersion/ cohesion
iv	Behavioural states/ activity budgets
v	Behavioural events
vi	Ranging patterns and habitat use
1b	Vocal behaviour
2	Long-term measures
2a	Habituation and sensitisation
2b	Ranging patterns and habitat utilisation
2c	Reproductive success
3	Stress and distress

1. Controlled experiments

Ideally, in controlled experiments, each individual animal (or group) provides its own control (i.e. each subject is observed under control and experimental situations). Miller *et al.* (2000) used systematic behavioural sampling techniques and a towed calibrated hydrophone array to monitor vocal and non-vocal behaviour of individual singing humpback whales (*Megaptera novaeangliae*) before, during and after exposure to controlled playbacks of low-frequency active sonar. This experimental design was essential to demonstrating variation in responses among individual humpback whales to man-made sounds broadcast underwater. This study also showed that it is possible to measure vocal responses of individual whales in controlled experiments at sea.

In another example, systematic behavioural sampling techniques and overhead video were used to monitor the behaviour of individual bottlenose dolphins (*Tursiops truncatus*) during controlled approaches of small vessels and thrill craft (Nowacek *et al.* 2001a). In these experiments, vessel type, speed and angle of approach were controlled in order to assess changes in the focal dolphin's travel speed, heading, respiration pattern, and distance to the nearest neighbour. By providing continuous records of both sub-surface and surface behaviour, and comparing the same animals under control and experimental conditions, this design was effective in quantifying several measures of avoidance and in identifying a class of particularly vulnerable animals.

In some experiments, control subjects are members of the same population as the animals observed under experimental conditions. For example, Goodson and Mayo (1995) recorded dolphin movement patterns and acoustic behaviour while controlling, over periods of days, the presence and absence of simulated gillnets with acoustic deflectors attached. This design showed the range at which dolphins detected the 'nets' and modified their paths to avoid collisions. Similarly, porpoise movements near simulated gillnets were recorded while controlling, over periods of days, the presence and absence of acoustic alarm devices (Culik *et al.* 2001). This design was used to show that the avoidance distance during pinger operation corresponded to the audible range of the acoustic alarm.

2. Opportunistic observations

Theodolite tracking was used to quantify movement patterns of groups of Hector's dolphins within a bay during opportunistic encounters with commercial dolphin watch vessels (Bejder *et al.* 1999). This method was effective in demonstrating increased group cohesion when vessels were present, and an initial attraction to vessels followed by avoidance when vessel exposure was prolonged. In a second example, Nowacek *et al.* (2001a) complemented the controlled experiments described above with systematic observations of the surface behaviour of individual dolphins during opportunistic approaches of passing vessels. These opportunistic observations provided the majority of data used to analyse changes in respiration rate in response to boat approaches. In addition, Richter *et al.* (2001) combined land-based theodolite tracking and boat-based acoustic recordings to document changes in sperm whale (*Physeter macrocephalus*) vocal and non-vocal behaviour during opportunistic encounters with whale watch vessels. Their study design demonstrated individual variation in behaviour of sperm whales and that resident whales off Kaikoura, New Zealand, may be more tolerant to vessels than transient whales.

There are many other examples. In fact, the majority of impact assessment studies come under the category of opportunistic observations (reviewed in Richter *et al.* 2000).

3. Historical data

Watkins (1986) reviewed historical, anecdotal records to assess changes in whale responses to vessels over a 25-year period. Because this time period encompassed the absence, initiation and growth of commercial whale-watch activities, this method was useful in revealing changes in whale behaviour associated with tourism that were gradual, both positive and negative, and species-specific. Laist *et al.* (2001) also used historical records and stranding databases to investigate collisions between ships and whales. Analysis of historical records revealed that fatal ship strikes were first documented in the 1800s when ships attained speeds of 13–15 kn, and the frequency increased during the 1950s–1970s as the number and speed of ships increased. Analysis of stranding records led to the recommendation that reducing ship speed to less than 14 kn in critical areas may be effective in minimising fatal collisions.

Analyses of long-term databases and comprehensive literature reviews might also be included in this category. For example, Mann *et al.* (2000) analysed data collected over a 10-year period to compare the reproductive success of food provisioned versus wild feeding bottlenose dolphins. In their study, use of long-term data revealed detrimental consequences of food provisioning on a small sample of individual animals. In another example, Richter *et al.* (2000) looked at a selection of studies that evaluated effects of vessels on cetaceans, focusing on choice of research platform, analytical design and statistical methods. In addition, Samuels *et al.* (2000) conducted a detailed review of the literature pertaining to swimming with wild cetaceans, the findings of which have been used to inform US policy (updated and summarised in Chapter 14, this volume).

ANALYTICAL DESIGN

The study designs described above are further partitioned into 'analytical designs' (Richter *et al.* 2000), including several designs typical in vessel-effect assessment studies, including 'control/impact' and 'before/during/after' (BDA) comparisons. Below, we expand on these categories and also consider the value of studies in which there are no control data.

1. Within effect comparison

In many studies, researchers look at cetacean behaviour only in the presence of a potential effect, then make a judgement as to whether observed behaviours constitute 'positive' or 'negative' responses. Interpreting the findings of such studies can be problematic when there are no adequate baseline ('undisturbed') behavioural data for comparison, which is unfortunately true for many aspects of cetacean behavioural biology. However, in many situations, this design is used of necessity due to an inability to obtain data on 'undisturbed' animals, for example, in locations where the level of human activity is very high (e.g. dusky dolphins and dolphin tour boats in Kaikoura, NZ (Barr and Slooten 1998)) or in cases where the research platform itself is potentially disturbing (e.g. observations of dolphin behaviour conducted from dolphin watch vessels (Constantine 2001)).

The 'impact only' design has been used effectively to look at changes in behavioural response over the course of encounters or over the long term, and to compare responses under gradations of the effect. As an example, in opportunistic observations of swim-with-dolphin attempts from the vantage of commercial tour vessels, Constantine (2001) (Constantine and Baker 1997) used a scan sampling technique to systematically record dolphin behaviour at specified time intervals within a specified distance, thus providing a record of changes in dolphin behaviour over the course of encounters. These data were later translated into categories to indicate the 'success' of an encounter, 'interaction' (at least one dolphin within 5 m of at least one swimmer for at least 15 s); 'neutral' (no apparent change in dolphin behaviour); and 'avoidance' (dolphins changed direction of travel and/or moved away from swimmers). This design was also used to compare dolphin responses to gradations of swim-with attempts, i.e. swimmer placement strategies such as 'in path', 'line abreast', and 'around boat'(Constantine and Baker 1997; Constantine 2001). Finally, Constantine (2001) used this design to compare dolphin responses to swim-with attempts over a several-year period, providing evidence that avoidance to swimmers increased over the long term.

Bejder *et al.* (1999) also used this design to evaluate dolphin behaviour over the course of encounters, demonstrating that dolphins were initially attracted to a tour vessel, but subsequently avoided the vessel when encounters lasted >70 min. Allen and Read (2000) provide another example in which this design was used to evaluate dolphin behaviour under gradations of effect, in the form of temporal and spatial differences in vessel traffic density. In addition, Lesage *et al.* (1999) compared beluga (*Delphinapterus leucas*) vocal behaviour under two treatments; a small motorboat moving rapidly and erratically and a large ferry moving slowly and predictably.

2. Control versus impact comparison

In the simplest of experiments, the goal is to vary one condition (independent variable) in order to measure the effects on outcome measure(s) (dependent variable) (e.g. Martin and Bateson 1986). One way to accomplish this is to compare a treatment group with a control group, members of control and treatment groups presumably being similar in all respects except the experimental treatment. For example, by conducting focal follows of dolphins in the same region that do and do not tolerate human swimmers nearby, Samuels and Bejder (1998, in press) were able to demonstrate dramatic differences in the behaviour of habituated versus unhabituated dolphins. In another example, Mann *et al.* (2000) compared long-term reproductive records for food provisioned versus wild-feeding dolphins within the same population, thus demonstrating lower survivorship of calves of provisioned females.

In order to minimise effects of individual variation, the same animals can be observed under both experimental and control conditions, thus serving as their own controls. Williams *et al.* (2002) conducted controlled experiments in which the movements of individual killer whales (*Orcinus orca*) were tracked by theodolite, first under control conditions (no boats present), followed by experimental vessel approaches. Similarly, Nowacek *et al.* (2001a) recorded respiration patterns of individual dolphins during boat-based focal follows and compared inter-breath intervals during conditions of control (no boats present) versus treatment (closest approach of vessel).

A variation of this design consists of looking at the behaviour of the same animals in the presence and absence of a potential effect situation. By recording the vocal behaviour of individual sperm whales in the presence and absence of whale-watch vessels, Richter *et al.* (2001) demonstrated that transient whales showed an increase in time elapsed from fluke-out to first click when whale-watch vessels were nearby. In contrast, the presence of whale-watch vessels did not appear to affect vocal behaviour of resident whales. In addition, Mann and Smuts (1999) conducted focal follows of food provisioned dolphin mothers and calves, within and away from the provisioning area. To evaluate effects of human activity on maternal behaviour, the behaviour of provisioned dolphins within the provisioning area was compared to the behaviour of provisioned and wild-feeding dolphins away from the provisioning area.

Janik and Thompson (1996) used both variations of this design to look at changes in dolphin surfacing patterns in response to boat traffic. By comparing the total number of dolphin surfacings during the minute preceding and following a vessel approach, they used the dolphin group as its own control, and showed that the number of surfacings significantly declined following the approach of the dolphin watch vessel. No such pattern was apparent in a second set of control data comprised of randomly-selected two-minute periods when no boats were present.

3. Before/during/after comparison

The BDA design (also known as 'pre-exposure', 'exposure' and 'post-exposure') is most commonly used in experimental studies. Pre- and post-exposure conditions are sometimes both considered controls; however, residual effects of the treatment may be apparent in the post-exposure period. In one example, individual humpback whales were used as their own controls by recording songs of individual whales during focal follows and comparing song duration before, during and after experimental playbacks of low-frequency active (LFA) sonar Miller *et al.* (2000). They found that whales sang significantly longer songs during exposure to LFA sonar. A BDA design was also used to demonstrate changes in the vocal behaviour of groups of beluga whales over the course of controlled vessel approaches (Lesage *et al.* 1999). Culik *et al.* (2001) used a variation of the BDA design in which conditions changed over successive days. They compared porpoise responses to: (1) an artificial non-lethal gillnet with no acoustic pinger (five days), (2) the same net with a continuously operating pinger (five days), and (3) the same net after removal of the pinger (two days). This design was essential to show that it was the pinger not the net that porpoises were avoiding.

The BDA design is comparable to a category of experimental designs referred to as 'BACI' (Before-After-Control-Impact) designs in that they both monitor impact variables over time in response to stimuli. However, in contrast to BDA studies, BACI experiments monitor variables over time at both control and impact *sites* (Stewart-Oaten *et al.* 1986; Underwood 1991, 1992, 1993, 1994), whereas BDA experiments typically monitor variables over time *within* the same site.

Study subjects

For cetaceans, the level at which an effect can be assessed is largely determined by characteristics of the species of interest, the research question, and the research platform. With respect to behavioural sampling, researchers typically select among such levels of focus as long-term cohesive group, ephemeral group, or individual, using measures based on these samples to extrapolate to community- or population-level effects. In studies of the behaviour of terrestrial animals, the individual has long been regarded as the appropriate unit of sampling, both from theoretical and methodological viewpoints (e.g. Williams 1966; Altmann 1974). It is the case in cetacean research, however, that for some species and circumstances, there are significant logistic obstacles to following and observing the behaviour of a single animal, for example wide-ranging species in which individuals cannot be readily identified, group size is typically large, and/or dive times are long (e.g. Mann 1999). Nevertheless, even when conditions indicate that an individual focus is appropriate and feasible, and conversely, that a group-level focus would introduce significant bias, studies of cetaceans seldom emphasise the behaviour of individual whales and dolphins (e.g. Mann 1999). This preference for group-level analyses has historical origins (reviewed in Samuels and Tyack 2000), but fortunately recent efforts are advancing the field towards approaches that are more objective, quantitative and precise. Several references provide guidance as to the suitability of an individual- versus group-level focus in cetacean behavioural research (e.g. Altmann 1974; Mann 1999).

On occasion, the source rather than the recipient of potential disturbance may be selected as the focus of an impact assessment. For example, due to logistical constraints on observing individual dolphins from land, Colborn (1999) selected human swimmers and tour vessels as the focal subjects in a study of dolphin-focused tourism in Florida, USA. Using a similar approach, Au and Green (2000) measured underwater acoustic characteristics of five types of whale watch vessels to evaluate potential impacts of vessel noise on the auditory system of humpback whales near Maui, Hawaii, USA.

1. Focus on the individual

A focus on individual animals is the preferred method for obtaining unbiased records of behaviour. When pseudo-replication can be avoided by treating the individual as the unit of analysis, such an emphasis provides the basis for quantitative measures of frequencies of behavioural events, duration of behavioural states, time budgets, etc. – all of which provide the basis for direct comparisons between disturbance conditions. Data obtained with a focus on the individual can be used to determine which animals, and what proportion of a local community, are more likely to interact with, be affected by, and/or avoid human activity. Conducted over time, such studies provide valuable information about the short-term, seasonal, and long-term effects of cetacean-focused tourism on the lives of individual cetaceans, on animals of different gender, age class, activity state, or reproductive condition, and on cetacean communities.

Several recent studies have employed a focal-animal sampling scheme (defined in Altmann 1974) in which a single animal is the subject of each observation session. For each focal subject, systematic records are made as to that animal's behaviour, including habitat selection and foraging behaviour (Allen and Read 2000), vocal behaviour (Miller *et al.* 2000; Richter *et al.* 2001), respiration patterns (Nowacek *et al.* 2001a), interactions with human swimmers (Samuels and Bejder 1998, in press), and movement patterns (Williams *et al.* 2002). A few of these studies were based upon longitudinal research that provided substantial demographic, reproductive and behavioural background on individual subjects. Thus, by tracking, via theodolite, individual killer whales from the well studied population near Vancouver, Canada, Williams *et al.* (2002) were able to determine sex-specific differences in movement patterns and in responses to boat traffic. Similarly, boat-based follows of individual dolphins from the well-studied Sarasota, Florida, USA, population enabled Nowacek *et al.* (2001a) to identify the particular vulnerability of inexperienced mothers to vessel traffic. In addition, by focusing on the vocal behaviour of individually-identified sperm whales, Richter *et al.* (2001) were able to show that transient, but not resident, whales responded to whale watch vessels.

Although background information is often unavailable in study populations, an individual focus was essential to the findings that food provisioning by humans may pose serious risks for juvenile dolphins, that there were different levels of habituation to humans among dolphins living in the same region (Samuels and Bejder 1998, in press), and that not all male humpback whales responded in the same way to underwater man-made noise (Miller *et al.* 2000). Although Constantine (2001) primarily used a group-level behavioural sampling method (see below), by recording the age class of individual dolphins that approached humans in the water, she determined that juveniles were significantly more likely than adults to interact with human swimmers.

A handful of studies on large whales challenge conventional wisdom that focal-individual follows are feasible only for coastal delphinids. Miller *et al.* (2000) and Richter *et al.* (2001) provide examples in which the focus was on the behaviour of individual humpback whales and sperm whales, respectively (see also, southern right whale, *Eubalaena australis*, mother-calf pairs: Taber and Thomas 1982; minke whales, *Balaenoptera acutorostrata*: Dorsey 1983; fin whales, *B. physalus*: Stone *et al.* 1992, Biassoni 1996).

An individual focus is also important in assessing the effect of human activity on the local community or sub-population. By identifying individual animals via photo-identification in order to determine the number of dolphins within the Bay of Islands, NZ, Constantine (2001) was able to estimate the number of swims attempted with the 'average' dolphin on an annual basis. Similarly, Samuels and Bejder (1998, in press) conducted a behavioural assessment of each animal identified by photo-identification in order to estimate a minimum number of dolphins habituated to human activity and food provisioning in Panama City, Florida, USA.

2. Focus on the group

Although cetologists have often cited Altmann (1974) to justify their use of group-level observations in behavioural studies, Altmann was quite clear in her landmark paper that such an emphasis is appropriate only under a stringent set of circumstances, which are rarely met in cetacean research or elsewhere. A group focus is typically not an appropriate unit for behavioural sampling because an observer cannot continuously monitor all the behaviour of all individuals within a group of animals (Altmann 1974). Thus, in behavioural studies of cetaceans, situations in which a focus on the group is acceptable will be the exception, not the rule. Below we discuss several recent studies in which a group focus was correctly employed.

Altmann (1974) endorsed focal sub-group sampling for pairs of animals, particularly for pairs comprised of a mother and young infant who tend to move together as a single unit. Accordingly, in their study of food-provisioned dolphins, Mann and Smuts (1999) followed mother-and-calf pairs, recording both maternal and calf behaviour. In focal sub-group sampling, a decision rule is needed as to which individual the observer will follow if the pair splits up (i.e. the calf in Mann and Smuts (1999)).

In some cases, rigorous behavioural sampling rules can offset drawbacks to a group-level focus. For example, in studying dolphin responses to 'swim-with' attempts from the vantage of tour vessels, Constantine (2001) compensated for lack of manoeuvrability of the research platform by developing careful criteria to systematically record group behaviour: i.e. at the initiation of a swim attempt a scan sample (defined in Altmann 1974) was conducted in which the behaviour of each dolphin within a specified distance of the tour vessel was recorded. Thus, dolphin responses to swim attempts were recorded within five seconds of the first swimmer's entry into the water. In another example, Lesage *et al.* (1999) compared the total number of vocalisations recorded from each group of belugas before, during and after an experimental boat approach. They set such high standards for ensuring that all vocalisations of the group could be detected that only six of 77 experiments were approved for analysis.

Under certain conditions group sampling can be effectively used to record all occurrences of a conspicuous behaviour. In a comparison of the behaviour of dolphins that do and do not interact with humans, Samuels and Bejder (1998, in press) conducted follows of individual dolphins (see above) as well as follows of focal groups of dolphins that were cohesive for the duration of the follow. They noted that sampling of group behaviour was adequate to continuously monitor whether any group members had interactions with humans. In another example, the effects of vessel traffic on dolphin behaviour were studied by videotaping surfacings within a circumscribed area and comparing the total number of surfacings occurring during ± 1 min of a vessel approach (Janik and Thompson 1996). They were careful to note that, since group size estimates were not exact, it was not appropriate to calculate individual rates or infer individual behaviour; rather, they interpreted the decrease in the number of surfacings after the vessel approach to indicate that at least some of the dolphins were diving for longer periods and/or moving away from the vessel.

RESEARCH PLATFORM

There are five types of research platforms typically used in assessing effects of nature tourism on cetaceans: observations are conducted from (1) land, (2) commercial tour vessels, (3) independent research vessels, (4) underwater, and (5) an aerial view. The underwater category includes both (4a) visual observations and (4b) acoustic recordings. The choice of an observation platform greatly influences the design of the study, how data are collected, and which response measures can be observed and recorded, reliably and without bias. A mismatch of platform and observational methods is a common design error, usually resulting in unrecognised biases in data collection and/or overgeneralisation of findings. Even when access to the platform of choice is limited by research budgets, geographic features, and/or characteristics of the species of interest, it is important to select methods and measures that are appropriate to the platform used.

The resolution of behavioural data that can be obtained from a single type of research platform is often inadequate to fully assess effects. To take advantage of the strengths of each platform type, and accommodate their respective weaknesses, it may be useful to collect multiple datasets from different vantage points. Such a strategy will result in complementary datasets in which the biases or gaps within data collected from one platform may be offset by the attributes of those collected from another platform. In addition, simultaneous data collection from multiple platforms can be used to identify the ways in which data collection methods and research platforms affect conclusions about anthropogenic disturbances on cetaceans.

1. Land-based research platform

As an example, Culik *et al.* (2001) used a land-based research platform to study responses of harbor porpoises (*Phocoena phocoena*) to an artificial gillnet with and without acoustic pingers. The close proximity of preferred porpoise habitat to cliffs along the shore enabled Culik *et al.* (2001) to use theodolite tracking from land to record movements of small groups of porpoises travelling along the coastline. They found that use of a pinger resulted in avoidance of the experimental net at distances that corresponded to the audible range of the acoustic alarm. In their study, a land platform was essential to record porpoise behaviour that was undisturbed by the presence of researchers, to conduct controlled experiments in which only one variable was modified, and to obtain an overview of porpoise movements within ± 1 km of the experimental net. Land-based platforms are valuable for studying coastal groups of cetaceans, having the advantage that remote observers on land are unlikely to have any impact on cetaceans in nearby waters. Disadvantages include restricted viewing of animals (i.e. only when they are within range of the land platform) and limited viewing of their behaviour. However, an elevated land platform is a good vantage point for getting a 'big picture' perspective, which is useful to track the speed and direction of movements of animals, vessels, or human swimmers within a circumscribed area, or to measure group cohesion and spread. A land platform is typically an appropriate choice for following movements and activities of *groups* of cetaceans, and may be the best option for small, coastal species that travel rapidly within large groups. A land platform may also be suitable for observing the movements of individuals (or small groups), particularly of large, solitary, slow-moving species. A land platform is sometimes used to record conspicuous surface displays, but is usually too remote to obtain accurate details about behaviour.

Bejder *et al.* (1999) used a land platform to conduct concurrent behavioural sampling and theodolite tracking in order to record responses of Hector's dolphins to the presence and absence of vessels. The combination of techniques provided simultaneous information about the movement pattern, behavioural state, and dispersion of dolphin groups. By recording group dispersion at 5 min intervals, Bejder *et al.* (1999) showed that dolphins formed groups that were significantly more compact in the presence of a vessel. The elevated land platform also provided an excellent perspective from which to assess the dispersion and cohesion of dolphin groups.

Janik and Thompson (1996) filmed from a pier to look at surfacing patterns of bottlenose dolphin groups in response to boat traffic. A narrow channel frequented by dolphins, boats, and tour vessels provided an opportunity for comprehensive surveillance of all occurrences of a specified behaviour within a circumscribed area. The measure 'surfacing', a behavioural event readily counted from video, was used to compare total number of surfacings within ± 1 min of a vessel approach. Overall, the number of surfacings significantly decreased after the dolphin-watch vessel approached the animals, indicating that dolphins made longer dives and/or left the region.

Williams *et al.* (2002) provide a good example in which the behaviour and movements of individually-identified killer whales were tracked by theodolite from a shore station. In another example, as a result of unusual circumstances in which dolphins visit a beach on a near-daily basis to be fed, Mann and Kemps (Chapter 15, this volume) were able to obtain from shore detailed records of the behaviour of individually-identified dolphins. In a similar situation in which tourist activities were facilitated by food provisioning, shore-based observations provided details about the interactions between humans and bottlenose dolphins (Colborn 1999). Other examples include land-based theodolite tracking to document responses to acoustic alarms (Goodson and Mayo 1995) and vessels (Baker and Herman 1989; Stone *et al.* 1992; Barr and Slooten 1998).

2. Commercial tour vessel as research platform

Commercial tour vessels are often used as platforms for studying various aspects of cetacean biology (reviewed in Robbins 2000; Robbins and Matilla 2000). However, using a tour vessel as a platform to measure effects of the selfsame vessel places a number of limitations on which behavioural sampling methods are appropriate, what kinds of data can be reliably collected, and how those data are interpreted. First, the observer is restricted to what can be seen when the tour vessel is in close proximity to cetaceans, making it possible to detect only those behaviours that occur near to the vessel, only those animals that are tolerant of vessel proximity, and only those behaviours that occur in the presence, but not the absence, of the vessel. In addition, the researcher rarely has control over which cetaceans are observed or identified, how much time is spent in proximity to the animals, and how the vessel is manoeuvred around the animals, constraints that preclude many types of behavioural sampling methods.

Despite these caveats, there are several benefits to using commercial tour vessels as a research platform, the most significant being that this is a relatively inexpensive way to gain regular and frequent access to the animals, and to obtain a large sample of observations of tourist-cetacean interactions. From tour vessels, it is sometimes possible to record systematically vessel approach strategies and swimmer placement types, and it may be possible to record on an *ad libitum* basis (Altmann 1974) behavioural details of in-water interactions between swimmers and cetaceans. During close encounters, observers onboard tour vessels can sometimes identify the individual identities or age classes of animals that interact with tourists or the tour boat. An additional, non-research related advantage is that researchers onboard tour vessels often impart accurate knowledge about cetaceans, marine life, and the ocean to tour operators and tourists, thereby influencing movements of tour vessels around cetaceans and the quality of educational programmes.

Commercial tour vessels have been used to good effect as a research platform in studying commercial swim-with-dolphin operations (Constantine and Baker 1997; Constantine 2001). There were species-specific differences in behavioural responses to tour vessels with groups of common dolphins being significantly more likely than bottlenose dolphins to change their behaviour as the tour vessel/research platform approached from 400 m to 100 m. For both species, socialising was the activity most likely to change; whereas, feeding and resting were least likely to be affected for bottlenose and common dolphins, respectively. Using tour vessels as a platform also enabled the assessment of responses of dolphin groups to specific swimmer placement types (i.e. the 'line abreast' strategy resulted in the lowest rates of avoidance but also low rates of swim success; in contrast, 'in path' resulted in the highest rates of avoidance (Constantine and Baker 1997)).

Constantine (2001) compared behavioural data that she collected from commercial tour vessels during two field seasons (1994/95 and 1997/98) to show increased avoidance over time by groups of bottlenose dolphins to commercial swim-with tours. Using tour vessels as the research platform enabled Constantine (2001) to re-evaluate responses of dolphin groups to swimmer placement methods, with greatest avoidance occurring when swimmers were placed in the dolphins' path of travel.

Observations from tour vessels also enabled the documentation of the proportion of dolphin groups, and the age class, which were likely to interact with swimmers (i.e. when swim attempts were successful, on average only 19% of dolphins were involved, and members of the juvenile age class were most likely to interact with swimmers). Observations made from tour vessels, combined with a photo-identification effort from an independent research vessel, and logbooks from commercial tour operators, were used to estimate the exposure of dolphins in this region to swim attempts.

Other examples in which commercial tour vessels were used as the research platform include ongoing studies of swimmer interactions with dwarf minke whales in the Great Barrier Reef Marine Park, Queensland, Australia (Arnold and Birtles 1998, 1999; Birtles *et al.* 2001). Ransom (1998) used commercial tour vessels as the research platform in a different way: she compiled records collected onboard tour vessels to show an increase in the duration of swim encounters over a five-year period.

3. Independent vessel as research platform

The use of an independent vessel as the research platform provides a number of controls over research design, including the ability to select and repeatedly follow specific individual animals, to confirm in real time the identity of animals under observation, and to designate the duration of follows. In addition, use of an independent research vessel facilitates the application of several analytical designs (the researcher can plan to make observations in the presence and absence of disturbance, or before, during and after experimental situations). Use of an independent vessel as the research platform is likely to be the best way to obtain information about the details of behaviour and/or behavioural responses of individual cetaceans. The primary drawback to using an independent research vessel is the potential for disturbance to the animals being studied by the research vessel itself. When the vessel is handled consistently in a manner intended to lessen disturbance, effects of the research vessel are likely to be minimised and constant. Impacts of an independent research vessel may be further reduced by using a 'quiet' vessel (a vessel under sail e.g. Corkeron 1995). However, the use of an independent vessel may confound interpretation of the data if the combined presence of tour and research vessels results in cumulative effects on cetacean behaviour, or when the behaviour of the research vessel is altered over the course of observations (when there are changes in vessel type, speed, engine noise, proximity, and/or approach angle relative to animals).

By using an independent research vessel, Samuels and Bejder (1998, in press) were able to select specific bottlenose dolphins for observing and to assess the effects of human interaction on individual animals. Specifically, use of an independent research vessel made it possible to observe dolphins that did and did not have interactions with humans (other than the research vessel) within the same region, to conduct repeated focal follows of individually-identified dolphins, and to quantify and record the details of the focal dolphins' interactions with humans. Human interaction for one specific juvenile dolphin occurred once every 12 min, including being fed by humans at least once per 59 min (Samuels and Bejder 1998). In this study, dolphins were so often surrounded by tourist vessels, to the exclusion of the research vessel, that it is unlikely the presence of a research vessel had a significant effect on the behaviour of focal dolphins.

The use of an independent vessel enabled Nowacek *et al.* (2001a) to conduct controlled approaches by experimental vessels at predetermined times during focal follows of individually identified bottlenose dolphins. In their experiments, the independent research vessel provided a platform for an innovative method for measuring a difficult to see disturbance response: the research vessel towed a tethered blimp mounted with an overhead video system (Nowacek *et al.* 2001b) which enabled Nowacek *et al.* (2001a) to quantify subsurface behavioural response, such as changes in inter-animal distance, heading, and swimming speed. Nowacek *et al.* (2001a) explicitly tested for, but did not detect, an effect of the research vessel on dolphin behaviour; however, they acknowledged that due to the presence of the research vessel, their experimental design actually tested the impact of multiple vessels in proximity to focal dolphins.

Other examples include Mann and Smuts (1999) who used an independent research vessel to conduct repeated focal follows of individually identified food-provisioned bottlenose dolphins when those dolphins were away from the provisioning area. In addition, Miller *et al.* (2000) and Allen and Read (2000) both used an independent research vessel to conduct focal follows of humpback whales and bottlenose dolphins, respectively, in order to evaluate impacts of anthropogenic disturbances on individual animals.

4. Underwater research platform

4a. Visual observations from underwater

Cetacean biologists are commonly asked by nonscientists whether their research is conducted by getting in the water with the animals. However, underwater observations are rarely effective for studying cetaceans and are the exception rather than the rule. In-water observations have been used to study the behaviour of spotted (*Stenella frontalis*) and bottlenose dolphins that are habituated to human swimmers (Herzing 1996; Dudzinski 1998). However, in-water visual observations are seldom useful for studying the effects of tourist activity because the factors that can preclude unbiased observations of behaviour from an independent vessel are all the more likely to come into play when people enter the water with un-habituated cetaceans. First and foremost, a person in the water near enough to view behaviour constitutes a potential effect. In addition, a swimmer in such close proximity is usually accompanied by a vessel, therefore, effects may be compounded. Moreover, an underwater observer, with a narrow range of view and limited mobility, is typically limited to fleeting glimpses of those animals that tolerate humans in the water and that come close enough to be seen. As a result of these limitations, in-water observations of human interactions with cetaceans are typically anecdotal, but may be useful to identify the gender (Glockner-Ferrari and Ferrari 1990) or identity (Arnold and Birtles 1999) of individual animals, or to record behaviour (Arnold and Birtles 1999).

4b. Acoustic recordings of underwater sound

Underwater research platforms can be used to make recordings of underwater sound. Because cetaceans rely on sound for communication, navigation, hunting, and detecting predators, there are many studies that evaluate how underwater man-made sound affects cetacean behaviour (e.g. reviewed in Richardson *et al.* 1995; Chapter 18, this volume). In addition, a few recent studies have examined the effects of potential anthropogenic disturbances, acoustic or otherwise, using cetacean vocalisations as the response measure. Collection of acoustic data is often associated with other research platform types and therefore subject to the attributes of that particular platform (acoustic recordings may be made via hydrophones deployed from an independent research vessel or from a land-based research platform). In addition, acoustic recordings are sometimes made from tags temporarily attached to animals or via remote recordings from moored recorders (sonobuoys).

From sonobouys, or hydrophones mounted at fixed locations, acoustic recordings can be made with minimal disturbance to the study animals. However, studies in which acoustic monitoring is conducted from fixed locations are time consuming because obtaining an adequate sample size is dependent on the movement of study animals into areas where recording equipment is deployed. These remote recording systems rarely permit identification of individual animals (but see Janik *et al.* 2000). In contrast, studies in which acoustic recordings are made from a manoeuvrable platform such as an independent research vessel are typically more efficient in obtaining an adequate sample size (e.g. Richter *et al.* 2000) and may permit identification of individual animals (e.g. Miller and Tyack 1998). In these cases, confounding factors may be introduced due to the physical and/or acoustic presence of the vessel.

Miller *et al.* (2000) used a calibrated hydrophone array, towed from an independent research vessel, to monitor the vocal behaviour of individual singing humpback whales while simultaneously monitoring the surface behaviour of each whale. In this experiment, the independent research vessel was a constant presence from which concurrent behavioural and acoustic observations were made before, during and after exposure to controlled playbacks of LFA sonar.

In studies of cetacean acoustics it is rarely possible to establish the identity and/or exact number of animals responsible for recorded vocalisations. Therefore, interpreting the measure, ‘change in vocal behaviour’, for a group of animals in response to anthropogenic activity can be problematic. Some individuals may *increase* vocal activity in response to stimuli, whereas other individuals in the same group or region may *decrease* vocal activity, such that all individuals alter their vocal behaviour but the overall net change at the group level is zero. Lesage *et al.* (1999) provide an example in which group vocal behaviour was carefully recorded and quantified. They recorded vocalisations of groups of beluga whales via hydrophones mounted on the sea floor, and by selecting only those experiments in which they could be sure of recording all emitted vocalisations, they were able to look at changes in vocal behaviour in response to controlled vessel approaches.

5. Aerial research platform

Aerial research platforms such as airplanes, helicopters and blimps, have occasionally been used to study reactions of cetaceans to anthropogenic impacts (Au and Perryman 1982). As is the case with elevated land-based observations, an aerial vantage can provide a ‘birds-eye view’ of group cohesion and large-scale animal movements in response to human activity. Aerial platforms share some of the negative aspects of elevated land-based platforms (e.g. restricted viewing of animals and behaviour due to the remoteness). Unlike elevated land-based observations, however, observations from air may have physical and/or acoustic impacts on cetaceans in nearby waters. And, in contrast to on-the-water research platforms that can be handled in a consistent and predictable manner around study animals, most types of aerial platforms are likely to be less predictable and more irregular sources of acoustic and physical disturbance.

Au and Perryman (1982) used a helicopter to quantify long-range movement patterns of spotted, striped (*S. coeruleoalba*) and spinner (*S. longirostris*) dolphins in reaction to controlled vessel approaches in the eastern Pacific. Specifically, the helicopter was used to spot dolphins and direct the approach of a ship from some distance (>10 km). During the approach, the helicopter hovered over the dolphins, providing a continuous marker of the dolphins’ location. Dolphin movements in response to the approaching ship were measured from ship to helicopter using the ship’s radar. In this study, use of an aerial platform was essential for documenting evasive responses of dolphins to an approaching vessel over a large distance, reactions not easily quantified solely from land- or vessel-based platforms.

Nowacek *et al.* (2001a) used a blimp mounted with an overhead video system to record sub-surface behaviour of individual dolphins in response to controlled vessel approaches. Analyses of video records provided information about the orientation and speed (via fluke stroke counts) of each focal dolphin in response to vessel traffic, showing that dolphins changed orientation away from the path of approaching vessels, and increased swimming speed more often during vessel approaches than during control periods. The overhead video system enabled them to detect quick and subtle reactions that would likely have gone unnoticed in observations from other observational platforms.

MEASURING RESPONSES

The potential effects of nature-based tourism on cetaceans are rarely as evident as the mortalities brought about by such activities as whaling and fisheries by-catch. Seldom has tourism been shown to be directly responsible for fatalities, although there are scattered reports of commercial whale-watch vessels colliding with humpback, fin and minke whales (e.g. M. Weinrich, person communication 2001). Instead, as noted above, exposure to nature tourism may have some cumulative, rather than catastrophic, effects (e.g. Duffus and Deardon 1990). Adverse effects are unlikely to result from single encounters with vessels or human swimmers, however, tourism focusing on free-ranging cetaceans may target specific individuals or sub-groups for repeated encounters. Such activities have the potential to result in chronic stress and/or repeated disruptions to critical social behaviours (e.g. maternal care, breeding, feeding and resting). These effects may ultimately be expressed as decreased survival or reproductive success.

At present, however, there are few, if any, studies in which baseline and disturbed behaviour are quantified such that behavioural responses can be translated to energetic costs and long-term impacts.'Ultimately, it would be valuable to estimate the direct energetic "cost" of human disturbance to … whales. This cost could then be compared with the whales' overall energy budget to determine the potential loss in long-term reproductive success as a result of disturbance. In other words, how much energy is expended or lost, as a result of disturbance that might otherwise be devoted to reproduction?'(Baker and Herman 1989).

Typically, researchers look at vocal and non-vocal behaviour to evaluate the potential effects of nature-based tourism on cetaceans. Immediate behavioural responses are more readily related to potential sources of impact than are long-term or cumulative impacts. Careful selection of biologically relevant behavioural measures is crucial, but decisions are often tempered by such logistical concerns as characteristics of the species, extent of species-specific background behavioural information, geographic location of animals in question, nature of the potential disturbance, selection of research platform and sampling methods, available technology, and constraints on researcher time and finances.

Interpretation of response measures in relation to disturbance can be tricky. In order to identify certain behaviours as responses, it is first necessary to be able to describe and quantify 'normal' undisturbed behaviour. In addition, the absence of a behavioural response to potential disturbance can be due to a variety of factors. Sometimes, the lack of response truly signifies that no effect has occurred. Alternatively, it may indicate that targeted animals have become habituated to the stimulus. Unfortunately, an apparent lack of response can also result from imperfect or inadequate monitoring techniques. For example, monitoring schemes that focus on reactions of groups to stimuli are likely to be biased towards detecting the behaviour of more conspicuous individuals, to the detriment of documenting effects on other individuals. Moreover, responses that are physiological with no visible sign will not be readily detectable in free-ranging animals. As exemplified by several of the studies highlighted here, simultaneous recording of multiple response measures appears to optimise the likelihood of response detection.

In the sections that follow, we use specific case studies to illustrate short-term behavioural measures, both vocal and non-vocal, and long-term measures that have been used to evaluate effects of human disturbance on cetaceans. In addition, we address the measurability of 'stress' and 'distress'.

1. Short-term measures

1a. Non-vocal behaviour

We know of no quantitative studies that directly relate short-term behavioural responses to energetic costs and long-term effects. Instead, short-term changes in behaviour are typically used as a measurable, quantifiable, best-guess proxy for long-term costs. For non-vocal behaviour, such short-term changes include alterations of (i) surfacing, ventilation and dive patterns; (ii) swim speed, course and orientation; (iii) group dispersion; (iv) behavioural states/activity budgets; (v) behavioural event frequencies; and (vi) ranging pattern and habitat use.

i) Surfacing, ventilation and dive patterns

Changes in surfacing, ventilation and dive patterns are commonly used as indicators of disturbance. These measures may be indicative of avoidance reactions; indeed, some researchers have claimed these as the most sensitive indicators of whale responses to vessels (Baker and Herman 1989). These measures are readily quantifiable and can be recorded from a variety of research platforms. As with most behavioural data, these measures are most informative when recorded for individual animals; group-level rates (e.g. total number of blows divided by number of animals in the group per time unit) are unlikely to be very meaningful due to age, sex, and individual differences in behaviour.

Nowacek *et al.* (2001a) used the measure, inter-breath interval, to compare the behaviour of individual dolphins during experimental and opportunistic vessel approaches. Focal animals had longer inter-breath intervals during vessel approaches than during control periods. In particular, females without calves and inexperienced mothers had significantly different inter-breath intervals from experienced mothers, with experienced mothers having the longest intervals of any dolphin class during vessel approaches. In their study, inter-breath interval was used to represent vulnerability to vessel strikes, with longer inter-breath intervals during vessel approaches corresponding to less time at the surface when boats are nearby, which was presumed to correspond to a lower probability of being struck.

Stone *et al.* (1992) recorded all occurrences of breaths taken by individual fin whales in conjunction with theodolite tracking of their movements in the presence and absence of whale watch vessels. There were significantly reduced dive durations, surface durations, and number of blows per surfacing sequence for individual whales when whale-watch vessels were nearby. However, the authors felt that observed differences were not of sufficient magnitude to warrant a practical definition of 'harassment.' In particular, they deemed that the definition for 'control' periods – no vessels within 450m of the focal whale – was unlikely to be compatible with whale perceptions of vessel presence, since other studies have shown that cetaceans may respond to acoustic stimuli at distances of up to tens of kilometres (e.g. Au and Perryman 1982; Richardson *et al.* 1985; Baker and Herman 1989).

Janik and Thompson (1996) recorded dolphin surfacings within a circumscribed area within ± 1 min of a vessel approach. Cognisant of the problems associated with calculating group-level rates, they used the total number of surfacings as their measure. They found a decrease in the total number of surfacings following vessel approaches (particularly approaches of the dolphin watch vessel), which they interpreted to mean that at least some of the dolphins either dived for longer periods and/or moved away after the boat approached them.

ii) Swim speed, course and orientation

Many researchers have looked at short-term changes in swimming speed, course of travel, and orientation relative to potential sources of disturbance as measures of the effects of anthropogenic activity on cetaceans. These parameters are most accurately recorded using a theodolite stationed on an elevated vantage point on land which provides an overview and precise measurements of the locations of study animals and sources of disturbance. Swim speed, course and orientation appear to be useful measures of short-term avoidance reactions to human activity. These measures are typically recorded immediately *before* and/or *during* interactions between study animals and sources of potential impact. In this way, spatial and temporal discontinuities between cause and effect can be isolated.

Bejder *et al.* (1999) used land-based theodolite tracking to determine orientation of Hector's dolphin groups relative to vessel movement. In their study, orientation was used as a measure of attraction and avoidance. In particular, they determined to measure if dolphin orientation varied with respect to the tour vessel with time during the encounter. Dolphins tended to orient towards vessels significantly more often during initial stages of the encounter but less frequently as the encounter duration increased beyond 70 min, which was presumed to indicate an initial attraction followed by avoidance. These findings led to pending proposals for permit conditions to restrict the duration of encounters (H. Kettles personal communication).

Williams *et al.* (2002) also used land-based theodolite tracking to record swim speeds and 'directness' of travel for individual killer whales under conditions of no vessels, experimental vessel approaches, and opportunistic vessel approaches. By following individually-identified animals of known age class and gender, they were able to document the potential for sex-specific responses to vessel traffic, including that, overall, male whales swam significantly faster than females, and female whales responded to vessel approaches by swimming faster and increasing the angle of successive dives.

iii) Group dispersion/cohesion

Dispersion or cohesion of cetacean groups is often considered to be a useful measure of disturbance, under the presumption that cetaceans will bunch together in situations of surprise, threat or danger (Johnson and Norris 1986). Various measures of group cohesiveness have been recorded from several platforms, and can often be directly related to potential sources of disturbance.

Bejder *et al.* (1999) scored relative group dispersion in Hector's dolphins on a scale from 1, tightly bunched together (dolphins within 0–2 body lengths of each other), to 4, spread out (dolphins generally >10 body lengths apart). Based on this assessment, they showed that dolphin groups were significantly more compact in the presence of dolphin-watch vessels than when no vessels were present. Similar responses to approaching vessels have been reported in other species (e.g. *Stenella* sp.: Au and Perryman 1982).

Nowacek *et al.* (2001a) used an overhead video system which afforded a 'big picture' view around the focal animal from which inter-animal distance was estimated based on the distance from the focal animal to the nearest neighbour. Their data showed that dolphins decreased the distance to the nearest neighbour (i.e. increased group cohesion) during controlled approaches by vessels relative to control periods.

iv) Behavioural states/activity budgets

Repeated disruptions due to human activity are likely to affect cetacean behavioural activity budgets (i.e. how much time animals spend foraging, resting, socialising with conspecifics) and could ultimately affect survival or reproductive success. Thus, many researchers record behavioural states to look at short-term changes induced by anthropogenic activity and/or to compare activity budgets.

Mann and Smuts (1999) recorded specific activities to compare the behaviour of mother dolphins and their calves within and away from a provisioning-and-human-interaction area. In their study the activity, 'echelon swim' with the mother, was recorded continuously during focal follows of individual calves. Time spent in echelon swim with the mother was used as an indicator of maternal care, as the calf may derive energetic benefits from swimming in contact with, or in the slipstream of, the mother. Mann and Smuts (1999) found that, although echelon swimming was common away from the provisioning area for both provisioned and wild-feeding dolphins, the proportion of time calves spent in echelon swim was significantly reduced within the provisioning area. In a follow-up study, Mann and Kemps (Chapter 15, this volume) observed provisioned dolphins within and away from the provisioning area, recording continuously when the calf was swimming in 'infant position.' Time spent in infant position was used as another indicator of maternal care, as swimming beneath the mother's ventrum is likely to correspond directly to opportunities for nursing. They found that nursing opportunities, (i.e. time spent in infant position) were significantly reduced when mothers and calves were in the provisioning area.

Samuels and Bejder (1998, in press) conducted focal follows of individuals and small groups to compare behaviour of dolphins living in the same region that did, and did not, have interactions with humans. Dolphin activity (or for groups, 'predominant group activity' (Mann 1999)) was recorded at specified intervals. In addition to standard activity categories, (i.e. travel, forage, rest, socialise with conspecifics) a 'human interaction' activity state was included to encompass a suite of human-focused behavioural events (see 'Behavioural events', below). The biases associated with sampling the behaviour of cetacean groups were minimised (see 'Study subjects', p. 235) because they were able to monitor continuously whether any group members had interactions with humans. They found that some dolphins, categorised as 'habituated', engaged in human-interaction activity during 77% of observation time, whereas other dolphins, categorised as 'unhabituated', never engaged in human-interaction activity.

Constantine and Baker (1997) used change in predominant group activity, as an indicator of disturbance during approaches by swim-with-dolphin vessels. From their tour vessel research platform, predominant group activity was assessed upon first sighting of a dolphin group and reassessed when the tour vessel was within 100 m. Thirty-two per cent of vessel approaches to bottlenose dolphins resulted in a change in group activity, with feeding being the activity least likely to be disrupted and socialising most likely; 52% of approaches to common dolphins resulted in behavioural change with resting least likely and socialising most likely to change.

v) Behavioural events

Presence/absence and frequency of specific behavioural events may be useful indicators of disturbance, and indeed, many researchers record some subset of discrete behaviours. However, with the exception of 'blows' (see 'Surfacing, ventilation and dive patterns', p. 241), there are few examples in which behavioural events have been used to assess disturbance. In part, this is because little is known for cetaceans about the functions of many behavioural events. In order to identify changes in behaviour or 'disturbance-responsive' behaviour, there must be familiarity with what is 'normal' behaviour or baseline levels. Generally, for most cetaceans, these are unknown, in part because the preferred group-level focus is not sensitive to individual or age/sex class variations in behaviour. In addition, only a few behavioural sampling techniques provide unbiased records of behavioural events. For example, focal-individual follows are appropriate for quantifying, or making detailed observations of social behaviour; group scan sampling is appropriate for recording frequencies of conspicuous behaviours as aerial displays.

In the course of focal follows from an independent research vessel, Samuels and Bejder (1998, in press) recorded specified behavioural interactions ('behavioural events') between dolphins and humans in order to classify individual dolphins as habituated or unhabituated to human activity (see 'Behavioural states', p. 242). Thus, the behavioural state of being habituated was defined by the presence of certain behavioural events. Human-interaction behaviours indicative of habituation included: remain close to vessels or humans, leap up or lunge at vessel, beg from humans or accept food from humans. In addition, behavioural events were also recorded to identify human-dolphin interactions that pose a risk for dolphins or humans, including: physical contact between dolphin and human, dolphin in close proximity to a vessel or deployed fishing gear, humans feeding or offering objects to dolphin.

Barr and Slooten (1998) recorded aerial behaviours of dolphins in the presence and absence of boats. At specified intervals, they conducted scans of the focal group from a cliff-top and recorded the number of 'clean leaps' and 'slaps' as indicators of disturbance or agitation. They found that aerial behaviour increased when boats were present, especially after midday during the dolphins' presumed rest period.

vi) Ranging patterns and habitat use

Human disturbance may also result in short-term changes in ranging patterns and habitat use. If preferred habitats are rendered less desirable through human presence, animals may be denied access to areas critical for breeding, foraging or resting. Disturbance may also result in redistribution of animals within a population, such that less tolerant individuals or members of certain age, sex or reproductive classes become sensitised and displaced to less optimal areas where food resources are less abundant or predators are more prevalent. Thus, several researchers have looked at effects of human activity on cetacean ranging patterns and habitat use.

Allen and Read (2000) found that habitat selection by foraging bottlenose dolphins differed between two time periods that varied in vessel density. At one site, foraging dolphins showed preferences for certain habitats during low vessel activity, but habitat preferences were not apparent during periods of high vessel activity. They suggested that dolphins shift habitat use either to directly avoid areas of high vessel traffic or in response to vessel traffic.

Samuels and Bejder (1998, in press) documented differences in the ranging patterns of habituated and unhabituated dolphins living in the same region. Focal follows of dolphins revealed that habituated dolphins remained within a <1 nm^2 area where they engaged in interactions with humans (including food provisioning); whereas, in follows of comparable duration, unhabituated dolphins utilised greater areas.

1b. Vocal behaviour

Because cetaceans rely on sound for navigation, communication with conspecifics, and locating predators and prey, it is often assumed that short-term changes in vocal behaviour may be responsive to human activities. Studies monitoring vocal behaviour may provide insights as to whether communication, navigation and/or predator/prey detection are compromised by anthropogenic disturbance, either by altering vocal patterns or by acoustic masking, (i.e. reducing the ability to detect conspecific calls and other underwater sounds). As with non-vocal behaviour, there are no quantitative studies that demonstrate links between short- and long-term measures; however, short-term vocal responses to disturbance may signal long-term impacts. Such measures include changes in vocal repertoire, cessation of vocalisations and changes in the frequency or duration of specific vocalisations. A change in the attributes of vocalisation is the most commonly used measure.

There are significant logistic hurdles to following and systematically recording the vocal behaviour of a single animal (see 'Study subjects', p. 235; Whitehead *et al.* 2000). There are few visual cues to assist human observers in identifying which animal within a group is making which sound, and recordings of vocalisations made from vessels may be obscured by ship noise. Moreover, vocal repertoires are poorly known for many species, as are vocalisations typically described using standardised classification systems.

Due to the technical difficulties associated with identifying vocalising individuals, researchers often record vocal behaviour of groups of cetaceans. This approach is fraught with many of the same biases associated with group-level analyses of non-vocal behaviour (see 'Study subjects' p. 235 and 'Non-vocal behaviour', p. 241). In particular, apparent changes in group vocal behaviour may be due to one, a subset, or all animals in a group; therefore, group-level analyses may well obscure actual responses. In a few studies, however, special care has been taken in the handling and interpretation of recordings of group vocal behaviour.

Lesage *et al.* (1999) recorded vocalisations of groups of beluga whales during experimental vessel approaches in order to study effects of vessel noise on whale vocal behaviour. Vocalisations were classified using a systematic scheme, and care was taken to include only those experiments in which all calls could be counted (i.e. an unbiased sample of vocalisations). Numbers of calls were compared between pre-exposure, exposure and post-exposure conditions. Despite a small sample, the results showed that experimental vessel approaches induced longer call durations, changes in calling rates, an upward shift in the frequency range, and a tendency to emit calls repetitively, with responses to the larger and slower of two experimental vessels being more persistent. The observed vocal responses to vessel noise appeared to be strategies to compensate for acoustic masking and increase signal detectability (Lesage *et al.* 1999).

The solitary nature of sperm whales near Kaikoura, NZ, enabled Richter *et al.* (2001) to use directional hydrophones to track individuals underwater, and thereby, to monitor effects of whale-watch vessels on the vocal behaviour of individual whales. Strictly speaking, in their study they evaluated additional effects of a whale-watch vessel on a whale that was already being followed by a research vessel. A response measure was calculated for individual whales (i.e. time elapsed from fluke-out to first click) and this measure was compared in the presence and absence of whale-watch vessels. Coupled with sighting histories for individual whales based on photo-identification, Richter *et al.* (2001) demonstrated that for 'transient' whales, time to first click increased by nearly 50% in the presence of whale-watch vessels, whereas effects on 'resident' whales were not detected.Despite the logistical obstacles listed above, several researchers have successfully recorded the vocalisations of single animals by taking advantage of technological advances and the particular characteristics of the species of concern. For example, recent techniques such as beamforming and two-dimensional hydrophone arrays have enabled researchers to make simultaneous acoustic and behavioural records for individual free-ranging cetaceans (e.g. Miller and Tyack 1998; Janik *et al.* 2000; Janik 2000a, b).

Miller *et al.* (2000) made continuous recordings of the songs of individual humpback whales using a towed hydrophone array, in order to study the effects of experimental sound playbacks on individual whales. This study evaluated the additional effects of anthropogenic sound on a whale that was already being followed by a research vessel. By recording song before, during and after experimental playbacks of LFA sonar, Miller *et al.* (2000) demonstrated a variety of individual responses to sound playbacks. Some whales responded to sound playback by ceasing to sing, other whales responded by increasing the duration of songs, and still others gave no apparent response. Those humpbacks that sang longer songs during sonar transmission may have done so in order to compensate for acoustic interference (Miller *et al.* 2000). As humpback song is thought to be a sexual display, alteration of song in response to man-made noise may affect reproductive success.

2. Long-term measures

The short-term measures described so far are intended to be surrogates for long-term effects that may have biological relevance. Ideally, the goal of this kind of research is to link such short-term reactions with long-term effects on the animals. In particular, it is important to know if the short-term responses elicited by human activity translate into long-term changes in behavioural repertoire, reproduction, physical condition, distribution and habitat use, and in what ways do these changes influence survival and population size. In practice, it has rarely been possible to demonstrate the biological significance of short-term behavioural change in response to anthropogenic activity. For example, when male humpback whales sing longer songs (a sexual display) during exposure to man-made sound (Miller *et al.* 2000), there may be some cost to whale reproduction, but obtaining the data needed to test this supposition is difficult.

Difficulties arise in distinguishing the effects of human activity from long-term change resulting from ecological factors. Spatial and temporal discontinuities between cause and effect can result in spurious correlations that erroneously point a finger at human activity as a causal agent. Further complications are highlighted by time-series modelling to assess trends in demographic parameters for right whales (Branao *et al.* 2000) and by power analyses to investigate trends in population size and effectiveness of monitoring programs for bottlenose dolphins (Wilson *et al.* 1999). Both studies show that nearly a decade of data is needed to detect demographic responses. In addition, the present funding of cetacean behavioural studies is not supportive of the baseline research needed to identify what is 'normal' behaviour for cetaceans of various species, age/sex classes and reproductive classes, nor of the longitudinal research needed to quantify long-term change in response to human activity.

Studies which explicitly set out to measure the long-term effects of cetacean-focused tourism are few. In some instances, follow-up studies have been designed for comparison with existing pre-tourism datasets but interpretation of these findings may be complicated by other factors (Brown 2000; Forest 2001). In several cases, historical data collected for other purposes have been analysed to investigate possible correlation between tourism and long-term change in behaviour (Watkins 1986; Ransom 1998) and reproductive success (Mann *et al.* 2000), but again, to conclusively link tourism with the observed trends may be difficult. We are aware of only one study in which longitudinal monitoring of the effects of cetacean-focused tourism has been an explicit part of the research design (Constantine and Baker 1997; Constantine 2001).

2a. Habituation and sensitisation

Habituation is defined as a gradual weakening of the behavioural response to a recurring stimulus that provides no apparent reward or punishment (Allaby 1999). In field studies of animal behaviour, habituation of animal subjects may be desirable when researchers want to study behaviour that is relatively unaffected by their own presence (e.g. Connor and Smolker 1985; Goodall 1986; Orams 1995; Herzing 1999). Some cetaceans that are repeatedly targeted by tourist activities may be similarly inclined towards habituation. In some circumstances this can cause problems when the reduction in the animals' natural wariness to human activity results in heightened vulnerability to vessel strikes, entanglement and vandalism (e.g. Samuels and Bejder 1998, in press; Spradlin *et al.* 1998, 2001; Stone *et al.* 2000).

Sensitisation is defined as an increased likelihood that repeated exposure to a particular and significant stimulus will produce a response in an animal (Allaby 1999). Thus, some animals may become sensitised to stimuli over time, with repeated or chronic exposure resulting in a higher frequency or intensity of avoidance reactions.

Quantification of the habituation or sensitisation status of individual cetaceans targeted by tourism should be a priority for impact assessment studies. Samuels and Bejder (1998, in press) identified certain dolphin behaviours to be indicative of habitual interaction with humans, and they classified individual dolphins as 'habituated' to human interaction or not based on the presence or absence of these behaviours in each animal's repertoire. Constantine (2001) documented sensitisation by comparing responses of individual dolphins to swim-with-dolphin tourism over a period of several years. Sensitisation was indicated by findings that the percentage of successful swim attempts decreased over time with a concomitant increase in swim attempts avoided by dolphins (Constantine 2001). Watkins (1986) inferred from historical records changes in the habituation and sensitisation of different whale species to whale-watch tourism: specifically, avoidance responses by humpback whales at the onset of cetacean-focused tourism were replaced with 'positive' curious responses following years of exposure to whale-watch tourism; conversely, the initially positive responses by minke whales changed to avoidance.

In addition to identifying habituation or sensitisation status, it is important to document what costs, if any, are incurred by such changes in wariness to human activity. Samuels *et al.* (2000) documented a high occurrence of mortality among 'lone sociable' habituated dolphins, those dolphins that eschew companionship of conspecifics and seek out humans and human activity. Based on a review of the literature pertaining to swimming with wild cetaceans, Samuels *et al.* (2000) identified 28 lone sociable dolphins whose lives were well documented. Of these, at least four were killed by humans, and five others disappeared under 'mysterious circumstances' (i.e. around the time of human-dolphin conflict). Other lone sociable dolphins repeatedly incurred serious injuries as a result of their habituation to humans. It was noted that although lone sociable dolphins are the ones which typically make first contact with humans, habituation is usually a gradual process achieved through considerable effort on the part of humans.

2b. Ranging patterns and habitat utilisation

Long-term displacement of cetaceans from preferred areas has been correlated with human activity in several instances. Spinner dolphin groups in Hawaii favour a particular bay for daytime rest and socialising (Norris and Dohl 1980). Forest (2001) documented a reduction in usage of the bay from pre-tourism frequencies, and speculated that dolphins may enter the bay less often due to increasing levels of dolphin-focused tourism. Forest (2001) suggested that the bay had become 'less suitable' due to increased human activity, but noted that other explanations are also possible (e.g. changes in population structure or ecology of the area). Other examples of habitat abandonment that may be related to human activity include reduced usage of Guerrero Negro Lagoon in Baja, California, by gray whales (*Eschrichtius robustus*) and Glacier Bay, Alaska, by humpback whales in apparent response to vessel disturbance (Gard 1974; Bryant *et al.* 1984; Dean *et al.* 1985). In all three examples, researchers were unable to confirm definitively that human activity was the cause of the observed change, which highlights the problems with inferring causation from correlation.

2c. Reproductive success

A long-term research project dedicated to studying the behaviour and social organisation of bottlenose dolphins in Australia provided useful data for investigating effects of tourism on dolphins in this population. Analysis of 10 years of demographic data revealed long-term consequences on the reproductive success of individual bottlenose dolphins fed by humans at a tourist resort (Mann *et al.* 2000). Specifically, provisioned female dolphins were found to have significantly lower calf survivorship than wild-feeding females in the same bay.

STRESS AND DISTRESS

Stress is 'the biological response elicited when an individual perceives a threat [stressor] to its homeostasis. When a stress response truly threatens the animal's well-being, then the animal experiences 'distress'.' (Moberg 2000) The term 'distress' has been used to 'indicate specifically that the stressor may cause harm or decrease the welfare and (or) fitness of the organism' (Lay 2000). Chronic stress, severe acute stress, and/or distress can contribute to reduced fitness, reproductive disorders, disease, and mortality (Ridgway 1972; Moberg 1985; Sapolsky 1987; Dierauf 1990; Sweeney 1990; Apaninus 1998; von Holst 1998; Waples and Gales 2002). Thus, one goal in assessing the effects of human disturbance on wildlife is to determine whether or not, and to what extent, human activity may be stressful for targeted animals.

Unfortunately, we have limited knowledge of how stress and distress are expressed. There are few quantitative studies that correlate physiological and behavioural measures, and there are many uncertainties and discrepancies associated with interpreting physiological measures. In addition, little is known about how short-term responses to disturbance may be linked to stress or distress. Another confounding factor is that a stress response is not necessarily harmful unless it results in distress (e.g. temporary changes in heart rate or blood pressure may or may not be significant in terms of an animal's welfare). Biological costs of stress are likely to be minimal when animals have adequate compensatory biological reserves. However, when costs exceed reserves, for example, under conditions of chronic, severe, prolonged and/or cumulative stressors, stress may have significant impacts on fitness, reproduction or mortality.

To identify biological indicators of animal distress, Moberg (2000) proposed a model in which the stress response is comprised of up to four components; behavioural, endocrine, immunological and/or autonomic nervous system. Ideally, measures of these four mechanisms could serve as indicators of stress and distress, however, no measure by itself has proven adequate to the task, in part because responses may be disturbance- or animal-specific (Moberg 2000). Further complicating the utility of these defence mechanisms as indicators of stress is that 'positive' and 'negative' stressors can elicit comparable responses (e.g. in stallions, similar cortisol levels were recorded during conditions of mating and confinement (Colborn *et al.* 1991)). To overcome obstacles in identifying stress and distress in animals, it may be advisable to monitor several potential indicators simultaneously and over the long term. For example, concurrent, longitudinal monitoring of behavioural and physiological measures may help pinpoint situations of stress by providing complementary evidence and baseline data for comparison (e.g. Waples and Gales 2002).

For cetaceans, links have been suggested between specific anthropogenic activities and stress or distress (e.g. Frohoff 2000), but these relationships have rarely, if ever, been substantiated. Although techniques have been developed for minimally-invasive collection of physiological stress measures in field studies of terrestrial mammals (e.g. Sapolsky 1992), to our knowledge, such measurements have not been collected for free-ranging cetaceans. There are several possible reasons for this. First, physiological measures are difficult to obtain from marine animals at sea. Second, collecting physiological samples typically requires darting, biopsies or temporary restraint, techniques that may be inherently stressful themselves. Indeed, several studies of wild dolphins show that temporary capture for biological sampling can elicit temporary physiological stress responses (Thomson and Geraci 1986; Aubin *et al.* 1996; but see: Ortiz and Worthy 2000). With respect to behavioural measures, although functions have been proposed for specific behavioural events, there are few, if any, quantitative studies demonstrating that certain behaviours are expressions of stress and distress.

Thus, in the absence of appropriate examples from field research on cetaceans, we highlight several studies of animals in captive settings. The examples illustrate potentially useful techniques derived from studies where minimally invasive biological sampling and detailed behavioural observations can be more easily accomplished.

Waples and Gales (2002) provide an example in which quantitative behavioural indices were correlated with physiological measures of stress for captive dolphins. The success of this study was due to ongoing collection of quantitative behavioural, clinical and physiological data for individual dolphins for months prior to one case of illness and two cases of mortality. Specifically, Waples and Gales (2002) documented changes in social dynamics and association patterns within the captive group that correlated with physiological measures of stress and poor physical condition. They concluded that stress resulting from social instability contributed to documented illness and mortalities.

Miksis *et al.* (2001) recorded cardiac responses of captive dolphins to sound playbacks of pool noise, familiar signature whistles, and agonistic jaw claps. By training dolphins to permit the temporary attachment of a suction-cup hydrophone, Miksis *et al.* (2001) were able to continuously monitor cardiac activity before and after playback sessions, using 'change in heart rate' as their response measure. They documented an initial acceleration in heart rate after playback of all three acoustic stimuli, particularly in response to jaw claps. Heart rate subsequently continued to increase after playbacks of signature whistles and jaw claps, but returned to normal after playbacks of pool noise.

Samuels and Spradlin (1995) conducted detailed behavioural observations of individual dolphins during captive swim-with-dolphin programs and during the dolphins' 'free' time. For certain swim programs in which dolphins and human swimmers were not controlled by trainers, they found that dolphins responded submissively to human swimmers. Samuels and Spradlin (1995) suggested, and there is ample evidence from studies of terrestrial animals, that behavioural expression of submission may be a marker for physiological response. Although physiological measures were not available to corroborate this claim, the study identifies specific behaviours that are demonstrated expressions of subordination (Samuels and Gifford 1997) and may be useful indicators of stress.

Conclusions

Current understanding of the effects of tourism on free-ranging cetaceans is far from satisfactory. This is partly attributable to a scarcity of studies that incorporate the longitudinal perspective vital both for studying such long-lived creatures and for evaluating the effects that may be cumulative rather than immediate. Current behavioural research methods have not been fully applied to this endeavour, with the result that detection and interpretation of possible effects are impaired. Nevertheless, many studies investigating the effects of tourism have demonstrated that these activities often elicit short-term changes in the behaviour of targeted cetaceans. Results of longitudinal monitoring are only starting to emerge, but again, available information points towards effects on those animals that are the focus of tourist activity. Existing studies provide an important first step in assessing potential long-term effects of cetacean-focused tourism; however, present knowledge of the biological significance of observed short-term effects is rudimentary, as are the methodologies used to evaluate such. It is clear that more refined, in depth, and longitudinal investigations are needed.

We identified several explanations for the limited nature of research to evaluate impacts of cetacean-focused tourism. In part, these limitations can be attributed to problems inherent to all studies of this nature, either aquatic or terrestrial, and in part, to the logistical difficulties specific to cetacean behavioural research. In particular, studies of cetacean-focused tourism tend to be handicapped by an incomplete understanding of undisturbed behaviour, and a lack of baseline data for comparative analysis. It is only recently that cetacean biologists have taken full advantage of the quantitative techniques developed for studying the behaviour of terrestrial animals. Contrary to a long-established focus on the individual in behavioural studies of terrestrial animals, the majority of studies of cetacean-focused tourism have concentrated on measuring the behaviour and responses of groups of animals. Because a group-level approach will sometimes promote unwanted bias and incomplete information, there is a pressing need to complement existing work with additional studies emphasising behaviour at the level of the individual. Such a focus provides the framework for precise quantification of behavioural responses to human activity, facilitates detection of inter-individual behavioural differences in attraction or vulnerability to tourism, and provides for comparison of behaviour of the same animals in the presence and absence of human activity. An individual focus maintained over the long term would provide valuable information about short- and long-term impacts of tourism on individuals, local communities, and populations.

As a result of these methodological shortcomings, and the subsequent inconclusiveness of current research efforts, both the scientific community and wildlife managers have voiced their discontent with the inadequacies in the knowledge base regarding the potential effects of nature-based tourism on cetaceans (IFAW 1995). However, as exemplified by the studies that we selected to highlight in this chapter, such deficiencies can be ameliorated by research designs that are meticulously and rigorously planned and executed, thereby promoting optimal environment for impact detection. These noteworthy case studies serve as helpful guides for future research whose goal is the assessment of the effects of cetacean-focused tourism.

The Nowacek *et al.* (2001a) study also illustrates ways in which future impact assessment studies may benefit from recent developments in cetacean biology. Some useful techniques for impact assessment were developed in captive settings, including quantitative fine-scale monitoring of behaviour (Samuels and Spradlin 1995), physiological measures (Miksis *et al.* 2001), or preferably, concurrent behavioural and physiological measures (Waples and Gales 2002). A number of recent field techniques provide ways to simultaneously monitor the behaviour and acoustics of individual animals at sea (Miller and Tyack 1998; Janik *et al.* 2000; Janik 2000a, b), including underwater movements of large whales recorded from a temporary tag attachment (Johnson and Tyack 2003), sub-surface behaviour of dolphins recorded from an overhead video system (Nowacek *et al.* 2001b), and behaviour and acoustics of large whales during controlled experiments (Miller *et al.* 2000). Some new field techniques also permit measurement of physiological responses from unrestrained cetaceans at sea, including measures of cardiac activity (Johnson and Tyack 2003) and body condition (Moore *et al.* 2001). Analysis of these case studies shows that their effectiveness can be attributed to a multi-faceted approach, including one or more of the following research design features: 1) collecting data from multiple research platforms, 2) utilising appropriate behavioural sampling techniques, 3) monitoring several response measures simultaneously, 4) supplementing opportunistic observations with controlled experiments, 5) analysing existing, historical data, and 6) taking advantage of innovative technologies. Nowacek *et al.* (2001a) incorporated all of these attributes to quantify the responses of individual bottlenose dolphins to vessel approaches. In their study, opportunistic observations of the approaches of passing vessels, made from an independent research vessel, were complemented by controlled vessel approaches, monitored from a newly developed overhead video system. Focal-animal sampling in the context of this multi-faceted methodology made it possible to document differences in both surface and sub-surface reactions to vessels by individually identified dolphins, each of whose history, age, gender, and reproductive condition were well known. As a result, Nowacek *et al.* (2001a) were able to identify a class of individuals that were particularly at risk. Taken together, complementary methods can be used to identify and minimise the shortcomings of solitary techniques. Such research designs facilitate cross-validation of findings and restrict biases and confounding factors, thus maximising the likelihood of detecting and defining effects, if any exist.

The scale of the cetacean-focused tourism industry, and its continued growth worldwide, calls for expansion and refinement of the ways in which potential impacts are monitored. In this chapter, we have highlighted several case studies that help to point the way for future research. We encourage colleagues to continue to build on the creative traditions within the field of cetacean biology, as well as to seek inspiration from other fields of research. We hope that the points made in this chapter will help to elevate and refine understanding of the effects of nature-based tourism on cetaceans, and thereby, minimise any potential impacts by promoting sound scientific evidence as the basis for informed management policies.

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APPENDIX I – RESEARCH ABSTRACTS

Allen, M. C., and Read, A. J. (2000). Habitat selection of foraging bottlenose dolphins in relation to boat density near Clearwater, Florida. *Marine Mammal Science* 16, 815–824.

Allen and Read (2000) conducted opportunistic observations of bottlenose dolphins (*Tursiops truncatus*) to assess potential effects of vessel traffic on foraging behaviour and habitat selection. Although this study does not specifically evaluate the effects of cetacean-based tourism, it illustrates a good design for comparing disturbance situations. Focal-animal sampling of identified individual dolphins from an independent research vessel was used to compare dolphin behaviour between two sites that varied in degree of human use and vessel density, and between two time periods (weekdays, weekends) that varied in vessel density. Within follows, instantaneous sampling was used to quantify dolphin behaviour (foraging *vs.* not foraging), dolphin location, and number of vessels underway within 800 m. Collection of fine-scale data on both spatial and temporal scales enabled quantification of short-term responses of dolphins to changes in vessel traffic. Research findings included; (1) dolphin foraging frequencies did not differ between the two time periods despite greater vessel activity on weekends and (2) habitat selection by foraging dolphins differed between the two time periods. At one site, foraging dolphins showed preferences for certain habitats during low vessel activity but habitat preferences were not apparent during periods of high vessel activity. The results suggest that dolphins may shift habitat use either to directly avoid areas of high vessel traffic or in response to vessel traffic.

Barr, K., and Slooten, E. (1998). Effects of tourism on dusky dolphins at Kaikoura. International Whaling Commission Scientific Committee, SC/50/WW10. 30 pp.

Opportunistic observations, from a cliff-top vantage point, of groups of dusky dolphins (*Lagenorhynchus obscurus*) were used to quantify exposure and responses to commercial and private dolphin watch vessels. The following information was recorded for dolphin groups; movement patterns and group dispersion were recorded via theodolite, surface behaviour, swimmer activity, and vessel activity were recorded via scan sampling. Although the goal was to record these data in the presence and absence of vessels, dolphins were seldom without boats nearby (i.e. dolphins were accompanied by vessels during 72% of observations). Other findings included: (1) nearly 10% of vessel approaches to dolphins violated national Marine Mammal Protection Regulations; (2) numbers of leaps and directional changes were significantly higher when a mix of vessels types was present; and (3) substantial changes in dolphin behaviour occurred when vessels were present during the afternoon. These findings led to conclusions that (1) despite long term exposure to vessels, dolphins still reacted to boat activity; (2) it would be difficult to determine whether boats and swimmers affect dolphin behaviour when periods without boats and swimmers were so few; and (3) dolphins may be more sensitive to disturbance in the afternoons, which is their normal resting period.

Bejder, L., Dawson, S. M., and Harraway, J. A. (1999). Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science* 15, 738–750.

Opportunistic observations were used to quantify responses of Hector's dolphins (*Cephalorhynchus hectori*) to casual swimmers and to a commercial dolphin-watch operation. The location, orientation and spread of a focal group of dolphins relative to swimmers or vessels were tracked by theodolite from a cliff-top vantage point. Findings included: (1) swimmers and the dolphin-watch vessel were present during 11% and 12% of observations, respectively; (2) 43% of in-water encounters were at least 'potentially disturbing'(i.e. dolphins moved >200 m away within 5 min of an approach by swimmers); (3) dolphins were more tightly bunched when the dolphin-watch vessel was in the bay; and (4) dolphins appeared to be initially attracted to the dolphin-watch boat but tended to orient away from the vessel if the encounter lasted >70 min. Given the importance of this bay to the small, resident dolphin population Bejder *et al.* (1999) suggested that some individual dolphins may be disproportionately affected by cetacean-focused tourism, and the potential for increased disturbance through an increase in tourism to the area may be cause for concern.

Constantine, R., and Baker, C. S. (1997). Monitoring the commercial swim-with-dolphin operations in the Bay of Islands, New Zealand. Department of Conservation, Wellington, New Zealand. 59 pp. [Available from the Department of Conservation, Wellington, NZ].

Commercial tour vessels were used as the research platform to monitor responses of groups of common and bottlenose dolphins (*Delphinus delphis* and *Tursiops truncatus*) to swim-with-dolphin operations in the Bay of Islands, New Zealand. They recorded predominate group activity upon the first sighting of a group (around 400 m), and this was subsequently reassessed when the tour vessel was within 100 m. Their findings included species-specific differences in response to vessel approaches (e.g. 32% of vessel approaches to bottlenose dolphins resulted in changes in group activity with feeding being the activity least likely to be disrupted and socialising most likely), whereas, 52% of approaches to common dolphins resulted in behavioural change with resting least likely and socialising most likely to change. They also evaluated responses of dolphin groups to specific swimmer placement methods, finding that the 'line abreast' strategy resulted in lowest rates of avoidance but also low rates of swim success; in contrast, 'in path' resulted in highest rates of avoidance.

Constantine, R. (2001). Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus*) due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science* 17, 689–702.

Opportunistic observations were used to document behavioural responses of groups of bottlenose, to swim attempts by commercial swim-with-dolphin tour operators during 1997–98. To obtain a longitudinal perspective, these data were compared with findings from an earlier study conducted in 1994–95 in the same location using the same methods (Constantine and Baker 1997). Photo-identification and survey techniques were used to estimate the exposure of individual dolphins to swim-with activities in this region. Behavioural response measures included 'interaction', 'neutral', and 'avoidance', recorded during swim attempts using systematic scan sampling of dolphin groups from a vantage aboard commercial tour vessels. Dolphin response was also evaluated with respect to method of swimmer placement in the water (e.g. 'line abreast', 'in path', or 'around boat'). Research findings included (1) tour operators' success with swim attempts decreased from 48% to 31% between study periods; (2) avoidance by dolphins to swim attempts increased from 22% to 31% between study periods; (3) dolphin response varied according to swimmer placement; (4) during successful swim attempts, juveniles were significantly more likely to interact with swimmers than adult dolphins; and (5) the 'average' dolphin in this region was estimated to be exposed to 31 swim attempts per year, a level of exposure which suggests that dolphins have become sensitised to swim attempts.

Culik, B. M., Koschinski, S., Tregenza, N., and Ellis, G. M. (2001): Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to acoustic alarms. *Marine Ecology Progress Series* 211, 255–260.

This study examined the responses of small groups of harbor porpoises to gillnets with and without acoustic alarm devices (pingers). Although this study does not specifically evaluate effects of cetacean-based tourism, it illustrates a good design for experimentally determining effects of an acoustic (or disturbance) stimulus on cetacean behaviour. Porpoise behaviour was recorded during three controlled conditions in a before/during/after design: (1) an artificial non-lethal gillnet with no acoustic pinger (5 days), (2) the same net with a continuously operating pinger (5 days), and (3) the same net after removal of the pinger (2 days). Assessment of responses to the acoustic stimulus was based on tracking movement patterns of small groups of porpoises via theodolite from land. Findings included that porpoises did not appear to react to presence of an experimental net, but pinger operation resulted in an exclusion zone around the net. Avoidance distance during pinger operation (median = 530 m) was estimated to correspond to the audible range of the acoustic alarm.

Goodson, D. A., and Mayo, R. H. (1995). Interactions between free-ranging dolphins (*Tursiops truncatus*) and passive acoustic gill-net deterrent devices. In *Sensory Systems of Aquatic Mammals.* (Eds R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall). pp. 365–379. De Spil Publishers, Woerden: The Netherlands.

This study observed bottlenose dolphins under controlled conditions in the Moray Firth, Scotland, to test the potential effectiveness of passive acoustic reflectors in preventing gillnet entanglement. Although this study does not specifically evaluate effects of cetacean-based tourism, it illustrates a good design for controlled experiments that mimic an impact situation. One or more simulated gillnets with acoustic reflectors attached was tethered at a near-shore location frequented by dolphins on a daily basis. To record dolphin responses to the experimental 'net', the movements of one or more dolphins were tracked by theodolite from land, and vocal behaviour was monitored using moored sonobuoys and a seabed hydrophone array cabled to shore. These observations were used to establish ranges at which dolphins could detect acoustic reflectors via sonar, to test responses of dolphins to acoustic reflectors, and to relate echolocation behaviour to avoidance responses. Findings included: (1) all echolocating dolphins appeared to detect the barriers at ranges of >50 m and modified their travel paths to avoid collisions; (2) detection echolocation behaviour was evidenced by a sudden increase in sonar activity and subsequent 'locked-to-target' patterns; and (3) non-echolocating dolphins travelling in association with others appeared to follow the course of the group and thereby avoid collision; however, a small percentage of solitary non-echolocating animals remained at risk of collision despite acoustic reflectors.

Janik, V. M., and Thompson, P. M. (1996). Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. *Marine Mammal Science* 12, 597–602.

Opportunistic observations of the surfacing patterns of groups of bottlenose dolphins (*Tursiops truncatus*) were used to assess the responses to boat traffic. A narrow channel frequented by dolphins and vessels provided an opportunity to conduct video surveillance from shore, thereby recording all occurrences of a specified behavioural event, 'surfacing' within a circuM.Sc.ribed area. Surfacings could be counted readily from the video record and total numbers compared before and after (±1 min) vessel approaches. As a control, surfacing numbers were also calculated for random 1-min periods when no boats were present. Findings included: (1) the dolphin-watch vessel was responsible for the majority of boat-dolphin encounters and differed from other vessels in its movements around dolphins; and (2) the total number of dolphin surfacings decreased significantly after the dolphin watch vessel approached; however, no such pattern was apparent in encounters with other vessels or in the control data. Although the behaviour of individual animals was not recorded in this study, the decrease in the number of surfacings can clearly be interpreted to indicate that at least some of the dolphins were diving for longer periods and/or moving away from the dolphin watch vessel. This result may be due to differences in the behaviour of the dolphin watch vessel (e.g. this vessel typically remained in the channel for longer periods and attempted to stay close to dolphins).

Laist, D. W., Knowlton, A. R., Mead, J. G., Collett, A. S., and Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science* 17, 35–75.

This study analysed historical records to quantify the frequency of ship strikes on large whales and investigate contributing factors. Historical records of collisions for the early 1600s into the 20th century were gleaned from newspaper reports, scientific publications, and early stranding records. More recent accounts were obtained from stranding databases, scientific publications, a survey conducted in the 1970s, and a recent request for information on 'Marmam.' Specific details were recorded for each collision report. Historical information on the speed and number of vessels was obtained from Lloyds Register of Shipping. Findings included: (1) 11 species of great whales (*i.e.* baleen and sperm whales) are known to be hit by ships, with fin whales being struck most often; (2) fatal ship strikes first occurred in the late 1800s when ships attained speeds of 13–15 kn, and increased during the 1950–70s as vessel numbers and speed increased; and (4) factors contributing to ship strikes include length and speed of vessel, with most injurious collisions involving vessels that are >80 m in length and/or travelling at speeds of >14 kn.

Lesage,V., Barrette, C., Kingsley, M. C. S., and Sjare, B. (1999). The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada. *Marine Mammal Science* 15, 65–84.

This study used controlled experiments to study effects of vessel noise on the vocal behaviour of beluga whales (*Delphinapterus leucas*) at a location where whales are chronically exposed to vessel traffic. Although this study does not specifically evaluate effects of cetacean-based tourism, it illustrates a good design for controlled experiments and careful handling of acoustic data. Vocal and surface behaviour of beluga groups were simultaneously recorded during pre-exposure, exposure and post-exposure conditions. The exposure condition consisted of controlled approaches by two familiar but different potential sources of acoustic disturbance: an outboard motorboat moving rapidly and erratically, and a ferry moving slowly and on a predictable path. Acoustic recordings were made from a hydrophone installed at 3–6m on the sea bottom. Vocalisations were classified using a scheme developed for arctic belugas (Sjare and Smith 1986), and exceptional care was taken to include only those samples in which all calls could be counted. Thus out of 77 experiments, only six satisfied the criteria for acoustic analysis. Despite a small sample of experiments with suitable recording quality, results showed that both vessels induced changes in calling rates, increased call durations, an upward shift in the frequency range, and a tendency to emit calls repetitively, an increase in call duration, with responses to the larger ferry being more persistent.

Mann, J., and Smuts, B. (1999). Behavioral development in wild bottlenose dolphin newborns *Tursiops* sp. *Behaviour* 136, 529–566.

Opportunistic behavioural observations of bottlenose dolphins were used to evaluate the effects of food provisioning on maternal and calf behaviour during the first 10 weeks of the calves' lives. Focal sub-group sampling (mother and calf) was carried out in which the behaviour of provisioned dolphins within a human-interaction area on shore was compared with the behaviour of the same dolphins as well as wild-feeding dolphins away from the human-interaction area. Because of the unusual circumstances in which specific dolphins visit a resort beach on a near-daily basis to be food provisioned by humans, detailed behavioural records for individual dolphins from shore were available. Focal follows of individually-identified mothers and calves away from the human-interaction area were conducted using an independent vessel as research platform. The time that calves spend in echelon swim with the mother was used as a behavioural measure of maternal care, as the calf may derive energetic benefits from swimming in contact with, or in the slipstream of, the mother. Mann and Smuts (1999) found that, although echelon swimming with the mother was common away from the human-interaction area both for provisioned and wild-feeding dolphins, the proportion of time calves spent in echelon swim position was significantly lower when provisioned dolphins were in the human-interaction area. Furthermore, away from shore, mothers foraged and socialized more often than mothers did while in the human-interaction area.

Miksis, J. L., Connor, R. C., Grund, M. D., Nowacek, D. P., Solow, A. R., and Tyack, P. L. (2001). Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (*Tursiops truncatus*). *Journal of Comparative Psychology* 115, 227–232.

This study used controlled experiments to assess the cardiac responses of two captive bottlenose dolphins to acoustic playback stimuli. Although this study does not specifically evaluate effects of cetacean-based tourism, it illustrates the potential use of physiological measures to evaluate cetacean responses to anthropogenic stimuli. Three categories of playback stimuli were used: (1) pool noise; (2) signature whistles from familiar poolmates; and (3) agonistic jaw claps from familiar poolmates. Heart rate responses were measured acoustically using a suction-cup hydrophone that each animal was trained to wear while remaining at station. This set-up allowed for continuous acoustic monitoring of cardiac activity before, during and after playback trials. By comparing the spacing and duration of the 10 heart beats preceding each acoustic stimuli with those of the 20 heart beats following playback stimuli, researchers found; (1) during the first set of 10 heart beats following the playback, all three acoustic stimuli elicited accelerated heart rates, with a significant increase in heart rate in response to jaw claps; and (2) during the subsequent 10 heart beats following the playback, pool noise responses returned to baseline whereas responses to conspecific vocalisations continued to accelerate. Results indicated 'patterns of defense and startle response consistent with those observed in humans and nonhuman primates.'

Miller, P. J. O., Biassoni, N., Samuels, A., and Tyack, P. (2000). Whale songs lengthen in response to sonar. *Nature* 405, 903.

This study used controlled experiments to assess the effects of man-made underwater sound, specifically, low-frequency active

(LFA) sonar on the vocal sexual displays of male humpback whales (*Megaptera novaeangliae*) near the Big Island, Hawaii, USA. Although this study does not specifically evaluate effects of cetacean-based tourism, it illustrates a good design for conducting controlled experiments at sea. A small, independent observation vessel was used to conduct focal-animal follows of individual whales before, during and after sound playbacks; strictly speaking, the study evaluates effects of LFA sonar on a whale already being followed by a research vessel. Non-vocal behaviour of the focal whale was recorded using systematic behavioural sampling, techniques while the vocal behaviour of the focal was recorded using a towed, hydrophone array. Each focal whale was typically followed for the duration of two or more songs before and after the sound playback; a playback typically consisted of ten 42-s LFA signals, broadcast at less than full strength at 6-min intervals, transmitted from a separate vessel. A variety of responses were identified, including: (1) in nine of 18 playback experiments, the focal singer stopped singing; in at least five of these, cessation of song appeared to be a response to the sound playback; and (2) songs of whales who sang continuously throughout experiments were 29% longer during LFA playbacks, suggesting that whales sang longer songs to compensate for acoustic interference.

Nowacek, S. M., Wells, R. S., and Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science* 17, 673–688.

This study quantified the behavioural responses of individual bottlenose dolphins to controlled experimental vessel approaches and opportunistic approaches by passing vessels. The study population is resident to Sarasota Bay, Florida, USA, where dolphins are regularly exposed to high levels of vessel traffic. On average each dolphin is approached by vessels to within 100 m once per six minutes during daylight hours. Assessment of dolphin responses was based upon focal-animal follows of 33 individually identified dolphins of known age and sex from an independent research vessel. Systematic behavioural sampling techniques were used to quantify dolphin behaviour in the presence and absence of vessel approaches. Opportunistic observations provided information about dolphin behaviour observable at the water's surface (inter-breath intervals, IBI). Controlled experiments made it possible for researchers to use a tethered blimp mounted with an overhead video system (Nowacek *et al.* 2001b) in order to assess sub-surface measures of behavioural response (inter-animal distance, heading and speed via fluke stroke counts). Observations of individually identified dolphins whose histories were well-known (Wells *et al.* 1987) made it possible for researchers to compare responses of different classes of dolphins. Findings included: (1) dolphins had longer IBI during vessel approaches compared to control periods; (2) during vessel approaches, IBI length was inversely correlated with distance to nearest boat; (3) dolphins decreased inter-animal distance, changed heading, and increased swimming speed more often during vessel approaches than during control periods; and (4) females without calves and inexperienced mothers had significantly different IBI from experienced mothers, with experienced mothers having the longest IBI of any class of dolphin during vessel approaches.

Richter, C. F., Dawson, S. M., and Slooten, E. (2001). Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Final Report for Research Investigation No. 2370. [Available from the Department of Conservation, Wellington, New Zealand].

Opportunistic observations of individual sperm whales (*Physeter macrocephalus*) were used to assess effects of whale-watch vessels on vocal and non-vocal behaviour. Whale movement patterns were recorded via theodolite from land. At other times, visual and acoustic behaviour was recorded from an independent research vessel. Strictly speaking, boat-based observations considered the additional impact of whale-watch vessels on whales already being followed by a research vessel. In boat-based follows, individual whales were tracked acoustically underwater using directional hydrophones. During each surfacing, the following information was recorded for the focal whale: initial and final position, timing of surfacing/dive, blow intervals, initial and final heading, all occurrences of specified aerial behaviours, presence/absence of whale-watch vessels and aircraft, and identification via fluke photos. Following each dive, the time elapsed from fluke-out to first click was also recorded. In the presence of whale-watch vessels (1) whales significantly increased time spent at the surface and frequency of heading change; (2) whales decreased frequency of aerial behaviours; (3) transient whales significantly increased the time to first click, whereas resident whales did not. The findings of Richter *et al.* (2001) highlight individual variation in behaviour of sperm whales and they suggest that resident whales are more tolerant of vessels than transient whales.

Samuels, A., and Bejder, L. (1998). Habitual interaction between humans and wild bottlenose dolphins (*Tursiops truncatus*) near Panama City Beach, Florida. Marine Mammal Commission, Silver Spring, Maryland. 13 pp. [Available from the MMC, Bethesda, Maryland, USA].

Samuels, A., and Bejder, L. (in press). Habitual interaction between humans and free-ranging bottlenose dolphins (*Tursiops truncatus*) near Panama City Beach, Florida, USA. *Journal of Cetacean Research and Management.*

This study used opportunistic observations of bottlenose dolphins near a state recreation area in Panama City Beach, Florida, USA, where dolphins have regular in-water encounters with members of the public and commercial tour operators. Photo-identification combined with behavioural assessment of all dolphins encountered were used to estimate what proportion of the local dolphin community was involved in interactions with humans. In addition, focal-animal follows of individual dolphins and small groups of dolphins from an independent research vessel were used to compare the behaviour of members of the same dolphin community that did and did not have interactions with humans. During follows, systematic behavioural techniques were used to quantify dolphin behaviour and proximity to human activity. Findings included: (1) 7 of 89 dolphins encountered had habitual interactions with humans and were classified as 'habituated'; (2) habituated dolphins engaged in interactions with humans during 77% of observation time; whereas, unhabituated dolphins never exhibited any human-dolphin interaction behaviours; (3) habituated dolphins remained in a small area where tourists congregate, whereas unhabituated dolphins travelled distances of several nautical miles during follows; (4) a high rate of food provisioning by humans indicated that human-dolphin encounters at this location were likely to be sustained by feeding; and (5) a focus on one juvenile dolphin revealed that this immature dolphin was at risk of injury or death once per 12 min as a result of proximity to humans, and was fed by humans once per 39–59 min.

Waples, K. A., and Gales, N. J. (2002). Evaluating and minimizing social stress in the care of captive bottlenose dolphins (*Tursiops aduncus*). *Zoo Biology* 21, 5–26.

The behaviour and physical health of individual captive bottlenose dolphins were monitored during the months leading up to one case of illness and two cases of mortality within the group. Although this study does not specifically evaluate stress and distress as a consequence of cetacean-based tourism in the wild, it illustrates the potential for correlating behavioural and physiological measures to evaluate stress. Specifically, a detailed study of the behaviour of individual animals was complemented by periodic blood samples from the same individuals as well as their health records. The behavioural data documented changes in social dynamics and association patterns within the group (measured by close proximity, physical contact, and synchronous movements between individuals); these behavioural measures were correlated with physiological measures of stress and health. The stress resulting from social instability, either from the perceived threat from group members or from changes within dominance hierarchy, contributed to documented mortalities and illnesses.

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science* 2, 251–262.

This study reviewed historical, anecdotal records to assess changes in whale responses to vessels near Cape Cod, Massachusetts, USA, from 1957 to 1982. *Ad libitum* descriptions of whale behaviour were based on opportunistic observations of scientists on research cruises in the region. By comparing data collected before (17 years) and after (8 years) the advent of commercial whale-watch activities, Watkins (1986) was able to look at long-term trends and show gradual changes in whale behaviour in relation to vessels. Watkins (1986: 252) noted that although 'the records are largely anecdotal and not readily quantifiable… they are representative and fairly depict the observable whale reactions.' Findings included: (1) whales apparently reacted to three kinds of stimuli produced by human activities: underwater sound, light reflectivity, and tactile sensation; (2) whale reactions were related to their perception of stimuli as interesting or disturbing, expected or unexpected, and as moving towards or away; and (3) exposure to presence of human activities resulted in some species-specific behavioural changes (i.e. avoidance responses by humpback whales (*Megaptera novaeangliae*) prior to whale watch activities have largely been replaced with 'positive' curious responses). Whereas, initially positive responses by minke whales (*Balaenoptera acutorostrata*) have changed to avoidance with exposure to whale watch activities.

Williams, R. M., Trites, A. W., and Bain, D. E. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology (London)* 256, 255–270.

This study quantified the responses of killer whales to whale-watch vessels. Specifically, they tested the relevance of the 100 m minimum approach distance specified in a voluntary code of conduct. Twenty-five individually-identified whales of known age and sex were tracked one at a time by theodolite during near-shore foraging (when animals are spread out searching for food). At the same time, observers recorded all occurrences of specified 'surface-active' behaviours by the focal whale. Observations were conducted from an elevated cliff-top from which whales could be observed both within a reserve where there was relatively little boat traffic and within adjacent waters where whale-watch vessels congregated. These methods provided information about dive times, swim speed, 'directness' of travel, and frequency of specified behaviours for individual whales under several conditions: (1) no vessels within 3 km, (2) experimental vessel approaches, and (3) opportunistic approaches of vessels. Experimental approaches followed a 'before/during' design in which 20 min of no-boat observations were followed by a controlled approach in which the experimental vessel mimicked vessel behaviour specified in local whale-watching guidelines. Findings included: (1) male whales swam significantly faster than females, indicating the potential for sex-specific responses to vessel traffic; (2) whales responded to experimental approaches by swimming in a less direct path; and (3) females responded by swimming faster and increasing the angle of successive dives.