Report of the Workshop on the Science for Sustainable Whalewatching

BREAKWATER LODGE

CAPE TOWN, SOUTH AFRICA

6 – 9 MARCH 2004

1. WELCOME

Oosthuizen welcomed the workshop participants and extended thanks to the British High Commission in South Africa and the United Kingdom Department of Foreign Affairs for funding the workshop. He also thanked those participants who funded their own attendance at the workshop. Next, Brownell welcomed the participants.

2. OPENING REMARKS

The objective of the workshop is to ensure that the best science is available for the sustainable management of whalewatching. Sustainable whalewatching needs to address the full "triple bottom line" of environmental, social and economic issues.

3. APPOINTMENT OF THE CHAIRMAN AND RAPPORTEURS

Brownell was appointed Chair, with Oosthuizen as his co-Chair. Corkeron and Williams were appointed rapporteurs.

4. BACKGROUND AND TERMS OF REFERENCE

Whalewatching is observing free-ranging cetaceans. This includes human activity from all platforms (vessels, aircraft, land), as well as swimming with and feeding cetaceans. The need for a workshop on the science of sustainable whalewatching was identified in the International Whaling Commission's (IWC) 2001 Scientific Committee meeting in London. At the 2003 meeting in Berlin, the Scientific Committee endorsed the idea of this workshop. An Intersessional Steering Group was created, with Birtles agreeing to serve as its Chair. The role of this Steering Group was to assist with the scientific aspects that should be included in the workshop agenda.

Whalewatching is recognised as having substantial social, economic and educational benefits and is growing worldwide (Hoyt 2001). In some countries the industry is expanding exponentially and in others there is pressure to allow the expansion of whalewatching. However, an increasing body of evidence suggests that whalewatching can impact individual cetaceans and populations. The workshop considered that proactive management of whalewatching is needed to ensure the industry's sustainability. Doing nothing is not considered an appropriate management response.

One approach is to see whalewatching managed in such a way that the quality-of-life, health and well being of individual cetaceans are addressed. Another approach requires evidence of population-level impacts of whalewatching on cetaceans before intervening. The difficulty of monitoring population-level trends in free-ranging cetaceans is notorious. Attributing any of these definitively to whalewatching is even more complex. In this context, it was agreed that managers concerned with impact on the level of populations should be encouraged to minimise impact on individual cetaceans. Preventing disruption of critical life-history processes at the individual level is one way to prevent population-level impacts of whalewatching on cetaceans from ever occurring.

The terms of reference for the workshop are:

"(i) to review the scientific basis for management of whalewatching, and (ii) to discuss future management development and implementation frameworks to ensure both the minimisation of negative impacts and optimal sustainable tourism."

5. ADOPTION OF THE AGENDA

The agenda was adopted as amended. The adopted agenda for the workshop is given in Appendix 1. Workshop participants are listed in Appendix 2.

6. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to the workshop were considered and are listed in Appendix 3.

7. SHORT DISCUSSION OF NATIONAL MANAGEMENT REGIME CASE STUDIES

AVAILABLE MANAGEMENT ACTIONS

Discussion of the national management regime case studies was initiated in the open workshop where the group heard presentations from several countries, including Taiwan, New Zealand, South Africa, México, Australia, USA, the UK, Brazil and Spain, including the Canary Islands. (See list of working papers in appendix ZZ.) National management regimes have also been well covered in recent reports on whale watching, notably the IFAW Report of the Workshop on the Legal Aspects of Whale Watching (IFAW, 2000). It was recognised that there is a wide range of situations around the world including different developmental stages, scales of operation and management approaches. The success of these approaches has varied from country to country and from location to location.

A number of options, used individually or in combination, are available for managing the effects of whale watching on cetaceans (Table 1). These may be put into practice through regulations, permit conditions, codes of conduct, voluntary codes of practice (or guidelines), or in the case of education, through targeted education programmes. One or more of these mechanisms for implementation of management options may be used depending on location and local circumstances.

Regulations and permit conditions provide the greatest level of management certainty and control, although voluntary codes of conduct can be effective where there is good industry cooperation. Education is an important tool in almost all circumstances especially where recreational marine mammal watching occurs.

Typically, **closed areas** are used to protect identified areas of significance to marine mammals; e.g. breeding or calving areas, nursery areas and important feeding grounds. Examples from around the world, implemented as a result of research studies in each area, include:

- two designated resting areas for bottlenose dolphins in the Bay of Islands, New Zealand, closed to commercial dolphin watching; and
- a quasi-reserve for killer whales in Robson Bight, British Columbia, Canada, which community and provincial government pressure keeps closed largely to whale watching boats.

Seasonal closures could also be employed to restrict whale watching during critical time periods such as at breeding grounds when newborn calves are present. An example of this is:

- Breeding and calving lagoons, Mexico, where certain areas are closed to anchoring and observing gray whales, as well as navigating and passenger disembarkation.

Closures may also be limited to certain **times of the day** to protect key behavioural periods. They could also be species specific or targeted at certain behavioural states. Examples include:

- a time-off period between 11.30 and 1.30 each day for dusky dolphin viewing at Kaikoura, New Zealand; and

- a rest period between 11.30 and 1.30pm is being introduced for bottlenose dolphins in the Bay of Islands, New Zealand.
  Both of these examples were based on behavioural studies on the impact of tourism on dolphins in these areas (see reference list for examples).

Commercial operations may be managed through **controls on the number of permits or the number of specific whale watching platforms**, including the type of platform: e.g., swimmers, kayaks, boat type, aircraft type, and propulsion system.

- Permits are required for commercial whale watching platforms in Queensland, Australia; throughout New Zealand, in the Canary Islands, and for commercial viewing of whales (but not dolphins) in South Africa. All of these permits include controls on number and type of platform. In some areas of the world, certain platforms are prohibited (such as aircraft or swimming).
- Swimming with cetaceans is banned in some countries, e.g. Mexico, Spain. In the United States, while not specifically banned, swimming is effectively discouraged through the Marine Mammal Protection Act, which forbids harassment. In Australia and New Zealand, there are swim-with cetaceans programmes that are regulated by permit. In South Africa, regulations prevent swimming with cetaceans. Management decisions have been based on varying degrees of science and a precautionary approach.
- Dolphin feeding programmes are regulated under permit in some states in Australia. Although unauthorised, feeding also occurs in some places in the USA. Scientific studies indicating unacceptable juvenile mortality at one feeding station in Australia (Mann *et al*. 2000) has resulted in management action, including action to phase out one feeding station.

Other effort controls include **limits on the duration of encounters** with cetaceans, **time between encounters**, the **total length of trips** and the **number of trips** that may be undertaken within a specified time period. Typically, these are implemented through commercial whale watching permits; for example, in New Zealand, Australia and South Africa. For viewing whales (excluding dolphins) in South Africa, there are limits on the number of boats, the length and number of encounters per group in a day and the time between encounters.

There are a large number of possible conditions that can be used to manage the behaviour of people and platforms in the immediate vicinity of cetaceans. The conditions governing behaviour around cetaceans in New Zealand are appended (Appendix 4) to help demonstrate what can be used in this regard and include:

- Approach distances
- Approach and departure speeds
- Approach orientation
- Numbers of platforms in the vicinity of cetaceans
- Restrictions on swimming with cetaceans.

At greater distances from cetaceans, speed controls may be implemented, mainly to reduce the risk of boats accidentally hitting cetaceans (*e.g.*, in Hervey Bay, Queensland, Australia), but also for other reasons such as minimising noise generation.

There are many educational tools available including pamphlets, signage, media campaigns, and public interaction, which are used to varying degrees in many areas of the world. In southern New England, USA, in the Stellwagen Bank National Marine Sanctuary, there is an active educational programme aimed at recreational boaters in the vicinity of cetaceans. In this same area, there are specific on-board education programmes, including numerous brochures and other educational items aimed at whale watchers, operators and naturalist guides. In the Canary Islands, educational courses aimed at operators and guides have improved the level of compliance with regulations.

7.1. DISCUSSION OF THE SCIENTIFIC BASIS FOR MANAGEMENT OF WHALEWATCHING

Basic biological information on cetacean populations is needed in order to assess impact of whalewatching on individuals or stocks. Some small populations may be so critically endangered that no whalewatching would be advisable.

A common theme in the discussions about management and science is that both need to be species- and location-specific. The scientific recommendations one would make to managers would vary widely depending on the taxonomic group and location. It was **agreed** that scientists should inform managers on a case-by-case basis about relevant research, and the appropriate critical parameters to monitor population status. However, in view of the possible differing levels of impact, it was felt that there is a need for general recommendations about, for example, assessing impact of whalewatching on baleen whales on migration routes, feeding grounds and mating and calving grounds, resident baleen whales, coastal odontocetes, and pelagic odontocetes. Thus, it was **agreed** that examining a variety of case studies would allow us to reach some broad conclusions about assessing impact of whalewatching on different taxonomic groups at a variety of life-history stages.

The response variables that one might measure to assess impact of whalewatching on cetaceans would also differ among taxonomic groups and life-history stages. Workshop participants, working from the list developed from the Whalewatching Subcommittee (Simmonds *et al*. 2001, IWC 2002), identified several of these candidate response variables, but noted that these variables varied widely in their importance, their feasibility to be measured, the timeframe required to supply the needed information, and the ability for scientists to attribute the critical response to the effects of whalewatching. The consensus opinion on critical response variables to be measured and the time frames in which they might be measurable is given in Table 2. A list of some suitable methods to do conduct such studies is presented in Table 3. Specific case studies are considered in more detail in the following sections. Where relevant peer-reviewed papers are known, they are referred to in the text.

7.1.1. Baleen whales on migration routes

An example of a migrating baleen whale is the gray whale in the northeast Pacific. The whalewatching industry on migrating gray whales has been largely unregulated for decades without demonstrated impact on whales. The number of boats around migrating gray whales is unrestricted, but the population continues to grow, and appears to have reached carrying capacity. However, it was noted that certain types of vessel approaches caused gray whales to divert from their migration path (Heckel et al. 2003), which, over time, could carry energetic costs to whales or make calves more vulnerable to predation. Alternatively, the fact that individuals are not subjected to repeated disturbance may make this population inherently robust to whalewatching.

In order to assess whether whalewatching traffic were causing deflection of migration paths, shore-based tracking can be used in conjunction with a good experimental design. This would include observations of focal individuals before, during and after (BDA) controlled approaches and BDA studies including extra controls (BDACI). The resulting data could be used to model whether boat traffic increased energetic demand of focal animals.

7.1.2. Baleen whales on feeding grounds

Baleen whales on their high-latitude feeding grounds, such as humpback whales in British Columbia, Canada, may be especially vulnerable to disturbance from whalewatching boats. These animals have a short period of time in which to replenish energy reserves that were utilised during migration. Baleen whales on the feeding grounds are more likely to be subjected to repeated disturbance than migrating whales. Another concern due to repeated disturbance might be displacement of animals from productive feeding areas.

Consequently, one important response variable to monitor is the foraging activity of baleen whales on the feeding grounds. This could be achieved using telemetry, tracking and/or acoustic studies, using BDA and BDACI experimental designs.

7.1.3. Baleen whales on breeding grounds

The southern right whale population in South Africa was used as a case study for discussing management of watching baleen whales on breeding grounds. Despite the approaches of cow-calf pairs being totally restricted in South Africa, the energetic consequences of disruption of parental care (possibly due to inadvertent approaches) could be a concern. Currently, the principal nursery areas are closed to whalewatching. Furthermore, the consequences of animals being attracted to vessels are uncertain.

It was noted that an important critical response variable to measure in this case could be calf survivorship. This could be achieved over the long term using photo-identification and an experimental design involving areas that would be open and closed to whalewatching activity. It should be noted that a 20-year pre-whalewatching industry photo-identification database exists for the South African right whale population.

It was noted that the terms "breeding grounds" and "calving grounds" are not synonymous. For example, the focus of the dwarf minke whale aggregations in the Great Barrier Reef, currently subjected to swim-with programs, is likely to be mating, whereas calving appears to be diffuse around the continental shelf of the southern half of Australia.

7.1.4. Non-migratory baleen whales

Several populations of baleen whales do not follow the typical balaenopterid life-history strategy of feeding at high latitudes and mating and calving in the tropics. Examples include humpbacks whales in the Arabian Sea, Gulf of California fin whales and Bryde's whales on the southern coast of South Africa. These populations represent a special case, due to their vulnerability because mating, feeding and calving is present in the same area.

For animals such as these, the conservation concerns outlined for breeding, feeding and migrating baleen whales apply all at once.

7.1.5. Odontocetes: coastal closed population

Coastal, closed populations of odontocetes tend to live in small populations, which are at inherently greater extinction risk than large populations. Examples include the resident, fish-eating populations of killer whales in the northeast Pacific and bottlenose dolphins in the Moray Firth, Scotland. The probability that individuals in closed populations will be exposed to whalewatching traffic repeatedly is higher than in open ones, thus it was noted that these cetaceans in closed coastal areas might be particularly vulnerable to the cumulative impacts of exposure to whalewatching activity. They are also often affected by various density-dependent factors such as resource limitation. The added energetic demand on individuals could affect populations. Added energetic demand can be assessed by quantifying the effects of interactions with boats on behavioural budgets (Lusseau, 2004), and relating these effects to their energetic costs (Williams *et al*., in prep.).

These animals tend to be highly social species, and an individual's social relationships may be an essential ingredient in determining what is its critical habitat. Thus, coastal, closed populations of odontocetes may be at special risk of disruption of social bonds and being displaced from important habitat.

7.1.6. Odontocetes: coastal open population

This situation refers to coastal whalewatching activity where the range of the target odontocete population is larger than the range covered by the whalewatch industry. From a human impact perspective, this means that these animals are less likely to be approached repeatedly by boats than animals that live in enclosed areas and populations (*e.g*., 7.1.5). This scenario might include the common dolphins off the Canary Islands, Spain. While many critical response variables can be measured on the population level for these animals, linking responses to whalewatching would be particularly challenging. One avenue to pursue might be to examine social behaviour, particularly between females and calves. Another may be to assess changes in distribution.

7.1.7. Odontocetes: oceanic

These populations are wide-ranging and their contact with whalewatching activity is sporadic. This category includes sperm whales generally, with the exception of sperm whales in some settings such as Kaikoura, New Zealand, Andenes, Norway, and in Dominica, eastern Caribbean. It is important for researchers to identify critical periods (e.g., seasonal or diurnal) when these animals are likely to be most vulnerable to disturbance. Habitat displacement is not likely to be a serious problem for odontocetes that are completely pelagic. However, some oceanic odontocetes alternate between the coastal and pelagic environments. Hawaiian spinner dolphins may be exposed to whalewatching while they rest in inshore waters during the day, but are unaffected by whalewatching when feeding offshore at night. Long-finned pilot whales off Cape Breton, Canada, however, appear to feed in the habitat covered seasonally by whalewatchers, and habitat displacement might be a larger concern.

Suitable critical response variables to measure, therefore, would vary widely on a case-by-case basis.

7.1.8. River dolphins

Globally, freshwater cetaceans represent one of the gravest conservation concerns. Their riverine habitat use overlaps strongly with that of human development. Examples include the baiji, boto, tucuxi, and the Ganges and Indus River susu. These animals are notoriously difficult to study at the level of the population, and consequently, linking whalewatching activity to changes in these critical response parameters would be virtually impossible. Researchers concerned with impact of whalewatching on freshwater cetaceans would be encouraged to focus on short-term reactions (including acoustic ones) of individuals, while trying to obtain basic biological information about the population and its habitat use.

8. MANAGEMENT OBJECTIVES AND NEEDS

8.1 WHAT ADVICE MANAGERS REQUIRE FROM SCIENTISTS

It was **agreed** that scientific management of whalewatching is an iterative process, whereby rules are adaptive. It was **agreed** that whalewatching should be managed such that whalewatching does not interfere significantly with the survival or ecological functioning of individuals, populations or species; and that therefore in the short-term, whalewatching should not result in unacceptable adverse change in population dynamics such as reproduction or mortality or impede normal patterns of habitat use or activity, including feeding, resting and reproduction.

The workshop discussed a possible general management approach that has obtained wide acceptance within environmental and marine resource management, focussing on the Principle 15 of the UNCED 1992 – The Rio Declaration:

> *"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."*

This principle has been considered and applied in a number of international and regional instruments, as well as in national legislation related both to fisheries and prevention of marine environmental degradation (IFAW 2000). The Workshop started to develop a framework for management of whale watching similar in concept to those codified in the FAO Code of Conduct for fisheries. Three reference points were suggested:

Target Reference Point: This reference point describes the ideal situation; that is, no impact on the natural or pristine situation. The TRP could include, *inter alia*, recovery of the population to pre-exploitation level; no anthropogenic mortality; no increase in the energetic demand of individuals; no changes in the behavioural budget of animals; no displacement from core areas; no reduction in the energy acquisition of individuals.

Limit Reference Point: This reference point describes the limit when the impact of a whale watching enterprise enters into a situation that is not acceptable, for example, a point above potential biological removal. The LRP should be developed with description of urgent management actions, and legal instruments to implement these, that should be triggered immediately when the limit reference point is exceeded.

Precautionary Reference Point (PRP): All human activity that takes place within an ecosystem has some impact on the system or the environment. The PRP describes how far down the scale from the TRP towards the LRP is regarded as an acceptable situation. This reference point includes an aspect of political acceptance of a risk for entering into an unacceptable situation, and the degree of risk that is regarded acceptable will probably vary according to socio-economic situation and the political situation associated with the respective whale watching case. The PRP should incorporate due consideration of scientific uncertainty (including uncertainty regarding other anthropogenic influences), and should not prevent or delay management decisions in the face of scientific uncertainty.

All reference points need to account for process and measurement uncertainty in our information on the systems under consideration. This means that the PRP and LRP may need to be separated sufficiently that one does not instantaneously (or almost instantaneously) lead to the other. When no data are available, the PRP may need to be set close to or at the TRP.

It was **recommended** that further consideration should be given to developing this approach. Further, it was **agreed** that scientists should participate in developing reference points by providing advice on:

1. Definition of the reference points

2. Critical parameters to measure

3. Techniques to monitor where a system is on the scale between the Target Reference Point and the Limit Reference Point.

In situations where data do not exist, this scheme may be difficult to implement. Therefore, it was noted that there is a need for pre-whalewatching assessment of target cetacean populations. Managers are urged to pay special attention to small populations, which are inherently more vulnerable to extinction than large ones. The meeting acknowledged that most management would need to be precautionary, and if no data are available to set reference points, a further level of precaution is needed.

Additionally, it was noted that there is a role for the social sciences to play in managing whalewatching in a sustainable manner. Managers are encouraged to solicit advice from social and economic scientists in the process of establishing reference points (Birtles et al. 2002a,b; Valentine et al. in press).

An example of the application of this framework is provided investigating the effect of dolphin watching on bottlenose dolphins in Doubtful Sound, New Zealand. In this case the Reference Point that is being considered is the proportion of time that dolphins have boats with them. The Target Reference Point (TRP) could be set at 0% (e.g. boats do not spend any time with dolphins). Studies have demonstrated that the amount of time dolphins spent with boats affected their behavioural budget and resting was the determined to be the most sensitive behavioural state to interactions with boats (Lusseau 2004). Lusseau (2004) showed that when dolphins spend 35% or more of their time interacting with boats, their overall time spent resting was significantly reduced. Based on this scientific study, the Limit Reference Point (LRP) would be set at 35% (e.g. proportion of time that dolphins have boats around them). Therefore the Precautionary Reference Point (PRP) would be set between the TRP of 0% and the LRP of 35%. The setting of this value would be made after including factors such as the degree of risk that is considered acceptable, socioeconomic issues, and a consideration of scientific uncertainty.

Another example of bottlenose dolphins in Milford Sound, New Zealand, is calf mortality related to whalewatching ship strike (Higham and Lusseau 2004). In this example, even one calf death per year is probably unsustainable, due to the small population size and low reproductive rate; therefore the TRP would be zero and the LRP would also be zero. Therefore, any demonstrable calf mortality attributable to whalewatching should trigger management action.

The Workshop developed a list of critical response variables and a set of categories of cetaceans (Table 2). The critical response variables were then ranked (0,1,2,3) relative to how useful they were likely to be for answering questions relating to whalewatching management (Desirable, Important and Critical). Further iteration resulted in decisions regarding which techniques were the most likely to provide data on each variable for each cetacean group (Table 3). This final iteration took account of technical feasibility, statistical power and timeframes likely to be useful for management.

The Workshop also identified specific management options and related these to the critical response variables. These are presented in the legend of Table 1 and provide a general list of options for managers to consider on a case-by-case basis. In addition, an attempt was made to highlight the best options for each variable. However, this latter step was unsuccessful because the options for each critical response variable are very case specific and typically, a range of management options are required.

8.2 HOW SCIENTISTS MEET THESE REQUIREMENTS

It was **agreed** that experiments (rather than opportunistic surveys) are the preferred method for measuring impact of whalewatching on cetaceans. It was further **agreed** that studies on known individual animals are the preferred method for obtaining unbiased records of behaviour. Focal-animal studies provide the basis for quantitative measures of, *inter alia*, sociality, movements, exposure to stimuli, activity and energy budgets – all of which provide the bases 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 detrimentally affected by, or avoid human activity. Conducted over time, such studies provide valuable information about the short-term, seasonal, and long-term impacts of cetacean-focused tourism on the lives of individual cetaceans, on animals of different sex, age class, activity state, or reproductive condition, and on cetacean communities.

Effective impact studies require 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. Controlled experiments include, but are not limited to, spatial and temporal controls (which requires time/area closures) and appropriate replication. For a more detailed review of methods to study impact of nature-based tourism on cetaceans, refer to Bejder and Samuels (2003).

There are multiple ways in which research can inform management of whalewatching. Among these are to assess the nature of the human activity around cetaceans as well as ways to minimise its impacts. Another aspect is to quantify the cost of human activity on the animals themselves. There is a focus on these below.

The impact of interactions depends on their characteristics (*i.e.*, their duration, the behaviour of the boat, the type of vessel etc.) and it is important to define which of these characteristics are the most significant in defining the intrusiveness of an interaction.

Characteristics of interactions

Duration of encounters

Tracking individuals can be used to quantify the maximum duration of an interaction between cetaceans and whalewatching boats. One can model the probability that cetaceans move toward or away from a vessel using shore-based theodolite tracking or boat-based compass tracking. These data can be used to measure the point during an encounter at which the probability of the focal animal staying or leaving is greater than that predicted from chance alone. Results such as these have been used to inform a management framework by defining the maximum length of time that operators ought to be in contact with cetaceans (Bejder *et al*., 1999).

Vessel type

Observing short-term responses can also help infer the characteristics of the interactions that are the least invasive. Experiments can be designed with multiple treatments, such as motorised versus non-motorised vessels. Au and Green (2000) provided an example in which the focus was on the source of potential disturbance: they measured underwater acoustic characteristics of five types of whalewatch vessels to evaluate potential impacts of vessel noise on the auditory system of humpback whales near Maui, Hawaii, USA. While the authors did not report on the reactions of whales to these vessels, the acoustic characteristics of the different engine types can be used to draft guidelines that minimise the level of boat noise received by the whale, and the level of masking likely to occur.

Vessel activity

Experiments have been designed to test the effects of various boat behaviours during interactions with killer whales (Williams *et al*., 2002a,b). These showed that 'leapfrogging' should be prohibited within 500m of whales. This mitigative measure was adopted subsequently by the local whalewatching community.

Number of commercial operators

In Shark Bay, Australia, long-term impacts of increasing commercial vessel activity were examined by contrasting the habitat use of individual animals between control and impact areas. As the number of commercial dolphin-watching operators increased, dolphin use of impact area fell by 12.5% (Bejder *et al*., in prep.). This information will be submitted shortly for review by local management agencies.

Maximum number of interactions

The likelihood that boats will interact with cetaceans depends on the distribution of the animals, the distribution of boats and the likelihood that a boat is searching for cetaceans. In Fiordland, New Zealand, the average duration of inter-interaction periods was related to boat traffic until approximately 900 trips in a season. When boat traffic exceeded this value, the average inter-interaction period remained constant at 69 minutes (Lusseau, 2004). The study revealed that dolphins required at least 69 minutes between two boat interactions to avoid displacement of the dolphins from the area.

Inferring the cost of whale watching to cetaceans

Several short-term responses can be quantified in a way that permits assessment of energetic costs. Both the cost of travel and basal metabolic rates can be estimated for some species (Tucker 1975). However, advances in understanding the physiology of cetaceans (such as basal metabolic rate and energetic states) will help us relate behavioural responses to energetic costs.

Path characteristics

Horizontal avoidance is a typical response to boat interactions. Some cetaceans try to evade boats by adopting less predictable paths in the presence of boats than those observed (from shore, for example) prior to the boat's arrival. One can quantify how much more individuals have to travel to go from A to B when they are with boats using tracks of focal individuals or groups collected with a theodolite (*e.g*., Williams *et al*. 2002a,b). Using both experimental and observational approaches, they showed that killer whales tended to travel 13-17% farther along a circuitous path when interacting with boats than in the absence of boats. This added travel time could carry energetic costs (Bain *et al*. 2002).

Behavioural budget

Behavioural modelling techniques can permit the assessment of mechanisms of impact. For example, one may find that dolphins spend more time travelling when boats are interacting with them. Markov-chain modelling could show whether dolphins are more likely to switch among socialising, resting, feeding or travelling during a boat interaction (Lusseau 2003) than in the absence of boats. Identification of the activity state in which animals are most vulnerable to disturbance can allow identification of which part of their habitat should be protected to confer most conservation benefit to animals: namely habitat that is used preferentially for that vulnerable activity (Lusseau and Higham 2003). In addition, these budgets can be used to convert the consequences of human activity to other currencies, such as caloric demand, for species in which energetic cost of activity states has been measured.

Sociality

Social factors have rarely been measured, or even considered, in impact assessments. For highly social species, social affiliations play a key role in the life history of individuals and populations. Spatial segregation of individuals, based on a continuum of tolerance levels among targeted animals within a social community, is likely to have negative impacts. Spatial segregation of sensitive animals within a study population in response to increasing exposure to boat-based tourism activities was detected in Shark Bay, Australia (Bejder *et al*. in prep,). Specifically, over two four-year periods, there was a 12.5% reduction in the number of individually identified dolphins using an impact area, while no effect was detected at a nearby control area.

8.3 INTERACTION BETWEEN MANAGERS AND SCIENTISTS

Concern was expressed that a disparity exists between the timeframes in which managers require information and the time that it takes for some biological effects to be detected. It was **agreed** that scientists must be clear about the limits to what is measurable and the difficulty in attributing changes in cetacean populations definitively to the effects of whalewatching. Similarly, it was **agreed** that if the research results are required for management, resources appropriate to the time-scale needed to complete the research must be made available.

It was noted that opportunities exist for management actions to benefit research. For example, marine protected areas can be used not only to mitigate impact of human activity on cetaceans, but also to allow measurement of impact by providing an experimental control. It was **recommended** that managers and scientists work together to make certain that mitigation measures also inform science.

Ultimately, scientists must rely on a variety of tools to answer the questions posed by managers. In the case of resident fish-eating killer whales of the northeast Pacific, ongoing efforts to link short-term behavioural responses of whales to boats to long-term population dynamics have required experimental and opportunistic studies on free-ranging and captive animals, combined with statistical modelling.

8.4 HOW TO MANAGE WHALEWATCHING IN THE FACE OF SCIENTIFIC UNCERTAINTY

Scientific investigations are based on sampling and statistical analyses that quantify the likelihood that an effect is detected. The design of the study, the sampling effort, other design parameters, and the size of the effect influence the likelihood to detect an effect. Results of such investigations are therefore always subject to a degree of uncertainty. It is important to quantify the likelihood that effects can be detected. Power analysis can help to determine these (Murphy & Myors 1998). Statistical power analysis can be used to determine how likely an experiment would be to detect a certain effect size (Taylor and Gerrodette 1993). Once the levels of uncertainty are ascertained in a study, there are methods to integrate this information in the decision making process in a quantitative, risk-averse framework (Harwood 2000). The group did not have the chance to expand on this issue but stress that it is necessary to take it into consideration. The reference point approach discussed above (Section 8.1) is a simple attempt to implement these ideas.

9. DISCUSSION OF GAPS AND KEY ISSUES IDENTIFIED DURING THE REVIEW PROCESS (SCIENTIFIC AND MANAGEMENT)

The Workshop identified the following list of gaps, but as insufficient time was available for discussion, the list is not exhaustive.

Science gaps

Background data
- Population status
- Distribution
- Baseline behaviour

Species-specific issues
- Few studies regarding whalewatching on baleen whales, especially oceanic rorquals
- Very few studies regarding whalewatching on river dolphins

Acoustic issues
- Critical ratios
- Audiograms
- Lack of modelling (*e.g.*, masking)

Physiological issues
- Energetics
- Stress hormones

Operation-specific issues
- Platform type, speed, activity, noise
- Swimming-with programmes
- Long-term / cumulative effects
- Attraction to boats
- Carrying capacity for vessel numbers
- New types of leisure craft (*e.g.*, jetskis)

Social science
- Design and effectiveness of education
- Visitor studies
- Compliance studies
- Economic studies (*e.g.*, cost-benefit analyses)

Management gaps

There was insufficient time for the workshop to address this issue in full. Two major initial issues that were identified by the workshop were:

- managing the activities of recreational users, and
- compliance by all users.

Other issues identified were:

- studies on compliance and effectiveness of current management regimes
- attraction to boats
- carrying capacity for vessel numbers
- human safety issues
- new types of leisure craft
- lack of industry involvement in decision-making in some places
- unlimited entry in some countries
- swimming-with programmes

10. STRENGTHENING THE SCIENTIFIC BASIS OF WHALEWATCHING MONITORING AND MANAGEMENT

The workshop concluded that the original IWC principles (IWC 1997) continued to be very helpful and appropriate. In light of:

1. *the spread of whalewatching to many new communities in developing and developed countries,*
2. *what has been learned about whalewatching through research and critical review of management regimes and*
3. *the remaining gaps in knowledge, we note the following points in addition to those identified below:*

1. Marine Protected Areas (MPAs)

The group highlighted the value of multiple-use MPAs to provide integrated management with a local management presence and a planning process that includes stakeholder participation. Appropriate zoning of MPAs can be helpful in providing science with the framework for experimental design, *e.g.*, provision of replicates and control areas. Setting aside areas that are not subject to extractive human use ('no take') is an important application of the precautionary approach. It is increasingly clear that refuge areas where no whale watching occurs are valuable both for management and for scientific evaluation as control areas in whale watch studies. Careful consideration needs to be given to identifying appropriate refuge areas to protect vulnerable animals and key behaviours.

2. **Monitoring**

Managers, operators and visitors can play a role in monitoring human-cetacean interactions, biological factors and compliance.

3. Enforcement & Surveillance

Even where regulations are adequate, enforcement has often proved problematic. We need an enhanced effort to find out how whale watching vessels operate through new and expanded methods of surveillance including the use of new technologies. Examples include VMS (vessel monitoring systems) and use of laser rangefinders.

4. **Visitor studies**

Whale watching is a two-way interaction that is managed through influencing the behaviour of the humans. This requires good social science-based studies. These provide information about the visitor demographics, attitudes, motivations, and the nature of their experiences. Passengers can also provide insight into the management of whale watching encounters.

5. Levies and licence fees

Levies and licence fees are useful in management of whale watching by providing funds necessary for education, research, enforcement etc.

6. Education/ training of operators (including incidental) and naturalists (guides)

High quality education and training of operators and naturalists could be a cost effective way of improving compliance and ensuring sustainability.

7. **Education and interpretation for whalewatch tourists**

High quality interpretation is also an important element to increase compliance with codes of practice, enrich tourists' experiences and raise their environmental awareness.

8. **Accreditation and certification of operations.**

Consideration should be given to the use of accreditation and certification systems to enhance the quality of whale watching and raise levels of compliance.

9. **Education and interpretation for the public (including recreational whale watchers)**

There is a large and growing problem of recreational (non-commercial) whale watchers and this presents an important challenge for management, especially in terms of education.

10. **Impact assessment**

Impact assessments should be conducted for whalewatching operations including consideration of environmental, social, cultural and economic issues (including ethical considerations).

11. **Importance of the iterative approach to management**

There is a need for international coordination and collaboration to ensure guidance of world's best practice in all aspects of sustainable whale watching management. This should include all stakeholders (including managers, whale watch operators, NGOs, researchers, tourism associations, local communities, etc.) who should meet on a regular basis in order to incorporate new expertise as part of an iterative management approach.

12. **Management of whale watching in the light of other threats.**

There should be consideration given to the impacts of whale watching in context of the full range of other threats to the population(s) of cetaceans being watched.

13. **Stakeholder involvement.**

A sustainable management framework needs to be initiated which incorporates full stakeholder involvement and develops a shared vision. It should include the full range of management options from law through to guidelines. In many cases, voluntary codes of conduct are not enough.

14. **Time spent with cetaceans.**

New scientific findings demonstrate that controls on the time spent with cetaceans can be important. The group noted that attention needs to be paid to protecting critical activities. For example, Bejder *et al.* (1999) showed that duration of interactions affected the likelihood that Hector's dolphins (*Cephalorhynchus hectori*) were attracted to boats. When interactions lasted more than 70 minutes, dolphins were less likely to approach boats than one would have expected by chance. This information was used to amend existing dolphin-watching permits in this location to limit the maximum length of interactions to 70 minutes. The group recognised that the importance of time closure has not been demonstrated for any baleen whales. The group noted that a precautionary approach had been taken to whale watch management to respect to time closure by ACCOBAMS (which recommended that cetaceans should be left alone for a period of one third of day-light hours).

15. **Managing whalewatching on a case-by-case basis.**

More attention needs to be given to species-specific, population-specific and behaviour-specific approaches to management of whalewatching as well as the particular characteristics of locations and the industry.

16. **High quality whalewatching.**

Consideration should be given to what constitutes the highest quality whale watching experience, noting that whalewatching with high educational and scientific value can make management easier.

17. **The triple bottom line.**

The whale watching industry has a particular responsibility to ensure that its activities are conducted sustainably. This includes full consideration of the triple bottom line of economic, social and environmental aspects and inclusion of a full analysis of impacts. The industry should recognise its responsibility for active support of research into whale watching and experimental management approaches.

18. **Feeding of wild cetaceans.**

The workshop endorsed the recommendations of the IWC Scientific Committee in 2000 and 2001 (IWC, 2001, 2002) that feeding of wild cetaceans should be prohibited and existing programmes phased out. In connection with this, new work (Mann and Kemps 2003, Samuels and Bejder in press) provides further evidence of the deleterious effects of feeding programmes on cetaceans.

11. RECOMMENDATIONS FOR THE INTERNATIONAL WHALING COMMISSION SCIENTIFIC COMMITTEE'S CONSIDERATION

The Scientific Management of Sustainable Whale-Watching Workshop, Cape Town, March 2004, was endorsed by the IWC. The IWC SC has incorporated the resulting report of this workshop into the agenda for its 2004 meeting. In addition to the report, the workshop agreed to highlight three topics for consideration by the Scientific Committee:

- The Workshop heard about new approaches and quantitative studies of relevance to the Scientific Committee (topics particularly relevant to the standing working group of environmental concerns, whale-watching sub-committee and small cetacean subcommittee). These studies, discussed in this report, have enhanced our capacity to refine and improve capacity to achieve sustainable whalewatching.

- The workshop considered these new approaches in light of the precautionary approach. This is a concept that is widely accepted and applied and the workshop agreed that the Scientific Committee could consider this approach for developing a framework for monitoring whalewatching.

- The workshop acknowledged the IWC 1997 General Principles for the Development of Regulatory Frameworks for Whalewatching and highlighted further developments for consideration, discussed in the previous section of the report.

12. RECOMMENDATIONS/ADVICE FOR FUTURE WORK

Advice for future work

Although this workshop focused on the research questions that are likely to lead to feasible, measurable critical parameters to link whalewatching to impact on cetaceans, it was recognised that there are many other important areas of research. One area of interest is the contribution of whalewatching vessels to data collection. It was noted that a major source of plastic debris in the marine environment could be from boats. Whalewatch vessels could play a role in cetacean conservation by monitoring and removing floating plastic debris. Research is also lacking, for example, on the contribution of whalewatching boats to hydrocarbons in the marine environment; the contribution of whalewatching boat exhaust to air quality around whales; and the introduction of raw sewage into the marine environment from whalewatching boats.

It was noted that whalewatching vessels have proven to be useful platforms for data collection. A classic example is the partnership between scientists and some whalewatching operations in the northeastern United States. In that case, the resulting collection of thousands of identification photographs has played a crucial role in the recent status assessment of North Atlantic humpback whales. An undervalued use of whalewatching vessels has been to assess the exposure of individual cetaceans to whalewatching traffic. The use of photo-identification to quantify levels of exposure would be of great interest and value to managers. Some dive vessels in the Great Barrier Reef (GBR) Marine Park, Australia are also beginning to provide just such valuable information for management of the minke whale swim industry.

Recommendations

Noting the value of interchange between scientists and managers, the Workshop **recommended** that interested scientists and managers form an e-mail discussion group to facilitate exchange of ideas and information relevant to the science of sustainable whalewatching.

Noting that the questions relating to managements gaps were not addressed adequately (due to time constraints), the participants highlighted the need for further dialogue and cooperation among whalewatching managers, including the possibility of a specific meeting to address these and other outstanding management issues.

13. OTHER BUSINESS

The workshop participants thanked the Chair, the co-Chair and the rapporteurs. The rapporteurs thank all the workshop participants for providing background information. Oosthuizen thanked Irma Maharaj and Bruce See for their help with organising the workshop. The Report will be placed on a website (possibly the Republic of South Africa's Department of Environmental Affairs and Tourism) at the earliest possible opportunity.

14. REVIEW AND ADOPTION OF REPORT

The report was adopted.

15. CLOSURE

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APPENDIX 1.

ADOPTED AGENDA

BREAKWATER LODGE

CAPE TOWN, SOUTH AFRICA

6 – 9 MARCH 2004

1. WELCOME

2. OPENING REMARKS

3. APPOINTMENT OF THE CHAIRMAN AND RAPPORTEURS

4. BACKGROUND AND TERMS OF REFERENCE

5. ADOPTION OF THE AGENDA

6. REVIEW OF AVAILABLE DOCUMENTS

7. SHORT DISCUSSION OF NATIONAL MANAGEMENT REGIME CASE STUDIES

    7.1. DISCUSSION OF THE SCIENTIFIC BASIS FOR MANAGEMENT OF WHALEWATCHING

8. MANAGEMENT OBJECTIVES AND NEEDS

    8.1 WHAT ADVICE MANAGERS REQUIRE FROM SCIENTISTS

    8.2 HOW SCIENTISTS MEET THESE REQUIREMENTS

    8.3 INTERACTION BETWEEN MANAGERS AND SCIENTISTS

    8.4 HOW TO MANAGE WHALEWATCHING IN THE FACE OF SCIENTIFIC UNCERTAINTY

9. DISCUSSION OF GAPS AND KEY ISSUES IDENTIFIED DURING THE REVIEW PROCESS (SCIENTIFIC AND MANAGEMENT)

10. STRENGTHENING THE SCIENTIFIC BASIS OF WHALEWATCHING MONITORING AND MANAGEMENT

11. RECOMMENDATIONS FOR THE INTERNATIONAL WHALING COMMISSION SCIENTIFIC COMMITTEE'S CONSIDERATION

12. RECOMMENDATIONS/ADVICE FOR FUTURE WORK

13. OTHER BUSINESS

14. REVIEW AND ADOPTION OF REPORT

15. CLOSURE OF THE WORKSHOP

APPENDIX 2.

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APPENDIX 3.

DOCUMENTS AVAILABLE TO THE WORKSHOP PARTICIPANTS.

Management of whale and dolphin watching in New Zealand	A Baxter	ww/2004/os/1
Socioeconomic research into whale watching	E Hoyt	ww/2004/os/2
Socioeconomic aspects of whale watching in Tenerife: A case study (1996 – 2004)	A Servidio	ww/2004/os/3
Management of whale watching activities in Spain: Application of the regulation and effectiveness	E Urquiola	ww/2004/os/4
A perspective on earlier whale watching workshops and related initiatives	M Simmonds	ww/2004/os/5
Directions in the scientific aspects of whale watching management	D Lusseau	ww/2004/os/6
Research in the development of boat-based whale watch management in South Africa	K Findlay	ww/2004/os/7
A review of existing mandatory and voluntary management systems for whale watching	C Carlson	ww/2004/os/8
Evaluation report 2003: Hermanus whale festival	Infonomics	ww/2004/os/10
Whale Watching Research off La Gomera (Canary Islands) Prospects & Implications	F Ritter	ww/2004/os/11
A review of international workshops organized by the International Fund for Animal Welfare (IFAW)	C Carlson	Ww/2004/os/12
Whale watching, Iconography and Marine Conservation	P Corkeron	ww/2004/cs/1
Getting closer to whales – passenger expectations and experiences, and the management of swim with dwarf minke whale interactions in the GBR	A Birtles *et al*	ww/2004/cs/2
Presentation 1	A Birtles	ww/2004/cs/3
Presentation 2	A Birtles	ww/2004/cs/4
Presentation 3	A Birtles	ww/2004/cs/5
The residency pattern of bottlenose dolphins (Tursiops spp.) in Milford Sound, New Zealand, is related to boat traffic	D Lusseau	ww/2004/cs/6
The hidden cost of Tourism: Detecting long-term effects of tourism using behavioral information	D Lusseau	ww/2004/cs/7
A theoretical approach to tourism sustainability	R Casagrandi *et al*	ww/2004/cs/8
A preliminary review of the management of whale (and dolphin) watching in the UK	M Simmonds *et al*	Ww/2004/cs/9
Review of data collection from whale watching platforms	M Simmonds	ww/2004/cs/10
Evaluating the effects of nature-based tourism on cetaceans	L Bedger *et al*	ww/2004/cs/11
Table 3: Linking monitoring techniques to critical parameters	Workshop doc	ww/2004/cs/12
Influence of the whale-watching boat(s) on behaviour of cetaceans at Haulien, Taiwan	Lien-Siang Chou *et al*	ww/2004/cs/13
The development of whale watching in Taiwan	Lien-Siang Chou *et al*	ww/2004/cs/14
Table 2: Linking monitoring variables to types of whale watching enterprises	Workshop doc	ww/2004/cs/15
Male and female bottlenose dolphins *Tursiops spp*. Have different strategies to avoid interactions with tour boats in Doubtful Sound, N.Z.	D Lusseau	ww/2004/cs/16
Managing the impacts of dolphin-based tourism through the definition of critical habitats: the case of bottlenose dolphins (*Tursiops spp.*) in Doubtful Sound, New Zealand	D Lusseau	ww/2004/cs/17
Effects of tour boats on the bahaviour of bottlenose dolphins: using Markov chains to model anthropogenic impacts	D Lusseau	ww/2004/cs 18

APPENDIX 4

NEW ZEALAND
New Zealand regulations governing behaviour around marine mammals

Marine Mammals Protection Regulations 1992

Part III - Behavior around marine mammals

17. Applications of this part:
Nothing in regulation 18 or regulation 19 or regulation 20 of these regulations shall apply to persons, vessels, aircraft, or vehicles rendering assistance to stranded or injured marine mammals.

18. Conditions governing commercial operations and behavior of all persons around any marine mammal- Every commercial operation, and every person coming into contact with any class of marine mammals, shall comply with the following conditions:

a) Persons shall use their best endeavors to operate vessels, vehicles, and aircraft so as not to disrupt the normal movement or behavior of any marine mammal:
b) Contact with any marine mammal shall be abandoned at any stage if it becomes or shows signs of becoming disturbed or alarmed:
c) No person shall cause any marine mammal to be separated from a group of marine mammals or cause any members of such a group to be scattered:
d) No rubbish or food shall be thrown near or around any marine mammal:
e) No sudden or repeated change in the speed or direction of any vessel or aircraft shall be made except in the case of an emergency:
f) Where a vessel stops to enable the passengers to watch any marine mammal, the engines shall be either placed in neutral or be switched off within a minute of the vessel stopping:
g) No aircraft, engaged in a commercial aircraft operation shall be flown beneath 150 meters (500 feet) above sea level, unless taking off or flying:
h) When operating at an altitude less than 600 meters (2,000 feet), above sea level, no aircraft shall be closer than 150 meters (500 feet) horizontally from a point directly above any marine mammal or such lesser or greater distance as may be approved by the Director General, by notice in the *Gazette*, from time to time based on the best available scientific evidence:
i) No person shall disturb or harass any marine mammal:
j) Vehicles must remain above the mean high water spring tide mark and shall not approach within 50 metres of a marine mammal unless in an official car park or on a public or private slipway or on a public road:
k) No person, vehicle or vessel shall cut off the path of a marine mammal or prevent a marine mammal from leaving the vicinity of any person, vehicle, or vessel:
l) Subject to paragraph (m) of this regulation the master of any vessel less than 300 metres from any marine mammal shall use their best endeavors to move their vessel at a constant, slow speed no faster than the slowest marine mammal in the vicinity, or at idle, or "no wake" speed":
m) Vessels departing from the vicinity of any marine mammal shall proceed slowly at idle or "no wake" speed until the vessel is at least 300 metres from the nearest marine mammal, except that in the case of dolphins vessels may exceed idle or "no wake" speed in order to outdistance the dolphins but must increase speed gradually, and shall not exceed 10 knots within 300 metres of any dolphin:
n) Pilots of aircraft engaged in a commercial aircraft operation shall use their best endeavours to operate the aircraft in such a manner that without comprising safety, the aircraft's shadow is not imposed directly on any marine mammal.

19. Special conditions applying to whales-
In addition to complying with the conditions set out in the regulation 18 of these regulations, every commercial operation and every person coming into contact with whales shall also comply with the following conditions:

a) No person in the water shall be less than 100 metres from a whale, unless authorized by the Director-General:
b) No vessel shall approach within 50 metres of a whale, unless authorized by the Director-General:
c) If a whale approaches a vessel, the master of the vessel shall, whenever practicable: maneuver the vessel so as to keep out of the path of the whale; and maintain a minimum distance of 50 metres from the whale:
d) No vessel or aircraft shall approach within 300 metres (1,000 feet) of any whale for the purpose of enabling passengers to watch the whale, if the number of vessels or aircraft or both already positioned to enable passengers to watch that whale is 3 or more:
e) Where 2 or more vessels or aircraft approach an unaccompanied whale, the masters concerned shall co-ordinate their approach and maneuvers, and the pilots concerned shall co-ordinate their approach and maneuvres:
f) No person or vessel shall approach within 200 metres of any female baleen or sperm whale that is accompanied by a calf or calves:
g) A vessel shall approach a whale from a direction that is parallel to the whale and slightly to the rear of the whale:
h) No person shall make any loud or disturbing noise near the whales:

i) Where a sperm whale abruptly changes its orientation or starts to make short dives of between 1 and 5 minutes duration without showing its tail flukes, all persons, vessels, and aircraft shall forthwith abandon contact with the whale;

20. Special conditions applying to dolphins and seals-

In addition to complying with the conditions set out in regulation 18 of these regulations, any commercial operation and any person coming into contact with dolphins and seals shall also comply with the following conditions:

a) No vessel shall proceed through a pod of dolphins:

b) Persons may swim with dolphins and seals but not with juvenile dolphins or a pod of dolphins that includes juvenile dolphins:

c) Commercial operators may use an airhorn to call swimmers back to the boat or to the shore:

d) Except as provided in paragraph C of this regulation, no person shall make any loud or disturbing noise near dolphins or seals:

e) No vessel or aircraft shall approach within metres (1,000 feet) of any pod of dolphins or herd of seals for the purpose of enabling passengers to watch the dolphins or seals, if the number of vessels or aircraft, or both, already positioned to enable passengers to watch that pod or herd is 3 or more:

f) Where 2 or more vessels or aircraft approach an unaccompanied dolphin or seal, the masters concerned shall co-ordinate their approach and maneuvers, and the pilots concerned shall co-ordinate their approach and maneuvers:

A vessel shall approach a dolphin from a direction that is parallel to the dolphin and slightly to the rear of the dolphin.

Table 1. Possible management options to minimise or eliminate the impacts of whale watching for each critical response variable. Each management option that can be used is identified in the table by either a lower case letter or a ‘Y’. The letter ‘Y’ indicates that this option can be used and lower case letters correspond to sub-categories of each management option as shown in the key. Table 1 provides a list of possible management actions that could be used to minimise or eliminate the impacts of whalewatching for each critical response variable. While it will be necessary to determine the most effective management option or combination of options to use on a case-by-case basis, this table provides useful guidance in which management actions should be considered. This table should be used in conjunction with Table 3, which has been used to identify which are the most important critical response variables by cetacean group and area. After identifying the ‘Best’ critical response variable from Table 3, one can then determine the best management action that can be used to minimise or eliminate that specific impact.

Key for Table XX and XY (see description of these categories in text)

1. Closures
    a. Area
    b. Season
    c. Time
    d. Type of whale
    e. Whale activity
2. Platform / permit
    a. Limit number
    b. Set type
3. Platform handling in the vicinity of whales
4. Speed limits while not in the vicinity of whales
5. Duration of interaction
6. Limitation on trips
    a. Number
    b. Duration
7. Education
    a. Operators
    b. Tourists
    c. Public
    d. IUU operators

Critical Response Variables	Management options						
	1. Closures	2. Platform \ permit	3. Platform handling in vicinity of	4. Speed limits *NOT* in vicinity of	5. Duration of interactions	6. Limitation on trips	7. Education
Demography							
❖ WW boat strike mortality	a,b	a,b	Y	Y		a,b	a,b,c,d,
❖ WW boat strike wounds	a,b	a,b	Y	Y		a,b	a,b,c,d
❖ Changes in reproductive rate	a,b,d,e	a,b	Y	Y	Y	a,b	a,b,c,d,
❖ Survivorship of calves/adults	a,b,c,d,e	a,b	Y	Y	Y	a,b	a,b,c,d
❖ Changes in population trend	a,b,c,d,e		Y	Y	Y	a,b	a,b,c,d
Behaviour							
❖ Avoidance behaviour	b,d,e		Y		Y	a,b	a,b,c,d,
❖ Attraction behaviour,	d,e		Y		Y	a,b	a,b,c,d
❖ Deflection of migration	a,b,d,e	a,b	Y		Y	a,b	a,b,c,d,
❖ Surface-ventilation- dive characteristics	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d
❖ Behavioural events	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d,
❖ Swimming behaviour and direction	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d
❖ Foraging	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d,
❖ Rest time	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d
❖ Reproductive behaviour							
o Mating	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d,
o Parental care	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d
❖ Social Behaviour	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d,
❖ Within-school spacing and cohesion of animals		a,b	Y		Y	a,b	a,b,c,d
Energetics ❖ Energetic demands ❖ Activity states ❖ Swim speed ❖ Foraging success ❖ Body condition	a-e	a,b	Y		Y	a,b	a,b,c,d
Physiology of stress ❖ Stress induced changes in reproductive hormones/fertility/fecundity ❖ Body condition	a,b,c,d,e	a,b	Y		Y	a,b	a,b,c,d
Acoustics ❖ Noise related TTS or PTS – temporary or permanent threshold shifts in hearing ❖ Impairment of hearing by ambient sound ❖ Changes in sound production	a-e	a,b	Y	Y	Y	a,b	a,b,c,d
Displacement Displacement from habitat/distribution changes	a-e	a,b	Y	Y	Y	a,b	a,b,c,d

Table 2. Linking monitoring techniques to critical parameters. The following broad research methods (columns) could be used to link whalewatching activity to a changes (rows) in cetacean behaviour or populations. The methods are described in greater detail below, and are cited in abbreviated form in Table 3.

	Photo-identification*	Distance sampling*	Post-mortem studies*	Relative abundance surveys*	Photogrammetry*	Ultrasound blubber meter*	Physiological studies*	Acoustics*	Telemetry*	Theoretical modelling*	Behavioural sampling*	Tracking*	Restrained animals*
Demography													
❖ Ship strike mortality			S										
❖ Wounds	S												
❖ Changes in reproductive rate	L	L											
❖ Survivorship of calves/adults	L												
❖ Changes in population trend	L	L		L				L					
Behaviour													
❖ Avoidance behaviour								S	S		S	S	
❖ Attraction behaviour								S	S		S	S	
❖ Deflection of migration				M				S	S			S	
❖ Surface-ventilation- dive characteristics									S	S	S	S	
❖ Surface-active behavioural events											S		
❖ Swimming behaviour and direction								S	S		S	S	
❖ Foraging								S	S		S		
❖ Rest time								S	S		S	S	
❖ Reproductive behaviour													
o Mating								S			S		
o Parental care											S		
❖ Social Behaviour											S		
❖ Within-school spacing and cohesion of animals					S						S	S	
Energetics													
❖ Energetic demands							S		S	S	S	S	S
❖ Activity states											S		
❖ Swim speed								S	S			S	

❖ Foraging success							S	S	S		S		
❖ Body condition	M				M	S	S		S				
Physiology of stress													
❖ Stress induced changes in reproductive hormones							M				M		
❖ Body condition	M				M	S	S		S				
Acoustics													
❖ Noise related TTS or PTS – temporary or permanent threshold shifts in hearing			S					S-L		S			S
❖ Masking								S					S
❖ Changes in sound production								S	S				S
Displacement													
Displacement from habitat/distribution changes	L	L		S				S-L	S			S	

Legend: 0 – Not applicable. S- Effect is measurable with short-term study (<3 years). M – Medium-term study is required to detect effect (3-10 years). L – long-term study is required to provide the information (>10 years).

* Definitions of categories of research techniques

Photo-identification (PI)
Photo-id can be used for longitudinal studies of individually recognisable cetaceans. See Hammond et al. 1990 "Individual recognition of cetaceans." IWC Special Issue 12.

Distance sampling (DS)
Distance sampling includes line-transect aerial or ship-board surveys and is used to estimate abundance and distribution. See www.ruwpa.st-and.ac.uk/distance

Post-mortem studies (PM)
Necropsies of stranded animals.

Relative abundance surveys (RA)

Any index of relative abundance (with an associated measure of observer effort), e.g., encounter rate (dolphins sighted per km of river); or call rate on hydrophones at a fixed location.

Photogrammetry (PG)
Obtaining measurements (e.g., animal length, range) from photographs or video.

Ultrasound blubber meter (US)
A device used to measure blubber thickness on free-ranging animals using high-frequency sound waves.

Physiological studies (PS)
The collection and analysis of biological material (tissue, feces, exhaled gases) to study the functioning of animal bodies.

Acoustics (AC)
The use of sounds produced and received by animals (as well as ambient noise) to determine various biological and ecological parameters.

Telemetry (TE)
Animal-borne instrumentation.

Theoretical modelling (TM)
Mathematical and computer modelling of biological systems.

Behavioural sampling (BS)
Sampling of behaviour.

Tracking (TR)
Non-animal-borne measurement devices used to track animal movement.

Restrained animal (cetacean) studies (RC)
Studies on animals that can be handled by researchers. Some examples include stranded, captive or entangled animals.

Table 3. Research techniques to link monitoring variables to types of whale watching enterprises. While a variety of critical response variables could be measured, using a variety of techniques, the following represent consensus opinion on the most feasible research method to employ in each broad category. The **highlighted** topics represent the methods that received the strongest recommendation from the workshop participants.

	Baleen whales, migrating	Baleen whales, feeding	Baleen whales, breeding ground	Resident baleen whales	Odontocetes, coastal closed population	Odontocetes, coastal open population	Odontocetes, oceanic	Odontocetes, oceanic
Demography								
❖ Ship strike mortality	PM	**PM**	PM	PM	PM	PM	PM	PM
❖ Wounds	PI	**PI**	PI	PI	PI	PI	PI	PI
❖ Changes in reproductive rate	DS/PI/PM	DS/PI/PM	DS/PI/PM	DS/PI/PM	DS/PI/PM	DS/PI/PM	**DS/PI/PM**	RA
❖ Survivorship of calves/adults	PI	PI	**PI**	PI	**PI**	PI	PI	PI
❖ Changes in population trend	DS/PI/RA/AC	DS/PI/RA/AC	DS/PI/RA/AC	DS/PI/RA/AC	DS/PI/RA/AC	DS/PI/RA/AC	DS/PI/RA/AC	RA/AC
Behaviour								
❖ Avoidance behaviour	TR/BS	TR/BS	TR/BS	TR/BS	**TR/BS**	**TR/BS**	**TE/BS**	**TE/BS**
❖ Attraction behaviour,		TR/BS	TR/BS	TR/BS	TR/BS			TR/BS
❖ Deflection of migration	**TR**							
❖ Surface-ventilation- dive characteristics					TE/BS			
❖ Behavioural events			BS	BS				
❖ Swimming behaviour and direction	TR/TE	TR/TE	TR/TE	TR/TE	TR/TE	TR/TE		TR/TE
❖ Foraging		**AC/TE/TR**		**AC/TE/TR**	AC/TE/TR	AC/TE/TR	AC/TE/TR	AC/TE/TR
❖ Rest time	BS/TR	BS/TR	BS/TR	BS/TR	BS/TR	BS/TR	BS/TR	BS/TR
❖ Reproductive behaviour								
o Mating	BS		BS	BS	BS	BS		BS
o Parental care	BS	BS	**BS**	**BS**	BS	BS	BS	BS
❖ Social Behaviour			BS	BS	BS	BS	BS	BS
❖ Within-school spacing and cohesion of animals					BS	BS	BS	BS
Energetics								

❖ Energetic demands ❖ Activity states ❖ Swim speed ❖ Foraging success ❖ Body condition	**TE/TR/TM** BS TR	TE/TR/TM BS **TR** UB/PG/PI	**TE/TR/TM** BS TR PG/PI	TE/TR/TM **BS** TR TR PG/PI	TR/TM/HA/BS **BS** TR BS PG/PI	TR/TM/HA/BS **BS** TR BS PG/PI	TR/TM/HA/BS **BS** AC/TE	RC **BS** TR PG
Physiology of stress ❖ Stress induced changes in reproductive hormones/fertility			**PS**	**PS**	**PS**			PS
Acoustics ❖ Noise related TTS or PTS – temporary or permanent threshold shifts in hearing ❖ Masking ❖ Changes in sound production	AC/RC/PM **AC/TM**	AC/RC/PM **AC/TM**	AC/RC/PM AC/TM **AC/TE**	AC/RC/PM **AC/TM** **AC/TE**	TM/AC/RC **TM/AC/RC** AC/TE	TM/AC/RC **TM/AC/RC** AC/TE	TM/AC/RC **TM/AC/RC** **AC/TE**	TM/AC/RC **TM/AC/RC** AC/TE
Displacement Displacement from habitat/distribution changes		**DS/PI/TR/RA**	**DS/PI/TR/RA**	**DS/PI/RA**	**DS/PI/RA**	**DS/PI/TR/RA**		**DS/TR/RA**