RESEARCH METHODS

Study Site

The study site is Whitehaven Beach, situated on the east coast of Whitsunday Island, Queensland, Australia. Whitehaven Beach is approximately six kilometres long and adjoins Hill Inlet to the north west and Solway Passage to the south east. The beach consists of white silica sand and is backed by two sand dune systems, the younger of which forms the landward boundary of the beach. Elevation reaches 20 meters above sea level at approximately 200 meters inland from the beach. Elevation climbs rapidly to 60 meters at the northern end of the beach and to 97 meters at the southern limit of the beach. Figure 3.1 shows Whitehaven Beach within the Whitsunday Islands. Figure 3.2 is a photograph taken from the air at about 1000 feet looking along Whitehaven Beach toward Hill Inlet.

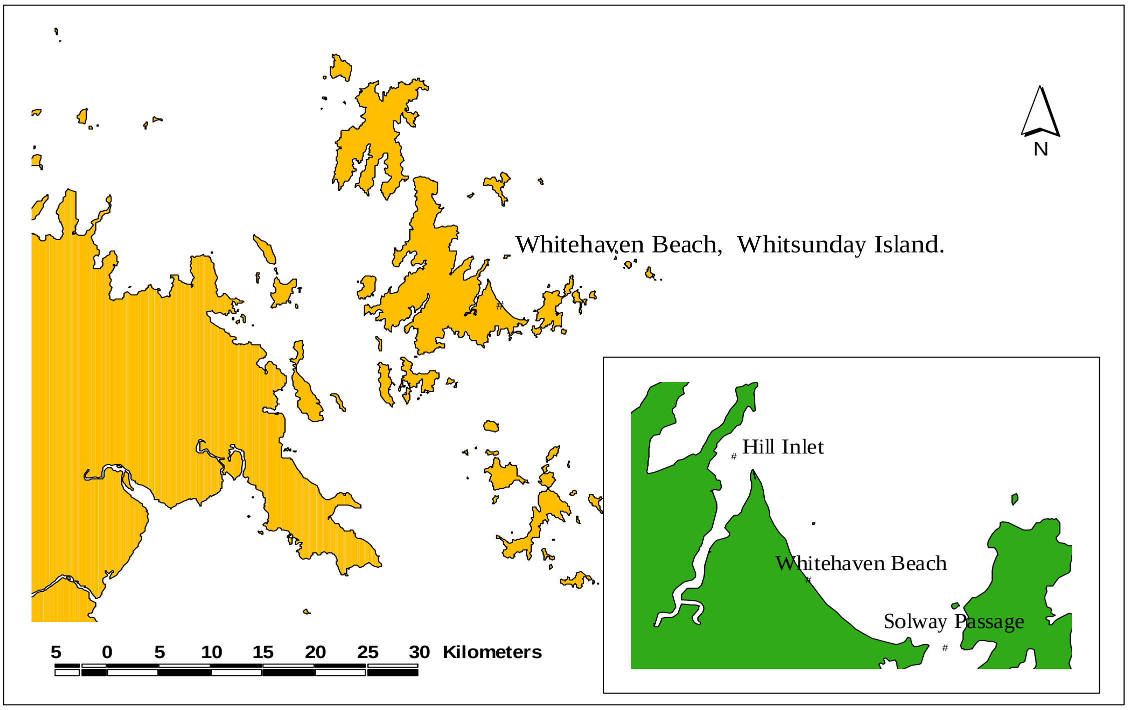

Figure 3.1. Whitsunday Islands and adjoining mainland, North Queensland, Australia. The insert shows Whitehaven Beach *(Source: GBRMPA)*.

Figure 3.2. Photograph of Whitehaven Beach looking NNW toward Hill Inlet.

The Whitsunday Islands are divided into five recreation opportunity settings which are classified; developed (also referred to as setting 1), high use (setting 2), moderate use (setting 3), natural (setting 4) and protected (setting 5). Setting 1 receives the most intensive use, motorised water sports are designated to be conducted only in setting 1. Along Whitehaven Beach are settings 2, 3, 4 and 5, graduating from a high use setting at the southern end of the beach to a protected setting at the northern end of the beach. Each setting along the beach is between approximately one and two kilometres wide. Setting 2 is described as a natural setting, experiencing high levels of visitation by larger vessels and aircraft (a vessel size of up to 35 meters with an unlimited passenger load is permitted). Appropriate facilities (e.g. pontoons, moorings and markers) are provided. Toilets and picnic tables are also provided behind the beach in setting 2 on Whitehaven Beach. Setting 3 is described as a natural setting expected to receive moderate levels of visitation with occasional visits by larger vessels and aircraft (a vessel size of up to 35 meters with a passenger load of up to 40 people is permitted). Setting 4 is described as a natural setting with low levels of visitation. Areas classified as setting 4 are expected to be generally free from facilities and larger vessels and aircraft (a vessel size of up to 20 meters with a passenger load of up to 15 people is permitted). Setting 5 is described as a protected natural setting. Areas classified as setting 5 are managed according to individual site plans. Hill Inlet is classified as a setting 5 area due to its conservation (mangroves, seabird nesting), scenic (silica sand inlet and delta which has become an icon) and cultural values. Aircraft are not to

access Hill Inlet (setting 5), however watercraft up to 12 meters in length are permitted. Although only the Hill Inlet end of Whitehaven Beach is classed as setting 5, the entire beach is described as a sensitive site. Individual management strategies for areas classified as sensitive sites are under development (GBRMPA 1998). Figure 3.3 depicts the settings along Whitehaven Beach and Bay.

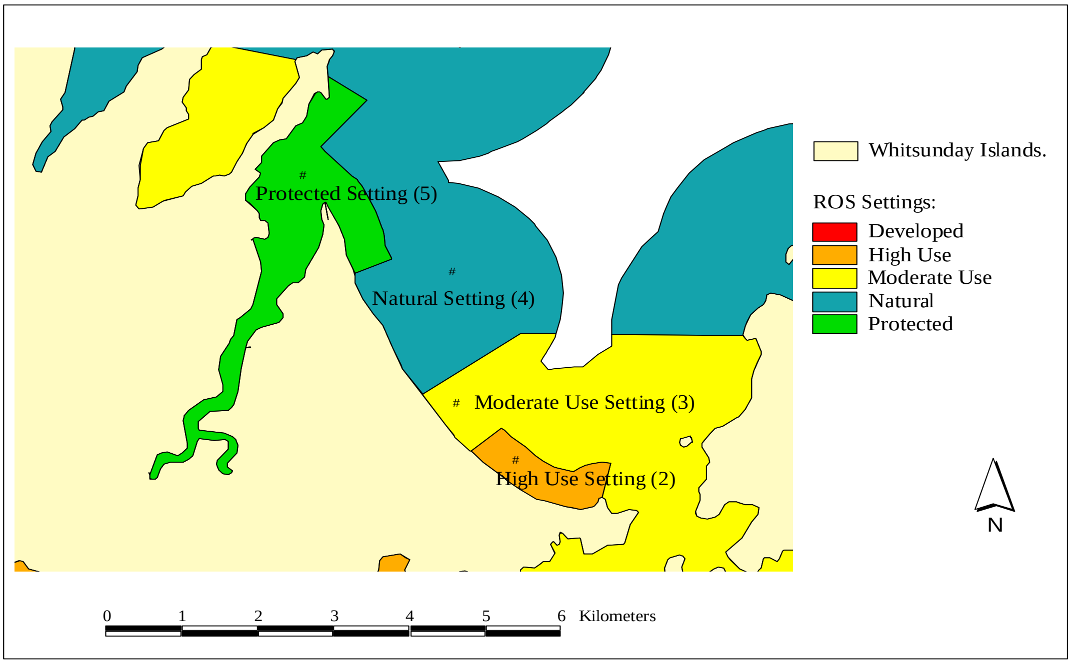

Figure 3.3. The recreation opportunity spectrum settings along Whitehaven Beach. *(Source: GBRMPA)*

Whitehaven Beach and the Whitsunday Islands generally have also been divided into five types of aircraft landing zones. The landing zones at Whitehaven Beach and its immediate surrounds are depicted in figure 3.4. The regular multiple landing area extends along the beach front from the boarder of settings 2 and 3 to the middle of setting 4. The seasonal multiple landing area encompasses the entire beach front of settings 3 and 4. Settings 2 and 5 along Whitehaven Beach are zoned as permanent closure areas. A seasonal multiple use landing area also occurs on the northern side of Hill Inlet (setting 5). Aircraft are restricted to accessing the area between the hours of 07:00 and 17:00 (McLeod, *pers. comm.*, 1998).

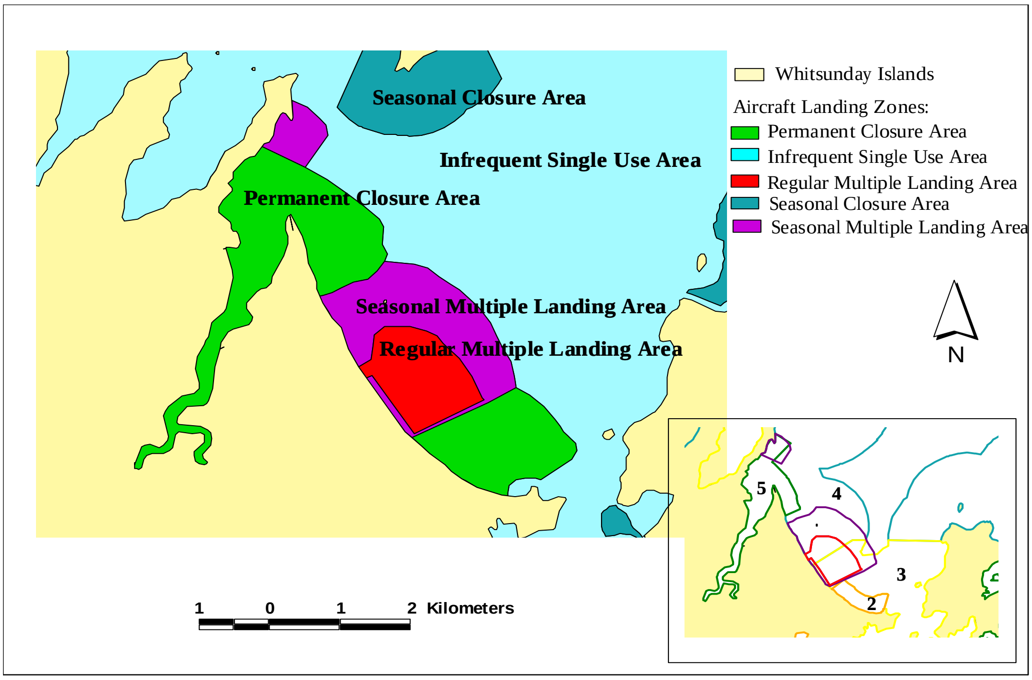

Figure 3.4. Aircraft landing zones along Whitehaven Beach. The insert shows the landing zones relative to the ROS settings *(Source: GBRMPA)*.

Survey Design

Sites of Data Collection

For the purposes of this study, sites for data collection were placed in the central area of each setting along Whitehaven Beach. A data collection site in the centre of each setting was necessary in order to ensure that results obtained for each setting were representative of the core of the setting. A Magellan GPS 3000 XL Satellite Receiver (accurate to within 100 metres horizontally and 150 metres vertically with greater inaccuracy about 5% of the time due to errors induced by selective availability) was used to locate universal transverse mercantor co-ordinates central to each setting. Stakes were driven into the sand at each site and maintained there throughout data collection trips 1 and 2. Sites were photographed to ensure later identification in the event of the stakes being removed. Stakes were placed at the top of the beach at the base of the sand dune at each data collection site. Figure 3.5 depicts the location of data collection sites relative to each setting. Figures 3.6 - 3.9 are photographs of each data collection site.

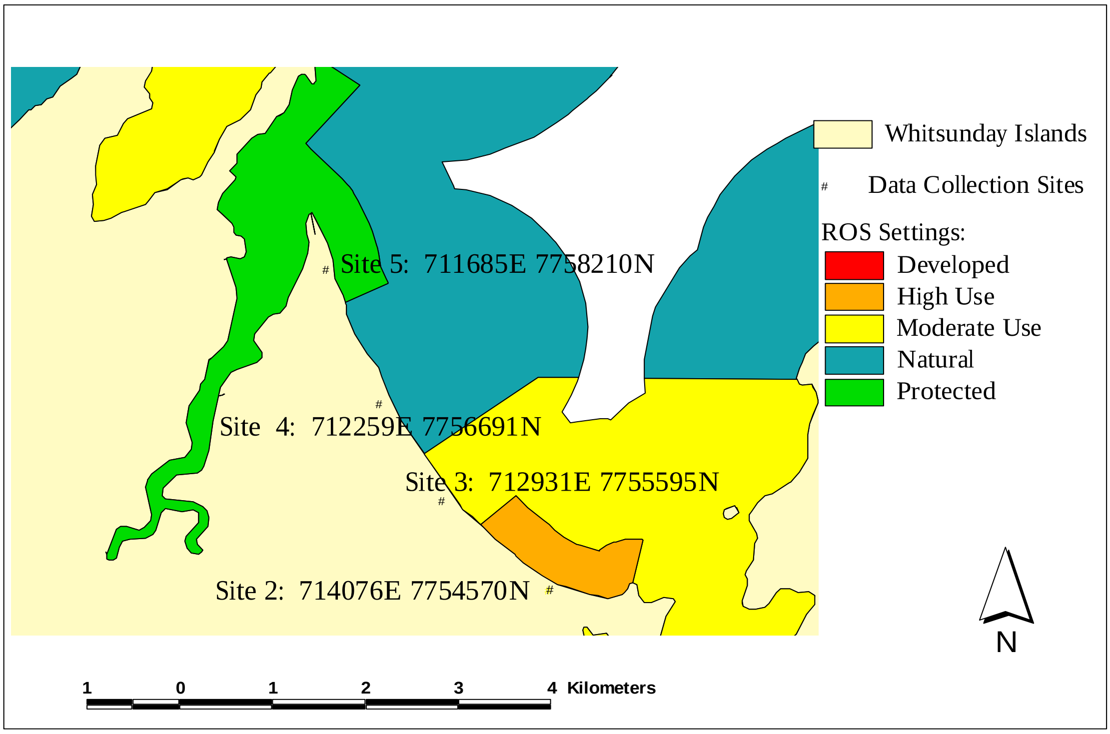

Figure 3.5. Data Collection sites relative to ROS settings, Whitehaven Beach. *(Source: GBRMPA)*

Figure 3.6. Study Site 2, Setting 2.

Figure 3.7. Study Site 3, Setting 3.

Figure 3.8. Study Site 4, Setting 4.

Figure 3.9. Study Site 5, Setting 5.

Data Collection Periods

Most of the data was collected during two four-day periods, two weeks apart, from the 10th - 13th of October (trip 1, data collection days 1 - 4) and from the 24th - 27th of October 1998 (trip 2, data collection days 5 - 8). Further data was collected with the aid of Hamilton Aviation on the 7th and 8th of December, 1998 (trip 3, data collection days 9 & 10).

During trips 1 and 2, data was collected at the four sites described in the previous section. Data was collected from the time of arrival at each site in the morning until 10:00, from 10:30 - 13:30 and from 14:00 - 17:00. The aim was to start collecting data at all sites from 08:00 however this was not possible on all days. During trip 3, data was collected from where Hamilton Aviation was operating for the day. Data was collected from the time of arrival until the time of departure. On both days this was from about 10:00 - 16:00.

Survey Methods

Variables Measured

The variables measured during the data collection trips, their periods of measurement, and the techniques used are outlined in tables 3.1 to 3.7. Please refer to the following descriptions when interpreting these tables.

Table 3.2 - Lp Sound recordings at 10s intervals: Recordings were started on a 00, 10, 20, 30, 40 or 50 second mark as close as possible to the start of the sound event (aircraft / watercraft) and at each ten second interval thereafter to allow readings taken at each site to be correlated temporally.

Table 3.2 - Distance between the recorder and an aircraft takeoff, landing or flyover: During trips 1 and 2, within the regular landing zone, red and white ranging poles were set up at 200m intervals in order to allow a rough judgement to be made of the distance between a recording site and a landing or take off. During trip 3 range finder binoculars were used to judge distance. In this case, distance measurements were taken at the same time as sound level recordings whenever the aircraft was within range.

Table 3.2 - Type of event: On trips 1 and 2, event types were categorized as follows: seaplane flyover landing, seaplane takeoff flyover, seaplane flyover only, helicopter flyover landing, helicopter takeoff flyover, helicopter flyover only, seaplane taxi only, high altitude jet flyover and other light aircraft flyover. Categories used on trip 3 were seaplane flyover, seaplane landing, seaplane takeoff, seaplane taxi (before takeoff / after landing), helicopter flyover, helicopter landing and helicopter takeoff.

Table 3.2 - Techcessories analogue sound level meters: Techcessories analogue sound level meters (decibel meters catalogue number: 33-2050). Featuring A and C weighting networks and fast (indicates peak sound levels) and slow (indicates average value sound levels) response settings but not meeting national or international requirements for types 0, 1, 2, or 3 sound level meters. All were new and correctly calibrated at the beginning of the data collection periods. These sound meters were unable to read below 50 decibels.

Table 3.2 - Integrated Type 2 Rion sound level meter: A Rion NA-29 octave band analyser and a UC-52 microphone, both conforming to the IEC standard for type 2 sound level meters. However, both were long overdue for a professional calibration check. When checked at Workplace Health and Safety the meter was reading approximately 1.8dBA lower than it should have been. This sound meter was used only to provide a comparison with the analogue sound meters. Results from the integrated meter were not used in the main analysis.

Table 3.2 - Range finder binoculars: 'Yardage Pro 800' Range finder binoculars with a maximum range of 800 yards / meters under most circumstances (dependant on the reflectivity of the target) and an accuracy of + / - 1 yard / meter.

Table 3.3 – Lmax of ‘significant’ events: Watercraft events were subjectively selected for recording based on whether or not observers judged them to have a significantly audible noise level (detectable above background decibel readings). Aircraft events occurring at the same time always took precedence.

Tables 3.4 - 3.7 – Note that boundaries between settings 2 & 3 and 4 & 5 were indicated by ranging poles which also marked the outer boundaries of the seasonal landing zone. The boundary between setting 3 & 4 was estimated by judging, with the aid of binoculars, the half way mark between data collection sites 3 and 4. It was assumed for the purposes of this study that the sites at which the variables, wind, temperature and humidity were collected are representative of all four data collection sites along the beach. Wind, temperature and humidity data were collected as recommended by Australian Standard 1055 (Standards Australia 1997).

Table 3.1. Background Sound Level Data Collection.

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 1. Trip 2. Trip 3.	• Average dBA / minute. Calculated from max and min decibel levels recorded over every 10s in a minute at 15 minute intervals (unless an aircraft event was taking place). ♦ Leq (5 or 10s).	• Four Techcessories analogue sound level meters. • Synchronised Digital/analogue watches. ♦ Integrated type 2 Rion sound level meter.	• Sites 2, 3, 4, 5 during trips 1 and 2 plus a site close to Hamilton Aviation's operation during trip 3. ♦ Site 5 during trip 1, site 3 during trip 2 and a site close to Hamilton Aviation's operation, trip 3.

Table 3.2. Aircraft Activity and Sound Level Data Collection

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 1. Trip 2. Trip 3.	• Lmax of each event. • Lp Sound recordings at 10s intervals. • Duration of sound events above background sound levels. • Frequency of Occurrence of events. ♦ Leq (5s), Lmax (5s). ❖ Distance between the recorder and an aircraft takeoff, landing or flyover. ❖ Type of event.	• Techcessories analogue sound level meters. • Synchronised Digital/analogue watches. ♦ Integrated type 2 Rion sound level meter. ❖ Ranging Poles. ❖ Tape measure. ❖ Range finder binoculars. ❖ Standard binoculars.	• Sites 2, 3, 4, 5 ❖ during trips 1 and 2 plus a site close to Hamilton Aviation's operation during trip 3. ♦ Site 5 during trip 1, site 3 during trip 2 and a site close to Hamilton Aviation's operation during trip 3.

Table 3.3. Watercraft Activity and Sound Level Data Collection

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 1. Trip 2.	• Lmax of 'significant' events. ♦ Leq(5 s), Lmax(5 s). ❖ Numbers of watercraft passing through settings. ❖ Numbers of events recorded.	• Techcessories analogue sound level meters. • Synchronised Digital / analogue watches. ♦ Integrated type 2 Rion sound level meter.	Sites 2, 3, 4 and 5.

Table 3.4. Levels of Human Use Data Collection

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 2.	• Numbers of people present on the beach within each setting at 10:30, 14:00 and 17:00.	• Standard binoculars. • Watch.	Sites 2, 3, 4 and 5.

Table 3.5. Wind Speed and Direction Data Collection.

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 1. Trip 2. Trip 3.	• Average wind speed during sound recordings (data collected as much as possible whenever a sound recording took place). ❖ Wind Direction.	• Aniometer. • Stopwatch. • Watch. ❖ Wind Direction Indicator. ❖ Compass.	Site 4.

Table 3.6. Temperature Data Collection

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 1. Trip 2.	• Atmospheric temperature (collected at 30 min. intervals).	• Thermometer. • Watch.	Site 2.

Table 3.7. Humidity Data Collection.

Sampling Period	Variable	Equipment Used	Sites of Data Collection
Trip 2.	• Atmospheric humidity (collected at 30 min. intervals).	• Wet and Dry Thermometer. • Watch.	• Site 2.

Data Collection

Sound level data was collected from two paces in front of the marking stake at each site. The main sound data was collected using analogue sound level meters. These were numbered and each site always used the same meter. Analogue sound meters were held horizontal at breast height, on the right hand side with the microphones facing directly to sea at all times. Recordings were made by pairs of volunteers, one person read the analogue sound meter while the other indicated when readings were due and recorded the results. Silence was maintained throughout the process other than when the person reading the meter stated the result. The volunteer noting the results stood to the left of the person with the sound meter to reduce interference with sound waves. Analogue sound meters were set to A-weighted network and fast response settings for all sound level recordings. Details of sound sources were also recorded.

Figure 3.10. Sound level data collection with the analogue sound level meters.

During aircraft and watercraft recordings, symbols were used to detail movement of the sound source relative to the observers, in order to aid later interpretation of the data (refer to appendix 1 for a list of the symbols used). Samples of the survey proforma used in the field to record background, aircraft and watercraft sound and activity levels, plus those used to record environmental conditions are in appendix 2.

Comparative automated sound recordings were made for all sound sources using a type 2 integrated sound level meter. This provided a means of assessing the accuracy of the analogue sound meters. As it was not possible to take continuous measurements over a day with the integrated meter, only selected events were

recorded. Background recordings made with the integrated meter were spread throughout the day at regular intervals. They were also made over ten minute intervals during break periods and at the end of the day. The integrated meter was also set to 'A' weighting and fast response settings for all sound recordings. Comparisons of recordings made with the two types of sound meter are presented in appendix 3.

The major difference between the methods of sound level recordings made on trips 1, 2 and 3 was that wind screens were used on the analogue sound meters on trips 2 and 3 but not on trip 1. This was because the analogue sound meters did not come with windscreens while the researcher had also been advised that windscreens would not be necessary. A windscreen was always used with the type 2 integrated sound meter.

Methods of Analysis

Data was collated, analysed and presented using the spreadsheet programs Excel and SPSS, and the mapping program ArcView. Data collected during trips 1 and 2 was divided into seven hourly periods of each day for analysis. Periods chosen were as follows: 9:00 - 10:00 (1); 10:30 - 11:30 (2); 11:30 - 12:30 (3); 12:30 - 13:30 (4); 14:00 - 15:00 (5); 15:00 - 16:00 (6); 16:00 - 17:00 (7). On all days, data had started to be recorded at all sites by 9:00 am, thus data from 9:00 am onward was included in the analysis. Forty-five hours of data was available for analysis from the first two data collection trips and was used to analyse differences between sites (settings) and times of day. It was also used to establish average background sound levels. Data collected during trip 3 was used to quantify the relationship between distance and sound level and to provide further data on the relative sound impacts of different types of aircraft events. Approximately eleven and a half hours of data was available for analysis from trip 3.

Prior to fully analysing sound level data, correlation analysis between average daily wind speed and sound level data collected during trips 1 and 2 was undertaken. As windshields were used on trip 2 but not on trip 1, wind noise was expected to have had a greater influence on trip 1. Correlation analysis (appendix 4.1 and 4.2) established a positive correlation between wind speed and sound level variables for trip 1 (days 1 - 4) but not for trip 2 (days 5 - 8). Subsequently sound level data from days 1 and 2 was excluded from further sound level analyses. However, sound level data from days 3 and 4 was used in further sound level analysis as wind speed averages were lower on those days while average background sound levels were within the range of the results from days 5 - 8.

Temperature and humidity data were not analysed relative to other variables as little variation in temperature or humidity was recorded and the data collected was not considered sufficient for meaningful analysis. Nevertheless daily averages were calculated and are presented in appendix 4.3.

Background Sound Data

Ideally both a natural (background) and a 'nuisance' noise threshold would be established and used for comparison with aircraft sound levels. Comparison with a nuisance threshold would allow the impact of noise at Whitehaven Beach on humans to be assessed. However, a nuisance threshold cannot be established without undertaking concurrent social surveys at the study site. As this was beyond the scope

of this study, aircraft sound levels were assessed relative to calculations of average background sound levels, established through the analysis of background sound level data collected on trips 1 and 2. Readings with anthropogenic influences (boats, people or aircraft) were excluded from analysis. Bird sounds were not excluded although they were observed to raise background sound levels by approximately 20dBA. Background sound levels were calculated in the following ways:

1. Average natural sound level at each site on each of days 1 - 8.
2. Average natural sound level at each site over days 3 - 8.
3. Average natural sound level for the entire study area over days 3 - 8.

An attempt was made to compare natural sound levels between times of day. However, due to variations in the size of data sets for individual time periods, this method of analysis was not pursued. A factorial analysis of variance was used to further compare differences in natural sound levels between sites and trips.

Aircraft Data

Of the data collected on trips 1 and 2, all aircraft events occurring in time periods 1 - 7 were analysed. Events, which overlapped with break periods, were included in the analysis. Aircraft events were analysed in terms of aircraft activity and aircraft sound.

Aircraft Activity

Analysis was based on 45 hours of data collected over days 1 - 8. Aircraft activity was investigated in terms of:

- numbers of aircraft events relative to sites and trips;
- types of aircraft events relative to sites;
- numbers and types of aircraft events relative to times of day;
- proportions of sites affected by the same aircraft visits.

All aircraft events recorded at data collection sites, regardless of whether or not they registered above background sound levels and whether or not the aircraft event passed through their setting, are regarded as having had an impact (or they wouldn't have been observed) and were therefore included in the analysis. Comparisons made were primarily qualitative. A factorial analysis of variance was used to further compare differences in activity between sites and trips.

Aircraft Sound

Analysis was based on 31 hours of data collected over days 3 - 8 unless otherwise stated. Aircraft sound levels are compared against either the 'average natural sound level over the entire study area' or against 'site specific average natural sound levels' (as discussed in the background sound data results). Aircraft sound is then described in terms of:

- the proportion of aircraft events which registered above average background sound at each site and over the entire study area (site specific analysis was based on 45 hours of data collected on days 1 - 8 and site specific average natural sound levels);
- maximum sound levels at each site, on each trip and over the entire study area;
- maximum sound levels relative to event types (analysed separately for data collected on days 3 - 8 and for data collected on days 9 and 10 (trip 3));
- maximum sound levels relative to distance from seaplane takeoffs (based on 11.5 hours of data collected on days 9 and 10);

- the duration of aircraft sound above background sound levels at each site and over the entire study area.

Comparisons made were primarily qualitative. A factorial analysis of variance was used to further compare differences in aircraft Lmax sound levels between sites and trips.

The duration of aircraft events above average natural sound level was estimated by counting up the number of readings for each event with values above the established overall average natural value (57dBA) and multiplying them by 10 seconds (the interval between recordings). When a single maximum sound level or duration was recorded for concurrent aircraft events, they were analysed as a single event and termed a 'cumulative event'. The number of cumulative events recorded at any site are noted and presented in the results along with events which were noted but which were not recorded.

Of the data collected on days 9 and 10 (trip 3), all seaplane events run by Hamilton Aviation and all helicopter events were analysed to further establish a relationship between event type and noise levels experienced on the beach. Maximum decibel levels recorded for seaplane takeoffs were also correlated with distance between the recorder and the sound source. Seaplane takeoffs were chosen for this analysis as they had been identified as causing the highest sound levels and also provided the largest database. Estimations of takeoff distances made using ranging poles during trips 1 and 2, were not used in the analysis due to the more accurate data collected during trip 3 using range finder binoculars.

Watercraft Data

The absolute maximum decibel level recorded for a single watercraft event, the average number of watercraft observed in a day, the total number of watercraft events recorded over all days, and the types of watercraft events occurring were all qualitatively compared between settings.

Human Use Data

The number of people in each setting, at 10:30, 14:00 and 17:00 was averaged over all days of data collection. Averages were then compared between settings both qualitatively and quantitatively using chi-squared analysis.