MARINE MANAGMENT SUPPORT
NINGALOO

REVIEW OF THE METHODS USED TO DETERMINE MONITORING SITE COORDINATES IN THE NINGALOO MARINE PARK MONITORING PROGRAM AND ROWLEY SHOALS MARINE PARK MONITORING PROGRAM

Review

A collaborative project between the Marine Conservation Branch
and Exmouth District Office of CALM

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SUMMARY

This data report presents a desktop review, conducted by the Marine Conservation Branch, on 52 long-term monitoring sites established as part of the *Ningaloo Marine Park Monitoring Program* (NMPMP) in 1998/1999 and 17 monitoring sites established in Bills Bay in 1989. The report identifies and addresses issues relating to the accuracy of monitoring site coordinates and presents corrected site coordinates standardised to the datum WGS84 and displayed as decimal degrees and northing/easting (AMG zone 49). The datum WGS84 is equivalent to the standard datum GDA98 adopted by the Australian Government. The corrected and standardised monitoring site coordinates for the NMPMP are listed in the appendices and supersede any monitoring site coordinates presented in previous field and data reports. The site coordinates listed in this report should be used in all future NMPMP surveys.

The data report also clarifies the standard procedures used for recording monitoring site coordinates and relocating established monitoring sites.

1 NINGALOO MARINE PARK

The Ningaloo Marine Park Monitoring Program (NMPMP) has established xxx sites in the Ningaloo Marine Park (NMP) and proposed southern extension bewteen 1989 and 2000. These include xxx transect site which are permanently marked using starpickets

1.1 GENERAL

In 1998 the Department of Conservation and Land Management (CALM) established the Ningaloo Marine Park Monitoring Program (NMPMP) to provide information on the health of benthic communities of the Ningaloo Marine Park (NMP) to detect any undesirable trends so that CALM, if necessary, can take remedial action to prevent irreversible changes from occurring. The locality and boundaries of NMP and surrounds are shown in Figure 1. The NMPMP has established a total of 52 monitoring sites (30 'transect' and 22 'non-transect') between 1998 and 1999 and surveyed 17 monitoring sites established in Bills Bay in 1989 after coral mortality from the mass coral spawning.

The *NMPMP* currently uses standard protocols for determining monitoring site positions. These protocols are based on using a differential global positioning system (DGPS) to record site coordinates to an accuracy of better than three meters using the datum WGS84. However since the commencement of the NMPMP a number of issues have been identified regarding these protocols, including:

- confusion in regards to datum usage;
- lack of experience in the use of position fixing equipment; and
- the use of GPS (which has an accuracy of between 5-10 meters but occasionally 200 meters).

To address these issues, the protocols need further refinement, need to be described clearly and field staff must gain expertise and confidence in the protocols and in the use position fixing equipment.

This report provides the results of a desktop review conducted by the GIS section of the Marine Conservation Branch in order to verify the accuracy of the site coordinates for NMPMP monitoring sites established between 1998 and 1999 and the monitoring sites established in Bills Bay in 1989. The review was initiated in response to the problems experienced in the re-location of monitoring sites caused by variations in the protocols used for recording monitoring site coordinates (eg site coordinates recorded in a variety of datums and formats. In addition the Australian Government has adopted GDA98 as a standard datum and CALM is legally required to convert all current data (including monitoring site coordinates) to this datum and collect all new data using this datum.

1.2 BACKGROUND

To date the NMPMP has conducted four field surveys to the NMP, with the first two focusing primarily on the establishment of monitoring sites. The first field survey of the *NMPMP* in May 1998 established 21 long-term monitoring sites ('transect') along the back reef of the NMP and proposed southern extension. The details of this survey are presented in the Cary *et al.*, 1998 (Field Program Report) and Cary *et al.*, 1999 (Data Report). The second survey in August 1999 established a further 31 monitoring sites (9 'transect' and 22 'non-transect') along the back reef, lagoons and shoreline of the NMP and re-surveyed two sites established in 1998. The details of this survey are presented in Daly *et al.*, 1999 (Field Program Report) and Cary *et al.*, 2000 (Data Report). The third survey in December 2000 re-surveyed ten 'non-transect sites established in 1999 located in areas of human usage. The details of this survey are presented in Grubba *et al.*, 2000 (Field Program Report) and Grubba *et al.*, 2000 (Data Report).

An additional NMPMP survey conducted in May 2000 monitored 17 monitoring sites established in Bills Bay in 1989. The sites were established throughout Bills Bay in order to monitor the impacts of the 1989 mass coral spawning event which resulted in the deoxygenation of the near shore waters of Bills Bay causing extensive coral mortality. Previously the sites had been monitored in 1989 and 1994. The details of the May 2000 survey are presented in Cary *et al.*, 2000 (Field Report) and Cary *et al.*, 2000 (Data Report). The May 2000 survey experienced significant problems with site re-location.

During the August 1999 field survey, two monitoring sites (N1 and N19) established in May 1998 were surveyed. One of these sites was re-located only after an extensive search, while the other site was not re-located. These difficulties experienced raised concerns regarding the ability to re-locate sites

effectively. To address this, CALM Exmouth staff tried re-locating a number of monitoring sites established in 1998 and 1999 and were able to re-locate sites established in 1999 relatively easily re-located. However sites established during 1998 were difficult if not impossible to re-locate. During the May 2000 survey, site relocation was trialed again with the monitoring sites established in 1999 were re-located easily. One 1998 monitoring site re-located after an extensive in-water search. The site was re-located approximately 200 meters southwest of its recorded position which could have been due to a datum shift or the accuracy of the GPS.

The July 2001 NMPMP field survey will select and monitor approximately 16 monitoring sites established during 1998 and 1999. This sample of monitoring sites will be monitored on an annual basis. It is essential that the issues relating to site coordinate accuracy and site relocation are addressed and a practical solution reached prior to continued monitoring surveys.

1.3 AIMS

2 DETERMINING SITE COORDINATES USING GLOBAL POSITIONING SYSTEM (GPS)RECORDING LONG TERM MONITORING SITE COORDINATES

2.1 GLOBAL POSTIONING SYSTEMS (GPS)

The most effective way of determining a site position in latitude and longitude and relocating a site is through the use of a Global Position System (GPS) and/or Differential Global Position System (DGPS). There have been issues relating to the accuracy and suitability of these two systems for use in long-term monitoring. The following sections summarise these issues and makes recommendations on which system/s are suitable for use in the Marine Conservation Branch long-term monitoring programs.

2.1.1 GPS

The Global Position System (GPS) is a hand held unit that receives and uses satellite signals to calculate the position on the surface of the earth in latitude and longitude. The accuracy of these positions is affected by the following error sources:

- Localised ionospheric refraction of the signal: the signal path between the receiver and the satellite may be bent which can lead to the over estimation of the satellite-receiver distance;
- The number of visible satellites and their geometry relative to the user; and
- The quality of the GPS unit.

In addition GPS units prior to May 1999 GPS accuracy was affected by "selective availability" an in-built error imposed by the US Government which caused errors of up to 100 meters. During this period GPS units were not used in long-term monitoring due to the large "selective availability" error. As of 1st May 1999 the US Government removed "selective availability" and current GPS accuracy is now affected only by the three error listed above.

The staff at Magellan GPS Systems in Perth tested their range of GPS receivers against a known survey coordinate and found barely 2.6 metres error in eastings and 3.4 meters in northings, which equates to a linear error of 4.28 meters (Measure & Map July 2000). Figure xx compares GPS reading variations prior to "selective availability" being turned off and after being turned off (xxxxx 2000). It is important to note that despite "selective availability" being removed the quoted accuracy of GPS units are based on statics. The current error is better than 10 meters 90% of the time and better than four meters 70% of the time. However it is still possible to get an error that is in excess of 100 meters.

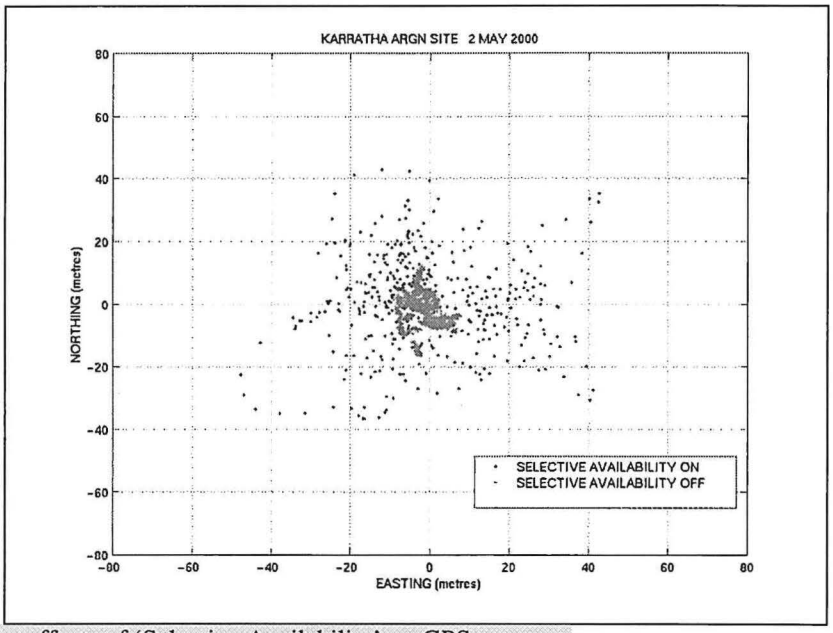

Figure xx. The effects of 'Selective Availability' on GPS accuracy

2.1.2 DGPS

Differential Global Position Systems (DGPS) use a standard GPS unit connected to a differential demodulator. The differential demodulator receives a correction signal from fixed ground stations, which are then applied, to the GPS coordinates. The correction signal removes the errors associated with "selective availability" (which was removed as of 1st May 1999) and isospheric refraction of the signal. The corrected coordinates have an error of approximately 1-2 meters.

The MCB used a DGPS unit for long-term monitoring when "selective availability" was applied. The DGPS unit (Fugro) used by MCB experienced many malfunctions in the field due to power problems and cost approximately $20 per hour to run and is a rather bulky unit that takes up value space in small boats.

2.1.3 Recommendations

The removal of "selective availability" from GPS units has reduced the potenial error and lesened the advantage that main advantage of using a DGPS over GPS units has been removed. GPS units are now capable of recording a site position to within 10 meters or better (errors are further minimised by taking multiple readings during a 5-10+ minute period). While DGPS units maintain their capability of recording a site position to within 2 meters or better.

GPS units are now suitable for use in long term monitoring as long as a little additional time is given to recording coordinates. However the use of DGPS is still preferred. MCBs current DGPS unit (Fugro) should be disposed of as it costs $20/hour to operate, is old (subject to malfunctions), is bulky and is difficult to use. There are new DGPS units available that are in-expensive to purchase/run, and are small and easy to use. It is important to note that new ground station coverage of differential signals is limited (in the future coverage will be increased) and accuracy will be lower in areas with little of no signal.

2.1.4 Datum

In the past the Marine Conservation Branch (MCB) recorded site coordinates using either a GPS or DGPS that was set to the datums WGS84 or AGD84. In some cases there has been confusion over which datum was used. Incorrect datum usage can lead to datum shifts that put site coordinates out by xxx meters.

In 2000 the Australian Government adopted a new standard datum known as the Geocentric Datum of Australia (GDA94). The Government has passed a law that requires all departments to collect new data and to transfer existing data to the standard datum GDA94. As of March 2001 the MCB has held off

from the transfer of its existing data. The branch is waiting for the transfer system (eg software) to be fully trailed and refined before committing to this task.

The current GPS units (Garmin 12) held by MCB do not have the datum GDA94 installed. However the datum WGS 84 can be used as a substitute for the GDA94. The purchase of future GPS units will need to take into account the need for the new datum.

2.1.5 Site coordinate format

In the past site coordinates were recorded in the field using the format degrees, and decimals of a minute as the same format is compatible with nautical charts. The site coordinates are then entered into geographical information systems (GIS) software package. Prior to entry the site coordinates are converted using a formula to a decimal degree format using a spreadsheet. This conversion is a often a source error due to formula errors and data entry errors. The increased dependence on GPS and GIS software requires that a standard format is adopted in order to remove the requirement to convert. In the future all data should be recorded as decimal degrees. This will be a requirement in cases where GPS units are linked to a PC laptop running GIS software in real time.

Site coordinates in decimal degrees should be recorded to five decimal places to ensure maximum accuracy. The table below details the distances represented by each decimal place using the example 23.12345. This can be useful to know when re-locating sites using site coordinates in decimal degrees.

xxx meters

Decimal Place	Meters
1st decimal place	
2nd decimal place	
3rd decimal place	
4th decimal place	
5th decimal place	

2.2 OTHER DESCRIPTIONS

In a perfect world recording only the site coordinates using a GPS or DGPS would be all that is required in order to re-locate the sites at a latter date. It is not a perfect world and errors do occur when recording site coordinates. Recording additional descriptive site position information can be very useful in re-locating sites.

2.2.1 "Mud maps"

Mud maps are probably one of the most effective means of recording the description of a monitoring site. All mud map must include three standard features including scale, direction, and labels. The position of the monitoring site must be clearly described in relation to prominent permanent features using distances and bearings. Mud maps also provide the opportunity to record the spatial extent of surrounding habitat, and impacts. Information including the best anchorage position and dangers can also be recorded.

2.2.2 Aerial photographs

When a site is first established its location should be marked on an aerial photograph using the pinprick method while in the field at the site. This provides a permanent record of the site location and provides a means of ensuring the sites a located the means to test the site coordinates recorded at a latter date when they overlaid over an image in Arcview.

2.3 COLLECTION OF SITE COORDINATES

The following section outlines the standard protocols for the collection of site coordinates. It is important to note that when establishing a monitoring site that will be revisited at latter dates, that additional time and accuracy should be given to ensuring that an accurate description of the site location is provided. It is always important to remember that the persons establishing the site and not always going to be the same persons revisiting the site, so nothing should be taken for granted.

GPS and DGPS
The most essential things to remember when
What Datum is existing data in
What datum is the GPS or DGPS unit set to
What

In most cases prior to going into the field there should be a process of site pre-selection. The coordinates of the pre-selected sites should be entered into the

Upon arriving at a site the GPS unit should be

2.4 PLOTTING LONG TERM MONITORING COORDINATES IN GIS SOFTWARE (ARCVIEW)

The coordinates of all monitoring sites when first established should be entered into a Arcview project. This enables the data to be viewed

3 RE-LOCATING LONG TERM MONITORING SITES

3.1 GLOBAL POSITIONING SYSTEMS (GPS)

There should be a high level of confidence that the sites can be re-located by simply entering the site coordinates into a GPS unit and using the GOTO feature.....

The coordinates of all monitoring sites to be re-located should be entered into the GPS unit prior to going into the field. When entering the coordinates ensure that the datum of the coordinates is ADG 98. If this is not the case then preferably the coordinates should be converted the datum ADG98. In cases where conversion is not possible the GPS datum (ADG98) will need to be changed to the appropriate datum. This change should be noted and the GPS SHOULD NOT be used for recording any new site coordinates why set in another datum. Care should be taken if coordinates already

4 FUTURE DEVELOPMENTS

One possible future development that has currently exists is the ability to connect a GPS to a PC to running GIS software in real time. This ability allows user to view their actual location on rectified images such as a high-resolution aerial image or an electronic nautical chart. The current limitations with the use of this technology in the monitoring program is finding a hardware that can be made waterproof for use in small inflatables which are a potentially wet environment.

For this technology to be utilised there needs to be extensive coverage of the coast with high resolution rectified images. As of March 2001 these images exist for the northern sections of the Ningaloo Marine Park.