Feasibility of operating remote surveillance systems in a marine environment

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ABSTRACT

This report evaluates the equipment and systems available for remote surveillance of boats in marine reserves. It is based on a desktop study that: investigated available options, e.g. satellite pictures, automatic surveillance systems; investigated the relative cost/benefits of the different systems; researched the capital and ongoing maintenance costs; and investigated operational costs. In evaluating the options the ideal solution was considered to be a fully automatic stand-alone remote surveillance system that records and identifies boats. In addition, the system should be able to either transmit the information collected at regular intervals, or store the information on-site for downloading to a laptop computer at a later date. From this, a network camera system is proposed and suitable manufacturers are listed.

Keywords: feasibility investigation, remote surveillance systems, marine environments

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1. Introduction

The Bay of Plenty Conservancy, Department of Conservation, administers the Tuhua (Mayor Island) Marine Reserve, and has jointly applied with the Whakaari Marine Protection Steering Committee for the establishment of the proposed Te Paepae Aotea (Volkner Rocks) Marine Reserve (Department of Conservation 2002). The distance from the mainland (26 km from Tuhua to Tauranga and 55 km from Te Paepae Aotea to Whakatane) means that monitoring of events, be they weather conditions, marine mammal movements (e.g. while surfacing), illegal activities (i.e. fishing within the reserve), or others, cannot always be done. One possible solution is to have in place remote surveillance to record such events, and if illegal activities occur, to identify the vessels involved.

Remote surveillance (also known as remote sensing) is a means of gathering information about an area or object, without direct contact (Creese & Kingsford 1998). For example, the remote surveillance identificatiion of vessels at sea requires:

- a method of acquiring a picture or data about any vessels in the area;
- a method of processing the picture/data; and
- a method of storing the pictures/data at the site or transmitting them to a base site.

In addition, picture/data acquisition must be possible in any environmental conditions and at any time of the day, and the data collected must be of high enough quality to identify what any vessels are doing and what they are.

Two methods of remote surveillance are available for monitoring events within a marine environment: satellite imagery/location, and ground-based imagery.

1.1 OBJECTIVE

This report was intended to identify current remote surveillance systems, and assess their relative merits. The feasibility of the different systems was investigated for conservation tasks, such as marine reserves compliance and law enforcement, that occur within an exposed marine environment. The key requirement was to assess the feasibility of detecting and identifying vessels by using remote stand-alone surveillance systems.

2. Satellite monitoring

There are two options available for monitoring vessels in marine reserves with satellites: satellite imagery (also known as Optical Satellite Remote Sensing) and the Vessel Monitoring System (VMS).

Satellite imagery involves taking photographs of the area from an overhead satellite. The advantages of this system are that photographs of the site (and therefore vessels present) can often be purchased off the internet, and some satellites (e.g. Radarsat) are capable of producing high-quality images in all environmental conditions and at any time of the day (Canadian Space Agency 2003). However, satellite imagery is of limited value in monitoring illegal activities in marine reserves because the timing of the photographs is dependent on the satellite pass frequencies (which can be as few as one pass over the site every two days) and there are problems with resolution below 30 m, e.g. fibreglass boats less than 25 m long cannot be detected by Radarsat-1 (Kourti & Shepherd 2003). This means that photographs would be of insufficient quality to identify vessels or determine what they were doing.

VMS is a widely used fisheries management tool for locating commercial fishing vessels (Fisheries Forum Agency 2003). It is a computer-based system that allows the position of vessels equipped with appropriate equipment to be monitored via a satellite. This is achieved by installing an Automated Location Communicator on the vessel. This is an integrated GPS and Inmarsat Unit. It is programmed to provide a position report via satellites at a set time or set times each day. Although it can provide an accurate location, speed and heading of a vessel, it cannot identify what the vessel is doing at any particular time. The system is also of limited value in monitoring recreational boats because it depends on an automated location communicator being attached to the vessel—it is designed to monitor commercial fishing boats, and the widespread voluntary fitting of this unit to recreational vessels is unlikely.

As a result of the limitations described above for both satellite surveillance systems, no further investigations into this form of remote surveillance were carried out.

3. Ground-based imagery

3.1 CONTINUITY AND LINKAGE

A ground-based imagery remote surveillance system involves taking images (video or stills) of an area from a fixed site. Ideally it should be an automated self-contained system. This type of system would have the following basic components:

- a high-resolution camera, possibly with tilt and zoom facilities;
- digitising hardware;
- hardware for storing data collected or a data cellular modem/satellite phone for transmitting the data collected;
- on-site power supply in the form of solar cells and a deep-cycle battery; and
- weatherproof housing for the camera, digitising hardware and modem.

In addition there must be software to capture, process and publish the recorded images.

The type of wireless link (cellular or satellite) used to transmit the data will principally depend on local site conditions and cellular coverage in the area.

3.2 IMAGE COLLECTION

There are four options available for collecting images of an area to monitor boats using an automated system. These are: continuous footage; time-controlled photographs/footage; photographs taken when movement is detected; and photographs taken when a 'change' occurs in the area being monitored. Each has different advantages and limitations.

Collecting images continuously (i.e. as video footage) would allow all the activities of boats and their occupants to be monitored. However, it would generate a large amount of information, and data storage and transmission would be a problem. There would also be high labour costs associated with reviewing the large footage.

Where images are collected on a time-controlled basis, a still photograph or short footage is taken at fixed intervals (i.e. half hourly or hourly). There would be some loss of information about the activities of boats in the area, but sufficient information could be collected to identify the boats and what they were doing. This would reduce the data storage/transmission requirements, but there would still be a relatively large amount of data generated.

Taking photographs or video footage in response to movement would reduce the number of images generated and allow for easier data storage and transmission, but its main limitation is that information about stationary boats would not be recorded.

The other option is taking photographs or footage in response to a change in 'scene'. This involves the automated systems camera continuously scanning the target area and comparing the image with an 'empty scene' image. On detecting a difference, the camera takes an image of the changed element (e.g. a boat). The advantages of this system are that images of moving and stationary boats are recorded, and are only produced when a boat is present, which in turn allows for easier data storage/transmission. The disadvantages are that this type of system would require a significant amount of computing power, and there may be 'false' images produced by environmental events (e.g. rough seas).

It should be noted that, whichever option is chosen, conditions of low light and high contrast can be a problem for the camera, resulting in poor-quality images (Axis 2002).

3.3 GROUND-BASED IMAGERY SYSTEMS

Currently there are two types of ground-based remote surveillance systems suitable for monitoring vessels in marine reserves, PC-based cameras and network cameras.

3.3.1 PC-attached cameras

This type of ground-based remote surveillance system relies on a camera being connected to an on-site PC. The data are converted from analogue to digital format through an on-board video card. The data are then either stored on the PC for downloading later, or transmitted by a modem via a wireless link (i.e. cellular or satellite communications) to a base site.

An example of this type of system is the camera used by the National Institute of Water and Atmospheric Research (NIWA 2003) to monitor remote coastal sites. It uses a video camera with a lens of fixed focal length. The data collected are processed by an on-site Pentium 200 MHz computer, with 2 Gb hard drive. A 2.4 GHz wireless link then transmits the video signal from the camera site to a receiving station from which it can be viewed on the internet.

The advantages of this type of system are:

- Where a wireless link is used to transmit the images, they can be accessed in real-time, but if the wireless link is broken data can be temporarily stored by the on-site PC until the link is fixed.
- Data can be stored on-site in the PC's internal hard drive for later collection.

Limitations of this type of system are:

- It requires a PC and associated software on-site.
- The camera must be within 3 m of the PC (cabling requirement).
- Data storage at the remote site increases power consumption.

Costs of installing this type of system are likely to be in the order of $15,000 for an inclusive package (G. Payne pers. comm. 2003). NIWA can custom-make systems to suit the customer's requirements.

3.3.2 Network cameras

In this system the camera and a single-board computer are incorporated into one unit. The unit generally has full computing facilities that:

- process the camera image into jpeg or mpeg files;
- allow pictures to be accessed directly or via the internet;
- store a limited number of picture frames;
- transmit data to remote servers using ftp or http; and
- enable operations to be programmed, so that all the image collection options are possible.

The unit is connected to an external modem that transmits the data collected to a base site through a wireless link. The images can then be viewed via an internet connect or stored on a server at the base.

The network camera has the following advantages:

- Generally the camera/computer unit has full computing facilities so no additional software is required.
- There si less hardware to 'go wrong'.
- It gives direct picture access or internet access via a web browser.
- It contains 4 Mb memory for picture frame storage in the event of a broken wireless link.

- It has lower power needs than a PC-based camera.

It has the following limitations:

- Generally, the lack of on-site long-term storage of data necessitates the use of real-time communications.
- If the network link is broken for any length of time the lack of long-term data storage means data collected is lost.
- If data storage is required on-site, a separate hard disk is required.

This technology is still relatively new, but the estimated cost of building a network system suitable for remote surveillance is in the order of $4,000–$7,000 per site.

4. Conclusions and recommendations

Based on the information available, an automated, self-contained system based around a network camera is considered to be the best solution for remote surveillance of boats in marine reserves.

Network cameras have all the advantages of PC-based cameras in a more compact unit. Nine manufacturers of network cameras were found, and their websites are:

Axis	http://www.axis.com/products/cam_2100/index.htm
Startdot	http://www.stardot-tech.com/
Panasonic	http://www.panasonic.com/consumer_electronics/gate/cameras.asp
Mobotix	http://www.mobotix.com/
EarthCam	http://www.webcamstore.com/solutions/index.cfm/Wireless
IQeye	http://www.iqeye.com/
Dlink	http://www.dlink.com/products/DigitalHome/DigitalVideo/dcs1000w/
JVC	http://pro.jvc.com/pro/vnet/site/index-e.html
Canon	http://www.x-zone.canon.co.jp/WebView-E/product/vb101/

Of these manufacturers, Axis, Stardot and IQeye appear to produce network cameras most suited to the requirements of marine remote surveillance. These manufacturers also appear to have the best software installed in the network camera for meeting the requirements discussed above. The specifications for these cameras are given in Table 1.

Before proceeding further with a remote surveillance system based on a network camera, the following site information would also need to be established: required field of view; required resolution; sunshine hours (approx.); duration of surveillance (hours of the day); duration of surveillance (months of the year); cellular coverage.

Only then can the cameras and modems most suited to the local site characteristics be established. The camera suppliers and/or their agents will also need to be consulted on designing the software to match the functions required of the camera and the best method of data reduction for communications. Thus, detailed capital, maintenance and operational costs can only be accurately estimated on a site-by-site basis.

It is recommended that future work include:

- Investigation of sites for mobile Jetstream and GPRS coverage.
- Specifying requirements on a site-by-site basis.
- Trials on boat detection.
- More detailed review of equipment with respect to revised requirements.
- Considering design requirements of weatherproof housing.

TABLE 1. SUMMARY OF NETWORK CAMERA SPECIFICATIONS

MODEL	FRAMES /SEC	RESOLUTION	TILT/ PAN/ ZOOM	ETHERNET	SERIAL	DETECTS MOTION	SENSITIVITY, lux	PRICE	POWER
Axis									
AX2100	10	640 × 480		Yes	Yes		3–10k	NZ$658	12 V, 7 W
AX2110	15	640 × 480		Yes	Yes	Yes	1–200k	NZ$1,410	12 V, 7 W
AX2120	30	704 × 480		Yes	Yes	Yes	1–200k	NZ$1,877	12 V
AX2130	30	704 × 480	Yes	Yes		Yes	2–200k	NZ$3,260	13 V, 25 W (max.)
AX2420	30	704 × 480		Yes	Yes	Yes	0.5–200k	NZ$2,522	9–15 V, 8 W
Panorama (180° view)	15	640 × 480 × 2	Yes	Yes	Yes	Yes	1–200k	NZ$1,900	12 V, 7 W
Stardot		640 × 480		Yes	Yes			US$599	7.2–10 V, 1 A
		1280 × 960		Yes	Yes			US$899	7.2–10 V, 1 A
IQEye (‘C’ programmable)		1.3 Mpixel	Digital only	Yes		Yes		US$1400	5 W, 12–33 V
DLink		640 × 480		Yes	Wireless			$US329	5 V, 6.5 W
JVC		380 kpix	Yes	Yes					
VNC30U									
VNC2WU									
VNC2U									
VNC!U									
Cannon									
VB101		640 × 480							
Panasonic									
Kx-hcm280		640 × 480	Tilt/pan	Probably			3–10k	US$1,300	
Kx-hcm270		640 × 480	Tilt/pan	Wireless	?		10–10k	US$1,000	
Kx-hcm230		640 × 480	Tilt/pan	Yes	?		10–10k	US$750	
Kx-hcm250		640 × 480	Tilt/pan	Yes	?		10–10k	US$750	
Kx-hcm10		640 × 480	Tilt/pan	Yes	?		10–10k	US$500	
Kx-hcm8		Tilt/pan	No	Yes	?		10–10k	US$400	

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