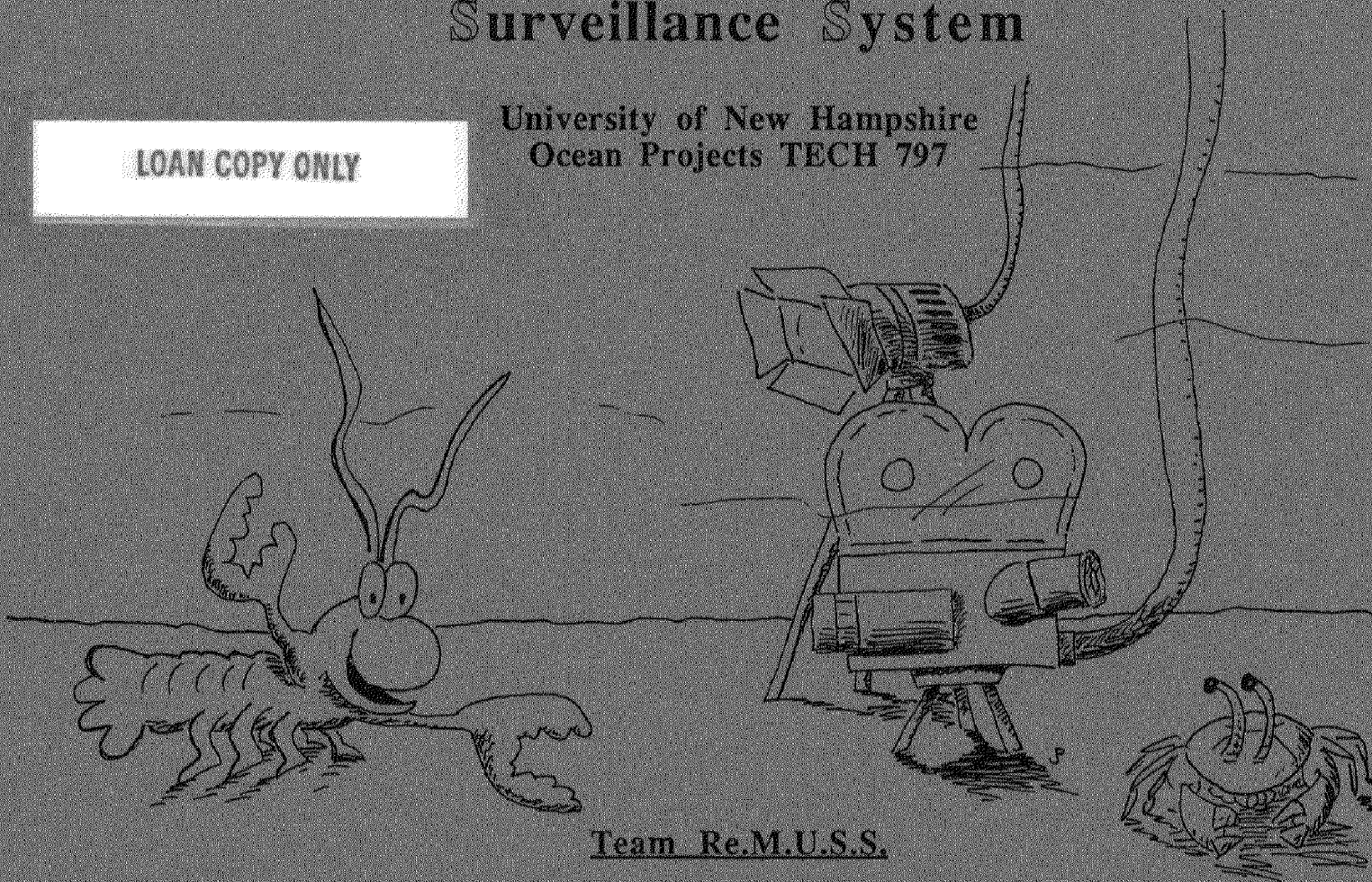


# Re.M.U.S.S.

## Remote Monitoring Underwater Surveillance System

LOAN COPY ONLY

University of New Hampshire  
Ocean Projects TECH 797



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## **ABSTRACT**

Traditional methods for measuring the density of mobile benthic marine animals have proven to be less than satisfactory (inaccurate, biased, etc.). There is clearly a need for a more efficient way of assessing the abundance and recording the behavior of benthic marine organisms. This need prompted the development of Re.M.U.S.S., a Remote Monitoring Underwater Surveillance System. This system is composed of a framework which supports an underwater video camera, a surface transmitter, a buoy system, and a shore-based receiver/recording setup. Preliminary testing has shown Re.M.U.S.S. to be a convenient, economical, and practical method for monitoring the benthic environment.

## **ACKNOWLEDGMENTS**

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# I. INTRODUCTION

## A. General Problem

The American Lobster, *Homarus americanus*, is a crucial component of the fishing industry in New England. This species is found in a wide variety of coastal habitats ranging from Labrador to North Carolina (Herrick 1895). Over exploitation of the lobster fishery is a major concern. Management of this industry is critical in order to reduce the likelihood of over-fishing . Quantification of the true abundance of lobsters is necessary for proper management of this resource .

## B. Background

There are two main methods currently being used to estimate lobster abundance. These are the beam trawl and the use of baited traps. In the first method, a trawl with certain beam width is lowered from a ship and dragged along the ocean floor for a predetermined distance. Trawling is very expensive and can't be used near the rocky shore which is highly inhabited by lobsters. Another disadvantage is the large amount of bycatch taken.

The second method, which involves the use of baited traps, can also provide misleading data. Variations in size and construction cause each type of trap to fish differently. Also, sublegal lobsters which can exit the traps can lead to underestimation of the true population abundance.

Various types of SCUBA surveys are also used to evaluate lobster abundance . Visual transects involve a diver placing a tape measure on the ocean floor and counting the number of target organisms in a predetermined

area. For example, observer experience and training have significant effects upon the accuracy of data obtained. Studies have shown that even with an extensive training program aimed to minimize diver error, biases still occur (Thompson and Mapstone 1997). MacDiarmid (1991) used transects to estimate densities of the spiny lobster on a coastal reef in northern New Zealand.

Watson (unpublished) used SCUBA to determine population densities and size frequencies of lobsters in New Hampshire's coastal waters. This was accomplished by randomly placing quadrats on the ocean floor in designated study areas. The average density of lobsters was found to be 0.37 lobsters/m<sup>2</sup>. These types of surveys are also subject to diver bias. Divers may be drawn to high density areas of lobsters, thereby decreasing the intended randomness of the survey. Results may have been skewed due to the fact that lobsters may have emigrated from the study site in response to diver presence. Also, numbers may also have been underestimated when divers were unable to reach lobsters hidden under rocks.

One method that has gained recent popularity in the research community is the use of video monitoring. Video monitoring has been used in many studies involving a great diversity of organisms. Trudel and Boisclair (1996) used video to observe the swimming behavior of natural populations of red belly and finescale dace. One-sea-winter Atlantic salmon were monitored in a sea cage to determine whether the amount of food obtained was related to social status and the ability to compete (Kadri, et al 1996). These methods of observation are important for improvement in current aquaculture techniques.

The current concern over the conditions of tropical reefs has prompted many studies. Video surveys have proven to be useful in

monitoring reefs and their associated populations. Extended observation time has allowed researchers to continuously survey the environment with minimal effort. Lindquist and Clavijo (1993) used video transects to estimate populations of deep reef fishes off North Carolina. To continuously monitor the feeding behaviors of fish on coral reefs, Dunlap and Pawlik (1996) used remote video equipment.

The use of video monitoring to observe lobster behavior in the field has been limited. Lawton (1987) used video monitoring to observe the diel activity and foraging behavior of *H. americanus* in the laboratory and the agonistic behavior in juvenile American lobsters was studied by Huber and Kravitz (1995).

An advantage of video monitoring is the elimination of the diver. This results in a reduction of the inaccuracy and bias due to diver inexperience and training, as well as extended observation time below the surface and a reduction in manpower required to gather data. Disturbance to the benthic environment and its residents is also minimized and is therefore a more accurate representation of natural conditions. By having the ability to manipulate the camera's field of view, the system has proven to have a wide variety of applications.

Due to the benefits and convenience of video monitoring, this method could be an improvement over current methods of quantifying the true abundance of lobsters.

### C. Objectives

Traditional methods of measuring the density of mobile benthic marine animals have proven to be less than satisfactory. The objectives of this study are: 1) To design and construct a drop camera system which can be easily used



from above the surface to observe the benthos and 2) To incorporate the drop camera into a remote underwater video monitoring system which is economical, convenient to use, and is able to record data for an extended period of time.

#### *D. Approach*

Our plan was to first design and construct the drop camera. Next, we designed the framework which supports the camera. The drop camera and framework were then joined to form the remote underwater monitoring system. A case was devised and constructed to hold the transmitter and batteries. We then developed a buoy system to support the case at the waters surface.

## **II. DESIGN SPECIFICATIONS**

In order to effectively monitor the benthic environment many criteria have to be met. The system needs to be economical and user friendly. Also of utmost importance is ease of deployment and retrieval. The video system should be able to monitor the benthic environment for a number of days without maintenance. Capability to withstand the challenging ocean environment is also a must. Video signals should be able to be transmitted from the study site (surface buoy) to a shore-based receiver station.

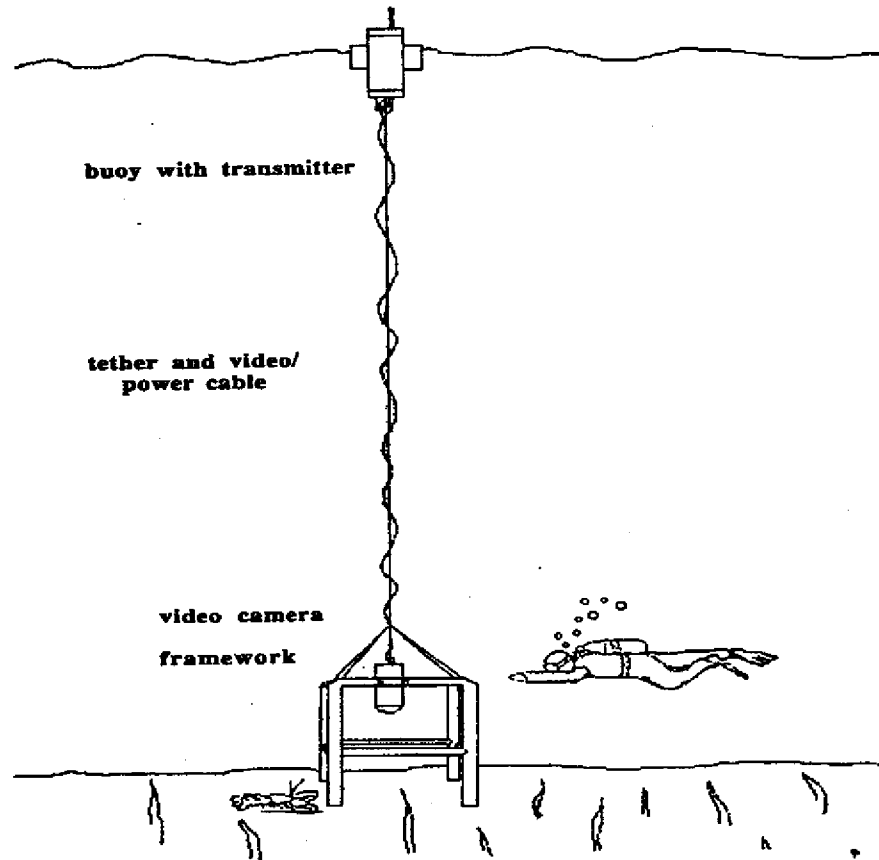


### **III. CONCEPT ALTERNATIVES**

An alternative to our framework could be a tripod design. This might be easier to deploy and retrieve and might also be more stable. A cylindrical foam buoy fitted to the transmitter case, though more expensive, could provide a better alternative to the buoy used for this project. The addition of solar panels would extend the battery life and allow for a longer data acquisition period. Lights added to the framework would allow for nighttime analysis of lobster movements. Multiple cameras mounted on each corner of the frame would allow for a greater field of view and thus a greater study area.

### **IV. FINAL DESIGN**

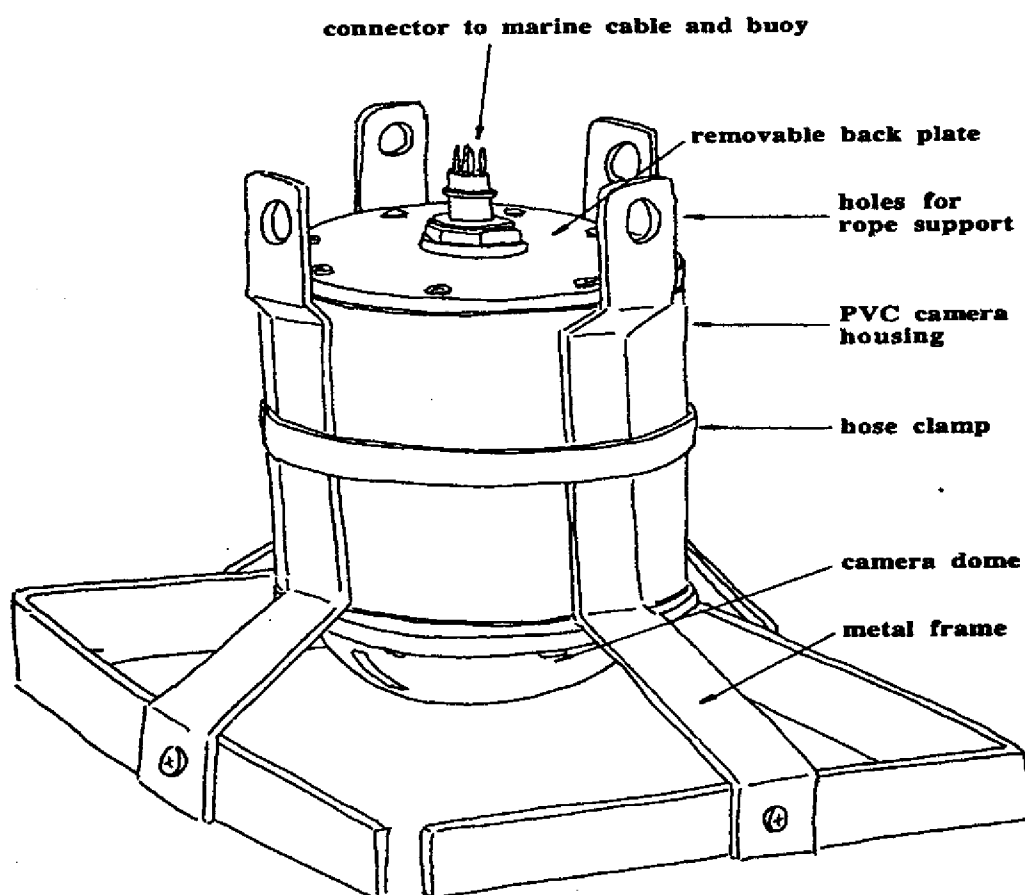
Our final design consisted of a PVC framework that supports an underwater video camera, a surface transmitter, a buoy system (that supports the transmitter) (Figure 1), and a shore-based recording setup (receiver, time lapse VCR, monitor, and batteries).



**Figure 1.** Field setup of the Remote Monitoring Underwater Surveillance System. Transmitter is supported by a buoy system, cable runs to drop camera, and framework with video camera on bottom.

Our first objective was to design and construct the drop camera system. A black and white board camera with a 3.6 mm lens and infrared light emitting diodes was placed inside a 6" section of PVC pipe 4.5" in diameter (Appendix A). This camera is sensitive to light levels as low as 0.1 lux. The pipe was sealed at one end with a removable PVC cap with o-ring. A six pin, glass reinforced epoxy, rubber/polyurethane molded electrical connector was placed through the cap to join the camera to a 50 foot marine cable. This cable would supply electrical power to the camera from two 12 volt rechargeable

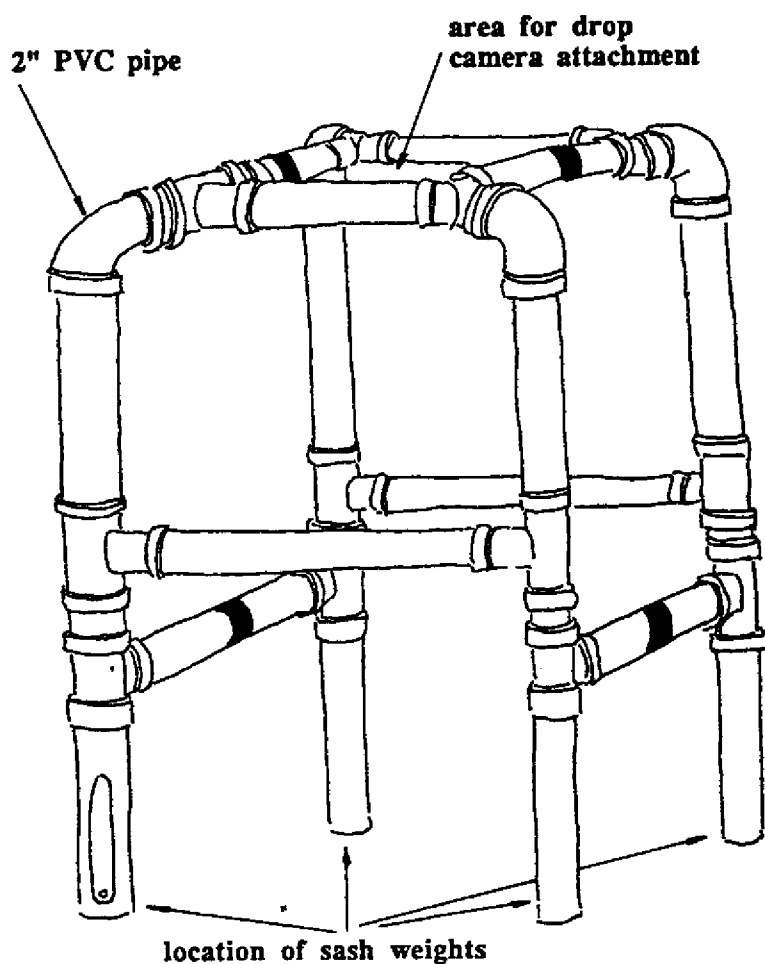
lead-acid batteries contained in the transmitter housing on the surface. The other end of the housing was sealed with a 4.06" diameter plastic compass dome to allow the camera a wide field of view. To protect the camera dome from damage during use, a stainless steel frame was placed around the housing (Figure 2). When using the drop camera system to survey the ocean floor, a Sony Handi-Cam Hi-8 video recorder with LCD screen was used as a video monitor.



**Figure 2.** Drop camera with frame to protect camera dome.

Next, we designed and constructed the frame to support the drop camera as part of the remote monitoring system. The frame was made out of

2" PVC pipe, cut to length and glued together with PVC cement (Figure 3). The frame was cut into two halves which are joined by removable stainless steel couplings to allow easy transport. Two lengths of perforated angle iron were u-bolted to the top of the frame. Bolted to the angle iron were two facing halves of PVC pipe. When hose clamped together, these halves held the drop camera in place between them. In order to create a tighter seal, sections of neoprene were inserted between the housing and the PVC halves (Figure 4). A sash weight was placed in each leg of the frame and secured with a bolt. This reduced buoyancy and ensured that the frame landed upright upon touchdown.



**Figure 3.** PVC framework constructed to hold the camera above the ocean floor.

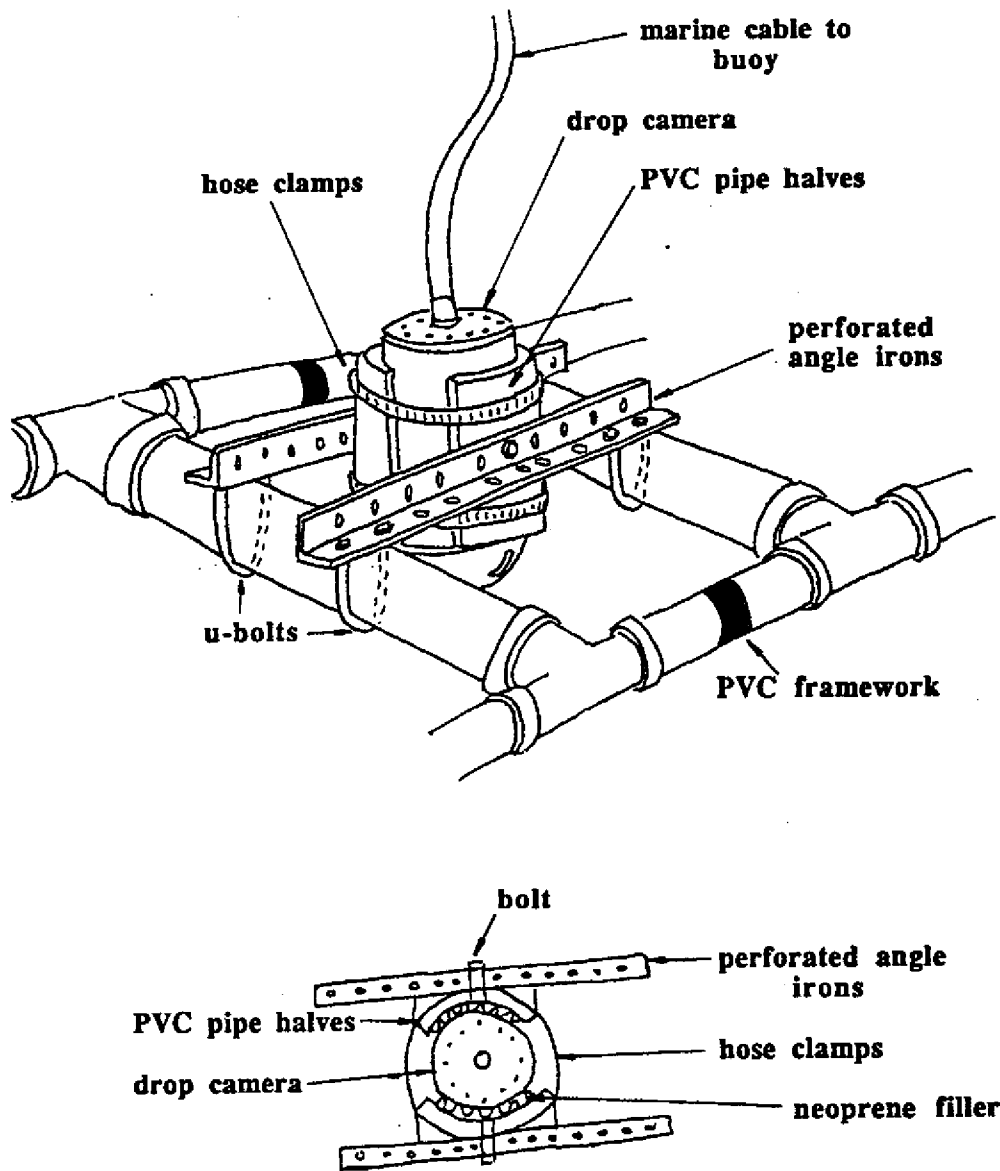
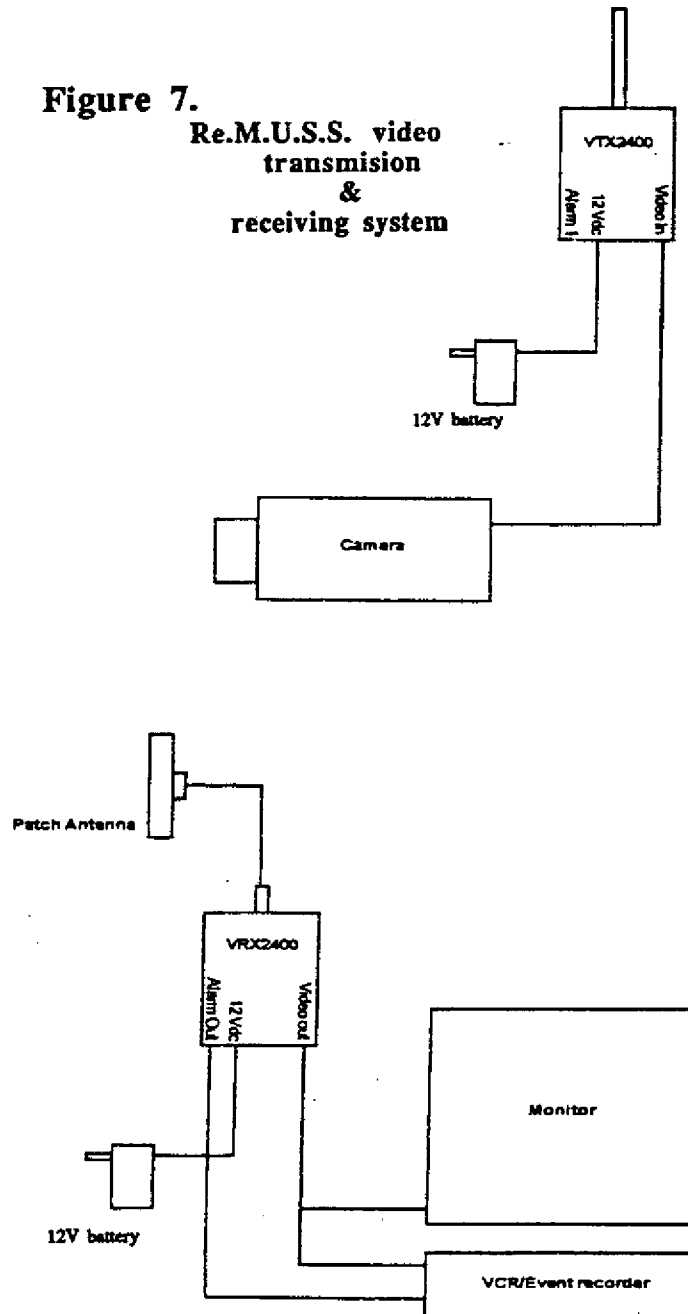


Figure 4. Attachment of drop camera to PVC frame.

A harness system was developed for deployment and retrieval of the frame. A piece of rope was attached to each corner of the frame and the pieces were joined in a caribener. This was united with a second caribener which

was attached to the cable-bearing rope. The cable was connected to the transmitter case, while the rope was tied to a bezel on the buoy which reduced stress on the cable (Figure 1).

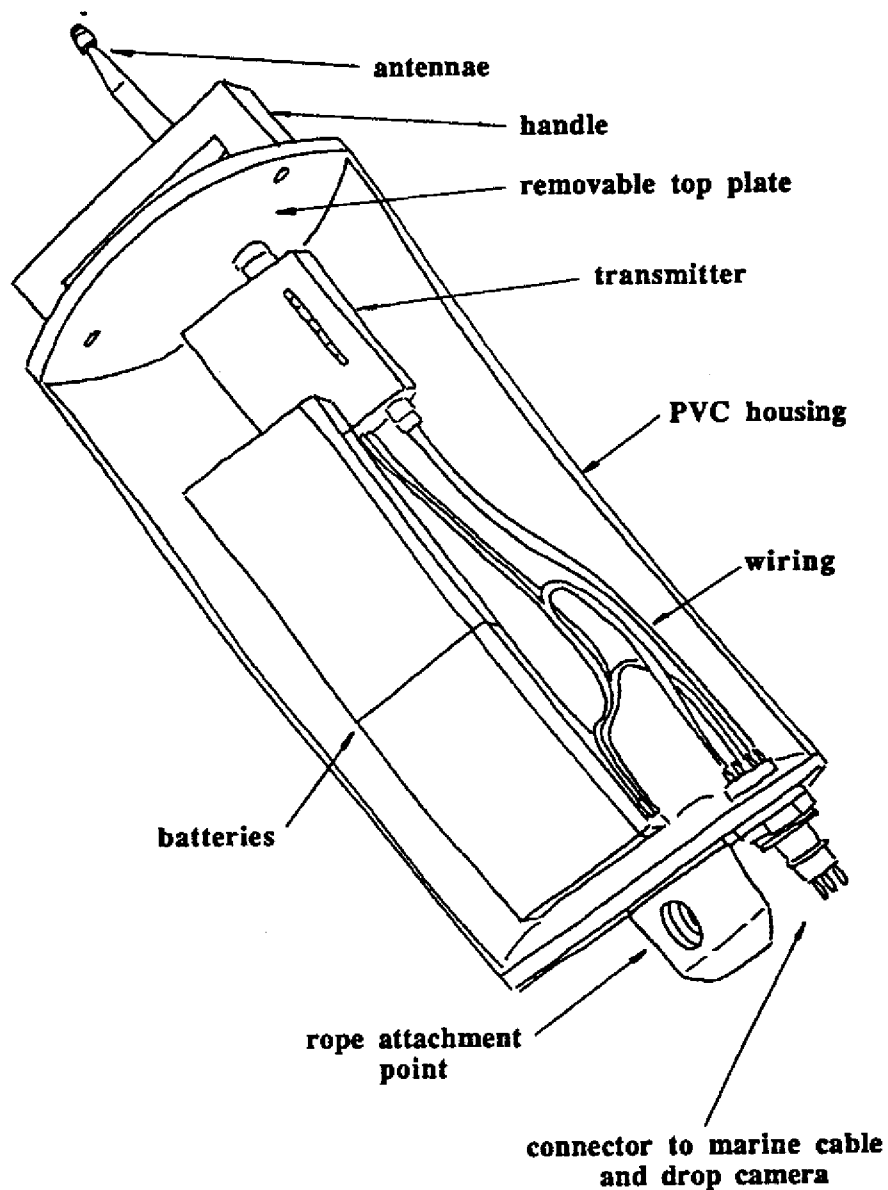
**Figure 7.**  
Re.M.U.S.S. video  
transmission  
&  
receiving system



**Figure 5.** Setup of transmission and receiving units.

The 2.4 Ghz wireless video transmitter (Figures 5-6; Appendix A) was housed in a section of PVC pipe, 16.75" in length and 6.75" in diameter. The transmitter was powered by two 12-volt batteries which also powered the video camera. The housing was capped at both ends with flat sections of PVC. A connector which joined the cable from the drop camera to the transmitter housing was placed through one end. An eyelet was also placed on that end for the attachment of a rope. The cable was wound around this rope to reduce stress on the connections. The antennae from the transmitter was placed through the other end of the housing, on which was also placed a handle for easy transport .





**Figure 6.** Transmitter housing showing internal components.

A buoy was constructed to support the transmitter housing. Three lobster buoys were attached to a triangular wooden framework. The transmitter housing was placed in the center of the framework and secured by hose clamps (Figure 7).

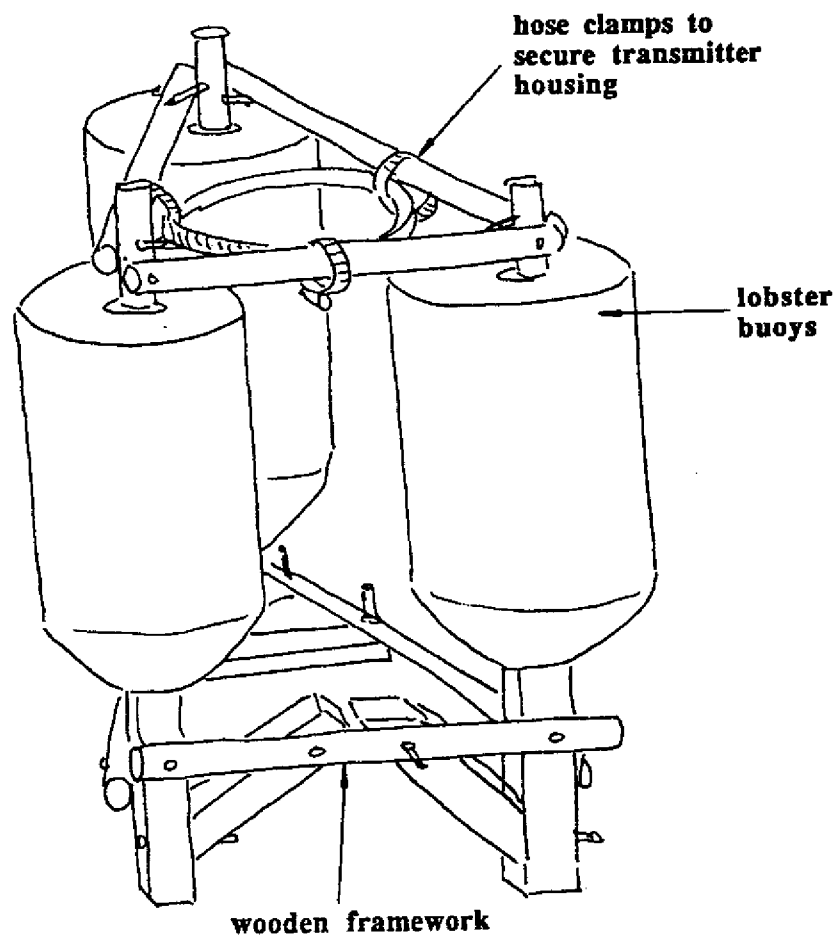


Figure 7. Buoy used to support transmitter housing.

When using the remote monitoring system, the signal is transmitted to a receiver located on shore. The receiver is powered by two 12-volt batteries and is connected to a time-lapse VCR for recording data observed by the camera.

## V. TESTING

After construction of the drop camera, we tested for water leakage and buoyancy in the test pool of the Ocean Engineering building at the University of New Hampshire. The drop camera was also field tested at Friday Harbor Laboratory in Friday Harbor, Washington. The camera was used in conjunction with an alternate framework in order to study *Melibe* ( a nudibranch found on the west coast). The tests were successful and the system proved to be very user friendly.

When the drop camera and frame were joined in the remote underwater monitoring system it was deployed in the pool at a depth of 25 feet to determine any problems related to buoyancy or logistics of handling. The buoy system was placed in the pool to determine any problems related to buoyancy or balance of the transmitter case.

Transmission distance was tested on the football field of the UNH Wildcats. The receiver and monitor remained stationary while the transmitter and drop camera were moved 200 yards in a direct line of site

The entire system was tested for two days off of the dock at the Coastal Marine Laboratory in Newcastle, NH. This process allowed us to determine any problems related to deployment, data recording, transmission distance and resilience. Data was recorded for a period of 35 hours on the time lapse VCR. Upon completion of these tests, we placed the entire system off of Great Island Common in order to gather data on lobster abundances.

Due to delayed arrival of materials, time for final testing of the remote monitoring system was minimal. Also, the UNH fleet was unavailable for use until April 20 which limited the final testing. Re.M.U.S.S. was deployed off the coast at Great Island Commons in New Castle, New Hampshire to a

depth of 25 feet. Data was unable to be collected due to technical difficulties. Deployment of the frame required little manual effort. The frame remained upright at the bottom and the buoy was stable. Retrieval of the remote monitoring system was more difficult than deployment but was still relatively easy. Care was taken not to place any unnecessary stress on the cable by using only the rope during deployment and retrieval.

## **VI. CONCLUSION**

The Remote Monitoring Underwater Surveillance System proved to be an excellent tool in underwater research. It provided a convenient and economical way to monitor the benthic environment without diver interference. The use of a time lapse VCR allowed for the creation of a permanent record for later analysis by many observers. This method also allowed for a longer observation time than standard SCUBA surveys. The transmission of live video footage from an oceanic environment and of live animals in their undisturbed, natural habitat is a unique and highly beneficial opportunity.

This system is very flexible and can be applied to a wide variety of studies involving free-swimming as well as benthic organisms.

## **VII. APPLICATIONS/FUTURE TESTING**

Re.M.U.S.S. has many applications in underwater research as well as in other areas. Monitoring organisms in the benthos as well as in the open water is an obvious application. Re.M.U.S.S. can also be used to display a real-time oceanic environment to observers, for example, in an aquarium or other

educational facility and might also be linked to the internet for observation. The drop camera of the remote monitoring system can be used as a separate component to perform an underwater search for a piece of lost equipment, an appropriate study site, or a specific habitat.

Many plans have already been made for Re.M.U.S.S. One major experiment involves quantifying the abundance of lobsters in the coastal areas of New Hampshire and comparing this data to population numbers attained by SCUBA surveys. Other possibilities include adding bait to the study area to observe foraging behavior, observing agonistic behavior, and predation studies involving tethering a lobster to determine predators.

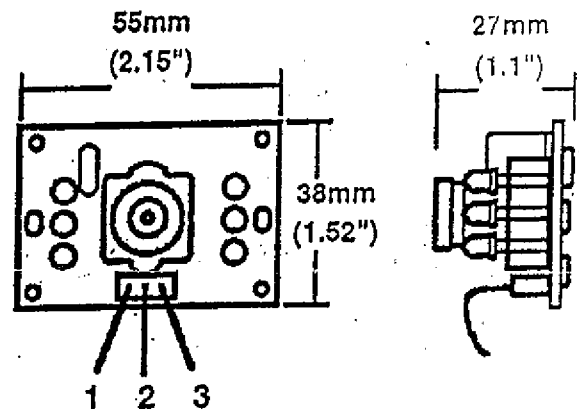
## VIII. Appendix A

# Camera P.C.B. Module Series CA-H34A

Size: W55 X H38 X D27mm

- \* Compact and light weight
- \* Low power consumption
- \* Low light illumination
- \* Maintenance free
- \* Built-in electronic auto Iris
- \* Internal synchronization


Camera	CA-H34A (EIA)
Image Sensor	1/3" 270K B/W LZ 2314J
Effective Pick up Area	512(H) X 482(V)
Image Input Pick up Area	5.9mm(H) X 5.1mm(V)
Image Signal Standard	EIA
Image Output	1.0V p-p/75 Ohm Negative Sync.
Scanning System	2:1 Interface
Scanning Frequency	Horz. 15.734Khz $\pm$ 1% Vert. 59.94Hz $\pm$ 1%
Synchronization System	Internal
Resolution	Horz. 360 TV-Line Vert. 420 TV-Line
Min Illuminance of Subject	0.1Lux (F1.8), IR LEDs On
S/N Ratio	50dB (AGC Off)
Gamma Characteristics	$\gamma$ -0.45
Input Voltage	DC-12V
Voltage Range	DC 11V - 13V
Current Draw	150mA
Lens	f=4.3mm / F1.8
Lens Angle	H=62° (Deg) V=47° (Deg) OA=78° (Deg)
Iris Control	Auto-Iris
Shutter Speed	1/60 - 1/32000 Sec.
Operating Temperature and Humidity	-10°C to 50°C RH 95% Max
Weight	33g

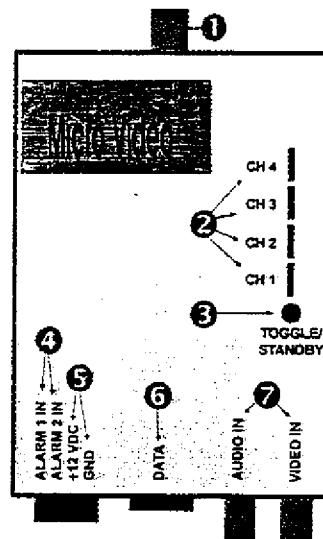


- 1 Ground (Power & Video)---Black  
 2 Video Signal Output-----Brown  
 3 +12VDC-----Red

MARLIN P. JONES & ASSOC. INC.  
 P.O. BOX 12685  
 LAKE PARK, FL 33403-0685  
 407-848-8236

## Front Panel Connectors & Controls:

1. Antenna Connector -- fixed per FCC regulations
2. Channel Selection LEDs -- current channel is illuminated
3. Channel Toggle/Standby Mode switch -- press and release to change channels, press and hold to place transmitter in standby mode
4. Alarm inputs
5. Power Connections
6. Serial data interface for connection to a PC with  Link
7. Audio & Video Inputs



**MICRO VIDEO PRODUCTS**

One Mill Line Road  
Bobcaygeon, Ontario  
Canada K0M 1A0

## **VTX2400 Transmitter Specifications**

### **RF SECTION**

**Frequency:** 2400-2483 MHz  
**RF Output Power:** 50mV/m at 3m per FCC  
part 15.249  
**Frequency Stability:** 0.005% PLL stabilized

### **AUDIO**

**Input Level:** 1 Vpp  
**Input Impedance:** 600 Ohms  
**Bandwidth:** 50Hz - 15kHz (3dB)

### **POWER**

**Input Voltage:** 12 Vdc nominal,  
8.5-13.5 Vdc range  
**Current Cons.:** 200mA in transmit mode  
10mA in standby mode  
**Max. Ripple Input:** 2 Vpp

### **ENVIRONMENTAL**

**Operating Temp.:** -20 to 70 °C  
**Storage Temp.:** -30 to 85 °C  
**Humidity:** 95% noncondensing  
**Shock:** sustain 3-axis drop from  
5' (1.52 m)

### **PHYSICAL DIMENSIONS**

**Size:** 3.4"W · 4.3"H · 1.2"D  
(8.5cm · 11cm · 3cm)  
**Weight:** 1.5 lb (0.675 kg)  
**Construction:** all-steel housing

### **VIDEO**

**Input Level:** 1 Vpp per NTSC/PAL  
standard  
**Input Impedance:** 75 Ohms

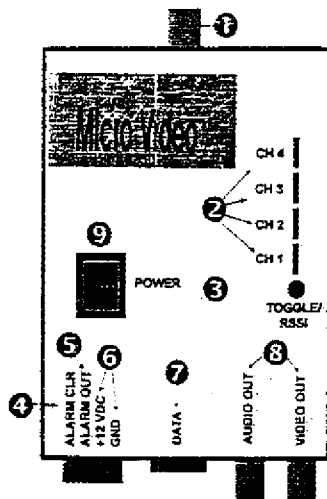
### **CONNECTORS & INDICATORS**

**RF Output:** right-angle omni antenna  
**PC Interface:** 6-pin RJ11  
**Video:** BNC female  
**Audio:** BNC female  
**Alarm/Power:** 4-post Euro-pluggable terminal  
block


### **ALARM**

**Input Level:** normally open, contact  
closure sends alarm to  
receiver. Configurable  
with software.





## Front Panel Connectors & Controls:

1. Antenna Connector
2. Channel Selection LEDs -- current channel is illuminated
3. Channel Toggle/RSSI Mode switch -- press and release to change channels, press and hold to allow LEDs to act as Received Signal Strength Indicators
4. Alarm Clear Input
5. 1 Amp Alarm Output
6. Power Connection
7. Serial Data Interface for connection to a PC with  Link
8. Audio & Video Outputs
9. Power Switch

MICRO VIDEO PRODUCTS

One Mill Line Road  
Bobcaygeon, Ontario  
Canada K0M 1A0

## VRX2400 Receiver Specifications

### RF SECTION

Cascade P1dB Input: > -18 dBm  
Image Rejection: > 60dB  
Adjacent Channel > 90dB Ch1-4,  
Rejection: > 60dB Ch 2-4, 3-1  
Cascade Noise Figure: < 4dB  
Receiver Sensitivity: -85 dBm for clear picture

### AUDIO

Output S/N: > 50dB with -80 dBm  
input  
Output Impedance: 600 Ohms  
Output Level: 1 Vpp nominal  
Bandwidth: 50Hz - 15 kHz (3 dB)

### VIDEO

Output Level S/N: > 45 dB at -80 dBm RF  
input signal  
Output Impedance: 75 Ohms

### ALARM

Coding: 24-bit code  
Output Level: Normally floating, grounded on  
alarm, removed when alarm is  
cleared

### POWER

Input Voltage Range: 12 Vdc nominal,  
10-13.5 Vdc range  
Current Cons.: 350mA in normal and  
RSSI modes  
Max. Ripple Input: 2 Vpp

### CONNECTORS & INDICATORS

Controls: On/Off -- SPST rocker  
Channel/Mode -- Momentary  
Indicators: 4 LEDs (incidate channel, act as signal  
strength indicator in RSSI mode)  
PC Interface: 6-pin RJ11  
Video: BNC female  
Audio: BNC female  
Antenna Input: TNC female  
Alarm: 4-post Euro-pluggable terminal block

### ENVIRONMENTAL

Operating Temp.: -20 to 70 °C  
Storage Temp.: -40 to 85 °C  
Humidity: 95% noncondensing  
Shock: sustain 3-axis drop from  
5' (1.52 m)

### PHYSICAL DIMENSIONS

Size: 3.4"W · 4.3"H · 1.2"D  
(8.5cm · 11cm · 3cm)  
Weight: 1.5 lb (0.675 kg) without antenna  
Construction: all-steel housing

## BUDGET

Video Camera	119.95
Custom Camera Housing	5.50
Cable and Connectors	162.00
Monitor/Handicam	400.00
Video Transmitter/ Receiver	920.00
Custom Buoy	50.00
Batteries	90.00
Hardware	40.00
Camera Frame	194.46
TOTAL	<hr/> 1981.91

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