S. O. L. E.

Study of Lobster Environment
Fall 1995/Spring 1996

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Sea Grant
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Introduction:

If the daily migratory movements of *Homarus americanus* can be understood, we might gain a greater ability to monitor populations in specific areas of the Gulf of Maine. This would allow for more accurate fishery management which results in a decreased chance of over fishing and perhaps a more consistent catch. Often times direct observation of animals in their natural habitats pose challenges, especially in marine environments. An obvious choice for this type of study would be the use of SCUBA. This has many significant drawbacks which prevent it from being applicable for a long term project.

A more practical method is to create a device that constantly monitors changes in an environment and the organisms' reactions to these changes. Using this device, readings are obtained while researchers remain at a distance. This device would monitor the environmental changes that effect the behavior of the lobster. SOLE members designed a system that meets these criteria and is currently being field tested. This technique is referred to as telemetry (tele-= distance, -metry = measure). Our objective is to design a telemetry system for use underwater in the monitoring of *Homarus americanus* (American lobster).

Telemetry is a versatile tool that can be used in virtually any setting. Depending on the constraints of the environment and the needs of the organism, certain aspects of the device need to be addressed (Walcott 1995). For the purposes of our study, several specifications have to be met in order for the telemetry device to withstand the effects of pressure and salt water. This device also has to be small enough to fit on the carapace of *Homarus americanus.*

Temperature can be seen as a characteristic of an animal's habitat. It is an integral part of what species look for in habitat selection. Thermal niches set the actual physiological or metabolic lethal limits of that organism (Magnuson et al 1979). Just as any other resource, such as food, temperature can be a measure of fitness by the animals success rate of obtaining the desired temperature range. The lethal temperatures only represent the absolute boundaries of thermal niches. Often times other abiotic or biotic factors "fine tune" or narrow the thermal niche. (Magnuson et al 1979)

Lobsters, being ectotherms, are metabolically dependent on environmental conditions for physiological functioning. In a lab setting, it is feasible to manipulate abiotic factors such as temperature and light to observe any preferences these organisms may have. Testing at the Coastal Marine Lab utilized Onset's Hobo data loggers for temperature and light in a waterproof plastic case. We established a temperature gradient of approximately 8^{o}C (ranging from 9-17^{o}C in the first week to 14-22^{o}C during the final week) in the closed water system. Information on temperature manipulation obtained here was then be compared to similar measurements taken in the natural environment.

It is our belief that *Homarus americanus* will prefer the warmer side of the tank. This is based on the fact that increased temperatures result in increased metabolism in ectotherms as well as increased growth rate. Optimal temperatures described by Templeman (1936) showed that walking activity of lobsters increased between 2-10 ^{o}C and 20-25 ^{o}C. Since lobsters are known to be nocturnal, we are also expecting to see increased activity levels and movement correlate to the decreased light levels associated with night or early morning.

Metabolic efficiency as a function of temperature is based on proper gonadal growth and ability to reproduce (Magnuson et al 1979). Growth rate is related to temperature in that larval growth and molting frequency increase over the temperature range of 6.7 ^{o}C to 24 ^{o}C (Templeman 1936). We believe that a faster growth rate is more desirable since larger animals may have an advantage over smaller individuals in competition for shelters, mates, and food items. It is our hypothesis that a lobster will travel to each section of the thermal gradient tank and stay there for several minutes until it decides if the water in this section is metabolically more efficient.

In order to test this hypothesis, a miniature recording device had to be built which could operate in the lobster's natural environment. Two different options were tested. The first, more simple design used preexisting dataloggers called HOBOs built by Onset Computer Corporation. These were chosen because they are simple to use and easy to implement, yet effective. Temperature (figure 1)and light (figure 2) were chosen to be studied using this technique.

Realizing that the HOBOs are impractical due to the limitations of expandability and size, the Tattletale Slow Lite (figure 3), a programmable microcomputer made by Onset Computer Corporation, was also chosen. This device is very small yet versatile. The Tattletale can operate and record data from up to five separate transducers, and operate for extended periods of time due to the low current drain. The four transducers required for this study were temperature, light, pressure, and vibration.

The last two variables, pressure and vibration, were chosen because of the unique data that they could offer. Through measuring pressure, it is possible to obtain relative depth of the test subject for use in telemetry. The vibration circuit was designed to record data regarding activity level changes with diel patterns of the lobster.

Methods:

Programming of the Tattletale microcomputer was accomplished using LiteLanguage (Onset Computer Corporation 1993), a language designed exclusively for the Tattletale Slow Lite microcomputer. The language is comprised of several existing languages, including basic and "C". The programmer can control 8 I/O lines, and 5 A/D converters. The A/D lines are used to operate the four transducers while the I/O lines are used for time sampling. Time allowing, the Tattletale will also be programmed to activate a self-contained retrieval system through an I/O line. At a predetermined time the microcomputer will send a voltage through a timing circuit which will active a servo. This mechanism will open a valve on the compressed air cartridge at depth, and fill a balloon to provide sufficient buoyancy to float the entire system including the lobster. This allows the lobster and telemetry system to be recovered without the use of SCUBA.

The telemetry system consists of two main components. The first being a Tattletale microcomputer which has complementary circuits used to sample environmental variables. The second main component is a reusable container which is waterproof, pressure resistant, and retrievable .

The design of the temperature circuit (figure 4) uses YSI 44006 Thermistor that is powered and regulated by the Tattletale. A MOSFET transistor (Supertex VP0104N3) is used as a switching device which regulates the temperature sampling time. This also limits power consumption by decreasing the total on time for the circuit.

The light sensor uses a cadmium sulfide photoresistor which is incorporated into a simple voltage divider and then into a LM351 operational amplifier to increase impedance, thus decreasing power consumption. The light intensity circuit diagram is shown in figure 5.

The pressure transducer, chosen for its small size and resistance to marine environment, is the model 150 0-60 psi miniature transducer from Precision Measurement Co. This is a three lead temperature compensated strain gage. The 0 - 60 psi version was chosen because our experimental environment is designed for is 30 to 70 feet deep resulting in pressure from 30 to 50 psi. The resolution is also very important, and this model yields the best resolution. Power consumption was regulated as above using the MOSFET transistor. The output is then read through a Wheatstone bridge (figure 6) and the voltage differential is converted to a depth reading via calibration of the transducer. The calibration was obtained using a portable hyperbaric chamber. The chamber was charged up to 50 psi in 10 psi intervals and this known was then compared to the voltage differential (graph 3). This relation was then converted to a depth (14.7 psi = 32.2 feet), and the Tattletale was programmed to directly present an output of depth.

A vibration detection circuit (figure 7) was designed and integrated into the Tattletale. The sensor used is a "phosphor bronze tab" from the Kynar Piezo Film department of Pennwalt. The circuit chosen uses an RC peak detecting arrangement with a time constant τ=.47sec. The operational amplifier used is an LM351 which increases the impedance to conserve power, but also creates the peak detector. When the piezo sensor is activated by the motion of the lobster the sensor is triggered and the capacitor charges. The discharge is then recorded until the sensor is triggered again.

The final circuit designed is for use in the triggering of the release mechanism. The release mechanism requires precise timing to be effective. The Tattletale is programmed to produce a 5 volt charge at a set time from activation. The circuit consists of the Supertex MOSFET which is the gate that closes the circuit and activates the servo. Once activated this will open a valve on a compressed air cartridge and inflate an attached balloon.

While the Tattletale system was being assembled and programmed, a sister experiment was pursued to test techniques to affix the box to the lobster and to obtain supporting data. In order to test for temperature preference, a tank with a substantial temperature gradient was needed. The main experimental focus at the UNH Coastal Marine Lab was on temperature manipulation. Natural light (ambient light from windows) and overhead lighting (fluorescent) was provided during daylight hours. At night a red light was used for video purposes because lobster eyes are not capable of detecting light waves in 525nm-600nm wavelength which is red light (Zeitlin-Hale 1978).

The first attempt at building a testing tank used a circular track in a round tank. This tank used an open water design and our power supply could not support the equipment required to generate an adequate gradient. We then switched to a closed system using a rectangular tank (figure 8) and through this a 7-9 ^{o} C gradient was obtained. The 26" x 48" plastic tank used brick dividers to separate the tank into five small sheltered areas. The water was recirculated using pumps. The warmer water was generated in a five gallon bucket using 3 aquarium heating rods. The colder water was generated using a water chiller which feeds into another 5 gallon bucket. This set up was originated by Haro in 1991.

The data measuring and recording devices are the HOBO temperature sensor (figure 1) and the HOBO light sensor (figure 2). These are self contained, simple to operate data loggers. Using a complementary program, the HOBOs were programmed for a total sampling of 1800 measurements, which is the maximum capacity.

A time lapse camera and VCR were used to observe the motion of the lobster. By correlating the data collected by the HOBOs and video, it was possible to ensure that the temperature spikes on the graphs created by HOBO were actually lobster movements and not just ambient water flow.

The box containing the telemetry device was constructed of PVC plastic that was machined at the UNH machine shop. The pilot study required two reusable, pressure resistant, water tight boxes (one for lab testing and one for field testing) with clear lids to enable the light sensors to work. The first box was large enough to contain two Hobo data loggers (figure 9). The Tattletale casing (figure 10) met the same requirements (except slightly larger proportions) as the HOBO box. An added feature of the Tattletale box was a hole drilled in the top which fit the strain pressure gauge so the pressure sensing face was flush with the top of the lid. The pressure gauge was then sealed using a silicone sealant.

The attachment site of the telemetry device was the carapace of the lobster. This was the only feasible location due to the size of the waterproof box. A mounting surface was needed to affix the flat bottomed box to the round shelled animal. This mounting surface, or "saddle", was custom fit to each individual lobster as quickly as possible to avoid desiccation. Several materials were applicable for this purpose, however only one fulfilled all criteria.

The thermal plastic called "FIMO" was found to possess the desired characteristics. FIMO was molded according to instructions listed on package. This substance is firm but malleable and hardens into a stiff plastic only after baking. We attached the thermal plastic saddle with a cyanoacrylate glue (super glue). This adhesive dries almost instantly and does not dissolve or corrode in the marine environment. Caution was used when gluing saddle to carapace in order to avoid contact of glue with any other body parts as this may be detrimental to the lobsters' health.

Field testing will occur at Jackson Estuarine Laboratory, Adam's Point, NH (see figure 11). In use at this testing site are three sonar buoy's which act as transmitters for a signal sent by a Vemco pinger (V16-4H-R transmitters), which is attached to the lobster. This signal is sent to the Jackson lab where a computer is set up to track lobster movement. The signal deployed by the Vemco pingers is received as XY coordinates. Z (depth) is recorded by the pressure transducer and can be added to the data at a later date. This data is then overlaid onto a detailed map of the testing area that was previously digitized. (Initial testing is under way using a caging system consisting of 8 units of the cage shown in figure 12). The field test data has not been compiled at this point do to delays caused by ice out in the spring of 1996.

Until the sonar buoys are deployed for the season, field testing will be done in a holding system, consisting of eight 25 x 60 x 90cm sections secured to the bottom of Great Bay Estuary at Jackson Estuarine Laboratory. The caging material is made of high density plastic and attached to the substrate with bricks and stakes.

Results:

Graph 1 is a representation of the raw data from the temperature HOBO (March 4-6). It shows a general trend of the lobster remaining in the 13-14°C range. The HOBO light data (graph 2) shows a diel pattern with some minor fluctuations for a two day cycle.

The HOBO data from Feb 14-20 and March 4-6 (figures 13 and 14 respectively) show that the lobsters spent most of their time in the thermal range of 12-14°C. Figure 15 is a representation of the average movement of our test lobsters from the section in which they spend most of their time to other temperature ranges. There is not much movement indicated. It seems that 200 mm is the extent of the lobsters range during most of the day. Figure 16 shows the greatest amount of movement we observed in a 24 hour period. It can be seen here that the animal moves about 1200 mm. These sampling movements took approximately 30 seconds to complete. The next figure (17) shows a comparison of lobster position over a 24 hour period. As you can see, the animal spent nearly all day in the 14°C range. Time spent outside this temperature range amounts to 1.5 min for the entire 24 hour period.

Graph 3 was taken from data collected during a calibration run in a portable hyperbaric chamber. This test showed that there was a problem in either circuit design or programming. Graphs 4-6 were taken from a test run from the UNH Coastal Marine Lab on May 4, 1996. They show that the Tattletale microcomputer is capable of simultaneously sampling four separate channels. The Tattletale has proved to have the ability to store and process this data in a test setting.

Discussion:

A total of 5 lobsters were used in the thermal gradient tank from January 31 to March 25. Our second test lobster died during testing due to a major flaw in our tank design. We failed to account for accumulation of ammonia waste products in the closed system. The water was changed before each subsequent run to eliminate this problem. This could have been avoided by incorporating a filtration system.

We are not sure what the caused the fluctuations in the HOBO light data from March 4-6. It may be due to the fluctuations in the fluorescent lights used in the Coastal Lab.

The video data from March 4, 1996 shows several movements by the test animal from the coldest area of the tank to the middle section and back. We expected to see a spike in the temperature data from the Hobo datalogger, however there was only a plateau (graph 1). Upon closer examination of the video, we observed that these movements took approximately 30 seconds to complete. We had not expected the lobster to move so quickly and assumed that it would take several minutes for the animal to sense the change and exhibit a positive or negative thermotaxis. The conclusions were reached by correlating the video and HOBO data lead us to believe that these sampling devices are too rigid for our study.

When a HOBO data logger is launched it has a storage capacity of 1800 measurements. It will always take 1800 measurements, regardless of the length of the sampling period. To run a Hobo for six days the Hobo will sample approximately every 4.8 minutes. Even by running a Hobo for one day the sampling rate would still be approximately every 48 seconds which is still too long to record the quick movements of the lobster. Shortening the sampling time would result in a higher probability of recording locomotion activity. This would however lead to additional handling of the lobster which might alter behavior even more. Therefore using a HOBO datalogger for this experiment is not appropriate.

Unlike the Hobo dataloggers, the Tattletale microcomputer is fully programmable in respect to the setting of sampling frequency. It is capable taking samples every 10 seconds, more or less as desired. The maximum number of samples that can be recorded is 13,200 per channel. The vibration circuit will provide data to correlate movement with light data to compare diel locomotory activity.

The most obvious problem with this study is the use of the telemetry device itself. As Walcott (1995) stated, "Telemetry has its own Heisenberg

Uncertainty Principle: affixing a transmitter may alter the phenomenon under study, but if the phenomenon cannot be observed without telemetry, assessing the magnitude of the artifact is nearly impossible." The large plastic box attached to a lobster generates increased drag as well as changing the buoyancy characteristics of the animal. The effects of these alterations may be widespread from interfering with normal locomotion to restricting movement during fight or flight reflexes. Since any direct observation will alter normal mannerisms of an animal (Walcott, 1995), we can only attempt to reduce the strain upon the animal in our experimental setup. In future studies, technological advancements will allow our telemetry device to be reduced in size and weight.

Lastly, a concern that we did not initially account for was the effect of storing lobsters in communal tanks. In an experiment conducted by Zeitlin-Hale (1978), lobsters that were kept communally in tanks with shelters retained their nocturnal patterns of activity while those without shelters lost their rhythmicity. The tank in which we stored our lobsters was fairly small and the one shelter available was dominated by a single larger lobster not involved in our study. Zeitlin-Hale (1978) also indicated that aggressiveness decreased and other normal behavioral and physiological patterns became altered with captivity. While we did not notice any decrease in aggressiveness in our lobsters, it is quite possible that the patterns they exhibited may be a result of this modified behavior.

The Tattletale system that was constructed met the criteria needed to monitor lobsters in their natural environment. In the future it will be possible to decrease the size of the circuitry and thus the case which will lessen the effects which interfere with normal behavior caused by the presence of such a device.

In future lab studies, we plan to use a larger thermal gradient tank, similar to the one we used in this study. Plans for future field work include use of the caging system described earlier as well as a sonar buoy system to track lobster movement. We were unable to complete the field testing at the Jackson Laboratory due to the weather and problems with deployment of the sonar buoys.

References:

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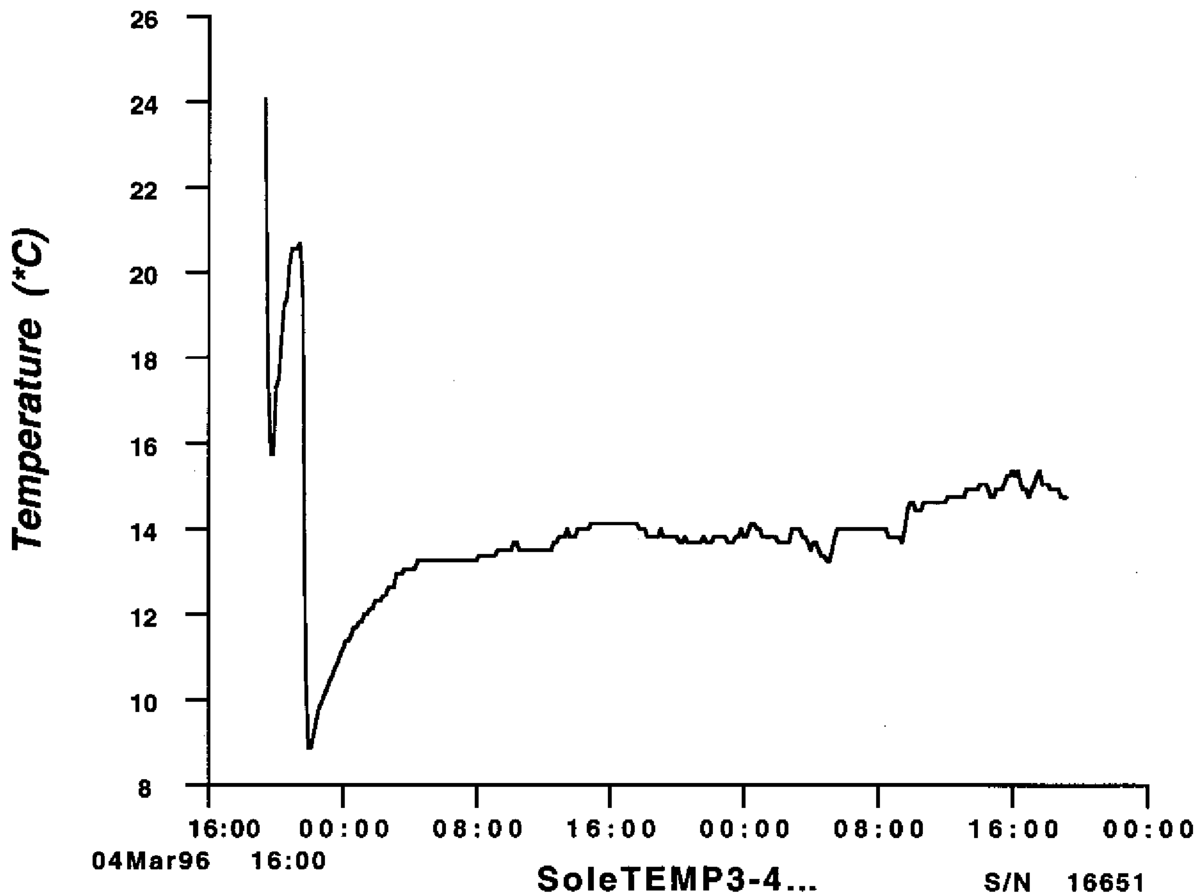
Walcott, Thomas G, 1995. New options in physiological and behavioral ecology through multichannel telemetry. Journal of Experimental Marine Biology and Ecology 193: 257-275.

Zeitlin-Hale, L and Sastry, A.N. 1978. Effects of environmental manipulation on the locomotor activity and agnostic behavior of cultured juvenile American lobster (*Homarus americanus*). Mar. Biol. 47: 369-379.

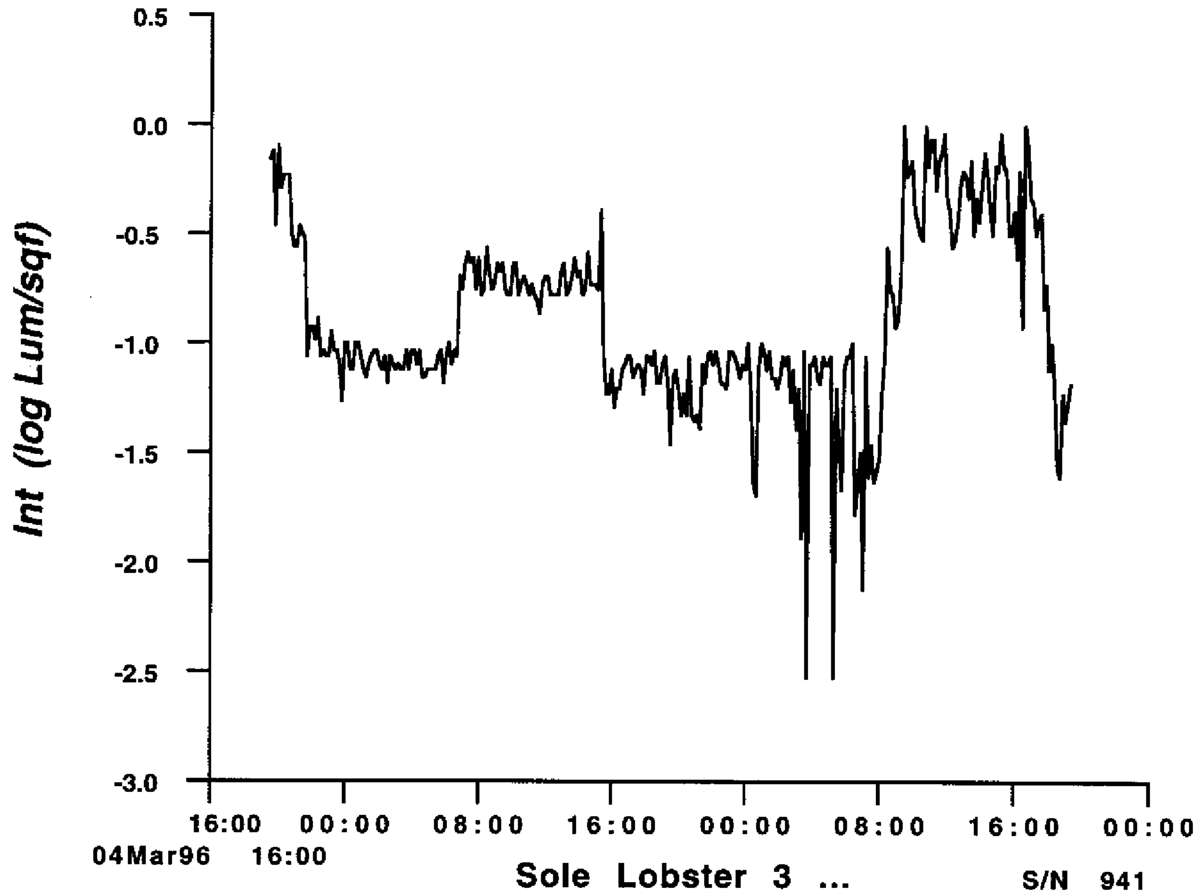
Acknowledgments:

This work is the result of research sponsored in part by the National Sea Grant College Program, NOAA, Department of Commerce, under grant #NA56R60159 through the University of New Hampshire/University of Maine Sea Grant College Program.

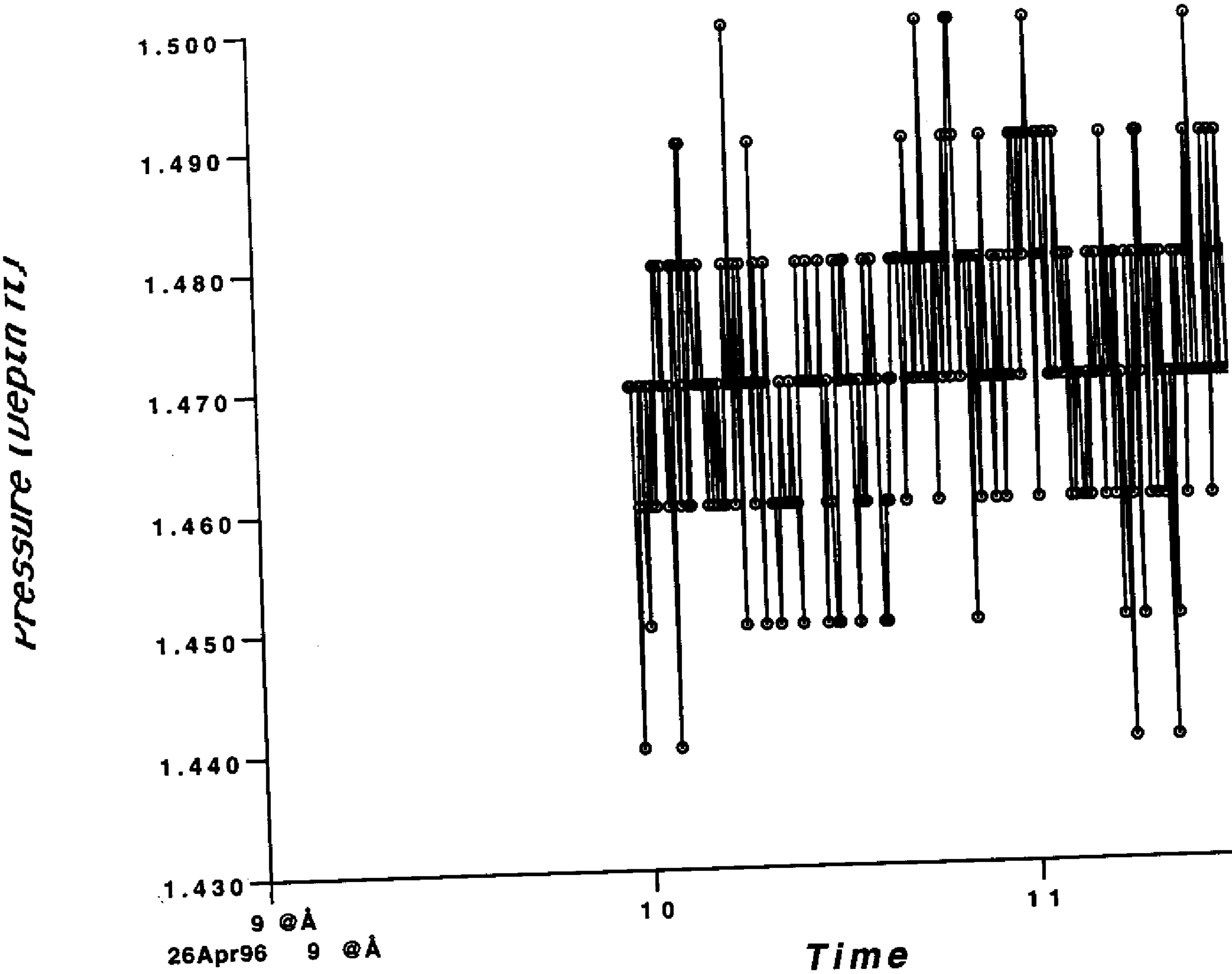
We would also like thank the following: Professor Winsor Watson for the project idea and guidance, Steven Jury for his time and patience. Kadee Lawrence and Charles Chester for their vital support in writing and advice in tight spots, Bob at the machine shop, and the following for various technical and other support: Professor Larry Harris, Noel Carlson, Christa Williams, Eric Abrahamson, Christina Rockel, William Mulliken, Scott Collins, Greg Komisar, Adam Perkins, John Canfield, John Nataloni, Mike Guildenstein, Sean Frazier, Kent Sawyer, James Marriott, William Wichman, Myles Lund, Captain Joseph Golter and finally John Scott and all those associated with the 1995-1996 Tech 797 class.



Graph 1: This is the data that was recorded by the Hobo datalogger device March 4, 1996. Lobster movements are not represented on this graph due to sampling error.

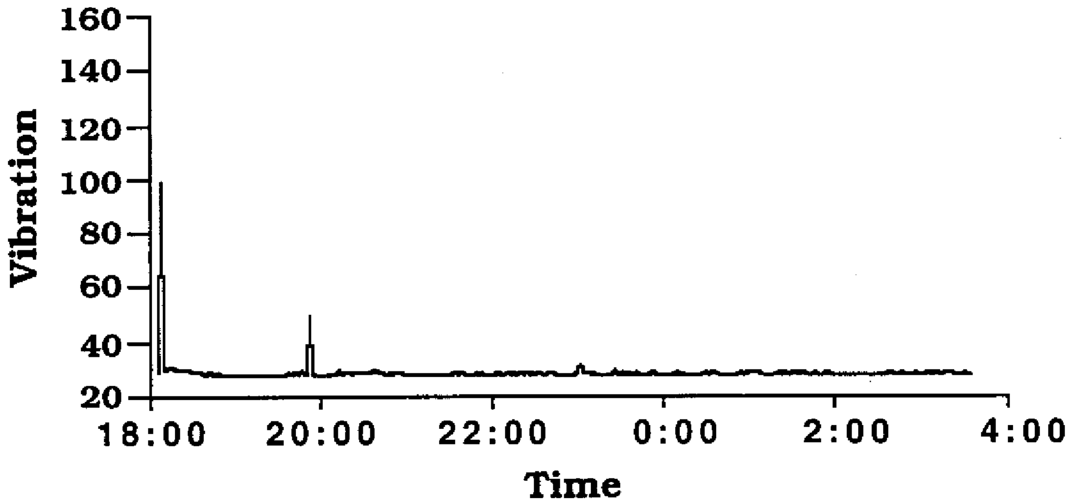


Graph 2: This is the data that was recorded by the Hobo datalogger device March 4, 1996. It is a representative graph of the lighting which the test lobster was exposed. A steady diel pattern is not represented here, perhaps due to people working late nights at the Coastal Marine Lab in New Castle, NH.

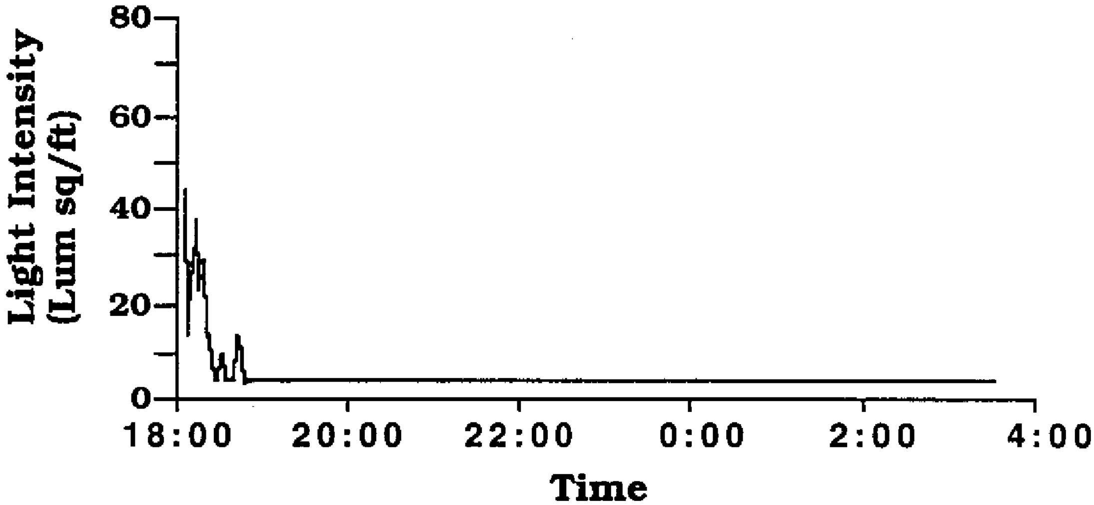


Graph 3: This represents the results of calibration of pressure transducer in a portable hyperbaric chamber. There is a problem in either the programming or wiring.

Graph 4.



Graph 5.



Graph 6.

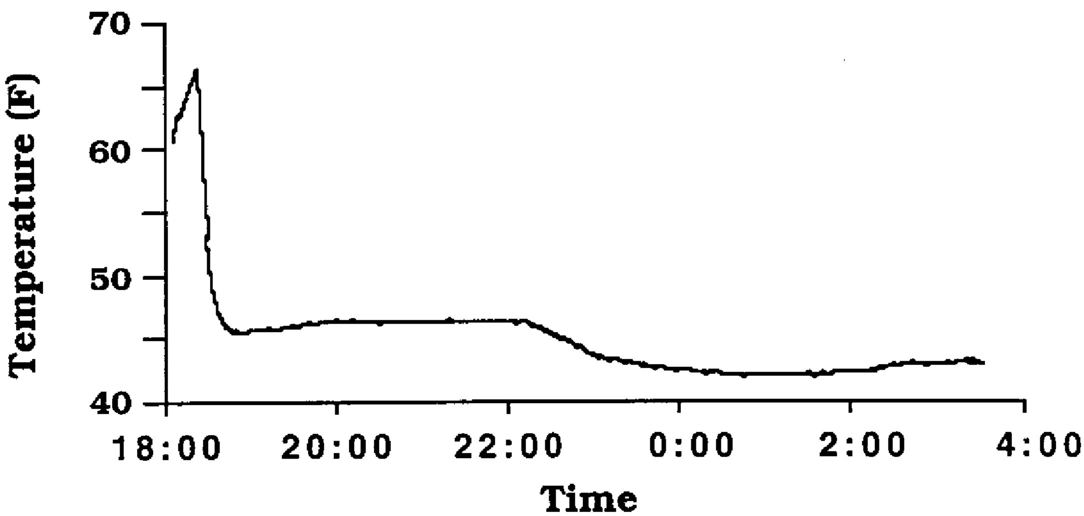
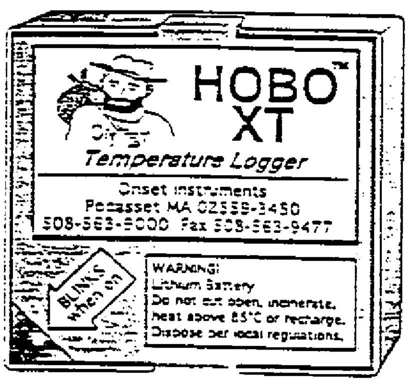


Figure 1 HOBO Temperature Logger

Hobo® and StowAway™ Single Channel Data Loggers



Hobo actual size!

the Hobo: miniature, low-cost data logger...

Features
- Reusable
- Deployments from 15 min. to 360 days
- 1800 measurements
- Easy to operate with BoxCar™ software
- Export to spreadsheet
- 2-year replaceable battery
- Non-volatile memory

Hobos for many applications
- Temperature
- Pressure
- Relative Humidity
- Light Intensity
- Voltage

Figure 2 HOBO Light Intensity Logger

Features

- Wide spectral response
- Wide dynamic range
- Various memory configurations from 2K to 32K taking from 1,800 to over 32,000 measurements
- Alarm indication
- Over 40 intervals including even hour/day increments
- Push button triggered start
- Delayed launch (up to three months)
- Multiple sampling with minimum, maximum or averaging
- Deployments from 15 minutes to 360 days
- Reusable logger has a replaceable battery (battery has a two year life)
- Launch, Plot and Read out data with software for DOS, Windows (3.1 and up) and Macintosh
- Data exportable to spreadsheet programs

Small

The figure depicts the StowAway-LI actual size: 1.8" x 1.9" x 0.6".

Overview

Designed as a durable, reusable and inexpensive, general purpose, light logger, the StowAway-LI has a dynamic range of about 1,000,000 recording intensities from about 0.001 lumens/square foot to 1000 lumens/square foot.

LogBook® Software

LogBook® software for Macintosh, PC or DOS (Windows 3.1 or up) makes launching, plotting and analysis a snap. Data is exportable to a spreadsheet.

Calibration

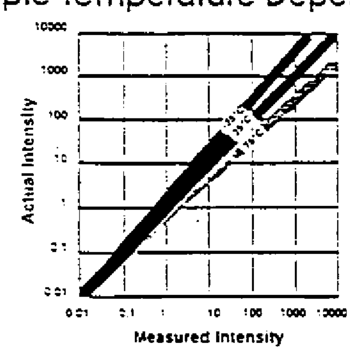
The StowAway-LI is roughly calibrated for incandescent sources. For your reference, full sunlight is about 10,000 lumens/sq ft, office lighting is about 50 lumens/ sq ft, and full moonlight is about 0.03 lumens per sq ft. The StowAway-LI's range goes from less than 0.001 lumens per sq ft to about 1,000 lumens per sq ft.

StowAway-Light Intensity Logger Characteristics

Temperature dependence

The StowAway LI is calibrated at room temperature. The logger will read high for temperatures above room temperature and low for temperatures below. The error is approximately a factor of two for every 25°C change. This means it will read a factor of two high at 0°C and a factor of two low at 50°C. A sample of the dependence is shown below.

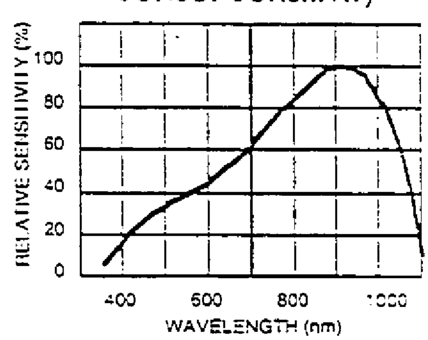
Sample Temperature Dependence



Spectral response

The light sensor in the logger measures a substantially broader spectrum, extending farther into the ultraviolet and into the infrared. This allows them to be used in applications that require sensitivity at these wavelenghts, but means that they do not measure in true lumens per sq ft or lumens per sq. m. The sensitivity verses wavelength is shown in the plot above and to the right.

Sensor Sensitivity



Angular dependence

The angular dependence of the logger from 0° to 45° vertical resembles the graph for Cosine. After 45° the graph drops off more rapidly.

Figure 3 Tattletale Slow Lite

The **Tattletale Lite** is the ideal non-dedicated logger for data gathering applications requiring portability, battery operation, easy data plotting, a display and a case. Choose one of two add-on boards for temperature, pressure and vibration measurement or use the PRLite2 board to add your own sensors.

Lite Features . . .

- Easy to use—program in LiteLanguage
- Only 2.25 x 4.7 x 1 inches and 2.5 ounces
- Automatic data plotting using LiteShow
- Export data to spreadsheet
- Integral LCD display
- Low power requirements—100µA (Slow Lite)
- 8 analog, 8 digital and 2 count channels
- Sampling rates up to 25,000 per second
- Up to 512K RAM for data storage (Fast Lite)
- Non-volatile program storage
- Reprogram as needed with LiteUp softwa
- 6 to 15V operating supply
- Inexpensive—S395 single quantity

Specifications . . .	Fast Lite	Slow Lite
Size (inches, inc. case)	2.25 x 4.7 x 1	2.25 x 4.7 x
Weight (ounces)	2.5	2.5
Processor	68HC05	68HC05
Data capacity (RAM)	512K	128K
Analog channels	Eight 8-bit	Eight 8-bit
Added resolution	13 15-bit	13 15-bit
Max. sampling rate (Hz)	25,000	2500
Analog input volt. (default)	0-5V	0-5V
Digital I/O lines	8	8
Minimum current	600µA	100µA
Peak current	7mA	1.6mA
UART baud rate (default)	9600	9600
Power supply range	6 to 15V	6 to 15V
Real-time clock	Software	Software
Prog. languages	LiteLanguage	LiteLanguage
Operating Temp	0°-70°C	0°-70°C
Relative Humidity	0-95% (non-condensing)	0-95% (non-condensing)

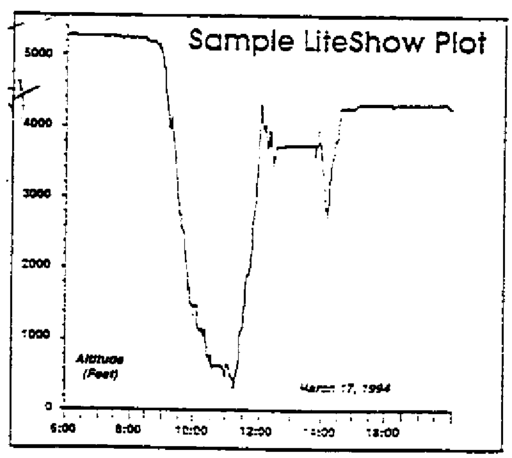


Figure 4 Temperature Circuit

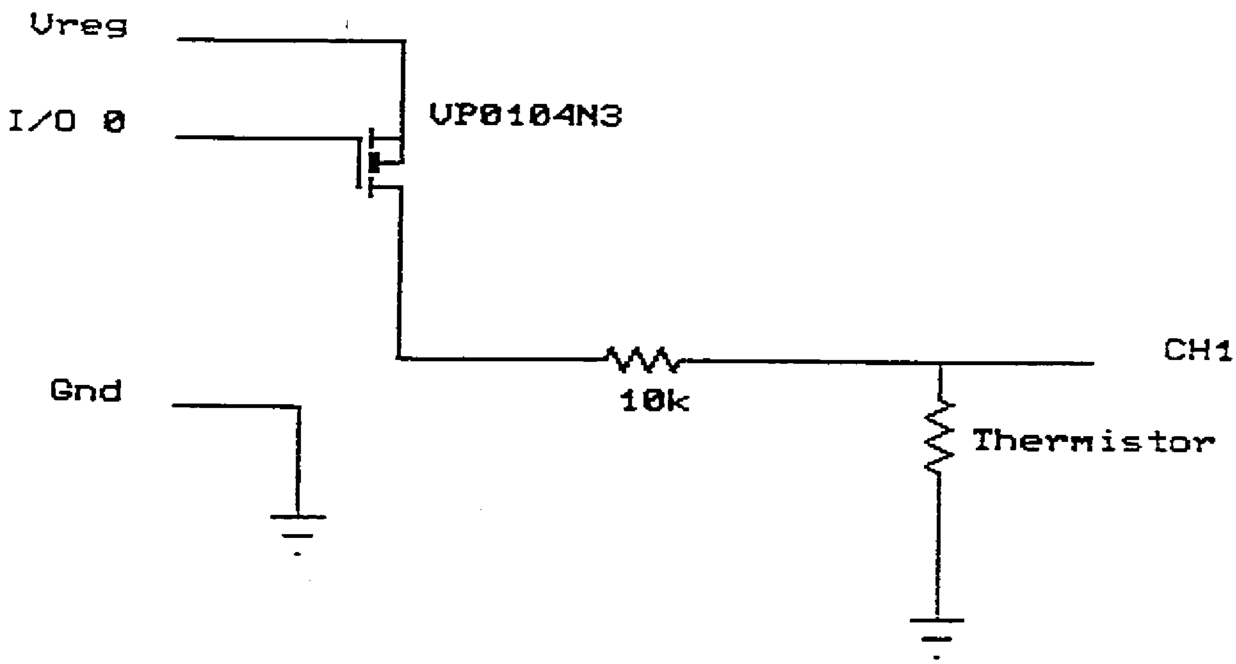


Figure 5 Light Intensity Circuit

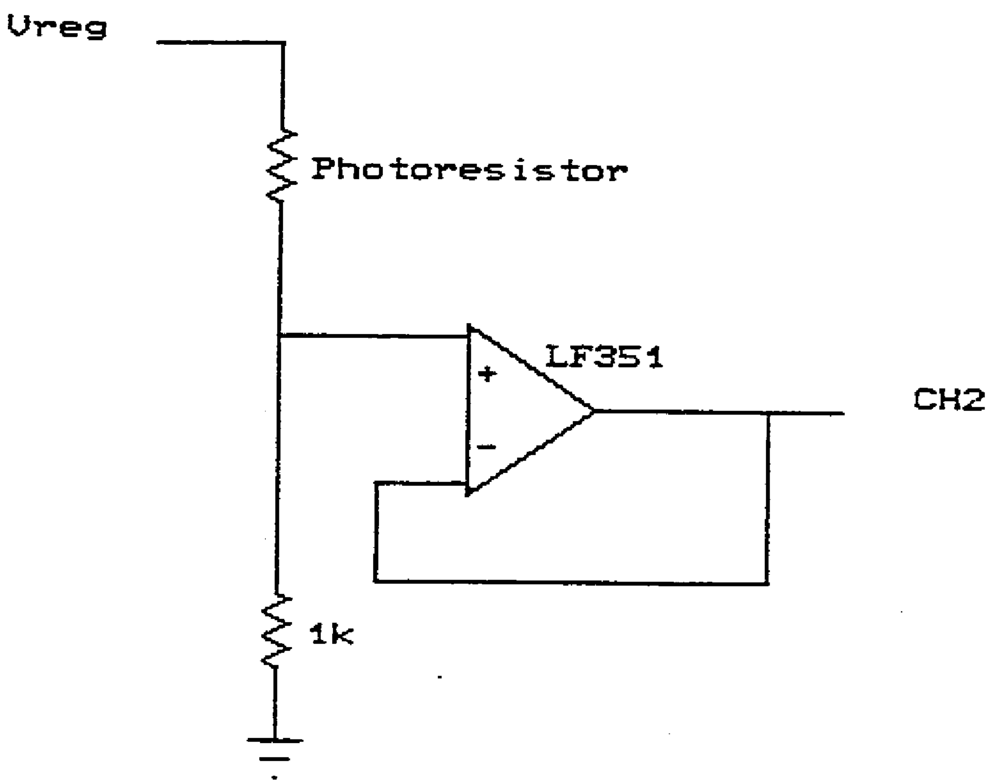


Figure 6 Pressure Circuit

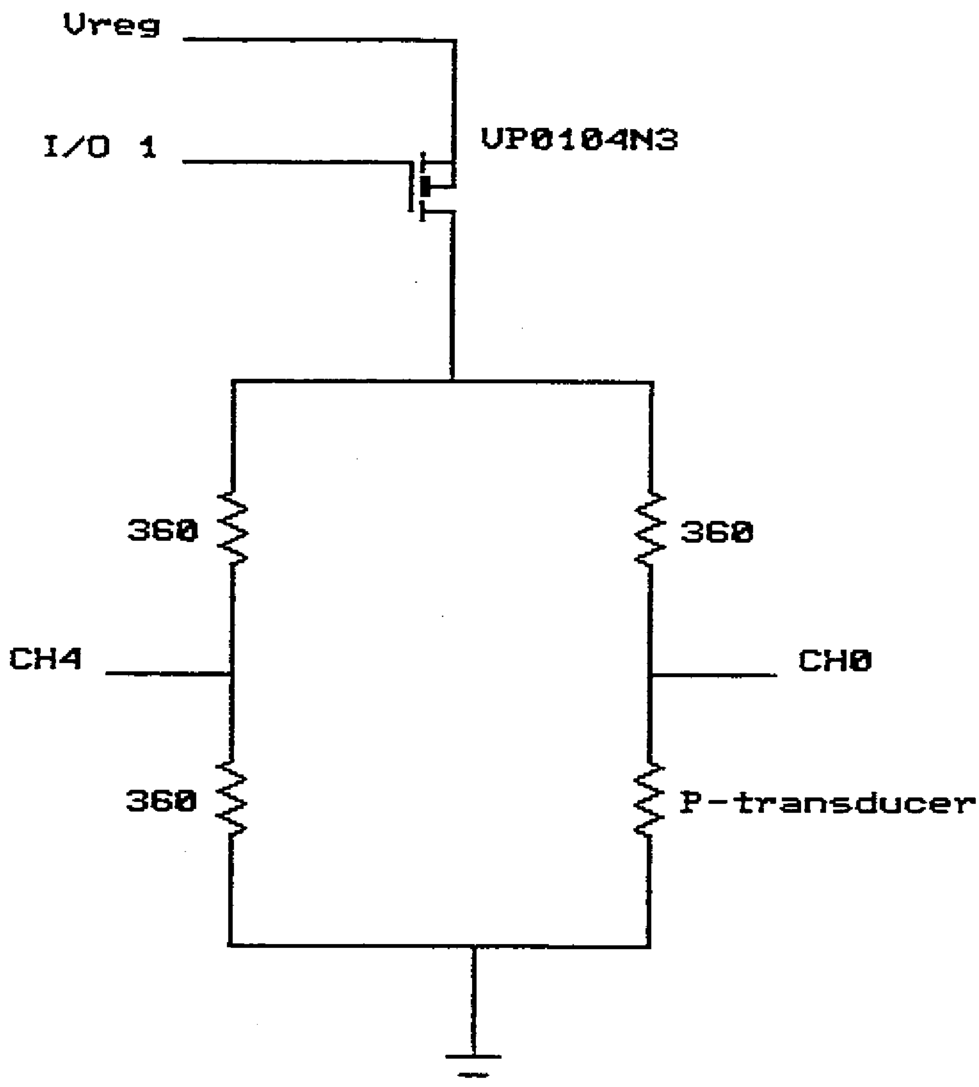


Figure 7 Vibration Detector

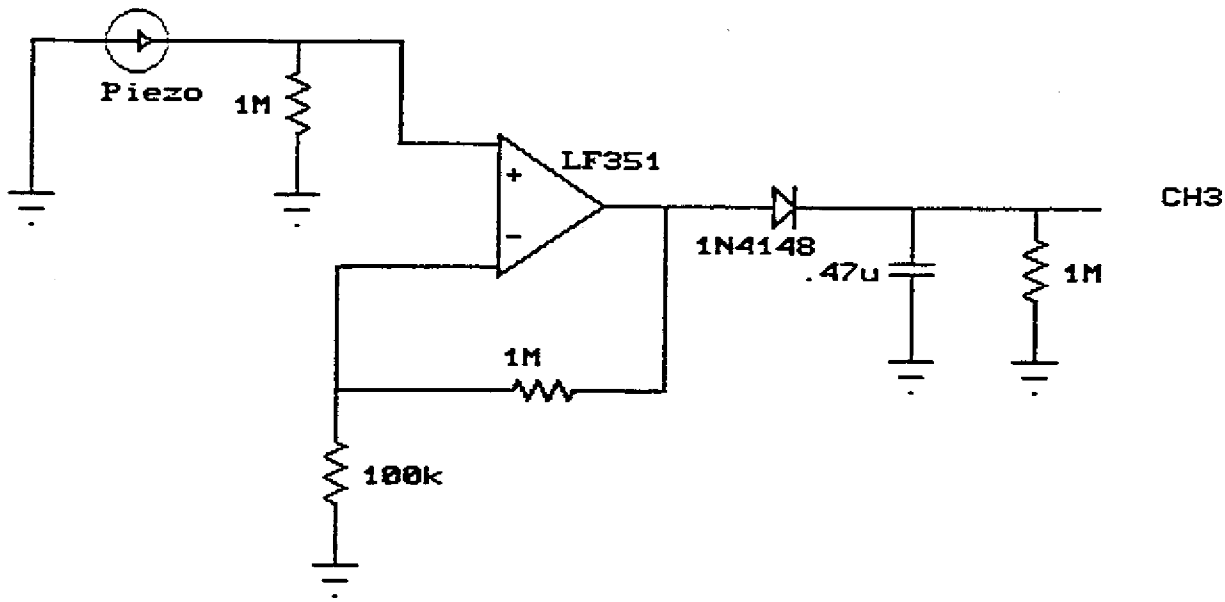
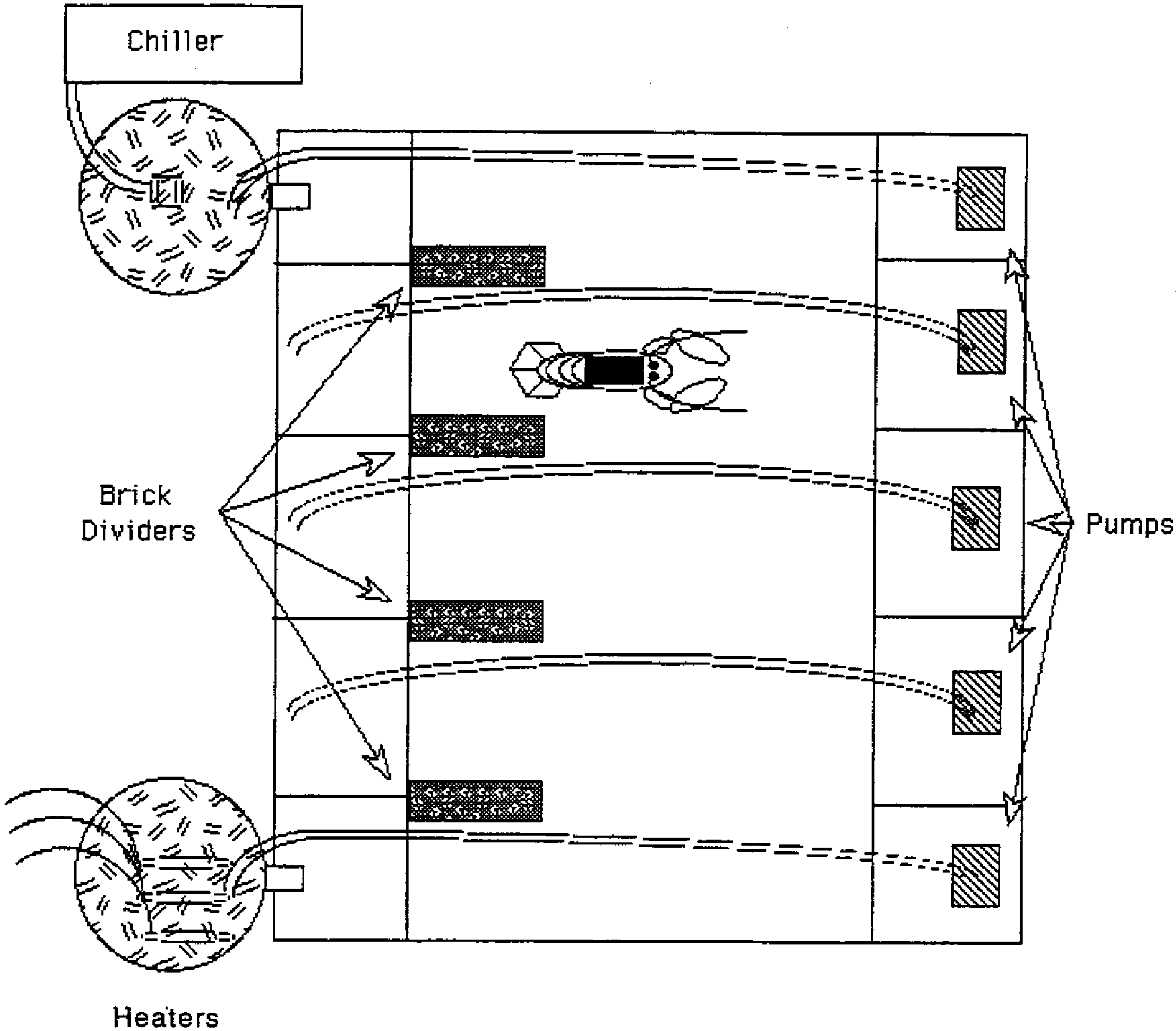


Figure 8

Experimental Thermal Gradient Tank Layout



This is the test tank at the UNH Coastal Marine Laboratory. This tank was constructed from plexiglass. The seperate sections of plexiglass were glued together using methaline chloride. When applied to plexiglass it fuses the plexiglass pieces together. The resulting tank is 26" x 48". A temperature gradient of 8 degree's celcius was established. This tank design was adapted from work done by Haro 1991.

Figure 9 Hobo Case

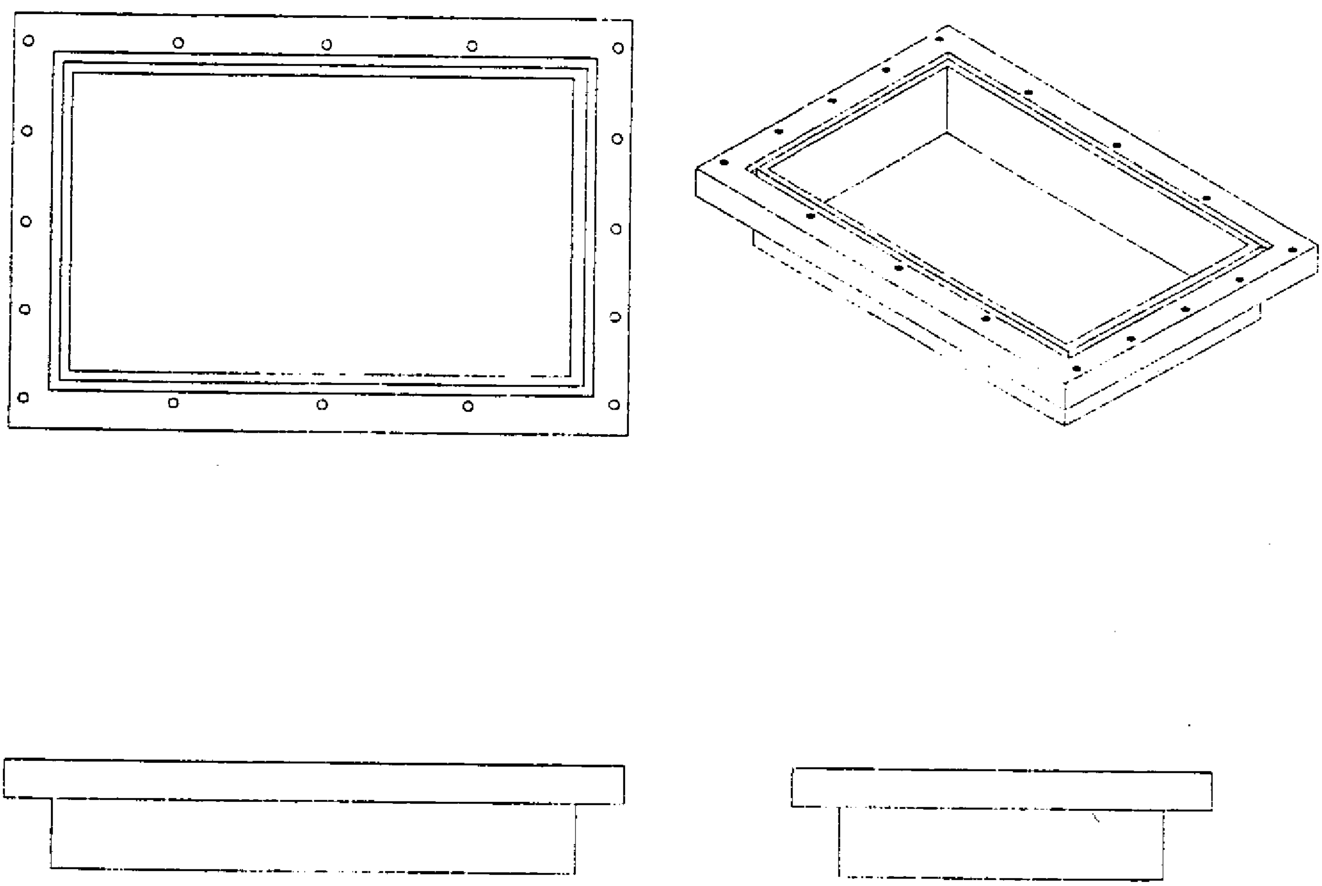


Figure 10 Tattletale Case

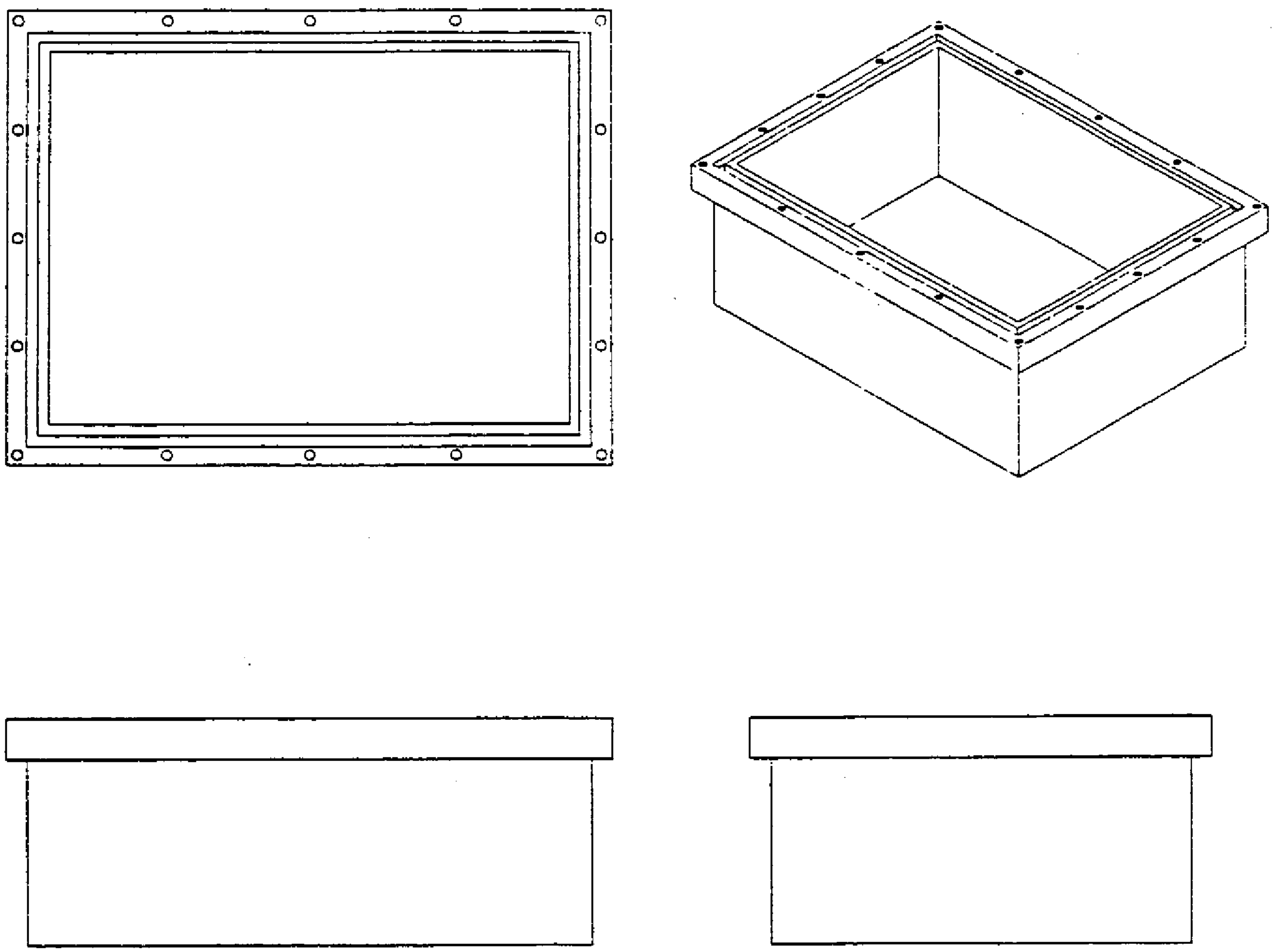


Figure 11

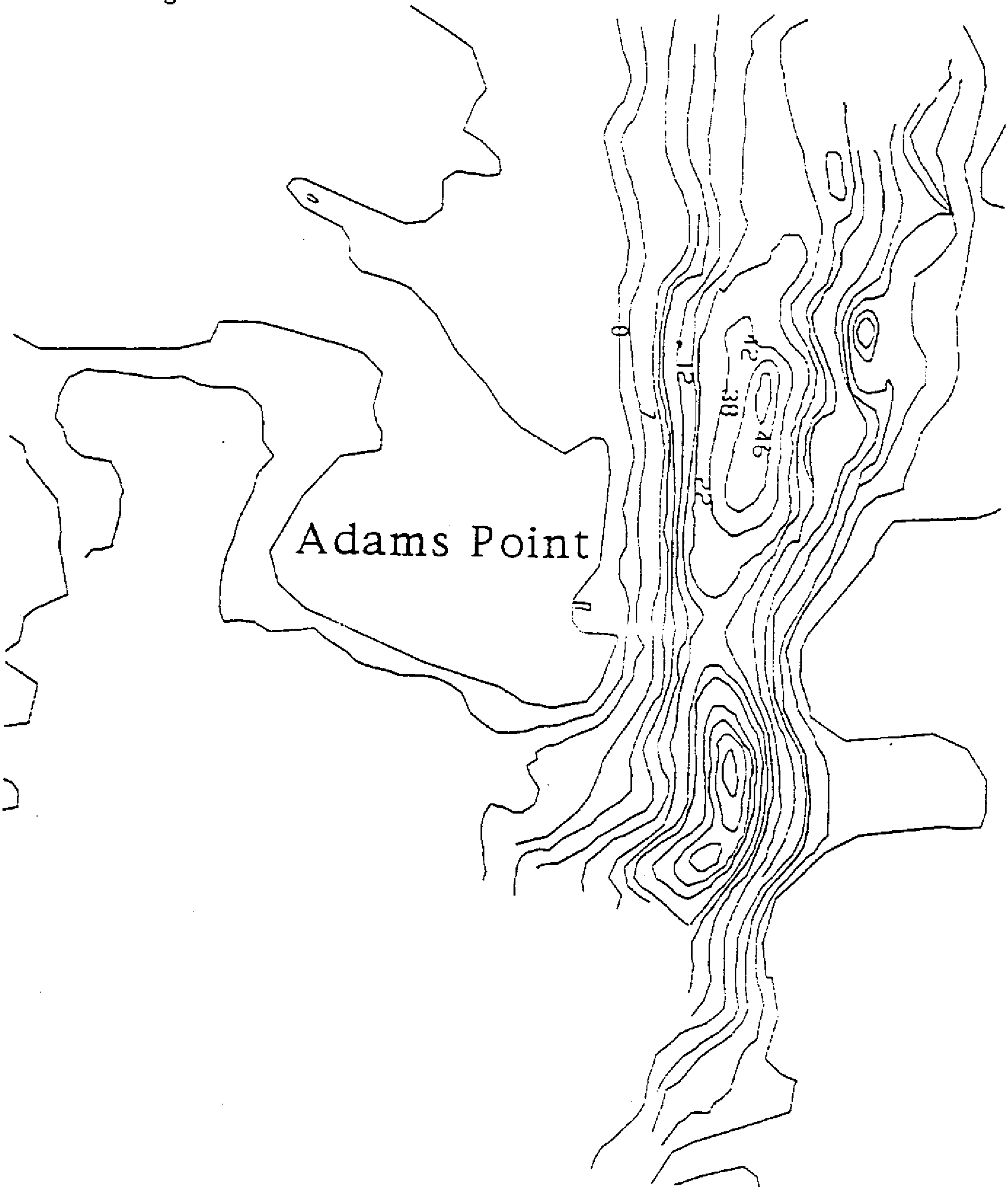
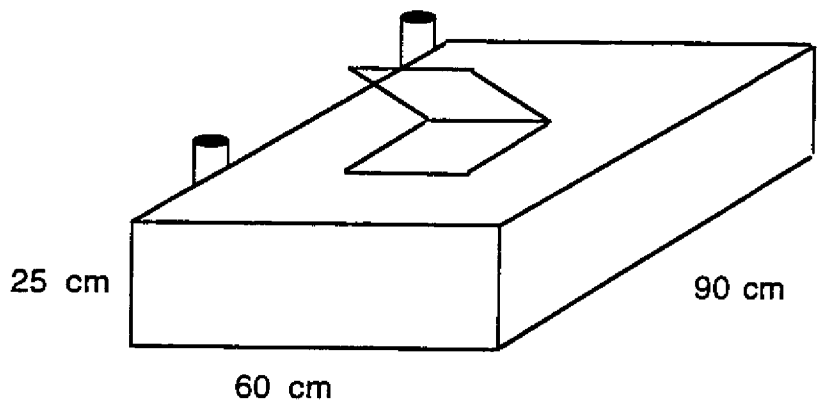


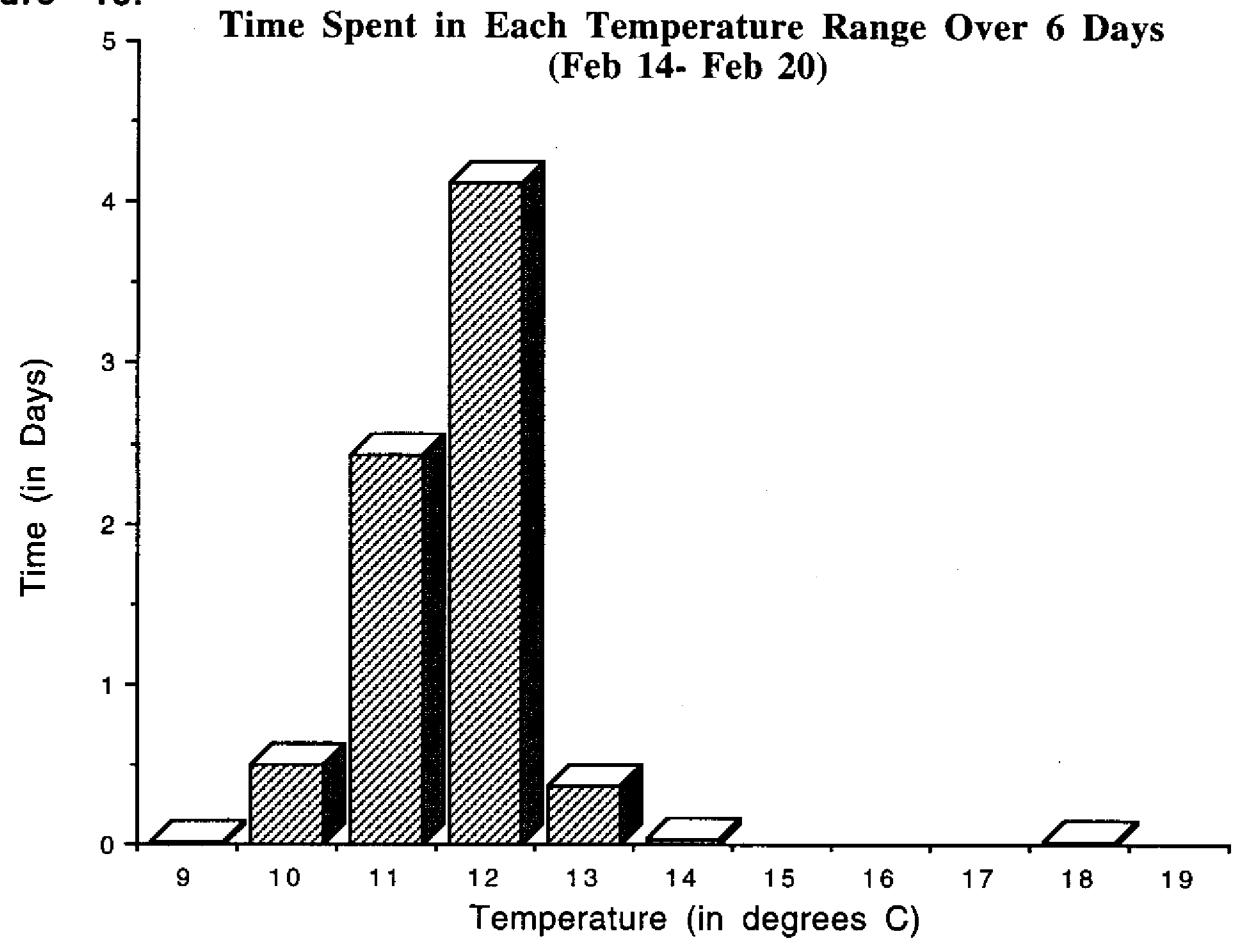
Figure 12

Field Testing Apparatus



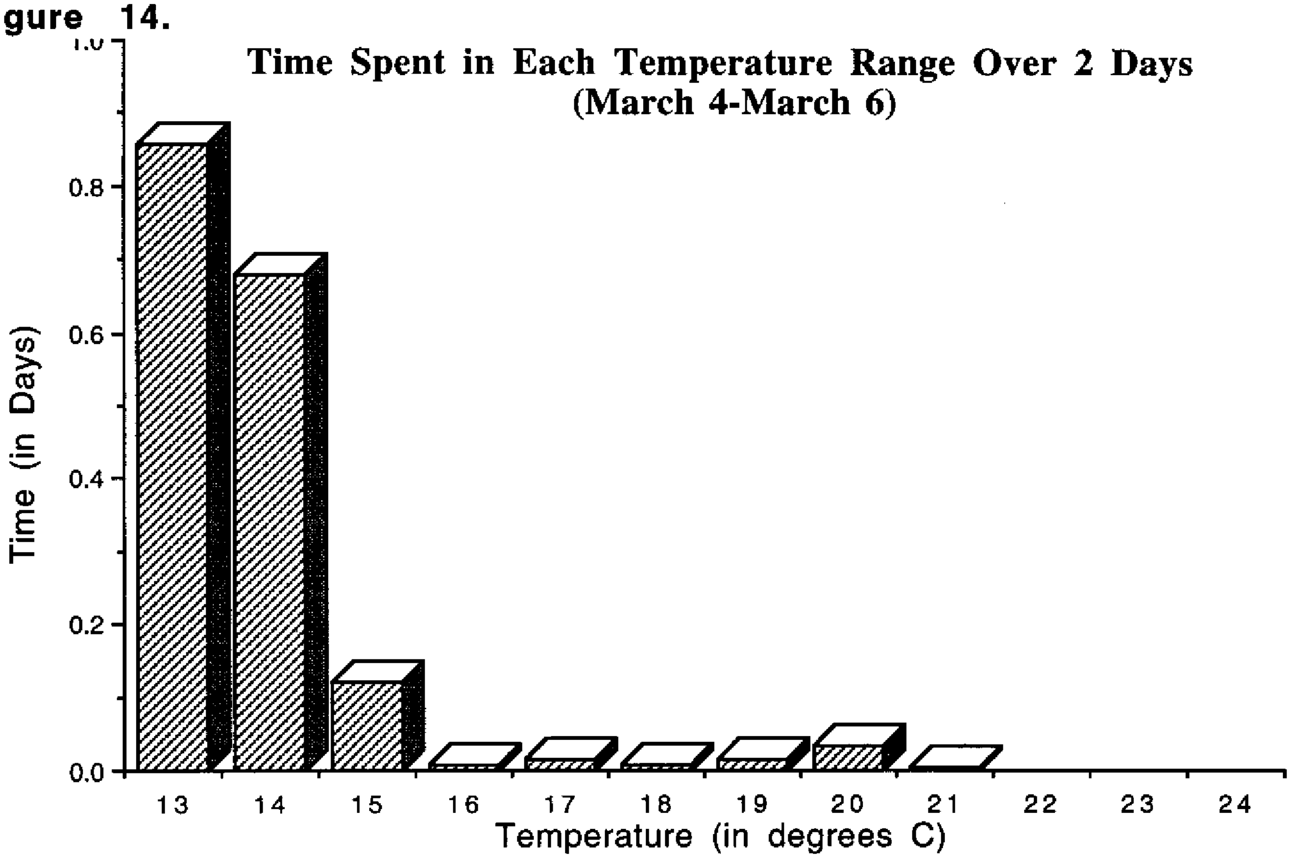
This is representative of the cage used in the initial field testing of the microcomputer and retrieval system. It is one of eight actual cages that are connected end to end. The material is made of a high density plastic. The sections were tied together using plastic cable ties. Bricks were added to each section to compensate for the positive boyancy of the material. Three foot long stakes were driven into the estuarine sediment approximately one foot at Jackson Estuarine Laboratory.

Figure 13.



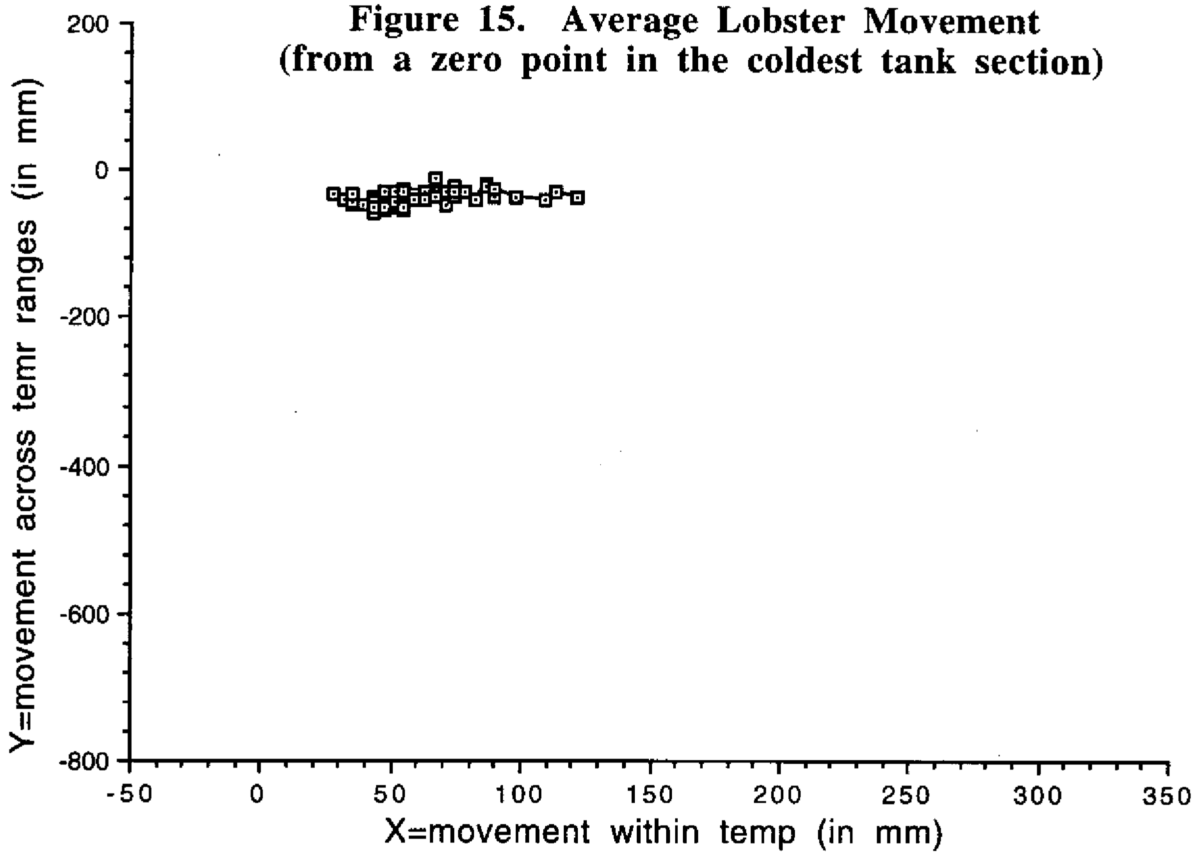
-Representation of general trend of lobster preference for 12-14C temperature range.

Figure 14.



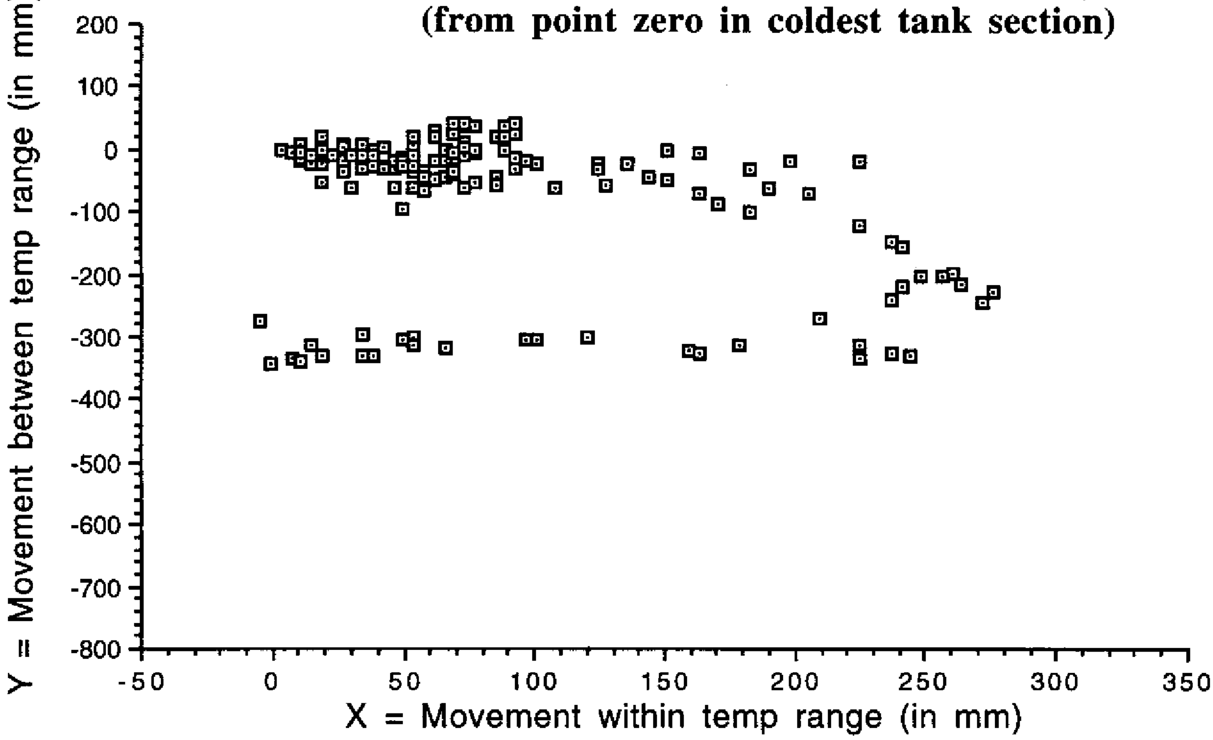
-Representation of general trend of lobster preference for 12-14C temperature range.

Figure 15. Average Lobster Movement (from a zero point in the coldest tank section)



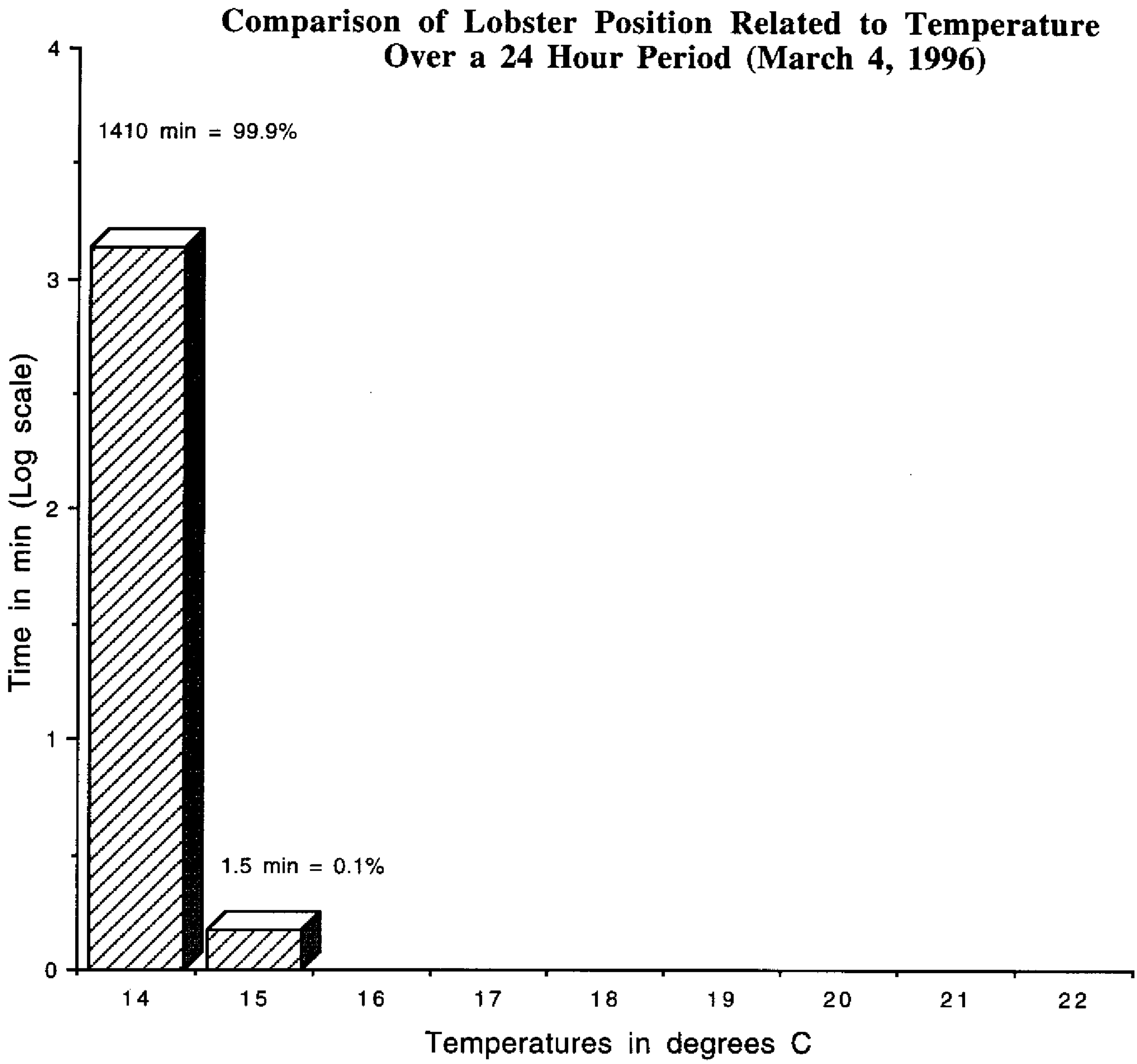
- This data is from digitized video from the March 4-6 run. This shows localized movement within the 13-14C region of the tank.

Figure 16. Third Lobster Movement of March 4, 1996 (from point zero in coldest tank section)



-This data is from digitized video from the March 4-6 run. It shows lobster movement at its most extreme.

Figure 17.



-Percentage of day spent at certain temperature ranges.

Appendix A

LiteLanguage

```
start   outputs 0,1,2,3,4,5,6,7  ' all I/O lines out (save current)

here    clear           ' zero the accumulator
        store V12       ' put that in V12 (maximum 'activity')
        store V13       ' put that in V13 (maximum 'activity')
        store V14       ' put that in V14 (maximum 'activity')
        store V15       ' put that in V15 (maximum 'activity')
        store V11       ' put that in V11 (maximum 'activity')
        sleep 15        ' sleep 1.5 seconds (default 'rate' is 10)

vhigh                           ' voltage to five volts
        pinlow 0        ' power up sensors
        sleep 1                 ' wait 1/10 sec
        adreject V1     ' measure temperature (chan 1 to V1)
        adreject V2     ' measure LIGHT (chan 2 to V2)
        adreject V3     ' measure VIBRATION (chan 3 to V3)
        adreject V0     ' measure Pressure (chan 0 to V0)
        adreject V4     ' measure Pressure (chan 4 to V4)

vlow                    ' back to 3v
        pinhigh 0       ' power off

        lcdpoint " *F=",V1, ltemp       'display temperature
        display "LItE"      'display light intensity
        sleep 38        ' wait 3.8 seconds

        plotprint  " ", V1, ltemp   ' stores
        plotprint  " ", V2, llight  'stores
        plotprint  " ", V3, lvib    'stores
        plotprint  " ", V0, lpress  'stores

        ifnotfull here          ' go back for more unless storage full
        display "FULL"      ' load 'FULL' to the display
        stop    ' drop to lowest power mode

llight  procedure "LIGHT INTENSITY"
        'light L
        endproc "L"
```

```
ltemp       procedure "Temperature"
        temp f
        endproc "F"

lvib    procedure "Vibration"
        endproc "V"

lpress  procedure "Pressure"
        minus V4
        endproc "depth (ft)"
```

*note

"LiteLanguage Lineage

LiteLanguage is a new programming language, borrowing some features from basic, and other from 'C', and even some from programmable hand calculators. Many of the features of LiteLanguage are new, since LiteLanguage was designed to address a very specifif set of needs."

-Onset Computer Corporation 1993