Project MASTER
Data Analysis: Cracking the Satellite Code

Grade: 9^{th} – 12^{th}

Goal: Students will be able to follow a marine animal and identify where it travels, how deep it dives, and various other behaviors. They will be able to answer questions related to these animals and construct a table based on this information.

Objective: Students will be able to:

- Learn how data is transmitted by satellite, and how to decode the messages
- Read a nautical chart
- Create a table

Standards:
Geography: A-1, A-2, B-1, E-1, E-2
Mathematics: A-1, A-3, A-4, A-6, B-2, B-4, B-6, B-7, B-8, C-1, D-1, D-2, D-3, E-3

Materials:

- Navigational chart of Gulf of Alaska and Bering Sea
- Work sheet

Introduction:
Satellite telemetry tags provide a variety of data about the animal's location and behavior. However, the data is transmitted as a series of numbers that scientists must decode. By accessing information found on the Project MASTER web site, students can complete the attached worksheet**.** The web site includes examples of the "raw data" as well as data sets that have already been decoded.

Explanations and first two data sets adapted from:
Greg Early
New England Aquarium
Central Wharf
Boston, Mass 02110

Example Data Reading:

21215 Date: 20.02.97 05:55:37 LC : 0 IQ : 45

Lat1: 51.254N Lon1: 50.136W
(Animal location by latitude and longitude)

We will not decode the following three lines for Project MASTER.

Nb mes: 004 Nb mes>-120dB: 002 Best level: -116 dB
Pass duration : 282s NOPC : 3
Calcul Freq: 401 649279.4 Hz Altitude: 0 m

The following sets of numbers are the dive data. These represent a "status message" if the first number is even.

Number series:

146, 144, 93, 188

09, 172, 15, 18

05, 56, 57, 121

What are the first two lines of the reading?

21215 = satellite tag identification number, this is the animal's ID number.
Date: 20.02.97 = 20 Feb. 1997
05:55:37 = Time in Greenwich Mean Time, GMT (hour:minute:second)
LC & IQ reflect transmission quality and accuracy.

LC stands for Location Class. Location Classes of 0 and up are best (derived from 4 or more messages). A Class 0 is good to within between 1,000 and 5,000 meters. Classes 1,2,3 get consistently more accurate. The letter classes are given no estimate of error, but the A's are better than the B's etc. It appears that some of the letter class locations are pretty good (i.e. several fixes over a short period are quite similar), but then others vary wildly, especially the longitude.

Lat1 and Long1 indicate where on the map the animal is.

What are the middle three lines of the reading?

This information refers to the type and quality of the transmission from the tag to the satellite. We will not be decoding this data for Project MASTER.

What is the series of numbers at the end of the reading?

This series of numbers is the dive data. There should be a series of 4, 8, or 12 numbers. All of the numbers in the series should add up to even multiples of 256. If they don't then the message was incomplete or garbled somehow. This is a check for accuracy of the satellite transmission.

How to interpret the dive data:

The first thing to do is add up all of the numbers and divide the sum by 256. If you get a number with no remainder the message is good.

The first number in the series is an identifier, that tells you what type of message you are getting. If the number is even, the message is a status message. Status messages should be a series of twelve numbers, all of which tell something about the tag. (If the number is odd go to histograms, below.)

Status message numbers from left to right:

1. The first number is also the deepest depth recorded by the tag in the past 24 hours (midnight to midnight). To get the actual depth you multiply that number by 4 (the depth resolution for the tag) and this will give you depth in meters (to convert it to feet divide by .3048).
2. The second number represents the animal's time at surface for the past 6-hour period (multiply by 90 to get the surface time in seconds).

3&4. The numbers of messages sent by the tag so far (multiply by 256 and add to #4). Remember that these tags will only transmit messages when they are out of the water.

5. Pressure sensor status (electronic test to accurately read dive depth) should be around 10.
6. Battery voltage (multiple by .064). The voltage should be around 11-12 volts. If it falls below 7, the tag will no longer work due to low power.
7. Seawater resistance at depth, checks the status of the seawater switch (senses when the satellite tag is out of the water and then turns on the transmission). This number should to be around 20.
8. Surface time for the 6 hours before #2 (multiply by 90 for time in seconds).

9, 10 &11. Time (hours, minutes and seconds) for the tag's clock. This should be pretty close to the satellite time in the message header. The tag clock will drift a bit (more so when it is cold). If it is way off there is a problem.

12. Checksum – this number adjusts the total of the number so they are evenly divisible by 256.

If the first number is not even then it is a data histogram (bar graph).

The first number is still an identifier that tells you whether it is a depth, duration or time at depth message. The tag stores data from four six-hour time periods (while collecting the current data). The first number also tells you which time period the data was collected in, and if the tag was "wet"(under water) or "dry".

This tag is programmed to think it is dry when it sends five signals without wetting the salt switch (this takes about 7 minutes out of the water). Numbers between 65 and 95 are "dry"; numbers between 97 and 127 are "wet".

Here are some examples, try and interpreting them:

1.

21215 Date: 20.02.97 10:20:18 LC: 0 IQ: 47

Lat1: 51.104N Lon1: 50.277W

Nb mes: 005 Nb mes>-120dB: 000 Best level: -124 dB
Pass duration: 558s NOPC: 3
Calcul freq: 401 649533.1 Hz Altitude: 0 m

146, 158, 94, 112

10, 177, 15, 144

10, 27, 05, 126

2.

21215 Date: 12.11.96 08:58:10 LC: A IQ: 00

Lat1: 67.247N Lon1: 60.383W

Nb mes: 003 Nb mes>-120dB: 001 Best level: -120 dB
Pass duration: 102s NOPC: 2
Calcul freq: 401 649125.2 Hz Altitude: 0 m

206, 137, 41, 110

10, 171, 14, 100

09, 01, 38, 187

3.

19134 Date: 07.09.01 15:09:00 LC: 2 IQ: 68

Lat1: 72.343N Lon1: 172.557W

Nb mes: 007 Nb mes>-120dB: 001 Best level: -120 dB
Pass duration: 543s NOPC: 2
Calcul freq: 401 649034.0 Hz Altitude: 0 m

34, 13, 33, 102

10, 101, 50, 00

16, 10, 22, 121

Satellite Tracking Data Worksheet

Satellite tag identification number: _____
Date: _____
Time at last location: _____

1. Is this a complete / good message? How do you know?

2. Is this a status or histogram message? How do you know?

If this is a status message then:
1. What is the actual depth in feet the animal dove in the last 24 hours? _____feet
2. How much time has the animal spent at the surface in the past six hours? _____minutes
3. How many messages has the tag sent so far? _____

If this is a histogram message then:
1. Is this a wet or dry tag, and how do you know?

More Questions:
1. What is the name of the animal we are tracking? _____
2. Genus, species: _____
3. Latitude: _____ Longitude: _____ (at last known location)
4. If near or on shore, list the regional area, village, town, or city the animal is closest to: _____
5. Where was the animal tagged and released? _____
6. How far has the animal traveled since it was released? _____
7. What is the depth of water at the current location? _____(feet)
8. What percent of a 24-hour day did the animal spend at the surface? _____

Extension activities:

1. Create a table including date, latitude, longitude, time and depth of dives for your animal.
   a. Plot the location of the dives. At what location did the animal make most of its deepest dives? What is the depth of the water at that location? Was there any pattern to the dive locations?
   b. Calculate the percent of dives made at each specific depth range. In what depth of water is it most of the time? Why do you think the animal most frequently goes to that depth?

c. What percentage of time is the animal spending at sea versus a haul out location (time animal is out of the water)?

2. The scale of distance is one nautical mile equals one minute of latitude. So if one degree equals 60 minutes of latitude, how many nautical miles equal one degree of latitude? Five degrees of latitude?
   Note: statute mile = 5280 ft. in length / nautical mile = 6076 ft. in length
   Statute miles x .87 = nautical miles
   Nautical miles x 1.15 = statute miles

3. The atmospheric pressure (atm) at sea level is about 14.7lbs. /square inch. When a person dives the pressure exerted by the water increases by 1 atm for every 10 meters (30-ft) the person goes down. Identify the deepest dive made by the marine animal. What is the approximate pressure exerted at that depth?