Visualization of Lobster Larvae Migration in the Gulf of Maine

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***Abstract*---A valuable tool in assessing migration of a large amount of creatures is to visualize simulation data. Simulation data has already been collected for the migration of lobster larvae in the Gulf of Maine. The visualization of this data will provide a way to see the effects of the currents on the lobster larvae in different regions of the Gulf of Maine. This paper outlines a methodology and series of code developed to visualize this simulation data.**

***Index Terms*---**

I. INTRODUCTION

II. RELATED WORK

A. Gulf of Maine Ocean Obsterving System (GoMoos)

The lobster larvae simulation model is embedded in the GoMoos physical model which provides information (currents, temperature, salinity, etc.) about the Gulf of Maine.

More information about GoMoos can be found at `http://www.gomoos.org/`

B. The simulation data was generated due to the work of Danya Xu and Huijie Xu. Their findings are located at `http://rocky.umeoce.maine.edu/synthesis_lobster.html` in a report entitled *'Numerical modeling and the development and transport of lobster larvae (Homarus americanus) in the Coastal Gulf of Maine*.

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III. SIMULATION DATA

The simulation model tracks the development of lobster larvae for a number of years. The model is broken down into 60 day runs staggered by 10 days starting on the 1st, 11th, and 21st day of each of the months of June, July, August, and September. 262,170 tracers (larvae) are tracked at five different depths. Tracers develop based on the temperature at the location of the tracer for each time step and the tracers drift with the currents in the Gulf of Maine. After 12 runs for each year, there is a large amount of data ready for analysis.

The simulation data is output in a certain format. A directory is created for each of the staggered 10-day runs – i.e. the data for June 2005 is contained in 3 folders starting at June 1, June 11, and June 21, respectively. The folders are named in a `yyyymmdd` format (e.g. `20050601` for June 1, 2005). Inside each folder a tracer file is generated each day for 60 days, starting from the date specified by the directory. This results in 60 tracer files, named `tracer.yyyymmdd` based on which day it represents (e.g. `tracer.20050618` for June 18, 2005).

The tracer files maintain certain simulation data in a specific format. There is a header line for the file, then 8 groups of information that represent time steps. Each of the 8 time steps has a header line with two fields – the number of days the run is from January 1, 2002 and the hours of the day. The body of each time step lists the following fields for each of the 262170 tracers: Tracer Number, Longitude, Latitude, Depth of Tracer, X Grid Point, Y Grid Point, Temperature, Salinity, Bottom Depth, Lobster Development Stage, Quality Flag.

An example:

If the data for June 1, 2005 was desired, this information would be in the file specified by `20050601/tracer.20050601` *It is in the* `20050601` *directory because June 1 falls in the first 10-day run for June 2005 that starts on June 1. The start of the file would contain the*

following text:

```
1     Particles= 262170 Time Steps= 0
      Time Step=  10800.0
2     1247.000    0
3     1  -70.99690  40.35210  5.00000
      1.00000  29.00000 12.45723
      33.86623  92.31500 1.0000
(etc)
```

Line 1 is the header for the file. Line 2 is the header for the first time step. Line 3 gives the following information:
Tracer Number = 1, Longitude = -70.99690,
Latitude = 40.35210, Depth of Tracer = 5,
X Grid Point = 1, Y Grid Point = 29,
Temperature = 12.45723, Salinity = 33.6623,
Development Stage = 92.315000, Quality Flag = 1.

The first time step is comprised of 262170 lines that are like Line 3, providing information for tracers number 1 through 262170. There are 8 time steps just like this.

If the Longitude and Latitude are 999.00000, this means that the tracer has gone out of the bounds of the simulation.

IV. PRIOR EFFORT

The visualization of the simulation data had already been attempted by Steve Cousins[b]. An effort was made to make the simulation data compatible with visualization code called GeoZui4D (`http://vislab-ccom.unh.edu/GeoZui4D`), created by the Data Visualization Research Lab at the University of New Hampshire.

The current project utilizes a modified version of a Perl script by Steve Cousins entitled `convert-and-subsample-tracer-to-utm.pl`. Cousins' code works with a tracer file to output a file with a subsample of the data. The subsample contains the Longitude and Latitude fields for the tracers that did not go out of bounds.

Cousins' code works by specifying specifying a range that valid latitudes and longitudes fall into. The lines of the tracer file are read in and the tracer number is placed into a hash file if the latitude and longitude are within the valid range. If a hash file for the tracer already exists, this step is skipped. Then, the array of desired tracer numbers is read in and processed according to the script's functionality.

V. PROCESS

The code for this project is based on two different programs. The first is a modified version of the Perl script described in the previous section and the second is a Matlab program used to plot the tracers and create a movie. The Matlab program calls an intermediary shell script.

A. Perl Script: get-lon-lat-at-depth.pl

Steve Cousins' Perl script was modified in a few ways. It now takes in two arguments: start date (in the format `yyyymmdd`) and depth. The start date refers to a directory that contains 60 days of runs starting from that date. The reason that depth is specified is because the migration data simulates the movement of the tracers at 5 different depths: 5, 10, 15, 20, 25. The movement at each depth is affected by currents differently, so they require separate visualizations. This code processes the desired tracer numbers by extracting just the Latitude and Longitude fields and appending them to an output file.

The result is a file that contains only the longitude and latitude fields for all of the tracers at the specified depth from the specified directory.

An example

Let's say that we want to run this script for July 1, 2005 and we want to analyze tracers at depth 5. We could call it from the command line as so:

```
> ./get-lon-lat-at-depth.pl 20050701 5
```

The start of the output file would contain the following text:

```
1     -66.77028,41.93633
2     -66.41722,41.97095
3     -6626086,42.22905
(etc)
```

B. Shell Script: coords.sh

This is a shell script that takes in two arguments: a directory specifying a start date and a depth. The start date must be either the 1st, 11th, or 21st of either June, July, August or September in the desired year. This script calls `get-lon-lat-at-depth.pl` with the specified depth on all 60 tracer files within the directory specified.

An example:

If we want to call coords.sh on the directory for August 11, 2006 for tracers at depth 5:

```
> ./coords.sh 20060811 5
```

This would give us 60 output files. Each file would be for one of the days from August 11 through October 9 (60 days). Each file would contain the Latitude and Longitude for tracers within the valid range specified in `get-lon-lat-at-depth.pl`.

C. Matlab M-file: move.m

This program uses a plot of the Atlalntic coast to put the tracers into context. The plot of the Atlantic coast is generated from the matrix data in `atlantic-us.dat` and the plotting program `plot_coast.m`. Both of these files were acquired from `http://rimmer.ngdc.noaa.gov` courtesy of Rich Signell. Calling plot_coast.m, produces Figure 1.

`move.m` is a Matlab function file that takes in the same arguments as `coords.sh`. It calls `coords.sh` with these arguments, generating 60 files with Latitude and Longitude information for a specified start date and depth. It plots a point at each of the Latitude Longitude pairs specified in the file. Each file represents one frame. Once all the frame have been generated, a 60-frame movie of the tracer movement is produced.

An example:

Let's say we want a movie of the tracers starting at June 1, 2005 at depth 5. We would make this call in the Matlab command window:

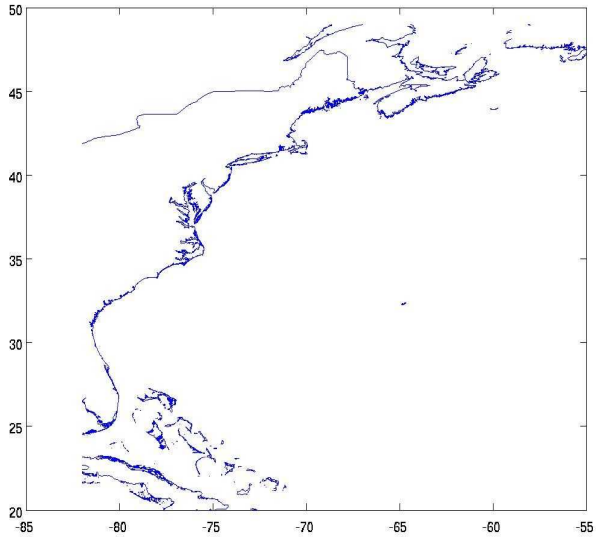


Figure 1: Plot of the Atlantic coast

```
>> move 20050601 5
```

This will produce a movie 60 frames long of tracer movement at depth 5 for 60 days starting from June 1, 2005. See Figure 2 for a series of frames produced by this call.

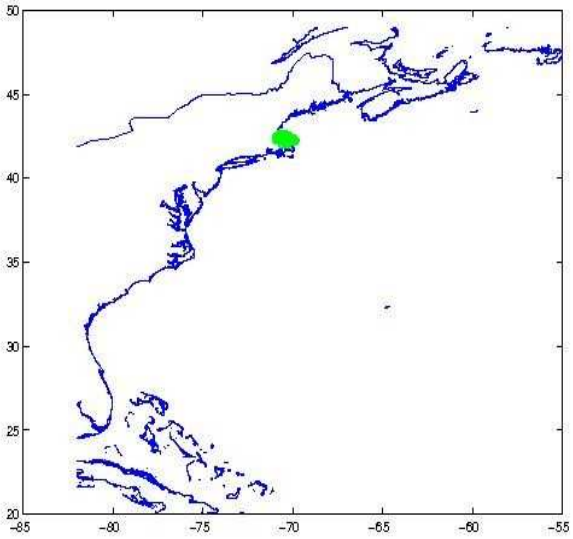
CONCLUSIONS

FUTURE WORK

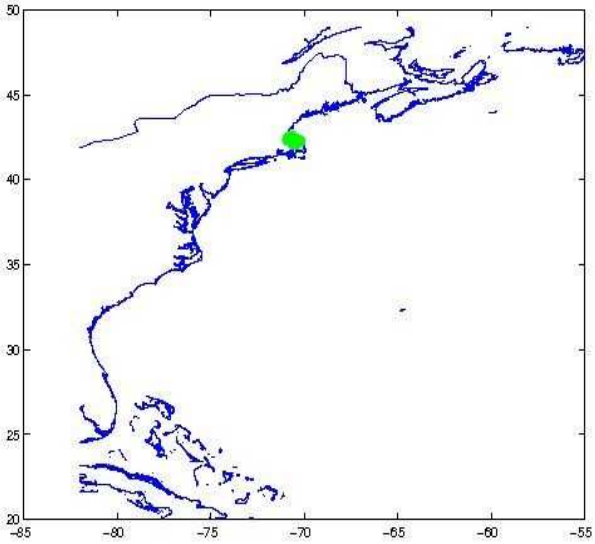
ACKNOWLEDGEMENTS

REFERENCES

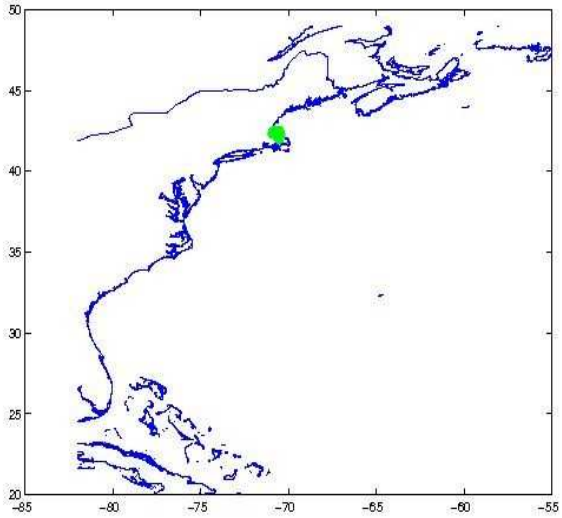
Figure 2: A series of movie frames after calling `>> move 20050601 5`



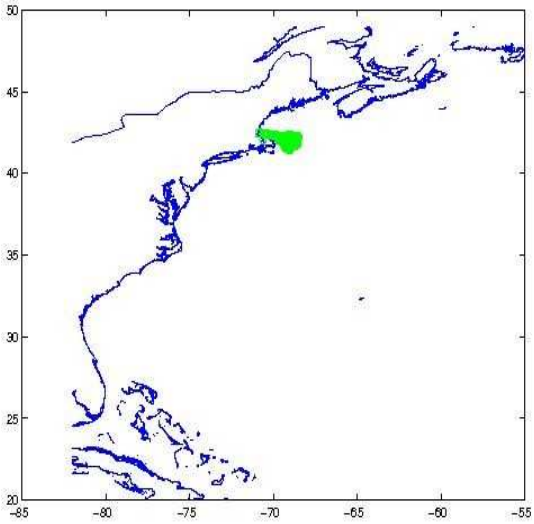
Frame 1



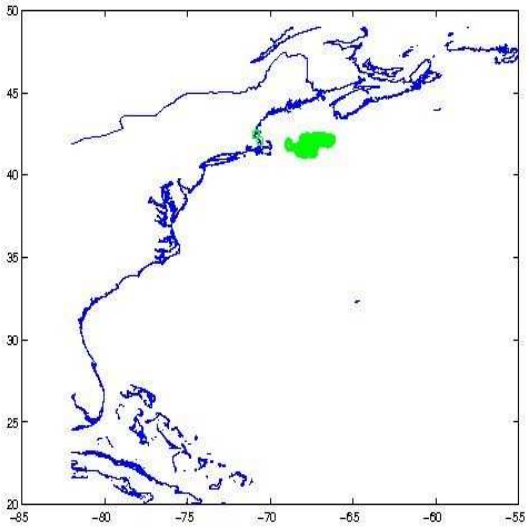
Frame 2



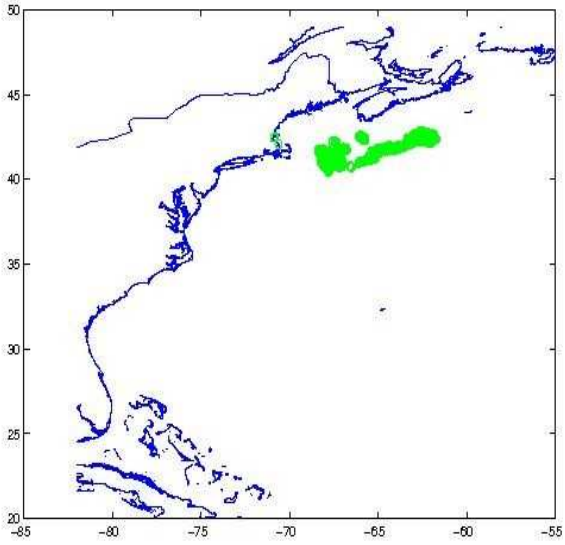
Frame 3



Frame 10

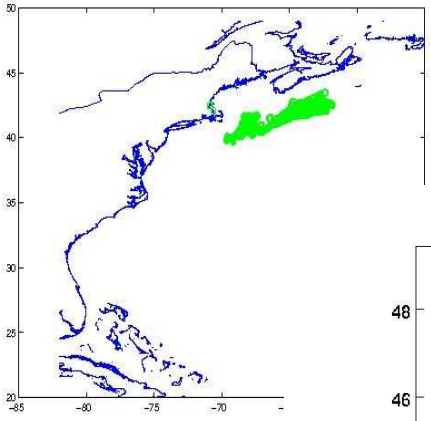


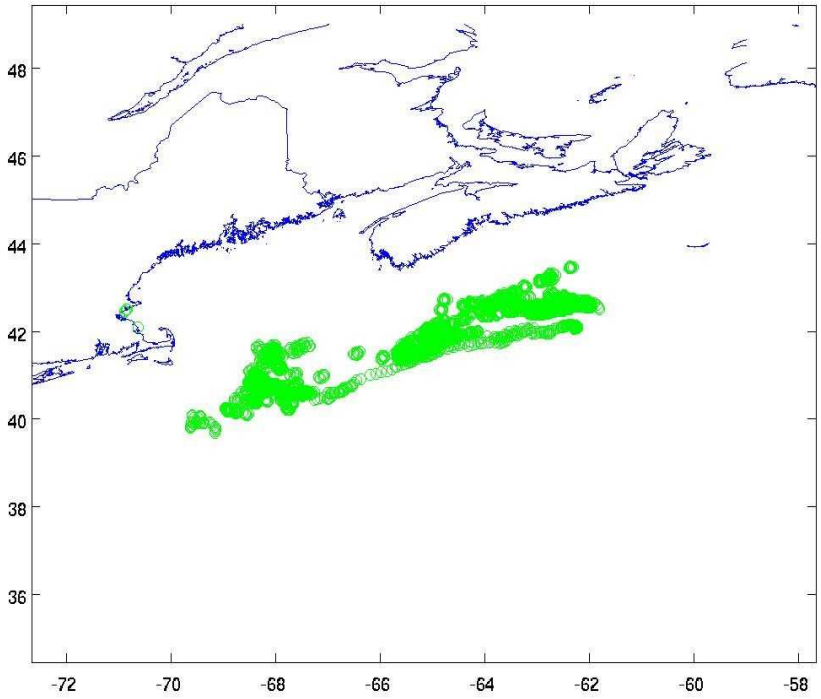
Frame 20



Frame 40

Frame 60 – Last Frame





Frame 60 – Last Frame - Close-up