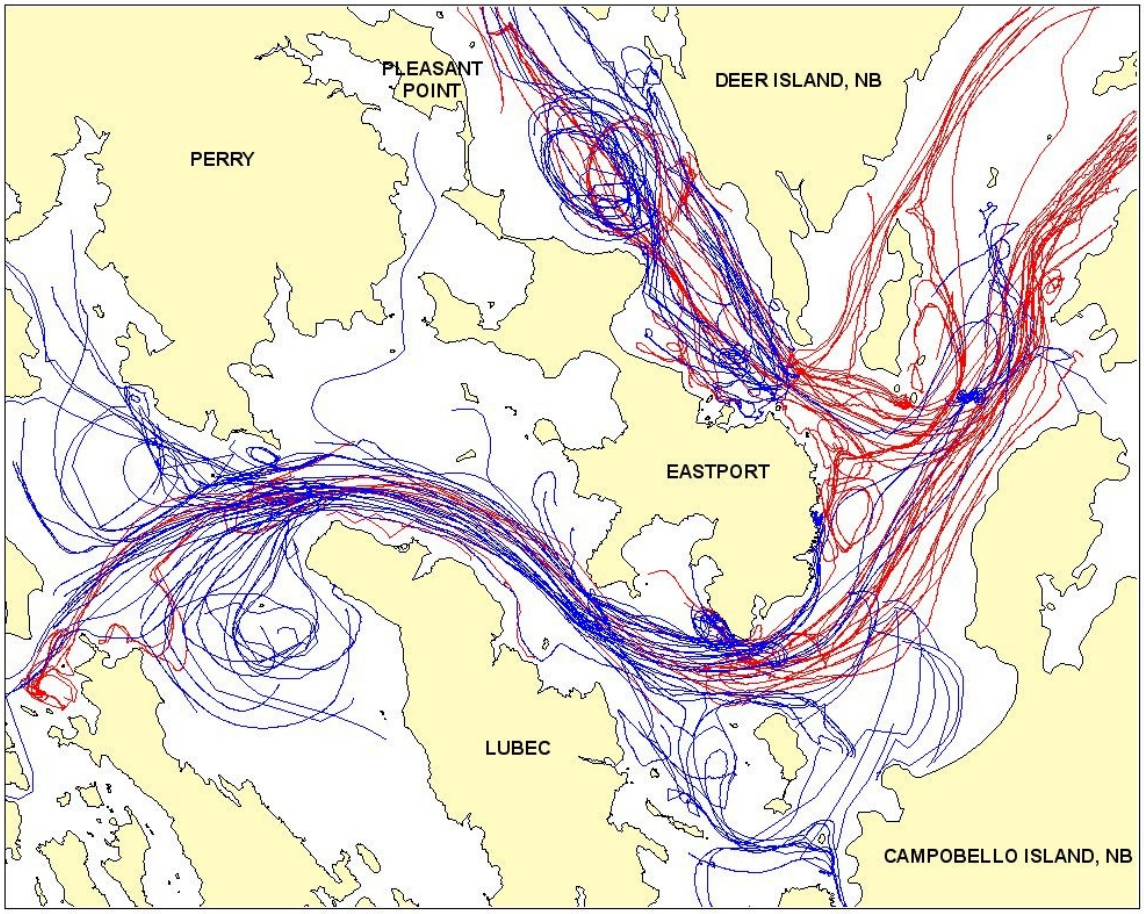

A Field Study of Circulation Patterns in Cobscook Bay

Final Report To
Maine Sea Grant,
Maine Department of Environmental Protection and
Maine Oil Spill Advisory Committee

Project Period: February 1, 2003 – January 31, 2008

Submitted By
Cobscook Bay Resource Center
4 Favor Street
Eastport, Maine 04631
www.cobscook.org

December 21, 2007

Cobscook Bay Resource Center: A Field Study of Circulation Patterns in Cobscook Bay
MOSAC Final Report
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Executive Summary

The Cobscook Bay Resource Center conducted a field drifter study of circulation patterns in Cobscook Bay. In a companion project, Dr. Huijie Xue used the field study data to validate a circulation model for Cobscook-Passamaquoddy Bays and contributed to the GNOME (General NOAA Operational Modeling Environment) oil spill trajectory model used by responders during an oil spill.

Five Seimac drifters with GPS and satellite transmitter capabilities were purchased to track surface currents. A Gonio 400 ARGOS Direction Finder was purchased to detect the signal that the drifters emit and from the signal determine the bearing of the drifter, allowing efficient retrieval of the deployed drifters.

A team of researchers and prospective data users selected field trial deployments sites. Initial discussions were held with a wide variety of organizations to address issues of marine safety and aquaculture bio-security. From these meetings protocols for notification of field work and reduction of pathogen transmission were developed.

Drifters were deployed and tracked from skiffs or small boats leased from fishermen, local residents or organizations. Drifters were released from pre-determined sites in one of three configurations: transects, clusters or timed release. All deployments were initiated at the beginning of a tide stage, i.e. at low water or at high water. Drift trials were short term, consisting of a half tide cycle or approximately six hours.

After each drifter trial was completed, data was downloaded directly from the drifter to a computer at the Cobscook Bay Resource Center. After data processing was completed the tabulated data was distributed to researchers at the University of Maine and Department of Fisheries and Oceans-Canada. An individual map layout for each trial completed was then created.

In addition to providing data to researchers and to MOSAC, data was provided to:

- **USDA-APHIS**: for use in the aquaculture industry's efforts to minimize the spread of infectious salmon anemia (ISA).
- **Maine Department of Marine Resources biotoxin group**: for use in evaluating how blooms of the toxic phytoplankton species *Alexandrium* are moved by currents in the Cobscook region.
- **Cooke Aquaculture**: for use in disease control and fish farm management efforts.
- **Electric Power Research Institute** tidal power research group: MOSAC drift study data was used in selecting locations for a tidal power demonstration site in the Cobscook Bay area. Researchers cited existence of the Drift Study as part of the local infrastructure needed to support the development of tidal electric power generation in the area.
- **Ocean Renewable Power Company** (ORPC).
- **The Passamaquoddy Tribe**

Outreach activities to the general public about this project included presentations and poster displays at the Cobscook Fisheries Forum in 2004, 2005, and 2006; a December, 2006 presentation in Lubec; and posting the results of all MOSAC drifter trials from 2003 to 2007 at www.cobscook.org/maps/driftStudy.htm. In addition, a total of 27 local high school students from Lubec and Eastport participated in three drift study trials.

The most important development during the course of the MOSAC project was the extension of the project period from two to five years. Boat time and satellite costs were substantially lower than we had anticipated; allowing us to conduct more trials, in additional locations, and of more varied types than originally planned. From 2003 to 2007 we conducted 35 drifter trials, rather than the 12 trials originally planned. Each of the thirty-five drift trials demonstrated the complexity and dynamic nature of the Cobscook/Passamaquoddy Bay ecosystem. Maps of each drifter trial with a short caption describing the event are included in this report. (See *Appendix*)

The greatest technical challenge was learning to use the CAST drifters. A data flow analysis of the project and its attendant components was conducted. Manuals, technical specifications, and other information for each component were compiled. Technical support was received from Argos, North American CLS, and Seimac. Randy Losier at the St. Andrews DFO field station provided practical, field-based knowledge of the components. Protocols and procedures were developed and documented for each phase of a field trial. The procedures manual was maintained and updated throughout the life of the project.

Obtaining timely delivery of the Gonio radio direction finder equipment from the manufacturer was a significant challenge to the project. In the absence of the Gonio direction finder we developed alternative methods for tracking and recovering the drifters, which, while successful, required a greater number of people and boats than if a working Gonio direction finder had been available.

Finally receiving delivery of the Gonio Radio Direction Finder, after an eighteen month wait, allowed us to deploy drifters with greater confidence that we would be able to retrieve them, therefore giving us greater freedom in the types of releases employed. We were able to use smaller, less expensive and fewer boats to conduct the drift trials once we received the Gonio direction finder.

Collaboration with the Pleasant Point Passamaquoddy Environmental Department was central to our success in this project. Another key to the success of this project was the assistance of Chris Bartlett, our local Sea Grant/Cooperative Extension agent.

We intend to continue mapping the currents in the region. We are open to working with researchers, entrepreneurs and communities to use our equipment and expertise to map currents for oil spill planning, tidal power projects, larval distribution studies, and similar efforts in other areas along the coast.

We would like to devote more resources to display and analysis of our existing data. We are particularly interested in developing a process to extract current speed data for each run. We would like to use a model to run some "what if" scenarios for Cobscook and Passamaquoddy Bays; for example, removing the existing causeway that connects Eastport to the mainland to explore the resultant changes in current. Finally, we would like work with a team of specialists; oceanographers, marine biologists and ecologists, and others, to develop a public presentation on what these drifter pathways and current maps reveal about the marine life of this ecosystem.

Introduction

Our project consisted of a field drifter study of tidal currents and the development of an oil spill model for the Cobscook/Passamaquoddy ecosystem. The objectives of the project were:

- To map particle trajectories in major passages and near critical navigation points in Cobscook-Passamaquoddy Bays during different tidal phases;
- To help validate the 3D circulation model for Cobscook-Passamaquoddy Bays ; and
- To develop an oil spill trajectory prediction model for the Cobscook-Passamaquoddy Bay region.

Methods

Equipment

Five Seimac CAST (Convertible Accurate Surface Tracker) drifters with ARGOS and GPS capability were purchased to track surface currents. The drifter design consists of a floating blue barrel with holes in the sides to allow filling and emptying of water. The onboard electronics are housed in an orange PVC pipe positioned in the top of the barrel. Ballast is provided by chain inside the bottom of the barrel and flotation by styrofoam in the top. The position of the drifter is recorded in two ways; first, by an onboard GPS receiver from which positional coordinates can be downloaded directly; second, by a satellite transmitter called a Smart Cat PTT (platform transmitter terminal). The transmitter sends signals to the ARGOS satellite system, which in turn transmits the drifter's position to a ground station. Users can access the data at the ground station through the ARGOS website. Using the Seimac CAST drifters allows us to coordinate data collection and data analysis with Department of Fisheries and Oceans-Canada (DFO) staff, as the same type of equipment is used by DFO staff during their drift studies in Passamaquoddy Bay.

The electronics inside the C-AST drifters are powered by 28 alkaline "D" cell batteries configured into one shrink-wrapped power pack. We have been able to use a battery pack for up to 3 seasons depending on the number of times the drifter is used. Battery life is monitored using a multimeter.

A Gonio 400 ARGOS Direction Finder was purchased to allow efficient retrieval of the deployed drifters. This piece of electronics detects the ARGOS signal that the drifters emit and from the signal determines the bearing of the drifter. Each drifter has a unique ID number which can be programmed into the Gonio. When the Gonio receives a signal from a particular drifter, it displays the bearing of the drifter in relation to the bow of the boat. The Gonio determines bearings to within 30° plus or minus of the direction displayed. When the Gonio is receiving a signal from a drifter, it indicates signal strength as well as the bearing. This lets the user know how close the Gonio is to the drifter. Signals are received by an antenna mounted on the bow of the boat and connected to the Gonio by a cable. The antenna must be mounted and programmed to work with the Gonio each time the drifters are deployed.

Drifter Trial Site Selection

A project meeting was held to determine field trial deployments sites, operational protocols, and to provide clarity about responsibilities for various stages of the project. The following people attended the meeting: Huijie Xue, University of Maine at Orono; David Brooks Texas A&M; Chris Bartlett,

Maine Sea Grant/Cooperative Extension; Laurie Gustofson, US Department of Agriculture (USDA-APHIS); Fred Page, Department of Fisheries and Oceans-Canada; Randy Losier, Department of Fisheries and Oceans-Canada; and Heidi Leighton and Will Hopkins, Cobscook Bay Resource Center.

Sites for drifter deployment were chosen from the broad area south of Navy Island, New Brunswick, and south and east of Deer Island, New Brunswick in Passamaquoddy Bay and in Cobscook Bay. This area allowed us to capture information about exchange between the two bays and about currents that have not been documented in previous studies. Specific deployment locations included a port (Estes Head); navigational turning points (southern tip of Cherry Island, and Treats Island); areas of small boat traffic(mouth of Lubec Narrows, Eastport Breakwater, and Reversing Falls); Gleason Point, Perry, and between Gove and Birch Points in Cobscook Bay.

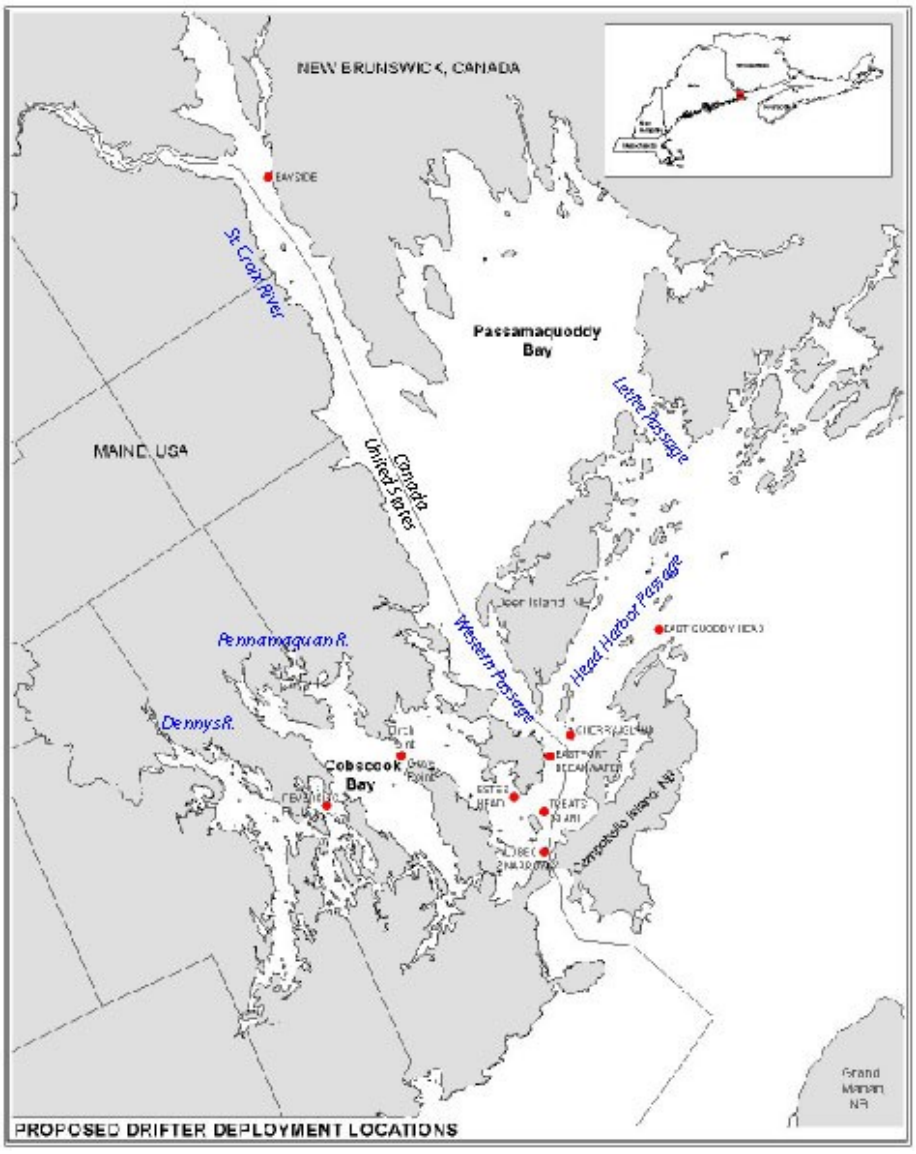

Figure 1. The mainland, islands and passages defining Cobscook and Passamaquoddy Bays. The initial drifter deployment locations are marked with red dots.

Pre-deployment Procedures
To address issues of marine safety and bio-security, initial meetings or discussions were held with the US Coast Guard, US Customs, Eastport Port Authority, Quoddy Pilots Association, Federal Marine Terminals, the Quoddy Spill Prevention Group, USDA-APHIS Infectious Salmon Anemia Program, and the Cobscook Bay Fishermen's Association. From these meetings protocols for notification of field work and reduction of pathogen transmission were developed. Specifically the following procedures were instituted:

- The local aquaculture industry and the US Coast Guard station in Eastport are notified of the drift study date and duration at least 24 hours prior to deployment of gear.
- Contact with aquaculture infrastructure by project gear is avoided if possible. If drifters do come in contact with aquaculture cage sites, the drifters are retrieved by aquaculture site personnel, and disinfected before further use.
- Before and after each release, all drifters are disinfected with a greater than 300 ppm solution of iodine to discourage the transmission of possible pathogens.

Deployment Procedures

Drifter deployment and tracking occurs from skiffs or small boats leased from fishermen, local residents or organizations. Drifters are released from pre-determined sites in one of three configurations: transects, clusters or timed release. All deployments are initiated at the beginning of a tide stage, i.e. at low water or at high water. Drift trials are short term, consisting of a half tide cycle or approximately six hours. The short duration of drift trials has been chosen to reduce the likelihood of retrieving drifters from offshore waters, which would require a move to larger boats and increased staff time. Also, anything left in the water for longer than six hours tends to run aground in this near shore area.

Each individual drifter is allowed to follow the currents without interference during the entire 6 hour trial. If a drifter runs aground at any time during the trial, the drifter is retrieved and that track is ended. If possible, drifters are retrieved before they encounter fixed aquaculture gear.

Data Processing
After each drifter trial is complete, data is downloaded directly from the data storage unit within the drifter to a computer at the Cobscook Bay Resource Center. The GPS unit inside the drifter is connected to the computer through a serial cable. Using software called ULogger, the user is able to interface with the GPS unit. Through ULogger an ASCII file of data is generated and stored in a .log file. The .log file is converted to a text file and brought into Excel. In Excel, the data is converted to a comma delimited file. The comma delimited text file is brought into ArcView and used to create an Event Theme. This process converts the latitude/longitude coordinates of the positions collected by the drifter's GPS unit into points on a map.

Because the drifters are collecting data points from the time they are turned on at the Resource Center office until they are turned off at the office, the actual deployment track positions must be filtered out of the entire file of points created. Data from each drifter for each trial is divided into three separate files: pre-trial data, showing the track followed from Resource Center office to the deployment point; the deployment track, showing the actual pathway from deployment to recovery; and post-trial data, from recovery point to the office.

The deployment tracks are displayed on maps as lines depicting the direction the drifter traveled during a particular trial.

The tabulated data is then exported from ArcView into a format for distribution to researchers at the University of Maine and Department of Fisheries and Oceans-Canada. An individual map layout for each trial completed is then created.

Results

Data Distribution

After drift trial data is processed, tabulated data is given to our project partners, Dr. Huijie Xue at the University of Maine and Dr. Fred Page and Randy Losier from the Department of Fisheries and Oceans-Canada.

Though the focus of our Maine Oil Spill Advisory Committee project has been on developing information useful for oil spill prevention and planning, we have found that our information is of interest to many different users. In addition to MOSAC, we have provided data to the following individuals and organizations:

- **USDA-APHIS**: for use in the aquaculture industry's efforts to minimize the spread of infectious salmon anemia (ISA).
- **Maine Department of Marine Resources biotoxin group**: for use in evaluating how blooms of the toxic phytoplankton species *Alexandrium* are moved by currents in the Cobscook region.
- **Cooke Aquaculture**: for use in disease control and fish farm management efforts.
- **Electric Power Research Institute** tidal power research group: data from our MOSAC drift study data was used in selecting locations for a tidal power demonstration site in the Cobscook Bay area. Researchers cited existence of the Drift Study as part of the local infrastructure needed to support the development of tidal electric power generation in the area.
- **Ocean Renewable Power Company** (ORPC): ORPC has filed applications with the Federal Energy Regulatory Commission (FERC) to consider tidal power projects at two locations in the area. We also introduced ORPC personnel to Dr. Huijie Xue. Dr. Xue will be incorporating the specifications for ORPC's turbine design into her model.
- The **Passamaquoddy Tribe**: The Tribe has filed an application with FERC for a tidal power site off Kendall Head and is researching other locations.

Outreach

Outreach activities to the general public about this project included:

- PowerPoint presentations and poster displays of field trial results at the Cobscook Fisheries Forum in 2004 and 2005. Participants at the Forum included local fishermen, scientists, resource managers, legislators and community members.
- Displaying maps of each drifter trial in large poster format at the Cobscook Fisheries Forum in 2006. In addition, a PowerPoint presentation was given to Forum participants about the progress of the project. That presentation is available on the Resource Center's website at http://www.cobscook.org/cobscook_bay/2006_Fisheries_Forum/drifters/Drift%20Study.html .
- A December, 2006 presentation *Mapping Cobscook Currents: What Happens When You Go With The Flow* as part of a series of monthly informational events. The presentation outlined the history of drift studies in the Cobscook region and detailed the methodology we have developed to conduct our drifter research. Results of our MOSAC drifter trials were presented in map form and discussed.

- Displaying the results of all MOSAC drifter trials from 2003 to 2007 on our website at www.cobscook.org/maps/driftStudy.htm.

Student Involvement
A total of 27 local high school students from Lubec and Eastport participated in three drift study trials.

- In June, 2004 we conducted a drifter run with area high school students using the PVC drifters, as the CAST drifters were still being tested. A classroom training exercise was conducted in the week before the trial occurred. Two students from Shead High School in Eastport and seven students from Lubec High School participated in this field trial.
- Classroom presentations were made to two groups of Shead High School Earth Science students.
- In September 2006 we released drifters in an ebb tide trial along a transect between Dog Island, Eastport and Deer Island Point, the general area of the Old Sow whirlpool. Six students from the Environmental Science class at Shead H.S. participated in the September 18 run. We released two of the original student-designed PVC drifters along with our five barrel drifters. This trial gave the students experience with the drift study project, as well as allowing us to test the movement of the PVC drifters compared to the barrel drifters. Of the seven drifters released, only one ended up traveling out Head Harbor Passage; all six remaining drifters ended up in the Indian River closer to Deer Island than to the Campobello shore.

Results of Research
From 2003 to 2007 we conducted 35 drifter trials. Thirty trials were completed with the CAST barrel drifters and five were completed with our original PVC drifters. Two of the trials were conducted in tandem with researchers from DFO St. Andrews, New Brunswick.

Each of the thirty-five drift trials we have conducted demonstrated the complexity and dynamic nature of the Cobscook/Passamaquoddy Bay ecosystem. Maps of each drifter trial with a short caption describing the event are included in this report. (See *Appendix*)

Discussion

Significant Developments
The most important development during the course of the MOSAC project was the extension of the project period from two to five years. Boat time and satellite costs were substantially lower than we had anticipated; allowing us to conduct more trials, in additional locations, and of more varied types than originally planned. We conducted 35 trials, rather than the proposed 12.

Challenges
Gonio Receiver Delivery
Obtaining timely delivery of the Gonio radio direction finder equipment from the manufacturer was a significant challenge to the project

The Gonio 400 receiver is used to find CAST drifters once they have been deployed in the field. It was specifically developed to work with the Argos transmitter in the CAST drifters. Canadian researchers in Passamaquoddy Bay have used this direction-finding equipment with great success.

In January 2004, we placed an order with North American CLS, the only company in the United States that handles orders for the Gonio receiver, which is produced in France. Delivery was scheduled for April. In April we learned production of the Gonio had been delayed and delivery would not occur until July. A rental unit was available, with the rental payment being deducted from the price for the new unit.

Delivery of a rental unit was received in May 2004. This unit was used in field trials in June and July with no success. We finally determined by using this unit in tandem with the unit used by researchers from DFO St. Andrews, New Brunswick, that the rental unit was operating improperly. The rental unit was returned to North American CLS. Unfortunately, at this time we were told that the French manufacturer had experienced a warehouse fire and that the new unit was not expected to be delivered until October at the earliest. The Gonio receiver was finally received in June, 2005.

Day of the Lost Drifters

Not having a working Gonio receiver led to another unanticipated difficulty: lost drifters. On June 17, 2004, we deployed the CAST drifters in our first field trial. This trial is notable not only for being the first time we deployed the CAST drifters, but also because, unknown to us, three of the drifters were removed from the water and taken home by Canadian fishermen. At some point during the trial visual contact was lost with these three drifters. Without a working Gonio to guide us several hours were spent searching for the drifters with no success. On the 18th we used the Argos on-line FTP site to obtain the last known positions of the drifters. When the positions were plotted it was discovered that the drifters were ashore on the New Brunswick mainland near Lepreau. Luckily, our colleagues at the St. Andrews Biological Station were willing to assist in the search for the missing drifters. Using satellite data, the drifters were found in the back of a pickup truck near Seeley's Cove, New Brunswick, the GPS units still collecting points and the Argos units still transmitting location data to the satellites. (See *Figure 2*, which shows the path the drifters traveled over the two days.)

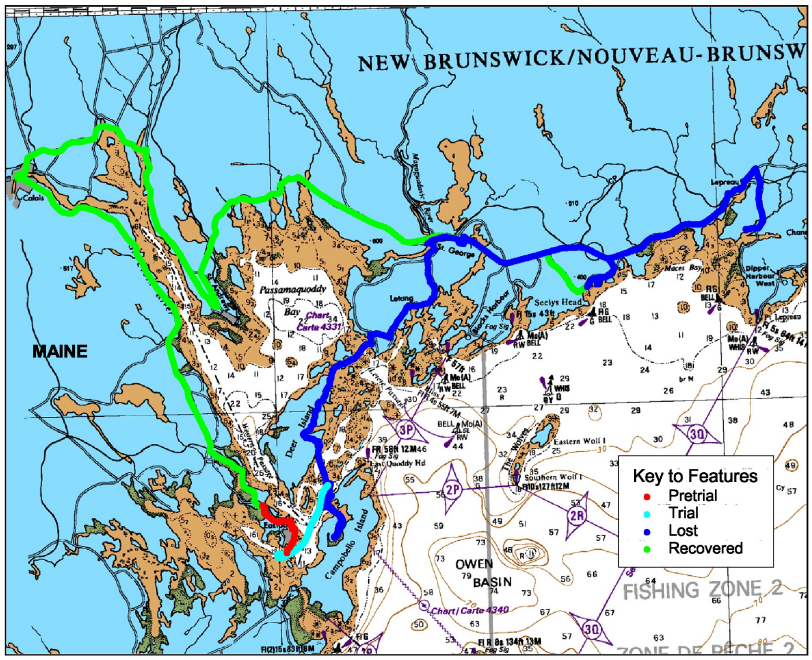

Figure 2. Pathway Traveled On *Day of the Lost Drifters*

Protocol and Procedure Development

The greatest technical challenge was learning to use the CAST drifters. We started with an extensive list of questions:

- How does the cost structure for use of the Argos satellite system apply to our needs?
- How is data retrieved from the Argos system by the end user?
- How is the GPS inside the CAST drifter configured?
- How is data downloaded from the GPS and what format is it in?
- How is the Argos PTT inside the CAST drifter configured?
- How can data both from the GPS and the PTT be converted for use in GIS mapping programs?
- How can data be converted for use by our partner researchers, Huijie Xue and Fred Page?
- How is the Gonio receiver set up and used?

The first step taken in working through these issues was to conduct a data flow analysis of the project and its attendant components. (See *Figure 3*) Manuals, technical specifications, and other information for each component were compiled. Technical support was received from staff at Argos, North American CLS (Gonio), and Seimac (CAST drifter and GPS). Randy Losier at the St. Andrews DFO field station provided practical, field-based knowledge of the components and how they work.

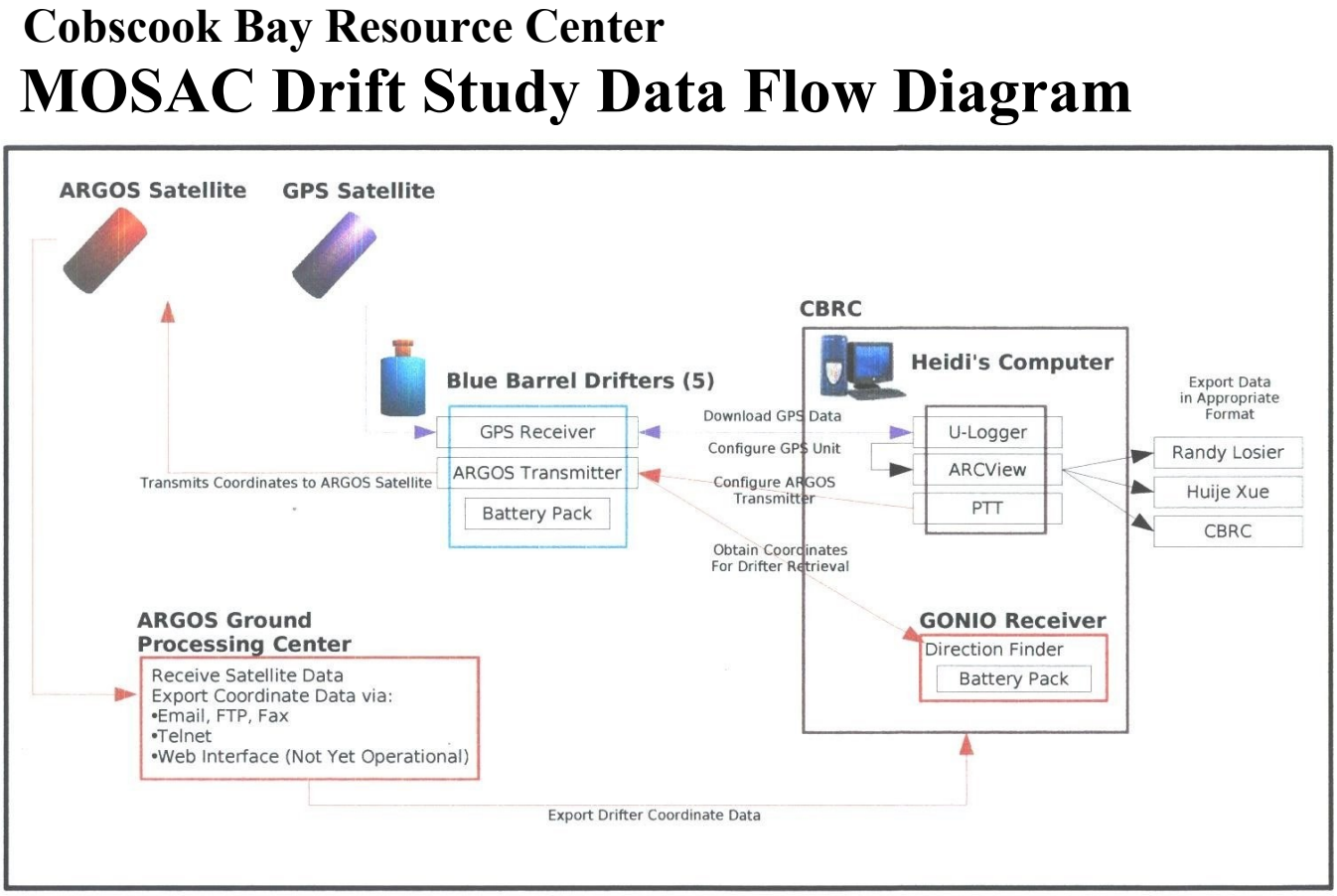

Figure 3.

Two test runs were completed: one on land and one in the water, before the drifters were deployed for the first field trial. Through this initial testing phase, protocols and procedures were developed and documented for each phase of a field trial. The procedures manual was maintained and updated throughout the life of the project.

An issue that surfaced later in the project involved replacement of the battery packs for the drifters. Finding reliable and affordable suppliers for the battery packs was something of a challenge, with prices ranging from $142 to $405 per unit. Documentation of the disassembly, rewiring, and soldering routines involved in replacing the power supplies was added to the procedures manual.

Project Revisions

In the absence of the Gonio direction finder we developed alternative methods for tracking and recovering the drifters. In the first two years of the project we were forced to track drifters with more than one boat in order to maintain close visual contact with the equipment. Standard GPS units were used aboard the tracking boats. The on-line Argos satellite system was also used for pinpointing the last known locations of drifters out of visual contact. This last technique required a person on shore to access the Argos satellite data and then convey positions to the tracking boat via cell phone. These methods, while successful, required a greater number of people and boats than if a working Gonio direction finder had been available.

Finally receiving delivery of the Gonio Radio Direction Finder, after an eighteen month wait, allowed us to put the drifters in the water and check their locations periodically throughout the day. This can be done using only one boat and two people. Before we had the Gonio, we had to use at least two boats and four people to keep track of the drifters by maintaining visual contact with them at all times.

Using the Gonio direction finder also allowed us to develop alternate deployment methods. The original proposal described use of a transect release during which five drifters are deployed in a line between two points. Using the Gonio allowed us to deploy drifters with greater confidence that we would be able to retrieve them, therefore giving us greater freedom in the types of releases employed. Two methods other than transects were used after the Gonio was received; timed release and cluster release deployments. Timed release deployments consist of a release of one drifter every hour from the same point and retrieval of all drifters at the end of a half tide cycle. Cluster releases involve setting out all five drifters at one site at the same time and tracking them through half a tide cycle. Timed release and cluster deployments more closely resemble conditions of an oil spill than do the transect releases.

Because we were able to extend the life of this project to five years rather than two, we were able to complete multiple runs from the original deployment locations described in the proposal as well as runs from new sites chosen as the project progressed. Original deployment locations included:

- Cherry Island
- Treat Island
- Eastport Breakwater
- Lubec Narrows
- Estes Head port
- Gove Point/Birch Point

Other deployment locations were added to increase the data about certain areas of the region and included:

- Gleason Point
- Deer Island Point/Dog Island
- Kendall Head/Cummings Cove
- Shackford Head/Cooper Island

Site		Type of Release			Drifter Type	
		Transect	Timed	Cluster	Barrel	PVC
Gleason Point	Flood	x			1	
	Ebb	x x		x	2	1
Cherry I/Harbor DeLute	Flood	x x x			2	1
	Ebb					
Estes Head/Treats I	Flood	x			1	
	Ebb	x x			1	1
Estes Head/Campobello	Flood	x			1	
	Ebb					
Eastport Breakwater	Flood	n/a	x	x	2	
	Ebb	n/a	x	x	2	
Estes Head Pier	Flood	n/a	x	x	2	
	Ebb	n/a	x x	x	3	
Deer Island Pt/Dog I	Flood	x x		x	2	1
	Ebb	x x			1	1
Leighton Pt/Denbow Pt	Flood					
	Ebb	x			1	
Lubec Narrows	Flood	n/a	x	x	2	
	Ebb	n/a	n/a	n/a		
Gove Pt/Birch Pt	Flood	x x			2	
	Ebb	x			1	
Kendall Head/Cummings Cove	Flood	x			1	
	Ebb	x x			2	
Shackford Head/Cooper Island	Flood	x			1	
	Ebb					

Figure 4. Table Showing Deployment Sites, Tide Stages and Types of Drifter Releases

Opportunities

Project Period

We took advantage of lower project costs than we had originally projected and extended the life of the project from two to five years. We were able to conduct more trials, in additional locations, and of more varied types than originally planned.

Tidal Power Sites

MOSAC drift study data was used in selecting locations for a tidal power demonstration site in the Cobscook Bay area. Researchers cited existence of the Drift Study as part of the local infrastructure needed to support the development of tidal electric power generation in the area.

Web Development
Internet and web access development over the past five years allowed us to post maps online easily and inexpensively.

Boat Use
Our original proposal was developed with the idea that we would use the *Otto Miller*, a 35' lobster boat owned by the Washington County Community College, as the primary platform from which we would conduct our research. We were able to use smaller, less expensive and fewer boats to conduct the drift trials once we received the Gonio direction finder.

Collaborative Efforts
Our collaboration with the Pleasant Point Passamaquoddy Environmental Department was central to our success in this project. By making their 25' warden boat available to us at a less expensive daily rate and by donating the captain's time on this project, they enabled us to complete many more runs than we might have otherwise. Likewise, the knowledge of their captain about local waters and his willingness to be flexible when scheduling runs was a large factor in our ability to complete the project.

Another key to the success of this project was the assistance of Chris Bartlett, our local Sea Grant/Cooperative Extension agent. In the early stages, he was invaluable in connecting us with many of the organizations who were helpful in designing the project. Chris also provided the Betadine solution necessary for disinfecting the drifters before and after each use throughout the five years of the project. Before we had the Gonio receiver and required more than one boat to conduct the drift trials, Chris made his personal skiff available to us, as well as helping us arrange use of other boats. For student drift runs, he made available his skiff or the Sea Grant boat, as well as his services as captain. Without his help with logistics and contribution to boat safety and operation, we would not have been able to include students in the project.

Next Steps
We intend to continue mapping the currents in the region. While the MOSAC project has focused primarily on strong currents in areas of high boat and ship traffic, we are particularly interested in looking at retention rates in the back coves of the Bay. We are also open to working with researchers, entrepreneurs and communities to use our equipment and expertise to map currents for oil spill planning, tidal power projects, larval distribution studies, and similar efforts in other areas along the coast.

We would like to devote more resources to display and analysis of our existing data. Our primary product displays the pathways taken by drifters in each trial. We are particularly interested in developing a process to extract current speed data for each run. Development of animated, 3-D, or interactive displays would be especially helpful in making this data available to a wider audience. We are interested in working with modelers to understand how the elements we've described through drifter pathways act in the dynamic realm of a model. We would like to use a model to run some "what if" scenarios for Cobscook and Passamaquoddy Bays; for example, removing the existing causeway that connects Eastport to the mainland to explore the resultant changes in current. Finally, we would like work with a team of specialists; oceanographers, marine biologists and ecologists, and others, to develop a public presentation on what these drifter pathways and current maps reveal about the marine life of this ecosystem.