

Constructing Adaptive Mission Planning and Real-Time Control Systems for Autonomous Underwater Vehicles with Open-Source Software.

<http://coolgate.mote.org/GeoTools2009/>

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What is FOSS?

- Free and open source software
- Liberally licensed to allow users to study, change, and improve
- Everyone has access to the source code
- Can be modified and redistributed
- Often based on open standards

Examples of FOSS

- Linux (Ubuntu, CentOS, OpenSuSe)
- Thunderbird email client
- Firefox web browser
- FireBug JavaScript/CSS Debugger
- bsb2png (NOAA chart to PNG converter)
- OpenOffice Suite
- MySQL database
- Python language
- R Project (statistical computing)
- GRASS/Quantum GIS

Why FOSS was right for us

- Small group w/1 IT person
- No funding for expensive commercial s/w
- Able to leverage others work
- Math/Oceanographic libraries available
- Google Earth/Maps free for basic usage

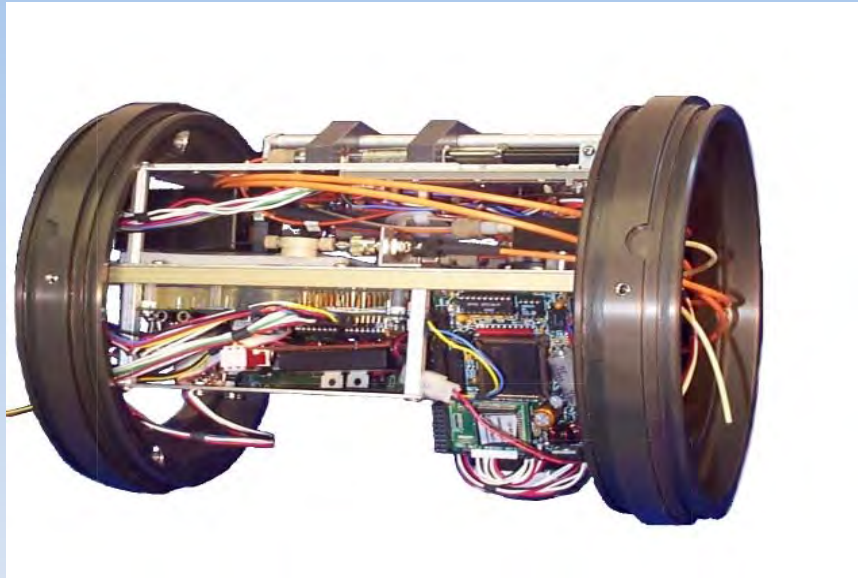
But Google Isn't FOSS!

- True – but it is free
- We subscribe to the “IIWUI” Principle:
 - “If it works – USE IT!”
- “Heavy Lifting” of building viz engine done
- Majority of our target users have GE/GM
- Don't be hard-core about using FOSS

About our program

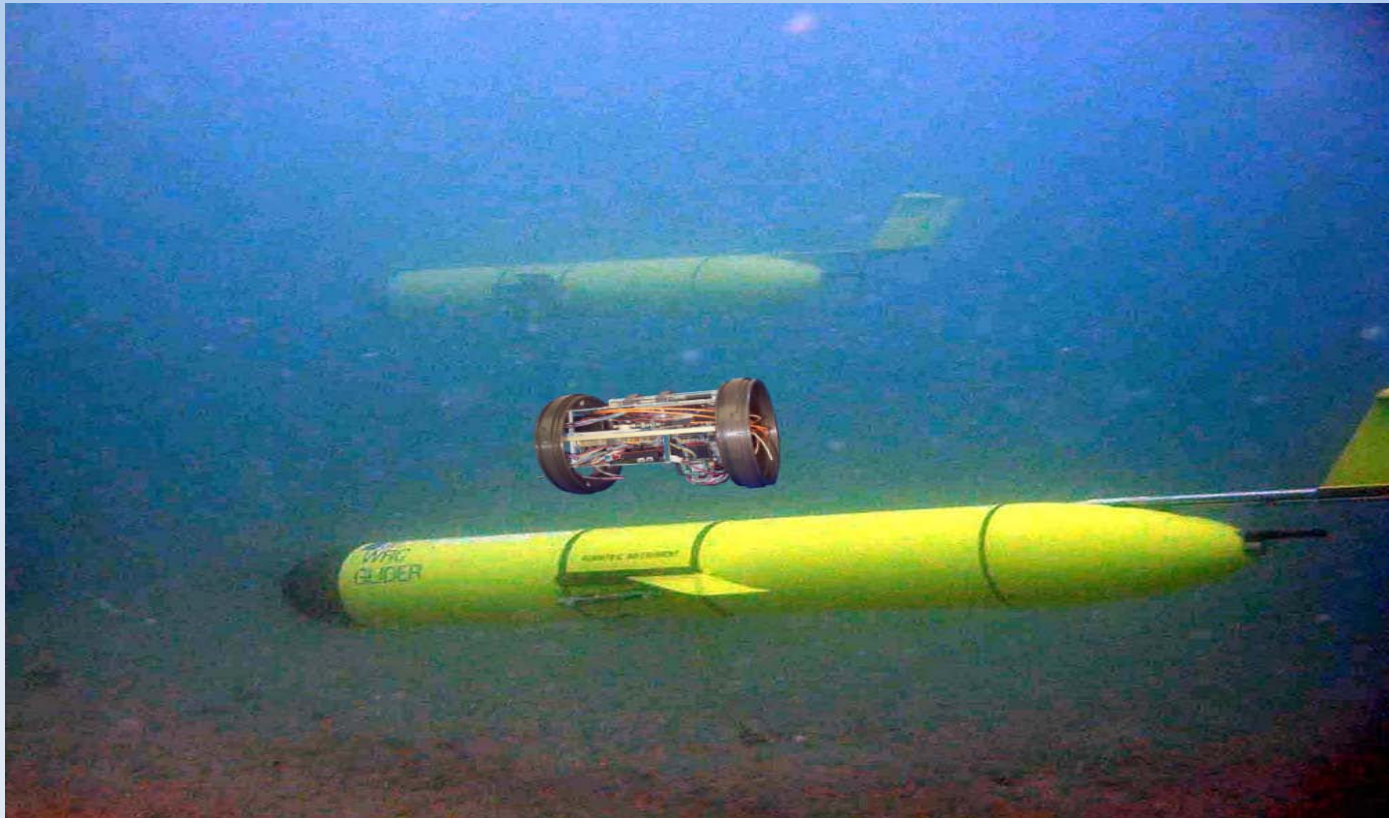
- SO COOL
- Home of the BreveBuster aka
 - Optical phytoplankton discriminator
- Located at Mote Marine Lab, Sarasota FL
- Brevebuster provides RT early warning
- Primarily deployed on Webb AUVs
- Also deployed on moorings/buoys

The BreveBuster



BreveBusters optically detect *Karenia brevis* blooms by comparing light absorption by particles in ambient water to the light absorption fingerprint that is characteristic of *K. brevis*. That comparison yields a Similarity Index (SI) which is related to the fraction of phytoplankton community biomass contributed by *K. brevis*. Values of SI below 0.5 indicate less than 10% *K. brevis*, values over 0.8 indicate greater than 90% *K. brevis*.

The Webb Slocum Glider



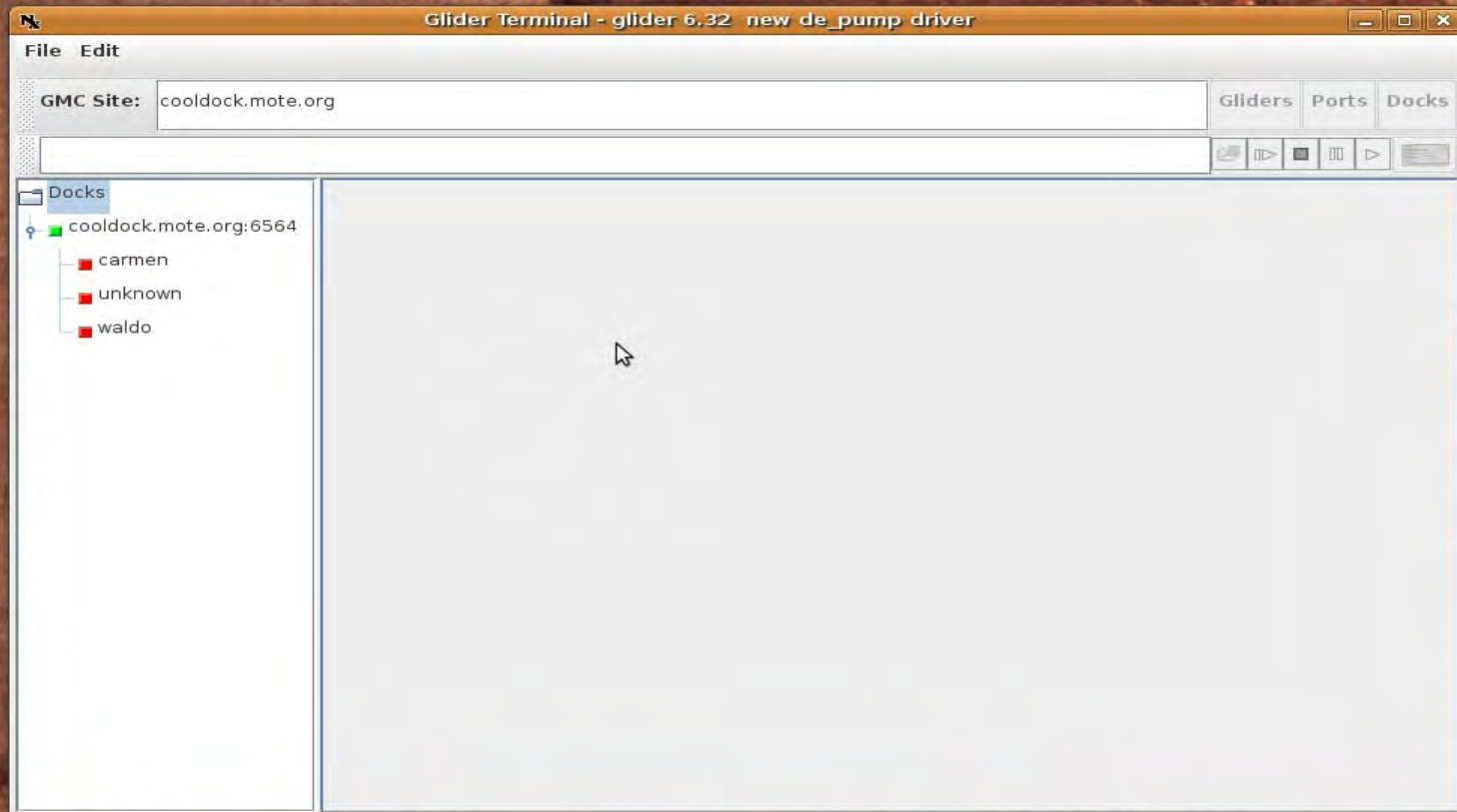
“As Delivered” Glider Data Management Tools

- Dockserver
 - Java-based client-server application
 - Until recently no built-in database support
 - Listens for glider comms via Iridium modem
 - Logs data in text files
 - Sends updated mission files to glider
 - Scriptable
 - “Talks” to users via Glider Terminal

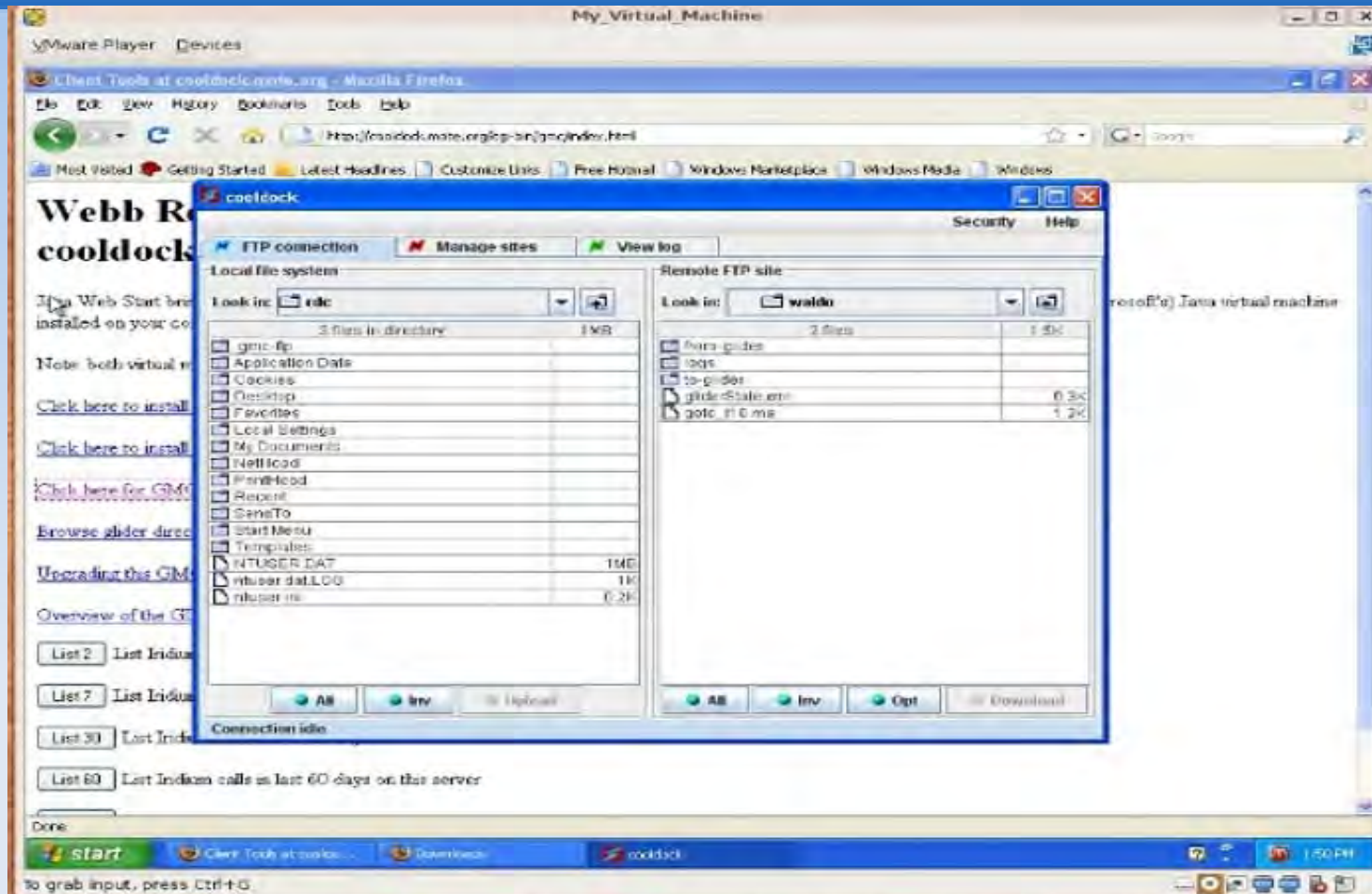
Glider Data Tools cont...

- Glider Terminal
 - Java-based client application
 - Like minicom or HyperTerminal
 - Can load scripts that:
 - send/retrieve files from glider
 - Ends mission
 - Alter waypoints

Glider Terminal



GMC FTP Client



Glider Data Files

- MA files: Waypoints
- MI files: Mission control statements
- Log files: Iridium modem text logs
- SBD files: Small binary data files
- DBD files: “Ginormous” binary data files

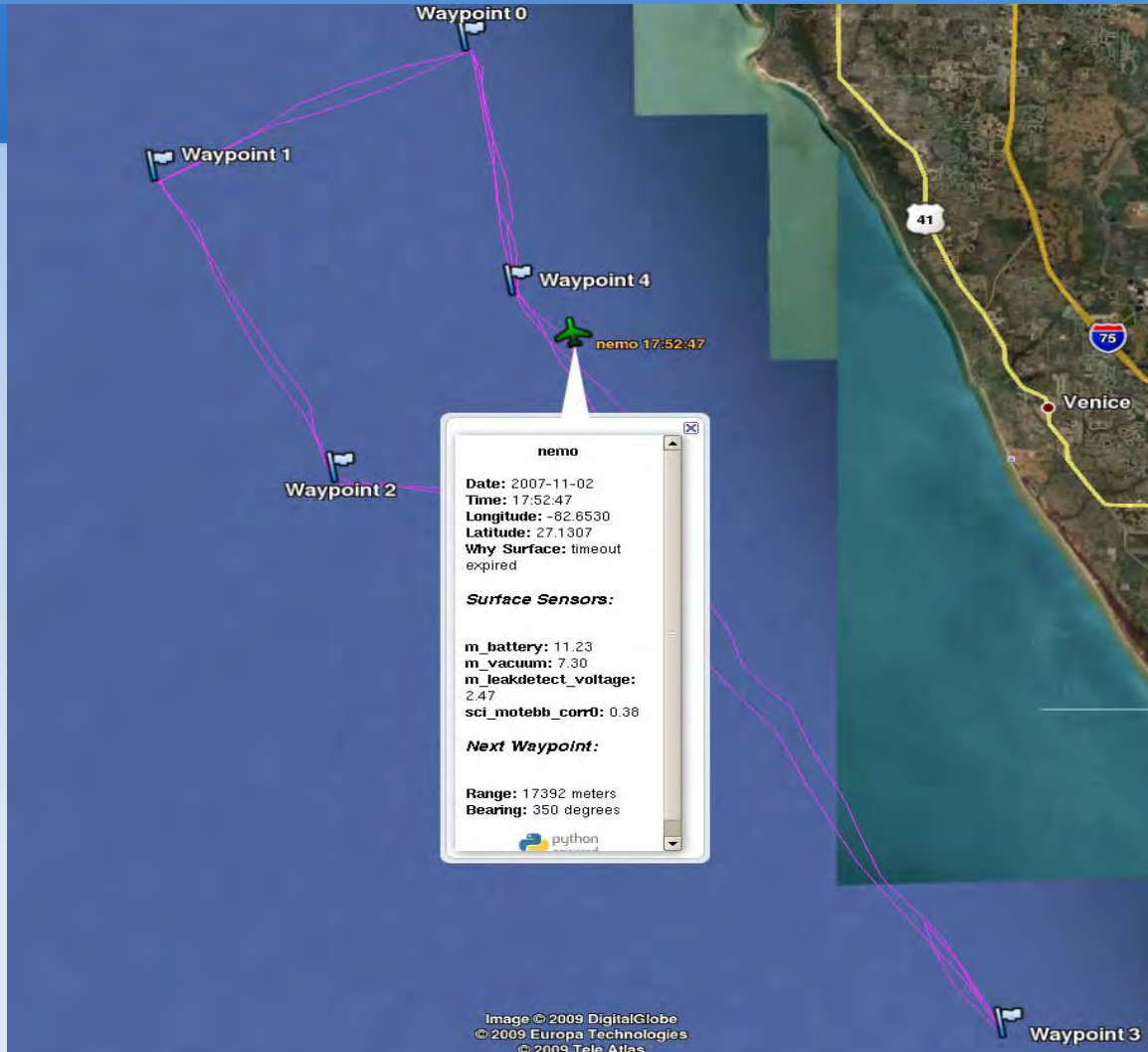
The Problem

- Many files to manage (MA, MI, SBD)
- GliderTerminal text-only
- No integration with imagery (MODIS)
- Changing waypoints error-prone
- Difficult to visualize retrieved data

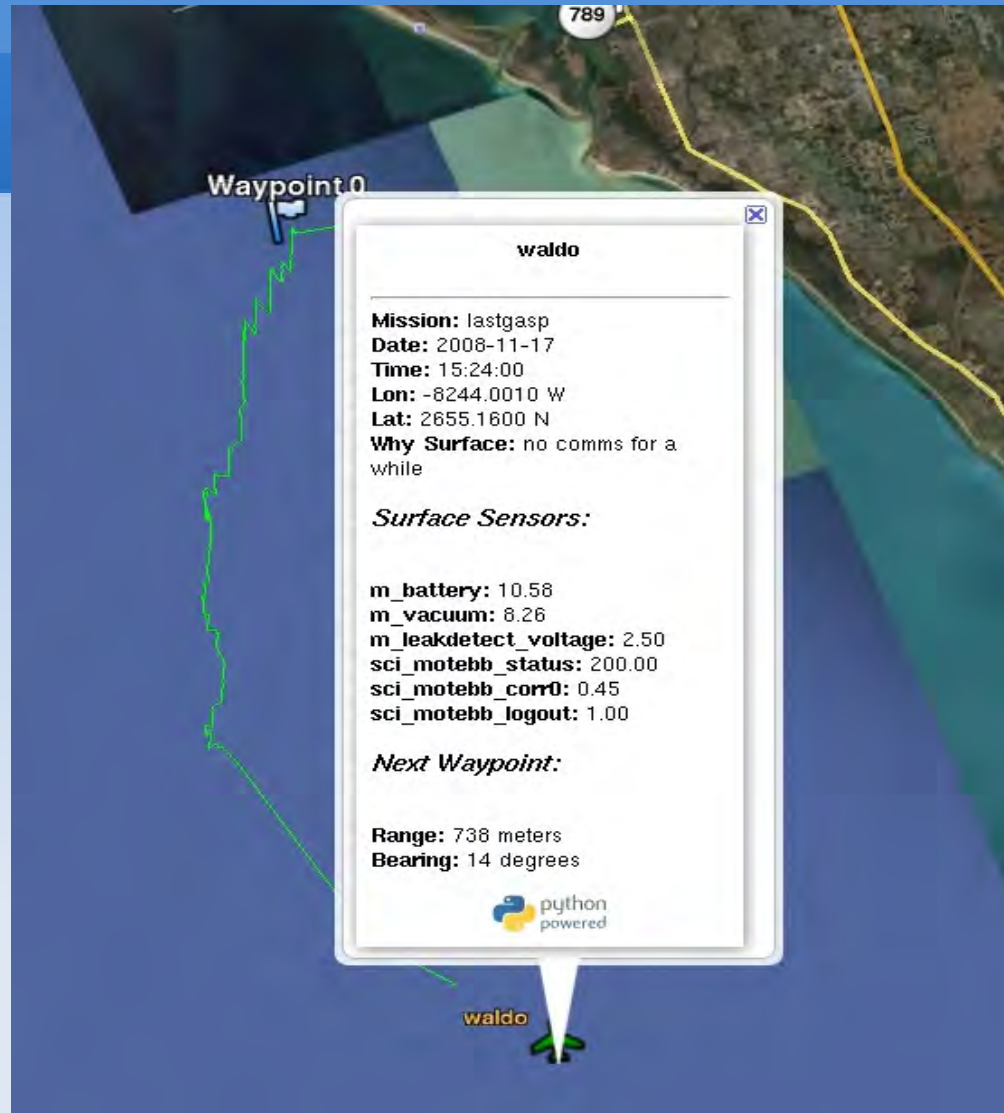
First Steps

- GliderTracker V1, written in TCL
- Used SQLite3 as embedded DB
- Parsed glider logfiles and exported KML
- Database 'in-memory' only
- Only dealt with surface reports
- Ran as cron job on CentOS server

Glider Tracker V1



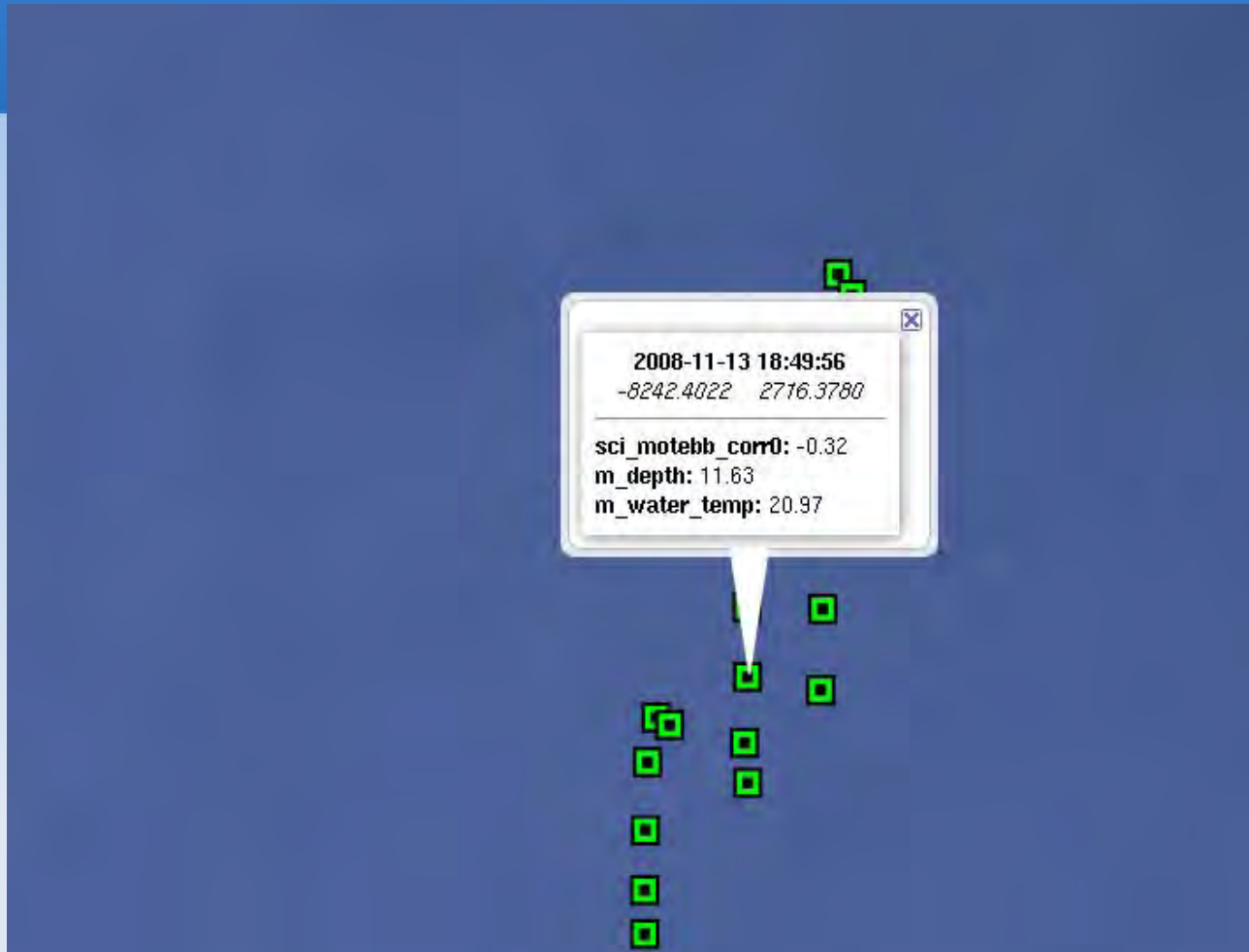
Glider Tracker V2



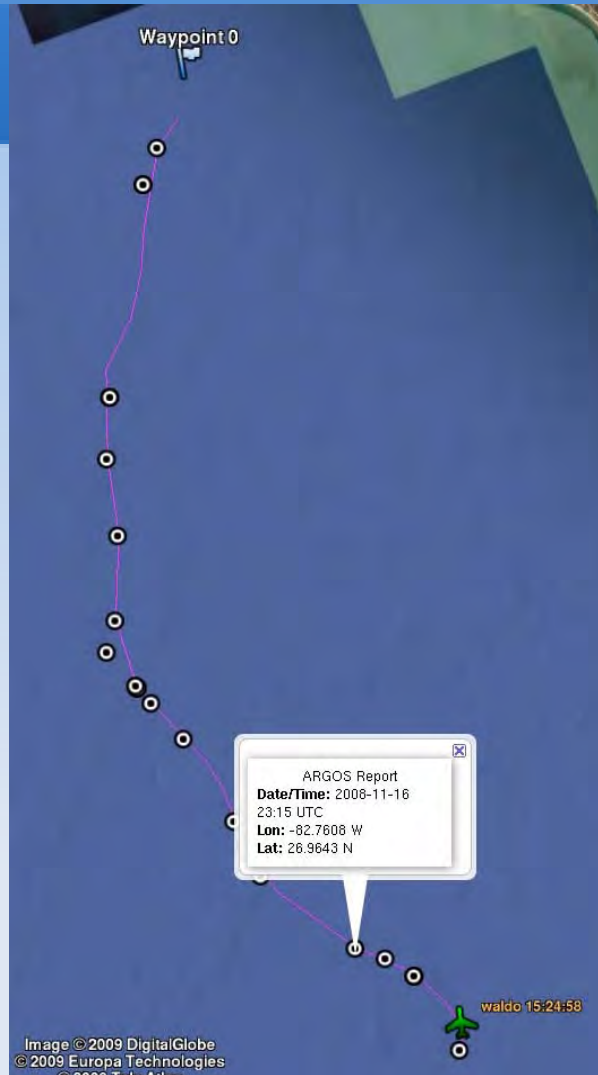
GliderTracker V3

- Written in python
- Still SQLite3 but...
- Database saved as file (persistent)
- Glider location/depth correlated with SI
- ARGOS location retrieved w/telnet library

GT v3 w/depth&SI correlation



...and ARGOS location display



GliderTracker Summary

- Great improvement over manual tracking
- Google Earth good visualization tool
- But...
- Requires lots of hands-on from sysadmin
- Not a true 'mission planning' tool
- GE not user programmable

What We Wanted

- 'Single Screen' app for glider operators
- Able to load waypoint files
- Ability to define new waypoints
- Error-checking of mission files
- Overlays of Chloro and SST
- Bottom profiles
- 'Auto deployment' of mission files

So we built COOLIO

- COOLIO: COOL Input/Output
- Browser-based
- Written in Javascript, PHP, Python, MySQL, SQLite3
- 'Web 2' AJAX application
- Google Maps provides visualization

COOLIO (Glider Mission Planner)

SO COOL Glider Mission Planner

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Map Satellite Hybrid Terrain

Map data ©2009 Tele Atlas - [Terms of Use](#)

Map data ©2009 Tele Atlas - [Terms of Use](#)

Lon: -8239.5856 Lat: 2730.9348 Status: Cleared waypoints

Gliders	Brevebusters	Overlays
<input type="checkbox"/> Waldo <i>Carmen Nemo</i>	<input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None	<input type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input type="checkbox"/> Bathymetry <input type="checkbox"/> Weather

Waypoints/MA Files

(right-click to manually create waypoint)

Clear Waypoints Load Goto Write Goto Deploy Goto

COOLIO Maps - Mozilla Firefox

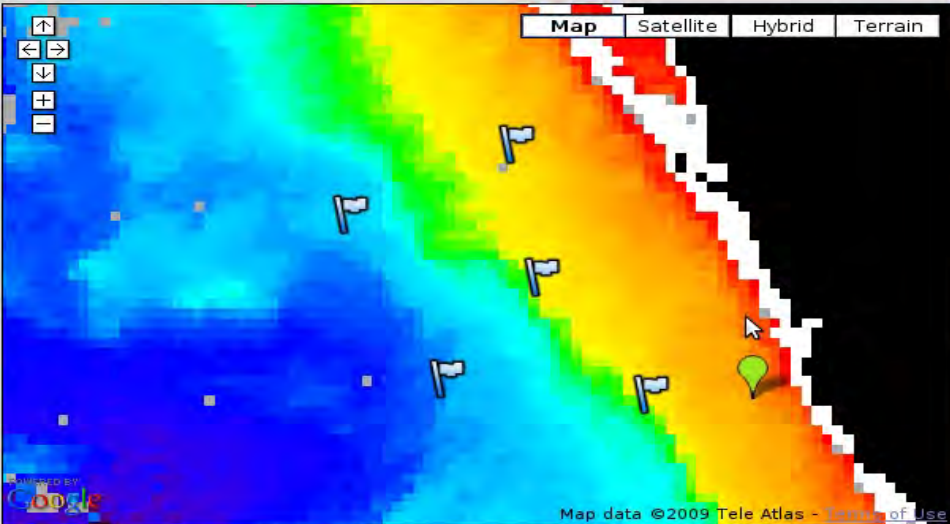
File Edit View History Bookmarks Tools Help

http://localhost/html/coolio/MA

Most Visited Getting Started Latest Headlines

SO COOL Glider Mission Planner

Map Satellite Hybrid Terrain



Map data ©2009 Tele Atlas - Terms of Use

Lon: 8230.6866 Lat: 2708.6087 Status: Loaded RedTideSurvey.ma

Gliders	Brewebusters	Overlays
<input type="checkbox"/> Waldo <input type="checkbox"/> Carmen <input type="checkbox"/> Nemo	<input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None	<input checked="" type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input type="checkbox"/> Bathymetry <input type="checkbox"/> Weather

Waypoints/MA Files

(right-click to manually create waypoint)

Clear Waypoints Load Goto Write Goto Deploy Goto

Done

COOLIO Maps - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/html/coolio/MA

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SO COOL Glider Mission Planner

Map Satellite Hybrid Terrain

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Lon: 8245.6830 Lat: 2716.6694 Status: Loaded RedTideSurvey.ma

Gliders <input type="checkbox"/> Waldo Carmen Nemo	Brevebusters <input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None	Overlays <input checked="" type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input type="checkbox"/> Bathymetry <input type="checkbox"/> Weather
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Waypoints/MA Files
(right-click to manually create waypoint)

Clear Waypoints Load Goto Write Goto Deploy Goto

Done

COOLIO Maps - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/html/coolio/MA

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Map Satellite Hybrid Terrain

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POWERED BY

Map data ©2009 Tele Atlas

Lon: 8252.9340 **Lat:** 2704.0612 **Status:** Wrote goto_l10.ma

<p style="text-align: center;">Gliders</p> <p><input type="checkbox"/> Waldo <input type="checkbox"/> Carmen <input type="checkbox"/> Nemo</p>	<p style="text-align: center;">Brevebusters</p> <p><input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None</p>	<p style="text-align: center;">Overlays</p> <p><input type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input checked="" type="checkbox"/> Bathymetry <input type="checkbox"/> Weather</p>
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Waypoints/MA Files
(right-click to manually create waypoint)

Done

COOLIO Maps - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/html/coolio/MA

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SO COOL Glider Mission Planner

Map Satellite Hybrid Terrain

Waypoint 3
Lon: 8237.0320
Lat: 2707.0320

Map data ©2009 Tele Atlas - Terms of Use

Lon: 8236.0270 Lat: 2706.9404 Status: Wrote goto_l10.ma

<p>Gliders</p> <p><input type="checkbox"/> Waldo <i>Carmen Nemo</i></p>	<p>Brevibusters</p> <p><input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None</p>	<p>Overlays</p> <p><input type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input checked="" type="checkbox"/> Bathymetry <input type="checkbox"/> Weather</p>
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Waypoints/MA Files
(right-click to manually create waypoint)

Clear Waypoints Load Goto Write Goto Deploy Goto

Done

COOLIO Maps - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/html/coolio/MAPS

Most Visited Getting Started Latest Headlines

SO COOL Glider Mission Planner

Map Satellite Hybrid Terrain

waldo

Surfaced At: 1223732526.0
 Mission: MML03
 Because: timeout expired
 Position: 8242.5340 2721.1860

Map data ©2009 Tele Atlas

Lon: 8238.8440 Lat: 2736.8954 Status:

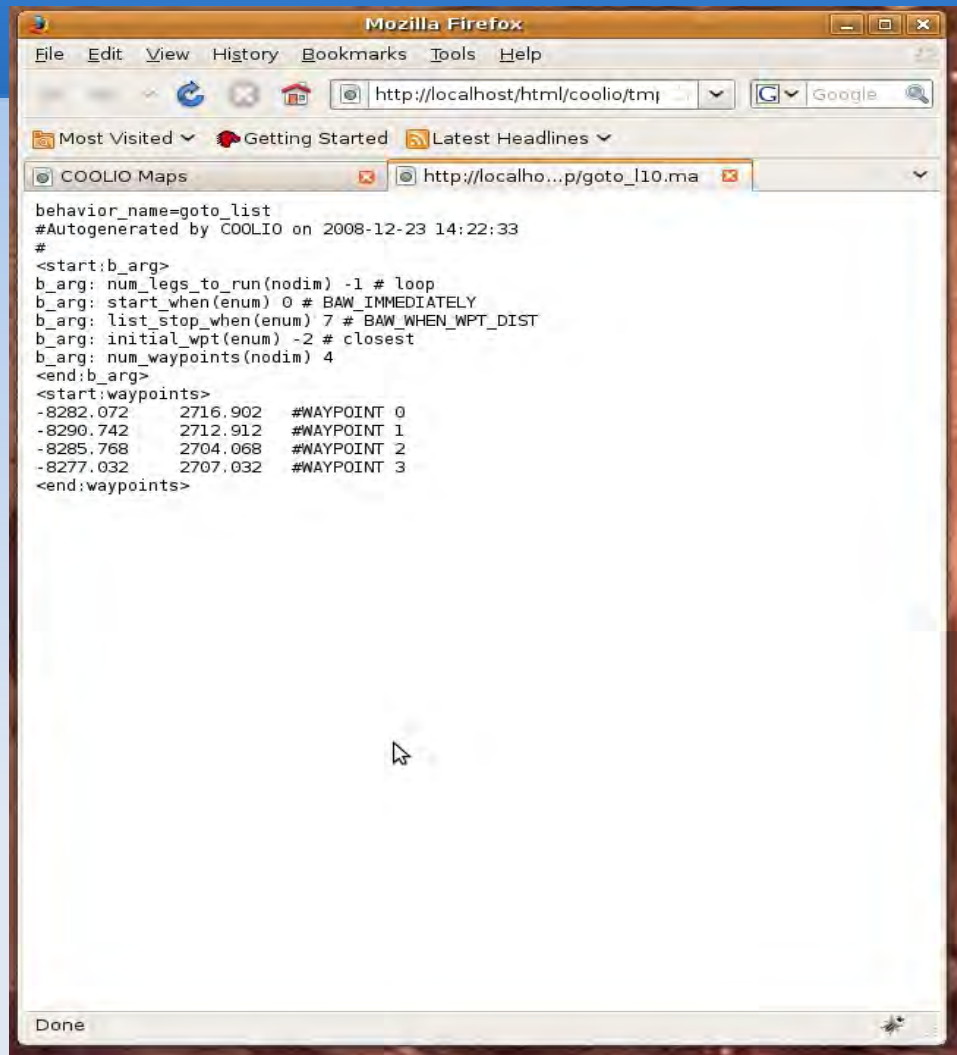
Gliders	Brevebusters	Overlays
<input checked="" type="checkbox"/> Waldo Carmen Nemo	<input checked="" type="radio"/> Active <input type="radio"/> All <input type="radio"/> None	<input type="checkbox"/> Chlor_a <input type="checkbox"/> SST <input type="checkbox"/> Bathymetry <input type="checkbox"/> Weather

Waypoints/MA Files

(right-click to manually create waypoint)

Clear Waypoints Load Goto Write Goto Deploy Goto

Done



COOLIO Architecture

- Javascript drives the browser
- PHP for server-side
- Python for server side
- Brevebuster data in MySQL DB
- Glider data in SQLite3 DB
- XmlHttpRequest and JSON
- SCP w/private key for file deployment

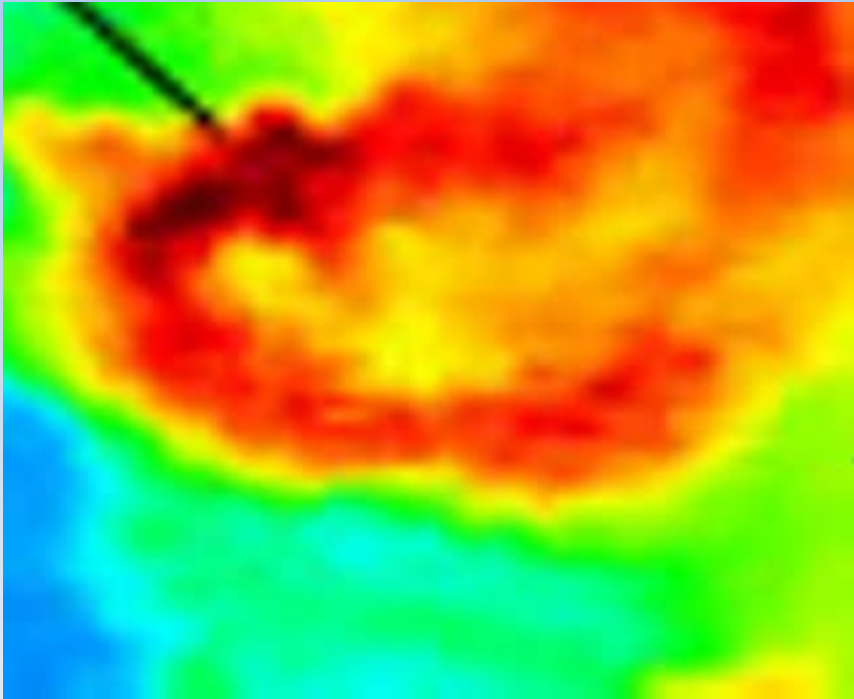
COOLIO Status

- Passed pre-deployment testing
- No active blooms
- Glider missions on hold due to budget
- Continuing development on adaptive mission planning modules
- Possible AMP testing by July 2009

Adaptive Mission Planning

- MODIS image analysis using python
- Edge-detection of blooms
- Bloom-mapping using active mission data
- New waypoints generated to fit bloom
- Goal: keep glider 'mowing the lawn'
- Goal: 'Hands-off' missions
- Will run as separate module out of 'cron'

Bloom Edge Detection in Python



Thanks

- NOAA-NOS
- START (Solutions To Avoid Red Tide)
- FWRI (Fish and Wildlife Research Institute)
- Webb Research
- Google
- All the hard-working FOSS contributors