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ChUM: Chart Update Mashup

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***Abstract*— Critical nautical chart corrections are disseminated weekly via the U.S. Coast Guard in the form of a PDF document called the "Local Notice to Mariners." Users of both paper and electronic nautical charts need to regularly apply these corrections to update their charts for safe navigation. This paper gives a detailed description of a tool, called ChUM (the Chart Update Mashup), that simplifies the process of combining nautical charts with the critical chart corrections and the U.S. Coast Pilot (an aid to navigation) using Google Maps. This geo-referenced interface simplifies finding chart corrections for a specific chart and allows for filtering and sorting the data.**

***Index Terms*—Geo-referenced data, nautical charts, Local Notice to Mariners, Google Maps, mashup, Coast Pilot.**

I. Introduction

Cruising down a river, along the coast or to a local island can be an exciting adventure but without proper preparation and an up-to-date nautical chart, it can quickly turn into a nightmare. More is at stake than just getting lost. Hitting a rock or running aground could mean damage to the boat, equipment or a person!

There are many examples of these kinds of tragedies throughout the ages due to the use of outdated nautical charts. According to the Oregon State Parks Service, the wreck of the U.S.S. *Peacock* in 1842 was due to the captain navigating with an out-of-date nautical chart that didn't show the shifting of the Columbia channel [1]. More recently, the London P & I (Protection and Indemnity) Club reported an incident involving a ship hitting a hazardous wreck. Again this was attributed to a failure to update the chart on board (a chart correction for the wreck had been announced three years earlier) [2].

To impress upon boaters the enormity of the updates that do occur between versions of charts, Jeppesen Marine hosted a contest at the 2009 Miami International Boat Show. The contest challenged people to find changes that were made between different versions of the same electronic chart. "Many boaters don't realize that things do change, so the contest is a great way to increase awareness of navigation safety issues," comments Michelle Buckalew, senior marketing manager for Jeppesen Marine [3].At least twice per year, Jeppesen Marine (an industry leader that provides innovative navigational solutions) makes thousands of changes to their database from sources such as the U.S. Coast Guard's (USCG) Local Notice to Mariners and the U.S. Army Corps of Engineers.

In 2010 NOAA (the National Oceanic and Atmospheric Administration) co-sponsored the Alliance for Safe Navigation (ASN) [4] to raise the boating community's understanding of and appreciation for up-to-date navigational information. The alliance is comprised of industry leaders that all "share a commitment to boating safety" [5]. Their website advocates public awareness of the large number of corrections made to charts and the need to keep paper and electronic charts accurate. A survey done by the ASN revealed 64% of the 7,570 people surveyed do not update their paper or electronic charts [6]. Bob Sweet, the National Education Officer of the United States Power Squadrons (USPS - the nation's largest boating education organization), stated: "Ask a recreation boater the date on his or her charts - typically their chart information is three to five years out of date" [7].

This paper will first present the current mechanisms to view chart corrections, and then discuss some of the drawbacks with them. It will then describe a solution that addresses these drawbacks and how that solution is implemented.

II. Background

A. How to get the Local Notice to Mariners

There are two different means by which the mariner can access chart updates: a text-based Portable Document File (PDF) format, called the "Local Notice to Mariners" (LNM), from the USCG Navigation Center website (http://www.navcen.uscg.gov/?pageName=lnmMain), and an online table from the Office of Coast Survey (OCS) website (http://ocsdata.ncd.noaa.gov/ntm/Default.aspx).

The USCG Navigation Center's webpage shows a map of the U.S. coastal waters divided up into nine separate districts. Each district assembles its own LNM, which are posted weekly on their website. Clicking on a district in the map displays a list of all the notices posted in that calendar year. At the end of each year, the notices are archived as a Zip file (which can range anywhere from 12 – 98 megabytes depending on the district) and are listed on the archive page.

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SECTION IV - CHART CORRECTIONS

This section contains corrections to federally and privately maintained Aids to Navigation, as well as NOS corrections.

12324 **35th Ed.** **01-MAR-12** **Last LNM: 17/12** **NAD 83** **21/12**

ChartTitle: **Intracoastal Waterway Sandy Hook to Little Egg Harbor**

Main Panel 683 SANDY HOOK TO LITTLE EGG HARBOR NEW JERSEY. Page/Side: A

CHANGE	Depth Legend - New York Harbor to:; 30 FT JAN 2012 (NOS NW-21719)	NOS 40-28-47.500N	074-03-06.500W

12327 **105th Ed.** **01-APR-12** **Last LNM: 19/12** **NAD 83** **21/12**

ChartTitle: **New York Harbor**

Main Panel 2245 NEW YORK HARBOR. Page/Side: N/A

CHANGE	Depth Legend - New York Harbor to:; 30 FT JAN 2012 (NOS NW-21719)	NOS 40-28-47.500N	074-03-06.500W
CHANGE	Tabulation - ARTHUR KILL, KILL VAN KULL, NEWARK BAY, PORT NEWARK & PORT ELIZABETH CHANNEL DEPTHS http://ocsdata.ncd.noaa.gov/ntm/SupportImage.aspx?ItemID=219052 ; Tabulation - ARTHUR KILL, KILL VAN KULL, NEWARK BAY, PORT NEWARK & PORT ELIZABETH CHANNEL DEPTHS (NOS NW-21699)	NOS 40-40-20.000N	074-15-17.000W
CHANGE	Tabulation - LOWER BAY, CHAPEL HILL, RARITAN BAY AND RIVER CHANNEL DEPTHS http://ocsdata.ncd.noaa.gov/ntm/SupportImage.aspx?ItemID=219051 ; Tabulation - LOWER BAY, CHAPEL HILL, RARITAN BAY AND RIVER	NOS 40-37-58.000N	074-15-23.000W

Fig. 1. Existing access method 1: Local Notice to Mariners – Chart Corrections Section

The weekly PDF files (typically 1-1.5 megabytes) contain all of the chart changes (Section 4 of the LNM) and other notices to the mariner that are in effect for the selected district. The section listing changes to the chart is set up as a tab-delimited table (see Fig. 1). The tables contain the following information: Chart Number, Chart Edition, Last Local Notice to Mariner, Horizontal Datum Reference, Source of Correction, Current Local Notice to Mariners, Chart Title, Aid Number/Name, Action, Description, Latitude and Longitude.

The second way a mariner can readily access updates is through NOAA's Office of Coast Survey (OCS). OCS disseminates a subset of the LNMs (Section 4 - the critical chart corrections) contained within an HTML table. However, to get to the table of corrections, a chart number needs to be entered. If the chart number is not known, there is also an option to click the "Paper/RNC Catalog" link to view the Interactive Catalog web page to search for a chart.

The Interactive Catalog shows a Google Map with polygons, depicting chart outlines, overlaid on it. The chart must be clicked and a polygon highlighted for chart numbers to show up in the side bar to the right. A link on the right labeled "Notice Listing" will then open a web page with a table view (see Fig. 2) of the critical corrections for that chart (web address for the example chart selected: http://ocsdata.ncd.noaa.gov/ntm/resultList.aspx?Chart=13285)

The webpage for this table version of the data also includes a way to view historical data; which is considerably easier than downloading and unzipping the archived files and then searching each PDF to find specific changes to a given chart – which must be done on the USCG Navigation Center site.

Chart: 13285, Current Edition: 11, Print Date: Jul. /2005
Portsmouth to Dover and Exeter

Download RNC
View Chart Image
Paper/RNC Catalog

Action	Item Name	Charting Label	Latitude	Longitude	Published Document	Kapp	RNC Panel	RNC Posted
Add	Sounding in Feet	31	N 43° 06' 43.700"	W 070° 48' 03.900"	LNM 46/11, 1st Dist	2060	13285_1	11/10/2011
Delete	Sounding in Feet	31	N 43° 06' 44.600"	W 070° 48' 04.200"	LNM 46/11, 1st Dist	2060	13285_1	11/10/2011
Add	Depth Legend - Portsmouth Harbor Turning Basin to:	34 FT MAR 2011	N 43° 07' 06.600"	W 070° 48' 36.000"	LNM 46/11, 1st Dist	2060	13285_1	11/10/2011
Add	Channel reach separator PT	(solid magenta line)	N 43° 06' 55.200"	W 070° 48' 29.200"	LNM 46/11, 1st Dist	2060	13285_1	11/10/2011

Fig. 2. Existing access method 2: OCS table of critical chart corrections

B. The Coast Pilot

The changes that affect the nautical charts also affect the U.S. Coast Pilot. For example, if a navigation aid name or position changes, any mention of that aid in the Coast Pilot needs to be updated too. The Coast Pilot is a supplement to the nautical chart that aids in safe navigation. It contains detailed information in it that is difficult to represent on a chart such as winds and currents, port facilities, and pilotage services. The OCS website for the Coast Pilot (http://www.nauticalcharts.noaa.gov/nsd/cpdownload.htm) disseminates the document in three formats: a PDF, HTML, and an XML version. Though the focus of the project is the LNM, the Coast Pilot was integrated into it as a proof-of-concept to demonstrate the ease of incorporating related data.

III. Issues

While the PDF LNM updates, the OCS online tables, and the Coast Pilot all provide essential information to the mariner, they can be cumbersome to use. This difficulty in use could be a contributing factor to a survey regarding LNM use conducted in 2011 by the ASN. The survey of boaters showed that 70 percent of respondents said though they were aware of LNMs they didn't obtain them [8].

The PDF version of the LNM chart correction section is more difficult to read than the OCS table view of the same information. Since the OCS table allows for filtering on a specific chart and viewing historical data, it greatly reduces the overload of information shown. But, there is no context for the information. Each item in the table is geo-referenced, which means that displaying it within the context of a nautical chart is the more intuitive way to present it. Currently, if a mariner wants to see chart changes for a specific location, he would need to plot each one on a nautical chart with a ruler and pencil- which can be time consuming.

The drawback with both the PDF and the table version of the chart corrections is that the user cannot interact with them. It is not possible to filter corrections based on such useful items as aid name, characteristic, action, or even geographic location.

Another issue with the OCS table view of this data is, it becomes cumbersome when a chart number isn't known- forcing the user to revisit the chart catalog to find the chart number. Using the online chart viewer to help in this task is just as awkward. The viewing area for the chart is small, it is not geo-referenced, and it can be panned or zoomed too much- which can result in "losing" the chart off the screen.

The Coast Pilot has its own set of issues. One in particular is that the XML version contains many geo-referenced bits of data that have no geo-referencing information in the XML markup.

Combining these tools into one interface (a one-stop shop) would make this data more accessible. Making the data more interactive would help the boating community with updating charts and with deciding when to buy new charts by helping them quickly visualize changes to the chart. It could also benefit the entities compiling the data as a quality assurance tool.

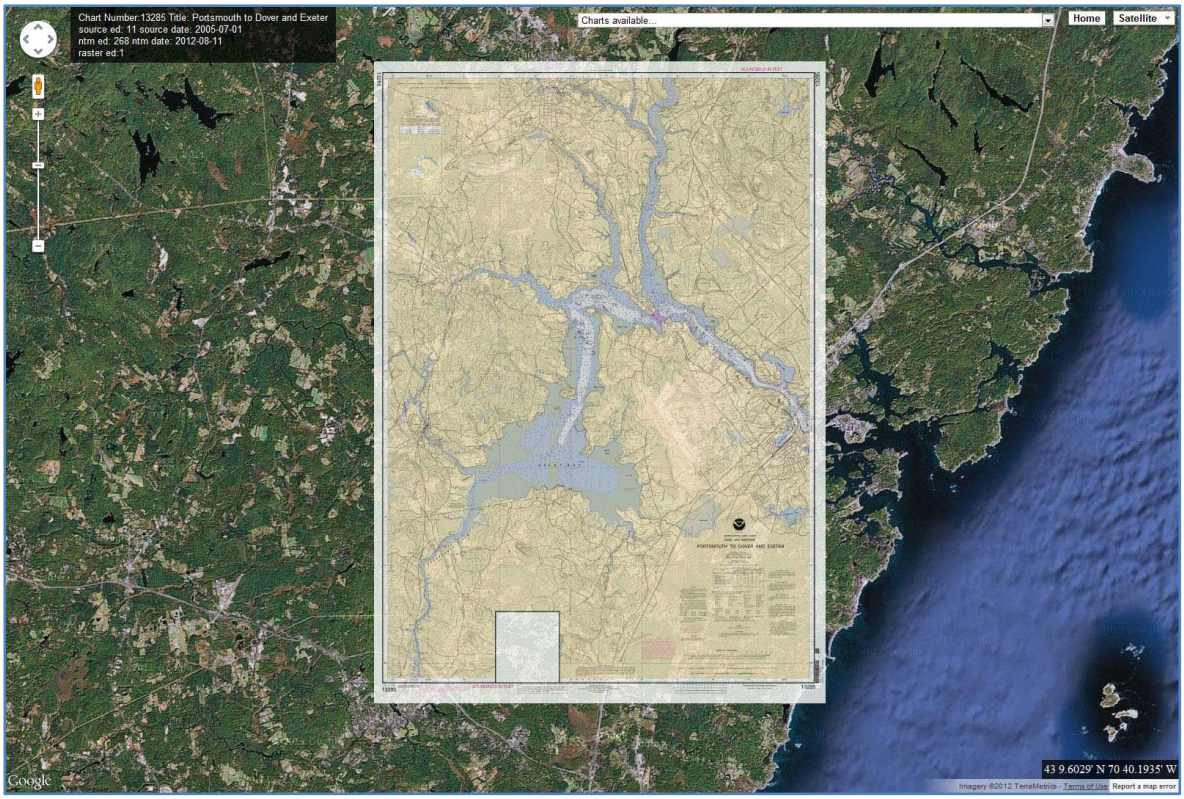

Fig. 3. The Nautical Charts APIUI

IV. METHODOLOGY

In an attempt to solve these problems ChUM was developed. ChUM stands for Chart Update Mashup and is a Google Maps mashup (a small, specialized application). ChUM was created to effectively display the chart catalog and nautical charts in a geo-referenced environment, along with the critical corrections to the chart and the Coast Pilot with geo-referenced links. ChUM is a web application "that uses and combines data, presentation or functionality from two or more sources to create a new service" [9] The elements used for this web app are: Google style controls, the Nautical Charts API, Google Maps API v3 and the Nautical Charts APIUI. The author integrated each element to work in conjunction with the other and are described in their own section below; starting with a custom control within the Google Map environment.

A. Google Style Controls

According to Jakob Nielsen (one of the world's foremost experts in Web usability), "Consistency is one of the most powerful usability principles" [10]. This project uses the Google Map API for its geo-referenced environment and for its familiar controls that are built-in: namely, the panning, zooming, markers/info boxes and various background-overlay options.

Since there is a Google Map drop-down box that allows the user to change the type of map that is displayed in the background, it was necessary to create a similar drop-down box that would hold options relating to the charts (and also make buttons that would reflect the same style). A generic drop-down box and buttons were created as a standalone project [11]- so they could be used again for other Google Map related projects. Each item is a JavaScript object that can be reused: button, checkbox, and a separator. Specifically for ChUM, a date input was added as a feature to query LNM historical data.

The Google style drop-down box is populated with a button, checkboxes and a date input box that make it possible to: set a location bookmark (the Home button) that saves a place in the map, view/hide the Coast Pilot, view/hide chart outlines (to visualize the chart boundaries- from the chart catalog), view/hide the chart metadata, view/hide chart corrections, view/hide the Corrections Table, and search the LNMs by date (to view historical data).

B. Nautical Charts API

Before changes to a chart can be viewed in context, there needs to be a chart. Knowing that the task of generating the chart tiles to be displayed in Google Maps would not be trivial, an online search was done to see if this work had already been done. The Nautical Charts API from the University of California, San Diego (UCSD) came up in the search results.

Paul Reuter of UCSD began development of a chart tile server in July 2008. Each night, the chart server acquires the NOAA RNC (Raster Nautical Charts) product catalog [12] and checks for changes. Any charts that have been modified are subsequently downloaded, tiled, and then added to a database. Static JSON data (a lightweight data-interchange format [13]) is then generated and pushed to the UCSD web servers. Eventually, an API (Application Programming Interface - the Nautical Charts API [14]) was built around the chart server so UCSD could use it on multiple domains.

The Nautical Charts API (NCAPI) is the foundation of this project. Since this project is a prototype, showing what is possible, the use of this preexisting API dramatically sped up the initial development time. However, after the author fully implemented the API, it appeared to load a bit slow. This API originally supported Google Maps version 2, however, version 2 was not mobile ready, which meant it was big and slow.

C. Google Maps

The final effort in integrating the NCAPI was to upgrade the version of Google Maps that UCSD was using. In 2009, Google released version 3 of its Map API. The blog announcing its release explains why the upgrade was necessary, “The primary motivation behind this new version was speed, especially for rendering maps on mobile browsers” [15]. This was the upgrade that the NCAPI needed, and so it was the author's next coding effort. UCSD used this new code to upgrade their servers as well. This upgrade sped up the online performance as well as laid the foundation for a mobile version of ChUM.

D. Nautical Charts APIUI

In an effort to make this project useful beyond its current goal of displaying LNM information, an API was created for the User Interface (UI) to the NCAPI (the NCAPIUI [16]). Enabling programmers/scientists who wish to integrate nautical charts into their own project to do so with a few lines of code. The NCAPIUI allows for quick and customized setup of the charts and the desired chart controls. Using JavaScript and the jQuery library, various features were added on top of the NCAPI that made it possible to: display the chart catalog, select/view specific charts (in a drop-down box), filter the charts depending on the viewport, see the latitude and longitude values for the cursor position, set the transparency of the chart image, do a Google search for place names, and set a home button (acts as a location bookmark – see Fig. 3).

V. THE LOCAL NOTICE TO MARINERS MASHUP

The NCAPIUI, enabled the creation of the Google Maps mashup, ChUM, that displays the LNM data from the OCS website (the critical chart corrections). Since this is so specialized, parts of the NCAPIUI needed to be altered to accommodate specific requests for data and displaying that data. The next few sections discuss: How the Google Map markers are used to display the chart updates, the integration and use of a plug-in called DataTables, the cross-coupling of the data table with the markers, and how the Coast Pilot was integrated.

A. Displaying the LNM Data

The NCAPI brought the nautical chart into a geo-referenced environment, laying the foundation for displaying the LNM Data. Using the Google Maps API makes it relatively easy to place geo-referenced objects as markers on the map. The most important part to generating markers in a Google Map is to have latitude and a longitude position, which can be extracted from the text output of the OCS server query: http://ocsdata.ncd.noaa.gov/ntm/Listing_Text.aspx?Chart=13282&DateSince=. This query is called each time a new chart is selected or when the LNM date changes. An example for the date input query in the custom control (see the section "**Error! Reference source not found.**") can be found at the following link: http://ocsdata.ncd.noaa.gov/ntm/Listing_Text.aspx?Chart=13282&DateSince=20000101.

The text returned from this query is then parsed with PHP (a server-side scripting language) and encoded as JSON data. The JSON data is what populates the Corrections Table, and the content of the Corrections Table is what drives the creation and display of the markers on the Google Map.

B. DataTables

The table that displays the LNM critical chart corrections on the OCS website needed some improvements: sorting columns, filtering data, highlighting the selected row, and triggering responses when the user hovers over a row or clicks on a cell. The Corrections Table uses DataTables for that improvement. DataTables [17], a plug-in for the jQuery JavaScript library, had all of the features and more that were needed to effectively show and interact with the data. Once DataTables was set up and integrated into the NCAPIUI (seeFig. 4, box 3), it was used to generate all the markers representing each chart correction.

The table also displays the total count of items in the table as well as the filtered count for easy reference - helping with data quality assurance.

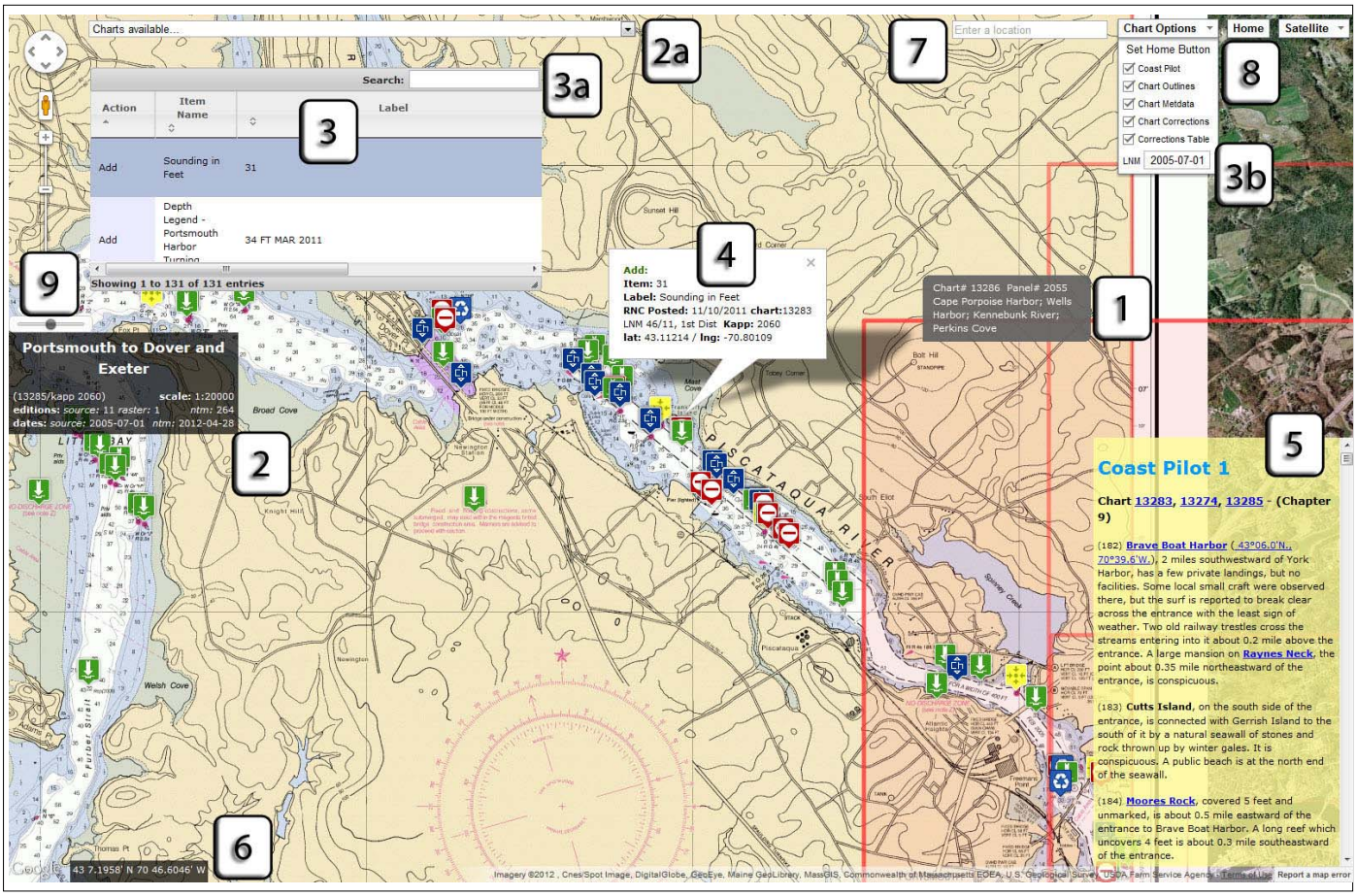

Fig. 4. ChUM - The Google Maps mashup for the Local Notice to Mariners

C. The Markers

Cross-coupling the data table with the markers makes it possible to support actions on the table resulting in actions with the markers- highlighting, clicking, and filtering. Highlighting a row in the table makes the associated marker "bounce" in place (which helps to draw attention to the selected marker in the midst of many other markers). Clicking on a cell in the table zooms to and centers the marker in the screen. When the table is filtered the markers are filtered as well. So, for example, if the filter "Add" is applied to the table search box, then only the items with "Add" in one of the fields is visible, likewise, the markers on the chart with the "Add" symbol will be shown.

The Markers are color-coded so they can easily be identified: red is for a deleted marker, green is for an added marker, yellow is for a relocated marker, blue is for a textual change to a marker. The markers also have symbols that help to clarify their meaning. An info box is displayed when a marker is clicked which shows all the details associated with that marker (see Fig. 4, box 4).

D. The Coast Pilot

ChUM can also display the U.S. Coast Pilot for the chart selected in the chart drop-down box (see Fig. 4, box 5 and 2a, respectively), with geo-referenced links to latitude/longitude locations for effortlessly finding points of interest on the chart.

Instead of using the XML version of the Coast Pilot on the OCS website, the Coast Pilot data comes from the OCS U.S. Coast Pilot Search tool (found at: http://www.nauticalcharts.noaa.gov/nsd/cpsearch.php); this allows for retrieving HTML text related to a specific chart. The text is then processed using PHP, and items in "bold" style tags are sent to the Google Geocoding service. A successful return from the service yields a latitude/longitude position that is used to make a geo-referenced link in the Coast Pilot text displayed. This vastly differs from the current way to find positions and features in the Coast Pilot- plotting the latitude/longitude position on a map each time one is encountered in the text and trying to visually search all the text in the chart for a specific place name (especially when in unfamiliar territory).

VI. Conclusion

ChUM has successfully demonstrated how to integrate the NOAA nautical charts, the NOAA chart catalog, critical chart corrections from the LNM and the Coast Pilot in a geo-referenced web-based environment. Here is an overview of all the features it offers (see Fig. 4, the outline numbers correspond to the numbers in the figure.):

1. Integrates NOAA chart catalogs
2. Integrates NOAA nautical charts
    a. Ability to filter charts depending on viewport
3. Integrates critical chart corrections from OCS as a dynamic/interactive table
    a. With the ability to filter data
    b. With the ability to view historical data
4. Integrates critical chart corrections as geo-referenced markers within the context of a nautical chart
5. Integrates Coast Pilot w/Geo-coded places
6. Geo-referenced environment
7. Ability to search place names
8. Ability to save a location bookmark
9. Ability to set the chart transparency

ChUM can assist with quality assurance and quality control for OCS/USCG internal use as well as help to raise awareness of the numerous changes made to a nautical chart- helping the mariner to effortlessly visualize corrections with an intuitive interface in a web-based geo-referenced environment.

This tool is publicly accessible at: http://vislab-ccom.unh.edu/~briana/ncapiui-v2/. Due to the proof-of-concept nature of this project it has only been tested in the Chrome web-browser. Unexpected results may occur with another browser, especially on a mobile platform.

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