Vessel Traffic Analysis in the Carquinez Strait

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Density Map by AIS
Marine Traffic in California
History of strong passing vessel incidents in the area

Documented interaction (Jan. 2012)

- The interaction occurred when a vessel was transiting Pittsburg to sea (...).
- On the passing of that vessel, a moored vessel experienced a sudden surge, which pulled the ship off the dock approximately four feet, moved her seven feet fore and aft, and separated three mooring pendants.
- The estimated distance between the two ships was approximately 150 feet.
Assessing Passing Vessel Loads

Need

Simplified methods
PASS-MOOR (Kriebel & Seelig, 2005)

Numerical methods
OPTIMOOR passing vessel load module

VH-LU (S. Fenical et al.)

DELPASS (Pinkster and Marin)

Hydrodynamic codes with moving boundary

Sample data showing typical measured force and moment records along with low pass filtering. From TR-6056-OCN by Kriebel (2005)
Dynamic mooring loads and motions

Dynamic mooring model (OPTIMOOR, aNyMOOR.TERMSIM and .DYNFLOAT, etc.)

Informed time-based passing vessel history using model

Meteocean parameters (waves, tides, currents, winds, etc.)

Vessel properties (hydrodynamic coefficients from AQWA, WAMIT, etc.) and mooring configuration

Need

Work Flow
Objectives and Methods

› Motivations
   › Inform design of new MOT in the San Francisco North Bay
   › History of passing vessel loads with documented incidents in that region

› Model Selected
   › PASS-MOOR by Kriebel (per MOTEMS requirements)

› Needs
   › Dimensions of likely vessel
   › Measured distance from MOT
   › Draft conditions
   › Other traffic data

› Methods
   › AIS data provided by the Marine Cadastre by NOAA
   › Use scripting tools and ArcGIS to extract data
Introduction

The NOAA Marine Cadastre

› MarineCadastre.gov
  › Partnership between NOAA Coastal Services Center and DOI Bureau of Ocean Energy Management (BOEM)

› Coverage
  › 48 states
  › All types of vessels equipped with AIS
  › Some data restricted by USCG

› Data
  › 1-minute Automated Information System (AIS)
  › Curated and hosted by the National Ocean Service (NOS), Coastal Services Center (CSC)
### Keys and Fields

#### Broadcast
- OBJECTID
- SOG
- COG
- Heading
- ROT
- BaseDateTime
- Status
- VoyageID
- MMSI
- X_Long and Y_Lat
- ReceiverType
- ReceiverID

#### Ship
- OBJECTID
- Status
- VoyageID
- MMSI
- X_Long and Y_Lat

#### Vessel
- OBJECTID
- MMSI
- IMO
- CallSign
- Name
- VesselType
- Length
- Width
- DimensionComponents

#### Voyage
- OBJECTID
- VoyageID
- Destination
- Cargo
- Draught
- ETA
- StartTime
- EndTime
- MMSI
Data Structure

- **Availability**
  - 2009, 2010 and 2011 available online
  - Provided as GIS database

- **Length and depth**
  - One dataset per month (20M points)
  - One year record: complete 2010 dataset comprises over 200M AIS points.

- **Attributes**
  - The database maintained by the MMC features unit/attribute pairs
  - UTM Zone 10, and spans the entire calendar year of 2010
  - Time is provided in the Coordinated Universal Time (UTC) 24-hour format ("1600Z" is 0700a UTC-0800 (PDT)).

- **Restrictions**
  - MMSI (Maritime Mobile Service Identity) field has been encrypted for the 2010 and 2011 data at the request of the U.S. Coast Guard.
# Standard Vessel Types

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>Not Available</td>
<td>51-51</td>
<td>Search and rescue vessels</td>
</tr>
<tr>
<td>10-19</td>
<td>Reserved for future use</td>
<td>52-52</td>
<td>Tugs</td>
</tr>
<tr>
<td>20-20</td>
<td>WIG</td>
<td>53-53</td>
<td>Port tenders</td>
</tr>
<tr>
<td>30-30</td>
<td>Fishing</td>
<td>54-54</td>
<td>Vessel with anti-pollution facilities or equipment</td>
</tr>
<tr>
<td>31-31</td>
<td>Towing</td>
<td>55-55</td>
<td>Law enforcement vessel</td>
</tr>
<tr>
<td>32-32</td>
<td>Towing and length of the tow exceeds 200m or breadth exceeds 25m</td>
<td>56-57</td>
<td>Spare for assignments to local vessel</td>
</tr>
<tr>
<td>33-33</td>
<td>Engaged in dredging or underwater operations</td>
<td>58-58</td>
<td>Medical Transport</td>
</tr>
<tr>
<td>34-34</td>
<td>Engaged in diving operations</td>
<td>60-69</td>
<td>Passenger ships</td>
</tr>
<tr>
<td>35-35</td>
<td>Engaged in military operations</td>
<td>70-79</td>
<td>Cargo ships</td>
</tr>
<tr>
<td>36-36</td>
<td>Sailing</td>
<td>80-89</td>
<td>Tankers</td>
</tr>
<tr>
<td>37-37</td>
<td>Pleasure craft</td>
<td>90-99</td>
<td>Other types of ship</td>
</tr>
<tr>
<td>38-38</td>
<td>Reserved for future use</td>
<td>140-140</td>
<td>Reserved for regional use</td>
</tr>
<tr>
<td>40-49</td>
<td>HSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-50</td>
<td>Pilot vessel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Implementation

Restrict Geographical Area of Interest

ArcGIS

Data points
Implementation

**Work flow**

- From 200M points to a manageable list of events
- Filter by relevance
  - Distance to MOT
  - Within specified time-window
- Tools
  - AIS database handled in ESRI ArcGIS
  - SQL queries designed to extract data points based on select criteria
  - Some scripting (repeatable in MatLab, Mathematica, Python, R, etc.) necessary
Data Analysis

Vessel Types and Frequency Analysis

![Bar Chart showing vessel types and frequency]

- **Towing 200m+ 25m+**: 3
- **Not Available**: 3
- **Passenger ships**: 1
- **Tugs**: 12
- **Cargo ships**: 11
- **Towing**: 7
- **Other types of ship**: 3
- **Tankers**: 15

Jun. 2010
Ship count: 55
Voyages: 105
Data Analysis

First Pass Filtering: Size
Data Analysis

Second Pass Filtering: Proximity

[Image: Diagram showing geographical data analysis with markers for Jun. 2010 and selected 28 points. The diagram includes markers for Proximity zone (PZ), Terminal, and Trajectories.]
Data Analysis

Preliminary Event List

› Criterion
  › Enforce a **time constraint** in order to discard any vessel passing event occurring while no vessel is moored at the MOT

› Additional steps
  › Determine the minimum distance at which a passing vessel comes during each selected voyage
  › Extract speed when the minimum distance is achieved.

<table>
<thead>
<tr>
<th>Speed [knot]</th>
<th>Distance [ft]</th>
<th>Heading [deg]</th>
<th>Length [m]</th>
<th>Beam [m]</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>777.923</td>
<td>65</td>
<td>183</td>
<td>27</td>
<td>Tankers</td>
</tr>
<tr>
<td>9</td>
<td>574.483</td>
<td>241</td>
<td>171</td>
<td>27</td>
<td>Cargo ships</td>
</tr>
<tr>
<td>6</td>
<td>482.607</td>
<td>245</td>
<td>179</td>
<td>32</td>
<td>Cargo ships</td>
</tr>
<tr>
<td>4</td>
<td>457.003</td>
<td>67</td>
<td>209</td>
<td>32</td>
<td>Cargo ships</td>
</tr>
<tr>
<td>8</td>
<td>428.595</td>
<td>64</td>
<td>154</td>
<td>26</td>
<td>Cargo ships</td>
</tr>
<tr>
<td>5</td>
<td>412.954</td>
<td>68</td>
<td>184</td>
<td>22</td>
<td>Tankers</td>
</tr>
<tr>
<td>5</td>
<td>409.737</td>
<td>246</td>
<td>154</td>
<td>26</td>
<td>Other types of ship</td>
</tr>
<tr>
<td>4</td>
<td>384.658</td>
<td>63</td>
<td>183</td>
<td>32</td>
<td>Tankers</td>
</tr>
</tbody>
</table>
Data Analysis

Monthly Design Events

› Illustration
  › Final passing vessel dataset for June 2010
  › Each dot is sized according to the dimensions of the passing vessel. Panamax vessels, with a beam of 32 m, are highlighted in red.

› Time-based filtering
  › **Top figure** Passing events occurring regardless of moored vessel conditions at the Plains terminal
  › **Bottom figure** Passing events screened to match moored vessel conditions
Data Analysis

Annual List of Event

<table>
<thead>
<tr>
<th>Yearly dataset characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of record</td>
<td>2010</td>
</tr>
<tr>
<td>Length of record</td>
<td>69</td>
</tr>
<tr>
<td>Large vessels</td>
<td>69</td>
</tr>
<tr>
<td>Panamax+</td>
<td>22</td>
</tr>
</tbody>
</table>
Data Analysis

Joint Probability Distribution

- Joint probability distribution for speed and separation.
  - Speed [knot]: 3.5, 4.5, 5.5, 6.5, 7.5, 8.5, 9.5, 10.5, 11.5
  - Separation [ft]: 375, 425, 475, 525, 575, 625, 675, 725, 775, 825
  - Frequency counts shown for each combination.
AIS Data a Key Component for Passing Vessel Analysis

- **Portable**
  - Straightforward GIS format
  - Exported data may be re-used for future risk analysis

- **Scalable**
  - Scalable from small to medium sized projects
  - Good geographical coverage and point density

- **Comprehensive**
  - AIS a powerful tool for ocean management
  - Provides realistic design events for passing vessel load assessments

- **Useful**
  - Allows for a well-informed implementation of passing vessel load model and subsequent dynamic mooring analysis