Vessel Encounter Module

Modeling Team
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Today’s outline

1 Background
2 Movement Module Update
3 Encounter Module Review
4 Encounter Module Selection Process and Next Steps
5 Questions and Comments
Today’s discussion topics

- Current status of our work on the Vessel Movement Module
- Current status of our work on the Vessel Encounter Module
- Next steps for the Vessel Encounter Module

Legislative background

- ESHB 1578 was passed in 2019 to reduce the risk of oil spills, and protect Southern Resident Killer Whales
- Ecology's Spills Program tasked to undertake or assist with multiple policy initiatives in the bill, including the development of an oil spill risk model
Modeling Approach

Vessel Movement Module
- Vessels move in the system according to their empirical distribution

Encounter Module
- Measures and evaluates relationship of each vessel to the shore and other vessels

Accident Module
- Evaluates situations for their potential to lead to accidents

Oil Outflow Module
- Estimates the size of oil spills that result from accidents

Purpose:
- Simulate vessel activity and potential changes in traffic volume with AIS driven model
Vessel Movement Module Review

- Identify vessel tracks
- Collect tracks into routes
- Statistical analysis of factors that could affect vessel distribution on tracks
- Simulate vessels on tracks based on distribution
- Simulate additional rules and non route based vessels

Vessel Movement Module: Components

- Geographic Area
- Track Selection Factors
- AIS Messages
- External Rules
- Track Identification
- Dependent Vessels
- Route Identification
- Non-AIS Vessels
Vessel Journey and Journey Network

Vessel Journey starts when a vessel enters the system, and ends upon departure.

Vessel Journey Network is a collection of linked route segments.

Time at anchor or facility is incorporated as a unique part of vessel journey.

Identify Route Waypoints

Waypoints are intersection lines along a route.

These intersection lines are now included in our list of origins and destinations.
Simulating Vessel Movements

Small test case based on one month of tanker movements

Vessels enter the simulation based on the distribution in the test data

Vessels select their next waypoint based on distribution of waypoint selection in the test data

“Look Back” for Next Waypoint Selection

Actual vessel movements include repetition

Vessels select their next waypoint based on distribution of waypoint selection in the test data – based on previous two or more waypoints visited
Location Within an Anchorage Area

Many anchorages in US waters have a capacity for more than one vessel.

We break down anchorages into subsections based on VTS reported capacity.

Simulated vessels select anchorage subsection based on distribution in the data.

Time at Anchor and Location While Anchored

Vessels select anchorage duration based on distribution in the data.

We will not be representing vessel swing while at anchor.

Vessel location data while at anchor will be based on the last point of their arrival track.
Movement Module: Next Steps

Near Term:
- Review and validation of vessel routes
- Adding more vessel data to our test set
- Continued testing of simulation algorithm

Longer Term:
- Non-AIS based vessels (sport fishing, whale watching, tribal fishing)
- Dependent vessels (pilot boats, escort and assist tugs)
- Module Description Document

Vessel Encounter Module

Purpose:
- To identify if a vessel or obstacle is nearby enough to represent the possibility of a collision or a powered grounding
Modeling Approach

- **Vessel Movement Module**: Vessels move in the system according to their empirical distribution.
- **Encounter Module**: Measures and evaluates relationship of each vessel to the shore and other vessels.
- **Accident Module**: Evaluates situations for their potential to lead to accidents.
- **Oil Outflow Module**: Estimates the size of oil spills that result from accidents.

Role of the Encounter Module

**Identify locations and potentialities of collisions**
- A collision requires at least two vessels
- Excludes from accident calculation areas and moments where collisions can’t occur

**Identify locations and potentialities of powered groundings**
- A powered grounding requires a shoreline or underwater hazard
- Excludes from accident calculation areas and moments where collisions can’t occur
Selecting an Encounter Model

Defining an encounter
• The simultaneous presence of a vessel and an obstacle in a finite area (Goerlandt et al. 2015)

How nearby is nearby enough
• No consensus on proximity measure and threshold

Many models
• Closest Point of Approach
• Ship Domain

Selecting an Encounter Model

Selection criteria
• Appropriate for restricted waters, a variety of vessels, and simulated data
• Computational efficiency

Selection process
• Select candidates
• Test and compare
A Ship Domain Based Approach

**Definition of Ship Domain**
- Area around the ship that should be free of other vessels or fixed objects

**Suitability of Ship Domain Approach**
- Relative ship domains are a function of the dimensions of the vessel
- Better suited for restricted waters
- Can incorporate speed
- Does not require detailed maneuvering data
Different Types of Ship Domains

**Empirical**
- Based on AIS data and representing area kept clear by actual navigators

**Analytical**
- Based on the properties of the ships, including size and maneuverability

**Knowledge-Based**
- Based on expert opinion, survey, or simulations

Hansen et al. (2013).

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Two Analytical Ship Domain Options

**Quaternion Ship Domain (QSD)**
(Wang 2010)

**Pentagonal QSD (Bakdi 2019)**
Variables for QSD and Pentagonal QSD

**Ship Characteristics**
- Length
- Beam
- Speed

**Calculated Maneuverability Data**
- Advance
- Tactical Diameter

Strengths and Challenges for QSD and Pentagonal QSD

**Strengths**
- Suitable for restricted waters
- Includes vessel maneuverability
- Well specified
- Computationally efficient
- Used in a number of recent papers

**Challenges**
- Maneuverability data points based on formula
- No discussion of towing vessels
- No discussion of smaller vessels
Encounter Criteria

- Vessel Enters Domain of Another Vessel
- Vessel Domain Overlaps Another Vessel Domain

Inputs and Outputs

Vessel Movement Module
- Vessel details
- Locations/times
- Speed and course

Encounter Criteria
- Vessel details
- Locations and times
- Course

Encounter Analysis
- Location
- Type

Accident Module
Outflow Module
Areas for Further Discussion

**Intentional Encounters**
- Escort and Assist Tugs, Crew/Pilot Boats
- Bunkering

**Tugs Towing Astern**
- Length of tow/length of barge

**Ship Domains for Small Vessels**
- Formula is derived from large vessel data

**Grounding Encounters**
- Representing the possibility of a collision or a powered grounding

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**Encounter Module: Next Steps**

**Near Term:**
- Test Four Approaches (2 Ship Domains and 2 Sets of Criteria)

**Longer Term:**
- Validate encounter model results for simulated data against AIS data
Webinars and Technical Discussions

- **Vessel Movement Module**
- **Vessel Encounter Module**
- **Vessel Accident Module**
- **Oil Outflow Module**

**Upcoming events**

- **March 17th, 2021** -- 1 pm to 3 pm
  - Technical Discussion: Ship domain examples

- **March 23rd, 2021** -- 1 pm to 3 pm
  - Vessel Encounter Module Updates and Follow Up
Discussion logistics

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References


