Model 101: A Review of Model Structure

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Model Development Team

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Today’s outline

1. Modeling Approach
2. Vessel Movements
3. Incident Simulation
4. Vessel Interactions
5. Discussion
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
Generates traffic levels, vessel routes, and movements

Encounter Module
Identifies opportunities for collisions and groundings

Vessel Accident Module
From a limited list of hazards, uses probabilities and mechanistic models to estimate accidents

Oil Outflow Model
From a limited list of accidents, uses probabilities and mechanistic models to estimate oil outflows
Vessel Movements: Ships

ATB (Articulated Tug and Barge)
Bulk Carrier
Cargo Vessel, General/Other (>40m)
Container Ship
Cruise Ship
Cruise Ship, Small (>40m, <2000 (ITC)
Fishing Vessel, Large (>40m)
Recreational Vessel/Yacht, Large (>40m)
Tanker, Crude
Tanker, Liquefied Gas
Tanker, Product
Tanker/Chemical Tanker
Vehicle Carrier
Vessel Characteristics

- Type: Bulk Carrier
- Length: 228m
- Beam: 32m

Waypoint

1. Vessels populate at edge of study area
2. Details are pulled from historical vessels
3. Route is pulled from historical routes
4. Vessels runs route at historical speeds
1. At each waypoint, vessel selects next route
2. Next route selected from historical routes, from vessels that share previous two waypoints
1. At each waypoint, vessel selects next route
2. Next route selected from historical routes, from vessels that share previous two waypoints
1. Select a route
2. Review all tracks for same vessel type along that route
3. Select an individual track
1. Select a route
2. Review all tracks for same vessel type along that route
3. Select an individual track
1. Select a route
2. Review all tracks for same vessel type along that route
3. Select an individual track
1. Vessel continues, selecting a route and track at each waypoint
2. At waypoints that precede a “destination,” vessel may anchor/moor
1. The individual tracks may lead to different anchorage locations
2. When vessel arrives at an anchorage it determines length of stay from historical data for same vessel type
3. The vessel only anchors at available anchorages
4. If an anchorage is occupied, the vessel selects a different track leading to a different anchorage

Plumper Sound “D”
26 hours
1. When departing the anchorage, the vessel selects a route
2. Route selection takes into consideration the previous two waypoints
3. This prevents vessels from illogically “turning around,” unless historical vessels did
1. Vessel continues, selecting a route and track at each waypoint.
2. At waypoints that precede a “destination,” vessel may anchor/moor.
3. When vessel arrives at a berth, it determines length of stay from historical data for same vessel type.

Roberts Bank Facility
12 hours
1. When departing the berth, the vessel selects a route
2. Route selection takes into consideration the previous two waypoints
3. This allows vessels to operate on complex multi call journeys, including novel combinations, but grounded in historical patterns
Vessel Movements: Ferries
1. Vessel populates at ferry dock based on a list of movements pulled from multiple years of ferry runs.
2. No novel combinations

Vessel Characteristics
• Type: Car Ferry
• Length: 84m
• Beam: 20m
1. When a laden tanker intends to enter escort required area, an escort is populated.
2. Populated tug is appropriate bollard pull/configuration for tank vessel.
3. Tug is populated in one of a few locations, based on historical origins for vessels providing escorts.

Vessel Characteristics:
- Type: Escort tug
- Bollard Pull (MT): 100
- Configuration: Tractor
- Length: 46m
- Beam: 14m

Vessel Characteristics:
- Type: Crude Tanker
- Status: Laden
- Length: 277m
- Beam: 48m
Vessel Movements: Bunkering
1. If a ship is anchored or docked in an area where bunkering takes place, the model uses a distribution to determine if they bunker.
2. A bunker vessel is populated in one of a few locations, based on historical origins for vessels providing bunkers.

Vessel Characteristics
- Type: Cruise Ship
- Length: 285m
- Beam: 32m

Vessel Characteristics
- Type: Towing (Bunker)
- Status: Laden
- Tug Length: 28m
- Tug Beam: 8m
- Barge Length: 73m
- Barge Beam: 20m
Vessel Movements: Other Types

**Non Route Based Vessels**
- Cargo Vessel, General/Other (<40m)
- Fishing Vessel (<40m)
- Other
- Recreational Vessel/Yacht (<40m)
- Research Vessel
- SAR/Military/USCG (<40m)
- SAR/Military/USCG, Large (>40m)
- Tour Vessel
- Tug, Smaller Harbor
- Tug/Workboat, Other
- Whale Watching

**Non AIS Vessels**
- Fishing, Sport
- Fishing, Tribal
- Recreational

**Towing Vessels**
- Towing Vessel (Non-Oil)
- Towing Vessel (Oil)
1. At one minute intervals, the model considers incident potential
2. Including sinking, capsizing, loss of propulsion, etc

*These are not actual probabilities. They are included as examples only.

<table>
<thead>
<tr>
<th>hazard</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinking</td>
<td>.00000021/minute*</td>
</tr>
<tr>
<td>Capsizing</td>
<td>.00000016/minute*</td>
</tr>
<tr>
<td>Loss of propulsion</td>
<td>.000048/minute*</td>
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</tbody>
</table>
1. The model also evaluates for collision encounters
2. Collision encounters are evaluated using a ship domain
3. Ship domain size/shape is linked to vessel size and speed
4. Collision encounters occur when ship domains overlap
5. Collision encounters are a prerequisite for collisions
1. The model also evaluates for grounding encounters
2. Grounding encounters are evaluated with two tools:
   1. A ship domain
   2. A 20 minute grounding vector
3. Ship domain is linked to vessel size and speed, vector is linked to vessel speed
4. Grounding encounters occur when domain or vector overlap shoreline or shallow water
5. Grounding encounters are a prerequisite for powered groundings
1. For each collision or grounding encounter, the model considers incident potential.

*These are not actual probabilities. They are included as examples only.
1. The model also considers incident potential at one minute intervals when a vessel is at anchor.

2. The list of hazards is adjusted to add anchor dragging and remove hazards that require a vessel to be underway (e.g. loss of propulsion).

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<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Sinking</td>
<td>.000000021/minute*</td>
</tr>
<tr>
<td>Capsizing</td>
<td>.000000016/minute*</td>
</tr>
<tr>
<td>Dragging Anchor</td>
<td>.000023/minute*</td>
</tr>
</tbody>
</table>

Vessel Characteristics
- Type: Tanker
- Status: Anchored
- Length: 228m
- Beam: 32m
1. The model also considers incident potential during an over water transfer.
2. If the vessel engaged in a transfer at a facility, or at an anchorage, the model applies the hazard probability.

*These are not actual probabilities. They are included as examples only.
1. When two vessels move in the model, they are unaware of each other
2. Route and track selection is made independent of vessel traffic

Vessel Characteristics
• Type: Tanker
• Status: Anchored
• Length: 228m
• Beam: 32m

Vessel Characteristics
• Type: ATB
• Status: Underway
• Length: 204m
• Beam: 23m
1. When two vessels move in the model, they are unaware of each other.
2. Route and track selection is made independent of vessel traffic.
1. Northern track is likely only operated on when anchorage is not occupied.
2. In the model, the inbound ATB may select northern track using historical frequencies even if anchorage is occupied.
1. If the ATB operates on the northern track the model identifies a collision encounter.
1. If the ATB operates on southern track, model identifies collision encounter
2. Ship domains are large enough to find an encounter even if ships are clear of one another
3. Ship domains don’t identify “dangerous” situations, just the minimum potential for an interaction to result in a collision

Via southern track
Outstanding Items

**Vessel Movement Module**
- Remaining vessel types
- Inclusion of navigational rules
- Vessels at anchor: *Technical discussion scheduled for July 14th, 2021*

**Vessel Encounter Module**
- Selecting a ship domain

**Vessel Characteristics**
- Assigning an amount of oil onboard
- Assigning Light or Burdened status to towing vessels

**Vessel Accident Module**
- Hazard Probabilities: *Technical discussion scheduled for July 28th, 2021*
- Momentum and Drift Model: *Webinar Scheduled for August 18th, 2021*
Model 101 In Review

• Ships move between waypoints on historical tracks

• Route selection, anchorage duration, and berth duration selected from distributions

• Dependent vessels like escort tugs, bunkering vessels, and pilot boats are populated only as needed

• Incidents are simulated based on probabilities when prerequisites are met:
  • Must be anchored to have a potential to drag anchor
  • Must be transferring to have a potential for transfer spill
  • Must have collision encounter to have a potential for collision
  • Must have grounding encounter to have a potential for grounding
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