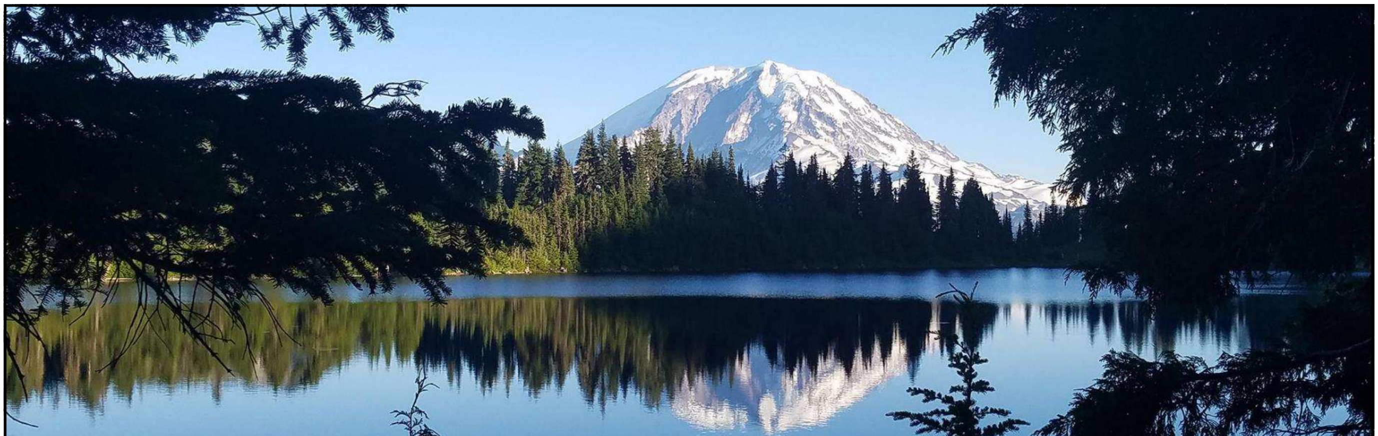

The Science of Risk Modeling and Modeling Approaches

Modeling Team

JD Ross Leahy (Presenter), Adam Byrd, Alex Suchar, Melba Salazar-Gutiérrez

DEPARTMENT OF ECOLOGY State of Washington

Today's agenda

1. Background
2. Oil Spill Risk
3. Our Planned Modeling Approach
4. Our Rationale
5. Next Steps and Discussion

Discussion topics

- Feedback on the foundational model approach?
- Feedback on the schedule and sequence for model development?
- How can we best provide you information and opportunities for input?

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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

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Our project team

- Adam Byrd, PhD
  Database administration, Geographic Information Systems
- Alex Suchar, PhD
  Statistical and mathematical modeling
- Melba Salazar-Gutierrez, PhD
  Statistical and mathematical modeling
- JD Ross Leahy, Licensed Master
  Maritime operations

Research philosophy

Transparent
- Open
- Inclusive

Reproducible
- Well documented
- Methodologically sound

Credible
- Peer reviewed
- Validated

Model development project goals

- Produce **a tool** to quantitatively assess current and potential oil spills risks from covered vessels in Washington waters
- Provide **a framework** for future oil spill risk analyses

Defining risk

- "A hazard, a probability, a consequence, or a combination of probability and severity of consequence."
  - National Research Council in Scientific Review of the Proposed Risk Assessment Bulletin
- "Risk is the combination of the likelihood of an event and the consequence if the event occurs."
  - Dept of Ecology in Columbia River Vessel Traffic Evaluation and Safety Assessment (CRVTSA)

Likelihood and consequence

- The chance that a vessel will be involved in an accident, e.g.
  - Days at sea
  - Waterway conditions where the vessel operates
- The severity of the consequences of a vessel accident, e.g.
  - Injury
  - Damage to vessel
  - Damage to other property
  - Damage to environment

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Describing oil spill risk

$$Risk = P \times C$$

$$Risk = f(S, P, C)$$

- P = probability of a vessel accident
- C = consequence of the accident
- *S* = various scenarios of what can go wrong in the system

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Describing oil spill risk

Scenarios
- Hazard identification: collision, allision, grounding, explosion, etc.

Probability
- How likely is each identified hazard?

Consequences
- If an accident happens, how likely is that an oil spill occurs, where it will occur, and what volume of oil will be released?

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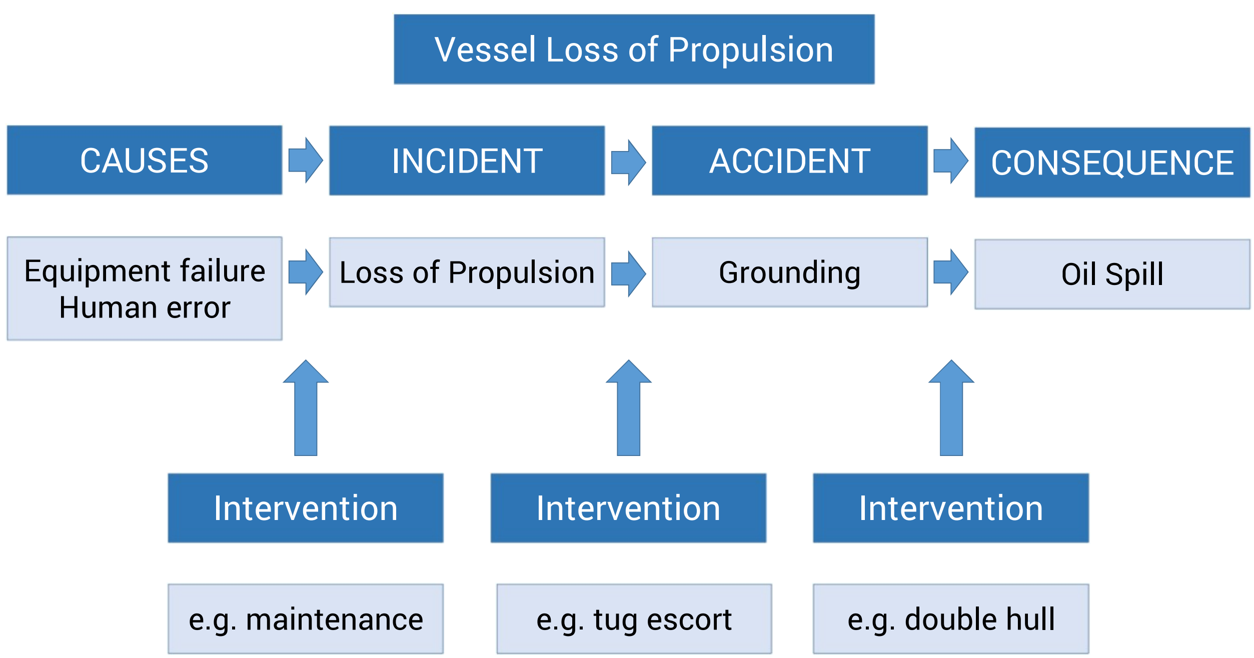

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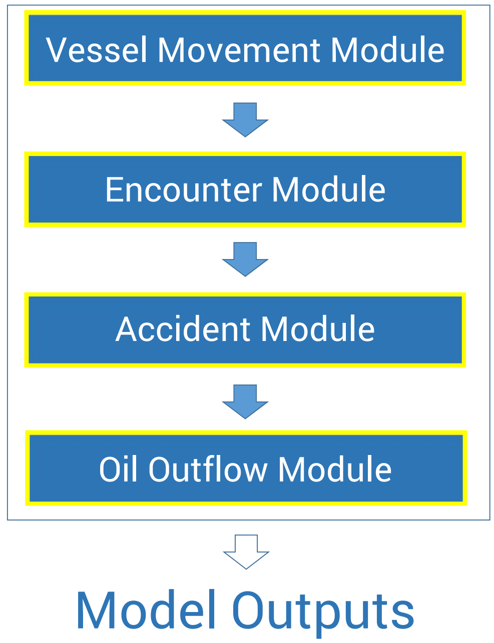
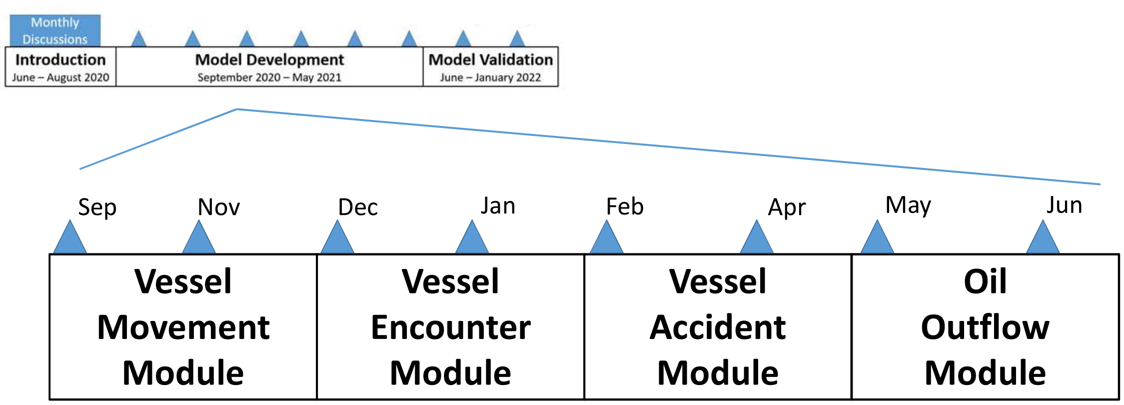
Modeling approach



A step by step approach to building modules



Vessel Movement Module | Vessel Encounter Module | Accident Module | Oil Outflow Module

Objective
- Represent vessel volume and distribution
- Simulate random traffic configurations that are based on data

Vessel Movement Module | Vessel Encounter Module | Accident Module | Oil Outflow Module

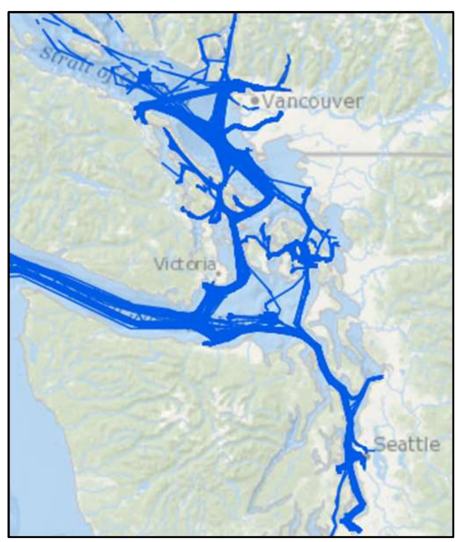
Approach
- Aggregate routes from AIS
- Populate vessels on routes
- Proceed at a given timestep.
- Organize by vessel type

Vessel Movement Module | Vessel Encounter Module | Accident Module | Oil Outflow Module

Inputs and Data
- AIS and other sources
- Common vessel routes
- Vessel characteristics
- Geographic range
- Navigational rules
- Temporal resolution
- Other factors

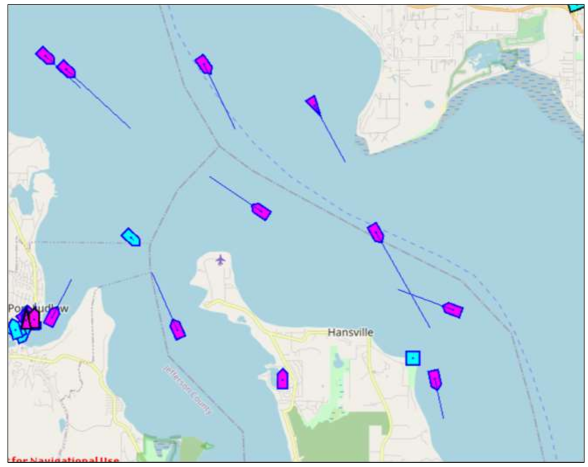
Vessel Movement Module | Vessel Encounter Module | Accident Module | Oil Outflow Module

Challenges
- Noisy AIS dataset
- AIS provided vessel types not sufficient
- Smaller vessels and barges don't have AIS



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

Objective
- Detect situations that could lead to accidents



When the relationship of a vessel to shore or another vessel creates the possibility of grounding or a collision

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

Approach
- Encounter detection based on various criteria

Indicator	Spatiotemporal proximity of the vessels
Safe boundary	Area around a vessel clear of other vessels
Minimum Distance to Collision	Minimum distance between two vessels that allows for collision avoidance

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

Inputs and Data
- Vessel navigational data
- Vessel characteristics
- Waterway characteristics
- Other encounter details

Indicator

Spatiotemporal proximity of the vessels

- Relative distance
- Distance and Time to Closest Point of Approach (CPA)
- Bearing / Speed
- Vessel characteristics
- Waterway conditions

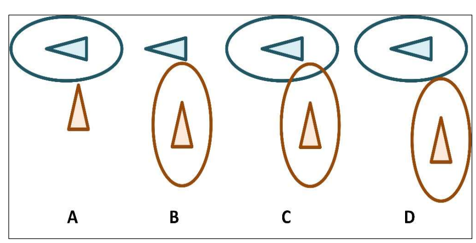
Vessel Movement Module → **Vessel Encounter Module** → Accident Module → Oil Outflow Module

Inputs and Data
- Vessel navigational data
- Vessel characteristics
- Waterway characteristics
- Other encounter details

Safe boundary

Area around a vessel clear of other vessels

- Circular
- Compound
- Elliptical
- Polygonal
- Empirical



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

Challenges

- Vessel behavior limited to AIS inputs
- Many approaches

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

Objective

- Determine likelihood of vessel accidents/spills for simulated scenarios
- Simulated scenarios include the following:
  - Groundings/Allisions
  - Collisions
  - Transfer Spills
  - Fire/explosion
  - Sinking

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

Approach
- Allow varying levels of complexity in accident probability estimation

Simple to complex

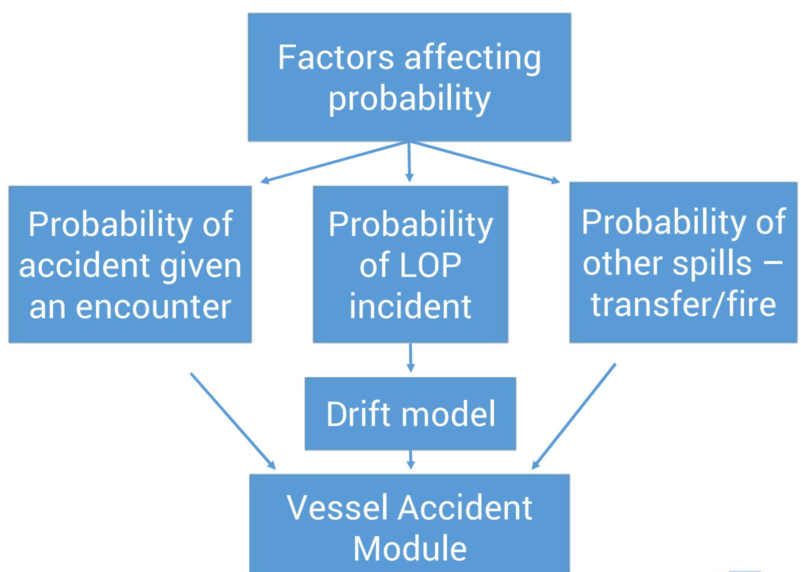
Probability of an accident, per encounter, per accident type

Probability of an accident, per encounter, per accident type & vessel characteristics

Probability of an accident, per encounter, per accident type, vessel characteristics & waterway conditions

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

Approach
- Probability of different accident types that may result in a spill



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

Inputs and Data

- USCG MISLE database
- USCG accident reports
- IHS Markit (Lloyd's)
- Transportation Safety Board (Canada)
- National Transportation Safety Board (US)
- Ecology incident data

nitialEvent	SummaryOfEvents	ShipType1	Consequences1	GrossTo
ire or explosion	Presence of high leve	Drilling Rig, semi	Loss of life,Ship	991
ire or explosion	The vessel was	Asphalt/Bitumen Tanker		1037
Collision	On May 31, 2018	Container Ship (Fully Cellular)		1812
Missing: assumed l	On 13 March 2018 a	Bulk Carrier		5271
tranding / groundi	On August 25, 2017	Drilling Ship		1427
atal injury	On 20 August 2017,	General Cargo Sh	Loss of life	2047
inking	The ship sank whilst	Research Survey	Total loss of the	29
tranding / groundi	The boat was strand	Tug	Pollution	33
Collision	The boat was in colli	Tug	Pollution	27
tranding / groundi	The tug was strande	Tug	Pollution	15
tranding / groundi	The ship was strande	Fishing Vessel	Total loss of the	22
inking	The boat sank in the	Fishing Vessel	Loss of life	25
Collision	On 8th.December 20	Container Ship (Fully Cellular)		7575
oundering	Sank off Dutch Harb	Fishing Vessel	Loss of life,Total	18
ire or explosion	El buque Aframax Ri	Crude Oil Tanker	Ship rendered un	5794
apsizing / listing	The ship capsized wh	Fishing Vessel	Pollution	14
ire or explosion	The tug caught fire o	Tug	Loss of life	12
oundering	Merchant ships rescu	Fishing Vessel	Total loss of the	165
inking	The ship sustained u	Fishing Vessel	Total loss of the	13
Collision	At approximately 12:	Container Ship (F	Ship rendered un	5348
tranding / groundi	The ship was strande	Fishing Vessel	Total loss of the	10
ire or explosion	On 14th.December	LPG Tanker		1720
Contact	On September 20,	Drilling Ship	Loss of life,Serio	6053
Contact	The bulk carrier Glob	Bulk Carrier	Pollution	2115

Example accident data

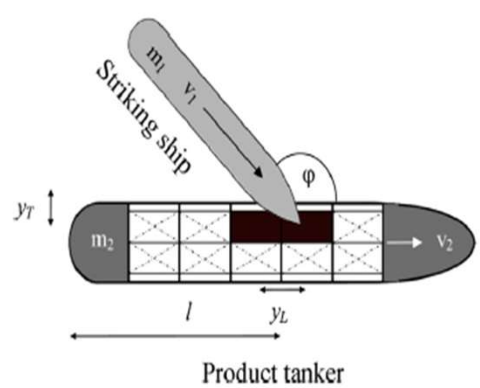
Vessel Movement Module | Vessel Encounter Module | **Accident Module** | Oil Outflow Module

Challenges

- Data availability
- Process uncertainty

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

Objective
- Estimate the amount of oil that is spilled to water from a simulated accident



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

Approach
- Estimate the amount of oil that is spilled to water from a simulated accident

Simple to complex

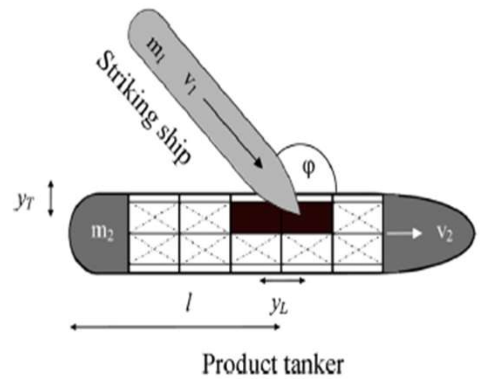
Statistical estimation of oil spill rates

Mechanistic models of oil spills

Combination of both approaches

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

Data and Inputs
- Vessel construction
- Tank location
- Amount of oil (cargo)
- Amount of oil (fuel)
- Oil type
- Accident details



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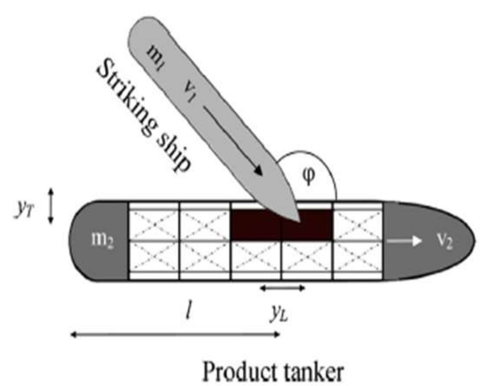
Vessel Movement Module | Vessel Encounter Module | Accident Module | **Oil Outflow Module**

Challenges
- Data availability for vessel characteristics
- Accurately simulating amount and type of onboard oil



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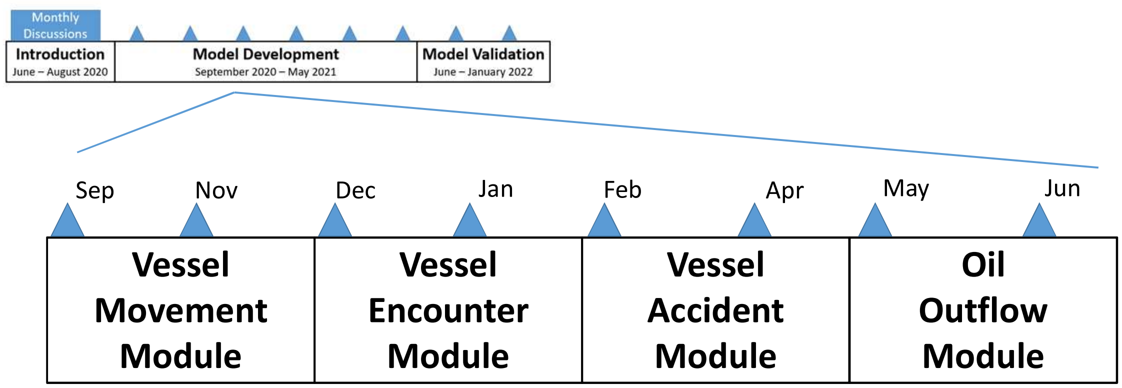
A step by step approach to building modules



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Running the model

- **Integrated modeling approach**
  - Both mathematical and statistical
- **Stochastic simulation**
  - Each model run will have unique outputs

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Requirements for the model

Quantitative	• Measurable & numerical results
Covered vessels	• Vessel type specific
Tribe and stakeholder involvement	• Ongoing outreach and transparent approach
Account for changes in traffic	• Explicit modeling of vessel traffic
Evaluate risk reduction measures	• Explicit modeling of accident causes
Updatable	• Based on data

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A flexible framework

Requests	Model Structure
Consider USCG data on number and size of spills from oil barges	Uses historical data
Deal with challenge of a lack of incidents to calibrate on	Uses stochastic simulation
Use engineering analysis to consider force needed to cause oil outflow	Includes oil outflow module

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A flexible framework

Requests	Model Structure
Consider the natural distribution of other tugs besides an ERTV	The simulator pulls from the historical distribution
Consider distribution of ships transiting in irregular patterns	The simulator pulls from the historical distribution
Differentiate between laden/unladen transits	Simulated vessels are uniquely represented
Include separate transit lines for tugs	Vessel typology allows for this

A flexible framework

Requests	Model Structure
Include fate, transport, and effects of a spill	Discrete model outputs
Compatibility with other models	Discrete model outputs
More robust treatment of spill consequence and impact	Initial description of consequence

Consequence

Model Outputs:

- Geographic location of spills
- Date and time of spills
- Type of oil spilled
- Amount of oil spilled
- Incident characteristics
- Accident characteristics

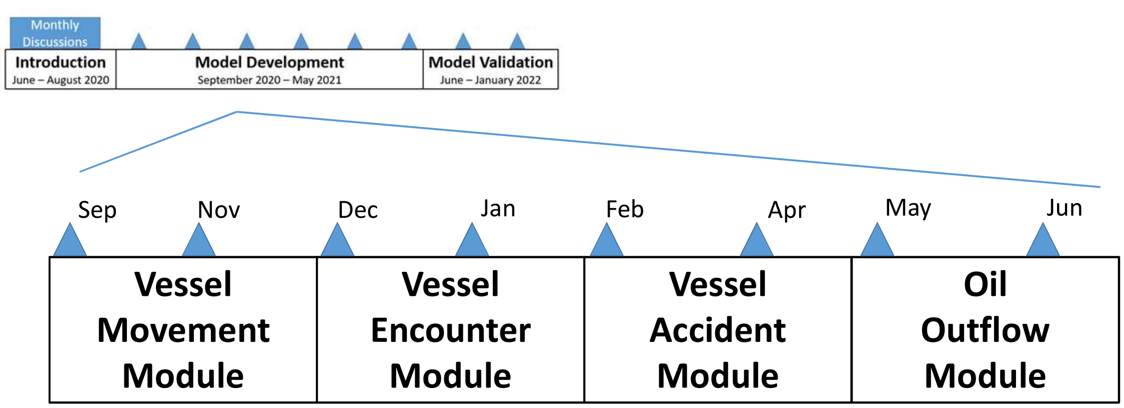
Cultural Damage

Ecological Damage

Economic Damage

Human Health Hazard

A step by step approach to building modules



Opportunities for updates

Vessel Movement Module	Vessel Encounter Module	Vessel Accident Module	Oil Outflow Module

Progress Briefings

October 2020

March 2021

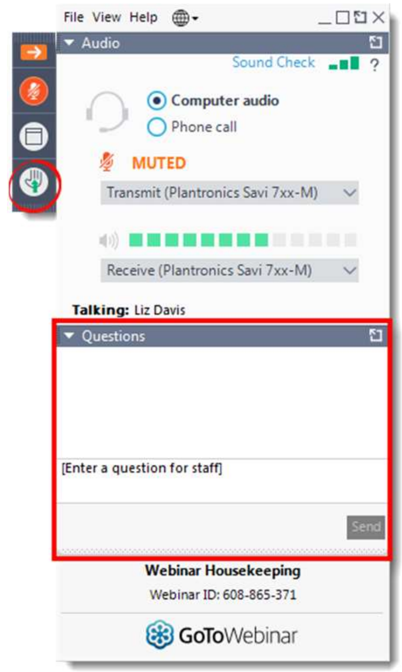
July 2021

Upcoming event

September 16th, 2020 -- 1 pm to 3 pm

- Vessel Movement Module

Discussion logistics



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Discussion topics

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- Feedback on the schedule and sequence for module development?
- How can we best provide you information and opportunities for input?

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Contact Info

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References

- **Slide 10:** National Research Council, NRC. 2007. Scientific Review of the Proposed Risk Assessment Bulletin from the Office of Management and Budget. Washington, D.C.: National Academies Press.
- **Slide 31:** Goerlandt F, Montewka J. A probabilistic model for accidental cargo oil outflow from product tankers in a ship-ship collision. *Mar Pollut Bull*. 2014;79(1-2):130-144.

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