Oil Spill Modeling Workshop
Sub-Committee Topics

Oil Spill Modeling: Biological Effects Model
Deborah French-McCay - group leader

Mission
The Biological Effect Model Subgroup will evaluate modeling approaches, available information, potential algorithms, and data needs for developing the next-generation oil spill biological effects model. The assumed inputs to the biological effects model include (1) wind data as time- and (optionally) spatially-varying velocities; (2) current data as time- and spatially-varying velocities; (3) environmental conditions such as temperature and salinity; and (4) physical fates model outputs that quantify spatial distributions, physical-chemical characteristics, and concentrations over time of floating oil, entrained oil droplets, dissolved hydrocarbons, oil in sediments, and oil on shorelines. Processes to be considered in the biological effects modeling review and model algorithm development include:

- Exposure evaluation
    - to floating oil, entrained droplets, dissolved hydrocarbons, oil in sediments, oil on shoreline
    - for habitats, wildlife, fish and invertebrates
    - including consideration of behavior, i.e., normal, avoidance and attraction.
- Uptake of hydrocarbons into biota (pathways and rates of uptake)
- Lethal and sublethal effects levels and algorithms for individual effects
    - Mechanical/smothering/thermal/toxicological effects of (whole) oil on wildlife and aquatic biota
    - Toxicity of hydrocarbons on aquatic biota
        - Acute effects of short-term exposures (considering duration of exposure from <12 hrs to weeks)
        - Long-term effects of short-term exposures on development, growth, reproduction, etc.
    - Phototoxicity of PAHs on aquatic biota
- Population level effects and recovery rate [identification of issue; review of modeling approaches; but not a review of specifics for individual species]
- Ecosystem level effects and recovery rate [identification of issue; review of modeling approaches; but not a review of specifics for individual ecosystems]
    - Trophic transfer
    - Change in competitive/synergistic relationships
- Scaling restoration with modeling [review of modeling approaches; but not a review of specifics for individual habitats or species]
    - Habitat Equivalency Analysis
    - Resource Equivalency Analysis

Areas of overlap of missions between subgroups
The biological effects model depends on the physical fates model to quantify spatial distributions, physical-chemical characteristics, and concentrations over time of floating oil, entrained oil droplets, dissolved hydrocarbons, oil in sediments, and oil on shorelines. Thus, these two models need to be coordinated in the methods and units used to describe the oil components in each environmental compartment. Most importantly, the chemical characterization of the oil is typically broken out into "pseudocomponents", or groups of hydrocarbons of similar physical-chemical and toxicological behavior. That characterization

needs to be consistent and appropriate for tracking both the fate of the oil and the potential effects.

Physical transport processes applying to oil and dissolved components also apply to planktonic organisms. Thus there is overlap between the biological effects, physical fates and transport model groups in resolving this issue. Spatial and time scales of the biological effects and physical fates models need to be coordinated such that appropriate processes and scales of contamination are resolved in both models.

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Oil Spill Modeling: Physical fates and Behavior
Bill Lehr and Mark Reed – group leaders

The objectives of this exercise are
1. to carry out a literature review, including collection of relevant data where appropriate and available;
2. to clarify what is needed and what is available to develop improved model algorithms;
3. to specify a 5-year study and development plan.

The physical fates and behavior group will review recent research into the processes that affect eventual distribution, effects, and recoverability of spilled oil:
- spreading,
- evaporation,
- dispersion,
- dissolution,
- emulsification,
- sedimentation,
- photo-oxidation,
- bio-degradation,
- shoreline and bottom interactions.

Of special interest are recent studies of the time-dependent changes in physical-chemical parameters of spilled oil including
- density,
- viscosity,
- rheology,
- water content,
- emulsion stability,
- droplet size distribution,
- surface tension,
- adhesion characteristics, and
- Chemical composition.

The review will include environmental factors only in so far as they affect the oil weathering and fate. These factors could include wave breaking, subsequent droplet formation, Langmuir processes, re-suspension, ice interaction, interactions with suspended particulate matter in the water column, interactions with seafloor sediments, and beaching.

The review will identify those areas where significant improvement has occurred in understanding the science and those areas in need of further research, and suggest methods for integrating new algorithms into next-generation models.

<u>Areas of overlap of missions between subgroups</u>
Transport
1. Drift characteristics will change as the oil weathers and/or goes sub-surface.
2. Transport processes strongly affect oil spreading, and therefore evaporation, dispersion and emulsification, and hence eventual biological effects.

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Biology
Physical and chemical transport and behavior of the oil determine in part the potential for interactions with the natural resources.

Response
1) The effectiveness of alternate response technologies, either for control of location (e.g. dispersing from surface to water column, or protective booming of stream mouths), or removal of spilled oil will depend on time-varying oil properties, as well as environmental conditions.
2) All response options (other than the no-response option) will affect the fate of the oil.

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Oil Spill Modeling: Physical Transport

Michel Boufadel and CJ Beegle-Krause - group leaders

Mission

The main hypothesis is that no theoretical development is needed on this topic, rather parameterizations that are more physically based than those in existing oil spill models. In addition, effort should be focused on identifying the parameterizations that are relatively accurate and easy to implement, in terms of data requirements and/or theoretical proficiency of users. For example, a method that evaluates the small scale diffusion coefficient based on a turbulence closure model should be discarded in favor of one that evaluates it based on the significant wave height and the dominant wave period at sea.

The tasks of this group are (or should be):

1) Conduct a literature review on existing parameterization of hydrodynamic processes.
2) Conduct a literature review on Meteorology and Oceanography of the following processes:
   a) Meteorology (prediction of winds, currents and wave properties).
   b) Waves
      i) Nonbreaking and breaking, two dimensional
      ii) Three dimensional, i.e., Langmuir effects.
   c) Mixed layer dynamics
      i) Changes in mixed layer depth
      ii) Parameterizations of mixing (e.g. Langmuir) for droplets and dissolved chemicals.
      iii) Papers (Overstreet, Spill Science special issue)
   d) Ice (Need input on what to look for)
      i) Measurement and prediction of surface distribution and concentration
      ii) Interactions between oil and ice in horizontal transport
      iii) Freezing / thawing cycle and effects of oil
         A) Surface
         B) Subsurface
      iv) Oil transport through brine channels
   e) Rivers – fresh and salt water
   f) Tidal and water mass convergence / frontal zones.
   g) Coastal circulation and larger scale currents.
      i) Processes that are important
      ii) Important models (POM, ROMS, FVCOM
   h) Deepwater circulation processes
   i) Beaching / refloating and hydraulics
      i) Cozoil model
3) Propose a conceptual framework to incorporate these processes in oil spill models.
   a) Review of models to put them in context (please add more)
      i) Cozoil
      ii) GNOME
      iii) OilMap
      iv) TAP
4) Develop algorithms cast in modular forms, and make them available to the oil spill community.
5) Data Management and Communications
   Mention netCDF CF standards; NOAA / Navy subset; USCG EDS

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Oil Spill Modeling: Response Modeling

Wolfgang Konkel and Debbie Payton - group leaders

Mission:

The response modeling subgroup mission is to synthesize the present requirements, capabilities and gaps for effectively implementing models in oil spill incidents.

Background

Oil spill response modeling may be utilized as the basis to respond to numerous questions during a spill response. The modeling outputs may be utilized to predict the trajectory or path and future location of the oil slick. This information is also valuable in determining whether there are particular habitats or species that may be at risk from oil exposure or contamination. The modeling may be utilized to estimate oil weathering, the physical changes that result when oil is released into the environment. These are typically parameters that are not easily measured and include: spreading, evaporation, dissolution, and entrainment. Response modeling may be utilized to inform responders, stakeholders, and the public about the location of the oil slick. Response modeling may also be utilized to evaluate the performance of various response alternatives such as mechanical equipment and dispersant application. Since this can be performed at the initial stages of a spill and provides quantitative insights into the likely success of the response, the analysis can be used as the basis to acquire additional or alternative response equipment. Understanding user needs, balancing evolving technologies with realistic response capabilities, ensuring data access and integrating forecasts and analysis into operations are all areas for consideration in the response modeling subgroup.

- What is needed from the response modeler?
    - Trajectory and timetable predictions
    - Weathering estimates
    - Response performance analysis
    - Visual outputs and maps
    - Mass balance
    - Expected exposures/species effect

- What does the modeler need?
    - Environmental and Scenario Data
        - Observed distributions (visual, measured, remotely sensed)
        - Release location(s) and characteristics
        - Meteorology (climatology, observations, forecasts)
        - Oceanography/Hydrology (modeled/observed)
        - Location(s) of sensitive habitats and species – Local or internationally recognized in digital format
        - Unique environmental issues (ice types/distribution (historical, observed, forecast), submerged oil distribution (observed, forecast, bottom type, oil/bottom interaction, etc.)
    - Oil data
        - Oil type(s)
        - Oil volume (s)
        - Spill duration

- Response equipment
  - Type and quantity
  - Performance specifications
  - Efficiency
  - Location relative to slick
  - Travel speed
  - Storage volume and ability to decant
  - Swath width
  - Response speed
  - Performance limits (wave heights, darkness, etc.)

- Modeler Integration
  - Who does the information go to? (UC/IC, FOSC, Team Leads, etc.)
- Formats/Distribution (hardcopy, shape files, kmz, WMS, pictures, movies, web-distributed, etc.)Feedback needed from other response parties
  - Oil type
  - Oil volume
  - Recovered volumes
  - Dispersant details
  - Overflight feedback
  - Resource information

<u>Areas of overlap of missions between subgroups</u>
The response modeling subgroup links to all three other groups, the effective use of modeling in a response is the ultimate goal. Particular areas of overlap include:

1. Fate and Transport – availability and standards for data access, needed time/length scales of met/ocean data, non-transport modeling needs (i.e., wave or water level forecasts for salvage operations)
2. Oil Fate – how oil is represented as components, cleanup technologies interaction with f&t and representation to end user
3. Biology – biological metadata, integrating resources with fate and transport forecasts