Using Models to Help Understand Risk to Wildlife from Oil Spills

Heather A. Parker Hall
National Oceanic Atmospheric Administration (NOAA) HAZMAT
Scientific Support Coordinator
Coast Guard Island, Bldg 50-5
Alameda, CA 94501, USA

ABSTRACT

A primary objective in any successful oil spill response is protection of wildlife. In California particularly, abundant natural resources and sensitive habitats place particular burden on spill responders to use all available tools in order to minimize impacts as quickly as possible. One such tool is a trajectory model. These computer programs input with incident-specific information such as spill size, type and location, as well as localized current, wind and other environmental parameters, will calculate an estimate of where oil could go. Models can also estimate the physical fate and behavior of spilled oil as it weathers in the marine environment, helping responders determine its persistence and the duration of threat to wildlife and habitats. These estimates of oil fate and behavior also allow responders to determine what natural resources are at risk and how to prioritize tactical operations to protect these resources and minimize damage. This paper will briefly describe the NOAA HAZMAT trajectory model and explore how it has been used in the recent Luckenbach case to help determine risk to wildlife.

BACKGROUND

Predicting the movement of a pollutant in the marine environment requires an understanding of a number of different physical processes, computational procedures, and observational techniques (Galt 1994). Computer models attempt to do this, and can be a very valuable tool to spill responders. Trajectory models essentially attempt to answer questions such as where spilled oil will go, who (or what) will be impacted, and when those impacts will occur. The National Oceanic and Atmospheric Administration's (NOAA) HAZMAT division has been engaged in the development and research of oil spill trajectory models for almost 30 years. NOAA HAZMAT's oil spill models have been and continue to be the principal model called upon by Federal On-Scene Coordinators around the country for planning tactical response operations and evaluating various protection measures.

<u>Using the GNOME Model:</u>

The latest iteration of NOAA HAZMAT's oil trajectory model is GNOME: General NOAA Oil Modeling Environment. GNOME simulates the movement of spilled oil from local currents, winds, tides, spreading and other physical processes. Depending on the conditions, users can choose from current files distributed with the model or input their own data. Figure 1 shows some of the current patterns available for the Santa Barbara Channel GNOME.

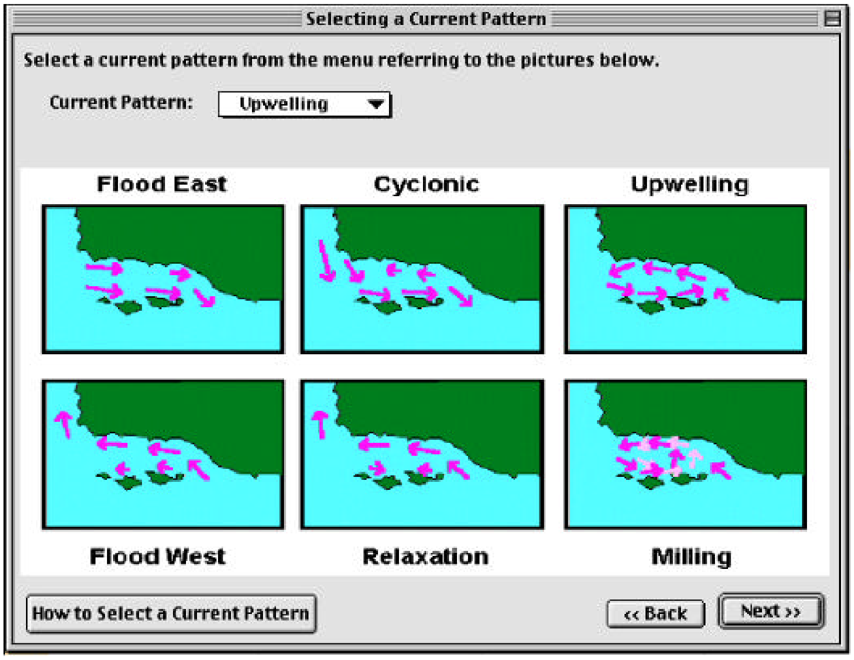
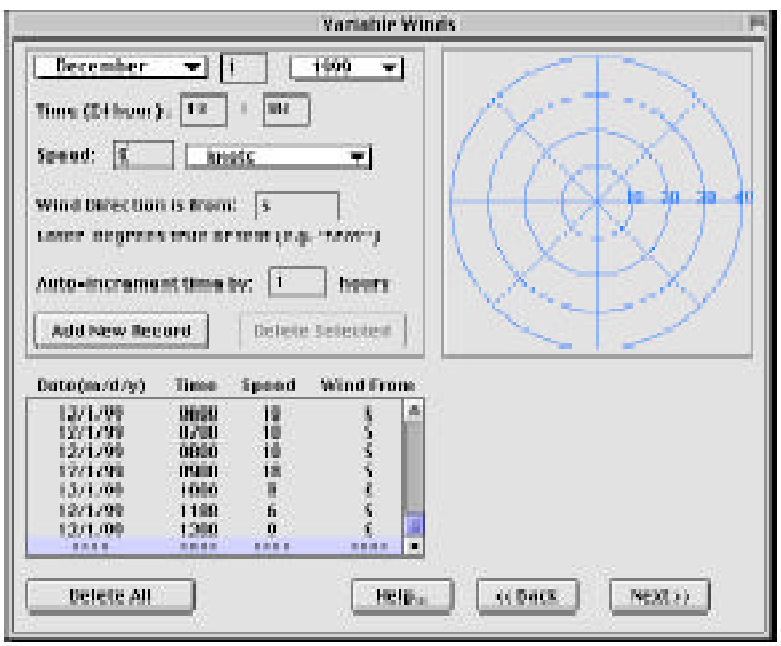


Figure 1. Circulation patterns for NOAA's Santa Barbara Channel GNOME.

To continue with model initialization, users input wind data either from their own file or through GNOME's wind tool (Figure 2). GNOME allows for two types of wind files, constant or variable with time. As a default, GNOME calculates that the oil will move between 1% and 4% of the wind speed, however users can change this parameter as desired.



Once the environmental parameters are initialized, the next step is to specify the spill details. Figure 3 shows the dialog box GNOME presents to gather this information, including date, time and location of the spill as well as pollutant type. Choices for pollutant type include several oil types and a non-weathering pollutant that can represent other hazardous chemicals. Users are then directed to a map window that will display their area of concern and their incident specific information.

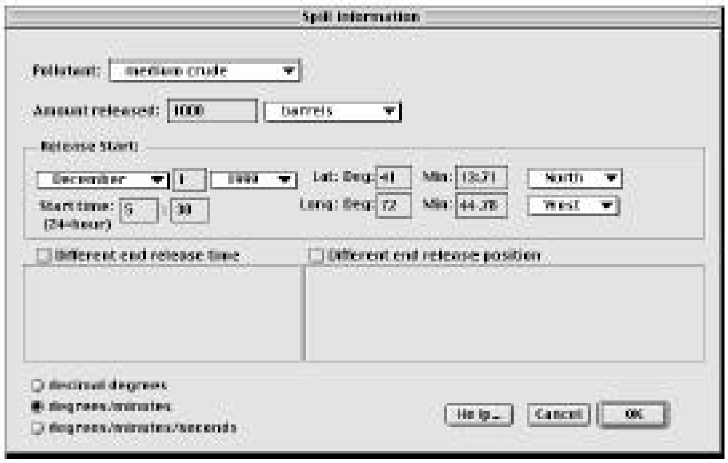


Figure 3. The Spill Information box for GNOME, prompting users to specify the parameters of a particular spill.

The model is then run for a specified length of time, creating a movie of frames, showing the path of the oil spill at individual time steps. At this level of the model, the oil slick is represented by a collection of particles. Each of these particles has the ability to account for spreading and weathering of the slick as it moves through the marine environment, affected by wind and seas. Some of these particles may evaporate over the model run time, some may disperse naturally and some may beach – depending on the product type and spill-specific parameters. Figure 4 shows an example of the GNOME map with one frame of a spill scenario in Long Beach Harbor, California.

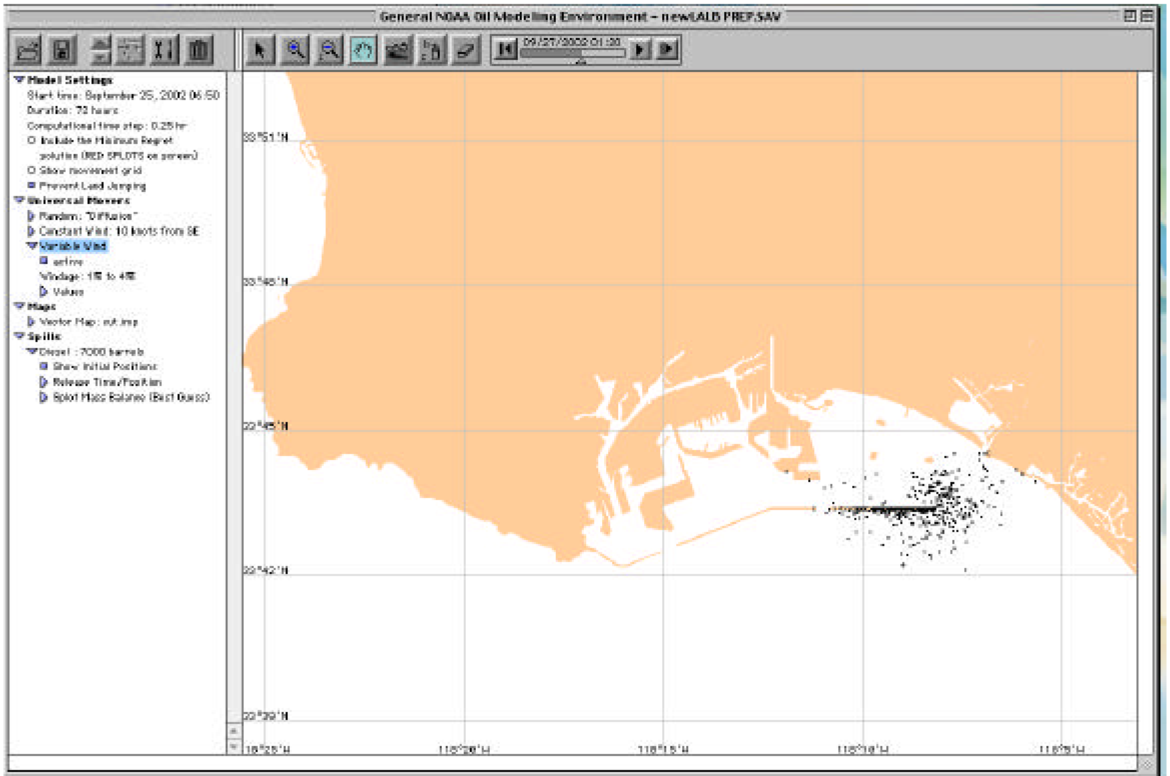


Figure 4. Example of a GNOME model run, showing the spread and movement of particles that represent the oil slick.

<u>Trajectory Analysis:</u>

Getting a trajectory from GNOME can be as simple as inputting incident-specific information such as spill location, size and start time, oil type and various environmental factors. However, interpreting these results into a tactical tool responders can use appropriately during a spill event is a bit more challenging. Trajectory models are essentially approximations of numerous parameters, based on subjective interpretation of sparse data (Galt et al, 1996). Depending on how it is used, the same trajectory model can produce quite different results that can confuse users, potentially misdirecting them. The key to avoiding misinterpretation and misuse of model results lies in the final interpretation of the model: trajectory analysis. One essential component of the analysis of the modeled trajectory is knowing what the model can and cannot do. It is impossible for any model to represent all of the complex processes at work in the marine environment – these models can only work with a subset of reality (Galt, 1994). With this in mind, the trajectory analyst needs to be familiar with the limitation of the model used and how to best interpret the deficit of data that is often characteristic of emergency spill events.

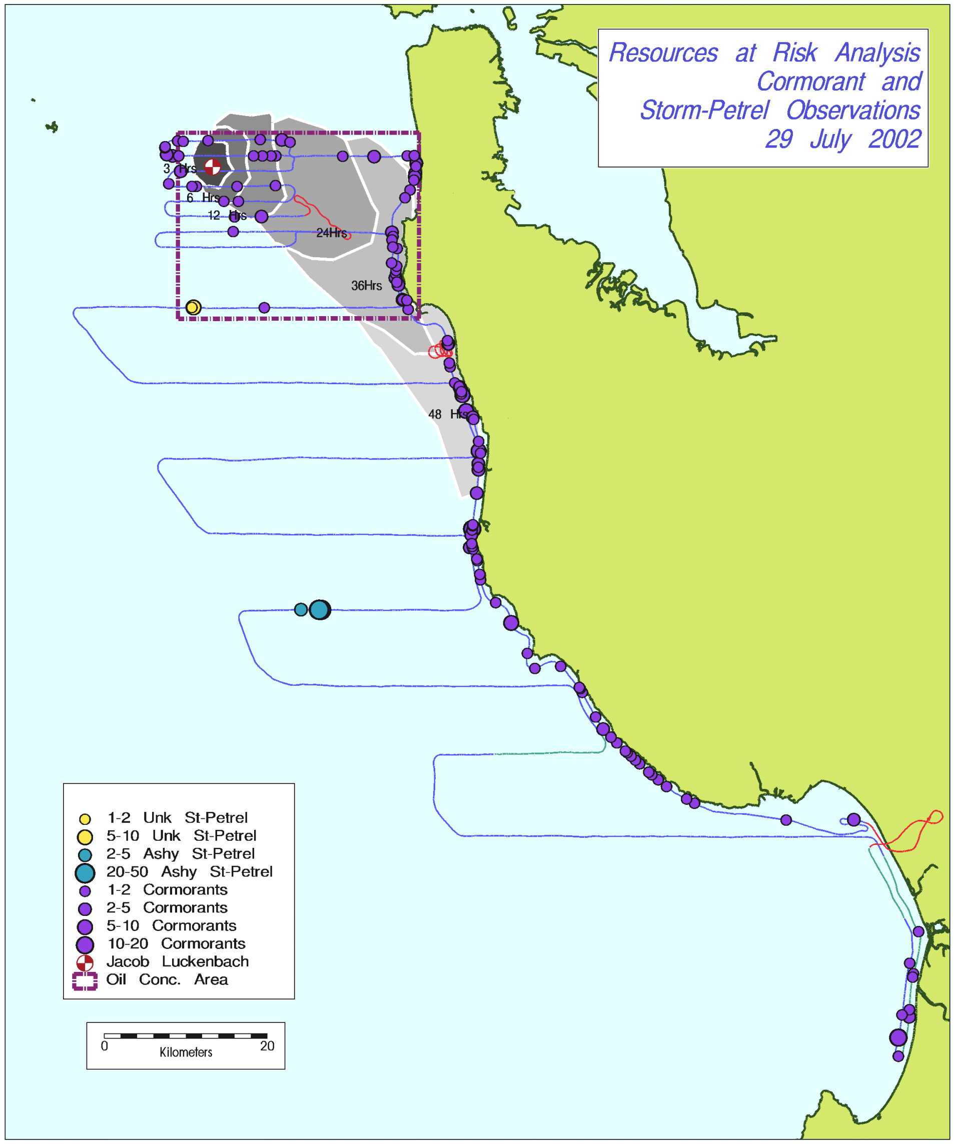
Trajectory analysis also requires an understanding of the spill responder's objectives. For example, if the model shows that most of the oil for a particular spill is headed toward a sandy beach where collection is easy, and a small amount will impact a wetland, this could interpreted as a positive situation or a drastic one. Cleanup crews in this case might feel confident they could remove this oil rapidly and thoroughly, resulting in an expeditious and effective response. Resource trustees, however, may feel quite differently about the threat to the extremely sensitive habitat and wildlife in the wetland, faced with the challenge of very limited cleanup options combined with potentially long term impacts. As stated in Galt, 1995, "given the uncertainty of this (modeling) process, it is important to understand that, regardless of how the estimates are obtained, the results are due to analysis, not deterministic modeling."

DISCUSSION

The GNOME model and subsequent trajectory analyses were put to task during a recent event off San Francisco, oil removal operations from the wreck SS Jacob Luckenbach. The Luckenbach is a C-3 cargo ship that sank 17 nm southwest of the Golden Gate in about 180 feet of water in 1953. This vessel was fully laden with fuel and cargo and had just left port en route to Korea to bring supplies for the war effort. Broken into two pieces on the bottom, this vessel was discovered recently to have been episodically leaking unknown quantities of bunker fuel oil into the surrounding highly vulnerable area, and impacting thousands of seabirds, shore birds and miles of coastline habitat. The Unified Command (UC) for this incident, made up of United States Coast Guard (USCG) and California Department of Fish and Game's Office of Spill Prevention and Response (OSPR), hired a salvage contractor in May 2002 to assess the amount of oil still left on board the vessel and determine how best to remove it.

Motivated by a heightened concern for the multitude of vulnerable wildlife in the area, the UC assembled a group of resource trustees and other specialists to help characterize the risk of impact. This Resources At Risk (RAR) Task Force was charged with determining what species, populations, habitats, etc. were particularly vulnerable not only to a release of oil from the Luckenbach, but from the removal operations themselves. Numerous discussions amongst the experts indicated that the operations posed very little threat of harm to resources, particularly when compared with the potential harm from Luckenbach fuel oil. The Task Force assembled several databases and spreadsheets of sensitive resources in the area, including a "short list" of about a dozen of those species most sensitive to oiling, based on listing as a threatened or endangered species, struggling population dynamics, particularly vulnerable stage of life history or other factors. This spreadsheet helped give the Unified Command a clear picture of what needed protection, but it fell short of providing an overall picture of the specific risk to these resources: It answered the question of "who will get hit", but it did not answer the question of "when and where will they get hit".

To answer these questions in a tactical sense, the RAR Task Force developed a new type of trajectory product, a Resources At Risk trajectory (Figure 5).



HAZMAT Trajectory Analysis

These estimates are based on estimated shelf currents and the National Weather Service 7-day forecast for Monday morning, 29 July 2002. The exact location and extent of an actual spill would depend on when the spill occurred and how much oil was spilled. If oil should spill between 29 July and 2 August, there is an 80% probability that it would be contained within the contour at the indicated time after the spill.

OSPR Wildlife Reconnaissance Surveys

These data are taken from the survey of 29 July 2002.

Figure 5. Resources At Risk Trajectory Product for the Luckenbach Oil Removal Operations. This maps shows the survey trackline, the observed locations and counts of numerous bird species and contours of probabilities of oil trajectories.

This product integrates weekly wildlife overflight survey data with a specialized type of trajectory model output – a random statistical run. To create this product, another more specialized NOAA Hazmat trajectory model is run for 48 hours for 2000 different oil spills, each starting at a random time over a 5 day period and originating at the site of the Luckenbach wreck. The model is initiated with two 7 day weather forecasts from the National Weather Service, one covering the offshore area while the other forecast is for the nearshore area around the entrance to the Golden Gate. Nearshore tidal currents, coastal wind-driven shelf currents and a deep offshore current representing the California current are simulated by the model and are used in the model to help drive the particles that represent each spill.

Instead of plotting the areal distributions of the oil slick over time, probability contours for 6 hours, 12 hours, 24 hours, 36 hours and 48 hours after a potential release are displayed over the wildlife data. The contours shown in this product (Figure 5) represent not the distribution of oil, but probability contours. In other words, the area shaded by each contour represents an area within which there is an 80% probability that oil spilled any time in that 5 day period would be within that area of the contour by that given time after the spill started. It is important to note that if oil were to spill, it would not cover the entire area defined by the contour, it would only have an 80% chance of being found somewhere within that bound. If a real spill occurs from the Luckenbach, this trajectory product is not representative of where this oil would go, instead a specific trajectory for this spill would have to be run, with the specific tides and wind information at the time of that release.

This type of statistical model run was chosen since there were no other options. To model a release from the Luckenbach at a specific date and time and plot its trajectory would be to produce a relatively worthless product – since there is no way to determine if oil were to leak from the Luckenbach what time and date it would release. Without knowing the time of a release, it is very difficult to determine the specific currents, winds and other time-specific factors the oil would be subject to, and that would ultimately determine its movement and spreading. A trajectory map showing the path of oil released at a given time and date would potentially misrepresent responders and the risk to wildlife since if we modeled a release at 0800 on a Monday, but the oil leaked at 1500 on a Wednesday, its trajectory could be significantly different. The Resources At Risk Trajectory map, while not a map of a specific trajectory of one release of Luckenbach oil, does have some utility in understanding not only what might get hit, but how soon. This type of product allows the UC to know what might get impacted in the first crucial 6 or 12 hours after a release, and allows them establish priorities for protecting these sensitive resources.

CONCLUSIONS

While it is clear that trajectory models can be a powerful tool in the response and planning toolbox, it is essential to understand and work within their numerous limitations. Model products can be developed specifically for an incident, tailored to the particular issues and objectives of concern. In the Luckenbach case, responders married two fairly common, yet distinct products used in many oil spills, trajectory models and resources at risk data. By overlaying sensitive resource distribution data onto a unique application of a trajectory model, responders were able to better qualify the risk of oiling to these sensitive species within 6, 12, 24 hours or more after a spill. This type of risk assessment gives responders an ability to plan for how quickly they will need to initiate mitigation procedures before these sensitive resources could be impacted from a release from the Luckenbach. The flexibility and creative thinking that resulted in this new type of spill response tool is a key factor in the success of any spill response.

REFERENCES

Galt, J.A. 1994. Trajectory analysis for oil spills. *Journal of Advanced Marine Technology Conference 11*:91-126.

Galt, J.A. 1995. The integration of trajectory models and analysis into spill response information systems. *Proceedings of the International Maritime Organization Second International Oil Spill Research and Development Forum*, 23-26 May 1995, London, England.

Galt, J.A. and D.L. Payton, H. Norris, and C. Friel. 1996. Digital Distribution Standard for NOAA Trajectory Analysis Information. NOAA HAZMAT Report 96-4. 49 pp.

BIBLIOGRAPHY

GNOME User's Manual. 2002. GNOME General NOAA Oil Modeling Environment User's Manual. National Oceanic and Atmospheric Administration, Office of Response and Restoration, Hazardous Materials Response Division Report, January 2002. 91 pp.

Spill Trajectory Analysis: Questions and Answers. 1996. NOAA/HAZMAT Modeling and Simulation Studies. (http://response.restoration.noaa.gov). 4 pp.

NOAA's GNOME model:

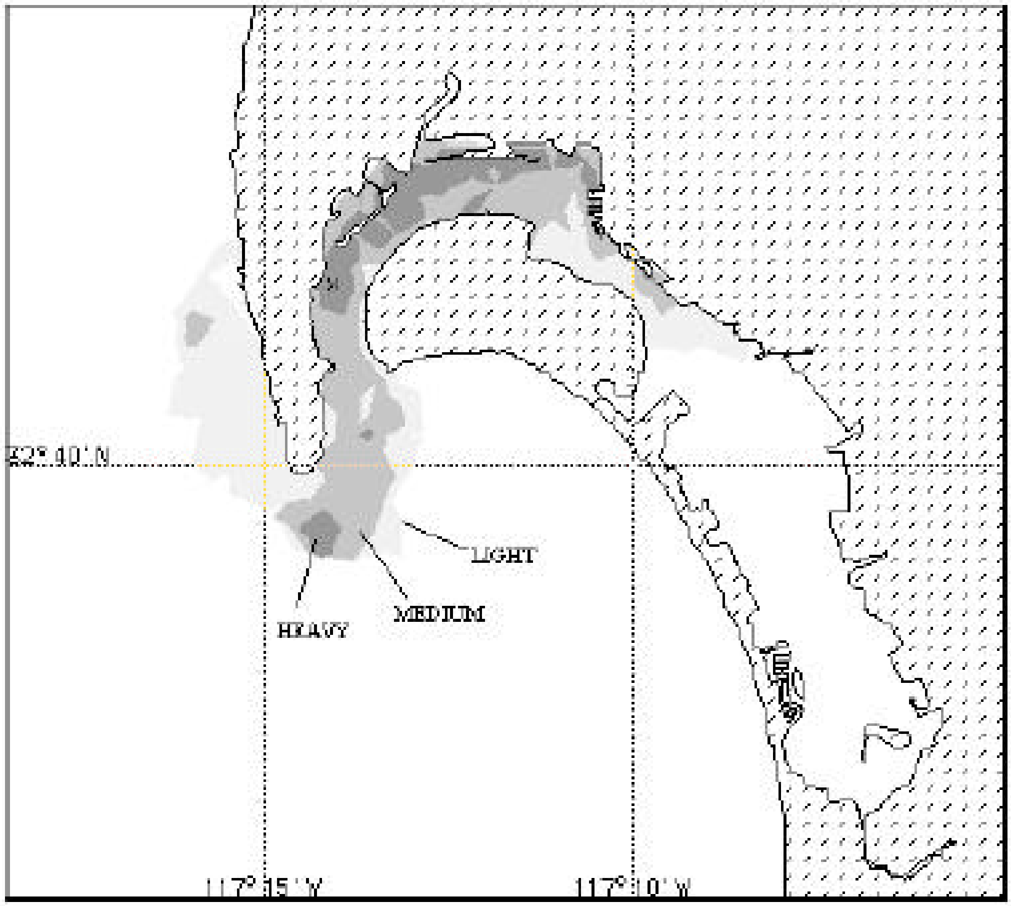


Figure _. Example of predicted distribution of heavy, medium and light concentrations of oil shown as contours (Galt et al., 1996).