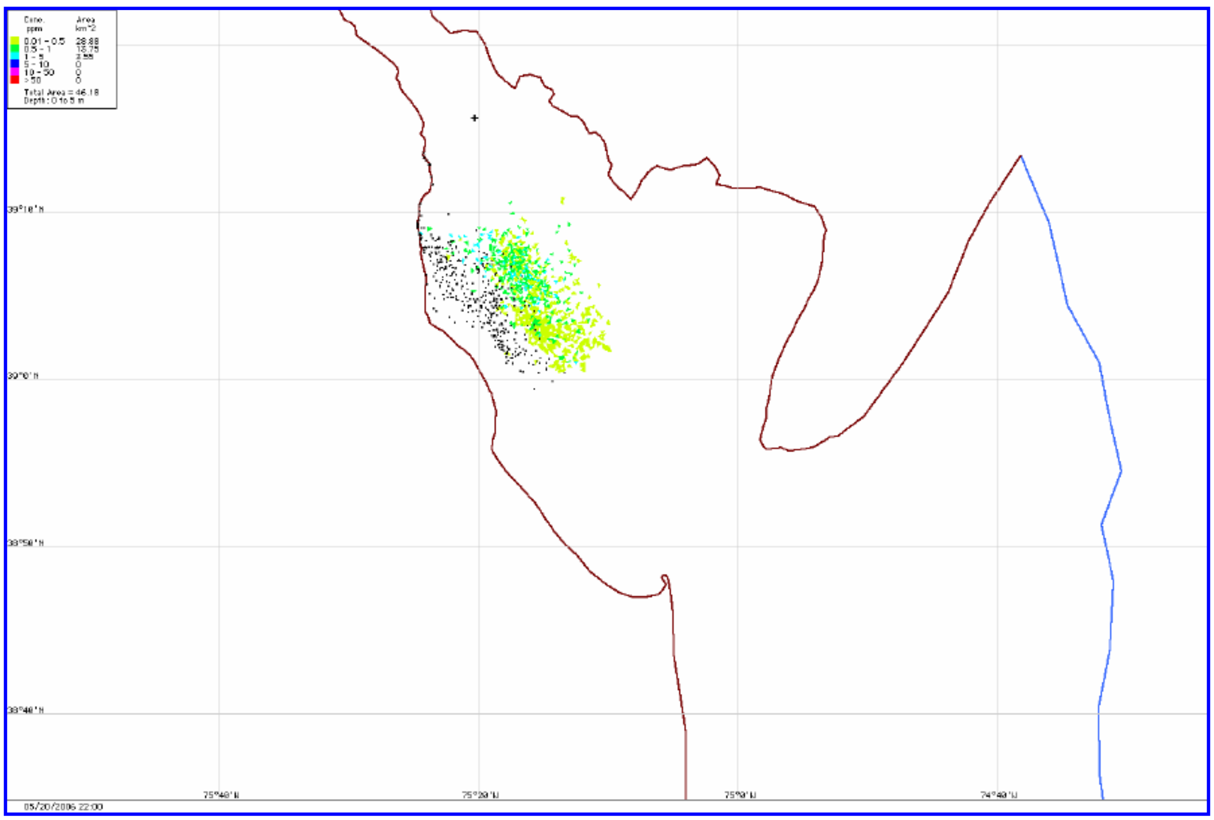
Ecological Risk Assessment: Consensus Workshop

Environmental Tradeoffs Associated With Oil Spill Response Technologies

Delaware Bay



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Delaware Bay

A Report to the US Coast Guard, Sector Delaware Bay

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Ecosystem Management & Associates, Inc.

Ecosystem Management & Associates, Inc.
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LIST OF ABBREVIATIONS, SYMBOLS, AND ACRONYMS

Term	Abbreviation, Symbol, or Acronym
Area Contingency Plan	ACP
Automated Data Inquiry for Oil Spills	ADIOS
Barrels	bbls
Cubic Kilometers	Km^3
Ecological Risk Assessment	ERA
Ecosystem Management & Associates, Inc.	EM&A
Environmental Protection Agency	EPA
Environmental Sensitivity Index	ESI
General NOAA Oil Modeling Environment	GNOME
Geographic Information System	GIS
Hazardous Materials Response Division (NOAA)	HazMat
Hours	hrs
In-Situ Burn	ISB
Knots	kts
Meters	m
Miles per hour	mph
National Oceanic and Atmospheric Administration	NOAA
non-governmental organization	NGO
Office of Response and Restoration (NOAA)	OR&R
Parts per million	ppm
Regional Response Team	RRT
Scientific Support Coordinator	SSC
Square Kilometers	Km^2
United States Coast Guard	USCG
United States Coast Guard, Headquarters	USCG HQ
United States Fish and Wildlife Service	USFWS

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Executive Summary

In January/February 2006, the United States Coast Guard (USCG) Sector Delaware Bay sponsored a workshop whose purpose was twofold: First, in response to the M/VAthos 1 oil spill in November 2004 and the ongoing work of the Area Committee, the USCG sought to bring together and educate the various non-spill response resource managers and scientist in the Delaware Estuary. Secondly, the workshop allowed the participants the opportunity to evaluate the relative risk to natural resources from various oil spill response options (on-water mechanical recovery, dispersant application, and on-shore mechanical recovery) compared to natural recovery.

The spill scenario designed by the Area Committee involved a release of approximately 60,000 gallons of Nigerian Qua Iboe crude oil due to an accident in the main channel of the upper estuary. The hypothetical date for the spill was mid-May. This period was selected to incorporate possible impacts to signature estuary species. During this period of time large populations of migratory shorebirds would be present in the estuary and Horseshoe Crab spawning would be occurring.

The workshop consisted of two three-day sessions, separated by approximately one month. Over 50 agency, academic and NGO personnel participated over the 6 day period. At the initial meeting in January, five focus groups were established and analyzed natural recovery and on-water mechanical recovery. At the second workshop in February, due to prior commitments and a spill in New Jersey, attendance was reduced and only three focus groups (including some participants from the two disbanded groups) were maintained; at that time the remaining three alternatives were ranked.

After evaluating the various spill response options within the parameters presented for this scenario the groups came to the consensus that the most benefit to the environment occurred with dispersant use, if the dispersant application was highly effective (85% removal). However, the groups questioned how realistic this scenario would be considering all the variables affecting a dispersant's effectiveness, e.g., weather, temperature, sea state, spill product, logistics of dispersal, time constraints, dispersant availability and supply, water depth, circulation patterns and flushing rates, natural resources, etc. When considering a more realistic effectiveness ranges within 35-50% the benefits of dispersant use, in this

scenario, are not quite as dramatic and overwhelming as the original 85% effectiveness rating.

Primary risks noted by all groups, to shore birds, waterfowl and Horseshoe Crabs on the water surface and along the shoreline, were all reduced in that case. Concerns were voiced regarding the increase over exposure of water column organisms to dispersed oil. This concern was less than the risk perceived to the other resources.

Overall, the participants felt that the ERA was a very valuable exercise. A list of recommendations was developed and is included at the end of this report. These recommendations will be reviewed by the Area Committee for further action. It was also strongly recommended that the USGC/Area Committee should consider sponsoring additional ERA's to examine other critical scenarios in other parts of the Estuary.

1.0 Objectives of the Delaware Bay Workshop

1.1 Background and Process

In 1998, the United States Coast Guard (USCG) began sponsoring efforts to develop a comparative risk methodology to evaluate oil spill response options. Interest in selecting response options based on a risk/benefit analysis predates the 1998 initiatives, but the current effort is different in that it emphasizes a consensus-building approach to evaluate risks and benefits.

Headquarters, USCG (G-MOR) sponsored the development of a guidebook on this process. The document, *Developing Consensus Ecological Risk Assessments: Environmental Protection in Oil Spill Response Planning. A Guidebook*, is available from G-MOR (Aurand et al., 2000). It can also be downloaded from the contractor's web site at www.ecosystem-management.net.

The process is designed to help planners compare ecological consequences of specific response options, especially in nearshore or estuarine situations. This is particularly important for consideration of dispersants and in-situ burning, which present difficult analytical issues. The process focuses on ecological "trade offs" or cross-resource comparisons. Through a structured analytical approach participants find "common ground" for evaluating impacts and they develop defensible logic to support their conclusions. The process is consistent with the U.S. Environmental Protection Agency's (EPA) Ecological Risk Assessment (ERA) guidelines (U.S. EPA, 1998), but emphasizes development of group consensus among stakeholders. The process uses a series of analytical tools specifically developed for use in a group environment. It is designed as a planning tool and should not be used during an actual event. However, knowledge gained by participants in the consensus-building process facilitates real-time decision-making.

Training usually involves two 2- or 3-day workshops lead by a facilitator. The ideal size is 25 to 30 participants, including spill response managers, natural resource managers and trustees, subject matter experts, and non-governmental organizations. The goal is to achieve consensus interpretations of potential risks and benefits associated with selected response options based on a scenario developed by local participants. Time between the two workshops is used by participants to research issues of concern before developing final conclusions. The process focuses heavily on achieving a consensus interpretation of the available technical information. Therefore, it is important to have broad stakeholder representation in the decision process; otherwise, results may not be accepted by all stakeholders involved in an actual spill event.

The workshop process includes three primary phases - **problem formulation, analysis,** and **risk characterization**. Details of the process are described in the Guidebook. In the first phase, **problem formulation**, participants develop a scenario for analysis, identify resources of concern along with associated assessment thresholds, and prepare a conceptual model to guide subsequent analysis. In the **analytical phase**, participants characterize exposure and ecological effects. The conceptual model, developed in the problem formulation phase, directs the analysis using standard templates and simple analytical tools that define and summarize the analysis for each resource of concern and each response option. Finally, participants complete a **risk characterization**. During this phase, participants interpret their results in terms of the costs and benefits of each response option to overall environmental protection as compared with natural recovery (i.e., baseline).

1.2 Sponsor's Objectives

The Delaware Bay workshop was sponsored by the Sector Delaware Bay Area Committee. The objectives of the meeting were to improve oil spill response strategies and enhance existing oil spill contingency planning in the area through open consultation between oil spill planners, managers, responders and resource trustee agencies. Through the consensus ERA process, the sponsors hope to facilitate a better understanding of resource trustee and response agency concerns, more timely and effective response decisions, and greater resource protection and recovery in the event of future oil spills.

1.3 Participants

A total of 48 individuals from 21 organizations attended the first workshop, with lesser numbers at the second session. Their names and affiliations are included in Appendix A. At the first workshop in January the participants were divided into five focus groups. At the second workshop in February, Focus Groups 2 and 4 were not well-represented, and the individuals from those groups joined Focus Group 1, 3 or 5. A significant portion of the reduction in attendance was due to an actual spill in New Jersey. Some persons had also indicated early in the process that they would only be able to attend the first session. The periods attended by each participant, and the focus groups they participated in are all indicated in Appendix A.

1.4 Organization of the Report and the Associated Compact Disk

This report is one of a series of files on a Compact Disk (CD) prepared as a project deliverable product. The report summarizes the results of the workshops, and presents the conclusions of the participants. It is formatted to be printed as an independent, double sided report. In addition, the CD contains copies of some of the presentations made at the workshops by the sponsors or by subject matter experts, as well as copies of documents provided as reference material by the sponsors. These files are cited at appropriate locations in the text of the report.

2.0 Overview of Workshop Events

This training exercise consisted of two 3-day workshops. The first workshop was held from 11 to 13 January, and the second from 14 to 16 February, 2006.

At the first workshop the meeting began with an overview of the ERA process (see ERA Overview on the workshop CD) followed by a discussion of the information developed prior to the meeting by the Steering Committee concerning the scenario, the resources at risk, and the response options to be considered (Problem Formulation Phase). This included a presentation by Dr. Alan Mearns, National Ocean and Atmospheric Administration (NOAA), Hazardous Materials Response Division (HazMat) which summarized the key elements of the scenario and the results of the NOAA trajectory modeling using the General NOAA Modeling Environment (GNOME) model and the Automated Data Inquiry for Oil Spills (ADIOS) model (see the Oil Spill Scenario file[1] and the Surface Oil Trajectory file on the workshop CD). The Steering Committee recommended that the group evaluate four response options, natural recovery (necessary as an analytical baseline), on-water mechanical recovery, use of dispersants, and on-shore mechanical recovery.

Since protective booming is a primary component of current response planning in Delaware Bay, the group discussed how that was to be considered.[2] Several options were presented. The Steering Committee considered the options and concluded that for natural recovery it would be assumed that no booming would occur, but for all other options protective booming would be in place. Since the GNOME model does not really account for the amount of oil entering the tidal creeks, the effect of booming will have to be done qualitatively by each focus group during their evaluation. This is a key assumption, because preventing contamination of marshes along the tributaries will reduce the level of concern.

The inclusion of an additional response option, on-shore in-situ burning, was discussed as well. The participants agreed to defer a decision on this until the second workshop, when it would be possible to better determine if sufficient time was available to complete an evaluation.

The participants then discussed the draft resources at risk matrix prepared by the facilitators and reviewed by the Steering Committee. There was a discussion about the value of adding salt marsh impoundments as a category, but it was decided that the tide gates would be closed during an oil spill and so they did not need to be added. Marine habitat was defined as the area beyond a line connecting Cape May and Cape Henlopen, while estuarine habitat was inside of that line. There was considerable discussion as to the water depth at which “shallow” and “deep” habitats should be divided, since Delaware Bay is quite shallow. Ultimately, the participants accepted the original suggestion to separate the two at a depth of 20 feet, based on the likely depth that dispersed oil concentrations were likely to be a concern.

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[1] The “Oil Spill Scenario” PowerPoint presentation includes the basic information on the oil spill, as well as a summary of the results of the trajectory and weathering analyses for the surface slick alone, and for the use of dispersants at an effectiveness of 85%. The dispersant use portion was not presented until the third day of the first workshop, at the beginning of the evaluation of the dispersant option.

[2] Protective booming involves the use of specially designed boom along the shoreline or across the mouths of inlets, bays or tidal streams to deflect oil away from sensitive shoreline habitats. The use of such boom to prevent oil from entering tidal creeks in Delaware Bay is a key element in existing plans, and significant quantities of such boom is pre-positioned as well as stockpiled by oil spill response organizations in the region.

Several other minor changes to the draft habitat list and the characteristic species listing were proposed and accepted.

Dr. Aurand (facilitator, EM&A) then reviewed the concept of "thresholds" with the participants, and suggested that the criteria listed on the "Final Thoughts on Thresholds" slide in the ERA process briefing offered conservative guidance for their discussions later in the process. There were no objections. The guidelines were as follows:

- Organisms (birds, turtles, marine mammals) on the water surface should be considered affected if they are likely to be in contact with sheen.
- Shoreline habitat should be considered to be affected if there is between 10 to 100 grams of oil or emulsified oil per square meter.
- Organisms in the water column can be evaluated by the criteria presented in Table 4.1.
- If necessary, sediment exposure effects can be based on the NOAA Screening Quick Reference Tables (SQuiRTs) (NOAA, 1999).

Discussions then moved on to the risk ranking matrix. The final matrix is presented as Figure 4.1. As part of the risk ranking discussion, the participants agreed that the definitions they would use for the different levels of population baseline units would be local (L), which meant the population was essentially restricted to Delaware Bay; regional (R) which meant the population was restricted to the Mid-Atlantic area, and national/international (N) for broader populations.

The second day began with a review of the discussions of Day 1. Some additional, minor changes were made to the resources at risk table, and the issue of where to divide shallow and deep habitat was again raised, with some participants suggesting that it might be useful to divide the less than 20-foot habitat into 0 to 10 feet and 10 to 20 feet. It was agreed that this could be discussed in the focus groups, but that the table would use the 20-foot demarcation. Dr. Aurand then gave an overview presentation on oil spill basics. Following that presentation, the participants were divided into focus groups (see Appendix A) and began the risk assessment process for natural recovery.

On day three the focus groups completed and discussed the risk scoring for natural recovery and on-water mechanical recovery, and began work on the dispersant use option. Prior to beginning consideration of any of the response options under review, Dr. Aurand, presented an overview of response options.[3] The on-water mechanical recovery discussions were preceded by a presentation by Mr. Eugene Johnson, Delaware Bay and River Cooperative, Inc. on available resources and recovery strategies for the Delaware Bay (see On-Water Recovery on the workshop CD). The participants agreed, after significant discussion, to use an effectiveness of 25% for on-water mechanical recovery. After the focus groups completed their review of on-water mechanical recovery, Dr. Aurand gave an introduction to dispersants. He was followed by Dr. Alan Mearns, who reviewed the results of the GNOME and ADIOS modeling for dispersant use at an assumed effectiveness of 85%

[3] The presentations "Overview of Response Options" and "Introduction to Dispersants" are part of a dispersant training course that is offered by EM&A. More information on these presentations may be obtained by contacting EM&A directly.

(see the Dispersant at 85% Surface Oil Shown and Dispersant at 85% No Surface Oil[4] files on the workshop CD). There was a great deal of discussion concerning the realism of the 85% effectiveness option. The facilitation team explained that it was not meant to imply that it was expected to be achieved, but rather to allow the analysis of a "worst case" situation for water column exposure. After questions and answers, the focus groups had approximately one hour to consider the dispersant option.

All of the groups successfully ranked natural recovery and on-water mechanical recovery, but did not complete the evaluation of the consequences of dispersant use. At the end of the session, they developed a list of items to be addressed at the beginning of the second workshop:

- Participants want information/presentation on current dispersant policy.
- Participants would like to see another percentage of effectiveness (35% modeling run); also loading rate data for shoreline impacts for all three scenarios.
- Is there more information on aquatic amphipods, mollusks, etc. – in general, what are they and what is their function within the environment?
- May be useful to show a foodweb (direct, indirect) for this system for this time of year (Living Resources of the Delaware Estuary – bring a copy for each participant).
- If there were a proposed change on dispersant use policy, what process would be used to approve it?
- Have five hard copies of the Environmental Sensitivity Index for the next workshop.
- Bring additional toxicity data (if available) on species and/or information on natural bioavailability at or in the benthic environment and in the water column.
- Provide the quantity of dispersed oil entering the Broadkill and Liepsic Rivers.
- Participants should review the current Delaware Bay Area Contingency Plan prior to the next meeting.
- Get information on dispersed oil impacts at the molecular level on Horseshoe Crab eggs.
- Bring toxicity data on oil and dispersed oil biouptake by polychaetes.

In addition, the participants noted that the risk from this scenario was serious (based on the season and trajectory) for what was a relatively small spill, and that it really presented a challenge to decision-makers based on the risks to shorebirds and Horseshoe Crab eggs. The participants recommended considering other scenarios (seasonality, different oils, and/or different locations) if possible.

After introductions, the second workshop (14-16 February) began with a movie entitled "Introduction to Dispersants and Their Application," prepared by Oil Spill Response Limited (OSRL). This was followed by a presentation by Drs. Aurand and Coelho (facilitators, EM&A) which addressed many of the questions raised at the end of the first workshop (see the Additional Data file on the workshop CD). This was followed by a

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[4] At the workshop, only the first of these files was available, but it was difficult to see the dispersed oil trajectory, so the second file, which does not show the oil remaining on the surface was developed for inclusion in the CD.

presentation by Mr. Gerald Conrad on the current dispersant policy in the Delaware Bay. The policy is available in the Sector Delaware Bay Area Contingency Plan, which is available at two internet locations. These are the USCG Sector Delaware Bay website at http://www.uscg.mil/d5/sector/delawarebay/Area_Committee.htm and the USCG Homeport website, http://homeport.uscg.mil/mycg/portal/home/do. He indicated that the ERA process will not directly result in any reconsideration or changes in policy, but that the issues being discussed are very important for future planning. If there were to be changes, there would need to be a formal consideration by the Sector Delaware Bay Area Committee, which would include extensive coordination and environmental review by both state and federal agencies. The current program for dispersant use monitoring was also discussed by Mr. Ben Anderson (also available in the Sector Delaware Bay Area Contingency Plan).

It should be noted that there was an oil spill incident in New Jersey which prevented a number of participants from attending and caused several others to leave early on the first day. This led to a decision to consolidate the remaining participants into three groups, since most of the missing participants were from two of the original groups. These changes are described in Appendix A (Participants). In Section 4, the results for all five groups are shown for natural recovery and on-water mechanical recovery, which were the two options scored in the first workshop. Results for dispersants and on-shore mechanical recovery are shown only for focus groups one, three and five (which had the additional members at meeting two).

Dr. Alan Mearns then presented the GNOME and ADIOS results for the use of dispersants at 35% effectiveness (see the Oil Spill Scenario 2[5], Dispersant at 35% Surface Oil Shown and Dispersant at 35% No Surface Oil files on the workshop CD). He also reviewed the results of the surface oil trajectory analysis and the evaluation of dispersant use at 85% effectiveness for a comparison. When this was completed, the participants were asked if they wanted to score dispersants at both effectiveness levels, or just one. The group chose to score both. The remainder of day one was spent with the focus groups completing the evaluation of the dispersant option.

Day two opened with a review of the results for natural recovery, on-water mechanical recovery, and dispersant use (35% and 85% effectiveness). The participants reviewed and discussed the differences between the various focus groups, and why they might have occurred. In general, however, there was good agreement between the three remaining groups. This was followed by an introduction to shoreline recovery by Dr. Aurand, and a presentation on shoreline recovery in the Delaware Bay area by Mr. Pat McGovern of Clean Venture, Inc. (see Delaware Bay Shoreline Recovery on the workshop CD). Dr. Alan Mearns also reviewed the results of a bioremediation study conducted on Slaughter Beach in the mid-1990s. The participants decided, based on Dr. Mearn’s presentation, that they did not need to consider bioremediation in this workshop. Participants then discussed the effectiveness of shoreline recovery, and decided that it would not be possible to select one value to use in the analysis. Participants were reminded that protective booming should be assumed during the evaluation. The participants completed their review of on-shore mechanical recovery prior to lunch.

The remainder of day two was spent discussing possible ways to address other scenarios and/or the critical factors in the scenario which they just completed. There was support for considering the effects of a larger spill, a different product, a different season, and

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[5] This presentation includes the information on dispersant use at 35% effectiveness, as well as many of the same slides used in the original presentation at the first workshop.

a location further up into the Delaware River. A number of participants felt, however, that we could not do justice to such discussions without a comprehensive scoring, and there was not sufficient time remaining to do that. A decision was made by the Steering Committee to have the three focus groups meet individually for approximately 1.5 hours to have open discussions about the key factors in their analysis and to develop a list of items they would like to share with the group. The focus groups were told to consider the following two questions:

- What were the ‘drivers’ that affected your decisions in this scenario?
- How would changes in those areas change your conclusions?

Day two ended with the participants reviewing the results of their discussions, which are presented in Section 5.1

Day three was a half-day session devoted to a discussion of recommendations and conclusions. These are presented in Section 5.2.

3.0 Exercise Scenario and Basic Analytical Information

3.1 Exercise Scenario

After considering a variety of options, the Steering Committee developed a scenario which threatened both the Delaware and New Jersey shorelines. This was done by changing the wind direction partway through the scenario. There was no narrative scenario developed, but the summary spill conditions are presented in Table 3.1. The weather conditions are within normal ranges for spring, and the volume released is consistent with a collision or grounding leading to a partial loss of cargo (one compartment on a larger vessel). Nigerian Qua Iboe crude oil is a commonly transported oil in the Delaware Bay, and it was tested and found to be dispersible by NOAA prior to the workshop. This information was presented to the participants on the first day for review and accepted. The participants felt that the scenario represented serious risk to natural resources, and really challenged the managers to discuss the risks to shore birds and breeding Horseshoe Crabs.

Table 3.1 Key Parameters for the Delaware Bay Scenario.

Time/Date	0600 on 20 May 2006
Location	39º15.66 N 75º20.33W
Volume	60,000 gallons (1432 barrels)
Oil Type	Nigerian Qua Iboe
Specific Gravity	API 36.2
Wind Speed	10 to 15 knots (variable directions)
Air/Water Temperature	15º C

3.2 Geographic Area of Concern

The general area of concern was the Delaware Bay south of the spill site, and the open ocean waters immediately adjacent to the mouth of the Bay. The approximate extent of the area is defined by the extent of the map in Figure 3-3, which shows the surface oil trajectory. The area includes all of Delaware Bay and its shoreline south of the release point, as well as the ocean area and associated shoreline immediately adjacent to the mouth of the Bay.

3.3 Resources of Concern

Participants reviewed and agreed to use the resource table developed by the facilitators for the Steering Committee prior to the meeting with minor modifications to the list of representative species, and some changes to the proposed habitats and subhabitats. The final table is presented in Appendix B. The major discussion items and their resolution were:

- Delaware salt marshes contain a large number of impoundments, which could be contaminated. Participants agreed to assume that tidal access (via tide gates) could be shut off during an oil spill, so that contamination would not occur.
- Marine habitat was defined as the area outside of a line connecting Cape May and Cape Henlopen. The bay is the area inside of the Capes.
- The category "Structured Hard Bottom Community" on the table refers to non-oyster communities, and includes sabellid reefs, dense clam or mussel beds, and artificial reefs.
- The issue of listing protected species as a separate category on the table was discussed and the participants agreed that it was unnecessary, based on the proposed ranking system (impacting such a species leads to a high percentage impact and/or long recovery, resulting in a high risk).
- There was considerable discussion as to whether or not a depth of 20 feet was the appropriate level at which to divide "shallow" and "deep" subtidal and water column communities. Since Delaware Bay has extensive areas which are less than 20 feet deep, there was some interest in having an area of 0-10 feet and then an area of 10-20 feet in depth. Ultimately, the one area was used, and the participants were instructed to discuss the issue in their focus groups, and to add comments to the ranking score if it proved to be critical to their discussions.

3.4 Conceptual Model

During discussions about the general analytical process, the participants agreed that developing a detailed conceptual model was not necessary for their purposes. As an alternative, they accepted the list of seven hazards developed initially in a detailed conceptual model prepared for the San Francisco Bay workshop (Pond et al., 2000) that have been used in all subsequent workshops. They agreed that these should be considered for each of the proposed response options (these hazards are air pollution, aqueous exposure, physical trauma, oiling/smothering, thermal, waste and indirect). The response options to be considered would be natural recovery (no response), on-water mechanical recovery, dispersant application, on-shore mechanical recovery and, if time was available, on-shore in-situ burning.

3.5 Modeling Results

The NOAA HazMat Modeling Group used the basic information in the scenario to develop a surface trajectory and a dispersed oil trajectory analysis using GNOME for the detailed risk assessment portion of the workshop. Basic weathering information was calculated using the ADIOS II program. Mass balance estimates are presented in Tables 3.2

(oil only) and 3.3 (emulsified oil) and in Figures 3.1 and 3.2. This oil (Nigerian Qua Iboe crude oil) emulsifies quite rapidly, but is dispersible early in the spill. The volume present in the environment more than doubles in twelve hours and ultimately more than 300,000 gallons of mousse are present, which is six times the volume that was originally released. Table 3.4 shows the volume of oil and emulsion present on six shoreline segments if no response options are implemented.

Table 3.2 Oil Budget (in Gallons) Budget for Undispersed and Dispersed Oil (35 and 85% Effectiveness) as Predicted in the Delaware Bay Scenario, Initial Spill Volume 60,000 Gallons.

Oil in the Environment, 24 Hours Post-spill				
Response	Floating	Beached	Dispersed	Evaporated
No Dispersal	24,348	6,804	4,656	24,192
Disperse 35%	15,444	4,692	17,688	22,176
Disperse 85%	3,516	1,116	36,024	18,344
Oil in the Environment, 48 Hours Post-spill				
Response	Floating	Beached	Dispersed	Evaporated
No Dispersal	22,080	7,944	4,656	25,320
Disperse 35%	14,172	5,352	17,688	22,788
Disperse 85%	3,072	1,356	36,024	19,548

Table 3.3 Water-in-oil Emulsion (Mousse) and Oil Budget (in Gallons) for Undispersed and Dispersed Oil (35 and 85% Effectiveness) as Predicted in the Delaware Bay Scenario, Initial Spill Volume 60,000 Gallons, 89.9% Emulsification in 30 Hours.

Emulsion in the Environment, 24 Hours Post-spill			
Response	Floating	Beached	Total Emulsion
No Dispersal	183,068	51,158	234,226
Disperse 35%	116,120	35,278	151,398
Disperse 85%	24,902	8,391	33,293
Emulsion in the Environment, 48 Hours Post-spill			
Response	Floating	Beached	Total Emulsion
No Dispersal	218,614	78,653	297,267
Disperse 35%	140,317	52,990	193,307
Disperse 85%	30,059	13,426	43,485

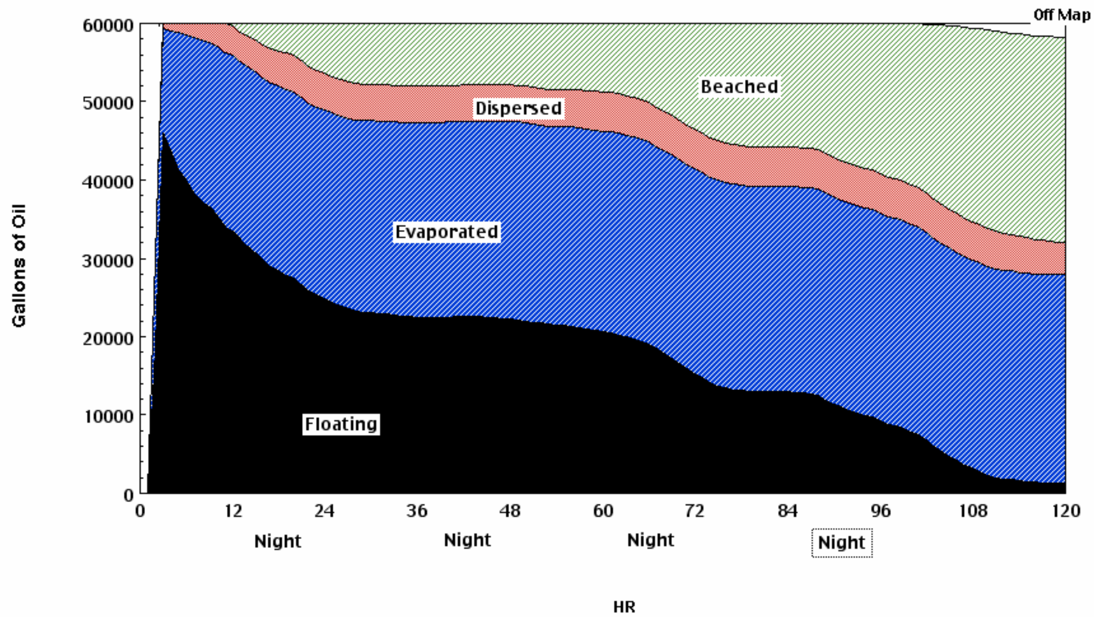


Figure 3.1 *The ADIOS predictions for the fate of the floating oil (emulsification not considered) in the Delaware Bay scenario if no response options are employed.*

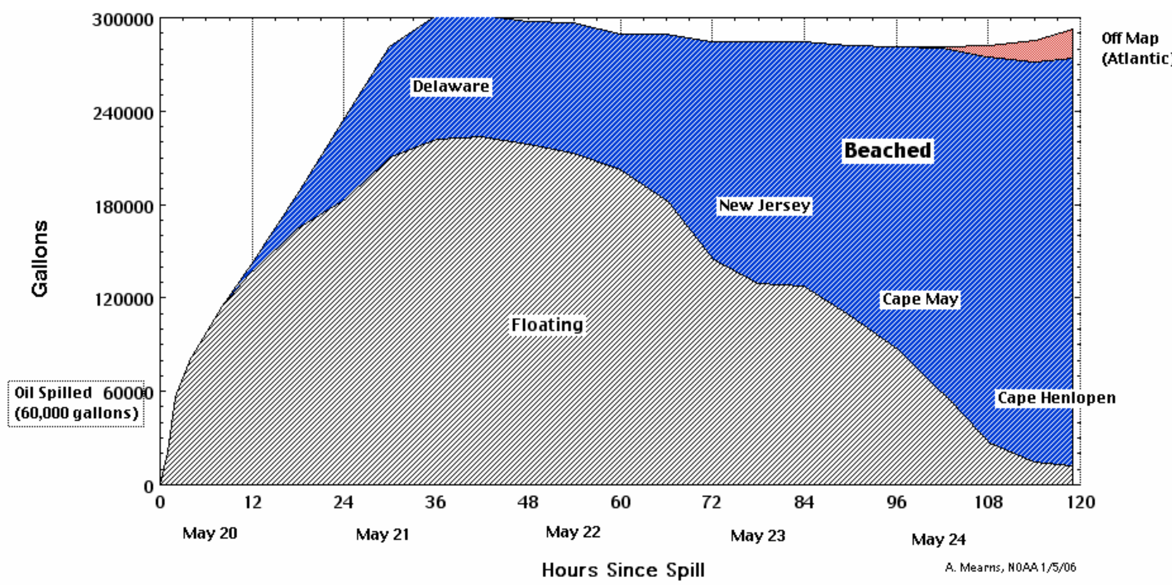


Figure 3.2 *The ADIOS predictions for floating and beached oil when emulsification is considered in the Delaware Bay scenario if no response options are employed.*

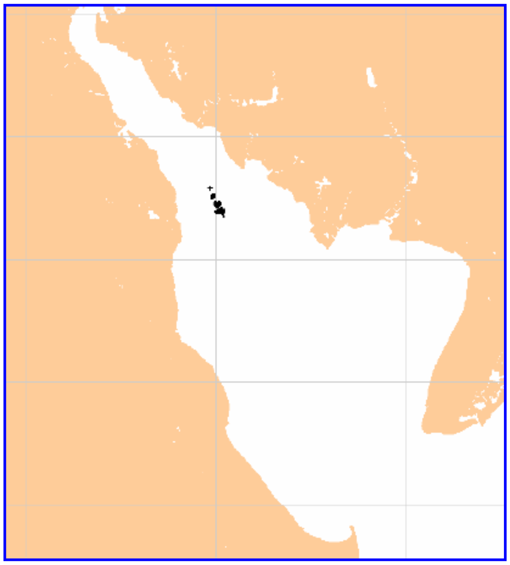
Selected snapshots from the surface oil trajectory modeling results are shown in Figure 3.3. The average concentration in the dispersed oil plume produced without the use of dispersants (Figure 3.4, at an expanded scale) is compared to toxicity threshold values for adult crustaceans (Figure 3.5) and sensitive life history stages (Figure 3.6) (see Table 4.1 and the associated discussion in Section 4 for information on development and interpretation of thresholds). Figure 3.7 presents the same data as in Figure 3.6, but at an expanded scale in order to clarify the relationship between thresholds and observed concentrations.

While the movement of the floating oil is heavily influenced by tidal flow, wind is the primary mover for surface oil. Under the modeled wind conditions the oil initially moves towards the Delaware shore, in the vicinity of Bombay Hook and further south. After approximately 30 hours the wind changes and the slick moves towards the New Jersey shore, stranding from the vicinity of Fortescue, NJ all the way to Cape May. Finally, after approximately three days the remaining floating oil leaves Delaware Bay and moves south along the Atlantic coast. The volumes of oil (or emulsion) present in several locations are given in Table 3.4. Given the volume of the initial spill, the volumes of emulsion which strand near Bombay Hook, DE and Cape May, NJ are quite large, and there is also considerable volume inside the hook of Cape Henlopen, DE as well as south of Cape Henlopen along the Atlantic shore.

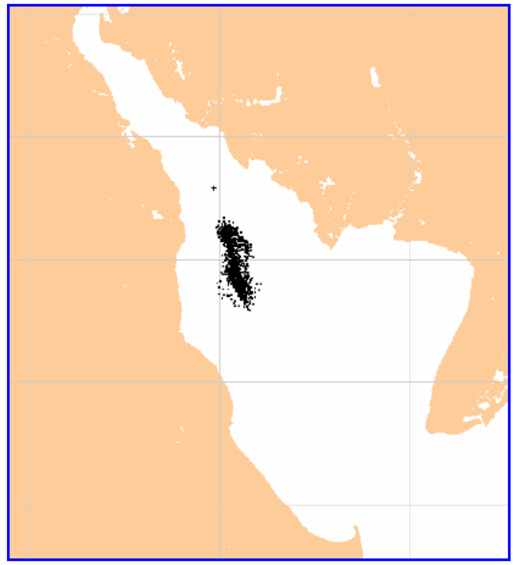
Table 3.4 The Estimated Gallons of Oil and Emulsion on Six Shoreline Segments for the Delaware Bay Scenario if No Response Options are Employed.

Shoreline	Oil	Emulsion
Bombay Hook	8,040	72,000
Egg Island area	420	3,800
North Cape May	64	600
Cape May	6,672	60,000
Cape Henlopen	3,012	27,000
South of Cape Henlopen	3,292	29,600

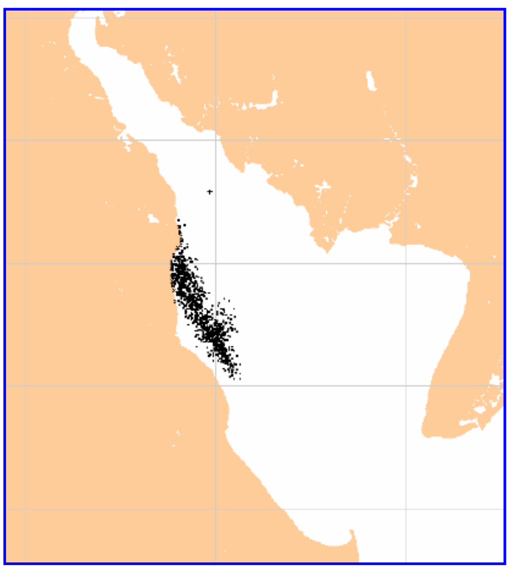
Average concentrations in the water column with no response (Figures 3.4 to 3.7) do not exceed any of the thresholds presented for adult crustaceans or for sensitive life history stages. The maximum concentrations exceed the ‘low level of concern’ threshold for sensitive life history stages but not for adult crustaceans. This situation would apply only to animals which remained in contact with maximum concentrations for a period of at least several hours. In general, there is insufficient oil dispersed or dissolved to represent a threat to water column organisms except in the immediate vicinity of the slick, and then only in the surface layer (0 to 2 meters).



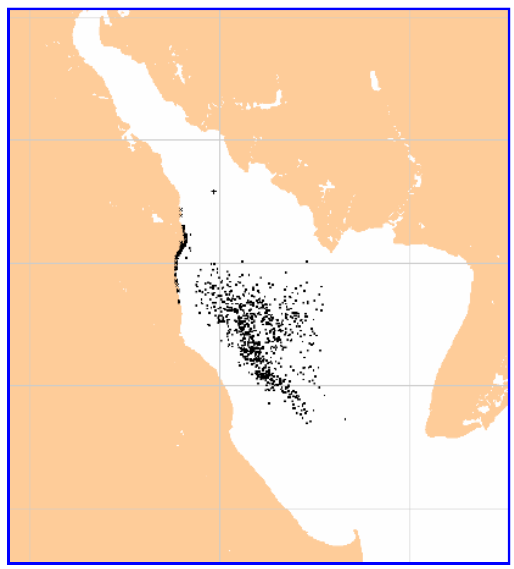
A: 1 Hour



B: 7 Hours



C: 18 Hours



D: 42 Hours

Figure 3.3 *Results from the NOAA GNOME modeling for the Delaware Bay scenario surface oil slick trajectory.*

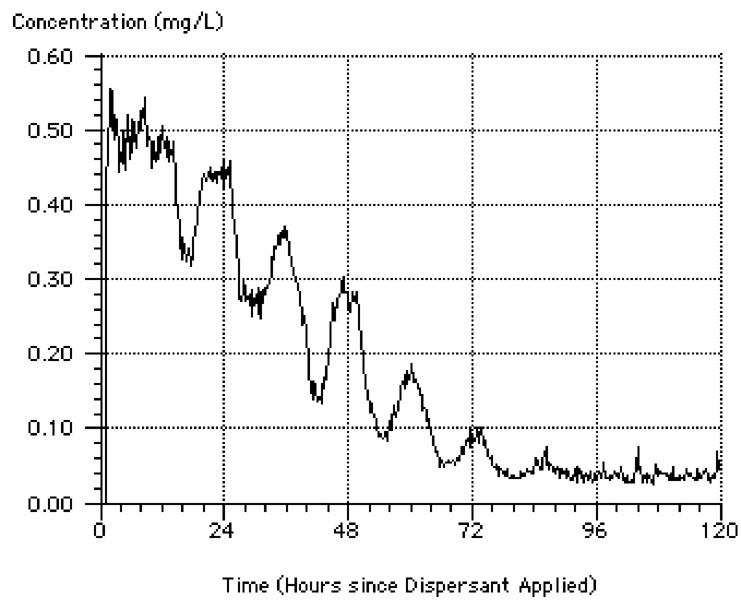


Figure 3.4 *Average dispersed oil concentration from 0 to 2 meters in the plume versus time without the use of dispersants.*

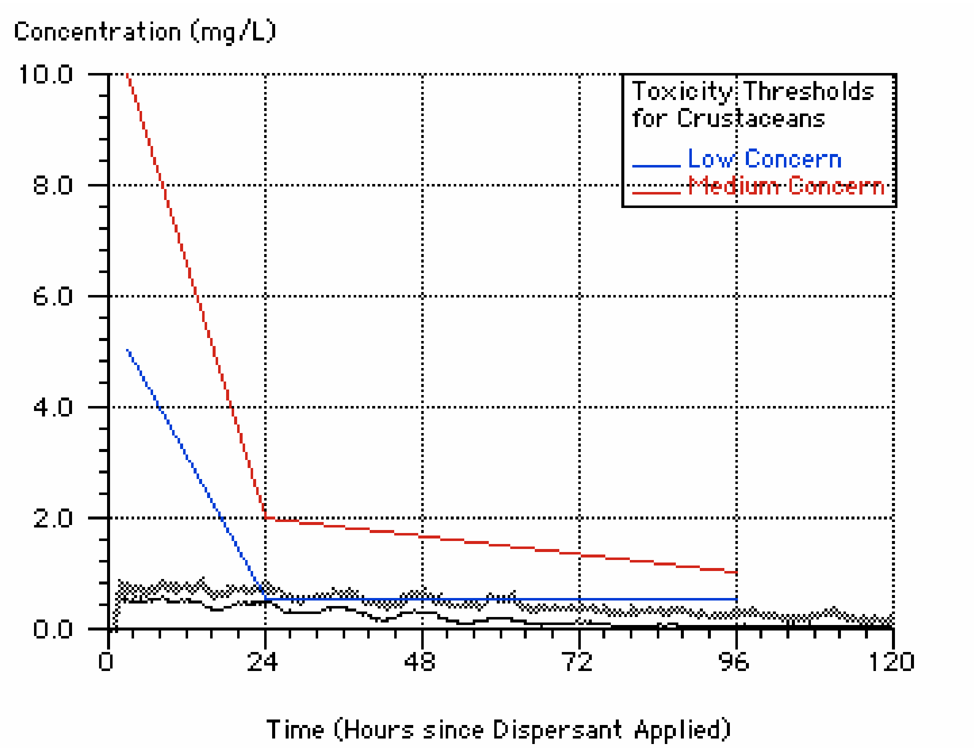


Figure 3.5 *Toxicity thresholds for dispersed oil for adult and juvenile crustaceans compared to maximum and average dispersed oil concentrations at 0 to 2 meters without the use of dispersants (based on the values presented in Table 4.1).*

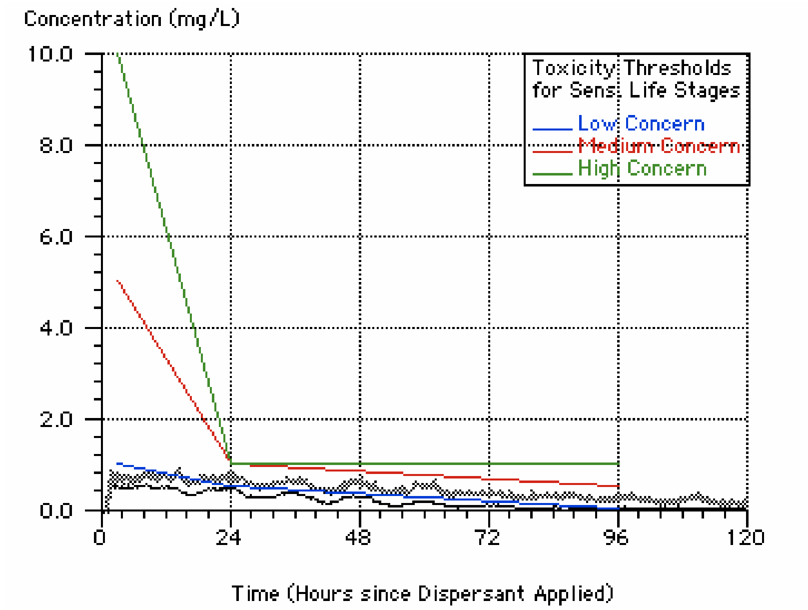


Figure 3.6 *Toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations at 0 to 2 meters without the use of dispersants (based on the values presented in Table 4.1).*

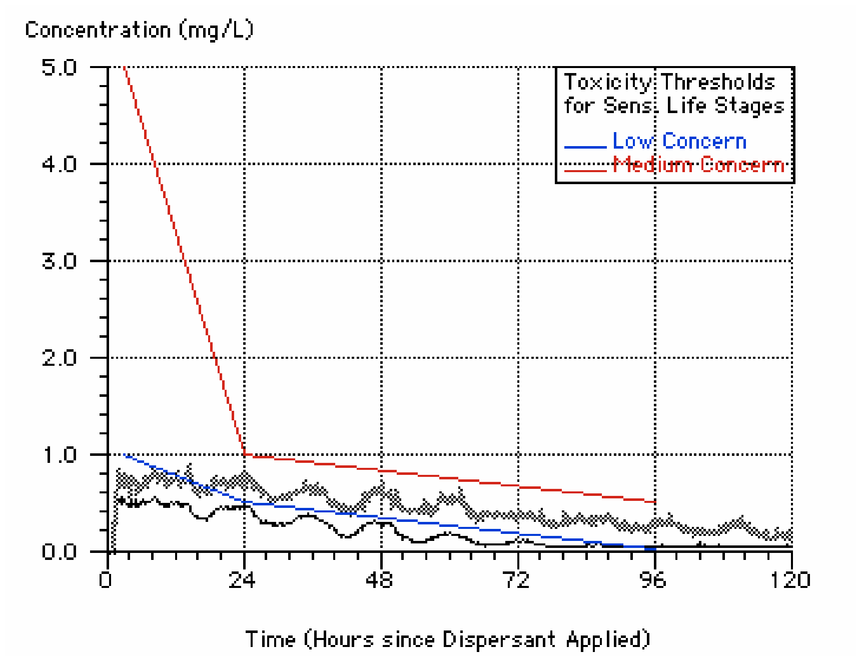


Figure 3.7 *Conservative toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations at 0 to 2 meters without the use of dispersants (based on the values presented in Table 4.1).*

Snapshots from the dispersed oil modeling results are shown in Figure 3.8 for 85% effectiveness and in Figure 3.9 for 35% effectiveness. For clarity, oil remaining on the surface has been removed from the frames. Figure 3.10 depicts fate of the oil slick when dispersants are applied at 85% effectiveness, while Figure 3.11 shows the effect of the dispersant application at 6 hours on emulsion formation.

By comparing Figure 3.3 to Figures 3.8 and 3.9, the differences in the trajectory for the surface oil and the dispersed oil plume are noticeable. This is even more obvious in the QuickTime trajectory movies on the workshop CD. The dispersed oil plume moves with the estuarine currents, and shows a strong tidal oscillation, while the surface slick responds to the wind field. As a result, different areas of the estuary are exposed when dispersants are applied. A second obvious result is the dramatic reduction in emulsion formation, and in the amount of oil stranding (Tables 3.2 and 3.3). For example, after 48 hours almost 79,000 gallons of emulsion have beached with no response, while with dispersant application at 85% effectiveness this number is reduced to approximately 13,500 gallons. On-water mechanical recovery, assuming an effectiveness of 25%, would lead to a reduction similar to that estimated for dispersants at 35% effectiveness, assuming that the emulsion could be effectively recovered and stored in the short term.

This reduction in shoreline impact with dispersant use comes at the expense of increased exposure to organisms in the water column. Figure 3.12 shows the maximum and average water column concentrations in the top 2 meters when dispersants are used at 85% effectiveness. Maximum concentrations initially peak at approximately 2 parts per million (ppm), and rapidly decline over time as dilution occurs. Average concentrations peak slightly later at approximately 0.75 ppm and then also decline with dilution. Table 3.5 shows the area of the dispersed oil plume (defined as any grid cell in the model where the presence of oil is predicted) over time, along with the average and maximum concentrations. For comparative purposes, the approximate volume of the Delaware Bay is 13 billion cubic meters, and the approximate surface area is 1,773 square kilometers (Sutton *et al*., 1996). So the contaminated area at 48 hours amounts to 4.7% percent of the total area of the Bay. The affected volume at that time, based on the assumed mixing depth of 2 meters, is less than 0.1%.

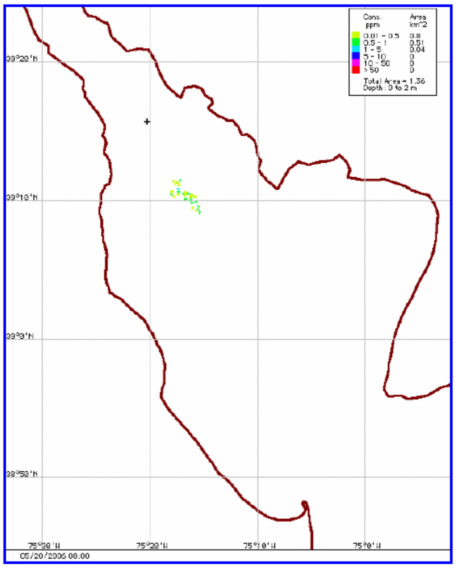
Table 3.5 Estimated Dispersed Oil Plume Extent and Concentrations, Over Time, When Dispersants are Used at 85% Effectiveness.

Hours Into Spill	Area (sq. km.)	Depth (m)	Average Concentration (ppm)	Maximum Concentration (ppm)
0	0.0	0.0	0.00	0.00
6 (Spill Dispersed)	25.7	2.5	1.00	2.00
12	38.8	4.5	0.75	1.60
24	58.3	2.5	0.47	0.63
48	83.6	2.0	0.34	0.66
72	213.5*	2.5	0.09	0.37

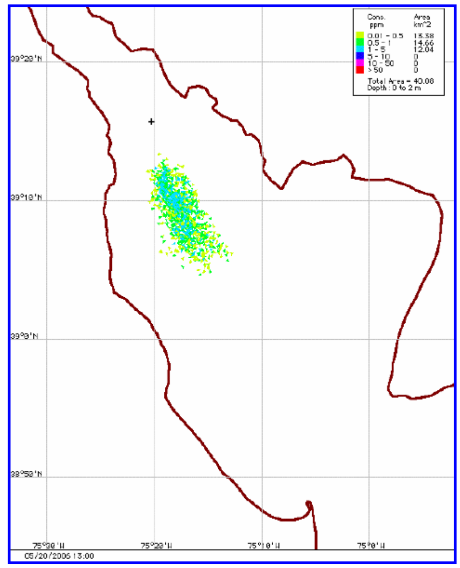
* Approximately 50% of the plume is outside of Delaware Bay at this time.

Figure 3.13 compares the maximum and average water column concentration in the top 2 meters when dispersants are used at 85% effectiveness to the thresholds of concern for adult and juvenile crustaceans. Figure 3.14 shows the same information at an expanded scale. Only the low level of concern threshold is exceeded, and then only for the maximum concentrations, which do not represent a large proportion of the plume. Figure 3.15 compares these concentrations to the conservative toxicity thresholds for sensitive life history stages. In this case the low level of concern threshold is exceeded for both the average and maximum concentrations, and the medium and high level of concern thresholds are approached at the 24-hour mark for the maximum concentrations. This suggests a low risk to planktonic organisms present in the dispersed oil plume, with a higher risk to those in the areas of high concentration. Figure 3.16 compares these concentrations to the low level of concern threshold for adult fish. The maximum concentration curve approaches the threshold at 24 to 36 hours, but does not exceed it. Figure 3.17 compares the exposure profile at a specific point in the Bay to the toxicity thresholds for adult and juvenile crustaceans (as representative of the benthic community). The data suggests that benthic organisms would be at low risk during this spill scenario.

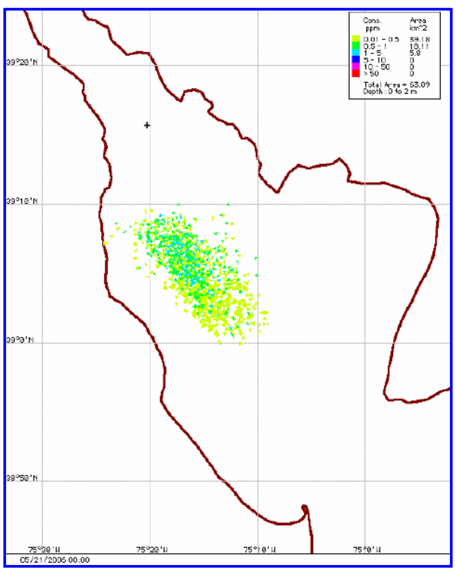
Finally, Figure 3.18 shows the maximum and average concentrations of dispersed oil when dispersants are used at 35% effectiveness. Figure 3.19 compares these values to the thresholds for sensitive life history stages. This is the only comparison presented, since it is the only one where predicted values at 35% effectiveness approached the thresholds. In this case, the low level of concern threshold falls between the average and maximum concentration curves, suggesting that animals in the portions of the plume with higher than average concentrations could be at risk.



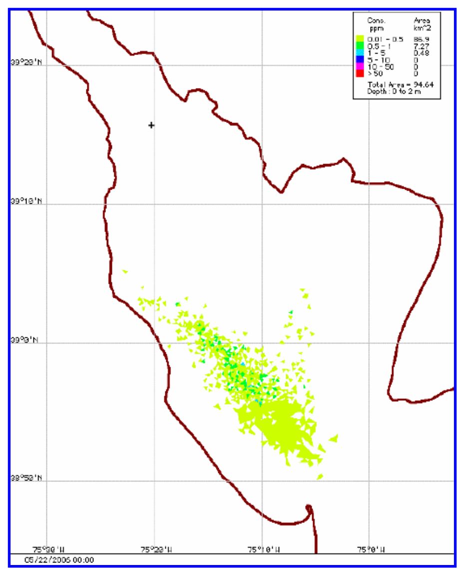
A: 3 Hours



B: 7 Hours (D + 1 Hour)



C: 18 Hours (D + 12 hours)

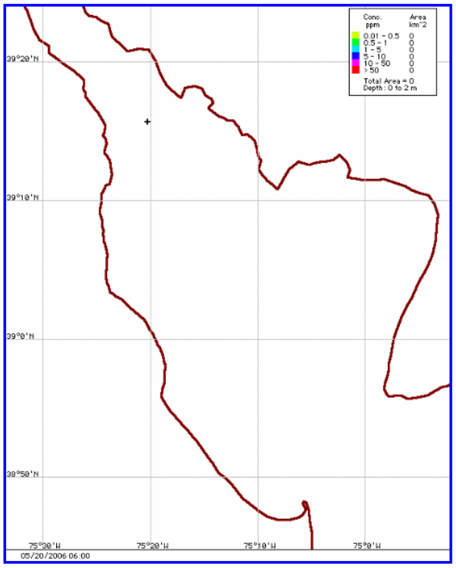


D: 42 Hours (D + 36 hours)

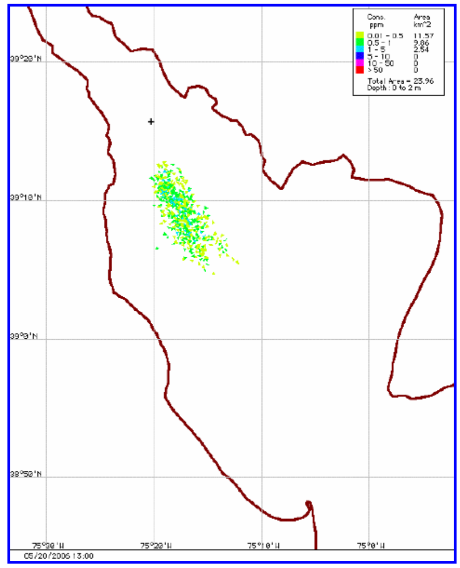
Key:

Light green	<0.5 ppm
Medium green	0.5 - 1 ppm
Light blue	1 - 5 ppm
Dark blue	5 - 10 ppm
Pink	10 - 50 ppm
Red	>50 ppm

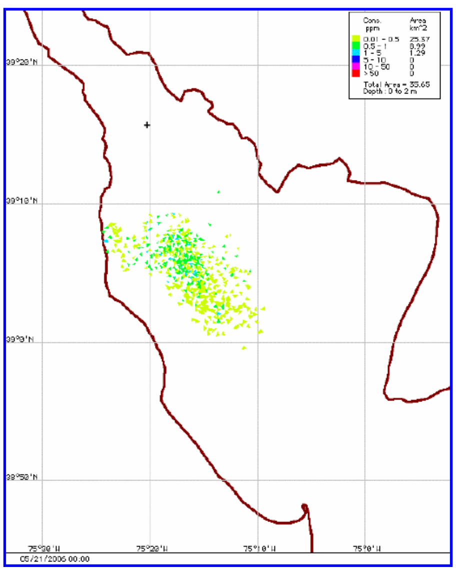
Figure 3.8 *Results from the NOAA GNOME modeling for the Delaware Bay scenario for dispersant use at 85% effectiveness showing average dispersed oil concentrations (in ppm) from 0 to 2 meters (surface oil remaining not shown).*



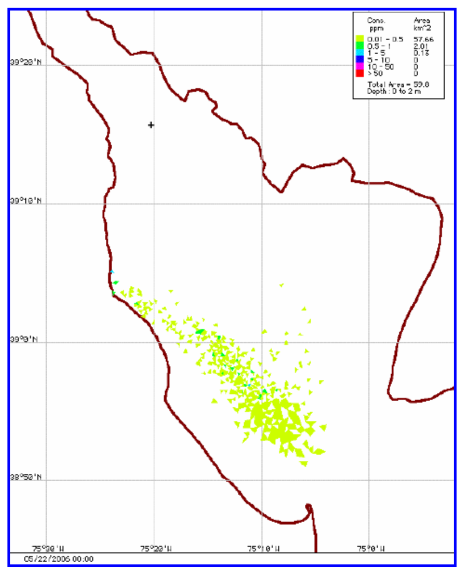
A: 1 Hour



B: 7 Hours (D + 1 Hour)



C: 18 Hours (D + 12 Hours)



D: 42 Hours (D + 36 Hours)

Key:

Light green	<0.5 ppm
Medium green	0.5 - 1 ppm
Light blue	1 - 5 ppm
Dark blue	5 - 10 ppm
Pink	10 - 50 ppm
Red	>50 ppm

Figure 3.9 *Results from the NOAA GNOME modeling for the Delaware Bay scenario for dispersant use at 35% effectiveness showing average dispersed oil concentrations (in ppm) from 0 to 2 meters (surface oil remaining not shown).*

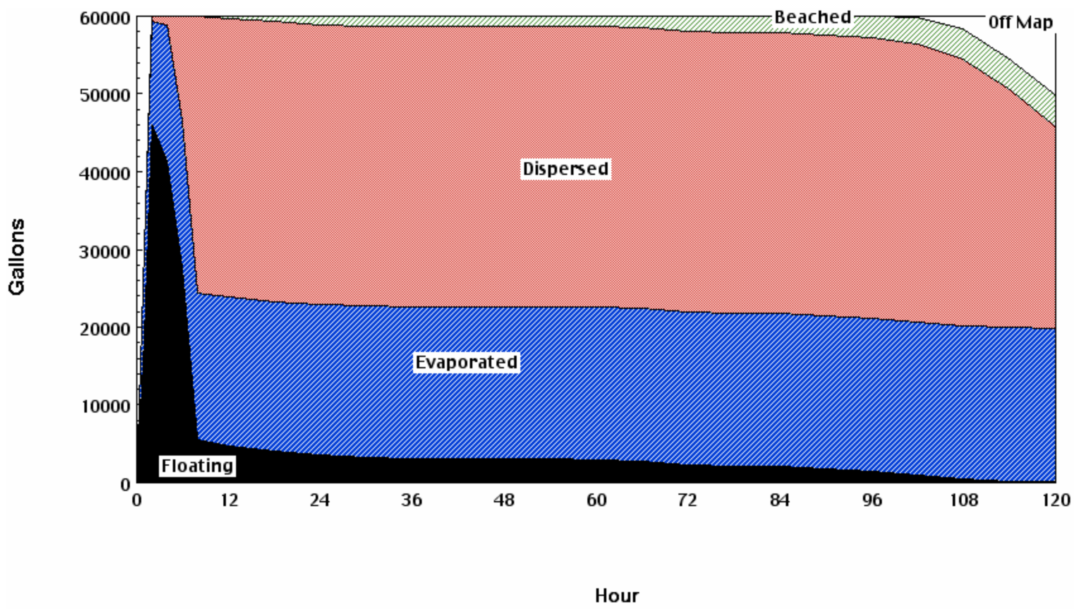


Figure 3.10 *The ADIOS predictions for the fate of the floating oil in the Delaware Bay scenario with the use of dispersants at 85% effectiveness.*

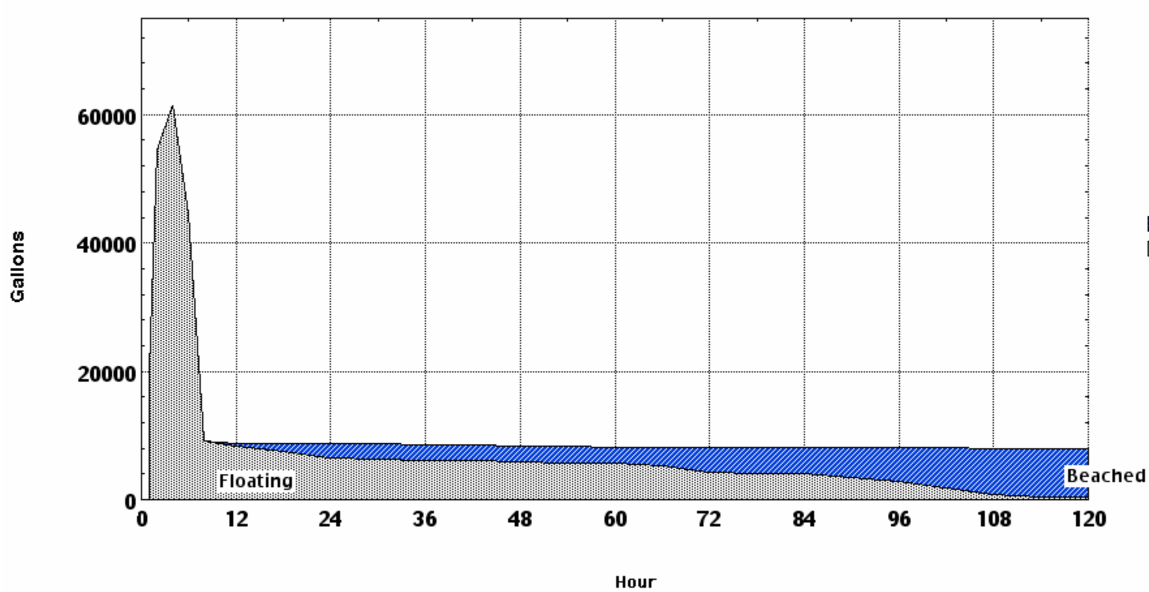


Figure 3.11 *The ADIOS predictions for the fate of emulsion in the Delaware Bay scenario with the use of dispersants at 85% effectiveness.*

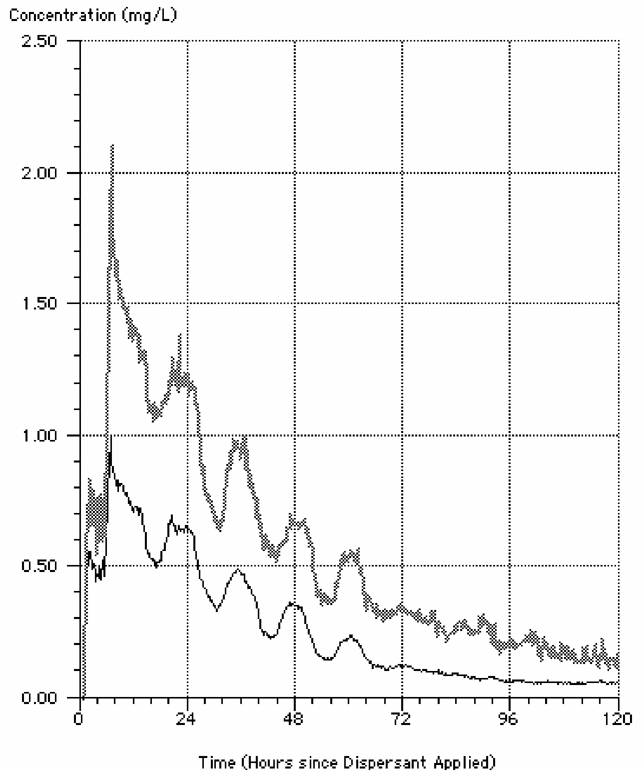


Figure 3.12 *Maximum and average dispersed oil concentration from 0 to 2 meters in the plume versus time with the use of dispersants at 85% effectiveness.*

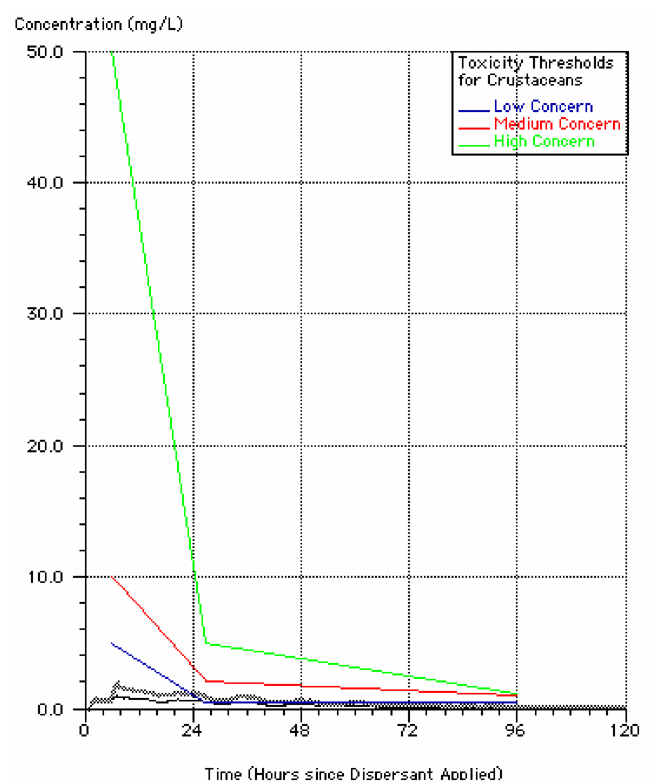


Figure 3.13 *Conservative toxicity thresholds for dispersed oil for juvenile and adult crustaceans compared to maximum and average dispersed oil concentrations with 85% effectiveness at 0 to 2 meters (based on the values presented in Table 4.1).*

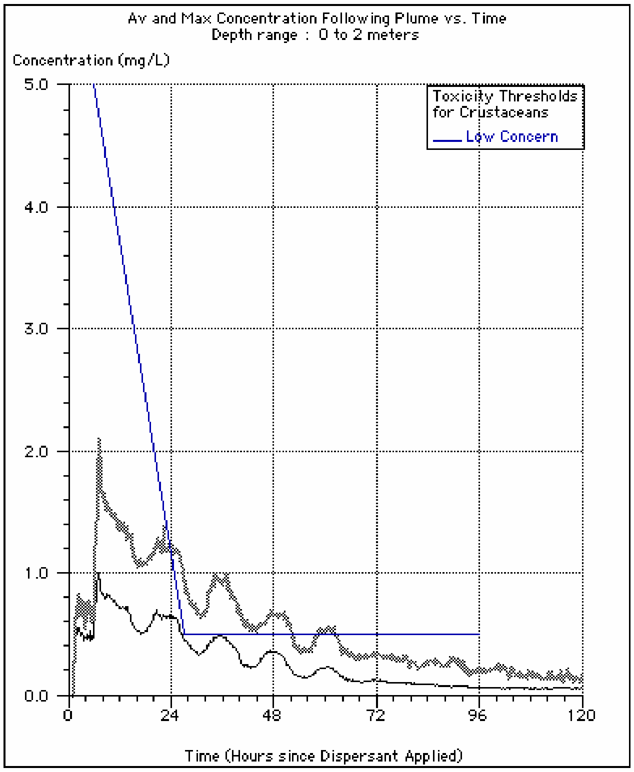


Figure 3.14 *An expanded view of the conservative low level of concern toxicity threshold for dispersed oil for juvenile and adult crustaceans compared to maximum and average dispersed oil concentrations with 85% effectiveness at 0 to 2 meters (based on the values presented in Table 4.1).*

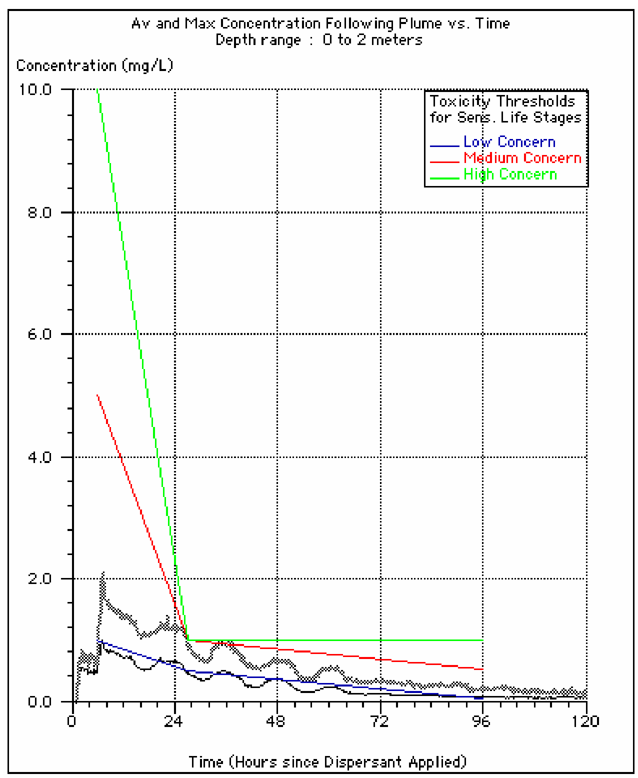


Figure 3.15 *Conservative toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations with 85% effectiveness at 0 to 2 meters (based on the values presented in Table 4.1).*

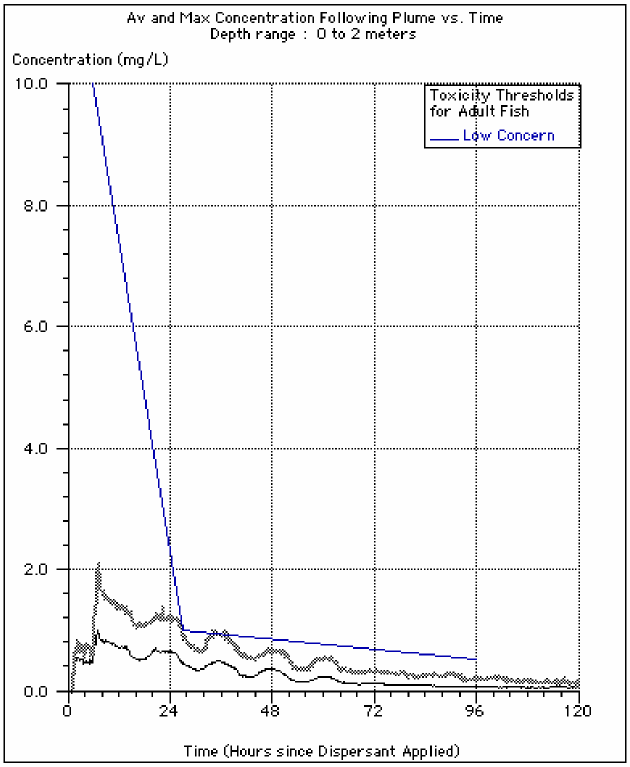


Figure 3.16 *Low level of concern toxicity threshold for dispersed oil for adult fish compared to maximum and average dispersed oil concentrations with 85% effectiveness at 0 to 2 meters (based on the values presented in Table 4.1).*

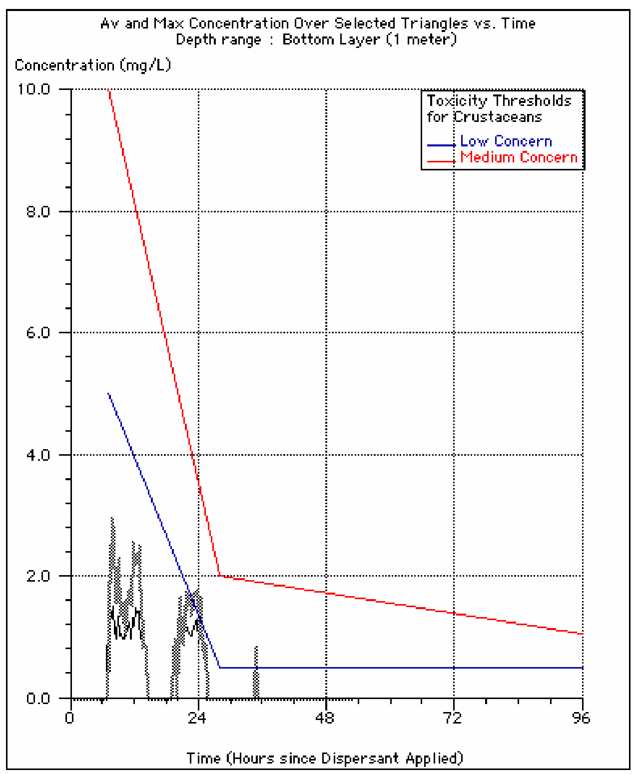
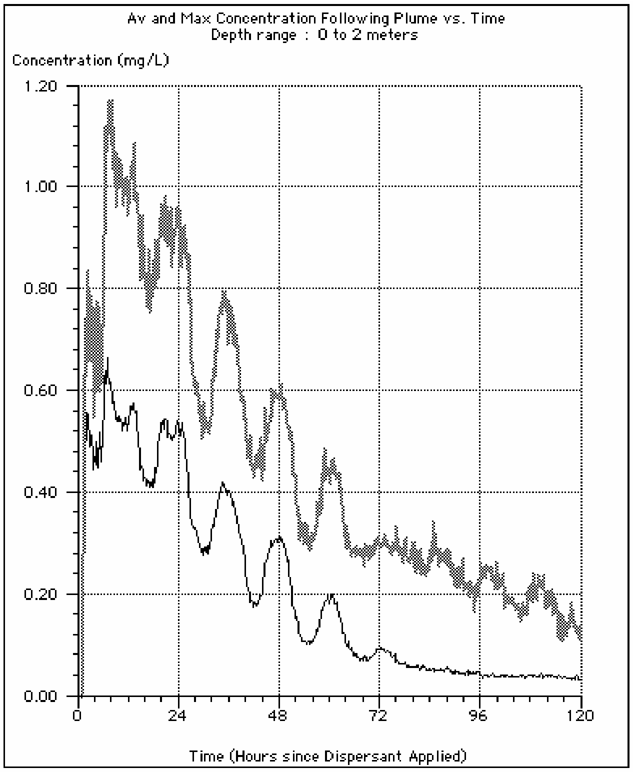


Figure 3.17 *Average and maximum exposure to dispersed oil for benthic habitat at a point on a shellfish reef in the middle of the Bay (39º48.21' W, 75º08.12' N) compared to maximum and average dispersed oil concentrations with 85% effectiveness (based on the values presented in Table 4.1).*

Figure 3.18 *Maximum and average dispersed oil concentration from 0 to 2 meters in the plume versus time with the use of dispersants at 35% effectiveness.*



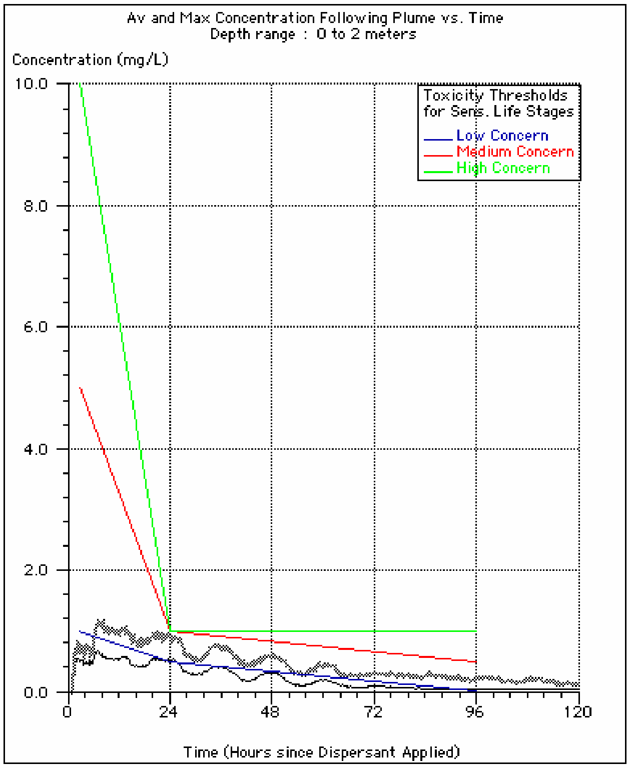


Figure 3.19 *Toxicity thresholds for dispersed oil for sensitive life history stages at maximum and average concentrations with 85% effectiveness (based on the values presented in Table 4.1).*

4.0 The Results of the Risk Analysis Process

Focus groups developed and then used the risk matrix presented in Figure 4.1 (see Section 2.0). Each focus group was tasked with reviewing the scenario, the modeling results, information on exposure and sensitivity to oil and dispersed oil, and basic life histories and distributions in order to develop a group estimate of the percent of each resource affected and the recovery time. In the initial evaluation, the groups used alphanumeric codes to rate the level of concern. After the scaling was developed in plenary session, color coding was used to indicate summary levels of concern.

		RECOVERY			
		> 10 years (SLOW) (1)	5 to less than 10 years (2)	1 to less than 5 years (3)	< 1 year (RAPID) (4)
PERCENT OF RESOURCE AFFECTED	> 50% (LARGE) (A)	1A	2A	3A	4A
	30 to 50% (B)	1B	2B	3B	4B
	10 to 30% (C)	1C	2C	3C	4C
	0 to 10% (SMALL) (D)	1D	2D	3D	4D

Legend: Red cells represent a "high" level of concern, yellow cells represent a "moderate" level of concern, and green cells represent a "limited" level of concern.

Figure 4.1 *Definition of levels of concern for the Delaware Bay risk assessment.*

Using the ranking matrix requires that the participants develop estimates of the proportion of the resource affected, and how long it will take the resource to recover. A key factor in determining whether or not a resource is affected is to apply thresholds at which impacts, either acute or chronic, would be expected to occur for the various resource groups under consideration. This is perhaps the most difficult part of the consensus process, and has been discussed in detail at all of the workshops. In this case, as in other workshops, very conservative assumptions were presented by the facilitator and accepted as guidelines by the participants.

The only thresholds which can be generally quantified are those related to aquatic toxicity. Table 4.1, reproduced from the Guidebook, presents a series of concentration thresholds which were made available to the participants. These values are based on a summary of published toxicity information initially developed during the early workshops. This table was reviewed by the National Academy of Sciences panel which recently considered issues related to dispersant use, and is included in their report (NRC, 2005).

Impacts to birds, mammals and turtles on the water surface were assumed if there was a high probability of any contact with the surface oil slick. The nature of these impacts was developed during the focus group discussions. For shoreline resources and habitats, damage was assumed if oil contacted the habitat. Table 4.2 presents estimates of shoreline exposure, based on varying loading rates. It was used for general guidance only and is based on average concentrations; actual shoreline accumulations of oil are generally irregularly distributed, especially at low concentrations.

It is important to keep in mind that the participants used the information available to them to develop levels of concern about the risk, and the risk scores do not represent a prediction of actual impacts. Instead they represent a consensus on the part of the participants that such consequences were likely to occur under the scenario under consideration.

Table 4.1 Consensus Exposure Thresholds of Concern (in ppm) for Dispersed Oil in the Water Column.

Continuous Exposure	Level of Concern	Protective of Sensitive Life Stages	More Protective Criteria	Protective of Adult Fish	More Protective Criteria	Adult Crustacea/ Invertebrates	More Protective Criteria
3 hours	Low	<5	<1-5	<10	<10	<5	<5
	Medium	5-10	5-10	10-100	10-100	5-50	5-50
	High	>10	>10	>100	>100	>50	>50
24 hours	Low	<1	<0.5	<2	<0.5	<2	<0.5
	Medium	1-5	.5-5	2-10	.5-10	2-5	.5-5
	High	>5	>5	>10	>10	>5	>5
96 hours	Low	<1	<0.5	<1	<0.5	<1	<0.5
	Medium			1-5	.0-5	1-5	.5-1
	High	>1	>0.5	>5	>5	>5	>1

The detailed results for all five focus groups for natural recovery (i.e. no response) are shown in Figure 4.2.[6] There were very high levels of concern in this scenario for organisms on the water surface, salt marshes, mud flats, sandy beaches and sand and gravel beaches in the estuary. There was also concern for sandy beaches (and in one group, terrestrial habitat) on the Delaware outer coast. The concerns within the bay were focused on the risk to shore birds and waterfowl, and to Horseshoe Crabs (adults and particularly eggs on the spawning beaches). The concern on the outer coast was for nesting Piping Plovers (and other threatened and endangered species), which are in the area, but only a few pairs are present. If there was to be any impact to the shore where these birds were known to nest, it was assumed they would be impacted. This elevated the level of concern. There was a consensus that exposure of benthic habitat and water column organisms were not a concern.

[6] For all options except natural recovery protective booming was assumed to be in place and reasonably effective (see Section 2.0 for further discussion).

Table 4.2 Estimates of Shoreline Exposure per Square Meter of Surface.

Width of Oiled Zone	Loading Rate											
	0.1 g/m			1 g/m			10 g/m			100 g/m		
	Volume per square meter (g/m^2)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m^2)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m^2)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m^2)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)
0.1 m	1	95	14	10	950	143	100	9,500	1,429	1000	95,000	14,286
0.5 m	0.5	47.5	2.86	5	475	28.6	50	4,750	286	500	47,500	2,857
1.0 m	0.1	9.5	1.43	1	95	14.3	10	950	143	100	9,500	1,429
10 m	0.01	0.95	0.143	0.1	9.5	1.43	1	95	14.3	10	950	143
100 m	0.001	0.095	0.0143	0.01	0.95	0.143	0.1	9.5	1.43	1	95	14.3

1. Oil density = 0.95 gms/cc
2. Soil density = 1.4 gms/cc

On-water mechanical recovery (Figure 4.3) did not significantly reduce the risk to the habitats of most concern, based on the estimate of the effectiveness of the equipment available (a maximum estimate of 25% recovery was used). Most groups did conclude that effective protective booming would protect salt marshes by preventing oil from entering tidal creeks.

The remaining three response options were analyzed at the second workshop, when only three focus groups were present.[7] The results for dispersant use at 85% and 35% effectiveness are presented in Figures 4.4 and 4.5 respectively. There was a consistent conclusion that the use of dispersants, if highly effective, would significantly decrease the impacts seen for the natural recovery and on-water mechanical recovery options.[8] While there was some increase in the level of concern for water column exposure, none of the focus groups felt it rose to beyond a moderate level of concern. The benefits were not seen by the focus groups unless the application was highly effective, but at the same time the concern for water column exposure also declined.

The final option, on-shore mechanical recovery (Figure 4.5), had essentially the same impacts as natural recovery and on-water mechanical recovery. While all of the groups felt shoreline cleanup was important, they did not believe it would mitigate their primary concerns. In some cases, concern over the impacts of the cleanup itself was expressed.

[7] As discussed in Section 2.0, two of the five groups lost enough members at the second workshop that the remaining participants were assigned to the other three focus groups. The changes in individual focus group assignments are documented in Appendix A.
[8] There was considerable discussion concerning how realistic it was to achieve this level of effectiveness. It was pointed out that the primary objective was to develop a "worst case" risk to the water column for evaluation purposes, and that there was no expectation that this would necessarily be achieved (see Section 2).

Estuary

Habitats	Terrestrial					
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	L 3C	4D	4D	3C
3	L 4D	L 4D	R 3D	L 4D	L 4D	3D
4	L 4D	L 4C	L 2B	L 4D	L 4D	2C
5	L 4D	L 4D	R 3D	L 4D	L 4D	3D

Habitats	Water Surface				
Group	Mammals	Birds	Reptiles and Amphibians	Plankton	Subhabitat
1	L 3C	L 2B	L 2B	L 4C	2B
2	4D	R 3B	N 2C	4D	2C
3	R 1D	L 2B	L 2B	L 3D	2B
4	L 4D	L 3A	L 3A	L 4D	3A
5	L 4D	R 2B	L 3D	L 4D	2B

Habitats / Subhabitats	Intertidal – Salt Marsh							
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Subhabitat
1	L 1B	L 2C	L 2A	L 1D	L 2C	L 3C	L 3D	1B
2	4C	4D	3C	4D	3D	3D	3D	3C
3	L 3D	L 3D	R 2B	L 2D	L 3D	L 3D	L 4D	2B
4	L 3B	L 3D	L 3D	L 3C	L 3C	L 3C	L 3C	3C
5	L 4D	L 3D	R 2B	L 4D	L 3D	L 3D	L 3D	2B

Habitats / Subhabitats	Intertidal – Mud Flat						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Subhabitat
1	L 4C	L 3A	L 4D	L 3C	L 3C	L 3C	3A
2	4D	2B	3C	3D	3D	3D	2B
3	L 4D	L 2C	L 3D	L 1C	L 3C	L 4C	1C
4	L 4D	N 1C	L 4D	L 4D	L 3C	L 3C	2C
5	L 3D	R 2B	L 4D	L 2D	L 4D	L 4D	2B

Habitats / Subhabitats	Intertidal – Sea Walls/Pilings/RipRap						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Subhabitat
1	L 4D	L 4C	L 3D	L 3D	L 3D	L 3D	3D
2	4D	4D	3D	4C	3D	3C	4C
3	L 4D	L 3D	L 4D	L 4D	L 3D	L 4D	3D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 2C	L 4D	L 3D	L 3D	L 4D	2C

Habitats / Subhabitats	Intertidal – Sandy Beach							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Subhabitat
1	L 4D	L 1A	L 4D	L 1C	L 4C	L 3C	L 3C	1A
2	4D	1A	3D	1B	4C	3D	2C	1A
3	L 3D	N 1B	L 4D	L 1B	L 4D	L 4D	L 2B	1B
4	L 4D	N 1A	L 4D	L 2B	L 4D	L 4D	L 4D	1A
5	L 4D	R 1A	L 4D	L 1B	L 4D	L 4D	L 3C	1A

Habitats / Subhabitats	Intertidal – Sand and Gravel Beach							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Subhabitat
1	L 4D	L 1A	L 4D	L 1C	L 3C	L 3C	L 3C	1A
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 3D	N 1B	L 4D	L 1B	L 4D	L 4D	L 2B	1B
4	L 4D	L 1C	L 4D	L 2C	L 4D	L 4D	L 4D	1C
5	L 4D	R 1A	L 4D	L 1B	L 4D	L 4D	L 3C	1A

Estuary (Cont.)

Habitats / Subhabitats	Subtidal – Shallow (<20 feet)							
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Subtidal – Deep (>20 feet)				
Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Subtidal – Oyster Reef						
Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4C	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Subtidal – Structured Hard Bottom							
Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Epifauna	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Water Column – Shallow (<20 feet)							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4C	L 4C	L 4D	4C
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 3D	L 3D	L 4D	L 4D	L 4D	3D

Habitats / Subhabitats	Water Column – Deep (>20 feet)							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Marine

Habitats	Terrestrial					
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 1A	L 4D	L 4D	1A
4	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats	Water Surface				
Group	Mammals	Birds	Reptiles and Amphibians	Plankton	Subhabitat
1	L 3D	L 3C	L 4D	L 4D	3C
2	4D	3D	2D	4D	2D
3	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 3C	L 4D	L 4D	3C
5	L 4D	R 2C	L 4D	L 4D	2C

Habitats / Subhabitats	Intertidal – Sea Walls/Pilings/RipRap						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Intertidal – Sandy Beach							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Subhabitat
1	L 4D	L 2C	L 4D	L 1D	L 4D	L 4D	L 4D	1D
2	4D	L 3A	4D	L 3A	4A	L 3A	4D	3A
3	L 4D	L 1A	L 4D	L 4D	L 4D	L 4D	L 4D	1A
4	L 4D	L 1C	L 4D	L 4D	L 4D	L 4D	L 4D	1C
5	L 4D	R 2D	L 4D	L 4D	L 4D	L 4D	L 4D	2D

Habitats / Subhabitats	Subtidal – Shallow (<20 feet)							
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Subtidal – Deep (>20 feet)					
Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Arthropods	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Water Column – Shallow (<20 feet)							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitats / Subhabitats	Water Column – Deep (>20 feet)							
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Subhabitat
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	4D	4D	4D	4D	4D	4D	4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Reference Area codes: L = local, R = regional, and N = national or international (see Section 2 for definitions).

Figure 4.2. *Detailed focus group risk analysis results for natural recovery.*

Estuary

Habitat: Terrestrial

Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Terrestrial
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 3C	L 4D	L 4D	3C
3	L 4D	L 4D	R 3D	L 4D	L 4D	3D
4	L 4D	L 4D	L 2C	L 4D	L 4D	2C
5	L 4D	L 4D	R 3D	L 4D	L 4D	3D

Habitat: Water Surface

Group	Mammals	Birds	Reptiles and Amphibians	Plankton	Water Surface
1	L 3C	L 2B	L 2B	L 4C	2B
2	L 4D	L 3C	L 2C	L 4D	3C
3	R 1D	L 2B	L 2B	L 3D	2B
4	L 4D	L 3B	L 3B	L 4D	3D
5	L 4D	R 2B	L 3D	L 4D	2B

Habitat: Intertidal – Subhabitat: Salt Marsh

Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Salt Marsh
1	L 1D	L 3D	L 2B	L 2D	L 2D	L 3C	L 3D	1D
2	L 4D	L 4D	L 3D	L 4D	L 3D	L 3D	L 3D	3D
3	L 3D	L 3D	R 2B	L 2D	L 3D	L 3D	L 4D	2B
4	L 3D	L 3D	L 3D	L 3D	L 3D	L 3D	L 3D	3D
5	L 4D	L 3D	R 2C	L 4D	L 3D	L 3D	L 3D	2C

Habitat: Intertidal – Subhabitat: Mud Flat

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Mud Flat
1	L 4D	L 3C	L 4D	L 3D	L 3C	L 3D	3C
2	L 4D	N 2B	L 3C	L 3D	L 3D	L 3D	2B
3	L 4D	L 2C	L 3D	L 1C	L 3C	L 4C	1C
4	L 4D	N 1C	L 4D	L 4D	L 3D	L 3D	2C
5	L 3D	R 2C	L 4D	L 2D	L 4D	L 4D	2C

Habitat: Intertidal – Subhabitat: Sea Walls/Pilings/RipRap

Group	Mammals	Birds	Fish	Aquatic Arthopods	Mollusks	Epifauna	Sea Walls/Pilings/RipRap
1	L 4D	L 4C	L 3D	L 3D	L 3D	L 3D	3D
2	L 4D	L 4D	L 3D	L 4C	L 3D	L 3C	4C
3	L 4D	L 3D	L 4D	L 4D	L 3D	L 4D	3D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 2D	L 4D	L 3D	L 3D	L 4D	2D

Habitat: Intertidal – Subhabitat: Sandy Beach

Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Sandy Beach
1	L 4D	L 1A	L 4D	L 1C	L 4C	L 3C	L 3C	1A
2	L 4D	N 1A	L 3D	L 1B	L 4C	L 3D	L 2C	1A
3	L 3D	N 1B	L 4D	L 1B	L 4D	L 4D	L 2B	1B
4	L 4D	N 1A	L 4D	L 2B	L 4D	L 4D	L 4D	1A
5	L 4D	R 1B	L 4D	L 1C	L 4D	L 4D	L 3D	1B

Habitat: Intertidal – Subhabitat: Sand and Gravel Beach

Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Sand and Gravel Beach
1	L 4D	L 1A	L 4D	L 1C	L 3C	L 3C	L 3C	1A
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 3D	N 1B	L 4D	L 1B	L 4D	L 4D	L 2B	1B
4	L 4D	L 1C	L 4D	L 2C	L 4D	L 4D	L 4D	1C
5	L 4D	R 1B	L 4D	L 1C	L 4D	L 4D	L 3D	1B

Estuary (Cont.)

Habitat: Subtidal – Subhabitat: Shallow (<20 feet)

Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Shallow (<20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Subtidal – Subhabitat: Deep (>20 feet)

Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Deep (>20 feet)
1	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Subtidal – Subhabitat: Oyster Reef

Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Oyster Reef
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4C	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Subtidal – Subhabitat: Structured Hard Bottom

Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Epifauna	Structured Hard Bottom
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Water Column – Subhabitat: Shallow (<20 feet)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Shallow (<20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4C	L 4C	L 4D	4C
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 3D	L 3D	L 4D	L 4D	L 4D	3D

Habitat: Water Column – Subhabitat: Deep (>20 feet)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Deep (>20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Marine

Habitat: Terrestrial

Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Terrestrial
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 1A	L 4D	L 4D	1A
4	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Water Surface

Group	Mammals	Birds	Reptiles and Amphibians	Plankton	Water Surface
1	L 4D	L 3D	L 4D	L 4D	3D
2	L 4D	L 3D	L 2D	L 4D	2D
3	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 3D	L 4D	L 4D	3D
5	L 4D	R 2C	L 4D	L 4D	2C

Habitat: Intertidal – Subhabitat: Sea Walls/Pilings/RipRap

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Sea Walls/Pilings/RipRap
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Intertidal – Subhabitat: Sandy Beach

Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Sandy Beach
1	L 4D	L 2D	L 4D	L 2D	L 4D	L 4D	L 4D	2D
2	L 4D	L 3A	L 4D	L 3B	L 4B	L 3B	L 4D	3B
3	L 4D	L 1A	L 4D	L 4D	L 4D	L 4D	L 4D	1A
4	L 4D	L 1C	L 4D	L 4D	L 4D	L 4D	L 4D	1C
5	L 4D	R 2D	L 4D	L 4D	L 4D	L 4D	L 4D	2D

Habitat: Subtidal – Subhabitat: Shallow (<20 feet)

Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Shallow (<20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Subtidal – Subhabitat: Deep (>20 feet)

Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Arthropods	Deep (>20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Water Column – Subhabitat: Shallow (<20 feet)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Shallow (<20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Habitat: Water Column – Subhabitat: Deep (>20 feet)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Deep (>20 feet)
1	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
2	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
3	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
4	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D
5	L 4D	R 4D	L 4D	L 4D	L 4D	L 4D	L 4D	4D

Reference Area codes: L = local, R = regional, and N = national or international (see Section 2 for definitions).

Figure 4.3 *Detailed focus group risk analysis results for on-water mechanical recovery.*

Estuary

Habitat	Subhabitat	Group	1 (ref.)	1 (risk)	2 (ref.)	2 (risk)	3 (ref.)	3 (risk)	4 (ref.)	4 (risk)	5 (ref.)	5 (risk)
Terrestrial		Vegetation	L	4D			L	4D	L		L	4D
Terrestrial		Mammals	L	4D			L	4D	L		L	4D
Terrestrial		Birds	L	4D	L		R	3D	L		R	4D
Terrestrial		Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Terrestrial		Insects	L	4D			L	4D	L		L	4D
Terrestrial		(overall)		4D				3D				4D
Water Surface		Mammals	L	4D			R	1D	L		L	4D
Water Surface		Birds	L	2D	R		L	2C	L		R	3D
Water Surface		Reptiles and Amphibians	L	2D	N		L	2C	L		L	4D
Water Surface		Plankton	L	4A			L	3D	L		L	4D
Water Surface		(overall)		2D				2C				3D
Intertidal	Salt Marsh	Vegetation	L	3D			L	3D	L		L	4D
Intertidal	Salt Marsh	Mammals	L	4C			L	3D	L		L	4D
Intertidal	Salt Marsh	Birds	L	2D			R	2C	L		R	2D
Intertidal	Salt Marsh	Fish	L	3D			L	2D	L		L	4D
Intertidal	Salt Marsh	Aquatic Arthropods	L	3D			L	3D	L		L	4D
Intertidal	Salt Marsh	Mollusks	L	3D			L	3C	L		L	4D
Intertidal	Salt Marsh	Polychaetes	L	3B			L	4C	L		L	4D
Intertidal	Salt Marsh	(overall)		2D				2C				2C
Intertidal	Mud Flat	Mammals	L	4D			L	4D	L		L	3D
Intertidal	Mud Flat	Birds	L	3C			L	2C	N		R	2D
Intertidal	Mud Flat	Fish	L	4D			L	3D	L		L	4D
Intertidal	Mud Flat	Aquatic Arthropods	L	4C			L	1C	L		L	2D
Intertidal	Mud Flat	Mollusks	L	4C			L	3C	L		L	4D
Intertidal	Mud Flat	Polychaetes	L	4C			L	3C	L		L	4D
Intertidal	Mud Flat	(overall)		3C				1C				2D
Intertidal	Sea Walls/Pilings/RipRap	Mammals	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Birds	L	4D			L	4D	L		R	2D
Intertidal	Sea Walls/Pilings/RipRap	Fish	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Aquatic Arthropods	L	4D			L	4D	L		L	3D
Intertidal	Sea Walls/Pilings/RipRap	Mollusks	L	4D			L	3D	L		L	3D
Intertidal	Sea Walls/Pilings/RipRap	Epifauna	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	(overall)		4D				3D				2D
Intertidal	Sandy Beach	Mammals	L	4D			L	3D	L		L	4D
Intertidal	Sandy Beach	Birds	L	2C			N	1D	N		R	1D
Intertidal	Sandy Beach	Fish	L	4D			L	4D	L		L	4D
Intertidal	Sandy Beach	Aquatic Arthropods	L	1D			L	1D	L		L	1D
Intertidal	Sandy Beach	Meiofauna	L	4D			L	4D	L		L	4D
Intertidal	Sandy Beach	Mollusks	L	4D			L	4D	L		L	4D
Intertidal	Sandy Beach	Reptiles/Amphibians	L	4D			L	2D	L		L	3D
Intertidal	Sandy Beach	(overall)		1D				1D				1D
Intertidal	Sand and Gravel Beach	Mammals	L	4D			L	3D	L		L	4D
Intertidal	Sand and Gravel Beach	Birds	L	2C			N	1D	L		R	1D
Intertidal	Sand and Gravel Beach	Fish	L	4D			L	4D	L		L	4D
Intertidal	Sand and Gravel Beach	Aquatic Arthropods	L	1D			L	1D	L		L	1D
Intertidal	Sand and Gravel Beach	Meiofauna	L	4D			L	4D	L		L	4D
Intertidal	Sand and Gravel Beach	Mollusks	L	4D			L	4D	L		L	4D
Intertidal	Sand and Gravel Beach	Reptiles/Amphibians	L	4C			L	2D	L		L	2D
Intertidal	Sand and Gravel Beach	(overall)		2C				1D				1D

Estuary (Cont.)

Habitat	Subhabitat	Group	1 (ref.)	1 (risk)	2 (ref.)	2 (risk)	3 (ref.)	3 (risk)	4 (ref.)	4 (risk)	5 (ref.)	5 (risk)
Subtidal	Shallow (<20 feet)	Vegetation	L	4B			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Mammals	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Birds	L	4C			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Fish	L	4C			L	4D	L		L	3D
Subtidal	Shallow (<20 feet)	Aquatic Arthropods	L	3C			L	3C	L		L	4D
Subtidal	Shallow (<20 feet)	Mollusks	L	3C			L	3C	L		L	4D
Subtidal	Shallow (<20 feet)	Polychaetes	L	3C			L	3C	L		L	3C
Subtidal	Shallow (<20 feet)	(overall)		4C				3C				3C
Subtidal	Deep (>20 feet)	Fish	L	4C			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Aquatic Arthropods	L	4C			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Mollusks	L	4C			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Polychaetes	L	4C			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	(overall)		4C				4D				4D
Subtidal	Oyster Reef	Vegetation	L	4C			L	4D	L		L	4D
Subtidal	Oyster Reef	Birds	L	4C			L	4D	L		L	4D
Subtidal	Oyster Reef	Fish	L	4C			L	4D	L		L	4D
Subtidal	Oyster Reef	Aquatic Arthropods	L	4C			L	4D	L		L	4D
Subtidal	Oyster Reef	Mollusks	L	4C			L	4C	L		L	4D
Subtidal	Oyster Reef	Epifauna	L	4C			L	4D	L		L	4D
Subtidal	Oyster Reef	(overall)		4C				4C				4D
Subtidal	Structured Hard Bottom	Vegetation	L	4B			L	4D	L		L	4D
Subtidal	Structured Hard Bottom	Birds	L	4B			L	4D	L		L	4D
Subtidal	Structured Hard Bottom	Fish	L	4B			L	4D	L		L	4D
Subtidal	Structured Hard Bottom	Aquatic Arthropods	L	4B			L	4C	L		L	4D
Subtidal	Structured Hard Bottom	Mollusks	L	4B			L	4C	L		L	4D
Subtidal	Structured Hard Bottom	Polychaetes	L	4B			L	4C	L		L	4D
Subtidal	Structured Hard Bottom	Epifauna	L	4B			L	4C	L		L	4D
Subtidal	Structured Hard Bottom	(overall)		4B				4C				4D
Water Column	Shallow (<20 feet)	Mammals	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Birds	L	4D			L	4D	L		R	4D
Water Column	Shallow (<20 feet)	Fish	L	4C			L	4D	L		L	3C
Water Column	Shallow (<20 feet)	Aquatic Arthropods	L	4C			L	4D	L		L	3D
Water Column	Shallow (<20 feet)	Mollusks	L	4B			L	4C	L		L	4D
Water Column	Shallow (<20 feet)	Plankton	L	4A			L	4C	L		L	4D
Water Column	Shallow (<20 feet)	Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	(overall)		4A				4C				3C
Water Column	Deep (>20 feet)	Mammals	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Birds	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Fish	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Mollusks	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Plankton	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	(overall)		4D				4D				4D

Marine

Habitat	Subhabitat	Group	1 (ref.)	1 (risk)	2 (ref.)	2 (risk)	3 (ref.)	3 (risk)	4 (ref.)	4 (risk)	5 (ref.)	5 (risk)
Terrestrial		Vegetation	L	4D			L	4D	L		L	4D
Terrestrial		Mammals	L	4D			L	4D	L		L	4D
Terrestrial		Birds	L	4D			L	1C	L		L	4D
Terrestrial		Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Terrestrial		Insects	L	4D			L	4D	L		L	4D
Terrestrial		(overall)		4D				1C				4D
Water Surface		Mammals	L	4D			L	4D	L		L	4D
Water Surface		Birds	L	4D			L	4D	L		R	2D
Water Surface		Reptiles and Amphibians	L	4D			L	4D	L		L	4D
Water Surface		Plankton	L	4D			L	4D	L		L	4D
Water Surface		(overall)		4D				4D				2D
Intertidal	Sea Walls/Pilings/RipRap	Mammals	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Birds	L	4D			L	4D	L		R	4D
Intertidal	Sea Walls/Pilings/RipRap	Fish	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Mollusks	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	Epifauna	L	4D			L	4D	L		L	4D
Intertidal	Sea Walls/Pilings/RipRap	(overall)		4D				4D				4D
Intertidal	Sandy Beach	Mammals	L	3D			L	4D	L		L	4D
Intertidal	Sandy Beach	Birds	L	3D	L		L	1C	L		R	2D
Intertidal	Sandy Beach	Fish	L	3D			L	4D	L		L	4D
Intertidal	Sandy Beach	Aquatic Arthropods	L	3D	L		L	4D	L		L	4D
Intertidal	Sandy Beach	Meiofauna	L	3D			L	4D	L		L	4D
Intertidal	Sandy Beach	Mollusks	L	3D	L		L	4D	L		L	4D
Intertidal	Sandy Beach	Reptiles/Amphibians	L	3D			L	4D	L		L	4D
Intertidal	Sandy Beach	(overall)		3D				1C				2D
Subtidal	Shallow (<20 feet)	Vegetation	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Mammals	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Birds	L	4D			L	4D	L		R	4D
Subtidal	Shallow (<20 feet)	Fish	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Mollusks	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	Polychaetes	L	4D			L	4D	L		L	4D
Subtidal	Shallow (<20 feet)	(overall)		4D				4D				4D
Subtidal	Deep (>20 feet)	Fish	L	4D			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Mollusks	L	4D			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Polychaetes	L	4D			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	Arthropods	L	4D			L	4D	L		L	4D
Subtidal	Deep (>20 feet)	(overall)		4D				4D				4D
Water Column	Shallow (<20 feet)	Mammals	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Birds	L	4D			L	4D	L		R	4D
Water Column	Shallow (<20 feet)	Fish	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Mollusks	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Plankton	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Water Column	Shallow (<20 feet)	(overall)		4D				4D				4D
Water Column	Deep (>20 feet)	Mammals	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Birds	L	4D			L	4D	L		R	4D
Water Column	Deep (>20 feet)	Fish	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Aquatic Arthropods	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Mollusks	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Plankton	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	Reptiles/Amphibians	L	4D			L	4D	L		L	4D
Water Column	Deep (>20 feet)	(overall)		4D				4D				4D

Reference Area codes: L = local, R = regional, and N = national or international (see Section 2 for definitions).

Figure 4.4 *Detailed focus group risk analysis results for dispersant application at 85% effectiveness.*

	Estuary																																									
Habitats	Terrestrial					Water Surface				Intertidal																																
Subhabitats										Salt Marsh							Mud Flat						Sea Walls/Pilings/RipRap						Sandy Beach							Sand and Gravel Beach						
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Mammals	Birds	Reptiles and Amphibians	Plankton	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians
1	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4C	2C	2C	4A	2D	3C	2C	3C	3C	3C	3C	4D	3B	4D	3D	3D	3D	4D	4C	3D	3D	3D	3D	4D	1A	4D	2C	4C	4C	4C	4D	1B	4D	1D	4C	4C	4C
	4D					2C				2C							3B						3D						1B							1B						
2			L				R	N																																		
3	L	L	R	L	L	R	L	L	L	L	L	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	N	L	L	L	L	L	L	N	L	L	L	L	L
	4D	4D	3D	4D	4D	1D	2B	2B	3D	3D	3D	2B	2D	3D	3D	4D	4D	2C	3D	1C	3C	4C	4D	3D	4D	4D	3D	4D	3D	1B	4D	1B	4D	4D	2B	3D	1B	4D	1B	4D	4D	2B
	3D					2B				2B							1C						3D						1B							1B						
4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	N	L	L	L	L	L	L	L	L	L	L	L	N	L	L	L	L	L	L	L	L	L	L	L	L
5	L	L	R	L	L	L	R	L	L	L	L	R	L	L	L	L	L	R	L	L	L	L	L	R	L	L	L	L	L	R	L	L	L	L	L	L	R	L	L	L	L	L
	4D	4D	3D	4D	4D	4D	3C	3D	4D	4D	3D	2B	4D	3D	3D	3D	3D	2B	4D	2D	4D	4D	4D	2C	4D	3D	3D	4D	4D	1B	4D	1C	4D	4D	3C	4D	1B	4D	1C	4D	4D	3C
	3D					3C				2B							2B						2C						1B							1B						

	Estuary (Cont.)																																					
Habitats	Subtidal																								Water Column													
Subhabitats	Shallow (<20 feet)							Deep (>20 feet)				Oyster Reef						Structured Hard Bottom							Shallow (<20 feet)							Deep (>20 feet)						
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Epifauna	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4C	4D	4C	4C	3D	3D	3D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4C	4C	4C	4C	4C	4C	4C	4D	4D	4C	4C	4C	4B	4D	4D	4D	4D	4D	4D	4D	4D
	4C							4D				4D						4C							4B							4D						
2																																						
3	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	4D	4D	3D	3D	3D	4D	4D	4D	4D	4D	4D	4D	4D	4C	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4C	4C	4D	4D	4D	4D	4D	4D	4D	4D
	3D							4D				4C						4D							4C							4D						
4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
5	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	R	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	3D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	3D	3D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D
	3D							4D				4D						4D							3D							4D						

	Marine																																														
Habitats	Terrestrial					Water Surface				Intertidal													Subtidal												Water Column													
Subhabitats										Sea Walls/Pilings/RipRap						Sandy Beach							Shallow (<20 feet)							Deep (>20 feet)					Shallow (<20 feet)							Deep (>20 feet)						
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects	Mammals	Birds	Reptiles and Amphibians	Plankton	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Arthropods	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	3D	3D	3D	3D	3D	3D	3D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D
	4D					4D				4D						3D							4D							4D					4D							4D						
2																	L		L		L																											
3	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	1B	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	1B	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D
	1B					4D				4D						1B							4D							4D					4D							4D						
4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
5	L	L	L	L	L	L	R	L	L	L	R	L	L	L	L	L	R	L	L	L	L	L	L	L	R	L	L	L	L	L	L	L	L	L	L	R	L	L	L	L	L	L	R	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	2C	4D	4D	4D	4D	4D	4D	4D	4D	4D	2D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D
	4D					2C				4D						2D							4D							4D					4D							4D						

Reference Area codes: L = local, R = regional, and N = national or international (see Section 2 for definitions).

Figure 4.5 *Detailed focus group risk analysis results for dispersant application at 35% effectiveness.*

Estuary

Habitats	Terrestrial				
Subhabitats					
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects
1	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				
2			L		
3	L	L	R	L	L
	3D	4D	3D	3D	4D
	3D				
4	L	L	L	L	L
5	L	L	R	L	L
	4D	4D	3D	4D	4D
	3D				

Habitats	Water Surface			
Subhabitats				
Group	Mammals	Birds	Reptiles and Amphibians	Plankton
1	L	L	L	L
	3C	2B	2B	4C
	2B			
2		R	N	
3	R	L	L	L
	1D	2B	2B	3D
	2B			
4	L	L	L	L
5	L	R	L	L
	4D	2B	3D	4D
	2B			

Habitats	Intertidal						
Subhabitats	Salt Marsh						
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes
1	L	L	L	L	L	L	L
	1B	2C	2A	1D	2C	3C	3D
	1B						
2							
3	L	L	R	L	L	L	L
	3D	3D	2B	2D	3D	3D	4D
	2B						
4	L	L	L	L	L	L	L
5	L	L	R	L	L	L	L
	4D	3D	2C	4D	3D	3D	3D
	2C						

Habitats	Intertidal					
Subhabitats	Mud Flat					
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes
1	L	L	L	L	L	L
	4C	3B	4D	3C	3C	3C
	3B					
2						
3	L	L	L	L	L	L
	4D	2C	3D	1C	3C	4C
	1C					
4	L	N	L	L	L	L
5	L	R	L	L	L	L
	4D	2C	4D	2D	4D	4D
	2C					

Habitats	Intertidal					
Subhabitats	Sea Walls/Pilings/RipRap					
Group	Mammals	Birds	Fish	Aquatic Arthopods	Mollusks	Epifauna
1	L	L	L	L	L	L
	4D	4D	3D	3C	3C	3C
	3C					
2						
3	L	L	L	L	L	L
	4D	3D	4D	4D	2D	3D
	2D					
4	L	L	L	L	L	L
5	L	R	L	L	L	L
	4D	2D	4D	3D	3D	3D
	2D					

Habitats	Intertidal						
Subhabitats	Sandy Beach						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	1A	4D	1C	4C	3C	3C
	1A						
2							
3	L	N	L	L	L	L	L
	3D	1B	4D	1B	4D	4D	2B
	1B						
4	L	N	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	1B	4D	1C	4D	4D	3D
	1B						

Habitats	Intertidal						
Subhabitats	Sand and Gravel Beach						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	1A	4D	1C	3C	3C	3C
	1A						
2							
3	L	N	L	L	L	L	L
	3D	1B	4D	1B	4D	4D	2B
	1B						
4	L	L	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	1B	4D	1C	4D	4D	3D
	1B						

Estuary (Cont.)

Habitats	Subtidal						
Subhabitats	Shallow (<20 feet)						
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

Habitats	Subtidal			
Subhabitats	Deep (>20 feet)			
Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes
1	L	L	L	L
	4D	4D	4D	4D
	4D			
2				
3	L	L	L	L
	4D	4D	4D	4D
	4D			
4	L	L	L	L
5	L	L	L	L
	4D	4D	4D	4D
	4D			

Habitats	Subtidal					
Subhabitats	Oyster Reef					
Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna
1	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D
	4D					
2						
3	L	L	L	L	L	L
	4D	4D	4D	4D	4C	4D
	4C					
4	L	L	L	L	L	L
5	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D
	4D					

Habitats	Subtidal						
Subhabitats	Structured Hard Bottom						
Group	Vegetation	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Epifauna
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

Habitats	Water Column						
Subhabitats	Shallow (<20 feet)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4C	4C	4D
	4C						
4	L	L	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	4D	3D	3D	4D	4D	4D
	3D						

Habitats	Water Column						
Subhabitats	Deep (>20 feet)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

Marine

Habitats	Terrestrial				
Subhabitats					
Group	Vegetation	Mammals	Birds	Reptiles/Amphibians	Insects
1	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				
2					
3	L	L	L	L	L
	4D	4D	1B	4D	4D
	1B				
4	L	L	L	L	L
5	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				

Habitats	Water Surface			
Subhabitats				
Group	Mammals	Birds	Reptiles and Amphibians	Plankton
1	L	L	L	L
	3D	3C	4D	4D
	3C			
2				
3	L	L	L	L
	4D	4D	4D	4D
	4D			
4	L	L	L	L
5	L	R	L	L
	4D	2C	4D	4D
	2C			

Habitats	Intertidal					
Subhabitats	Sea Walls/Pilings/RipRap					
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna
1	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D
	4D					
2						
3	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D
	4D					
4	L	L	L	L	L	L
5	L	R	L	L	L	L
	4D	4D	4D	4D	4D	4D
	4D					

Habitats	Intertidal						
Subhabitats	Sandy Beach						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Meiofauna	Mollusks	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	2C	4D	1D	4D	4D	4D
	1D						
2		L		L		L	
3	L	L	L	L	L	L	L
	4D	1B	4D	4D	4D	4D	4D
	1B						
4	L	L	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	3D	4D	4D	4D	4D	4D
	3D						

Habitats	Subtidal						
Subhabitats	Shallow (<20 feet)						
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Polychaetes
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	L	R	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

Habitats	Subtidal				
Subhabitats	Deep (>20 feet)				
Group	Fish	Aquatic Arthropods	Mollusks	Polychaetes	Arthropods
1	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				
2					
3	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				
4	L	L	L	L	L
5	L	L	L	L	L
	4D	4D	4D	4D	4D
	4D				

Habitats	Water Column						
Subhabitats	Shallow (<20 feet)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

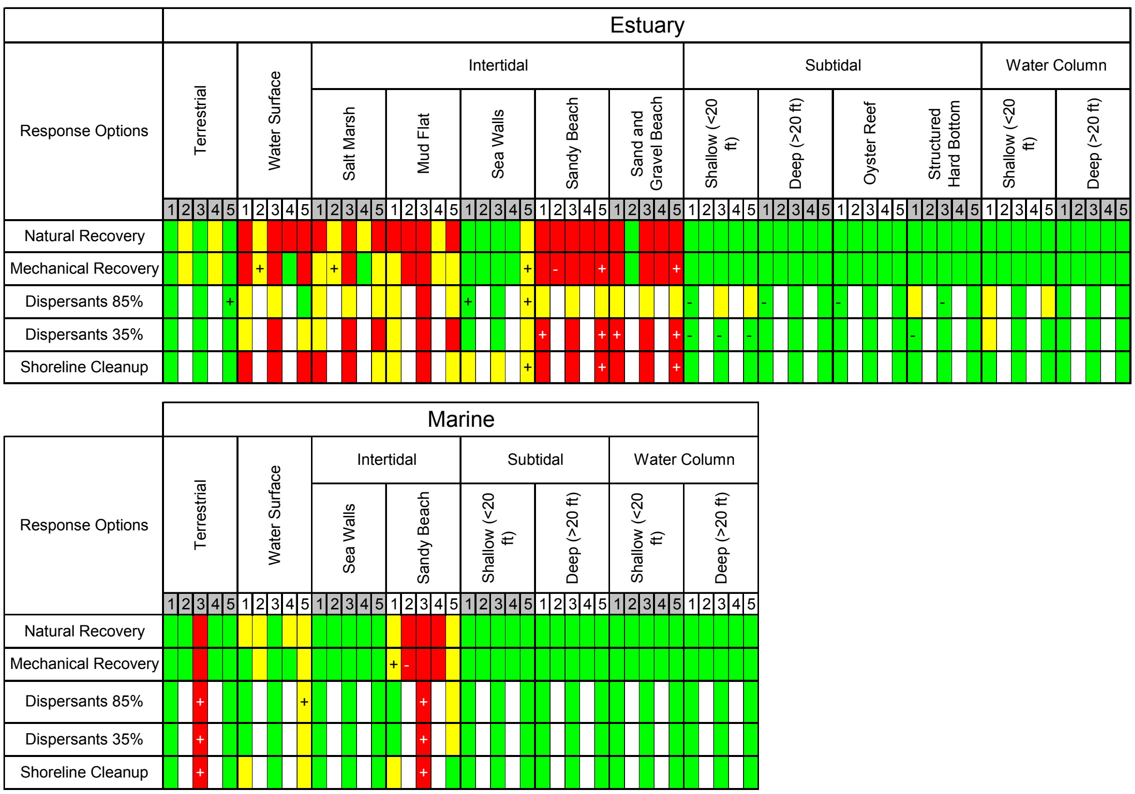
Habitats	Water Column						
Subhabitats	Deep (>20 feet)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles/Amphibians
1	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
2							
3	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						
4	L	L	L	L	L	L	L
5	L	R	L	L	L	L	L
	4D	4D	4D	4D	4D	4D	4D
	4D						

Reference Area codes: L = local, R = regional, and N = national or international (see Section 2 for definitions).

Figure 4.6 *Detailed focus group risk analysis results for on-shore mechanical recovery.*

5.0 Summary Risk Analysis Results and Lessons Learned

Table 5.1 presents the summary results for this workshop. Five response options were analyzed along with natural recovery: on-water mechanical recovery, dispersant application at 85% effectiveness, dispersant application at 35% effectiveness and on-shore mechanical recovery. This table is based on the detailed data in Section 4 and allows an easy comparison across response options. All options were analyzed by only three of the five groups, as discussed in Section 2. In summary, participants felt that the most benefit to the environment resulted from the use of dispersants, provided they were relatively highly effective (see footnote 8). The increased risk to the water column was a concern, but was not as high as the risk to the shoreline and water surface areas which would be protected by dispersant use. No attempt was made to resolve differences between focus group scores, but they were discussed. It was emphasized that there is no one best way to respond to a spill, and that the best option is to use all acceptable techniques in concert with one another.



Legend: Red cells represent a "high" level of concern, yellow cells represent a "moderate" level of concern, and green cells represent a "limited" level of concern. There are two group scores per sub-habitat type (columns). A + indicates reduced concern within the broad risk category, while a – indicates an increased concern within the category.

Figure 5.1 *Final relative risk matrix for the Delaware Bay risk assessment.*

5.1 Key Factors Influencing Decisions in this Scenario

On the afternoon of the second day of the second workshop, the focus groups were asked to review the factors which influenced their discussions, and how changes in those factors might alter their conclusions. As future response plans are developed, these issues should be kept in mind. The comments from each of the three focus groups were as follows:

- **Group 1**
  - What if the oil spill volume is larger (10X)?
    - Overall risk is higher.
    - Concern over dispersed oil reaching toxic concentrations in the water column.
  - What if the oil spill is further up river?
    - The available time to respond would be shorter because of closer shorelines.
    - There would be fresh water vs. brackish water issues (because of dispersant use limitations in fresher water).
  - What if it is a different season?
    - Summer - Recreational uses are both a concern for protection and for interfering with response. Impact of higher temperatures on evaporation of the oil.
    - Fall - Driver would be migratory birds and waterfowl, as well as butterflies.
    - Winter - Response logistics due to the season (e.g.- frozen water, access, etc.).
    - Overall for all seasons - Living resources are drivers. Need for awareness of sensitive organisms with information from environmental managers on wildlife and vegetation (e.g., oysters and fisheries).
  - What if a different product was spilled?
    - Need a list of bulk petroleum materials entering the port and a table of effective dispersability of those products.
    - How effective should a dispersant be to be used?
    - Does the petroleum product shipped in the estuary vary by season?
  - General comment
    - Diagram that reflects the dispersant use policy areas in the Area Contingency Plan should be more detailed with bathymetry of the estuary.

- **Group 3**
  - Drivers - For most recovery methods, birds/Horseshoe Crabs/mollusks were species of concern (Piping Plover, eagles, etc.). Diamondback Terrapins were also important to this group.
  - Theory behind scores
    - Time of spill was critical to species that drove scores.

        - Spatial spread of oil was a factor – large portion of marshes and mudflats in entire bay (impact to individual marsh may be large, but to the entire resource, the impact would be less).
        - Delaware side is more heavily impacted during initial hours of spill.
        - Group did not feel 25% mechanical recovery affected scores enough to create improvement.
        - Dispersants were beneficial at 85%, but not so much at 35% effectiveness.
        - Food web dynamics become more important in dispersant response scenario, as do juvenile/larval stages in various species.
        - During on-shore mechanical recovery, there were not many changes in scores due to tradeoffs (less oil, but greater impact due to staging and equipment).
    - Change in volume
        - Greater impacts overall, longer mechanical and on-shore recovery time.
        - Resource levels may change, for example, local to regional.
    - Change in season
        - Species of concern would shift (e.g., fish spawning, mussel spat, dolphins, etc.).
        - Important to note that there is no time where there is not a species of concern, either in water or on-shore.
        - Decision related to dispersants may change given time and specific resource.

- **Group 5**
    - What were the drivers affecting decisions in this scenario?
        - Concern for birds (Red Knots, Piping Plovers) at the water surface, mudflats, and beaches.
        - Horseshoe Crabs on beaches and mudflats.
        - Minimal effects in water column and benthos.
        - Economic and political drivers were not considered.
        - When dispersants were assumed to be effective (85%), shoreline impacts were significantly reduced to a point where they outweighed concerns for the water column effects.
        - Assumed that logistics for getting dispersants was not an issue.
    - Modifications
        - Change Season to July/August - Much larger concern for fish, oyster, crab, clam larvae would affect decision to use dispersant. Lower concern for birds and horseshoe crabs would affect response decisions.
        - Change in Location (up river in May) - Spawning of Striped Bass, Shad, etc. in upper river sections would affect decision to use dispersants. Lower concern for birds.
        - Change in Location to Offshore Ocean (1/2 mile) - More likely to approve dispersant use due to concern for oiling beaches and lower concern for dispersed oil in water column.

  - Increase Size of Spill 10x - Increased concern for all species on beaches, marshes, mudflats for natural recovery. Questionable whether dispersants will be worth using on majority of slick. May want to selectively use dispersants to protect selected areas.

5.2 Consensus Recommendations

On the last day of the workshop, the participants reviewed the comments listed in Section 5.1, and developed the following list of consensus comments for consideration in future oil spill response planning efforts. They suggested these be presented to the Sector Delaware Bay Area Committee for consideration.

- This scenario focused on impacts to the mid and lower bay and did not consider treatment options for cleaning upper bay and river. The Area Committee should pursue future workshops to address these areas.
- Update the Environmental Sensitivity Index (ESI) maps (a lot of work, relating to ecologically significant resources, has been done in the past 10-15 years that is not reflected in those maps):
  - Database is somewhat rigid, and sometimes difficult to use, since it doesn't prioritize the resources,
  - We do not have the most up to date information related to ecologically significant species and critical habitats in the atlas (e.g., oyster, Atlantic sturgeon, white cedar swamps, freshwater tidal wetlands),
  - Consider breaking out eggs, larvae and juveniles rather than having the information combined,
  - Consider using C. Stern information system, United States Fish and Wildlife Service, to capture this information,
  - Involve non-governmental organizations during ESI data collection.
- Initiatives to integrate ESI maps with Geographic Information System (GIS) systems are worthwhile. This could facilitate rapid decisions between the Incident Command System and resource managers.
- The Area Committee needs to address ways to improve GIS information exchange/centralization.
- USCG would benefit from obtaining internal GIS capabilities to enhance inter-agency planning and response.
- Need more information to assess the impacts of oil and dispersed oil on:
  - eggs/juvenile/adult Horseshoe Crabs,
  - post D-hinge stage larval oysters and mussels (e.g., veliger, etc.),
  - indirect food web impacts on critical species.
- Evaluate Coastal Response Research Center research and other funding opportunities to address these needs.
- Need to better integrate information needs with response options (provide localized information on ESI maps; focus research needs with response options).
- Suggest developing a working committee to identify scenarios throughout the area of responsibility (conditions and locations) where dispersants would NOT be used,

would be IDEAL to use, and where the "grey area" in between occurs (natural resource trigger points):
  - Although this was a beneficial exercise, it did not provide enough detailed information to assess whether dispersant use would be a viable response under other conditions or scenarios,
  - Confidence in the benefit of using dispersants would improve if more detailed information was provided on the extent of shoreline oiling for a given scenario.

- Take advantage of spills of opportunity to explore fate and effects.
- Need to develop a method to rapidly determine how effective a dispersant application will be on an actual spill.
- Evaluate current process to assess "real-time" dispersant use to streamline the decision-making.
- Residence time and operational limitations are key components of dispersant use decision-making.
- Protective booming strategy is an effective mechanism in the ACP, so the Area Committee should re-evaluate it for further improvements (e.g., resource protection and prioritization).
- The Area Committee should evaluate shoreline protection strategies for ecologically important areas (e.g., Horseshoe Crab beaches, Red Knots).
- The identification of oil collection areas could be an important component of shoreline protection.
- Develop " protection and response" strategies for Atlantic Ocean coastal bays and beaches.
- Closer linkage of GNOME model (NOAA) output with local hydrographic predictive modeling to enhance evaluation of response options.
- The Area Committee should engage resource managers, NGOs, and local resource experts in planning, exercises and/or training opportunities.
- Communication is an important part of oil spill response management. The Area Committee should continue to evaluate portals/partnering for rapid information dissemination.
- Area Committee meetings are open to the public. ERA workshop participants are encouraged to attend.

6.0 References

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Appendix A

Participants

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√	√	1	Sweeney	Dave	Chief, Bureau of Emerg. Resp.	NJ Dept. of Environ. Protection	609-633-2168	david.sweeney@dep.state.nj.us
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√		2	Dickson	Ryan	Petty Officer 1st Class	U.S. Coast Guard	609-724-0008 x214	ryan.n.dickson@uscg.mil
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Mtg 1 (Jan 06)	Mtg 2 (Feb 06)	Group	Name (Last)	(First)	Title	Agency	Telephone	Email
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√		4	Babb	Russell	Principal Fisheries Biologist	NJ Department of Environmental Protection	856-785-0730	rbabb@gtc3.com
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Mtg 1 (Jan 06)	Mtg 2 (Feb 06)	Group	Name (Last)	(First)	Title	Agency	Telephone	Email
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√	√	Float	Anderson	Bennett	Environmental Scientist	DE Dept. Natural Res. and Environ. Control	302-739-9939	Bennett.Anderson@state.de.us
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Appendix B

Resource Table

Region	Habitat	Subhabitat	Resource Category	Example Organisms
Estuary	Terrestrial	Upland and Supratidal	Vegetation	deciduous trees, shrubs, grasses agricultural crops
			Mammals	opossum, raccoon, red fox, deer, Delmarva fox squrrel
			Birds	bald eagle; cattle egret; rail; snipe; killdeer, woodcock, vultures, wood ducks, wild turkey perigrine falcon
			Reptiles/Amphibians	diamond back terrapins, black snake, frogs and toads, salamanders
			Insects	butterflies, damsel flies
	Water Surface and Surface Microlayer		Mammals	otters, muskrat, dolphins, humpback whales
			Birds	osprey, black duck, mallard, tundra swan, mergansers, loon, bald eagle
			Reptiles/Amphibians	diamond back terrapins, northern water snake, loggerhead and Kemp's ridley sea turtles, frogs and toads, salamanders
			Plankton	Fish eggs and larvae, crustacean larvae, copepods, phytoplankton
	Intertidal	Salt Marsh	Vegetation	common three-square rush, salt meadow cord grass, salt meadow hay, big cord grass, common reed, groundsel, marsh elder, diatoms, bluegreen algae
			Mammals	muskrat, opossum, raccoon, red fox, deer, rice rat
			Birds	great blue heron, black duck, blue and green-winged teal, mallards, Northern harrier, osprey, rails, red wind blackbird,widgeon, shovelers
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides
			Aquatic Arthropods	blue crab, mud crab, amphipods, grass shrimp
			Mollusks	snails, clams, mussels
			Polychaetes	worms
		Mud Flat	Mammals	muskrat, opossum, raccoon, red fox, deer, rice rat
			Birds	wading birds, great blue heron, black duck, blue and green-winged teal, mallards, Northern harrier, rails
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy, Silversides, skates and rays
			Aquatic Arthropods	blue crab, mud crab, amphipods, grass shrimp
			Mollusks	snails, clams, mussels
			Polychaetes	worms
		Sea Walls Pilings/RipRap	Mammals	rice rat, racoons, domestic pets
			Birds	gulls, cormorants, terns, herons, killdeer, osprey
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides, gobies, blennies

Region	Habitat	Subhabitat	Resource Category	Example Organisms
Estuary (cont.)	Intertidal (cont.)	Sea Walls Pilings/RipRap (cont.)	Aquatic Arthropods	blue crab, mud crab, amphipods, grass shrimp, barnacles
			Mollusks	snails, clams, mussels
			Epifauna	sea squirts, bryozoans, macroalgae
		Sandy Beach	Mammals	opossum, raccoon, red fox, deer, domestic animals
			Birds	wading birds, sandpipers, gulls, terns, plover, red knots, ruddy turnstones, perigrine falcon
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides
			Aquatic Arthropods	horseshoe crab
			Meiofauna	copepods, amphipods, nematodes
			Mollusks	snails
			Reptiles/Amphibians	diamondback terrapin, loggerhead and Kemp's Ridley sea turtles, northern water snake
		Sand and Gravel Beach	Mammals	opossum, raccoon, red fox, deer, domestic animals
			Birds	sandpipers, gulls, terns, plover, perigrine falcon
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides
			Aquatic Arthropods	horseshoe crab
			Meiofauna	copepods, amphipods, nematodes
			Mollusks	snails
			Reptiles/Amphibians	diamondback terrapin, loggerhead and Kemp's Ridley sea turtles, northern water snake
	Subtidal	Shallow (<20 feet)	Vegetation	macroalgae, benthic diatoms
			Mammals	otters, humpback whales
			Birds	pelicans, diving ducks, loons, cormorants, canvasbacks, tundra swan
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides, sturgeon, flounder, blue fish, hard head, shad, eels, croaker, weakfish, skates and rays, menhaden, sharks
			Aquatic Arthropods	blue crab, mud crab, amphipods, horseshoe crab, barnacles, amphipods
			Mollusks	razor clams, softshell clams, hard clams,
			Polychaetes	worms
		Deep (>20 feet)	Fish	rockfish, perch, herring, sturgeon, flounder, blue fish, hard head, shad, eels, croaker, weakfish,
			Aquatic Arthropods	blue crab, mud crab, amphipods, horseshoe crab, amphipods
			Mollusks	clams

Region	Habitat	Subhabitat	Resource Category	Example Organisms
Estuary (cont.)	Subtidal (cont.)	Deep (>20 feet) (cont.)	Polychaetes	worms
		Oyster Reefs	Vegetation	macroalgae, benthic diatoms
			Birds	tundra swan, dabbling and diving ducks
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides, flounder, shad, eels, croaker, weakfish, skates and rays, menhaden
			Aquatic Arthropods	blue crabs, amphipods, isopods, grass shrimp
			Mollusks	oysters, snails
			Epifauna	bryozoans, sea squirt
		Structured Hard-Bottom Community	Vegetation	macroalgae, benthic diatoms
			Birds	tundra swan, dabbling and diving ducks
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides, flounder, shad, eels, croaker, weakfish, skates and rays, menhaden
			Aquatic Arthropods	blue crabs, amphipods, isopods, grass shrimp
			Mollusks	snails
			Polychaetes	sabellid worms
			Epifauna	bryozoans, sea squirt
	Water Column	Shallow Water (<20 feet)	Mammals	otters, dolphins, humpback whales
			Birds	diving ducks, loons, cormorants
			Fish	rockfish, perch, herring, sturgeon, flounder, shad, eels, croaker, weakfish, menhaden
			Aquatic Arthropods	blue crabs, horseshoe crabs
			Mollusks	
			Plankton	copepods, fish eggs and larvae, invertebrate larvae, jellyfish, diatoms, green algae, dinoflagellates
			Reptiles/Amphibians	loggerhead and Kemp's Ridley sea turtles
		Deep Water (>20 feet)	Mammals	dolphins, humpback whales
			Birds	loons
			Fish	rockfish, perch, herring, sturgeon, flounder, shad, eels, croaker, weakfish, menhaden
			Aquatic Arthropods	blue crab, horseshoe crabs
			Mollusks	
			Plankton	copepods, fish eggs and larvae, invertebrate larvae, jellyfish, diatoms, green algae, dinoflagellates
			Reptiles/Amphibians	loggerhead and Kemp's Ridley sea turtles
Marine	Terrestrial	Upland and Supratidal	Vegetation	deciduous trees, Atlantic white cedar, shrubs, grasses agricultural crops
			Mammals	opossum, raccoon, red fox, deer, Delmarva fox squrrel
			Birds	bald eagle; cattle egret; rail; snipe; killdeer, woodcock, vultures, wood ducks, wild turkey perigrine falcon
			Reptiles/Amphibians	diamond back terrapins, black snake, frogs and toads, salamanders
			Insects	butterflies, damsel flies
	Water Surface including Surface Microlayer		Mammals	dolphins, humpback whales
			Birds	osprey, black duck, mergansers, sea ducks
			Reptiles/Amphibians	loggerhead and Kemp's ridley sea turtles
			Plankton	Fish eggs and larvae, crustacean larvae, copepods, phytoplankton

Region	Habitat	Subhabitat	Resource Category	Example Organisms
Marine (cont.)	Intertidal	Sea Walls Pilings/RipRap	Mammals	rice rat, racoons, domestic pets
			Birds	gulls, cormorants, terns, herons, killdeer, osprey
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides, gobies, blennies
			Aquatic Arthropods	blue crab, mud crab, amphipods, grass shrimp, barnacles
			Mollusks	snails, clams, mussels
			Epifauna	sea squirts, bryozoans
		Sandy Beach	Mammals	opossum, raccoon, red fox, deer, domestic animals
			Birds	sandpipers, gulls, terns, plover, perigrine falcon
			Fish	killifish, mummichug, rockfish, perch, herring, bay anchovy. Silversides
			Aquatic Arthropods	ghost crabs
			Meiofauna	copepods, amphipods, nematodes
			Mollusks	snails
			Reptiles/Amphibians	loggerhead and Kemp's Ridley sea turtles
	Subtidal	Shallow (<20 feet)	Vegetation	macroalgae, benthic diatoms
			Mammals	
			Birds	diving ducks, loons, cormorants, canvasbacks, tundra swan
			Fish	rockfish, perch, herring, flounder, shad, eels, croaker, weakfish, skates and rays, menhaden
			Aquatic Arthropods	blue crab, lobster, amphipods, horseshoe crab, barnacles, amphipods
			Mollusks	clams, mussels
			Polychaetes	worms
		Deep (>20 feet)	Fish	rockfish, perch, herring, flounder, shad, eels, croaker, weakfish, skates and rays, menhaden
			Aquatic Arthropods	blue crab, lobster, amphipods, horseshoe crab, amphipods
			Mollusks	scallops, hard clams
			Polychaetes	worms
	Water Column	Shallow Water (<20 feet)	Mammals	dolphins, humpback whales
			Birds	sea ducks, loons, cormorants
		Shallow Water (<20 feet) (cont.)	Fish	rockfish, perch, herring, sturgeon, flounder, shad, eels, croaker, weakfish, menhaden, sharks
			Aquatic Arthropods	blue crabs
			Mollusks	
			Plankton	copepods, fish eggs and larvae, invertebrate larvae, jellyfish, diatoms, green algae,
			Reptiles/Amphibians	loggerhead and Kemp's Ridley sea turtles
		Deep Water (>20 feet)	Mammals	dolphins, humpback whales
			Birds	loons
			Fish	rockfish, perch, herring, sturgeon, flounder, shad, eels, croaker, weakfish, menhaden, sharks
			Aquatic Arthropods	blue crab
			Mollusks	
			Plankton	copepods, fish eggs and larvae, invertebrate
			Reptiles/Amphibians	loggerhead and Kemp's Ridley sea turtles