Ecological Risk Assessment: Consensus Workshop

Environmental Tradeoffs Associated With Oil Spill Response Technologies

Guayanilla Bay Area, Puerto Rico

Ecological Risk Assessment: Consensus Workshop

Environmental Tradeoffs Associated With Oil Spill Response Technologies

Guayanilla Bay Area, Puerto Rico

A Report to the US Coast Guard, Sector San Juan

Don Aurand and Gina Coelho (Compilers)
Ecosystem Management & Associates, Inc.

Ecosystem Management & Associates, Inc.
Report 07-01

REPORT AVAILABILITY

Copies of this report can be obtained from the following address:

Commandant (G-RPP)
United States Coast Guard
2100 Second Street, SW
Washington, DC 20593
202-267-1983

CITATION

Suggested Citation:

Aurand, D. and G. Coelho (Compilers). 2007. Ecological Risk Assessment: Consensus Workshop. Environmental Tradeoffs Associated With Oil Spill Response Technologies. Guayanilla Bay Area, Puerto Rico. A report to the US Coast Guard, Sector San Juan. Ecosystem Management & Associates, Inc., Lusby, MD. 20657. Technical Report 07-01, 61 pages.

SPONSOR

This report was prepared under Purchase Order HSCG23-06-J-DPP170 for US Coast Guard Headquarters (G-RPP), 2100 2nd Street, SW, Washington, DC 20593.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS, AND ACRONYMS

Term	Abbreviation, Symbol, or Acronym
Automated Data Inquiry for Oil Spills	ADIOS
Barrels	bbls
Chemical Response to Oil Spills: Ecological Effects Research Forum	CROSERF
Cubic Kilometers	Km^3
Department of Natural and Environmental Resources	DNER
Ecological Risk Assessment	ERA
Ecosystem Management & Associates, Inc.	EM&A
Emergency Response Division (NOAA)	ERD
Environmental Protection Agency	EPA
Environmental Sensitivity Index	ESI
General NOAA Oil Modeling Environment	GNOME
Hours	hrs
In-Situ Burn	ISB
Knots	kts
Meters	m
Miles per hour	mph
National Marine Fisheries Service	NMFS
National Oceanic and Atmospheric Administration	NOAA
National Research Council	NRC
Non-governmental organization	NGO
Oil Spill Response Limited	OSRL
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
United States Virgin Islands	USVI

ACKNOWLEDGEMENTS

Ecosystem Management & Associates, Inc. and the sponsors of this project extend their thanks to all those who participated in the risk assessment workshop. Special recognition is extended to LT Blanca Rosas (USCG Sector San Juan), who served as the Assessment Coordinator, and to LCDR Patrick Keane (USCG District 7), Mr. Bradford Benggio (NOAA ERD Scientific Support Coordinator), Mr. Felix (US Fish and Wildlife Service, USFWS), and Mr. Craig Lilyestrom (Puerto Rico Department of Natural and Environmental Resources, DNER), who served as the Assessment Planning Team, to Dr. Alan Mearns and Ms. Mary Evans (NOAA ERD) for preparing the NOAA presentations on fate and effects and for their support at the workshop and Dr. Glen Watabayashi (NOAA ERD) for his help with oil fate modeling. Contractor support to assist in the planning and facilitation of the workshops and in the preparation of the report was provided by the Office of Incident Management and Preparedness, Headquarters, USCG (G-RPP) under Task Order HSCG23-06-J-DPP170, issued under Contract Number DTCG23-03-D-MER148A. The support and guidance of the Project Manager, LCDR Paul Lattanzi of G-RPP is gratefully acknowledged.

Ecological Risk Assessment: Consensus Workshop

Environmental Tradeoffs Associated With Oil Spill Response Technologies

Guayanilla Bay Area, Puerto Rico

Executive Summary

In February/March 2007, the United States Coast Guard (USCG) Sector San Juan sponsored a workshop to provide training in dispersant use in oil spills and to evaluate the relative risk to natural resources from various oil spill response options including no response (natural recovery), on-water mechanical recovery, dispersant application and on-shore mechanical recovery. The workshop was held for five consecutive days, with a one-day dispersant training session on the third day.

The spill scenario designed by the Steering Committee was designed to present the participants with a situation where nearshore coral reefs and sea grass beds, as well as mangrove forests, were at risk. According to the scenario, a tanker carrying 100,000 barrels of Venezuelan Recon crude oil went hard aground on a reef at the entrance to Guayanilla Harbor, Puerto Rico and had two releases of oil, the first of 4000 barrels, and the second an additional 10,000 barrels (approximately 48 hours later). A total of 14000 bbls, or 588,000 gallons, was released over the 2-day and 6 hour period.

Participants were divided into two focus groups to review and evaluate the relative risks and benefits of each of the response options. After evaluating the options within the parameters presented for this scenario the groups concluded that, because of the size of the spill, there were serious risks to both shoreline and shallow water habitats. On-water mechanical recovery was viewed as being of limited utility in this scenario. Dispersant use raised serious concerns because of the large volume of dispersed oil but did provide some benefit to shoreline and intertidal habitats. Likewise, on-shore mechanical recovery was beneficial to some habitats, but raised serious concerns in mangrove areas. The size of the spill made it unlikely that any alternative would be effective in preventing serious impacts. At the end of the workshop participants developed a list of lessons learned and recommendations for future oil spill response planning in the area.

1.0 Objectives of the Guayanilla Bay Area, Puerto Rico 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 (NGO). 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 Guayanilla Bay area workshop was sponsored by the USCG Sector San Juan, and had the objectives of evaluating the possible impacts of a large oil spill in the coastal waters of Puerto Rico and assessing local oil spill response capabilities. The goal of the workshop was to improve local oil spill response strategies and enhance contingency planning by discussions concerning the likely impacts of a simulated spill and the potential risks and benefits of response tools available to mitigate a spill. There are often tradeoffs associated with emergency response decision-making that call for compromises between agencies to achieve a best response. The workshop was intended to provide a forum for emergency response managers and resource trustees to review and evaluate these tradeoffs before an actual spill occurs in order to facilitate future discussions about the optimal response strategies, and to identify opportunities for improvement.

1.3 Participants

A total of 22 individuals from 13 organizations attended the workshop. The days 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 a single, week-long workshop held from Monday, 26 February 2007 to Friday, 2 March 2007. On Wednesday, February 28, the facilitation team presented a training course on dispersant use in oil spill response. This was a condensed version of a 2-day training course offered by Ecosystem Management & Associates, Inc. The training was requested in order to provide participants with a basic level of information concerning dispersants appropriate to the discussion of dispersant use in this exercise scenario.

Prior to the workshop a Steering Committee was organized which was responsible for planning the workshop and also developed the basic framework of the scenario. The Steering Committee decided to use a scenario originally proposed for the US Virgin Islands (USVI) ERA workshop (held in June 2003), when that ERA was going to be a joint initiative examining scenarios in the USVI and Puerto Rico. Since the scenario was ultimately not included in that workshop, it represented a good option for this ERA (see Section 3.1).

Day one of the workshop began with a quick administrative introduction, followed by welcoming remarks by CAPT Perry. Dr. Aurand (facilitator) then gave an overview of the ERA process (see ERA Overview on the workshop CD). LT Rosas then led 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 (see the Oil Spill Scenario 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.

Dr. Alan Mearns, National Ocean and Atmospheric Administration (NOAA), Emergency Response Division (ERD) then gave an overview of the role of his office in spill response and an overview of the General NOAA Modeling Environment (GNOME) model and the Automated Data Inquiry for Oil Spills (ADIOS) model (see GNOME Model file on the workshop CD). Dr. Mearns then showed the QuickTime spill model movie for the no response option (see the Surface Oil Trajectory file on the workshop CD). Finally, he made a third presentation (see Guayanilla ERA Part 1 on the workshop CD) which provided more detail on the spill trajectory, including oil fate (for no response), for the Guayanilla Bay area and other shoreline points along the spill trajectory. The presentation included:

- Graphics (from model output) of surface oil movement;
- Photos of what different oil thicknesses actual look like on a shoreline;
- What resources are at risk;
- Graphics of natural dispersion concentrations (maximum naturally dispersed oil concentration reached about 4 ppm); and
- Overlays of concentrations relative to levels of concern for fish, crustaceans and sensitive life stages.

Dr. Mearns was followed by two presentations on regional and local ecological resources. The first was by Mr. Felix Lopez of the US FWS (see Caribbean Resources Overview presentation on the workshop CD). This presentation highlighted basic Caribbean geography, threats to resources, an overview of coral reef ecology and other Caribbean habitats (sea grass systems, mangrove systems, white sand beaches, limestone undercut and volcanic shorelines) with the associated populations. Mr. Lopez also showed the four relevant NOAA Environmental Sensitivity Index (ESI) maps (see ESI Maps PR-55 through PR-58 on the workshop CD), and noted that the scenario drives oil into the Guanica Commonwealth Forest that is part of the UNESCO Man and the Biosphere Program. The forest includes 4000 hectares and extends 9 nm offshore.

Dr. Lisamarie Carrubba followed Mr. Lopez and gave a presentation on NOAA, National Marine Fisheries Service (NMFS) resources at risk and regulatory responsibilities (see NMFS Resources on the workshop CD). She also showed a single picture (see Coastal Habitat on the workshop CD) that compares an aerial photo with a pictorial representation of habitats in the general area of concern for this scenario (similar information to the ESI maps). These presentations were followed by an open discussion about the habitats and how they related to the proposed resources at risk table (presented to the group by Dr. Aurand). The participants were asked to review the resources at risk table and to be prepared to discuss any modifications that need to be made early on day two.

Dr. Aurand then reviewed a draft risk ranking matrix with the participants. The draft matrix is a standard five by four matrix which is presented to all workshops as a starting point for discussions. It is presented as Figure 8.2 in the Guidebook (Pond et al., 2000), without any cell aggregation boundaries for high, medium, or low levels of concern. The final matrix for this workshop is shown as Figure 4.1, and is a four by four matrix (the number of categories for the percentage of resources affected was reduced from five to four).

Day two began with an overview of the results to date, and then Dr. Aurand guided participants through a discussion of "reference populations." In order to estimate the percentage of a population that is affected, a base population must be assumed, and experience in previous workshops has demonstrated that unless this issue is explicitly addressed, group scores can vary widely because of different baseline assumptions. Final definitions agreed to by the participants are:

- Local (L) – Southwest Coast of Puerto Rico and adjacent waters;
- Regional (R) –Puerto Rico and adjacent waters; and
- National or International (N) – Caribbean basin or greater.

Dr. Aurand then provided participants with updates and corrections to the Resources at Risk Table, which were provided by Dr. Carrubba (NOAA NMFS) and reviewed by Mr. Lopez (USFWS). That table is presented in Appendix B. These changes were limited to the lists of representative species in the table. Dr. Carrubba identified additional changes to the representative species list for her Focus Group during subsequent sessions, but since not all of those changes were considered by the other Focus Group they are not included in the table in Appendix B.

In preparation for the evaluation of the scenario, Dr. Aurand gave an overview presentation on oil spills (see Oil Spill Basics on the workshop CD). When this presentation was completed, the facilitators reviewed the procedures for evaluating the baseline response option (natural recovery/no intervention) and the participants were divided into two focus groups (see Appendix A). The remainder of day two was spent evaluating the natural recovery option.

Day three began with an overview presentation entitled "On Water Mechanical Recovery" by MST2 K. Hendrix (USCG Sector San Juan) to prepare for discussion of that alternative (see On Water Mechanical Recovery on the workshop CD). Dr. Aurand then led a discussion on encounter rates and other limitations associated with on-water mechanical recovery, and opened the floor for a discussion of what the overall efficiency of on-water recovery was likely to be in this scenario. Ultimately, participants agreed on an on-water mechanical recovery efficiency of 5-20%. Participants then broke into their two focus groups to rank the "On-Water Mechanical Recovery" response. They completed the analysis by mid-day and the facilitators moved into the dispersant training portion of the workshop.

This training began with an introductory movie entitled "An Introduction of Dispersants and Their Application" prepared by Oil Spill Response Limited (OSRL) of Southampton, United Kingdom. This was followed by a PowerPoint presentation prepared for this workshop by the facilitation team (see Dispersant Training Puerto Rico on the workshop CD). After a question and answer session on the presentation, Mr. Michael Gass from Clean Caribbean and Americas gave his presentation on their response capability, which could be available in the event of a spill in Puerto Rico (see Clean Caribbean and Americas presentation on the workshop CD). Dr. Mearns then gave his second presentation (see Guayanilla ERA Part 2), and showed the QuickTime movies of dispersant use at 30% and 80% effectiveness (see Dispersed Oil Trajectory at 30% Effectiveness and Dispersed Oil Trajectory at 80% Effectiveness on the workshop CD). These two movies show the dispersant plume in the upper five meters of the water column. Dr. Mearns then showed a movie which contains only the concentration predicted in the bottom one meter, which was used to estimate exposure at a coral reef shown as a small circle of dots in the trajectory (see Dispersed Oil Trajectory at Bottom on the workshop CD).

Dr. Coelho then reviewed how to use the toxicity information provided in the workshop notebooks, and presented a summary of the results of a cooperative dispersant effects research program (see Section 7 from CROSERF and Section 8 from CROSERF on the workshop CD).[1]

Participants started day four in their two focus groups, and began scoring dispersant response at 30% and 80% effectiveness. Both groups were finished by noon. After the lunch break Chief Garcia (USCG Sector San Juan) gave a presentation on shoreline recovery and clean up (see Overviews of On-Shore Mechanical Recovery on the workshop CD). Participants then scored shoreline recovery, completing that activity by mid-afternoon, which ended the analytical portion of the exercise.

At this point, the two focus groups were asked to discuss the following five questions in preparation for developing "lessons learned":

- What are you conclusions about response options in this scenario?
- What if the spill occurred in a different season?
- What if the spill was a smaller volume?
- What if the spill occurred further offshore?
- How does the sensitivity of resources in this spill trajectory compare to other regions of Puerto Rico?

[1] CROSERF stands for "Chemical Response to Oil Spills: Ecological Research Forum" which was a working group of state, federal and industry representatives focused on improving and coordinating research on chemical tools for oil spill response. A summary report is currently in final review for publication at the American Petroleum Institute, Washington, DC. The chapters provided here are from the draft of this report, and are for the use of the participants only.

After this was done the focus group conclusions were reviewed in plenary session (see Section 5.1) and then the meeting was adjourned.

On the morning of the last day the participants met in plenary session to review the results of the workshop, and to develop recommendations for future planning efforts. These recommendations are presented in Section 5.2.

3.0 Exercise Scenario and Basic Analytical Information

3.1 Exercise Scenario

The scenario developed by the Steering Committee was designed to present the participants with a situation where nearshore coral reefs and sea grass beds, as well as mangrove forests, were at risk (see Section 1.2). According to the scenario, at 0600 on February 27, 2007, a tanker carrying 100,000 barrels (bbls) of Venezuelan Recon crude oil went hard aground on a reef at the entrance to Guayanilla Harbor, Puerto Rico and began losing oil at a rate of 4000 bbls (168,000 gallons) per day. This release was stopped at 0600 on February 28. However, while attempting to re-float the tanker at 0600 on March 1, the vessel was damaged and released an additional 10,000 bbls (420,000 gallons) of crude oil over the next 6 hours (until noon, March 1) at which time the release of all oil was finally stopped. A total of 14000 bbls, or 588,000 gallons, was released over the 2-day and 6 hour period.

- Grounding Location: 17º 57.65´ N, 66º 45.55´ W
- Wind: Variable 10 to 15 knots (kts) from E and ENE, mornings (midnight to noon): E, 10 kts. Afternoons (noon to midnight) ENE 10 kts except 15 kts after noon on March 1.
- Water temperature: 75º F
- Oil and Characteristics
  - Venezuelan Recon[2]
  - API Gravity: 34.9
  - Viscosity: 4.38 cSt at 38º C
  - Pour Point: 5º F

The NOAA ERD Modeling Group used the basic information in the scenario to develop a surface trajectory and a dispersed oil trajectory analysis for the workshop. Basic weathering information was calculated using the ADIOS II program for the oil under consideration. Trajectory calculations were made using the GNOME model. QuickTime movies and time-series snapshots were produced for both the surface slicks and the dispersed oil plumes.

Response options modeled included: No Response, were the released oil was allowed to weather (evaporation, natural dispersion) and strand on shore with no intervention; and use of dispersants (at an overall effectiveness of either 30% or 80%). For dispersant application, both spills (4,000 bbl and 10,000 bbl) were subject to dispersant application and dispersion. In the model, intentional dispersion only occurred during daylight hours. The first intentional dispersion occurred beginning at 0900 on Day 1 (February 27) of the incident and ended at dusk (1800) the same day. There was no release and no dispersion on February 28. The second dispersant application began at 0900 on March 1 and ended at dusk (1800) the same day.

[2] Recon crude oil is much lighter than many other Venezuelan varieties.

Table 3.1 Key Parameters for the Guayanilla Bay Area, Puerto Rico Scenario.

Time/Date	**0600 February 27 and 0600 March 1, 2007**
Location	**17º 57.65´ N, 66º 45.55´ W**
Volume	**4,000 and 10,000 bbls**
Oil Type	**Recon Crude Oil (Venezuelan)**
Specific Gravity (60º F)	**0.85**
Wind Direction/Speed	**Variable, 10 to 15 kts**
Air/Water Temperature	**75º F**

3.2 Geographic Area of Concern

The general areas of concern were the nearshore coastal waters and shoreline of the far southwestern coast of Puerto Rico. The area began at the entrance to Guayanilla Bay and continued to the west to the vicinity of Cabo Rojo, a distance of slightly more than 30 miles. The offshore extent was defined as the waters affected by the trajectory and landward of the shelf break. The area is described in Plates PR-55 through PR-58 of the NOAA Environmental Sensitivity Atlas for Puerto Rico.

3.3 Resources of Concern

The Steering Committee chose to use the final resources at risk table from the consensus ERA done for the US and British Virgin Islands (Aurand and Coelho, 2003) as the starting point for the Guayanilla Bay workshop. A copy of this table was sent to Steering Committee members Bradford Benggio (NOAA SSC), Craig Lilyestrom (Puerto Rico DNER) and Felix Lopez (USFWS) for review prior to the workshop. Minor modifications were made to the table based on that review. As described in Section 2.0, this draft table was distributed to the participants for review and comment at the beginning of the workshop. All of the changes suggested by the end of the second day are included in the table in Appendix B. As discussed in Section 2.0, Group B continued to annotate their version of the table during their analysis, and those later changes are not reflected in the version in Appendix B.

3.4 Conceptual Model

During discussions about the general analytical process, the facilitators suggested and 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 participants also agreed that they would consider the response options recommended by the Steering Committee. These were natural recovery (no response), on-water mechanical recovery, dispersant application, and on-shore mechanical recovery.

3.5 Modeling Results

The NOAA ERD 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 Table 3.2 for untreated oil, and for oil treated with dispersant at 30 and 80% effectiveness. Table 3.3 shows the volume of oil present on eleven shoreline segments for the same three conditions. Dr. Mearns noted that this oil can emulsify (absorb water) creating a floating "mousse" product that may be up to ten times the volume of the oil. Early dispersion would prevent this.

Table 3.2 Oil Budget (in Gallons) Budget for Undispersed and Dispersed Oil (30 and 80% Effectiveness) as Predicted in the Guayanilla Bay Area, Puerto Rico Scenario, Spill Volume 588,000 Gallons (168,000 plus 420,000 Gallons).

Time (Hrs)	Volume (Gallons)	Undispersed					30% Dispersion					80% Dispersion				
		Float	Evap	Disp	Beach	Off Map	Float	Evap	Disp	Beach	Off Map	Float	Evap	Disp	Beach	Off Map
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	17506	9509	7090	907	0	0	9509	7090	907	0	0	9508.8	7090	907.2	0	0
6	38506	21437	15154	1915	0	0	15859	12163	10315	168	0	4569.6	8904	24931	100.8	0
9	59506	33298	23318	2722	168	0	24595	18010	16834	67	0	7224	10450	41765	67.2	0
12	80506	44957	31450	3696	403	0	32458	23621	24125	302	0	8937.6	12466	59002	100.8	0
18	122506	54667	48048	4939	14851	0	39917	34709	37464	10416	0	10584	15355	93374	3192	0
24	164472	62496	54398	5813	41765	0	45326	39211	49829	30106	0	12331	16699	126571	8870	0
30	168000	55541	57758	6653	48048	0	40286	41597	51475	34642	0	10382	17640	129629	10349	0
36	168000	57490	59774	7526	43210	0	40320	43109	52450	32122	0	11088	18144	129797	8971	0
42	168000	45730	60514	7560	54197	0	32256	43646	52450	39648	0	8836.8	18278	129797	11088	0
48	168000	37901	60883	7560	61656	0	26208	44016	52450	45326	0	7526.4	18446	129797	12230	0
51	343035	211382	61085	7560	63008	0	200399	44083	52450	46103	0	181776	18514	129797	12949	0
54	552983	415187	61387	7560	68849	0	361135	44318	95481	52049	0	270073	18614	246328	17968	0
57	588000	449936	61723	7627	68714	0	352678	44654	138722	51946	0	187085	18682	363298	18936	0
60	588000	443008	62362	7627	75004	0	314019	45158	174227	54596	0	89340	18850	462680	17130	0
66	588000	385904	63336	7762	130864	134	271079	45898	174437	96520	67	76973	18917	463468	28642	0
72	588000	303253	63571	7762	211399	2016	215651	46133	174542	150297	1378	60272	18984	463520	44787	436.8
78	588000	276614	63672	7762	231048	8904	200951	46234	174647	160322	5846	55824	19018	463625	47718	1814.4
84	588000	308433	64344	7829	194559	12835	221336	46771	174909	136618	8366	62141	19118	464308	39913	2520
90	588000	283840	65184	7829	215691	15456	206932	47342	174995	148012	10718	57588	19219	464465	43905	2822.4
96	588000	260784	71047	7829	227138	21202	186988	53424	175048	157790	14750	53542	20059	464518	46118	3763.2
102	588000	239318	103784	7829	210424	26645	175447	76138	175048	142888	18480	48878	26985	464728	42706	4704
108	588000	243071	116949	7829	188803	31349	173846	85216	175048	132353	21538	49888	29663	464833	37737	5880
114	588000	238917	128142	7862	179924	33155	168340	92700	175014	128923	23022	48525	31901	464818	36315	6440.7
120	588000	206384	135860	8230	191066	46460	143241	99068	175333	136036	34322	41586	33424	464736	38518	9735.6

Selected snapshots from the surface oil trajectory modeling results are shown in Figure 3.1. The average and maximum concentration from 0 to 5 meters in the dispersed oil plume produced without the use of dispersants (Figure 3.2) is compared to toxicity threshold values for sea grass (Figure 3.3), adult corals (Figure 3.4), adult fish (Figure 3.5), adult crustaceans (Figure 3.6), and sensitive life history stages (Figure 3.7) (see Table 4.1 and the associated discussion in Section 4.1 for information on development and interpretation of thresholds).

Table 3.3 The Estimated Gallons of Oil on Eleven Shoreline Segments for the Guayanilla Bay Area, Puerto Rico Scenario With and Without the Use of Dispersants.

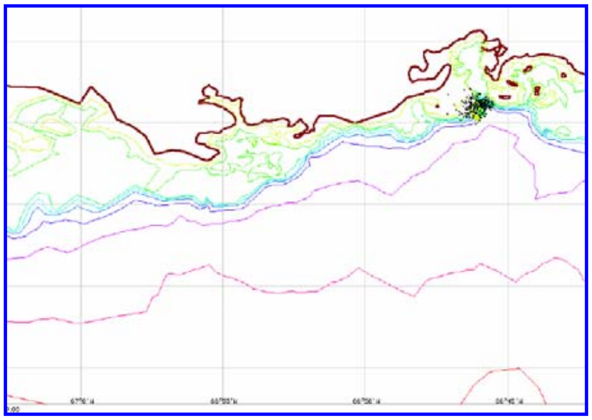
Shore Sector	Start Point (East to West)	Embayment Name	Segment Length (Miles)	Shoreline Oil Loading at 96 Hours (Gallons per Segment)		
				No Response	30% Disperse	80% Disperse
1	Playa Guayanilla	Bahia de Guayanilla	7.07	536	498	191
2	Punta Verraco	n/a	2.44	8448	6029	2167
3	Punta Ventana	n/a	2.33	68985	48407	14072
4	Punta Vaquero	Bahia Ballena	3.12	50266	32695	10168
5	Cayos de Cana Gorda	n/a	3.95	13005	9366	2814
6	Punta Meseta	Bahia de Guanica	4.19	158	139	86
7	west end Guanica Bay	Bahia de Guanica	1.87	3152	1544	277
8	Punta Pescadero	Ensenada las Pardas	1.68	13318	10294	3043
9	west end Ensenada las Pardas	Ensenada las Pardas	1.30	59711	40595	10935
10	Punta Brea	Arrecife Baul	2.71	7193	5613	1686
11	Punta Jorobado	Bahia Montalva	4.76	0	158	0
		Total	35.4	224,771	155,337	45,440

Under the modeled wind conditions the floating oil from both releases moves to the west, hugging the coastline. The general direction of movement for naturally dispersed oil in the water column is essentially the same. Oil begins to strand on the shoreline within nine hours, and the volume continued to increase as oil spread along the coast to the west. At the end of 96 hours, a total of nearly 225,000 gallons was stranded on the shoreline (the model predicts that some of this oil would refloat). Evaporation removes roughly 23% of the oil after 120 hours (the end of the simulation), and was still continuing slowly. The remaining oil moves out to sea to the west and south of Puerto Rico, and at the end of the modeling run slightly more than half of the oil is still floating (Tables 3.2 and 3.3).

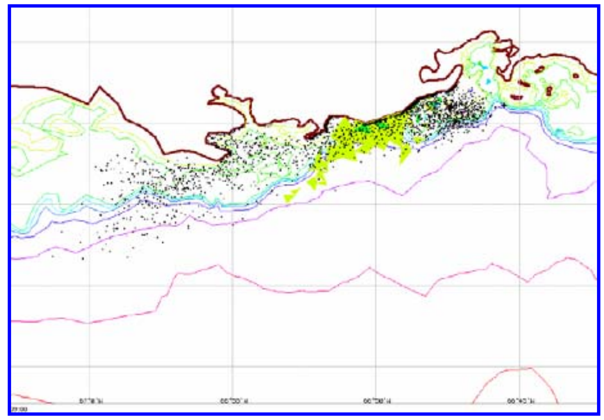
Maximum concentrations in the surface 0 to 5 meters of the water column with no response (Figure 3.2) do not exceed any of the high level of concern thresholds presented for receptor organism groups (Figures 3.3 to 3.7) except for sensitive life history stages after 24 hours of exposure (Figure 3.7). These maximum concentrations exceed or approach the ‘medium level of concern’ threshold for adult crustaceans (Figure 3.6). Finally, they approach the low level of concern threshold for adult coral (Figure 3.4). Sea grass thresholds (Figure 3.3) are never exceeded. Concern for exceedences would apply only to organisms which remained in contact with maximum concentrations for a period of at least several hours.

Average concentrations in the surface 0 to 5 meters of the water column never exceed the high level of concern threshold for any of the receptor organism groups. Medium level of concern thresholds were exceeded or approached for adult fish (Figure 3.5) and adult crustaceans (Figure 3.6) after 24 hours of exposure, and the low level of concern threshold was approached for adult corals (Figure 3.4) and sensitive life history stages (Figure 3.7). Average concentration values would be more widely distributed along the trajectory path.

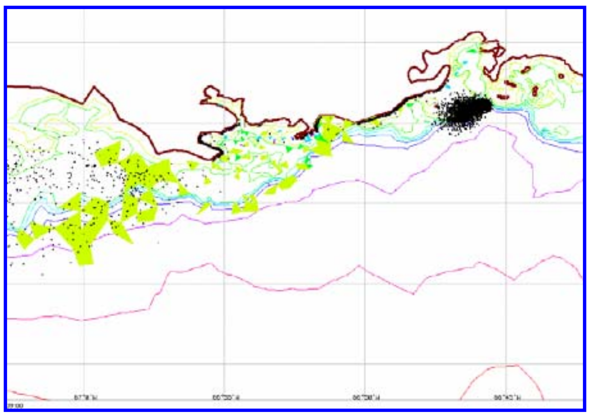
Snapshots from the dispersed oil modeling results are shown in Figure 3.8 for 80% effectiveness and in Figure 3.9 for 30% effectiveness. By comparing Figure 3.1 to Figures 3.8 and 3.9, the differences in the extent and concentration of the dispersed oil plume are easily seen. This is even more obvious in the QuickTime trajectory movies on the workshop CD. Also obvious is the reduction in the amount of oil stranding (Tables 3.2 and 3.3). For



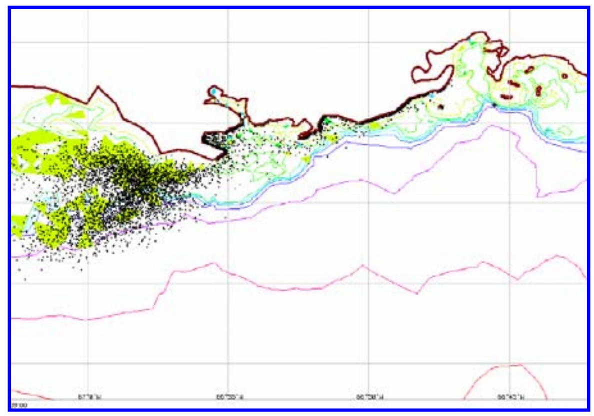
A: 3 Hours



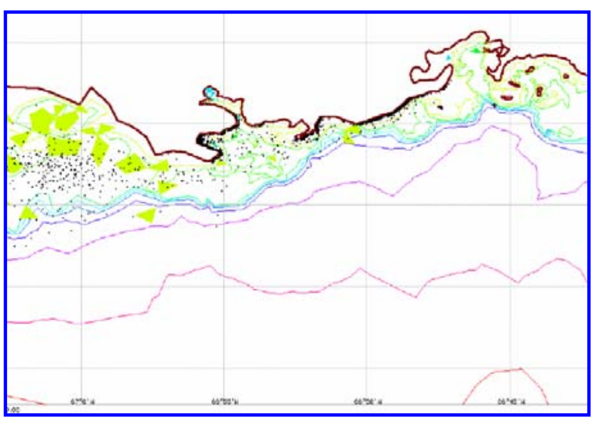
B: 27 Hours



C: 51 Hours



D: 75 Hours



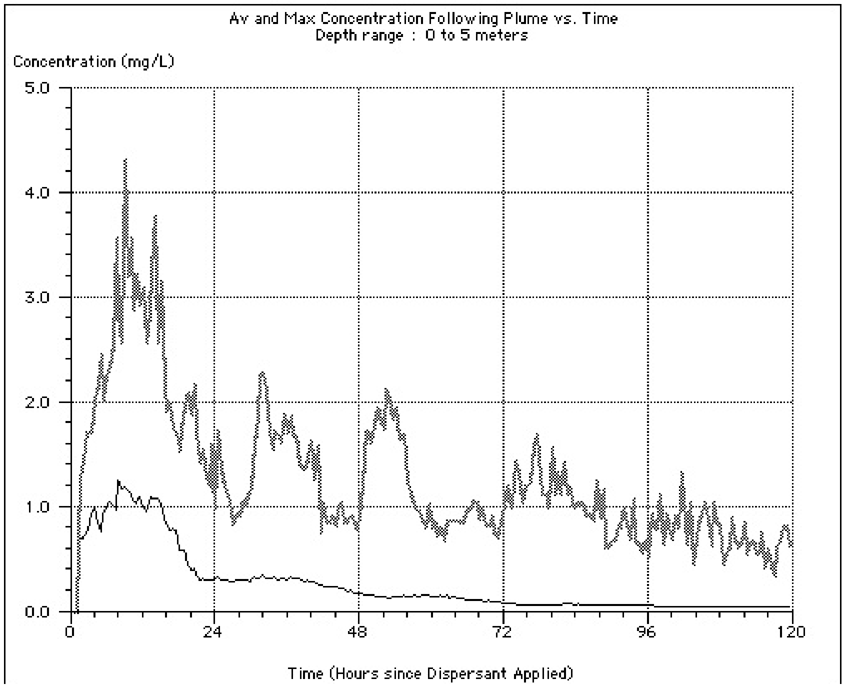
E: 99 Hours

Key to Dissolved Oil Concentration:

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 3.1 *Results from the NOAA GNOME modeling for the Guayanilla Bay Area, Puerto Rico scenario without the use of dispersants showing surface oil and average dispersed oil concentrations from 0 to 5 meters.*

A



B

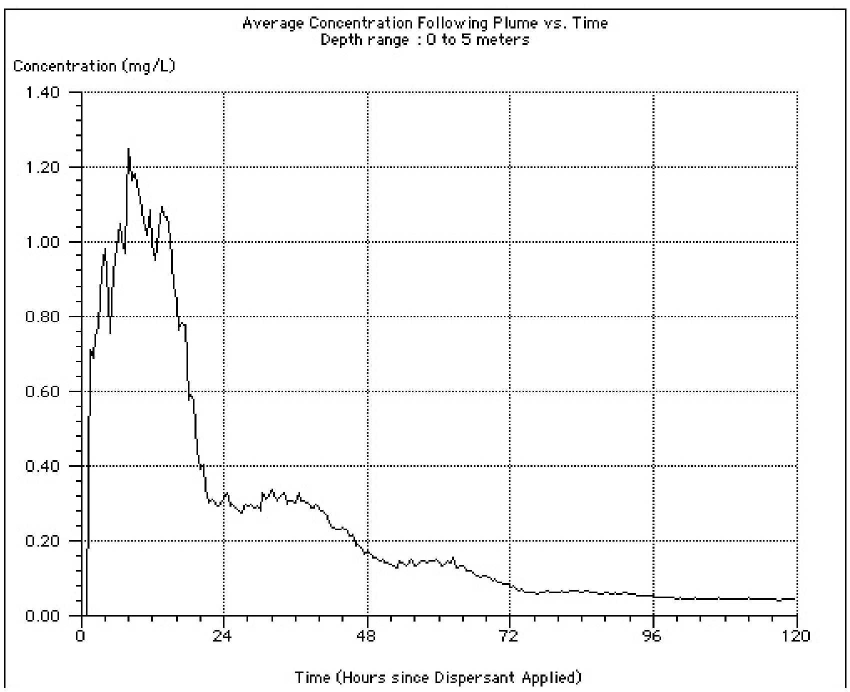


Figure 3.2 *Dispersed oil concentration from 0 to 5 meters in the plume versus time without the use of dispersant: Part A – average and maximum concentrations, Part B – average concentrations only (note expanded scale).*

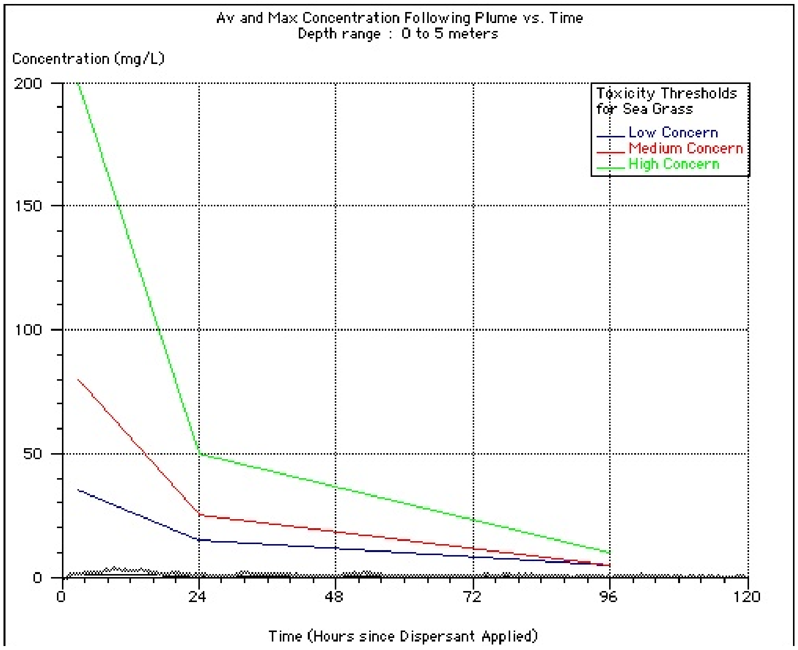


Figure 3.3 *Toxicity thresholds for dispersed oil for sea grass compared to maximum and average dispersed oil concentrations at 0 to 5 meters without the use of dispersants (based on discussion in Section 4.1).*

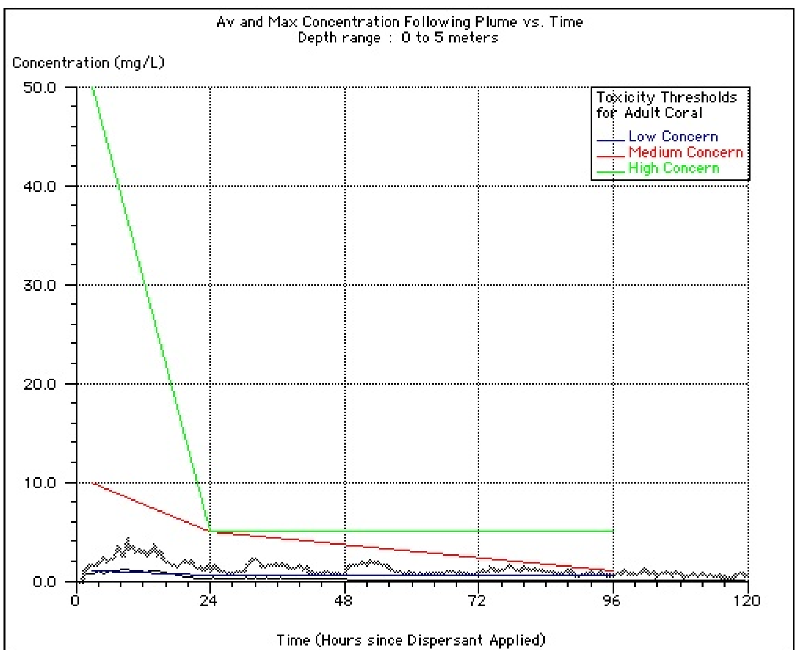


Figure 3.4 *Toxicity thresholds for dispersed oil for adult coral compared to maximum and average dispersed oil concentrations at 0 to 5 meters without the use of dispersants (based on discussion in Section 4.1).*

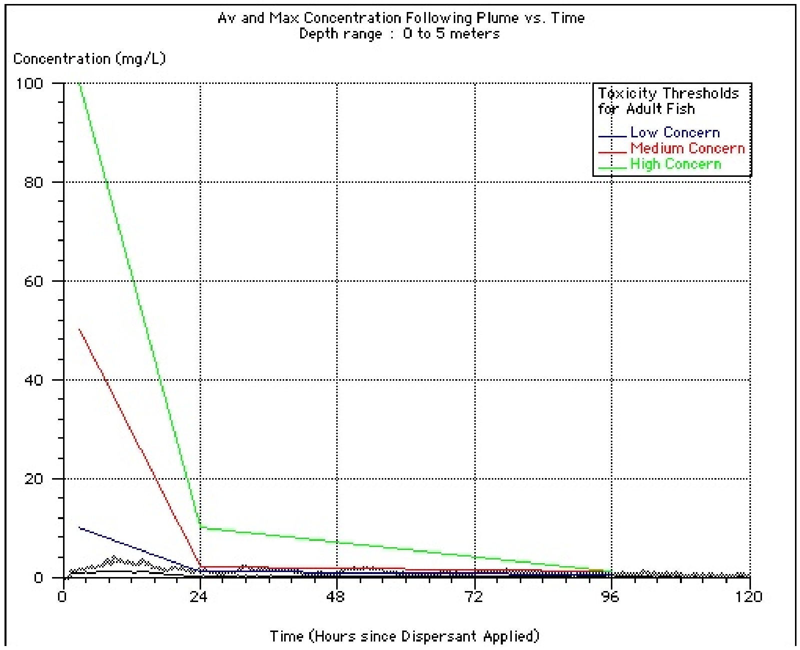


Figure 3.5 *Conservative toxicity thresholds for dispersed oil for adult fish compared to maximum and average dispersed oil concentrations at 0 to 5 meters without the use of dispersants (based on the values presented in Table 4.1).*

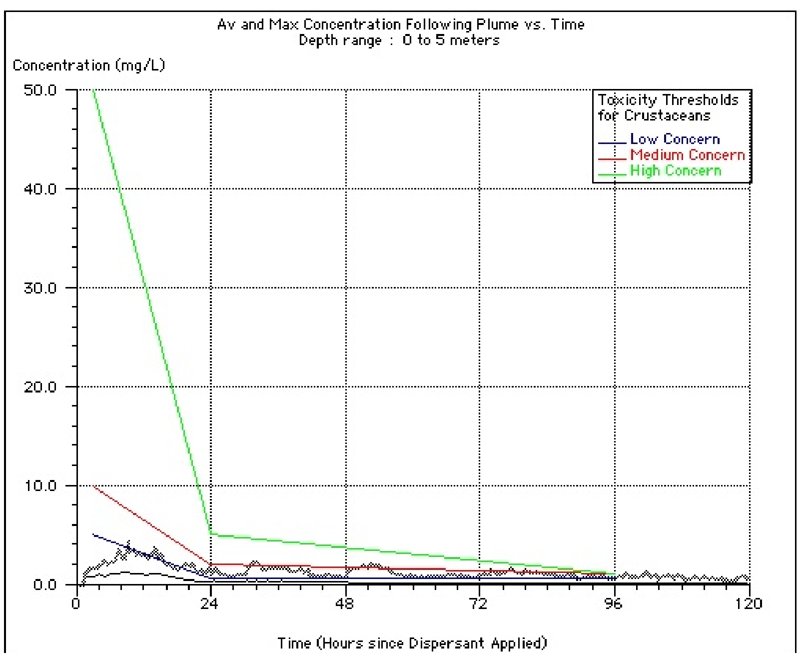


Figure 3.6 *Conservative toxicity thresholds for dispersed oil for adult crustaceans compared to maximum and average dispersed oil concentrations at 0 to 5 meters without the use of dispersants (based on the values presented in Table 4.1).*

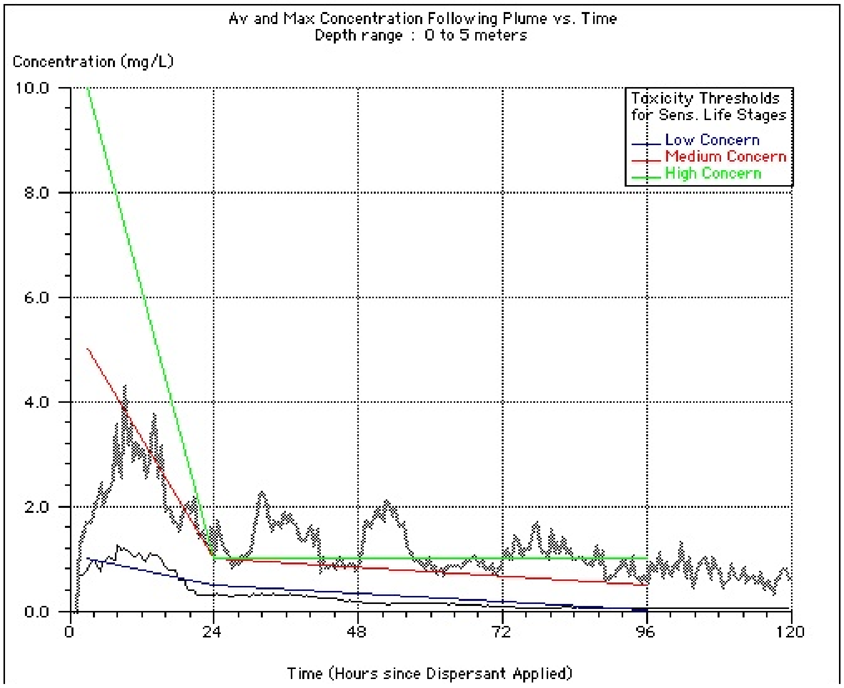


Figure 3.7 *Conservative toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations at 0 to 5 meters without the use of dispersants (based on the values presented in Table 4.1).*

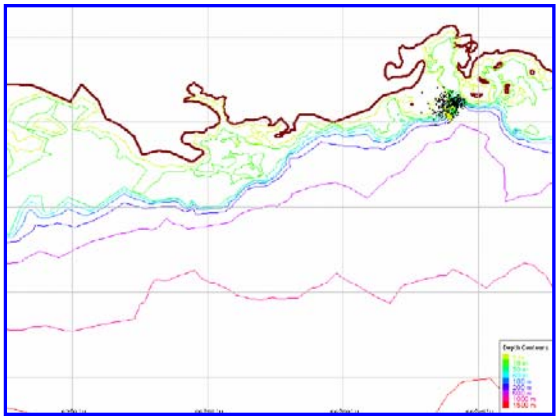
example, after 72 hours almost 212,000 gallons of oil have beached with no response, while with dispersant application at 80% effectiveness this number is reduced to approximately 45,000 gallons. On-water mechanical recovery, assuming an effectiveness of 20%, would lead to a reduction approximately one-third less than that estimated for dispersants at 30% effectiveness.

This reduction in shoreline impact with dispersant use comes at the expense of increased exposure to organisms in the water column. Figure 3.10 shows the maximum dispersed oil concentration by depth in the model cell with the highest concentration in the plume versus time with the use of dispersants at 80% effectiveness. Model estimates suggest that peak concentrations (in limited areas) could exceed 50 ppm in the top five meters, and values up to 5 to 10 ppm could occur to a depth of 10 meters in peak concentration areas. Snapshots of the extent and location of the dispersed oil plume from 0 to 5 meters at 80% effectiveness are presented in Figure 3.8, and also in the QuickTime movie on the workshop CD. Because both of the releases in this scenario were sizeable (4000 and 10,000 bbls), the resulting dispersed oil plume at 80% effectiveness is also extensive, and concentrations as high as 5 to 10 ppm are predicted to persist for at least five days. Concentrations in excess of 50 ppm are predicted only briefly in a small area after the initial release, but are more extensive and last perhaps 24 hours after the second release. Figure 3.9 shows snapshots of the predicted 0 to 5 meter dispersed oil concentration at 30% effectiveness, with a similar distribution pattern, but lower concentrations.

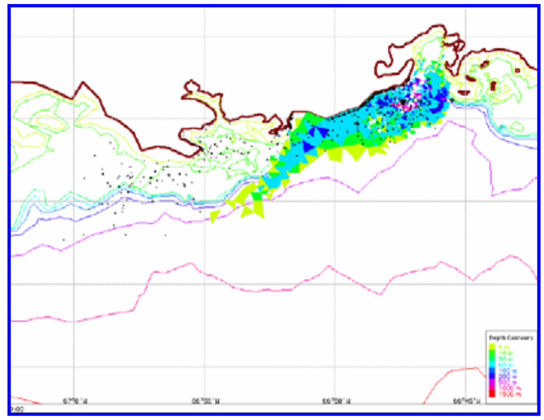
Figure 3.11 compares the maximum and average water column concentration in the top 5 meters when dispersants are used at 80% effectiveness to the thresholds of concern for sea grass. Note that, in this and all subsequent figures related to dispersed oil plume exposure levels, there are two graphs in each figure. Since there are two releases, the thresholds must be applied to each release. Only the low level of concern threshold is exceeded, and then only for the maximum concentrations observed after the second release, which do not represent a large proportion of the plume. Figure 3.12 compares these concentrations to the toxicity thresholds for adult corals. In this case the high level of concern threshold is exceeded for maximum concentrations after both releases, and the low level of concern threshold is exceeded for average concentrations. This suggests a risk to coral present in the path of the dispersed oil plume, especially those affected by peak concentrations. Figure 3.13 compares these concentrations to the thresholds for adult fish. The maximum concentration curve approaches the high level of concern threshold after the initial release, and exceeds it after the second release. The average values approach the medium concern threshold after both releases. Figure 3.14 shows the results for adult crustaceans, which are slightly more sensitive than adult fish. Sensitive life history stages (Figure 3.15) are at the most risk, with the maximum values exceeding the high level of concern threshold after both releases, and the average values exceeding the low level of concern threshold after both releases and the medium level of concern threshold after the initial release.

In addition, concentrations of dispersed oil (at 80% effectiveness) in the bottom one meter were calculated for a coral reef (reef "B") approximately eight miles downstream of the release point (see Figure 3.16). The site is centered at 17º 56.15´ N and 66º 52.60´ W. It is a reef about 300 m long by 150 m wide straddling a depth range of 5 to 10 m. Figure 3.17 shows the maximum and average exposure to dispersed oil at this location over time. Figure 3.18 shows the concentration of dispersed oil at 80% effectiveness at reef "B", compared to thresholds of concern for coral and sea grass. The data suggests that sea grass would be at low risk during this spill scenario, but that the level of concern for corals would be high.

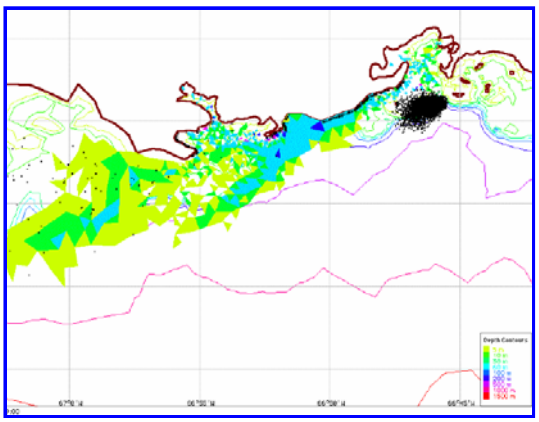
Finally, Figures 3.19 through Figure 3.23 show the maximum and average concentrations of dispersed oil in the plume when dispersants are used at 30% effectiveness relative to the various thresholds. The concentration patterns are the same as for 80% effectiveness, only lower. Figure 3.19 compares these estimates to the thresholds for sea grass, with no indication that even the low level of concern threshold would be exceeded. The situation with adult corals (Figure 3.20) suggests a low to moderate level of concern could exist in areas exposed to the maximum concentration, with the potential for approaching the high level of concern threshold if the exposure is long enough. Given the limited extent of such concentrations, and the movement of the plume, the affected areas would be relatively limited. Adult fish (Figure 3.21) and adult crustaceans (Figure 3.22) could be exposed to concentrations predicted to exceed the moderate level of concern threshold if they remained in areas of maximum concentration, but only low level of concern thresholds would be exceeded at average predicted concentrations. Finally, sensitive life history stages (Figure 3.23) could be exposed above the high level of concern threshold in areas of maximum concentration.



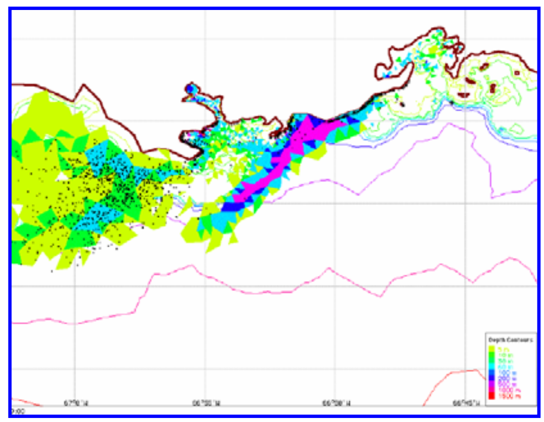
A: 3 Hours



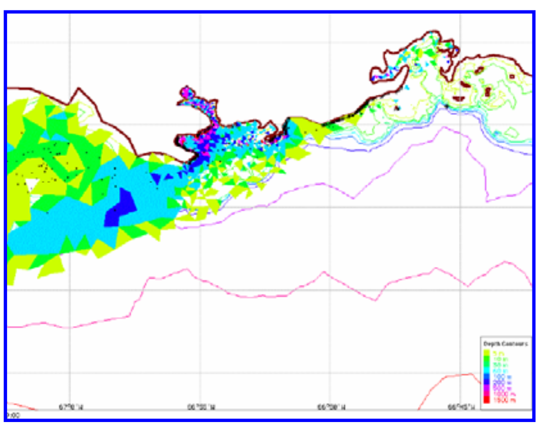
B: 27 Hours



C: 51 Hours



D: 75 Hours

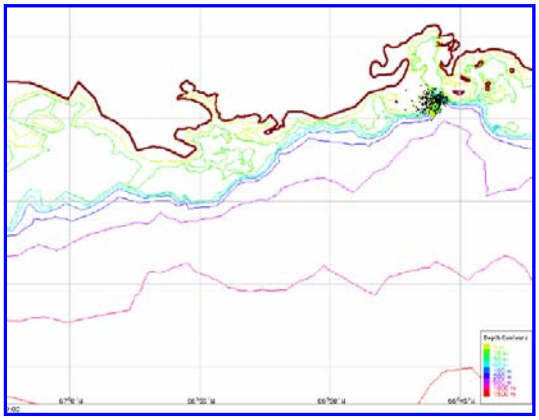


C: 99 Hours

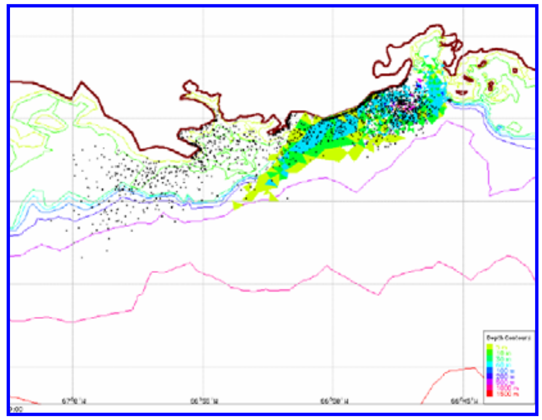
Key to Dispersed Oil Concentration:

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

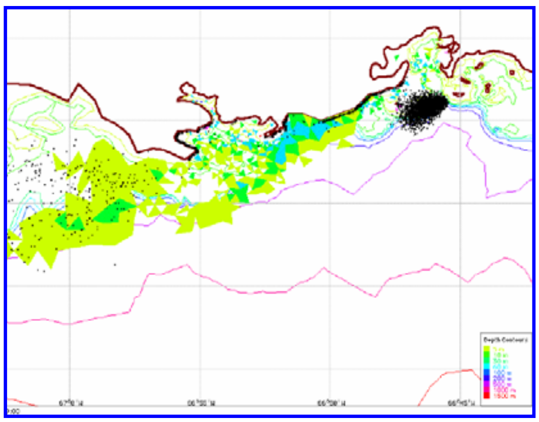
Figure 3.8 *Results from the NOAA GNOME modeling for the Guayanilla Bay Area, Puerto Rico scenario for dispersant use at 80% effectiveness showing average dispersed oil concentrations (in ppm) from 0 to 5 meters and remaining surface oil.*



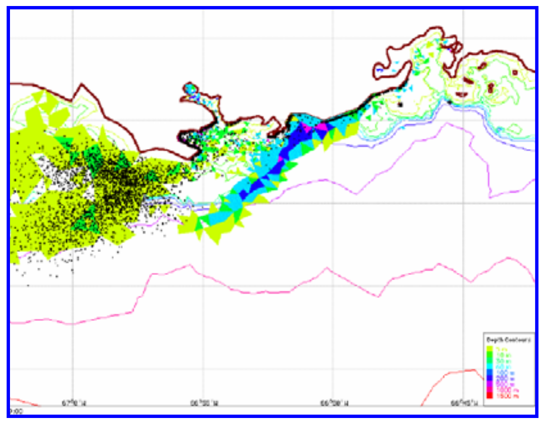
A: 3 Hours



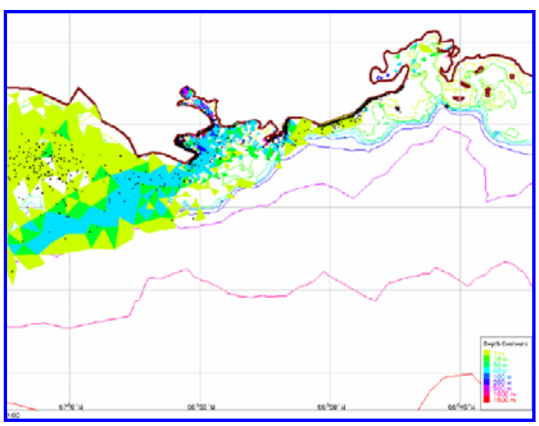
B: 27 Hours



C: 51 Hours



D: 75 Hours

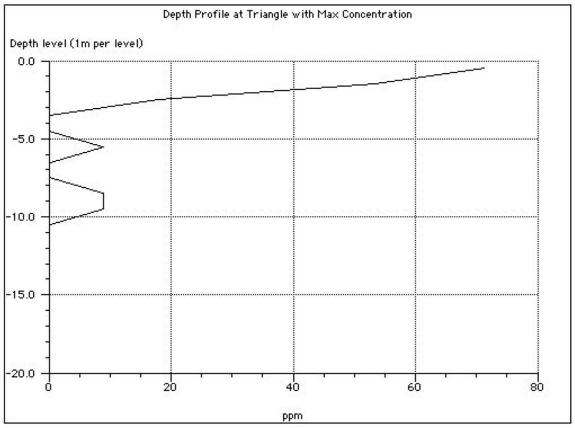


E: 99 Hours

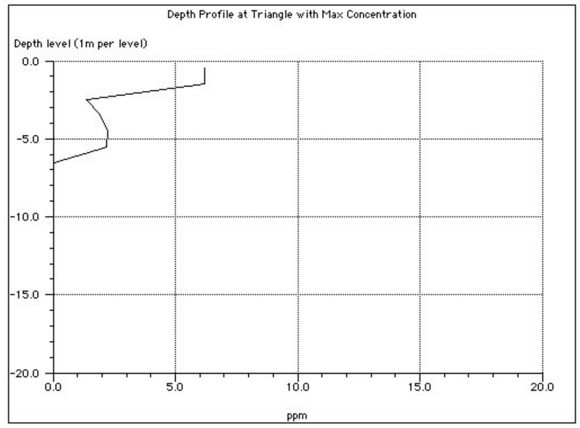
Key to Dispersed Oil Concentration:

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

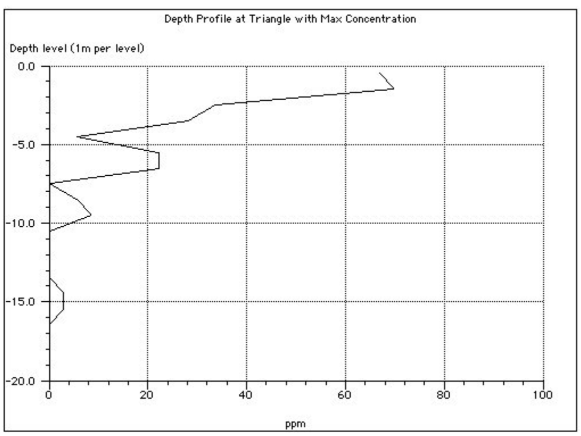
Figure 3.9 *Results from the NOAA GNOME modeling for the Guayanilla Bay Area, Puerto Rico scenario for dispersant use at 30% effectiveness showing average dispersed oil concentrations (in ppm) from 0 to 5 meters and remaining surface oil.*



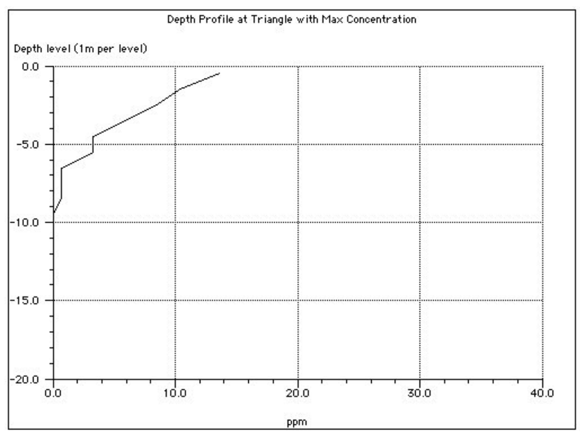
12 Hours



48 Hours

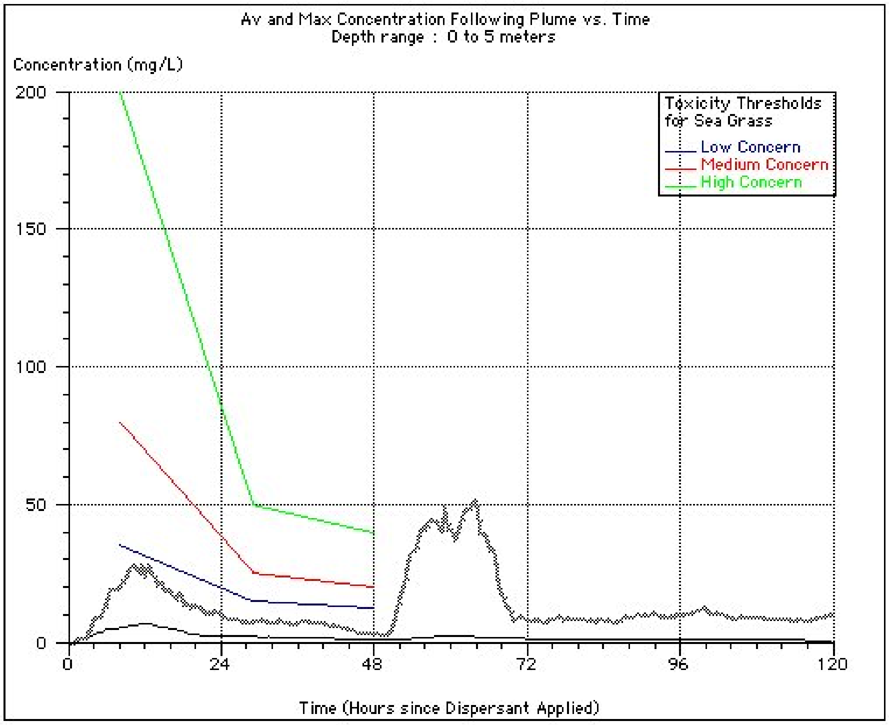


60 Hours



72 Hours

Figure 3.10 *Maximum dispersed oil concentration by depth in the model cell with the highest concentration in the plume versus time with the use of dispersants at 80% effectiveness.*



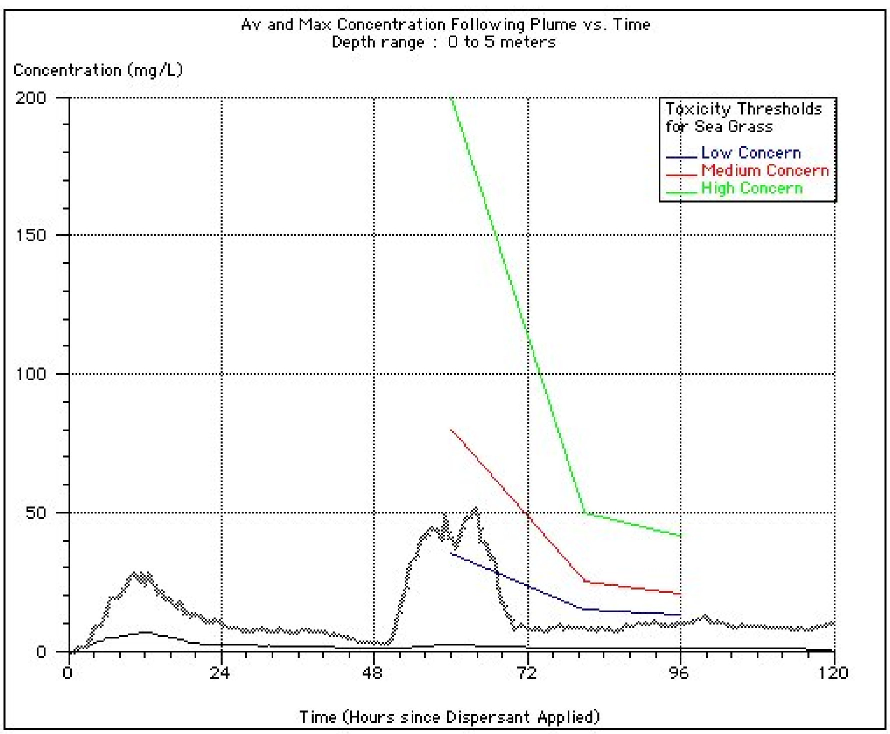
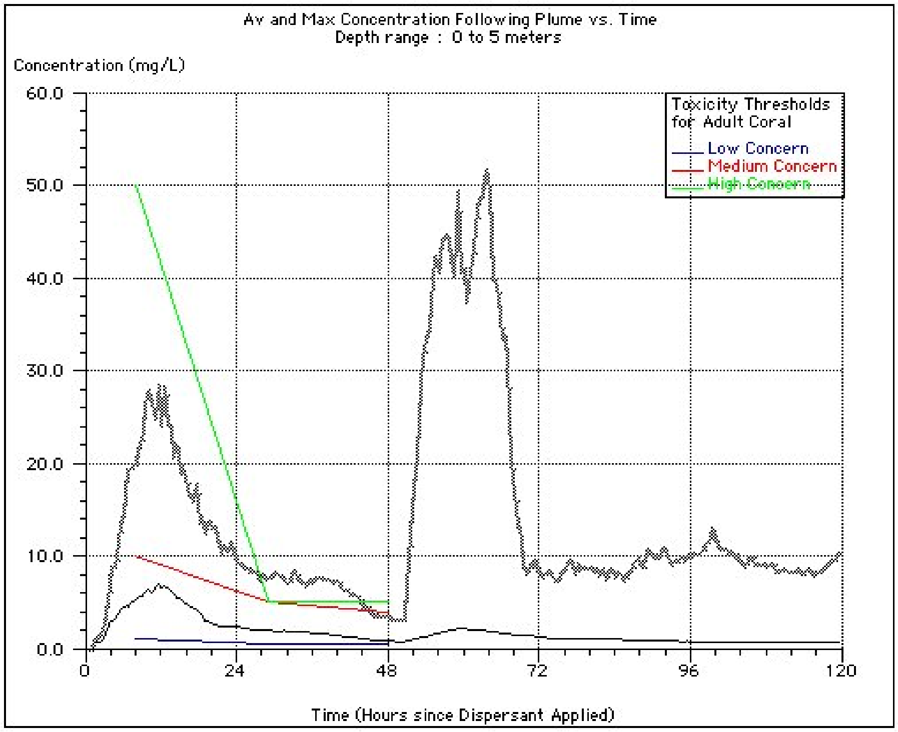


Figure 3.11 *Toxicity thresholds for dispersed oil sea grass compared to maximum and average dispersed oil concentrations with 80% effectiveness at 0 to 5 meters (based on discussion in Section 4.1).*



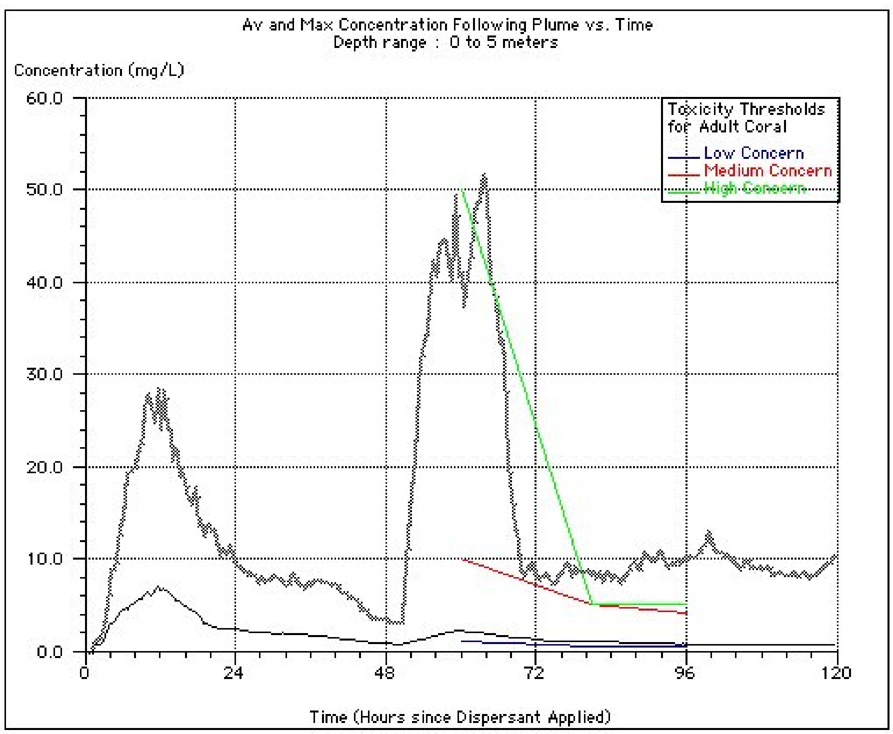


Figure 3.12 *Toxicity thresholds for dispersed oil for adult coral compared to maximum and average dispersed oil concentrations with 80% effectiveness at 0 to 5 meters (based on discussion in Section 4.1).*

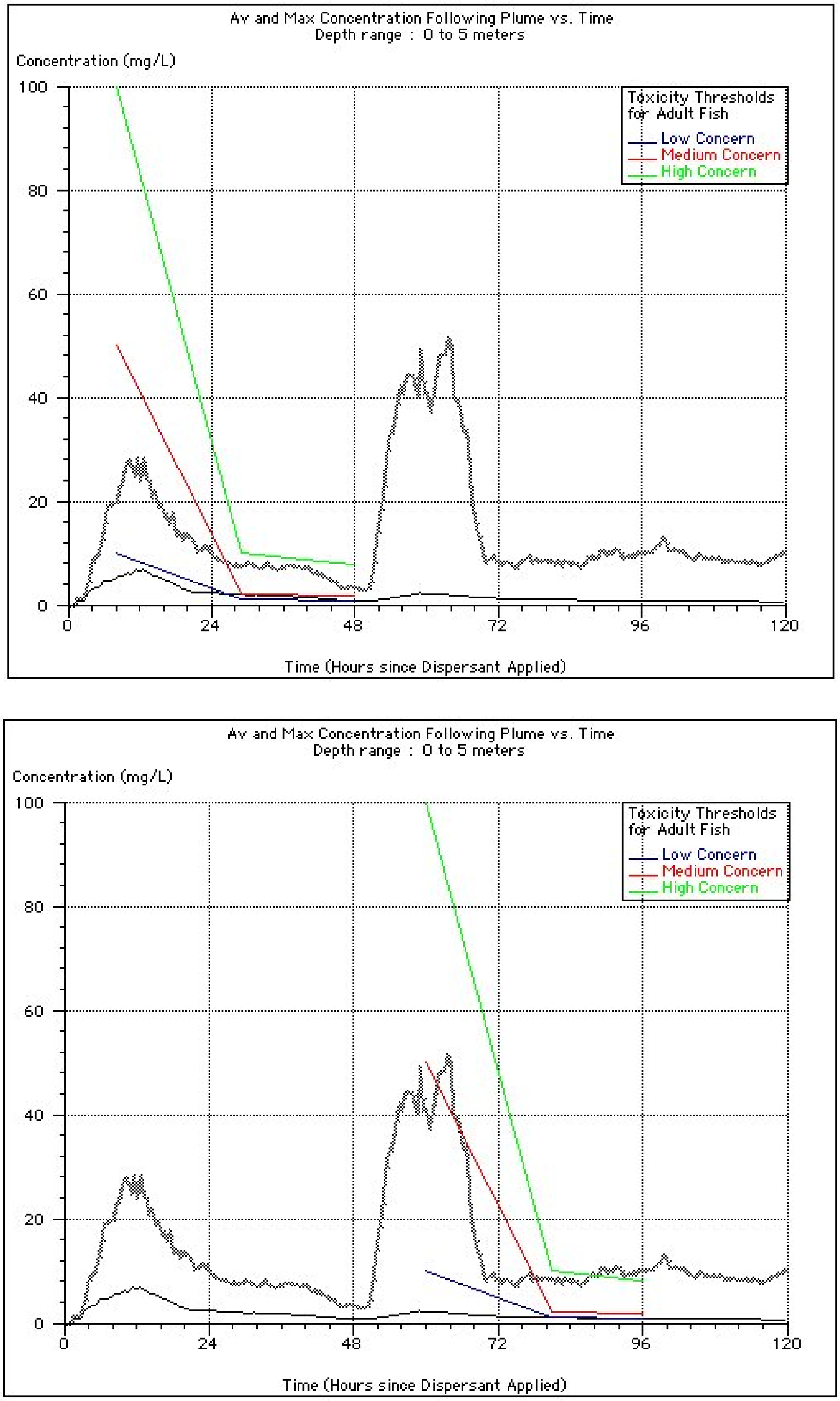
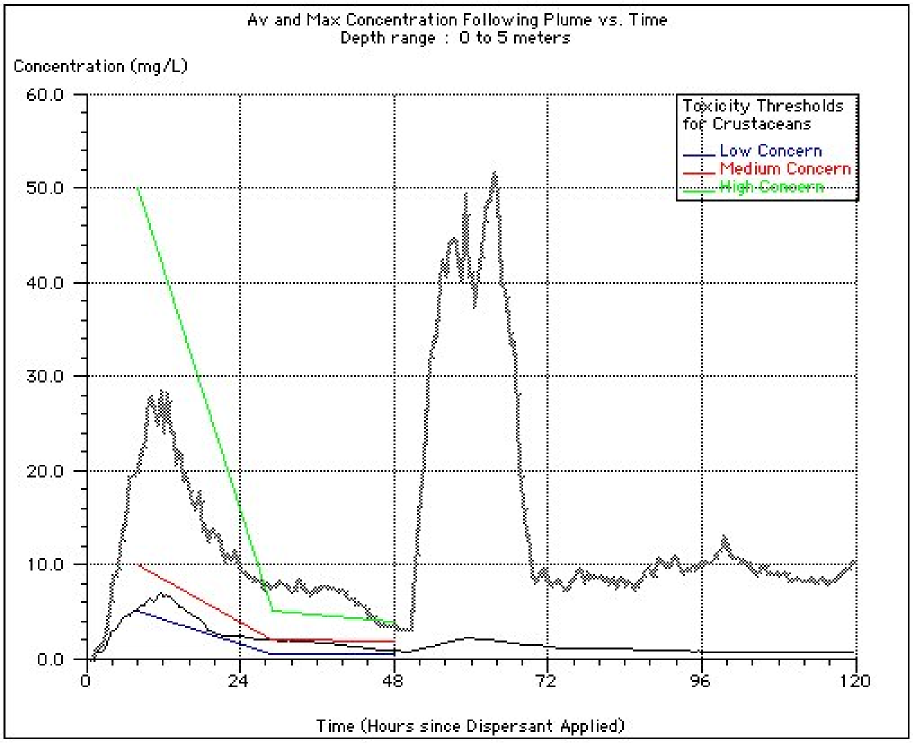


Figure 3.13 *Toxicity thresholds for dispersed oil for adult fish compared to maximum and average dispersed oil concentrations with 80% effectiveness at 0 to 5 meters (based on the values presented in Table 4.1).*



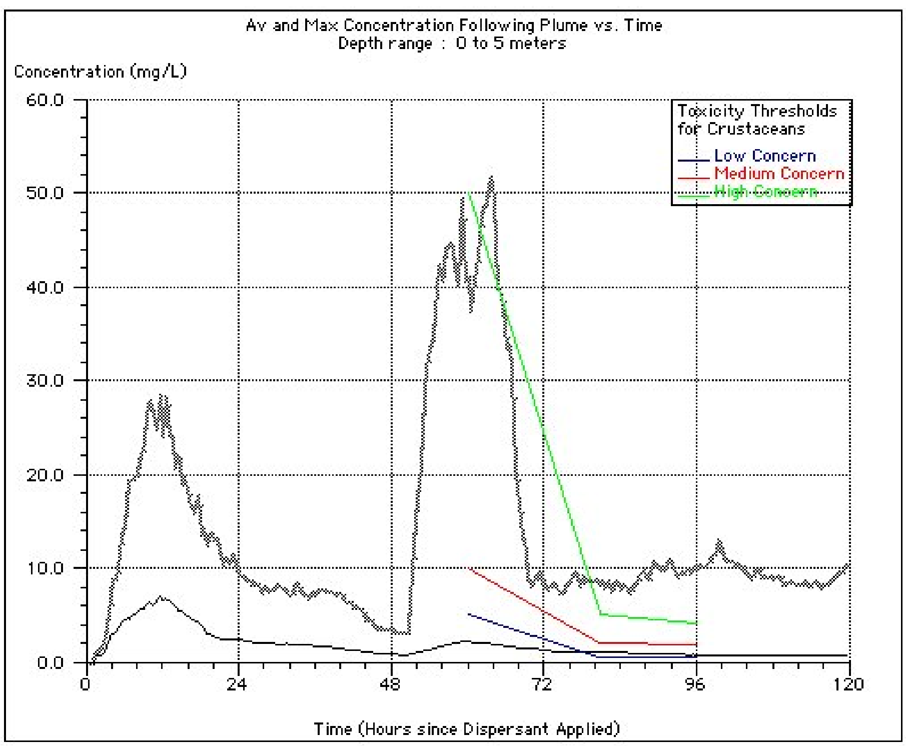
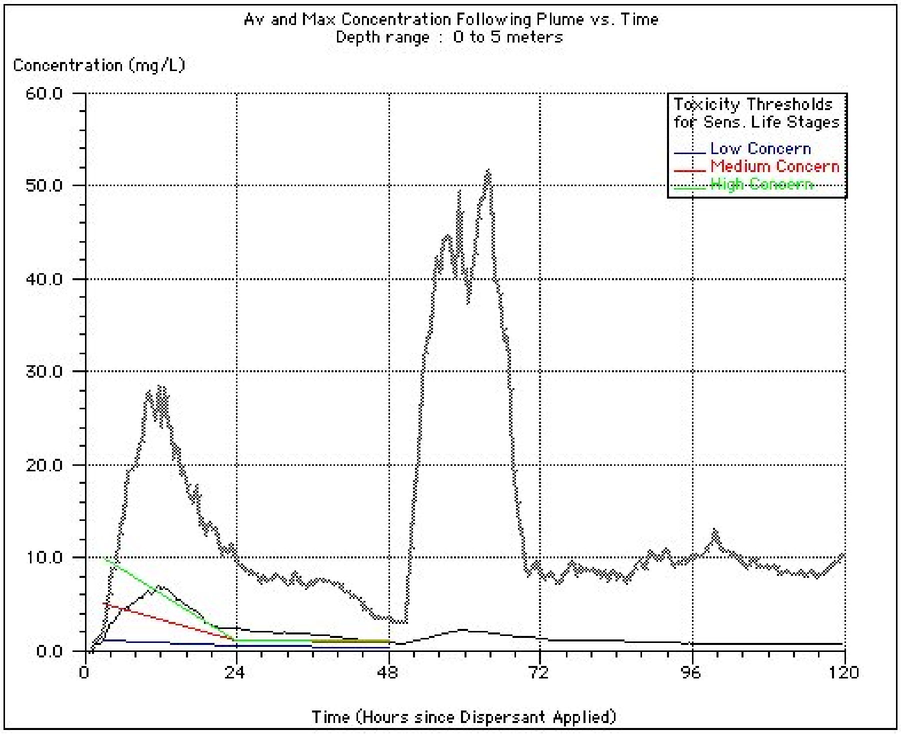


Figure 3.14 *Toxicity thresholds for dispersed oil for adult crustaceans compared to maximum and average dispersed oil concentrations with 80% effectiveness at 0 to 5 meters (based on the values presented in Table 4.1).*



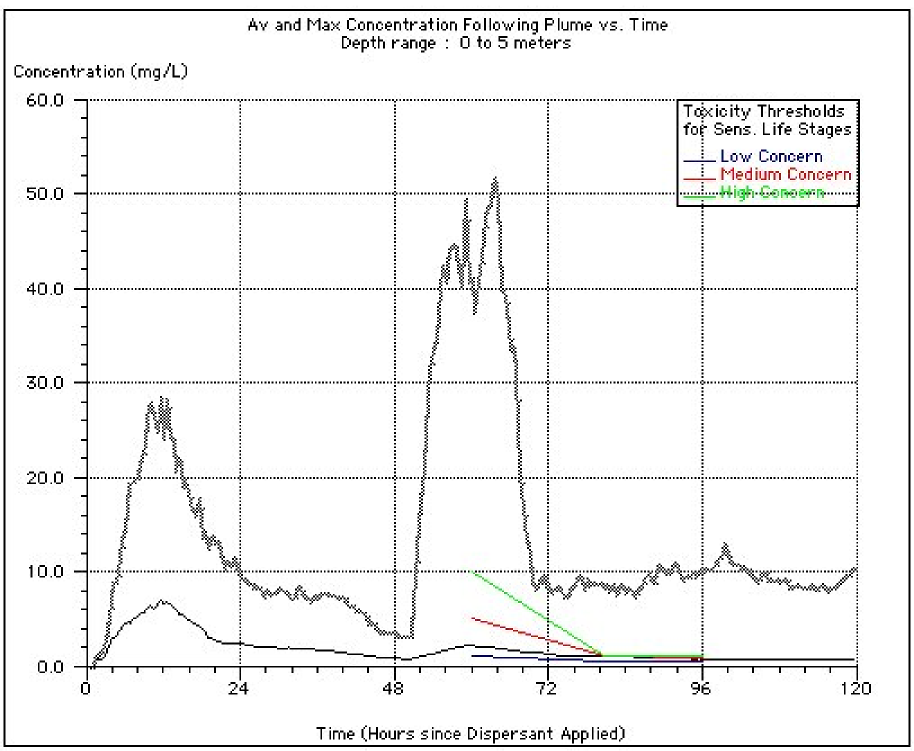


Figure 3.15 *Toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations with 80% effectiveness at 0 to 5 meters (based on the values presented in Table 4.1).*

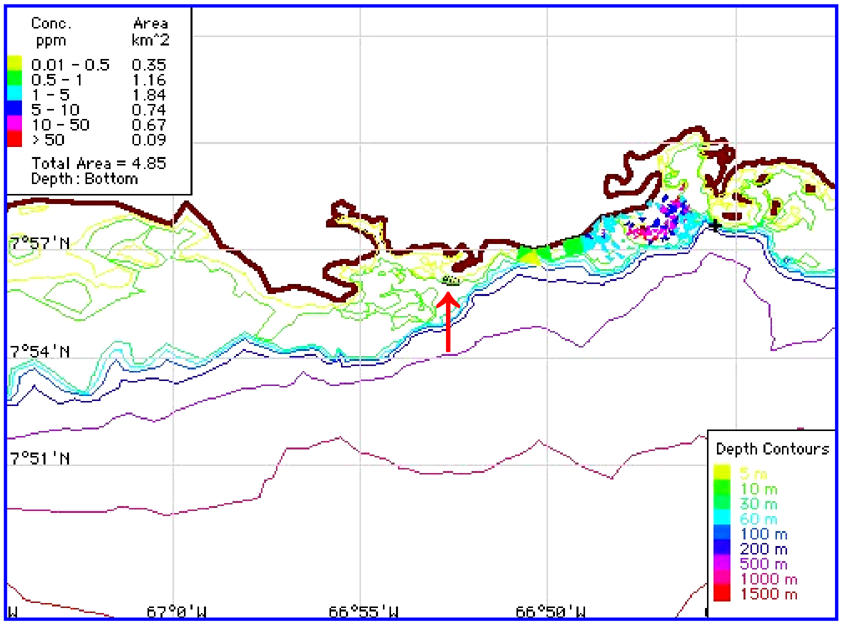


Figure 3.16 *Location of coral reef "B" (see red arrow).*

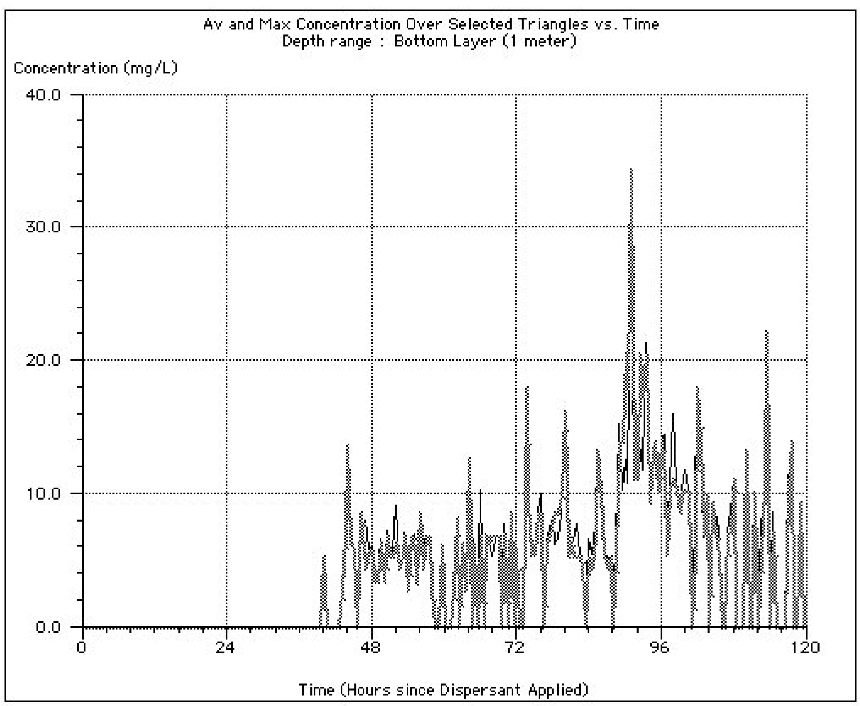
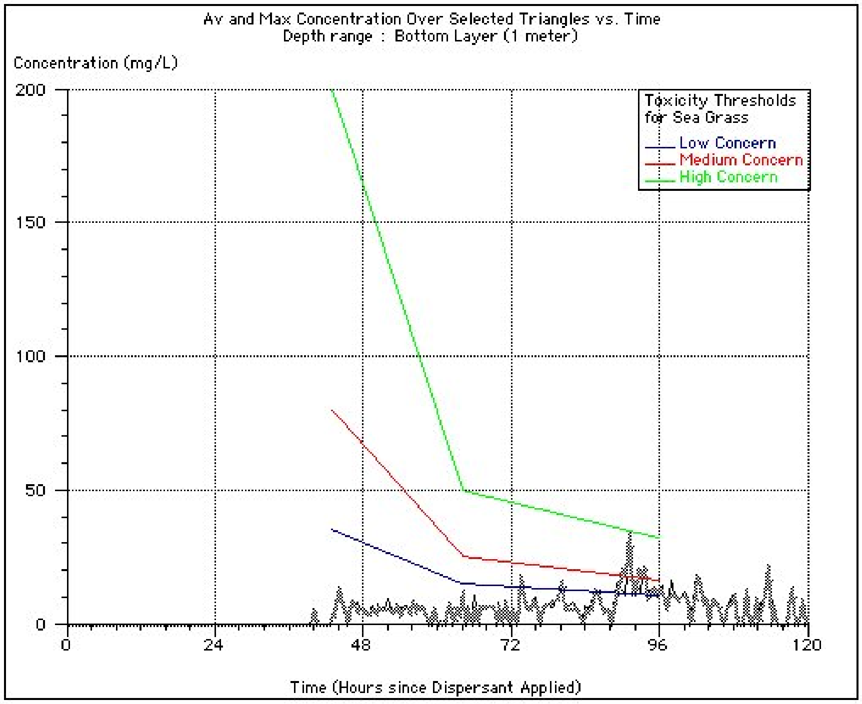


Figure 3.17 *Average and maximum exposure to dispersed oil for benthic habitat at coral reef "B".*



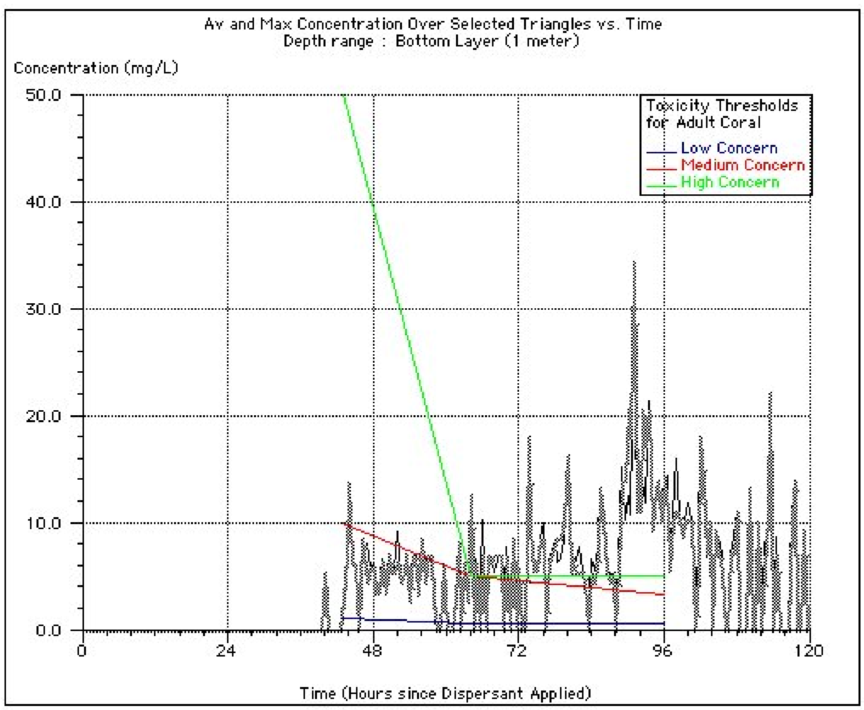
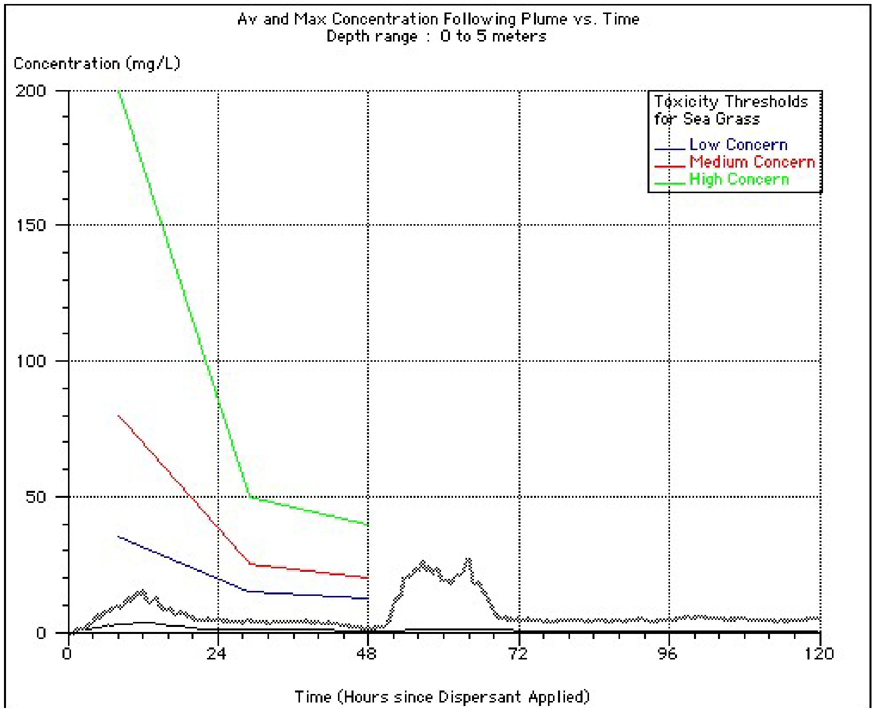


Figure 3.18 *Toxicity thresholds for dispersed oil for sea grass and adult coral compared to maximum and average concentrations at the bottom 1 meter at reef "B" with 80% effectiveness (based on discussion in Section 4.1).*



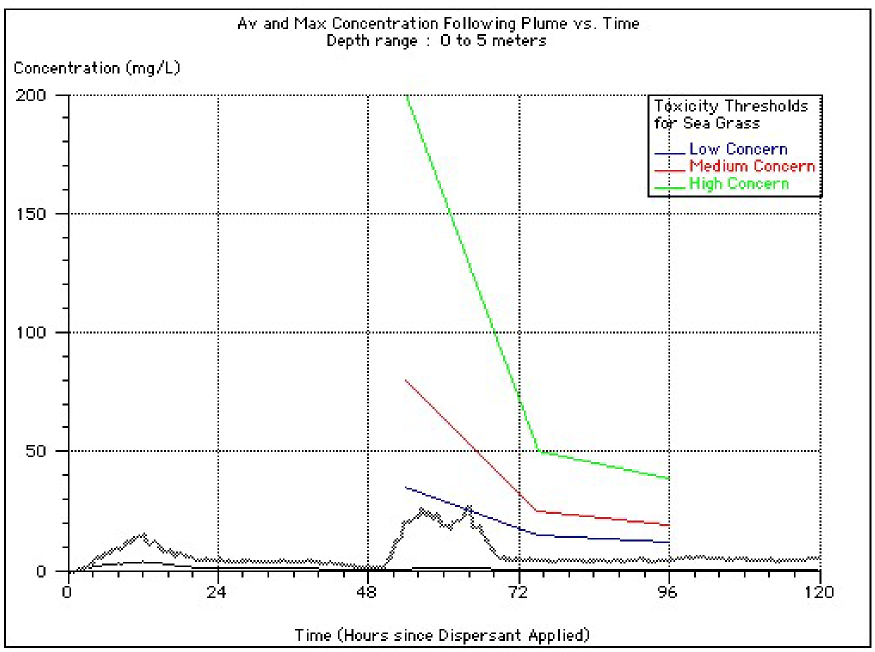


Figure 3.19 *Toxicity thresholds for dispersed oil for sea grass compared to maximum and average dispersed oil concentrations at 0 to 5 meters with the use of dispersants at 30% effectiveness (based on the values presented in Table 4.1).*

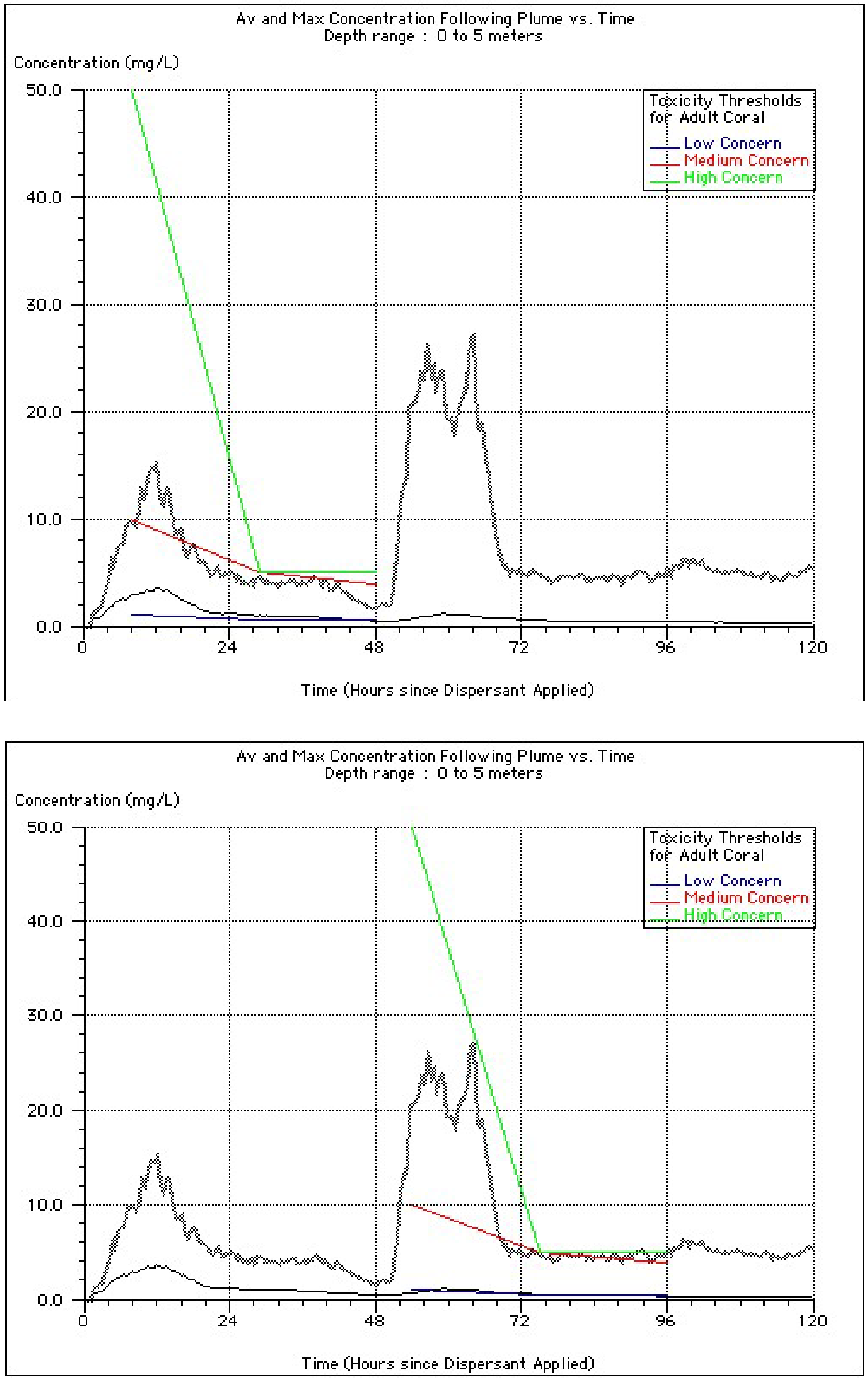


Figure 3.20 *Toxicity thresholds for dispersed oil for adult coral compared to maximum and average dispersed oil concentrations at 0 to 5 meters with the use of dispersants at 30% effectiveness (based on the values presented in Table 4.1).*

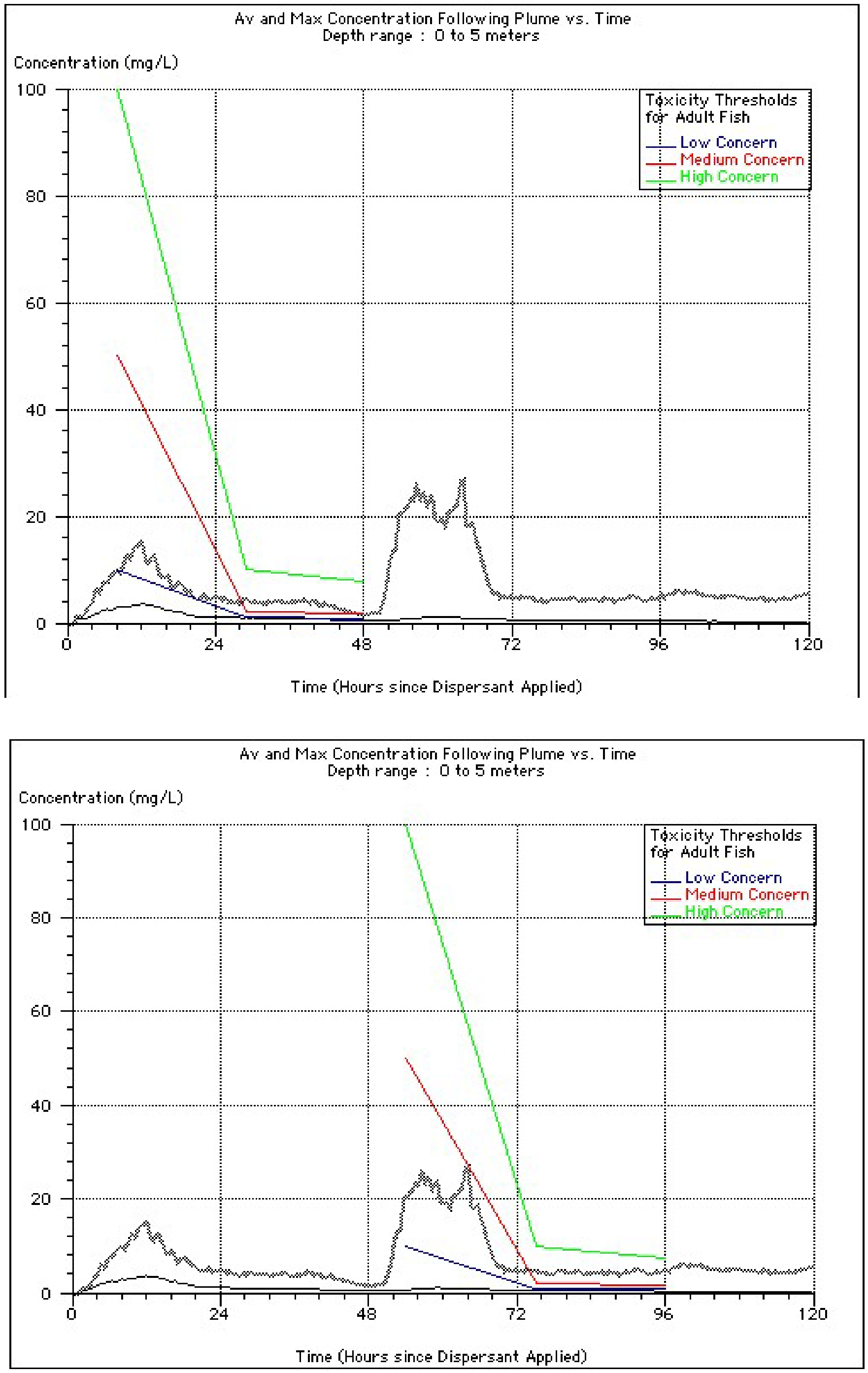
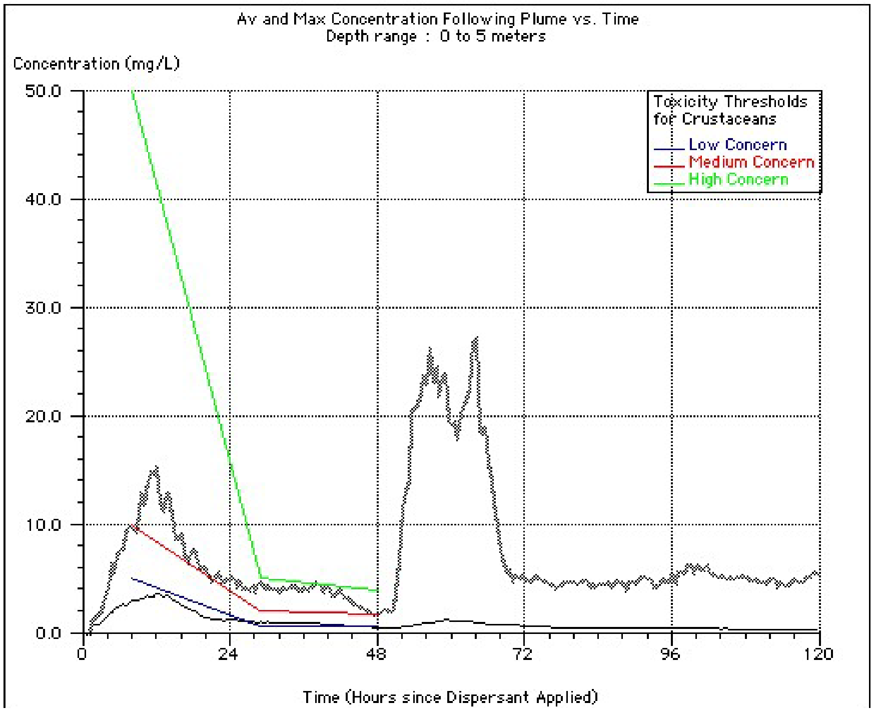


Figure 3.21 *Toxicity thresholds for dispersed oil for adult fish compared to maximum and average dispersed oil concentrations at 0 to 5 meters with the use of dispersants at 30% effectiveness (based on the values presented in Table 4.1).*



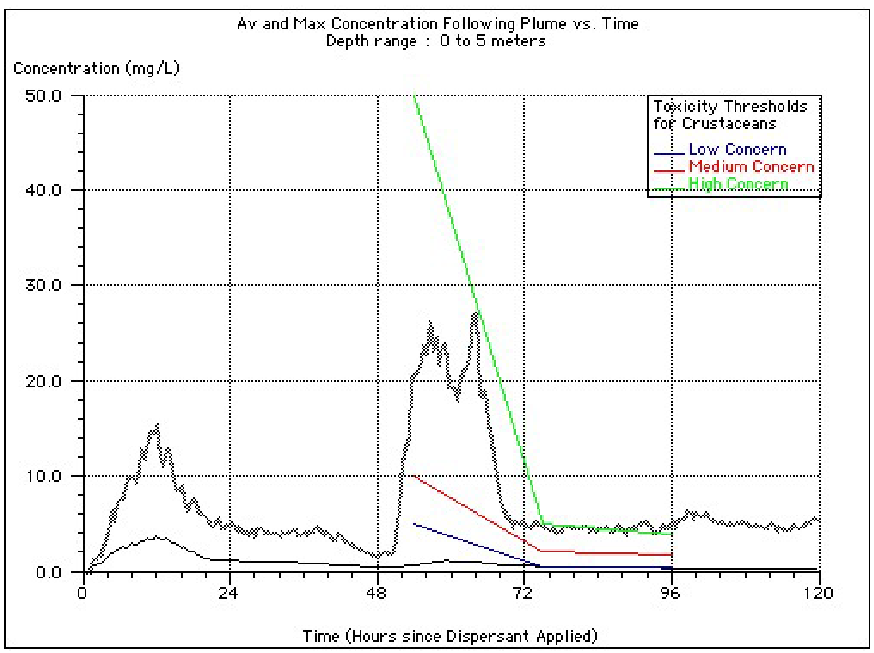
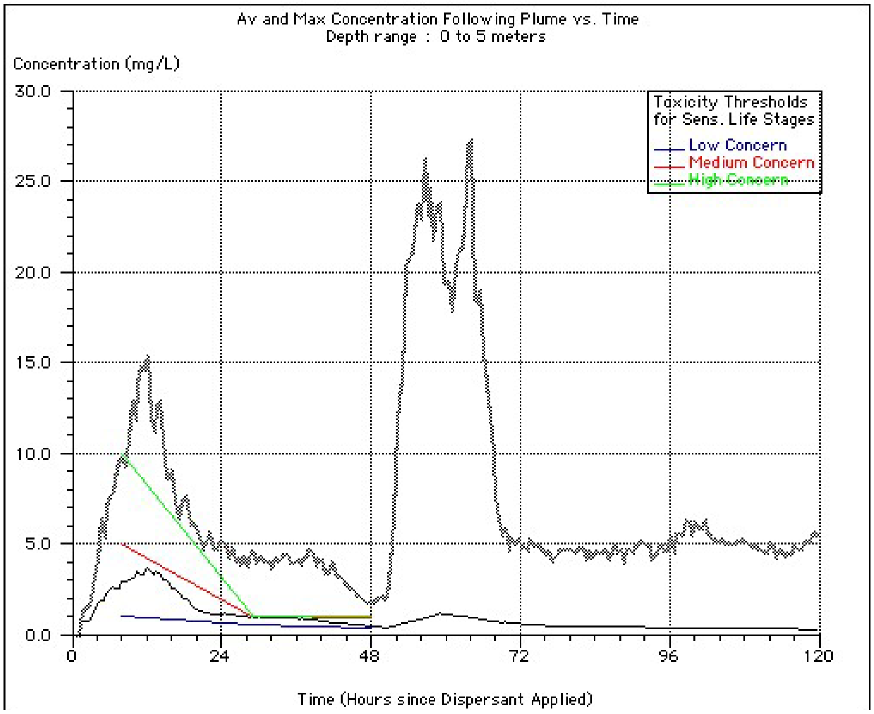


Figure 3.22 *Toxicity thresholds for dispersed oil for adult crustaceans compared to maximum and average dispersed oil concentrations at 0 to 5 meters with the use of dispersants at 30% effectiveness (based on the values presented in Table 4.1).*



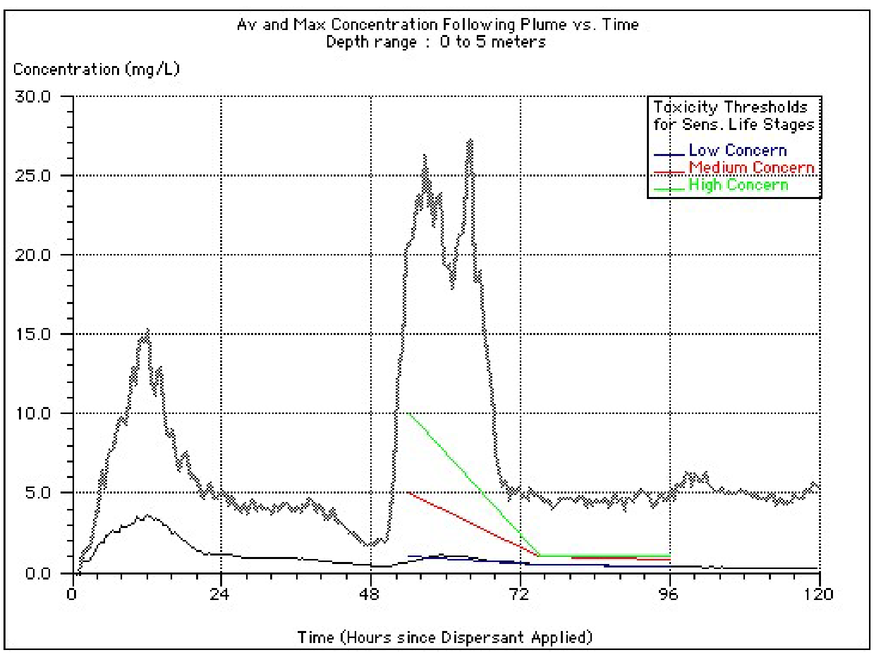


Figure 3.23 *Toxicity thresholds for dispersed oil for sensitive life history stages compared to maximum and average dispersed oil concentrations at 0 to 5 meters with the use of dispersants at 30% effectiveness (based on the values presented in Table 4.1).*

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			
		> 7 years (SLOW) (1)	**3 to 7 years (2)**	**1 to <3 years (3)**	**< 1 year (RAPID) (4)**
% of RESOURCE AFFECTED	**> 50% (LARGE) (A)**	**1A**	**2A**	**3A**	**4A**
	25 to 50% (B)	**1B**	**2B**	**3B**	**4B**
	5 to <25% (C)	**1C**	**2C**	**3C**	**4C**
	0 to <5% (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 Guayanilla Bay area, Puerto Rico risk assessment.*

4.1 Thresholds

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). The values in Table 4.1 are the basis for most of the level of concern thresholds shown in the Figures in Section 3. Those graphical representations were created by plotting the 3, 24, and 96-hour values in the table and then connecting the points. The 'protective,' not 'more protective,' thresholds were used in the graphs. In addition, for this workshop Dr. Alan Mearns (NOAA ERD) developed thresholds for sea grass and adult corals, which are not addressed in Table 4.1. His preliminary estimates (shown on Figures 3.11, 3.12, 3.19 and 3.20) are taken from draft material being prepared for a future NOAA ERD publication, tentatively designated the "Tropical Dispersant Guide."

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

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.

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/m²)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m²)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m²)	Average Thickness[1] (µm)	Concentration in Top 1 square cm[2] (ppm dry wt)	Volume per square meter (g/m²)	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

4.2 Summary Results

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. A summary of the groups' conclusions is presented below.

The detailed results for both focus groups for natural recovery (i.e. no response) are shown in Figure 4.2. The two sets of risk scores are similar for many of the subhabitats, but not all. For intertidal habitats, there were two areas of divergence. For rocky shores Group A concluded there was a moderate level of concern, while Group B felt the level of concern was high. The difference was the perception of risk to shore birds which nest along the southwestern cliffs. For exposed flats, the levels of concern were reversed, with Group A having a high level of concern. The difference was the perception of the extent and level of risk for intertidal sea grass associated communities, which Group A felt could show a long-term impact. Group B shared these concerns but felt the risk was lower. The two groups showed the most difference for two subtidal subhabitats: submerged aquatic vegetation (SAV) and the shallow coral community (<5m). Group A scored SAV and shallow corals fairly low because they felt that concentrations in the water were low enough to cause only a low level of concern. Group B scored SAV and shallow corals very high because they considered re-oiling off the beach which might cause oil to mix with sand, then release back into the water and sink. Groups A & B both agreed that initial floating oil was only a low concern for these two habitats, so the difference was based on longer term effects, which Group A did not feel was a concern, and Group B felt was a concern. Both groups expressed a high level of concern for long-term effects on mangroves. Water column impacts were viewed as moderate by both groups, with special concern for manatees and sea turtles. The risk to the deep coral community and to the water column (both shallow and deep) was viewed as low. It was noted that concern for impacts in the water column would be higher if coral spawning was occurring.

On-water mechanical recovery (Figure 4.3) did not change the scores significantly for either group. Group B saw minor benefits for sand beaches, while Group A saw a slightly reduced risk to the shallow water column. This was based on the conclusion that on-water efforts were unlikely to be very effective, and that most of the anticipated impacts would still occur.

The results for dispersant use at 80% and 30% effectiveness are presented in Figures 4.4 and 4.5, respectively. Because of the size of the spill, both of the focus groups were concerned about increased risk to subtidal habitat, especially shallow coral reefs and the invertebrate fauna of sea grass beds. Deep coral reefs were a low to moderate concern. In all cases, the level of concern was greater with increased effectiveness of the dispersant application. Both groups concluded that there would be reduced risk to organisms on the water surface (especially manatees) and intertidal habitats, with more benefit as the effectiveness of the operation increased. There were differences of opinion as to how much benefit would occur, since even with dispersant application the size of the spill meant a lot of oil could still be expected to strand in shoreline habitats.

The final option, on-shore mechanical recovery (Figure 4.6), was viewed by both groups as having limited benefit to specific habitats, especially those of lesser ecological concern that were easily cleaned, such as sand beaches. Both groups also saw a potential long-term benefit by decreasing oil which could represent a threat to shallow near-shore habitats, but both groups were also concerned that shoreline recovery activities in sensitive habitats, especially mangroves, would be detrimental.

Habitats	Water Surface						Terrestrial		
Subhabitats									
Group	Mammals	Birds	Fish	Mollusks	Plankton	Reptiles	Mammals	Birds	Reptiles
A	L	L	L	L	L	L	L	L	L
	1D	2B	4D	4D	4A	1C	4D	4D	3D
	2C						4D		
B	R	L	L	L	L	L	L	L	L
	3C	3C	4D	4D	4D	4D	3D	3C	3D
	3C						3D		

Habitats	Intertidal						
Subhabitats	Mangrove Forest						
Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna
A	L	L	L	L	L	L	L
	1A	4D	3B	2C	3C	3A	3A
	1A						
B	L	R	R	L	L	L	L
	1C	1C	2C	1C	1B	1B	3B
	1C						

Habitats	Intertidal								
Subhabitats	Rocky Shores					Sand Beach			
Group	Vegetation	Birds	Aquatic Arthropods	Coelenterates	Mollusks	Epifauna	Birds	Reptiles	Mollusks
A	L	L	L	L	L	L	L	L	L
	4D	3D	3C	4C	2A	NA	3B	3B	3A
	3C					3B			
B	L	L	L	L	L	L	L	L	L
	2D	1B	3C	3D	2B	3D	3D	1D	3D
	2B					1D			

Habitats	Intertidal					
Subhabitats	Exposed Flats					
Group	Vegetation	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks
A	L	L	L	L	L	L
	2A	3B	4D	3B	1A	3A
	2A					
B	L	L	L	L	L	L
	3C	4D	4D	4D	3C	4D
	3C					

Habitats	Subtidal								
Subhabitats	Submerged Aquatic Vegetation								
Group	Epifauna	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	L	L	L	L	L	L	L	L	L
	4D	4D	4D	4D	4D	3D	4D	4D	4D
	4D								
B	L	L	R	L	L	L	L	L	L
	2B	3A	3C	3C	3A	3A	3C	2B	3C
	2B								

Habitats	Subtidal													
Subhabitats	Shallow Coral Commun. (<5 m)							Deep Coral Commun. (>5 m)						
Group	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	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							4D						
B	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	2B	3D	1C	1B	1B	2C	1D	3D	4D	4D	4D	4D	4D	4D
	1B							4D						

Habitats	Water Column													
Subhabitats	Shallow (<5m)							Deep (>5m)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
A	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							4D						
B	R	L	L	NA	L	L	L	R	NA	L	L	L	L	L
	4C	4C	4B	NA	4D	4B	4D	4D	NA	4D	4D	4D	4D	4D
	4B							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.*

Habitats	Water Surface						Terrestrial			Intertidal																					
Subhabitats										Mangrove Forest							Rocky Shores					Sand Beach				Exposed Flats					
Group	Mammals	Birds	Fish	Mollusks	Plankton	Reptiles	Mammals	Birds	Reptiles	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Vegetation	Birds	Aquatic Arthropods	Coelenterates	Mollusks	Epifauna	Birds	Reptiles	Mollusks	Vegetation	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks
A	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
	1C	2B	4D	4D	4A	1C	4D	4D	3D	1A	4D	3B	2C	3C	3A	3A	4D	3D	3C	4C	2A	NA	3B	3B	3A	2A	3B	4D	3B	1A	3A
	2C						4D			1A							3C					3B				2A					
B	R	L	L	L	L	L	L	L	L	L	R	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	1C	3C	4D	4D	4D	4D	3D	3C	3D	1C	1C	2C	1C	1B	1B	3B	2D	1C	3C	3D	2B	3D	3D	2D	3D	3C	4D	4D	4D	3C	4D
	1C						3D			1C							2B					2D				3C					

Habitats	Subtidal																						
Subhabitats	Submerged Aquatic Vegetation									Shallow Coral Commun. (<5 m)							Deep Coral Commun. (>5 m)						
Group	Epifauna	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	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	4D	4D	4D	4D	4D	4D	4D	4D
	4D									4D							4D						
B	L	L	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	2B	3A	3C	3C	3A	3A	3C	2B	3C	2B	3D	1C	1B	1B	2C	1D	4D	4D	4D	4D	4D	4D	4D
	2B									1B							4D						

Habitats	Water Column													
Subhabitats	Shallow (<5m)							Deep (>5m)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
A	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							4D						
B	R	L	L	NA	L	L	L	R	NA	L	L	L	L	L
	4D	4D	4D	NA	4D	4D	4D	4D	NA	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 4.3 *Detailed focus group risk analysis results for on-water mechanical recovery.*

Habitats	Water Surface						Terrestrial			Intertidal						
Subhabitats										Mangrove Forest						
Group	Mammals	Birds	Fish	Mollusks	Plankton	Reptiles	Mammals	Birds	Reptiles	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna
A	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	1D	2D	4B	4D	4A	1D	4D	4D	4D	3C	4D	3D	3D	4C	3D	3D
	2D						4D			2D						
B	R	L	L	L	L	L	L	L	L	L	R	R	L	L	L	L
	4D	4C	4D	4D	4D	4D	4D	4D	4D	2D	4D	3D	3B	3A	3A	3A
	4C						4D			3A						

Habitats	Intertidal														
Subhabitats	Rocky Shores					Sand Beach				Exposed Flats					
Group	Vegetation	Birds	Aquatic Arthropods	Coelenterates	Mollusks	Epifauna	Birds	Reptiles	Mollusks	Vegetation	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks
A	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	3D	3D	4D	3D	NA	3D	3D	3D	3D	3D	3B	3A	1A	3B
	3D					3D				2B					
B	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	3D	3D	4D	4D	4A	4D	4D	3D	4D	4B	4D	4D	4C	4B	4C
	4A					3D				4B					

Habitats	Subtidal																						
Subhabitats	Submerged Aquatic Vegetation									Shallow Coral Commun. (<5 m)							Deep Coral Commun. (>5 m)						
Group	Epifauna	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4B	4D	4D	4D	4A	3B	1B	2B	4D	4B	4D	4A	3B	1B	1B	4D	4C	4D	4D	3D	1D	2D	4D
	2B									2B							1D						
B	L	L	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4A	4A	4B	4C	4A	4A	4B	4A	4B	3A	4C	3A	3A	1A	3B	3C	4C	4C	4B	4C	3B	4C	4C
	4A									1A							3B						

Habitats	Water Column													
Subhabitats	Shallow (<5m)							Deep (>5m)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
A	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	4D	4D	4C	4C	3D	4A	4D	4D	4D	4C	4C	3D	4C	4D
	4C							4C						
B	R	L	L	NA	L	L	L	R	NA	L	L	L	L	L
	4C	4B	4A	NA	4B	4A	4C	4C	NA	4B	4C	4C	4B	4C
	4A							4B						

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 80% effectiveness.*

Habitats: Water Surface — Subhabitats: (none)

Group	Mammals	Birds	Fish	Mollusks	Plankton	Reptiles
A	L	L	L	L	L	L
	1D	2C	4C	4D	4A	1D
	2D					
B	R	L	L	L	L	L
	3C	3C	4D	4D	4D	4D
	3C					

Habitats: Terrestrial — Subhabitats: (none)

Group	Mammals	Birds	Reptiles
A	L	L	L
	4D	4D	4D
	4D		
B	L	L	L
	3D	4C	3D
	3D		

Habitats: Intertidal — Subhabitats: Mangrove Forest

Group	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna
A	L	L	L	L	L	L	L
	2C	4D	3C	3C	4C	3C	3C
	3C						
B	L	R	R	L	L	L	L
	2C	2C	3C	2B	2A	2A	2B
	2A						

Habitats: Intertidal — Subhabitats: Rocky Shores

Group	Vegetation	Birds	Aquatic Arthropods	Coelenterates	Mollusks
A	L	L	L	L	L
	4D	3D	3D	4D	3C
	3C				
B	L	L	L	L	L
	2D	3B	4C	3D	3B
	3B				

Habitats: Intertidal — Subhabitats: Sand Beach

Group	Epifauna	Birds	Reptiles	Mollusks
A	L	L	L	L
	NA	3C	3C	3C
	3C			
B	L	L	L	L
	3D	3D	1D	3D
	1D			

Habitats: Intertidal — Subhabitats: Exposed Flats

Group	Vegetation	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks
A	L	L	L	L	L	L
	3C	3C	3C	3B	1A	3B
	2B					
B	L	L	L	L	L	L
	3B	4D	4D	4C	3B	4C
	3B					

Habitats: Subtidal — Subhabitats: Submerged Aquatic Vegetation

Group	Epifauna	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	L	L	L	L	L	L	L	L	L
	4C	4D	4D	4D	4B	3C	1C	2C	4D
	2B								
B	L	L	R	L	L	L	L	L	L
	2A	3A	3B	3C	3A	3A	3B	2A	3B
	2A								

Habitats: Subtidal — Subhabitats: Shallow Coral Commun. (<5 m)

Group	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	L	L	L	L	L	L	L
	4C	4D	4B	3C	1C	2C	4D
	2B						
B	L	L	L	L	L	L	L
	2A	3C	2B	2B	1B	2C	1D
	1B						

Habitats: Subtidal — Subhabitats: Deep Coral Commun. (>5 m)

Group	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
A	L	L	L	L	L	L	L
	4D	4D	4D	3D	1D	2D	4D
	1D						
B	L	L	L	L	L	L	L
	4D	4D	4C	4D	4C	4D	4D
	4C						

Habitats: Water Column — Subhabitats: Shallow (<5m)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
A	L	L	L	L	L	L	L
	4D	4D	4C	4C	3D	4A	4D
	4C						
B	R	L	L	NA	L	L	L
	4D	4C	4B	NA	4C	4B	4D
	4B						

Habitats: Water Column — Subhabitats: Deep (>5m)

Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
A	L	L	L	L	L	L	L
	4D	4D	4C	4C	3D	4D	4D
	4C						
B	R	NA	L	L	L	L	L
	4D	NA	4C	4D	4D	4C	4D
	4C						

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 30% effectiveness.*

Habitats	Water Surface						Terrestrial			Intertidal																						
Subhabitats										Mangrove Forest							Rocky Shores					Sand Beach				Exposed Flats					
Group	Mammals	Birds	Fish	Mollusks	Plankton	Reptiles	Mammals	Birds	Reptiles	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Epifauna	Vegetation	Birds	Aquatic Arthropods	Coelenterates	Mollusks	Epifauna	Birds	Reptiles	Mollusks	Vegetation	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks
A	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
	1D	2C	4D	4D	4A	1C	4D	3D	3D	1B	4D	3B	2C	3C	3A	3A	4D	3D	4C	4C	3A	NA	4B	4B	3A	3A	4B	4D	4B	1A	3A
	2D						3D			1B							3C					4B				2A					
B	R	L	L	L	L	L	L	L	L	L	R	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	1C	3C	4D	4D	4D	4D	2C	2C	2D	1B	1C	1B	1C	1B	1A	2A	3B	2B	3B	3D	3B	4C	4D	3D	4D	2B	4D	4D	3C	2B	4D
	1C						2C			1A							2B					3D				2B					

Habitats	Subtidal																						
Subhabitats	Submerged Aquatic Vegetation									Shallow Coral Commun. (<5 m)							Deep Coral Commun. (>5 m)						
Group	Epifauna	Vegetation	Mammals	Birds	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles	Epifauna	Vegetation	Fish	Aquatic Arthropods	Coelenterates	Mollusks	Reptiles
Group																							
A	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	4D	4D	4D	4D	4D	4D	4D	4D
	4D									4D							4D						
B	L	L	R	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	2B	3A	3C	3C	3A	3A	3C	2B	3C	2B	3D	1C	1B	1B	2C	1D	4D	4D	4D	4D	4D	4D	4D
	2B									1B							4D						

Habitats	Water Column													
Subhabitats	Shallow (<5m)							Deep (>5m)						
Group	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles	Mammals	Birds	Fish	Aquatic Arthropods	Mollusks	Plankton	Reptiles
Group														
A	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							4D						
B	R	L	L	NA	L	L	L	R	NA	L	L	L	L	L
	4D	4D	4D	NA	4D	4D	4D	4D	NA	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. Four response options were analyzed in addition to natural recovery: on-water mechanical recovery, dispersant application at 80% effectiveness, dispersant application at 30% 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. In summary, participants felt that the large size of this spill presented a significant response challenge. On-water mechanical recovery was viewed as having limited success, and while dispersant use offered some benefits to shoreline and intertidal habitats, the risk to coral reefs (especially shallow reefs) was a serious concern. 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.

Response Options	Water Surface		Terrestrial		Intertidal: Mangrove Forest		Intertidal: Rocky Shores		Intertidal: Sand Beaches		Intertidal: Exposed Flats		Subtidal: Submerged Aquatic Vegetation		Subtidal: Shallow Coral Community (<5m)		Subtidal: Deep Coral Community (>5m)		Water Column: Shallow (<5m)		Water Column: Deep (>5m)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Natural Recovery	Yellow	Yellow	Green	Green	Red	Red	Yellow	Red	Yellow	Yellow	Red	Yellow	Green	Red	Green	Red	Green	Green	Green	Green	Green	Green
Mechanical Recovery	Yellow	Red	Green	Green	Red	Red	Yellow	Red	Yellow	Yellow +	Red	Yellow	Green	Red	Green	Red	Green	Green	Green +	Green	Green	Green
Dispersants (30%)	Yellow +	Yellow	Green	Green	Yellow	Red -	Yellow	Yellow	Yellow +	Yellow	Red +	Yellow -	Red	Red -	Red	Red	Yellow	Green -	Green -	Green	Green -	Green -
Dispersants (80%)	Yellow +	Green	Green	Green +	Yellow	Red -	Green	Yellow	Green	Green	Red +	Green	Red	Yellow	Red	Red -	Yellow	Yellow	Green -	Yellow	Green -	Green -
Shoreline Cleanup	Yellow +	Red	Green -	Yellow	Red -	Red -	Yellow	Red	Green	Green	Red	Red	Green	Red	Green	Red	Green	Green	Green	Green	Green	Green

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 Guayanilla Bay area, Puerto Rico risk assessment.*

5.1 Key Factors Influencing Decisions in this Scenario

On the afternoon of the fourth day, the participants were presented with five questions by the facilitators and asked to break into their focus groups and discuss each of the questions in preparation for developing recommendations and lessons learned. The talking points developed by each of the focus groups are presented below for each of the five questions. It should be noted that these points represented the views only of the particular group, and the opinions represented were refined while developing the consensus recommendations in Section 5.2.

5.1.1 Group A Discussion Points

Question 1. What are your conclusions about response options in this scenario?

- None of the response options is ideal; each one involves tradeoffs.
- Mechanical recovery alone is not sufficient, at least for a spill of this scale.
- Overall in this scenario, using dispersants would be a benefit, but they are not a replacement for mechanical response. This assumes they can be applied in a timely fashion.
- There is a big tradeoff between the mangroves and the coral. Dispersants help the mangroves and hurt the coral in the short-term, at least. In the long-term, loss of mangroves would increase sedimentation on the reefs.
- Based on local knowledge of members in the group, they recognize that most spill response stockpiles are in San Juan, so readiness is insufficient at this time. In reality, these response options would likely be initiated more slowly than what would be ideal.
- Recommend that dispersants, boom and spraying equipment be strategically stockpiled around Puerto Rico.
- *In situ* burning (on water) should be considered along with the other response options. If found practical, fire boom and associate equipment for *in situ* burning would need to be stockpiled.

Question 2. What if the spill occurred during a different season?

- This season (Feb) is the best case season for a spill in this location. Later (in the summer) sea turtles will nest and hatch. In Aug and Sept, other invertebrates will spawn. In these seasons, there are tradeoffs between beach and water spawning events. During Aug and Sept, this group would probably choose to prioritize corals. Prevention of spills would be especially important during Aug and Sept.

Question 3. What if the spill was a smaller volume?

- Need to know what size exactly to answer the question.
- Recognize that some levels of concern would be lower.
- Damage would be less overall.
- In case of very small spill, mechanical response alone could be sufficient.

Question 4. What if the spill occurred farther offshore?

- There would be a larger area affected.

- Fewer concerns about using dispersants because larger water volume available for dilution and more time to apply dispersant before it reaches the shore.
- More time would be required to get mechanical equipment on scene.
- Possibility that if the spill was far enough away, it may not affect Puerto Rico.

Question 5. How does the sensitivity of resources in this spill trajectory compare to other regions of Puerto Rico?

- Based on local knowledge, concluded that this is a particularly sensitive part of Puerto Rico.
- The west coast is also very sensitive, but winds/currents would tend to push oil offshore.
- North coast is higher energy, therefore less sensitive.
- East coast includes less undeveloped coastline and more manatees, so overall considered less sensitive by Group A.

5.1.2 Group B Discussion Points

Question 1. What are your conclusions about response options in this scenario?

- All response options are not available locally, so a lot of things would have to be mobilized.
- It is a very sensitive area, so all response options would have some degree of negative impact, and all would be limited in their effectiveness.
- We would use on-water recovery as one of the first responses, even though it isn't all that effective, in order to help contain the second release.
- The access and geography to a lot of spots in this area make mechanical methods perhaps infeasible.
- Use of dispersants would be a difficult decision because of all of the sensitive resources requiring short and long-term trade-off evaluation. Under this scenario, we would still likely use dispersants.

Question 2. What if the spill occurred during a different season?

- Sea turtle nesting concerns and concerns for hatchlings in the water.
- Mass spawning for important coral species.
- Fish spawning.
- Queen conch spawning in July to September period.
- Land crab breeding in June through September.
- Bird nesting.
- Other seasons would have different wind and sea state conditions that would affect response.

Question 3. What if the spill was a smaller volume?

- Smaller must be defined for an accurate analysis.
- Might be equipped to deal with the spill locally.
- Response options might change because we might not need dispersants and shoreline clean up and might use more conventional methods like mechanical on-water cleanup if the spill is small enough.

Question 4. What if the spill occurred farther offshore?

- More likely to use dispersant (and decision would come faster) because there are not as many resource issues.
- There might be issues with mobilization of other equipment.

Question 5. How does the sensitivity of resources in this spill trajectory compare to other regions of Puerto Rico?

- Felt that the area that might have the least concern would be the North coast because of smaller platform, more deep water, fewer coral resources, and higher energy.

5.2 Consensus Recommendations

On the morning of the last day of the workshop, the participants reviewed the results of their discussions throughout the week in plenary session and developed a list of recommendations for future consideration by the response community. These recommendations are listed below in the order that they were developed. They are not in priority order.

- Through existing research programs such as Coastal Response Research Center, encourage universities, industry and other agencies to conduct research on impacts of oil, dispersants and dispersed oil in tropical ecosystems, especially nearshore. This would include toxicity tests using realistic exposures on corals, sea grass (not just turtle grass), sea turtles and other tropical marine organisms (e.g., queen conch, spiny lobster, whelk, seahorses, and long-spined black sea urchin).
- Redo threshold table for toxicity values (used in the ERA workshop) compiling and analyzing data for tropical studies and oil spill case histories.
- There needs to be a focus on long-term recovery through appropriate studies at sites around spills of opportunity, including long-term consequences of dispersant use on fecundity, reproductive success, mutation, etc. Information should be available to response planners through appropriate government websites.
- Through the local Area Committees, implement an outreach program to increase participation by NGOs, local agencies and industry in the planning process and ensure the results from this ERA workshop are distributed for review and discussion.

- Compile information on impacts to organisms and fate and effects of surfactants in the water column (e.g., what is the effect for filter feeders, photosynthesis, nutrient absorption through skin, opening of coral polyp, etc.).
- Review and update planning and policy documents for dispersant use and in-situ burning. This includes pre-approval zones, letters of agreement and necessary consultations. They need to be updated to comply with current regulations (i.e., EFH, etc.) and to incorporate currently available information.
- Update ESI maps to include more specific information on time of year for bird species nesting, sea turtle nesting, turtle concentrations in areas, and land crab species. Future updates at regular intervals are an important component of response planning.
- Compile data on local surface and subsurface currents and bathymetry data to ensure best available information is used in the GNOME model and is available to on-scene spill responders.
- Encourage use of NOAA 3-D model for actual spill response when dispersant use is under consideration, rather than just for planning and exercises.
- Have information available on residence time of particles of different grain sizes on beaches, to assist prediction of impacts from different response options. This could be added to the NOAA shoreline assessment manual.
- Translate the NOAA shoreline assessment manual into Spanish.
- The Area Planning Committee should establish a local technical forum (agency, industry, academia, NGO reps etc.) to develop a science plan that would determine the fate and effect of oil and/or dispersed oil that is ready to be implemented in the event of a spill. We need a compilation of baseline data from marine studies conducted around Puerto Rico
- Once plans and policies are updated, conduct a dispersant use exercise (encouraging good participation from local partners) to test the plan.
- Provide more information to users of GNOME model output on model assumptions, equations, data, etc. (i.e., Technical Reference Manual).
- Review where spill response equipment, including dispersants, is presently stockpiled (availability, quantities and types) and whether it should be distributed or stocked differently. Develop a cadre of local dispersant applicators such as operators of agricultural aircraft.

6.0 References

Aurand, D., L. Walko and R. Pond. 2000. Developing Consensus Ecological Risk Assessments: Environmental Protection in Oil Spill Response Planning. A Guidebook. United States Coast Guard, Washington, DC. 148 pages. (Also Ecosystem Management & Associates, Inc. Technical Report 00-01)

Aurand, D. and G. Coelho (Compilers). 2003. Ecological Risk Assessment: Consensus Workshop. Environmental Tradeoffs Associated With Oil Spill Response Technologies. U.S. and British Virgin Islands. A Report to US Coast Guard District 7. Ecosystem Management & Associates, Inc., Lusby, MD 20657. Report 03-03, 34 pages.

National Oceanic and Atmospheric Administration (NOAA). 1999. Screening Quick Reference Tables (SQuiRTs). NOAA HazMat Report 99-1. Seattle, WA.

National Research Council (NRC). 2005. Oil Spill Dispersants: Efficacy and Effects. National Academy of Sciences Press, Washington, DC. 377 p.

Pond, RG., D.V. Aurand, and J.A. Kraly (compilers). 2000. Ecological Risk Assessment Principles Applied to Oil Spill Response Planning in the San Francisco Bay Area. California Office of Spill Prevention and Response. California Department of Fish and Game, Sacramento, CA.

U.S. Environmental Protection Agency. 1998. Guidelines for Ecological Risk Assessment. Federal Register 63 (93) of Thursday, May 14, 1998. pp. 26846-26924.

Appendix A

Participants

Attendance By Day					Group #	Name (Last)	Name (First)	Title	Agency	Address	Phone	Fax	Email
M	T	W	Th	F									
x	o	x	x	x	A	Broje	Victoria	Dr., Spill Response Specialist	Shell Global Solutions (US), Inc.	3333 Hwy 6 South, EC-135B, Houston, TX 77082	281-660-4353		victoria.broje@shell.com
o	o	o	x	x	A	deSoto	Ricardo	GuardaMar (CoastKeeper)	Waterkeeper Alliance	P.O. Box 906-5112, San Juan, PR 00906	787-455-0300		guardamar@yahoo.com
x	x	x	x	x	A	Evans	Mary	Research Scientist	University of WA./NOAA	7600 Sand Point Way, NE, Seattle, WA 98115	206-526-6691	206-526-6329	mary.evans@noaa.gov
x	x	x	o	o	A	Gonzalez	Marie E.	Hurricane/Earthquake Program Manager	FEMA/Caribbean Division	PO Box 70105, San Juan, Puerto Rico 00936	787-296-3506	987-296-3542	marie.gonzalez1@dhs.gov
x	x	x	o	x	A	Hendrix	Kimberly A.	MST2	USCG, Sector San Juan/Response	5 Calle La Puntilla Final, San Juan, Puerto Rico 00901	787-729-5364		kimberly.a.hendrix@uscg.mil
x	x	x	x	x	A	Keane	Patrick T.	Mr., Environmental Specialist	USCG	909 SE First Avenue, STE 802, Miami, FL 33131	305-415-6871	305-415-6848	patrick.t.keane@uscg.mil
x	x	x	o	x	A	Lilyestrom	Craig	Director, Marine Resources Division	Puerto Rico DNER	PO Box 366147, San Juan, PR 00936-6147	787-999-2200 x2615	787-999-2266	craig.lilyestrom@drna.gobierno.pr
x	x	x	x	x	A	Lopez	Felix	Ecologist	US FWS	PO Box 491, Boqueron, Puerto Rico 00622	787-851-7297 x226	787-851-7440	felix_lopez@fws.gov
x	x	x	x	x	A	Puntanen	Urho Gonzal	Contingency Planner	Panama Canal Authority	Building 752, Arnulfo Arias Madrid Street, Balboa-Ancon, Republic of Panama	507-272-4605	507-272-4610	ugonzal@pancanal.com
x	x	x	x	x	A	Rosas	Blanca	LT, Contingency Planner	USCG, Sector San Juan	5 Calle La Puntilla Final, San Juan, Puerto Rico 00901	787-289-2089	787-729-6618	blanca.rosas@uscg.mil
x	x	x	x	x	B	Benggio	Bradford	Scientific Support Coord.	NOAA	909 SE 1st Ave., Rm 714, Miami, FL 33131	305-530-7931	305-530-7932	brad.benggio@noaa.gov
x	x	x	x	x	B	Cansino	Aldo	Environmental Officer	Belize Dept. of Environment	1012 Ambergris Ave, Belmopan, Belize	501-822-2816 or 501-822-2542	501-822-2862	envirodept@btl.net
x	x	x	x	x	B	Carrubba	Lisamarie	Dr., Ecologist	NOAA Fisheries Service	Caribbean Field Office, PO Box 1310, Boqueron, PR 00622	787-851-3700	787-851-5588	lisamarie.carrubba@noaa.gov
x	x	x	o	o	B	Diaz	Carlos A.	Asst. Field Supervisor	USFWS	Caribbean Field Office, Boqueron, PR 00622	787-851-7297 x230	787-851-7440	carlos_diaz@fws.gov
o	o	x	x	o	B	Gass	Michael	Mr.	Clean Caribbean & Americas	2381 Stirling Road, Fort Lauderdale, FL 33312	954-983-9880		mgass@cleancaribbean.org
x	x	x	x	x	B	Meadows	Fred	LT, Incident Management Division	USCG, Sector San Juan	5 Calle La Puntilla Final, San Juan, Puerto Rico 00901	787-729-6800x2038		fred.meadows@uscg.mil
x	x	x	x	x	B	Rivera Solis	Jose A.	Environmental Specialist/Logistic Support	FEMA Caribbean Division Office	PO Box 70105, San Juan, Puerto Rico 00936	787-296-3580	787-296-3542	jose.rivera-solis@dhs.gov
x	x	x	x	x	B	Touw	Steve	OSC/RRT Coordinator	US EPA Region 2	Response and Prevention Branch (MS-211), 2890 Woodbridge Avenue, Edison, NJ 08837-3679	732-906-6900	732-321-4425	touw.steve@epa.gov
x	x	x	x	x	Fac	Aurand	Don	Dr., Facilitator	Ecosystem Mgt. & Associates, Inc.	Ship Point Business Park, 13325 Rousby Hall Rd., Lusby, MD 20657	410-394-2929	410-394-2909	d.aurand@ecosystem-management.net
x	x	x	x	x	Fac	Coelho	Gina M.	Dr., Facilitator	Ecosystem Mgt. & Associates, Inc.	Ship Point Business Park, 13325 Rousby Hall Rd., Lusby, MD 20657	410-394-2929	410-394-2909	g.coelho@ecosystem-management.net
x	x	x	x	x	Fac	Mearns	Alan	Senior Staff Scientist	NOAA Emergency Response Division	7600 Sand Point Way, NE, Seattle, WA 98115	206-526-6336	206-526-6329	alan.mearns@noaa.gov
x	x	x	o	x	na	Perry	Raymond	CAPT	USCG, Sector San Juan	5 Calle La Puntilla Final, San Juan, Puerto Rico 00901			
x	o	o	o	o	na	Rodriguez	Jose Ismael	Emergency Management Specialist	DHS/FEMA			787-296-3547	jose.i.rodriguez@dhs.gov
x	o	o	o	o	na	Aviles	Victor		Marine Spill Response Corporation		787-641-5369		aviles@msrc.org

Appendix B

Resource Table

Habitat	Subhabitat	Resource Group	Example Species
Water Surface		Mammals	cetaceans, West Indian manatee, fish eating bat, pinnipeds
		Birds	tropic birds, pelican, diving birds, rafting birds
		Fish	pelagic fish
		Mollusks	pteropods
		Plankton	phytoplankton, fish eggs and larvae, copepods, coral larvae
		Reptiles	sea turtles
Terrestrial		Mammals	bats
		Birds	osprey, frigate birds
		Reptiles	geckos, iguana, boas, anoles, sea turtles (nesting)
Intertidal	Mangrove Forest	Vegetation	red, white and black mangrove, button mangrove, macroalgae, herbaceous and woody species
		Mammals	West Indian manatee
		Birds	great blue heron, willets, pelicans, egret, shorebirds
		Fish	jack, mullet, butterfly fish, snook, tarpon, snapper, grouper, queens, anchovies and minnows
		Aquatic Arthropods	barnacles, amphipods, shrimp, spiny lobster, brittlestars, blue crabs
		Mollusks	clams, oysters, mussels, snails
		Epifauna	algae, sponges, bryozoans
	Rocky Shores	Vegetation	macroalgae, button wood tree, seagrape
		Birds	boobies, terns, frigate birds, tropic birds
		Aquatic Arthropods	crabs, amphipods
		Coelenterates	cup coral, anemones, acropora
		Mollusks	West Indian topshell snail, mussels, limpets
	Sand Beach	Epifauna	sponges, sea urchins, sea squirt, crabs
		Birds	shore birds, wading birds
		Reptiles	sea turtles
		Mollusks	Donax clams
	Exposed Flats	Vegetation	macroalgae, sea grasses
		Birds	shore birds, wading birds, heron
		Fish	bonefish, mullet, tarpon, snook, reef fish
		Aquatic Arthropods	crabs, barnacles, lobster, shrimp, seastars, brittlestars
		Coelenterates	anemones, numerous coral species
		Mollusks	snails, clams, mussels, octopus

Habitat	Subhabitat	Resource Group	Example Species
Subtidal	Submerged Aquatic Vegetation	Epifauna	sponges, sea urchins, sea squirt
		Vegetation	turtle grass, shoal grass, Halodule
		Mammals	West Indian manatee, dolphins
		Birds	heron, brown pelican
		Fish	snappers, grunts, barracuda, grey snapper, gobies, pipefish, eel
		Aquatic Arthropods	shrimp, spiny lobster, amphipods, crabs
		Coelenterates	cup coral, anemones, star coral
		Mollusks	queen conch, snails, clams, mussels, octopus
		Reptiles	green, hawksbill sea turtles
	Shallow Coral Reef Community (<5 m)	Epifauna	sponges, bryozoans, sea urchins, sea stars
		Vegetation	macroalgae, sea grasses
		Fish	snappers, grunts, barracuda, reef sharks, butterfly fish, wrasses, parrotfish, other reef fish
		Aquatic Arthropods	spiny lobsters, shrimp, amphipods, crabs
		Coelenterates	numerous coral species including elkhorn
		Mollusks	snails, clams, octopus
		Reptiles	green and hawksbill sea turtles
	Deep Coral Reef Community (>5 m)	Epifauna	sponges, bryozoans, algae, snails, sea urchins, sea stars
		Vegetation	macroalgae, sea grasses
		Fish	snappers, grunts, barracuda, reef
		Aquatic Arthropods	spiny lobsters, shrimp, amphipods,
		Coelenterates	numerous coral species including staghorn
		Mollusks	snails, clams, octopus
		Reptiles	green and hawksbill sea turtles

Habitat	Subhabitat	Resource Group	Example Species
Water Column	Shallow Water (<5 m)	Mammals	West Indian manatee, dolphins
		Birds	black-legged kittiwake, northern gannet
		Fish	snappers, grunts, barracuda, eel, seatrout, spot, snappers, grunts, sharks, butterfly fish, wrasses, parrotfish, other reef fish
		Aquatic Arthropods	shrimp
		Mollusks	squid
		Plankton	fish eggs and larvae, invertebrate eggs and larvae, copepods, diatoms, green algae
		Reptiles	green, loggerhead and hawksbill sea turtles
	Deep Water (>5 m)	Mammals	bottlenose dolphins
		Birds	common loon, black-legged kittiwake, northern gannet
		Fish	snappers, grunts, barracuda, eel, snappers, grunts, sharks, butterfly fish, wrasses, parrotfish, groupers
		Aquatic Arthropods	shrimp
		Mollusks	squid
		Plankton	fish eggs and larvae, invertebrate eggs and larvae, copepods, diatoms, algae
		Reptiles	green, hawksbill and leatherback sea turtles