

JACQUELINE MICHEL, Ph.D.

Geochemist, President of Research Planning, Inc.

Dr. Michel is a geochemist specializing in terrestrial and marine pollution studies, coastal geomorphology, and environmental risk assessments. She has specialized expertise in the behavior, tracking, recovery, and effects of submerged oil. Having worked in 32 countries, she has extensive international experience and has worked in many different coastal and marine environments.

Dr. Michel is one of the founders of RPI and has been President since 2000. She often leads multi-disciplinary teams on projects where her problem-solving skills are essential to bringing solutions to complex issues. For example, her work during spill emergencies requires her to rapidly develop consensus and provide decision-makers needed information. Because of her routine scientific support for spills, she has extensive knowledge of and practical experience in pollutant fate, transport, and effect issues. She has been a leader in the development of methods and the conduct of Natural Resource Damage Assessments following spills and groundings. She has taken a lead role in 29 damage assessments for Federal and State Trustees.

Dr. Michel has been recognized for her achievements through appointments to many respected committees and panels, including four National Academies committees: Spills of Nonfloating Oil (1999); Oil in the Sea (2002); Chairman of Spills of Emulsified Fuels: Risks and Response (2001); and Chairman of Committee on Understanding Oil Spill Dispersants: Efficacy and Effects (2005). She was on the Oceans Studies Board for 2001-2005 and is a Lifetime Associate of the National Academies. She was on the Science Advisory Panel to the U.S. Commission on Ocean Policy. She is currently on the Applied Sciences Analysis Group supporting the NASA Earth Science Division. She is an Adjunct Professor in the School of the Environment, University of South Carolina. She has written over 185 technical publications.

EDUCATION

Ph.D., Department of Geology, University of South Carolina (USC), Columbia (1980).

Dissertation Title: Behavior of Uranium and Thorium Decay-Series Isotopes in the Hydrologic Cycle

M.S., Department of Geology, USC, Columbia (1976). Thesis Title: Ground Water Pollution and Geochemical Variations in Leachate from Solid Waste Disposal

B.S., Department of Geology, USC, Columbia (1974)

HONORS

Distinguished Alumni Achievement Award, 2002, College of Science and Mathematics, USC
Lifetime Associate of the National Academies

PROFESSIONAL EXPERIENCE

Expertise in three main technical areas is outlined separately below:

- 1) Natural resource damage assessment/ecological risk assessment
- 2) Oil and chemical emergency spill response, research, and contingency planning
- 3) Environmental assessment/geology

OIL AND CHEMICAL SPILL RESPONSE, RESEARCH, AND CONTINGENCY PLANNING

Multidisciplinary Assessment of Coastal Ecosystems Impacted by Oil and Chemical Spills, Dr. Michel was part of the original team of RPI scientists who pioneered much of the early research on oil spill impacts on coastal ecosystems. This work, sponsored by the National Oceanic and Atmospheric Administration, has involved multidisciplinary studies of hazardous materials spill impacts and the development of strategies to mitigate these impacts. Scientific support for hazardous materials spills includes rapid assessment of the aquatic toxicology, chemical hazards, field methods, and fate and effects for a wide range of chemicals. Because of her routine scientific support for spills, she has extensive knowledge of and practical experience in pollutant fate, transport, and effect issues.

Spills of note where field responses have been conducted include the following:

T/V <i>Metula</i>	Strait of Magellan, Chile	1976
T/V <i>Amoco Cadiz</i>	Brittany, France	1978
T/B <i>Peck Slip</i>	Puerto Rico	1978
IXTOC well blowout	South Texas	1979
Funiwa 5 blowout	Nigeria	1982
Cape Fear River	Wilmington, N.C.	1983
T/V <i>Puerto Rican</i>	San Francisco, Calif.	1985
T/V <i>Amazon Venture</i>	Savannah, Ga.	1986
M/V <i>Pac Baroness</i>	Santa Barbara, Calif.	1987
Shell Refinery	Martinez, Calif.	1988
T/V <i>Exxon Valdez</i>	Valdez, Alaska	1989
T/V <i>American Trader</i>	Huntington Beach, Calif.	1990
T/B <i>Bella Vista</i>	St. Kitts/Puerto Rico	1991
Gulf War Spill	Saudi Arabia and Kuwait	1991
T/V <i>Katina P</i>	Mozambique	1992
Benzene Trail Derailment	Duluth, Minn.	1992
Greenhill Petroleum Blowout	Timbalier Bay, Louisiana	1992
UNOCAL refinery	Neches River, Texas	1993
Colonial Pipeline Break	Reston, Va.	1993
T/B <i>Bouchard 255</i>	Tampa, Fla.	1993
T/B <i>Morris J. Berman</i>	Puerto Rico	1994
RASA Refinery	Acajutla, El Salvador	1994
Kharyaga-Usinsk Pipeline Spills	Komi Republic, Russia	1995
Powell-Duffryn Chemical Fire	Savannah, Georgia	1995
T/B <i>North Cape</i>	Rhode Island	1996
Colonial Pipeline–Reedy River	Greenville, South Carolina	1996
T/V <i>Julie N</i>	Portland, Maine	1996
Lake Barre Texaco Pipeline Spill	Lake Barre, Texas	1997
Kapitan Egorov Grounding	Guayanilla, Puerto Rico	1998
BP Offshore Platform	Southwest Pass, Louisiana	1998
M/V <i>New Carissa</i>	Coos Bay, Oregon	1999
Chevron Pipeline	Quatre Bayou, Louisiana	1999
Petrobras Pipeline	Guanabara Bay, Brazil	2000
Sun Oil Co. Pipeline	John Heinz NWR, Penn.	2000
PEPCO Pipeline	Patuxent River, Maryland	2000

M/V <i>Westchester</i>	Mississippi River, RM 38	2000
Williams Pipeline Break	Mosquito Bay, Louisiana	2001
Oiled Shoreline Survey	Saudi Arabia	2002
T/B <i>Bouchard-120</i>	Buzzards Bay, Mass.	2003
M/V <i>Fortune Epoch</i>	Savannah, Ga.	2004
M/T <i>Athos 1</i>	Delaware River, Pa, NJ, DE	2004
Hurricane Katrina and Rita spills	Louisiana	2005
T/B <i>DBL-152</i>	Offshore Louisiana	2005
Bayou Perot	Louisiana	2007
M/V <i>Cosco Busan</i>	San Francisco, CA	2007
T/V <i>Hebei Spirit</i>	South Korea	2008
Deepwater Horizon/MC252	Gulf of Mexico	2010

Shoreline Assessment and Cleanup. Dr. Michel is an international specialist in shoreline assessment and cleanup. In 1995, she was Senior Advisor to the World Bank responsible for development and oversight of a \$45 million emergency oil spill cleanup in the Komi Region of the Former Soviet Union. The plan was to prevent the release of massive amounts of oil into rivers draining to the Arctic Ocean. In 1997-8, she was again asked to assist the World Bank on cleanup of onshore oil production fields in Azerbaijan. In 2000, she was asked by the Inter-American Development Bank to advise the environmental agencies of Brazil on assessment of a major oil spill in Guanabara Bay.

Lecturer and Instructor on Oil Spill Response. Dr. Michel is the primary lecturer of 3-5 day courses on the behavior, effects, and cleanup considerations at oil spills. Through the use of case histories via slide presentations and training manuals, participants are given experience in oil spill response needs for protection of natural resources. This course has been conducted more than 40 times since 1992.

Scientific Adviser on Pollutant Fate and Effects. In 1991-1992, Dr. Michel was the Chief Scientist on Leg II–Nearshore Biogeochemical Processes for the *Mt. Mitchell* cruise in the Arabian Gulf. This project studied the fate and transport mechanism for contamination of the intertidal and subtidal habitats in Saudi Arabia following the Gulf War spill. She coordinated the studies of 25 scientists from ten countries for a 22-day cruise and a six week shoreline survey. In 2002-2003, she was the Senior Scientist on the \$6 million Oiled Shoreline Survey to assess the injury and need for remediation of intertidal habitats along the 800 km of shoreline of Saudi Arabia affected by the Gulf War oil spill. She developed the study plan, participated in the fieldwork, and was the senior author of the technical report.

Environmental Sensitivity Index Mapping. Dr. Michel was one of the original creators of the concept of Environmental Sensitivity Index (ESI) mapping. In 1990, she spearheaded the use of Geographic Information Systems (GIS) technology for data management and map production, including the development of standards for the production of sensitivity maps and databases. This work includes the Gulf-Wide Information System (G-WIS) projects for Minerals Management Service. She conducted field mapping and authored the following ESI atlases:

- Northern Puget Sound, Wash.
- Central Puget Sound, Wash.-
- Florida (1980 original and 1993-update)
- Cook Inlet and Kenai Peninsula, Alaska
- South Alaska Peninsula

- Bristol Bay, Alaska
- Lake Michigan, WI, IL, IN, MI
- Lake Superior
- Lake Huron
- Central/Northern California
- Southeastern Alaska
- Lake Ontario
- Prince William Sound, AK

Remote Sensing Imagery for Shoreline Delineation and Habitat Classification. Dr. Michel worked with Dewitt Braud of the Louisiana State University to test the use of IKONOS remote sensing imagery for shoreline delineation and habitat classification. She conducted the field validation surveys of the classified imagery. She also worked with Thematic Mapper and Quickbird imagery for mapping of intertidal habitats along the Saudi Arabian coastline in 2003.

Mapping of Unusually Sensitive Areas, Office of Pipeline Safety. As Project Manager for the contract for mapping of Unusually Sensitive Areas (USAs), Dr. Michel developed the technical definition of drinking water USAs based on aquifer characteristics and development of a complex GIS model to create USAs from available datasets. Over a two-year cooperative development process, RPI worked closely with industry representatives to refine and finalize the technical processes for creating USAs.

Selected Publications and Abstracts

OIL/CHEMICAL SPILL EFFECTS AND FATE RESEARCH

- Hale, J. C.D. Cormack, L. Cotsapas, T.M. Montello, O. Langman, J.J. Gabriel, and J. Michel. 2011. Relationships between key indicators of environmental condition and degrees of oiling in sediments in salt marsh habitats: A balance between contamination and ecological recovery by natural processes Proc. 2011 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., 14 pp.
- Michel, J., Z. Nixon, M.O. Hayes, G. Irvine, and J. Short. 2010. The distribution of lingering subsurface oil from the *Exxon Valdez* oil spill. Proc. 2011 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., 14 pp.
- Bejarano, A.C. and J. Michel. 2010. Large-scale risk assessment of polycyclic aromatic hydrocarbons in shoreline sediments from Saudi Arabia: Environmental legacy after twelve years of the Gulf War Oil Spill. *Environmental Pollution* 158:1561-1569.
- Michel, J., Z. Nixon, M.O. Hayes, J. Short, G. Irvine, D. Betenbaugh, C. Boring, and D. Mann. 2010. Distribution of subsurface oil from the *Exxon Valdez* oil spill. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 070801), National Oceanic and Atmospheric Administration, Juneau, AK. 121 pp. + app.
- Michel, J., Z. Nixon, J. Dahlin, D. Betenbaugh, M. White, D. Burton, and S. Turley. 2009. Recovery of interior brackish marshes seven years after the Chalk Point oil spill. *Marine Pollution Bull.* 58:995-1006.
- Michel, J., Z. Nixon, J. Dahlin, D. Betenbaugh, M. White, D. Burton, and S. Turley. 2008. Monitoring of Recovery of Marshes Impacted by the Chalk Point Oil Spill. NOAA Office of Response & Restoration, Silver Spring, MD. 68 pp. + appendices.
- Henry, C., D. Helton, J. Michel, and C. Woodle. 2008. Bayou Perot and the unusual situation of stranded oil adhered to mud flats. Proc. 2008 International Oil Spill Conference, American Petroleum Institute, Washington, D.C.

- Etkin, D.S., D. French-McCay, and J. Michel. 2008. Integrating state-of-the-art shoreline interaction knowledge into spill modeling. Proc. 2008 International Oil Spill Conference, American Petroleum Institute, Washington, D.C.
- Michel, J., Z. Nixon, and L. Cotsapas. 2006. Evaluation of oil remediation technologies for lingering oil from the *Exxon Valdez* oil spill in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 050778), National Marine Fisheries Service, NOAA, Juneau, AK, 47 pp. + appendices.
- Nixon, Z. and J. Michel. 2006. Assessment of hazardous materials and debris from Hurricane Rita in the Sabine National Wildlife Refuge. Report to U.S. Fish and Wildlife Service, Washington, D.C., 29 pp.
- Michel, J., M.O. Hayes, C.D. Getter, and L. Cotsapas. 2005. The Gulf War oil spill twelve years later: Consequences of eco-terrorism. Proc. 2005 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., 5 pp.
- Getter, C.D., J. Michel, and M. Hayes. 2005. Natural recovery of salt marshes from the 1991 oil spill on the Saudi Arabian Gulf coast. Proc. 2005 International Oil Spill Conference, American Petroleum Institute (CD-ROM), Washington, D.C.
- Michel, J. and D. Helton. 2003. Environmental considerations during wreck removal and scuttling. International Tug & Salvage, November/December 2003, pp. 16-18.
- Lord, C. and J. Michel. 2003. Conceptual models for assessing the risk of seafood tainting during oil spills. Proc. 2003 International Oil Spill Conference, American Petroleum Institute Publ. No. 14730 A (CD-ROM), Washington, D.C.
- Walker, D., J.C. Coleman, K. Michel, and J. Michel. 2003. Oil in the Sea: Changes in the nature of sources and inputs since 1985. Proc. 2003 International Oil Spill Conference, American Petroleum Institute Publ. No. 14730 A (CD-ROM), Washington, D.C.
- Michel, J., C.B. Henry, Jr., and S. Thumm. 2002. Shoreline assessment and environmental impacts from the *M/T Westchester* oil spill in the Mississippi River. *Spill Science & Technology Bull.* 7:155-161.
- Hayes, M.O. and J. Michel. 2001. A primer for response to oil spills on gravel beaches. 2001 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 1275-1279.
- Michel, J. and M.O. Hayes. 1999. Weathering patterns of oil residues eight years after the *Exxon Valdez* oil spill. *Marine Pollution Bull.* 38:855-863.
- Hayes, M.O. and J. Michel. 1999. Factors determining the long-term persistence of *Exxon Valdez* oil in gravel beaches. *Marine Pollution Bull.* 38:92-101.
- Sauer T.C., J. Michel, M.O. Hayes, and D.V. Aurand. 1998. Hydrocarbon characterization and weathering of oiled intertidal sediments along the Saudi Arabian coast two years after the Gulf War oil spill. *Environment International*.
- Michel, J., S.M. Lehmann, and C.B. Henry, Jr. 1998. Oiling and cleanup issues in wetlands, *M/T Julie N* spill, Portland, Maine. Proc. 21st Arctic and Marine Oilspill Program Tech. Seminar, Environment Canada, pp. 841-856.
- Michel, J. and C.B. Henry, Jr. 1997. Oil uptake and depuration in oysters after use of dispersants in shallow water in El Salvador. *Spill Science & Technology Bull.* 4:57-70.
- Hayes, M.O. and J. Michel. 1998. Evaluation of the condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent shoreline treatment: 1997

- geomorphological monitoring survey. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 109 pp. + app.
- Zengel, S.A. and J. Michel. 1996. Vegetation cutting as a clean-up method for salt and brackish marshes impacted by oil spills: a review and case history of the effects on plant recovery. *Marine Pollution Bull.* 32:876-885.
- Michel, J. and M.O. Hayes. 1996. Geomorphological shoreline monitoring survey of the *Exxon Valdez* spill site, Prince William Sound, Alaska, July 1994. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, Wash., Technical Memo. NOS ORCA 82, 119 pp.+ app.
- Michel, J. and M.O. Hayes. 1996. Evaluation of the condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent shoreline treatment: volume II: 1994 geomorphological monitoring survey, July 1994. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 120 pp. + appendices.
- Zengel, S.A. and J. Michel. 1995. Cutting oiled marshes: a review of the effects on vegetation recovery, with illustrated examples from riverine, salt, and brackish-water environments. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, HAZMAT Report 95-6, 41 pp.
- Michel, J. and J.A. Galt. 1995. Conditions under which floating slicks can sink in marine settings. Proc. 1995 Intl. Oil Spill Conference, API Publ. No. 4620, American Petroleum Institute, Washington, D.C., pp. 573-576.
- Hayes, M.O., J. Michel, T.M. Montello, D.V. Aurand, T.C. Sauer, A. Al-Mansi, and A.H. Al-Momen. 1995. Distribution and weathering of oil from the Iraq-Kuwait conflict oil spill within intertidal habitats-two years later. Proc. 1995 Intl. Oil Spill Conference, API Publ. No. 4620, American Petroleum Institute, Washington, D.C., pp. 443-451.
- Wolfe, D. A., M. J. Hameedi, J. A. Galt, G. Watabayashi, J. Short, C. O'Clair, S. Rice, J. Michel, J. R. Payne, J. Braddock, S. Hanna, and D. Sale. 1994. The fate of the oil spilled from the T/V EXXON VALDEZ. *Environmental Science and Technology* 28(13):560A-568A.
- Michel, J. and C.B. Henry. 1994. Oil uptake and depuration in oysters after use of dispersant in shallow water during the RASA Refinery, El Salvador oil spill. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, HAZMAT Report 95-5, 38 pp.
- Hayes, M.O., J. Michel, T.M. Montello, and T.C. Sauer. 1994. ROPME Sea oil spill nearshore geochemical processes study, distribution and weathering of oil in intertidal sediments for year 2 (1993). Prepared for the Marine Spill Response Corporation, Washington, D.C., Technical Report Series 94-009, 140 pp.
- Hayes, M.O., J. Michel, and T.M. Montello. 1994. ROPME Sea oil spill nearshore geochemical processes study, volume 1, distribution and weathering of oil in intertidal and subtidal sediments for year 1 (1992). Prepared for the Marine Spill Response Corp., Washington, D.C., Technical Report Series 93-002.1, 230 pp.
- Jensen, J., S. Narumalani, M.O. Hayes, and J. Michel. 1994. ROPME Sea oil spill nearshore geochemical processes study, volume 3, remote sensing derived habitat classification and error evaluation year 1 (1992). Prepared for the Marine Spill Response Corporation, Wash., D.C., Technical Report Series 93-002.3, 43 pp.

- Michel, J., M.O. Hayes, R.S. Keenan, J.R. Jensen, and S. Narumalani. 1993. Oil in nearshore subtidal sediments of Saudi Arabia from the Gulf War spill. Proc. 1993 Intl. Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 383-388.
- Michel, J., M.O. Hayes, R.S. Keenan, T.C. Sauer, J.R. Jensen, and S. Narumalani. 1993. Contamination of nearshore subtidal sediments of Saudi Arabia from the Gulf War oil spill: Marine Pollution Bulletin 27:109-116.
- Hayes, M.O., J. Michel, T.M. Montello, D.V. Aurand, A.M. Al-Mansi, A.H. Al-Momen, T.C. Sauer, and G.W. Thayer. 1993. Distribution and weathering of shoreline oil one year after the Gulf War oil spill. Marine Pollution Bulletin 27:135-142.
- Sauer, T.C., J.S. Brown, P.D. Boehm, D.V. Aurand, J. Michel, and M.O. Hayes. 1993. Hydrocarbon source identification and weathering characterization of intertidal and subtidal sediments along the Saudi Arabian coast after the Gulf War oil spill: Marine Pollution Bulletin 27:117-134.
- Hayes, M.O., J. Michel, and six others. 1993. Distribution of oil from the Gulf War oil spill within intertidal habitats—one year later. Proc. 1993 Intl. Oil Spill Conference, American Petroleum Inst., Washington, D.C., pp. 373-381.
- Michel, J. and M.O. Hayes. 1993. Persistence and weathering of *Exxon Valdez* oil in the intertidal zone—3.5 years later. Proc. 1993 Intl. Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 279-286.
- Montello, T.M., M.O. Hayes, J. Michel, Ahmed M. Al-Mansi, Abdul Halim Al-Momen, D.V. Aurand, and G.W. Thayer. 1993. Persistence of Gulf War oil versus intertidal morphology and sediments—one year later. Proc. 1993 Intl. Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 894-895.
- Michel, J. and M.O. Hayes. 1993. Evaluation of the condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent shoreline treatment: volume I: summary of results—geomorphological shoreline monitoring survey of the *Exxon Valdez* spill site, Prince William Sound, Alaska, September 1989-August 1992. Prepared for Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 94 pp. + appendices.
- Michel, J. and M.O. Hayes. 1993. Summary of results—geomorphological shoreline monitoring survey of the *Exxon Valdez* spill site, Prince William Sound, Alaska, September 1989-August 1992. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 113 pp. + app.
- Scholz, D. and J. Michel. 1992. The *Mega Borg* oil spill: fate and effect studies. Prepared for the Damage Assessment Regulations Team, NOAA Damage Assessment Center, Rockville, MD, 145 pp. + appendices.
- Michel, J. and A. Al-Thukair. 1992. End of cruise report—nearshore biogeochemical processes - leg II *Mt. Mitchell* cruise of the Gulf War oil spill. Prepared for the NOAA Gulf Program Office, Washington, D.C.
- Michel, J. and M.O. Hayes. 1991. Geomorphological controls on the persistence of shoreline contamination from the *Exxon Valdez* oil spill. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 307 pp. + appendix.
- Michel, J. and J.A. Dahlin. 1991. Rate of recovery of intertidal vegetation and sediments associated with various oil spill response activities during the Shell oil spill. Rept. to the State of California, Department of Justice; Research Planning, Inc., Columbia, SC, RPI/SR/91/7/15-11, 77 pp. + appendices.

- Michel, J. 1991. Oiled marshes and tidal flats in the Arabian Gulf, What is going to happen? Inter-government Oceanographic Commission IMS Newsletter, September 1991, Paris, France, p. 9.
- Michel, J., M.O. Hayes, W.J. Sexton, J.C. Gibeaut, and C. Henry. 1991. Trends in natural removal of the *Exxon Valdez* oil spill in Prince William Sound from September 1989 to May 1990. Proc. 1991 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 181-187.
- Michel, J. 1991. Prince William Sound, Alaska: the cleanup continues. *Geotimes*, March 1991, pp. 16-17.
- Hayes, M.O., J. Michel, and D.C. Noe. 1991. Factors controlling initial deposition and long-term fate of spilled oil on gravel beaches. Proc. 1991 Intl. Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 453-460.
- Hayes, M.O., J. Michel, and B. Fichaut. 1990. Oiled gravel beaches: a special problem. Proc. Conf. on Oil Spills: Management and Legislative Implications, 15-18 May 1990, Newport, RI, pp. 444-457.
- Michel, J., C. Henry, W.J. Sexton, and M.O. Hayes. 1990. The *Exxon Valdez* winter monitoring program results. Proc. Conf. on Oil Spills: Management and Legislative Implications, 15-18 May 1990, Newport, RI, pp. 396-407.
- Michel, J. 1990. The EXXON VALDEZ oil spill: status of the shoreline. *Geotimes*, May 1990, pp. 20-22.
- Biedenbender, P.L. and J. Michel. 1989. Response strategies in a high tidal range estuarine system: the Savannah River oil spill. Proc. 1989 Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 95-100.
- Nwankwo, J.N., J. Michel, and M. Murday. 1987. Environmental baseline studies for oil pollution control in Nigeria. Proc. 1987 Oil Spill Conf., American Petroleum Institute, Washington, D.C. pp. 517-519.
- Baca, B.J., J. Michel, T.W. Kana, and N.G. Maynard. 1983. Cape Fear River oil spill (North Carolina): determining oil quantity from marsh surface area. Proc. 1983 Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 419-422.
- Michel, J., D.D. Domeracki, and W.J. Sexton. 1982. Site evaluation methodology and results, American Creosote Plant site, Louisiana. Proc. Hazardous Materials Spills Conf., 19-22 April 1982, Milwaukee, WI, pp. 50-55.
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- Michel, J., with four others. 1979. Occurrence of oil in offshore bottom sediments at the AMOCO CADIZ spill site. Proc. 1979 Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 187-192.

ENVIRONMENTAL SENSITIVITY INDEX MAPPING/UNUSUALLY SENSITIVE AREA MAPPING

- Born, K., C. Locke, C., J. Michel, J., and B. DeWitt. 2004. Using IKONOS Imagery for Mapping Coastal Habitats for Oil Spill Applications. *ASPRS 2004 Annual Conference, May 23-28, 2004*. Denver, CO.

- Owens, E.H. and J. Michel. 2003. Planning for shoreline response to spills in Arctic environments. Proc. 2003 International Oil Spill Conference, American Petroleum Institute, Washington, D.C.
- Plank, C., W.T. Holton, M. White, J. Michel, C. Sherman, I. Csato, and C. Sames. 2003. Nationwide assessment and mapping of drinking water "Unusually Sensitive Areas" (USAs). Proc. 2003 International Oil Spill Conference, American Petroleum Institute, Washington, D.C.
- Petersen, J., J. Michel, S. Zengel, M. White, C. Lord, and C. Plank. 2002. Environmental Sensitivity Index Guidelines Version 3.0. NOAA Technical Memo NOS OR&R 11. NOAA, Seattle, WA, 89 pp. + appendices.
- Zengel, A., M.O. Hayes, J. Michel, M. White, B. Benggio, F. Lopez, Steve Towu, and E. Mosher. 2001. Integrated planning from the mountains to the sea: Environmental Sensitivity Index mapping in the Caribbean. Proc. 2001 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., pp. 1113-1117.
- Jensen, J.R., J.N. Halls, and J. Michel. 1998. A systems approach to Environmental Sensitivity Index (ESI) mapping for oil spill contingency planning and response. Photogrammetric Engineering & Remote Sensing 64:1003-1014.
- Hayes, M.O., J. Michel, and T.M. Montello. 1997. The Reach Sensitivity Index (RSI) for mapping rivers and streams. Proc. 1997 International Oil Spill Conference, API Publ. 4651, American Petroleum Institute, Washington, D.C., pp. 343-350.
- Halls, J., J. Michel, S. Zengel, J. Dahlin, and J. Petersen. 1997. Environmental sensitivity index guidelines, Version 2.0. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, Wash., NOAA Tech. Memo. NOS ORCA 115, 79 pp. + app.
- Hayes, M.O., J. Michel, J.A. Dahlin, and K. Barton. 1995. Identifying and mapping sensitive resources for inland area planning. Proc. 1995 Intl. Oil Spill Conference, API Publ. No. 4620, American Petroleum Institute, Washington, D.C., pp. 365-371.
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- Narumalani, S., J.R. Jensen, M.O. Hayes, J. Michel, T.M. Montello, and J. Robinson. 1993. Gulf War legacy using remote sensing to assess habitat in the Saudi Arabian Gulf before the Gulf War oil spill. GeoInfo Systems, pp. 33-41.
- Michel, J. and J. Dahlin. 1992. Guidelines for developing digital environmental sensitivity index atlases and databases. Prepared for the Hazardous Materials Response and Assessment Division, NOAA, Seattle, WA, 43 pp. + app.
- Jensen, J.R., with seven others. 1992. Utilization of remote sensing and GIS technologies for oil spill planning and response: case studies in Florida, UAE, and Saudi Arabia. Proc. First Thematic Conf. on Remote Sensing for Marine and Coastal Environments, ERIM, Ann Arbor, MI.
- Jensen, J.R., E.W. Ramsey, J.M. Holmes, J. Michel, B. Savitsky, and B.A. Davis. 1990. Environmental sensitivity index (ESI) mapping for oil spills using remote sensing and

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Hayes, M.O., J. Michel, and P.J. Brown. 1977. Vulnerability of coastal environments of lower Cook Inlet, Alaska, to oil spill impact. Proc. 4th Intl. Conf. on Port and Ocean Engineering, Newfoundland, 12 pp.

SPILL TECHNOLOGIES - *IN-SITU* BURNING

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NATURAL RESOURCE DAMAGE ASSESSMENT/ECOLOGICAL RISK ASSESSMENT

Dr. Michel has been a leader in the development of methods and the conduct of natural resource damage assessments (NRDA) following spills and groundings. She has taken a lead role in numerous damage assessments Federal and State Trustees. Since 1991, she has been the project manager for RPI's work under contract to the Damage Assessment Center of NOAA on many different aspects of natural resource damage assessments. She worked on the NRDA for the following incidents and waste sites:

- *T/V Amazon Venture*, Savannah River, Georgia/South Carolina (1985)
- Shell Martinez tank farm, Martinez, California (1988)
- *T/V Exxon Valdez*, Prince William Sound, Alaska (1989)
- *T/V American Trader*, Huntington Beach, California (1991)
- Arthur Kill spills in New York/New Jersey (1991)
- Mobil Mining and Minerals Company spill of phosphoric acid into the Houston Ship Channel, Texas (1992)
- *M/V Mega Borg* spill off the Texas coast (1992)
- Colonial Pipeline oil spill into Sugarland Run and the Potomac River, Virginia (1993)
- Unocal Spill, California (1994)
- *T/B North Cape* barge home heating oil spill in Rhode Island (1995)
- *T/V Julie N* tanker spill of IFO 180 in Portland, Maine (1996)
- Lake Barre, Louisiana pipeline crude oil spill by Texaco (1997)
- Chevron pipeline crude oil spill, Gulf of Mexico (1998)
- *M/V New Carissa* bunker and diesel spill, Coos Bay, Oregon (1999)
- Tuna Longliners Vessel Removal Action, American Samoa (1999)
- Petrobras Pipeline, Guanabara Bay, Brazil (2000)
- PEPCO pipeline spill, Patuxent River, Maryland (2000)
- Tug Gilbert grounding, Gulf Islands National Seashore (2001)
- *M/T Westchester*, Mississippi River (2001)
- Pryor Oil Well Fire and Spill, Obed Wild and Scenic River, Tennessee (2002)
- *Bouchard Barge-120*, Buzzards Bay, Massachusetts and Rhode Island (2003)
- *M/T Athos I*, Delaware River, PA, NJ, DE (2004)
- Citgo Refinery, Lake Charles, LA (2006)
- *Cosco Busan*, San Francisco, CA (2007)
- Burton Island Ash Landfill, Delaware (2008)
- *Selendang Ayu*, Unalaska Island, AK (2008)
- Deepwater Horizon, Gulf of Mexico (2010)

She has developed specialized training courses on natural resource damage methodologies for the California Department of Fish and Game, Office of Oil Spill Prevention and Response, the Louisiana Department of Wildlife and Fisheries, and NOAA. She wrote a detailed manual that is used during the courses.

Selected Publicly Available Reports

Dunagan, H., J. Michel, and J. Burr. 2011. Assessment and restoration scaling of stream services impaired by the Obed River 2002 oil spill. Proc. 2011 International Oil Spill Conference, American Petroleum Institute, Washington, D.C., 11 pp.

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- Michel, J., C. Boring, and C. Locke. 2008. Rapid assessment protocols for small vessel groundings. Proc. 2008 International Oil Spill Conference, American Petroleum Institute, Washington, D.C.
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- Greer, R., P. McGowan, J. Michel, and N. Meade. 2005. Injury to muskrats (*Ondatra zibethicus*) from the Chalk Point Oil Spill, Patuxent River, Maryland. Proc. 2005 International Oil Spill Conference, American Petroleum Institute Publ. Washington, D.C.
- Michel, J., H. Hinkeldey, N. Meade, and P. McGowan. 2003. Injury to birds and diamondback terrapins resulting from the Chalk Point oil spill, Maryland. Proc. 2003 International Oil Spill Conference, American Petroleum Institute Publ. No. 14730 A (CD-ROM).
- Michel, J. S. Zengel, H. Hinkeldey, and D. Helton. 2003. Ephemeral data collection during the emergency phase of a spill: Protocols on design and methods. Proc. 2003 International Oil Spill Conference, American Petroleum Institute Publ. No. 14730 A (CD-ROM).
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- Michel, J., K. Smith, M. Keiler, A. Rizzo, R. Ayella, and G. Harmon. 2002. Injury to wetlands resulting from the Chalk Point oil spill. Report to the Trustee Council for the Chalk Point Oil Spill. NOAA Damage Assessment Center, Silver Spring, MD, 31 pp + app.
- Michel, J. 2001. Mangrove habitat injury assessment and scaling protocols. Report to NOAA Damage Assessment Center, Silver Spring, MD, 27 pp + 41 pp. annotated bibliography.
- Hinkeldey, H, J. Michel, T. Tomasi, R. Greer, W. Kicklighter, R. Wood and N. Meade. 2001. Estimate of the total injury to diamondback terrapins from the Chalk Point oil spill. Report to the Trustee Council for the Chalk Point Oil Spill. NOAA Damage Assessment Center, Silver Spring, MD, 12 pp.
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- Michel, J., F. Csulak, D. French, and M. Sperduto. 1997. Natural resource impacts from the *North Cape* oil spill. Proc. 1997 Intl. Oil Spill Conference, API Publ. No. 4651, American Petroleum Institute, Washington, D.C., pp. 841-850.
- Helton, D., J. Michel, and T.J. Reilly. 1997. Incorporating oil behavior in the design of natural resource damage assessment studies: three case histories. Proc. 20th Arctic and Marine Oilspill Program Tech. Seminar, Environment Canada.
- Michel, J. 1996. *North Cape* oil spill natural resource damage assessment, preassessment data report. Prepared for Damage Assessment Center, NOAA; Ninigret National Wildlife Refuge, U.S. Fish and Wildlife Service; and Rhode Island Department of Environmental Management, 85 pp. + app.
- Huguenin, M.T., D.H. Haury, J.C. Weiss, D. Helton, C. Manen, E. Reinharz, and J. Michel. 1995. Injury Assessment Guidance Document for Natural Resources and Services under the Oil Pollution Act of 1990. Prepared for the Damage Assessment and Restoration Program, NOAA, Silver Spring, MD.
- Michel, J., R.E. Unsworth, D.K. Scholz, and E. Snell. 1994. Oil spill damage inventory and assessment: preliminary protocols and methodologies. Prepared for the Florida Marine Research Institute, St. Petersburg, FL, 204 pp. + appendices.
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- Michel, J. and D. Scholz. 1992. Natural resources damage assessment emergency procedures manual. Prepared for the Damage Assessment Center, NOAA, Rockville, MD, 93 pp. + appendices (version 2.0 published October 1995).

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- Michel, J. 1989. Natural resource damage assessment of the *Amazon Venture* oil spill. Proc. 1989 Oil Spill Conference, API Publ. No. 4479, American Petroleum Institute, Washington, D.C., pp. 303-306.

ENVIRONMENTAL ASSESSMENTS/GEOLOGY

Dr. Michel has assisted the Minerals Management Service (now the Bureau of Ocean Energy Management, Regulation, and Enforcement) on numerous projects related to environmentally sound management of alternative resources and sand and gravel borrow sites in the Outer Continental Shelf:

- 1) Principal Investigator and Senior Editor of the 2011 Literature Synthesis of the South Atlantic Planning Area of the southeastern U.S. which covers the topics of Physical Oceanography, Geological Oceanography, Chemical Oceanography, Plankton Communities, Benthic Communities, Fish and Fish Habitat, Birds, Marine Mammals, Sea Turtles, Areas of Special Concern, Socioeconomic Resources, and Research and Development Technologies. This 1,000+ page synthesis report addresses current conditions and potential environmental impacts associated with oil and gas exploration and production, sand and gravel extraction, and alternative energy development of the outer continental shelf of the southeast U.S. shelf and slope.
- 2) Principal Investigator and Senior Author of the 2007 Literature Synthesis study on potential environmental impacts associated with alternative energy uses of the OCS. She also authored the Workshop Summary for the workshop held by MMS in June 2007.
- 3) Principal Investigator and Senior Author of the 2007 report on a critical review of the studies techniques being used by the MMS Marine Minerals Program. In this report, many recommendations were made to generate baseline data, evaluate the effectiveness of mitigation measures, and detect cumulative impacts.
- 4) Design and manage regional sand management working groups for Louisiana and Florida. This work involves coordination of agencies, private industry, academia, and stakeholders in the complex issues of dredging offshore sand deposits for habitat restoration. She also developed Monitoring Protocols for Environmental Sound Management/ Development of Federal Offshore Sand Borrow Areas on the East and Gulf Coasts;
- 5) Archaeological damage from offshore dredging: recommendations for pre-operational surveys and mitigation during dredging to avoid adverse impacts;
- 6) Recommendations for environmentally friendly dredging techniques; and
- 6) Review of the state of the art on modeling interactions between spilled oil and shoreline for the development of algorithms for oil spill risk analysis modeling.

Dr. Michel was the senior author of the Environmental Assessment for the Offloading of *USS Mississinewa*, a World War II tanker that started leaking oil into Ulithi Lagoon, Federated States of Micronesia in 2002. She also contributed to the Programmatic EIS for the U.S. Coast

Guard Proposed Rulemaking requiring the availability of dispersants in vessel and facility response plans.

Dr. Michel was the Project Manager for the Baseline Studies for Oil Pollution Control in Nigeria (1982-1985), a multidisciplinary study of the chemistry and biology of the Niger Delta for the Nigerian National Petroleum Corporation. Extensive field surveys were conducted over a 3-year period characterized the ecological components, water quality, physical processes, and legal/socioeconomic issues for development of criteria and standards against oil pollution in the Niger Delta ecosystems.

Selected Publications

- Hayes, M.O., J. Michel, and D.V. Betenbaugh. 2010. The Intermittently Exposed, Coarse-Grained Gravel Beaches of Prince William Sound, Alaska: Comparison With Open-Ocean Gravel Beaches. *J. Coastal Research* 26(1):4-30.
- Barnea, N., J. Michel, B. Bray, Z. Nixon, G. Imahori, and C. Moegling. 2009. Marine Debris Response Planning in the North-Central Gulf of Mexico. June 2009. NOAA Technical Memorandum. 43 pp.
- Michel, J., Dunagan, H., Boring, C., Healy, E., Evans, W., Dean, J.M., McGillis, A. and Hain, J. 2007. Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf. U.S. Department of the Interior, Minerals Management Service, Herndon, VA, MMS OCS Report 2007-038, 254 pp.
- Michel, J. and Burkhard, E. 2007. Workshop to Identify Alternative Energy Environmental Information Needs: Workshop Summary. U.S. Department of the Interior, Minerals Management Service, Herndon, VA, MMS OCS Report 2007-057, 55 pp. + appendices.
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- Michel, J. and B. Drucker. 2005. Regional management strategies for Federal offshore borrow areas: The Louisiana Sand Management Working Group. Proc. Coastal Zone '05, Coastal Services Center, NOAA, Charleston, SC.
- Nairn, R., T. Kenny, F. Marvan, J. Michel, R. Newell, and Nick Bray. 2004. Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies. U.S. Department of the Interior, Minerals Management Service, Marine Minerals Division, Herndon, VA. OCS Report MMS 2004-076, 150pp.
- Michel, J. 2004. Regional management strategies for Federal offshore borrow areas, U.S. East and Gulf of Mexico coasts. *J. Coastal Research* 20:149-154.
- Nairn, R. J.A. Johnson, D. Hardin, and J. Michel. 2004. A biological and physical monitoring program to evaluate long-term impacts from sand dredging operations in the United States outer continental shelf. *J. Coastal Research* 20:126-137.
- Michel, J., R. Nairn, and J. Johnson. 2001. Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-term Impacts of Offshore Dredging Operations on the Marine Environment. U.S. Department of the Interior, Minerals Management Service, Marine Minerals Division, Herndon, VA. OCS Report MMS 2001-089, 116pp.

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- Kana, T.W., J. Michel, M.O. Hayes, and J.R. Jensen. 1984. The physical impact of sea-level rise in the area of Charleston, South Carolina. M.C. Barth and J. Titus (eds.), Greenhouse Effect and Sea Level Rise: A Challenge for This Generation: Van Nostrand Reinhold Co., New York, NY, pp. 105-151.
- Kana, T.W., J. Michel, M.O. Hayes, and J.R. Jensen. 1983. Shoreline changes due to various sea-level rise scenarios. Proc. Coastal Zone Management '83, ASCE, NY, pp. 2768-2776.
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- Hayes, M.O., J. Michel, and T.W. Kana. 1978. Man's modification of the Kuwait City waterfront (abs.). Proc. Amer. Assoc. Geog., New Orleans, LA.