



JACQUELINE MICHEL, Ph.D.
Geochemist, President

Research Planning, Inc.

Dr. Michel is a geochemist specializing in terrestrial and marine pollution studies, coastal geomorphology, and environmental risk assessments. Having worked in 34 countries, she has extensive international experience and has worked in many different coastal and terrestrial 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 (NRDA) following spills and groundings. She has taken a lead role in 33 NRDA cases for Federal and State Trustees since 1985.

Dr. Michel has been recognized for her achievements through appointments to many respected committees and panels, including six National Academies committees:

- Spills of Nonfloating Oil (1999);
- Oil in the Sea (2002);
- Spills of Emulsified Fuels: Risks and Response (2001), Chair;
- Committee on Understanding Oil Spill Dispersants: Efficacy and Effects (2005), Chair;
- Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response (2016); and
- 2016-2018: Committee on Ocean Science and Assessment for Ocean Energy Management, advising the Bureau of Ocean Energy Management.

She was on the Oceans Studies Board at the National Academies 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 an Adjunct Professor in the School of the Earth, Ocean and Environment, University of South Carolina. She has written over 250 technical reports and publications, including 45 peer-reviewed journal articles and ten chapters in books.

She co-authored five books on the coastal geology and ecology of different coastal states, targeted to the layperson living on or visiting the coast: South Carolina (2008), Central California (2010), Georgia (2013), Southern Alaska (2017), and Oregon/Washington (2019).

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 four technical areas is outlined separately below:

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

NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION

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 Assessment and Restoration Division, Office of Response and Restoration on many different aspects of natural resource damage assessments. She worked on the NRDA for the following incidents and waste sites:

1. *T/V Amazon Venture*, Savannah River, Georgia/South Carolina (1985)
2. Shell Martinez tank farm, Martinez, California (1988)
3. *T/V Exxon Valdez*, Prince William Sound, Alaska (1989)
4. *T/V American Trader*, Huntington Beach, California (1991)
5. Arthur Kill spills in New York/New Jersey (1991)
6. Mobil Mining and Minerals Company spill of phosphoric acid into the Houston Ship Channel, Texas (1992)
7. *M/V Mega Borg* spill off the Texas coast (1992)
8. Colonial Pipeline oil spill into Sugarland Run and the Potomac River, Virginia (1993)
9. Unocal Spill, California (1994)
10. *T/B North Cape* barge home heating oil spill in Rhode Island (1995)
11. Colonial Pipeline spill of No. 2 fuel oil into the Reedy River, South Carolina (1996)
12. *T/V Julie N* tanker spill of IFO 180 in Portland, Maine (1996)
13. Lake Barre, Louisiana pipeline crude oil spill by Texaco (1997)
14. Chevron pipeline crude oil spill, Gulf of Mexico (1998)
15. *M/V New Carissa* bunker and diesel spill, Coos Bay, Oregon (1999)
16. Tuna Longliners Vessel Removal Action, American Samoa (1999)
17. Petrobras Pipeline, Guanabara Bay, Brazil (2000)
18. PEPCO pipeline spill, Patuxent River, Maryland (2000)
19. Tug Gilbert grounding, Gulf Islands National Seashore (2001)
20. *M/T Westchester*, Mississippi River (2001)
21. Pryor Oil Well Fire and Spill, Obed Wild and Scenic River, Tennessee (2002)
22. *Bouchard Barge-120*, Buzzards Bay, Massachusetts and Rhode Island (2003)
23. *M/T Athos I*, Delaware River, PA, NJ, DE (2004)
24. Citgo Refinery, Lake Charles, Louisiana (2006)
25. *Cosco Busan*, San Francisco, California (2007)
26. Burton Island Ash Landfill, Delaware (2008)
27. *Selendang Ayu*, Unalaska Island, Alaska (2008)
28. *Deepwater Horizon*, Gulf of Mexico (2010)
29. Motiva, Arthur Kill, New York (2012)
30. ExxonMobil Pegasus Pipeline, Arkansas (2013)

31. Zavanna Oil Field Spill, Williston, North Dakota (2014)
32. Texas City Y, Texas (2014)
33. Refugio Bay, CA (2015)

From 2009-2013, Dr. Michel was the Senior Science Advisor for RPI's four-year project to speed the ecological recovery the coastal habitats affected by the Gulf War oil spill. Through technical management of 23 individual projects (totaling over \$400 million) to restore tidal channel functions, decrease ponding, and reduce physical barriers including thick algal mats, over 1,800 hectares of marshes, tidal flats, and beaches are now recovering faster.

Selected Publicly Available Reports

- Michel, J., S.R. Fegley, J.A. Dahlin, and C. Wood. 2017. Oil spill response-related injuries on sand beaches: When shoreline treatment extends impacts beyond the oil. *Marine Ecology Progress Series* 576:201-218, doi: 10.3354/meps11917.
- Bejarano, A.C. and J. Michel. 2016. Oil spills and their impacts on sand beaches: A literature review. *Environmental Pollution* 218:709-722.
- Nixon, Z., S. Zengel, M. Baker, M. Steinhoff, G. Fricano, S. Rouhani, and J. Michel. 2016. Shoreline oiling from the *Deepwater Horizon* oil spill. *Marine Pollution Bulletin* 107:170-178.
- Zengel, S., C.L. Montague, S.C. Pennings, S.P. Powers, M. Steinhoff, G. Fricano, C. Schlemme, M. Zhang, J. Oehrig, Z. Nixon, S. Rouhani, and J. Michel. 2016. Impacts of the *Deepwater Horizon* oil spill on salt marsh periwinkles (*Littoraria irrorata*). *Environmental Science & Technology* 50:643-652.
- Michel, J., S.R. Fegley, and J.A. Dahlin. 2015. *Deepwater Horizon* Sand Beach Injury Assessment Technical Report. U NS_TR.24). DWH Shoreline NRDA Technical Working Group Report. 111 pp + app.
- Michel, J. and Z. Nixon. 2015. Coastal wetland vegetation: Response-related injuries. Final Report. (NS_TR.28). DWH Shoreline NRDA Technical Working Group Report.
- Nixon, Z. and J. Michel. 2015. Predictive modeling of subsurface shoreline oil encounter probability from the *Exxon Valdez* oil spill in Prince William Sound, Alaska. *Environmental Science & Technology* 49:4354-4361.
- Michel, J. and Z. Nixon. 2015. Coastal wetland vegetation: Response-related injuries during the *Deepwater Horizon* oil spill. NOAA Assessment and Restoration Division, Seattle, WA. 19 pp.
- Bejarano, A., J. Michel, and S.E. Allan. 2014. Guidelines for Collecting High Priority Ephemeral Data for Oil Spills in the Arctic in Support of Natural Resource Damage Assessments. Prepared for the Office of Response and Restoration, National Oceanic and Atmospheric Administration, Seattle, WA. 271 pp.
- Minter, T.G., J.A. Hale, C.D. Cormack, L. Cotsapas, and J. Michel. 2014. Tidal flat and sand beach remediation: Choosing remediation techniques to speed ecological recovery of habitats still impacted 20 years after the Gulf War oil spill. Proc. 2014 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 1719-1733.
- Bejarano, A., J. Michel, and L. Williams. 2012. Net Environmental Benefit Analysis (NEBA) relative risk ranking conceptual design, Kalamazoo River System, Enbridge Line 6B Release. August 8, 2012; document and appendixes; AR-0963.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C. 14 pp.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., 11 pp.

- Michel, J. and Z. Nixon. 2010. Chapter 2: Distribution of surface and subsurface oil on shoreline habitats four years after the *Selendang Ayu* oil spill. In: Assessment of Remaining Oil from the M/V *Selendang Ayu* Spill as of 2008. NOAA, Anchorage, AK. 33 pp.
- Bejarano, A. and J. Michel. 2010. Chapter 4: Analysis of PAH body burdens in blue mussels in winter 2008. In: Assessment of Remaining Oil from the M/V *Selendang Ayu* Spill as of 2008. NOAA, Anchorage, AK. 16 pp.
- Carls, M.G., J. Michel, and Z. Nixon. 2010. Chapter 5: Synthesis Discussion of Remaining Oil from the M/V *Selendang Ayu* Spill as of 2008. In: Assessment of Remaining Oil from the M/V *Selendang Ayu* Spill as of 2008. NOAA, Anchorage, AK. 14 pp.
- Michel, J. and A.C. Bejarano. 2010. The *Deepwater Horizon* Oil Spill: Shoreline Cleanup Assessment Technique as a key data source in Habitat Equivalency Analysis. SETAC. New Orleans, LA, USA.
- 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 Bulletin* 58:995-1006.
- Michel, J., C. Boring, and C. Locke. 2008. Rapid assessment protocols for small vessel groundings. Proc. 2008 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 381-386.
- Nixon, Z., J. Michel, J. Hoff, D. Forsell, S. Krest, K. Clark, T. Nicols, J. Dunn, and K. Kalasz. 2008. Estimating bird injury from the M/T *Athos I* incident. Proc. 2008 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 995-1001.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 787-791.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 797-803.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 1139-1145.
- RPI. 2003. Preassessment Phase Report for the Howard/White Unit No. 1 Oil Spill NRDA, Obed Wild and Scenic River, Morgan County, Tennessee. Prepared for National Park Service, 47 pp. + apps.
- Michel, J., S. Zengel, C. Lord, and Z. Nixon. 2002. Surveys of Abandoned Vessels: U.S. Caribbean Region. NOAA Office of Response and Restoration, Silver Spring, MD. 52 pp. + app.
- 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.
- Michel, J., P. McGowan, and R. Greer. 2001. Estimate of total acute mortality to birds and production foregone resulting from the Chalk Point oil spill, Swanson Creek, Maryland, April 7, 2000. Report to the Trustee Council for the Chalk Point Oil Spill. NOAA Damage Assessment Center, Silver Spring, MD. 15 pp.
- Michel, J. 2001. Preassessment Data Report for the M/T *WESTCHESTER* oil spill, Mississippi River Mile 38, Louisiana. Report to the Trustees, NOAA Damage Assessment Center, Silver Spring, MD. 19 pp. + app.
- Michel, J., S. Zengel, L. Cotsapas, J. Dahlin, and J. Hoff. 2001. Scaling of injury to reef flat habitats resulting from removal actions of grounded vessels in Pago Pago, American Samoa. Proc. 2001 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 671-678.

- Michel, J. 2000. Interim Preassessment Report, *M/V New Carissa* Oil Spill. NOAA Damage Assessment Center, Silver Spring, MD.
- RPI. 1999. Restoration Plan and Environmental Assessment, Tuna Longliners Cleanup, Pago Pago, American Samoa. NOAA Damage Assessment Center, Silver Spring, MD.
- Michel, J., S. Zengel, D. Helton, J.R. Payne. 1999. Protocols for sample design and implementation: field methods, sample handling, and chemical analysis for natural resource damage assessments of oil spills. Proc. 1999 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 1109-1111.
- Michel, J. and S. Zengel. 1998. Monitoring of oysters and sediments in Acajutla, El Salvador. *Marine Pollution Bulletin* 36(4):256-266.
- Michel, J. 1997. Extent of oiling of wetlands, *Julie N* oil spill, Portland, Maine. Prepared for the *Julie N* Trustee Council, Maine Department of Environmental Protection, Portland, ME, 12 pp. + app.
- Michel, J. 1997. Natural Resources Damage Assessment Handbook for Thailand. Prepared for the Pollution Control Department, Ministry of Science Technology and Environment, Bangkok, Thailand. 86 pp.
- 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, American Petroleum Institute, Wash., 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.
- Reinharz, E. and J. Michel. 1996. Preassessment Phase Guidance Document for Natural Resources Damage Assessment Under the Oil Pollution Act Of 1990. Prepared for the Damage Assessment and Restoration Program, National Oceanic and Atmospheric Administration, 1305 East-West Highway, SSMC #4, Silver Spring, Maryland. 47 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. + app.
- Scholz, D. and J. Michel. 1992. The *Mega Borg* oil spill: chronology and summary of spill response activities (chap. 1); and fate of the lost oil (chap. 2). Prepared for the Damage Assessment Center, NOAA, Rockville, MD, 88 pp. + app.
- Michel, J. and D. Scholz. 1992. Natural resources damage assessment emergency procedures manual. Prepared for the Damage Assessment Center, NOAA, Rockville, MD. 93 pp. + app. (version 2.0 published October 1995).
- Michel, J. 1991. Simplified Type B assessments: a cost-effective and rational approach to natural resource damage assessments for spills. Invited Paper, Am. Fisheries Society, San Antonio, TX.
- Michel, J. 1989. Natural resource damage assessment of the *Amazon Venture* oil spill. Proc. 1989 Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 303-306.

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, North Carolina	1983
T/V <i>Puerto Rican</i>	San Francisco, California	1985
T/V <i>Amazon Venture</i>	Savannah, Georgia	1986
M/V <i>Pac Baroness</i>	Santa Barbara, California	1987
Shell Refinery	Martinez, Calif.	1988
T/V <i>Exxon Valdez</i>	Valdez, Alaska	1989
T/V <i>American Trader</i>	Huntington Beach, California	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, Minnesota	1992
Greenhill Petroleum Blowout	Timbalier Bay, Louisiana	1992
UNOCAL refinery	Neches River, Texas	1993
Colonial Pipeline Break	Reston, Virginia	1993
T/B <i>Bouchard 255</i>	Tampa, Florida	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, Louisiana	1997
<i>Kapitan Egorov</i> 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, Massachusetts	2003
M/V <i>Fortune Epoch</i>	Savannah, Georgia	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, California	2007
T/V <i>Hebei Spirit</i>	South Korea	2008
<i>Deepwater Horizon/MC252</i>	Gulf of Mexico	2010
ExxonMobil Pegasus Pipeline	Mayflower, Arkansas	2013
Texas City Y barge spill	South Texas	2014
Refugio Incident	Santa Barbara, California	2015

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 60 times since 1992.

Gulf War Oil Spill Assessment and Restoration. 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. From 2009-2013, she was a Senior Scientist in support of the \$460 million restoration program. Starting in 2018, she is part of the RPI team conducting a five-year monitoring program to track recovery of restored tidal flats and marshes.

Selected Publications

OIL/CHEMICAL SPILL EFFECTS AND FATE RESEARCH

- Hale, J., J. Weaver, J. Michel, L. Cotsapas, and H. Fravel. 2019. Annual Monitoring Report 1 - Fall 2018 and Spring 2019 Monitoring Events. Coastal Environments Long-Term Monitoring Program. Report submitted to the General Authority of Meteorology and Environmental Protection, Jeddah, Saudi Arabia. 170 pp.
- Nixon, Z. and J. Michel. 2018. A Review of distribution and quantity of lingering subsurface oil from the *Exxon Valdez* Oil Spill. Deep Sea Research Part II. <http://dx.doi.org/10.1016/j.dsr2.2017.07.009>
- Michel, J. and M. Fingas. 2016. Oil Spills: Causes, Consequences, Prevention, and Countermeasures. In: G.M. Crawley (ed.), Fossil Fuels: Current Status and Future Directions, World Scientific Series in Current Energy Issues, Volume 1. World Scientific., pp. 159-202.
- Michel, J., D. Esler, and Z. Nixon. 2016. Studies on *Exxon Valdez* Lingering Oil: Review and Update on Recent Findings. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. 39 pp.
- Bejarano, A.C, H. Dunagan, and J. Michel. 2015. Effects of Oil, Shoreline Treatment, and Physical Disturbance on Sand Beach Habitats. Report to NOAA Office of Response and Restoration, NOAA, Seattle, WA, 145 pp.

- Zengel S, B.M. Bernik, N. Rutherford, Z. Nixon, and J. Michel. 2015. Heavily oiled salt marsh following the *Deepwater Horizon* oil spill, ecological comparisons of shoreline cleanup treatments and recovery. PLoS ONE 10(7): e0132324. doi:10.1371.
- Hoff, R. and J. Michel. 2014. Oil Spills in Mangroves: Planning & Response Considerations. Office of Response and Restoration, NOAA, Seattle, WA. 90 pp.
- Michel, J. and N. Rutherford. 2014. Determining the need for treatment of oiled marshes: Rates of recovery and treatment options by oil type and degree. Proc. 2014 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 294746.
- Michel, J. and N. Rutherford. 2014. Impacts, recovery rates, and treatment options for spilled oil in marshes. Marine Pollution Bulletin 82(1-2):19-25.
- Zengel, S., N. Rutherford, B. Bernik, Z. Nixon, and J. Michel. 2014. Salt marsh remediation and the *Deepwater Horizon* oil spill, the role of planting in vegetation and macroinvertebrate recovery. Proc. 2014 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 1985-1999.
- Michel, J. and N. Rutherford. 2013. Oil Spills in Marshes: Planning & Response Considerations. Emergency Response Division, NOAA, Seattle, WA and American Petroleum Institute, Wash., D.C. 129 pp.
- Nixon, Z., J. Michel, M.O. Hayes, G.V. Irvine, and J. Short. 2013. Geomorphic factors related to the persistence of subsurface oil from the *Exxon Valdez* oil spill. In: Kana, T., J. Michel, and G. Voulgaris (eds.), Proceedings, Symposium in Applied Coastal Geomorphology to Honor Miles O. Hayes, Journal of Coastal Research, Special Issue No. 69:115-127.
- Michel, J., E.H. Owens, S. Zengel, A. Graham, Z. Nixon, T. Allard, W. Holton, P.D. Reimer, A. Lamarche, M. White, N. Rutherford, C. Childs, G. Mauseth, G. Challenger and E. Taylor. 2013. Extent and degree of shoreline oiling: *Deepwater Horizon* oil spill, Gulf of Mexico, USA. PLoS ONE 8(6):e65087.
- Zengel, S. and J. Michel. 2013. *Deepwater Horizon* Oil Spill: Salt Marsh Oiling Conditions, Treatment Testing, and Treatment History in Northern Barataria Bay, Louisiana (Interim Report October 2011). U.S. Dept. of Commerce, NOAA Technical Memorandum NOS OR&R 42. Emergency Response Division, NOAA, Seattle, WA. 74 pp.
- Michel, J., Z. Nixon, M.O. Hayes, G. Irvine, and J. Short. 2011. The distribution of lingering subsurface oil from the *Exxon Valdez* oil spill. Proc. 2011 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C.
- Boufadel, M.C., B.A. Wrenn, B.E. Moore, K.J. Boda, and J. Michel. 2011. Biodegradation assessment tool for decision on beach response. Proc. 2011 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C.
- 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 Bulletin 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. + app.
- 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 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 551-556.

- Etkin, D.S., D. J. Michel, French-McCay, M. Boufadel, and H. Li. 2008. Integrating state-of-the-art shoreline interaction knowledge into spill modeling. Proc. 2008 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 915-922.
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PLANNING AND TRAINING

- Michel, J. and M. Ploen. 2016. Inland Oil Spills—Options for Minimizing Environmental Impacts of Freshwater Spill Response, Technical Report 425. American Petroleum Institute, Wash., DC. 112 pp.
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- Savitsky, B. and J. Michel. 1986. Qualitative risk assessment for hazardous material spills in ports. Proc. Hazardous Material Spill Conf. American Petroleum Institute, Wash., D.C.

ENVIRONMENTAL RISK ASSESSMENTS/GEOLOGY

Development Projects on the OCS: Dr. Michel has assisted the Bureau of Ocean Energy Management (BOEM) on numerous projects related to environmentally sound management of resources in the Outer Continental Shelf, including:

- 1) Co-author: 2018 Projected OCS Sand Resource Needs and Effort. Study for Marine Minerals Program that made a forecast of activities that could require OCS sand resources through 2028.
- 2) Principal Investigator (PI) and Co-author: 2013 Environmental Risks, Fate and Effects of Chemicals Associated with Wind Turbines on the Atlantic Outer Continental Shelf.
- 3) PI and Senior Author: 2013: Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand. She authored the sections for foraging seabirds, sea turtles, and marine mammals.
- 4) PI, Co-Author, and Editor: 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 900+ 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.
- 5) PI and Senior Author: 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.
- 6) PI and Senior Author: 2007 Critical Technical Review and Evaluation of Site-Specific Studies Techniques for the MMS Marine Minerals Program. Recommendations were made to generate baseline data, evaluate the effectiveness of mitigation measures, and detect cumulative impacts.
- 7) Co-author: 2007 Review of the State-of-the-Art on Modeling Interactions between Spilled Oil and Shorelines for the Development of Algorithms for Oil Spill Risk Analysis Modeling

- 8) Design and manage regional sand management working groups for Louisiana and Florida. This work involved coordination of agencies, private industry, academia, and stakeholders in the complex issues of dredging offshore sand deposits for habitat restoration.
- 9) PI and co-author: 2004 Archaeological Damage from Offshore Dredging: Recommendations for Pre-Operational Surveys and Mitigation During Dredging to Avoid Adverse Impacts;
- 10) Co-author: 2004 Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies;
- 11) Co-author: 2002 Environmental Sensitivity Index Shoreline Classification of the Beaufort Sea and Chukchi Sea; and
- 12) PI and Senior Author: 2001 Biological and Physical Monitoring Protocols to Evaluate the Long-Term Impacts of Offshore Dredging Operations on the Marine Environment.

Programmatic Environmental Impact Statements (PEIS)/Biological Assessments:

Dr. Michel assisted the NOAA Restoration Center in preparation of the PEIS for the *Deepwater Horizon* Programmatic Damage Assessment and Restoration Plan (PDARP). She assisted the U.S. Department of the Interior in preparation of the Biological Assessment for the PDARP. In 2013, she co-authored the Biological Assessment required under Section 7 of the Endangered Species Act for the Regional Response Team 9 California Dispersant Use Plan and the Regional Response Team 4 Plan for Preapproval of the use of dispersants and in-situ burning. She also co-authored the PEIS for the U.S. Coast Guard rulemaking that requires the inclusion of in-situ burning and dispersant capability in vessel and facility oil spill response plans in 2004.

She prepared Environmental Assessments for: two development projects associated with the Jazan Economic City on the Red Sea in Saudi Arabia in 2015; removal of nine wrecked tuna longliner vessels on a reef in Pago Pago, American Samoa in 1999; a spill in the Obed Wild and Scenic River, TN in 2003; and the offloading of *USS Mississinewa*, a World War II tanker that started leaking oil into Ulithi Lagoon, Federated States of Micronesia in 2002. In 2009-2010 she used data on contamination sources to conduct site-specific hazard assessments and develop a vulnerability index of coastal and marine resources to oil spills and releases of hazardous substance resulting from changes in sea level rise.

Environmental Risk/Pollution Assessments: She worked on the assessment of marine oil spill risk and environmental vulnerability for the State of Alaska (2013); risk assessment for Potentially Polluting Shipwrecks in U.S. Waters (2013); risks and effects of chemical spills from offshore wind turbines (2013); an Environmental Vulnerability Index to support coastal management and planning in the Emirate of Abu Dhabi (2011); and the Coastal Pollution Assessment for Jeddah, Saudi Arabia (2008).

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 three-year period to characterize 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.

Coastal Habitat 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 coastal resource maps and databases. This work includes the Gulf-Wide Information System (G-WIS) projects for the Minerals Management Service. She conducted field mapping and authored the following atlases:

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

Mapping of Unusually Sensitive Areas, Office of Pipeline Safety. Dr. Michel developed the technical definition of drinking water Unusually Sensitive Areas (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. In 2016-2018, she assisted the Pipeline and Hazardous Materials Safety Administration with the updates to the drinking water USAs for all 50 states plus Puerto Rico and the District of Columbia.

Selected Publications

- Miller, J.D., M.O. Hayes, J. Michel, P.K. Krishnakumar, and R.A. Loughland. 2019. Chapter 3.1: Coastal Beach and Island Ecosystems. In: Al-Abdulkader, K.A., R.A. Loughland, and M.A. Qurban (eds.), *Ecosystems and Biodiversity of the Arabian Gulf: Saudi Arabian Waters, Fifty Years of Scientific Research*, Saudi Aramco and King Fahd University of Petroleum & Minerals, pp. 68-99.
- Huyster, M., A. Bejarano, and J. Michel. 2017. Improving biological assessments and consultations for Regional Response Team Preauthorization Plans: An example with Federal Region 4. Proc. 2017 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 589-604.
- Symons, L., J. Michel, J. Delgado, D. Reich, D. French McCay, D.S. Etkin, and D. Helton. 2014. The Remediation of Underwater Legacy Environmental Threats (RULET) risk assessment for potentially polluting shipwrecks in U.S. Waters. Proc. 2014 Intl. Oil Spill Conference, American Petroleum Institute, Wash., D.C., pp. 783-793.
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- Reich, D.A. D. French McCay, J. Fontenault, J. Rowe, D.S. Etkin, J. Michel, Z. Nixon, C. Boring, M. McBrien, and B. Hay. 2013. Assessment of Marine Oil Spill Risk and Environmental Vulnerability for the State of Alaska. Restoration Center Northwest, NOAA, Seattle, WA. 134 pp.
- Bejarano, A.C., J. Michel, J. Rowe, Z. Li, D. French McCay, L. McStay and D.S. Etkin. 2013. Environmental Risks, Fate and Effects of Chemicals Associated with Wind Turbines on the Atlantic Outer Continental Shelf. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2013-213. 261 pp.
- Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss 2013. Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand. U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS Study BOEM 2013-0119. 258 pp.
- Michel, J. (ed.). 2013. South Atlantic Information Resources: Data Search and Literature Synthesis. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2013-01157. 942 pp.
- 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.
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- 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. + app.
- Michel, J., R. Nairn, C.H. Peterson, S.W. Ross, R. Weisberg, and R. Randall. 2007. Critical Technical Review and Evaluation of Site-Specific Studies Techniques for the MMS Marine Minerals Program. Minerals Management Service, Herndon, VA. MMS OCS Report 2007-047. 47 pp. + app.
- Etkin, D.S., D. French-McCay, and J. Michel. 2007. Review of the State-of-the-Art on Modeling Interactions between Spilled Oil and Shorelines for the Development of Algorithms for Oil Spill Risk Analysis Modeling. Minerals Management Service, Herndon, VA. MMS OCS Study 2007-063. 157 pp.
- Nairn, R.B., Q. Lu, S.K. Langendyk, and J. Michel. 2005. A study to Address the Issue of Seafloor Stability and the Impact on Oil and Gas Infrastructure in the Gulf of Mexico: U.S. Department of Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA, OCS Study MMS 2005-043, 179 pp. + appendices.
- Michel, J., D. Etkin, T. Gilbert, J. Waldron, C.T. Blocksidge, and R. Urban. 2005. Potentially Polluting Wrecks in Marine Waters: An Issue Paper Presented at the 2005 Intl. Oil Spill Conference. American Petroleum Institute, Wash., D.C. 76 pp.
- 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.
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- 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. 116 pp.
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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.
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- Hayes, M.O. and J. Michel. 1982. Shoreline sedimentation with a forearc embayment, lower Cook Inlet, Alaska. *Jour. Sed. Petrol.* 52:251-263.

ENVIRONMENTAL RADIOCHEMISTRY

Since 1976, research has been conducted on the distribution and geochemistry of natural radionuclides in soils, groundwater, and surface water. The results have been applied to problems on the occurrence of radionuclides in public drinking water sources, drinking water standards, and understanding the geological factors that affect their distribution, with emphasis on radium and radon isotopes. Models have been developed to predict the levels of uranium, radium, and radon in groundwater nationwide, and these levels have been mapped at the county scale.

Dr. Michel has participated on numerous review panels for EPA's Office of Drinking Water dealing with radionuclides and was a consultant to the Radiation Advisory Committee of the Science Advisory Board. She has provided expert review and testimony on radiological contamination and risk associated with the phosphate industry. She has also conducted various studies on radiological contamination at the Savannah River Site, Aiken, South Carolina. Selected publications resulting from her research are cited below.

Chapters in Books

- Michel, J. 1991. Chapter 7: Relationship of Radium and Radon with Geological Formations. In: C.R. Cothorn and P. Rebers (eds.), *Radioactivity in Drinking Water*, Plenum Press, New York, pp. 83-95.
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- Crawford-Brown, D.J. and J. Michel. 1987. Chapter 3, Measurement. In C.R. Cothorn and J.E. Smith, Jr. (eds.), *Environmental Radon*, Environmental Science Research Volume 35, Plenum Press, New York, pp. 59-80.
- Michel, J. and M. Jordana. 1987. Nationwide Distribution of Ra-228, Ra-226, Rn-222, and Uranium in Ground Water. In: B. Graves (ed.), *Radon, Radium, and other Radioactivity in Ground Water*, Lewis Publishers, Chelsea, Mich., pp. 227-240.
- Michel, J., P.T. King, and W.S. Moore. 1982. Technique for Ra-228 and Ra-226, with Results from South Carolina. In: E.C. Perry and C.W. Montgomery (eds.), *Isotopic Studies of Hydrologic Processes*, North. Ill. Univ. Press, pp. 83-90.

Selected Publications and Abstracts

- Michel, J. 1988. Natural radioactivity in ground water near the Savannah River Plant. Rept. to E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken S.C. 45 p. + appendices.
- Michel, J. 1988. Distribution of radon in groundwater in California: Rept. for California Public Health Foundation, Berkeley, Calif., by RPI. 46 pp.
- Michel, J. 1988. Relationship between radon levels and geological formations. (abs.) *Proc. American Chemical Society*, Los Angeles, Calif., Sept. 1988.
- Michel, J. 1988. Geological aspects of radon: Invited Paper-Symposium on Radon, 9th Annual Meeting American College of Toxicology, Baltimore, Md.
- Michel, J. and C.R. Cothorn. 1986. Predicting the occurrence of radium-228 in groundwater. *Health Physics* 51:715-723.
- Cothorn, C., W.L. Lappenbusch, and J. Michel. 1986, Drinking water contribution to natural background radiation. *Health Physics*, 50:33-47.

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- Cothern, C.R., P. Lassovszky, W.L. Lappenbusch, and J. Michel. 1984. Review of advances in analytical measurement techniques and treatment methodology for radioactivity in drinking water (abs.). American Chemical Society Annual Meeting, Philadelphia, PA.
- Michel, J. 1984. Redistribution of uranium and thorium series isotopes during isovolumetric weathering of granite. *Geochim. Cosmochim. Acta* 48:1249-1255.
- Michel, J. and C. Pollman. 1983. Phase II, Ra-228 model, North-central region of the U.S. EPA, Office of Drinking Water, Wash., D.C. 55 pp.
- Michel, J. and C. Pollman. 1982. A model for the occurrence of Ra-228 in ground water: EPA, Office of Drinking Water, Wash., D.C. 50 pp.
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- Michel, J., W.S. Moore, and K. Cole. 1982. Uraniferous gorceixite in the South Carolina coastal plain. *Chemical Geology* 35:227-245.
- Michel, J., W.S. Moore, and P.T. King. 1981. Gamma x-ray spectrometry for determination of ^{228}Ra and ^{226}Ra in natural waters. *Analytical Chem.* 53:1885-1889.
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