But offshore exploration is a high-cost, high-risk enterprise. A deepwater drilling rig alone runs half a million dollars a day (https://www.rigzone.com/data/dayrates) just in rental fees, and may have an onboard crew of more than 100, so companies need to know they are drilling in the right area while also minimizing the risk of catastrophic blowouts such as the Deepwater Horizon. Seismic exploration followed by computer modeling takes a lot of the guesswork and expense out of drilling a hole and is far cheaper and more reliable than trial and error.

As ConocoPhillips CTO Ram Shenoy said in an April 2014 interview published by Offshore Energy Today (http://www.offshoreenergytoday.com/conocophillips-working-to-reduce-deepwater-exploration-cost/): “Advances in high-performance computing, coupled with advances in algorithms for modeling and simulation in different fields ... in geophysics is leading to better ways of imaging the subsurface to find hydrocarbon accumulations that we couldn’t find before.” Given the costs, coupled with a potential payback in the billions, it is not surprising that the world’s fastest privately owned supercomputer on last fall’s Top 500 list (http://top500.org/list/2013/11/) is the Pangaea system owned by France’s Total Exploration Production (http://top500.org/system/178071#U5JHkD-EV8E).

And, once that deepwater oil deposit is found through geophysical and seismic imaging, the safest and lowest cost methods are needed for profitable extraction. “We also are looking at technological advances in deepwater facilities – for instance, subsea and downhole power management; more effective ways of managing drilling processes; and assuring access to hydrocarbons in a safe and predictable manner – to reduce the cost of exploiting deepwater, while being safe and environmentally responsible,” Shenoy said.

However, there is still much work to be done to realize the benefits of risk reduction. For example, those supercomputers rely on advances in the underlying sensing technologies that provide the raw data for computer simulations. Fred Aminzadeh, Professor of Petroleum Engineering at the University of Southern California and former president of the Society of Exploration Geophysicists, asserts that many of the predictions made a few years ago regarding how improvements in imaging technologies would directly impact the success ratio in subsalt drilling have already been validated; and that the “integration of seismic and other geophysical measurement (e.g. Controlled Source Electromagnetics) have also yielded some positive results.” Other areas of research, while promising, are not yet to the point needed.

“Real time imaging, although it is quite mature for creating azimuthal resistivity, density and Gamma ray to help in geosteering, needs to be extended to real time azimuthal velocity determination using real time seismic data,” explains Aminzadeh. “The whole integration concept from satellite data all the way to nano technology data (such as nano onions) and crossing the scale boundaries (both in time and space) will need to mature further to yield the expected results.”

In his 2013 book, Geophysics for Petroleum Engineers, Volume 60 of the Development in Petroleum Science Series (http://www.sciencedirect.com/science/bookseries/03767361/60/supp/C), he highlights the importance of geophysical technology application, not only for reducing exploration risk but also for many other engineering issues from drilling, formation pressure detection and reservoir characterization and monitoring. The book also discusses the four main exploration risk factors—Structure, Source, Reservoir, and Seal—and how to reduce them.

“The 3D seismic technology and various imaging techniques helps reduce the structure risk,” says Aminzadeh. “The reservoir risk could be reduced by various seismic attributes (both post-stack, e.g., attenuation, and pre-stack, e.g., AVO [Amplitude vs. Offset]). For the other two risk factors (seal and source) we have shown that chimney technology, in conjunction with geochemistry, can be helpful.”
There is a huge amount of research on methods of characterizing undersea reservoirs in publications such as Computers & Geosciences (www.sciencedirect.com/science/journal/00983004) and the Journal of Applied Geophysics (http://www.sciencedirect.com/science/journal/09269851). But rather than each exploration company having to start from scratch, there are commercial resources such as ESRI’s GIS for Petroleum (http://resources.arcgis.com/en/communities/petroleum) geospatial software and third-party applications (http://www.esri.com/industries/petroleum/solution_guides/explorationpreview) that use ESRI’s platform for geospatial data but add other features such as collaboration, workflow and analysis. In addition, Geofacets from Elsevier aggregates maps extracted from dozens of peer-reviewed publications and places them into one easily searchable platform. Maps can then be downloaded and integrated directly into GIS and other software programs.

There are public resources available to the exploration industry, as well.

“Our reservoir monitoring consortium (rmc.usc.edu) addresses many topics for different types of reservoirs, including those in deep waters,” notes Aminzadeh.

University of Oklahoma Professor of Petroleum Geology and Geophysics Roger M. Slatt researches “stratigraphic characterization of deepwater reservoirs using seismic, well logs, cores and outcrop analogs, all within a sequence stratigraphic framework” and wrote the volume immediately after Aminzadeh’s in the Developments in Petroleum Science Series Stratigraphic Reservoir Characterization for Petroleum Geologists, Geophysicists, and Engineers Origin, Recognition, Initiation, and Reservoir Quality (http://www.sciencedirect.com/science/bookseries/03767361/61/supp/C).

“By defining and quantifying architectural elements of identified deepwater reservoirs using these tools, one can better predict where to drill for both exploration and development objectives,” says Slatt.

To further spread the information, and give others hands-on experience, Slatt also runs the university’s Institute for Reservoir Characterization (http://vpr-norman.ou.edu/centers-institutes/list/institute-reservoir-characterization). There, geophysicists, geologists, engineers, mathematicians and computer scientists use a test reservoir owned by the university to develop and test reservoir characterization tools and methods. In addition to teaching reservoir characterization to graduate students, he also teaches an intensive course on deepwater petroleum geology for industry professionals working at petroleum companies and government agencies, as well as for organizations such as the American Association of Petroleum Geologists (AAPG) and the Society of Exploration Geophysicists (SEG).

There are also private and governmental efforts to assemble and disseminate undersea information. The site UKOilandGasData.com, operated by The United Kingdom Offshore Oil and Gas Industry Association, combines the data from the British Geographical Service’s Digital Energy Atlas and Library (DEAL) with private industry data, including offshore oil and gas wells, 2D and 3D seismic surveys, infrastructure, licenses and fields.
One additional factor in ensuring profitable exploration is preventing the risks caused by blowouts. BP had to set up a $20 billion trust (http://www.deepwaterhorizoneconomicsettlement.com/index.php) to handle claims from the 2010 Deepwater Horizon oil spill (http://www.sciencedirect.com/science/article/pii/S0025326X13001562), and the final total may be much higher.

“Recent natural and anthropogenic events, such as Hurricanes Katrina and Rita and the Deepwater Horizon oil spill, have identified significant gaps in our ability to predict risks associated with offshore hydrocarbon production as well as our capabilities to respond to deleterious events of varying scope, magnitude and duration,” says Kelly Rose, Research Geologist & Offshore Portfolio Lead for the U.S. Department of Energy’s National Energy Technology Laboratory (NETL).

“As offshore hydrocarbon development in the Gulf of Mexico continues to push into new territory, there is a need to develop computational tools that enable the rapid prediction of outcomes associated with unexpected hydrocarbon release events from deepwater and ultra-deepwater systems in the Gulf of Mexico.”

The NETL is developing the Gulf of Mexico Integrated Assessment Model (GOM IAM), which will allow for the assessment and quantification of risks and environmental impacts from deepwater and ultra-deepwater oil and gas drilling and production, and additionally will provide the information necessary to reduce losses in future spill events (https://edx.netl.doe.gov/dataset/netl-factsheets/resource/d1106c21-1d4b-41cc-91cd-5b11bc0b4148). GOM IAM includes numerical modeling tools and datasets (http://www.netl.doe.gov/publications/factsheets/rd/R%26D194-GAIA.pdf) to predict the range of potential behaviors of the reservoir, wellbore flow rates and water column discharge, and allow the user to simulate conditions.

“The approach for the GOM IAM project is similar to previous U.S. Department of Energy hydrocarbon resource and environmental research and development efforts such as DOE’s eastern and western gas shales programs from the 1970s to early 2000s,” Rose explains. “Like those programs, the GOM IAM effort is a suite of activities focused on reducing knowledge gaps while developing new tools and approaches that DOE and other entities can use to identify and reduce technology and knowledge gaps for a resource base with unique challenges.”

As it develops new data and tools, such as the GeoCube web mapping application that spans surface and subsurface information, these are all being released through NETL’s Energy Data eXchange (EDX) (https://edx.netl.doe.gov/offshore). The GOM IAM project is scheduled to run through 2015 and NETL plans to expand the project beyond the Gulf of Mexico.

“As more products from the project mature and are ready for dissemination,” says Rose, “the project team plans to see that data, tools, reports and pertinent products from the project are offered for consumption and use by other users via EDX as well.”