After The Gulf: What Did We Learn?

A Forum of the Aquarium of the Pacific's Marine Conservation Research Institute

October 21-22, 2010

Photo 21 April 2010, eoearth.org

AQUARIUM OF THE PACIFIC

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Acknowledgements

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Jerry R. Schubel
December 30, 2010

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Introduction

Background and Organization of Forum

On October 21-22, 2010 the Aquarium of the Pacific's Marine Conservation Research Institute (MCRI) conducted a Forum entitled "After the Gulf: What Did We Learn?" Support for the Forum was provided by the Aquarium and MCRI. The focus of the first day of the forum was preventing recurrence of a similar event and when, if one does occur, how to respond more efficiently and effectively. The focus of the second day was on the consequences of a continued reliance on fossil fuels, the role the ocean will probably play in meeting the continuing demand for oil, and strategies to accelerate a movement away from fossil fuels to renewable sources of energy. A secondary theme was whether an event similar to *Deepwater Horizon* could occur off California's coast.

The rationale for choosing these themes was that a relatively large number of meetings, conferences, and workshops have been held, or are planned, to deal with the environmental impacts of the *Deepwater Horizon* event that occurred on April 20, 2010, few focused on prevention and response.

The forum was by invitation only and was kept small to ensure a lively dialogue with ample opportunity for all participants to contribute their ideas and to challenge those of others. To further this objective of full engagement, nearly all of the participants used Google Wave throughout the forum to input ideas in real time. Each day began with several relatively short keynote talks to provide context and perspective and to set the stage for discussion.

The entire forum was videotaped. Nearly all presentations can be found on the Aquarium's website www.aquariumofpacific.org. Brief written summaries of most of the presentations are included in this report. The agenda is presented in Appendix A. The participants are presented in Appendix B. Brief biographies of the participants can be found in Appendix C.

The *Deepwater Horizon* event has been called the *Deepwater Horizon* Disaster, the BP Disaster, the *Deepwater Horizon* Spill, and the Macondo Blowout. It is clear that whatever name it goes by, functionally it was a blowout and not a spill. It was a sub-seabed blowout. The word "spill" implies a defined volume of liquid released during a period of limited duration. What happened in the Gulf was a "blowout." Had the well not been successfully capped, the flow would have continued for a very long time, perhaps decades. The Exxon Valdez event was a spill. Throughout most of this report we refer to the event as the *Deepwater Horizon* Blowout[1]. One of the most important issues was that a blowout of this nature or magnitude apparently had not been considered seriously.

[1] In the section "*Deepwater Horizon* Spill: A Brief Overview of the Event and the Response", we have preserved the language used by USCG LCDR A. Hidalgo.

Intended Audiences for Report

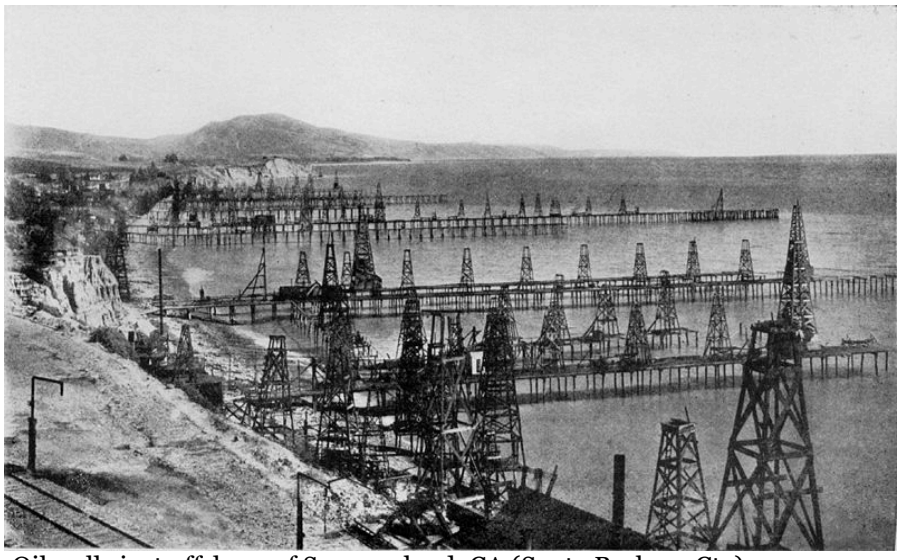
The primary audiences for this report and any other forum products are the general public and organizers of other workshops/conferences/forums on the *Deepwater Horizon* blowout. A secondary audience is decision-makers. The working hypothesis going into the forum was that in spite of the vast amount of media coverage of the *Deepwater Horizon* blowout, the public understanding of the causes and the consequences of the event, and the importance of the ocean sub-seabed in shallow and in deep water in satisfying society's growing demand for oil and gas is not fully grasped.

California—The Place It All Started

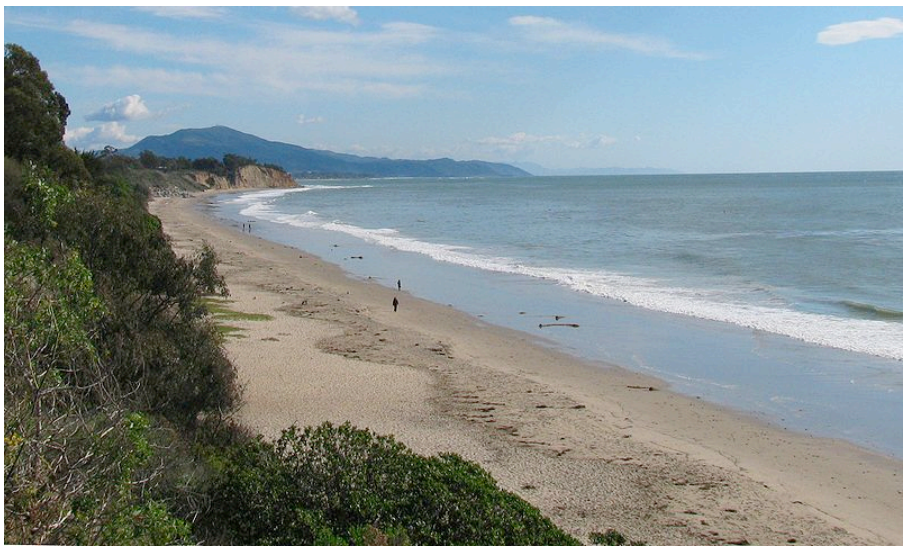
It's easy for many Californians to forget that the U.S offshore oil industry started right here in California. The world's first offshore production platform was off Summerland, California in 1896. By 1906 there were dozens of wells along the Summerland beach and in contiguous offshore waters.

Production in the Summerland nearshore area peaked before 1910, although most of the rigs remained into the 1920s. Standard Oil Co. of California (now Chevron) discovered the large Summerland Offshore Oil Field several miles offshore that was shut down in the 1990s. Peak production from the onshore portion of the Summerland Field did not actually occur until 1930.

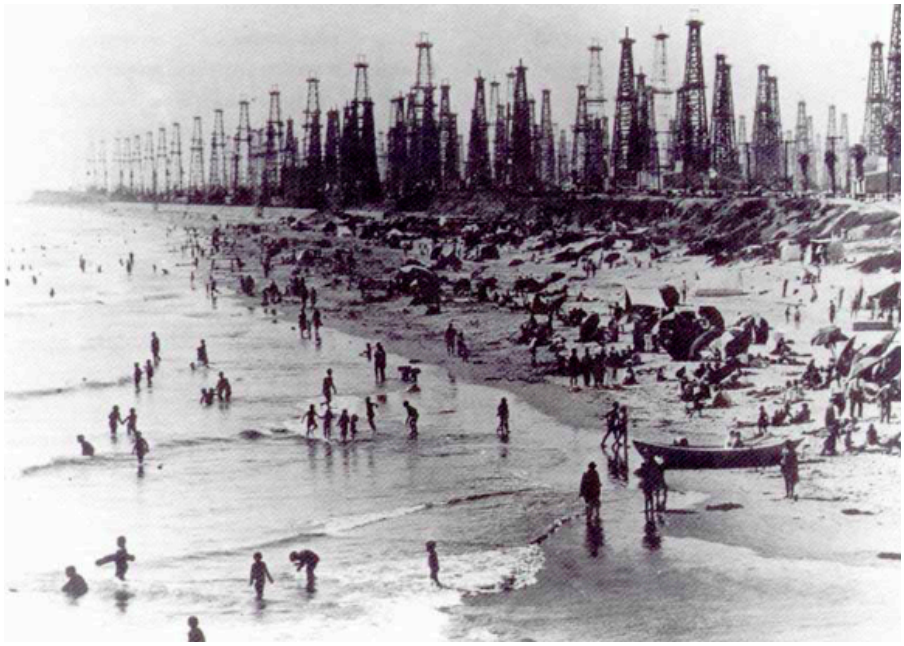
In January 1969, a blowout at the Dos Cuadras Field, about five miles offshore of Santa Barbara produced the infamous Santa Barbara Oil Spill, a formative event in the modern environmental movement and one that continues to drive California's policy on offshore oil exploration and exploitation.



Oil wells just offshore of Summerland, CA (Santa Barbara Cty) c 1906. Source: Wikimedia Commons. Original source: http://www.photolib.noaa.gov/htmls/line 2969.htm



Summerland Oil Field in 2006. Source: Wikimedia Commons.



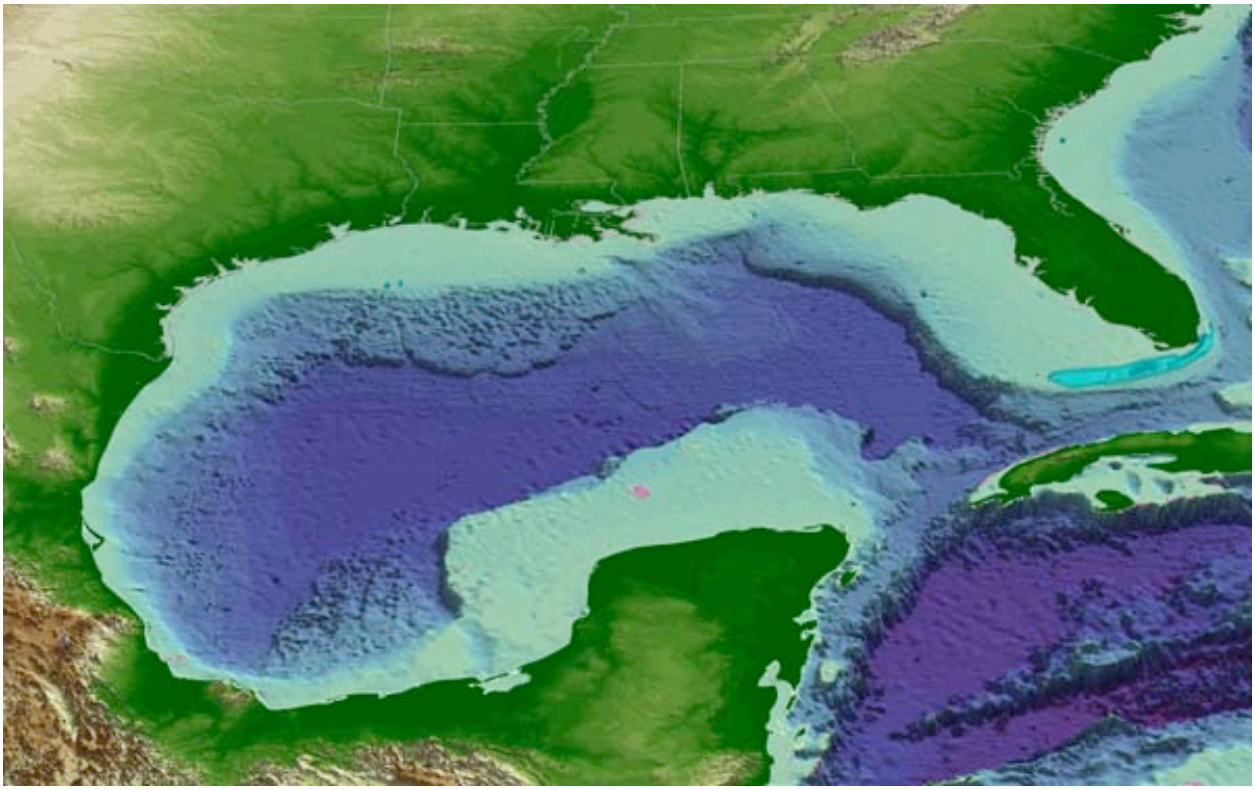
Huntington Beach, California in the 1920s. Source: Wikimedia Commons.

The Regional Setting of the Gulf of Mexico

The Gulf of Mexico has been referred to as the Nation's fish market and the Nation's gas station[2]. It provides more seafood—finfish, shrimp ad shellfish—each year than the south Atlantic and mid-Atlantic, Chesapeake Bay, and New England regions combined. The value of the recreational fisheries of the Gulf accounts for nearly 50% of the nation's recreational fisheries' economic impact. Clearly, the Gulf of Mexico is a major component of the Nation's commercial and recreational fisheries.

[2] Dr. Larry McKinney, Director of the Harte Research Institute for Gulf of Mexico Studies

The Gulf accounts for more than 50% of the nation's liquid natural gas production, 44% of the nation's crude oil production, and 43% of the natural gas production. And, the region accounts for 47% of the nation's petroleum refining capacity. It clearly is the nation's gas station and as long as we rely on oil and gas, much of it will come from the Gulf of Mexico, and from waters of increasing depth because that's where the new discoveries are being made.



Gulf of Mexico, Regional Setting

While there is a fairly long history of offshore oil and gas production, modern deepwater technology dates back only about 15 years. Over that brief period, it has evolved rapidly as we have moved into deeper and deeper water. *Deepwater Horizon* was in 1500m of water; production wells in the Gulf are operating in depths greater than 2700m; wells have been drilled in water depths of 3000m; and there are plans for wells in waters deeper than 3600m[3].

There is a great lack of understanding outside of the industry by many, including some of those in the media who covered the *Deepwater Horizon* blowout, of the design of offshore structures, the different kinds of rigs, and the engineering challenges of deep water oil exploitation that have been overcome and those that remain.

[3] For reference the average depth of the world ocean is 3800m.

Deepwater Horizon Spill: A Brief Overview of the Event And the Response

From Presentation by LCDR A. Hidalgo
(See her presentation on the Aquarium's website www.aquariumofpacific.org for all slides)

Introduction

On the evening of April 20, 2010, an explosion aboard the Mobile Offshore Drilling Unit (MODU) *Deepwater Horizon* set off an unfortunate series of events that led to the sinking of the drilling unit and the worst oil spill in U. S. history. Given the size and scope of the spill, Secretary Janet Napolitano designated the incident a Spill of National Significance (SONS) and designated then Commandant of the Coast Guard, Admiral Thad Allen, the National Incident Commander (NIC). Both of the designations were firsts.

Because of the size and severity of the spill, the complexity of the response effort, and the large-scale potential for adverse impacts on public health and the environment, the response required extraordinary coordination of federal, state, local and commercial resources to contain and mitigate the effects of the spill.

Using the framework provided in the National Contingency Plan, a monumental response was undertaken through the unified efforts of over 48,000 federal, state, and local responders, including over 7,000 active and reserve Coast Guard members. Five incident command posts were established across the Gulf Coast states and 15 staging areas to help flow critical resources to impacted locations. Over 835 oil skimmers were employed; over 9,700 response boats; training of over 10,000 vessels of opportunity; and over 120 aircraft. More than 34.7 million gallons of oily-water mix have been recovered through skimming and 411 controlled in-situ burns have removed over 11 million gallons of oil from the open water.

Background

- *Deepwater Horizon* was owned by TransOcean LLC.
- BP Exploration and Production, Inc. leased and operated the MODU.
- *Deepwater Horizon* was crewed by 126 people while operating in the Mississippi Canyon, Grid 252, over 50 miles offshore Louisiana, in 5,000 ft of water.
- *Deepwater Horizon* was a dynamically positioned, semi-submersible drilling unit
- CGD8 Command Center was alerted to SAR call following fire and explosion aboard *Deepwater Horizon* around 2200 hrs on April 20, 2010. They initiated SAR procedures and coordinated offshore firefighting efforts.
- Initial indications suggested 11 people were missing and ultimately perished as a result of this incident. 115 crewmembers were rescued by a combination of commercial offshore supply vessels and Coast Guard resources.
- On April 23, 2010, the *Deepwater Horizon* sank, collapsing the riser. The condition of the Blow Out Preventer, a safety device designed to secure the well in the event of a catastrophic failure could not be verified.

D8 Command Center established Incident Command Posts in Houma, LA and Mobile, AL and initiated actions described in the Area Contingency Plans for a worst case discharge.

Timeline and Key Events

Day 1: APR 20: Fire and Explosion aboard *Deepwater Horizon*.
Day 3: APR 22:*Deepwater Horizon* sinks with over 700,000 gallons of diesel fuel aboard.
Day 10: APR 29: Incident declared a Spill of National Significance
Day 12: MAY 01: ADM Allen designated as National Incident Commander
Day 19: MAY 08: "Cofferdam" attempt unsuccessful;
Day 40: MAY 29: "Top Kill" attempt unsuccessful
Day 82: JUL 10: "Capping Stack" installed
Day 87: JUL 15: "Capping Stack" secured, well shut-in, source secured.
Day 107: AUG04: Static Kill complete;
Day 121: AUG18: Bottom Kill delayed to assess well integrity.
Day 138: SEP 04: New BOP installed, no pressure concerns at well head.
Day 150: SEP 16: Relief Well Intercept confirmed
Day 153: SEP19: Bottom Kill complete.

Organization

The size and scope of this incident required significant coordination of public and private resources. The command and control structure maximized the Federal On Scene Coordinator's ability to work with other federal, state and local stakeholders to address the highest operational needs.

One National Incident Command was established in Washington DC to coordinate the government's overall response to the incident. The NIC established a staff to focus on strategic communication and the resolutions of interagency conflicts. The NIC worked directly for the President and the Secretary of Homeland Security.

One Unified Area Command was established to oversee operational activities across the entire Gulf Region.

Five Unified Incident Command Posts were established to coordinate operations and act as liaison with local and regional elected officials. Each command post focused on a specific operational area. Dr. Chu, the Secretary of Energy, led a Science Team of the nation's top engineers and scientists to evaluate BP's proposals to safely secure the Macondo well.

Two Area Command Staging Areas were established to coordinate the efficient and effective distribution of critical resources across regional boundaries. Protective Boom and Skimmers were delivered to these areas and then redistributed to those areas most affected by the oil, allowing on scene responders to focus on removing oil.

NIC Responsibilities

As described in the National Contingency Plan (40CFR300) and Coast Guard doctrine, the National Incident Commander (NIC) will:

- Lead national level communication and develop strategic objectives;
- Coordinate interagency issues;
- Coordinate federal, state, local and international resources;
- Oversee Unified Area Command activities for an effective response.

Unity of Effort became the theme for NIC staff.

As stated earlier, this was the first time in U. S. history that a SONS—a Spill of National Significance—and a National Incident Command—NIC —had been established. Because operational doctrine was untested it, evolved as the conditions warranted a more robust NIC influence to resolve conflicts and address issues including resolution of public health & seafood safety concerns and claims adjudication.

NIC Organization

Originally, the NIC staff was expected to be a small group tightly focused on national policy conflict resolution. As conditions changed and issues warranted, the NIC staff evolved to include (1) a division to address congressional and legislative concerns, (2) a current operations division focused on maintaining situational awareness, (3) a strategic planning division focused on developing and documenting strategic intent and (4) an Interagency Solutions Group (IASG). The Interagency Solutions Group served as the 'think tank' and was comprised of subject matter experts from across the federal government. The IASG created the Interagency Alternative Technologies Assessment Program (IATAP) to evaluate thousands of offers of innovative response technologies from both domestic and international entities. The IASG stood up the Flow Rate Technical Group (FRTG) composed of scientific technical experts, from government and academia, to quantify the daily rate of release from the Macondo well and the total amount of oil released into the Gulf. The IASG also chartered a Oil Budget Calculator Science and Engineering Team to estimate the fate of the oil. They developed a tool called the Oil Budget Calculator to determine what happened to the oil (recovered, dispersed, evaporated, residual, etc.).

Unified Area Command(UAC)

The UAC had the overall responsibility for the strategic management of the incident and set overall response strategies, objectives, priorities; and allocated critical resources according to priorities to ensure the response to the incident was properly managed, and that objectives were met and strategies followed. The UAC includes the USCG as the Federal On-Scene Coordinator (FOSC) and representatives from federal agencies, the affected states, and the responsible party (RP).

The Unified Area Command served as the Operational Commander for this incident. It developed strategic and operational objectives aligned with NIC strategies. The UAC worked directly with other federal, state and local officials to deploy critical resources to

the areas most in need. Early in this response, the UAC established a Critical Resources Unit focused solely on identifying sources of supply for containment boom to protect the sensitive coastline of the Gulf in accordance with Area Contingency Plans.

Incident Commanders

Incident Commanders coordinated operations regionally, usually along state borders. Each Incident Commander also held FOSC representative authorities and could authorize removal activities. ICs served as the first line of communication with state and local elected officials and often served as the local face of the response. ICs participated in local town hall meetings, hearing firsthand accounts of the spill's impact to local economies. ICs in Mobile and Houma led efforts to employ Vessels of Opportunity (VoO) where appropriate. Over 10,000 VoOs were trained and contracted to provide a force multiplier on the water. The importance of the ICs in strategic communication cannot be overstated. These individuals became the local face of the government's response

Concept of Operations

In any large scale operation, effective command and control is a critical element in the operation's success. Areas of operation were divided by geographic boundaries or zones, largely based on the functional response operations required to combat the oil. These areas were:

- Well Site: a circle with a diameter of 5 nautical miles (NM) around the well. Source control, coordinated out of IC Houston.
- Offshore Zone: 3NM from shore to 5 NM from the well site. Coordinated by IC Houma and focused on aerial application of dispersants, in-situ burns and large-scale offshore skimming.
- Nearshore Zone: Baseline – 3NM. Coordinated by ICs within state boundary. Heavy emphasis on VoO employment and nearshore skimming.
- Inshore Zone: Inland waters. Coordinated by ICs within state boundaries. Heavy emphasis on VoO employment and coordination with shoreline assessment teams, inshore skimming, beach clean-up, and volunteer coordination.
- Air Operations: Aviation assets coordinated out of Tyndall AFB for sorties across each area of operation. The Aviation Coordination Center reported directly to the UAC and effectively served as an Operations Section across each IC Area of Responsibility.

Source Control at the Well Site

Efforts to secure the Macondo well have been well publicized. Countless hours of video footage showed the armada of vessels above the well site, but few people truly understood the significant effort that took place 5000 feet below those vessels. This was also the first application of subsea dispersants.

The complexity of the undersea response cannot be overstated. Every action, from simply making a quarter turn on a valve to removing the 5 story, 450 ton Blow Out Preventer, was completed using robots. Extreme pressures, swirling undersea currents

and the constant threat of adverse weather further complicated planning efforts to secure the well. On three separate occasions, vessels supporting subsurface well operations ceased work to evade tropical storms or hurricanes. Over 15 Remotely Operated Vehicles worked around the clock to remove, install and monitor equipment used to secure the well. While relief well drilling continued, multiple offshore supply vessels, production units and drill rigs orchestrated a delicate dance in accordance with engineering procedures heavily scrutinized by BP Engineering Teams, Secretary of Energy Chu's Science Team, and Coast Guard engineers.

Each proposed engineering solution required equipment to be designed and built, unique to this well. Ultimately, the final capping effort involved the design, manufacture and testing of a 3-ram capping stack, custom built to fit the existing damaged blow out preventer. The process to complete this 'part' took nearly 30 days before the first test was complete. There simply was not an inventory of response solutions available for a well in this water depth.

On July 15, the 3-ram capping stack was installed and finally secured, eliminating the source of the discharge. Between April 20 and July 15, 87 days passed with the continuous release of oil from the Macondo well. Another 76 days passed before the well could be deemed 'dead' following the successful intersection of the relief well on Sept 19. Extensive testing confirmed that the pressure on the well head following 'bottom kill' (cementing of the drill casing and surrounding structure), eliminated any threat of additional discharge.

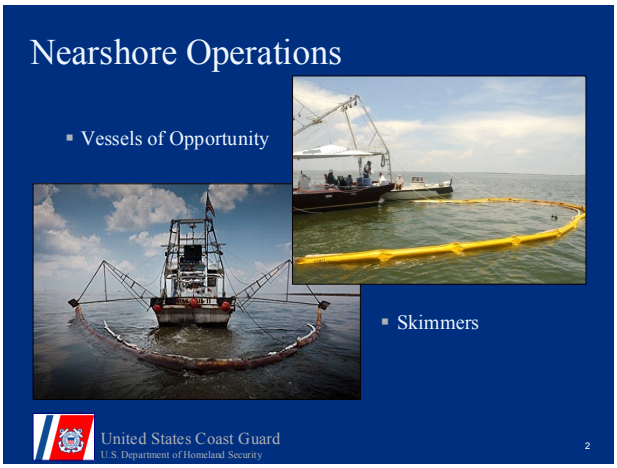
Offshore Operations

Deepwater Horizon Unified Area Command placed a high priority on preventing oil from reaching the ecologically and economically sensitive Gulf Coast shores. In fact, this response involved more vessels than were used in the D-Day invasion of Normandy. For the first time in history, large-scale offshore in-situ burns were conducted – burning over 11 million gallons of surface oil in 411 controlled burns. Over 800 skimmers were assembled to intercept the oil as far offshore as possible. The Aviation Coordination Center at Tyndall AFB coordinated over hundreds of logistics, operations, and surveillance flights that focused on pinpointing the locations of thousands of smaller oil patches across the Gulf. Once identified, boats worked to remove them using the latest technologies in surface oil skimming. Even with these efforts, given the size and scope of the spill, some oil made its way toward shore.

- Skimming—835 skimmers at peak
- Dispersing—1.8 million gallons dispersed
- Burning—over 400 in-situ burns, burning over 11 million gallons of oil

Nearshore Operations

Where oil made its way close to shore, thousands of Vessels of Opportunity (VoO) attacked individual oil patches with vessel-borne skimmers and boom. The VoO program employed fishermen and charter boats with specific local knowledge of the Gulf Coast to find and remove oil. Vessels and crews of all sizes were hired to provide the necessary on-water support for response efforts across the region. As you might expect, coordination of these efforts posed a significant command and control challenge.



Bays, Beaches, and Marshes Operations

Within inland waters, teams of Shoreline Cleanup and Assessment Teams combed marshes, beaches and tidal basins to identify impacted areas. Fifteen staging areas deployed response equipment to affected areas, or redirected gear to those areas to accelerate clean-up activities when oil reached the coast. Responders used a variety of methods to erect barriers across the Gulf coast, including over 3.8 million feet of containment boom and 9.7 million feet of absorbent material to soak up what recoverable oil remained. All told, over 48,000 responders, largely made up contract support, focused on removal activities. Thousands of volunteers supported the relocation of over 1,200 birds, 284 turtles and 3 marine mammals. Over the response period, 8,000 birds, 1,100 turtles and 100 mammals were collected.

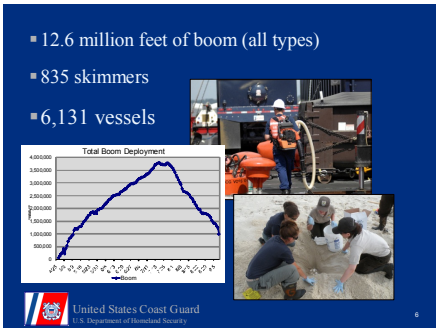
Critical Resources

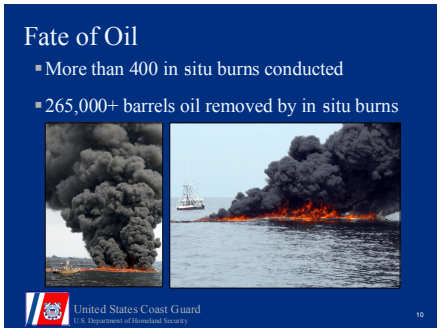
The sheer size of this incident stressed locally available response resources. Working with Oil Spill Response Organizations and the Coast Guard's National Strike Force Coordination Center, the Coast Guard identified manufacturers of boom throughout the country to meet initial resource demands identified in Gulf Area Contingency Plans. Even with this effort, all oil spills are local and it was not possible to physically protect every inch of shoreline along the Gulf Coast.

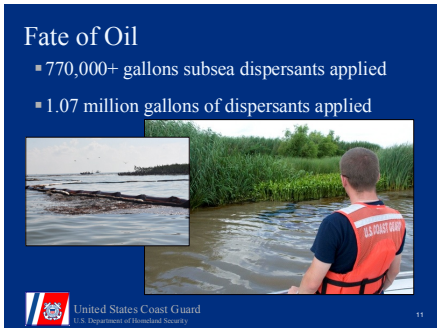
An Executive Order authorized the reallocation of spill response equipment from other regions of the U.S. to support ongoing response efforts. In addition, over 60 countries provided offers of assistance ranging from technical expertise to offshore skimming vessels. The Interagency Alternative Technologies Assessment Program (IATAP) was established to evaluate thousands of offers of innovative response technologies from both domestic and international entities.

Fate of Oil

Of the many functions the IASG performed, one of the most visible was determining the size and scope of the discharge from the damaged riser. The assembled scientific teams, led by Dr. Marcia McNutt, the Director of the U. S. Geological Survey, analyzed video footage obtained from multiple ROV sources, aerial overflights and engineering analysis, and determined, after considerable debate, that the discharge rate was between 55-80 thousand barrels per day. Using this figure, the Oil Budget Calculator Science and Engineering Team developed empirical methods to assess the fate of oil. Roughly 1.2 million barrels of the 4.93 million barrels released was estimated to be remaining in the environment in some form.







Complexity

The *Deepwater Horizon* oil spill is the largest and most complex our nation has ever confronted, more analogous to the challenges posed by Apollo 13 than the Exxon Valdez spill of 1989. It was complicated by the lack of human access to the Macondo wellhead which was located 5,000 feet below the ocean surface and over 50 miles offshore. Responders were fully dependent upon the use of remotely operated vehicles to access the well site to control the release of oil. The continuous discharge of oil from the well, from April 22, 2010 until July 15, 2010 did not result in a single monolithic spill, but rather thousands of smaller disconnected spills that repeatedly threatened and impacted the coastlines of all five Gulf Coast states. In addition, the complexity of accurately measuring the volume of oil being discharged and responding to the continuous omni-directional spread of the oil added to the challenge. Every day, for 87 days, the response team faced a major new oil spill. This incident tested national, regional and local contingency planning efforts and identified multiple areas needing improvement.

The Way Forward

Overall, the Coast Guard believes that the Oil Pollution Act of 1990 (OPA 90) and the National Contingency Plan served the Nation well in its response, and any future considerations to amend the National Contingency Plan as a result of lessons learned from the *Deepwater Horizon* spill should not change its fundamental governance structure. Moving forward, *before* the next major oil or hazardous substance release occurs, there are key efforts that should be undertaken with urgency to improve the Nation's collective ability to respond. Efforts should continue to develop collaborative organizational response models that involve federal, state and local partners, including commercial interests, and outreach organizations to refine response efforts when similar incidents occur in the future.

The Natural Resources Damage Assessments will attempt to restore the Gulf to its pre-incident condition; however, the damage may never fully be understood. Public Health programs to assist those persons affected physically and mentally will move forward. The claims process, now managed by the Gulf Coast Claims.

Facility continues to process claims to aid Gulf coast residents in restoring their livelihoods.

Day 1

Reducing The Risks Of Another Blowout And Enhancing The Capacity To Respond

In this section we focus not on the engineering design flaws of the *Deepwater Horizon* platform and associated drilling system, but rather on the inadequacies of the human interactions with this complex system under conditions of aberrant performance.

The first day of the forum started with three perspectives by experts on the risks associated with offshore oil production, particularly in deep water; how to assess those risks; and how to manage them. The three speakers were

- Elisabeth Paté-Cornell, Burt and Deedee McMurty Professor of Engineering, Stanford University
- J. Ford Brett, Managing Director, PetroSkills
- Greg Anderson, President, Consulting & Training Division, Moody International

This section is a summary of the major findings and recommendations from these three presentations and from the ensuing discussion. Summaries of the three presentations can be found at the end of this section. The full presentations are on the Aquarium's website http://www.aquariumofpacific.org.

Creating Cultures of Safety

Finding

Most accidents are caused by people and not by nature or acts of God, and some industries are more complex than others and thus have increased chances for accidents. The offshore oil industry and the engineering structures and systems needed to support it are sophisticated and complex. The *Deepwater Horizon* platform and supporting engineering structures and systems had a number of serious design and fabrication flaws. The penultimate cause of the *Deepwater Horizon* Blowout however, was a failure of human systems to respond appropriately to the series of clear engineering and technological failures. There were enough indications of design flaws and deviant/anomalous performance metrics in the days and weeks leading up to the blowout that the operation should have been shut down, thus preventing the incident.

Recommendation

That BP and other oil companies operating in the Gulf, and elsewhere, develop strong cultures of safety. Cultures of safety are key in preventing accidents and incidents[4]. They are difficult to create and to sustain, and take on particular importance in organizations/industries, such as the offshore oil industry, whose operations can result in events that have been characterized as "low probability, high impact events". Experience has shown that it can take years to create an effective culture of safety, and that such a culture can unravel quickly under crisis.

That Cultures of Safety start at the top of an organization and be pervasive throughout the entire organization. Safety is everyone's business, not just that of the safety department. Everyone in an organization should be required to participate in safety training and be held accountable for mastery of the material covered. That a company's incentive system reward desired safety behaviors, and assessing safe behaviors should be part of all personnel evaluations. An organization's incentive system should be structured to praise and reward everyone in the organization for speaking up when things look unsafe. Everyone should be empowered to take appropriate action to ensure safe operations. Organizations should encourage and reward reporting of safety violations and errors. Safety needs to "trump" production and schedule.

In the case of *Deepwater Horizon*, people on the rig needed to be empowered to act and to know they would have had the support of those above them—all the way to the top. The power to act must extend to "stopping work." There were enough indications of design flaws and deviant/anomalous performance metrics in the days and weeks leading up to the blowout to warrant the operation's shut down. Doing so would have prevented this catastrophic incident.

Finding

The individual responsible for safety on the *Deepwater Horizon* platform was the same person responsible for schedule and production.

Recommendation

That the individual responsible for safety be a different person than the one responsible for schedule and production.

[4] The word incident is preferable to accident because it implies greater control and accountability.

Inspections, Checklists and Audits

Finding

The Minerals Management Service (MMS) did not have the resources needed to provide the appropriate level of oversight of rigs in the Gulf—particularly those operating in deep water—to ensure compliance with the highest levels of engineering and safety standards. California's offshore oil industry has some important programs to ensure safety that are transferrable and scalable to the Gulf of Mexico. They have an admirable safety record.

Recommendation

That the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)—the successor to MMS—be given the resources needed to provide the oversight it is charged with carrying out. Funding should come from a dedicated source. A comparison of BOEMRE staffing levels in the Gulf, with California's staffing levels in oversight of its offshore activities with appropriate scaling would be instructive. The California program is well funded, well staffed, and safety audits are taken seriously. Congress might consider imposing an oil industry user fee like California's and dedicate the funding stream to developing and implementing a comprehensive safety program in the Gulf of Mexico comparable to California's.

Finding

Checklists can be helpful in reducing the probability of incidents, but only if taken seriously and applied purposefully. Safety audits conducted by third parties can help in ensuring vigilance in the pursuit of safety.

Recommendation

Implement a system of checklists and third party audits in the Gulf of Mexico with adequate funding comparable to those used in the California offshore oil industry to reduce the probability of accidents.

Finding

Many companies create "near miss" lists of incidents that almost occurred. They have little impact and often get little attention.

Recommendation

That institutions and industries create "near hit" lists with documentation of the impacts that might have resulted. The slogan that should guide all individual and organizational actions needs to be "Risk Dollars; Not People."

The attitude "It can't happen to me" is a big part of the problem in creating and maintaining cultures of safety. Good safety records can lead to complacency. To combat this, vigilance is needed.

On The Need For Relevant Research And Ways To Fund It

Finding

Advances in the capacity to effectively respond to spills since *Exxon Valdez* are disappointing. After the *Exxon Valdez* event, there was a flurry of well-funded research initiatives, but they were of relatively short duration. Memories of *Exxon Valdez* faded quickly and with them, support for oil spill research. As long as we rely upon the ocean for oil—and that will be as long as we rely upon oil as major sources of energy—incidents will occur and research is needed to reduce their frequency and magnitude, and to design and develop technologies and strategies to respond to them more efficiently and effectively when they do occur.

The data collected during the response to the *Deepwater Horizon* blowout may be a valuable source of information on the efficacy of dispersants and on their environmental effects. The data on burning may also provide valuable insights. The amount of oil burned during *Deepwater Horizon* exceeded the entire volume of oil released by the *Exxon Valdez*. We consumed approximately one-third of the global supply of dispersants in responding to this incident. Research on all aspects of rig design and fabrication could reduce the probability of failure. There were fundamental errors in the design of Piper Alpha which blew up in the North Sea in 1988 and in the design and construction of *Deepwater Horizon*.

Another area in which research is needed is risk analysis.

Recommendation

That a source of dedicated funding be established to support research in the areas identified above. It might be created by adding a tax on every barrel of oil produced from the ocean or adding a tax on every gallon of gasoline sold. The latter strategy might have the added benefit of reducing consumption of oil and gas.

That systematic probabilistic studies of risk analysis be given a high priority for funding. The analyses need to be extended to human and organizational factors using what is called the SAM Model—Risk analysis of the physical **system;** people who operate that system, and decisions and **actions** that influence the risk; and the effect of **management** decisions (incentives, information, constraints, etc.) on the probability of error. That much of the research needed to reduce risks in the offshore oil sector be done as collaborative ventures of academic, government and industry scientists and engineers. It is important to have the end-users of the information involved in the process from start—problem formulation—to finish—application—if the new knowledge is to be used to greatest benefit.

Is More Federal Regulation Needed?

Finding

Following the *Deepwater Horizon* blowout, many in the public called for more federal regulation to control the U.S. offshore oil industry.

Recommendation

Enforce existing regulations more systematically. There was a strong consensus among forum participants that more regulations were not needed or desirable. Simply changing the name of the Minerals Management Service (MMS) to the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is not the answer. Funding for adequate staffing on a sustained basis is a key ingredient in ensuring compliance with regulations. The MMS and its successor organization, the BOEMRE, remain challenged in hiring the best people in the industry. They are competing with the oil companies who are able to offer higher salaries. This needs to be addressed.

On The Need To Minimize Political Intervention

Finding

Political intervention (from all levels: federal, state, and parish/local) early in the response to *Deepwater Horizon* got in the way of an effective response to minimize impacts on the environment and the people who make their livelihoods from the Gulf's oil industry. There was a strong feeling among most forum participants for the need to minimize political intervention when major incidents occur. Most, but not all participants, felt that the moratorium on drilling was a political move motivated by the desire to have a high visibility action. Any moratorium should have been restricted to drilling into petroleum reservoirs, but should have allowed non-reservoir drilling. This would have eliminated risks of any further releases of hydrocarbons without having the large socio-economic impact on those involved directly and indirectly in the Gulf oil industry.

Recommendation

That experts be put in charge and be empowered and given the tools to act. Decisions need to be made by best professional judgment (and supported by sound science where possible) from those knowledgeable in the relevant disciplines.

Creating A Comprehensive Catalog of Lessons Learned From The Deepwater Horizon Blowout

Finding

Many lessons can be learned from the numerous studies of the *Deepwater Horizon* Blowout and there are plans by the U.S. Coast Guard to do this. Two U.S. Coast Guard officials participated in the forum.

Recommendation

Catalog lessons from *Deepwater Horizon* promptly using the best experts representing a diversity of perspectives. The lessons should be documented, and distributed broadly within the industry, to those who have oversight of it, and to other interested parties. Once this task has been completed, it might be followed by an industry-government-NGO forum to explore how these lessons can be integrated into best practices for the offshore oil and gas industry. Every time another incident or a "near hit" occurs, it should be analyzed promptly and the new knowledge integrated into this evolving doctrine to guide the offshore oil and gas industry. Synthesis is most useful when done around a carefully crafted architecture of questions.

The concept of "doctrine" is a useful one. It can be defined as the codification of teachings, instructions, principles, and cultural values of an organization or industry. When done properly, an institutional "doctrine" becomes the basis for institutional teaching and learning. It is clear that in the offshore oil and gas industry we need institutional and industry mechanisms for continuous learning, *i.e.* we need our oil companies to be models of "learning organizations." Funding for these activities should be given a priority by the offshore oil industry.

When Can We Get Out Of The Ocean?

Finding

Roughly 45% of the U.S. oil production comes from offshore sources and most of the new oil discoveries are in the ocean, and in relatively deep water—waters greater than 1000 m deep. Given our dependence on oil, our dependence on oil from the ocean, and the size and importance of the offshore oil industry, it is unlikely that we will "get out of the ocean" as has been proposed by some environmental organizations—at least not until we significantly reduce our use of fossil fuels.

Recommendation

That the U.S. move more aggressively to reduce its dependence on oil through conservation, by developing renewable sources of energy, and by using nuclear energy—at least as a transitional strategy. This transition may take decades to accomplish and

during that period efforts to reduce the probability of major oil spills and blowouts should be given a priority along with efforts to respond efficiently and effectively when one does occur. This will require a sustained source of dedicated financial support.

On The Case For A Greater National Investment In Ocean Observing

Finding

Good decisions depend upon having good information. Good information comes from good data. The emphasis of the Obama Administration on Coastal and Marine Spatial Planning (CSMP) will only bear fruit if continually refreshed with real time, comprehensive and sustained data streams.

Recommendation

That the Nation make a significantly larger investment in the Integrated Ocean Observing System and in the Regional Coastal Ocean Observing Programs to improve management of our Nation's ocean resources—including oil and gas. That enhanced efforts in Ocean Observing be tightly coupled to a broader end-user community—one that goes beyond researchers and is focused on operational private and public sector users. The future of our ocean economy depends on it. The offshore oil and gas industry is just one critical user group. Government agency partnerships with all ocean and coastal related user groups need to be comprehensive and focused on the spectrum of user communities, particularly in the formulation of the questions the system is designed to answer, and in defining the informational products that will be most useful to the clients and our economy.

Brief Summaries of Individual Presentations, Day 1

Full presentations can be found on the Aquarium's website

http://www.aquariumofpacific.org

Fires on Offshore Platforms: A Risk Analysis Perspective on Piper Alpha

Elisabeth Paté-Cornell, Professor, Stanford University[5]

I will speak about risk analysis and extend it to include human and organizational factors, using the Piper Alpha accident as an illustration. People act according to what they are rewarded for, based upon what they know, and what their managers expect.

Classical risk analysis—probabilistic risk analysis or PRA—begins with an identification of initiating events, which could be a force of nature such as a hurricane, or a platform fire, or a blowout. One challenge is to characterize the risks of fires and blowouts. There are fewer data on them than on hurricanes or very large waves.

Let me make a few general observations.

- Most accident sequences and technical failures involve human errors.
- Most of these human errors are rooted in management decisions, for example the incentive system.
- Most regulations—government and industry—fail to include proactive risk management. For example, Piper Alpha was operating under British regulations, and at the time they were determined to increase the production of oil.
- Precursors to fires and blowouts and near-misses are not systematically recorded, learned from, and therefore acted upon.

A few horror stories include the case of launching (from barges) rig jackets that embedded upside down, installing some platforms without appropriate foundations, and using the wrong kind of steel simply because it was available. Those are described in my full presentation on the Aquarium's website.

Probabilistic risk analysis for offshore platforms has been done on and off, but not in any systematic and sustained way that I know of. An outline of how a probabilistic risk analysis is done is found in Figure 1. As Figure 1 shows, one first looks at the functions that have to be performed and assesses the probability of failure of each including the dependencies, which often are major contributors to the risk. Next, one assesses the probabilities of failure and the probability distribution of the "source term", e.g., the amount of oil released; and finally one assesses the probability distribution of the accident consequences.

[5] Professor Paté-Cornell pointed out that she is a member of an NRC Committee investigating the *Deepwater Horizon* incident and is prohibited from speaking about it, but that she was very involved in the study of the Piper Alpha blowout that occurred in the North Sea in 1988, that there are similarities with *Deepwater Horizon*, and that she would describe what happened on Piper Alpha and what the subsequent investigation revealed.

Using the SAM model (System-Actions-Management), one starts with a risk analysis of the physical system and extends it to the people who operate that system and the decisions and actions they take that influence the risks— including the chances of error. One then needs to assess the effects of management decisions on how operators carry out their work. For example, incentives that affect the flow of information, and constraints on employees' ability to carry out their tasks, influence the probability of occurrences of errors. Incentives are critical. If people are paid only on the basis of the amount of oil produced, they may lose sight of other things such as the operation of safety features and they may not stop production to fix problems .

Piper Alpha

The Piper Alpha platform is shown in Figure 2. Piper Alpha blew up in the North Sea in July 1988, killing 167 people and costing more than $3.4 billion in damages in 1988 dollars. This marked a turning point in the offshore oil industry, which led to a number of industry-wide measures and new regulations. The post-mortem analysis demonstrated the power of the SAM model to connect the accident sequence to human errors and management factors.

Figure 2 Piper Alpha

The sequence of events that led up to the blowout started with the unsupervised repair of a pump by an inexperienced worker. He left the work unfinished when he quit for the day. That night, the redundant pump failed. The crew tried to restart the pump that had not been actually repaired, which led to a series of fires and explosions and finally a major blowout.

Figure 3 Blowout on Piper Alpha

The SAM analysis revealed a number of organizational problems at different levels that contributed to the Piper Alpha blowout.

First, there was a lack of governmental safety guidelines and/or the failure to enforce them. On the platform itself, there were problems of personnel management. It was July and some people had been promoted above their levels of competency; and too little attention was paid to maintenance and inspection. Management was mostly focused on production and much less on safety. The analysis showed that there were clear links between technical failures and operators' decisions and actions and between operators' decisions and management factors. The analysis also revealed flaws in design philosophy and in execution.

This combination of physical deficiencies and human deficiencies led us to pose the following question: Which would have had the greater benefit in reducing risk of the blowout—structural improvements to the platform such as adding more steel to the structure, or having an external review of the design for the platform?

The analysis showed that about 40% of the failure probability came from design errors—25% from high-severity errors and 15% from low-severity errors; and that 15% of the failure probability came from gross errors (e.g. mistakes in calculations) and 25% from errors of judgment. The balance of the probability of failure often came from synergies among errors. Low-severity errors had a lot of influence even though 80% of the failure probability involved scenarios that contained at least one high-severity error.

Of the total risk, 95% of it involved some kind of human error—in design and construction or in operation. Only 5% could be attributed to "bad luck" such as the 500 year wave occurring during the lifetime of a platform.. The analysis showed that one could reduce the overall failure risks by 20%--reducing by half the contribution of design errors from 40% to 20% of total risk—through a proper design review at a cost of about $100,000 in the late 1980's. To achieve the same benefits through structural changes would cost an estimated $9 million (still in 1988 dollars), but this approach was preferred because companies felt that they see the benefits they were getting.

To sum up:

- The design review process was inadequate
- Time pressures on the critical path led to corner cutting (e.g., in maintenance), parallel processing, etc.
- There was poor communication of uncertainties among the parties involved.
- The incentive system rewarded mostly productivity, much less safety.
- The organization was not learning well. There was a tendency to cover up incidents.
- There was a loss of industry expertise in retirements and departures caused in part by the ups and downs of the oil market.
- Some critical contracts went to the lowest bidder.

The Piper Alpha blowout thus resulted both from design problems (and modifications of the design) and organizational problems. Management and organizational factors are often key contributors to failure probabilities. We need systematic risk analyses to set priorities and support decisions, and we need to systematically document accident precursors and near misses so that organizations can learn from them. Organizational measures (in addition to technical ones) can be very cost-effective ways of reducing risk.

BP Macondo Tragedy: What We've learned

Context—Deepwater Drilling Technology and History of Safety

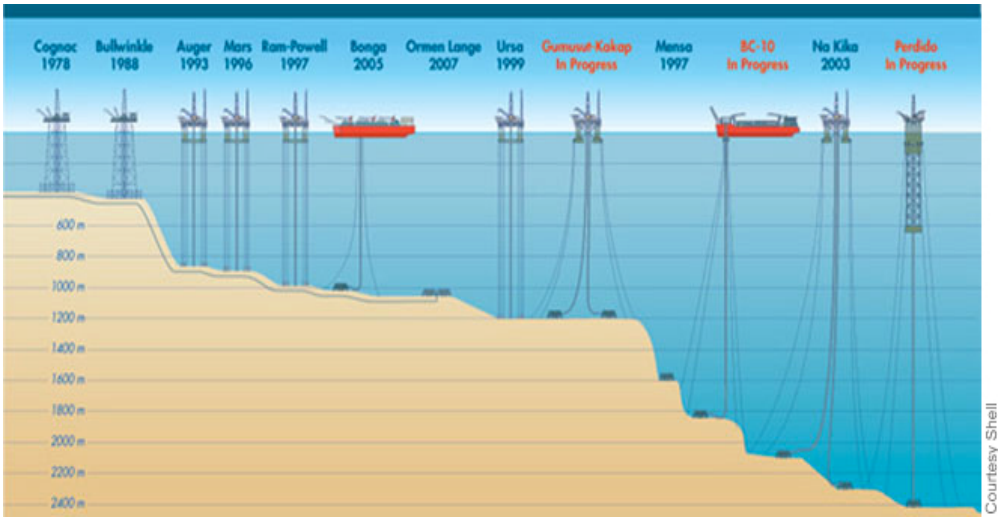
J. Ford Brett, Managing Director, PetroSkills

People have been drilling offshore since the early 1900's – the first offshore production was from simple platforms built off of the beach in Summerland California.

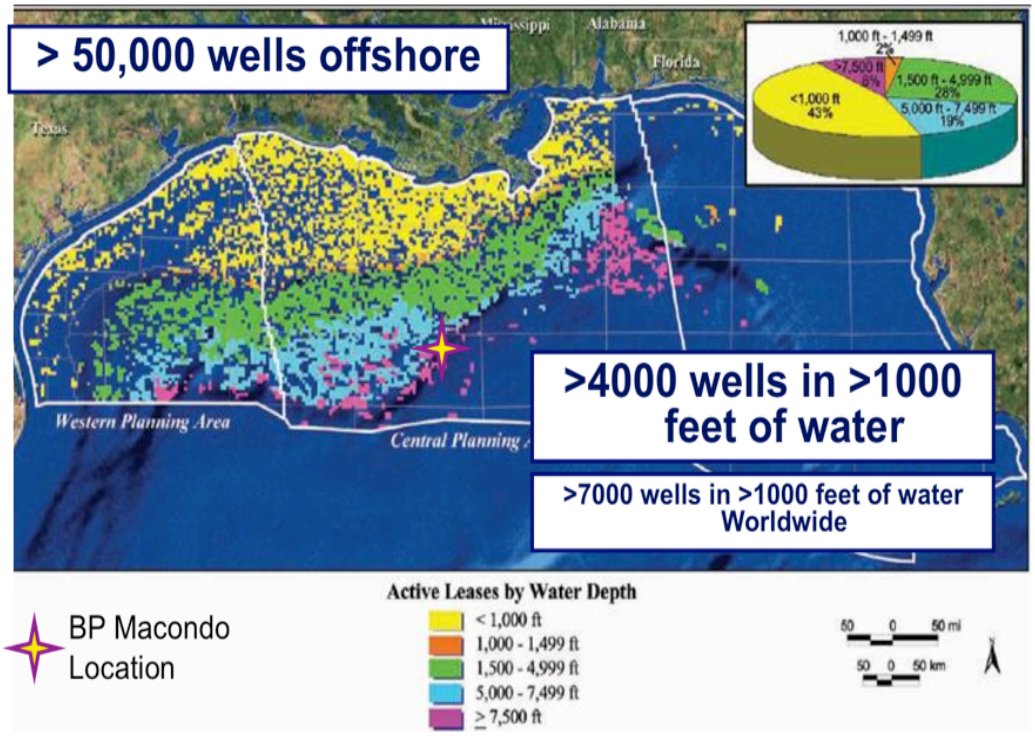
From 1900 through the 1980's offshore development, while increasingly complex, was intellectually the same idea – build an offshore platform (an offshore tower) and put oil production equipment on it. These bottom supported platforms limited production to depths less than 500 meters. Since the 1980's, the industry made giant leaps in its ability to operate in deep water. Developing technology to drill and produce from floating structures (that may or may not be moored to the bottom) has allowed drilling and production in water over 3000 meters deep - almost 10 times the height of the Eiffel tower.

The industry was, and still is proud of this pre-Macondo Gulf of Mexico record. It took tremendous advancements in technology to safely drill over 50,000 wells - over 4,000 in more than 1,000 feet. Since 1970, the industry accomplished all this in an environmentally responsible and increasingly safe manner. The last major incident resulting in oil coming ashore was 41 years ago in 1969 (Santa Barbara).

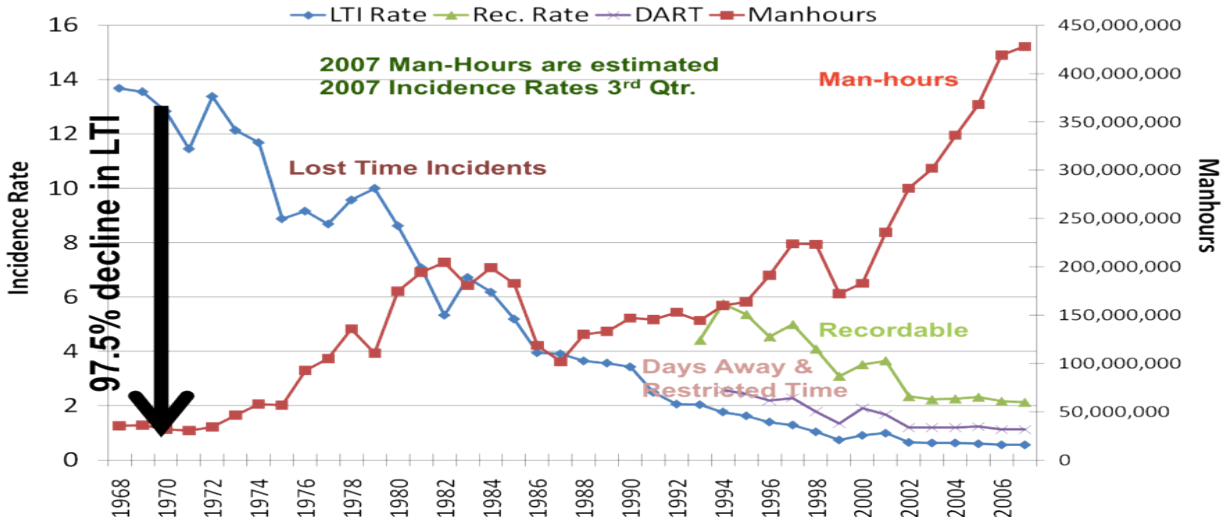
Between 1970 and April 2010, a total of 1,800 barrels of oil spilled due to blowouts. Natural seeps release about 1,500,000 bbls into the Gulf of Mexico every year. Lost time accidents declined 97.5% since the modern MMS regulations came into effect, and the Gulf of Mexico's offshore record is better than or equal to any other region in the world. On an hours-per-person worked basis – including the Macondo Tragedy – working offshore is safer than driving a car. The industry was working hard to make it as safe as sitting in your living room. The industry believed they had, and had proven they had, mastered the ability find and produce oil in deep water.



Advancements in Deep Water Operations



Deep Water Operations in the Gulf of Mexico



Gulf of Mexico Safety Record Since 1970

But Something Clearly Went Wrong…

No matter what the safety record was, and how many deep-water wells had been drilled safely, something clearly went very wrong on the BP Macondo project – about five million barrels of oil was spilled, the Gulf's economy was disrupted, and, even worse, 11 people perished.

There isn't space in this short summary to describe in detail what specifically went wrong. The purpose of this short summary is to outline the possible causes, and to describe what can, has, and is being done to address similar causes in the future.

Judgment of specific causes should be suspended until the final detailed findings. But as information has been discovered it is increasingly clear that best practices were not followed.

- The well design was not as robust (fault tolerant) as it could have been.
- Human errors in judgment were made at very key operational decision points.
- Warning signs were overlooked on the rig.
- There may have been some failure of equipment.

Further, all this was preventable by following standard practices that are currently in place. It is also becoming increasingly clear, that as in other oil field disasters, there was not a single root cause. Rather, a combination of factors worked together to cause the disaster. We don't yet have the final results from those conducting detailed studies, but based on what's been learned to date, we can expect a 'fault tree' similar to that of North Sea's 1988 Piper Alpha disaster - which cost 167 lives.

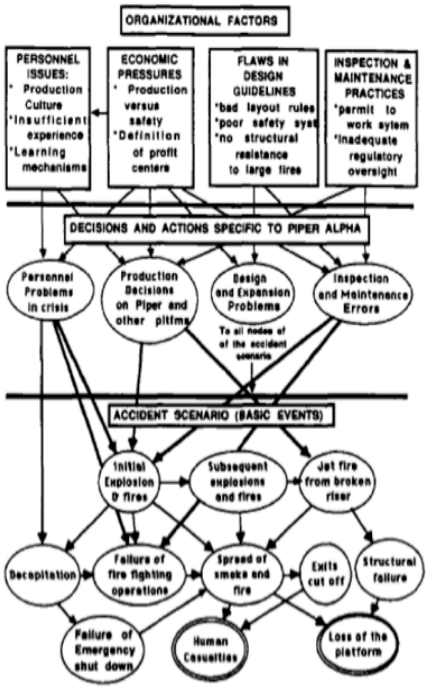


Fig. 4. Dependencies among basic events of the accident scenarios, decisions, and actions specific to Piper Alpha, and organizational factors (influence diagram representation; the lower part is a simplified version of Fig. 3).[4]

Pate-Cornell, Risk Analysis Vol 13, No 1993

Piper Alpha Influence Diagram

The figure is too complicated to follow here, but the fact that it is extremely complicated illustrates the point. It is very, very rarely 'one thing' that causes tragedies such as this, but a combination of factors working together. Perhaps the only common cause is a cavalier "this-can't-happen-to-me" attitude that is often in play in addition to the specific technical and equipment issues.

Responses to Macondo

Since the Macondo Tragedy, there have been seven formal US government investigations or reports, at least three formal reviews of regulations by other governments, four study teams created by industry associations, reviews by professional associations, university lead review efforts, and a $1billion dollar effort funded by the industry to build a containment system with the capacity to handle a similar situation in the future. Well meaning, and technically qualified people, from many backgrounds and perspectives are working to prevent something similar in the future.

The new Bureau of Ocean Energy Management (BOEM) has issued detailed regulations that institute new requirements directed at dealing with each of the possible causes of the disaster. They will significantly improve offshore safety, because they address the broad set of interacting factors – not the specific set that will turn out to be the combination that caused this disaster. Humans caused the explosion and resulting spill. The well was in control on one day, and people took specific actions that caused it be out of control the next.

Perhaps the most important thing that will improve offshore safety happened the day after Macondo. Everyone in the industry, from senior management to the most junior worker now no longer believes "this-can't-happen-to-me". That is the first, and necessary, step to creating a change in attitude. Moving from "we've done great things… we're invincible" to a culture where safety always comes first.

"Nothing is more dangerous than to be grudging in taking safety precautions lest they turn out to have been unnecessary.

Safety at sea for a thousand years has depended on exactly the opposite philosophy."

…Admiral Chester Nimitz

Establishing a Culture of Safety

Greg Anderson, President, Consulting & Training Division, Moody International

The goal of this Paper is to provide a point of reference when talking about a company or industry's safety culture; the importance of human behavior; and a Systems approach for improving safety; It should be noted, all of the foregoing can be used to specifically address Well Control safety.

A company or project's "Culture" is a culmination of individual beliefs and behaviors, and every person, from the CEO to the newest hire, has an impact on the culture that currently exists. This can be an opportunity or a continuing challenge because people, whether employee or contractor, will propagate the safety behaviors of their co-workers. One of the findings from a major industrial incident was "hazard training was largely passed down by experience from others. Sometimes this guidance was poor, perhaps due to an element of complacency…"

We constantly need to ask ourselves whose behaviors our people are adopting and are they the ones we want passed along.

There is a significant difference in a safety culture and a culture of safety. A safety culture simply describes the beliefs and behaviors demonstrated within an organization or during a project's lifetime. Therefore, a safety culture may be good, focused on reducing incidents and injuries, or it might be poor, tolerating at-risk behaviors that put people and the environment at unnecessary risk. A culture of safety is what we all want to achieve.

In a newspaper article[6], Dr. Najmedin Meshkati, professor of civil, environmental and system engineering at the University of Southern California, said, "…culture creates the necessary framework within an organization – whose development and maintenance is the responsibility of top management – and the attitude of staff at all different levels in responding to and benefiting from the framework."

The petroleum sector has made significant strides towards improving workplace safety, as evidenced by the fact the industry's Lost Time Incident rate was over 14.0 in 1963 and stands at 0.37 at the end of 2009. Too often though, people still rely on compliance with safety policies, procedures and equipment in everyday operations rather than a belief in safety. To eliminate incidents, safety must become a personal issue where each employee and contractor takes personal responsibility for choosing to follow the regulations, using the equipment properly and, most importantly, recognizing and reducing unnecessary at-risk behaviors.

[6] Houston Chronicle, January 2007

An SPE Whitepaper[7] entitled, "Safety Leadership that Engages the Workforce to Create Sustainable HSE Performance," offers compelling evidence to support the paper's conclusion, "We think Safety Leadership is the fuel, while the engine that really drives the performance improvement is engaged workers who are committed to Health, Safety and Environment as values."

Based on over 15 years of research by the Organization for Economic Cooperation and Development (OECD)[8], as well as extensive in-the-field practical assessments[9], sufficient evidence exists to demonstrate a productive and safe workplace requires a number of inter-dependent people-related "Systems" (see below) working well together. Failure to recognize and build on these inter-dependencies will make successful work outcomes, including safety, more difficult and problematic.

What follows are some of the specific items that need to be addressed with regard to each system. It should be noted, each of these Systems can be narrowly defined to focus specifically on Well Control.

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[7] 126901

[8] Moody International Consulting & Training (www.moodyint.com) has conducted assessments and designed/implemented behavior-based safety solutions for more than 100,000 people over the past decade.

[9] www.oecd.org

The right people are recruited and hired

- Have defined actual competencies required for each position.
- Peoples' skills match the requirements of the job they are being asked to perform.
- Orientation person receives is structured, consistent and effective.

The team and organizational culture they enter supports working safely

- Leadership has established and, more importantly, effectively and continuously communicates the safety vision and values.
- Managers, supervisors and team members demonstrate and encourage personal belief in safety.

The organization's work processes support safety

- Standard Operating Procedures are up-to-date and consistently understood and utilized.
- Risks are regularly assessed and hazards mitigated or eliminated.
- Job Safety or Risk Analysis are effectively implemented.
- Audits are regularly conducted and the results followed-up on.
- Time outs are utilized and individuals calling them are positively recognized.

Performance expectations are clearly defined and consistently understood

- Job responsibilities, particularly relevant to safety, are documented and communicated to both employees and contractors.
- Leading and lagging performance indicators are in place, understood and measured.

People have the resources necessary to do their jobs safely

- People receive the training and equipment they need to do their jobs safely.
- When faced with a safety related problem, the right people are brought in if necessary to help resolve it.
- A behavior-based approach to safety has been established and people utilize it effectively.

Safety improvements are sustained because a process exists for continuously evaluating and expanding performance.

- Regular meetings are scheduled to review HSE performance.
- People are encouraged to provide suggestions for improving safety.
- People are provided effective feedback on how to improve their performance.
- Lessons learned from near hits are communicated throughout the organization.

California State Lands Commission Offshore Safety and Pollution Prevention Program

Gregory D. Scott, Division Chief, Mineral Resources, California State Lands Commission

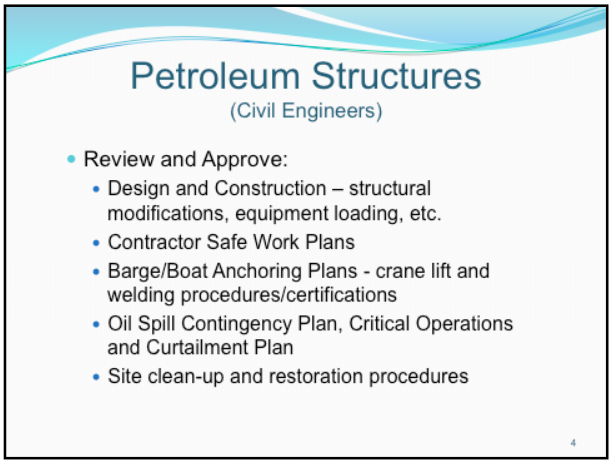
The California State Lands Commission, through its Mineral Resources Management Division (MRMD) is responsible for the safe and environmentally sound development, regulation, and management of all energy and mineral resources on sovereign and school lands under the jurisdiction of the California State Lands Commission. The State's resources include oil, gas, geothermal energy, gold and other solid minerals. In managing the prudent development of these resources, the MRMD's highest priorities are public safety, environmental protection, and maximizing the revenue generated from them for the benefit of the public.

The MRMD is comprised of technical staff with unique roles and expertise dealing with offshore oil and gas production, and who apply safety and pollution prevention programs to those activities. Some of the programs and objectives are described below.

Operations And Compliance

The Operations and Compliance programs provide expertise in the area of safety and field inspection to ensure that the State's lessees conduct accident and pollution free operations at State drilling sites, production facilities, and offshore platforms, and to ensure that the production streams from which the State derives its share of the petroleum are accurately measured and recorded. The program organization is composed of a Field Inspection Unit and a Safety Audit Unit, which work together as an integrated team.

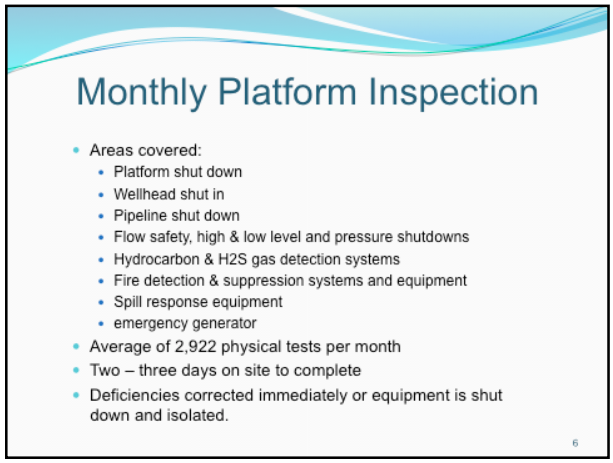
The Field Inspection Unit's primary responsibility is the Platform Inspection Program. This program involves comprehensive inspection of offshore oil and gas facilities, and has been carried out by the MRMD for more than forty years. The platform inspection program includes monthly function testing of all detection, control, and automatic shutdown devices installed on a platform, which can number in the hundreds. The goal of these inspections is to ensure the reliability of the safety systems installed on the platforms to prevent injuries and pollution, and to verify that the equipment to respond to incidents is on hand and in operating condition. These are the most rigorous inspections for offshore facilities in the nation.



The inspection unit is also responsible for ensuring that the State receives its proper royalty share of the crude oil, gas, and condensates produced from State lands. The goal is to verify that the volumes and quality of oil and gas sold by lessees are accurately measured. This is accomplished by gauging and sealing crude oil shipping tanks before shipment, by running laboratory tests to determine the amount of impurities in the crude and its density, and by witnessing the calibration of the meters used to measure the amount of oil and gas sold from each lease.

The Safety Audit Unit analyzes the design of a facility and its safety systems to ensure that it meets regulations of the Commission and the State as well as all nationally recognized process safety, pressure vessel, fire, and electrical codes. This program started in 1986 has greatly enhanced the safety and environmental protection of oil and gas facilities in California. During a safety audit, Unit staff inspect and evaluate the design, specifications, condition, and effectiveness of well and processing equipment safety and pollution prevention systems; fire detection and control systems; electrical power distribution systems and equipment; gas detection and alarm systems; spill prevention and response equipment; operator training and certification; and facility Operation Manuals. The value of these evaluations and the importance of the safety audit program itself are reinforced by the fact that nearly all State drilling and production facilities were designed and installed over forty-five years ago. Further, the design standards used, and the alarm and control equipment installed, are now outdated. Many of the facilities have undergone major design changes to accommodate production expansions, new production and processing methods, new state-of-the-art alarm and control systems, and companies other than the original operator now operate

all the facilities. Facility audits have resulted in more than five thousand action items, all of which have been corrected or are in the process of being corrected. This represents a major achievement in improving safety and preventing pollution.

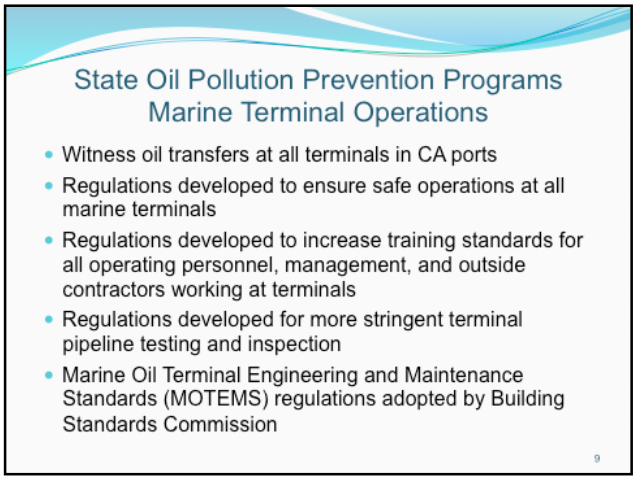


Engineering

The Engineering Section provides expertise in civil and structural engineering to MRMD and all other CSLC divisions, and in specialized petroleum disciplines such as reservoir geology, reservoir engineering, drilling and production engineering, environmental engineering, oil and gas well work, and abandonment engineering. It provides engineering analyses and support, as well as technical oversight of projects, for other sections and divisions. It monitors the work for safety and compliance with applicable standards and regulations, and reviews new technologies to determine their applicability for use in MRMD operations. The program provides technical evaluations and oversight of offshore oil drilling and production platforms to analyze for structural integrity and the ability to withstand earthquakes and severe sea conditions. It oversees the testing of offshore and certain onshore oil and gas pipelines for safety and pollution, and analyzes plans for removal of offshore platforms when no longer needed. It also reviews the design, plans, and construction procedures for offshore oil and gas pipelines, offshore liquefied natural gas facilities, wastewater outfalls, and projects involving power and telecommunication cables, before construction is authorized, to ensure that they meet current safety standards and can withstand earthquakes.

The Engineering staff reviews proposals for drilling, re-drilling, production, completion and reworks of oil and gas wells on State leases. A thorough review is conducted on each proposal which includes casing design, BOPE specifications, directional and mud programs and alterations in casing. The staff reviews plans and construction procedures for onshore pipelines designed to carry oil, natural gas, or petroleum products, before construction is authorized, to ensure that they meet current safety standards including earthquake hazards.

The Engineering section is responsible for the annual Pipeline Inspection Program that involves comprehensive inspection of offshore oil and gas pipelines, and has been carried out by the MRMD for more than thirty years. The goal of these inspections is to ensure the integrity and reliability of the pipelines to prevent offshore pollution, and to verify that the pipelines are in good operating condition. The California State Lands Commission offshore pipelines regulations are the most stringent pipeline regulations in the country.



DAY 2

Perspectives on Reducing Our Reliance on Fossil Fuels

The second day of the forum was devoted to examining whether or not the *Deepwater Horizon* blowout could or should be used as a wake-up call for a campaign to rapidly wean ourselves off fossil fuel. Such mitigation would limit our impact on global climate change and improve the ability of Earth to allow humans to thrive. To introduce this topic, we recruited one of the world's leading experts on climate change, Professor Richard Somerville of the Scripps Institution of Oceanography. He described the driving forces behind climate change and what science tells us about how different actions and the timing of those actions will affect the kind of future we might leave to our descendents. The speakers on day 2 were

- Richard Somerville, Professor, Scripps Institution of Oceanography, University of California, San Diego
- Meredith Blake, Founder and CEO, Cause & Affect
- Wayne Leighty, Sustainable Transportation Energy Program, UC Davis Institute of Transportation Studies
- Robert Bienenfeld, American Honda Motor Company, Inc.
- Woodrow W. Clark II, Founder/Managing Partner, Clark Strategic Partners
- Bob Foster, Mayor, City of Long Beach, California
- Edwin Feo, Founder, USRG Renewable Finance
- Thomas Grimm, The Omega Project

The findings and recommendations based upon the presentations and the group discussion on Day 2 are presented below. Brief summaries of the presentations follow. The full presentations, along with others, can be found on the Aquarium's website, www.aquariumofpacific.org.

Finding

As conventional petroleum resources are depleted, the search for and production of petroleum will continue to shift into more challenging areas like the deep-water Gulf of Mexico. One way to reduce the risk of incidents like the Macando blowout is to reduce petroleum use, thereby alleviating some of the need for deep-water oil exploration.

Recommendation

To mitigate the risk of future Macando-type incidents, reduce petroleum use.

Finding

Carbon dioxide released from the burning of fossil fuels is the major factor in causing climate change. Industrialized nations were the primary driver up until 2003. Since 2003, global emissions from developing economies have increased more rapidly than those from the industrialized world. Rapid industrialization, fueled by coal, especially in China and India, is the primary driver of that increase.

Recommendation

That the United States and a number of other industrialized nations set an example of reducing greenhouse gas emissions from burning of fossil fuels and assist developing nations in accelerating their transitions to non-fossil fuels.

Finding

Unless there is a significant reduction—more than 50%—of global emissions of greenhouse gases within the next two decades, global mean temperature will very likely increase to more than 2°C above pre-industrial levels. We are already nearly half the way there. This will have a number of serious consequences for human society including: sea level rise and coastal flooding, increase in the frequency and duration of severe droughts, loss of crop yields, and increase in severe summer hot spells.

Recommendation

That the U.S. and other nations move quickly and decisively to reduce emissions of greenhouse gases to the atmosphere. That short-term and longer-term strategies be adopted to move to a less carbonized global society.

Finding

Transitioning to a less carbonized world on the time scale needed will require a campaign that becomes a global movement. Developing and implementing an effective campaign requires strategic thinking done upfront through a comprehensive "landscape

analysis." It also will require patience and constancy of commitment and the exploitation of every social marketing tool available.

Recommendation

Initiate a comprehensive landscape analysis soon to formulate the strategic frames of reference for a campaign to reduce our use of fossil fuels. The messaging needs to communicate a sense of urgency, a call to action, and a portfolio of alternative solutions that are actionable by individuals, organizations, and governments. The campaign should tap into the youth market and what appeals to them.

Finding

Transportation is an important sector for global petroleum use; 70% of petroleum used in the United States is used for transportation. Consequently, change in transportation technologies and systems is necessary for significant reduction in petroleum use.

Recommendation

Look to the transportation sector for opportunities to make the biggest reductions in petroleum use.

Finding

Reducing petroleum use will require changes on the demand side rather than the supply side. This is because the demand for petroleum use in transportation is very inelastic due to a lack of viable fuel substitutes (96% of transportation fuel comes from petroleum), viable alternatives to the automobile, and patterns of land use that require less mobility. Given this inelastic demand, changes on the supply side will cause price volatility but very little change in the quantity of petroleum used. Thus, reducing petroleum use depends on increasing the elasticity of demand.

Recommendation

Develop viable substitutes for petroleum-derived fuels, vehicles that are less energy intensive, and patterns of land use that allow for access to the things we want to do without requiring transportation over long distances.

Finding

We buy horsepower and cup-holders rather than fuel economy, and alternative-fuel vehicles will cost more than conventional equivalents until production volumes increase. Consumer choice alone will not select reduced petroleum use in transportation – it's too good of a fuel with too diffuse negative externalities.

Recommendation

That public policy is needed to induce changes on the demand side of petroleum use since consumer choice alone will not suffice.

Finding

Policies have emerged recently in California (and other places) that will induce development of alternative fuels (the Low Carbon Fuel Standard), will improve the fuel economy of vehicles (tailpipe emissions standards for CO2), and will change land-use patterns to reduce the need for mobility. The basis for these policies is California's goal of reducing greenhouse gas emissions 80% from 1990 levels by the year 2050. Achieving this goal is likely to reduce petroleum use from 96% of total fuel today to somewhere between 2% and 34% of total fuel use in 2050. A demand-side revolution, motivated by policy to reduce greenhouse gas emissions, could effectively reduce petroleum use. Policy provides the framework

Recommendation

Formulate and implement a comprehensive national energy policy similar to California's energy policy to reduce petroleum use, to lower the risk of another Macando-type incident, and to reduce greenhouse gas emissions.

Finding

The U.S. is blessed with robust renewable energy sources—wind, solar, biomass, and geothermal—but even after years of policy support, they still account for only a small percentage of the nation's total energy use. The challenges are primarily price, state of technology development, customer acceptance, lack of infrastructure, and environmental impacts—real and perceived—and siting issues.

Recommendation

That the nation pass a comprehensive energy bill with appropriate incentives (in both amount and duration of availability) in the form of tax benefits, low cost loans and grants, a much larger investment in research and development, and mandates for utilities to purchase renewable energy on a nationwide basis for development of renewable energy sources on the scale needed to move to a reduced fossil fuel economy.

Finding

The development of domestic sources of carbon-neutral biofuels is a critical for U.S. business and vital for U.S. national security. This essential national need will not be resolved through increased oil exploration and exploitation in unsafe environments.

Recommendation

That an integrated microalgae cultivation and production process be designed and tested that doesn't compete with agriculture for land, water, or fertilizer. That the system uses solar energy, wave energy, the heat capacity of the ocean, and the salt solution gradient between seawater and wastewater for algae cultivation.

"Energy is a national security issue, both for the Navy and the nation. Our use of this critical resource must be looked at in strategic terms. Reforming energy use within the Navy will increase our combat capability, while advancing our energy security and promoting environmental stewardship."

Admiral Philip Cullom, Director of the U.S. Navy's Task Force
Energy and Environmental Readiness Division

Brief Summaries of Individual Presentations, Day 2

Full presentations can be found on the Aquarium's website

http://www.aquariumofpacific.org

The Kind of World We Would Leave To Our Grandchildren Unless We Make Major Changes In Our Energy Choices On A Global Scale Soon

Richard C. J. Somerville, Professor, Scripps Institution of Oceanography, University of California, San Diego

My task is to summarize very briefly the state of climate science and to say what we know about the impacts of possible levels of climate change in the future.

The Keeling curve (Fig. 1) shows the rise of carbon dioxide in the atmosphere since 1958. Dave Keeling died 5 years ago, in 2005, but the measurements he began are continuing. Carbon dioxide is rising more rapidly now than before. The rise is entirely human-caused, primarily due to burning fossil fuels, and secondarily to land use practices, particularly deforestation. CO_2 is still going up. It's now some 35% higher than it was in the 19th century, and 25% higher than when Keeling began his measurements. This graph is the tacit reference for everything we have in mind when we talk about climate, and the longer ahead we look, the more important carbon dioxide is as the main factor causing climate change.

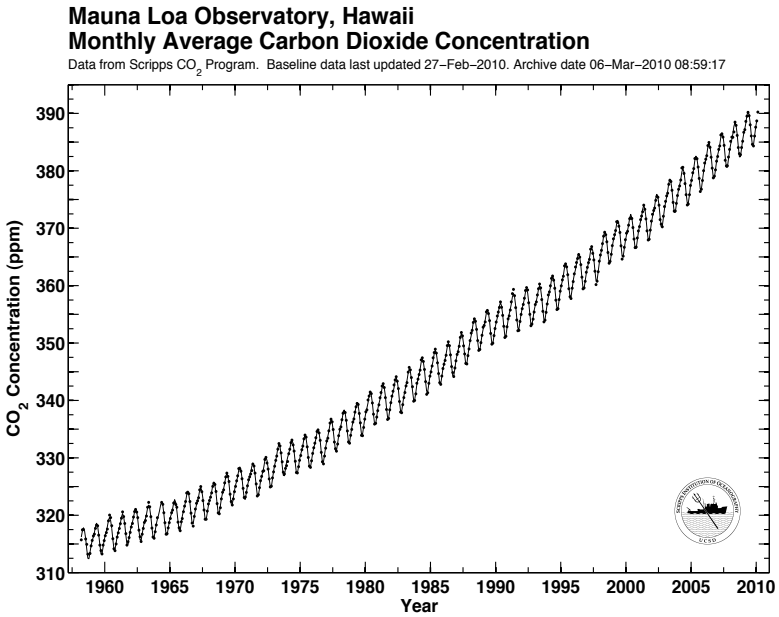


Fig. 1 The Keeling curve, showing atmospheric carbon dioxide concentrations from 1958 to the present.

A report, *The Copenhagen Diagnosis*, was put together a year ago by 26 climate scientists, of whom I am one. It is available at www.copenhagendiagnosis.com for free download. It was published in advance of the Copenhagen UN Climate Negotiations in December 2009. It is not an IPCC report, but we wrote it to summarize new scientific advances that had occurred since the publication of the IPPC report in 2007. Science doesn't stand still. Enough new science had happened that we wanted to bring the important new findings to the attention of the negotiators.

Figure 2, from *The Copenhagen Diagnosis,* shows the growth in fossil fuel CO2 emissions since 1990. It's up by 41%. 1990 was the base year of the ill-fated Kyoto Protocol, incidentally, so if that Protocol had had its intended effect of reducing emissions, they would be a few percent below 1990 levels today, instead of more than 40% above them. The developed West caused the problem, but since 2003, emissions are increasing more rapidly. This is due mainly to rapid development, often based on coal, especially in China and India and other major developing countries. Rapid and large reductions in the global rate of emitting CO_2 and other greenhouse gases are urgent scientifically in order to keep global warming limited to 2 °C above pre-industrial temperatures. This target is subjective, depending on risk tolerance, values, economic priorities, and other considerations, but it is a target on which almost all nations have now agreed as a limit on allowable global warming. Once such a target is set, climate science can provide highly relevant information on what must happen in order to limit warming to the target amount. The answer from science is that, unless strong action is taken within the next decade, there is almost no chance of meeting that target.

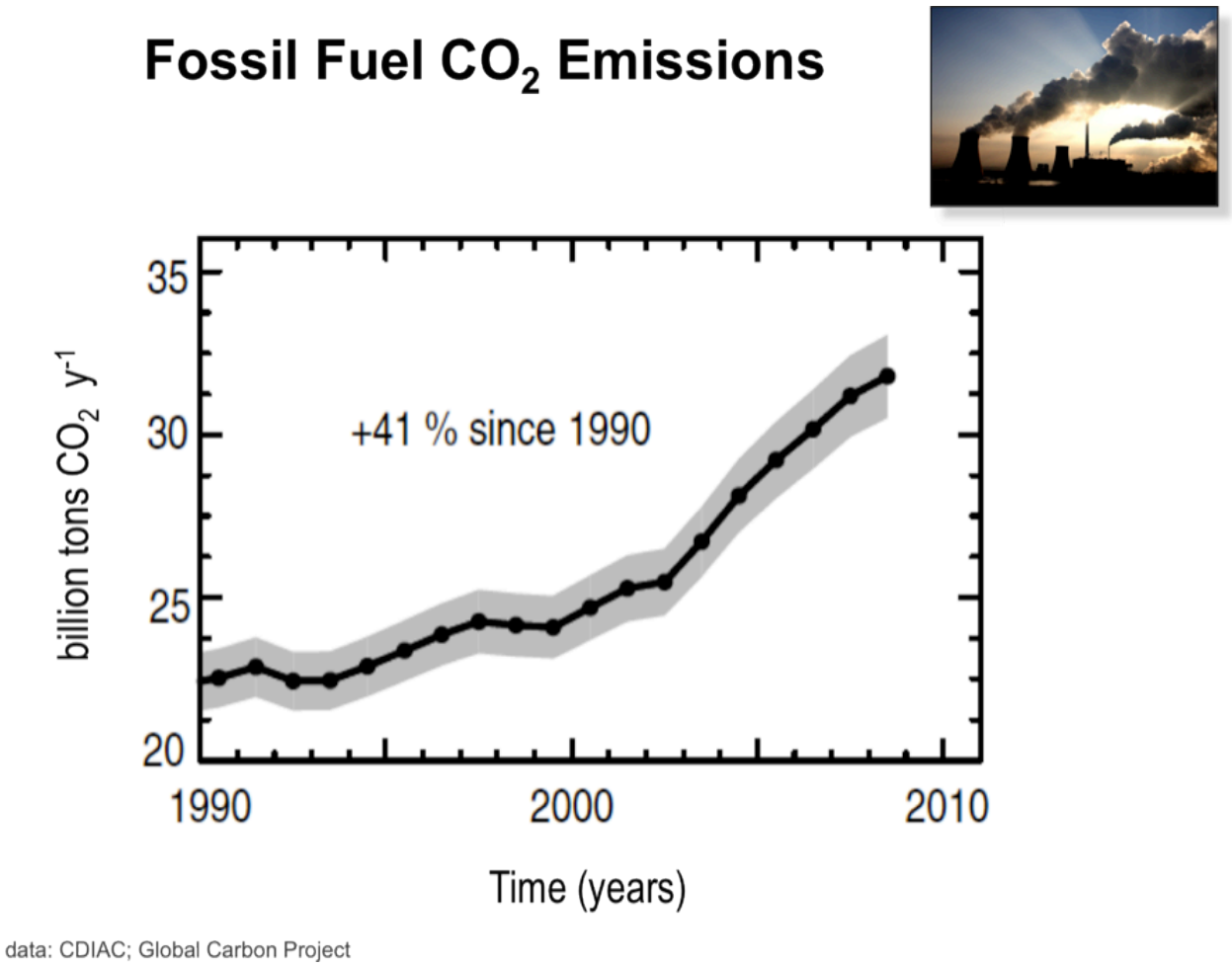


Figure 2. Fossil Fuel CO_2 Emissions

The world continues to warm at a rate of about one-third degree Fahrenheit per decade (five-ninths of a degree Celsius per decade). Figure 3 shows the increase in the Earth's average surface temperature since 1960. The long-term trend is clearly upward, and most of the variability is attributed to El Niños and La Niñas. In some ways the warming is a symptom of the many facets of climate change. Temperature is just a handy single number.

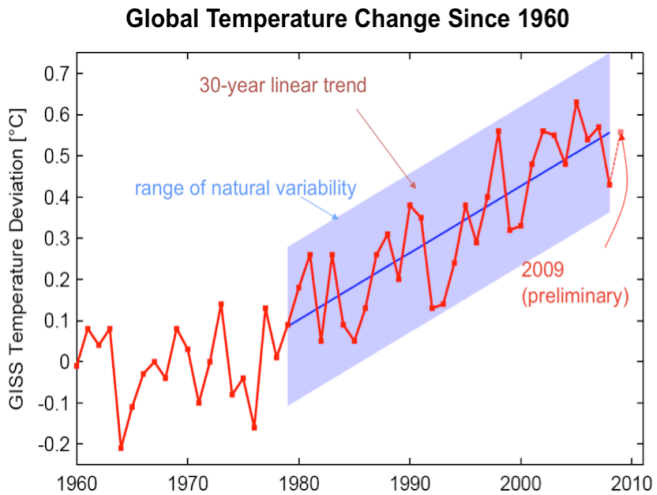


Fig 3: Global Temperature Change Since 1960

Arctic sea ice extent has dropped below the worst-case forecast of all the models used. Sea ice is tricky, and the physics involved is highly complex, but it is a very useful index for what is happening in the far north, which is the part of the world that is warming more rapidly than the rest of the world.

Sea level rise is one of the surest consequences of a warming world. In recent years, the rate of sea level rise has accelerated. It may be 2 or 3 feet higher, or even more, by the end of this century. There are several factors involved: ocean thermal expansion, melting ice on land, destabilization of ice sheets on Greenland and Antarctica, and possibly even ground water extraction.

The next important graph is from The Copenhagen Diagnosis showing alternative future scenarios for global emissions of CO_2. Once again, we must recognize that the agreed-upon limit by the nations of allowing a maximum of 2 °C warming, above the pre-industrial temperatures of the 19th century, is an arbitrary limit; it does not have a strictly scientific basis. Once selected however, science can inform a number of alternative strategies to achieve it and can evaluate how the timing of the initial actions will affect the needed rates of reduction of CO_2 emissions in order to achieve the 2 °C target. We are now experiencing average global temperatures of about 0.7 °C above pre-industrial levels. Figure 4 shows three strategies to achieve the 2 °C target. All of the strategies indicate clearly that we must act soon if we are to avoid exceeding the 2 °C increase above pre-industrial levels. The longer we delay in beginning seriously to reduce greenhouse gas emissions, the more rapid the reductions will have to be to avoid exceeding the 2°C limit. This is shown clearly in Figure 4 which depicts three possible

alternative future emissions scenarios to keep the rise in Earth's average temperature below 2°C. Emissions means the rate at which humanity puts the carbon dioxide into the atmosphere. CO_2 concentration is the total amount of CO_2 that is in the atmosphere. Roughly 60% of what we put in the atmosphere remains there, the rest being transferred to the oceans and the terrestrial biosphere. And temperature increase scales with CO_2 concentration. Nearly all of the resulting warming will last for centuries.

Science also provides important information on the impacts of different degrees of warming. *Climate Stabilization Targets*, a recently published US National Academy of Sciences report, tells you, as a function of warming, what the various aspects of the impacts of warming are likely to be. Many of these impacts scale linearly with the temperature increase. Thus, impacts at 2°C warming will be about twice those of 1°C warming.

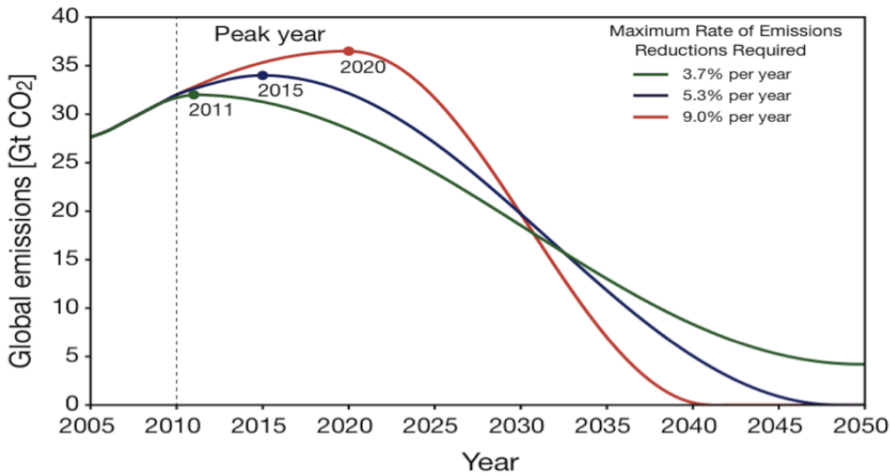


Fig. 4. Alternative future CO_2 emissions pathways, each of which will offer a 67% chance of limiting global warming to an average of 2° above pre-industrial temperatures of the 19th century.

As the Earth's average temperature increases, summers will become much warmer, and precipitation patterns will change, with the southwest U.S. becoming drier. For every 1°C increase in temperature, the southwest U.S. will experience a decrease in precipitation of 5-10%. Less rain is falling in gentle events, incidentally, and more as torrential downpours. Risk of severe wild fires in the southwest will increase by 2 to 4 times for every 1 °C increase in temperature.
For every increase of 1°C rise in the Earth's average temperature:

- The yield of many important food crops decreases by 5-15%
- Arctic sea ice decreases in extent by 15%
- Rainfall in the southwest U.S. decreases by 5-10%

Because of the long residence time of CO2 in the atmosphere, it is thoroughly mixed by the winds, and the average concentration in the atmosphere is nearly the same everywhere. It is the total amount of CO2 emitted globally that matters, not what any individual nation or region emits.

About 60% of the CO_2 emitted since the Industrial Revolution is still in the atmosphere. The other 40% has been transferred to plants and to the ocean—the ultimate sink for CO_2—and has increased the ocean's acidity by about 30% since the Industrial Revolution. The long time scale of the ocean means that even if all emissions of CO_2 were to be stopped tomorrow, warming would continue for many centuries. As a result of actions taken over the past couple of hundred years, we have committed the Earth to a warmer future, and the longer we delay acting to dramatically reduce emissions, the more the Earth will warm. Thus, the power to determine the climate that our children and grandchildren will experience is in our hands today.

Take Away Message:

It's urgent to take action to strongly reduce global greenhouse gas emissions, not for ideological, political, or economic reasons, but for scientific reasons. Once the world has agreed on limiting warming to a target of 2 °C above pre-industrial temperatures, then the best science that we have today says humanity must act so as to peak global emissions very soon and then decrease them rapidly, and the longer we delay for them to peak, the more rapid the decrease must be. If emissions haven't peaked and begun to decline by about 2020, then, according to our current understanding, the chances of meeting this 2 °C target are very slight.

Strategies To Put Us Onto A Different Trajectory. Observations On Designing And Executing Effective Public Outreach Campaigns

Meredith Blake, Founder and CEO, Cause & Affect

In my presentation I want to explore what the opportunities are around this issue, in public engagement and mobilization, from a communications standpoint.

The first question is—

How do we translate the science and activate the public to be part of the solution? What is that nexus, that point of intersection, when you are looking to create movement in public engagement campaigns, and what is the role of media, particularly entertainment media, beyond just pitching the story to the mass media and the press?

It is my belief that there are four critical elements to effective change campaigns, so in my company we have four verticals: we have media property, anybody producing mass media entertainment property; corporate, particularly consumer brands with wide reach and the resources to effect change; social enterprise and expertise, non-profits, government entities, experts in the field with expertise and on the ground programming; and influential individuals who can command media attention.

Social change doesn't happen overnight. Mobilization doesn't happen overnight. You have to be committed for the long haul. To build a campaign, strategic planning comes first. Any time you are taking an issue to mobilize the public, you need to develop a sense of urgency. This requires a timeline.

Questions that need to be addressed to develop a strategy—a framework for thinking about the issue—include those below. To complete this analysis may require 6 months or a year. Creative marketing ideas may be interesting and even important, but not sufficient. They need to be grounded in research.

- What are the critical unmet needs?
- What are the levers for change?
- What are the service gaps?
- What campaigns and efforts have already been tried? Which have succeeded and which have failed?
- Who are the core audiences we are trying to reach? Who are hardest to reach but may be the right audience to go after?

In a mass mobilization campaign, preaching to the converted first may be the way to begin. Have them start that nucleus of what you're trying to build and reach out from there. It generates the initial momentum.

So the campaign you're building is looking at scope, pace and sequence of how you're reaching different audiences.

Strategy Work begins with a thorough landscape analysis:

- What are the market definitions, trends?
- Identify the competition: who are they, what are they doing? Which can you use to help your case?
- Understand public opinion and awareness levels.
- What are consumer perceptions and behavior?
- What are the market segments and their values?
- Study product services and channels. There are very positive economics to environmentalism right now that would make behavior change more tolerable to the general public.
- Understand who your other stakeholders are.

Only after you have completed this landscape analysis do you move into developing and shaping a strategy…what kind of entertainment, what channels, what kind of distribution, the who, what and where …only then do you begin to architect a campaign.

How are you reaching people? Digital and new media; and very significant, traditional entertainment media—TV, films, radio, books; short form video; on-line mobile media; plus social media. Package the message in an understandable way, and deliver it where they are. That's the framework.

Our campaigns are driven by 6 to 12 months of strategy work and supported by at least a minimum of a 12 month post release commitment because this is how long it takes to create an Ecosystem for change.

There's no one solution. Solutions will come about because we have a consistent and significant level of media awareness and cultural transmission of these ideas coupled with transforming the marketplace, coupled with a consistent level of a sense of urgency translating that into enlightened self interest, how it effects your wallet.

So there are four categories of things when you're talking about messaging and translating message to engagement:

1. Communicating urgency. What matters to people.

2. Call to action: Clear, do-able, strategy driven.

3. Alternatives and solutions that are do-able and affordable.

4. Tapping the "cool" factor in the youth market, trends that become life style. Children often lead parents to behaviors such as in the anti-smoking campaign, and now the green movement.

We have to rise above the noise to communicate the urgency and galvanize people. There is a point at which it is too late. How do we do it now and how do we get them involved?

Implications of Climate Stabilization for Energy Use in Transportation: the Demand Side of Shifting Away from Petroleum Use

Wayne Leighty, Sustainable Transportation Energy Program, Institute of Transportation Studies, University of California at Davis.

I sought to demonstrate three basic points:

1. Reducing petroleum use in transportation will require changes on the demand side rather than the supply side;
2. Realizing changes on the demand side of energy use in transportation will require public policy;
3. Policies have emerged recently that could affect demand-side changes that will dramatically decrease petroleum use in transportation.

Transportation is an important sector for understanding global petroleum use. Spaghetti diagrams of energy supplies and use for the United States show that petroleum accounts for about 38% of the total primary energy used in the United States (37.8 of 99.2 quads) and 70% of that petroleum goes to the transportation sector. Looking at the flip side of this coin, about 96% of transportation fuel comes from petroleum, which means at present there are ***no viable substitutes*** for gasoline and diesel.

The objective of reducing the use of fossil fuels in transportation is one of supply and demand. The total quantity of petroleum used is anequilibrium between the supply curve and the demand curve.

- The supply curve slopes upward, with production from easily accessible low-cost fields on the bottom left and hard-to-access fields on the upper right.
- The demand curve slopes downward, with high willingness to pay on the upper left and low willingness to pay on the lower right.

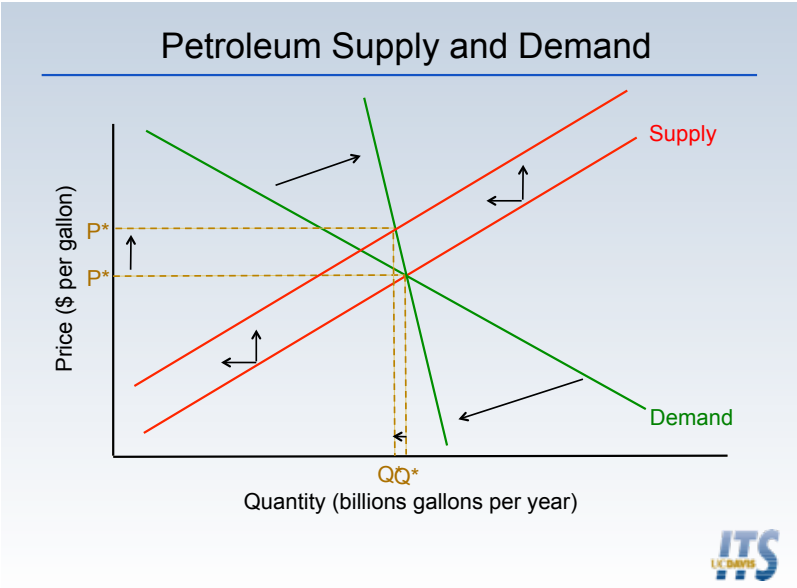
The single market clearing price and quantity occurs at the intersection of supply and demand. Those oil fields with higher marginal cost than the market price are not developed and those consumers with lower willingness to pay than the market price forego their use of petroleum.

In the transportation sector, where 70% of the petroleum goes in the United States, the demand for petroleum is quite inelastic. This is because we do not have any available substitutes for gasoline and diesel to run our cars and, arguably, do not have any viable alternatives to driving due to the land use pattern we have built. In the long term we can buy a smaller, more fuel efficient car and we can move to a different location closer to our work and play, but the demand is still quite inelastic due to lack of available substitutes for the fuel (petroleum) and activity (driving).

Although not entirely correct in the academic sense, we can show this price inelasticity of demand on our diagram with a steeper demand line.

Yesterday we talked a lot about the supply side – specifically, whether and how offshore production should be allowed. We were basically talking about shifts in the supply curve. As the easier to reach portions of this finite resource are used and as policy decisions restrict access to some resources, the supply curve will ***shift*** upward (i.e., the marginal barrel at each annual production rate becomes more expensive). But, continued technological progress tends to shift the curve downward (i.e., we get better at finding and producing the oil, which reduces the cost).

But here's the really important point: the inelastic demand means that shifts in the supply curve like this example will cause large ***price*** fluctuations but relatively little change in the ***quantity*** of oil we use. Consequently, the question of how to use less petroleum in transportation must be addressed on the demand side rather than supply side, essentially by flattening the demand curve (i.e., make it more elastic). This implies a need to develop 1) substitutes for petroleum fuels, 2) substitutes for the automobile that are less energy intensive, and 3) alternatives to mobility for accessing the things we want to do.



Let's also dispense with a common supply-side fallacy – namely, that high oil prices will encourage development of alternative energy resources. Consider this from the perspective of a profit-maximizing energy company in this grossly simplified example.

- Suppose the price of oil today is $60/barrel with marginal cost of $40/barrel, yielding profit of $20 per barrel. Also today the price of electricity is $100/barrel equivalent with marginal cost $80/barrel equivalent, yielding profit of $20 per barrel equivalent. An energy company is indifferent about where to invest capital.
- Now suppose the price of oil goes up while everything else stays the same. The price of oil is now $100/barrel, which means profit is now $60/barrel, while profit from producing renewable-source electricity is still only $20/barrel equivalent.

Higher oil price, all else equal, will cause the energy company to shift resources to producing ***more*** oil, and ***not*** toward producing more alternative energy! In fact, this is the behavior we have seen from major oil companies in response to the dramatic increase in oil prices in recent years – divesting alternative energy subsidiaries to focus

on developing petroleum resources. Finally, recall that the recent dramatic increase in oil prices is largely due to inelasticity of demand in the transportation sector.

Thus, the focus should be on the ***cost*** side rather than ***price***. Capital allocation will shift toward developing alternative energy resources when the marginal cost of oil production increases and/or the marginal cost of alternative energy resources decreases.

So, what can change the demand for petroleum use in transportation? In other words, what can increase the availability of fuel substitutes and alternatives for mobility such that elasticity increases?

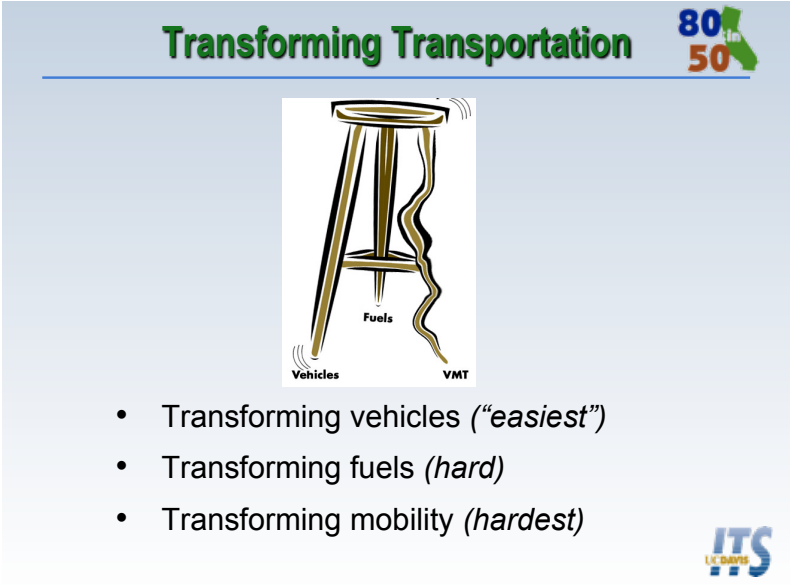
In a word: policy. The history of Corporate Average Fuel Economy or CAFE standards shows that we buy horsepower and cupholders, not fuel economy. Consequently, policy is needed to induce change on the demand side because consumer choice alone will not pick reduced petroleum use in transportation—it's just too good a fuel with too diffuse negative externalities.

One area of policy that might induce dramatic changes in the demand side of fuel use in transportation is greenhouse gas emission reductions to mitigate climate change. Climate scientists say humans need to reduce CO_2 emissions 50 to 80% below business as usual by 2050 in order to stabilize the climate. Since this climate science is the basis for California's "80in50" goal – and not an assessment of technical feasibility – the policy raises basic questions like can we do it, how do we get there, and does the path we take matter.

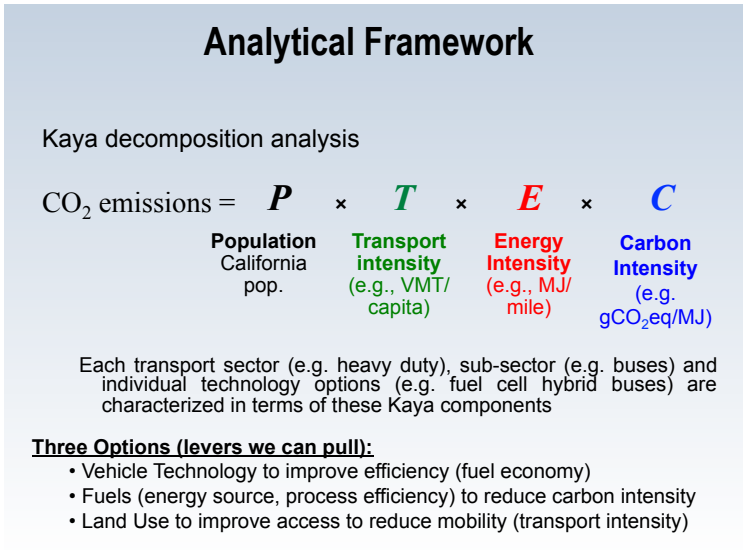
The "80in50" modeling conducted at UC Davis endeavored to answer these questions for the transportation sector.

When we think about transforming transportation to reduce GHG emissions or fossil fuel use, there are basically three legs to the stool:

1. Changing vehicle technology to improve efficiency is the easiest - with options ranging from lightweight materials, aerodynamics and reduced rolling resistance to more efficient internal combustion engines to electric drivetrains powered by fuel cells or batteries;
2. Changing fuels to reduce the carbon intensity is a bit harder, requiring development of alternative energy sources like wind, solar, nuclear and biomass, changes in the production of energy sources with things like carbon capture and sequestration, and new distribution infrastructure like a "smart" electric grid and hydrogen pipelines;
3. Changing our patterns of mobility is perhaps the hardest because it generally requires changing our patterns of land use. Mobility is a derived demand that is necessary to enable access to the activities we enjoy (e.g., shopping, work, play), so reducing mobility without sacrificing access generally requires mixed use and more dense development.



To study the 80in50 goal, we first built a model of the entire ***California*** transportation sector in 2050 that we can use to define scenarios that achieve the goal. The modeling framework is based on the three-legged stool, with total emissions calculated as the product of (population) X (transportation intensity per person) X (energy intensity per mile of transportation) X (carbon intensity per unit of energy). Taking population projections as given, we then have three “levers” available for tinkering with to reduce emissions and petroleum use: vehicle technology to improve efficiency, fuels to reduce carbon intensity, and land use to reduce mobility.



The Analytical Framework for the 80in50 Studies at UC Davis

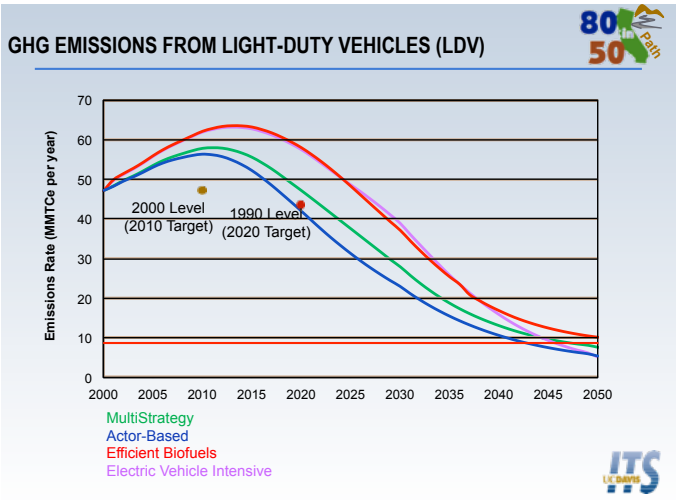
Subject to limits to feasible rates of technological development, consumer adoption and market penetration, infrastructure build-out, etcetera, we defined four scenarios that meet the 80in50 goal.

1. The Actor-Based scenario describes a future in which energy prices have increased, motivating compromise in vehicle performance that enables dramatic improvement in fuel economy.
2. The Electric-Drive scenario describes a future in which electrification of vehicles as FCV and BEV enables dramatic improvement in fuel economy.
3. The Efficient Biofuels scenario describes a future in which success with second and third generation biofuels provides a large supply of very low carbon biofuel, dramatically reducing the carbon intensity of transportation fuels.
4. The Multi-Strategy scenario combines elements of the three other scenarios.

All four scenarios require significant action on all three levers (vehicle efficiency, fuel carbon intensity, travel reduction) – in other words, there is no silver bullet or single approach that can do it all. Except in the Efficient Biofuels scenario, the light-duty vehicle fleet has transitioned past conventional internal combustion engine vehicles and past hybrids to become comprised only of PHEV, FCV and BEV. And most importantly for this forum, petroleum use in transportation has dropped from 96% of total fuel use today to somewhere between 2% and 34% of total fuel use in 2050!

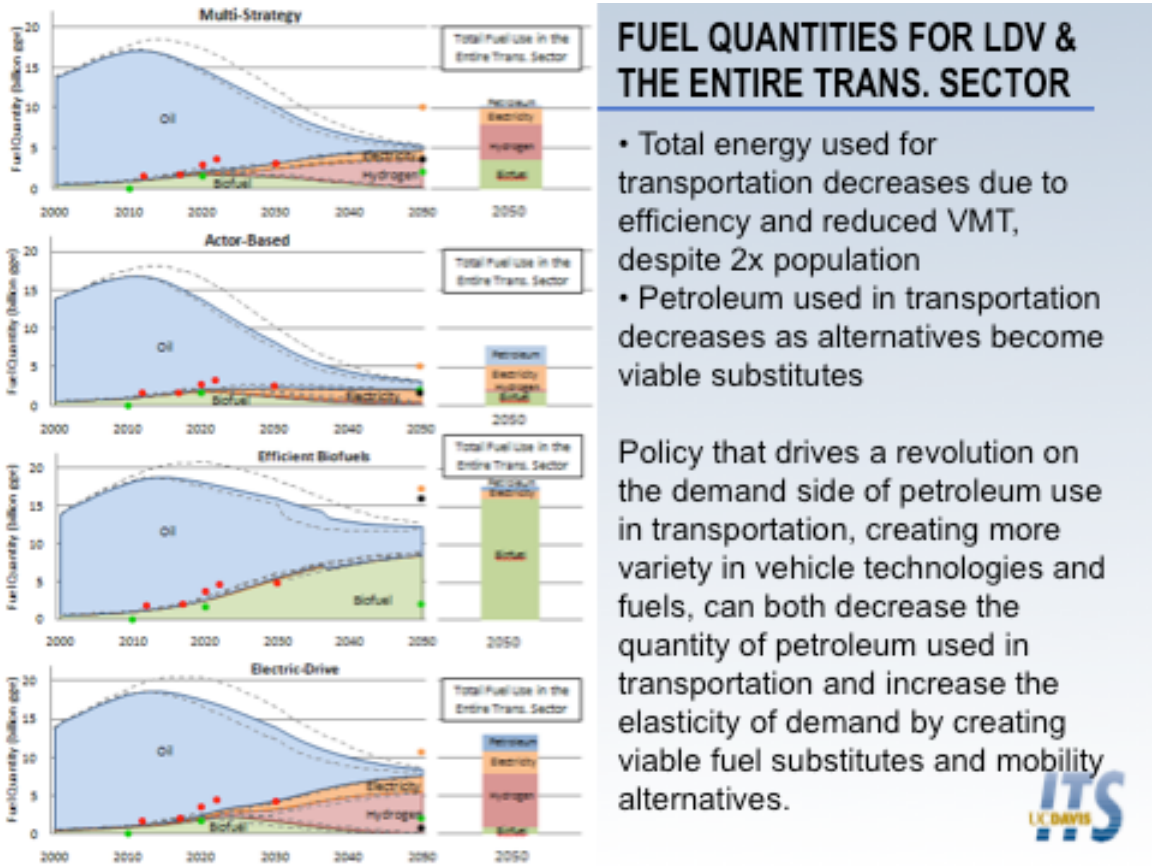
A demand-side revolution, motivated by policy to reduce GHG emissions, will effectively reduce petroleum use in transportation! The next step in our research was to model the dynamics of vehicle fleet and infrastructure turnover in order to map out the transition path from where we are today to where we need to be in 2050 in terms of the parameters that define each 80in50 scenario.

The transition paths in GHG emission reductions from light-duty vehicles that would be accomplished under each of the four scenarios shows that the scenario and transition does matter for the goal of climate change mitigation. Although all four 80in50 scenarios are equal in achieving 80% reduction by 2050, the ***cumulative emissions*** from 2010 to 2050 (the area under these lines) differ by as much as 30 percent. Since GHGs generally have long residence time in the atmosphere, it is the cumulative emissions that matter for climate change mitigation.



GHG Emissions From Light-Duty Vehicles Over Time

Finally, the total quantity and composition of energy use in the transportation sector changes quite dramatically over time in each of the 80in50 scenarios. The total quantity of energy used for transportation decreases due to large improvements in efficiency and decreases in travel activity. The total quantity of petroleum used in the transportation sector decreases even more because alternative energy forms become viable substitutes.



In other words, policy that drives a revolution on the demand side of petroleum use in transportation, creating more variety in vehicle technologies and fuels, can both decrease the quantity of petroleum used in transportation ***and*** increase the elasticity of demand by creating viable fuel substitutes and mobility alternatives.

Subject to limits to feasible rates of technological development, consumer adoption and market penetration, infrastructure buildout, etcetera, we defined four scenarios that meet California's goal to reduce GHG emissions 80% from 1990 levels by 2050. All four scenarios require significant action on all three legs of the stool – there is no silver bullet. But, petroleum use for transportation in these scenarios drops from 96% of total fuel use today to somewhere between 2% and 34% of total fuel use in 2050! A demand-side revolution, motivated by policy to reduce GHG emissions, will effectively reduce petroleum use in transportation!

Renewables: Getting from Promise to Performance—What Will It Take?

Ed Feo, USRG Renewable Finance

The United States is blessed with robust renewable energy resources—wind, solar, biomass and geothermal. These resources are not uniformly distributed around the country, but in each region there is some level of renewable resource. Despite years of policy support, renewable energy today still only accounts for a small percentage of the overall energy usage in the United States.

The challenges to renewable energy use are principally price, stage of technology development, customer acceptance, lack of infrastructure and environmental impact and siting issues.

The cost of renewable energy varies widely depending on the type of technology. Most renewable energy technologies are making progress in reducing costs, but are still well above the cost of older coal plants or new gas fired generation.

Renewable energy generation sources are often located outside of the existing transmission infrastructure, requiring investment in that infrastructure to promote renewable energy generation. Transmission planning takes a significant amount of time, is political and requires large investment. Currently the transmission interconnect queues are backlogged with proposed renewable energy projects.

Renewable energy benefits from federal and state incentives. These include tax benefits, low cost loans and grants, and mandates for utilities to purchase renewable energy. Such mandates have been passed in twenty nine states thus far. In California, current statutes require that 20% of the generation purchased by California investor owned utilities come from renewable energy sources. That level will be increasing to 33% as AB 32 (the Global warming Solutions Act) is implemented.

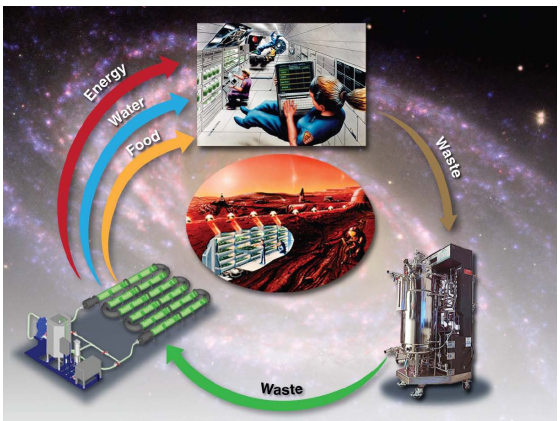
Federal legislation has been proposed to provide further incentives for renewables. These include a proposed national renewable electric standard, cap and trade on carbon, and enhanced federal transmission siting authority. No energy bill has passed Congress since 2007.

The potential of significant renewable energy deployment was considered in a 2008 study by the Department of Energy. The study examined the likelihood and costs of achieving 20% wind energy generation nationally by 2030. The study demonstrated that that target would require 300,000 MW of installed wind generation; that adequate resources were available to achieve that level of wind generation installation; that the costs of integrating wind were relatively modest compared to the potential long term savings from not using fossil fuels.

The OMEGA Project
Technology Transfer and Commercialization Pathway

Thomas Grimm, OMEGA Project, NASA Research Park

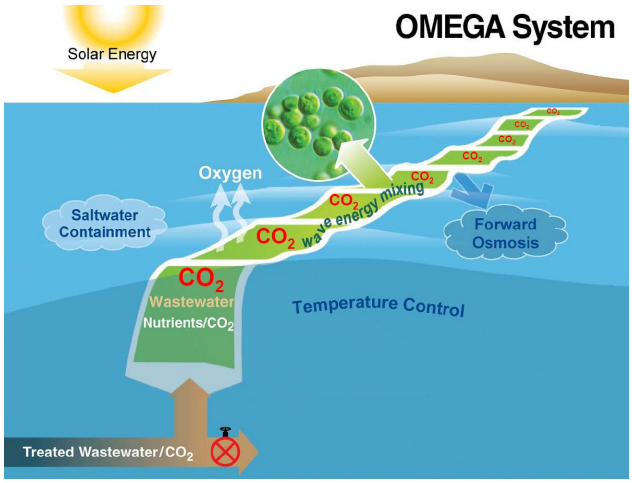
NASA scientists are developing a system for rapidly cultivating freshwater microalgae in offshore membrane enclosures using municipal wastewater currently being discharged into the ocean. The system is called *"OMEGA,"* an acronym for *"Offshore Membrane Enclosures for Growing Algae."* The OMEGA system is designed to produce a domestic source of carbon-neutral aviation biofuels through an integrated cultivation and production process. OMEGA uses solar energy, wave energy, the heat capacity of the ocean, and the salt solution gradient between seawater and wastewater for algae cultivation. OMEGA does not compete agriculture for freshwater, nutrient- rich fertilizer or land because it uses wastewater as a nutrient feedstock and is deployed offshore where it does not use productive, arable land.

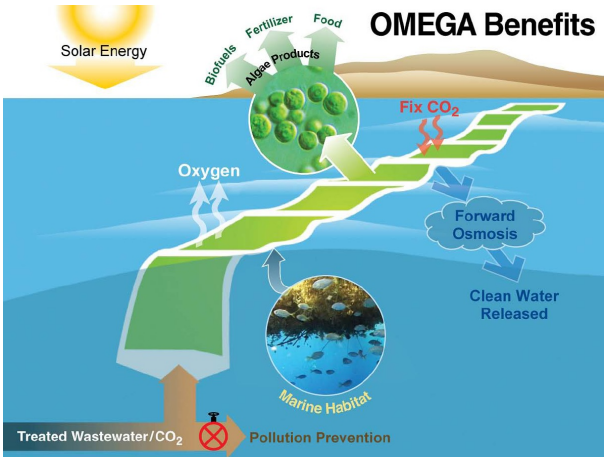


OMEGA Systems was developed at NASA Ames Research Center

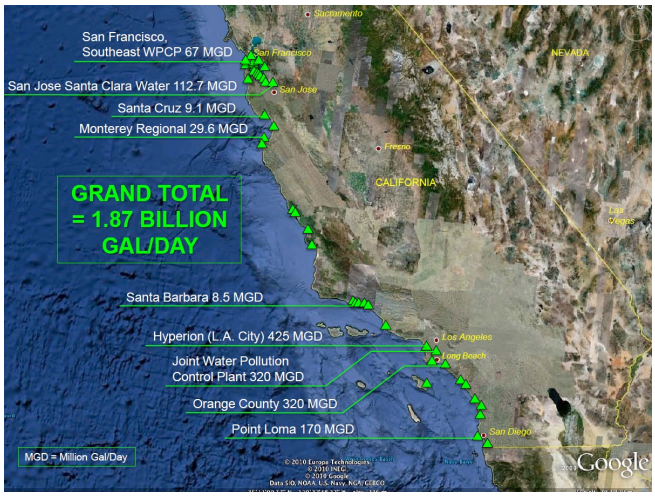
The OMEGA system is a method for large-scale microalgae cultivation and biofuel production that can improve environmental conditions in marine coastal ecosystems by preventing harmful wastewater algae blooms. OMEGA redirects wastewater outfall into floating photobioreactors made of flexible plastic where nutrients are consumed by microalgae, effectively cleaning the wastewater that is otherwise dumped into the ocean. The algae also capture wastewater plant flu gas being discharged into the air, releasing oxygen into the atmosphere rather than the heat trapping CO_2.

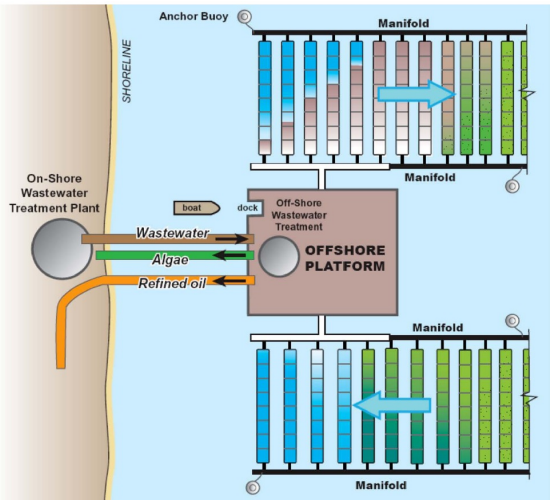
OMEGA uses floating, forward osmotic membranes developed by NASA. The osmotic membranes take advantage of the saltwater gradient between wastewater and the surrounding seawater to passively dewater the wastewater and concentrate wastewater nutrients to stimulate algal growth and facilitate algae harvesting when the algae cultures mature. OMEGA uses the heat capacity and the thermal inertia of the surrounding ocean for temperature control, where wave action helps drive the mixing and circulation of growing algae cultures. The closed recycling system of membrane enclosures contain the wastewater and freshwater algae. In the process freshwater is recovered and returned on shore for reuse.





Each day 1.87 billion gallons of wastewater is discharged into California's coastal waters. The OMEGA system offers an innovative approach to recovering billions of gallons of freshwater from municipal wastewater by redirecting the wastewater into offshore floating membranes where microalgae are grown for the sustainable production of aviation biofuels, and various other biofuels and fertilizers needed by our society.





OMEGA Project Funding. R&D is funded by the NASA Aeronautics Research Mission Directorate and the California Energy Commission. Initial funding was provided by Google. Funding is being used to demonstrate the feasibility of deploying OMEGA photobioreactors in lab and pilot settings that perform the following functions: (1) Grow freshwater, oil-producing algae; (2) Process and purify wastewater; and (3) Sequester carbon dioxide as algal bi-products.

OMEGA Commercialization Strategy. OMEGA systems represent an "Ecology of Technologies" in which all processes are integrated and interdependent, where wastewater is treated as a resource. An independent consortium, (OMEGA Alliance) of business, academic research institutions, and government agencies is being formed to advise, support and hasten the development of fully integrated marine-based microalgae biomass and biofuel production facilities. Strategic partnerships and OMEGA spin-off commercial ventures based in the U.S. and abroad are envisioned. In the phased development

scheme, government funding will be followed by private investment.

OMEGA Alliance and the Future OMEGA R&D. The Alliance is being established as an interdisciplinary consortium that puts OMEGA in the forefront of algal biofuel development. The Alliance will develop an algal-biofuel collaboration framework that describes the R&D pathways to achieving goals for developing an environmental and economically sustainable future for algal biofuel production. The Alliance will foster the factors that lead to innovation, such as increased levels of collaborative research, sharing of information and exchanges of personnel, creation of virtual labs and shared-use research facilities.

Appendix A

Agenda
After the Gulf Forum: What Did We Learn?

Aquarium of the Pacific
October 21-22, 2010

I. Forum Rationale

The Aquarium of the Pacific will organize, facilitate, and summarize a Forum to explore what is at stake in the Gulf and beyond because of "blow-outs", other large releases of oil in the ocean, and our reliance on fossil fuels. The emphasis shall be on developing a research and action agenda for reducing risks to the ocean, the nation, and the planet—short-term and long-term.

We will map out the offshore oil "blow-out" and "blow out response landscape" and identify the areas that are important and uncertain—areas that action and research should focus on. The hypothesis is that action and research on preventing and responding to "blow-outs" and other major oil spills has received too little attention relative to the efforts to document the impacts of such releases on the environment.

On the second day we will focus attention on identifying strategies that might stimulate disruptive strategies to move us in the direction of non-fossil fuel sources of energy, and the reasons why this is so important.

II. Forum Structure

Each day will begin with a few plenary speakers whose charge will be to give succinct high level summaries of the issues to be discussed that day and challenge the participants to exploit what we know to shift the focus to identifying the important and uncertain so that research and action can be concentrated on these areas. Throughout the two days experts will present short (10-15 minute) overviews of the state-of-knowledge relative to specific issues with an emphasis on the important and unknown. Their summaries will be reviewed, revised, and enhanced in breakout sessions. These will form the basis for developing an action and research agenda.

III. The Immediate Challenge

a. Reducing the risks of another "blow-out": What did we learn from the Gulf—with an emphasis on what we discovered that we do not know or fail to put appropriate emphasis on? This might include human factors, corporate culture, regulatory oversight, etc.
b. Reducing the impacts if/when another one does occur: What did we learn from the Gulf—with an emphasis on what we discovered that we do not know?
    i. Challenges of capping in Deepwater and ways to reduce the risk.
c. Cleaning-up after a major release of oil: What did we learn from the Gulf with an emphasis on what we discovered that we do not know?
    i. Burning

ii. Skimming
iii. Dispersants
iv. Innovative Technological Approaches
v. Governance & Management: Who's In Charge?

d. Developing a research agenda for action.
    i. A draft research agenda will be worked on throughout the day. Over dinner on the first evening it will reviewed and revised to gain consensus on the major findings and recommendations.

IV. <u>The Longer-term challenge: Reducing our reliance on oil from the ocean and on fossil fuels.</u>

a. The existing situation
    i. Energy use by sector and where it comes from
b. A desired energy future & triggers to get us onto a better trajectory.
    i. Policies
    ii. Rules & Regulations
    iii. Financial Tools
    iv. Energy Engineering Challenges and Opportunities by Sector
        1. Transportation
        2. Heating and Cooling
        3. Industry
c. The Roles of Design
d. Developing a Research Agenda for Action
    i. A draft action and research agenda will be developed throughout the day and will be presented in the closing plenary for review and revision to gain a consensus on major findings and recommendations.

V. <u>Report Preparation</u>

a. Within 4 weeks of the Forum, participants will be provided with a draft of the report for review and revision. They will have one week to present their suggested changes in "tool tracker." Within 10 days of the end of this period, Forum organizers will send to all participants the final report. At this same time it will be distributed to a broader audience.

VI. <u>Public Outreach</u>

a. Within 2 weeks of the release of the Forum report, a panel made up of three of the participants in the Forum will present the findings to the public and the media at the Aquarium of the Pacific.

October 21, 2010

8:30 Welcome and Self Introductions

9:00 Overview of Forum: Review of Desired Outputs and Outcomes (Jerry Schubel)

9:15 Reducing the Risks of Another Blow-Out: Three Perspectives

- Elisabeth Paté Cornell, Stanford University
- Ford Brett, PetroSkills

10:30 Break

10:45 Three Perspectives, Continued

- Greg Anderson, Moody International

11:15 Formulating a "Top 10" (or top 5 or 3 or…) List of Strategies to Reduce the Risks of A Recurrence of a Blowout: Convergence on a Consensus

12:00 Working Lunch: Discussion Continued

1:00 Offshore Oil Production and Marine Terminal Spill Prevention Programs for the Protection of California State Waters, Greg Scott, California State Lands Commission

1:30 Enhancing the Effectiveness & Efficiency of Responding to a Blow-Out or Major Spill.

- Assessment of the State-of-the-Art of
  - Skimming
  - Dispersants
  - Burning

  Lieutenant Commander Angelina Hidalgo, Assistant Chief of Law Enforcement, U.S. Coast Guard, Los Angeles-Long Beach Sector.

2:30 Break

2:45 Identification of R & D Needs and Discussion

3:45 Perspectives on Reducing the Risk of Another Blowout and Responding More Efficiently & Effectively When One Does Occur. Everyone is Invited to Comment. Each Presentation is Limited to 5 Minutes.

4:45 Summary of the Day: A Convergence on Consensus

5:30 Adjourn for the Day

6:30 Reception at the Aquarium of the Pacific

October 22, 2010

8:30 Overview of Objectives for the Day (Jerry Schubel)

8:45 "The Kind of World We Could Leave to Our Grandchildren Unless We make Major Changes in Our Energy Choices on a Global Scale Soon." (Richard Somerville, UCSD)

9:15 "Strategies to Put Us Onto a Different Trajectory. Observations on Designing and Executing Effective Public Outreach Campaigns." (Meredith Blake, Cause & Affect)

9:45 "Perspectives on Generating Movement Away From Fossil Fuels." Everyone is Invited to Comment: Each Presentation is Limited to 5 Minutes.

10:30 Break

10:45 Perspectives Continued

11:00 The Current U.S. Mix of Energy Sources

11:30 Energy Use By End-Use Sector—And Opportunities for Conservation and Shifts Away from Fossil Fuels

- "Transportation Sector: Implications of Climate Stabilization for Energy Use in Transportation—the Demand Side of Shifting Away from Fossil Fuel Use." (Wayne Leighty, Sustainable Transportation Energy Program, UC Davis Institute of Transportation Studies.)

12:00 "Advanced Automotive Technologies and the Role of Government" (Robert Bienenfeld, American Honda Motor Co., Inc.)

12:20 Working Lunch

- Industrial Sector Energy Use
- "Buildings—Commercial and Residential" (Woodrow W. Clark II, Managing Director, Clark Strategic Partners)

1:15 The U.S. Electrical Generation Industry

- "Observations on Opportunities and Obstacles for Reduction of Dependency on Fossil Fuels in the Electric Generating Industry." (Bob Foster, Mayor of Long Beach, Former CEO of Southern California Edison)

1:45 "Renewables: Getting From Promise to Performance—What Will It Take?" (Ed Feo, USRG Renewable Finance)

2:15 "A Promising Source of Biofuel That Offers Other Benefits: The Omega Project. (Thomas Grimm, The Omega Project)

2:30 A "Ten Point" (or 5 point, or ...) To Move Away From Fossil Fuels: Converging on a Consensus.

Appendix B

Names and Contact Information of Participants

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Retired President
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Appendix C
Brief Biographies of Participants

Greg Anderson
Greg Anderson is president of the Consulting & Training division of Moody International (MI C&T). MI C&T specializes in providing behavior-based safety and Leadership training for companies operating in high-risk environments, as well as Well Control and other technical training specifically for the petroleum sector.

Anderson is considered a leading authority on creating a culture of safety in organizations and has conducted training and spoken on this topic for more than seven years. A true internationalist, Anderson has lived, worked and traveled to more than 40 countries. Some of the more interesting aspects of his career involved battling oil fires in Kuwait, providing infrastructure for large industrial projects in Haiti and drilling for oil in Egypt. Anderson is co-author of *Safety 24/7* a book about how to build an incident-free culture in the workplace. He earned a Bachelor of Science degree in public affairs from the University of Southern California, where he was a three-time All American athlete.

Sean Anderson, Ph.D.
Sean Anderson is an Assistant Professor of Environmental Science and Resource Management at California State University Channel Islands. He created and leads the NCEAS National Working group on the Ecotoxicology of the Gulf Oil Spill. Sean is a broadly trained coastal ecologist who has assessed environmental impacts for the past two decades, increasingly within the context of large-scale ecological restoration projects. His work on coastal pollutants includes the effect of produced water from oil production on pelagic and demersal organisms, heavy metal contamination of coastal estuaries, emerging contaminant impacts upon endangered fish, mercury contamination of seafood, and nutrient loading across coastal watersheds.

While Sean has worked from Alaska to Antarctica, his current work centers around several large-scale ecological restoration projects in California, Louisiana, and eastern Turkey (for which his team was awarded the 2008 Whitley Gold Award for International Conservation). His passion for developing new science-based management tools is only rivaled by his passion for education. Sean's novel approach to teaching emphasizes community service and includes a course wherein students travel to New Orleans, Louisiana to examine drivers of wetland loss and policy failures, conduct post-Hurricane Katrina (and now post-*Deepwater Horizon*) environmental impact assessments, rebuild homes, and install community food gardens. Sean's energetic and innovative teaching efforts were acknowledged with the Maximus Outstanding Faculty of the Year award in 2007.

Sean is an elected or appointed member of several governmental and non-governmental boards and joint power authorities including California's Sustainable Seafood Initiative Panel and the Ventura County Resource Conservation District.

Rear Admiral Richard A. Appelbaum
Dick completed thirty-five years of active service in the United States Coast Guard. During his career, he experienced a broad variety of shipboard and shore-based operational and administrative assignments, including commands at sea and several positions within the field of law. He served on the East, West, and Gulf Coasts, The Great Lakes, overseas, and on the U. S. Coast Guard Academy faculty.

As a flag officer, Admiral Appelbaum commanded the Ninth (Great Lakes) and Eleventh (Pacific Southwest) Coast Guard Districts and the National Pollution Funds Center, which he created to manage the billion-dollar Oil Spill Liability Trust Fund established by the Oil Pollution Act of 1990, following the Exxon Valdez incident. Additionally, Admiral Appelbaum served in Coast Guard Headquarters as the Chief of the Office of Navigation Safety and Waterway Services, and the Chief of the Office of Law Enforcement and Defense Operations (Chief of Operations). As such, he directed every major operational program of the Coast Guard. He was the capital resources director for all Coast Guard ships, boats, and aircraft (fixed and rotary wing), as well as several types of shore units and training facilities.

Since retirement from active duty, Admiral Appelbaum has been of counsel to Keesal, Young, and Logan, a West Coast maritime and securities law firm. He also consults, privately and with The SPECTRUM Group. Admiral Appelbaum holds a Bachelor of Science degree (Engineering), with honors, from the U. S. Coast Guard Academy and a Juris Doctor degree, with honors, from George Washington University (National Law Center).

Captain Jerry A. Aspland
Capatain Aspland is President Emeritus of the California Maritime Academy, a campus of the California State University. Captain Aspland served as the Academy's President for five years beginning in 1996. The Academy is one of the six maritime colleges in the United States educating students to become part of the marine industry including becoming licensed officers for the merchant marine fleets of the world. In 1962 Captain Aspland graduated from the Academy to begin a distinguished career in the marine industry. His career began at sea as a third officer and ended in 1968 serving as Master of a US flag tanker. In 1971 he received his Masters of Business Administration degree from California State University, Long Beach with emphasis in general management and personnel. After assignments in the marine transportation fields of liquid bulk cargoes and liquefied natural gas, Captain Aspland joined the Atlantic Richfield Company in 1978 as the navigation and safety manager for ARCO's marine tanker subsidiary. In 1985 he assumed the Presidency of ARCO Marine, Inc. and remained in that position until his retirement in 1995. During his tenure he not only made significant changes to the culture and management of the company but played a significant role in the development and implementation of safety and operation laws and regulations for the tanker industry in the United States. In 1995 the US Coast Guard recognized Captain Aspland's contribution by presenting him with the U.S. Coast Guard's Distinguished Public Service Award, the Coast Guard's highest civilian award.

Robert Bienenfeld
Robert is Senior Manager for American Honda Motor Co., Inc. Bienenfeld's current responsibilities include Environment and Energy Strategy for Honda's Product Regulatory Office. He is part of a team responsible for reviewing legislative proposals and regulatory rule-making as it relates to the automobile and its impact on the environment.

Bienenfeld is also responsible for long-term trend reporting, future product opportunity analysis, consumer research and brand and model attribute tracking. In addition to Bienenfeld's responsibilities in strategic planning, he is an advisor on product development review committees, and serves on the Safety and Environment planning committees. Just prior to his current position, Mr. Bienenfeld was an Advisor to Honda's Product Review Committee, and was responsible for Strategic Research and Planning. Other previous responsibilities include: Honda and Acura Product Planning, New Business Development, Alternative Fuel Vehicle Sales and Marketing, and Intellectual Property Management (Licensing).

Key accomplishments include: the proposal for Honda's Safety for Everyone strategy; the introduction of telematics in the Acura Brand; Honda's investments in Flexcar, a car-sharing company (now merged with Zip Car) and FuelMaker, a home refueling appliance for CNG; as well as the sales and marketing launch of Honda's first battery electric car, the EV PLUS, the Civic GX natural-gas powered vehicle, and the Honda Insight, the first gasoline-electric hybrid vehicle sold in the United States. A 20+ year Honda veteran, Bienenfeld spent 10 years marketing alternative fuel vehicles, and continues advising the company on alternative fuel vehicle infrastructure strategies. During that 10-year period he was a board member of the Electric Vehicle Association of America (EVAA) and Chairman of the Natural Gas Vehicle Coalition (NGVC). He has been a speaker at alternative fuel vehicle industry conferences. Bienenfeld graduated from St. John's College in Santa Fe, New Mexico and resides in Long Beach, California. He is on the Board of Visitors and Governors of St. John's College.

Meridith Blake
Meredith Blake is a nationally recognized public interest attorney and social entrepreneur with twenty years of experience in creating positive social change. Founder and CEO of Cause & Affect, a strategy consulting and management firm in the business of high-impact social change, Meredith works with clients to create social action campaigns that use entertainment media as a catalyst for movement-building—delivering superior value to businesses, social enterprises and influencers in entertainment and media. Prior to launching Cause & Affect, Meredith worked as Executive Vice President at Participant Productions where she oversaw the social action campaign accompanying Vice President Al Gore's Oscar-winning documentary, "An Inconvenient Truth". Before building the social action department at Participant, Meredith spent ten years running Break the Cycle, the nonprofit organization she founded to empower youth to end domestic violence. She lives in Los Angeles with her husband, Jeremy, and their two sons.

J. Ford Brett
Ford is Managing Director of PetroSkills – the world's largest petroleum training organization. In 2010 PetroSkills will train some 18,000 petroleum professionals in more than 50 countries. Prior to joining OGCI, he was with Amoco Production Co. where he worked on drilling projects in the Bering Sea, North Slope of Alaska, Gulf of Mexico, offshore Trinidad, and Wyoming. He was honored by the 2000 Crosby Medallion for Global Competitiveness from the American Society for Competitiveness for its work in "global competitiveness through quality in knowledge management, best practices transfer, and operations improvement". In 1996, along Tommy M. Warren as co-inventor were honored for their work on improved drilling techniques with a nomination for the National Medal of Technology, the US Government's highest technology award. Mr. Brett has been granted over 30 U.S. and International patents, authored or co-authored over 30 technical publications, and has consulted in the area of technical and drilling project management in over 35 countries. He is a member of Phi Beta Kappa, and holds a B.S. in mechanical engineering and physics from Duke University, an M.S.E. from Stanford University, and an M.B.A. from Oklahoma State University.

Woodrow W. Clark II, Ph.D.
Dr. Clark founded Clark Strategic Partners (CSP) in 2004, whose major clients have included: Energy Advisor, LA Community College District; Renewable Energy Advisor for Paramount Pictures (solar and renewable systems); Senior Foreign Energy Advisor (Asian Development Bank) Inner Mongolia Autonomous Region (IMAR), Peoples Republic of China . Currently he is Co-Chair, CleanTech Institute, University of California, Berkeley, Haas Business School Executive Program, "Green Advisor" to the State of California, Workforce Investment Board and "Green Advisor" to the Producers' Guild of America. In 2007, Clark was a co-recipient of the Nobel Peace Prize due to his co-authorship and co-editorship for the United Nations Intergovernmental Panel on Climate Change (IPCC) from 1995-2000. Clark co-authored "Agile Energy Systems: global lessons from the California energy crisis" (Elsevier Press 2004). His last book was "*Qualitative Economics: toward a science of economics*" (Coxmoor Press 2008) and most recent is "*Sustainable Communities*" (Springer Press December, 2009). Clark's next book is "Sustainable Development Partnership Mechanisms" (Elsevier Press, due in the Fall 2010). "*The Third Industrial Revolution*" is being reviewed now for 2010 publication.

William H. Collier, Jr.
Bill was born in Galveston, Texas in 1952 and attended Rice University where he received a B.A. degree *(cum laude)* in 1975. While at Rice, he was President of Sid Richardson College and Chairman of the University's Honor Council. He later obtained a J.D. degree from Tulane University in New Orleans in 1978. He is admitted to practice law in the courts of Texas, Louisiana and California. Mr. Collier joined Keesal, Young & Logan in 1980 and became a shareholder in 1984. He heads the firm's trade and transportation group from the firm's Long Beach office.

Mr. Collier primarily practices in the area of civil litigation and represents multinational companies involved in international trade and marine transportation as well as oil and refining companies and marine and energy

underwriters in connection with commercial disputes, casualties, personal injuries and environmental matters. He has significant trial experience in both the state and federal courts of California, and is "AV" rated by Martindale-Hubbell.

Mr. Collier is Chairman of the Board of Trustees for Torrance Memorial Medical Center. He is also a Director of the U.S. Coast Guard Foundation, a Board Member of the International Trade Education Program, a Board Member of The World Trade Center Association of Los Angeles/Long Beach, a Board Member of the Long Beach Qingdao Sister Cities Association, a Board Member of the International Seafarer's Center and a Board Member of the International City Theater. He has been recognized repeatedly as one of Southern California's "Super Lawyers" by the editors of *Law and Politics Magazine* and for the 12th year by *Best Lawyers in America*, a publication of Woodward

Edwin F. Feo

Ed is a former partner in the international law firm of Milbank, Tweed, Hadley & McCloy LLP. He co-chaired the Firm's project finance and energy practice. Mr. Feo was named in 2010 by the National Law Journal as one of "The Most Influential Lawyers of the Decade" for his work on energy and environmental transactions. He was the only attorney to be named one of the "Five Most Influential People in Renewable Energy" in 2008 by Institutional Investor. While at Milbank, Ed led their renewable energy team which was recognized as one of the leading renewable energy law firms in the world, having been named in 2010 as the leading global M&A legal advisor and leading global project finance firm by Bloomberg New Energy Finance. He is currently a founder and managing partner of USRG Renewable Finance, a company providing long term financing of renewable energy projects. Ed graduated with a B.A. and J.D. from UCLA, and was elected to Phi Beta Kappa, the Board of Editors of the UCLA Law Review and Order of the Coif. He is a member of the Board of Governors of the Aquarium of the Pacific and the Board of Directors of the Pacific Coast Sailing Foundation.

Thomas Grimm

Tom is an entrepreneur with a successful history of creating and producing innovative, collaborative projects in partnership with academia, business, and government. Thomas is a lead contractor and technical advisor for the NASA Ames Research Center, presently focused on the technology transfer and commercialization of the OMEGA Project, (Offshore Membrane Enclosures for Growing Algae). The OMEGA project is being developed to meet the needs of commercial-scale microalgae cultivation for biofuel production in a way that does not compete with agriculture for land, water or fertilizer. OMEGA is being developed to generate biomass and biofuels, while sequestering CO_2 from the atmosphere. OMEGA systems are designed to improve environmental conditions in marine ecosystems by preventing harmful algae blooms. The OMEGA system involves floating photobioreactors made of inert plastic modules filled with treated domestic wastewater from offshore outfalls. The forward osmotic membrane in the OMEGA modules concentrates the nutrients in the wastewater to stimulate increased algal growth, while purifying the wastewater and producing freshwater that can be captured or released into the surrounding area, enriching the local marine habitat. Near term plans involve pilot-scale testing in San Francisco in collaboration with the San Francisco Public Utilities Commission. Field testing sites for

OMEGA are being indentified in Chesapeake Bay with the support of the Chesapeake Bay Commission and in San Diego Bay in collaboration with the U.S. Navy.

Robert S. Grove
Bob is a Senior Scientist, Southern California Edison Company, Environmental Projects. Bob has worked in ocean-related projects for Edison for 37 years, and has been responsible for marine environmental monitoring and marine impact studies as they relate to the Edison's coastal facilities. He is a member of the technical team that manages scientific and engineering input for a kelp mitigation project. Further, he was on the technical team that developed the 150-acre wetland restoration at the mouth of the San Dieguito River in San Diego. Bob has taught the Ocean Science class at the Art Center College of Design in Pasadena, 2001 – present. Bob studied oceanography and marine ecology at Woods Hole Oceanography Institution through Sea Grant - University of Michigan; and has a BS degree in Oceanography from the School of Engineering, University of Michigan.

Michael M. Hertel
Dr. Hertel has spent more than three decades as a national leader, advisor, and analyst in the field of environmental policy and protection. Currently the Director of Corporate Environmental Policy for Southern California Edison Company, Dr. Hertel manages the Company's programs and activities in the areas of environmental issues, legislation, regulation, and policies. In addition, he oversees the Company's communications with such agencies as the US and California Environmental Protection Agencies, the California Air Resources Board, the South Coast Air Quality Management District, and the California Water Resources Control Board, the California Coastal Commission, and the California Department of Fish and Game among many others. From 1971 to 1972, Dr. Hertel was Assistant Professor of Political Science & Government at Pitzer College, a member of the Claremont Colleges. He taught courses in environmental policy, urban planning and American government. Dr. Hertel is a graduate of California State University at San Jose where he received his B.A. (International Relations) in 1967. In 1970, he earned his M.A. (Government) from Claremont Graduate School and went on to earn his Ph.D. there in 1972.

Lieutenant Commander Angelina Hidalgo
Angelina is currently the Assistant Chief of Law Enforcement at Coast Guard Sector Los Angeles-Long Beach, California. Specifically, she coordinates Coast Guard law enforcement efforts in the ports of Los Angeles and Long Beach to include the surrounding harbors and marinas. She also oversees the operations of four Coast Guard Patrol Boats assigned between Morro Bay and St. Clemente, California. Her previous operational assignments include Commanding Officer of Coast Guard Cutter KINGFISHER an 87 foot Patrol Boat homeported in Jacksonville, Florida and as Deck Watch Officer aboard Coast Guard Cutter DAUNTLESS, stationed in Galveston, Texas. While assigned to KINGFISHER she became the nation's second Coast Guard Hispanic female to command a Coast Guard Cutter.

In 2005, after earning a Master's Degree in Strategic Intelligence from the National Defense Intelligence College in Washington D.C., Lieutenant Commander

Hidalgo served as a maritime terrorism analyst at the National Counterterrorism Center where she was responsible for writing and briefing threat assessments for the White House and to key policymakers. Upon the conclusion of her intelligence tour, she served as protocol officer on the staff of Admiral Thad W. Allen then Commandant of the Coast Guard. Most recently, she served as the strategic planner and scheduler for Admiral Allen in his capacity as the National Incident Commander for *Deepwater Horizon* Response efforts on the Gulf coast. A 2000 graduate of the U.S. Coast Guard Academy in New London, Connecticut, Lieutenant Commander Hidalgo earned a Bachelor of Science Degree in Government. A California native, she is the oldest daughter of Luis Hidalgo Jr. and Yolanda Cisneros. She is married to Commander Sean Carroll who currently serves as the Coast Guard's liaison to the Motion Picture Industry in Los Angeles. Her personal awards include a Coast Guard Meritorious Service Medal, two Coast Guard Commendation Medals and two Coast Guard Letters of Commendation.

Conrad C. Lautenbacher, Ph.D., Vice Admiral (USN Ret.)
Adm. Lautenbacher currently is Vice President, Science Programs, at CSC Corporation and working to expand CSC expertise and develop new business opportunities in earth sciences related services and climate change applications. As former head of the National Oceanic and Atmospheric Administration from 2001 to 2008, he directed an extensive review and reorganization of NOAA to meet the environmental challenges of the 21st century. Accomplishments include leading the development of the Group on Earth Observation (GEO), a body involving more than 80 nations and 51 international and intergovernmental organizations dedicated to building a global climate observation network to inform policy development. He previously headed the Consortium for Oceanographic Research and Education, now known as the Consortium for Ocean Leadership. Ocean Leadership is a Washington, DC-based non-profit organization that represents 94 of the leading public and private ocean research and education institutions, aquaria, and industry and seeks to increase basic knowledge and public support across the spectrum of ocean sciences. During his 40 year Navy career, he served as the Commander of the U.S. Third Fleet at sea, and the Deputy Chief of Naval Operations (N-8) in charge of programs, budget and force structure, while ashore.

Wayne Leighty
Wayne joined the Institute of Transportation Studies at UC Davis in 2006 as a technological optimist, having built and operated three alternative-fueled vehicles. Since then, he has earned three masters degrees—in transportation technology and policy, agricultural and resource economics, and business administration—and is nearing completion of a Ph.D. in transportation technology and policy. While at UC Davis, Wayne has also worked as an Emerging Venture Analyst at the UC Davis Energy Efficiency Center and participated in the Green Technology Entrepreneurship Academy of the UC Davis Center for Entrepreneurship. Wayne's research in the Sustainable Transportation Energy Program at ITS-Davis has included modeling of optimal petroleum production, analysis of barriers and benefits to repowering in the California wind industry, study of short-term electricity conservation behavior, and modeling of transition paths in the transportation system to achieve deep reductions in greenhouse gas emissions.

Wayne has accumulated experience as Chief of Staff for an Alaska state Senator, as a high-potential MBA intern with Shell Chemical, and as an intern with the Advanced Technology group at Southern California Edison where he worked on smart grid and plug-in vehicle planning. In December, Wayne and his wife will return to their home state of Alaska to work with Shell Oil in the Regulatory Affairs and Permitting group of Sustainable Development.

Bill O'Toole
Bill has worked for THUMS Long Beach company for over 30 years. He began at THUMS as a Drilling Engineer and has held various positions over the years, including Production Engineer, Island Superintendent, and Safety and Environmental Coordinator. He is currently the Health, Environment and Safety Manager for Oxy Long Beach, which oversees the Thums operations. Prior to working at Thums, Bill worked five years as a seasonal lifeguard in Long Beach, primarily at Cherry Street Beach. Bill has a BS in Mechanical Engineering from Cal Poly Pomona and a Masters in Business Administration from Cal State Fullerton. Bill is an avid backpacker and camper and enjoys water related activities, including swimming most days of the week and an occasional scuba dive.

M. Elisabeth Paté-Cornell
Professor Paté-Cornell has been chair of MS&E at Stanford University since its creation in January 2000. Her research has focused on the extension of probabilistic risk analysis models to include organizational factors with application to a wide variety of problems such as the management of the tiles of the space shuttle, offshore platforms during oil and gas production, and anesthesia during surgery. She is currently working on mathematical models that allow management of programmatic risks for the development of safety-critical systems, for instance, in the space industry. Professor Paté-Cornell was recently elected to the French Académie des Technologies for her work in engineering risk analysis.

Karla Perri
Karla is a Principal in The Spectrum Group, a consulting and government affairs firm. At Spectrum Ms. Perri co-manages the environment and energy division and works on various issues related to national security, energy, and environment. She also consults on DoD health affairs matters for clients with innovative drug and device products. Ms. Perri has strategic responsibility for marketing business to commercial and federal clients, and provides advice to position private sector clients for the government marketplace. She provides strategic direction for working with federal funds at the state and local level, and is conversant on the federal grant process in the energy and environmental area. She recently helped a port client write a grant proposal, with an emphasis on environmental sustainability, from which they were awarded over $6 million in DOT TIGER funds to rebuild the port. She is an expert in the Congressional authorizations and appropriations process and the federal budget process. This knowledge allows her to provide business development and execution strategies for companies interested in taking advantage of federal technical and policy programs that seek innovative solutions.

From 1997-2001, Ms. Perri was the Assistant Deputy Undersecretary of Defense for Environment and had oversight responsibility for a $2 billion dollar defense department environmental remediation program. She also had worldwide responsibility for the Defense Department's Base Realignment and Closure (BRAC) program. She received the Secretary of Defense Medal and award for Exceptional Public Service, January 2001, for numerous accomplishments and contributions having a significant impact on national security.

Ms. Perri spent the majority of her career interacting with Members of Congress and their staff on issues of national importance. She began her career as an analyst at the Congressional Research Service, specializing in environment and natural resource issues. She then moved to the Senate to work on agriculture and environmental issues, was a chief lobbyist with a major trade association, and interacted on legislation before the major Congressional committees on Environment, Energy and Natural Resources. Ms. Perri has also practiced environmental law and worked at the U.S. EPA in both the Office of Pesticides and Toxic Substances, and the Office of Air and Radiation, climate change division. She produced numerous Congressional publications and has spoken at many conferences and events as a Congressional expert and on national issues while at EPA and at the Department of Defense. Ms. Perri has executive level as well as program level contacts at EPA, DOE, USDA, DoD and DHS.

Ms. Perri received a J.D. from the George Washington School of Law, and has a Masters in Public Administration from Colorado State University. She received her Bachelor of Arts from the University of South Carolina.

Jerry R. Schubel

Dr. Jerry R. Schubel joined the Aquarium of the Pacific as president in June 2002. He also directs the Aquarium's Marine Conservation Research Institute. He was dean and director of the Marine Sciences Research Center at the State University of New York at Stony Brook. He is a distinguished service professor emeritus, and an endowed graduate fellowship has been created in his honor. He is an honorary Professor of East China University in Shanghai. In 2004 Schubel was selected as a National Associate of the National Academies. He has served on a number of National Research Council commissions, committees, and boards and chaired the Marine Board. He is past chair of the National Sea Grant Review Panel and has served on the National Science Foundation's Education and Human Resources Advisory Council, and US EPA's Science Advisory Board. He was a member of the Marine Board, chaired the St. Lawrence Seaway Committee for the National Research Council, chaired the Ocean Research and Resources Advisory Panel, and was a member of the Science Advisory Team for the California Ocean Protection Council. He is president emeritus of the New England Aquarium, where he was president and CEO from 1994-2001. He has written extensively for both scientific journals and for general audiences. He has published more than 200 scientific papers and is the author or editor of six books. A Michigan native, Schubel holds a Bachelor of Science degree with honors from Alma College, Alma, Michigan; a Masters degree from Harvard University; and a Ph.D. in oceanography from John Hopkins University in Baltimore, Maryland. He received an honorary doctorate from the Massachusetts Maritime Academy in 1998.

Gregory D. Scott
Greg is the Division Chief of the California State Lands Commission's Mineral Resources Management Division located in Long Beach. Mr. Scott has spent over 20 years with the State Lands Commission overseeing oil and gas activities on offshore State leases in the Southern and Central California coastal areas. He is responsible for the protection of the State's mineral resources and for the development of safety and pollution prevention programs that minimize the risks associated with development of those mineral resources. The State Lands Commission regulates all offshore oil and gas activities in State waters, including offshore drilling, platform operations, subsea oil and gas pipeline operations and maintenance, and performs frequent inspections of equipment associated with these activities. Previously, Mr. Scott worked in the oil industry for over 18 years as Petroleum and Production Engineer with Texaco, Inc., in Midland, Texas, and Production Manager with Union Pacific Resources Company in Denver, Colorado. He received his Bachelor of Science Degree in Mechanical Engineering from California State University Long Beach.

Richard C. J. Somerville
Richard, a theoretical meteorologist, is Distinguished Professor Emeritus at Scripps Institution of Oceanography, University of California, San Diego. His Ph.D. is from New York University, and he has been a professor at Scripps since 1979. He has received awards for both his research and his popular book, *The Forgiving Air: Understanding Environmental Change*, a new edition of which was published in 2008. His honors include election as a Fellow of both the American Association for the Advancement of Science and the American Meteorological Society. Somerville was a Coordinating Lead Author for the most recent climate science assessment report of the Intergovernmental Panel on Climate Change (IPCC). The 2007 Nobel Peace Prize was shared equally between Al Gore and the IPCC.

Michael E. Utt
Mike is a native of Corvallis, Oregon. He graduated from Oregon State University in 1969, and entered the U.S. Navy. He was commissioned an officer in the Navy Civil Engineer Corps, and spent most of his active duty time in San Diego. Upon leaving the Navy in 1972, he returned to Oregon State, where he earned a Master's degree in the Ocean Engineering program.

He joined Union Oil Company of California in 1974. His first job was as an engineer in the Reservoir, Ocean and Arctic Engineering group of the Research Department in Brea, California. In 1986, he became Supervisor of Ocean & Arctic Engineering. In the following years he held several management and technical positions, all related to oil and gas drilling and production technology. In 1995, he moved to Sugar Land, Texas with Unocal's Exploration & Production Technology group. He retired in 2004 from the position of Manager, Deepwater Technology, in Unocal's Engineering & Construction organization. Mike is currently a self-employed engineering consultant, based in Yorba Linda, California. In addition to consulting for oil industry organizations, he currently serves as Chairman of the Los Angeles Section of the Society of Petroleum Engineers.

Joseph A. Walsh II
Joe is a principal with Keesal, Young & Logan, a US based law firm with national and international reputation as a leading law firm in maritime and environmental law. He is a 1983 honors graduate of the U.S. Merchant Marine Academy at Kings Point, NY. He received his J.D. degree, *cum laude*, from the University of Arizona. He retired with the rank of Captain from the U.S. Navy following over 26 years of continued service on active duty and reserve tours. Capt. Walsh also held licenses issued by the U.S. Coast Guard as Master (1600 tons) and Second Mate (Unlimited).

Joe's practice focuses primarily on oil and chemical pollution matters, casualty investigation and crisis response. He has served as lead counsel for responsible parties in unified command activities, third-party claims, and natural resource damage assessments. Joe has also been involved in numerous investigations and criminal enforcement actions initiated by federal and state agencies throughout the U.S. relating to pollution. He has led internal investigations, audits and implementations of environmental compliance programs in defense of those actions. Joe is credited with successfully trying to a jury what is believed to be the nation's first third-party lawsuit under the Oil Pollution Act of 1990 ("OPA '90") resulting in a favorable verdict in excess of $5 million. He acted as lead counsel in several high profile incidents including a 1997 vessel fuel oil spill in Northern California and off-shore and on-shore pipeline ruptures in 1997 and 2005 in Central California. He is currently the lead attorney on behalf of the Responsible Party and its underwriter with respect to the November 2007 bridge allision and oil spill in San Francisco Bay. Joe has published articles and presented on pollution matters in national and international forums. He is a Proctor in Admiralty in the Maritime Law Association of the United States. He has been recognized for inclusion in *Best Lawyers in America* (Woodward), and listed in *Chambers USA* (Chambers & Partners).

Evan H. Zimmerman, JD
Evan is the Manager of Technical Services for Delmar Systems, Inc. and Technical Director of Delmar North Sea LTD. He holds a bachelor of science in Ocean Engineering from Texas A&M University and a Doctor of Jurisprudence from the South Texas College of Law. He serves as a council member and technical subcommittee chair of the Marine Technology Society, member of API subcommittee 2 which oversees all API standards for offshore structures, and sits on the advisory board of Texas A&M University's Ocean Engineering program. He is also an active researcher in various industry and government funded projects aimed at improving safety, efficiency, and technology.

Evan is a patented inventor of various anchor technology and founding author of ConStat, an offshore risk assessment software and database. He received the Corporate Leadership Award from the MMS for providing leadership in addressing mooring reliability and improving anchoring, as well as demonstrating outstanding commitment to providing the best and safest practices in the offshore oil and gas industry. Evan has also received various other awards from the Offshore Operator Committee, API, the Marine Technology Society, the Offshore Technology Conference, and the Society of Naval Architects and Marine Engineers.