From the Beginning: The 40 Year History of NOAA's Emergency Response Division

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The National Oceanic and Atmospheric Administration (NOAA) Emergency Response Division's success over 40 years draws on the nascent and sustained vision of its founders and the people that dedicated themselves to providing state of the art science in combatting oil spills and hazardous material releases. Lessons in research, development, partnership, reinvention, reorganization, and adaptation season the story that describes what is now the scientific touchstone in the United States' maritime spill response vanguard. But the voyage to present day was (and is) not all smooth sailing. The scientists who built the unit and staffed it for decades recall the best, worst, and in between history of a small but highly influential division in the Federal government that helped pioneer spill science in the United States and internationally by responding to over 4,000 incidents. This retrospective highlights the genesis and growth of the 1970's Outer Continental Shelf Environmental Assessment Program (OCSEAP) and its evolution through Hazardous Materials Response Division (HMRD) to the now Emergency Response Division (ERD). The paper concludes with the vision of what growth areas lie ahead for the Division and oil spill response.

Borne in Disaster

Dark and stormy nights at sea have likely brought about a few disasters. But darkness and storms aren't always the precipitators for misfortune; humans contribute as well. The T/V Argo Merchant was sailing to Salem, MA, in December of 1976 laden with 7.7 million gallons of #6 heating oil when a combination of poor seamanship, ill preparation, and rough weather grounded her on Middle Rip Shoal off of Nantucket, MA. Within days, the hull structure was compromised from unforgiving wave and tidal action and the entire contents of the cargo spaces were ejected into the sea. Providentially, the oil drifted away from shore and Nantucket Island. This major oil spill also gave rise to a scrappy and innovative team within the U.S. government that would combat oil spills for the next 40 years (NOAA, 1977).

1969's Santa Barbara, CA, oil well blowout made environmental scientists keen on the idea of how to better clean up and address unintentional pollution in the ocean. The Outer Continental Shelf Environmental Assessment Program (OCSEAP), a consortium of a number of Federal agencies in the mid 1970s saw the need to better understand the behavior of oil in the marine environment. John Robinson, at the time working for the National Oceanic and Atmospheric Administration's (NOAA[1]) Pacific Marine Environmental Laboratory in Boulder, CO, saw an opportunity. Cobbling together a small band of experts, the Spilled Oil Research (SOR) team's job was to determine the trajectory and fate of the pollutant on the surface of the ocean. Onscene Spill Simulation Model (OSSM) was the first model designed in house using FORTRAN and punch cards

[1] NOAA had only been an agency since 1970 when President Nixon decreed it in an Executive Order. NOAA was placed within the Department of Commerce.

(Torgrimson, 1981). Robinson's vision was that this team would travel on scene to consult with the U.S. Coast Guard but would also be supported by a "home team" of scientists that could work outside of the chaos of the command post and focus on the problems of prediction and clean up. The Modeling and Spill Simulation Team (MASS) complemented the Scientific Support Coordinators (SSC) who often times were the literal eyes and ears of NOAA at a spill scene.

Pulling people from various disciplines and backgrounds, Robinson's assembled force would launch an array of products that led (and still lead) the world in understanding the behavior of oil in the marine environment. Given the primitive nature of the spill response industry and the remoteness of the locations they traveled to, Robinson was also keen on selecting people who could innovate on the spot and had diverse skills (at one point, field response employees were directed to either acquire a private pilot's license or diving certification.) But some of that innovation was also put to use in other areas that weren't that common: developing film in the sink of a remote motel, designing their own carrying cases for Apple desk top computers that were about to become "portable" computers, and devising their own tools for sample gathering. The driver was always the client and providing them with a legitimate scientific answer to their problem. By 1981 the scope and structure of ERD was laid out in the *Hazardous Materials Response Project: Program Plan (Anon., 1981)*

But about the time that the first oil spill modeling was taking place, there was also a cyber revolution taking place too: computers were transitioning from the major main frames to desk top units. In 1981, a significant transition took place when the NOAA main frame Boulder (Colorado) Cyber computer was abandoned for the MacIntosh ("Mac") desktop computer. The stepping stone to the Mac was an IBM 9000 with Fortran 4, a hard drive, and 8" floppy drives and cost less than $10,000. It took a year to convert the OSSM code so it would run on the IBM 9000. Soon thereafter, Hypercard on the Mac became the choice for programming; other computer code languages followed later. Moore's law, demand from the On Scene Coordinators, and the accelerated growth of the nascent World Wide Web propelled rapid advancement in the sophistication and features of the software that was being designed and how it was shared.

While the T/V Argo Merchant was the claimed genesis of ERD, it was followed in several years by the Ixtoc I blowout in Mexico. As oil moved north toward Texas, the SOR team, including Dr. Miles Hayes, conducted overflights and plotted trajectories, advising the On Scene Coordinator of the progress and fate of the oil. The anticipated spawn of clean up activity on U. S. soil resulted in the design of the Environmental Sensitivity Index (ESI). As 140 million gallons of crude oil was released in the Gulf of Mexico, NOAA contractors created ESIs to prioritize areas for environmental cleanup and highlight the natural resources that were already populating the areas. They proved immensely valuable and the value was not lost on other coastal states. ESI atlases now are on a periodic update cycle for most of the U.S. shoreline including Alaska, Hawaii, the Great Lakes, and the territories of Guam, Puerto Rico, and the U.S. Virgin Islands.

<u>Just Five Simple Questions</u>

Since the beginning of ERD, there have been some simply phrased questions that drove the objectives of the consultation that the scientific team provided:

1. What happened? (i.e. what got spilled?)
2. Where is it going?
3. Who gets hit?
4. How does it hurt?
5. What do we do about it?

The questions may be simple but the best answers are rarely so. ERD's "response" priority is within 15 minutes of notification to determine what material is or could be spilled (Question 1). This includes information about the physical/chemical nature of the material and its potential threat to life, and how much could be spilled. Within the first hour ERD's goal is to provide: 1) a preliminary forecast of the fate and trajectory of the material (Question 2, utilizing tools such as ADIOS and GNOME)); and, 2) what resources will be at risk (Question 3, an important outcome being the development of Environmental Sensitivity Indices (ESI), eventually for the entire nation.) As the response develops, ERD home team staff and contractors provide what is known about the response of resources at risk due to exposure to the material (Question 4). ERD then provides, to the extent possible, advice on counter measures that would help reduce the overall impact of the incident or spill (Question 5); this may include advice on response actions such as deballasting, places of refuge, or dispersant use and other countermeasures such as shoreline cleaners and bioremediation. Each event is different, each involves many details and consequences and each has its own set of "tradeoffs".

Over decades, the same five questions have calibrated and reminded the team of what they are to provide and why it matters. The questions also serve to acclimate the clients to ERD's focus areas.

T/V Puerto Rican foundered off of the entrance to the Golden Gate in San Francisco in 1984 when she experienced an explosion and fire in a void space adjacent to a cargo tank while inbound with a load of caustic soda. The vessel eventually sank in approximately 250 fathoms off the entrance to San Francisco's Golden Gate. What made this event pivotal in the history of ERD was that the trajectory was wrong; not just a little error but 180º off. The effect of getting that trajectory wrong sent the scientists to a quiet corner to figure out what led to the inaccuracy. In the end, the California long shore current was the culprit and the annual switchover had occurred (where it changes direction between north and south). But that oversight had a deeper impact. The trajectories and information that is produced by the Division means that resources are routed to particular locations, certain decisions get made based on the prognostications and opinions find foundation on the products that ERD generates. The general agreement was that ERD needed to not just be more careful (the answers still were needed in emergency situations) but it was better to not give an answer than to give a wrong answer. But it was almost a decade later, on the Tampa Bay spill in 1993, that the division devised a way to portray confidence in the product (Galt, 1997 a and b). The idea of visually depicting confidence bounds on the trajectories that came out of GNOME. In a way, some of the assumptions made in generating the trajectory were now on display for all to see (Beegle-Krause, 2001). By the time of the North Cape spill in 1996, GNOME Analyst had a confidence limit built into the display.

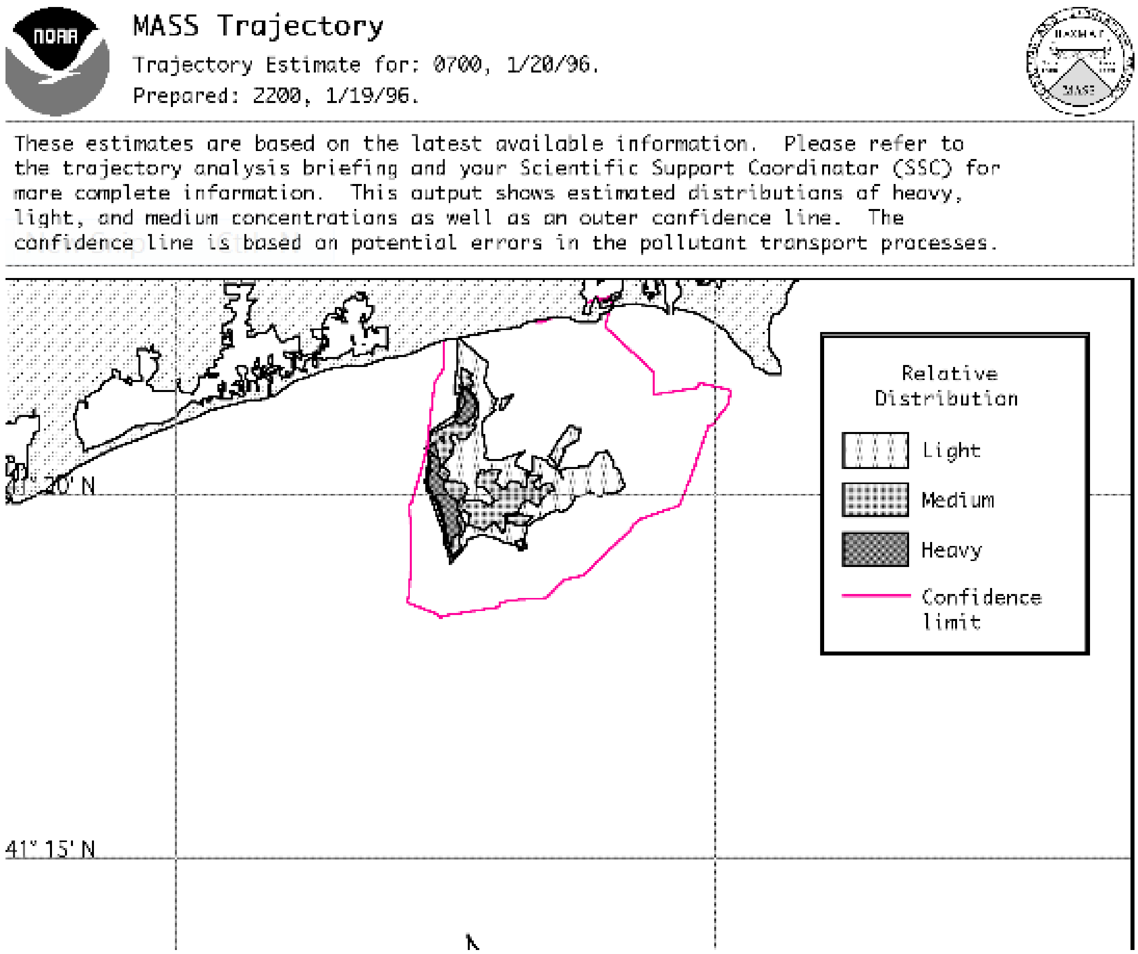


Figure 1. GNOME forecast from North Cape spill showing early depiction of the confidence contour. The single, colored line would later become a colored area that showed the 90% level of confidence.

Follow the Leader

Over the course of ERD's history, nine people have led the Division, as shown in Table 1.

John Robinson	1976-1991
David Kennedy	1992-1998
Jerry Galt	1998 - 2000
Michael Heeb	2001
Roger Parsons	2001-2002
Robert Pavia	2003-2004
William Conner	2004-2011
Debbie Payton	2011-2015
Scott Lundgren	2015 - present

Table 1. ERD leadership over 40 years

With only one exception, all of the leaders were from within NOAA and often from within the ranks of NOS or OR&R. That made for rapid integration of the leader and fostered trust. Retaining the knowledge capital in the team also benefited such a small group.

Leaders were the inspiration of some unique ideas. Sinking oils have been around for some time but responders often lacked a way to find them and clean them up. Jerry Galt's idea of dragging a weighted sorbent pad (AKA "dragging diapers") helped find some of the pockets of hidden oil down below on early spills. (More sophisticated techniques like side scan SONAR would help find sunken oil in the 2015 APEX 3508 barge case in the Mississippi River.) More often ERD leaders were responsible to explain and protect the team below while they worked problems. The political "spill" that occurs soon after an oil spill many times requires an expert of sorts to help tidy up. ERD leaders, though, are most valuable for the vision they produce. For the past eight years, ERD has worked from a "HAZMAT Operating Plan" (or "HOP") that guides the division on tasks for a year at a time. The HOP consists of five or six goal areas but is driven by goal zero – the areas that the leader wants to focus on in the long term. The Arctic, personnel continuity, sharpening tools and like topics have all made the HOP at some point. ERD leaders interface with the many national committees (e.g. National Response Team, Interagency Coordinating Committee for Oil Pollution Research) and teams that ERD serves on as well as higher levels of bureaucracy and they filter the commands from higher up.

Spill Response Tools Should Emulate A Fire Extinguisher

Clearly, ERD's approach evolved from academic experience and research. But it went, and continues to go, beyond. The programming and design work of ERD models must address the needs of novice spill responders as well as experts and so a lot of work was (and is) done on usability testing with actual responders in the field (Evans *et al.* 1999). The utility, look, feel and output of the tool has to resonate with some basic instincts of the responder i.e. human factors engineering goes into the tool design from the beginning.

This philosophy was addressed early on with ERD's development of CAMEO (Computer Aided Management of Emergency Operations) (Hielshiser et al., 1991), ALOHA (Areal Locations Of Hazardous Atmospheres) (Lehr et al., 2008), and ADIOS (Automated Data Inquiry for Oil Spills) (Lehr et al., 2002) with the idea being that responders, particularly to chemical hazards, could have a "tool in the fire truck" to assess risks on-scene at the local level[2]. The "fire extinguisher" is that the tool provided that should be useful to both levels of users. And it should provide value in the initial and critical phases of the response; an excellent fire extinguisher offered days after the structure is reduced to cinders has little value. ERD's CAMEO, ALOHA and Chemical Reactivity Worksheet (Farr et al., 2006) software met those criteria for tools that were trustworthy, rapid, and straightforward to use.

By 1989, and the Exxon Valdez spill, ERD had developed skills in fate and trajectory forecasting. The Exxon Valdez event ushered in new biology and chemistry staff to address emerging resource and resource use issues including ecological tradeoffs associated with aggressive shoreline cleaning (Mearns, 1996). Questions needed answers about the effectiveness and effects of bioremediation, shoreline cleaners, dispersants, and in situ burn residues. During the following decade ERD biologists, chemists, and contractors joined industry, government, and academia in various committee efforts to define testing and methods for effectiveness and effects of alternative cleanup approaches (e.g., Hoff et al., 1995; Mearns, 1997a and b; Shigenaka et al. 1994; Shigenaka et al., 1995; Daykin et al. 1994) resulting, in part, in the EPA product schedule, and including "small science" testing of products at subsequent spills. ERD biologists conducted a 10 year program monitoring the recovery of Prince William sound shoreline biota, documenting the effects and effectiveness of aggressive hydraulic shoreline cleaning (e.g., Shigenaka et al. 1999). ERD staff and contractors produced a number of job aids addressing effects of spills and response methods to sea turtles, coral reefs and mangroves and marshes.

[2] Evans, M., B. Lehr, D. Wesley and D. Simecek-Beatty. 1999. Why spill response should emulate a fire extinguisher. 63-67 In Proceedings, 1999 International Oil Spill Conference. API Washington DC.

During and following the Exxon Valdez there was increased concern about commercial and subsistence seafood safety. Closing fisheries was the easy part; re-opening them wasn't. Prompted by the SSCs, the ERD Biological Assessment Team led efforts, joined by NOAA fisheries, to develop seafood and subsistence fishery closure and reopening guidelines (Yender et al. 2002) and took advantage of spills to document contaminations and recovery of shellfish (e.g. Mearns et al., 2014).

The concept of Species Sensitivity Distributions (SSDs) developed in the late 1990's, prompted ERD and its associates to develop tools for quickly ascertaining the potential ecological effects of oil and chemical spills, introducing the Chemical Aquatic Fate and Effects (CAFÉ) tool (Bejarano et al. 2013 and Bejarano et al. 2016).

A Distributed and Diverse Presence

Early on, the founders of ERD recognized that scientific support staff were needed at key locations around the U.S. coastline. The original 1981 Hazardous Materials Response Project designated Scientific Support Coordinators (SSCs) to be located around the U.S. and eventually co-located with U.S. Coast Guard District offices (Anon, 1981) or units. ERD has maintained an active (and often refreshed) SSC presence in New England, the mid-Atlantic, Florida, California, Pacific Northwest, Alaska and the Great Lakes. Once notified at any hour of the day by the U. S. Coast Guard, the SSC quickly calls on ERD's home team experts for assistance, as needed.

The SSCs provide multiple layers of coverage for one another while they bring their own discipline to the response. SSCs arrive with an array of talents ranging from geology, oceanography, toxicology, chemistry, and biology, to name a few disciplines. The SSC, intentionally, has to be a translator of scientific data, facts, and results into operationally valuable information and intelligence. As well, they serve as a "truth broker" to the On Scene Coordinator: chromatograms, millibars of pressure, necropsies, LD50s, etc., can present a palette where chaos emerges instead of coherence. Sorting through the matrix of data to answer the crucial questions brings the SSC and the client credibility. SSCs have also been known to call out the "snake oil" salespeople that arrive at the doorstep trying to peddle a product or method that can do the trick at the response. The SSC is required to be fluent in a number of scientific disciplines, experimental processes, instrumentation, report outputs and theories; if they don't have the requisite knowledge, their diplomacy, and sometimes cunning, seeks out the scientists who can interpret the data. NOAA Corps officers also serve in the role of SSC and inject fresh perspective into the cadre as well as operational afloat experience from the NOAA fleet. Vice Admiral Michael Devany was one such NOAA SSC who later went on to become the Deputy Under Secretary for Operations in NOAA.

As ERD developed the Division needed additional support and sometimes in short order. It was recognized that other academic teams had valuable spill experience. Notably, ERD contracted with scientific consultants where several of the nation's scientific response staff were working. This resulted in a long-term collaboration for activities such as ESI production and additional spill response capability. Information management became a huge issue and ERD contracted with Genwest. In the absence of a chemical laboratory, ERD also contracted with expert chemists at LSU. Behind the scenes and sometimes alongside, ERD has been supported by expert logistics teams, including travel, cost recovery, information management, and other critical administrative functions.

<u>ERD goes to war</u>

The request was familiar: predict where the oil will go. The location was unfamiliar: the Persian Gulf. The cause: war and conflict. Iran and Iraq were pitched in battle and offshore platforms were targets, intentional or not. The era, however, was 1983. ERD deployed personnel to Department of Defense sites in the Middle East to assist with predicting and plotting the movement movement of the oil emanating from stricken platforms and vessels. Less than a decade later, ERD would return to the region for Operation Desert Storm as the Kuwaiti oil fields were lit afire or vandalized by the retreating Iraqi forces. What turned out to be an oil spill (really, spills) of mammoth proportions was perhaps the warm up for events that would appear closer to home. ERD also contributed to Department of Defense requests for support during Operation Iraqi Freedom.

Besides being a multi war “veteran”, the Division also collaborated with the Department of Defense on a number of other peace time projects. ERD regularly supported the U.S. Navy in annual field response exercises for oil releases involving foreign bases and deployed ships. The Division has shared software code and efforts with research arms of the Navy too. In 2006, ERD began a multi year project with the Department of Defense to study a site off of Hawai’i where munitions had been disposed of years prior. Peculiarly, ampules had washed up on the sands in Oahu and they were later traced to the munitions. The ability of ERD to model ocean currents and chemical releases was once again tested and adapted to attempt to establish a plausible pathway and speculation on the likelihood of further contamination (the risk was determined to be extremely low).

Though not a combat theater in the traditional sense, the 2010 Deepwater Horizon blowout would propel ERD as if the nation was at war; the iconic event required more of ERD than anyone could fathom. In fact, nearly every possible former member of the Division was contacted to see if they would consent to coming back to the team for a portion of the response. Many of those that were contacted did come back for portion of the fight. By contracting them through a number of channels, ERD was able to weather some of the turbulence in what was a struggle for years. Deepwater is chronicled in many other forms of literature and the lessons it taught were many. One of the lasting memories of the event was that not all events are scalable – Deepwater jumped orders of magnitude and ERD responded with some innovations that were both small and large.

Leading up to Deepwater, other major or highly influential spills (EXXON VALDEZ, ATHOS 1, Hurricane Katrina, NORTH CAPE, BERMAN, COSCO BUSAN and many others) gave the Division the annealing and experience that would be required to withstand the sustained pressure exerted by Deepwater. Decades of discussions, research, and deliberation on dispersants, shoreline cleaners, shoreline cleanup assessment technique (SCAT), bioremediation, three dimensional modeling and other topics would all come into play on this event. The "campaign" lasted well after the news crews left; ERD personnel would maintain some active connection to the response (not the assessment and restoration) for over five years.

Where did this come from?

Over the years, ERD has participated in a number of forensic searches on the sea. A notable incident in 1983 was the disappearance of flight KAL 007 over the Western Pacific ocean. The models that predicted the fate of oil on water could be adapted to predict the location of debris, couldn't they? ERD was able to assist investigators with information that was useful in this case.

The same code and assumptions that predicted oil movement could be used to render information about floating objects. GNOME was employed to hindcast (or give a reverse trajectory) for a number of cases over the years which included bodies, body parts, unmanned vessels, whale carcasses, mystery spills, dead birds, munitions disposed of at sea, and other objects. Though not often in the spotlight, the use of ERD talent in this arena can bring closure to either a grieving family or cast light on a promising lead for an investigator. In the case of oiled dead birds, hindcasting their journey has elucidated the likely source of the oil and points responders in the right direction. Whale strike information is often shared with other offices and agencies leading to enforcement actions.

One of the more recent episodes that had ERD adapting the GNOME tool was the Japanese tsunami marine debris event in March of 2011. The devastating earthquake and ensuing tsunami created millions of tons of marine debris. ERD was asked to prognosticate on the arrival times and locations of the debris on United States shores. This adaptation was an ocean wide stretch for the team - predicting the movement of objects with unknown features across thousands of miles with next to no data to initialize the model. For the most part, it guided expectations and helped to understand the progress of the debris. When individual items (boat hulls, dock pieces, etc.) began to appear in U.S. waters (where hydrodynamic models and input data could calibrate the GNOME), ERD was again tasked to predict the precise arrival time and location of the object on shore. Debris that began a multi-year journey caused a sensation but also tied ERD to a Japanese team that was also engaged in modeling the journey. Providentially, the outcome of a natural disaster thousands of miles away was greater oceanographic knowledge and friendship.

Whether from the necessity of the moment or the lessons learned following the last engagement, ERD has developed an impressive catalogue of products over the last 40 years. Many of the tools found in Table 2 are still in use and are frequently updated.

Software (partial list)	**Training Offerings (partial list)**
OSSM	Science of Oil Spills
GNOME	Science of Chemical Releases
ALOHA	Shoreline Cleanup Assessment Technique
ADIOS	California EROS
SHIO	Aerial Observer training (online and live)
ESI	International Oil Spill Conference short courses
CAFÉ	Specialty workshops
GOODS	U.S. Coast Guard Yorktown Training Center Crisis Management Class
TAP	U.S. Coast Guard Yorktown Training Center On Scene Coordinator Class
CAMEO	CAMEO

Spill Tools	Incident Command System
NUCOS	Northwest Oil Spill Control Class

Table 2. Listing of products and training offered by NOAA's Emergency Response Division.

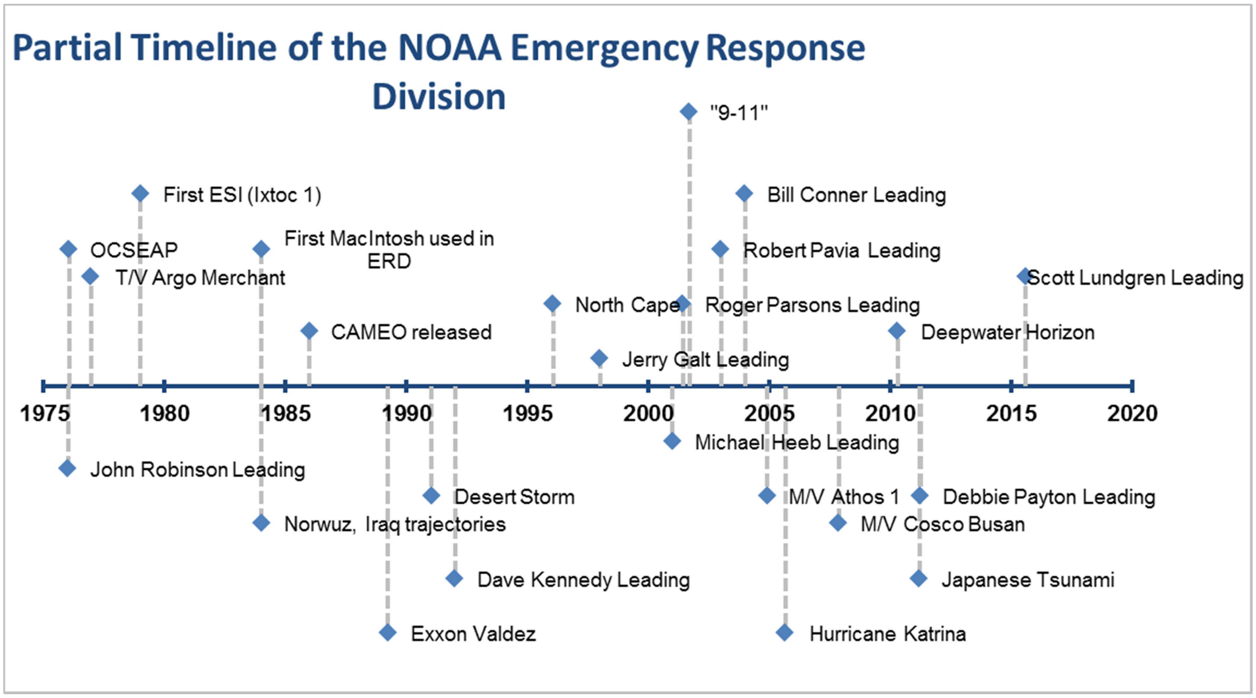
Postcards from afar

ERD travels the globe. With passport in hand, ERD has responded to spills in some far reaches including the Middle East, southern Chile, South Korea, Caribbean, Bangladesh, the South Pacific, and Europe to name a few places. Supporting the U.S. Coast Guard or the U. S. Department of State, ERD has seldom turned down an opportunity to assist another nation in need (e.g. Henry and Levine, 2003). The notoriety of the Division may have earned the invitation overseas but the experience gathered was infinitely valuable. Spills in the U.S. are often not that far from improved facilities, logistical support, and abundant reachback resources. This is not so in other corners of the globe. The nearest dock may be dozens of miles away, the danger of tiger attack looms in performing SCAT, or there are no storage barges or bladders; this is when the innovation muscles begin to twitch and advice is adapted to the materials on hand. Marine safety has over many years produced some perceptible payoffs from prevention and enforcement measures; experience in larger spills comes, unfortunately, at the expense of and on the shores of our international allies. Going abroad to consult on cases retains the edge on the ERD skill set while aiding a neighbor.

Besides doing casework abroad, ERD has also worked collaboratively with foreign governments and international organizations to further the understanding of response science and advancement of sound policy. ERD has taught courses in or hosted students from over 30 countries, cosponsors the triennial International Oil Spill Conference, attends multiple international conferences annually, supports international planning efforts with the Canadian, Mexican and Panamanian governments, supports other regional planning efforts (e.g. Association of South East Asian Nations - ASEAN), hosts visiting scientists from other nations, and assists in the U. S. delegation to the International Maritime Organization in London. In maintaining a vibrant and extensive network of associates internationally (as well as domestically), ERD has access to affiliates that are experts in portions of spill science that are not organically present in the cadre.

The Course Ahead

The NOAA Emergency Response Division (ERD) is the current permutation of what has been a forty year evolution that began in 1976 with the sinking of the T/V Argo Merchant. ERD now has 50 personnel (mostly federal employees but also including five NOAA Corps officers and over a dozen on site contractors) and offices in 12 locations. With an average annual training throughput of over 1,200, the Division has trained an estimated 40,000 students in its history, traveled to over 35 countries to consult on cases, and responded to over 4,000 cases with trajectories and advice. Given the relatively small size of the Division, there are 800+ years of experience embodied in the full time personnel.



The "eco-cowboy[3]" days are as bygone as saloons with swinging doors and hitchin' posts out front. Hazardous material responses are now part of the mainstream emergency response community and the instruments and processes needed to mount a successful response are quite common. Incident Command System is "spoken" widely. Within the government, every dollar spent receives attention and needs to show return; the expediency (and näivete) that could excuse some past actions is now more strictly governed by experience and greater organizational oversight. Non-governmental organizations and the public exert more interest in pollution incidents and, to a degree, raise accountability.

But there are always new challenges and some of those "frontiers" evoke the ingenuity that is part of the DNA in ERD. Shipping is moving to new locations (e.g. Arctic), vessel sizes are increasing, LNG as fuel is more common. Fluctuations in sea level make

[3] Seattle Times October 13, 1991

shoreline habitats more dynamic and changeable. Oils even from the same play change over time so even familiar products are subject to alteration; the matrix of products has grown too (e.g. Bakken, biofuels). There are new tools to take advantage of (e.g. drones and dogs for SCAT), computing power that wasn't accessible heretofore is now handheld, shipment by rail has changed the national dynamic and river spills may be on the rise.

Two certainties will greet ERD though: continue to answer the five questions and adapt. The Division anticipates a new phase ahead as retirements of senior associates occur and newer faces fill in. The threads of adaptation, innovation and adventure weave through the history of ERD and will continue in this small but mighty division within the National Ocean Service.

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