CALIFORNIA
DEPARTMENT OF FISH AND WILDLIFE
OFFICE OF SPILL PREVENTION AND RESPONSE

REPORT ON
BEST ACHIEVABLE TECHNOLOGY
MECHANICAL RESPONSE

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Table of Contents

EXECUTIVE SUMMARY 1
INTRODUCTION 1
SECTION I: OIL SPILL CONTAINMENT 5
Boom Technology 5
Types of Boom 7
Boom Performance and Failure 8
Current Procedures for Testing Boom Performance 9
Limitations on Current Boom Technology 10
Emerging Boom Technology 11
Recommendations 13
SECTION II: ON-WATER RECOVERY SYSTEMS 14
Skimming Technology 14
Types of Skimmers 15
Skimmer Performance and Failure 16
Skimmer Performance as a Function of Spill Encounter Rate 16
Testing Skimmer Efficiency 17
New ASTM Standard for Measuring Skimmer Capacity 17
Effective Daily Recovery Capacity 18
Estimated Recovery System Potential 19
Mechanical Recovery Calculator 20
Limitations in Current Skimming Technology 20
SECTION III: ON WATER RECOVERY SYSTEMS AND COMPONENTS 21
Vessel of Opportunity Skimming Systems 21
Response Vessel 21
Temporary Storage Vessels 22
Oil/Water Separators 23
Technological Advancements 24

Recommendations 26
SECTION IV: SHORELINE CLEANING 26
Shoreline Protection Overview 27
Rocky Intertidal/Cobble Habitat 27
Sandy Beach Habitat 29
Recommendations 31
SECTION V: AGENCY REQUIRMENTS 31
California Department of Fish and Wildlife Office of Spill Prevention and Response 31
Containment 32
Initial On Water Recovery 32
On Water Recovery 33
Current Requirements 34
Daily Recovery Rate 34
Bureau of Safety and Environmental Enforcement 35
U.S. Coast Guard 35
REFERENCES 37

FIGURES

Figure 1 Fence Boom 7
Figure 2 Curtain Boom 7
Figure 3 External Tension Boom 7
Figure 4 Fire-Resistant Boom 7
Figure 5 Tidal Seal Boom........ 8
Figure 6 NOFI Skimmer System 11
Figure7 MOS Sweeper System 12
Figure 8 DESMI Speed Sweep 12
Figure 9 NorLense Oil Trawl 12
Figure 10 ROC Barrier 12
Figure11 Boom Vane 13
Figure 12 Oleophilic Skimmer 15
Figure 13 Weir Skimmer 15
Figure 14 Vacuum Skimmer 15
Figure 15 Submersion Plan Skimmer 16
Figure 16 Fasflo3 25 Skimmer 16
Figure 17 Towable Tanks 23
Figure 18 Rock Cleaner 29
Figure 19 Thermal Desorption Unit 29
Figure 20 Beach Cleaning Equipment 30
Figure 21 Beach Cleaning Equipment (second image)........ 30
Figure 22 Drum Roller........ 30

EXECUTIVE SUMMARY

Senate Bill 414 (Jackson), Ch. 609, Statutes of 2015, amended §8670.13 of the Government Code, requiring the Department of Fish and Wildlife's Office of Spill Prevention and Response (OSPR) Administrator to submit a report to the Legislature assessing the Best Achievable Technology (BAT) for oil spill prevention, preparedness, and response for all waters of the State. This report addresses the Best Achievable Mechanical Technology for oil spill response and includes discussions on boom, skimmers, oil water separators, and shoreline cleanup equipment. The technology review resulted in the following primary conclusions: there have not been significant changes in mechanical response equipment in many years; general improvements in existing equipment have resulted in increased efficiency, effectiveness, and ability to operate in faster currents and/or at faster collection speeds; and maintaining equipment training programs, by the Oil Spill Response Organizations, is necessary to ensure mechanical equipment performs as well as possible.

Per SB 414, as part of the report, the Administrator was also required to "evaluate studies of estimated recovery system potential as a methodology for rating equipment in comparison to effective daily recovery capacity." Presently, the State of California and United States Coast Guard use the Effective Daily Recovery Capacity (EDRC) as a planning standard to calculate recovery potential for individual skimmers. The calculated value is determined by calculating 20% of the nameplate collection volume provided by the manufacturer. Data from the *Deepwater Horizon* oil spill demonstrated that the EDRC for skimmers may not be an accurate planning standard. The Bureau of Safety and Environmental Enforcement recently released a new "whole system" approach, Estimated Recovery System Potential (ERSP), that considers the entire skimmer system (skimmer, pumps, collection tanks, etc.) and its collection of oil over three days of declining oil thickness. Though this approach, as with the EDRC, is not considered a measure of actual skimmer performance, the robust design of the ERSP is expected, with further testing, to more accurately estimate collection capabilities for planning purposes.

INTRODUCTION

The Administrator of OSPR is required to periodically evaluate technologies regarding oil spill prevention, response, containment, and cleanup for both marine and inland waters of the State. The Administrator is required to submit to the Legislature by January 1, 2017, a report assessing BAT for oil spill prevention, preparedness, and response. As part of fulfilling this mandate, this report covers mechanical spill response, including the use of boom, skimmers, response vessels, and shoreline cleaning technology (Ref. Gov. C. §8670.13).

This report is the result of a collaboration of representatives from OSPR, California Coastal Commission, the United States Coast Guard (USCG), Clean Seas LLC, Bureau of Safety and Environmental Enforcement (BSEE) [formerly known as the

Minerals Management Service or MMS], Marine Spill Response Corporation (MSRC), and the National Oceanic and Atmospheric Administration (NOAA). Each organization provided their expertise and review of the report.

For the most part, BAT improvements are in support of Best Achievable Protection (BAP) improvements. BAP improvements include areas such as training, manning, delivery platforms, dedicated resources, drills, rating Oil Spill Response Organization (OSRO) capabilities, matching equipment to the environment, pre-positioning response equipment, and recognition of and improvements to a comprehensive "systems" approach to oil spill response.

In terms of mechanical response to oil spills, the basic principles of containment boom, skimmers, and shoreline cleanup equipment have not changed significantly in many years. Little new technology has appeared that circumvents the forces of the physical dynamics of oil entrainment (i.e., oil movement) under boom, skimmers, and other mechanical devices. However, improvements to these basic tools over the years have generally increased the efficiency and effectiveness of existing mechanical response equipment, and these improvements, along with a focus on a "systems" approach to oil spill response, should be encouraged.

Once oil spills into state waters, the magnitude and severity of impacts depend on many factors, including size of the spill, location, type of oil, weather and wave conditions, environmental sensitivity to oil, responder access, resource availability, time of day, and season. While every attempt has been made to "pre-stage" response equipment for the most timely and effective response, predicting when and where an oil spill will occur and how effective the equipment will be in handling the spill is difficult. For these reasons, a "one-size-fits-all" approach to oil spill response does not exist.

Spill responders utilize a variety of response tools; different types of equipment and procedures are tailored and used for different oil spill conditions and locations. Additionally, trade-offs must often be considered; in managing a response, decisions must be made about the deployment of resources (e.g., on-water recovery versus shoreline protection), response strategies (e.g., deflection of oil from environmentally sensitive sites toward sandy beaches where it can more effectively be cleaned up), and the types of response technology used. Oil spill response is neither simple nor completely effective. All of these considerations need to be taken into account when managing an oil spill response effort.

This report summarizes the current state-of-the-art for mechanical response to oil spills and the scope and limitations of those activities. In determining which emerging technologies to evaluate, the following sources of information were used:

- Ohmsett, the National Oil Spill Response and Renewable Energy Test Facility results, with limitations;
- Expert opinion on conditions where each technology can best be used;

- User opinions on ease of use, durability, effectiveness, available platforms, and advances over current technology; and
- American Society for Testing and Materials International (ASTM) ratings.

This report does not include response to activities such as vessel bunkering (fueling), lightering (off-loading oil cargo from larger to smaller vessels), salvage, or pumping operations. However, mechanical response operations are involved in the preparation for and response to spills that may occur during these activities.

INDUSTRY/AGENCY INITIATIVES AND RESEARCH PROGRAMS

There is no single source of information on emerging technologies and how these new enhancements relate to BAT. Sources of information range from government agencies that conduct research to equipment manufacturers that develop new products. Developments of new response technologies are international in scope.

International Governments

Internationally, there are several government-sponsored research and development programs for the advancement of oil spill response capability. In Europe, there are government programs sponsored by countries involved in the North Sea production areas including Denmark, Sweden, Germany, and Norway. Much of the North Sea research has shifted to the Artic region. Additionally, Environment Canada sponsors a robust oil spill research and development program, specializing in oil chemistry and analysis and the testing of equipment for use in the Artic. The Department of Fisheries and Oceans-Canada in Halifax, Canada, has also become a primary source of oil spill response research. Their small test tank complements research conducted at the larger-scale tank at Ohmsett, the National Oil Spill Response & Renewable Energy Test Facility, in Leonardo, NJ.

U.S. Government Agencies

In the United States, there are several federal agencies advancing technology and practices used in spill response. The United States Environmental Protection Agency's (US EPA) National Response Team publishes a report entitled "*Annual Science and Technology Report*" that details current research and development activities. The BSEE sponsors a research and development program that includes the Ohmsett test facility, where new technologies are tested in a simulated marine environment. The BSEE program also includes a Response Research Branch that conducts and funds oil spill response research and development. The NOAA Office of Response and Restoration is active in developing and evaluating computer response tools and programs. The USCG Research and Development Center administers a spill response research and development program on a national level.

The USCG chairs the Interagency Coordination Committee on Oil Pollution Research (ICCOPR), a 15-member body established to coordinate federal oil spill research initiatives and policies. In its latest Biennial Report submitted to Congress on June 1, 2016, the ICCOPR identified 378 publications and described 211 projects connected to its membership organizations. In 2016, the ICCORP also released its "*Oil Pollution Research and Technology Plan (OPRTP) – Fiscal Years 2015-2021*" that provided current assessments of the oil pollution research needs and priorities.[1]

California Government Agencies
OSPR co-sponsors a biennial Technology Workshop to bring together the government, industry, and commercial oil spill response community for demonstrations, presentations, and discussions on current and cutting-edge technologies in the field of oil spill prevention and response. Working through the USCG Area Committees, OSPR initiated the Sensitive Site Strategy Evaluation Program (SSSEP). This program, carried out in cooperation with OSROs, conducts field testing to validate and improve the Shoreline Protection Strategies contained within the California Area Contingency Plans (ACPs) and Shoreline Protection Tables. Modifications and updates to these strategies are part of a continuous improvement loop as revisions are added to the ACPs and regulatory Shoreline Protections Tables. Additionally, the OSROs are required by law to be drilled to ensure they can implement the strategies, through OSPR's OSRO Rating Program.

Industry Initiatives
Industry efforts in the development and evaluation of new technologies are accomplished in several ways. Individual companies typically sponsor research and development when their company is confronted with unique technology issues. Internationally, the Industry Technical Advisory Committee was established in 1996 to address issues of interest to its member organizations. On a broader scale, industry efforts are focused through the American Petroleum Institute (API) or other International organizations, including the International Maritime Organization (IMO) and the International Petroleum Industry Environmental Conservation Association (IPIECA). API sponsors a Spills Advisory Group that brings together federal and state agencies, industry, and industry partners to discuss developments in the field of oil spill response.

Conferences and Tradeshows
One of the primary means of sharing developments in emerging technology and best practices is through conferences and workgroups. The International Oil Spill Conference is held once every three years, with the next meeting scheduled in Long Beach, California, in May 2017. International experts are brought together to share developments in the field and exhibit spill response tools and programs; here, vendors display their latest developments in equipment and technology. Regional conferences occur on a more frequent basis. The Clean Pacific Conference was held most recently in Seattle, Washington, in June, 2016, while the Prevention First workshop was held in Long Beach, California, in October, 2016. The annual Clean Gulf Conference recently took place in Tampa, Florida, in November, 2016.

[1] http://www.uscg.mil/iccopr/files/Approved%202015%20ICCOPR%20R&T%20Plan.pdf

OSPR and Chevron Corporation will present their seventh Oil Spill Response Technology Workshop in February, 2017, in San Ramon, California. The intent of the workshop is to bring together California's government, industry, and commercial oil spill response community to share new advancements in oil spill prevention and response.

SECTION I: OIL SPILL CONTAINMENT

Worldwide, the preferred approach to address on-water oil spills is mechanical cleanup. This method involves the use of booms and skimmers to contain and physically remove oil from the environment. Although this technique can be used with some degree of effectiveness, it has limitations with respect to large marine oil spills where the recovery rate of spilled oil is typically limited to about 20% or less (IPIECA, 1993).

BOOM TECHNOLOGY

Many types of boom are presently available and can be categorized into several different classifications, but there are structural components that all oil spill containment booms have in common. These structural components include the flotation chamber, freeboard, skirt, tension members, and ballast. The following definitions for each of these are taken from the World Catalog of Oil Spill Response Products, Tenth Edition (Potter, 2013).

- **Floatation Chamber** – The floatation chamber keeps the boom riding on the surface of the water through an enclosed compartment of air or other buoyant material providing floatation for the boom. Heavier booms and those used in rough seas need more buoyancy and therefore have a larger volume of float materials. Air filled floatation elements generally provide more buoyancy than foam-filled members. Ideally, the floatation maintains the designed freeboard and draft. To do this, buoyancy of the float must balance the weight of the boom (and ballast) and other downward forces caused by currents and waves. Floats may be rigid or flexible. Flexible and segmented floatation elements provide better boom wave-following characteristics. Floatation elements should be relatively smooth so that they do not trap debris or produce vortices in moving water (causing loss of oil under the boom).

- **Freeboard** - the minimum vertical height of a boom above the water line. The freeboard prevents oil from washing over the top of the boom, but if it is too high, the boom may be pushed over in high winds. In open water the boom must be able to maintain freeboard in high waves; it must be flexible enough to raise and fall with the waves so that freeboard is not lost with every passing wave.

- **Skirt** - the continuous portion of a boom below the floats that act as a barrier to contain the oil. In most cases, a deeper skirt is more effective in containing oil; however, most operators find there is an optimum skirt depth for different applications. Since the force of current on a boom is proportional to the skirt area, increasing skirt depth beyond what is necessary puts an unusually high load on tension members of the boom.

• **Tension Members** - any component that carries horizontal (axial) tension loads imposed upon a boom. Tension members are often cables, chains, or lines running along the skirt of the boom and/or along the freeboard. The position of tension members effects how the boom rides in the water. Sometimes tension members are exterior to the boom. In these situations, tension members are upstream from the boom, attached to the top and bottom in a series of bridles. Some boom skirts are made of a heavy fabric or a rigid material which can act as tension members.

• **Ballast** - weight applied to the skirt to improve performance. Some booms have weights for ballast along the lower edge of the skirt to help maintain a vertical position in the water. Ballast may be a series of weights attached to the skirt along the entire length, a chain, or metal rods supported along the bottom of the skirt. Ballast helps to keep the skirt vertical; however, if a tension member is at the water line, the skirt may still be deflected away from vertical by currents. Deflection may permit oil to pass under the boom.

In addition to structural components, three physical processes determine how booms operate in any given environment: buoyancy, roll response, and heave response.

• **Buoyancy** is important to keep the boom afloat and to maintain the adequate vertical height of boom above the water line, known as freeboard.

• **Roll response** is the rotation of the boom from rest due to wave, wind, and current forces. Oil may be lost under a boom if the skirt is deflected excessively or has "rolled" from the vertical position. Booms with high roll stiffness are best for operating in high currents and waves. High roll stiffness is achieved either by placing heavy ballast weights at the bottom of the skirt or by moving floatation away from the boom centerline so that the float exerts a large torque to resist forces trying to roll the boom.

• **Heave response** is the ability of the boom to react to the vertical motion of the water surface. A boom with good "heave stiffness" is one that can closely follow the water surface as a wave passes and will have minimum losses due to splash over.

TYPES OF BOOM

Schulze (2008) defines five general types of boom in use today: Fence Booms, Curtain Booms, External Tension Booms, Fire Resistant Booms, and Tidal Seal Booms.

Fence Booms use a rigid or semi-rigid material as a vertical screen against floating oil (Fig. 1).

Fig. 1 Fence Boom

Curtain Booms have a flexible skirt that is held down by ballasting or separate tension line. Curtain booms (Fig.2) have centerline flotation that may be internal foam, external foam, self-inflatable, or pressure-inflatable

Fig. 2 Curtain Boom

External Tension Booms are slightly flexible and are controlled with an external tension bridle. These booms are only used for sweeping or in a current. They are one directional in that the bridle is in the direction of movement or the direction from which the current is coming (Fig. 3).

Fig. 3 External Tension boom

Fire-resistant Booms are named after what the boom does rather than how it is constructed. Current examples of fire-resistant boom are curtain boom with internal floatation, self-inflation, or pressure inflation; stainless-steel fence boom; and water-cooled curtain boom (Fig. 4). This type of boom is typically short-lived and must be replaced after a few uses.

Fig. 4 Fire-resistant boom

Tidal Seal Booms use a water ballast so that they float free in high tide and seal to the intertidal shore during low tide (Fig. 5).

Fig. 5 Tidal Seal Boom

BOOM PERFORMANCE AND FAILURE

Booms may be highly successful in containment of oil on water, diversion into specific areas for recovery, or shoreline protection; however, they do not perform well in every case. Therefore, to understand how booms operate and how features improve their performance, it is useful to understand how booms fail. There are five basic modes of operating failure for booms (Schulze, 2008): entrainment, drainage, splash over, submergence, planning, and structural failure.

Entrainment Failure: In strong currents, a head wave often builds upstream of the boom. At high current velocities, turbulence occurs at the downstream side of the head wave. This turbulence causes oil droplets to break away from the head wave, become trapped in the flowing water, and pass under the boom. Unless the head wave is a considerable distance upstream, oil droplets will not have time to resurface and be contained by the boom. The amount of oil lost in entrainment failure depends on the thickness of the oil in the head wave, which is a combination of water velocity, specific gravity, and viscosity of the oil. The velocity at which the head wave becomes unstable and droplets of oil begin to strip off is called critical velocity. The critical velocity is the component of water speed perpendicular to the boom. Both currents and waves contribute to critical velocity for entrainment failure. Specifically, waves cause oil particles to have a velocity that is added to current velocity. Entrainment failure can be delayed by reducing velocity perpendicular to the boom (i.e., boom may be deployed at an angle of less than 90 degrees to the flow). The critical velocity for many crude oils and refined products ranges from 0.7 to 1.2 knots (generally 0.7 knots are accepted as a conservative estimate). Entrainment loss determines how fast a boom can be towed or the maximum current in which it will be effective.

Drainage Failure: As oil collects at the boom face, it increases in depth until it flows under the face of the boom and escapes to the other side. This loss is known as drainage failure. Water at the boom face is diverted downward, accelerating to keep up with water flowing directly under the skirt. The problem is aggravated by having a deeper skirt. Increasing skirt depth also increases the distance water on the face of the boom must travel to stay with the flow, which causes drainage failure to occur at a lower critical velocity.

Splash over Failure: This usually occurs in choppy seas when oil splashes over the boom's freeboard. This may occur if the wave height is greater than the boom freeboard and the wave length to height ratio is less than 10:1. When the length-to-height ratio falls below 5:1, as in choppy or rapidly shoaling water, most booms will have some splash over failure (Schulze, 1993). On the other hand, most booms perform well in a gentle swell, even when the wave height is much larger than the freeboard. In a medium swell, "bridging" may occur (unless the boom is very flexible), and oil could pass under it.

Submergence Failure: This usually occurs when the boom is deployed or anchored in a fast current or is being towed at a high velocity in still water. The tendency to submerge at a given velocity is determined by its reserve buoyancy. Reserve buoyancy is the buoyancy in excess of that required to keep a boom afloat in still water; higher reserve buoyancy reduces the tendency to submerge. Booms with air-chamber floatation generally have greater reserve buoyancy than those with solid floatation and are less likely to suffer submergence failure. Submergence failure is not common due to entrainment failure usually occurring earlier at a lower speed (Schulze, 2008).

Planning Failure: A strong wind and strong current moving in opposite directions may cause a boom to heel flat on the water surface. The resulting loss of oil is called planning failure. This failure is most likely to occur when a boom has inadequate ballasting or when an internal tension member is near or above the water line.

Structural Failure: Structural failure is the most catastrophic boom failure mode. Wind and current are approximately proportional to the product of boom area exposed to the flow and the square of relative velocity (Schulze, 2008). Wave action further increases the average forces, normally by a factor of two or three. In addition, local dynamic loads due to the acceleration of boom modules in waves may be many times greater than the static value.

Current Procedures for Testing Boom Performance
The American Society for Testing and Materials International (ASTM) published two standard methods in 1990 for boom performance testing: *F-625 Standard Practice for Describing Environmental Conditions Relevant to Spill Control Systems for Use on Water* and *F-818 Standard Definitions of Terms Relating to Spill Response Barriers* (Both F-625 and F- 818 were last updated in 2012). These standards identify the types and amounts of specific data that need to be collected to evaluate boom performance. All ASTMI standards are developed and used on a voluntary basis and, as such, are not legally binding until a government agency adopts them as part of statutory or regulatory law. To date, the ASTMI standards for boom equipment have not been required by either the USCG or the State of California.

In 1992, the BSEE (then MMS) adopted ASTM F-625 and F-818 standards as an integral part of the *Test Protocol for the Evaluation of Oil Spill Containment Booms - MMS Protocol 14-35-30551* (Chapman, 1992). The protocol was developed to ensure consistency in evaluating booms at the Ohmsett test facility. The major purpose of the protocol was to provide, through a series of tests and simulation modeling, a way to test boom performance in the open ocean without having to spill oil. Although the Ohmsett facility and test protocols are generally accepted and recognized throughout the industry, there are no regulatory requirements to test the equipment at the facility or to utilize the protocols.

For booms to work effectively, the "boom connectors" that fasten boom sections together must be reliable. In 1986, the ASTM Subcommittee F20.11 adopted ASTM F962-86 Standard Specification for Oil Spill Response Connection. The standard was established to ensure booms from various sources will fit together without specifying how the connector must be made. The standard was subsequently replaced in 2012 by ASTM Standard 2084, which considers greater connector strength standards, as well as other problems discovered since initial adoption.

Limitations of Current Boom Technology

Creating an effective barrier to floating oil can be challenging. Boom provides its protective characteristics by an ability to contain or divert the movement of oil on water. The success of containment, deflection, and exclusion booming is dependent on currents, wind, and waves. Most booms are not capable of containing oil in currents greater than 0.7 knots; at this velocity, the oil will begin to entrain under the boom. Even minor currents can entrain and draw oil under the booms; waves may cause splash-over, and wind and currents may cause the boom to sink or plane. Sea state conditions, such as wave height and period, play a critical factor in the limitations of boom technology in the offshore environment.

High velocity water currents (>1 knot) pose a considerable challenge to current boom technology and its deployment for shoreline protection in both marine and inland waters. Numerous environmentally sensitive sites in California marine waters are situated in areas that have significant oil threats and strong currents, some exceeding 4 knots. These sites are typical in California’s many coastal embayments, including San Francisco Bay, Bolinas Lagoon, Bolsa Chica slough, and Humboldt Bay. Many of these “swift water” sensitive sites have protective booming strategies identified. Through testing of these strategies, OSPR has found that protection of these sites with conventional boom can be very challenging, especially during periods of high current flow. Typical deployment strategies in swift water conditions call for a cascade-type diversion or deflection booming, employing multiple legs of cascading boom to move oil in or out of the current to a recovery pocket or skimmer. These deployments can be difficult and may not be effective when currents impede the necessary deflection angle of the boom. These issues are also common in inland waters, especially during periods of high runoff during spring conditions.

Shallow-water areas (6 feet in depth or less) offer some of the most challenging conditions for response operations, including booming. Shallowness amplifies the forces created by weather, currents, and tides. Shallow-water bay, inlet, and marsh areas along the California coast are environmentally very sensitive. The Area Planning process identified many of these areas as critical for protection in the event of an oil spill. Unfortunately, the vulnerability of these areas also hinders response personnel and operations. Strong currents, high tidal fluctuations, and uneven topography render some of the identified boom strategies incapable of adequately protecting these areas. While tidal seal booms were designed specifically for shallow areas, they are not completely effective. Leaking is common underneath the boom, and the boom has a propensity to roll during tidal changes. Finally, the time required to access these sites and deploy boom may be a limiting factor in a response situation.

EMERGING BOOM TECHNOLOGY

Among the most notable recent advances in containment technology are high-speed oil recovery and boom deployment systems which include the NOFI Current Busters, the MOS Sweeper System, the DESMI Speed Sweep, and the NorLense Oil Trawl. Each is a hybrid boom system with either a skimmer, pump, or collection bag in the cod end (narrow end of the tapered boom) to collect oil.

Fig. 6 NOFI Skimmer System

- The NOFI Current Buster skimmer system (Fig. 6) is designed to work in currents up to 5 knots and can be either tethered in place or pulled through the water by one or two vessels. Oil is collected by a skimmer in the cod end of the system and moved to either floating storage or storage on a support vessel. There are four sizes available, designed to work in areas from bays to offshore waters. The NOFI system has been part of the US Navy's SUPSALV spill response in California since the mid 2000's. In 2009, the NOFI Current Buster was presented at the OSPR/Chevron Technology Workshop and later, at the request of the OSPR, the Navy SUPSALV provided a field demonstration in a fast-current environment proving its utility. MSRC has added the system to its nationwide response fleet and over 50 Current Busters were used during the 2010 *Deepwater Horizon* oil spill response with very positive results (Qual Tech, 2015[2]).

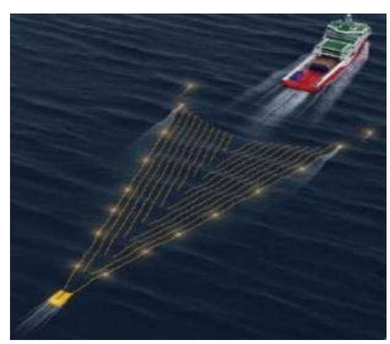

Fig.7 MOS Sweeper System

- The MOS Sweeper System (Fig.7) works at speeds up to 4.5 knots and can be pulled by either one or two vessels. It is part of the Norwegian Clean Seas Association for Operating Companies (NOFO) response program. The MOS Sweeper is designed to capture spilled oil and pump it into storage tanks

[2] http://www.qualitechco.com/env/products/boom-vane

aboard the tow vessel. In 2015, the MOS Sweeper System was tested in the North Sea with test results indicating a recovery rate of 96.4% (World Oil, 2015[3]). Without further testing, the reported recovery rate must be considered questionable. Even so, the reported results suggest the MOS Sweeper System has the potential to effectively collect spilled oil.

-The DESMI Speed Sweep system (Fig 8) is designed to work at speeds up to 3 knots (DESMI, 2013[4]). It can be pulled by two vessels, a single vessel with a paravane system, or attached to the support vessel as a Vessel of Opportunity Skimming System (VOSS). Oil is collected by a skimmer located in the cod end of the system and pumped to a storage container on the support vessel. The DESMI Speed Sweep comes in three sizes, and the mouth openings can be adjusted to fit the area being skimmed.

Fig. 8 DESMI Speed Sweep

-The NorLense Oil Trawl (Fig. 9) is a fast-current system designed to operate at 4-5 knots and is pulled by a single vessel (ROGTEC, 2014[5]) using a paravane system. Oil is captured in a floating storage unit located at the cod end of the system. The storage unit is easily disconnected and replaced by a new unit, while the disconnected unit is then floated to shore where it can be emptied and placed back into service. All the above high speed recovery systems have been tested at Ohmsett with positive results.

Fig. 9 NorLense Oil Trawl

- A unique technological development that was presented at the 2009 OSPR/Chevron Technology Workshop is the Rapid Oil Containment Barrier System (ROC Barrier[6]). This is a boom system (Fig. 10) stored in a box and designed to reach and contain oil spills rapidly. The boom uses a proprietary high-extension sorbent barrier and has been tested in calm water and non-breaking waves at the Ohmsett facility for its ability to contain oil. Due to the small circumference of the boom, it will likely be best used for protecting the entrance of marinas or containing small spills.

Fig. 10 ROC Barrier

[3] www.worldoil.com/news/2015/8/14/new-oil-spill-recovery-record-set-in-north-sea-exercise
[4] http://www.desmi.com/desmi-products/speed-sweep.aspx
[5] www.rogtecmagazine.com/norlense-oil-trawl-sets-new-standards-oil
[6] https://www.environmental-expert.com/products/roc-barrier-model-roc-barrier-rapid-response-system-153303

Two types of boom deployment technologies that have demonstrated application in fast-water conditions are The Boom Vane (Fig. 11) and Boom Deflectors (not pictured). Both systems use a float/rudder system to counter against water currents, pulling the boom into an effective angle to divert oil on the water surface. Both systems reduce the amount of boats, rigging, anchors, personnel, and effort necessary to either deflect oil towards a recovery point on the shore or away from sensitive areas. The Boom Vane can also be rigged off a vessel as part of a towed skimming or collection system.[7] Both systems perform best in steady currents (0.5 – 5 kts) and are generally unaffected by small changes in currents or waves, so tending is simplified. They are more difficult to use in tidal currents and should be deployed when strong and consistent currents exist. OSPR and the USCG have deployed the Boom Vane for demonstrations of applicability in several California locations. The results confirm the usefulness of the Boom Vane when used in a manner consistent with swift water steady conditions.

Fig. 11 Boom Vane

RECOMMENDATIONS

The research conducted for this report indicates that state-of-the-art boom technology may have reached its maximum capability, given currently available materials. Development of new materials, such as preferentially-permeable screens, may increase boom effectiveness by reducing the likelihood of specific types of entrainment. However, critical factors other than strictly "technological" ones directly affect the efficiency of booming operations. These factors include equipment compatibility, personnel training, and availability of test information on new booms.

The effectiveness of oil spill containment equipment is a function of not only the type and amount of equipment that can be brought to the scene of a spill but also of the compatibility of specific pieces of equipment. Universal boom connectors, for example, are a critical component in improving boom technology. The work of the ASTM in this area is valuable, and OSPR will continue to monitor such work and other improvements in boom connectors.

OSROs generally agree that the quality of their training is at least as important as the quality of the equipment they deploy. Although the training level of response personnel does not constitute advancement in boom technology it could generate an "improvement" in oil spill response capability and efficiency in general. OSPR should work with the USCG and oil spill response contractors in California to ensure that adequate training of oil spill response workers is systematically accomplished, tested, and verified.

[7] www.elastec.com/oilspill/containmentboom/boomvane/1.5mstandard/

To maximize the effectiveness of current state-of-the-art booming technology, the importance of fundamental response components, including well-trained personnel, can't be understated and are critical to ensuring BAP. Specific areas of improvement include the following:

- Regulatory Agencies facilitating the use of emerging technologies as a tool in spill response;
- Timely notification to response personnel to identify location of on-water petroleum and resources likely to be impacted;
- Identification of sensitive site priorities and the relaying of this information to responding OSROs;
- Effective OSRO training levels, which are a critical component to proper boom placement within a timely manner;
- Deployment of correct boom type and anchoring systems to effectively protect sensitive site resources;
- Boom-tending around-the-clock, while floating petroleum remains a threat to sensitive sites;
- Recognizing potential site protection failures and implementing procedures to prevent them; and
- Limiting access pathways into sensitive areas to prevent additional habitat damage.

SECTION II: ON-WATER RECOVERY SYSTEMS

As the term implies, an on-water recovery system is comprised of a combination of operational components. Every system will have a containment component, a skimming component, and a storage component.

SKIMMING TECHNOLOGY

A skimmer is a device that collects and removes oil from the surface of the water. Skimmers can be towed, self-propelled, moored in river currents, or even used from shore. Whether a skimmer is stationary or advancing, all skimmers require mechanism which allows oil to be brought to the skimmer. Stationary skimmers, as the name implies, remain in one place during skimming operations. This is accomplished either by floating the skimmer on the water or by holding the skimmer in place with a crane. Additionally, these skimmers are usually outfitted with a device like a vortex that brings oil to the skimmer. Advancing skimmers, on the other hand, must move in the water for skimming to occur -- this is usually accomplished by using the skimmer in conjunction with a vessel. Many types of skimmers are available for use, dependent on the type of oil spilled and the environmental conditions.

TYPES OF SKIMMERS

The World Catalog of Oil Spill Response Products, Tenth Edition (Potter 2013), defines specific skimmers types per the ASTM Standard F1778. These include the following categories: suction, weir, rope, mop, disc, drum, vortex, belt, brush, and submersion plane. Additional sub-types of weir, belt, and brush skimmers are also identified. For ease of discussion in this report, these ten categories will be simplified into four distinct groups: oleophilic surfaces, weir, vacuum units, and submersion plane.

Oleophilic Skimmers: Oleophilic skimming systems (Fig. 12) utilize oil-attracting surfaces, such as ropes, belts, brushes, or discs to remove oil from the water surface. Since oil preferentially adheres to these surfaces, very little water is removed with the oil (except the water which is emulsified in the oil). As a result, a high oil/water ratio can be achieved.

Fig. 12 Oleophilic Skimmer

Weir Skimmers: Weir skimmers (Fig. 13) use gravity to drain oil off the water surface. The oil drains into the weir and is then collected. The skimmer works best if the edge of the weir (or lip) is right at the water/oil interface. However, in the field, this positing is difficult to achieve, and water is collected with the oil.

Fig. 13 Weir Skimmer

Vacuum Skimmer: These skimmers generally use some variation of the weir principal to collect oil (i.e., the force of gravity is used to drain the oil from the water surface). The pump suction draws the oil to the skimmer head. The suction skimmer (Fig. 14) improves the performance of a vacuum truck or a trash pump by keeping the hose floating on the surface of the water and by increasing the area for oil collection at the water surface. Hoses are often equipped with floatation collars to help the hose and skimmer head maintain this position.

Fig. 14 Vacuum Skimmer

Submersion Plane Skimmers: This skimmer (Fig. 15) uses a solid plane that forces the oil under water. The fixed plane is advanced through the oil, submerging and directing the oil into a collection area. This may be a simple collection well or more complex. Many collection areas act as oil/water separators using baffles. This is a tremendous advantage, because the mixture is processed without water coming on-board and being "discharged."

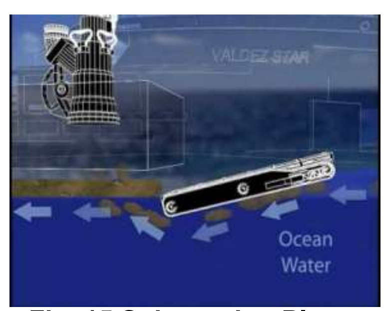

Fig. 15 Submersion Plane Skimmer

SKIMMER PERFORMANCE AND FAILURE

Skimmer performance varies widely depending on the viscosity of the oil being recovered. Although there are no hard and fast rules, skimmers can be grouped according to the range of oil viscosities with which they are most effective. Most weir-type, submersion plane, and vacuum skimmers work best in light products, such as jet and diesel fuels. Since these three systems rely on the oil either "pouring" into a weir or "flowing" through a vacuum hose or over a plane, increased viscosity greatly reduces their efficiency. Oleophilic skimmers, on the other hand, work well on heavier products, such as crude and fuel oils.

Waves and currents have a significant effect on skimmer performance. Waves affect performance by moving the skimmer collection mechanism away from the oil floating on the water surface. Simple devices, such as weirs, often perform poorly in rough seas because the lip is alternately above or below the oil/water interface causing the skimmer to alternately draw in air or water.

Lifting belt, submersion belt, and chain brush skimmers are oleophilic systems that can operate in a range of wave patterns. Theoretically, they are not considered effective in waves higher than the vertical dimension of their belts; however, since these belt skimmers are attached to floatation devices, waves coming over the top of the belt are unlikely. Similarly, submersion plane skimmers can't operate in waves that are higher than the vertical dimension of their submersion planes.

Currents generally affect the performance of skimmers by causing oil to escape from booms. Also, high currents may swamp intakes or cause surface oil to move past the collection element so fast that it is not effectively recovered. Skimmers effective in high currents, in general, have a rope mop or sorbent belt collection element that moves in a well or between a catamaran's hulls. Some of these devices are purported to effectively recover oil in currents up to 6 knots (Schulze, 1993). The Fasflo weir skimmer (Fig.16), recently developed by Vikoma, is reportedly able to skim in currents up to 5 knots and is designed for use in streams, rivers and the marine environment as a VOSS. The small Fasflo system can skim up to 75 cubic meters of oil per hour.[8]

Fig. 16 Fasflo 25 Skimmer

Skimmer Performance as a Function of Spill Encounter Rate

Many oil spill experts agree that the single most important factor in a successful on-water cleanup is "encounter rate." Oil released at sea spreads over a very wide area in a relatively short period of time. Even with fast response times, spill cleanup crews are generally faced with the problem of cleaning up a broad area. Skimmers can only operate at high capacity if they have a high oil encounter rate, which can be

[8] www.vikoma.com/Oil_Spill_Solutions/Skimmers/Fasflo.html

enhanced by placing skimmers in collection areas where oil is concentrated. Due to the physical characteristics and dynamics of the marine environment, this is not always possible. As a result, some responders believe it is better to spread several small skimming systems over a large area rather than utilizing a few large dedicated skimming systems/vessels that can only cover a relatively small area in the same time. However, the advantages of dedicated large skimming systems/vessels are their flexibility in spill response and their ability to operate in variety of sea state conditions.

Testing Skimmer Efficiency

In 1988, the ASTM published two standard methods for the testing of skimming equipment: *F-631-Standard Method for Testing Full Scale Advancing Spill Removal Devices* and *F-808-Standard Guide for Collecting Skimmer Performance Data in Uncontrolled Environments*. These standards identify the types and amounts of specific data that need to be collected to evaluate skimmer effectiveness. All ASTM standards are developed and used on a voluntary basis and, as such, are not legally binding until a government agency adopts them as a part of statutory or regulatory law. To date, the ASTM standards for skimming equipment have not been required for skimmer evaluation by either the USCG or the state of California.

In 1992, the BSEE (then MMS) adopted ASTM F-631 and F-808 standards as an integral part of the *Suggested Test Protocol for the Evaluation of Oil Spill Skimmers for the Outer Continental Shelf* (MMS Protocol 14-35-30551, 2012). The protocol was developed to ensure consistency in evaluating skimmers at the Ohmsett facility. The major purpose of the protocol is to provide, through a series of tests and simulation modeling, a way to evaluate skimmer effectiveness in the open ocean without having to spill oil. Although the Ohmsett facility and test protocols are generally accepted and recognized throughout the industry, industry is not required to test equipment at the facility or to utilize the protocols outside of the facility.

Prior to marketing a piece of skimming equipment, the manufacturer will test the equipment to determine its rate of oil removal. This removal rate is known as the manufacturer's nameplate capacity. As stated previously, a manufacturer is under no obligation to utilize ASTM testing standards or the BSEE test protocols. Consequently, the manufacturer often determines the following parameters for equipment tests: oil thickness and type, wind and current velocity, wave height, and duration of the test. Often, manufacturers test skimming equipment under conditions most favorable to the technology. Therefore, it is generally accepted that the manufacturer's nameplate capacity reflects the maximum rate at which a piece of equipment can operate under ideal weather and sea state conditions.

New ASTM Standard for Measuring Skimmer Capacity

To standardize industry's testing procedures for the development of skimmer nameplate recovery rates, ASTM developed a new standard testing procedure. The following is the abstract from the Application of the ASTM New Skimmer Test Protocol (*ASTM F-2709 – 08, Standard Test Method for Determining Nameplate*

Recovery Rate of Stationary Skimmer Systems), which provides a good summary of the new ASTM Standard:

> "The ASTM subcommittee on skimmers recently adopted a standard methodology for measuring the nameplate capacity for a given skimmer system. Current industry practice allows manufacturers to label skimmers with a nameplate capacity that may bear little relationship to the ability of the skimmer, as a system, to recover oil. Manufacturers frequently base nameplate capacity solely on the skimmer's offload pump capability. Typically, this value is unrealistic when estimating the oil recovery rate (ORR) of a skimming system. In the absence of verifiable third party data or USCG witnessed testing, in accordance with 33 CFR 155 §6, the USCG will derate manufacturer's claimed nameplate capacity by 80% or more when calculating the Effective Daily Recovery Capacity (EDRC). The USCG uses EDRC as a key component in rating and regulating the oil spill response capability of responsible parties and OSROs."

In March 2008, the new skimmer test protocol was used at Ohmsett to test four oleophilic skimmers and evaluate their potential use as alternatives to the skimmers currently used in the Prince William Sound (PWS) oil spill response plan. The skimmers currently used in the PWS plan are weir-type devices, which generally have low recovery efficiencies (as they recover substantial volumes of water along with the oil). This can add greatly to the storage requirement, which is logistically complex and costly. It is anticipated that oleophilic devices would offer an advantage because of their generally higher recovery efficiencies.

These tests were intended to provide a comparison between four different skimmers in conditions that replicate fresh oil and the 72-hour oil spill cleanup scenarios mandated by the state of Alaska. This test initiated the first real-world application of ASTM's new skimmer test protocol.

This skimmer testing conducted at Ohmsett led to the development and publication of a new ASTM standard, "*F-2709-Standard Test Methods for Determining Nameplate Recovery Rate of Stationary Skimmer Systems*." Most skimmers were tested in Type I and Type II test oils as defined by ASTM F631 standard. Skimmers were tested in a boomed area within the Ohmsett tank in calm conditions with an initial slick thickness of three inches. Data collected included Oil Recovery Rate (ORR) and Oil Recovery Efficiency (ORE) for each skimming system as defined in ASTM F2709-08".

Effective Daily Recovery Capacity (EDRC)

Unfortunately, oil spills rarely occur under ideal weather conditions; rather, many occur during adverse weather conditions or nightfall. In general, the effectiveness of a skimmer in recovering oil decreases with increasing wave action and increasing current speed (Chapman, 1992). Thus, it is difficult to know just how well a specific piece of equipment will work under real-world spill conditions based solely on the manufacturer's nameplate capacity. In order to more realistically reflect the limitations of response equipment efficiency as a result of weather, sea state, current velocity, hours of operation, and visibility, OSPR and the USCG vessel and facility contingency plan regulations incorporate an EDRC consistent with the states of Washington and Oregon. A manufacturer can petition the USCG or OSPR to change the EDRC for a specific piece of equipment if it can be shown that the equipment has a different capacity than the EDRC allows.

The *Deepwater Horizon* oil spill response has highlighted that the EDRC for an oil skimmer may overestimate the equipment's oil recovery capabilities and may not be an effective or accurate planning standard and predictor of oil response equipment recovery capacity (Ricks, 2016). EDRC is a regulation that greatly influences vessel and facility response planning standards nationwide and established the basis for the initial capitalization of OSROs in the U.S. The primary EDRC regulation is in 33 CFR (Code of Federal Regulations) Part 154, Appendix C and Part 155, Appendix B, and in 30 CFR 254.44; these provisions are administered by the USCG and BSEE. EDRC is also included by reference in 40 CFR Part 112 as amended by the USEPA.

Estimated Recovery System Potential (ERSP)

In September 2011, the BSEE contracted Genwest Systems, Inc. (Genwest) to conduct an objective and independent assessment of the existing EDRC planning standard. In addition, Genwest was to consider improvements that might be made to the EDRC approach and recommend new methods and guidelines to enhance or replace that method of calculating a recovery system's daily potential for removing oil spilled on water.

A final report, dated December 7, 2012, was submitted to BSEE providing Genwest's assessment of the EDRC and a new Estimated Recovery System Potential (ERSP) model for developing planning standards. The model was much more robust in design than EDRC and accounted for the performance of a skimming system as it accesses and contains oil, recovers and stores oil, and then transits to a backup vessel, barge, or facility to offload the recovered fluids. This model allows for the calculation of an ERSP over a three-day period, based on nominal average oil thicknesses following the release of a significant oil spill. Given the significance of the study and of potentially replacing EDRC with a new methodology, BSEE contracted the National Academy of Science to conduct an independent peer review of the final report. The peer review was completed[9] in 2013 and BSEE is working with Genwest to update their final report.

As part of their study, Genwest developed the ERSP Calculator.[10] This calculator allows the user to enter the key parameters of a skimming system, including swath width, speed of advance, pumping capacities, associated temporary storage capacity, daily operating period, and other key system parameters. The calculator uses standard assumptions for oil thickness and emulsification to calculate daily

[9] www.nap.edu/catalog.php?record_id=18579
[10] http://www.genwest.com/ERSP%20Calculator%20User%20Manual_20150222.pdf

recovery rates for the skimming system over a three-day period. The results provide a basis for comparing the ERSP for a skimming system to the EDRC of the skimmer that is a part of the skimming system. For planning purposes, the robust design of the ERSP calculator is expected to more accurately estimate skimmer collection capability than the EDRC process of using 20 percent of the equipment's nameplate capacity. The ERSP calculator was released to the public in August of 2016.

Mechanical Recovery Calculator

The ASTM has developed a standard guide to estimate oil spill recovery system effectiveness (ASTM Designation F 1780 – 97 (2002)). The standard relies on the theory that oil spill recovery can be estimated by making a number of assumptions regarding a skimming system, oil spill encounter rates, and oil thickness. System effectiveness can then be calculated by multiplying the speed of advance, by the swath width, by the slick thickness. In order to effectively use the guide, the user must make several assumptions regarding skimming system configuration, slick thickness, and environmental conditions.

The purpose of the guide is to provide the user with information on assessing the effectiveness of spill cleanup equipment. The Standard Guide stresses that the guide should only be used as a tool to compare the effectiveness of one skimming system to another and not as a tool to estimate slick property changes or calculate predicted oil clean up rates.

Limitations of Current Skimming Technology

As discussed previously, no single skimmer type can work with high efficiency in all environments. In open water, skimmers must contend with heavy weather and sea states. In more sheltered embayment areas, the weather may be more amenable to skimming; however, sea state and currents will affect skimmer efficiency. Shallow-water areas offer some of the most challenging conditions for skimming operations. Shallowness amplifies the forces created by weather, currents, and tides. In addition, bathymetric conditions can often prohibit the use of most deep draft vessels, large skimmers, or skimming systems that require more than six feet of water, and/or booms with large skirts. Many vessels can be considered "shallow draft" when empty but not once fully laden with recovered oil.

Since many of the most environmentally sensitive resources along the California coast are found in shallow-water areas, such as salt marshes and mud flats, adequate protection and cleanup of these areas are extremely important. As with other response technologies, it is not only the "skimming technology" that is important but also the "delivery system" employed (i.e. shallow-draft vessels) in shallow-water areas. Over the past several years, much emphasis has been placed on developing shallow-water skimming capabilities to address the environmentally sensitive marine embayments found along the California coast. California oil spill contingency plan regulations have been revised to require shallow-water response capabilities.

Two operational considerations which could constitute limitations on current technology are employee training and compatibility of equipment.

Training. As with boom deployment, well-trained people can make a bad piece of equipment work well and poorly trained people can cause a good piece of equipment to operate poorly. Operational practices and employee training are tools used with the BAT to meet California's BAP policy for oil spills. California regulations have been amended to require dedicated response personnel and unannounced drill requirements aimed at demonstrating OSRO capabilities.

Equipment compatibility. In the event of a large marine oil spill in California, response resources could arrive from several private response organizations outside the state. Equipment incompatibility, including joints, fittings, belts, anchors, and hoses could greatly complicate a response effort between organizations could greatly complicate a response effort. Fortunately, due to industry standardization, this has not proven to be an area of concern.

SECTION III: ON-WATER RECOVERY SYSTEMS AND COMPONENTS

An on-water recovery system is comprised of a number of components. Every system will have a containment component, a skimming component, and a storage component. Some systems will have all three components packaged in one unit. This is typical of an Oil Spill Response Vessel (OSRV). Other systems will be assembled at the time of a response. A stand-alone skimmer, boom, and temporary storage device can be placed together and work as a system. The following sections discuss the various types of on-water recovery systems and components.

VESSEL OF OPPORTUNITY SKIMMING SYSTEMS

VOSS consist of specific packages of skimming equipment that can be used with several different vessel types, including fishing vessels, tugs, ice breakers, etc. This allows maximum utilization and flexibility of skimming equipment during an oil spill response. "Dedicated" response vessels, on the other hand, have skimming systems incorporated into the vessel's operations and/or have this equipment and vessel devoted solely to skimming operations.

RESPONSE VESSELS

California OSROs have several large, medium, and small oil spill response vessels that are dedicated solely to oil spill response. A few of the vessels also utilize oil/water separators as part of the recovery system allowing for a high skimming capacity while taking on large quantities of water. The presence of an oil-water separator is often critical since most dedicated response vessels have limited storage capacity (this will be covered in greater detail in the oil/water separator section of this report). A few of the dedicated response vessels utilize oleophilic "brush-type" skimmers. As discussed previously, these skimmers do not normally take on large amounts of water, so oil/water separators may not be critical for efficient skimming operations.

TEMPORARY STORAGE CONTAINERS

As skimmers become more efficient, the need for large amounts of storage becomes more of a concern. High-capacity skimmers are still being used to meet plan holders' on-water recovery requirements; however, once filled, these storage containers must be off-loaded, taking the skimmer out of service. California now requires, for marine waters, dedicated storage to be on-scene within the first six hours of the spill. In High-Volume Ports, plan holders must have adequate storage on-scene to support skimming operations for the initial four hours. At four hours, 520 barrels (bbls) of temporary storage must be on-scene, and at six hours, 12,000 bbls of dedicated temporary storage must be on-scene. Inland response requires that sufficient storage be made available for no less than the EDRC for the skimming equipment.

Descriptions below pertain to containers and technologies specifically designed to be utilized for oil spill response. These include storage vessels such as barges, towable tanks, and stationary tanks.

Barges: Barges represent the best temporary storage devices during on-water oil spill response. If possible, barges should be designed for spill response or at least be of a suitable size that can be maneuvered along with a skimming system. Barges used for the commercial transportation of oil typically have a storage capacity of 42,000 bbls. These vessels are so big that they are difficult to maneuver with a skimming system. Additionally, because barges do not have a means of self-propulsion, they need a tug of adequate size to transport it. The ready availability of tugs is critical.

Towable Tanks: Towable tanks are generally dedicated to oil spill response and may be the most important storage devices for recovered oil in the first 24 - 48 hours of a spill, as larger barges may not be immediately available (Potter, 2013). Towable tanks are generally known by their trade names or a name that describes their shape or configuration. The types of tanks considered in this category are towable flexible tanks, towable open tanks, and towable collapsible tanks (including devices referred to as bladders (Fig. 17)), and dragones. These towable tanks are small enough to be used with skimming devices on-scene during a response.

Fig. 17 Towable oil tank

Stationary Tanks: Stationary tanks can be used ashore or, in some cases, on the decks of response vessels or barges. Types of stationary tanks include open inflatable pools and collapsible tanks.

OIL/WATER SEPARATORS

Most oil/water separators operate best with a high percentage of water in the mixture they process. In fact, most gravity separators work best when the recovered mixture is 90 - 95 percent water and are likely not to perform effectively when the incoming mixture is nearly all oil (Potter, 2013).

A major concern with the use of high-capacity oil/water separators is size. For most industrial uses, separators do not have to be mobile nor do they have the space constraints commonly associated with response vessels. Some high-capacity separators may be contained in basins 100+ feet long and 30 feet wide. Above-ground separators can also be very large and heavy since they are filled with water during operation. The size of gravity separators increases dramatically with increased flow capacity. Additionally, separator size, particularly operating weight, increases much more rapidly than capacity. Size considerations can become important if oil/water separators are to be incorporated into a vessel design or if mobile units are to be placed either on the deck of a response vessel or in other areas in close proximity to on-water skimming operations.

For the reasons listed above, stand-alone oil/water separators are not widely used in oil spill cleanup. Some purpose built OSRVs have incorporated oil/water separators into the vessel design. These systems enhance these vessels' ability to handle and store larger volumes of recovered oil.

The other common method used for oil/water separation is simple gravity separation. This method involves placing the recovered oil/water mixture in a temporary storage tank. As the mixture is left to settle, oil will rise to the top with water at the bottom of the tank. Upon request, permission from the appropriate regulatory authorities is often granted to decant the clean water from the bottom of the tank into the containment area adjacent to the recovery vessel. This process results in the ability to process additional recovered oil/water mixture.

Ocean Therapy Solutions invented a high-speed centrifuge that was used during the *Deepwater Horizon* incident to separate oil and water. A demonstration of this technology can be found at the following link: http://www.youtube.com/watch?v=cWy5UgZYEUU .

BSEE funded a project in 2016 with the University of California, Riverside, entitled "*OSRR-052-Enhanced Oil Recovery from Oil-Seawater Mixtures through the Coupling of Magnetic Nanoparticles and Electrically Conducting Ultrafiltration Membranes*." The objective of this project was to develop a continuous oil/sea/water separation process that could be developed in artic conditions aboard a skimming vessel to recover a majority of skimmed oil while producing an oil-free water stream that could be safely discharged. This separation technique relies on the coupling of electrically conducting ultrafiltration membranes with ferromagnetic nanoparticle-stabilized oil droplets allowing for efficient collection and separation of spilled oil without the need for storing vast volumes of contaminated water[11]. This technology is still in its infancy, and OSPR will continue to follow its progress as in evolves.

TECHNOLOGICAL ADVANCEMENTS

The literature is sparse with respect to emerging skimming technologies. Most response contractors agree that any equipment currently being marketed as "new technology" is more accurately characterized as a "new variation" on existing technology. This is not to undermine the value of refining current technology, which would constitute advancement; however, truly "new technology" is not common. As a result, improved response may be better accomplished by focusing attention on areas with greater possibility for real improvement, including oil spill prevention and response personnel training.

Advancements in Response Vessels

There have been improvements over the past decade in response vessel technology. Historically, OSRV's had been constructed similarly to off-shore supply vessels that have slow maximum speeds. New response vessels have been constructed to incorporate more speed and built-in on-water recovery systems that can operate with a smaller crew size, without compromising safety. They incorporate containment boom arms, skimming, and temporary storage to operate as a complete skimming system.

Lessons learned during the *Deepwater Horizon* incident demonstrated that there is a wide variety of on-water tasks required to support a fleet of recovery and response vessels. Simultaneous Operations (SIMOPS) management was needed to mitigate the risks and enable support vessels to maneuver as needed to complete their tasks. The SIMOPS team, with the cooperation of the owners and captains of responding vessels, implemented the following mechanisms for precision planning and risk management of up to 19 principal vessels up to 250 meters in length within a 500-meter radius of the wellhead, and 40 to 50 within a one-mile radius, operating at times with separations of 25 feet or less:

- Establishment of a rotating on-site branch director, working in coordination with the Houston-based team, with 24/7 command of vessel operations;
- Robust, proven systems and tools for planning and implementing the management of large numbers of vessels at extremely close quarters, including storyboarding and a centralized, onsite control regime;

[11] www.bsee.gov/research-record/osrr-1052enhanced-oil-recovery-oil-seawater-mixtures-through-coupling-magnetic

- Deployment of an Automatic Information System (AIS) as an enabling technology for real-time visualization and management of offshore marine operations.

Advances in Skimming Technology
Although advancements have been made in oleophilic and weir skimmers and vessel design, it is important to assess these developments within a specific context. Weather, sea state conditions, and oil type often dictate the kinds of oil spill response operations that can be undertaken. For example, skimming vessels designed for relatively calm waters may not be appropriate for use along the open coast. The USCG reviews oil spill response vessel design issues and considerations as a part of the Oil Pollution Act of 1990 (OPA 90) requirements. As with all vessels, the USCG looks at vessel seaworthiness and general safety concerns. OSPR reviews any findings made by the USCG for applicability to oil spill response in California.

While skimming oil from water had been tried and tested through other responses, the scale and duration of the *Deepwater Horizon* response, along with the associated dynamic and variable nature of oil characteristics, proved a new challenge for skimming. This challenge drove significant improvements to skimming equipment, along with new approaches to the organization, maintenance, and deployment of skimmers. Specifically, the response team took the following actions:

- Deployment of more than 60 open-water skimmers, at the peak of the response, through retrofit of existing vessels and international cooperation. This deployment included twelve responder-class vessels on-site by day five, as well as a number of vessels provided by the USCG;
- Implementation of an innovative “command and control” system that provided air intel to an on-water director that better coordinated all skimming activities by optimally placing vessels;
- Deployment of four “Big Gulp”[12] skimmers, based on an innovation by a barge owner who retrofitted his own vessel to handle emulsified oil and sea grass. The barge, pushed by a tug boat, was capable of skimming in seas to six feet at speeds to five knots and collected up to 200,000 gallons of oil a day;
- Development of an innovative 72-hour “pit stop” for skimmers extending runtime to more than 100 days; and
- Use of new techniques to improve the efficiency of skimming operations, including enhanced booming, centrifuge separation of fluid on skimming vessels, and barges, deployment of the TransRec 150 oil recovery system on a 280-foot Platform Support Vessel and the use of a new generation skimmer from Norway (NOFI Skimmer Systems).

[12] http://www.sea-technology.com/features/2012/0412/gulp_oil_skimmers.php

BSEE has funded research for the development of an Autonomous Oil Skimmer (Project 1037). The goal of this project is to develop a strap-on navigation sensor and computer control system that could be used to direct a variety of commercial off-the-shelf skimmers and vessels to autonomously maneuver and skim the oil from a given area with automatic tracking and reporting of progress and performance. This system will monitor the thickness of the oil skimmed in real time and have the capability to continually direct the skimmer in to the thickest area of oil. BSEE has tested the proof of concept design at Ohmsett in 2016.[13]

RECOMMENDATIONS

As with booming technology, in order to maximize the effectiveness of current state-of-the-art on-water recovery technology, the importance of the following fundamental response practices to ensure BAP is also needed:

- Regulatory agencies facilitating the use of emerging technologies as a tool in spill response;
- Timely notification to response personnel to identify the location of the spilled oil to determine most effective on-water recovery operations;
- Utilization of a complete "system approach" to on-water recovery, which includes adequate delivery platforms, manning, pre-staging, etc.; and
- Effective OSRO training, which is a critical component of ensuring proper on-water recovery operations.

OSPR continues to monitor efforts made by industry on improvements to on-water recovery operations. One example of a resource that is tracking improvements in oil spill response operations is the work of the USCG Research and Development Center through its report entitled "*Institutionalizing Emerging Technology Assessment Process into National Incident Response.*[14]" The report outlines the primary goal of the National Incident Management System's Emerging Technology Assessment Program, which identifies response technologies that can improve the efficiency and effectiveness of emergency response operations.

SECTION IV: SHORELINE CLEANING

Shoreline cleaning comes in many forms including manual washing, mechanical, and vacuum. The methods used depend on the type of shoreline, its location, and the type of oil. Definitions, methods, and equipment types may be found in the World Catalog of Oil Spill Response Products (Potter, 2013).

[13] www.bsee.gov/research-record/osrr-1052-enhanced-oil-recovery-oil-seawater-mixtures-through-coupling-magnetic
[14] http://www.uscg.mil/iccopr/files/Institutionalizing%20Emerging%20Technology%20Assessment%20into%20National%20Incident....pdf

SHORELINE PROTECTION OVERVIEW

Federal and state laws and regulations require plan holders to demonstrate, through contract(s) or other approved means, the response resource capabilities to protect each site they could impact by an oil spill.

Shoreline Protection booming measures, in the marine environment, are put into place before oiling of sensitive habitat or beaches can occur. Shoreline Protection strategies are outlined in the Area Contingency Plan (ACP) and are exercised and tested by the OSRO's. Since 2007, OSPR has promulgated regulations governing shoreline protection requirements through published Shoreline Protection Tables (SP Tables), which were developed to outline planning requirements for tank vessels and nontank vessels in California's marine waters. Working through the USCG Area Committees, OSPR initiated the Sensitive Site Strategy Evaluation Program (SSSEP) in 1993. In cooperation with the OSROs, the SSSEP program conducts field testing to validate and improve the shoreline protection strategies contained within the California ACPs and SP Tables.

For inland waters, OSPR staff is identifying waterways that will require protection and is in the process of developing Geographic Response Plans (GRPs) for these waterways. Unlike the marine response plans, the inland plans will focus more on diversion and collection booming strategies than site protection.

Even with the focus on containment, on-water recovery, and shoreline protection, there are times when shorelines are oiled and mechanical shoreline cleaning technology may be necessary.

ROCKY INTERTIDAL / COBBLE HABITAT

Pressure washing is one of the few mechanical cleanup technologies used in the rocky intertidal region. Water pressures range from deluge flows used to remove stranded oil from the lower intertidal region to high-pressure jets (exceeding 1200 psi) used to remove oil adhering to the substrate in the upper intertidal region, cliff faces, sea walls, and other hard substrates supporting little or no biological growth. High-pressure wash can be performed using water temperatures from ambient to over 140°F. The process may also be aided by the application of chemical beach cleaning agents (see the 2017 Best Available Technology: Applied Response Technology Report). High-pressure washing was not used during the 2015 Refugio oil spill response.

Pressure washing apparatus can be operated from portable shore facilities or from specially modified boats or barges. During the *Exxon Valdez* oil spill cleanup, three variations of boats/barges evolved to meet various needs for high-pressure wash cleanup activities. The vessels contained the necessary generators, heaters, pumps, hoses, and articulated arms necessary to wash stranded oil from the rocky intertidal region (Nauman, 1991). Presently, there are no standards for developing pressure washing equipment. Each time the necessity arises for high-pressure washing, off-the-shelf equipment are fitted together to form the necessary cleaning apparatus.

The use of high-pressure washing to remove oil from rocky intertidal regions must be thoroughly evaluated and specific directions and limitations developed before the cleanup measure is employed. High-pressure washing, with or without the use of heated water, should be monitored by biological observers to ensure that as little harm as possible is done to the biological community. Studies conducted in Prince William Sound suggest that high-pressure washing coupled with the high-temperature used in this region significantly retarded the return of the intertidal epifaunal community to pre-spill conditions (Houghton et al., 1993a) and had a significant impact on the existing infauna intertidal and subtidal community (Houghton et al, 1993b). Native American representatives and/or archeologists may be necessary to help ensure that no harm is done to historically significant sites.

Dry ice blasting, a technology closely related to high-pressure washing, can be used to clean weathered oil from rocky areas and other hard substrates and has several benefits: it is not applied at high temperature; it produces no liquid waste stream; removed oil is able to be collected on a tarp or sorbent pads surrounding the worksite; and the process does not require the use of cleaning solvents. First used in the aerospace industry in the early 1970s (Pacific Dry Ice. 2016[15]) to clean equipment of oil and grease, dry ice blasting was later used in the 2010 *Deepwater Horizon* response to quickly clean oil from boat hauls and boom (Bradshaw, 2010). In 2015, the technology was used in California at the Refugio Beach oil spill response to clean oil from selected areas of the high intertidal region. As with high-pressure washing, dry ice blasting will be limited to areas of rocky substrate with little or no epifaunal growth and will require a biological and tribal/archeological monitor.

Mechanical equipment may also be used to clean oiled cobble and gravel from the intertidal and supratidal regions. Cobble and gravel can be placed into “washing machines” that use high-pressure water and cleaner. This technology is designed to clean cobble/gravel and separate collected oil and debris for disposal. Because such equipment is typically designed for specific individual oil spill responses, it is not an off-the-shelf item and its use is normally limited to the availability of access roads.

[15] http://www.pacificdryice.com/dry-ice-cleaning-blasting.php

In addition to the cobble and gravel washing machines, earth-moving equipment such as bulldozers and front-end loaders can be employed to move oiled cobble and gravel into the surf zone where cleaning is accomplished by wave action. Though this process can clean the oiled sand and cobble, it does not remove the oil from the environment. The use of any mechanical equipment for cleaning cobble and gravel beaches should be thoroughly evaluated before it is employed, in order to prevent unnecessary damage to biological communities. As with high-pressure washing, monitors should oversee the removal and placement of the cobble in the surf zone. Presently, there are no standard processes for evaluating the use of earth-moving equipment; approval is granted on a case-by-case basis. A hand-held hydraulic-driven rock cleaner can be used for smaller-scaled operations. It is comprised of a brush wheel, suction nozzle, and an oil collection hopper (Fig. 18). This piece of equipment is used to clean oil from rocky shorelines, ditches, roads, and vessels. Vacuum equipment can also be employed in the rocky intertidal region to clean stranded oil. The feasibility and efficacy of using a vacuum are dependent on the amount and types of oil stranded. Use of the technology is only possible when the area to be cleaned is readily accessible and there are significant amounts of stranded oil present.

Fig. 18 Hydraulic Rock Cleaner

SANDY BEACH HABITAT

Though workers with shovels and collection equipment comprise the primary element of a beach cleanup response, mechanical cleaning devices can play an important role in removing spilled oil from sandy beaches. The devices come in various forms and their use is dependent on the type and location of the spilled oil. While a few have been designed for specific beach cleanup scenarios (Potter, 2013), many present day devices designed for other service can be useful during spill response. Construction equipment (e.g. bulldozers, front-end loaders, etc.) is useful in excavating contaminated beach sands or skimming oil from the beach. Excavated sand can be deposited into the lower intertidal region where it is surf washed (Potter 2013) or into machines that use water and chemical cleaning agents or heat (Thermal Desorption Unit) to clean the sand. A Thermal Desorption Unit (Fig.19) was used successfully during OSPR's 1994 Guadalupe Dunes spill response.

Fig. 19 Thermal Desorption

Fig. 20 Beach Cleaning Devices

Several forms of self-powered beach cleaning devices are helpful tools for removing tar balls and tar patties from beaches. Originally designed to remove trash and other debris, these beach cleaning devices (Fig. 20) were used successfully during the *Deepwater Horizon* spill response. Newly designed beach cleaners, including the Sand Shark[16] (Fig. 21) were also employed during the response to address tar balls too small and too deep in the sand to be collected by existing cleaners. All beach cleaners were limited to the cooler periods of the day in the Gulf as excess heat made the oil "gooey" and difficult to collect.

Fig. 21 Sand Shark

Another form of beach cleaner is a drum roller (Fig 22), covered with oleophilic material (Potter, 2013). The drums can be either motorized or hand-operated by a member of the cleanup crew and are best used on smaller tar balls. The drum roller was used successfully in California on Ventura Beach during the 1993 McGrath Lake spill response and on Ocean Beach during the 1996 M/V *SS Cape Mohican* spill response.

Fig. 22 Drum Roller

During the *Deepwater Horizon* spill, the continual effect of tides on the sand, failure to reach oil on the beach before the next tide cycle led to deposits becoming buried below the surface. Rapid beach cleaning was a top priority. On the other hand, large-scale beach-cleaning operations can also have an intrusive, disconcerting effect on wildlife, beachgoers and the general public. The response team took the following actions:

- Assessment and adaption of mechanical equipment to condition and clean beaches of rocks, sea grass and other debris and the application of new attachments and procedures to allow deeper and faster cleaning of oiled shoreline;
- Evolution of transitional techniques, using continuously-improved methodology into the "Sand Shark," a fit-for-purpose mechanical beach-cleaning vehicle, that digs deeper and "lifts and sifts" sand to remove oil while minimizing sand removal;
- Increased strategic focus on removing oil within a single tide cycle, providing the right tool for the right problem, and coordinating with local officials;
- Deployment of oil-removal and waste management protocols for a range of operating conditions; and

[16] http://blog.al.com/live/2010/08/bp_unveils_sand_shark_to_deep.html

- Establishment of organizational structure and control-of-work methods to maximize effectiveness of beach cleaning (e.g., working in cooler evenings where heat of the day melted tar balls, making them hard to remove).

RECOMMENDATIONS

In general, the use of high-pressure wash, with and without hot water, has become an acceptable procedure to remove spilled petroleum from rocky substrate in the upper intertidal zone under selected circumstances. The use of this procedure and its effect on the intertidal environment should be further investigated to determine: 1) if and under what circumstances the technique is an appropriate cleanup tool; 2) what impact the procedure has on the habitat; and 3) what are the alternatives to using high-pressure wash to remove stranded petroleum in the intertidal region.

Large mechanical cleaning devices, such as rock and sand cleaning apparatuses and earth movers should be used with caution and only after their effects on the intertidal community are weighed against the impacts of the spill. Other types of mechanical cleanup devices, such as beach cleaning equipment used to collect tar balls from the beach face, are thought to have little impact on the intertidal community; however, standard operating procedures should be developed for their use.

SECTION V: AGENCY REQUIREMENTS

OFFICE OF SPILL PREVENTION AND RESPONSE

In response to the *Exxon Valdez*, the federal government enacted OPA 90, which required fundamental changes in safety procedures, incident planning, and design of equipment related to the transport of oil products. Also in 1990, the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act (Act) was enacted in California to protect marine waters of the state from oil pollution. This Act created a new and comprehensive statewide program, OSPR, which consolidated the primary authority for prevention and response for marine oil spills. The Act included the regulatory responsibility for contingency planning (both prevention and response), wildlife rehabilitation, and cleanup and abatement for marine oil spills. In June 2014, the authority of the OSPR Administrator was expanded to include oil spills to all waters of the state. OSPR is unique in that it is believed to be the only state agency in the United States with combined regulatory, law enforcement, pollution response, and public trust authority for state waters.

Marine oil spill contingency response plan regulations require that each vessel (tankers, barges, vessels carrying oil as secondary cargo, and nontank vessels) and facility (marine facilities and small marine fueling facilities) plan holder (i.e., the owner/operator of a tank vessel, nontank vessel, marine facility, small marine fueling facility, or vessel carrying oil as secondary cargo) ensure, by contract or other approved means, the availability of specified amounts of containment equipment, mechanical oil recovery equipment, and storage in order to ensure adequate response to a Reasonable Worst Case Spill (RWCS; i.e. the amount of oil that could be potentially spilled by a vessel or facility, as defined in the regulations).

Inland contingency plans for facilities, pipelines, and railroads that pose a threat to waterways are required to identify personnel and equipment necessary to perform containment, recovery, and storage of oil and oily waste associated with a RWCS. The plan holder may either contract with a rated OSRO or demonstrate that the facility owns the equipment and has the personnel necessary to undertake the required response. Inland facilities, pipelines, and railroads that pose a threat to ephemeral waterways with measurable flow less than 180 days a year (average over 5 years) must demonstrate access to sufficient equipment to cleanup oil in dry waterways identified in their contingency plans. Inland facilities, pipelines, and railroads that pose a threat to waterways that have measurable flow exceeding 180 days a year (average over 5 years) are required to demonstrate access to sufficient equipment to conduct both on-water oil recovery and dry waterway cleanup (14 CCR §817.04(n) and (o)).

Containment

For marine spills, prescribed quantities of oil containment equipment are required if the vessel or facility is engaged in activities of “higher risk,” such as over-water oil transfers at marine terminals or bunkering/lightering operations. During such activities, equipment to contain a 50-barrel spill is required within 30 minutes (this generally translates to 600 feet of boom appropriate to the area). Containment equipment to contain an additional 50 bbls (i.e., an additional 600 feet of containment boom) must be standing by such that it can be deployed within one hour.

There are also requirements for containment and recovery equipment to be pre-identified, under contract, and on-scene during the critical early hours of a spill. Having adequate containment and recovery equipment can mean the difference between a spill remaining on-water, where it is relatively easy to clean up and a spill impacting the shoreline.

With respect to inland spills, regulations require that the operators must have sufficient equipment on site within six hours to contain 10% of the RWCS, 50% containment within 12 hours, and sufficient equipment to contain 100% of the spilled oil within 24 hours.

Initial On-Water Recovery

During the critical early hours of a spill, it is imperative that on-water containment and recovery equipment be deployed and operating to stop the spread of the spill and prevent the oil from reaching the shoreline. This is especially critical in many areas of marine waters where swift tidal and current conditions exist. Because of this need for early response, on-water recovery capability is required to be on-scene within two hours of notification of a marine spill, and six hours for an inland spill.

Rated OSROs must pre-stage equipment in these areas to meet the requirements.

On-Water Recovery

The marine waters regulations require that each vessel and facility ensures the availability of mechanical recovery equipment necessary to respond to all spills up to their RWCS. The regulations provide a method for calculating the amount of equipment necessary for the volumes of oil that each vessel or facility could expect to discharge under various scenarios. These calculations determine the "Response Planning Volume", which is the RWCS volume multiplied by factors that reflect the persistence and emulsification of the type of oil that may be spilled. These Response Planning Volumes are used to determine the amount of equipment and personnel that the plan holder must ensure are available by contract or other approved means at the time of a spill. The goals of these regulations are to ensure prompt response to, and effective cleanup of, oil discharges anywhere within California's marine waters.

The original tank vessel contingency plan regulations were promulgated with a 12-hour response for on-water recovery for vessels operating in high-volume ports. In 1998 these standards were reviewed and it was determined that a six hour requirement for a subset of high-volume ports was needed. As stated in that rulemaking:

> "…The shortened timeframe will provide for better recovery during the initial hours of a spill. The change provides consistency with the timeframes for facilities in high volume ports… The primary benefit to the environment is protection and recovery during the critical early hours of a spill. The *MV Cape Mohican* spill in October 1996 demonstrated that the key factor for resource protection in high volume ports, in that instance San Francisco Bay, is speed in on-water containment and recovery. Strong currents and short distances from the potential spill sites to the shoreline can increase the likelihood that on-water oil will reach the shoreline where it can do much more damage and be much more expensive to clean up than if it is recovered on-water. The six hour requirement is achievable in the areas specified and therefore meets the best achievable protection mandate for these areas…."

Presuming technological and operational advances would be made over time, language was included in the regulations stipulating that the on-water recovery rates would be periodically raised by 25% for vessels and marine facilities. The standards were increased by a factor of 25% on July 1, 1997 and again on July 1, 2001. It was determined that these increases were feasible and necessary to provide for BAP along the coast.

In October 2002, OSPR established a program to "rate" OSROs for identified oil spill response services within pre-determined time frames. As part of the approval process the OSROs are required to participate in unannounced drills and equipment verification inspections conducted by OSPR. For the purpose of meeting the regulatory requirements, vessel and facility plan holders can only contract with rated OSROs for containment booming, on-water recovery, and shoreline protection services.

Since 2007, tank vessel and nontank vessel plan holders must demonstrate the shoreline protection response resources necessary to protect each type of shoreline and all applicable sensitive sites as outlined in the appropriate SP Tables.

OSPR reviewed its on-water recovery requirements and in May 2009, promulgated regulations that shortened on-water recovery response times and added containment requirements to high-volume port areas to improve oil containment and recovery in these high-vessel traffic areas.

Inland regulations for minimum oil recovery capability require that the operator have sufficient on-water or terrestrial response resources in place, capable of recovering 50% of a RWC spill or 820 bbls (whichever is less) within 6 hours of the spill; 4,100 bbls or 75% of the RWCS (whichever is less) by 12 hours; and 8,214 bbls or sufficient on-water or terrestrial response resources to respond to the remaining 25% of the oil spilled within 24 hours.

Current Requirements[17]

See Title 14, California Code of Regulations:
§ 817.02 – Marine Facilities
§ 817.03 – Small Marine Fueling Facilities
§ 817.04 – Inland Facilities
§ 818.02 – Tank Vessels
§ 818.02 – Vessels Carrying Oil as Secondary Cargo
§ 827.02 – Nontank Vessels

Daily Recovery Rate

OSPR recognizes that there are limits to the capability of mechanical on-water recovery equipment. The regulations, therefore, establish on-water Daily Recovery Rates (DRR) that vessel and facility plan holders must ensure are available by contract or other approved means. A DRR is expressed as the barrels per day capability of on-water recovery equipment that must be at the scene of the spill by the hour specified, following notification of the spill to the OSRO. The DRR's reflect the limits of the existing capability and technology of oil cleanup resources including the EDRC of skimmers, transportation logistics, and commercial availability of equipment, including containment booms, skimmers, and storage for recovered oil.

[17] https://www.wildlife.ca.gov/OSPR/Legal/OSPR-Regulations-Index

BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT (BSEE)

The BSEE oil spill response requirements can be found in federal regulations at 30 CFR Part 254. Owners or operators of an oil handling, storage, or transportation facility located seaward of the coastline are regulated by BSEE and must have the capability to respond quickly and effectively to clean up an oil spill from their facility. The owner or operator must have the means to respond to a Worst-Case Discharge (WCD) from their facility with spill response equipment suitable for the type of oil handled and the environment in which they operate. BSEE can require performance testing of any spill response equipment listed in the operator's response plan to verify its capabilities.

Operators generally meet this WCD requirement by contracting with dedicated OSROs that maintain the necessary response equipment and trained personnel to operate the equipment and are available to respond at all times. The OSROs maintain spill response equipment to contain, recover, and store spilled oil as well as equipment to disperse and burn spilled oil.

In addition, facility operators in the Pacific Outer Continental Shelf Region must be able to contain a spill from their facility and begin recovery of the spilled material within response times specified in their Oil Spill Response Plans. To meet the response times, facility operators either maintain oil spill response equipment (boom and skimmers) at or near their facility or have OSRO vessels equipped with response equipment that can respond within the necessary time frames.

Owners of spill response equipment are required to maintain and periodically inspect the equipment to ensure it is in optimal condition and to keep maintenance records. Personnel who operate the equipment must receive annual training in the use of the equipment. All oil spill response equipment, maintenance, and personnel training records required to be kept by the OSRO or operator must be made available for inspection by BSEE. In addition, operators who are required to maintain response equipment at the facility, or on dedicated vessels, must participate in biennial equipment deployment exercises and must deploy and operate each type of this equipment at least once per year.

U.S. COAST GUARD

The USCG requirements for control of pollution by oil and hazardous substances and discharge removal can be found at Title 33 Code of Federal Regulation, Subchapter O -- Pollution. Provisions of this Subchapter apply to owners or operators of vessels or onshore or offshore facilities. Each person removing or arranging removal of oil from coastal waters must use, to the maximum extent possible, mechanical methods and sorbents that most effectively expedite oil removal and minimize secondary pollution from the removal operations. Recovered oil and oil contaminated materials must be disposed of in accordance with applicable state and local government procedures. Chemical agents, such as dispersants, may be used in accordance with the provisions of Subpart H of the National Contingency Plan and prior approval from the Federal On-Scene Coordinator and Regional Response Team (Region IX).

Oil tankers and offshore oil barges must carry appropriate equipment and supplies for the containment and recovery of on-deck oil spills. In addition, tank vessel owners or operators must have contracts or other approved agreements with OSROs to respond to their average most probable discharge, maximum most probable discharge, and worst case discharge from their vessel. To ensure OSROs can meet these response levels, the USCG evaluates and classifies their capabilities. Tank barge owners or operators must also be able to deploy discharge removal equipment.

Spill response resources must be available within the time frames specified in the regulations. Vessel, facility, and OSRO personnel operating spill response resources must be trained, and records documenting the training must be maintained. OSRO equipment deployment drills must be conducted annually, in addition to other exercises required to be conducted by vessel and facility owners and operators. All response resources must be maintained and inspected periodically to ensure the equipment is in good operating condition. All inspections and maintenance must be documented and the records maintained.

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