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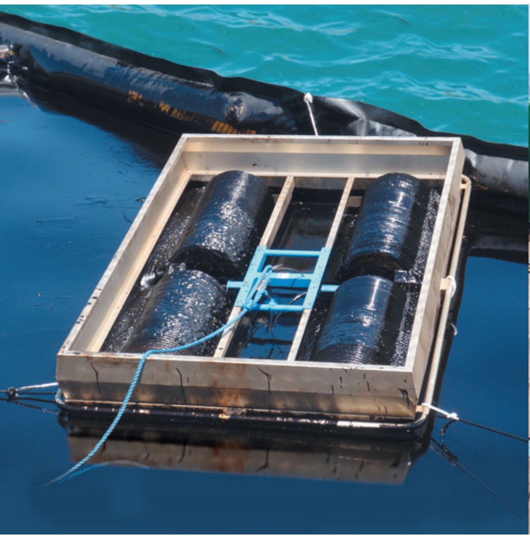
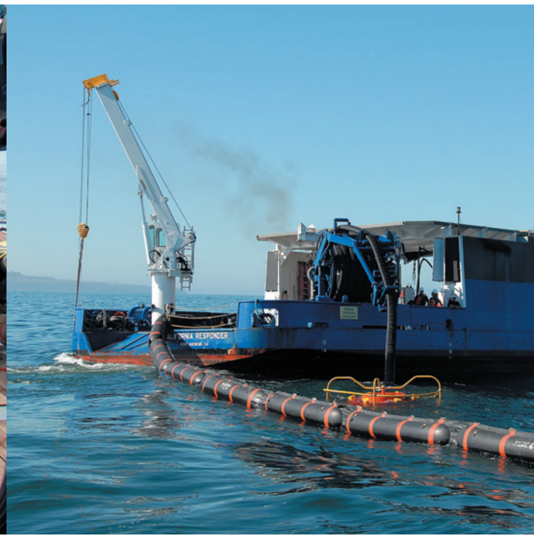
At-sea containment and recovery

Good practice guidelines for incident management and emergency response personnel





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Preface

This publication is part of the IPIECA-IOGP Good Practice Guide Series which summarizes current views on good practice for a range of oil spill preparedness and response topics. The series aims to help align industry practices and activities, inform stakeholders, and serve as a communication tool to promote awareness and education.

The series updates and replaces the well-established IPIECA 'Oil Spill Report Series' published between 1990 and 2008. It covers topics that are broadly applicable both to exploration and production, as well as shipping and transportation activities.

The revisions are being undertaken by the IOGP-IPIECA Oil Spill Response Joint Industry Project (JIP). The JIP was established in 2011 to implement learning opportunities in respect of oil spill preparedness and response following the April 2010 well control incident in the Gulf of Mexico.

Note on good practice

'Good practice' in this context is a statement of internationally-recognized guidelines, practices and procedures that will enable the oil and gas industry to deliver acceptable health, safety and environmental performance.

Good practice for a particular subject will change over time in the light of advances in technology, practical experience and scientific understanding, as well as changes in the political and social environment.

Contents

Introduction

Prevention of oil spills remains the primary objective of any operator. However, despite all efforts to reduce the likelihood of a spill occurring, a residual risk will always remain. This can be further mitigated through robust preparedness measures. The planner will need to consider the range of response options available, and determine the most appropriate preparedness measures through a process of net environmental benefit analysis (NEBA).

At-sea containment and recovery is just one of many response options available in the oil spill response toolbox. It involves the controlled encounter and collection of oil from the water's surface. Floating barriers or booms are used to corral and concentrate the spilled oil on the sea surface into a suitable surface thickness, to allow its mechanical removal using a recovery device such as a skimmer, which pumps the oil from the water surface into temporary storage.

Effective containment and recovery can reduce the:
- impact on wildlife such as seabirds, fish and mammals;
- impact on sensitive shoreline environments by removing floating oil at sea;
- complexity and duration of a shoreline response; and
- volume of waste generated by a response.

At-sea containment and recovery is often considered the primary or preferred response option due to the perceived neutral net impact of its operation on the environment. However, as with all response options, the overall effectiveness of containment and recovery can be limited by a combination of operational, environmental and logistical constraints, as indicated below:
- Operational constraints: equipment mobilization and deployment time; encounter rate; skimmer suitability and efficiency; competence of responders; maintenance downtime; repair and logistical support.
- Weather-related constraints: suitable weather and sea state conditions for safe operations within daylight hours and within the limitations of the deployed equipment.
- Logistical constraints: availability of suitably equipped vessels, aerial surveillance support and transit time; requirement for adequate facilities for the storage and disposal of oil and water mixtures; and vessel and operator logistics, e.g. the organization of personnel and crew changes, the supply of food, water and consumables, and the management of black water and personnel waste.
- Safety and health constraints: failure to consider the increased potential for injuries to responders from equipment deployment and operation, and the health effects from exposure to the oil.
- Environmental considerations: increased carbon footprint from the fuel burned by vessels, recovery equipment and aircraft engaged in equipment spotting, and impacts from the handling, transportation and treatment/disposal of waste.

Experience has shown that the efficiency of at-sea containment and recovery operations can vary widely depending on the above constraints, and recovery is usually limited to between 5% and 20% of the initial spilled volume. The effectiveness of this method should be considered when selecting from among the available response options during the NEBA process. The method should, where possible, be incorporated alongside other available response options in an effort to build the most appropriate, multi-faceted response strategy.

Overview

The key components of a containment and recovery system are:

- a boom or barrier to encounter and contain oil;
- a recovery device, most commonly a skimmer to remove oil; and
- a pump to transfer the collected oil and water mixture into temporary storage.

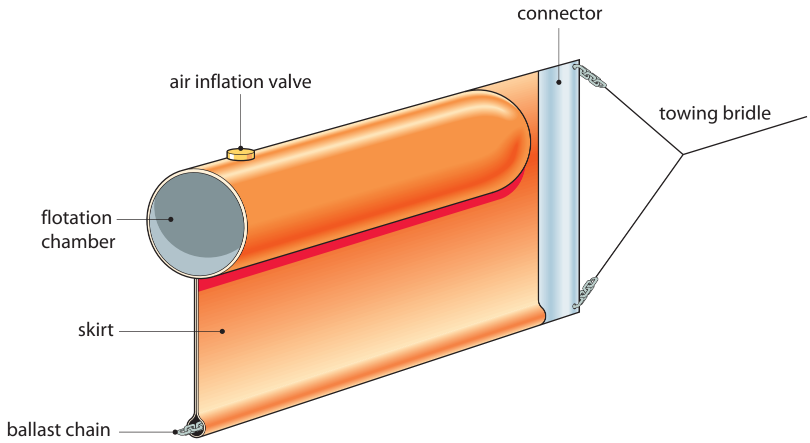
MSRC

Left: containment and recovery at sea

Containment booms

A containment boom consists of a flotation chamber (i.e. an air-filled or foam-filled compartment) to provide buoyancy, and a skirt which hangs below the sea surface. The skirt is usually reinforced by a ballast chain or cable to absorb the tensional forces exerted on the boom; a ballast chain also provides weight to help the boom maintain a vertical orientation (Figure 1). The combined function of these components is to provide a barrier which can be used to encounter and contain the spilled oil.

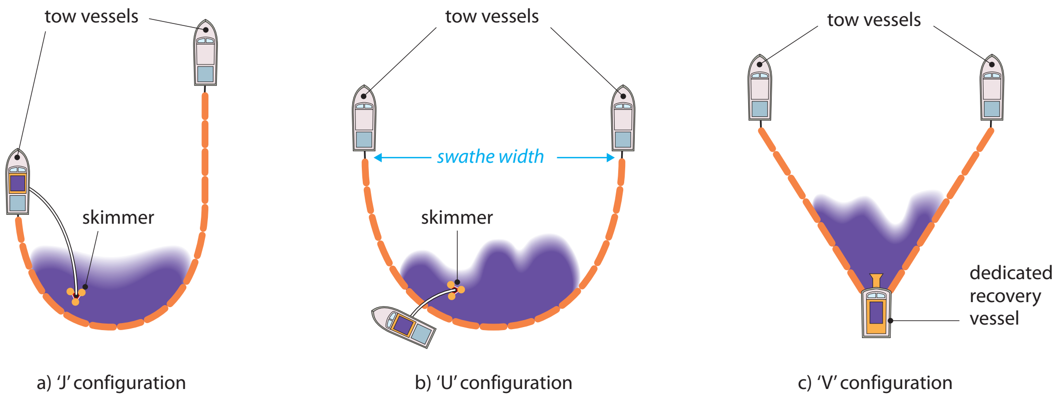
Figure 1 *Components of an inflation boom*



Boom configuration

Once deployed, a containment boom is towed into the floating oil, usually by two vessels, and typically forms a 'U', 'J' or 'V' configuration (see Figure 2). As the spilled oil is encountered it becomes concentrated at the apex of the boom. Skimming can commence once there is a suitable concentration or thickness of oil at the apex.

Figure 2 *Boom configurations used for containing and recovering oil simultaneously*



Encounter rate

The rate at which the spilled oil can be captured within the boom is known as the encounter rate, and is a product of the:

- swathe width of the boom configuration;
- speed at which the boom is being towed; and
- thickness and continuity of the oil slick that is being encountered.

The following actions can help to maximize the encounter rate:

- Commence containment operations at the earliest opportunity, before the slick begins to spread and fragment.
- Maintain the boom configuration, using the maximum swathe width and the optimum towing speed for the chosen configuration.
- Utilize aerial surveillance assets to direct vessels to areas where they are able encounter the thickest oil.
- Where possible, utilize technology that enables a faster operation, e.g. fast advancing collection systems.

Daily recovery rate

Actions that can increase the daily recovery rate include:

- optimization of supporting logistics, such as vessels, crew shifts and use of daylight hours;
- provision of adequate storage; and
- use of technology such as infra-red cameras and X-band radar to enable night/low visibility recovery operations.

Recovery components

A variety of different types of skimmers are used to recover the corralled oil from the apex of the boom and transfer it into vessel storage tanks or to a dedicated floating storage system. Skimming systems are generally comprised of the following common components:

- a source of power;
- a method of flotation to create a stable platform;
- a recovery method which removes the oil from the water surface; and
- a pump with associated hoses to transfer the recovered oil.

Selection of the appropriate skimmer type will depend upon:

- the type/physical characteristics of oil;
- environmental conditions; and
- operational conditions during the response.

Skimmers are generally grouped into the following categories, based on their operating principles:

- weir skimmers: used for recovering medium to heavy oils;
- oleophilic skimmers: used for recovering medium to light oils;
- hydrodynamic skimmers; and
- other: e.g. paddle, belt, trawl, etc.

As the oil weathers and its properties change, skimmer selection will need to be reviewed and amended to ensure optimum efficiency.

Some of the more advanced technologies found in skimmer design may include:

- advanced pump technology;
- use of debris screens;
- steam injection ports (for more efficient use in extremely cold temperatures);
- annular water injection (to aid in pumping high viscosity products); and
- thrusters to manoeuvre the skimmer in the apex of the boom for optimal performance.

Waste considerations

Before recovering, transferring or handling oil, it is important to be aware of the local regulatory requirements and to ensure that these are complied with. It is also vital that a detailed waste management plan is in place to ensure the proper handling and disposal of recovered products.

Regardless of the recovery device used, it is inevitable that water will be collected along with the oil and transferred to the temporary storage device. Some vessels may be able to use onboard oil/water separators to reduce the volume of water recovered. While in the relatively low-energy environment of the temporary storage device the recovered mix of oil and water will begin to separate; in some jurisdictions it may be permissible to decant the recovered water back to the sea to maximize the storage space available for the recovered oil. The use of decanting is discussed in IPIECA-IOGP, 2013.

Supporting resources and logistics considerations

The use of vessels that are suitably specified and carry appropriate equipment is essential to ensure that containment and recovery operations are carried out safely and effectively. The preferred specifications for deployment vessels include:

- a clear deck space;
- an open stern, if possible;
- sufficient bollard pull;
- the ability to manoeuvre and/or tow at a low speed;
- accommodation/shelter for responders; and
- onboard storage for recovered oil.

Containment is most effective when the deployment vessels are supported by resources and logistics that can provide guidance to help vessels encounter the highest concentrations of surface oil. Such resources include:

- aerial surveillance, including use of aerostats;
- oil spill detection radar (OSDR);
- infrared cameras; and
- drifting tracking buoys.

The success of at-sea containment and recovery is dependent on having trained and competent responders to ensure that operations are conducted safely and efficiently.

Containment and recovery methodologies

A number of methodologies are available to responders performing at-sea containment and recovery operations.

Vessels and towing configurations

As described on page 6, containment booms are towed in various configurations to encounter, corral, concentrate and contain floating oil for effective recovery from the sea surface before subsequently transferring the oil to temporary storage. The length of a containment boom used in the various configurations is typically between 200 and 500 metres. Beyond this length, coordination between vessels becomes more complex and increases the risk of damage to the boom, potentially limiting its effectiveness.

A containment boom is typically connected to the towing vessel(s) by means of a towing line, which needs to be of sufficient strength to cope with the forces generated. Towing lines are commonly 50 metres in length and constructed from a buoyant material to reduce the risk of fouling the vessel's propeller or other underwater obstacles.

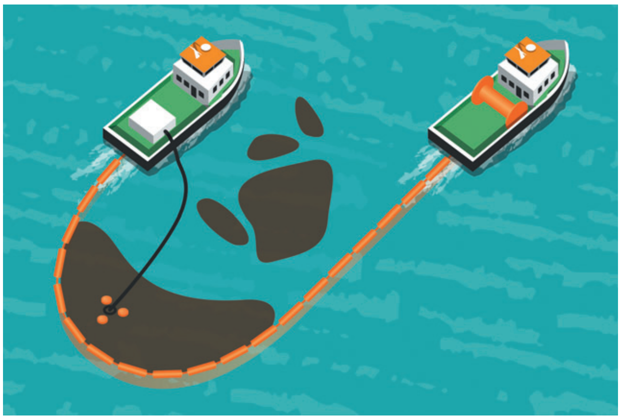
Conventional boom configurations are, as a general rule of thumb, limited to a transit speed of approximately 0.75 knots through the water. Speeds in excess of this may lead to boom failure (loss of containment of the oil in the apex) and/or boom damage.

The choice of boom configuration will vary depending on the nature of the release, the spread and distribution of the oil, and vessel and resource availability.

The 'J' configuration

This configuration is conducted by two vessels which tow the containment boom in a 'J' shape; this has the advantage that it is possible to continue skimming while towing is in motion (Figure 3). This is achieved by maintaining the collected oil in the boom apex close to the trailing vessel which holds the skimming system and temporary storage.

Figure 3 *The 'J' configuration*



OSRL

The 'U' configuration

As with the 'J' configuration, the 'U' configuration uses a minimum of two vessels. However, the 'U' configuration allows for a wider swathe width compared to the 'J' configuration (see Figure 4), which can serve to increase the encounter rate. Once oil has been contained in the apex of the boom, a 'J' configuration can then be adopted in order to recover the product using one of the two towing vessels. If a third vessel is available, the 'U' configuration can be maintained while this vessel recovers the product from the apex of the boom, thereby allowing continuous operations.

Figure 4 *The 'U' configuration*

OSRL

The 'V' configuration

Two vessels tow the containment boom in a 'V' configuration and a third, specialized vessel dedicated to recovery of the spilled oil is positioned at the apex of the boom (Figure 5). This configuration allows for a marginal increase in speed and an increased swathe width, thereby increasing the encounter rate of the configuration. With a dedicated recovery vessel in place, this configuration can increase the duration of the operation and, hence, the amount of oil recovered, provided that sufficient temporary storage capacity is available.

Figure 5 *The 'V' configuration*

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Single-vessel side-sweep system

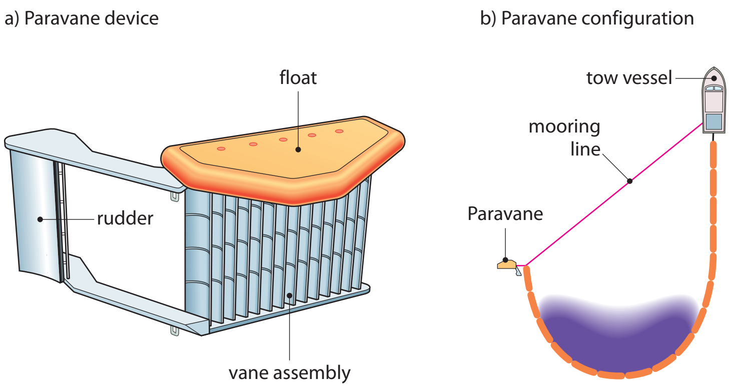
In certain situations where resources are limited or where a large swathe width is less advantageous (such as for a small or highly fragmented spill) a single-ship system can be deployed. Various approaches exist to enable a single vessel to conduct both containment and recovery operations, which can be carried out simultaneously if required. The single-vessel side-sweep system involves deployment of a single boom supported by a boom arm (outrigger) extending from the side of the vessel; a skimmer may also be deployed from the vessel to recover contained oil directly to storage onboard the vessel (Figure 6). A single-vessel system has fewer logistical constraints and greater manoeuvrability than systems employing two or more vessels. However, because of the narrower swathe width, the encounter rate can be greatly reduced compared to that of more conventional boom configurations. Two side-sweep systems can be deployed from a single vessel—one from each side of the vessel—to maximize the encounter rate.

Figure 6 *Single-vessel side-sweep operations*

Single-vessel system using a paravane

If the availability of vessels is limited, a paravane can be deployed in lieu of a second towing vessel or outrigger. The paravane is attached to the far end of the boom, and its position in the water is controlled from the vessel by way of a single mooring line (Figure 7). This enables the boom to be guided into the optimum position to encounter the oil.

Figure 7 *Example of a paravane device and single-vessel configuration*



Use of the single-vessel paravane configuration reduces the complexity of operation and the risk of collision associated with two vessels operating in close proximity, and is relatively easy to maintain once launched and under way. However, it may not be able to provide as great a swathe width as some dual-vessel towing configurations.

Enhanced containment and recovery methods

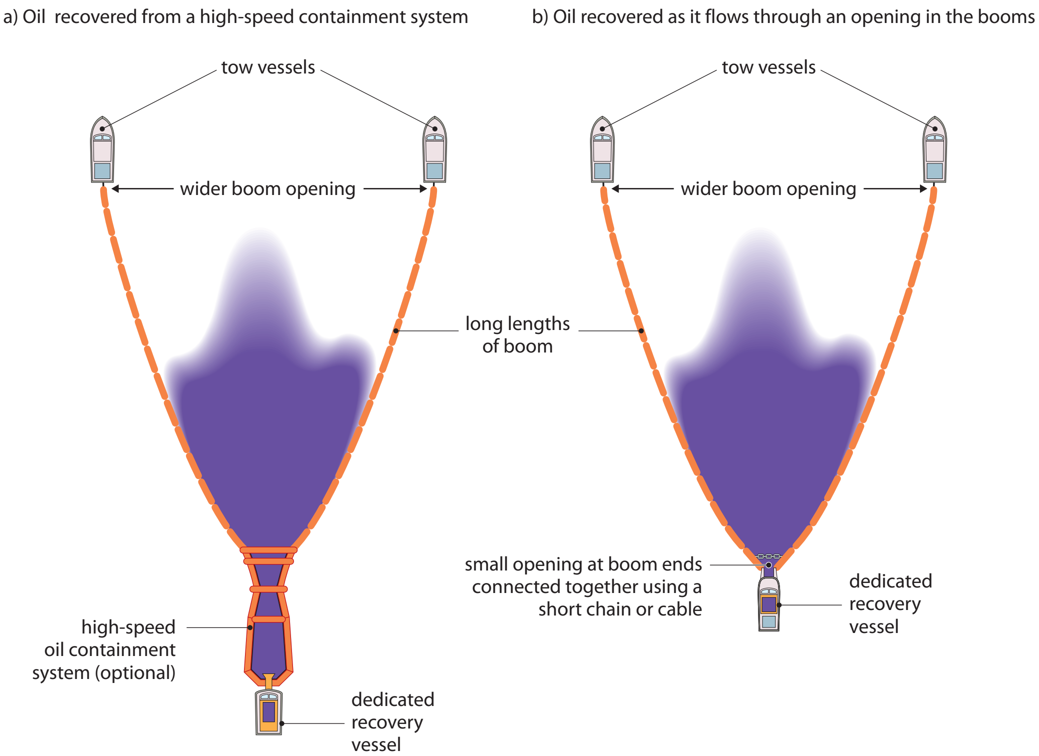
When sufficient suitable vessels are available, the encounter rate and collection of oil can be improved through an 'enhanced containment' configuration. In this configuration a much wider front opening is achieved by joining two long lengths of boom together with a cable or chain. In addition, oil may be further concentrated at the apex of the boom through the addition of a high-speed containment system, which not only concentrates the oil but also allows for an increased towing speed without loss of oil, as well as providing a facility for water separation prior to the oil being collected by a dedicated recovery vessel or integrated skimmer (Figure 8a).

An additional option is to create a small opening at the apex by using a short chain or cable to connect the boom ends together and having one of the previous containment and recovery systems follow behind to collect the concentrated oil as it escapes through the opening (Figure 8b).

The enhanced containment method requires close coordination of vessels and competent response crews.

The enhanced containment method allows a wide front opening to the boom, and includes a dedicated vessel following behind to recover the oil; it may also incorporate a high-speed oil containment system to provide enhanced oil containment and separation at increased towing speeds.

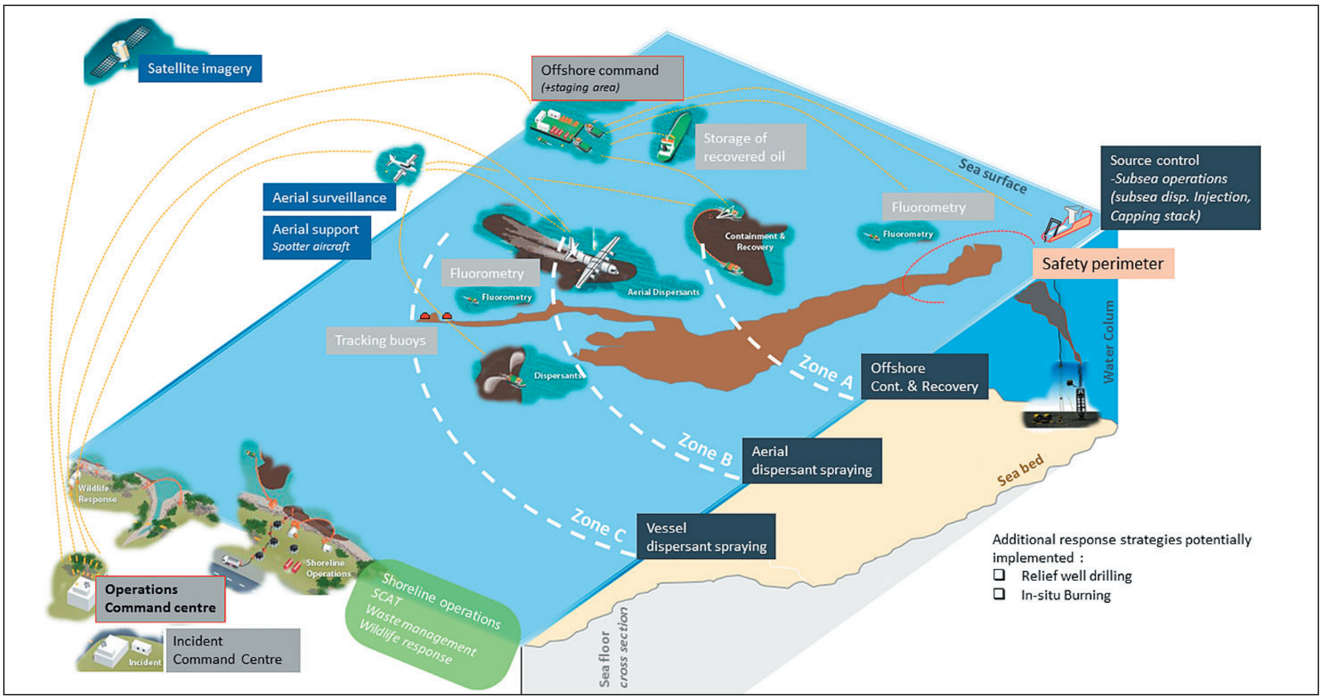
Figure 8 *Enhanced containment configuration*



Managing containment and recovery operations

To maximize the effectiveness of the overall response effort, the most effective and advantageous response options should be deployed as close to the source as possible, depending on safety and operational limitations, and supplementary actions taken radiating out from this location. This approach is known as the 'cone of response' model (Figure 9). Optimizing the response in this way can help to maximize the removal of oil from the water's surface.

Figure 9 *Optimized response options—the 'cone of response' model*



Source: EOSP, 2012

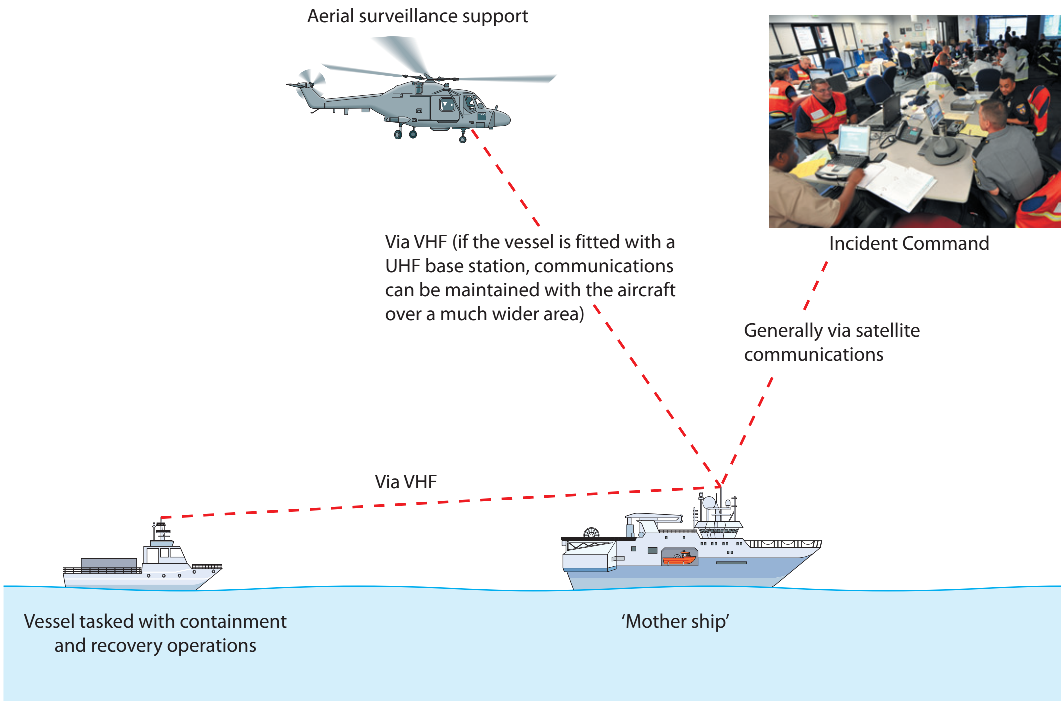
Simultaneous operations (SIMOPS)

In large incidents, multiple response techniques will be employed simultaneously. Care should be taken to avoid conflicts in areas where vessels and aircraft are working in close proximity. The coordination of simultaneous operations (SIMOPS) is key to ensuring the safety of those involved, and to ensure the effective and efficient allocation of response resources. SIMOPS are often coordinated from an onshore incident command centre, supported by command vessels in the field.

When multiple vessels are tasked with conducting containment and recovery operations in the same area, the use of 'mother ships' (Figure 10) may be considered to help maintain clear lines of communication and a coordinated response effort. A mother ship may also be used to provide additional support to vessels conducting response operations, which may include provision of:

- replacement or additional equipment;
- welfare stores for vessel crews;
- personnel protective equipment (PPE); and
- temporary storage of recovered product.

Figure 10 *Example of effective operational communication*



Effective demarcation and management of the operating zones designated under the 'cone of response' model will help to ensure that the deployment of selected response methods are complementary. It would not be appropriate, for example, to perform containment and recovery operations in an area where the oil has been treated with dispersant.

The coordination of SIMOPS can be enhanced if vessels are fitted with an Automatic Identification System (AIS) to enable their movements to be tracked from the incident command centre, providing the Incident Management Team (IMT) with a visual representation of where the vessels and aircraft are operating.

At-sea containment and recovery efficiency

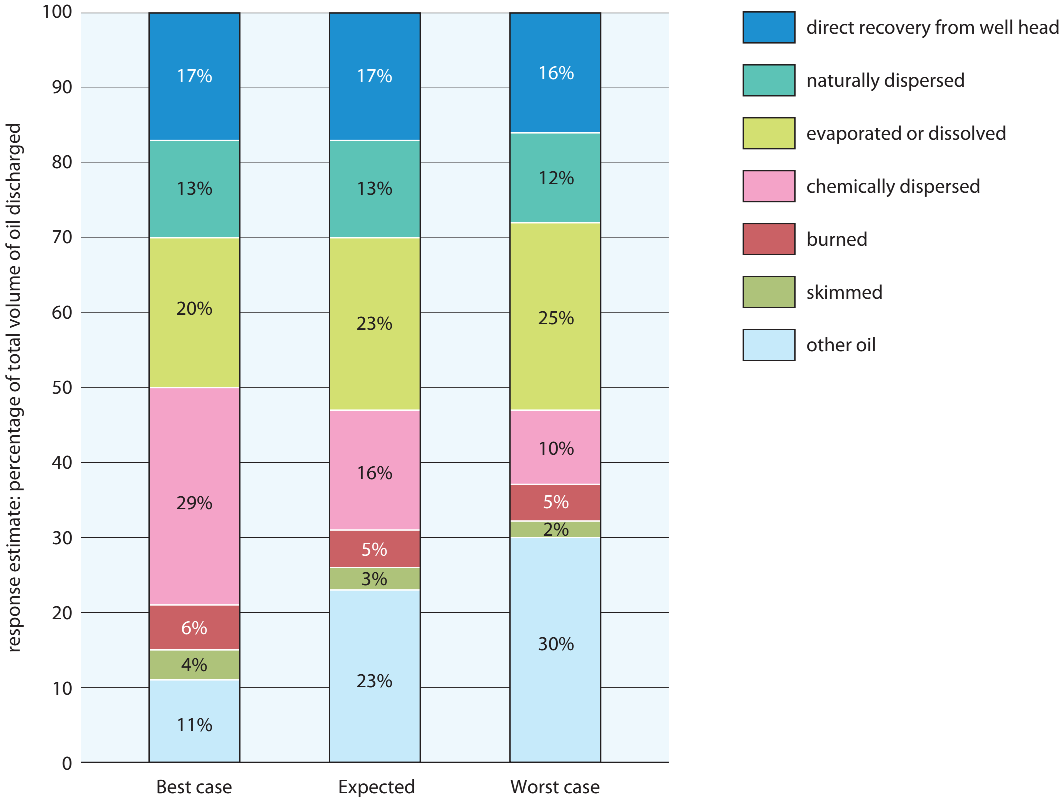
Experience from responding to shipping spills has shown that approximately 5–20% of the volume of oil spilled may be removed using containment and recovery. The following incidents provide examples:

- **MV *Erika*—tanker spill, 1999:** an estimated 19,000–20,000 tonnes of No. 6 Heavy Fuel Oil was spilled off the western coast of France. Oil remained on the sea surface for around two weeks but harsh weather conditions meant that containment and recovery was restricted to just a few days during fair weather. It is estimated that a total of 1,200 tonnes was recovered (approximately 6% of the initial volume spilled). (Source: CEDRE, 2009.)

- **Montara incident—well blowout, 2009:** an estimated 4,800 m^3 of light crude oil was released during a well blowout in the Montara field in the Timor Sea. The weather and sea conditions were favourable for at-sea containment and recovery operations, which were carried out from 5 September to 30 November by a pair of vessels working together. In total, 844 m^3 of emulsified oil was recovered, of which 493 m^3 was crude oil—approximately 10% of the total oil spilled. (Source: CEDRE, 2009.)

- **Macondo incident, 2010:** approximately 4.9 million barrels of oil were released during the Macondo oil spill in the Gulf of Mexico. It has been estimated that only around 4% of the oil was removed via at-sea containment and recovery (Figure 11). The primary response options identified during the incident were dispersant application and in-situ burning. Essential support equipment, such as aerial surveillance assets, was therefore assigned to these response options rather than to containment and recovery operations. This highlights the success of an integrated response where a variety of response options were employed.

Figure 11 *Response estimates expressed as percentages of the cumulative volume of oil discharged during the Macondo incident, through July 14 2010, in the best, expected, and worst cases*



Source: adapted from FISG, 2010

Note: these estimates served solely as a guide for the national response to the Deepwater Horizon MC252 Gulf Incident.

Challenges

A number of factors can reduce the efficiency of at-sea containment and recovery operations. These need careful consideration during both the oil spill contingency planning and response phases.

Challenges include:
- the availability of logistical support (including vessels) for an escalating response;
- the likelihood of oil rapidly spreading and fragmenting;
- prevailing environmental conditions (sea state, current, wind);
- the ability of vessels to tow and manoeuvre at low speeds;
- limited encounter rates due to slow boom towing speeds and narrow swathe-width;
- offshore temporary storage capacity versus skimmer recovery rates;
- the availability of competent personnel to conduct and support the operation;
- limited field of vision caused by low height of eye above sea level or poor weather; and
- lack of aerial support and communications.

A high level of preparedness can help to overcome these challenges, and can enhance and increase the efficiency of the response. Key elements in building response preparedness include:
- understanding the oil's properties, fate and potential effects;
- use of sensitivity mapping and oil spill modelling (i.e. to predict the trajectory of the spilled oil and where it is likely to have an impact);
- selecting the appropriate equipment for responding to the type of oil spilled;
- training response teams to ensure that they are familiar with the equipment and have an understanding of the appropriate response techniques;
- encouraging response teams to build an efficient interface between teams with different roles in the response; and
- periodic exercising including mobilization of response equipment.

Oil behaviour and the 'window of opportunity'

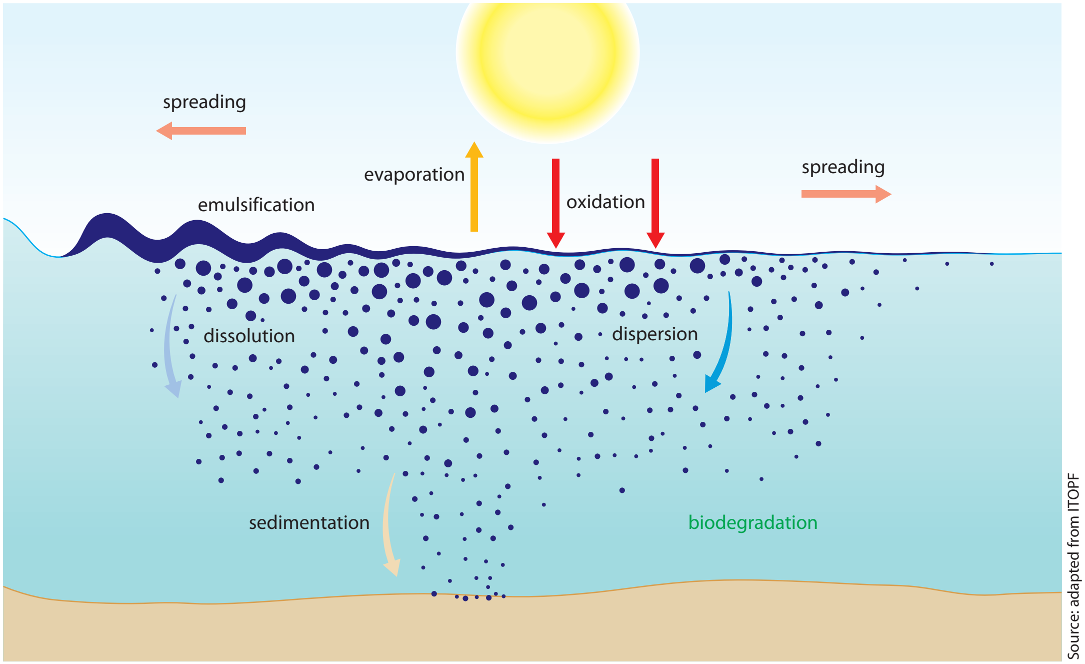
The success of any response method depends on the response taking place during a specific time frame in which that particular response will have the greatest degree of success. This time frame is known as the 'window of opportunity'. For at-sea containment and recovery operations, the window of opportunity will usually be as soon as possible after the oil release has taken place, i.e. the sooner containment and recovery operations commence, the more effective they will be.

When oil is released into the marine environment it is subjected to natural weathering processes. The weathering processes that are most relevant to at-sea containment and recovery are evaporation, spreading, fragmentation and emulsification. The chemical properties of the oil in question, and the environmental conditions at the time of release, will determine the rate and type of weathering that takes place (Figure 12).

Evaporation

Evaporation of the lighter, more volatile components of any oil will begin as soon as oil enters the marine environment. The rate of evaporation will depend upon the distillation characteristics (volatility) of the product, the ambient temperature, wind speed and sea state, and may increase

Figure 12 *Oil weathering processes*



as the oil spreads and the thickness of the slick is reduced. In general, the majority of the lighter components evaporate within the first 24 hours following the release.

Although the process of evaporation reduces the overall volume of oil on the sea surface, the viscosity of the remaining oil will increase. This will influence the selection of the recovery device, and may affect the rate of recovery of the spilled oil.

Evaporation of the lighter components of oil can also create a gaseous hazard for responders. It is therefore essential that, as a minimum, gas monitoring is in place for the protection of the workforce. The safety of personnel is always of paramount importance.

Spreading

Spilled oil will spread rapidly after its release, quickly covering a large area and reducing in thickness until an equilibrium thickness is reached. The rate at which oil spreads is dependent on several factors, including:

- oil viscosity: oil of low viscosity will spread at a faster rate than medium or heavy crudes. This is defined by the oil's specific gravity, which is commonly expressed as API°;
- ambient air and sea temperature: as temperature increases, oil viscosity reduces, thus increasing the rate of spreading; and
- current and wind speed: higher currents and wind speeds will accelerate the gravity-induced spread of oil.

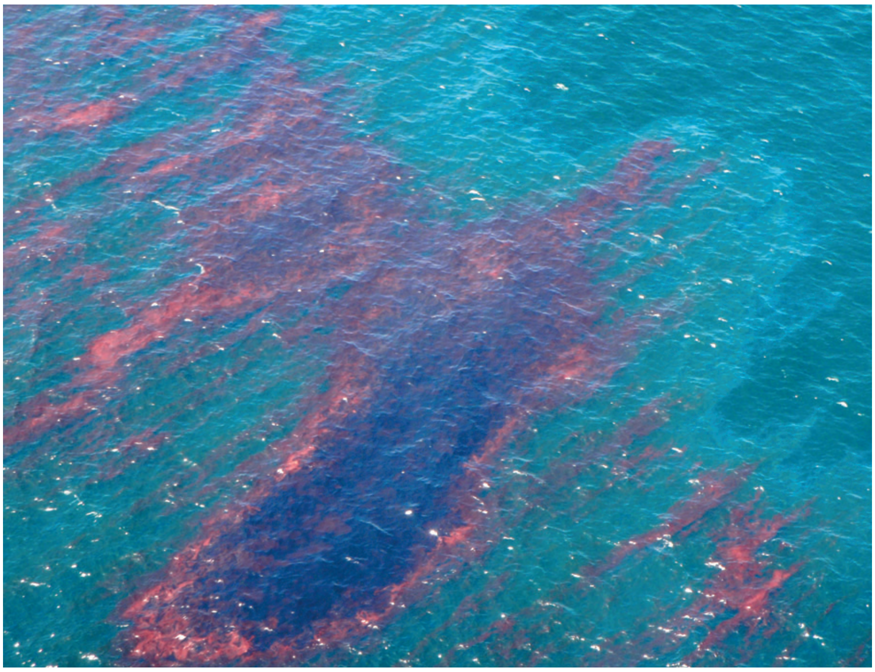
The effects of current and wind mean that spilled oil does not generally spread in a uniform manner or to a uniform thickness. This non-uniform spreading can lead to up to 90% of the oil volume being concentrated in as little as 10% of the impacted area.


OSRL

Non-uniform spreading of oil under the influence of gravity, wind and surface currents.

Fragmenting

Once spilled oil has started to spread, it also begins to fragment, separating into patches, streamers or windrows under the influence of wind and surface currents. Fragmentation further increases the total area of coverage, leaving areas of open 'clean' water, interspersed with patches of surface oil.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Fragmented oil in the form of windrows running parallel to the wind direction.

Emulsification

Emulsification occurs when wave action causes water droplets to become suspended in the spilled oil to form a water-in-oil emulsion. This process increases the viscosity of the oil and its persistence in the marine environment.

Emulsions may be stable or unstable, with each type having distinct physical properties. Stable emulsions have a high water content (generally greater than 70%) and are usually highly viscous; they can remain stable for several weeks unless treated with emulsion-breaking chemicals or exposed to heat. These persistent emulsions exhibit a reddish-brown colour and are often referred to as 'chocolate mousse'. An unstable emulsion has lower water content (generally less than 50%) after mixing. Unstable emulsions generally decompose to separate water and oil phases soon after the mixing energy is removed or after a temperature increase. An unstable emulsion may decompose after a matter of days, or may persist for as little as 24 hours, for example where an emulsion forms as the slick cools at night but breaks up when the sun warms the oil in daylight hours. Unstable emulsions retain the colour of the original oil, i.e. either dark brown or black.

Environmental conditions, in particular wave energy, play a key role in the emulsification process, with higher-energy conditions having a greater mixing effect than lower-energy, calm conditions. The greater the mixing effect, the more water is mixed with the oil, and hence the volume of the emulsion will increase. In some circumstances the volume of a water-in-oil emulsion can be up to 80% greater than the volume of oil originally spilled.

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Emulsified oil at sea.

Natural dispersion

Waves and turbulence on the sea surface will cause some of the oil to break up into smaller droplets that will mix into the upper water column. This is a natural process which, over time, can greatly reduce the volume of oil on the sea surface. In some circumstances, these naturally dispersed oil droplets can re-coalesce on the surface when the wave energy reduces.

What does this mean for at-sea containment and recovery operations?

At-sea containment and recovery operations are most efficient when targeted in areas with the highest concentration of spilled oil. These are generally the areas with the least evaporation, spreading and fragmentation.

Oil spill modelling and surveillance (including remote sensing) can assist in locating and quantifying spilled oil, enabling containment and recovery vessels to be in the right place at the right time to maximize the encounter rate with the oil.

The weathering processes need to be understood and monitored so that the most appropriate choice of recovery equipment can be made. This, in turn, will ensure that the efficiency of the recovery operation is not compromised. For example, if an oil type and environmental conditions indicate that the spilled oil will quickly emulsify, mechanical skimmers or weir skimmers (see page 7) would be preferred for their versatility and ability to collect the product at different stages of weathering.

Environmental considerations

The combination of a wide range of environmental conditions—in particular visibility, wave height, current speed and wind speed—will influence decisions regarding the specific type of containment equipment that is selected and the viability of response operations.

Care will need to be taken when evaluating these environmental considerations. For example, a choppy sea with 4-metre waves, short wave periods and wind-driven cross seas is likely to prevent at-sea response operations due to responder safety concerns; however a sea swell with 4-metre waves but a significantly longer wave period may be workable.

Since the viability of the response and the selection of appropriate equipment will depend on the precise circumstances at the time of the release, it would be impractical to attempt to specify definitive environmental limitations regarding at-sea response operations in general. However, the indicative guidelines shown in Table 1 may be considered from an equipment performance perspective.

Table 1 *Guidelines on environmental limitations for conventional containment and recovery*

General environmental limitations*			
Visibility	Maximum wave height	Maximum current/ towing speed	Maximum wind speed
Daylight hours, fog	2.5 metres	0.75 knots	20 knots

* The safety of personnel is paramount. A decision to respond should be made at each operational stage.

Recent developments have focused on expanding the range of environmental conditions in which successful at-sea containment and recovery can be achieved, in particular improving the ability of containment booms to perform effectively in higher current speeds and in more extreme wind and wave conditions.

Operational limitations

In addition to managing the challenges and limitations presented by the environmental conditions and the weathering processes of the oil, it will also be the responsibility of responders to maximize the overall effectiveness of the response operation.

For example, where the ability to respond safely is influenced by environmental factors such as high winds and sea states or extremes of temperature, the deployment of a single-vessel system may be appropriate as it could provide greater flexibility and reduce logistical constraints. However, this advantage could also be offset by other operational limitations.

A further operational challenge is presented by the need to maintain efficient at-sea containment and recovery operations when oil has undergone significant spreading and fragmentation over large geographical areas. This will require careful attention to the response approach and the selection of appropriate equipment.

Types and causes of boom failure

Containment operations are not always successful. Where this is the case, the cause generally falls into one of the categories presented below.

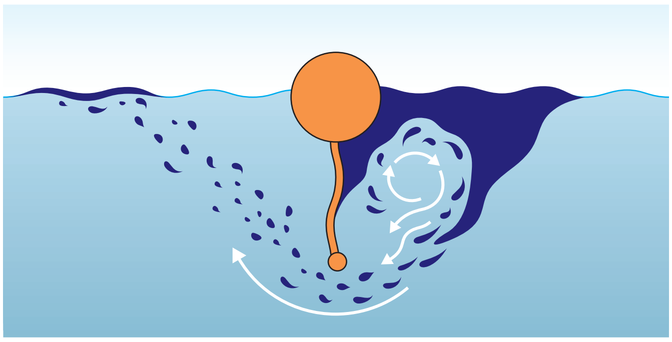
Current and entrainment failure

Current and entrainment failures occur when the surface current is too fast or the vessels are moving faster than the maximum towing speed for containment booms (generally around 0.75 knots for a conventional boom).

During current failure, the speed of the boom through the water causes it to plane across the sea surface allowing the oil to escape underneath. This can also occur when the wind and current are present in opposite directions.

During entrainment failure, the speed of the boom through the water creates a vortex allowing oil to pass under the skirt of the boom (Figure 13).

Figure 13 *Boom failure due to entrainment of the oil*

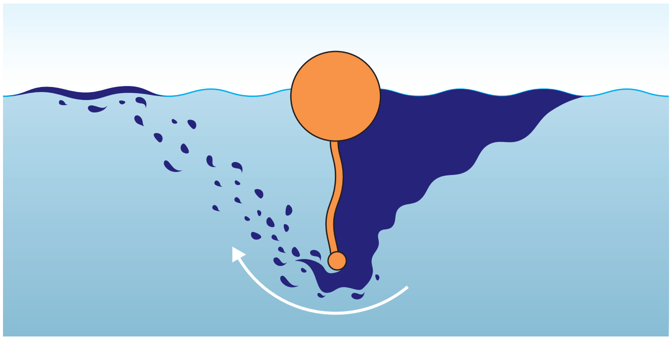


Visual clues to boom failure include the appearance of vortices behind the boom apex and entrainment of the concentrated oil. It is normal to see light sheening behind the apex even for the most successful operations. Generally, boom failure occurs when vessels are towing too quickly or when the type/capacity of the boom is inappropriate for the circumstances in which it is being deployed. Both types of failure can be avoided or mitigated through training of vessel crews.

Drainage failure

Drainage failure occurs when the volume of oil concentrated at the apex of the boom exceeds the maximum retention capacity of the type of boom in use (Figure 14). As the volume of encountered oil increases it is forced down the side of the boom's skirt. If the holding capacity of the boom becomes overwhelmed by the increasing volume of oil, the collected oil is pushed under the skirt and escapes. To prevent drainage failure from occurring, the contained oil should be recovered and transferred to temporary storage before the maximum capacity of the boom is reached.

Figure 14 *Boom failure due to drainage of the oil as it exceeds the holding capacity of the boom*



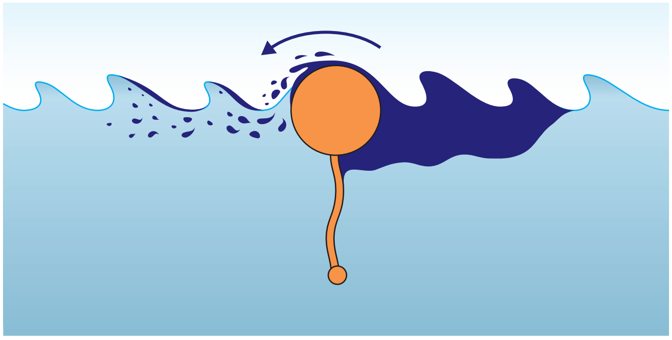
Splash-over failure

Splash-over occurs when wave action is too great for the boom in use. Short-wavelength, high-amplitude waves (high wave steepness) are more likely to cause splash-over failure than long-wavelength short-amplitude (low wave steepness) waves. Steep waves are typically generated by strong surface winds, especially when moving against the direction of the water currents.

The rounded profile of the inflation chamber of a containment boom helps to counter the effect by 'following' all but the steepest of waves. This wave-following characteristic is a key design consideration in an effective containment and recovery system. Other design features that reduce this effect are high freeboards (i.e. the distance from the waterline to the top of the boom) and the inclusion of a water ballast chamber in place of a traditional skirt. The nature of spilled oil creates a calming effect on the surface which, in itself, can assist responders by contributing towards reducing loss of containment caused by splash-over failure.

Figure 15 on page 23 illustrates the failure of a boom due to splash-over in high-amplitude wave conditions.

Figure 15 *Boom failure due to splash-over in high-amplitude wave conditions*



Boom damage

Containment booms are designed to be robust and able to withstand repeated and extended deployment in a range of offshore environments. Despite this, damage can occur when the safe operating parameters of the boom are exceeded.

Boom damage can occur when the tension chain or cable fails and the towing force is exerted through the boom material. This often occurs when the boom is being operated outside its design parameters or being towed too quickly. To avoid this type of failure, clear communication between vessels is paramount to prevent damage to equipment or injury to personnel. Crew competence is essential for the safe and effective deployment of a containment boom. Training and exercising plays an important role in maintaining crew competence by building awareness of the limitations of different types of booms and the potential impacts on vessel performance.

Damage can also occur when the containment boom collects floating debris which can puncture or tear the boom material.

Other limitations

A number of additional factors have the potential to impact on at-sea containment and recovery operations. These include:

- equipment maintenance and repair;
- sailing time to and from the spill location to a port or harbour;
- crew changes;
- vessel logistics, such as fuelling, welfare stores (food, water, etc.); and
- waste management, including available storage, the time it takes to transfer recovered oil from skimmers to vessel tankage or barges, etc.

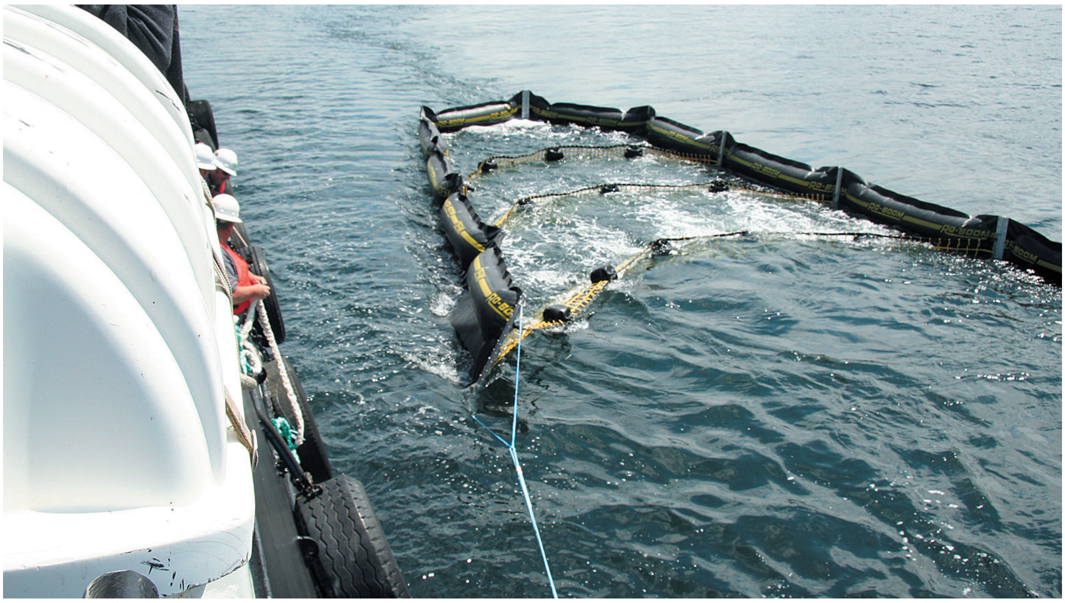
Technological advances

In recent years there has been a focus on ways to increase encounter rates to match the potentially high recovery rates of modern skimmers, thereby providing a greater effectiveness for at-sea containment and recovery operations. Technological advances in containment system design include:

- improved design to reduce deployment time;
- hydrodynamic design to allow increased towing speed;
- integrated oil/water separator within the boom;
- a system of nets to reduce the surface speed of contained oil and water;
- temporary storage of contained oil within the structure; and
- improved integrated skimmers in active booms.

Conventional containment methods can provide large swathe widths but are generally limited to current/towing speeds of around 0.75 knots. This configuration is effective at achieving a high encounter rate in scenarios where containment operations commence at the early stages of weathering, or are performed close to the source of a continuous release.

High-speed containment systems offer a narrower swathe width, but can operate at current/towing speeds of up to 5 knots. In scenarios where the oil has spread and fragmented significantly, or where manoeuvrability is required, such systems may achieve a higher encounter rate than conventional containment methods.



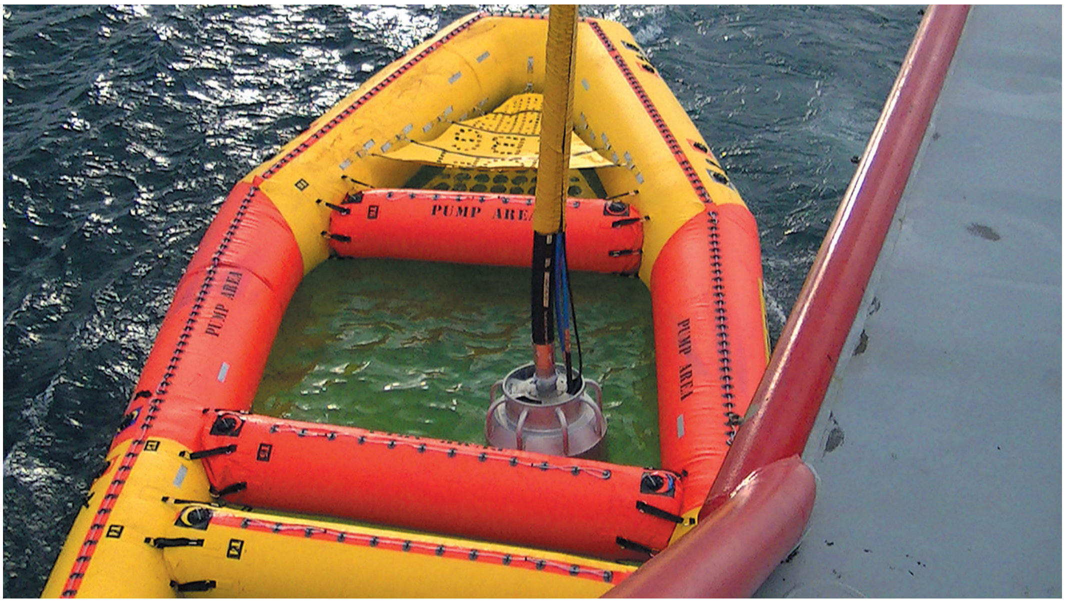
Desmi

High-speed boom with integrated netting to reduce surface oil/water speed.

Skimmer nameplate capacities (i.e. the operating capacities published by the manufacturers) can be relatively high and may be up to 300 m^3 per hour for some devices. However, even though skimmers and transfer pumps may be technically capable of achieving such levels of throughput, these capacities may not be representative of the effective oil recovery rate in a real-world operational scenario. A range of additional factors, such as slick thickness/encounter rate, oil viscosity, the availability of sufficient storage capacity, etc. will all influence the level of throughput in the field.

Enhancements in skimmer technology are helping to improve their efficiency in recovering oil. These include the application of a fibre coating to disc skimmers and the introduction of groove disc/drum skimming.

The availability of temporary storage facilities can have a large impact on the quantity of oil recovered at sea. Integrated containment systems have been developed in recent years that combine higher-speed containment with temporary storage capacity; in some systems these can hold up to 30 m^3 of contained oil. Although these benefits are tangible, the need to account for temporary or intermediate storage remains important for operational success. A further challenge, presented by both integrated and conventional booms, is the collection of debris that can potentially block or damage the boom and/or the oil recovery device.



NOFI

Integrated temporary storage in the apex of the boom.

Response resources

At-sea containment and recovery operations rely on the combination and integration of a number of resources including:
- vessels;
- containment booms;
- recovery device;
- waste storage;
- ancillary equipment; and
- trained and competent personnel.

Vessels

For a typical at-sea containment and recovery operation, a deployment vessel and at least one tow vessel is required. These may be vessels that have been designed specifically for spill response operations, or they may be vessels of opportunity (VOO), i.e. local commercial and recreational vessels (e.g. trawling vessels) contributed by their owners to assist during an oil spill response.

Some organizations have specific criteria or standards (generally related to safety) that need to be met by any vessel engaged during a response. A survey of the vessel should be completed prior to the start of operations to ensure that it meets both safety and regulatory requirements. Consideration should also be given for the operational environment in which the vessel will be required to operate; for example, ice-class vessels are required for operating in Arctic environments.

Ideally, a suitable deployment vessel should have:
- adequate deck space to safely load, secure and deploy the response equipment;
- an open stern;
- a deck crane to lift equipment, with a reasonable safe working load at an extended reach;
- a means of (or ability to have installed) vessel-to-vessel and vessel-to air-communication;
- suitably certified vessel tanks capable of storing recovered oil, or adequate/suitable deck space for temporary storage tanks; and
- adequate accommodation and facilities for personnel on board.

A method of transferring and transporting the recovered oil will need to be considered. In some instances particularly in cold climates, heated tanks will be required to ensure that oil does not become too viscous to pump.

During prolonged operations and where ship-to-ship transfers are permitted, consideration should be given to the use of a separate vessel to shuttle supplies and recovered product between the containment and recovery vessels and the shore, or to an in-field storage vessel to offload product. This will allow working vessels to remain on station in recovery mode for extended periods to maximize encounter rates.

Containment booms

A comparison of containment systems is presented in Table 2, with a summary of their advantages and disadvantages.

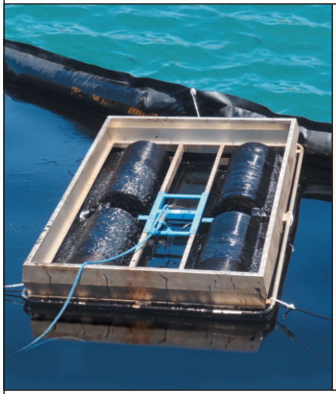
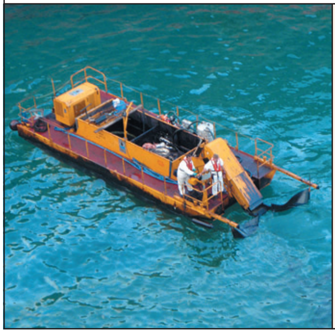
Table 2 *Advantages and disadvantages of different types of containment booms*

	Description	Advantages	Disadvantages
Conventional booms			
	Conventional inflation booms are generally used for offshore activities as they have good wave-following characteristics. Although there are many variations of conventional offshore booms the principles of operation remain the same.	A conventional boom is relatively simple to deploy and maintain, and is therefore ideally suited to spills where it may be necessary to deploy and recover the boom frequently as the vessels 'chase' the oil. Conventional inflation booms require considerably less storage space.	To complete the system a suitable recovery device and waste storage facility will need to be identified. Conventional booms are sensitive to damage caused by debris in the water. Inflatable booms generally take longer to deploy.
Active systems			
	Active boom systems incorporate a pump or skimmer within the boom structure to create a combined or integrated containment and recovery system. The recovery device is positioned at the apex to remove contained oil. Active booms are generally equipped with high recovery-rate devices.	Greater convenience of operation is achieved through the smaller number of components that need to be deployed, operated and maintained in an integrated containment and skimming system. Active systems have greater recovery potential.	Active booms are more complicated to deploy, recover, maintain and repair than conventional booms. They collect a considerable amount of water along with the oil so are best used in areas with higher oil concentrations/thicknesses.
High-speed systems			
	High-speed systems are capable of being towed at increased speeds. Some incorporate temporary storage facilities and an oil/water separator to increase response efficiency.	High-speed systems can be towed at faster speeds, and therefore have an increased encounter rate. Incorporating temporary storage and a weir separator maximizes the amount of oil that is recovered, thereby minimizing water uptake.	A vessel dedicated to recovering oil from the boom is generally required as the apex is a considerable distance from the tow vessels; alternatively, once full, the towing can be stopped and one of the tow vessels can be utilized to recover the oil. High-speed systems are prone to collecting debris which can reduce containment efficiency and has the potential to cause damage to the system.

Recovery devices

A comparison of recovery devices is presented in Table 3, with a summary of their advantages and disadvantages.

Table 3 *Advantages and disadvantages of different types of recovery devices*

	Description	Advantages	Disadvantages
Oleophilic skimmers			
	An oleophilic skimmer uses belts, brushes, discs, drums or rope which have oleophilic ('oil loving') properties. The oleophilic surface picks up the oil which is then removed by scrapers and pumped to storage.	The amount of water collected is reduced compared to other types of skimmers. In optimum conditions up to 95% of recovered liquid is oil.	Disc and drum skimmers are not suitable for use in heavy oil, and lose efficiency if the oil emulsifies (i.e. the high percentage of water in the oil inhibits the ability of the oil to adhere to the oleophilic surface). Other than some brush skimmers, oleophilic skimmers are generally limited to use in relatively calm waters.
Weir skimmers			
	A weir skimmer places a weir edge at the oil/water interface, and the oil flows into a collection area from which it can be pumped into storage.	Weir skimmers generally have higher recovery capacities and are effective for use on light, medium and some high-viscosity oils (the recommended viscosity ranges will depend on the model and manufacturer).	Weir skimmers are sensitive to weather conditions and tend to recover a relatively high proportion of water. Weir skimmers generally require continuous monitoring and frequent adjustment by the operator to ensure maximum efficiency.
Mechanical skimmers			
	A mechanical skimmer physically removes oil from the water's surface by the use of nets, drums,conveyor belts (e.g. Marco Belt skimmer) or crane-operated buckets.	Mechanical skimmers are effective on oils of high viscosity, and on weathered or emulsified oils. They can operate in areas where small amounts of debris are present.	A thick layer of oil is preferred to maximize the efficiency of the operation. Water or steam injection may be required to enable the oil to be transferred by the device.

Waste storage

A comparison of waste storage facilities is presented in Table 4, with a summary of their advantages and disadvantages.

Table 4 *Advantages and disadvantages of different types of waste storage facilities*

	Description	Advantages	Disadvantages
Intermediate bulk containers (IBCs) or barrels			
	IBCs are plastic containers with a cubic capacity of around 1–2 m^3 surrounded by a metal frame. They can be stored and secured easily on deck.	IBCs/barrels are often readily available, and are easily transportable	IBCs take up valuable space on deck and have limited capacity.
Mini and inflatable storage devices			
	Inflatable storage barges comprise an inflated sponson, with a plastic skirt floating below. They typically have a capacity of up to 50 m^3. Floating storage bladders are also available that can be rolled up for storage and then deployed on the water surface where they will expand as recovered liquids are transferred from the skimmers.	Recovered oil is not stored onboard the towing vessel. Storage barges or bladders can be towed by a separate vessel, allowing containment operations to continue for extended periods. Once deflated, they can be stored in relatively small areas.	Storage barges are susceptible to damage, which may lead to the loss of recovered oil. The manoeuvrability of the towing vessel may be restricted due to the proximity of a storage barge(s) or bladder(s). Special arrangements may need to be made for the recovery of the barge at a port or harbour. The large draft of some barges prevents their use in shallower waters.
Vessel tanks/tanker vessel			
	These are the towing vessels' own internal storage tanks; the capacity will vary depending on the vessel.	Oil is stored internally onboard the towing vessel without having to source temporary storage. Some vessels have heated tanks which can help to reduce the viscosity of the oil.	Vessels' internal systems may not comply with regulatory requirements for the handling of recovered oil. Vessel owners are not always willing to have oil stored in their ship's tanks.

Note: transfer options need to be considered for transferring waste; vessel transfer pumps or portable pumps will be required to transfer recovered oil from temporary to intermediate storage. Ship-to-ship transfer regulations may apply in some locations.

Ancillary equipment

Various items of ancillary equipment are required when carrying out at-sea containment and recovery options. These items include:

- safety equipment, such as air monitoring devices and personal protective equipment (PPE);
- a source of power for the boom reel (if used), skimmer and pumps—this will often be a hydraulic power pack or a vessel's onboard hydraulic power systems;
- hydraulic hoses or other means of connecting power to the skimmer and pumps—these need to be sufficiently long to deploy the equipment into the apex of the boom;
- oil discharge hoses;
- air inflator;
- hose floats and buoys;
- boom towing bridles;
- consumable items (fuel, oil, sorbent material, ropes, etc.);
- decontamination equipment;
- washing equipment for personnel, equipment and vessels; and
- support vessel—this would be a multiple-purpose vessel which may carry out tasks including air monitoring, debris removal and the re-inflation of air chambers.

Personnel

The following key personnel are essential for successful at-sea containment and recovery operations:

- **Vessel captain:** accountable for the safety of the vessel and crew, and for overseeing or carrying out vessel movements.
- **Deck supervisor:** needs to be appointed to manage the on-deck operations and advise the vessel captain of towing speeds. This role is the main communications link between the bridge of the vessel and the deck. Where possible, the deck supervisor should maintain a strictly supervisory role focusing on monitoring deployment techniques and ensuring safety of operations.
- **Deployment crews:** need to be of sufficient size to carry out operations on deck, but should be limited to personnel who are essential for the deployment activities in order to maintain effective and safe operations.

Operational personnel carrying out at-sea containment and recovery operations will require training and a high level of competence to perform safe and effective operations.

Vessels sourced for response operations will need to come with a crew large enough to operate the vessel and support the boom deployment and oil recovery operations. Generally, this crew will have substantial marine experience, and at least some degree of local knowledge. If night-time operations are anticipated, additional crew members will be required to form two shifts.

Where practicable, it is preferable to train vessel crews in advance of any spill. For example an oil company carrying out offshore exploration and production activities will have its own vessels and crews, and in this instance a training programme should be established to build crew competence.

In other circumstances, in particular where vessels of opportunity are sourced during a response, experienced responders will need to be sourced to supervise vessel crews and provide them with on-the-job training while performing containment and recovery operations.

As a minimum, personnel should be trained in:
- the health and safety requirements of conducting containment and recovery operations, and general safety at sea;
- conducting pre-deployment checks and the safe operation of equipment;
- towing configurations and techniques; and
- the causes of boom failure and how to prevent it.

Regular planned training including drills and exercising should be conducted to maintain competency of trained personnel. These events can be made more effective through the use of 'oil mimics' such as popcorn or other floating aids, which can be employed to add realism to an exercise.

Tracking and surveillance

Aerial support

One of the challenges of effective containment is the visibility of oil while operating at sea level. Aerial surveillance (e.g. using aircraft or aerostats) can be useful to increase efficiency of at-sea containment and recovery operations by using the high vantage point to guide recovery vessels into areas with the highest concentrations of oil. Aircraft and vessels require a suitable means of communicating, preferably marine band ultra-high frequency (UHF), very high frequency (VHF) or high frequency (HF) radios.

Aircraft assigned to a response can serve as multipurpose assets, conducting a number of roles in support of a wide range of response techniques, including:
- quantification and characterization of slicks (e.g. the Bonn Agreement Oil Appearance Code[2])
- acting as a spotter plane to monitor and guide operations including containment and recovery, dispersant application and in-situ burning;
- carrying out aerial dispersant application operations; and
- observation of wildlife.

Unmanned aerial systems (UAS) have the potential to fill an important gap in surveillance capability, being able to operate at a scale traditionally associated with fixed-wing aircraft through to almost in-situ (close tactical) scales. Some can fly at very low altitudes, with high degrees of flight flexibility and with no human exposure. They are therefore complementary to manned aircraft and, indeed, to satellites. UAS represent a new technology in the civilian domain, and it is worth considering their potential and the associated challenges, which are outlined in IPIECA-IOGP (2014) and API (2013).

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[2] The Bonn Agreement Oil Appearance Code (BAOAC) is a series of five categories or 'Codes' that describe the relationship between the appearances of oil on the sea surface and the thickness of the oil layer. See: www.bonnagreement.org/site/assets/files/3952/current-status-report-final-19jan07.pdf

UAS will play an increasingly important role in oil spill response operations in the future, with the market likely to expand rapidly over the next five years. The industry should ensure that it is ready to exploit this technology effectively, which requires keeping a close eye on developments in both technical and regulatory requirements over the next few years.

Vessel-mounted spill detection technologies

Tethered aerostats are a low-level surveillance alternative to manned aircraft. Tethered aerostats are buoyant, helium gas-filled balloons attached to a vessel by a wire tether. A camera, which may include thermal imaging sensors, is installed to the underside of the balloon. This can provide a direct live feed to assist the vessel captain. Additionally, depending upon the system and vessel's data transmission capabilities, it may be possible to transmit spill data directly to the Incident Command Centre.

Near right: a tethered aerostat attached to a vessel by a wire tether.

Far right: example of direct live feed from a tethered aerostat.

OSRL

OSRL

Unlike aircraft which are only able to stay on scene and provide assistance to the vessels for a limited period, an aerostat can be deployed from the vessel and give near continuous cover during the operational period.

Careful planning and control of the air space must be considered if these devices are to be used simultaneously with low flying aircraft; in some parts of the world, regulatory restrictions may apply. Increasingly, infra-red and multispectral technologies are able to provide an approximation of relative oil thickness in variable light conditions.

Ship mounted spill detection radar systems have evolved to allow oil spills to be detected up to 12 nautical miles from the vessel (subject to the height of eye of the radar). The radars are able to define details of the slick via a display monitor mounted on the bridge to highlight information such as slick size and other useful data.

Safety

At-sea containment and recovery operations are inherently hazardous, and measures should be put in place to protect response personnel. Risks to the health and safety of personnel, such as operating near water and exposure to the elements, are typical of any offshore operation, and are exacerbated by the conditions faced during containment and recovery of oil. Slippery decks, trip hazards caused by trailing hoses, towing ropes under high tension and working long hours under high pressure all impose additional hazards to crews and response teams. Floating oil can also present inhalation and fire and explosion hazards depending on the volatility of the oil or its state of weathering.

Operations should be conducted in a way that aims to reduce the risk to health and safety of all personnel to a minimum. Equipment should be operated according to manufacturers' recommended guidelines, within specified limitations and in accordance with good operating procedures and practice. It is also essential that responders wear the correct PPE and that air/gas monitoring be conducted as described later in this section.

It is of utmost importance that sufficient training and a base level of competence is established prior to commencing operations. A comprehensive daily safety briefing, based on an operationally-specific risk assessment, should be given to all personnel onboard the vessel by a qualified person. Personnel who are not usually part of the vessel crew should be given a briefing on general safety and emergency procedures; this is normally provided by the vessel captain or a nominated crew member.

Working patterns will differ from a responder's regular routine during an actual response. Fatigue presents a potential risk multiplier and consideration must be given to working hours and crew changes; these should follow the safety plan developed by the Incident Management Team. Careful planning should be undertaken to ensure that vessels can support the welfare of personnel, including the provision of medical supplies, trained first-aid personnel and medevac procedures in case the need arises.

Environmental hazards

Personnel conducting at-sea containment and recovery operations are exposed to environmental hazards, many of which can be mitigated through proper planning and training. Containment and recovery operations would not normally be conducted in conditions that exceed the prescribed limitations relating to the safety of personnel and assets, the increased loss of response efficiency and additional hazards associated with some sea states. Dehydration, cold/heat stress, sunstroke and seasickness are also important considerations which must be properly managed. The Incident Management Team will support field operations by providing safety guidance, however, vessel captains and deck supervisors should ensure that good safety practices are followed at all times. Shift patterns introduced during working periods can prevent prolonged exposure to the prevailing conditions, especially when working in extreme temperatures and other environmental conditions.

Gas monitoring

As oil evaporates it releases gases into the atmosphere that can be harmful to health. When working with, or near, oil it is important to carry out specific site entry protocols; vessels should approach the operational area upwind while conducting atmospheric gas monitoring which should continue throughout the operation. Wind direction should be continuously monitored and, if concentrations reach an unsafe level, vessels should vacate the zone in a crosswind direction until a safe area is reached. Gas monitors should measure:

- hydrogen sulphide (H_2S);
- oxygen;
- volatile organic compounds (VOCs);
- carbon monoxide;
- lower explosive limit (LEL) (based on methane); and
- benzene.

Some oil types will release more H_2S and VOCs than others, so it is important to know the oil type or predicted properties of the oil. Both personal and area gas monitors can be used to monitor gas levels, and an emergency evacuation plan should always be made and communicated prior to entering the area of operation.

Risk assessment

At-sea containment and recovery operations are conducted in changeable and sometimes unpredictable environments. Operating in such environments can be a potentially stressful situation for personnel, which may mean that responders are engaged for long hours and conducting operations that may be very different from their day-to-day work. These additional factors can further compound the risks associated with at-sea containment and recovery.

Site- and operation-specific risk assessments should be developed and reviewed on a regular basis. Risk assessments may also need to be updated when something occurs to alter the operational environment; for example, this may be a change in weather or the use of a different type of equipment. A dynamic risk assessment process should be implemented and used on all vessels and at all work sites to ensure that activities are carried out at all times with appropriate risk mitigations in place.

As part of the safety regime, safety briefings should be carried out at the start of each operational period to ensure that responders remain aware of the hazards and control measures, and especially how such measures may be adjusted to take into account, for example, the weather forecast for a particular period, or variations in tasks and roles.

The five stages of a site- and operation-specific risk assessment are:

- identify the hazards;
- determine who is exposed to each hazard;
- evaluate how individuals may be impacted by this hazard and identify risk control measures;
- record the assessment and implement the risk control measures; and
- review the assessment and update when necessary.

Preparedness measures

It is always a goal of the oil and shipping industry to avoid the occurrence of an oil spill. However, while significant measures are taken to prevent spills from occurring, a residual risk will always remain.

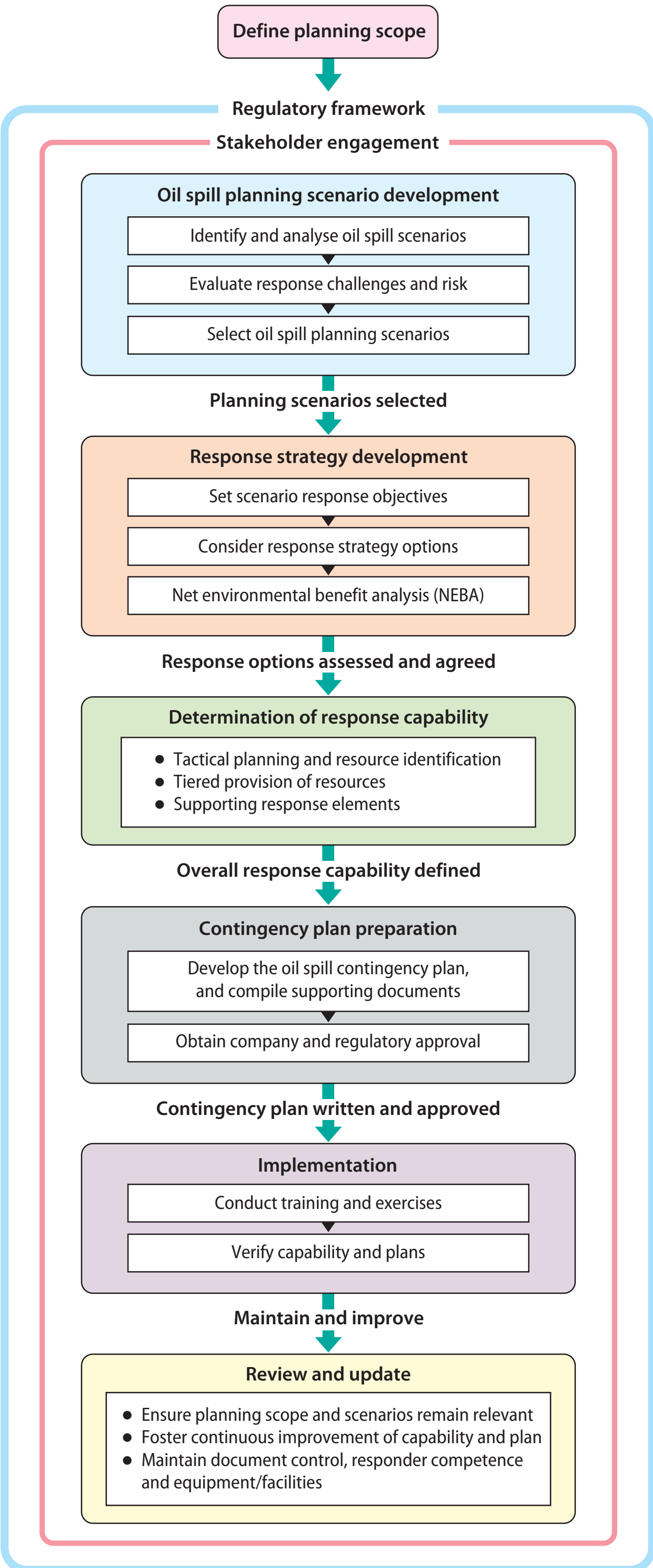
Preparedness is a fundamental element of establishing a strong response framework that is capable of dealing with oil spill scenarios ranging from small spills up to a worst credible case, as defined in the oil spill risk assessment.

The core components of the preparedness process are:
- oil spill planning scenario development;
- response strategy development;
- determination of response capability;
- contingency planning documentation;
- implementation; and
- review and update.

Further details can be found in the IPIECA-IOGP good practice guide on contingency planning for oil spills on water (IPIECA-IOGP, 2015a).

Specific considerations during the planning phase which are relevant to at-sea containment and recovery include:
- selection of the type, number and amount of containment booms, based on the operating location and associated risk(s);
- selection of the most efficient recovery device, based on expected volumes and predicted changes in the oil's characteristics as well as the prevailing environmental conditions;
- storage options for recovered oil/water, with capacities able to accommodate the volumes that could potentially be recovered during an operational period;
- access to suitable vessels for the safe and effective deployment and operation of equipment;
- proximity to ports and harbours to act as staging areas for the mobilization of personnel and equipment as well as the receiving of recovered oil/water; and
- access to competent and trained response personnel, or the development of appropriate training for those responders.

Figure 16 *The oil spill contingency planning process*



When carrying out tactical response planning for at-sea containment and recovery, the tiered preparedness and response philosophy should be borne in mind, especially when considering the size and location of stockpiles to be established, identifying locations where vessels may be sourced and determining timescales for deployment.

There is often a desire to predict the quantity of response equipment required based on a mathematical formula that use the estimated volume of oil released as an input. There are a number of challenges with this approach, for example it may not be possible to predict the eventual size of a response during the planning phase. It is therefore generally preferred for planners to establish response capabilities with greater emphasis placed on factors such as the ability to escalate and cascade resources into the theatre of response to build the required capability. For further information on this topic, see the IPIECA-IOGP Good Practice Guide on tiered preparedness and response (IPIECA-IOGP 2015b).

Drills, training and exercising

Drills, training and exercise programmes are an important part of oil pollution emergency arrangements. These programmes often share a variety of common elements, although the specifics will be determined by an operation's oil spill contingency plan or regulatory requirements.

Individuals with emergency response roles should receive training related to the role they will perform. This ensures that personnel are fully aware of their assigned roles and are practised in the execution of those roles.

A programme of exercises and drills can provide the assurance that the equipment, logistics, systems and communications required during an oil spill response are in a state of readiness. Exercises are most beneficial when linked directly to scenarios described in the oil spill contingency plan.

Containment boom training.

OSRL

The International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC Convention) obliges governments that have ratified the Convention to establish a programme of exercises for oil pollution response organizations, together with the training of relevant personnel.

Operators of offshore installations should seek to integrate their programmes within the governmental framework, where these have been developed at the national level.

A typical exercise will include a variety of participants including:

- Incident Management Team;
- Field Response Team;
- supporting third parties (e.g. vessel or barge operator);
- regulators; and
- stakeholders.

Command and control

An Incident Management Team (IMT), usually located within the Incident Command Post (ICP), is responsible for taking valuable intelligence from the field to determine the most appropriate response options for the incident. Each operational element should receive a briefing and tasking document prior to operations taking place. For at-sea containment and recovery this could include:

- a safety plan;
- the command structure;
- the area of operation;
- vessels, equipment and personnel required;
- specific instructions for booming techniques;
- a waste management plan;
- a communications plan;
- notice of other operations taking place in the same area; and
- any major changes to incident objectives or priorities.

The IMT is also responsible for coordinating the logistical effort to support the incident. This activity can range from organizing food and water for personnel to providing the appropriate number of VHF radios for efficient operations in the field. For at-sea containment and recovery operations, the logistical requirements can be vast and will include:

- sourcing suitable vessels;
- transportation of personnel and equipment and continuity of personnel;
- arranging removal of recovered oil and oily waste from vessels;
- sourcing and procuring consumables such as PPE, sorbents and fuel;
- maintaining, repairing and replacing equipment;
- setting up suitable communications networks; and
- safety support and advice.

Communications

Establishing effective communication for containment and recovery operations is essential to ensure safe and effective operations. Ineffective communication between the ICP and vessels, the aerial surveillance support and vessels, or between the bridge and the deck can lead to the unsuccessful recovery of oil, or to unsafe situations or accidents.

A communication plan should include:

- call signs and transmission frequencies of the assets deployed;
- methods and alternate methods of communication; and
- emergency communications protocols.

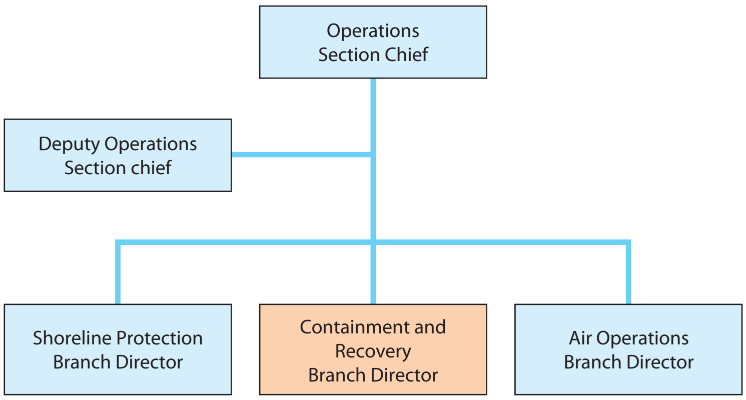
Methods of communication can include various bands of radios, satellite telephones and mobile (cellular) phones. Communication equipment held on vessels may vary, particularly when vessels of opportunity are utilized in a response; which may result in the need to adapt the methods of communication deployed.

Incident management for containment and recovery

An Incident Management System (IMS) such as the Incident Command System (ICS) can provide benefits to a response, enabling a large-scale response to be managed by defining command and control to manageable groups and teams of various functions. The fundamentals of an IMS lie in management according to objectives. An IMS includes standardized terminology, a scalable structure, defined roles and responsibilities and clear lines of communication.

At-sea containment and recovery should be undertaken as part of the Operations Section of an IMS, and can be set up as a branch or a group. Ultimately, the Director or Supervisor responsible for containment and recovery should report to the Operations Section Chief (see Figure 17).

Figure 17 *Example Incident Command Structure for the Operations Section*



Both formal and informal communications will be critical to organizing an effective and coordinated response effort. Data from all parts of the response can be collated to help inform a comprehensive Incident Action Plan (IAP) containing operational objectives and priorities.

It is the responsibility of the Containment and Recovery Branch Director (or similar) to coordinate containment and recovery assets. This will involve close coordination and cooperation with other elements of the IMT including;

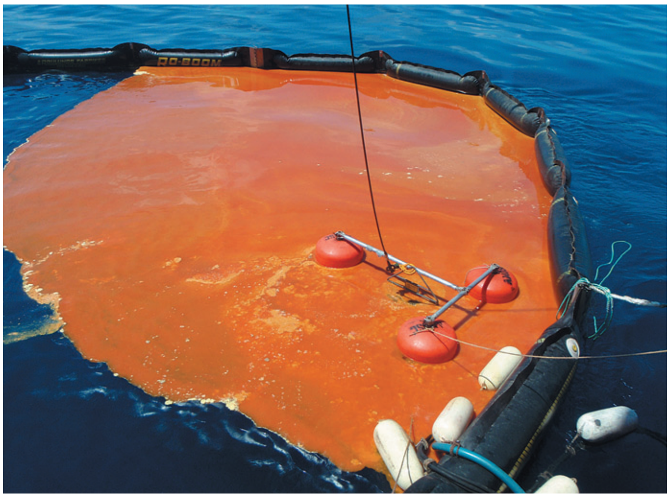
- Air Operations;
- In-situ Burning Operations;
- Dispersant Operations;
- Source Control;
- Logistics; and
- Planning.

Realities of containment and recovery—a case history

The Montara spill incident, 2009

The Montara spill occurred in August 2009 as a result of a well blowout in the Timor Sea, off the northern coast of Western Australia. An estimated 4,800 tonnes of waxy light crude oil was released, forming large slicks on the sea surface.

Verbal accounts from a member of the offshore response team are given below, along with key messages of reality.



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Recovering oil using a weir skimmer.

Reality message: Low efficiency skimmers can quickly inundate offshore storage with excess water.

Verbal account: *'We recovered about 30 tonnes of liquid per day, some of which was water. Ideally we could have decanted the water out, but the approval wasn't granted. There was limited storage on deck and this really slowed down our progress; as once they were full we had to wait to have them emptied by another vessel.'*

Reality message: Trained crew, good communication and suitable vessels are essential for a safe and effective response.

Verbal account: *'The boom was damaged due to the large forces acting on it, you do need to be going at very slow speeds when towing. Ideally, you'd want a smaller towing vessel, but both the deployment and towing vessels were large.'*

Reality message: Safety is of the utmost importance and hazards are often exacerbated in the offshore environment.

Verbal account: *'The heat was also a big issue working on deck, on most days it was over 50°C which made dehydration and heatstroke a major hazard. We had very limited shelter on deck. Logistically, this was a difficult spill to manage as we were operating 230 km from land and so medivac and support was somewhat remote.'*

Reality message: Surface debris can impede recovery rates.

Verbal account: *'The number one problem has got to be debris. There's often lots and lots of debris floating offshore; bits of wood, plastic, polystyrene etc. It really gets in the way when you're trying to work, it collects in the boom and there's no effective way of getting it out without releasing the oil that you've collected. It can also damage the boom when it builds up. It also poses a problem for skimmers and hoses can easily become blocked.'*

Reality message: Product transfer must form part of the containment and recovery system.

Verbal account: *'With oil of high viscosity, containment isn't really the problem. And neither is recovery using the skimmer, where we struggle is with pumping the viscous oil up and into storage tanks.'*

Reality message: Waste storage is often the limiting factor.

Verbal account: *'Storage is another major issue, and can really be the overall limiting factor when it comes to containment and recovery. Storage on deck is naturally very limited, and although pumping into the ship's tanks would seem like an obvious solution, vessel owners are often not keen to have their tanks full of oil. One solution I have seen work well, is to have storage barges that can shuttle between our vessel and the shore to take away our recovered oil.'*

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Reality message: Weather conditions offshore often limit the opportunities to conduct containment and recovery operations.

Verbal account: *'There is a very narrow window of opportunity for containment and recovery operations in terms of weather conditions. In some parts of the world, for example the North Sea, weather conditions can be unsuitable to operate in, in some instances. Many spill responses include waiting for good enough weather to start work. Other constraints include daylight hours to safely operate in (unless remote sensing technology is available to assist), the fatigue imposed on personnel during long response periods, can reduce the efficiency of the operation also.'*

Conclusions

At-sea containment and recovery is a valuable tool within the oil spill response toolkit, as it physically removes spilled oil from the sea surface. As with all response options, the responder can face a multitude of challenges which have the potential to reduce the overall effectiveness of containment and recovery as a response option. However, with rigorous planning, and a robust preparedness framework that enables rapid access to appropriate equipment and to qualified and trained resources, at-sea containment and recovery remains an effective method and an important part of the response toolkit.

To maximize protection of the wide range of environmental resources that may be affected by a spill, it is important to consider every option within the response toolkit so that the optimum combination of response options can be selected according to the outcomes of a full net environmental benefit analysis.

List of acronyms

E&P	Exploration and Production
GIRG	Global Industry Response Group
GPG	Good Practice Guide
HF	High Frequency
IAP	Incident Action Plan
ICP	Incident Command Post
ICS	Incident Command System
IMS	Incident Management System
IMT	Incident Management Team
IOGP	International Association of Oil & Gas Producers
IPIECA	The global oil and gas industry association for environmental and social issues
ISB	In-Situ Burn
OSCP	Oil Spill Contingency Plan
PPE	Personal Protective Equipment
SIMOPS	Simultaneous Operations
UHF	Ultra High Frequency
VHF	Very High Frequency
VOC	Volatile Organic Compound

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IPIECA

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance; and is the industry's principal channel of communication with the United Nations. Through its member led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

www.ipieca.org

IOGP International Association of Oil & Gas Producers

IOGP represents the upstream oil and gas industry before international organizations including the International Maritime Organization, the United Nations Environment Programme (UNEP) Regional Seas Conventions and other groups under the UN umbrella. At the regional level, IOGP is the industry representative to the European Commission and Parliament and the OSPAR Commission for the North East Atlantic. Equally important is IOGP's role in promulgating best practices, particularly in the areas of health, safety, the environment and social responsibility.

www.iogp.org