USE OF BOOMS IN OIL POLLUTION RESPONSE

TECHNICAL INFORMATION PAPER

3

Introduction

Booms are routinely used to surround and contain oil spilled at sea and to deflect its passage away from sensitive resources or towards a recovery point. The success of booming operations can be limited by the rapid spread of floating oil and the effects of currents, tides, wind and waves. Effective boom design and a well-planned and coordinated response can reduce these problems, although in some circumstances the use of any boom might be inappropriate.

This paper describes the principles of boom design and the two main modes of operation, namely towing by vessels at sea and mooring in shallow or inshore waters.

Design principles

Booms are floating barriers designed to perform one or more of the following functions:

- **Oil containment and concentration**: surrounding floating oil to prevent its spread over the water surface and increase its thickness to facilitate recovery;
- **Deflection**: diverting the oil to a suitable collection point on the shoreline for subsequent removal, for example by vacuum trucks, pumps, or other recovery methods;
- **Protection**: diverting the oil away from economically important or biologically sensitive sites such as harbour entrances, power station cooling-water intakes, mariculture facilities or nature reserves.

Booms come in a variety of sizes, materials and designs in order to meet the demands of these differing situations and environments. They can range from small, inexpensive, lightweight models for manual deployment in harbours (*Figure 1*), to large, expensive and robust units for offshore use, which may require the use of reels, cranes and sizeable vessels to handle them. Booms are available in a variety of lengths with couplings to allow sections to be combined to the desired overall length. Couplings also provide towing and anchoring points. In addition to reels, a variety of ancillary equipment such as towing bridles, air blowers and anchors may be required.

▲ *Figure 1: Fence boom deflecting oil from moorings.*

The most important characteristic of a boom is its oil containment or deflection capability, determined by its behaviour in relation to water movement. All booms normally incorporate the following features to enhance this behaviour:

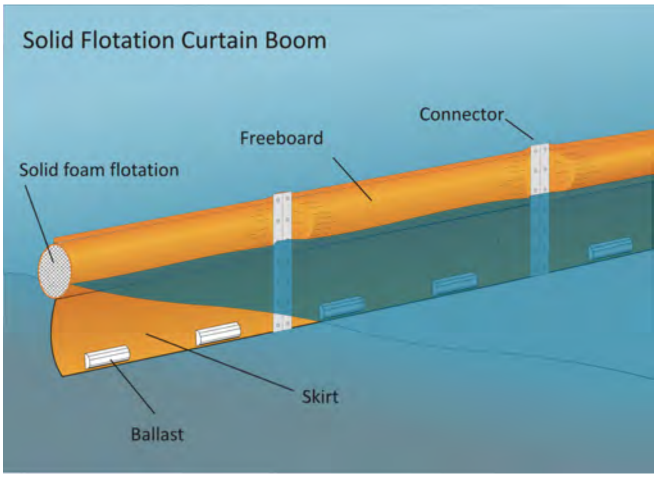
- freeboard to prevent or reduce splash-over;
- sub-surface skirt to prevent or reduce escape of oil under the boom;
- flotation in the form of air, foam or other buoyant material;
- longitudinal tension member (chain or wire) to withstand forces from winds, waves and currents;
- ballast to maintain the vertical aspect of the boom.

The majority of boom designs fall into two broad categories:

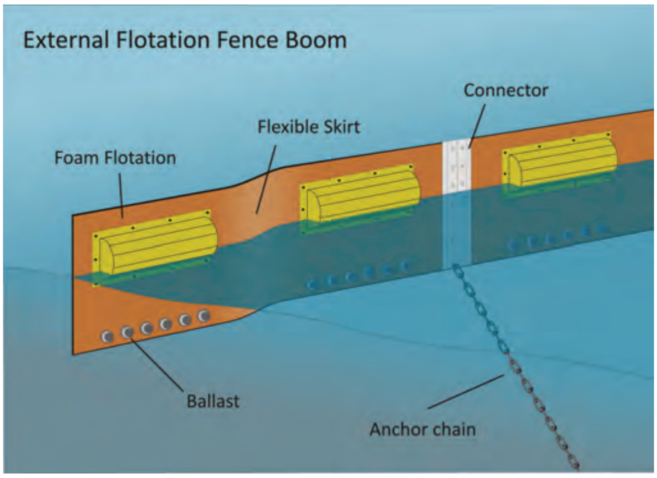
Curtain Booms – providing a continuous sub-surface skirt or flexible screen supported by an air or foam-filled flotation chamber usually of circular cross-section (*Figures 2a and 2c*).

Fence Booms – generally with a flat cross-section held vertically in the water by integral or external buoyancy, ballast and bracing struts (*Figure 2b*).

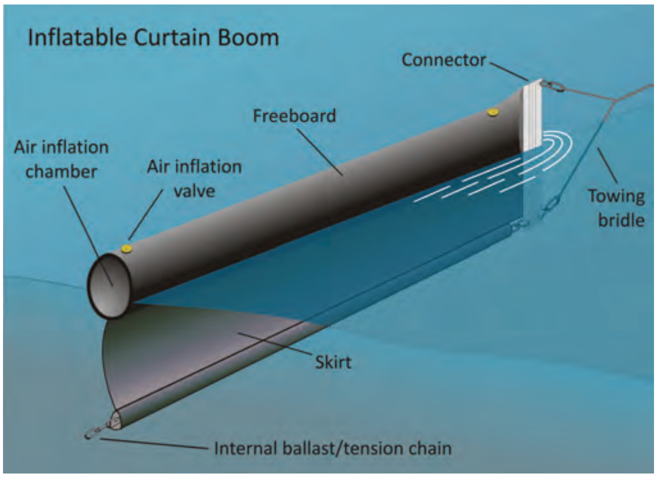
Shore-sealing or beach-sealing booms are also available whereby the skirt is replaced by water-filled chambers allowing the boom to settle on an exposed shoreline at low tide (*Figure 2d*). Fire boom is specifically constructed to withstand the high temperatures generated by burning



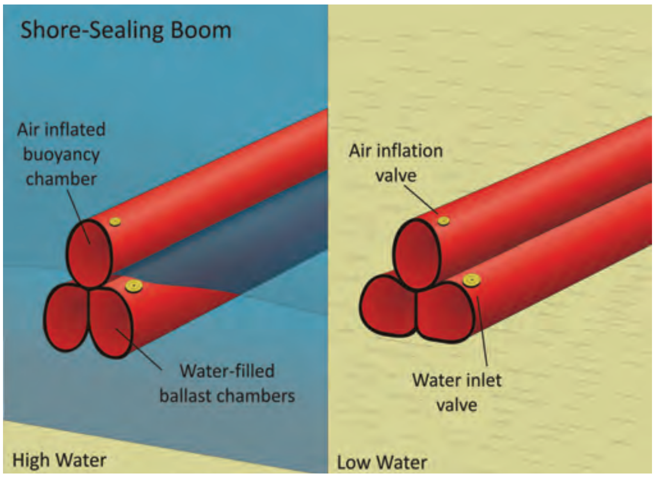
▲ *Figure 2a: A solid flotation curtain boom with external ballast.*



▲ *Figure 2b: An external flotation fence boom with external flotation and ballast. Mooring points are located at intervals along its lower length.*



▲ *Figure 2c: An inflatable curtain boom with a combined ballast and tension chain fitted in an integral pocket attached to the bottom of the skirt.*



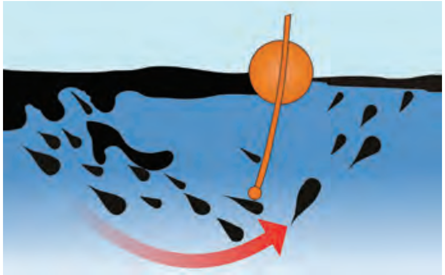
▲ *Figure 2d: Intertidal shore-sealing boom. Upper air inflation pocket to allow flotation, lower water filled pockets to provide ballast when floating and to ensure a good seal with the substrate at low tide.*

oil and can be of either fence or curtain design with the associated abilities and limitations of these two designs in containing oil.

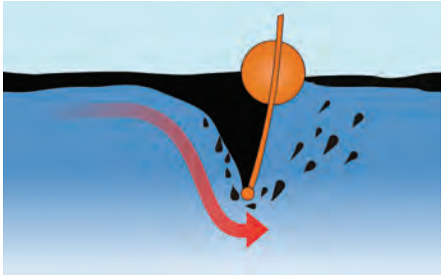
Booms should be sufficiently flexible to follow wave motion yet sufficiently rigid to retain as much oil as possible. Some designs of fence and solid flotation curtain boom exhibit poor wave-following characteristics, causing the freeboard to sink below the surface or the skirt to ride between crests as a wave passes, allowing oil to escape. Consequently, these types of boom should be limited to use in calm waters.

Although boom systems have been developed for use in fast flowing water and others for towing at relatively high speeds, most conventional booms designs are not capable of containing oil against water velocities much in excess of 0.5 ms^{-1} (1 knot) acting at right angles to it. In practice, the escape velocity for most booms is around 0.35 ms^{-1} (0.7 knots) irrespective of skirt depth. The way in which oil escapes, and its relationship to water velocity, is as much a function of oil type as of boom design. Low viscosity oils escape at lower velocities than more viscous oils. With the former, turbulence in the headwave, caused by high currents, shears droplets from the underside of the oil layer that then are carried under the boom, a process termed 'entrainment' (*Figure 3a*). Low viscosity oils are also prone to 'drainage failure' (*Figure 3b*), whereby the high currents cause droplets to break away from the oil accumulating at the boom face, to flow vertically down and under the skirt. More viscous oils are less likely to become entrained in the water and can form thicker layers at the boom face. At a certain critical accumulation thickness, the oil will be swept under the boom (*Figure 3c*).

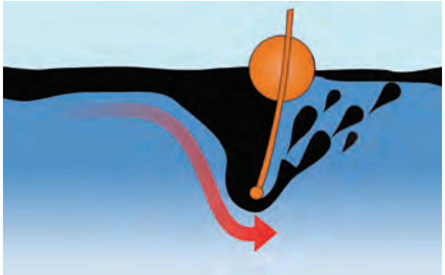
Besides river and tidal currents, wind and waves can generate water movement in excess of the escape velocity, as well as causing splash-over of contained oil (*Figure 3d*). Very high currents may cause the boom to submerge, particularly if insufficient buoyancy is provided (*Figure 3e*), or to plane allowing oil to flow past (*Figures 3f and 4*). Oil escape can also be induced by turbulence along a boom and therefore a uniform profile without projections is desirable.



▲ Figure 3a: Entrainment.

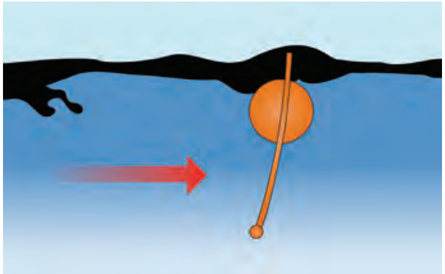


▲ Figure 3b: Drainage failure.

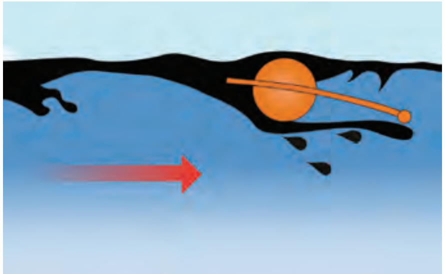


▲ Figure 3c: Critical accumulation.

▲ Figure 3d: Splash-over.



▲ Figure 3e: Submergence.



▲ Figure 3f: Planing.

▲ *Figure 3: Boom failure modes. The arrows indicate current direction. (After a diagram in Oil Spill Science and Technology, courtesy Merv Fingas).*

The size and length of boom sections are important considerations. The optimum size of a boom is largely related to the sea state in which it is to be used. As a general rule, the minimum height of freeboard to prevent oil splash-over should be selected. The depth of skirt should be of similar dimensions. Too high a freeboard may cause problems of windage, whereby the freeboard acts as a sail. Increasing the depth of the skirt can make the boom more prone to drainage failure due to the increasing velocity of water passing under the boom. Short sections of boom can be easier to handle and can protect the integrity of the boom as a whole should one section fail, but these advantages must be weighed against the inconvenience and difficulty of connecting sections effectively. Connections interrupt the boom profile and, wherever possible, should not coincide with the point of heaviest oil concentrations. The design of connectors should allow easy fastening and unfastening during deployment and when the boom is in the water.

Many different types of boom connector have been made available from manufacturers. While the prevalence of Unicon or American Society for Testing and Materials (ASTM) standard connectors have reduced the variety, the many designs available can cause difficulties when joining booms from different sources and care should be taken when ordering booms from different suppliers.

Other important characteristics are tensile strength, ease and speed of deployment, reliability, weight and cost (*Table 1*). It is essential that a boom is sufficiently robust and durable for its intended purpose as it will often need to tolerate inexpert handling, twisting, large and heavy floating debris and abrasion from rocks, dock walls or coral (*Figure 5*). Structural strength is required, to withstand the forces of water and wind on a boom, when it is either towed or moored. Ease and speed of deployment, combined with reliability, are clearly very important in a rapidly changing situation and may influence the choice made.

Some low-cost booms are designed for single use, after which they can be incinerated or returned to the manufacturers for recycling. Many of the more expensive, robust booms, if properly deployed and maintained, can be reused time and time again. Booms usually require

▲ *Figure 4: The strong current has caused the boom to plane, allowing any oil to be lost under the skirt.*

Type of Boom	Flotation Method	Storage	Wave Following Property	Moored or Towed?	Ease of Cleaning	Relative Cost	Preferred Use
Curtain Boom	Inflatable	Compact when deflated	Good	Both	Straightforward	High	Inshore or offshore
	Solid foam	Bulky	Reasonable	Moored	Easy / Straight-forward	Mid-range to Low	Sheltered inshore waters e.g. harbours
Fence Boom	External foam floats	Bulky	Poor	Moored	Difficult/Medium; oil can become trapped behind external floatation or in the junctions of the chambers	Low	Sheltered waters (e.g. ports, marinas)
Shore-Sealing Boom	Inflatable upper chamber, lower chambers water filled	Compact when deflated	Good	Moored	Medium; oil can become trapped in junction of the chambers	High	Along sheltered intertidal shores (no breaking waves)

▲ *Table 1: Characteristics of common boom types.*

cleaning after use and this can prove difficult for some designs (*Figure 6*). Steam cleaning or solvents are usually employed but when using the latter it is important to ensure that the boom fabric is compatible with such chemicals. Proper retrieval, maintenance and storage are important to prolong the life of a boom and to ensure that it is always ready for use at short notice. Some booms, particularly self-inflating models, are prone to damage from abrasion unless retrieved carefully. Emergency repair kits should be kept on hand for dealing with minor damage, which could otherwise make a section or even the whole length of boom unusable. Major damage to boom fabric is often difficult to repair and may necessitate replacement of the whole section. Correct storage of booms is important to minimise long-term degradation of the boom material by high temperatures, UV light rays or mildew, although this is generally less of a problem with more advanced materials such as polyurethane or neoprene. Air flotation booms take up only a small storage area when deflated, whereas solid flotation booms are bulky. This should be considered when transporting booms to site and if storage is at a premium, such as on board a vessel.

▲ *Figure 5: A boom can be easily damaged once deployed. Regular attention is required to ensure its effectiveness is maintained throughout the tidal cycle.*

▲ *Figure 6: Oil trapped behind external floats of fence boom can be particularly difficult to clean.*

Forces exerted on booms

To estimate the approximate force F (kg) exerted on a boom with a sub-surface area A (m²) by a current with velocity V (ms^{-1}) the following formula can be used:

$F = 100 \times A \times V^2$

Thus, the approximate force acting on a 100 metre length of boom with a 0.6 metre skirt in a 0.25 ms^{-1} (0.5 knot) current would be:

$F = 100 \times (0.6 \times 100) \times (0.25)^2 \approx 375$ kg (force)

From the graph in Figure 7, it can be seen that doubling the current velocity would entail a four-fold increase in load. The approximate force exerted by wind directly on the freeboard of the boom can also be considerable. For the purpose of estimating this windage, the above formula can be used on the basis that roughly equivalent pressures are created by a water current and a wind speed 40 times greater. For example, the approximate force on a 100 metre length of boom with a 0.5 metre freeboard in a 7.5 ms^{-1} (15 knots) wind would be:

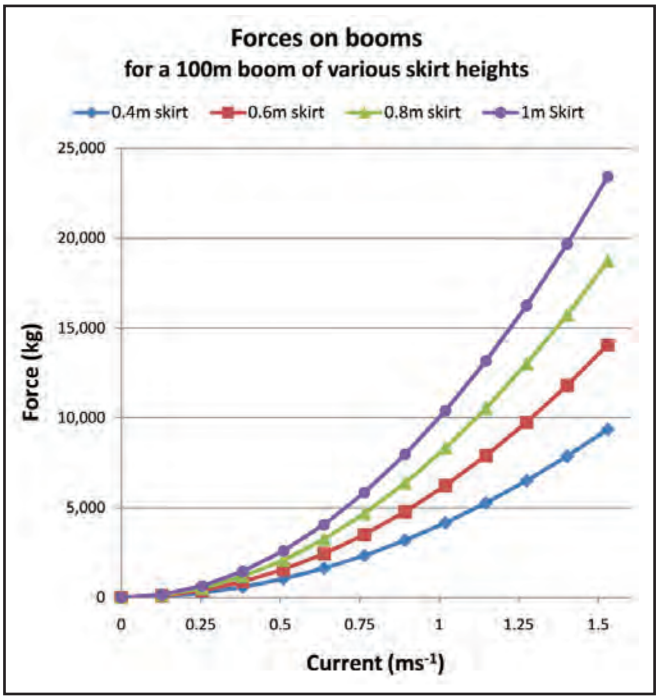
$F = 100 \times (0.5 \times 100) \times (7.5/40)^2 \approx 175$ kg (force)

In the above examples the combined forces of current and wind would be approximately 550 kg if they were acting in the same direction on a rigid barrier. In practice, the boom would be positioned at an angle to the flow forming a curve, thereby modifying the magnitude and direction of the forces (also see *Table 2* on page 9). However, these calculations provide a guide to the forces and are an aid to the selection of moorings or towing vessels. When a boom is towed, its velocity through the water should be entered as V in the formula set out in the beginning of this section.

The forces acting on booms from non-breaking waves or swell are usually insubstantial. Provided the boom has the required degree of flexibility, it can follow the surface movement of the water with little consequence. However, when a wave breaks against a boom, the resultant instantaneous loading may cause the boom to tear if the tensional and material strength are insufficient.

Deployment of booms

The deployment of booms can be a difficult and potentially hazardous operation. Poor weather and rough seas impose limitations on operations and the handling of wet and oily equipment on vessels that are pitching and rolling is demanding and can place personnel at risk. Even in ideal, calm conditions, it is important that operations are well thought out and controlled to minimise these risks and the potential for damage to the boom. A suitable strategy should be developed as part of the contingency planning process. Local conditions, deployment sites, boom types and lengths available, appropriate boom configurations and the availability of work boats and other resources should be fully considered before an incident occurs. In addition, the installation of fixed boom mooring points should be considered where appropriate and their position noted in a contingency plan. Planning is particularly relevant for oil terminals and similar installations where both the source and most likely size of spill can be predicted. Regular boom deployment exercises should be carried out in order that response personnel become fully familiar with operational procedures.



▲ *Figure 7: Forces exerted on a 100 metre length of boom of various skirt depths, showing an exponential rise with increasing current.*

Towed booms

The rapid spread of oil over a large area poses a serious challenge to the success of containment and recovery operations at sea. In an effort to prevent spreading and to contain the oil to maximise the encounter rate for skimmers, long booms in U, V or J configurations may be towed using two vessels (*Figure 8*). For example, a 300 metre towed boom may allow a swath up to 100 metres in width to be swept. Suitable recovery devices and sufficient on-board storage are crucial to the overall success of the operation. Skimmers can be either deployed from one of the towing vessels or from a third vessel behind the boom (*Figure 9*). Combined containment and recovery systems, with skimmers incorporated into the face of the boom, are now rarely deployed due to their ability to recover only a limited range of oils and due to their complexity. The use of skimmers is covered in greater detail in a separate paper.

Oil may more readily escape beneath the inflexible connections between boom sections. Consequently, to minimise the escape of oil, when towing a sectioned boom in either U, V or J configuration, it is important to ensure that there are no connectors at the apex of the boom. With a U configuration, using an odd number of sections of boom will alleviate this problem. To avoid sharp strain or

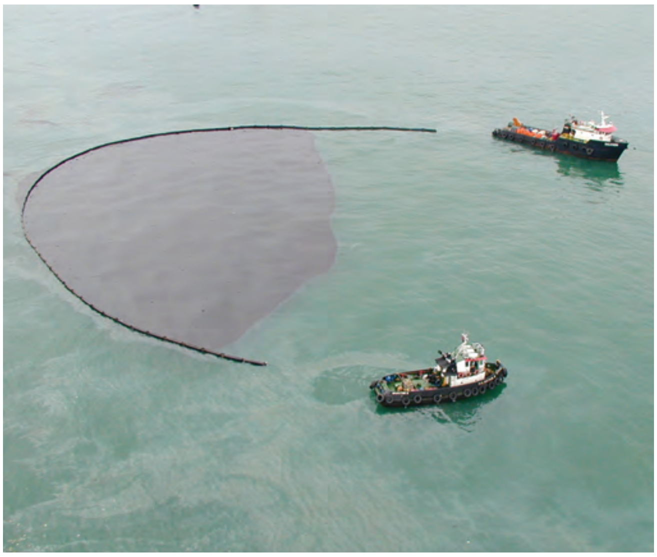


Figure 8: Inflatable boom deployed in a U configuration between two vessels to contain a heavy crude oil. Recovery of the oil will bring the operation to a successful conclusion.

Figure 9: Curtain boom employed in a V configuration by two towing vessels with a separate skimming vessel at the apex.

snatching, booms should not be attached directly to towing vessels. Instead, towing lines of sufficient length should be used between boom ends and the towing vessel with lines of 50 metres or more typically appropriate for towing a 300 metre length of boom.

Boom performance is best judged by observation. Oil lost under the boom will appear as globules or droplets rising behind the boom. Sheens may be present even with good boom performance. Vortex formations behind the boom imply that it is being towed too fast.

To maximise performance, vessels should be able to maintain both the correct configuration of the towed booms and the desired very low speeds through the water, i.e. at less than the escape velocity. This means that each of the two towing vessels will require at least half the total power necessary to tow the boom at the maximum speed consistent with oil retention and should be able to manoeuver sufficiently at slow speeds. As a guide, each rated horse-power of an inboard engine corresponds to the ability to provide a pull of 20 kg force. Twin propulsion units, bow and stern thrusters and variable pitch propellers are valuable. In addition, an open and low aft deck working area with winch, lifting gear or a boom reel are necessary when handling bulky and heavy booms. However, experience has shown that the exposed nature of the deck on such vessels can make conditions hazardous for crew in heavy sea conditions.

The ideal towing point aboard the vessel will need to be found by experiment and may need to be altered according to the course and wind direction. For example, a single screw vessel towing from the stern will have difficulty manoeuvering, and towing from a forward point of the ship is preferable. Good communication between the two towing

Figure 10: Single ship collection system employing a short length of curtain boom deployed from an oil recovery catamaran, in heavily emulsified crude oil.

Figure 11: Whilst sufficiently flexible to be able to follow the motion of the waves, the boom has risen from the water where it attaches to the hull, potentially allowing oil to escape from the apex.

▲ *Figure 12: Inflatable boom moored around a partially sunken wreck to contain any potential leakage of bunker fuel.*

▲ *Figure 13: Curtain boom deployed in front of a power station cooling-water intake.*

vessels must be maintained so that both move at the same speed and in a controlled and coordinated manner. Aircraft equipped with air-to-sea communications could also be used to coordinate the movement and activities of vessels and direct them to the thickest areas of oil.

A single vessel may perform the multiple roles of oil containment, collection, separation and storage. Either a flexible boom attached to an outrigger (*Figure 10*) or a rigid sweeping arm can be used to contain and enable collection of the oil. With all vessel-based containment and recovery systems, oil can be lost from boom that is rigidly attached to the vessel in swell (*Figure 11*). Single vessel systems are more flexible than the more complex multi-ship approach, although the oil encounter width or swath is limited, being similar to the vessel's beam. If the swath is too great, the set-up can become cumbersome and prone to damage in rough weather. This limitation on the swath may be less significant when floating oil has been driven into narrow windrows.

The limitations on boom performance, combined with additional constraints on the use of skimmers, mean containment and recovery operations at sea will, in most cases, be only partially successful.

Moored booms

In rare circumstances it can be appropriate to anchor booms to contain spilled oil close to a source such as a leaking vessel (*Figure 12*). However, waters may be too exposed and currents too strong for moored booms to be effective and anchoring booms in deeper water may be difficult. In addition, placing booms close to the source may create a fire hazard and interfere with attempts to stem the flow of oil or to salve the vessel. Even in calm conditions, large instantaneous discharges of oil can easily swamp a boom, rendering it ineffective. This is especially true for light oils, which will normally dissipate naturally and more effectively without booming.

More frequently, booms are deployed close to shore to protect sensitive areas such as estuaries, marshes, mangroves, amenity areas and water intakes (*Figure 13*). In practice, it may not be possible to protect all such sites. Careful planning should therefore be devoted to identifying first those areas that can be boomed effectively, and second, placing these in order of priority.

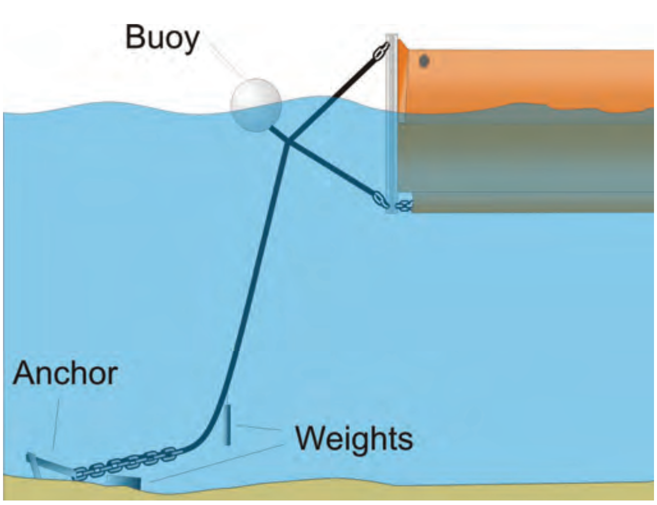
An aerial survey can be valuable in identifying potentially suitable sites for using booms, including access points. In selecting a location and method of deployment it may be necessary to compromise between conflicting requirements. For instance, although it may be desirable to protect a complete river, the estuary may be too wide or the currents too strong to achieve this, particularly if there is appreciable tidal influence. Strong outflow from rivers or estuaries may negate the need to deploy booms against oil approaching from the sea.

Where necessary, a more suitable location may have to be sought further upstream, bearing in mind the need for access to deploy the boom and remove the collected oil. If the oil is not removed at the rate of its arrival at the inshore position, it will accumulate and move out towards the centre of the river where the stronger currents may sweep the oil under the boom.

It is frequently better to use booms to deflect oil to relatively quiet waters (*Figure 14*) where it may be recovered rather than attempt containment. As shown in Table 2, it is feasible to deflect floating oil even in a 1.5 ms^{-1} current (3 knots) where a boom positioned at right angles to the flow would fail to contain any oil. Following this principle, a river can be protected by placing a boom obliquely to the direction of flow. To maintain a navigation channel or to deflect oil from one side of a river to another for ease of collection, two sections of boom can be staggered from opposite banks taking into account reversal of tidal flow.

Correct mooring of the boom is crucial since performance is dependent upon the angle of deflection remaining appropriate to the prevailing current strength. To maintain this angle and prevent the formation of pockets in the boom that will trap oil, frequent anchoring points may be required,

▲ *Figure14: Boom used as a spur to deflect oil to the shore for recovery (© Norwegian Coastal Administration).*



▲ *Figure 15: Typical boom mooring arrangement. The same system would be employed at regular intervals along the boom.*

although the laying of multiple moorings may be impractical in an emergency. The formula to determine forces on page 6 can be used together with Tables 2 and 3 as a guide to the minimum size and number of moorings required to hold a boom in a current of known strength and taking the likely maximum wind effect into account. Whilst a Danforth-type or fluked anchor is effective on sand and mud substrates (*Figure 15*), a fisherman's type or hook anchor is better on rocky bottoms. If time is available, concrete blocks can be cast to give convenient and reliable mooring points, but their weight in air must be at least three times the expected load, to compensate for their buoyancy in sea water. The use of a workboat with lifting gear would be required to handle heavy moorings.

Whichever type of mooring is used, it is important to select the length of the mooring lines to suit the expected water depth, swell and tidal range (*Figure 16*). If the lines are too short the boom will not ride well in the water and the snatching produced in the lines by waves may dislodge the moorings or damage the booms. Conversely, if the lines are too long it will be difficult to control the configuration. A length of heavy chain between the anchor and line greatly improves the holding power of an anchor, and the use of an intermediate buoy between the boom and anchor will help prevent submersion of the end of the boom. Equally, a weight hung from the mooring lines stops them floating on the surface when slack.

Magnetic mooring points allow boom to be attached directly to a ship side. Sliding moorings allow vertical movement of a boom throughout the tidal cycle when attached to a predetermined point such as at a harbour entrance.

When deploying a boom from a shoreline it is often possible to make use of fixed objects on the shore such as trees or rocks. On a featureless shoreline, multiple stakes (*Figure 17*) or a buried object such as a log provides an excellent mooring point. Water-ballasted beach- or shore-sealing booms are most suitable for deployment in this environment as their design enables containment during the tidal cycle. However, care should be taken when positioning these booms prior to ballasting as they are difficult to manhandle on land once filled (*Figure 18*). Such booms are often used in conjunction with curtain boom.

The outcome of the considerations above can be combined into a site specific booming plan, which identifies mooring points, oil collection points, access routes and the length and type of boom for the particular location. Before such plans are incorporated into local contingency plans, they should be subject to practical verification trials under a range of tidal conditions so that there can be confidence that the arrangements will perform as expected.

Current Strength (knots)	Current Strength (m/s)	Max. Angle (degrees)
0.7	0.35	90
1.0	0.5	45
1.5	0.75	28
2.0	1.0	20
2.5	1.25	16
3.0	1.5	13

▲ *Table 2: Maximum deployment angles to flow direction at different current strengths for bottom tension booms to prevent escape of oil Calculations are based on an escape velocity of 0.7 knots (0.35 m/s) at 90°.*

Anchor Weight (kg)	Holding Stength (kg force)		
	Mud	Sand	Clay
15	200	250	300
25	350	400	500
35	600	700	700

▲ *Table 3: Holding strength of Danforth type anchors in loose mud, sand or gravel, and clay.*

Figure 16: *Use of an insufficiently long mooring line has caused the boom to become suspended at low tide, allowing oil to pass beneath. Regular adjustment of lines would be required to maintain the boom in an effective position throughout the tidal cycle. Sliding moorings would be more effective in this scenario.*

Figure 17: Mooring stakes to hold boom in place on shoreline without trees or other natural anchors.

As winds, currents and tides change, so will the configuration of a boom. Frequent checks and re-adjustment of the moorings will be necessary and contained oil and debris must be removed promptly, since the performance and benefit of the boom will otherwise be severely reduced. In conditions where the air temperature is hot by day and cool by night it is important to allow for the expansion and contraction of air in inflatable booms. This may necessitate releasing air during the day and re-inflating at night. Booms are vulnerable to damage by passing vessels, particularly at night and precautions, such as notifying mariners and marking booms with warning lights, can help to prevent such damage. Brightly coloured booms are more visible in daylight and are better picked out by lights at night.

As well as using booms to intercept or deflect oil they can be used in sheltered areas, where oil has collected naturally, to prevent it moving should conditions change (*Figure 19*). This not only minimises the extent of the contamination but also allows the controlled removal of the trapped oil. Booms can also assist shoreline clean-up by containing oil washed off beaches and rocks, for example by flushing or pressure washing operations. By drawing in the boom, the oil can be concentrated and moved towards collection devices. In some circumstances, simple expendable sorbent booms can be used to collect thin oil films although their use should be tightly controlled. The use of sorbent materials is addressed in a separate paper.

Alternative systems

Bubble barriers have been permanently installed to protect harbours, where currents are relatively low and where floating booms would hinder vessel movement. A rising curtain of bubbles is produced when air is pumped into a perforated

Figure 18: Shoreline sealing boom deployed in an estuary. The lower water ballast chambers allow the boom to sit on the shore at low tide. In this instance, sections of shoreline sealing boom are connected to sections of inflatable curtain boom.

Figure 19: Semi-solid oil held against the shoreline by a section of inflatable boom to facilitate recovery.

Figure 20: Improvised boom constructed from netting and straw. While not expected to survive more than one tidal cycle, this may nevertheless serve to reduce contamination of the shoreline from incoming floating oil.

Figure 21: Barrier constructed from oyster-shells, held in place by stakes and nets.

pipe located on the sea-bed. The air bubbles create a counter-current on the surface that holds the oil against a water flow of up to 0.35 ms^{-1} (0.7 knots). However, their effectiveness is limited to thin layers of oil in calm conditions as even a slight wind can cause oil to escape. Even simple systems require substantial compressors to provide sufficient air. Regular checks of such systems are essential to ensure that the air holes in the perforated pipes are not blocked by silt or marine organisms.

When purpose-built equipment is unavailable, oil may be contained or collected with improvised systems made with locally available materials. Alternative moored booms can be constructed from wood, oil drums, inflated fire hoses, rubber tyres or fishing nets filled with straw (*Figure 20*). In shallow waters stakes may be driven into the bottom to support screens or mats made from sacking, reeds, bamboo or other such materials (*Figure 21*). In these instances, the boom or barrier may also act as a sorbent to assist recovery of the oil.

On long sandy beaches, sand bars can be built out into shallow water with bulldozers to intercept oil moving along the shoreline or to prevent oil entering narrow estuaries or lagoons. However, such measures should be used with caution as they require considerable effort, can be rapidly washed away by currents or successive tides and could possibly damage the structure or ecology of the beach.

Key points

- Determine priorities for protection in order to maximise effective use of available booms.
- Decide whether selected areas can be protected by either towed or moored booms.
- Obtain as much information as possible on currents, tides and winds.
- Calculate forces likely to be exerted on booms.
- Review available boom designs and select the best for the conditions of expected use.
- Consider reliability, ease, speed of deployment and arrangements for suitable storage, maintenance and repair.
- Select suitable vessels for towing and consider necessary logistics to support operations at sea.
- Identify locations for successful boom deployment and develop and verify booming plans for incorporation in national and local contingency plans.
- Thoroughly train personnel and maintain their skills by practical exercises.
- Appreciate the limitations of booms in containing oil and be aware of the need to improvise as required.

TECHNICAL INFORMATION PAPERS

ITOPF is a not-for-profit organisation established on behalf of the world's shipowners and their insurers to promote effective response to marine spills of oil, chemicals and other hazardous substances. Technical services include emergency response, advice on clean-up techniques, pollution damage assessment, assistance with spill response planning and the provision of training. ITOPF is a source of comprehensive information on marine oil pollution and this paper is one of a series based on the experience of ITOPF's technical staff. Information in this leaflet may be reproduced with the prior express permission of ITOPF. For further information please contact:

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