Spill Response Gap Study for the Canadian Beaufort Sea and the Canadian Davis Strait

Contract No. 110027

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1. Introduction

This report was prepared under contract No. 110027 with the National Energy Board (NEB) to complete an oil spill response gap study for the Canadian Beaufort Sea and the Canadian Davis Strait. The spill response "gap" is broadly defined as the percentage of time that a spill response option cannot be implemented due to environmental conditions such as winds, waves, temperature, visibility, and daylight.

This gap analysis is part of the NEB's Arctic Review initiative that is engaging industry and the public to review Arctic safety and environmental offshore drilling requirements. The gap analysis will provide valuable input to three major areas of interest in the review as presented in its scope summary:

1. Identification and effectiveness of measures employed to prevent and mitigate the risks associated with Arctic offshore drilling, including the use of management systems.
2. State of knowledge on the Arctic offshore, including the physical environment, biological environment and geosciences; and
3. The effectiveness and availability of spill containment and clean-up options under Arctic conditions, including tracking methods, recovery technologies, procedures, equipment and trained personnel.

2. Project Objective

The primary project objective, as outlined in the original NEB Request for Proposals, is to: "Provide estimates about when and how long primary recovery and clean-up techniques of mechanical recovery, dispersants, and in-situ burning would be unavailable due to environmental factors such as adverse ice conditions, fog, darkness, higher sea states, etc."

3. Study Approach

The project objectives were achieved in four broad tasks:

1. Assimilation of pertinent meteorological and oceanographic information.
2. Identification of primary countermeasures operating limitations.
3. Completion of response gap analysis.
4. Preparation of summary and final reports.

4. Assimilation and Evaluation of Meteorological and Oceanographic Information

In this initial task the data needed to assess the extent of the response gap was identified and acquired. Data sets were built for the two geographic locations; the Beaufort Sea northwest of Tuktoyaktuk and the Canadian Davis Strait west of Disko Bay, Greenland. The available meteorological and oceanographic information affecting the successful implementation of the three primary response techniques were gathered, including:

- Wave height and period
- Wind speed
- Air temperature (for wind chill and icing; worker safety)
- Visibility
- Cloud Ceiling
- Ice cover

4.1 Wave Height, Wave Period, Wind Speed, and Ice Cover

Wave height, wave period, and wind speed data for the two study areas are available in the Meteorological Service of Canada (MSC) hindcast data sets for the Beaufort Sea (MSC Beaufort, Swail 2007) and the North Atlantic (MSC Atlantic, Swail 2006). The hindcast data are modeled wind and wave values based on archived surface pressure fields augmented by various other data sets. Detailed information on these data sets and their development can be found at http://www.oceanweather.net/MSC50WaveAtlas/.

The MSC Beaufort data set covers the time period from 1970 to 2008 and provides hourly data at selected points within the region on a 0.05 degree latitude x 0.15 degree longitude grid. The data from two specific grid points were acquired through the ftp site, ftp://ftp.isdm.gc.ca/mschindcast/Bfort. The grid points selected for use in the study are MB000880 (70° Latitude, -133.95° Longitude, in near offshore waters) and MB002321 (70.75° Latitude, -135.9° Longitude, in waters further offshore). Twenty years of the most recent data, from 1989 to 2008 were used in the analysis.

The MSC North Atlantic hindcast data set covers the period from 1954 to 2008 and provides data every 3 hours at locations on a 0.5 degree grid. The data from two specific grid points were acquired through the ftp site, ftp://ftp.isdm.gc.ca/mschindcast/Atlantic. The grid points selected for use in the study are M3017102 (69° Latitude, -60° Longitude, central Davis Strait) and M3017094 (69° Latitude, -64° Longitude, west-central Davis Strait). Twenty years of the most recent data, from 1988 to 2007 were used in the analysis. The 2008 data was not used because accompanying weather data for 2008 was not complete.

In the development of both of these datasets MSC identified the location of the 50% ice cover using Canadian Ice Service archives to identify time periods with wave versus no-wave conditions that were then used in the MSC hindcast modeling. This designation was used to identify an “open-water” season in the statistical assessment of the environmental information for countermeasures applicability. In reality the true open-water season is slightly shorter than that identified using the 50% ice cover identified in the MSC datasets but the wind and wave statistics for the shoulder season months where this is an issue will only be marginally different and adequate for the purposes of the gap analysis.

4.2 Air Temperature, Visibility, and Ceiling

Environment Canada’s National Climate Data and Information Archives were used as the source for air temperature, visibility, and ceiling data in this study. The historical data records for the towns of Tuktoyaktuk, Northwest Territories and Clyde River, Nunavut were acquired through the Ontario Climate Centre (Ontario.Climate@ec.gc.ca). These two towns provided the closest weather data available for the two areas of interest: appropriate long-term weather data is not available from any specific offshore locations. This raw data was processed to retrieve the air temperature, visibility and ceiling data on an hourly basis for Tuktoyaktuk (1989 through 2008) and on a three-hourly basis for Clyde River (1988 through 2007) to match the frequency and duration of the wave and wind data sets described in 4.1.

The Tuktoyaktuk weather data is missing the first seven hours of data for each day. These missing data were replaced with the last hourly record of the previous day, for the first four missing hours and the first hourly record present in the day for the remaining three hours. A few complete days of weather information were also missing in the data sets. These days were marked and excluded from the overall analysis of environmental conditions affecting countermeasures.

4.3 Daylight

The National Research Council of Canada's (NRC) sunrise/sunset calculator provided at http://www.nrc-cnrc.gc.ca/eng/services/hia/sunrise-sunset.html was used to identify daylight and darkness periods for Tuktoyaktuk, NWT and Clyde River, NU, respectively. Twenty years of either hourly (for the Beaufort Sea study area) or three-hourly (for Davis Strait) daylight durations were compiled to match the temporal structure of the other environmental data sets.

4.4 Superstructure Icing

Vessel superstructure icing has been modeled using the numerical method used in NOAA's Operational Forecast System for Superstructure Icing (Feit 1987) and NOAA's National Weather Service Environmental Modeling Center's definition of icing levels shown in Table 1 http://polar.ncep.noaa.gov/marine.meteorology/vessel.icing/.

Table 1: NOAA's Icing Level Definitions

Icing Level	Ice Accumulation Rate (cm/h)
Light	<0.7
Moderate	0.7 to 2.0
Heavy	>2.0

The icing rate equation used is as follows:

$$I\ (\text{cm/h}) = 2.73 \times 10^{-2}P + 2.91 \times 10^{-4}P^2 + 1.84 \times 10^{-6}P^3$$

Where: $P = V\,(T_f - T_a) / (1 + 0.4\,(T_w - T_f))$

V - Wind speed, m/s

T_f - Freezing temperature of sea water (-1.7°C)

T_a - Air temperature, °C

T_w - Water temperature, °C

4.5 Wind Chill

Wind chill is not considered in this analysis. Deployment and tendering of large, Tier 3 type spill response equipment is done primarily using large vessels with crane deployment of equipment by operators in climate-controlled cabs so operator exposure is not a primary issue.

5. Assessment of Primary Countermeasures Operating Limitations

The environmental operating limits that are used in the gap analysis are identified in this section.

The limits are described for the primary response options of in-situ burning, containment and recovery, and chemical dispersants. For context, the primary focus here is for a large-scale response to a significant offshore spill; it is acknowledged that there may be different limits for smaller spills or those that occur inland or in nearshore waters. For the purposes of the analysis the following is a brief description of the components involved in the three primary options:

- In-situ burning: would require the use of fire-resistant booms to collect and thicken oil for burning, or the use of chemical herding agents to achieve the same effect.

- Containment and recovery: would require the use of containment booms to collect and thicken oil for recovery.

- Dispersants: would be based on large fixed-wing aircraft for application.

All of the above techniques would also require on-site aerial surveillance to direct response operations to the most significant portions of the slick.

5.1 In-Situ Burning

The use of in situ burning (ISB) has long been recognized as one of the few effective response techniques for oil spills in ice (e.g., Dickins and Buist 1999). The use of ISB with fire booms during the Macondo blow-out response resulted in the removal of more than 38,000 m^3 of oil without the need for skimming, temporary storage, transfer and disposal of recovered oil (USCG 2011). ISB is particularly suited to blow-out spill response because there is a constant supply of fresh oil. When oil weathers and forms water-in-oil emulsions with water contents exceeding about 25% to 50% ignition is extremely difficult.

5.1.1Environmental Factors Affecting ISB in Open Water

Waves

Well designed, constructed and maintained fire booms when consistently towed by experienced vessel operators at speeds “over the water” of less than 0.4 to 0.5 m/s (¾ to 1 knot) will effectively contain oil and allow efficient burning in waves with significant heights up to 1 m. This was noted to be the case during the Macondo blow-out response (Allen et al. 2011). In waves between 1 and 1.5 metres, the ability to burn oil in present-day fire booms will be marginal and in waves exceeding 1.5 m, oil cannot be effectively burned in presently available fire booms (Buist et al. 2003).

Wind

In addition to wave effects, ignition of slicks in winds above 10 m/s is not possible. Waves of approximately 1 m significant height are associated with winds in the 6 to 7 m/s range, so burning is also considered marginal in open water in winds between 5 and 10 m/s (Buist et al. 2003).

Visibility and Flying Conditions

In conditions where the visibility is restricted to less than 1 km it is impossible to direct response operations from the air and extremely difficult to find and recover oil slicks using vessels, even with state of the art remote sensing techniques. The importance of aerial spotting and direction in a successful ISB operation offshore was reinforced by the response during the Macondo blow-out response (Allen et al. 2011). Minimum visual flight rules (VFR) flying conditions should be used to establish viable operating periods for in-situ burning operations. Canadian VFR for areas in uncontrolled airspace state that a minimum visibility of 1.6 km (1 mile) and a minimum ceiling of 300 m (1000 ft) must be present for safe operation of a fixed wing aircraft (http://www.tc.gc.ca/eng/civilaviation/regserv/cars/part6-602-2436.htm).

Daylight

Although it may be possible to complete an in situ burn of oil in a fire boom at dusk, it is not possible with the state of the art to continue ISB operations at night (Buist et al. 2003, Allen et al. 2011).

Superstructure Icing

Water spray during periods of cold temperatures and higher wind speed in the offshore can result in vessel and equipment superstructure icing that can affect both operation safety and performance. For large-scale burning operations it has been assumed that operations will be able to function normally under light icing conditions as defined by the NOAA (see Table1), will be marginally effective when icing rates are moderate, and will not be possible under high ice build-up.

5.1.2Environmental Factors Affecting ISB in Ice Conditions

It is possible to use fire booms to collect and burn oil in trace ice conditions (<1/10th) using open water techniques and the environmental criteria noted above. In ice conditions =1/10th and = 3/10ths burning with fire booms will be marginal and, with ice conditions >3/10ths the use of fire booms would be unfavourable (Potter and Buist 2010). Visibility/VFR and daylight limitations would apply as described above. Winds above 10 m/s would prevent ignition of slicks.

In ice concentrations = 6/10ths herding agents can be used to thicken free-floating slicks for uncontained burning (Buist et al. 2011). Herding agents are a class of chemicals that, when added to the water surface surrounding an oil slick, cause the slick to contract, reducing the slick's area and increasing its thickness. Visibility/VFR, daylight and wind >10 m/s limitations would apply.

For oil deposited under ice (e.g., from a subsea well blow-out or pipeline release) in all ice conditions and for oil deposited on ice or under snow on pack ice over winter, the oiled ice would be tracked and ISB operations would be deferred until the oil appears on the ice surface the following spring (e.g., Dickins and Buist 1999).

Once the oil appears on the surface of the ice in spring, it will remain there for several weeks until breakup occurs. For springtime ISB operations, daylight, VFR (or visibility), and wind = 10 m/s statistics would be used to determine the level of support required to carry out complete ISB coverage of the oiled area, rather than a percentage of the time that ISB operations could take place (e.g., SL Ross and COGLA 1991). That is, oil that could not be ignited on one day due to visibility or wind limitations would still be available the next day.

5.2 Containment and Recovery

One of the key factors that impacts the success of a spill response is the weather and sea state at the time of the response. For example, oil spill containment boom is designed and built in different sizes and strengths for different wave environments. Offshore-type containment boom designed and built to accepted standards (e.g., ASTM F1523) will function effectively to hold oil when towed at speeds below the entrainment limit (approximately 0.4 to 0.5 m/s) and when the waves do not exceed about 2 m in height. Visibility is also crucial to spill response operations in order to effectively identify target slicks and direct on-water response efforts accordingly. The presence of ice will also affect a spill response operation, necessitating a change in strategies and techniques.

This section discusses the limits imposed by the physical environment on large-scale oil spill response operations in the two areas of interest, the Beaufort Sea and Davis Strait. The following discussion applies to large-scale clean-up efforts that would require the use of booms to concentrate oil for recovery. It should be noted that for small and modest –size spills in dense ice conditions, purpose-built skimmers could be used without booms to collect oil contained in leads and among pack ice (SINTEF 2010).

5.2.1Environmental Factors Affecting Containment and Recovery in Open Water

Waves

Well designed, constructed and maintained offshore containment booms, when consistently towed by experienced vessel operators at speeds “over the water” of less than 0.4 to 0.5 m/s

(0.75 to 1 knot), will effectively contain oil in all waves with heights up to 1 m and in waves between 1 and 2 m high that have periods > 6 seconds (i.e., those waves that are not too short and steep as to cause oil to be lost from the boom) (Potter 2007). Wave heights between 1 and 2 m but with a period of less than 6 seconds would be considered a marginal condition, with reduced containment effectiveness. In wave conditions exceeding 2 m, oil cannot be effectively contained in booms for recovery by skimmers.

Wind

In addition to wave effects, winds above 10 m/s will make oil containment difficult, and would be defined as a marginal condition. Winds greater than 15 m/s would preclude effective containment.

Visibility

In conditions where the visibility is restricted to less than 1 km it is difficult to direct response operations from the air and extremely difficult to find and recover oil slicks using vessels, even with state of the art remote-sensing techniques. For the purposes of this analysis, visibility greater than 1 km is defined as a “favourable” condition, between 0.5 and 1 km as a “marginal” condition, and less than 0.5 km as a “not possible” condition.

Daylight

Although it may be possible to recover oil already collected and contained in a boom, it is not possible with the state of the art to continue offshore oil clean-up operations at night.

Superstructure Icing

Water spray during periods of cold temperatures and higher wind speed in the offshore can result in vessel and equipment superstructure icing that can affect both operation safety and performance. For large-scale containment and recovery it has been assumed that operations will be able to function normally under light icing conditions as defined by NOAA (see Table 1), will be marginally effective when icing rates are moderate and will not be possible under high ice build-up.

5.2.1 Environmental Factors Affecting Containment and Recovery in Ice Conditions

It is possible to use conventional booms to collect oil in trace ice conditions (<1/10th) using open water techniques and the environmental criteria noted above. In ice conditions =1/10th and = 3/10ths, collecting and concentrating oil with booms will be possible, but will be compromised by ice building up in the collection area (Bronson et al. 1999). In ice conditions >3/10ths the use of booms would be unfavourable. As described above for open water conditions, visibility/VFR and daylight limitations would apply, and winds above 10 m/s would prevent effective oil collection.

The above discussion applies to the large-scale clean-up efforts that would require the use of booms to concentrate oil for recovery. It should be noted that for small and modest –size spill in dense ice conditions, purpose-built skimmers could be used without booms to collect oil contained in leads and among pack ice.

5.3 Dispersants

Use of dispersants is a primary response tool for spills in open water in many jurisdictions and has been effective for spills in broken ice in large-scale experiments (Owens and Belore 2004, Spring et al. 2006) and field trials (Sintef 2010). Dispersants have formed a major part of the clean-up in a number of major spills, including the *Sea Empress* (Lunel et al. 1997), but their greatest use to date was in the recent Macondo blow-out response (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2010). Dispersants were applied by aircraft to oil slicks on the sea surface and injected into the subsea oil plume at the point of discharge in order to disperse as much of the spill as possible before it could rise to the sea surface. Most of the discussion below refers to conventional surface spraying operations using large aircraft. Extensive use of subsea dispersant injection in the Macondo response, for the first time in a major well release, may lead to it becoming a primary response method for subsea blow-outs. Subsea injection of dispersant is referred to separately in section 5.6 on alternative countermeasures.

5.3.1 Environmental Factors Affecting Dispersants in Open Water

Waves

Dispersants are most effective when slicks of fresh or lightly weathered oils can be sprayed with an adequate dose of effective dispersant product in the presence of breaking waves (NRC 2005).

In offshore environments breaking waves develop when wind speeds exceed 7 to 10 knots (3.5 to 5.4 m/s) and waves are 0.5 to 1 m in height. Dispersants can be applied in non-breaking wave conditions, where dispersion might not occur immediately, if breaking waves are likely to occur within a reasonable time after dispersant application. Research has shown that dispersants applied to slicks on calm seas will cause effective dispersion if the treated slicks are exposed to breaking waves within 48 hours (Lewis, et al. 2009).

Dispersant effectiveness begins to be impaired at wave heights of 3 m and above, as at this point waves begin to entrain a considerable proportion of the slick into the water and hold it in suspension temporarily, making it difficult to hit the oil with dispersant spray.

Winds

Dispersants can be applied by large aircraft until wind speeds are high enough to impair the dispersant spraying operation. At speeds greater than 30 to 35 knots large aircraft have difficulty maintaining their spray path and the high winds affect the dispersant fallout (Exxon 2000).

Daylight, Visibility and Flying Conditions

Visibility and flying conditions are critical for operating both the dispersant spraying aircraft and the airborne spotter that directs the spraying. While both spraying and spotting aircraft are generally equipped for instrument flight rules (IFR) operation, flight operations in offshore areas designated for dispersant spraying can operate only when VFR minimums are exceeded. Beyond that, daylight is required both for slick spotting/targeting and for aircraft safety when low altitude flying over water, as required for dispersant spraying. Some operators have experimented with night-time dispersant spraying from vessels, but actual spill operations have not yet been tried.

Icing, Temperature and Wind Chill

Superstructure icing, temperature and wind chill are not factors that will affect a large aircraft dispersant application operation. All response personnel operate in climate controlled cabins and aircraft icing will not be an issue under VFR conditions.

5.3.2 Environmental Factors Affecting Dispersant Use in Ice Conditions

The presence of ice-cover may affect dispersant operations. Dispersant operations can be carried out effectively under conditions of partial ice cover as long as the oil in open areas between ice floes can be sprayed with dispersant and there is sufficient movement of ice floes and water to disperse the treated oil into the seawater (Owens and Belore 2004, Spring et al. 2006).

For oil deposited under ice (e.g., from a subsea well blow-out) in all ice conditions and for oil deposited on ice/under snow on pack ice over winter, the oiled ice would be tracked until the spring. Dispersant use on oil in melt-pools will not be useful, but could be effective on oil patches occurring among floes during breakup (Owens and Belore 2004, Spring et al. 2006).

5.4 Response Operating Limits Summary

Environmental response operating limits have been established for each of the primary response options based on the information presented in sections 5.1 through 5.3. Limits have been assigned for each environmental parameter in three categories: Favourable, Marginal and Not Possible. The operating limits used in the final gap analysis are provided in Tables 2 through 4.

Table 2: Response Operating Limits for In-situ Burning

***In-Situ* Burning**	**Favourable**	**Marginal**	**Not Possible**
Wind Speed (m/s)	<= 10		> 10
Wave Height (m)	<= 1.0	>1 and <=1.5	> 1.5
Superstructure Icing (cm/h)	<0.7	0.7 to 2.0	>2.0
Daylight	Daylight		Night
VFR Visibility km Ceiling (m)	>=1.6 >= 300		<1.6 <300
Ice Cover with Boom (10^{ths})	<1/10	>1/10 to <3/10	>3/10
Ice Cover with Herding Agents (10^{ths})	<3/10	>3/10 to < 6/10	>6/10

Table 3: Response Operating Limits for Containment and Recovery

Boom / Skim	**Favourable**	**Marginal**	**Not Possible**
Wind Speed (m/s)	< 10	>=10 and <=15	> 15
Wave Height -h (m) Wave Period -p (s)	h<= 1.0; OR h<= 2; p>6	h>1.0 AND h<=2.0; p<6	h>2.0
Superstructure Icing (cm/h)	<0.7	0.7 to 2.0	>2.0
Daylight	Daylight		Night
VFR Visibility (km) Ceiling (m)	>=1.6 >= 300		<1.6 <300
Ice Cover (10^{ths})	<1/10	1/10 to 3/10	>3/10

Table 4: Response Operating Limits for Large Aircraft Dispersant Operations

Aerial Dispersant Application (large aircraft)	Favourable	Marginal	Not Possible
Wind Speed (m/s)	<13	>=13 to <=15	>15
Wave Height (m)	>0.6 and <3.0 OR >0.0 and <3.0 if >=0.6 in following 48 h	>=3.0 and <=4.6	> 4.6 OR <0.6 if <0.6 in following 48 h
Daylight	Daylight		Night
VFR			
Visibility (km)	>=1.6		<1.6
Ceiling (m)	>= 300		<300
Ice Cover (10^{ths})	<5/10	5/10 to 9/10	>9/10

5.5 Potential Application of a Deferred Response

Up to this point in the analysis, the gap has been defined the percentage of time that response would not be possible due to environmental conditions at the time. It is important to make the distinction that a response gap, by this definition, may only mean that an immediate response is not possible and that a deferred response may be possible and effective. This is discussed below for the three main offshore countermeasures of containment and recovery, in-situ burning, and dispersant use.

5.5.1 Containment and Recovery

For a containment and recovery response for a large spill in open water, it is likely that any deferral of the response would lead to significantly reduced effectiveness. This would particularly be the case if the response were deferred by high winds and rough seas. Over time, and abetted by inclement weather, slicks would tend to spread out and change in character, which would lead to significantly lower encounter rates for containment and recovery systems. Therefore, for a containment and recovery response in open water, the response gap is an entirely valid concept in that the lack of an immediate response likely means an ineffective response or, at best, one with reduced effectiveness.

This would not necessarily be the case for a spill in moderate or dense ice concentrations, where the ice would tend to reduce the spread of oil. In this case, recovery operations could be effective for significant periods of time following a spill, even following periods of inclement weather that could prevent an immediate response.

5.5.2 In-situ Burning

For an in-situ burning response in open water, using fire-resistant booms to collect and concentrate oil, a similar logic applies as for a containment and recovery response: if the response is significantly delayed the effectiveness will drop sharply due to the rapid spreading and changes in character of the oil and the resulting difficulties in encountering and concentrating oil for burning. An additional problem with the feasibility of in-situ burning is the onset of emulsification: once a water-in-oil emulsion exceeds approximately 25% water content, ignition of the oil may become difficult. The rate of emulsification varies a great deal from oil to oil, but for many crude oils, this upper limit of water content could be reached within a 24-hour period, particularly with energetic sea conditions.

For an in-situ burning response in moderate and dense ice concentrations the situation would be quite different. In these conditions the oil would be at least partially contained against spreading by the ice, and the generally lower wave energies within the ice would lead to much slower rates of emulsification. In this case, a deferred response could be feasible, and could possibly be as effective as if an immediate response had been carried out.

For spills that occur under the ice during freeze-up or through the winter, the response technique is to track the oil through the winter months while it remains encapsulated in the ice, and then to apply in-situ burning when the oil appears on the surface of the ice during the subsequent melt season. In this case the response could be deferred for several months or more, but could be applied effectively subject to the environmental limitations during the spring melt season. As noted previously, oil that is present in melt pools would not weather or emulsify to the extent that burning would be negated, i.e., oil that could not be ignited on one day due to visibility or wind limitations would still be available the next day. As such, the environmental limits for springtime burning operations would determine the level of logistical support required to carry out complete coverage of the oiled area, and would not present a response gap that would necessarily limit the overall effectiveness of the operation.

5.5.3 Dispersant Use

For a dispersant-based response for spill in open water, a deferred response may still be effective, depending on the properties of the oil. As oil weathers, it increases in viscosity and becomes more resistant to natural or chemical-aided dispersion. The viscosity limits for the effective use of dispersants varies from oil to oil, and is not precisely known, but is thought to be in the range of up to 20,000 centipoise (cP). For many crude oils, it is unlikely that this viscosity would be reached within 24 to 48 hours, so it is quite likely that a dispersant operation that were interrupted by darkness could still be effectively carried out the following day, should environmental conditions permit. In this case, a deferred response could have an overall effectiveness that would be comparable to an immediate response.

The same is true for a dispersant-based response for spills in moderate and dense ice conditions. Indeed, the reduced wave energies within the ice field would lead to slower rates of weathering and emulsification, which would tend to increase the time window in which dispersant operations could be effective. In this case, it is likely that a deferred response would have an overall effectiveness that would be comparable to an immediate response.

5.5.4 Summary

The above discussion describes several situations in which an immediate response may not be possible but a deferred response may be effective. In these situations, the inability to perform an immediate response may not represent a true response gap. The feasibility and potential effectiveness of a deferred response may vary somewhat according to the specifics of the spill scenario, as described above. As a result it is difficult to factor these into the calculation of response gap and they are not included in results described in the next section. They should however be included by contingency planners and plan evaluators depending on the specific spill scenarios under consideration.

5.6 Alternative Countermeasure Techniques

During the response to the Macondo blow-out in the Gulf of Mexico 2010, two relatively untried techniques were used that show some promise for mitigating spill effects. They are both outside the scope of this study, but are mentioned briefly here given their possible utility in future well-related incidents.

For the first time in a major blow-out spill, dispersants were injected into the stream of oil as it was discharged from the well. The goal was to modify the oil's properties prior to its leaving the wellhead site such that it would disperse more readily in the water column prior to reaching the water surface. An estimated 3,000 m^3 of dispersant was injected into the oil at the discharge point (compared with approximately 4,000 m^3 applied to oil slicks on the water surface). In terms of the environmental limitations of this operation, most of the critical portions of the equipment are located subsea, near the discharge, and would not be subject to climate or sea conditions. The main requirement would be for the vessel supplying the dispersant to be able to maintain station at the required location, which could be compromised by extreme wind and wave conditions or by encroaching ice.

Another technique used in the Macondo response was at-source containment. A number of techniques were used, starting in the first few days of the blow-out, with a relatively effective device being positioned over the discharge in the final stages of the incident. This was a somewhat complex operation involving multiple Remote Operated Vehicles (ROV's) working at the wellhead, multiple workboats at the surface to support them, and a succession of tank vessels to store collected oil. As with dispersant injection, most of the critical portions of the equipment are located subsea, and would not be subject to climate or sea conditions. The main requirement would be for the storage vessels and the vessels supporting the ROV's to be able to maintain station, which could be affected by extreme wind and wave conditions or by encroaching ice.

6. Gap Analysis Results

The operational limits identified in section 5.4 have been combined with the environmental data described in section 4 to identify the spill response gaps for the two regions of interest. For each region, and for each of the countermeasures strategies of containment and recovery, dispersant use, and in-situ burning, the fraction of time that response would be possible has been estimated based on the environmental applicability factors.

Additionally, context as to how these overall applicability factors should be used in a broad evaluation of capabilities is provided. This is particularly important when considering dispersant use and when evaluating strategies for spills in ice conditions.

With dispersant use, an inability to apply dispersants due to, for example, darkness, may not rule out their use the subsequent day. This would be the case for oils that do not readily emulsify, and in conditions where the slick does not spread to cover unmanageable areas.

Another example would be with the use of in-situ burning for oil spilled within or under a growing ice sheet. Presently, the preferred strategy for this situation would be the use of in-situ burning in springtime when the oil surfaces in melt pools. In this situation, an active response would not be attempted in the winter months but would be deferred until the spring, and any environmental conditions that would limit an immediate response may not necessarily constitute a response gap. Similarly, during the spring-time burning operation, weather conditions that might limit an aerial ignition operation might not represent a true response gap in that the oil would remain contained in melt pools on the ice surface and be available for ignition and burning if and when weather conditions were to improve.

6.1 Methodology

Wave height is a critical response operating parameter for all three of the primary countermeasures options. During periods of ice cover waves are not present and none of the three countermeasures operations is possible in a conventional implementation. For these reasons the percentage of time that a countermeasure option is possible has only been determined using the hourly or three-hourly data where open water exists. Open water is defined by the MSC hindcast data set as those hours when wave heights are greater than zero as discussed in section 4.1.

Favourable, Marginal and Not Possible operating percentages have been established on a monthly basis for two locations in each of the study areas. The percentage of hours in each month when open water is present has also been determined to illustrate the average duration available for countermeasures operations in a given month based on the past 20 years of ice data for each region analysed.

The wind speed and temperature data were processed to identify periods of light, moderate and heavy icing that apply to oil recovery and burning operations. Daylight hours available in each month were established as were the hours where visibility and ceiling data indicated favourable flying conditions based on VFR. Both of these parameters were applied to all three countermeasures options.

The hours where Favourable, Marginal and Not Possible conditions exist as a function of waves and wind operational limits were evaluated separately for each countermeasure option. A final analysis was completed that evaluated all of the operational limits for each hour or three-hourly period of available data to establish a combined assessment of the operation as being Favourable, Marginal or Not Possible. The basic logic used in this combined assessment for a specific countermeasure can be summarized as follows. For a given hour a check was made to see if open water was present. If it was then the data was included in the assessment. If daylight, minimum VFR conditions, and light icing conditions were met, the hour was considered valid for inclusion in the Favourable category. The wind speed for the hour was then checked to see if it met the favourable criteria and the wave height and period were checked to see if they also met the favourable limits. If both the wind and wave criteria met favourable conditions then the hour was flagged as being Favourable. Similar logic was applied to the Not Possible category where only one of the environmental factors (open water, daylight, VFR, icing, wind or wave conditions) had to meet a not possible criteria for the hour to be flagged in this category. By default if the data representing the hour being checked did not meet the Favourable or Not Possible criteria it was flagged as Marginal. The total hours in each category were summed and divided by the total number of hours of open water to determine the percentage of time that the countermeasure option was Favourable, Marginal, or Not Possible. When rounding values to the nearest whole number the percentages for Favourable, Marginal and Not Possible do not always sum to 100%.

The data was then processed one step further and the percentage of time that at least one of the countermeasure options was Favourable was determined, at least one was Favourable or Marginal and when none of them were Possible.

6.2 Data Results

6.2.1 Beaufort Sea

Tables 5 and 6 show the percentage of time in each month with open water based on the 20 years of data contained in MSC Beaufort from 1989 to 2008. Also shown in these tables are the percentage occurrences of the operational parameters that are common to all three of the countermeasures operations. The percentages shown have been determined only for the times when open water is present. For example, in Table 5 in October: open water exists for 54 percent of the time, daylight is present for 40% of the time that open water is present, conditions for zero or light superstructure icing exist 31% of the time that open water is present, and favourable VFR conditions occur 32% of the time when open water is present. The values in Tables 5 and 6 are similar since they are both partially based on the same Tuktoyaktuk weather station information. The minor differences in these Tables are due to the difference in open water periods for the two locations.

Table 5: Occurrences of Operational Parameters Common to All Countermeasures for Near Offshore Beaufort Sea

Month	Percentage of Time With Open Water	Percentage Occurrence When Open Water is Present				
		Daylight	Zero or Light Icing	Moderate Icing	Heavy Icing	Favourable VFR
January	0	--	--	--	--	--
February	0	--	--	--	--	--
March	0	--	--	--	--	--
April	0	--	--	--	--	--
May	4	100	69	15	16	79
June	43	100	100	0	0	80
July	62	98	100	0	0	76
August	82	74	100	0	0	57
September	88	55	98	1	0	41
October	54	40	31	20	49	32
November	4	24	5	11	84	21
December	0	--	--	--	--	--

Table 6: Occurrences of Operational Parameters Common to All Countermeasures for Far Offshore Beaufort Sea

Month	Percentage of Time With Open Water	Percentage Occurrence When Open Water is Present				
		Daylight	Zero or Light Icing	Moderate Icing	Heavy Icing	Favourable VFR
January	0	--	--	--	--	--
February	0	--	--	--	--	--
March	0	--	--	--	--	--
April	0	--	--	--	--	--
May	0	--	--	--	--	--
June	23	100	100	0	0	80
July	47	98	100	0	0	77
August	65	74	100	0	0	56
September	79	55	99	1	0	41
October	46	40	28	21	51	33
November	5	23	4	8	88	20
December	0	--	--	--	--	--

In Tables 5 and 6, the frequency of open water is highly variable through the “summer season” and perhaps less than one might expect. It should be noted that this frequency is the result of several years with very little open water throughout the season combined with most years which have predominantly open water: it does not reflect a year by year frequency with an “average” amount of ice. From a strictly mathematical perspective, one could combine, for example, the 65% open water frequency for August (Table 6) with the percent favourable due to other environmental factors, however this would be misleading. In fact, the 65% frequency of open water is composed of, roughly, 65% of the years with close to 100% open water, and 35% with little open water. From a response perspective this would not represent a gap, rather it would necessitate a change in tactics, the use of burning in dense ice, or a combination of containment and recover, burning, and/or dispersant use in moderate or light ice conditions. Based on this, the frequency of open water conditions is presented for information purposes, but is not combined with the other environmental limitations in the subsequent tabulations.

Tables A1 to A6, in Appendix A, show the percent occurrences of Favourable, Marginal and Not Possible wind and wave conditions for the three countermeasures operations. This data is included so interested readers can see how the different operational parameters contribute to the final gap assessment.

An analysis was completed that evaluated all of the operational limits (parameters common to all countermeasures operations from Tables 5 and 6 and the countermeasures specific wind and wave parameters summarized in Tables A1 to A6) for each hourly period of available data to establish a combined assessment of the operation as being Favourable, Marginal or Not Possible. The results of this assessment for the Near- and Far-Offshore Beaufort Sea areas are shown in Tables 7 and 9, respectively. When rounding values to the nearest whole number the percentages for Favourable, Marginal and Not Possible do not always sum to 100%. As an example of how the numbers in these tables are derived, refer to the results in Table 7 for In-Situ Burning. The gap analysis indicates that this countermeasure is Favourable for 67% of the time in the month of July and 45% Favourable in August. From Table A1 it is clear that winds are not a primary limiting factor in either month as they are favourable for 97% and 98% of the time. Also from Table A1, waves are Favourable for 84% of the time in July and 76% in August and so the waves are accounting for some of the reduction in Favourable conditions in August versus July. From Table 5 it can be seen that daylight (98% July vs. 74% August) and VFR (76% July vs. 57% August) are more restrictive in August than July and this is main contributing factor for the reduction in Favourable conditions when comparing the August results with July. The monthly percentages from Table A1 and Table 4 cannot be multiplied together to get the final results in Table 7 but they do provide an indication of which environmental parameters are influencing the final gap outcome the most.

A final processing of the data was completed to identify:

1. the percentage of time that conditions were Favourable for at least one countermeasure,
2. the percent of time conditions were Favourable or Marginal for at least one countermeasure, and
3. the percentage of time when conditions preclude the use of any of the countermeasures.

The results of this analysis for the Near- and Far-Offshore Beaufort Sea area are shown in Tables 8 and 10, respectively.

Table 7: Percentage of Time that Countermeasure Options are Favourable, Marginal, or Not Possible for Near Offshore Beaufort Sea During Periods of Open Water

Month	In-Situ Burning			Containment & Recovery			Aerial Dispersant Application		
	Fav.	Marg.	Not	Fav.	Marg.	Not	Fav.	Marg.	Not
June	70	8	22	70	10	20	60	0	40
July	67	7	26	66	10	24	46	0	53
August	45	9	46	46	13	41	48	0	52
September	20	11	69	21	17	62	41	2	58
October	5	7	88	5	9	85	32	3	65

Table 8: Percentage of Time when at Least One Countermeasure Option is Favourable for Near Offshore Beaufort Sea During Periods of Open Water

Month	At Least One Countermeasure Option Favourable	At Least One Countermeasure Option Favourable or Marginal	No Countermeasure Option Possible
June	80	80	20
July	77	77	23
August	60	60	40
September	42	44	56
October	32	35	65
For periods of freeze-up and winter (mid-October through June), response deferred to spring-time melt season.			

Table 9: Percentage of Time that Countermeasures Options are Favourable, Marginal, or Not Possible for Far Offshore Beaufort Sea During Periods of Open Water

Month	In-Situ Burning			Containment & Recovery			Aerial Dispersant Application		
	Fav.	Marg.	Not	Fav.	Marg.	Not	Fav.	Marg.	Not
June	67	10	23	67	13	20	57	0	43
July	64	11	26	63	13	23	56	0	44
August	43	10	47	43	14	43	48	0	51
September	19	11	70	21	16	63	41	2	57
October	4	7	89	4	9	87	31	3	65

Table 10: Percentage of Time when at Least One Countermeasure Option is Favourable for Far Offshore Beaufort Sea During Periods of Open Water

Month	At Least One Countermeasure Option Favourable	At Least One Countermeasure Option Favourable or Marginal	No Countermeasure Option Possible
June	80	80	20
July	78	78	22
August	59	59	41
September	42	44	56
October	31	35	65
For periods of freeze-up and winter (mid-October through June), response deferred to spring-time melt season.			

6.2.2 Davis Strait

Tables 11 and 12 show the percentage of time in each month with open water based on the 20 years of data contained in MSC Atlantic from 1988 to 2007. Also shown in these tables are the percentage occurrences of the operational parameters that are common to all three of the countermeasures operations. The percentages shown have been determined only for the times when open water is present. For example, in Table 11 in August; open water exists for 95 percent of the time, daylight is present for 77% of the time that open water is present, conditions for zero or light superstructure icing exist 100% of the time that open water is present, and favourable VFR conditions occur 55% of the time when open water is present. The values in Tables 11 and 12 are similar since they are both partially based on the same Clyde River weather station information. The minor differences are due to the slight difference in open water periods for the two locations.

Compared with the frequency of open water for the two locations in the Beaufort Sea (Tables 5 and 6), the situation in Davis Strait is more well-defined, particularly for the west-central location (Table 12): in the months August through November the area is virtually ice-free, and in the months December through July there is little open water. The situation is less distinct for the Central location (Table 11), but still fairly well-defined between open water and not.

Table 11: Occurrences of Operational Parameters Common to All Countermeasures for Central Davis Strait

Month	Percentage of Time With Open Water	Percentage Occurrence When Open Water is Present				
		Daylight	Zero or Light Icing	Moderate Icing	Heavy Icing	Favourable VFR
January	0	--	--	--	--	--
February	0	--	--	--	--	--
March	0	--	--	--	--	--
April	0	--	--	--	--	--
May	0	--	--	--	--	--
June	0	--	--	--	--	--
July	25	100	100	0	0	73
August	95	77	100	0	0	55
September	100	56	99	1	0	45
October	100	37	58	26	16	32
November	100	12	4	16	79	10
December	30	0	1	5	95	0

Table 12: Occurrences of Operational Parameters Common to All Countermeasures for West-Central Davis Strait

Month	Percentage of Time With Open Water	Percentage Occurrence When Open Water is Present				
		Daylight	Zero or Light Icing	Moderate Icing	Heavy Icing	Favourable VFR
January	0	--	--	--	--	--
February	0	--	--	--	--	--
March	0	--	--	--	--	--
April	0	--	--	--	--	--
May	0	--	--	--	--	--
June	5	100	100	0	0	23
July	5	100	100	0	0	27
August	90	77	100	0	0	24
September	100	56	99	1	0	27
October	100	37	59	27	14	29
November	100	12	7	21	71	27
December	5	0	100	0	0	30

Tables A7 to A12, in Appendix A, show the percent occurrences of Favourable, Marginal, and Not Possible wind and wave conditions for the three countermeasures operations. This data is included so interested readers can see the influence of the different operational parameters on the final gap assessment.

An analysis was completed that evaluated all of the operational limits (parameters common to all countermeasures operations from Tables 11 and 12 and the countermeasures specific wind and wave parameters summarized in Tables A7 to A12) for each hour period of available data to establish a combined assessment of the operation as being Favourable, Marginal or Not Possible. The results of this assessment for the Central and West-Central Davis Strait areas are shown in Tables 13 and 15, respectively. When rounding values to the nearest whole number the percentages for Favourable, Marginal and Not Possible do not always sum to 100%.

A final processing of the data was completed to identify:

1. the percentage of time that conditions were Favourable for at least one countermeasure,
2. the percent of time conditions were Favourable or Marginal for at Least one countermeasure, and
3. the percentage of time when conditions preclude the use of any of the countermeasures.

The results of this analysis for the Central and West-Central Davis Strait areas are shown in Tables 14 and 16, respectively.

Table 13: Percentage of Time that Countermeasure Options are Favourable, Marginal, or Not Possible for Central Davis Strait During Periods of Open Water

Month	In-Situ Burning			Containment & Recovery			Aerial Dispersant Application		
	Fav.	Marg.	Not	Fav.	Marg.	Not	Fav.	Marg.	Not
July	59	9	31	36	35	29	53	0	46
August	40	15	45	31	30	39	59	0	41
September	23	17	60	22	27	52	54	2	45
October	9	13	78	9	20	71	39	2	59
November	0	3	97	0	3	97	15	1	83
December	0	0	100	0	0	100	0	0	100

Table 14: Percentage of Time When At Least One Countermeasure Option is Favourable for Central Davis Strait During Periods of Open Water

Month	At Least One Countermeasure Option Favourable	At Least One Countermeasure Option Favourable or Marginal	No Countermeasure Option Possible
July	73	73	27
August	63	63	37
September	54	56	44
October	39	41	59
November	15	17	83
December	0	0	100
For periods of freeze-up and winter (December through July), response deferred to spring-time melt season.			

Table 15: Percentage of Time that Countermeasure Options are Favourable, Marginal, or Not Possible for West-Central Davis Strait During Periods of Open Water

Month	In-Situ Burning			Containment & Recovery			Aerial Dispersant Application		
	Fav.	Marg.	Not	Fav.	Marg.	Not	Fav.	Marg.	Not
August	52	9	38	38	26	36	48	0	52
September	33	15	52	31	21	48	52	0	48
October	14	14	72	14	18	67	40	1	59
November	1	4	95	1	4	95	16	0	84

Table 16: Percentage of Time When At Least One Countermeasure Option is Favourable for West-Central Davis Strait During Periods of Open Water

Month	At Least One Countermeasure Option Favourable	At Least One Countermeasure Option Favourable or Marginal	No Countermeasure Option Possible
August	65	65	35
September	55	56	44
October	40	42	58
November	16	16	84
For periods of freeze-up and winter (December through July), response deferred to spring-time melt season.			

7. Summary

Environmental conditions that could impede or limit oil spill response operations have been summarized for two locations in the Beaufort Sea and two locations in Davis Strait.

In the Beaufort Sea, the frequency of open water is highly variable through the “summer season”, with a frequency of open water ranging from 54 to 88% in the near offshore location and 46 to 79% in the far offshore location, for the months of July through October in each case. It should be noted that these open water frequency values are the result of several years with very little open water throughout the season combined with most years which have predominantly open water: it does not reflect a year by year frequency with an “average” amount of ice. From a response perspective these occurrences of ice in the summer season would not necessarily represent a gap, rather they would necessitate a change in tactics, the use of burning in dense ice, or a combination of containment and recover, burning, and/or dispersant use in moderate or light ice conditions. Based on this, the frequency of open water conditions is presented for information purposes, but is not combined with the other environmental limitations in the subsequent tabulations.

In Davis Strait, the situation is more well-defined, particularly for the west-central location: in the months August through November the area is virtually ice-free, and in the months December through July there is little open water. The situation is less distinct for the Central location, but still fairly well-defined between open water and not, with the months of August through November virtually ice-free, 25 to 30% frequency of open water in July and December, and no open water January through June.

For each of the Beaufort Sea and Davis Strait locations, data was compiled to estimate the frequency of time that conditions would be favourable for a response. The conditions included wind, waves, visibility, and daylight as would possibly affect in-situ burning, containment and recovery, and dispersant-use operations. The frequency of time each of these conditions would allow the effective use of each of these countermeasures was combined to produce a frequency of time that response would be Favourable, Marginal, or Not Possible.

Based on the historical frequency of these conditions, response with at least one of the three listed countermeasures options would be possible for the period when open water is usually present, July through October for the Beaufort Sea and August through December for Davis Strait:

- From 32 to 77% of the time in this period for the Near Offshore location in the Beaufort Sea;
- From 31 to 78% of the time in this period for the Far Offshore location in the Beaufort Sea;
- From 16 to 65% of the time in this period for the West-Central Davis Strait location;
- From 15 to 63% of the time in this period for the Central Davis Strait location;

For portions of the year outside the above periods, an active response would be deferred until the following melt season.

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Appendix A: Percentage Occurrence of Wind and Wave Conditions by Location and Countermeasure

Note: When rounding values to the nearest whole number the percentages for Favourable, Marginal and Not Possible do not always sum to 100%.

Table A1: Wind and Wave Data for Near Offshore Beaufort Sea: In-situ Burning

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
May	77	0	23	57	12	31
June	98	0	2	87	10	4
July	98	0	2	84	10	6
August	97	0	3	76	16	9
September	85	0	16	49	24	28
October	75	0	25	38	24	37
November	80	0	20	61	19	20

Table A2: Wind and Wave Data for Near Offshore Beaufort Sea: Containment and Recovery

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
May	77	23	0	61	22	17
June	98	2	0	87	12	1
July	98	2	0	84	13	2
August	97	3	0	77	20	2
September	85	15	1	52	35	13
October	75	23	2	42	36	22
November	80	20	0	63	23	13

Table A3: Wind and Wave Data for Near Offshore Beaufort Sea: Dispersant Use

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
May	97	3	0	98	0	2
June	100	0	0	74	0	26
July	100	0	0	62	0	38
August	100	0	0	82	0	18
September	96	3	1	94	2	3
October	92	6	2	92	5	3
November	95	5	0	86	3	11

Table A4: Wind and Wave Data for Far Offshore Beaufort Sea: In-situ Burning

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	98	0	2	84	12	4
July	97	0	3	80	14	6
August	97	0	3	71	18	10
September	84	0	16	45	23	32
October	75	0	25	34	25	40
November	86	0	14	66	11	23

Table A5: Wind and Wave Data for Far Offshore Beaufort Sea: Containment and Recovery

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	98	2	0	84	14	1
July	97	3	0	81	16	2
August	97	3	0	73	22	4
September	84	15	1	50	33	17
October	75	23	2	38	36	25
November	86	14	0	69	19	13

Table A6: Wind and Wave Data for Far Offshore Beaufort Sea: Dispersant Use

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	100	0	0	73	0	27
July	100	0	0	73	0	27
August	100	0	0	83	0	17
September	96	3	1	94	3	3
October	92	6	2	89	6	4
November	98	2	0	87	1	13

Table A7: Wind and Wave Data for Central Davis Strait: In-situ Burning

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
July	99	0	1	79	14	7
August	98	0	2	62	24	15
September	93	0	7	40	29	31
October	86	0	14	27	28	45
November	84	0	17	25	26	49

Table A8: Wind and Wave Data for Central Davis Strait: Containment and Recovery

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
July	99	1	0	49	17	3
August	98	2	0	48	30	5
September	93	7	0	38	43	15
October	86	13	1	29	45	24
November	84	15	2	26	44	29

Table A9: Wind and Wave Data for Central Davis Strait: Dispersant Use

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
July	100	0	0	72	1	27
August	100	0	0	94	1	5
September	99	1	0	96	3	1
October	96	3	1	93	6	1
November	96	3	1	90	7	3

Table A10: Wind and Wave Data for West-Central Davis Strait: In-situ Burning

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	100	0	0	100	0	0
July	100	0	0	99	1	0
August	99	0	1	80	15	5
September	95	0	5	58	25	17
October	88	1	11	43	28	29
November	90	1	9	50	24	27

Table A11: Wind and Wave Data for West-Central Davis Strait: Containment and Recovery

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	100	0	0	65	0	0
July	100	0	0	61	1	0
August	99	1	0	57	18	1
September	95	5	0	55	33	7
October	88	12	1	45	39	15
November	90	10	1	45	35	14

Table A12: Wind and Wave Data for West-Central Davis Strait: Dispersant Use

Month	Winds			Waves		
	Favourable	Marginal	Not Possible	Favourable	Marginal	Not Possible
June	100	0	0	23	0	77
July	100	0	0	25	0	75
August	100	0	0	77	0	23
September	99	1	0	93	1	6
October	97	2	0	95	3	2
November	98	2	0	91	3	7