SHORELINE CLEANUP IN NORWAY: LESSONS LEARNED AND RECOMMENDATIONS

Chantal C. Guénette
SINTEF Applied Chemistry, Environmental Engineering
N-7034 Trondheim
Norway

Linn Aasnes
Norwegian University of Science and Technology (NTNU)
Department of Zoology
N-7055 Dragvoll
Norway

Odd Arne Follum
Norwegian Pollution Control Authority (NPCA)
Statens forurensningstilsyn (SFT)
Oil Pollution Control Department (OPCD)
P.O. Box 125, N-3191 Horten
Norway

ABSTRACT: *A summary of shoreline cleanup case studies in Norway is presented. Six spills, spanning more than two decades, are reviewed in terms of spill size, oil type, shoreline type, extent of oiling, cleanup techniques that were used, and lessons learned. This evaluation is based on situation reports, follow-up studies, and papers.*

The lessons learned and recommendations for improving the current response practices are discussed in terms of recent advances regarding current state of knowledge in oil spill behavior and cleanup techniques. These issues are addressed with reference to the Norwegian Pollution Control Authority's stated aim to strengthen shoreline cleanup response capabilities in Norway.

Oil drilling and production in Norway began in the 1960s and was primarily focused on the Norwegian continental shelf within the North Sea. The oil spill contingency effort was predominantly aimed at offshore response. The drilling platforms were in remote locations from the shoreline, and it was thought that any potential risk from a drifting oil spill near a platform was insignificant. Over the past decade, however, increased maritime traffic and drilling operations have been encroaching upon coastal waters. Because of the nature and extent of Norway's coastline, the risk of a spill reaching the shoreline has become a serious concern. The gross length of Norway's coastline is approximately 2650 km. However, when fjords, inlets, and islands are included, the exposed length of shoreline totals more than 21,000 km.

The typical coastline consists of, in order of prevalence, bedrock (svaberg), beaches with sandy sediment extending to boulders, cliffs, and clay beaches. Bedrock shorelines are typically dotted with pockets of sandy beaches (Lein *et al*., 1992). In general, soft bottom beaches and boulder beaches are more prevalent in northern Norway. In sheltered areas, mixed substrate is often found with varying percentages of clay, sand, and pebbles (Lein *et al*., 1992). Norway has an environmentally rich coastline in terms of wildlife, bird habitat, fish farming, and traditional deep sea fishing.

The Public Review Panel Tanker Safety and Marine Spills Response Capability (Brander-Smith *et al*., 1990) defines spill incidents according to the following size categories:

Minor spills	$<$1 ton
Moderate spills	1–100 tons
Major spills	100–10,000 tons
Catastrophic spills	$>$10,000 tons

Most of the larger spills that have impacted the Norwegian shoreline could be described as "major spills." According to the above criteria, Norway fortunately has not experienced a catastrophic spill. However, the Norwegian Pollution Control Authority (NPCA) considers the volume of spilled oil less of a concern than the location of the incident and the time of year with regard to vulnerable local resources.

Shoreline cleanup strategy in Norway

Organizational structure. The Norwegian Pollution Control Authority (NPCA) is the statutory authority for shoreline cleanup. The shoreline response organizational structure is in principle similar to that for offshore response, shown in the organogram in Figure 1. The actual cleanup activities are carried out by several bodies, which can include municipal manpower (local labor), volunteers, private organizations, hired consultants, the regular armed forces, and the civil defense. NPCA has an agreement with the Directorate of Labour to use local employment offices for the provision of manpower in the event of larger operations. Contingencies are set in place with the Directorate for Civil Defence and Emergency Planning for the provision of manpower, transportation, and emergency supplies (clothing, food, washing facilities, etc.). The regular armed forces can be called on during critical phases of the response operation, but in

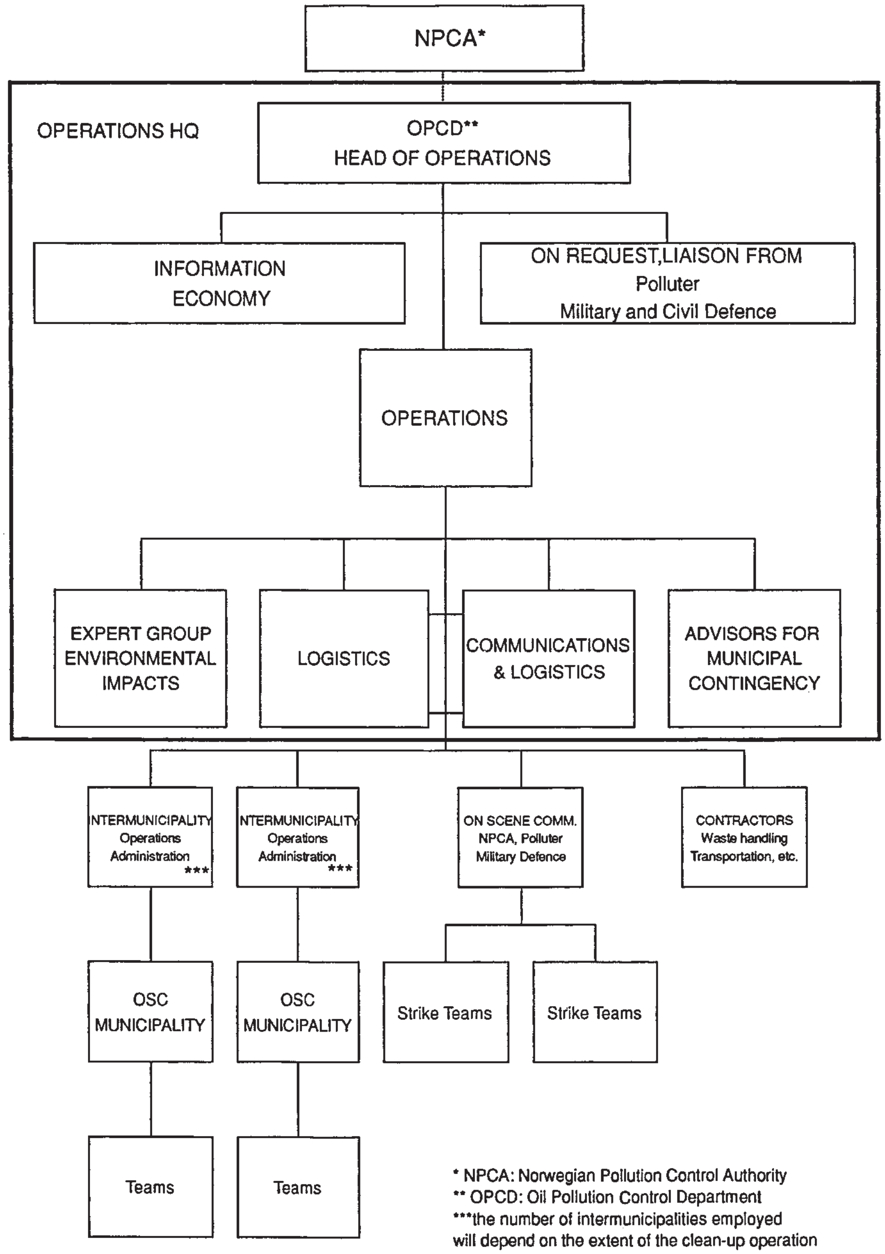

Figure 1. Organization plan for national oil spill response operations

principle, the army is not engaged if civilian forces can provide the necessary assistance. Toward the end of a shoreline cleanup operation, private expert consultants are normally hired to expedite the final cleaning (e.g., using chemical beach cleaners, washing man-made structures, etc.).

Although the polluter is responsible for all costs and financial claims incurred by damages caused by a spill, NPCA oversees the cleanup operations and is responsible for ensuring the execution of a response action. Very few potential polluters have the capability of actually performing cleanup operations themselves. NPCA has therefore prepared contingency plans in the event of such incidents. This scheme is established in the national contingency plan for acute pollution, which is administered by NPCA. Cleanup operations involve the municipalities, each of which has its own local spill contingency organization. Coordination is handled by the state government (NPCA) rather than by private organizations or the responsible polluter.

Guidelines and policies. The main objective of the national oil spill response plan is to prevent oil from reaching the shore in the first place (SFT, 1994). The primary oil spill response method in Norway has traditionally been mechanical recovery; however, other methods, such as dispersant application, are now considered if they are deemed more effective. If and when the oil does reach the shore, the overall policy for shoreline cleanup operations is to ensure that, whatever actions are initiated in responding to the spill, the total impact on the natural environment should be minimized to the greatest possible degree (SFT, 1994). This implies that every operational strategy (e.g., mechanical recovery, dispersants or beach cleaners, bioremediation, burning) should be considered and used as long as the environmental net benefit analyses show that the chosen method is the most environmentally beneficial option. However, economic and political issues may influence the final decision. For example, even though this policy would suggest that under NPCA guidelines a fish farm and its stock can be replaced, it is not easy to convince local industrial, administrative, or public interest that a bird sanctuary should be given priority in the cleanup operations. Moreover, the Pollution Control Act (§ 1, second paragraph) states that NPCA should ensure that pollution will not create human suffering, be it social, economic, or environmental. The issue of targeting resources can therefore become a very political one, which is not easily resolved in the midst of an emergency situation. The general approach taken toward shoreline cleanup is outlined below:

1. Prevent the oil from reaching vulnerable shorelines by protecting the beaches with booms if possible.
2. If shoreline oiling cannot be prevented, determine whether oil can be directed toward selected areas that may already be contaminated, or select sacrificial areas. Once the oil reaches the shoreline, it should be stabilized with booms to prevent further oiling of other areas. This requires that one establish priorities among beaches in the area before one establishes the local contingency plan.
3. According to the established priorities, the response strategy and cleanup activities are determined by constructing a map and plan over the polluted area.
4. The plan should contain a map of the oiled shorelines, an outline of the vulnerable features at risk, the types of methods to be used, manpower and equipment requirements, and any seasonal activities in the area (hatching, nesting, and other ecological events, recreational use, etc.).
5. The cleanup operations are closely scrutinized by the responsible authorities. Plans are periodically updated and revised to decide on any changes in methods used, reallocation of manpower, and so forth.
6. The plans and follow-up work are discussed by NPCA, DN (Directorate for Natural Management), county officials, and other specialists on wildlife and nature conservation, municipal representatives on tourism, local fisheries, fish farm operators, and other parties. For operations under NPCA auspices, NPCA will make decisions on any further cleanup activities. During local cleanup operations, the municipalities can make decisions regarding response plans, provided they do not conflict with national or international interests.

Shoreline cleanup methods. Shoreline cleanup is based on the guidelines presented in the *Handbook for Shoreline Cleanup* (SFT, 1984). This handbook outlines the typical shoreline types found in Norway, explains how to assess the contaminated areas, identifies vulnerable resources, and outlines an approach for selecting cleanup methods. Common treatment methods include manual and mechanical techniques, water flooding or washing (high and low pressure, cold and hot water, and steam), water wash combined with the use of chemical dispersants, and the use of commercially available sorbents (Zugo—pine bark, Natur—fine-grained spruce bark, Dracoline—fine-grained polyurethane foam). Of the alternative cleanup methods (those other than manual or mechanical removal), only chemical dispersants are commonly employed because of the general understanding of dispersant use. Bioremediation is considered in the final beach-cleaning stage if mechanical recovery would be prohibitively expensive or impractical or would achieve little benefit. Mud flats are a shoreline type where bioremediation would typically be used. In-situ burning is still not a relevant alternative in Norway.

Termination of cleanup efforts. A number of conflicting interests determine the termination point of the cleanup operation. The polluter would like to see this occur as soon as possible, since cleanup is a costly undertaking. The municipalities, on the other hand, may wish to see the cleanup operation prolonged because it is a source of employment and temporarily boosts the economy in the community. It is important to consider at what point the cleanup operations are causing more damage to the environment than the remaining oil. Biologists familiar with the site and the cleanup operation are usually consulted to assist with this decision. Furthermore, under NPCA guidelines, NPCA is the authority responsible for making this final decision, which is primarily based on environmental considerations.

Overview of spills impacting Norwegian shorelines

Table 1 summarizes the major spills, in terms of impact, that have occurred along the coast of Norway and that have resulted in considerable shoreline contamination. A map showing the location of these spills is depicted in Figure 2. As can be seen from this map, the majority of the spills have occurred in the southern part of Norway, where drilling activities are concentrated. Of the 13 spills outlined in Table 1, 6 have been fairly well documented and monitored in terms of the cleanup action taken, the extent of oiling, and the effectiveness of the cleanup activities. This discussion focuses on those spills. The following information has been compiled from published papers, NPCA logbooks and reports, and the municipal oil spill response organization logbooks.

***Gallic Stream*, 1975.** In January 1975, the *Gallic Stream* released an unknown amount of bunker oil near the Hamarøy district (Sendstad and Gåseidnes, 1983). The extent of shoreline oiling was very limited, although the exact length was not documented. The contaminated shorelines consisted of bedrock, cobbles ranging from 6 to 28 cm in size, fine sand and clay beaches, salt marshes, and cliffs. In some areas, the contaminated macro-algae and debris were collected and either burned or landfilled in sandy soil. The most common cleanup technique used for salt marshes was to manually mix sorbent material (Zugol, Natur, and Dracoline) into the oiled beach sediment. The contaminated material was then covered with a 3-cm layer of sand. Hard substrate beaches were treated by water washing in combination with dispersants. Sand beaches were cleaned by removing the oiled substrate, and clay beaches were not treated at all. Cliffs in high-energy areas were left to recover naturally, because of the self-cleaning effect of high-wave exposure. Priority was given to areas used for recreational purposes (sport fishing), commercial fishing, and grazing (mainly sheep).

***Deifovos*, 1981.** The *Deifovos* sank off the coast of South Helgeland during a hurricane in January 1981, releasing 1000 tons of heavy bunker oil (SFT, 1982a). This spill was by far the largest spill impacting Norwegian shorelines, in terms of both volume and length of shoreline oiled. Because of severe weather conditions and high tides at the time of the spill, the oil was stranded along the upper intertidal and supratidal zones of the beaches. The oil was heavily emulsified and very sticky. The affected area, which contained approximately 300 islands, consisted primarily of exposed steep rock and rounded cobble shorelines, with pockets of sandy beaches and sheltered areas.

The response strategy adopted was based on the sediment type, the exposure of the beach, and the vulnerability of the areas (SFT, 1982a). However, the extreme weather conditions (high winds, snow, and very low temperatures) made it difficult to gain a perceptive overview of the situation. Since the breeding season for seabirds was approaching, areas with important bird populations were given highest priority. As long as snow covered the beaches, recreational and populated areas were given medium priority. High-energy areas with steep shorelines (e.g., cliffs) and less vulnerable resources were determined to be low-priority areas.

A number of cleanup methods were employed, depending on the type of beach sediment (SFT, 1982a; Wikander, 1981, 1982). Sand beaches were cleaned by excavating the contaminated sand with a tractor (SFT, 1982a). Rocky beaches were cleaned using water wash (temperature and pressure not documented). This type of cleanup was only executed in selected areas because of the extent of the oiled area, the labor-intensiveness of this method, and the shallow waters near some of the beaches, which made boat access and boom deployment difficult. In some areas, the oil was manually removed (racks, shovels, pumps); this was followed by treatment with natural sorbents (the commercial pine bark sorbent Zugol). Other areas were not treated and were left to natural recovery.

Troms, 1982. This spill occurred in the Troms area in northern Norway in April 1982 (SFT, 1982b). The source and amount of oil spilled were unknown, but the total length of shoreline affected, as observed from the air, was approximately 250 km. The oil was unevenly distributed along the coastline, and oil cover ranged from 1% to 10% per square meter. The coastline in this region is dotted with many islands, islets, holms, and rocks. Because the oil was stranded at high tide during stormy weather, it was deposited predominantly along the upper intertidal and supratidal zones. The spilled crude oil was found in very thick, sticky lumps of approximately 5 to 40 cm in diameter. The actual cleanup techniques used in responding to this spill have not been documented. Since the contaminated area was particularly extensive, cleanup operations were focused on the most heavily oiled areas. The location of these areas was determined by bird specialists and the intermunicipal oil spill response authorities.

***Mercantil Marica*, 1989.** In late October 1989, the *Mercantil Marica* ran ashore in the outer Sognesjøen, near Sogn and Fjordane, releasing 340 tons of heavy crude oil and 60 tons of diesel (Lindeman *et al.*, 1989). The spill occurred near important commercial fish farming areas. Local author-

Table 1. Summary of oil spills that impacted upon shorelines in Norway

Year	Ship/source	Spill size (tons)	Oil type	Cause of spill	Location	Extent of oiling (km)
1975	*Gallic Stream*	Unknown	Bunker	Unknown	Hamarøy	Limited
1976	*Drupa*	2400	Crude		Sola, Rogaland	—
1977	*Bravo* platform	20,000–30,000	Crude Gas	Blowout	Ekofisk	—
1980	*Stylis*	Unknown	Crude	Bilge spill	Skagerrak	—
1981	*Deifovos*	1000	Bunker	Sank in storm	Helgel-kysten	2500
1982	Unknown	Unknown	Crude	Unknown	Troms	250
1983	*Bayard*	60	—	Grounding	Brevik	—
1983	*Baldwin*	3	—	Grounding	Brevik	—
1984	*Carthago Nova*	600	—	Transfer operation	Hellesøy Rogaland	24
1989	*Mercantil Marica*	420	Crude Diesel	Ran ashore	Sognesjøen	30
1990	*Azalea*	337	Bunker Diesel	Sank under tow	Haugesund	42
1991	*Sonata*	150	—	Sank under tow	Ålesund	9
1992	*Arisan*	150	Heavy fuel oil	Grounding, sunk	Runde	32

ities considered that the potential damage to the environment and bird life was small in this area; therefore, priority was given to protecting the fish farms. All available booms in the responding municipality were immediately deployed around the fish farms, leaving other areas unprotected. Several days later, the oil reached nearby shorelines, and booms were made available from neighboring municipalities to protect the quay and boats. Approximately 30 km of shoreline was oiled. The shoreline was predominantly bedrock with cliffs and small pocket beaches of sand and silt. The oiled shoreline had exposed and sheltered areas. Repeated reoiling of the beaches occurred as the ship continued to leak oil.

In one location, the shoreline cleanup operations were carried out by local volunteers, led by the fire chief who was trained for this type of situation. The army was also called in to assist in the cleanup operations for approximately 1 week. Bulk oil was removed by trucks or boats mounted with vacuum pumps. The cleanup methods employed were documented, but unfortunately the locations or beach types on which

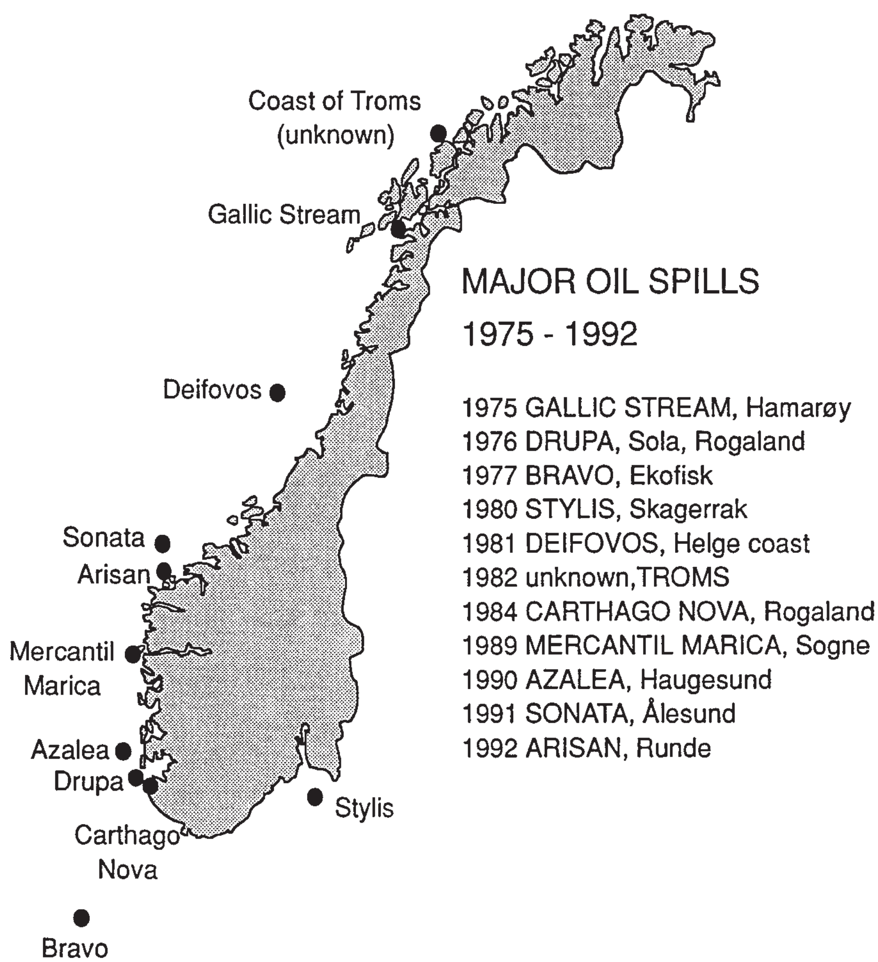

Figure 2. Location of major spills impacting shorelines in Norway

they were used were not. The guidelines in the *Handbook for Shoreline Cleanup* were followed. The shoreline material was cleaned by water washing combined with chemical dispersants, manual removal (shovels, buckets, scrapers, hands, etc.), and the application of sorbents. A total of 565 tons of emulsified oil was collected, approximately 40% to 50% of the oil initially contained in the ship.

The classification society Det Norske Veritas criticized the local response effort's planning and preparation, specifically the lack of equipment (shovels, protective clothing, etc.), the lack of qualified leaders, poor management of personnel, and the lack of planning concerning how to carry out the rough shoreline cleanup. In some cases oil was lost from containment booms that had been improperly secured. This resulted in the reoiling of certain beaches. The cleanup operation caused secondary contamination on land because staff were not fully trained in this area. Despite these criticisms, the insurance company was generally satisfied with the cleanup operation.

***Azalea*, 1990.** On March 22, 1990, the ship *Azalea* sank off the coast of Haugesund, releasing 300 tons of bunker oil and roughly 40 tons of diesel, causing over 40 km of shoreline to be oiled (SFT, 1990). The spill impacted an exposed, vulnerable, and highly populated area. The cleanup effort was carried out for approximately 4 months. The affected shoreline types consisted of bedrock, mixed sediment beaches, and salt marshes.

Cleanup methods included manual recovery, cutting of oily brown algae, and mechanical removal of sediment using a tractor. Water flushing with cold seawater was used to clean beaches, while high-pressure warm water was used to clean quays. Chemical dispersants were also used. Detailed documentation regarding which methods were used on what type of sediment is not available. However, the response leaders' general approach was to avoid the use of heavy equipment and vehicles on vulnerable areas to prevent any further damage. The methods chosen were based on the location of hatching areas, and efforts were made to prevent oiling of birds. In populated and recreational areas, the emphasis was placed on quick and effective oil removal, rather than on reducing the impact of the cleanup methods.

***Arisan*, 1992.** The *Arisan* ran aground in mid-January 1992, off the coast of Møre and Romsdal, but did not sink until 2 months later (SFT, 1992). Over this period of time, a total of 150 tons of heavy bunker oil, diesel, lubrication oil, and hydraulic fluid was released. Oil stranded over a shoreline length of 32 km consisting of bedrock, rocky cliffs, boulders, cobble, and some sand.

Response operations were initiated shortly after the spill incident and were carried out for a period of approximately 8 months (after recognition of the area). At this point, the area was declared clean and the cleanup operation was terminated. The criteria for prioritizing areas to be cleaned were based primarily on the feeding and hatching areas of the local seabird populations. This spill occurred in an important seabird area. The main concern was to prevent oiling of these birds.

Also considered was the self-cleaning ability of some beaches, particularly those with hard substrate and medium to high wave energy. The primary cleanup methods used were vacuum pumping, cutting and removing of oiled algae, manual cleanup (gathering of oiled debris, recovery of oil with shovels, trowels, wooden scrapers, and by hand), and application of bark-type sorbents followed by removal of oiled material and then reapplication of the clean sorbent. In addition, water wash (warm water, low and high pressure) was employed in some areas.

Lessons learned

Many of the guidelines and methods recommended today are based on experience gained from previous spill incidents, including the *Mercantile Marica* (Lindeman *et al.,* 1989; Hjohlman *et al.,* 1991; Hjohlman and Lein, 1994), the *Azalea* (SFT, 1990) and the *Arisan* (SFT, 1992) in Norway, as well as the *Exxon Valdez*, *Braer* and *Sea Empress* incidents abroad. Much has been learned from these spills in terms of logistics, natural recovery, transportation, dealing with the media and the public, and the introduction of new products at the time of the spill response.

Communications. Good communication was essential to successful spill response operations. This included communications on site between response teams and the local responsible authorities, and dialogue between the local authorities and NPCA.

Transportation. Cleanup operations often occurred in areas with poor or no road access and where shallow waters prevented larger boats from coming close to shore. The problem of dealing with waste material collected in empty drums was solved by using a helicopter to transport the drums from the beaches to a boat located a short distance offshore. This solution proved to be very economical; it saved time and required limited manpower, and it had little impact on the environment.

Natural recovery. The ability of some beaches to self-clean was found to be an important consideration in shoreline cleanup. In some cases, allowing a beach to recover naturally was or would have been the best response action to take. In the case of the *Arisan* spill (SFT, 1992), it was obvious that the self-cleaning potential of some beaches, particularly in the lower and mid-intertidal zones, was a significant factor in the rate of oil removal from the beach. In such areas, it may have been more effective to delay recovery operations until most of the oil had washed out of the lower to mid-intertidal zone, and to focus cleanup efforts on the upper intertidal zone where the oil eventually became stranded. Following the *Azalea* spill (SFT, 1990), it was recommended that, to the greatest extent possible, the use of heavy materials and machinery in vulnerable areas should be avoided. Such areas may have been better left to recover naturally, or less intrusive methods could have been employed (e.g., bioremediation).

Media and public relations. One important lesson learned was how to improve public relations with the media, environmental organizations, and the general public, particularly local residents. It was very important to provide information to the public and media. Often the technical requirements of the spill are easier to deal with than the media and local public opinion. This is particularly true when the most effective response action is that of leaving the beaches to self-clean rather than to use intrusive methods that could potentially cause more damage to the area than the oil itself would. It is believed that by adopting an active attitude toward the media and public, keeping them informed of current strategies and the justification behind the decision-making process, one can avoid negative publicity.

Some years ago, the notion of allowing a beach to recover naturally would have been met with opposition because this option was often seen as inaction. Responders and decision makers require documentation to justify such decisions and to demonstrate that taking no action at all, other than monitoring, can be the best solution. This course of action requires data on previous spill experiences, results from test spills, and related research. To be able to arrive at such a decision, the responders need to have good maps of the affected shorelines detailing substrate type, exposure, wildlife considerations, and so forth; recommended recovery techniques for the corresponding shoreline conditions; and logistical support.

New products and innovations. As is often the case during a major oil spill, responders are approached by innovators, suppliers, and producers with new but unproven or untested oil spill cleanup products. Some of these products may have serious applications, but many are promoted following the initial outcry over the spill incident. During the *Azalea* spill (SFT, 1990), after much pressure from a number of producers, a few product were tested, which in this case turned out to be completely ineffective. The experience gained from the responding municipality was that only proven products, equipment, and techniques should be used during a spill. At the present time, NPCA has no systematic decision process in place for dealing with these issues. However, there are plans to implement a process that could involve, for example, establishing a group of experts or advisors to deal with innovators, suppliers, and producers.

Recommendations

Handbooks, field guides, and guidelines. The aim of the handbook was to provide some guidelines on how to deal with an oil spill cleanup on a shoreline. Under the assumption that response methods, equipment, and the general understanding of oil spill fate and behavior on shoreline would improve over time, the intent was to update this handbook on a regular basis as more experience was gained through the various spill response activities (SFT, 1984). It is therefore recommended that this handbook be updated. A process should be put in place whereby responders, advisors, and observers can communicate their experiences to the policymakers and contingency planners. Such information could be used to periodically update the handbook.

In addition to or included in this handbook should be a standardized system for documenting and describing the oiled shorelines, the effectiveness of the methods, and the lessons learned during actual spill response. This would facilitate updating the response guidelines so that they can be used with future spills. Local municipalities and authorities who will be responsible for shoreline response should be given written documentation and guidelines for oil spill cleanup operations in their area.

Contingency planning. Contingency plans should provide an overview of the data and resources concerning cleanup decisions, and they should give a priority list for the different areas.

Training. Oil spill response training has typically focused on offshore response. NPCA does perform some exercises with the municipalities, but these are often aimed at offshore response. More training and instruction of potential responders should be undertaken. Training of all personnel involved is not possible or necessary. However, key personnel in charge of the beach-cleaning operations should be competently trained so that they can give clear, concise instruction and on-the-spot training to volunteers and others involved in the cleanup operation. Key personnel from different areas of oil spill response should train together so that they can obtain an overall understanding of the various roles and responsibilities involved. A new facility, the Norwegian Centre for Marine Environment and Safety, will open in the coming year; it will be targeted at providing prevention, response, and training related to maritime traffic safety and pollution control. It is recommended that regular standardized training courses, specifically dealing with shoreline response, be included in its training programs.

Resource persons. Good contact should be maintained with resource persons (e.g., biologists) with past spill experience who may no longer be actively involved in spill response. These people could serve as important and invaluable advisors in the event of a spill. They should be integrated into the action command groups so that they can provide advice, regulations, and guidelines to personnel working in the field. They should follow up on each work group's field activities, make field observations, and provide guidance throughout the cleanup operation. These resource people should be consulted in the general contingency planning activities that occur outside of actual spill response activities; they can provide advice concerning training, guidelines, and cleanup manuals. Contact with local residents for information on the shorelines and the resources in specific areas should be encouraged.

Public relations. Good contact with media, environmental organizations, and local residents is important during a spill response operation. These parties should be kept informed of cleanup activities and priorities and should be provided with information that can justify and defend the actions taken. One should provide a mechanism for the exchange of information between responders and the public, and in particular allow for local residents to voice their concerns.

Future research and long-term recovery studies. Areas of research should be identified that can provide decision makers with the information and facts they require to plan their response strategy and to justify their decisions to the media, the general public, local residents, and environmental organizations. Old spill sites could be revisited to evaluate the effectiveness of the cleanup methods used and to monitor the long-term fate and recovery of the oiled shorelines. This information could be used to update the cleanup handbook.

Biography

Chantal Guénette is a research scientist with the Environmental Engineering Department at SINTEF Applied Chemistry in Norway. She received degrees in biochemistry and chemical engineering at the University of Ottawa, Canada. She currently manages the in-situ burning and physical and chemical shoreline cleanup research activities in the department.

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