INTERCALIBRATION EXERCISE FOR REMOTE SENSING AIRCRAFT

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ABSTRACT: *Intercalibration exercises are organized each year in the North Sea area. In 1991, the tests revealed that airborne detection techniques have limits that are not completely taken into account by the regulations (MARPOL 73–78). It was also shown that using color codes could reduce the risks of error in evaluating the volume of a spill, which can occur even when made by very experienced crews.*

Within the framework of the Bonn Agreement, cooperation concerning aerial surveillance in the North Sea area has been achieved through the following programs.

- Coordinating national flight plans carried out by the contracting parties themselves
- Reaching regional (bi- or multilateral) agreements to cooperate in areas of mutual interest
- Setting up special flights, such as Tour d'Horizon, joint flights, and intercalibration exercises
- Standardizing reporting formats and exchange of information to the contracting parties
- Working together to improve existing systems and develop new techniques to enhance the information obtained

Thus, each year, intercalibration exercises are organized by the authorities of the countries within the Bonn Agreement. The exercise normally consists of field trials, using limited quantities of oil; special substances to study the detectability by remote sensing; evaluation of the data recorded during the exercise; a workshop for the exchange of information and discussions of improvements or new developments on remote sensing equipment (Bonn Agreement Manual).

This paper summarizes the data obtained from detecting spills of oil and harmful substances, in an exercise in the Bay of Biscay off the coast of Lorient. The exercise was organized by the French Navy under the authority of the Maritime Prefect in Brest, in November 1991.

Field trials

Aircraft participating in the exercise were:

- France: Cessna 406 (Customs)
- Great Britain: Cessna 402 (Marine Pollution Control Unit)
- Netherlands: Cessna 404 (RWS Noordzee)
- Belgium: Br. No. Islander (Unité de Gestion du Móadele Mathématique de la Mer du Nord)
- Denmark: Piper N.P31

The intercalibration exercise took place from November 19 to 22, 1991. Different types of oily wastes, heating oil, and chemicals were released into the sea from the tanker *Durance* and from the supply ship *Ailette*. The characteristics of the released substances are given in Table 1, and the properties of the heating oil 50/50 in Table 2.

Concerning the various releases, we can add that:

- On November 20, the speed of the tanker during the discharge was adjusted between 6 and 3 knots for obtaining 30, 50, 70 and 140 liters of oil/nautical mile.
- On November 21, after an aerial survey by the fixed wing aircraft and two reconnaissance flights by the helicopters, the slick was treated with dispersant sprayed by one ship and one helicopter with a SOKAF bucket.
- On November 22, only three aircraft flights for reconnaissance of the chemical spills were carried out (by the Netherlands, Denmark, and France).

Throughout the exercise, the weather and sea conditions were recorded every hour on board the destroyer *Duperre* and are presented in Table 3. The helicopters of the tanker *Durance* and of the destroyer *Duperre* were used for tracking and monitoring each slick as well as for taking photographs. Dimensions of the slicks were estimated on the basis of the speed of the helicopter making a low flight.

Surface sampling was done by the analytical chemistry laboratory with the participation of the personnel of CEPPOL and CEDRE. The sampling objectives were: to evaluate the risk of explosion, and to map the polluted area and to estimate the level of pollution.

Results

Different sensors were used by the aircraft engaged in the exercise: side-looking airborne radar; infrared sensor, which allows a discrimination between the thicker and thinner parts; an ultraviolet sensor; a movie camera; and other cameras.

Side-looking airborne radar (SLAR) was unable to detect the oily waste discharge (heating oil 50/50 between 2,000 and 4,200 ppm) because of the choppy sea (Table 3, and Figures 1 and 2). A 15 m^3 slick of plain heating oil 50/50 was detected by each aircraft. Its size could be estimated using a grid superimposed on the image. Detection of the chemicals (alkane petroleum cut, hexanol, and xylene) was impossible.

The first slick (oily waste) was not detected by the infrared scanner. The thermographies of the Marine Pollution Control Unit (MPCU, Great Britain) and of France revealed a greyish surface along the port side of the tanker *Durance*, but this shadow was not sufficient to reduce any ambiguity (Figure 3).

The main slick (15 m^3) was detected by the IR sensors, and the outline of the slick was very precisely determined with clear delinea-

Table 1. Spill characteristics

Date	Nature of release	Quantity	Rate
November 19	oily waste		heating oil 50/50 mixed with water—
		15 m^3	2,400 ppm
		18 m^3	4,000 ppm
November 20	oily waste	2.5 hour release	heating oil 50/50 mixed with water— 3,000 ppm 4,200 ppm
November 21	heating oil 50/50	15 m^3	200 m long
November 22	chemicals:		
	alkane petroleum cut	1 m^3	
	hexanol	1 m^3	
	xylene	1 m^3	

Table 2. Heating oil 50/50 properties₁

Viscosity	cs, at 50° C	48
Pour point	°C max	−9

1. NATO F 77

tion of the areas appearing "hot" and "cold." The three chemical slicks also were detected by IR sensors (Netherlands, Denmark, France).

The ultraviolet radiometer detected only the main slick (15 m^3 of heating oil), although the images there show a clear outline of the slick.

Two types of photographs, oblique and vertical, were taken with the movie camera. The last one, despite very good resolution, does not allow an overall view of the slick.

Some good quality pictures were taken with a video camera (for example, the Panasonic camera of the Belgian aircraft). They constitute supplementary information for the thermographies (IR), and enable us to quantify the slick by using the color code.

One of the aims of the exercise was to estimate the size of the main slick (15 m^3 spilled between 8:47 and 8:51 a.m.), its thickness, and the volume of spilled oil using indicators such as the color codes. Different tables are currently used to assess the quantity of the oil on the basis of the sheen's color. The relation between the appearance, thickness, and volume of floating oil are shown in Tables 4 and 5.

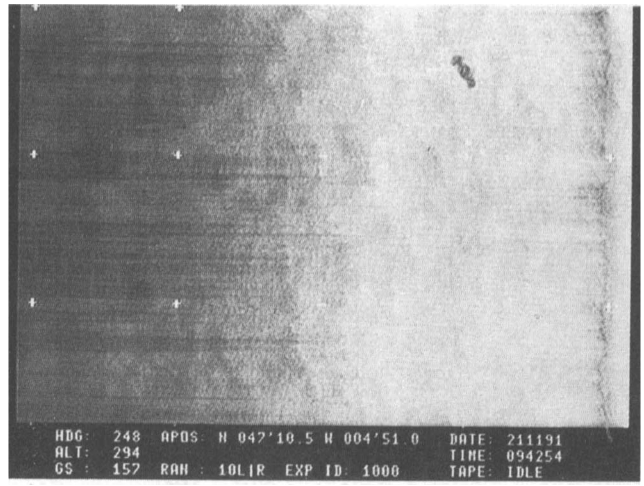

Figure 1. SLAR image, Great Britain—November 21, 1991

The size of the slick was calculated after a low-altitude flight by helicopter. These measures are considered as reference data, and the observations from the different aircraft participating in the exercise were compared to the reference data. It appears that the dimensions given for the slick are generally correct (Tables 6 and 7).

The second objective for the crew members was to estimate the volume of the slick after comparing the color and the color codes of the Bonn Agreement pollution observation log, after determining the surface area of the various colors, and after estimating the percentage of oil cover of each type. The results of the crews' observations are given in Table 8

The technique used for sampling involves the use of a sorbent: a polypropylene pad containing adsorbed oil is agitated with aliquots of toluene and the removed oil is evaluated by spectrophotometry. Sampling was done by the personnel of CEDRE and CEPPOL at four points along the slick (Table 9).

Table 3. Environmental conditions

Date	Time	Sea state	Wind direction	Wind speed (knots)	Visibility (nautical miles)	Nebulosity	Ceiling (feet)
November 19	2:00 p.m.	5	320	28	6	7/8	1,500
	3:00 p.m.	5	337	28	>6	7/8	2,000
	4:00 p.m.	5	334	21	6	8/8	
	5:00 p.m.	5	346	26	6	8/8	
November 20	1:00 p.m.	4	010	36	10	2/8	
	2:00 p.m.	4	020	28	8	2/8	
	3:00 p.m.	4	010	34	8	2/8	
	4:00 p.m.	4	005	28	9	4/8	
November 21	8:00 a.m.	3	035	20	10	4/8	3,000
	9:00 a.m.	3	012	25	8	4/8	2,500
	10:00 a.m.	3	020	24	8	2/8	2,500
	11:00 a.m.	3	025	26	>10	2/8	2,500
	12 noon	3	020	24	>10		
	1:00 p.m.	3	094	16	10	2/8	
	2:00 p.m.	3	013	14	10	3/8	
	3:00 p.m.	2	006	15	10	3/8	
	4:00 p.m.	2	010	18	10	2/8	
	5:00 p.m.	2	006	15	10	2/8	
November 22	9:00 a.m.	2	355	2	10	6/8	
	10:00 a.m.	2	350	2	10	6/8	

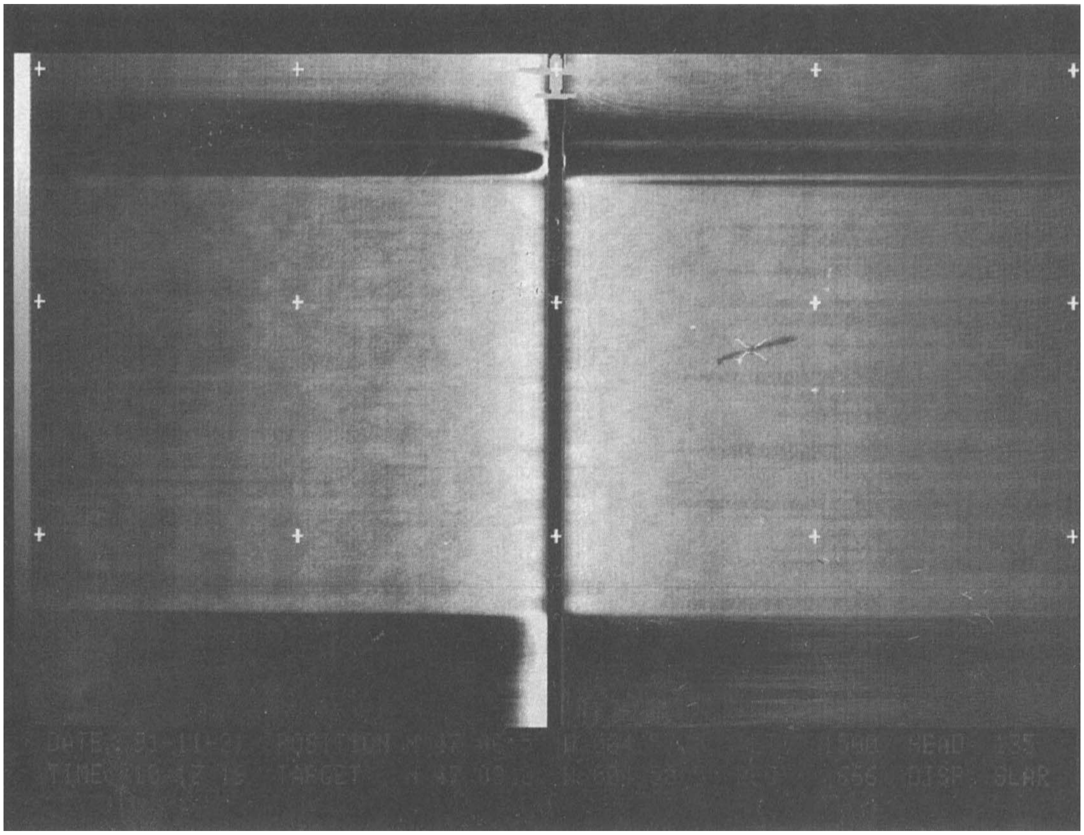

Figure 2. SLAR image, Netherlands—November 21, 1991

Table 4. A guide to the relation between the appearance, thickness, and volume of floating oil[1]

Oil type	Appearance	Approximate thickness (mm)	Approximate quantity (m^3/k^2)
Oil sheen	silvery	>0.0001	0.1
Oil sheen	iridescent	>0.0003	0.3
Crude and fuel oil	black/dark brown	>0.1	100
Water-in-oil emulsions ("mousse")	brown/orange	>1	1,000

1. Extract from technical information paper—ITOPF[2]

Table 5. Oil quantity

Color code	Quantity (m^3/km^2)
1. silvery	0.01
2. grey	0.1
3. rainbow	0.3
4. blue	1
5. blue/brown	5
6. brown	15
7. black/brown	>25

1. Extract from Bonn Agreement pollution observation log

An estimation of the volume was made taking into account the results of sampling at Point 2 (average thickness 76 μm), the thickest part of the slick, the surface area of the slick (the size of the slick calculated with the IR image and the altitude of the flight—width covered = 2 × flight altitude), and the percentage of cover. The volume was estimated to be 15.5 m^3 at 9:37 a.m.

CEDRE also chose one IR image and asked the Ecole Nationale Supérieure des Télécommunications de Bretagne[1] to process the image in the school's image processing department. The IR image 21.11 taken at 9:37 a.m. on November 21, 1991, (Figure 4) was digitized, and using Optilab software and an algorithm designed to define the contours of the slick, a calculation of the surface area of the slick was made. The contour of the slick (grey level 0 up to 62) was defined and the surface was calculated to be 172, 320 m^2 or 162,400 m^2 depending on the method used to define the contour of the slick. A calculation of the volume (taking into account the thickness obtained from the samples) has given a volume of 13 m^3 (Figures 5 and 6).

Table 6. Dimension of the slick estimated after helicopter overflight

Time	Length (m)	Width (m)
9:43 a.m.	1,000	300
10:52 a.m.	2,100	400
3:30 p.m.	8,800	300 to 500

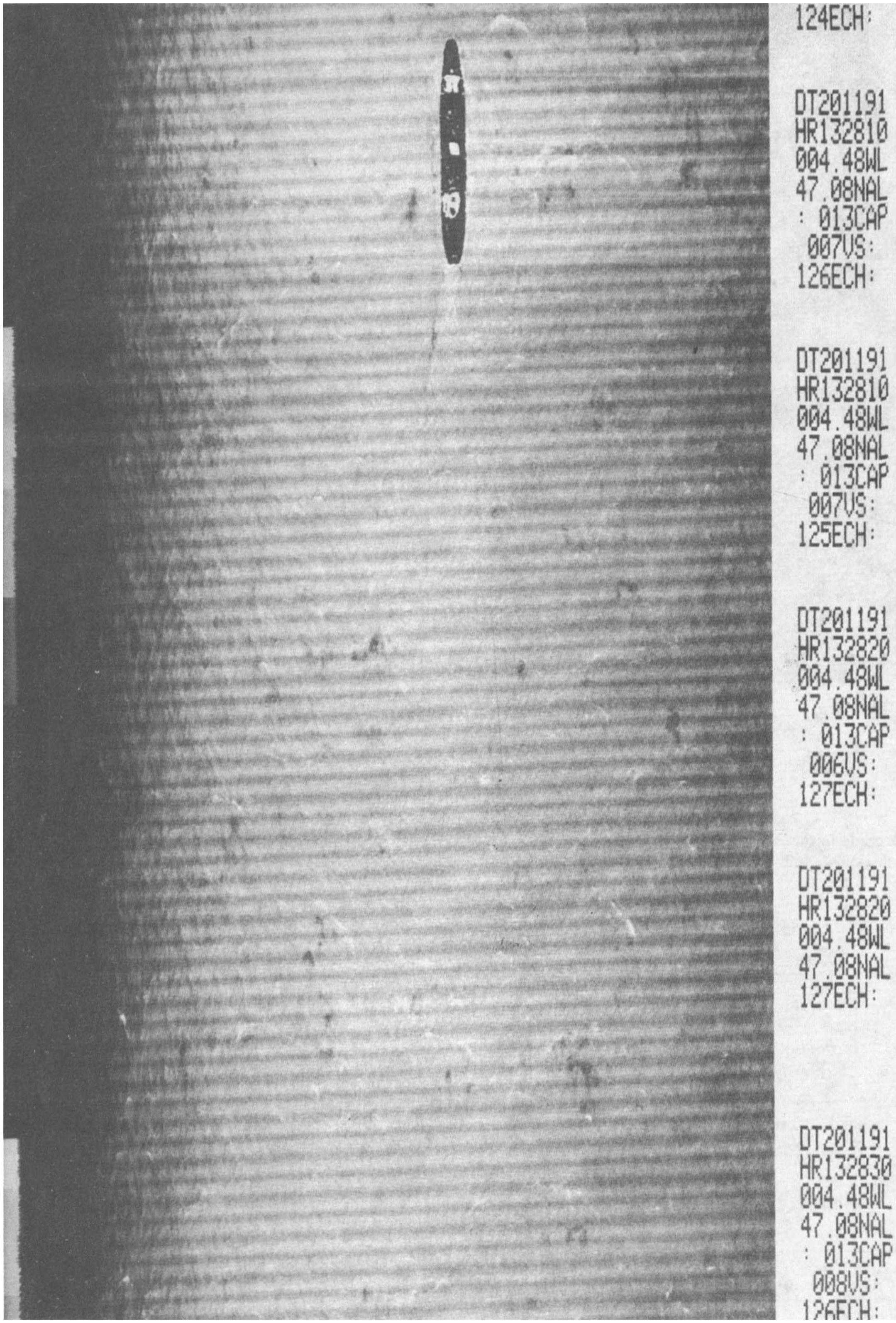

Figure 3. IR image, the tanker *Durance*—November 20, 1991—the discharge at 1,500 ppm appears as a greyish surface

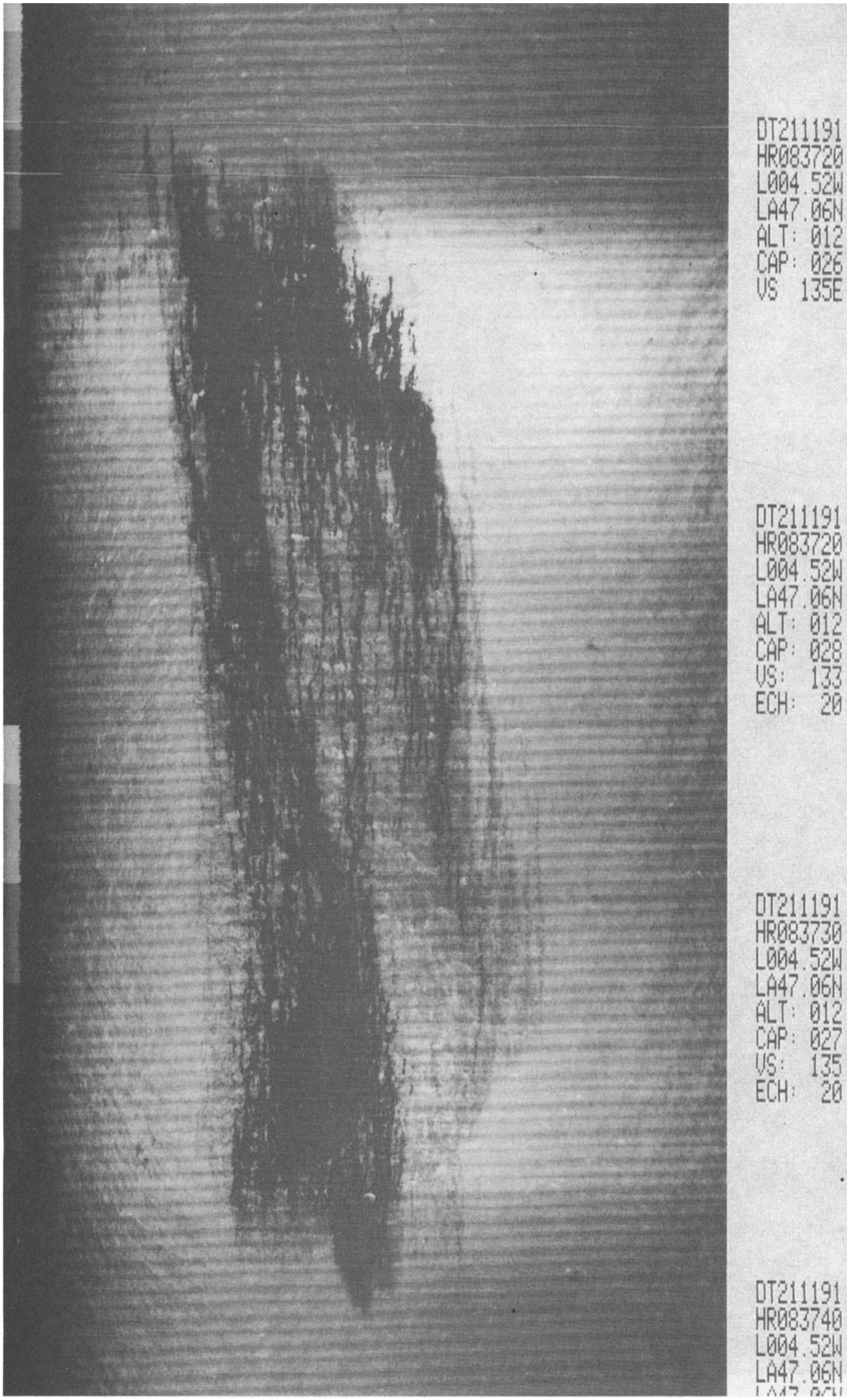

Figure 4. Thermography (French Customs aircraft), 9:37 a.m., November 21, 1991

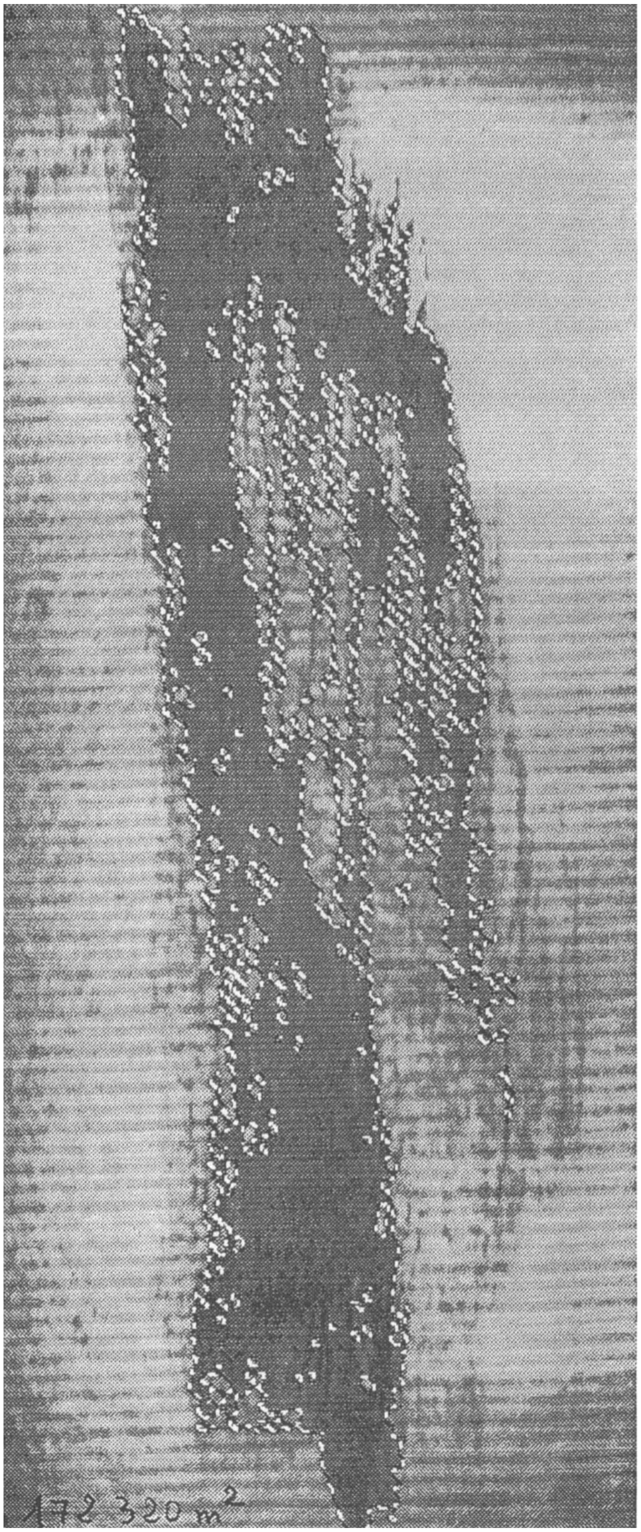

Figure 5. Contour of the slick in Figure 4 after threshold marking: grey level 0 to 62

Figure 6. Contour of the slick in Figure 4 after image processing

Table 7. Comparison between observed dimensions and reference data

	Observations of the crews			Reference data		
	Time	Length (km)	Width (km)	Nature	Length (km)	Width (km)
France	9:11 a.m. to 9:49 a.m.	1	0.3	helicopter overflight 9:43 a.m.	1	0.3
Great Britain	9:32 a.m. to 10:20 a.m.	1.54	0.6			
Belgium	. . . . to 10:48 a.m.	1.9	0.5	helicopter overflight 10:52 a.m.	2.1	0.4
Denmark	. . . . to 11:02 a.m.	2.9	0.8			
Netherlands	. . . . to 11:29 a.m.	3	0.2			

Table 8. Percentage coverage and thickness estimation

	Dimensions (km)		Cover	Cover area	Percent area covered with color code							Quantity
	Length	Width	(%)	(km^2)	1	2	3	4	5	6	7	(m^3)
France	1.00	0.3	100	0.3					50	50		3
Great Britain	1.54	0.6	90	0.833	10	10	40			40		5.1
Belgium	1.90	0.5	95	0.905		6	75	4			15	3.62
Denmark	2.90	0.8	95	2.2			10	90				2.1
Netherlands	3	0.2	80	0.48				20		80		12.1

1. See Table 5 for description of numbered color codes

Table 9. Sampling data of heating oil 50/50 absorbed on polypropylene sheets (thickness 8 mm)

Position	Time	Sampling	Weight (g)	Average weight
Point 1	9:37 a.m.	1	4.2	
		2	9.4	
		3	4.0	4.8 g
		4	3.8	
		5	2.7	
Point 2	10:00 a.m.	1	43.0	
		2	14.2	
		3	66.0	28.5 g
		4	8.4	
		5	11.1	
Point 3	10:30 a.m.	1	21.6	
		2	24.2	
		3	17.2	21.1 g
		4	20.0	
		5	22.6	
Point 4	11:00 a.m.	1	17.2	
		2	26.4	
		3	21.0	19.1 g
		4	12.0	

Conclusions

The weather conditions and the roughness of the sea (sea state 5 and 4, the two first days) prevented detection of the spill despite the fact that the rate of release into the sea exceeded the limits of the MARPOL 73–78 Convention regulations (15 or 100 ppm).

Under poor weather conditions, the procedures that are usually recommended, such as detection using SLAR, or low altitude flight and recording with IR/UV sensors, did not permit identification of the polluting ship.

Some differences appear when comparing observed dimensions and reference data (Table 8). The IR sensor is the most accurate for estimates of dimension. The distance on the video screen must be recalculated with those calculations done according to the speed/time parameters.

It appears that the eye is a limited sensor, because of the restricted area of the field of vision and the surveying aircraft's high speed, making evaluation of slick volume with the color code difficult. In this case, using the color code is inoperative if there is no Polaroid photo or video tape to enable us to distinguish the sheens, the colors, and the coverage. Without such graphic documents, it is impossible to calculate the percentage of oil.[2] No crew was equipped with both video and Polaroid cameras, and this has resulted in a lack of precision for the estimations.

This intercalibration operation was also part of a yearly exercise organized under the authority of the Maritime Prefect in Brest, involving vessels and helicopters in charge of simulating a situation resulting from a spill off Lorient in the Bay of Biscay. Ships and helicopters were used to disperse part of the fictitious spill and to recover other parts by concentration of the slick with a boom towed by a couple of vessels and recovery with a trawl. The exercise confirmed that increasing the surface area swept by a recovery device through use of a concentrating boom was an adequate solution (see Castor tests organized by the French Navy in 1985).

It should be mentioned that in each maritime region, the Maritime Prefect is the authority in charge of policy at sea and is in charge of setting in action the Polmar-sea plan. Therefore the exercise was entirely under his control for both the maritime and the aerial surveillance aspects.

Acknowledgments

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