# Bonn Agreement Oil Appearance Code

## BAOAC

# Bonn Agreement Oil Appearance Code

A correlation between the visual appearance and the thickness of oil on the sea

used to estimate spilled oil volume

# Developing the BAOAC

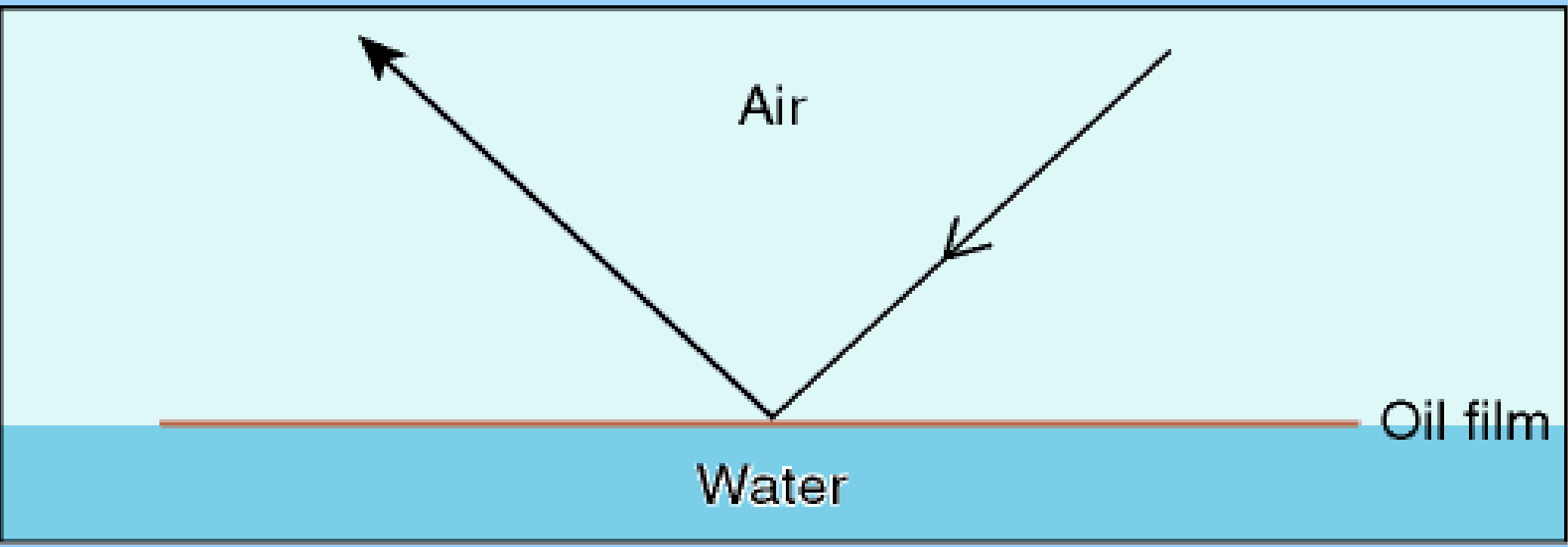
- Literature survey (1997)
  - Who had claimed what and when ? Scientifically justified ?
- Laboratory studies
  - Thin oil films studied under laboratory conditions
- Fjord studies
  - Small-scale outdoor experiments
- Bonnex 2002
  - Full-scale experiments at sea

# The BAOAC

| Code | Appearance | QUANTITY $m^3/ km^2$ | Thickness ($\mu m$) |
|---|---|---|---|
| 1 | Sheen (Silvery / Grey) | 0.04 - 0.3 | 0.04 - 0.3 |
| 2 | Rainbow | 0.30 – 5.0 | 0.3 – 5.0 |
| 3 | Metallic | 5.0 - 50 | 5 - 50 |
| 4 | Discontinuous True Oil Colour | 50 - 200 | 50 - 200 |
| 5 | Continuous True Oil Colour | > 200 | > 200 |

# Observing Oil On The Sea

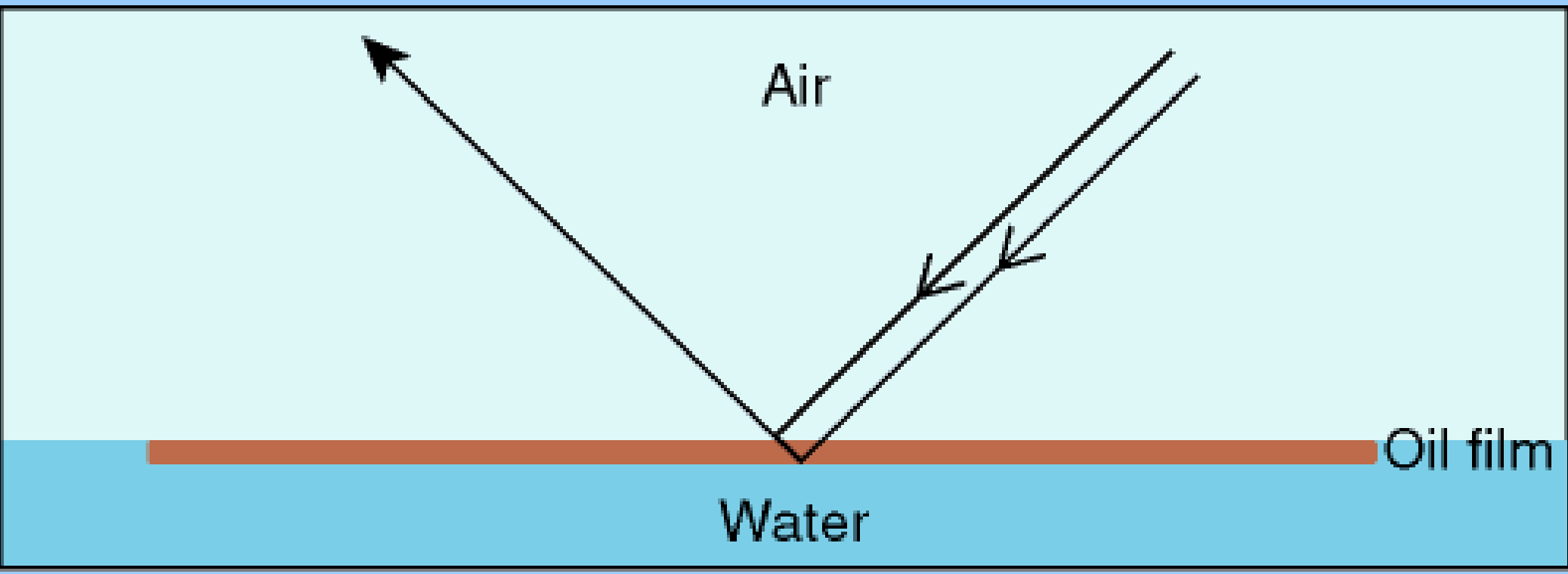
- A combination of reflected and transmitted light is seen when looking at oil on the sea
- With thin layers of oil you see the light reflected from the sea surface, filtered through a layer of oil
- With thick layers of oil you see only the surface of the oil




**Appearance Code 1**

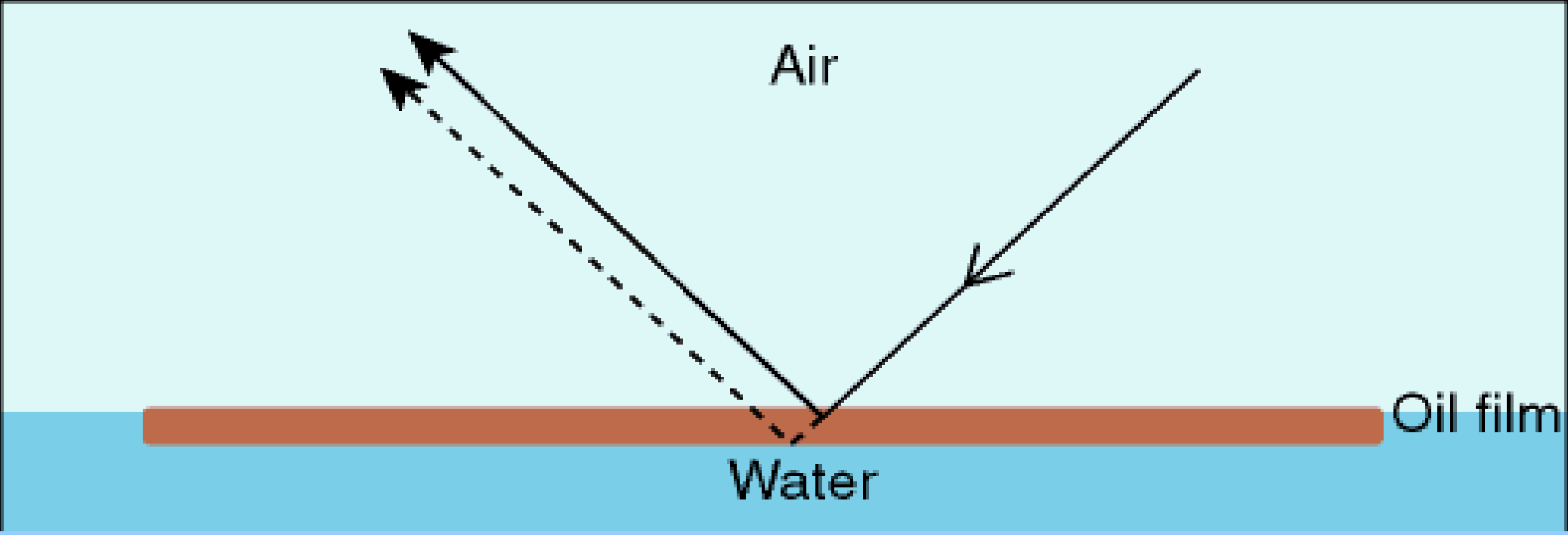
**Sheen (0.04 μm – 0.3 μm)**

The oil layer reflects white light slightly more effectively than the water.




**Appearance Code 2**

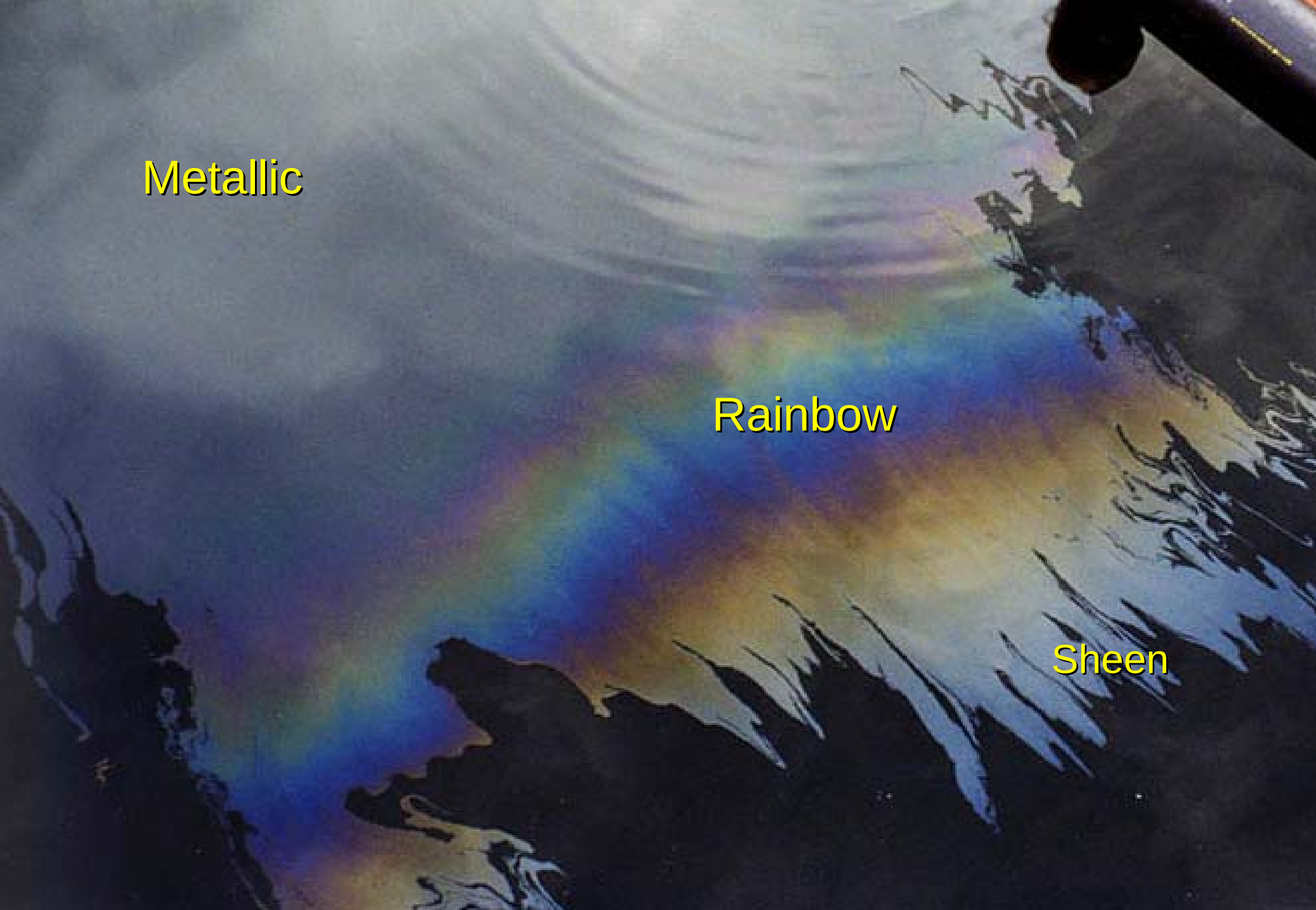
**Rainbow Region (0.3 μm to 5 μm)**
Light reflected from both oil/water surface
(the sea surface) and oil/air surface (the oil surface)



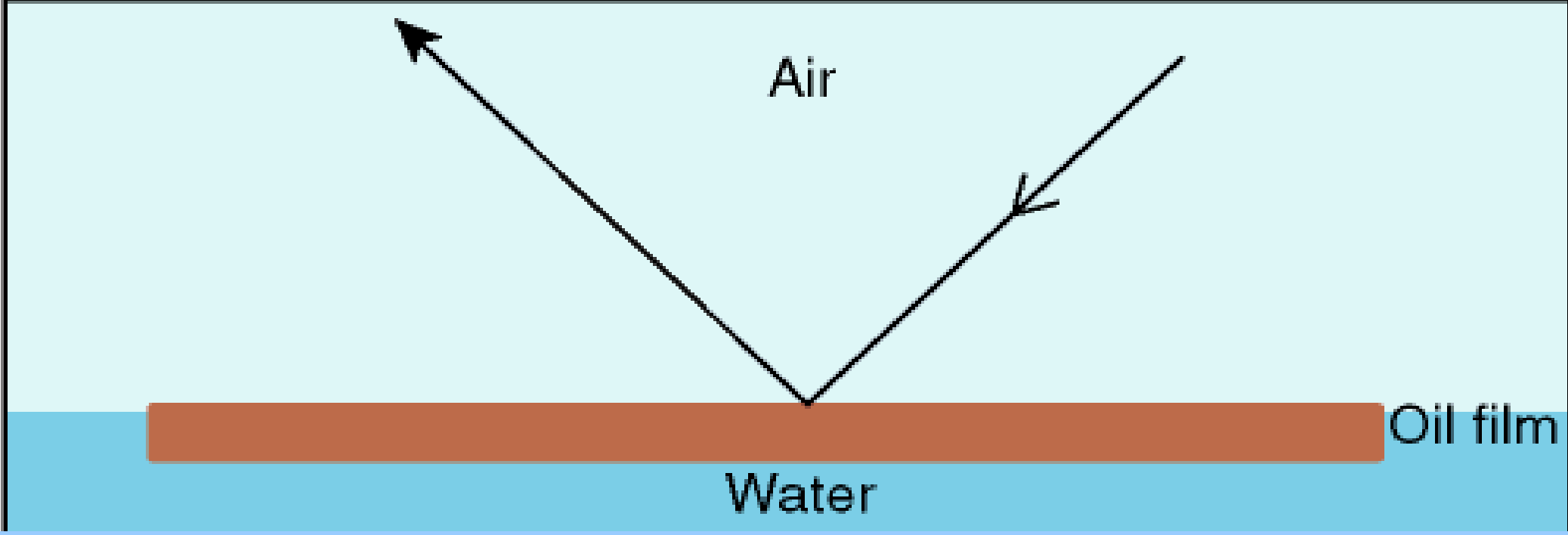

## Appearance Code 3

**Metallic (3 μm to 50μm)**

Majority of light is reflected from oil surface,
but a minority passes through oil film and is reflected from sea surface.


Metallic
Rainbow
Sheen


Sheen
Metallic
Rainbow




## Appearance Codes 4 and 5

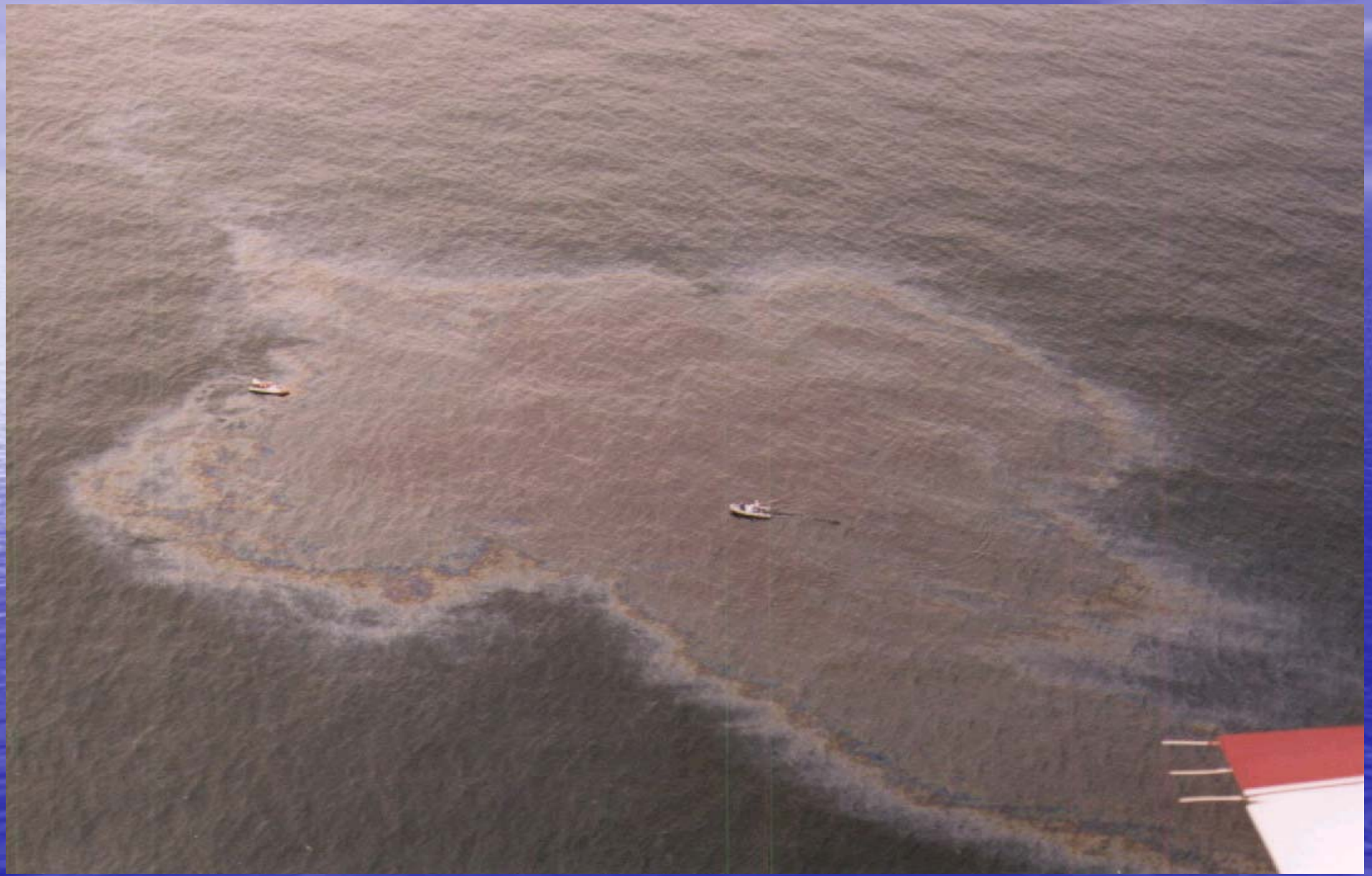
## Discontinuous True Colour and True Colour (50μm - < 200 μm)

Light is being reflected from the oil surface rather than from the sea surface


Discontinuous True Oil Colour
and
True Oil Colour

# The True Colour of Oils

- Crude oils are black or brown
- Diesel fuel is nearly colourless
- Heavy Fuel Oils are black
- The observed colour depends on oil film thickness
  - Optical density of oil
  - Background
  - Viewing angle



# HEAVY FUEL OIL

# THE OIL APPEARANCE CODE

| CODE | APPEARANCE | QUANTITY $m^3$ / $km^2$ | THICKNESS µm |
|---|---|---|---|
| 1 | SHEEN (SILVERY / GREY) | 0.04 - 0.3 | 0.04 – 0.3 |
| 2 | RAINBOW | 0.3 – 5.0 | 0.3 – 5.0 |
| 3 | METALLIC | 5.0 – 50 | 5 – 50 |
| 4 | DISCONTINUOUS TRUE OIL COLOUR | 50 – 200 | 50 – 200 |
| 5 | TRUE COLOUR | 200 - > 200 | 200 - > 200 |

# Appearance Description

| | |
|---|---|
| SHEEN: | SILVERY / GREY – ALL OILS WILL APPEAR THE SAME |
| RAINBOW: | RANGE OF COLOURS – ALL OILS WILL APPEAR THE SAME |
| METALLIC: | A HOMOGENEOUS COLOUR – DEPENDENT ON THE LIGHT AND SKY CONDITIONS – A BLUE SKY WILL BE MIRRORED IN THE OIL |
| DISCONTINUOUS TRUE COLOUR: | THE BROKEN NATURE OF THE COLOUR, DUE TO THINNER AREAS WITHIN THE SLICK IS DESCRIBED AS DISCONTINUOUS. THE TRUE COLOUR OF THE OIL WILL GRADUALLY DOMINATE. |
| TRUE COLOUR: | TRUE COLOUR IS OIL SPECIFIC |

# “Metallic” a mirror to the sky

Oil layers that look metallic reflect the colour of the sky, but with some element of oil colour

# Using the BAOAC to obtain spilled oil volume estimates

1. Estimate slick length
2. Estimate slick width
3. Estimate oil coverage as percentage
4. Calculate total slick area
5. Estimate proportions of different BAOAC Codes
6. Calculate spilled oil volumes (minimum and maximum) in each Code area
7. Calculate minimum and maximum spilled oil volume

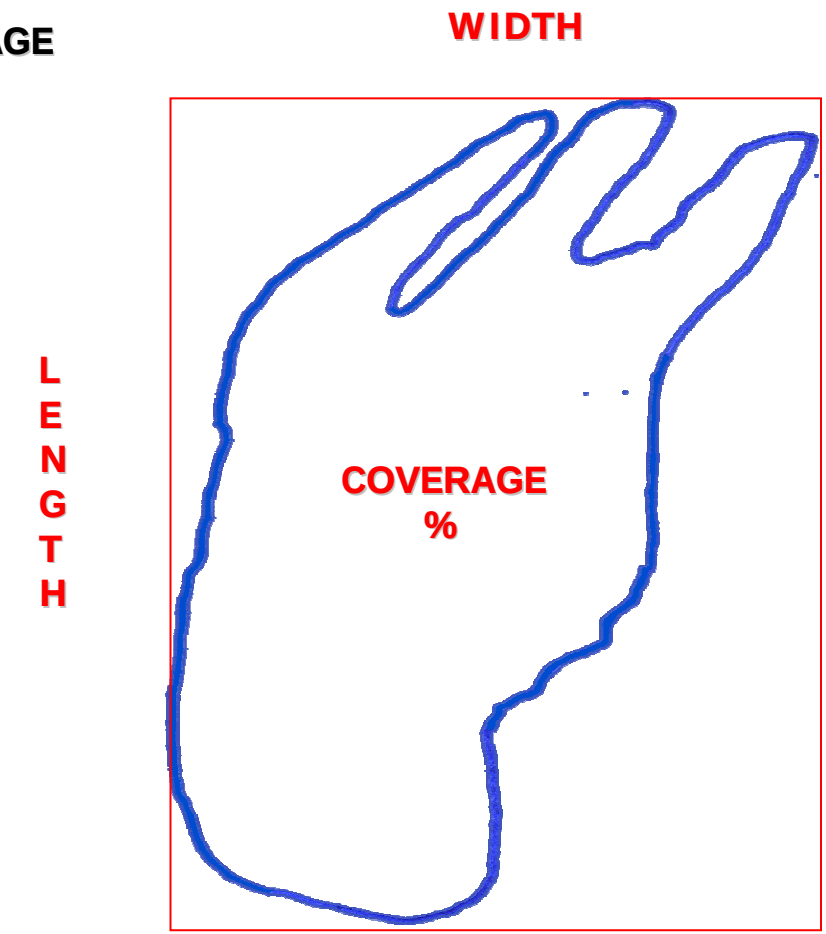
# AREA MEASUREMENT

## VISUAL OBSERVATION / MEASUREMENT OF SLAR IMAGE

1. LENGTH X WIDTH = AREA OF 'IMAGINARY' RECTANGLE

2. ESTIMATED AREA OF 'IMARGINARY' COVERED WITH OIL AS A PERCENTAGE.

3. CALCULATE THE AREA COVERED WITH OIL
   LENGTH X WIDTH X COVERAGE % = AREA



# OILED AREA MEASUREMENT

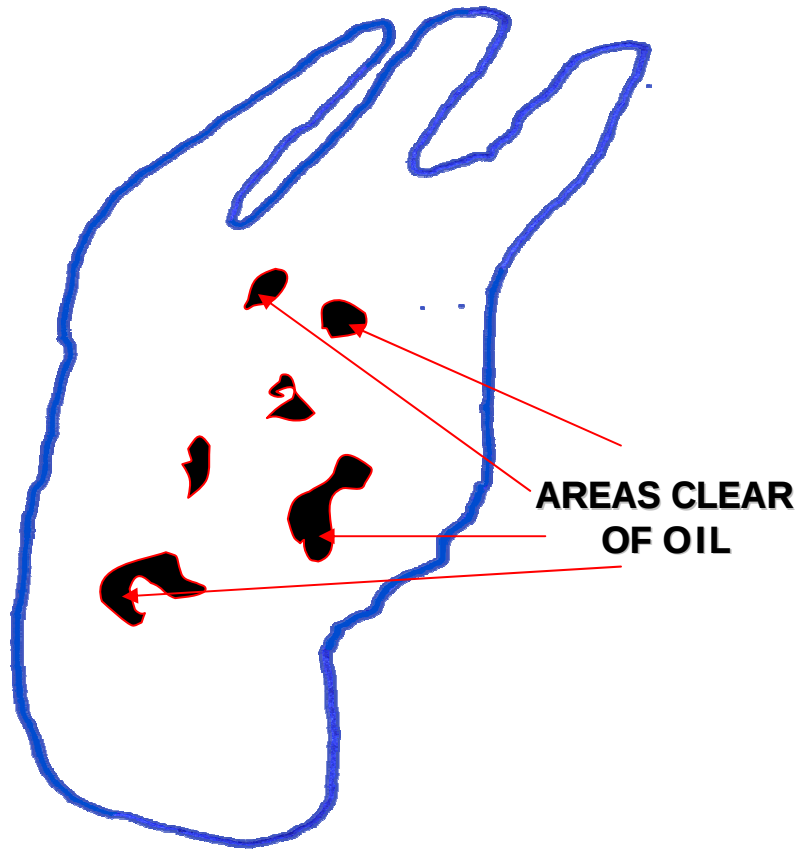
## AREA ADJUSTMENT (CLEAR WATER)

**UV / VISUAL ASSESSMENT**

**(AREAS OF CLEAR WATER WITHIN THE OIL**

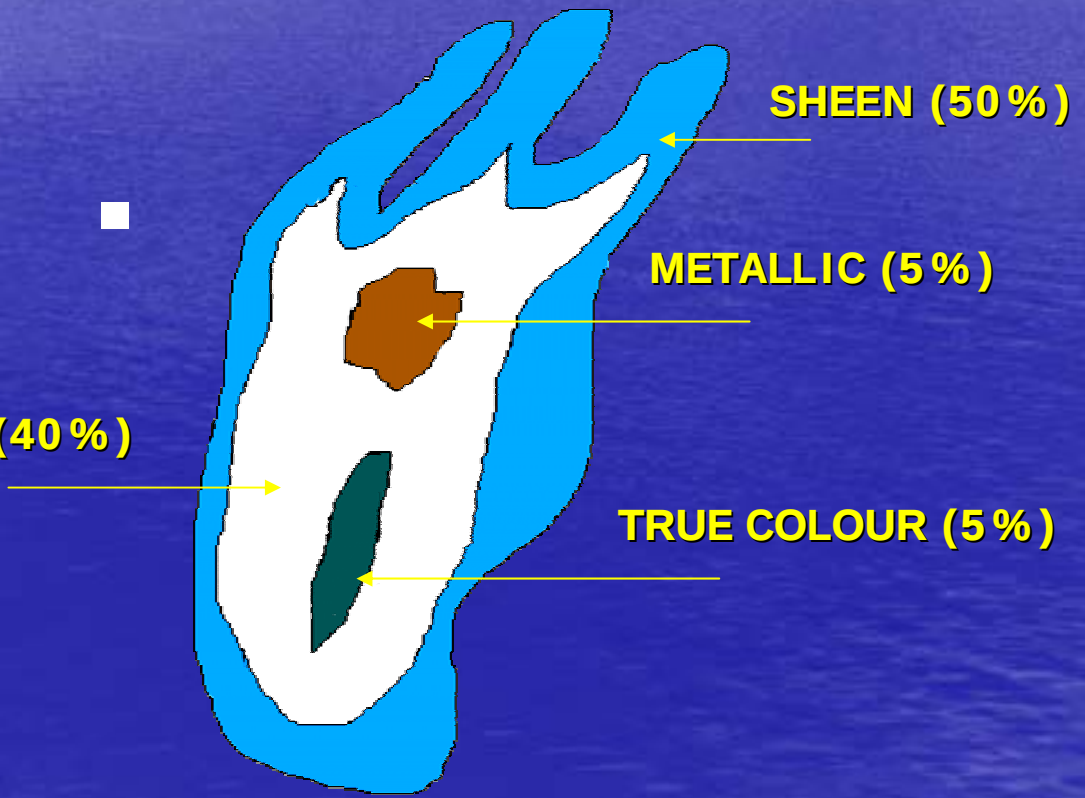
**EXPRESSED AS A PERCENTAGE %)**

**AREA X ADJUSTMENT % = OILED AREA**



# PERCENTAGE OF OILED AREA COVERED BY APPEARANCE

VISUAL ASSESSMENT



# VOLUME ESTIMATION

## MINIMUM VOLUME CALCULATION

1. LENGTH X WIDTH = RECTANGLE AREA
2. RECTANGLE AREA X PERCENTAGE % COVERAGE = AREA
3. AREA X 'CLEAR WATER' ADJUSTMENT % = OILED AREA
4. OILED AREA X INDIVIDUAL APPEARANCE AREA (EXPRESSED AS A PERCENTAGE OF THE OILED AREA) = AREA OF OIL APPEARANCE
5. AREA OF OIL APPEARANCE X MINIMUM THICKNESS = MINIMUM VOLUME FOR THAT OIL APPEARANCE
6. AS PARA 5 ABOVE FOR EACH APPEARANCE (MINIMUM VOLUME)
7. ADD UP ALL THE MAXIMUM VOLUMES FOR ALL THE OIL APPEARANCES TO FIND THE 'OVERALL' MINIMUM VOLUME.

# VOLUME ESTIMATION

MIMIMUM VOLUME CALCULATION EXAMPLE

1. 12 KM X 2 KM = 24 $KM^2$
   (LENGTH X WIDTH = RECTANGLE AREA)

2. 24$KM^2$ X 50 % = 12 $KM^2$
   (RECTANGLE AREA X PERCENTAGE % COVERAGE = AREA (OR POLYGON)

3. 12 $KM^2$ X 90 % = 10.8 $KM^2$
   (AREA X 'CLEAR WATER' ADJUSTMENT % = OILED AREA)

4. 10.8 $KM^2$ X 50 % (SHEEN) = 5.4 $KM^2$
   (OILED AREA X INDIVIDUAL APPEARANCE AREA (EXPRESSED AS A PERCENTAGE OF THE OILED AREA) = AREA OF OIL APPEARANCE)

5. 5.4 $KM^2$ X 0.04um (MIMIMUM THICKNESS FOR SHEEN) = 0.216 $m^3$
   (AREA OF OIL APPEARANCE X MINIMUM THICKNESS = MINIMUM VOLUME FOR THAT OIL APPEARANCE)

6. AS PARA 5 ABOVE FOR EACH APPEARANCE (MINIMUM VOLUME)

7. ADD UP ALL THE MINIMUM VOLUMES FOR ALL THE OIL APPEARANCES TO FIND THE 'OVERALL' MINIMUM VOLUME.

# VOLUME ESTIMATION

MAXIMUM VOLUME CALCULATION

1. LENGTH X WIDTH = RECTANGLE AREA

2. RECTANGLE AREA X PERCENTAGE % COVERAGE = OUTSIDE AREA

3. OUTSIDE AREA X 'CLEAR WATER' ADJUSTMENT % = OILED AREA

4. OILED AREA X INDIVIDUAL APPEARANCE AREA (EXPRESSED AS A PERCENTAGE OF THE OILED AREA) = AREA OF OIL APPEARANCE

5. AREA OF OIL APPEARANCE X MAXIMUM THICKNESS = MAXIMUM VOLUME FOR THAT OIL APPEARANCE

6. AS PARA 5 ABOVE FOR EACH APPEARANCE (MAXIMUM VOLUME)

7. ADD UP ALL THE MAXIMUM VOLUMES FOR ALL THE OIL APPEARANCES TO FIND THE 'OVERALL' MAXIMUM VOLUME.

# VOLUME ESTIMATION

MAXIMUM VOLUME CALCULATION EXAMPLE

1. 12 KM X 2 KM = 24 $KM^2$
   (LENGTH X WIDTH = RECTANGLE AREA)

2. 24$KM^2$ X 50 % = 12 $KM^2$
   (RECTANGLE AREA X PERCENTAGE % COVERAGE = AREA (OR POLYGON)

3. 12 $KM^2$ X 90 % = 10.8 $KM^2$
   (AREA X 'CLEAR WATER' ADJUSTMENT % = OILED AREA)

4. 10.8 $KM^2$ X 50 % (SHEEN) = 5.4 $KM^2$
   (OILED AREA X INDIVIDUAL APPEARANCE AREA (EXPRESSED AS A PERCENTAGE OF THE OILED AREA) = AREA OF OIL APPEARANCE)

5. 5.4 $KM^2$ X 0.3um (MAXIMUM THICKNESS FOR SHEEN) = 1.62 $m^3$
   (AREA OF OIL APPEARANCE X MAXIMUM THICKNESS = MAXIMUM VOLUME FOR THAT OIL APPEARANCE)

6. AS PARA 5 ABOVE FOR EACH APPEARANCE (MAXIMUM VOLUME)

7. ADD UP ALL THE MAXIMUMMUM VOLUMES FOR ALL THE OIL APPEARANCES TO FIND THE 'OVERALL' MAXIMUM VOLUME.

# AREA CALCULATION

| DIMENSIONS | | AREA | ASSESSED COVERAGE PERCENTAGE | POLYGON OR CALCULATED AREA | ASSESSED ADJUSTMENT PERCENTAGE | *OILED AREA* |
|---|---|---|---|---|---|---|
| LENGTH | WIDTH | | | | | |
| 12 km | 2 km | 24 $km^2$ | 50 % | 12 $km^2$ | 90 % | 10.8 $km^2$ |

# ‘OIL’ APPEARANCE / VOLUME CALCULATION

| OIL APPEARANCE DESCRIPTION | % OF OILED AREA COVERED BY APPEARANCE | OILED AREA | AREA OF OIL APPEARANCE | MINIMUM THICKNESS | MINIMUM VOLUME | MAXIMUM THICKNESS | MAXIMUM VOLUME |
|---|---|---|---|---|---|---|---|
| SHEEN | 50 % | 10.8 $km^2$ | 5.4 $km^2$ | 0.04 µm | 0.216 $m^3$ | 0.30 µm | 1.62$m^3$ |
| RAINBOW | 30 % | 10.8 $km^2$ | 3.24 $km^2$ | 0.30 µm | 0.972 $m^3$ | 5.00 µm | 16.2$m^3$ |
| METALLIC | 15 % | 10.8 $km^2$ | 1.62 $km^2$ | 5.00 µm | 8.1$m^3$ | 50.0 µm | 81$m^3$ |
| DIS. TRUE COLOUR | - % | 10.8 $km^2$ | - | 50.0 µm | - | 200 µm | - |
| TRUE COLOUR | 5 % | 10.8 $km^2$ | 0.54 $km^2$ | 200 µm | 108$m^3$ | > 200 µm | >108$m^3$ |
| OTHER | - % | 10.8 $km^2$ | | | | | |
| TOTAL | 100 % | | | | | | |

| TOTAL MINIMUM ‘OIL’ VOLUME | 117.288 $m^3$ |
|---|---|

| TOTAL MAXIMUM ‘OIL’ VOLUME | > 206.82 $m^3$ |
|---|---|