

A photograph of a large oil spill in the ocean. The water is dark blue with a thick, dark brown oil slick floating on the surface. The oil is breaking apart into smaller droplets and splashes, creating a dynamic and polluted scene. The text "Oil Pollution" is overlaid in white, bold, sans-serif font in the center of the image.

Oil Pollution

Coastal & Marine Science

Pollution

- Limited capacity to assimilate waste
- 80% marine pollution comes from land-based activities (WWF, 2016)
- Chemical and toxic
- Nutrient
- Noise
- Thermal
- Litter - 718 items of rubbish per 100m of beach (MCS, 2017)
- 12m tonnes plastic entering ocean pa. (MCS, 2018)

MCS Beach Clean 2019



- The Great British Beach Clean 2019 saw 437 beach cleans and litter survey take place with over 10,800 volunteers getting involved to remove 10,833 kg of litter from the UK's beaches...That's almost 11 tonnes of litter in one weekend alone.

The Clean Seas Wales Partnership's action plan (O'Neill, 2020)

- To tackle marine litter
- Joint venture between MCS, Keep Wales Tidy and environmental consultants, Eunomia
- Part funded by the European Maritime & Fisheries Fund
- Source-pathway-sink and tackling the problem locally
- Litter strategy workshops
- Beach Clean data informs the strategy – first phase of the project (evidence gathering) is complete
- Aim to work with tourism businesses, coastal attractions and schools

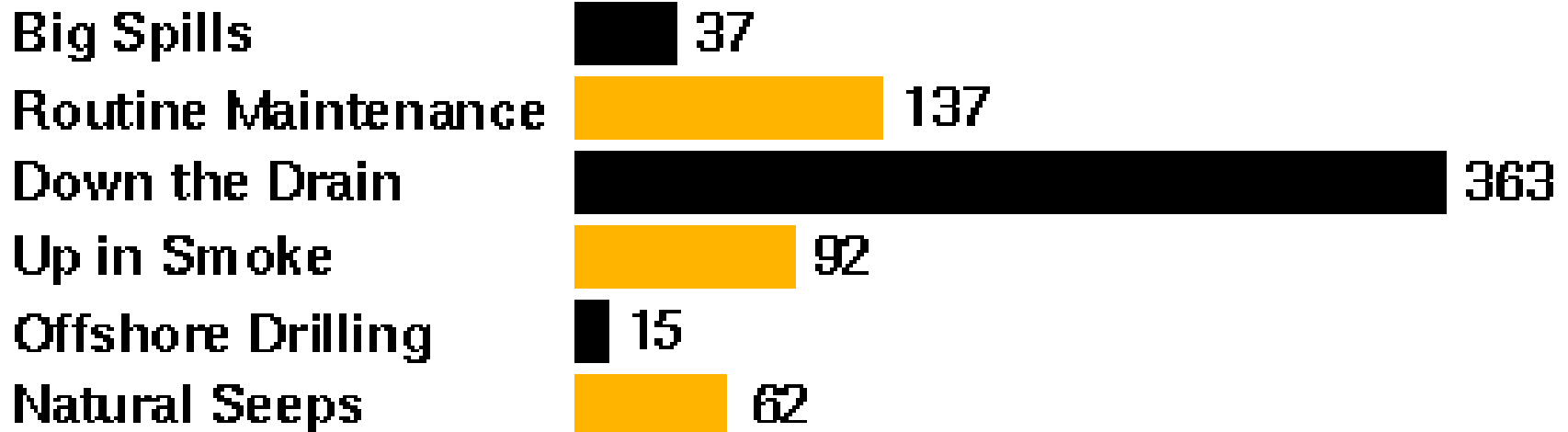
Anthropogenic Threats

1. Shipping
2. Fisheries
3. Run-off and discharges from land
4. Dumping materials at sea
5. Offshore minerals – BP: Deepwater Horizon!
6. Coastal pressures
7. Atmospheric effects

Pollution

- Limited capacity to assimilate waste
- Chemical and toxic – Sea Empress case study & Deepwater Horizon
- Nutrient
- Noise
- Litter – the Plastic Whale
- Thermal

Oil Pollution



(Million gallons per year worldwide
EPA, 2002)

- Road runoff from a city of 5 million could contain as much oil as one large tanker spill (National Research Council, 1985).
- Ships routinely discharge between 70 and 210 million gallons of oil at sea each year (Lee, 2012) <http://www.marinedefenders.com/video/>

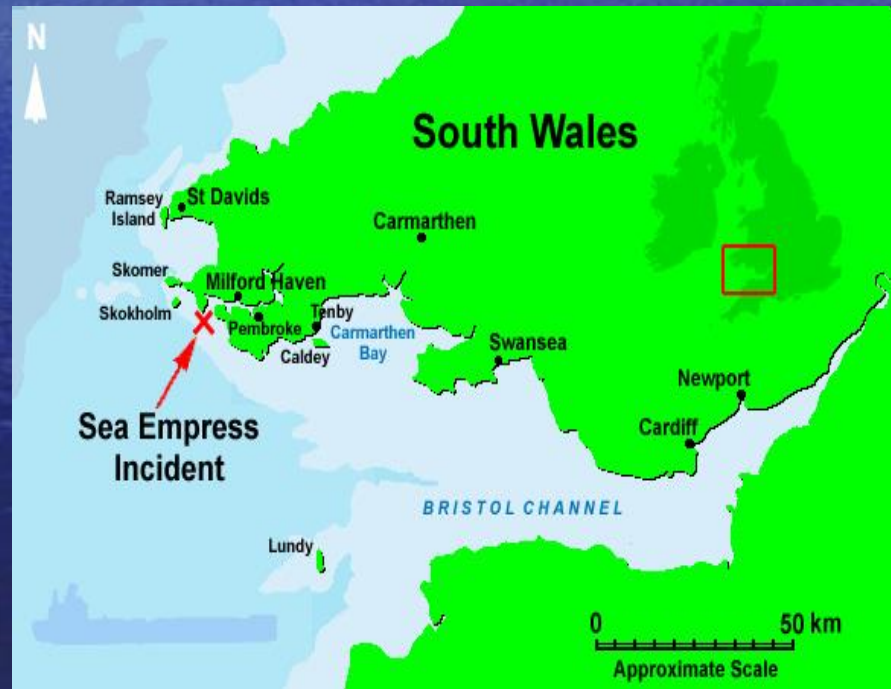
Oil Pollution

- ❖ Effects of spill:
 - ❖ Currents and wind
 - ❖ Amount spilled
 - ❖ Chemical properties of oil
 - ❖ Salinity
 - ❖ Water temperature
 - ❖ Type and slope of shoreline



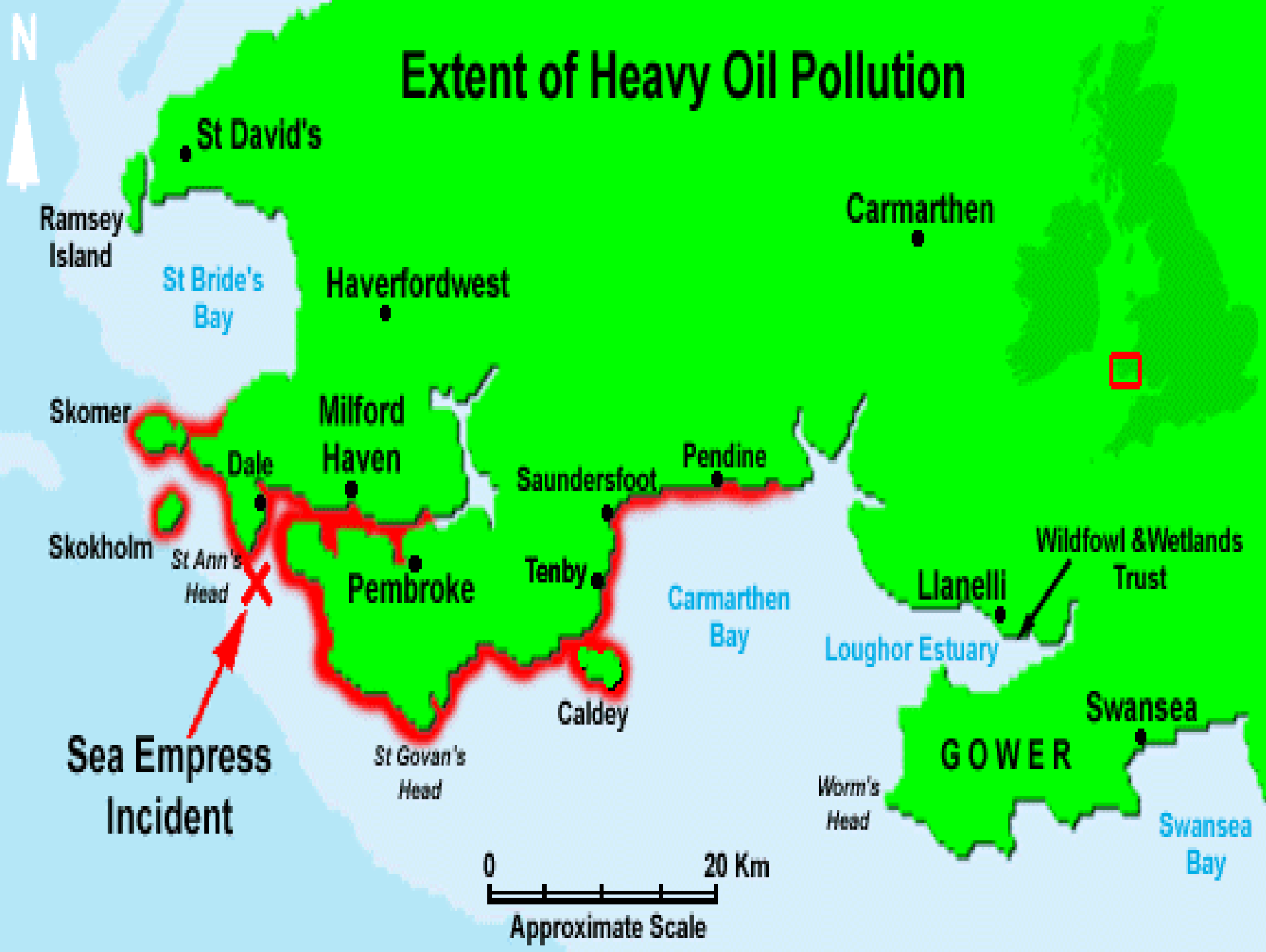
Sea Empress

- 72,000 tonnes crude oil
- Wave exposed shores cleansed quickly
- Shingle, sands and mud persisted
- Shore seaweeds and invertebrates killed in large numbers
- Autumn storms buried oil



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Extent of Heavy Oil Pollution





- **Pilot error & miscalculation tidal stream**
- **Sea Empress – 7 day period leaking oil**
- **72,000 tonnes light crude oil**
- **250 tonnes heavy fuel oil (power ship's engine)
plus a further 230 tonnes once towed to jetty**



- 50 vessels
- 19 aircraft
- 25 organisations
- 25 staff on vessel; 950 on shoreline



40% evaporated

50% dispersed in water column

1-2% collected from recovery vessels

8% came ashore

200km coastline affected

(SEEEEC, 1999)

- Absorbent scrubbing
- High pressure hosing



Clean-up

- Aircraft – spray chemical dispersants
- Booms – protect ecologically sensitive areas
- Hand scrapers
- Mechanical diggers & bowzers
- Inaccessible shores – natural cleansing
- Total cost of cleanup - £60m





- **Factors that reduced impact:**

- **Time of year**
- **Wind direction**
- **Type of oil spilled**
- **Success of chemical dispersants**

CASUALTIES



- **7,000 oiled birds washed ashore**
- **60% survived cleaning – variable success rate post release**
- **90% of birds were common scoter, guillemot or razorbill**
- **Diver species but few gulls**
- **3,500 common scoter – 10,000 fewer in 1997**

- Feather damage
- Breakdown of insulation – hypothermia
- Skin irritations
- Ingestion



Without use of dispersants, bird mortalities would have been higher



- **90% mortality in West Angle Bay**
- **Topshells and periwinkles**
- **Overgrowth of algae**
- **Reduction of barnacle larvae**
- **Polychaete worms**





Cushion Star *Asterina phylactica*



West Angle Bay, Pembrokeshire

Mammals appeared not to be affected

Short-term – eye or respiratory tract irritation

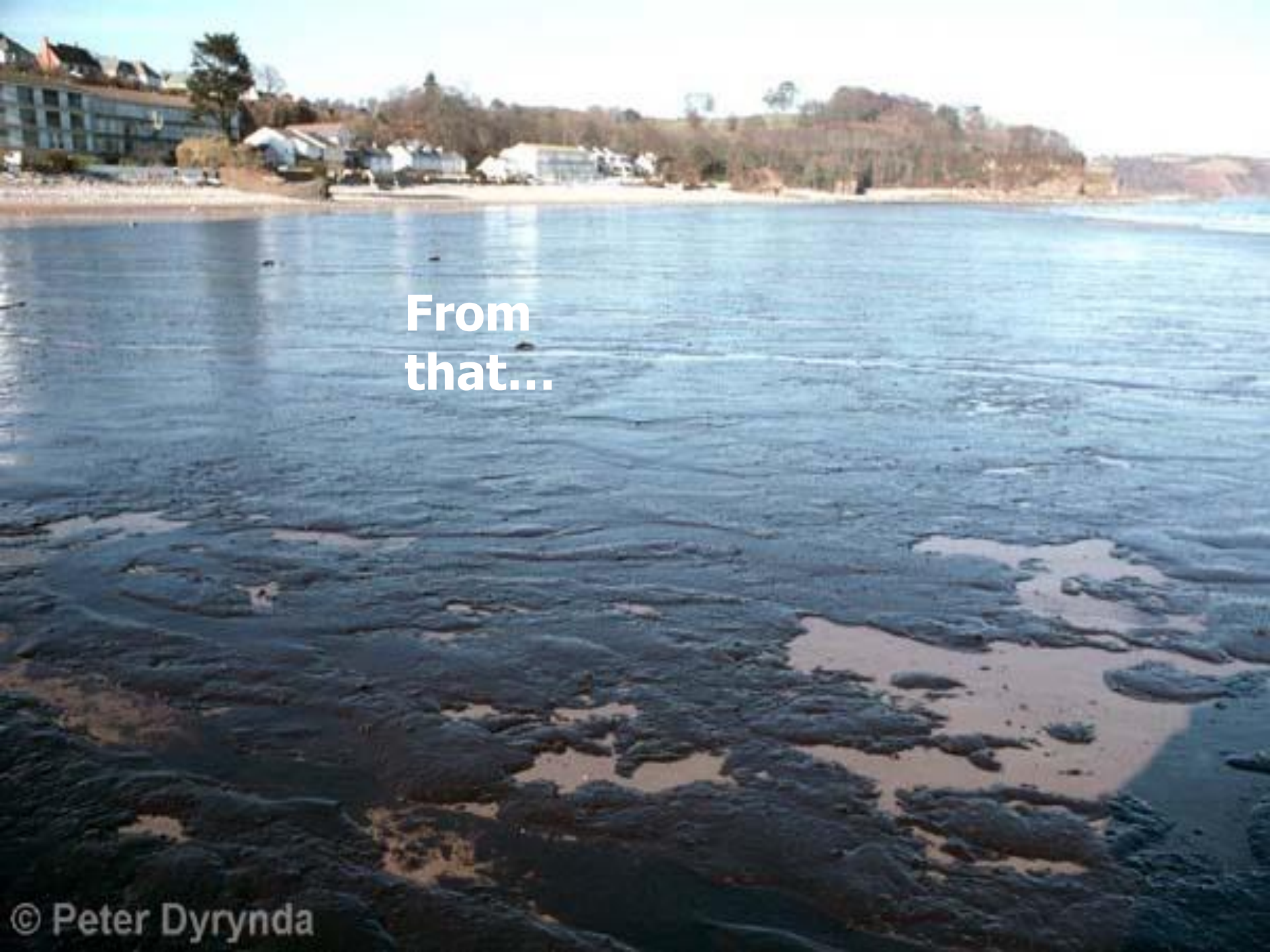
Long-term?



- **Ban on collection edible plants & shellfish – St David's Head – Port Eynon**
- **Fishing for salmon & trout in rivers**
- **Samples analysed**



- **Catch rate in Tywi of sea trout ↓ 1996**
- **Bivalve molluscs**
- **Absence of amphipods**



**From
that...**

A wide-angle photograph of a coastal scene. In the foreground, a grassy cliff edge with tall, dry grasses is visible on the right. Below it is a vast, flat, sandy beach. The ocean is on the left, with several waves breaking onto the shore, creating white foam. In the distance, a rugged coastline with cliffs and hills is visible under a cloudy sky. A single dark rock sits on the sand near the water's edge.

**To this in just 6
months.....**

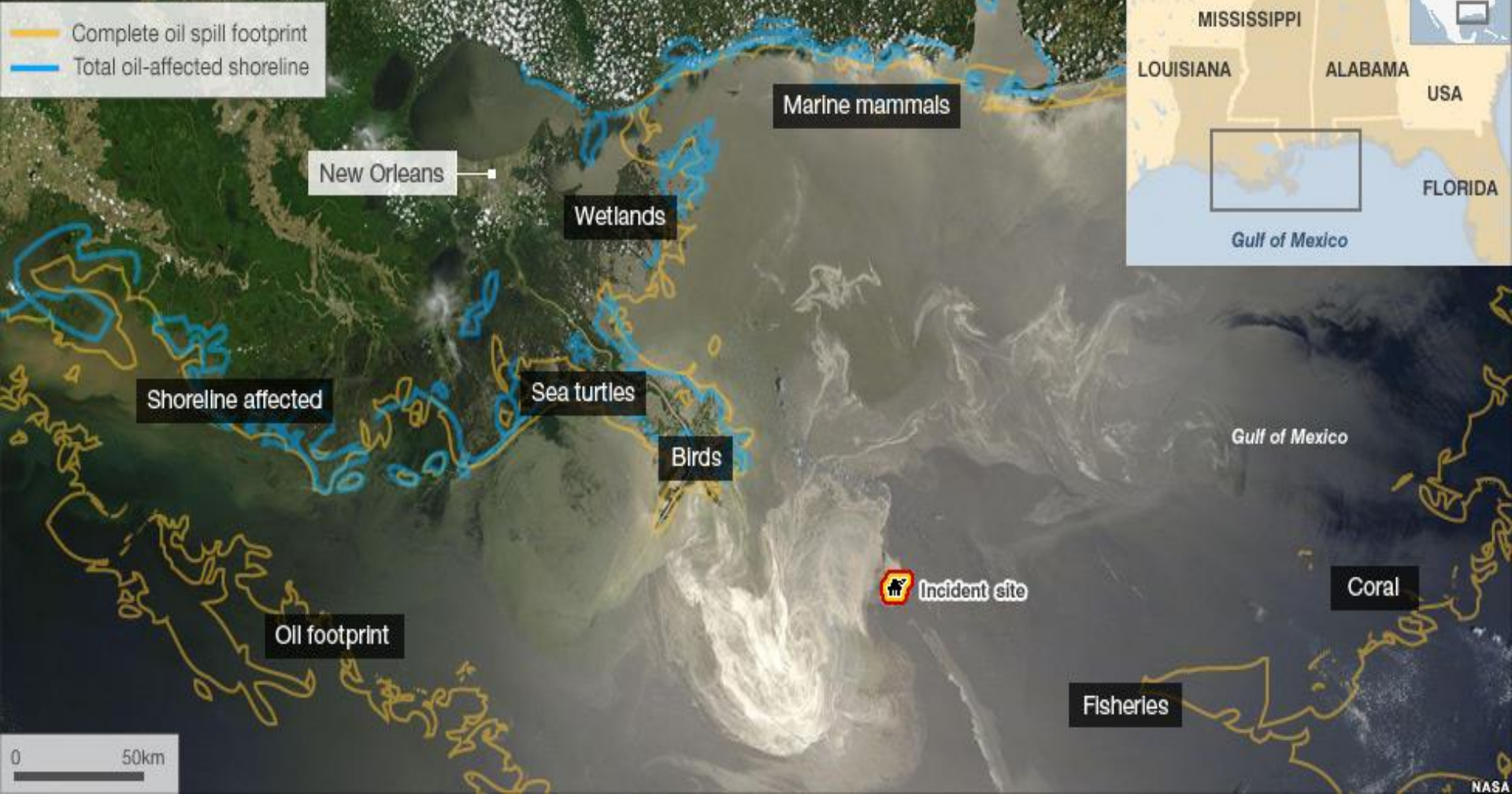
Cost of Clean-up

- Sea Empress - £60 million – 70,000 gallons
- 5 years to completely clean
- C.f. Exxon Valdez - \$2.5bn – 10 mill gallons crude oil
- Deepwater Horizon - \$62bn - 205 mill gallons

Deepwater Horizon Spill: April 2010

- Explosion killed 11 people
- 4.9 million barrels of oil discharged
- 10 years on, what impact on marine wildlife and coastal communities?



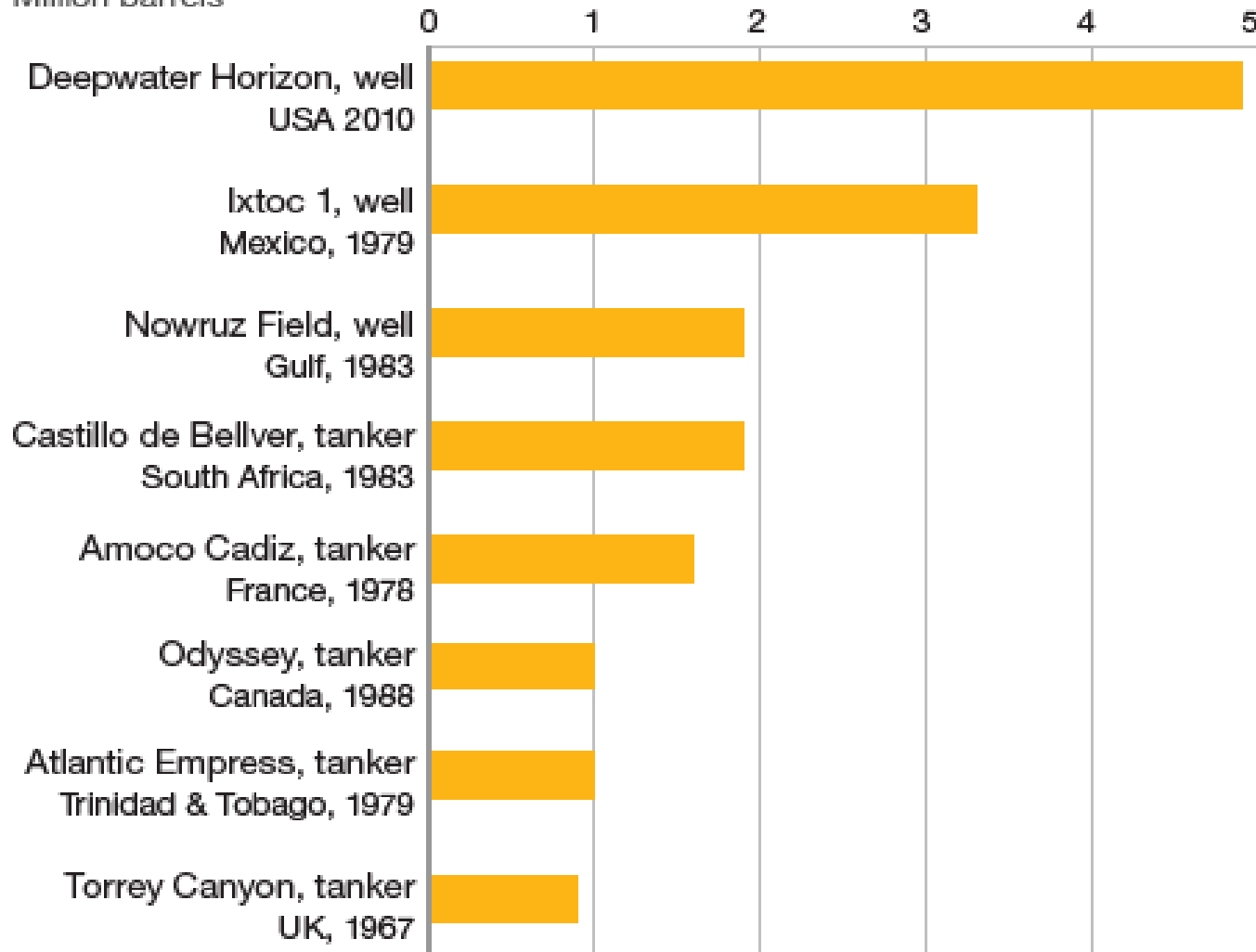


- Spill covered thousands of square miles
- Well (1.5km below surface) released crude oil for 3 months
- Of the 4.9 million barrels, 800,000 barrels recovered; 265,000 were burned off; 1.8 million gallons dispersants used

Major accidental oil spills into the ocean

- Well 50 miles offshore – management was unprecedented
- Fine in region of \$19bn – EPA fine
- \$22 bn – compensation fund & money for marine research

Million barrels



Largest recent US oil spill

Exxon Valdez
USA, 1989



Source: Oil Spill Intelligence Report

Ecological Damage

- According to the Federal Government:
- 6,104 birds
- 609 sea turtles
- 100 mammals
- Very conservative estimates



Birds

- 120 species affected
- > 50% died once oiled
- Brown Pelican *Pelecanus occidentalis* most badly affected – feeding strategy
- Flooding farmland lessened the impact
- Oil came ashore in June 2010 – favourable conditions initially
- 2,500 miles of protective booms



Marine Mammals

- Increase in Bottlenose dolphin *Tursiops truncatus* mortality
- First calving season post spill-calf mortality increased by 50%
- Likely to be under reported
- Affected at sea – absorption, inhalation and ingestion
- Some sperm whales *Physeter macrocephalus* relocation recorded (Ackleh *et al.*, 2012)





Turtles don't instinctively avoid oil:

- Effects include:
 - Burning in mucous membranes of the eyes and mouth
 - Irritation or inflammation of the skin
 - Gastrointestinal inflammation, ulcers, bleeding, poor digestion
 - Respiratory irritation, inflammation, pneumonia, emphysema
 - Organ damage, suppression of the immune system, reproductive failure
- Dispersants and 'burn boxes' impacts
- Hatchlings at risk

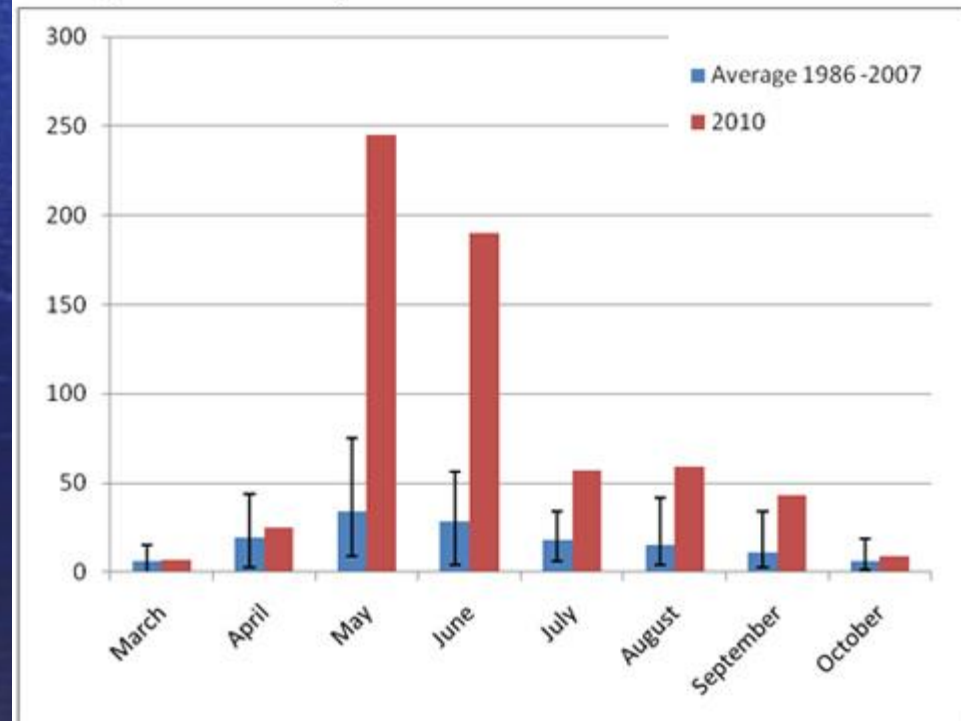


Sea Turtles

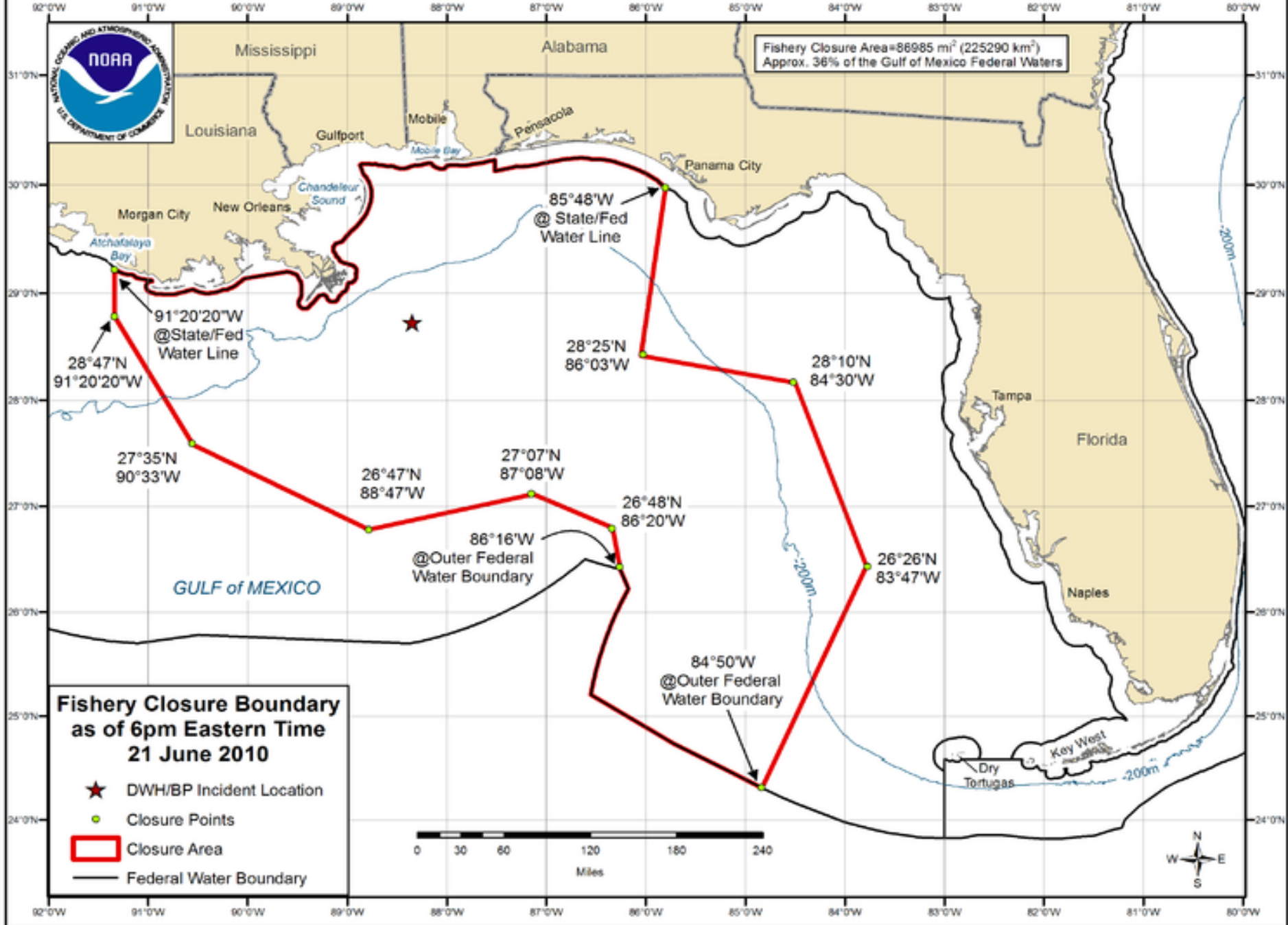
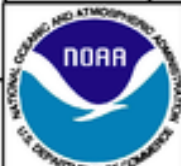
- 5 species affected: Green *Chelonia mydas*, Loggerhead *Caretta caretta*, Kemp's ridley *Lepidochelys kempii*, Leatherback *Dermochelys coriacea*, Hawkesbill *Eretmochelys imbricata*
- 1066 collected from spill zone – 450 oiled; 600 mortalities
- Kemp's Ridley most badly affected (n=approx 500)
- 6 times more average monthly strandings following spill
- Already under threat in this area – habitat degradation & bycatch
- Swift action taken – 25,000 eggs transported to Florida's Atlantic coast



Monthly Sea Turtle Strandings In 2010 Compared To Long-term Averages



Note: The black error bars represent the maximum and minimum number of strandings over the 22 years of records.



Fisheries



- Large parts of the Gulf closed to fishing
- One year on , a 400% increase in sharks and a 200% increase in fin fish recorded
- 20% juvenile bluefin tuna killed
- Deformed shrimp; tumours; 75% fewer crabs caught; 70% decline in shrimp numbers (AP, 2012)
- Long-term disruption unknown
- Livelihoods of fishing communities affected substantially

Corals



- Northernmost examples of tropical reef
- Impact unclear to-date
- Where some completely oil-covered = mortality – corals & sea fans
- Of 54 corals sites in area, 43 were surveyed – 86% were severely damaged
- Benthic areas smothered:
 - oil 10cm thick covering seabed in places
 - Filter-feeding organisms, invertebrate worms
 - detrital feeders - sea cucumbers, brittle stars

Wetlands

- Swift action and favourable conditions minimised damage
- Important migratory environment
- Some marshlands affected however
- In places, grasses and marshes were weakened by spill → erosion & subsidence
- Area further impacted by Hurricane Isaac



Delta Bulrush *Schoenoplectus deltarum*

- Detoxifying properties
- Relay oxygen to underwater micro-organisms needed to break down the oil

“Bulrushes are also more tolerant of oil than many other marsh plants. This suggests that the delta bulrush will persist regardless of the oil and continue to stabilize the marshes in the delta” (Schuyler, 2010:1)



Economic cost to region?

- Emergency shrimping season opened 29th April 2010
- Estimate cost to fishing industry - \$2.5bn
- Estimated loss to tourism industry - \$23bn
- April 2011 most fishing grounds re-opened
- Oyster beds still remain closed
- Early estimates – loss of 22,000 jobs in region
- By Feb 2012, unemployment rate Louisiana 7% (Foden, 2012)

Did the Authorities choose the right strategy?



- **“Gulf of Mexico deep-cleaned itself” (Palmer, 2011)**
- **Explosion of oil-digesting micro-organisms (Schleifstein, 2013)**
- **A year after capping, levels of alkane molecules (from oil) returned to background levels**
- **Chemical dispersants did more harm than good!**
- **Dispersants 52 x more toxic**
- **Dispersants also cause sediment absorption**





The State of the Gulf: BP Oil Spill Beach Pollution Report for Monday, February 24, 2014

"Since the end of BP's official cleanup efforts in June 2013, over 34,316 tar balls and 501 pounds of Deepwater Horizon oil have been documented and removed from Florida's beaches alone " (Young, 2014:1)

"These hardened balls are often filled with deadly, flesh-eating bacteria. Do not handle without protective gloves" ... *vibrio vulnificus* (Young, 2014:1)



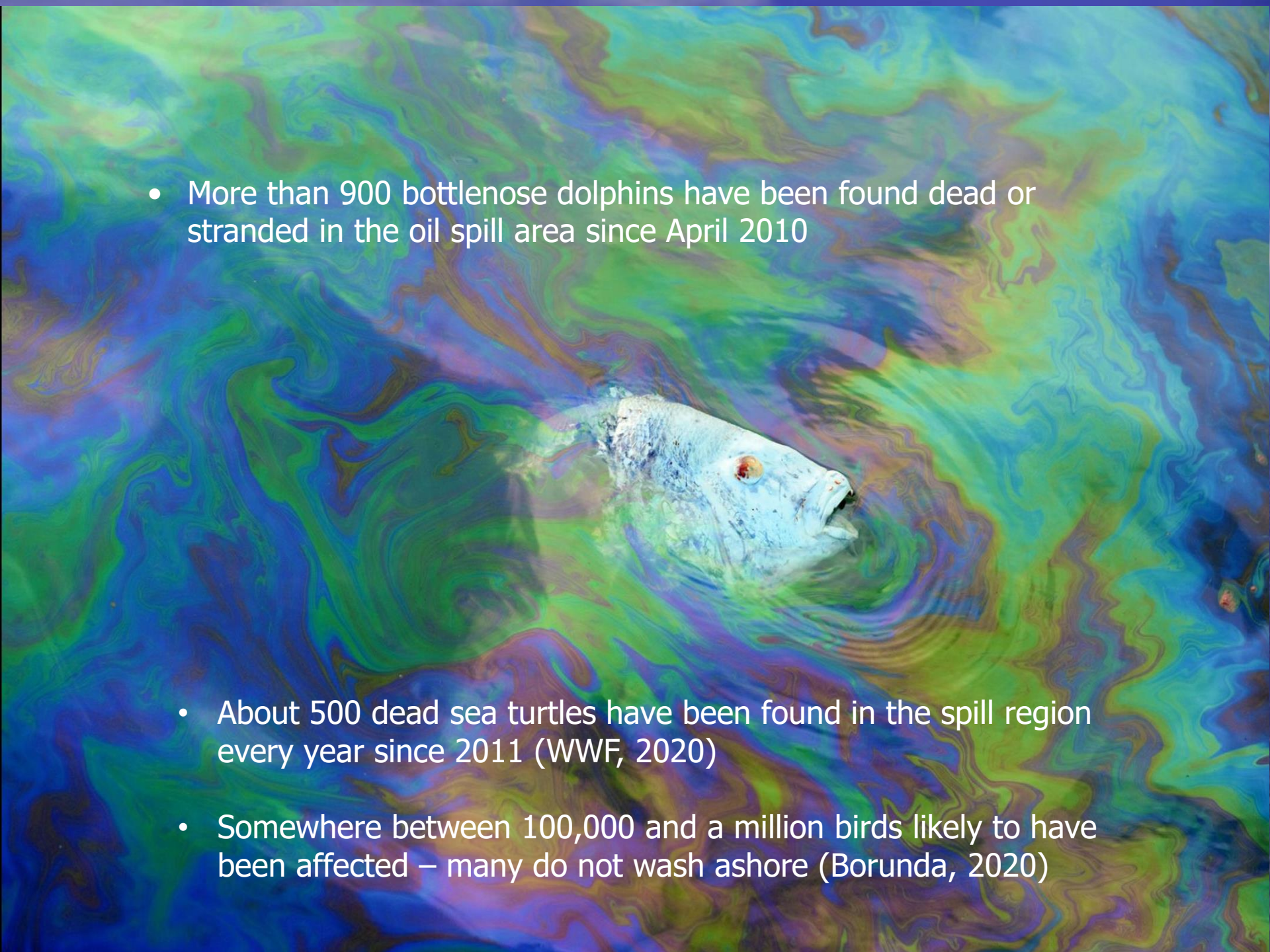
- Tar acts as a magnet for the bacteria.
- Humans affected through eating raw oysters/shellfish or through the skin – cuts.
- 30 deaths in Florida in 2013



“Whilst the Deepwater Horizon oil spill has undoubtedly caused problems, the one-off event looks modest by comparison to annual pollution from agricultural fertilisers. The chemical pollution derived mostly from fertilisers that run-off into the mouth of the Mississippi Delta into the Gulf of Mexico has created a dead-zone. Exceeding 21,000 km², it is one of the largest dead zones to be found” (Foden, 2012:1)

20 Years on

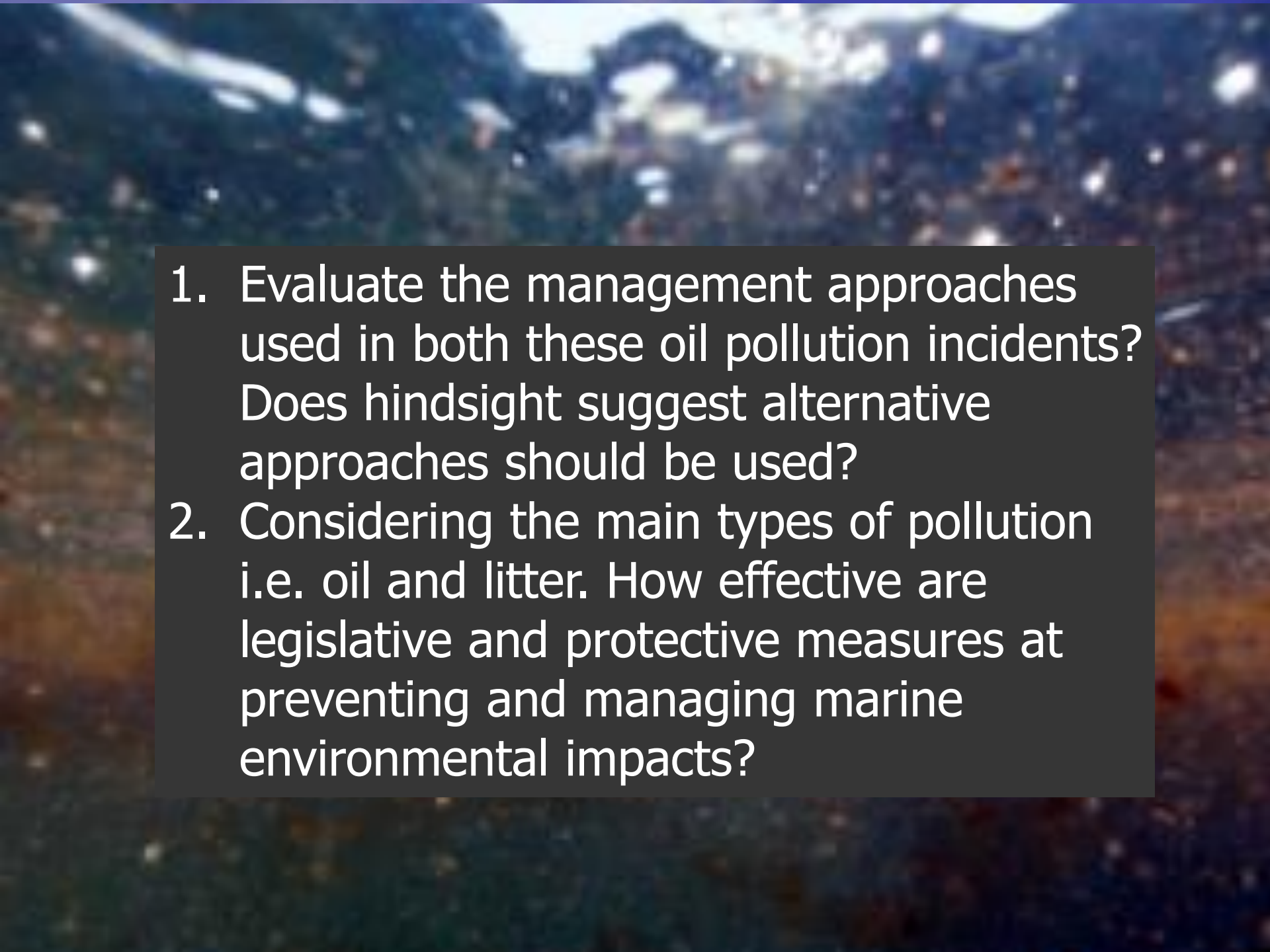
- Scientists realized they lacked much of the basic background science necessary to predict where, when, and how the oil would spread or what its impacts on the region would be.
- Satellite imagery revealed that there was much more oil than had been reported. The final tally showed that the spill dumped more than 250 million gallons of oil.
- Recent studies showed that oil continued to sink to the seafloor for more than a year post spill.
- Immediately after the spill, the 1,300 miles of contaminated coasts saw oil concentrations 100 times higher than background levels! even eight years later, concentrations were 10 times higher than before the spill.
- A study in Feb (2020) showed that the footprint of the oil spread some 30 percent wider than previously estimated, potentially contaminating many more fish communities than previously thought.

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- The background of the slide is a photograph of a dead fish floating on the surface of water. The water is heavily contaminated with oil, creating a complex, swirling pattern of colors including green, blue, yellow, and brown. The fish is a light-colored, possibly silver or white, and its body is partially obscured by the oil slick. Its eyes are visible, and its mouth is slightly open.
- More than 900 bottlenose dolphins have been found dead or stranded in the oil spill area since April 2010

- About 500 dead sea turtles have been found in the spill region every year since 2011 (WWF, 2020)
- Somewhere between 100,000 and a million birds likely to have been affected – many do not wash ashore (Borunda, 2020)

A photograph of a fish, possibly a blue tang, swimming in water that is heavily contaminated with a colorful oil spill. The oil has created a complex, swirling pattern of green, blue, yellow, and purple, resembling a marbled or tie-dye effect. The fish is positioned in the center-right of the frame, facing right, with its mouth slightly open. The background is entirely filled with the swirling oil slick, creating a dramatic and concerning visual.

It could take decades to understand how oil affects the next generation of whales, coral, sea turtles, birds, fish, and more.

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- An aerial photograph showing a large, dark, irregular oil slick floating on the surface of the ocean. A white cleanup vessel is visible near the center of the slick, surrounded by smaller boats and equipment. The surrounding water is a deep blue, and the coastline with some buildings is visible in the upper left corner.
1. Evaluate the management approaches used in both these oil pollution incidents? Does hindsight suggest alternative approaches should be used?
 2. Considering the main types of pollution i.e. oil and litter. How effective are legislative and protective measures at preventing and managing marine environmental impacts?

LEGISLATION

- **MARPOL** – International Convention on the prevention of Pollution from Shipping
- **Merchant Shipping (Prevention of Oil) Regulations 1996**
- **Merchant Shipping Regulations 1988 (Prevention of Pollution by Garbage)**
- **Marine & Coastal Access Act** – marine licensing, spatial planning
- **Urban Waste Water Treatment Directive**
- Double skinned vessels
- Marine Conservation - 'Adopt a Beach' initiative