

A photograph of a large oil spill in the ocean. The water is dark blue with a thick, dark, viscous oil slick floating on the surface. The oil is splashing and creating white foam as it moves. The background shows more of the oil slick extending across the water.

Oil Pollution

Coastal & Marine Science

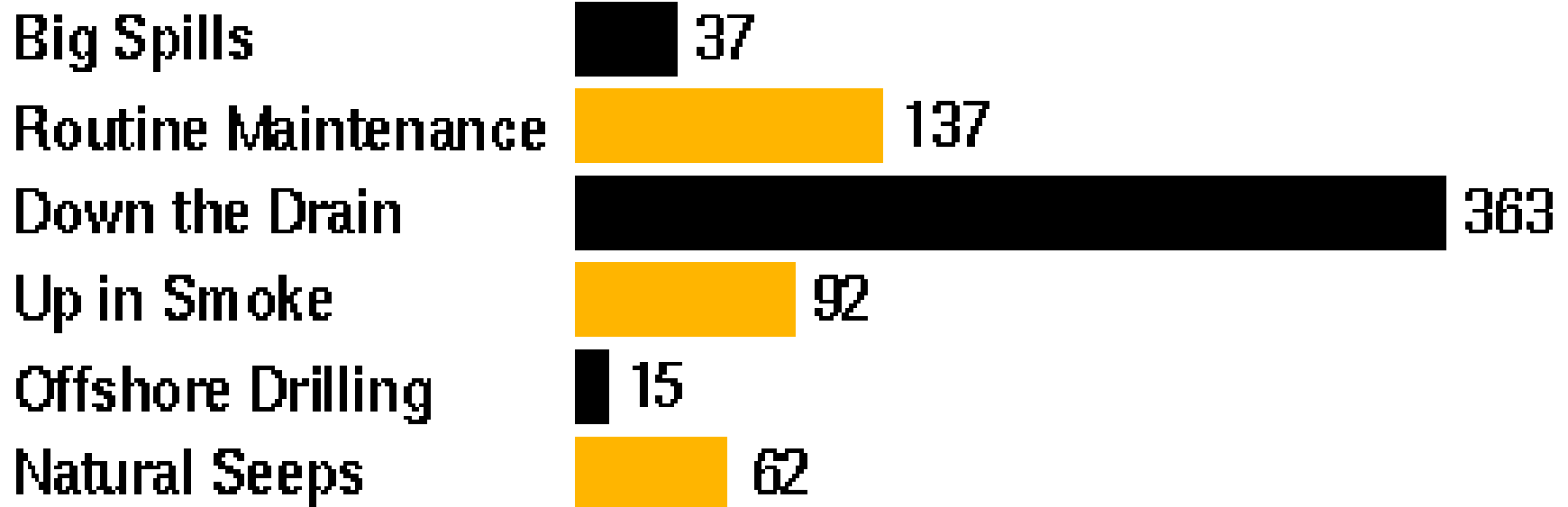
Pollution

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

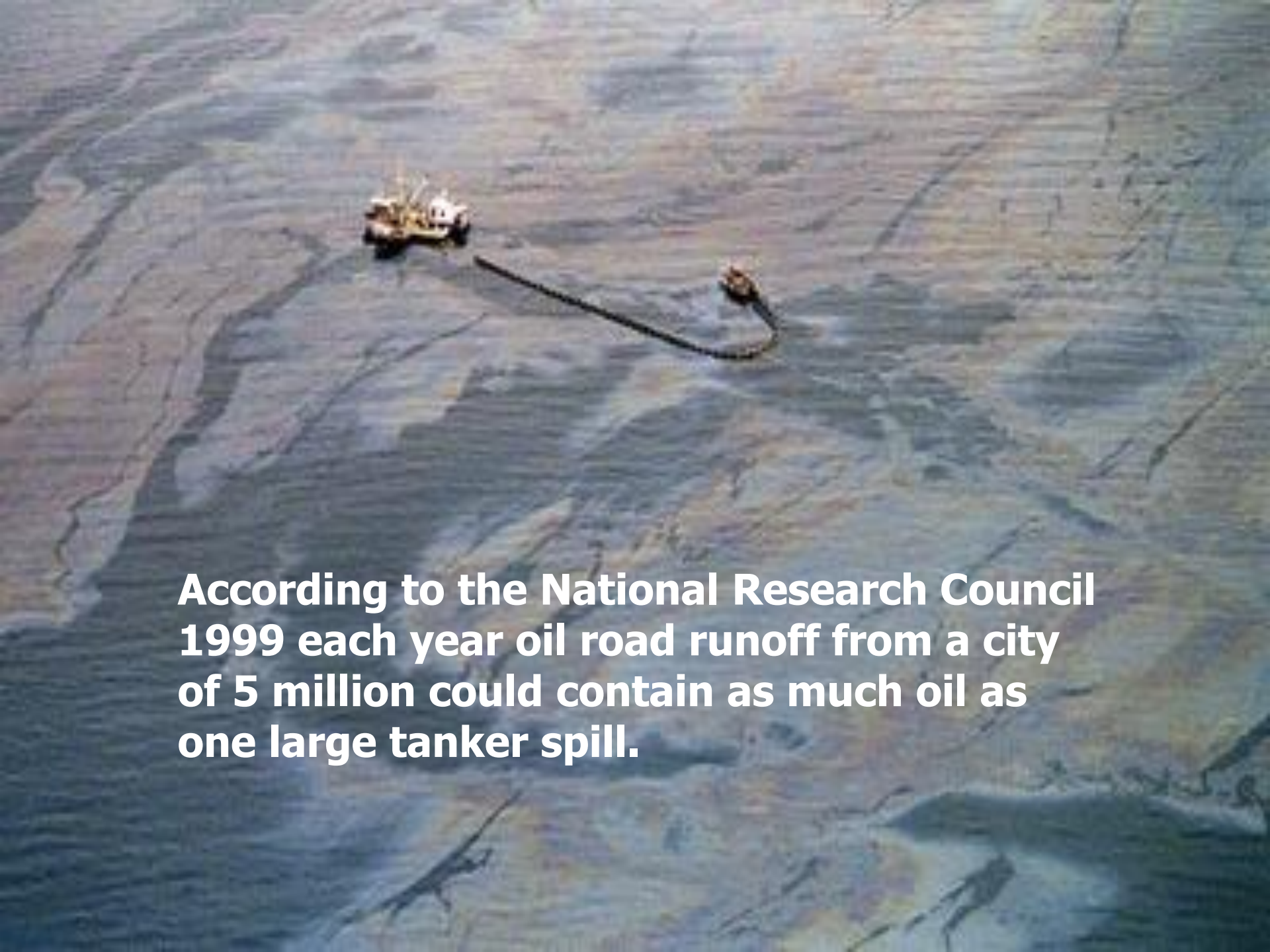
Anthropogenic Threats

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

Oil Pollution



(Million gallons per year worldwide
EPA, 2002)

An aerial photograph showing a large-scale oil spill cleanup operation. Two vessels are visible on the water, connected by a long, dark, flexible hose or skimmer. The water is heavily contaminated with a thick, dark, brownish-black oil slick that spreads across the surface in various patterns. The vessels are positioned in the upper left and center of the frame, with the hose extending towards the right. The overall scene depicts a significant environmental disaster and the efforts to contain it.

**According to the National Research Council
1999 each year oil road runoff from a city
of 5 million could contain as much oil as
one large tanker spill.**

Oil Pollution

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

- ❖ Oil trapped in sediment can leach out slowly for decades



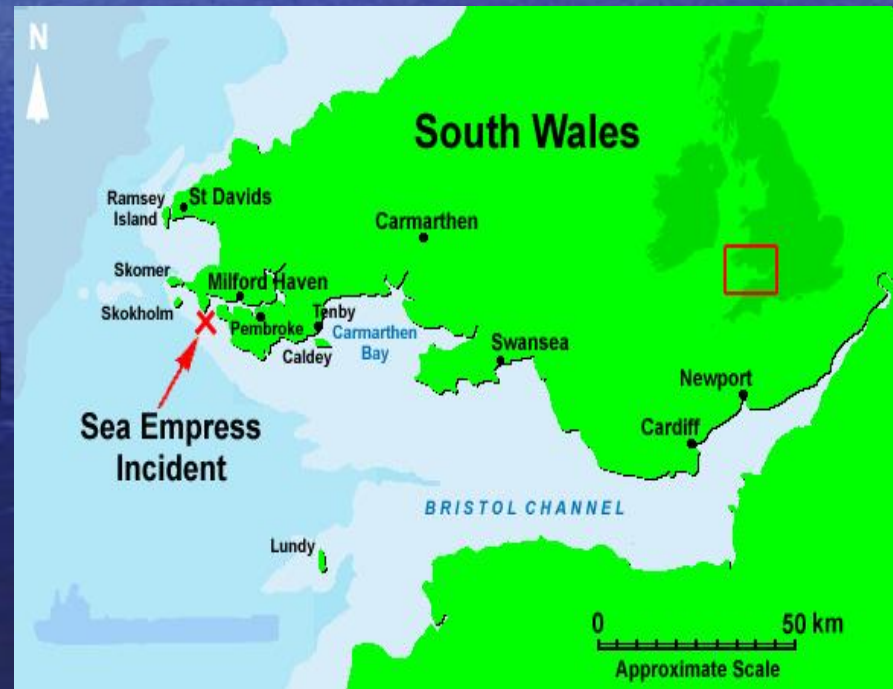
Oil and litter pollution

- Bio accumulation – air they breath, food ingested and through water absorption
- High hydrocarbon exposure – diseased porpoises (Evans, 2002)
- PCB's and mercury – immune suppressants
- White Oyster Ledge – litter sink

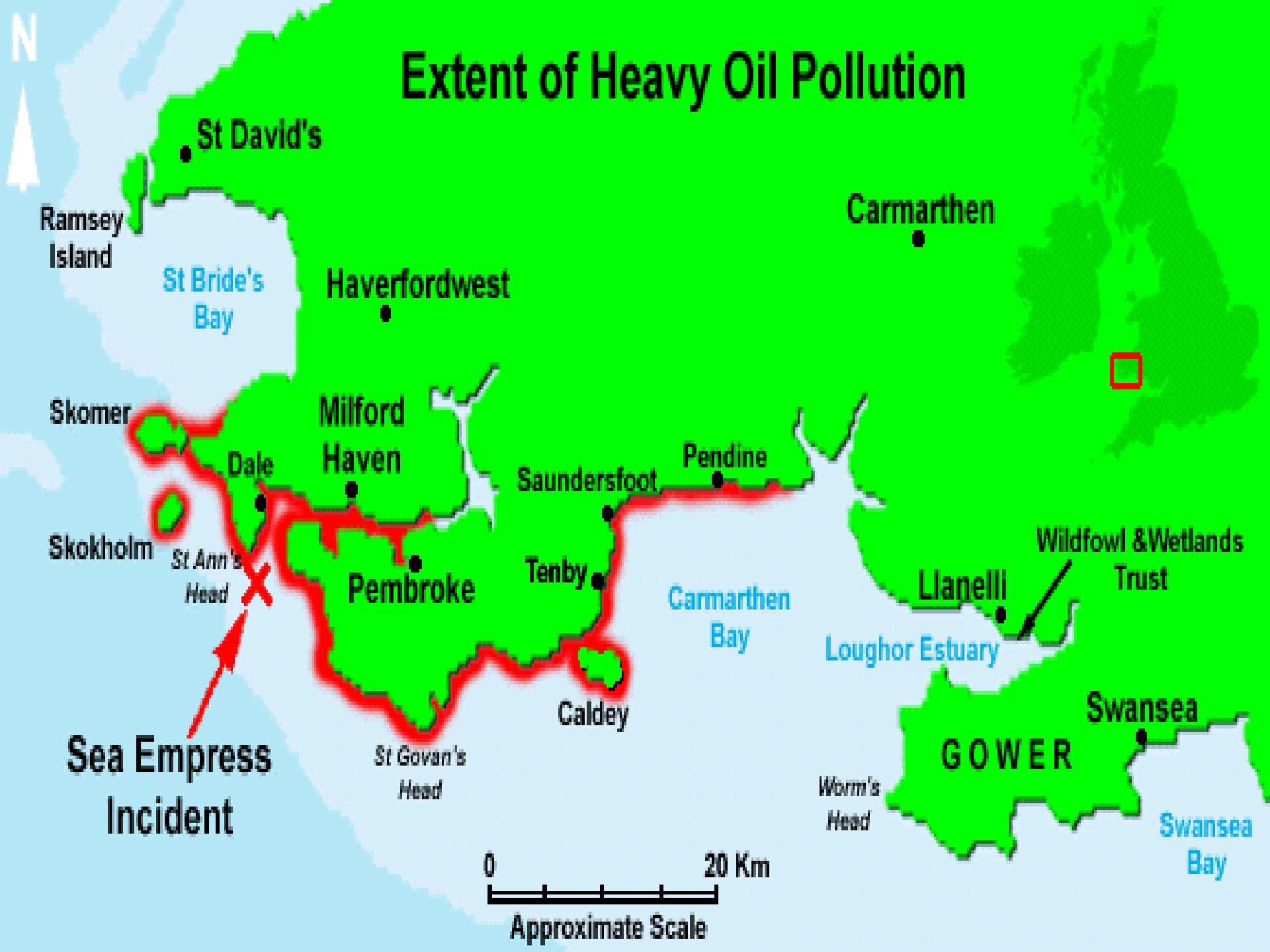


Sea Empress

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



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

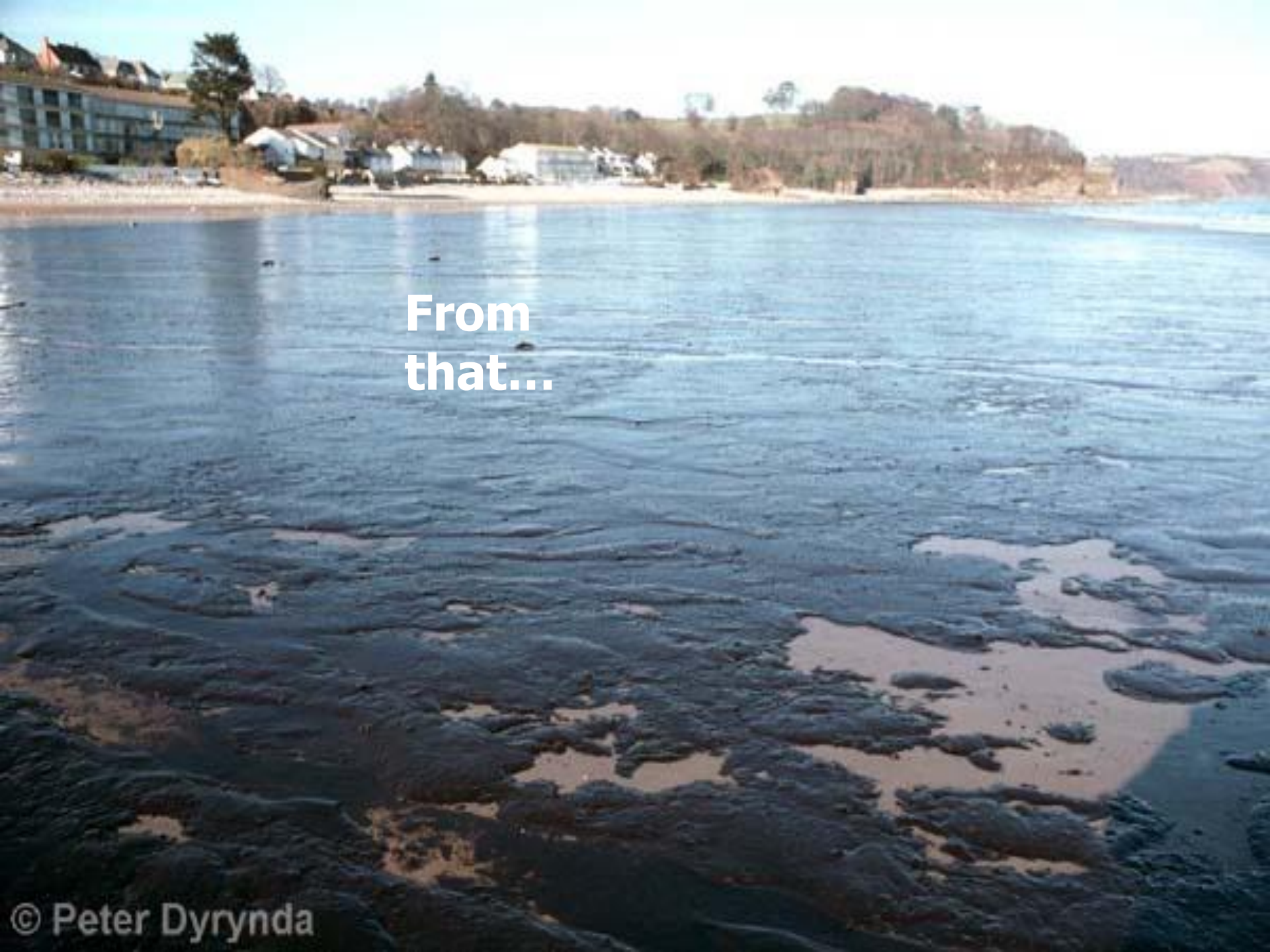
Long-term?



- **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 lines of white-capped waves breaking onto the shore. In the distance, a rugged coastline with cliffs and green 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.....**

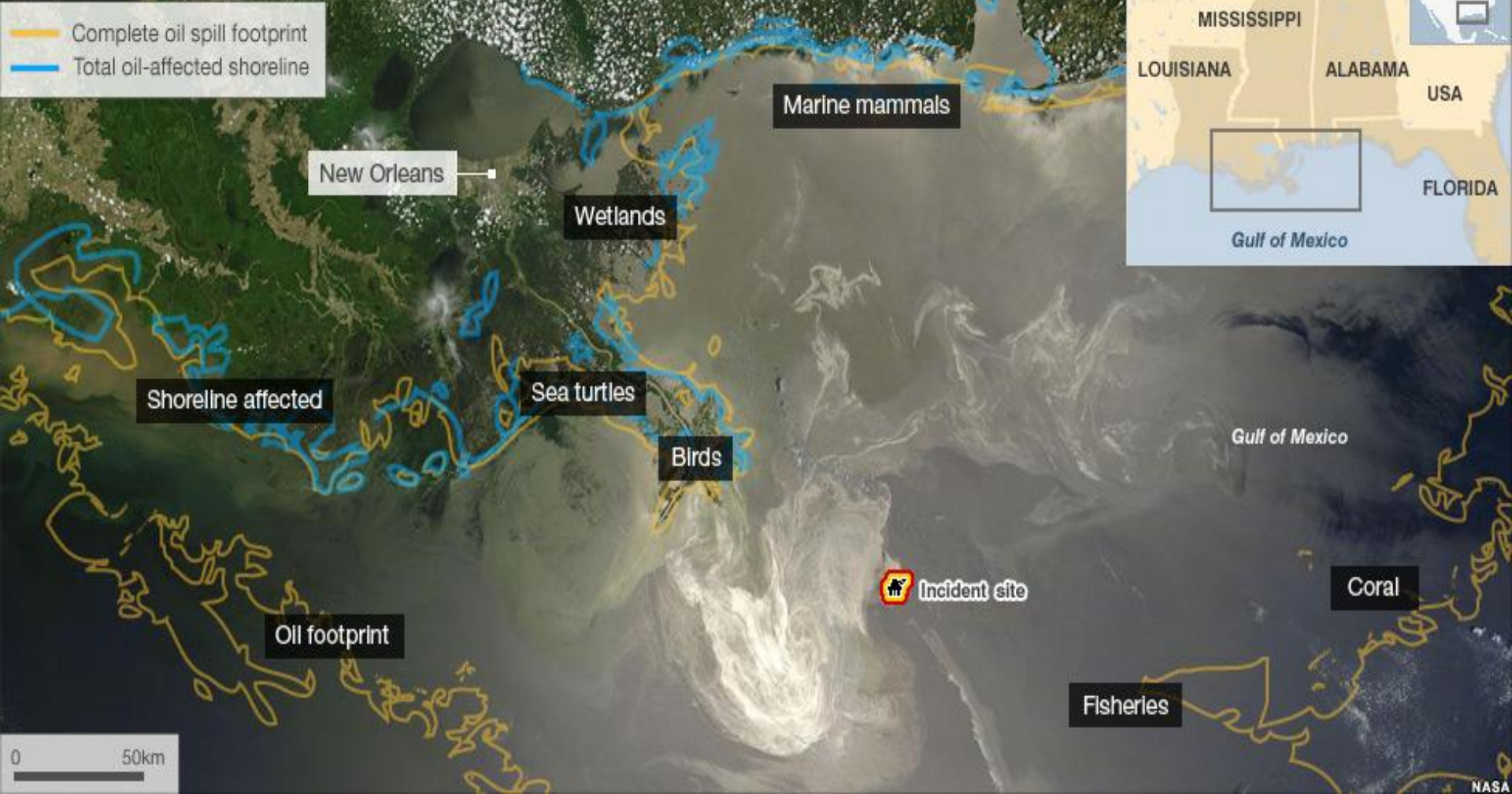
Cost of Clean-up

- Sea Empress - £60 million
- 5 years to completely clean
- C.f. Exxon Valdez - \$2.5bn – 10 mill gallons crude oil
- Deepwater Horizon - \$40bn - 205 mill gallons

Deepwater Horizon Spill: April 2010

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



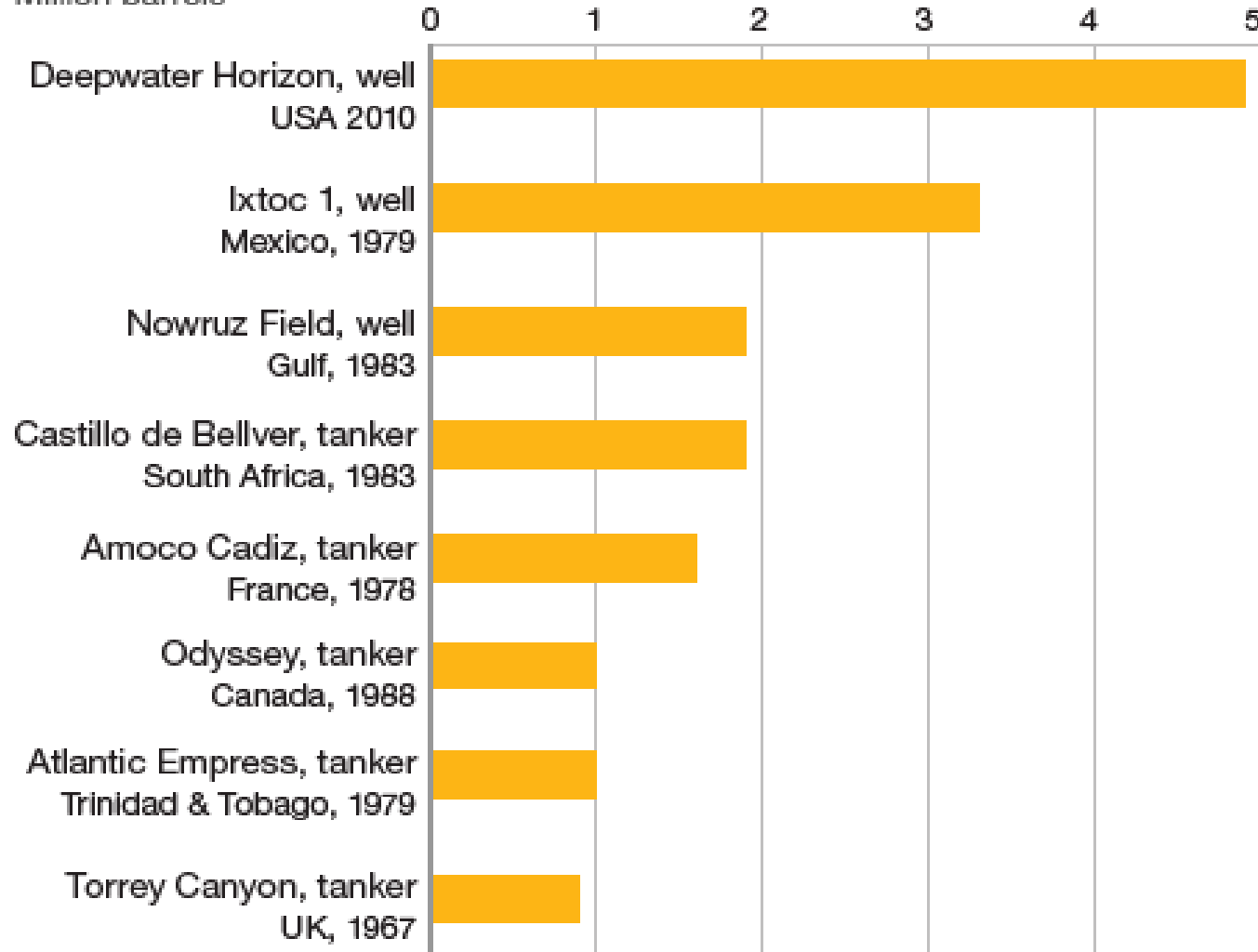


- Spill covered thousands of square miles
- Well (1.5km below surface) released crude oil for 3 months
- Of the 4.9 million barrels, 800,000 barrels recovered; 265,000 were burned off; 1.8 million gallons dispersants used

Major accidental oil spills into the ocean

- Well 50 miles offshore – management was unprecedented
- Fine in region of \$19bn – EPA fine between \$1100 and \$4300 per barrel oil spilled
- \$22 bn – compensation fund & money for marine research

Million barrels



Largest recent US oil spill

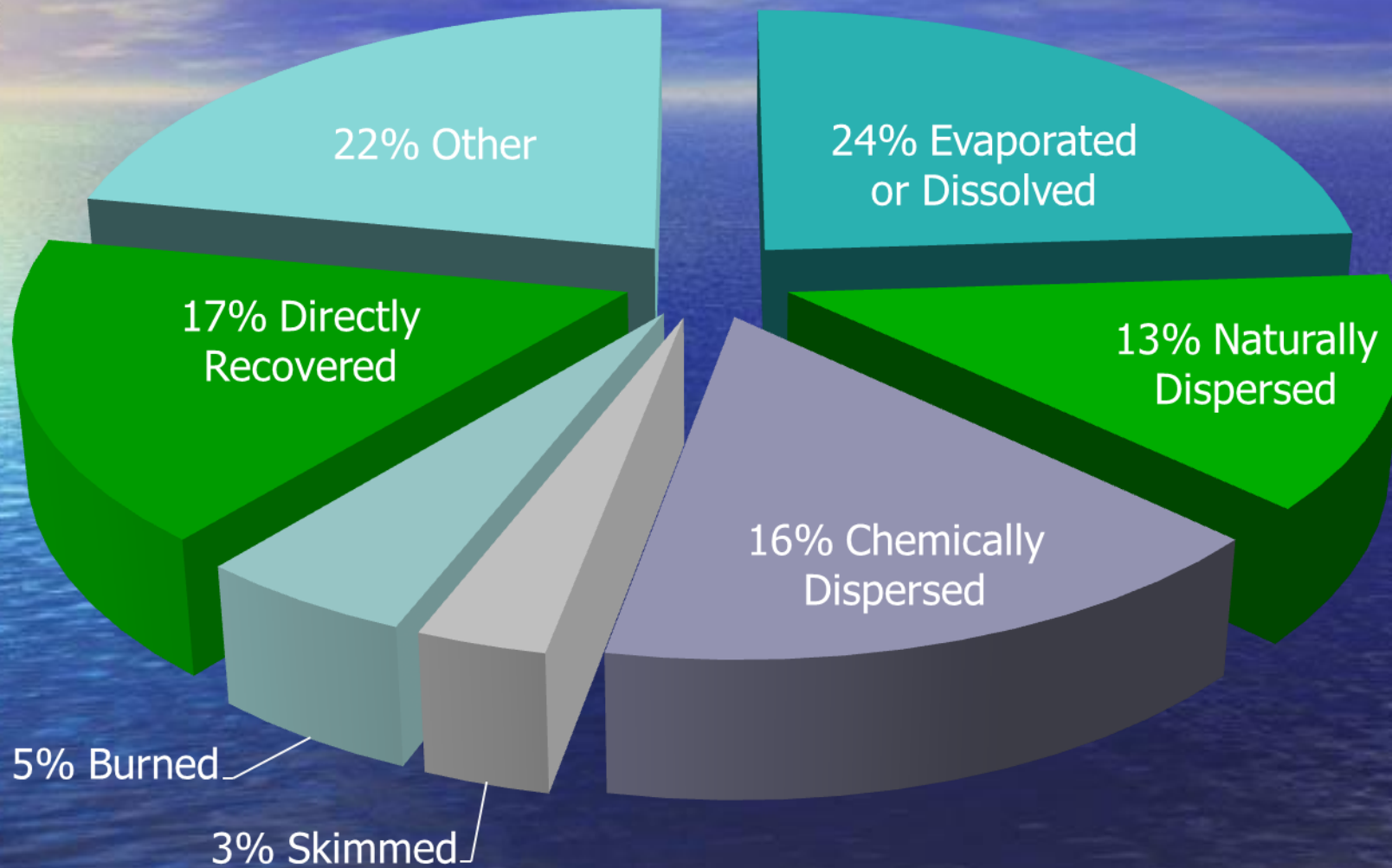
Exxon Valdez
USA, 1989



Source: Oil Spill Intelligence Report

Fate of Spilled Oil

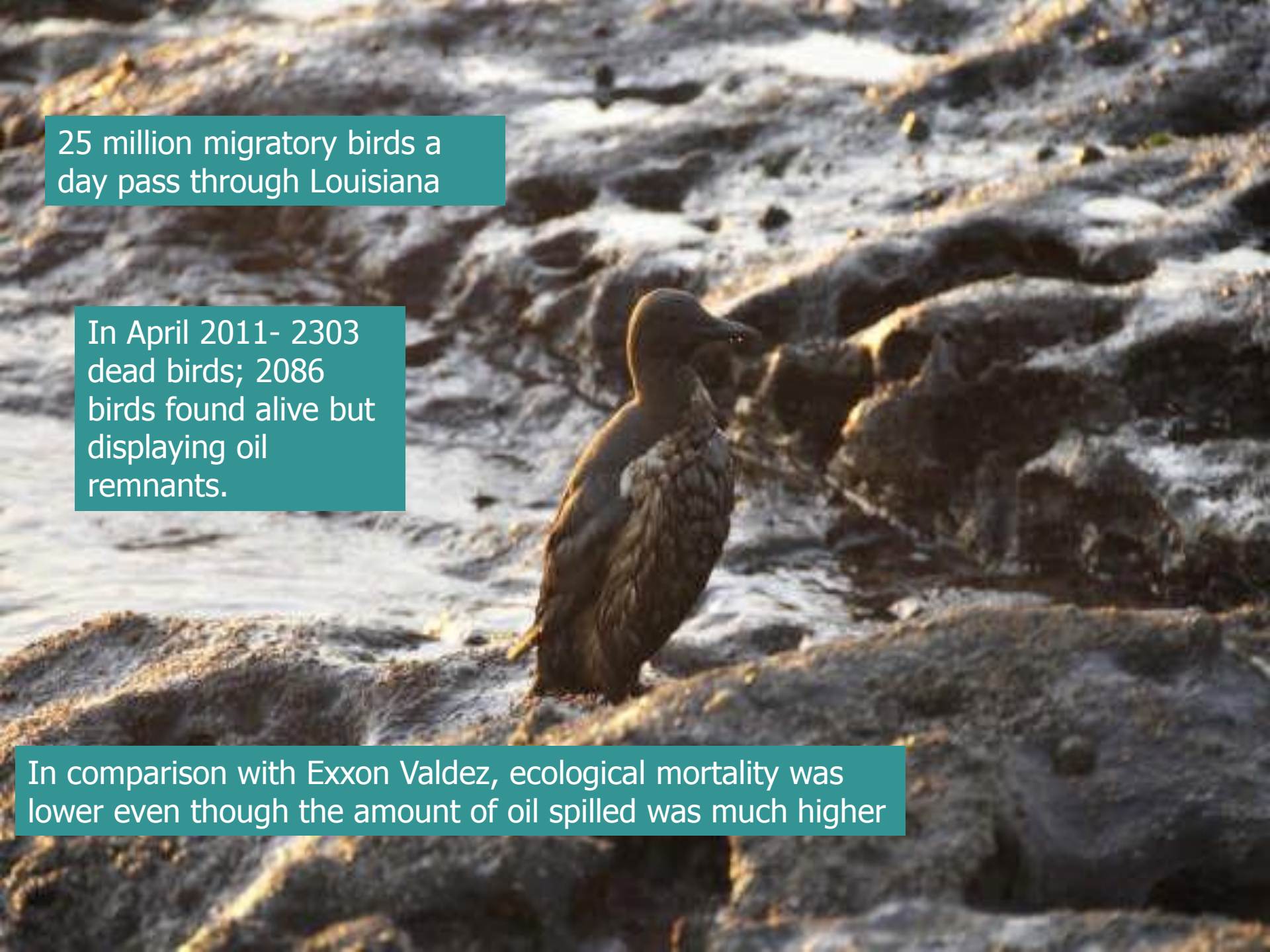
Estimates based on calculations made July 2010
(Ramseur, 2011)



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





25 million migratory birds a day pass through Louisiana

In April 2011- 2303 dead birds; 2086 birds found alive but displaying oil remnants.

In comparison with Exxon Valdez, ecological mortality was lower even though the amount of oil spilled was much higher

Marine Mammals

- 10 dead 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:

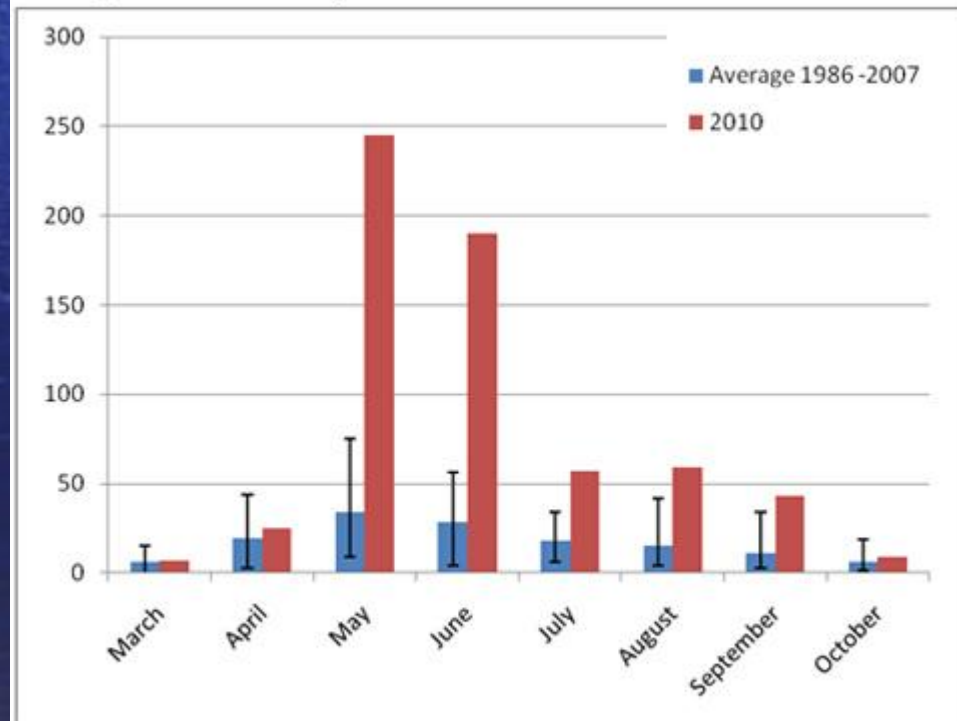
- Effects include:
 - Burning in mucous membranes of the eyes and mouth
 - Irritation or inflammation of the skin
 - Gastrointestinal inflammation, ulcers, bleeding, poor digestion
 - Respiratory irritation, inflammation, pneumonia, emphysema
 - Organ damage, suppression of the immune system, reproductive 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

- Planktonic communities marginally affected
- Early-stage survival (in seagrass nurseries) were not negatively affected
- Catch rates were high in 2010 after the spill
- No shifts in composition generally
- Bluefin tuna spawning coincided with spill
- <10% spawning area and <12% larval habitat
- Long-term impacts may still occur

(Norwegian Institute for Water Research, 2012)

Fisheries



- Large parts of the Gulf closed to fishing
- One year on , a 400% increase in sharks and a 200% increase in fin fish and shrimp 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

Fisheries

- Impacts at a cellular level but positive at a population level!
- 2010 levels strengthened rather than weakened
- Fisheries closures?
- But often time-delayed effects
- Oil stored in sediments – chronic exposure

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

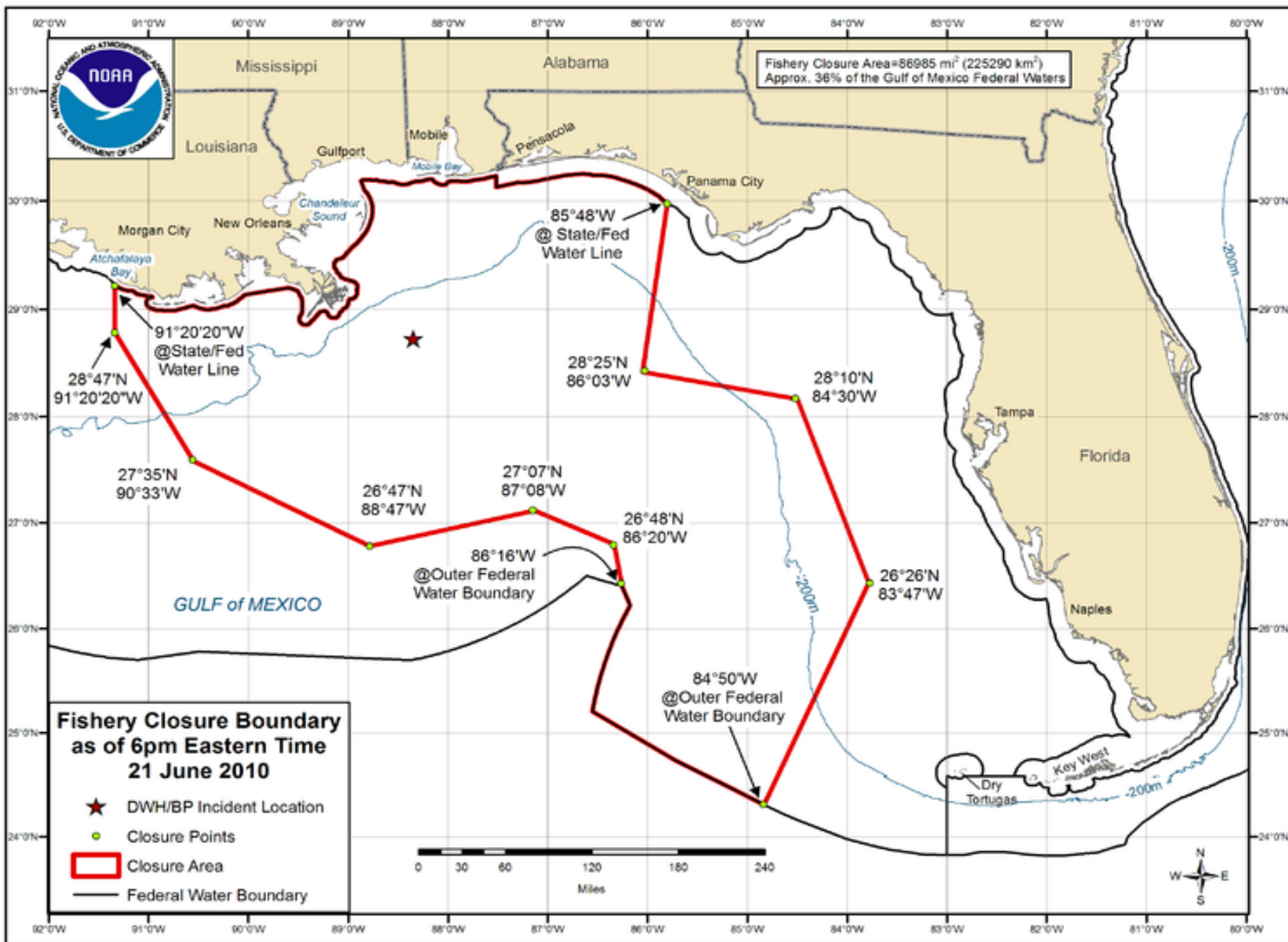
Wetlands

- 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





“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)



Economic cost to region?

- Emergency shrimping season opened 29th April 2010
- Estimate cost to fishing industry - \$2.5bn (\$4.36bn (NIWA, 2012))
- 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)
-

A close-up photograph of a fish, possibly a snapper, caught in a fishing net. The fish is positioned on the left side of the frame, facing right. Its mouth is slightly open, and its eyes are visible. The net is made of thick, dark green and blue ropes. The background is a blurred view of the ocean under a grey, overcast sky. The overall tone of the image is somber and environmental.

A study in Louisiana reported that 70% of consumers expressed some level of concern about seafood following the spill and 23% of consumers have reduced their consumption of seafood. Length of time to regain markets and confidence remains unknown

- 1.8 million gallons used
- Added at well head as well as at surface
- Two basic components:
 - Surfactant (emulsifies oil)
 - Solvent mixtures that helps break oil up.
- Concerns :
 - Toxicity
 - Endocrine disruptions
 - Inhibition of microbial activity



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!**
- **Toxicity was 52 x higher**
- **Dispersants also cause sediment absorption**



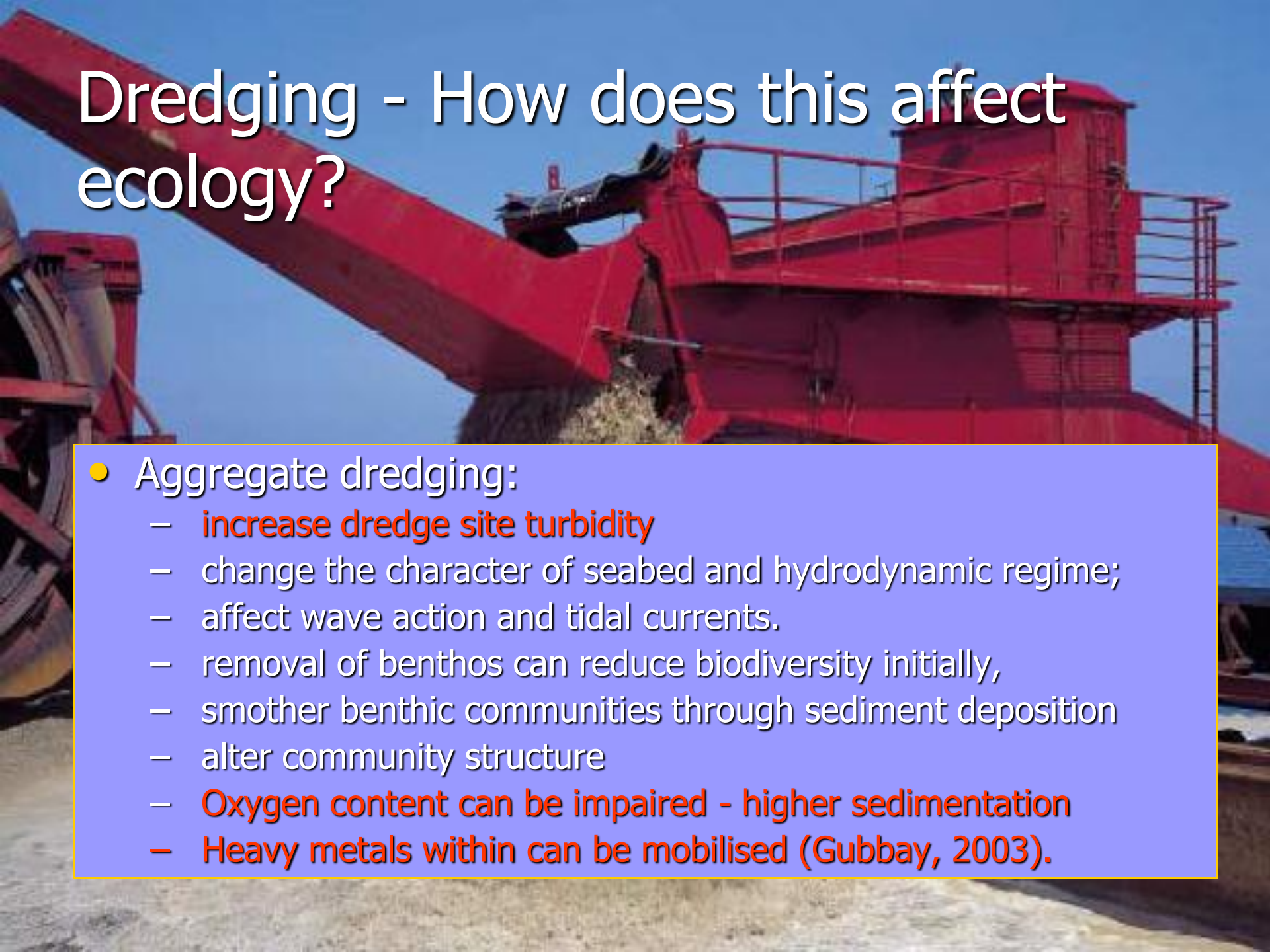








Dredging - How does this affect ecology?

A large red dredging vessel is shown in operation. A long, red boom extends from the vessel, and a large pile of sediment is being discharged from its end. The vessel has a complex structure with multiple levels and railings. The background is a clear blue sky.

- Aggregate dredging:
 - **increase dredge site turbidity**
 - change the character of seabed and hydrodynamic regime;
 - affect wave action and tidal currents.
 - removal of benthos can reduce biodiversity initially,
 - smother benthic communities through sediment deposition
 - alter community structure
 - **Oxygen content can be impaired - higher sedimentation**
 - **Heavy metals within can be mobilised (Gubbay, 2003).**

An aerial photograph showing a massive oil spill in the ocean. The dark, viscous oil has spread across a large area of the water's surface, creating a complex pattern of dark patches and streaks. The surrounding water is a deep blue, and the coastline is visible in the upper left corner. The text is overlaid on the lower half of the image.

Considering the main types of pollution i.e. oil, litter, nutrient and invasive species, 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