IPEN-SSNC Ocean Pollutants Workshop
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Ocean Pollutants Sources and Impacts

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IPEN
a toxics-free future

NTN
NATIONAL TOXICS NETWORK

All life depends on health of the ocean

Jimmy, the Green Turtle

Lorde, the Loggerhead

Oxygen, Climate, 97%H_2O

Ocean Pollutants disproportionately affect remote Arctic peoples, Pacific Island communities, subsistence fishers, vulnerable groups

Outdated notion:
'*vast ocean with capacity to absorb and 'dilute' pollution'*

Mixtures of persistent organic pollutants (POPs), persistent bioaccumulative toxins, (PBTs), endocrine disrupting compounds (EDCs), mercury compounds, pesticides, pharmaceuticals, oil, plastic wastes & additives e.g., BPA, phthalates

Viggo, the Hawksbill

Ocean chemical pollution originates on land

100,000 chemicals

- via atmospheric transport, runoff into rivers, direct disposal into ocean

Hazardous air emissions :

- Factories, smelters, cars, waste incineration, coal fired power stations, oil & gas production

Direct release into aquatic environment :

- Industrial facilities, sewerage outfalls, pesticide runoff, mining activities, urban-based runoff

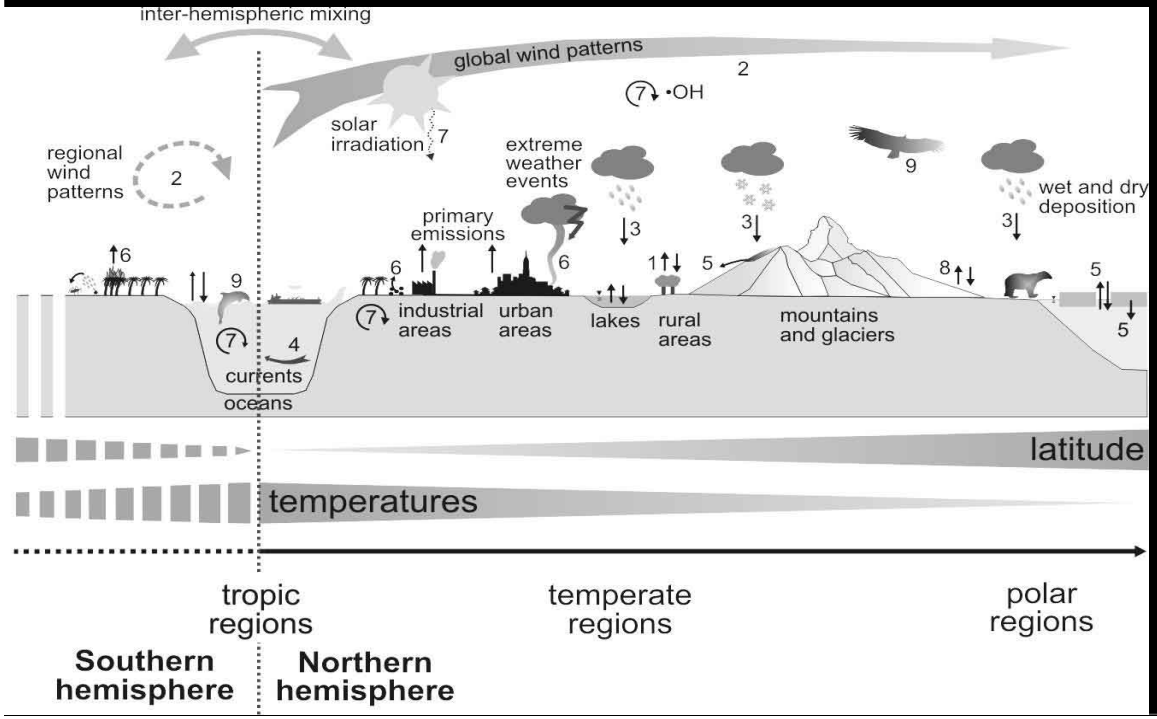
Old & New

- 1974 PCB & DDT in sea turtle eggs in South Atlantic Ocean
- 2018 Novel Perfluoroether Carboxylic & Sulfonic Acids in Surface Water

Climate Change impacts on ocean pollutants

Volatile & semi-volatile POP/PBTs to polar regions via atmospheric & oceanic processes

Increased temperatures re-mobilise contaminants polar sinks - ice, snow, water



Influence partitioning rate : air – soil, air – water

- materials, stockpiles, contaminated sites

Alters distribution : wind, extreme weather, flooding

Affects: salinity & oxygen levels, acidification

- affect bioaccumulation in marine organisms

Chemical degradation, bioavailability, toxicity

- water temps increase toxicity to aquatic species

Increasing disease risks & species vulnerability

Endocrine disrupting compounds

EDCs mimic, compete with or disrupt synthesis of hormones
- reproduction, development & immune function
- hormone sensitive cancers, infectious diseases
- *'windows of vulnerability'* critical developmental stages

1970-80s DDT & PCBs Baltic Ringed Seals & Dall Porpoises

Current EDC burdens (PCBs, methylmercury)
- impact breeding & immune system
- higher EDC exposure = high rates of reproductive problems

Tributyl tin (TBT) antifouling paint
- ***imposex*** in whelks & oysters
- TBT banned but tin-containing plastic stabilisers

"significant role in worldwide loss of species and reduced population numbers of amphibians, mammals, birds, reptiles, freshwater and marine fishes and invertebrates"

UNEP / WHO

Mercury - a ubiquitous EDC ocean pollutant

Coal fired power generation, chlor-alkali plants, small-scale gold mining

Global air emissions - 2,063 t - 2010

Inorganic mercury - toxic organic methylmercury

- biomagnifies - 1 million times greater in sharks, tuna, swordfish
- toxic to birds 4 ppm - Flesh-Footed Shearwaters 30,000 ppm

Human consumption of contaminated fish

- toxic levels accumulating in body tissues
- brain, heart, kidneys, lungs, immune system, developing nervous system, IQ

'dependent on seafood for protein, suffer a chronic, disproportionate & more dangerous dose of toxic mercury'

Pacific Island participants - 96% above 1ppm Hg in hair

POPs in the marine environment

Toxic, highly persistent, long-range transport, bioaccumulate

- biomagnify in marine food chains
- PCB, DDT, HCH (lindane), HCB. HCBD, PeCB, PCP, HBCD, PBDE, PFOS, PFOA, PFHxS, SCCP, Endosulfan

Cancers, birth defects, immune & reproductive impacts, susceptibility to disease

Manufacture, agriculture, waste stockpiles, consumer products, by-products & incineration

Stockholm Convention on Persistent Organic Pollutants 2001

- 28 POPs, 3 being assessed
- 500 chemicals exceed all POPs criteria, 10 HPV

Seawater, sea-ice, snow, air & biota

- higher in Arctic than Antarctic
- Antarctic species low elimination rates

POPs continue & continue……..

Polychlorinated biphenyls (PCBs)

- electrical transformers, cables & PVC coatings
- carcinogens, immuno, repro & development toxin, EDC
- aquatic species growth & reproduction
- PCBs in harbour sediments
- concentrations in Antarctic fish still rising
- 2025 final elimination

Per- & poly-fluoroalkyl substances (PFAS)

- PFOS, PFOA, PFHxS
- industrial & consumer chems eg fire-fighting foams, non-stick /Teflon
- 3,000 - 4,730 PFAS most no toxicity data
- toxic to aquatic organisms, biomagnifies

- PFOS intergenerational effects, immune function in dolphins & sea turtles.
- PFOA immunotoxins, EDCs, carcinogens
- PFCAs > 80% of 30 surface seawater samples
- Novel PFAS water contaminants

Pesticides as Ocean Pollutants

Endosulfan : POPs insecticide, genotoxic, neurotoxic, EDC

- 40% of samples of Antarctic krill
- fish, seabirds, shrimp, crabs, seals, minke whales, beluga, narwhal

Current use pesticides: cancers, tumours, repro & immuno toxins, EDCs, cellular & DNA damage, behavioral changes

Neonicotinoids : >90% Canadian surface water samples

- **Imidacloprid** impair Mysid shrimp growth
- Prawn farms - sensitivities to low concentration neonics

Organophosphates : **Chlorpyrifos** bioaccumulates in aquatic organisms & seabirds, sub-lethal effects on fish eg smell & behaviour

Pyrethroid insecticides : more toxic than organophosphates

Glyphosate : surface water, groundwater & marine sediments

Ocean Pollutants, Coral & Great Barrier Reef

'Agricultural runoff significant factor in decline of coral cover across large parts of the GBR'

- seagrass meadows, mangrove systems

'Persistent herbicides pose greatest risk'

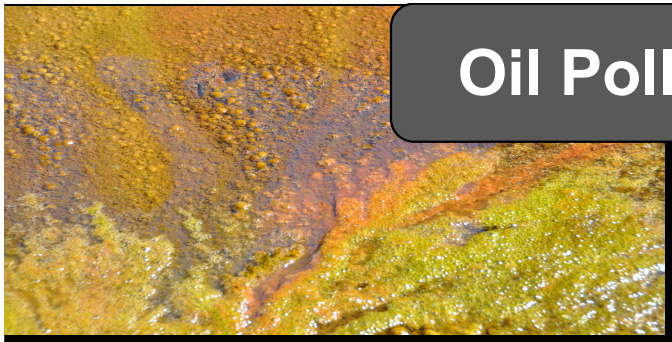
- Diuron, atrazine, hexazinone, ametryn
- GBR fish exposed to oestrogenic pesticides from sugar cane

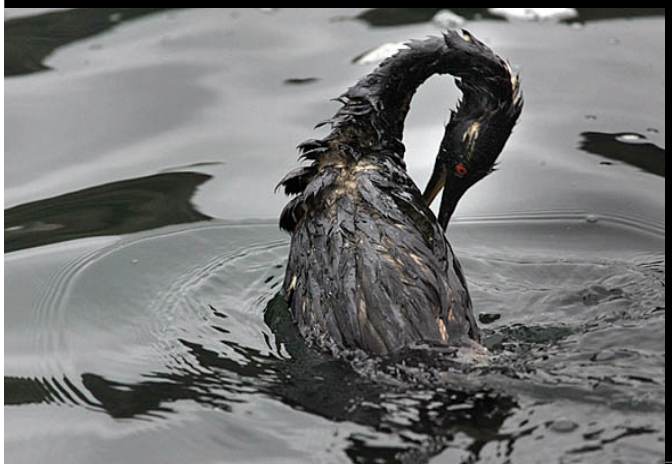
Sunscreens
6,000-14,000 tons to coral reefs p.a

Oxybenzone : promotes viral infections, deformities in baby coral, skeletal EDC
'*baby coral encase itself in its own skeleton*'

61/ 631 pharmaceuticals, highly active at low concentrations

Oil Pollution & polycyclic aromatic hydrocarbons





2,673 megalitres enters ocean every year

- 50% storm water drainage, waste disposal
- boats, oil tanker incidents, 10 M litres US tanker sunk 1944
- offshore drilling operations - disposal of oil-based drilling fluid, pipeline leaks, well failures & blowouts

Mass mortality, contamination of fish & wildlife, reproductive impacts, altered behaviours, disruption of marine food chain

- fish & shellfish : changes in reproduction, growth rates

PAHs coastal sediments for over 20 years

- highly toxic, cancers, mutations & birth defects in fish embryo, long-term locomotor & behavioural effects
- higher levels detected in seafood samples after spills
- mussels near oil platforms

Impacts of ocean pollutants

Endangered Australian Sea lion
40% human giardia bacteria

POPs in fish affect reproduction, growth, development, immune & endocrine systems
DDT, PCBs HCH : DNA damage, multigenerational effects PBDEs: decreased hatching, altered thyroid hormone levels

PCBs : increased cytocrome P450, reduced immune response, in fur seals, polar bears, gulls

Neoplastic / tumour growth : 15 bivalve species

- tumours in marine mammal with elevated pollutant levels

Loggerhead turtles : mercury, PCBs, DDE reduce immune function

Green turtle eggs : 100% OCPs, PCBs, chlordanes, HCHs
65% Arsenic : high risk of embryo mortality & reduced hatching

'considerable risks to sea turtle conservation'

Marine Sentinel Species

Californian sea lion, Atlantic Bottlenose dolphin, Southern Sea otter, Bowhead whale, polar bear, West Indian manatee

California sea lions live in close proximity to human communities

- newly identified urogenital cancer, novel herpes virus & higher PCBs & DDTs in blubber

Dolphins & manatees :

- resurgence of infectious & neoplastic disease

Biomagnification of POPs, PBTs, heavy metals among polar bears & Bowhead whales

- threats to human communities dependant on native foods
- humans & polar bears feed on similar prey

'Diets high in fish, shellfish, or high fat wild foods particular risk of POPs & PBT exposure'

Gullah people, South Carolina, U.S. linked high local seafood diet with high levels of DDT, HCHs, BDE-99, PCBs PAHs in women with non-cancerous uterine growth, an endocrine condition

Fish are 40% protein for 2/3 of population

- Indigenous peoples, island communities, subsistence fishers

- Hg double in North Pacific Ocean by 2050
- HCB, DDE & PCBs in Bluefin tuna, swordfish, Atlantic mackerel
- Chinese intake PBDEs fish (45%) & molluscs (45%)

Green turtle eggs - POPs & heavy metals
"current concentrations posed considerable risks to human health"

Inuit peoples high POPs,

- cardiovascular disease, high cholesterol levels, diabetes, inflammatory chronic diseases

Intermission

Microplastic pollution in every marine ecosystem

Open ocean, sea surface - floor, deep-sea sediments, Arctic sea ice

- Estuaries - fish breeding grounds

"plastic rubbish will outweigh fish in the ocean by 2050"

- Est five trillion pieces >250,000 tons

Microplastic (< 5 mm) resin pellets, microbeads, polystyrene, cigarette butts, fibres from ropes, nets, synthetic clothing,

Nanoplastics (<100nm) engineered plastic nanoparticles

- industrial abrasion (e.g. air blasting), car tyres

Polymers weather & degrade

- UV solar radiation, chemical & biodegradation
- break apart with sea motion or in the gut
- eg Fulmars seabird, reshape & redistribute 6 t p.a.

Contamination of marine plastics

Shearwater chick plastic load

Plastic polymer additives

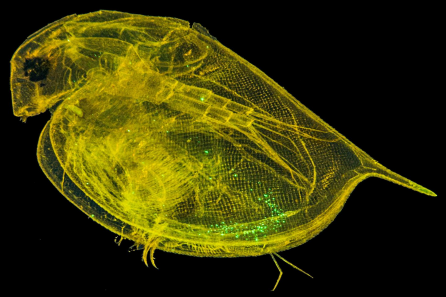
Different colours & polymers sorb POPs differently
- preferred by different marine species

Biodegradation aids sorption
- nano - & microplastics - larger surface area to volume ratio
- POPs & PBTs orders of magnitude higher
- smaller size more easily ingested / cross the gastrointestinal tract

'Dimethyl sulphide signature' - scent attracts aquatic & marine wildlife

Plastic nurdles / pellets
- open ocean, remote & urban beaches
- PCBs, PAHs, DDT PBDEs, PFAS, alkylphenols, BPA
- 1 to 10,000 ng/g - ppb

Trophic transfer of microplastics



Green algae - planktonic water flea - fish

Ingestion by all commercial fish species - low levels

Nanoplastics penetrate the embryo walls & present in yolk sac of hatched juveniles

Increased immune response, decreased food consumption, weight loss & energy depletion, decreased growth rate & fertility, intergenerational effects

8.5% 528 stranded & by-caught marine mammals (seals, whales) marine debris in digestive tracts

Loggerhead sea turtles : 35.2% stranded or dead in Adriatic Sea

Seabird highest levels: 95% Northern fulmar

- critical level of 0.1 g of plastic exceeded by 58%
- reduced body condition & increased contaminant load

Increased availability of chemical contaminants

Green turtles : PCBs positively correlated with plastic ingested

Flesh-footed Shearwater fledglings - chromium & silver

Mussels: PAH (pyrene) from PAH microplastic

- immunological & neurotoxic effects

Myctophid fish : greater plastic densities associated with higher PBDEs

Baleen whales :

- surface plankton with phthalates contaminated microplastic
- phthalate (MEHP) in blubber of stranded fin whales.

"overall amount of PBTs bioaccumulated from natural prey overwhelms the amount from ingested microplastics" FAO

Increased sorption to nanoplastics eg PCB to carbon nanotubes
3-4 orders of magnitude stronger than to micro-sized polyethylene.

Microplastic pollution of the human food chain

Microplastics in seafood
- Swedish blue mussels, Norway lobster, cod, haddock, prawns
- 27 fish species from Shanghai fish markets

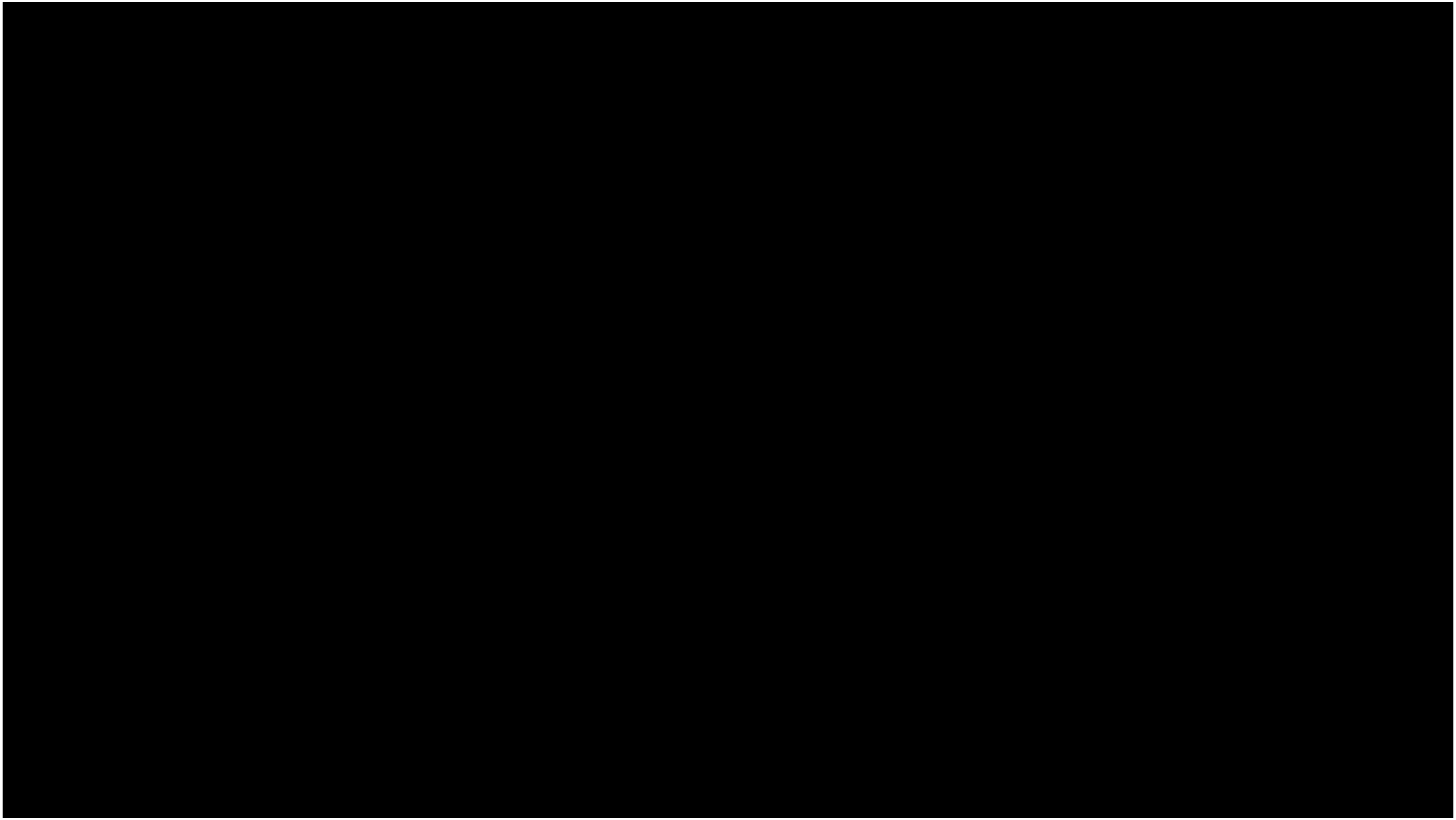
Gastro-intestinal tract of fish but most fish species are gutted
- oysters, mussels, small fish eg sardines eaten whole

Persian Gulf exoskeleton & muscle of tiger prawn
- fish skin, muscles, liver

World Health Organisation investigation

Microplastic contamination of drinking water
- 83% of tap water samples
- 11 different bottle water brands in 9 countries found 93% (polypropylene most common)

Thankyou for listening



Unconventional Gas : Credible Concerns

Gas : Credible Concerns