Ocean Resources

Economics and Sustainability

OCEAN RESOURCES - Key Concepts

A. Marine Resources Divided Into Several Categories

1) Biological

- ✓ Fish, Crustaceans, Mollusks and Mammals; Plants; Drugs

2) Physical

- ✓ Mineral Deposits; Oil and Gas; Fresh Water

3) Energetic

- ✓ Wind; Waves and Currents; Thermal gradient; Tides

4) Nonextractive

- ✓ Transportation; Recreation; Real Estate

B. Extraction of Most Ocean Resources Comes at a Steep Cost

1) Pollution 2) Habitat Destruction, 3) Extinction, and 4) Loss of Resource

- ✓ Negative costs not calculated into market price of resource
- ✓ Entire marine ecosystems are being threatened

C. Extraction of Most Ocean Resources Not Sustainable

1) Rates of Extraction Exceed Replenishment

- ✓ Driven by short-term supply and demand: Lack of long-term management

2) "Madhouse Economics" of Marine Fisheries Best Example

- ✓ Government subsidies; Legal loopholes; High-tech efficiency

D. Laws of the Sea Govern Ocean Resources Control and Trade

1) National and International Laws and Agreements – Lack of Enforcement

BIOLOGICAL RESOURCES – The "Fisheries"

1) **Fishes**
   - ✓ Herring, sardines, anchovies
   - ✓ Cods, hakes, and haddocks
   - ✓ Tunas, bonitas, billfishes
   - ✓ Salmons, trouts, smelts
   - ✓ Flounders, halibut

2) **Crustaceans**
   - ✓ Shrimps, crabs, lobsters, krill

3) **Mollusks**
   - ✓ Clams, oysters, mussels, scallops, squids, octopus

4) **Echinoderms**
   - ✓ Sea urchin, sea cucumber

3) **Marine Mammals**
   - ✓ Whales, dolphins, seals

5) **Plants**
   - ✓ Seaweed, kelp, sea grasses

Our Worldwide Fish Market

The Jet Age Has Created a Global Seafood Market

Since the late 1960's the entire world now has ready access to fresh seafood from every corner of the ocean.

The Worldwide Sushi Bar

Ever wonder where all that seafood comes from?

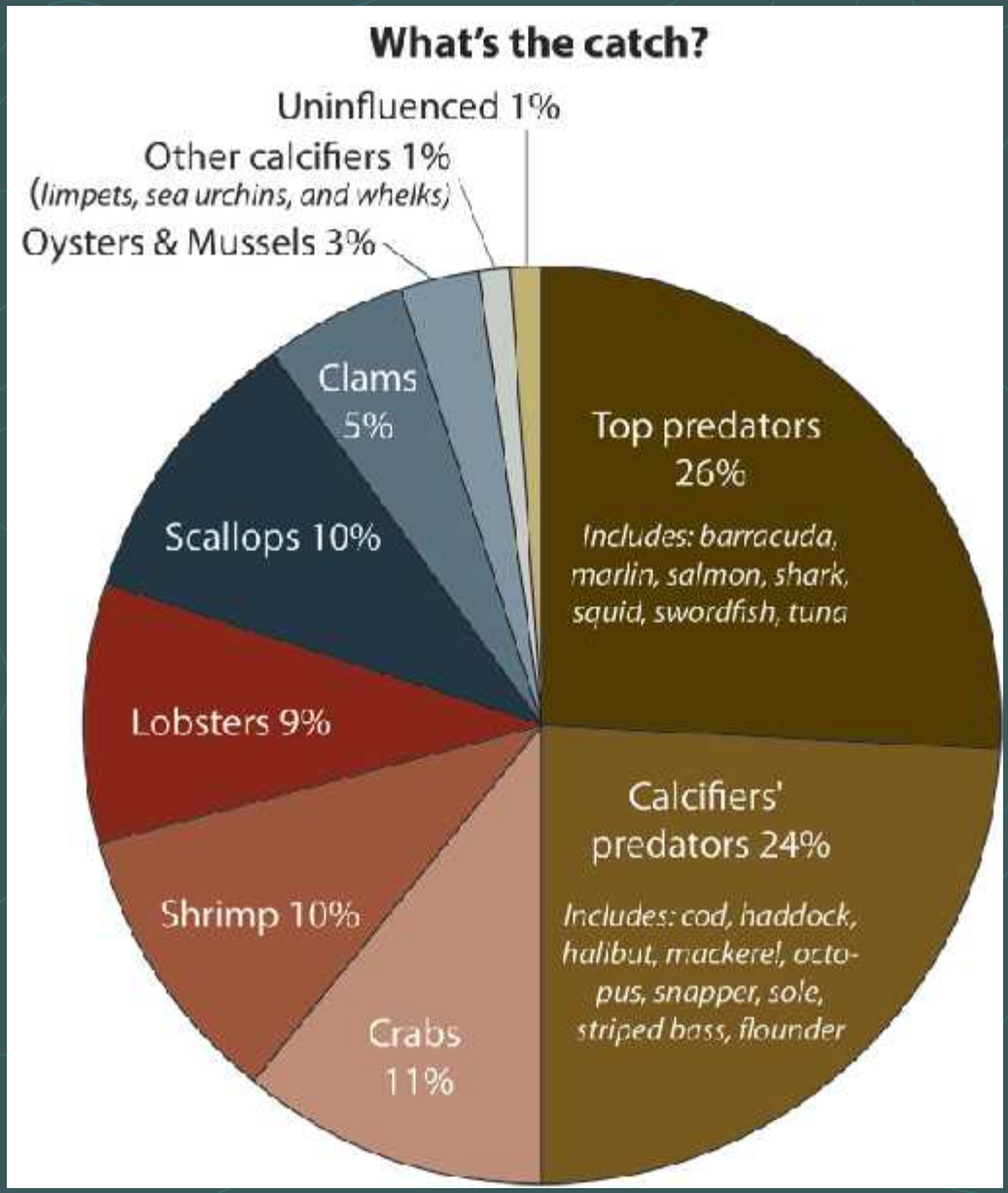
Ever wonder if there's a never-ending supply of sushi?

Marine Fisheries Productivity

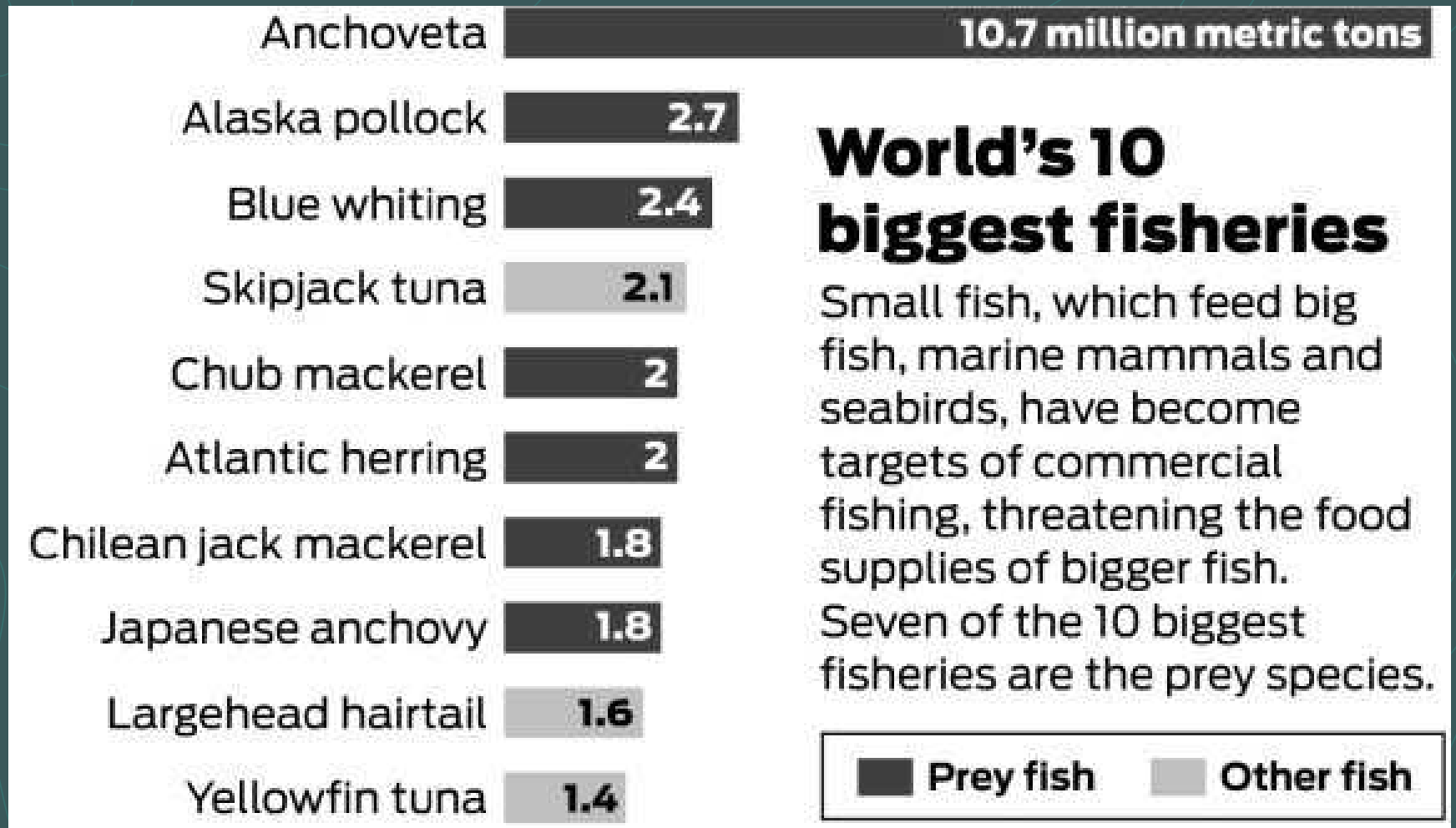
1. Low productivity provinces
2. Middle productivity provinces
3. High productivity provinces

What's Being Caught Out There?

- ✓ Top Predators
- ✓ Benthic Predators
- ✓ Crustaceans
- ✓ Bivalves
- ✓ Others



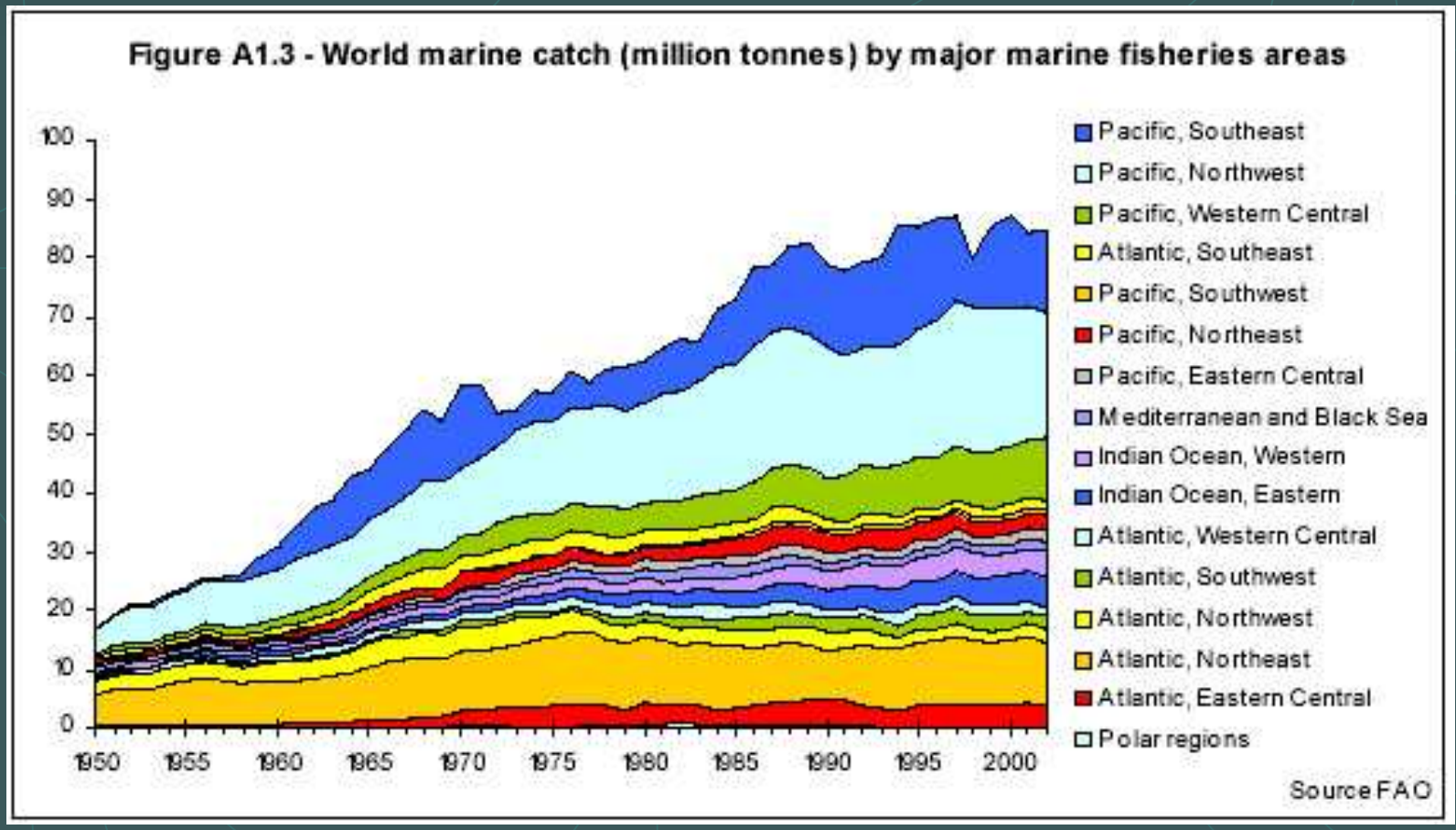
The Top-10 Global Marine Fisheries



Source: United Nations Food and Agriculture Organization, 2006; Oceana

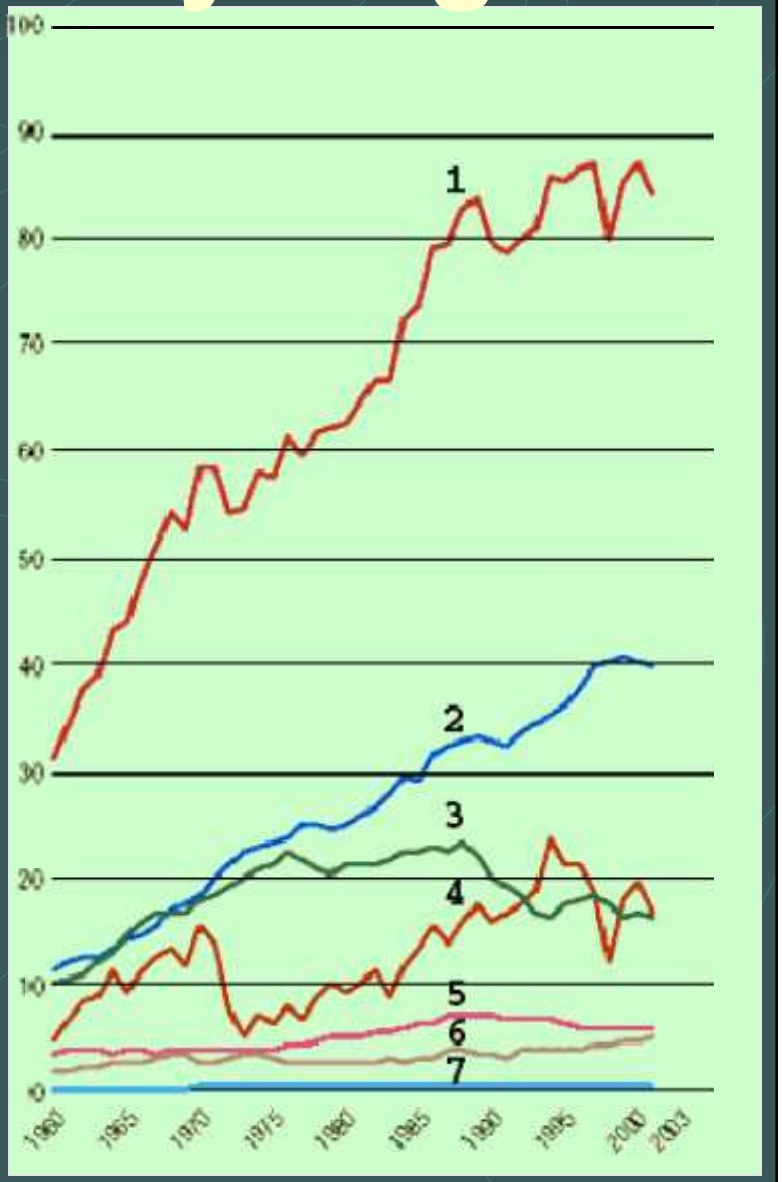
Todd Trumbull / The Chronicle

Historic World Marine Catch by Region



1. Pacific Northwest most productive
2. Pacific Southeast second most productive
3. Atlantic Northeast third most productive

World Marine Catch by Region



Map Key:

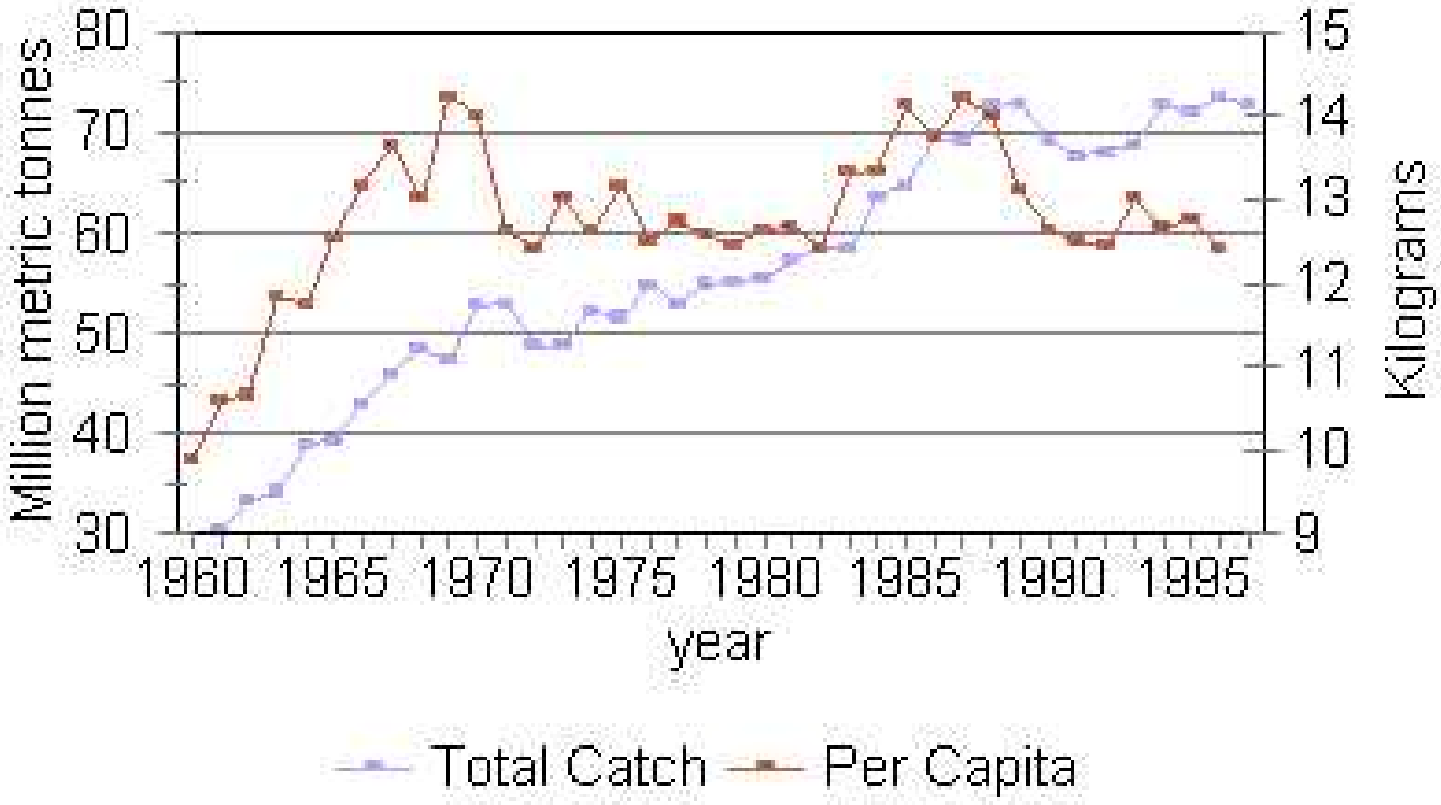
1. GLOBAL
2. Asia and the Pacific
3. Europe
4. Latin America and the Caribbean
5. North America
6. Africa
7. West Asia

Catch in millions of tons

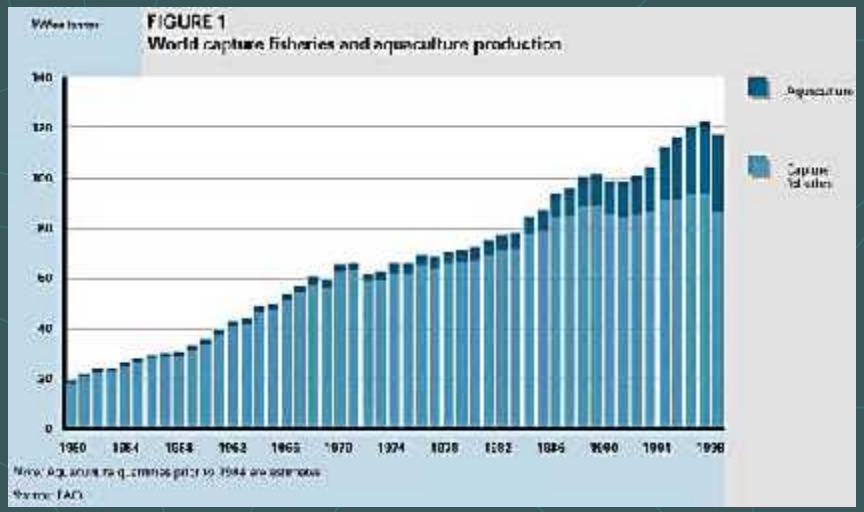
source: *http://www.unep.org/geo/yearbook/108.htm 6may04*

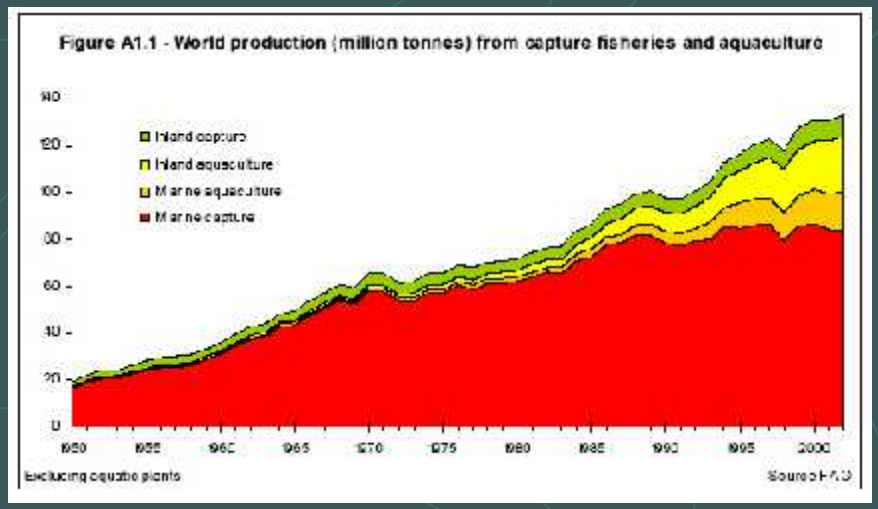
World Marine Fish Catch

Catch per capita



Marine Capture Fisheries and Increasing Aquaculture





1) Capture fishing of wild ocean fish shellfish has topped out.

2) Increased marine aquaculture is occurring worldwide as a means to supplement the maxed-out wild catch production.

3) Marine aquaculture includes farming and ranching methods.

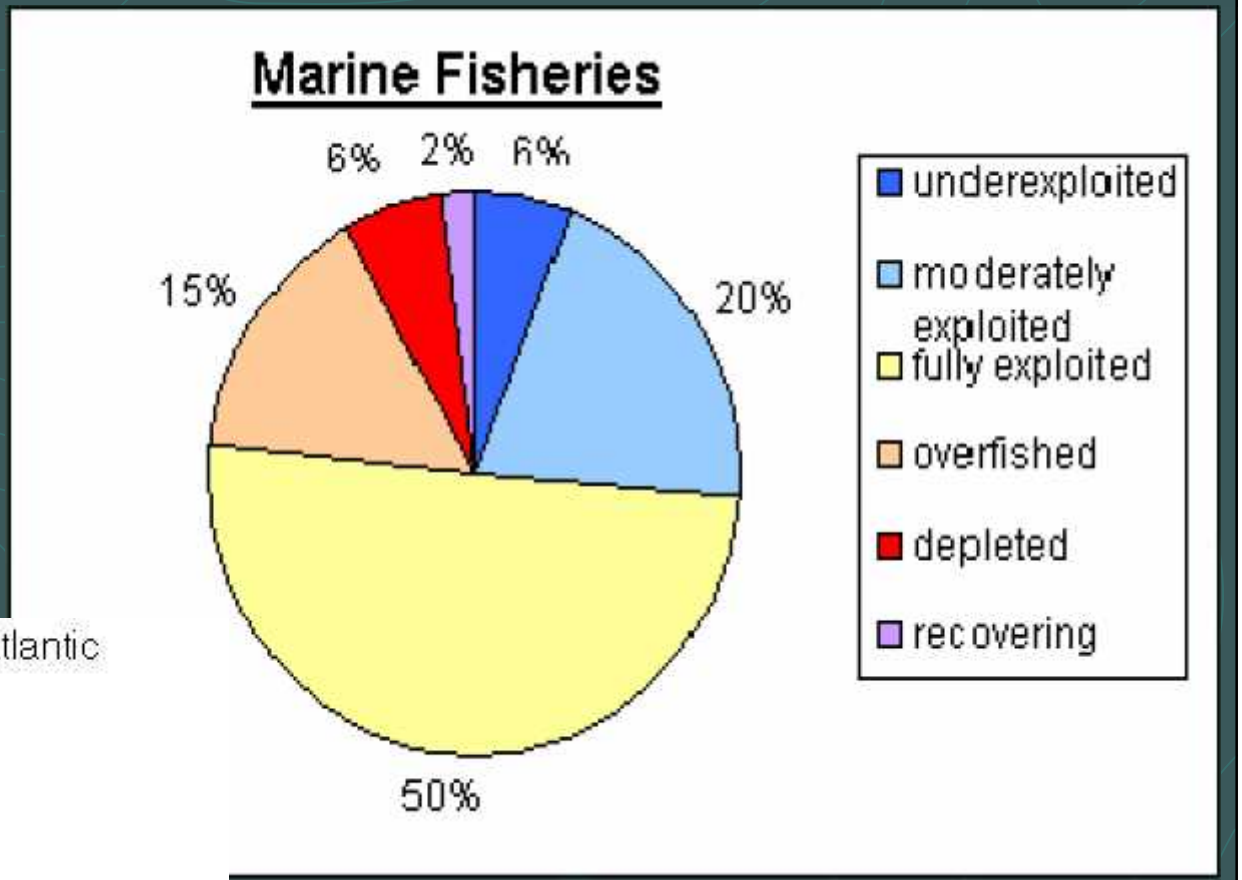
4) Marine aquaculture has several environmental drawbacks.

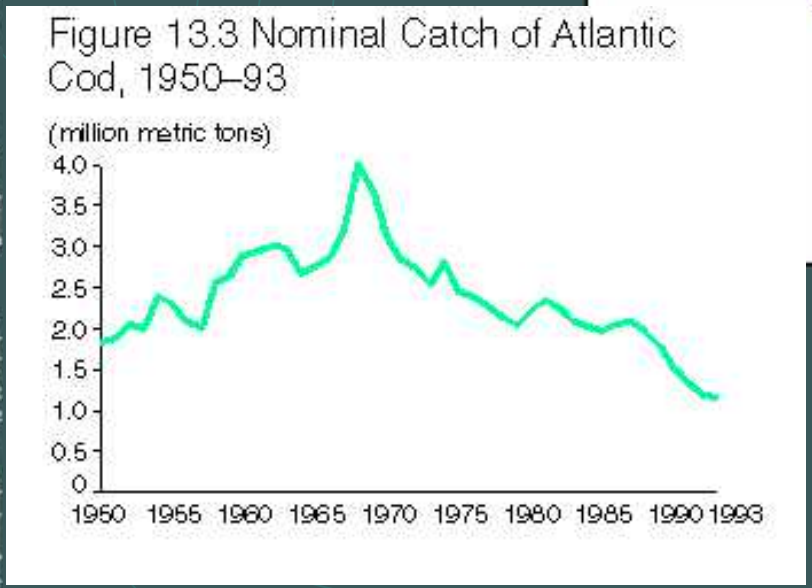
- Need for large amounts of wild catch bait feed stocks
- Farmed fish live in small penned waters that have high concentrations of waste materials

Exploitation of the Marine Fisheries

Major Points

- ✓ 50% Fully exploited
- ✓ 20% Mod exploited
- ✓15% Overfished
- ✓ 6% Depleted



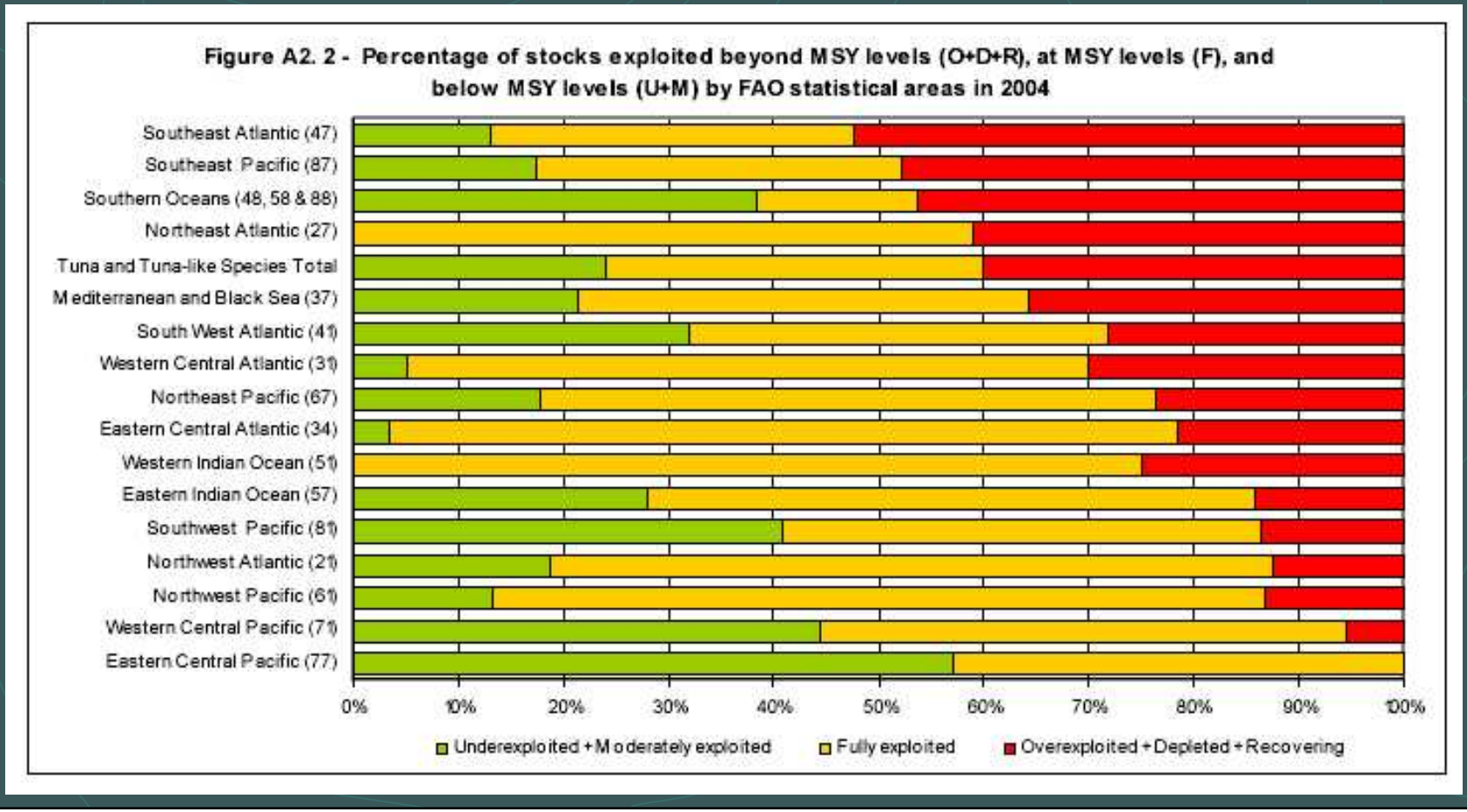


Atlantic Cod: Example of Fish Depletion

Global Marine Fisheries – Exploitation by Region

Key

- ✓ Red = Overexploited
- ✓ Yellow = Fully Exploited
- ✓ Green = Under to Moderately Exploited



Threatened Pacific Coast Fisheries

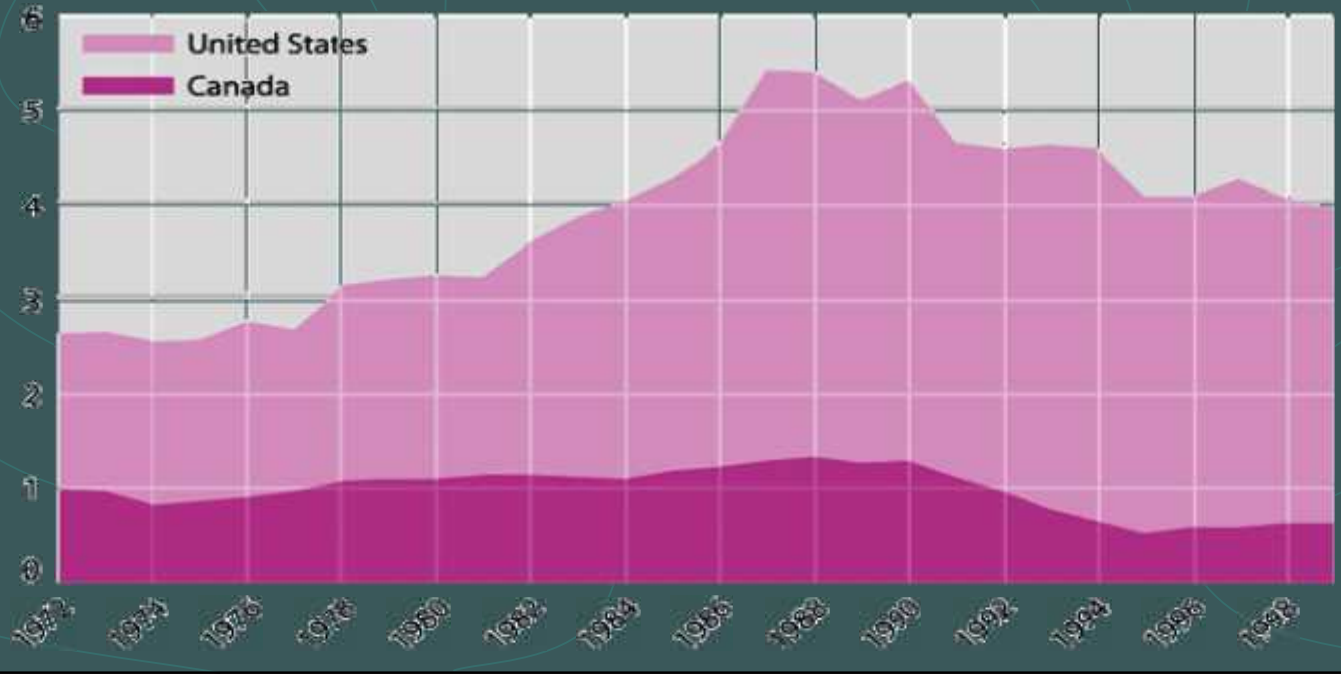
2010 overfished stocks

Pacific

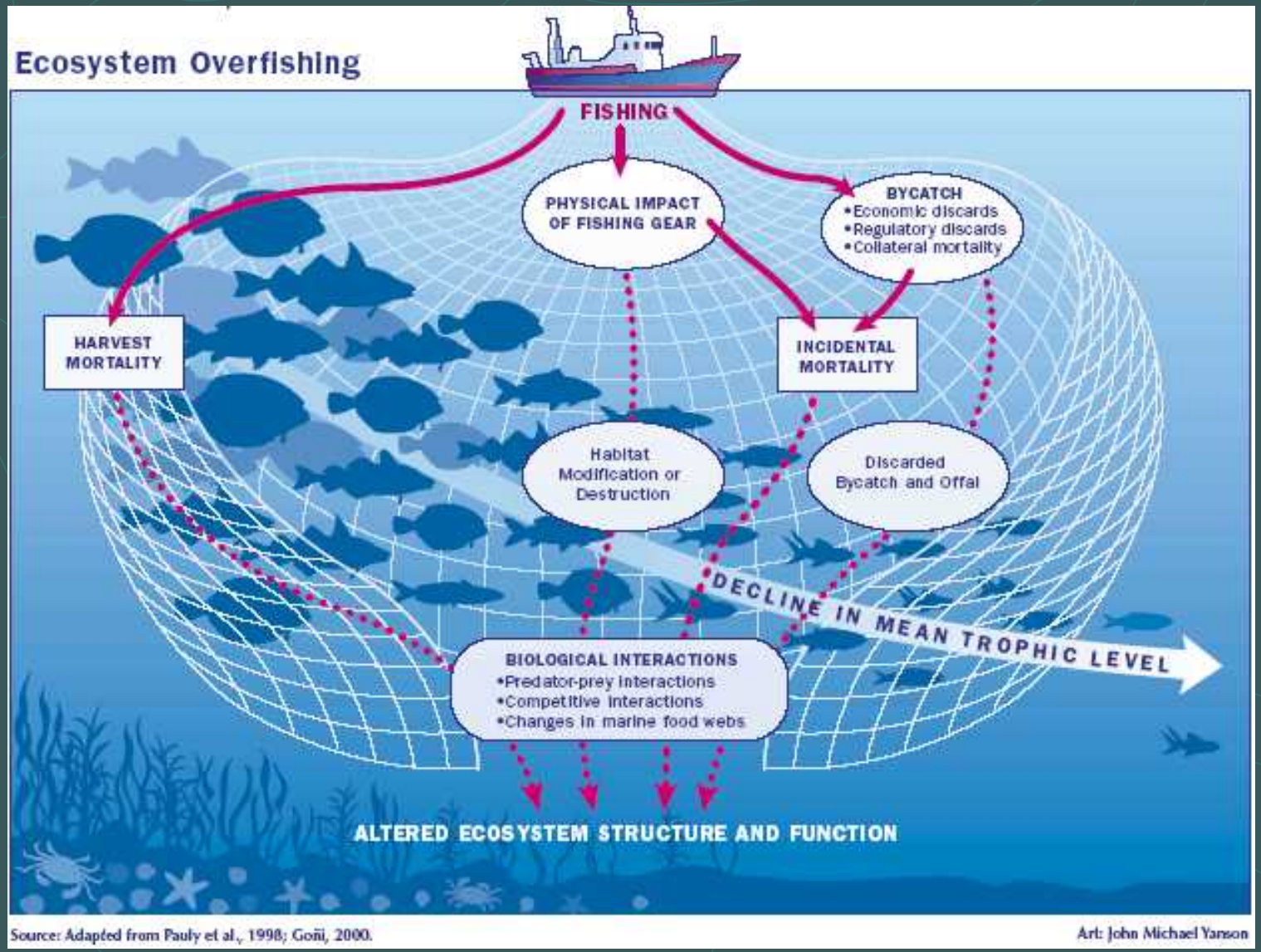
1. Canary rockfish
2. Cowcod
3. Petrale sole
4. Chinook salmon
   California Central Valley:
   Sacramento (fall)
5. Coho salmon
   Washington Coast: Queets
6. Coho salmon
   Washington Coast:
   Western Strait of Juan de Fuca
7. Yelloweye rockfish

6 Factors Leading to Fishery Decline

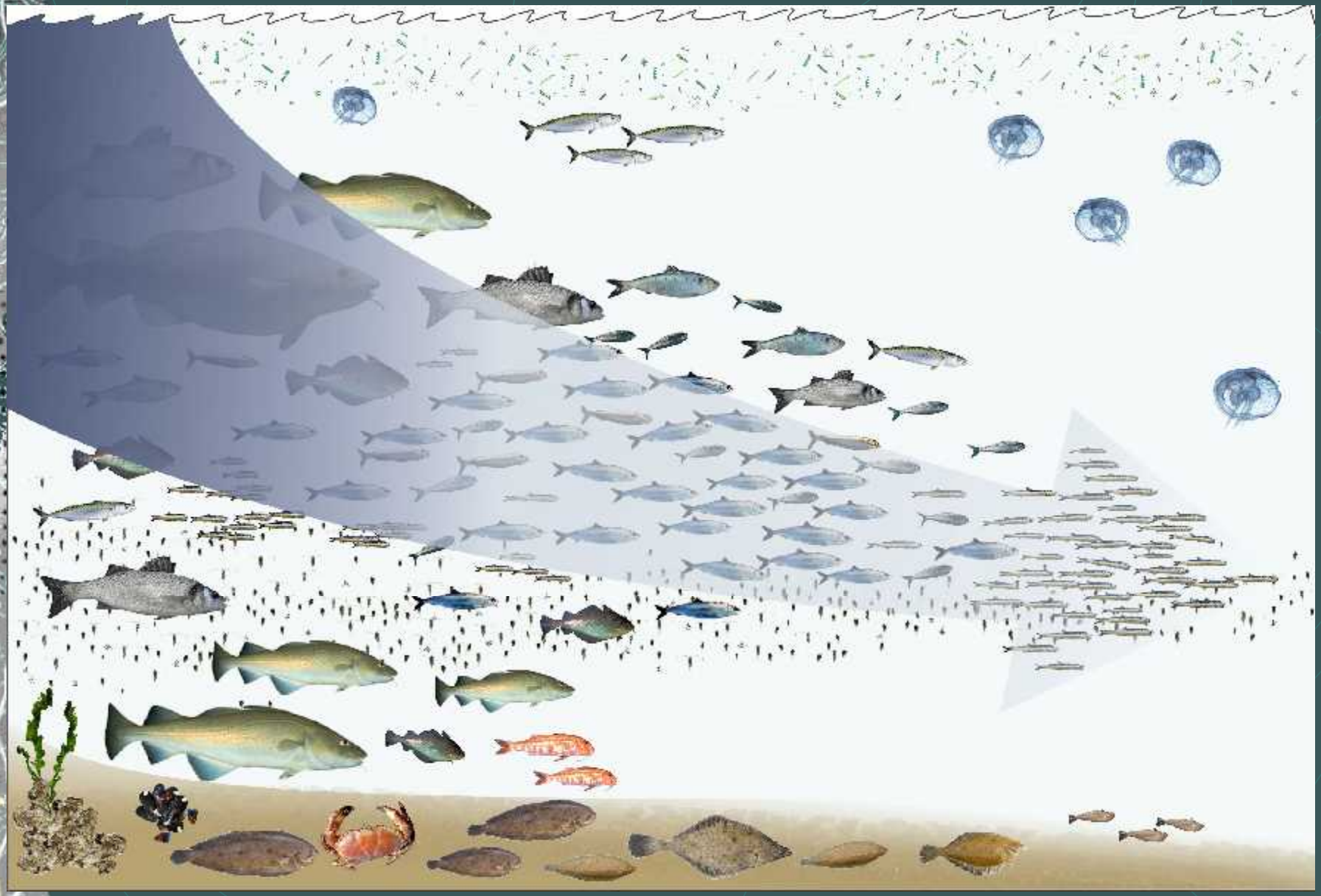
- 1) Depletion of large, mature fish
- 2) Increased fishing for smaller bait fishes
- 3) Increasing consumer demand
- 4) Fishing techniques – Too good, too big, bad techniques
- 5) Pollution
- 6) Climate changes



Overfishing the Ocean



Fishing Down the Trophic Levels



Overfishing and Bycatch Concerns

The catch from the recovered net (64% moratorium species). This mix of species is consistent with a "take-it-all" fishing strategy.

Measuring the recovered net using a gauge. Juvenile fish cannot escape through the small (illegal) mesh.

Shrimp trawl catch. The 95% of the catch in this photo that was not shrimp died on deck and was shoved overboard.

Types of Ocean Fishing Techniques

- ✓ Trawling
- ✓ Fixed Netting
- ✓ Drift Netting
- ✓ Purse Seining
- ✓ Pole Hooking
- ✓ Longline Hooking
- ✓ Trapping
- ✓ Others

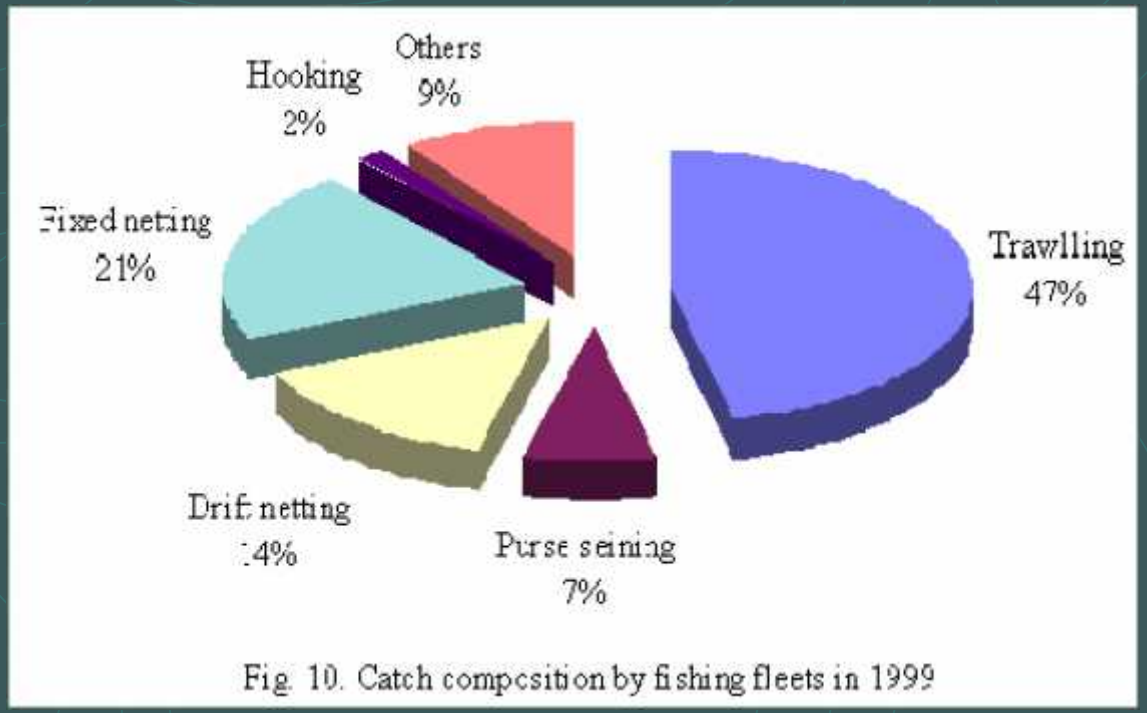


Fig. 10. Catch composition by fishing fleets in 1999

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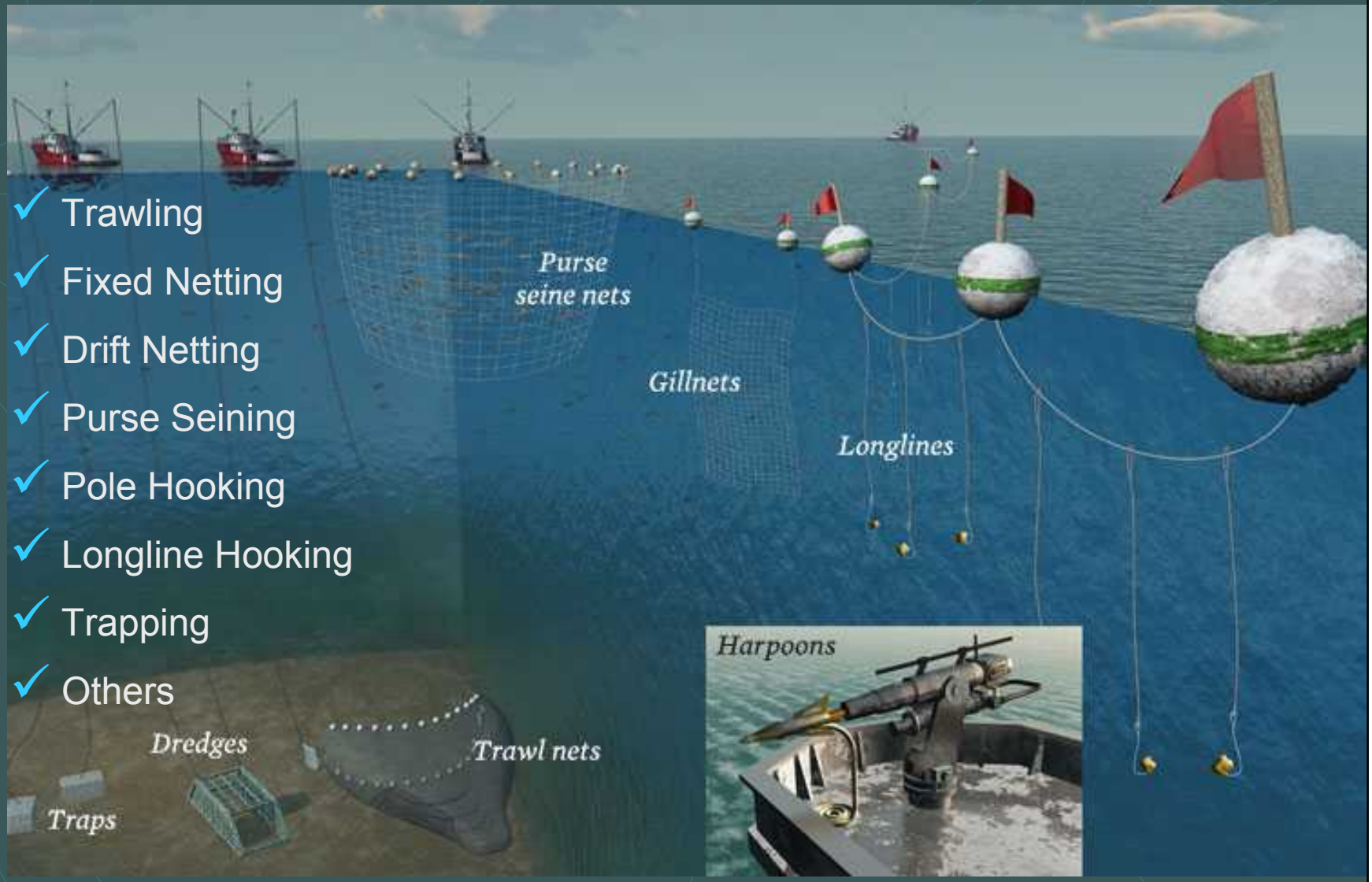

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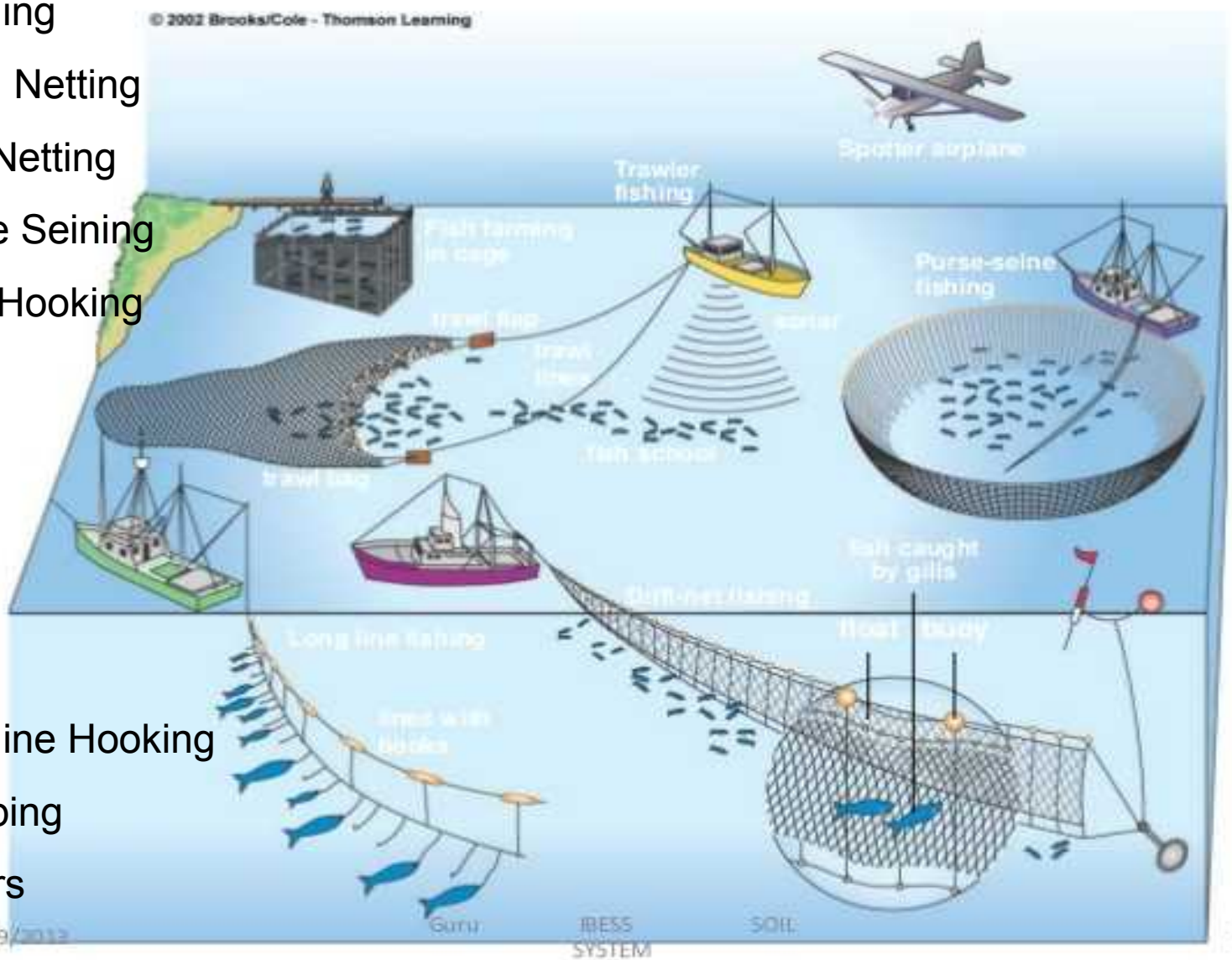
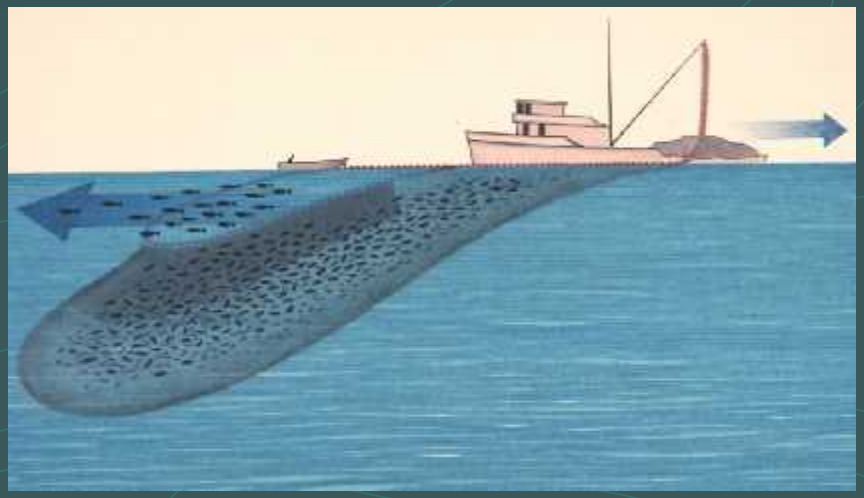


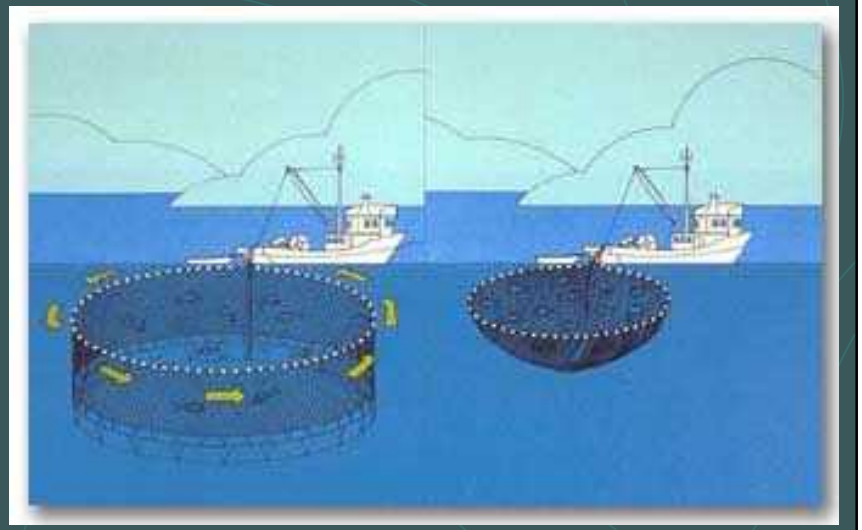
“OK” Large-Scale Fishing Techniques

Pole/Line Hooking

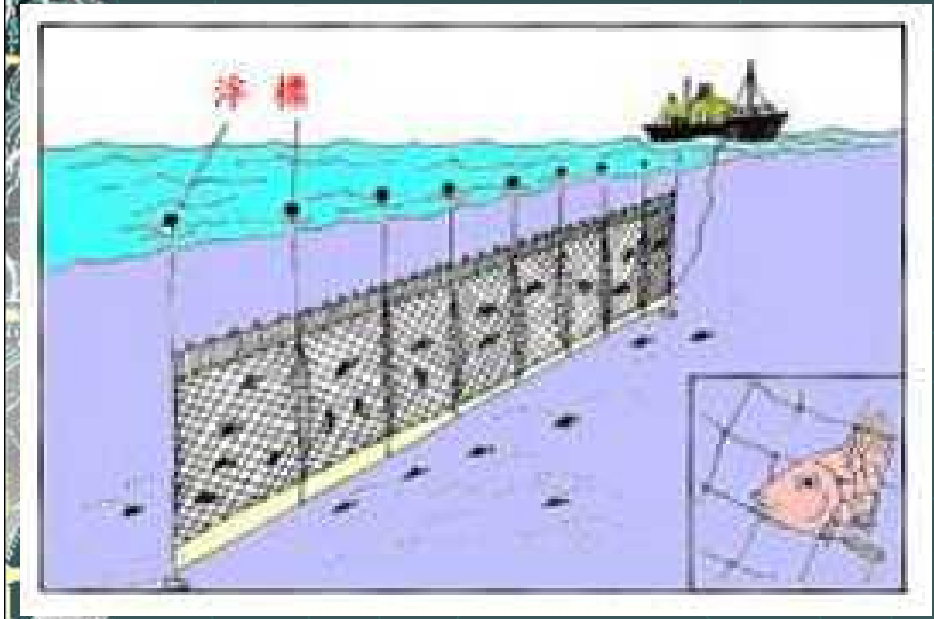


Surface Trawling

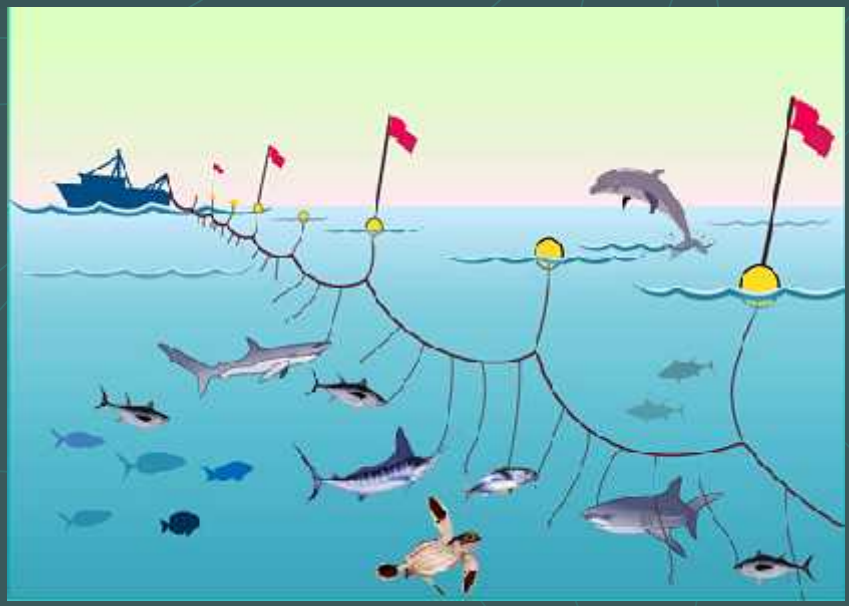
Seining



“Bad” Large-Scale Fishing Techniques



Drift-Gill Netting



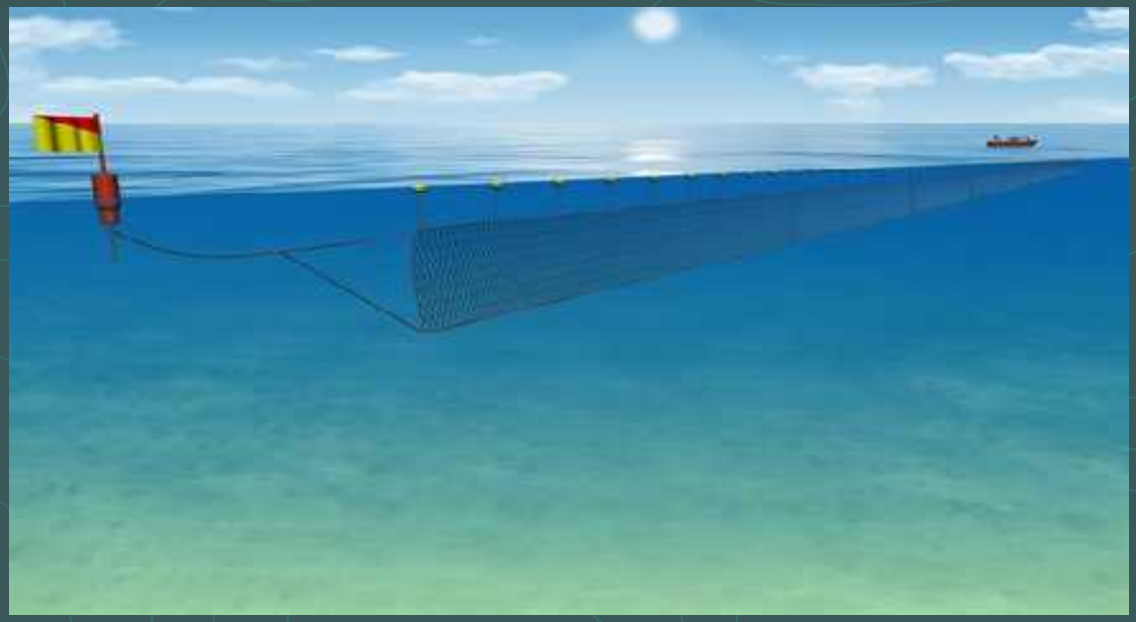
Long-Line Hooking

Bottom Trawling

Bottom Trawling - Function / Problems

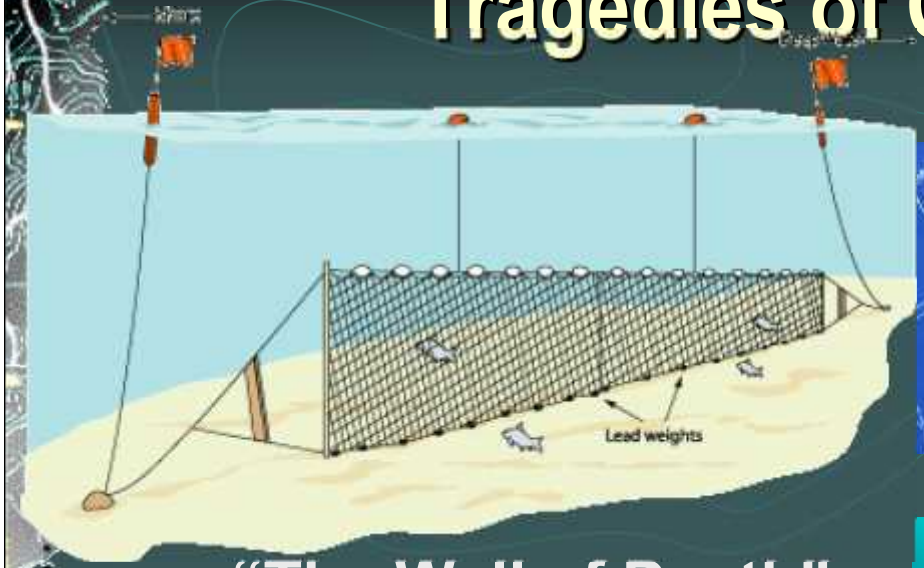
https://www.youtube.com/watch?v=bUHcD_jTgVA

Drift Netting – Function / Problems



https://www.youtube.com/watch?v=R8-2gI9fFSE

Tragedies of Gill and Drift Netting



"The Wall of Death"

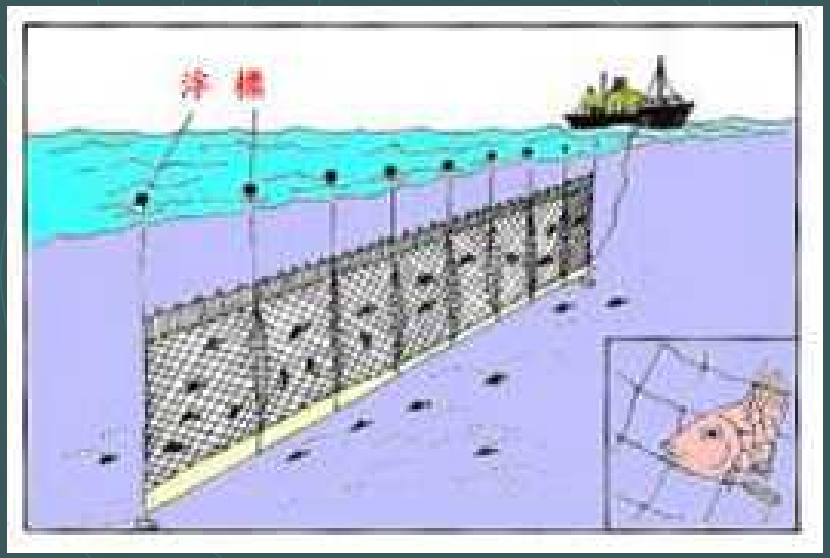
Hidden Costs of Gill and Drift Netting

Net Gain

Net Loss

Cut Losses

Ban all gillnets

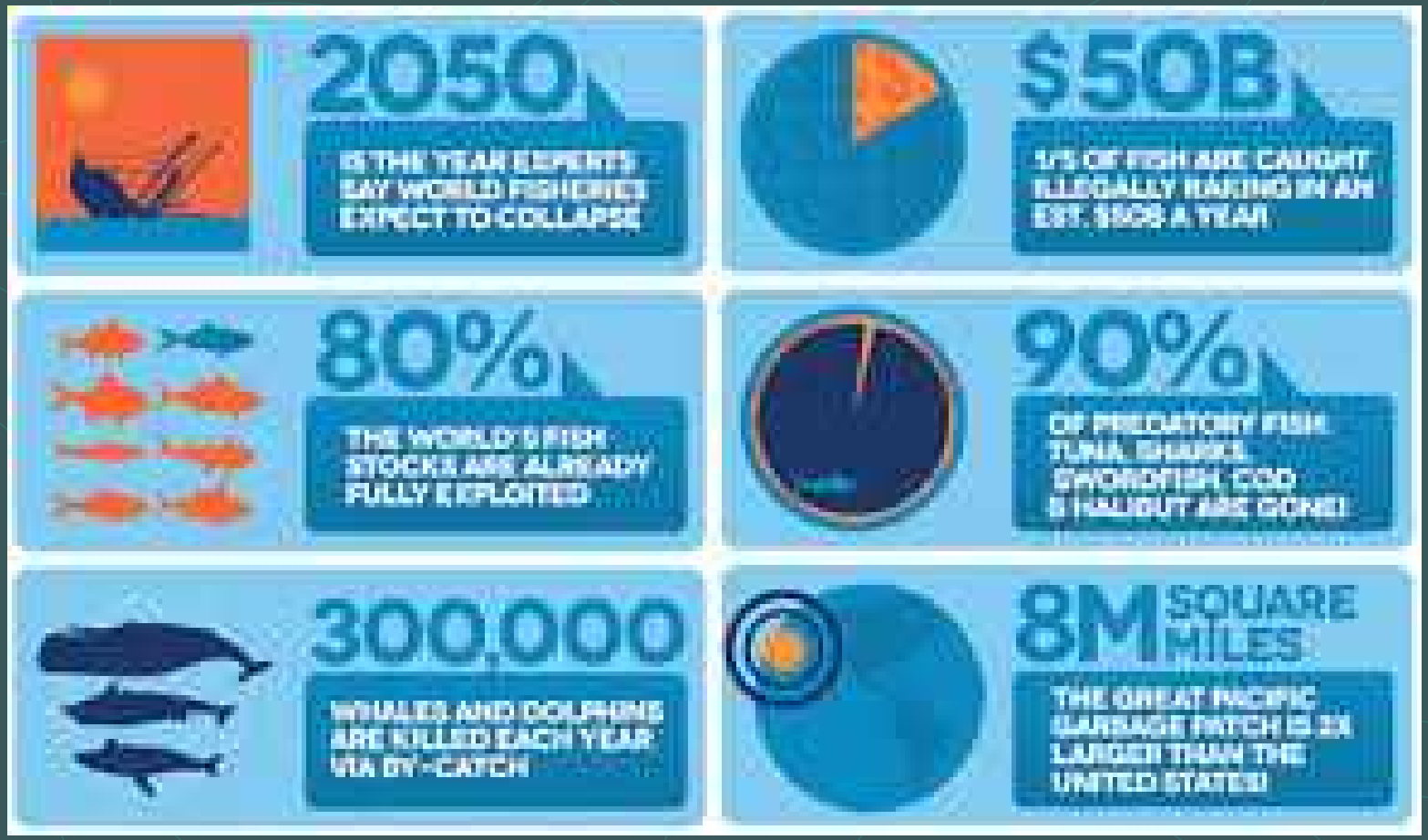


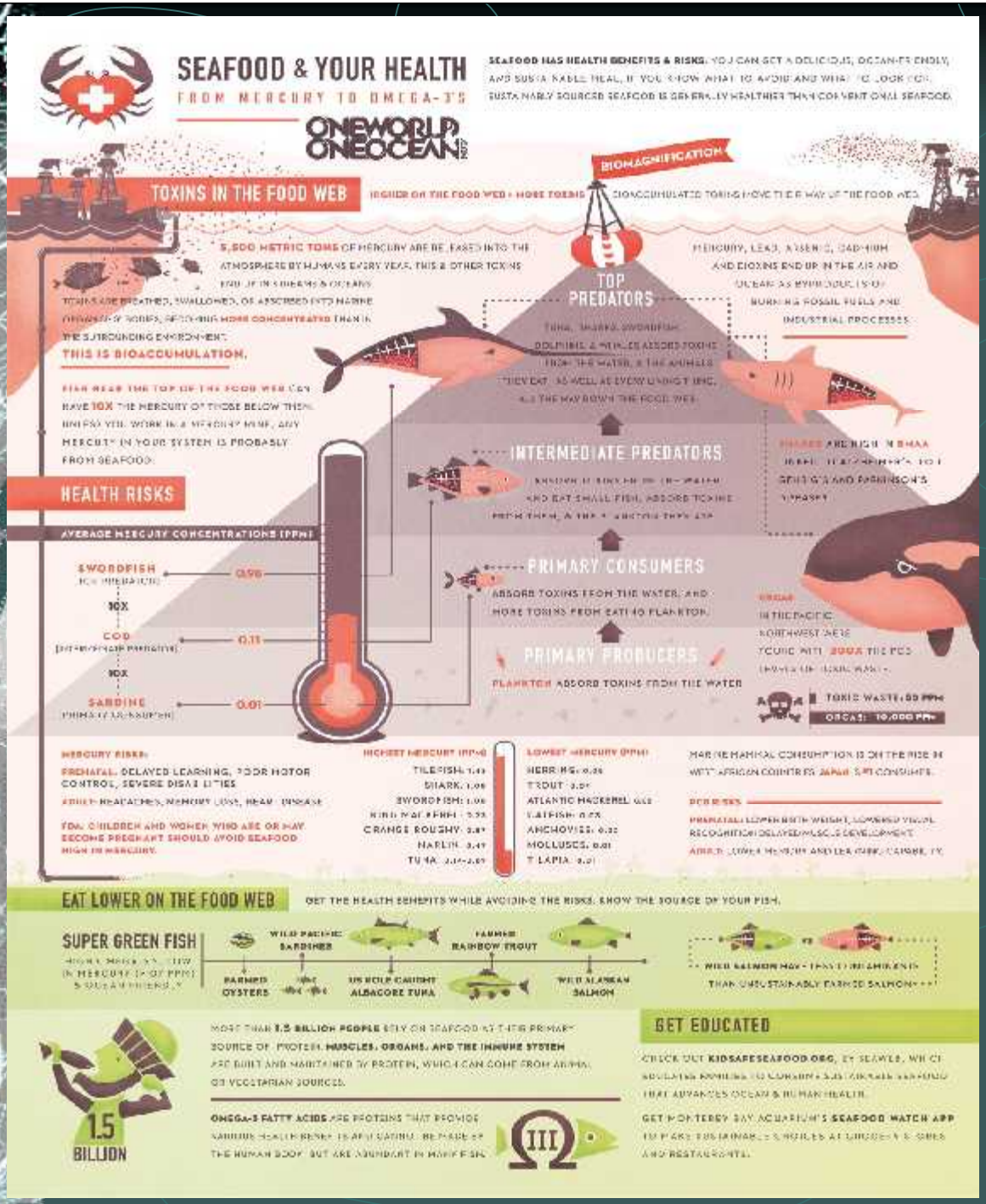
"The Wall of Death"

Recovered "lost" drift netting

FLAGS OF CONVENIENCE OCEAN FISHING

Scary Fishing Facts





Seafood and Your Health

1) Toxins in food web
2) Lower toxins, the lower the trophic level
3) Eat lower on the food web
4) Eat sustainably caught seafood

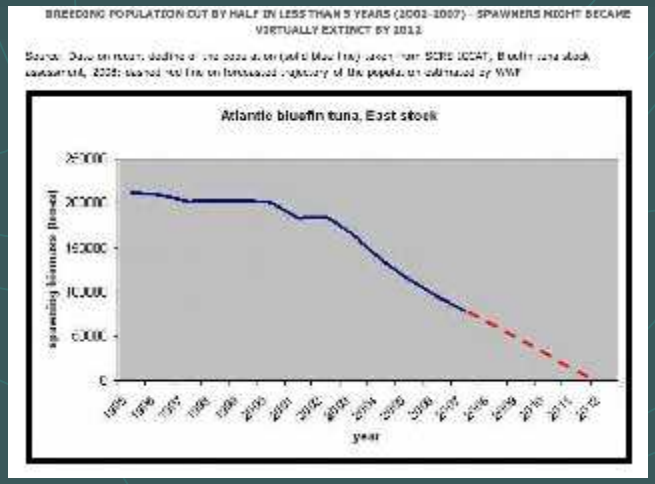
Climate Change Effects on Ocean Fisheries

POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE ECONOMICS OF FISHERIES

Based on information from published literature

IMPACTS	REGIONS	CATCH	PRICES	COST	
				Fishing	Adaptation
Shift in distribution of species	Arctic	• **Catch potential**: increase • Invasion of warmer water species	↓	↓	↑
	Temperate	• **Catch potential**: no change • Changes in species composition resulting from both species gains and losses	Not yet known	Not yet known	↑
	Tropics	• **Catch potential**: decrease • Species losses	Not yet known	↑	↑
Ocean acidification	Global	• **Catch potential**: decrease	↑	↑	↑
Expansion of oxygen minimum zones	Global	• **Catch potential**: decrease	↑	↑	↑
Reduction in body size	Global	• No change	↑	No change	↑
Increased variability	Global	• No change	↓ Variable ↑	↑	↑
Increased extreme weather	Global	• **Actual catch**: decrease	↑	↑	↑

Case Study: The Bluefin Tuna



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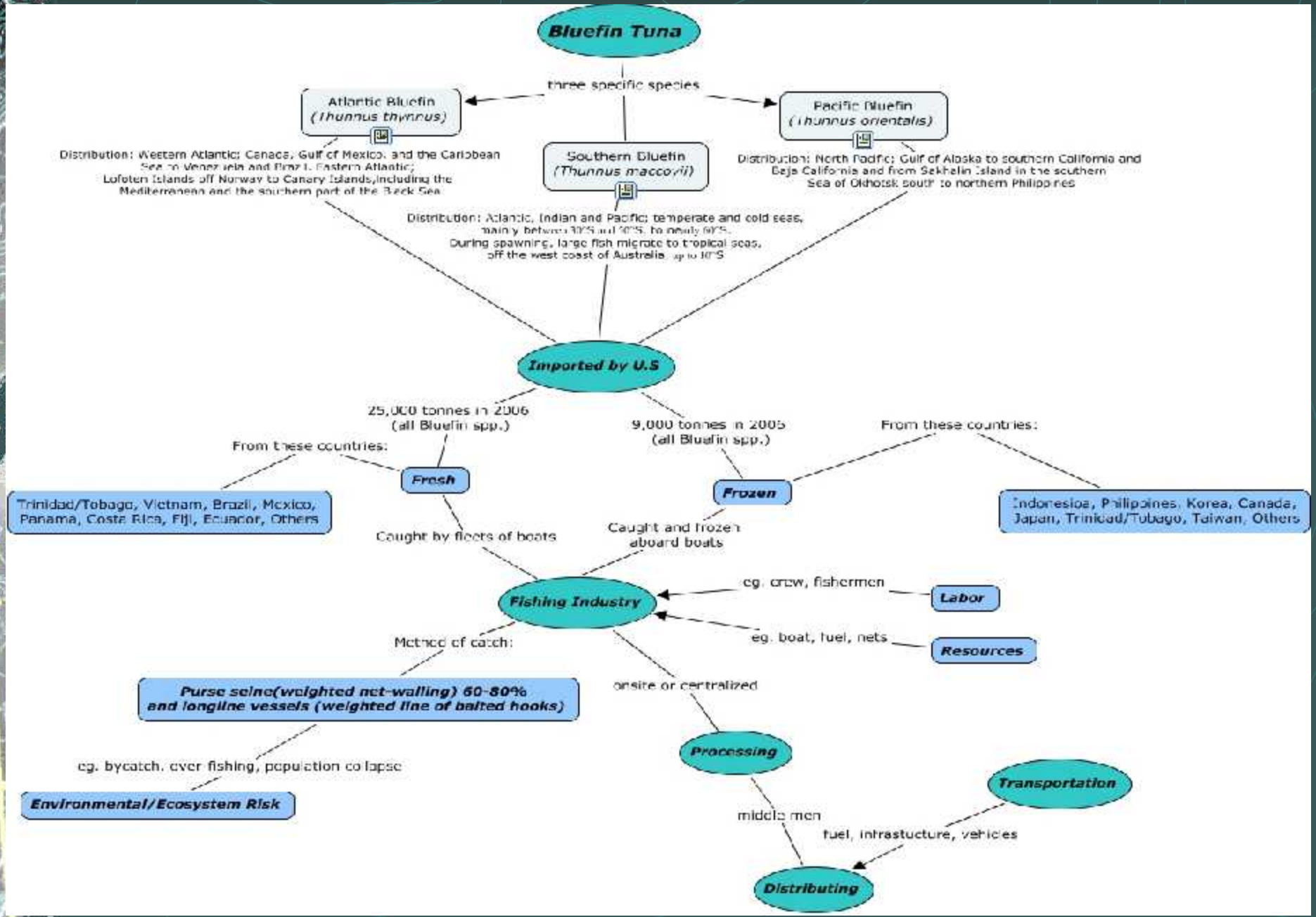
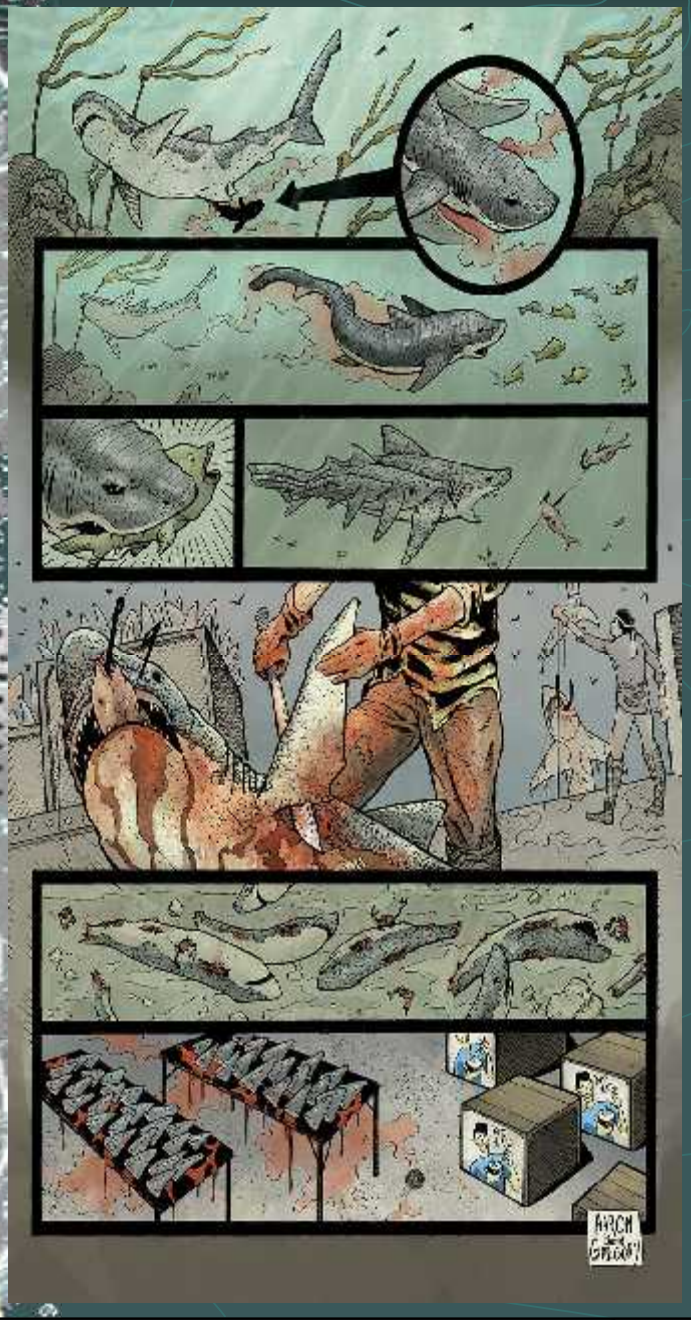


Case Study: Shark-Finning



WHAT IS SHARK FINNING?

ENDANGERED RATE

AN ESTIMATED **32%** OF OPEN OCEAN SHARKS ARE THREATENED WITH EXTINCTION

SOME SHARK POPULATIONS HAVE DECREASED BY **99%** OVER THE LAST **50** YEARS

WHAT'S HAPPENING?

AN ESTIMATED **100 MILLION** SHARKS ARE KILLED EVERY YEAR

73 MILLION EQUIVALENT TO 1.73 MILLION TONS OF SHARK

WHAT IS FINNING?

SHARKS ARE CAPTURED AT SEA

HAULED ON DECK

AND ARE OFTEN STILL ALIVE WHEN THEIR FINS ARE SLICED OFF

THE MAIMED ANIMALS ARE USUALLY TOSSED OVERBOARD TO DROWN OR BLEED TO DEATH

UP TO **98%** OF THE ANIMAL IS WASTED, SINCE THE FINS ARE MORE VALUABLE THAN THE REST

THE BUSINESS OF SHARK FINS

FINS CAN SELL FOR AS MUCH AS USD $880 PER POUND

MAKING IT ONE OF THE MOST EXPENSIVE SEAFOOD PRODUCTS IN THE WORLD

$100 A BOWL OF SHARK FIN SOUP CAN SELL FOR AS MUCH AS $100 PER BOWL

IN HONG KONG 88% OF PEOPLE SURVEYED HAVE EATEN SHARK FIN SOUP AT A WEDDING BANQUET

145 COUNTRIES PARTICIPATE IN THE GLOBAL SHARK FIN TRADE

50 to 80% OF FINS COME THROUGH HONG KONG

AS MANY AS **360** RESTAURANTS STILL SERVE SHARK FIN SOUP IN CALIFORNIA

85% OF THE US SHARK FIN TRADE IS IN CALIFORNIA

THE IMPORTANCE OF SHARKS

SHARKS ARE AT THE TOP OF THE FOOD CHAIN, THEIR DEPLETION CAN DRASTICALLY AFFECT THE ENTIRE MARINE ECOSYSTEM

SHARKS ARE SLOW GROWING, LATE MATURING, LONG LIVED AND GIVE BIRTH TO FEW YOUNG, MAKING THEM ESPECIALLY VULNERABLE TO OVERFISHING

$2 MILLION DOLLARS THE TOURISM VALUE EACH INDIVIDUAL FREE SHARK CAN CONTRIBUTE TO A COASTAL COMMUNITY OVER IT'S LIFETIME

$108 DOLLARS THE VALUE OF A SHARK KILLED FOR CONSUMPTION

80 Hg MERCURY

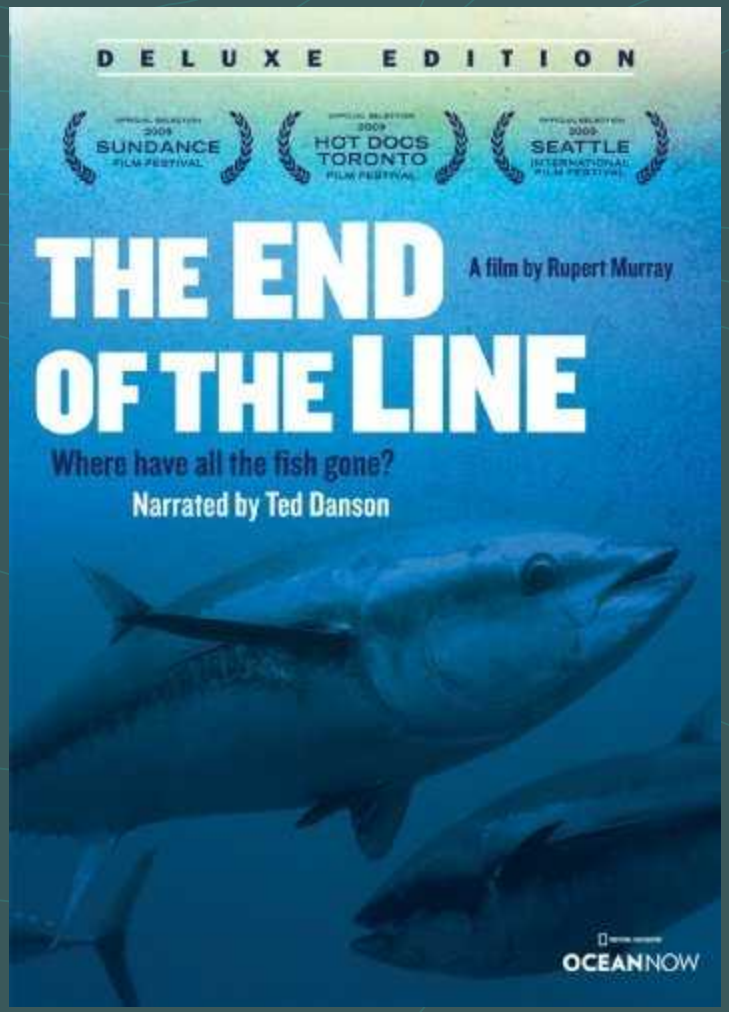
CONTRARY TO THE MYTH THAT SHARK FINS ARE NUTRITIONAL, SHARK FINS HAVE MERCURY LEVELS UP TO **42X** HIGHER THAN THE SAFE LIMIT

WILDAID

DESIGNED BY: Kirk Hanson

SOURCES: International Union for the Conservation of Nature; Australian Institute of Marine Science; Bloom Association; Journal of Wildlife Conservation; Oceana; Pew Environment Group; Shark Savers

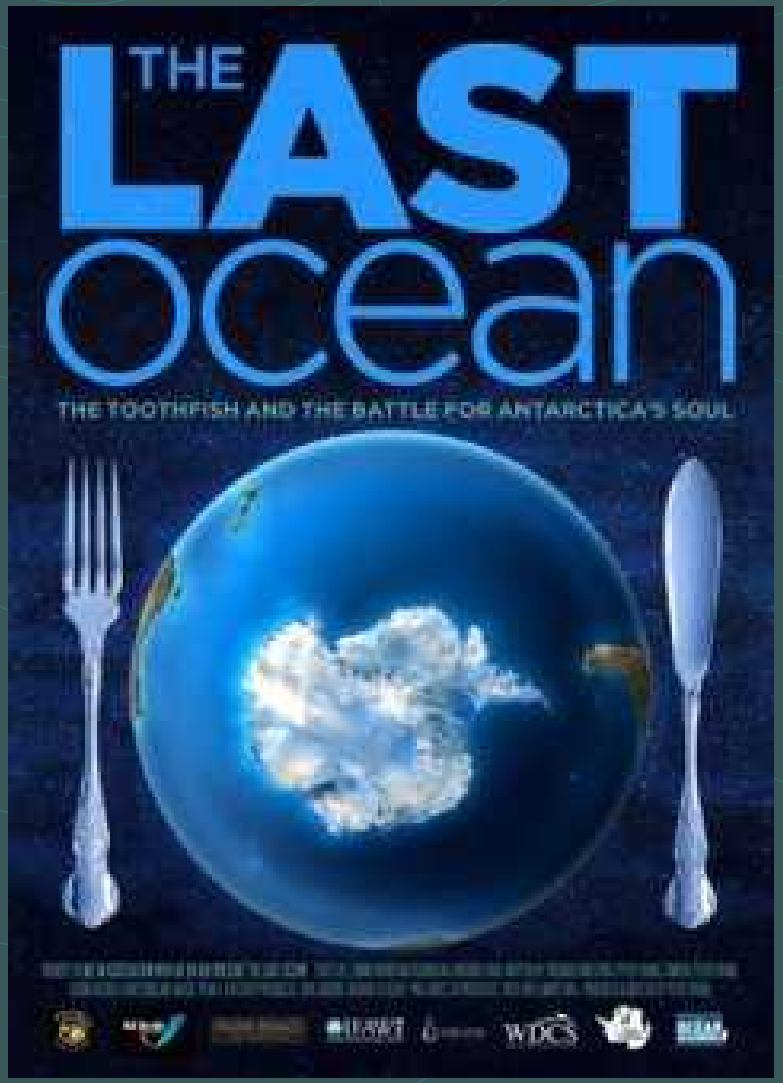
- End of the Line - Fishing Documentary



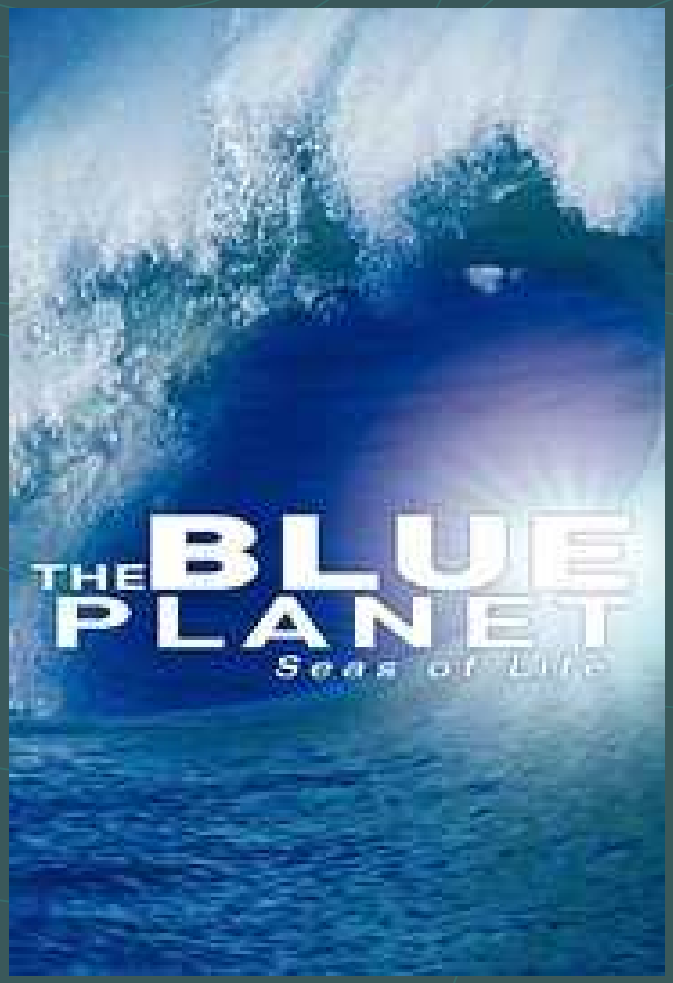
- Troubled Waters - Fishing Documentary

- The Last Fish – Fishing Documentary

- The Last Ocean - Fishing Documentary



- Deep Trouble -
Fishing Documentary



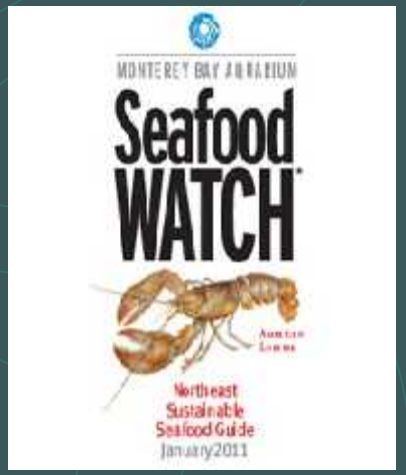
- Fishing Wars - Fishing Documentary

Consuming Ocean Fish Responsibly

Question: Which fish are safe to harvest and consume for you and the ocean ecosystems?

Seafood List http://www.edf.org/page.cfm?tagID=1540

Sushi List http://www.edf.org/page.cfm?tagID=1540



Homework Assignment: 3 points

1) Print out a Seafood Watch booklet
2) List three of your favorite types of seafood.
3) Locate your favorite seafood in the booklet
4) Note the column choices of your favorite seafood: BEST CHOICES / GOOD ALTERNATIVES / AVOID
5) Write down only those choices that are found in the first two columns.
6) If you had any “BAD” choices, substitute with alternative BEST/GOOD choices

Non-food Uses of Biological Ocean Resources

- Medical
- Chemicals
- Perfumes
- Farming
- Textiles
- Paints and pigments
- Pharmaceuticals
- Paper

Marine Life Resources
Discussion

PHYSICAL MARINE RESOURCES

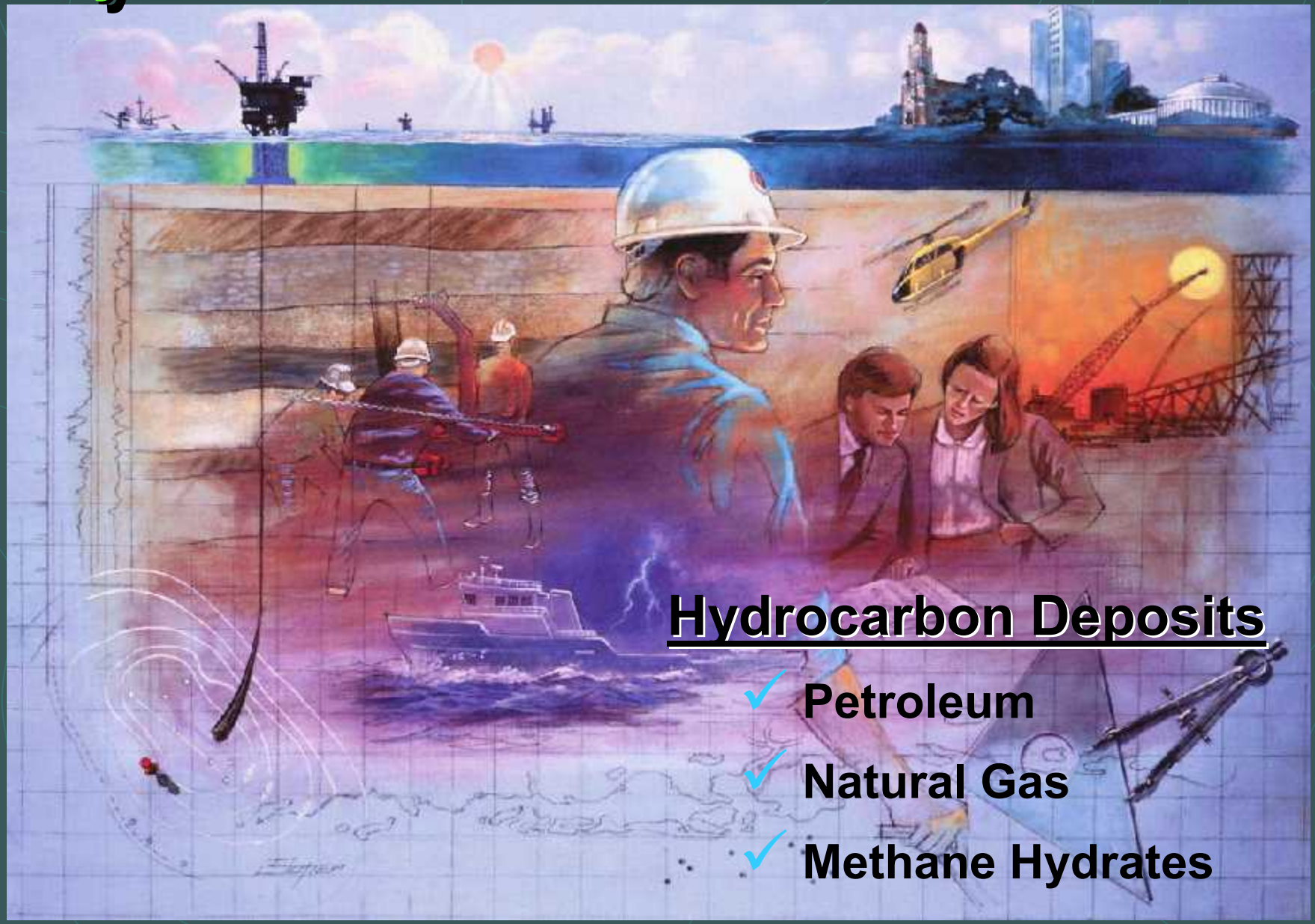
1) Hydrocarbon Deposits

- ✓ Petroleum
- ✓ Natural Gas
- ✓ Methane Hydrates

2) Mineral Deposits

- ✓ Sand and Gravel
- ✓ Magnesium
- ✓ Salts
- ✓ Manganese Nodules
- ✓ Phosphorite
- ✓ Metallic Sulfides and Muds
- ✓ Fresh Water

Hydrocarbon Marine Resources



Hydrocarbon Deposits

- ✓ Petroleum
- ✓ Natural Gas
- ✓ Methane Hydrates

PETROLEUM and GAS RESOURCES

1. Petroleum and natural gas found under continental shelf

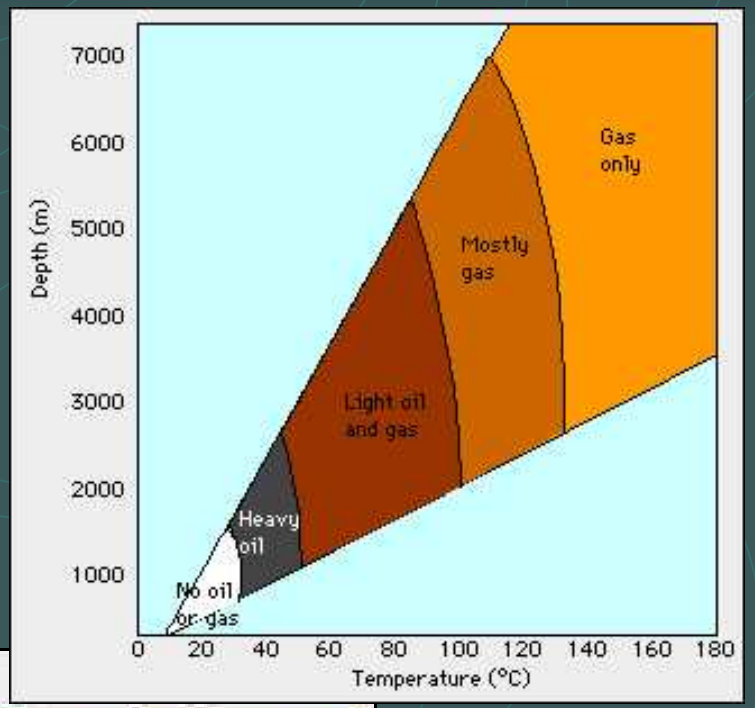
- ✓ Roughly 35% of world's petroleum production comes from seabed
- ✓ Roughly 26% of world's natural gas production comes from seabed
- ✓ About 1/3 of all known world reserves of oil and gas are marine
- ✓ Deep seafloor contains little to no oil or natural gas

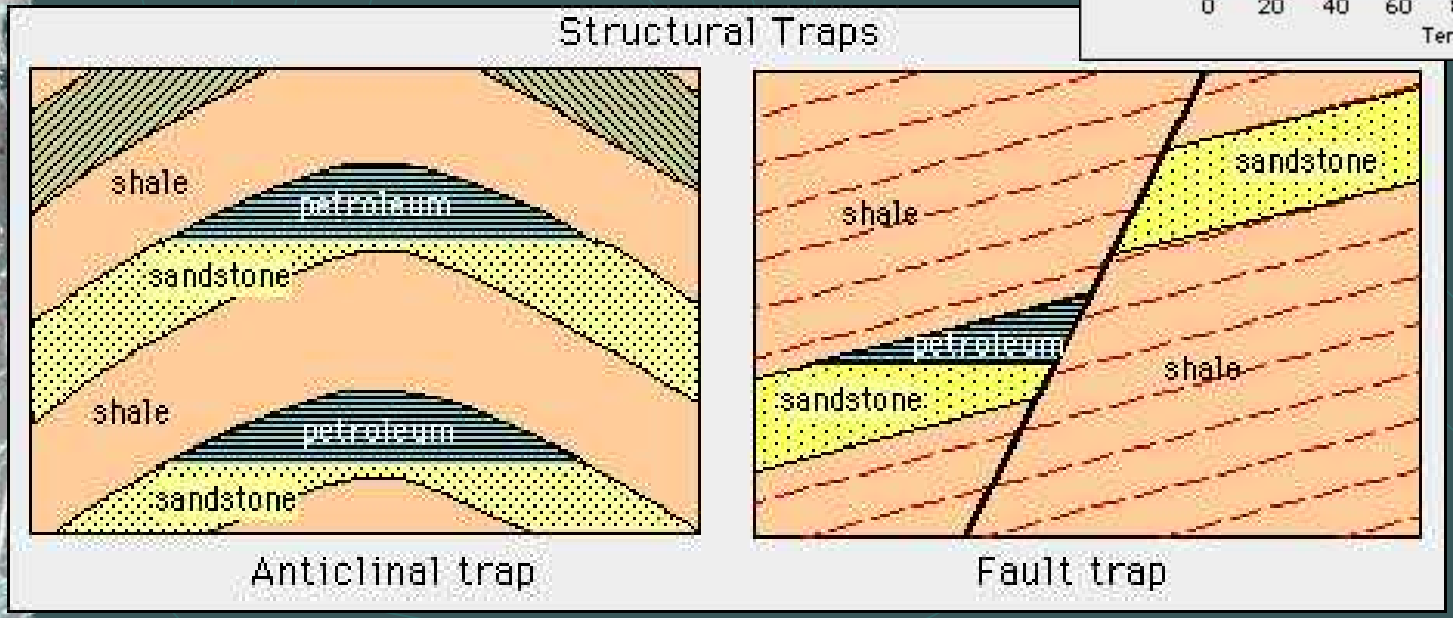
2. Formation of petroleum and gas deposits requirements

- ✓ Massive accumulation and burial of tiny marine organisms
- ✓ Low-oxygen depositional environment in closed marine basins
- ✓ Anaerobic bacteria action and deep burial temperature and pressures convert complex organic tissue to simpler hydrocarbons
- ✓ Development of structural traps due to folding and faulting
- ✓ Structural traps must have a reservoir rock and overlying cap rock

FORMATION of PETROLEUM and GAS DEPOSITS

1. Need the right temperature and pressure
2. Need proper rock types and structure to trap the petroleum and gas deposits

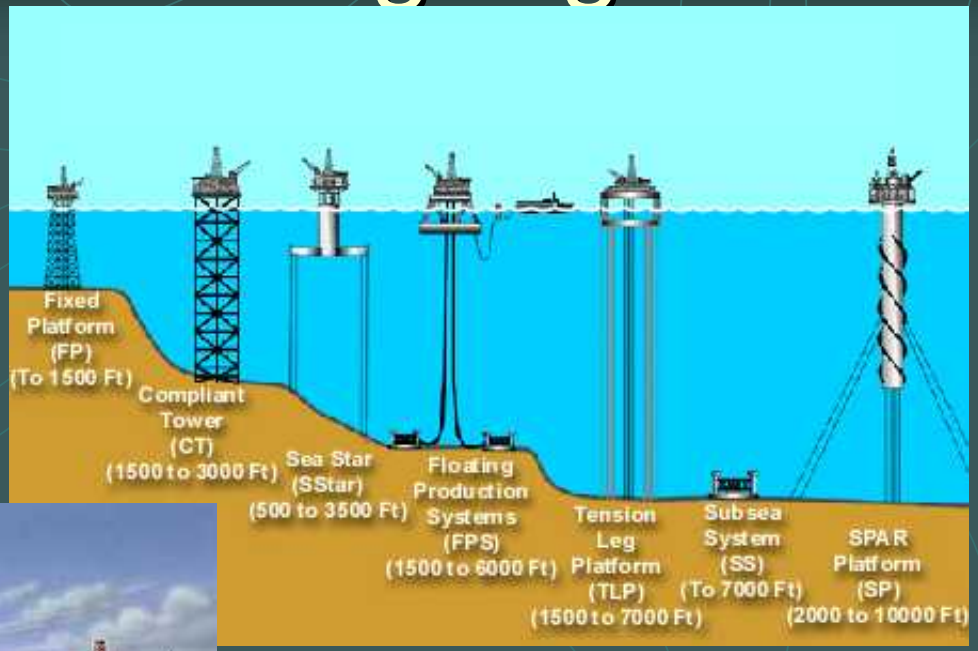


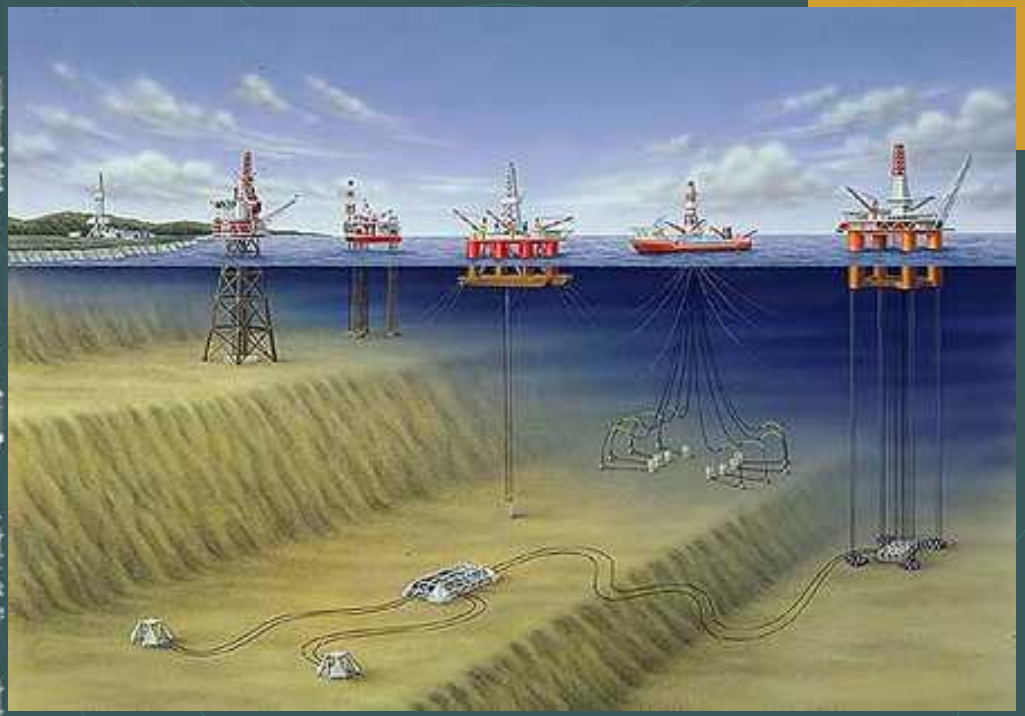


Offshore Drilling for Oil and Gas

Types of Offshore Drilling Rigs

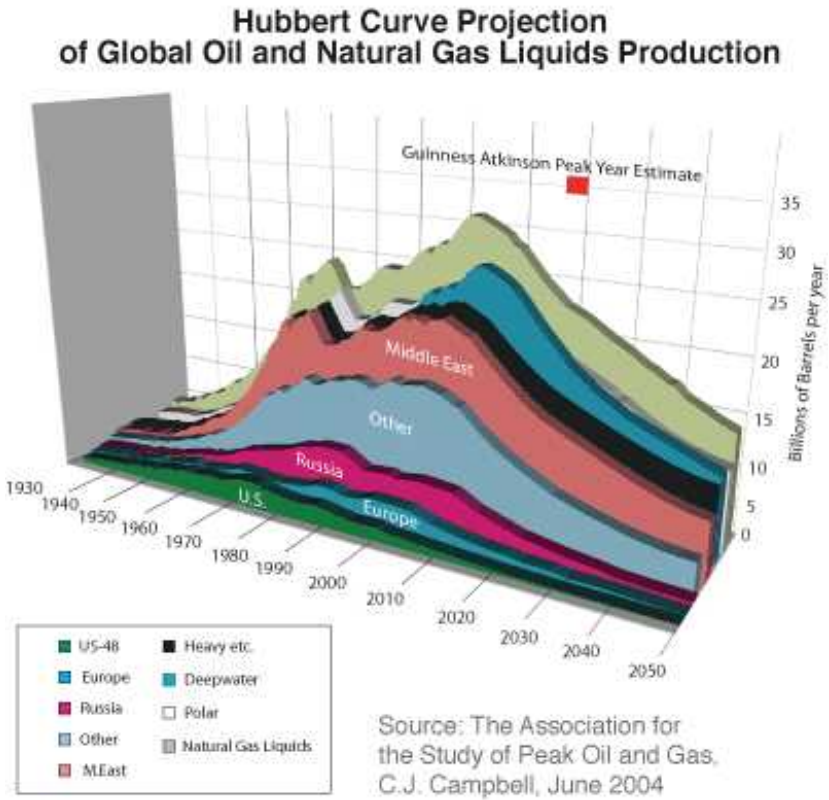
- Fixed Platform
- Compliant Tower
- Sea Star
- Floating Platform

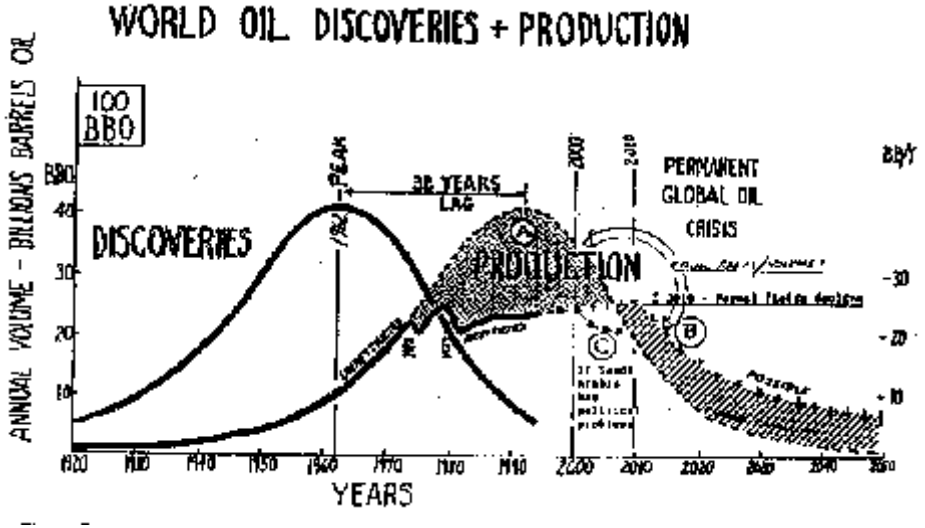


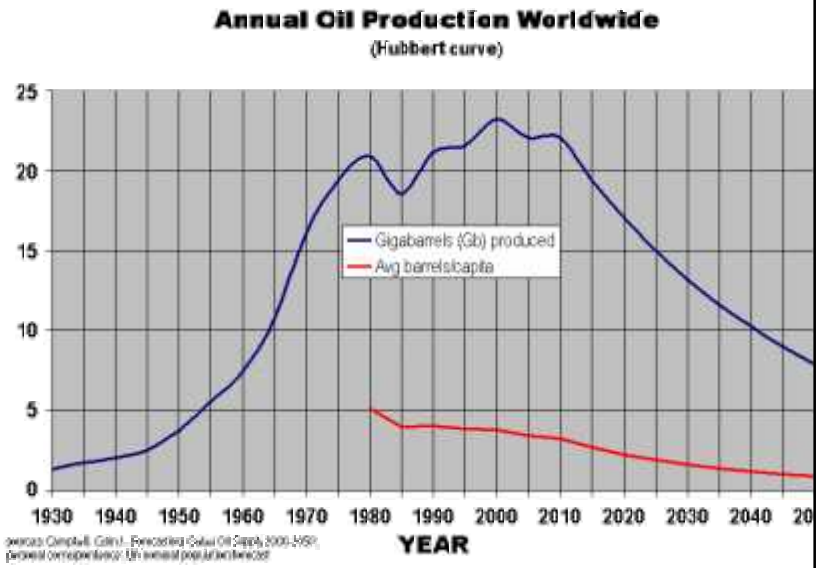


- Tension Leg Platform
- Subsea System
- SPAR Platform
- Floating Drill Ship

Oil Discoveries Versus Production

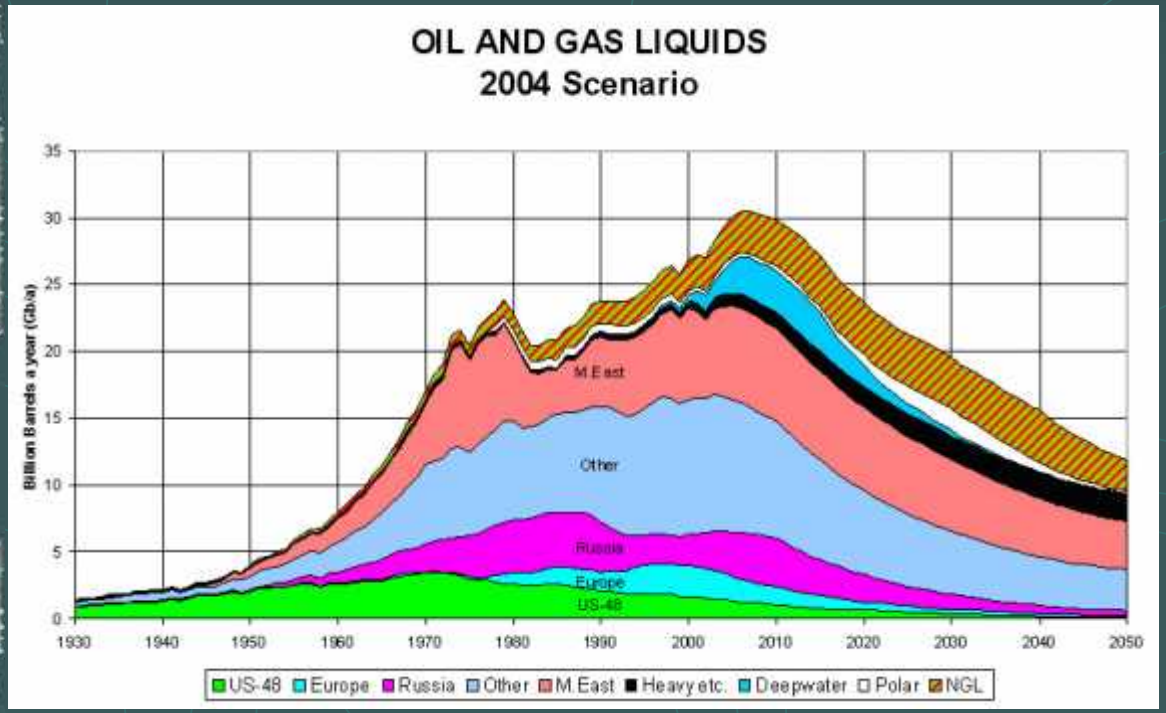


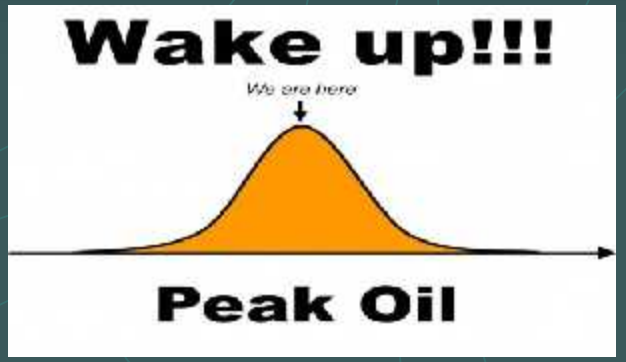




- Discoveries precede Production
- Discoveries peaked in the 1960's
- Production is soon to peak
- Timing of production peak (peak oil) is controlled by several factors

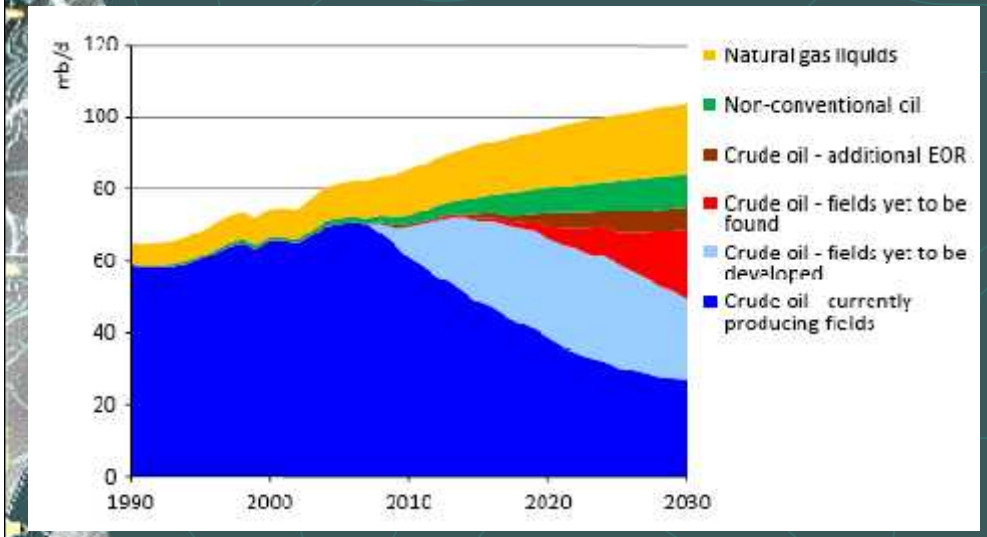
The Global PEAK OIL Scenario

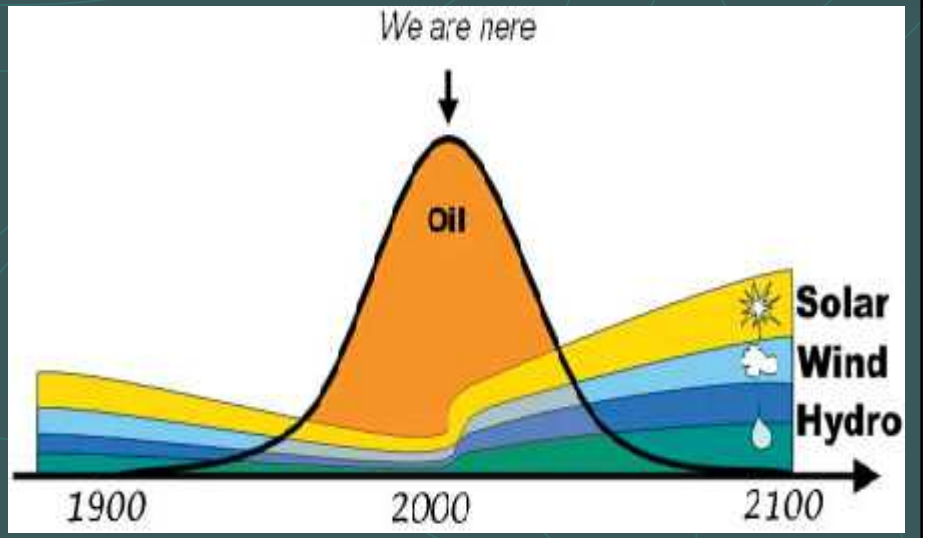




- Topping out of oil production is called “peak oil”
- Each oil-producing regions has its own “peak oil”
- Production has already peaked in some regions and is soon to peak in others
- Question 1: Has the USA oil production peaked yet?
- Question 2: Global “peak oil” is inevitable. Why?

"Solutions" to Global PEAK Oil?



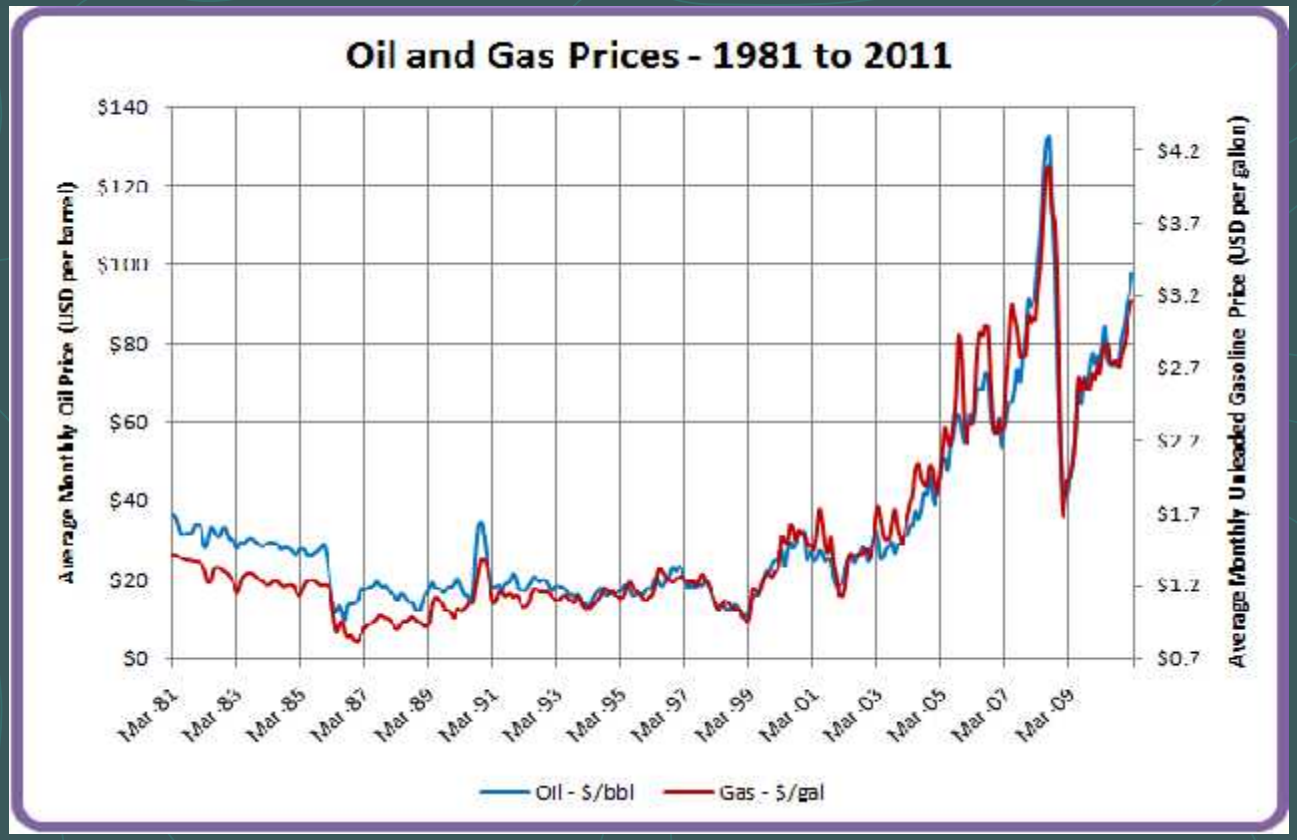


Most-likely Short Term Solution

Alternative Energy Solution

- Once global "peak oil" occurs, other energy sources MUST replace oil in order to satisfy world's increasing energy demands.
- Several viable substitutes for crude oil. **Question:** What are they?
- Energy substitutes must have several attributes to make it viable.
- **Question:** What must a major energy source have to make it a viable global-scale replacement for crude oil? Best contenders?

The Cost of Oil and Gasoline

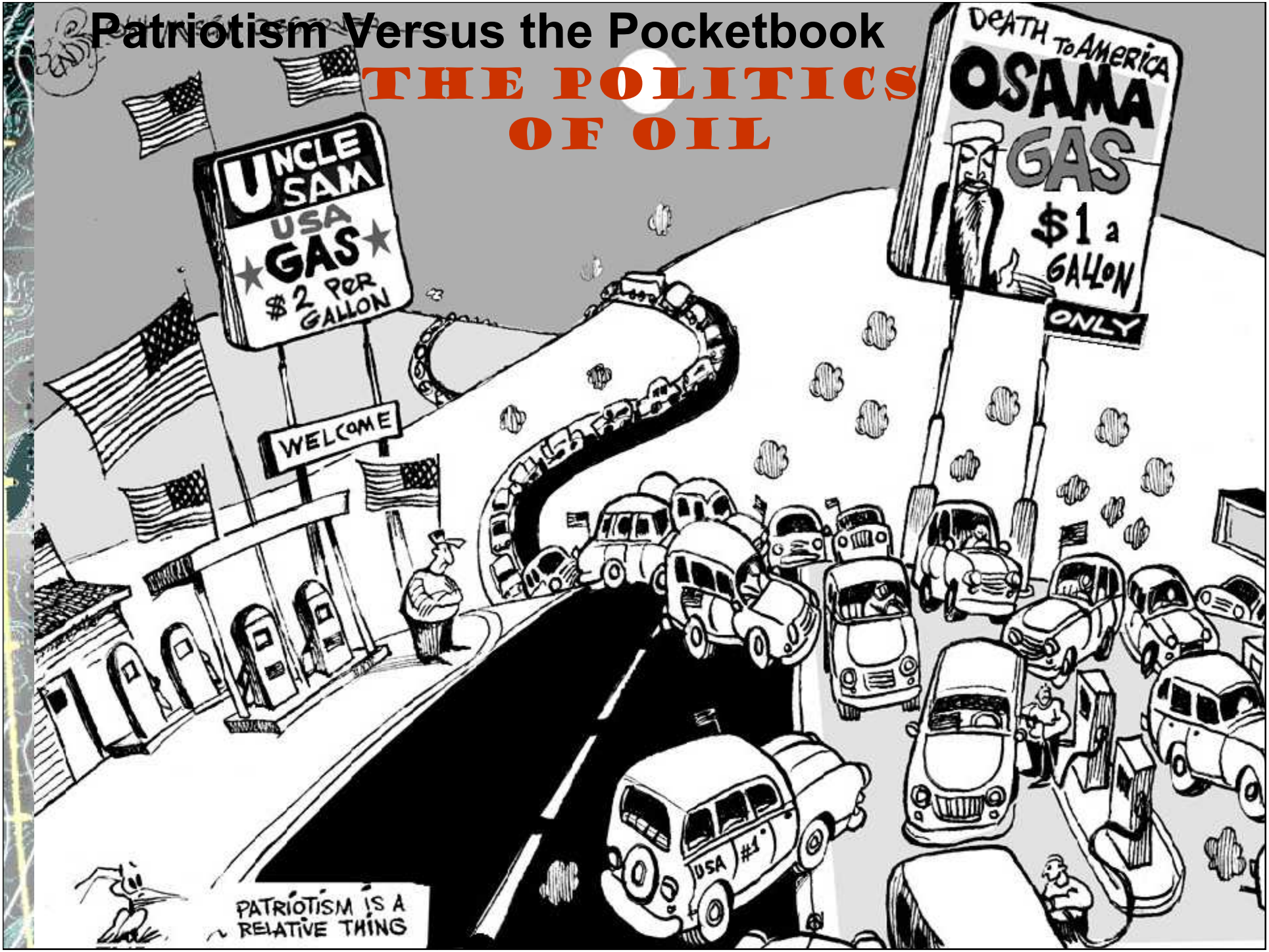


- The price of crude oil and gasoline shot up in the last 10 years.

Question: Why?

- **Question:** Will the price ever go back down to $2 a gallon? Why or why not?

Patriotism Versus the Pocketbook

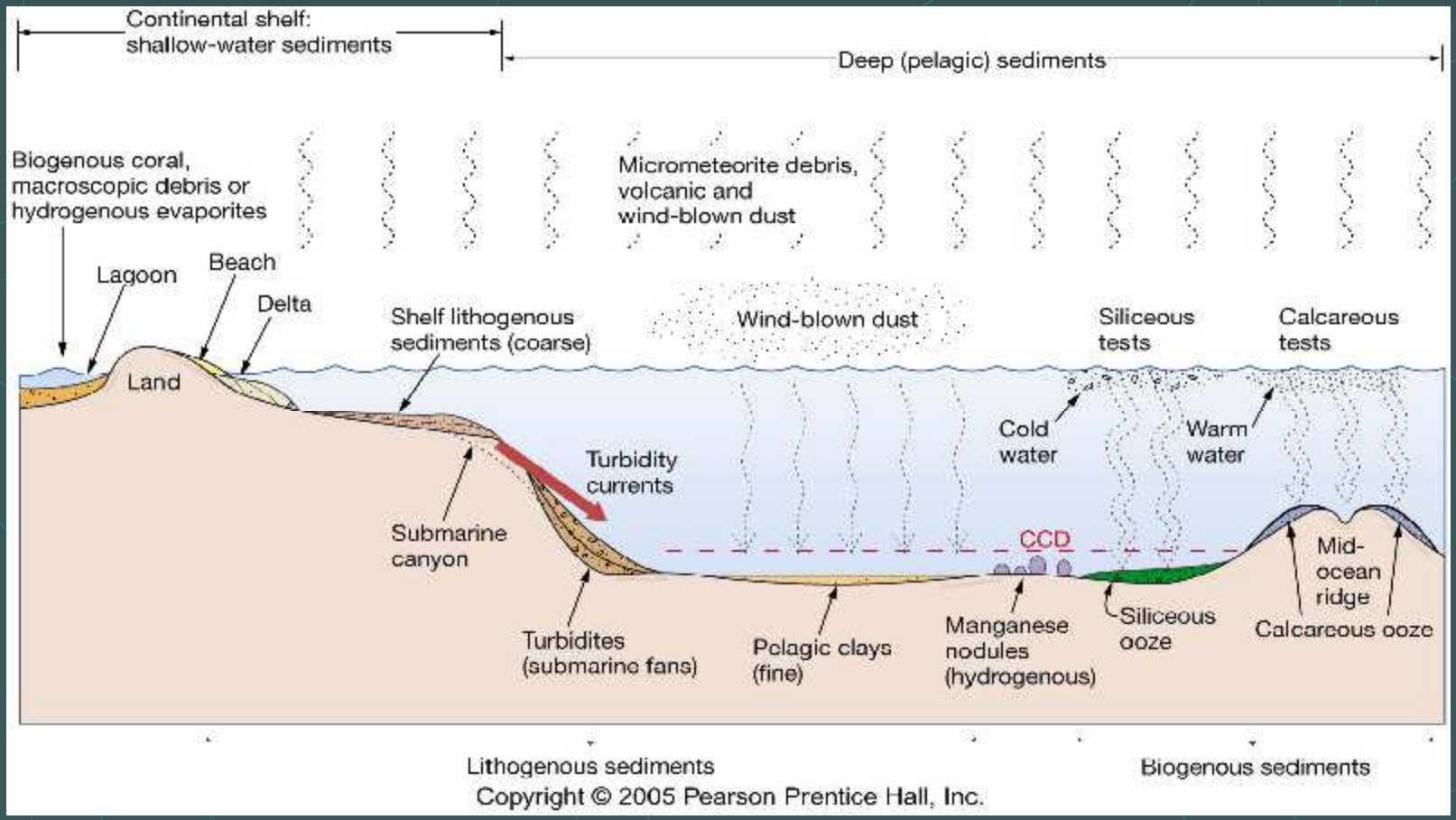


PHYSICAL MARINE RESOURCES

Mineral Deposits

- ✓ Sand and Gravel
- ✓ Magnesium
- ✓ Salts
- ✓ Manganese Nodules
- ✓ Phosphorite
- ✓ Metallic Sulfides and Muds
- ✓ Fresh Water

Distribution of Ocean Bottom Mineral Resources



- Valuable, non-fuel, mineral marine resources are abundant, but widely distributed in the ocean, and across the seafloor.
- They are generally harder to exploit than similar land resources.

Question: Why are marine mineral resources tougher to exploit?

Shallow Marine Sediments

Sands, Gravel, and Rock Coral

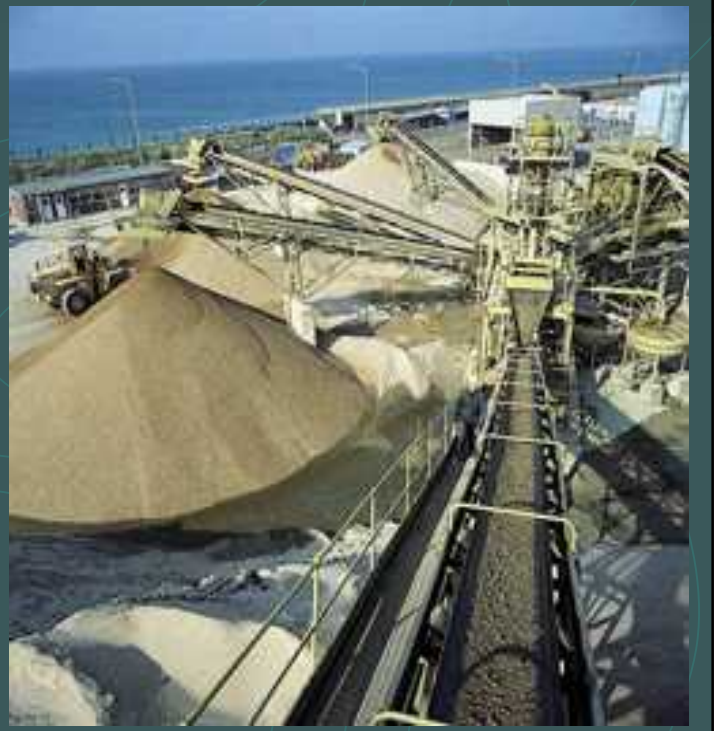
Key Points

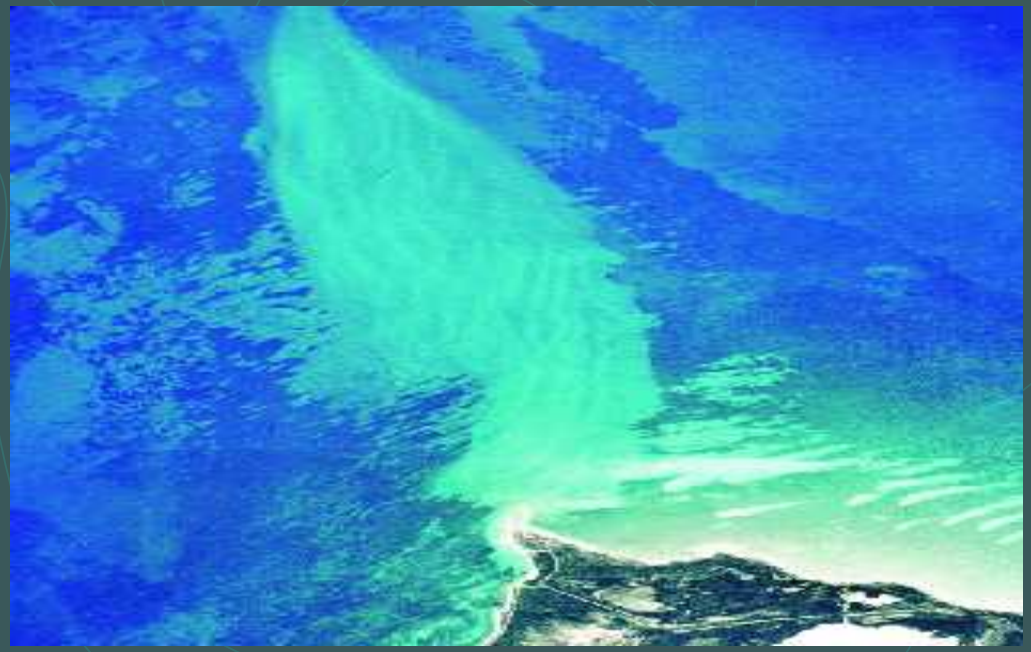
- Shallow marine sands and gravels are second only to oil and natural gas as an economic marine resource.
- Shallow coastal sediments consist mainly of coarse, inorganic rock and mineral fragments having gravel, sand, and silt sizes.
- Coastal sediment mostly arrive via rivers.
- Coastal sediments are easily exploitable and dredged for use as building material and beach replenishment.

Marine Sand and Gravel Extraction

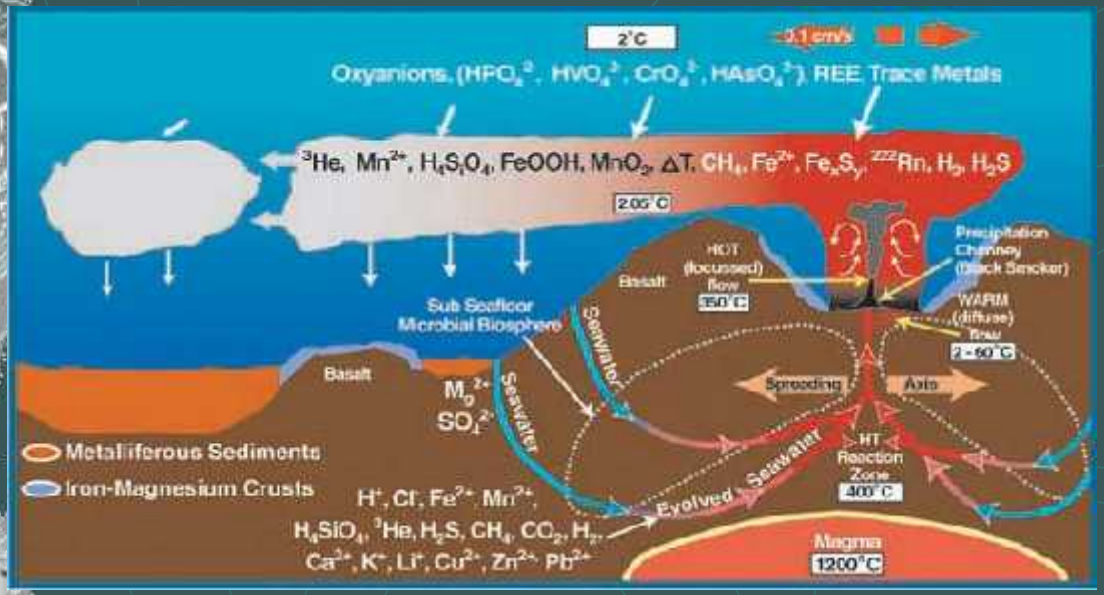
Key Points:

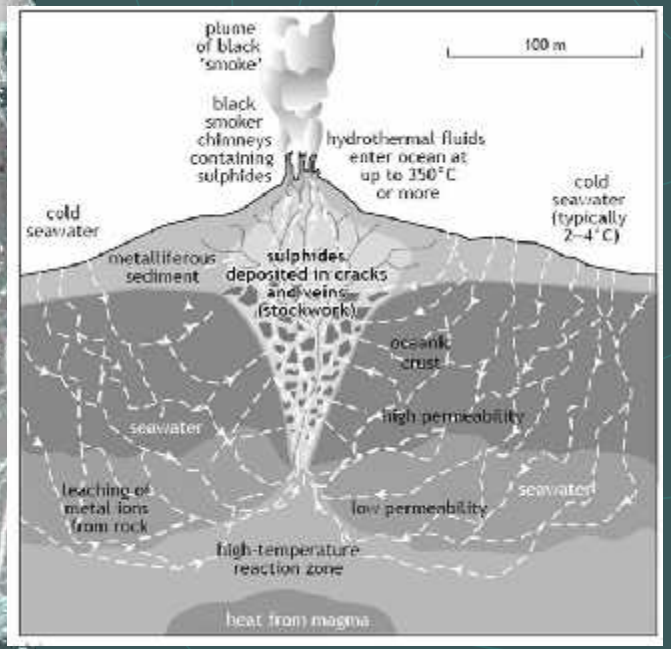
1) Very abundant source
2) High quality material
3) Easy to extract – low cost
4) Close to development sites
5) Excellent for beach replenishment
6) 3rd most valuable marine resource

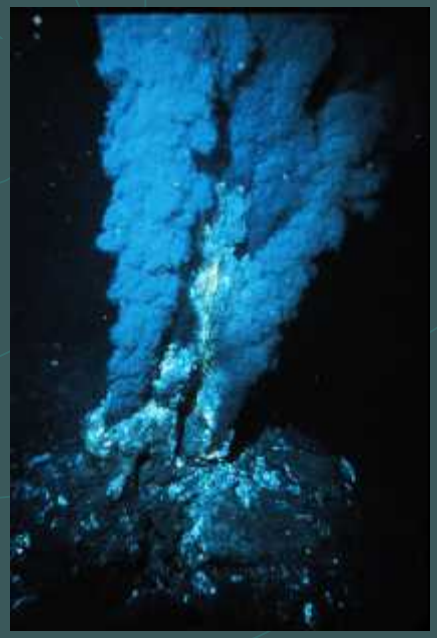




Sulfide-Rich Hydrothermal Vents



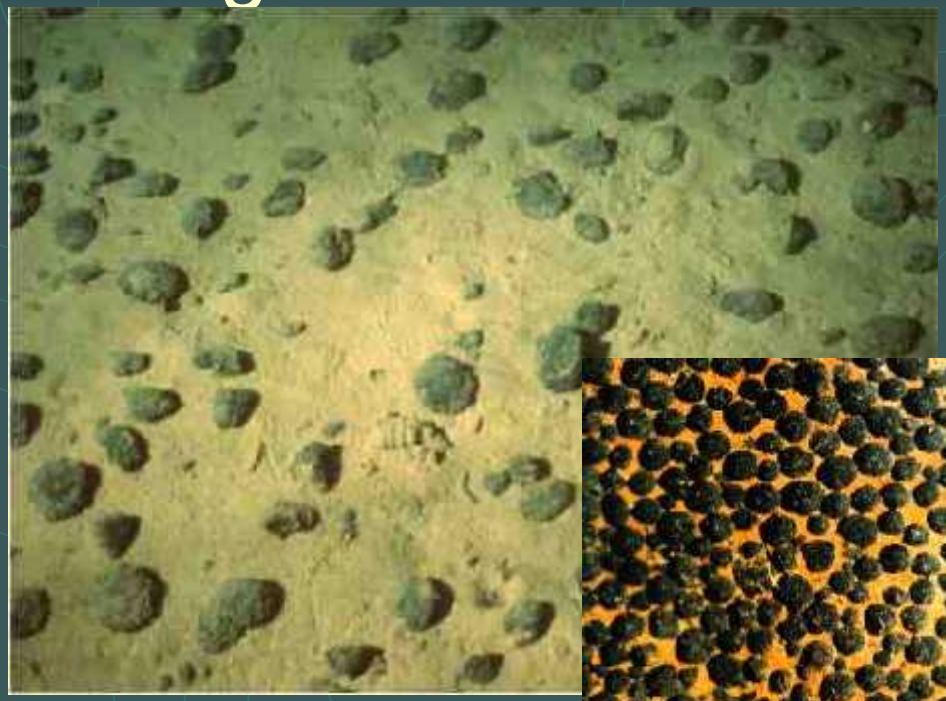


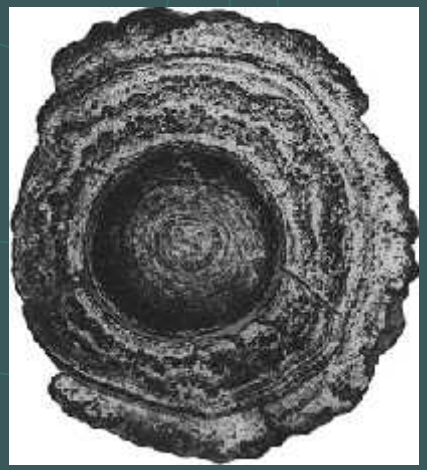


Key Points

- Deep sea hydrothermal vents release hot, mineral-rich waters that precipitate metal sulfides on impact with the cold seawater
- The metal sulfides form chimney-like structures that contain highly-concentrated precious metals, such as copper, zinc, and cobalt
- The surrounding sediments around hydrothermal vents also contain high concentrations of metal sulfides

Manganese Nodules and the Abyssal Floor

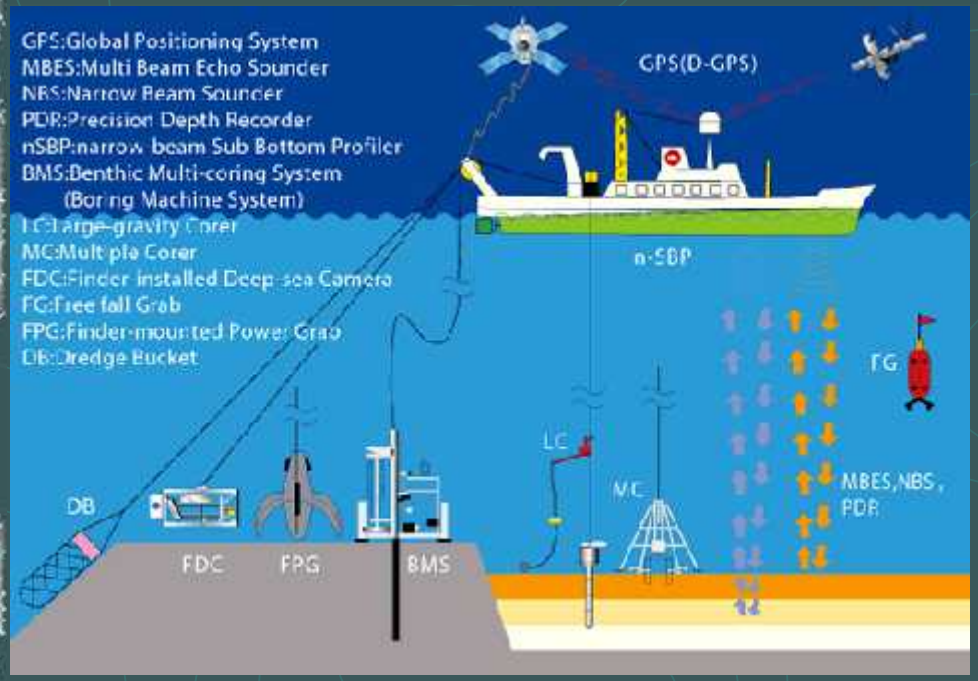




Key Points

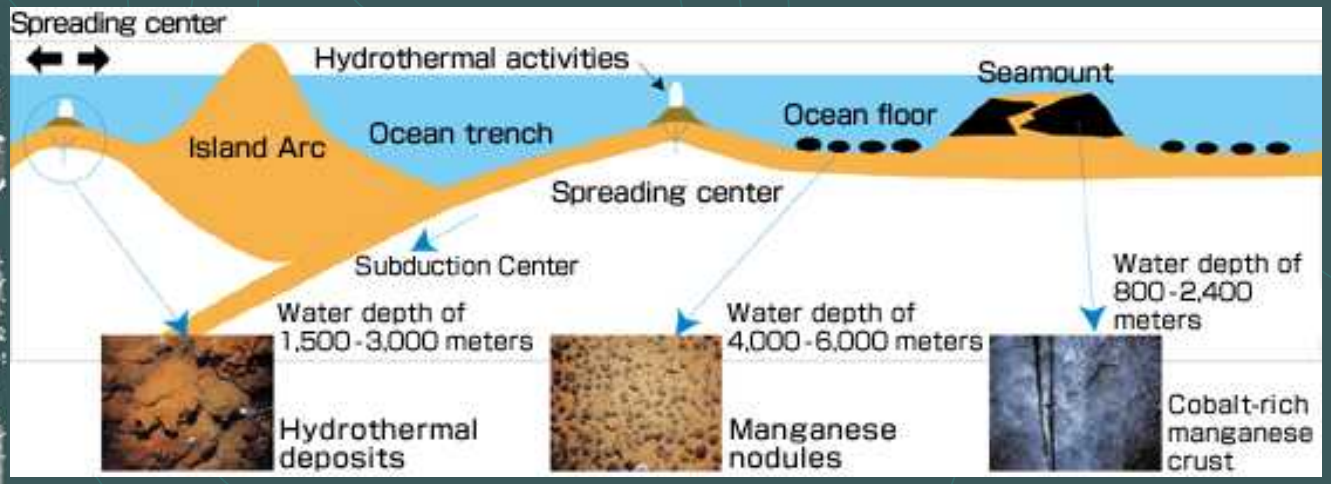
- Abyssal sediments are predominately clays and oozes
- Manganese nodules grow extremely slowly on the surface of the sediments as an inorganic chemical precipitate
- Manganese nodules are rich in iron and manganese, plus nickel, and copper
- Estimated that they cover 30% to 50% of deep sea floor
- Takes millions of years to form a nodule

Mining the Deep Sea Floor



Key Points

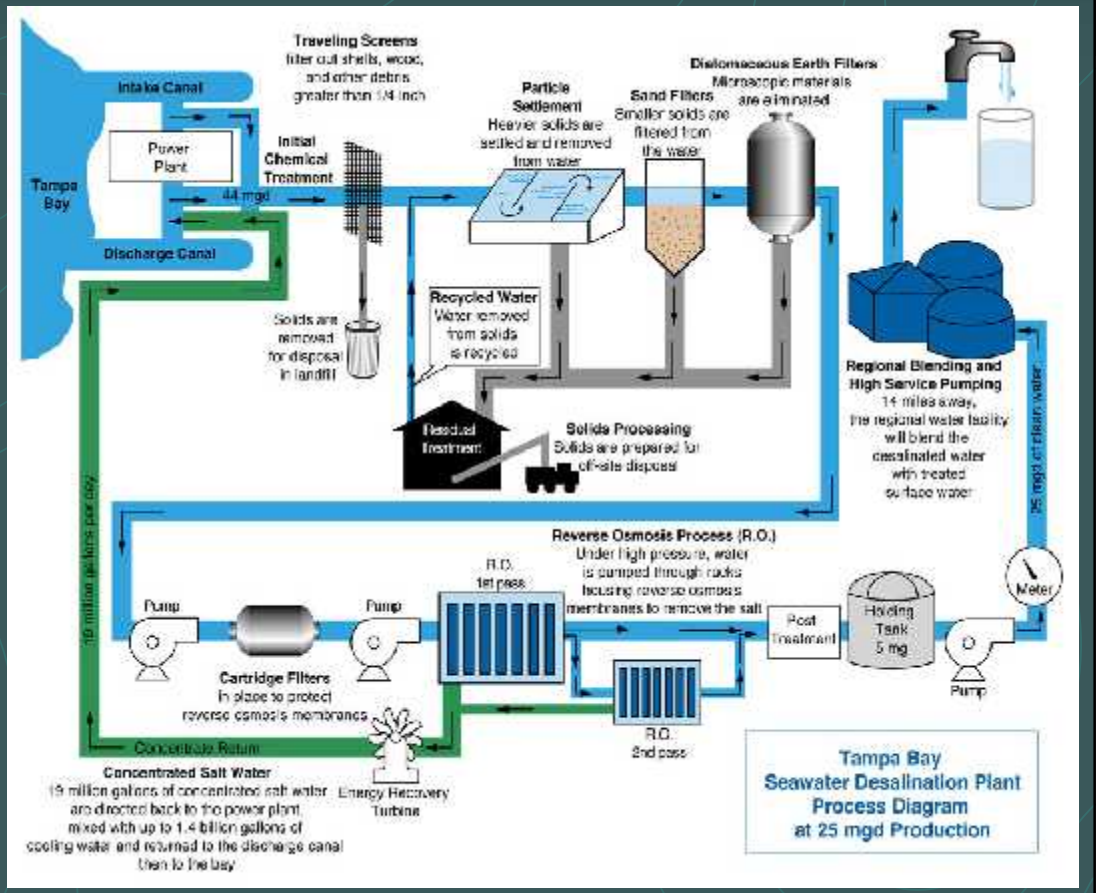
- Extreme engineering is required to collect and lift the widely scattered minerals from the deep seafloor to the surface
- Hydrothermal sulfides, manganese nodules, and manganese crusts are the three most sought-after minerals



Desalinization – Seawater to Fresh Water

Key Points

- Removal of salts from seawater to produce potable fresh water
- Inexhaustible water source for coastal cities
- Need large amounts of money and energy to build and operate large-scale production
- Most common method used in large-scale desalinization operations is by reverse osmosis
- Only large-scale plants operate in arid coastal regions, like the Mid-East



Typical Desalination System – Tampa Bay, Florida

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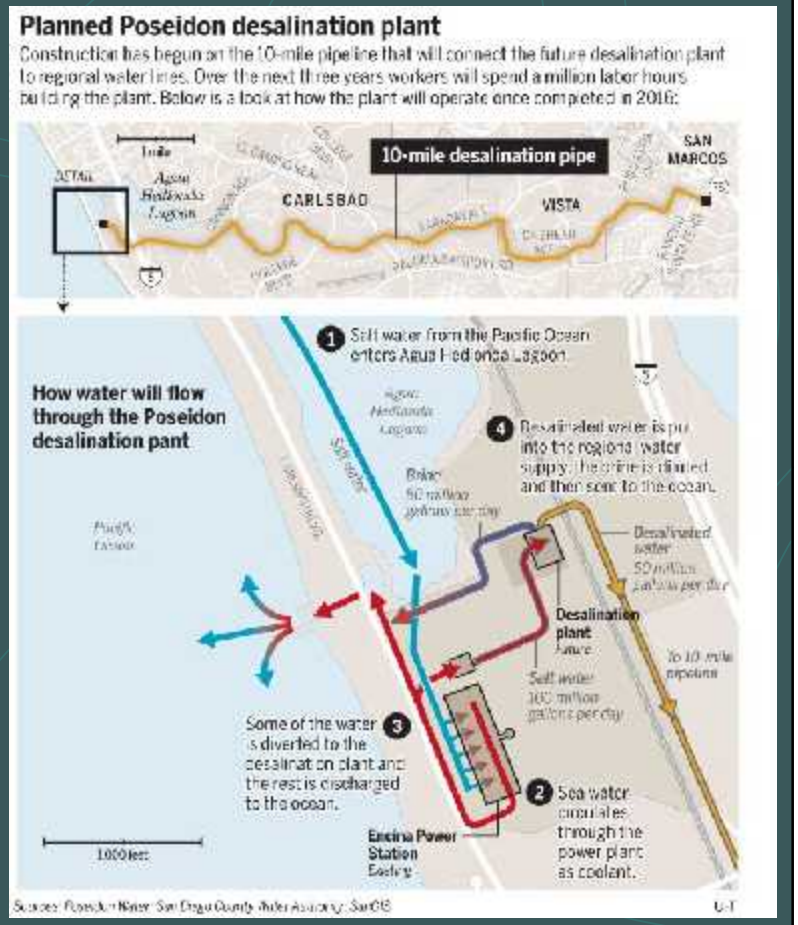
Reverse Osmosis Systems

Desalinization in North County

Key Points

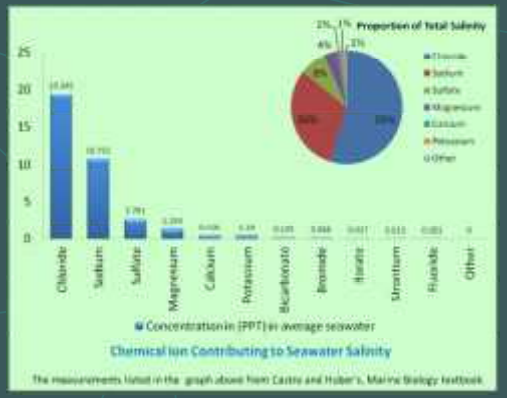
- Current construction of largest desalinization plant in Western Hemisphere here in Carlsbad, CA
- Reverse osmosis of 100 million gallons of seawater per to produce 50 million gallons of fresh water per day
- Cost of project around 1 billion dollars
- Cost will be double that of typical water sources = $2000 per acre-foot
- Plant will provide enough water for around 60,000 homes
- Environmental challenges exist with desalinization: What might those be?



Sea Salt Production

Key Points

- Evaporation of shallow seawater ponds to form various sea salts
- Production of sodium chloride, calcium and magnesium sulfates, plus several other salts
- Salts for food and industrial processes
- Various bright colors of evaporation ponds caused by different bacteria and algae



San Francisco Bay Area Salt Ponds

Energy From Tides Today = Tidal Bores

Key Points

- Tides cause daily back-and-forth ocean currents in narrow straights, river mouths, and bays
- Inexhaustible energy
- Need large tidal range and current motion
- Tidal dams have sets of reversible turbines connected to electrical generators
- Today, tidal energy is harvested mostly by tidal dams – France, example

Tidal Bore Turbines

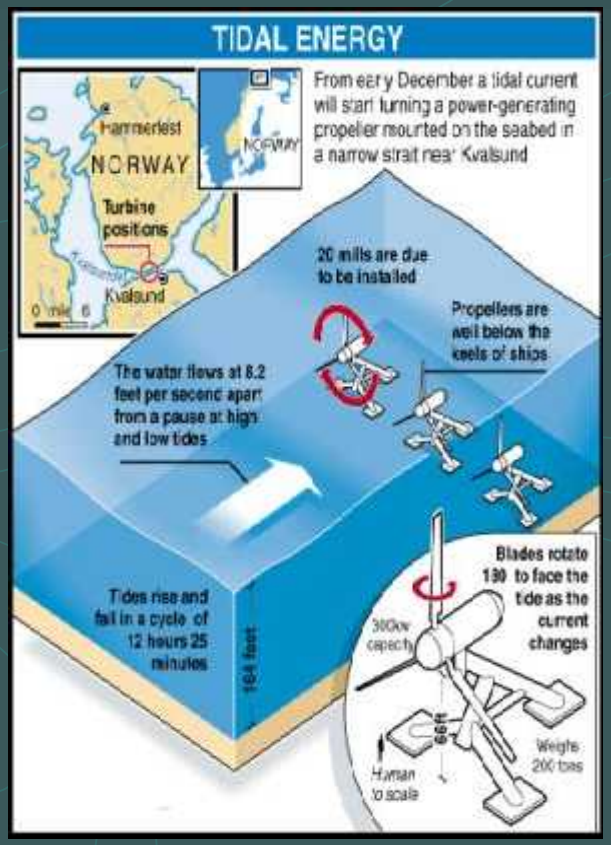
La Rance, France

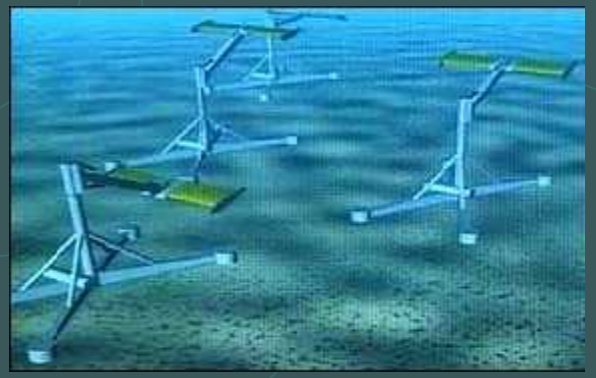
Severn River, France

Energy From Tides - Future

Key Points

- Many potential places where tidal currents are sufficiently strong close to shore
- Propellers or paddles connected to turbine electrical generators
- Many technical issues still exist that prevent commercial-scale systems
- What those be?

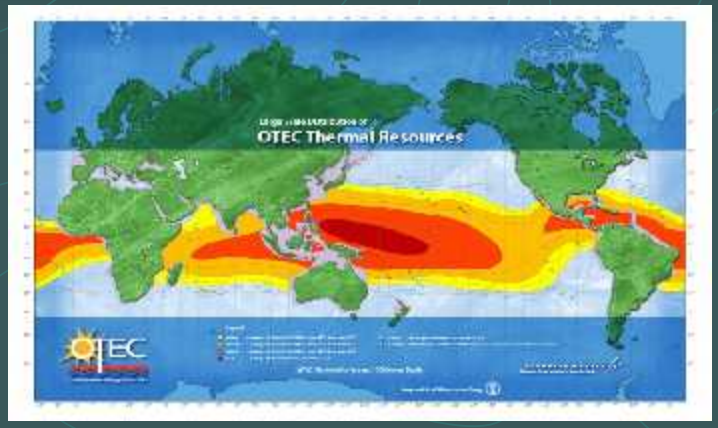


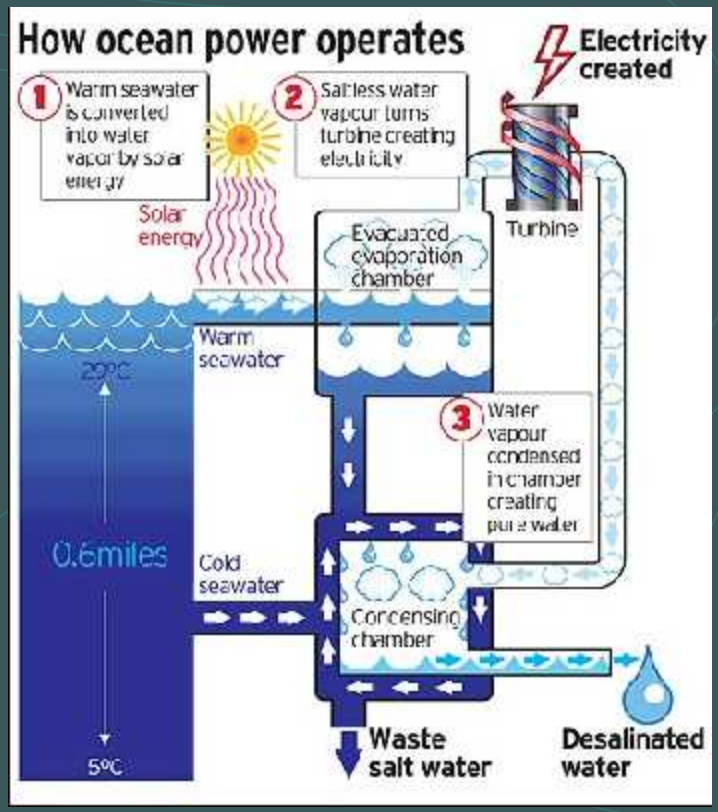


Ocean Water Column Thermal Gradient

Key Points

- Potential energy from temperature difference between warm surface waters and cold deep waters = OTEC (Ocean thermal energy conversion
- Pumping of cold water to surface and interfacing with warm waters to turn a turbine generator
- Other applications include 1) condensation of cold water to make fresh water and 2) fertilization of surface waters
- Several commercial-scale systems exist





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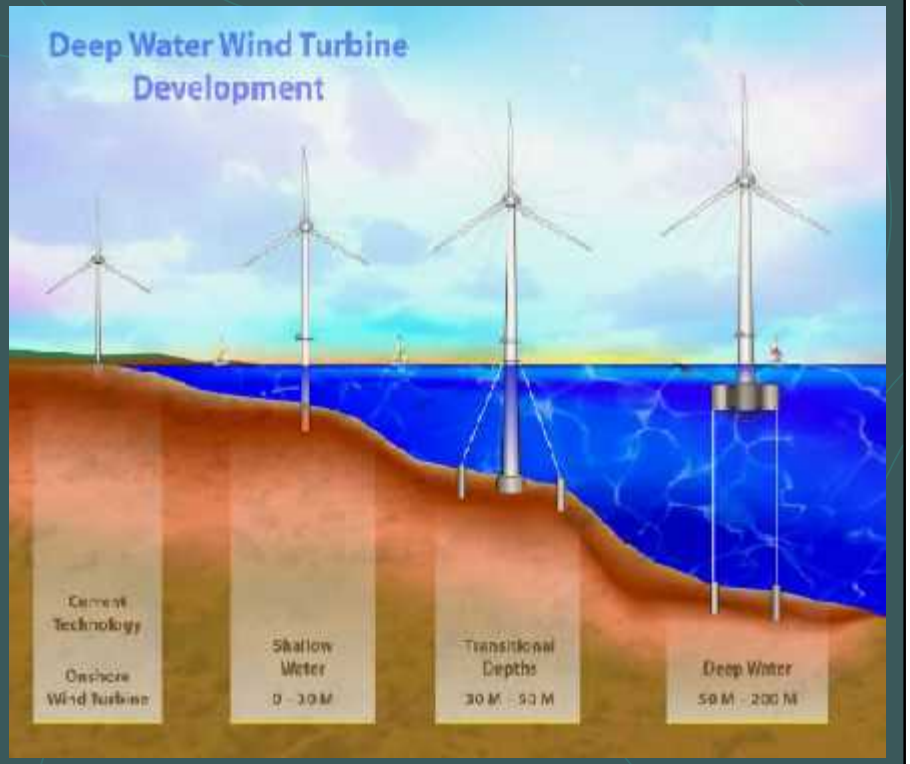
Offshore Wind Energy

Key Points

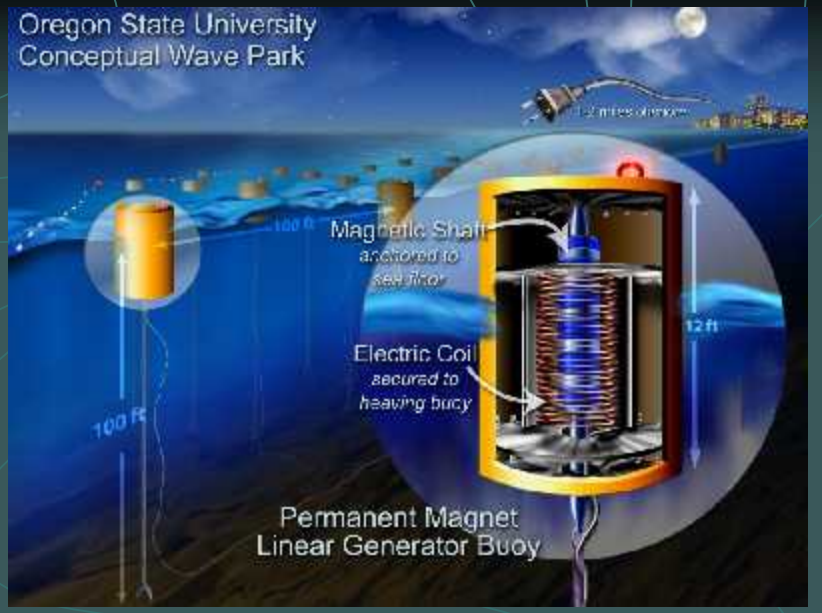
- Kinetic wind energy over ocean surface converted to electricity
- Wind turns platform-mounted turbine blades that turns an electrical generator
- Inexhaustible energy
- Several commercial-scale systems exist and many more are in development
- A number of technical and environmental issues exist

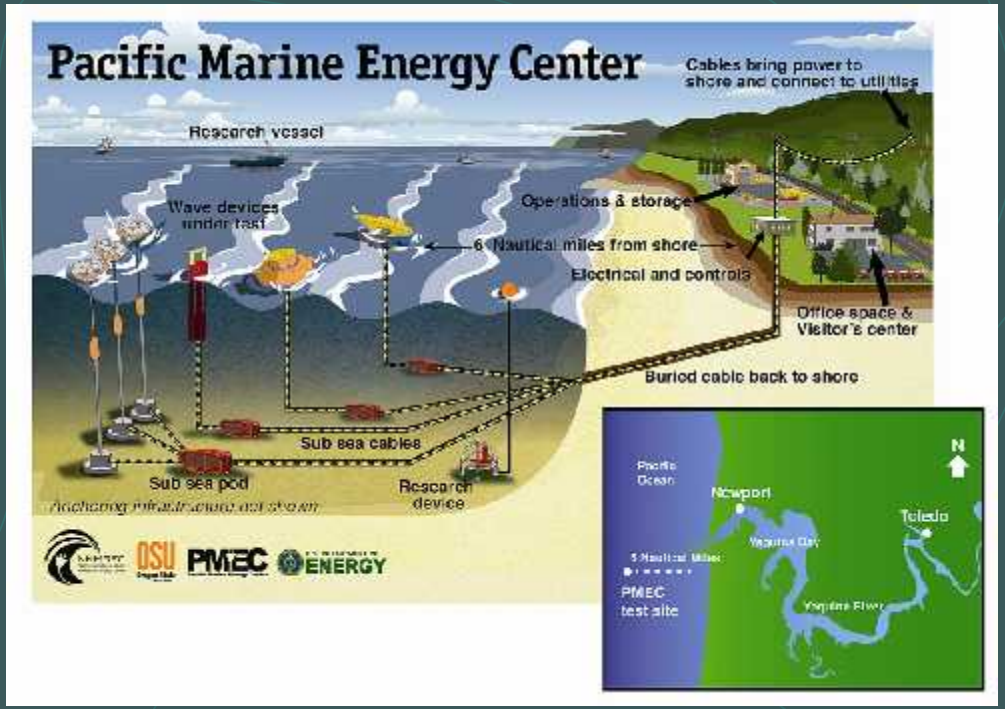


Offshore Wave Energy

Key Points

- Kinetic wave energy in ocean surface waters converted to useable energy like electricity
- Wave motion moves an object up-and-down or side-to-side to run an electrical generator or pump system
- Inexhaustible energy
- No commercial-scale systems exist at present time, but many different designs are currently in development and testing
- A number of technical and environmental challenges exist with wave energy too – what might those be?





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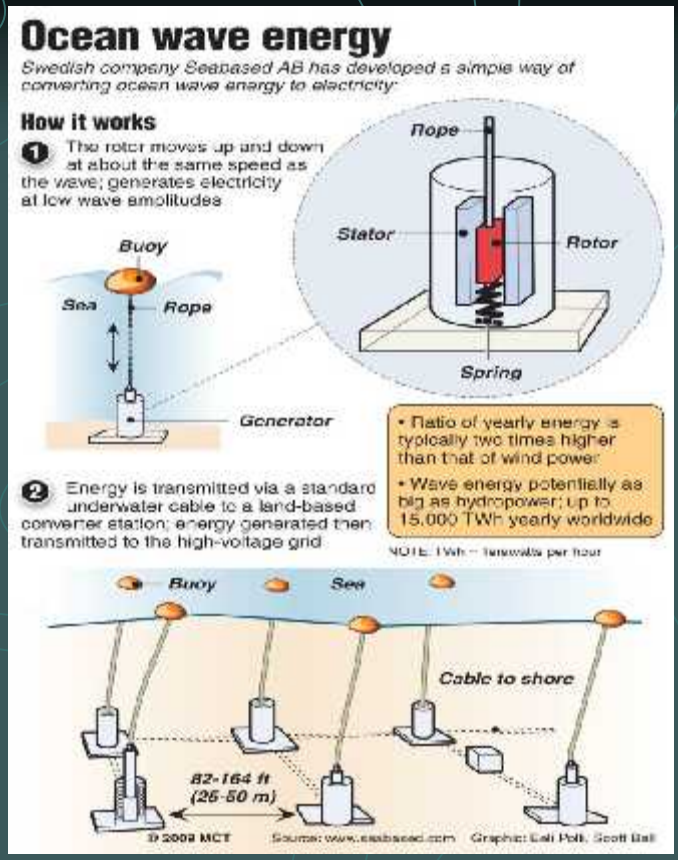

PHYSICAL and ENERGY RESOURCES of OCEAN

Physical Resources

1) Hydrocarbon Deposits

- ✓ Petroleum
- ✓ Natural Gas
- ✓ Methane Hydrates

2) Mineral Deposits

- ✓ Sand and Gravel
- ✓ Magnesium
- ✓ Manganese Nodules
- ✓ Phosphorite
- ✓ Metallic Sulfides

3) Water/Salt Separation

- ✓ Fresh Water
- ✓ Sea Salts

Energy Resources

1) Tides

- ✓ Tidal bores on rivers
- ✓ Offshore tidal currents

2) Ocean Thermal Gradient

- ✓ Ocean thermal energy conversion
- ✓ Desalinization
- ✓ Surface water fertilization

3) Wind

- ✓ Offshore islands and platforms
- ✓ Electricity conversion

4) Waves

- ✓ Offshore / Shoreline

OCEAN RESOURCES - Key Concepts

A. Marine Resources Divided Into Several Categories

1) Biological

- ✓ Fish, Crustaceans, Mollusks and Mammals; Plants; Drugs

2) Physical

- ✓ Mineral Deposits; Oil and Gas; Fresh Water

3) Energetic

- ✓ Wind; Waves and Currents; Thermal gradient; Tides

4) Nonextractive

- ✓ Transportation; Recreation; Real Estate

B. Extraction of Most Ocean Resources Comes at a Steep Cost

1) Pollution 2) Habitat Destruction, 3) Extinction, and 4) Loss of Resource

- ✓ Negative costs not calculated into market price of resource
- ✓ Entire marine ecosystems are being threatened

C. Extraction of Most Ocean Resources Not Sustainable

1) Rates of Extraction Exceed Replenishment

- ✓ Driven by short-term supply and demand: Lack of long-term management

2) "Madhouse Economics" of Marine Fisheries Best Example

- ✓ Government subsidies; Legal loopholes; High-tech efficiency

D. Laws of the Sea Govern Ocean Resources Control and Trade

1) National and International Laws and Agreements – Lack of Enforcement

Ocean Resources Discussion