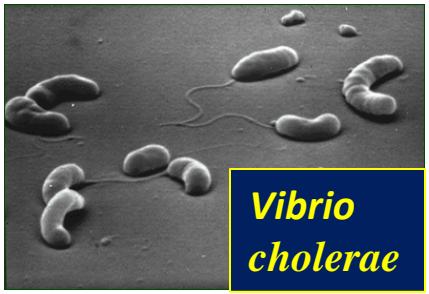
Assessment of the health of the Oceans

Dr. Lidita Khandeparker




Ballast water

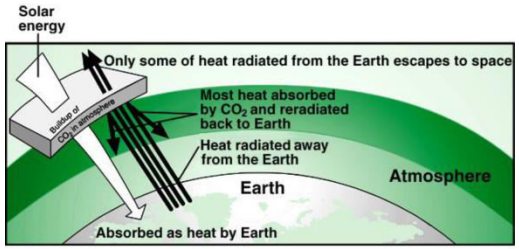

HAB


Oil


Harmful chemicals


Biofouling


Eutrophication



Global Warming

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Management of marine ecosystems and resources increasingly demands comprehensive and quantitative assessments of health of the oceans

The global pattern of ecosystem structure and processes is strongly governed by climate

Natural events (**Climate Forcings**) affecting climate

Milankovitch Cycles -These are movements of the Earth that affect the amount of solar radiation that it gets

Sun Spots and Solar Flares - Sunspots are storms on the surface of the sun and are associated with extremely strong magnetic activity, solar flares, hot gaseous emissions

Plate Tectonics - Change ocean circulation patterns which transport heat around the Earth and in turn influences atmospheric circulation processes

Major Volcanic Eruptions - Volcanic eruptions of ash and gases into the troposphere and above cause SHORT TERM cooling

El Nino and La Nina - **El Niño** is a large scale change in oceanic and atmospheric circulation in the eastern equatorial Pacific and involves rapid, large scale warming of the sea-surface. **La Niña** is the opposite, a rapid cooling in this area

Forest Fires - Forest fires produce a lot of smoke – made up of particulates and gases

Solar radiations

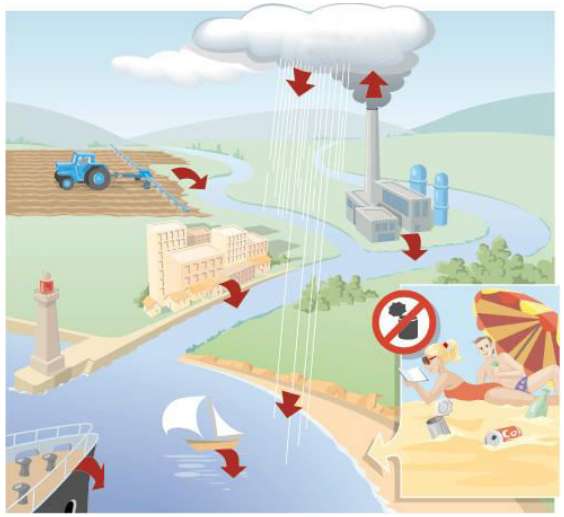
Anthrosphere

The Earth is made up of many systems that work together.
One way to classify these systems that are essential to climate is to divide them into five “spheres”

Climate change impacts the ocean

- **Temperature rise**
- **Shifts in wind and radiation regimes**
- **Changes in the hydrological cycle**
- **Alterations related to oceanic circulation and stratification**
- **Changes in the frequency of episodic extreme events (such as storms)**
- **Acidification**

Anthropogenic impacts on the ocean



Includes a range of threats from land-based sources

- Oil
- Sediments
- Eutrophication (nutrient enrichment)
- Harmful chemicals
- Radioactive substances
- Marine litter
- Thermal
- Noise
- Acidification
- Alien species

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Oil

Cause

Oil tanker operations

Shipping

Accidents at sea

Offshore oil drilling

Natural seepage

Effect

Low level contamination can kill larvae and cause disease in marine life. Oil slicks kill marine life, especially in coastal habitats. Tar balls from coagulated oil litter beaches and coastal habitat. Loss of sensitive marine habitats – loss of flora and fauna. Tourism – becomes nuisance

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Contd..

- When oil is spilled it spreads over the sea surface to form a thin film and called as oil-slick
- Light oil spreads faster than heavy wax oil
- Low molecular weight fractions evaporate
- Water soluble components dissolve
- Non-water soluble components emulsify and forms a viscous mass – “chocolate mousse or pudding”
- Heavy residues form tar balls

Tar balls

Appear along the entire coast of India, and their appearance on the west coast is usually seasonal, with high likelihood during May-October

Various physical, chemical, and biological processes change appearance of the oil. These processes are generally called "weathering."

Sediments

Cause

Erosion from mining, forestry, farming, and other land-use; coastal dredging and mining

Effect

Cloud water; impede photosynthesis below surface waters. Clog gills of fish. Carry toxins and excess nutrients.

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Eutrophication

Cause

Sewage effluent

Agricultural runoff

Aquaculture

Industrial wastes

Effect

Feed algal blooms in coastal waters. Decomposing algae depletes water of oxygen, killing other marine life. Can spur algal blooms (red tides), releasing toxins that can kill fish and poison people.

Harmful chemicals (POP's, Heavy metals, etc.)

Cause

Industrial discharge; wastewater discharge from cities; pesticides from farms, forests, home use etc.; seepage from landfills.

Effect

Poison or cause disease in coastal marine life, especially near major cities or industry. Contaminate seafood. Fat-soluble toxins that bio-accumulate in predators can cause disease and reproductive failure.

Radioactive substances

Cause

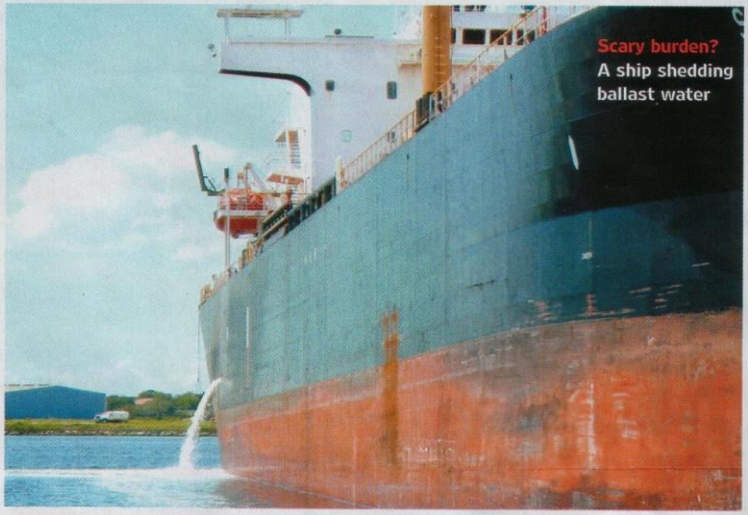
Discarded nuclear submarine and military waste; atmospheric fallout; also industrial wastes.

Effect

Hot spots of radio activity. Can enter food chain and cause disease in marine life. Concentrate in top predators and shellfish, which are eaten by people

Contd..

by **Debarshi Dasgupta**



Scary burden? A ship shedding ballast water

THE SEA CHANGE

Ballast water from Japan—the latest scare

IS radioactive seawater from off Japan reaching India? It's a far-fetched fear, but it has gained ground in at least one Indian port, Mormugao, as cargo ships return and offload ballast water—seawater admitted into tanks at the bottom of a ship to stabilise it for the high seas.

After the near-meltdown at the Fukushima nuclear plant, caused by the March 11 temblor and tsunami, some 57 million litres of seawater has been used to cool the crippled reactors and drained back into the Pacific as radioactive waste. The Goa State Pollution Control Board (GSPCB), it seems, was so worried that it ordered the Mormugao Port Trust (MPT) to ensure that no ship—not just those that had touched Japan—empties ballast tanks at the port. "The south Goa collector received some reliable information that two ships that had touched Japanese ports recently were likely to visit MPT," says GSPCB chairman S.N. de Sousa. One of these ships—the *MV Azul Integra*—was on arrival held in quarantine for ten days and examined by experts from the Bhabha Atomic Research Centre, who said radiation levels were within permissible limits. "The ship's agents claimed it had already deballasted in the South China Sea and in Colombo," says de Sousa. There's no word yet on the second ship, but the order stands as a precautionary measure.

From Goa, as from other ports in India, ships laden with consignments such as iron ore set sail for destinations across the world. They fill up their ballast tanks for the unladen journey back and pump out the seawater on returning. Bans on deballasting haven't been reported from other ports in the country, but the GSPCB order has set environmentalists and the authorities thinking about how to prevent the unsolicited entry of dangerous waste and alien organisms through the country's ports. For, beyond the threat of bringing in radioactivity from Japanese shores, ballast water is also under scrutiny for bearing alien species into Indian waters, upsetting local ecosystems.

A.C. Anil, a scientist with the National Institute for Oceanography (NIO), Dona Paola, has listed several organisms that may have come into Indian waters through ballast water. These include black-stripped mussel, a native of the Atlantic Ocean, now spotted around Mumbai and Visakhapatnam. Some species of barnacles native to the east coast of Africa and the Persian Gulf have been found on India's west coast.

Organisms transported via ballast water have also been blamed for pernicious algal blooms, occurring when certain harmful species of phytoplankton multiply rapidly in a limited area. Experts have suggested measures such as filtration, thermal shock and ozonisation of ballast water before discharge to prevent such eventualities.

NIO has announced a ballast water management programme at eight of India's major ports. This includes a baseline study to document local marine species and the likely impact invasive species from ballast water could have.

In four years, the ports are expected to have an electronic monitoring facility to help them keep track of any shedding of ballast water. "But the responsibility to ensure that ships either carry out a mid-ocean exchange or have the required treatment technologies for treating ballast water before discharging lies with the ports, according to the International Maritime Organisation," says Anil. ◘

Weight watching...

- There's fear that ballast water from ships arriving from Japanese ports may be radioactive. Ballast tanks are laden to stabilise ships.
- Goa's pollution control board has asked Mormugao port not to let any ship shed ballast water
- One ship was quarantined and released after radioactivity tests
- Another fear is that alien organisms in ballast water may interfere with local ecosystems

Marine Litter

Cause

Fishing nets; cargo and cruise ships; beach litter; wastes from plastics industry and landfills.

Effect

Discard fishing gear continues to catch fish. Other plastic debris entangles marine life or is mistaken for food.

Thermal

Cause

Cooling water from power plants and industrial sites

Effect

Kill off corals and other temperature sensitive sedentary species. Displace other marine life.

Noise

Cause

Supertankers, other large vessels and machinery

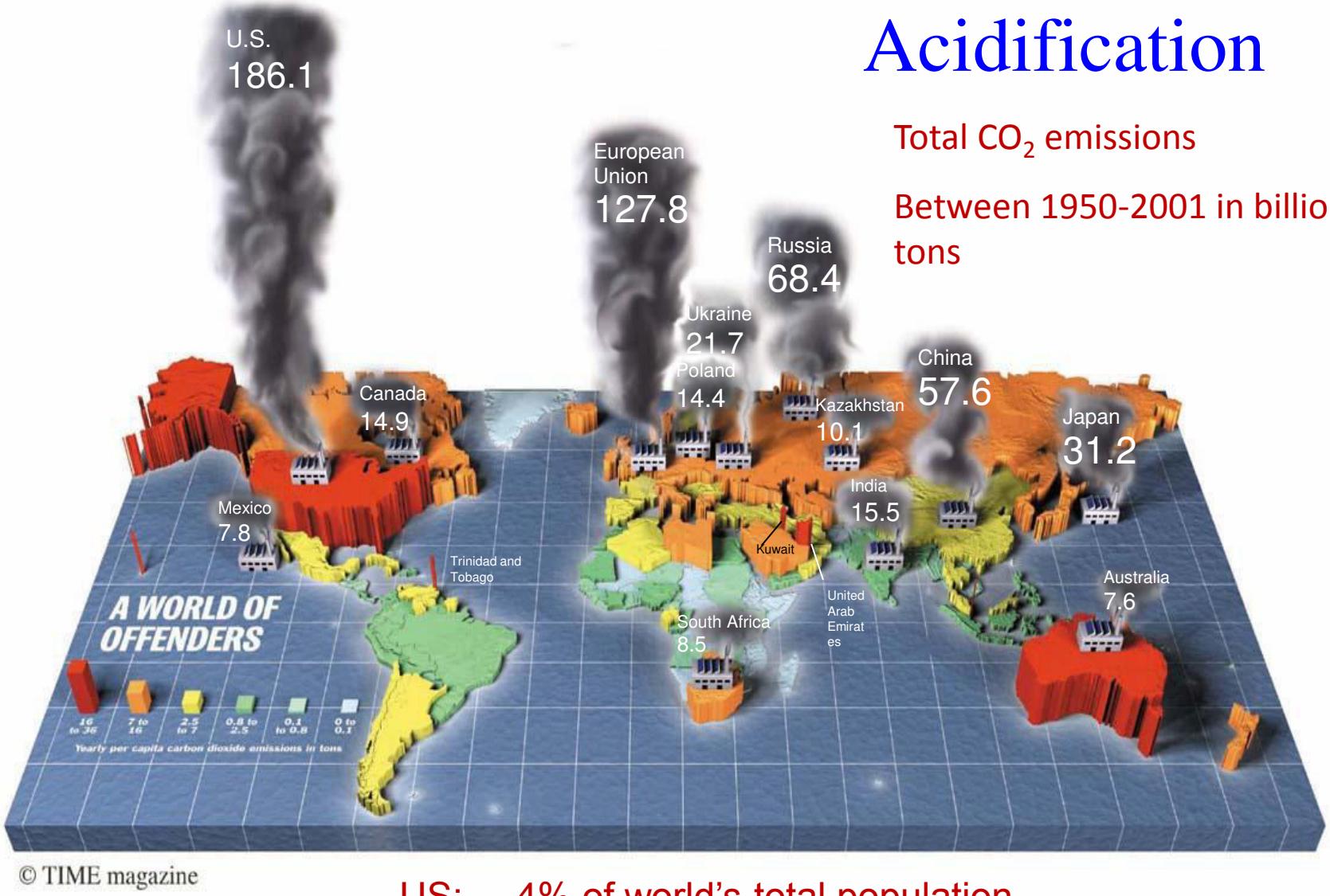
Effect

Can be heard thousands of kilometers away under water. May stress and disrupt marine life.

Acidification

Total CO_2 emissions

Between 1950-2001 in billions of tons



US: 4% of world's total population

25% of the world's greenhouse gases

China: 25% of the world's population

8.5% of the world's greenhouse gases (since 1950)

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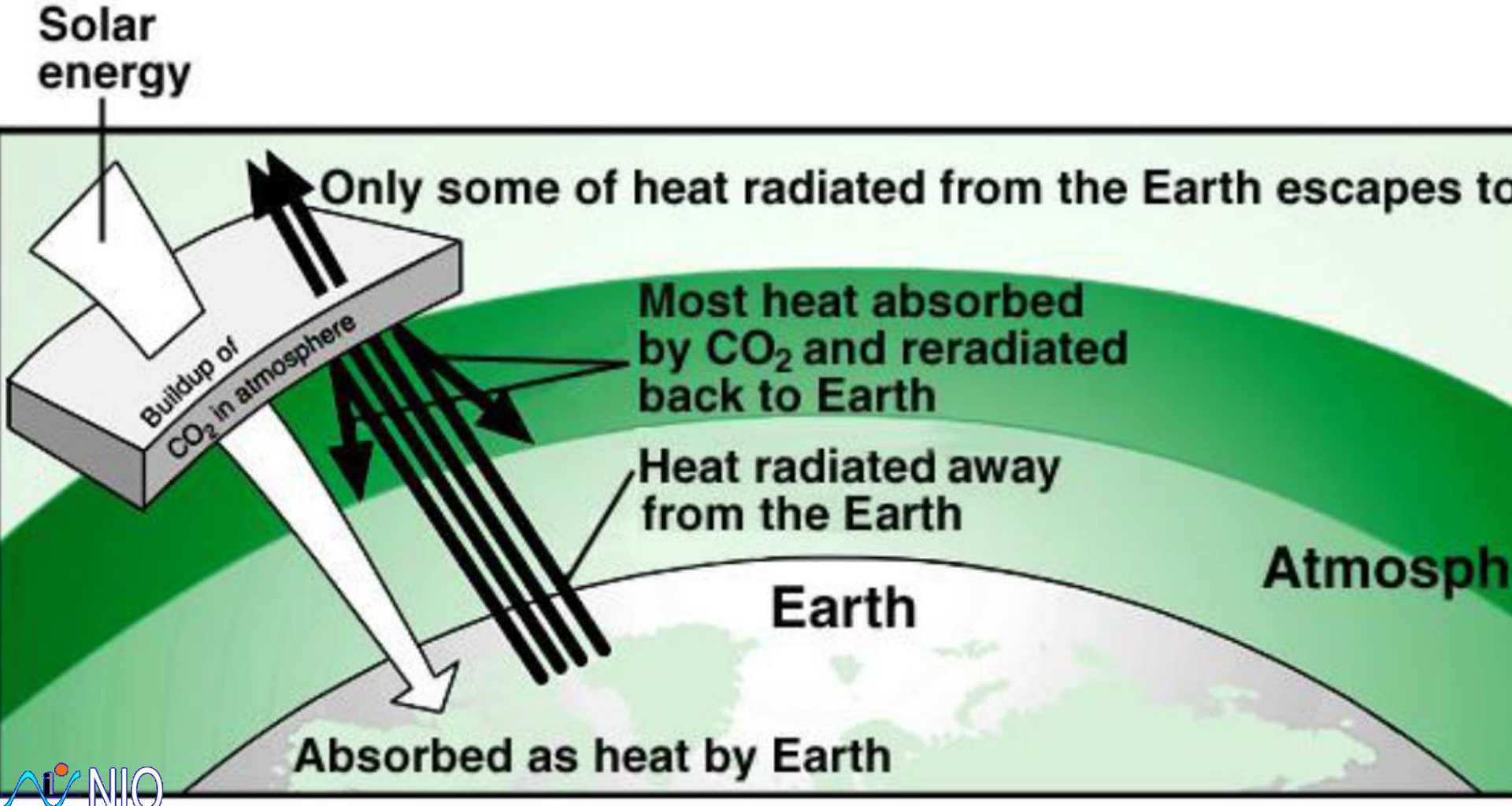
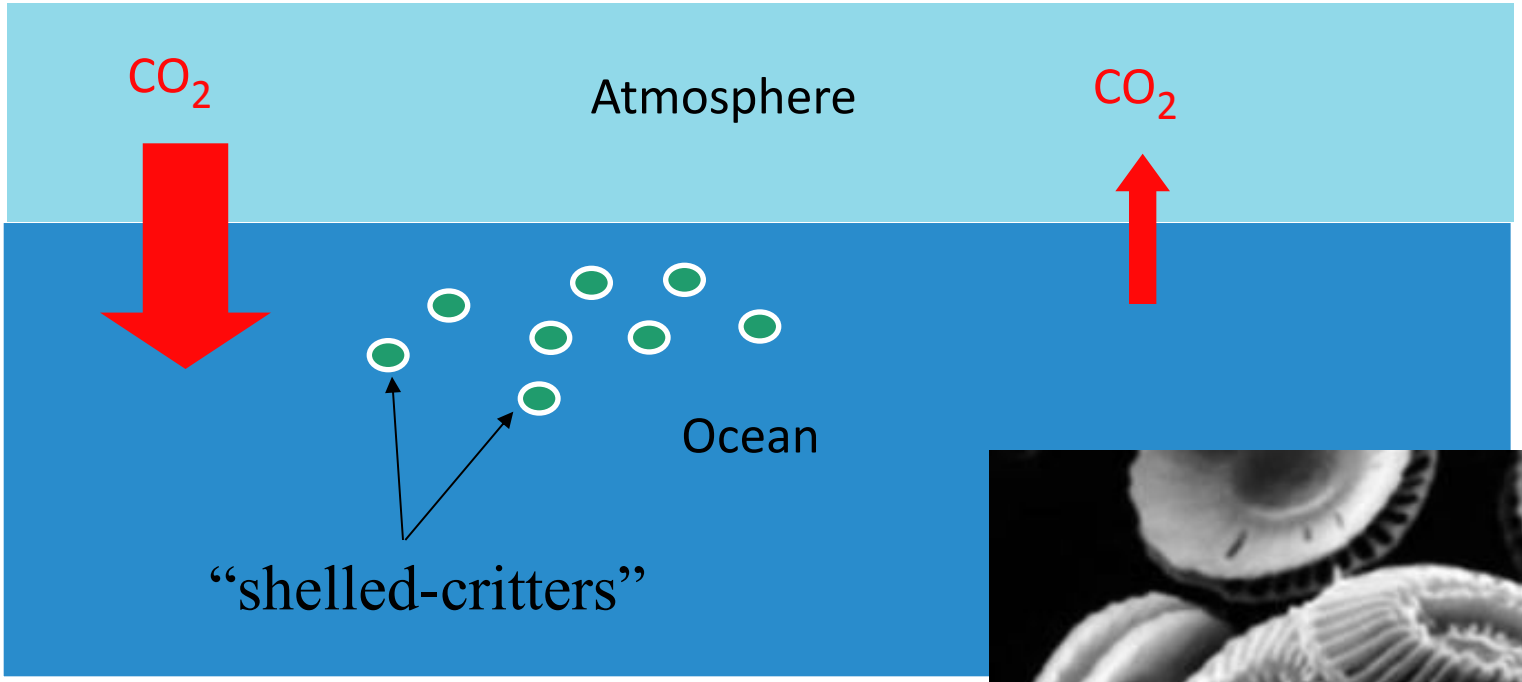
TIME magazine, 2001

Global Warming



Carbon dioxide acidifies seawater



- CO2 and carbonate (which plankton use to make shells) combine in the ocean.
- The ocean is already more acidic than it was 50 years ago.

Source: Alfred-Wegener-Institute

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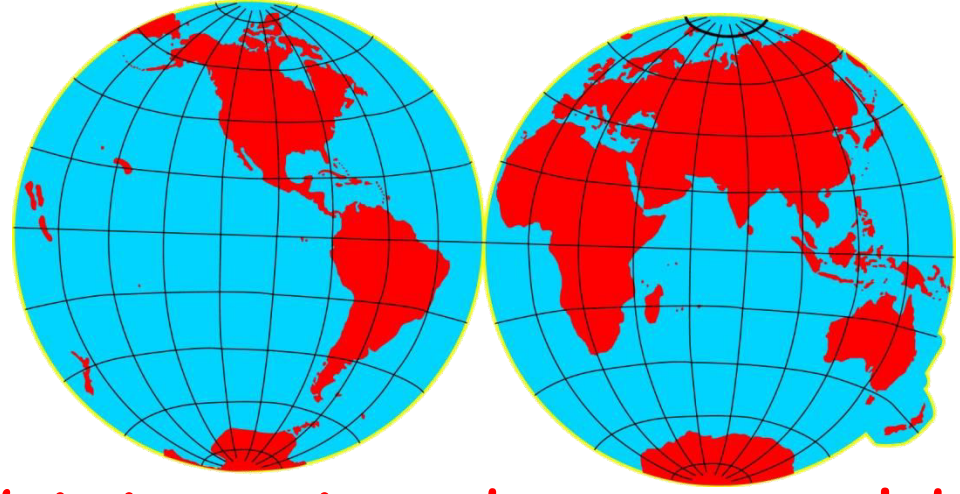
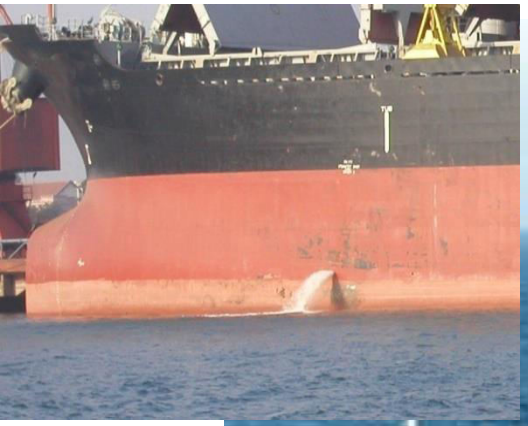
Human activities such as overfishing, coastal development and pollution have altered marine ecosystems and eroded their capacity to provide benefits to mankind

Marine environment is a reservoir of resources, both living and non-living and is extensively used for connecting the different economies of the world through shipping.



Threats of bioinvasion due to world shipping



Shipping carries more than 90% of the world's commodities

Ballast water

Biofouling

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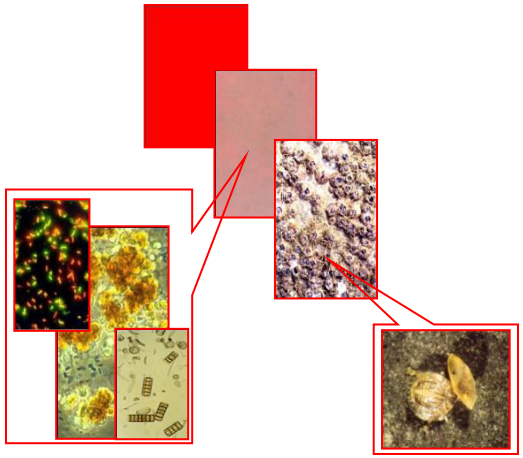
What is Bio invasion ?

- Introduction of alien organisms into the ecosystem is termed as Bio invasion. It has been flagged as one of the greatest threats to the health of the ocean.

- When in the native environment, an organism lives in semblance and is controlled by many ecosystem interactions. But when introduced into a non-native environment, more often than not, they not only change the biodiversity of the food web but also cause many ecological impacts and health hazards.

BIOINVASION



Organisms are transferred unintentionally in the Ballast water and on the hulls of ships (Biofouling), and a portion of these organisms are able to establish upon arrival to a new port

Alien Species

Cause

Several thousand per day transported in ballast water; also spread through canals linking bodies of water and fishery enhancement projects.

Effect

Out compete native species and reduce biological diversity. Introduce new marine diseases. Associated with increased incidence of red tides and other algal blooms. Problem in major ports.

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❖ The bioinvasion problem in marine environment has recently been described as an *exogenic unmanaged pressure*.

❖ Not all non-indigenous species (NIS), which were deliberately or accidentally introduced by humans outside their native range, will necessarily cause harm to the environment.

❖ It is very difficult to predict which of NIS introductions may result in detrimental effects on environmental quality which result in changes to the biological, chemical and/or physical properties of an invaded ecosystem.

Impact of IAS has been interpreted as a decline in ecological quality resulting from changes in biological, chemical and physical properties of an aquatic ecosystem

- Local elimination or extinction of sensitive and/or rare species
- Alteration of native communities
- Algal blooms or other outbreak formations and
- Massive population expansions
- Modification of substratum conditions including shore zones
- Alteration of oxygen and nutrient concentration, pH and transparency of the water
- Accumulation of synthetic pollutants

Can disturb ecological quality by effects on one or more levels of biological organisation:

- An individual (parasites or pathogens),
- A population (by genetic change, i.e. hybridization)
- A community (by structural shift)
- A habitat (by modification of physical-chemical conditions)

or/and an

- Ecosystem (by alteration of energy and organic material flow

The biological and ecological effects of bio pollution may also cause adverse economic consequences

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Facts and Figures




- Shipping carries more than 90% of the world's commodities and is essential to global economy
- A single bulk cargo ship of 200,000 tones can carry up to 60,000 tones of ballast water
- It is estimated that 12 billion tones of ballast water is carried around the world each year
- Every nine weeks a marine species invades a new environment somewhere in the world

Ten of the Most Unwanted

Marine plants, animals and microbes are being carried around the world attached to the hulls of ships and in ships' ballast water. When discharged into new environments, they may become invaders and seriously disrupt the native ecology and economy. Introduced pathogens may cause diseases and death in humans.

Cholera

Vibrio cholerae (various strains)

Native to: Various strains with broad ranges.

Introduced to: South America, Gulf of Mexico and other areas.

Impacts: Some cholera epidemics appear to be directly associated with ballast water. One example is an epidemic that began simultaneously at three separate ports in Peru in 1991, sweeping across South America, affecting more than a million people and killing more than ten thousand by 1994. This strain had previously been reported only in Bangladesh.

North American Comb Jelly

Mnemiopsis leidyi

Native to: Eastern Seaboard of the Americas

Introduced to: Black, Azov and Caspian Seas

Impacts: Reproduces rapidly (self fertilising hermaphrodite) under favourable conditions. Feeds excessively on zooplankton. Depletes zooplankton stocks; altering food web and ecosystem function. Contributed significantly to collapse of Black and Azov Sea fisheries in 1990s, with massive economic and social impact. Now threatens similar impact in Caspian Sea.

Cladoceran Water Flea

Cercopagis pengoi

Native to: Black and Caspian Seas

Introduced to: Baltic Sea

Impacts: Reproduces to form very large populations that dominate the zooplankton community and clog fishing nets and trawls, with associated economic impacts.

North Pacific Seastar

Asterias amurensis

Native to: Northern Pacific

Introduced to: Southern Australia

Impacts: Reproduces in large numbers, reaching 'plague' proportions rapidly in invaded environments. Feeds on shellfish, including commercially valuable scallop, oyster and clam species.

Mitten Crab

Eriocheir sinensis

Native to: Northern Asia

Introduced to: Western Europe, Baltic Sea and West Coast North America

Impacts: Undergoes mass migrations for reproductive purposes. Burrows into river banks and dykes causing erosion and siltation. Preys on native fish and invertebrate species, causing local extinctions during population outbreaks. Interferes with fishing activities.

Zebra Mussel

Dreissena polymorpha

Native to: Eastern Europe (Black Sea)

Introduced to: Western and northern Europe, including Ireland and Baltic Sea; eastern half of North America

Impacts: Fouls all available hard surfaces in mass numbers. Displaces native aquatic life. Alters habitat, ecosystem and food web. Causes severe fouling problems on infrastructure and vessels. Blocks water intake pipes, sluices and irrigation ditches. Economic costs to USA alone of around US$750 million to $1 billion between 1989 and 2000.

Toxic Algae (Red/Brown/Green Tides)

Various species

Native to: Various species with broad ranges.

Introduced to: Several species have been transferred to new areas in ships' ballast water.

Impacts: May form Harmful Algae Blooms. Depending on the species, can cause massive kills of marine life through oxygen depletion, release of toxins and/or mucus. Can foul beaches and impact on tourism and recreation. Some species may contaminate filter-feeding shellfish and cause fisheries to be closed. Consumption of contaminated shellfish by humans may cause severe illness and death.

Asian Kelp

Undaria pinnatifida

Native to: Northern Asia

Introduced to: Southern Australia, New Zealand, West Coast of USA, Europe and Argentina

Impacts: Grows and spreads rapidly, both vegetatively and through dispersal of spores. Displaces native algae and marine life. Alters habitat, ecosystem and food web. May affect commercial shellfish stocks through space competition and alteration of habitat.

Round Goby

Neogobius melanostomus

Native to: Black, Azov and Caspian Seas

Introduced to: Baltic Sea and North America

Impacts: Highly adaptable and invasive. Increases in numbers and spreads quickly. Competes for food and habitat with native fishes including commercially important species, and preys on their eggs and young. Spawns multiple times per season and survives in poor water quality.

European Green Crab

Carcinus maenas

Native to: European Atlantic Coast

Introduced to: Southern Australia, South Africa, USA and Japan

Impacts: Highly adaptable and invasive. Resistant to predation due to hard shell. Competes with and displaces native crabs and becomes a dominant species in invaded areas. Consumes and depletes wide range of prey species. Alters inter-tidal rocky shore ecosystem.

Further information:

Global Ballast Water Management Programme
International Maritime Organization, London, UK
Fax +44 (0)20 7587 3261
Web http://globallast.imo.org

The species presented here are for illustrative purposes only. Their introduced ranges may be greater than depicted. There are numerous other examples of serious marine bio-invasions around the world.

Global Ballast Water Management Programme · GEF · undp · IMO

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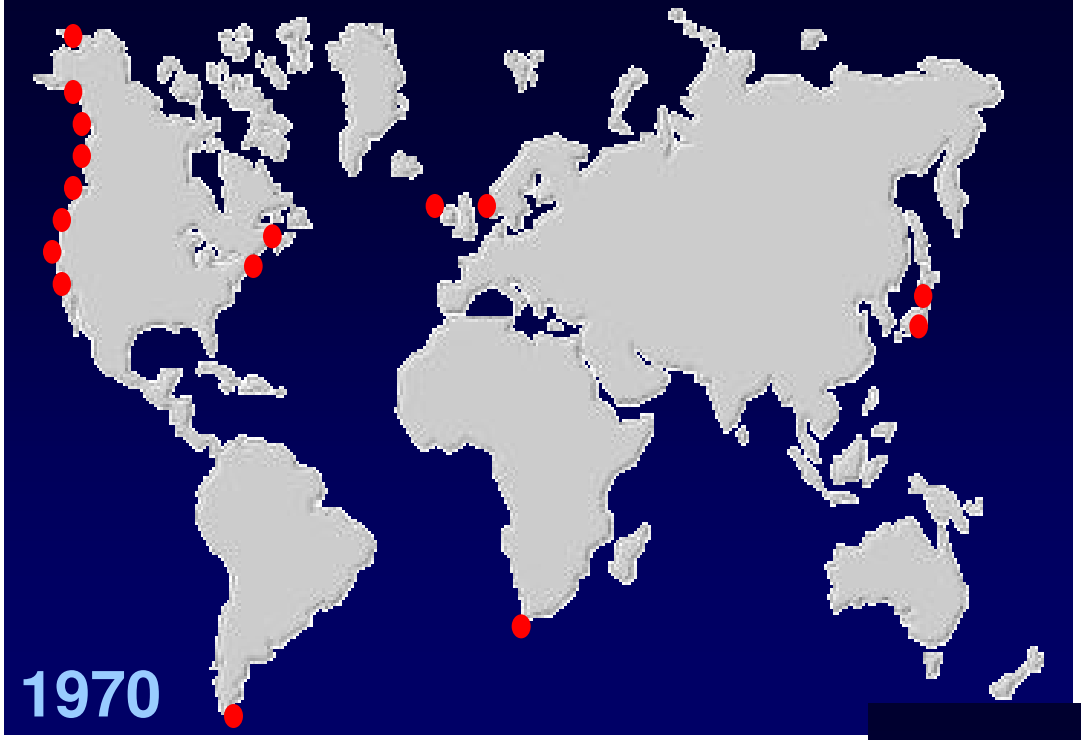
Harmful algal bloom
Red Tide

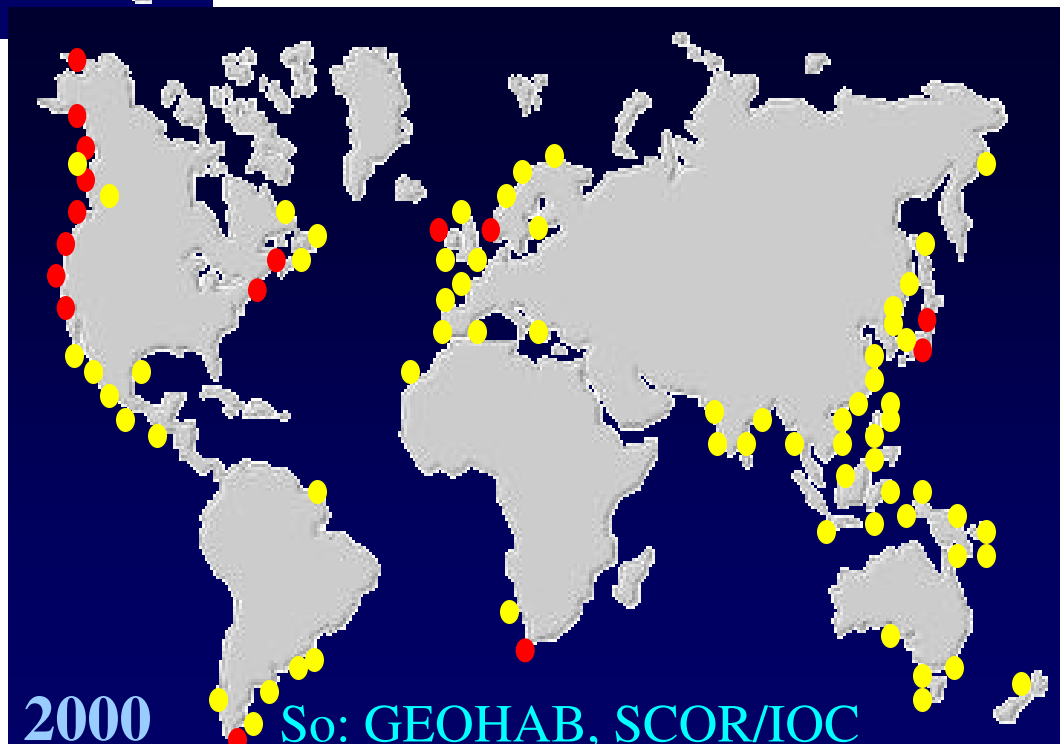
Harmful algal blooms

Dense phytoplankton population appearing suddenly & colouring the water red or red-brown

Paralytic Shell Fish Poisoning (PSP)




Alexandrium sp.



So: GEOHAB, SCOR/IOC

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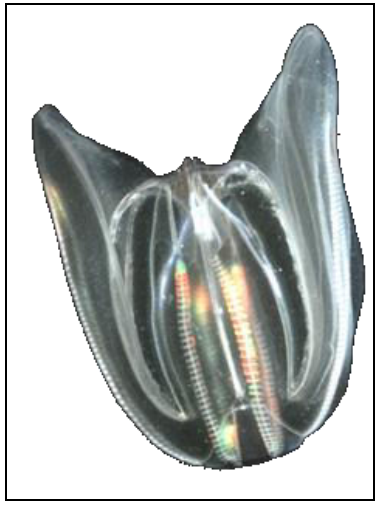
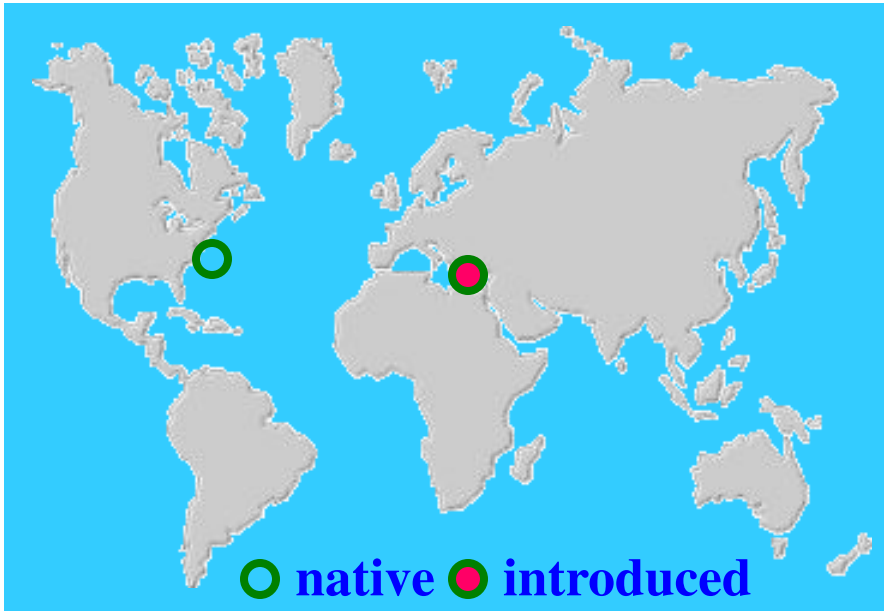


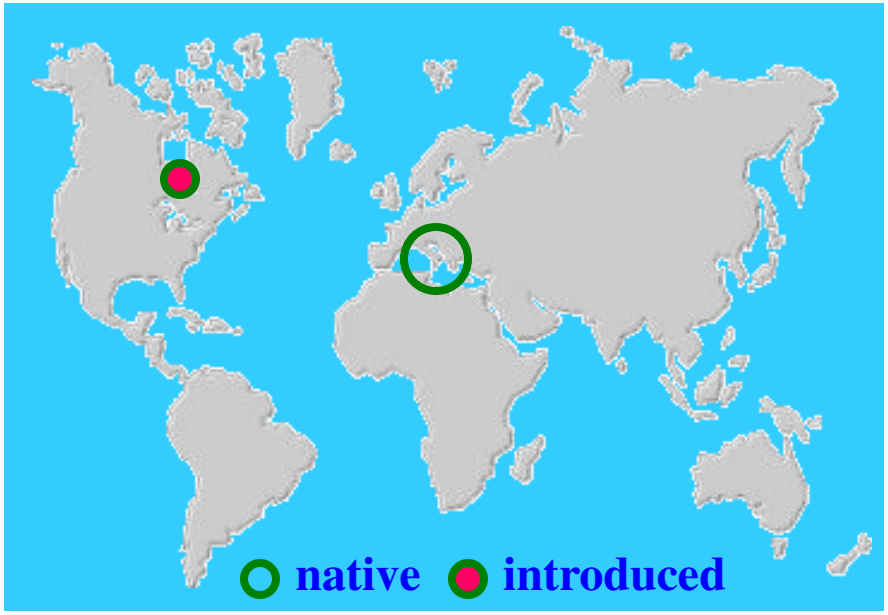
Comb jelly
Mnemiopsis leidyi



- 95% biomass in Black Sea
- Feeds on fish larvae

- Reduced anchovy fishery worth US$ 250 million per year

Zebra mussel
Dreissena polymorpha



- **Biofouling of water intake pipes**
- **Established in rivers & lakes**

- **In 1990 US Govt. pledged US$ 11 million to fight Zebra mussel**

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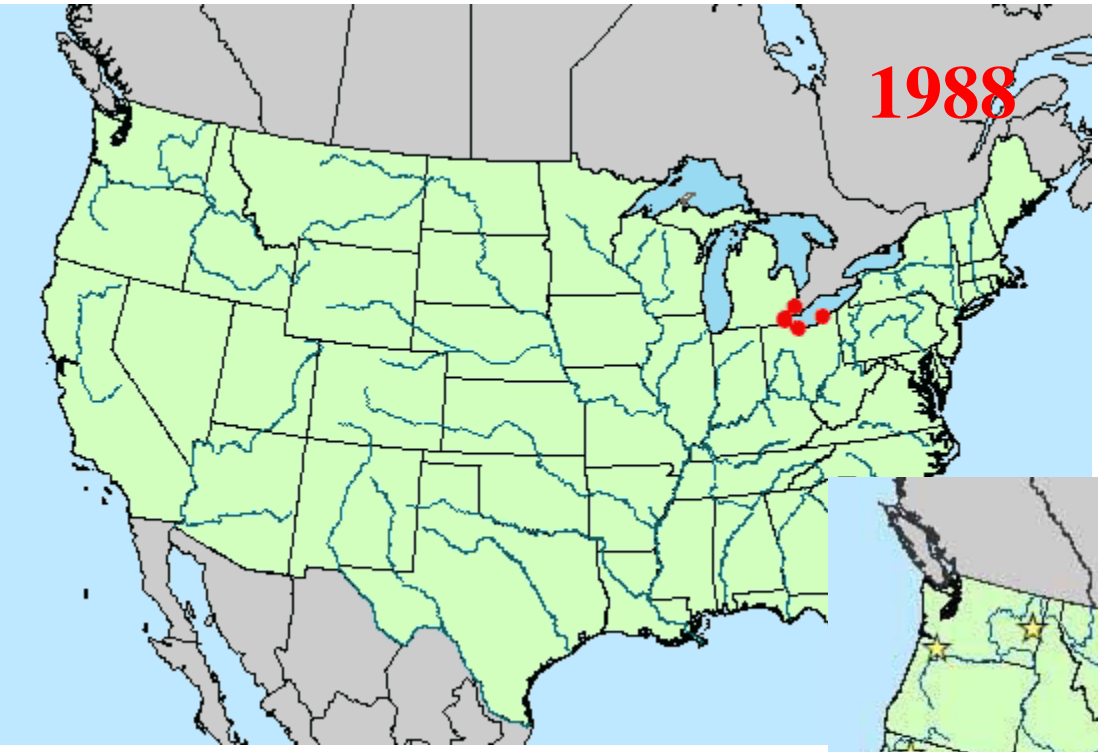
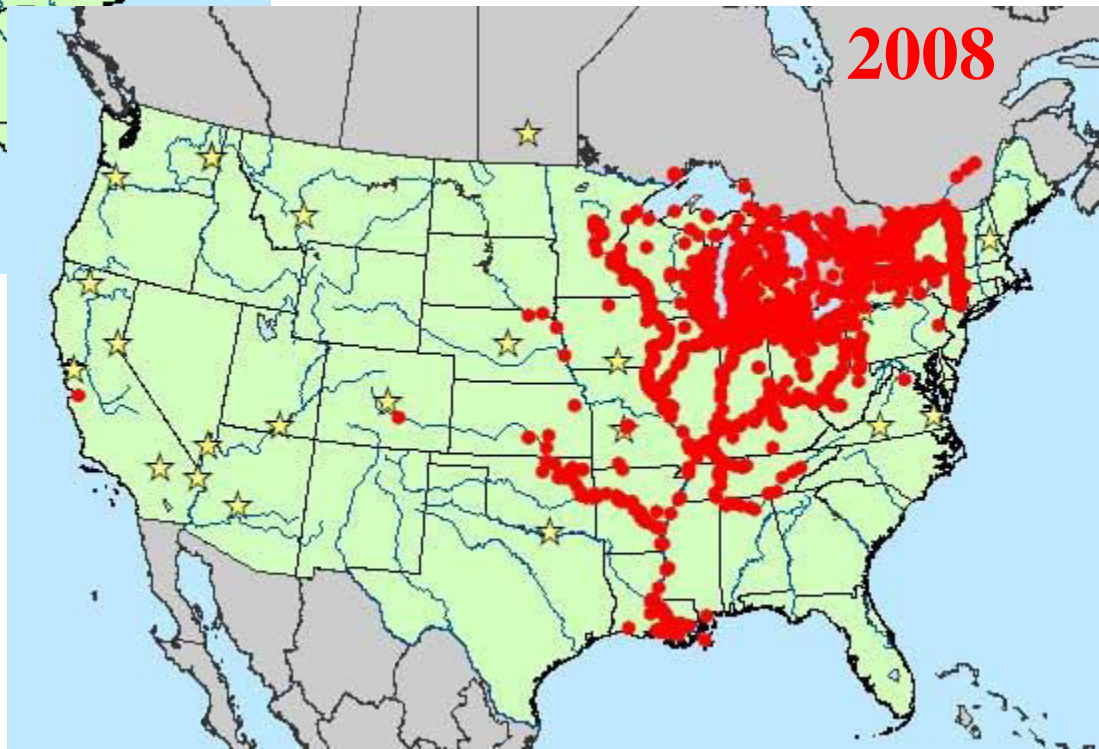
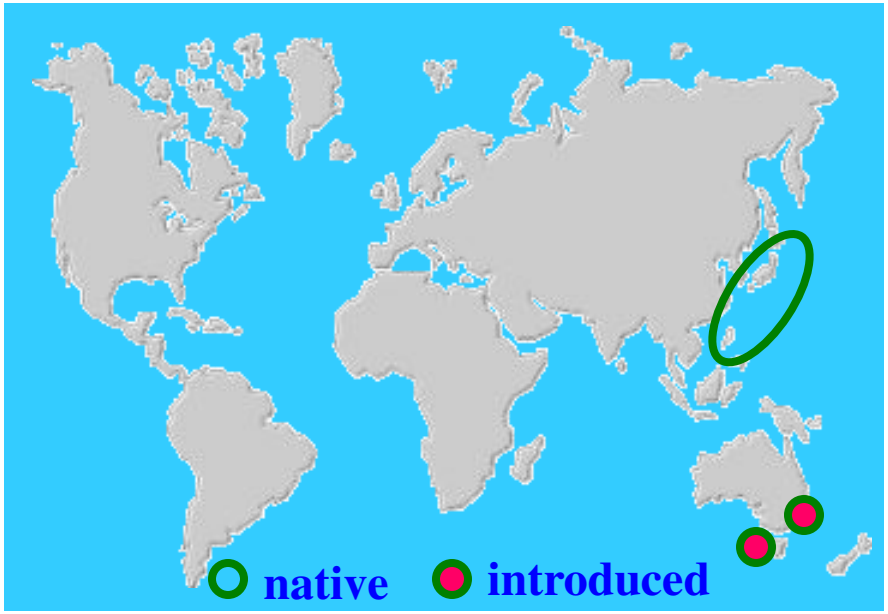
Example of marine bioinvasion – Spread of zebra mussel





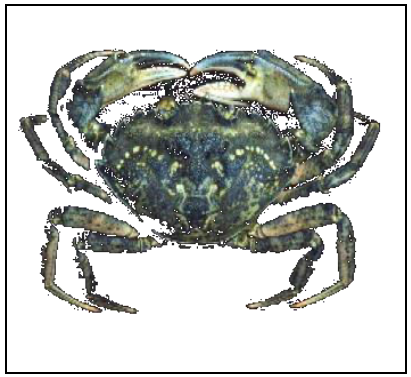
Japanese starfish

Asteria amurensis

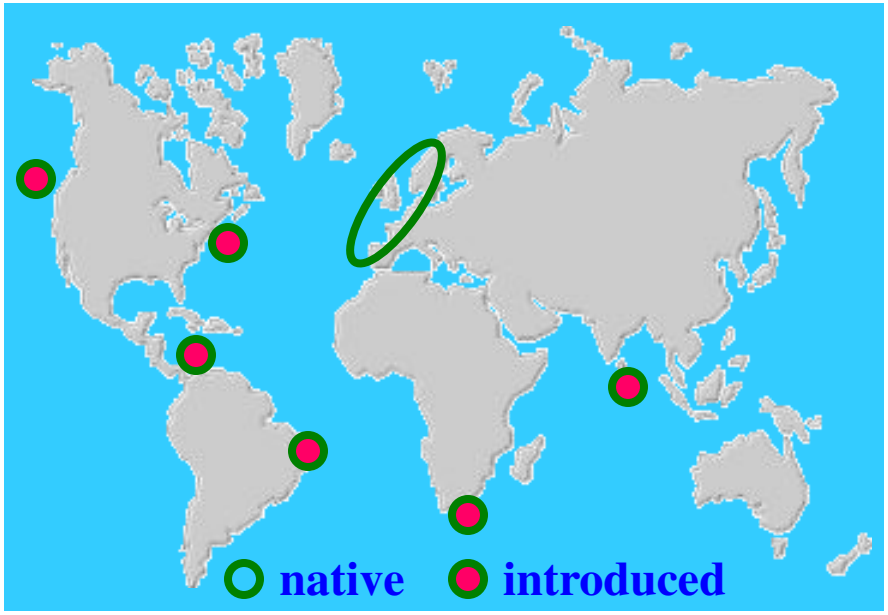


- Consumes native shell fish
- Control efforts unsuccessful

- Mariculture & fishing industry
- Millions of dollars annually



Green crab
Carcinus meanas



- **Mollusc, crustacean, polychaete population effected**

- **Major threat to scallop industry**

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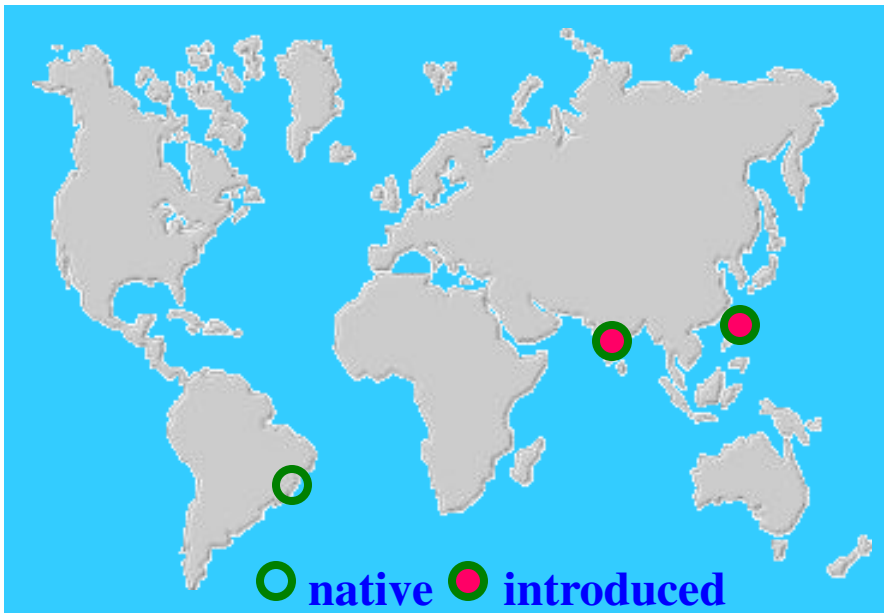
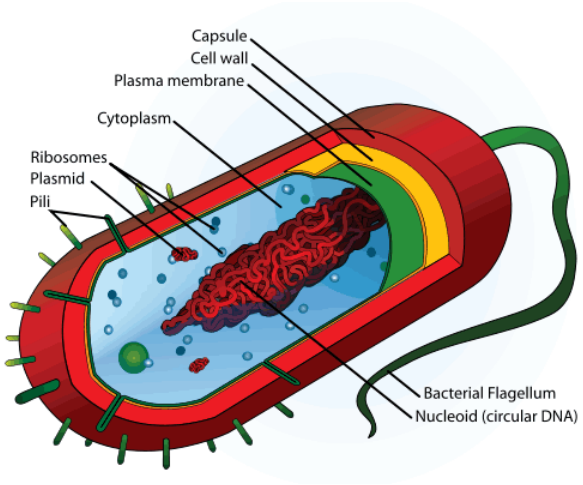
Black Striped Mussel
Mytilopsis sallei



- Small delicate bivalve
- Invaded India ~ 1967
- Recorded in Visakhapatnam & Mumbai

- Spread to Hong Kong, threatened Australia

Pathogenic Bacteria



A typical bacterium

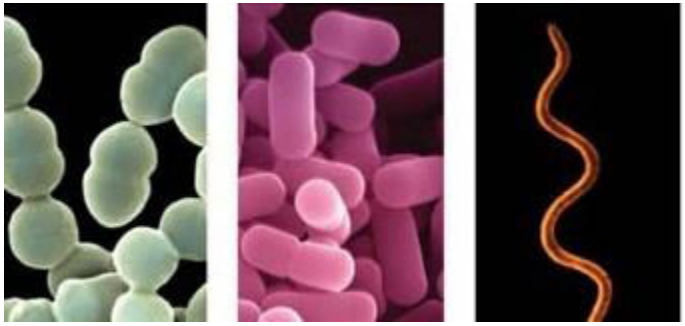
✓ Bacteria are a group of single-celled microorganisms with prokaryotic (an organism without a nucleus) cellular configuration

✓ The organelles of eukaryotes (mitochondria and chloroplasts) are thought to be remnants of Bacteria that invaded, or were captured by primitive eukaryotes in the evolutionary past

✓ Numerous types of eukaryotic cells that exist today are inhabited by endosymbiotic prokaryotes

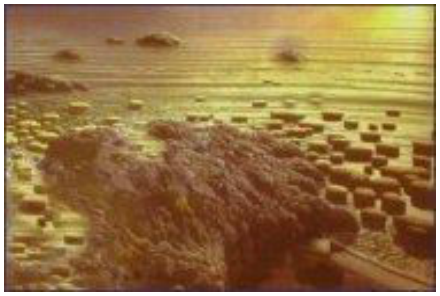
✓ A typical bacterial cell is about 1 micrometer in diameter or width

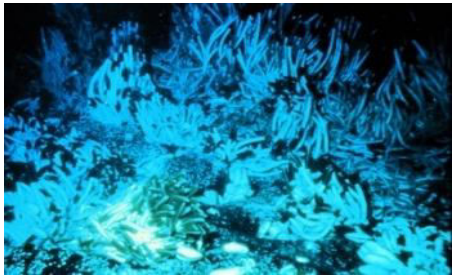
Bacteria occur in three main shapes



Spherical **Rod shaped** **Spiral**

Bacteria are found everywhere





- Soil
- Radioactive waste
- Water
- Plants
- Animals
- Deep in the earth's crust
- Organic material
- Arctic ice
- Glaciers
- Hot springs
- The stratosphere (between 6 to 30 miles up in the atmosphere)
- Ocean depths - they have been found deep in ocean canyons and trenches over 32,800 feet (10,000 meters) deep.
- They live in total darkness by thermal vents at incredible pressure.

NIO understanding the seas

Threats of bio-invasion by pathogenic bacteria due to world shipping

Ballast water

Shipping carries more than 90% of the world's commodities

Biofouling

Microorganisms are introduced into alien environments in large numbers than any other organisms

- Abundance
- Capability to form resting stages
- Potential pathogenicity
- Capability to withstand wide range of environmental conditions

NIO understanding the seas

Ballast water – a means of translocation of pathogenic bacteria

One of the most common methods of transportation of alien species from one place to another is via ballast water carried by cargo ships.

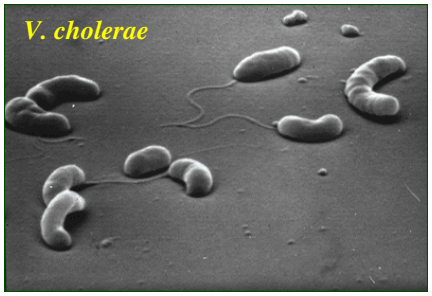
- Transport of ballast water through ships to different regions has created long distance inoculation and distribution of various microorganisms.
- Concentrations of bacteria in ballast water exceed other taxa by 6 to 8 orders of magnitude

Where they are found in ballast water

- ✓ ships ballast water
- ✓ Residual sediment
- ✓ Biofilms formed on interior tanks surface
- ✓ Associated macro organisms or metazoans

Regulation D2 Water Quality Standard

Category	IMO Standard
> 50 µ (Zooplankton)	<10 per m^3
10-50 µ (Phytoplankton)	<10 per ml
Bacteria	
-Toxicogenic *Vibrio cholerae* **(O1 & O139)**	1 cfu/100 ml
-*Escherichia coli*	250 cfu/100 ml
-Intestinal Enterococci	100 cfu/100 ml



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- Bacterial population, an important component of the microbial loop, influences the food web dynamics and ecosystem functioning.

- The response of the bacterial population to changing environment is rapid and assessment of the health of such an ecosystem benefits from high resolution observations.

*Vibrio cholera*e – The deadliest pathogen causing the life threatening Cholera

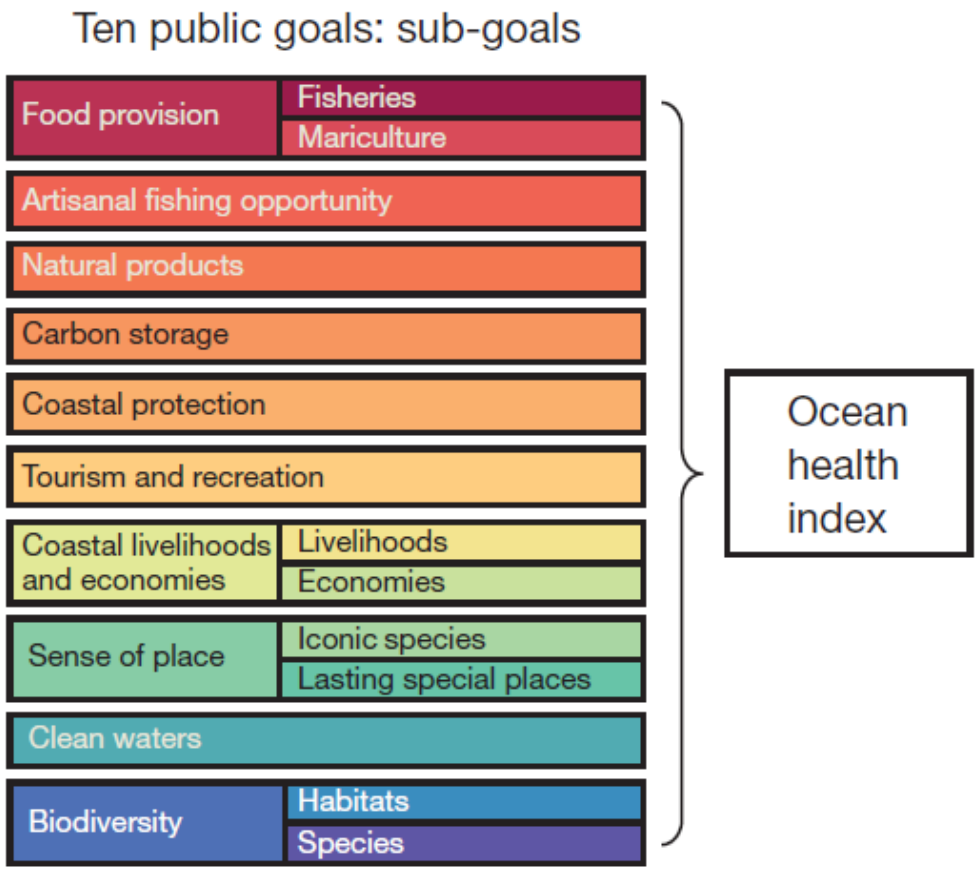
- *Vibrios* are ubiquitous in marine environment and under favorable conditions mediate important ecological functions.
- Gram-negative, curved or comma-shaped rods with a single polar flagellum, whose natural habitat is usually salt or fresh water.
- Consists of 206 serogroups
- Produce Cholera toxin
- *V. cholera*e is autochthonous to marine and estuarine environments generally, including in non-endemic areas.

- A plethora of *V. cholerae* strains exist in the natural environment, yet apparently only toxigenic serogroup strains belonging to O1 and O139 predominate in causing cholera.

- Disease outbreaks are very dependent on environmental and seasonal factors.

- While non-O1/O139 strains are ubiquitous and isolated year-round from a variety of aquatic ecosystems, the pandemic strains are rarely, if ever, isolated from surface waters of endemic regions even during seasonal outbreaks, in part because toxigenic strains may be present in a non-culturable state.

- An index was created comprising ten diverse public goals for a healthy coupled human–ocean system and calculated the index for every coastal country.
- Globally, the overall index score was 60 out of 100 (range 36–86), with developed countries generally performing better than developing countries, but with notable exceptions.
- Only 5% of countries scored higher than 70, whereas 32% scored lower than 50.
- The index provides a powerful tool to raise public awareness, direct resource management, improve policy and prioritize scientific research.



A framework to assess ocean health and motivate better data collection to strengthen future iterations of the index
(Source: Benjamin S. Halpern et al. 2 0 1 2, Vol 488, Nature)

Thank you