

*Marine Bioinvasion :*  
*Concerns for Ecology and*  
*Shipping*



**Vibrio cholerae**



**North Pacific seastar**



**Green crab**



**Mitten crab**



**Red tide**



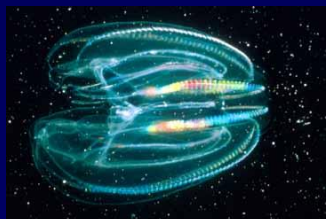
**Zebra mussel**



**Asian kelp**



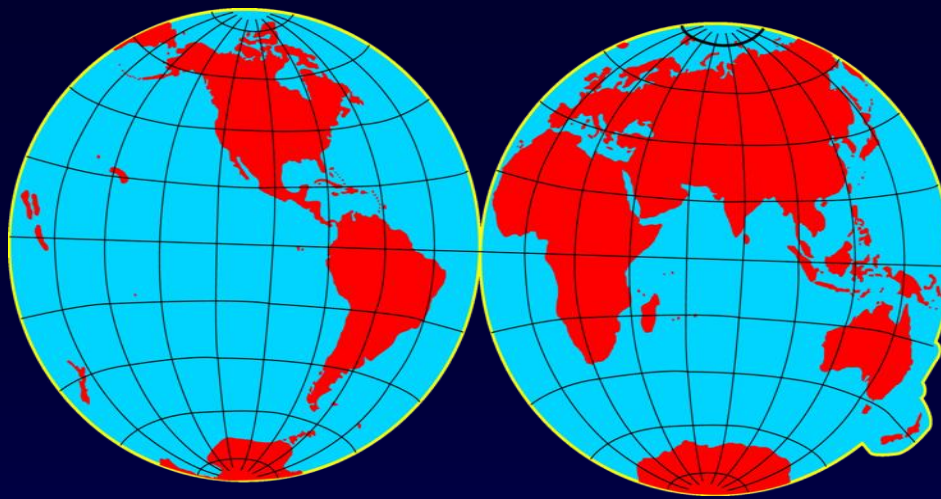
**Cladoceran water flea**



**Comb jelly**



**Round goby**



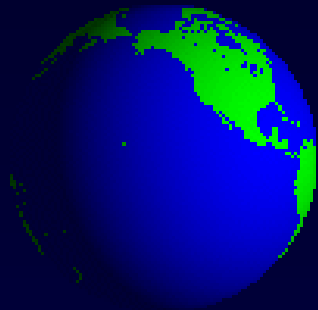
# Threats of bioinvasion due to world shipping



Ballast water

Biofouling

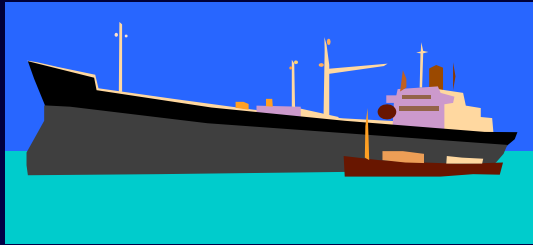
# Facts & Figures



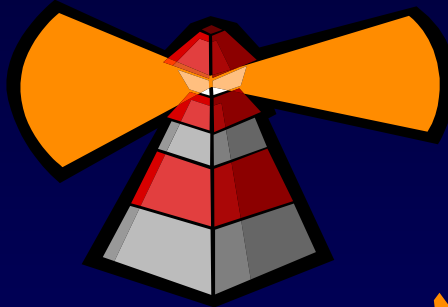
- Shipping carries more than 90% of the world's commodities and is essential to global economy
- A single bulk cargo ship of 200,000 tonnes can carry up to 60,000 tonnes of ballast water
- It is estimated that 2-3 billion tonnes of ballast water are carried around the world each year
- Every nine weeks a marine species invades a new environment somewhere in the world

# Common Marine Bioinvasion Vectors

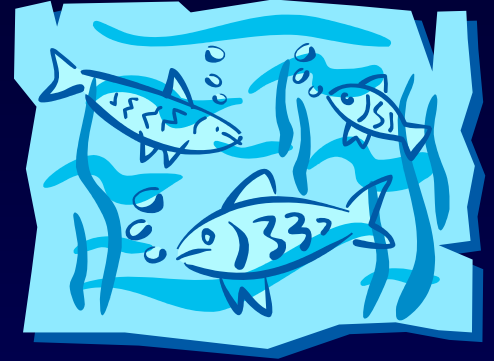
Ships



Navigational buoys  
& Marina Floats



Public aquaria



Drilling platforms



Research



Amphibious planes,  
Seaplanes

Education



# Common Marine Bioinvasion Vectors

## Dry Docks



## Aquarium Pet Industry



Recreational equipment



Floating marine debris

## Canals



Restoration



Fisheries, Including Marine Aquaculture (Mariculture)

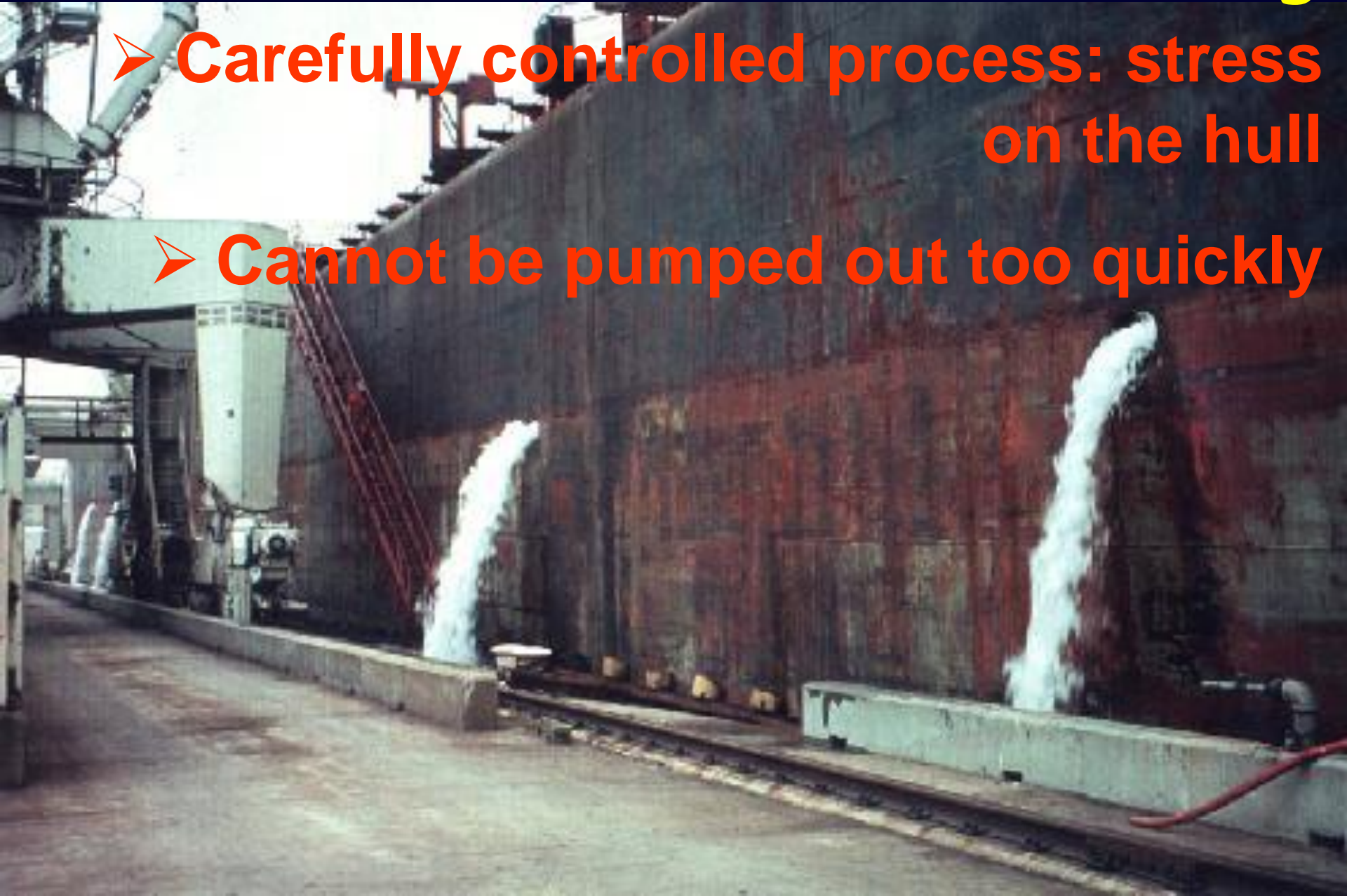
# Ballasting

- Submergence of propeller and rudder for steerage
- Maintain stability
- Avoid hull stress

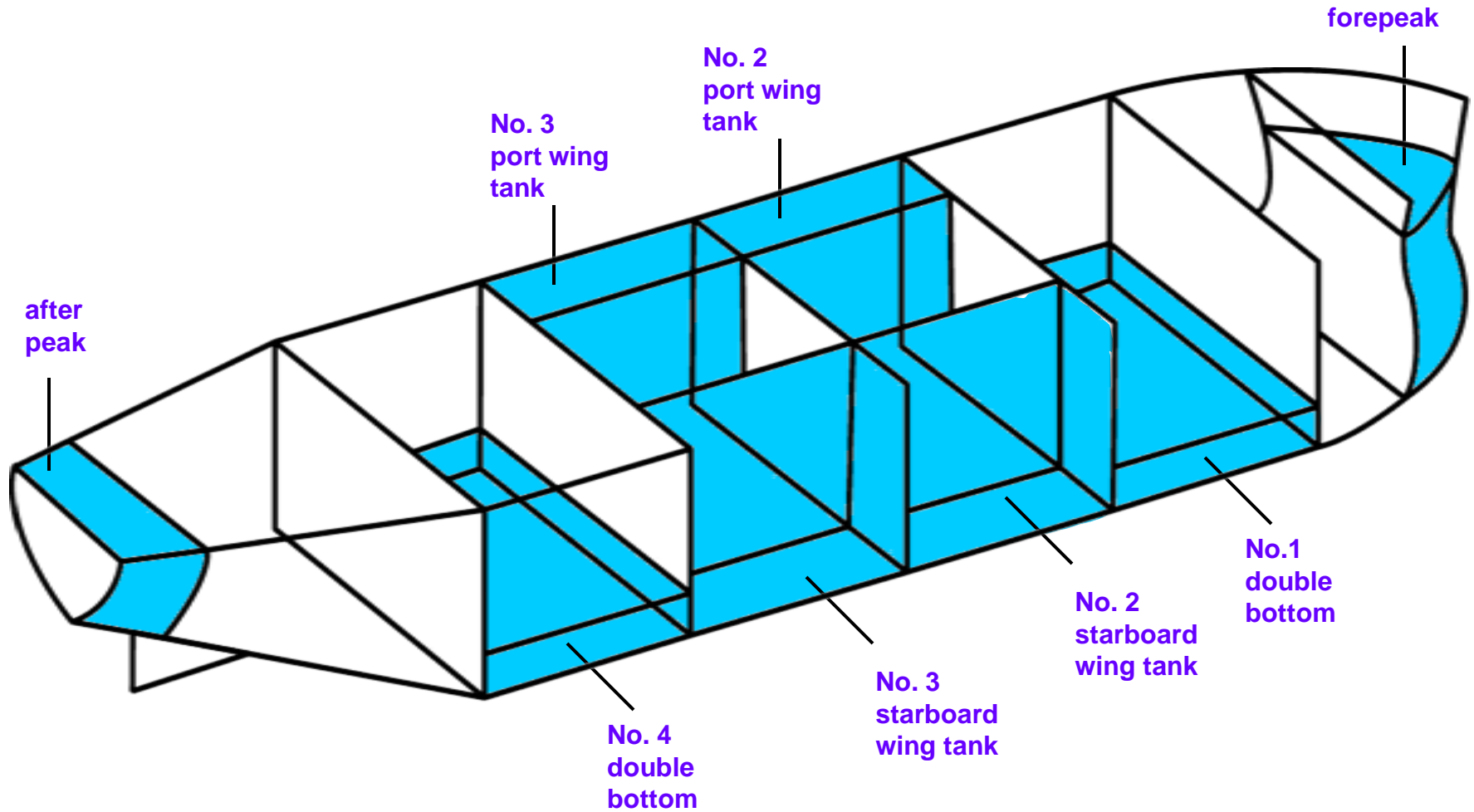


# Deballasting

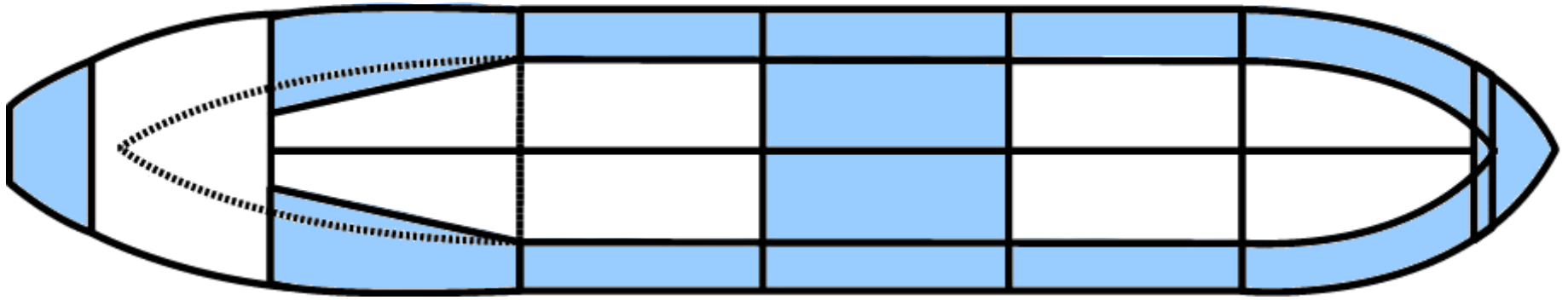
- **Carefully controlled process: stress on the hull**
- **Cannot be pumped out too quickly**



# Schematic diagram of ballast tanks



# Ballast water arrangements



**Storm ballast**

# Representative Ballast capacities

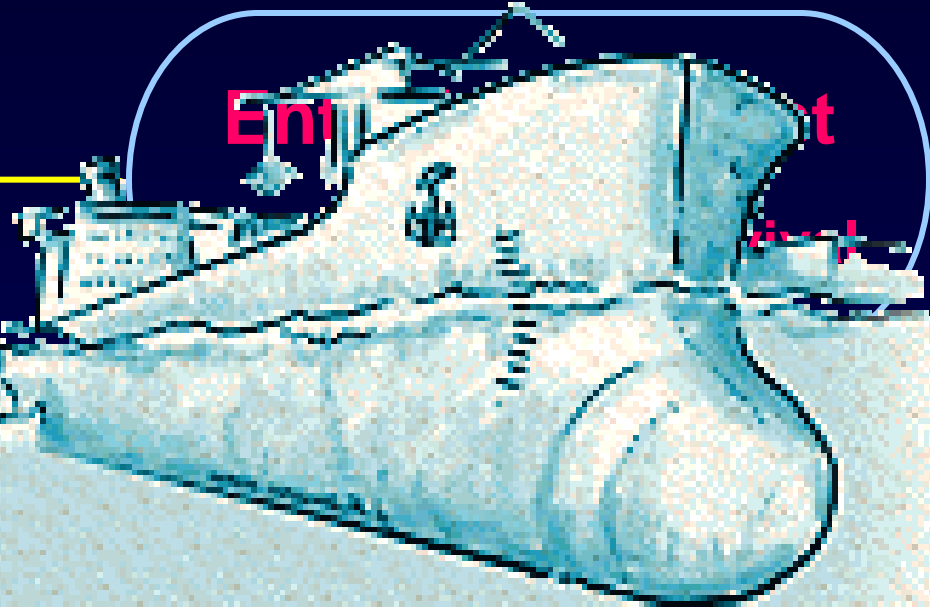
Vessel Type	DWT	Ballast Condition			
		Normal (tonnes)	% of DWT	Heavy (tonnes)	% of DWT
Bulk Carrier	250,000	75,000	30	113,000	45
Bulk Carrier	150,000	45,000	30	67,000	45
Bulk Carrier	70,000	25,000	36	40,000	57
Bulk Carrier	35,000	10,000	30	17,000	49
Tanker	100,000	40,000	40	45,000	45
Tanker	40,000	12,000	30	15,000	38
Container	40,000	12,000	30	15,000	38
Container	15,000	5,000	30	n/a	
General Cargo	17,000	6,000	35	n/a	
General Cargo	8,000	3,000	38	n/a	
Passenger/RORO	3,000	1,000	33	n/a	

# Ballast water implications



# The Ballast Concern

Native population  
Diverse organisms



Biodiversity  
implication

# *Ballast Water - its use and Management*

- Risk factors more important than volume of ballast water are frequency of ship visits & environmental similarity of ports

# *Ballast Water - its use and Management*

- Ships are essential to world trade
- Ships use ballast water to operate effectively & safely
- Ballast water can be the vector of translocation of harmful aquatic organisms & pathogens

- Manage ships ballast water in a manner that minimizes the risk
- Attempt to find more satisfactory long term solutions

Fresh ballast  
Source community



Aged ballast  
Destination community



Status quo  
Sturdy forms

Increase  
Incubation  
Favourable conditions

Transformation  
Cyst & resting cells

Decrease  
Light requirement  
Specific food  
Short lived forms

# 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.

## Indo-Pacific Winter 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

*Eiocheir 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 surface in mass numbers. Displaces native aquatic life. Alters habitat, ecosystem and food web. Causes severe fouling problems of 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 Crab

*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

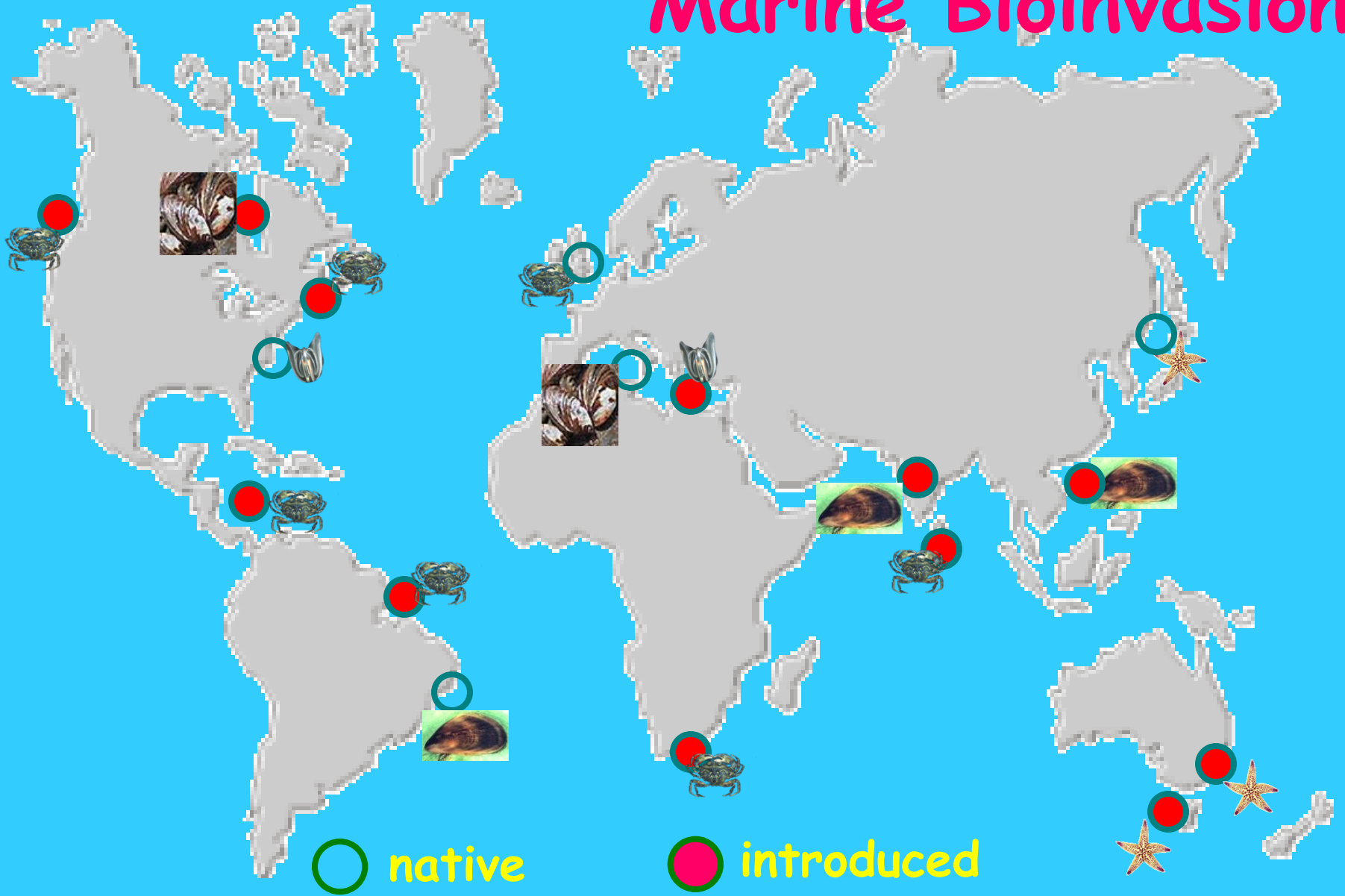
Global Ballast Water Management Programme  
 www.globalballastwater.org  
 www.unep.org/wwap  
 www.undp.org/wwap  
 www.gef.org/wwap

Photo credits: Ship Discharging Ballast Water – CRIMP, CSIRO Marine Research, Australia; Zebra Mussel – Sergei Orlov; Indo-Pacific Winter Flea – Mirja Rosenberg; Cholera – Gloria Casals; Comb Jelly – Richard Harrison; Asian Kelp & North Pacific Seastar – CSIRO Australia; European Green Crab – T. Huisepop; Toxic Algae – D.A. Hontman; Mitten Crab – Stephan Gollach; Round Gobly – David Jude

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.

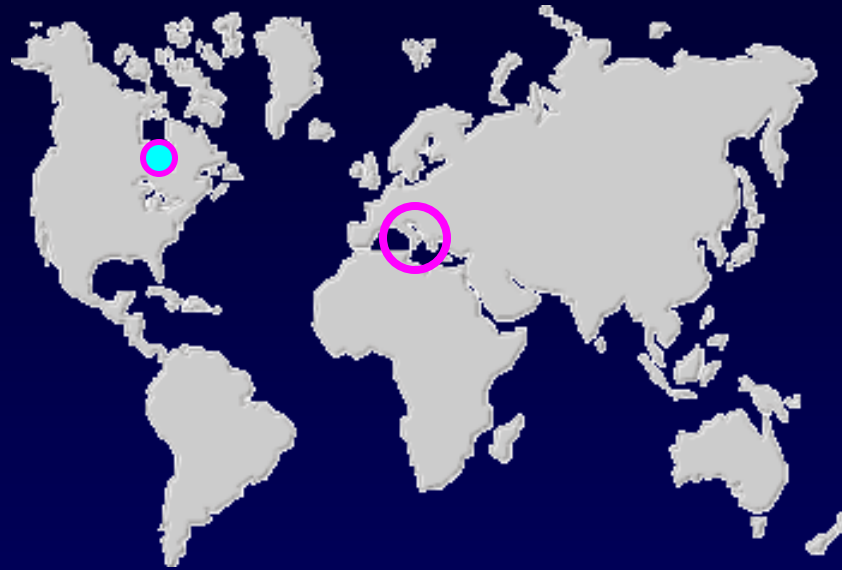


# Marine Bioinvasion



# Zebra mussel

*Dreissena polymorpha*

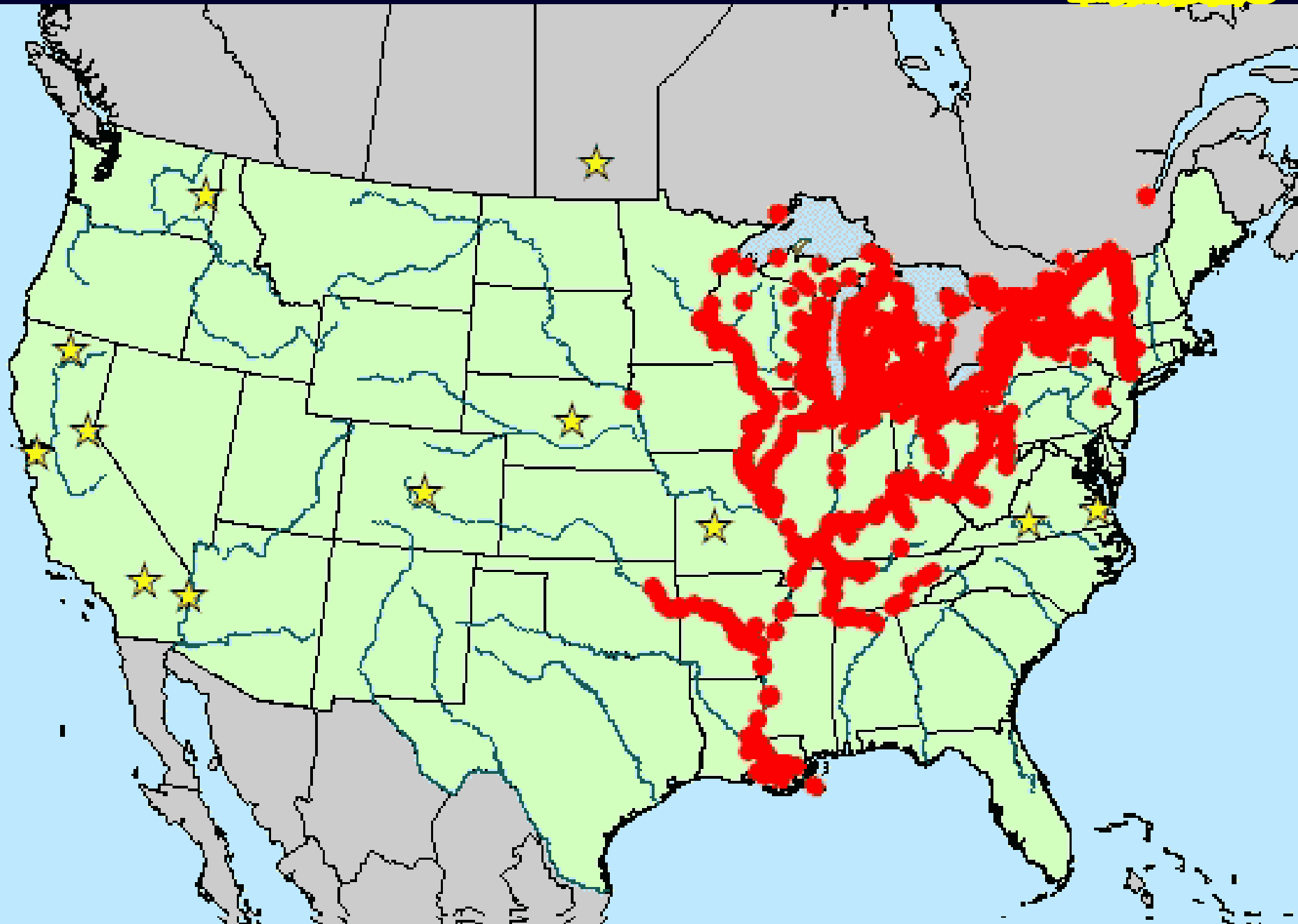


○ native  
● introduced

- Biofouling of water intake pipes
- Established in rivers & lakes
- ❖ In 1990 US Govt. pledged US\$ 11 million to fight Zebra mussel

# Spread of zebra mussel

2003



Harmful algal bloom

**Red Tide**



# Harmful algal bloom

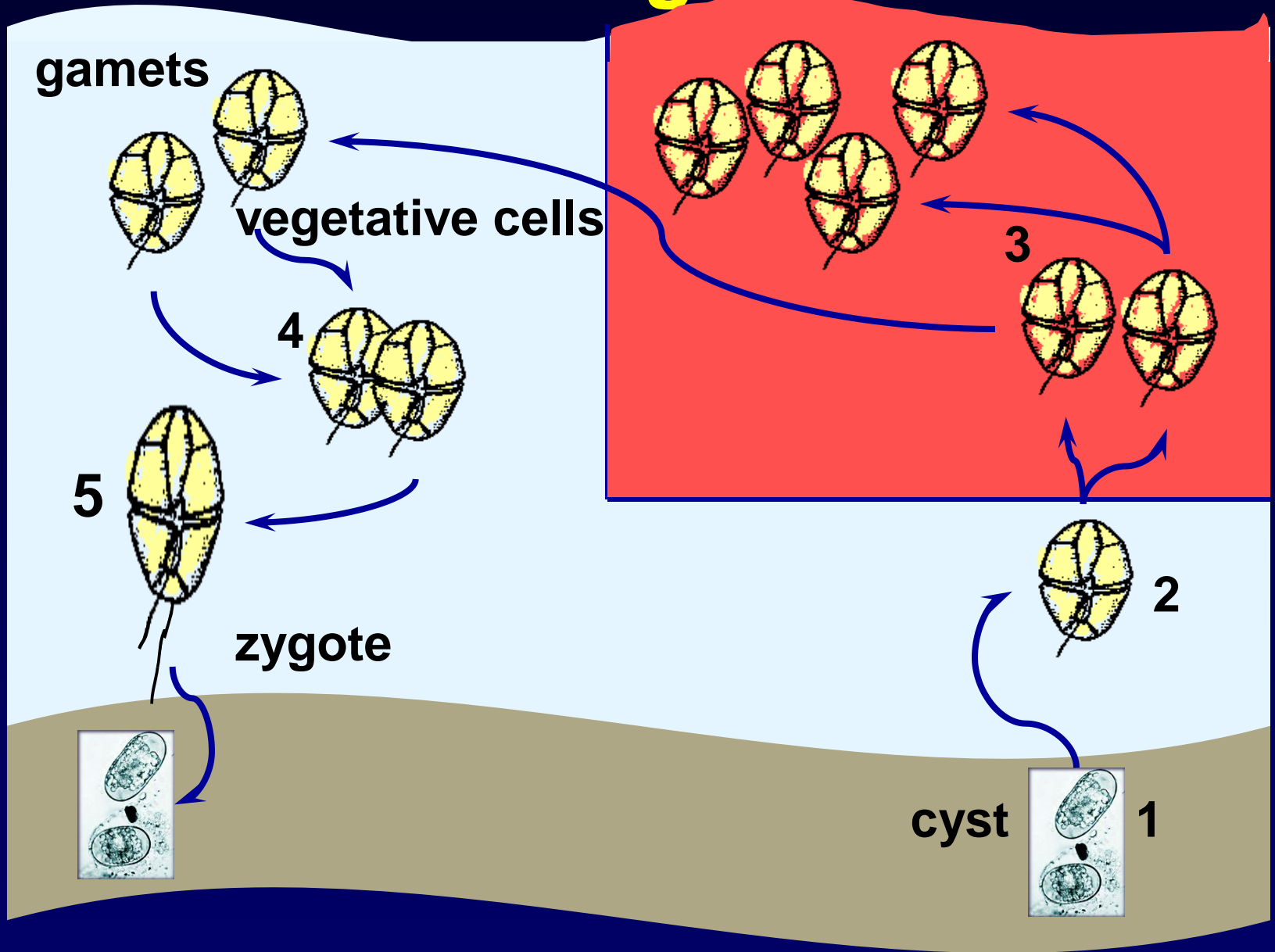
## Red Tide

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



**Effects**  
**Toxic**  
**Anoxia**  
**Clogging**

# Harmful algal bloom



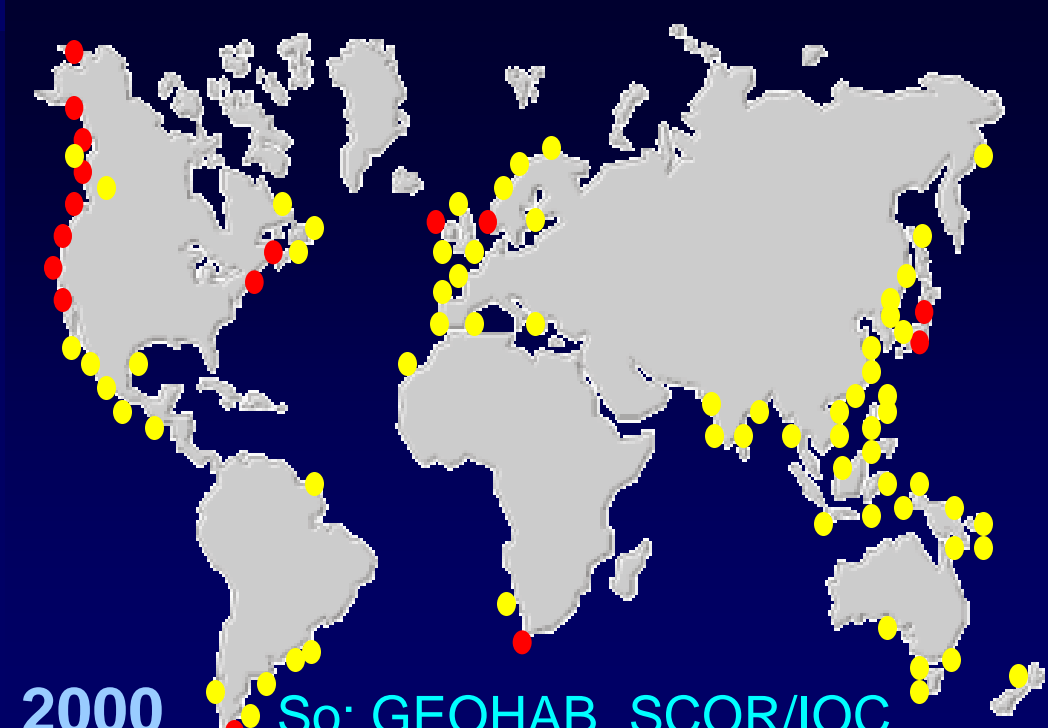
# Paralytic Shell Fish Poisoning (PSP)



1970

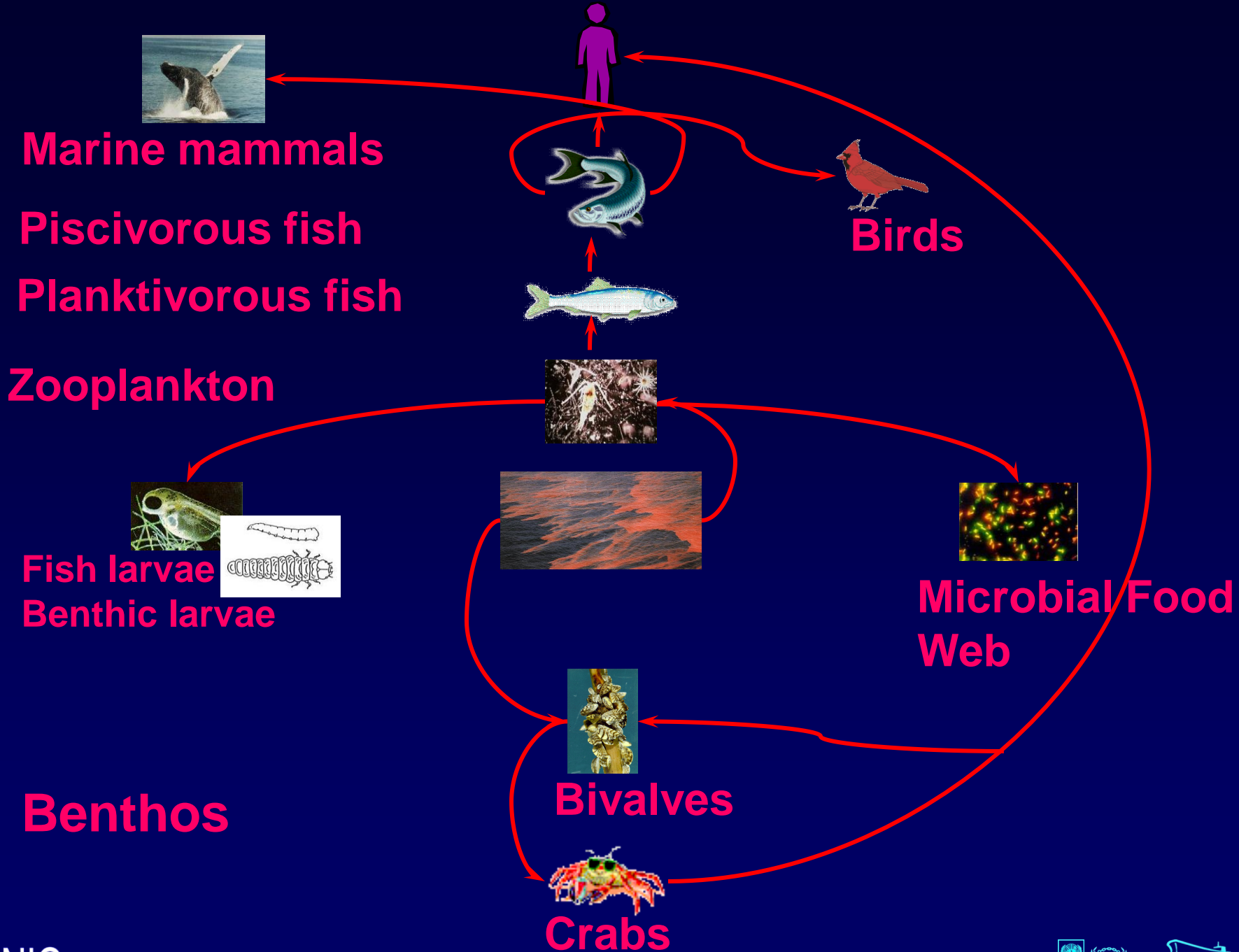


*Alexandrium* sp.



2000

So: GEOHAB, SCOR/IOC



# *Ecological impacts*

- Competing with native species for space & food
- Preying upon native species
- Altering habitat
- Altering environmental conditions
- Altering the food web & overall ecosystem
- Displacing native species, reducing biodiversity & causing local extinction

# *Economic impacts*

include .....

- Reduction in fisheries production
- Impacts on aquaculture
- Physical impacts on coastal infrastructure
- Reduction in the economy & efficiency of shipping due to fouling
- Closure of recreational & tourism facilities
- Secondary economic impacts from human health concern
- Secondary economic impacts from ecological impacts & biodiversity loss
- Costs of responding to the problem

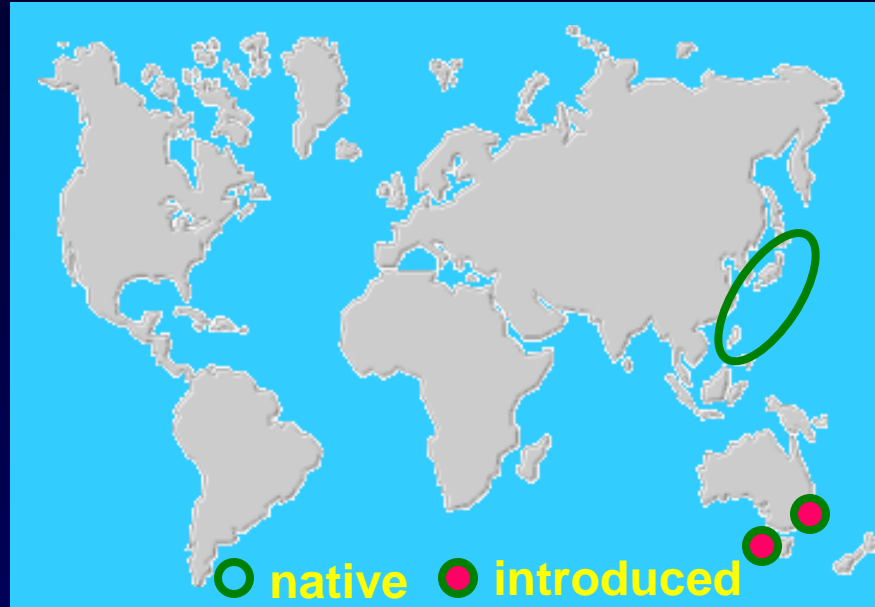
# Thank you



Visit: [www.nio.org](http://www.nio.org)



# Japanese starfish *Asteria amurensis*



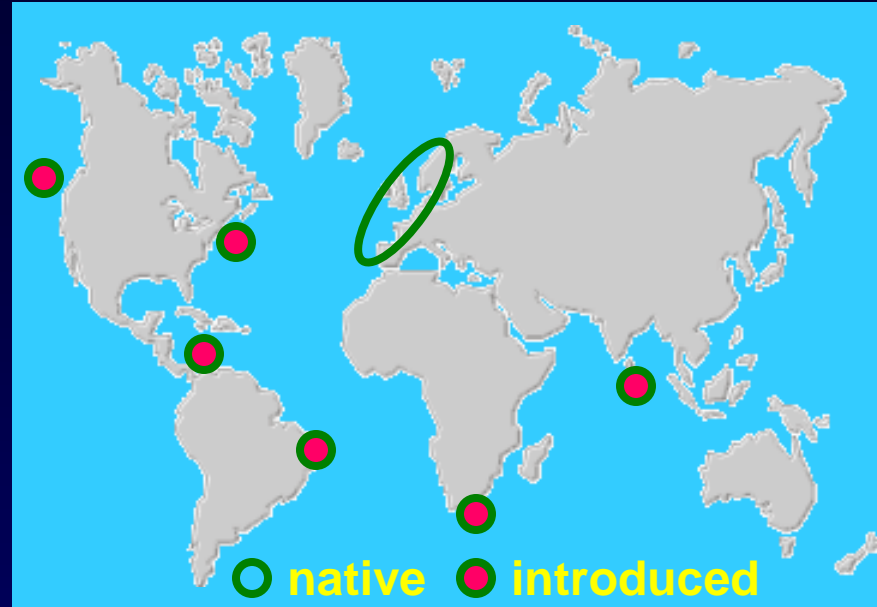
- Consumes native shell fish
- Control efforts unsuccessful
- Mariculture & fishing industry
- Millions of dollars annually





# Green crab

## *Carcinus maenas*



➤ Mollusc, crustacean, polychaete population effected

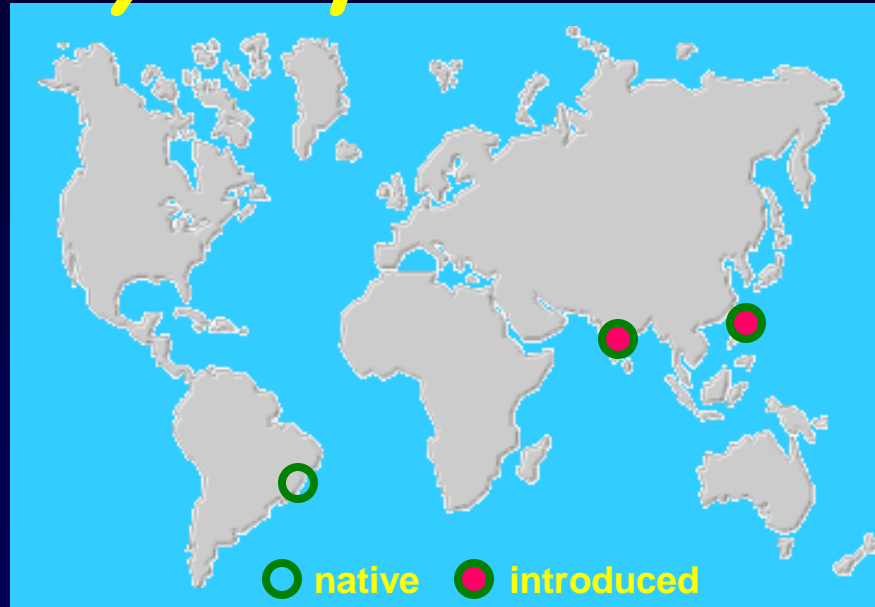


➤ Major threat to scallop industry



# Black Striped Mussle

## *Mytilopsis sallei*



- Small delicate bivalve
- Invaded India ~ 1967
- Recorded in Visakhapatnam & Mumbai
- Spread to Hong Kong, threatened Australia



