Trans boundary threats in the marine environment

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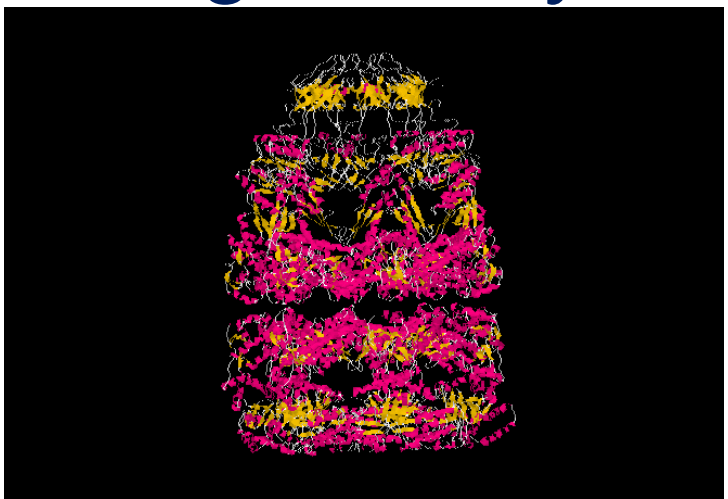
A single introduced species can cause severe harm to the ecology, economy & health of the habitat it is introduced to, & the effects are generally irreversible

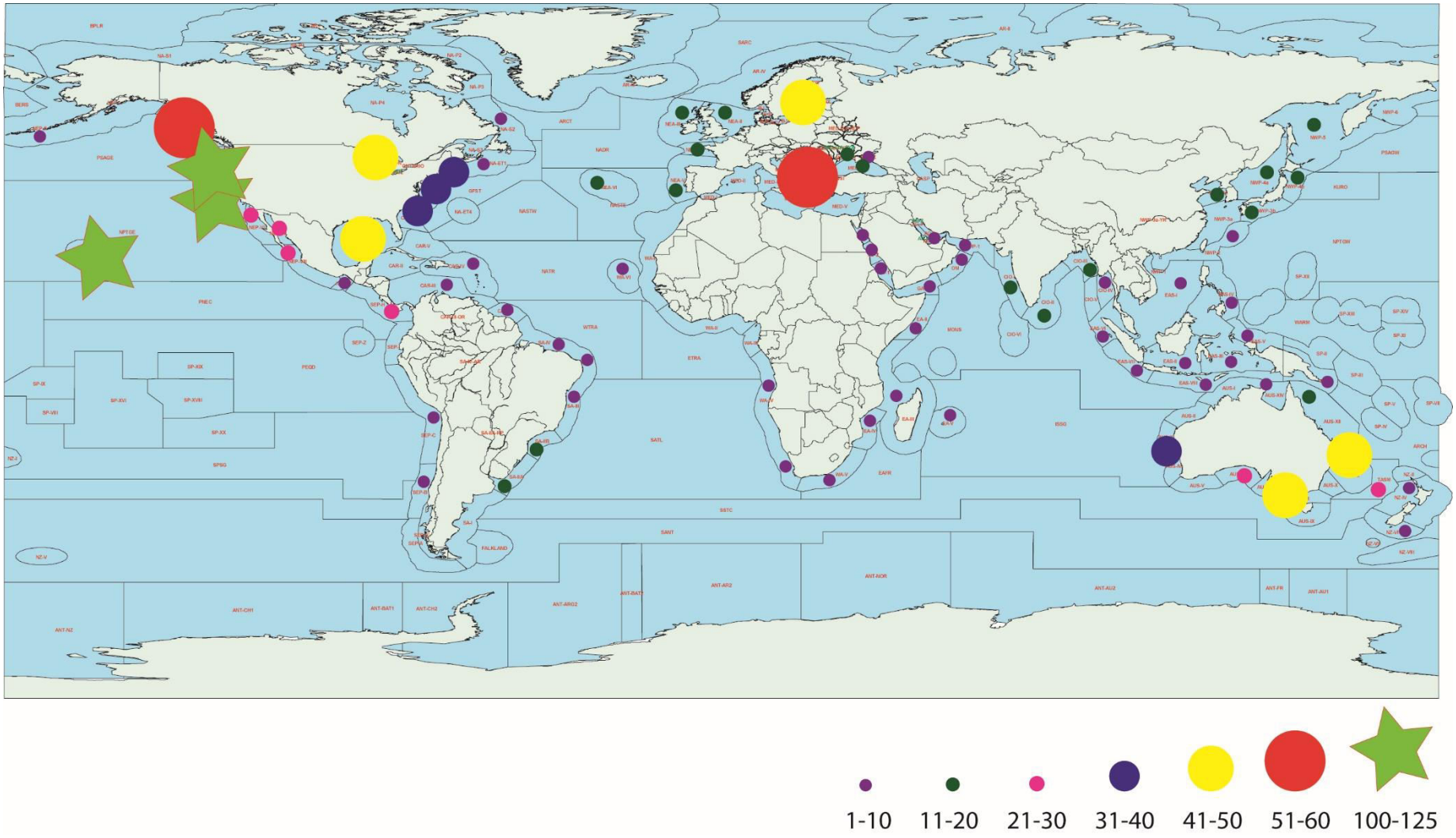


Invertebrate invasions

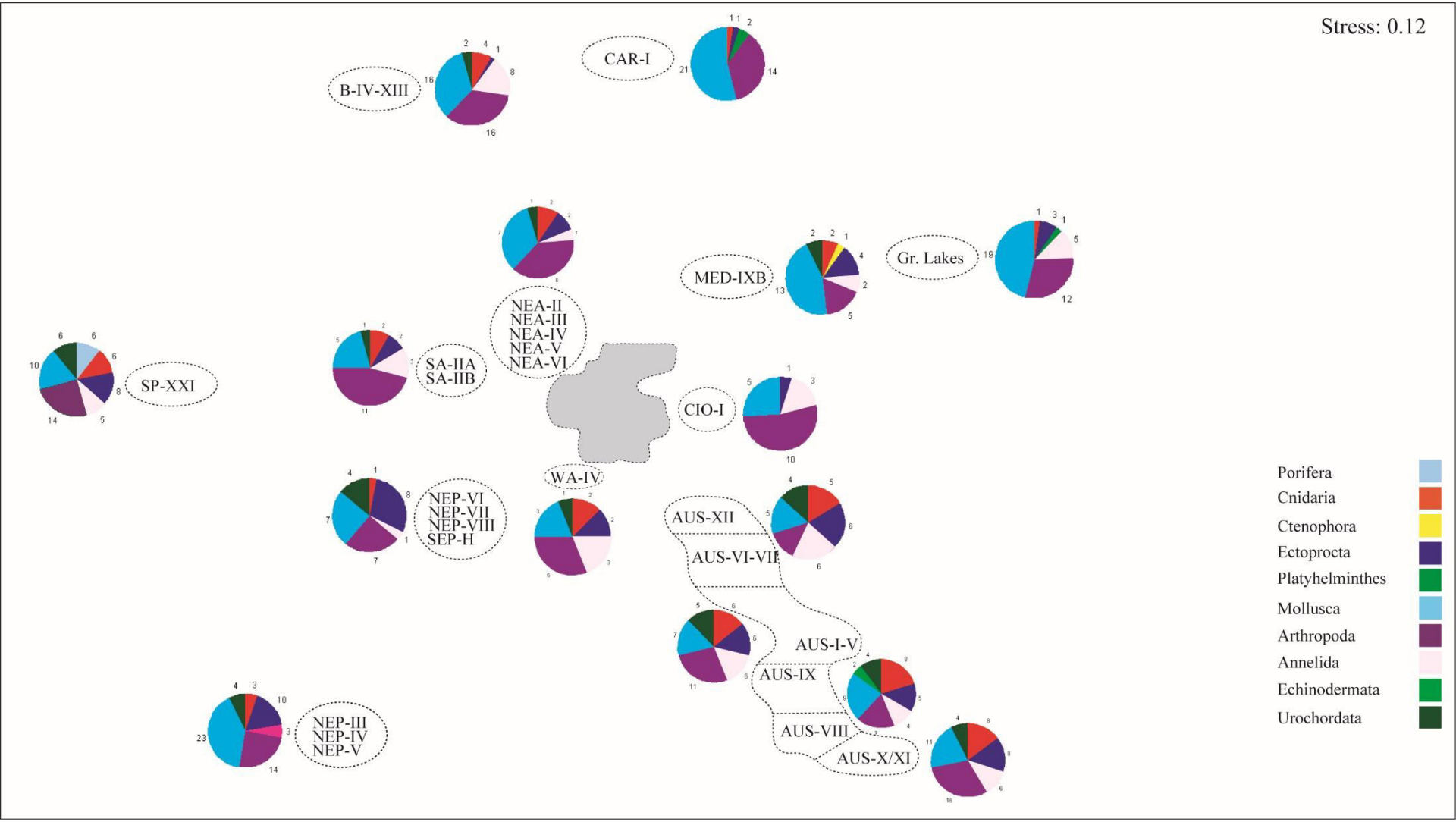
Databases

- ✓ GloBallast –BWRA
- ✓ CIESM –Atlas of exotic crustaceans in the Mediterranean
- ✓ The Australian Introduced Marine Pest Information System
- ✓ Baltic Sea Alien Species Data Base
- ✓ Grate Lakes Exotic Species
- ✓ Presentations from Invasive aquatic species surveys & monitoring workshop – GloBallast at Brazil GloBallast at Brazil
- ✓ Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) Non- indigenous Species Bibliographic Database
- ✓ Nonindigenous Aquatic Species (NAS) information resource for the United States Geological Survey
- ✓ National Exotic Marine and Estuarine Species Information System - The Smithsonian Environmental Research Center
- ✓ The Lithuanian Invasive Species Database
- ✓ Published Literature (Various sources)

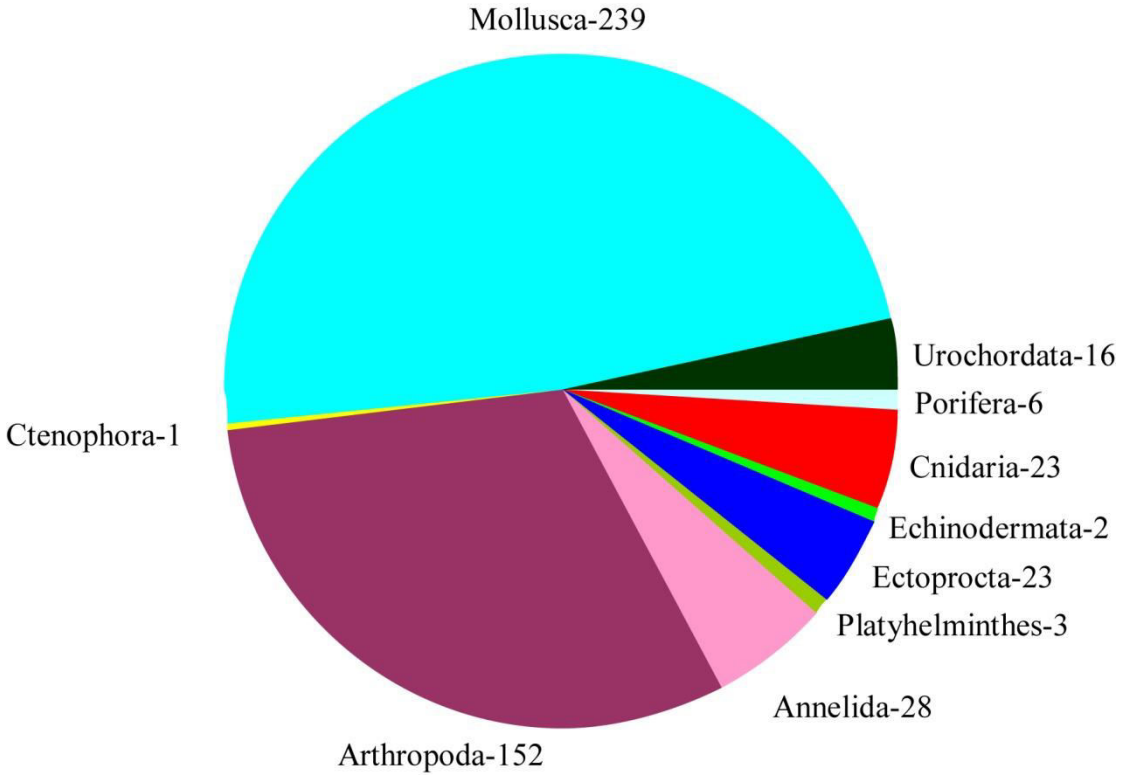
Invasive invertebrate species
Bioregion perspective



The invasion potential of different organisms

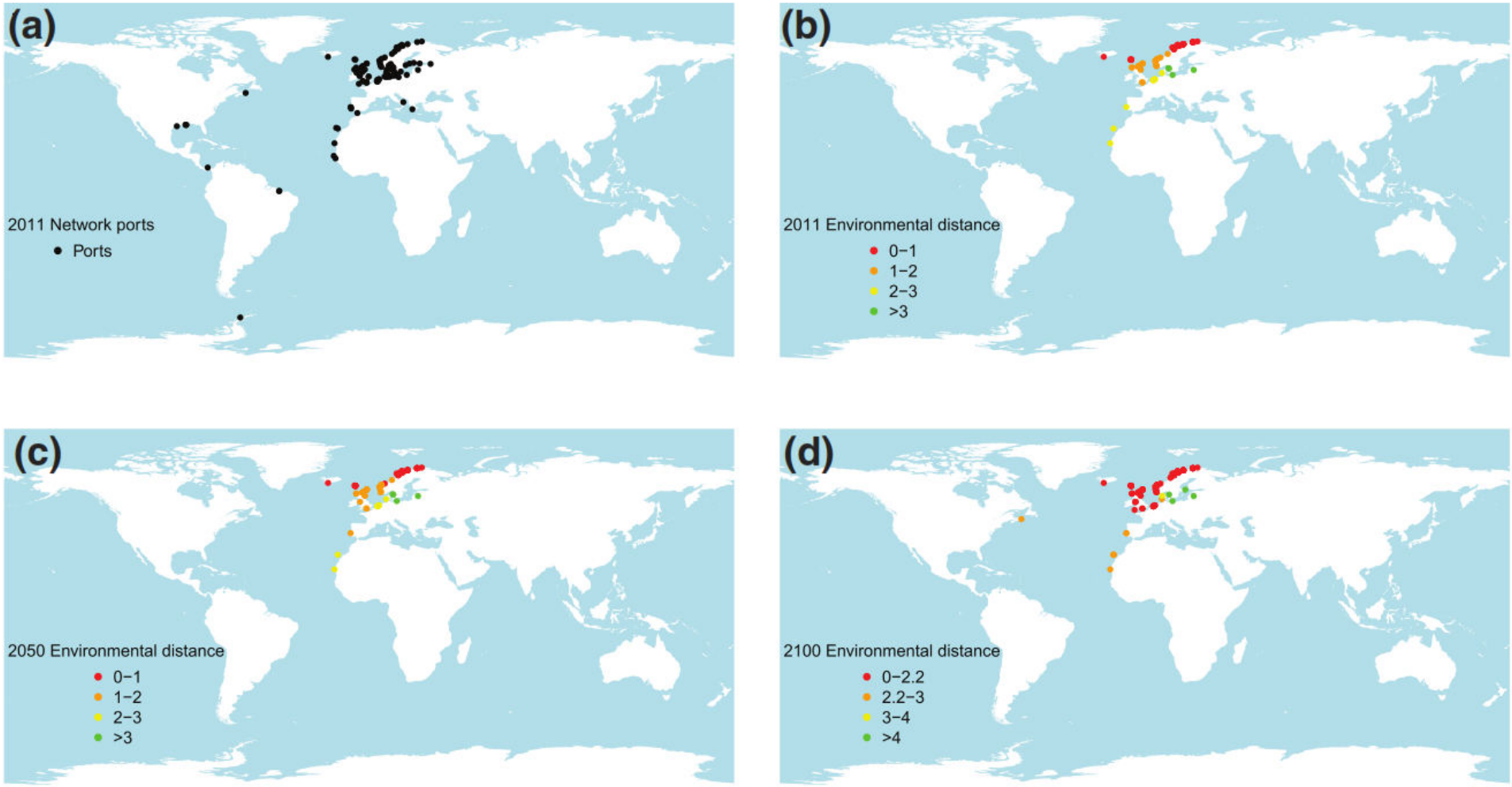


Invasive invertebrate species
Phylum perspective



Invasive invertebrate species Phylum similarity

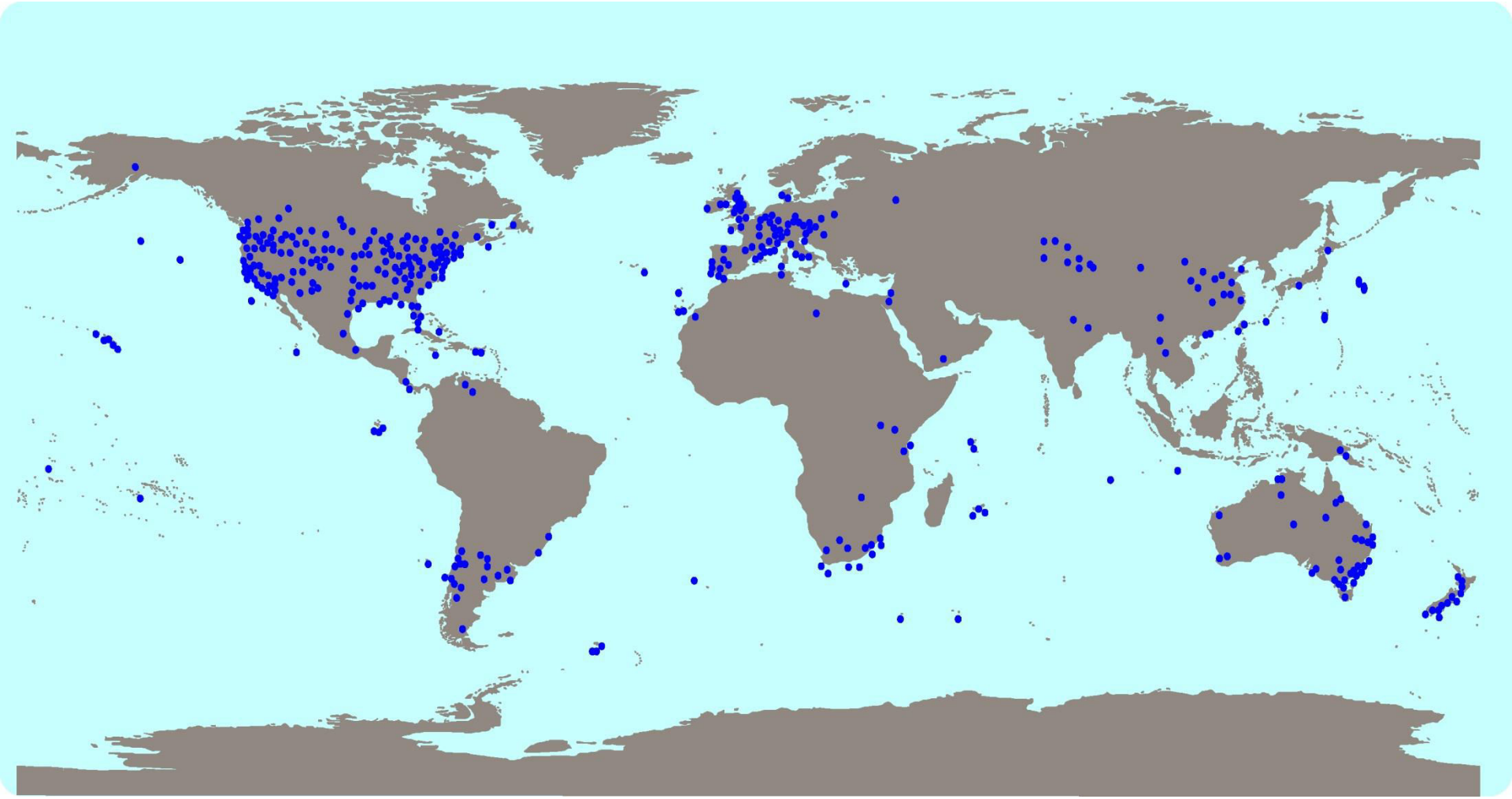
Climate change, non-indigenous species and shipping: assessing the risk of species introduction to a high-Arctic archipelago



Ports connected to Svalbard through the 2011 shipping network and environmental distances from Svalbard. Environmental distance (d) is based on temperature and salinity with lower values of d indicate higher environmental match. Panel (a): all primary, secondary and tertiary ports connected to Svalbard during 2011. Panel (b): environmental distances from primary ports of call for the year 2011 and also environmentally matched (d < 1 for b–c; d < 2.2. for d)secondary and tertiary ports.

So: Ware et al. Diversity & Distributions, 2010

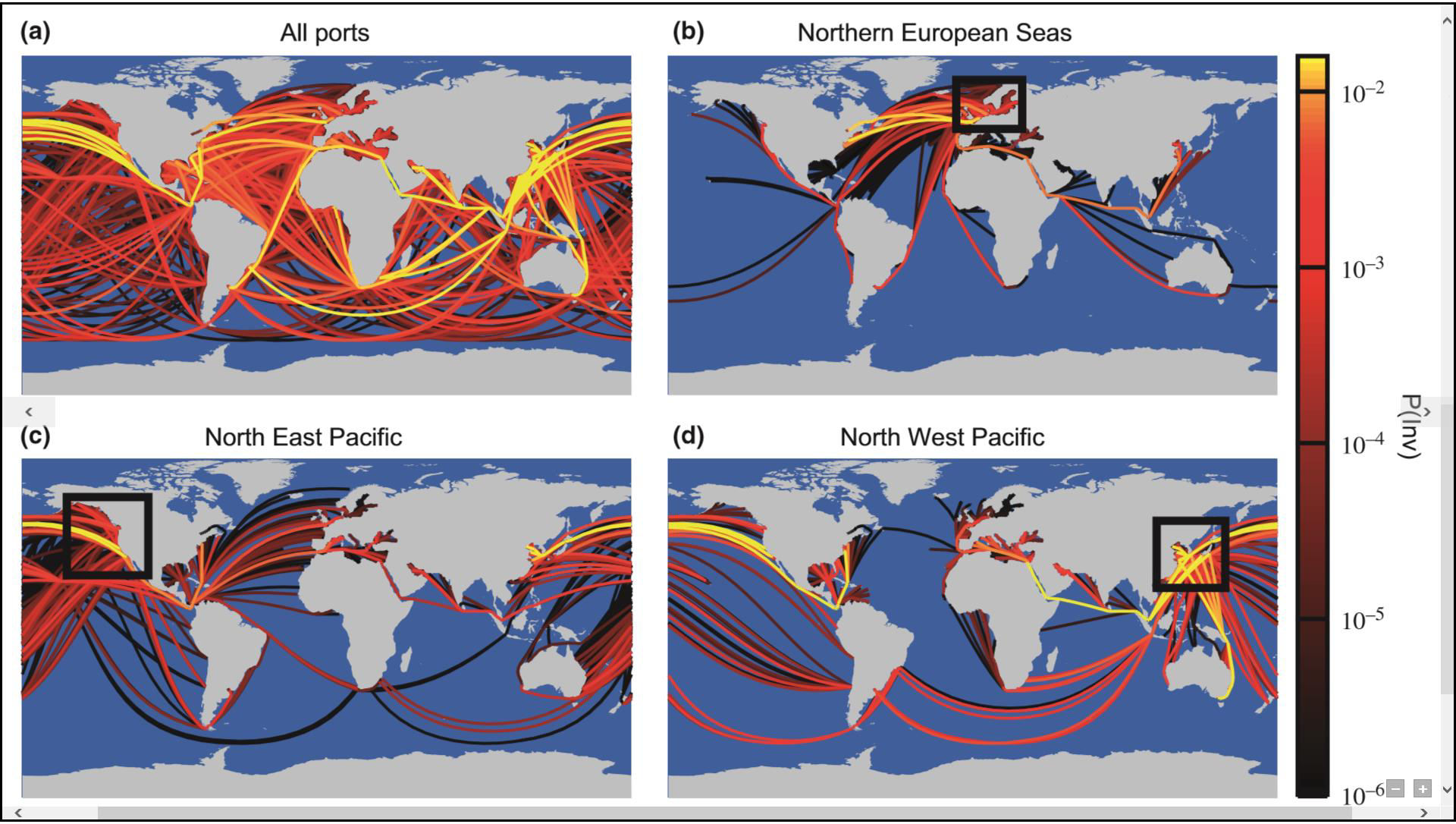
Biological invasions: a field synopsis, systematic review, and database of the literature



831 locations in 704 publications (more than one location per publication could potentially be included).

So: Lowry et al. *Ecology & Evolution*, 2012

Major introduction pathways. (a) Invasion probability along every shipping connection between two ports in the network indicated in colour coding. (b-d) Same as in (a) but restricted to all connections with destination in one of the three target regions (black rectangles): (b) Northern European Seas, (c) North-East Pacific and (d) North-West Pacific. Shipping routes are calculated as the shortest geodesic paths on water (Kaluza et al., 2010).



So: Seebens et al. *Ecology Letters*, 2013

Assessing the global threat of invasive species to marine biodiversity

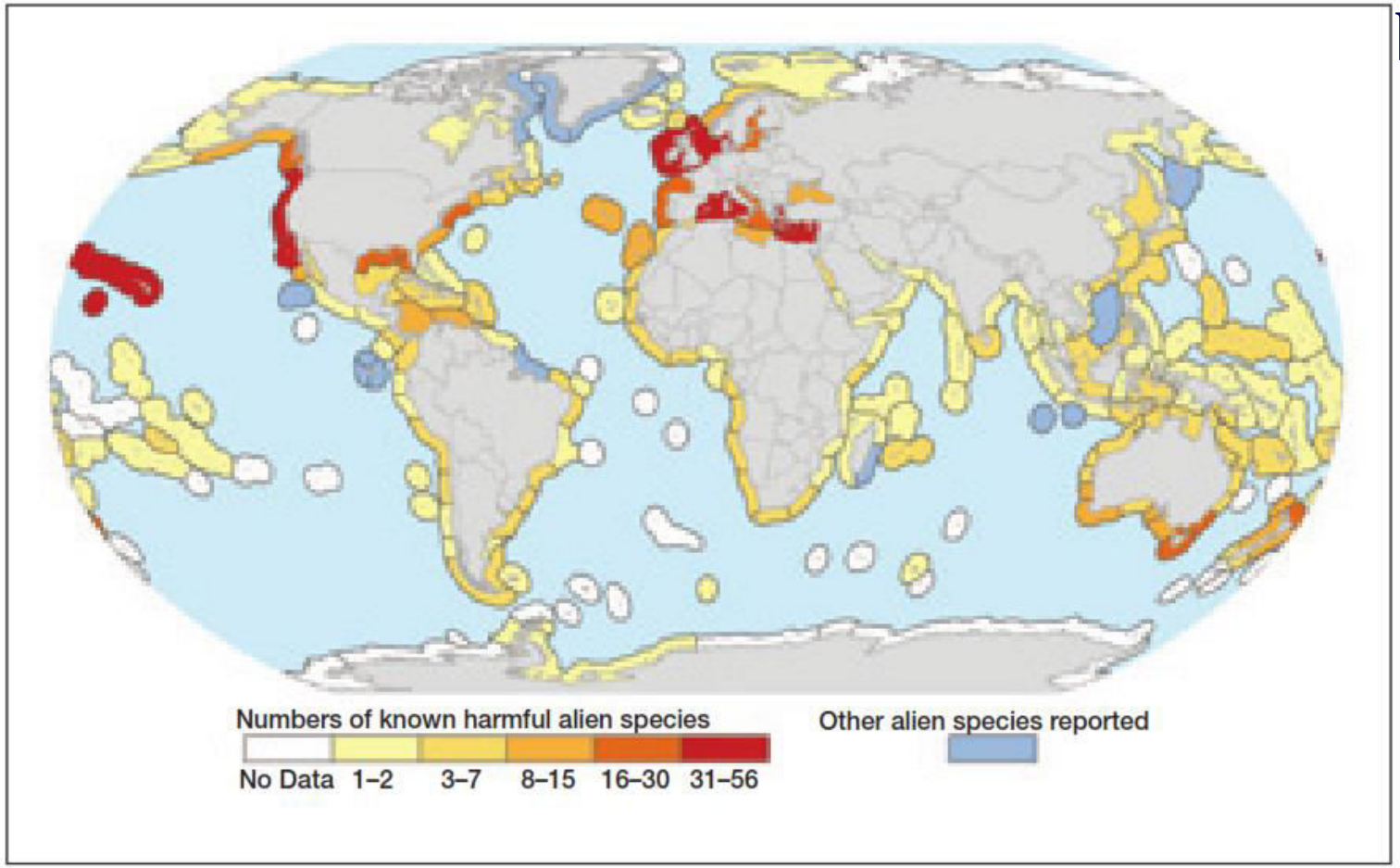


Figure 1. Map of the number of harmful alien species by coastal ecoregion, with darker red shades indicating a greater number of species with high ecological impact scores (3 or 4). Ecoregions in which only less harmful species have been documented are shown in dark blue.

So: Molnar et al. *Front. Ecol. Environ.*, 2008

Assessing the global threat of invasive species to marine biodiversity

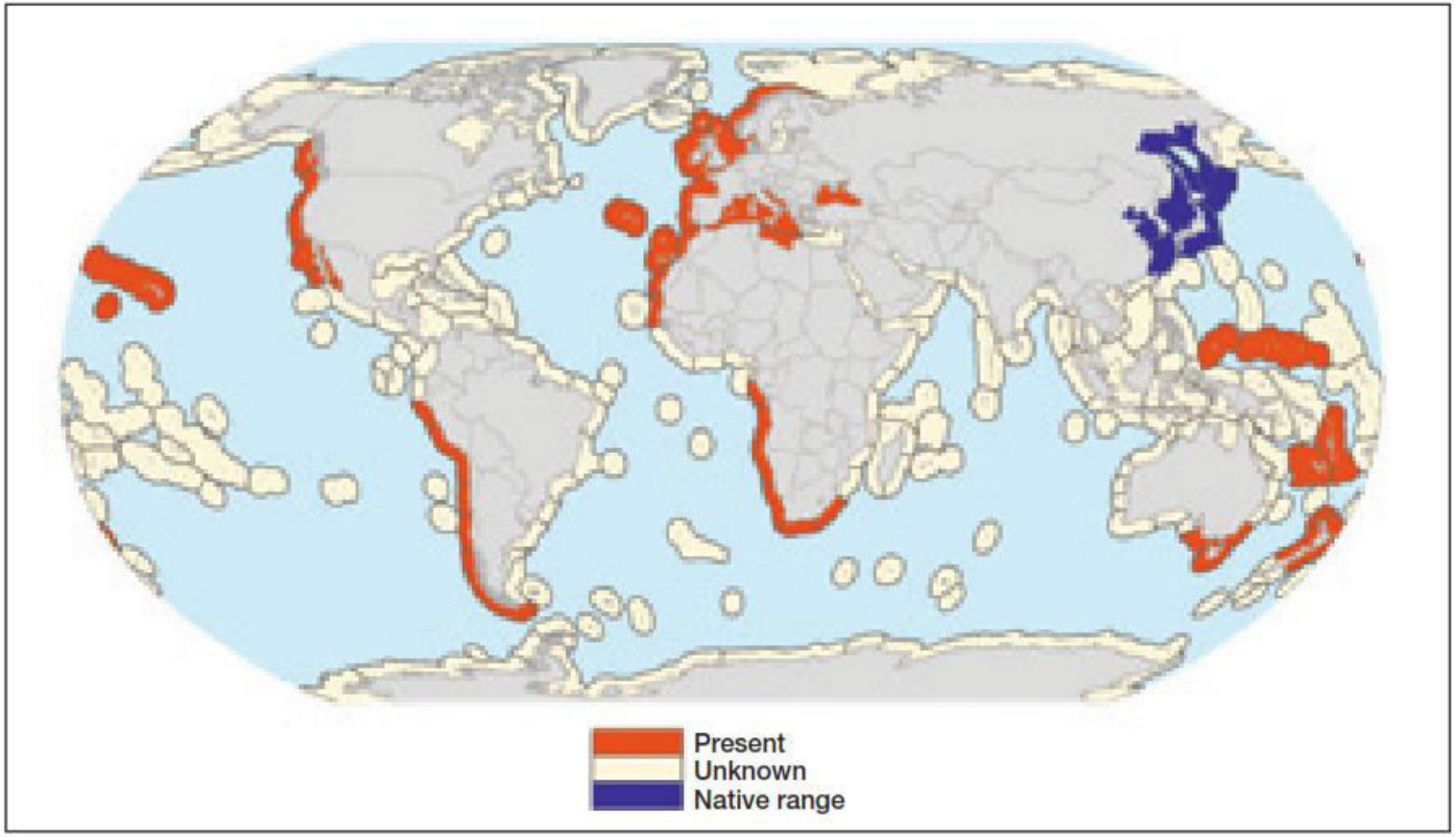


Figure 4. The Pacific oyster (Crassostrea gigas) *has been intentionally released and cultured in coastal waters around the world. It can dominate native species and destroy habitat (ecological impact = 3). The map shows its distribution; its invasive range is indicated in red, its native range in blue.*

So: Molnar et al. *Front. Ecol. Environ.*, 2008

Oyster Reefs at Risk

So: Beck et al. *BioScience*, February, 2011

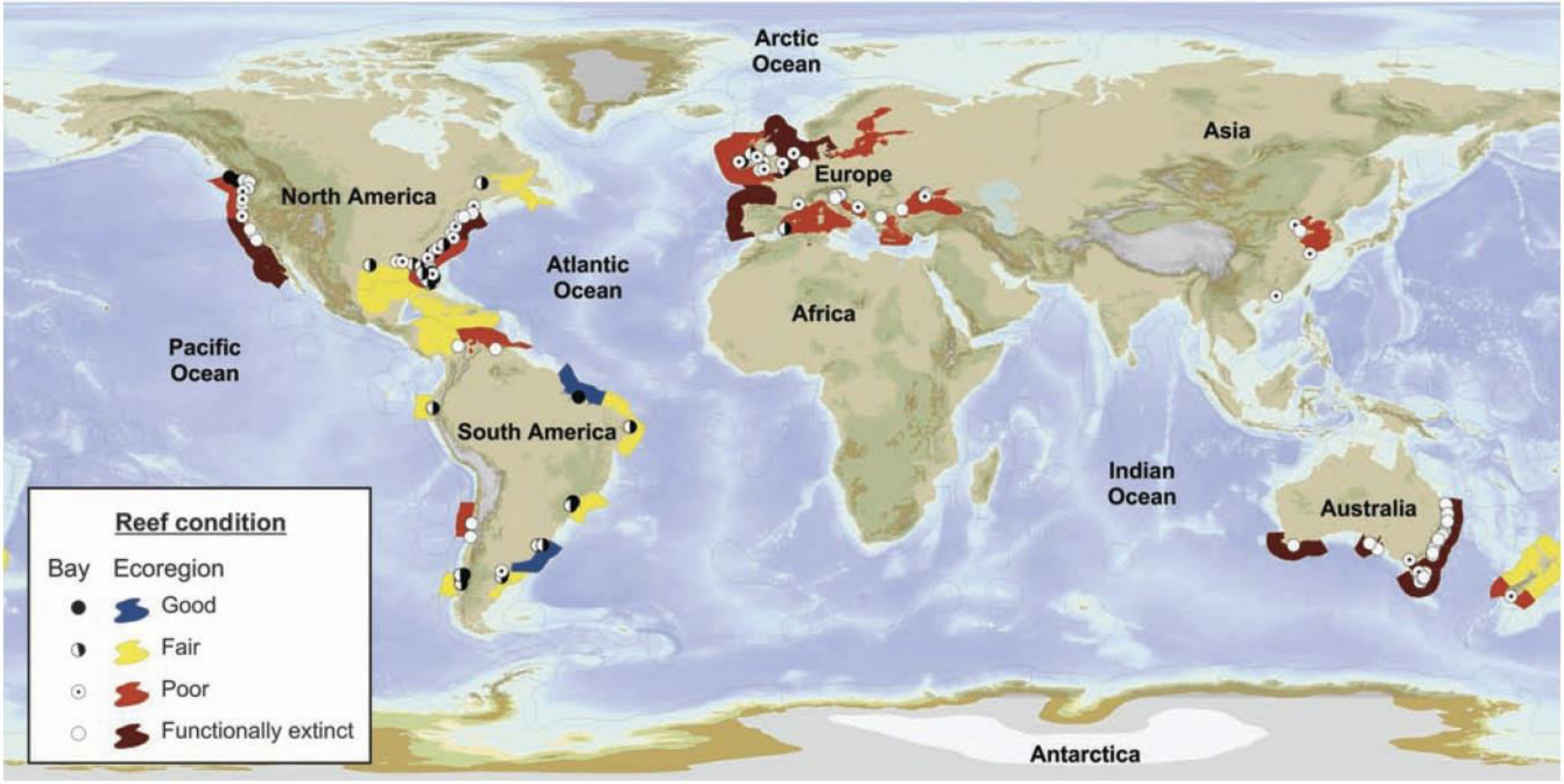


Figure 1. The global condition of oyster reefs in bays and ecoregions. The condition ratings of good, fair, poor, and functionally extinct are based on the percentage of current to historical abundance of oyster reefs remaining: less than 50% lost (good), 50% to 89% lost (fair), 90% to 99% lost (poor), more than 99% lost (functionally extinct). Ecoregion boundaries are from Spalding and colleagues (2007). Not all regions with oysters could be assessed because of a lack of data (see text).

Risk Assessment factors for invertebrates

- ✓Mode of reproduction
- ✓Mode of development
- ✓Larval life span
- ✓Starvation threshold
- ✓Influence of metamorphosis delay
- ✓Vector weightings (fouling vs. ballast)

Impacts caused by marine bioinvasions

- Economic
- Human health
- Ecological

Economics

Human health

Red Tide

Harmful algal bloom

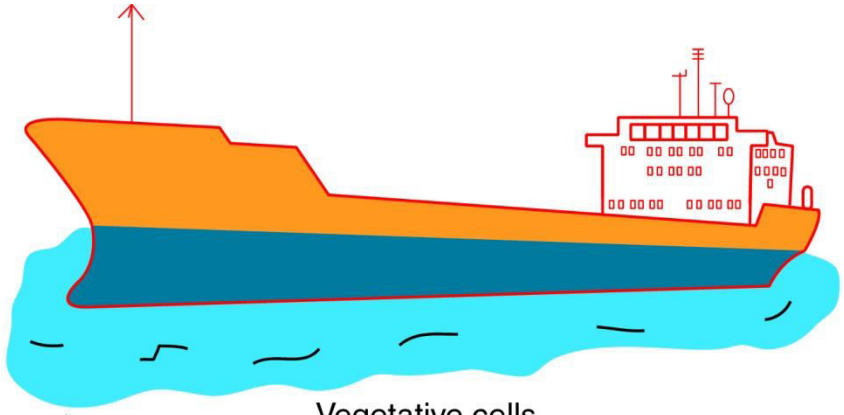
Effects

Toxic

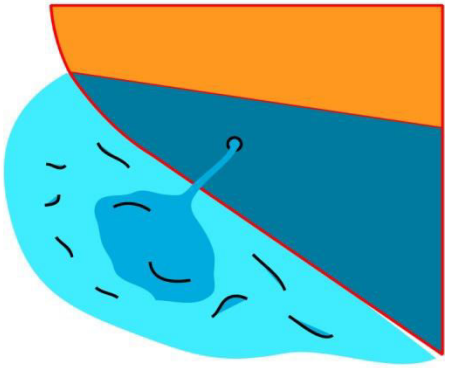
Anoxia

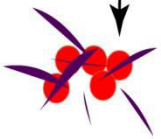
Clogging

Epidemics



Vegetative cells
Spores
Associated forms
Microbial film





Non-pathogenic

Pathogenic

Coastal water
Sewage
Industrial waste

Epedimic

Ecological

Actions to be taken when species are introduced

- Evaluation of presence & distribution of species
- Risk for environment and society
- Options for management (eradicate, control, monitor)
- Models to estimate cost-benefit
- Stakeholders responsibility

1. Assessment of the risks posed by the species

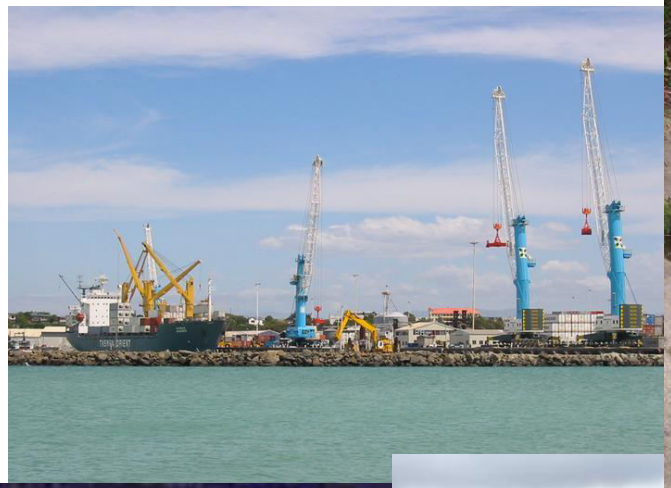
1) Definition of Risk

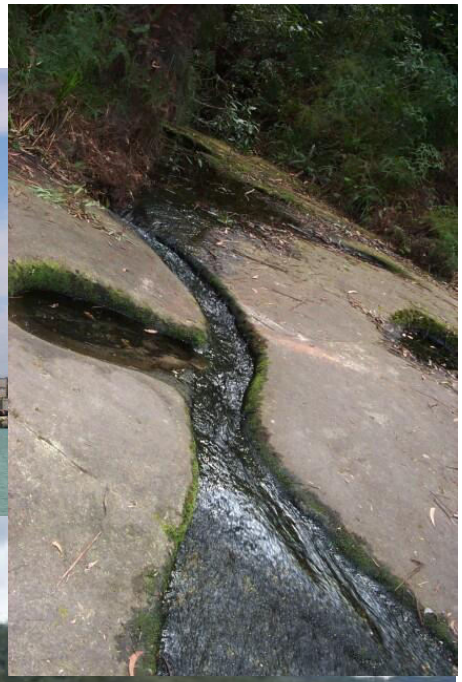
- Determine the extent of invasion
- Identify the species source
- Determine the resources under risk

2) Methodologies for ecological risk assessment

1) Definition of Risk

Determine the extent of invasion





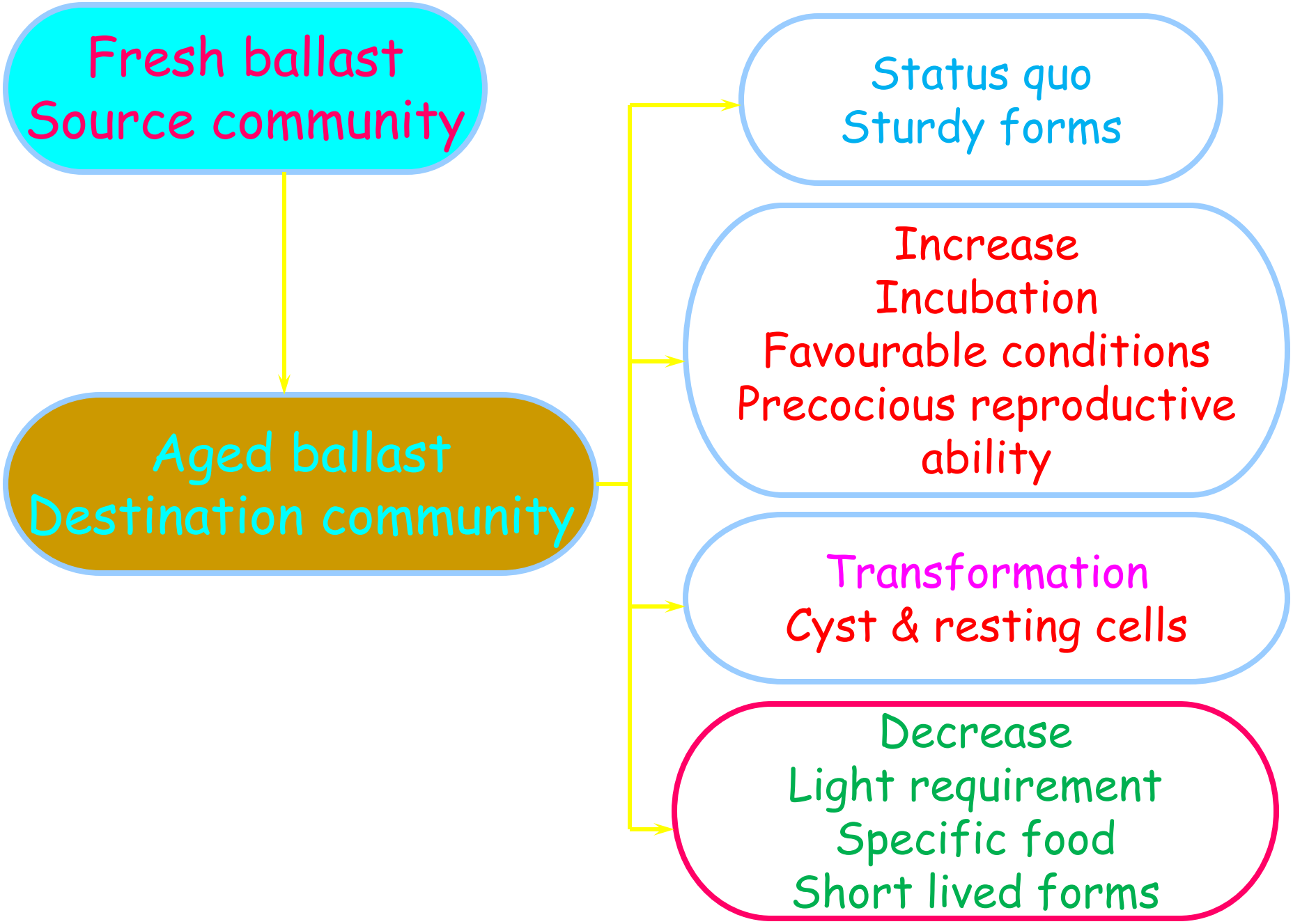
Awareness

- Community network

- What species is it ?
- Will it become a successful invader ?

Where to begin ?

Species identification
taxonomy & natural history

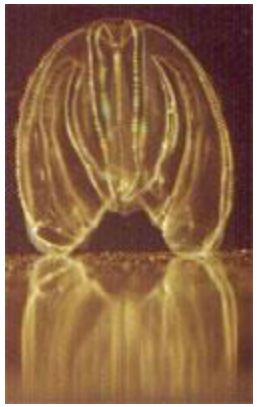

Fresh ballast
Source community
Aged ballast
Destination community
Status quo
Sturdy forms
Increase
Incubation
Favourable conditions
Precocious reproductive ability
Transformation
Cyst & resting cells
Decrease
Light requirement
Specific food
Short lived forms

Successful Invader

- ✓ Known as an invader in other areas
- ✓ Robust species
- ✓ High tolerance to abiotic factors
- ✓ Wide spectrum of food preferences
- ✓ Extended breeding season
- ✓ Grows earlier in the season
- ✓ Ability to produce resting stages
- ✓ Hermaphroditic reproduction
- ✓ Potential to occupy ecological niche
- ✓ Potential to genetically swamp or pollute the gene pool
- ✓ Host to disease or parasites communicable
- ✓ Threaten the continued existence and stability of native species
- ✓ Potential to cause negative impacts

Vector identification

Ctenophore

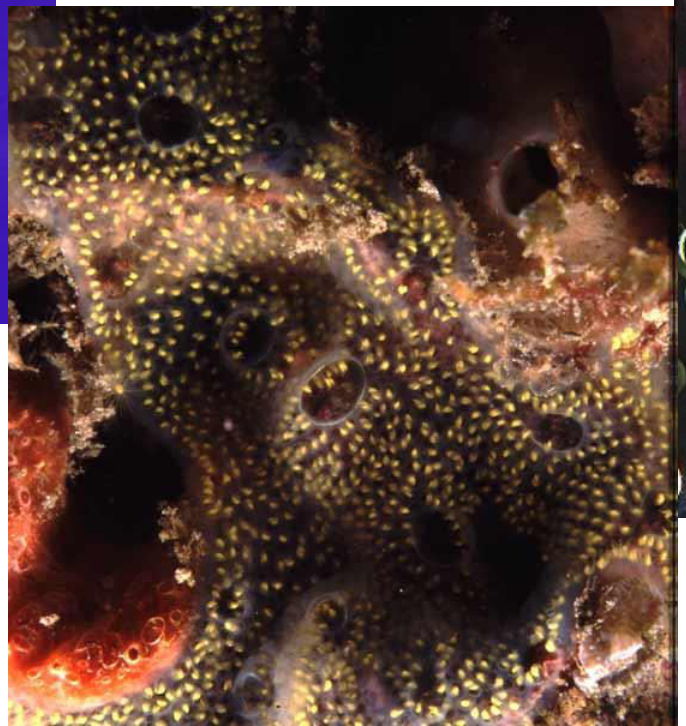


- ✓ Cydippid larva able to produce viable gametes
- ✓ Precocious development reported in stable “half animals”

So: M.Q. Martindale, Mar. Biol., 1987

Tunicates

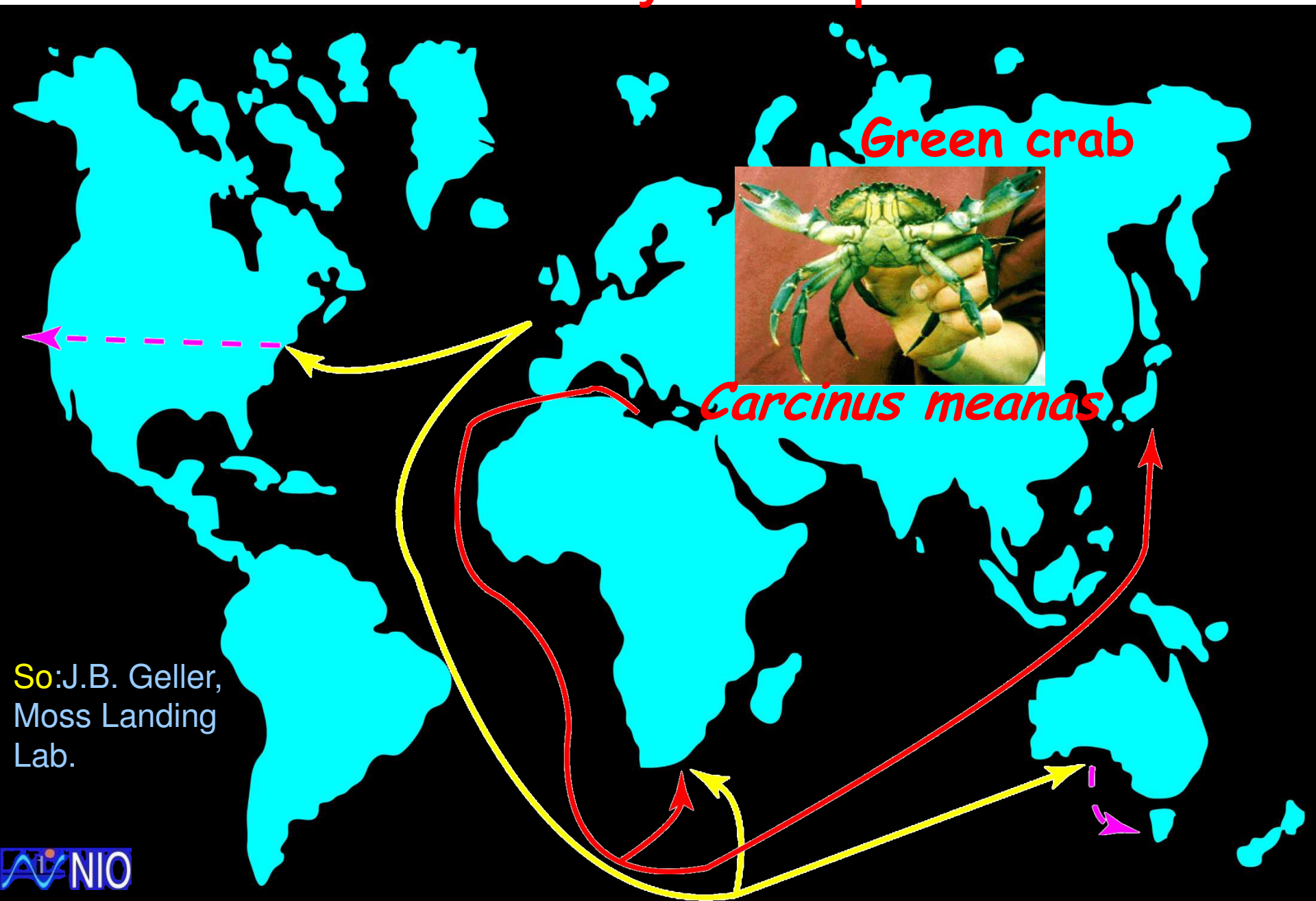
- ✓Larval life span short
- ✓Important component of fouling community
- ✓Dispersal predominantly through hull fouling



Black striped mussel : *Mytilopsis sallei*

- Small delicate bivalve (2.5 cm max.)
- Reproduces in 4 weeks (50,000 offspring)
- Native of tropical and sub-tropical Atlantic waters
  - Invaded India ~ 1967
  - Spread to Hong Kong
  - Threatened Australia

Identify the species source



Determining the resources at risk

End points of harm

- Displacement of native species
- Predation of native species
- Disease causing agents
- Release of toxins
- Coastal infrastructure

2) Methodologies for ecological risk assessment

Step 1 – the resources of the affected site must be listed and scored from not important (0) to very important (5)

Step 2 – the impact of the invasion on these same resources should be scores from very harmful (-3) to very beneficial (3)

Step 3 – both matrices are combined and the product of the two previous scorings is calculated for each one of the resources listed

Three step exercise of risk assessment

Step 1	Rating of resource	Unknowns
Commercial stocks		
Other biota		
Human health		
Water quality		
Habitat		
Fisheries		
Aquaculture		
Water abstractions		
Aquatic transports		
Tourism		

Three step exercise of risk assessment

Step 2	Rating of impacts	Unknowns
Commercial stocks		
Other biota		
Human health		
Water quality		
Habitat		
Fisheries		
Aquaculture		
Water abstractions		
Aquatic transports		
Tourism		

Three step exercise of risk assessment

Step 3	Rating of the resource	Rating of the impacts	Resource X impacts
Commercial stocks			
Other biota			
Human health			
Water quality			
Habitat			
Fisheries			
Aquaculture			
Water abstractions			
Aquatic transports			
Tourism			

2. Actions for incursion management

Eradication
Control
Monitoring

Eradication

Attempted if:

- ✓ It is ecologically feasible
- ✓ It has necessary financial and political commitment to be completed
- ✓ The target species is confined to very limited range
- ✓ It is ‘safe’

Control

Physical methods

- ✓ Mechanical removal
- ✓ Manual removal
- ✓ Physical barriers
- ✓ Trapping
- ✓ Hot water & freshwater treatment

- ✓ Potential extraction fisheries

Chemical methods

Example

Eradication of black stripped mussel *Mytilopsis sallei* using chlorine and copper sulphate

So: Bax, 2001

Chemical methods

Example

Control of *Caulerpa taxifolia*

- ✓Found in Southern California (2000)
- ✓Algal beds treated with liquid chlorine
- ✓High initial mortality
- ✓Survival of individual plants

So: McEnnulty, et al. 2001

Biological methods

- Developing research area
- Not a rapid response but a long time control
- Yet to receive sanctions to use in marine environments

So: Carlton 2001

Control

Biological methods

Enemy release hypothesis

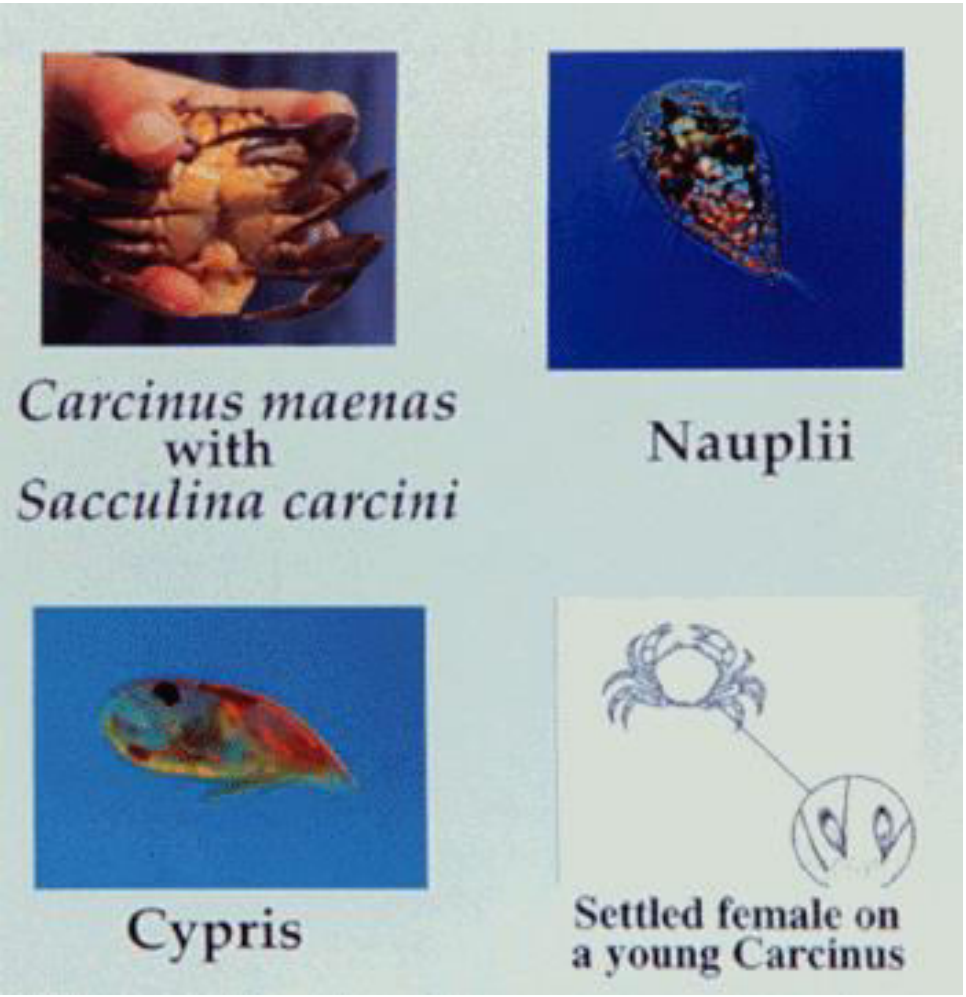
(1) NIS are affected by fewer enemies than those in the source region

(2) NIS are less affected by enemies native to the invaded region

(3) Enemies co-introduced with their hosts will behave similarly in the invaded and source regions

(4) Release from natural enemies results in increased vigor and advantage over competitors

Invasive species: Healthier in alien environment



Carcinus meanas
(Green crab)

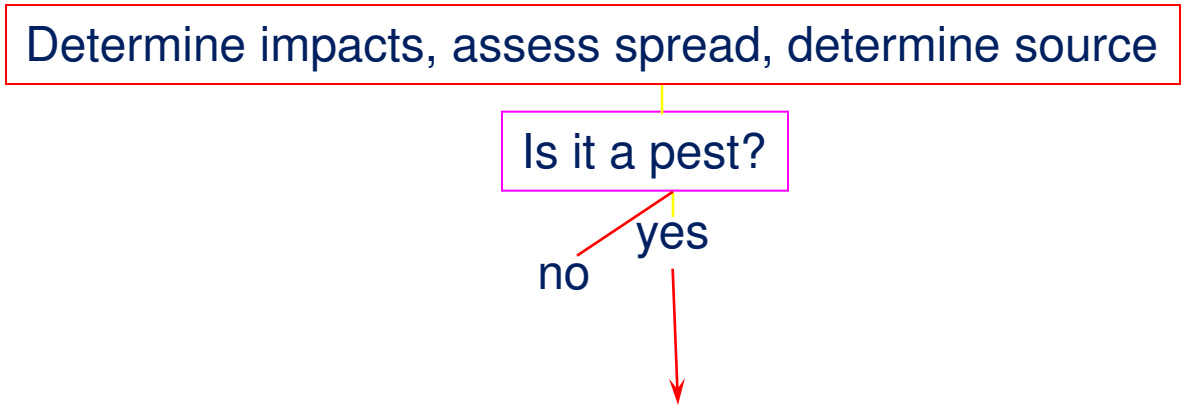
Monitoring

Eradication success of a target species determined by fine scale sampling

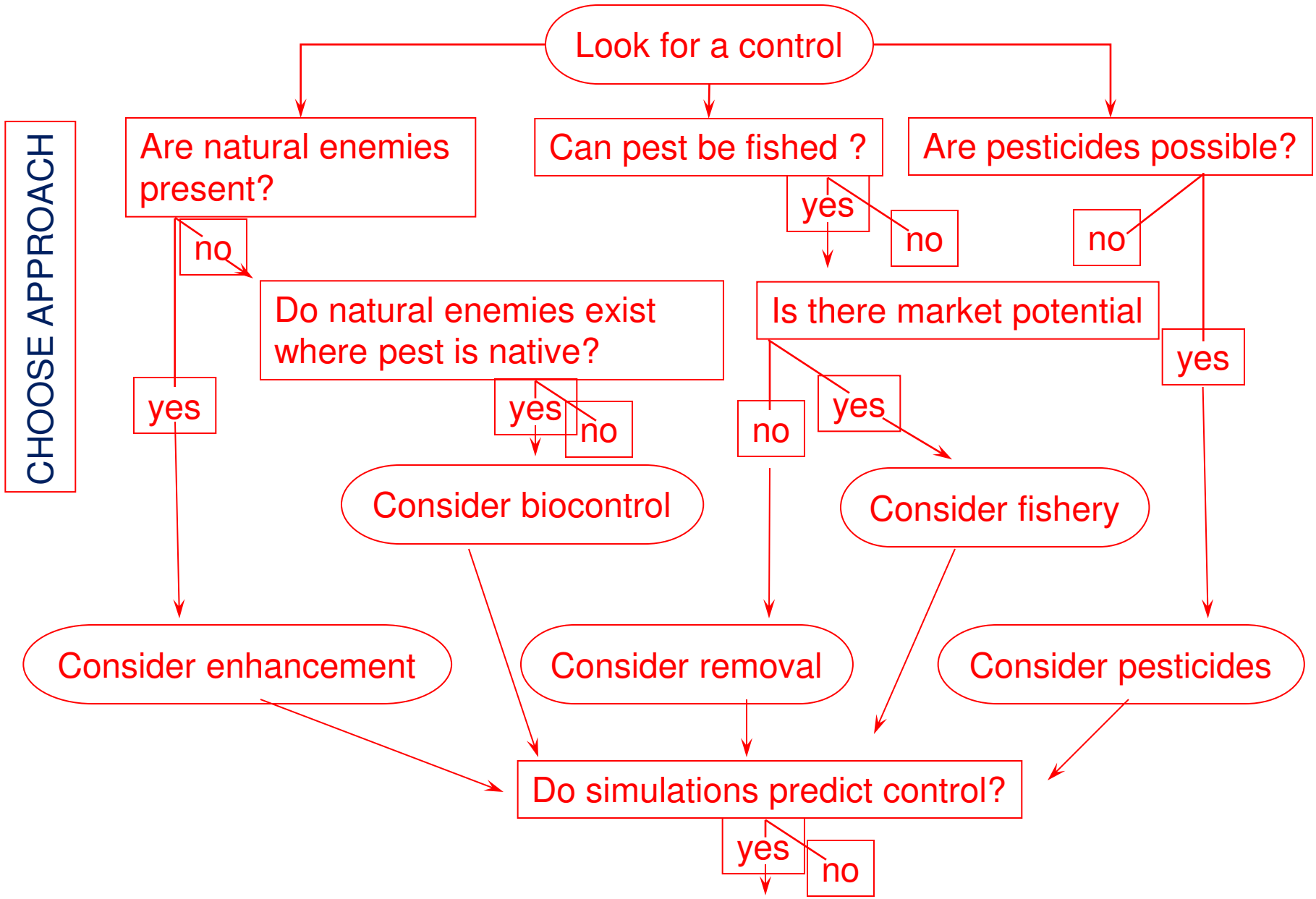
Programme for early warning of incursion – implementation on a broader scale focused on hot spots

Incursion Management Step

ASSESS PEST

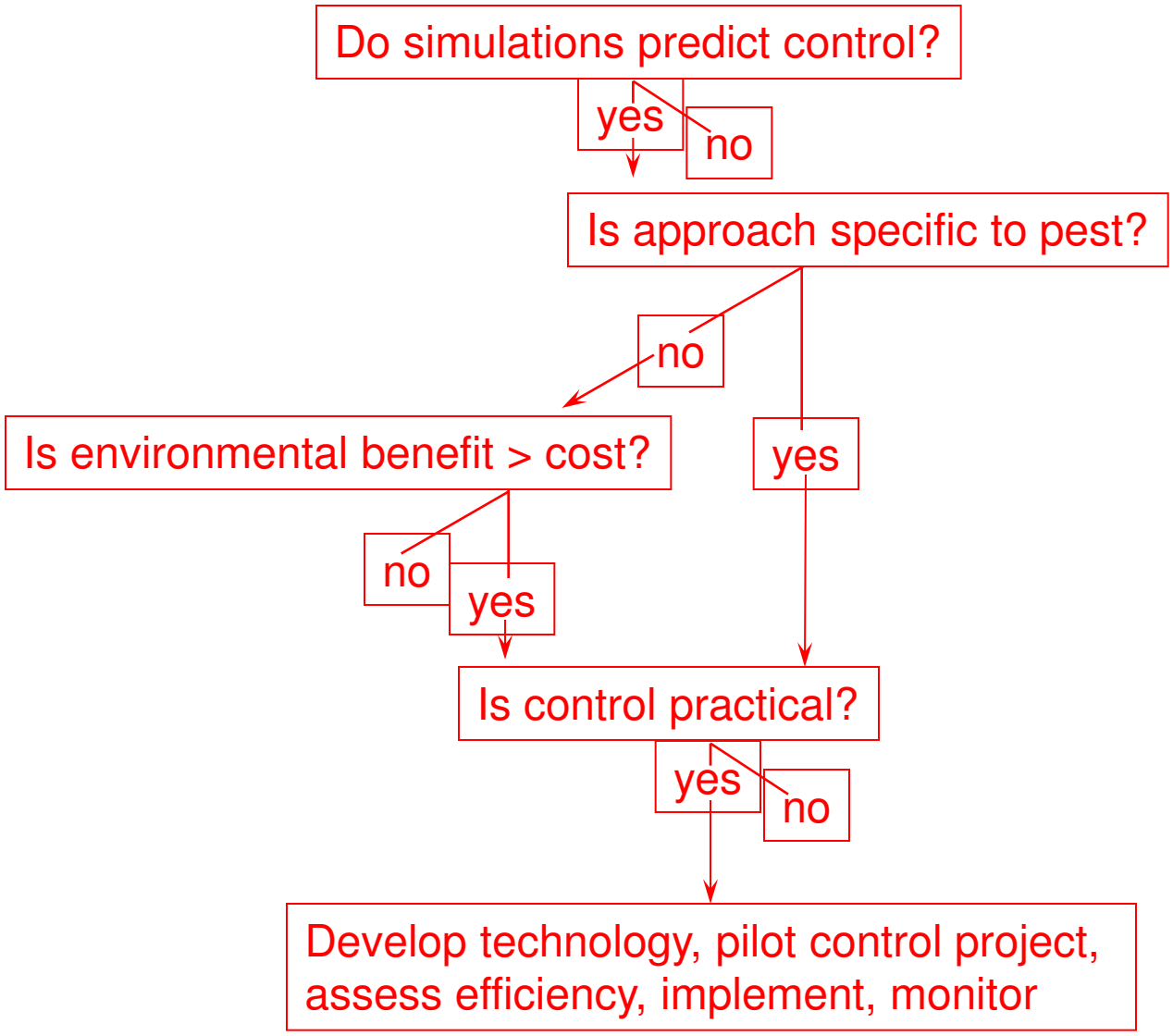


Incursion Management Step



Incursion Management Step

EVALUATE APPROACH



IMPLEMENT

3. Cost-benefit analysis of management practical options

Damage quantification
Determining which option to employ

Damage quantification

Step 1

Quantification of risk identified

Step 2

Providing monitory attribute values to the impacts (Environment, Economy & Health)

4. Incursion Response

- ✓ Preventing incursion of new species
- ✓ Early detection of incursion followed by rapid response
- ✓ Control and management of established pest populations

Recommended practice

- ✓ Incursion management response plan linked to National strategy
- ✓ Port ballast water management plan

Determination of changes to port operation

- ✓ Monitoring of port biota
- ✓ Identifying shipping arrival patterns

Preventive measures:

- ✓ Checking for possible contamination using shipping register
- ✓ Zoning port areas
- ✓ Mapping the substrates available for colonizing by new species

Developing a bioinvasion response plan

From an aquatic perspective rapid response is a very poor and inadequate second choice, not a substitution for prevention

Prevention is better than cure


Thank you