NIO
understanding the seas

Marine biofouling research in India

A.C. Anil
National Institute of Oceanography
Council of Scientific & Industrial Research
Dona Paula, Goa - 403 004, INDIA

Historical background

Dates back to Sir Humphry Davy (1824)

First publication giving some information of organisms that foul hulls of boats - Erlanson in 1936

So: Nagabhushanam & Sarojini, 1997 (In: Fouling organisms of the Indian Ocean: Biology & Control Technology, A.A. Balkema, USA)

Following this.....

Some of the institutions involved in biodeterioration studies

- ✓ Forest Research Institute, Dehradun.
- ✓ Naval Chemical and Metallurgical Laboratory, Bombay.
- ✓ Central Institute of Fisheries Technology, Cochin.
- ❖ Universities of Andhra, Annamalai, Bombay, Cochin, Karnataka, Madras, Madurai Kamaraj, Mangalore, Marathwada.
- ✓ National Institute of Oceanography, Goa
- ✓ Water and Steam Chemistry Division, BARC Facilities, Kalpakkam.
- ✓ National Institute of Ocean Technology, Chennai.

In India through the 40's to 90's

- ✓ Emphasis on distribution and abundance of species
- ✓ Site specific – Coastal areas, harbours, offshore platforms, ship hull - dry docks etc.

Water and Steam Chemistry Division
BARC Facilities, Kalpakkam

Biofouling and Biofilm Processes

Areas of Interest

- ✓ Biofouling and its control in industrial coolant circuits
- ✓ Biofilms and larval settlement
- ✓ Microbiologically influenced corrosion (MIC)
- ✓ Periphyton succession in freshwater
- ✓ Biofilms architecture using confocal microscopy
- ✓ Biotechnological applications of biofilms
- ✓ Environmental impact of cooling water treatment chemicals (chlorine, trihalomethanes)

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National Institute of Ocean Technology, Chennai

Programmes underway

- ✓ Evaluation of Biocidal Dose and Regime for Heat exchangers
- ✓ Marine natural produces as antifoulants
- ✓ Surface modification approach
- ✓ Behaviour of materials
- ✓ Biodegrading of materials
- ✓ Biofouling on heat exchanger

International Conference on Recent Advances in Marine Antifouling Technology (RAMAT 6–8 November 2006)

Technology areas in NIOT with reference to biofouling

- OTEC plant
- Wave energy plant
- Moored data buoy
- Underwater sensors
- Moored current meters
- Desalination plant intakes
- Ocean going vessels
- Argo Float
- Acoustic tide gauges

An International Conference on Marine Biodeterioration was held at Goa (1986).

Facilitated Initiation of several projects under United States-India collaborative research programs.

US-India collaborative research programs

- Determination of environmental, biological and biochemical parameters that control macrofouling of surfaces in Indian waters.
- Studies on antifouling properties of selective bioactive substances from marine organisms of the Indian Ocean.
- Studies on microfilm formation in relation to physico-chemical, biological & biochemical parameters.
- Comparative physiology of temperate and tropical wood-borers
- Laboratory & field studies on the efficacy of antifouling agents and their probable impact on the bioecology of marine organisms.

Outcome

International Conference on Recent developments on biofouilng control, (1994) India

US-Pacific Rim Workshop (Emerging nonmetallic materials for the marine environment , (1997) USA

Several other publications

Biofouling and barnacle adhesion data for fouling-release coatings subjected to static immersion at seven marine sites

- Used 3 silicone formulations and 1 epoxy control

Results:

- ✓ Statistically significant differences in type & intensity of fouling that developed on coatings and barnacle adhesion strength among sites

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So: Swain et al., Biofouling, 2000

Highlights

Research on specific topics since 90's till date

A simple method to asses bacterial attachment to surfaces

- ✓ Crystal violet micro-plate adhesion assay was modified to evaluate bacterial adhesion to metal and non-metal surfaces
- ✓ Method relatively simple, sensitive, less time consuming

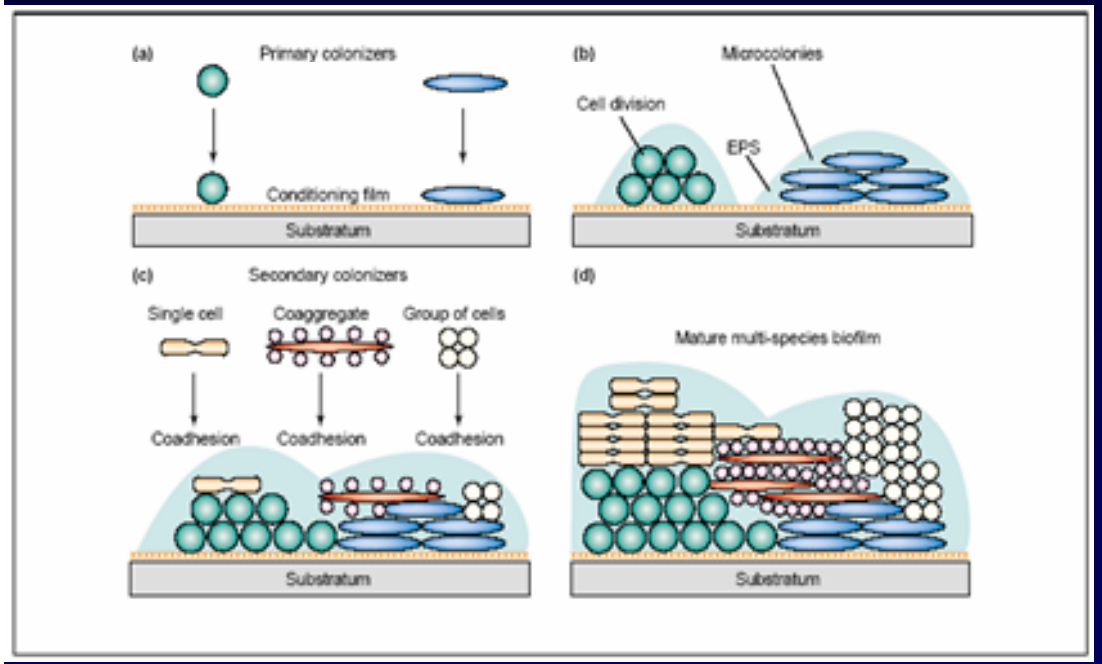
So: Sonak & Bhosle, Biofouling, 1995

Biofouling control measures in power plant cooling systems

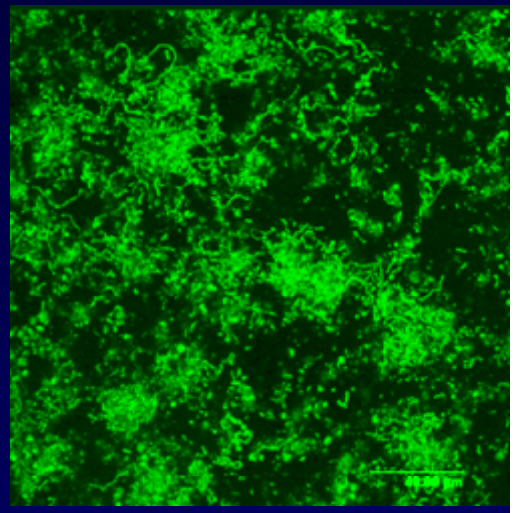
- ✓ A 1000 MW(e) power plant uses approximately 30-45 cu. m/sec water for condenser cooling
- ✓ Fouling of cooling water circuits leads to loss of plant efficiency & mechanical damage

So: K.K. Satpathy, Marine Biofouling & Power Plants, 1990

Biofilm development & control:
emphasis on interfacial biological processes

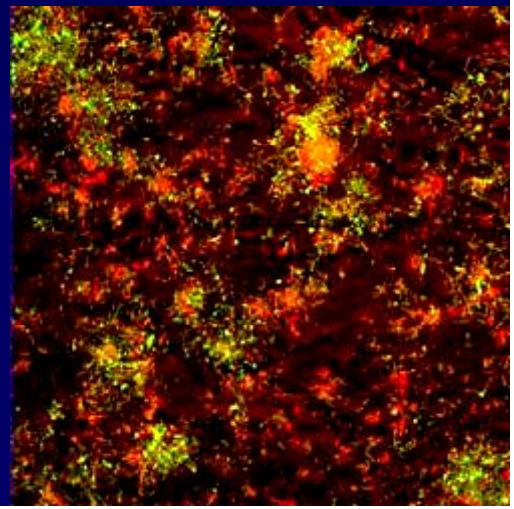


Biofilm development – sequential stages



Control

Live/dead distribution of bacteria in a chlorine-treated biofilm sample (confocal image)



Treated

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Biofilm development & control:
emphasis on interfacial biological processes

- ✓ Biofilm development is an interfacial process.
- ✓ Biological interactions such as auto and co-aggregation that take place at interfaces play key role in biofilm development.
- ✓ Similarly, interspecies and intraspecies interactions plays major role in biofouling development on surfaces.
- ✓ Understanding these processes is important not only for better insight into the development process, but also for devising more efficient control strategies.

Relevance of biofilm bacteria in modulating the larval settlement of *Balanus amphitrite*

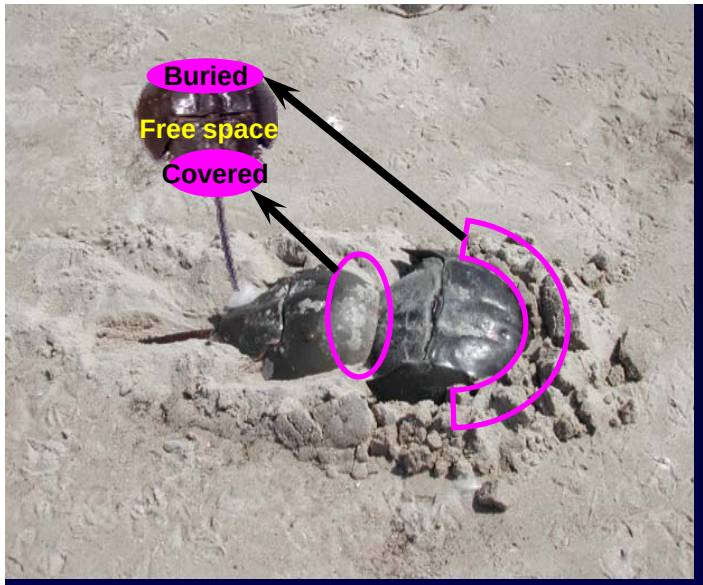
- ✓ Settlement-inducing compounds from bacteria colonizing barnacle shell surfaces influenced its larval settlement
- ✓ The production of these compounds was influenced by the nutrient media in which they were grown
- ✓ Bacteria-lectin interactions can alter the synthesis of these compounds
- ✓ Waterborne and surface-associated cues from bacteria function differentially in mediating larval metamorphosis

So: Khandeparker et al., FEMS Microbiol. Ecol., 2006

Ecology of the barnacle *Balanus amphitrite* in a tropical estuary

- ✓ Influence of food and temperature on breeding and molting
- ✓ Temporal variation in gonad condition
- ✓ Spatial, temporal and substratum related recruitment variations
- ✓ Factors that regulate larval development and their ecological implications
- ✓ The role of food type, temperature and starvation on larval development
- ✓ Significance of food concentration, temperature and nucleic acids on larval development
- ✓ Comparison of nutritional status of laboratory and field reared larvae

So: Desai, Anil, Venkat, Khandeparker – Publ in Mar. Biol., JEMBE, JMBA UK



Epibiotic community of the horseshoe crab *Tachypleus gigas*

- ❖ Gender variations in epibiotic population
- ✓ Changing habitat
- ✓ Mechanical abrasion & surface availability
- ✓ Surface properties of carapace

Chemical Defence

- ❖ Evaluated for antidiatom properties
- ➢ Inhibition by female horseshoe crab

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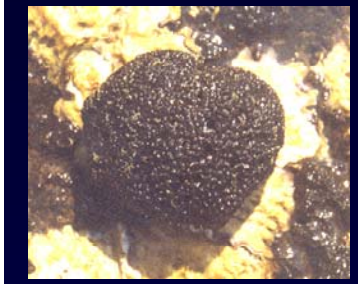
So: Patil & Anil, Marine Biology (2000)

Antibacterial Activity of the Sponge *Ircinia ramosa*: Importance of its Surface-associated bacteria



- Chemical nature and production of antibacterial compounds produced by sponge or its associated bacteria appears to be governed by the environment.
- Inverse relationship was observed between the epibacterial abundance over the sponge surface in nature and the antibacterial activity displayed by the sponge extracts in laboratory bioassays.
- Importance of collection period as well as the role of associated bacteria in the evaluation of antibacterial activity.
- Possible role of sponge surface-associated bacteria in the epibacterial defense of the host.

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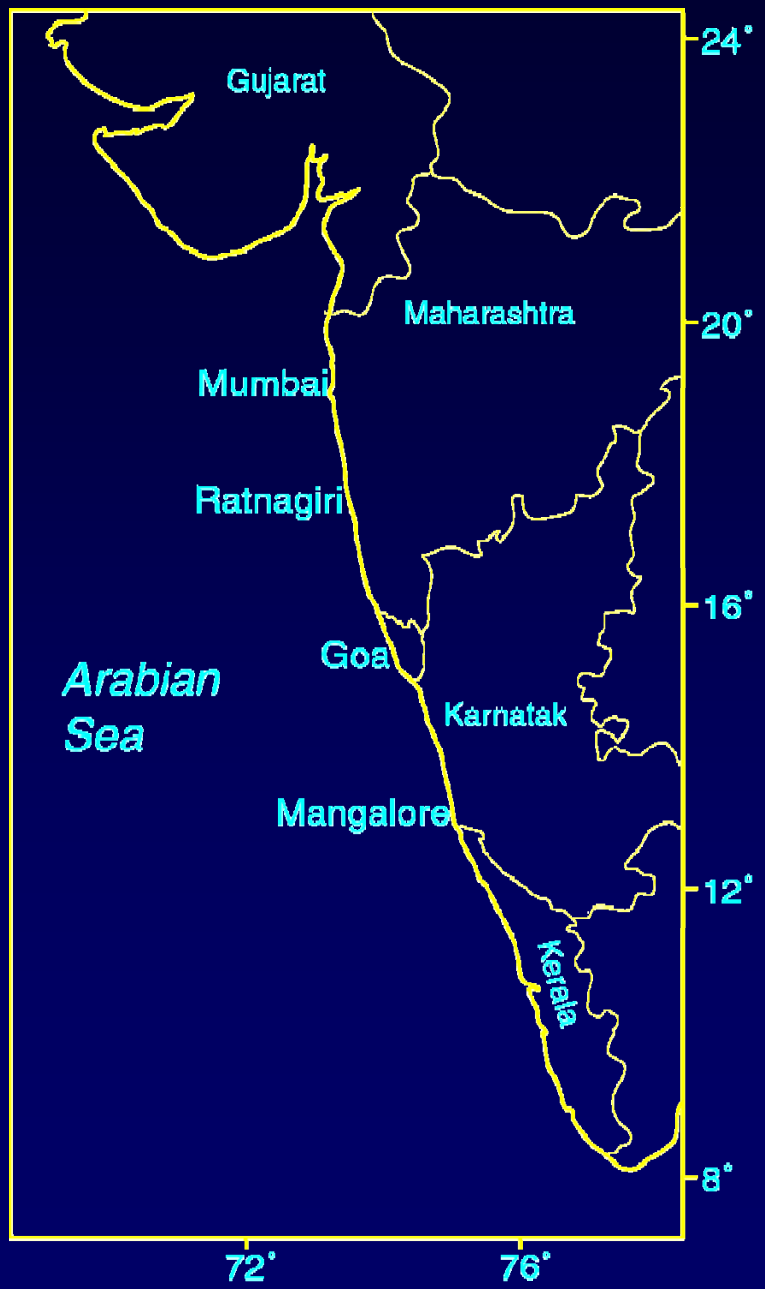
So: Thakur & Anil, J. Chem. Ecol (2000) ; Thakur et.al. Aquat. Microb. Ecol. (2004)

Gyrenium natator: A potential indicator of imposex along the Indian coast

So: Vishwakiran et. al. Chemosphere (2006)



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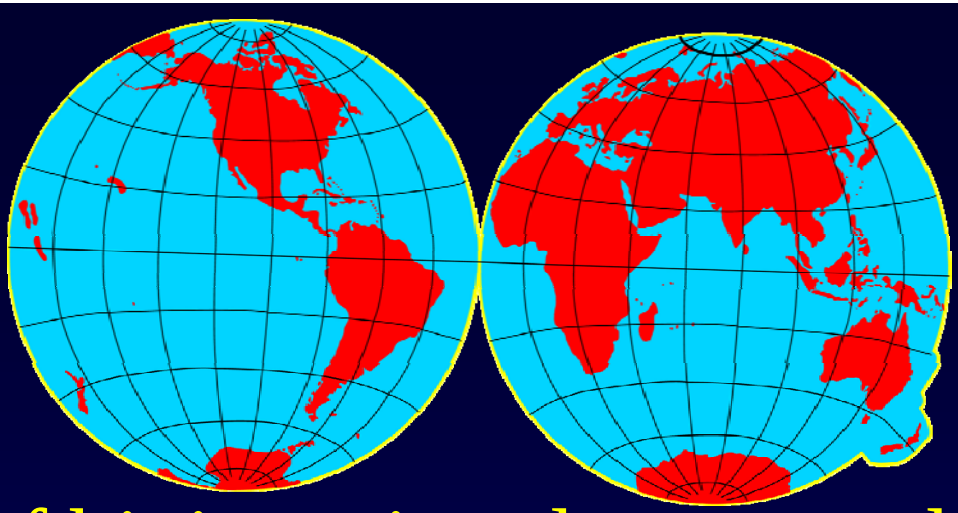

Threats of bioinvasion due to world shipping

Six demonstration sites

Global Ballast Water Management Programme

Rio de Janeiro – **Brazil**
Dalian – **China**
Mumbai – **India**
Kharg Is – **IR of Iran**
Saldhana Bay – **S. Africa**
Odessa - **Ukraine**

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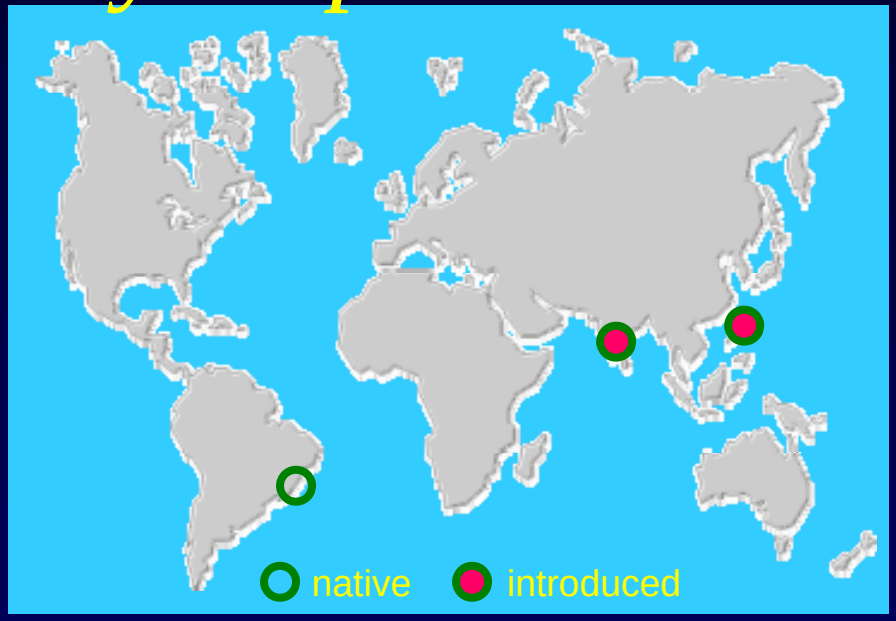
Black Striped Mussle
Mytilopsis sallei



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

- Spread to Hong Kong, threatened Australia

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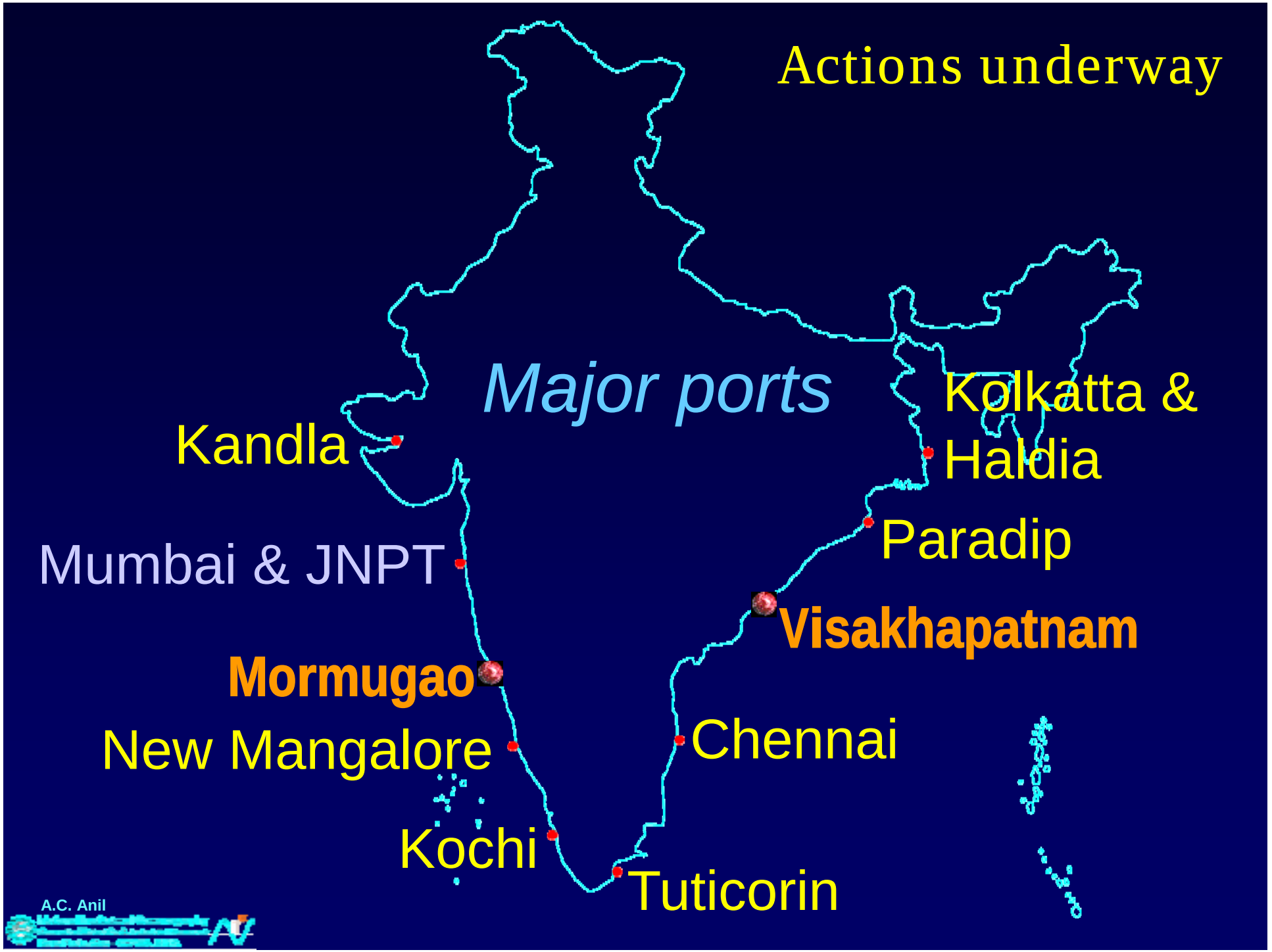
Actions underway
Major ports
Kandla
Kolkatta &
Haldia
Paradip
Mumbai & JNPT
Visakhapatnam
Mormugao
New Mangalore
Chennai
Kochi
Tuticorin
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International Conference on

Biofouling and Ballast Water Management

February 05 to 07, 2008

National Institute of Oceanography, Goa, India

Invited talks – 15
Oral Presentations – 30
Poster Presentation – 52

http://www.icbab.nio.org

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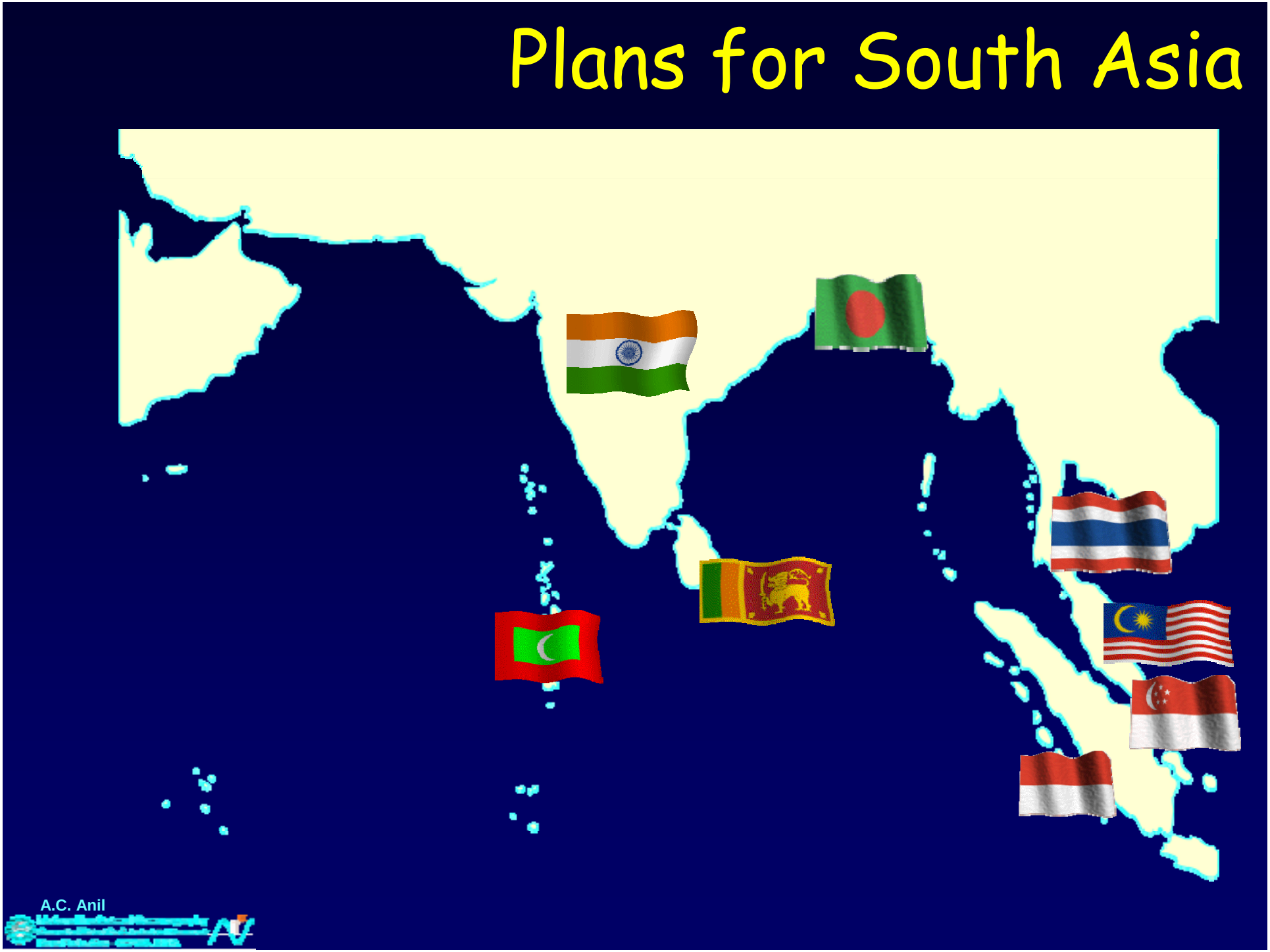
Plans for South Asia



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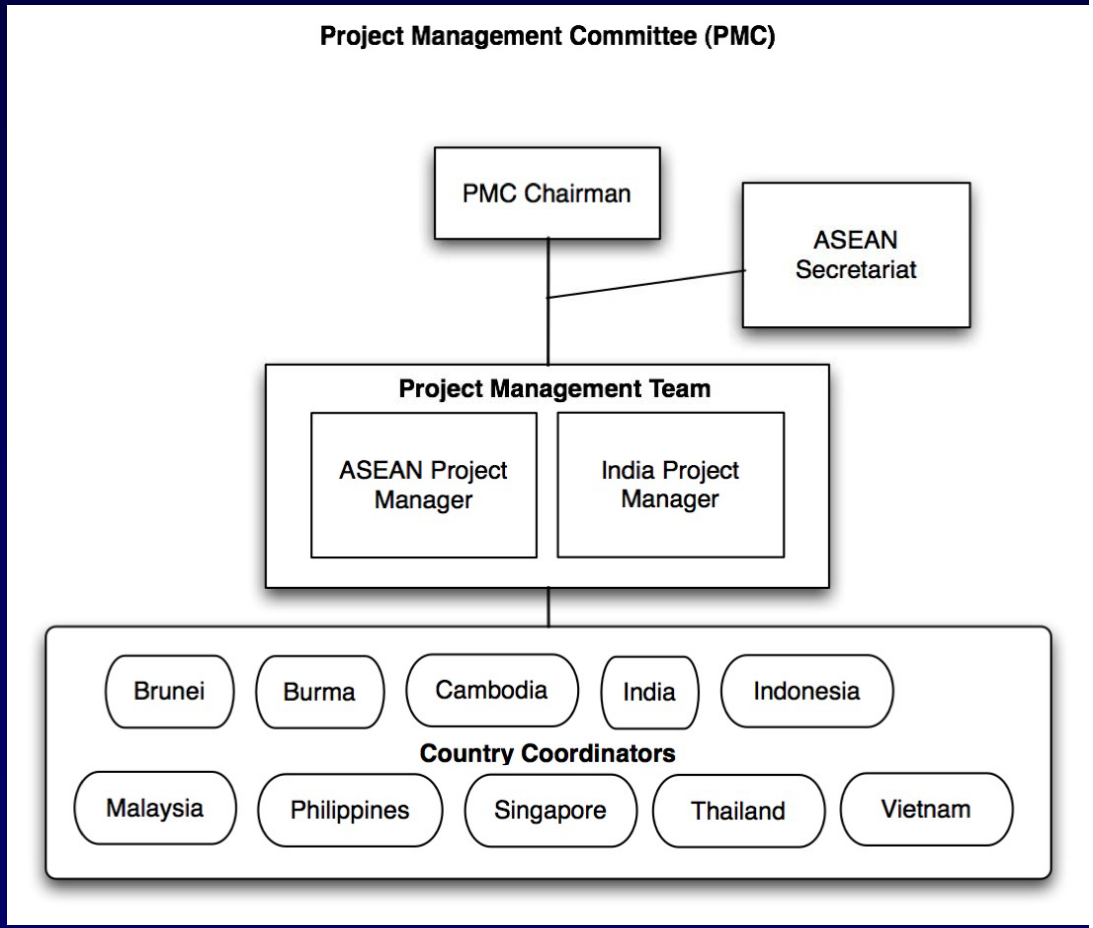
Extent of transfer of alien invasive organisms in South/SE Asia region by shipping

ASEAN-India Cooperation Fund



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