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Farming the waters for People and Food

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Global Conference on Aquaculture 2010

Climate change: Challenges confronting aquaculture

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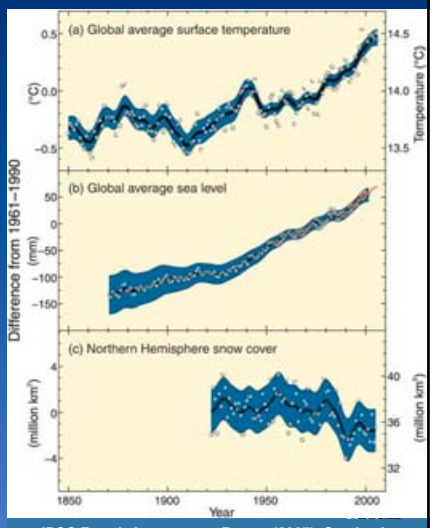
22–25 September 2010, Phuket, Thailand

Climate change?

- Perhaps most intensive science-based reporting on a global issue
- CC is real & measurable
  - In many forms
- Anthropogenic activities; major contributor
  - Controversy still exists



IPCC Fourth Assessment Report (2007); Synthesis Report Figure 1.1

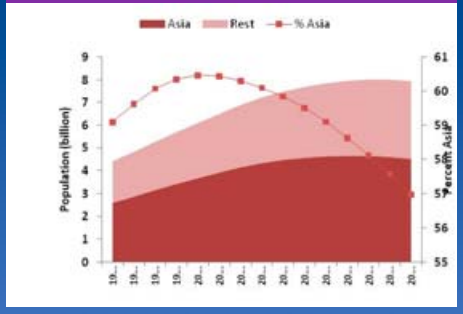
What would CC do? Examples

- 1 m sea level rise
  - Displace $24*10^6$ people along
    - Ganges, Brahamaputra, Salween, Mekong, Yangtze & Yellow Rivers
    - The above basins support 25% of the humanity
- 2m rise
  - Will displace/ uproot $14*10^6$ on the Mekong
- Melting of Himalayan glaciers:
  - Cause floods
  - Erosion upstream
    - Boosting the price of rice
- In essence problems of CC Impacts much greater on problems related to humanity

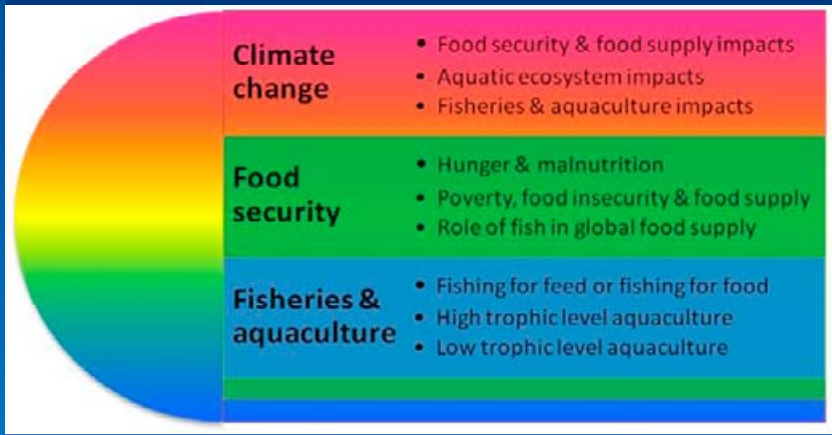
CC impacts – Generalities

- CC will
  - Decrease agricultural activities in the tropics and sub-tropics *for almost any amount of warming*
- One third of the world's population is now subjected to water scarcity
  - Population facing water scarcity will more than double over the next 30 years
- Estimated 10-15% of the world's species could become extinct over the next 30 years
  - CC will exacerbate the loss of biodiversity

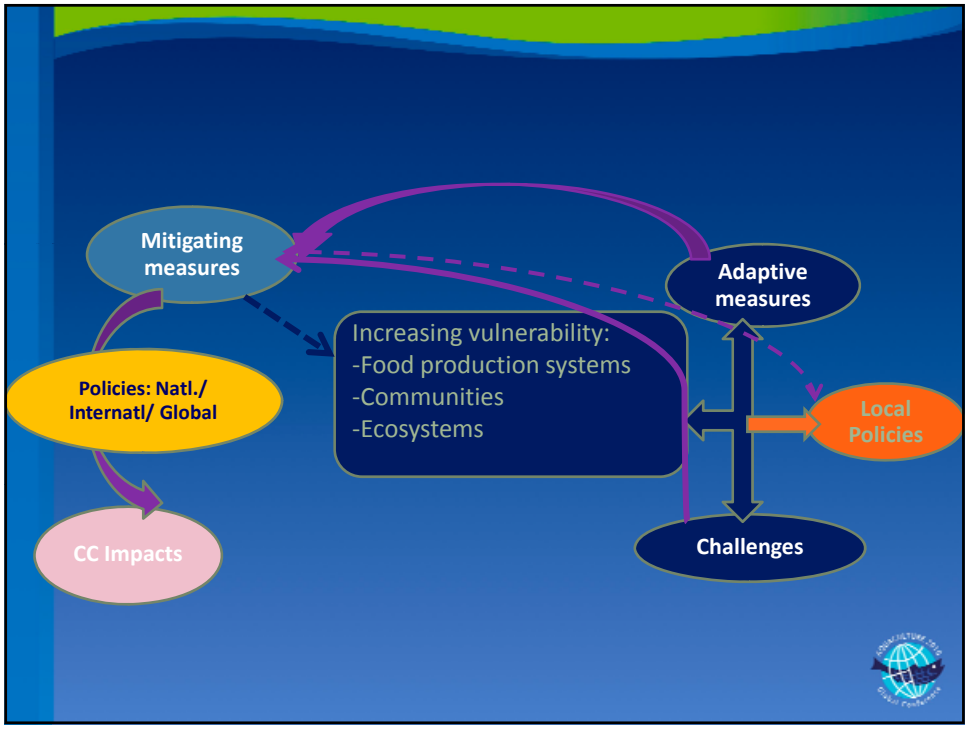
Food needs to double to meet the needs of an additional 3 billion people in the next 30 years



CC, food security and aquaculture – a continuum –



Source: Tacon, Metian & De Silva, 2010

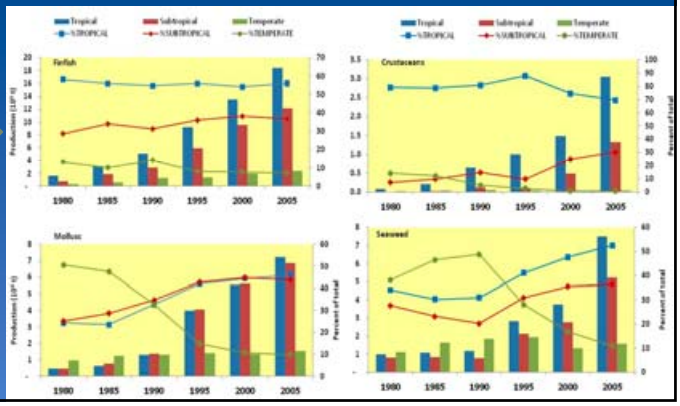


CC impacts on aquaculture

- All cultured organisms are POIKILOTHERMS
- Aquaculture is practised in all CLIMATIC REGION
  - Tropical, sub-tropical and temperate
  - Temperature range of 32-35°C, to 2-3°C

AQUACULTURE IS PREDOMINANT IN THE TROPICS

CHALLENGES, THERFORE, WILL NECESSARILY BE VARYING



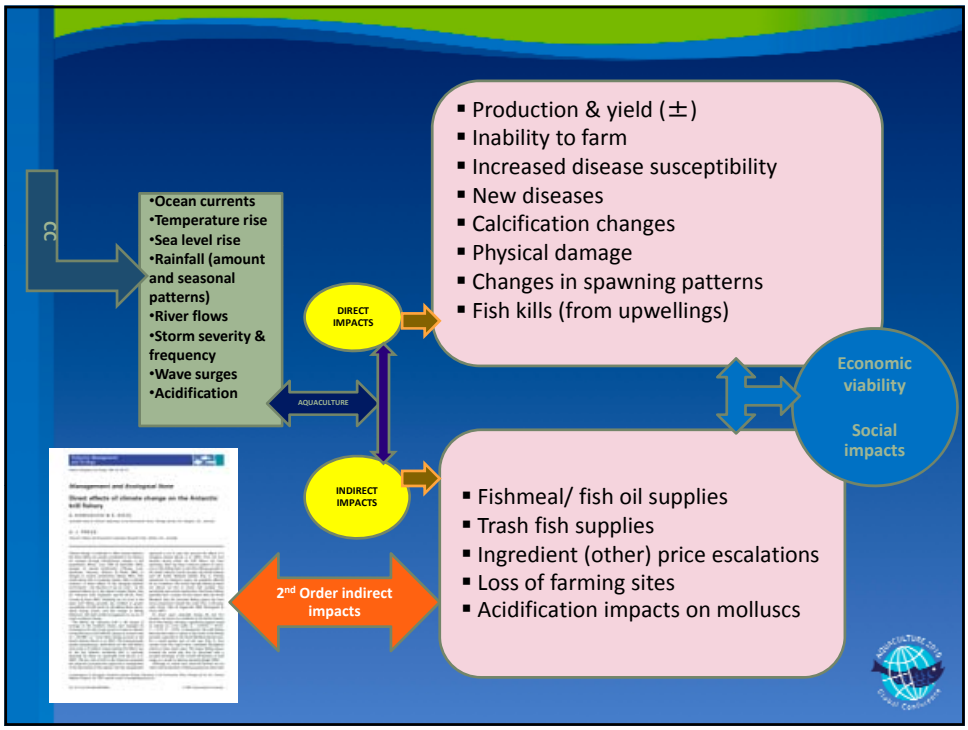
Climate Change

Ocean currents
•Temperature rise
•Sea level rise
•Rainfall (amount and seasonal patterns)
•River flows
•Storm severity & frequency
•Wave surges
•Acidification
•Algal blooms
•Enhanced stratification

AQUACULTURE

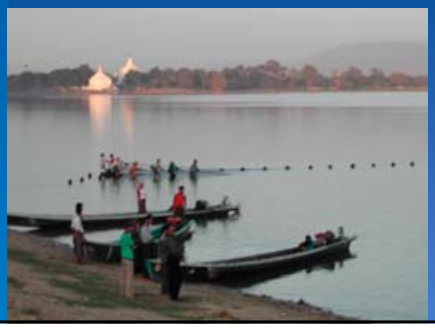
DIRECT IMPACTS

INDIRECT IMPACTS



Sea level rise

- Deltaic regions impacted by
  - – Sea level rise, reduced water flow
    - Saline water intrusion
    - Potential flooding



6 WORLD

World deltas erode as land sinks, seas rise

Study says Nile, Rhone, Chao Phraya are at risk

- Deltaic region
  - Potentially, highly significantly impacted
- Deltaic regions in the tropics are hubs of aquaculture activities
  - Mekong Delta, Vietnam
    - Home to the striped catfish industry (+black tiger shrimp)
  - Ganges-Brahamaputra, Bangladesh
    - Home to shrimp culture

Intensive culture activities in deltaic regions

Case study:
Striped catfish farming in the Mekong Delta, Vietnam

- Possibly the biggest single species in small geographic area (<7,000 ha) based aquaculture activity in the world
  - $1.2*10^6$ t, worth 1 billion US$ (in 2007)
  - ~98% exported
  - Employs over 180,000; >80% women

How CC impacts striped catfish farming?

Sea level rise

Reduced river flow

Salinity intrusion

Impact on farming
(5-10 years time frame

What is (are) the possible adaptation(s)
Or is (are) there any?

Striped catfish farming: Challenges & possible adaptations

- Move upstream?
  - Land prices (exorbitant)?
  - Capital expenses
  - Dislocation

Least probable and possible

- Change to new salinity tolerant species?
  - Possible
    - Fresh expertise
    - Infrastructure (major changes)
    - Market?
- Develop salinity tolerant strains of striped catfish
  - Scientifically plausible
  - Minor changes needed (hatcheries only)

- Study the challenges
  - In time and space
- Look at all possibilities/adaptations
  - Social and economic implications
- The decision finally:
  - Comes from the people at the coal face (aquaface)
- The world needs this new substitute for the "traditional white fish:
  - Challenges to keep the sector thriving

A possible positive for deltaic regions

- Sea water intrusion
  - Salinisaiton of agricultural lands
  - Traditional agricultural activities
    - E.g. Rice farming
    - Possible any longer?
- Mekong Delta:
  - 2.5 g/L salinity intrusion
  - 20-35 km upstream intrusion
  - Loss of 70,000 ha three crop rice farming area (Khang *et al.*, 2009)
  - 100 cm sea level rise
    - 40,000 km² loss of land
    - Impact on 17.1 million people
- Ganges-Brahmaputra Delta
  - Inundation of 2,500; 8,000 & 14,000 km2 have been predicted for 0.1; 0.3 and 1.0 m rise sea level, respectively (Handisyde *et al.*, undated)
  - World Bank (2000) reported a reduction of 0.5 million t in rice production associated with 0.3 m level sea rise

Challenge to aquaculture

- Provide alternative livelihoods to millions
- A positive change to aquaculture
  - Capacity building on alternate farming activity
  - Provide necessary infrastructure
    - New hatcheries to meet increasing seed stock demands
    - Marketing infrastructure
  - New emerging species to meet the challenge?
    - Make appropriate evaluations
    - Decide on suitable "new" species

NOT TOO EARLY TO COMMENCE PLANNING/ MODELLING

COMMENCE DISCUSSIONS WITH STAKEHOLDERS

PREPARE POLICY CHANGES REQUIRED

COMMENCE REQUIRED CAPACITY BUILDING

Temperature rise – temperate aquaculture

- Major challenge to cold water aquaculture
- Increased temperature will:
  - Closer to upper range of tolerance of some cultured species
  - Dormant pathogens become virulent
    - New diseases in new areas
      - E.g. *Vibrio parahaemolyticus* (in oysters in Alaska & S. Chile
        - » Attributed to higher summer sea temperature
    - Abalone, *Haliotis tuberculata*; Brittany & Normandy
      - Reproductive stress exacerbated by higher temperature and the pathogen *Vibrio harveyi* (Traverse *et al.*, 2010)
    - Increased range of distribution of pathogens
      - E.g. Protozoan parasites (*Perkinsus marinus*, *Haplosporidium nelsonii*: Gulf of Mexico to Delaware Bay

- Challenges
  - Develop higher temperature tolerant strain
  - Treatment for new diseases
  - Better risk assessment on potential sites
  - Shift to other species?

Temperature rise – tropical aquaculture

- Surprising, but increasing occurrence
- At times associated
  - With extreme weather conditions
  - Changes in current patterns
- Most tropical species (fw & marine)
  - Susceptible to temperature reductions
    - 3-5°C
- Recent examples
  - Loss of grouper stocks in Thailand
  - Loss of tilapia broodstock in China
- Challenges
  - Be alert and vigiliant

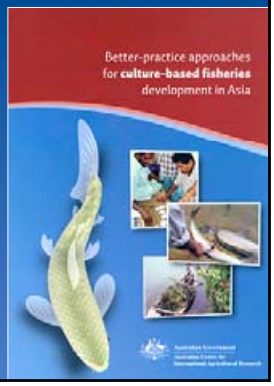
A species that is sensitive to a 2-3°C sudden drop in temp.

Change in rainfall and patterns – tropical systems

- In the tropics the monsoonal rain patterns
  - Influence on reproductive seasonality
    - Most broodstock subjected to natural cycles
- Challenges
  - Research on change in seasonality
  - Relevant modifications to hatchery systems
  - Fresh coordination plans with grow-out operations

- Natural productivity of inland waters
  - Used for aquaculture
    - Through culture-based fisheries (small water bodies)
      - Community activity
      - Effective secondary, non-consumptive use of water resources
      - Only input seedstock
      - Low-cost rural activity
    - Totally dependent on weather pattern
      - Stocking
      - Harvesting
    - Increasingly popular in many countries
    - Target 5-8*10^6 t in 10 years

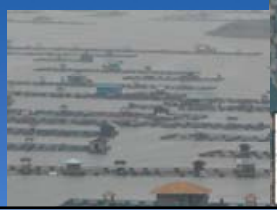
- Challenges
  - Determine the impacts of potential changes on the water regimes
  - Introduce selection criteria for water bodies
  - To make adjustments in the production cycle
    - Seed stock production
    - Stocking and harvesting regimes
    - Marketing channels

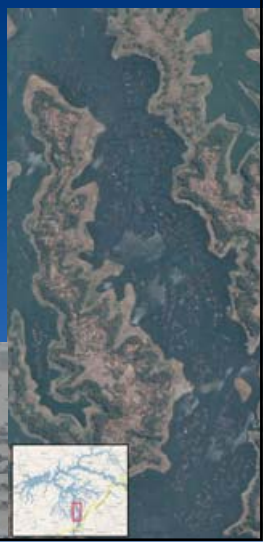


Change in rainfall and patterns – tropical large inland water bodies

- Large water bodies
  - Lakes & reservoirs
  - Increasingly used for cage culture
- Changes in productivity & stratification patterns
  - Algal blooms
  - Increased up-welling

Potential fish kills



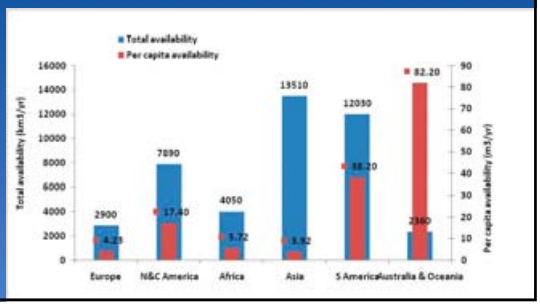


- Challenges
  - Maintain viability
    - Do not intensify activities
    - Avoid/minimise crowding
    - Maintain activities within the carrying capacity
    - Extra vigilance and continuous monitoring
    - Make siting changes
      - Move to areas of high water flow




General water stress – mostly in tropics

- Freshwater – one of the most limiting natural resource on the planet
  - Uneven distribution continent wise
    - E.g. Asia has the highest but the least per capita
- Challenge
  - Needs to conserve water

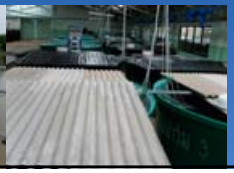


Nguyen & De Silva (2006)

- Water abstraction reduced & better planned
  - Along rivers
    - Introduce "water abstraction & discharge calendars"
    - Done on a community/cluster basis
      - Other advantages
        - » Reduce disease widespread, increase productivity

- Need to conserve water
  - Recirculation technology
    - Make more energy efficient
      - Reduction in GHG on unit production
    - Encourage simple, outdoor recirculation technologies
      - Cost effective
      - Reduced GHG emission per unit of production
      - Useful by-products
        - » E.g. Artemia biomass

5 th Generation SPF Broodstock

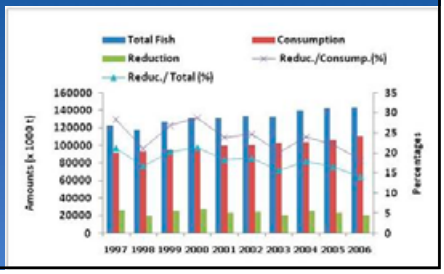


Extreme weather events

- Manifested in many forms
  - Wave surges
  - Storms
  - Extreme unseasonal cold bursts
- Greatest difficulty in predicting
- More adaptabilities than challenges
  - Better infrastructure
  - Understand the risks, take precautionary steps
    - E.g. Increase dyke high
  - Be prepared to move stocks
  - Socio-economically: embrace insurance

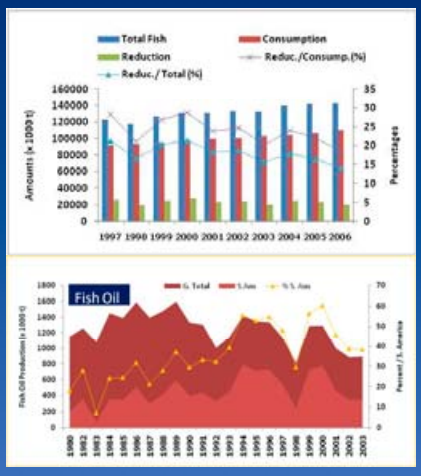
Fish meal & fish oil

- To put in perspective
  - Aquaculture currently utilises 45% and 85% of global fish meal and fish oil
- Reduction industry
  - A "bone of contention"
  - Is it ethically correct to use nearly 25% of world marine fish production?
  - Should this resource not be used for direct human consumption
    - Reduce malnutrition
      - Currently 1 billion, ~17% of the world population
      - MDG



Fish meal & fish oil

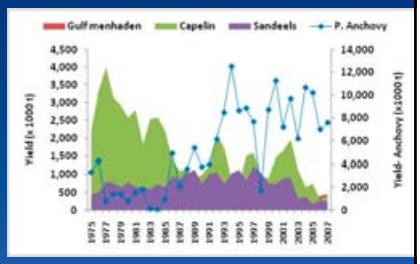
- SA and Europe dominate lead of the reduction industry
- Main raw material
  - Pelagic industrial fisheries
    - E.g. Peruvian anchovy, capelin, sand eels etc.
- Reduction in raw material usage
- General reduction in fish meal & fish oil



De Silva et al. (2010)

Fish meal & fish oil

- Raw material availability in the past – fluctuating
- CC impacts on raw material supplies?
  - Reduction in ocean productivity
    - N. Atlantic: ~50%
    - Others: ~20%
  - El Nino impacts
    - Peruvian anchovy supplies
  - N. Atlantic oscillation winter index
    - Sand eel (*Ammodytes*) supplies



Bottom line

• Reduced raw material supplies (from CC impacts)
• Renewed & more vigorous social pressures on the reduction industry
• Escalating cost- placing those cultures at the brink of economic collapse

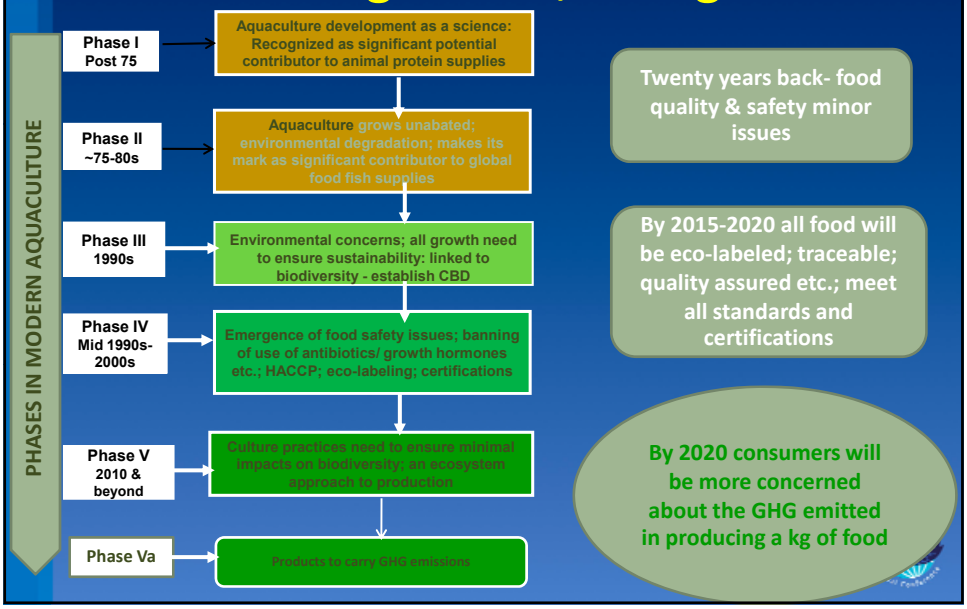
Challenge to Aquaculture:

• Reduce dependence on fish meal and fish oil
• Soon and fast

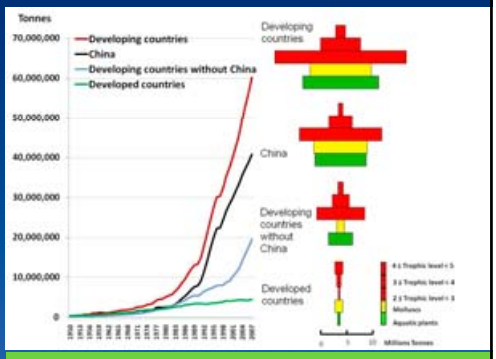
Reduce dependence on fish meal & fish oil

- Traditional approaches
  - Develop feeds with less fish meal & fish oil
    - Use more agricultural by-products
    - Better use of meat industry processing waste (with caution)
  - Improvements to feed management
- Develop new technologies
  - Genetic modifications
    - Reduce capabilities to elongate and de-saturate long chain fatty acids (PUFA into HUFA)
- Most challenging
  - PARADIGM SHIFT/CHANGE
    - Also link to other social aspirations

Paradigm shift/change



- If "*by 2020 consumers will be more concerned about the GHG emitted in producing a kg of food*"
- Challenge to aquaculture
  - Shift to low tropic species
    - Even now > 65% of produce is low trophic
    - Need to be a global approach
  - Make aquaculture the most GHG "friendly" animal protein production sector



From: ***Tacon, Metian & De Silva, 2010***:
Global trends in aquaculture production expressed in weighted mean trophic level by economic country grouping, including China (weighted trophic levels calculated from Froese and Pauly, 2007 and FAO, 2009c)

Perhaps & Overall Assessment on CC Impacts on Aquaculture may be an appropriate starting point

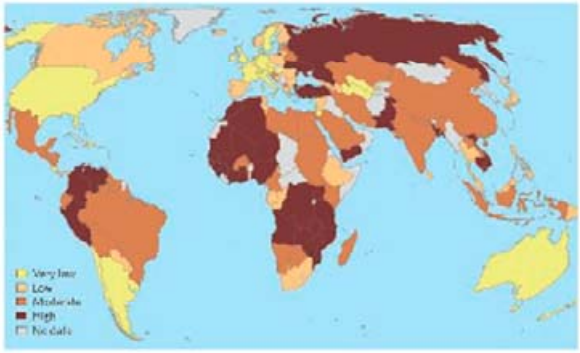


Figure 1 Unequal vulnerability. The vulnerability of national economies to potential climate change impacts on fisheries was calculated on the basis of exposure, sensitivity and adaptive capacity, assuming slowly increasing global emissions (scenario B2 of the Intergovernmental Panel on Climate Change). Colours represent quartiles, with dark brown for the upper quartile (highest vulnerability), yellow for the lowest quartile and grey where no data were available. Originally published in ref. 3.

From Dulvy & Allinson, 2009

Take home message

- Certain aquaculture systems, in different locations, have to make adaptive changes
  - Through changes in the farming systems
  - Make relevant technological innovations for some
- Aquaculture may also be an option to millions of other primary producers whose livelihoods are at risk
- Aquaculture has to make the hard decisions to bring about paradigm shifts
- If the above challenges are met with effectively aquaculture may become the least GHG emitting food production sector