CLIMATE CHANGE, FOOD SECURITY & AQUACULTURE:

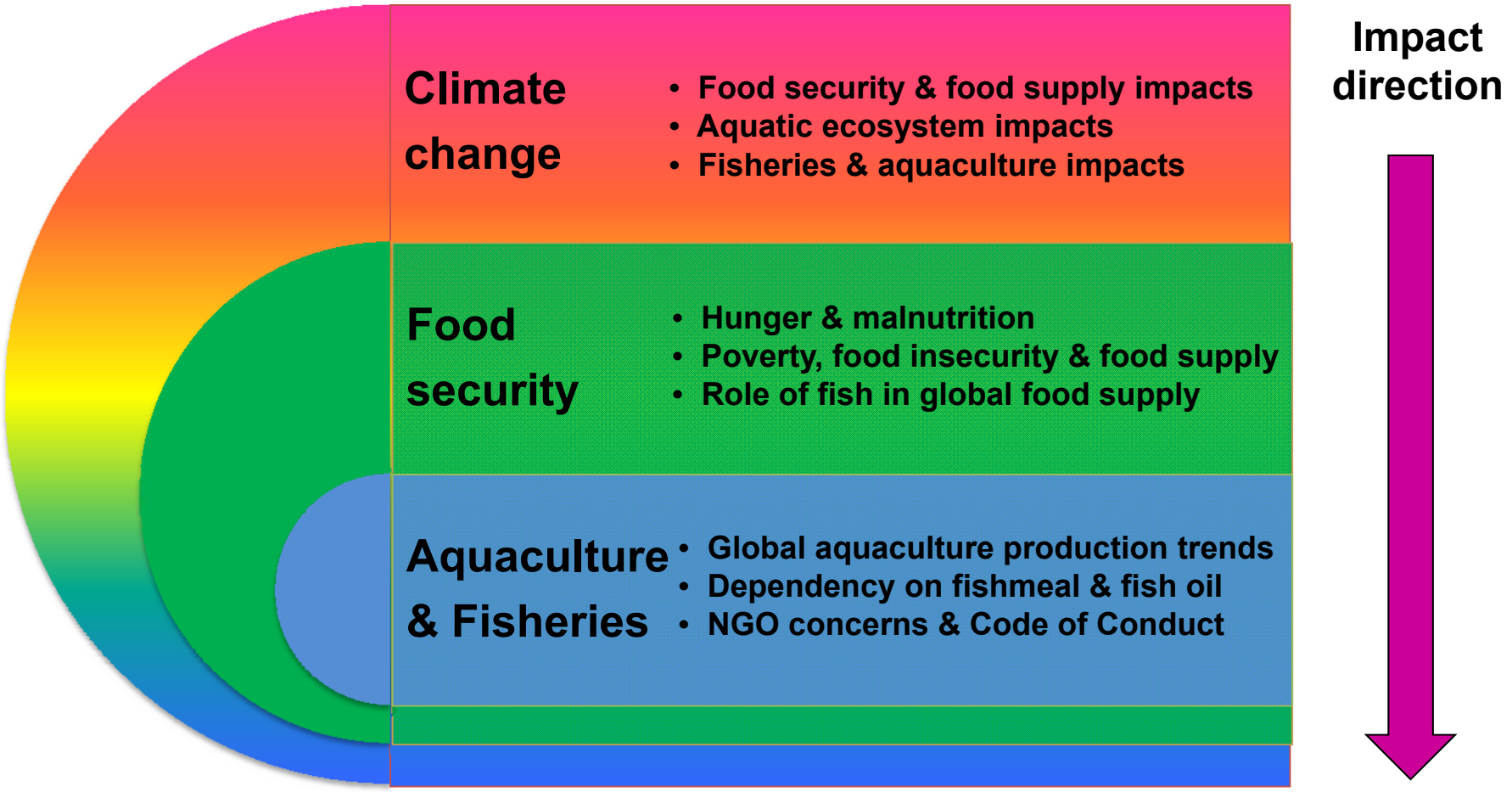
Policy implications for ensuring the continued green growth & sustainable development of a much needed food sector

Albert G.J.Tacon[1], Marc Metian[2] & Sena S. De Silva[3]

[1]Instituto de Investigaciones Oceanologicas, Universidad Autonoma de Baja California, Km 107 carretera Tijuana/Ensenada, 22860 Ensenada BC, Mexico

[2]University of Hawaii, Hawaii, HI 96744 USA

[3]Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand



Climate change, food security, and aquaculture continuum - major discussion points of this presentation

1. Climate change

According to the UN Framework Convention on Climate Change the average temperature of the earth's surface has risen by 0.74ºC since the late 1800s, and is expected to increase by another 1.8°C to 4°C by the year 2100.

The reason for this global warming is believed to be due to the increase of heat-trapping `greenhouse gases' in the atmosphere, in particular CO_2 , methane & nitrous oxide.

Whilst `greenhouse gases' occur naturally and are critical for life on earth, in augmented and increasing quantities they are believed pushing the global temperature to artificially high levels & altering the climate

Climate change

The main causes of global warming are believed to be due to industrialization and the burning of fossil fuels (coal, oil and gas) to meet increasing energy demands, and the spread of intensive agriculture to meet increasing food demand, which is often accompanied by deforestation.

Moreover, the process of global warming shows no signs of abating and is expected to bring about long term changes in weather conditions - (FAO, 2008).

For the purposes of the present paper, it is suffice to summarize here those potential impacts of climate change on food security and global food supply, as follows:

Climate Change Impacts: on Agriculture & food security (FAO, 2008)

Agriculture is important for food security in two ways, by producing the food people eat, & by providing the primary source of livelihood for 36% of the worlds workforce.

In heavily populated countries of Asia & Pacific, this share ranges from 40-50%, and in sub-Saharan Africa, 2/3^{rds} of the working population still make their living from agriculture

It follows therefore, that if agricultural production in the low-income developing countries of Asia & Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk & consequently their vulnerability to food insecurity increased.

Climate Change Impacts: on Food, fibre and forest products (http://unfccc.int)

Crop yield is projected to increase in temperate regions for a local mean temperature rise of 1-3 °C, and then decrease beyond that in some regions;

In tropical areas, crop yield is projected to decrease, even with relatively modest rises of 1-2 °C in local temperature, increasing the risk of hunger;

Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes;

CLIMATE CHANGE

Ocean Currents
ENSO
Sea level rise
Rainfall
Rivers flows
Lake levels
Thermal structure
Storm severity
Storm frequency
Acidification

Effect on :

- Production Ecology
- Fishing & Aquaculture operations
- Communities livehoods
- Wider society & Economy

Impact on :

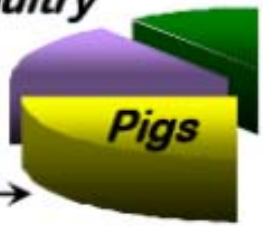
- Species composition
  Production & yield
  Distribution
  Diseases
  Coral Bleaching
  Calcification
- Safety & efficiency
  Infrastructure
- Loss/damage to assets
  Risk to health & life
  Displacement & conflict
- Adaptation & Mitigation costs
  Market impacts
  Water allocation

Diagrammatic representation of climate change effects on fisheries & aquaculture (adapted from Allison, 2009)

The Global Fish-meal industry – climate-fisheries-trade interactions

Global Climate → Small Pelagic Fish ← Global economy

6Mt Fishmeal + 1.2 Mt Fish oil
(from 30 Mt fish or 25 % Global catch)



Dr. Edward H. Allison
Director – Policy, Economics and Social Sciences
The WorldFish Center Penang

2. Food security

Nutrition & Food Supply

is the cornerstone that determines the health and well-being of all people, both rich and poor.

It allows people to grow, develop, work, play, resist infection and aspire to realization of their fullest potential as individuals and societies.

In marked contrast, malnutrition makes people all more vulnerable to disease and premature death.

Without adequate food, people cannot lead healthy, active lives - they are not employable - they cannot care for their children, and their children cannot learn to read and write.

Food security

“

The Right to Food

cuts across the entire spectrum of Human Rights – its fulfilment is essential to the fight against poverty, and to ensure a world free from hunger.

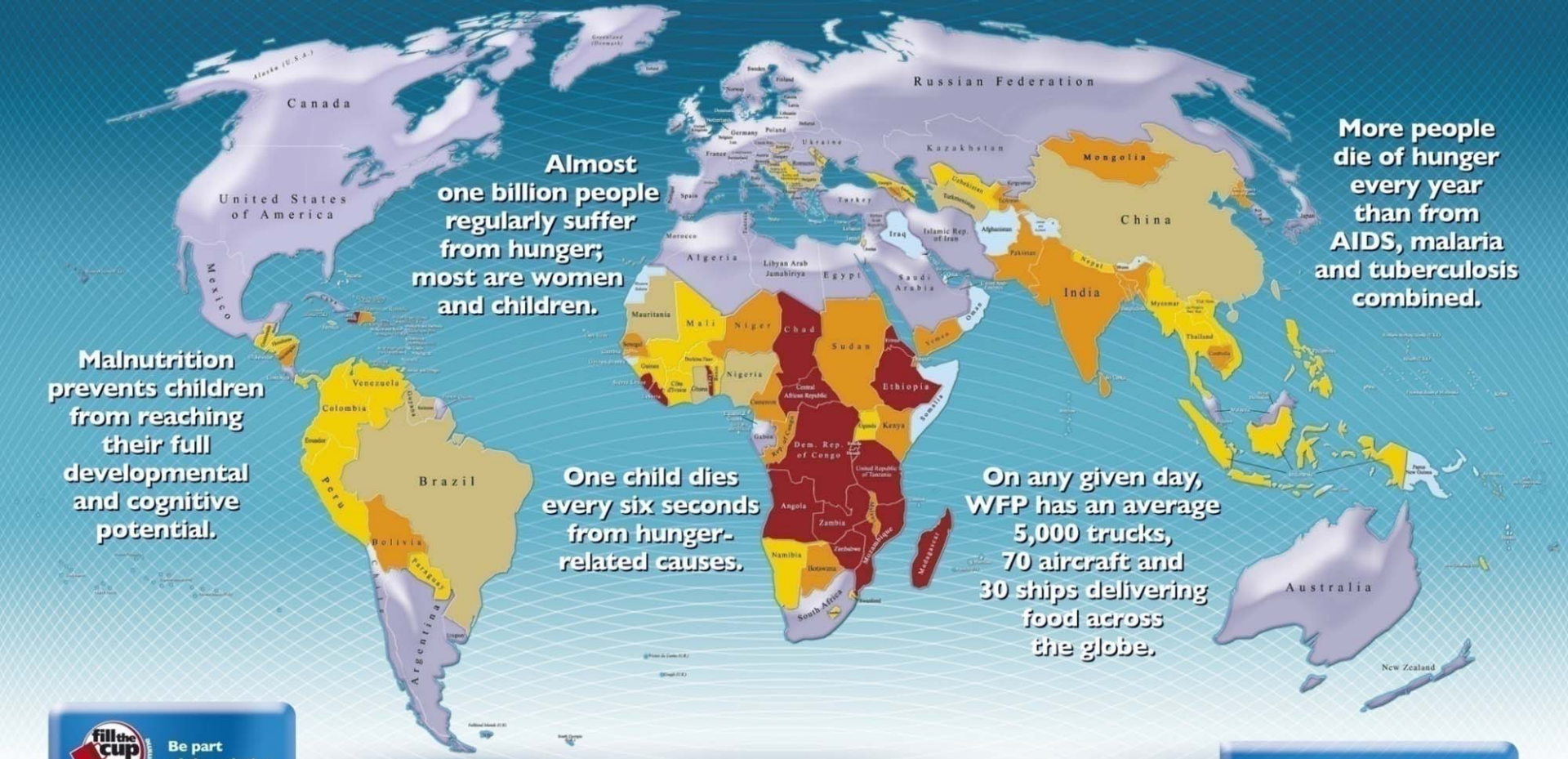
Sadly, hunger and malnutrition remain among the most devastating problems facing the world’s poor and needy, and continue to dominate the health and well-being of the world’s poorest nations;

MALNUTRITION

is still the number one killer & cause of suffering on earth; causing more deaths than HIV/AIDS, warfare, genocide, terrorism, or any other ailment

Malnutrition remains a continuing travesty of the recognized fundamental human right to adequate food and nutrition, and freedom from hunger, particularly in a world that has both the resources and knowledge to end this catastrophe

2009 Hunger Map



fill the cup wfp.org World Food Programme

Be part of the solution

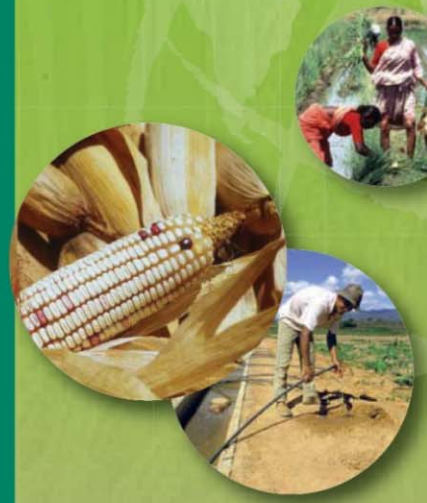
Category	1	2	3	4	5	
Undernourished	<5%	5-9%	10-19%	20-34%	≥35%	Insufficient data
Description	Extremely low	Very low	Moderately low	Moderately high	Very high	

WFP World Food Programme

Sources: *The State of Food Insecurity in the World 2008*, Food and Agriculture Organization of the United Nations and *FAOSTAT*.

wfp.org

2009



The State of

Food Insecurity in the World

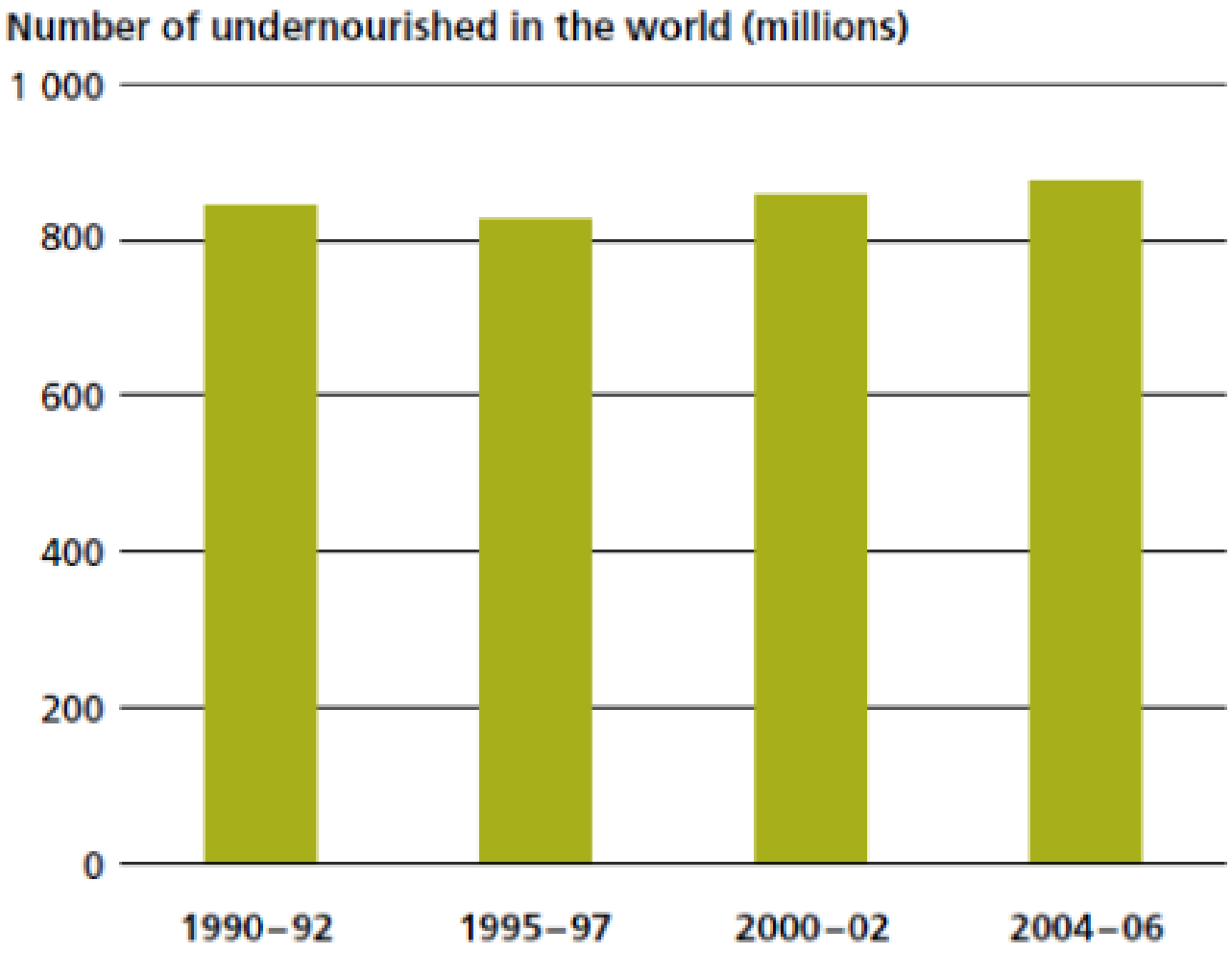
Economic crises – impacts and lessons learned

WFP

FAO FIAT PANIS

FIGURE 1

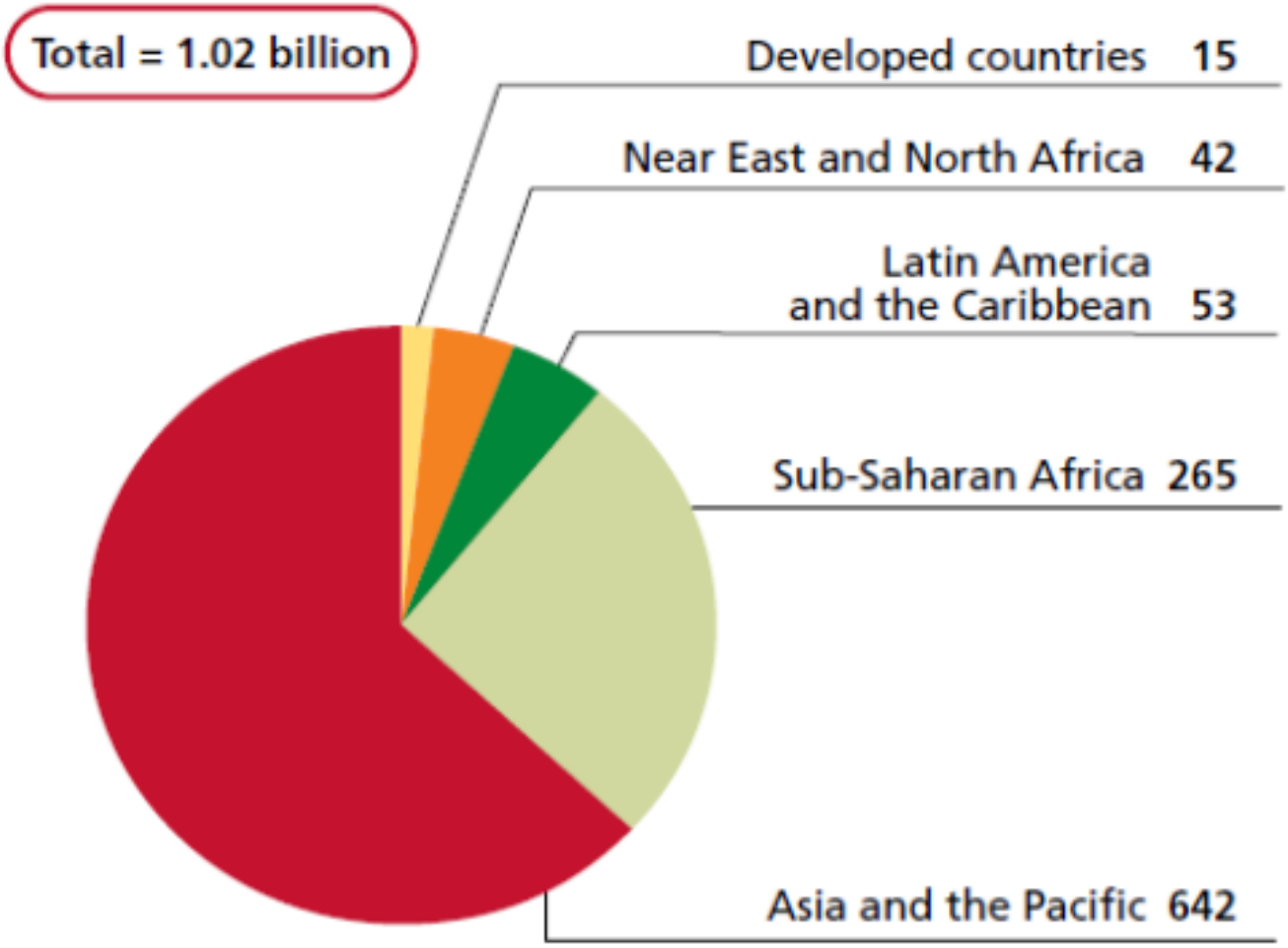
Chronic hunger has been increasing since 1995–97



Source: FAO.

FIGURE 4

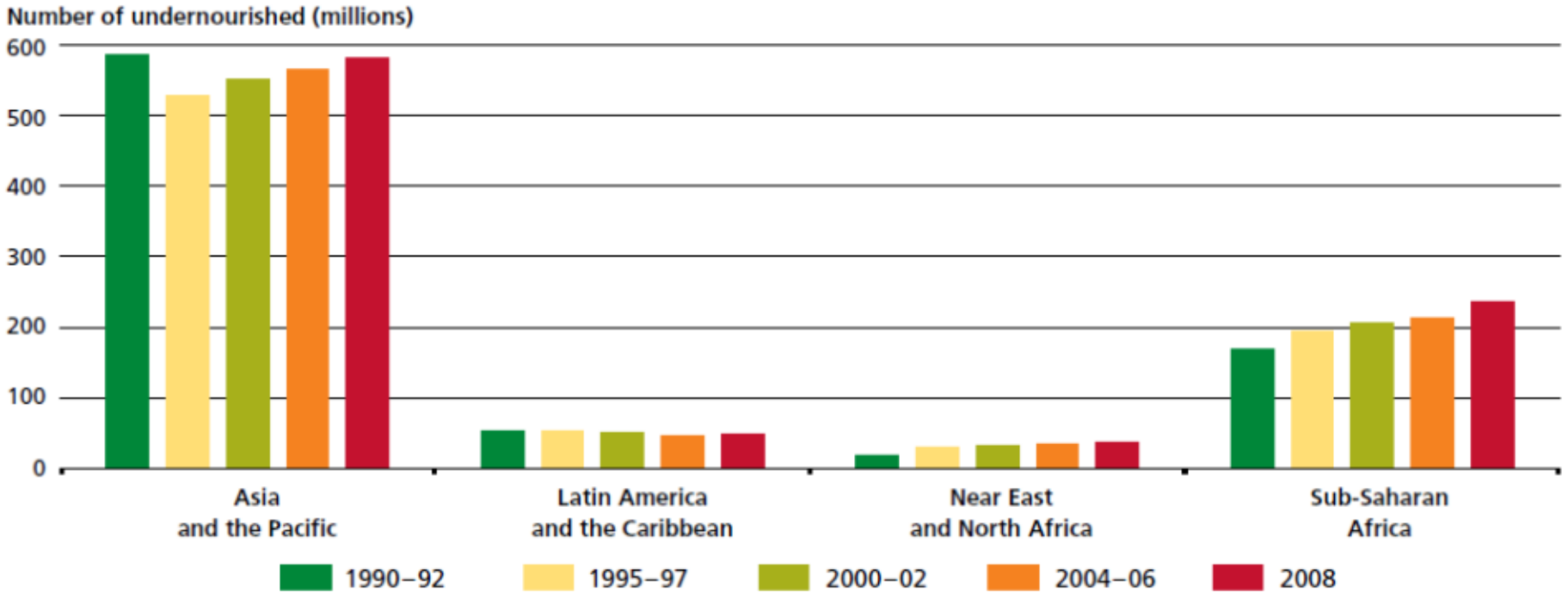
Undernourishment in 2009, by region (millions)



Source: FAO.

FIGURE 2

Undernourishment on the rise throughout the world: number of undernourished in selected regions, 1990–92 to 2008



Source: FAO.

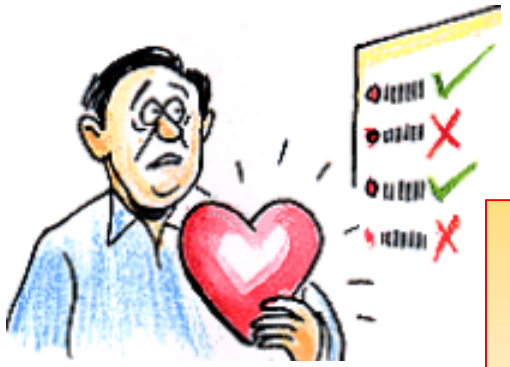
Malnutrition is still the number one killer & cause of suffering on earth

It is estimated that about **one-fifth** of the world's population is currently living in **extreme economic poverty**; defined as living on less than **US$ 1/d**

- **4 billion** earn less than $ 4/day
- **23** under 5 years of age children die every minute
- **6 million** under 5 children die from hunger every year
- **842 million** under nourished people
- **170** million under weight children
- **30** million intrauterine growth retardation
- As many as **2 billion** affected by iron deficiency aneamia, mainly women & children
- More than **800 million** people suffering from iodine deficiency disorders & brain damage & growth retardation
- More than **250 million** children with vitamin A deficiency

Role of fish in global food supply

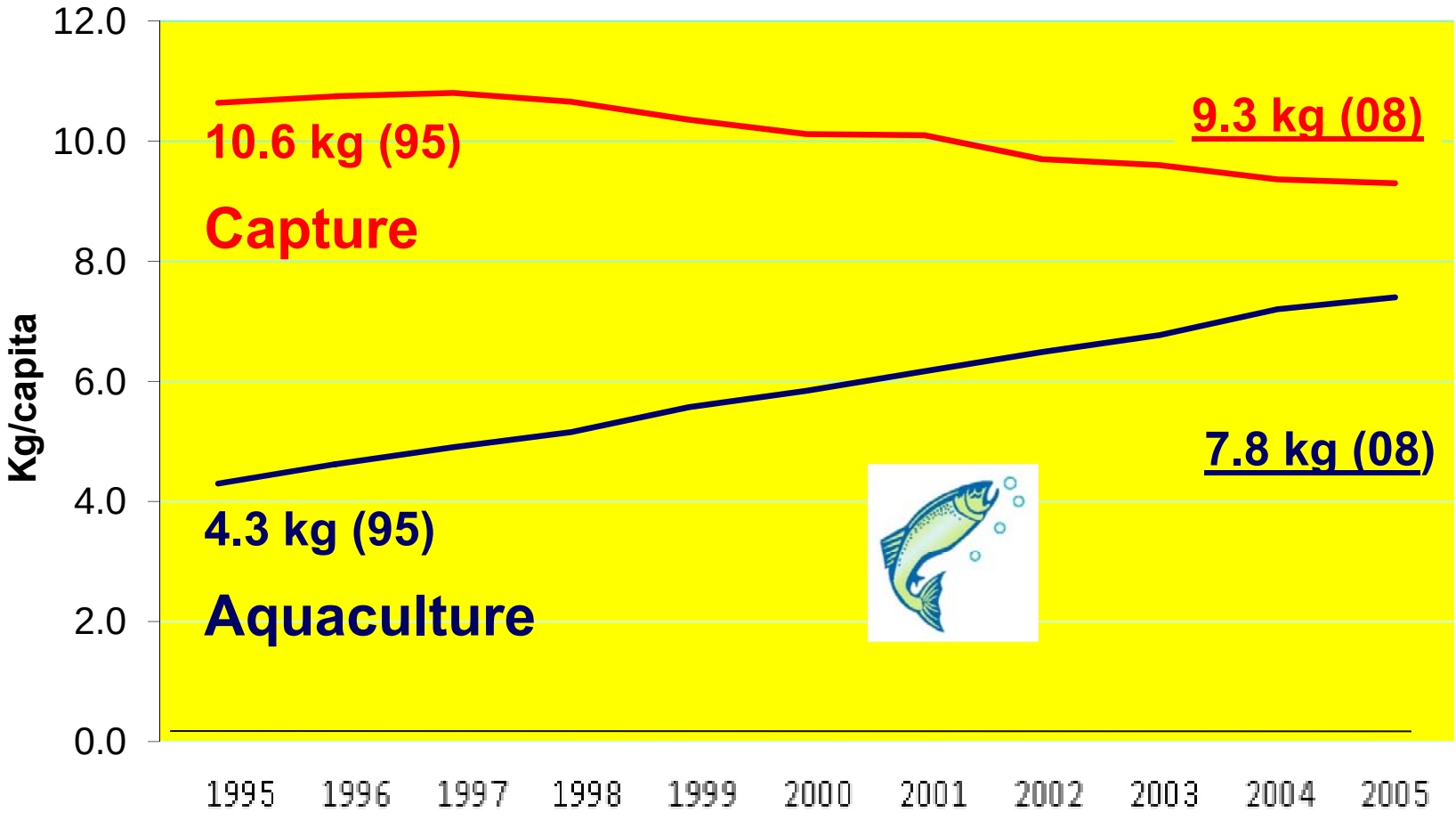
Food fish, whether captured or cultured plays an important role in human nutrition & global food supply, particularly within the diet & food security of the poor & needy as a source of much needed essential dietary nutrients



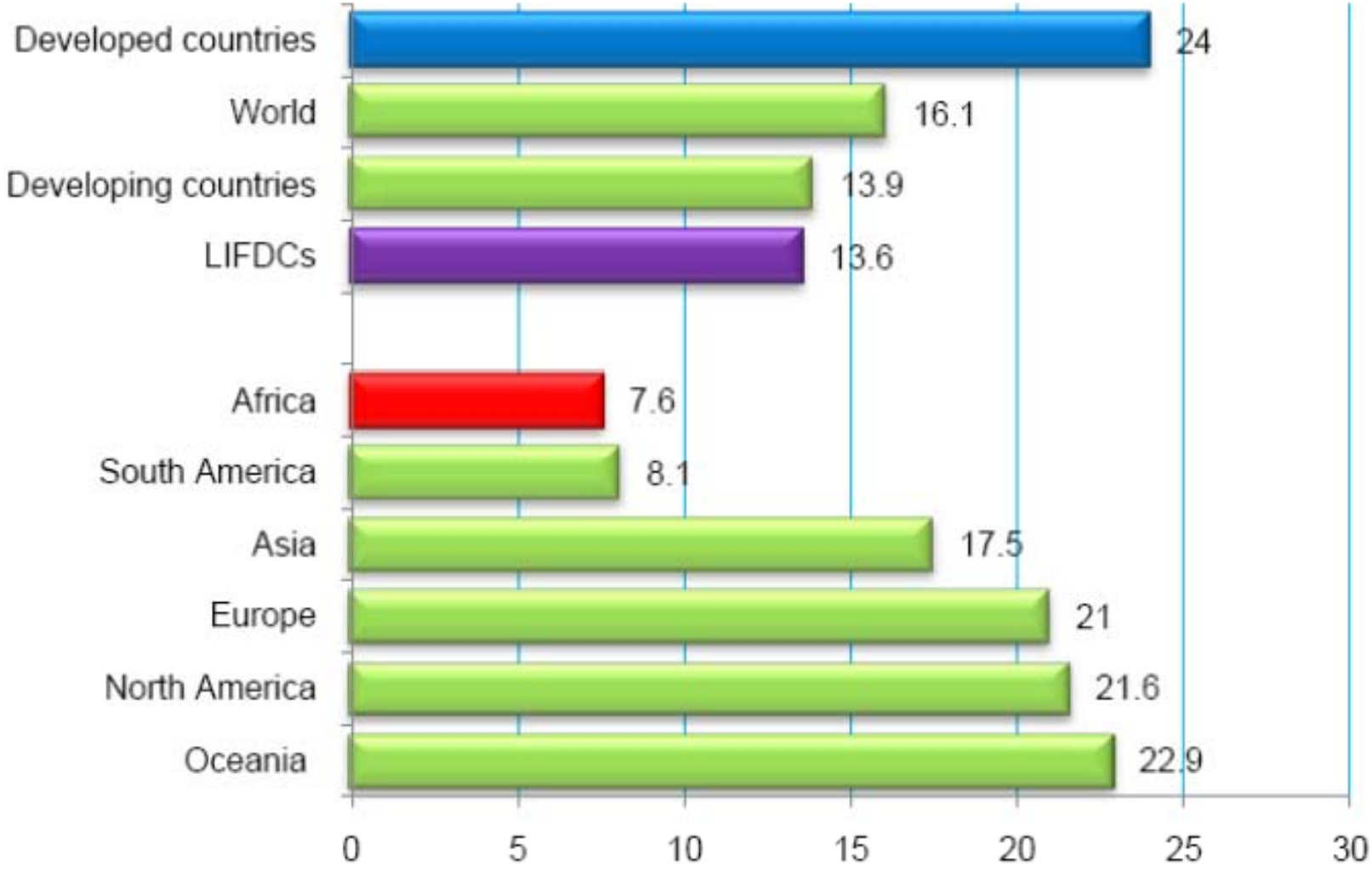
NUTRITIONAL VALUE OF FISH & SEAFOOD

Proteins, Amino acids, Omega-3 fatty acids, Energy, Ca, P, Mg, Fe, Zn, I, F, Cr, Se, vitamin A, D, E, B etc

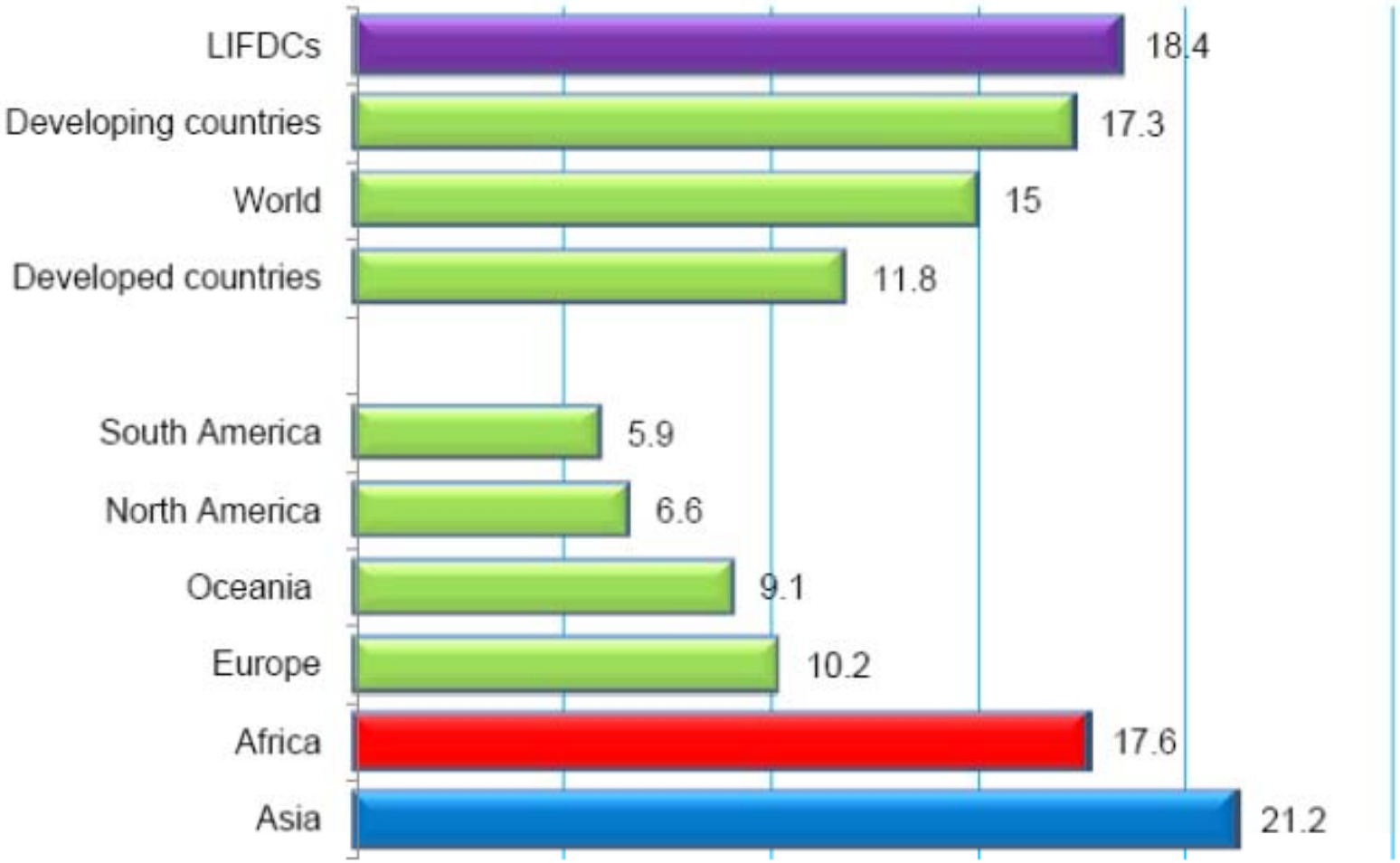
Per capita food fish supply from capture fisheries and aquaculture 1995 to 2008 (FAO, 2010)



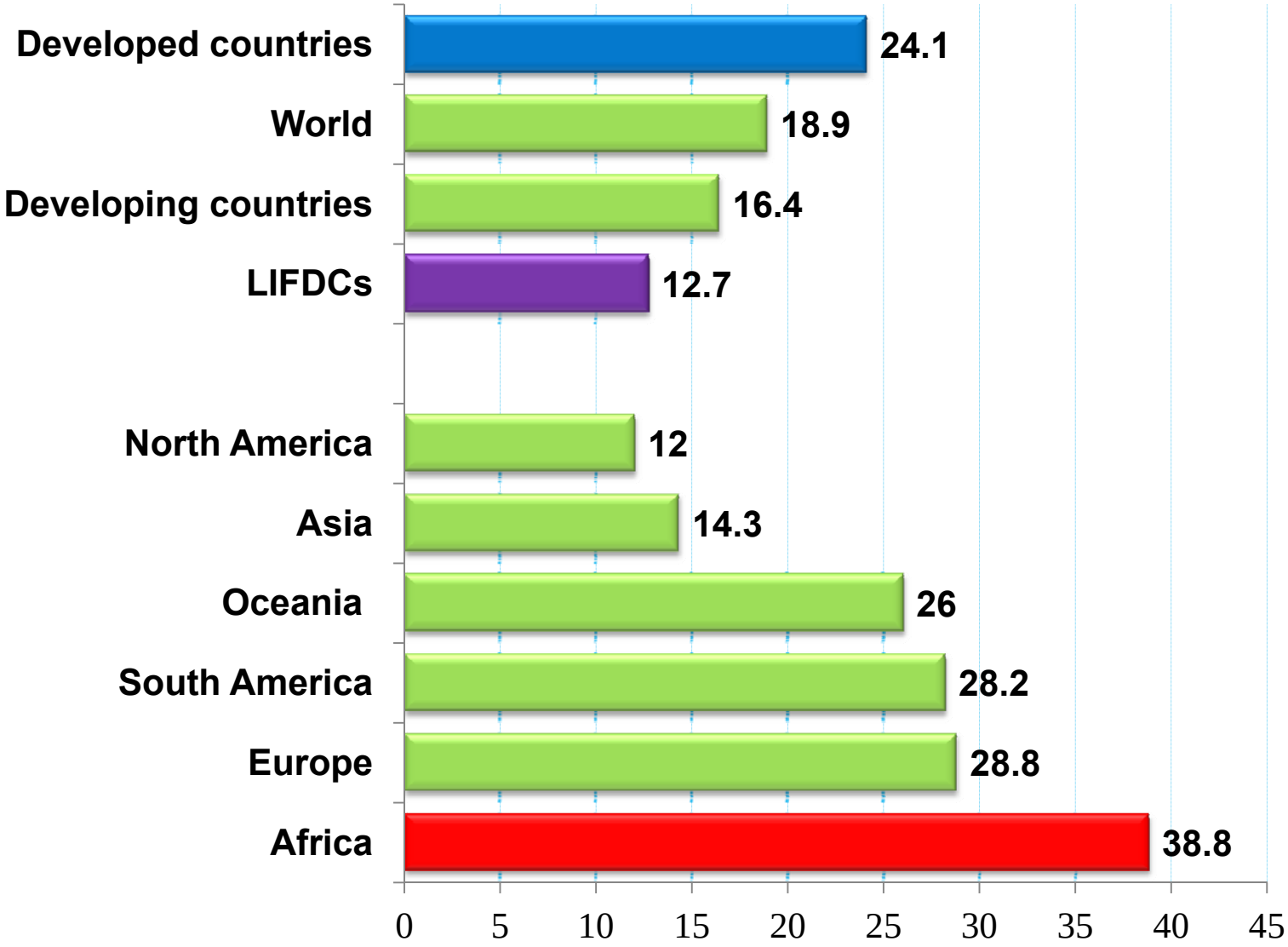
Per capita fish supply by region and economic country grouping in 2003 (values as Kg per capita supply: FAO, 2008)



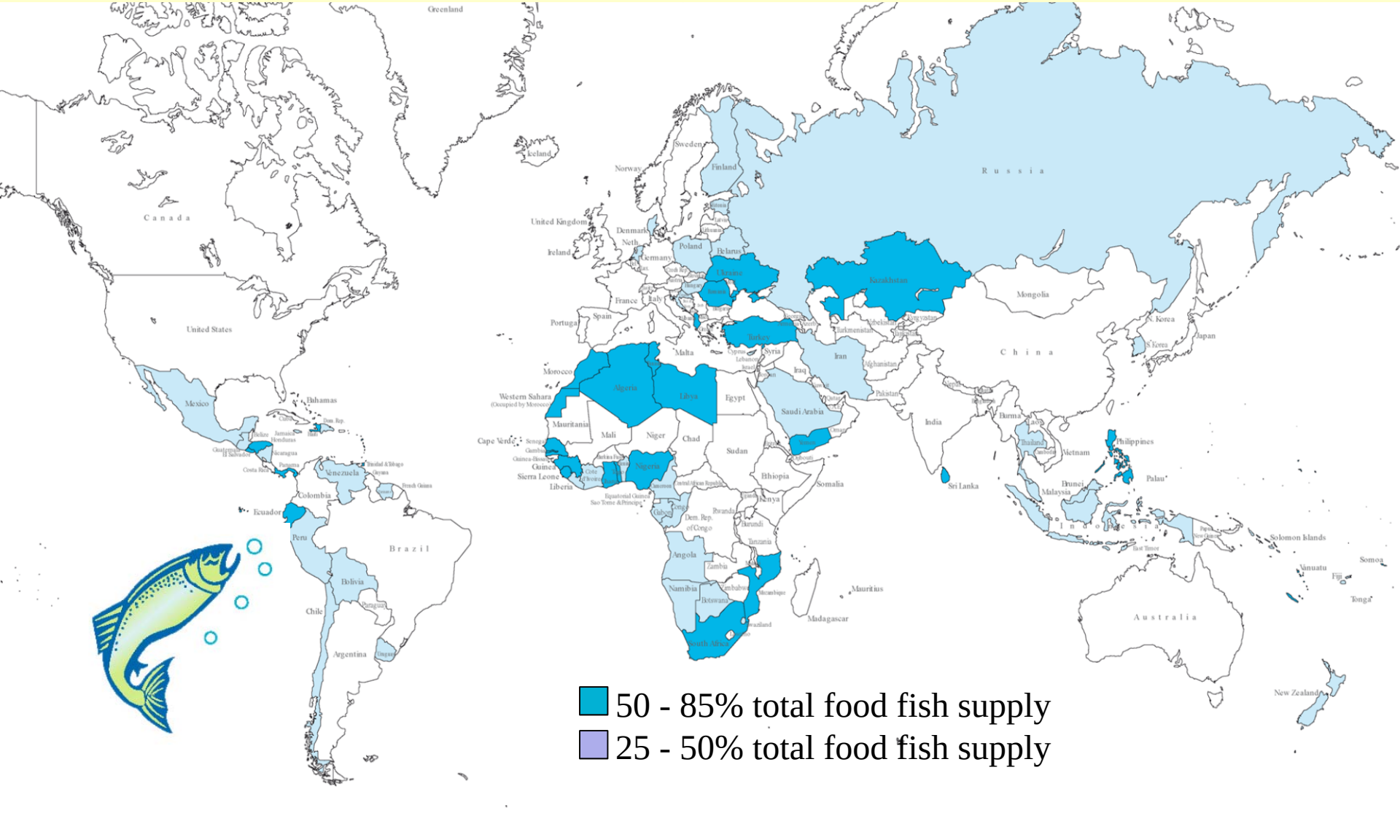
Contribution of fish to animal protein consumption in 2003
(values expressed as % total supply: FAO, 2008)

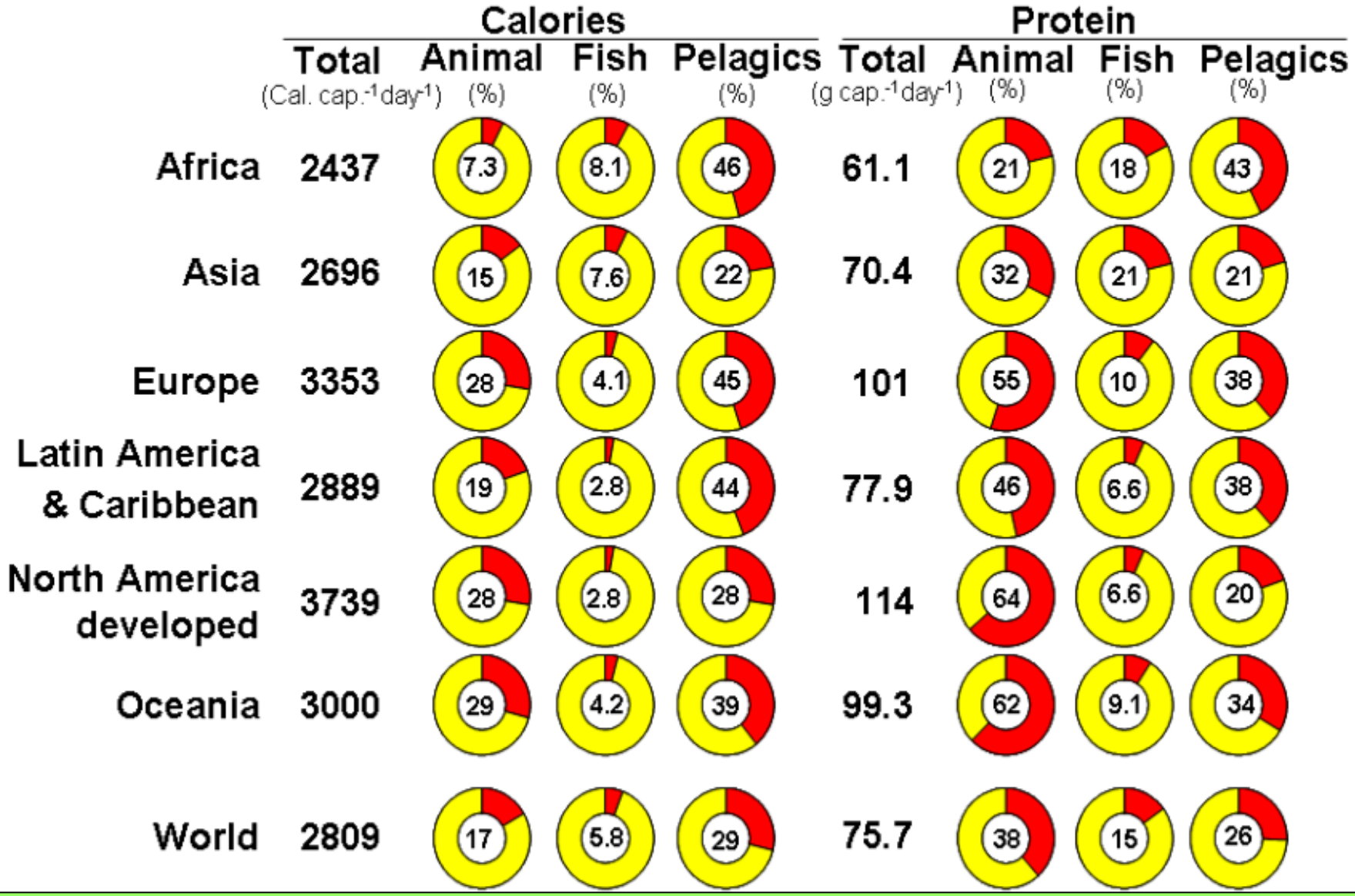


Contribution of marine pelagic fish to total fish consumption in 2003 (values as percent total fish consumption; FAO, 2008)



Contribution of pelagic fish to total food fish supply (calculated from FAO, 2008b)





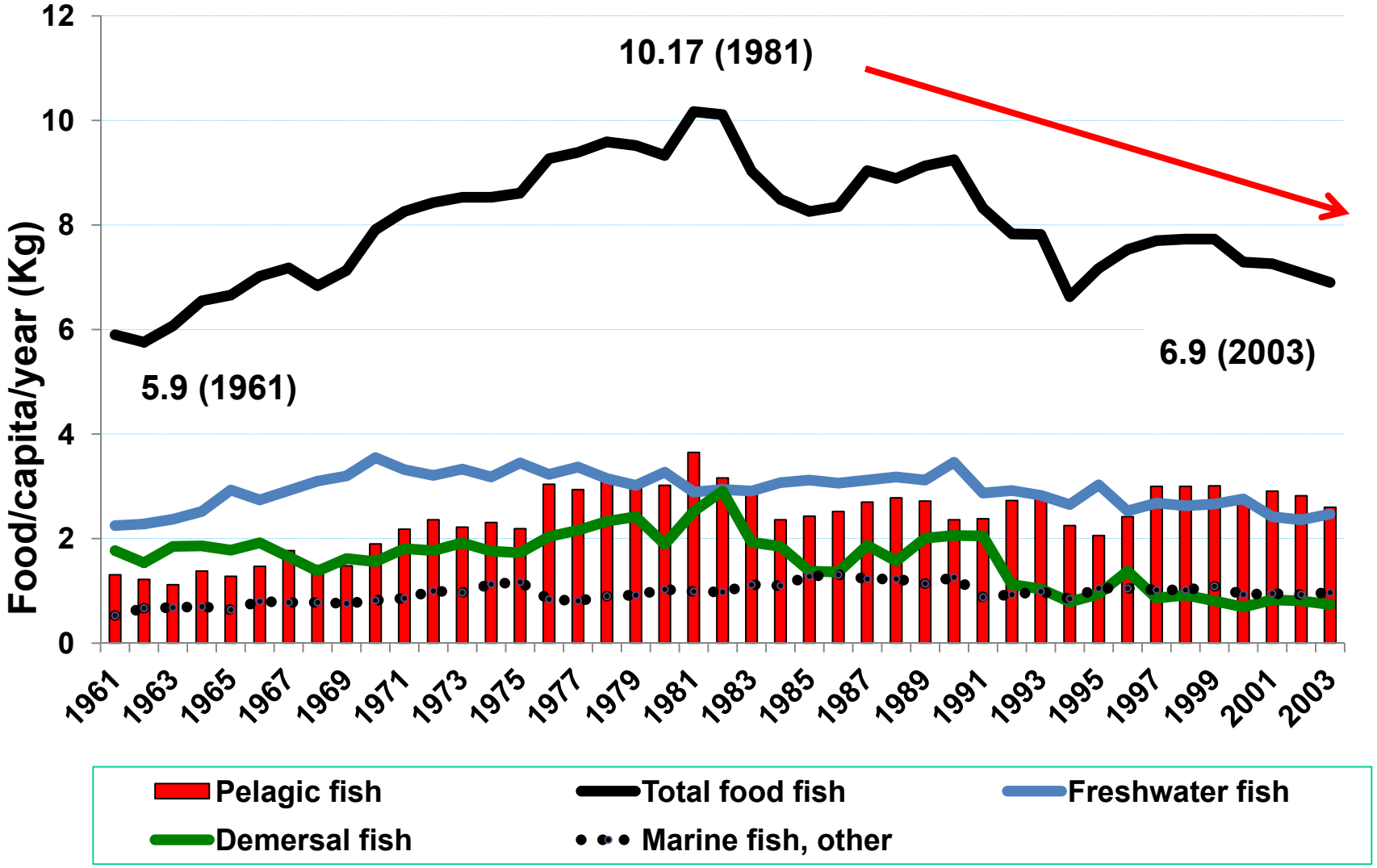
Contribution of fish (including pelagic fish to total daily per capita calorie and animal protein intake by major geographical region & country grouping in 2003 (Source: Tacon & Metian, 2009)

Role of fish in global food security

Food fish currently represents the major source of animal protein (contributing more than 25% of the total animal protein supply) for about 1.25 thousand million people within 39 countries worldwide, including 19 Sub-Saharan countries

Despite importance of food fish in Africa, the **Sub-Saharan** region is the only region of the world where per capita consumption of food fish has fallen (FAO, 2009)

Food fish supply in the Sub-Saharan African region by major fish group (taken from the FAO Balance Sheets; FAO, 2008)



Moreover, with the world population expected to grow by another 2.5 billion between 2005 & 2050 (a number equal to the total population in 1950), there are growing doubts as to the long term sustainability of many existing agriculture & aquaculture food production systems to meet the increasing global demand for food

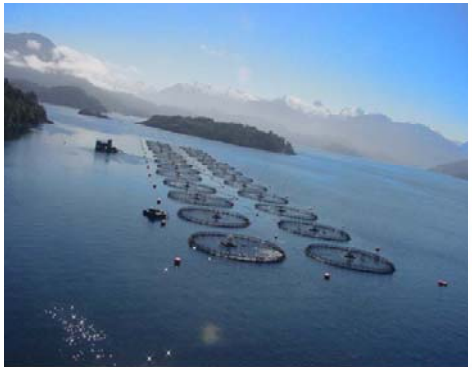
REVIEW

Food Security: The Challenge of Feeding 9 Billion People

H. Charles J. Godfray,[1]* John R. Beddington,[2] Ian R. Crute,[3] Lawrence Haddad,[4] David Lawrence,[5] James F. Muir,[6] Jules Pretty,[7] Sherman Robinson,[8] Sandy M. Thomas,[9] Camilla Toulmin[10]

Continuing population and consumption growth will mean that the global demand for food will increase for at least another 40 years. Growing competition for land, water, and energy, in addition to the overexploitation of fisheries, will affect our ability to produce food, as will the urgent requirement to reduce the impact of the food system on the environment. The effects of climate change are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably. A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security, different components of which are explored here.

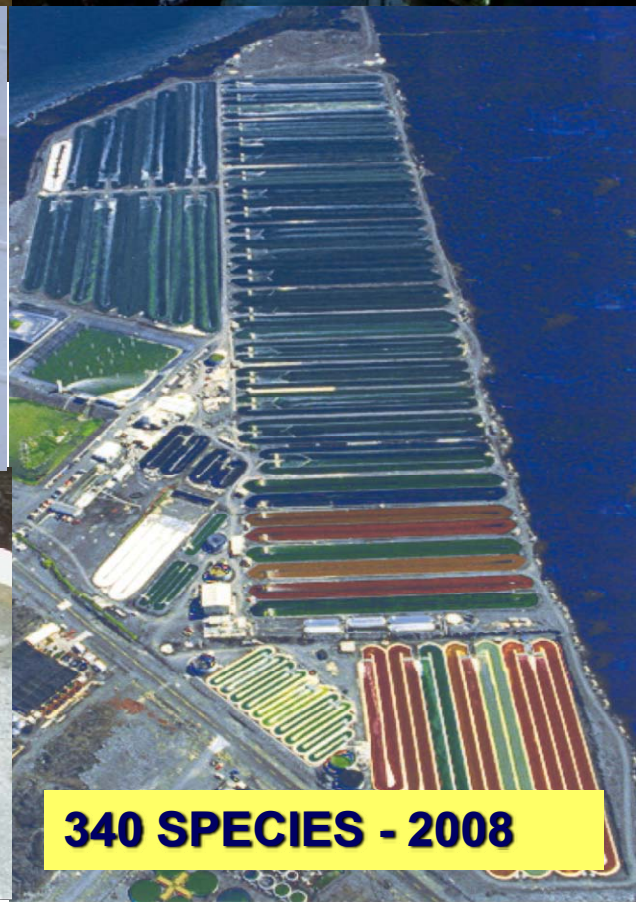
3. AQUACULTURE:
role in global food supply & sustainability implications



Of the different agricultural food production systems, aquaculture is widely viewed as an important weapon in the global fight against malnutrition & poverty, particularly within developing countries where over 93% of global production is currently realised; the aquaculture sector providing in most instances an affordable & much needed food source rich in essential nutrients.

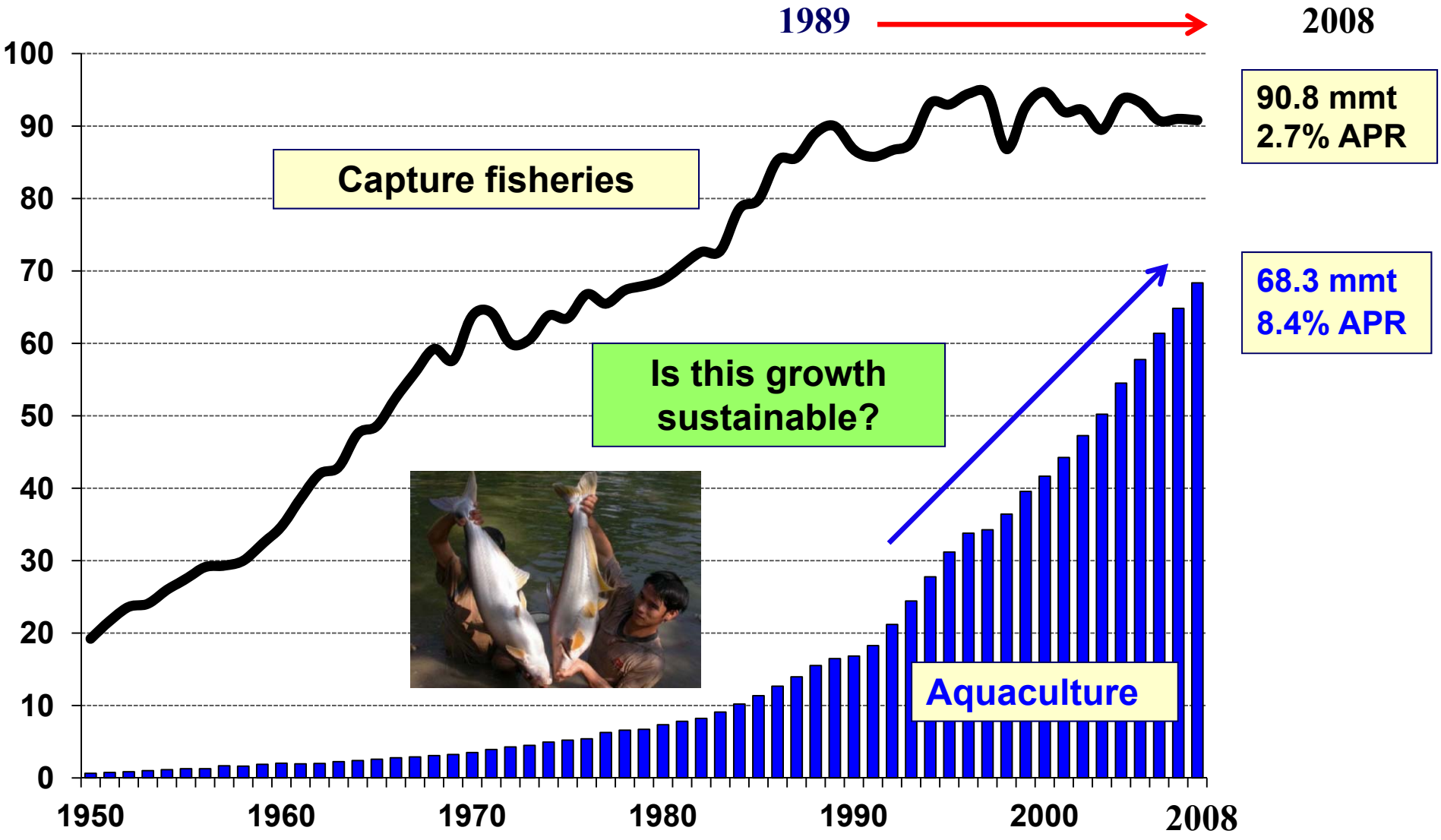



AQUACULTURE - AGRICULTURE

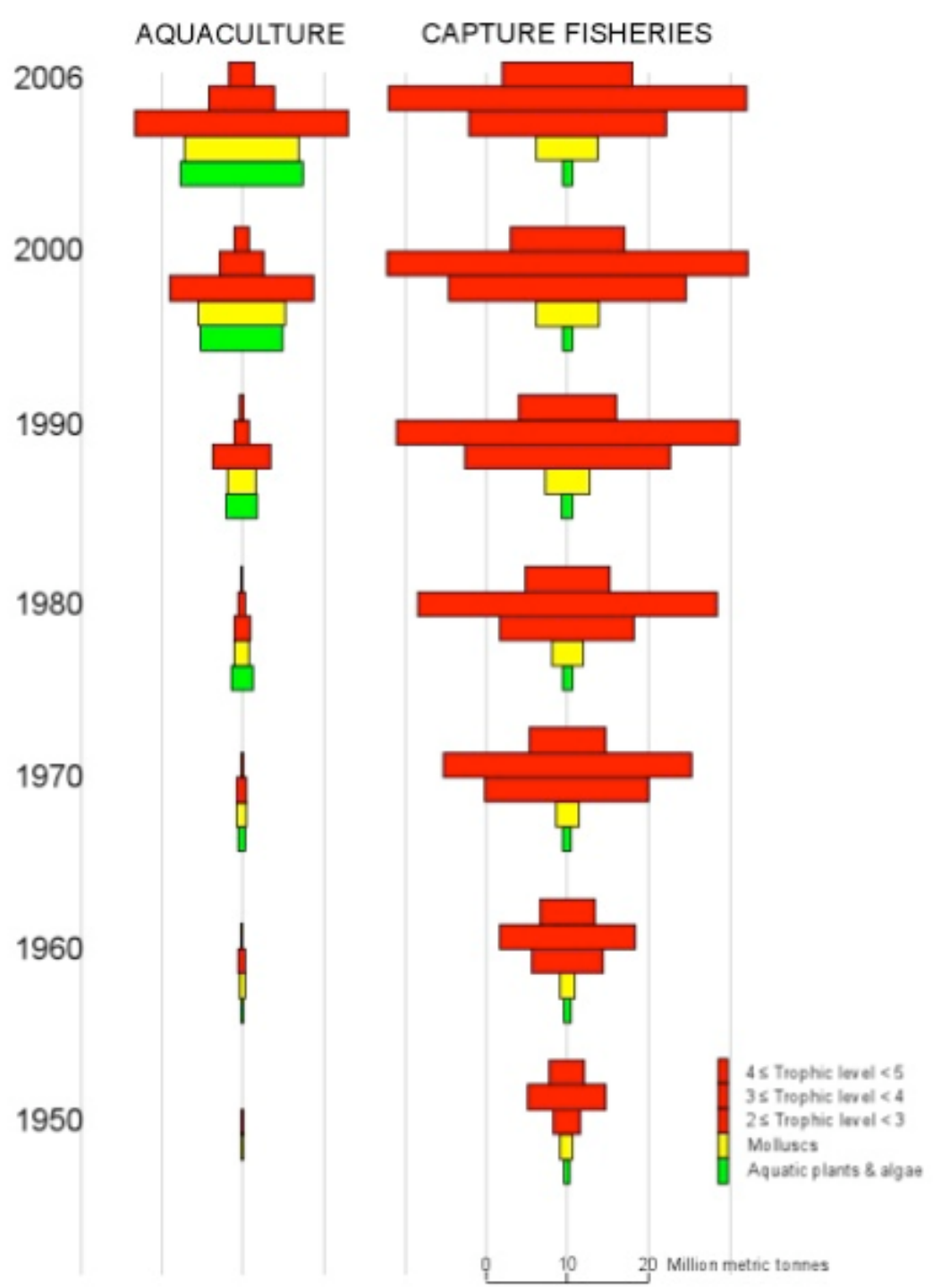


GLOBAL CAPTURE FISHERIES & AQUACULTURE PRODUCTION

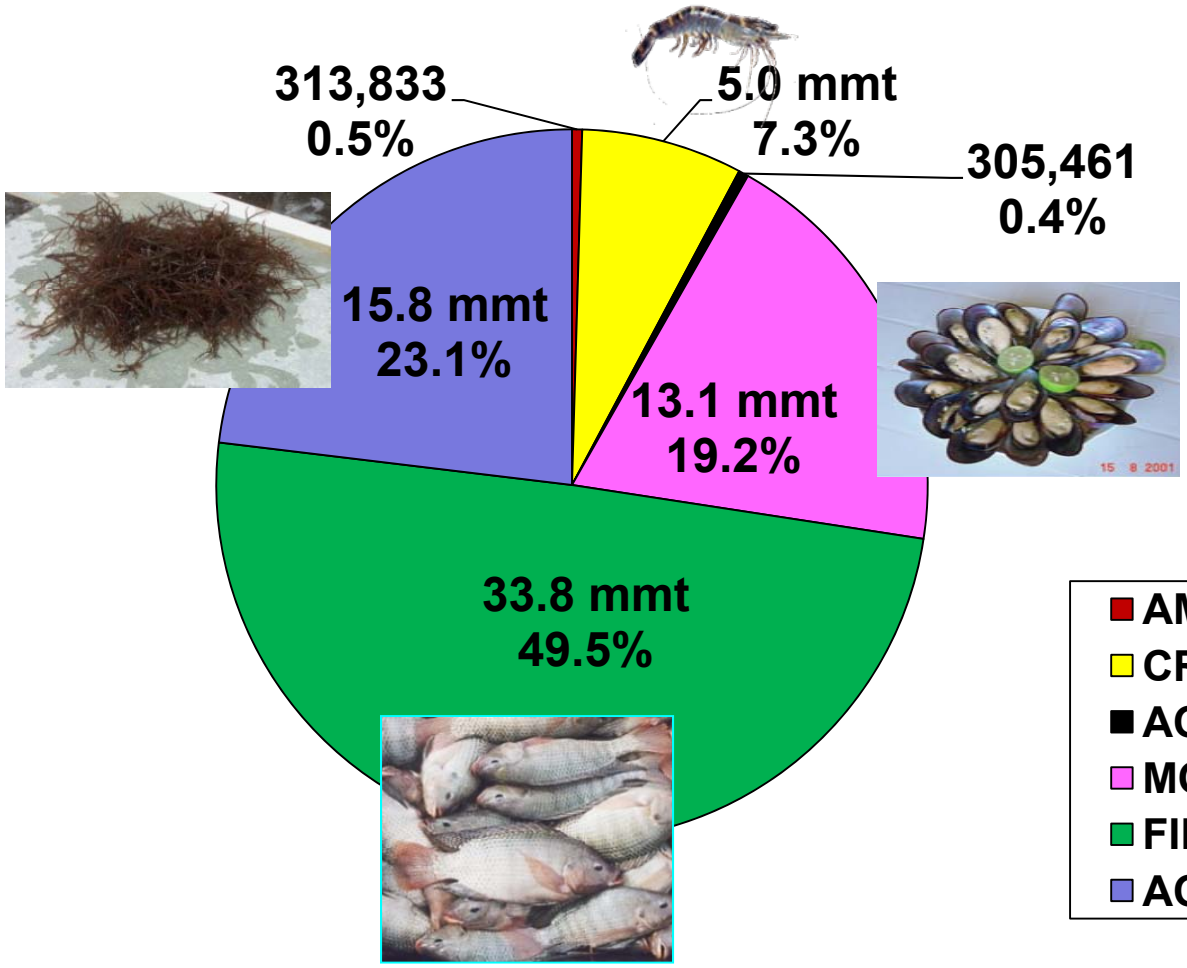
1950 – 2008 (Million tonnes; Source: FAOSTAT, 2010)



Global trend in weighted mean trophic level of total landings from capture fisheries & aquaculture



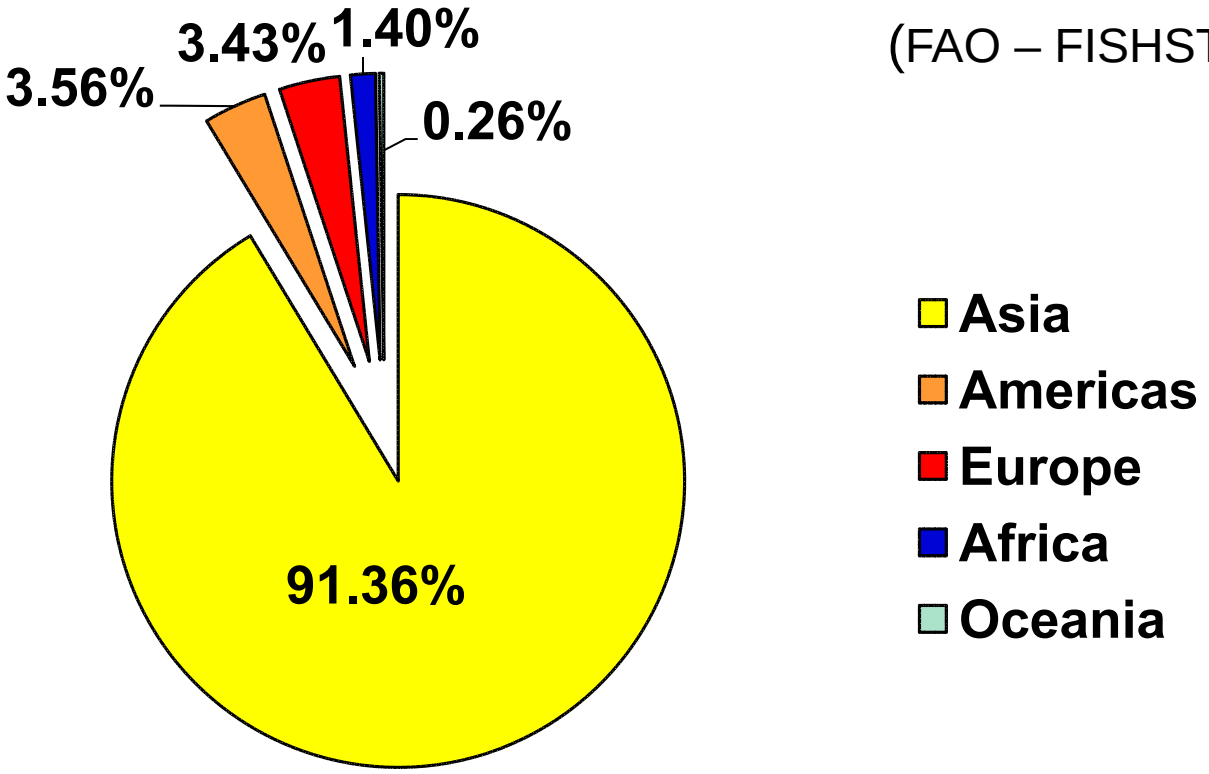
Total global aquaculture production – 2008
over 340 plant & animal species



68.3 million tonnes (valued at US $ 106 billion)

(FAO – FISHSTAT, 2010)

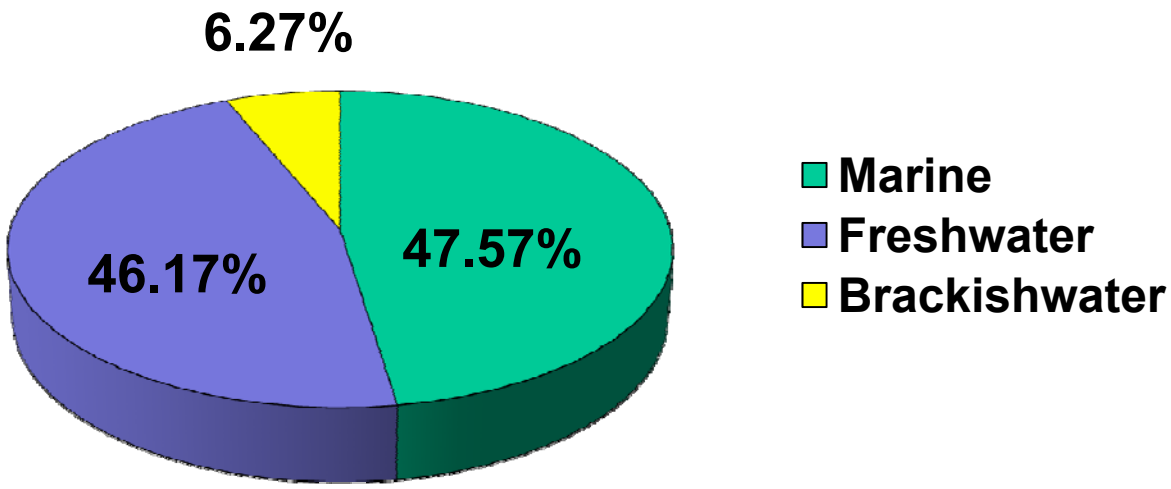
Total global aquaculture production – 2008
over 91% of production in Asia



(FAO – FISHSTAT, 2010)

Asia:	**62.44** million tonnes	APR **9.38%** since 1950 (344,390 mt)
Americas:	**2.43** million tonnes	APR **6.45%** since 1950 (64,623 mt)
Europe:	**2.34** million tonnes	APR **4.63%** since 1950 (169,101 mt)
Africa:	**955,237** tonnes	APR **10.87%** since 1950 (2,393 mt)
Oceania:	**176,325** tonnes	APR **6.75%** since 1950 (4,000 mt)

Total global aquaculture production – 2008 by culture environment



Marine:	**32.51** mmt	APR **5.56**% since 1995 (16.09 mmt)
Freshwater:	**31.55** mmt	APR **6.73**% since 1995 (13.53 mmt)
Brackishwater:	**4.28** mmt	APR **8.02**% since 1995 (1.57 mmt)

Top aquaculture country producers – 2008

(Values in metric tonnes; FAO – FISHSTAT, 2010)

Top 10 countries

China	42,669,744	(62.4%)
Indonesia	3,854,844	(5.6%)
India	3,478,692	(5.1%)
Viet Nam	2,497,400	(3.6%)
Philippines	2,407,698	(3.5%)
Korea Rep.	1,394,818	(2.0%)
Thailand	1,374,024	(2.0%)
Japan	1,187,774	(1.7%)
Bangladesh	1,005,542	(1.5%)
Chile	870,845	(1.3%)

Top 11-20 countries

Norway	843,730
Egypt	693,815
Myanmar	674,812
Korea DPR	508,000
USA	500,114
Malaysia	354,379
Taiwan	330,861
Brazil	290,186
Spain	249,074
France	237,868

AQAUACULTURE:
role in global food supply & sustainability implications

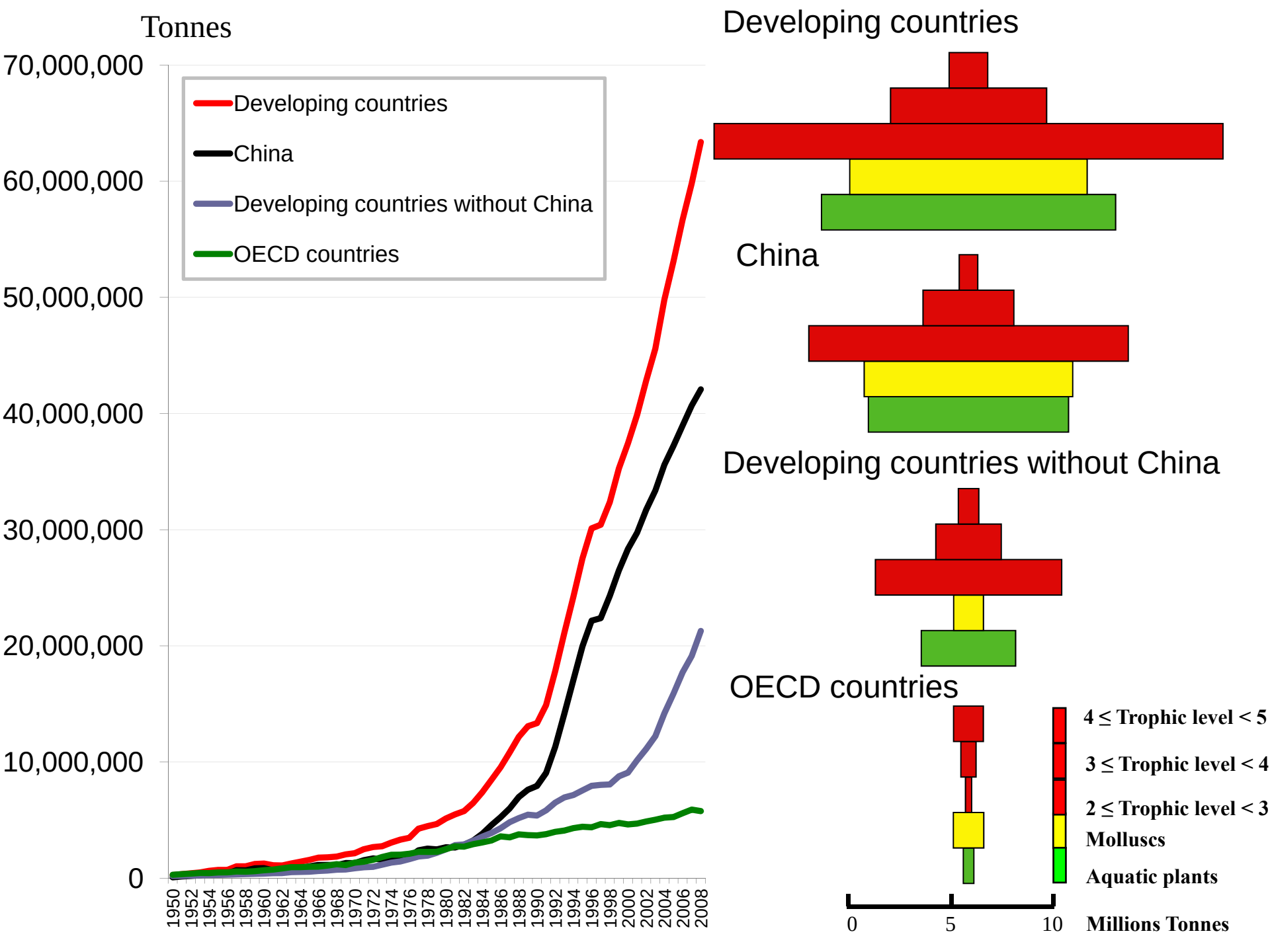
In marked contrast with capture fisheries where the bulk of the fish species harvested are marine carnivorous fish species positioned high in the aquatic food chain,

the mainstay of farmed fish production are freshwater omnivorous and herbivorous fish species positioned low in the aquatic food, including carps, tilapia and catfishes.

AQAUACULTURE:
role in global food supply & sustainability implications

Moreover whereas marine capture fisheries have been feeding the world on high trophic level carnivorous fish species since mankind has been fishing the oceans,

aquaculture production within developing countries has focused, by and large, on the production of lower trophic level species – but this is changing

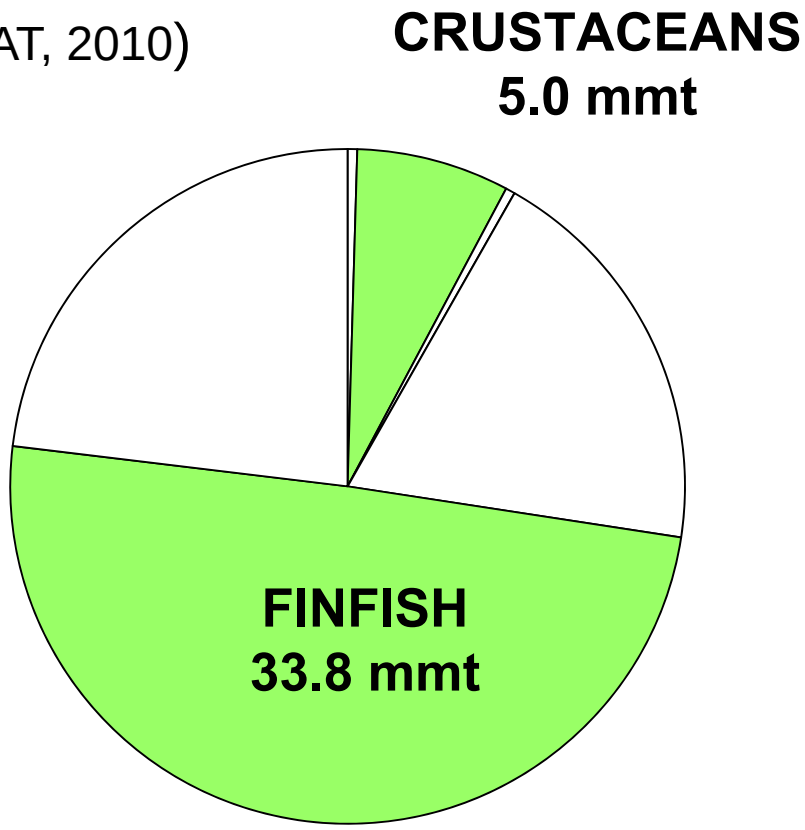

Tonnes
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
Developing countries
China
Developing countries without China
OECD countries
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Developing countries
China
Developing countries without China
OECD countries
4 ≤ Trophic level < 5
3 ≤ Trophic level < 4
2 ≤ Trophic level < 3
Molluscs
Aquatic plants
0
5
10
Millions Tonnes

AQAUACULTURE:
role in global food supply & sustainability implications

Like capture fisheries, aquaculture focus within OECD or economically developed countries has been essentially on the culture of high value-, high trophic level-carnivorous fish species. The long term sustainability of these production systems is questionable unless the industry can reduce its dependence upon capture fisheries for sourcing raw materials for feed formulation and seed inputs

Fed aquaculture species production – 2008 (commercial feeds, farm made feeds, fresh feeds)

(FAO – FISHSTAT, 2010)



Total fish & crustaceans: 38.8 million tonnes
Fed species: 31.5 million tonnes

Top fed aquaculture & livestock producers – 2008

(FAO – FISHSTAT/FAOSTAT, 2010)

Values in million tonnes - Mt

Top eight fed aquaculture species	
Grass carp	3,775,267 mt
Common carp	2,987,433 mt
Nile tilapia	2,334,432 mt
Catla	2,281,838 mt
Whiteleg shrimp	2,259,183 mt
Crucian carp	1,957,337 mt
Atlantic salmon	1,456,721 mt
Pangasius catfish	1.38 Mt∑58%
Total fed sp production – 31.5 Mt	

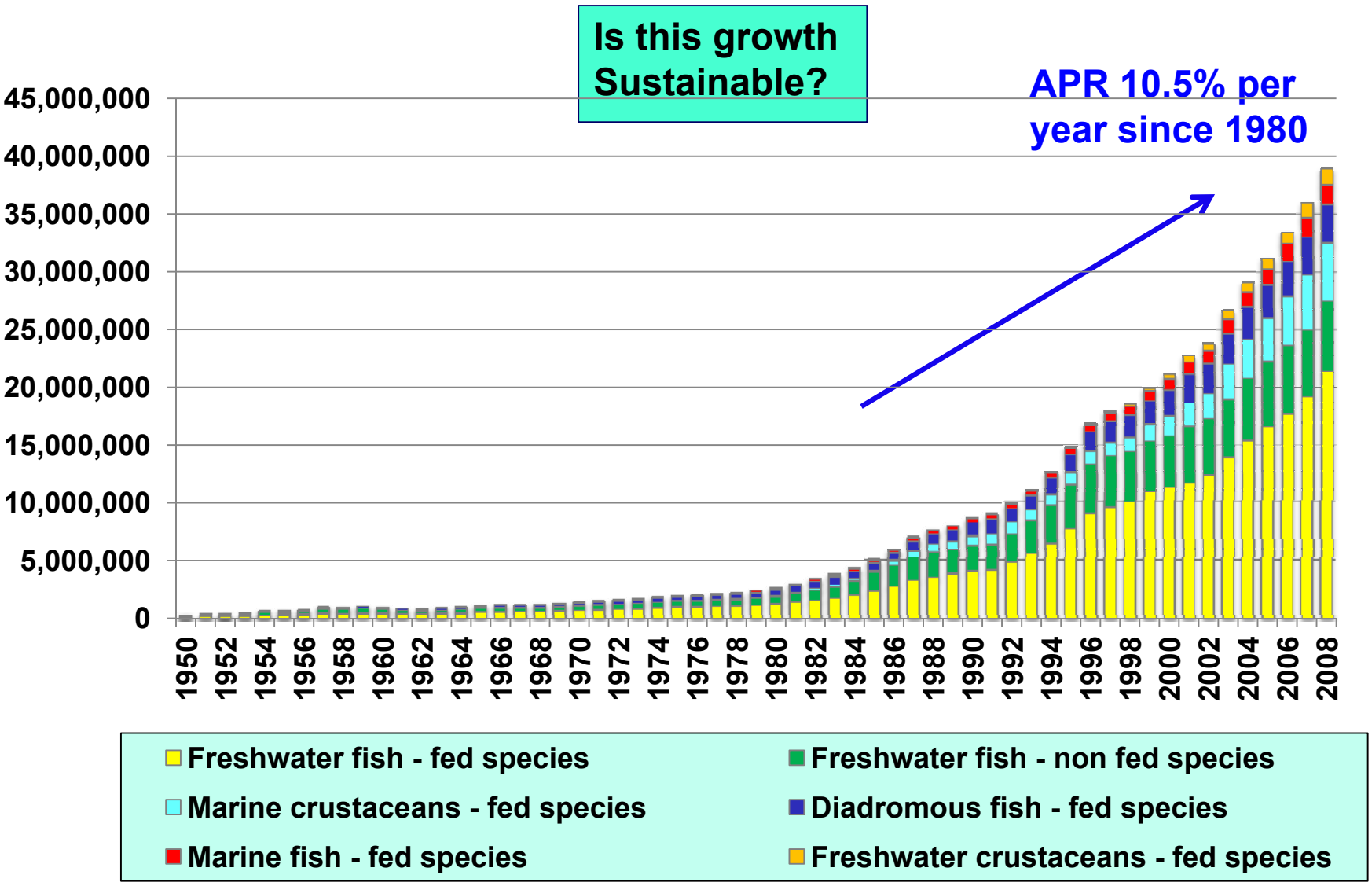
Top eight fed livestock species	
Pig	103.2 Mt
Chicken	79.4
Cattle	62.4
Sheep	8.3
Turkey	6.1
Goat	4.9
Duck	3.8
Buffalo	3.4 ∑ 97%
Total meat production - 280 Mt	

APR 10.59% since 1980

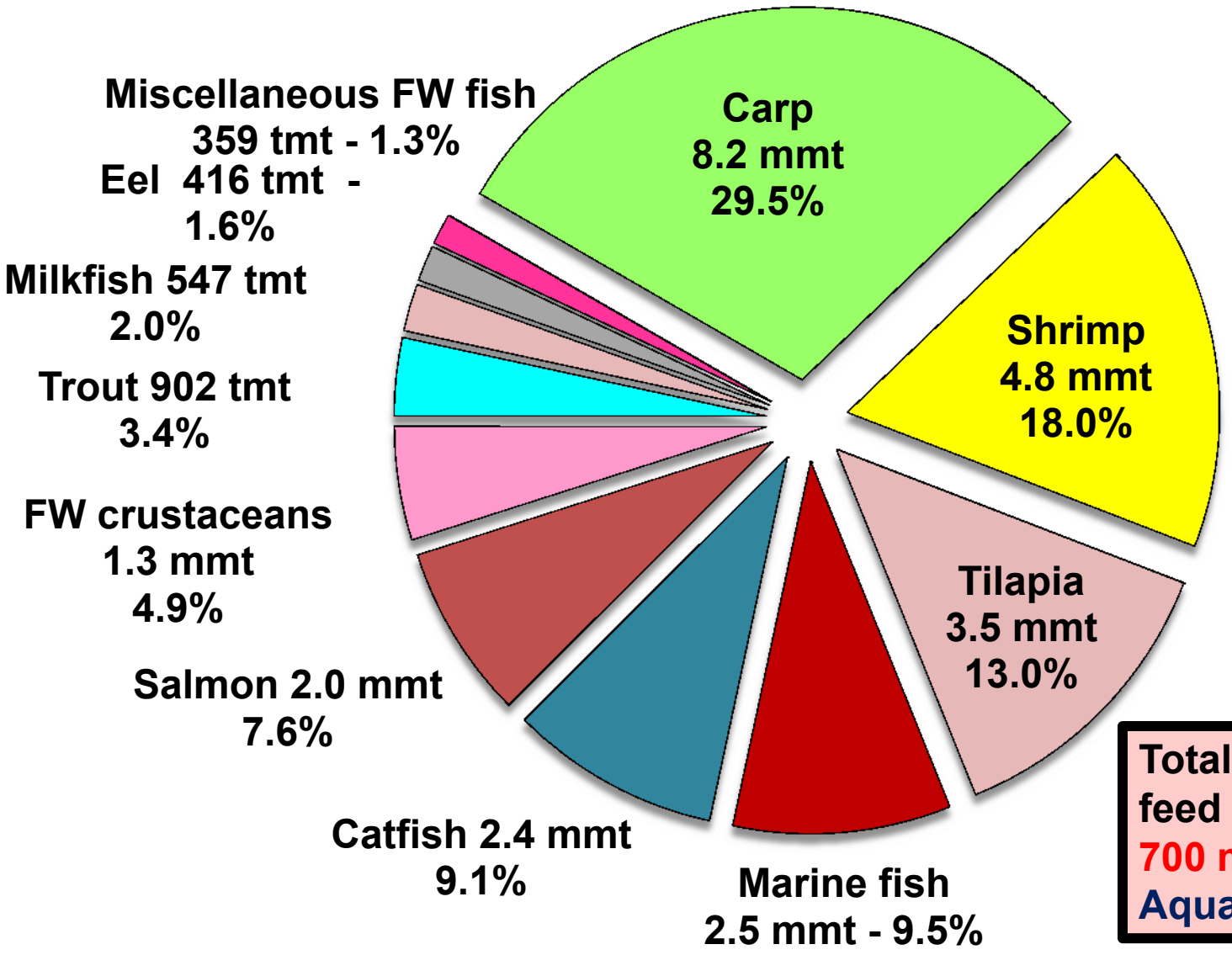
APR 2.59% since 1980

Total global production of fed fish & crustacean species

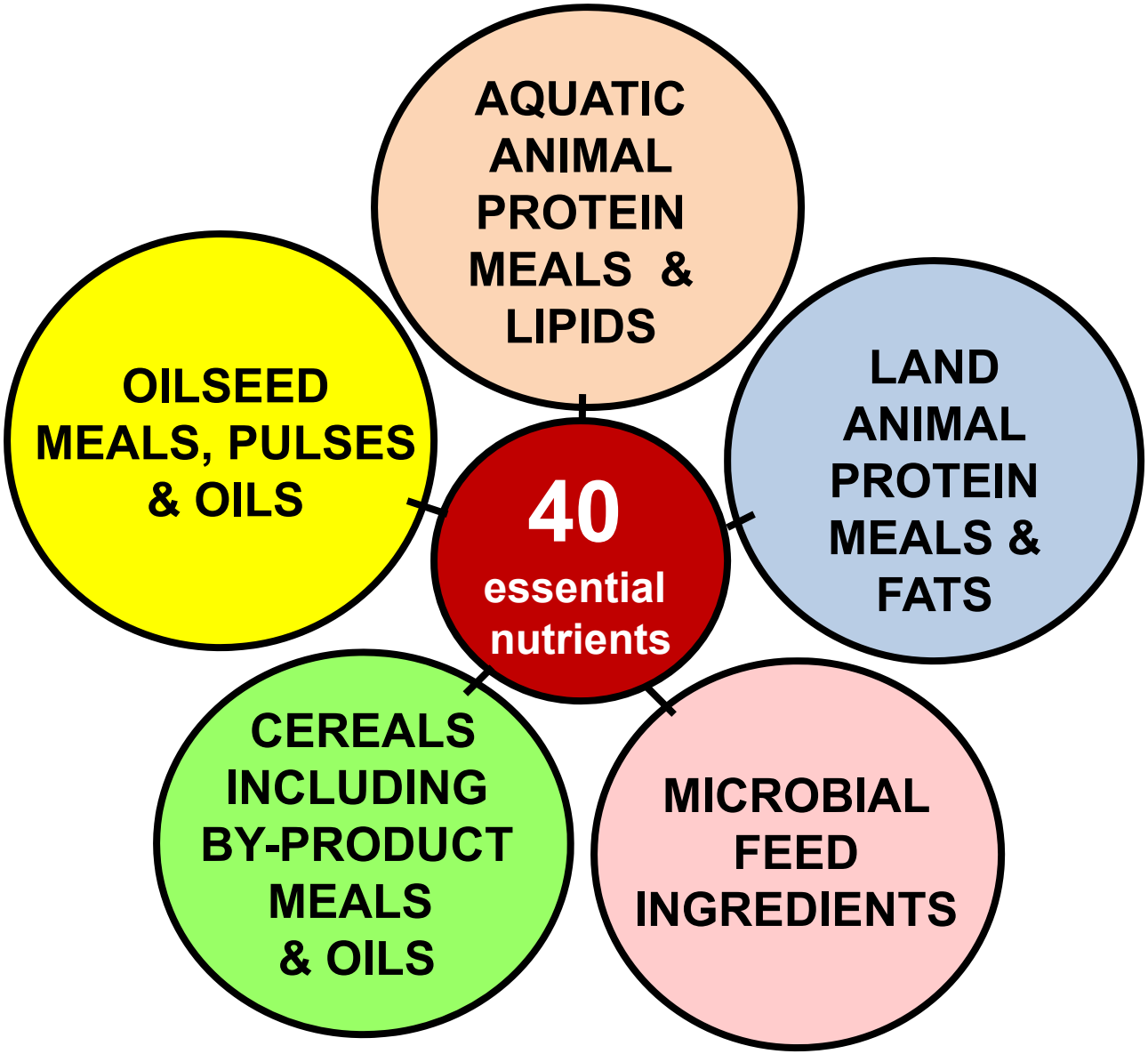
FAO - FISHSTAT (2010)



Estimated global production of commercial aquaculture feeds by major species grouping in 2007: 27.1 million tonnes



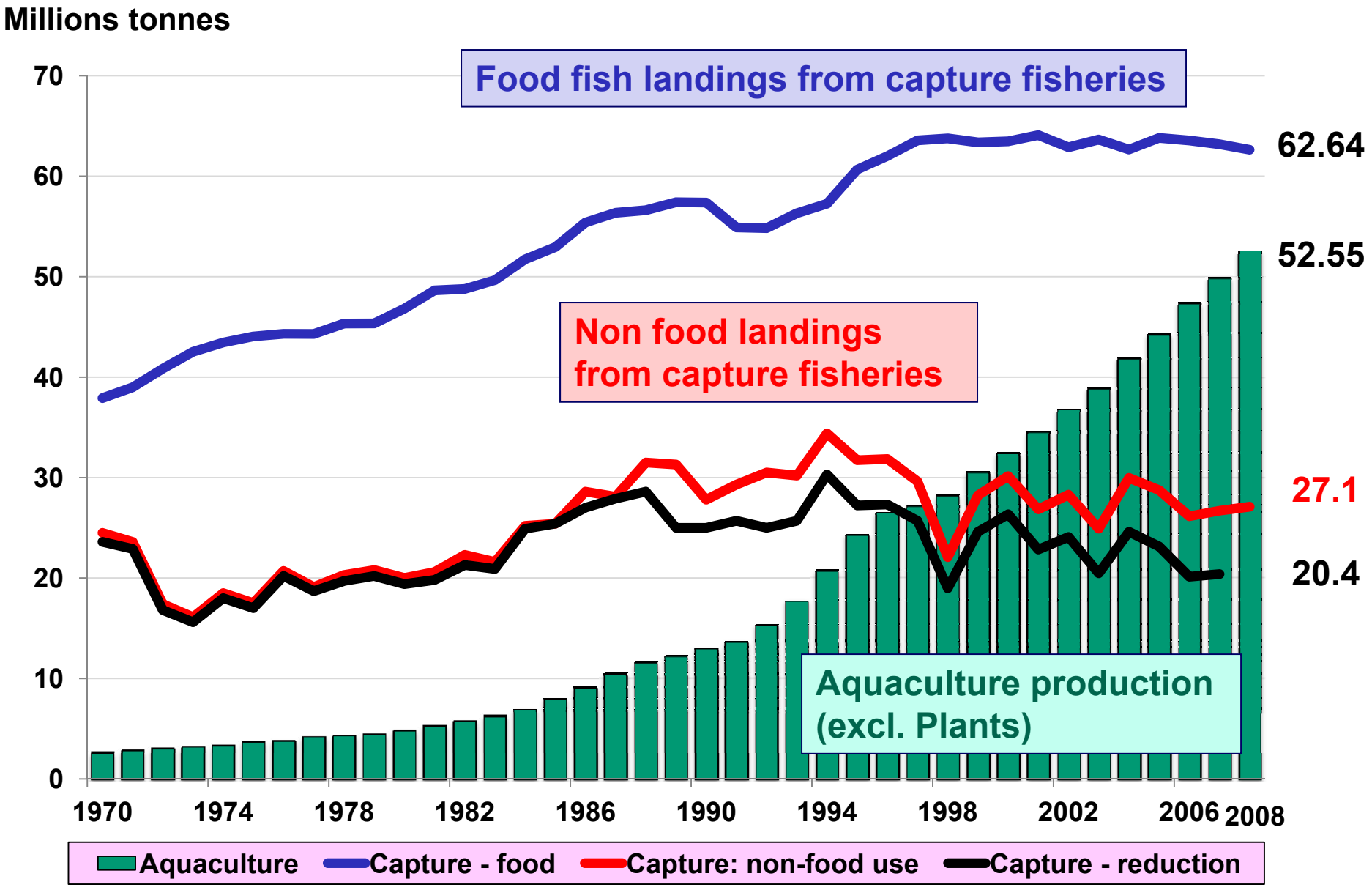
Total global animal feed production:
700 mmt in 2008;
Aquafeed ca. 4%



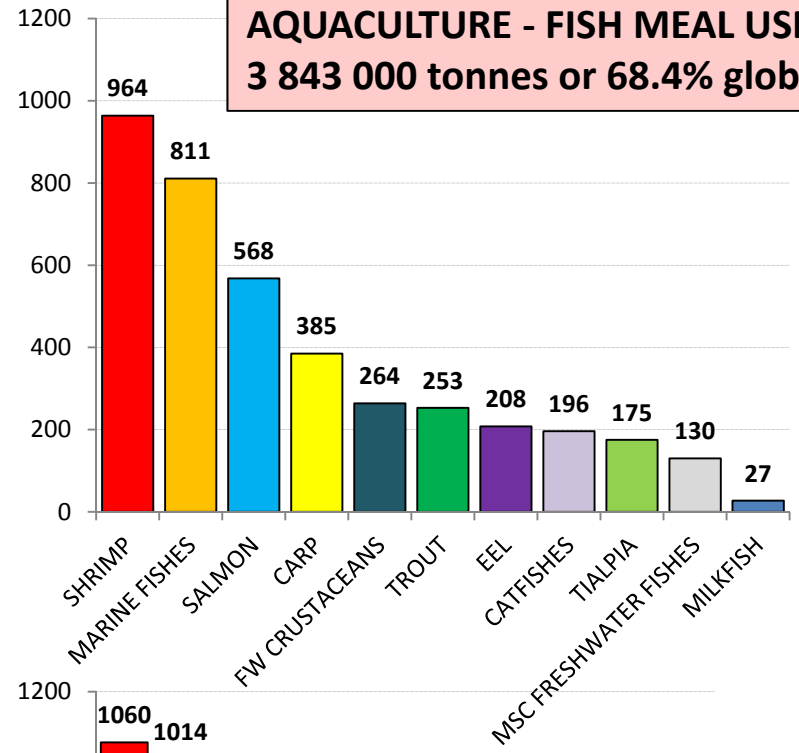
MAJOR DIETARY NUTRIENT SOURCES USED IN AQUAFEEDS

Disposition of the fisheries catch and aquaculture production

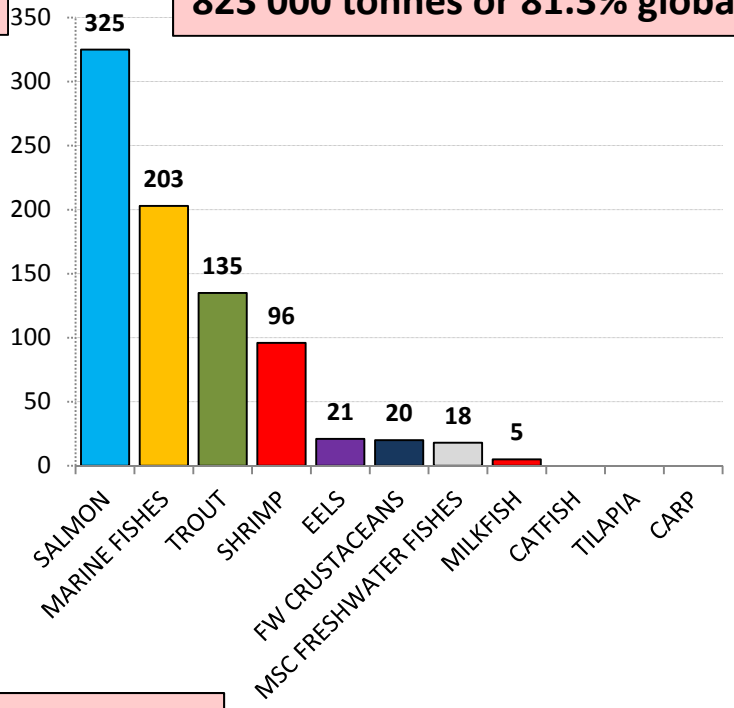
(Values given in million tonnes: FISHSTAT, 2010)



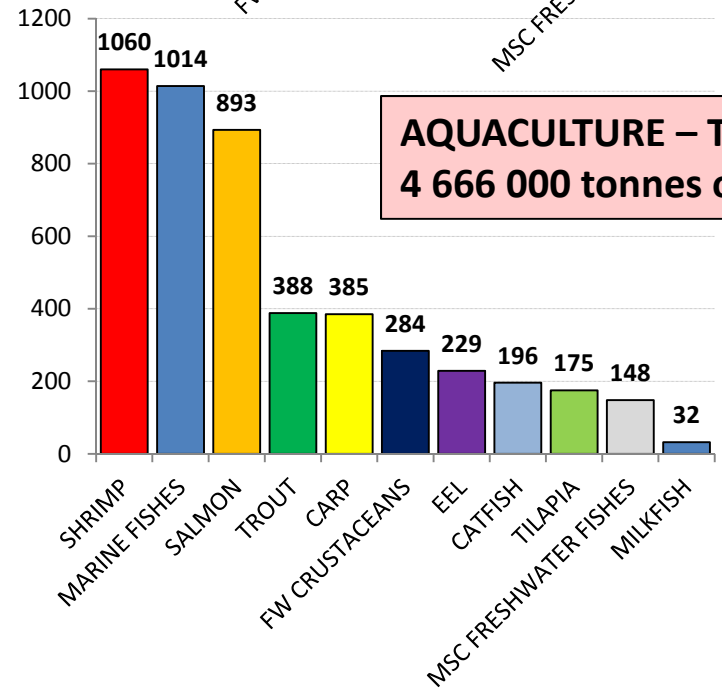
AQUACULTURE - FISH MEAL USE – 2007
3 843 000 tonnes or 68.4% global total

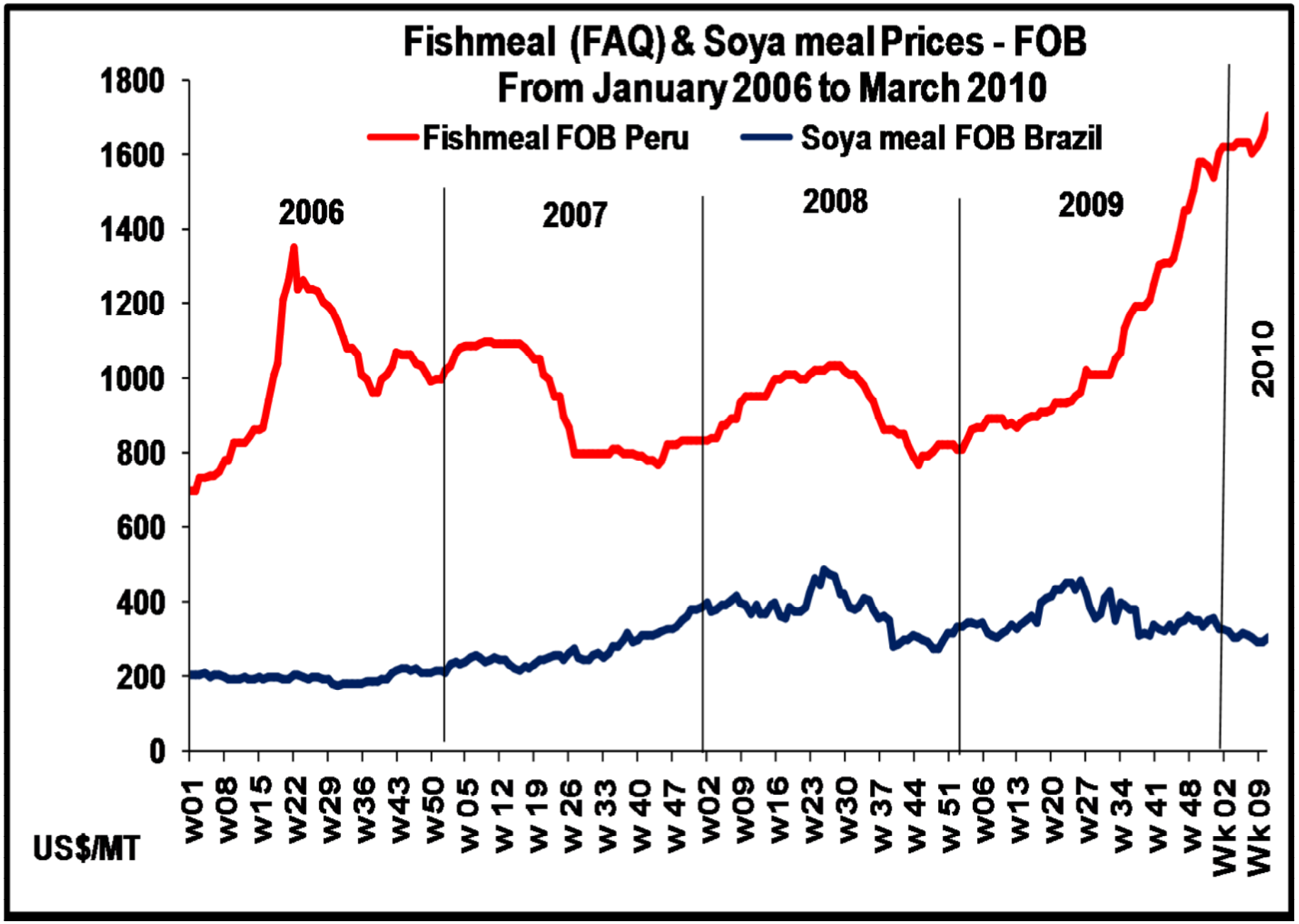


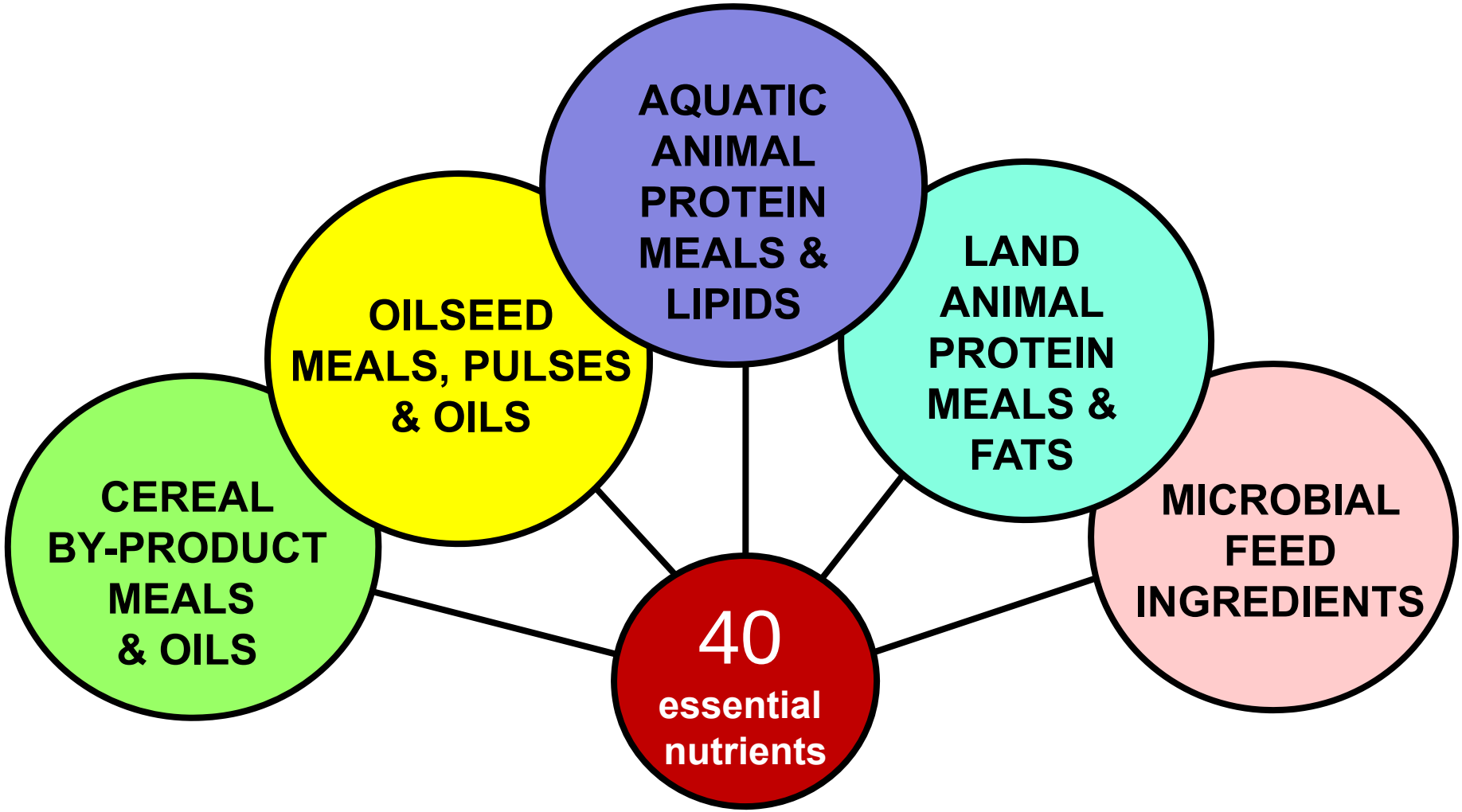
AQUACULTURE - FISH OIL USE – 2007
823 000 tonnes or 81.3% global total



AQUACULTURE – TOTAL FM + FO USE - 2007
4 666 000 tonnes or 70.3% global total

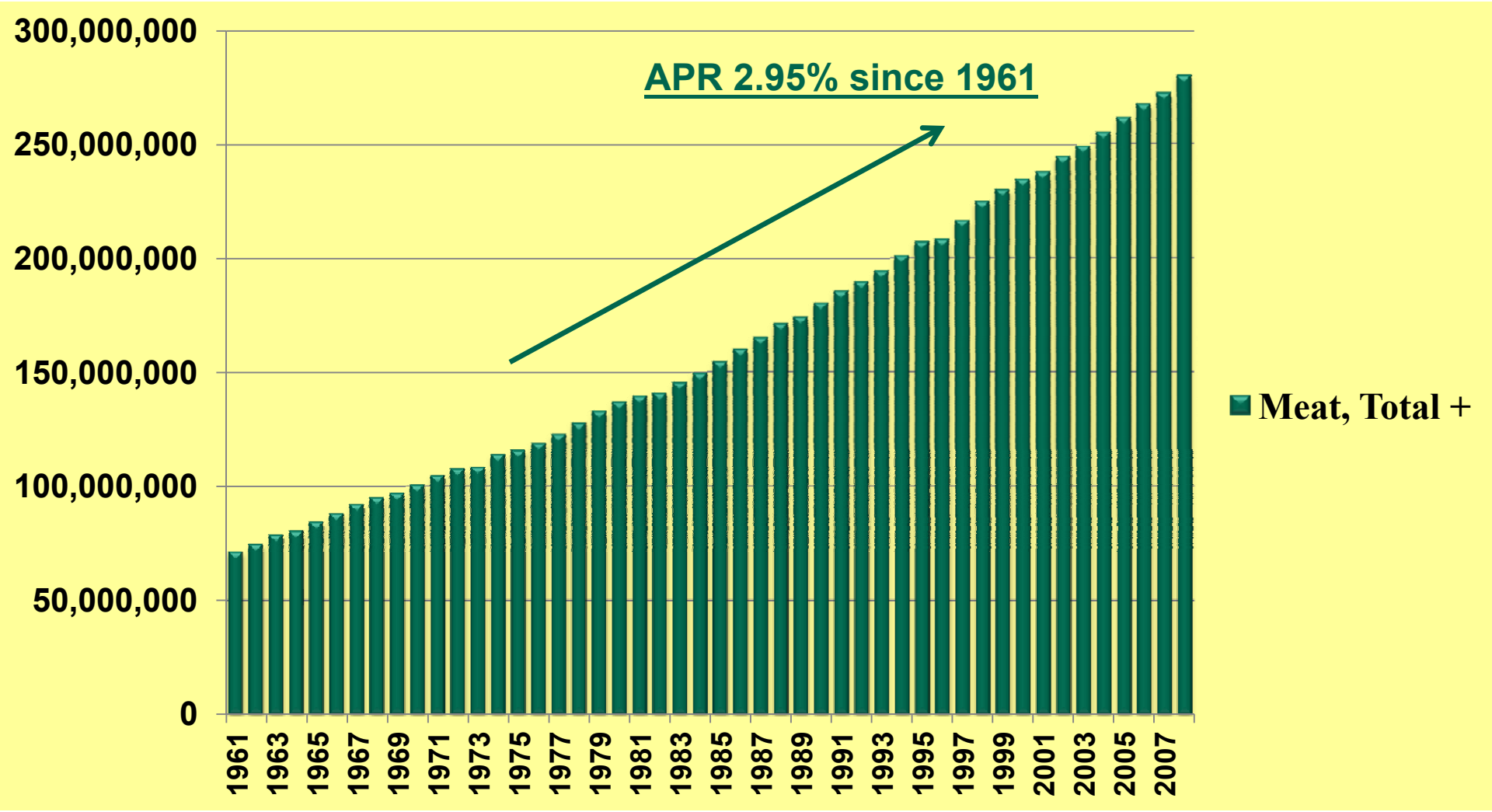



Fishmeal (FAQ) & Soya meal Prices - FOB
From January 2006 to March 2010
Fishmeal FOB Peru
Soya meal FOB Brazil
2006
2007
2008
2009
2010
1800
1600
1400
1200
1000
800
600
400
200
0
US$/MT
w01
w08
w15
w22
w29
w36
w43
w50
w 05
w 12
w 19
w 26
w 33
w 40
w 47
w02
w09
w16
w23
w30
w 37
w 44
w 51
w06
w13
w20
w27
w 34
w 41
w 48
Wk 02
Wk 09



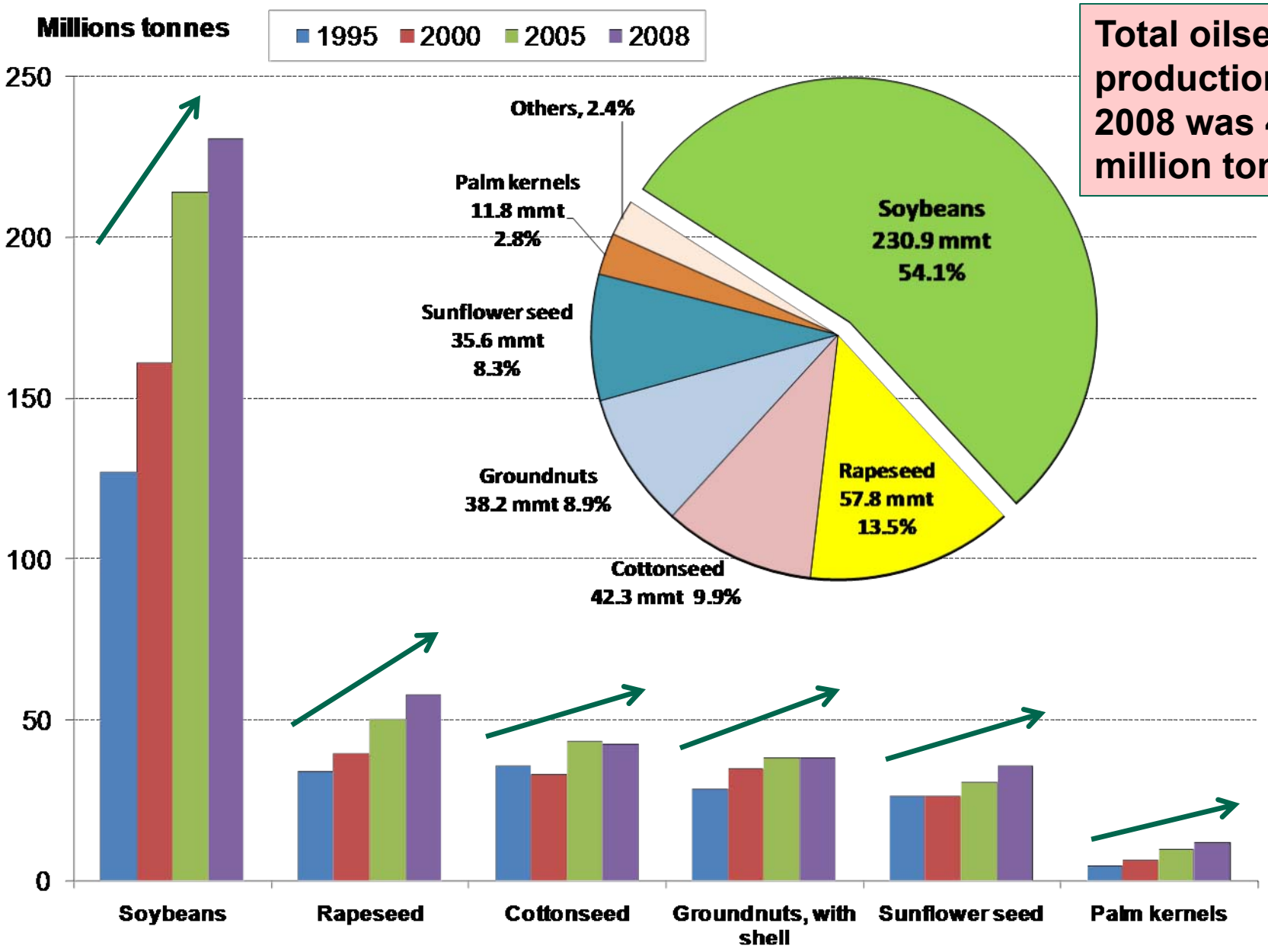
We need to be able to use ALL of the above listed feed ingredient sources: and in particular those feed-grade ingredient sources that can be sustainably produced and keep pace with the growth of the aquaculture sector

Global production of terrestrial meat products
(expressed in tonnes; FAO, 2009)



Global production of major plant oilcrops

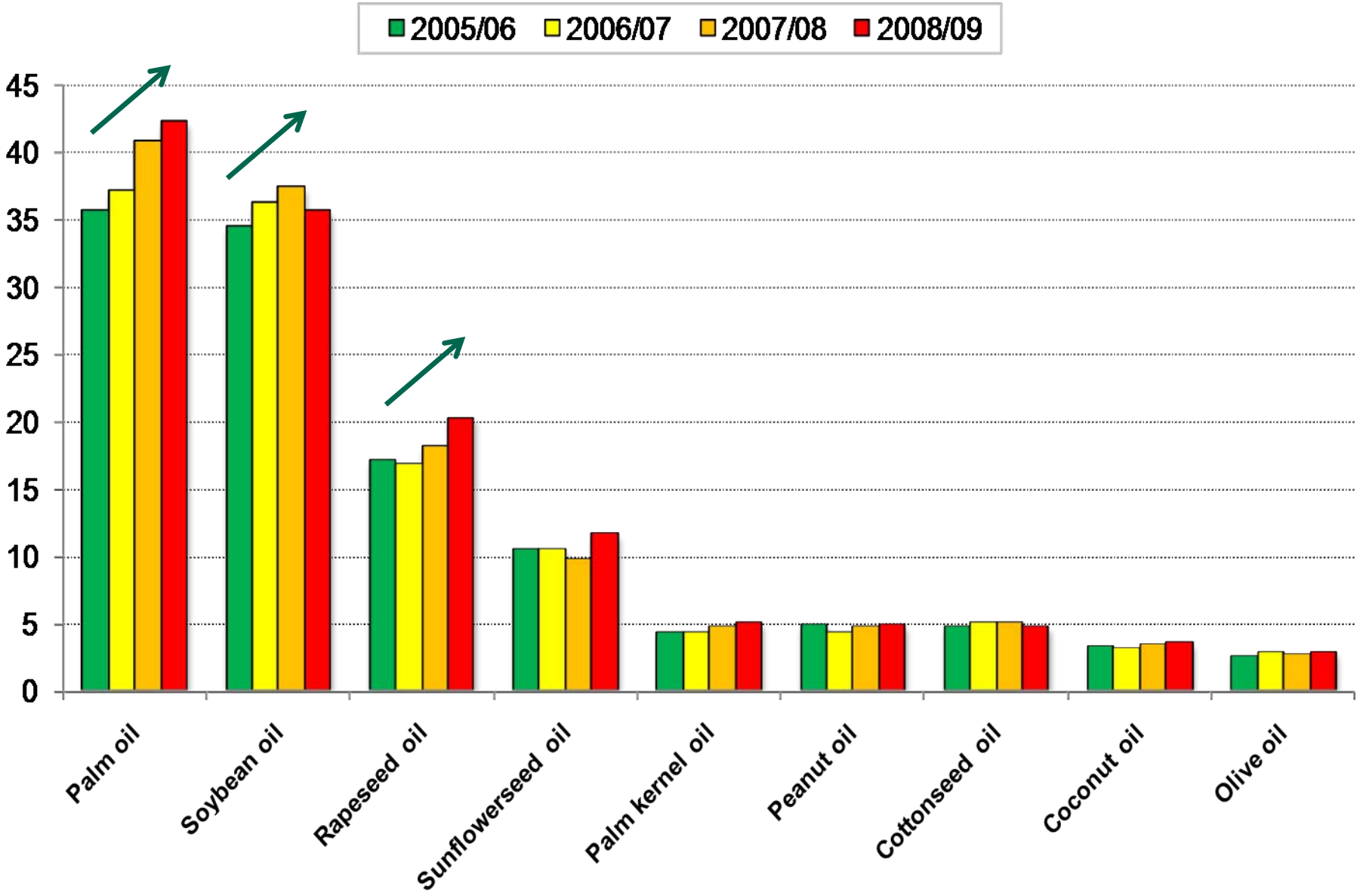
(Values given in million tonnes: FAOSTAT, 2009)



Total oilseed production in 2008 was 427.1 million tonnes

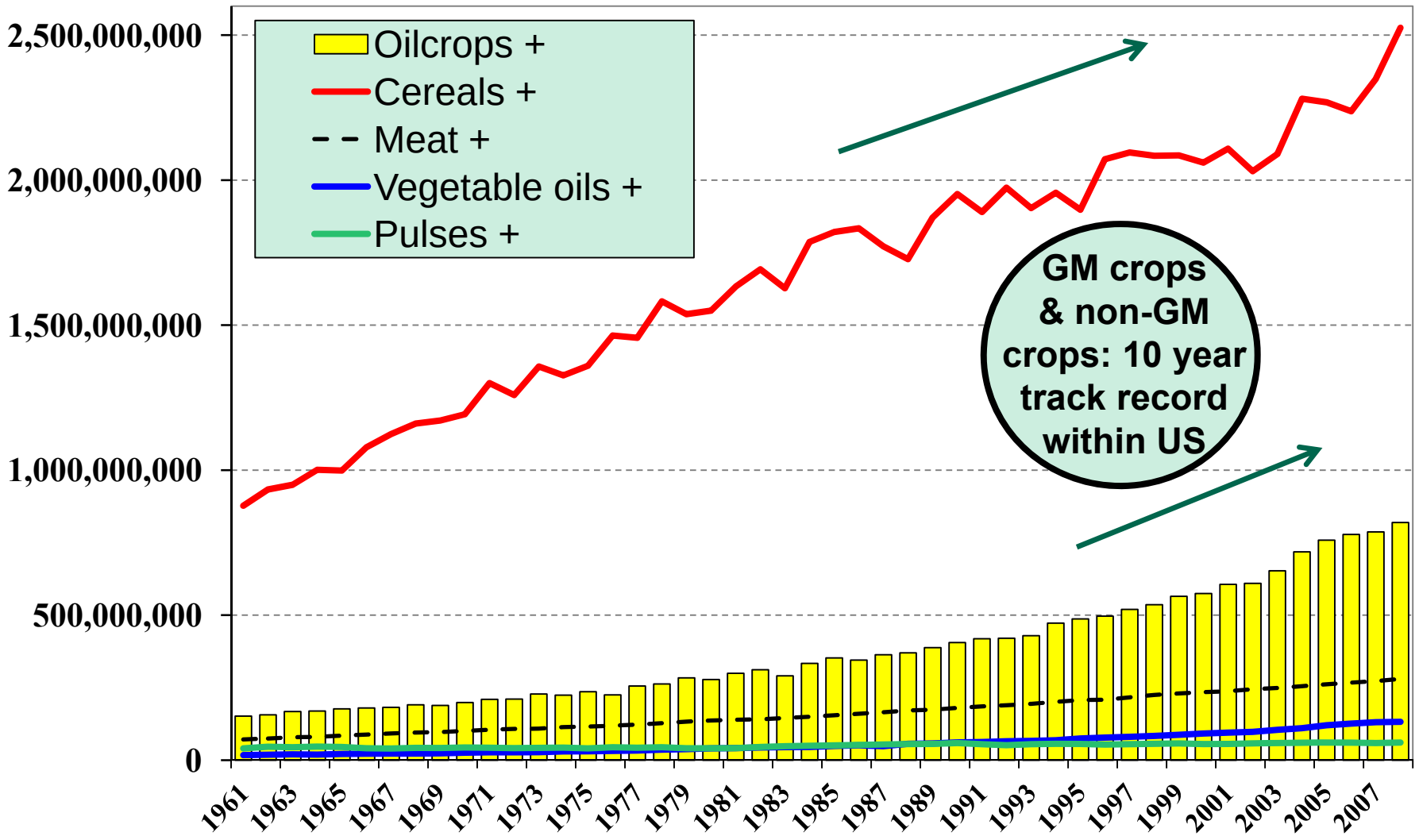
Global production of major oilseed oils

(Values given in million tonnes: USDA, 2010)



Global production of agricultural crops and meat

(expressed in tonnes; FAO, 2009)



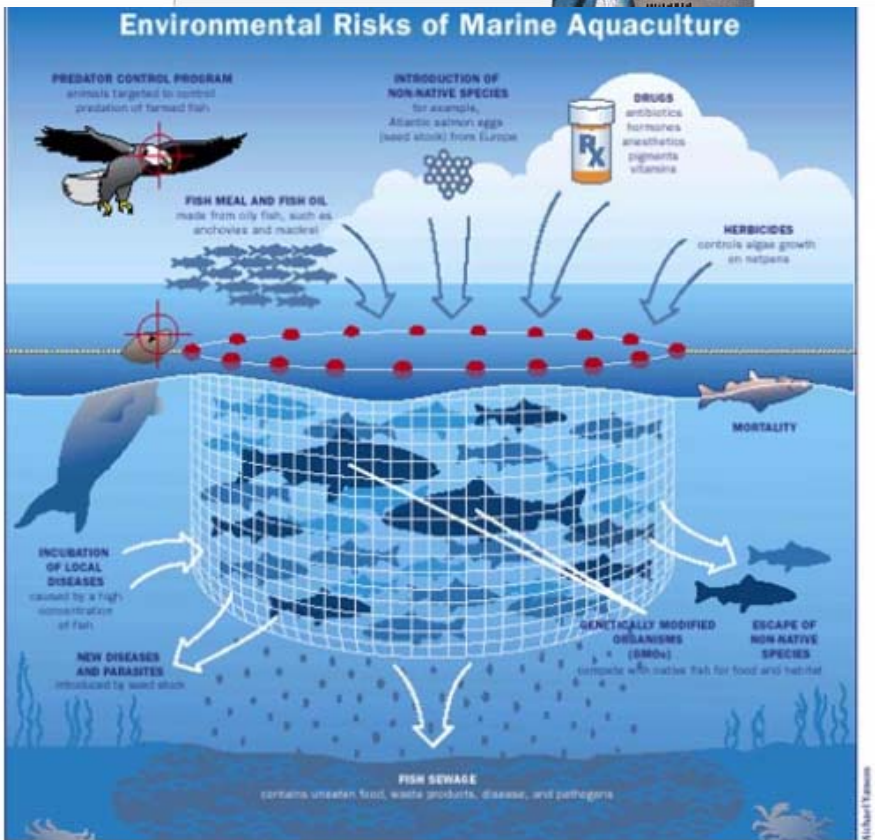
Challenging the Aquaculture Industry on Sustainability

Authors: Michelle Allsopp, Paul Johnston and David Santillo at Greenpeace Research Laboratories, University of Exeter, UK.

greenpeace.org

GREENPEACE

Defending our oceans



MAJOR NGO CONCERNS

As with all agricultural terrestrial food production systems, the aquaculture sector has not been without its problems & critics.

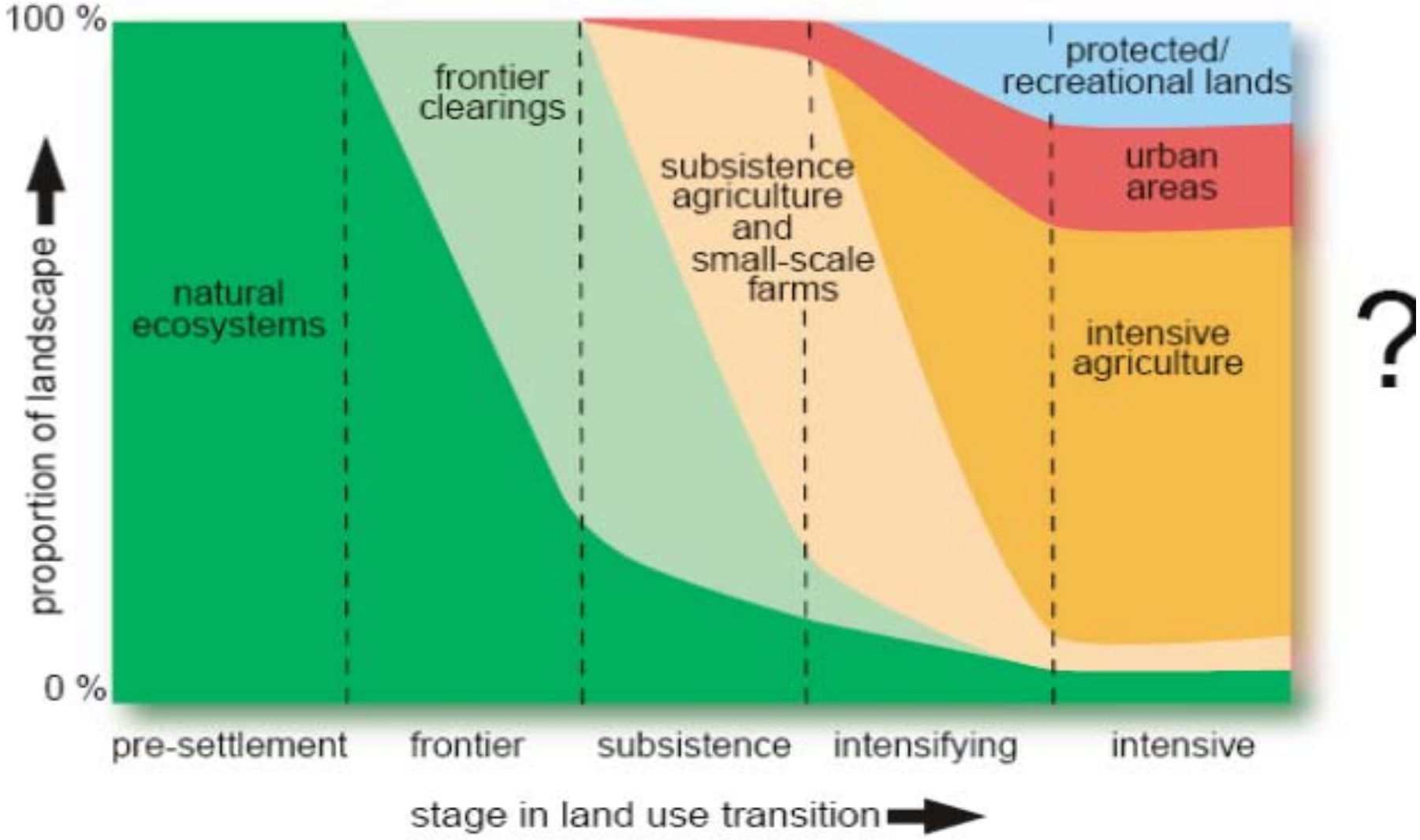
Major problems and issues raised have been mainly related with the unregulated development of more intensive commercial scale production systems,

and in particular with farming systems for high value crustacean species and higher trophic level (TL) carnivorous finfish species

Global Consequences of Land Use

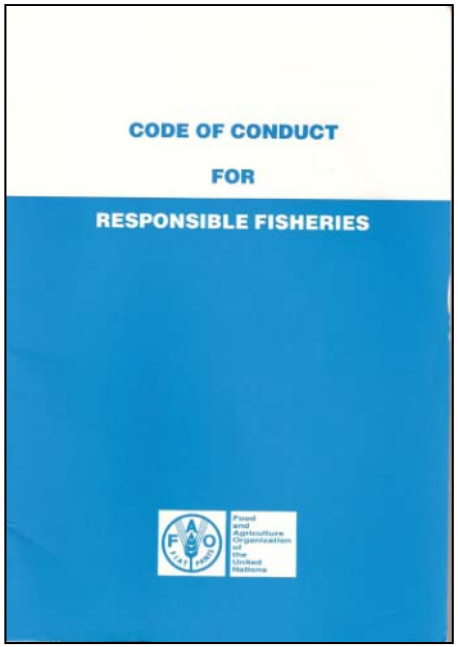
Jonathan A. Foley,[1*] Ruth DeFries,[2] Gregory P. Asner,[3] Carol Barford,[1] Gordon Bonan,[4] Stephen R. Carpenter,[5] F. Stuart Chapin,[6] Michael T. Coe,[1†] Gretchen C. Daily,[7] Holly K. Gibbs,[1] Joseph H. Helkowski,[1] Tracey Holloway,[1] Erica A. Howard,[1] Christopher J. Kucharik,[1] Chad Monfreda,[1] Jonathan A. Patz,[1] I. Colin Prentice,[8] Navin Ramankutty,[1] Peter K. Snyder[9]

www.sciencemag.org SCIENCE VOL 309 22 JULY 2005



SPECIFIC ISSUES RAISED (16) HAVE INCLUDED:

1. Mangrove destruction and habitat loss;
2. Pollution & degradation of the aquatic and benthic environment;
3. Escapes and genetic interactions with wild fish populations;
4. Parasite and disease transfer to wild fish populations;
5. Use of non-native species and genetically modified organisms;
6. Use of toxic/bio-accumulative chemicals and antibiotics;
7. Use of low value/trash fish, fish meal and fish oil as feed inputs;
8. Interactions with marine mammals, turtles and birds;
9. Use of wild caught seed and associated by-catch;
10. Displacement of coastal fishing and farming communities;
11. Disruption of seafood prices, local food supplies & food security;
12. Livelihood impacts and reduced access to community resources;
13. Salinization of potable water and ground water;
14. Social exclusion, social unrest and conflicts;
15. Conflicts with tourism, recreational fish, and commercial fishing;
16. Environmental contaminants and food safety concerns;



MAJOR NGO CONCERNS

However, it must also be stated that the majority of the above listed issues and concerns are usually species, farm and country specific, and can be mitigated or their impacts greatly minimized by strict adherence to the principles and guidelines within the FAO Code for Responsible Fisheries (CCRF), and in particular article 9 of the CCRF dealing with aquaculture development (FAO, 1995, 1997, 2001).

The solution is better governance, not just by policymakers to ensure this adherence, but by operators, too.

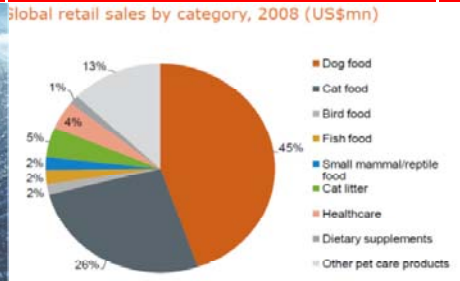
The dilema: ingredient selection & use criteria: economic, nutritional, environment, safety and/or food security

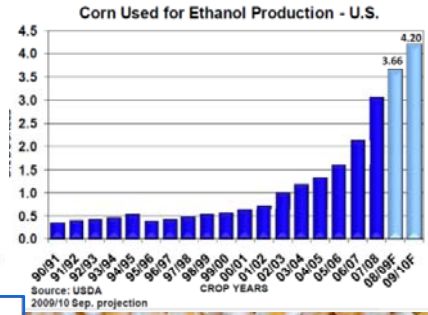
ANIMAL FEED

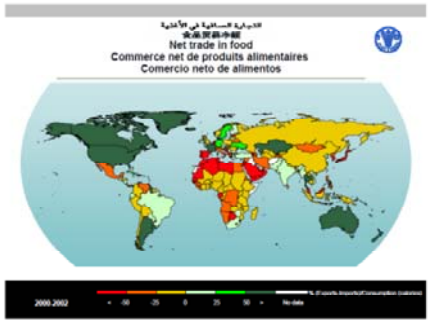
PET FOOD

BIOFUEL

FOOD







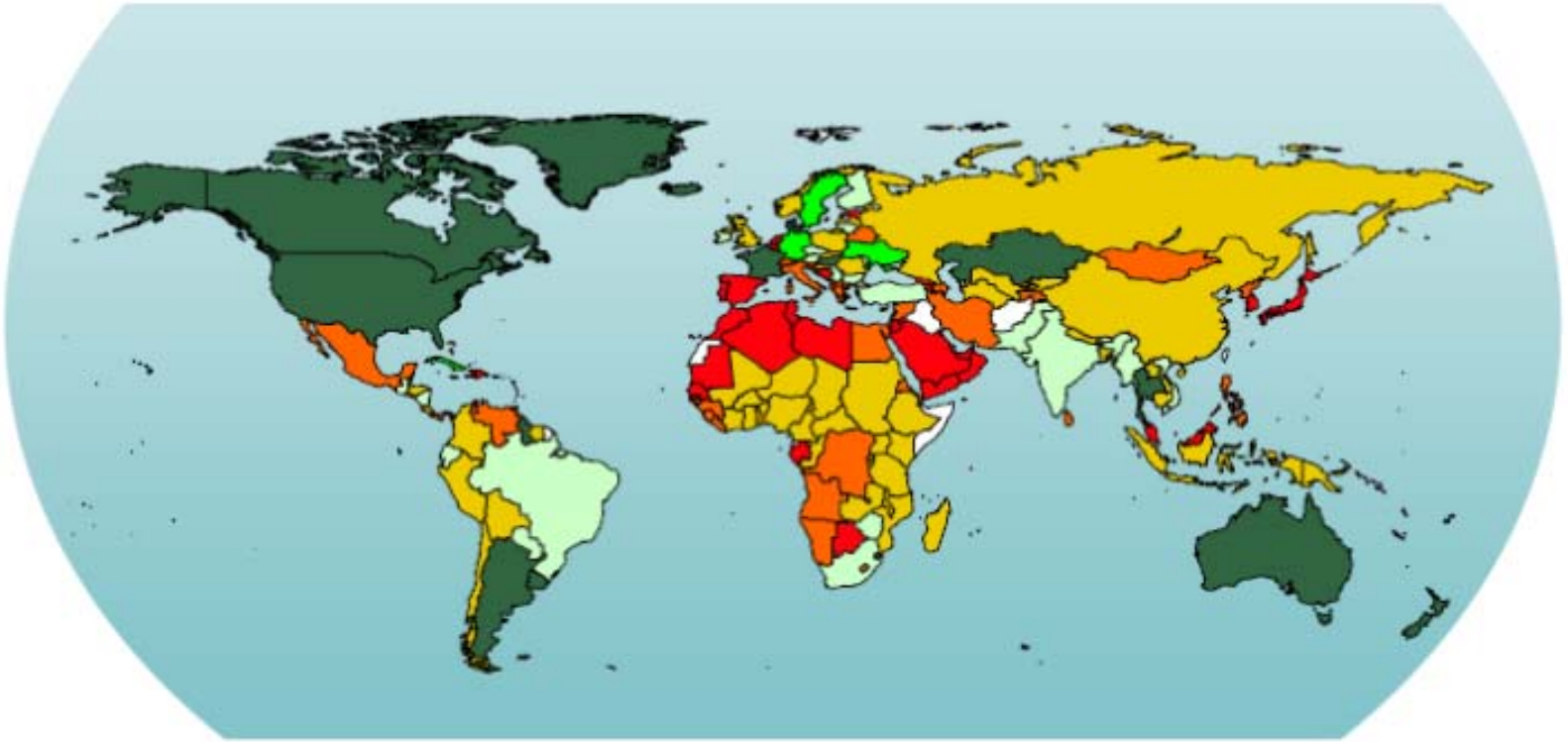
التجارة الصافية في الأغذية

食品贸易净额

Net trade in food

Commerce net de produits alimentaires

Comercio neto de alimentos

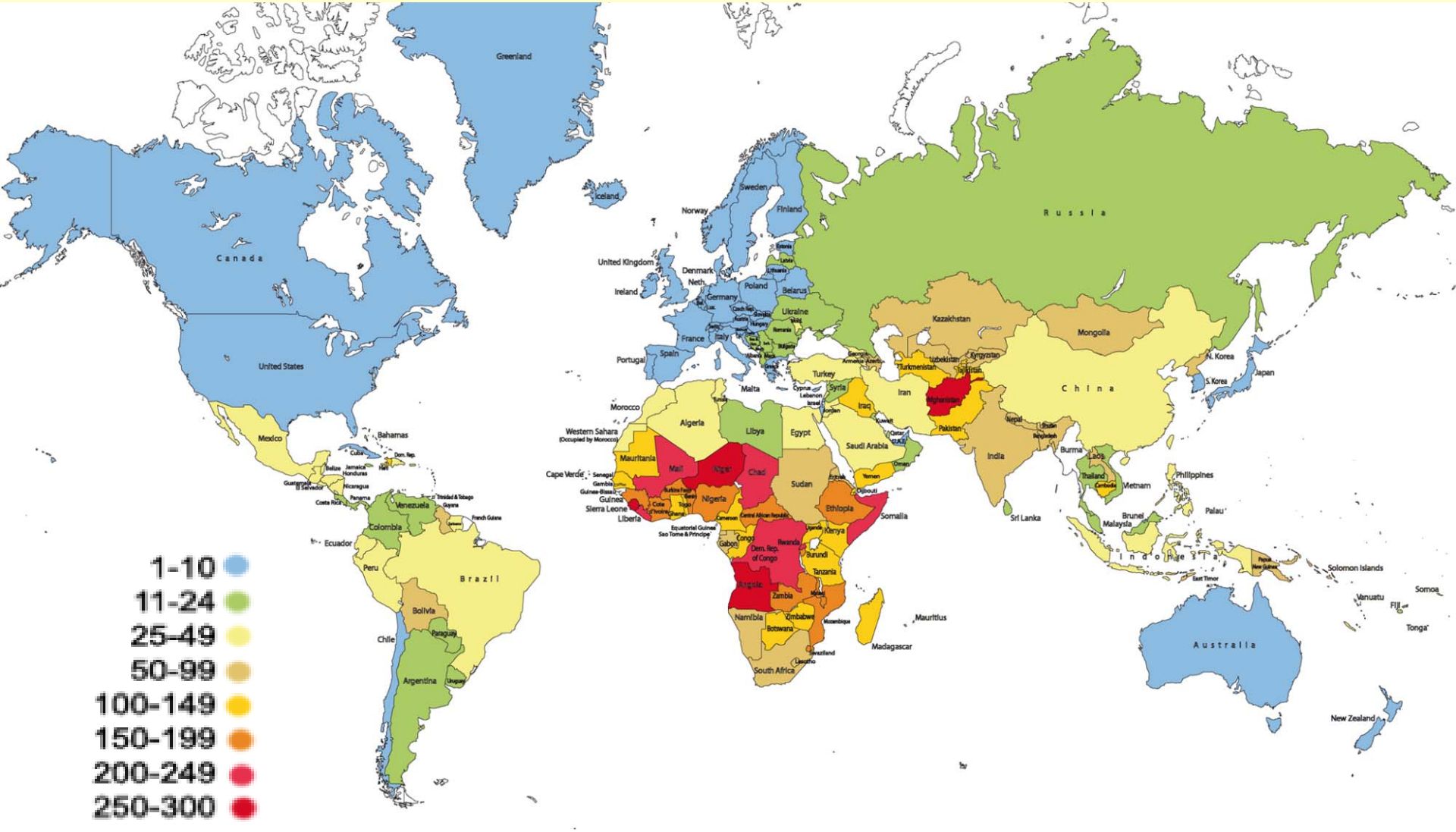


2000-2002

< -50 -25 0 25 50 > No data

% (Exports-Imports)/Consumption (calories)

Probability of dying (per 1,000) for children under 5 years of age (WHO, 2006)



Centre for African Studies in Sustainable Aquaculture & Fisheries Management

<CASA ><

International Cooperation Platform
for improving food security and poverty alleviation in Africa through the development of sustainable and responsible aquaculture and fisheries management practices

Major aquaculture platform activities

Malnutrition & food security impacts
Poverty alleviation & income generation impacts
Farming systems & sustainable development
Research & technology development
Training, education & outreach

Increased food production through fisheries & aquaculture

Project idea

Mahalo