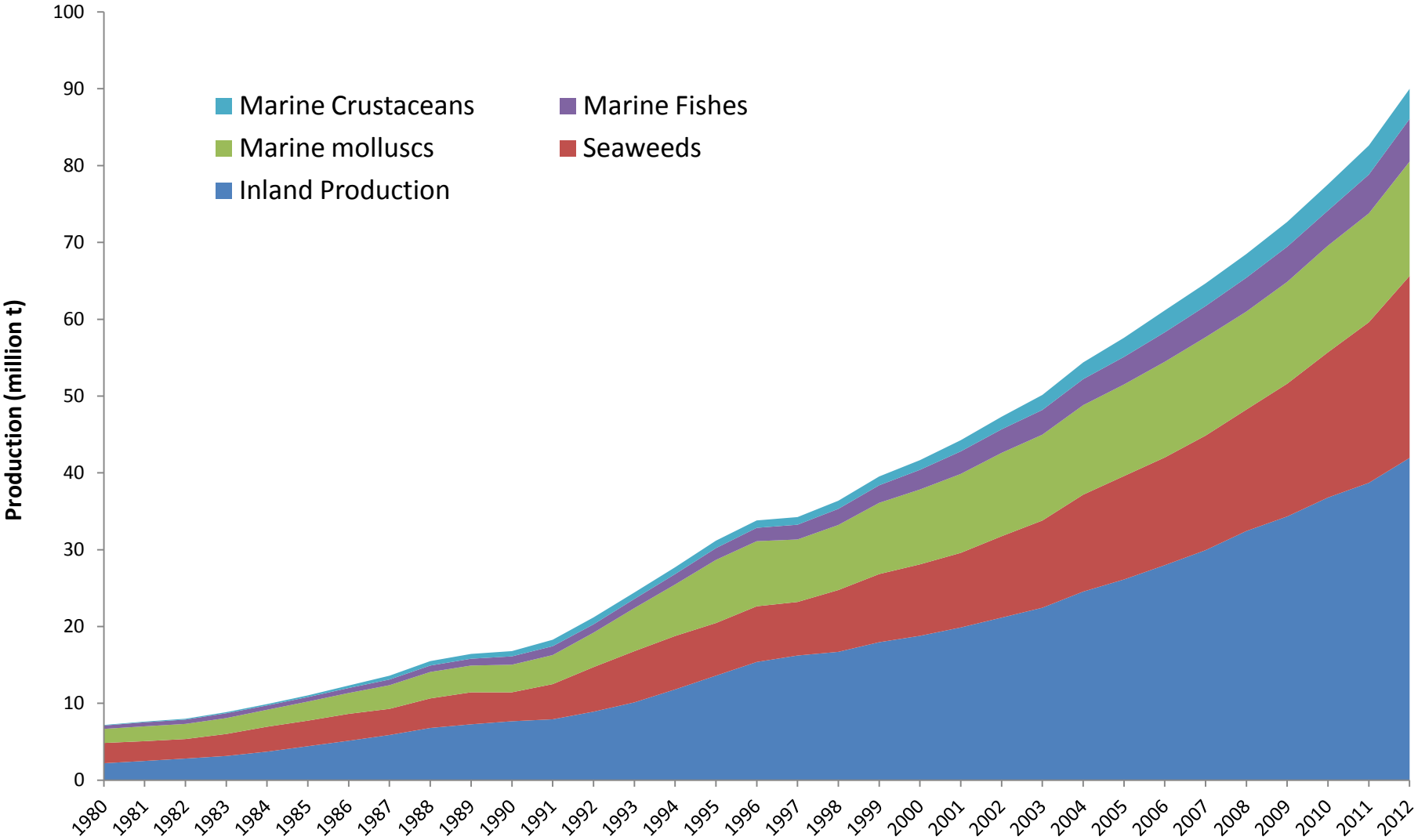
Sustainable Aquaculture

THE WORLD BANK

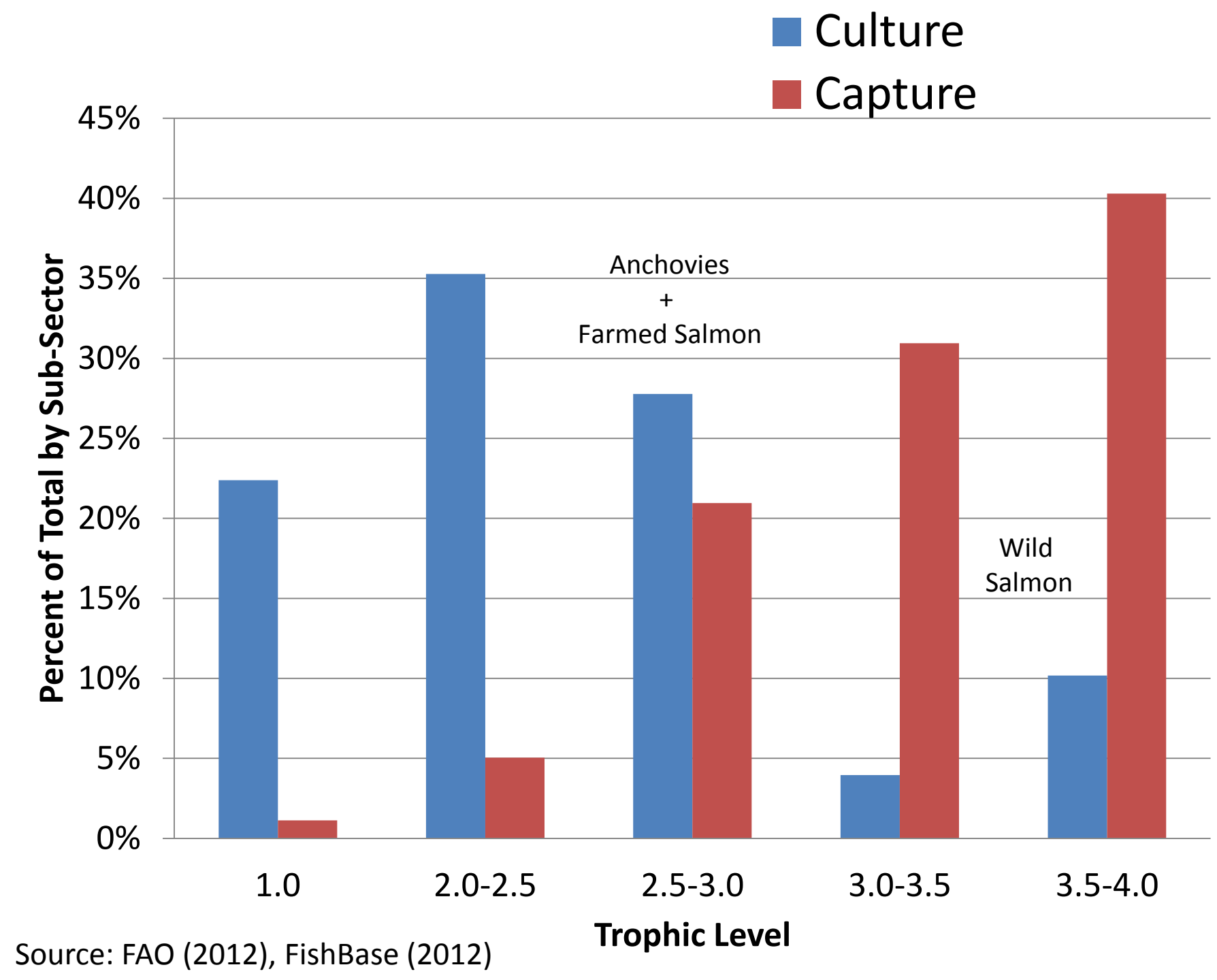
Inland Vs. marine aquaculture



Species Groups

	Metric Tons	
Carps	19,122,022	27.98%
Aquatic plants	14,357,258	21.01%
Filter Feeding Bivalves	8,562,112	12.53%
Misc (Mostly) Indigenous Finfish	5,477,122	8.01%
Crustaceans	5,009,989	7.33%
Gastropods & Eichinoderms	3,875,408	5.67%
Salmonids	3,657,843	5.35%
Tilapias	2,797,819	4.09%
Omnivorous Catfishes	2,599,929	3.80%
Misc Marine Carnivores	1,591,983	2.33%
Other Aquatic Vertebrates	1,296,766	1.90%
	68,348,251	100.00%

FAO 2010



Source: FAO (2012), FishBase (2012)

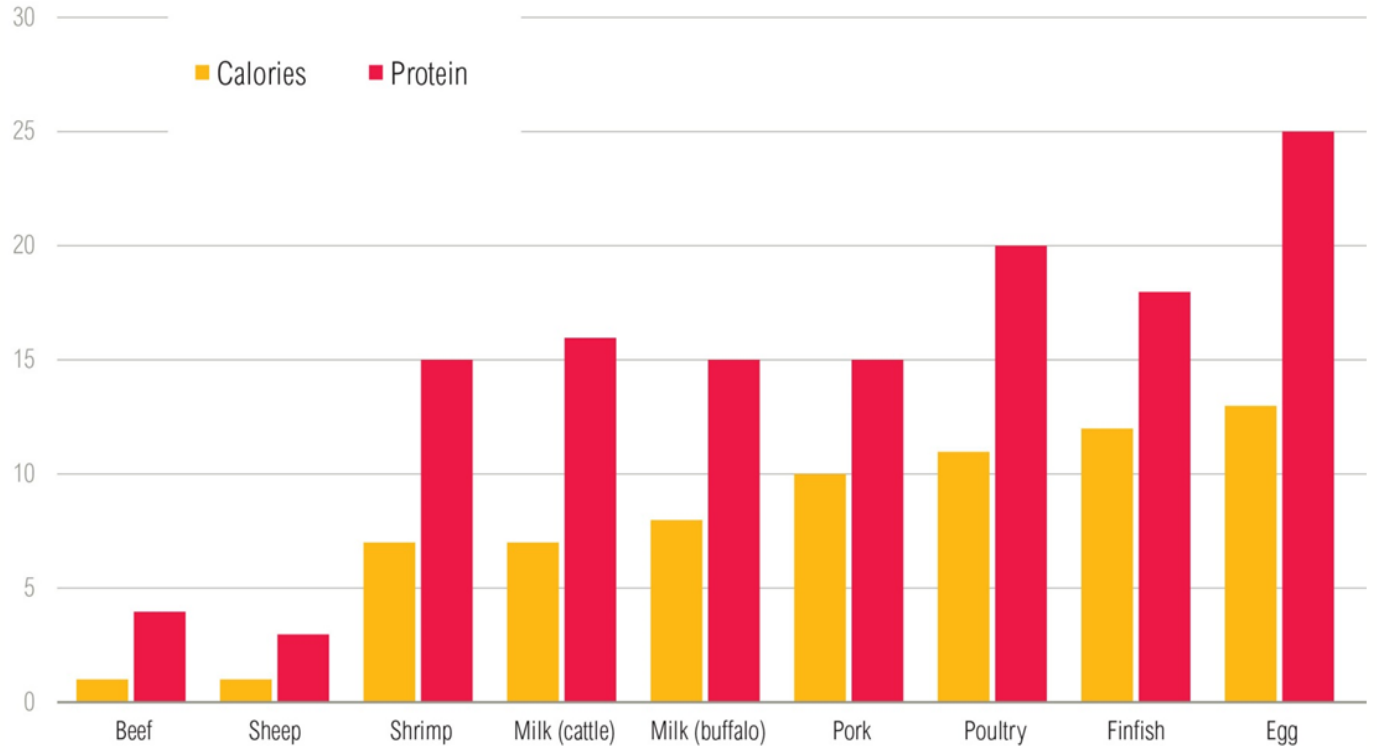
Sustainability indicators of animal protein production systems

	Protein Efficiency (%)	N Emissions (kg/ton protein produced)	P Emissions (kg/ton protein produced)	Land (tons edible product/ha)	Consumptive Freshwater Use (m^3/ton)
Beef	5	1200	180	0.24-0.37	15497
Chicken	25	300	40	1.0-1.20	3918
Pork	13	800	120	0.83-1.10	4856
Finfish (average)	30	360	48	0.15-3.70	5000 (760-252,000)*
Bivalve Mollusks	not fed	-27	-29	0.28-20	0

* Consumptive use is difficult to compare across the wide spectrum of aquaculture production systems. In the vast majority of cases, water outfalls from aquaculture are much cleaner and more easily recycled than for land animals.

(Phillips et al. 1991, FAO 2003, Hall et al. 2011, Bouman et al. 2013)

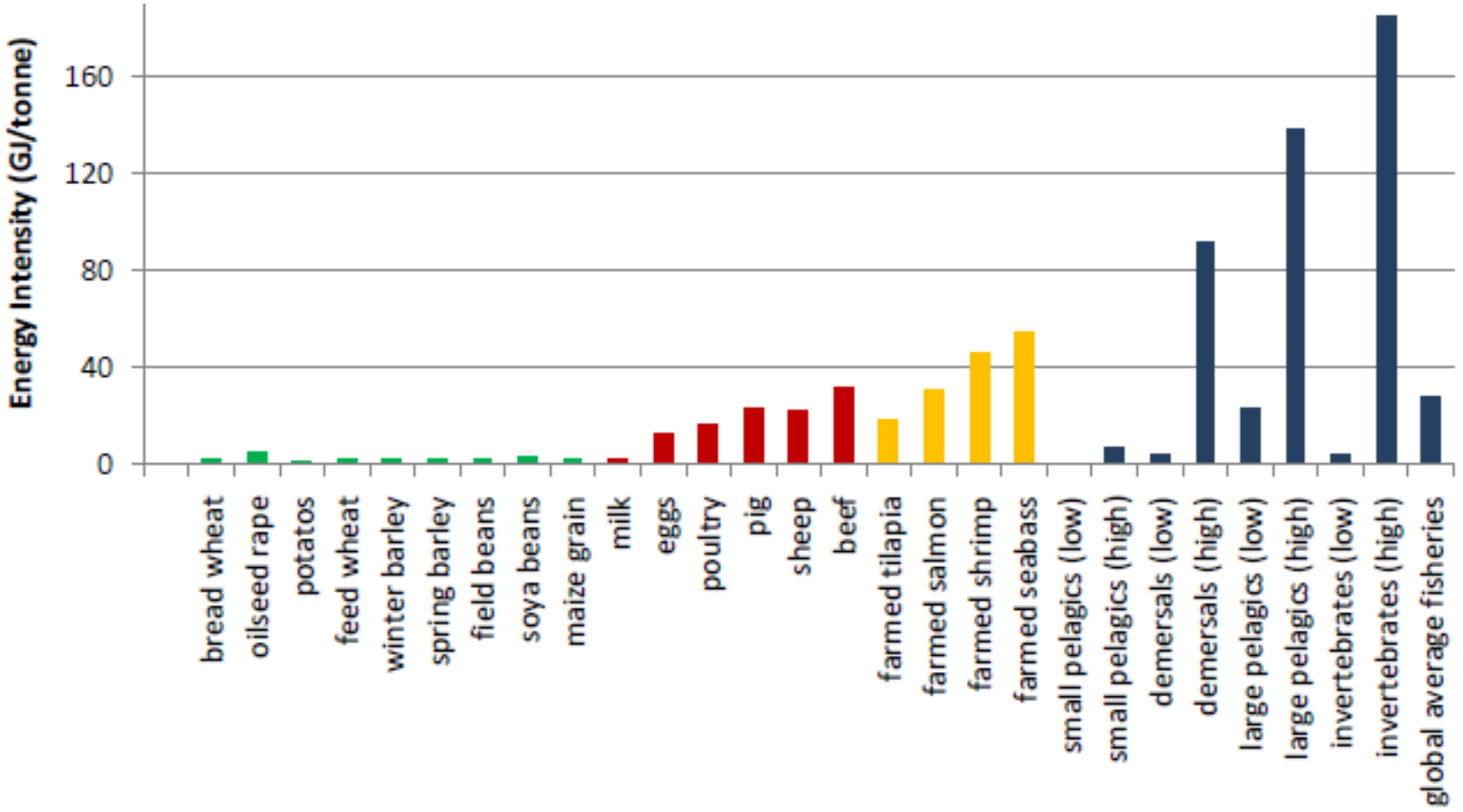
Edible Output per 100g Feed Input



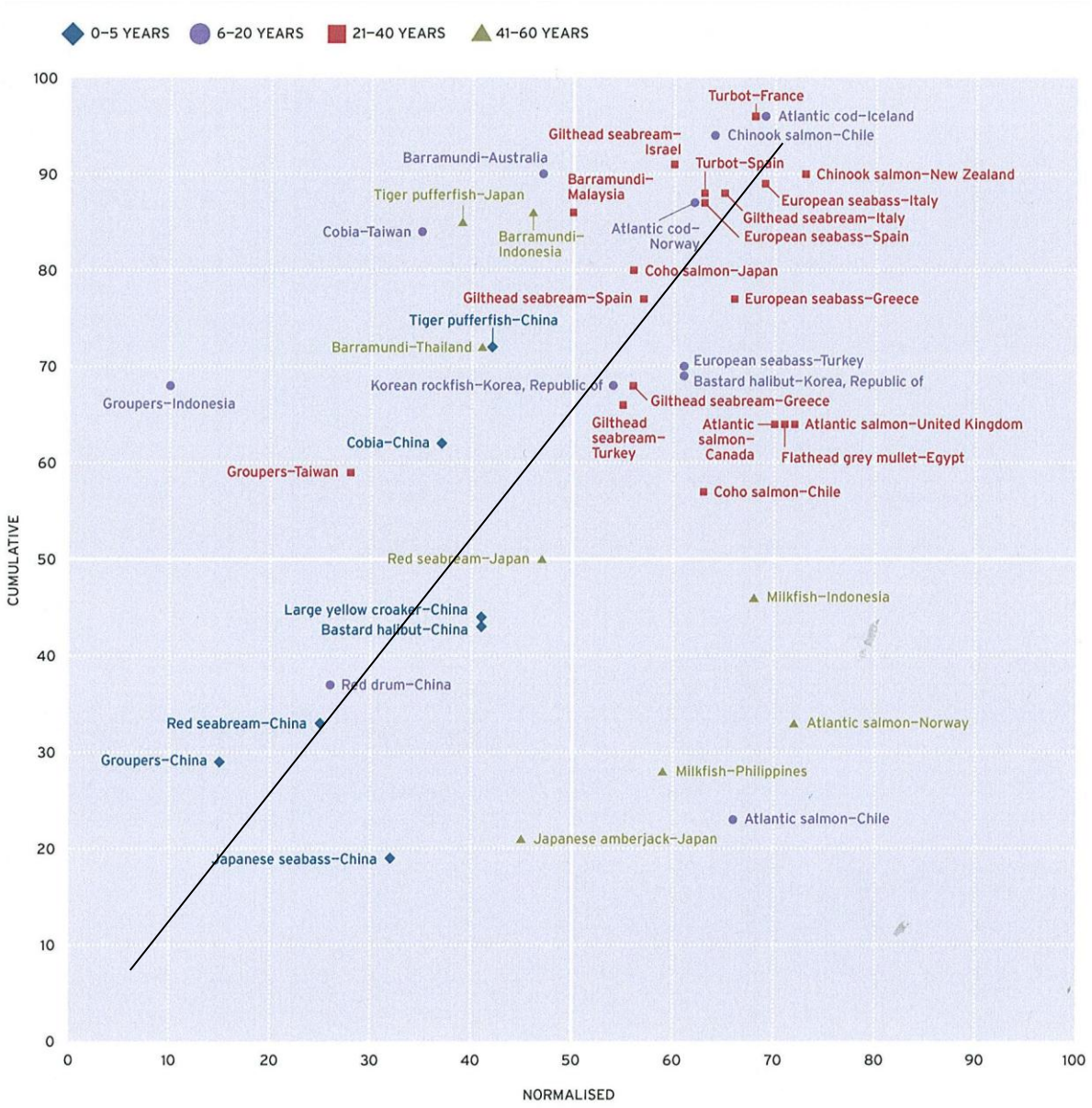
Note: "Edible output" refers to the calorie and protein content of bone-free carcass. All calculations refer to farmed animals.

Source: Terrestrial animal products: Wirsenius et al. (2010) (extra unpublished tables), Wirsenius (2000). Finfish and shrimp: WRI analysis based on USDA (2013), NRC (2011), Tacon and Metian (2008), Wirsenius (2000), and FAO (1989).

WORLD RESOURCES INSTITUTE

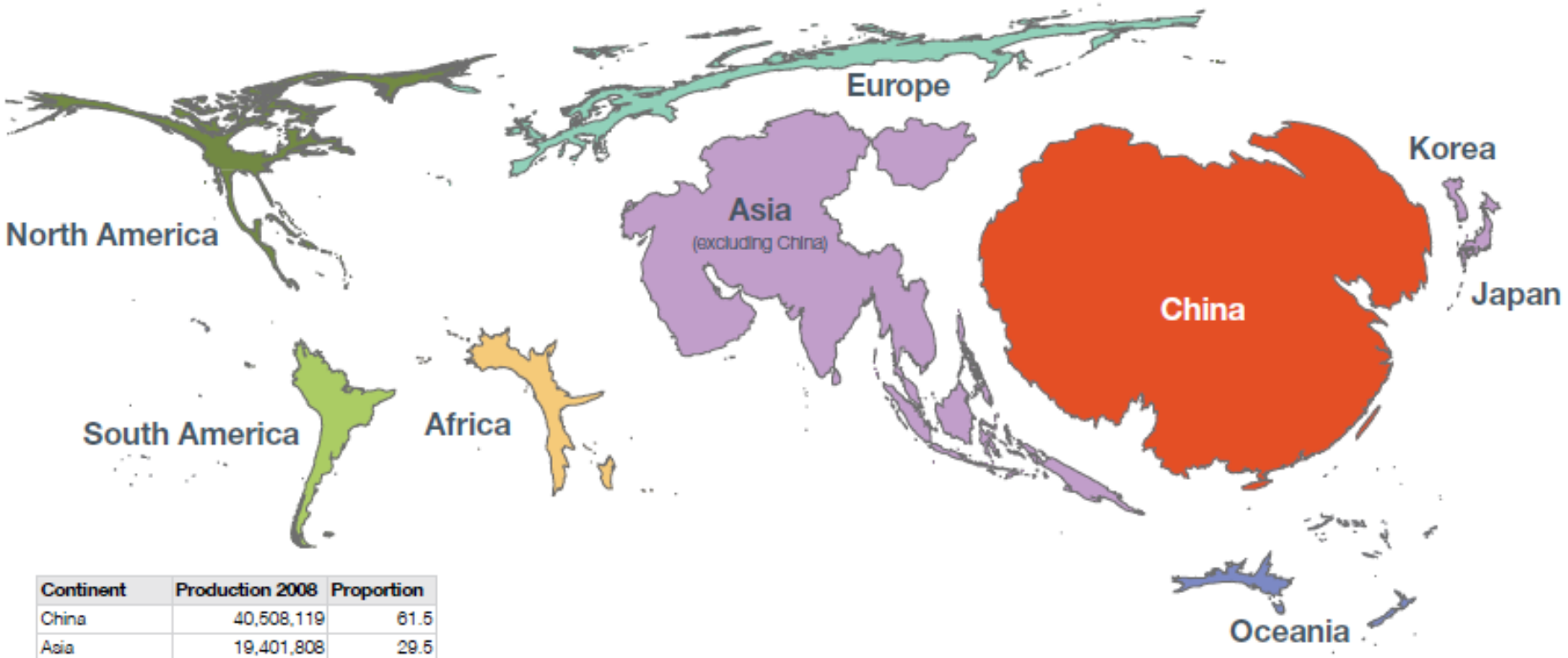


Pelletier et al. 2011. Ann Rev. Env. Resources



Source: University of Victoria & Lenfest (2010)

Who are the Producers?



Continent	Production 2008	Proportion
China	40,508,119	61.5
Asia	19,401,808	29.5
Europe	2,341,646	3.6
South America	1,461,061	2.2
North America	965,792	1.5
Africa	952,133	1.4
Oceania	176,181	0.3

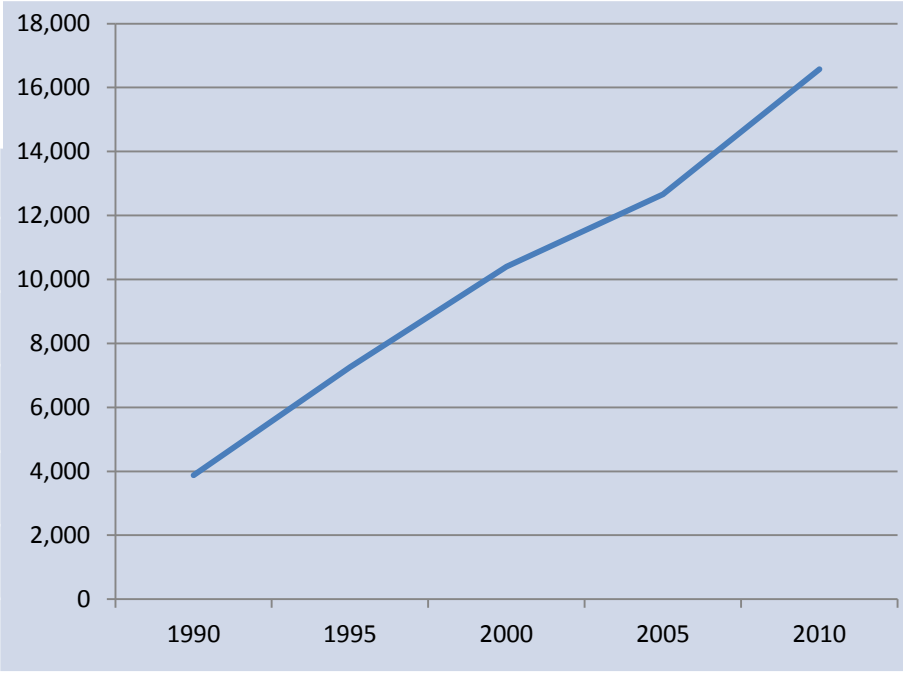
WorldFish CENTER




23.4 million workers; 17 million (74%) “small-scale”, 92% in Asia; Livelihoods for 117 million (FAO)




Small is Beautiful

Region	Aquaculture Employment (thousands)	Productivity (2010)
		Tons of fish per farmer
Africa		8.59
Asia		3.32
Europe		29.68
LAC		7.74
N America		164.00
Oceania		30.67
World Total		3.61

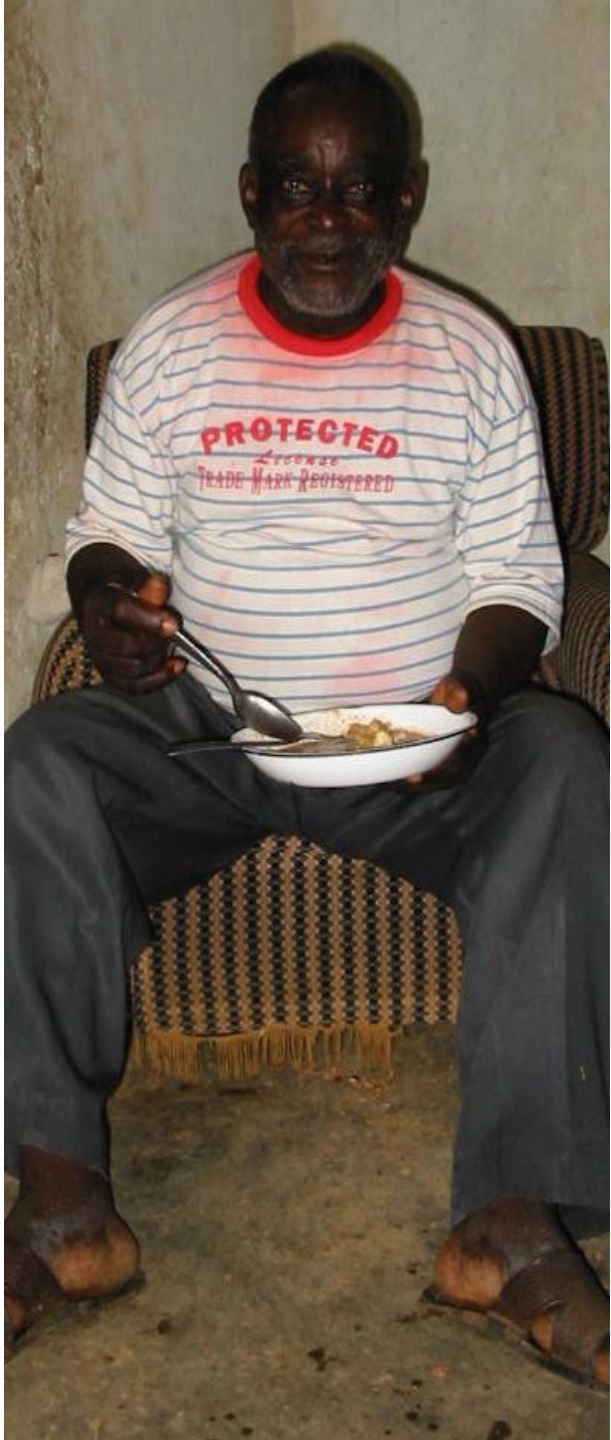
Who are the Consumers?

	Data (000 tons)	Projection (000 tons)			Share in global total		% Change
	2006	2010	2020	2030	2010	2030 (Projection)	2010–30
Total	111,697	119,480	138,124	151,771	100.0%	100.0%	27.0%
ECA	16,290	15,488	15,720	16,735	13.0%	11.0%	8.1%
NAM	8,151	7,966	9,223	10,674	6.7%	7.0%	34.0%
LAC	5,246	4,900	5,165	5,200	4.1%	3.4%	6.1%
EAP	3,866	2,975	3,068	2,943	2.5%	1.9%	-1.1%
CHN	35,291	44,094	52,867	57,361	36.9%	37.8%	30.1%
JAP	7,485	8,180	7,926	7,447	6.8%	4.9%	-9.0%
SEA	14,623	14,175	17,160	19,327	11.9%	12.7%	36.3%
SAR	4,940	5,063	7,140	9,331	4.2%	6.1%	84.3%
IND	5,887	6,909	8,688	10,054	5.8%	6.6%	45.5%
MNA	3,604	3,571	4,212	4,730	3.0%	3.1%	32.5%
AFR	5,947	5,980	6,758	7,759	5.0%	5.1%	29.7%
ROW	367	179	198	208	0.2%	0.1%	15.7%

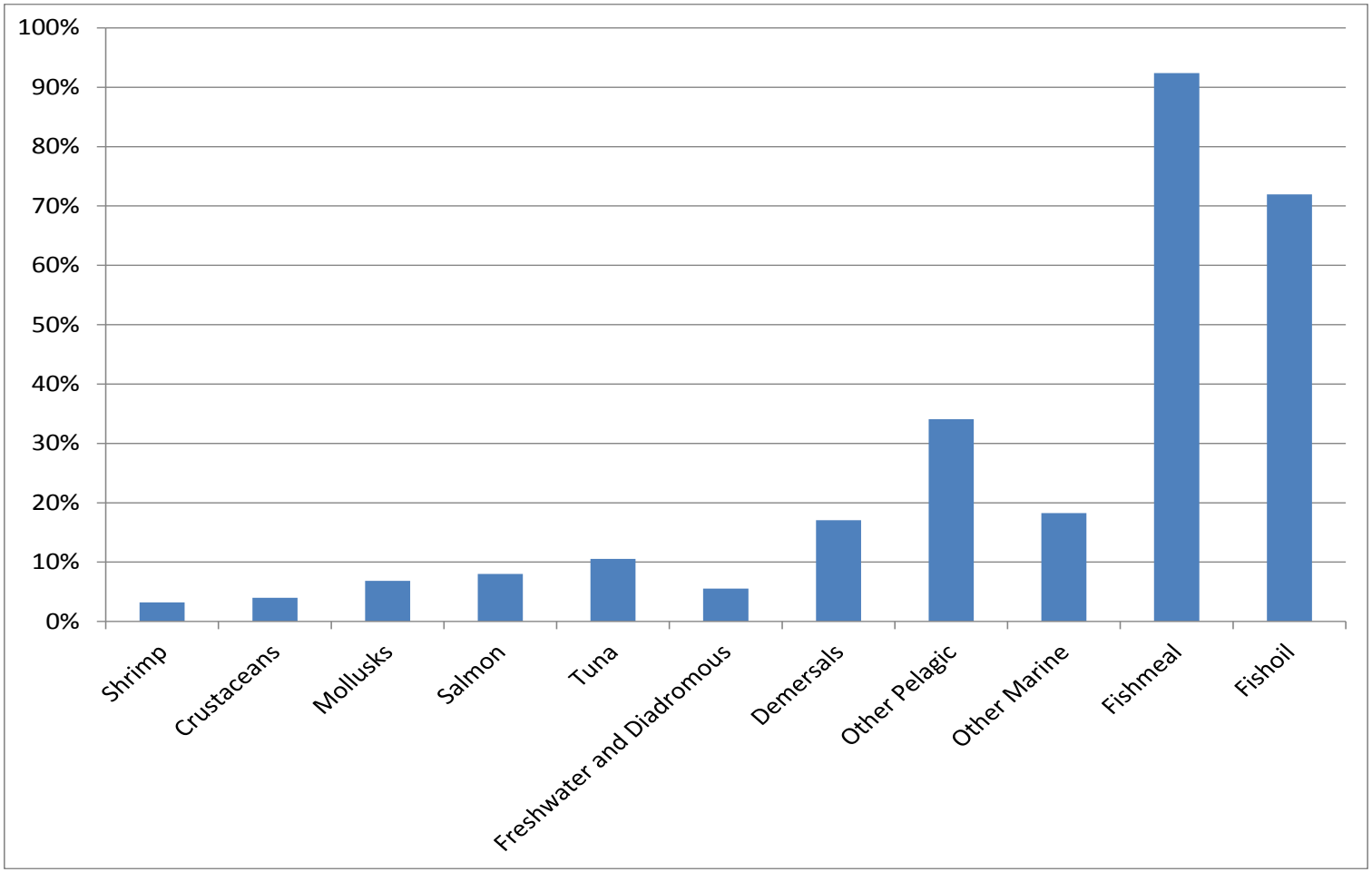
86% of consumption in LDCs

Fish is essential for > 1 billion people

>50% of animal protein for 400 million in the poorest countries



Price Projections



Constraining Sustainable Growth

Space

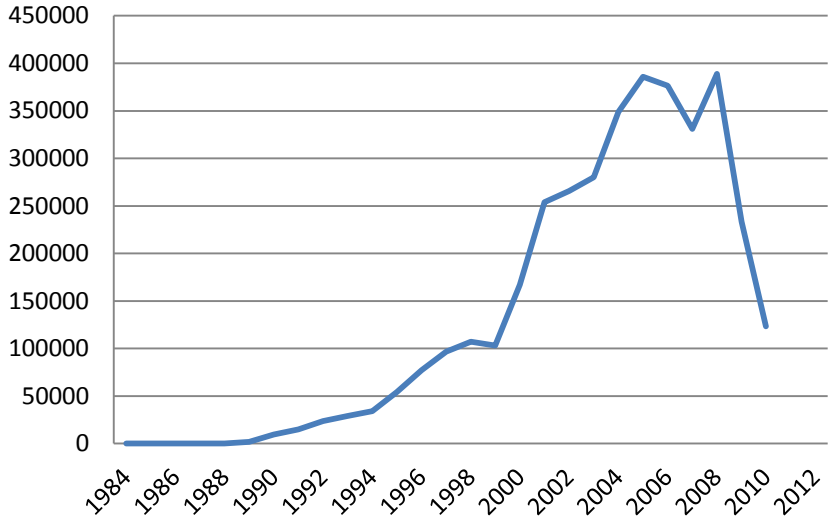
Capital

Feed

Technical Efficiency

- Asia: 0.64; US/Europe: 0.73
- 500 Vs 20,000 kg/ha/yr
- 12% Vs 1% breeding gain
- Energy???

Protecting Environments, Fish Health & Investments



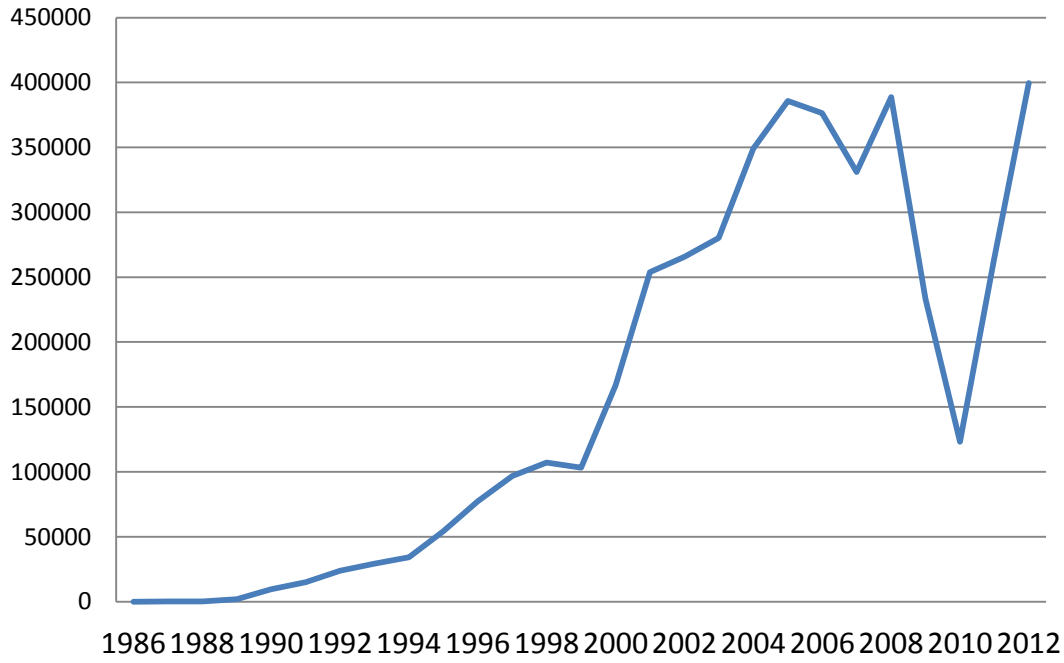
Ecological Issues

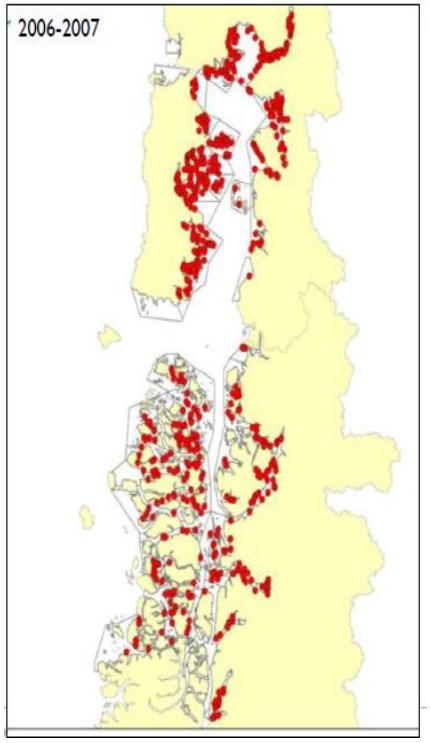
- Siting – identify zones that are good for aquaculture; away or downstream of important ecosystem and biodiversity assets.
- Carrying Capacity – measure how fast the ecosystem is moving towards the limit.

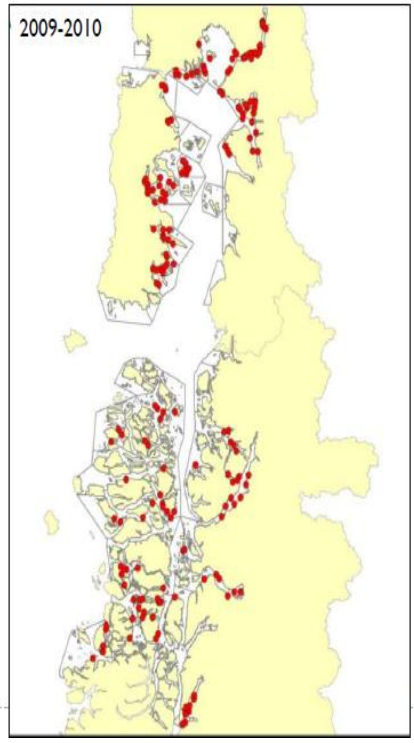
Institutional Issues

- Setting Limits - set with the local community key criteria for impact assessment.
- Enforcement - establish regulatory framework, local authority and trade association that represents the interests of the aquaculture value chain.

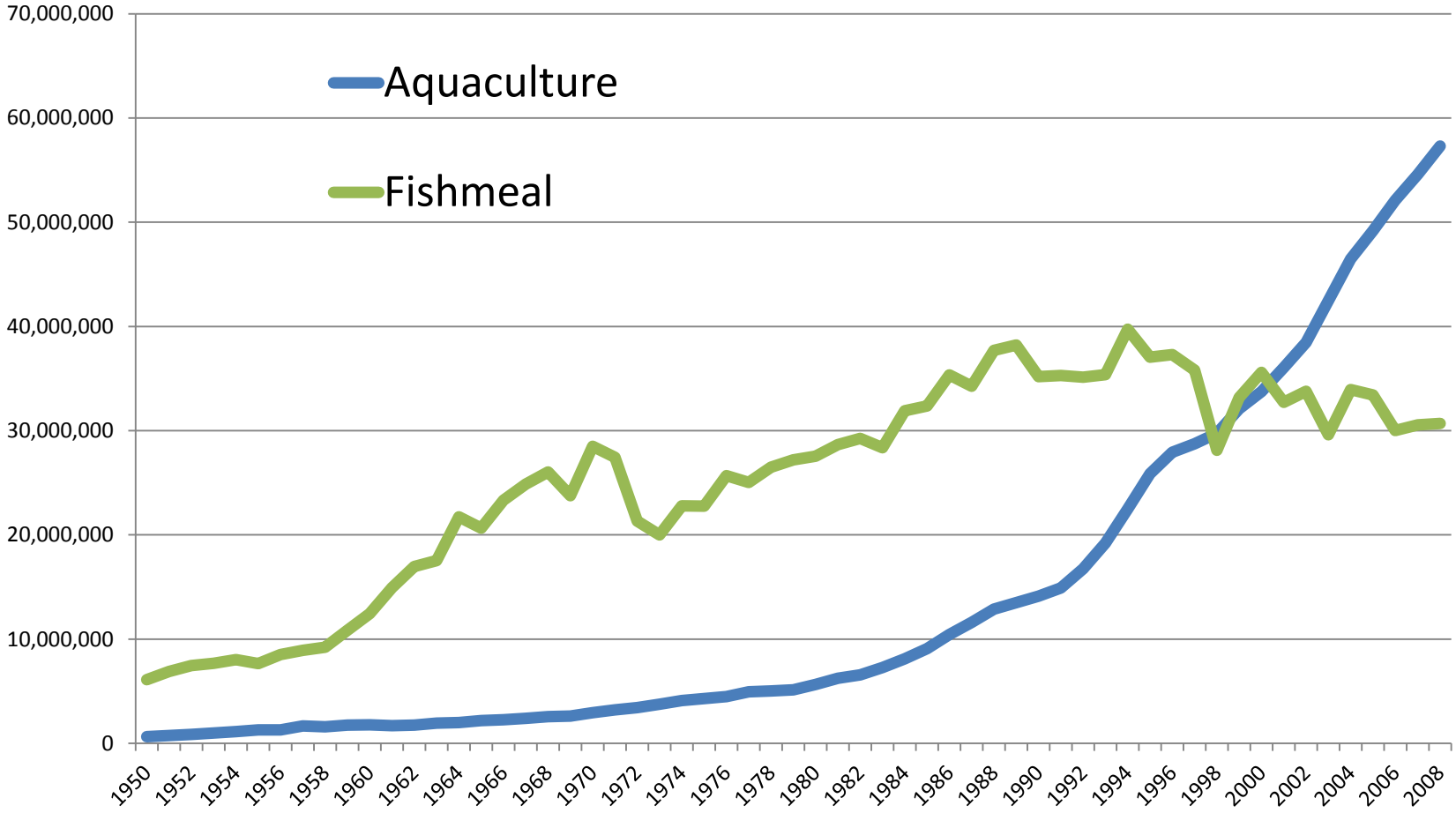
Back from the Brink: Lessons from Chile







13 million Tons of Forage Fish



FAO

Price Driving Innovation

Farmed Fed Category	2000	2010	Production increase %
Eels	3.0	1.8	14
Salmonids	2.6	1.4	53
Marine fish	1.5	0.9	81
Crustacea including shrimps & crabs	0.9	0.4	232
Tilapia	0.3	0.2	143
Other fed freshwater fish (e.g. catfish & pangasius)	0.6	0.2	462
Fed Cyprinids	0.1	0.1	42
Total for fed Aquaculture	**0.6**	**0.3**	**97**

Aquaculture now uses approximately 10 million tonnes of whole fish in fishmeal & fish oil to produce 30 million tonnes of farmed product

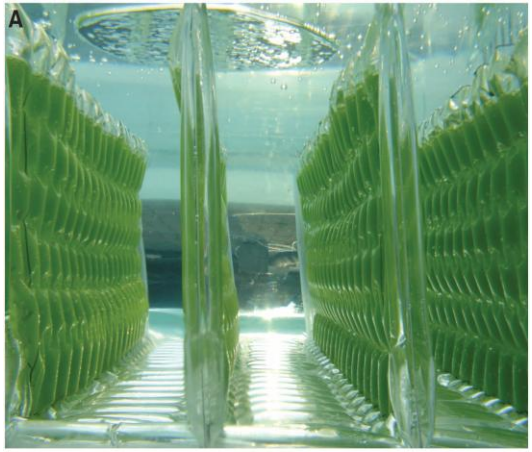
Based on FAO & IFFO data

Plant Proteins

3% fishmeal + 40% SPC + 30% SBM

40% SPC + taurine

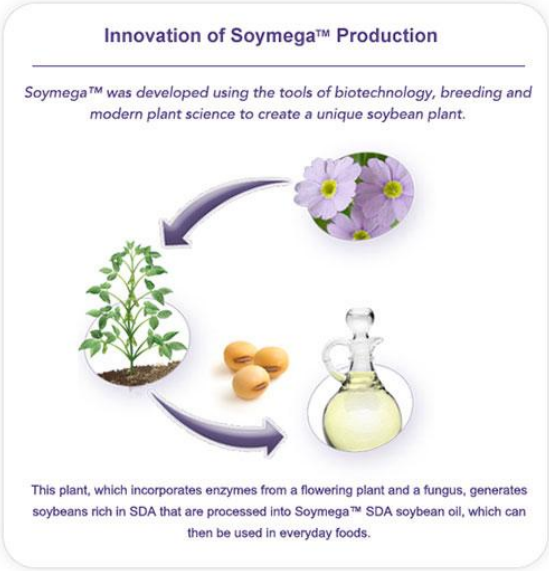
64% fishmeal


A


B

Fish Oil

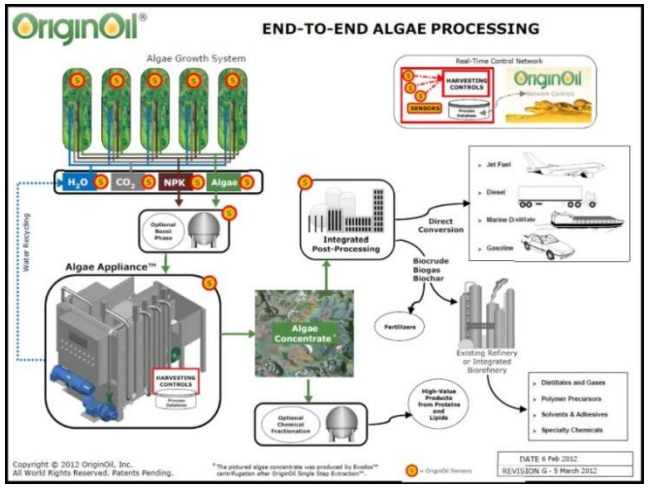

C


Innovation of Soymega™ Production
Soymega™ was developed using the tools of biotechnology, breeding and modern plant science to create a unique soybean plant.
This plant, which incorporates enzymes from a flowering plant and a fungus, generates soybeans rich in SDA that are processed into Soymega™ SDA soybean oil, which can then be used in everyday foods.


Science

Moving Off Shore

- Zones Easier to Implement
- Low Energy Systems
- No Land or Freshwater
- Established Hatchery & Culture Technology
- Turn Carnivores to Herbivores
- Keeping the small-scale players in the game?

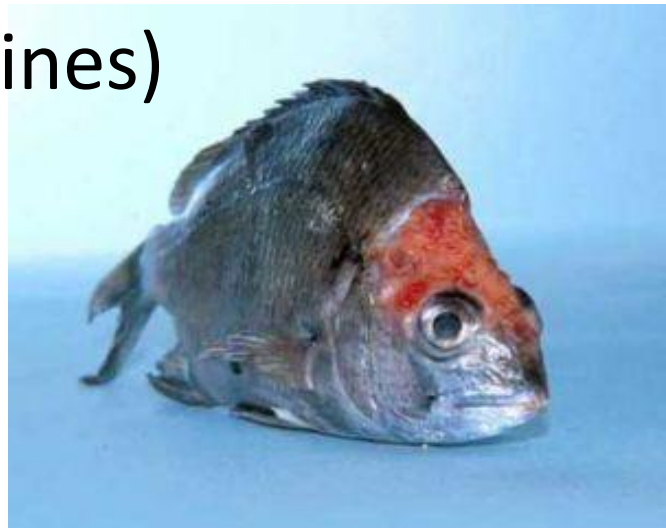


Thank You!

THE WORLD BANK

Symptoms of Unsustainability

- Massive disease outbreaks
- Declines in water quality
- Loss of biodiversity
- Loss of recreation, capture fisheries
- Reduced efficiency due to stress, inbreeding
- Increasing operation costs (medicines)
- Lowered market appeal
- INCREASED RISK



Defining Ecological Sustainability

- ‘Sustainability’ is multidimensional incorporating physical resources, biodiversity AND people.
- ‘Sustainability’ is context specific; priorities differ between the Maldives and Mississippi.
- ‘Sustainability’ is an attribute of ecosystems, not individual farms.

Practicalities:

- Clearly defined area
- Meaningful and visible indicators
- Ease and repeatability of measurements
- Incentives (e.g., collective certification) and disincentives (e.g., credible penalties) to manage free ridership



We measure this.

We are concerned about this.

Shouldn't we be measuring what we care about: biodiversity, clean water and beaches?



Lowering Risk

Ecological Issues

- Siting – identify zones that are good for aquaculture; away or downstream of important ecosystem and biodiversity assets.
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Institutional Issues

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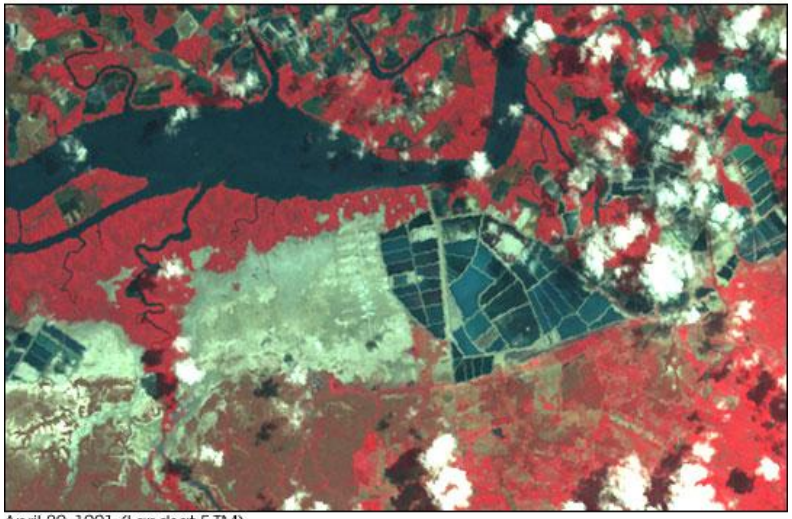
Mangroves (actually salt-flats) and Shrimp

March 6, 2006 (Terra ASTER)


November 19, 1999

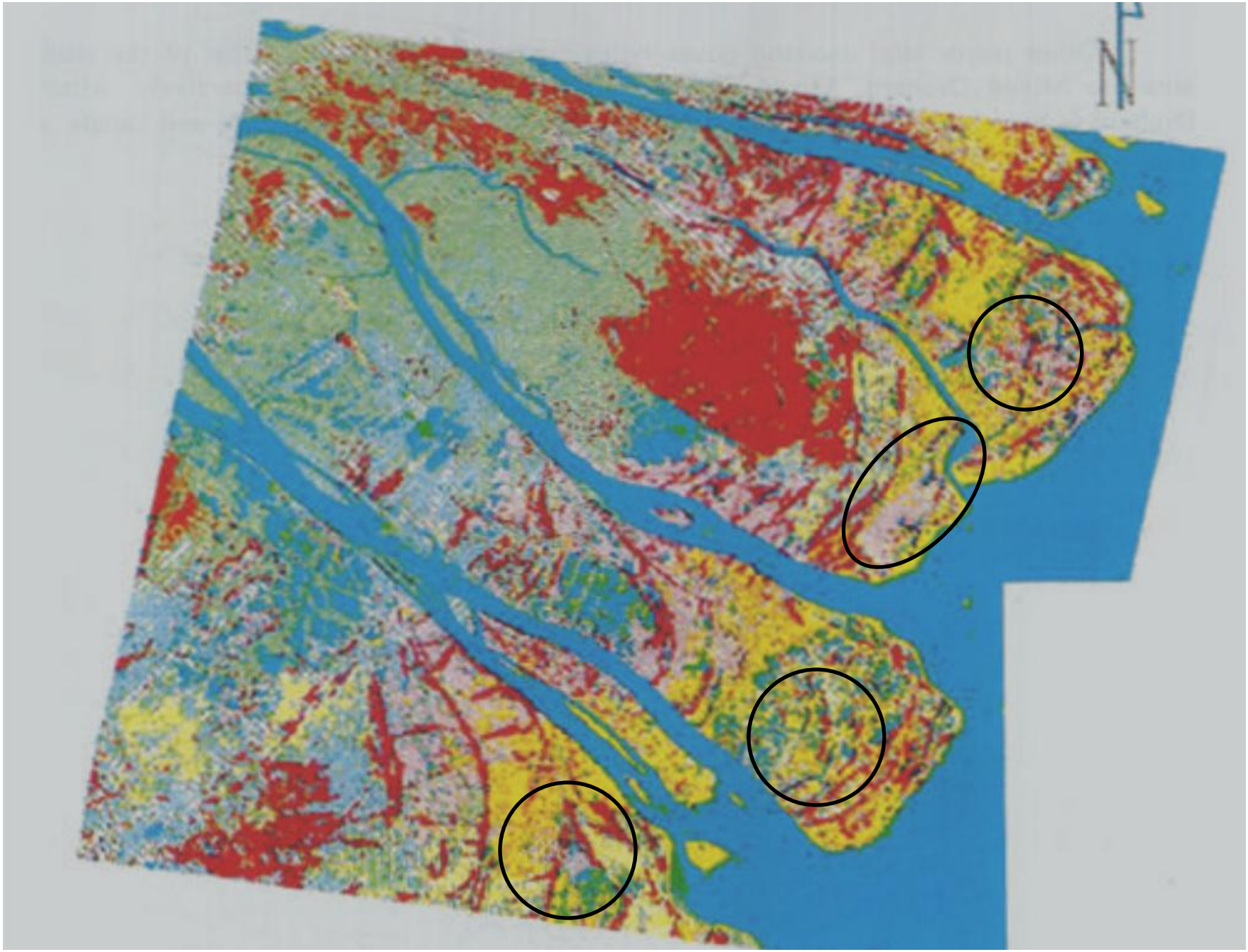

April 29, 1991 (Landsat 5 TM)

January 6, 1987

Evolution of Mangrove Loss in Vietnam

- 1891 - > 1 million ha of brackishwater forests
- 1899 – most large trees already gone
- 1911 – efforts to regulate deforestation begin
- 1938 – 329,000 ha of mangroves left
- War – agent orange
- Post-War – massive conversion to rice and urban infrastructure (salinization)
- 1990's - R&R shrimp explosion
- 2000 – government regulation of shrimp farming
- 2008 – 620,250 ha of shrimp farms in Vietnam

Sources: GTZ, Soc Trang Provincial People's Committee (2010); UNEP 1998, De Silva (2012) Biodiversity Conservation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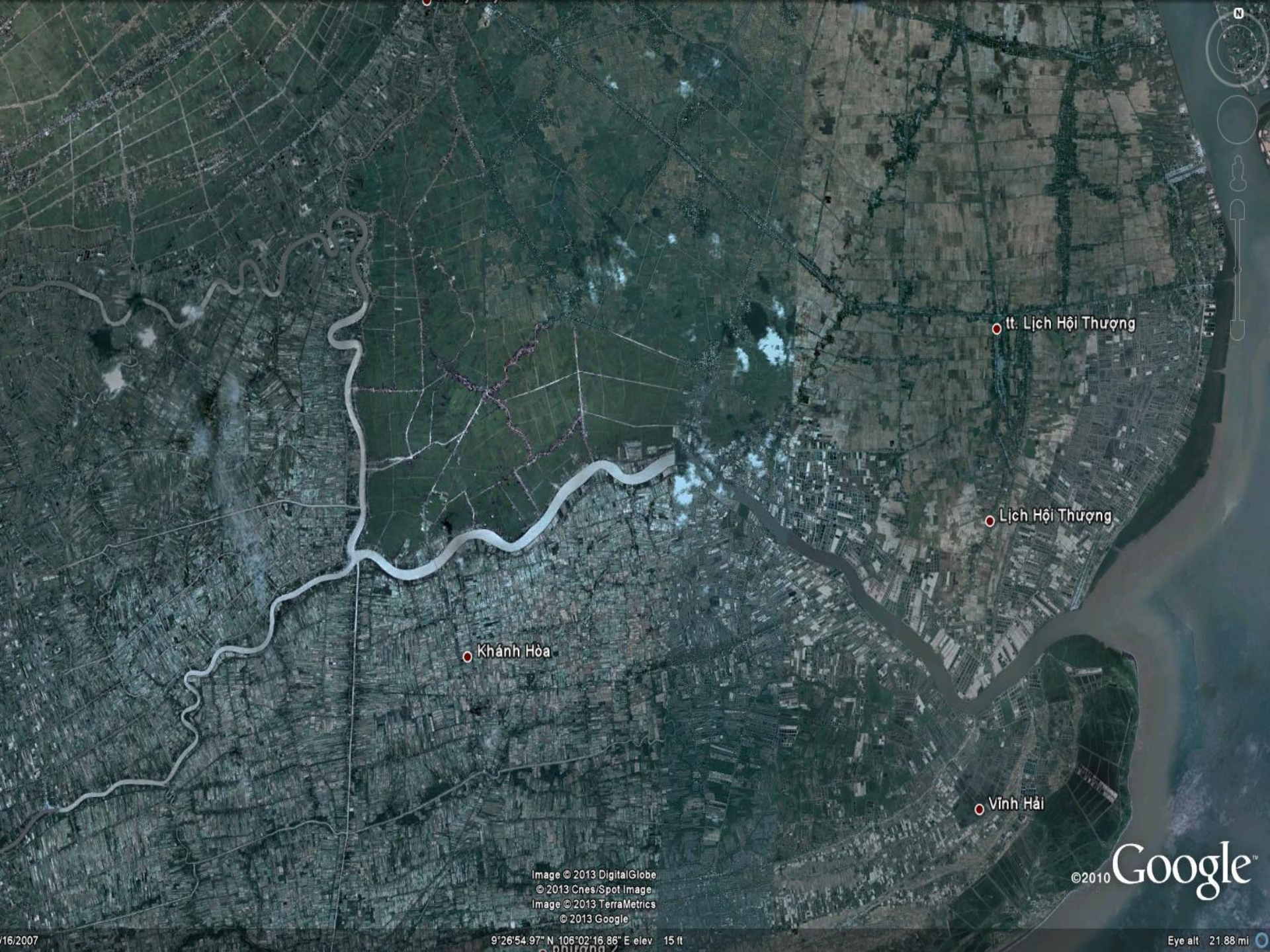
An aquaculture landscape?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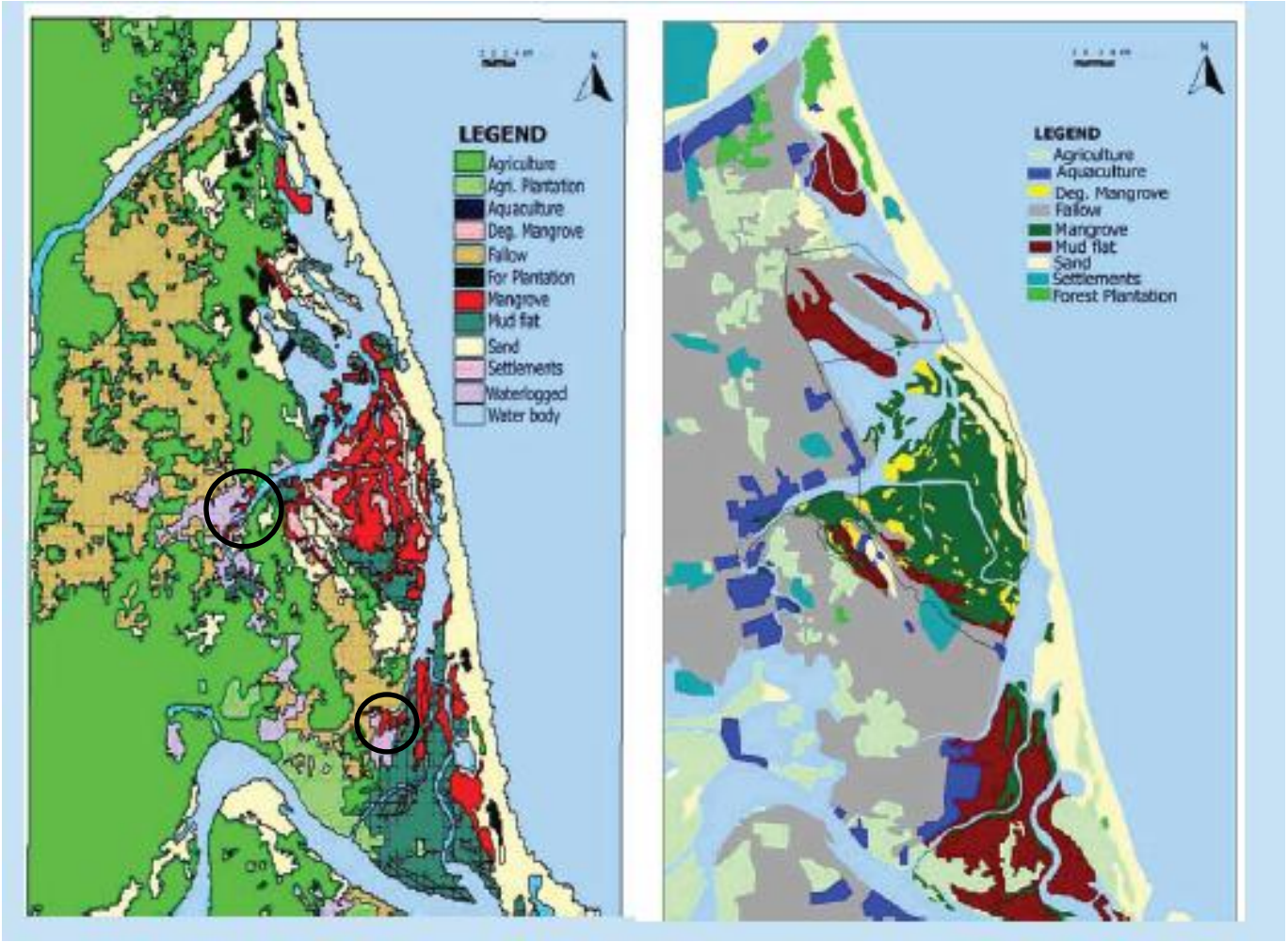
Lịch Hội Thượng
Khánh Hòa
Vĩnh Hải
Image © 2013 DigitalGlobe
© 2013 Cnes/Spot Image
Image © 2013 TerraMetrics
© 2013 Google
©2010 Google
9°26'54.97" N 106°02'16.86" E elev 15 ft
Eye alt 21.88 mi

…and Tamil Nadu



1987

2004

Source: Jayanthi et al. 2010.

Getting the Facts Straight

- **Myth:** 198 kg of CO_2 eq per 100 g shrimp cocktail due largely to mangrove destruction
- **Laugh Test:** 3.3 billion tons of CO_2 = 6 X emissions of the world's motor vehicle fleet
- **Reality:** 3-12 kg CO_2 eq/kg*; <10% of shrimp farms converted mangroves; little direct conversion; almost none since 2000.

* Compared to 3-32 for land animals

Sources: Boyd & Clay (1998) Scientific American; Cao et al (2011) Environ. Sci. Tech. Sonesson et al. (2009) Swedish Institute for Food & Biotechnology, US EPA (2012).

Constraints to Sustainable & Equitable Growth

- Double supply in the next 2 decades
- Competition for land and water
- Need >$100 billion in new capital
- Must lower risk to attract investors