Aquaculture Adaptation Strategies to Climate Change: An Industry Perspective

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Outline

- Aquaculture Adaptation to
  - Water stress
  - Storms
  - Temperature stress
  - Harmful algae blooms
  - Acidification

- Aquaculture
  - Its ability to respond
  - The best adaptation strategy of fisheries to climate change

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Adaptation to Water Stress

- More efficient use of water
  - Intensification
  - Low and zero water exchange systems
  - Development and application of better irrigation for feed crops

Farming fish to save water

Food	Freshwater consumption m^3kg^{-1}
Beef	100
Broiler chickens	3.5
Trout	<3.5
Channel catfish	3.3 – 6.5
Tilapia	2.8

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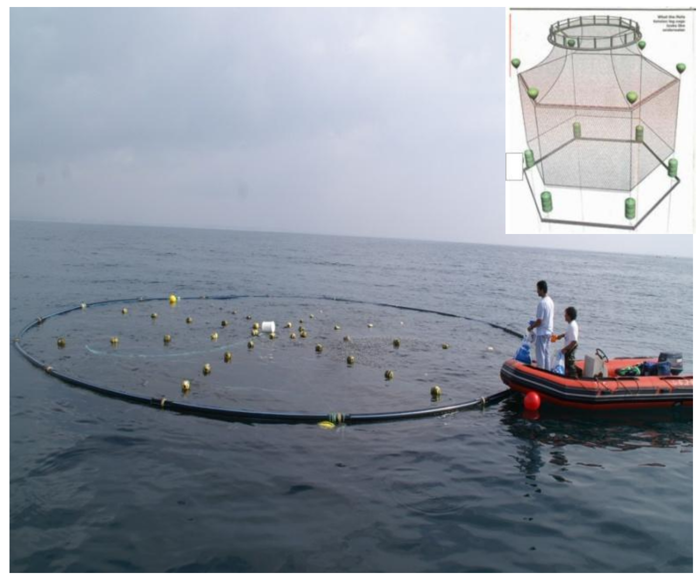
Adaptation to Storms

- Offshore, submersible cages
- Raise construction standards for cages and moorings
- Build shrimp farms within the mangrove fringe
- Insurance

Offshore cage aquaculture, IPIMAR, Portugal




1985
Honduras


1998
Honduras

Adaptation to Temperature Stress

- Offshore, submersible cages
- Breeding technology
- GM

Breeding technology

- Hormonal sex-reversal in tilapia
- Genetically male tilapia
- Hormone induced spawning in *Pangasius*
- Triploid oysters
- Selective breeding for disease resistance

Genetic Engineering

- GM feed ingredients
  - Soya
  - Rapeseed (canola) oil
- GM aquaculture species
  - Salmon
  - Tilapia
- GM research in government labs is needed to help dispel worries about monopolistic private companies

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Response to Harmful Algae Blooms


Increased production
of nutrient
consuming species
Mussels

Adaptation to Ocean Acidification

Acidification Example

Result of lab experiment

- 740 ppm CO_2, pH 7.1 causes a 25% drop in calcification rate of *M. edulis* (mussels)

Assumption

- Equates to a 25% drop in mussel production

Economic analysis

- Overall economic impact measured as a drop in the NPV of the mussel industry. Horizon 50-60 years.

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Adaptation to Ocean Acidification

- Support research into low carbon energy technology to reduce global CO_2 emissions
- Avoid ‘feel-good’ solutions
- (Support free trade and adopt Doha)

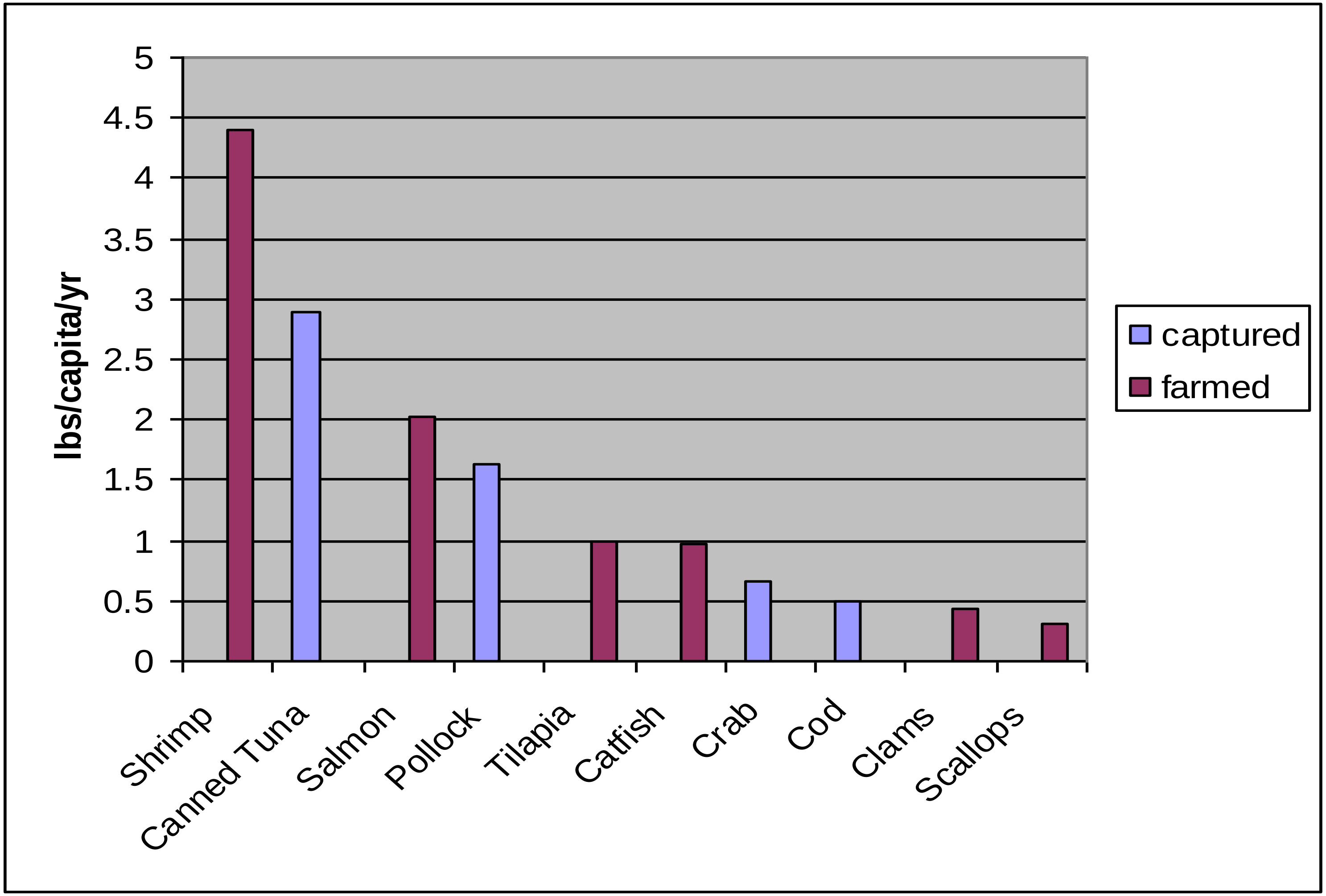
Avoid the costly approach of directly cutting carbon emissions now because this will stunt economic prospects of developing nations that are most at risk from climate change and will leave them less able to adapt.

(Aquaculture is the best adaptation of fisheries to climate change.)

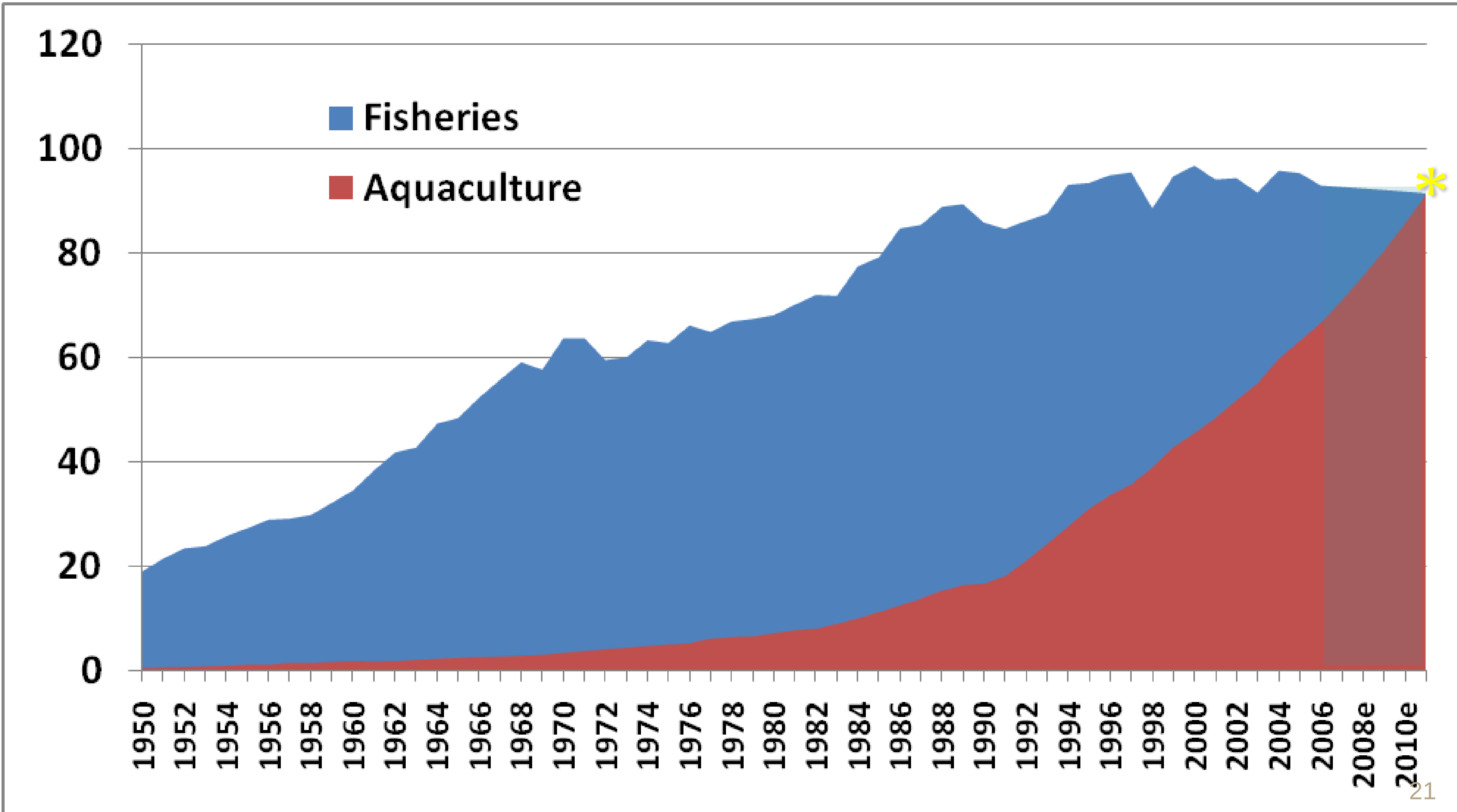
Aquaculture's Ability to Respond

- To demand
- By improving efficiency of resource use
- By overcoming disease shocks

Top 10 Seafoods in the USA



Aquaculture to Surpass Fisheries
(Production, million mt)



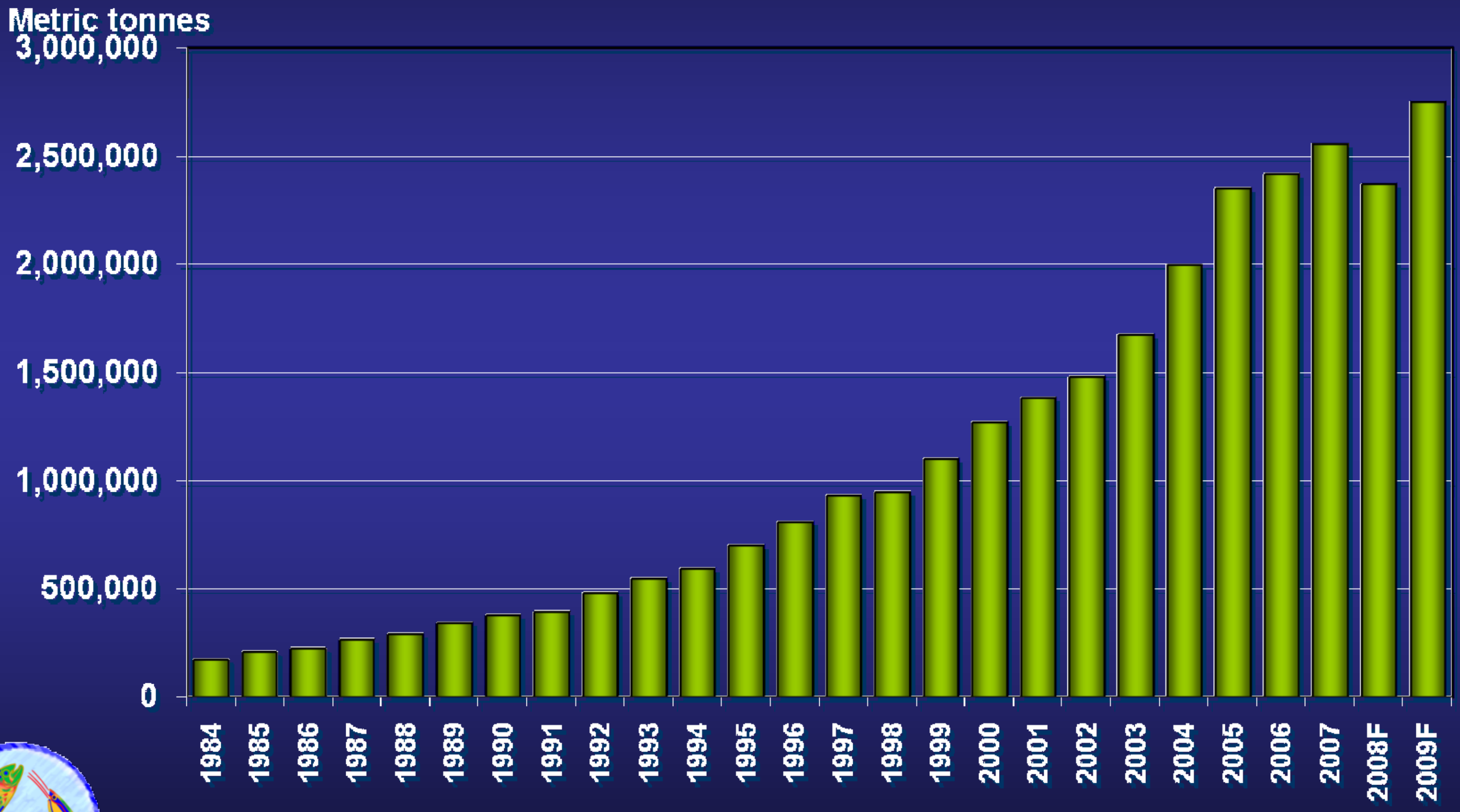
Improving efficiency of resource use

- Farming <u>down</u> the food chain
- Feed
  - Improved
    - feeding technology
    - diet formulation
    - conversion
  - Integration on a global scale
- Water
  - Zero exchange systems
  - Recirculation systems
  - Integration with irrigation
- Intensification
  - e.g. *Pangasius* production up to 300mt/ha

Expansion of the farming of low trophic level fish

Tilapia

Global Aquaculture Production



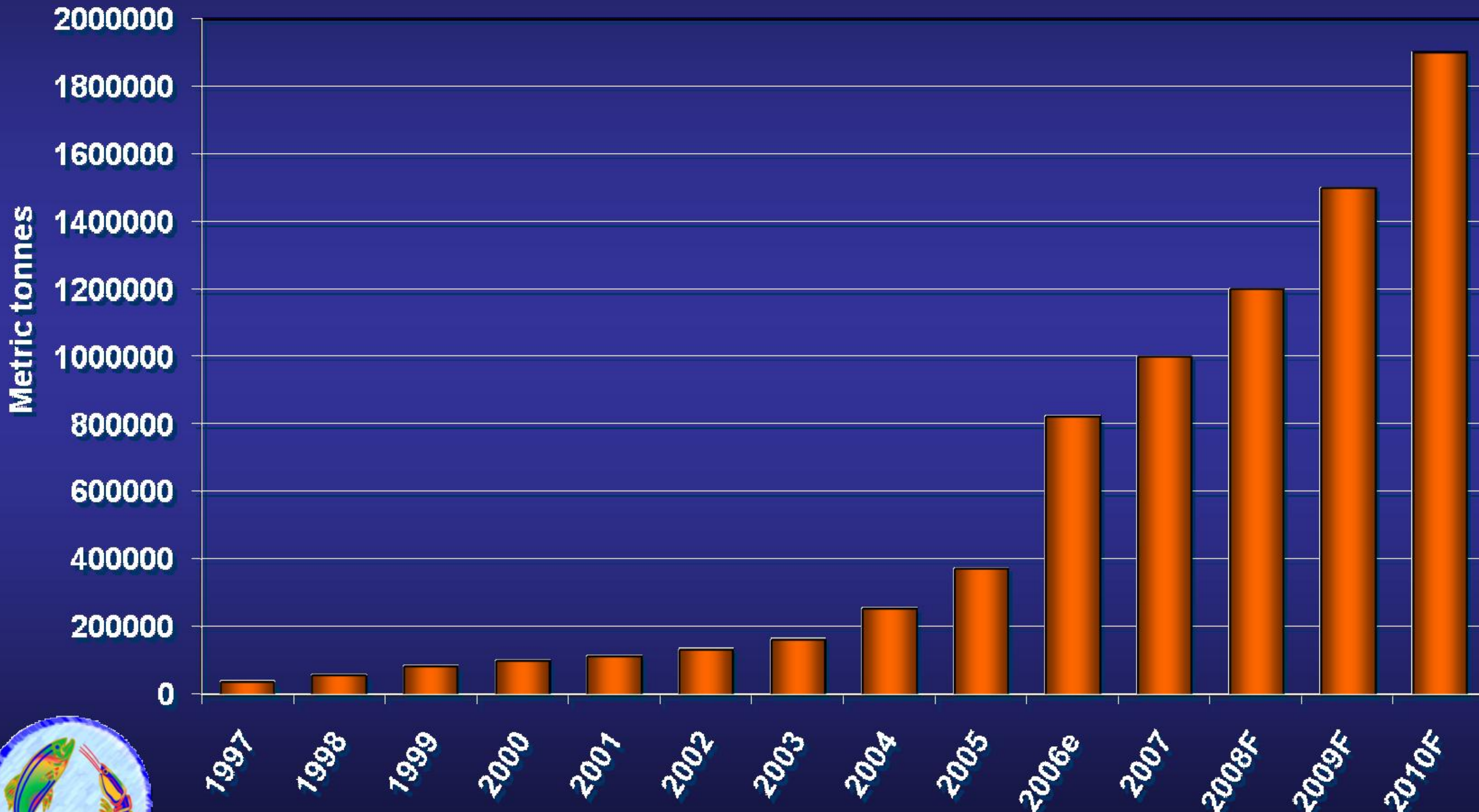
Sources: FAO (1984-2003) , Kevin Fitzsimmons, University of Arizona (2004-2009), Luis Fernando Castillo Campo (Colombia and Mexico), and other anonymous sources

Example: Pangasius

Photo courtesy of VASEP

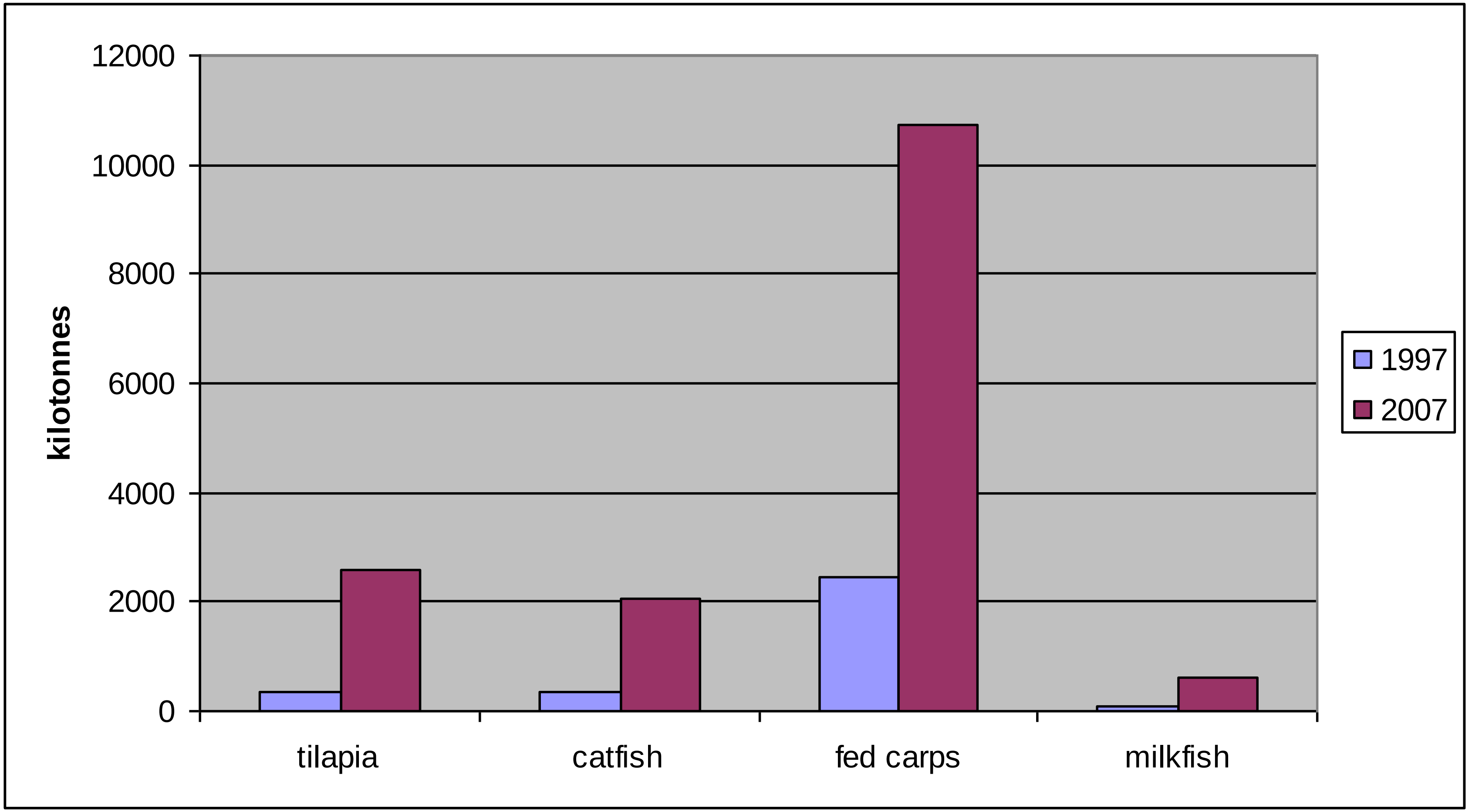
Pangasius Catfish

Production in Vietnam



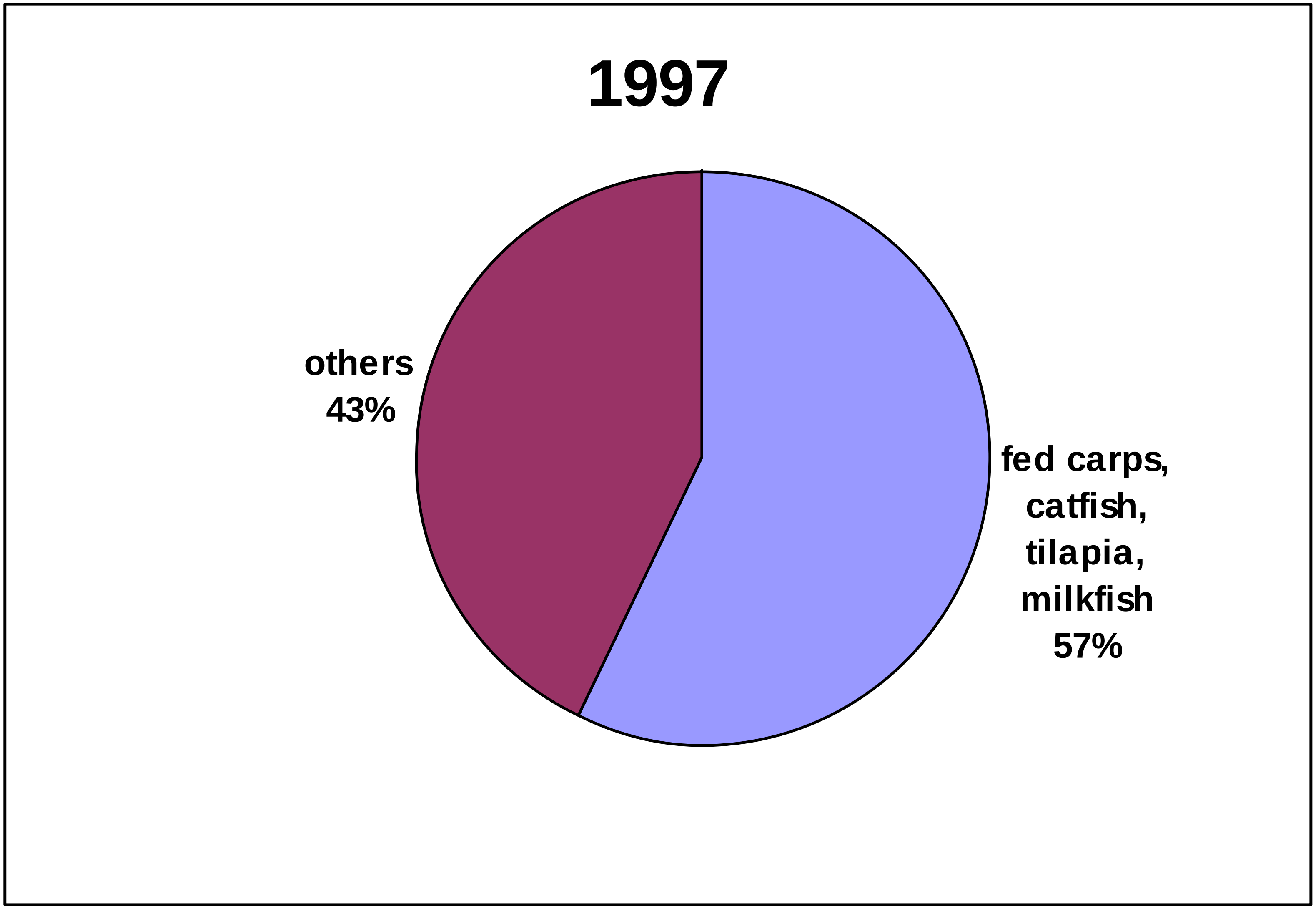
Sources: FAO, Vietnam Association of Seafood Exporters & Producers (VASEP), Globefish market report, anonymous source

Low trophic level fish

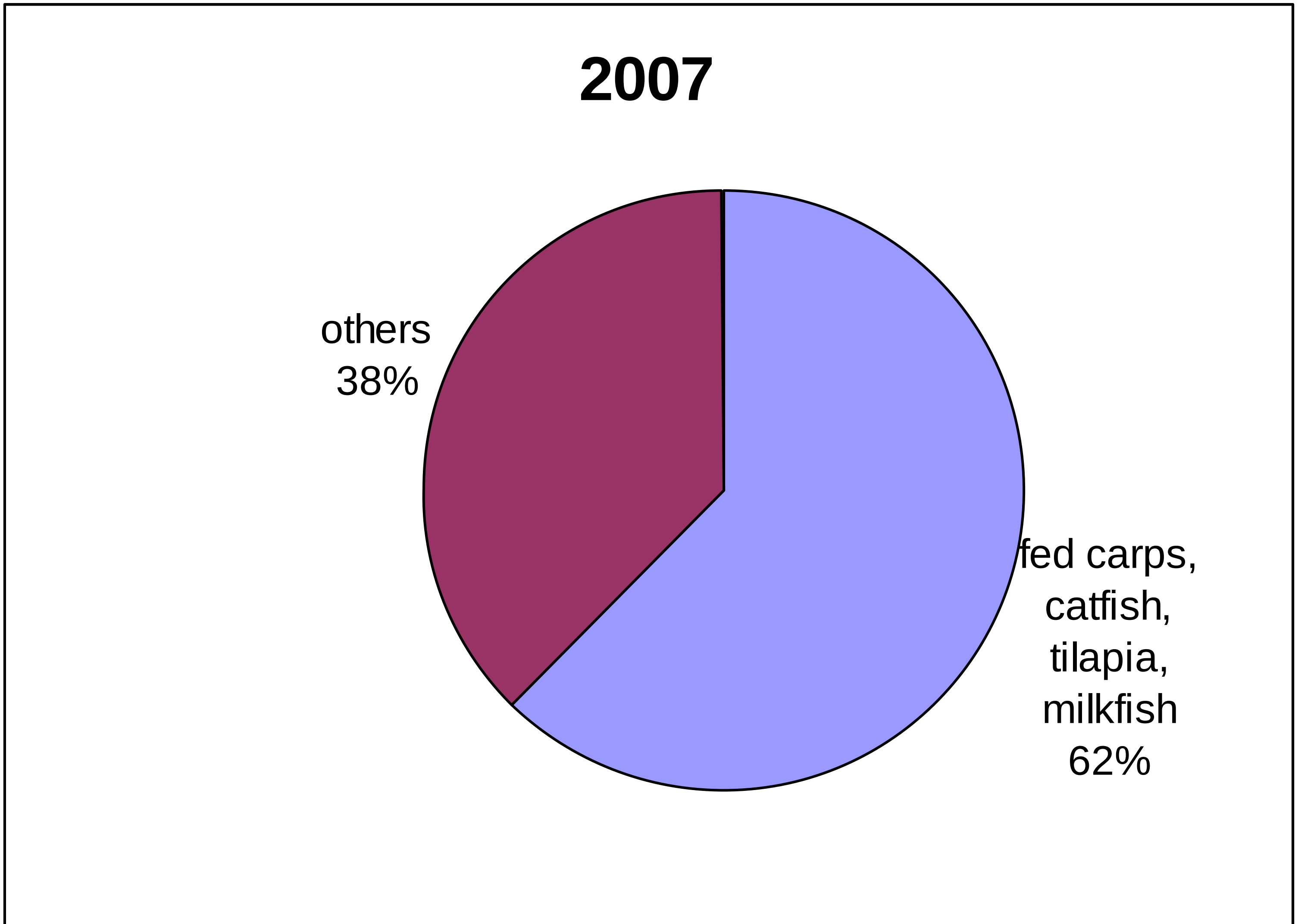


Data from Naylor *et al.* (2000) and Tacon and Metian (2008)

Relative changes



Evidence of farming down the food chain



More efficient shrimp: *Litopenaeus vannamei* vs *Penaeus monodon*

- More efficient feed conversion
- Lower protein and fishmeal content in diet
- Zero water exchange systems
- Closed breeding cycle
- Domesticated, SPF and SPR strains

More efficient use of fish meal and fish oil inputs

Wild fish used in feed for fish and shellfish in 1997*

Species/group	Production with compound diets (kilotonnes)	fishmeal (%)	fish oil (%)	FCR	wild fish used	fish in: fish out ratio
marine finfish	377	50	15	2.2	1944	5.16
eel	117	50	10	2	546	4.69
shrimp	725	30	2	2	2040	2.81
salmon	737	45	25	1.5	2332	3.16
trout	473	35	20	1.5	1164	2.46
tilapia	331	15	1	2	466	1.41
milkfish	78	10	3	2	74	0.94
catfish	351	10	3	1.8	296	0.84
fed carps	2445	8	1	2	1834	0.75
Overall	**5634**				**10696**	**1.90**

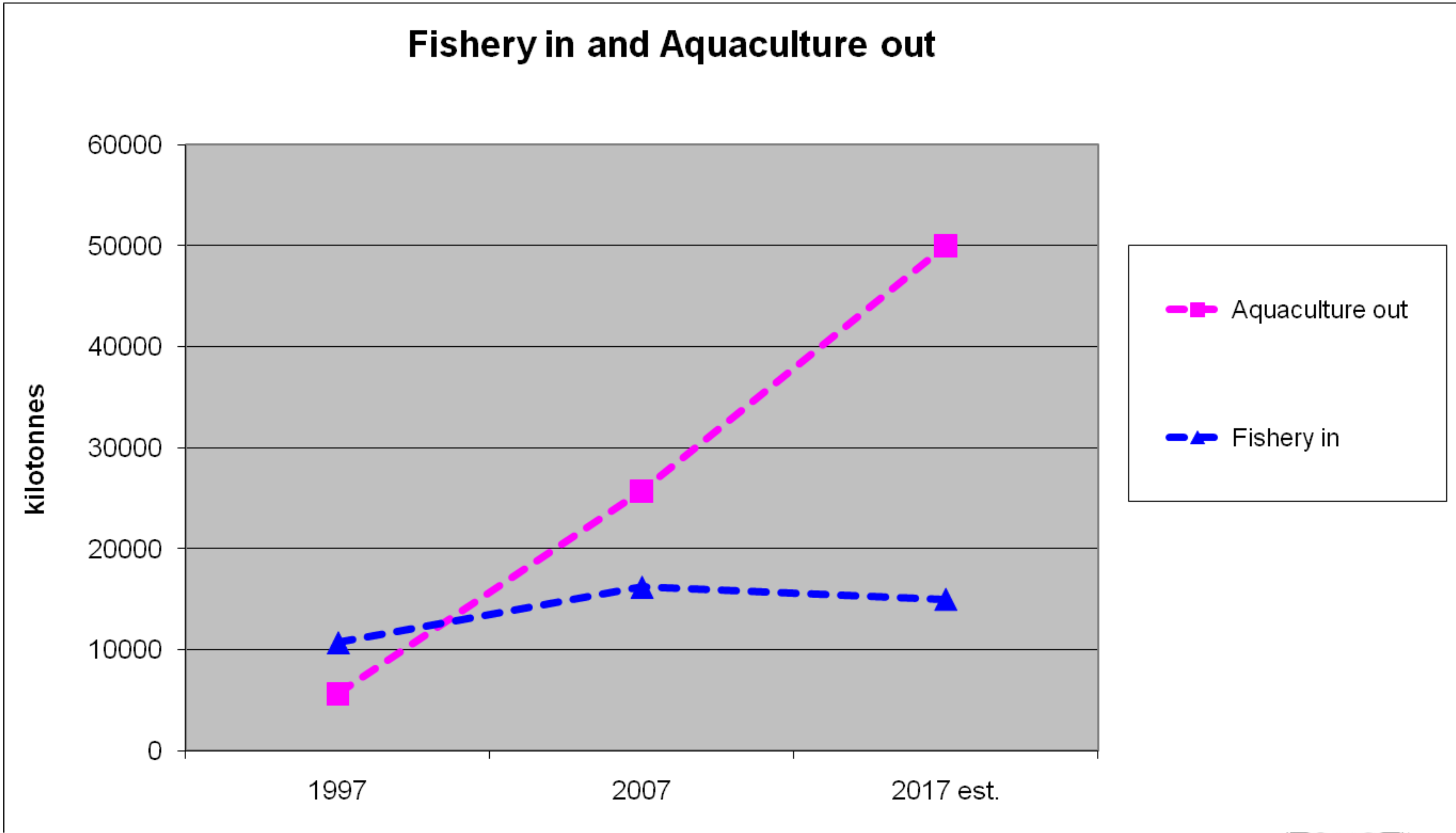
* Naylor *et al.* 2000, excluding filter feeding carps and molluscs

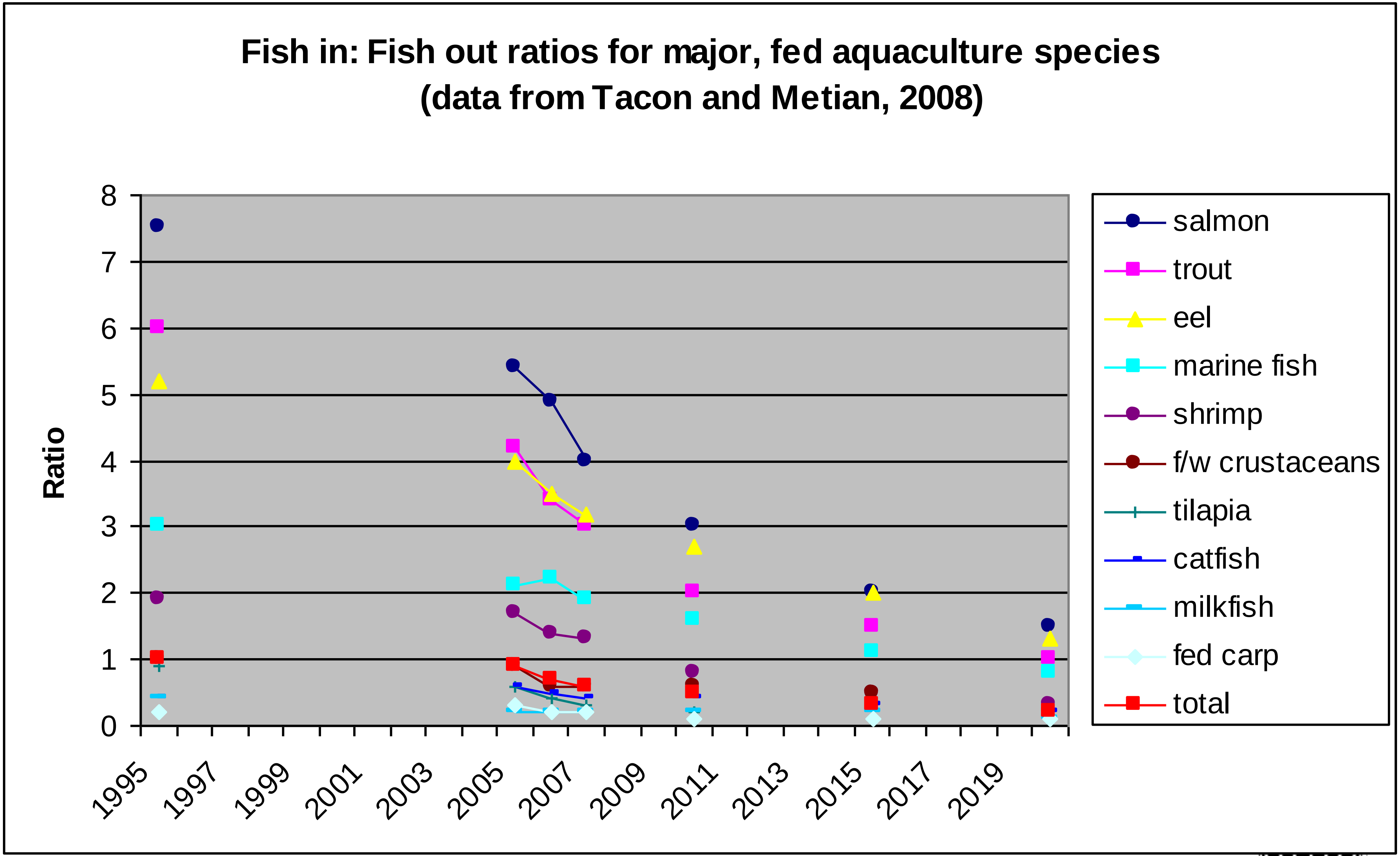
Wild fish used in feed for fish and shellfish in 2007

Species/group	Production with compound diets (kilotonnes)	fishmeal (%)	fish oil (%)	FCR	wild fish used (m.)	wild fish used (o.)	fish in: fish out ratio (m.)	fish in: fish out ratio (o.)
shrimp	3544	18%	2%	1.58	4484	2240	1.27	0.63
marine fish	1690	30%	7%	1.37	3080	3240	1.82	1.92
salmon	1538	24%	16%	1.25	2053	6160	1.33	4.01
trout	683	24%	12%	1.25	911	2040	1.33	2.99
chinese carps	10736	5%	0%	0.80	1906	0	0.18	0.00
catfish	2080	8%	2%	1.08	800	760	0.38	0.37
eel	279	50%	5%	1.43	884	400	3.17	1.43
misc f/w carnivores	855	40%	5%	0.34	516	300	0.60	0.35
f/w crustaceans	1119	14%	2%	0.99	689	340	0.62	0.30
tilapia	2575	5%	0%	1.39	800	0	0.31	0.00
milkfish	608	3%	1%	0.82	67	100	0.11	0.16
Overall	**25707**				**16189**		**0.63**	

Tacon and Metian (2008)

Aquaculture escapes the 'fishmeal trap'!





Fish in: Fish out ratios for major, fed aquaculture species
(data from Tacon and Metian, 2008)
Ratio
0
1
2
3
4
5
6
7
8
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
salmon
trout
eel
marine fish
shrimp
f/w crustaceans
tilapia
catfish
milkfish
fed carp
total

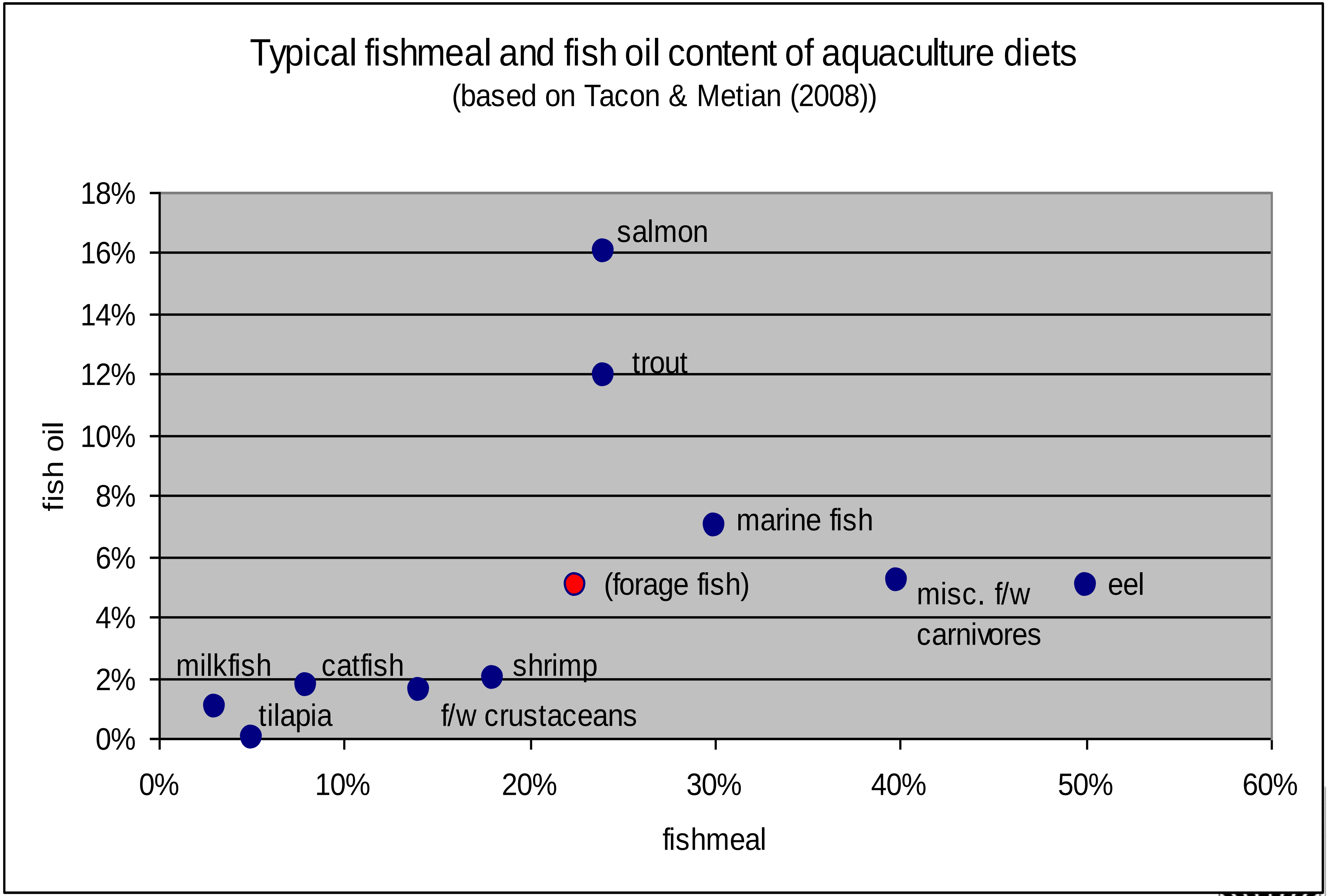
Development of integrated farming systems

Can salmon and shrimp farming be classed as integrated aquaculture ?

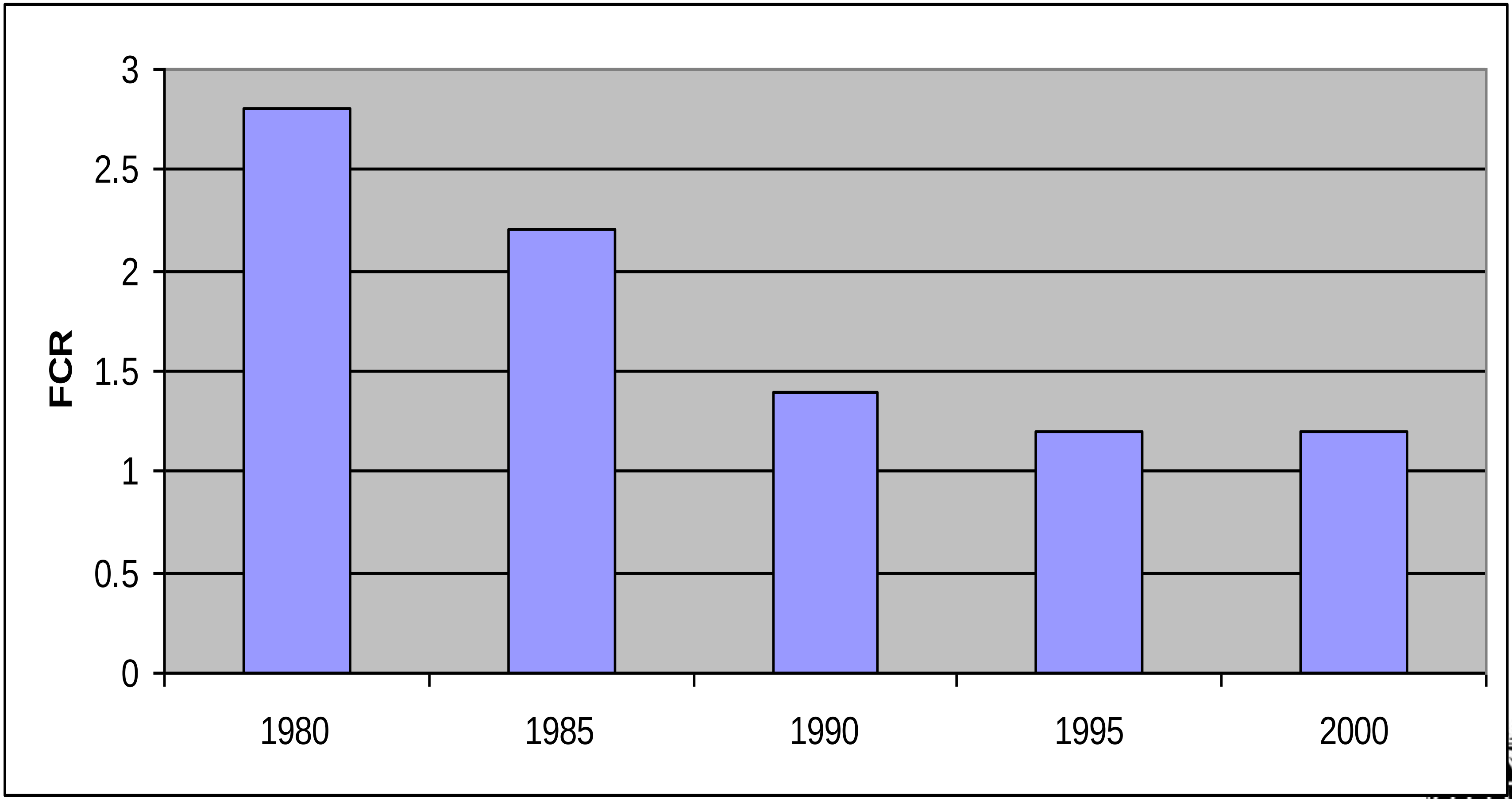
- Integrated Multi-Trophic Aquaculture (IMTA)

  " is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another."

  (definition from Wikipedia)


Typical fishmeal and fish oil content of aquaculture diets
(based on Tacon & Metian (2008))
fish oil
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
salmon
trout
marine fish
(forage fish)
misc. f/w carnivores
eel
milkfish
catfish
shrimp
tilapia
f/w crustaceans
0%
10%
20%
30%
40%
50%
60%
fishmeal

Norwegian salmon: FCRs



Asche and Tveterås (2005)

Aquaculture's ability to respond to disease shocks

- Salmon
  - Better site selection
  - Vaccines
- Shrimp
  - Low and zero water exchange systems
  - Selective breeding of disease-free and disease resistant stocks
- Oysters
  - Introduction of new species

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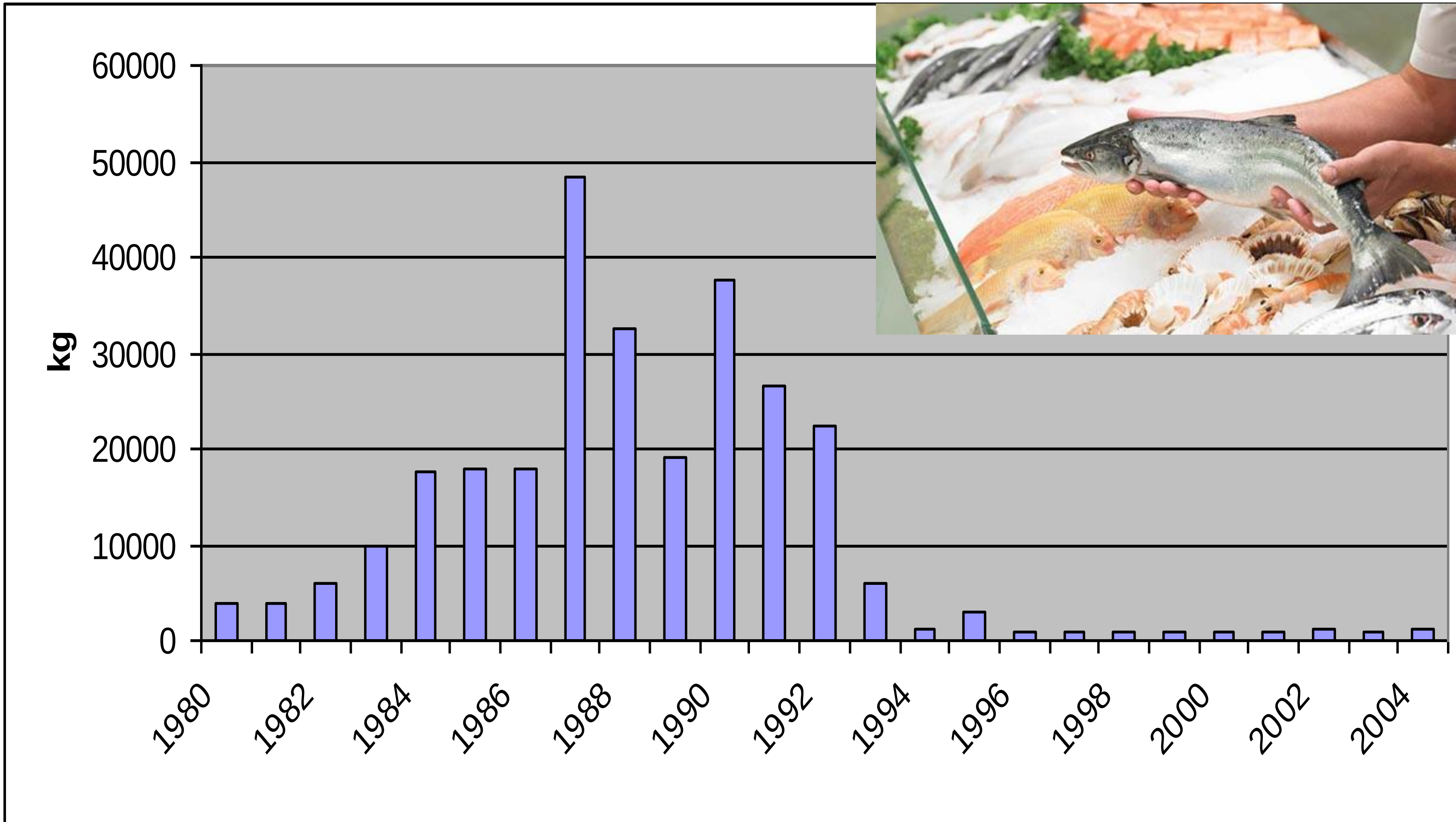
Norwegian salmon: antibiotics



Asche and Tveterås (2005)

Aquaculture responds more quickly than fisheries

Aquaculture

- Property rights for sites and stocks are clearly assigned
- incentives to address many externalities (like disease and pollution)

Problems with fisheries

- Open-access (tragedy of the commons) overfishing
- Government subsidies

Aquaculture:

the best adaptation strategy of fisheries to climate change

Thank You.

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