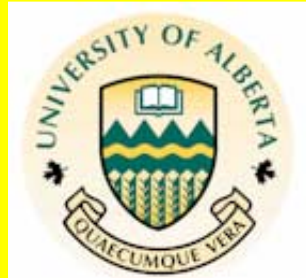


John P. Volpe
Dept. of Biological Sciences
University of Alberta

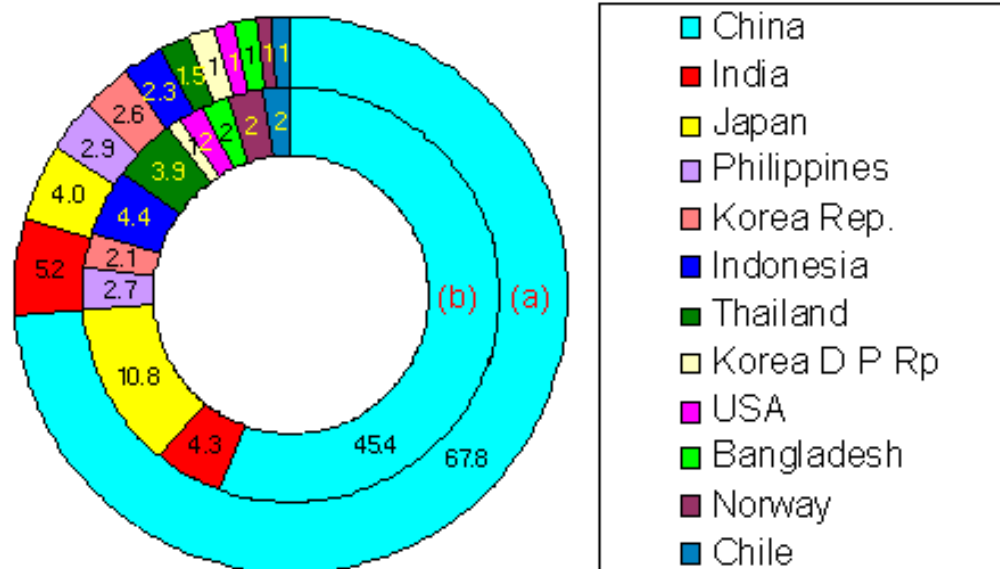


**Salmon Farming by the Numbers:
Understanding modern
industrial aquaculture**

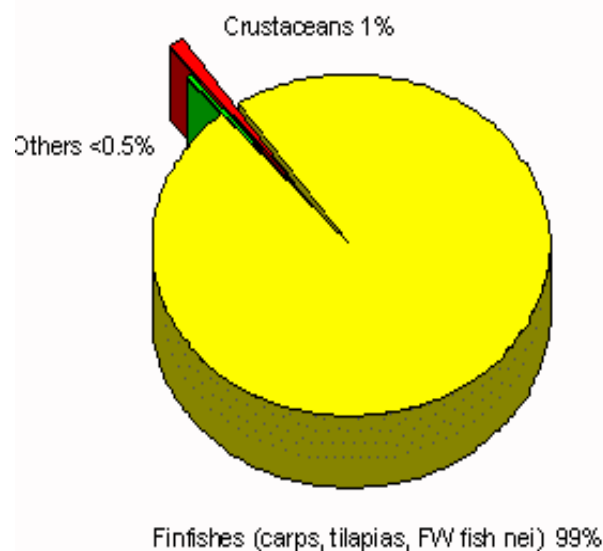


Aquaculture Production Diversity

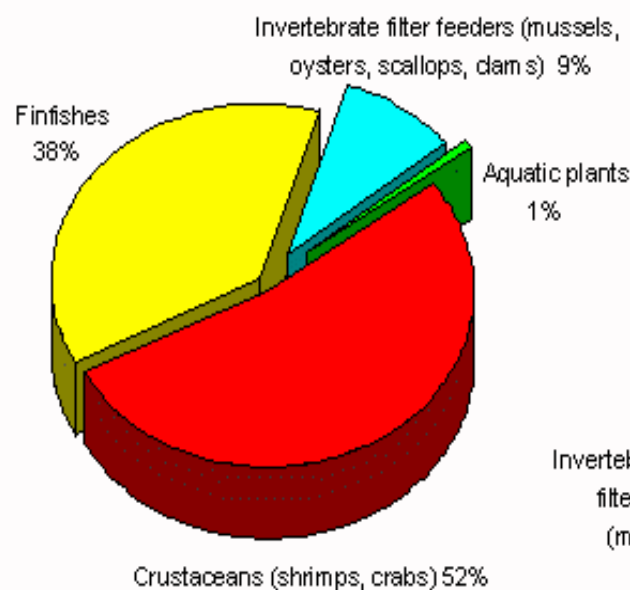
- World production dominated by LIFDCs
- Industrial production of salmonids a minor contributor to world production



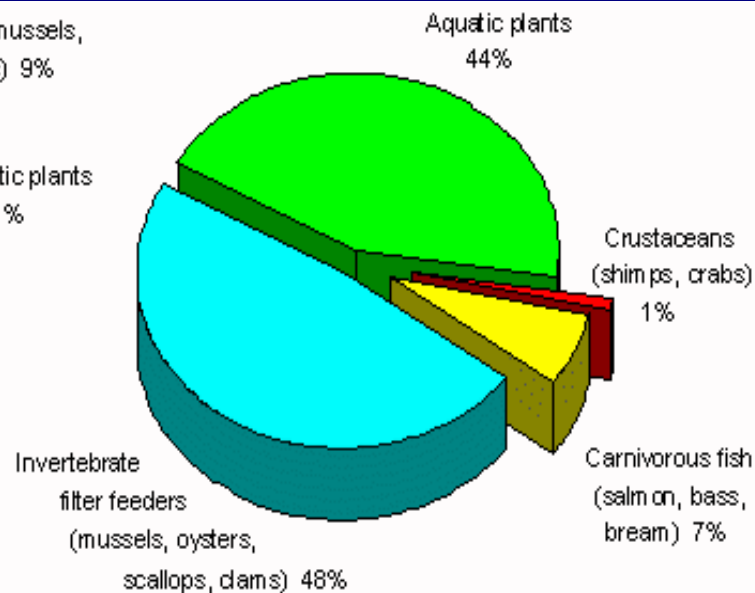
Source: FAO



(a)



(b)



(c)



2002 Production

73,119 tonnes (dressed)

(Capture fishery all salmon spp. 18,800 t)

\$349M farm gate (capture fishery \$50M)

82% Atlantic salmon

BC's largest agricultural export product (80%) - 4th largest salmon producer in the world



ESCAPES



The Explanation Cascade

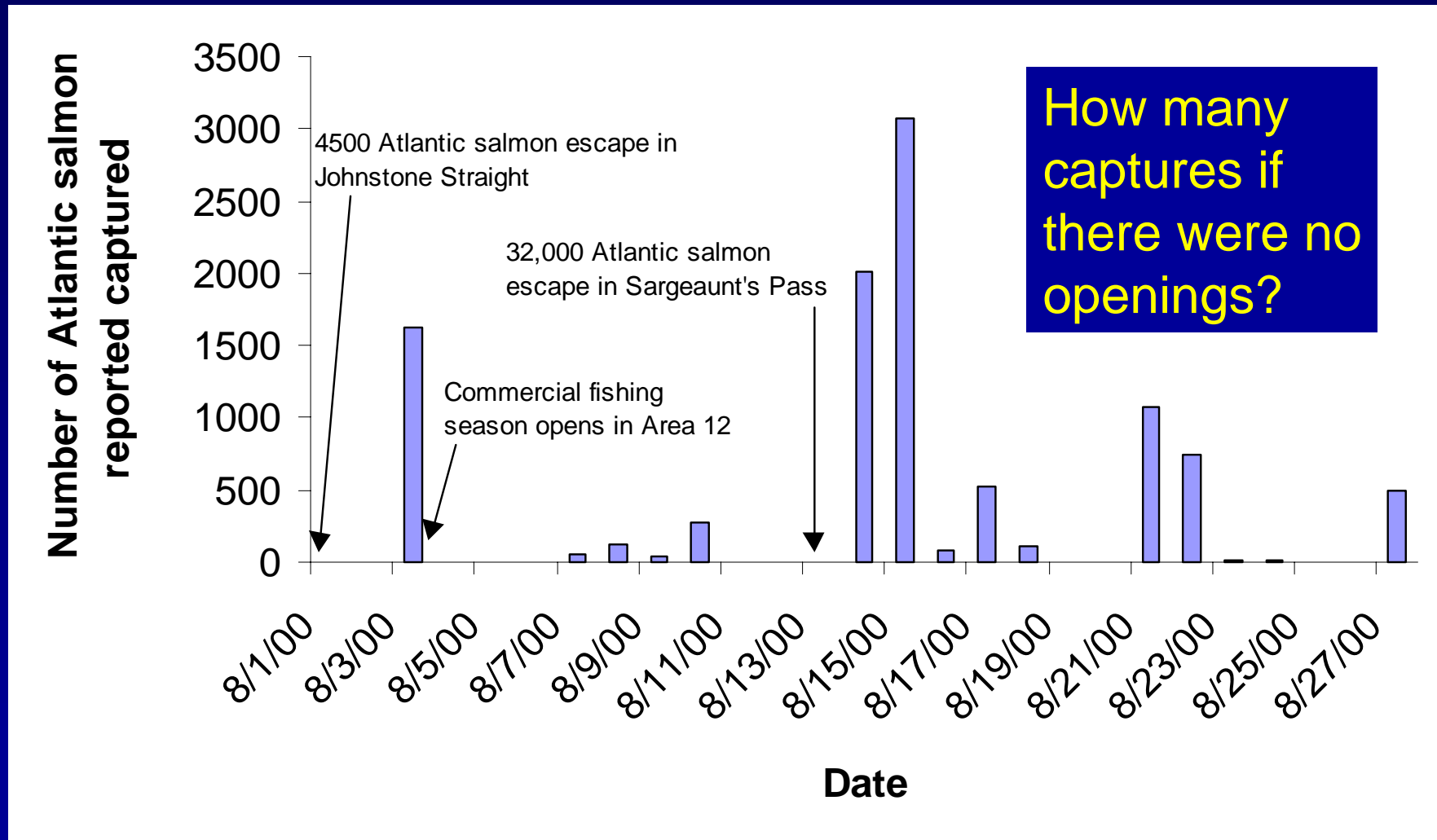
- Escapes of Atlantic salmon are rare
- Escapes of Atlantic salmon are inevitable but they won't survive in the wild
- Some Atlantic salmon may survive but will not ascend freshwater rivers
- Some adult Atlantic salmon are likely to be found in freshwater rivers but can't spawn
- Spawning is likely to occur but progeny will not be competitively viable

And finally, the current position,

- There is no scientific evidence to show that the presence of feral juvenile Atlantic salmon in some rivers pose a threat to native populations.

Two major farm escapes in summer 2000

DFO's passive ASWP = 7833 AS; All BC marine waters, whole year



15 day active survey in only Area 12 = 10,826 AS (+41%)

Atlantic salmon in Competition

+ residency

- residency

**Perform well
relative to steelhead**

**Perform poorly
relative to steelhead**

**1905-1934: Very low likelihood of establishing prior
residency in Vancouver Island rivers**

But,

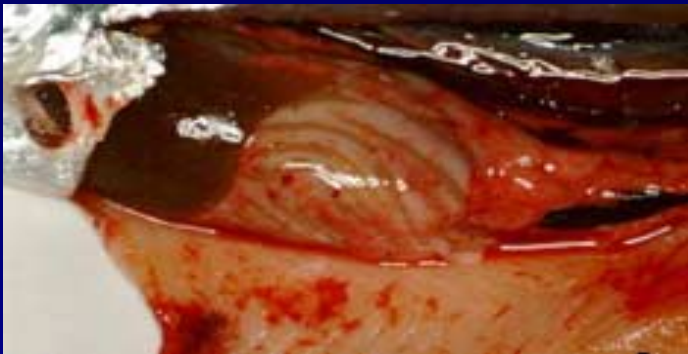
**Today: Vancouver Island steelhead populations are at
~ 10 - 20% of historical abundance**

∴

**Potential for successful colonization is likely much
higher today than during historical intentional introductions**



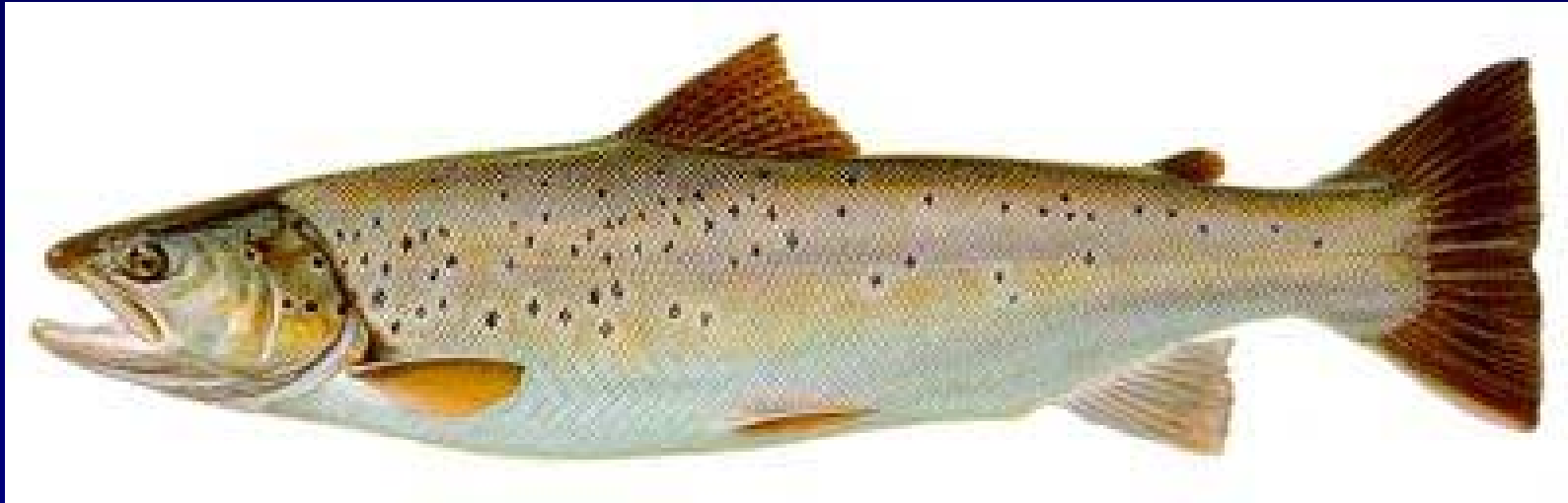
**Chinook salmon smolt
July 31, 2001
Broughton Archipelago**



Disease



Sea Lice







June 15, 2006
Tribune channel



Denham Island
June 12, 2001



Old Pass June 11, 2001



Pink salmon from non-exposed control site
Bond Sound salinity 25%
June 2001

- Per capita mean lice load prior to farm exposure <1 ; After >6
- Population collapse largely restricted to those populations exposed to farms in Broughton Archipelago (98% collapse)

Parasite epidemiology – *Sea lice*



Species specific susceptibility and mortality

Lice footprint of farms

Temporal / spatial structured epidemiological model of lice spread as a function of farm size and location

Rosette agent

- attacks spleen and kidney
- decimated farm Atlantic salmon on east coast and chinook susceptible too

***Neoparamoeba pemaquidensis* (amoebic gill disease)**

- devastating farmed Atlantic salmon and rainbow trout in Tasmania
- found in coho salmon in netpens in Washington St.
- *N. pemaquidensis* is nearly ubiquitous in sea water

***Ceratothoa gaudichaudii* (isopod)**

- impacted several Chilean netpen sites - both coho and Atlantic salmon.
- *C. gaudicaudii* attaches to the inner mouth surface and gills where it feeds on host blood.



Habitat Impacts



i) Sulphide levels accurately and precisely portray system functions

“...the use of a single parameter does not adequately address the subject of ecosystem function”

PFRCC, Senate Briefing Notes March 18 2003

1300 micromols is a ‘trigger’ level and
4500 – 6000 micromols is the ‘standard’ level for penalties

ii) Background sulphide levels are invariable

Background levels vary from 1 -1000 micromols in the absence of salmon farms

iii) Trigger and Standard levels set conservatively

Trigger level = 50% of overall biodiversity is lost
90% of bottom dwelling fauna made up of
6 species (worms)

Standard level = Toxic to even sulphide tolerant organisms



Organic Inputs

Salmon, unlike all other cultured “farm” animals (save shrimp) are carnivorous – feed is 45% fishmeal and 25% fish oil.

2.8 kg wild fish to produce 1 kg farm fish
(+ by-catch)

∴ The marine area required to produce the feed consumed in a salmon farm is 40,000 to 50,000 times the production area

The European industry (production leaders) consume the equivalent of 90% of the North Sea’s 1^o production

The current BC industry consumes the biological productivity of ~ 7.8 million hectares of ocean (278 times the area of all terrestrial horticulture in BC)

Inputs

Energy

	Industrial Energy Inputs per round tonne (litres of diesel equivalent)	Greenhouse Gas Emissions (tonnes of CO ₂ equivalent per round tonne) ¹
Cultured Atlantic	2,612	6.5
Cultured Chinook	3,244	8.0
Captured Chinook	977	2.0
Captured Coho	1,144	2.9
Captured Sockeye	755	2.3
Captured Chum	665	2.0
Captured Pink	616	1.8

1989 – 75 companies
1997 – 15 companies
2003 – 11 companies

Five multinationals control
109 of 131 (83%) farm licenses
and 82% of production

<u>NAME</u>	<u>#BC LIC.</u>	<u>BASE</u>	<u>2001 Assets</u>	<u>2001 Rev</u>
Stolt-Nielson (Stolt)	28	Norway	\$5.7 billion	\$3.9 billion
Pan Fish (Omega)	27	Norway	\$1.7 billion	\$1.1 billion
Nutreco (Marine Harvest)	21	Netherlands	\$3.1 billion	\$6.0 billion
Cermaq (Cermaq)	18	Norway	\$1.6 billion	\$1.4 billion
Geo. Weston (Heritage)	15	Canada	\$16.3billion	\$24.7billion

GDP of Marine – Based Industries 2001

<u>Sector</u>	<u>GDP(\$Million)</u>
Salmon Aquaculture	87 (7.6%)
Fish Processing	102 (9.0%)
Sport Fishing (marine)	134 (11.8%)
Commercial Fisheries	164 (14.4%)
Marine Tourism	182* (16.0%)
\$582 M (51.1%)	
Total BC Provincial GDP	113,849

Employment and Income in BC Marine – Based Industries 2001

<u>Sector</u>	<u># Employed</u>	<u>Salaries (\$Million)</u>
Aquaculture	1,900	37
Fish Processing	3,900	152
Marine Tourism	4,300	134
Sport Fishery (Marine)	4,700	72
Commercial Fishery	5,400	62

Wild Marine Fisheries

Salmon Aquaculture

GDP (\$ Million)

396

91

People Employed

13,844

1,936

Wages (\$ Million)

280

40

Exports (\$Million)

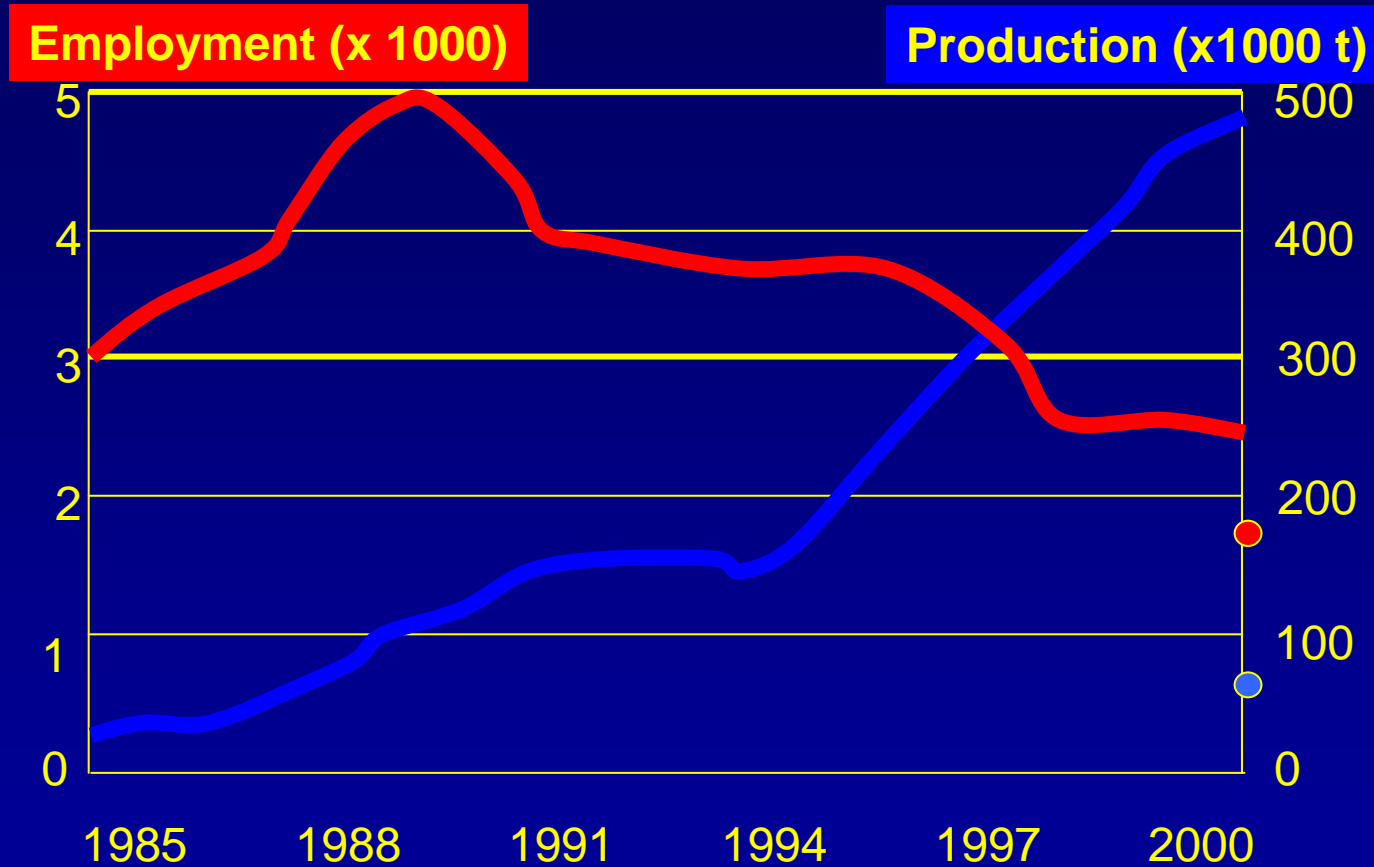
944

273

2000 – 02 BC production up 68%

Employment up 5.8%

The Norway Experience 1985 - 2000



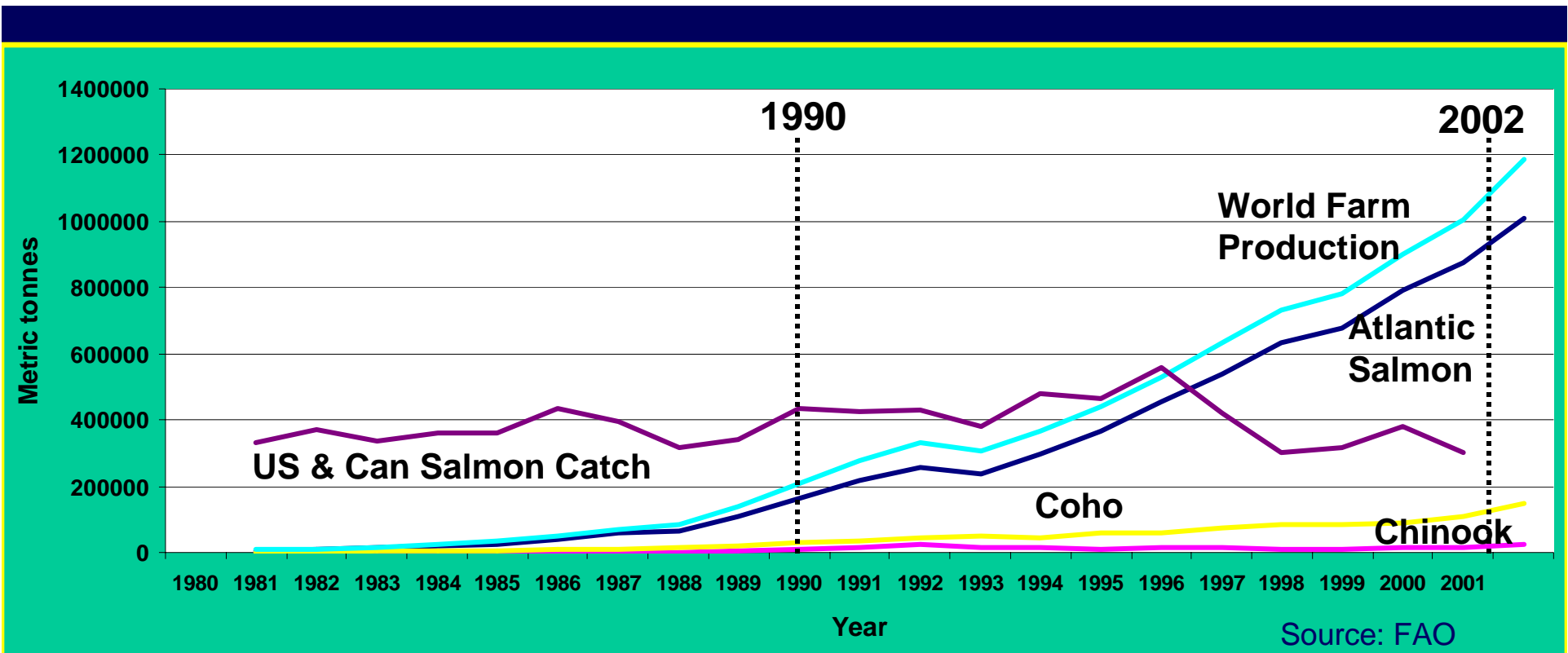
Production per FTE: Norway 196 tonnes BC 38 tonnes
Therefore Norway is currently >5x more efficient

World salmon production (metric t) by country

	<u>1996</u>	<u>2002</u>
Chile	135,300	454,400
Norway	280,600	480,000
Scotland	74,700	141,000
BC	25,000	73,000
Faroe Islands	-----	56,000

Chilean production in 2002 – 454,000 tonnes (depreciation of Chilean currency and modest regulatory regime)

- Production increase results in unit value drop ... leading to;
- i) offload production costs (mechanization, natural subsidies)
 - ii) increase overall production



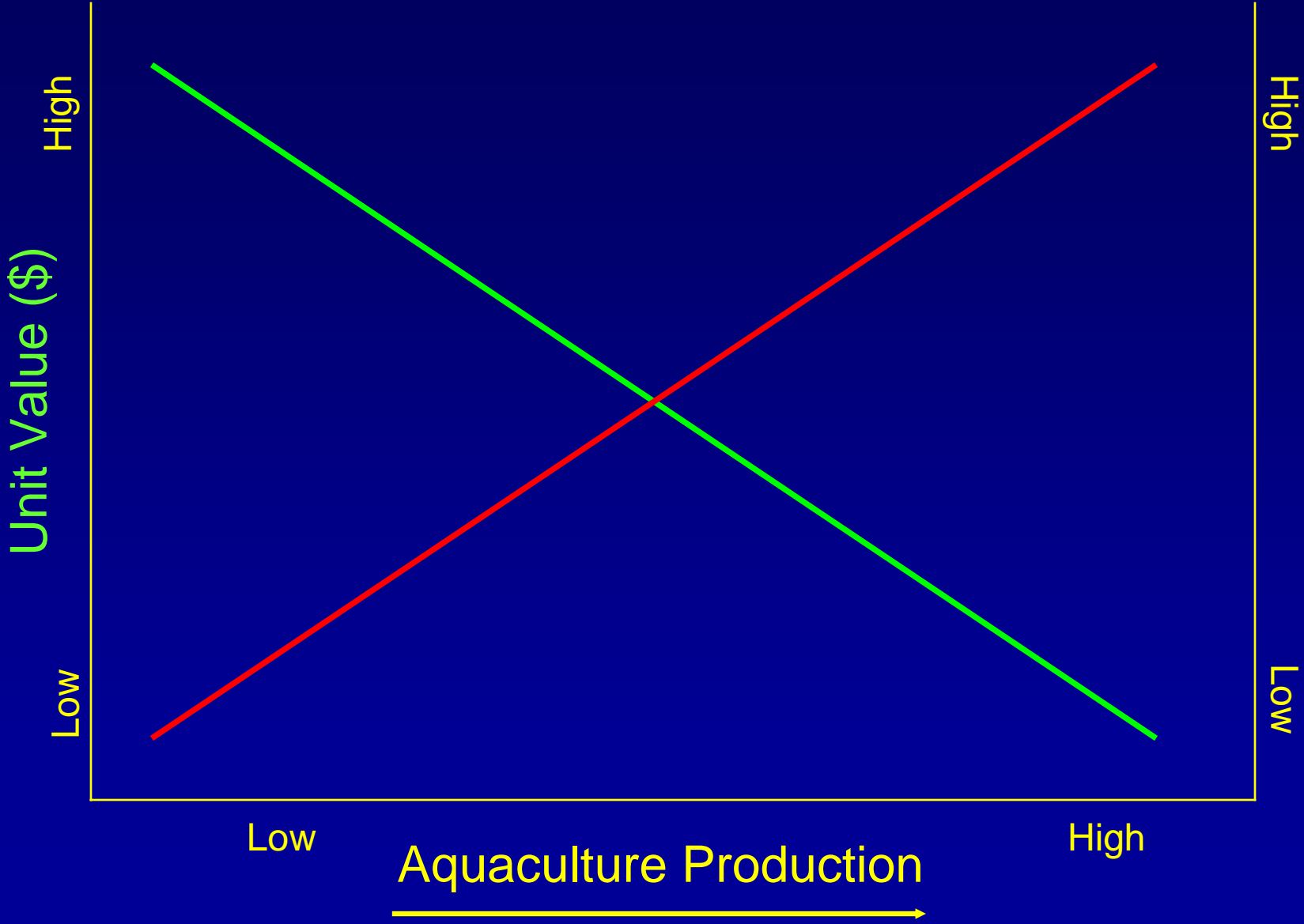
	<u>1990</u>	<u>2002</u>
Prince William Sound		
<i>Purse Seine</i>	\$273,000	\$20,000
Bristol Bay		
<i>Gillnet</i>	\$216,000	\$20,000
South-East Alaska Region		
<i>Purse Seine</i>	\$110,000	\$23,000

Species	1988 Production 1000 mt*	2002 Production 1000 mt*	1988 Ex-vessel US\$ / lb*	2002 Ex-vessel US\$ / lb*	% Change
Chinook	23.4	12.9	2.69	1.23	-45 -54
Chum	90.0	57.9	0.86	0.16	-36 -81
Coho	24.5	17.9	1.72	0.37	-27 -78
Pink	112.2	124.1	0.79	0.06	+11 -92
Sockeye	95.8	70.5	2.37	0.55	-26 -77
Farm Atlantic	0.08	78.6	3.11	1.21	+98,250 -61

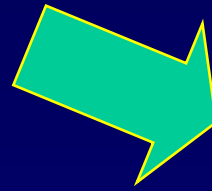
*US + Canada values

Source: Naylor et al. 2003; NMFS; BCMAFF; BCSFA; FAO

Environmental & Social Impacts



High value species
(value correlated
to availability)

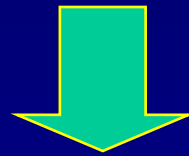


Commercial
Culture

\$\$\$

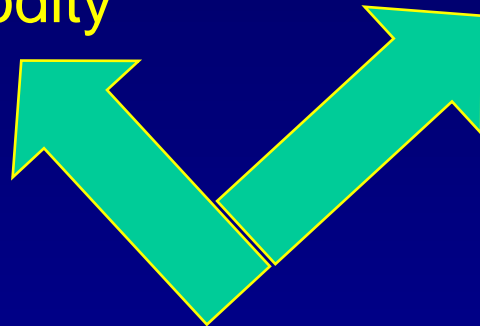
Low value
commodity

Industry
rationalization

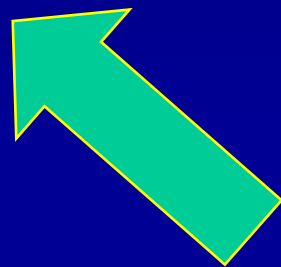


-ve Social
&
Enviro

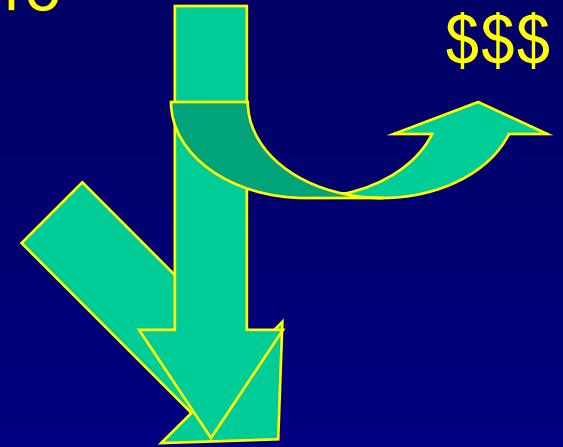
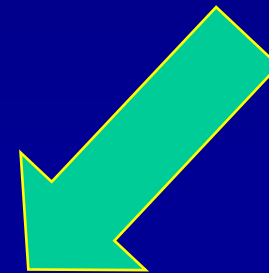
Production increase



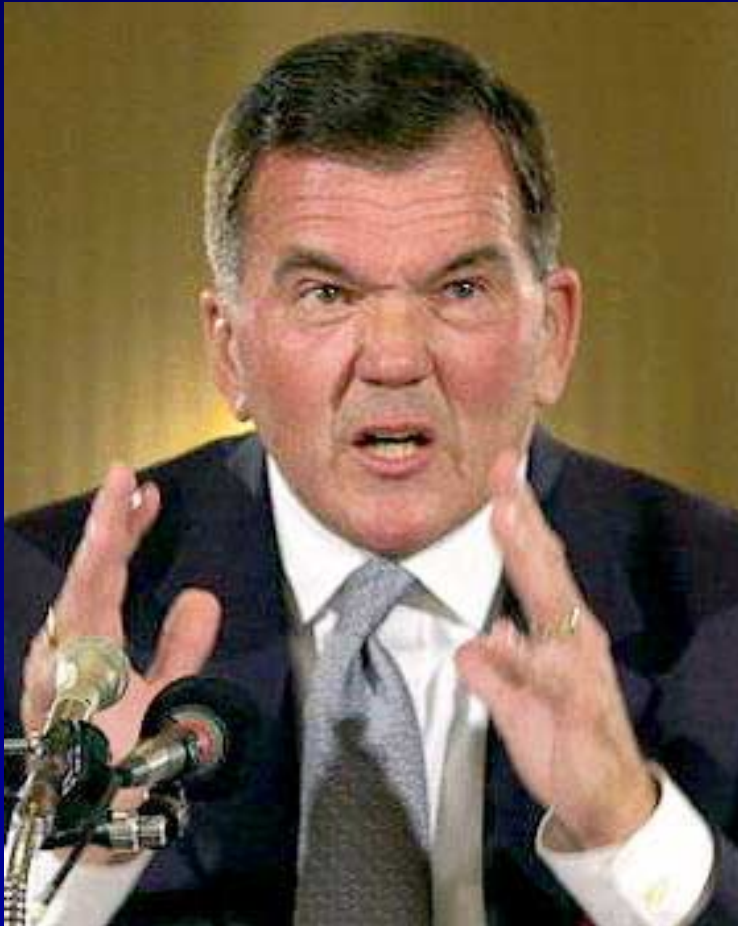
Unit value drops



Market
globalization



The newest disciple of the “Blue Revolution”?



Tom Ridge
Office of Homeland Security

US International Trade Deficit

- 1) Oil
- 2) Cars
- 3) Seafood

State resistance – WA, OR, CA



Privatization of the EEZ



Amberjack
4.5 FL, HI



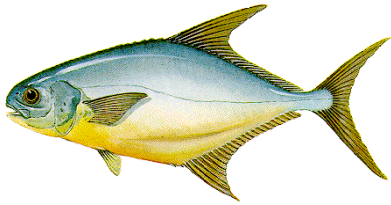
Red Snapper
4.1 FL



Red Drum
4.3 AL, FL, TX



Cobia
4.5 FL, PR



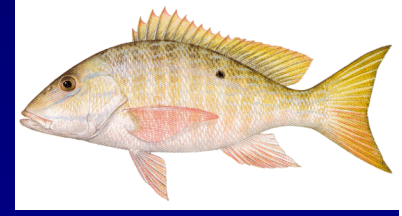
Florida Pompano
3.8 FL



Atlantic salmon
4.2



Summer Flounder
4.5 NH



Mutton Snapper
3.9 PR



Halibut
4.2 NH



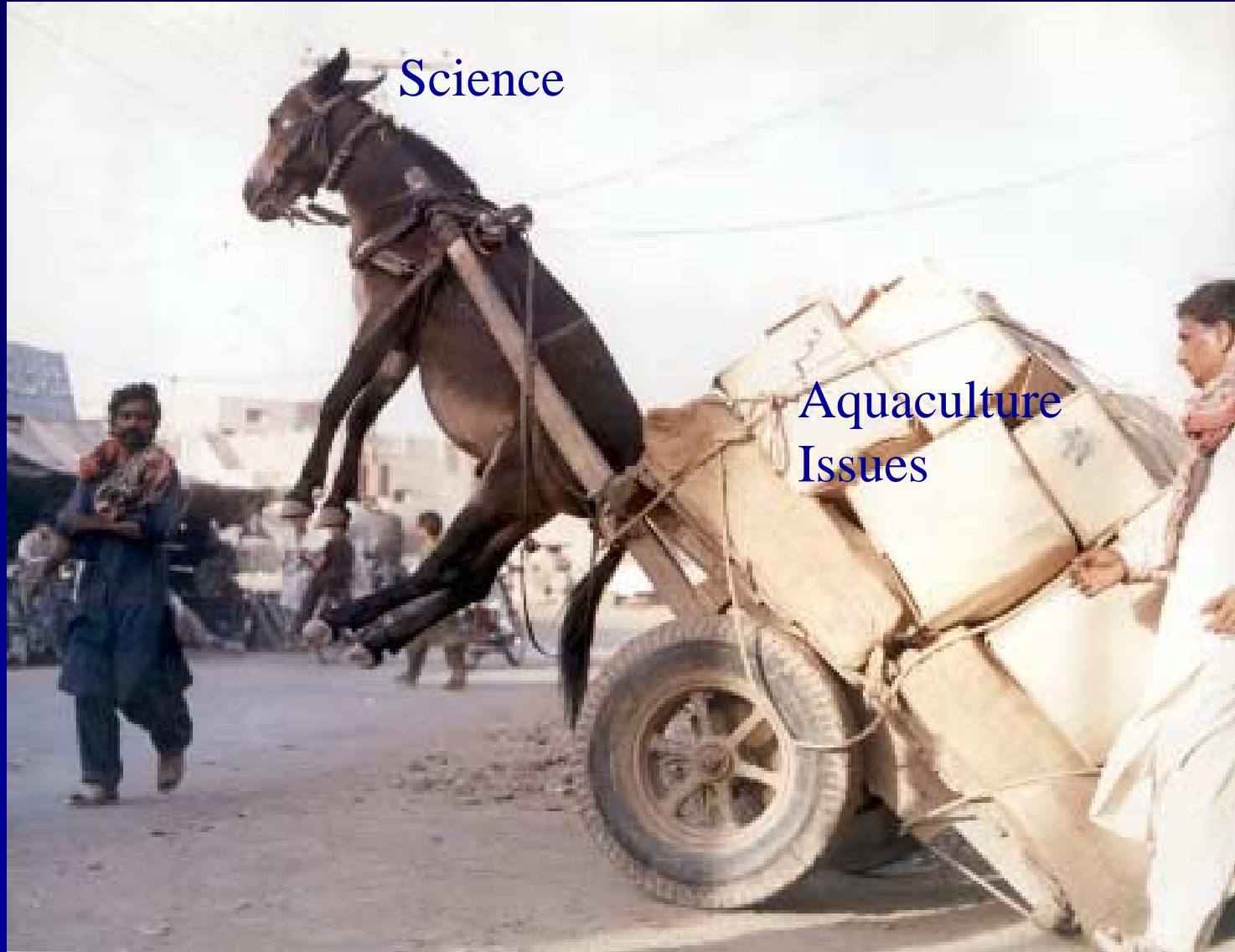
Pacific Threadfin
3.8 HI



Atlantic Cod
4.3 NH



Haddock
3.5 NH



Science

Aquaculture
Issues