

Aquaculture: Fact and Fiction



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Role of Aquaculture in Meeting Global Seafood Demand
June 2005
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Contents

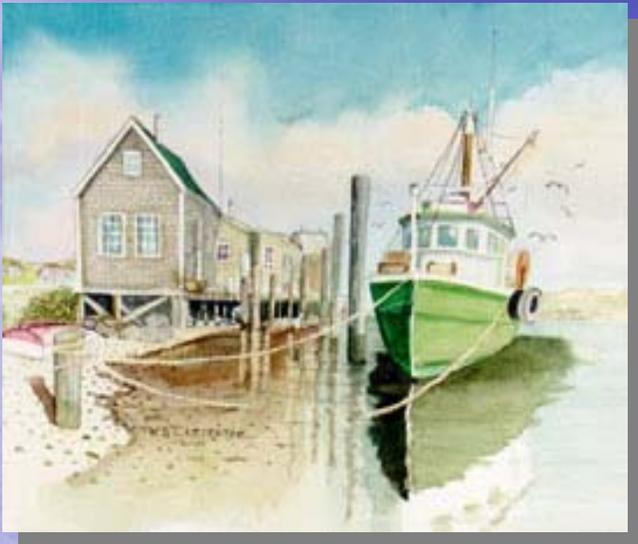


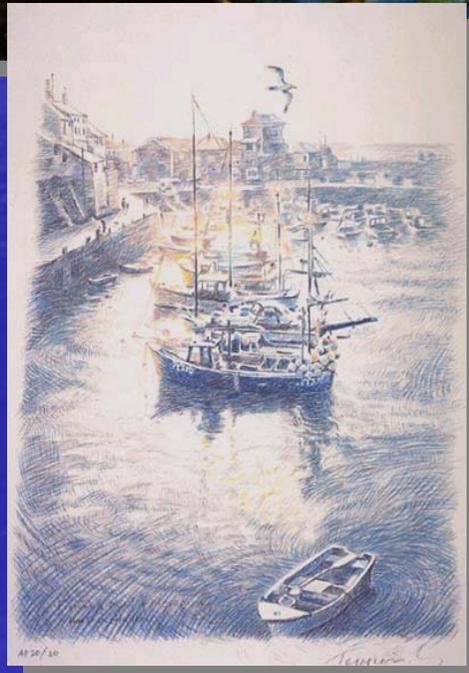
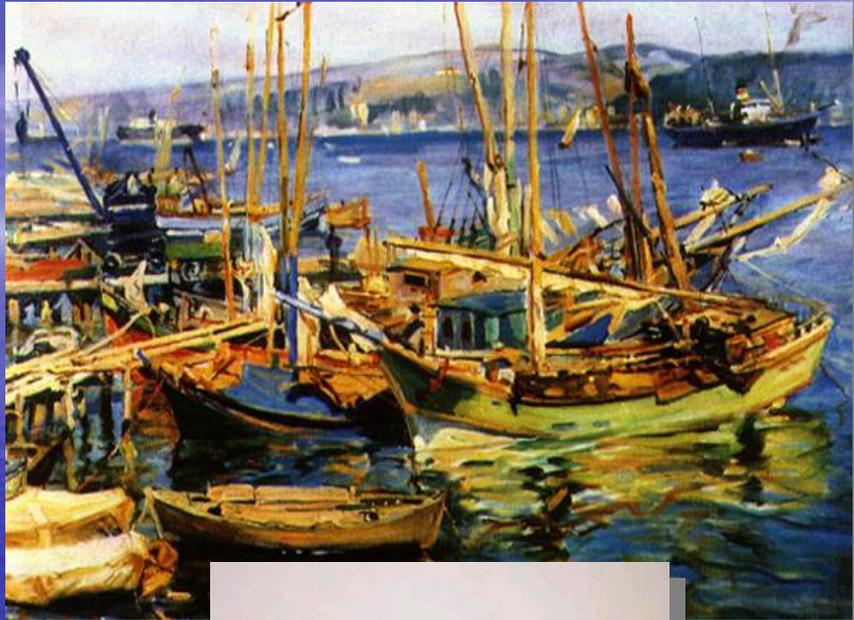
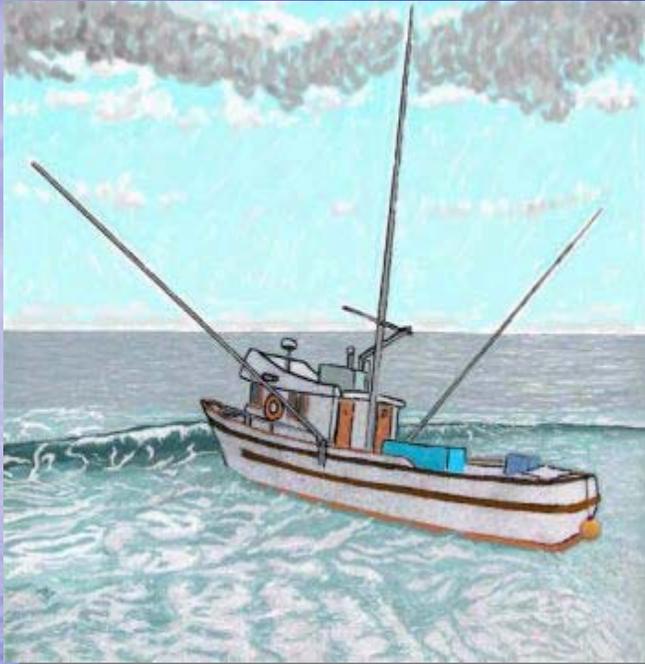
- Fisheries tradition
- Aquaculture around the globe
- US Aquaculture
- Salmon Farming
- Salmon farming issues
- Conclusion

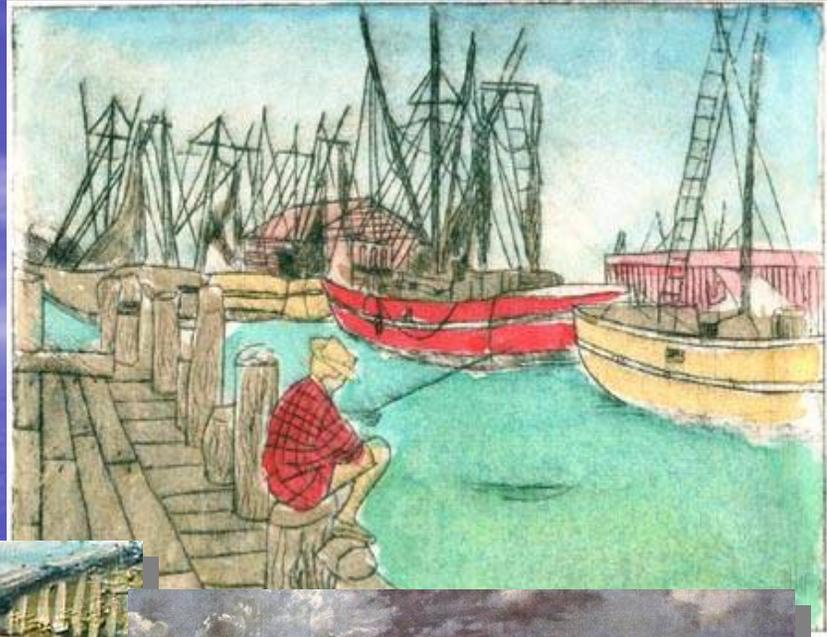
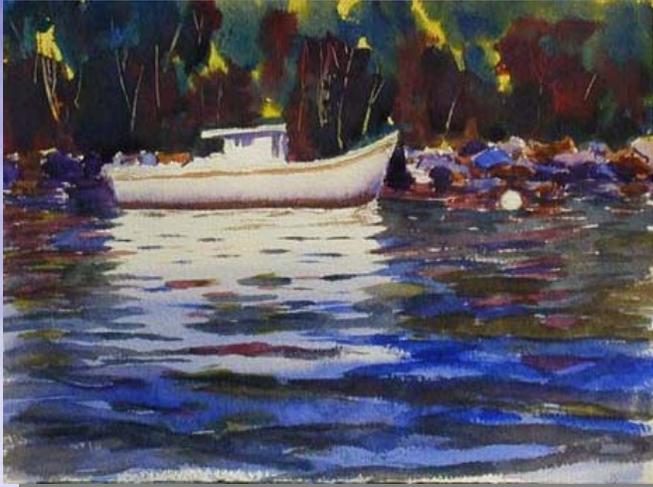


FISHING HAS TRADITION, FAMILIARITY, LORE and ROMANCE



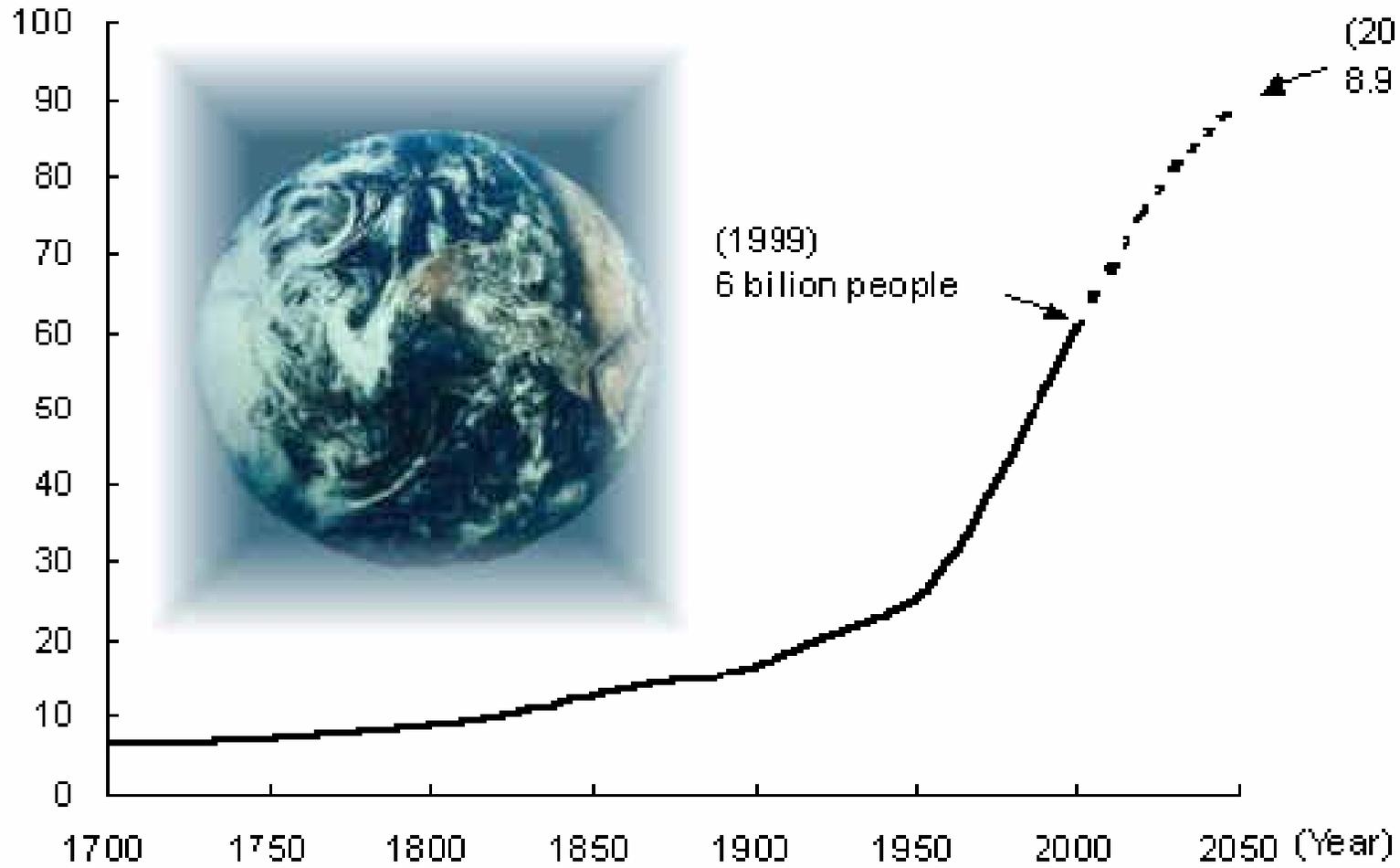








(100 million people)





"In his exploitation of the sea man is still a barbarian, a ruthless hunter slaughtering whole species of animals without heeding the consequences. With earth's burgeoning human populations to feed we must turn to the sea with new understanding and new technology. We need to farm it as we farm the land. This is called mariculture. It has just begun. ... In such controlled volumes the ideal conditions can be maintained all year and by ensuring fertilization and protecting the larvae from predators, incredibly high yields can be obtained from a number of protein-rich populations. **High efficiency sea farms totalling the size of Switzerland would produce more food than all fisheries combined.**"

Jacques Cousteau, 1973



Is Aquaculture the Future of Seafood?



Aquaculture (w. plants) value

- 2001: 49.8 mill. MT and \$60.9 billion USD

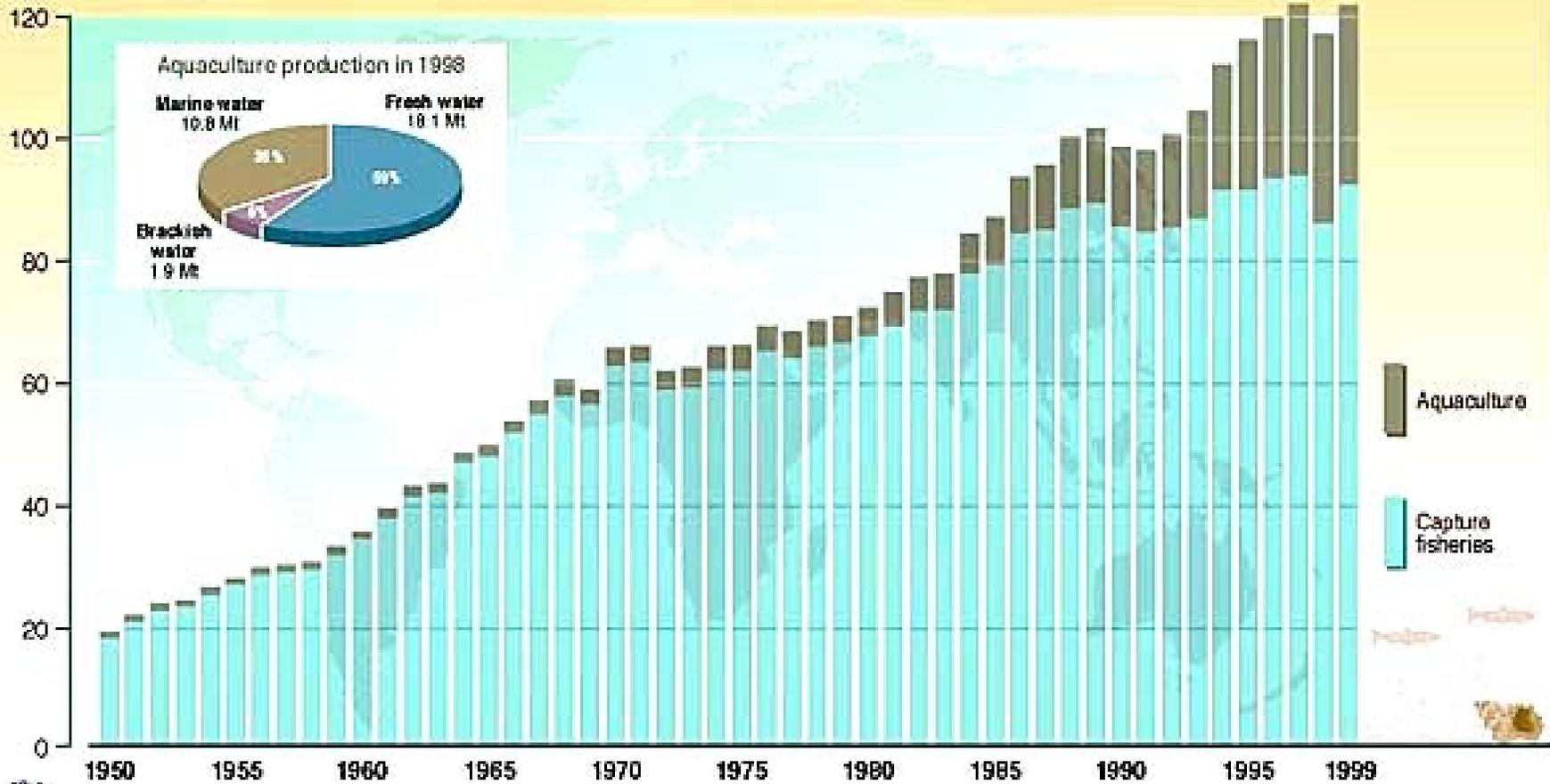
Capture fisheries (stable since 1995):

- 2001: 92 mill. MT



Global Capture Fisheries and Aquaculture Production, 1950-1999

Million tonnes (Mt)



WORLD AQUACULTURE
TRENDS 2002

Source: *The State of World Fisheries and Aquaculture 2000*, Food and Agriculture Organisation of the United Nations (FAO)



**FAO conservatively predicts
that aquaculture production
will double to**

80 million MT by 2030.



Global annual per capita consumption: 16 to 20 kg by 2030





Definition of "Aquaculture":

"Aquaculture involves the managed reproduction and grow out of aquatic animals (+/- plants) under controlled conditions."



("MARICULTURE": Marine aquaculture)



AQUACULTURE

- ▶ ~ 300 sp. cultured world-wide
- ▶ 29 species comprise 78% of global production

2 key criteria define aquaculture:

- ▶ Ownership
- ▶ Intervention in production cycle



From FAO's:

State of the World Fisheries and Aquaculture Report, 2002

<http://www.fao.org/DOCREP/005/Y7300E/Y7300E00.htm>

- Growing more rapidly than all other animal food producing sectors
- % of total fish production:

1970: 3.9%

2000: 27.3%

2001: 29%



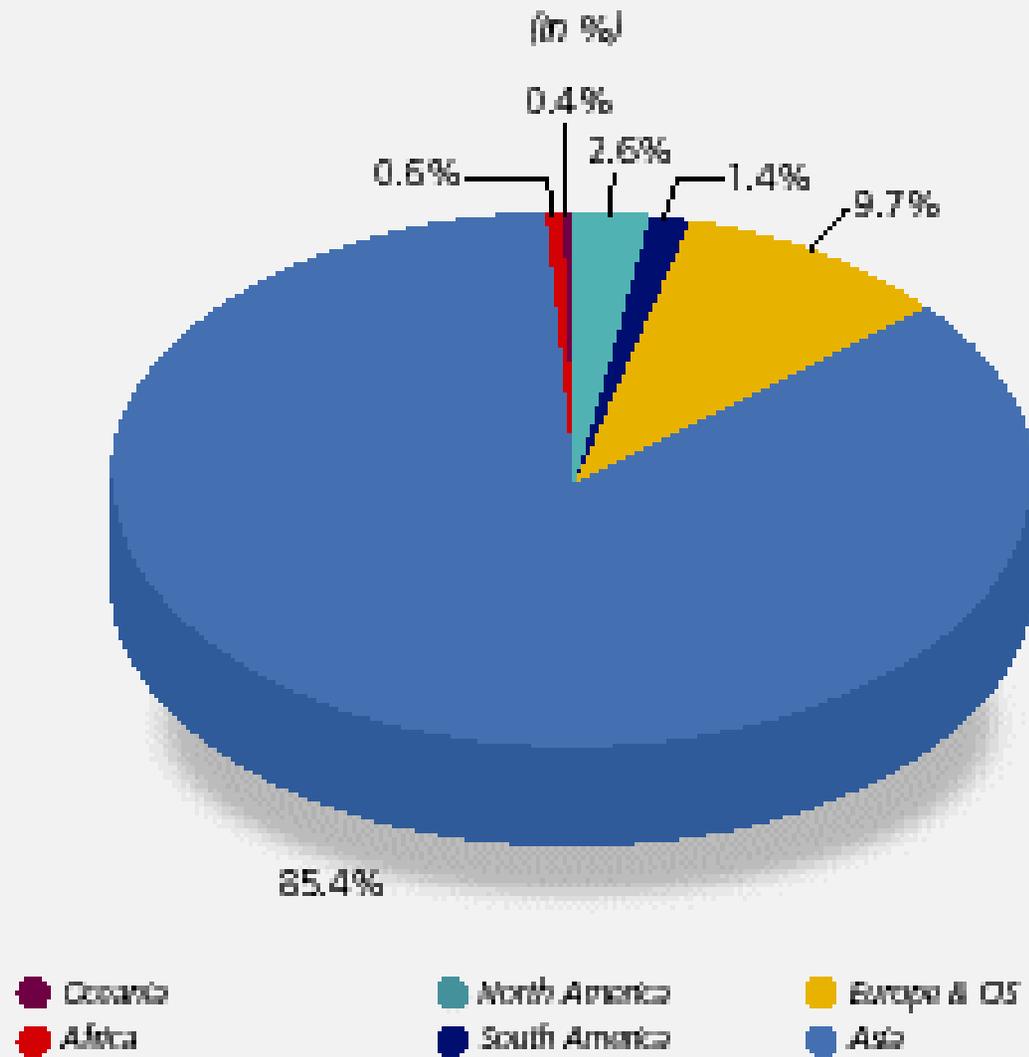
Comparison with other animal protein sources



- Average compounded rate of increase since 1970
 - Aquaculture 9.2%
 - Capture fisheries 1.4%
 - Terrestrial farmed meat 2.8%



Share of the world seafarming production

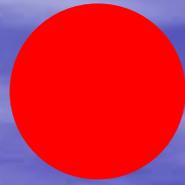


Asia

- continues to be the powerhouse of the aquaculture industry.
- 11 of top 20 aquaculture-producing nations.
- produced 38,886,957 mt worth an estimated \$US 44,100,179,100.00.
- The greatest aquaculture producing nation continues to be China with 30,044,177 mt worth \$US 26,567,202,900.00.



Japan



- **World's third largest aquaculture producer and largest importer of seafood.**
- **In 1999, top species were:**
 - **Laver (NORI) (409,850 MT)**
 - **yesso scallops (216,017 MT)**
 - **Japanese amberjack (140,411 MT).**
- **Produced 1,315,299 MT worth \$US 4,562,530,600.00 in 1999**

<http://www.aquaculturemag.com/siteenglish/printed/buyers/web-worldoutlook.pdf>
World Aquaculture Outlook 2002, Aquaculture Magazine.



Australia

Australia farms 23 different species. The top species in 1999 were:

1.	Atlantic salmon	9,195 MT
2.	Southern bluefin tuna	6,635 MT
3.	Pacific cupped oysters	5,600 MT
4.	Sydney cupped oysters	2,290 MT

- The fastest growing sector is **Southern BlueFin Tuna**, which began in 1991 as a means to add value to a severely diminished tuna catch quota.
- **Tuna aquaculture in Australia is worth tens of millions \$US**

<http://www.aquaculturemag.com/siteenglish/printed/buyers/web-worldoutlook.pdf>
World Aquaculture Outlook 2002, Aquaculture Magazine.



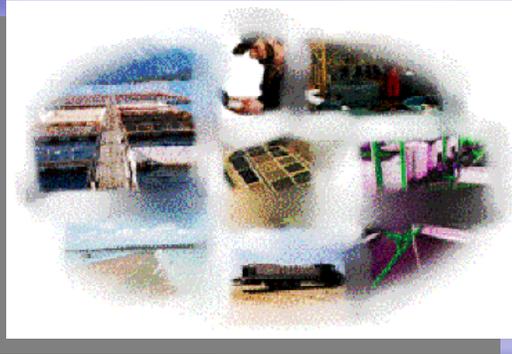
US Aquaculture: "Current" status



(1998 Census of Aquaculture, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS))

- \$978 million dollars of product
- 4028 farms
- Fastest growing segment of U.S. agriculture
- 22 fold increase since 1974
- 20% increase in from 1997 (1 year)





FARMGATE VALUE OF U.S. AQUACULTURE INDUSTRIES

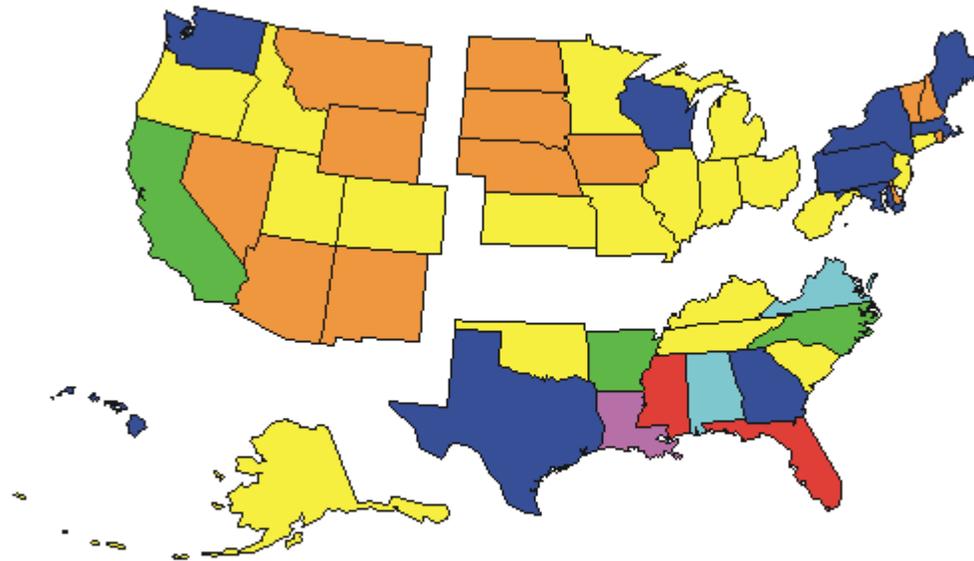
(\$1000USD)

<u>Industry</u>	<u>Value</u>
Catfish	\$450,710
Salmon	\$103,873
Trout	\$72,473
Ornamental	\$68,983
Baitfish	\$37,482
Hybrid Striped Bass	\$28,173
Tilapia	\$24,309
Carp, Perch, Walleye, Sturgeon, Other	\$12,177
Sport or Game Fish	\$7,390
Other fish	\$267
Crustaceans	\$37,318
Mollusks	\$89,128
Other animal aquaculture	\$46,734

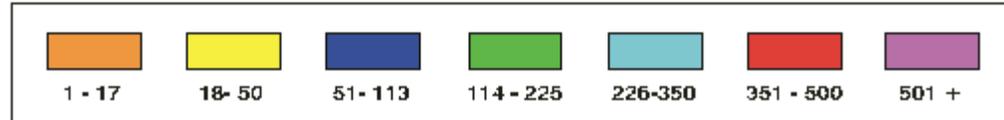


Aquaculture Farm Count

U.S. Total = 4,028
(Regional Groupings)



Farm Count

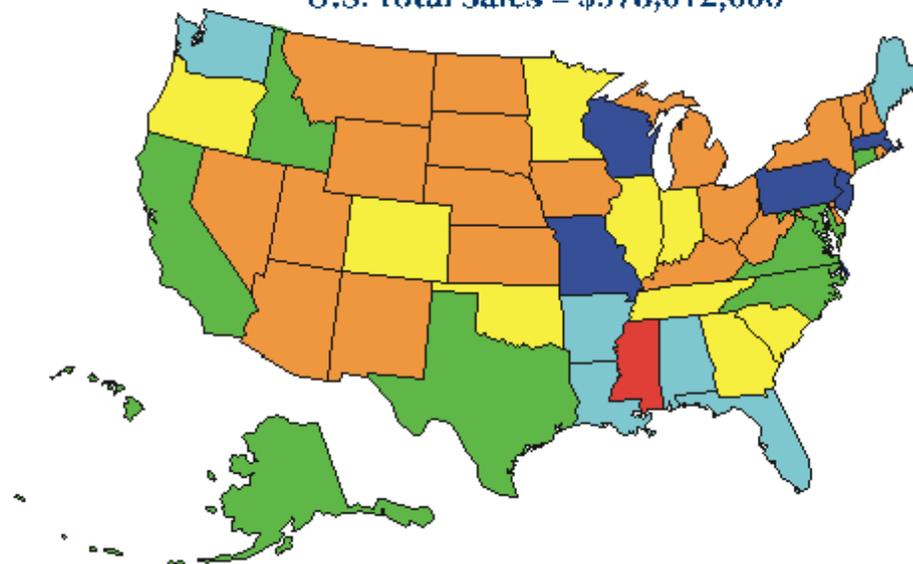


Source: 1998 Census of Aquaculture, USDA-NASS



Aquaculture Sales

U.S. Total Sales = \$978,012,000



Sales in Millions

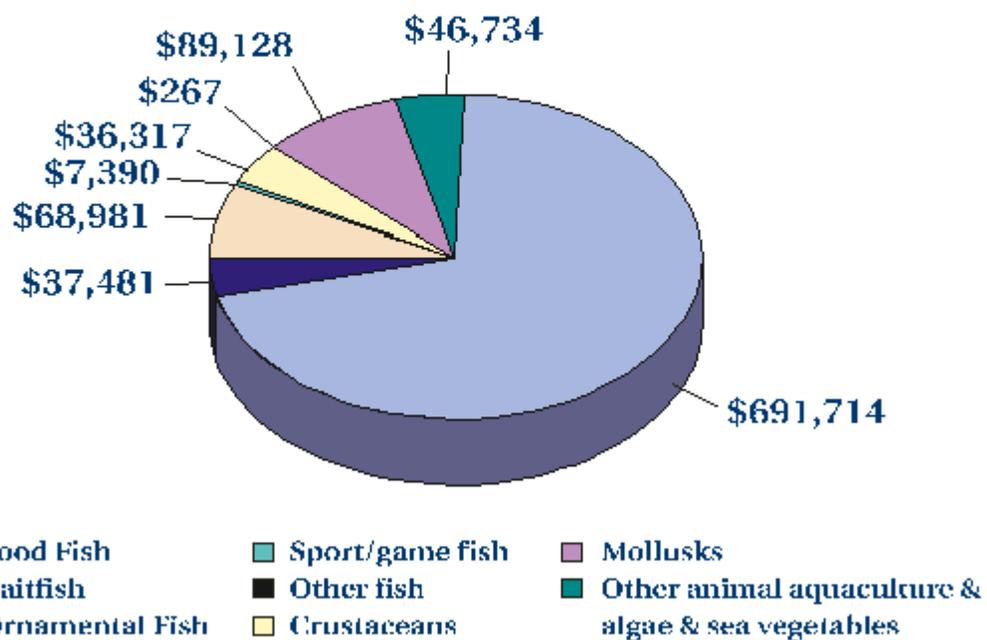


Source: 1998 Census of Aquaculture, USDA-NASS



Value of Aquaculture Products Sold by Category

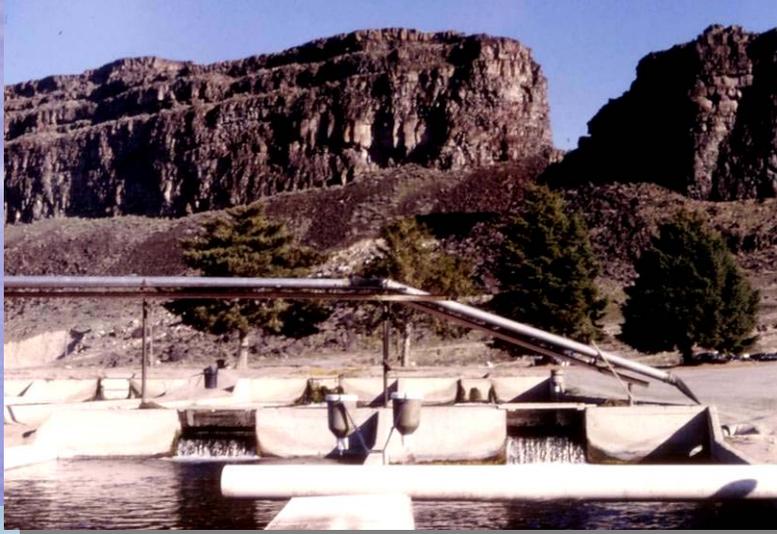
U.S. Total Sales = \$978,012,000
(\$1,000)



Source: 1998 Census of Aquaculture, USDA-NASS



U.S. Trout Farming

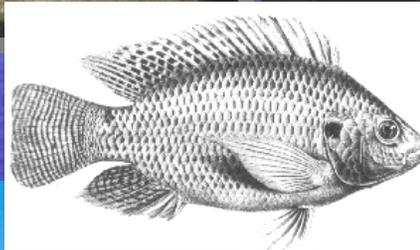


Idaho



U.S. Tilapia Farming

Tilapia facility near Houston, Texas



A tropical fish farmed in Minnesota? Heat effluent used from a near-by sugar beet processing plant!



U.S. Hybrid Striped Bass Farming



U.S. Baitfish & Goldfish farming

Arkansas



U.S. Ornamental farming



U.S. Catfish Farming









US Aquaculture: "Current" status



WE STILL HAVE AN \$8 billion/year seafood deficit!!!

- We are becoming a nation of NIMBY's when it comes to food and esp. seafood production
- We are paying for the continued leadership, expertise & development of foreign aquaculture
- Most aquaculture products are being produced outside of our environmental and food safety jurisdiction
- We are missing out on the future, as revolutionary as the INTERNET



U.S. Salmon Farming



Washington State

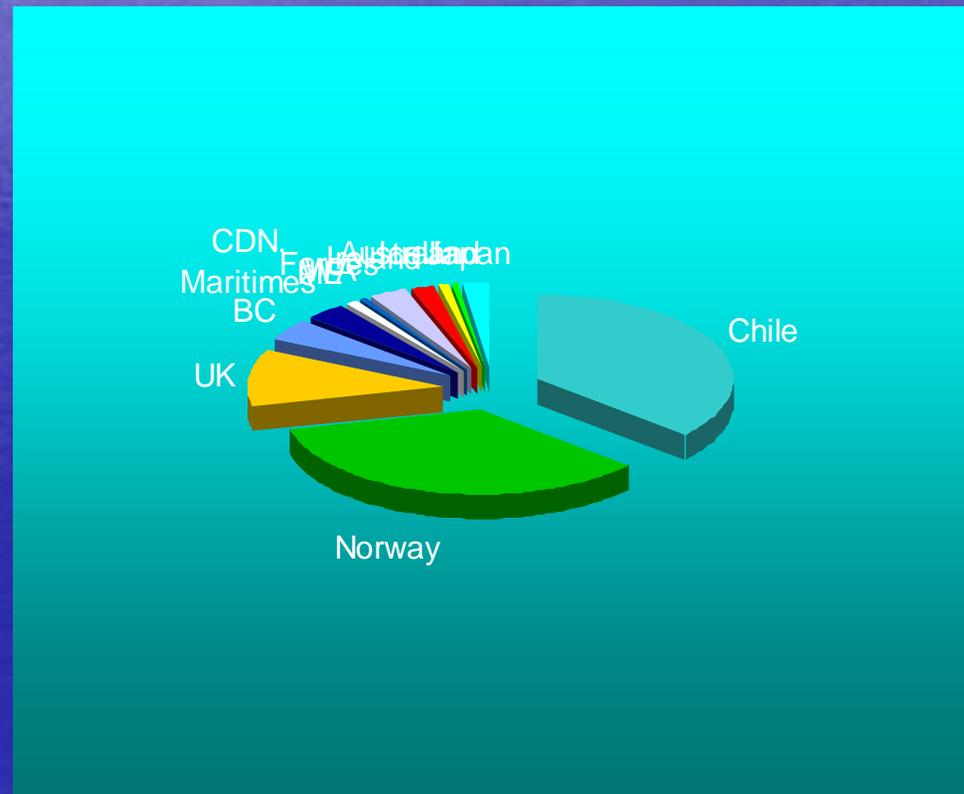
Maine



ESTIMATED 2001 SALMON PRODUCTION

In 1000 MT

•CHILE	510
•NORWAY	490
•UK	150
•BC	60
•CDN MARI.	47
•ME	13
•WA	7
•FAROES	45
•IRELAND	25
•AUSTRALIA	15
•ICELAND	7
•JAPAN	30



1300



Atlantic salmon (*Salmo salar*) Life Cycle

EGGS



1500 to 1800 /
kg

ALEVIN



Eye-up: 245 TU
Hatch: 510 TU

FRY

Emerge: 800 TU



SMOLT



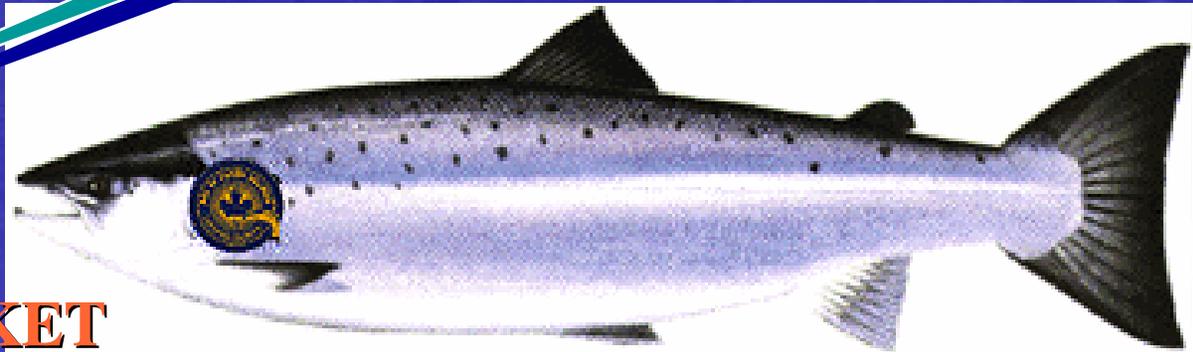
PARR



-typically: second spring to sea entry

FRESHWATER
SALTWATER

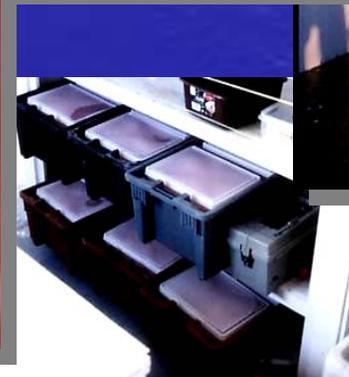
MARKET



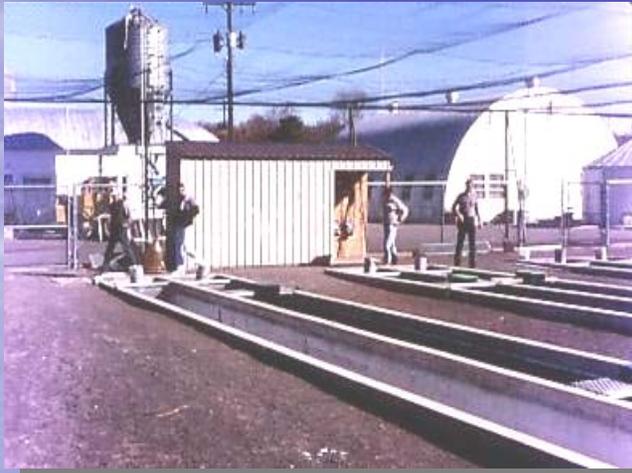
Goal: under 12 months in sea cage (12 to 18 typical).



Spawning



Hatchery (egg to smolt)



Hatchery (egg to smolt)



Sea Cage Growout Net Pen Pacific Northwest



Sea Cage (“netpen”) Grow Out



Sea Cage (“netpen”) Grow Out





Production of wholesome seafood in an extremely efficient fashion, at low ecological cost.



Farmed fish fast food: “McSalmon Burger” in Norway!

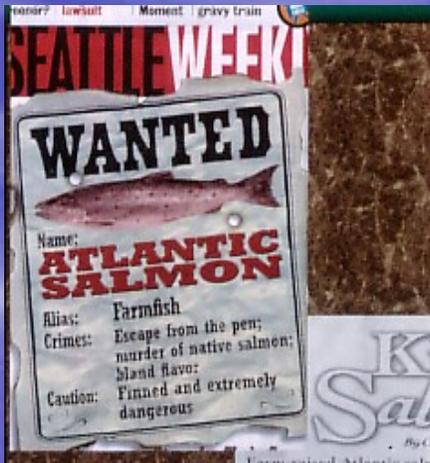


Salmon has only been domesticated for 40 years!!

- Exponential improvement in technology and know-how (economic and ecological efficiency):
 - Feed technology and constituents
 - Feed quality control
 - Feed efficiency
 - Containment technology
 - Breeding
 - Husbandry savvy
 - Siting
 - Utilization of processing waste
 - Humane treatment of stock
 - Protecting stock from wild diseases



CHANGE BRINGS STRESS AND SOCIAL ANGST



Many people think that buying farmed salmon saves wild fish. **Think again.**

Salmon farms don't protect wild salmon. Instead, they infect wild fish with parasites and diseases, and compete for precious habitat when farmed fish escape their pens.



Salmon farm, British Columbia

These problems can spell disaster for wild fish. In British Columbia, at least three rivers have now been populated by escaped Atlantic salmon, an invader to our Pacific waters that competes with native fish. In Norway, the government has resorted to the deliberate poisoning of whole rivers to wipe out the spread of a parasite from a farming hatchery.

Now that we recognize these problems, it's time to demand that salmon farmers clean up their act. The farms can improve by raising the fish on land, in ponds whose waste is treated before it is released into the sea. That would at least isolate them from the wild fish they are harming.

Salmon farming expanded from just 10% of global salmon production in 1986 to 58% in 2001 — much faster

The Hidden Costs of Farmed Salmon

Selling authenticity short

Eating wild salmon connects us to natural cycles that are older and wiser than we are. Wild salmon is a natural food, not a manufactured one. By contrast, a farmed salmon is about as natural as a hormone-laden feedlot steer.

Not surprisingly, that difference means a lot in the taste. Chefs around the country rate wild salmon far superior to farmed. "To be perfectly honest, it [farmed salmon] is crap," says Executive Chef Daniel Long of Bon Appetit Management Company. In fact, a Wall Street Journal taste test scored farmed salmon at 4.83 out of 10, while wild salmon rated 9.7.

Dye! Wild salmon get their beautiful hue from the prey they eat. But their farmed cousins rely on a dye to color their flesh pink. Without that added pigment, their meat would be a pale gray.

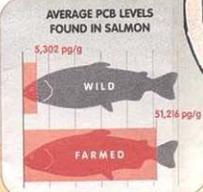


Farmed salmon color selection fan

Toxins!

The fishmeal and fish oil fed to farmed salmon are more con-

taminated with dioxins than any other livestock feeds, according to a study by the European Union. As a result, an analysis of British Columbian salmon found that farmed salmon was nearly ten times higher in PCBs than the wild variety.



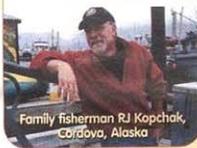
A pure food no more

We live in a time of nutritional uncertainty, when it seems that every week scientists announce that a food we thought was good for us is actually a threat to our health. Salmon had been spared that treatment, until they started to be raised in pens. Wild salmon range the open sea and eat low enough on the food chain that they are a good source of lean protein. But by raising caged salmon on fish meal, industrialists have tampered with our diet once again, tainting a tasty food we thought we could count on.

"When we eat these hidden costs..."

Oligopoly?

The salmon farming industry is controlled by a short list of global corporations — just four companies produce more than half of the farmed salmon sold in North America. By flooding the market with their product, they've put harvesters of wild fish — and the communities that depend on them — in an economic bind.



Family fisherman RJ Kapchak, Cordova, Alaska

Poop!

Farmed salmon are raised in open cages, thousands of them in a net-pen the size of a small house. Usually, a dozen or so of these pens are tethered together. The fish pass their feces right into the waters around them, contaminating the water with as much raw sewage as a town of 65,000.



Photo: Friends of Clayoquot Sound

Treating the ocean like a cesspool

The waters where salmon are raised are remote and pristine — the fjords of Norway and the crystal inlets of British Columbia. These regions boast vast forests and dramatic waterfalls and serve as a reminder of just how awesome nature can be. But salmon waste overloads these waters with nutrients. The result is a no-oxygen "dead zone" that can extend up to 500 feet. If we wouldn't put a hog farm in Yosemite, why would we put a salmon farm on British Columbia's spectacular coast?

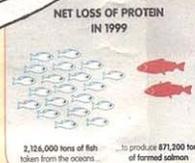


Photo: Friends of Clayoquot Sound

Epidemics!

Diseases and infestations can spread rapidly in crowded pens where salmon are raised. Fish farmers dose their fish to combat these outbreaks, using seven tons of antibiotics in British Columbia in 1998 alone.

Still, epidemics can infect and decimate wild stocks. The 2002 collapse of the pink salmon run on the central B.C. coast is blamed on parasites known as sea lice, contracted from the area's numerous salmon farms.



Less Food!

Salmon aren't your everyday livestock — they're carnivores. Their feed is made from mackerel, sardines, and other smaller fish, but something is lost in the translation. It takes nearly two and a half pounds of smaller fish to raise one pound of farmed salmon — reducing the amount of seafood by 59 percent.

Emptying the oceans

It used to be that the oceans seemed like a limitless frontier. How could something so vast be depleted? But with today's increasingly sophisticated fishing fleets, that's exactly what's happening. Annual catch in the world's oceans is reaching the maximum that can be sustained; a quarter of the world's fisheries are already depleted or in the process of being overfished.

• Expect transparency • Promote the common good • Pursue sustainability • There are no bystanders

The Nature of the Criticism is Curious

- Feels more like a marketing campaign vs. honest critique (destructive vs. constructive)
- “Choose wild salmon instead of cultivated”
- Sensational, visceral statements without context
- Reject cultivated salmon outright instead of:
 - *“We need these kinds of monitoring regulations (environment and food safety) – current ones are lacking in these areas”*
 - *“Here’s how we can help farmed salmon to be more acceptable ...”*
 - *“Here are the parameters that we would find farmed salmon acceptable”*
- Same allegations are repeated over and over despite being discredited
- Research and comments outside fields of expertise
- Criticisms made that are unrelated to an initial / central area of concern
 - E.g.: food safety, when environmental matters are the topic



Opponents:

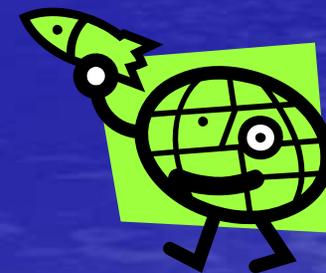
Commercial Salmon Fishermen

- The most threatened and the most vocal opposition
 - Accustomed to 100 year-old monopoly; lucrative livelihood
 - Industry shrunk from \$400 million to \$130 million from '98 to '02
 - Extreme hardship for Pacific coastal communities
 - Powerful political connections in D.C.
 - Alaska made fish farms illegal in early '90s
 - \$40 million/year in marketing support from Congress
 - Large corporate fishing interests
 - Against USDA Organic Standards recommendations had wild Salmon declared organic thru rider attached to Iraqi War Funding bill
 - Dedicated organizations promoting virtues of wild over cultivated salmon
 - Only “sustainable” through farming of early life cycle!!!



Other Opponents:

- **MISGUIDED OR DISINGENUOUS “ENVIRONMENTALISTS”**
 - **SAFE TARGET!** Little resistance or advocacy from public
 - **Now: don't want to be wrong!**
 - **All or nothing – never willing to dialog.**
 - **BIG MONEY** behind this!
- **SOME STATE AND FEDERAL AGENCIES**
 - **About 3 billion stock enhancement fish produced by public**
 - **Facilities in the US in 2000 – 448 million were salmonids**
 - **Private aquaculture seen as competition?**
- **RIPARIAN LAND OWNERS**
- **“THE WILD SALMON MYSTIQUE”**



The Passion of the Wild Salmon

- "Icon in religious proportions"
- "Spirit of the wild"
- "Emissary from the ocean and a larger realm than us"
- "Not just a food"
- "Real salmon"
- "Traditional way of life" ...
- "No right to eat salmon 12 months a year ..."



Creed:

The salmon is a mystical animal and domestication is some sort of gross perversion.



*“They **aren’t playthings** for their two-legged fellow creatures to move about and do with as they will. They are **sacred creations** of an almighty God, placed here to be used and conserved - and enjoyed ... Again, **a noble resource would be treated like a flock of chickens that man can shoo around and haul at will.** The Atlantic salmon is to the waters as the eagle is to the air or the grizzly bear is to the land ...”*

Editor, Maine Sunday Telegram, 199.



Hint of "BRANDING CAMPAIGN" is understandable!

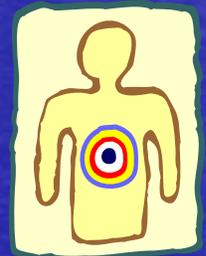
"Portray eating wild salmon is a *greener* and healthier choice than eating cultivated salmon"



Tactic: Hit Salmon Farming with everything you can

(make the public forget about similar issues regarding the fisheries)

1. Lack of regulations
2. Excessive Organic pollution (“Sewage”)
3. High risk of Disease Spread / Amplification
4. Lack of wholesomeness (“Not safe to eat”)
5. Net drain on ocean’s fish protein
6. Flesh dyed to be more appealing
7. Excessive chemicals and antibiotics used
8. Genetic pollution to wild stock
9. Escapees will endanger wild stock habitat
10. Aesthetic pollution



Typical Accusations:

“Salmon farms are allowed to operate with little regulatory oversight”

Anon

1. What level of regulations and monitoring would make salmon farming acceptable?



CURRENT REGULATORY AUTHORITIES FOR MAINE AQUACULTURE INDUSTRY

- **NATIONAL AUTHORITIES**

- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- Army Corps of Engineers
- Environmental Protection Agency
- Department of Agriculture
- U.S. Department of Commerce
- U.S. Coast Guard
- U.S. Department of Labor
- FDA
- ISSC

- **REGIONAL AUTHORITIES**

- New England Fisheries Management Council
- Atlantic States Marine Fisheries Commission

- **STATE AUTHORITIES**

- Department of Environmental Protection
- Department of Marine Resources
- Inland Fish and Wildlife
- Department of Agriculture
- Department of Health and Human Services
-

- **FEDERAL REGULATORY OVERSIGHT**

- Clean Water Act
- National Environmental Policy Act
- Coastal Zone Management Act
- Rivers and Harbors Act
- Endangered Species Act
- Lacey Act
- Migratory Bird Treaty Act
- Marine Mammal Protection Act
- Magnuson-Stevens Fisheries & Conservation Act
- Sustainable Fisheries Act
- Food Drug & Cosmetic Act
- Nonindigenous Aquatic Nuisance Prevention & Control Act
- Federal Insecticide, Fungicide and Rodenticide Act
- Virus-Serum-Toxin Act
- Federal Sanitation Standards (HACCP) Regulations
- National Marine Sanctuary Act.



Typical Accusations:

“... their excrement and excess feed drift down to smother the ocean floor. Waste from just a dozen salmon farms can equal the treated sewage from a small city.”

Organic Style Sep./Oct 02.

“... the waste produced for farmed salmon in Norway is roughly equivalent to the sewage produced by Norway’s four million people.”
A Guide to Modern Science. W. Da Silva. 2002

“Salmon farms are akin to huge floating pig farms.” Anon.

2. What kinds and amounts of discharge would be acceptable?



Fish Farms:

- e.g.: 1000 MT
- 90 kg of N per day
- (R. Hardy Nov/Dec 01)

Makeup:

- fish feces (no fecal coliforms)
- fish ammonia
- excess fish feed
- fish meal
- fish oil
- wheat binders
- vitamins, minerals
- carotenoid pigments

- occasional FDA/EPA approved antibiotics and chemotherapeutants (see later)

Sources of Organic Pollution

- Agricultural runoff
- Failed onsite wastewater disposal systems
- Municipal sewage treatment plants
- Storm water
- Erosion from forest practices and stream bank alterations
- Natural factors such as phytoplankton blooms and upwelling of bottom waters

Perspective: Organic Pollution Nitrogen is the important nutrient to the oceans

APPLES to ORANGES



Municipalities:

- 7.2 g N/person/day
- 1000 MT salmon farm equivalent: 125,000 people

Makeup:

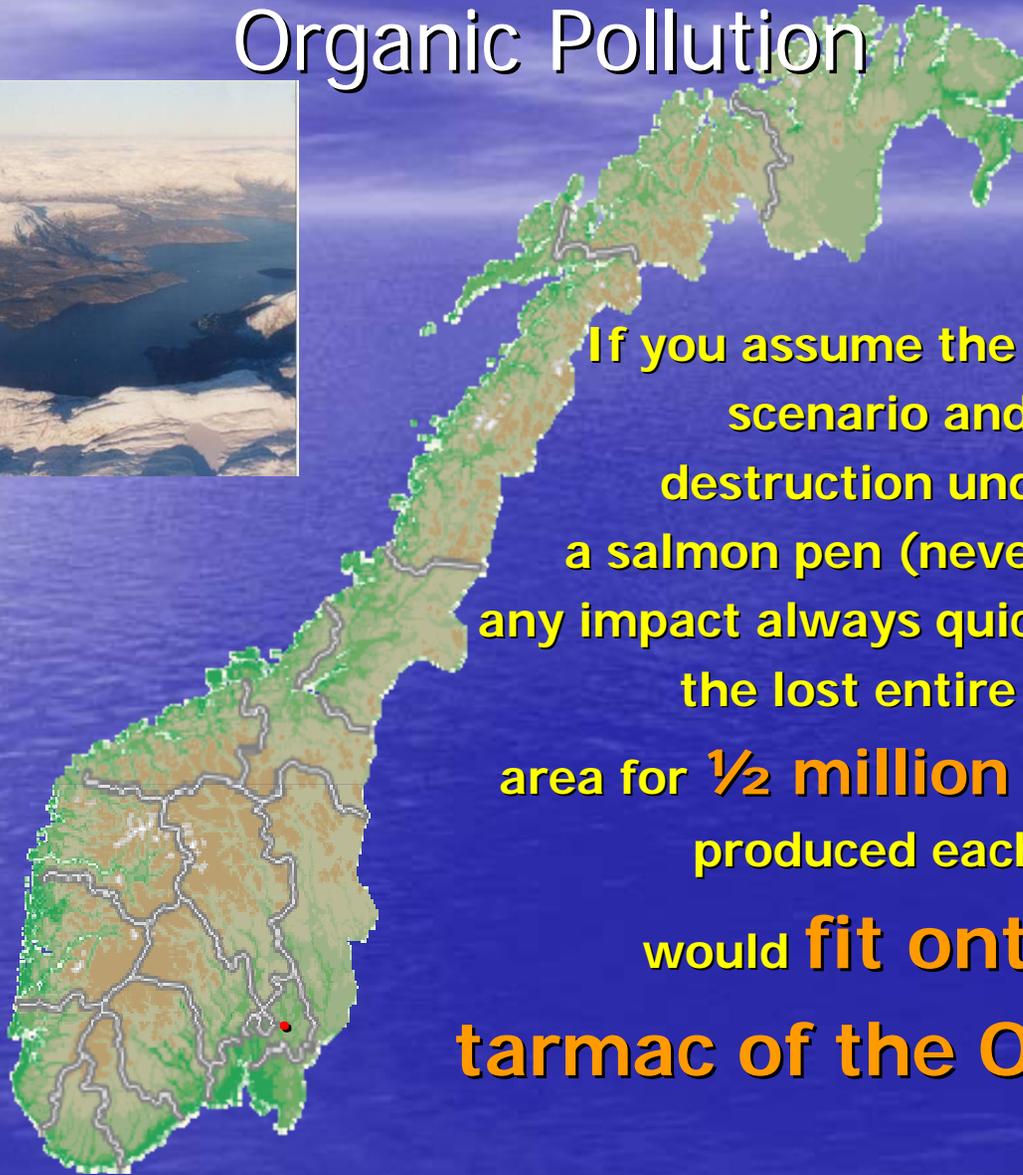
- Human excrement and urine
- fecal coliforms (up to 50%!!)
- German research group report on waters discharged from city sewage treatment plant showed traces of:
- 30 common medicines
- antibiotics
- cholesterol-lowering medicines
- sex hormones in birth control pills and hormone-replacement therapy for menopausal women
- special dyes used in diagnosing artery blockages
- epilepsy medicine
- ibuprofen
- vitamin supplements
- personal-care product chemicals such as: underarm deodorants, soaps, fragrances, antiseptics and sun-screens.
- veterinary drugs from domestic pet and farm animal wastes as rain washes into waterways

(Note: phytoplankton growth is nitrogen and light limiting in marine environment, not phosphorus)

Perspective: Organic Pollution

- Sowles and Churchill – lease requirements of benthic monitoring of Maine industry for past 15 years – no permanent damage
- WA Dept. of Fisheries:
 - Modeled **worst case scenarios** (5 farms in an embayment area):
 - **0% increase in dissolved N above ambient in summer**
 - **0.57 % increase in winter**
 - **0.22% increase in phytoplankton & zooplankton in summer**
 - **0% increase in winter**
- Rensel (1988)
 - Worst case scenario – Large farm in shallow passage
 1. Monitored phytoplankton density & growth rates on farm with and without fish.
 2. Monitored nitrogen levels downstream from farm.
 - **No diff. In #1 & some N increase was seen in one tidal flushing but not other; 30 m downstream 80% ammonia was nitrite**
 - **rapid decomposition.**

Perspective: Organic Pollution



If you assume the worst case scenario and total destruction underneath a salmon pen (never happens & any impact always quickly reversible), the lost entire surface area for **½ million MT** of salmon produced each year, would **fit onto the tarmac of the Oslo airport.**



Typical Accusation:

“... farmed salmon breeding deadly epidemics that could spread to wild stocks. Packing salmon into a tight space causes stress, which lowers immunity to illnesses and parasites, and so salmon farmers lace feed with antibiotics.”

Organic Style Sep./Oct 02.

3. What is the actual risk of disease spread between cultivated and wild salmon?



**DISEASES
FROM
WILD FISH**



**DISEASES
FROM
CULTURED FISH**

Reed-Frost Model of Infectious

Disease:

$$I_{t+1} = S_t(1 - q^{I_t})$$

Where:

I_{t+1} = no. of infections at time t+1

S_t = no. susceptible fish at time t

q = probability of avoiding effective contact (=1-p)

p = contact rate (=k/(n-1))

k = no. of effective contacts made by a fish during t

n = population size

Contact rate is affected by:

-pop. Density

-environmental factors

-host resistance & husbandry

-pathogen virulence, survivability, & life history



**DISEASES
FROM
WILD FISH**



**DISEASES
FROM
CULTURED FISH**

1. **The same pathogens are generally less destructive to wild fish in the natural environment (evolutionary pressure).**
2. **Farmed fish are at a much greater risk of being infected and propagating disease within their own populations than occurs in wild populations.**
3. **Pathogens from epidemics on fish farms are not likely to be in any concentration close to minimum infective dose even a few meters from a farm.**
4. **Farmers have more options at mitigating any disease problems that may occur, whereas occurrences in wild populations must almost always run their course thereby endangering farmed stock.**

“Escapees will colonize wild salmon habitat, displace them, steal their resources, and endanger the populations”

Anon.

9. What is the risk of displacement of wild stock?



Escapees:

- not in farmer's interest (cuts into margins)
- great advancement in sea cage technology

British Columbia Monitoring Program:

55 different river systems were surveyed by trained crews looking for Atlantic salmon in 2001

- 166 sq. miles of streams with over 389,000 salmon found
- no spawning Atlantic salmon and only 2 adult Atlantics

Can't survive very easily in Pacific waters:

Mid-1800's – Failed attempts to establish Atlantic salmon outside its native range:

South Africa, India, Australia, New Zealand, Argentina, Ecuador, Columbia, Indonesia, Japan, and Western North America

(1905 to 1935 some 8.5 million Atlantic salmon were deliberately placed in B.C. Waters – no offspring can be found)

Not the Zebra mussel, Kudzu weed, or Snakehead!!!

-12 other fish species intentionally planted in WA state by WA Fish and Wildlife

- thriving, no disaster

1.5 billion "wild" hatchery fish released annually contribute to about 25% of "wild" salmon harvested.



"Hatchery fish have long been known to be much less genetically varied than their wild counterparts ... These fish because of the way they are raised and when they are released, tend to harm wild stocks in myriad ways, such as crowding out the wild fish and eating their food."



"Because over-exploitation of pelagic fisheries has negative ecological and social consequences, developing a strategy to replace fish meal and fish oil in feeds should become both a private and public-sector priority. "

Nature: 405, p. 1022, 2000.

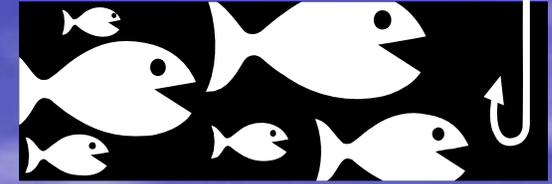
"... salmon farming doesn't relieve pressure on ocean wildlife. Instead, the industry is literally gobbling up smaller fish all over the world. Unlike, say, farmed catfish or tilapia, salmon are carnivorous predators. To make feed, fleets scour the oceans for lower dwellers on the food chain, such as herring, mackerel, anchovies, and sardines. It can take 4 pounds of the small fish to produce 1 pound of salmon. That equation is just not sustainable ... "

Organic Style Sep./Oct 02.

5. What is the best source of cultivated fish feed towards sustainability?



Perspective: Ocean's fish protein



- All fish populations are not equal (different trophic levels)
- Over fished populations are all fish for human consumption
 - long-lived, slow-growing,
 - less able to support high exploitation rates
 - Fish meal industry may be only sustainable fishery! Same production for 5 decades!
 - Only 1/3 of fish meal industry goes toward fish feed.

• IMARPE (Peruvian government's research unit):
• **“anchovy resource in sound biological condition”**

- **Demand for direct human consumption small**
- **Demand higher when converted to higher value fish**
- **Cultivated salmon FCR -> 1:1 to 3:1**
- **Wild salmon FCR-> 10:1, 20:1 and 40:1 (take into account spawners)**

ALSO A PRESERVATION OF BIOLOGICAL CAPITAL!

- **Conservation of proteins and fats for high quality foods**
- **Not squandered on fertilizer or industrial applications**



Typical Accusations:

“One study found that compared to wild, the farmed fish had far higher pesticide levels and enough toxic PCB’s to pose a threat to children eating the fish more than once a week. The scientists theorized that the high levels of contaminants might have been caused by pollution concentrated in processed feed”

Organic Style Sep./Oct 02.

“Farmed salmon are fatter and have lower concentrations of Omega III’s”
Anon.

4. How wholesome /safe is cultivated salmon?



Nutritional data for various sources and species of salmon. Values grams per 100 gram portion

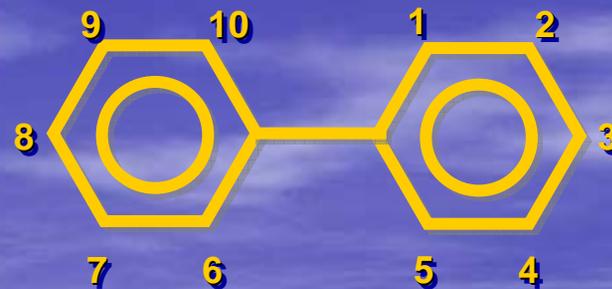
	Farmed Atlantic	Wild Chinook	Wild Chum	Wild Coho	Wild Pink	Wild Sockeye
Protein	19.90	20.06	20.14	21.62	19.94	21.30
Lipid	10.85	10.44	3.77	5.93	3.45	8.56
Total Saturated Fatty Acids	2.18	2.51	0.84	1.26	0.56	1.50
Total Monounsaturated F.A.	3.86	4.48	1.54	2.13	0.93	4.13
Total Polyunsaturated F.A.	3.91	2.08	0.90	1.99	1.35	1.88
Total Omega 3 F.A.	2.00	1.68	0.74	1.50	1.14	1.30
Total Cholesterol	0.06	0.07	0.07	0.05	0.05	0.06

Figures from U.S.D.A. (2002)



PCB's

Polychlorinated Biphenyls



- From:
 - Non-flammable oils in transformers, hydraulic systems, condensers, paints, plastics, flame retardants and adhesives (production now severely curtailed)
 - Very “point source” in distribution
 - Very persistent
 - Accumulates in fat
 - Declining in nature steadily since ban in 1976
- Very low acute toxicity:
 - Need multiple dose at LD50 300 mg/kg
 - Inversely proportional to chlorination of basic biphenyl structure



"Preliminary examination of contaminant loadings in farmed salmon, wild salmon and commercial salmon feed"
Easton et al 2002, Chemosphere 46: 1053-1074.
(funded by The David Suzuki Foundation)

"... the **data were presented in an unconventional manner** <50,000 ppt> that would tend to misinform the reader into believing that farm-raised salmon is a heavily contaminated fish that should be avoided by at-risk populations."

Charles R. Santerre
Associate Professor
Purdue U.
2002

Values reported: 50 ppb (Easton et al, 2002)



"Preliminary examination of contaminant loadings in farmed salmon, wild salmon and commercial salmon feed" Easton et al 2002, Chemosphere 46: 1053-1074.

(funded by The David Suzuki Foundation)

- Statistical methodology <8 fish!!!>

"The samples within the groups of farmed and wild salmon consist of different species (Atlantic and chinook farmed salmon; Chinook, chum and sockeye wild salmon) in different geographical locations (Alaska and British Columbia in wild salmon) with possibly differing ages (especially for the wild salmon – samples were not aged).

As a consequence of the small sample size and the heterogeneous nature of the within-group samples characterized as to contaminant load, no statistical test of this data was done. The data are summarized as simple mean values to enable interpretation by the reader."

Values reported: 50 ppb (Easton et al, 2002)



- HEADLINE:

**“STUDY IN *SCIENCE*
SHOWS PCB LEVELS IN
FARMED SALMON 10X
HIGHER THAN WILD
SALMON”**



1 ppb = a small drop in a 130,000 gal Olympic-sized swimming pool

PCB LEVELS IN OTHER FOODS

	FDA Legal Tolerance Limit:	2000
Butter, salted		70
Tuna, canned in oil		45
Chicken breast, roasted		32
Brown gravy, homemade		30
Salmon steak or fillet, baked		26*
Pancake, from mix		24
Meatloaf		23
Beef steak, pan-cooked		22
Pork chop, pan-cooked		21
Egg, fried		19
Pork roast, baked		18
Popcorn, popped in oil		17
Biscuit, refrigerated dough, baked		16
Veal cutlet, pan-cooked		13
Cornbread		11
Chuck roast, baked		10
English muffin, plain, toasted		10
Raisin		10
Chicken, fried		9
Caramel candy		6

Few foods are immune from contamination by PCBs, which have spread worldwide despite bans in the United States and most other countries. These foods have been tested by the Food and Drug Administration. Figures in parts per billion.

*Puget Sound salmon tested higher.
Source: FDA



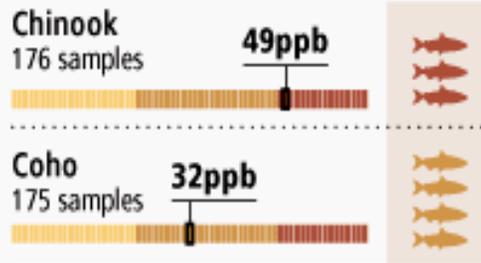
PCB salmon values in literature

PCB LEVELS IN SALMON

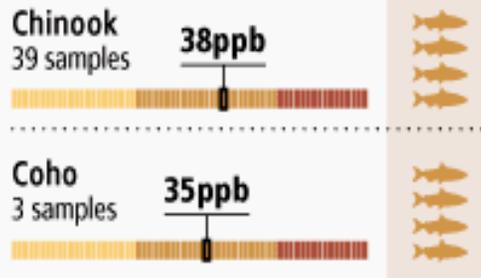
For two species of salmon sampled during the 1990s.

PCB RANGES In parts per billion (ppb):	MEALS PER MONTH*
23 to 47 ppb PCBs	4
47 to 63 ppb PCBs	3

Puget Sound fillets without skin



Columbia River fillets with skin



*Environmental Protection Agency guidelines for 8-ounce portions.

Sources: U.S. Environmental Protection Agency; state Department of Fish and Wildlife

SEATTLE POST-INTELLIGENCER

Farmed salmon (other studies):

27 ppb (EWG)

50 ppb (Easton et al, 2002)

25 to 40 ppb (Deacon, 2003)

Copper River Salmon: 60 ppb

(Circumpolar Conserv. Union, 1998)

JUNK SCIENCE WITH AN AGENDA

Hites et al

Science 203(226-229):

Farmed: 36.6 ppb

Wild: 4.8 ppb



1 ppb = a small drop in a 130,000 gal Olympic-sized swimming pool

PCB LEVELS IN OTHER FOODS

	FDA Legal Tolerance Limit:	2000
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*Puget Sound salmon tested higher.
Source: FDA



“Quirky” things that hint at wild salmon bias and favoritism in Hites et al, 2004

- Title: “contaminants in farmed salmon” – should be farmed AND wild salmon
- Concluding statement irresponsible and not supported by authors’ data:
 - “Although risk/benefit computation is *complicated*, consumption of farmed Atlantic salmon may pose risks that detract from the beneficial effects of fish consumption”
- Graphs: farmed salmon as red bars and wild as green
- Abstract mentions “Salmon farms have been criticized for their ecological effects ...” but no mention in body of paper
- Error bars in Fig. one were unconventional 10th and 90th percentiles, not SE or SD (may have overlapped given sample sizes)
- Critique of FDA action and tolerant limits as “not strictly health-based”, suggesting a political bent
- No context that all values fall within other foodstuffs that we eat on a regular basis – NO CONTEXT! REPORTED AS 10X to be alarmist(?)
- No mention that cooking destroys 50% of PCB’s
- **Analyzing with skin on** (not eaten) serves to elevate PCB levels

Values reported (ppb): 36.6 for farmed/4.8 for wild ppb (Hites, et al. 2004)



“Salmon farms are unsightly, use public resources, and lower land values of riparian owners.”

Anon.

“Net pen complexes are and extremely adverse visual intrusion, except possibly in already developed commercial or industrial areas”

Anon.

**10. What about
aesthetic pollution?**



Perspective: Salmon Farm Aesthetics

REACTIONS:

VISUAL INTRUSION $\leftarrow==\rightarrow$ INTERESTING PART OF ENVIRONMENT

Factors (WA Dept. of Fisheries, 1990)

- Farm size
- Spacing
- Less obtrusive if in area with other man-made objects
- Thin line on horizon if further away than 1500 or 2000 feet
- Less visible from shore at elevations below 50 feet



Fish Farming TRADITION & AESTHETICS?

























Up close and personal with the
crop!





Why is farmed salmon so competitive?

Cultivation vs. **Wild Extraction**

TENDING ONE'S OWN CROP
- INVESTMENT AND RISK IN FISH

FISH HELD IN ONE PLACE
- Red. time, energy, resources

POINT SOURCE ACCOUNTABILITY
- Stationary, activities more visible and more easily monitored by regulators, trace back to source easier

ECOLOGICAL COSTS MORE EASILY ASSESSED
- Minimal, local and traceable
- Excellent track record

TAKING OF PUBLIC RESOURCES FOR PROFIT - "MAD SCRAMBLE"

CHASING
- Excess marina & hydrocarbon use

NO POINT SOURCE ACCBLTY.
Ghost nets, boat refuse, lead line impacts on bottom, hooking mort., gillnet drop-out, size selection mortality, marine mammal and bird impacts

ECOLOGICAL COSTS ARE EXTREMELY DIFFICULT TO ACCOUNT FOR
- Complex interactions
- Wide ranging
- Accountability more difficult
- Poor track record



**BECOMING INCREASINGLY
ECOLOGICALLY
AND RESOURCE EFFICIENT**

- Self-contained
- Wild forage needed: 1.5:1 to 3:1
- Wild forage used to be 92% of feed, now 35%
- Cannot pollute own waters or productivity & fish health suffers.

**EVERYTHING PUT INTO FEED CAN BE
MEASURED, Q-Ced, REGULATED
& CLEANED (IF NECESSARY)**

**PROCESSING PLANTS NEAR FARMS
MUST INSTITUTE TREATMENT
PROTOCOLS FOR OWN FISH HEALTH**

**VITAMINS AND MINERALS
(EG: ASTAXANTHIN FOR FLESH
COLORING) PURE AND CONSISTENT**

**INTERNAL PARASITES RARER DUE TO
PROCESSED FEED**

**MOST HIGH-VALUE SPECIES PROVEN NOT
TO BE SUSTAINABLE (e.g.: salmon)**

- 1.5 billion juveniles released from Alaska's enhancement program in 2002 & only 3% return rate
- Resource competition impact with truly wild salmon ???
- Wild forage needed: 10:1 to 40:1 (not easily improved on)
- By-catch impact

**NO CONTROL OVER PERSISTANT ORGANIC
POLLUTANTS OR QUALITY OF FORAGE**

**PROCESSING PLANTS HAVE OFTEN BEEN
ALLOWED TO POLLUTE WATERWAYS**

- EPA website (fines)
- No incentive (fish far away & out of sight)

**VITAMINS AND MINERALS
(EG: ASAXANTHIN FOR FLESH
COLORING MUST BE OBTAINED
THROUGH FORAGE)**

- Other pollutants, inconsistent

**INTERNAL PARASITES MORE PREVALENT
FROM INTERMEDIATE HOSTS INGESTED IN
FEED - Like wild game**



"In the past 10,000 years we have learned to irrigate, fertilize, and develop hardy breeds of grain and stock. An acre of land, scientifically farmed, is far more useful in human terms than an agriculturally idle one. Yet thousands of years after we abandoned hunting on land as an efficient method of obtaining food, we continue to pursue the creatures of the sea with the attitudes of cavemen.

Ocean farming – mariculture – can protect the natural stock in the sea as well as vastly supplement our food supply."



Jacques Cousteau, 1979



Aquaculture is a more efficient way to produce seafood:
both economically & ecologically



©2001 H. Mitchell



**POST
PRESENTATION
SLIDES FOR
QUESTIONS**



JUNK SCIENCE #2:

What is wrong with the methodology and discussion in:
Hites, et al. 2004. Global assessment of organic contaminants in farmed salmon. Science 203:226-229?

Comparison between categories termed “farmed versus “wild” was too coarse to make inferences – too many interactive effects within these two broad categories

1. Species effect

- no wild Atlantic salmon included despite 8000 MT European fishery (geographically where PCB's appeared highest)

2. Geographic effect

- Disproportionate amount of wild salmon from Northern Alaska yet none from Puget Sound of Washington State (known to have high PCB values)
- Research did indicate regional differences between Europe, North America, and South America mirroring history of industrialization

3. Trophic level effect

- Chum and pink salmon are more planktivorous and not farmed, whereas sockeye, coho and Chinook are carnivorous
- the inclusion of lower-trophic level planktivores skews to lower PCB levels (Coho, Chinook and sockeye are the most readily eaten wild salmon fillets or steaks, as with farmed Atlantics)

4. Seasonality of lipid levels

- Chums and pinks were maturing (sampled in fall) and much lipid in muscle would have begun to translocate to reproductive products lowering PCB levels
Values reported (ppb): 36.6 for farmed/4.8 for wild ppb (Hites, et al. 2004)

JUNK SCIENCE 2:

What is wrong with the methodology and discussion in:
Hites, et al. 2004. Global assessment of organic contaminants in farmed salmon. Science 203:226-229?

5. **No review of previously published literature on PCB's (e.g.: Ewald et al, 1994)**

- As keeping with standard scientific procedure, no historical information provided to show that wild Sockeye have previously been found to have PCB levels many times higher than farmed salmon (**67 to 79 ppb in WILD Copper River Sockeye**).
- EPA and WA Dept., **32 to 49 ppb** in WILD Puget Sound Chinook and Coho

6. **Authors “boast” large sample size as “2 metric tons”, however actual sampling was much less**

- due to grouping as composite samples of only 153 for farmed and 45 for wild. Replicates were only three from each location – may not be enough degrees of freedom given potential interactive effects

Values reported (ppb): 36.6 for farmed/4.8 for wild ppb (Hites, et al. 2004)

PIGMENT



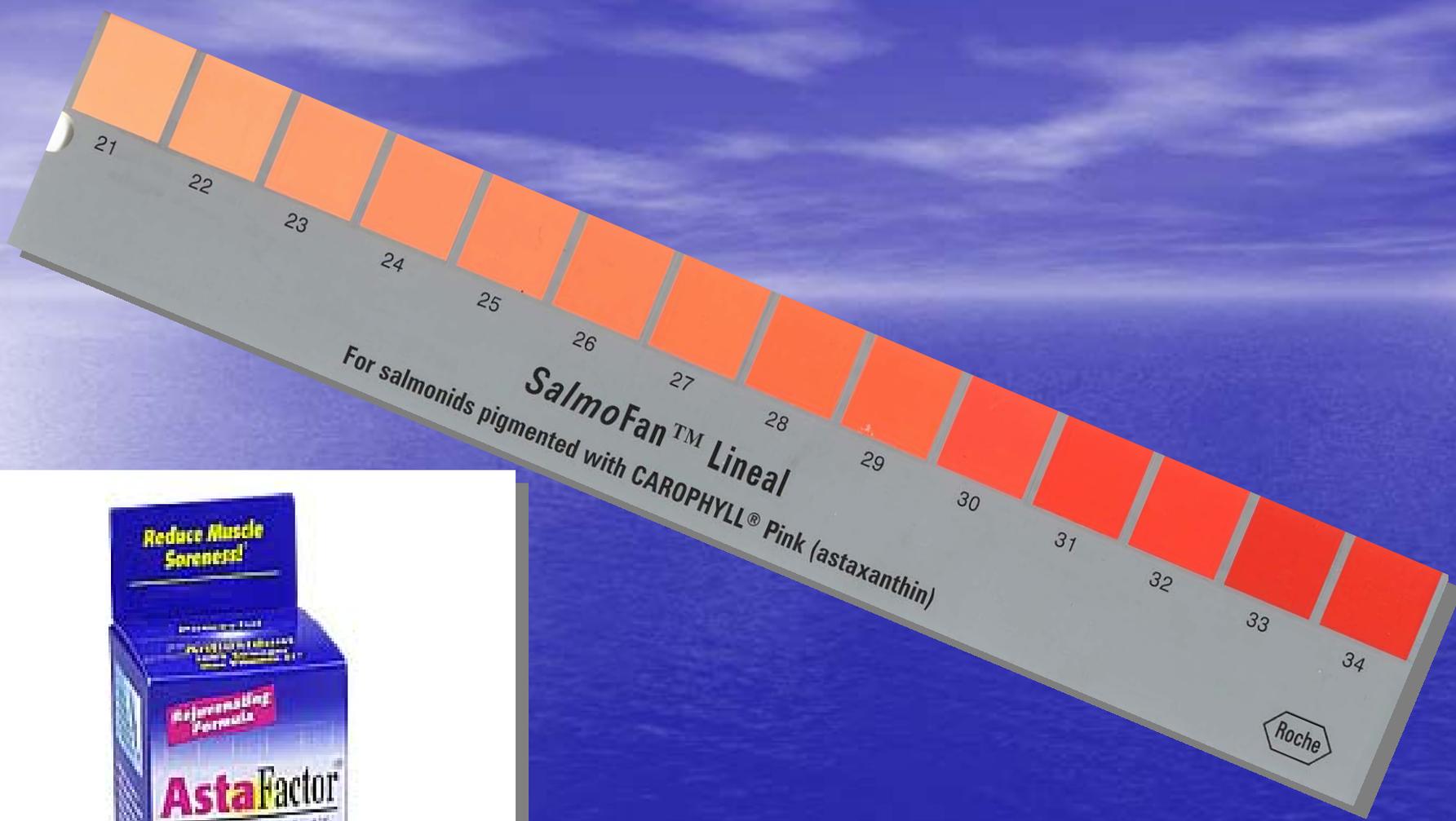
Perspective: Salmon flesh pigment



Carotenoids:

- physiological pigments, not dyes
- naturally occurring in carrots, corn, tomatoes and many other living organisms
- salmon cannot synthesize, so must get it from their food
 - Wild salmon – krill, etc.
 - Farmed salmon – added to feed
 - Something about salmonid muscle that has affinity for it. Other fish fed carotenoids won't retain same color
- ASTAXANTHIN – occurs naturally in many commonly eaten foods, including salmon commonly used to pigment chicken egg yolks
 - Shown to be important to health of chickens and mammals
 - Research investigating role in growth, vitamin activity, sw and ap immunity, anti-oxidant action and reproduction.





TASTE



Taste



June 16, 2004 –

- “In a blind taste test conducted by the Deseret Morning News, a Utah-based newspaper, **six of 12 tasters preferred farmed salmon to the wild variety**. Three tasters preferred the wild salmon while the remaining three had no preference
- the majority of tasters were impressed with both the taste and texture of the farmed salmon.
 - One taster remarked that the **farmed salmon was “firmer and a little more flavorful”**
 - others stated that the **farmed variety had “great salmon flavor” and was “delicious and authentic.”**
- most of the tasters were **“not impressed with the wild king salmon”** from Alaska, which costs twice as much as farmed salmon.
- Commenting on the taste of **wild Alaskan salmon**, some tasters remarked
 - **“I had no idea, other than sight and texture, that I was eating salmon”**
 - **“I seemed to detect an aftertaste that wasn’t as pleasing to me.”**



Canadian First Nations participating in aquaculture with Pan Fish Inc.

- **Gwa'Sala-'Nakwaxda'xw** Nation on the north end of Vancouver Island
- **Kwakiutl Nation** also on the north end of Vancouver Island
- **Gitkxaahla** (aka and typically referred to as **Kitkatla**) being part of the **Tsimshian** Nation and located in coastal north BC.

