Debate ammunition

Farmed vs wildcaught fish: which is better?

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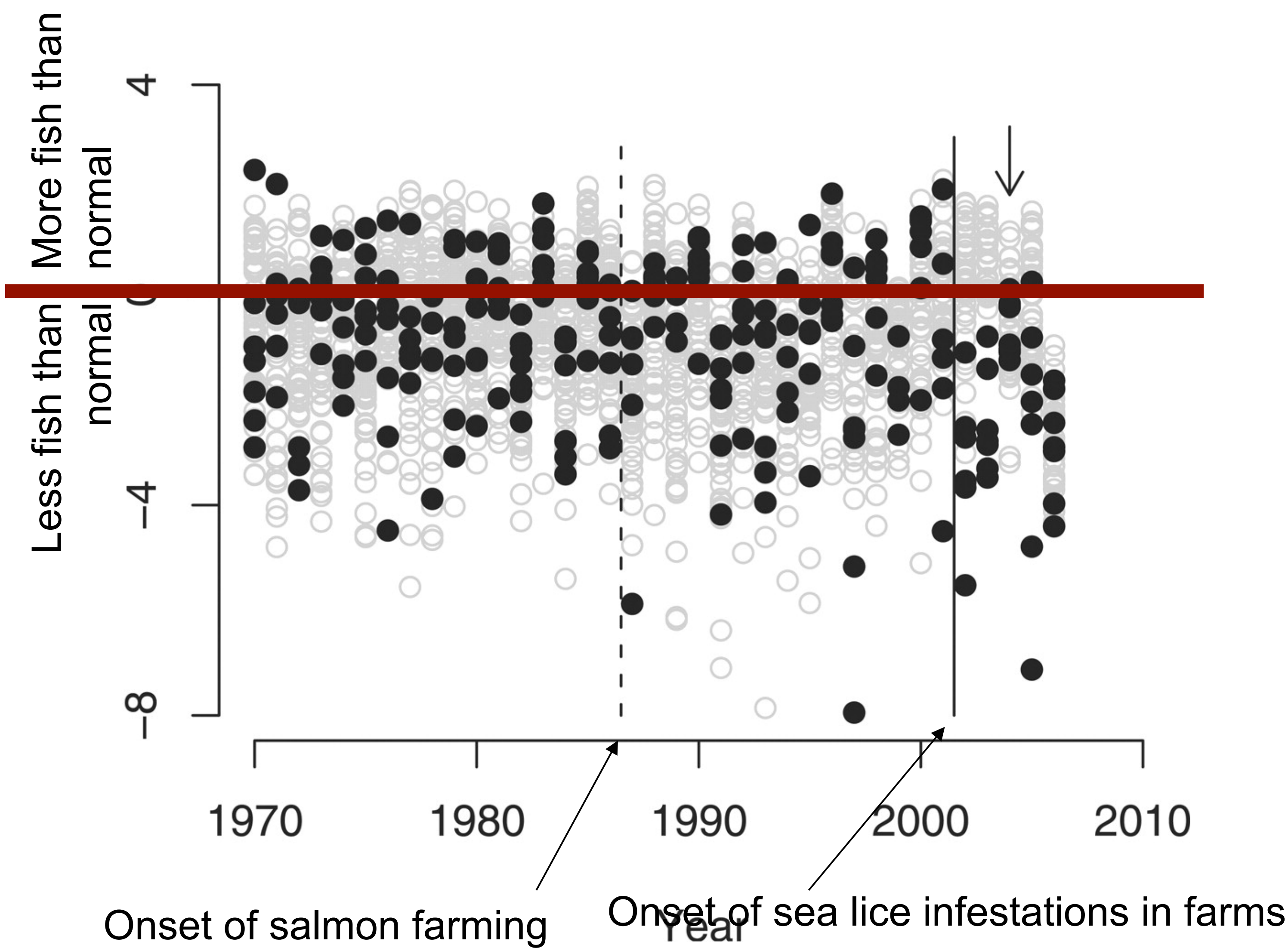
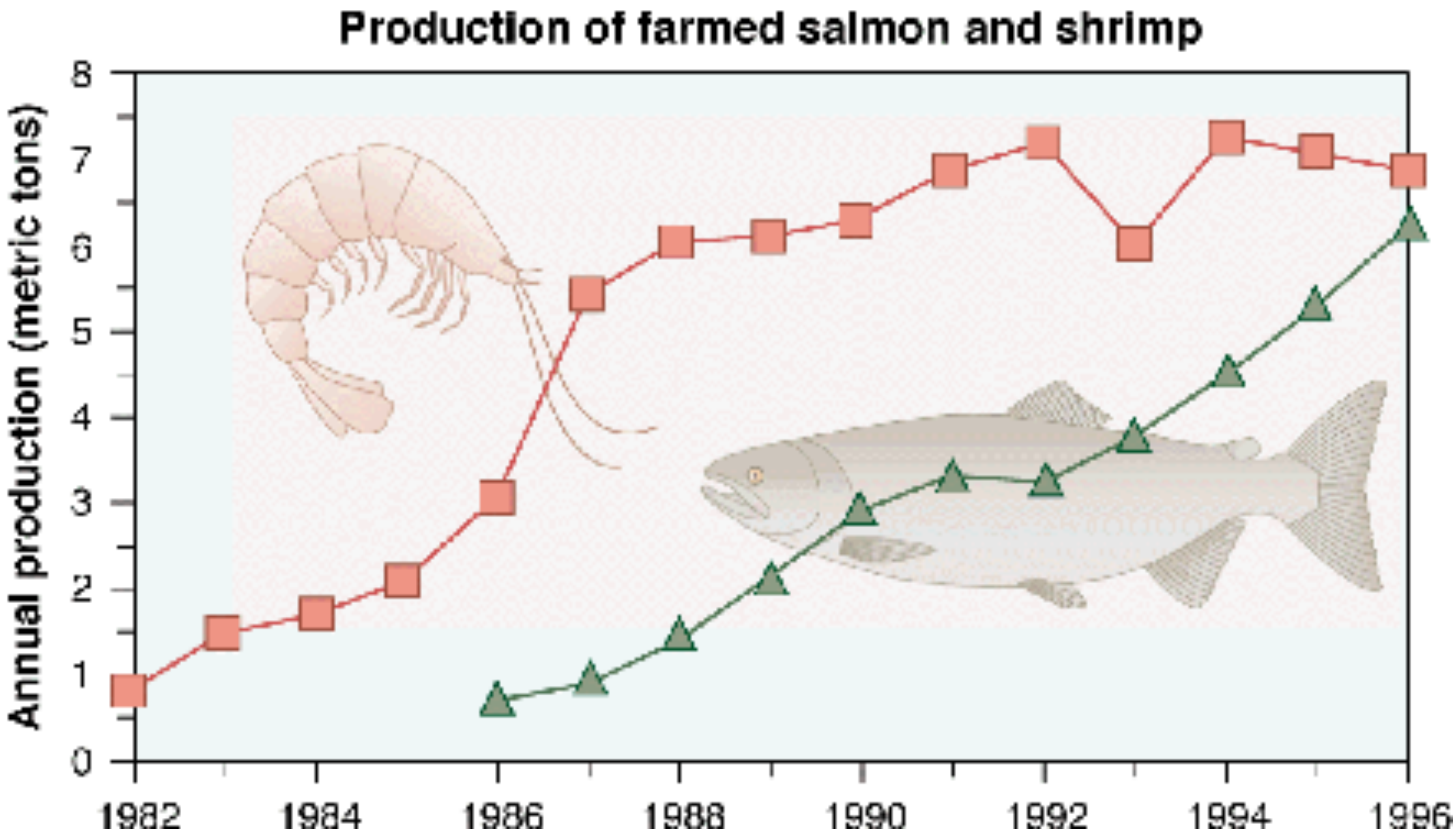
Grey dots: wild pink salmon
Black dots: wild pink salmon exposed to salmon farms.



Krkosek et al. 2007 Science 318:1772-1775.



Naylor et al. 1998: Science 282:883-884

Table 1 Global weight and value for nine of the most widely consumed aquaculture species[1,87]

Species	1997 weight (kilotonnes)	Annual weight growth (1987–97) %	1997 value in US$ (millions)
Common carp	2,237	7.6	2,709
Grass carp	2,662	15.9	2,444
Silver carp	3,146	7.8	2,917
Nile tilapia	742	18.0	885
Channel catfish	238	3.4	372
Atlantic salmon	639	22.4	2,113
Milkfish	393	1.7	697
Giant tiger prawn	490	10.6	3,501
Pacific cupped oyster*	2,968	9.5	3,164

* Weight includes shell.

Naylor et al. 2000: Nature 405:1017-1024

High trophic level eats higher on the food web (3+ = predator)
Low trophic level eats lower on the food web (2 = herbivore)

Species group	Catch (ww; t × 10^3)	*n*	*k*	Trophic level Mean	Trophic level s.e.
Tunas, bonitos, billfishes	2,975	1	3	4.2	0.04
Krill	344	—	—	2.2*	—
Anchovies, sardines	11,597	24	97	2.6	0.28
Jacks	4,785	8	28	3.2	0.06
Mackerels	1,096	10	44	3.3	0.10
Squids†	248	6	31	3.2	0.14
Small pelagics	7,127	5	20	2.8	0.27
Misc. teleosteans	5,342	22	16	3.5	0.26
Jacks, mackerels	2,053	8	46	3.3	0.28
Tunas, bonitos, billfishes	1,275	8	44	4.0	0.12
Squids, cuttlefishes, octopuses	1,114	6	31	3.2	0.14
Shrimps, prawns	650	4	21	2.7	0.35
Lobster, crabs and other invertebrates	544	7	35	2.6	0.30
Sharks, rays, chimaeras	344	9	51	3.6	0.24
Cods, hakes, haddocks	12,209	5	49	3.8	0.25
Redfishes, basses, congers	3,837	2	5	3.4	0.06
Miscellaneous marine fishes	3,362	1	5	3.2	0.11
Jacks, mullets, sauries	2,871	1	3	3.8	0.13
Herrings, sardines, anchovies	2,319	3	8	3.0	0.15
Shrimps and other crustaceans	1,195	3	10	2.3	0.24
Squids, cuttlefishes, octopuses†	1,114	6	31	3.2	0.14
Flounders, halibuts, soles	1,098	3	10	2.9	0.12
Mackerels, cutlassfishes	1,096	3	16	3.4	0.29
Diadromous fishes	819	14	49	2.4	0.25
Sharks, rays, chimaeras	344	2	15	3.7	0.28
Bivalves and other molluscs	5,150	4	12	2.1	0.13
Miscellaneous marine fishes	3,424	15	86	2.8	0.41
Herrings, sardines, anchovies	2,319	9	52	3.2	0.20
Seaweeds	1,683	1	—	1.0	—
Jacks and mackerels	1,322	17	97	3.3	0.22
Diadromous fishes†	819	3	13	2.8	0.19
Shrimps, prawns	748	8	42	2.6	0.33
Crustaceans and other invertebrates	566	14	49	2.4	0.25
Turtles	2	2	7	2.4	0.37
Misc. freshwater fishes	5,237	41	273	3.1	0.28
Misc. diadromous fishes	1,210	23	121	3.6	0.27
Invertebrates and amphibians	896	14	54	2.2	0.23
Carp-like fish	632	15	79	2.7	0.34
Tilapias and other cichlids	579	24	11	2.5	0.18

Table 2 Wild fish inputs used in feed for the ten types of fish and shell fish most commonly farmed in 1997*

Farmed fish	Total production (kilotonnes)	Percentage produced with compound feeds (by weight)	Production with compound feeds (kilotonnes)	Percentage fishmeal in feed	Percentage fish oil in feed	Average feed conversion ratio	Wild fish used for fishmeal (kilotonnes)	Ratio of wild fish: fed farmed fish†
Marine finfish‡	754	50	377	50	15	2.2	1,944	5.16
Eel	233	50	117	50	10	2	546	4.69
Marine Shrimp	942	77	725	30	2	2	2,040	2.81
Salmon	737	100	737	45	25	1.5	2,332	3.16
Trout	473	100	473	35	20	1.5	1,164	2.46
Tilapia	946	35	331	15	1	2	466	1.41
Milkfish	392	20	78	10	3	2	74	0.94
Catfish	428	82	351	10	3	1.8	296	0.84
Carp§								
Fed	6,985	35	2,445	8	1	2	1,834	0.75
Filter-feeding	5,189	0	0	–	–	–	–	–
Molluscs	7,321	0	0	–	–	–	–	–
Total	24,400		5,634				10,695	1.90

* Taken from refs 1, 16, 23 and A. Tacon, personal communication.
† Ratio is wild fish used for fishmeal to farmed fish produced using compound feeds. We assume a 5:1 conversion ratio of fish ('wet weights') to fishmeal and that one-sixteenth of fishmeal is obtained from processing byproducts[22].
‡ Marine finfish (other than salmon, which is listed separately because it is diadromous and because of its market significance) include flounder, halibut, sole, cod, hake, haddock, redfish, seabass, congers, tuna, bonito and billfish.
§ Fed carp refers to carp species that are sometimes fed compound feeds. Filter-feeding carp are silver carp, bighead carp and catla.

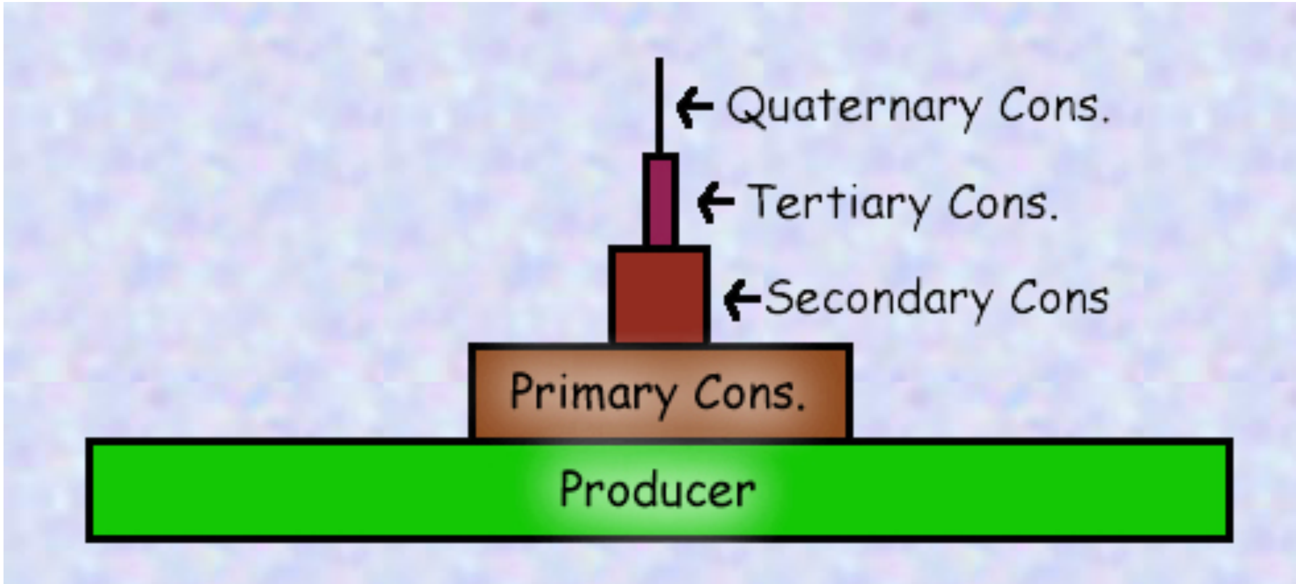
Naylor et al. 2000: Nature 405:1017-1024

From 1988-1997, fishing wild salmon increased by 27%.

Naylor et al. 2000: Nature 405:1017-1024

About 80% of carp and 65% of farmed tilapia are not fed with manufactured products

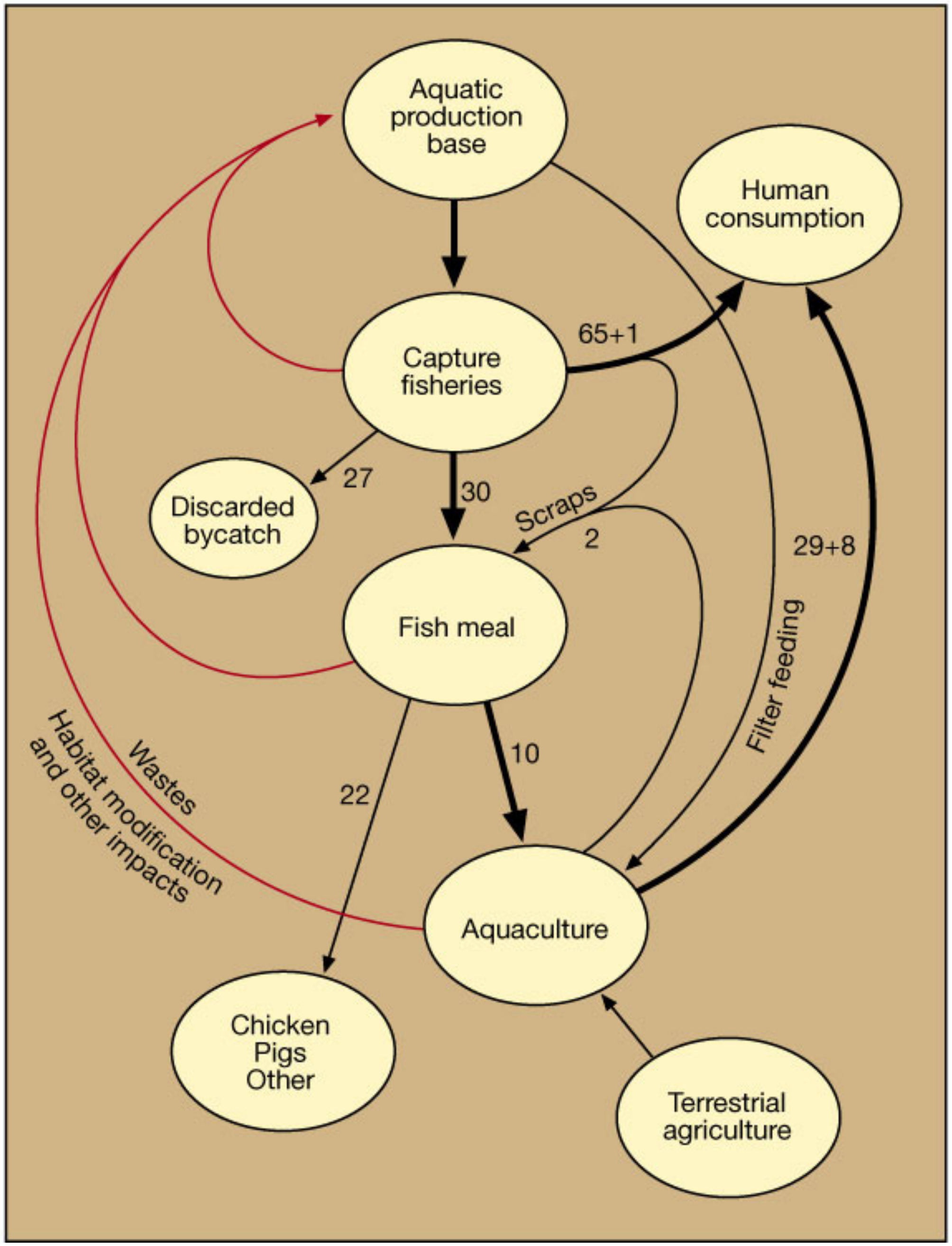
Naylor et al. 2000: Nature 405:1017-1024



In nature, only about 10% of the energy from one trophic level makes it to the next trophic level—the rest is lost as waste. (For example, it should take 10 lbs of prey to make 1 lb of predator.)

Fish and other cold-blooded animals have a natural advantage because they are more efficient converters of energy (10-40% efficiency for marine animals instead of 5-10% efficiency for birds and mammals)

http://www.cod.edu/PEOPLE/FACULTY/FANCHER/TrophicPyramids.htm



1997 data.

Numbers are in units of megatons (million metric tonnes) of fish.

Naylor et al. 2000: Nature 405:1017-1024

To farm milkfish and shrimp, hundreds of thousands of hectares of mangroves and coastal wetlands have been destroyed.

In Thailand, destroying enough mangrove to produce 1kg of shrimp destroys the habitat that would have produced 400 g of wild-caught fish and shrimp.

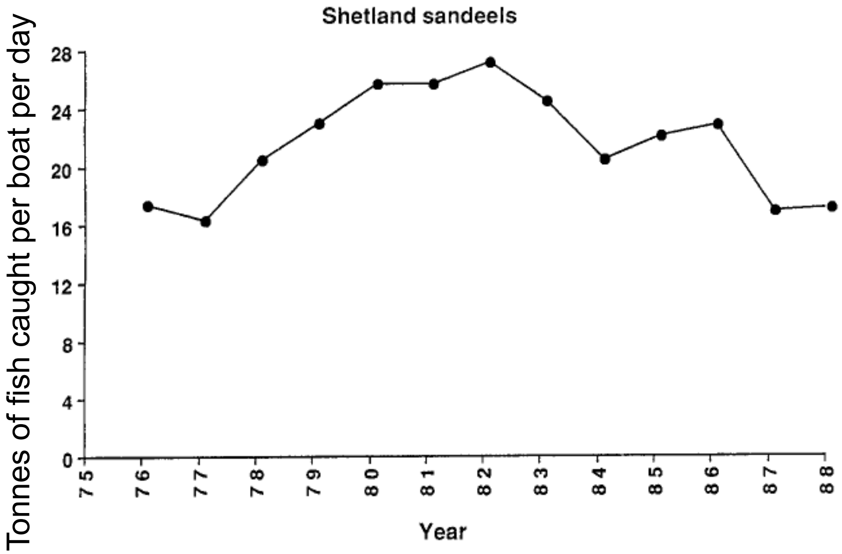
10% of Thailand’s mangroves have been converted to shrimp farms since 1980.

Naylor et al. 2000: Nature 405:1017-1024

Some farmed fish are grown up from wild-caught fry (baby fish).

Giant tiger shrimp farms in India and Bangladesh, for example, fish for fry to farm, discarding up to 160 fish and shrimp fry for every one fry they keep.

Naylor et al. 2000: Nature 405:1017-1024

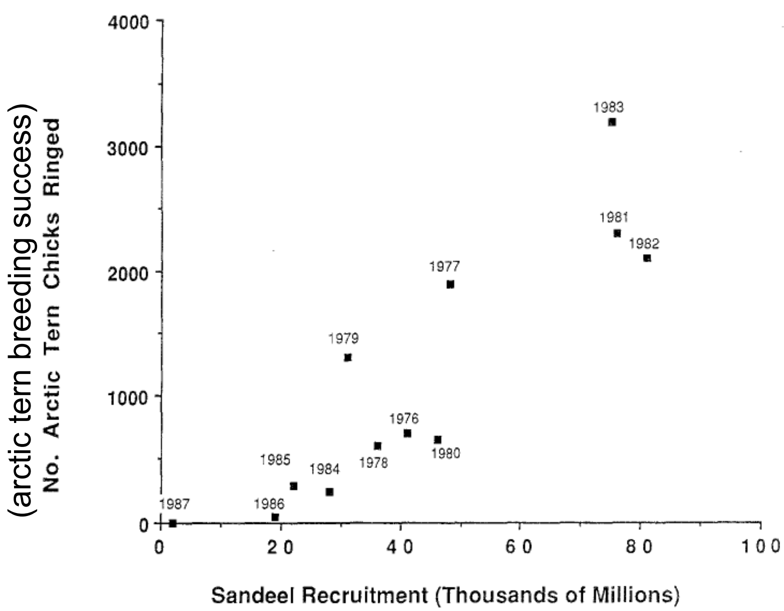


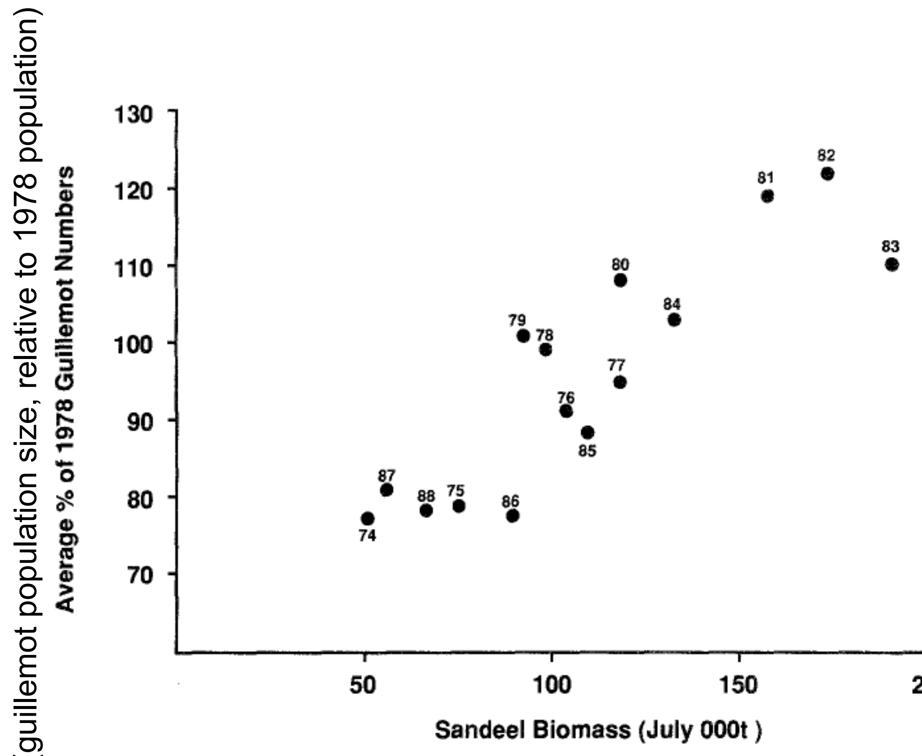
Arctic terns

http://www.birds.cornell.edu/
AllAboutBirds/BirdGuide/Arctic_Tern.html

Puffins eat sandeels

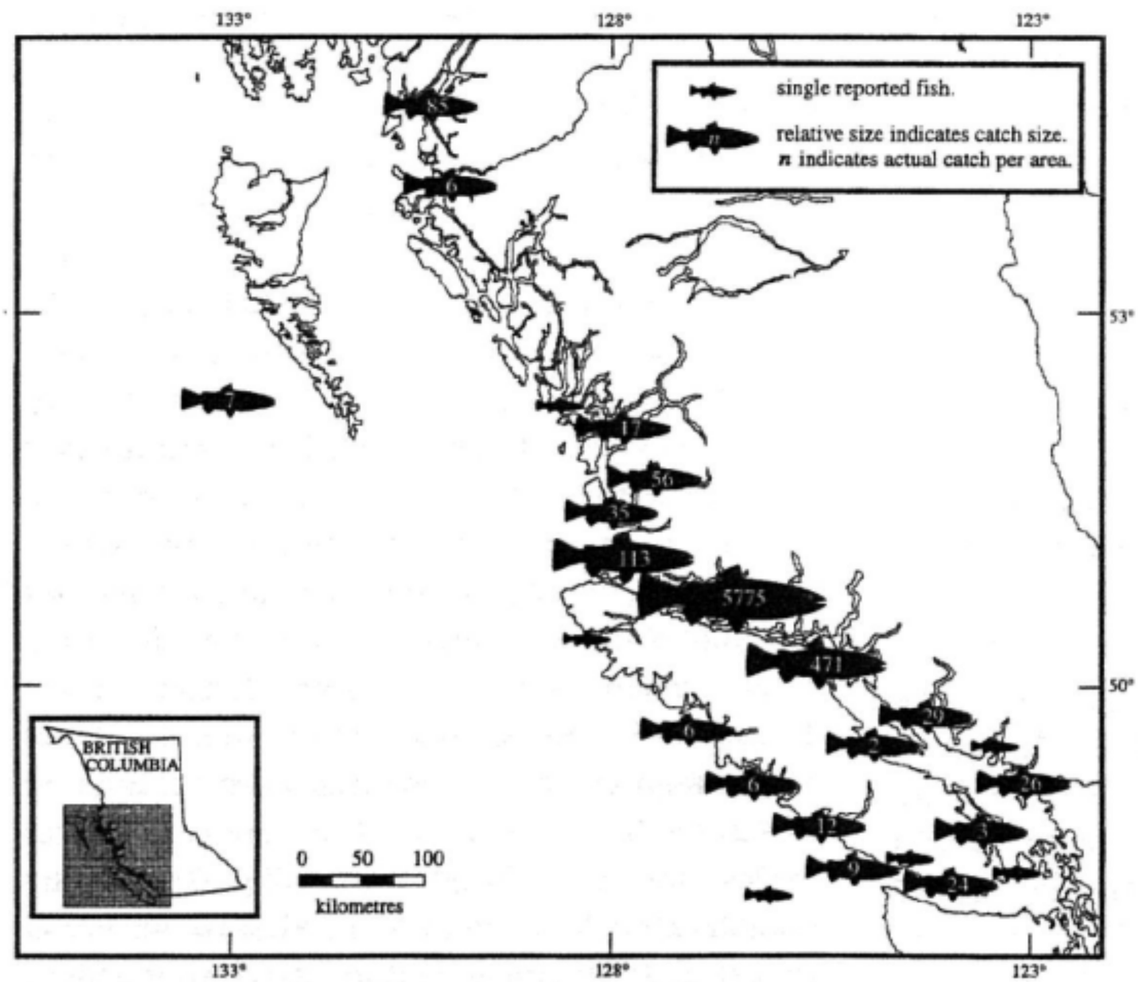
http://news.bbc.co.uk/1/low/scotland/3408113.stm





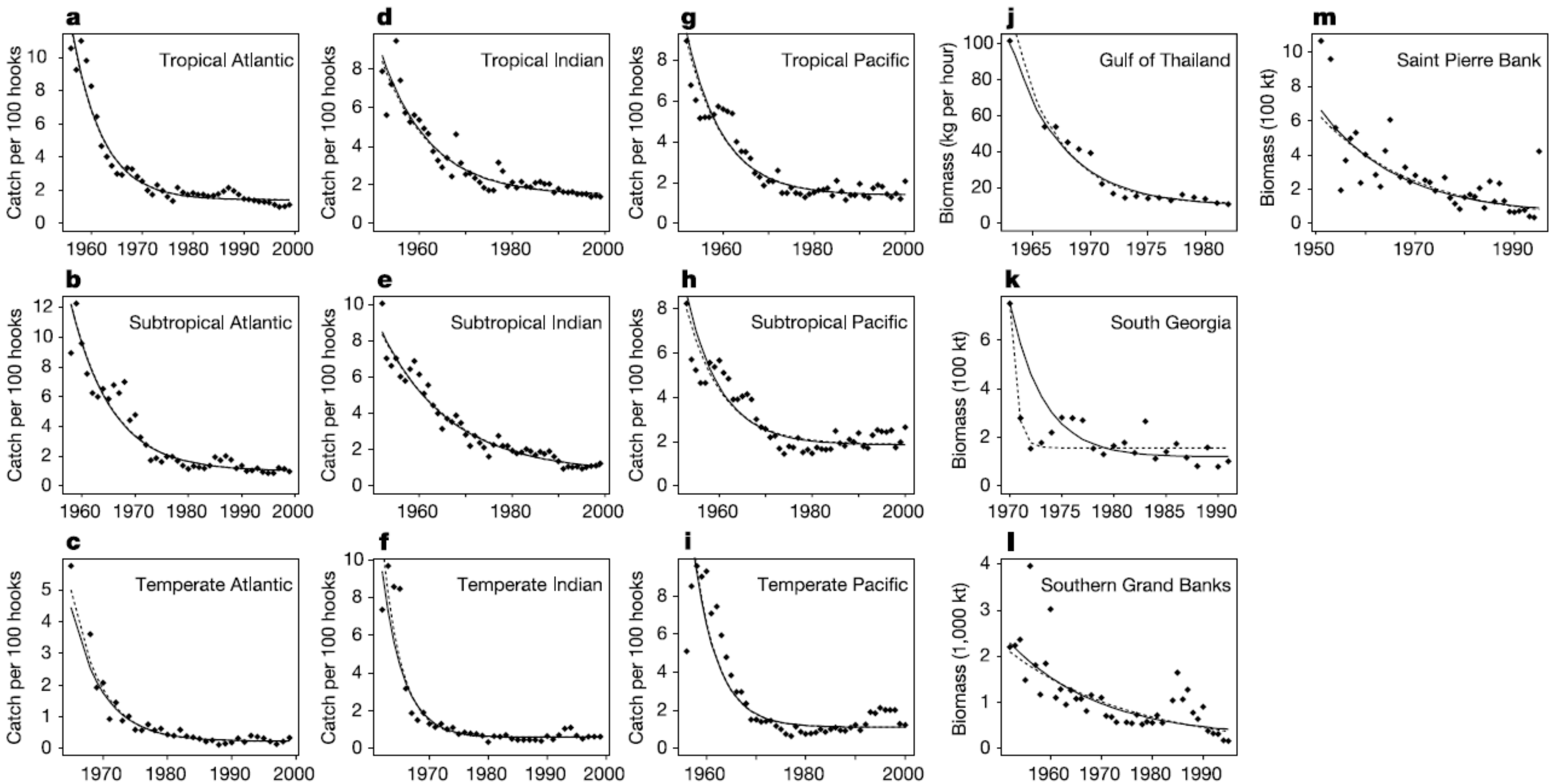
Monaghan 1992: Biology and Conservation 1:98-111

Farmed Atlantic salmon escape from fisheries in British Columbia and Washington state. The number of captured escapees (1987-1995) is represented with fish of different sizes in the figure.



McKinnell et al. 1997: Aquaculture Research 28:145-157

Abundance of predatory fish has declined since "industrialized" fishing began



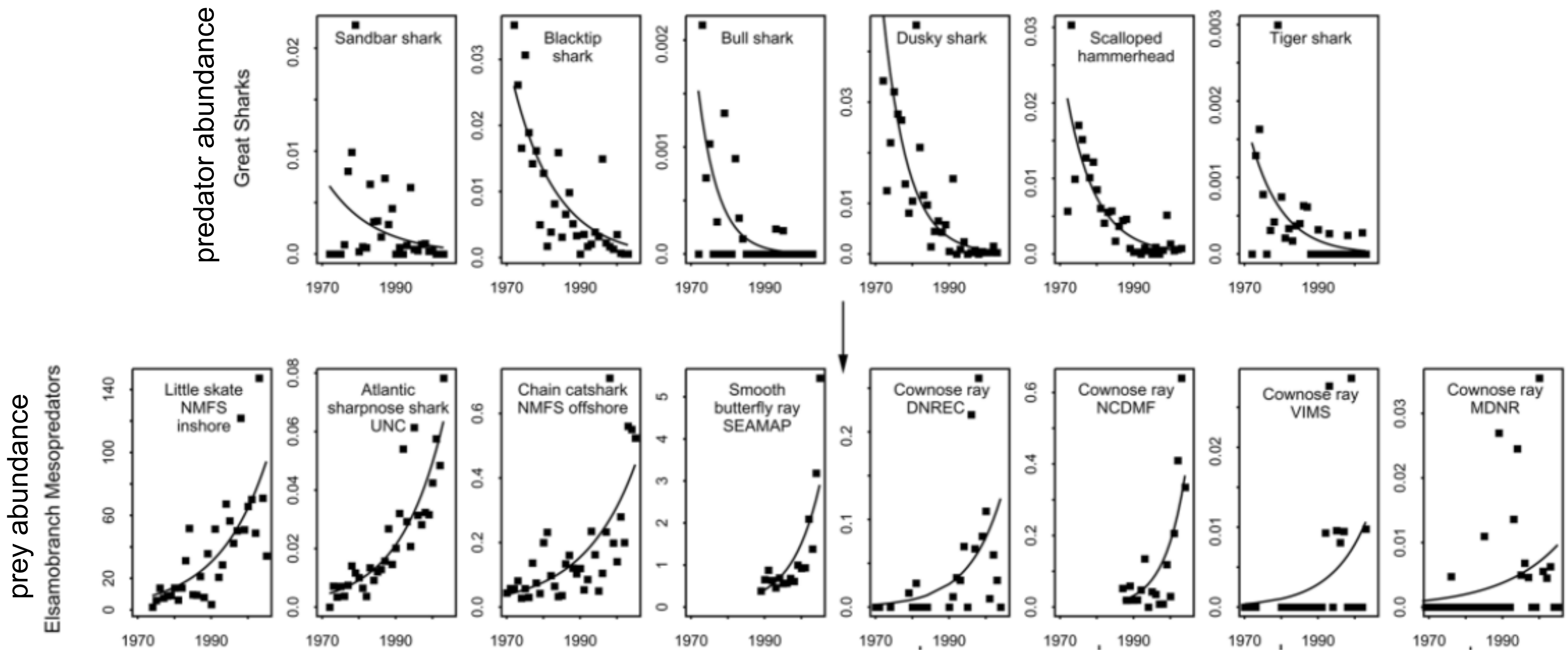
Myers and Worm 2003: Nature 423:280-283

Fishing leads to trophic cascades

- Fishing of sharks → increased grouper → decreased parrotfish → increased algae → decreased coral (Dulvy et al., Ecology Letters 7:5, 410–416; J. Bascompte, C. J. Melián, E. Sala, *Proc*. *Natl. Acad. Sci. U.S.A.* **102**, 5443 (2005).)

Trophic cascade

Sharks hunted for sharkfin soup.



Skates and rays eat bivalves—their populations are decreasing too.

Myers et al. 2007: Science 315:1846-1850

- From 50-90% of protein fed to shrimp and salmon ends up as nitrogen pollution in the water
- Only 1-2% of N and P pollution in Mexican waters comes from fish farming
- Could potentially cause algal blooms and disrupt marine ecosystems….this is still controversial
- Still unknown how well the tides disperse nutrient overloading
- Low oxygen resulting from nutrient pollution (dead zone) in immediate vicinity of cages (Holmer and Kristensen, 1992. Marine Ecology Progress Series 80: 191-201).

- Heavy use of antiparasitics in farmed fish may foster drug-resistant parasites
- Antiparasitics used in Maine salmon aquaculture are toxic to shrimp and lobster, so net effect on fishery production may actually be negative (Haya et al., 2001, Journal of Marine Science 58: 492-496)

- Herbivorous fish and shellfish (tilapia, clams, mussels, oysters, catfish, carp) can actually improve water clarity by filtering eating algae
- Tilapia, carp, and mussels suppress algae and other green plankton,,,…it has been proposed that farming these animals could be a way to clean up polluted lakes and streams (Turker et al., 2003; Aquaculture 215:1-4, 93-101)

- If integrated with agricultural systems (growing seaweed, rice or other aquatic plants) nutrient-rich effluent from fish farms could be used as a fertilizer

- Overfishing of oysters in Chesapeake Bay led to a decline in ability of the bay to process toxic pollutants (residence time of pollutants increased 100 fold)

- Maryland is currently trying to increase mollusk (oysters, clams, etc) numbers in order to clean up the bay

Introduction of foreign abalones and oysters has brought with them parasitic worms, snails and seaweeds (Naylor et al., Science 294(5547): 1555-1556)

- Salmon often escape from aquaculture and interbreed with wild salmon

- Domestic salmon are faster-growing and more aggressive feeders, but also less well equipped to deal with predation and have lower survival in the wild.

- Farmed salmon genes could ‘swamp’ the wild gene pool with lower quality genes and leave them less genetically fit (Gross, 1998: Canadian Journal of Fisheries and Aquatic Science, Supp. 1: 131-144)

- Cultivated fish and mollusks, in areas where they are not native, could potentially become invasive
  - Black carp has escaped into the wild in ALL countries where it is cultivated
  - Northern Snakehead, cultivated in China and Korea, is now invasive in India, Africa, and N. America
  - Tilapia have become invasive in Australia and N. America
  - The attributes that make for a good farmed fish (tolerance of varied water quality, fast reproductive rate, etc.) also increase risk of invasiveness

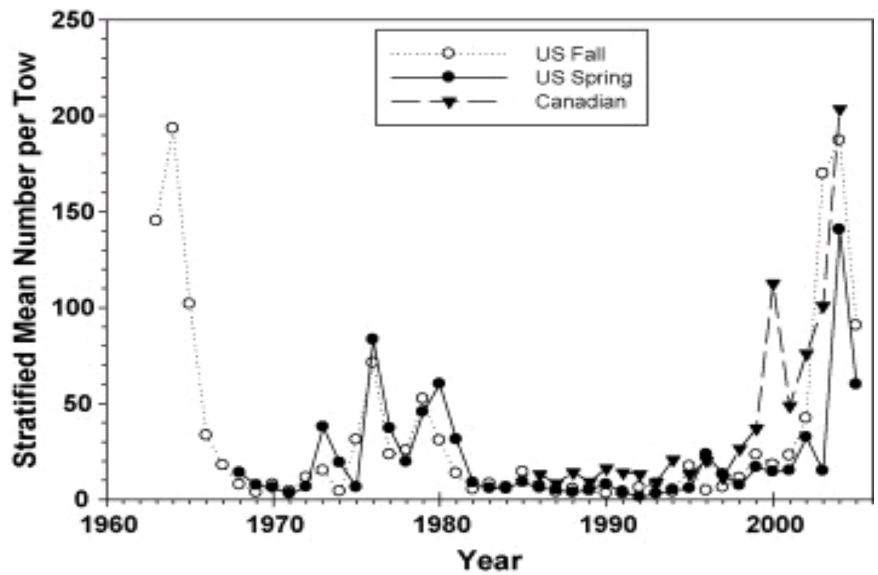
- Black carp an invasive in Missisippi Basin in 2003: pose a potential competitive thread to other filter feeding fish like paddlefish, buffalo, shad

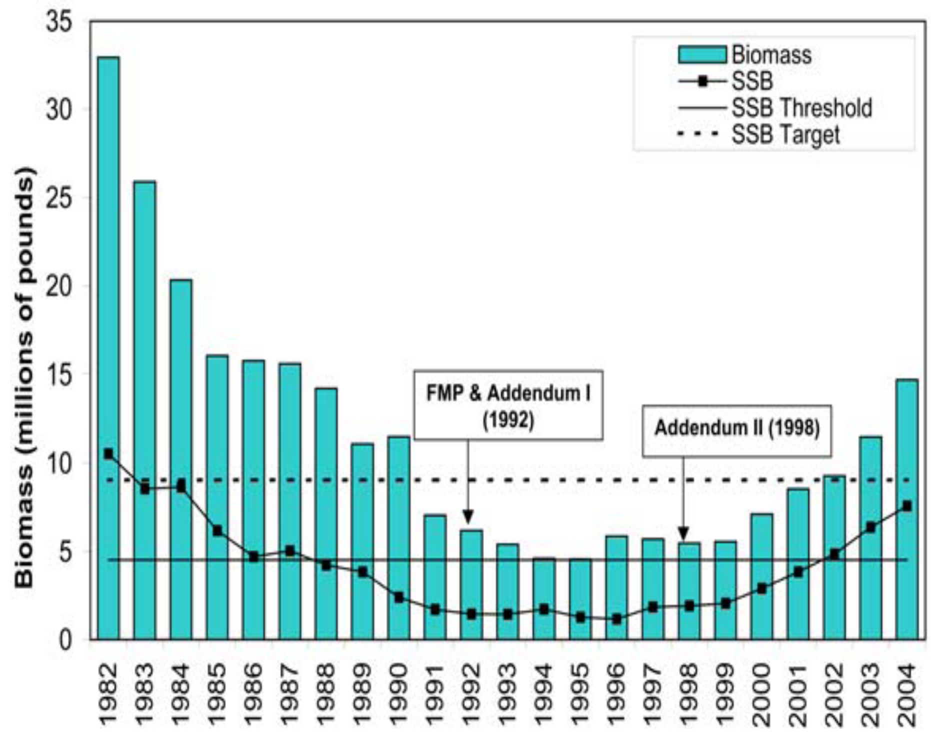
- Fish are critical food source for people worldwide
- 16% of global human protein production: higher in coastal areas and in developing countries

- Estimating fish stocks can be difficult
- The biology of fish population growth and interactions with other fish species are not well understood
- How to define sustainable harvesting rate? Should it be defined as a number of catches? A certain number of trips? A percentage of the stock removed?
- Interactions of fishing and weather can lead to unpredictable effects on populations

- Fish are mobile and move between different national waters so regulation is difficult

- Pollock heavily fished but still highly productive
- Flounder, lingcod, haddock, snapper fisheries have shown ability to recover from overharvesting
- Squid fishery (Falklands)
  - Uses cautious, conservative management: monitors fishery each year and shuts it down when population is reduced to 30-40% of “natural” density





- Needed for sustainable fishery:

- Ability to monitor populations and adjust harvesting rate
- Moderate harvesting rate
- Marine reserves that allow population to reproduce
- Technologies that involve as little impact to environemnt and other species as possible
- Even when sustainable, there will still be tradeoffs…..e.g. fishery in Falklands has reduced penguin populations, sustainable fisheries in Alaska have reduced seals

Examples of sustainable fish farming

- **Tilapia (tropical fish): largely herbivorous**
- Eats algae and weeds but can be fed on grain
- Reproduce fast, can tolerate a range of salinities and water quality
- Can improve water quality by filtering out algae and cyanobacteria (remove 60-60% of algae, Turker et al.
- Effluent often used to fertilize rice or other crops

- **Clams, oysters, mussels**
- Filter feeders: can help clean the water in an area
- Mostly herbivorous (feed off algae in water)
- Raising the young is energy-intensive but adults do not need feeding
- Can increase diversity in immediate area
- Non-mobile organisms so harvesting is contained
- “Few environmental impacts” according to FAO
- Maryland considering increasing mollusk production in part to improve water quality

- In general, most sustainably raised organisms are herbivorous (tilapia, carp, catfish, mollusks)