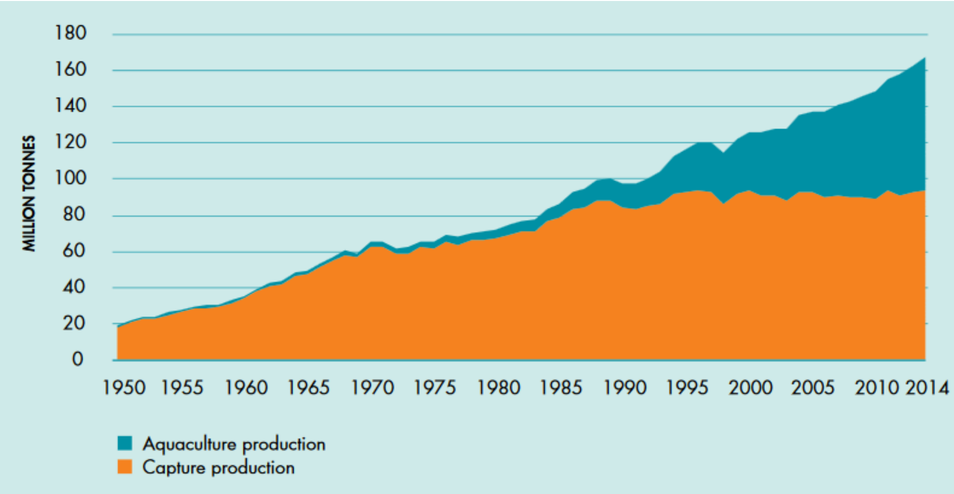
Fish Production & Density

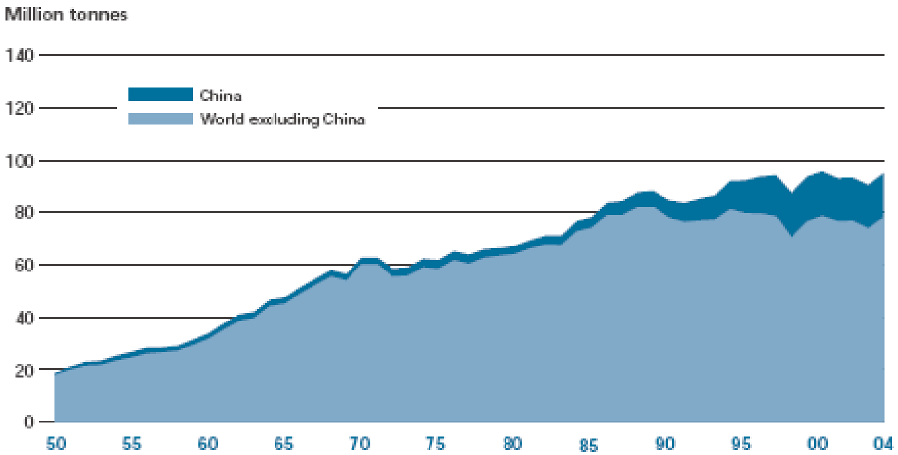
LO: extrapolate how temporal variation potentially influences world fisheries catches, sustainability, and food security

World Fisheries Catch

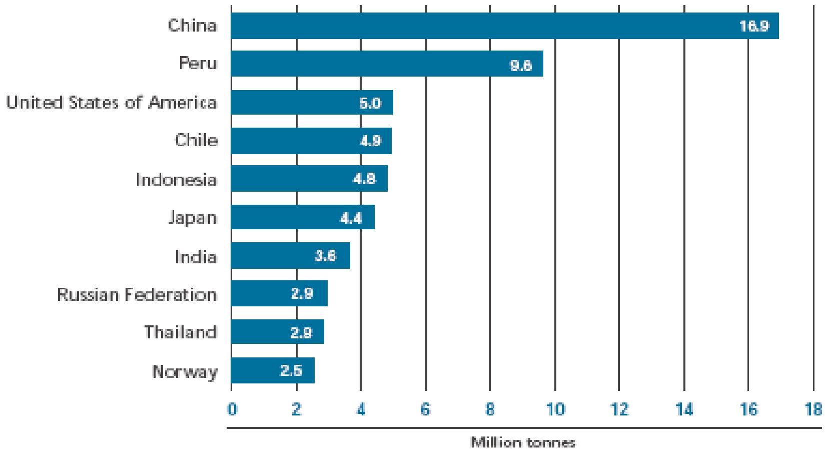
Catch & Aquaculture



Catch



Catch %



FAO 2006, 2012, 2016

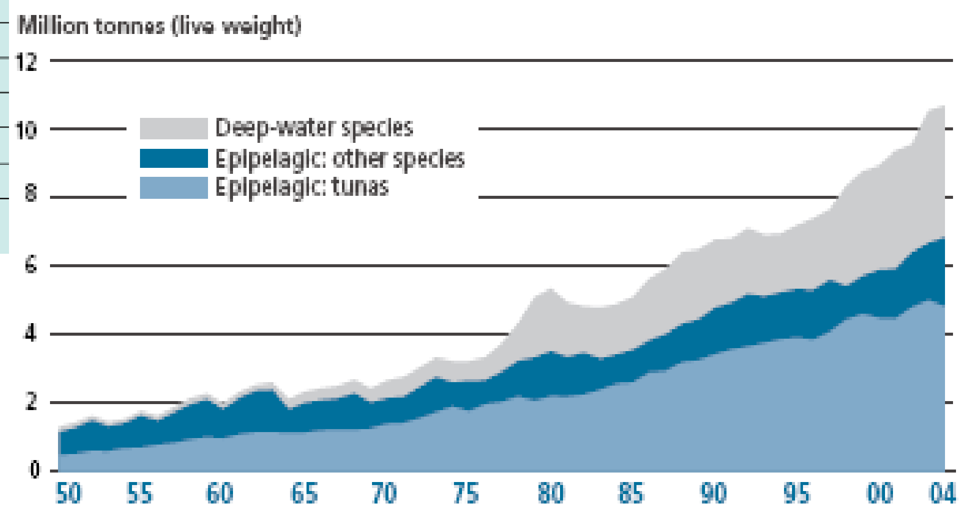
Fish Catch

Diverse ~ 25,000-30,000 species, nearly 500 families, 1/2 marine species (Jennings et al. 2001)

MARINE CAPTURE PRODUCTION: MAJOR SPECIES AND GENERA

					VARIATION		
SCIENTIFIC NAME	FAO ENGLISH NAME	AVERAGE 2003–2012	2013	2014	AVERAGE (2003–2012) –2014	2013–2014	2013–2014
			(Tonnes)		*(Percentage)*		*(Tonnes)*
Theragra chalcogramma	Alaska pollock (= walleye pollock)	2 860 840	3 239 296	3 214 422	12.4	−0.8	−24 874
Engraulis ringens	Anchoveta (= Peruvian anchovy)	7 329 446	5 674 036	3 140 029	−57.2	−44.7	−2 534 007
Katsuwonus pelamis	Skipjack tuna	2 509 640	2 974 189	3 058 608	21.9	2.8	84 419
Sardinella spp.[1]	Sardinellas nei	2 214 855	2 284 195	2 326 422	5.0	1.8	42 227
Scomber japonicus	Chub mackerel	1 804 820	1 655 132	1 829 833	1.4	10.6	174 701
Clupea harengus	Atlantic herring	2 164 209	1 817 333	1 631 181	−24.6	−10.2	−186 152
Thunnus albacares	Yellowfin tuna	1 284 169	1 313 424	1 466 606	14.2		
Decapterus spp.[1]	Scads nei	1 389 354	1 414 958	1 456 869	4.9		
Scomber scombrus	Atlantic mackerel	717 030	981 998	1 420 744	98.1		
Engraulis japonicus	Japanese anchovy	1 410 105	1 329 311	1 396 312	−1.0		
Gadus morhua	Atlantic cod	897 266	1 359 399	1 373 460	53.1		
Trichiurus lepturus	Largehead hairtail	1 311 774	1 258 413	1 260 824	−3.9		
Sardina pilchardus	European pilchard (= sardine)	1 088 635	1 001 627	1 207 764	10.9		

Catch Zone

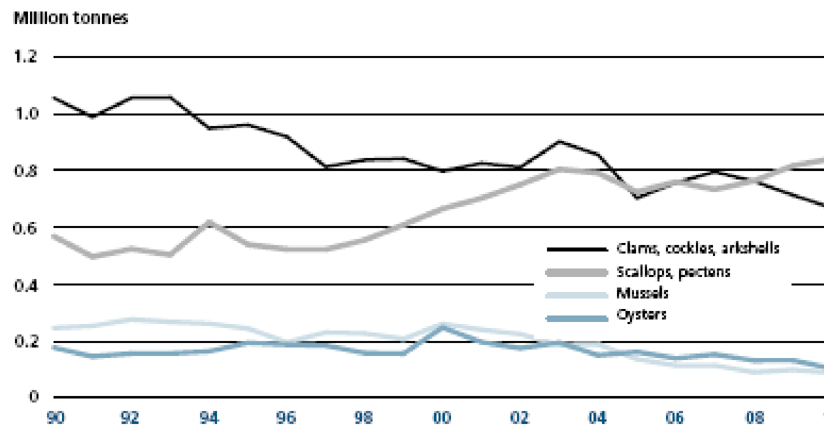


FAO 2016

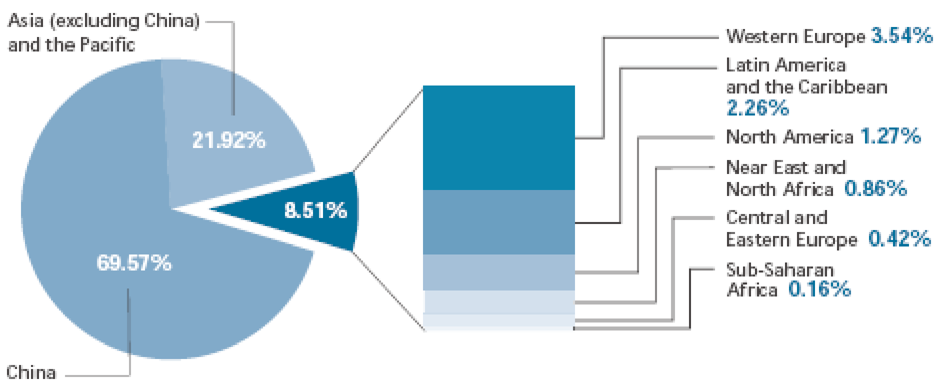
Invertebrate Production & Catch

- molluscs (~50,000 species, including squid) ~7%
- crustaceans (~35,000 species; esp. shrimp and prawns) ~6% of total landings (Jennings et al. 2001)

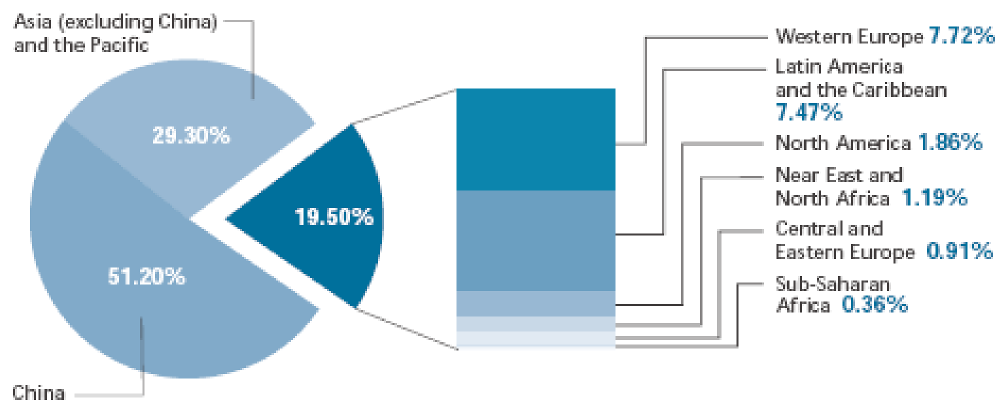
Trend



Catch

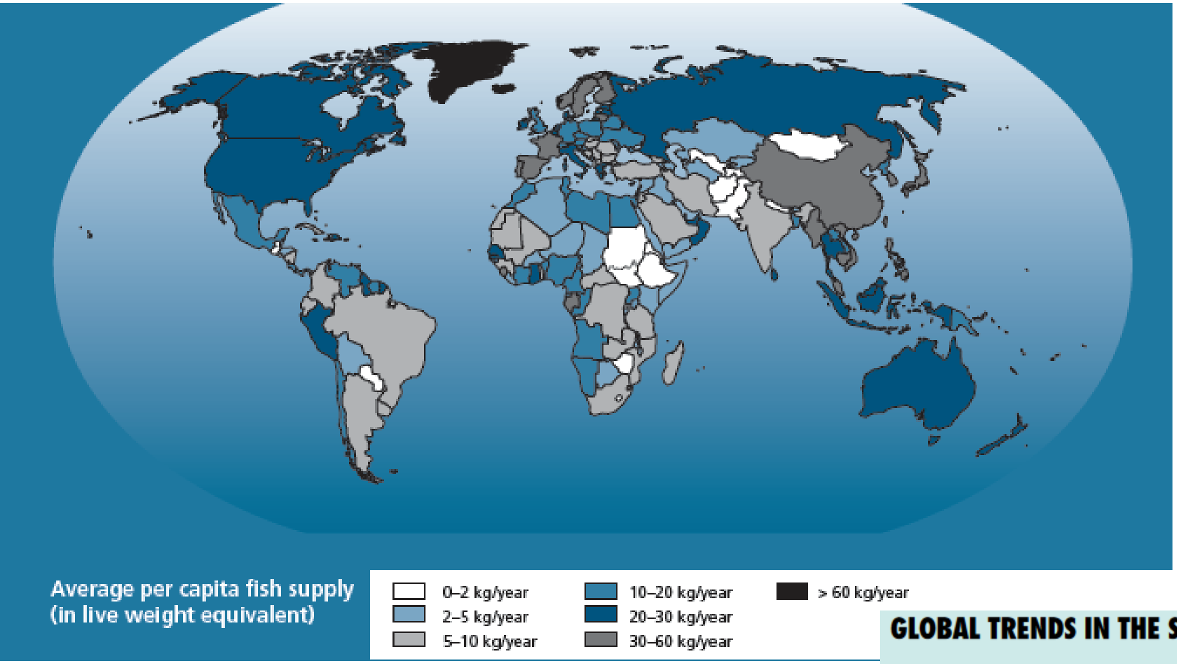


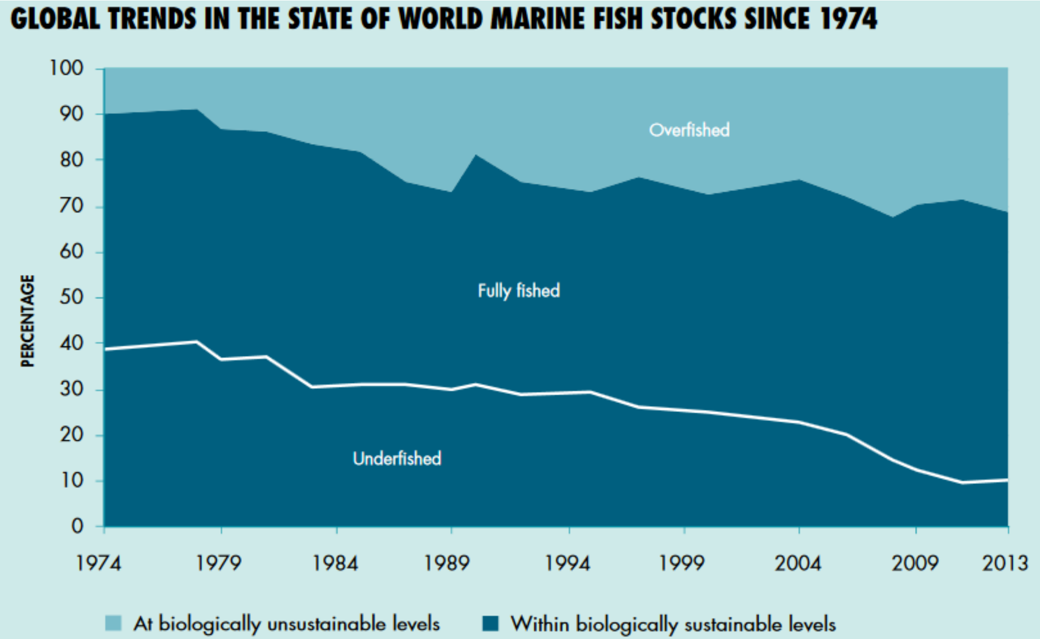
Value



FAO 2006, 2012

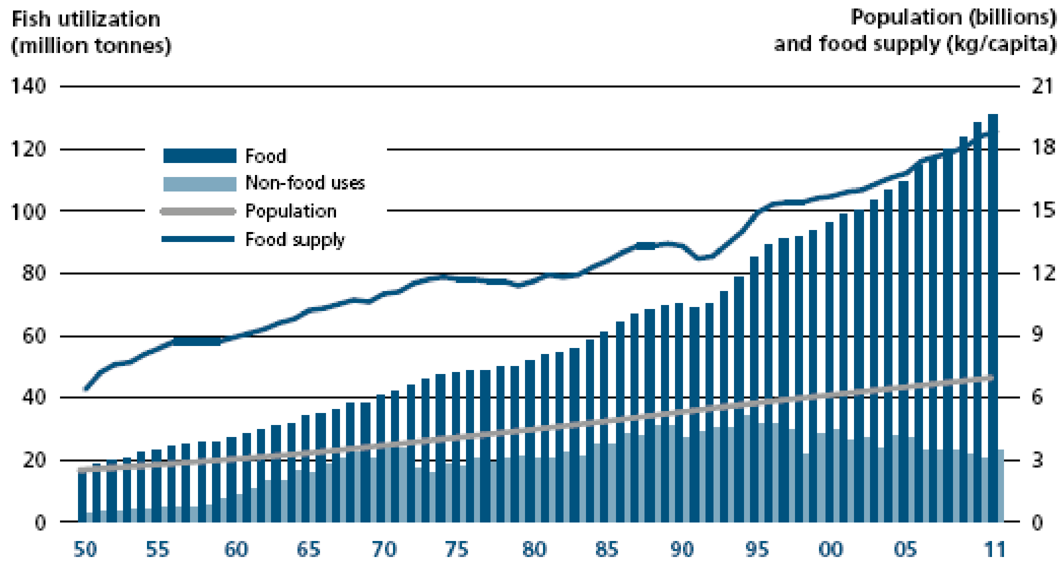
Catch Locations & Management

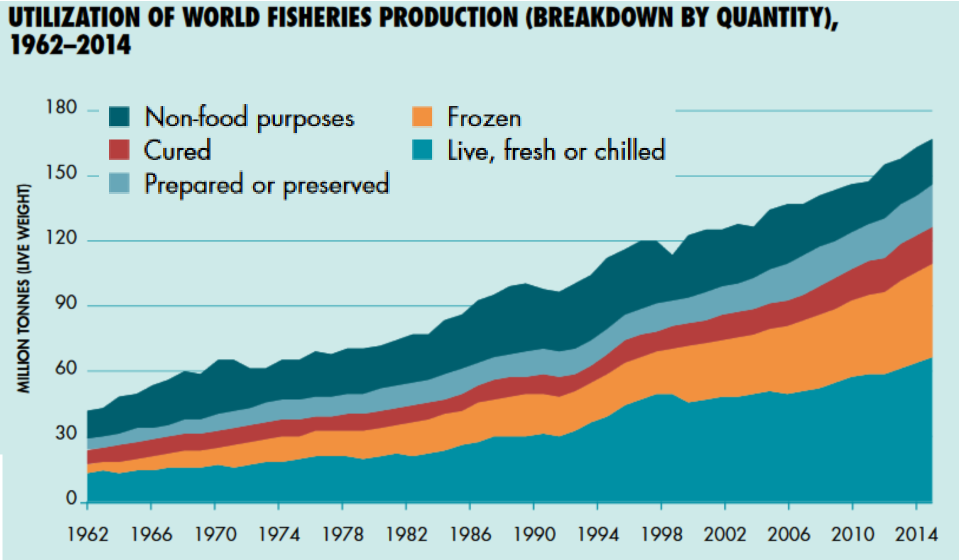




FAO 2014, 2016

World Fish Supply & Use

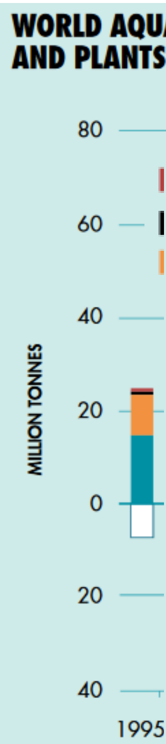


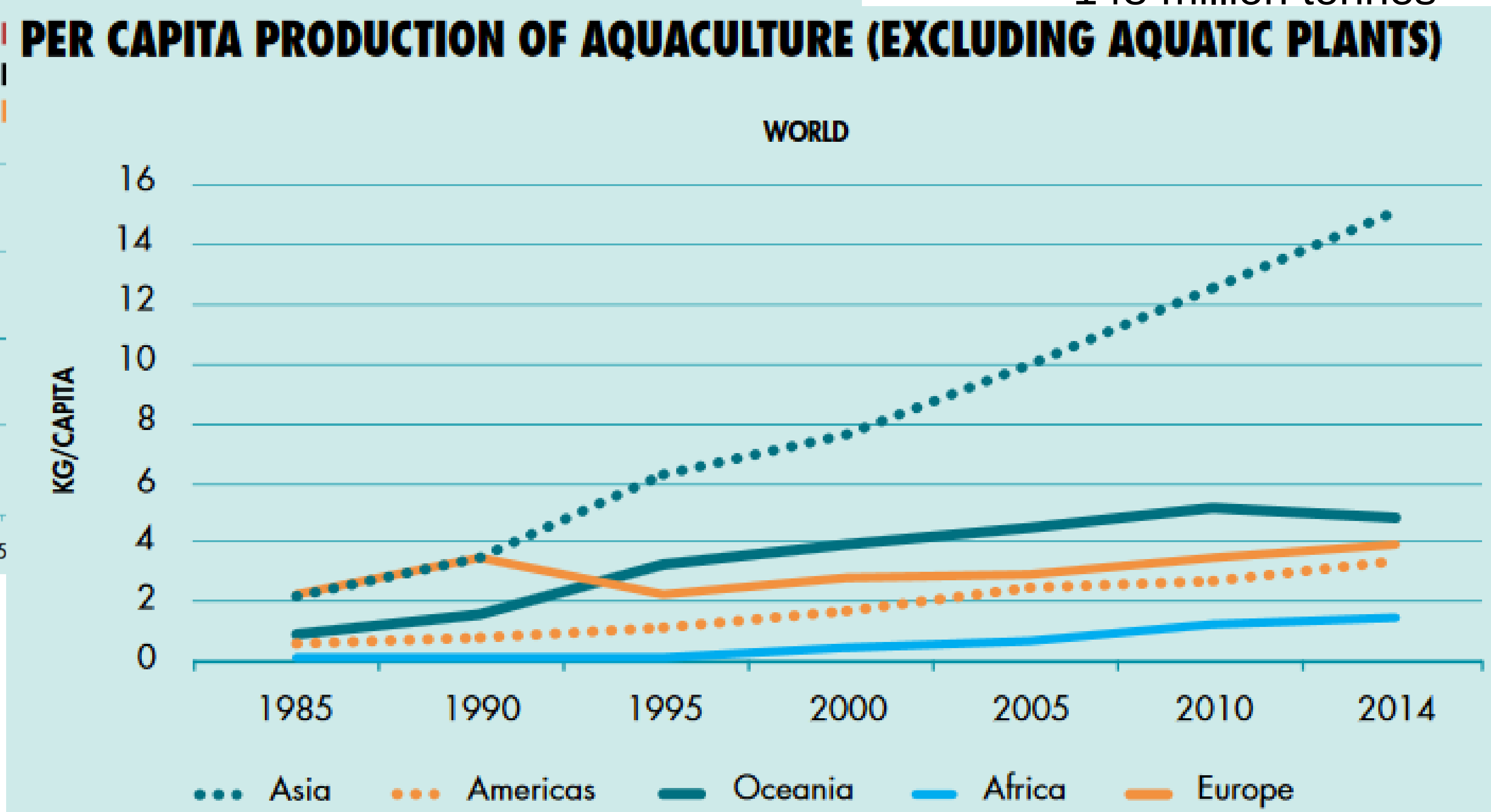


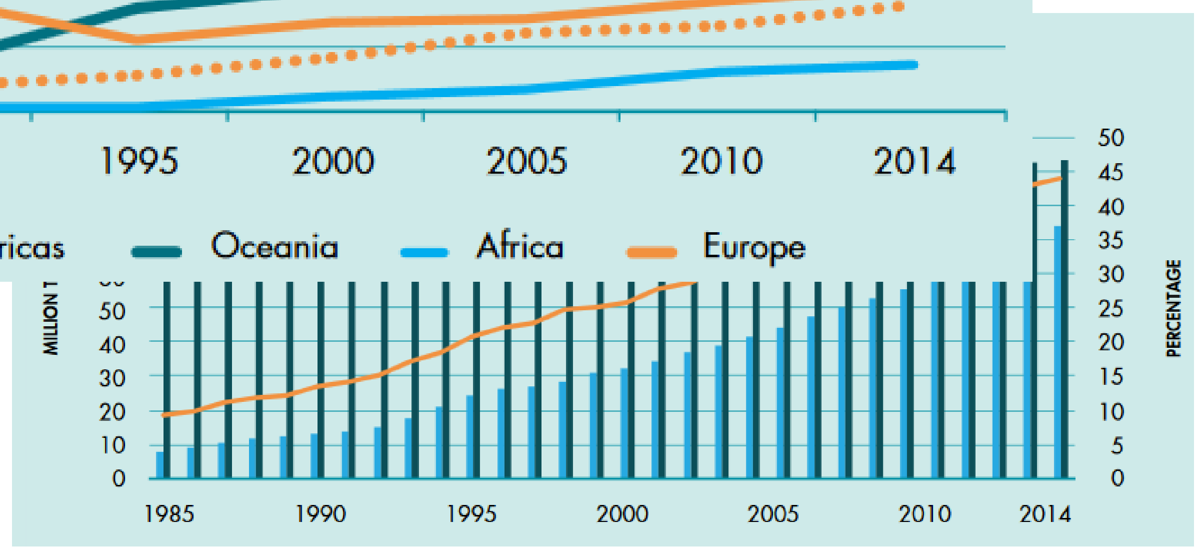
Aquaculture Trends

2010 Total Capture + Aquaculture

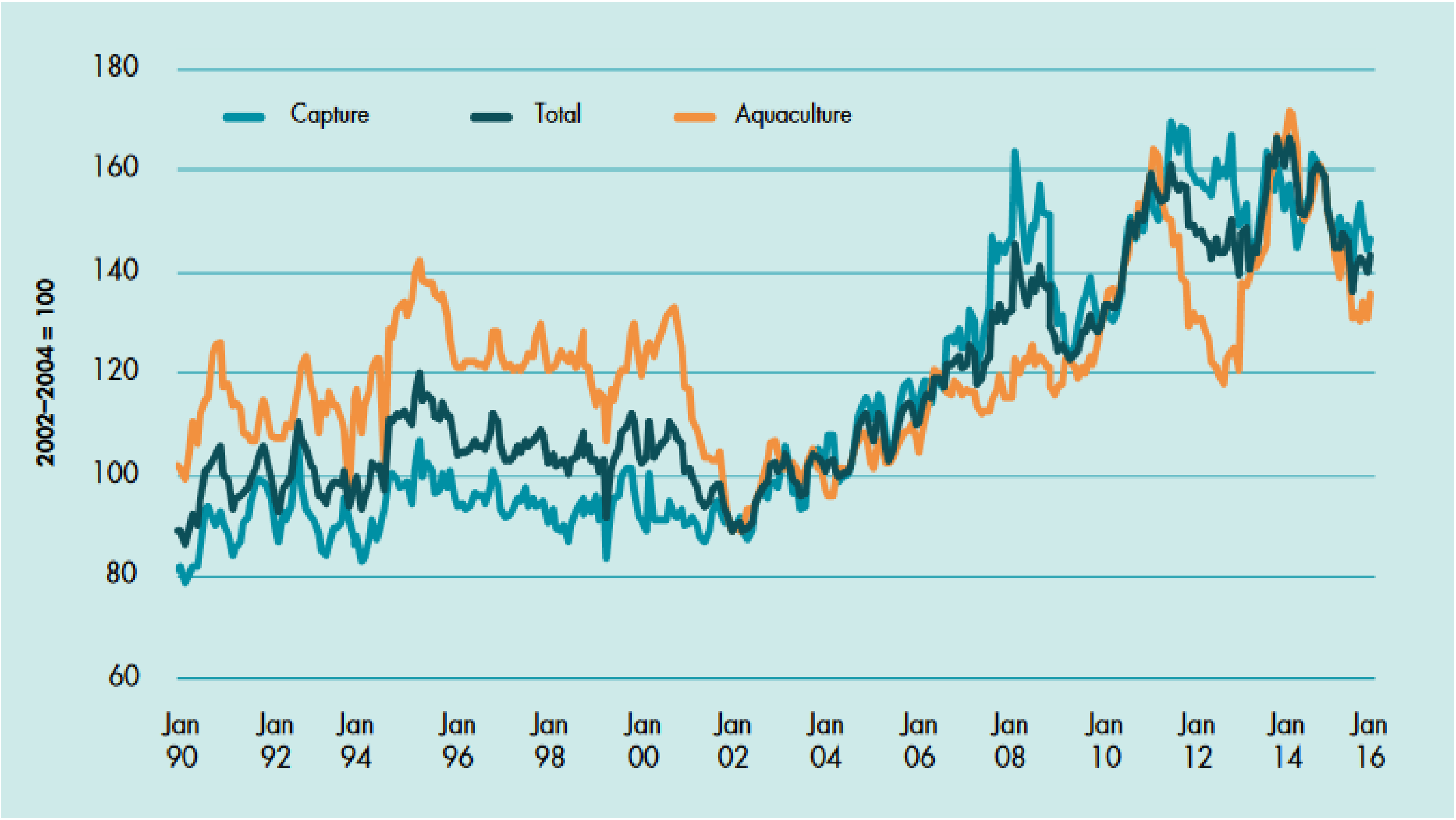
148 million tonnes







Fish Price Index



Data from Norwegian Seafood Council

Fish Production: physiology

Physiological & organismal perspective 2 approaches:

1. Size - Dependent Function (e.g. von Bertalanffy)

    - based on mass, not food dependent

$$\frac{dw}{dt} = Hw^m - Dw^n$$

food intake

metabolism

- growth as two size-dependent functions
- basis of Beverton & Holt model

Fish Production: physiology

2. Mass Balance (e.g. Winberg 1956)

- based on food consumption

$$\frac{\Delta w}{\Delta t} = aR - T$$

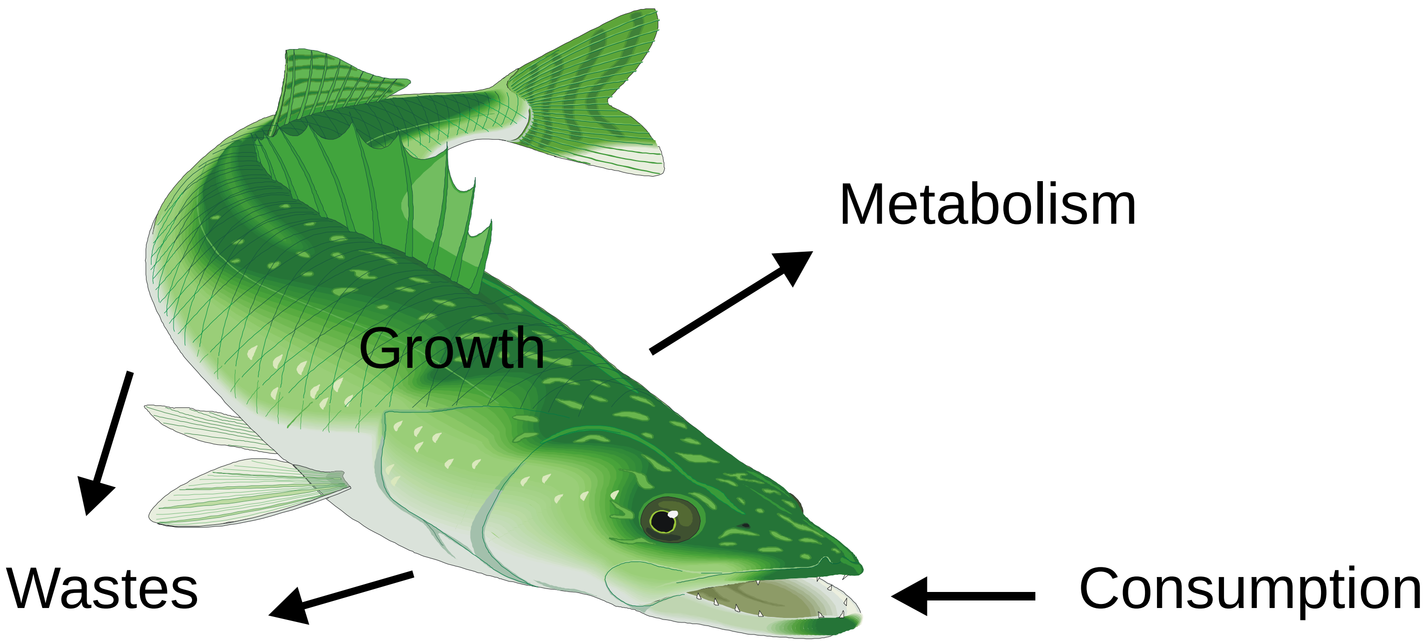
a= fraction assimilated

R= Ration

T=Metabolism

Energy Equation: Winberg (1956)

Growth = Consumption - (Metabolism + Wastes)



Cod Predation Bioenergetic Summary

Model Component	8 capelin	12 capelin
Ration	1057 kJ	1585 kJ
Egestion and Excretion	-317 kJ	-476 kJ
Maintenance	-58 kJ	-58 kJ
Digestion	-125 kJ	-188 kJ
Swimming	-79 kJ	-79 kJ
Surplus Energy	478 kJ	784 kJ
	45%	49%

Horne and Schneider 1994

Factors Affecting Metabolism

1. **Temperature** controlling factor (10ºC increase 2x metabolism)

   - affects chemical breakdown: $\log_{10}(O_2) \propto T^{0.036}$

   - standard metabolism (SM) increases with T, active metabolism (AM) peaks then declines

2. **Starvation** – SM decreases logarithmically, AM no change

3. **Limiting factors**: O_2 (amount of water past gills)

4. **Masking factors**: toxics, particulates

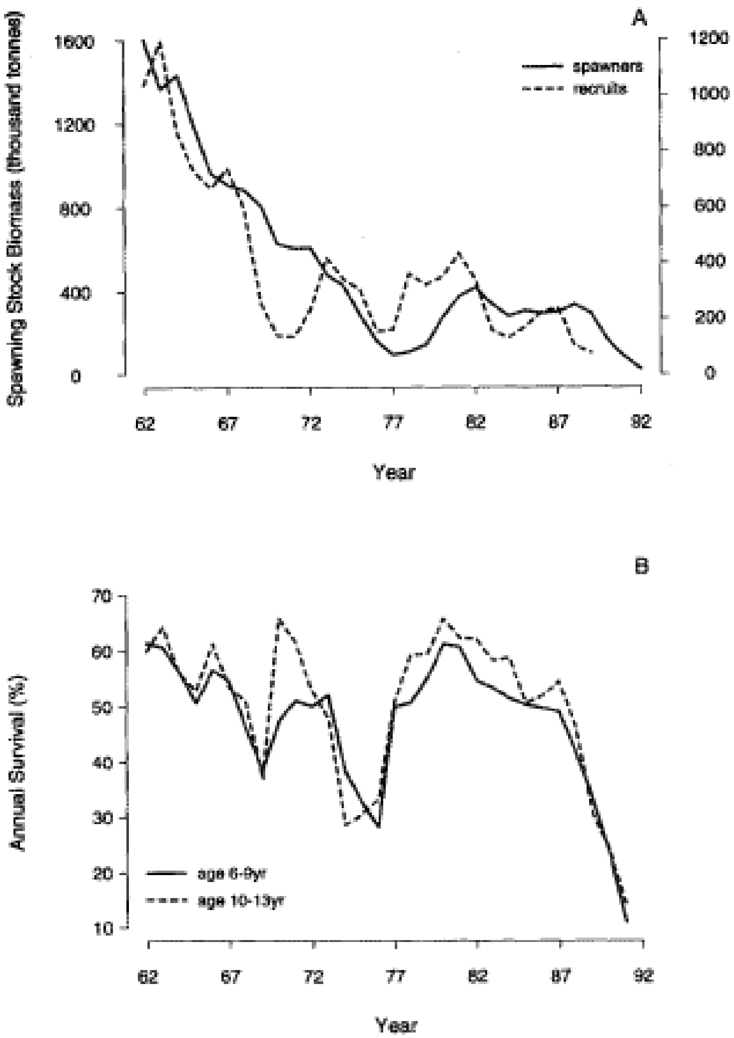
   - particulates increases SM x 2 in salmon at 1/10 $LD_{50(96\ \text{hours})}$

5. **Directive factors**: diurnal, seasonal rhythms

+ multiple stressors: direct and indirect effects

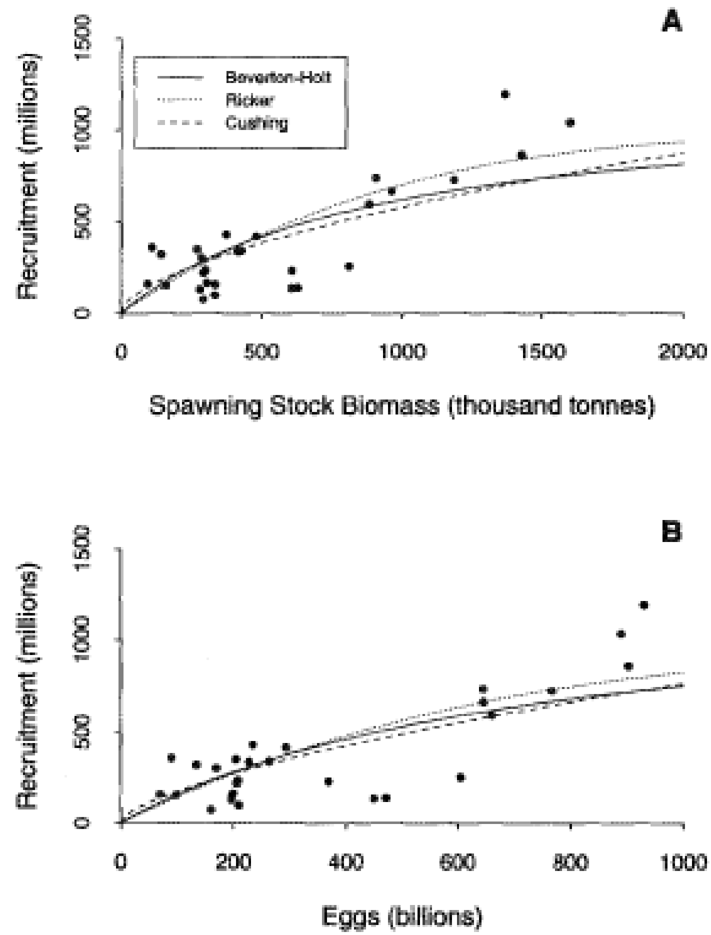
Fry 1971

Northern Cod Production Decline



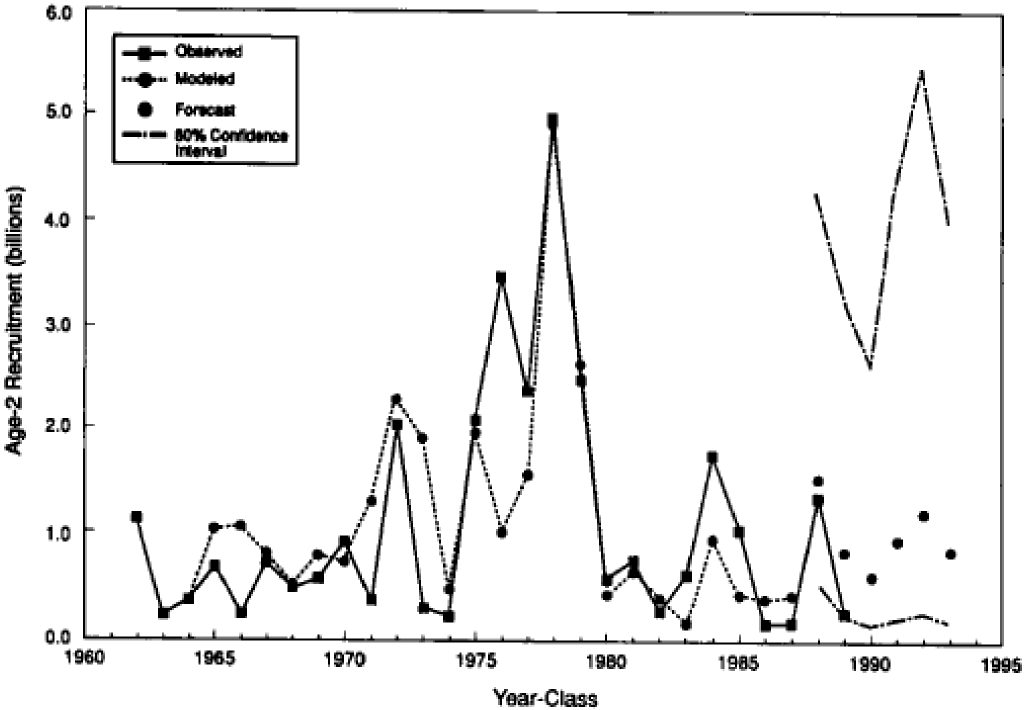
- - - 3 yr old recruits

— 7+ spawners



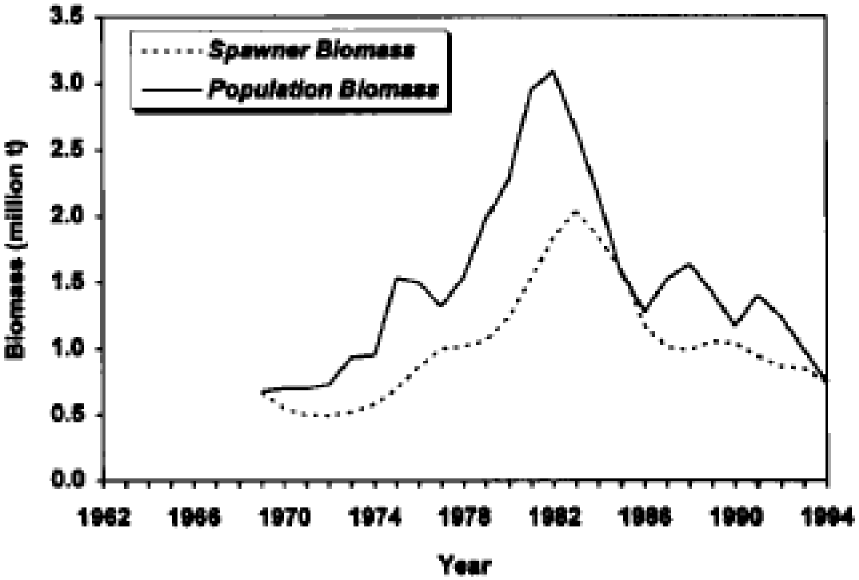
Hutchings & Myers 1994

Estimating Walleye Pollock Production



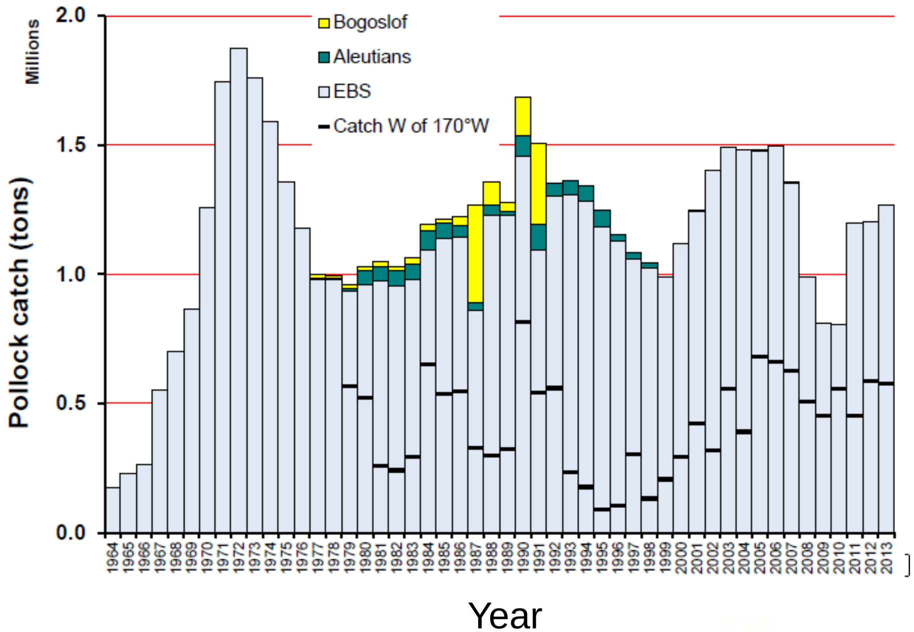
Gulf of Alaska, Shelikof Strait

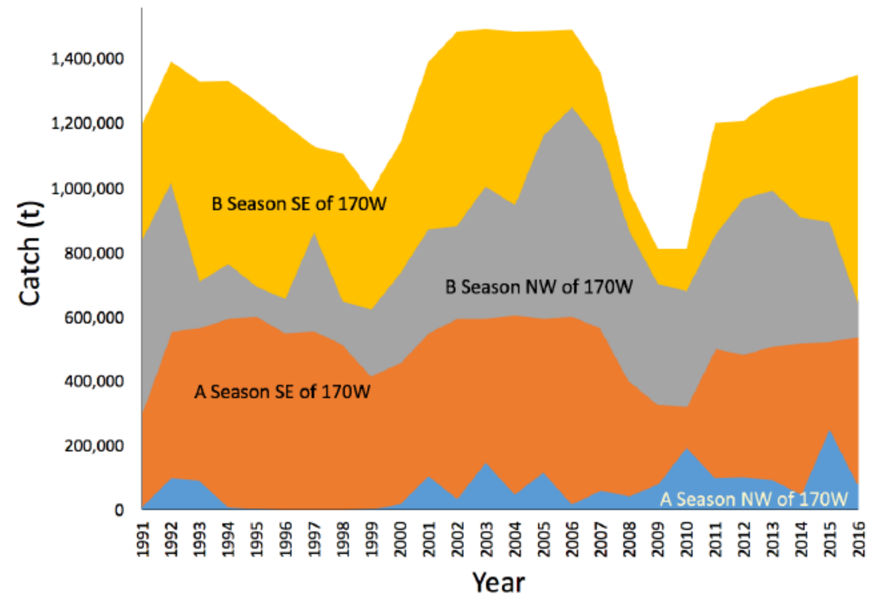
- age 2 recruitment
- ocean stratification & circulation during spring and summer
- rainfall Jan. & Feb.
- model used 1988 - 1993

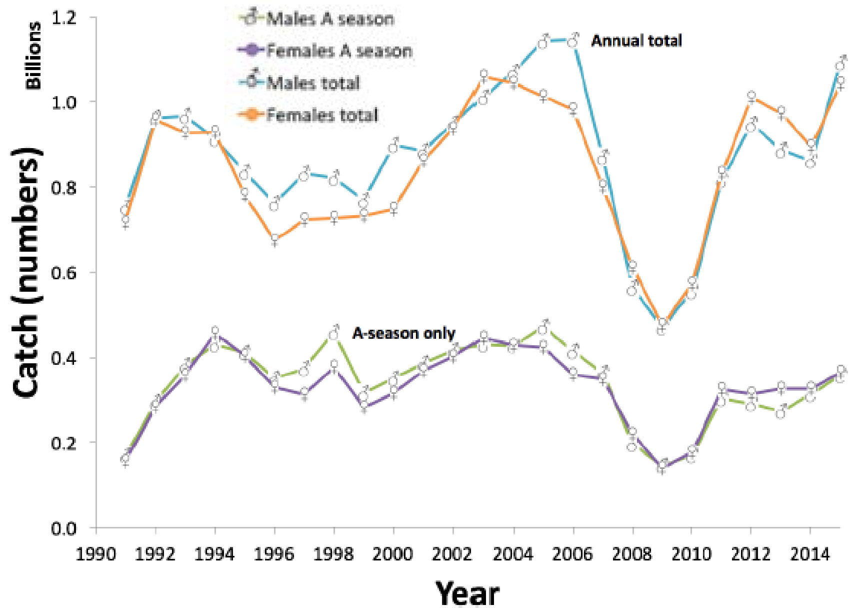


Megrey et al. 1996

Walleye Pollock EBS Catch

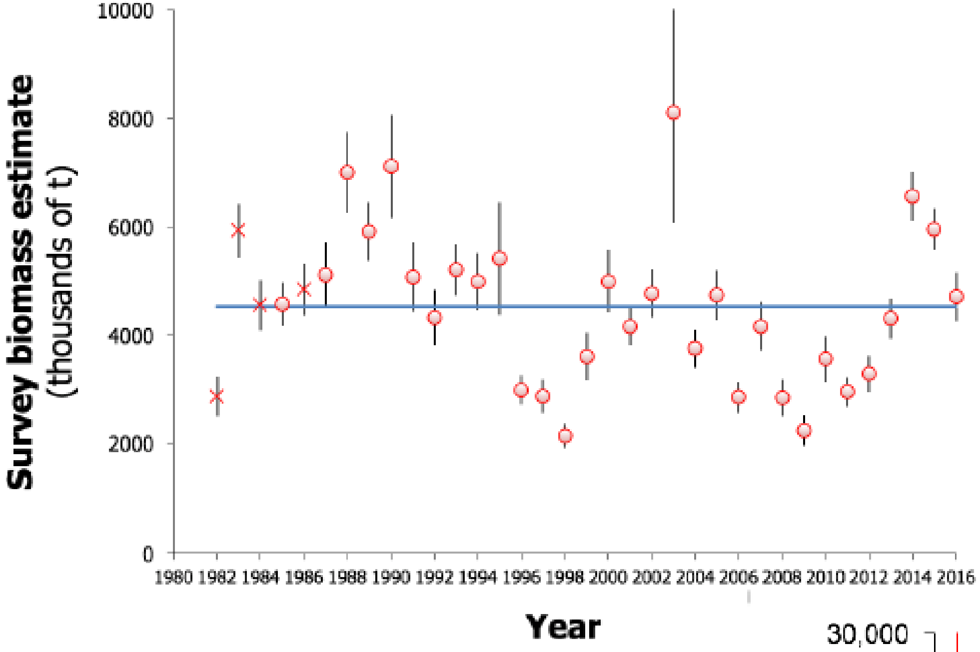


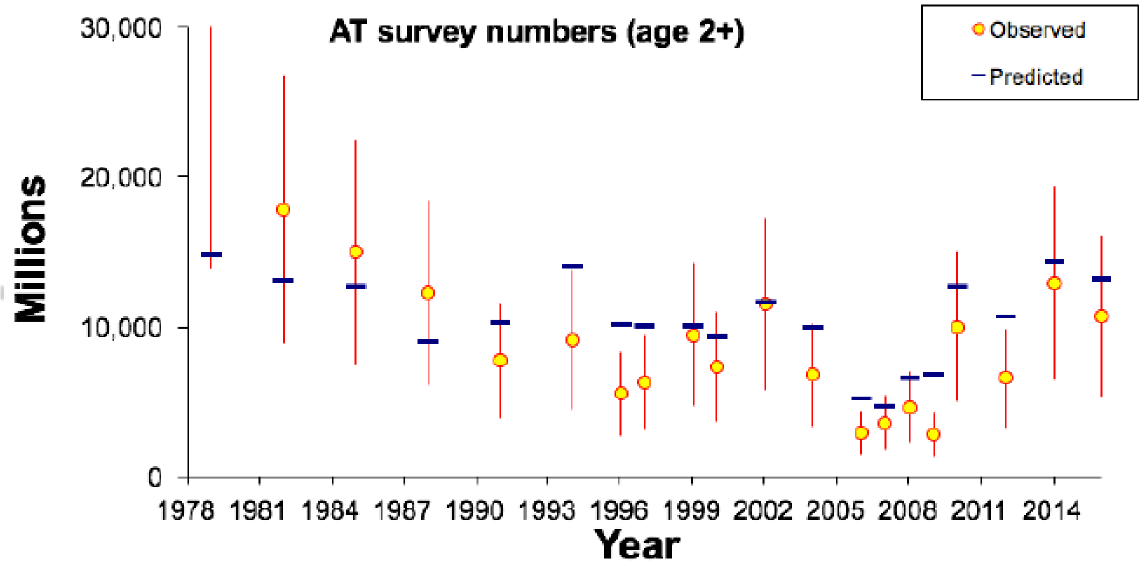




SAFE 2013, 2016

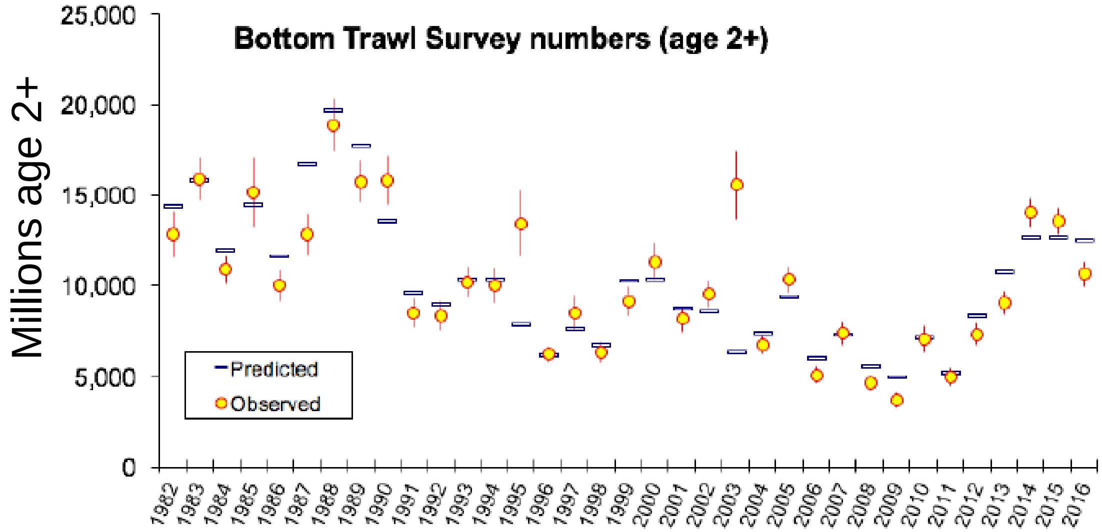
Bottom Trawl & Acoustic Biomass Estimates

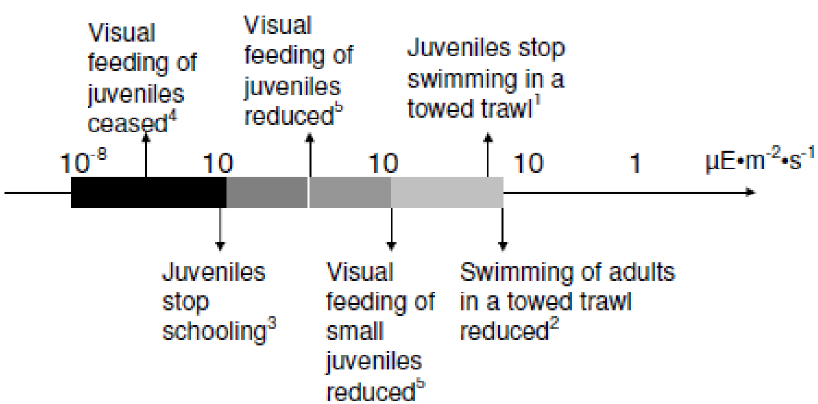


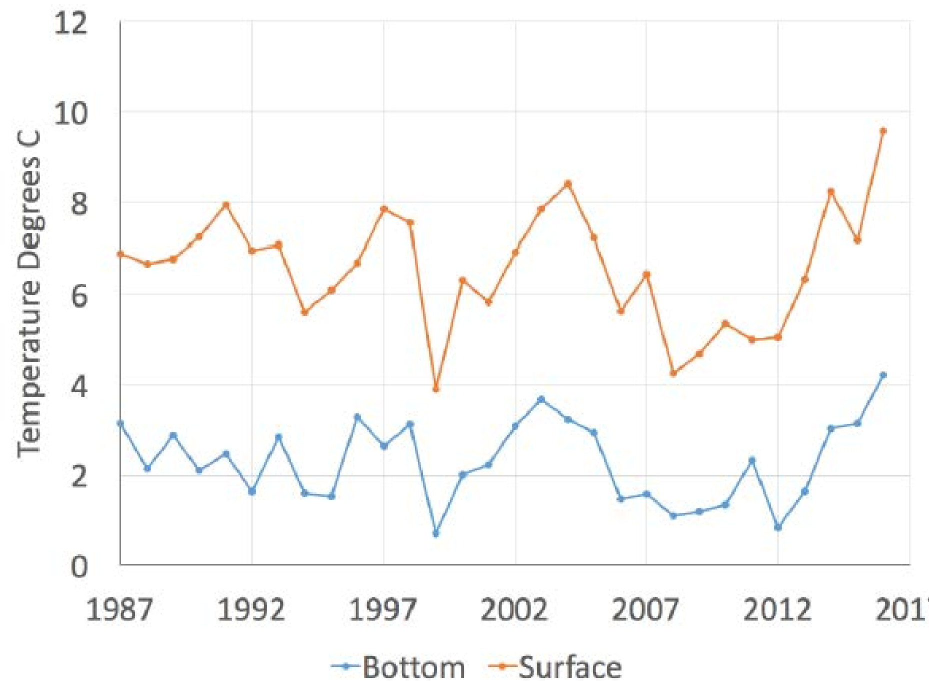


SAFE 2016

Potential Influence of Water Temperature?



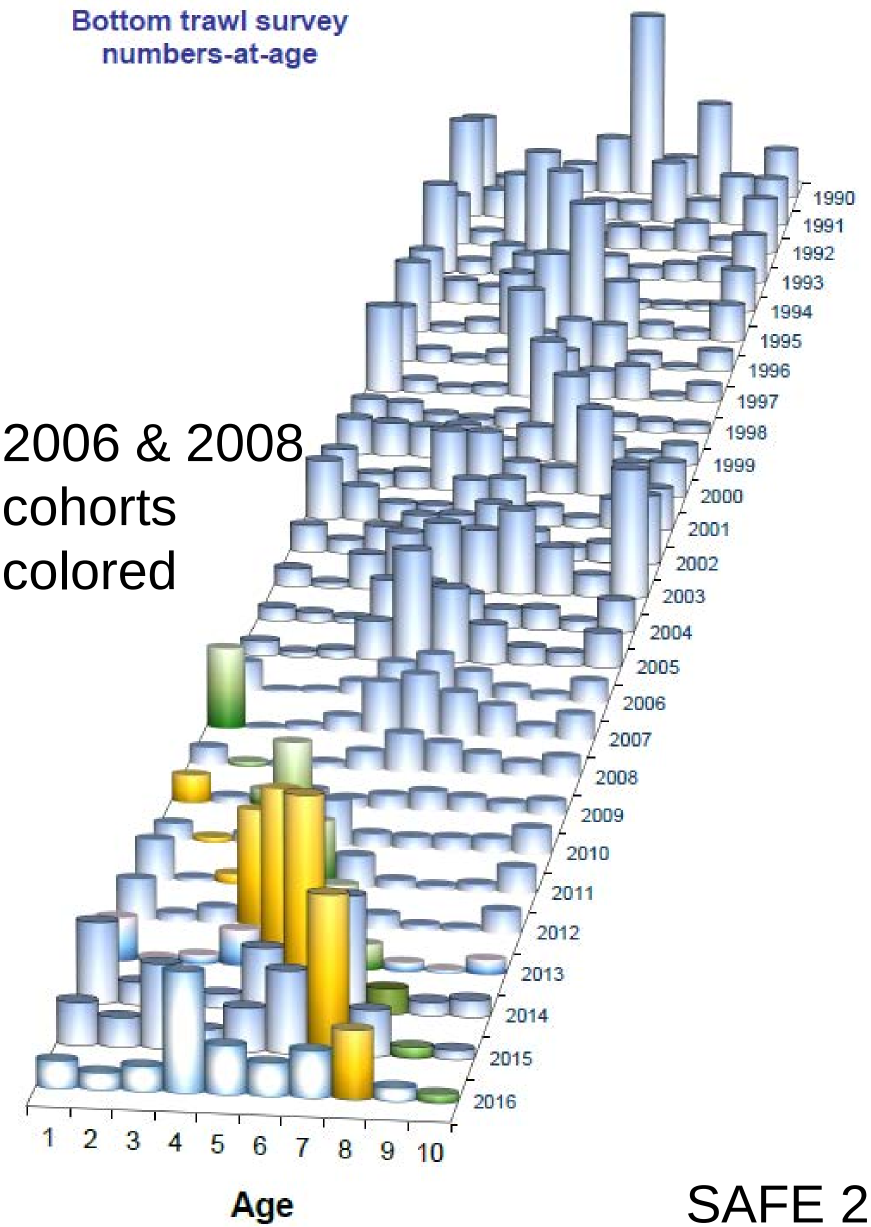




Kotwicki et al. 2009

SAFE 2016

Pollock Abundance Estimate

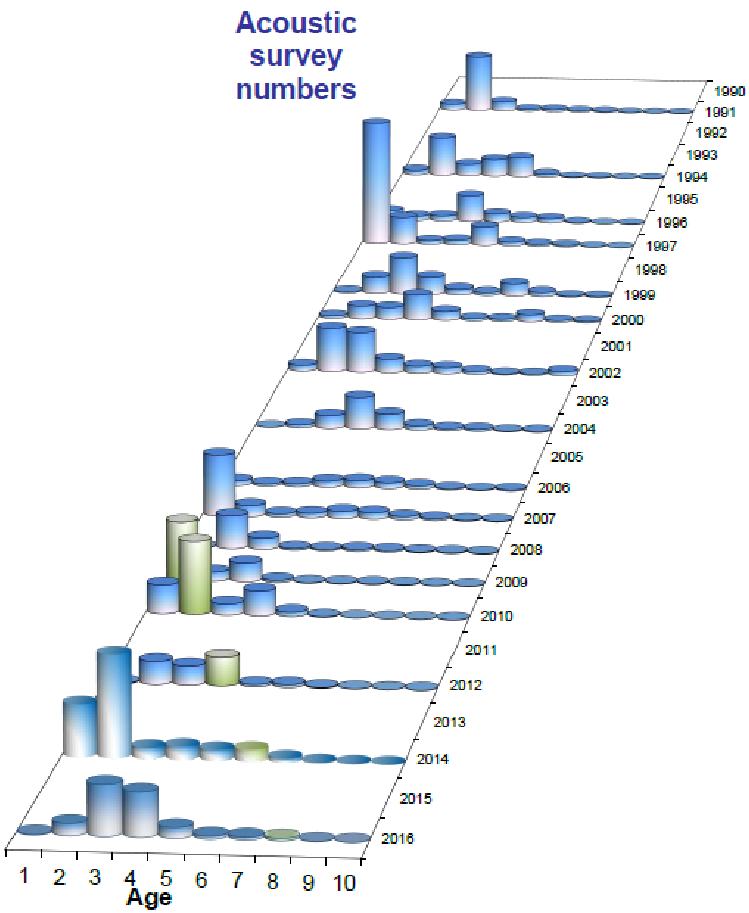


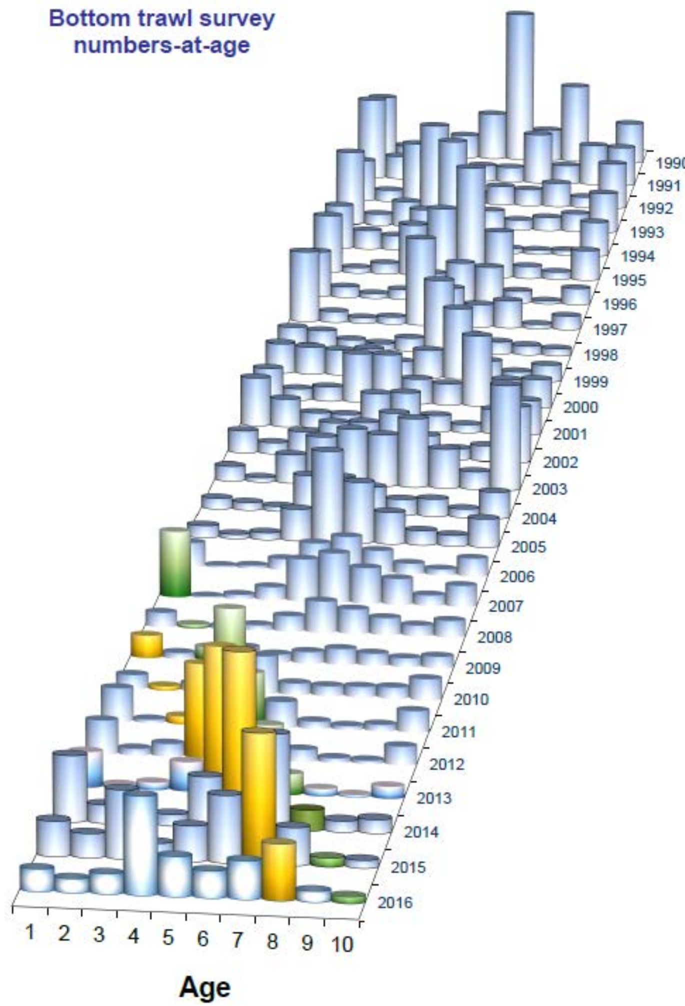
2006 & 2008 cohorts colored

- population sustained by single cohorts after recruiting to fishery
- occurrence of large cohort aperiodic and unpredictable
- large age-1 abundance may not result in large year class
- 2006, 2008 may be large year classes. 2013?

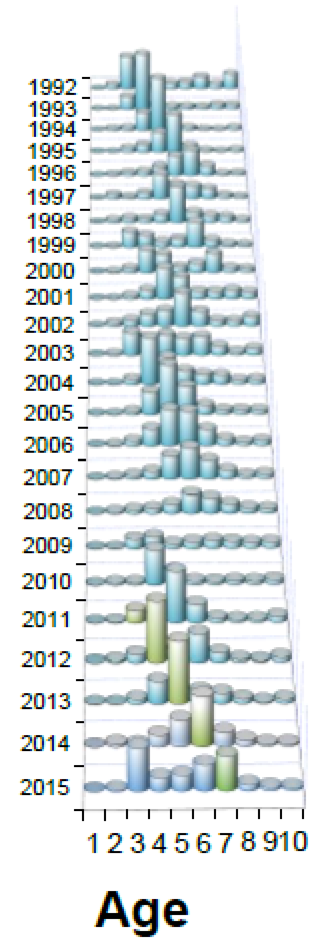
SAFE 2016

Acoustic, Bottom Trawl, Commercial Abundance at Age Estimates





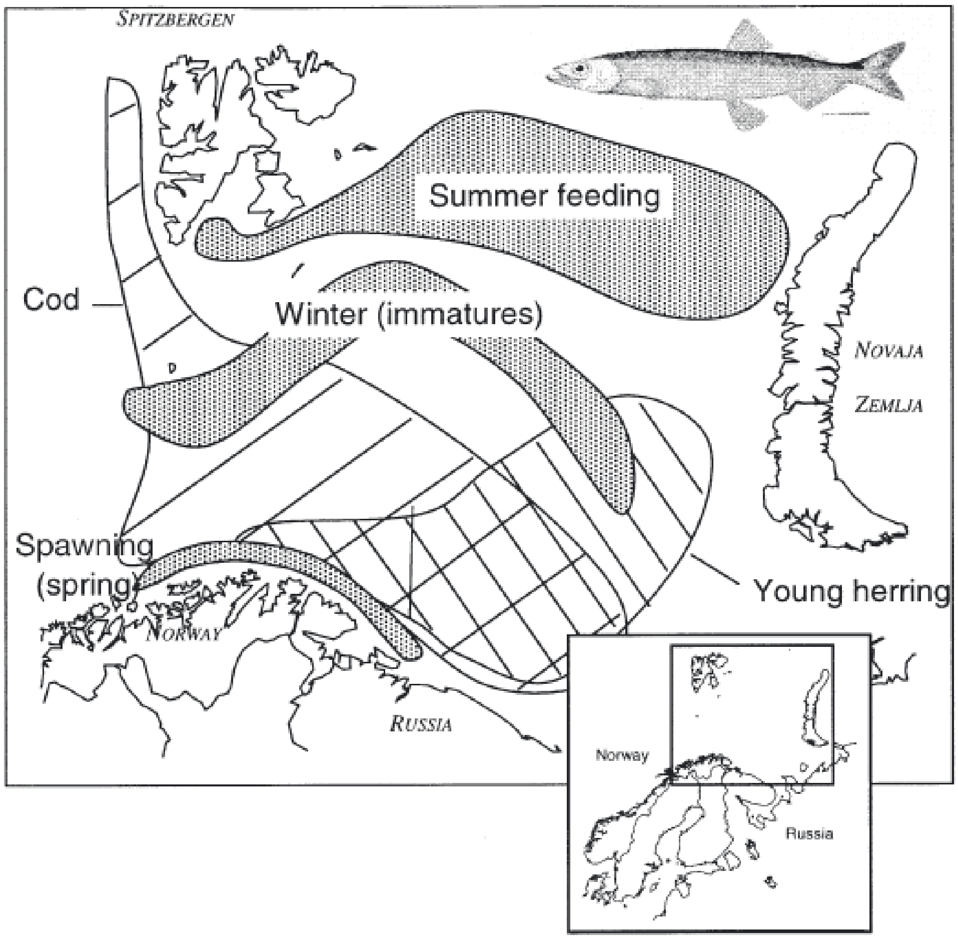
Commercial
Numbers-at-age



SAFE 2016

Abiotic and Biotic Effects

Barents Sea Capelin



What influences capelin production?

- overlap with herring and cod predators
- water temp influences herring and cod more than capelin
- results in a lagged effect on capelin due to predation 1 to 2 years after warm year (which increases herring and cod)

Hjermann et al. 2004