

# Reconstructing the time series of abundance of Northeast Arctic cod (*Gadus morhua*), taking cannibalism into account

12th Norwegian-Russian symposium, Tromsø,  
21-22 August 2007

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# Overview

- Cod cannibalism important factor in cod population dynamics
- Quantitative stomach content data available from 1984-present
- Qualitative stomach content data available from 1947-present
- Will describe cod cannibalism and its variations in time/space
- Long-term goal: Extend time series of cod abundance (VPA) down to age 1 back to 1947



# Cod stomach data available

- Joint IMR-PINRO stomach content data base (1984-present), > 200 000 stomachs analysed (weight, prey composition etc.)
- PINRO investigations of qualitative stomach content (prey species found, degree of fullness) 1947-present: > 1.5 million stomachs analysed

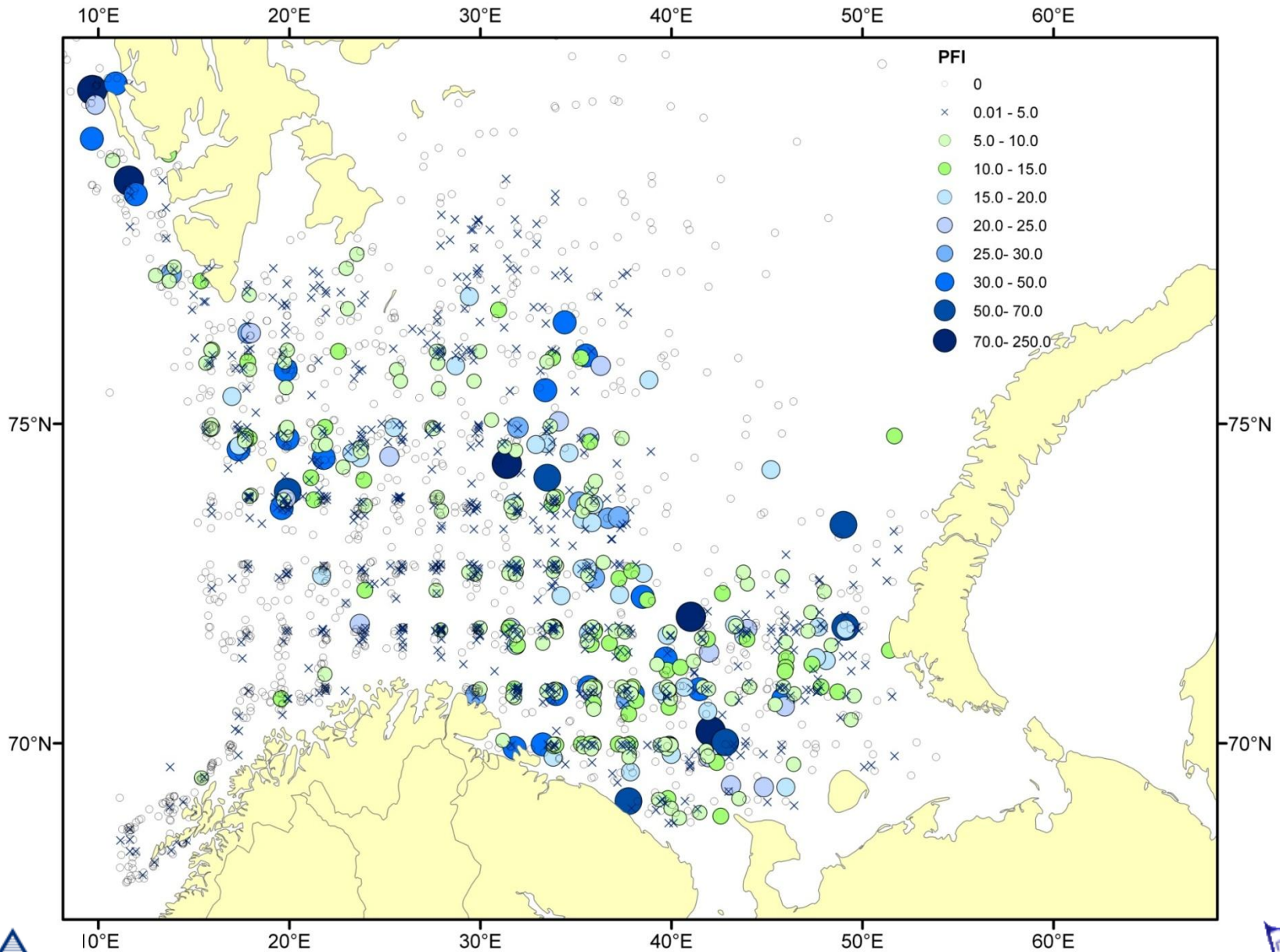


# Definitions

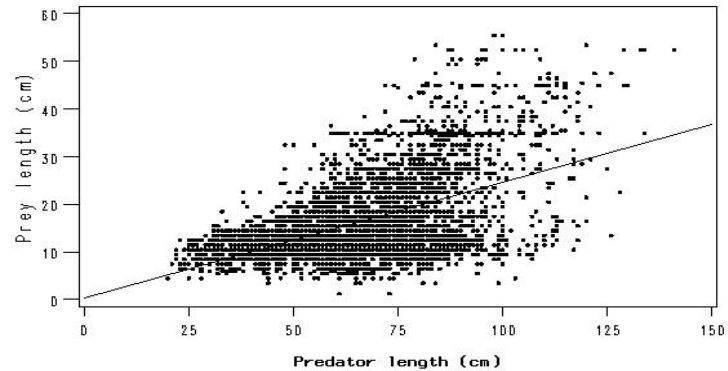
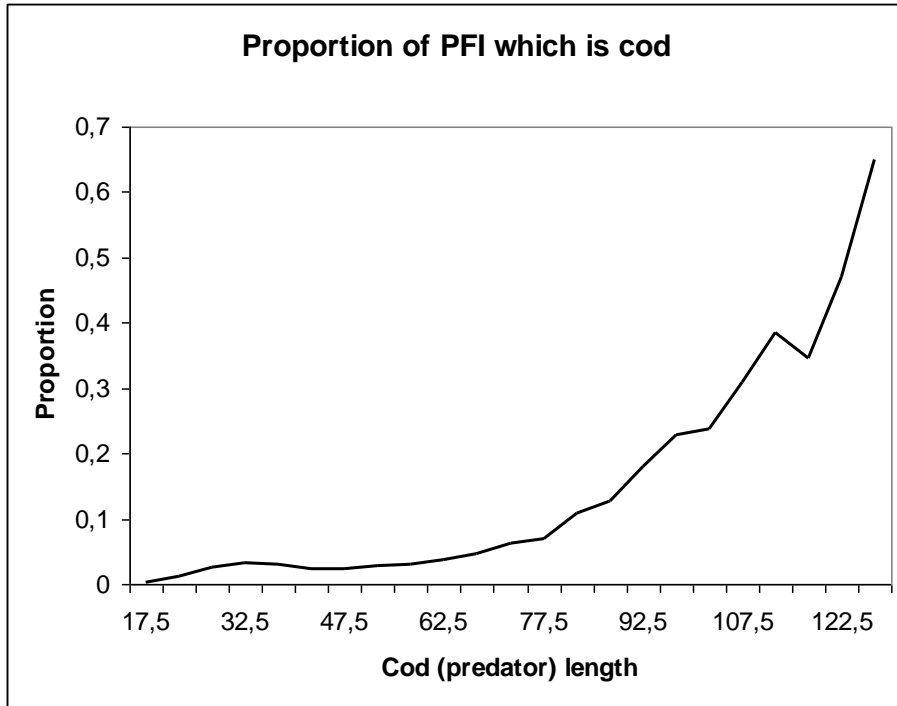
- PFI: Partial Fullness Index (prey weight\*10000/L<sup>3</sup>)
- FO<sub>cod</sub>: Frequency of occurrence of cod in cod stomachs
- M2: Mortality due to cannibalism
- XSA: eXtended Survivors Analysis (a VPA-type assessment method)



# Cod predation by cod (>40 cm) for the period 1984-2005



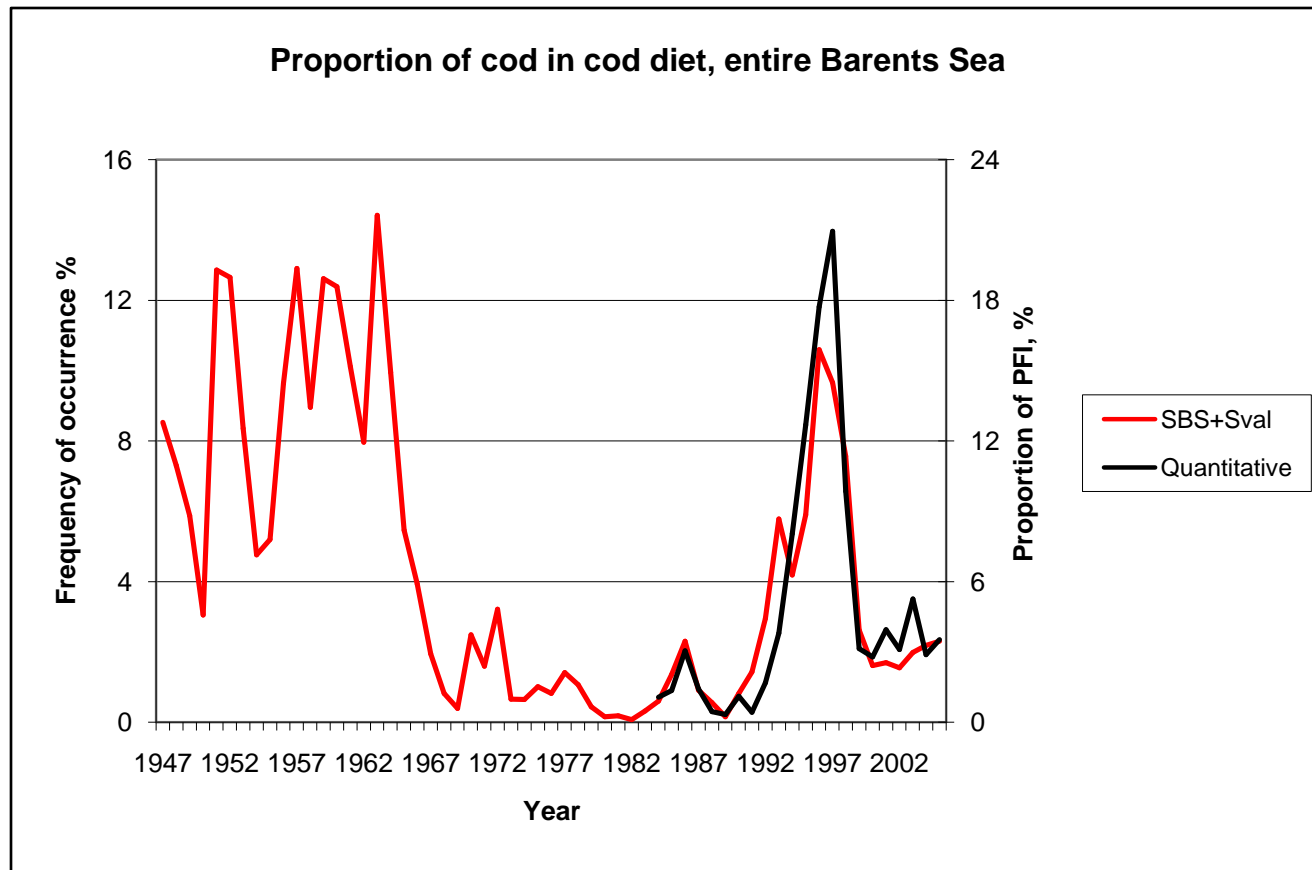
# Predator size vs. prey size



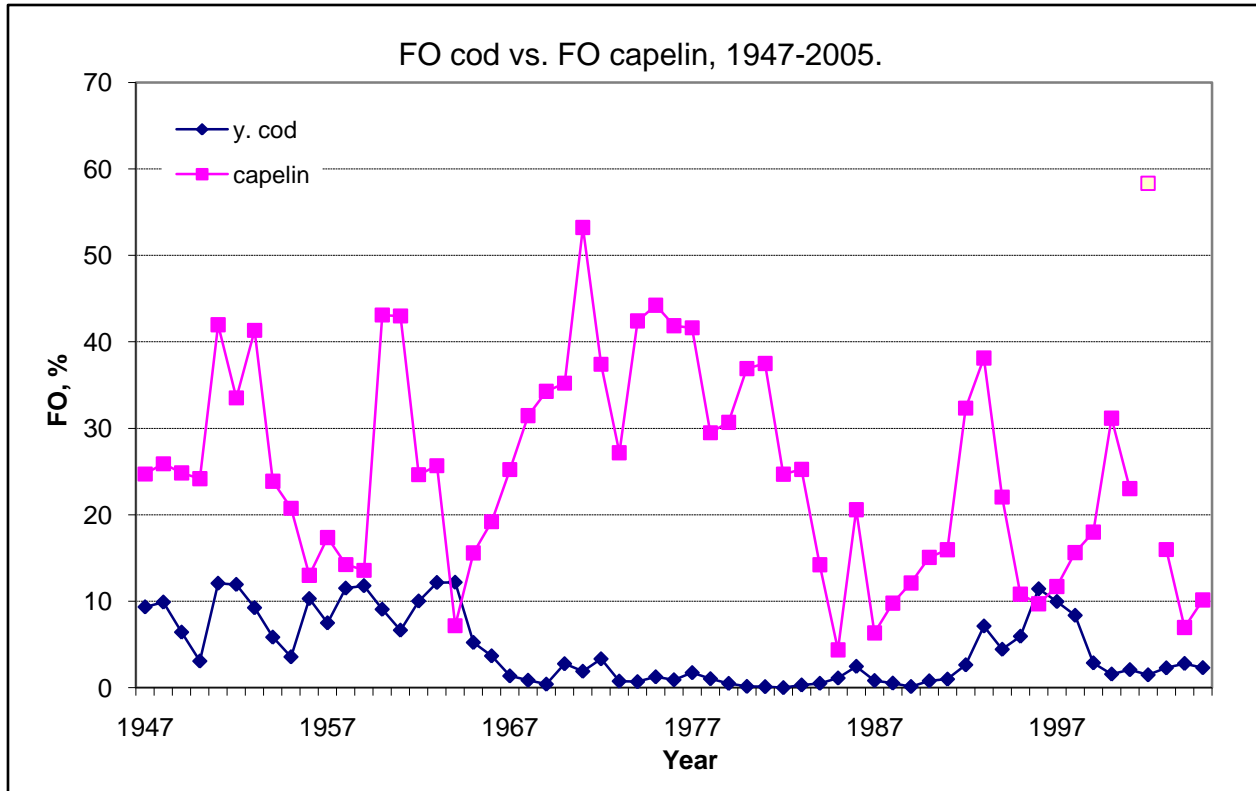
Prey size vs. predator size for cod preying on cod, for the period 1984-2005.



# Frequency of occurrence of cod in cod stomachs



# Frequency of occurrence of cod and capelin





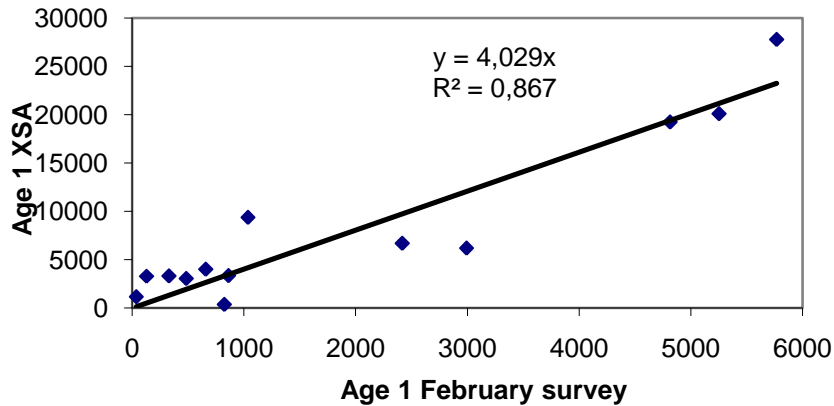
# Present use of cod cannibalism data in assessment

- Calculate amount of cod eaten per predatory cod (by half-year, predator and prey age group) for period 1984-present
- Assume that cannibalism mortality comes in addition to  $M=0.2$
- Run XSA down to age 1 using number of cod eaten as additional catches
- Iterate until convergence
- Problem: Quantitative data not available before 1984

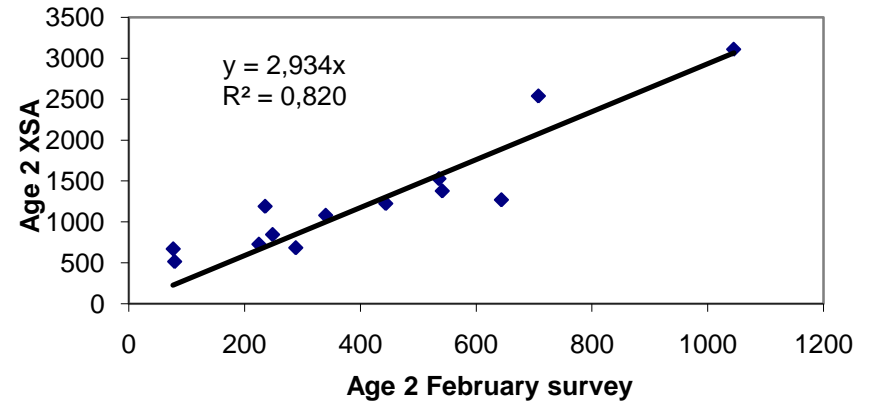


# Survey abundance vs XSA estimate

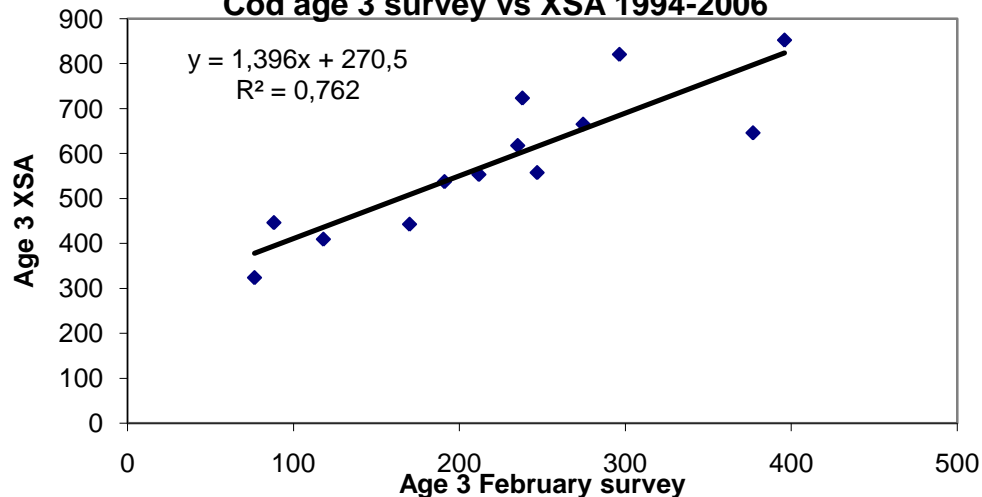
Cod age 1 survey vs XSA 1994-2006



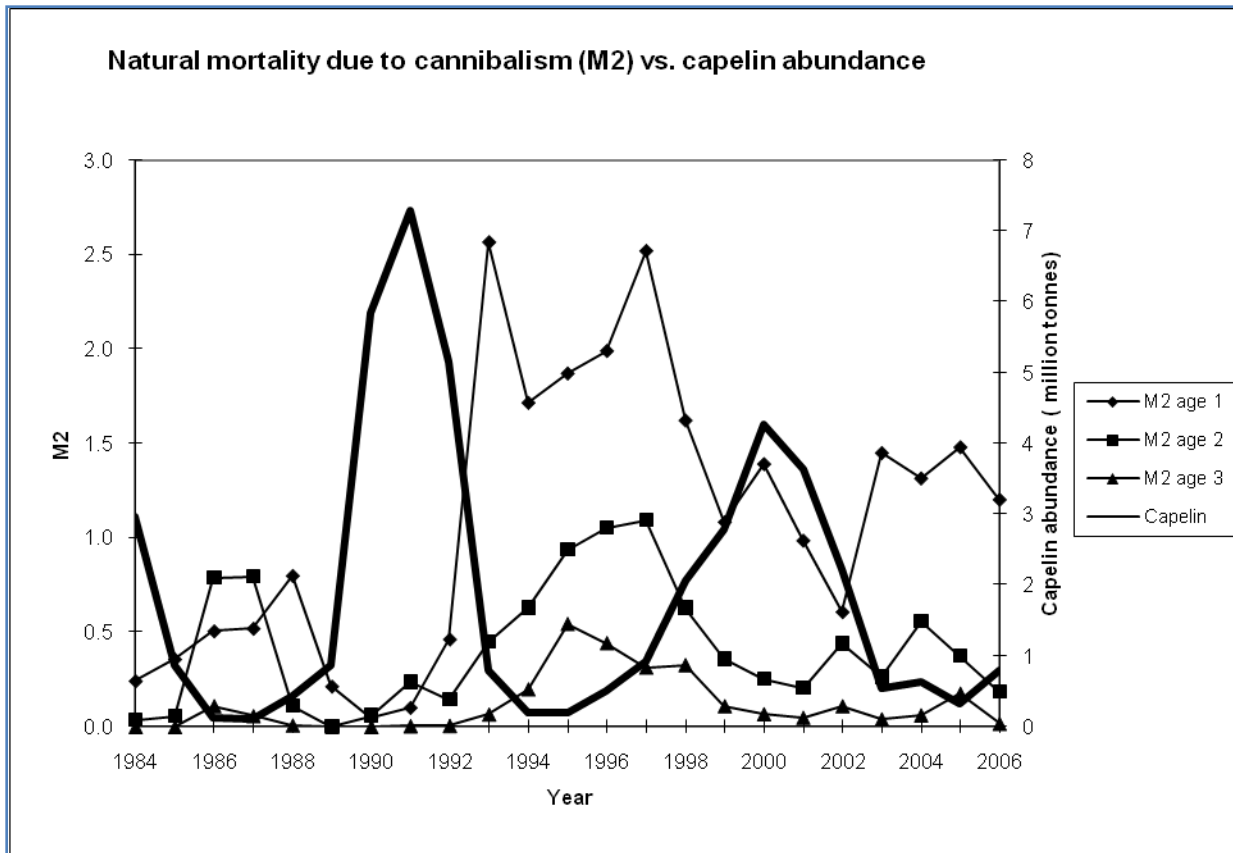
Cod age 2 survey vs XSA 1994-2006



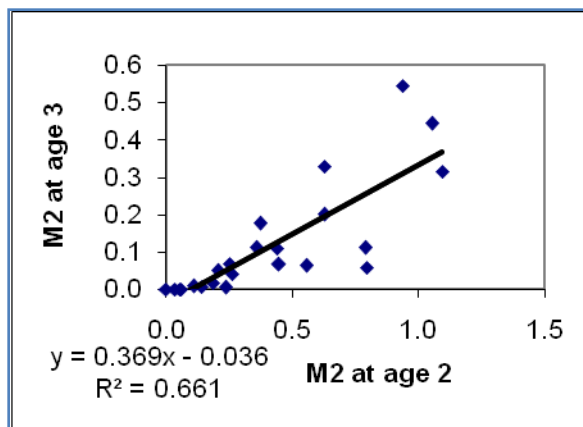
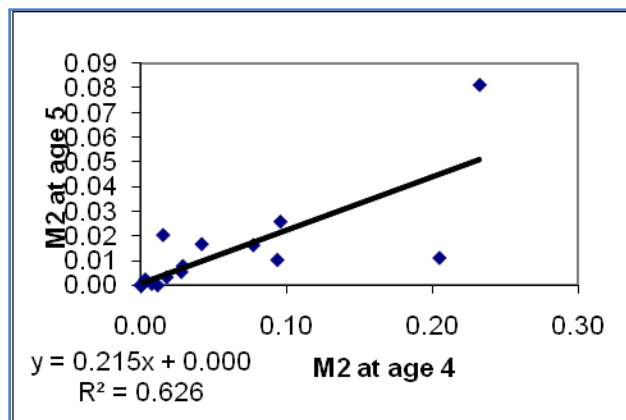
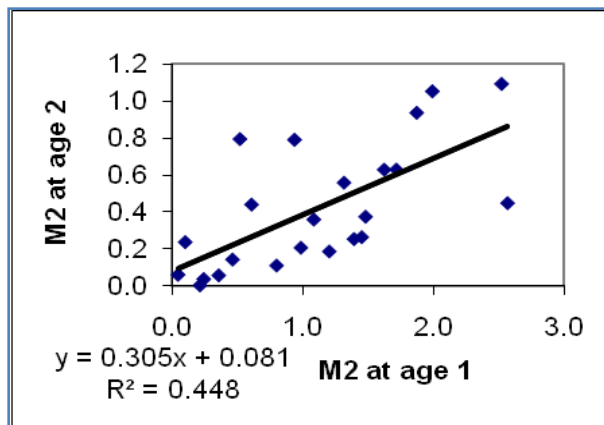
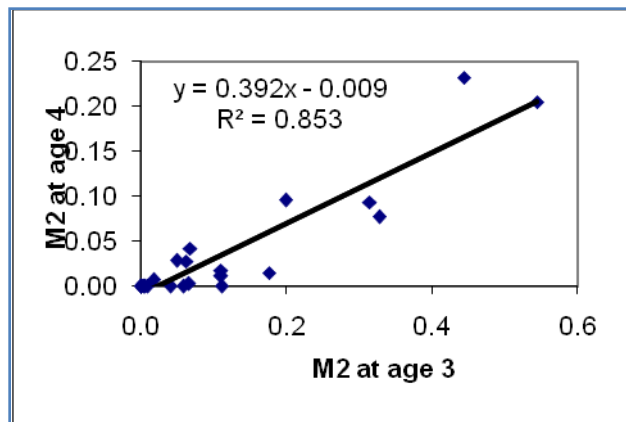
Cod age 3 survey vs XSA 1994-2006



# Cannibalism mortality (M2) vs. capelin abundance



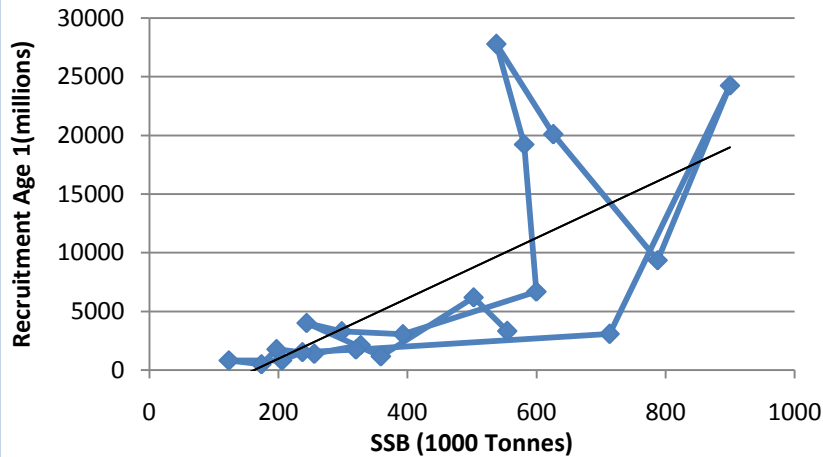
# Correlation between M2 for different prey age groups



# SSB-recruitment relationship, 1983-2003 cohorts

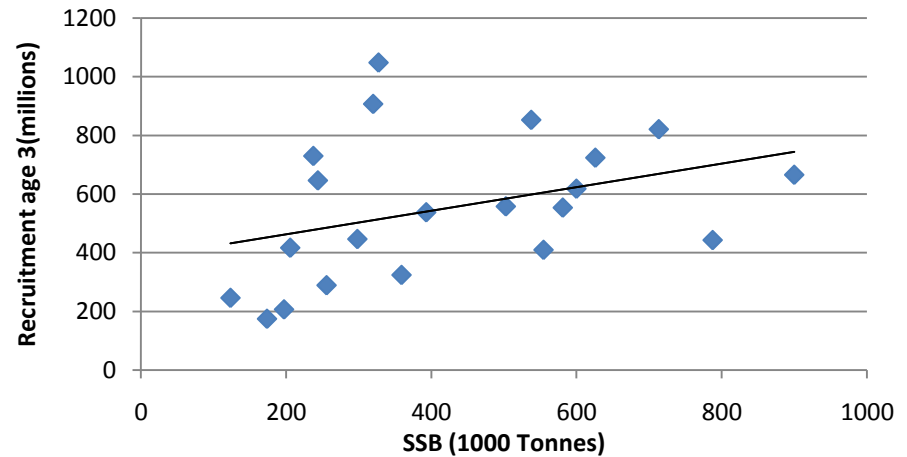
### Age 1

$$y = 25,71x - 4171, \\ R^2 = 0,449$$



### Age 3

$$y = 0,401x + 382,3 \\ R^2 = 0,133$$



# Conclusions (I)

- Cannibalism mortality may be considerable on age 1-3 cod
- Length of predatory cod is at least twice length of cod prey
- Proportion of cod in cod diet increases with predatory cod size
- Large spatial variation in cannibalism



# Conclusions (II)

- Survey estimates of age 1-3 cod (1994-2006) consistent with cannibalism data
- Cannibalism inversely related to capelin abundance
- Unexplained long-term trends in cannibalism level
- Including cannibalism improves stock-recruitment relationship



# Future work

- Make model for cannibalism as a function of predator and prey (cod, capelin, other) abundance based on quantitative stomach content data
- Hindcast cannibalism (and thus number at age) down to age 1 and back to 1947, based on qualitative stomach content data
- Study stock/recruitment relationship and harvesting strategies based on revised time series

