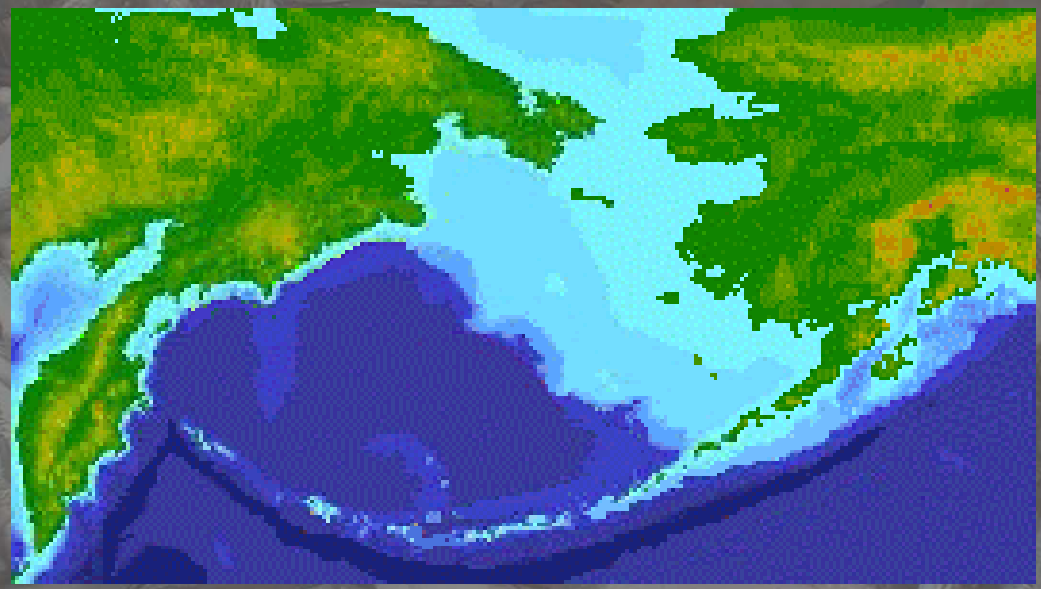
Wasp-waist control and beer-belly oscillations
Population control in the Bering Sea and Gulf of Alaska



Kerim Aydin
Sarah Gaichas
Pat Livingston
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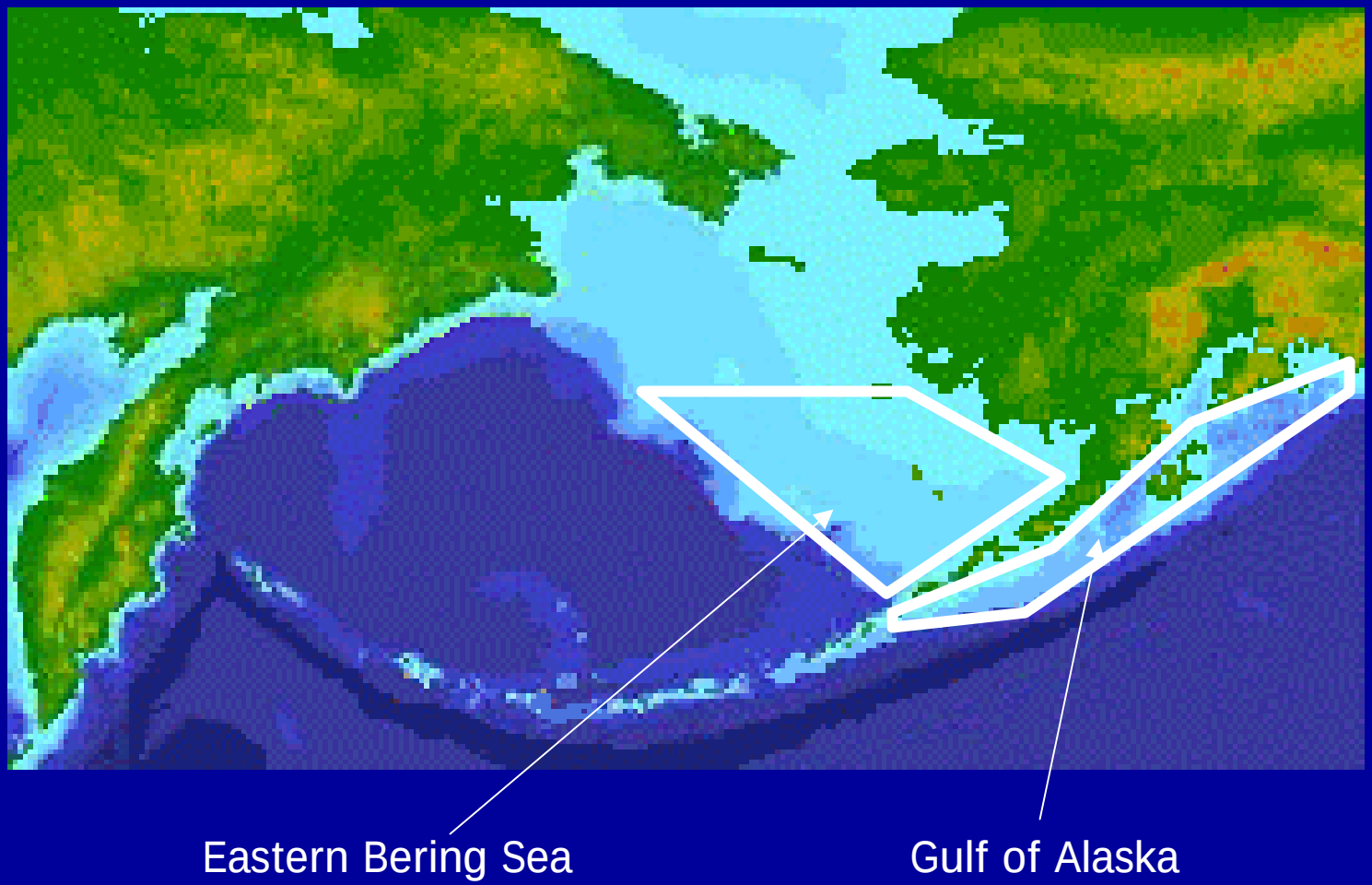
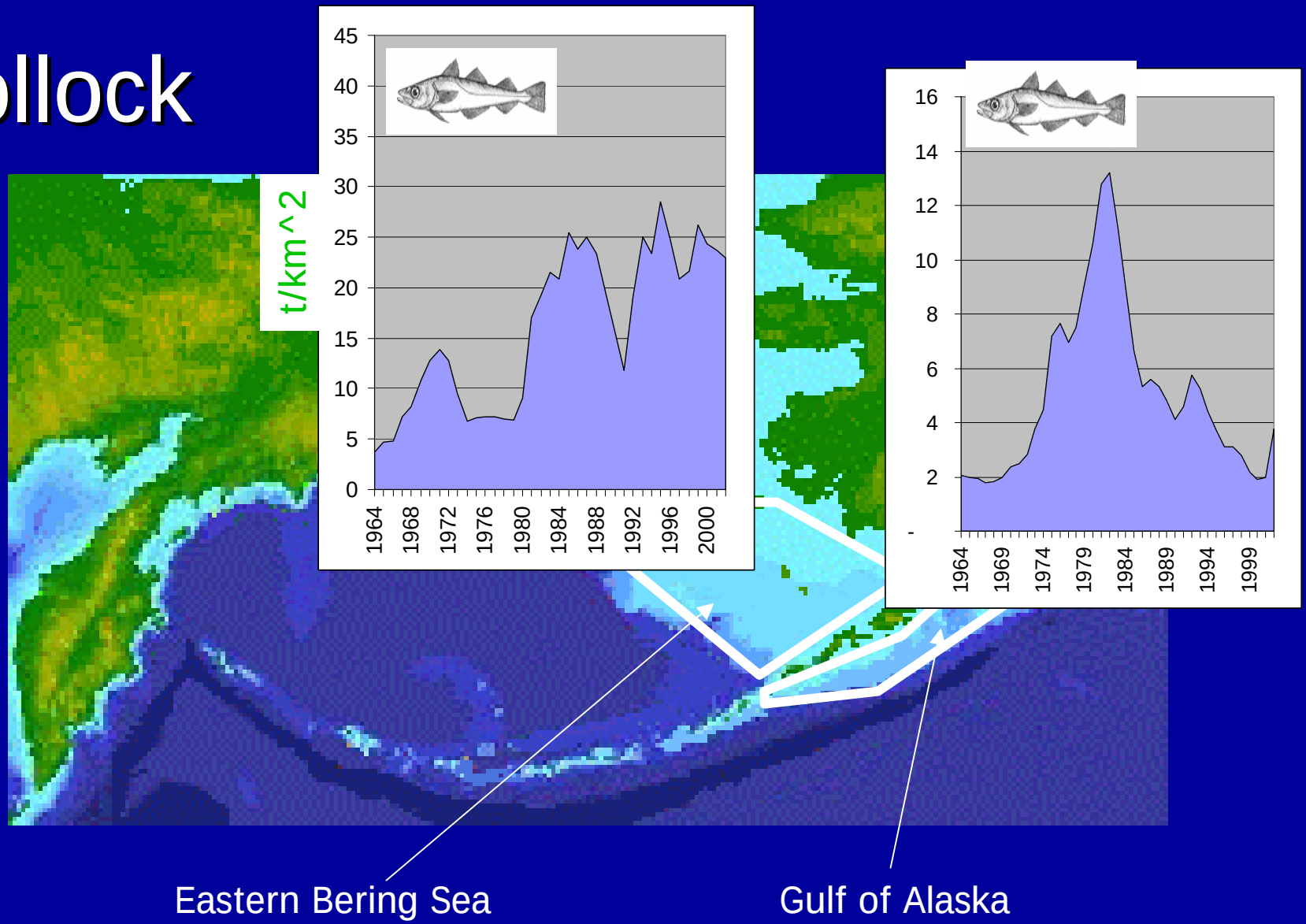
U.S. NOAA Fisheries

Regions



Pollock


t/km^2
45
40
35
30
25
20
15
10
5
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
16
14
12
10
8
6
4
2
-
1964
1969
1974
1979
1984
1989
1994
1999
Eastern Bering Sea
Gulf of Alaska

The data

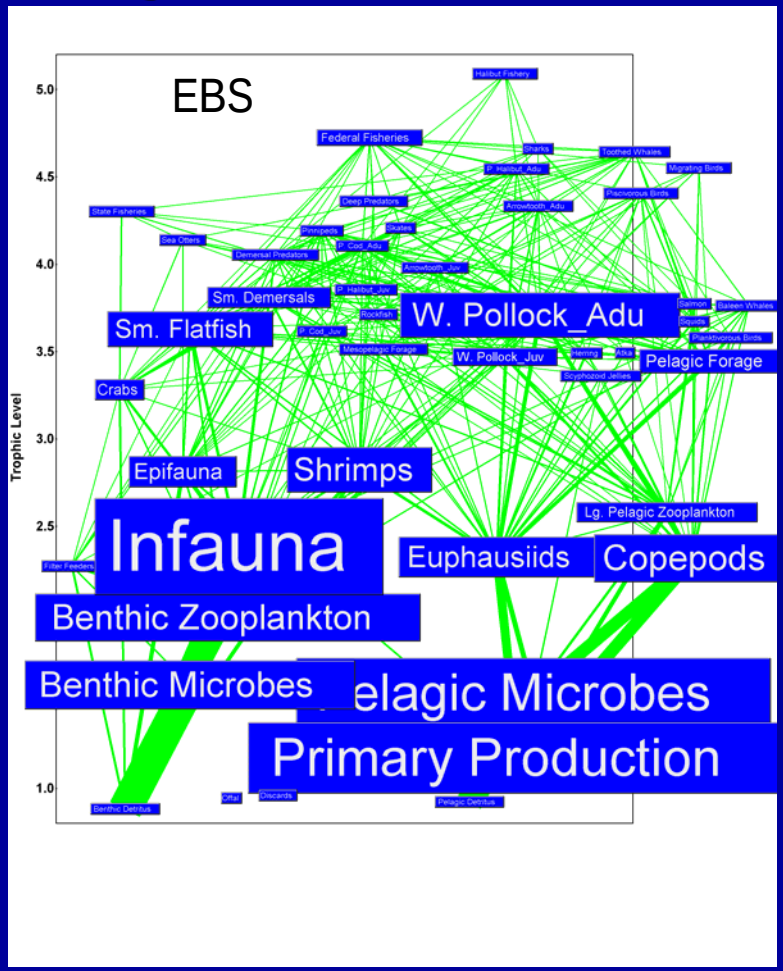
Biomass data is a mix of trawl survey data and stock assessments

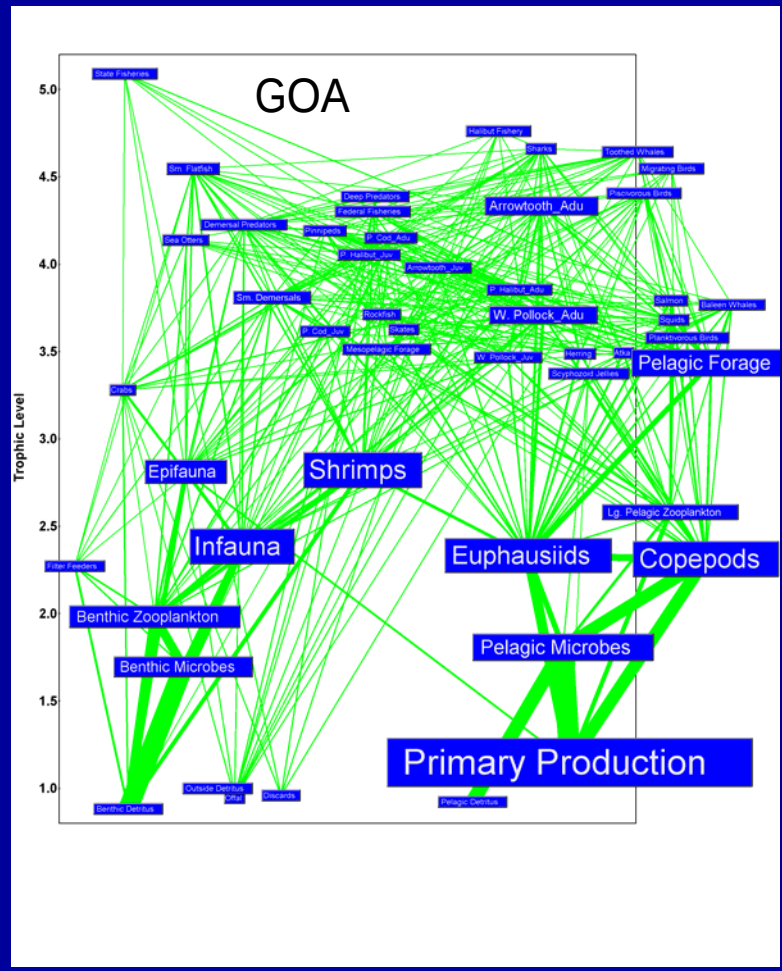
Stomach collection 1981-1998 (P. Livingston et al.)

Season	Summer																		
	Year																		
Species	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Grand Total
AK Plaice						97	207	77	214	341	215	239	276	222	308	147	345	191	2,879
Arrowtooth Fl.			365	352	166	479	190	124	232	246	86	186	406	278	314	240	277	197	4,138
FH Sole				513	402	883	410	165	484	696	366	323	367	255	363	58	244	136	5,665
Gr. Turbot			10	150	245	130	44	71	66	17		28	69	67	55		40	1	993
P. Cod	1,631			702	777	1,482	793	585	1,518	1,235	1,515	1,906	2,446	2,494	2,443	1,363	1,177	1,302	23,369
P. Halibut						5			207	252	206	280	364	239	211	1	277	354	2,396
Rock Sole						61	223	172	266	535	233	338	403	288	448	224	386	231	3,808
Sculpin			18		9	253	73	13		4				147			225	58	800
Skates					1	5	11			16		387	333	417	322	361	284	39	2,176
W. Pollock	123	625	126		222	877	1,480	946	1,928	3,103	2,858	2,831	3,227	3,371	3,146	1,854	3,224	2,219	32,160
YF Sole				900	660	1,308	1,080	452	702	882	714	616	519	721	1,003	2	298	325	10,182
Grand Total	1,754	625	519	2,617	2,482	5,580	4,511	2,605	5,617	7,327	6,193	7,134	8,410	8,499	8,613	4,250	6,777	5,053	88,566

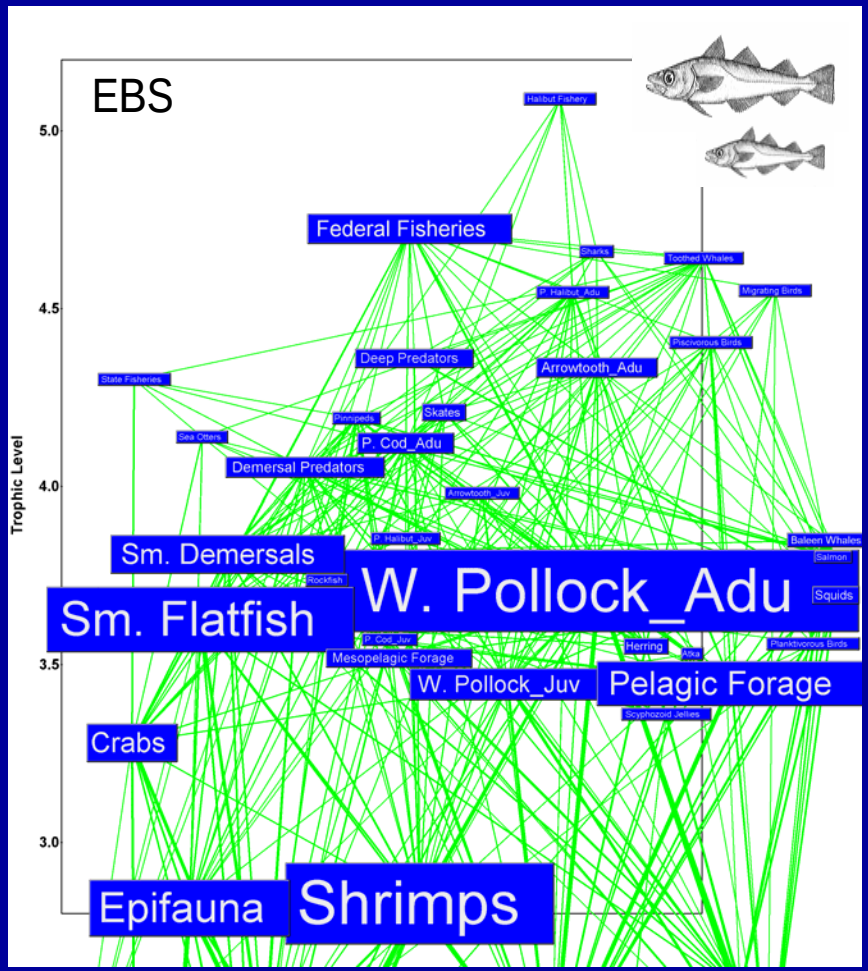
Food habits data is critical to measuring control – primarily data driven study

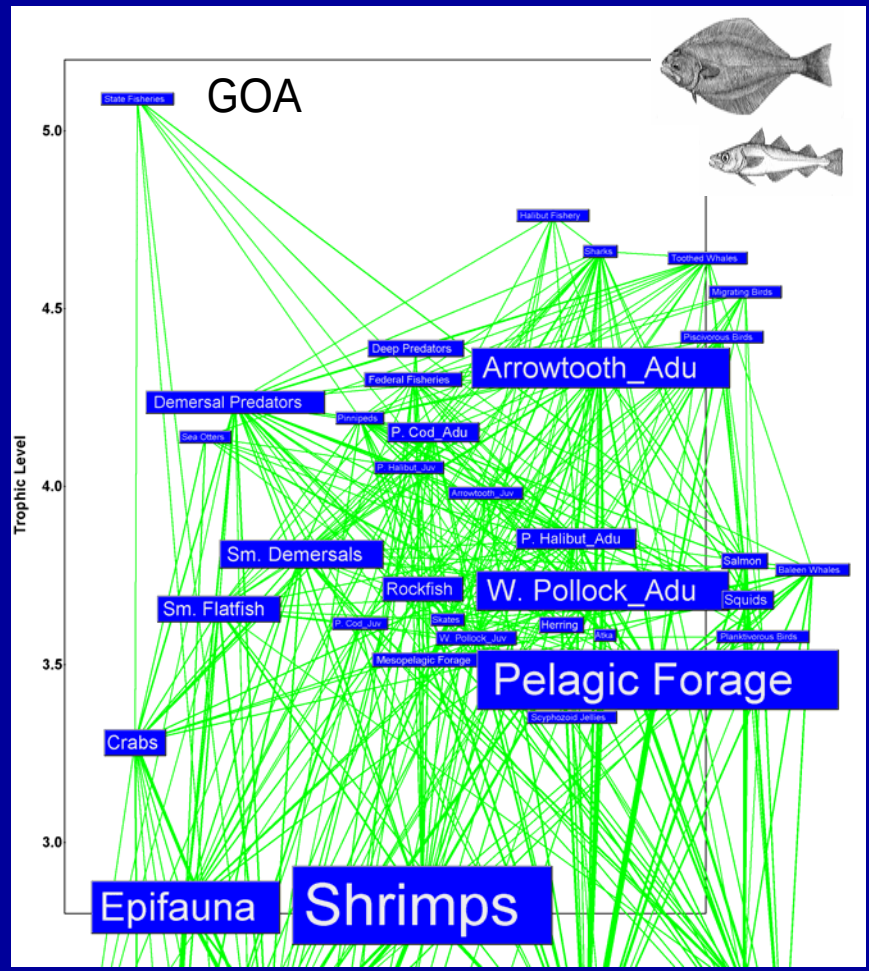
Regional food webs: mid 1990s





Regional food webs





Do these structural differences result in differences in *control*?

CONCLUSIONS

- Control is NOT EXCLUSIVE
  - A species may be bottom-up, top-down, both, or neither.
- Control is SITUATIONAL
  - Control for a species may vary as part of a longer cycle.
- The CLIMATE CHALLENGE
  - Control MIGHT NOT be linked to regime-scale climate.

Definition of control

- $dB/dt = f(Prey) - g(Predators) + \varepsilon$

Strong or weak bottom-up

Strong or weak top-down (includes fishing)

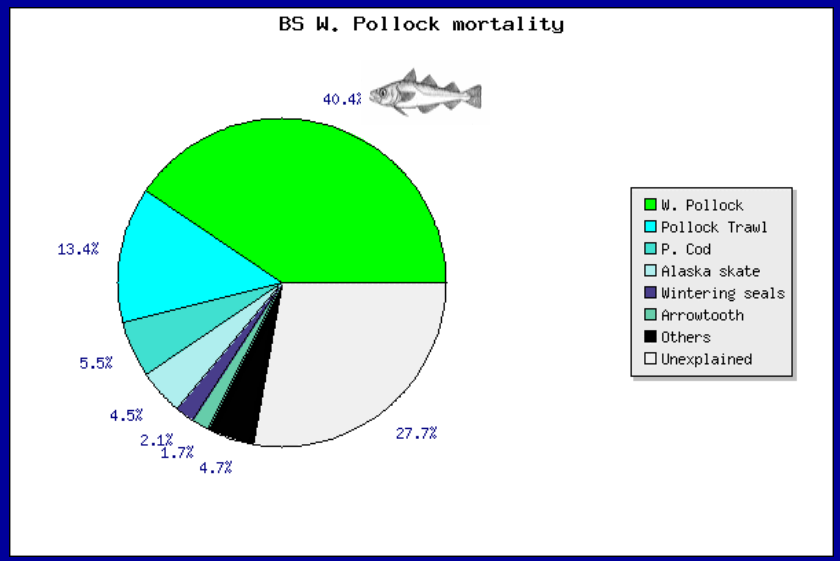
Strong or weak “climate” (direct mechanisms only)

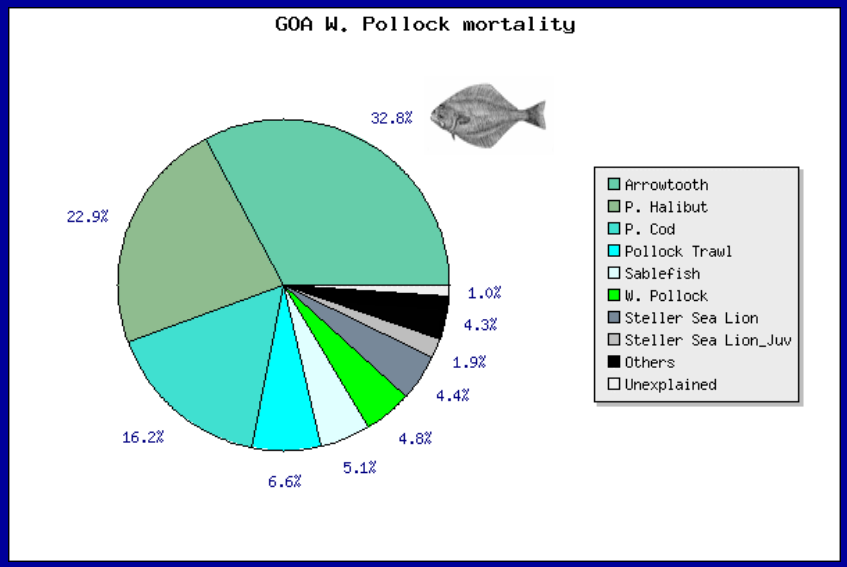
Population-scale: dB/dt = ???

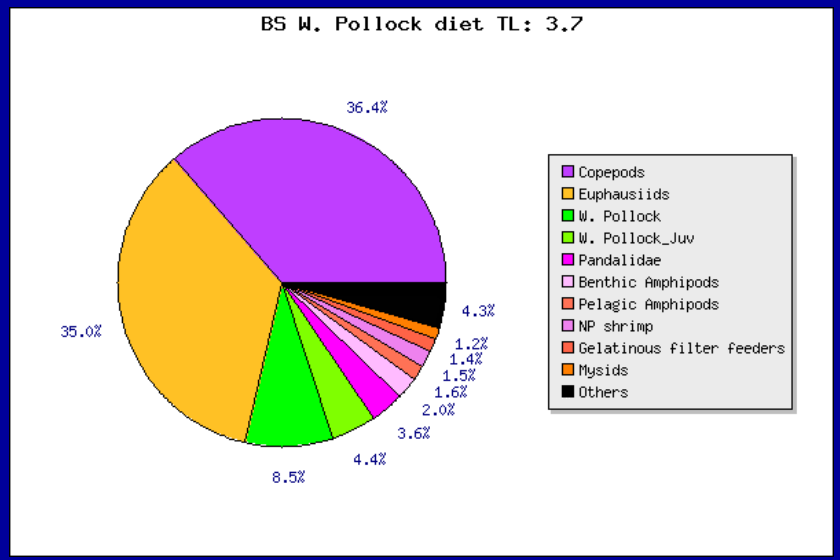
	Top-down control	Bottom-up control vs. prey switching	Life-history: Age structure and energetics	Life-history: Recruitment (younger ages than SS)
MSFOR	**Set by age structure**	**100% prey switching**	Explicit age-structure, energetics shift with age-structure	External, S-R relationship possible.
Ecosim	**Set by foraging parameter**	**100% bottom-up**	Juvenile/adult to year class for some species, energetic bias of "current" age structure for others	"Emergent" from parameter apportioning food to growth vs. fecundity
Blended dynamics/ bioenergetics	**Age structure proxy parameter plus prey relative selectivity.**	**Set by satiation parameter.**	Explicit age-structure, energetics shift with age-structure	External, S-R relationship possible.
NEMURO.FISH	Bottom-up only on individual scale, LOCAL model with no stock-limitation dynamics, if scaled to stocks, (?)		Explicit bioenergetics, no explicit age structure.	No explicit recruitment.

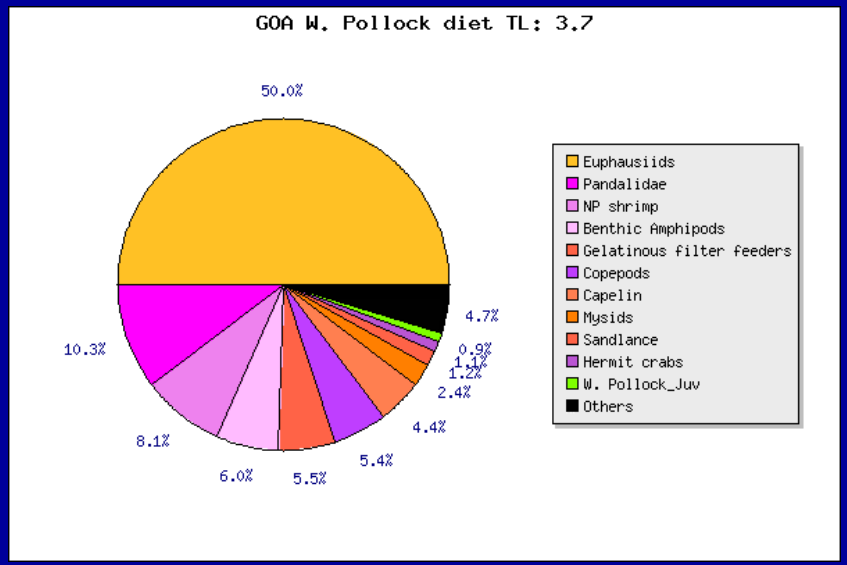
Only way to evaluate these is to fit historical data, or test results for robustness over a range of parameter values.

Calculations

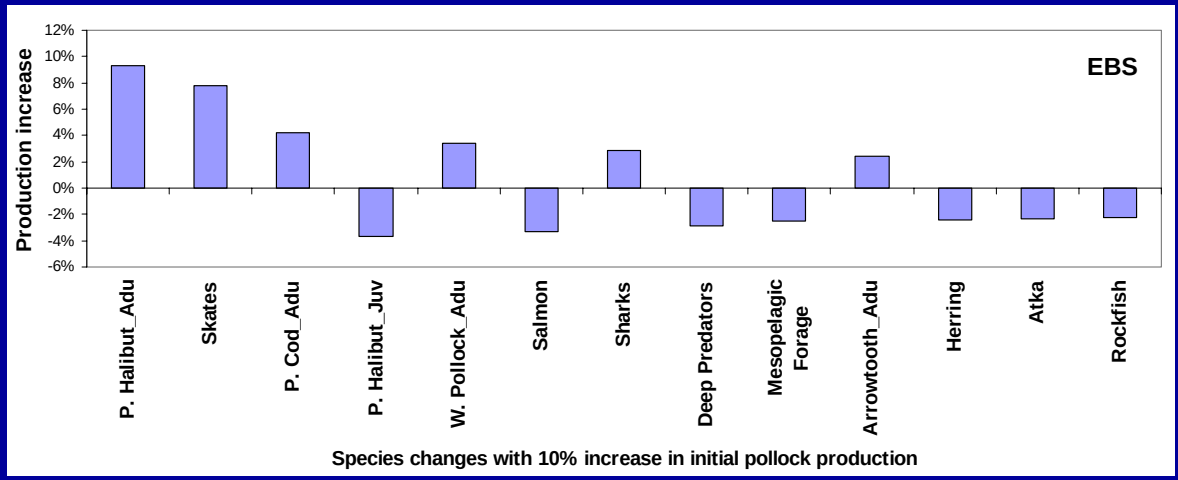


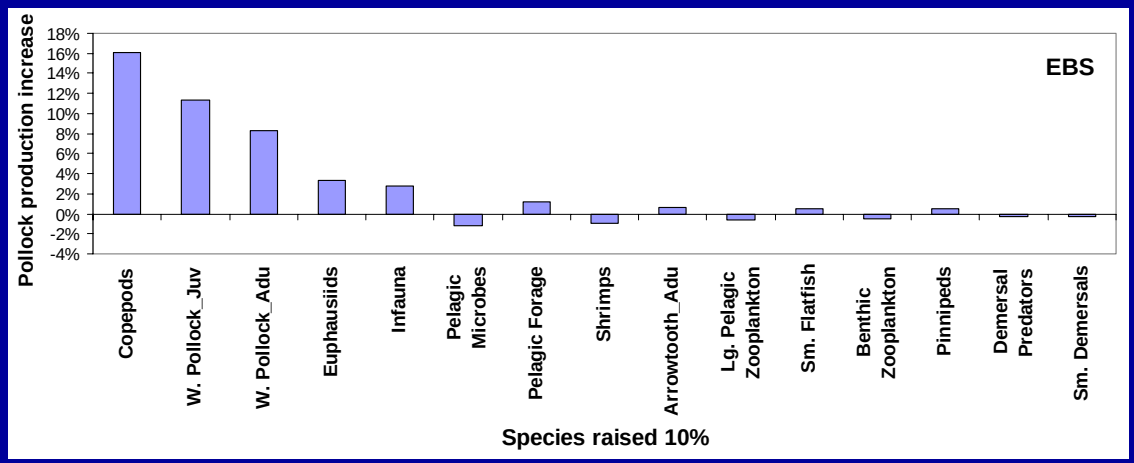




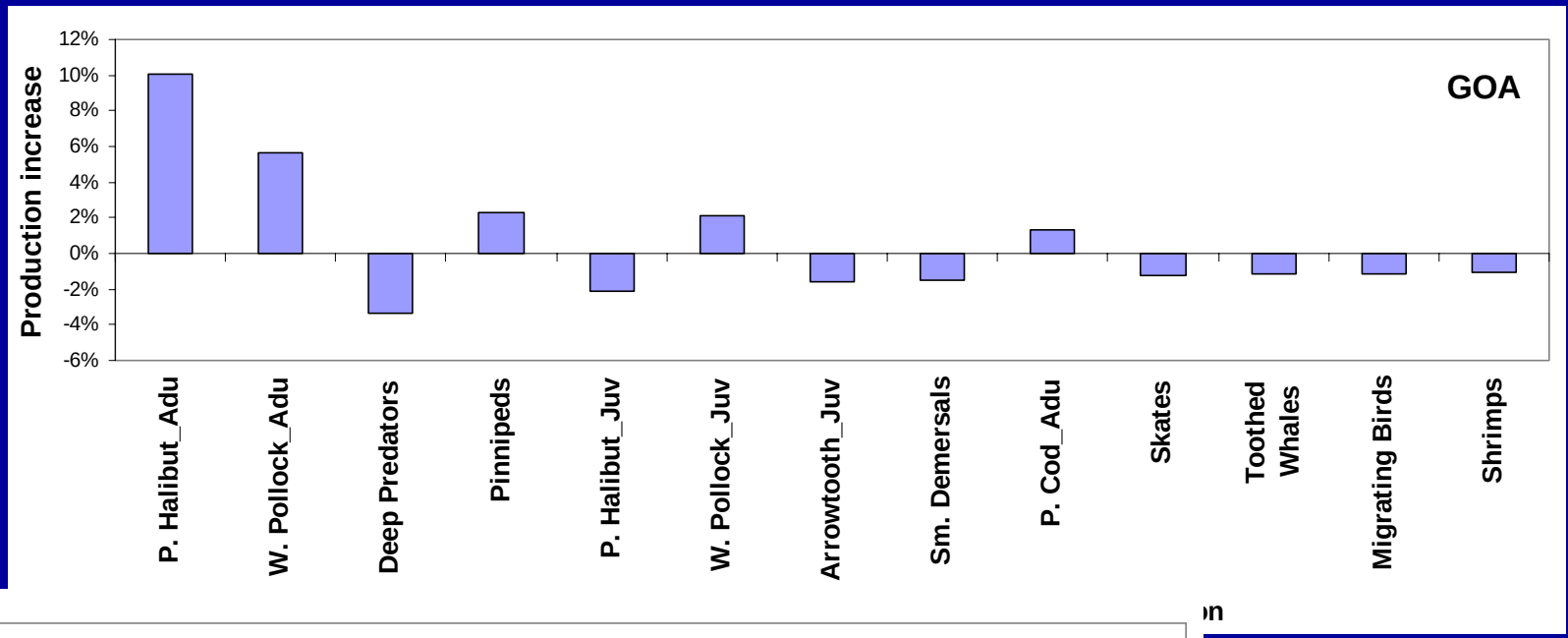


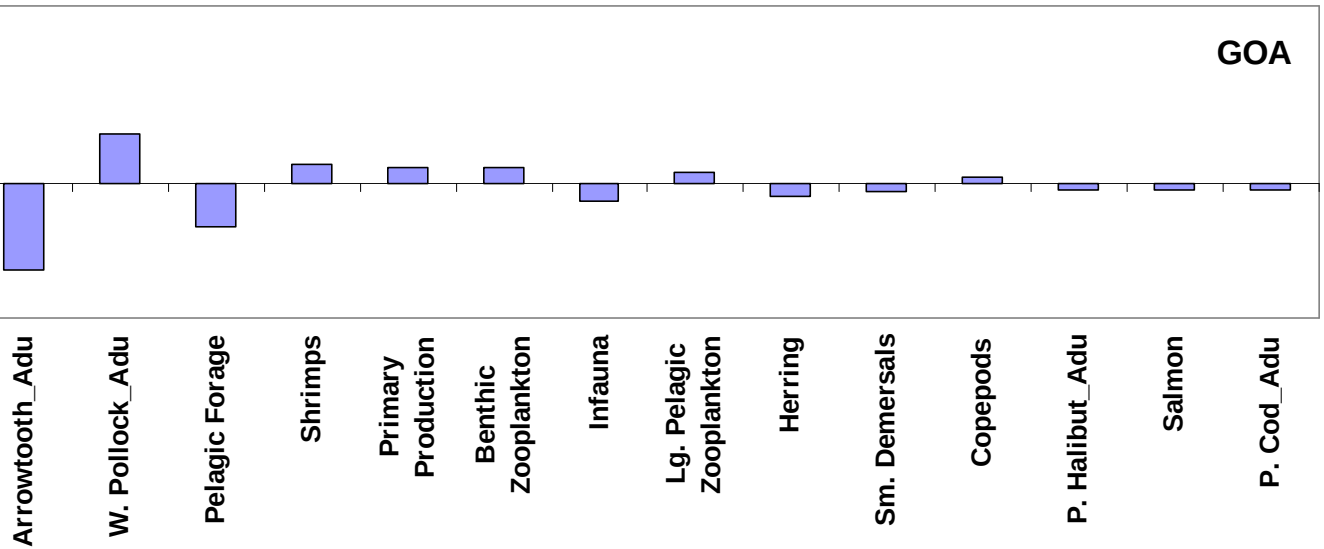
Calculations





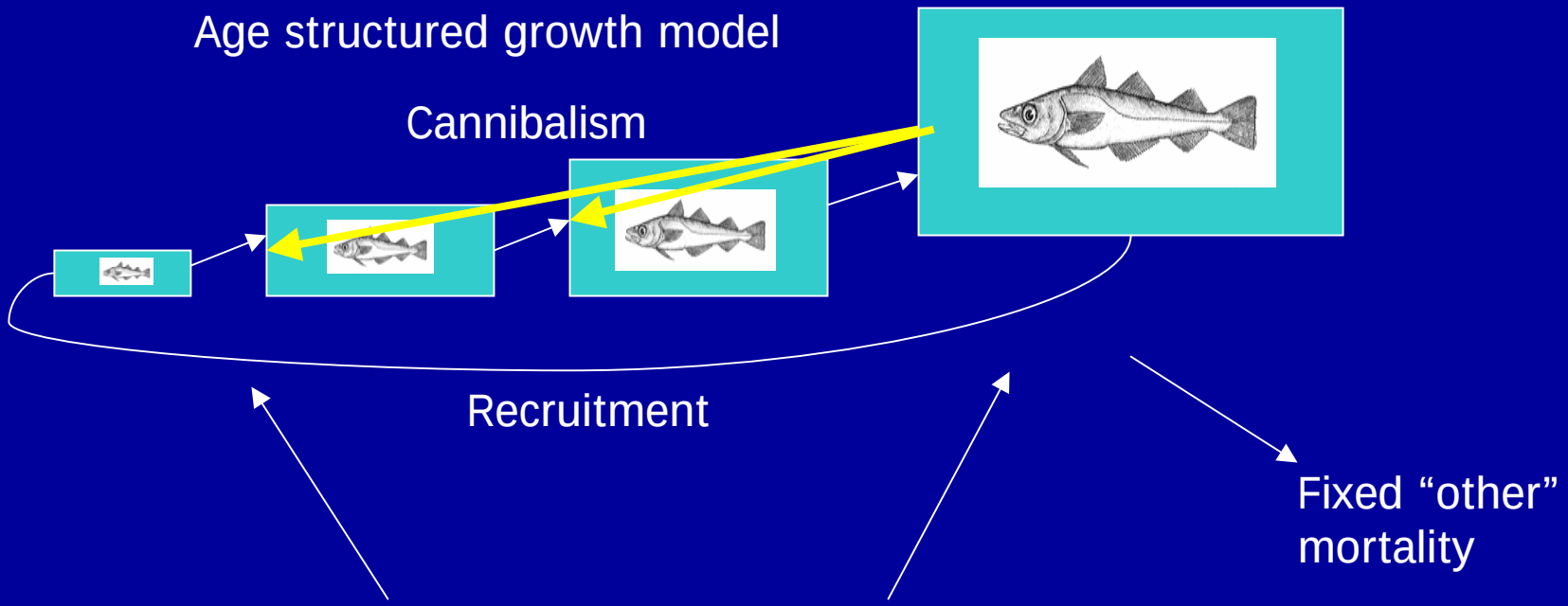
Calculations





Situational

- A simple Pollock model



ε: uncorrelated white noise (yearly scale) in “bottom up” (growth) terms

Integrated as stochastic differential equations

Results (recruitment only).

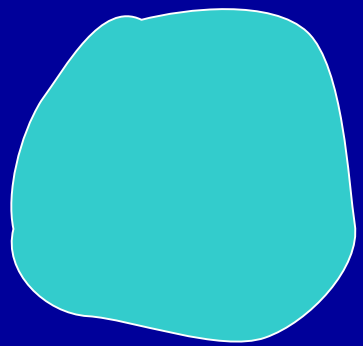
- hhh

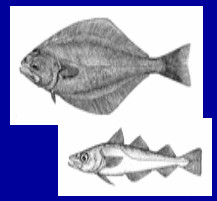
Situational

- The simple EBS model

Results:

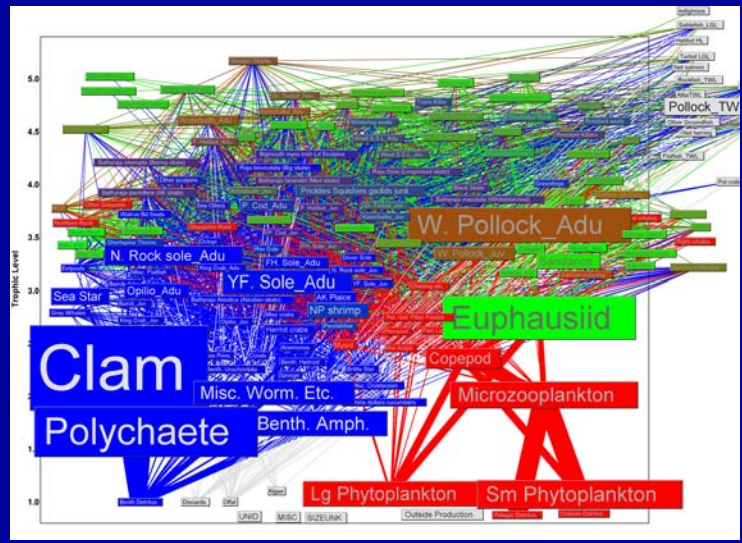
- Control is NOT EXCLUSIVE and SITUATIONAL
- The “beer belly” and the “wasp waist”





THE CLIMATE CHALLENGE

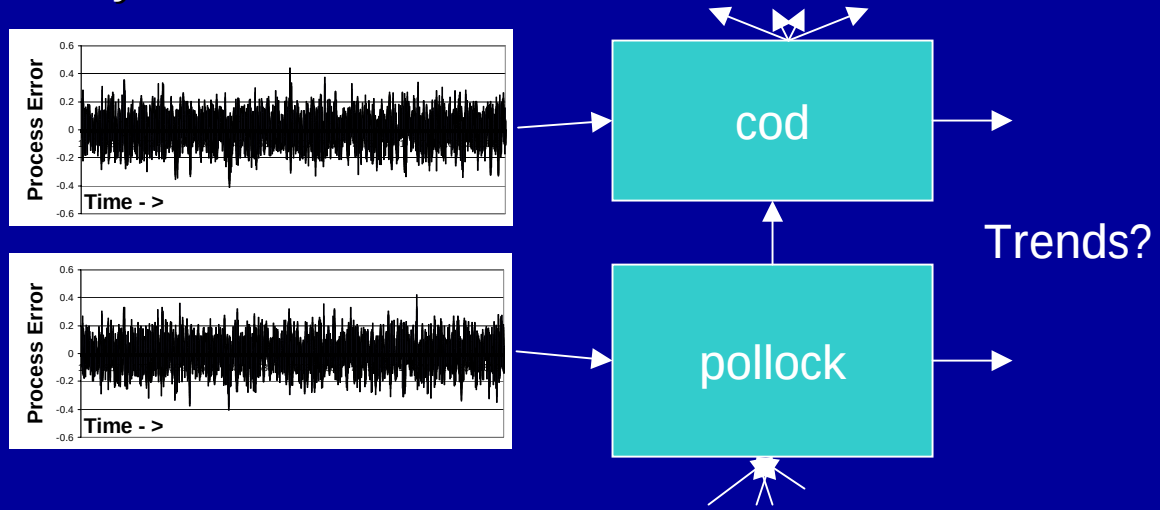
MANAGEMENT THROUGH CORRELATION?



A THOUGHT EXPERIMENT

- A box model, made dynamic with 2 sets of equations (Ecosim and vB with Holling Type II functional responses...)

- Run model while applying uncorrelated white noise process error to all groups simultaneously:

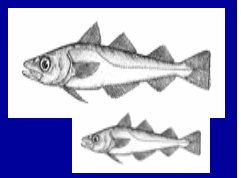


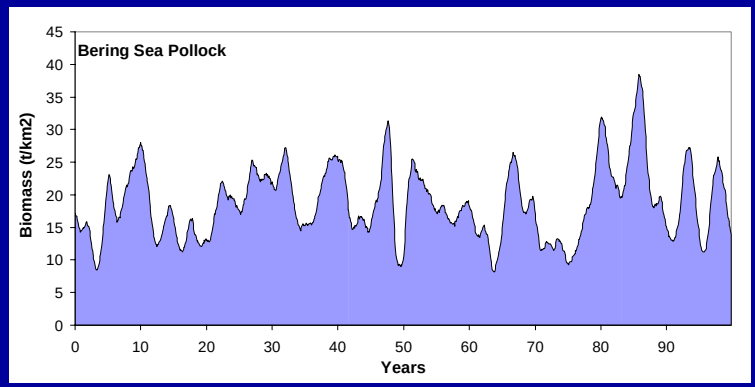
THE CLIMATE CHALLENGE

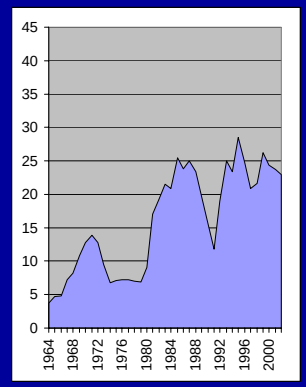
Simulated

Actual

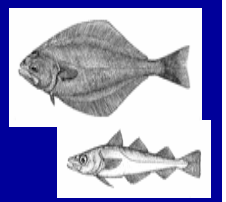
EBS

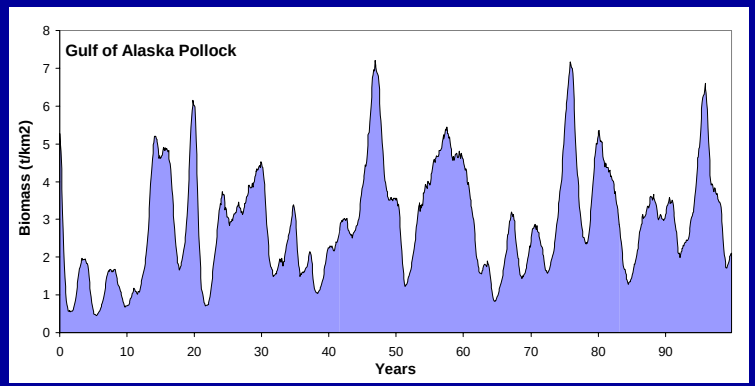


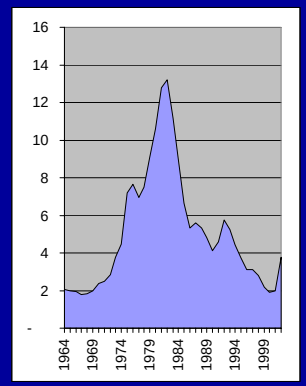




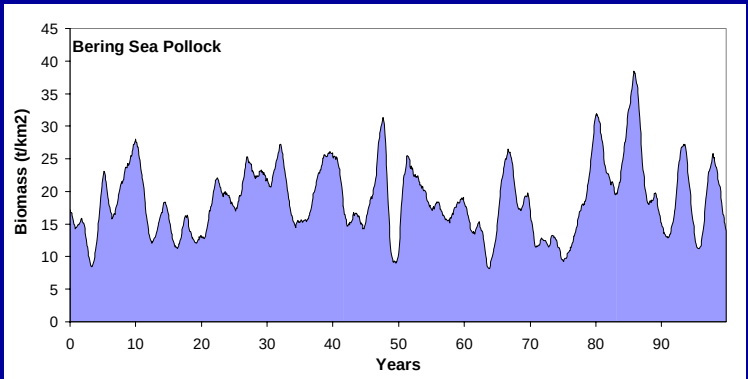
GOA

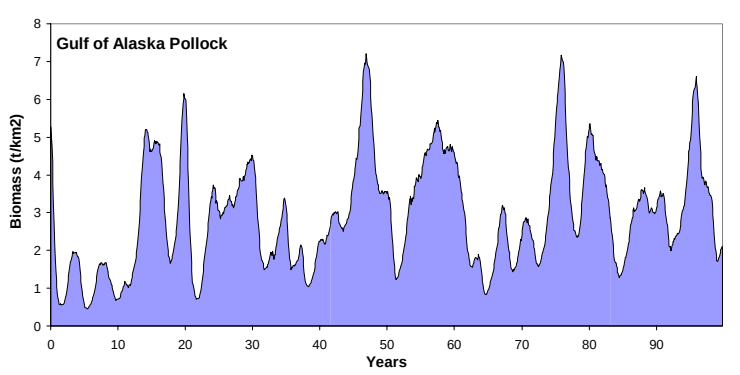






THE CLIMATE CHALLENGE





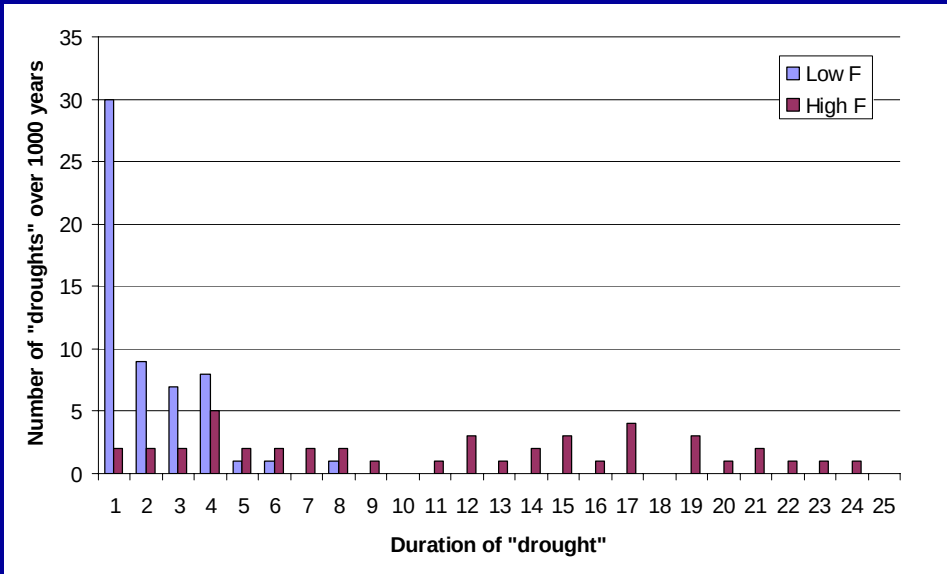
RESULTS

IMPLICATIONS

- FREQUENCY OF VARIATION (periods of high and low) is emergent from web and species life-history.
- Slow climate variables not required: Correlations of regimes to biology must include NULL HYPOTHESIS of this emergent autocorrelation.
- “Correlations” to regimes work in the short-term, but for strategic evaluation, is “white noise” response predictable?

“Do we control, nudge, or ride?”

What if correlation with climate doesn’t work?



“Pollock drought” is a length of time during which pollock catch remains below a reference level.

- MOVING FROM ONE TROPHIC CONTROL STRUCTURE TO ANOTHER: Aggregate risks will tend to be *greater, not less.*

REMOVE A PREDATOR? Half the time a decade of herring, half the time a decade of jellyfish (not a mix, not reversible).