Basin Ecosystems (BASS) Task Team

Results of modeling/ data synthesis workshops

Work to date

1. Publication of data
   - Progress in Oceanography volume

2. Synthesis:
   – Workshops
   – PICES Report #25
   – Deep-Sea Research II volume from first Linkages topic session (PICES XII)

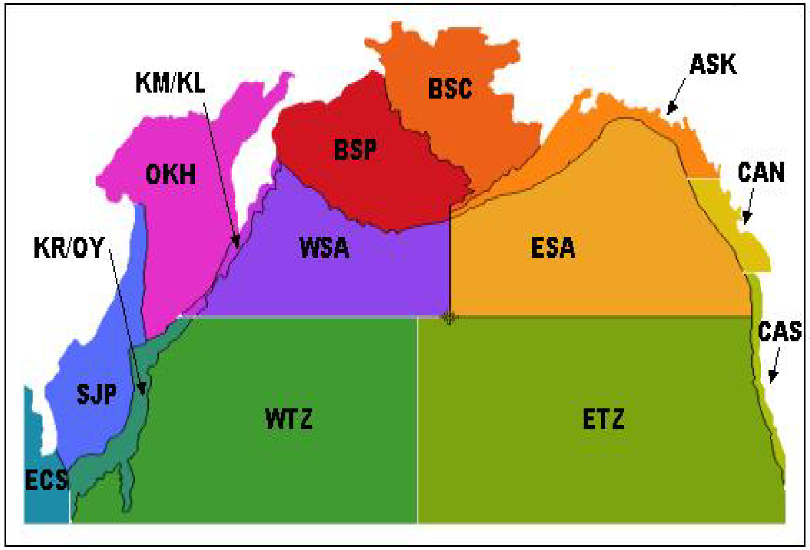


Fig. 1 Sub-regions in the PICES area (north of 30°N and including the marginal seas) of the North Pacific Ocean. ASK - Gulf of Alaska Continental Shelf; BSC - Bering Sea Continental Shelf; BSP - Bering Sea Pelagic; CAN – California Current North; CAS – California Current South; ECS - East China Sea; ESA - Eastern Subarctic; ETZ - Eastern Tropical Zone; KM/KL - Kurile Islands Region; KR/OY - Kuroshio/Oyashio Region; OKH - Sea of Okhotsk; JP - Sea of Japan; WSA - Western Subarctic; WTZ - Western Tropical Zone.

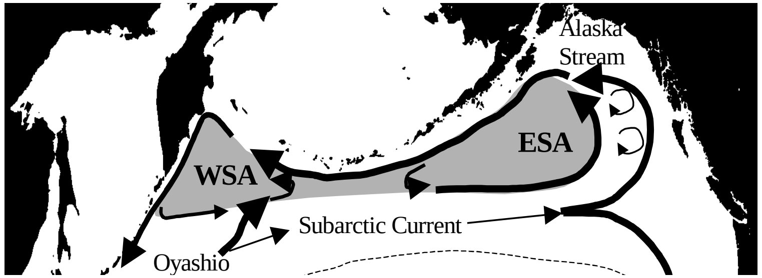
Synthesis

– Synthesis workshops

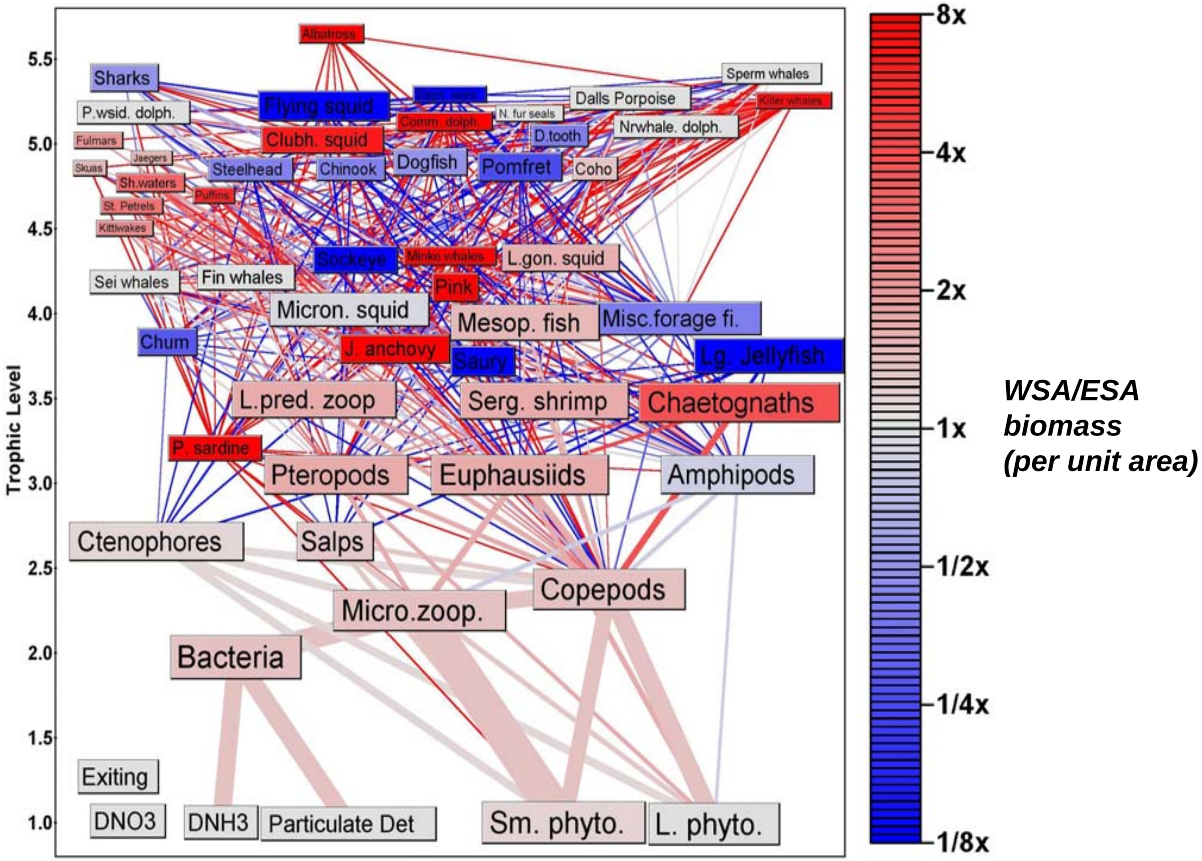
Not shown: Michio Kishi (Hokkaido University, Japan), Takashige Sugimoto, Ichiro Yasuda and Sachihiko Itoh (University of Tokyo, Japan).

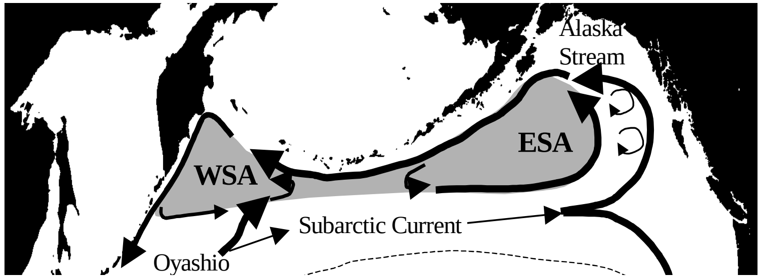
Resulting publications: PICES Scientific Report #25

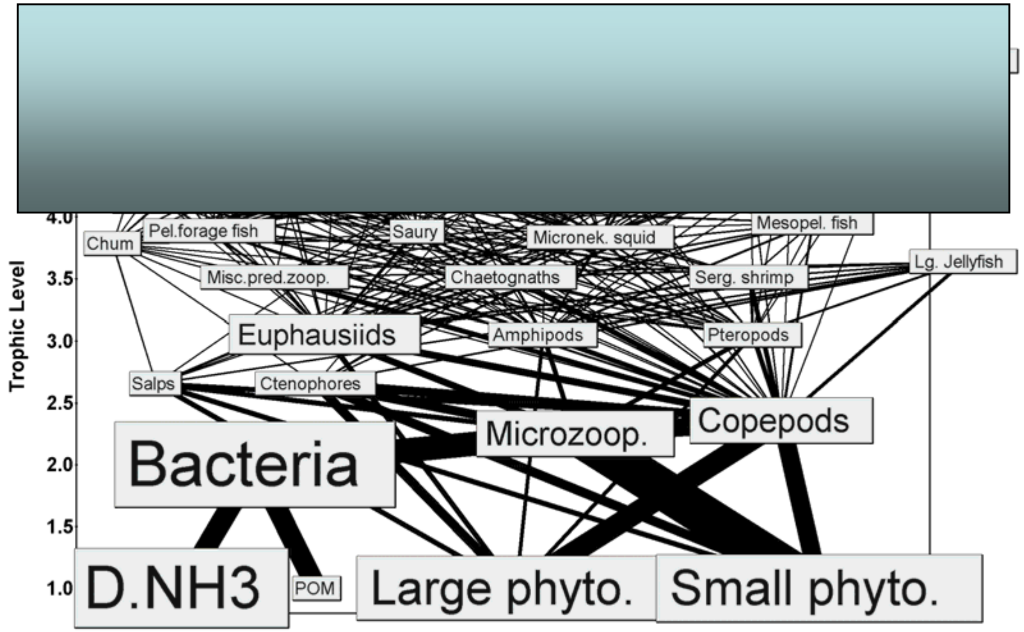
Article (Aydin et al.) in session volume of Deep-Sea Research II



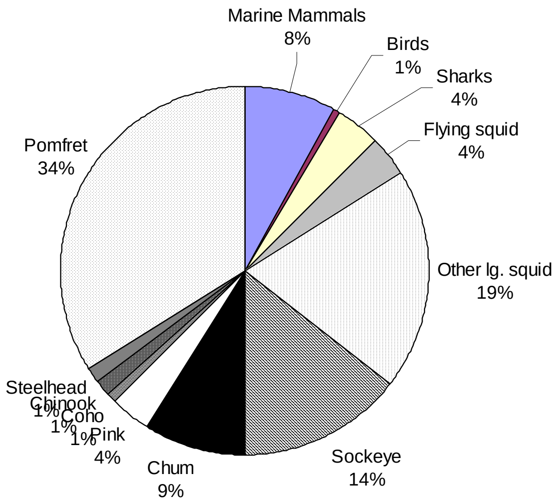
A food web
(biomass and rates)



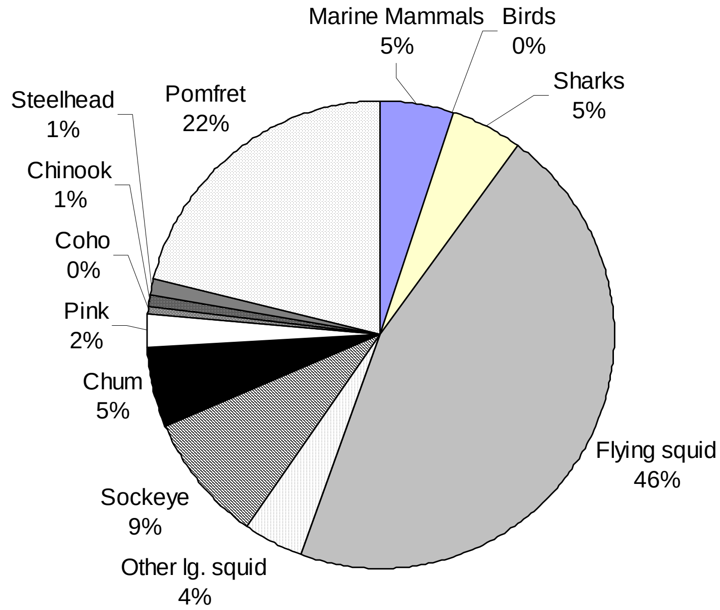


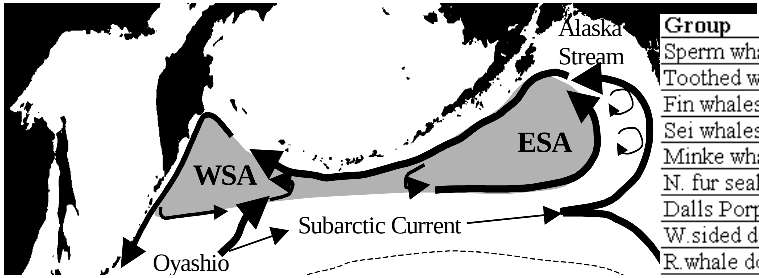


WSA biomass



ESA biomass





Data Quality

- Good
- Medium
- Poor

WSA

Group	Biomass	Prod/Bio	Cons/Bio	Diet
Sperm whales	0.50	0.40	0.20	0.70
Toothed whales	0.50	0.40	0.20	0.70
Fin whales	0.50	0.40	0.20	0.70
Sei whales	0.50	0.40	0.20	0.70
Minke whales	0.50	0.40	0.20	0.70
N. fur seals	0.50	0.40	0.20	0.70
Dalls Porpoise	0.50	0.40	0.20	0.70
W.sided dolph.	0.50	0.40	0.20	0.70
R.whale dolph.	0.50	0.40	0.20	0.70
Common dolph.	0.50	0.40	0.20	0.70
Albatross	0.50	0.40	0.20	0.70
Shearwaters	0.50	0.40	0.20	0.70
Storm Petrels	0.50	0.40	0.20	0.70
Kittiwakes	0.50	0.40	0.20	0.70
Fulmars	0.50	0.40	0.20	0.70
Puffins	0.50	0.40	0.20	0.70
Skuas	0.50	0.40	0.20	0.70
Jaegers	0.50	0.40	0.20	0.70
Sharks	0.80	0.60	0.40	0.80
Lg. gon. squid	0.80	0.60	0.60	0.60
Clubhook squid	0.50	0.60	0.60	0.60
Flying squid	0.50	0.60	0.60	0.60
Sockeye	0.50	0.10	0.10	0.10
Chum	0.50	0.10	0.10	0.10
Pink	0.50	0.10	0.10	0.10
Coho	0.50	0.10	0.10	0.10
Chinook	0.50	0.30	0.30	0.30
Steelhead	0.50	0.30	0.30	0.30
Pomfret	0.50	0.40	0.40	0.50
Saury	0.50	0.40	0.70	0.70
Japan. anchovy	0.50	0.20	0.40	0.50
Pacific sardine	0.50	0.20	0.40	0.50
Pel. forage fis	0.80	0.60	0.70	0.70
Micron. squid	0.80	0.60	0.70	0.70
Mesopel. fish	0.80	0.60	0.70	0.70
Lg. Jellyfish	0.80	0.70	0.70	0.70
Ctenophores	0.50	0.70	0.70	0.70
Salps	0.50	0.70	0.70	0.70
Chaetognaths	0.50	0.70	0.70	0.70
Serg. shrimp	0.80	0.70	0.70	0.70
Misc. pred. zoo	0.80	0.70	0.70	0.70
Amphipods	0.80	0.70	0.70	0.70
Pteropods	0.80	0.70	0.70	0.70
Euphausiids	0.80	0.40	0.60	0.50
Copepods	0.80	0.40	0.60	0.50
Microzoop.	0.50	0.40	0.60	0.50
Bacteria	0.50	0.40	0.60	0.50
Large phyto.	0.50	0.40	0.60	0.50
Small phyto.	0.50	0.40	0.60	0.50
D.NH3	0.50	0.40	0.60	0.50
POM	0.50	0.40	0.60	0.50

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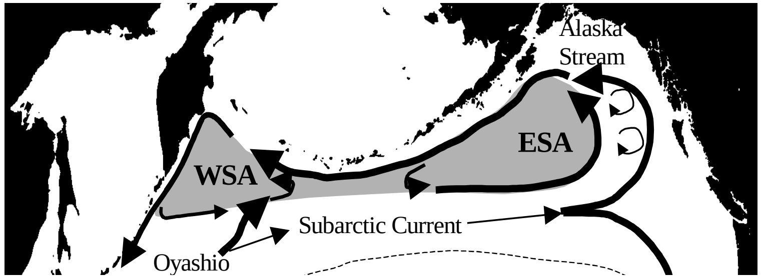
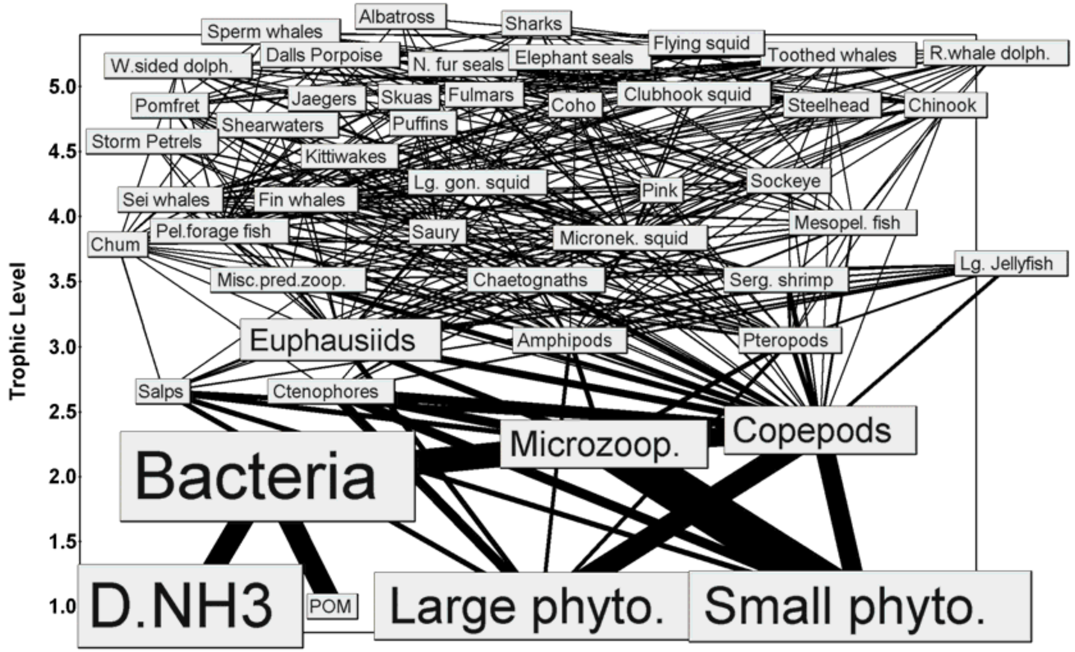
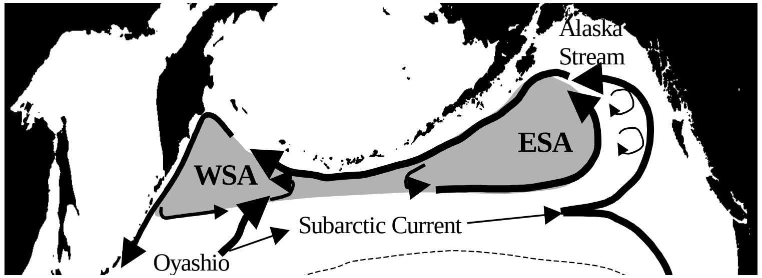




Mainly data synthesis and data quality analysis: a data-driven “bookkeeping” evaluation on a “fisheries management” (basin stock) scale. In itself, hypotheses testing and predictive capability is limited.



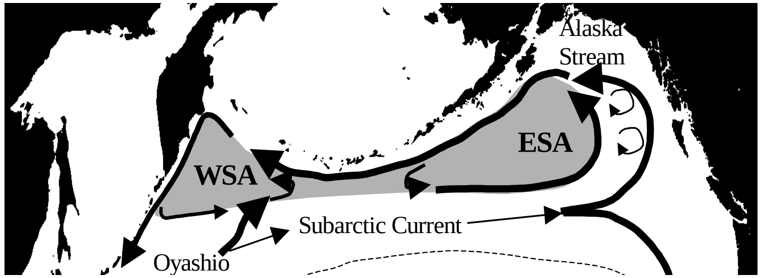
A food web
(biomass and rates)

Sensitivity Analyses

Run Ecosim (dynamic)

Linkages I: Use as component for linking scales and regions

Linkages II: Seasonal, geographical, interannual?



Sensitivity Analyses

A food web
(biomass and rates)

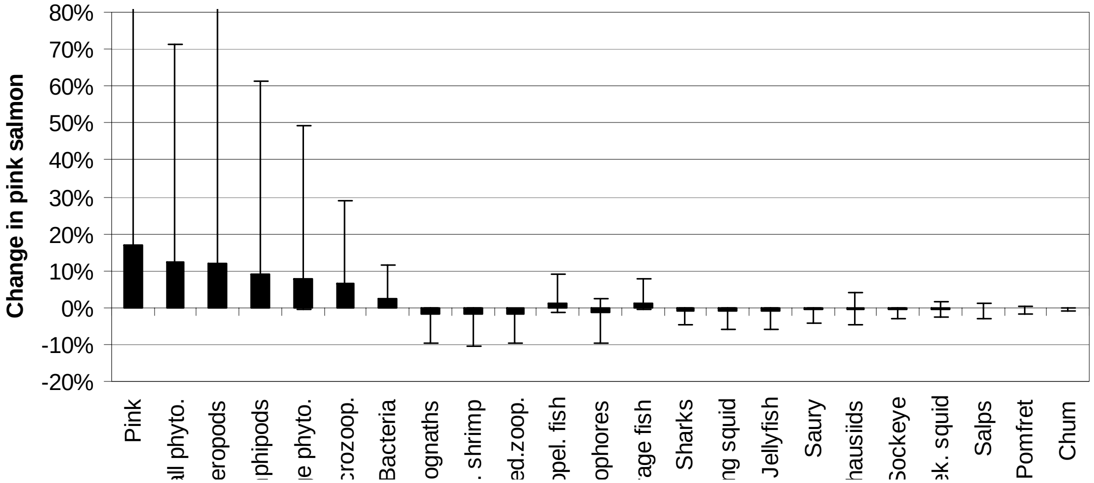
Sensitivity analysis

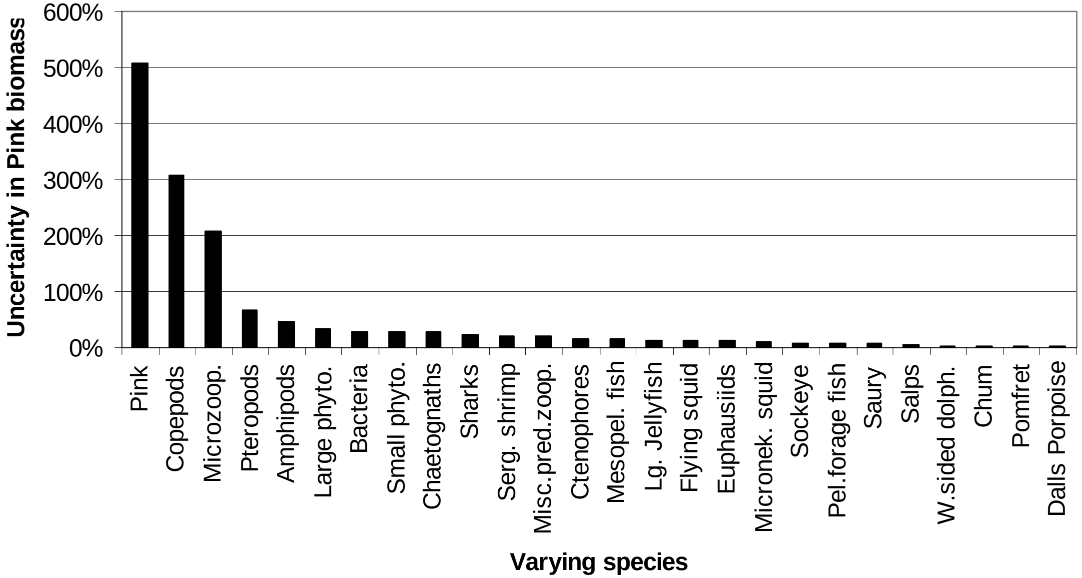
-Exploratory perturbations

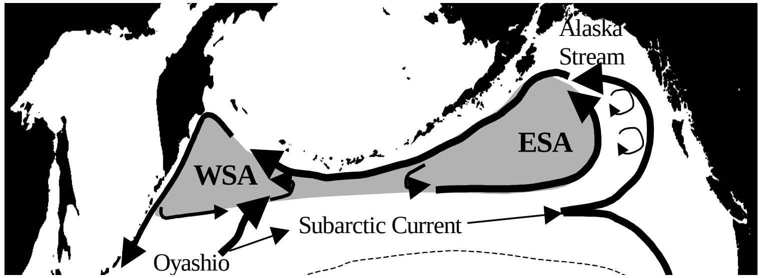
-Data evaluation

-Sensitivity to uncertainty

- Aid monitoring priorities







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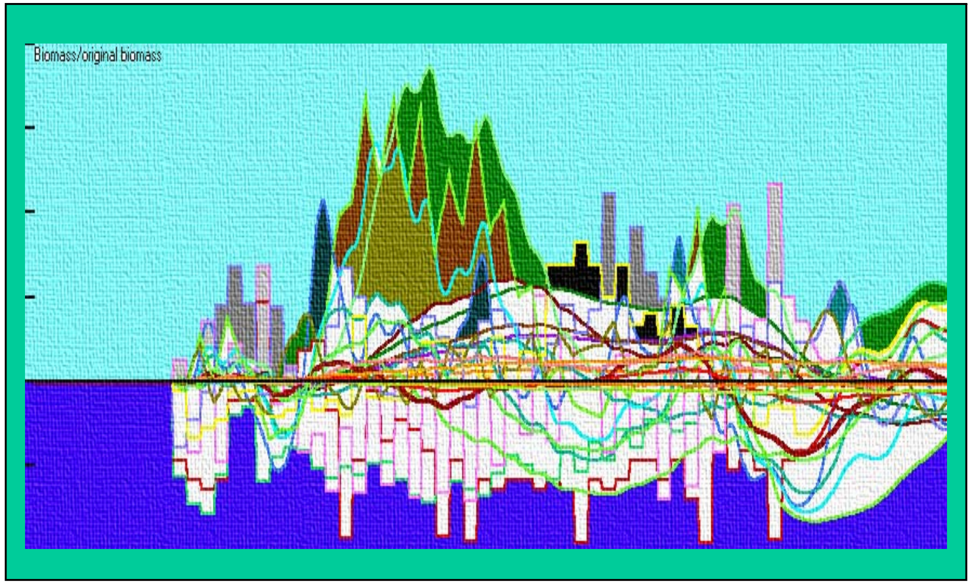


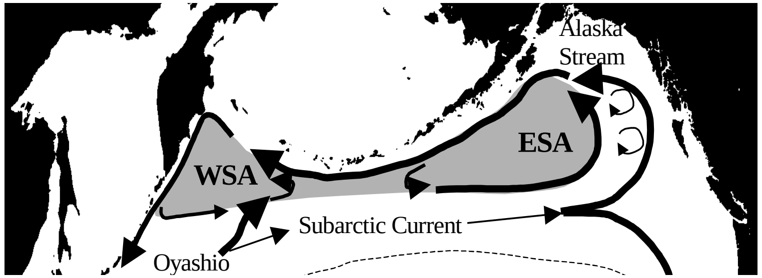
Ecosim: population-scale dB/dt = ???

	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
NEMURO.FISH	Bottom-up only on individual scale, LOCAL model with no stock-limitation dynamics, if scaled to stocks (?)		?	?

Only way to evaluate these is fitting to historical: Ecosim has relatively poor fit to Basin data (although data is limited): other functional response models may work better. None of these stock-scale models adequately capture range of life history strategies (e.g. King and McFarlane 2003).

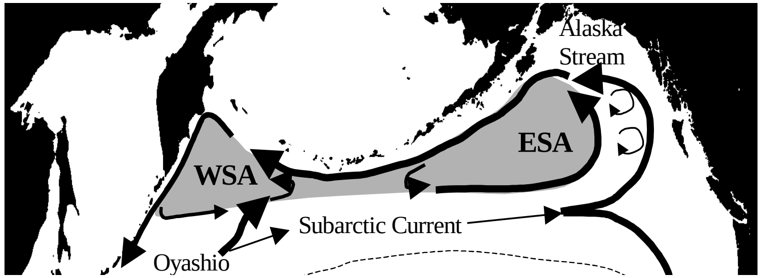
However, useful as extended perturbation analysis (e.g. PICES Sci. Report #25).

Ecosim: scale??



SCALE doesn't work for our purposes (linking ecosystems, investigating climate interactions in species with strong seasonal, migratory, or bottleneck dynamics).

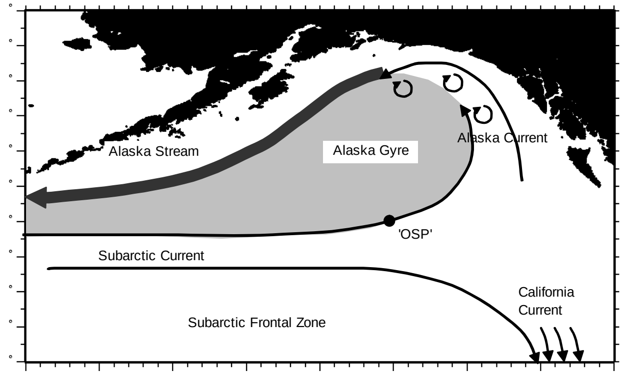
Ecosim on its own works well for stock-scale top-down perturbations (fishing) on relatively closed populations, NOT for mechanisms: in particular, VERY poor for Pacific salmon.

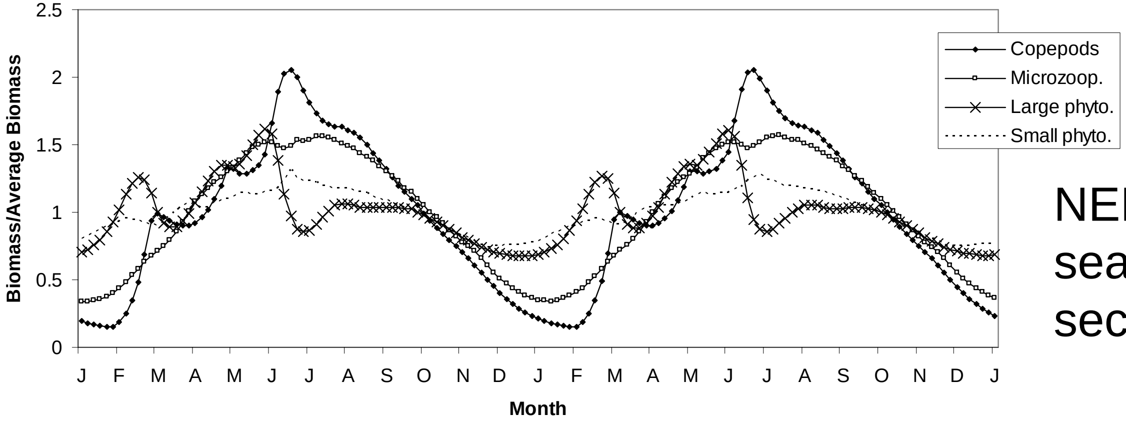


A food web
(biomass and rates)

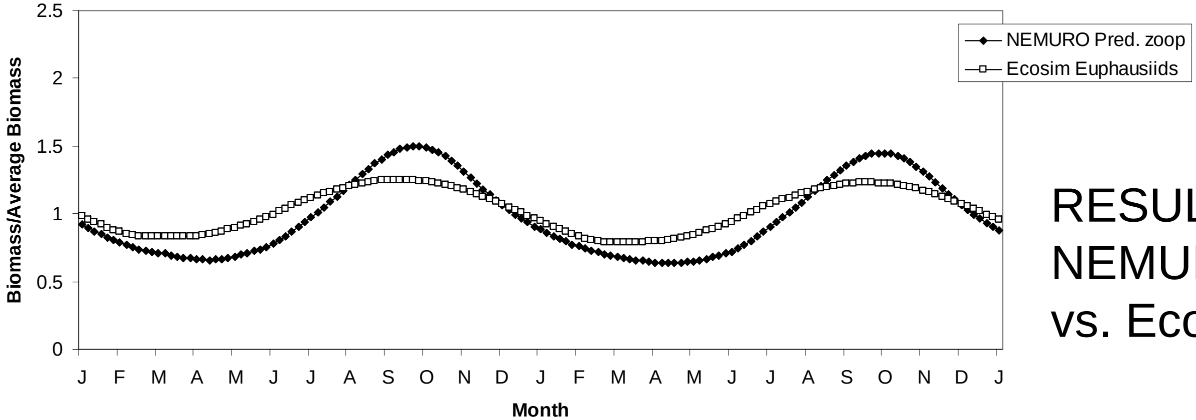
Linkages I: Use as component for linking scales and regions

NEMURO vs. ECOSIM



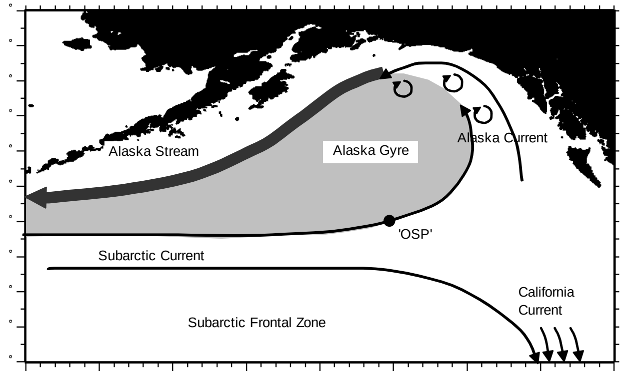


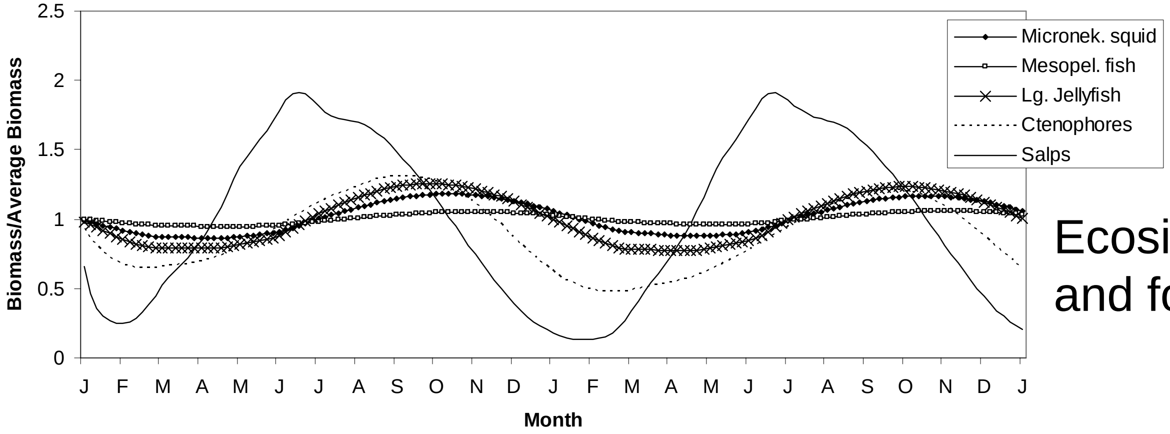
NEMURO output drives seasonality in primary and secondary production in Ecosim



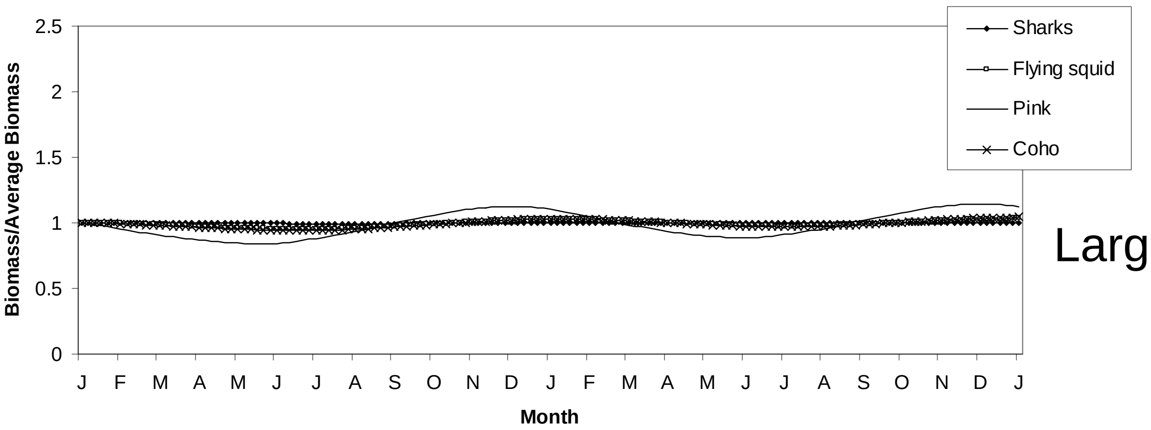
RESULT:
NEMURO predatory zooplanktion vs. Ecosim Euphausiids

NEMURO vs. ECOSIM



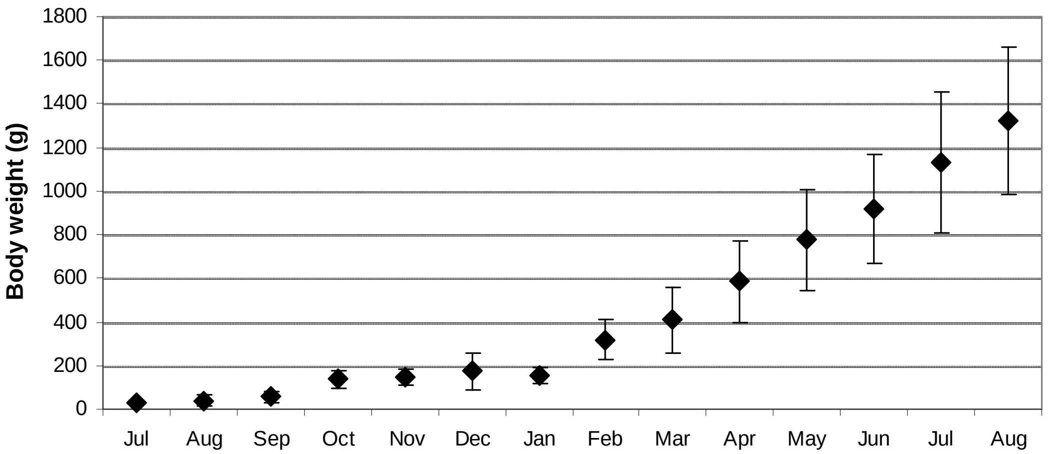


Ecosim gelatinous zooplankton and forage fish

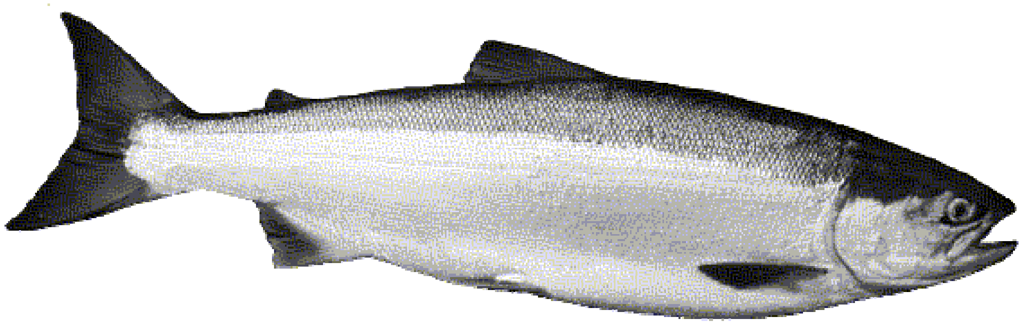


Large predators, and salmon (???)

Pink salmon growth



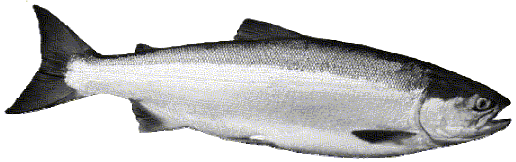
(Ishida et al. 1998)



Month	Body weight (g)	s.d.	N (millions)	N/km^2	t/km^2
Jul	31.8	5.8	1,159	320	0.010
Aug	39.5	27.5	945	261	0.010
Sep	58.1	25.5	770	213	0.012
Oct	138.7	40.7	628	173	0.024
Nov	145.7	38.5	512	141	0.021
Dec	172.9	81.4	418	115	0.020
Jan	154.9	36.7	340	94	0.015
Feb	318.5	93	278	77	0.024
Mar	408.3	153.7	226	62	0.026
Apr	584.5	184.8	185	51	0.030
May	777.6	232.3	150	42	0.032
Jun	919.0	252.3	123	34	0.031
Jul	1128.9	322.5			
Aug	1320.6	336.6			
Sep	1523.1	397.6			

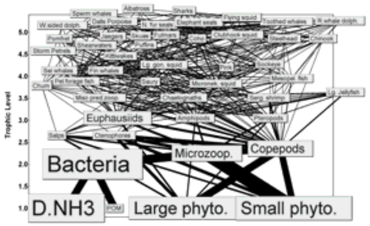
Model linkages

Pink salmon bioenergetics model, predicts daily pink salmon growth and numerical mortality based on input ration.



Pink salmon body weight and numbers used to set Ecosim biomass for predator and prey equations in next timestep.

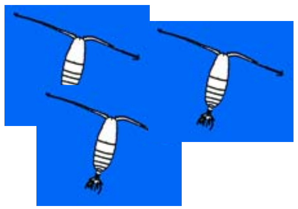
Consumption and mortality rates for Pink salmon based on predator and prey biomass.



Ecosim (ecosystem biomass dynamics model), run on a daily timestep.

No direct feedback to NEMURO: Ecosim parameters for predatory zooplankton (euphausiids) tuned to match NEMURO predictions for same species.

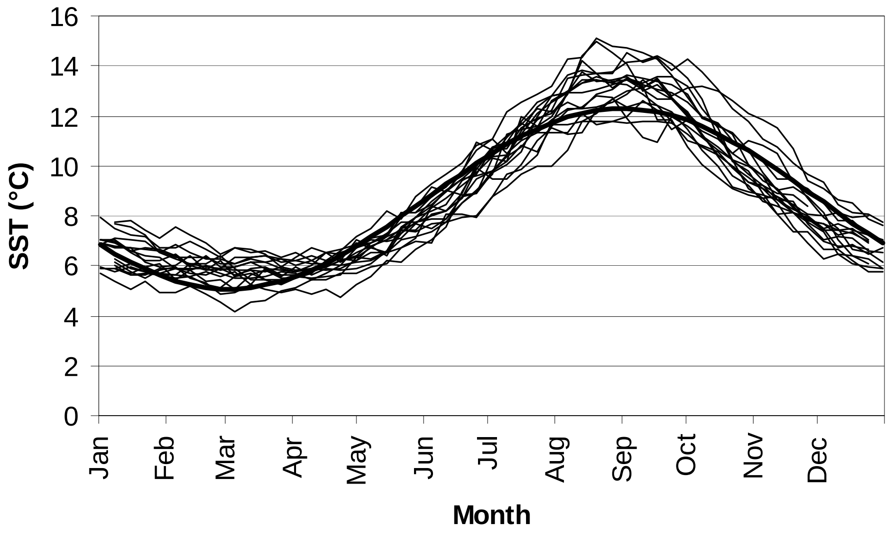
Daily biomass density of phytoplankton, microzooplankton, large zooplankton



NEMURO (nutrient-phytoploankton-zooplankton-detritus): 1-dimensional water column model integrated on an hourly timestep.

Additional data

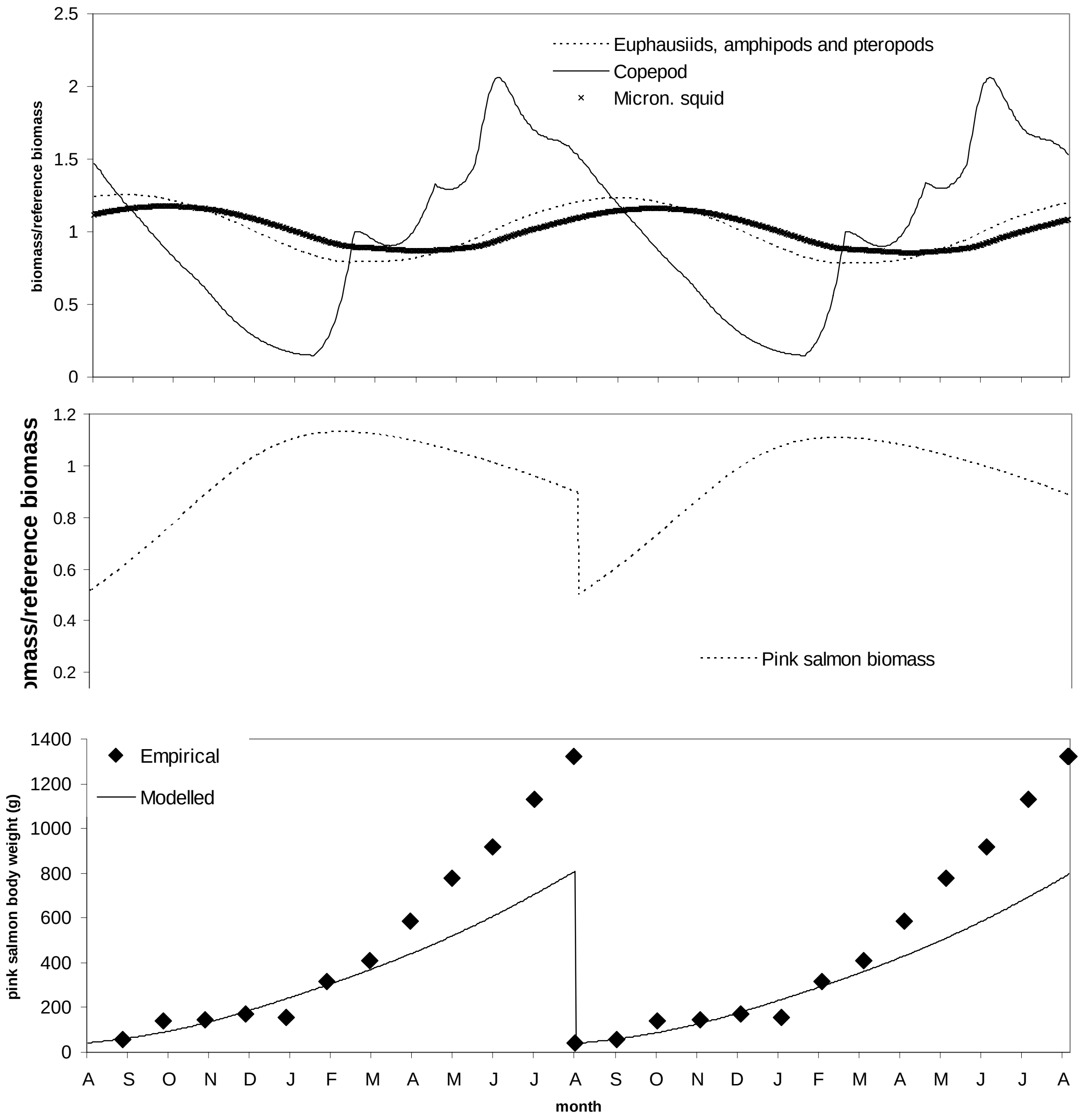
OSP temperature



Prey group	cal/g wet weight	species and range
Copepods	700	*Neocalanus cristatus*, 627-748
Euphausiids	1000	*Thysanoessa* spp., *Euphausia* spp., 840-1050
Pteropods	650	*Limacina helicina*; 624-940
Amphipods	800	*Parathemisto pacifica*; 852-1010
Ctenophores	50	*Beroe* sp., 47
Salps	36	*Salpa* sp., 36
Chaetognaths	450	*Sagitta elegans*; 455-488
pelagic forage fish	1200	*Gasterosteus aculeatus*; 1166-1533
mesopelagic forage fish	2000	*Stenobrachius leucopsarus; Tarletonbeania crenularis; Leuroglossus schmidti*; 2041-2365 (Bering Sea)
Micron. squid	1500	*Berryteuthis anonychus*; 1307-1737 (increases with increasing mantle length).

Prey quality

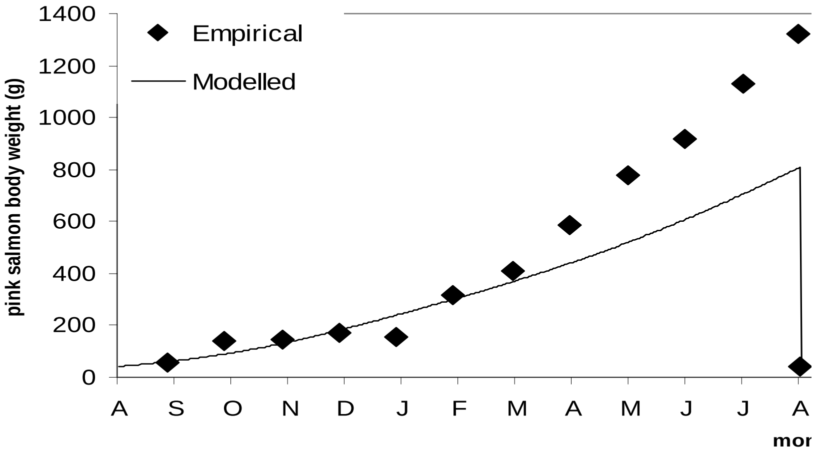
Results



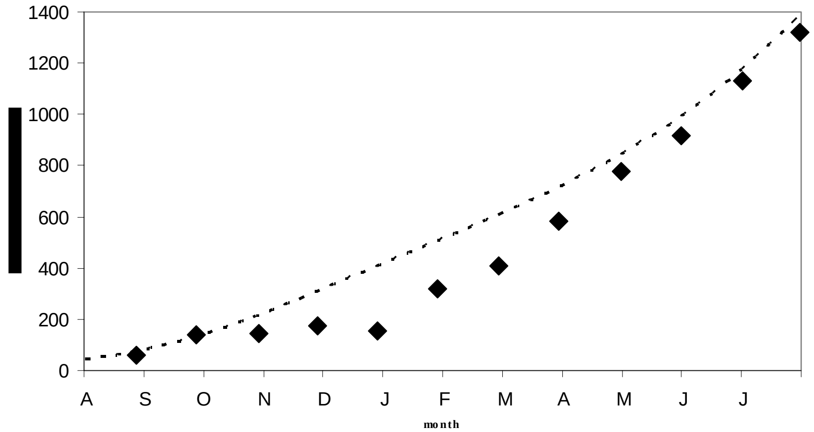
2.5
2
1.5
1
0.5
0
biomass/reference biomass
Euphausiids, amphipods and pteropods
Copepod
Micron. squid
1.2
1
0.8
0.6
0.4
0.2
omass/reference biomass
Pink salmon biomass
1400
1200
1000
800
600
400
200
0
pink salmon body weight (g)
Empirical
Modelled
A S O N D J F M A M J J A S O N D J F M A M J J A
month

Matching growth rates

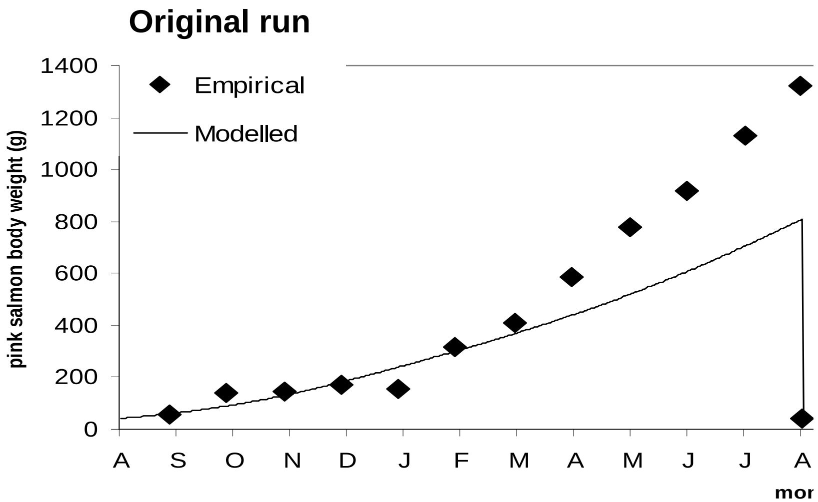
Original run



Run calibrated for “fast growth” (fits base growth rate to later data points)



Sensitivity analysis

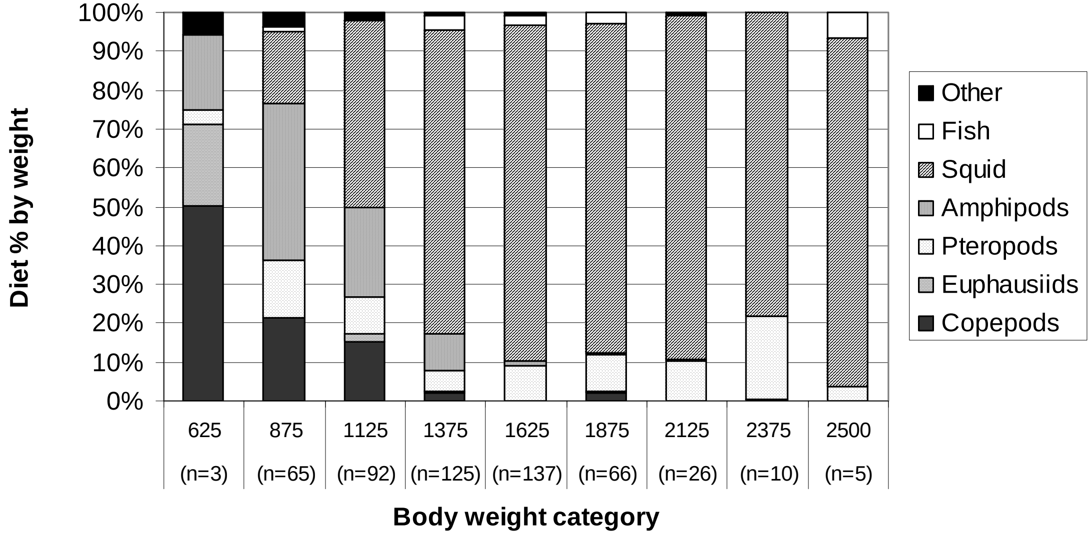


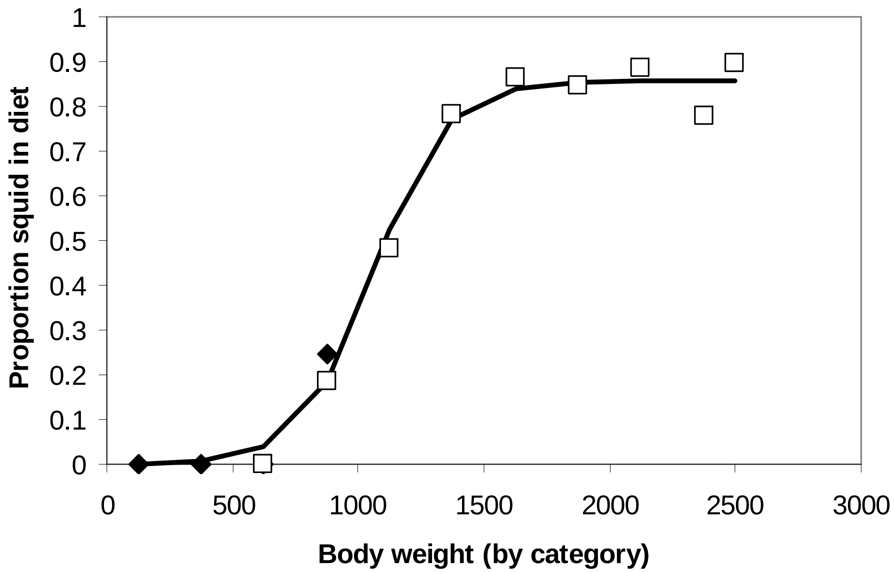
% change in input variable

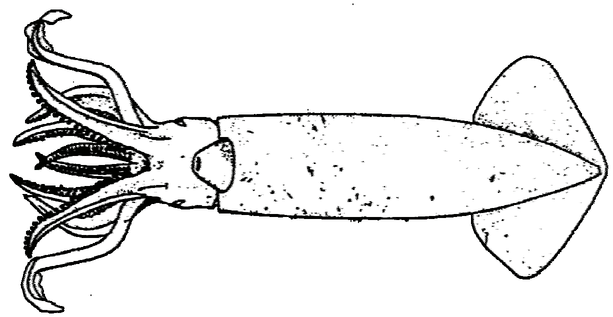
Parameter	**Base**	**+10%**	**-10%**
Salmon entry day	228 (Julian day)	-0.8%	+1.1%
Starting body weight	39.5 g	+3.8%	-4.1%
Average water temperature	8.68 °C	-2.8%	+1.1%
Seasonal temperature amplitude	3.16 °C	-1.2%	+1.1%
Prey cal/gram wet weight	Varies by diet item	+24.3%	-22.1%

% change in final pink salmon body weight

Diet switching?

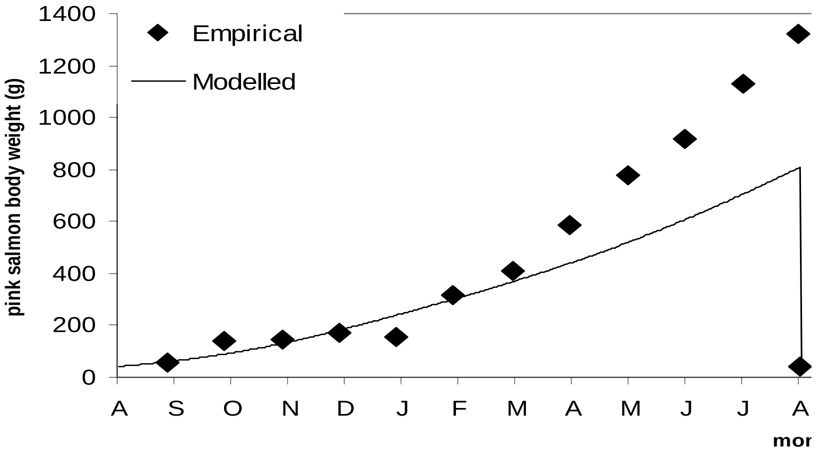




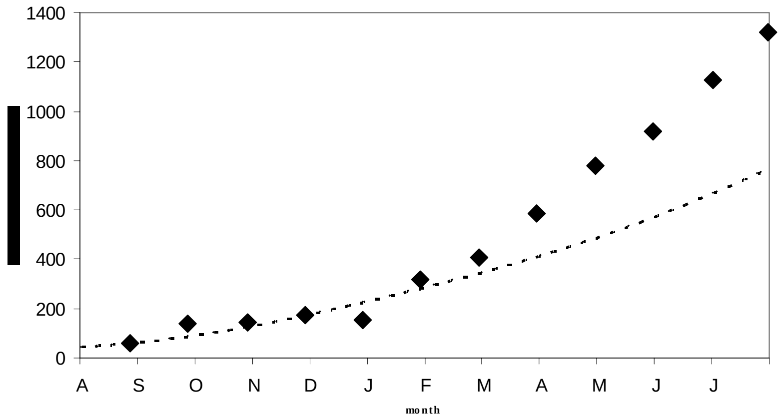


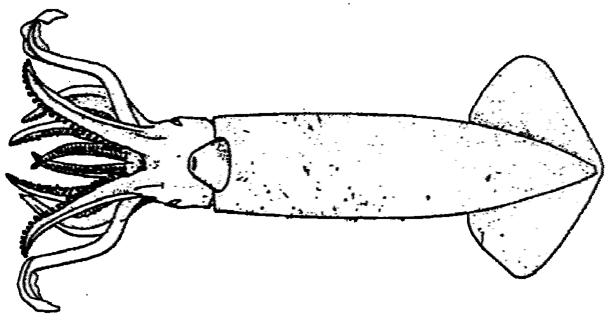
Diet switch result

Original run

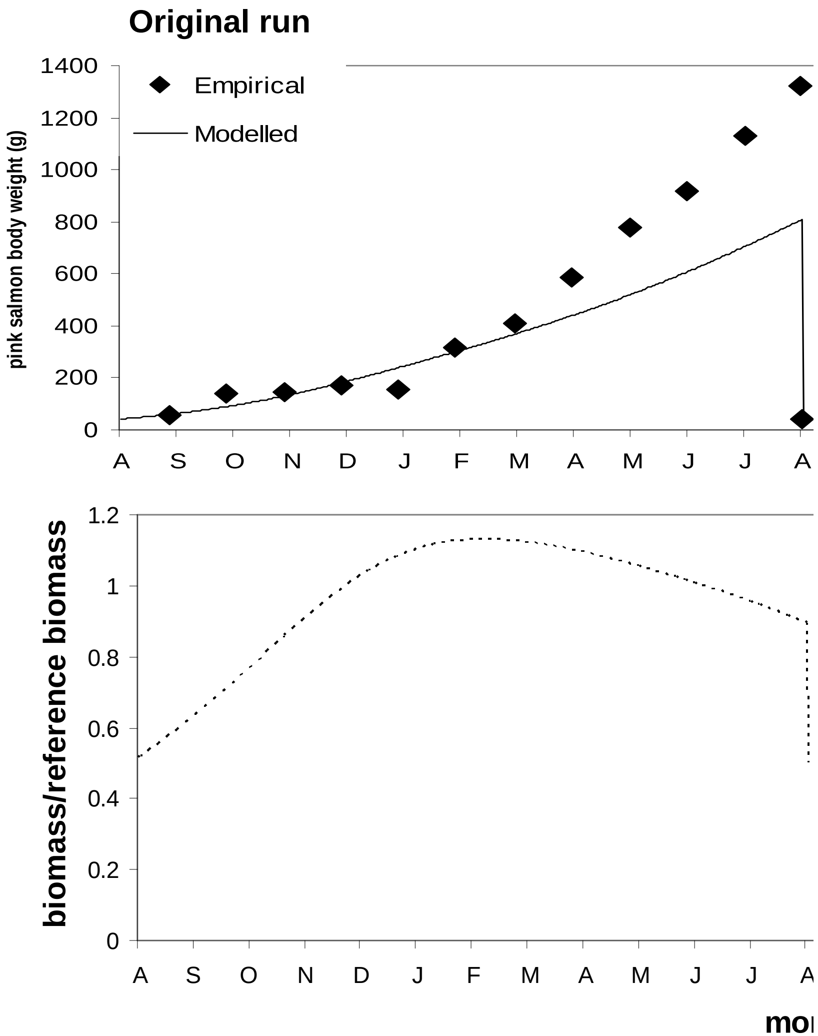


Diet switch to squid



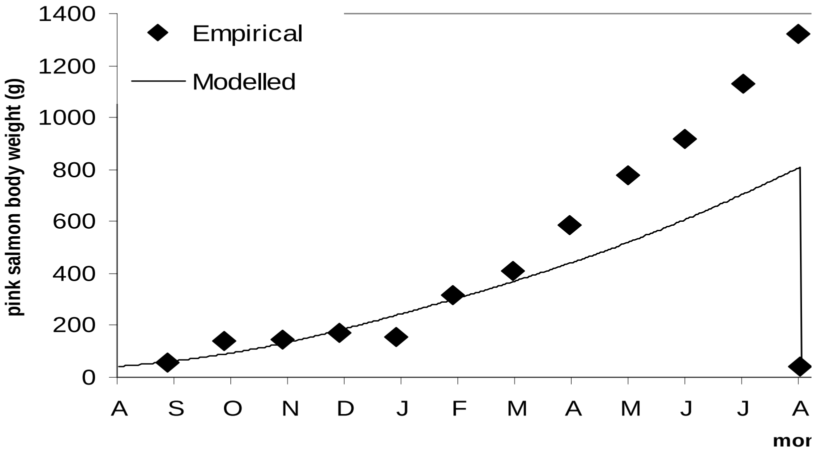


Density dependence?

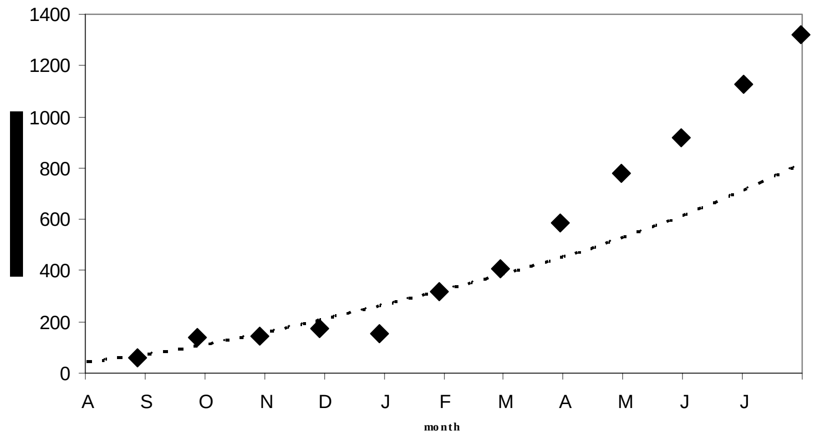


Density dependence result

Original run



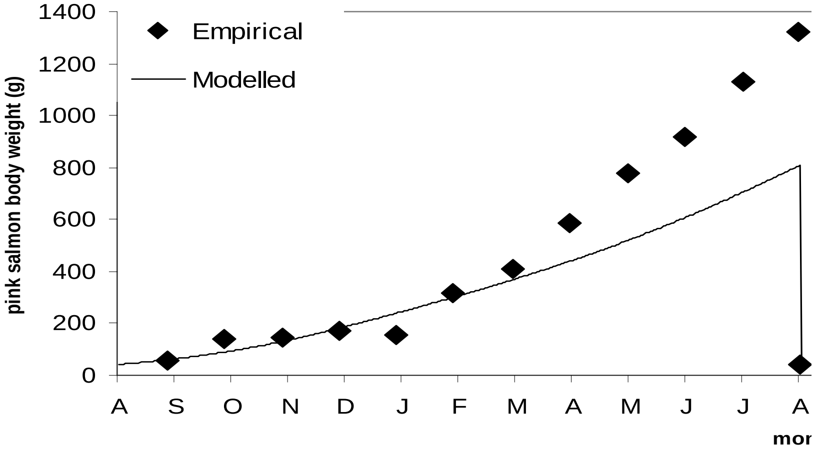
Density dependence



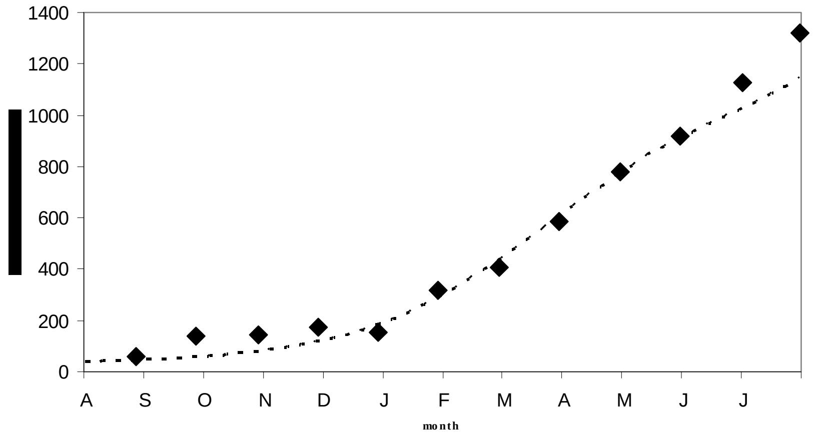
(note: density dependence + fast growth did improve fit)

Finally: mixed layer depth

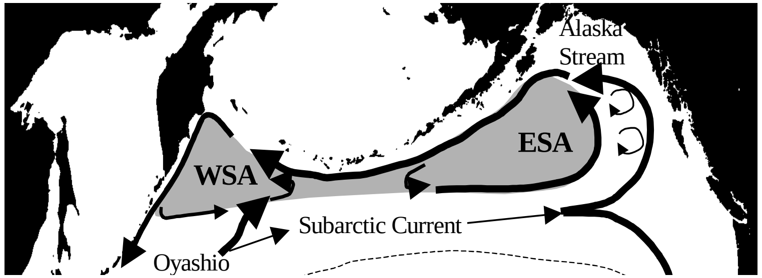
Original run



Mixed-layer depth



Concentration of prey density inversely proportional to mixed-layer depth.



WHAT NEXT?

Biogeography: N/S or E/W??

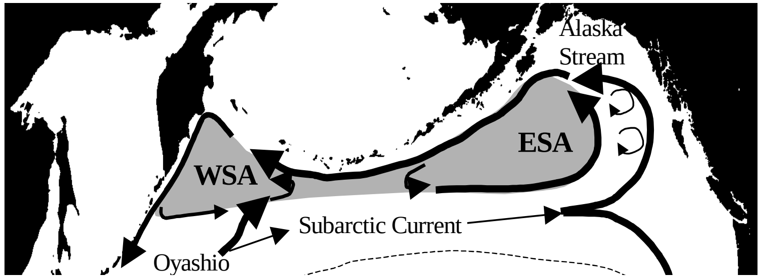
Circulation connecting gyres (squid and other species).

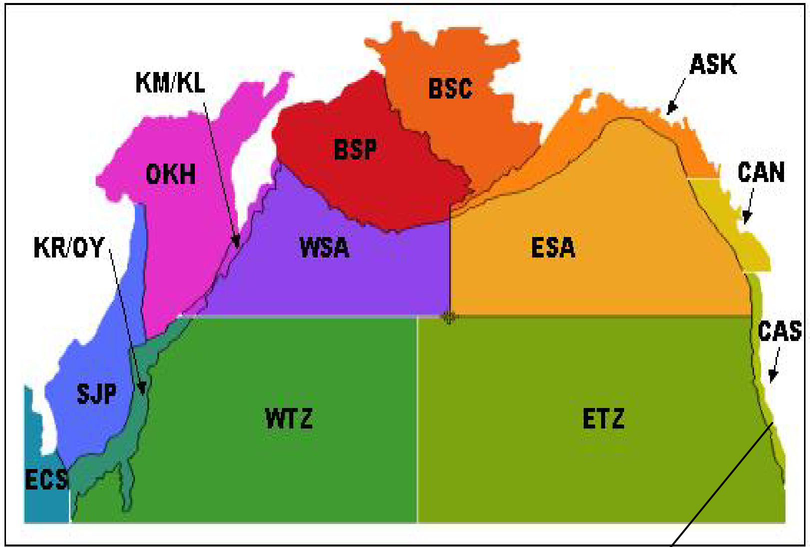
More detailed salmon models with more detailed density-dependence: MULTIPLE BOTTLENECKS model.

More realistic climate scenarios (eg. changes in mixed-layer depth -> NEMURO -> food webs in coupled models).

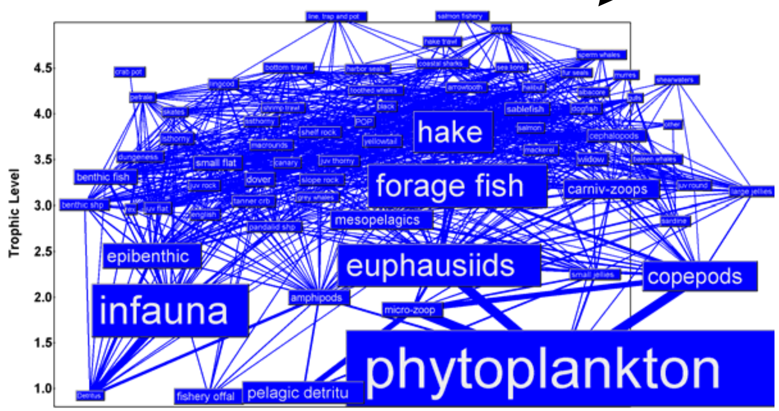
A food web
(biomass and rates)

Linkages II: Seasonal, geographical, interannual?





A food web
(biomass and rates)



Food web models exist for many/most PICES regions (e.g. J. Field 2004 for the Northern California Current), while the tool format (Ecosim) has reached its limits, especially for migratory species (e.g. sardine, hake). Extending these data syntheses into a biogeographic framework of nested/communicating models of may aid in extending hypotheses on predation, climate, seasonality, and linkages between Pacific ecosystems.

Linkages II: Seasonal, geographical, interannual?