Use of a Biophysical NPZ model to Investigate the Effect of Alongshore vs. Cross-Shelf Transport in the Coastal Gulf of Alaska on Quality of Habitat for Migrating Juvenile Salmon or What is the Source of Nutrients?

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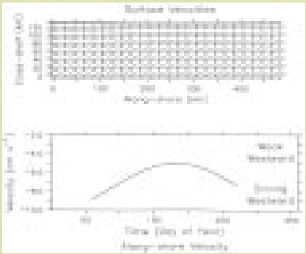
Introduction

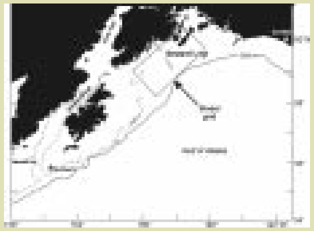
- Why is the coastal GOA such a productive area? (A downwelling system, sometimes upwelling for short periods in the summer)
- What is the origin of nutrients fueling this productivity?
- What is the role of alongshore vs. cross-shelf transport of nutrients?
- Is cross-shelf surface transport of nutrients due to downwelling (Ekman transport) important for productivity in the coastal Gulf?

- Offshore NPZ boundary conditions: from a biological model (Kawamiya et al. 1995) for the deep North Pacific
  - First simulation: diffusivity high above a mixed layer, low below, resulted in nutrient-depletion in the oceanic area (surface waters).
  - Second simulation: diffusivity from Kawamiya et al. = isotropic over depth. Produced HNLC as seen in oceanic areas.

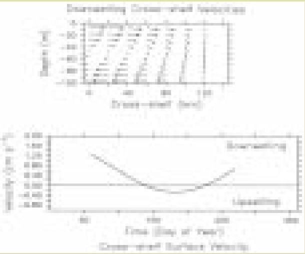


Methods

- 10-compartment NPZ model of the coastal area, with 3D hydrodynamic model
- 3D grid, an idealized, alongshore segment of the continental shelf in the CGOA
- Encompasses the GLOBEC NEP study area
- Flat bottom
- Offshore boundary = oceanic regime
- Upstream/downstream boundary = shelf
- Inshore boundary = edge of the ACC



- Velocity field derived from idealized SCRUM case
- Modified by 4 parameters controlling amplitude and seasonal variation of alongshore and cross-shelf flow:
  - "Aoff" = alongshore yearly mean velocity
  - "Aamp" = alongshore seasonal range
  - "Coff" = cross-shelf yearly mean
  - "Camp" = cross-shelf seasonal range



- Monte Carlo optimization and sensitivity analysis procedure used to understand what combination of cross-shelf and alongshore transport:

(1) the <u>biomasses</u> of zooplankton are most <u>sensitive</u> to.

(2) <u>maximizes</u> the amount of food available for migrating juvenile salmon

- What <u>velocity field</u> produces zooplankton biomasses like those seen at Seward Line in 1999?

Results

Sensitivity Analysis

- The higher the correlation coefficient (r), the stronger the effect of the input parameter on the output variable

- Output variables are density (mg C per m-3) of Coastal Copepods (C), Oceanic Copepods (NC), and Euphausiids (E) on several dates

Results

Sensitivity (r, correlation coefficient) of Output Variables to each Input Parameter

Output Variable

Input Parameter	June 1st C	June 1st NC	June 1st E		July 1st C	July 1st NC	July 1st E
aoff	-0.46	0.51	0.33	aoff	-0.15	0.51	-0.45
aamp	0.12	-0.13	-0.15	aamp	0.13	-0.13	-0.01
coff	-0.83	0.77	0.81	coff	-0.61	0.77	-0.2
camp	0.29	-0.28	-0.46	camp	0.39	-0.28	-0.23

	August 1st C	August 1st NC	August 1st E		September 1st C	September 1st NC	September 1st E
aoff	-0.16	0.51	-0.32	aoff	-0.07	no NC	-0.07
aamp	0.13	-0.13	0.11	aamp	0.18	no NC	0.18
coff	-0.69	0.77	-0.69	coff	-0.72	no NC	-0.61
camp	0.5	-0.28	0.41	camp	0.59	no NC	0.57

<u>Summary of Sensitivity Analysis</u>

- Sensitivity Analysis indicates that cross-shelf velocities more influential than alongshore velocities in affecting the biomass of Coastal Copepods, Oceanic Copepods and Euphausiids

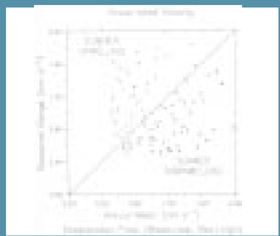
<u>Question</u>:

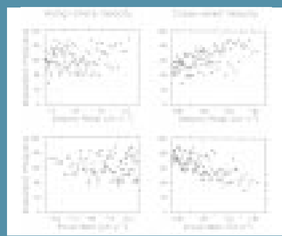
What combination of cross- and alongshore velocities produce the Maximum Zooplankton Production?

(Coastal Copepods + Oceanic Copepods + Euphausiids)

<u>Answer</u>:

Maximum Production is associated with the longest period of upwelling (no surprise here)

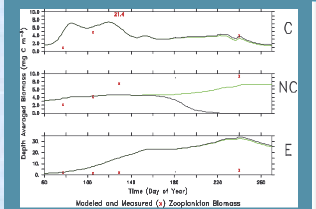




<u>Interpretation</u>:

- When the mean annual cross-shelf flow is near zero, small fluctuations can kick the system into upwelling

- If the mean is significantly above zero, it takes large seasonal fluctuation to kick the system into upwelling



Comparison with Data (summary)

- Euphausiids consistently overestimated by the model
- Coastal copepods in general agreement, model missed early bloom
- Oceanic copepods OK in the spring,
  - Underestimated by the model in late summer, model diapause was early
  - When diapause removed, model closer to data
  - Some species, e.g Eucalanus bungii, diapause later, these may have been present on the Seward Line later in the summer

Comparison with Data

- Model run agreeing best with Seward Line data (1999) characterized by a long period of upwelling between late April and the end of August.

- 1999 NOT a year of much upwelling at the Seward Line (Stabeno et al. In press)

More Results

<u>Second simulation</u> (with offshore supply of nutrients, ie. HNLC conditions):

- Very similar results to the first simulation, ie.
  - Significant upwelling necessary for maximum zooplankton production,
  - Upwelling necessary to get biomass comparable to Seward Line in 1999

Conclusions

Conclusions

<u>Is it Onshore Transport of Nutrients in Surface Water (Ekman transport)?</u>

- Time scales for Ekman transport (1-2 km/day) much <u>slower</u> than for biological response to an influx of nutrients (10-15 days between nutrient influx and bloom of copepods)

- In the model, nutrients advected from the open ocean used up quickly, never make it to inner coastal areas

- We may need to look for another explanation as to the source of nutrients onto the shelf:
  - Influx through cross-shelf canyons?
  - Influxes from offshore, eddies or diversions of the Alaskan Stream?
  - Tides?

Poster designed by Wendy Carlson of the Alaska Fisheries Science Center - Graphics Unit