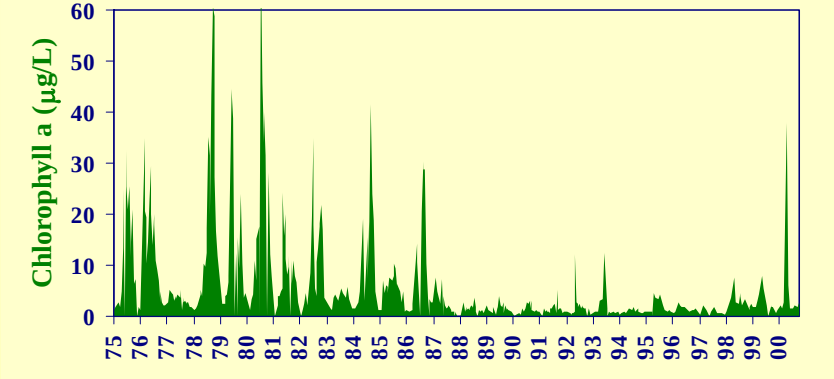
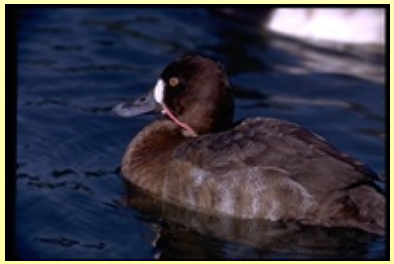
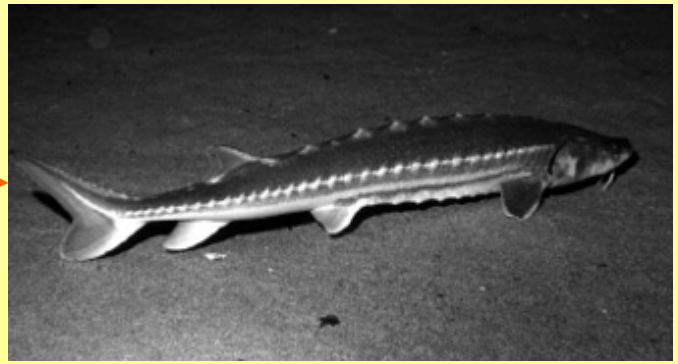
Bivalves: The Scourge of the Estuary?



Using Conceptual and Numerical Models to Inform Our Water Management Options



Selenium



http://www.dfg.ca.gov/marine/status/green_sturgeon.pdf

Jan Thompson
US Geological Survey
Menlo Park, California

My charge

- Any good models on the shelf? No
- How can we use conceptual models like those developed in DRERIP? Strengths? Weaknesses?
- How do conceptual models differ from numerical models being developed in CASCADE? Strengths? Weaknesses?
- What's the future for bivalve models?

Status:

Invaded 1986 and limited laboratory studies

✓DRERIP conceptual model

❑STELLA population model – not dynamically linked

Invaded 1940 and more laboratory studies

✓DRERIP conceptual model

❑STELLA population model – not dynamically linked

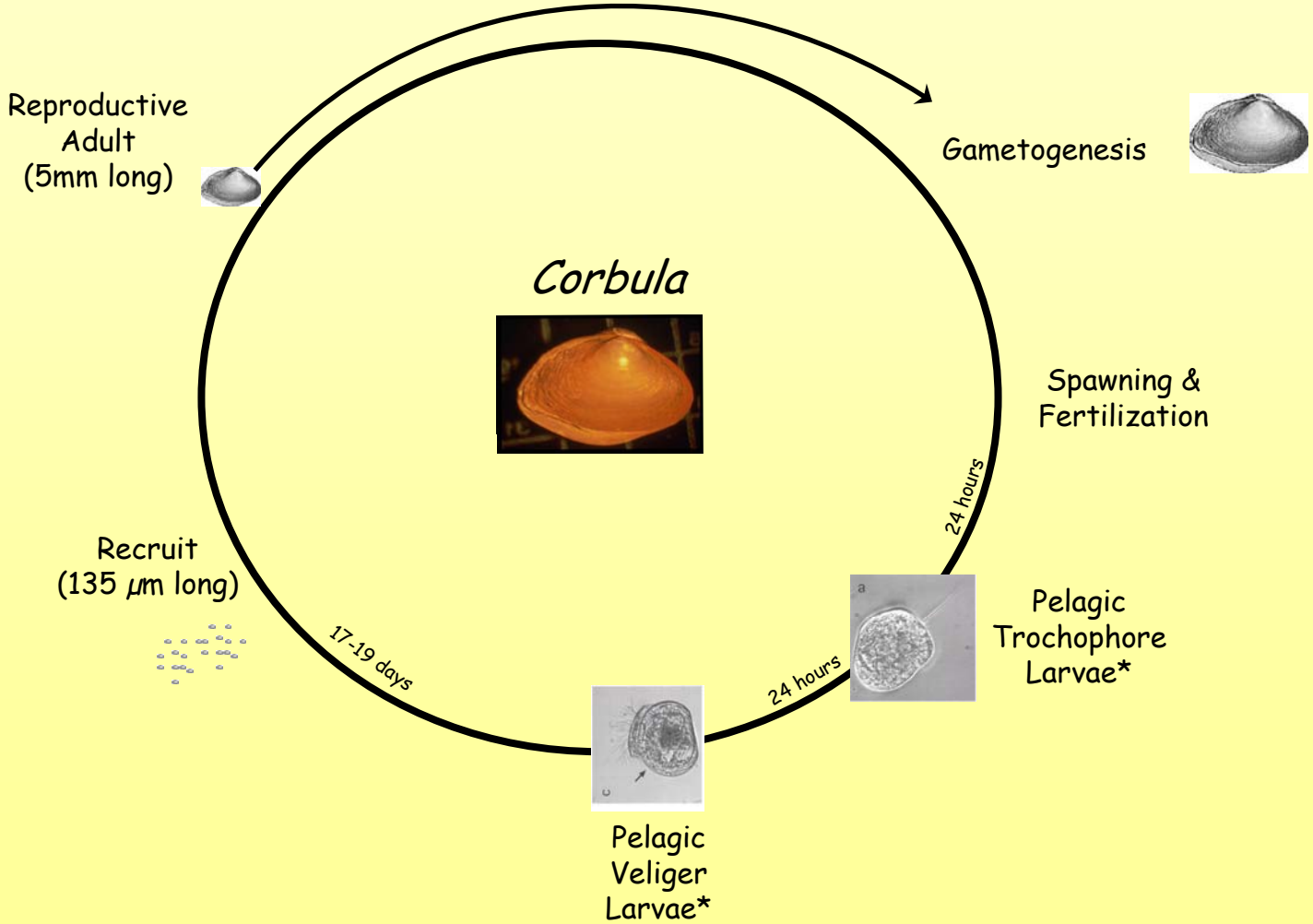
Bivalve models are connected to many submodels but must be connected to hydrodynamic models at a minimum to

- Distribute gametes and young
- Maintain/change water quality
- Deliver food to the sedentary animals

Conceptual models such as DRERIP models are critical for:

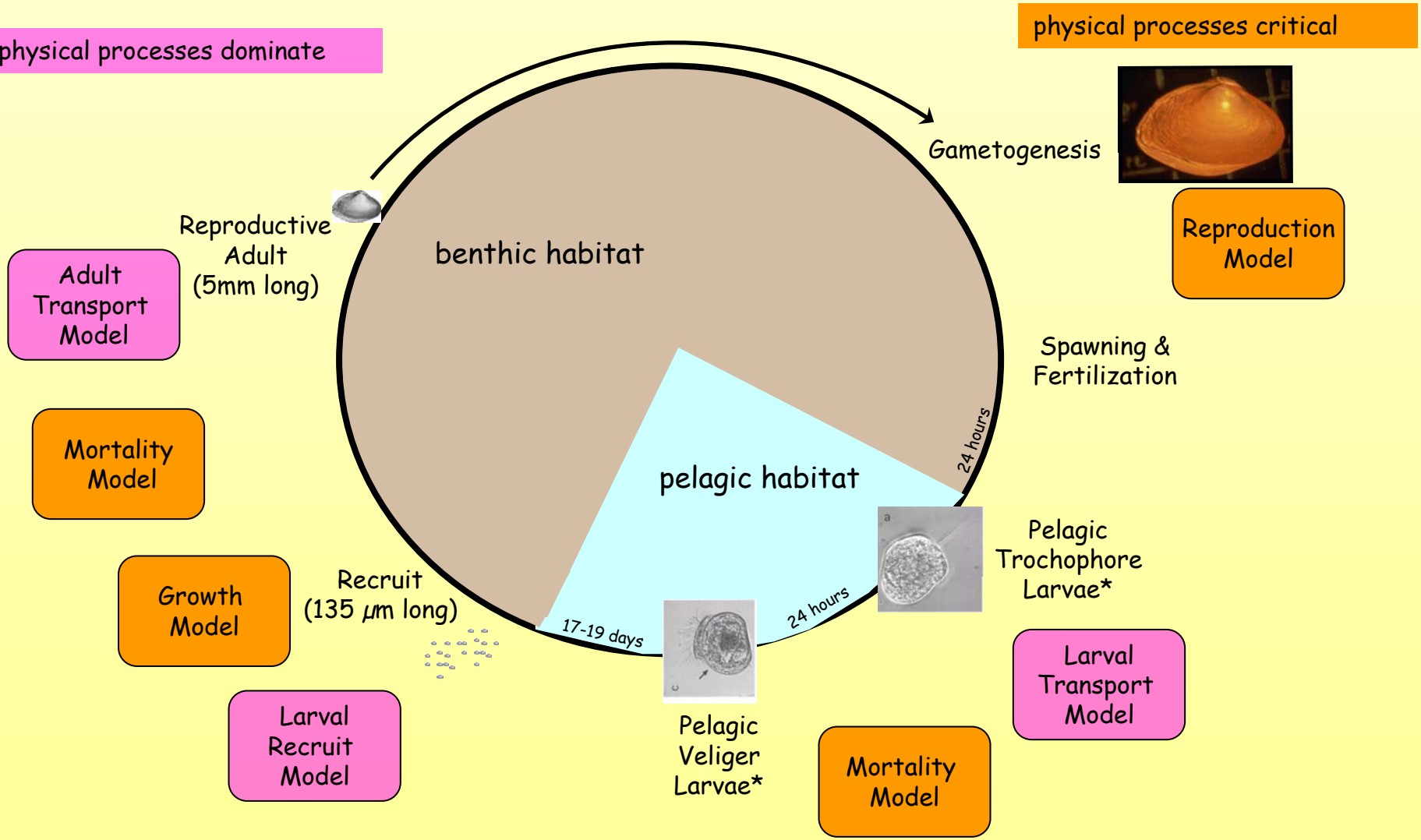
- Designing numerical models – particularly valuable in making connections between bivalves and other factors (physical transport & mixing, phytoplankton etc)
- Highlighting data needs and prioritizing research needs and dollars
- Examining processes which may not be modeled in the near term

DRERIP: We have developed *Corbula* and *Corbicula* Life Cycle Models, the first step in building conceptual models



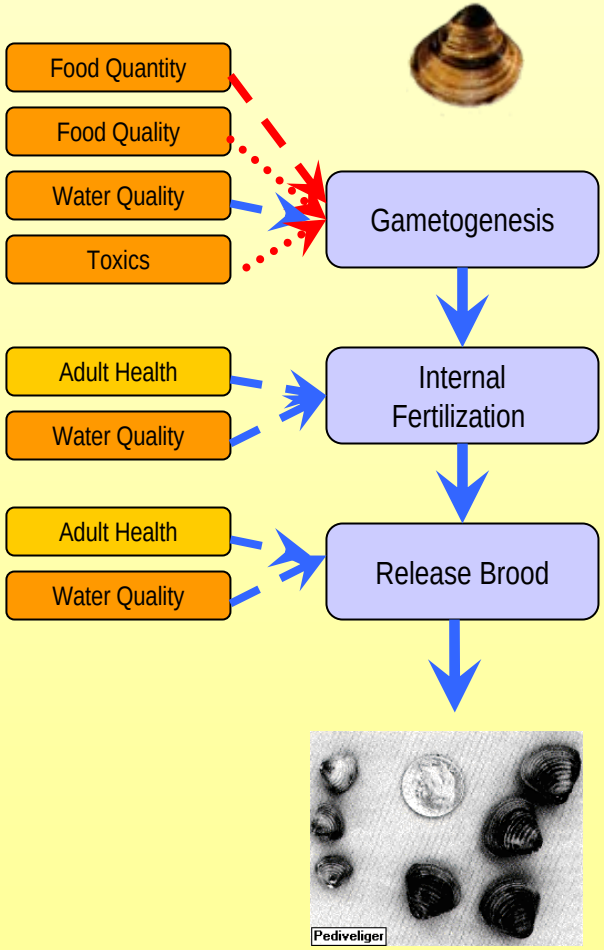
*From Nicolini, MH and DL Penry. 2000. Spawning, fertilization, and larval development of *Potamocorbula amurensis* (Mollusca: Bivalvia) from San Francisco Bay, California. Pacific Science: 54(4):377-388 NO PERMISSION FOR PUB.

DRERIP sub-models have been connected to each Life Cycle Model and coded for habitat and critical processes

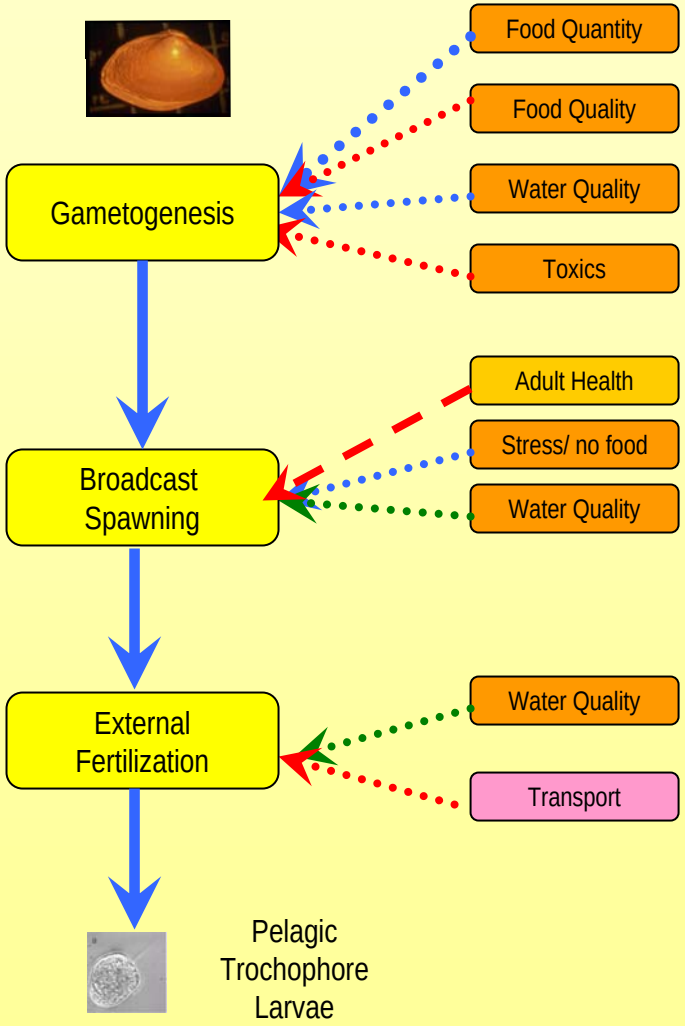


*From Nicolini, MH and DL Penry. 2000. Spawning, fertilization, and larval development of *Potamocorbula amurensis* (Mollusca: Bivalvia) from San Francisco Bay, California. Pacific Science: 54(4):377-388 NO PERMISSION FOR PUB.

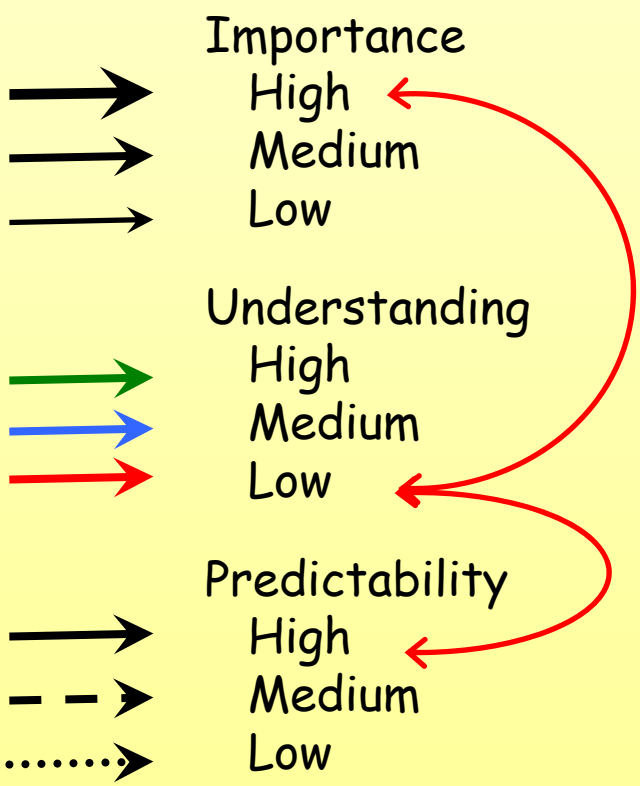
Each DRERIP sub-model includes triggers or forcing factors and stressors

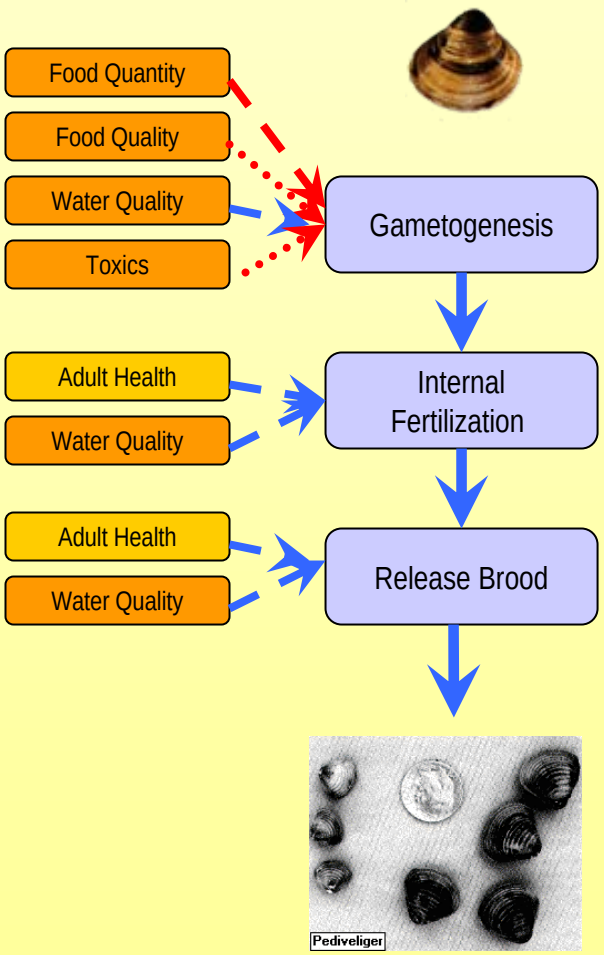


el.erdc.usace.army



DRERIP models help us build numerical models AND tell us what we know, how well we know it, and what critical data are lacking





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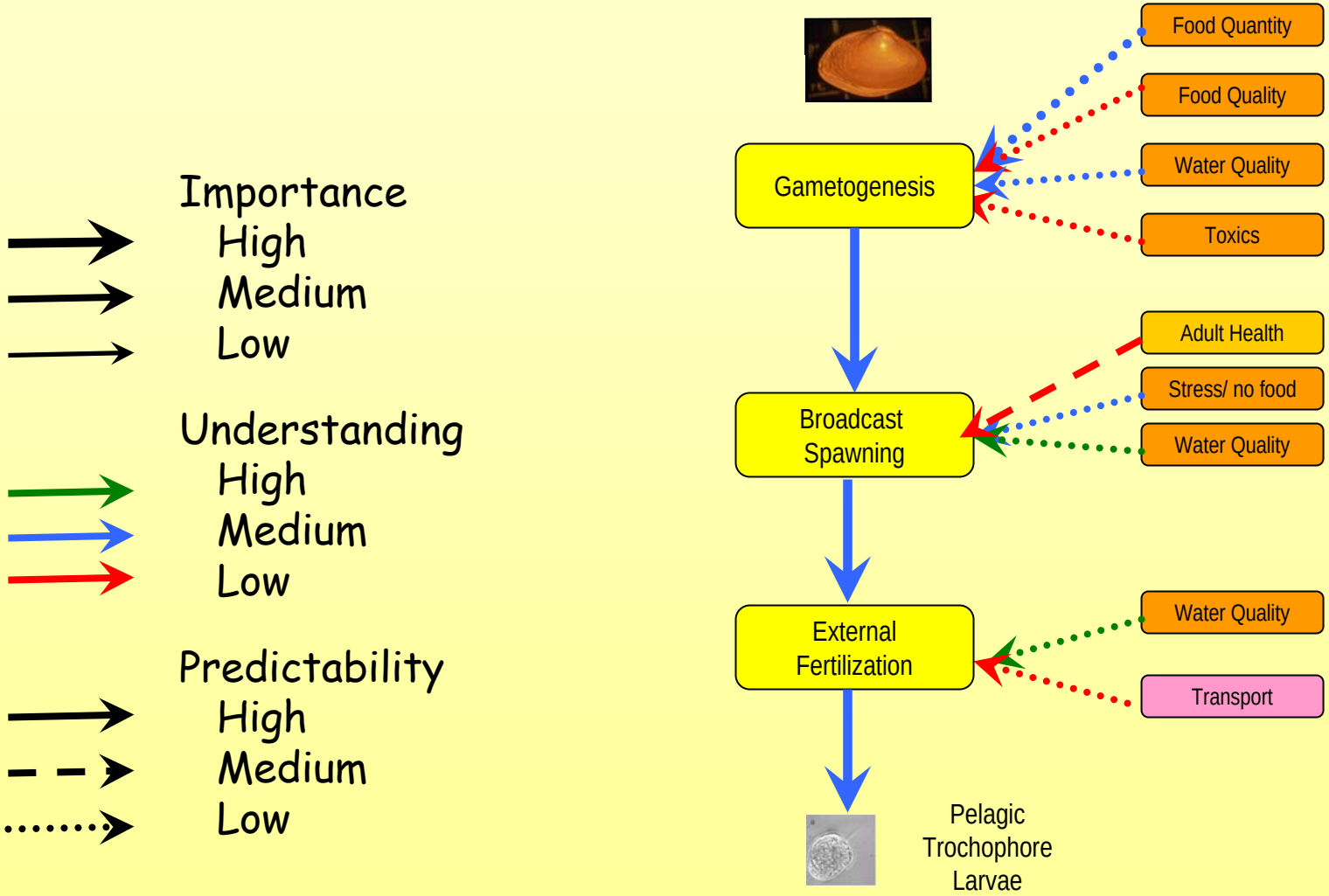
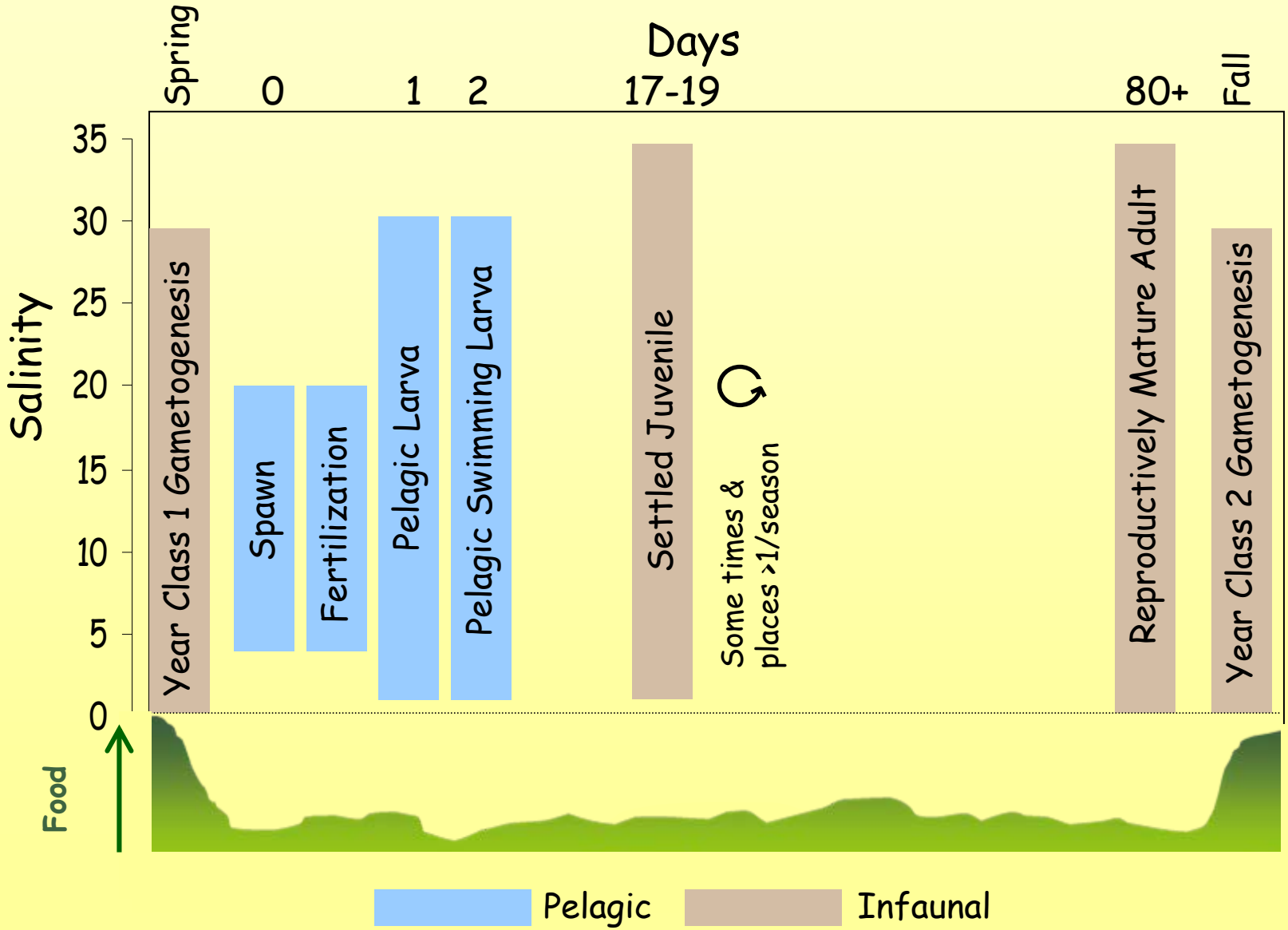
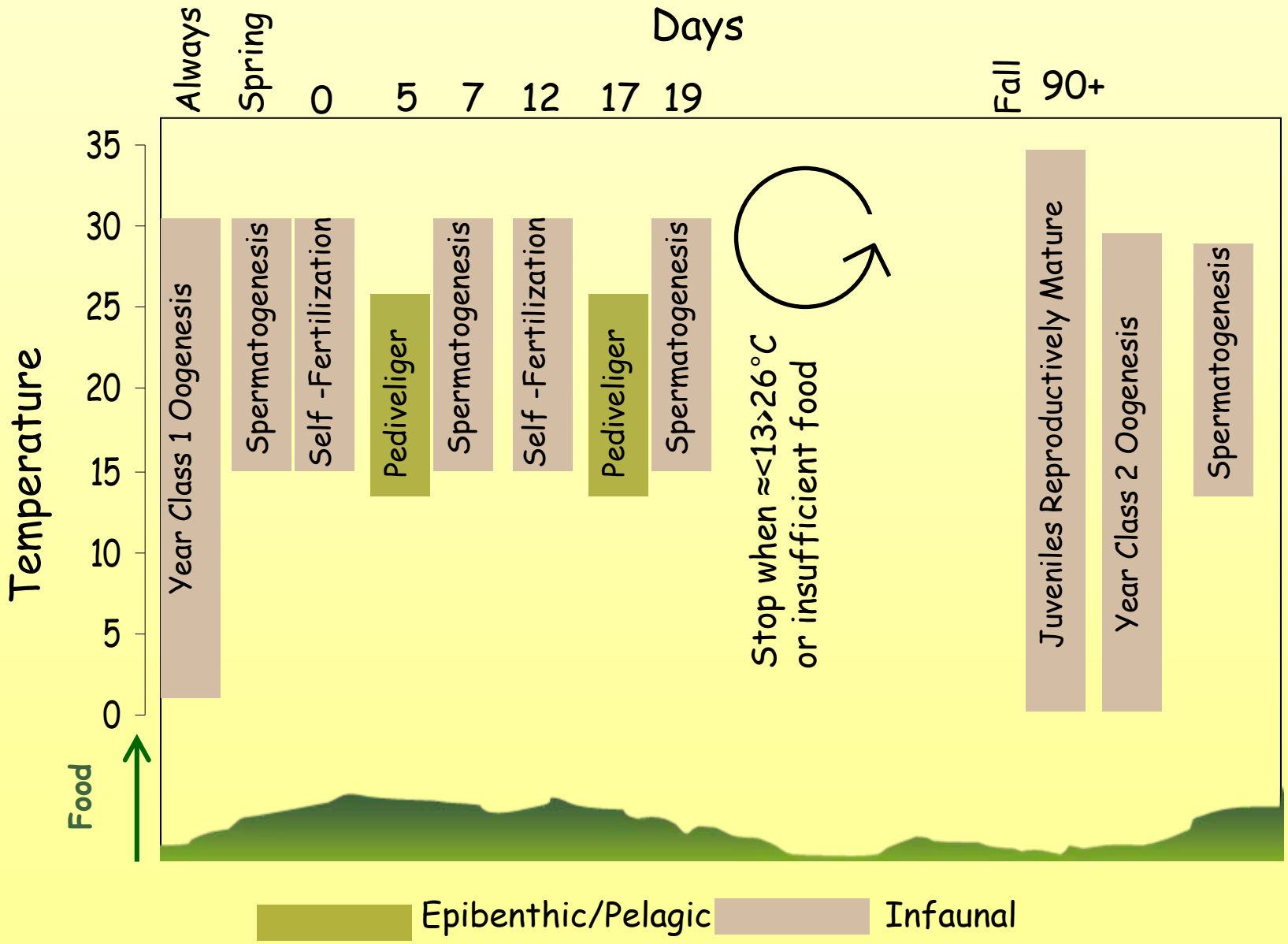
A similar exercise for *Corbula* shows different data gaps and needs



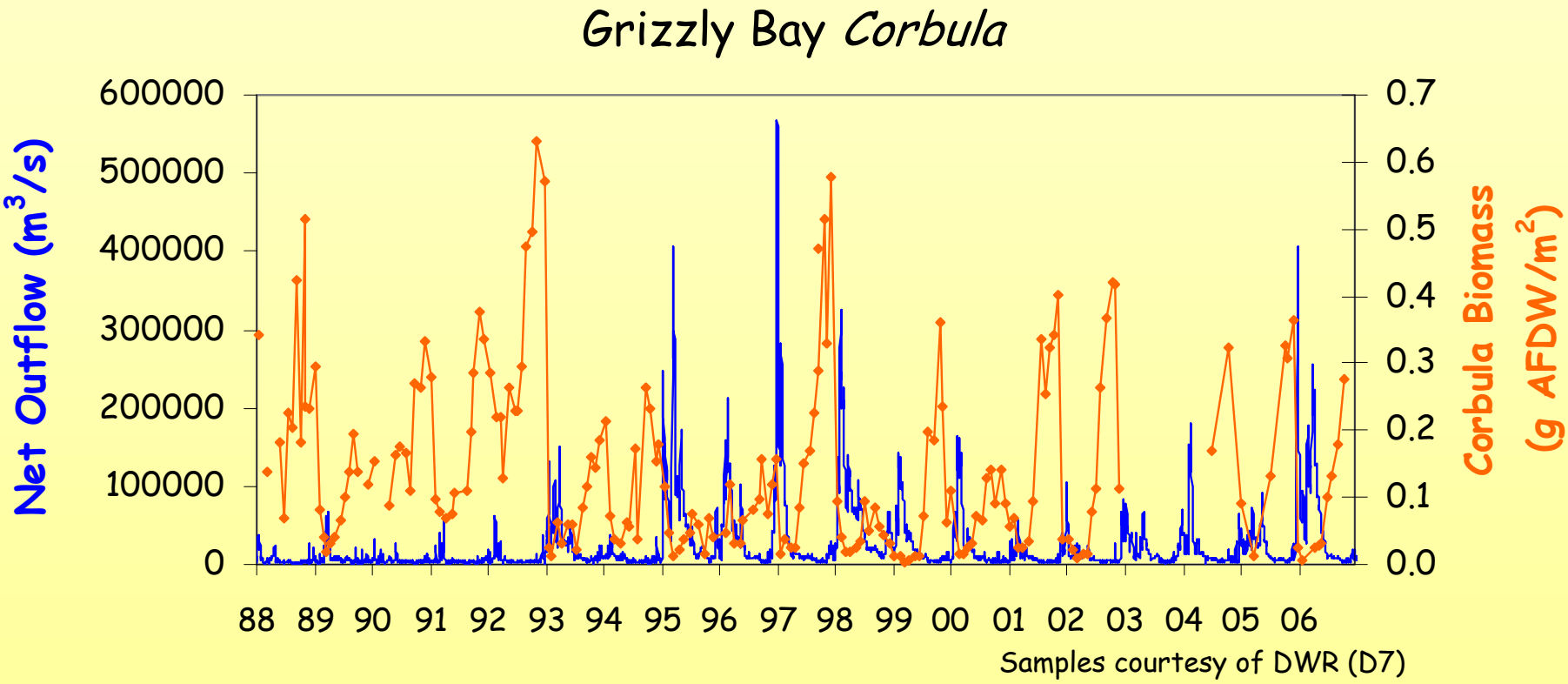
Extended Life Cycle Models further our understanding of controls on a species distribution



And allow us to contrast controls on different species



DRERIP can help us discover critical processes before we are ready to model them. Eg. Why do the clams disappear in winter? Does it matter?



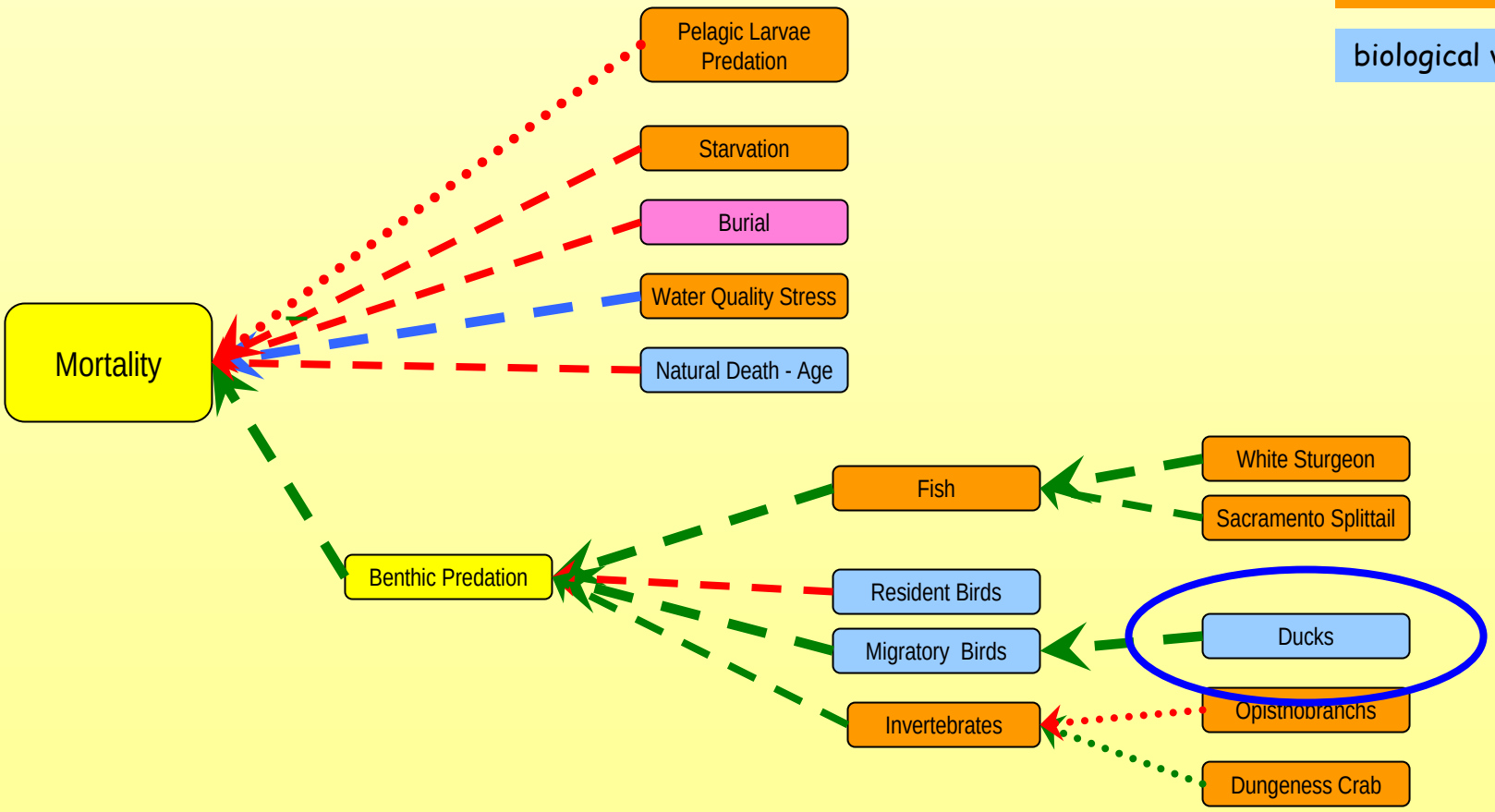
Migratory ducks heavily prey upon shallow water *Corbula* and they are bio-accumulating Se.

Corbula Mortality Model

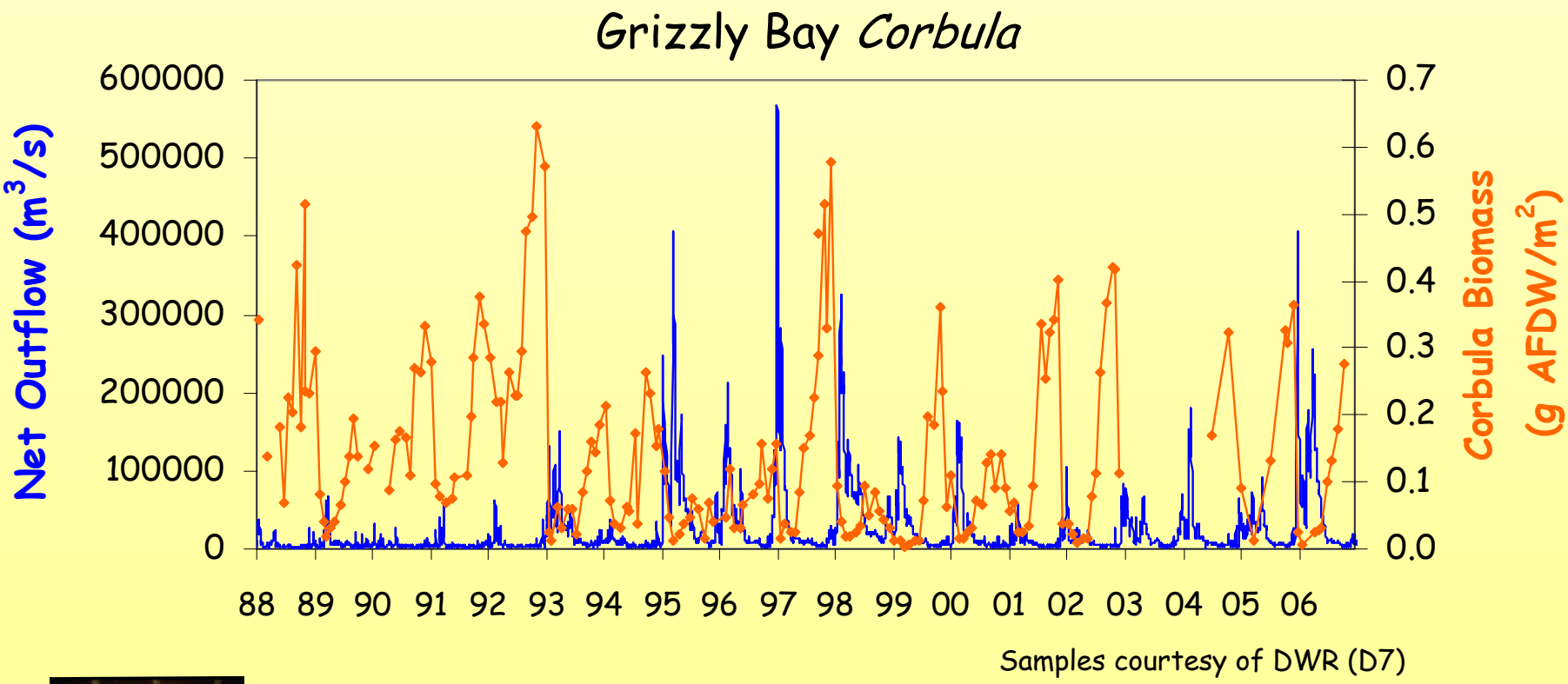
physical processes dominate

physical processes critical

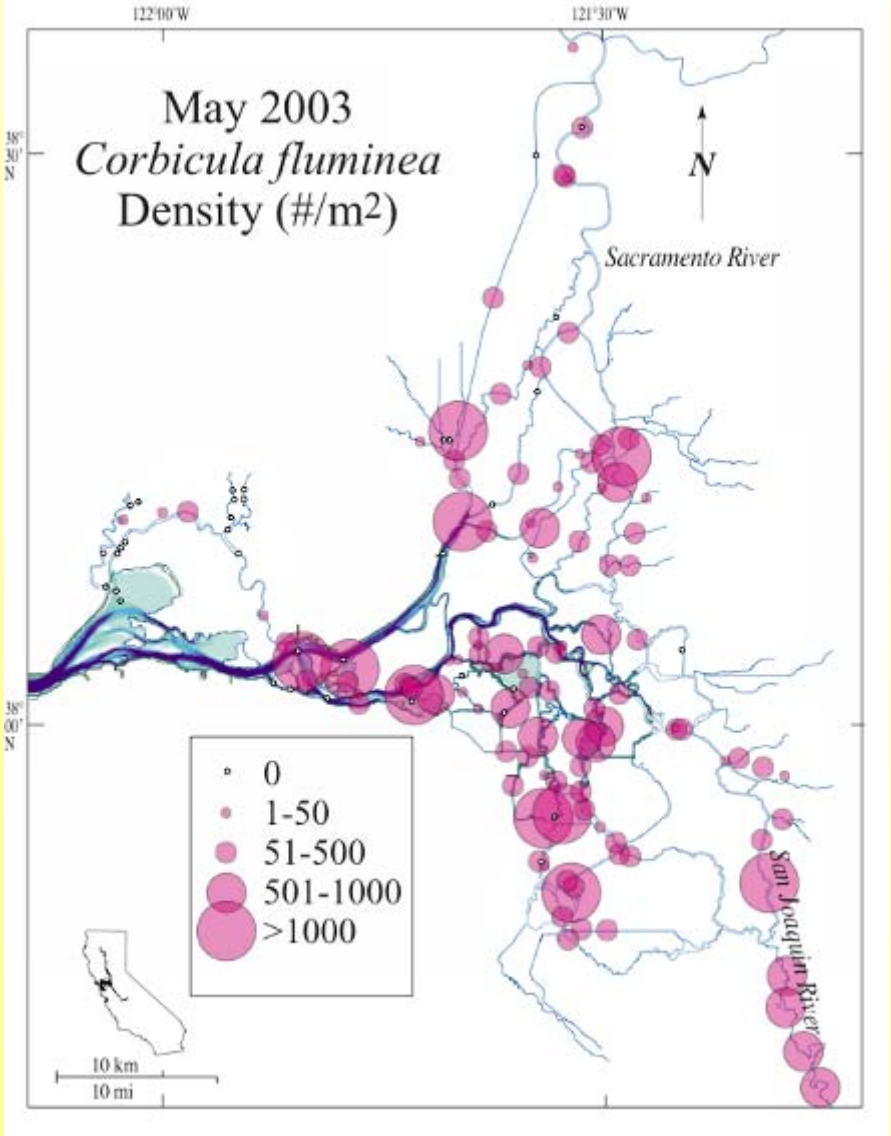
biological variables

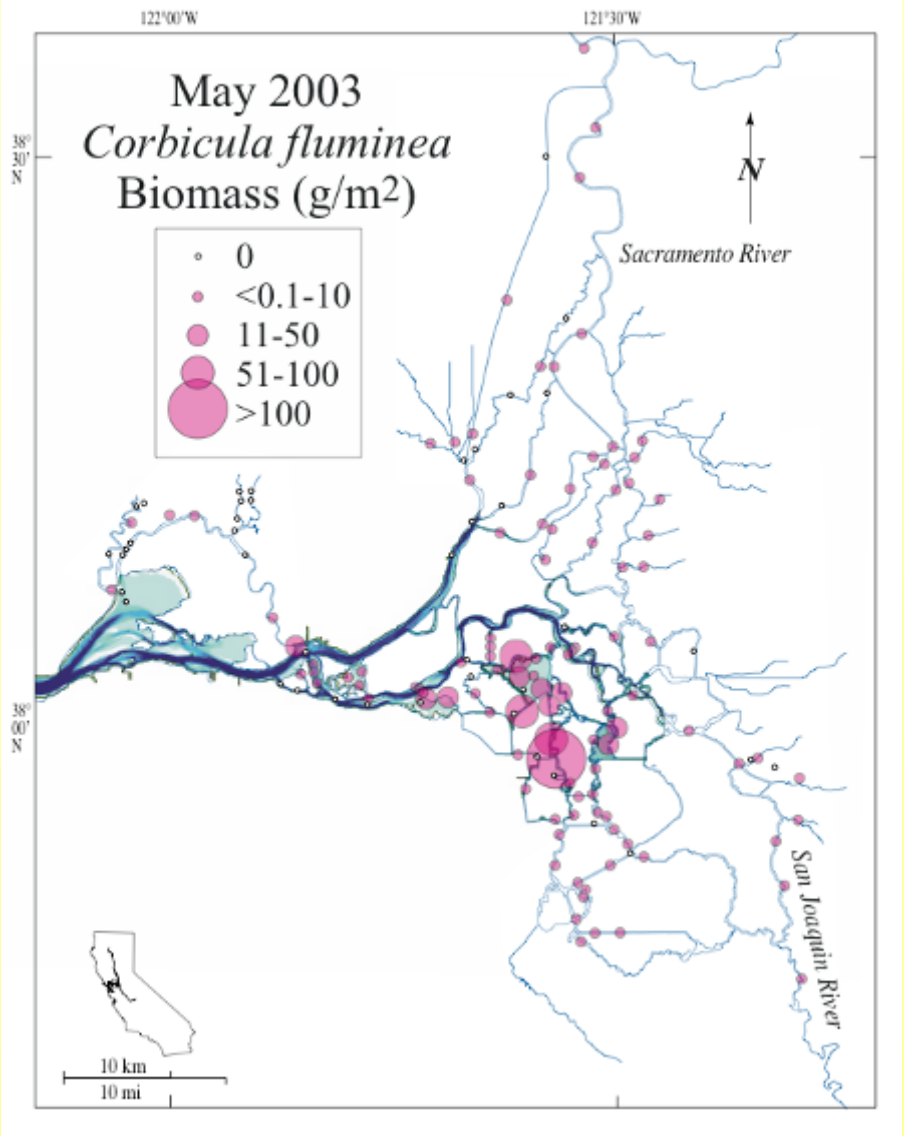


However DRERIP models can't explain the inter-annual variability in biomass (and thus grazing) peaks



DRERIP models also can't tell us why *Corbicula* juveniles occur throughout the Delta but only grow-up in the central Delta.





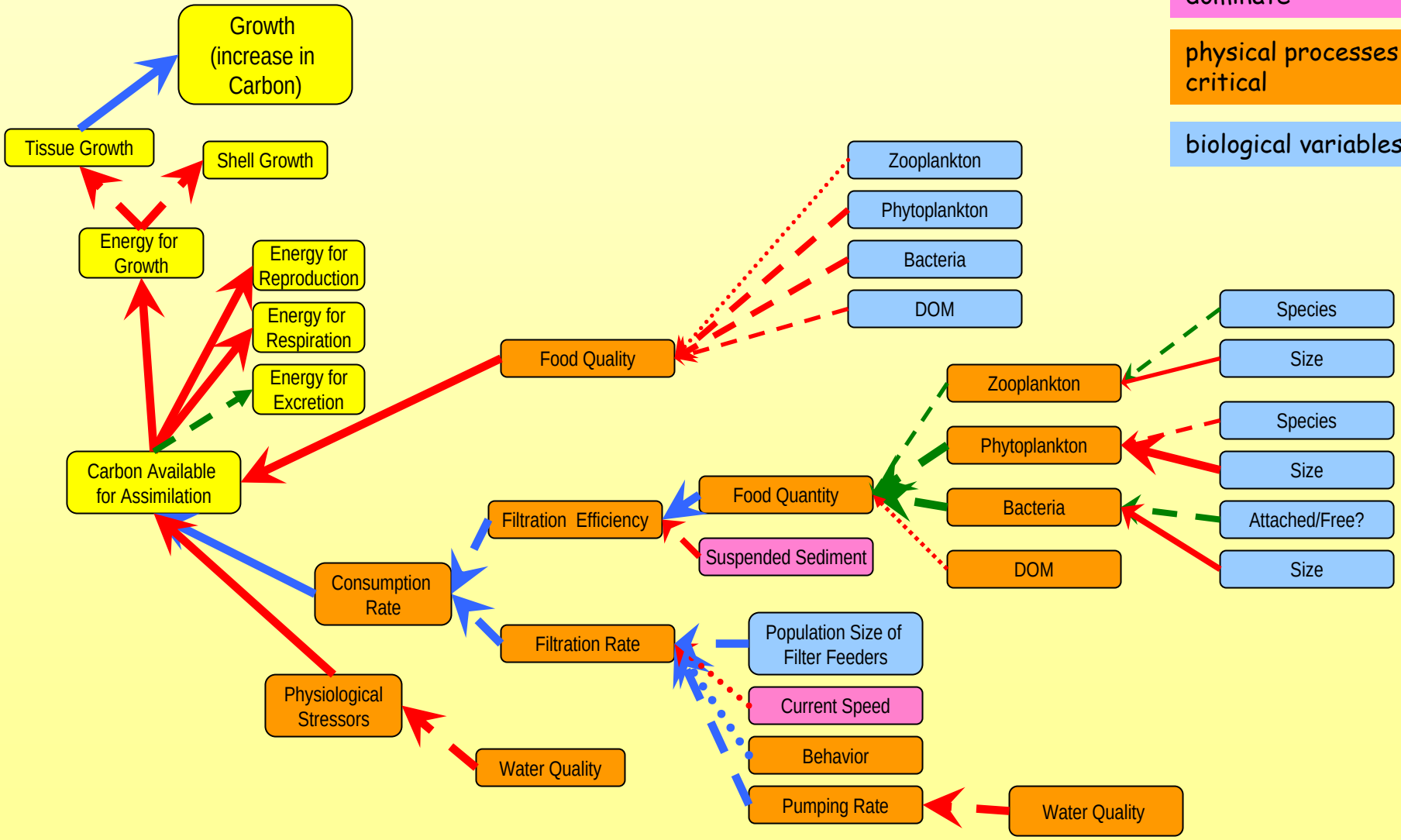
To do that we need to look at growth models and it becomes obvious that we need more than a conceptual model.

Corbula Growth Model

physical processes dominate

physical processes critical

biological variables



In Summary, conceptual models such as DRERIP models <u>do not</u>

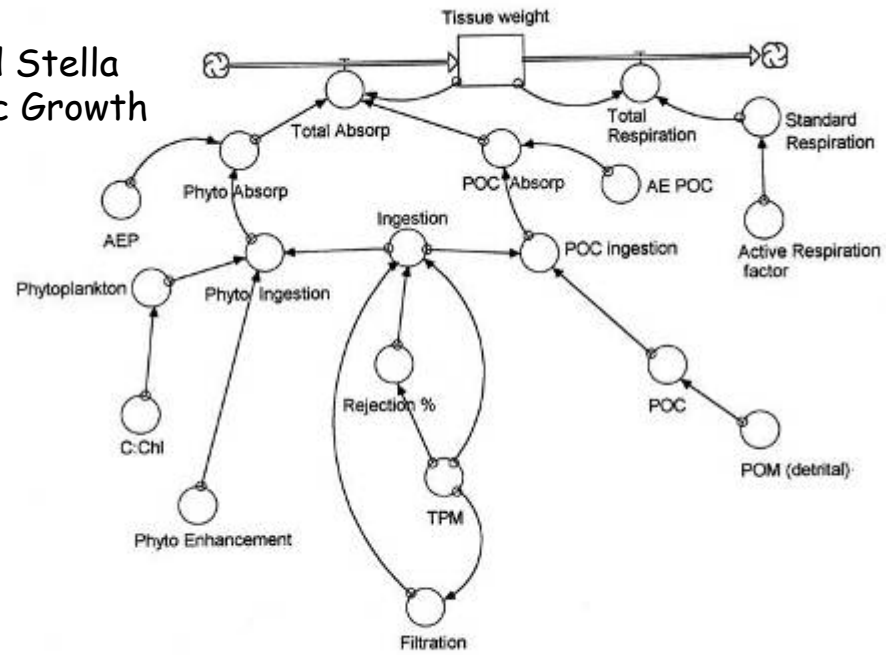
- Tell us the magnitude of the bivalves ecological functions (eg. consuming phytoplankton)
- Tell us the temporal and spatial variability of those ecological functions, <u>the causes of which might be exploited by water management</u>
- Tell us if the model is wrong – surprises are when we learn
- Allow us to dynamically link and manipulate variables

Numerical models within CASCADE

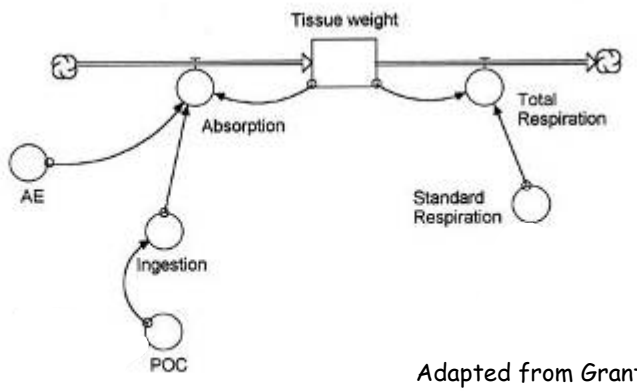
- We are using STELLA models until we know more – adapted to be spatially variable and responsive to stressors
- Will tell us about processes and limits on populations – I will discuss some today
- Allow us to dynamically link and manipulate some variables
- We expect and look forward to surprises

We are simplifying STELLA models to operate with statistical relationships instead of using energetic principles.

Standard Stella Energetic Growth Model

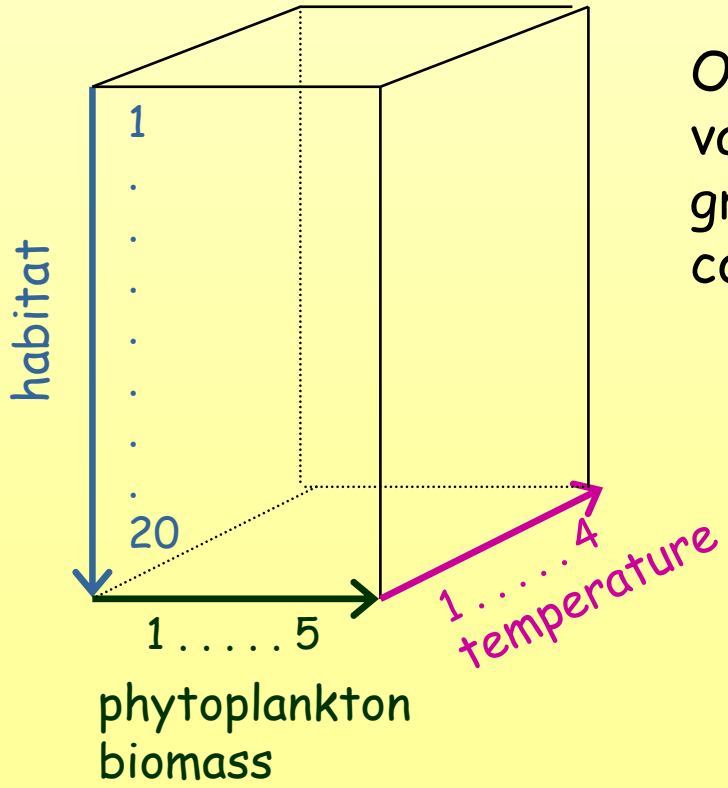


Statistical Stella Growth Model



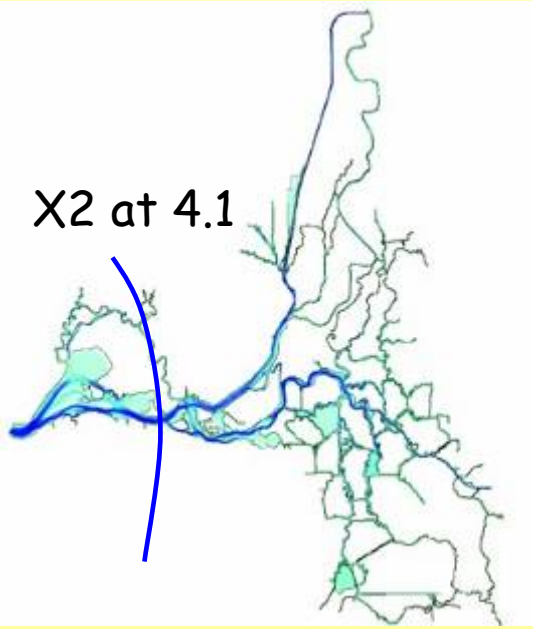
Adapted from Grant and Bacher 1998

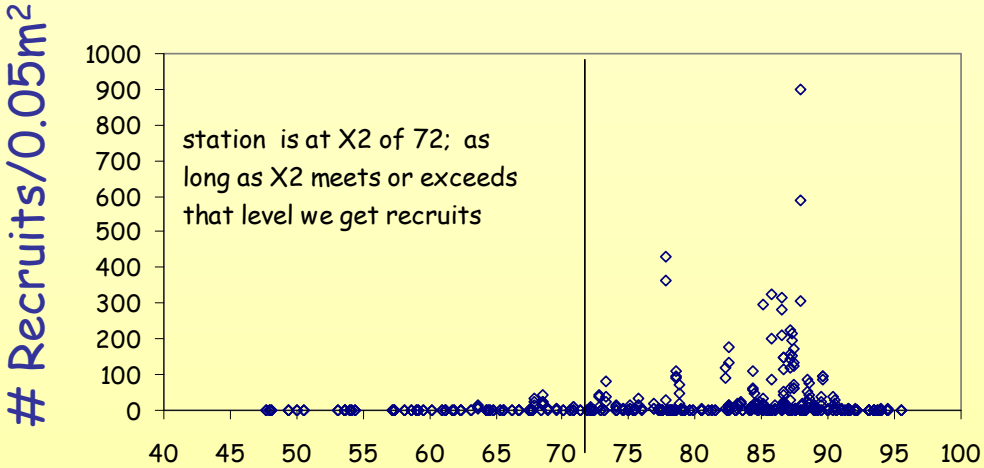
Spatial resolution and physical variables known to dynamically interact with clam functions will be run sequentially to produce a "look up" table for other models.

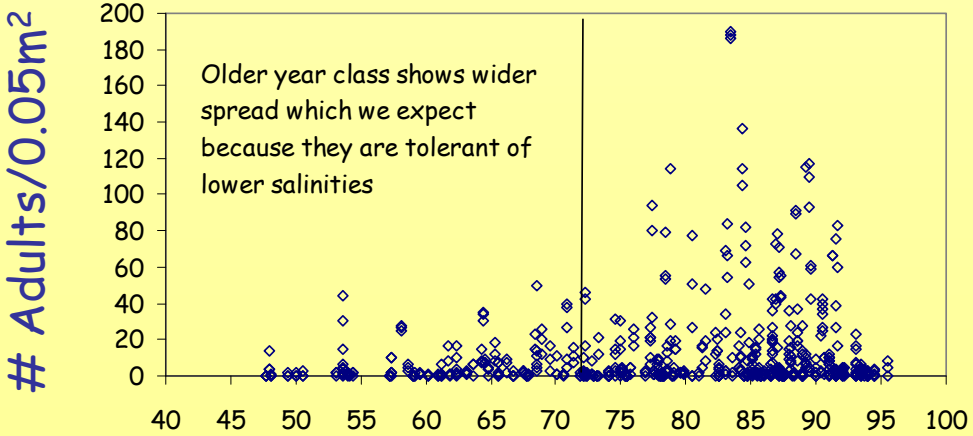


Output: Temporally and spatially varying growth rate, biomass, grazing rate for phytoplankton and contaminant models

Step 1: Initial Conditions: Where are the two species in space? *Corbula* recruits settle downstream of X2 (*Corbicula* juveniles settle upstream of X2!)

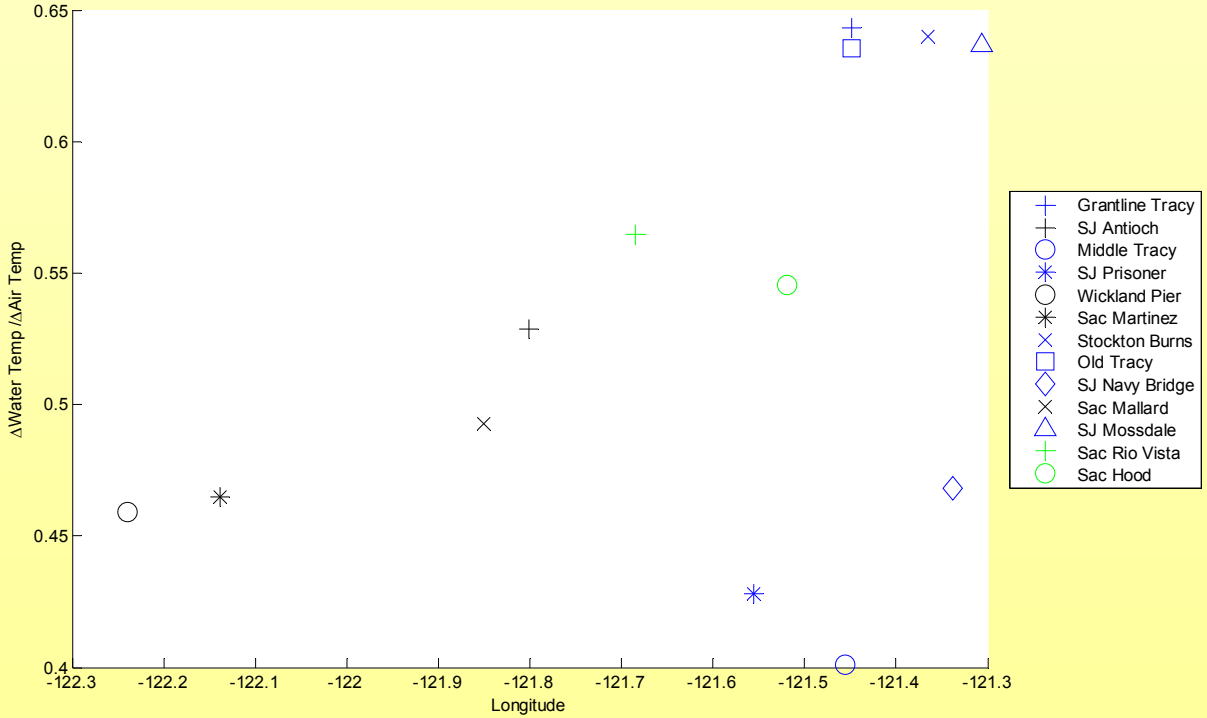






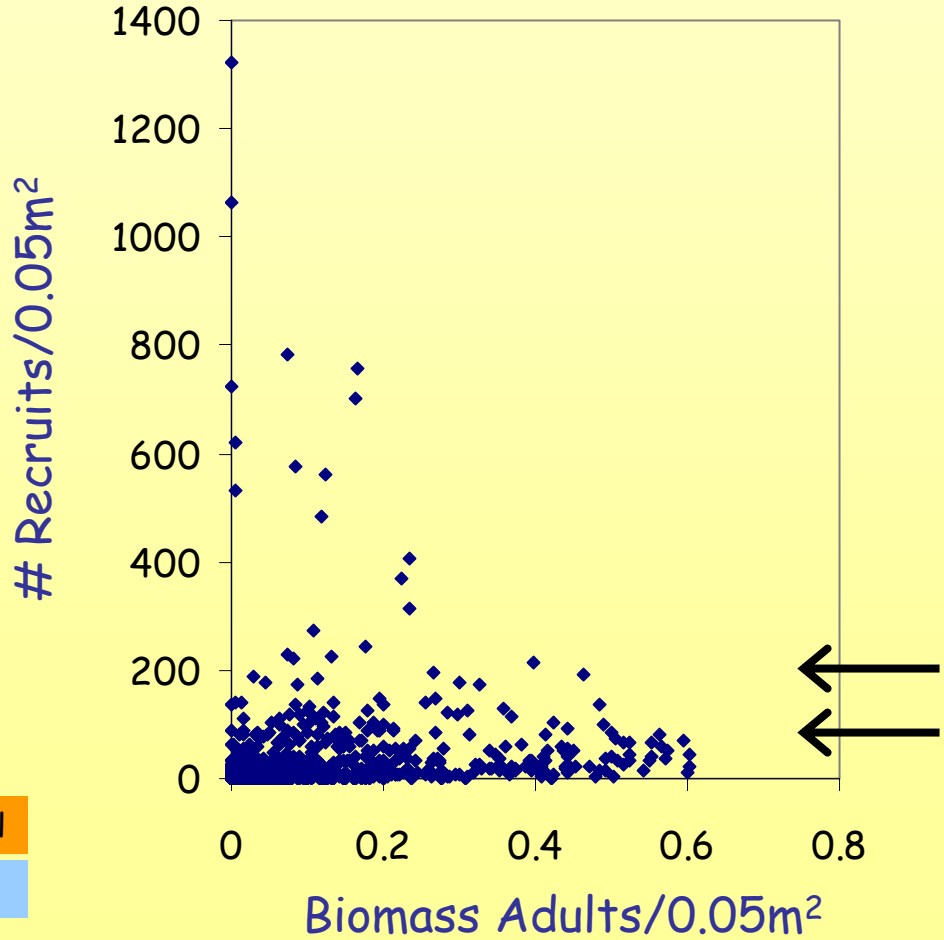
physical processes dominate

In order to establish some statistical bounds to our results, we will use an ensemble of salinity and temperature distributions in time and space to establish a range of distributions for each scenario



Preliminary data from Wayne Wagner & Mark Stacey

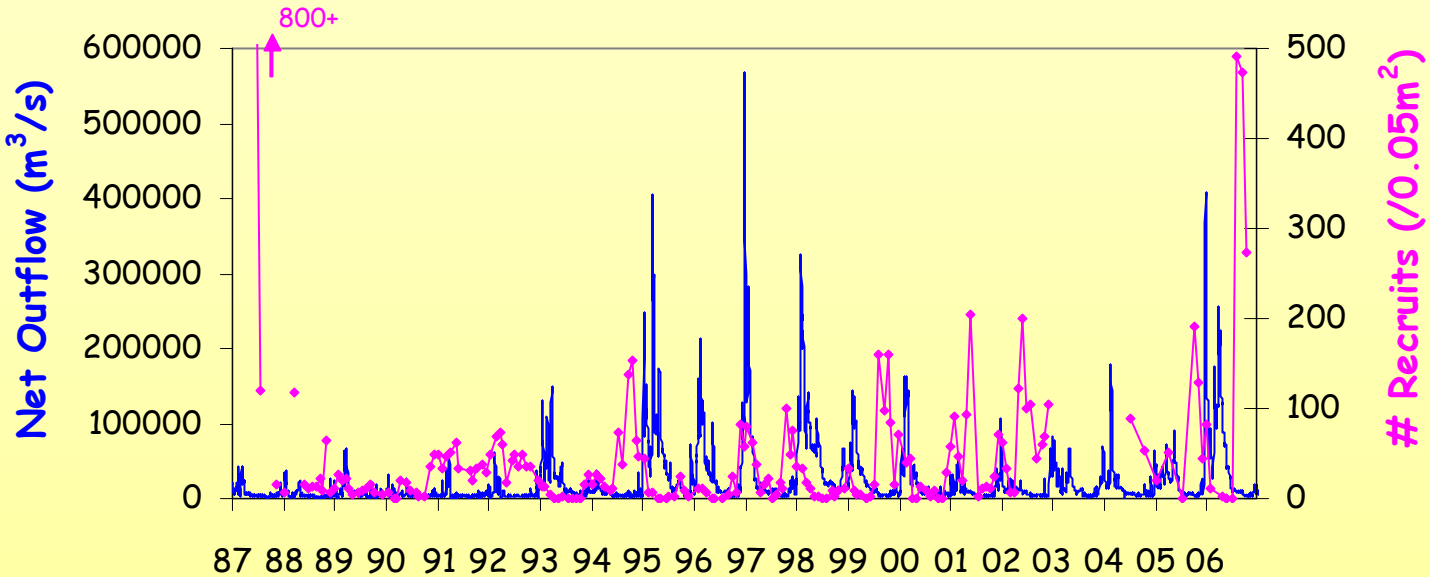
Initial Conditions: Number of recruits is partially dependent on the biomass of adults present; there is a physical and biological basis for this relationship



physical processes critical

biological variables

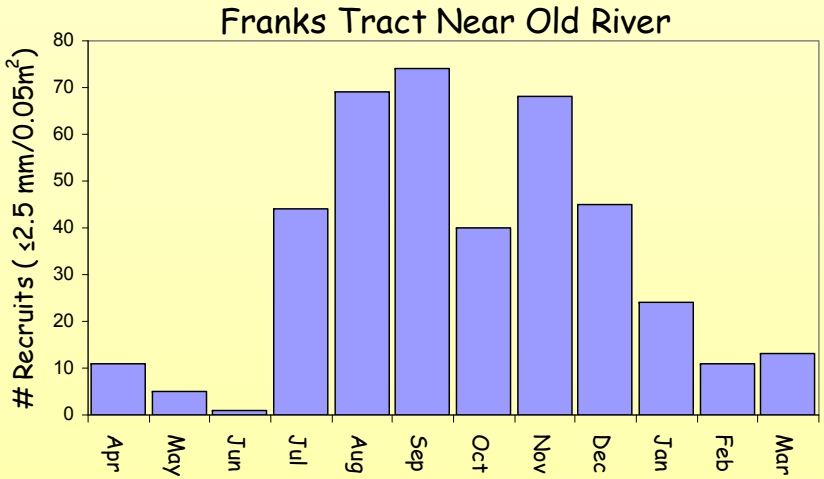
We assign *Corbula* recruit abundance based on biomass of adults and antecedent outflow events – note the grouping of abundances around 100, 200 and <20.

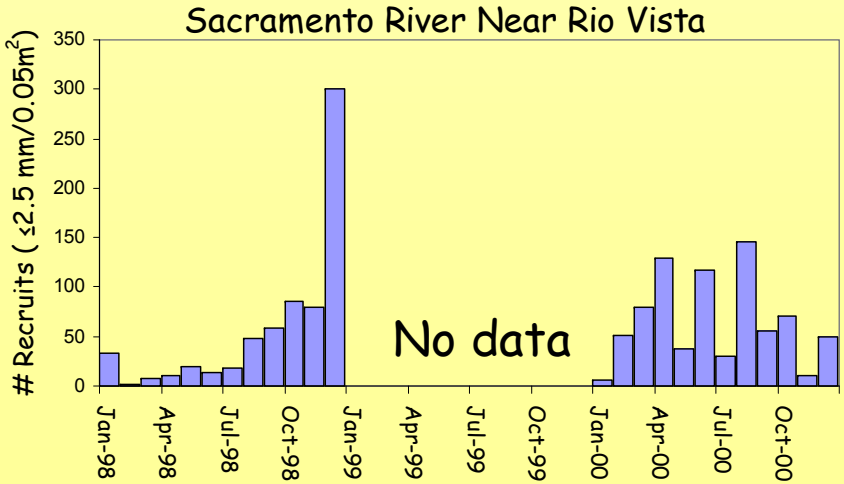


Recruit numbers are assigned as ≈100, ≈200, ≈10 (prolonged high outflow), and 400 (sufficient outflow to remove adults plus phytoplankton 'bloomlet' in region)

physical processes critical

We observe *Corbicula* recruit abundance at ≈20 recruits/0.05 m^2 throughout the year at monitoring stations





We are determining if transport of larvae from non-local sites, where temperature regimes may be staggered, accounts for the near continuous pattern of recruitment observed in areas like the <u>central delta where many sources of water are mixed.</u>

If so changing temperatures throughout the tributaries and Delta could alter this population distribution

physical processes critical

Corbicula's present and potential biomass distribution is likely based on food limitation so a growth relationship is critical to our model

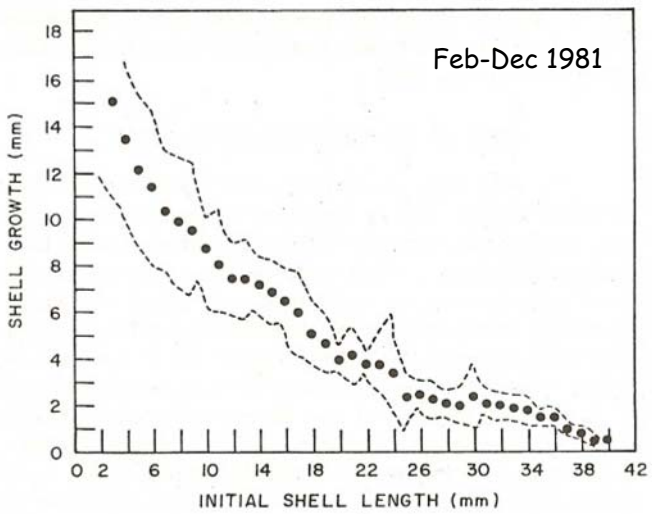
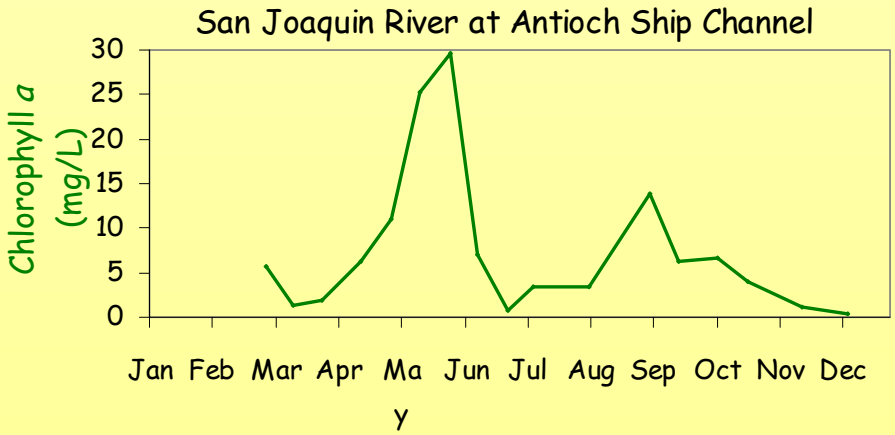


Fig. 7. Annual size-specific growth of *Corbicula* caged in the Western Sacramento-San Joaquin Delta, California during 1981. Data points are the mean of 5 to 10 clams; the dotted lines are ± standard deviation.

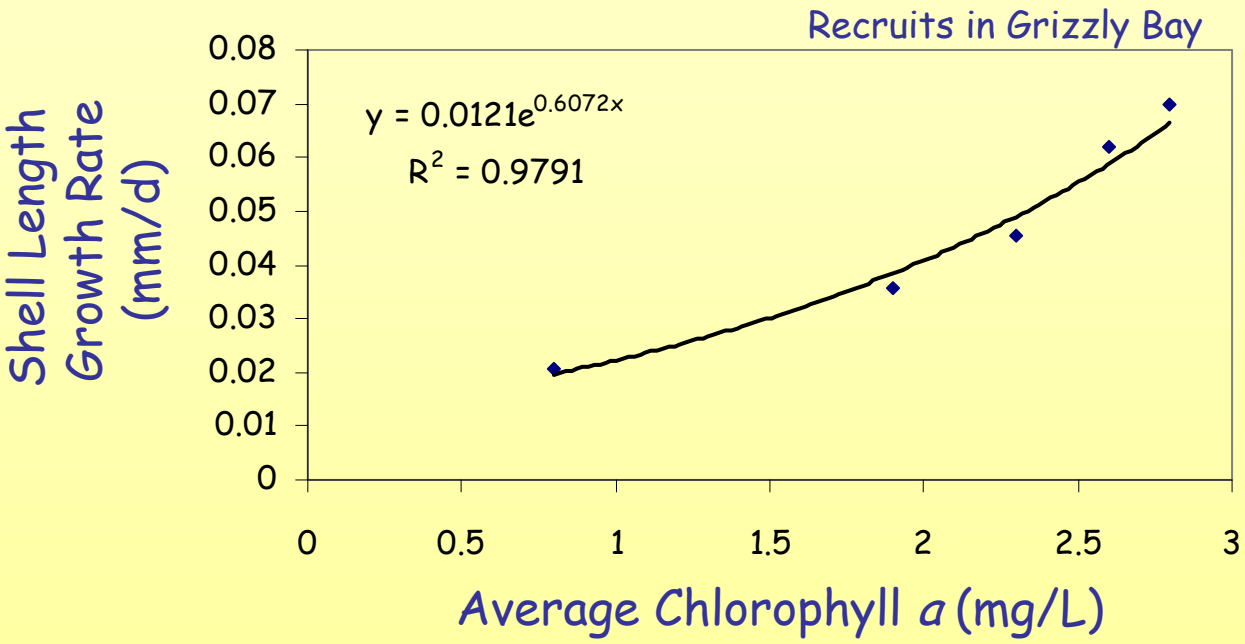
Foe & Knight 1985

Corbicula growth is food limited at 20 mg/L chlorophyll a at 15°C and 47 mg/L at 20-24°C. Growth was limited in the San Joaquin River except for two months in 1981 so this relationship is probably as good as is available for this system



physical processes critical

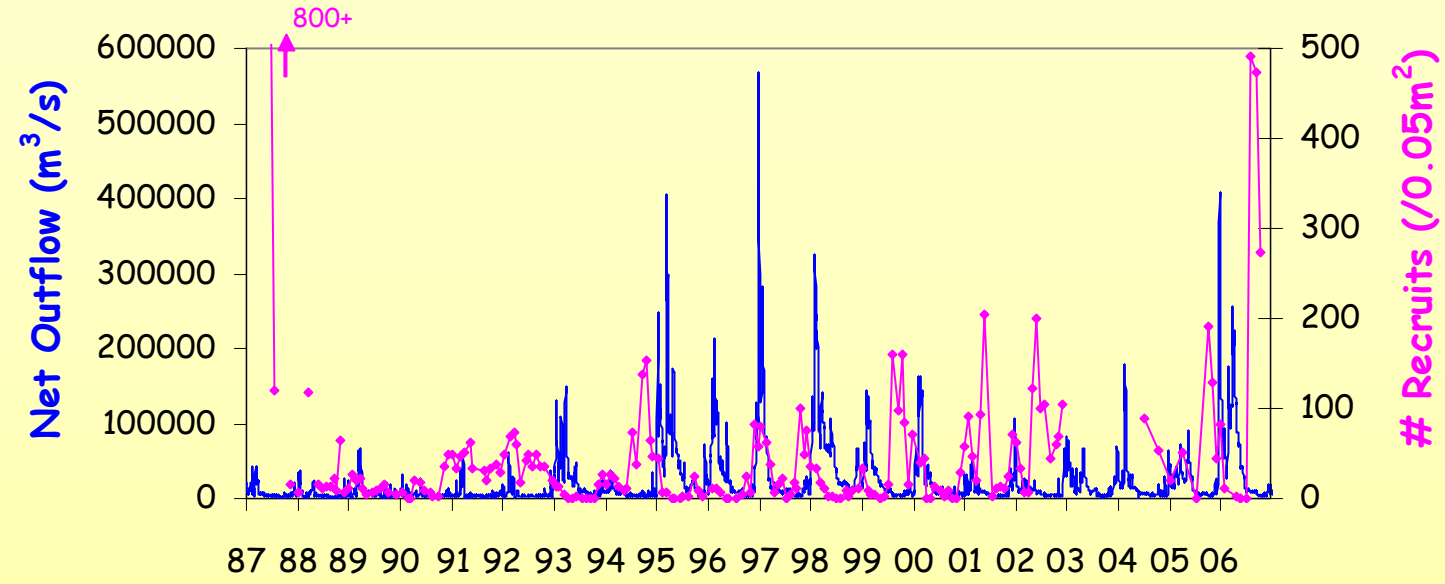
We believe that *Corbula* is also food limited in this system but we do not have laboratory data similar to that for *Corbicula* to verify our beliefs.



Our preliminary analyses of field data confirm food limitation in bivalves in the shallow water.

Summary

- Our skill with both bivalve models is limited by data
- Data gaps and priorities are well summarized by conceptual models (DRERIP)
- Developing relationships for use in the numerical models is ongoing and is helping us define important processes and thresholds
- Given the best data and models, ecologists are still struggling with multi-generation, spatially explicit population models of benthic animals. We also expect to have problems so we are taking it slow, linking sub-models one step at a time


800+
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500000
400000
300000
200000
100000
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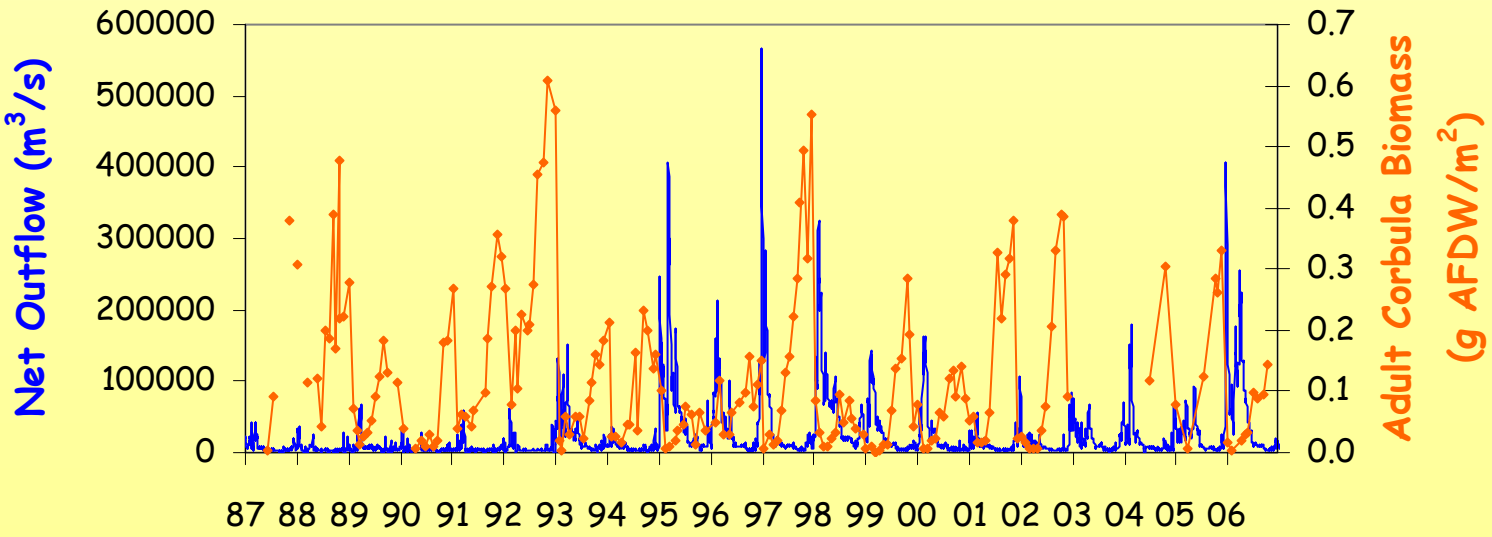
Recruits (/0.05m2)
87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06


600000
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Adult Corbula Biomass
(g AFDW/m2)
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