The effects of seasonal variability on copepod overwintering and population success: the match-mismatch of zooplankton and phytoplankton

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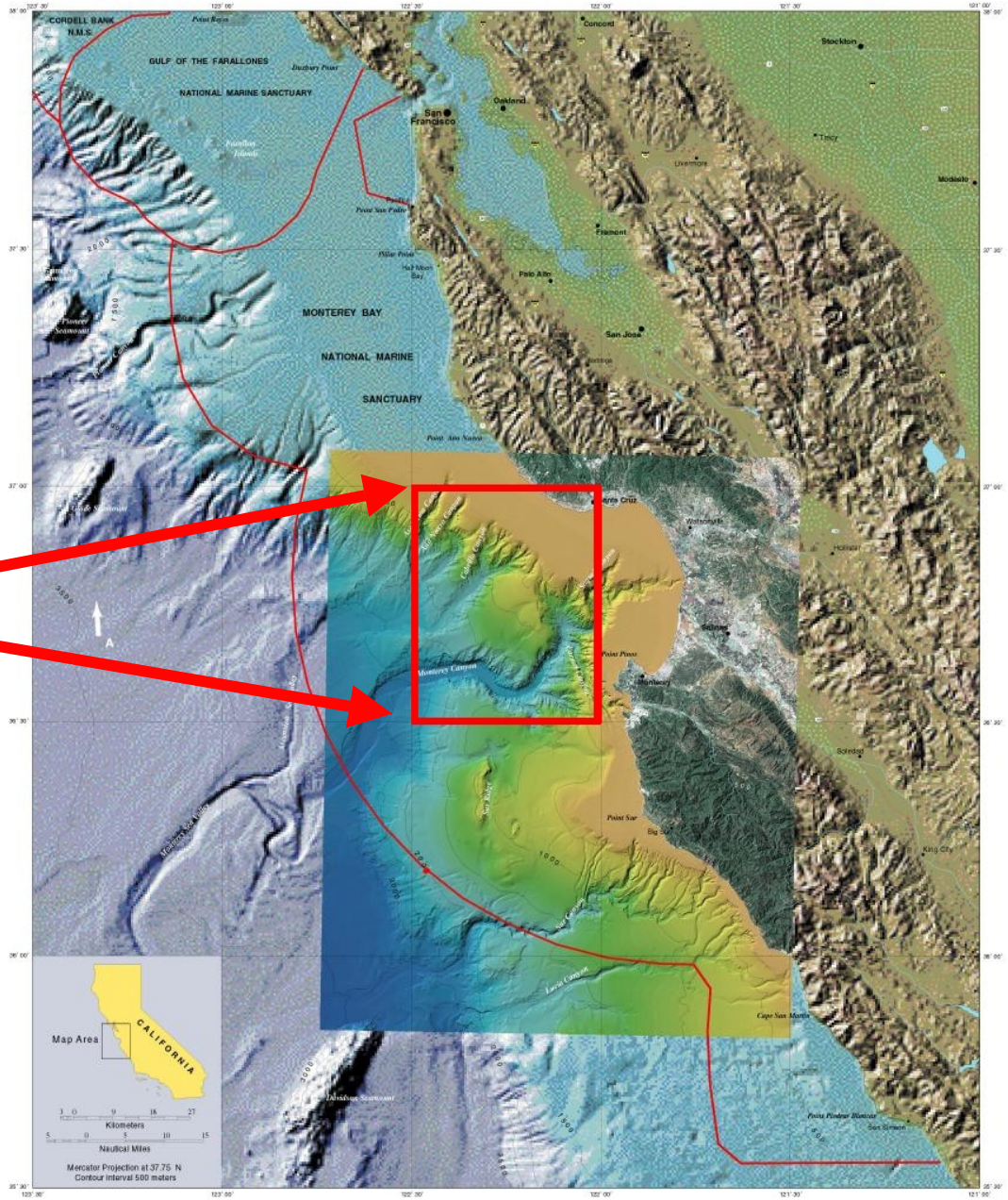
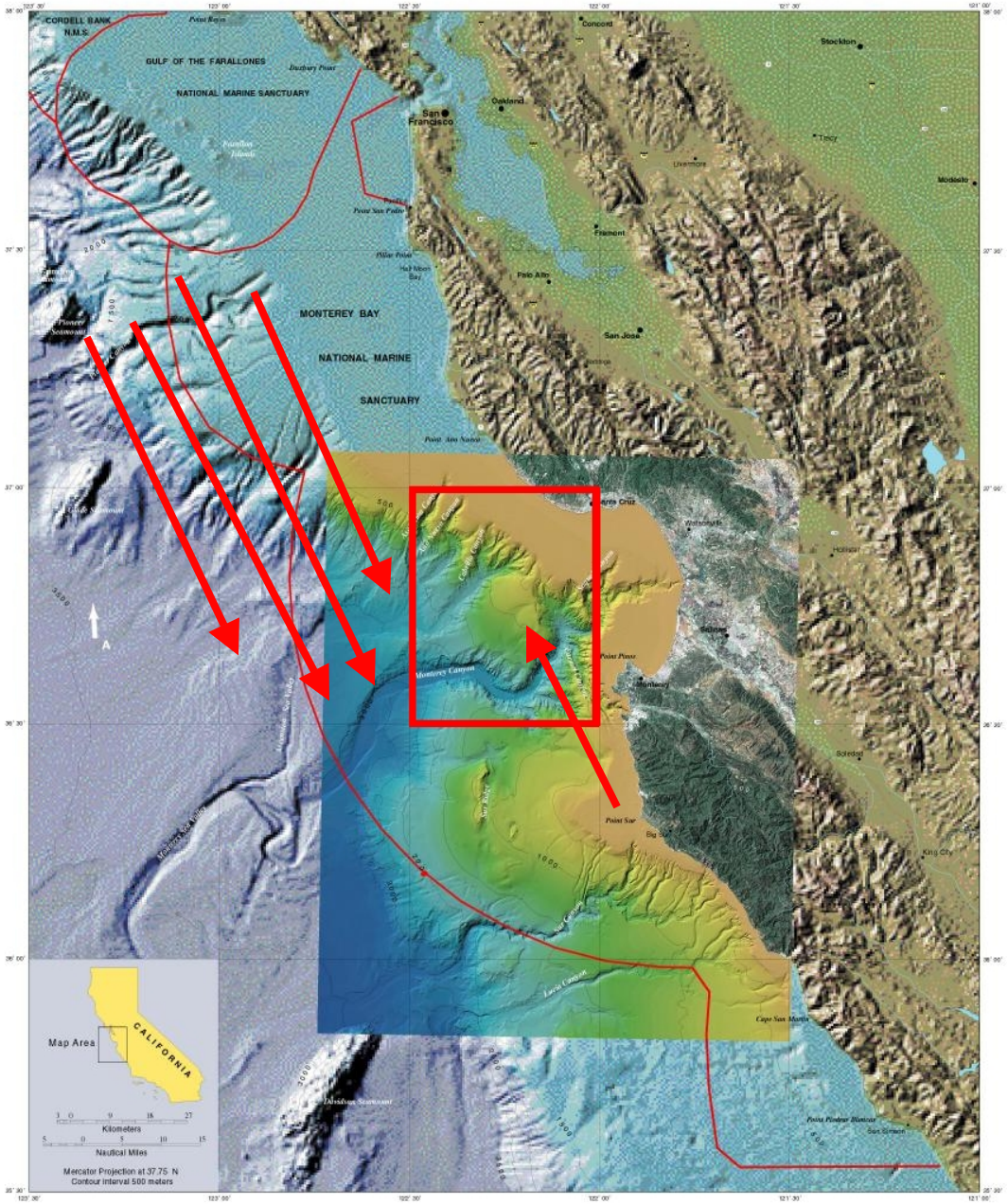
Study Area

1 ° x 1° Box



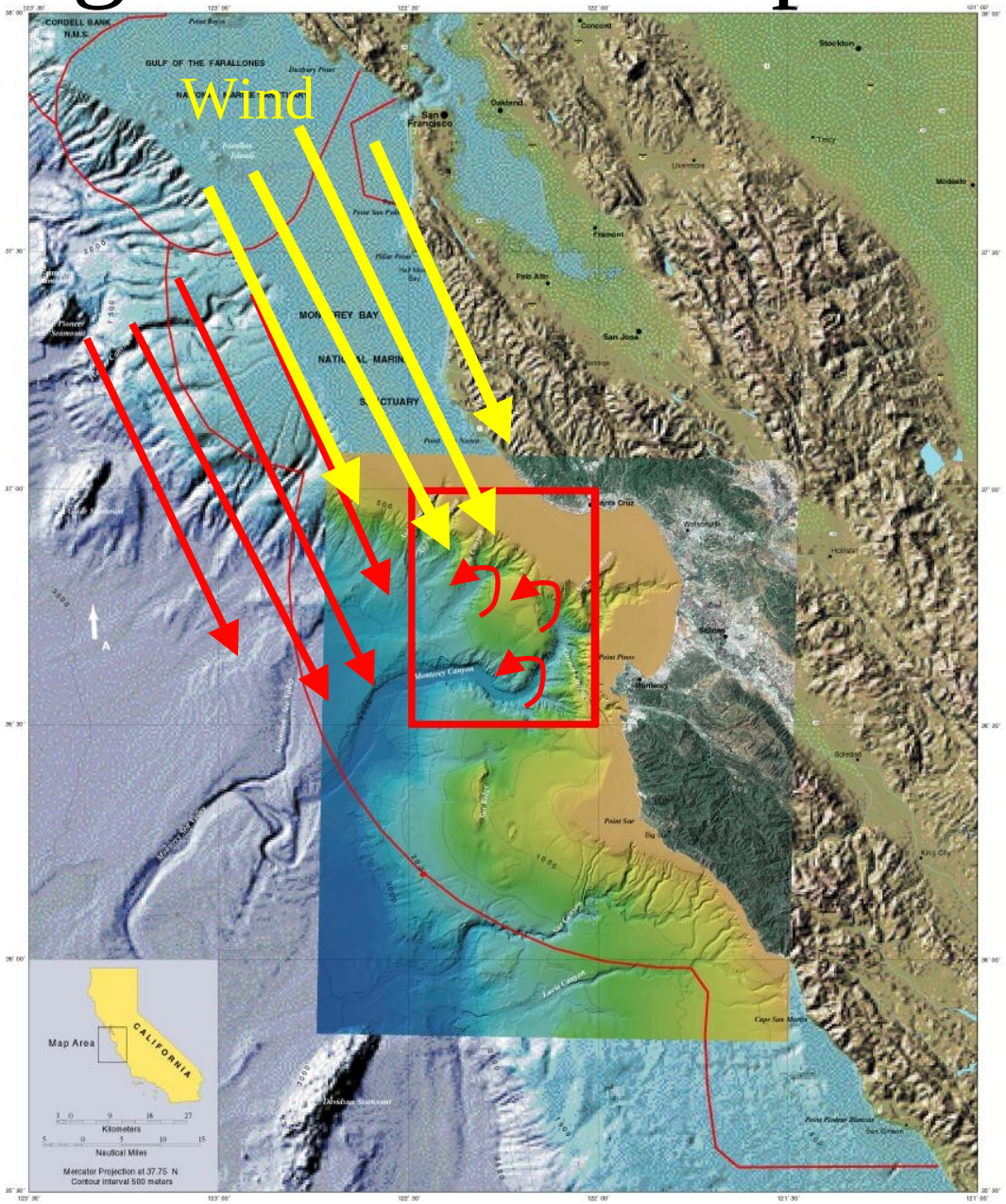
Map from MBARI Website

Winter time, no upwelling



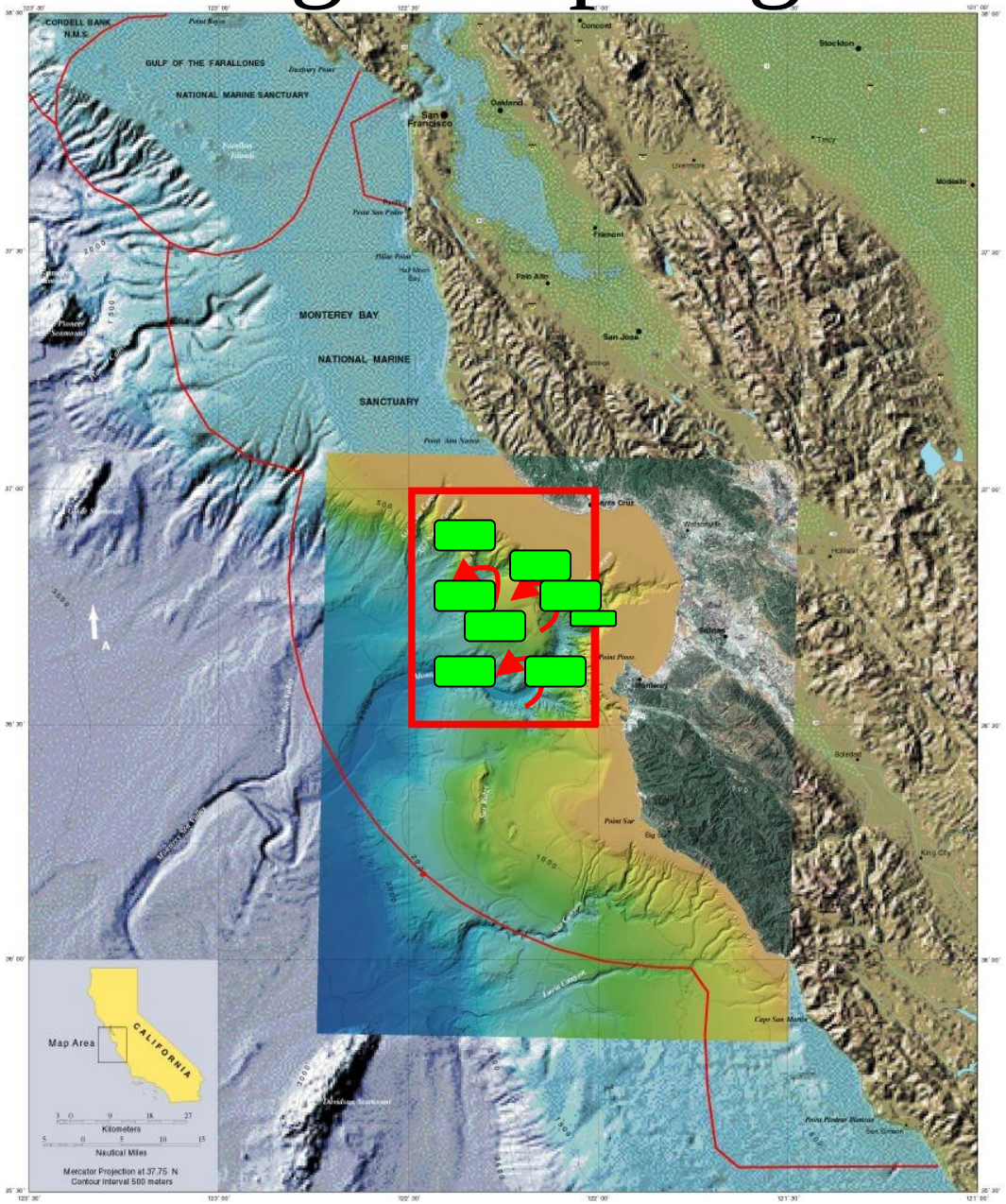
Map from MBARI Website

Spring transition to upwelling



Map from MBARI Website

Upwelling => spring bloom



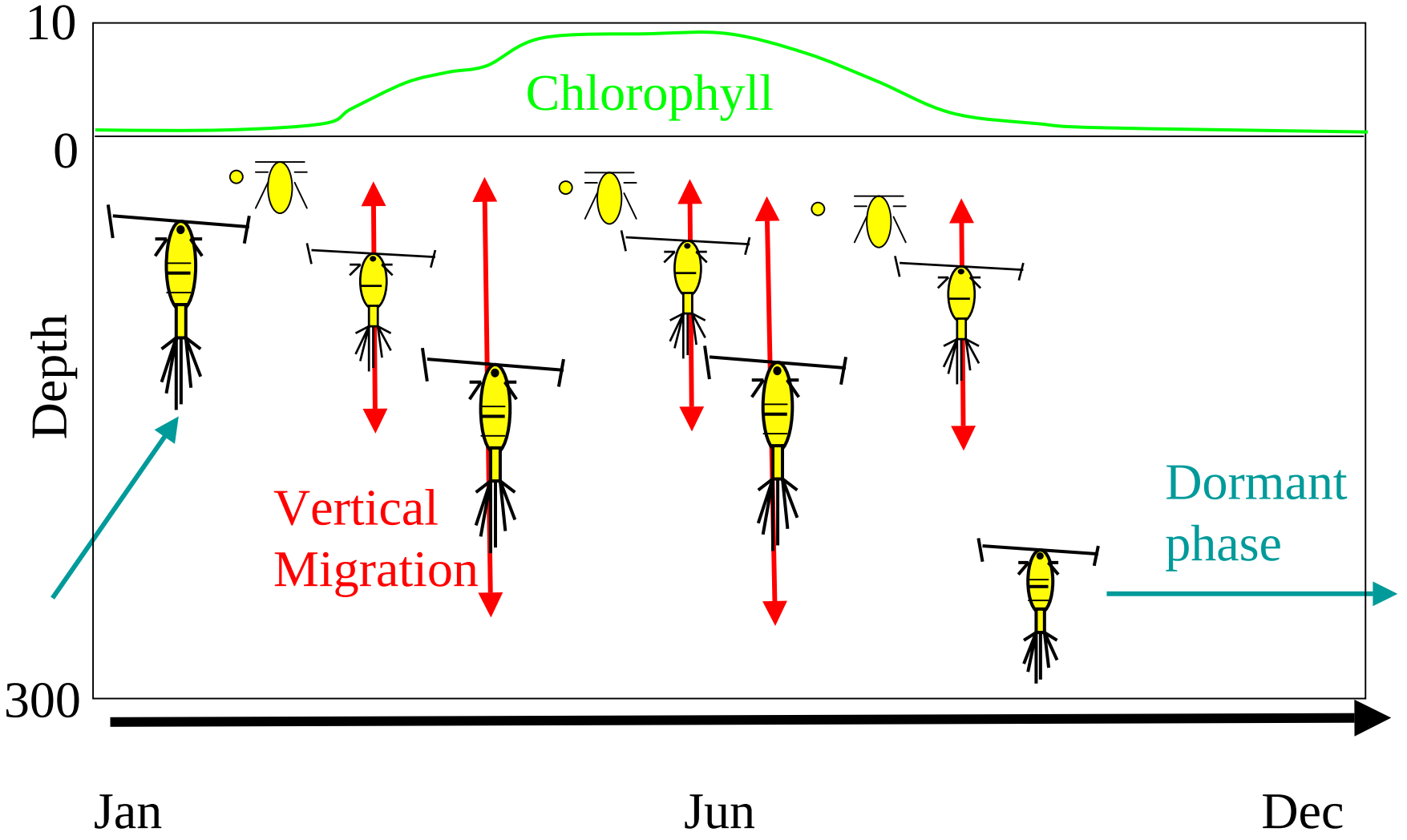
Map from MBARI Website

Main Questions:

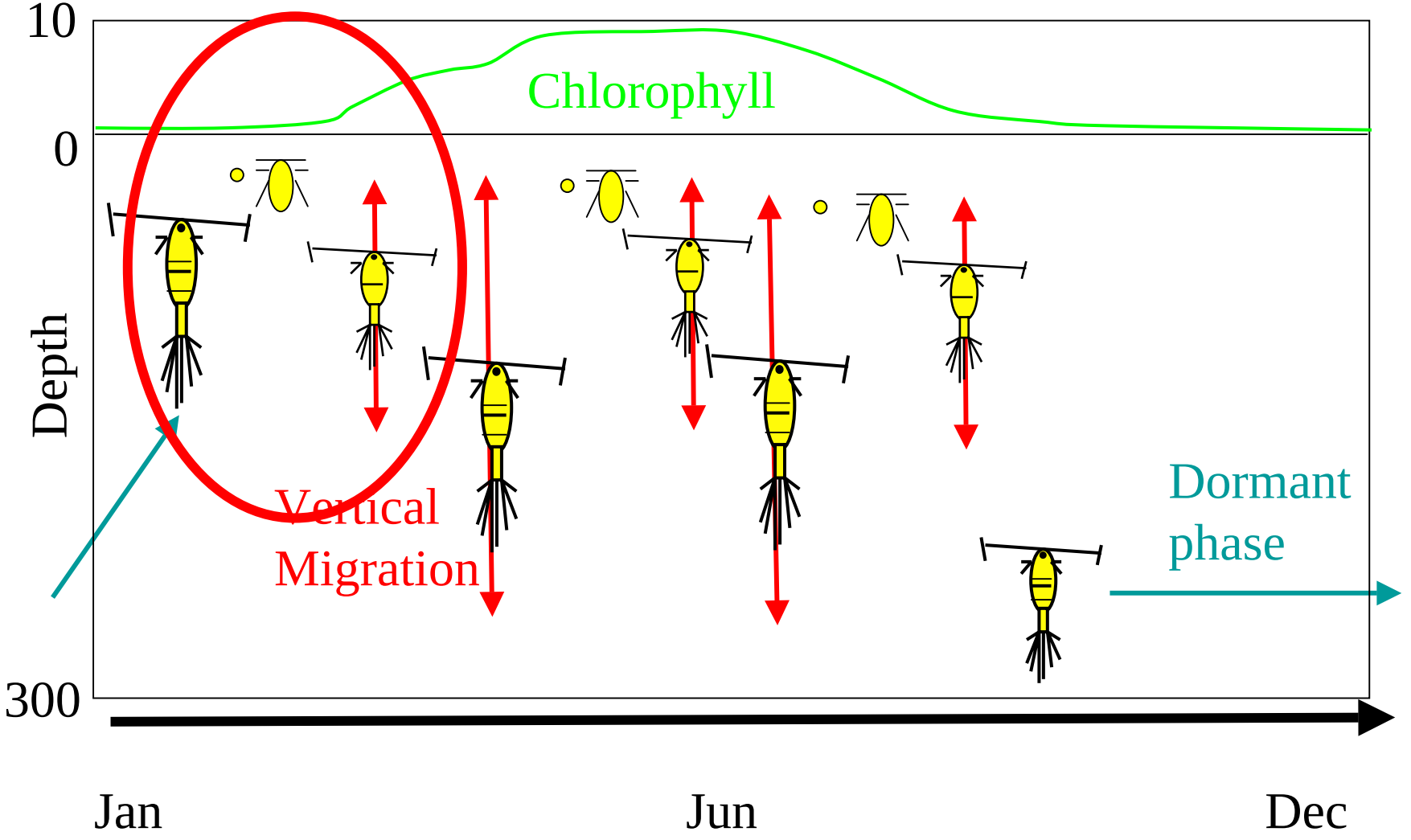
- How do shelf organisms (copepods) interact with the spring transition?

- How does interannual variability in the spring transition/spring bloom affect copepod populations over time?

Calanus pacificus life cycle



How critical is spring bloom timing?



How to address this?

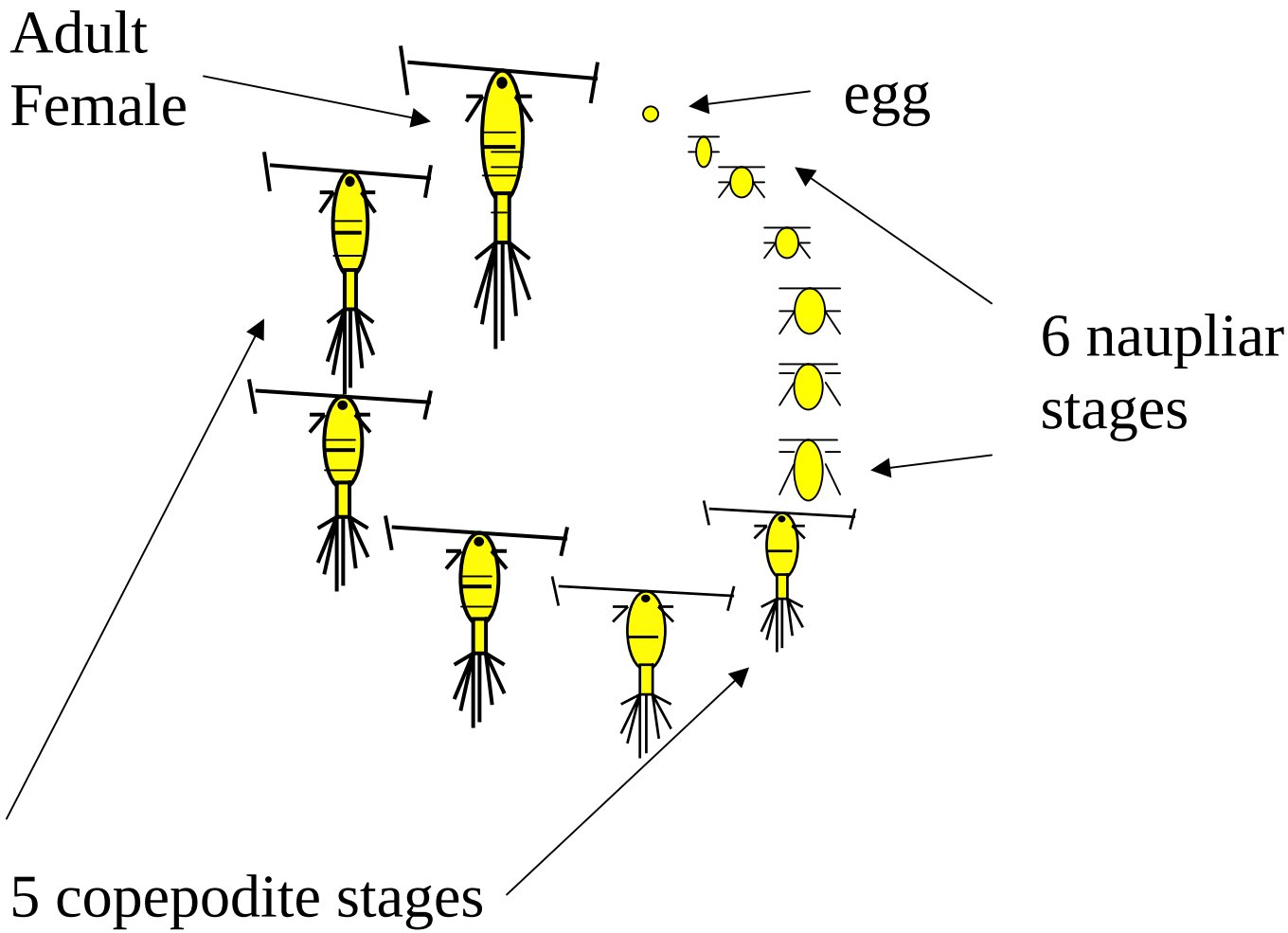
- IBM of *Calanus pacificus*

1) Examine how specific changes in bloom timing, strength, water temperature, etc. affect the population through time

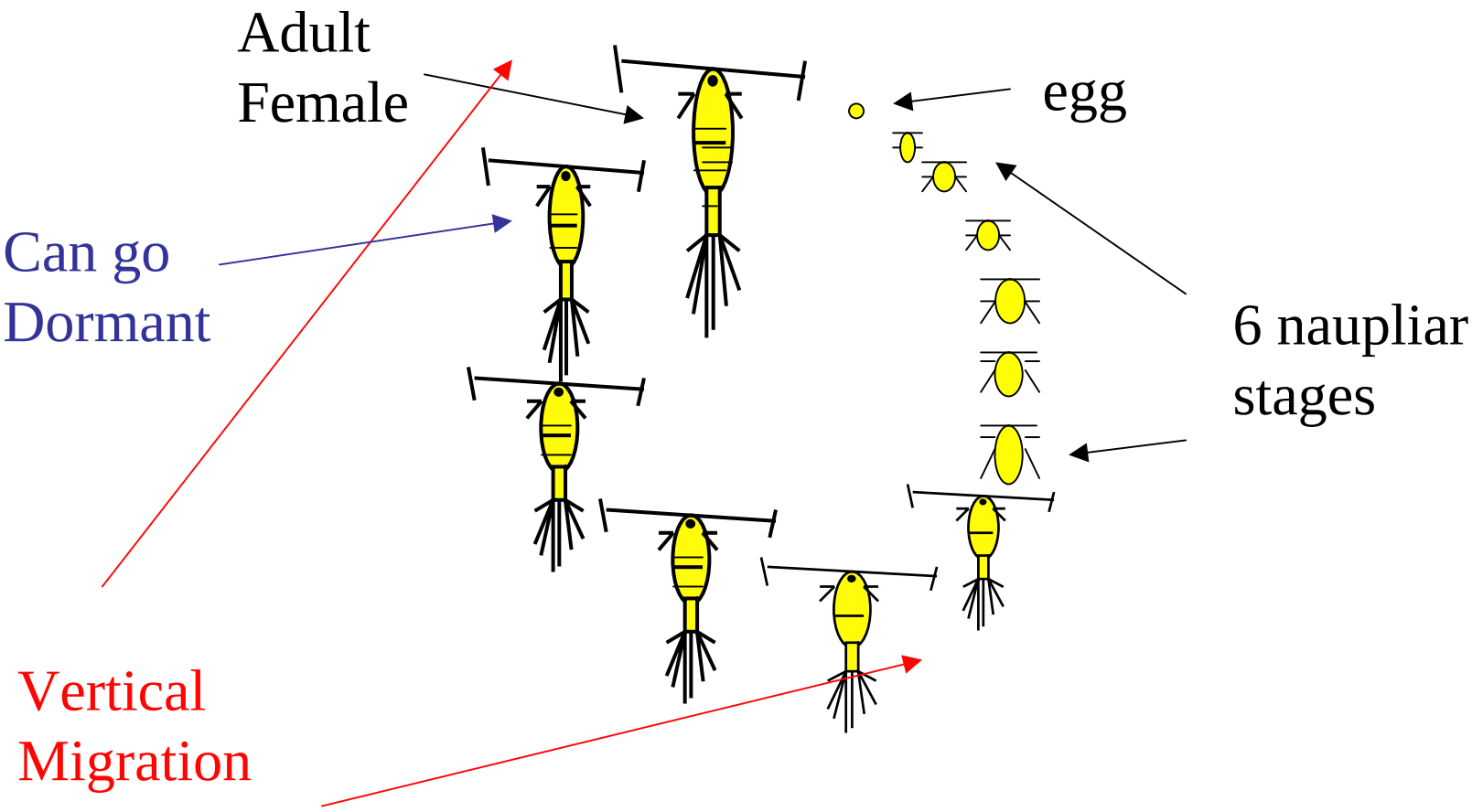
2) Examine long observationally forced runs

-use insight from 1) to interpret 2)

The copepod IBM

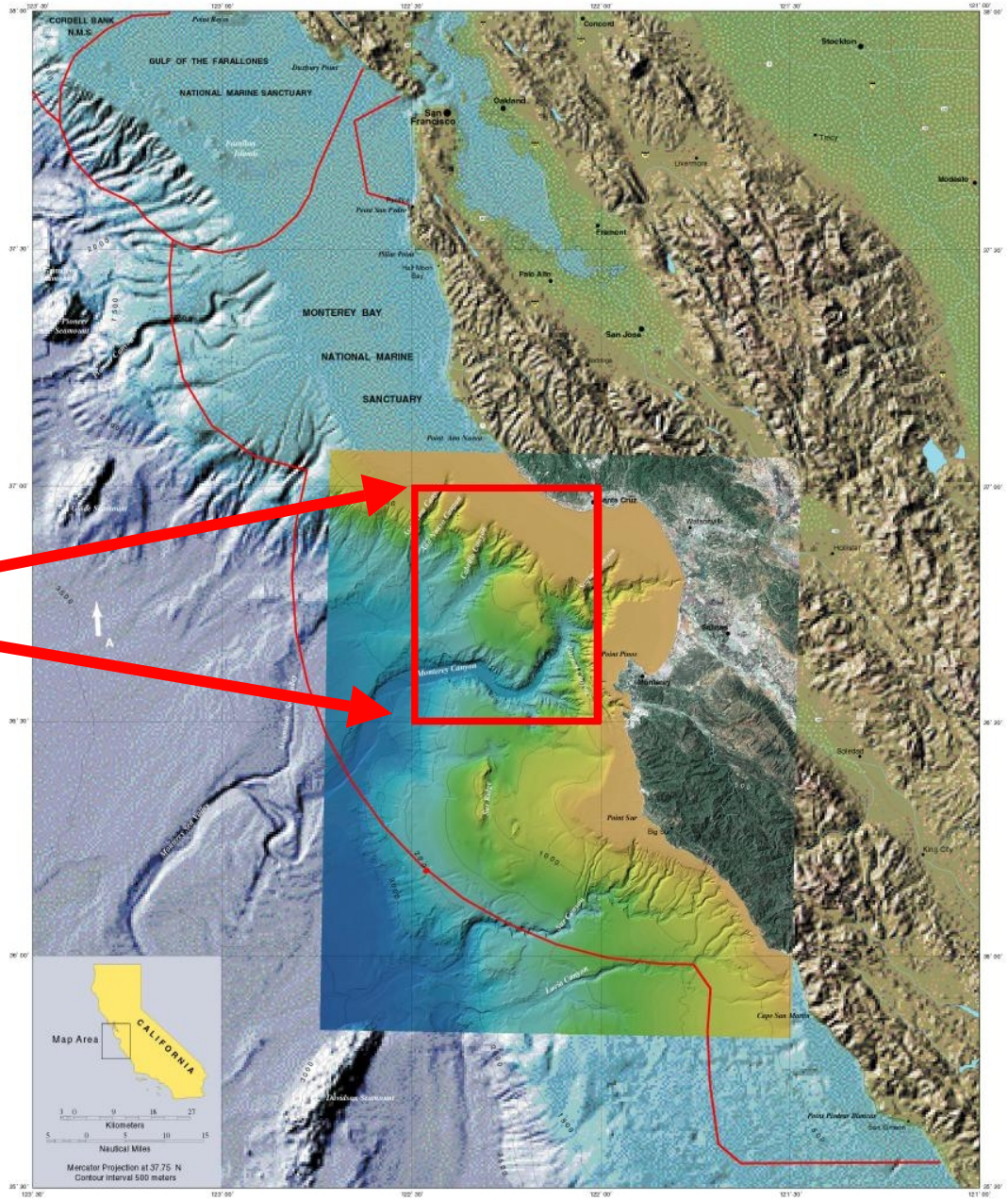


Respond to Prey *and* Temperature



Study Area

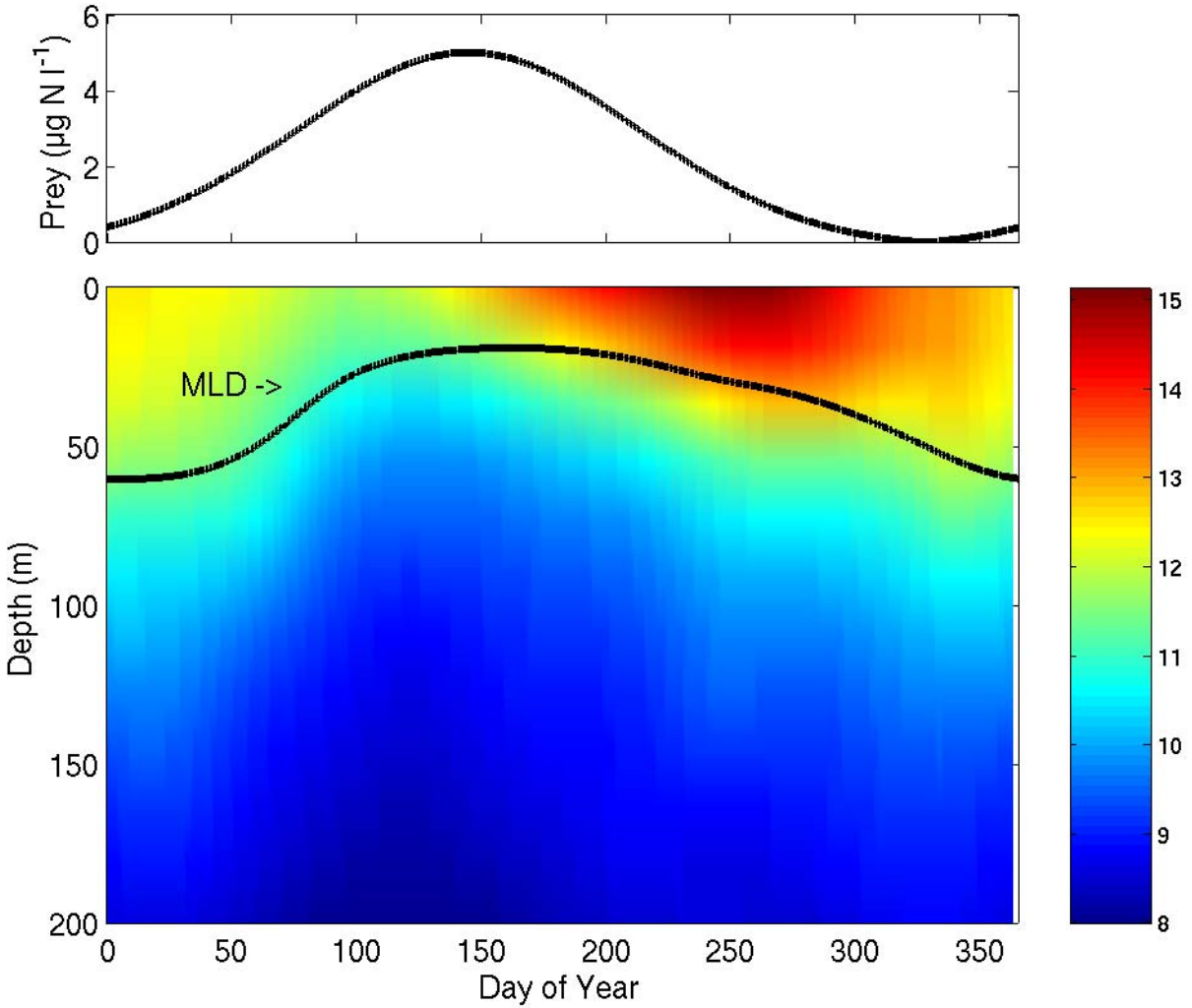
1 ° x 1° Box



Map from MBARI Website

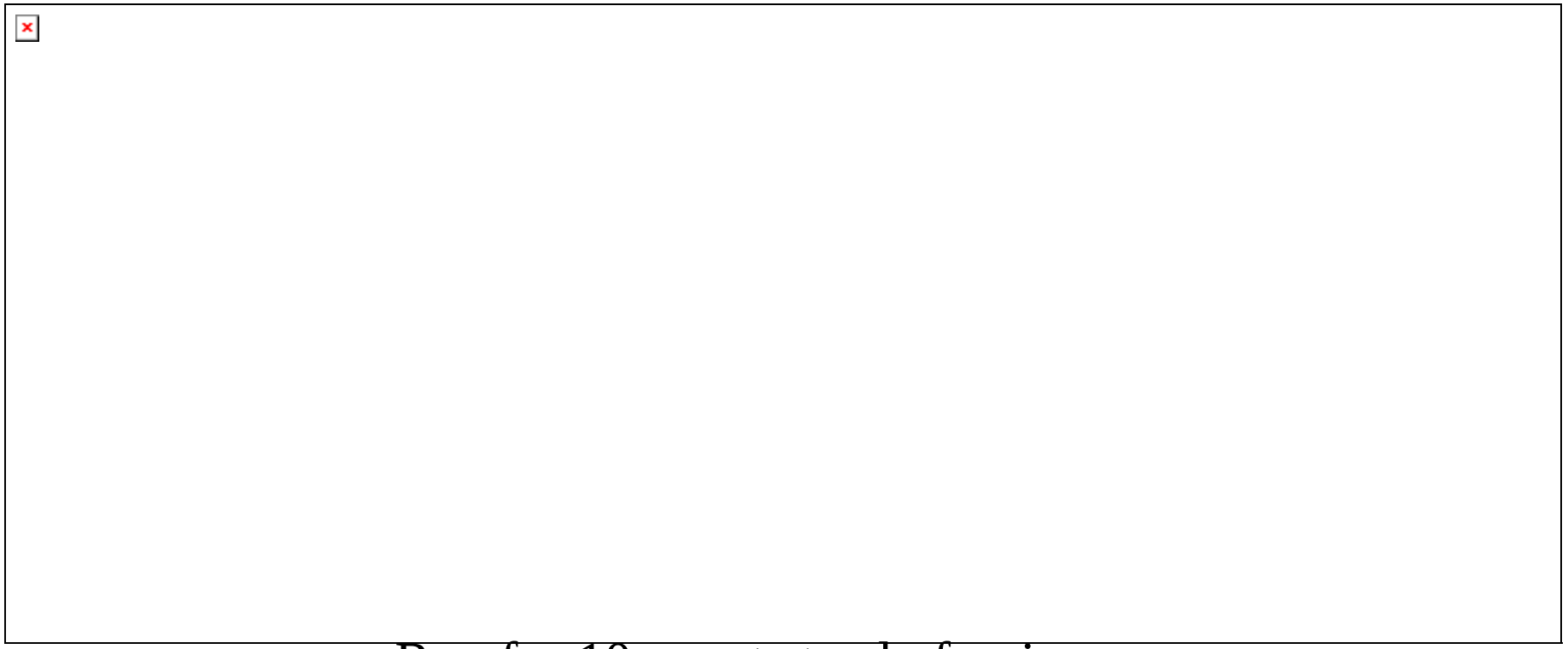
Mean Climatological Forcing

Based on 1950-1993 climatology of 1 x 1° Box near Monterey, CA



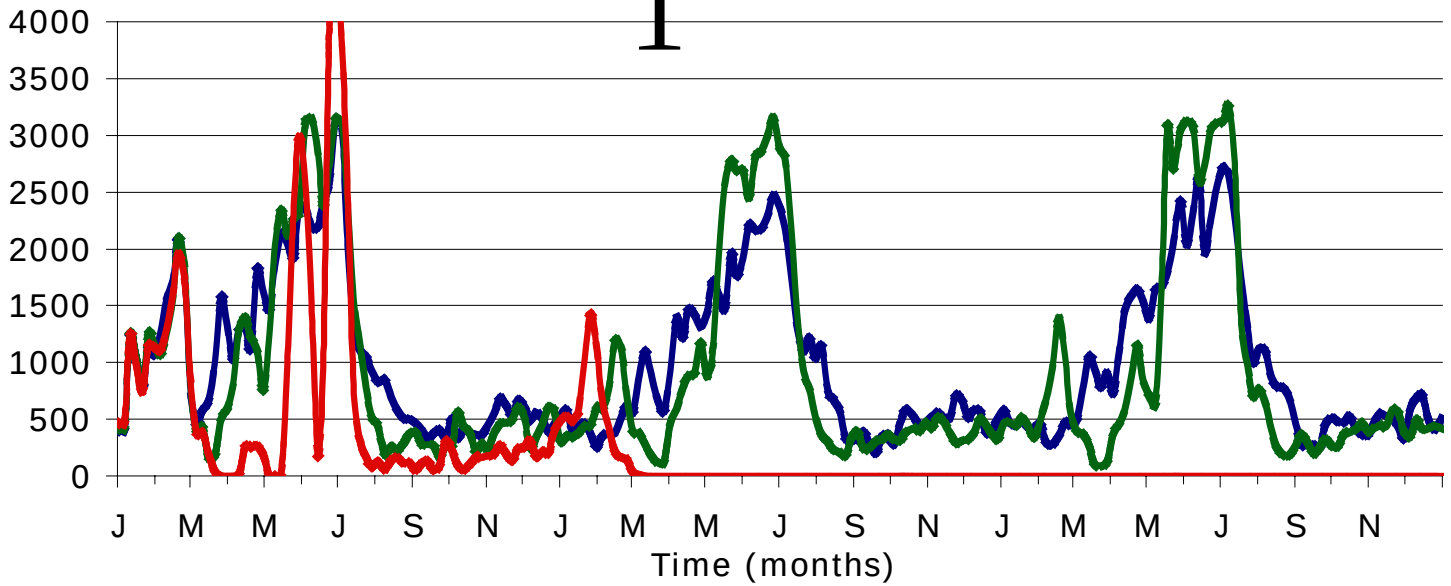
From D. Palacios, PFEL

Model Forcing

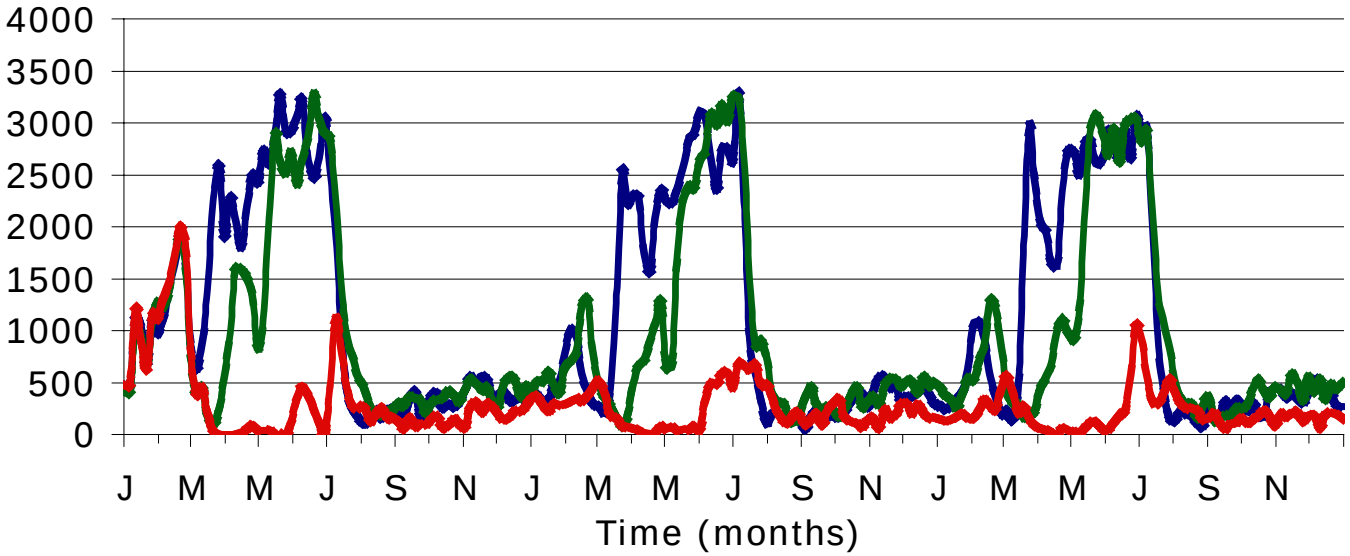


- Run for 10 yrs at steady forcing
- change Temp and/or prey on Jan 1st
- continue run 3 more years

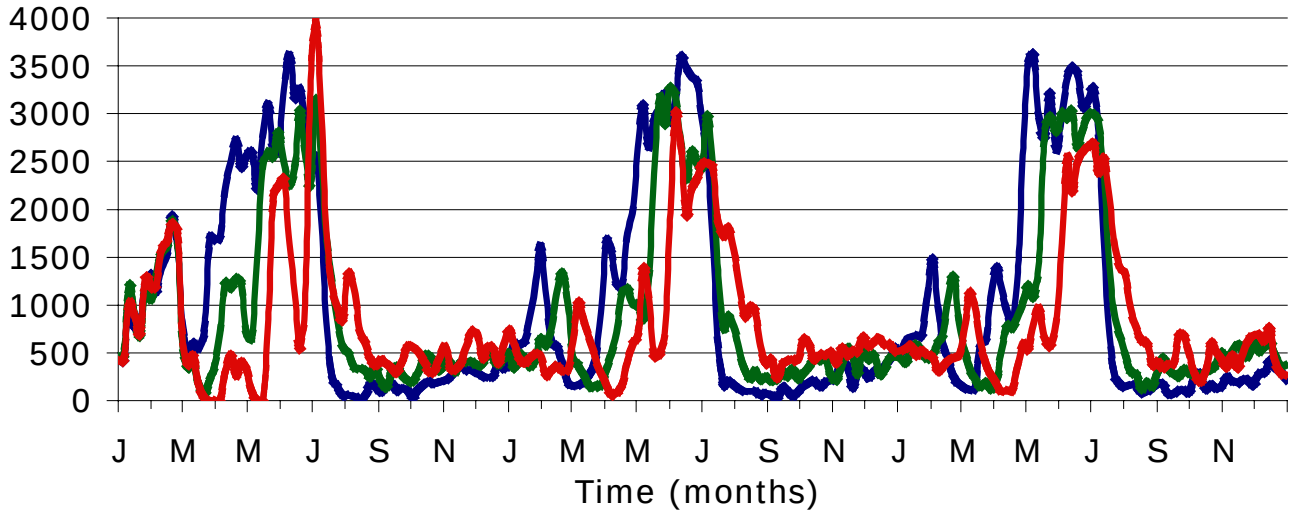
Bloom Length ± 25%, Temp ± 1°



Timing ± 30 d, Max Conc. ± 25%



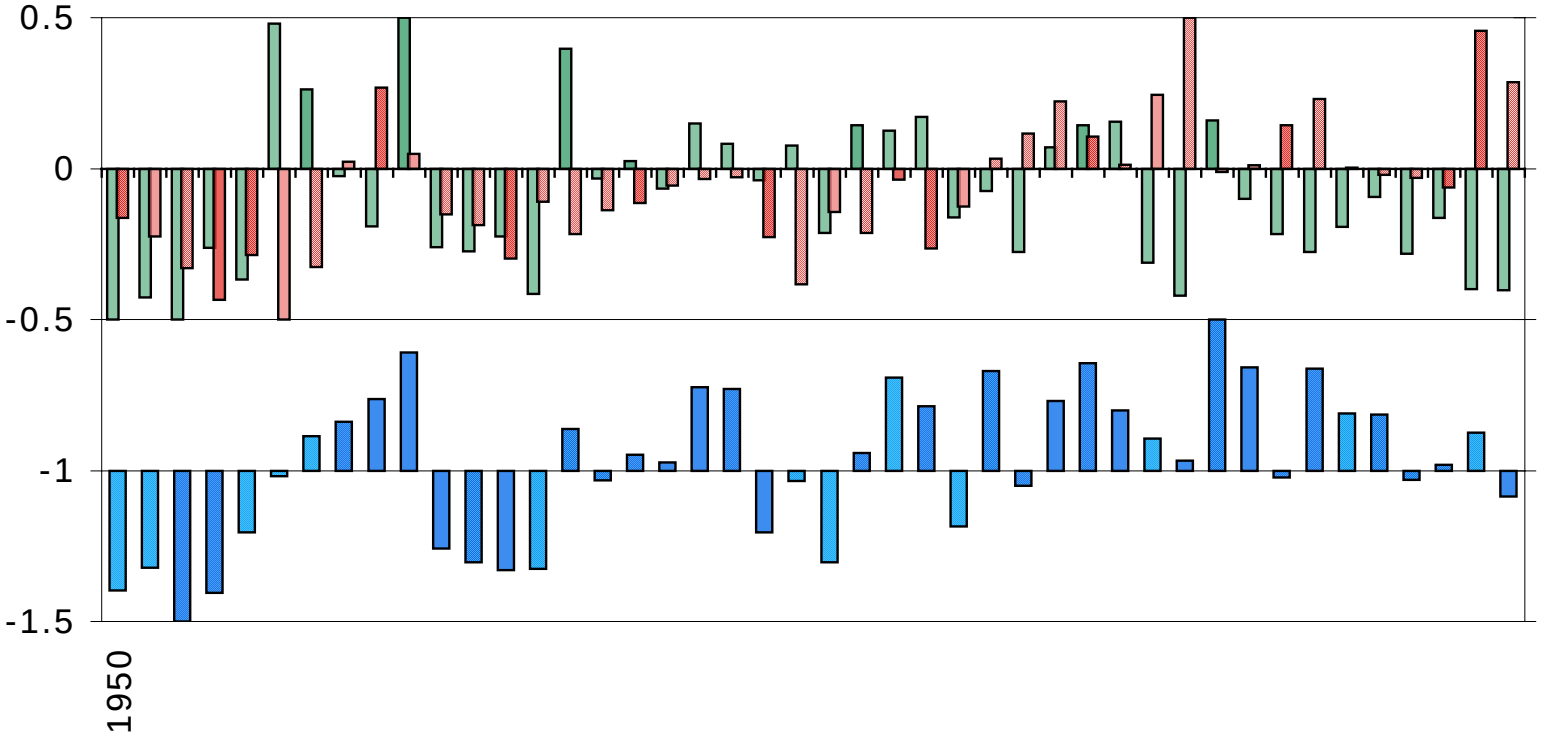
Bloom + Physical Timing ± 30 d



Summary

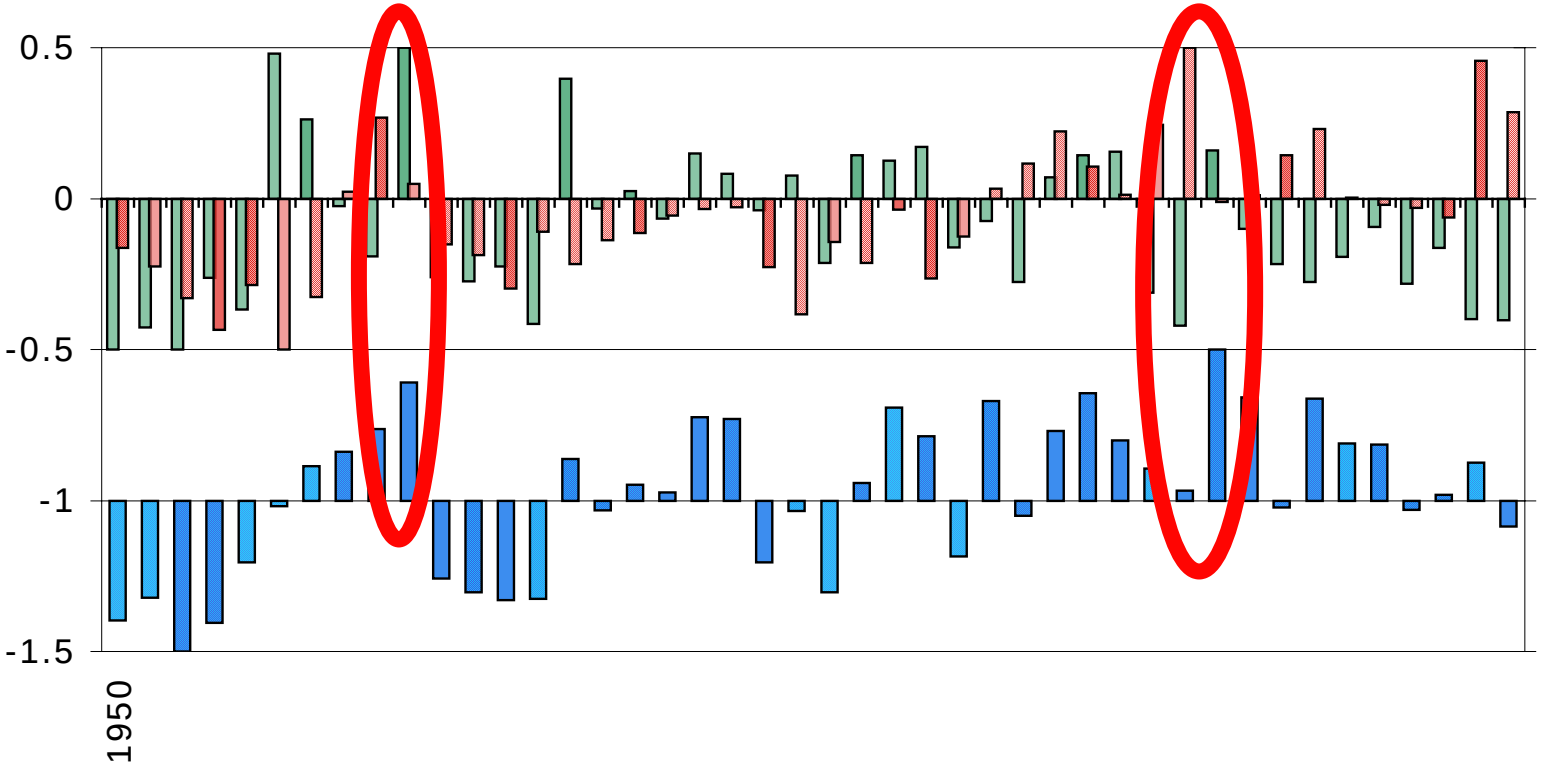
- Longer upwelling season (colder temperatures)
  - Lower maximum copepod biomass
  - But spread out over longer period
- Early spring transition (longer bloom season)
  - Earlier peak copepod biomass
  - Too late a bloom (+low food) causes pop. crash
- Early bloom + physical cycle
  - Shifts population accordingly
  - Make take some time for full effect

44 year observational forced run



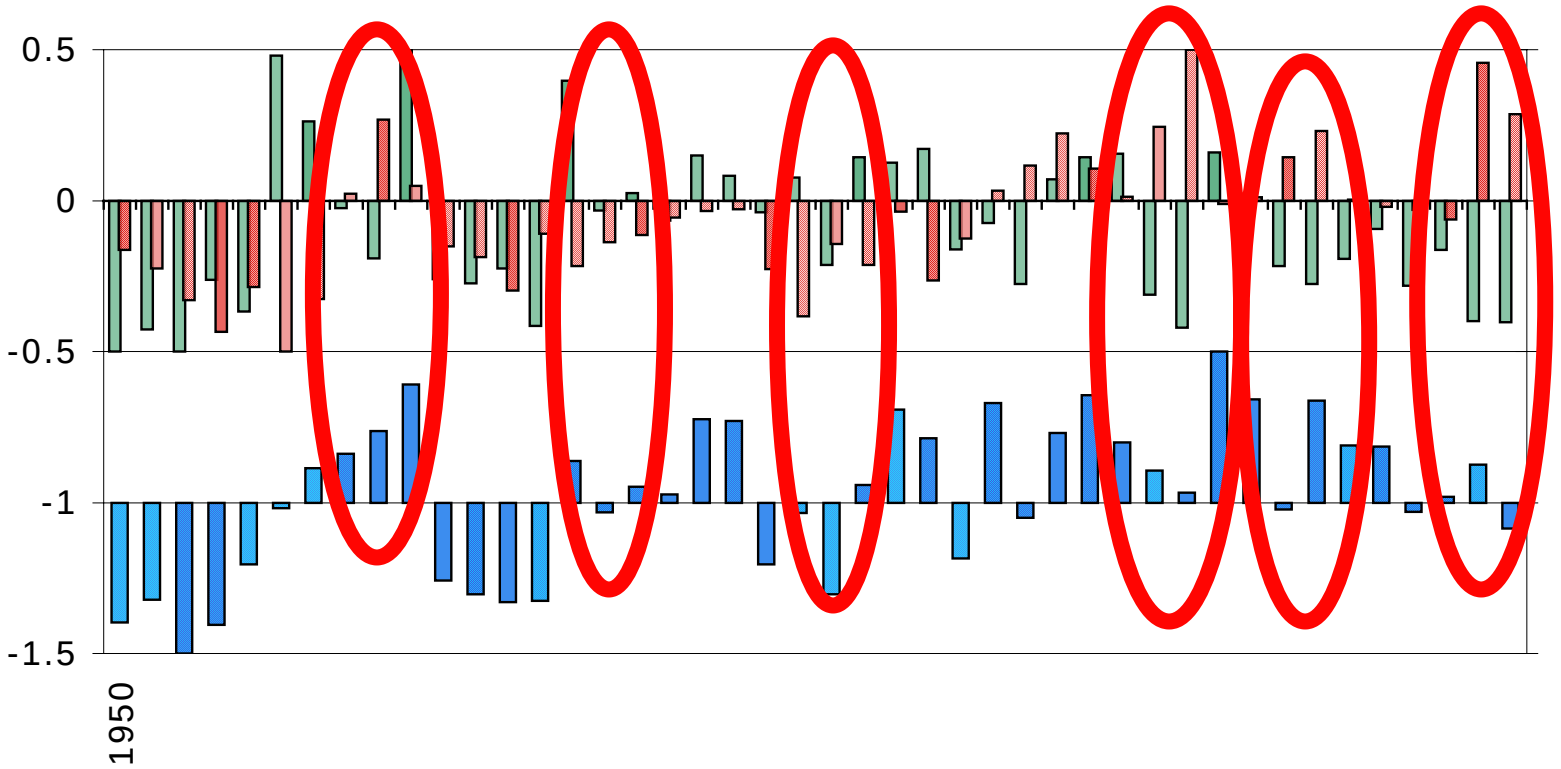
- Upwelling Index was used as a proxy for copepod prey

44 year observational forced run



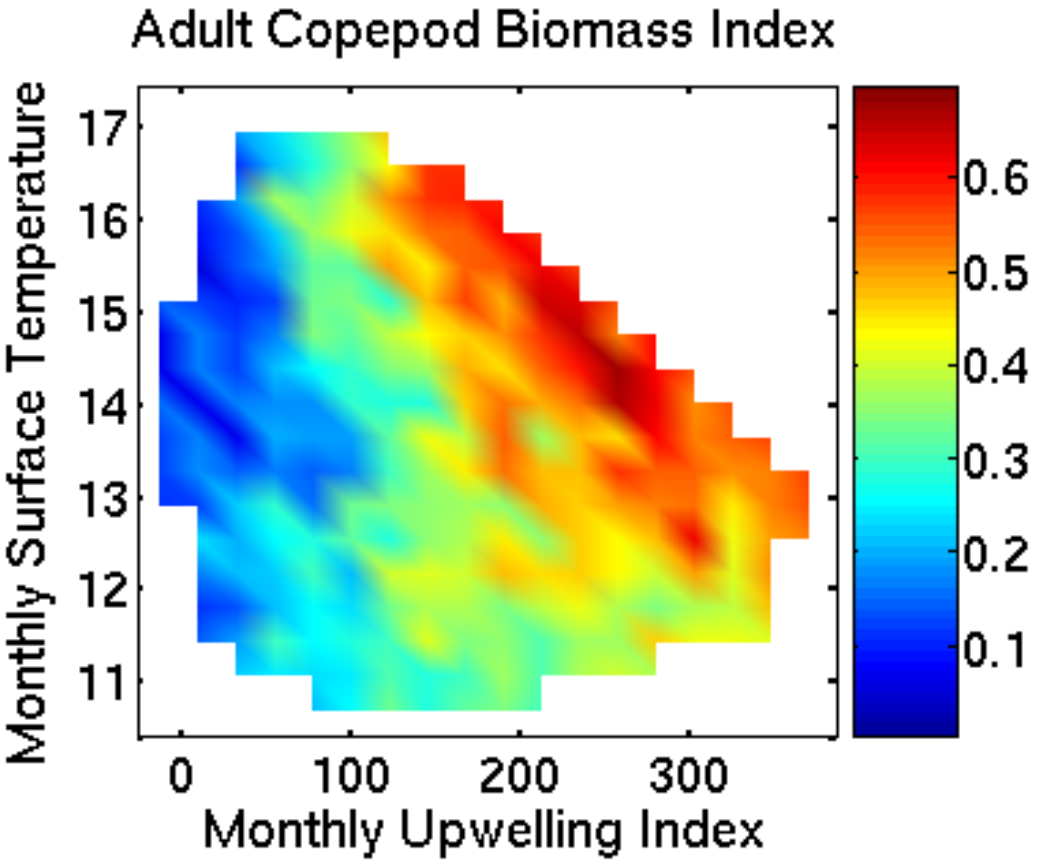
• Highest production = Moderate Upwelling, Following High Temperatures

44 year observational forced run



- El niño's not always evident ("Monterey effect")

Monthly Anomaly Over 44 years

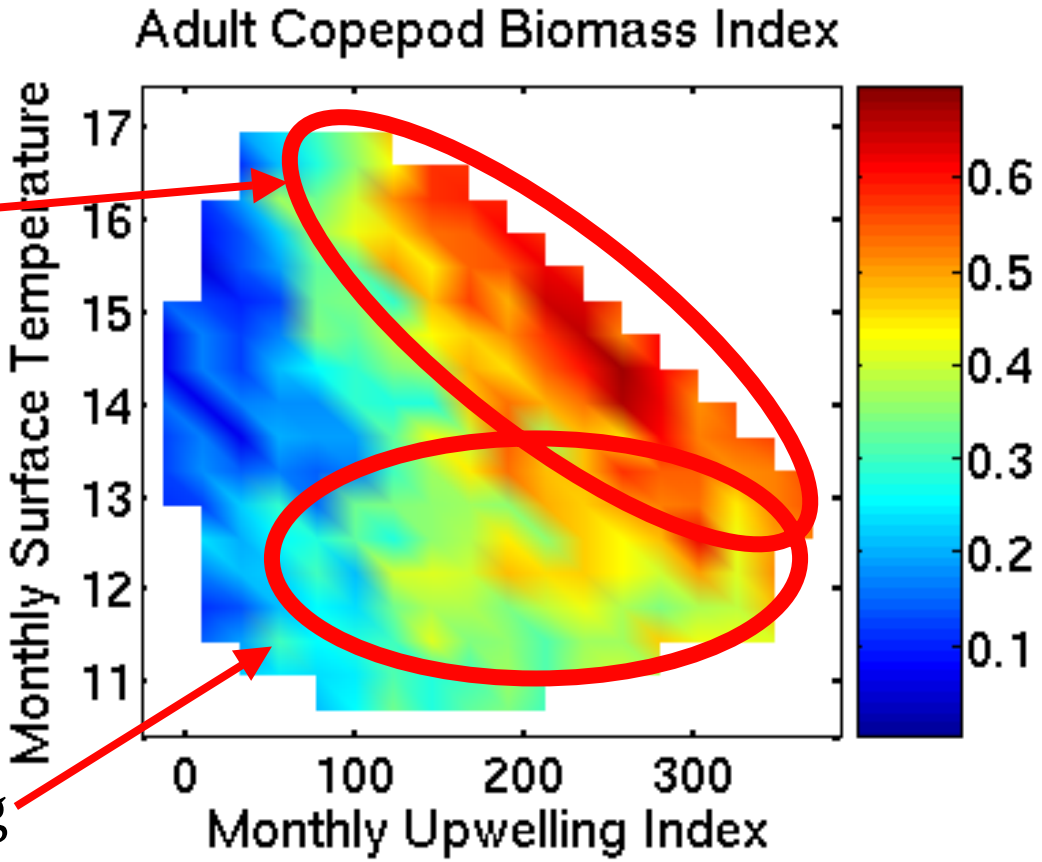


(~Prey Field)

Monthly Anomaly Over 44 years

2nd + 3rd Generations

Overwintering Population when they "wake" up



(~Prey Field)

Conclusions

- Response of copepods to both T + Prey need to be considered
- Spring bloom characteristics have strong impacts on population dynamics
- Some responses take time to manifest
- Recovery from “bad” years can be quick
- El niño impact not always evident
- Higher temperature leads to higher biomass for 2nd + 3rd generations, if prey is adequate

Further questions:

- Is upwelling really a good index of copepod prey availability?
- How would these “maps” of copepod success look in other regions?
- Other species?
- Coherence of physical forcing between inland water and shelf:
  - Ex:. if spring transition was delayed in coastal region, would outmigration of salmon smolts also be delayed?