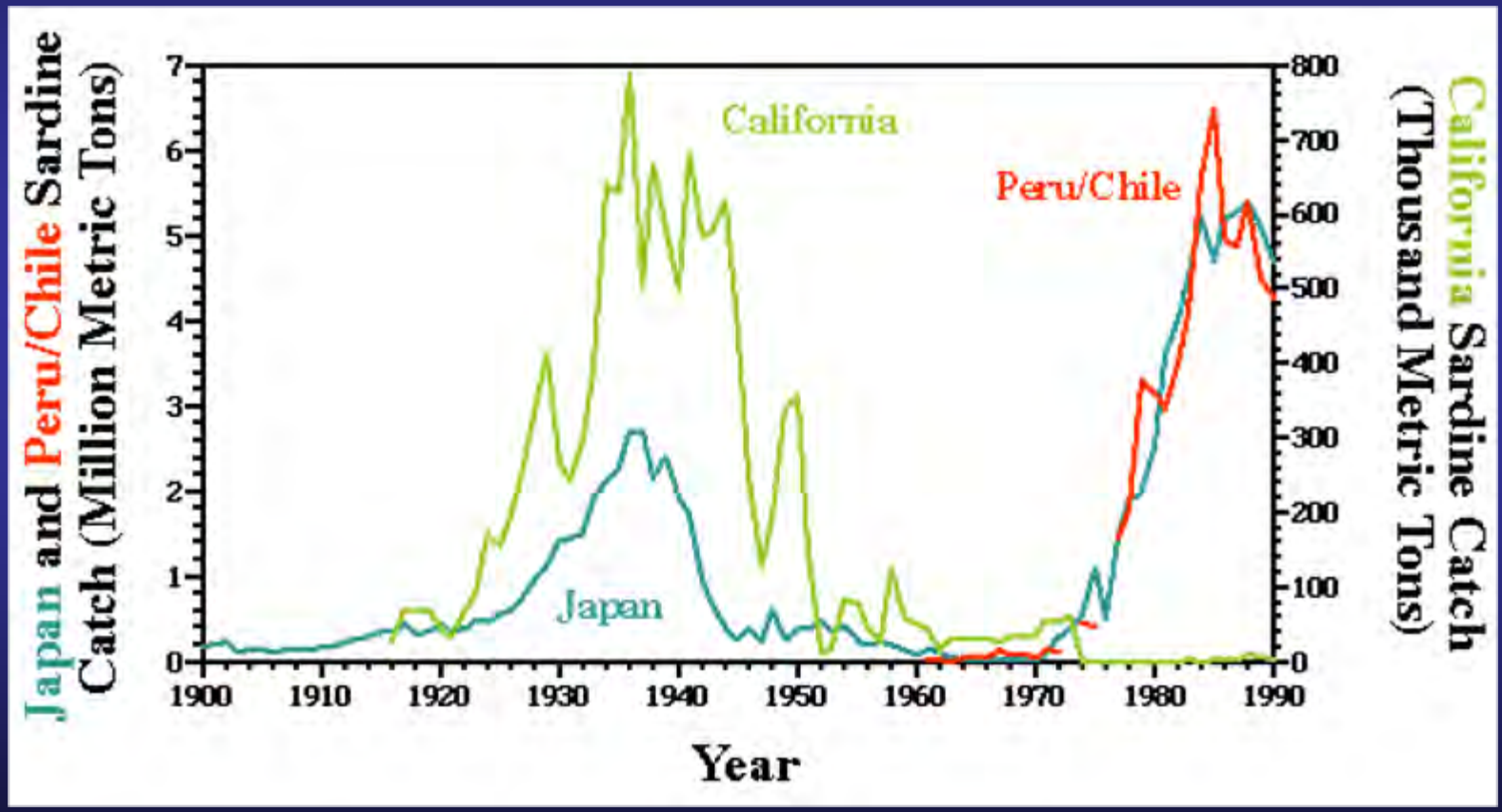
# Development of a climate-to-fish-to-fishers model: data structures and domain decomposition

Kate Hedstrom, Jerome Fiechter, Kenny Rose, Enrique Curchitser, Miguel Bernal, Shin-ichi Ito, Salvador Lluch-Cota and Alan Haynie

# Outline

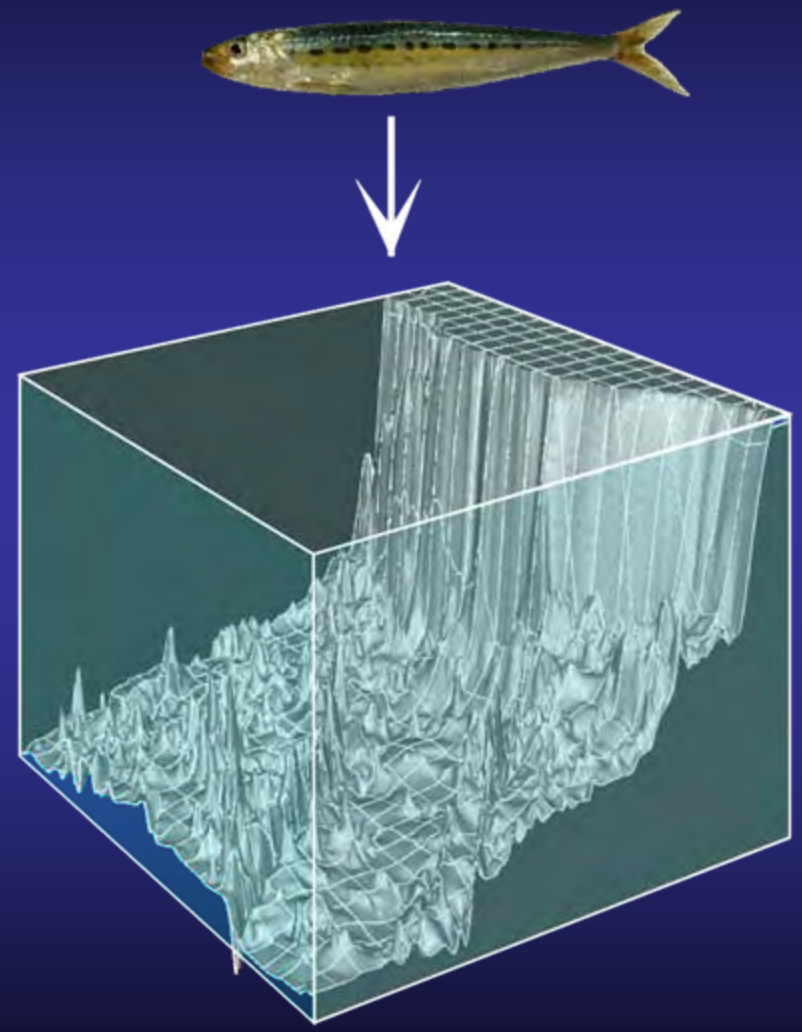
- Goals
- Methods
- Results
- Conclusions and future work

# Sardine Landings in the Pacific



# Goals

- Reproduce these cycles
- Build onto physical model
- Start simple – but not too simple



# Model Components

- Physics
- NPZ
- Fish
  - Species 1
  - Species 2
  - Predatory fish
- Fishing fleet

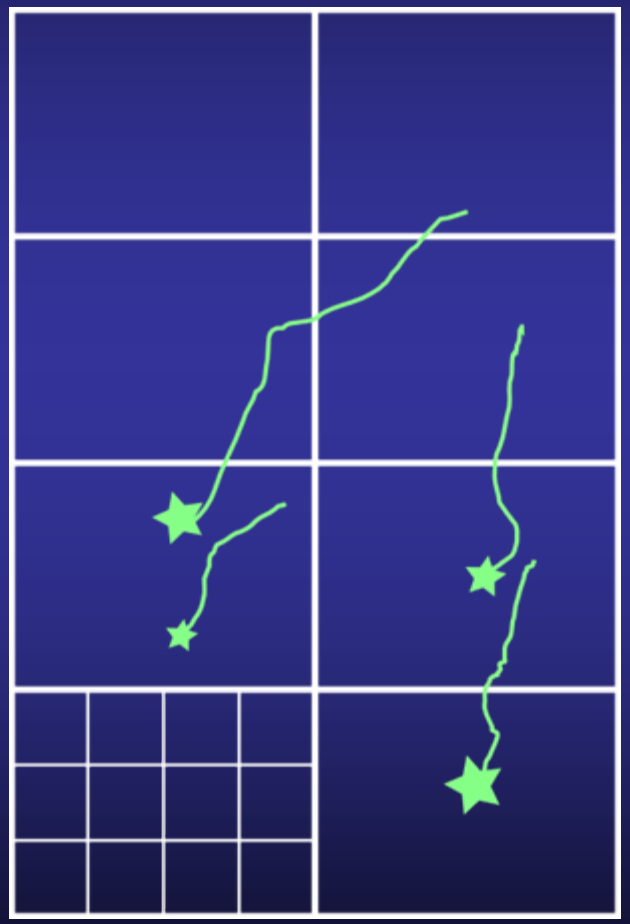
# Superindividuals

# Methods

- “Fish” as modified floats
- Fixed number of fish
- Feedback to NPZ
- Fish-eat-fish
  - Adults eat eggs
  - Predatory fish
- Fishing once per day

# Parallel Computing (MPI)

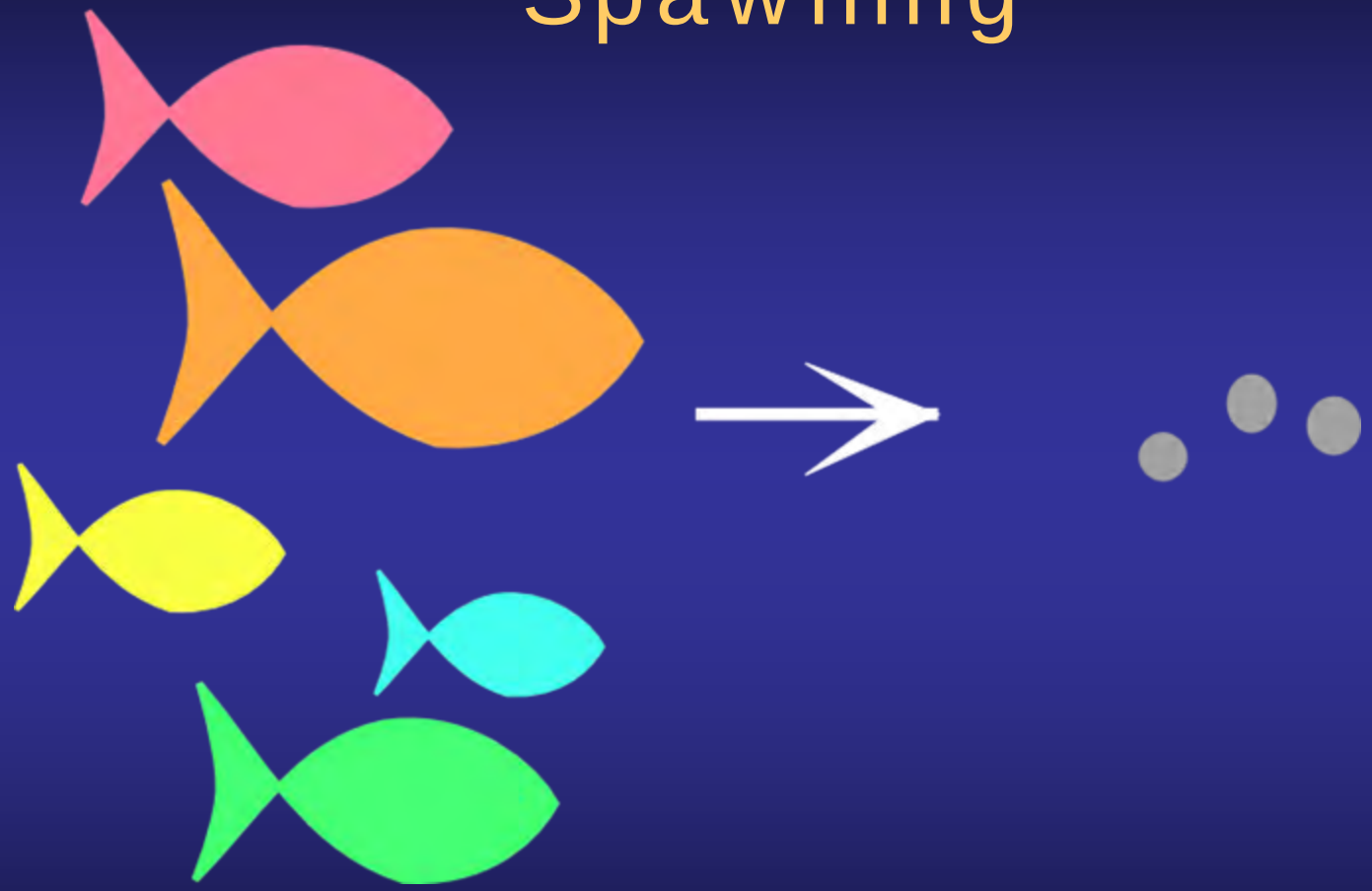
- Domain decomposition
- Each process has one tile, but knows about all fish
- Update fish on own tile
- Exchange at end of timestep



# Behavior

- Eggs and yolk-sacs are advected by currents
- Larger fish swim with size-dependent speed
- Choice of behavior:
  - Humston: optimize temperature (kinesis)
  - Railsback: maximize growth (fitness)
- No spawning migration yet

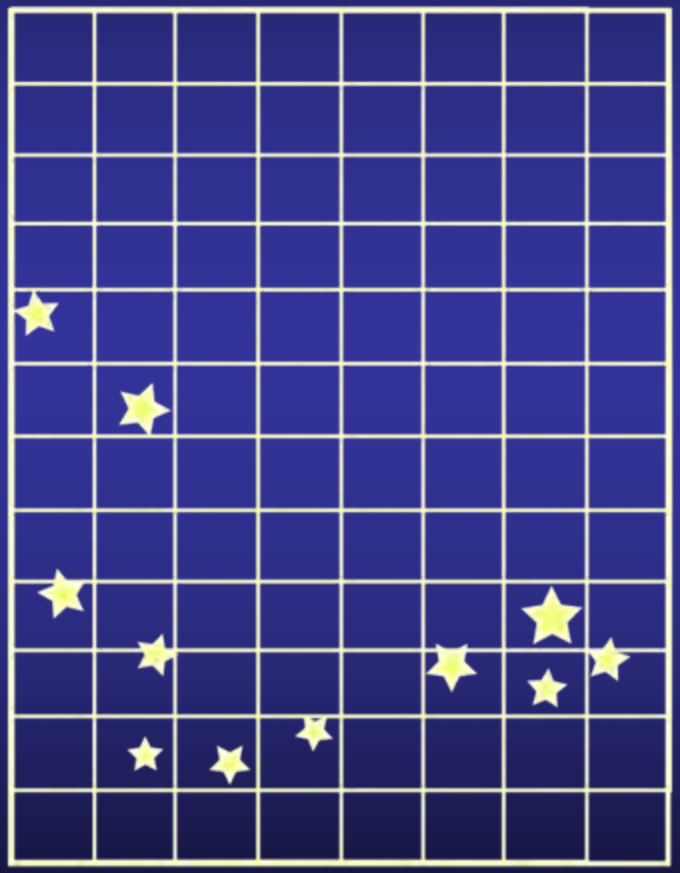
# Spawning

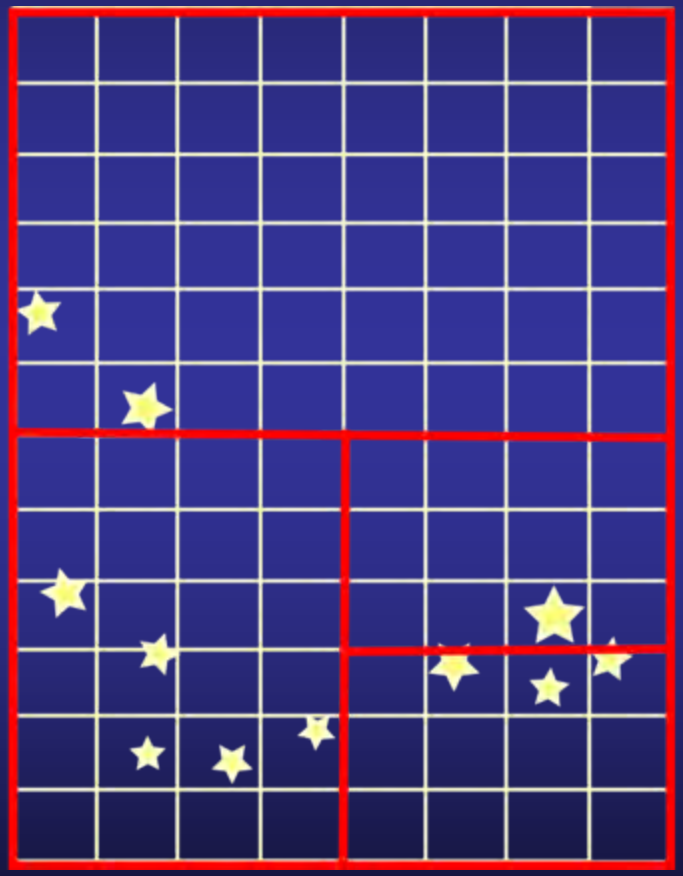


Adult spawners

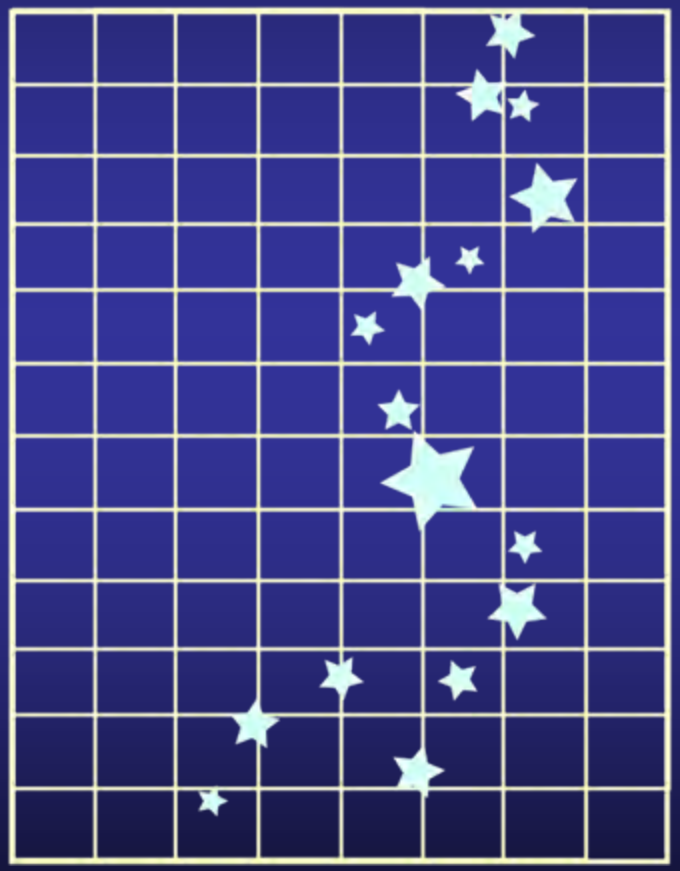
Available eggs

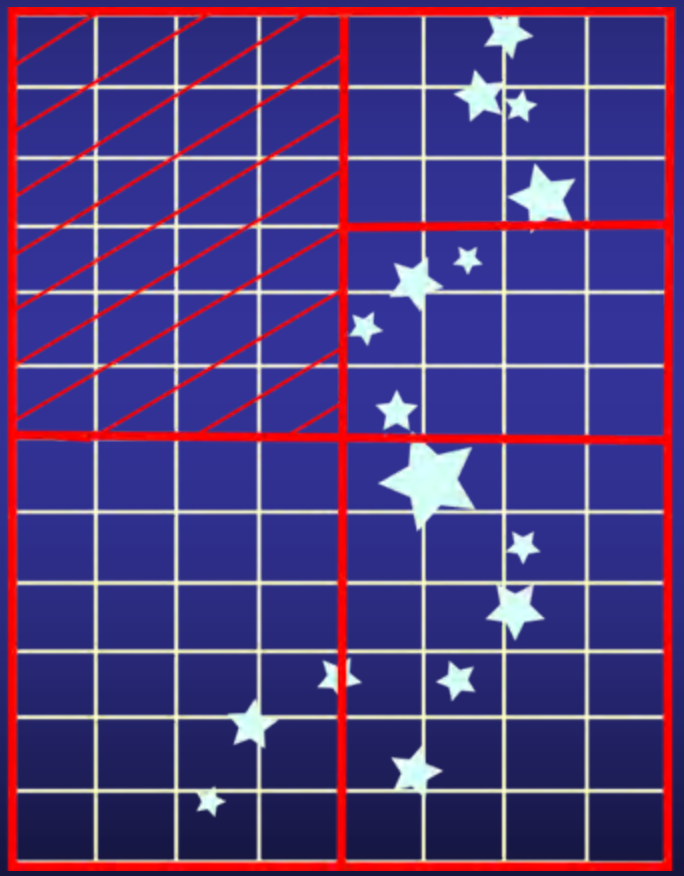
# Bisection





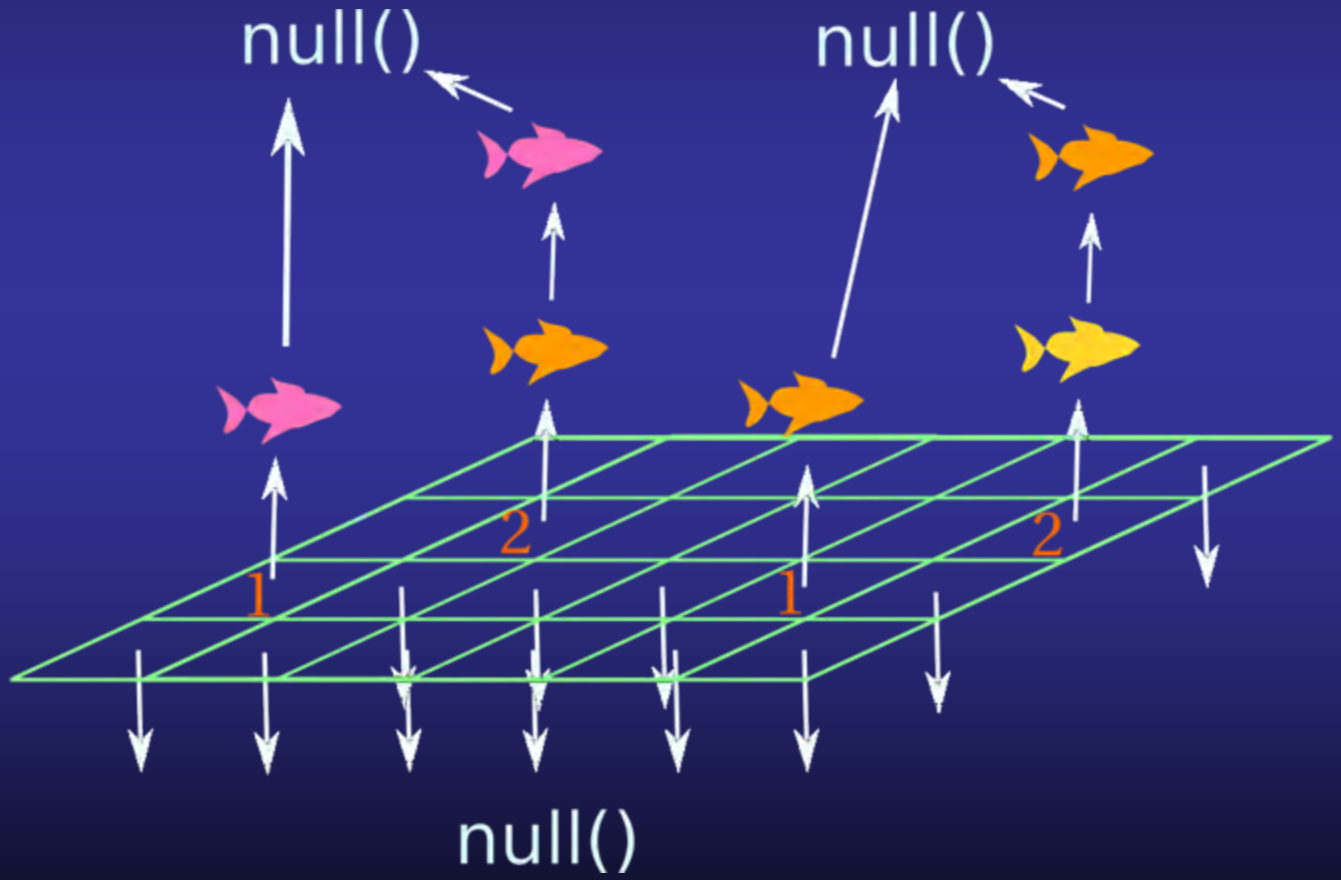
# Another Example





# Mortality #1: Predators

# fish_list on Master process



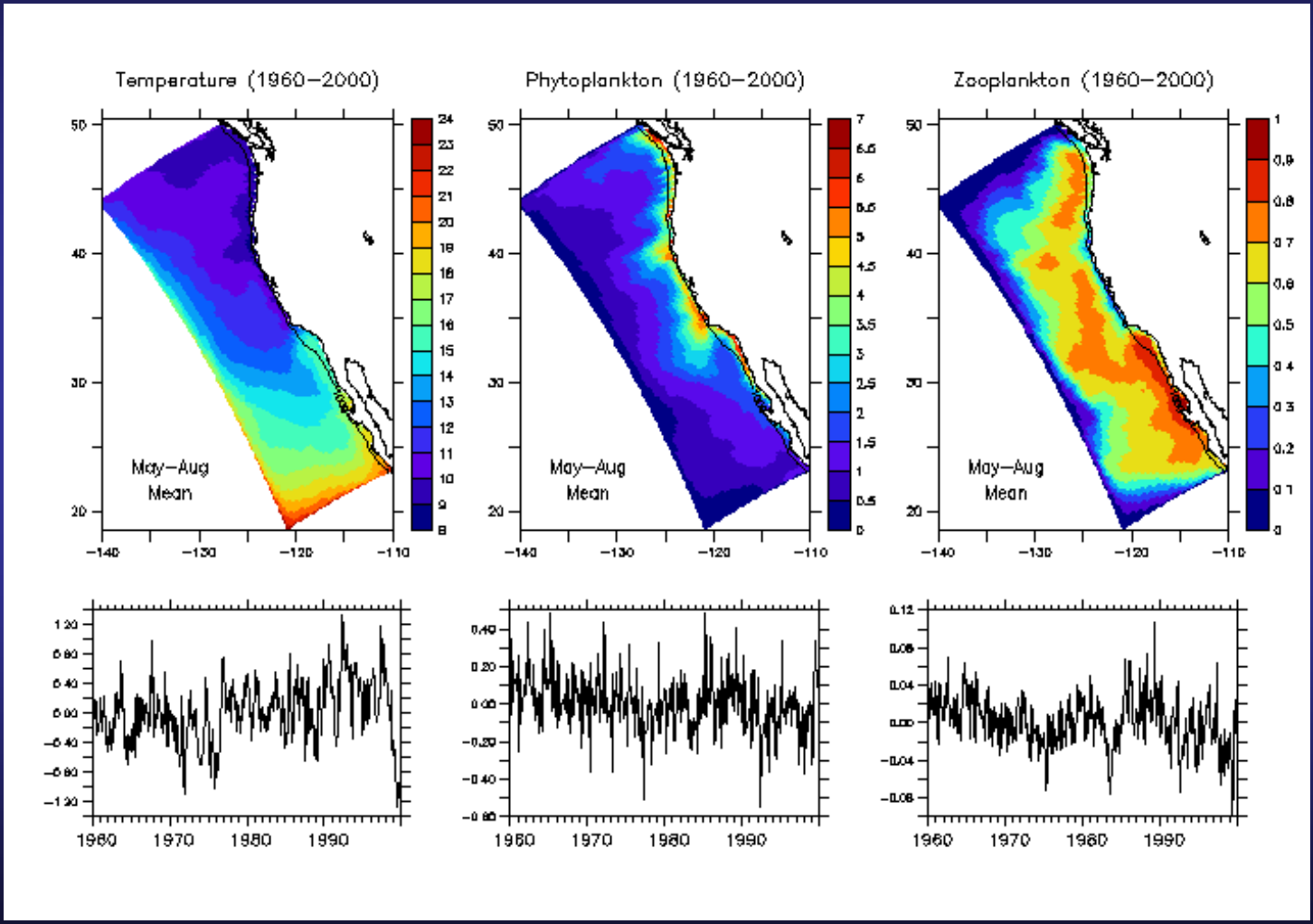
# Fish-eat-fish

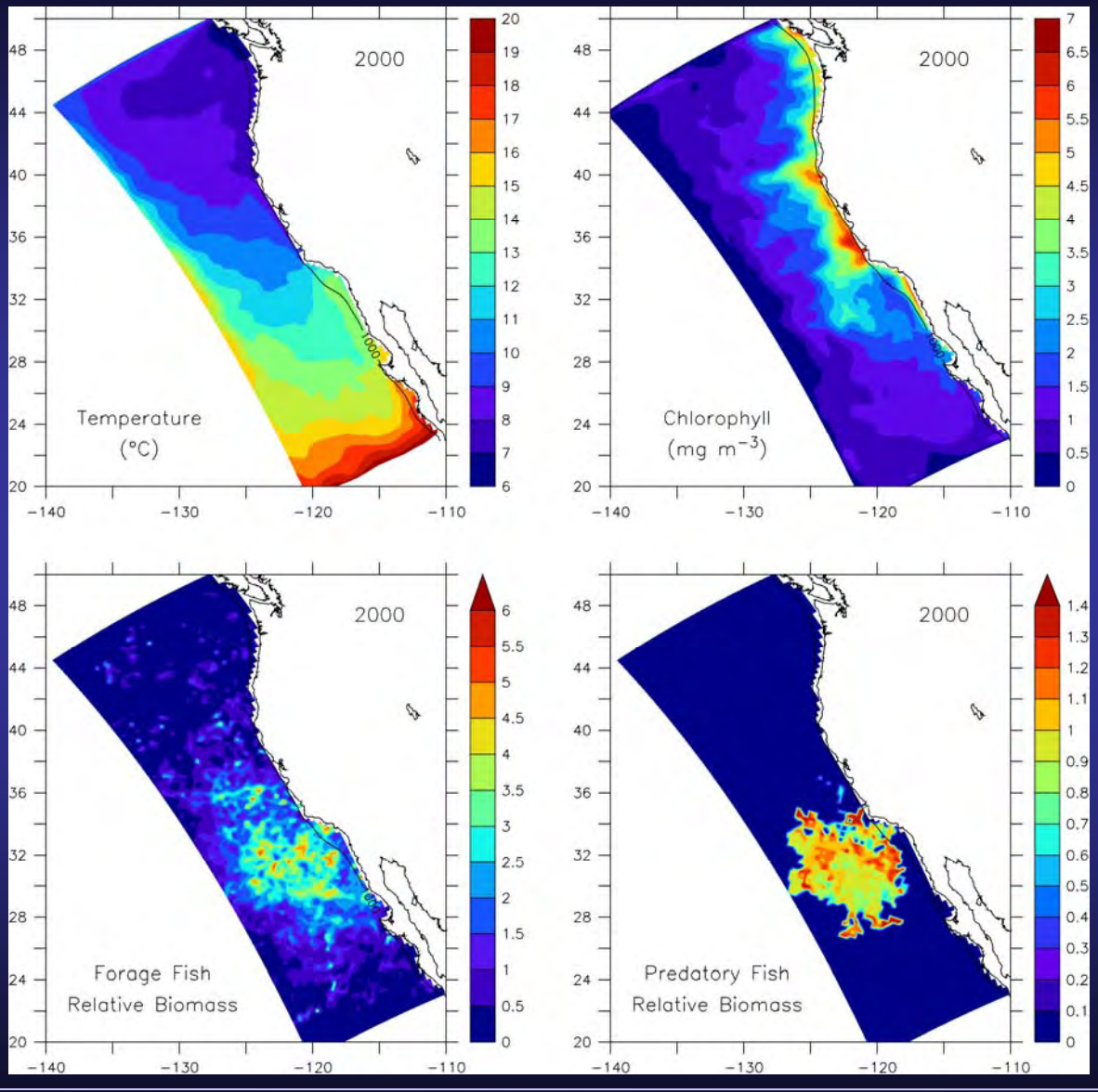
- Loop through fish on tile – if I eat fish:
  - Eat fish in own cell
  - Are they the kind I eat?
  - Look over whole water column for now
  - Worry about order? It's always going to be the same unless explicitly randomized

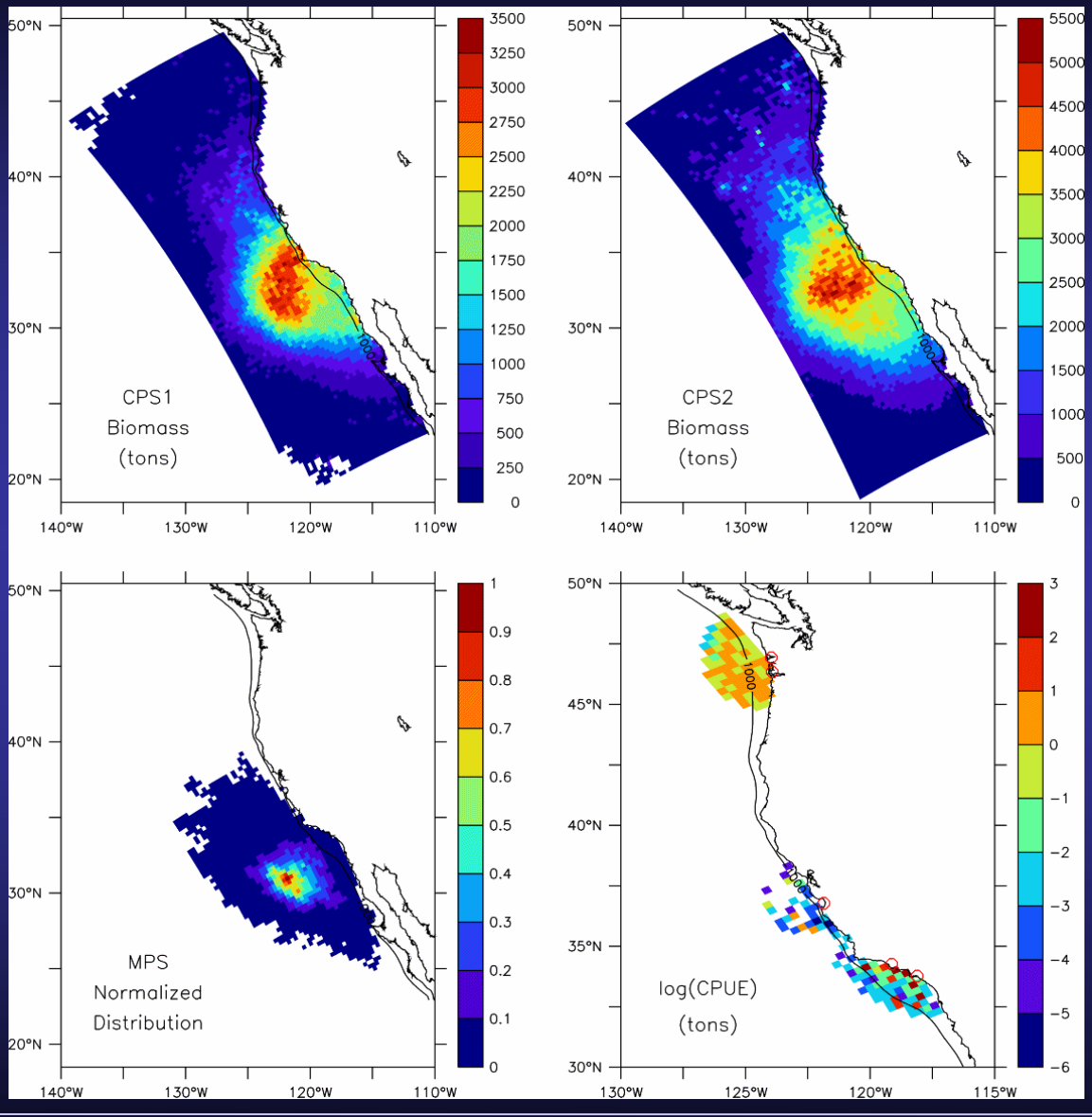
# Mortality #2: Fishing Fleet

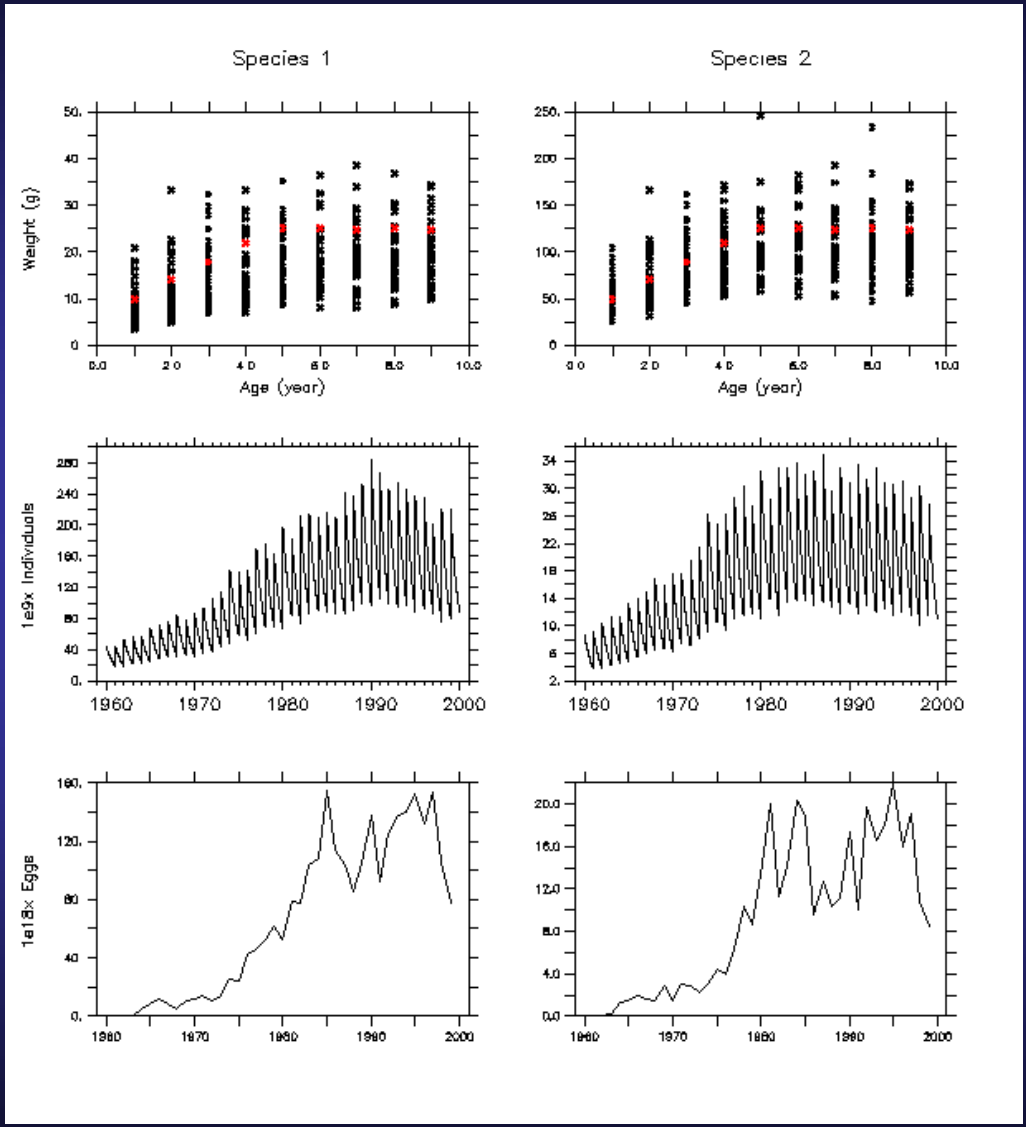
- Western US sardines
- Movement once per day
- Maximize revenue based on expected CPUE

# Forty-year Run




2000
Temperature
(°C)
2000
Chlorophyll
(mg m$^{-3}$)
2000
Forage Fish
Relative Biomass
2000
Predatory Fish
Relative Biomass


CPS1
Biomass
(tons)
CPS2
Biomass
(tons)
MPS
Normalized
Distribution
log(CPUE)
(tons)
1000
50°N
40°N
30°N
20°N
45°N
35°N
140°W
130°W
120°W
110°W
125°W
115°W


Species 1
Species 2
Weight (g)
Age (year)
Age (year)
1e9x Individuals
1e18x Eggs

# Conclusions

- We are well on the way towards having a full lifecycle model of fish in ROMS
- These fish represent small pelagics, up to 5-10 species
- Depends on bioenergetics data
- Need to “prime the pump” with adult fish, then run for decades

# Future Plans

- Tuning of fish bioenergetics and behavior
  - Warm/cold behavior switch
  - Migration
  - Starvation
- Look to neighboring cells