Presentation of an ATLANTIS Application for the NEUS Ecosystem: A Scary Model, Lots of Data, Comforting Validation, and a Naïvely Optimistic Step Towards EAM

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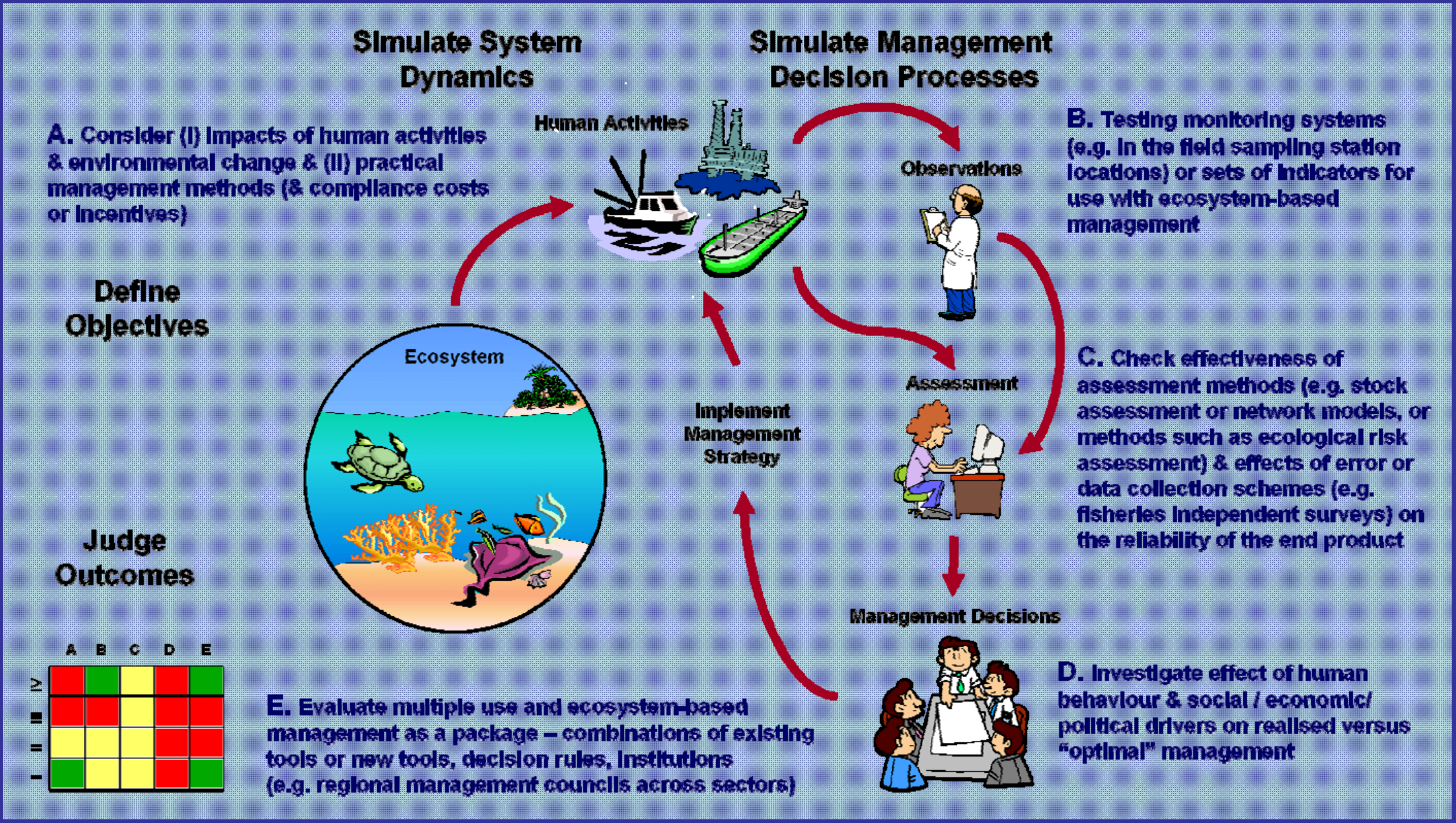
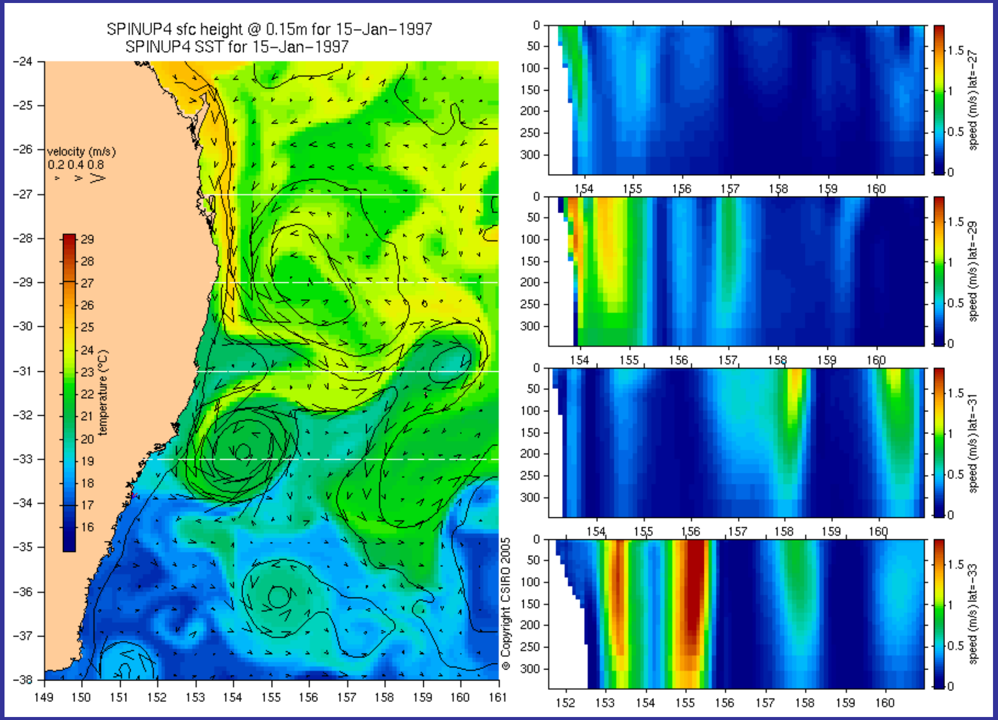
Main Use of this Approach: MSE



Physical Forcing

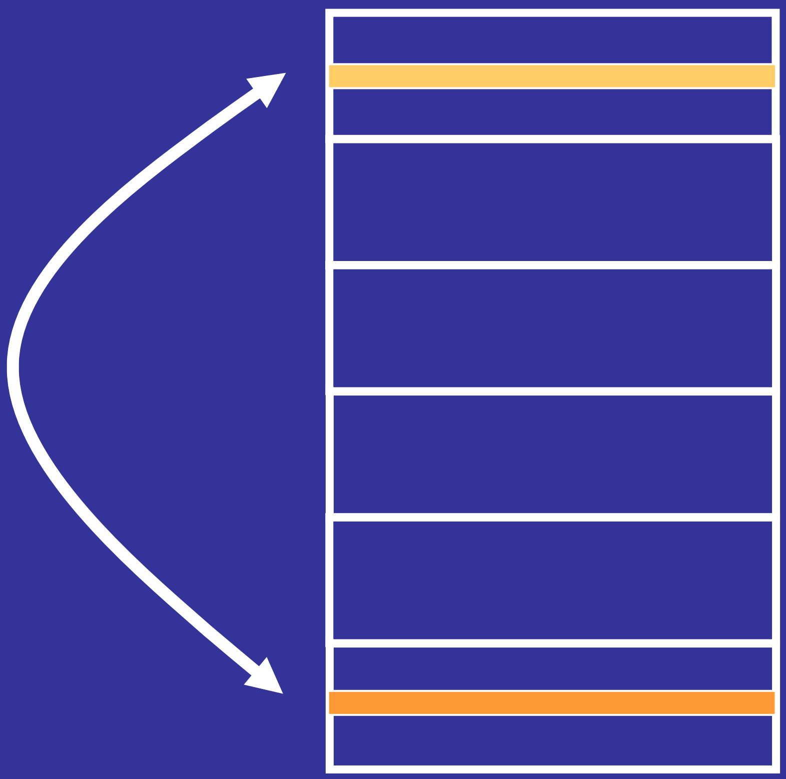
- Advection & (most) horizontal diffusion is forced
  - – transport vectors from altimetry data or fine-scale 3D resolved hydrodynamic models
  - – recycling necessary
  - – realistic fluxes
  - – realistic variation



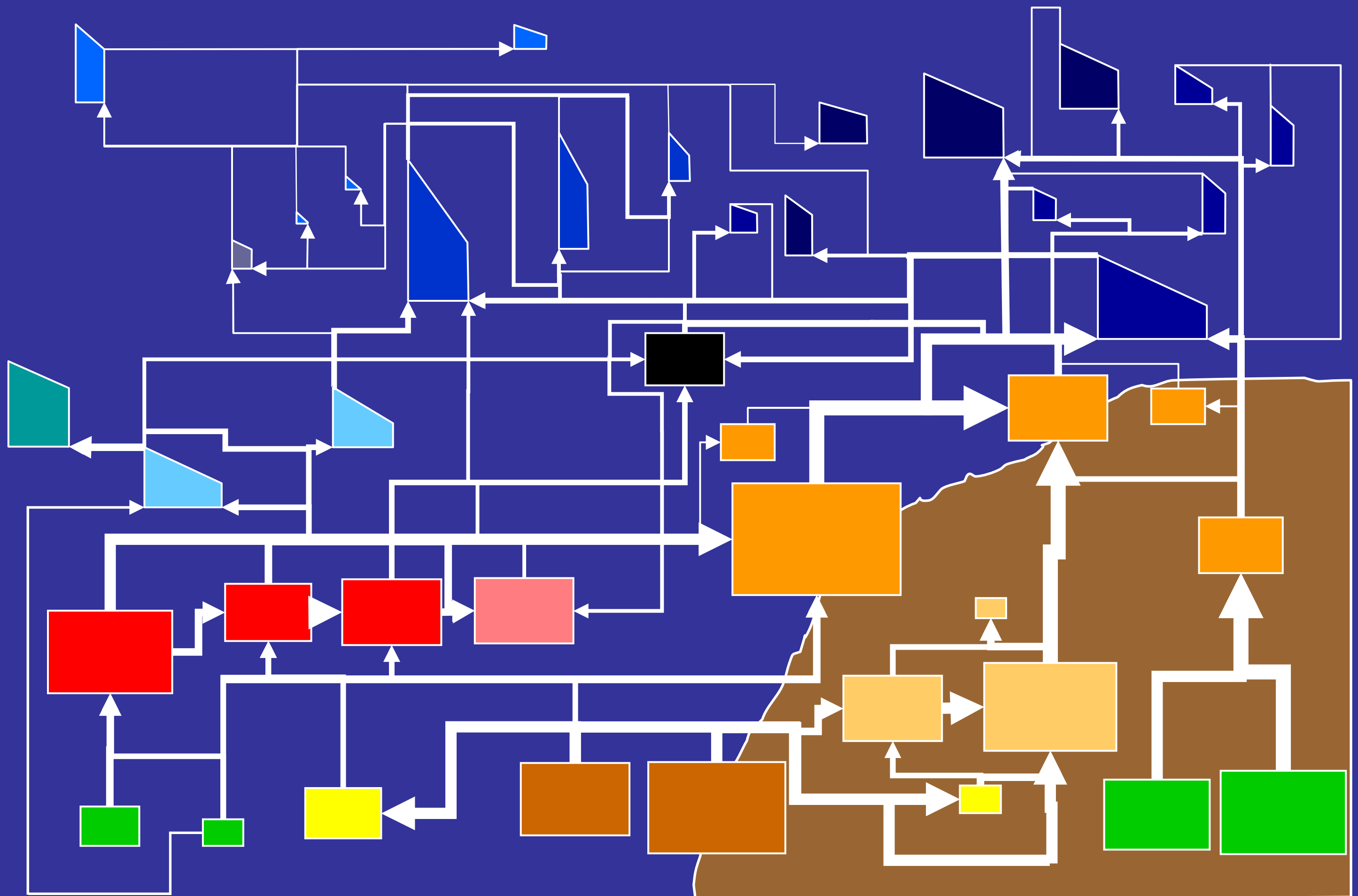
- Hyperdiffusion
  - – corrections
  - – new transports

Other Physical Processes

- Gas exchange
- Mixing
- Settling
- Resuspension
- Decay
- Burial
- Bioturbation
- Bioirrigation
- Coriolis

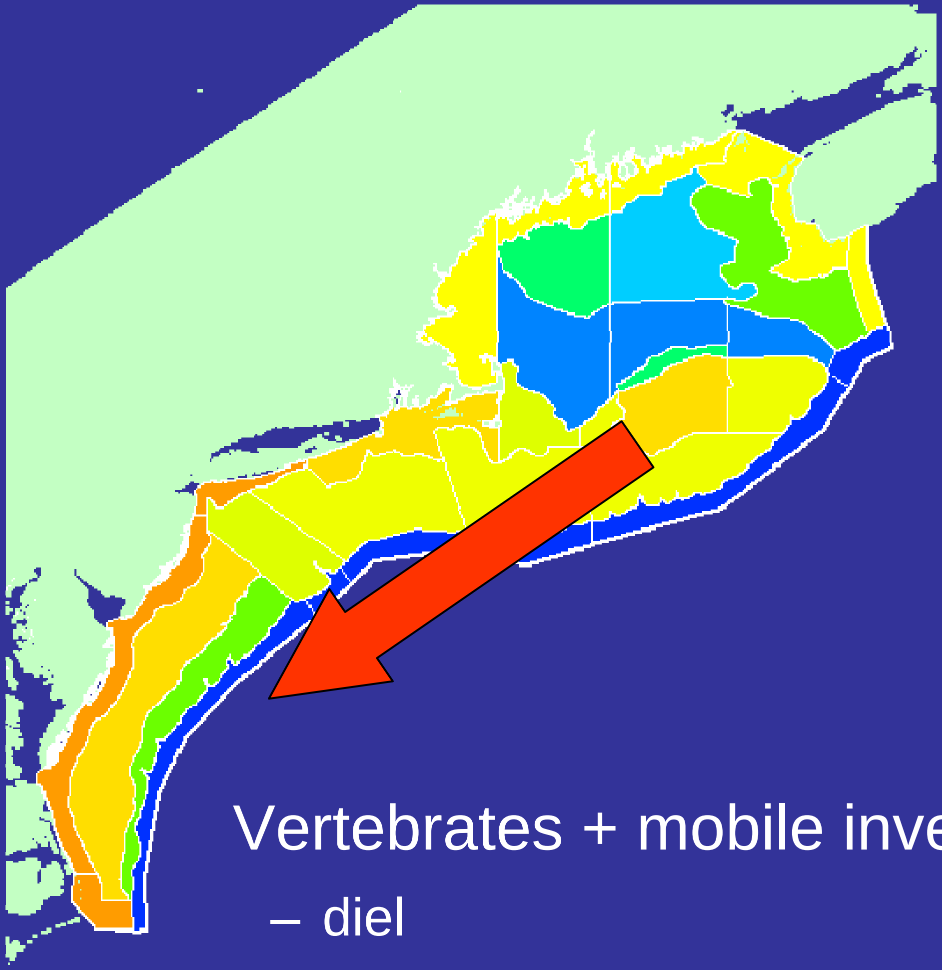


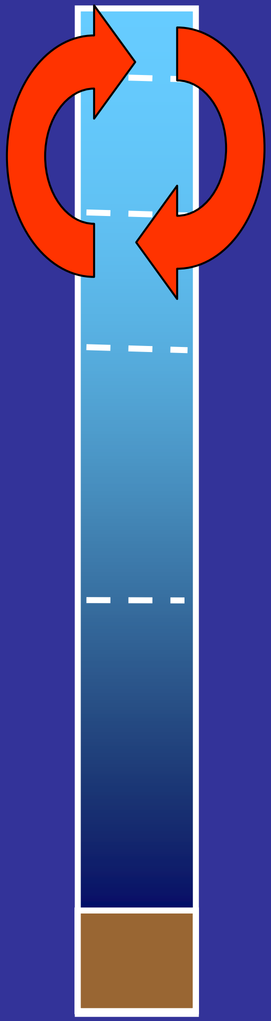
Ecological



Multiple options (e.g. feeding, reproduction)

Movement





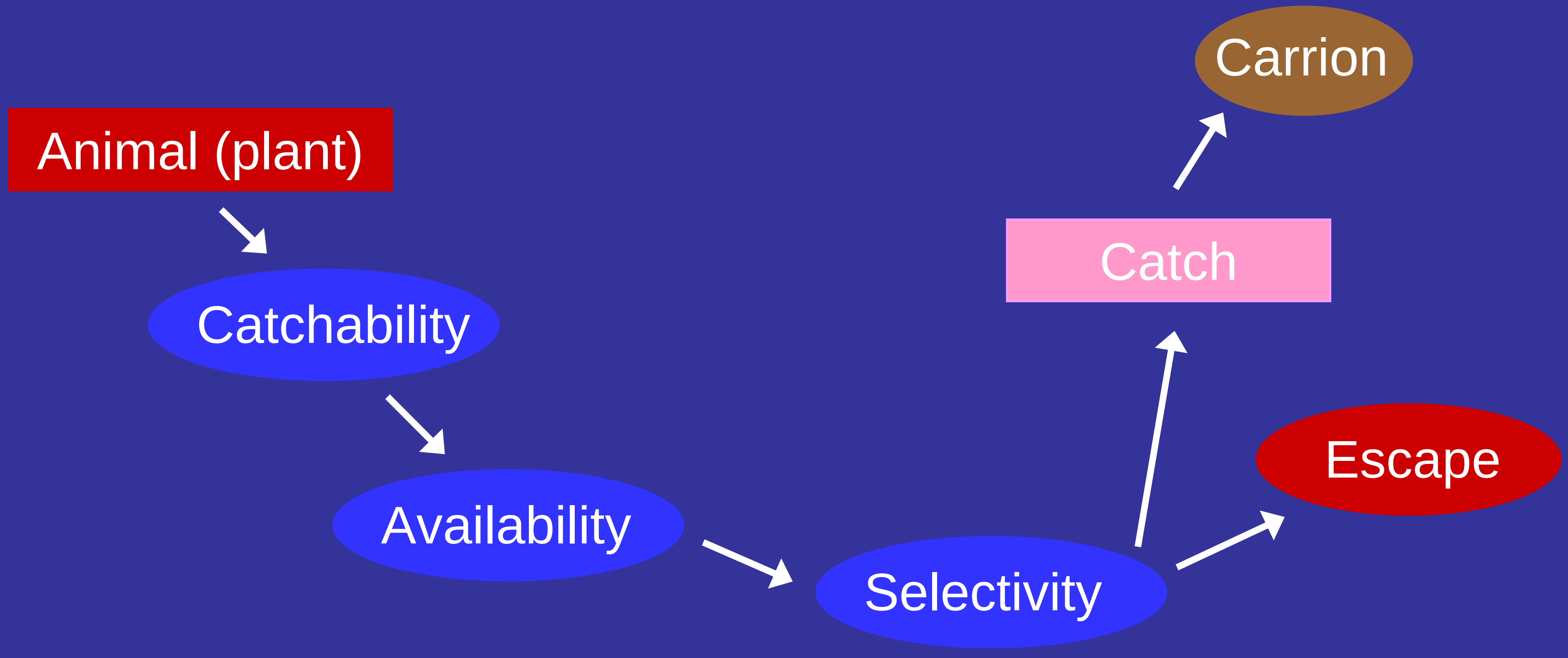
Vertebrates + mobile invertebrates

- diel
- seasonal (e.g. spawning)
- forage-dependent vs sedentary vs prescribed

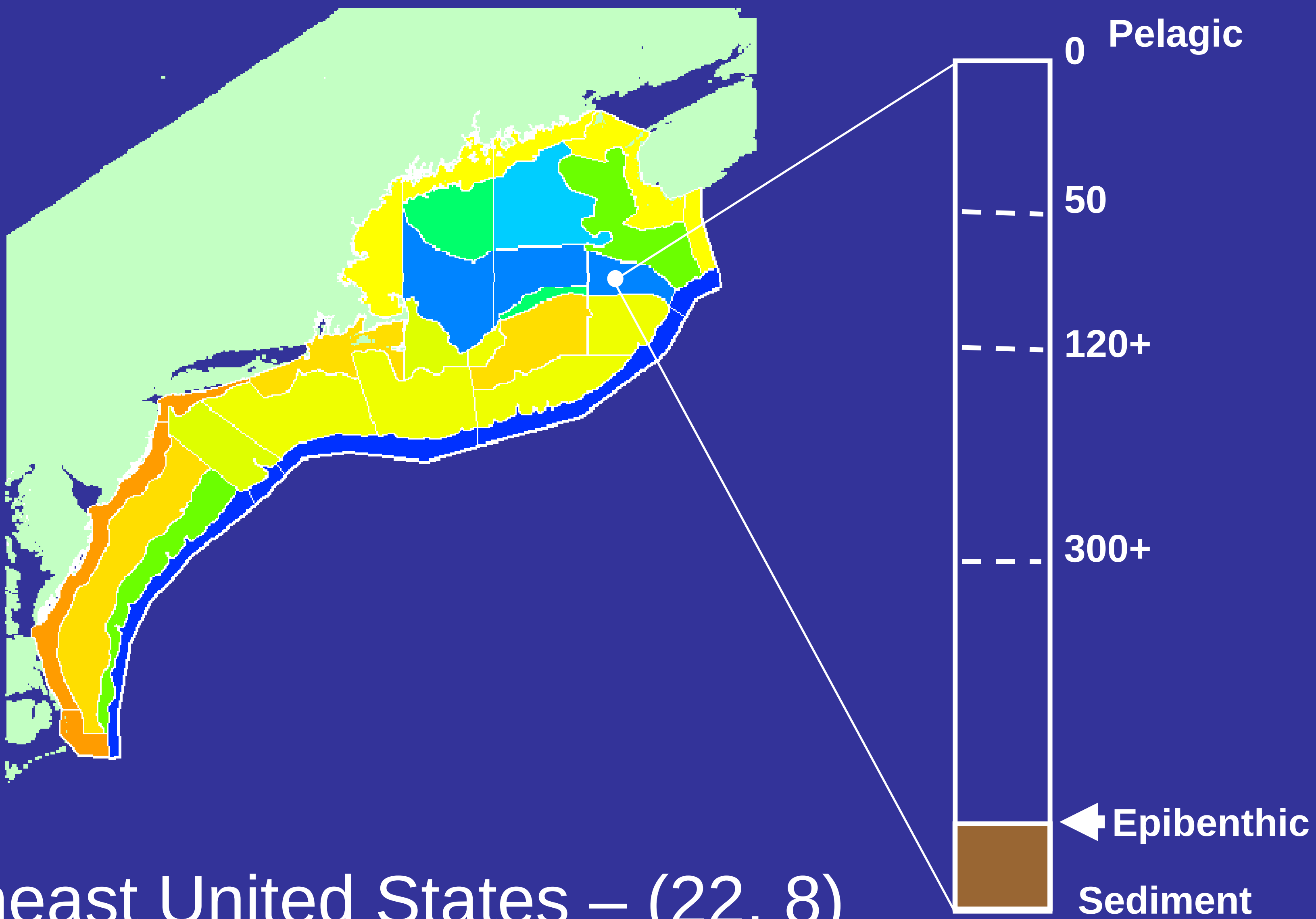
Other Ecological Processes

- Metabolism and waste production
- Feeding
  - different forms
  - gape limited feeding
- Growth
  - partitioning
  - starvation
- Reproduction
  - different forms (including semelparous)
- Other mortality
  - disease and senescence
  - hypoxia
  - density dependent

Fishing Operations



As an example… NEUS



Northeast United States – (22, 8)

NEUS – Biological groups (45)

- Phytoplankton (small, large)
- Zooplankton (micro-, meso-, large-crustacean, gelatinous)
- Squid
- Zoobenthos (meiobenthos, infauna, deposit feeders, scallops, other filter feeders, urchins, lobster, decapod shrimp, other macrozoobenthos)
- Bacteria (pelagic, benthic)
- Planktivores (herring, mackerel, anadromous small pelagics, other pelagics)
- Piscivores (billfish & tuna, bluefish, white hake, other)
- Mesopelagics
- Demersal fish (goosefish, haddock, yellowtail flounder, cod, silver hake, other)
- Sharks (pelagic, demersal, spiny dogfish)
- Skates and rays
- Pinnipeds
- Seabirds, Turtles
- Whales (baleen, toothed)
- Detritus (labile, refractory, carrion)

NEUS – Fleets (18)

- Dredge (scallops)
- Trap/pot (lobster, goosefish)
- Bottom trawl (shrimp, squid, demersal)
- Midwater trawl (squid, small pelagics, international)
- Purse seine (small pelagics)
- Gillnet (small pelagics)
- Demersal longline/troll-line
- Demersal gillnet
- Demersal handline/jig
- Large pelagic longline/troll-line
- Large pelagic harpoon/spear
- Harpoon/Spear
- Recreational

NEUS – Fisheries Mgt

- With redefined fleet as a gear x target species/group combo: 18
- Number of Mgt Plans, including ESA/MMPA: 32 to 25

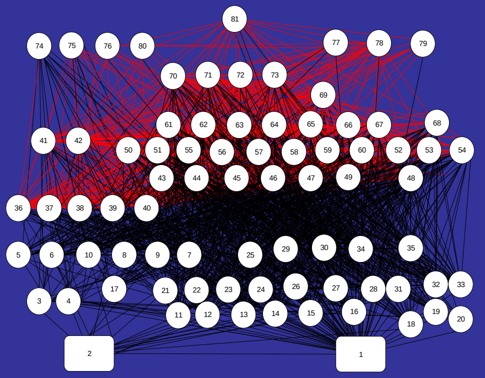
- 450 possible Fishery-Plan interactions to consider, including bycatch

NEUS – Fisheries Mgt

- Average Number of Mgt Tools (i.e. actions/conditions/ factors) used per plan: 5-6 (none less than 3)
- Recall, there are 450 possible Fishery-Plan interactions to consider, including bycatch

- Thus, there are approximately 2,325 to 2,800 Fishery-Plan alternatives to track as they can affect the fisheries

For perspective, there are 1,562 species interactions in the US NW Atlantic food web

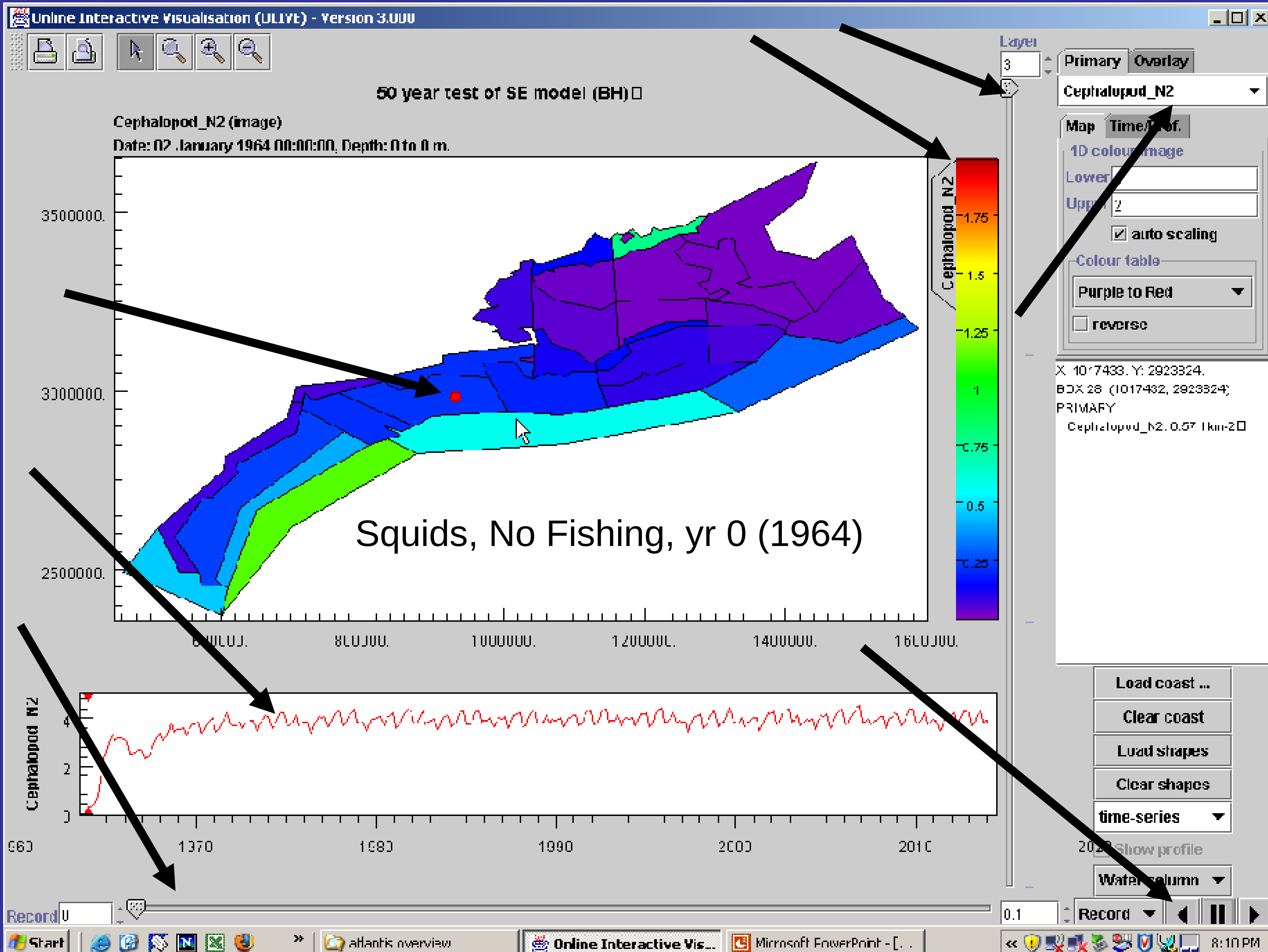


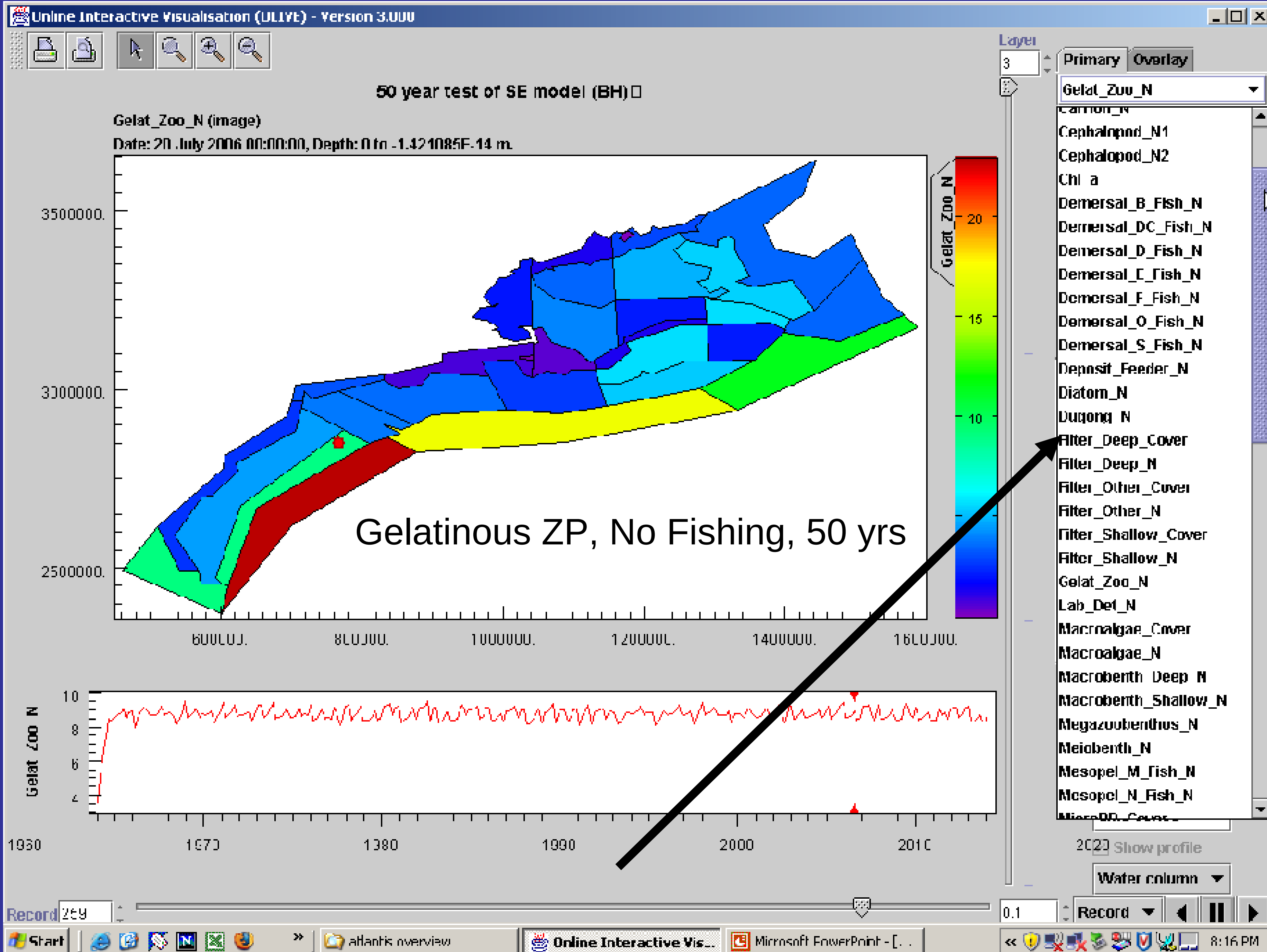
Levels of Atlantis Calibration

1. Biophysical
   - Hydrodynamic model doesn’t sweep nutrients off shelf
   - We checked for coriolis
   - Nothing dies too often too quickly
   - Tuning physics and background for biota
2. Forced (fixed) Catch, no Effort
   - Can have exploitation so that none of the biology dies outright
   - Most (>75%) biomass trajectories within +/- 1 orders of magnitude (OOM)
   - Tuning biology to catch

Levels of Atlantis Calibration

3. Dynamic Catch, Forced Effort
   - Tuning catch to effort
   - Most (85%) biomass trajectories and shapes within +/- 0.5 OOM
   - Most (75%) catch trajectories within +/- 1 OOM
4. Dynamic Effort
   - Letting fleet behaviour be tuned to effort
   - Most biomass (90%) and catch (85%) trajectories & shapes within +/- 0.5 & 1 OOM, respectively
   - Most (85%) effort trajectories and shapes within +/- 1 OOM


Online Interactive Visualisation (OLIVE) - Version 3.000
50 year test of SE model (BH)
Cephalopod_N2 (image)
Date: 02 January 1964 00:00:00, Depth: 0 to 0 m.
Squids, No Fishing, yr 0 (1964)
Cephalopod_N2
Layer
Primary
Overlay
Map
auto scaling
Colour table
Purple to Red
reverse
Load coast ...
Clear coast
Load shapes
Clear shapes
time-series
Show profile
Record


Online Interactive Visualisation (OLIVE) - Version 3.000
50 year test of SE model (BH)
Gelat_Zoo_N (image)
Date: 20 July 2006 00:00:00, Depth: 0 to -1.421085E-14 m.
3500000.
3000000.
2500000.
600000.
800000.
1000000.
1200000.
1400000.
1600000.
Gelat_Zoo_N
20
15
10
Gelatinous ZP, No Fishing, 50 yrs
Layer
3
Primary
Overlay
Gelat_Zoo_N
Cephalopod_N1
Cephalopod_N2
Chl_a
Demersal_B_Fish_N
Demersal_DC_Fish_N
Demersal_D_Fish_N
Demersal_E_Fish_N
Demersal_F_Fish_N
Demersal_O_Fish_N
Demersal_S_Fish_N
Deposit_Feeder_N
Diatom_N
Dugong_N
Filter_Deep_Cover
Filter_Deep_N
Filter_Other_Cover
Filter_Other_N
Filter_Shallow_Cover
Filter_Shallow_N
Gelat_Zoo_N
Lab_Det_N
Macroalgae_Cover
Macroalgae_N
Macrobenth_Deep_N
Macrobenth_Shallow_N
Megazoobenthos_N
Meiobenth_N
Mesopel_M_Fish_N
Mesopel_N_Fish_N
Gelat_Zoo_N
10
8
6
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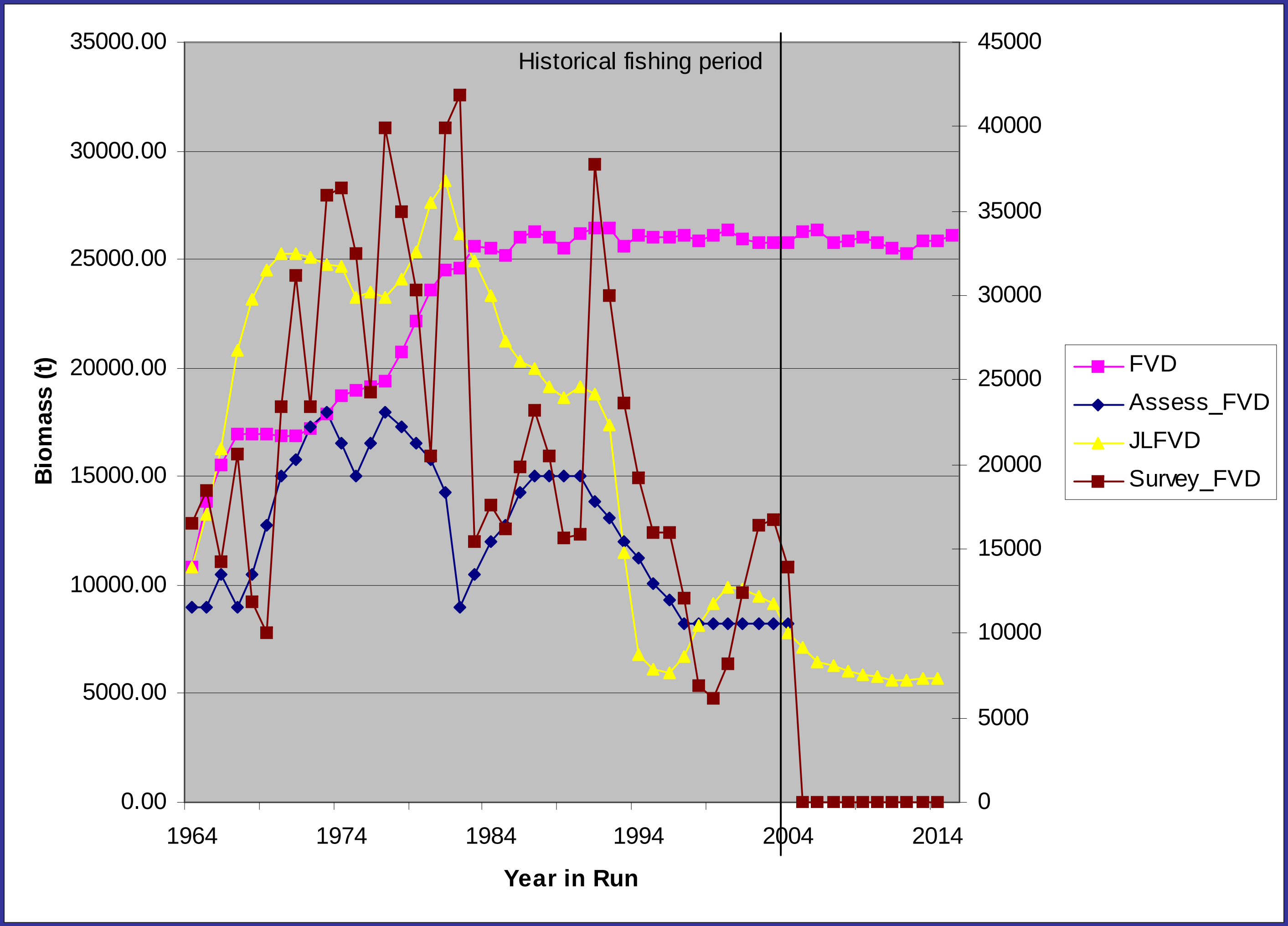
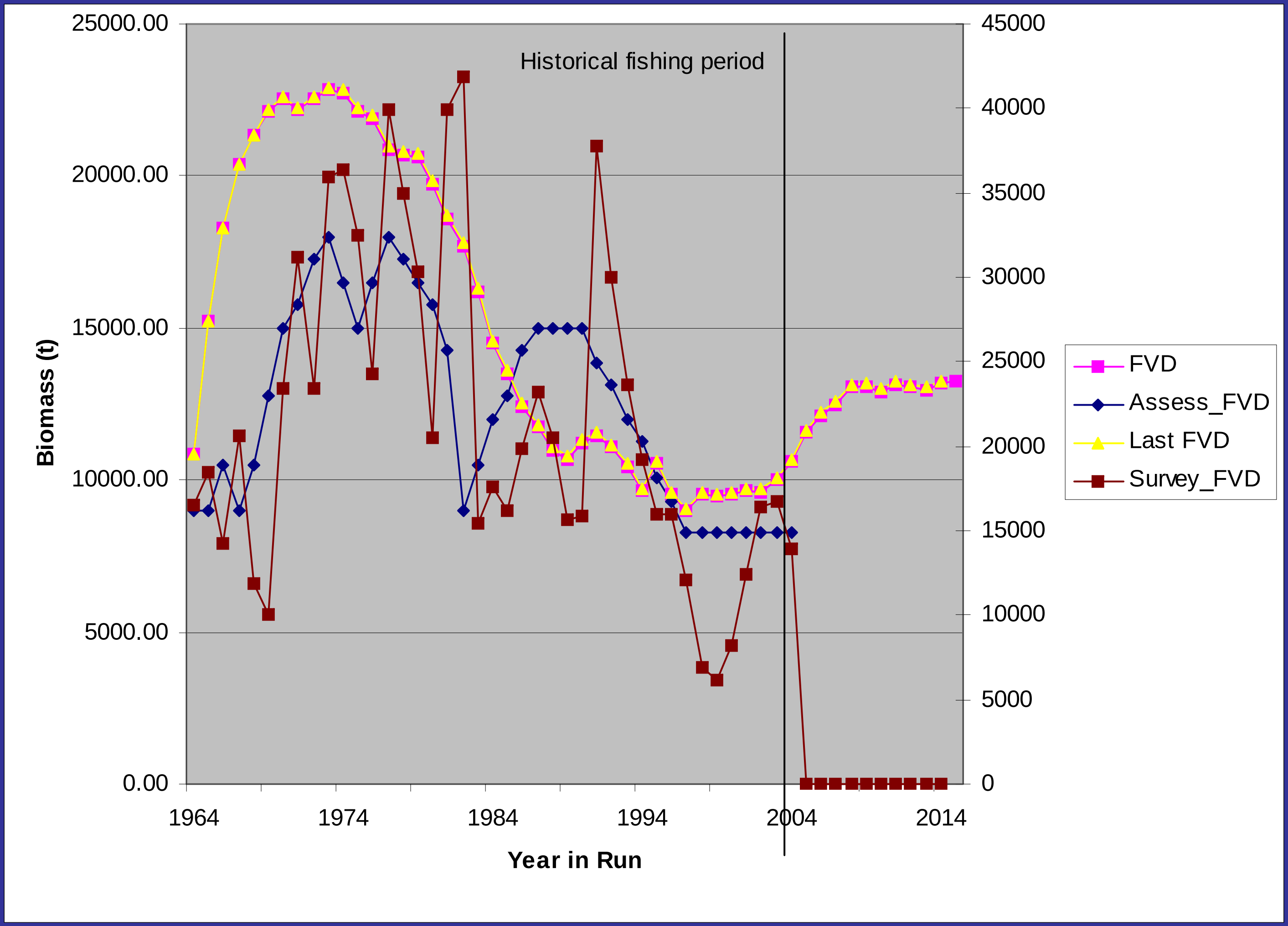
1960
1970
1980
1990
2000
2010
2020
Show profile
Water column
Record
0.1
Start
atlantis overview
Online Interactive Vis...
Microsoft PowerPoint - [...
8:16 PM

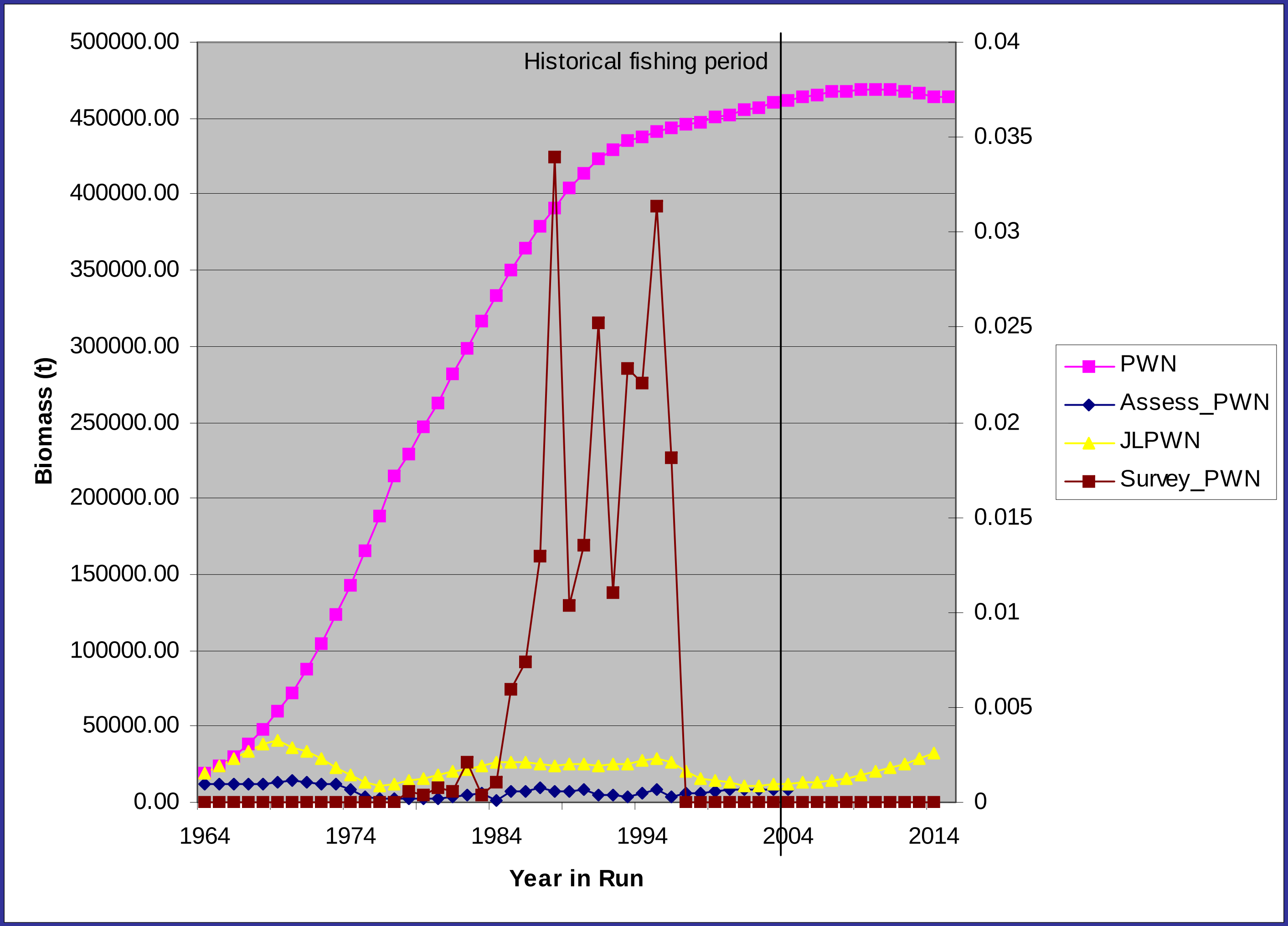
White hake, biophysical fitting only



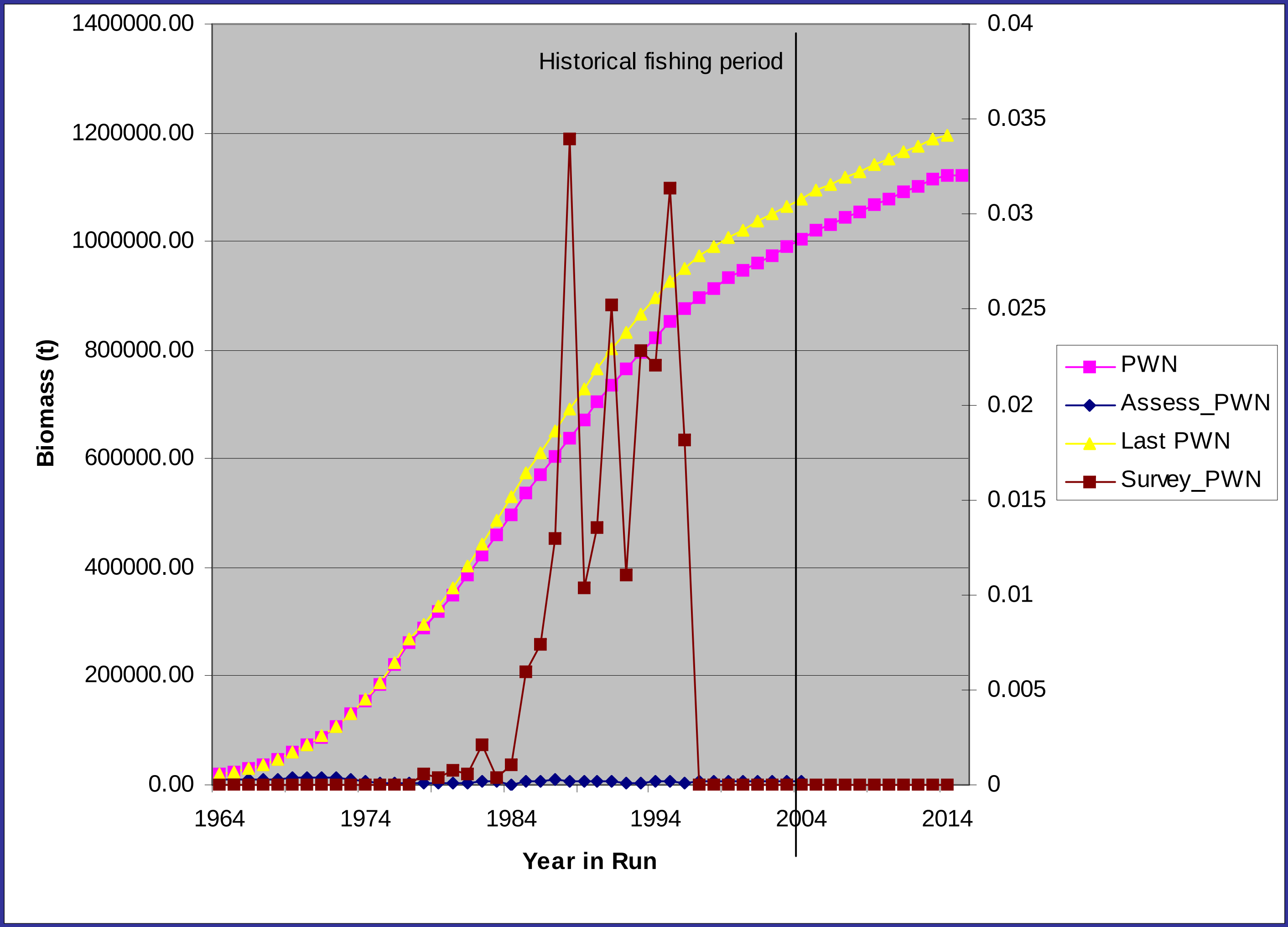
White hake, forced effort



Shrimp biophysical fitting only

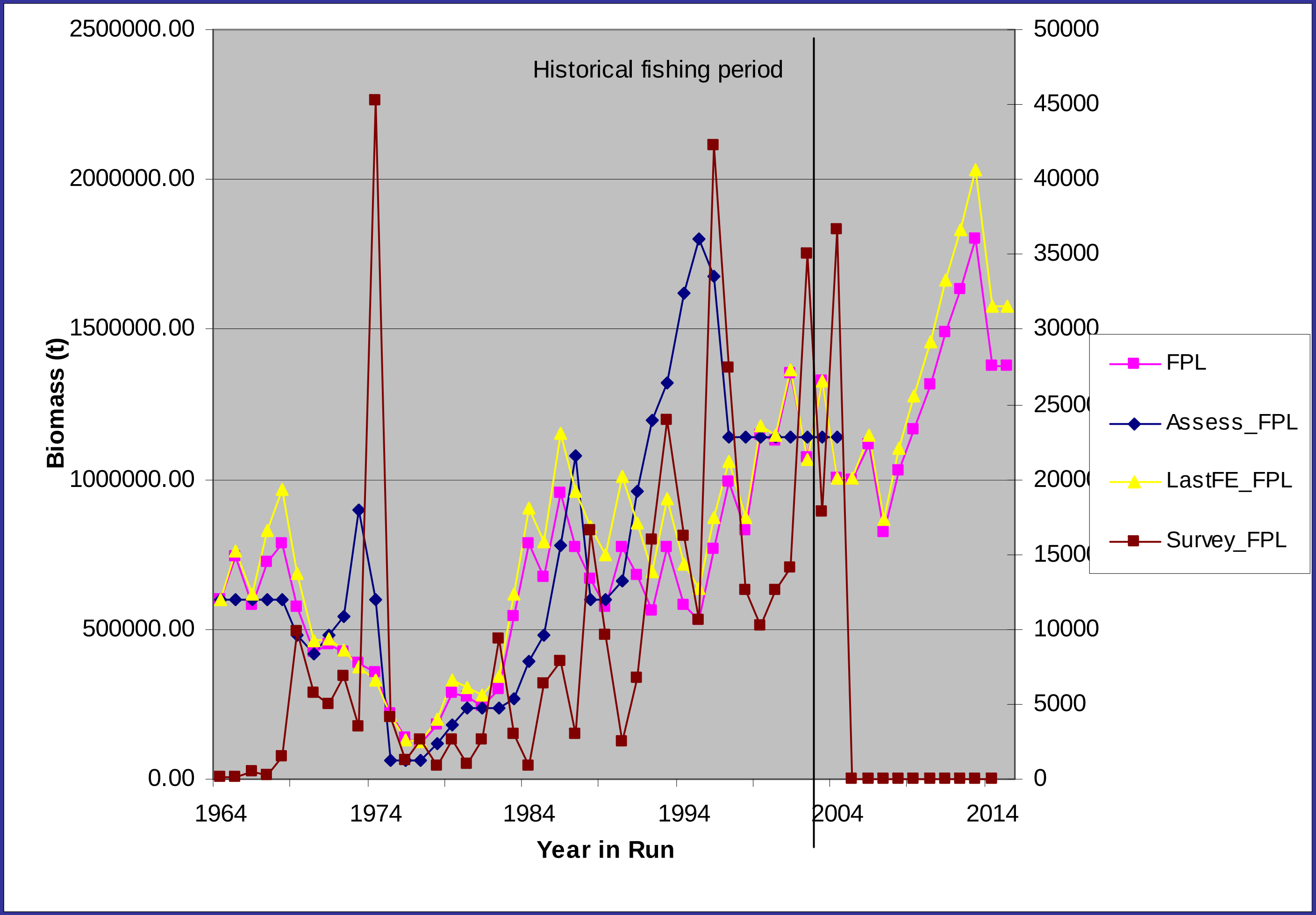


Shrimp, forced effort

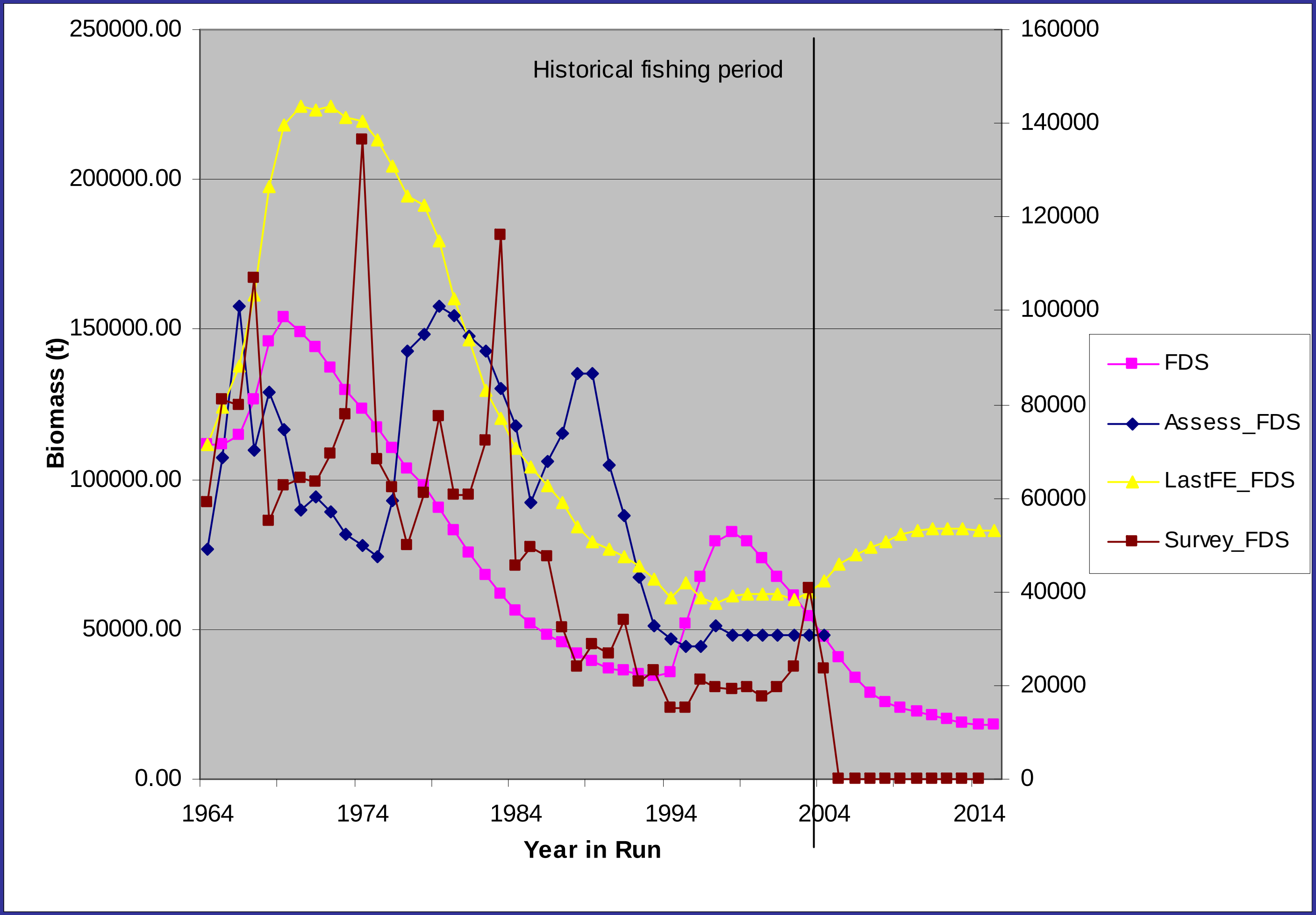


These runs were done before recent assessments and predicted the increase in biomass that we have subsequently observed

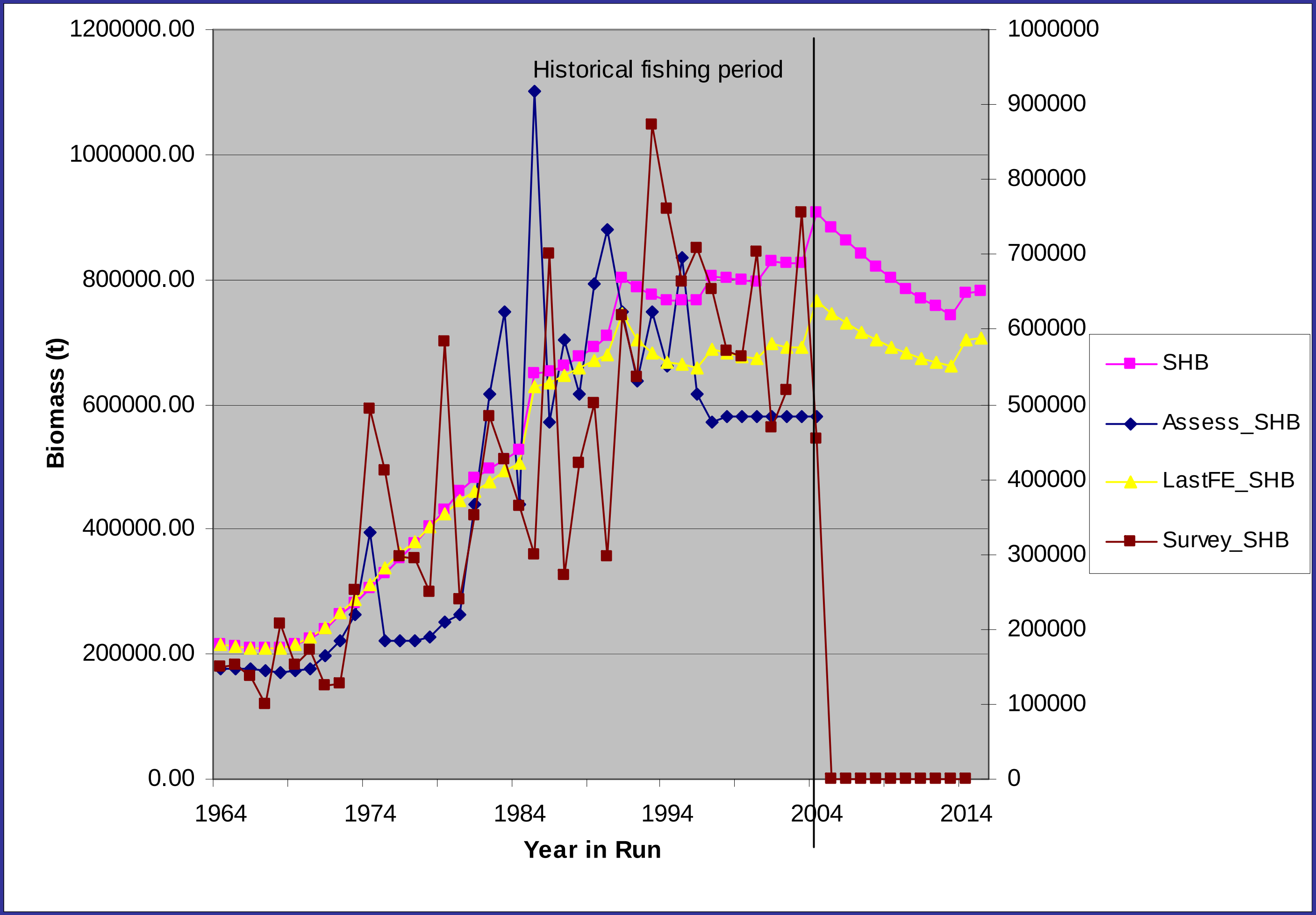
Atlantic mackerel – dyn. effort



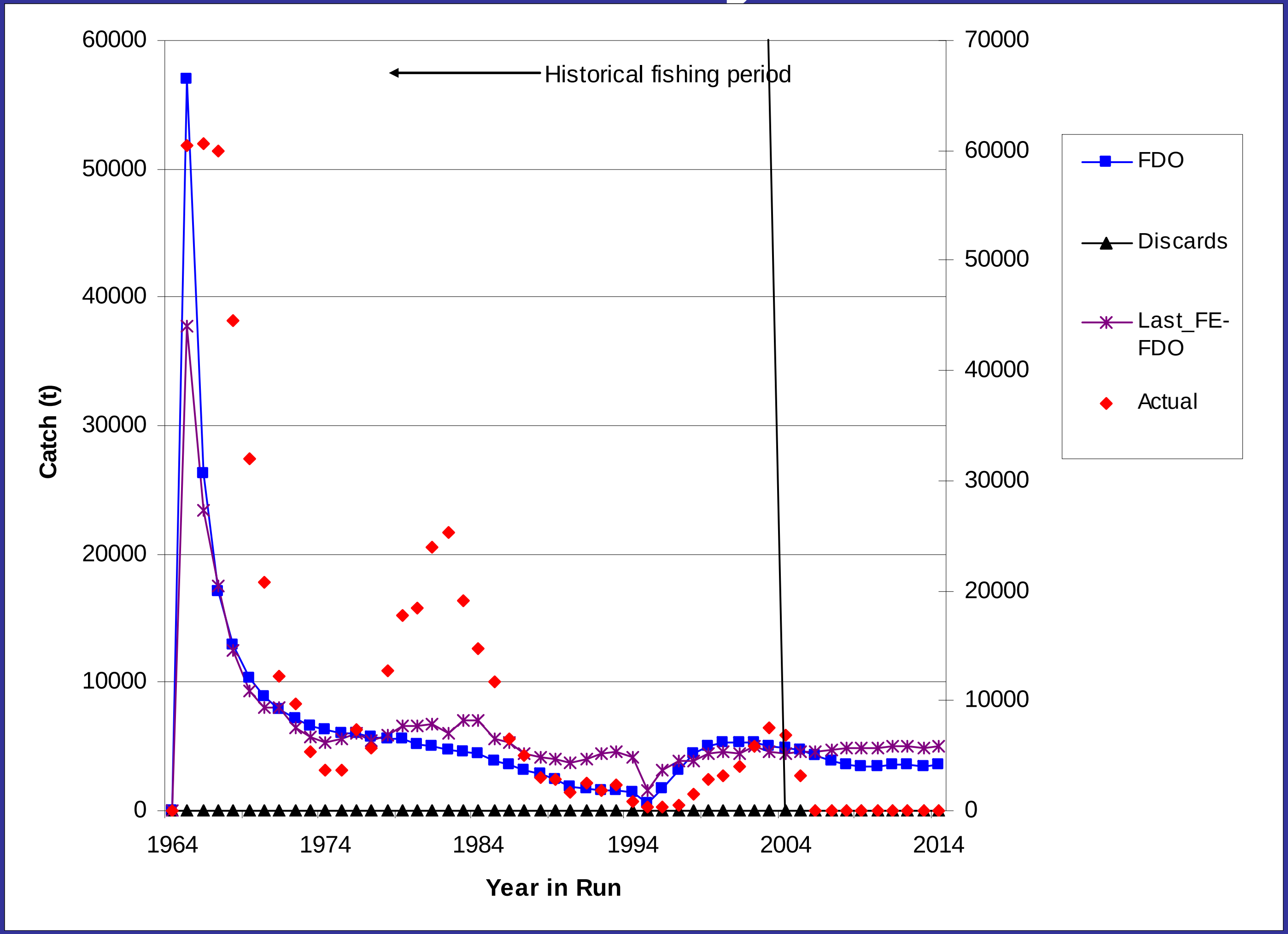
Atlantic cod – dyn. effort



Spiny dogfish – dyn. effort



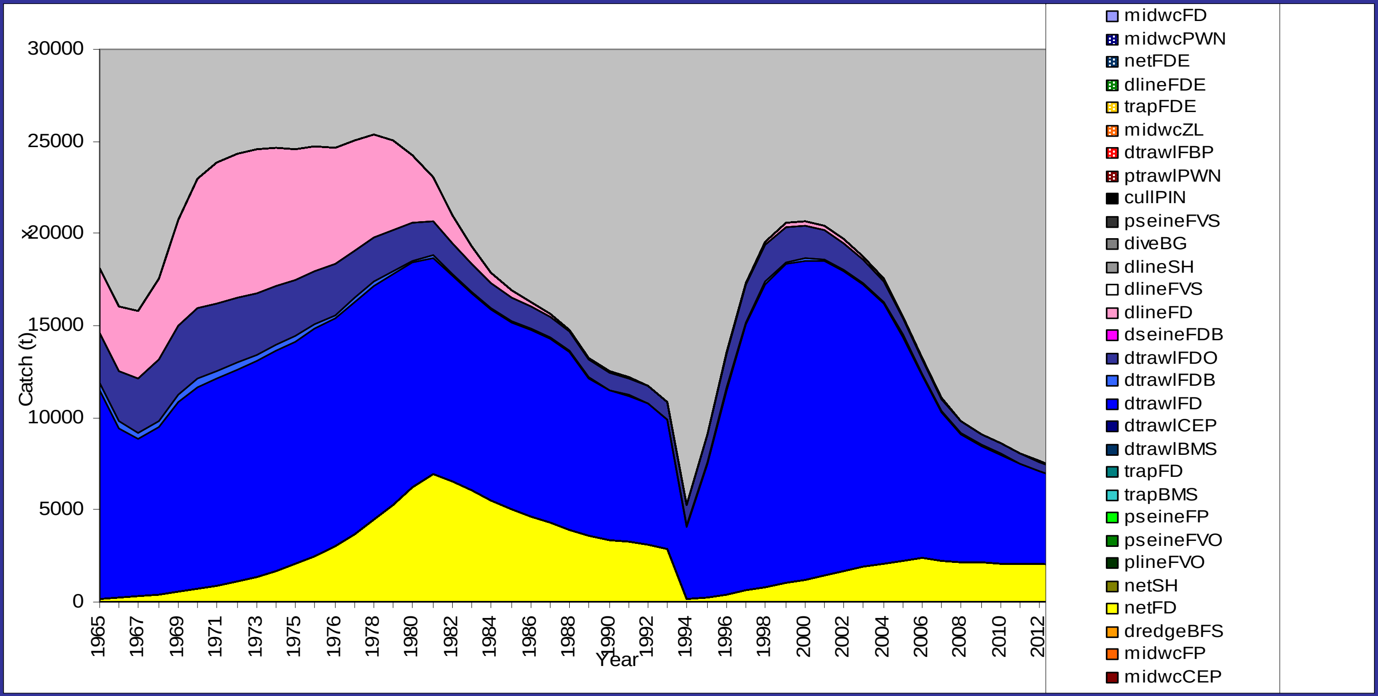
Haddock – dyn. effort



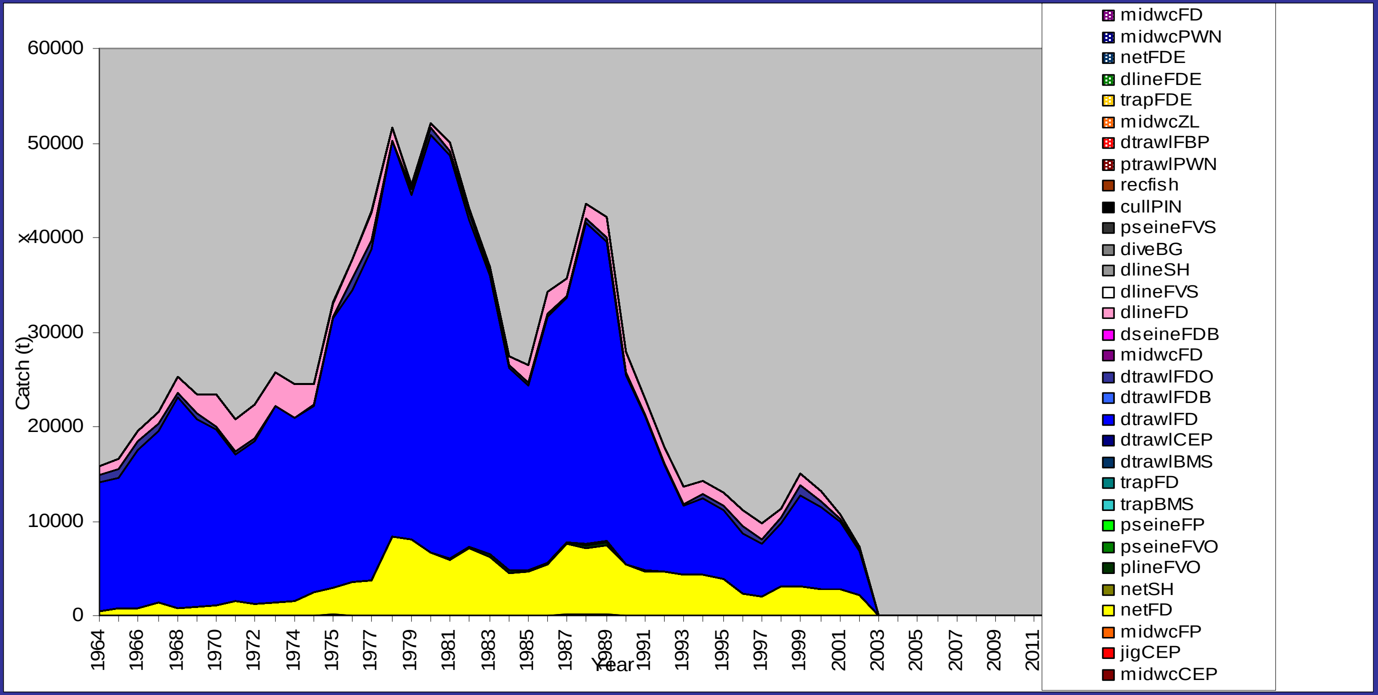
Most modeled catches are slightly lower than observed by a factor of 2-4

Atl. cod

Modeled Catch per fleet

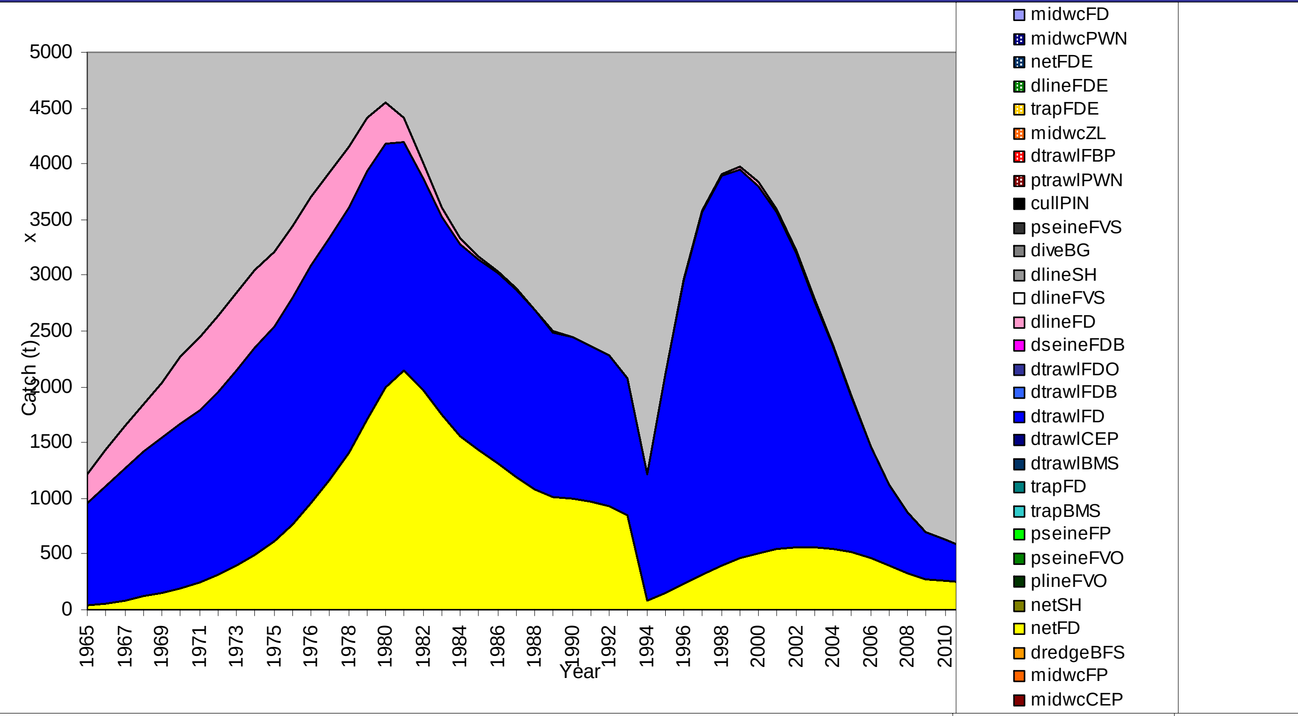


Observed catch per fleet

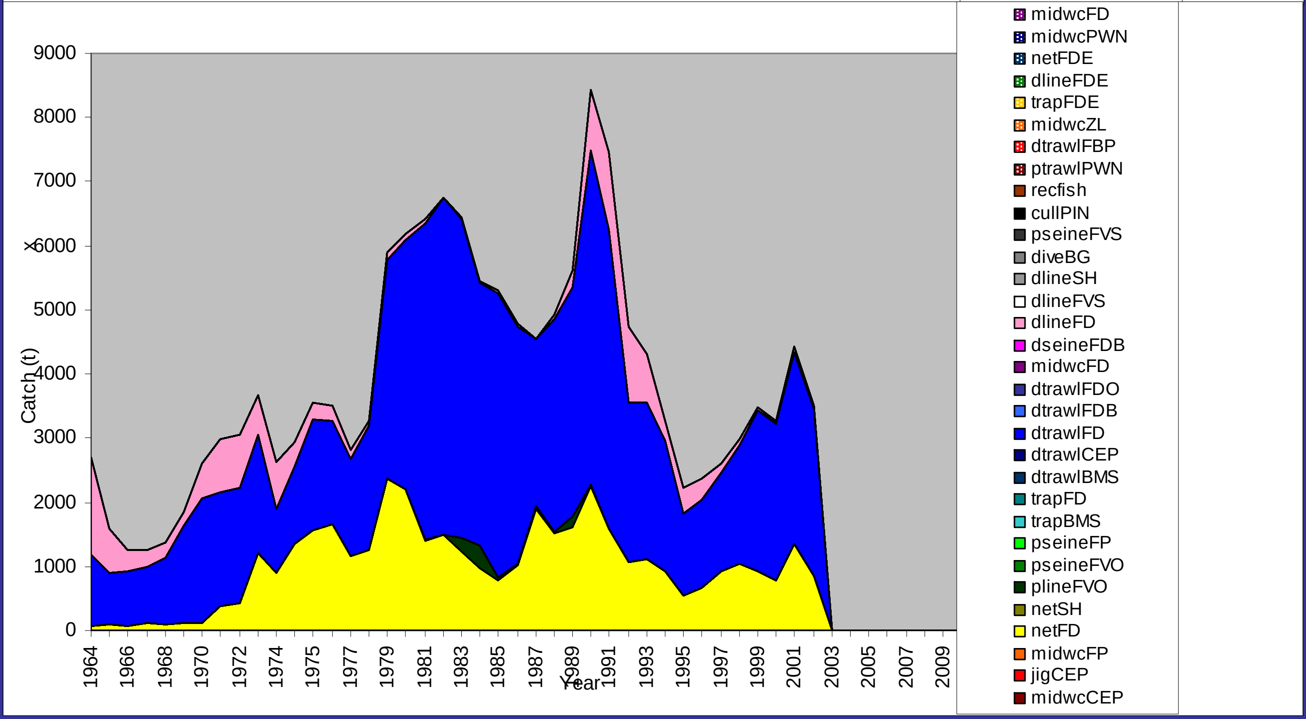


White hake

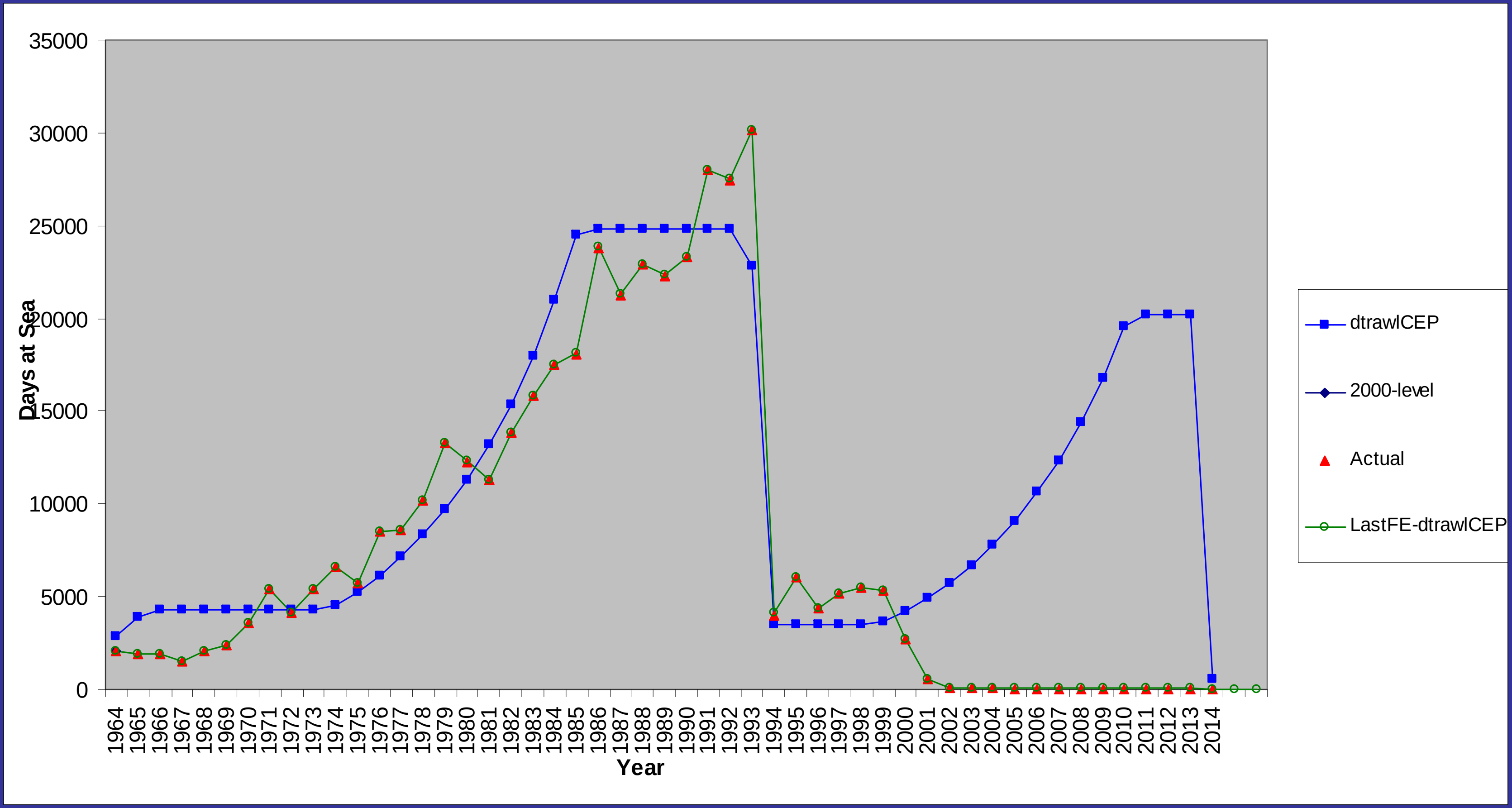
Modeled Catch per fleet



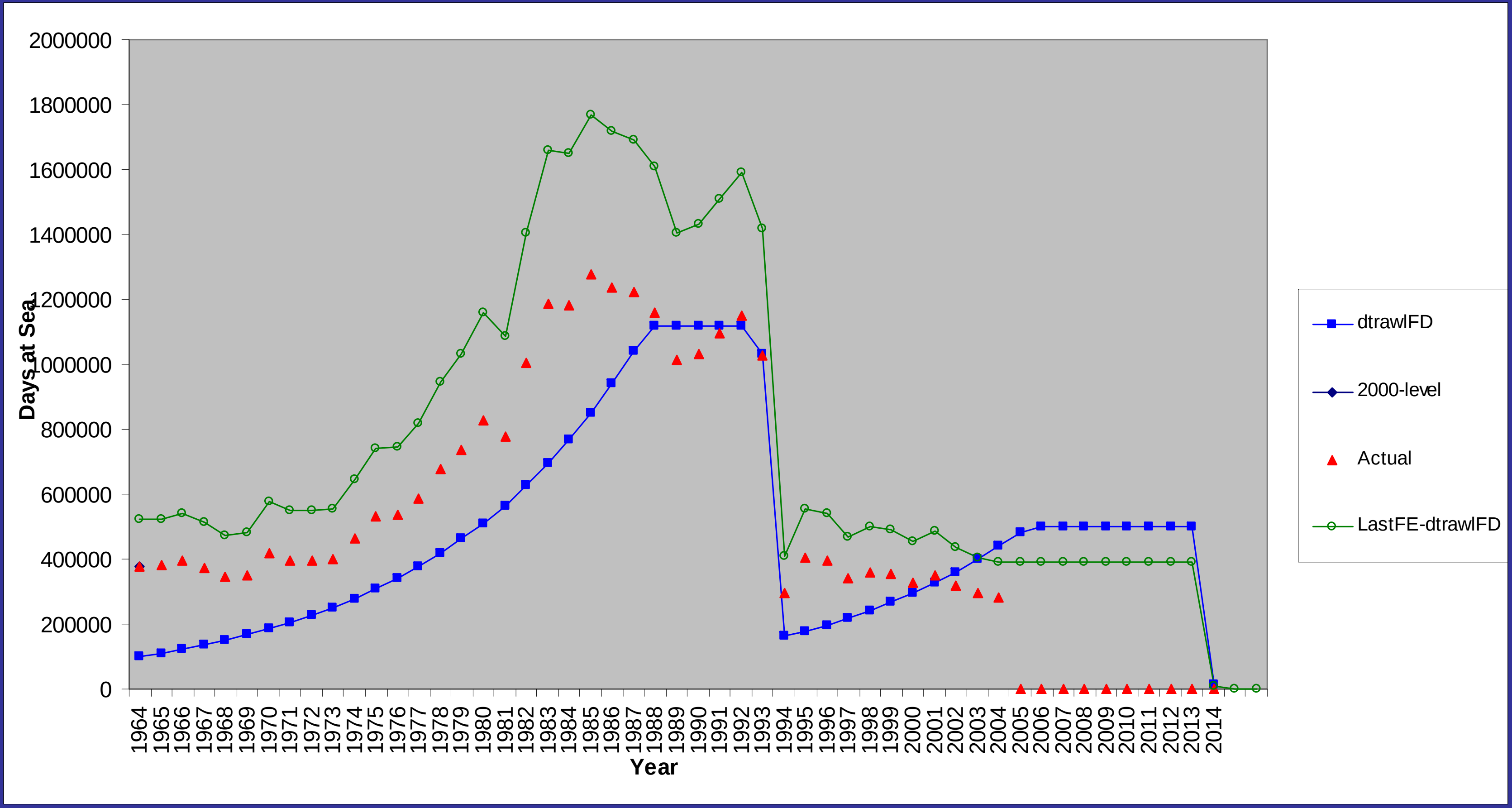
Observed catch per fleet



Squid trawls



Demersal Bottom Trawl



NEUS Atlantis – Results Summary

- In the final model run, were within limits of tolerance (model cf. data) for:
- Biomass- 44 out of 45 spp groups
- Catch – 26 out of 35 targeted spp
- Catch per fleet - 27 out of 35 targeted spp
- Effort – 16 out of 18 fleets

NEUS Atlantis – Results Summary

- At different levels of tuning, the results diverged more from the previous 'finished' versions.
  - i.e., dynamic effort matched a bit less precisely than dynamic catch + fixed effort, etc.
- The species/gears that fall outside of our limits of tolerance did so because:
  - Atlantis may not properly handle the fisheries for those groups
  - We may not have good data for those groups/fisheries (not enough data, misreported, etc.)
- In general, those species that we best modeled where those with the most confident data and were the most important (ecologically) to the system

NEUS / Atlantis – Lessons Learned

- Multiple factors affect LMR and LMEs; *ergo,* need simultaneous evaluation/examination
- Can't overlook the role of nutrients, physics, PP, 2P in LMEs and for producing LMR
  - It takes an ecosystem to grow a fish
  - It takes the right kind of ecosystem to grow bigger fish
- It's all about tradeoffs
  - We can't optimize everything

NEUS / Atlantis – Lessons Learned

- Patterns are detectable from complex bio-physical systems
- Calibrated Prediction is possible for LMEs, now
  - Precision of those predictions vs. accuracy
- Simple LMR mgt options are usually better

- Scenario test next- stay tuned!

“We are confronted with insurmountable opportunities."

-Pogo