Model Evaluations of MLPA North Central Coast Regional Stakeholder Group Marine Protected Area Proposals (March 2008)

"Modeling Work Group" of the
MLPA Master Plan Science Advisory Team (SAT)

MLPA I-Team staff, Bjorkstedt, Botsford, Costello, Gaines, Hilborn, Walters, White

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Why models help inform good decisions

- How will we know if a given MPA network achieves goals of MLPA?
- Initial models generated size/spacing guidelines
- Refine/extend using best available science to:
  - Inform initial MPA networks
  - Evaluate and help improve on stakeholder proposals
  - Inform tradeoffs inherent in a given MPA proposal
  - Compare across proposals
  - Inform monitoring
  - Inform management changes outside MPAs

Focusing on two models

- Initially 4 models (Botsford, Walters, Costello, Hilborn)
- Condensed into 2 models:
  - UC Davis (UCD): focused on sustainability, current status of stocks as predictor of future, considers species individually
  - EDOM: focused on fleet dynamics, economic returns, optimization, multi-species fisheries
- Models have been vetted with SAT, inputs are consistent

Basic model features

- Spatially-explicit habitat data, MPA locations, larval dispersal, adult home range, dynamics to equilibrium
- Predict equilibrium spatial larval supply, biomass, harvest

- Critical question: Future management in open areas?
- Scenarios considered:
  1. Conservative (both models)
  2. Maximum Sustainable Yield (MSY) -type (both models)
  3. Unsuccessful (both models)
  4. Current management as predictor of future (UCD only)
  5. Spatially optimized for economic returns (EDOM only)

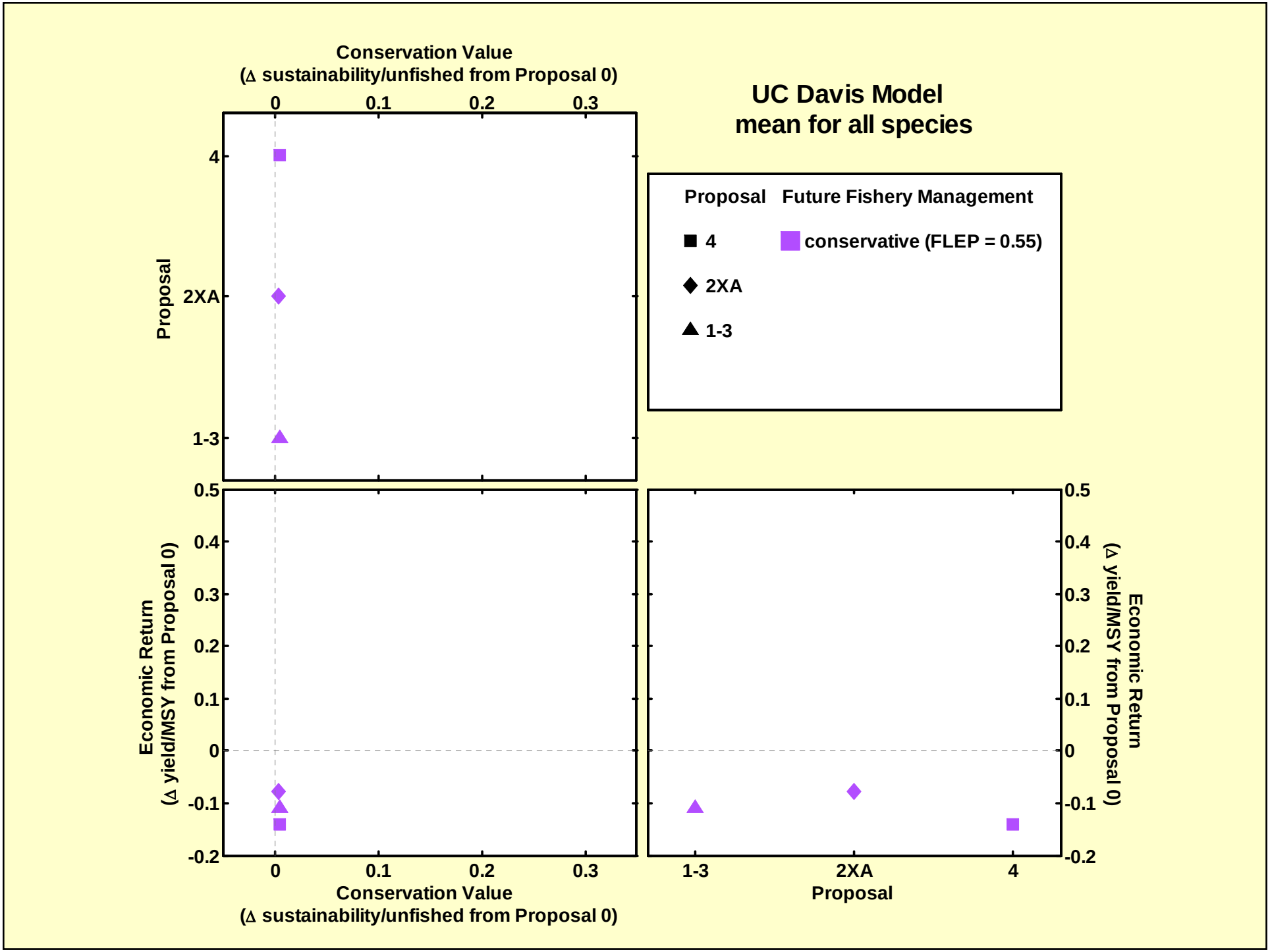
Proposal evaluations

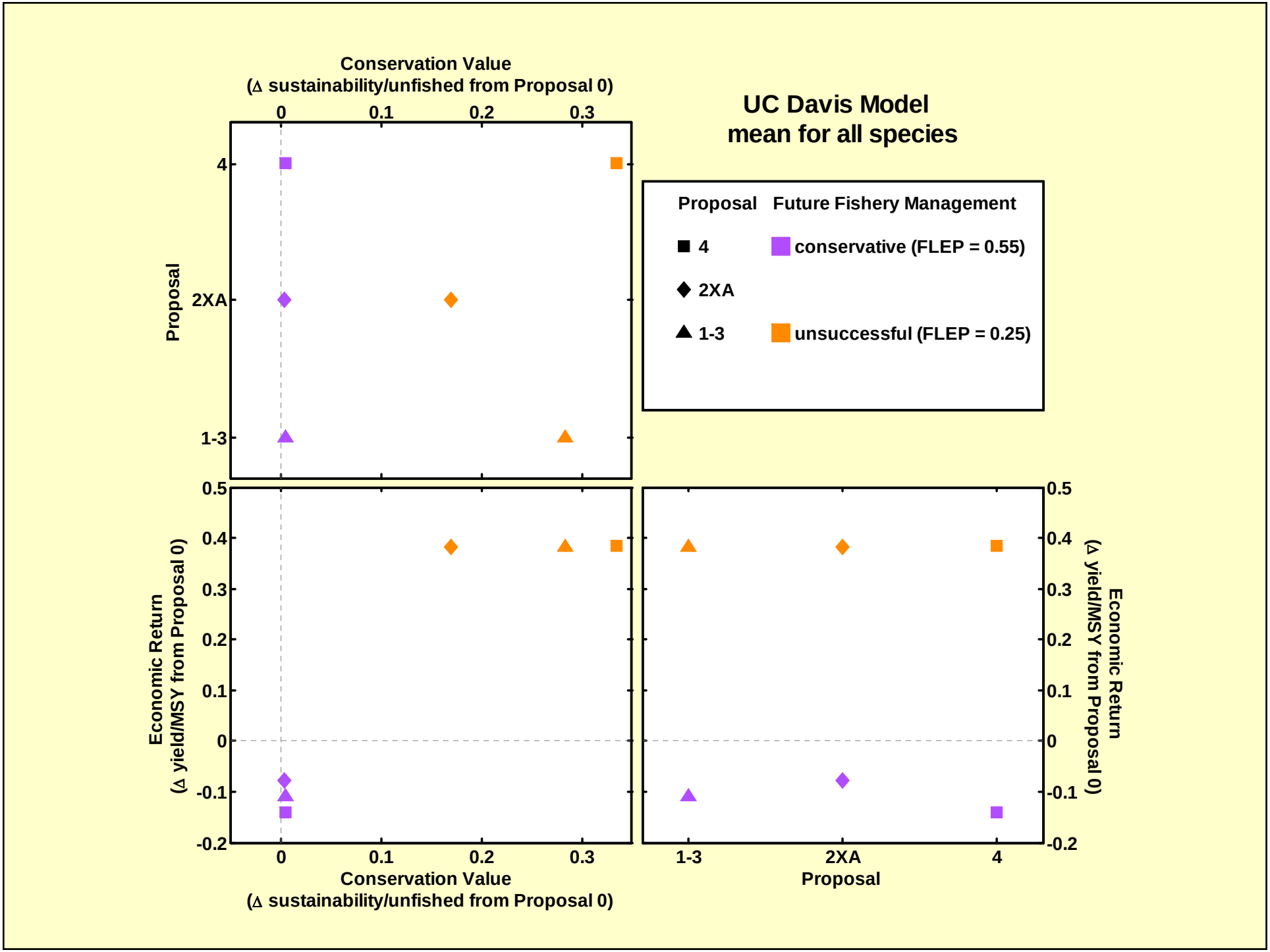
- Four evaluations for each proposal
  1. Predicted spatial effects on biomass for range of species
  2. Predicted spatial effects on yield and profits
  3. Tradeoff between yield and biomass
  4. Sensitivity of predictions to
     - Larval dispersal assumptions
     - Adult home range assumptions
     - Future fishing mortality (level and distribution)

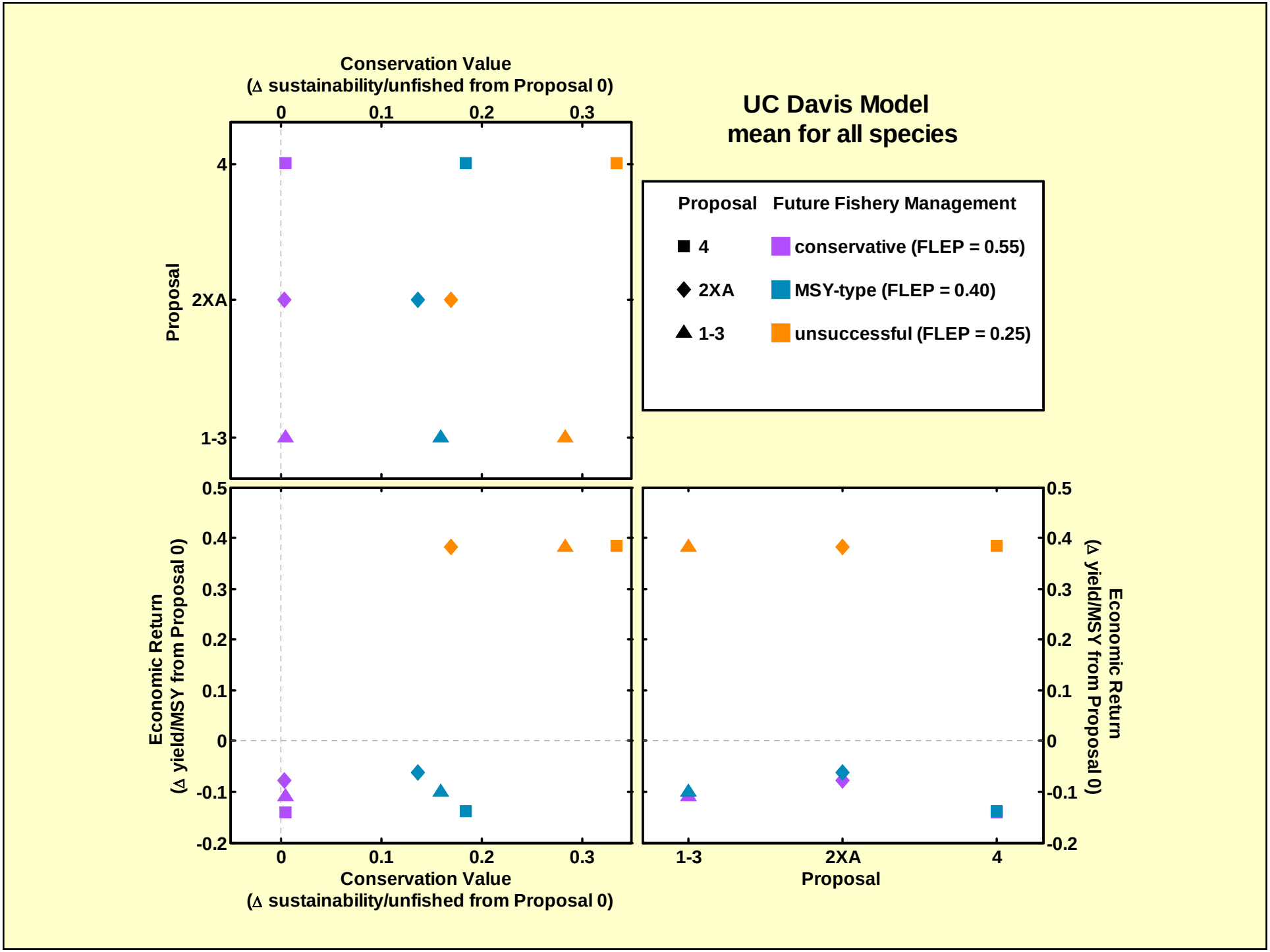
An initial observation

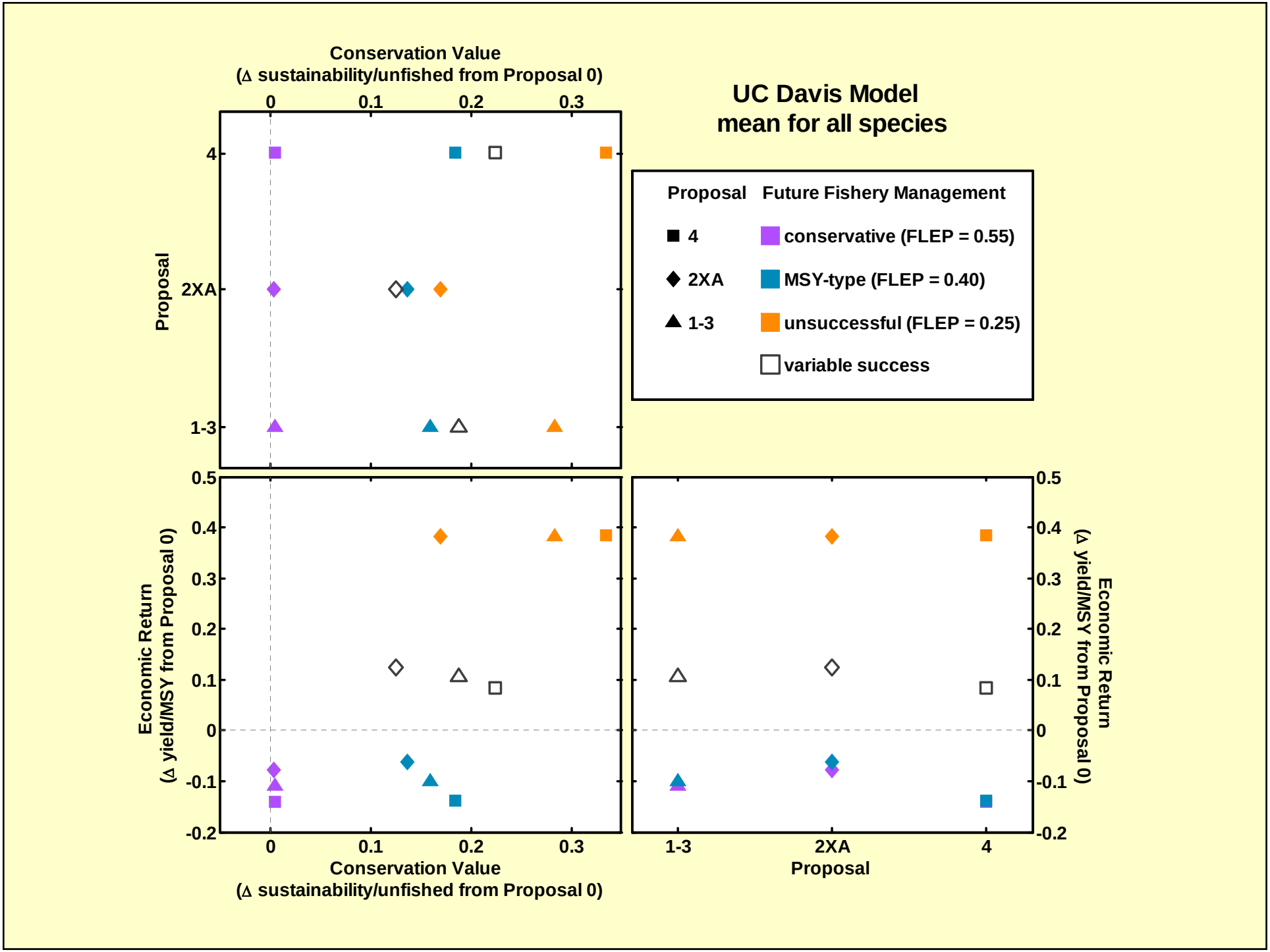
- Proposals have converged significantly in both economic and conservation dimensions

- In many cases assumptions about fishing outside dwarf differences among proposals


Conservation Value
(Δ sustainability/unfished from Proposal 0)
0
0.1
0.2
0.3
Proposal
4
2XA
1-3
UC Davis Model
mean for all species
Proposal
Future Fishery Management
4
conservative (FLEP = 0.55)
2XA
1-3
Economic Return
(Δ yield/MSY from Proposal 0)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Conservation Value
(Δ sustainability/unfished from Proposal 0)
1-3
2XA
4
Proposal
Economic Return
(Δ yield/MSY from Proposal 0)

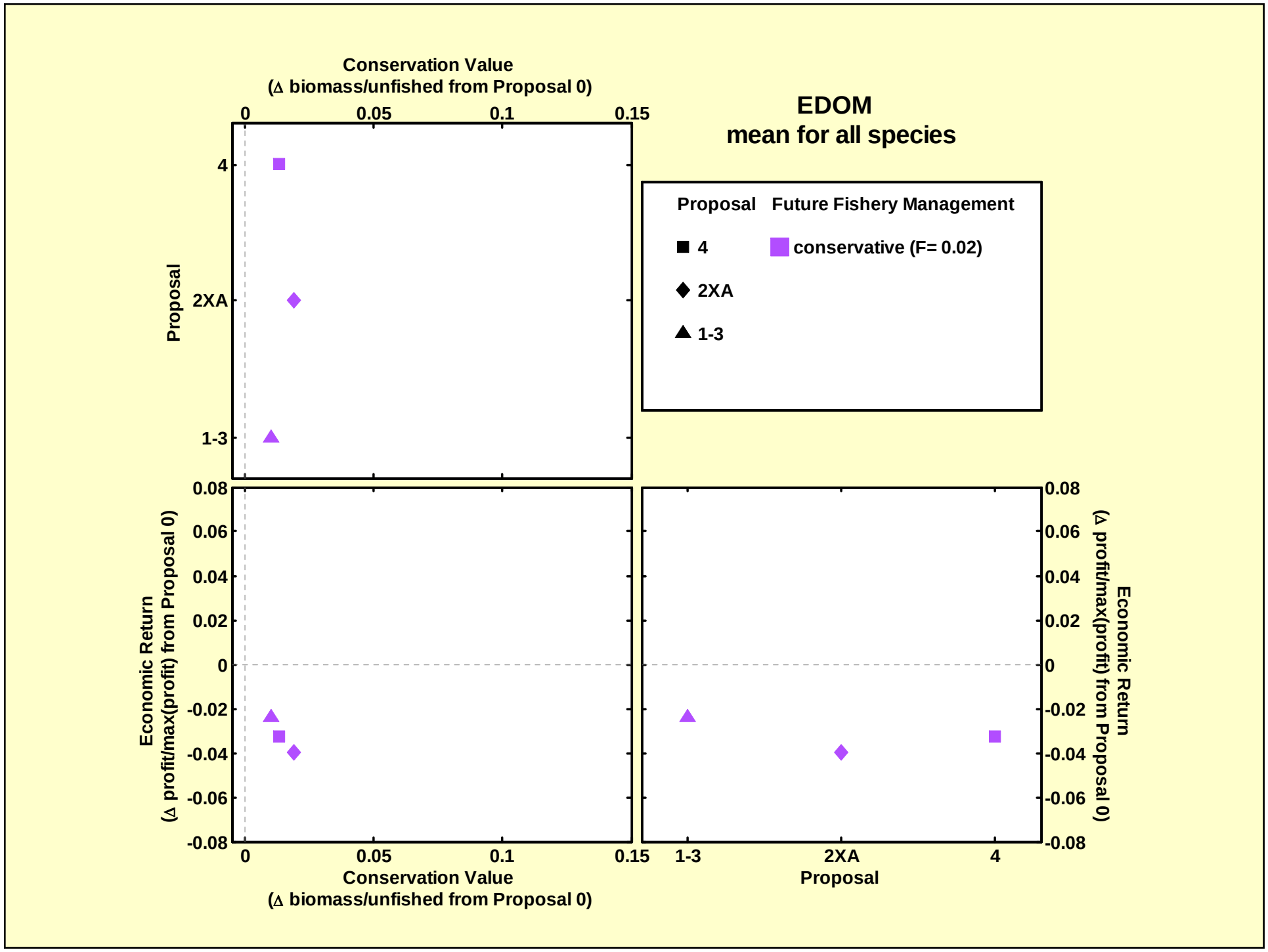

Conservation Value
(Δ sustainability/unfished from Proposal 0)
0
0.1
0.2
0.3
Proposal
4
2XA
1-3
UC Davis Model
mean for all species
Proposal
Future Fishery Management
4
conservative (FLEP = 0.55)
2XA
1-3
unsuccessful (FLEP = 0.25)
Economic Return
(Δ yield/MSY from Proposal 0)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Conservation Value
(Δ sustainability/unfished from Proposal 0)
1-3
2XA
4
Proposal
Economic Return
(Δ yield/MSY from Proposal 0)

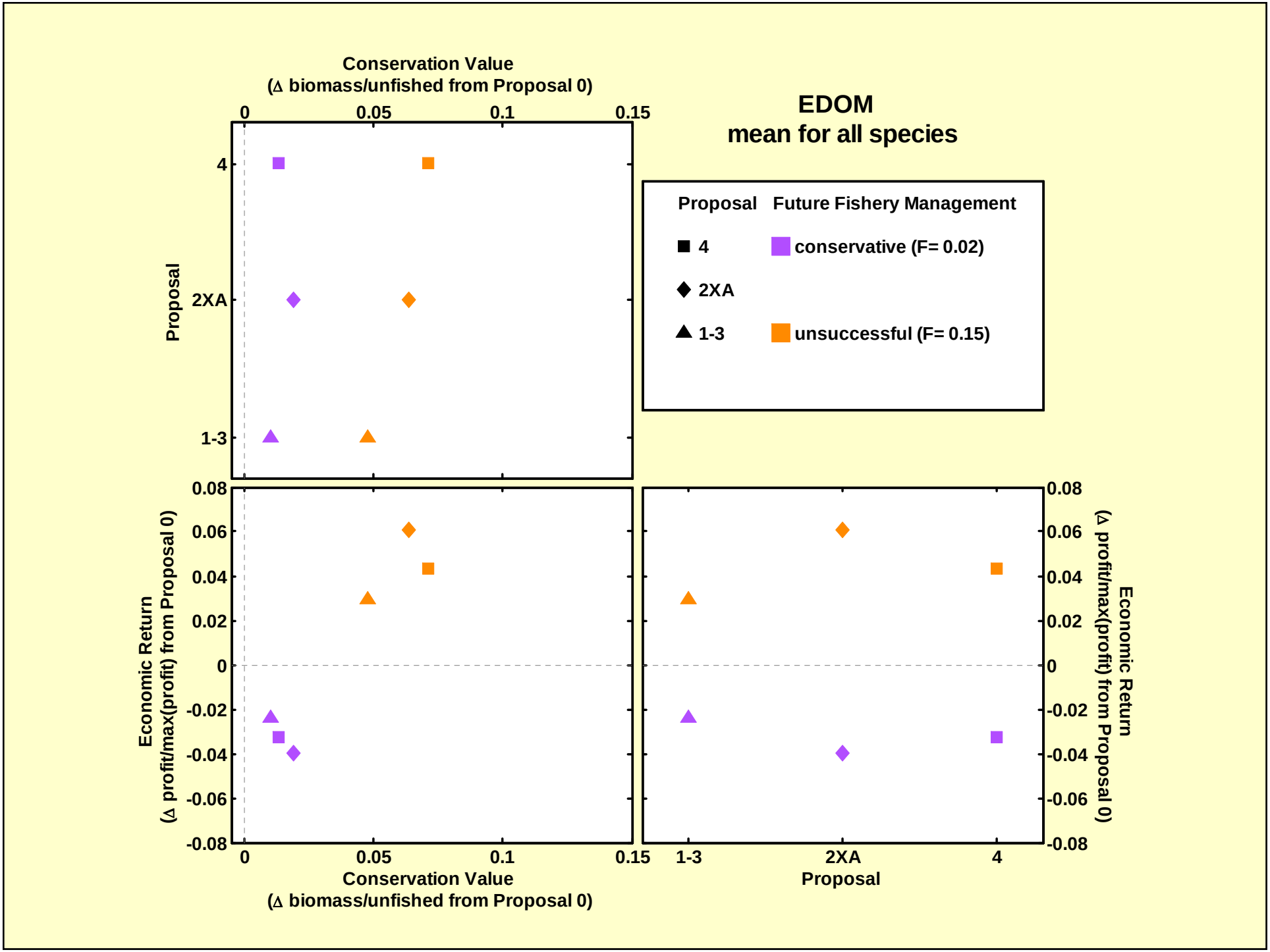

Conservation Value
(Δ sustainability/unfished from Proposal 0)
0
0.1
0.2
0.3
Proposal
4
2XA
1-3
UC Davis Model
mean for all species
Proposal
Future Fishery Management
4
2XA
1-3
conservative (FLEP = 0.55)
MSY-type (FLEP = 0.40)
unsuccessful (FLEP = 0.25)
Economic Return
(Δ yield/MSY from Proposal 0)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Conservation Value
(Δ sustainability/unfished from Proposal 0)
Proposal

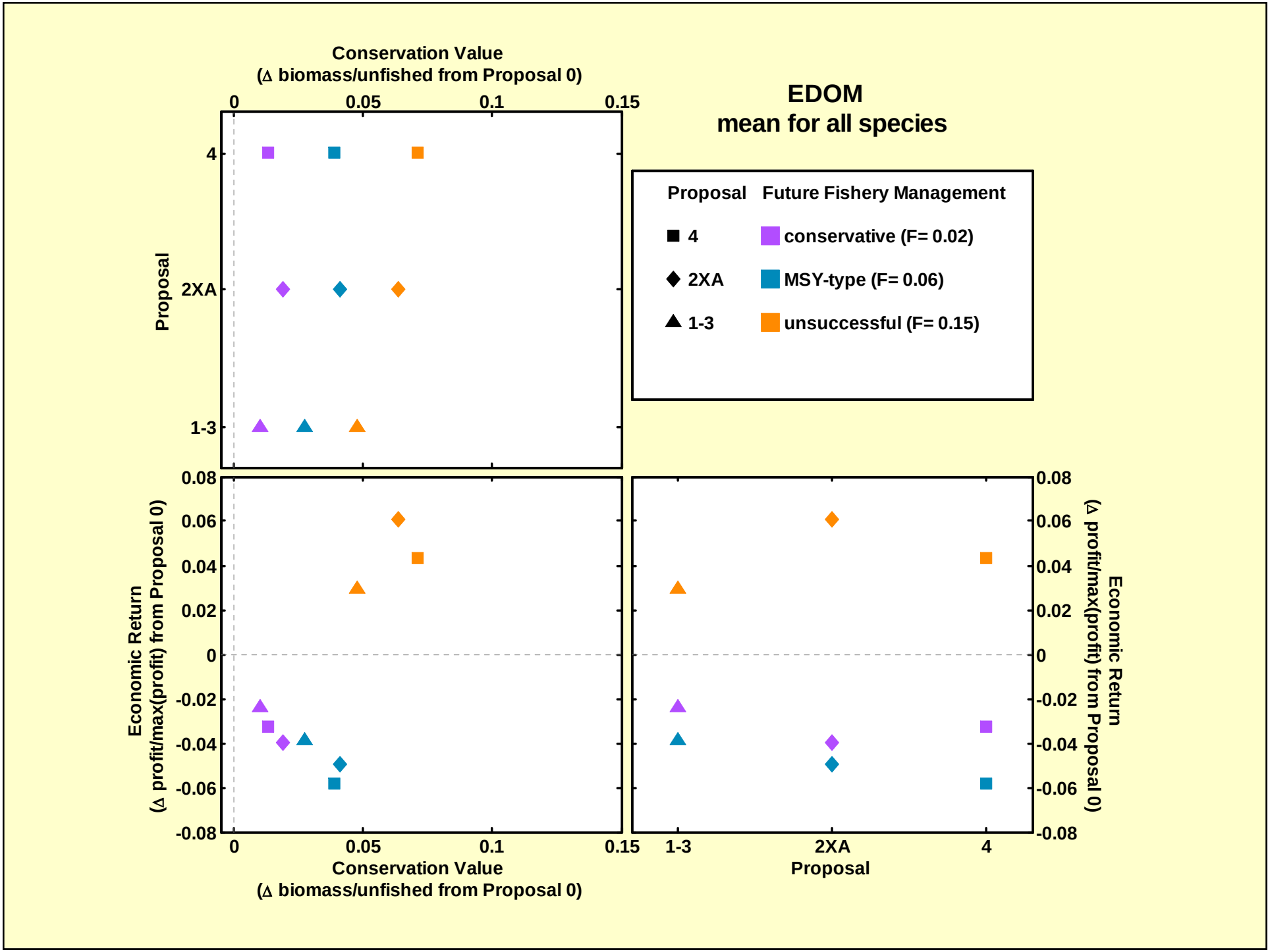

Conservation Value
(Δ sustainability/unfished from Proposal 0)
0
0.1
0.2
0.3
Proposal
4
2XA
1-3
UC Davis Model
mean for all species
Proposal
Future Fishery Management
4
conservative (FLEP = 0.55)
2XA
MSY-type (FLEP = 0.40)
1-3
unsuccessful (FLEP = 0.25)
variable success
Economic Return
(Δ yield/MSY from Proposal 0)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Conservation Value
(Δ sustainability/unfished from Proposal 0)
1-3
2XA
4
Proposal
Economic Return
(Δ yield/MSY from Proposal 0)

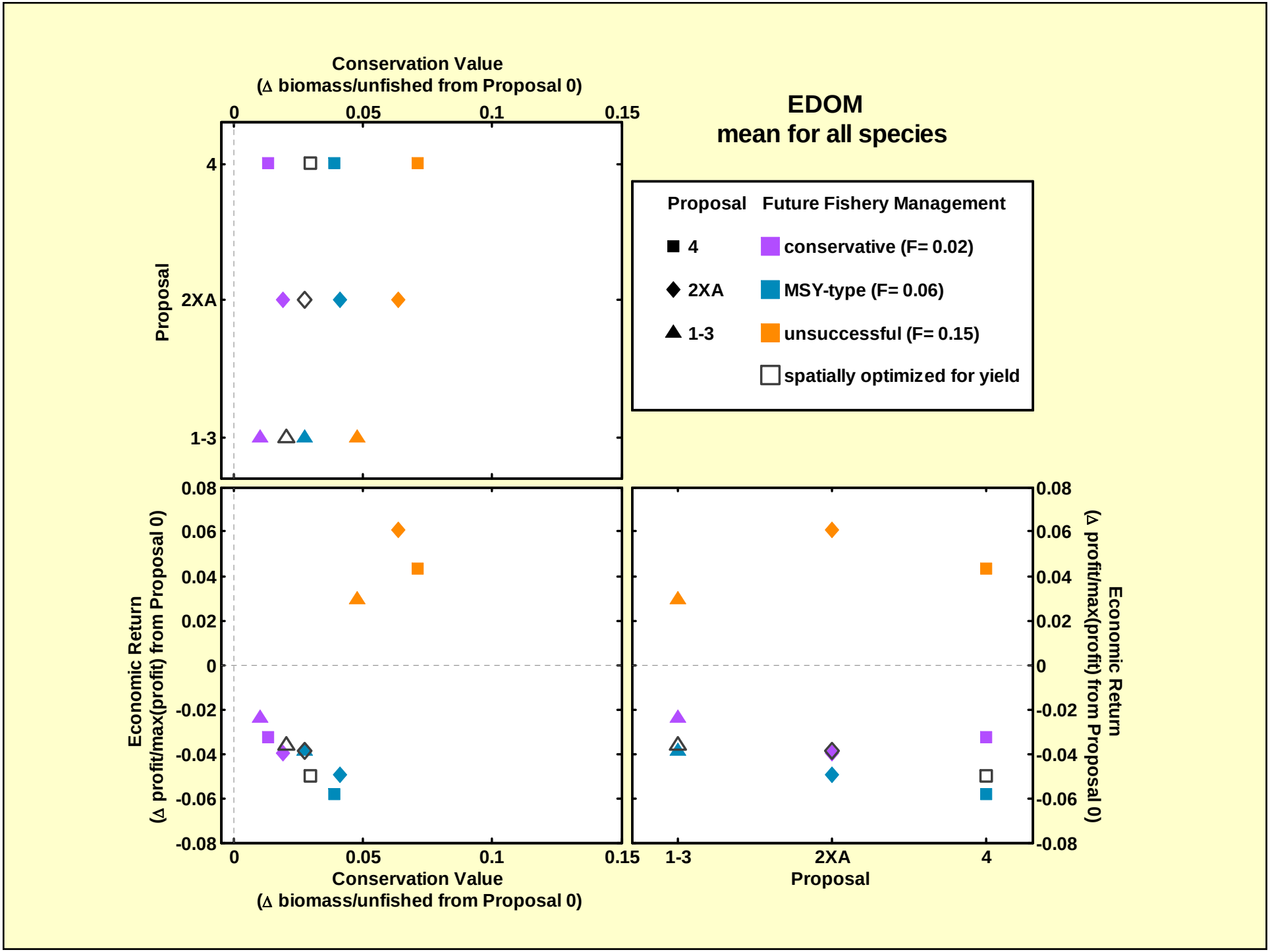
Summary of UC Davis model

- Ranking for conservation value (1 is best):
  - (1) Prop 4, (2) Prop 1-3, (3) Prop 2-XA
  - Differences tend to diminish as management outside becomes more conservative
  - If management very conservative, all proposals equal.
- Ranking for yield
  - (1) Prop 2-XA, (2) Prop 1-3, (3) Prop 4
  - If management very unsuccessful, all proposals equal


Conservation Value
(Δ biomass/unfished from Proposal 0)
0
0.05
0.1
0.15
Proposal
4
2XA
1-3
EDOM
mean for all species
Proposal
Future Fishery Management
4
conservative (F= 0.02)
2XA
1-3
Economic Return
(Δ profit/max(profit) from Proposal 0)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Conservation Value
(Δ biomass/unfished from Proposal 0)
Proposal
Economic Return
(Δ profit/max(profit) from Proposal 0)


Conservation Value
(Δ biomass/unfished from Proposal 0)
0
0.05
0.1
0.15
Proposal
4
2XA
1-3
EDOM
mean for all species
Proposal
Future Fishery Management
4
conservative (F= 0.02)
2XA
1-3
unsuccessful (F= 0.15)
Economic Return
(Δ profit/max(profit) from Proposal 0)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Conservation Value
(Δ biomass/unfished from Proposal 0)
1-3
2XA
4
Proposal
Economic Return
(Δ profit/max(profit) from Proposal 0)


Conservation Value
(Δ biomass/unfished from Proposal 0)
0
0.05
0.1
0.15
EDOM
mean for all species
Proposal
4
2XA
1-3
Proposal
Future Fishery Management
4
conservative (F= 0.02)
2XA
MSY-type (F= 0.06)
1-3
unsuccessful (F= 0.15)
Economic Return
(Δ profit/max(profit) from Proposal 0)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Conservation Value
(Δ biomass/unfished from Proposal 0)
1-3
2XA
4
Proposal
Economic Return
(Δ profit/max(profit) from Proposal 0)

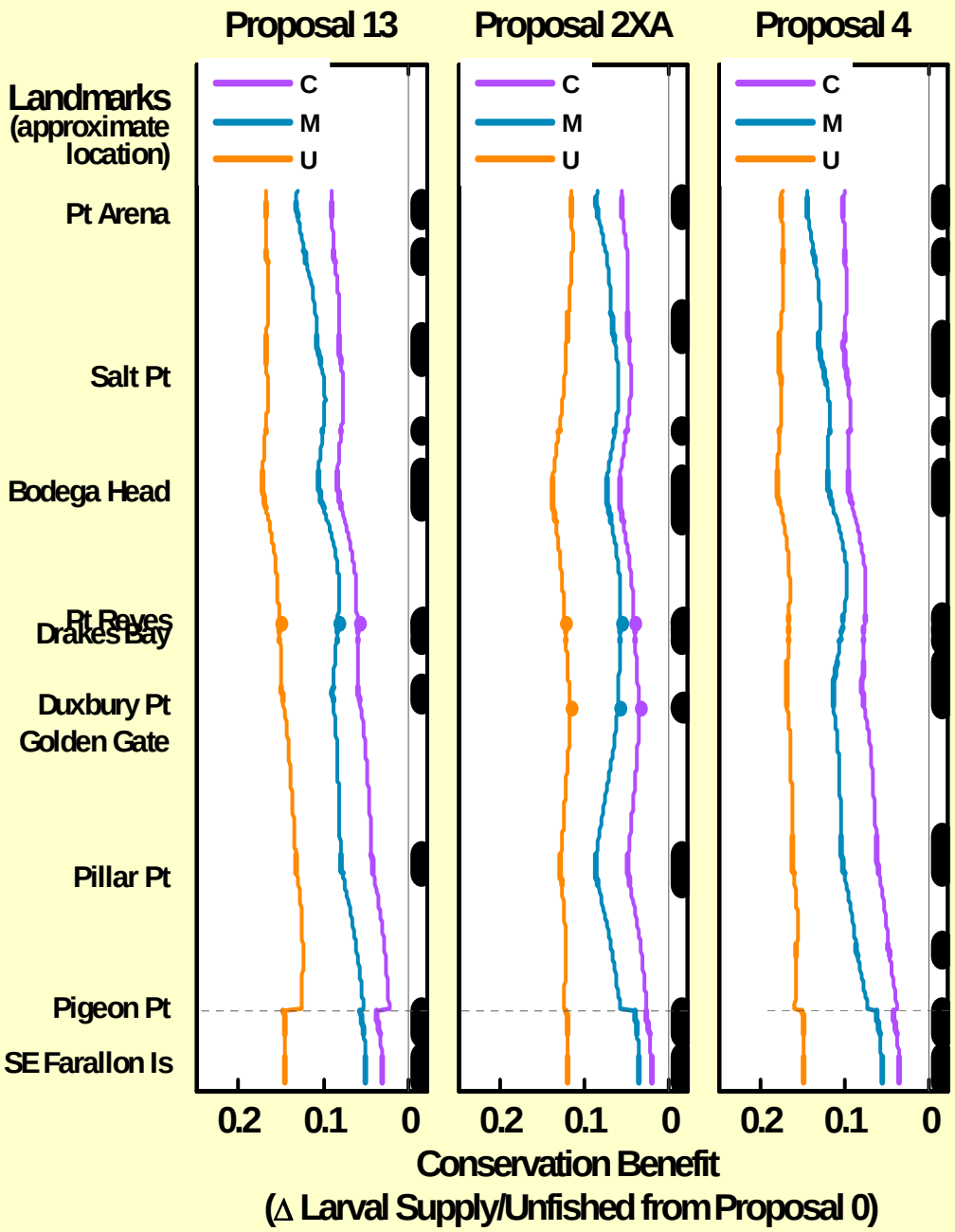

Conservation Value
(Δ biomass/unfished from Proposal 0)
0
0.05
0.1
0.15
EDOM
mean for all species
Proposal
4
2XA
1-3
Proposal
Future Fishery Management
4
conservative (F= 0.02)
2XA
MSY-type (F= 0.06)
1-3
unsuccessful (F= 0.15)
spatially optimized for yield
Economic Return
(Δ profit/max(profit) from Proposal 0)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Conservation Value
(Δ biomass/unfished from Proposal 0)
Proposal

Summary of EDOM Model

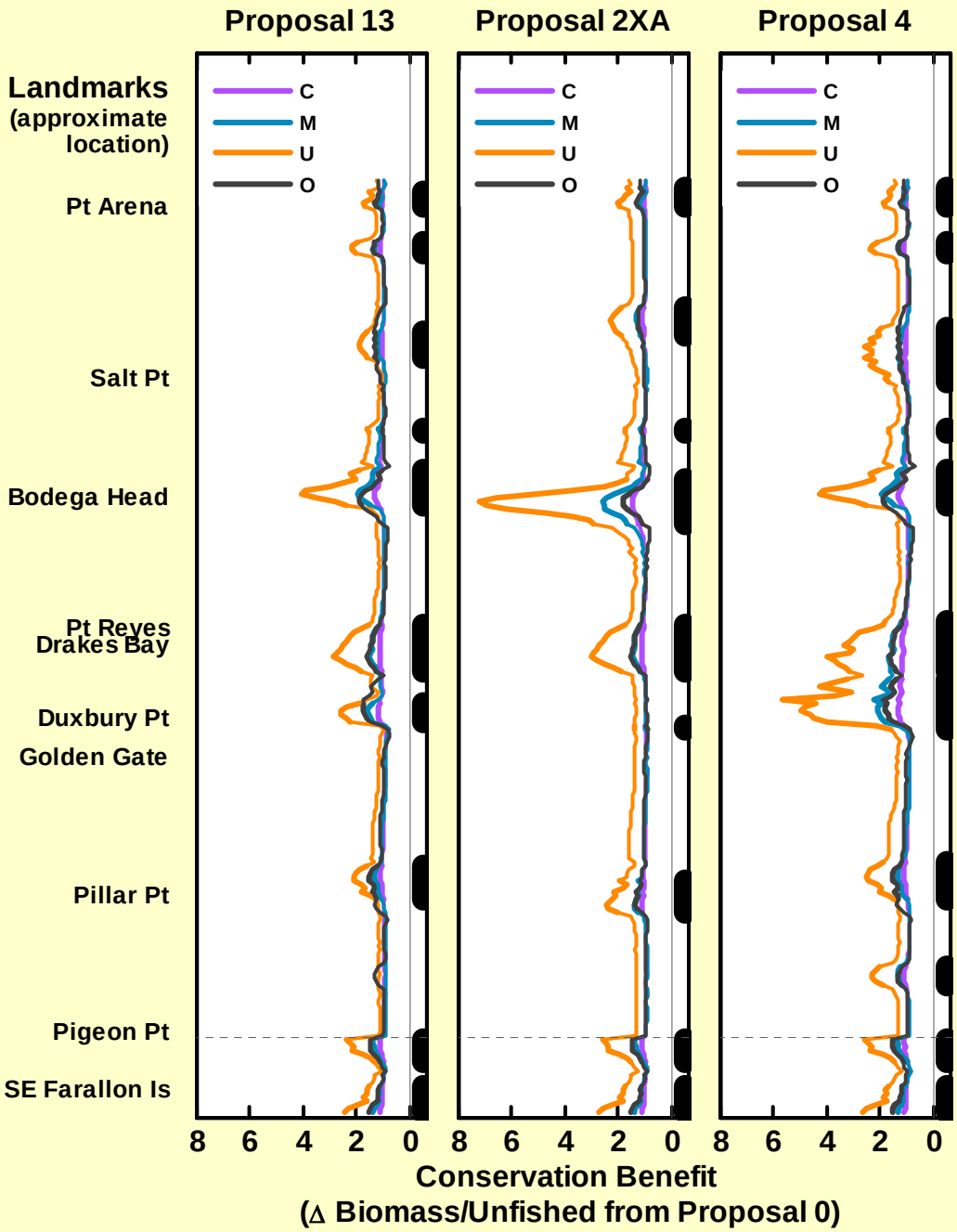
- Ranking for conservation value – depends on future fishery management scenario:
  - Conservative/MSY: (1) Prop 2-XA, (2) Prop 4, (3) Prop 1-3
  - Optimize Profit/Unsuccessful: (1) Prop 4, (2) Prop 2-XA, (3) Prop 1-3
- Ranking for yield –depends on future fishery management scenario:
  - Conservative: (1) Prop 1-3, (2) Prop 4, (3) Prop 2-XA
  - MSY-type/Optimal: (1) Prop 1-3, (2) Prop 2-XA, (3) Prop 4
  - Unsuccessful: (1) Prop 2-XA, (2) Prop 4, (3) Prop 1-3

Spatial results

- What are spatial implications for conservation?
- MPA size and placement interacts with habitat, dispersal, home ranges to create complex spatial consequences.
- Use spatially-explicit models to predict:
  - Larval supply across space (UCD Model)
  - Biomass of modeled fish species across space (EDOM Model)



- Larval Supply tends to increase in MPAs
- This effect is similar across proposals, but some spatial differences
- Largest change (relative to Proposal 0) occurs when future fishery management is "unsuccessful"
- How will changes in larval supply affect biomass of fish we are trying to conserve?



- Use EDOM model to predict biomass across space

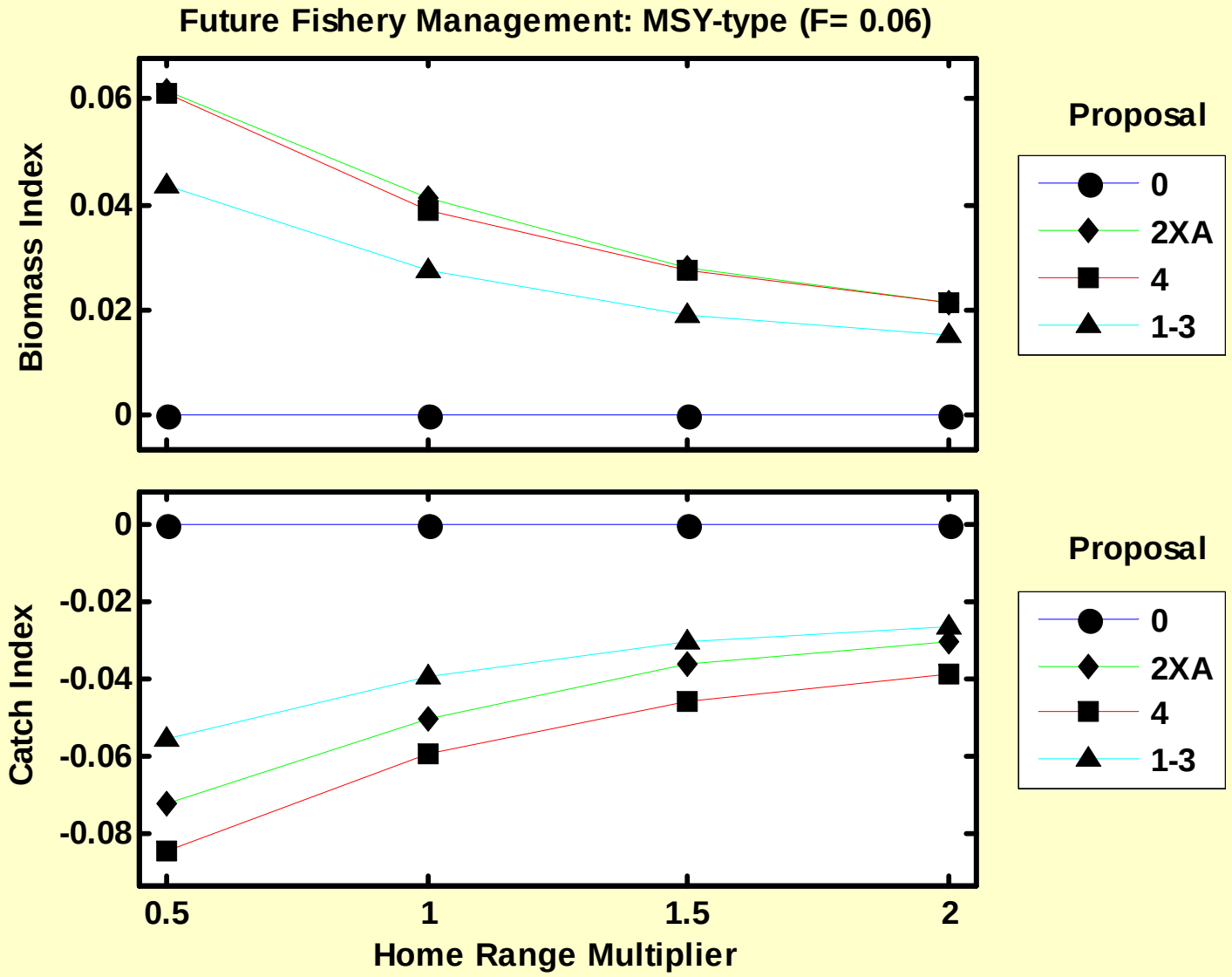
- Notice large biomass increases inside MPAs
- Generates predictions for monitoring

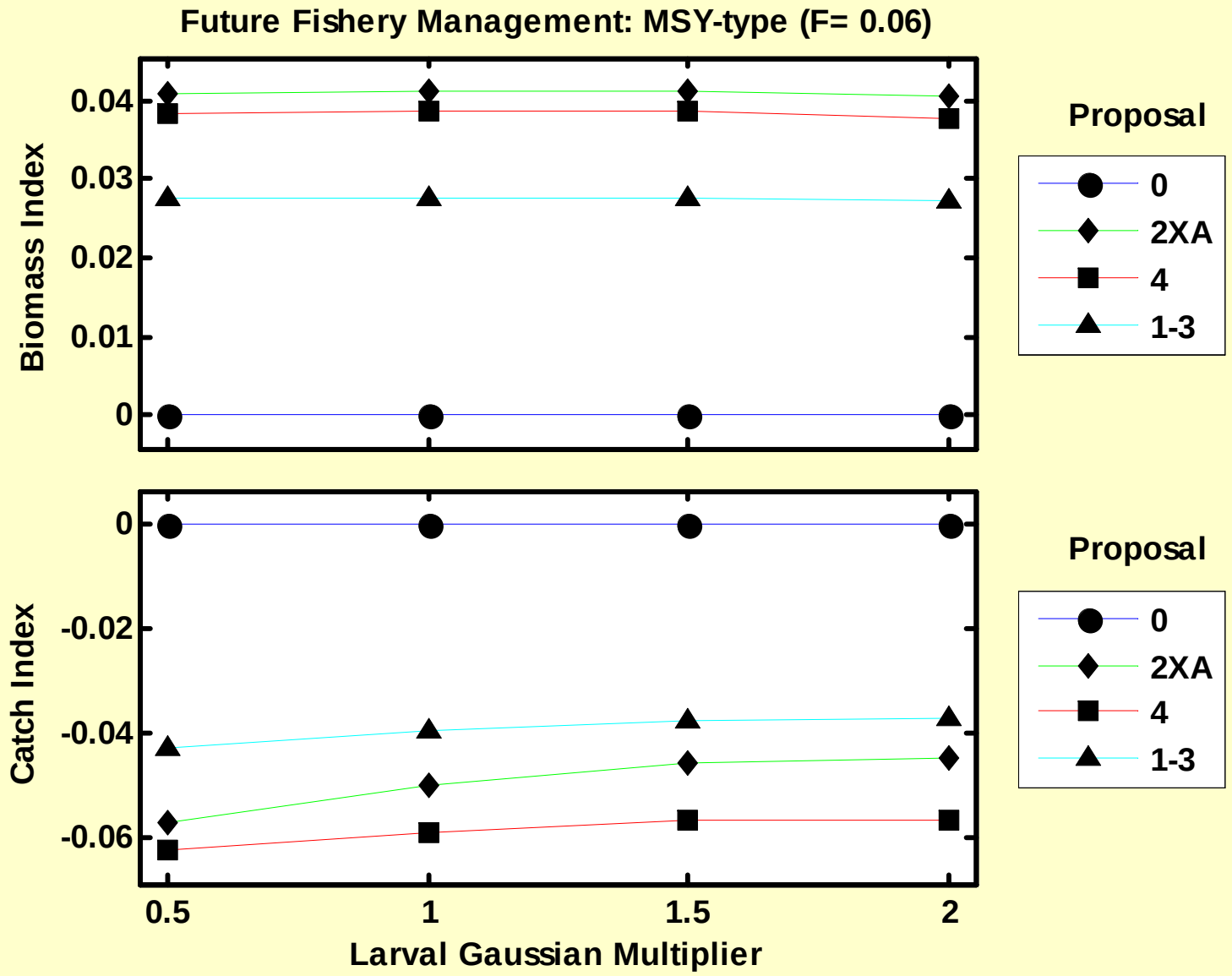
- Largest change (relative to Proposal 0) occurs when future fishery management is "unsuccessful"

Sensitivity Analysis

- Larval dispersal distance
- Home range of adults

- How sensitive is biomass prediction?
- How sensitive is yield prediction?
- How sensitive is ranking of proposals?


Future Fishery Management: MSY-type (F= 0.06)
Biomass Index
0.06
0.04
0.02
0
Proposal
0
2XA
4
1-3
Catch Index
0
-0.02
-0.04
-0.06
-0.08
Proposal
0
2XA
4
1-3
0.5
1
1.5
2
Home Range Multiplier


Future Fishery Management: MSY-type (F= 0.06)
Biomass Index
0.04
0.03
0.02
0.01
0
Proposal
0
2XA
4
1-3
Catch Index
0
-0.02
-0.04
-0.06
Proposal
0
2XA
4
1-3
0.5
1
1.5
2
Larval Gaussian Multiplier

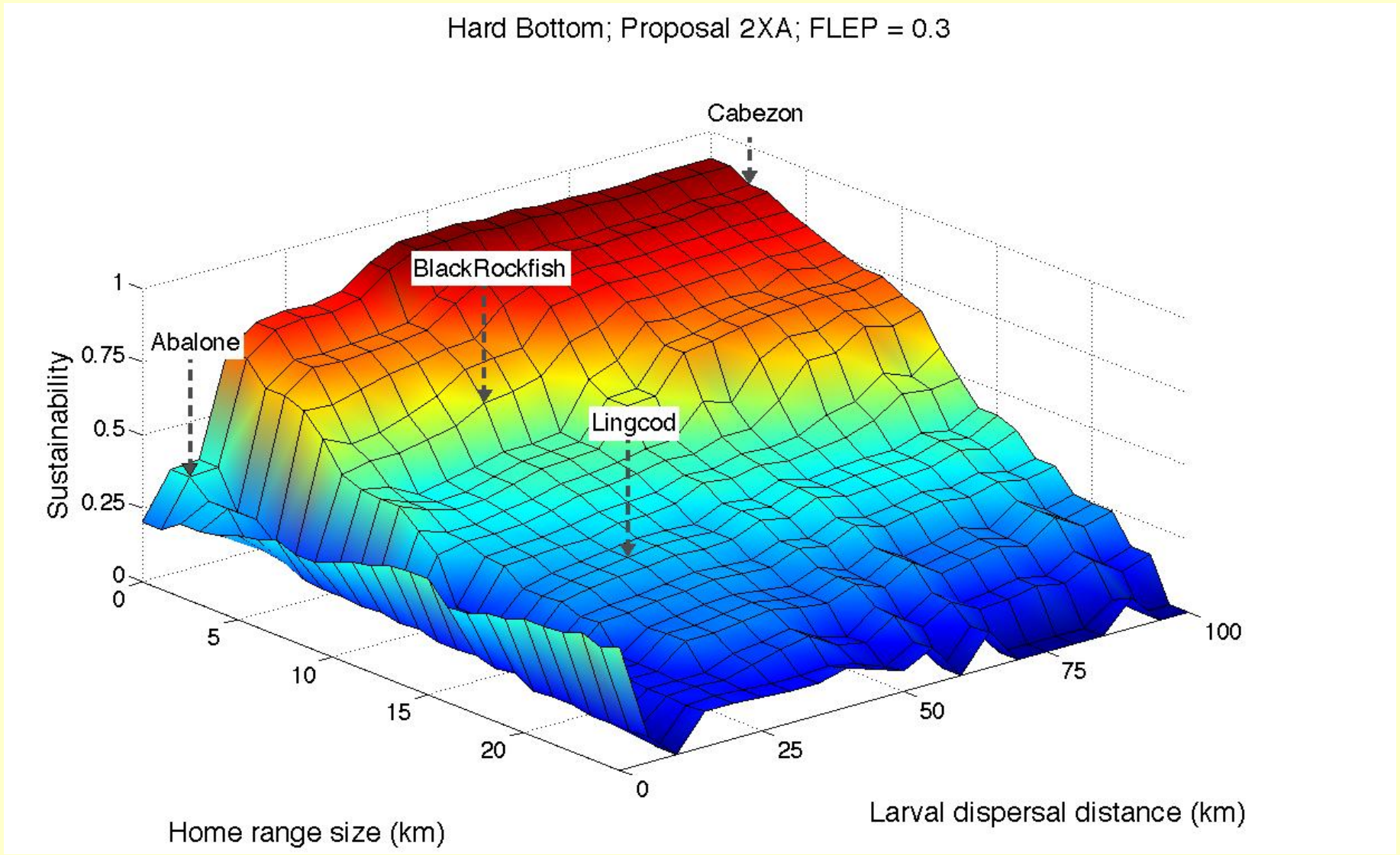
Summary of sensitivity analyses

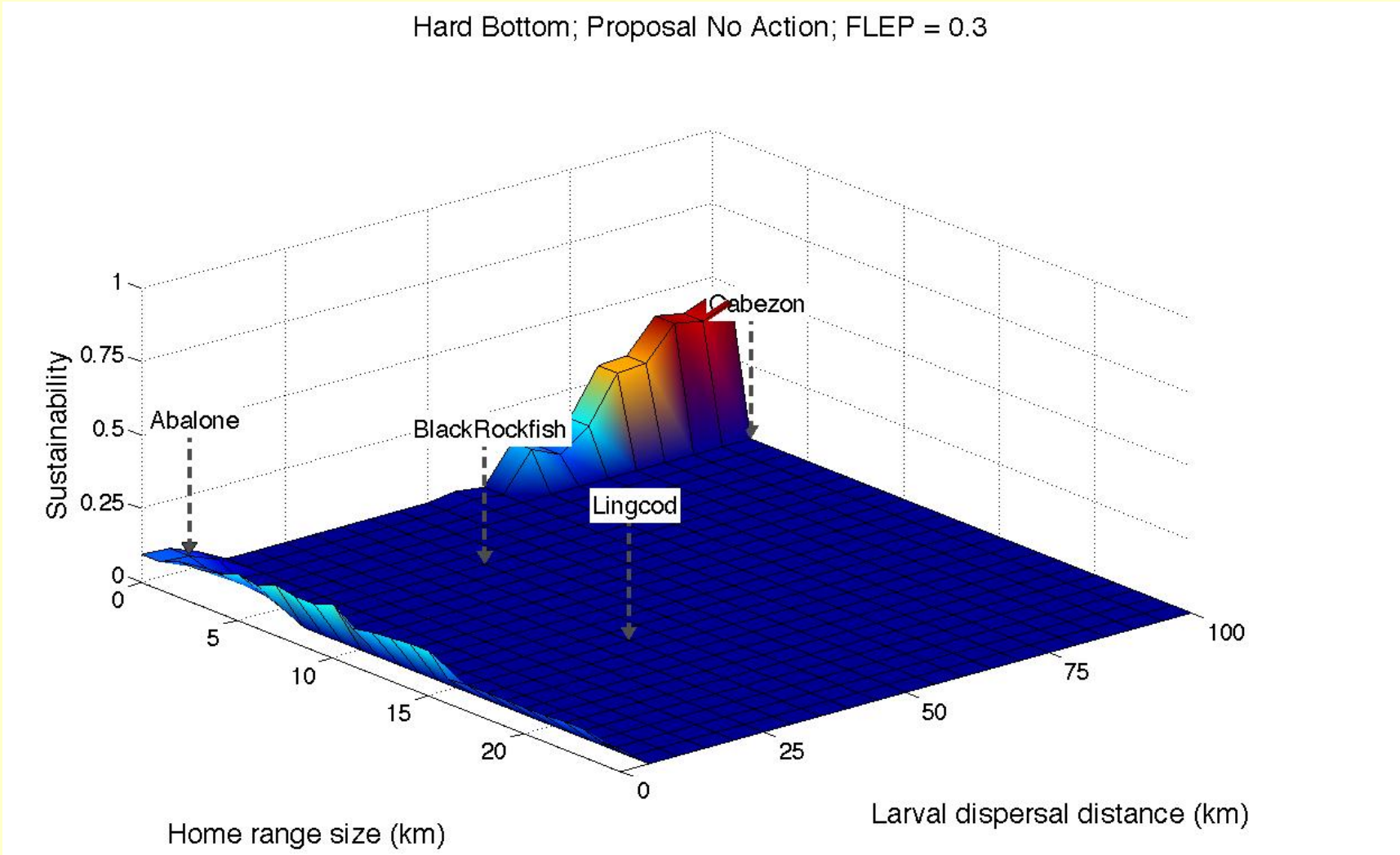
- Package performance is sensitive to home range assumptions, relatively insensitive to larval dispersal distance assumption.
- But, ranking of packages is insensitive to these multipliers
  - Conservation value as a metric of performance
  - Yield as a metric of performance

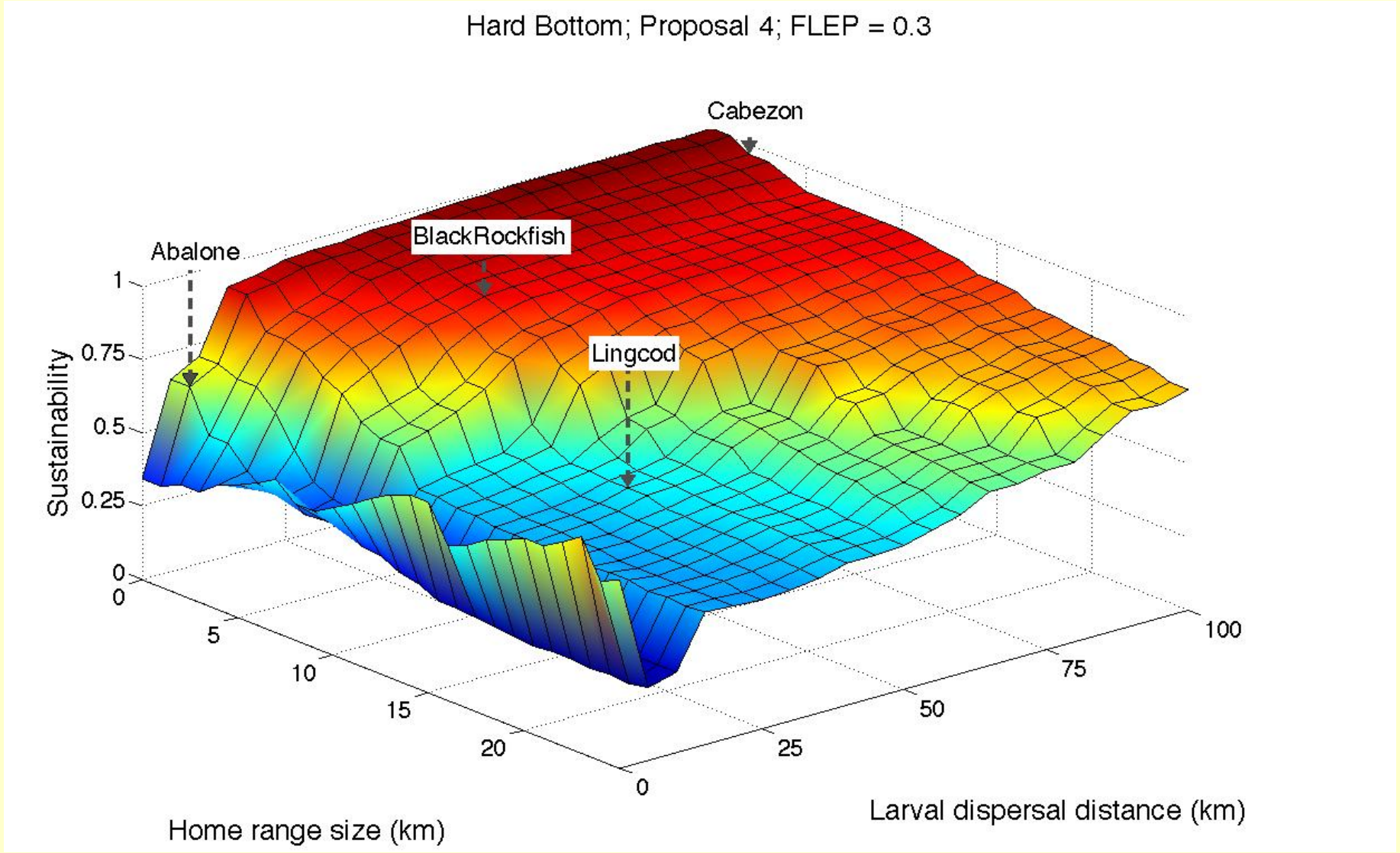
Surface plots

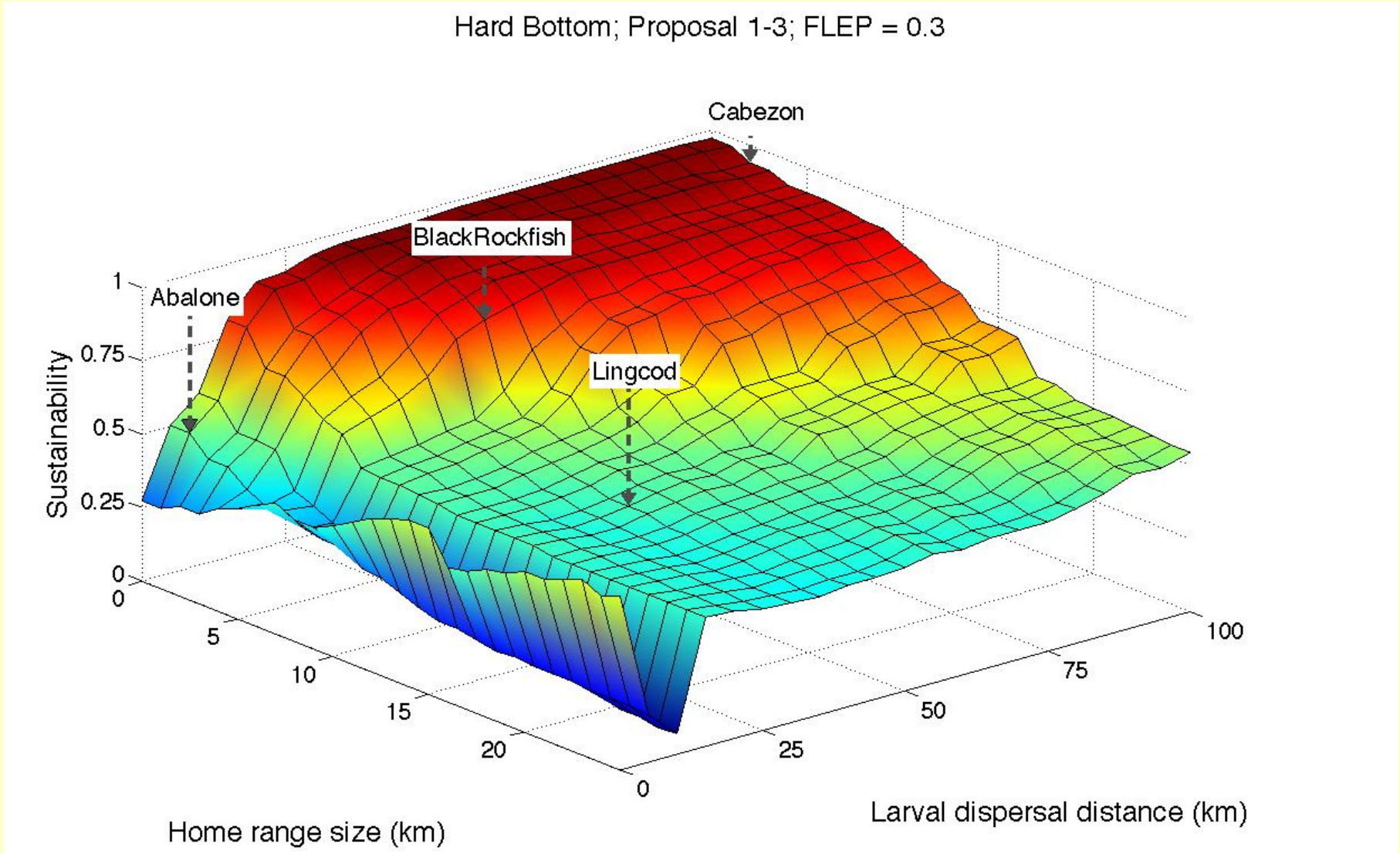
- How will each package affect species with other life-history traits?

- Set up “generic” model, assess conservation implications for a range of species types.


Hard Bottom; Proposal 2XA; FLEP = 0.3
Cabezon
BlackRockfish
Abalone
Lingcod
Sustainability
1
0.75
0.5
0.25
0
0
5
10
15
20
0
25
50
75
100
Home range size (km)
Larval dispersal distance (km)


Hard Bottom; Proposal No Action; FLEP = 0.3
Sustainability
1
0.75
0.5
0.25
0
Abalone
BlackRockfish
Cabezon
Lingcod
0
5
10
15
20
Home range size (km)
0
25
50
75
100
Larval dispersal distance (km)


Hard Bottom; Proposal 4; FLEP = 0.3
Cabezon
BlackRockfish
Abalone
Lingcod
Sustainability
1
0.75
0.5
0.25
0
0
5
10
15
20
0
25
50
75
100
Home range size (km)
Larval dispersal distance (km)


Hard Bottom; Proposal 1-3; FLEP = 0.3
Cabezon
BlackRockfish
Abalone
Lingcod
Sustainability
1
0.75
0.5
0.25
0
0
5
10
15
20
0
25
50
75
100
Home range size (km)
Larval dispersal distance (km)

Summary of surface plots

- Under Proposal 0, small range of species life histories that will be sustainable (under moderately unsuccessful mgt.)
- All proposals have generally good performance for range of life histories
- Some species may not benefit

A general recommendation for future use of models

- Integrate models more completely into planning process
  - Early in the process, possibly as tools for stakeholders
  - Integral part of evaluation process
- Continue model development
  - Better represent population dynamics, larval dispersal, redistribution of fishing effort, system variability
  - Model calibration
- Continue to build on foundation of size/spacing guidelines